This Agreement (‘the Agreement’) is between the following parties:

on the one part,

the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

represented for the purposes of signature of this Agreement by Head of Unit, Executive Agency for Small and Medium-sized Enterprises (EASME), OPERATIONS, H2020 Environment & Resources, Arnoldas MILUKAS,

and

on the other part,

1. ‘the coordinator’:

ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG (AWI) DE2, established in AM HANDELSHAFEN 12, BREMERHAVEN 27570, Germany, VAT number DE114707273, represented for the purposes of signing the Agreement by Head of Research Support Department, Lars HENNING

and the following other beneficiaries, if they sign their ‘Accession Form’ (see Annex 3 and Article 56):

2. BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION (BSC), E4A82CE203194C3C, established in Calle Jordi Girona 31, BARCELONA 08034, Spain, VAT number ESS0800099D,

3. EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS (ECMWF), established in SHINFIELD PARK, READING RG2 9AX, United Kingdom,

4. UNIVERSITETET I BERGEN (UiB), 874789542, established in Museplassen 1, BERGEN 5007, Norway, VAT number NO874789542MVA,

5. UNI RESEARCH AS (UNI RESEARCH) AS, 985827117, established in THORMOHLENS GATE 55, BERGEN 5008, Norway, VAT number NO985827117MVA,

6. METEOROLOGISK INSTITUTT (MET Norway), 971274042, established in HENRIK MOHNS PLASS 1, OSLO 0313, Norway, VAT number NO971274042MVA,

7. MET OFFICE (MET OFFICE), established in FitzRoy Road, EXETER EX1 3PB, United Kingdom, VAT number GB888805362,

8. UNIVERSITE CATHOLIQUE DE LOUVAIN (UCL) BE6, 419052272, established in PLACE DE L UNIVERSITE 1, LOUVAIN LA NEUVE 1348, Belgium, VAT number BE0419052272,

1 Text in italics shows the options of the Model Grant Agreement that are applicable to this Agreement.
9. THE UNIVERSITY OF READING (UREAD) GB22, n/a, established in WHITEKNIGHTS CAMPUS WHITEKNIGHTS HOUSE, READING RG6 6AH, United Kingdom, VAT number GB200012659,

10. STOCKHOLMS UNIVERSITET (SU), 2021003062, established in Universitetsvaegen 10, STOCKHOLM 10691, Sweden, VAT number SE202100306201,

11. CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS (CNRS-GAME), 180089013, established in RUE MICHEL ANGE 3, PARIS 75794, France, VAT number FR40180089013,

12. CENTRE EUROPEEN DE RECHERCHE ET DE FORMATION AVANCEE EN CALCULScientifique (CERFACS) FR13, 407875434, established in Avenue Gaspard Coriolis 42, TOULOUSE 31057, France, VAT number FR26407875434,

13. NORDURSLODAGATTIN EHF (AP) EHF, 6203720569, established in KRISTNIBRAUT 87, REYKJAVIK 113, Iceland, VAT number IS11790,

14. UNIVERSITETET I TROMSOE (UiT) NO11, 970422528, established in HANSINE HANSENS VEG 14, TROMSO 9019, Norway, VAT number NO970422528MVA,

15. P.P. SHIRSHOV INSTITUTE OF OCEANOLOGY OF RUSSIAN ACADEMY OF SCIENCES (IORAS), 1037739013388, established in NAKHIMOVSKY PROSPECT 36, MOSKVA 117997, Russian Federation, VAT number RU7727083115, as ‘beneficiary not receiving EU funding’ (see Article 9),

16. THE FEDERAL STATE BUDGETARY INSTITUTION VOEIKOV MAIN GEOPHYSICAL OBSERVATORY (MGO), 1027801554604, established in KARBYSHEV 7, SAINT PETERSBURG 194021, Russian Federation, VAT number RU7802031006, as ‘beneficiary not receiving EU funding’ (see Article 9),

Unless otherwise specified, references to ‘beneficiary’ or ‘beneficiaries’ include the coordinator.

The parties referred to above have agreed to enter into the Agreement under the terms and conditions below.

By signing the Agreement or the Accession Form, the beneficiaries accept the grant and agree to implement it under their own responsibility and in accordance with the Agreement, with all the obligations and conditions it sets out.

The Agreement is composed of:

Terms and Conditions

Annex 1 Description of the action
Annex 2 Estimated budget for the action
Annex 3 Accession Forms
Annex 4 Model for the financial statements
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Annex 6 Model for the certificate on the methodology
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CHAPTER 1   GENERAL

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This Agreement sets out the rights and obligations and the terms and conditions applicable to the grant awarded to the beneficiaries for implementing the action set out in Chapter 2.

CHAPTER 2   ACTION

ARTICLE 2 — ACTION TO BE IMPLEMENTED

The grant is awarded for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and Linkages associated with ArctiC ClimATE change — APPLICATE’ (‘action’), as described in Annex 1.

ARTICLE 3 — DURATION AND STARTING DATE OF THE ACTION

The duration of the action will be 48 months as of 1 November 2016 (‘starting date of the action’).

ARTICLE 4 — ESTIMATED BUDGET AND BUDGET TRANSFERS

4.1 Estimated budget

The ‘estimated budget’ for the action is set out in Annex 2.

It contains the estimated eligible costs and the forms of costs, broken down by beneficiary (and linked third party) and budget category (see Articles 5, 6, and 14). It also contains the estimated costs of the beneficiaries not receiving EU funding (see Article 9).

4.2 Budget transfers

The estimated budget breakdown indicated in Annex 2 may be adjusted by transfers of amounts between beneficiaries or between budget categories (or both). This does not require an amendment according to Article 55, if the action is implemented as described in Annex 1.

However, the beneficiaries may not add costs relating to subcontracts not provided for in Annex 1, unless such additional subcontracts are approved by an amendment or in accordance with Article 13.

CHAPTER 3   GRANT

ARTICLE 5 — GRANT AMOUNT, FORM OF GRANT, REIMBURSEMENT RATES AND FORMS OF COSTS

5.1 Maximum grant amount

The ‘maximum grant amount’ is EUR 7,999,591.25 (seven million nine hundred and ninety nine thousand five hundred and ninety one EURO and twenty five eurocents).
5.2 Form of grant, reimbursement rates and forms of costs

The grant reimburses 100% of the action's eligible costs (see Article 6) (‘reimbursement of eligible costs grant’) (see Annex 2).

The estimated eligible costs of the action are EUR 8,715,066.25 (eight million seven hundred and fifteen thousand sixty six EURO and twenty five eurocents).

Eligible costs (see Article 6) must be declared under the following forms ('forms of costs'):

(a) for direct personnel costs:
   - as actually incurred costs (‘actual costs’) or
   - on the basis of an amount per unit calculated by the beneficiary in accordance with its usual cost accounting practices (‘unit costs’).

Personnel costs for SME owners or beneficiaries that are natural persons not receiving a salary (see Article 6.2, Points A.4 and A.5) must be declared on the basis of the amount per unit set out in Annex 2 (unit costs);

(b) for direct costs for subcontracting: as actually incurred costs (actual costs);

(c) for direct costs of providing financial support to third parties: not applicable;

(d) for other direct costs: as actually incurred costs (actual costs);

(e) for indirect costs: on the basis of a flat-rate applied as set out in Article 6.2, Point E (‘flat-rate costs’);

(f) specific cost category(ies): not applicable.

5.3 Final grant amount — Calculation

The ‘final grant amount’ depends on the actual extent to which the action is implemented in accordance with the Agreement’s terms and conditions.

This amount is calculated by the Agency — when the payment of the balance is made (see Article 21.4) — in the following steps:

Step 1 – Application of the reimbursement rates to the eligible costs

Step 2 – Limit to the maximum grant amount

Step 3 – Reduction due to the no-profit rule

Step 4 – Reduction due to improper implementation or breach of other obligations

5.3.1 Step 1 — Application of the reimbursement rates to the eligible costs

The reimbursement rate(s) (see Article 5.2) are applied to the eligible costs (actual costs, unit costs and flat-rate costs; see Article 6) declared by the beneficiaries and linked third parties (see Article 20) and approved by the Agency (see Article 21).
5.3.2 Step 2 — Limit to the maximum grant amount

If the amount obtained following Step 1 is higher than the maximum grant amount set out in Article 5.1, it will be limited to the latter.

5.3.3 Step 3 — Reduction due to the no-profit rule

The grant must not produce a profit.

‘Profit’ means the surplus of the amount obtained following Steps 1 and 2 plus the action’s total receipts, over the action’s total eligible costs.

The ‘action’s total eligible costs’ are the consolidated total eligible costs approved by the Agency.

The ‘action’s total receipts’ are the consolidated total receipts generated during its duration (see Article 3).

The following are considered receipts:

(a) income generated by the action; if the income is generated from selling equipment or other assets purchased under the Agreement, the receipt is up to the amount declared as eligible under the Agreement;

(b) financial contributions given by third parties to the beneficiary or to a linked third party specifically to be used for the action, and

(c) in-kind contributions provided by third parties free of charge and specifically to be used for the action, if they have been declared as eligible costs.

The following are however not considered receipts:

(a) income generated by exploiting the action’s results (see Article 28);

(b) financial contributions by third parties, if they may be used to cover costs other than the eligible costs (see Article 6);

(c) financial contributions by third parties with no obligation to repay any amount unused at the end of the period set out in Article 3.

If there is a profit, it will be deducted from the amount obtained following Steps 1 and 2.

5.3.4 Step 4 — Reduction due to improper implementation or breach of other obligations — Reduced grant amount — Calculation

If the grant is reduced (see Article 43), the Agency will calculate the reduced grant amount by deducting the amount of the reduction (calculated in proportion to the improper implementation of the action or to the seriousness of the breach of obligations in accordance with Article 43.2) from the maximum grant amount set out in Article 5.1.

The final grant amount will be the lower of the following two:
the amount obtained following Steps 1 to 3 or
- the reduced grant amount following Step 4.

5.4 Revised final grant amount — Calculation

If — after the payment of the balance (in particular, after checks, reviews, audits or investigations; see Article 22) — the Agency rejects costs (see Article 42) or reduces the grant (see Article 43), it will calculate the ‘revised final grant amount’ for the beneficiary concerned by the findings.

This amount is calculated by the Agency on the basis of the findings, as follows:

- in case of rejection of costs: by applying the reimbursement rate to the revised eligible costs approved by the Agency for the beneficiary concerned;
- in case of reduction of the grant: by calculating the concerned beneficiary’s share in the grant amount reduced in proportion to its improper implementation of the action or to the seriousness of its breach of obligations (see Article 43.2).

In case of rejection of costs and reduction of the grant, the revised final grant amount for the beneficiary concerned will be the lower of the two amounts above.

ARTICLE 6 — ELIGIBLE AND INELIGIBLE COSTS

6.1 General conditions for costs to be eligible

‘Eligible costs’ are costs that meet the following criteria:

(a) for actual costs:

(i) they must be actually incurred by the beneficiary;

(ii) they must be incurred in the period set out in Article 3, with the exception of costs relating to the submission of the periodic report for the last reporting period and the final report (see Article 20);

(iii) they must be indicated in the estimated budget set out in Annex 2;

(iv) they must be incurred in connection with the action as described in Annex 1 and necessary for its implementation;

(v) they must be identifiable and verifiable, in particular recorded in the beneficiary’s accounts in accordance with the accounting standards applicable in the country where the beneficiary is established and with the beneficiary’s usual cost accounting practices;

(vi) they must comply with the applicable national law on taxes, labour and social security, and

(vii) they must be reasonable, justified and must comply with the principle of sound financial management, in particular regarding economy and efficiency;

(b) for unit costs:
(i) they must be calculated as follows:

\[
\text{amounts per unit set out in Annex 2 or calculated by the beneficiary in accordance with its usual}
\]

\[
\text{cost accounting practices (see Article 6.2, Point A)}
\]

\[
\text{multiplied by}
\]

\[
\text{the number of actual units};
\]

(ii) the number of actual units must comply with the following conditions:

- the units must be actually used or produced in the period set out in Article 3;
- the units must be necessary for implementing the action or produced by it, and
- the number of units must be identifiable and verifiable, in particular supported by records
  and documentation (see Article 18);

(c) for flat-rate costs:

(i) they must be calculated by applying the flat-rate set out in Annex 2, and

(ii) the costs (actual costs or unit costs) to which the flat-rate is applied must comply with the
  conditions for eligibility set out in this Article.

6.2 Specific conditions for costs to be eligible

Costs are eligible if they comply with the general conditions (see above) and the specific conditions
set out below for each of the following budget categories:

A. direct personnel costs;
B. direct costs of subcontracting;
C. not applicable;
D. other direct costs;
E. indirect costs;
F. not applicable.

‘Direct costs’ are costs that are directly linked to the action implementation and can therefore be
attributed to it directly. They must not include any indirect costs (see Point E below).

‘Indirect costs’ are costs that are not directly linked to the action implementation and therefore cannot
be attributed directly to it.

A. Direct personnel costs

Types of eligible personnel costs

A.1 Personnel costs are eligible, if they are related to personnel working for the beneficiary under
an employment contract (or equivalent appointing act) and assigned to the action (‘costs for
employees (or equivalent)’). They must be limited to salaries (including during parental leave),
social security contributions, taxes and other costs included in the remuneration, if they arise
from national law or the employment contract (or equivalent appointing act).
Beneficiaries that are non-profit legal entities\(^2\) may also declare as personnel costs additional remuneration for personnel assigned to the action (including payments on the basis of supplementary contracts regardless of their nature), if:

(a) it is part of the beneficiary’s usual remuneration practices and is paid in a consistent manner whenever the same kind of work or expertise is required;

(b) the criteria used to calculate the supplementary payments are objective and generally applied by the beneficiary, regardless of the source of funding used.

Additional remuneration for personnel assigned to the action is eligible up to the following amount:

(a) if the person works full time and exclusively on the action during the full year: up to EUR 8 000;

(b) if the person works exclusively on the action but not full-time or not for the full year: up to the corresponding pro-rata amount of EUR 8 000, or

(c) if the person does not work exclusively on the action: up to a pro-rata amount calculated as follows:

\[
\frac{\text{EUR 8 000}}{\text{the number of annual productive hours (see below)}}, \quad \text{multiplied by} \quad \text{the number of hours that the person has worked on the action during the year}.
\]

A.2 The costs for natural persons working under a direct contract with the beneficiary other than an employment contract are eligible personnel costs, if:

(a) the person works under the beneficiary’s instructions and, unless otherwise agreed with the beneficiary, on the beneficiary’s premises;

(b) the result of the work carried out belongs to the beneficiary, and

(c) the costs are not significantly different from those for personnel performing similar tasks under an employment contract with the beneficiary.

A.3 The costs of personnel seconded by a third party against payment are eligible personnel costs, if the conditions in Article 11.1 are met.

---

\(^2\) For the definition, see Article 2.1(14) of the Rules for Participation Regulation No 1290/2013: ‘non-profit legal entity’ means a legal entity which by its legal form is non-profit-making or which has a legal or statutory obligation not to distribute profits to its shareholders or individual members.
A.4 **Costs of owners** of beneficiaries that are small and medium-sized enterprises (‘SME owners’) who are working on the action and who do not receive a salary are eligible personnel costs, if they correspond to the amount per unit set out in Annex 2 multiplied by the number of actual hours worked on the action.

A.5 **Costs of beneficiaries that are natural persons** not receiving a salary are eligible personnel costs, if they correspond to the amount per unit set out in Annex 2 multiplied by the number of actual hours worked on the action.

**Calculation**

Personnel costs must be calculated by the beneficiaries as follows:

\[
\text{hourly rate} \times \text{number of actual hours worked on the action},
\]

plus

for non-profit legal entities: additional remuneration to personnel assigned to the action under the conditions set out above (Point A.1).

The number of actual hours declared for a person must be identifiable and verifiable (see Article 18).

The total number of hours declared in EU or Euratom grants, for a person for a year, cannot be higher than the annual productive hours used for the calculations of the hourly rate. Therefore, the maximum number of hours that can be declared for the grant is:

\[
\text{number of annual productive hours for the year (see below)} - \text{total number of hours declared by the beneficiary for that person in that year for other EU or Euratom grants}.
\]

The ‘**hourly rate**’ is one of the following:

(a) for personnel costs declared as **actual costs**: the hourly rate is the amount calculated as follows:

\[
\frac{\text{actual annual personnel costs (excluding additional remuneration) for the person}}{\text{number of annual productive hours}}.
\]

The beneficiaries must use the annual personnel costs and the number of annual productive hours for each financial year covered by the reporting period. If a financial year is not closed at the end of the reporting period, the beneficiaries must use the hourly rate of the last closed financial year available.

For the ‘number of annual productive hours’, the beneficiaries may choose one of the following:

(i) ‘fixed number of hours’: 1 720 hours for persons working full time (or corresponding pro-rata for persons not working full time);
(ii) ‘individual annual productive hours’: the total number of hours worked by the person in the year for the beneficiary, calculated as follows:

\[
\text{annual workable hours of the person (according to the employment contract, applicable collective labour agreement or national law)} + \text{overtime worked} - \text{absences (such as sick leave and special leave)}.
\]

‘Annual workable hours’ means the period during which the personnel must be working, at the employer’s disposal and carrying out his/her activity or duties under the employment contract, applicable collective labour agreement or national working time legislation.

If the contract (or applicable collective labour agreement or national working time legislation) does not allow to determine the annual workable hours, this option cannot be used;

(iii) ‘standard annual productive hours’: the ‘standard number of annual hours’ generally applied by the beneficiary for its personnel in accordance with its usual cost accounting practices. This number must be at least 90% of the ‘standard annual workable hours’.

If there is no applicable reference for the standard annual workable hours, this option cannot be used.

For all options, the actual time spent on parental leave by a person assigned to the action may be deducted from the number of annual productive hours;

(b) for personnel costs declared on the basis of unit costs: the hourly rate is one of the following:

(i) for SME owners or beneficiaries that are natural persons: the hourly rate set out in Annex 2 (see Points A.4 and A.5 above), or

(ii) for personnel costs declared on the basis of the beneficiary’s usual cost accounting practices: the hourly rate calculated by the beneficiary in accordance with its usual cost accounting practices, if:

- the cost accounting practices used are applied in a consistent manner, based on objective criteria, regardless of the source of funding;

- the hourly rate is calculated using the actual personnel costs recorded in the beneficiary’s accounts, excluding any ineligible cost or costs included in other budget categories.

The actual personnel costs may be adjusted by the beneficiary on the basis of budgeted or estimated elements. Those elements must be relevant for calculating
the personnel costs, reasonable and correspond to objective and verifiable information;

and

- the hourly rate is calculated using the number of annual productive hours (see above).

B. Direct costs of subcontracting (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible if the conditions in Article 13.1.1 are met.

C. Direct costs of providing financial support to third parties not applicable.

D. Other direct costs

D.1 Travel costs and related subsistence allowances (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible if they are in line with the beneficiary’s usual practices on travel.

D.2 The depreciation costs of equipment, infrastructure or other assets (new or second-hand) as recorded in the beneficiary’s accounts are eligible, if they were purchased in accordance with Article 10.1.1 and written off in accordance with international accounting standards and the beneficiary’s usual accounting practices.

The costs of renting or leasing equipment, infrastructure or other assets (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are also eligible, if they do not exceed the depreciation costs of similar equipment, infrastructure or assets and do not include any financing fees.

The costs of equipment, infrastructure or other assets contributed in-kind against payment are eligible, if they do not exceed the depreciation costs of similar equipment, infrastructure or assets, do not include any financing fees and if the conditions in Article 11.1 are met.

The only portion of the costs that will be taken into account is that which corresponds to the duration of the action and rate of actual use for the purposes of the action.

D.3 Costs of other goods and services (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible, if they are:

(a) purchased specifically for the action and in accordance with Article 10.1.1 or

(b) contributed in kind against payment and in accordance with Article 11.1.

Such goods and services include, for instance, consumables and supplies, dissemination (including open access), protection of results, certificates on the financial statements (if they are required by the Agreement), certificates on the methodology, translations and publications.
D.4 Capitalised and operating costs of ‘large research infrastructure’\(^3\) directly used for the action are eligible, if:

(a) the value of the large research infrastructure represents at least 75% of the total fixed assets (at historical value in its last closed balance sheet before the date of the signature of the Agreement or as determined on the basis of the rental and leasing costs of the research infrastructure\(^4\));

(b) the beneficiary’s methodology for declaring the costs for large research infrastructure has been positively assessed by the Commission (‘**ex-ante assessment**’);

(c) the beneficiary declares as direct eligible costs only the portion which corresponds to the duration of the action and the rate of actual use for the purposes of the action, and

(d) they comply with the conditions as further detailed in the annotations to the H2020 grant agreements.

E. Indirect costs

Indirect costs are eligible if they are declared on the basis of the flat-rate of 25% of the eligible direct costs (see Article 5.2 and Points A to D above), from which are excluded:

(a) costs of subcontracting and

(b) costs of in-kind contributions provided by third parties which are not used on the beneficiary’s premises;

(c) **not applicable**;

(d) **not applicable**.

Beneficiaries receiving an operating grant\(^5\) financed by the EU or Euratom budget cannot declare indirect costs for the period covered by the operating grant.

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\(^3\) ‘Large research infrastructure’ means research infrastructure of a total value of at least EUR 20 million, for a beneficiary, calculated as the sum of historical asset values of each individual research infrastructure of that beneficiary, as they appear in its last closed balance sheet before the date of the signature of the Agreement or as determined on the basis of the rental and leasing costs of the research infrastructure.

\(^4\) For the definition, see Article 2(6) of Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020) (OJ L 347, 20.12.2013 p.104)- (‘**Horizon 2020 Framework Programme Regulation No 1291/2013**’): ‘**Research infrastructure**’ are facilities, resources and services that are used by the research communities to conduct research and foster innovation in their fields. Where relevant, they may be used beyond research, e.g. for education or public services. They include: major scientific equipment (or sets of instruments); knowledge-based resources such as collections, archives or scientific data; e-infrastructures such as data and computing systems and communication networks; and any other infrastructure of a unique nature essential to achieve excellence in research and innovation. Such infrastructures may be ‘single-sited’, ‘virtual’ or ‘distributed’.

\(^5\) For the definition, see Article 121(1)(b) of Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002 (OJ L 218, 26.10.2012, p.1) (‘**Financial Regulation No 966/2012**’): ‘**operating grant**’ means direct financial contribution, by way of donation, from the budget in order to finance the functioning of a body which pursues an aim of general EU interest or has an objective forming part of and supporting an EU policy.
F. Specific cost category(ies)

Not applicable

6.3 Conditions for costs of linked third parties to be eligible

Costs incurred by linked third parties are eligible if they fulfil — mutatis mutandis — the general and specific conditions for eligibility set out in this Article (Article 6.1 and 6.2) and Article 14.1.1.

6.4 Conditions for in-kind contributions provided by third parties free of charge to be eligible

In-kind contributions provided free of charge are eligible direct costs (for the beneficiary or linked third party), if the costs incurred by the third party fulfil — mutatis mutandis — the general and specific conditions for eligibility set out in this Article (Article 6.1 and 6.2) and Article 12.1.

6.5 Ineligible costs

‘Ineligible costs’ are:

(a) costs that do not comply with the conditions set out above (Article 6.1 to 6.4), in particular:

(i) costs related to return on capital;

(ii) debt and debt service charges;

(iii) provisions for future losses or debts;

(iv) interest owed;

(v) doubtful debts;

(vi) currency exchange losses;

(vii) bank costs charged by the beneficiary’s bank for transfers from the Agency;

(viii) excessive or reckless expenditure;

(ix) deductible VAT;

(x) costs incurred during suspension of the implementation of the action (see Article 49);

(b) costs declared under another EU or Euratom grant (including grants awarded by a Member State and financed by the EU or Euratom budget and grants awarded by bodies other than the Agency for the purpose of implementing the EU or Euratom budget); in particular, indirect costs if the beneficiary is already receiving an operating grant financed by the EU or Euratom budget in the same period.

6.6 Consequences of declaration of ineligible costs

Declared costs that are ineligible will be rejected (see Article 42).
This may also lead to any of the other measures described in Chapter 6.

CHAPTER 4  RIGHTS AND OBLIGATIONS OF THE PARTIES

SECTION 1   RIGHTS AND OBLIGATIONS RELATED TO IMPLEMENTING THE ACTION

ARTICLE 7 — GENERAL OBLIGATION TO PROPERLY IMPLEMENT THE ACTION

7.1 General obligation to properly implement the action

The beneficiaries must implement the action as described in Annex 1 and in compliance with the provisions of the Agreement and all legal obligations under applicable EU, international and national law.

7.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 8 — RESOURCES TO IMPLEMENT THE ACTION — THIRD PARTIES INVOLVED IN THE ACTION

The beneficiaries must have the appropriate resources to implement the action.

If it is necessary to implement the action, the beneficiaries may:

- purchase goods, works and services (see Article 10);
- use in-kind contributions provided by third parties against payment (see Article 11);
- use in-kind contributions provided by third parties free of charge (see Article 12);
- call upon subcontractors to implement action tasks described in Annex 1 (see Article 13);
- call upon linked third parties to implement action tasks described in Annex 1 (see Article 14).

In these cases, the beneficiaries retain sole responsibility towards the Agency and the other beneficiaries for implementing the action.

ARTICLE 9 — IMPLEMENTATION OF ACTION TASKS BY BENEFICIARIES NOT RECEIVING EU FUNDING

9.1 Rules for the implementation of action tasks by beneficiaries not receiving EU funding

Beneficiaries not receiving EU funding must implement the action tasks attributed to them in Annex 1 according to Article 7.1.
Their costs are estimated in Annex 2 but:

- will not be reimbursed and
- will not be taken into account for the calculation of the grant (see Articles 5.2, 5.3 and 5.4, and 21).

Chapter 3, Articles 10 to 15, 18.1.2, 20.3(b), 20.4(b), 20.6, 21, 23a, 26.4, 27.2, 28.1, 28.2, 30.3, 31.5, 40, 42, 43, 44, 47 and 48 do not apply to these beneficiaries.

They will not be subject to financial checks, reviews and audits under Article 22.

Beneficiaries not receiving EU funding may provide in-kind contributions to another beneficiary. In this case, they will be considered as a third party for the purpose of Articles 11 and 12.

9.2 Consequences of non-compliance

If a beneficiary not receiving EU funding breaches any of its obligations under this Article, its participation of the Agreement may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6 that are applicable to it.

ARTICLE 10 — PURCHASE OF GOODS, WORKS OR SERVICES

10.1 Rules for purchasing goods, works or services

10.1.1 If necessary to implement the action, the beneficiaries may purchase goods, works or services.

The beneficiaries must make such purchases ensuring the best value for money or, if appropriate, the lowest price. In doing so, they must avoid any conflict of interests (see Article 35).

The beneficiaries must ensure that the Agency, the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their contractors.

10.1.2 Beneficiaries that are ‘contracting authorities’ within the meaning of Directive 2004/18/EC\textsuperscript{6} or ‘contracting entities’ within the meaning of Directive 2004/17/EC\textsuperscript{7} must comply with the applicable national law on public procurement.

10.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 10.1.1, the costs related to the contract concerned will be ineligible (see Article 6) and will be rejected (see Article 42).


If a beneficiary breaches any of its obligations under Article 10.1.2, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 11 — USE OF IN-KIND CONTRIBUTIONS PROVIDED BY THIRD PARTIES AGAINST PAYMENT

11.1 Rules for the use of in-kind contributions against payment

If necessary to implement the action, the beneficiaries may use in-kind contributions provided by third parties against payment.

The beneficiaries may declare costs related to the payment of in-kind contributions as eligible (see Article 6.1 and 6.2), up to the third parties’ costs for the seconded persons, contributed equipment, infrastructure or other assets or other contributed goods and services.

The third parties and their contributions must be set out in Annex 1. The Agency may however approve in-kind contributions not set out in Annex 1 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and
- their use does not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiaries must ensure that the Agency, the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards the third parties.

11.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the costs related to the payment of the in-kind contribution will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 12 — USE OF IN-KIND CONTRIBUTIONS PROVIDED BY THIRD PARTIES FREE OF CHARGE

12.1 Rules for the use of in-kind contributions free of charge

If necessary to implement the action, the beneficiaries may use in-kind contributions provided by third parties free of charge.

The beneficiaries may declare costs incurred by the third parties for the seconded persons, contributed equipment, infrastructure or other assets or other contributed goods and services as eligible in accordance with Article 6.4.

The third parties and their contributions must be set out in Annex 1. The Agency may however approve in-kind contributions not set out in Annex 1 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and
The beneficiaries must ensure that the Agency, the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards the third parties.

12.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the costs incurred by the third parties related to the in-kind contribution will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 13 — IMPLEMENTATION OF ACTION TASKS BY SUBCONTRACTORS

13.1 Rules for subcontracting action tasks

13.1.1 If necessary to implement the action, the beneficiaries may award subcontracts covering the implementation of certain action tasks described in Annex 1.

Subcontracting may cover only a limited part of the action.

The beneficiaries must award the subcontracts ensuring the best value for money or, if appropriate, the lowest price. In doing so, they must avoid any conflict of interests (see Article 35).

The tasks to be implemented and the estimated cost for each subcontract must be set out in Annex 1 and the total estimated costs of subcontracting per beneficiary must be set out in Annex 2. The Agency may however approve subcontracts not set out in Annex 1 and 2 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and

- they do not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiaries must ensure that the Agency, the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their subcontractors.

13.1.2 The beneficiaries must ensure that their obligations under Articles 35, 36, 38 and 46 also apply to the subcontractors.

Beneficiaries that are ‘contracting authorities’ within the meaning of Directive 2004/18/EC or ‘contracting entities’ within the meaning of Directive 2004/17/EC must comply with the applicable national law on public procurement.

13.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 13.1.1, the costs related to the subcontract concerned will be ineligible (see Article 6) and will be rejected (see Article 42).
If a beneficiary breaches any of its obligations under Article 13.1.2, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 14 — IMPLEMENTATION OF ACTION TASKS BY LINKED THIRD PARTIES

14.1 Rules for calling upon linked third parties to implement part of the action

14.1.1 The following affiliated entities and third parties with a legal link to a beneficiary (‘linked third parties’) may implement the action tasks attributed to them in Annex 1:

- METEO-FRANCE (METEO-FRANCE), affiliated or linked to CNRS-GAME

The linked third parties may declare as eligible the costs they incur for implementing the action tasks in accordance with Article 6.3.

The beneficiaries must ensure that the Agency, the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their linked third parties.

14.1.2 The beneficiaries must ensure that their obligations under Articles 18, 20, 35, 36 and 38 also apply to their linked third parties.

14.2 Consequences of non-compliance

If any obligation under Article 14.1.1 is breached, the costs of the linked third party will be ineligible (see Article 6) and will be rejected (see Article 42).

If any obligation under Article 14.1.2 is breached, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

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9 For the definition, see Article 2.1(2) of the Rules for Participation Regulation No 1290/2013: ‘affiliated entity’ means any legal entity that is:
- under the direct or indirect control of a participant, or
- under the same direct or indirect control as the participant, or
- directly or indirectly controlling a participant.

‘Control’ may take any of the following forms:
(a) the direct or indirect holding of more than 50% of the nominal value of the issued share capital in the legal entity concerned, or of a majority of the voting rights of the shareholders or associates of that entity;
(b) the direct or indirect holding, in fact or in law, of decision-making powers in the legal entity concerned.

However the following relationships between legal entities shall not in themselves be deemed to constitute controlling relationships:
(a) the same public investment corporation, institutional investor or venture-capital company has a direct or indirect holding of more than 50% of the nominal value of the issued share capital or a majority of voting rights of the shareholders or associates;
(b) the legal entities concerned are owned or supervised by the same public body.

10 ‘Third party with a legal link to a beneficiary’ is any legal entity which has a legal link to the beneficiary implying collaboration that is not limited to the action.
ARTICLE 15 — FINANCIAL SUPPORT TO THIRD PARTIES

15.1 Rules for providing financial support to third parties

Not applicable

15.2 Financial support in the form of prizes

Not applicable

15.3 Consequences of non-compliance

Not applicable

ARTICLE 16 — PROVISION OF TRANS-NATIONAL OR VIRTUAL ACCESS TO RESEARCH INFRASTRUCTURE

16.1 Rules for providing trans-national access to research infrastructure

Not applicable

16.2 Rules for providing virtual access to research infrastructure

Not applicable

16.3 Consequences of non-compliance

Not applicable

SECTION 2   RIGHTS AND OBLIGATIONS RELATED TO THE GRANT ADMINISTRATION

ARTICLE 17 — GENERAL OBLIGATION TO INFORM

17.1 General obligation to provide information upon request

The beneficiaries must provide — during implementation of the action or afterwards and in accordance with Article 41.2 — any information requested in order to verify eligibility of the costs, proper implementation of the action and compliance with any other obligation under the Agreement.

17.2 Obligation to keep information up to date and to inform about events and circumstances likely to affect the Agreement

Each beneficiary must keep information stored in the 'Beneficiary Register' (via the electronic exchange system; see Article 52) up to date, in particular, its name, address, legal representatives, legal form and organisation type.

Each beneficiary must immediately inform the coordinator — which must immediately inform the Agency and the other beneficiaries — of any of the following:

(a) events which are likely to affect significantly or delay the implementation of the action or the EU's financial interests, in particular:
(i) changes in its legal, financial, technical, organisational or ownership situation or those of its linked third parties and

(ii) changes in the name, address, legal form, organisation type of its linked third parties;

(b) circumstances affecting:

(i) the decision to award the grant or

(ii) compliance with requirements under the Agreement.

17.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 18 — KEEPING RECORDS — SUPPORTING DOCUMENTATION

18.1 Obligation to keep records and other supporting documentation

The beneficiaries must — for a period of five years after the payment of the balance — keep records and other supporting documentation in order to prove the proper implementation of the action and the costs they declare as eligible.

They must make them available upon request (see Article 17) or in the context of checks, reviews, audits or investigations (see Article 22).

If there are on-going checks, reviews, audits, investigations, litigation or other pursuits of claims under the Agreement (including the extension of findings; see Articles 22), the beneficiaries must keep the records and other supporting documentation until the end of these procedures.

The beneficiaries must keep the original documents. Digital and digitalised documents are considered originals if they are authorised by the applicable national law. The Agency may accept non-original documents if it considers that they offer a comparable level of assurance.

18.1.1 Records and other supporting documentation on the scientific and technical implementation

The beneficiaries must keep records and other supporting documentation on scientific and technical implementation of the action in line with the accepted standards in the respective field.

18.1.2 Records and other documentation to support the costs declared

The beneficiaries must keep the records and documentation supporting the costs declared, in particular the following:

(a) for actual costs: adequate records and other supporting documentation to prove the costs declared, such as contracts, subcontracts, invoices and accounting records. In addition, the beneficiaries’ usual cost accounting practices and internal control procedures must enable direct
reconciliation between the amounts declared, the amounts recorded in their accounts and the amounts stated in the supporting documentation;

(b) for **unit costs**: adequate records and other supporting documentation to prove the number of units declared. Beneficiaries do not need to identify the actual eligible costs covered or to keep or provide supporting documentation (such as accounting statements) to prove the amount per unit.

In addition, **for direct personnel costs declared as unit costs calculated in accordance with the beneficiary's usual cost accounting practices**, the beneficiaries must keep adequate records and documentation to prove that the cost accounting practices used comply with the conditions set out in Article 6.2, Point A.

The beneficiaries **and linked third parties** may submit to the Commission, for approval, a certificate (drawn up in accordance with Annex 6) stating that their usual cost accounting practices comply with these conditions ('**certificate on the methodology**'). If the certificate is approved, costs declared in line with this methodology will not be challenged subsequently, unless the beneficiaries have concealed information for the purpose of the approval.

(c) for **flat-rate costs**: adequate records and other supporting documentation to prove the eligibility of the costs to which the flat-rate is applied. The beneficiaries do not need to identify the costs covered or provide supporting documentation (such as accounting statements) to prove the amount declared at a flat-rate.

In addition, **for personnel costs** (declared as actual costs or on the basis of unit costs), the beneficiaries must keep **time records** for the number of hours declared. The time records must be in writing and approved by the persons working on the action and their supervisors, at least monthly. In the absence of reliable time records of the hours worked on the action, the **Agency** may accept alternative evidence supporting the number of hours declared, if it considers that it offers an adequate level of assurance.

As an exception, **for persons working exclusively on the action**, there is no need to keep time records, if the beneficiary signs a **declaration** confirming that the persons concerned have worked exclusively on the action.

**For costs declared by linked third parties (see Article 14), it is the beneficiary that must keep the originals of the financial statements and the certificates on the financial statements of the linked third parties.**

**18.2 Consequences of non-compliance**

If a beneficiary breaches any of its obligations under this Article, costs insufficiently substantiated will be ineligible (see Article 6) and will be rejected (see Article 42), and the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.
ARTICLE 19 — SUBMISSION OF DELIVERABLES

19.1 Obligation to submit deliverables

The coordinator must submit the ‘deliverables’ identified in Annex 1, in accordance with the timing and conditions set out in it.

19.2 Consequences of non-compliance

If the coordinator breaches any of its obligations under this Article, the Agency may apply any of the measures described in Chapter 6.

ARTICLE 20 — REPORTING — PAYMENT REQUESTS

20.1 Obligation to submit reports

The coordinator must submit to the Agency (see Article 52) the technical and financial reports set out in this Article. These reports include requests for payment and must be drawn up using the forms and templates provided in the electronic exchange system (see Article 52).

20.2 Reporting periods

The action is divided into the following ‘reporting periods’:

- RP1: from month 1 to month 18
- RP2: from month 19 to month 36
- RP3: from month 37 to month 48

20.3 Periodic reports — Requests for interim payments

The coordinator must submit a periodic report within 60 days following the end of each reporting period.

The periodic report must include the following:

(a) a ‘periodic technical report’ containing:

   (i) an explanation of the work carried out by the beneficiaries;

   (ii) an overview of the progress towards the objectives of the action, including milestones and deliverables identified in Annex 1.

   This report must include explanations justifying the differences between work expected to be carried out in accordance with Annex 1 and that actually carried out.

   The report must also detail the exploitation and dissemination of the results and — if required in Annex 1 — an updated ‘plan for the exploitation and dissemination of the results’;

   (iii) a summary for publication by the Agency;
(iv) the answers to the ‘questionnaire’, covering issues related to the action implementation and the economic and societal impact, notably in the context of the Horizon 2020 key performance indicators and the Horizon 2020 monitoring requirements;

(b) a ‘periodic financial report’ containing:

(i) an ‘individual financial statement’ (see Annex 4) from each beneficiary and from each linked third party, for the reporting period concerned.

The individual financial statement must detail the eligible costs (actual costs, unit costs and flat-rate costs; see Article 6) for each budget category (see Annex 2).

The beneficiaries and linked third parties must declare all eligible costs, even if — for actual costs, unit costs and flat-rate costs — they exceed the amounts indicated in the estimated budget (see Annex 2). Amounts which are not declared in the individual financial statement will not be taken into account by the Agency.

If an individual financial statement is not submitted for a reporting period, it may be included in the periodic financial report for the next reporting period.

The individual financial statements of the last reporting period must also detail the receipts of the action (see Article 5.3.3).

Each beneficiary and each linked third party must certify that:

- the information provided is full, reliable and true;
- the costs declared are eligible (see Article 6);
- the costs can be substantiated by adequate records and supporting documentation (see Article 18) that will be produced upon request (see Article 17) or in the context of checks, reviews, audits and investigations (see Article 22), and
- for the last reporting period: that all the receipts have been declared (see Article 5.3.3);

(ii) an explanation of the use of resources and the information on subcontracting (see Article 13) and in-kind contributions provided by third parties (see Articles 11 and 12) from each beneficiary and from each linked third party, for the reporting period concerned;

(iii) not applicable;

(iv) a ‘periodic summary financial statement’ (see Annex 4), created automatically by the electronic exchange system, consolidating the individual financial statements for the reporting period concerned and including — except for the last reporting period — the request for interim payment.
20.4 Final report — Request for payment of the balance

In addition to the periodic report for the last reporting period, the coordinator must submit the final report within 60 days following the end of the last reporting period.

The final report must include the following:

(a) a ‘final technical report’ with a summary for publication containing:

(i) an overview of the results and their exploitation and dissemination;

(ii) the conclusions on the action, and

(iii) the socio-economic impact of the action;

(b) a ‘final financial report’ containing:

(i) a ‘final summary financial statement’ (see Annex 4), created automatically by the electronic exchange system, consolidating the individual financial statements for all reporting periods and including the request for payment of the balance and

(ii) a ‘certificate on the financial statements’ (drawn up in accordance with Annex 5) for each beneficiary and for each linked third party, if it requests a total contribution of EUR 325 000 or more, as reimbursement of actual costs and unit costs calculated on the basis of its usual cost accounting practices (see Article 5.2 and Article 6.2, Point A).

20.5 Information on cumulative expenditure incurred

Not applicable

20.6 Currency for financial statements and conversion into euro

Financial statements must be drafted in euro.

Beneficiaries and linked third parties with accounting established in a currency other than the euro must convert the costs recorded in their accounts into euro, at the average of the daily exchange rates published in the C series of the Official Journal of the European Union, calculated over the corresponding reporting period.

If no daily euro exchange rate is published in the Official Journal of the European Union for the currency in question, they must be converted at the average of the monthly accounting rates published on the Commission’s website, calculated over the corresponding reporting period.

Beneficiaries and linked third parties with accounting established in euro must convert costs incurred in another currency into euro according to their usual accounting practices.

20.7 Language of reports

All reports (technical and financial reports, including financial statements) must be submitted in the language of the Agreement.
20.8 Consequences of non-compliance — Suspension of the payment deadline — Termination

If the reports submitted do not comply with this Article, the Agency may suspend the payment deadline (see Article 47) and apply any of the other measures described in Chapter 6.

If the coordinator breaches its obligation to submit the reports and if it fails to comply with this obligation within 30 days following a written reminder sent by the Agency, the Agreement may be terminated (see Article 50).

ARTICLE 21 — PAYMENTS AND PAYMENT ARRANGEMENTS

21.1 Payments to be made

The following payments will be made to the coordinator:

- one **pre-financing payment**;

- one or more **interim payments**, on the basis of the request(s) for interim payment (see Article 20), and

- one **payment of the balance**, on the basis of the request for payment of the balance (see Article 20).

21.2 Pre-financing payment — Amount — Amount retained for the Guarantee Fund

The aim of the pre-financing is to provide the beneficiaries with a float.

It remains the property of the EU until the payment of the balance.

The amount of the pre-financing payment will be EUR **4,266,448.67** (four million two hundred and sixty six thousand four hundred and forty eight EURO and sixty seven eurocents).

The Agency will — except if Article 48 applies — make the pre-financing payment to the coordinator within 30 days either from the entry into force of the Agreement (see Article 58) or from 10 days before the starting date of the action (see Article 3), whichever is the latest.

An amount of EUR **399,979.56** (three hundred and ninety nine thousand nine hundred and seventy nine EURO and fifty six eurocents), corresponding to 5% of the maximum grant amount (see Article 5.1), is retained by the Agency from the pre-financing payment and transferred into the ‘Guarantee Fund’.

21.3 Interim payments — Amount — Calculation

Interim payments reimburse the eligible costs incurred for the implementation of the action during the corresponding reporting periods.

The Agency will pay to the coordinator the amount due as interim payment within 90 days from receiving the periodic report (see Article 20.3), except if Articles 47 or 48 apply.

Payment is subject to the approval of the periodic report. Its approval does not imply recognition of the compliance, authenticity, completeness or correctness of its content.

The **amount due as interim payment** is calculated by the Agency in the following steps:
Step 1 – Application of the reimbursement rates

Step 2 – Limit to 90% of the maximum grant amount

21.3.1 Step 1 — Application of the reimbursement rates

The reimbursement rate(s) (see Article 5.2) are applied to the eligible costs (actual costs, unit costs and flat-rate costs; see Article 6) declared by the beneficiaries and the linked third parties (see Article 20) and approved by the Agency (see above) for the concerned reporting period.

21.3.2 Step 2 — Limit to 90% of the maximum grant amount

The total amount of pre-financing and interim payments must not exceed 90% of the maximum grant amount set out in Article 5.1. The maximum amount for the interim payment will be calculated as follows:

\[
\left\{90\% \text{ of the maximum grant amount (see Article 5.1)}
\right.
\]

minus

\[
\left\{\text{pre-financing and previous interim payments}\right\}.
\]

21.4 Payment of the balance — Amount — Calculation — Release of the amount retained for the Guarantee Fund

The payment of the balance reimburses the remaining part of the eligible costs incurred by the beneficiaries for the implementation of the action.

If the total amount of earlier payments is greater than the final grant amount (see Article 5.3), the payment of the balance takes the form of a recovery (see Article 44).

If the total amount of earlier payments is lower than the final grant amount, the Agency will pay the balance within 90 days from receiving the final report (see Article 20.4), except if Articles 47 or 48 apply.

Payment is subject to the approval of the final report. Its approval does not imply recognition of the compliance, authenticity, completeness or correctness of its content.

The amount due as the balance is calculated by the Agency by deducting the total amount of pre-financing and interim payments (if any) already made, from the final grant amount determined in accordance with Article 5.3:

\[
\left\{\text{final grant amount (see Article 5.3)}
\right.
\]

minus

\[
\left\{\text{pre-financing and interim payments (if any) made}\right\}.
\]

At the payment of the balance, the amount retained for the Guarantee Fund (see above) will be released and:

- if the balance is positive: the amount released will be paid in full to the coordinator together with the amount due as the balance;
- if the balance is negative (payment of the balance taking the form of recovery): it will be deducted from the amount released (see Article 44.1.2). If the resulting amount:
  - is positive, it will be paid to the coordinator
  - is negative, it will be recovered.

The amount to be paid may however be offset — without the beneficiary’s consent — against any other amount owed by the beneficiary to the Agency, the Commission or another executive agency (under the EU or Euratom budget), up to the maximum EU contribution indicated, for that beneficiary, in the estimated budget (see Annex 2).

21.5 Notification of amounts due

When making payments, the Agency will formally notify to the coordinator the amount due, specifying whether it concerns an interim payment or the payment of the balance.

For the payment of the balance, the notification will also specify the final grant amount.

In the case of reduction of the grant or recovery of undue amounts, the notification will be preceded by the contradictory procedure set out in Articles 43 and 44.

21.6 Currency for payments

The Agency will make all payments in euro.

21.7 Payments to the coordinator — Distribution to the beneficiaries

Payments will be made to the coordinator.

Payments to the coordinator will discharge the Agency from its payment obligation.

The coordinator must distribute the payments between the beneficiaries without unjustified delay.

Pre-financing may however be distributed only:

(a) if the minimum number of beneficiaries set out in the call for proposals has acceded to the Agreement (see Article 56) and

(b) to beneficiaries that have acceded to the Agreement (see Article 56).

21.8 Bank account for payments

All payments will be made to the following bank account:

Name of bank: DEUTSCHE KREDIT BANK A.G. BERLIN
Address of branch: . BERLIN, Germany
Full name of the account holder: ALFRED WEGENER INSTITUT FUR POLAR UUND MEERESFORSCHUNG
Full account number (including bank codes):
IBAN code: DE39120300001008362640
21.9 Costs of payment transfers

The cost of the payment transfers is borne as follows:

- the Agency bears the cost of transfers charged by its bank;
- the beneficiary bears the cost of transfers charged by its bank;
- the party causing a repetition of a transfer bears all costs of the repeated transfer.

21.10 Date of payment

Payments by the Agency are considered to have been carried out on the date when they are debited to its account.

21.11 Consequences of non-compliance

21.11.1 If the Agency does not pay within the payment deadlines (see above), the beneficiaries are entitled to late-payment interest at the rate applied by the European Central Bank (ECB) for its main refinancing operations in euros (‘reference rate’), plus three and a half points. The reference rate is the rate in force on the first day of the month in which the payment deadline expires, as published in the C series of the Official Journal of the European Union.

If the late-payment interest is lower than or equal to EUR 200, it will be paid to the coordinator only upon request submitted within two months of receiving the late payment.

Late-payment interest is not due if all beneficiaries are EU Member States (including regional and local government authorities or other public bodies acting on behalf of a Member State for the purpose of this Agreement).

Suspension of the payment deadline or payments (see Articles 47 and 48) will not be considered as late payment.

Late-payment interest covers the period running from the day following the due date for payment (see above), up to and including the date of payment.

Late-payment interest is not considered for the purposes of calculating the final grant amount.

21.11.2 If the coordinator breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or the participation of the coordinator may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 22 — CHECKS, REVIEWS, AUDITS AND INVESTIGATIONS — EXTENSION OF FINDINGS

22.1 Checks, reviews and audits by the Agency and the Commission

22.1.1 Right to carry out checks
The *Agency or the* Commission will — during the implementation of the action or afterwards — check the proper implementation of the action and compliance with the obligations under the Agreement, including assessing deliverables and reports.

For this purpose the *Agency or the* Commission may be assisted by external persons or bodies.

The *Agency or the* Commission may also request additional information in accordance with Article 17. The *Agency or the* Commission may request beneficiaries to provide such information to it directly.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

**22.1.2 Right to carry out reviews**

The *Agency or the* Commission may — during the implementation of the action or afterwards — carry out reviews on the proper implementation of the action (including assessment of deliverables and reports), compliance with the obligations under the Agreement and continued scientific or technological relevance of the action.

Reviews may be started **up to two years after the payment of the balance**. They will be formally notified to the coordinator or beneficiary concerned and will be considered to have started on the date of the formal notification.

If the review is carried out on a third party (see Articles 10 to 16), the beneficiary concerned must inform the third party.

The *Agency or the* Commission may carry out reviews directly (using its own staff) or indirectly (using external persons or bodies appointed to do so). It will inform the coordinator or beneficiary concerned of the identity of the external persons or bodies. They have the right to object to the appointment on grounds of commercial confidentiality.

The coordinator or beneficiary concerned must provide — within the deadline requested — any information and data in addition to deliverables and reports already submitted (including information on the use of resources). The *Agency or the* Commission may request beneficiaries to provide such information to it directly.

The coordinator or beneficiary concerned may be requested to participate in meetings, including with external experts.

For **on-the-spot** reviews, the beneficiaries must allow access to their sites and premises, including to external persons or bodies, and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the review findings, a ‘**review report**’ will be drawn up.

The *Agency or the* Commission will formally notify the review report to the coordinator or beneficiary concerned, which has 30 days to formally notify observations (‘**contradictory review procedure**’).

Reviews (including review reports) are in the language of the Agreement.
22.1.3 Right to carry out audits

The *Agency or the* Commission may — during the implementation of the action or afterwards — carry out audits on the proper implementation of the action and compliance with the obligations under the Agreement.

Audits may be started **up to two years after the payment of the balance.** They will be formally notified to the coordinator or beneficiary concerned and will be considered to have started on the date of the formal notification.

If the audit is carried out on a third party (see Articles 10 to 16), the beneficiary concerned must inform the third party.

The *Agency or the* Commission may carry out audits directly (using its own staff) or indirectly (using external persons or bodies appointed to do so). It will inform the coordinator or beneficiary concerned of the identity of the external persons or bodies. They have the right to object to the appointment on grounds of commercial confidentiality.

The coordinator or beneficiary concerned must provide — within the deadline requested — any information (including complete accounts, individual salary statements or other personal data) to verify compliance with the Agreement. The *Agency or the* Commission may request beneficiaries to provide such information to it directly.

For **on-the-spot** audits, the beneficiaries must allow access to their sites and premises, including to external persons or bodies, and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the audit findings, a ‘**draft audit report**’ will be drawn up.

The *Agency or the* Commission will formally notify the draft audit report to the coordinator or beneficiary concerned, which has 30 days to formally notify observations (‘**contradictory audit procedure**’). This period may be extended by the *Agency or the* Commission in justified cases.

The ‘**final audit report**’ will take into account observations by the coordinator or beneficiary concerned. The report will be formally notified to it.

Audits (including audit reports) are in the language of the Agreement.

The *Agency or the* Commission may also access the beneficiaries’ statutory records for the periodical assessment of unit costs or flat-rate amounts.
22.2 Investigations by the European Anti-Fraud Office (OLAF)

Under Regulations No 883/2013\textsuperscript{15} and No 2185/96\textsuperscript{16} (and in accordance with their provisions and procedures), the European Anti-Fraud Office (OLAF) may — at any moment during implementation of the action or afterwards — carry out investigations, including on-the-spot checks and inspections, to establish whether there has been fraud, corruption or any other illegal activity affecting the financial interests of the EU.

22.3 Checks and audits by the European Court of Auditors (ECA)

Under Article 287 of the Treaty on the Functioning of the European Union (TFEU) and Article 161 of the Financial Regulation No 966/2012\textsuperscript{17}, the European Court of Auditors (ECA) may — at any moment during implementation of the action or afterwards — carry out audits.

The ECA has the right of access for the purpose of checks and audits.

22.4 Checks, reviews, audits and investigations for international organisations

In conformity with its financial regulations, the European Union, including the European Anti-Fraud Office (OLAF) and the European Court of Auditors (ECA), may undertake, including on the spot, checks, reviews audits and investigations.

This Article will be applied in accordance with any specific agreement concluded in this respect by the international organisation and the European Union.

22.5 Consequences of findings in checks, reviews, audits and investigations — Extension of findings

22.5.1 Findings in this grant

Findings in checks, reviews, audits or investigations carried out in the context of this grant may lead to the rejection of ineligible costs (see Article 42), reduction of the grant (see Article 43), recovery of undue amounts (see Article 44) or to any of the other measures described in Chapter 6.

Rejection of costs or reduction of the grant after the payment of the balance will lead to a revised final grant amount (see Article 5.4).

Findings in checks, reviews, audits or investigations may lead to a request for amendment for the modification of Annex 1 (see Article 55).


Checks, reviews, audits or investigations that find systemic or recurrent errors, irregularities, fraud or breach of obligations may also lead to consequences in other EU or Euratom grants awarded under similar conditions (‘extension of findings from this grant to other grants’).

Moreover, findings arising from an OLAF investigation may lead to criminal prosecution under national law.

22.5.2 Findings in other grants

The Agency or the Commission may extend findings from other grants to this grant (‘extension of findings from other grants to this grant’), if:

(a) the beneficiary concerned is found, in other EU or Euratom grants awarded under similar conditions, to have committed systemic or recurrent errors, irregularities, fraud or breach of obligations that have a material impact on this grant and

(b) those findings are formally notified to the beneficiary concerned — together with the list of grants affected by the findings — no later than two years after the payment of the balance of this grant.

The extension of findings may lead to the rejection of costs (see Article 42), reduction of the grant (see Article 43), recovery of undue amounts (see Article 44), suspension of payments (see Article 48), suspension of the action implementation (see Article 49) or termination (see Article 50).

22.5.3 Procedure

The Agency or the Commission will formally notify the beneficiary concerned the systemic or recurrent errors and its intention to extend these audit findings, together with the list of grants affected.

22.5.3.1 If the findings concern eligibility of costs: the formal notification will include:

(a) an invitation to submit observations on the list of grants affected by the findings;

(b) the request to submit revised financial statements for all grants affected;

(c) the correction rate for extrapolation established by the Agency or the Commission on the basis of the systemic or recurrent errors, to calculate the amounts to be rejected if the beneficiary concerned:

   (i) considers that the submission of revised financial statements is not possible or practicable or

   (ii) does not submit revised financial statements.

The beneficiary concerned has 90 days from receiving notification to submit observations, revised financial statements or to propose a duly substantiated alternative correction method. This period may be extended by the Agency or the Commission in justified cases.

The amounts to be rejected will be determined on the basis of the revised financial statements, subject to their approval.
If the *Agency or the* Commission does not receive any observations or revised financial statements, does not accept the observations or the proposed alternative correction method or does not approve the revised financial statements, it will formally notify the beneficiary concerned the application of the initially notified correction rate for extrapolation.

If the *Agency or the* Commission accepts the alternative correction method proposed by the beneficiary concerned, it will formally notify the application of the accepted alternative correction method.

22.5.3.2 If the findings concern **improper implementation** or a **breach of another obligation**: the formal notification will include:

(a) an invitation to submit observations on the list of grants affected by the findings and

(b) the flat-rate the *Agency or the* Commission intends to apply according to the principle of proportionality.

The beneficiary concerned has 90 days from receiving notification to submit observations or to propose a duly substantiated alternative flat-rate.

If the *Agency or the* Commission does not receive any observations or does not accept the observations or the proposed alternative flat-rate, it will formally notify the beneficiary concerned the application of the initially notified flat-rate.

If the *Agency or the* Commission accepts the alternative flat-rate proposed by the beneficiary concerned, it will formally notify the application of the accepted alternative flat-rate.

**22.6 Consequences of non-compliance**

If a beneficiary breaches any of its obligations under this Article, any insufficiently substantiated costs will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

**ARTICLE 23 — EVALUATION OF THE IMPACT OF THE ACTION**

**23.1 Right to evaluate the impact of the action**

The *Agency or the* Commission may carry out interim and final evaluations of the impact of the action measured against the objective of the *EU* programme.

Evaluations may be started during implementation of the action and up to **five** years after the payment of the balance. The evaluation is considered to start on the date of the formal notification to the coordinator or beneficiaries.

The *Agency or the* Commission may make these evaluations directly (using its own staff) or indirectly (using external bodies or persons it has authorised to do so).

The coordinator or beneficiaries must provide any information relevant to evaluate the impact of the action, including information in electronic format.
23.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the Agency may apply the measures described in Chapter 6.

SECTION 3 RIGHTS AND OBLIGATIONS RELATED TO BACKGROUND AND RESULTS

SUBSECTION 1 GENERAL

ARTICLE 23a — MANAGEMENT OF INTELLECTUAL PROPERTY

23a.1 Obligation to take measures to implement the Commission Recommendation on the management of intellectual property in knowledge transfer activities

Beneficiaries that are universities or other public research organisations must take measures to implement the principles set out in Points 1 and 2 of the Code of Practice annexed to the Commission Recommendation on the management of intellectual property in knowledge transfer activities.18

This does not change the obligations set out in Subsections 2 and 3 of this Section.

The beneficiaries must ensure that researchers and third parties involved in the action are aware of them.

23a.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the Agency may apply any of the measures described in Chapter 6.

SUBSECTION 2 RIGHTS AND OBLIGATIONS RELATED TO BACKGROUND

ARTICLE 24 — AGREEMENT ON BACKGROUND

24.1 Agreement on background

The beneficiaries must identify and agree (in writing) on the background for the action (‘agreement on background’).

‘Background’ means any data, know-how or information — whatever its form or nature (tangible or intangible), including any rights such as intellectual property rights — that:

(a) is held by the beneficiaries before they acceded to the Agreement, and

(b) is needed to implement the action or exploit the results.

18 Commission Recommendation C (2008) 1329 of 10.4.2008 on the management of intellectual property in knowledge transfer activities and the Code of Practice for universities and other public research institutions attached to this recommendation.
24.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 25 — ACCESS RIGHTS TO BACKGROUND

25.1 Exercise of access rights — Waiving of access rights — No sub-licensing

To exercise access rights, this must first be requested in writing (‘request for access’).

‘Access rights’ means rights to use results or background under the terms and conditions laid down in this Agreement.

Waivers of access rights are not valid unless in writing.

Unless agreed otherwise, access rights do not include the right to sub-license.

25.2 Access rights for other beneficiaries, for implementing their own tasks under the action

The beneficiaries must give each other access — on a royalty-free basis — to background needed to implement their own tasks under the action, unless the beneficiary that holds the background has — before acceding to the Agreement —:

(a) informed the other beneficiaries that access to its background is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel), or

(b) agreed with the other beneficiaries that access would not be on a royalty-free basis.

25.3 Access rights for other beneficiaries, for exploiting their own results

The beneficiaries must give each other access — under fair and reasonable conditions — to background needed for exploiting their own results, unless the beneficiary that holds the background has — before acceding to the Agreement — informed the other beneficiaries that access to its background is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel).

‘Fair and reasonable conditions’ means appropriate conditions, including possible financial terms or royalty-free conditions, taking into account the specific circumstances of the request for access, for example the actual or potential value of the results or background to which access is requested and/or the scope, duration or other characteristics of the exploitation envisaged.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

25.4 Access rights for affiliated entities

Unless otherwise agreed in the consortium agreement, access to background must also be given — under fair and reasonable conditions (see above; Article 25.3) and unless it is subject to legal
restrictions or limits, including those imposed by the rights of third parties (including personnel) — to affiliated entities\(^19\) established in an EU Member State or ‘\textit{associated country}’\(^20\), if this is needed to exploit the results generated by the beneficiaries to which they are affiliated.

Unless agreed otherwise (see above; Article 25.1), the affiliated entity concerned must make the request directly to the beneficiary that holds the background.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

\textbf{25.5 Access rights for third parties}

\textit{Not applicable}

\textbf{25.6 Consequences of non-compliance}

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

\textbf{SUBSECTION 3 RIGHTS AND OBLIGATIONS RELATED TO RESULTS}

\textbf{ARTICLE 26 — OWNERSHIP OF RESULTS}

\textbf{26.1 Ownership by the beneficiary that generates the results}

Results are owned by the beneficiary that generates them.

‘\textit{Results}’ means any (tangible or intangible) output of the action such as data, knowledge or information — whatever its form or nature, whether it can be protected or not — that is generated in the action, as well as any rights attached to it, including intellectual property rights.

\textbf{26.2 Joint ownership by several beneficiaries}

Two or more beneficiaries own results jointly if:

(a) they have jointly generated them and

(b) it is not possible to:

(i) establish the respective contribution of each beneficiary, or

(ii) separate them for the purpose of applying for, obtaining or maintaining their protection (see Article 27).

\(^{19}\) For the definition, see ‘affiliated entity’ footnote (Article 14.1).

\(^{20}\) For the definition, see Article 2.1(3) of the Rules for Participation Regulation No 1290/2013: ‘\textit{associated country}’ means a third country which is party to an international agreement with the Union, as identified in Article 7 of Horizon 2020 Framework Programme Regulation No 1291/2013. Article 7 sets out the conditions for association of non-EU countries to Horizon 2020.
The joint owners must agree (in writing) on the allocation and terms of exercise of their joint ownership ('joint ownership agreement'), to ensure compliance with their obligations under this Agreement.

Unless otherwise agreed in the joint ownership agreement, each joint owner may grant non-exclusive licences to third parties to exploit jointly-owned results (without any right to sub-license), if the other joint owners are given:

(a) at least 45 days advance notice and

(b) fair and reasonable compensation.

Once the results have been generated, joint owners may agree (in writing) to apply another regime than joint ownership (such as, for instance, transfer to a single owner (see Article 30) with access rights for the others).

26.3 Rights of third parties (including personnel)

If third parties (including personnel) may claim rights to the results, the beneficiary concerned must ensure that it complies with its obligations under the Agreement.

If a third party generates results, the beneficiary concerned must obtain all necessary rights (transfer, licences or other) from the third party, in order to be able to respect its obligations as if those results were generated by the beneficiary itself.

If obtaining the rights is impossible, the beneficiary must refrain from using the third party to generate the results.

26.4 Agency ownership, to protect results

26.4.1 The Agency may — with the consent of the beneficiary concerned — assume ownership of results to protect them, if a beneficiary intends — up to four years after the period set out in Article 3 — to disseminate its results without protecting them, except in any of the following cases:

(a) the lack of protection is because protecting the results is not possible, reasonable or justified (given the circumstances);

(b) the lack of protection is because there is a lack of potential for commercial or industrial exploitation, or

(c) the beneficiary intends to transfer the results to another beneficiary or third party established in an EU Member State or associated country, which will protect them.

Before the results are disseminated and unless any of the cases above under Points (a), (b) or (c) applies, the beneficiary must formally notify the Agency and at the same time inform it of any reasons for refusing consent. The beneficiary may refuse consent only if it can show that its legitimate interests would suffer significant harm.

If the Agency decides to assume ownership, it will formally notify the beneficiary concerned within 45 days of receiving notification.

No dissemination relating to these results may before the end of this period or, if the Agency takes a positive decision, until it has taken the necessary steps to protect the results.
26.4.2 The Agency may — with the consent of the beneficiary concerned — assume ownership of results to protect them, if a beneficiary intends — up to four years after the period set out in Article 3 — to stop protecting them or not to seek an extension of protection, except in any of the following cases:

(a) the protection is stopped because of a lack of potential for commercial or industrial exploitation;

(b) an extension would not be justified given the circumstances.

A beneficiary that intends to stop protecting results or not seek an extension must — unless any of the cases above under Points (a) or (b) applies — formally notify the Agency at least 60 days before the protection lapses or its extension is no longer possible and at the same time inform it of any reasons for refusing consent. The beneficiary may refuse consent only if it can show that its legitimate interests would suffer significant harm.

If the Agency decides to assume ownership, it will formally notify the beneficiary concerned within 45 days of receiving notification.

26.5 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to the any of the other measures described in Chapter 6.

ARTICLE 27 — PROTECTION OF RESULTS — VISIBILITY OF EU FUNDING

27.1 Obligation to protect the results

Each beneficiary must examine the possibility of protecting its results and must adequately protect them — for an appropriate period and with appropriate territorial coverage — if:

(a) the results can reasonably be expected to be commercially or industrially exploited and

(b) protecting them is possible, reasonable and justified (given the circumstances).

When deciding on protection, the beneficiary must consider its own legitimate interests and the legitimate interests (especially commercial) of the other beneficiaries.

27.2 Agency ownership, to protect the results

If a beneficiary intends not to protect its results, to stop protecting them or not seek an extension of protection, the Agency may — under certain conditions (see Article 26.4) — assume ownership to ensure their (continued) protection.

27.3 Information on EU funding

Applications for protection of results (including patent applications) filed by or on behalf of a beneficiary must — unless the Agency requests or agrees otherwise or unless it is impossible — include the following:

“The project leading to this application has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 727862”.
27.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 28 — EXPLOITATION OF RESULTS

28.1 Obligation to exploit the results

Each beneficiary must — up to four years after the period set out in Article 3 — take measures aiming to ensure ‘exploitation’ of its results (either directly or indirectly, in particular through transfer or licensing; see Article 30) by:

(a) using them in further research activities (outside the action);

(b) developing, creating or marketing a product or process;

(c) creating and providing a service, or

(d) using them in standardisation activities.

This does not change the security obligations in Article 37, which still apply.

28.2 Results that could contribute to European or international standards — Information on EU funding

If results are incorporated in a standard, the beneficiary concerned must — unless the Agency requests or agrees otherwise or unless it is impossible — ask the standardisation body to include the following statement in (information related to) the standard:

“Results incorporated in this standard received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 727862”.

28.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced in accordance with Article 43.

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 29 — DISSEMINATION OF RESULTS — OPEN ACCESS — VISIBILITY OF EU FUNDING

29.1 Obligation to disseminate results

Unless it goes against their legitimate interests, each beneficiary must — as soon as possible — ‘disseminate’ its results by disclosing them to the public by appropriate means (other than those resulting from protecting or exploiting the results), including in scientific publications (in any medium).
This does not change the obligation to protect results in Article 27, the confidentiality obligations in Article 36, the security obligations in Article 37 or the obligations to protect personal data in Article 39, all of which still apply.

A beneficiary that intends to disseminate its results must give advance notice to the other beneficiaries of — unless agreed otherwise — at least 45 days, together with sufficient information on the results it will disseminate.

Any other beneficiary may object within — unless agreed otherwise — 30 days of receiving notification, if it can show that its legitimate interests in relation to the results or background would be significantly harmed. In such cases, the dissemination may not take place unless appropriate steps are taken to safeguard these legitimate interests.

If a beneficiary intends not to protect its results, it may — under certain conditions (see Article 26.4.1) — need to formally notify the Agency before dissemination takes place.

### 29.2 Open access to scientific publications

Each beneficiary must ensure open access (free of charge online access for any user) to all peer-reviewed scientific publications relating to its results.

In particular, it must:

(a) as soon as possible and at the latest on publication, deposit a machine-readable electronic copy of the published version or final peer-reviewed manuscript accepted for publication in a repository for scientific publications;

Moreover, the beneficiary must aim to deposit at the same time the research data needed to validate the results presented in the deposited scientific publications.

(b) ensure open access to the deposited publication — via the repository — at the latest:

(i) on publication, if an electronic version is available for free via the publisher, or

(ii) within six months of publication (twelve months for publications in the social sciences and humanities) in any other case.

(c) ensure open access — via the repository — to the bibliographic metadata that identify the deposited publication.

The bibliographic metadata must be in a standard format and must include all of the following:

- the terms “European Union (EU)” and “Horizon 2020”;

- the name of the action, acronym and grant number;

- the publication date, and length of embargo period if applicable, and

- a persistent identifier.
29.3 Open access to research data

Regarding the digital research data generated in the action ('data'), the beneficiaries must:

(a) deposit in a research data repository and take measures to make it possible for third parties to access, mine, exploit, reproduce and disseminate — free of charge for any user — the following:

(i) the data, including associated metadata, needed to validate the results presented in scientific publications as soon as possible;

(ii) other data, including associated metadata, as specified and within the deadlines laid down in the 'data management plan' (see Annex 1);

(b) provide information — via the repository — about tools and instruments at the disposal of the beneficiaries and necessary for validating the results (and — where possible — provide the tools and instruments themselves).

This does not change the obligation to protect results in Article 27, the confidentiality obligations in Article 36, the security obligations in Article 37 or the obligations to protect personal data in Article 39, all of which still apply.

As an exception, the beneficiaries do not have to ensure open access to specific parts of their research data if the achievement of the action’s main objective, as described in Annex 1, would be jeopardised by making those specific parts of the research data openly accessible. In this case, the data management plan must contain the reasons for not giving access.

29.4 Information on EU funding — Obligation and right to use the EU emblem

Unless the Agency requests or agrees otherwise or unless it is impossible, any dissemination of results (in any form, including electronic) must:

(a) display the EU emblem and

(b) include the following text:

“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 727862”.

When displayed together with another logo, the EU emblem must have appropriate prominence.

For the purposes of their obligations under this Article, the beneficiaries may use the EU emblem without first obtaining approval from the Agency.

This does not however give them the right to exclusive use.

Moreover, they may not appropriate the EU emblem or any similar trademark or logo, either by registration or by any other means.

29.5 Disclaimer excluding Agency responsibility

Any dissemination of results must indicate that it reflects only the author's view and that the Agency is not responsible for any use that may be made of the information it contains.
29.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 30 — TRANSFER AND LICENSING OF RESULTS

30.1 Transfer of ownership

Each beneficiary may transfer ownership of its results.

It must however ensure that its obligations under Articles 26.2, 26.4, 27, 28, 29, 30 and 31 also apply to the new owner and that this owner has the obligation to pass them on in any subsequent transfer.

This does not change the security obligations in Article 37, which still apply.

Unless agreed otherwise (in writing) for specifically-identified third parties or unless impossible under applicable EU and national laws on mergers and acquisitions, a beneficiary that intends to transfer ownership of results must give at least 45 days advance notice (or less if agreed in writing) to the other beneficiaries that still have (or still may request) access rights to the results. This notification must include sufficient information on the new owner to enable any beneficiary concerned to assess the effects on its access rights.

Unless agreed otherwise (in writing) for specifically-identified third parties, any other beneficiary may object within 30 days of receiving notification (or less if agreed in writing), if it can show that the transfer would adversely affect its access rights. In this case, the transfer may not take place until agreement has been reached between the beneficiaries concerned.

30.2 Granting licenses

Each beneficiary may grant licences to its results (or otherwise give the right to exploit them), if:

(a) this does not impede the rights under Article 31 and

(b) not applicable.

In addition to Points (a) and (b), exclusive licences for results may be granted only if all the other beneficiaries concerned have waived their access rights (see Article 31.1).

This does not change the dissemination obligations in Article 29 or security obligations in Article 37, which still apply.

30.3 Agency right to object to transfers or licensing

Not applicable

30.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).
Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 31 — ACCESS RIGHTS TO RESULTS

31.1 Exercise of access rights — Waiving of access rights — No sub-licensing

The conditions set out in Article 25.1 apply.

The obligations set out in this Article do not change the security obligations in Article 37, which still apply.

31.2 Access rights for other beneficiaries, for implementing their own tasks under the action

The beneficiaries must give each other access — on a royalty-free basis — to results needed for implementing their own tasks under the action.

31.3 Access rights for other beneficiaries, for exploiting their own results

The beneficiaries must give each other — under fair and reasonable conditions (see Article 25.3) — access to results needed for exploiting their own results.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

31.4 Access rights of affiliated entities

Unless agreed otherwise in the consortium agreement, access to results must also be given — under fair and reasonable conditions (Article 25.3) — to affiliated entities established in an EU Member State or associated country, if this is needed for those entities to exploit the results generated by the beneficiaries to which they are affiliated.

Unless agreed otherwise (see above; Article 31.1), the affiliated entity concerned must make any such request directly to the beneficiary that owns the results.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

31.5 Access rights for the EU institutions, bodies, offices or agencies and EU Member States

The beneficiaries must give access to their results — on a royalty-free basis — to EU institutions, bodies, offices or agencies, for developing, implementing or monitoring EU policies or programmes.

Such access rights are limited to non-commercial and non-competitive use.

This does not change the right to use any material, document or information received from the beneficiaries for communication and publicising activities (see Article 38.2).

31.6 Access rights for third parties

Not applicable
31.7 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

SECTION 4 OTHER RIGHTS AND OBLIGATIONS

ARTICLE 32 — RECRUITMENT AND WORKING CONDITIONS FOR RESEARCHERS

32.1 Obligation to take measures to implement the European Charter for Researchers and Code of Conduct for the Recruitment of Researchers

The beneficiaries must take all measures to implement the principles set out in the Commission Recommendation on the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers, in particular regarding:

- working conditions;
- transparent recruitment processes based on merit, and
- career development.

The beneficiaries must ensure that researchers and third parties involved in the action are aware of them.

32.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the Agency may apply any of the measures described in Chapter 6.

ARTICLE 33 — GENDER EQUALITY

33.1 Obligation to aim for gender equality

The beneficiaries must take all measures to promote equal opportunities between men and women in the implementation of the action. They must aim, to the extent possible, for a gender balance at all levels of personnel assigned to the action, including at supervisory and managerial level.

33.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the Agency may apply any of the measures described in Chapter 6.

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ARTICLE 34 — ETHICS

34.1 Obligation to comply with ethical principles

The beneficiaries must carry out the action in compliance with:

(a) ethical principles (including the highest standards of research integrity — as set out, for instance, in the European Code of Conduct for Research Integrity\(^{23}\) — and including, in particular, avoiding fabrication, falsification, plagiarism or other research misconduct) and

(b) applicable international, EU and national law.

Funding will not be granted for activities carried out outside the EU if they are prohibited in all Member States.

The beneficiaries must ensure that the activities under the action have an exclusive focus on civil applications.

The beneficiaries must ensure that the activities under the action do not:

(a) aim at human cloning for reproductive purposes;

(b) intend to modify the genetic heritage of human beings which could make such changes heritable (with the exception of research relating to cancer treatment of the gonads, which may be financed), or

(c) intend to create human embryos solely for the purpose of research or for the purpose of stem cell procurement, including by means of somatic cell nuclear transfer.

34.2 Activities raising ethical issues

Activities raising ethical issues must comply with the ‘ethics requirements’ set out in Annex 1.

Before the beginning of an activity raising an ethical issue, the coordinator must submit (see Article 52) to the Agency copy of:

(a) any ethics committee opinion required under national law and

(b) any notification or authorisation for activities raising ethical issues required under national law.

If these documents are not in English, the coordinator must also submit an English summary of the submitted opinions, notifications and authorisations (containing, if available, the conclusions of the committee or authority concerned).

If these documents are specifically requested for the action, the request must contain an explicit reference to the action title. The coordinator must submit a declaration by each beneficiary concerned that all the submitted documents cover the action tasks.

\(^{23}\) The European Code of Conduct for Research Integrity of ALLEA (All European Academies) and ESF (European Science Foundation) of March 2011.

34.3 Activities involving human embryos or human embryonic stem cells

Activities involving research on human embryos or human embryonic stem cells may be carried out only if:

- they are set out in Annex 1 or

- the coordinator has obtained explicit approval (in writing) from the Agency (see Article 52).

34.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or participation of the beneficiary may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 35 — CONFLICT OF INTERESTS

35.1 Obligation to avoid a conflict of interests

The beneficiaries must take all measures to prevent any situation where the impartial and objective implementation of the action is compromised for reasons involving economic interest, political or national affinity, family or emotional ties or any other shared interest (‘conflict of interests’).

They must formally notify to the Agency without delay any situation constituting or likely to lead to a conflict of interests and immediately take all the necessary steps to rectify this situation.

The Agency may verify that the measures taken are appropriate and may require additional measures to be taken by a specified deadline.

35.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or participation of the beneficiary may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 36 — CONFIDENTIALITY

36.1 General obligation to maintain confidentiality

During implementation of the action and for four years after the period set out in Article 3, the parties must keep confidential any data, documents or other material (in any form) that is identified as confidential at the time it is disclosed (‘confidential information’).

If a beneficiary requests, the Agency may agree to keep such information confidential for an additional period beyond the initial four years.

If information has been identified as confidential only orally, it will be considered to be confidential only if this is confirmed in writing within 15 days of the oral disclosure.
Unless otherwise agreed between the parties, they may use confidential information only to implement the Agreement.

The beneficiaries may disclose confidential information to their personnel or third parties involved in the action only if they:

(a) need to know to implement the Agreement and

(b) are bound by an obligation of confidentiality.

This does not change the security obligations in Article 37, which still apply.

The Agency may disclose confidential information to its staff, other EU institutions and bodies or third parties, if:

(a) this is necessary to implement the Agreement or safeguard the EU’s financial interests and

(b) the recipients of the information are bound by an obligation of confidentiality.

Under the conditions set out in Article 4 of the Rules for Participation Regulation No 1290/2013, the Commission must moreover make available information on the results to other EU institutions, bodies, offices or agencies as well as Member States or associated countries.

The confidentiality obligations no longer apply if:

(a) the disclosing party agrees to release the other party;

(b) the information was already known by the recipient or is given to him without obligation of confidentiality by a third party that was not bound by any obligation of confidentiality;

(c) the recipient proves that the information was developed without the use of confidential information;

(d) the information becomes generally and publicly available, without breaching any confidentiality obligation, or

(e) the disclosure of the information is required by EU or national law.

36.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 37 — SECURITY-RELATED OBLIGATIONS

37.1 Results with a security recommendation

Not applicable

37.2 Classified results

Not applicable

37.3 Activities involving dual-use goods or dangerous materials and substances

Not applicable

37.4 Consequences of non-compliance

Not applicable

ARTICLE 38 — PROMOTING THE ACTION — VISIBILITY OF EU FUNDING

38.1 Communication activities by beneficiaries

38.1.1 Obligation to promote the action and its results

The beneficiaries must promote the action and its results, by providing targeted information to multiple audiences (including the media and the public) in a strategic and effective manner.

This does not change the dissemination obligations in Article 29, the confidentiality obligations in Article 36 or the security obligations in Article 37, all of which still apply.

Before engaging in a communication activity expected to have a major media impact, the beneficiaries must inform the Agency (see Article 52).

38.1.2 Information on EU funding — Obligation and right to use the EU emblem

Unless the Agency requests or agrees otherwise or unless it is impossible, any communication activity related to the action (including in electronic form, via social media, etc.) and any infrastructure, equipment and major results funded by the grant must:

(a) display the EU emblem and

(b) include the following text:

For communication activities: “This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 727862”.

For infrastructure, equipment and major results: “This [infrastructure/equipment/[insert type of result]] is part of a project that has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 727862”.

When displayed together with another logo, the EU emblem must have appropriate prominence.
For the purposes of their obligations under this Article, the beneficiaries may use the EU emblem without first obtaining approval from the Agency.

This does not, however, give them the right to exclusive use.

Moreover, they may not appropriate the EU emblem or any similar trademark or logo, either by registration or by any other means.

38.1.3 Disclaimer excluding Agency responsibility

Any communication activity related to the action must indicate that it reflects only the author's view and that the Agency is not responsible for any use that may be made of the information it contains.

38.2 Communication activities by the Agency

38.2.1 Right to use beneficiaries’ materials, documents or information

The Agency may use, for its communication and publicising activities, information relating to the action, documents notably summaries for publication and public deliverables as well as any other material, such as pictures or audio-visual material that it receives from any beneficiary (including in electronic form).

This does not change the confidentiality obligations in Article 36 and the security obligations in Article 37, all of which still apply.

However, if the Agency’s use of these materials, documents or information would risk compromising legitimate interests, the beneficiary concerned may request the Agency not to use it (see Article 52).

The right to use a beneficiary’s materials, documents and information includes:

(a) use for its own purposes (in particular, making them available to persons working for the Agency or any other EU institution, body, office or agency or body or institutions in EU Member States; and copying or reproducing them in whole or in part, in unlimited numbers);

(b) distribution to the public (in particular, publication as hard copies and in electronic or digital format, publication on the internet, as a downloadable or non-downloadable file, broadcasting by any channel, public display or presentation, communicating through press information services, or inclusion in widely accessible databases or indexes);

(c) editing or redrafting for communication and publicising activities (including shortening, summarising, inserting other elements (such as meta-data, legends, other graphic, visual, audio or text elements), extracting parts (e.g. audio or video files), dividing into parts, use in a compilation);

(d) translation;

(e) giving access in response to individual requests under Regulation No 1049/200125, without the right to reproduce or exploit;

(f) **storage** in paper, electronic or other form;

(g) **archiving**, in line with applicable document-management rules, and

(h) the right to authorise **third parties** to act on its behalf or sub-license the modes of use set out in Points (b),(c),(d) and (f) to third parties if needed for the communication and publicising activities of the **Agency**.

If the right of use is subject to rights of a third party (including personnel of the beneficiary), the beneficiary must ensure that it complies with its obligations under this Agreement (in particular, by obtaining the necessary approval from the third parties concerned).

Where applicable (and if provided by the beneficiaries), the **Agency** will insert the following information:

“© – [year] – [name of the copyright owner]. All rights reserved. Licensed to the **Executive Agency for Small and Medium-sized Enterprises (EASME)** under conditions.”

38.3 **Consequences of non-compliance**

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

**ARTICLE 39 — PROCESSING OF PERSONAL DATA**

39.1 **Processing of personal data by the **Agency and the Commission**

Any personal data under the Agreement will be processed by the **Agency or the Commission** under Regulation No 45/2001 \(^{26}\) and according to the ‘notifications of the processing operations’ to the Data Protection Officer (DPO) of the **Agency or the Commission** (publicly accessible in the DPO register).

Such data will be processed by the ‘**data controller**’ of the **Agency or the Commission** for the purposes of implementing, managing and monitoring the Agreement or protecting the financial interests of the EU or Euratom (including checks, reviews, audits and investigations; see Article 22).

The persons whose personal data are processed have the right to access and correct their own personal data. For this purpose, they must send any queries about the processing of their personal data to the data controller, via the contact point indicated in the ‘service specific privacy statement(s) (SSPS)’ that are published on the **Agency and the Commission** websites.

They also have the right to have recourse at any time to the European Data Protection Supervisor (EDPS).

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\(^{26}\) Regulation (EC) No 45/2001 of the European Parliament and of the Council of 18 December 2000 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data (OJ L 8, 12.01.2001, p. 1).
39.2 Processing of personal data by the beneficiaries

The beneficiaries must process personal data under the Agreement in compliance with applicable EU and national law on data protection (including authorisations or notification requirements).

The beneficiaries may grant their personnel access only to data that is strictly necessary for implementing, managing and monitoring the Agreement.

The beneficiaries must inform the personnel whose personal data are collected and processed by the Agency or the Commission. For this purpose, they must provide them with the service specific privacy statement (SSPS) (see above), before transmitting their data to the Agency or the Commission.

39.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 39.2, the Agency may apply any of the measures described in Chapter 6.

ARTICLE 40 — ASSIGNMENTS OF CLAIMS FOR PAYMENT AGAINST THE AGENCY

The beneficiaries may not assign any of their claims for payment against the Agency to any third party, except if approved by the Agency on the basis of a reasoned, written request by the coordinator (on behalf of the beneficiary concerned).

If the Agency has not accepted the assignment or the terms of it are not observed, the assignment will have no effect on it.

In no circumstances will an assignment release the beneficiaries from their obligations towards the Agency.

CHAPTER 5 DIVISION OF BENEFICIARIES’ ROLES AND RESPONSIBILITIES

ARTICLE 41 — DIVISION OF BENEFICIARIES’ ROLES AND RESPONSIBILITIES — RELATIONSHIP WITH COMPLEMENTARY BENEFICIARIES — RELATIONSHIP WITH PARTNERS OF A JOINT ACTION

41.1 Roles and responsibilities towards the Agency

The beneficiaries have full responsibility for implementing the action and complying with the Agreement.

The beneficiaries are jointly and severally liable for the technical implementation of the action as described in Annex 1. If a beneficiary fails to implement its part of the action, the other beneficiaries become responsible for implementing this part (without being entitled to any additional EU funding for doing so), unless the Agency expressly relieves them of this obligation.

The financial responsibility of each beneficiary is governed by Articles 44, 45 and 46.

41.2 Internal division of roles and responsibilities

The internal roles and responsibilities of the beneficiaries are divided as follows:
(a) Each **beneficiary** must:

(i) keep information stored in the 'Beneficiary Register' (via the electronic exchange system) up to date (see Article 17);

(ii) inform the coordinator immediately of any events or circumstances likely to affect significantly or delay the implementation of the action (see Article 17);

(iii) submit to the coordinator in good time:

- individual financial statements for itself and its linked third parties and, if required, certificates on the financial statements (see Article 20);

- the data needed to draw up the technical reports (see Article 20);

- ethics committee opinions and notifications or authorisations for activities raising ethical issues (see Article 34);

- any other documents or information required by the *Agency* or the *Commission* under the Agreement, unless the Agreement requires the beneficiary to submit this information directly to the *Agency* or the *Commission*.

(b) The **coordinator** must:

(i) monitor that the action is implemented properly (see Article 7);

(ii) act as the intermediary for all communications between the beneficiaries and the *Agency* (in particular, providing the *Agency* with the information described in Article 17), unless the Agreement specifies otherwise;

(iii) request and review any documents or information required by the *Agency* and verify their completeness and correctness before passing them on to the *Agency*;

(iv) submit the deliverables and reports to the *Agency* (see Articles 19 and 20);

(v) ensure that all payments are made to the other beneficiaries without unjustified delay (see Article 21);

(vi) inform the *Agency* of the amounts paid to each beneficiary, when required under the Agreement (see Articles 44 and 50) or requested by the *Agency*.

The coordinator may not delegate the above-mentioned tasks to any other beneficiary or subcontract them to any third party.

**41.3 Internal arrangements between beneficiaries — Consortium agreement**

*The beneficiaries must have internal arrangements regarding their operation and co-ordination to ensure that the action is implemented properly. These internal arrangements must be set out in a written ‘consortium agreement’ between the beneficiaries, which may cover:*
- internal organisation of the consortium;
- management of access to the electronic exchange system;
- distribution of EU funding;
- additional rules on rights and obligations related to background and results (including whether access rights remain or not, if a beneficiary is in breach of its obligations) (see Section 3 of Chapter 4);
- settlement of internal disputes;
- liability, indemnification and confidentiality arrangements between the beneficiaries.

The consortium agreement must not contain any provision contrary to the Agreement.

41.4 Relationship with complementary beneficiaries — Collaboration agreement

Not applicable

41.5 Relationship with partners of a joint action — Coordination agreement

Not applicable

CHAPTER 6   REJECTION OF COSTS — REDUCTION OF THE GRANT — RECOVERY — PENALTIES — DAMAGES — SUSPENSION — TERMINATION — FORCE MAJEURE

SECTION 1   REJECTION OF COSTS — REDUCTION OF THE GRANT — RECOVERY — PENALTIES

ARTICLE 42 — REJECTION OF INELIGIBLE COSTS

42.1 Conditions

42.1.1 The Agency will — at the time of an interim payment, at the payment of the balance or afterwards — reject any costs which are ineligible (see Article 6), in particular following checks, reviews, audits or investigations (see Article 22).

42.1.2 The rejection may also be based on the extension of findings from other grants to this grant, under the conditions set out in Article 22.5.2.

42.2 Ineligible costs to be rejected — Calculation — Procedure

Ineligible costs will be rejected in full.

If the Agency rejects costs without reduction of the grant (see Article 43) or recovery of undue amounts (see Article 44), it will formally notify the coordinator or beneficiary concerned the rejection of costs, the amounts and the reasons why (if applicable, together with the notification of amounts
due; see Article 21.5). The coordinator or beneficiary concerned may — within 30 days of receiving notification — formally notify the Agency of its disagreement and the reasons why.

If the Agency rejects costs with reduction of the grant or recovery of undue amounts, it will formally notify the rejection in the ‘pre-information letter’ on reduction or recovery set out in Articles 43 and 44.

42.3 Effects

If the Agency rejects costs at the time of an interim payment or the payment of the balance, it will deduct them from the total eligible costs declared, for the action, in the periodic or final summary financial statement (see Articles 20.3 and 20.4). It will then calculate the interim payment or payment of the balance as set out in Articles 21.3 or 21.4.

If the Agency — after an interim payment but before the payment of the balance — rejects costs declared in a periodic summary financial statement, it will deduct them from the total eligible costs declared, for the action, in the next periodic summary financial statement or in the final summary financial statement. It will then calculate the interim payment or payment of the balance as set out in Articles 21.3 or 21.4.

If the Agency rejects costs after the payment of the balance, it will deduct the amount rejected from the total eligible costs declared, by the beneficiary, in the final summary financial statement. It will then calculate the revised final grant amount as set out in Article 5.4.

ARTICLE 43 — REDUCTION OF THE GRANT

43.1 Conditions

43.1.1 The Agency may — at the payment of the balance or afterwards — reduce the maximum grant amount (see Article 5.1), if the action has not been implemented properly as described in Annex 1 or another obligation under the Agreement has been breached.

43.1.2 The Agency may also reduce the maximum grant amount on the basis of the extension of findings from other grants to this grant, under the conditions set out in Article 22.5.2.

43.2 Amount to be reduced — Calculation — Procedure

The amount of the reduction will be proportionate to the improper implementation of the action or to the seriousness of the breach.

Before reduction of the grant, the Agency will formally notify a ‘pre-information letter’ to the coordinator or beneficiary concerned:

- informing it of its intention to reduce the grant, the amount it intends to reduce and the reasons why and

- inviting it to submit observations within 30 days of receiving notification

If the Agency does not receive any observations or decides to pursue reduction despite the observations it has received, it will formally notify confirmation of the reduction (if applicable, together with the notification of amounts due; see Article 21).
43.3 Effects

If the Agency reduces the grant at the time of the payment of the balance, it will calculate the reduced grant amount for the action and then determine the amount due as payment of the balance (see Articles 5.3.4 and 21.4).

If the Agency reduces the grant after the payment of the balance, it will calculate the revised final grant amount for the beneficiary concerned (see Article 5.4). If the revised final grant amount for the beneficiary concerned is lower than its share of the final grant amount, the Agency will recover the difference (see Article 44).

ARTICLE 44 — RECOVERY OF UNDUE AMOUNTS

44.1 Amount to be recovered — Calculation — Procedure

The Agency will — after termination of the participation of a beneficiary, at the payment of the balance or afterwards — claim back any amount that was paid but is not due under the Agreement.

Each beneficiary’s financial responsibility in case of recovery is limited to its own debt (including undue amounts paid by the Agency for costs declared by its linked third parties), except for the amount retained for the Guarantee Fund (see Article 21.4).

44.1.1 Recovery after termination of a beneficiary’s participation

If recovery takes place after termination of a beneficiary’s participation (including the coordinator), the Agency will claim back the undue amount from the beneficiary concerned, by formally notifying it a debit note (see Article 50.2 and 50.3). This note will specify the amount to be recovered, the terms and the date for payment.

If payment is not made by the date specified in the debit note, the Agency or the Commission will recover the amount:

(a) by ‘offsetting’ it — without the beneficiary’s consent — against any amounts owed to the beneficiary concerned by the Agency, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU’s financial interests, the Agency may offset before the payment date specified in the debit note;

(b) not applicable;

(c) by taking legal action (see Article 57) or by adopting an enforceable decision under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial regulation No 966/2012.

If payment is not made by the date specified in the debit note, the amount to be recovered (see above) will be increased by late-payment interest at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the Agency or the Commission receives full payment of the amount.
Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

44.1.2 Recovery at payment of the balance

If the payment of the balance takes the form of a recovery (see Article 21.4), the Agency will formally notify a ‘pre-information letter’ to the coordinator:

- informing it of its intention to recover, the amount due as the balance and the reasons why;
- specifying that it intends to deduct the amount to be recovered from the amount retained for the Guarantee Fund;
- requesting the coordinator to submit a report on the distribution of payments to the beneficiaries within 30 days of receiving notification, and
- inviting the coordinator to submit observations within 30 days of receiving notification.

If no observations are submitted or the Agency decides to pursue recovery despite the observations it has received, it will confirm recovery (together with the notification of amounts due; see Article 21.5) and:

- pay the difference between the amount to be recovered and the amount retained for the Guarantee Fund, if the difference is positive or
- formally notify to the coordinator a debit note for the difference between the amount to be recovered and the amount retained for the Guarantee Fund, if the difference is negative. This note will also specify the terms and the date for payment.

If the coordinator does not repay the Agency by the date in the debit note and has not submitted the report on the distribution of payments: the Agency or the Commission will recover the amount set out in the debit note from the coordinator (see below).

If the coordinator does not repay the Agency by the date in the debit note, but has submitted the report on the distribution of payments: the Agency will:

(a) identify the beneficiaries for which the amount calculated as follows is negative:

{beneficiary’s costs declared in the final summary financial statement and approved by the Agency multiplied by the reimbursement rate set out in Article 5.2 for the beneficiary concerned plus

its linked third parties’ costs declared in the final summary financial statement and approved by the Agency multiplied by the reimbursement rate set out in Article 5.2 for each linked third party concerned)

divided by

the EU contribution for the action calculated according to Article 5.3.1

multiplied by

the final grant amount (see Article 5.3),

minus

{pre-financing and interim payments received by the beneficiary},

(b) formally notify to each beneficiary identified according to point (a) a debit note specifying the terms and date for payment. The amount of the debit note is calculated as follows:

\[
\text{amount calculated according to point (a) for the beneficiary concerned} \div \text{sum of the amounts calculated according to point (a) for all the beneficiaries identified according to point (a)} \times \text{amount set out in the debit note formally notified to the coordinator}.
\]

If payment is not made by the date specified in the debit note, the Agency will recover the amount:

(a) by ‘offsetting’ it — without the beneficiary’s consent — against any amounts owed to the beneficiary concerned by the Agency, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU’s financial interests, the Agency may offset before the payment date specified in the debit note;

(b) by drawing on the Guarantee Fund. The Agency or the Commission will formally notify the beneficiary concerned the debit note on behalf of the Guarantee Fund and recover the amount:

(i) not applicable;

(ii) by taking legal action (see Article 57) or by adopting an enforceable decision under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by late-payment interest at the rate set out in Article 21.11, from the day following the
payment date in the debit note, up to and including the date the Agency or the Commission receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

44.1.3 Recovery of amounts after payment of the balance

If, for a beneficiary, the revised final grant amount (see Article 5.4) is lower than its share of the final grant amount, it must repay the difference to the Agency.

The beneficiary’s share of the final grant amount is calculated as follows:

\[
\left\{ \left\{ \begin{array}{c}
\text{beneficiary’s costs declared in the final summary financial statement and approved by the Agency multiplied by the reimbursement rate set out in Article 5.2 for the beneficiary concerned} \\
\text{plus } \\
\text{its linked third parties’ costs declared in the final summary financial statement and approved by the Agency multiplied by the reimbursement rate set out in Article 5.2 for each linked third party concerned} \\
\end{array} \right\} \\
\text{divided by} \\
\text{the EU contribution for the action calculated according to Article 5.3.1} \\
\text{multiplied by} \\
\text{the final grant amount (see Article 5.3)}
\right\}.
\]

If the coordinator has not distributed amounts received (see Article 21.7), the Agency will also recover these amounts.

The Agency will formally notify a pre-information letter to the beneficiary concerned:

- informing it of its intention to recover, the due amount and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If no observations are submitted or the Agency decides to pursue recovery despite the observations it has received, it will confirm the amount to be recovered and formally notify to the beneficiary concerned a debit note. This note will also specify the terms and the date for payment.

If payment is not made by the date specified in the debit note, the Agency will recover the amount:

(a) by ‘offsetting’ it — without the beneficiary’s consent — against any amounts owed to the beneficiary concerned by the Agency, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU’s financial interests, the Agency may offset before the payment date specified in the debit note;
(b) by drawing on the Guarantee Fund. The Agency or the Commission will formally notify the beneficiary concerned the debit note on behalf of the Guarantee Fund and recover the amount:

   (i) not applicable;

   (ii) by taking legal action (see Article 57) or by adopting an enforceable decision under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by late-payment interest at the rate set out in Article 21.11, from the day following the date for payment in the debit note, up to and including the date the Agency or the Commission receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

ARTICLE 45 — ADMINISTRATIVE AND FINANCIAL PENALTIES

45.1 Conditions

Under Articles 109 and 131(4) of the Financial Regulation No 966/2012, the Agency may impose administrative and financial penalties if a beneficiary:

(a) has committed substantial errors, irregularities or fraud or is in serious breach of its obligations under the Agreement or

(b) has made false declarations about information required under the Agreement or for the submission of the proposal (or has not supplied such information).

Each beneficiary is responsible for paying the financial penalties imposed on it.

Under Article 109(3) of the Financial Regulation No 966/2012, the Agency or the Commission may — under certain conditions and limits — publish decisions imposing administrative or financial penalties.

45.2 Duration — Amount of penalty — Calculation

Administrative penalties exclude the beneficiary from all contracts and grants financed from the EU or Euratom budget for a maximum of five years from the date the infringement is established by the Agency.

If the beneficiary commits another infringement within five years of the date the first infringement is established, the Agency may extend the exclusion period up to 10 years.

Financial penalties will be between 2% and 10% of the maximum EU contribution indicated, for the beneficiary concerned, in the estimated budget (see Annex 2).

If the beneficiary commits another infringement within five years of the date the first infringement is established, the Agency may increase the rate of financial penalties to between 4% and 20%.
45.3 Procedure

Before applying a penalty, the *Agency* will formally notify the beneficiary concerned:

- informing it of its intention to impose a penalty, its duration or amount and the reasons why and
- inviting it to submit observations within 30 days.

If the *Agency* does not receive any observations or decides to impose the penalty despite of observations it has received, it will formally notify *confirmation* of the penalty to the beneficiary concerned and — in case of financial penalties — deduct the penalty from the payment of the balance or formally notify a *debit note*, specifying the amount to be recovered, the terms and the date for payment.

If payment is not made by the date specified in the debit note, the *Agency or the Commission* may *recover* the amount:

(a) by ‘*offsetting*’ it — without the beneficiary’s consent — against any amounts owed to the beneficiary concerned by the *Agency, the Commission* or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU’s financial interests, the *Agency* may offset before the payment date specified in the debit note;

(b) by *taking legal action* (see Article 57) or by *adopting an enforceable decision* under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by *late-payment interest* at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the *Agency or the Commission* receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

SECTION 2   LIABILITY FOR DAMAGES

ARTICLE 46 — LIABILITY FOR DAMAGES

46.1 Liability of the *Agency*

The *Agency* cannot be held liable for any damage caused to the beneficiaries or to third parties as a consequence of implementing the Agreement, including for gross negligence.

The *Agency* cannot be held liable for any damage caused by any of the beneficiaries or third parties involved in the action, as a consequence of implementing the Agreement.
46.2 Liability of the beneficiaries

46.2.1 Conditions

Except in case of force majeure (see Article 51), the beneficiaries must compensate the Agency for any damage it sustains as a result of the implementation of the action or because the action was not implemented in full compliance with the Agreement.

Each beneficiary is responsible for paying the damages claimed from it.

46.2.2 Amount of damages - Calculation

The amount the Agency can claim from a beneficiary will correspond to the damage caused by that beneficiary.

46.2.3 Procedure

Before claiming damages, the Agency will formally notify the beneficiary concerned:

- informing it of its intention to claim damages, the amount and the reasons why and
- inviting it to submit observations within 30 days.

If the Agency does not receive any observations or decides to claim damages despite the observations it has received, it will formally notify confirmation of the claim for damages and a debit note, specifying the amount to be recovered, the terms and the date for payment.

If payment is not made by the date specified in the debit note, the Agency or the Commission may recover the amount:

(a) by ‘offsetting’ it — without the beneficiary’s consent — against any amounts owed to the beneficiary concerned by the Agency, the Commission or another executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU’s financial interests, the Agency may offset before the payment date specified in the debit note;

(b) by taking legal action (see Article 57) or by adopting an enforceable decision under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by late-payment interest at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the Agency or the Commission receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.
SECTION 3  SUSPENSION AND TERMINATION

ARTICLE 47 — SUSPENSION OF PAYMENT DEADLINE

47.1 Conditions
The Agency may — at any moment — suspend the payment deadline (see Article 21.2 to 21.4) if a request for payment (see Article 20) cannot be approved because:

(a) it does not comply with the provisions of the Agreement (see Article 20);

(b) the technical reports or financial reports have not been submitted or are not complete or additional information is needed, or

(c) there is doubt about the eligibility of the costs declared in the financial statements and additional checks, reviews, audits or investigations are necessary.

47.2 Procedure
The Agency will formally notify the coordinator of the suspension and the reasons why.

The suspension will take effect the day notification is sent by the Agency (see Article 52).

If the conditions for suspending the payment deadline are no longer met, the suspension will be lifted — and the remaining period will resume.

If the suspension exceeds two months, the coordinator may request the Agency if the suspension will continue.

If the payment deadline has been suspended due to the non-compliance of the technical or financial reports (see Article 20) and the revised report or statement is not submitted or was submitted but is also rejected, the Agency may also terminate the Agreement or the participation of the beneficiary (see Article 50.3.1(l)).

ARTICLE 48 — SUSPENSION OF PAYMENTS

48.1 Conditions
The Agency may — at any moment — suspend, in whole or in part, the pre-financing payment and interim payments for one or more beneficiaries or the payment of the balance for all beneficiaries, if a beneficiary:

(a) has committed or is suspected of having committed substantial errors, irregularities, fraud or serious breach of obligations in the award procedure or under this Agreement or

(b) has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (extension of findings from other grants to this grant; see Article 22.5.2).
48.2 Procedure

Before suspending payments, the *Agency* will formally notify the coordinator:

- informing it of its intention to suspend payments and the reasons why and

- inviting it to submit observations within 30 days of receiving notification.

If the *Agency* does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify confirmation of the suspension. Otherwise, it will formally notify that the suspension procedure is not continued.

The suspension will take effect the day the confirmation notification is sent by the *Agency*.

If the conditions for resuming payments are met, the suspension will be lifted. The *Agency* will formally notify the coordinator.

During the suspension, the periodic report(s) (see Article 20.3) must not contain any individual financial statements from the beneficiary concerned and its linked third parties. When the *Agency* resumes payments, the coordinator may include them in the next periodic report.

The beneficiaries may suspend implementation of the action (see Article 49.1) or terminate the Agreement or the participation of the beneficiary concerned (see Article 50.1 and 50.2).

**ARTICLE 49 — SUSPENSION OF THE ACTION IMPLEMENTATION**

49.1 Suspension of the action implementation, by the beneficiaries

49.1.1 Conditions

The beneficiaries may suspend implementation of the action or any part of it, if exceptional circumstances — in particular force majeure (see Article 51) — make implementation impossible or excessively difficult.

49.1.2 Procedure

The coordinator must immediately formally notify to the *Agency* the suspension (see Article 52), stating:

- the reasons why and

- the expected date of resumption.

The suspension will take effect the day this notification is received by the *Agency*.

Once circumstances allow for implementation to resume, the coordinator must immediately formally notify the *Agency* and request an amendment of the Agreement to set the date on which the action will be resumed, extend the duration of the action and make other changes necessary to adapt the action to the new situation (see Article 55) — unless the Agreement or the participation of a beneficiary has been terminated (see Article 50).
The suspension will be **lifted** with effect from the resumption date set out in the amendment. This date may be before the date on which the amendment enters into force.

Costs incurred during suspension of the action implementation are not eligible (see Article 6).

### 49.2 Suspension of the action implementation, by the *Agency*

#### 49.2.1 Conditions

The *Agency* may suspend implementation of the action or any part of it:

(a) if a beneficiary has committed or is suspected of having committed substantial errors, irregularities, fraud or serious breach of obligations in the award procedure or under this Agreement;

(b) if a beneficiary has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (extension of findings from other grants to this grant; see Article 22.5.2), or

(c) if the action is suspected of having lost its scientific or technological relevance.

#### 49.2.2 Procedure

Before suspending implementation of the action, the *Agency* will formally notify the coordinator:

- informing it of its intention to suspend the implementation and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If the *Agency* does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify confirmation of the suspension. Otherwise, it will formally notify that the procedure is not continued.

The suspension will **take effect** five days after confirmation notification is received by the coordinator (or on a later date specified in the notification).

It will be **lifted** if the conditions for resuming implementation of the action are met.

The coordinator will be formally notified of the lifting and the Agreement will be **amended** to set the date on which the action will be resumed, extend the duration of the action and make other changes necessary to adapt the action to the new situation (see Article 55) — unless the Agreement has already been terminated (see Article 50).

The suspension will be lifted with effect from the resumption date set out in the amendment. This date may be before the date on which the amendment enters into force.

Costs incurred during suspension are not eligible (see Article 6).

The beneficiaries may not claim damages due to suspension by the *Agency* (see Article 46).
Suspension of the action implementation does not affect the Agency’s right to terminate the Agreement or participation of a beneficiary (see Article 50), reduce the grant or recover amounts unduly paid (see Articles 43 and 44).

**ARTICLE 50 — TERMINATION OF THE AGREEMENT OR OF THE PARTICIPATION OF ONE OR MORE BENEFICIARIES**

50.1 Termination of the Agreement by the beneficiaries

50.1.1 Conditions and procedure

The beneficiaries may terminate the Agreement.

The coordinator must formally notify termination to the Agency (see Article 52), stating:

- the reasons why and
- the date the termination will take effect. This date must be after the notification.

If no reasons are given or if the Agency considers the reasons do not justify termination, the Agreement will be considered to have been ‘terminated improperly’.

The termination will take effect on the day specified in the notification.

50.1.2 Effects

The coordinator must — within 60 days from when termination takes effect — submit:

(i) a periodic report (for the open reporting period until termination; see Article 20.3) and
(ii) the final report (see Article 20.4).

If the Agency does not receive the reports within the deadline (see above), only costs which are included in an approved periodic report will be taken into account.

The Agency will calculate the final grant amount (see Article 5.3) and the balance (see Article 21.4) on the basis of the reports submitted. Only costs incurred until termination are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

Improper termination may lead to a reduction of the grant (see Article 43).

After termination, the beneficiaries’ obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.

50.2 Termination of the participation of one or more beneficiaries, by the beneficiaries

50.2.1 Conditions and procedure

The participation of one or more beneficiaries may be terminated by the coordinator, on request of the beneficiary concerned or on behalf of the other beneficiaries.

The coordinator must formally notify termination to the Agency (see Article 52) and inform the beneficiary concerned.
If the coordinator’s participation is terminated without its agreement, the formal notification must be done by another beneficiary (acting on behalf of the other beneficiaries).

The notification must include:

- the reasons why;

- the opinion of the beneficiary concerned (or proof that this opinion has been requested in writing);

- the date the termination takes effect. This date must be after the notification, and

- a request for amendment (see Article 55), with a proposal for reallocation of the tasks and the estimated budget of the beneficiary concerned (see Annexes 1 and 2) and, if necessary, the addition of one or more new beneficiaries (see Article 56). If termination takes effect after the period set out in Article 3, no request for amendment must be included unless the beneficiary concerned is the coordinator. In this case, the request for amendment must propose a new coordinator.

If this information is not given or if the *Agency* considers that the reasons do not justify termination, the participation will be considered to have been terminated improperly.

The termination will take effect on the day specified in the notification.

### 50.2.2 Effects

The coordinator must — within 30 days from when termination takes effect — submit:

(i) a report on the distribution of payments to the beneficiary concerned and

(ii) if termination takes effect during the period set out in Article 3, a ‘termination report’ from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, an overview of the use of resources, the individual financial statement and, if applicable, the certificate on the financial statement (see Articles 20.3 and 20.4).

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 20.3).

If the request for amendment is rejected by the *Agency*, (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the Agreement may be terminated according to Article 50.3.1(c).

If the request for amendment is accepted by the *Agency*, the Agreement is amended to introduce the necessary changes (see Article 55).

The *Agency* will calculate — on the basis of the periodic reports, the termination report and the report on the distribution of payments — if the (pre-financing and interim) payments received by the beneficiary concerned exceed the beneficiary’s EU contribution (calculated by applying the reimbursement rate(s) to the eligible costs declared by the beneficiary and its linked third parties and approved by the *Agency*). Only costs incurred by the beneficiary concerned until termination takes
If the payments received **exceed the amounts due:**

- if termination takes effect during the period set out in Article 3 and the request for amendment is accepted, the beneficiary concerned must repay to the coordinator the amount unduly received. The *Agency* will formally notify the amount unduly received and request the beneficiary concerned to repay it to the coordinator within 30 days of receiving notification. If it does not repay the coordinator, the *Agency* will draw upon the Guarantee Fund to pay the coordinator and then notify a **debit note** on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);

- in all other cases (in particular if termination takes effect after the period set out in Article 3), the *Agency* will formally notify a **debit note** to the beneficiary concerned. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the *Agency* the amount due and the *Agency* will notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);

- if the beneficiary concerned is the former coordinator, it must repay the new coordinator according to the procedure above, unless:

  - termination is after an interim payment and
  
  - the former coordinator has not distributed amounts received as pre-financing or interim payments (see Article 21.7).

In this case, the *Agency* will formally notify a **debit note** to the former coordinator. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the *Agency* the amount due. The *Agency* will then pay the new coordinator and notify a debit note on behalf of the Guarantee Fund to the former coordinator (see Article 44).

- If the payments received **do not exceed the amounts due:** amounts owed to the beneficiary concerned will be included in the next interim or final payment.

If the *Agency* does not receive the termination report within the deadline (see above), only costs included in an approved periodic report will be taken into account.

If the *Agency* does not receive the report on the distribution of payments within the deadline (see above), it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned and that

- the beneficiary concerned must not repay any amount to the coordinator.

Improper termination may lead to a reduction of the grant (see Article 43) or termination of the Agreement (see Article 50).

After termination, the concerned beneficiary’s obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.
50.3 Termination of the Agreement or the participation of one or more beneficiaries, by the Agency

50.3.1 Conditions

The Agency may terminate the Agreement or the participation of one or more beneficiaries, if:

(a) one or more beneficiaries do not accede to the Agreement (see Article 56);

(b) a change to their legal, financial, technical, organisational or ownership situation (or those of its linked third parties) is likely to substantially affect or delay the implementation of the action or calls into question the decision to award the grant;

(c) following termination of participation for one or more beneficiaries (see above), the necessary changes to the Agreement would call into question the decision awarding the grant or breach the principle of equal treatment of applicants (see Article 55);

(d) implementation of the action is prevented by force majeure (see Article 51) or suspended by the coordinator (see Article 49.1) and either:

(i) resumption is impossible, or

(ii) the necessary changes to the Agreement would call into question the decision awarding the grant or breach the principle of equal treatment of applicants;

(e) a beneficiary is declared bankrupt, being wound up, having its affairs administered by the courts, has entered into an arrangement with creditors, has suspended business activities, or is subject to any other similar proceedings or procedures under national law;

(f) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has been found guilty of professional misconduct, proven by any means;

(g) a beneficiary does not comply with the applicable national law on taxes and social security;

(h) the action has lost scientific or technological relevance;

(i) not applicable;

(j) not applicable;

(k) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed fraud, corruption, or is involved in a criminal organisation, money laundering or any other illegal activity affecting the EU’s financial interests;

(l) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has — in the award procedure or under the Agreement — committed:

(i) substantial errors, irregularities, fraud or

(ii) serious breach of obligations, including improper implementation of the action, submission of false information, failure to provide required information, breach of ethical principles;
(m) a beneficiary has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant ('extension of findings from other grants to this grant').

50.3.2 Procedure

Before terminating the Agreement or participation of one or more beneficiaries, the Agency will formally notify the coordinator:

- informing it of its intention to terminate and the reasons why and
- inviting it, within 30 days of receiving notification, to submit observations and — in case of Point (l.ii) above — to inform the Agency of the measures to ensure compliance with the obligations under the Agreement.

If the Agency does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify to the coordinator confirmation of the termination and the date it will take effect. Otherwise, it will formally notify that the procedure is not continued.

The termination will take effect:

- for terminations under Points (b), (c), (e), (g), (h), (j), and (l.ii) above: on the day specified in the notification of the confirmation (see above);
- for terminations under Points (a), (d), (f), (i), (k), (l.i) and (m) above: on the day after the notification of the confirmation is received by the coordinator.

50.3.3 Effects

(a) for termination of the Agreement:

The coordinator must — within 60 days from when termination takes effect — submit:

(i) a periodic report (for the last open reporting period until termination; see Article 20.3) and
(ii) a final report (see Article 20.4).

If the Agreement is terminated for breach of the obligation to submit the reports (see Articles 20.8 and 50.3.1(l)), the coordinator may not submit any reports after termination.

If the Agency does not receive the reports within the deadline (see above), only costs which are included in an approved periodic report will be taken into account.

The Agency will calculate the final grant amount (see Article 5.3) and the balance (see Article 21.4) on the basis of the reports submitted. Only costs incurred until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

This does not affect the Agency’s right to reduce the grant (see Article 43) or to impose administrative and financial penalties (Article 45).
The beneficiaries may not claim damages due to termination by the *Agency* (see Article 46).

After termination, the beneficiaries’ obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.

(b) for *termination of the participation of one or more beneficiaries*:

The coordinator must — within 60 days from when termination takes effect — submit:

(i) a report on the distribution of payments to the beneficiary concerned;

(ii) a request for amendment (see Article 55), with a proposal for reallocation of the tasks and estimated budget of the beneficiary concerned (see Annexes 1 and 2) and, if necessary, the addition of one or more new beneficiaries (see Article 56). If termination is notified after the period set out in Article 3, no request for amendment must be submitted unless the beneficiary concerned is the coordinator. In this case the request for amendment must propose a new coordinator, and

(iii) if termination takes effect during the period set out in Article 3, a *termination report* from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, an overview of the use of resources, the individual financial statement and, if applicable, the certificate on the financial statement (see Article 20).

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 20.3).

If the request for amendment is rejected by the *Agency* (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the Agreement may be terminated according to Article 50.3.1(c).

If the request for amendment is accepted by the *Agency*, the Agreement is amended to introduce the necessary changes (see Article 55).

The *Agency* will calculate — on the basis of the periodic reports, the termination report and the report on the distribution of payments — if the (pre-financing and interim) payments received by the beneficiary concerned exceed the beneficiary’s EU contribution (calculated by applying the reimbursement rate(s) to the eligible costs declared by the beneficiary and its linked third parties and approved by the *Agency*). Only costs incurred by the beneficiary concerned until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

- If the payments received exceed the amounts due:
  - if termination takes effect during the period set out in Article 3 and the request for amendment is accepted, the beneficiary concerned must repay to the coordinator the amount unduly received. The *Agency* will formally notify the amount unduly received and request the beneficiary concerned to repay it to the coordinator within 30 days of
receiving notification. If it does not repay the coordinator, the Agency will draw upon the Guarantee Fund to pay the coordinator and then notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);

- in all other cases, in particular if termination takes effect after the period set out in Article 3, the Agency will formally notify a debit note to the beneficiary concerned. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the Agency the amount due and the Agency will notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);

- if the beneficiary concerned is the former coordinator, it must repay the new coordinator the amount unduly received, unless:
  - termination takes effect after an interim payment and
  - the former coordinator has not distributed amounts received as pre-financing or interim payments (see Article 21.7)

In this case, the Agency will formally notify a debit note to the former coordinator. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the Agency the amount due. The Agency will then pay the new coordinator and notify a debit note on behalf of the Guarantee Fund to the former coordinator (see Article 44).

• If the payments received do not exceed the amounts due: amounts owed to the beneficiary concerned will be included in the next interim or final payment.

If the Agency does not receive the termination report within the deadline (see above), only costs included in an approved periodic report will be taken into account.

If the Agency does not receive the report on the distribution of payments within the deadline (see above), it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned, and that
- the beneficiary concerned must not repay any amount to the coordinator.

After termination, the concerned beneficiary’s obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38 and 40) continue to apply.

SECTION 4  FORCE MAJEURE

ARTICLE 51 — FORCE MAJEURE

‘Force majeure’ means any situation or event that:

- prevents either party from fulfilling their obligations under the Agreement,
- was unforeseeable, exceptional situation and beyond the parties’ control,
was not due to error or negligence on their part (or on the part of third parties involved in the action), and

- proves to be inevitable in spite of exercising all due diligence.

The following cannot be invoked as force majeure:

- any default of a service, defect in equipment or material or delays in making them available, unless they stem directly from a relevant case of force majeure,
- labour disputes or strikes, or
- financial difficulties.

Any situation constituting force majeure must be formally notified to the other party without delay, stating the nature, likely duration and foreseeable effects.

The parties must immediately take all the necessary steps to limit any damage due to force majeure and do their best to resume implementation of the action as soon as possible.

The party prevented by force majeure from fulfilling its obligations under the Agreement cannot be considered in breach of them.

CHAPTER 7  FINAL PROVISIONS

ARTICLE 52 — COMMUNICATION BETWEEN THE PARTIES

52.1 Form and means of communication

Communication under the Agreement (information, requests, submissions, ‘formal notifications’, etc.) must:

- be made in writing and
- bear the number of the Agreement.

Until the payment of the balance: all communication must be made through the electronic exchange system and using the forms and templates provided there.

After the payment of the balance: formal notifications must be made by registered post with proof of delivery (‘formal notification on paper’).

Communications in the electronic exchange system must be made by persons authorised according to the ‘Terms and Conditions of Use of the electronic exchange system’. For naming the authorised persons, each beneficiary must have designated — before the signature of this Agreement — a ‘Legal Entity Appointed Representative (LEAR)’. The role and tasks of the LEAR are stipulated in his/her appointment letter (see Terms and Conditions of Use of the electronic exchange system).

If the electronic exchange system is temporarily unavailable, instructions will be given on the Agency and Commission websites.
52.2 Date of communication

Communications are considered to have been made when they are sent by the sending party (i.e. on the date and time they are sent through the electronic exchange system).

Formal notifications through the electronic exchange system are considered to have been made when they are received by the receiving party (i.e. on the date and time of acceptance by the receiving party, as indicated by the time stamp). A formal notification that has not been accepted within 10 days after sending is considered to have been accepted.

Formal notifications on paper sent by registered post with proof of delivery (only after the payment of the balance) are considered to have been made on either:

- the delivery date registered by the postal service or
- the deadline for collection at the post office.

If the electronic exchange system is temporarily unavailable, the sending party cannot be considered in breach of its obligation to send a communication within a specified deadline.

52.3 Addresses for communication

The electronic exchange system must be accessed via the following URL:


The Agency will formally notify the coordinator and beneficiaries in advance any changes to this URL.

Formal notifications on paper (only after the payment of the balance) addressed to the Agency must be sent to the following address:

Executive Agency for Small and Medium-sized Enterprises (EASME)
H2020 Environment & Resources
MADO 31/057
B-1049 Brussels Belgium

Formal notifications on paper (only after the payment of the balance) addressed to the beneficiaries must be sent to their legal address as specified in the 'Beneficiary Register'.

ARTICLE 53 — INTERPRETATION OF THE AGREEMENT

53.1 Precedence of the Terms and Conditions over the Annexes

The provisions in the Terms and Conditions of the Agreement take precedence over its Annexes.

Annex 2 takes precedence over Annex 1.

53.2 Privileges and immunities

Nothing in the Agreement may be interpreted as a waiver of any privileges or immunities accorded to the EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS by its constituent documents or international law.
ARTICLE 54 — CALCULATION OF PERIODS, DATES AND DEADLINES

In accordance with Regulation No 1182/71, periods expressed in days, months or years are calculated from the moment the triggering event occurs.

The day during which that event occurs is not considered as falling within the period.

ARTICLE 55 — AMENDMENTS TO THE AGREEMENT

55.1 Conditions

The Agreement may be amended, unless the amendment entails changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

Amendments may be requested by any of the parties.

55.2 Procedure

The party requesting an amendment must submit a request for amendment signed in the electronic exchange system (see Article 52).

The coordinator submits and receives requests for amendment on behalf of the beneficiaries (see Annex 3).

If a change of coordinator is requested without its agreement, the submission must be done by another beneficiary (acting on behalf of the other beneficiaries).

The request for amendment must include:

- the reasons why;
- the appropriate supporting documents;
- for a change of coordinator without its agreement: the opinion of the coordinator (or proof that this opinion has been requested in writing).

The Agency may request additional information.

If the party receiving the request agrees, it must sign the amendment in the electronic exchange system within 45 days of receiving notification (or any additional information the Agency has requested). If it does not agree, it must formally notify its disagreement within the same deadline. The deadline may be extended, if necessary for the assessment of the request. If no notification is received within the deadline, the request is considered to have been rejected.

An amendment enters into force on the day of the signature of the receiving party.

An amendment takes effect on the date agreed by the parties or, in the absence of such an agreement, on the date on which the amendment enters into force.

ARTICLE 56 — ACCESSION TO THE AGREEMENT

56.1 Accession of the beneficiaries mentioned in the Preamble

The other beneficiaries must accede to the Agreement by signing the Accession Form (see Annex 3) in the electronic exchange system (see Article 52) within 30 days after its entry into force (see Article 58).

They will assume the rights and obligations under the Agreement with effect from the date of its entry into force (see Article 58).

If a beneficiary does not accede to the Agreement within the above deadline, the coordinator must — within 30 days — request an amendment to make any changes necessary to ensure proper implementation of the action. This does not affect the Agency’s right to terminate the Agreement (see Article 50).

56.2 Addition of new beneficiaries

In justified cases, the beneficiaries may request the addition of a new beneficiary.

For this purpose, the coordinator must submit a request for amendment in accordance with Article 55. It must include an Accession Form (see Annex 3) signed by the new beneficiary in the electronic exchange system (see Article 52).

New beneficiaries must assume the rights and obligations under the Agreement with effect from the date of their accession specified in the Accession Form (see Annex 3).

ARTICLE 57 — APPLICABLE LAW AND SETTLEMENT OF DISPUTES

57.1 Applicable law

The Agreement is governed by the applicable EU law, supplemented if necessary by the law of Belgium except for EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS.

57.2 Dispute settlement

If a dispute concerning the interpretation, application or validity of the Agreement cannot be settled amicably, the General Court — or, on appeal, the Court of Justice of the European Union — has sole jurisdiction. Such actions must be brought under Article 272 of the Treaty on the Functioning of the EU (TFEU).

As an exception, if such a dispute is between the Agency and UNIVERSITETET I BERGEN, UNI RESEARCH AS, METEOROLOGISK INSTITUTT, NORDURSLODAGATTIN EHF, UNIVERSITETET I TROMSOE, P.P. SHIRSHOV INSTITUTE OF OCEANOLOGY OF RUSSIAN ACADEMY OF SCIENCES, THE FEDERAL STATE BUDGETARY INSTITUTION VOEIKOV MAIN GEOPHYSICAL OBSERVATORY, the competent Belgian courts have sole jurisdiction.

As an exception, for the following beneficiaries:

- EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

such disputes must — if they cannot be settled amicably — be referred to arbitration.
The Permanent Court of Arbitration Optional Rules for Arbitration Involving International Organisations and States in force at the date of entry into force of the Agreement will apply.

The appointing authority will be the Secretary-General of the Permanent Court of Arbitration following a written request submitted by either party.

The arbitration proceedings must take place in Brussels and the language used in the arbitral proceedings will be English.

The arbitral award will be binding on all parties and will not be subject to appeal.

If a dispute concerns administrative or financial penalties, offsetting or an enforceable decision under Article 299 TFEU (see Articles 44, 45 and 46), the beneficiaries must bring action before the General Court — or, on appeal, the Court of Justice of the European Union — under Article 263 TFEU. Actions against enforceable decisions must be brought against the Commission (not against the Agency).

ARTICLE 58 — ENTRY INTO FORCE OF THE AGREEMENT

The Agreement will enter into force on the day of signature by the Agency or the coordinator, depending on which is later.

SIGNATURES

For the coordinator

For the Agency

Signed by Arnolds MILUKAS with ECAS id milukas as an authorised representative on 12-10-2016 16:43:21 (transaction id Sgjid-344894-AbiyOdB4gSghWxd9OwubpDRUY3Jo0iBCiCFOFmSwpZwlSinBw46zyYi wOAJA2j5UB8MCdegrSRPhmpHi3v3a8oLUCA- JI7IzYDbvYfyGQ2dxs0-459yOgwfFgOHD4Yo6jDxGEdyU0wBk3ka33zexpgQfzrm) Wed Oct 12 16:43:27 CEST 2016

Lars HENNING with ECAS id rhenniis signed in the Participant Portal on 22-09-2016 09:34:04 (transaction id Sgjid-156574. WNO6z2zqX6IEx8zpoMEUNEtZwdYMuYeX8qU8zzszeZXQ5FTxbo mbLFrLWNBSmCJeELOQrfvBqZon7HO-7f17xY6boyYfyGQJtfxs0- 52OyDqFHpomQOrQvn1EVAfFqadTqsz7LepmisDHQOFcm). Timestamp by third party at Thu Sep 22 09:34:14 CEST 2016

ANNEX 1 (part A)

Research and Innovation action

NUMBER — 727862 — APPLY
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## 1.1. The project summary

<table>
<thead>
<tr>
<th>Project Number</th>
<th>727862</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Acronym</td>
<td>APPLICATE</td>
</tr>
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</table>

### General information

<table>
<thead>
<tr>
<th>Project title</th>
<th>Advanced Prediction in Polar regions and beyond: Modelling, observing system design and Linkages associated with ArctiC ClimATE change</th>
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<td>Duration in months</td>
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<td>Call (part) identifier</td>
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<td>Topic</td>
<td>BG-10-2016 Impact of Arctic changes on the weather and climate of the Northern Hemisphere</td>
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<td>Free keywords</td>
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### Abstract

Arctic climate change increases the need of a growing number of stakeholders for trustworthy weather and climate predictions, both within the Arctic and beyond. APPLICATE will address this challenge and develop enhanced predictive capacity by bringing together scientists from academia, research institutions and operational prediction centres, including experts in weather and climate prediction and forecast dissemination. APPLICATE will develop a comprehensive framework for observationally constraining and assessing weather and climate models using advanced metrics and diagnostics. This framework will be used to establish the performance of existing models and measure the progress made within the project. APPLICATE will make significant model improvements, focusing on aspects that are known to play pivotal roles in both weather and climate prediction, namely: the atmospheric boundary layer including clouds; sea ice; snow; atmosphere-sea ice-ocean coupling; and oceanic transports. In addition to model developments, APPLICATE will enhance predictive capacity by contributing to the design of the future Arctic observing system and through improved forecast initialization techniques. The impact of Arctic climate change on the weather and climate of the Northern Hemisphere through atmospheric and oceanic linkages will be determined by a comprehensive set of novel multi-model numerical experiments using both coupled and uncoupled ocean and atmosphere models. APPLICATE will develop strong user-engagement and dissemination activities, including proactive engagement of end-users and the exploitation of modern methods for communication and dissemination. Knowledge-transfer will also benefit from the direct engagement of operational prediction centres in APPLICATE. The educational component of APPLICATE will be developed and implemented in collaboration with the Association of Early Career Polar Scientists (APECS).
## 1.2. List of Beneficiaries

<table>
<thead>
<tr>
<th>No</th>
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<th>Project exit month</th>
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<tbody>
<tr>
<td>1</td>
<td>ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG</td>
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<tr>
<td>2</td>
<td>BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION</td>
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## 1.3. Workplan Tables - Detailed implementation

### 1.3.1. WT1 List of work packages

<table>
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<tr>
<th>WP Number</th>
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<td>WP4</td>
<td>Support for Arctic observing system design</td>
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<td>WP7</td>
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**Total** 1,013.50
### 1.3.2. WT2 list of deliverables

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<tr>
<td>D1.1</td>
<td>Model assessment plan</td>
<td>WP1</td>
<td>1 - AWI</td>
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<td>D1.2</td>
<td>Provision of process-focused, user-relevant and Arctic linkages metrics through ESMValTool</td>
<td>WP1</td>
<td>1 - AWI</td>
<td>Other</td>
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<td>D1.3</td>
<td>Provision of novel metrics, which can be effectively determined from short time series, through ESMValTool</td>
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<td>8 - UCL</td>
<td>Other</td>
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<td>D1.4</td>
<td>Assessment of CMIP5 and CMIP6 experiments including recommendations for model development activities in WP2</td>
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<td>Report on potential for emergent constraints to reduce uncertainty in projections of Arctic climate and linkages to Northern Hemisphere circulation</td>
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<td>D1.7</td>
<td>Interim report from the analysis of the NWP system in support of WP2 and WP4</td>
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<td>Report on individual impacts of improved process-representation, treatment of snow, ensemble generation and increased resolution on the weather and climate prediction performance</td>
<td>WP5</td>
<td>6 - MET Norway</td>
<td>Report</td>
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<td>36</td>
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<td>5.4</td>
<td>Simulation carried out with the models available at the end of APPLICATE (Task 5.4) and following the protocol described in Task 5.1, completed and made available within the consortium</td>
<td>WP5</td>
<td>6 - MET Norway</td>
<td>Demonstrator</td>
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<td>Contributions to the SIPN activities through sea ice predictions produced with the forecast systems available at the end of APPLICATE</td>
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<td>Report on integrated added-value from APPLICATE on weather and climate prediction and projection</td>
<td>WP5</td>
<td>3 - ECMWF</td>
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<td>Synthesis report on priorities for future forecasting system development</td>
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<td>Launch of a web portal providing an overview of the project data catalogue</td>
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<td>First summary report of stakeholder interaction activities</td>
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<td>D7.13</td>
<td>Provision of all 30 FrostByte videos of APPLICATE and APECS websites</td>
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<td>Invite coordinators of relevant projects to the YOPP planning meetings</td>
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<td>D8.2</td>
<td>Invite coordinators of BG-09 and other BG-10 projects to become members of external advisory board in APPLICATE</td>
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<td>Update the clustering plan to reflect specific clustering strategy with projects funded under H2020- BG09-2016 and BG10-2016</td>
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<td>D8.5</td>
<td>Provide report from US CLIVAR Working Group meeting including recommendations for adjustments to the WP3 part of the APPLICATE numerical experimentation plan</td>
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<td>Update the clustering plan to reflect specific joint clustering activities with projects funded under earlier H2020 and FP7 calls</td>
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<td>Provide draft concept for a joint YOPP-APPLICATE summer school including a list of possible co-sponsors</td>
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<td>Report</td>
<td>Confidential, only for members of the consortium (including the Commission Services)</td>
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\(^{14}\) Deliverable Number
\(^{9}\) WP number
\(^{15}\) Type
\(^{16}\) Dissemination level
\(^{17}\) Due Date (in months)
1.3.3. WT3 Work package descriptions

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**Objectives**

- Develop metrics and diagnostics that facilitate effective model assessment (Arctic-specific, process-oriented, user-relevant);
- Incorporate new metrics in ESMValTool and make them available to all project partners and the wider scientific community;
- Apply existing and newly developed metrics and diagnostics to assess models used across time scales;
- Develop a new generation of process-based heat budget diagnostics to narrow model uncertainty in Arctic climate change response;
- Explore the concept of emergent constraints in an Arctic context to narrow the uncertainty of climate change projections;
- Develop and apply diagnostics that can be used to infer atmospheric and oceanic linkages from observational and model data sets;
- Provide guidance for the model development activities in APPLICATE and beyond.

**Description of work and role of partners**

**WP1 - Weather and climate model evaluation** [Months: 1-48]

AWI, BSC, ECMWF, UiB, UNI RESEARCH, MET OFFICE, UREAD, SU, CNRS-GAME, CERFACS, IORAS, MGO

WP1 will be led by AWI (Thomas Jung) and UREAD (Len Shaffrey).

The aim of WP1 is threefold. Firstly, an Arctic-specific framework, entailing advanced metrics and diagnostics for model assessment and analysis, will be developed and disseminated through ESMValTool to the APPLICATE partners and the wider scientific community. Secondly, this framework will be applied to establishing a baseline understanding of the realism of models across time scales, which will provide insight into the mechanisms governing Arctic climate change and the linkages between the Arctic and the rest of the Northern Hemisphere. Thirdly, the concept of emergent constraints will be explored to test the possibility of narrowing the uncertainty of regional climate change projections.

Task 1.1 – Development of a model assessment plan (AWI, UREAD, UCL, IORAS) (M1-M4)

This task will develop a detailed plan (D1.1) that outlines the model assessment strategy of APPLICATE exploiting the concept of metrics and diagnostics, and utilizing comprehensive sets of observational data. The focus of Task 1.1 will be on expanding the subset of metrics currently available in ESMValTool. The plan will also include details for an ESMValTool training workshop that will be held during the Kick-off meeting (Month 3). Furthermore, the plan will outline how collaboration with the H2020 project CRESCENDO will be envisaged with respect to developing ESMValTool. The plan will be developed in close cooperation with other related European and international activities.

Task 1.2 – New targeted metrics for model assessment (AWI, CERFACS, CNRS-GAME, UiB, UREAD, UCL, SU, UNI Research, BSC, IORAS, MGO) (M1-M24)

Task 1.2.1 – Development of process-based metrics for the Arctic and implementation in ESMValTool (AWI, SU, CNRS-GAME, UCL, UiB, UNI Research, IORAS, MGO) (M1-M12)

This task will develop a series of metrics to enable the assessment of the ability of weather and climate models to represent processes important for the Arctic. Emphasis will be placed on those processes being targeted in APPLICATE’s model developments efforts (WP2). This includes atmospheric boundary layer and clouds, snow on sea ice, sea ice dynamics and thermodynamics, atmosphere-sea ice-ocean coupling as well as the circulation and water mass characteristics in the Arctic Ocean. This task will also consider other aspects such as the atmospheric circulation and storm track activity. Central to this task is gathering relevant high-quality observational data sets, both from existing (e.g. Obs4MIPs- and reanalysed) and new sources (e.g. Earth observations). Key-metrics will be made available through ESMValTool (D1.2).

Task 1.2.2 – Co-Development of user-relevant impact metrics and implementation in ESMValTool (UREAD, AWI, BSC, IORAS) (M1-M12)
This task will co-develop with stakeholders a series of metrics with stakeholders (as defined in section 2.2 of the proposal) interested in the impacts and opportunities of potential changes in the Arctic and their effects on the Northern Hemisphere. Initial conversations that APPLICATE partners have held with stakeholders have revealed the following list of possible foci: ocean temperatures for fisheries; sea ice free regions for shipping; severity and frequency of strong winds associated with storms as a hazard to shipping, fishing vessels and coastal communities; winds for wind farm operators and transmission systems; temperature and precipitation for food security in the Arctic and beyond. This task will co-develop the list of user-relevant metrics together with stakeholders, benefitting from coordination with activities in WP7 Task 7.2. Key-metrics will be made available through ESMValTool.

Task 1.2.3 – Development of metrics that describe linkages in atmosphere and ocean and implementation in ESMValTool (CNRS-GAME, AWI, CERFACS, UREAD, IORAS) (M1-M24)

This task will develop metrics that can be used to quantify and assess linkages between the Arctic and the Northern Hemisphere atmosphere and ocean. This includes developing diagnostics to investigate mass, heat and fresh water fluxes through the passages connecting the North Atlantic and Arctic Oceans. Here the focus will be on Fram Strait, the Barents Sea and the Canadian Arctic Archipelago. Furthermore techniques will be developed to quantify interannual lead-lag relationships between Arctic sea ice/Siberian snow cover and the AO/NAO and ENSO. Finally, the flow-dependence of atmospheric Arctic-mid-latitude linkages will be addressed by investigating changes in the equator-to-pole temperature gradients in the lower troposphere, upper troposphere and lower stratosphere, and their impact on mid-latitude jet streams, storm tracks and blocking across the Northern Hemisphere. Key-metrics developed in this task will be made available through ESMValTool (D1.2).

Task 1.2.4 – Development of novel sea ice metrics from YOPP intensive observing periods and implementation in ESMValTool (UCL) (M1-M36)

YOPP will include several intensive observing periods (IOPs) during which comprehensive observational datasets will be generated. This task will work with YOPP observational groups to develop new sea ice metrics focused on specific processes and/or feedbacks which will be robustly sampled even though the observing periods are relatively short (e.g. heat conduction through sea ice and sea ice albedo feedback). These novel metrics will be used for the assessment of models in Task 1.3. The novel metrics will also be disseminated to the groups participating in the YOPP IOPs, thereby further establishing links between modelling and observational experts. Metrics will be made available through ESMValTool (D1.3).

Task 1.3 – Assessment of weather and climate prediction models (UREAD, AWI, ECMWF, MGO) (M9-M48)

This task will assess the ability of weather and climate models to represent key processes in the Arctic, linkages between the Arctic and Northern Hemisphere, and user-relevant metrics. The assessment will serve as the baseline from which the model developments carried out in WP2 of APPLICATE will be evaluated.

Task 1.3.1 – Assessment of CMIP5 and CMIP6 climate models (UREAD, AWI, MGO) (M9-M30)

This task will initially assess the metrics developed in Task 1.2 in the CMIP5 HISTORICAL simulations and the CMIP5, RCP2.6, RCP4.5 RCP6.0 and RCP8.0 climate change simulations. This assessment will determine i) the systematic errors in the CMIP5 models and ii) the ensemble mean and inter-model spread in CMIP5 climate projections. Particular attention will be paid to assessing the sampling uncertainties in metrics that arise from the internal variability inherent in observations and climate models. As they become available during 2017, the WP1 metrics will be used to assess the CMIP6 climate model simulations, especially those carried out by the APPLICATE partners. The assessment of CMIP6 models will also identify any potential reductions in systematic errors between CMIP5 and CMIP6 and potential changes in climate projections. This task will also provide the baseline assessment for model developments in WP2 and inform the numerical experiments in WP3 (D1.4).

Task 1.3.2 – Assessment of NWP systems (ECMWF) (M6-M48)

This task will establish and test the diagnostic framework that will be applied to short-to-medium range predictions and initial conditions to establish sources of model error in WP2 and the impact of observational data in WP4. The task will contribute to the revision of atmosphere and snow model components in WP2 and guide observing system experiments in WP4. Novel diagnostics targeting the coupled surface-atmosphere-snow-sea ice system will be developed and applied to identify key sensitivities in coupled models and key sources of model error. These diagnostics will also be used to support the model development in single-column mode (WP2, Task 2.2.1).

Diagnostics linking the contributions from individual physical processes to model tendencies and analysis increments in the atmosphere will be developed. These diagnostics will allow model error to be traced back to individual processes represented in the short-range forecast. Furthermore, statistics of analysis increments will enable the impact of observations in the analysis to be evaluated (WP4, Task 4.1.2).

The statistics from ensemble data assimilation can also be used to assess model and observation contributions to ensemble spread in NWP systems. This provides guidance for model error formulation in ensemble systems, but also
information on the observational impact in the analysis. This will be further exploited in WP4, Task 4.1.1 and 4.1.2. This task will also support recommendations for operational monitoring and evaluation capabilities dedicated to polar requirements. A demonstration of such monitoring will be introduced with a focus on surface radiation, cloud and snow observation networks and satellite retrievals.

An interim report on the assessment will be written and made available to WP2 and WP4 (D1.7).

Task 1.3.3 – Synthesis: Growth of model error across time scales (AWI) (M24-M36)
In this task, the insight gained from Tasks 1.3.1 to 1.3.2 will be synthesized to improve our understanding of the processes that lead to common model errors in both weather and climate models (D1.8). To this end, also the YOPP Analysis and Forecast Data Set (WP6) will be exploited. This understanding will enable APPLICATE to identify error in climate models that are determined by processes occurring on shorter time scales of hours to weeks. This in turn will inform the model development activities in WP2. Understanding the commonalities in error growth will also help foster the exchange of ideas for model development between the weather and climate modelling communities.

Task 1.4 – Assessment of the Arctic heat budget in climate models (Met Office, CERFACS, IORAS) (M12-48)
This task will assess the ability of the climate models used in APPLICATE to represent the seasonal cycle and long-term trends in the heat budget of the Arctic – including atmosphere, ocean, sea ice and snow components. Building on the approach of Keen et al. (2013), the assessment of the Arctic heat budget will identify important feedbacks and processes that govern Arctic climate variability and change.

A more detailed assessment of the heat budget of the Arctic Ocean will also be performed. It will focus on the links between changes in oceanic heat transport into the Arctic and Arctic sea ice. The vertical mixing processes that redistribute heat within the Arctic Ocean, and thus lead to impacts on sea ice, will also be evaluated. The ability of the APPLICATE models to capture the observed heat budget of the Arctic will be evaluated using the metrics developed in Tasks 1.2 and Tasks 1.3. Coordinated analysis of the CESM climate model will also be performed at NCAR in the US. A synthesis of the two heat budget approaches will be made (D1.5). This task will also contribute to the IPCC through SIMIP (Sea Ice Model Intercomparison Project).

This task will be done in collaboration with colleagues from NCAR.

Task 1.5 – Assessing the utility of observational emergent constraints in reducing the uncertainty of CMIP5 and CMIP6 climate change projections in the Arctic and mid-latitudes (Met Office, CERFACS, CNRS-GAME, UCL, UREAD) (M12-M48)
This task will explore the potential of the metrics and analysis in Tasks 1.2, 1.3 and 1.4 to provide observational emergent constraints on climate model projections. Emergent constraints are metrics which show strong relationships between the biases in historical climate model simulations and the sensitivity of climate projections. An example of an emergent constraint is the relationship found between biases in Arctic sea ice cover and future trends in CMIP3 climate models (Boé et al, 2009). Emergent constraints potentially enable the uncertainty in climate model projections to be reduced, since projections from climate models with smaller biases should be more plausible. Emergent constraints in the Arctic will be investigated using biases in the seasonal cycle, past trends, interannual variability, and their relationship with Arctic climate change. Emergent constraints will also be investigated in the context of links between the Arctic and Northern Hemisphere atmospheric and oceanic circulation, e.g. through changes in Arctic warming, in the equator-to-pole temperature gradient and in subsequent impacts on mid-latitude atmospheric circulation. A synthesis of the results on emergent constraints will be made (D1.6).

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<tr>
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### List of deliverables

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<tbody>
<tr>
<td>D1.1</td>
<td>Model assessment plan</td>
<td>1 - AWI</td>
<td>Report</td>
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<td>D1.3</td>
<td>Provision of novel metrics, which can be effectively determined from short time series, through ESMValTool</td>
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<td>24</td>
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<td>D1.4</td>
<td>Assessment of CMIP5 and CMIP6 experiments including recommendations for model development activities in WP2</td>
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<td>48</td>
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<tr>
<td>D1.6</td>
<td>Report on potential for emergent constraints to reduce uncertainty in projections of Arctic climate and linkages to Northern Hemisphere circulation</td>
<td>7 - MET OFFICE</td>
<td>Report</td>
<td>Public</td>
<td>48</td>
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<tr>
<td>D1.7</td>
<td>Interim report from the analysis of the NWP system in support of WP2 and WP4</td>
<td>3 - ECMWF</td>
<td>Report</td>
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List of deliverables

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<td>Synthesis report on the growth of systematic model error across time scales</td>
<td>1 - AWI</td>
<td>Report</td>
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Description of deliverables

D1.1 : Model assessment plan [4]
Detailed plan that outlines the model assessment strategy of APPLICATE exploiting the concept of metrics and diagnostics, and utilizing comprehensive sets of observational data.

D1.2 : Provision of process-focused, user-relevant and Arctic linkages metrics through ESMValTool [12]
Provision of process-focused, user-relevant and Arctic linkages metrics through ESMValTool

D1.3 : Provision of novel metrics, which can be effectively determined from short time series, through ESMValTool [24]
Provision of novel metrics, which can be effectively determined from short time series, through ESMValTool

D1.4 : Assessment of CMIP5 and CMIP6 experiments including recommendations for model development activities in WP2 [30]
Baseline assessment for model developments in WP2 and inform the numerical experiments in WP3

D1.5 : Report on the synthesis of heat budget approaches for the Arctic [48]
Synthesis of the two heat budget approaches to inform about the mechanism determining Arctic climate variability and change.

D1.6 : Report on potential for emergent constraints to reduce uncertainty in projections of Arctic climate and linkages to Northern Hemisphere circulation [48]
Synthesis of the results on emergent constraints

D1.7 : Interim report from the analysis of the NWP system in support of WP2 and WP4 [20]
The interim report from the analysis of the NWP system supports the WP 2 'Enhanced weather and climate models' and WP 4 'Support for Arctic observing system design'.

D1.8 : Synthesis report on the growth of systematic model error across time scales [36]
Synthesis of the understanding of the processes that lead to common model errors across time scales.

Schedule of relevant Milestones

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<tr>
<th>Milestone number</th>
<th>Milestone title</th>
<th>Lead beneficiary</th>
<th>Due Date (in months)</th>
<th>Means of verification</th>
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<tr>
<td>MS1</td>
<td>Enhanced version of ESMValTool available</td>
<td>1 - AWI</td>
<td>12</td>
<td>Metrics in ESMValTool have been incorporated, tested and accepted.</td>
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<tr>
<td>MS18</td>
<td>Consolidated clustering plan</td>
<td>1 - AWI</td>
<td>9</td>
<td>Revised version of clustering plan after consultation with all APPLICATE key partners</td>
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### Objectives

- Improve models in their representation of Arctic weather and climate through improved process descriptions, more consistent coupling methodology and a better representation of feedbacks;
- Develop innovative methods, using observations and a variety of model configurations, to facilitate parameter optimization for physical processes in coupled model systems for NWP and climate;
- Assess the added value of the APPLICATE development on process representation in weather and climate models in the Arctic.

### Description of work and role of partners

#### WP2 - Enhanced weather and climate models [Months: 1-48]

SU, AWI, ECMWF, UNI RESEARCH, MET OFFICE, UCL, CNRS-GAME, CERFACS

WP2 will be led by SU (Gunilla Svensson) and CNRS-GAME (Matthieu Chevallier).

Improved modelling capabilities will be achieved through improved process descriptions in the various components of the models. Our primary targets will be to address well-known problems in processes that contribute to momentum transfer at the surface and to the surface energy budget. Other improvements are related to coupling processes between the atmosphere and the land or sea-ice/ocean surface. A novel approach of a coupled single-column model will be extensively used as an intermediate step to constrain the model physics towards fully coupled modelling for NWP and climate. Based on a set of coordinated model experiments, using available and coming observations, we will assess the impact of model improvements.

**Task 2.1 – Improve process representation (M1-M42)**

**Task 2.1.1 – Improve description of atmospheric processes (SU, CNRS-GAME, AWI) (M1-M36)**

This task will focus on the representation of the atmospheric boundary layer (ABL) and clouds that strongly impact the energy and moment exchange at the surface. An improved description of these atmospheric processes is expected to be important for forecasts on time scales spanning weather to climate. Recently developed schemes for the atmospheric ABL and surface exchange will be tested. Information from Large-Eddy Simulation (LES) and observations will also be used to better constrain parameters in cloud and cloud microphysics schemes, with the goal to improve the representation of their effect on the surface radiative energy fluxes. The improved process descriptions will be incorporated in the atmospheric model components that are shared by NWP (IFS, AROME and ARPEGE) and climate models (EC-Earth and CNRM-CM). This will allow for assessing their impact for both weather and climate time scales.

Recommendations on the inclusion of improved description of atmospheric processes in NWP models (D2.3) as well as an Assessment of their impact in coupled mode (D2.5) will be made.

**Task 2.1.2 – Improve description of snow on land and sea ice (ECMWF, CNRS-GAME, UCL) (M1-M20)**

The focus of this task is to achieve a better representation of snow on the land surface and on sea ice. The role of snow in the surface energy balance is well known. Over sea ice, it directly contributes to the sea ice heat/mass balance. A good knowledge of the snow cover is also needed for satellite retrieval of sea ice thickness. Given the high vertical heterogeneity of the snow cover, multi-layer snow models are well adapted to capture the different types of snow.

At CNRS-GAME, a multi-layer snow scheme will be implemented in the sea ice model (GELATO), with the same complexity as the snow scheme present in the land surface module of CNRM-CM (SURFEX). UCL will refine its already comprehensive representation of snow over sea ice by accounting for the sub-grid scale distribution of snow depth and by improving the formulation of the radiative transfer through snow. An advanced multi-layer snow scheme will be implemented in the IFS over land and the UCL-model will be imported over sea ice. Observational data will be used in the model development and for evaluation.

Recommendations on the inclusion of improved description of snow on land and sea ice in NWP models (D2.3) as well as an assessment of their impact in coupled mode (D2.5) will be made.

**Task 2.1.3 – Improve sea ice properties affecting the momentum transfer between the atmosphere and ocean, and the surface energy budget (CNRS-GAME, UCL, Met Office) (M1-M18)**
The descriptions of surface properties and processes in the different sea ice models used in climate models will be improved, focusing on aspects that directly impact the energy and momentum budgets. Parts of these developments will benefit NWP models that share the sea ice component of a climate model (IFS, AROME, ARPEGE).

Existing parameterisations for melt ponds will be implemented and/or refined in CICE and GELATO. This will allow a better representation of the seasonal cycle of the surface albedo, and it will provide new prognostic information on the surface roughness. New parameterisations for the surface roughness will be tested in CICE and GELATO, including form drag. This will allow for a better representation of the energy transfer from the atmosphere to the ocean through sea ice, and will contribute to the improved representation of ABL done in Task 2.1.1. Parameterisations for land-fast ice will be included in GELATO and LIM3, which will allow for a more realistic representation of sea ice growth in some areas of ice formation. The representation of lateral ice melt will also be improved, and an ice-floe size distribution will be included in LIM3. Thus, the representation of the seasonal cycle of sea ice formation/melting will be more realistic.

Such developments will also be included in the sea ice component of the Canadian systems (Environment and Climate Change Canada), depending on resources.

Recommendations on the inclusion of improved sea ice properties in NWP models (D2.3) as well as an assessment of their impact in coupled mode (D2.5) will be made.

Task 2.1.4 – Improve the representation of oceanic circulation and sea ice conditions in the Arctic (UNI Research, AWI, Met Office, CERFACS, UCL) (M24-M42)

In this task, the role of enhanced horizontal resolution in the representation of the Arctic Ocean circulation and sea ice conditions will be explored. The focus will be on exchange processes at the Arctic gateways: Bering Strait, Fram Strait and the Barents Sea Opening. Outflows of Arctic water through the Canadian Arctic Archipelago should also benefit from a better representation of the different channels due to enhanced resolution.

The role of enhanced resolution will be explored using unstructured meshes (AWI-CM). AWI-CM will be run globally with horizontal resolutions typical for CMIP6 climate models; except the Arctic, where it will be increased to 4 km. Met Office will use a global configuration with zooms over selected areas (Arctic gateways to the North Atlantic Ocean). NorESM will be run in global configuration with 0.25° nominal horizontal resolution (~10 km in the Arctic) of ocean and sea ice components (D2.6). Regarding the impact of resolution, APPLICATE will also build on the results from the EMBRACE project.

The role of novel sea ice rheology schemes (Maxwell elasto-brittle or anisotropic) will be assessed in LIM3 and CICE. In FESOM sea ice module, new schemes for sea ice dynamics will be tested, based on an adaptive version of the widely used Elasto-Viscous-Plastic rheology. These schemes will be more stable and numerically more efficient to get converging solutions. Furthermore, a multi-column ocean module that resolves exchanges of mass, momentum and energy for each sea ice thickness category will be implemented in NEMO-LIM3 and tested in coupled mode in EC-Earth.

Tasks 2.3.1 and 2.3.2 will assess the improved representation of oceanic circulation and sea ice conditions in coordinated experiments.

Task 2.2 – Improve atmosphere-sea ice-ocean coupling (M1-M36)

Task 2.2.1 – Test parameterizations and optimize parameters in the Single Column Model framework (SU, CNRS-GAME, ECMWF) (M1-M36)

At the ocean-sea-ice-atmosphere, time steps, horizontal resolution, treatment of sub-grid scale heterogeneity and energy fluxes vary between the model components. The impact of these differences in comparison to the parameterisation issues are difficult to assess in the full global coupled model. A novel Single Column Model (SCM) framework will therefore be developed to help constrain the problem. The SCM will extend from the deep ocean, include the sea ice and snow, and continue through the atmosphere (D2.1).

Procedures will be developed on how to perform simulations in the SCM framework, handling the conceptual difficulties with different advection directions and speed of the subcomponents of the system, to be able to test new parameterisations in coupled mode and to constrain the coupling fluxes.

A number of test cases will be defined and run in coordinated SCM experiments with the aim to isolate errors in the representation of these parameterized processes and their influence on the surface energy fluxes. These will be designed based on existing past observations (e.g. SHEBA, AOE, ASCOS, ACSE, Eureka, Barrow and IAOSO buoys), LES cases and the coming intensive observing periods during YOPP (D2.4). It will be possible to study the full atmosphere-snow-sea ice-ocean system using the coupled SCM and observations, especially targeting the observations from the drifting station during MOSAiC that will provide observations for the entire coupled column. The atmospheric-surface component of the SCM will be imported into the IFS and the coupling between surface, boundary layer and clouds will be evaluated in the full three-dimensional context. New diagnostics for coupled processes developed in WP1, Task 1.2
(D1.2 and D1.3) will be employed. Environment and Climate Change Canada plans to carry out similar experiments with an SCM based on GEM and CICE.

(MOSAiC: The multi-disciplinary drifting Observatory for the Study of Arctic Climate is a planned year-round campaign (mid-2019 to mid-2020) that will provide detailed, and comprehensive measurements of the central Arctic Basin, extending from the atmosphere through the sea-ice into the ocean, As outlined in the MOSAiC science plan (www.mosaicobservatory.org) “Developing a coupled ocean-ice-atmosphere single-column model would greatly facilitate such studies.”)

Task 2.2.2 – Develop optimal coupling framework in global models (CNRS-GAME, SU, CERFACS, ECMWF, Met Office) (M18-M30)

In this task, the focus will be on implementing the best practices found from the SCM framework experiments (Task 2.2.1) into the global fully coupled models. Effects of how to aggregate fluxes, spatial heterogeneity on the sub-grid scale, and transfer of heat and momentum are issues that need to be optimized in the full three-dimensional coupled model. Temporal inconsistency also arises from the fact that the time steps of the ocean model, of the sea ice model and of the coupling are often different. We will use the SCM framework to compare the methodology used in a NWP model, where a more direct coupling is used, and using a flux coupler (OASIS) as is usually done in climate models. This will also include a comparison with models that use an alternative location for the atmosphere-sea ice interface. New approaches to improve the consistency of the full air-ice-ocean surface layer will then be implemented and tested in the three-dimensional configurations of IFS, EC-Earth and CNRM-CM. The experience gained in WP2 Task 2.2.1 from integrating the SCM-physics in the IFS will guide the recommendations (D2.2).

Task 2.3 – Assess model enhancements in coordinated experiments (M12-M48)

Task 2.3.1 – Coordinate experiments for the evaluation of model enhancements (AWI, CNRS-GAME, SU, Met Office, UNI Research) (M12-M36)

Model enhancements, as well as improvements of the coupling methodology, will be assessed in the five participating global climate models: AWI-CM, CNRM-CM, EC-Earth, HadGEM and NorESM. A numerical experimentation plan has been developed. The target is to be able to directly compare the performance of enhanced models to the set of CMIP6-DECK and CMIP6 historical experiments that will be run by all models outside the project, and that will be considered as “stream 1”.

Modelling centres will test the impact of each individual feature, using their usual practices (e.g. atmosphere-only or ocean-only modes and control runs). Once the implementation of model enhancement is completed, modelling centres will perform a “stream 2” suite of experiments, using a version of their models with the set of new features that appear the best based on their own evaluation. Stream 2 experiments will consist of a 200-year long control simulation under preindustrial forcing, a CMIP historical experiment, and a +1%CO2 simulation.

Task 2.3.2 – Assess the influence of model developments on the simulated state and dynamics of the atmosphere-sea ice-ocean system in the Arctic (UCL, CERFACS, AWI, UNI Research) (M24-M48)

This task is devoted to the comprehensive analyses of coordinated experiments for assessing the benefit of new model developments in Task 2.3.1. It will use the metrics developed in WP1 and other related projects (e.g. PRIMAVERA). The focus will be put on a suite of dedicated diagnostic. This task will produce a an interim report (D2.5), that includes aspects related to: (i) changes in the various components of the Arctic surface energy budget (radiative, turbulent); (ii) changes in the transfer of momentum from the atmosphere to the ocean; (iii) the overall realism of the simulated climate system; (iv) effects on the Arctic Ocean circulation; and (v) changes in the Arctic climate sensitivity in the +1%CO2 simulation. A synthesis report on priorities for future model developments in coupled models will be issued towards the end of the project (D2.7).

Task 2.3.3 – Recommend model enhancements to be included in weather prediction systems (SU, CNRS-GAME, ECMWF, Met Office) (M24-36)

This task aims at providing recommendations for weather prediction systems. Based on the tests run with SCM and climate models, a synthesis report will be produced (D2.3), in which the inclusion in NWP systems of selected model enhancements developed during APPLICATE will be discussed. This report will guide dedicated tests carried on within WP5 with participating NWP systems.

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### List of deliverables

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<td>Report on the application of the fully coupled SCM to test cases based on Arctic YOPP IOPs</td>
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<td>D2.5</td>
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<tr>
<td>D2.6</td>
<td>Report on the impact of increased resolution on the simulated Arctic Ocean circulation and on Arctic-Atlantic and Arctic-Pacific oceanic linkages</td>
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<td>D2.7</td>
<td>Synthesis on priorities for future model developments for coupled models</td>
<td>11 - CNRS-GAME</td>
<td>Report</td>
<td>Public</td>
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**Description of deliverables**
D2.1 : Demonstrator of a fully coupled SCM [18]
A novel Single Column Model (SCM) framework will be developed. The SCM will extend from the deep ocean, include the sea ice and snow, and continue through the atmosphere.

D2.2 : Recommendations on the coupling methodology in prediction and climate models [30]
Recommendations based on the experience gained in WP2 Task 2.2.1 from integrating the SCM-physics in the IFS

D2.3 : Recommendations on the inclusion of APPLICATE model enhancements in NWP models [30]
Synthesis report based on the tests run with SCM and climate models, in which the inclusion in NWP systems of selected model enhancements developed during APPLICATE will be discussed. This report will guide dedicated tests carried on within WP5 with participating NWP systems.

D2.4 : Report on the application of the fully coupled SCM to test cases based on Arctic YOPP IOPs [36]
A number of test cases will be defined and run in coordinated SCM experiments with the aim to isolate errors in the representation of these parameterized processes and their influence on the surface energy fluxes. These will be designed based on existing past observations (e.g. SHEBA, AOE, ASCOS, ACSE, Eureka, Barrow and IAOOS buoys), LES cases and the coming intensive observing periods during YOPP

D2.5 : Interim report on model developments and their evaluation in coupled mode [36]
Interim report, that includes aspects related to: (i) changes in the various components of the Arctic surface energy budget (radiative, turbulent); (ii) changes in the transfer of momentum from the atmosphere to the ocean; (iii) the overall realism of the simulated climate system; (iv) effects on the Arctic Ocean circulation; and (v) changes in the Arctic climate sensitivity in the +1%CO2 simulation.

D2.6 : Report on the impact of increased resolution on the simulated Arctic Ocean circulation and on Arctic-Atlantic and Arctic-Pacific oceanic linkages [40]
Results from exploring the role of enhanced resolutions by using different methodologies (unstructures meshed, nesting, globally enhanced resolution) will be synthesized.

D2.7 : Synthesis on priorities for future model developments for coupled models [48]
Synthesis report on priorities for future model developments in coupled models issued towards the end of the project

<table>
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<tr>
<th>Schedule of relevant Milestones</th>
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<tbody>
<tr>
<td><strong>Milestone number</strong></td>
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<td>MS3</td>
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<td>MS18</td>
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</table>
WP3 - Atmospheric and oceanic linkages [Months: 1-48]

MET OFFICE, AWI, BSC, UiB, UNI RESEARCH, MET Norway, UREAD, CNRS-GAME, CERFACS, IORAS, MGO

WP3 will be led by Met Office (Doug Smith) and UiB (Helge Drange).

Coordinated multi-model experiments with coupled and atmosphere-only models will be performed to assess the impact of substantial Arctic sea ice depletion as expected in the coming decades on the atmospheric and oceanic circulation. The systematic use of coordinated multi-model experiments will minimize the potential model-dependence of the results and conclusions, which is a major concern in most existing studies. The models to be used in these experiments are summarized in Tab. 2. MGO will be participating with the atmospheric model MGO-3.

Analysis of these experiments will particularly focus on understanding the physical mechanisms, both thermodynamic and dynamic, through which Arctic climate change impacts mid-latitude weather and climate. This will include analysis of the North Atlantic Oscillation (including the potential role of wave-mean flow interactions), the strength of the Siberian High, the potential for sea ice anomalies to initiate Rossby wave trains with subsequent downstream influences over USA, Europe and Asia, and changes in the ocean including the AMOC.

Preliminary Task – Liaise with the international community over the design of coordinated multi-model numerical experiments to investigate the influence of Arctic sea ice decline on lower latitude climates prior to the start of the project (all partners, in kind contribution).

Our initial suggested experiments are detailed below, but the details may be changed slightly in order to be consistent with experiments to be performed by the international modelling community. International coordinated experiments will be discussed at a meeting at the Aspen Global Change Institute (July 2016, co-chairs Doug Smith, Clara Deser and James Screen) and at a meeting of the US CLIVAR Arctic Mid-latitude Working Group (tentatively scheduled for 1-3 February 2017).

In Tasks 3.1 to 3.6 the impact of Arctic sea ice will be assessed by comparing two ensembles of model integrations, a control ensemble generated with present day Arctic sea ice conditions, and a perturbed ensemble generated with reduced Arctic sea ice conditions.

Task 3.1 – Coupled model experiments to assess the impact of Arctic sea ice depletion on lower latitude climate (BSC, AWI, CERFACS, MET Norway, Met Office) (M1-M36)

Fully coupled model experiments are essential in order to simulate both oceanic and atmospheric linkages between the Arctic region and northern mid-latitudes and to include the effects of ocean-atmosphere coupling. This task will assess linkages on seasonal to inter-annual time scales (D3.1, D3.4) whereas Task 3.5 will assess decadal and longer time scales.

Task 3.1.1 – Control experiment. Coupled model constrained by observed sea ice (BSC, AWI, CERFACS, MET Norway, Met Office) (M1-M36)

Sea ice will be constrained by relaxing models to the monthly varying observed climatological average concentration over the period 1980 to 1999. Each simulation will be at least 12 months long, starting June 1st. At least 50 (preferably 100) ensemble members (generated by bit level perturbations to the initial conditions).

Task 3.1.2 – Perturbed Arctic sea ice experiment (BSC, AWI, CERFACS, MET Norway, Met Office) (M1-M36)

Repeat Task 3.1.1 but with reduced Arctic sea ice. This will be achieved by relaxing models to the monthly varying climatological average sea ice concentration and thickness over the period 2080 to 2099 from the ensemble mean CMIP5 simulations (RCP8.5 scenario).
Task 3.2 – Atmosphere-only model experiments to assess the impact of Arctic sea ice depletion on the atmospheric circulation (MET Norway, BSC, CERFACS, Met Office, MGO) (M1-M36)

Further understanding of the processes linking Arctic climate change with the northern mid-latitudes will be gained by repeating Task 3.1 but with atmosphere-only models. The comparison with Task 3.1 will allow some assessment of the roles of atmospheric and ocean pathways and of ocean-atmosphere coupling (D3.2, D3.4). However, the model background state will also be different between Tasks 3.1 and 3.2, so that Task 3.3 is also required to fully assess the different factors.

Task 3.2.1 – Control experiment (MET Norway, BSC, CERFACS, Met Office, MGO) (M1-M36)

The atmospheric model forced by observed sea surface temperatures (SSTs) and sea ice. Models will be forced by monthly varying observed climatologies of sea ice concentration and SST averaged over the period 1980 to 1999. Each simulation will be at least 12 months long, starting June 1st. At least 50 (preferably 100) ensemble members (generated by bit level perturbations to the initial conditions).

Task 3.2.2 – Perturbed Arctic sea ice experiment (MET Norway, BSC, CERFACS, Met Office, MGO) (M1-M36)

Repeat Task 3.2.1 but with reduced Arctic sea ice. This will include the same sea ice concentration as used in the coupled model experiments (Task 3.1.2), with projected SSTs imposed where the sea ice has vanished.

Task 3.3 – Atmosphere model experiments to assess the how the response to Arctic sea ice depletion depends on the background flow (Met Office, BSC, CERFACS, MET Norway, MGO) (M24-M48)

Differences between Tasks 3.1 and 3.2 can be caused by two factors: coupling or differences in the model background state (especially the climatological location and strength of the jet stream). This task will isolate the influence of the background state (D3.4). This will be achieved by repeating Task 3.1, but using climatological SSTs from the ensemble mean of the coupled model control experiments (Task 3.1.1). Tasks 3.1 to 3.3 will therefore enable the relative importance of the model background state and of ocean-atmosphere coupling on the linkages between the Arctic and mid-latitudes to be deduced.

Task 3.4 – Atmosphere model experiments to assess how the response depends on the pattern of Arctic sea ice anomalies (Met Office, BSC, MGO) (M24-M48)

Some studies suggest that sea ice changes in the Atlantic and Pacific sectors may have opposing influences on the mid-latitude atmospheric circulation. This task will investigate this possibility by repeating the perturbed sea ice experiments (Task 3.2.2) but imposing sea ice reductions in the Atlantic and Pacific (if resources allow) sectors separately (D3.4). This will improve our understanding of the physical processes, especially the potentially important role of interference between background waves and those induced by sea ice.

Task 3.5 – Coupled model experiments to assess the decadal and longer time scale impact of Arctic sea ice on the ocean (CERFACS, AWI, UREAD, UiB, UNI Research) (M1-M36)

Task 3.5.1 – Control experiment (CERFACS, AWI, UREAD, UiB, UNI Research) (M1-M36)

Coupled model simulations with present day sea ice (as in Deser et al 2015). They will start in 1990 and run for 75 years, with radiative forcing kept constant at year 2000 values.

Task 3.5.2 – Perturbed Arctic sea ice experiment (CERFACS, AWI, UREAD, UiB, UNI Research) (M1-M36)

Repeat Task 3.5.1, but with reduced Arctic sea ice by applying an artificially enhanced longwave heat flux warming over sea ice following Deser et al. (2015) to determine the impact of Arctic sea ice decline on longer time scales, especially for the ocean (D3.3). Specifically designed tracers will be used to map the transport and the age of key water masses leaving the Arctic, quantifying multi-model, large-scale, decadal to long-term changes in the ocean state induced by Arctic sea ice loss. Duration of the coupled model runs: 75 years.

Task 3.6 – Improved coupled model experiments to assess the impact of Arctic sea ice depletion on lower latitude climate using improved models from WP2 (UiB, UNI Research, AWI) (M36-M48)

This task will assess the impact of model improvements (D3.4) developed in APPLICATE by repeating Task 3.1 and/or 3.5, but using some of the improved models proposed by WP2. The improved understanding of the physical mechanisms through which the Arctic influences mid-latitude weather and climate gained from Tasks 3.1 to 3.5 will be used to assess the linkages simulated by the improved models.

Task 3.7 – Study atmospheric linkages between the Arctic and mid-latitudes from a prediction perspective (AWI, CNRS-GAME, IORAS) (M1-M48)

In this task the influence of the Arctic atmosphere on mid-latitude weather and climate will be studied from a prediction perspective (D3.5). More specifically, seasonal forecast experiments will be carried out in which the atmosphere is relaxed towards ERA-Interim data in the Arctic troposphere, leaving the model run freely elsewhere. This approach, which has been successfully applied by Jung et al. (2014a) for medium-range and subseasonal predictions during boreal winter, provides insight into the potential that enhanced predictive capacity in the Arctic has on mid-latitude forecast
skill. Here, previous work will be extended by carrying out coordinated experiments with two different coupled models (EC-Earth and CNRM-CM) to explore sensitivity to model formulation. Furthermore, the forecasts horizon will be extended to include seasonal time scales, and spring, summer and autumn seasons will also be considered. Finally, the relaxation experiments will be thoroughly analysed, including the verification of teleconnections, the diagnosis of mechanisms including storm tracks and the investigation of a possible flow-dependence of the atmospheric linkages.

### Participation per Partner

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<td>9 - UREAD</td>
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### Description of deliverables

D3.1 : Report on coordinated coupled multi-model assessment of the seasonal to inter-annual impact of Arctic sea ice decline on lower latitudes [36]
Assessment of atmospheric and oceanic linkages on seasonal to inter-annual time scales

D3.2 : Report on coordinated atmosphere-only multi-model assessment of the seasonal to inter-annual impact of Arctic sea ice decline on lower latitudes [36]
Assessment of the roles of atmospheric pathways and of ocean-atmosphere coupling

D3.3 : Report on coordinated coupled multi-model assessment of the decadal and longer impact of Arctic sea ice decline on lower latitudes [36]
Impact of Arctic sea ice decline on longer time scales, especially for the ocean

D3.4 : Final report on coordinated multi-model assessment of seasonal to inter-annual impact of Arctic sea ice decline on lower latitudes, including influence of background state and pattern of anomalies [48]
Comprehensive synthesis report that summarizes the main finding regarding the impact of Arctic climate change on the weather and climate of the Northern Hemisphere.

D3.5 : Report on the influence of the Arctic atmosphere on mid-latitude weather and climate and role for mid-latitude prediction [48]
Influence of the Arctic atmosphere on mid-latitude weather and climate studied from a prediction perspective

### Schedule of relevant Milestones

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<td>12</td>
<td>Metrics in ESMValTool have been incorporated, tested and accepted.</td>
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<td>MS4</td>
<td>Final design of coordinated multi-model numerical experiments in liaison with the international community</td>
<td>7 - MET OFFICE</td>
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<td>The numerical experimentation plan has been updated.</td>
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<td>MS18</td>
<td>Consolidated clustering plan</td>
<td>1 - AWI</td>
<td>9</td>
<td>Revised version of clustering plan after consultation with all APPLICATE key partners</td>
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Work package number 9  WP4  Lead beneficiary 3 - ECMWF

Work package title Support for Arctic observing system design
Start month 1  End month 48

Objectives
- Derive recommendations for the design of the future observing system in the Arctic by examining the spatio-temporal variability of key climatic variables and linkages as represented in current systems and by dedicated numerical experiments representing enhanced systems;
- Assess the impact of Arctic observations (type, coverage, frequency) on the skill of coupled predictions from medium to seasonal time scales;
- Produce recommendations for a coupled experimentation strategy and for the set up observing system experiments for YOPP and its consolidation phase;
- Produce recommendations for future coupled reanalysis system design in support of YOPP related to (i) analysis system set-up and (ii) observational data usage.

Description of work and role of partners

WP4 - Support for Arctic observing system design [Months: 1-48]
ECMWF, AWI, BSC, MET OFFICE, UCL, UREAD, CNRS-GAME
WP4 will be led by ECMWF (Peter Bauer) and UCL (Thierry Fichefet).
This work package will provide guidance for a better exploitation of existing observational datasets and the optimal design of future observing systems. This guidance will be based on (1) an assessment of the representation of the natural climate variability in the Arctic in long-term reanalyses, (2) the use of observations for process understanding of the Arctic weather/climate and its linkages to lower latitudes, and (3) the enhancement of initial condition accuracy leading to improved forecast skill from short/medium-to-seasonal time scales. Guidance for future observing system configurations will be provided by making use of model experiments and by focusing on data-rich periods such as YOPP. As in other WPs, the aspect of prediction will be central to WP4. WP4 will define an experimentation plan to (i) characterize the sensitivity of forecast skill across time ranges to the initial conditions in the atmosphere, the cryosphere and ocean, (ii) define the key observations that are crucial for constraining physical processes and their coupling, (iii) define temporal and spatial sampling set-ups, and (iv) employ key metrics for assessing skill as compiled in WP1.
Forecast skill assessment from short/medium-to-seasonal time ranges requires a focus on the characterization of analysis accuracy using diagnostics that quantify the exploitation of observational information content. A wide range of existing datasets (e.g., operational datasets, reanalyses) and new types of simulations based on data-denial type observing system experiments will be employed to derive conclusions on the importance of the initial conditions and the observations constraining the initial conditions. The results will be directly relevant for further experiments to be performed during the YOPP consolidation phase employing YOPP observations. This work package presents an obvious link to the successful proposal funded under Horizon 2020 BG-09-2016 ‘An integrated Arctic observation system’.
The configuration of parameters, observational datasets, models and numerical experiment types planned for each forecast range is summarized in the following table:
Forecast range: Short/medium range
Parameters: Surface pressure, wind, moisture, temperature snow depth, sea ice cover
Observations: Buoys, SYNOP, NOAA, MetOp, DMSP, MSG
Models: IFS
Experiment: Data denial (operational configuration)
Forecast range - Sub-seasonal to seasonal:
Parameters: Sea ice concentration, sea ice thickness
Observations: CryoSat-2, SMOS, SSMI/S, Envisat, IceSat, ERS-1/2
Models: EC-Earth, HadGEM, GloSea
Experiment: Data denial (idealized configuration)

Task 4.1 – Evaluation of existing datasets with a polar focus (CNRS-GAME, ECMWF, UCL, UREAD) (M1-M24)
This task will gather datasets existing at the start of the project. A comprehensive assessment will be made of the added value, quality and relevance of these datasets for understanding the Arctic climate system’s variability and for improving predictions.

Task 4.1.1 – Assessment of reanalyses in the Arctic (CNRS-GAME, UCL, UREAD) (M1-M24)
Existing oceanic and coupled reanalyses will be investigated to assess the added value of observational constraints on our understanding of long-term variability of atmosphere, sea ice and ocean states. For that purpose, these reanalyses will be evaluated against both assimilated and non-assimilated observations and compared to free model simulations. Particular attention will be given to the relationship between variables across components, for example between the sea ice cover and the Arctic atmospheric circulation (e.g., storm paths and intensities). This task will build upon the data collected as well as the lessons from the GODAE/OceanView ORA-IP, and be carried out in collaboration with the COST (EOS) action on ocean reanalyses.

The work will be carried out in collaboration with scientists from Environment and Climate Change Canada.

Task 4.1.2 – Assessment of operational analyses in the Arctic (ECMWF, UCL) (M1-M24)
Advanced data assimilation diagnostics available from operational atmospheric analyses will be used to identify areas where observations provide significant impact in analysis and forecast, with a focus on short time ranges. Key skill measures are the forecast sensitivity to observation influence (FSOI, Cardinali 2009) and the ensemble data assimilation spread analyses produced in WP1 (Task 1.3.2). These tools will be applied in full-observing-system and data-denial (Task 4.2) contexts to characterize whether the observational impact is consistently represented in both.

The output of Task 4.1 will be a report (D4.1, CNRS-GAME; MS4.1) that assesses the added value of observations in existing datasets and that provides guidance for future reanalyses, but also for the numerical experiments to be performed in Task 4.2 and the YOPP experiment/reanalysis preparation works in Task 4.4.

Task 4.2 – Numerical observing system experiments (UREAD, UCL, ECMWF) (M1-M48)
This task will use numerical models to infer which enhancements to the existing observational network would benefit forecast skill the most, pushing further the current predictability of the Arctic climate system and its impacts to lower latitudes.

Task 4.2.1 – Coupled observing system experiments (UREAD, UCL) (M1-M36)
As part of the APPOSITE research programme, Day et al. (2014) devised an original method to assess the importance of sea ice initial conditions for prediction skill of sea ice and the atmospheric circulation within a perfect model framework (i.e., using the model as the true reference state). It was found that sea ice thickness initialization was crucial for the skillful prediction of summer sea ice cover. This work will be extended to a wider range of models, including the latest versions of HadGEM and EC-Earth, to assess the robustness of this finding. These data-denial experiments will be performed with a focus on the importance of sea ice initialization for atmospheric forecast skill. The idealized experiments conducted in this task will provide a theoretical understanding, which will also allow conclusions to be drawn on the outcomes of the sea ice thickness assimilation work to be done in Task 4.3.

Task 4.2.2 – Atmospheric observing system experiments (ECMWF) (M1-M36)
Observing system experiments will be performed to assess the importance of selected observations for short/medium-range predictive skill in the atmosphere. The experiments will be run as data-denial experiments, whereby selected data types will be withdrawn from the analysis. A sub-set of experiments will apply this methodology for selected regions to investigate hot spots of data impact. The importance of key observing platform types, such as buoys (providing surface pressure), atmospheric motion vectors (providing atmospheric winds), microwave radiances (providing estimates of atmospheric moisture and clouds), and station data over land (providing snow depth), will be evaluated. Forecast skill will be evaluated using standard NWP metrics. Data-rich periods (e.g. IPY, YOPP) will be selected to produce robust data denial experiments.

Task 4.2.3 – Optimal sampling (UCL) (M13-M48)
A number of key sea ice, ocean and atmosphere parameters exhibit significant covariance in space, time, and with each other. For that reason, it is not required to observe these components at all times and everywhere: a minimal number of well-chosen stations can already reveal the dominants modes of Arctic climate variability. Analyses of EC-Earth historical simulations will be conducted to reveal these dominant modes and the number of degrees of freedom associated with each of them. Such a study will bring a quantitative support to important design questions: where, when and at what frequency should observations be taken?

Task 4.2 will produce a comprehensive report (D4.2, UREAD; MS4.2) assessing the numerical experimentation output from both idealized pseudo-observing system and actual data-denial experiments. It will present an investigation into the sensitivity of forecast skill to the initial conditions in the atmosphere and the coupled atmosphere–ocean–sea ice system, constrained by both conventional and satellite observations.
Task 4.3 – Sensitivity of forecast skill to initialization approach and use of novel observations (UCL, ECMWF, BSC, Met Office) (M12-48)
This task will provide support to WP5 by recommending which initial conditions and/or initialization strategies to use for improved sub-seasonal-to-seasonal predictions. It will also consider novel products for data assimilation in prediction systems.

Task 4.3.1 – Forecast skill assessment (UCL, BSC) (M12-M48)
Three methods of initialization will be investigated and compared with each other for the prediction of Arctic conditions at the seasonal scale using EC-Earth. Method 1: interpolation of existing oceanic and atmospheric reanalyses (e.g., ORAS4, ERA-Interim) on the model grid. Method 2: use of ocean and sea ice states from an ocean–sea ice reconstruction forced by the atmosphere, along with the use of existing atmospheric reanalyses. Method 3: same as Method 2 but with additional data assimilation of ocean salt content, heat content and sea ice concentration. Adequate metrics of verification will be developed together with WP1 in order to attribute skill enhancements in the Arctic and at lower latitudes (WP3).

Task 4.3.2 – Sea ice thickness assimilation (Met Office, UCL) (M24-M48)
An assessment of the potential impact of sea ice thickness assimilation within the EC-Earth and GloSea seasonal prediction systems will be performed. This will include an evaluation of the sea ice thickness fields used to initialize EC-Earth and GloSea – initially via comparisons with Earth observation data (such as CryoSat-2, SMOS, Envisat, IceSat, ERS-1/2) – and an empirical analysis of the relationship between winter sea ice thickness conditions and summer sea ice extent errors.

Task 4.3.3 – Snow assimilation (ECMWF) (M12-M48)
Consistent snow initial conditions will be generated in collaboration with WP2 (Task 2.1.2), taking full advantage of recent snow observations. The focus will be on snow over land. In IFS, the two-dimensional optimal interpolation scheme used at ECMWF will be extended to account for model developments in WP2. In-situ observations of snow depth and satellite snow cover information will be used and a new operator to transform satellite snow cover into snow depth will be developed and tested. Pilot experiments initializing snow cover will be conducted to assess the benefit of this method on the representation of land-atmosphere and ocean-atmosphere heat fluxes in late fall/winter. The assimilation experiments will be compared to forecasts from open-loop integrations.

Task 4.3 (Subtask 4.3.1, 4.3.2 and 4.3.3) will collectively produce an interim report (D4.5, M24) and a final report (D4.3, M48) recommending the initialization strategy to use in WP5.

Task 4.4 – Design of the future Arctic observing system – Gap analysis (AWI, ECMWF, UCL) (M36-M48)
This task will evaluate the experiments and diagnostics produced in Tasks 4.2 and 4.3 to derive an analysis of observational gaps and identify shortcomings in current data assimilation methods and models limiting predictive skill from short/medium-to-seasonal time scales (D4.4, AWI; MS4.2). Recommendations for overcoming these limitations will be made with reference to:
- short-term enhancements of the observing system during YOPP, and longer-term improvements that feed into the global integrated observing system efforts coordinated by WMO;
- the initialization of community models used within GloSea and EC-Earth, i.e. the NEMO ocean model, with particular emphasis on the inclusion of sea ice thickness;
- the initialization of operational prediction models such as IFS;
- future model improvements through process parameterization allowing a better use of observations.

Further, Task 4.4 will produce recommendations for further numerical experimentation that should be performed in the period after YOPP in order to benefit from the experience of APPLICATE through complementary studies.

### Participation per Partner

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### Description of deliverables

D4.1: Initial assessment of the added value of observations in existing long time-series datasets, also providing guidance for dedicated observing system experiments [24]

Assessment of the added value of observations in existing datasets and that provides guidance for future reanalyses, but also for the numerical experiments to be performed in Task 4.2 and the YOPP experiment/reanalysis preparation works in Task 4.4.

D4.2: Evaluation of the contribution of the Arctic observing system to forecast skill from short/medium-to-seasonal time scales [48]
Assessment of the numerical experimentation output from both idealized pseudo-observing system and actual data-denial experiments.

D4.3 : Final evaluation of initialization experiments investigating the impact of novel observations in the coupled atmosphere–land–ocean–sea ice system [48]
Final report recommending the initialization strategy

D4.4 : Recommendations for the design of the future Arctic observing system [48]
Analysis of observational gaps and identification of shortcomings in current data assimilation methods and models limiting predictive skill from short/medium-to-seasonal time scales

D4.5 : Interim evaluation of initialization experiments investigating the impact of novel observations in the coupled atmosphere–land–ocean–sea ice system [24]
Interim report recommending the initialization strategy to be used in WP5

### Schedule of relevant Milestones

<table>
<thead>
<tr>
<th>Milestone number</th>
<th>Milestone title</th>
<th>Lead beneficiary</th>
<th>Due Date (in months)</th>
<th>Means of verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS5</td>
<td>Initial assessment of the value of observations for producing reanalyses and initial conditions for forecasts</td>
<td>3 - ECMWF</td>
<td>24</td>
<td>Draft recommendations have been formulated</td>
</tr>
<tr>
<td>MS6</td>
<td>Synoptic analysis of observational data gaps and recommendations for future observing systems</td>
<td>3 - ECMWF</td>
<td>48</td>
<td>Draft recommendations have been formulated</td>
</tr>
<tr>
<td>MS18</td>
<td>Consolidated clustering plan</td>
<td>1 - AWI</td>
<td>9</td>
<td>Revised version of clustering plan after consultation with all APPLICATE key partners</td>
</tr>
</tbody>
</table>
Objectives

- Advance our understanding of the predictability mechanisms by analysing extensive data-bases for weather to seasonal prediction as well as climate projection;
- Provide a strong contributions to the next generation of weather and climate prediction systems by enhanced exploitation of Arctic observations, improved weather and climate models and advanced understanding of linkages between the Arctic and mid-latitudes;
- Assess the added-value of APPLICATE developments in terms of weather and climate predictions.

Description of work and role of partners

WP5 - Improved predictive capacity [Months: 1-48]

**BSC, AWI, ECMWF, MET Norway, MET OFFICE, UCL, CNRS-GAME**

WP5 will be led by BSC (Virginie Guemas) and co-led by MET Norway (Trond Iversen). WP5 synthesises the main results of the APPLICATE project. This synthesis will serve as a basis for, providing recommendations for the development of future weather and climate prediction system and their operational use. Reliable regional weather and climate information from daily to decadal time scales are crucial for socio-economic planning and societal preparedness. WP5 will exploit the knowledge gained in WP3 about the mechanisms linking the Arctic with mid-latitudes, the model developments carried out in WP2 and the strategies proposed in WP4 on how to make the best use of observational data in the Arctic. Thus, WP5 builds on WP2, WP3 and WP4 in order to propose and evaluate new weather and climate prediction systems to better capture impacts of polar features on the large-scale atmospheric circulation in mid-latitudes as well as fast-developing meso-scale events in the vicinity of polar regions, such as polar lows.

Task 5.1 – Numerical experimentation plan for WP5 Stream 1 and Stream 2 experiments (BSC, MET Norway, CNRS-GAME, Met Office, ECMWF, AWI) (M1-M3)

This task aims at defining the experimental protocol for the two streams of experiments that will carried out within WP5: Stream 1 with the operational or near-operational forecast systems available at the start of APPLICATE; Stream 2 with the same forecasting systems incorporating model developments from WP2 and refined initialization schemes from WP4.

Task 5.1.1 - Numerical weather prediction (NWP) (MET Norway, ECMWF) (M1-M3)

Numerical weather prediction experiments will include deterministic and ensemble runs. The evaluation of datasets from the operational output of the IFS will comprise 10-day single forecasts (medium range) at higher resolution and 51-member ensemble 15-30 day forecasts that will be initialized twice per day. The amount of cases will depend on the investigated phenomena: for severe weather events targeted periods will be selected, while for larger-scale phenomena regular forecasts over several months may be required. Limited-area models with boundary data from IFS for predictions up to 3 days will focus on Arctic sub-regions covering open and ice-covered sea-areas, where meso-scale weather systems are known to develop very fast. Deterministic forecasts from AROME-Arctic over a winter season with favorable conditions for polar lows in the Atlantic sector, preferably the first winter of YOPP, will be used to evaluate the state-of-the-art of limited-area predictions. A similar protocol will be used for AROME with dynamical adaptation over a subdomain of the AROME-Arctic domain, with higher resolution (1.3km), using lateral boundary data from the global ARPEGE and initial conditions from the ARPEGE-4DVAR system.

Task 5.1.2 – Seasonal prediction (BSC, CNRS-GAME, Met Office) (M1-M3)

Seasonal prediction experiments will consist of 10-member 7-month long simulations initialized from reanalyses every 1st November and 1st May every year from 1992 to 2015. EC-Earth, CNRS-CM and GloSea forecast systems will be employed.

Task 5.1.3 – Climate change simulations (AWI, BSC, MET Norway) (M1-M3)

Climate change simulations will follow the simplified protocol proposed for the HighResMIP project. This protocol consists in a 50-year spin-up from the EN4 observational database under 1950 conditions followed by a 3-member 1950-2050 simulation. AWI-CM and EC-Earth will be employed. MET Norway considers participation in this task on an in kind basis, if technical aspects have been addressed when the experiments will start.
Task 5.2 – State-of-the-art weather and climate prediction and projection (CNRS-GAME, BSC, ECMWF, MET Norway, Met Office, UCL) (M1-M30)

This task will provide a comprehensive assessment of the performance of state-of-the-art weather and climate forecasting systems available at the start of APPLICATE. Aspects addressed include capturing the Arctic state, variability as well as impacts on the mid-latitude variability and forecast skill on daily, subseasonal and seasonal time scales. Climate change will also be considered, but only in terms of projection uncertainties. This task will contribute to (D5.2), which summarizes the strengths and limitations of current forecasting systems. This assessment will serve as a reference for further forecasting system developments carried out in APPLICATE.

Task 5.2.1 – Scores of weather and climate prediction performance and projection uncertainties (CNRS-GAME, BSC, ECMWF, MET Norway, UCL, AWI) (M1-M24)

An atlas of prediction scores, or score card, will be built based on existing databases at the start of APPLICATE. Multi-model databases available from other projects, such as the THORPEX Interactive Grand Global Ensemble (TIGGE), the Subseasonal-to-Seasonal (S2S), Sea Ice Prediction Network (SIPN), C3S and ScenarioMIP will be exploited. Probabilistic scores for the short-range will be evaluated making use of operational grand limited area ensemble prediction system (GLAMES). Uncertainties on multi-decadal time scales will be assessed by estimating the spread of the multi-model ensembles.

This task will be carried out in collaboration with the US Sea Ice Prediction Network (SIPN).

Task 5.2.2 – APPLICATE stream 1 (MET Norway, CNRS-GAME, Met Office, AWI, BSC, ECMWF) (M3-M30)

Stream 1 of experiments will be conducted with the forecasting systems available at the start of APPLICATE following the experimental protocol described in Task 5.1 leading to (D5.1). The performance of weather and climate predictions and the projection uncertainties will be compared with the atlas built under Task 5.2.1. This approach will help to estimate to which extent our multi-model ensembles are representative of wider databases and to what degree conclusions from APPLICATE can be generalized.

Task 5.2.3 – Sources of predictability for polar climate and its influence on the mid-latitudes (Met Office, CNRS-GAME, BSC) (M1-M24)

The contribution of relatively slow oceanic and sea ice processes for the seasonal predictive skill the Arctic in general and regional sea ice conditions in particular, will be quantified. Arctic processes, including those in the stratosphere, will also be evaluated in terms of their impact on the predictive skill in mid-latitudes. Furthermore, possible precursors (e.g. sea ice, snow and ocean heat content anomalies) for mid-latitude weather and climate anomalies will be considered by employing statistical approaches. Emphasis will be put on the role of autumn sea ice in the Barents-Kara Seas as a potentially strong precursor.

Task 5.2.4 – Empirical statistical models for benchmarking (UCL) (M1-M24)

Empirical prediction systems will be developed from the statistical analyses conducted in Task 5.2.3. These systems will be used as a benchmark, against which dynamical prediction systems will be tested, both those available at the start and at the end of APPLICATE. The performance of our empirical predictions systems will be compared with those from the SIPN summer Sea Ice Outlook for the period 2008 to today.

This task will be carried out in collaboration with the US Sea Ice Prediction Network (SIPN).

Task 5.2.5 – Evaluating forecasts of extreme events (ECMWF, BSC, CNRS-GAME, AWI) (M1-M24)

The ability to capture extreme events will be assessed on time scales of days to seasons. Supported by sensitivity experiments and advanced diagnostics (WP1), an attribution of causes for extreme events will be carried out. For shorter time scales the impact of the initial conditions on predictability of extreme events will be addressed. The emphasis will be on polar lows and severe snow storms on daily time scales; on subseasonal and seasonal time scales the focus will be on blocking, cold waves and September sea ice minima. Particular importance will be given to, extreme events that will happen during the relatively well-observed YOPP core period (mid-2017 to mid-2019). This Task will benefit from Tasks 1.2.2 and 1.2.3 (which will deliver D1.2).

Task 5.3 – Added value of improved process representation for operational or near-operational prediction systems (MET Norway, BSC, CNRS-GAME, ECMWF, UCL) (M13 – M42)

Although model enhancements could improve the climate of models the impact on actual prediction skill may be neutral or even detrimental. It is necessary, therefore, to assess the impact of model enhancements in a prediction framework. This task will provide a thorough assessment of the added value of various individual model developments (WP2) on the forecast quality on daily to seasonal time scales. The conclusions, which will be gathered in (D5.3), provide the basis for recommendations on which of the APPLICATE developments to include in Stream 2 (D5.4).

Task 5.3.1 – Enhanced sea ice models and air-sea interactions in weather and climate prediction (UCL, BSC, CNRS-GAME, ECMWF) (M13 – M36)
In this task, the impact of the enhanced formulation for air-sea ice interactions will be assessed with AROME, and also tested in a seasonal forecasting framework using CNRS-CM6. The role of improved snow schemes and of the number of sea ice categories on numerical weather prediction performance will be assessed with the IFS. The role of an improved sea ice rheology scheme (Maxwell-Elasto-Brittle) and of the number of sea ice categories on seasonal forecast quality will be assessed with EC-Earth.

Task 5.3.2 – Increased atmospheric resolution in weather prediction (MET Norway, CNRS-GAME) (M13 – M36)

The use of Limited Area Models (LAMs) is one way of increasing resolution, and hence our ability to simulated small-scale features, in a geographical area of interest. Traditionally, the value of LAMs has been determined by comparing their skill with that of comparable global NWP systems. Given the need for high-resolution observational data for such an assessment, this classical approach is of limited value in the data sparse Arctic. Here, we will exploit an approach that has been recently pioneered by the Regional Climate Model (RCM) community (e.g. Di Luca et al, 2015), which follows the “Big-Brother Experiment” protocol (Denis et al., 2002). The expected outcome will be recommendations for more optimal LAM configurations and use of LAM output. The results will also provide insight into added value of LAMs when global models continue to increase their resolution in the future and how to distribute resources between resolution, domain size, lead times and number of ensemble members. The impact of high-resolution analysis will be tested with AROME in dynamical adaptation: AROME will be run on the same subdomain as AROME-Arctic (similar to Stream 1), using initial conditions from AROME-Arctic (2.5 km) instead of from the global ARPEGE model with coarser (8 km).

Task 5.3.3 – Increased atmospheric and oceanic resolution in seasonal prediction (BSC, CNRS-GAME) (M13 – M36)

With both the CNRM-CM and EC-Earth seasonal forecasting system, sets of retrospective seasonal predictions will be run with two different resolutions: about 1 degree (for both the atmosphere and ocean) and about 0.25 degree (for both the atmosphere and ocean) globally. This set will be complemented with similar experiments performed with the Canadian system CanSIPS.

This task will be carried out in collaboration with Environment and Climate Change Canada.

Task 5.3.4 – Improved ensemble generation techniques for weather and climate predictions (CNRS-GAME, MET Norway) (M13 – M36)

An innovative ensemble generation technique will be jointly developed for CNRM-CM and EC-Earth to account for model uncertainties on seasonal time scales in both the ocean and atmosphere. Stochastic modeling of temperature and salinity in the ocean (based on Brankart, 2013) will be combined with stochastically perturbed parameterization tendencies (SPPT) in the atmosphere in both coupled models. Uncertainties in the sea ice and sea surface temperature boundary conditions for LAMs will be accounted for through a novel ensemble generation approach in a NWP framework using a high-resolution limited area model for an Arctic domain.

Task 5.4 – Performance of weather and climate forecast systems developed under APPLICATE (ECMWF, AWI, CNRS-GAME, Met Office, MET Norway, UCL) (M37 - M48)

Based on the recommendations on the optimal initialisation strategy (WP4) and on those from the evaluation of the impact of model enhancements in a prediction framework (Task 5.3), optimal configurations will be defined to maximize weather and climate prediction skill in Stream 2. Recommendations for configurations used in climate change simulations will be solely based on recommendations from WP2. Stream 2 will be launched following the common experimental protocol defined in Task 5.1. The progress achieved within APPLICATE will be evaluated in this task and conclusions will be gathered in (D5.6).

Task 5.4.1 – Benefits from APPLICATE in numerical weather prediction (MET Norway, ECMWF, CNRS-GAME) (M37 - M48)

Stream 2 will be carried out with the ECMWF, MET Norway and CNRS-GAME forecasting systems. For AROME-Arctic, the lessons learned from Task 5.3.2 will guide the choice of domain-size and forecast lead-time. This may release computer time, which may be utilized for improving other aspects, such as grid-resolution or small ensembles where sea ice and SSTs are perturbed. For AROME, Stream 2 will use the same configuration as in Task 5.3.2 with improved boundary conditions from global ARPEGE, resulting from the implementation of model enhancements in WP2.

Task 5.4.2 – Benefits from APPLICATE in seasonal prediction (BSC, CNRS-GAME, Met Office) (M37 - M48)

Stream 2 will be carried out with the EC-Earth, CNRM-CM and GloSea seasonal forecasting systems. These improved seasonal forecast systems will take part in the Sea Ice Prediction Network (SIPN) sea ice outlook exercise during the last year of APPLICATE (D5.5). Physical understanding will be used as much as possible to explain possible improvements from Stream 1 and Stream 2. This task will be carried out in collaboration with the US Sea Ice Prediction Network (SIPN).

Task 5.4.3 – Benefits from APPLICATE for climate change projections (AWI, BSC) (M37 - M48)
Stream 2 will be carried out with AWI-CM and EC-Earth. The spread of the multi-model ensemble climate change projections in Stream 1 and 2 will be compared to assess the extent to which APPLICATE research impacts of climate change projections along with their uncertainties. The refined projections from Stream 2 will be disseminated through WP7, standing as the top-quality climate information for the coming years available for end users.

Task 5.5 – Recommendations for future forecasting system development (BSC, CNRS-GAME, MET Norway, ECMWF, Met Office, AWI, UCL) (M45-M48)

This task will synthesize the knowledge gained during the APPLICATE project. Recommendations and prioritization will be formulated regarding future forecasting system development. A synthesis report will be produced (D5.7) which we aim to publish in a high-level journal such as Bulletin of the American Meteorological Society.

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<thead>
<tr>
<th>Partner number and short name</th>
<th>WP5 effort</th>
</tr>
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<td>3 - ECMWF</td>
<td>12.00</td>
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<td>6 - MET Norway</td>
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<td>7 - MET OFFICE</td>
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<td>8 - UCL</td>
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**List of deliverables**

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<tr>
<th>Deliverable Number</th>
<th>Deliverable Title</th>
<th>Lead beneficiary</th>
<th>Type</th>
<th>Dissemination level</th>
<th>Due Date (in months)</th>
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<tbody>
<tr>
<td>D5.1</td>
<td>Simulation carried out with the models available at the beginning of APPLICATE (Task 5.2.2) and following the protocol described in Task 5.1, completed and made available within the consortium</td>
<td>2 - BSC</td>
<td>Demonstrator</td>
<td>Confidential, only for members of the consortium (including the Commission Services)</td>
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<td>D5.2</td>
<td>Report on the strengths and limitations of state-of-the-art weather and climate prediction systems</td>
<td>11 - CNRS-GAME</td>
<td>Report</td>
<td>Public</td>
<td>24</td>
</tr>
<tr>
<td>D5.3</td>
<td>Report on individual impacts of improved process-representation, treatment of snow, ensemble generation and increased resolution on</td>
<td>6 - MET Norway</td>
<td>Report</td>
<td>Public</td>
<td>36</td>
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## List of deliverables

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<tr>
<td>14</td>
<td>the weather and climate prediction performance</td>
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<tr>
<td>D5.4</td>
<td>Simulation carried out with the models available at the end of APPLICATE (Task 5.4) and following the protocol described in Task 5.1, completed and made available within the consortium</td>
<td>6 - MET Norway</td>
<td>Demonstrator</td>
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<tr>
<td>15</td>
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<td>Due Date (in months)</td>
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<tr>
<td>D5.5</td>
<td>Contributions to the SIPN activities through sea ice predictions produced with the forecast systems available at the end of APPLICATE</td>
<td>8 - UCL</td>
<td>Demonstrator</td>
<td>Public</td>
<td>44</td>
</tr>
<tr>
<td>D5.6</td>
<td>Report on integrated added-value from APPLICATE on weather and climate prediction and projection</td>
<td>3 - ECMWF</td>
<td>Report</td>
<td>Public</td>
<td>48</td>
</tr>
<tr>
<td>D5.7</td>
<td>Synthesis report on priorities for future forecasting system development</td>
<td>2 - BSC</td>
<td>Report</td>
<td>Public</td>
<td>48</td>
</tr>
</tbody>
</table>

## Description of deliverables

D5.1 : Simulation carried out with the models available at the beginning of APPLICATE (Task 5.2.2) and following the protocol described in Task 5.1, completed and made available within the consortium [12]

Simulation carried out with the models available at the beginning of APPLICATE (Task 5.2.2) and following the protocol described in Task 5.1, completed and made available within the consortium.

D5.2 : Report on the strengths and limitations of state-of-the-art weather and climate prediction systems [24]

Summary of strengths and limitations of current forecasting systems

D5.3 : Report on individual impacts of improved process-representation, treatment of snow, ensemble generation and increased resolution on the weather and climate prediction performance [36]

Assessment of the added value of various individual model developments (WP2) on the forecast quality on daily to seasonal time scales

D5.4 : Simulation carried out with the models available at the end of APPLICATE (Task 5.4) and following the protocol described in Task 5.1, completed and made available within the consortium [42]

Simulation carried out with the models available at the end of APPLICATE (Task 5.4) and following the protocol described in Task 5.1, completed and made available within the consortium.

D5.5 : Contributions to the SIPN activities through sea ice predictions produced with the forecast systems available at the end of APPLICATE [44]

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Contributions to the SIPN activities through sea ice predictions produced with the forecast systems available at the end of APPLICATE.

D5.6 : Report on integrated added-value from APPLICATE on weather and climate prediction and projection [48]
Evaluation of progress achieved within APPLICATE

D5.7 : Synthesis report on priorities for future forecasting system development [48]
Synthesis report to be published in a high-level journal

### Schedule of relevant Milestones

<table>
<thead>
<tr>
<th>Milestone number</th>
<th>Milestone title</th>
<th>Lead beneficiary</th>
<th>Due Date (in months)</th>
<th>Means of verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS1</td>
<td>Enhanced version of ESMValTool available</td>
<td>1 - AWI</td>
<td>12</td>
<td>Metrics in ESMValTool have been incorporated, tested and accepted.</td>
</tr>
<tr>
<td>MS3</td>
<td>Final design of enhanced models to be assessed in climate and prediction mode</td>
<td>11 - CNRS-GAME</td>
<td>36</td>
<td>Enhanced models can be used to evaluate their predictive skill in WP5</td>
</tr>
<tr>
<td>MS7</td>
<td>Database downloaded</td>
<td>2 - BSC</td>
<td>3</td>
<td>Databases for the atlas of prediction scores downloaded by the partners</td>
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<tr>
<td>MS8</td>
<td>Sensitivity experiments</td>
<td>2 - BSC</td>
<td>30</td>
<td>Sensitivity experiments to improved process representation performed</td>
</tr>
<tr>
<td>MS18</td>
<td>Consolidated clustering plan</td>
<td>1 - AWI</td>
<td>9</td>
<td>Revised version of clustering plan after consultation with all APPLICATE key partners</td>
</tr>
</tbody>
</table>
WP6 - Data and HPC Management

MET Norway, AWI, ECMWF

WP6 will be led by MET Norway (Øystein Godøy). The work in this WP will focus on activities related to producing and managing data and products. Existing HPC resources are utilised for production, but coordination is required to exploit emerging resources on the European scene. Data management (sharing and preservation) is focused on integration with WMO activities, including WMO Information System, which is supporting YOPP. In addition to products developed during the project, ECMWF operational output is prepared for sharing through a dedicated service. For coordinated analysis of the project results a common post-processing environment is established. WP6 will also act as a hub for sharing information among the work packages.

Task 6.1 – Oversee HPC activities (AWI) (M1-M48)

As part of APPLICATE, comprehensive numerical experimentation will be carried out. Therefore, it is important that sufficient HPC resources will be available. APPLICATE partners have access to some of Europe’s leading HPC resources, including model and forecasting systems that are well adjusted to the available HPC and data facilities. Therefore, rather than coordinating all modelling activities on one HPC system, a more distributed approach will be followed. In this task, progress on the HPC side of the project will be overseen. This included periodic enquiries regarding availability of HPC resources in relation to the upcoming tasks and deliverables. Furthermore, this task will inform partner about upcoming opportunities for applying for HPC resources. Finally, this task will consider joint proposals for PRACE supercomputing resources.

Task 6.2 – Preparation and publication of operational ECMWF model output for YOPP (ECMWF) (M1-M30)

This task comprises the preparation and dissemination of operational model output from the ECMWF archives in support of forecast performance studies and model error analyses. This YOPP Analysis and Forecast Dataset will contain two full years (mid 2017—mid 2019) that are aligned with the YOPP period (D6.4). Selected data on model levels, pressure levels and surface fields will be made available. In addition to standard output also model tendencies (physical and dynamical processes) will be included along the first steps of the forecast for detailed process studies. A commitment by ECMWF of this kind has already been made in the past in support of the Year of Tropical Convection (YOTC), which produced significant impact on the science community (Moncrieff et al. 2012). Apart from process studies, the dataset can be used to force sea ice-ocean models, carry out predictability studies and serve as a basis for Transpose-AMIP experiments (Williams et al. 2013).

Producing this dataset requires the definition of output fields, the definition of data structures to accommodate this data (grib_api, MARS, and entire software stack), the definition of the data server layout, and the development of a suite that will reformat data into the YOPP convention, its archival in the ECMWF meteorological archiving system (MARS), and the establishment of a data catalogue on the data server (D6.2). The web interface will follow the YOTC template (http://apps.ecmwf.int/datasets/data/yotc-od/levtype=sfc/type=an/). A server is required to add to the webapi infrastructure for serving this data. The data will be stored in GRIB following WMO standards applicable to NWP. Since the data will be archived in MARS, full back-up and recovery capabilities will be made available, as for other operational model output.

Task 6.3 – APPLICATE data framework (MET Norway) (M1-M48)
This task consists of 4 subtasks: Development of a data management plan, development of guidance material, Data management implementation and maintenance and Post-Processing Environment implementation, maintenance and support. In order to streamline the data documentation, sharing and preservation, best practices are developed. Data management is focused on linking datasets to user communities internally in the project as well as presentation of results to external stakeholders. This calls for the adoption of internationally accepted standards for documenting and accessing data. The work on data management will be linked to observational frameworks, both through WMO (WIS and WIGOS) and of EU origin. At the data management level there is a strong linkage to a proposal (Arctic-UNION) for an Arctic Observing System. However, as long internationally accepted interoperability standards are used any community or framework can be connected. This approach is directly linked to YOPP data management.

Task 6.3.1 – Development of a data management plan (MET Norway) (M1-M6)
The purpose of this task is to develop a data management plan, which provides a detailed outline of APPLICATE data management strategy, including technical details and time lines (D6.1).

Task 6.3.2 – Development of guidance material (MET Norway) (M1-M12)
The purpose of this task is to provide guidance material (Best practises) and tools enabling the partners to properly document and format their data in order to facilitate long term data preservation including life cycle management of data, data publication and data sharing (D6.3). This work will draw on existing material developed in the context of the Arctic Data Committee (SAON/IASC), WMO, GEO, ICSU, RDA etc. but is adapted to the specific challenges of this project and its stakeholders. Standardisation of data documentation and interfaces to data is a prerequisite for cost effective data curation, sharing and consumption.

Task 6.3.3 – Data management implementation and maintenance (MET Norway) (M1-M48)
The purpose of this task is to provide a structured approach to data management including sharing and consumption. Following a distributed data management approach similar to Copernicus Marine Environment Monitoring Service (CMEMS) and Earth System Grid Federation (ESGF) standardizing on NetCDF following the Climate and Forecast Convention, including embedded discovery metadata according the NetCDF Attribute Convention for Dataset Discovery and data transportation/access using OPeNDAP allows for integration of data across data repositories and for combination with other relevant data (e.g. in situ products). This solution supports life cycle management, dataset publication, dataset search and retrieval as well as data streaming into applications used for analysis following the Common Data Model (CDM). Discovery metadata describing the products and how to retrieve them will be exchanged with relevant Arctic and stakeholder data management frameworks through the efforts of the combined SAON and IASC Arctic Data Committee, and WMO Information System (WIS). Metadata technologies utilised will e.g. be OAI-PMH (exchange of metadata) and ISO19115/GCMD DIF (metadata standards). Linkages to WMO Information System will be provided through the approved WIS Data Collection and Production Centre the Arctic Data Centre. This work package has a commitment beyond the project duration. Usually, modelling data are archived at least for 10 years, observational data on an indefinite temporal horizon. Each dataset handled require specification of the life cycle management. This task includes a dedicated web portal providing an overview of the projects data catalogue (D6.5).

Task 6.3.4 – Post-Processing Environment implementation, maintenance and support (MET Norway) (M1-M48)
A dedicated post-processing environment will be set up to support analysis of multiple datasets and creation of new combined datasets (D6.6). This will be available for partners and include a storage system for processing and staging of datasets for long term archival and data sharing though task 7.2. Support will be provided to facilitate remote visualisation (e.g. Vapor, ParaView, VisIt, Jupyter/iPython Notebook) and other software tools (e.g. Python, R) the project community is requiring. The post processing environment can utilise datasets stored in connection to the environment or access remote datasets using OPeNDAP if supported by the remote data centre. This task cover implementation, maintenance and user support.

### Participation per Partner

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>1 - AWI</td>
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</tr>
<tr>
<td>3 - ECMWF</td>
<td>3.00</td>
</tr>
<tr>
<td>6 - MET Norway</td>
<td>11.00</td>
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<th>Type</th>
<th>Dissemination level</th>
<th>Due Date (in months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D6.1</td>
<td>Data management plan</td>
<td>6 - MET Norway</td>
<td>ORDP: Open Research Data Pilot</td>
<td>Public</td>
<td>6</td>
</tr>
<tr>
<td>D6.2</td>
<td>Data catalogue and services</td>
<td>6 - MET Norway</td>
<td>Report</td>
<td>Public</td>
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</tr>
<tr>
<td>D6.3</td>
<td>Provision of guidance material and tools for effective data management</td>
<td>6 - MET Norway</td>
<td>Report</td>
<td>Public</td>
<td>12</td>
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<td>D6.4</td>
<td>Start with the archiving and dissemination of YOPP Analysis and Forecast Dataset</td>
<td>3 - ECMWF</td>
<td>Report</td>
<td>Public</td>
<td>18</td>
</tr>
<tr>
<td>D6.5</td>
<td>Launch of a web portal providing an overview of the project data catalogue</td>
<td>6 - MET Norway</td>
<td>Websites, patents filling, etc.</td>
<td>Public</td>
<td>24</td>
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<tr>
<td>D6.6</td>
<td>Post Processing Environment</td>
<td>6 - MET Norway</td>
<td>Report</td>
<td>Public</td>
<td>30</td>
</tr>
</tbody>
</table>

### Description of deliverables

D6.1 : Data management plan [6]
Data management plan providing a detailed outline of APPLICATE data management strategy, including technical details and time lines

D6.2 : Data catalogue and services [12]
Definition of output fields, the definition of data structures to accommodate this data, the definition of the data server layout, and the development of a suite that will reformat data into the YOPP convention, its archival in the ECMWF meteorological archiving system (MARS), and the establishment of a data catalogue on the data server

D6.3 : Provision of guidance material and tools for effective data management [12]
Guidance material (best practises) and tools enabling the partners to properly document and format their data in order to facilitate long term data preservation including life cycle management of data, data publication and data sharing

D6.4 : Start with the archiving and dissemination of YOPP Analysis and Forecast Dataset [18]
YOPP Analysis and Forecast Dataset eventually containing two full years (mid 2017—mid 2019) that are aligned with the YOPP period

D6.5 : Launch of a web portal providing an overview of the project data catalogue [24]
Devolopment and launch of a web portal, which provides an overview of the projects data catalogue.

D6.6 : Post Processing Environment [30]
Set up of a dedicated post-processing environment to support analysis of multiple datasets and creation of new combined datasets.
<table>
<thead>
<tr>
<th>Milestone number</th>
<th>Milestone title</th>
<th>Lead beneficiary</th>
<th>Due Date (in months)</th>
<th>Means of verification</th>
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</thead>
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<td>MS9</td>
<td>Setup YOPP Analysis and Forecast Dataset Infrastructure</td>
<td>6 - MET Norway</td>
<td>15</td>
<td>Data can be archived and external access has been setup and tested</td>
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<tr>
<td>MS18</td>
<td>Consolidated clustering plan</td>
<td>1 - AWI</td>
<td>9</td>
<td>Revised version of clustering plan after consultation with all APPLICATE key partners</td>
</tr>
</tbody>
</table>
WP7 - User engagement, dissemination and training [Months: 1-48]

AP, BSC, UiT

WP 7 will be led by AP (Halldor Johannsson / Kamil Jagodziński) and BSC (Francisco Doblas-Reyes / Isadora Jiménez), supported by UiT (Gerlis Fugmann).

WP7 integrates three main areas of action: communication and dissemination of the project results, user engagement and training. All the activities will be carefully targeted to different groups of potential audiences (e.g. research community, EU projects, general public) and stakeholders defined as key (business and governmental stakeholders in the Arctic within and outside the EU), primary (meteorological and climate national services, NGOs or local communities) and secondary stakeholders (business stakeholders from mid-latitudes). The interaction with this wide range of stakeholders will be also fostered by the actual involvement and contact of APPLICATE partners with many of them.

Task 7.1 - Communication and dissemination (AP, BSC, UiT) (M1-M48)

Task 7.1 will apply modern communication tools for online facilitation, and the most efficient channels for communication and dissemination of information and data. The focus will be on the impact of Arctic changes on both weather and climate, not only in the Arctic area, but also its linkages with lower latitude phenomena in the Northern Hemisphere.

Task 7.1.1 - Communication and dissemination plan (AP, BSC) (M1-M2)

An outline of the Communication and dissemination plan (CDP) is provided in section 2.2 and will be further discussed during the kick-off meeting with all the partners. This plan will be further developed in D7.2, providing a full framework for the development of this task along the lifetime of the project detailing target audiences, communication tools and channels, key messages and practical information such as branding project style, logo, guide, templates, etc. This plan will be revised and updated during the project lifetime.

Task 7.1.2 - On-line communication and tools (AP, BSC) (M3-M48)

A website will be designed to contain and offer the project description and its various outputs like public reports, general information, and news and dissemination material. The website will be initially set up to identify the project (providing visual identity materials and templates in a password protected partners area) and promote early engagement with other EU projects, international initiatives and communities (D7.1). In a second phase, the structure and contents will be critically revised, taking into account all the feedback collected from both partners and stakeholders, and modified accordingly (MS 7.5) so that it can take a role in serving more specific needs: promoting project results with high impact multimedia communication material, disseminating promotional campaigns of the project through social media (Facebook and Twitter accounts), publishing press releases and providing online feedback mechanisms to the target audiences, including the users and stakeholders contacted in Task 7.2. The website will include a compilation of skill training resources relevant for early career researchers in the APPLICATE project. Maintenance and updates of on-line content will follow the sequence set in the Communication and dissemination plan (D7.2).

Task 7.1.3 - Dissemination materials (AP, BSC) (M3-M48)
Dissemination materials (mainly online, although some printed material will be made available at key events) presenting a selection of project activities and results will be prepared in English in order to reach the audiences identified in D7.2 and D7.3. The material will be made available in different versions to accommodate to the various levels of experience in weather and climate and needs of those audiences. Materials will include: brochure, leaflets, roll-ups, factsheets etc. (D7.5, D7.6, D7.7, D7.8, D7.9).

Task 7.1.4 - FrostBytes videos (AP, UiT) (M3-M48)
Production support for the FrostBytes videos, which are short videos (up to 60 seconds) from the Summer School that explain to the general public what research participants are conducting (public outreach activity). FrostBytes will be also posted in external websites, for instance, that of APECS.

Task 7.1.5 - Promoting project and disseminating results in international fora of relevance (AP, BSC) (M6-M48)
To strengthen the role of the project as a base of cutting edge research, the project will be advertised and explained during international relevant events, particularly outside the EU. Additional promotion, dissemination of results and illustration of the implications (e.g. impact and opportunities for socioeconomic sectors) will help strengthening the recognition of the project and the EU as a state-of-the-art research provider for the objectives that APPLICATE addresses. Special attention will be given to interaction with other projects (ClimatEurope, link to C3S activities, and especially contribution to YOPP).

Task 7.2 - User engagement (AP, BSC) (M1-M48)
Active engagement with all groups of interest within and outside the EU including users and intermediaries (e.g. national services, NGOs, industrial sectors and indigenous communities, among others) is crucial for maximizing knowledge exchange and obtaining the necessary feedback that can guide some aspects of APPLICATE research. Task 7.2 will aim to understand the impacts and the opportunities of potential changes in the Arctic through a proactive dialog with users and intermediaries from Arctic and mid-latitudes.

Task 7.2.1 - User engagement plan (BSC, AP) (M1-M2)
A first draft of the strategic plan for user engagement will be presented during the kick-off meeting to all the partners to complete the vision of the potential users of Arctic and lower latitude weather and climate information and to maximize the synergies that the APPLICATE partners can create with the users identified in other EU funded projects and committees where they participate (see section 2.2.a.4). This plan will be further developed in D7.3 that will identify key, primary and secondary stakeholders, their contact details and their level of use of weather and climate information, effective mechanisms for engaging users in the implementation of the project, Key performance indicators (KPI) for each mechanism, etc. This plan will be revised and updated during the project’s lifetime.

Task 7.2.2 - The user group (AP, BSC) (M3-M48)
To support the project with an external user-specific perspective and to provide continuous feedback on the relevance of the results obtained and the way they are presented, a group of 7-10 representatives of key stakeholders - the User Group (UG) will be defined. The UG will serve the WP, the project, Coordinator and Management Support Team as an additional advisory mechanism. The UG will meet either in person or on-line following a frequency defined in the user engagement plan (D7.3). Feedback and comments of the UG will be provided by WP7 to support implementation of the management and decision making structure (Task 9.1.2) of WP9 Project Coordination and Management.

Task 7.2.3 - Organizing and performing workshops, meeting and interviews with key stakeholders (BSC, AP) (M3-M48)
To illustrate the benefits of climate forecasts with improved polar representation to a range of stakeholders in the Arctic and mid-latitudes, the partners will participate in relevant external events or initiatives organized by the target sectors (half-a-day events at professional conferences rather than general-purpose workshops) and will carry out workshops and interviews during those events to get direct feedback from a user perspective by actors not usually linked to the weather and climate research communities. These activities will be jointly organized with other EU projects such as PRIMAVERA, IMPREX or CLIM4ENERGY when linked to a common target stakeholder. (D7.11, D7.12)

Task 7.2.4 - Online user feedback tool (AP, BSC) (M3-M48)
An online tool for collecting feedback and organizing virtual consultations will improve the interaction of the stakeholders identified by the project. The virtual tools will provide additional feedback mechanisms and traceability (always respecting all due confidentiality), while providing a wider perspective on the challenges, discrepancies, misconceptions and important issues overlooked by the experts. The outcome of this task will be provided to the key players in the C3S User Interface Platform (MS 7.7). (D7.11, D7.12)

Task 7.3 - Training (UiT, AP, BSC) (M1-M48)
The tailor-made set of training activities will include webinar series, summer school, online course on project-relevant aspects, and other training options. Training will be organized in relation to the usual training activities carried out by each partner (i.e. YOPP Summer School in mid-2018 organized by AWI, PRACE Advance Training Courses (PATC)
organized by BSC). Coordination of training activities and synergy with ongoing and planned projects will increase the desired impact, ensure cost-effectiveness and potentially help to get external funding.

Task 7.3.1 - Training plan (UiT, AP, BSC) (M1-M48)

The plan defining all the training activities and their time of execution will be detailed in D7.4 that will take into account the possibility of coordination with other activities (BG-9, BG-10, YOPP, WCRP, WWRP, RCOFs, etc.) and the alignment with other training activities in the context of the YOPP. This plan will be revised and updated during the project’s lifetime.

Task 7.3.2 - Connection and training opportunities for early career researchers (UiT) (M1-M48)

This will include several components: a) an email list; b) the compilation of a thematic website with skill training resources relevant for early career researchers in the APPLICATE project that will serve as an open resource; c) dedicated “mentor” sessions connecting early career and senior researchers involved in the project at meetings and workshops related to the project throughout the project.

Task 7.3.3 - Webinar series in connection with the APPLICATE project (UiT, AP) (M9-M12)

A webinar series directed towards early career researchers (but open to the general public) will introduce the APPLICATE project and increase the awareness about the impact of Arctic changes on the weather and climate of the Northern Hemisphere. The webinars (2) will be recorded and provided as an open resource on the websites of the APPLICATE project and that of the Association of Polar Early Career Scientists.

Task 7.3.4 - Summer School for PhD students and postdoctoral researchers from APPLICATE partners and in connection to YOPP Summer School (UiT, AP, BSC) (M17-M19)

APPLICATE will benefit from a unique, high-level, summer school program for 30 PhD students and postdoctoral researchers, covering some of the theories and methods used within the research project. This 10-day training course will be organized by UiT in cooperation with other projects and external partners. WP will investigate the possibility of including YOPP as co-sponsor for the summer school. Each of the participants will also create FrostBytes on their research projects (D7.13, in connection to Task 7.1.4).

Task 7.3.5 - Online course (UiT, AP, BSC) (M26-M28)

A 3 months course on “Advancing predictive capacity of Northern Hemisphere weather and climate” will be organized for early career scientists (but open to anyone interested) with weekly interactive online sessions. Recordings will be made openly available afterwards on the APPLICATE website and the website of the Association of Polar Early Career Scientists.

Task 7.3.6 - Follow up assessment of the outcomes of the learning experience (UiT) (M46-M47)

A report assessing the lessons learnt from summer school and online course will contribute to the improvement of these training tools into future APECS teaching strategy (D7.10).

### Participation per Partner

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<td>14 - UiT</td>
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<th>Lead beneficiary</th>
<th>Type</th>
<th>Dissemination level</th>
<th>Due Date (in months)</th>
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<td>D7.1</td>
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<td>13 - AP</td>
<td>Websites, patents filing, etc.</td>
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List of deliverables

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<th>Due Date (in months)</th>
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<td>Report</td>
<td>Websites, patents filling, etc.</td>
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<td>Report</td>
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<td>D7.11</td>
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<td>Report</td>
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<td>D7.12</td>
<td>Second summary report of the stakeholder interaction activities</td>
<td>13 - AP</td>
<td>Report</td>
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<td>36</td>
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<td>D7.13</td>
<td>Provision of all 30 FrostByte videos of APPLICATE and APECS websites</td>
<td>14 - UiT</td>
<td>Websites, patents filling, etc.</td>
<td>Public</td>
<td>19</td>
</tr>
</tbody>
</table>

Description of deliverables

D7.1 : Website, incl. online tool for end-users feedback [2]
A website will be designed to contain and offer the project description and its various outputs like public reports, general information, and news and dissemination material. The website will be initially set up to identify the project (providing visual identity materials and templates in a password protected partners area) and promote early engagement with other EU projects, international initiatives and communities

D7.2 : Communication and dissemination plan [6]
Full framework detailing target audiences, communication tools and channels, key messages and practical information such as branding project style, logo, guide, templates, etc.

Identification of key, primary and secondary stakeholders, their contact details and their level of use of weather and climate information, effective mechanisms for engaging users in the implementation of the project, Key performance indicators (KPI) for each mechanism, etc.

D7.4 : Training plan [6]
Plan defining all the training activities and their time of execution

D7.5 : Dissemination materials 1 [6]
Material will be made available in different versions to accommodate to the various levels of experience in weather and climate and needs of those audiences. Materials will include: brochure, leaflets, roll-ups, factsheets etc.

D7.6 : Dissemination materials 2 [13]
Update/revision of material in D7.5

D7.7 : Dissemination materials 3 [25]
Update/revision of material in D7.6

D7.8 : Dissemination materials 4 [37]
Update/revision of material in D7.7

D7.9 : Dissemination materials 5 [45]
Update/revision of material in D7.8

D7.10 : Final assessment of the outcomes of the training experience [47]
A report assessing the lessons learnt from summer school and online course will contribute to the improvement of these training tools into future APECS teaching strategy

D7.11 : First summary report of stakeholder interaction activities [18]
First summary report of the stakeholder interaction activities including the list stakeholders reached, what feedback was received and for the benefit of which WP.

D7.12 : Second summary report of the stakeholder interaction activities [36]
Second summary report of the stakeholder interaction activities including the list stakeholders reached, what feedback was received and for the benefit of which WP.

D7.13 : Provision of all 30 FrostByte videos of APPLICATE and APECS websites [19]
Provision of all 30 FrostByte videos on APPLICATE and APECS websites.

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<th>Lead beneficiary</th>
<th>Due Date (in months)</th>
<th>Means of verification</th>
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<td>MS10</td>
<td>Start of social media campaign on Facebook and Twitter</td>
<td>13 - AP</td>
<td>7</td>
<td>Active accounts, regular updates, online visibility statistics</td>
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<tr>
<td>MS11</td>
<td>First meeting of User Group</td>
<td>13 - AP</td>
<td>10</td>
<td>List of participants. Meeting minutes and conclusions of the User Group</td>
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<tr>
<td>MS12</td>
<td>1st Strategic meeting of WP7 – revision of communication and dissemination, user engagement, and training plans</td>
<td>13 - AP</td>
<td>17</td>
<td>Minutes of the meeting, suggestions to Project Manager</td>
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<tr>
<td>MS13</td>
<td>Summer school</td>
<td>14 - UiT</td>
<td>19</td>
<td>List of attendance of Summer school</td>
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## Schedule of relevant Milestones

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<th>Due Date (in months)</th>
<th>Means of verification</th>
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<tr>
<td>MS14</td>
<td>Start of website second phase</td>
<td>13 - AP</td>
<td>20</td>
<td>Changes in the contents and structure of the website</td>
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<td>MS15</td>
<td>2nd Strategic meeting of WP7 – revision of communication and dissemination, user engagement, and training plans</td>
<td>13 - AP</td>
<td>35</td>
<td>Minutes of the meeting, suggestions to Project Manager</td>
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<tr>
<td>MS16</td>
<td>Share outcomes of user feedbacks with key players in the C3S User Interface Platform</td>
<td>2 - BSC</td>
<td>41</td>
<td>Information made available from APPLICATE website</td>
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<tr>
<td>MS18</td>
<td>Consolidated clustering plan</td>
<td>1 - AWI</td>
<td>9</td>
<td>Revised version of clustering plan after consultation with all APPLICATE key partners</td>
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Work package number 9 | WP8 | Lead beneficiary 10 | 1 - AWI
---|---|---|---
Work package title | Clustering | | |
Start month | 1 | End month | 48 |

**Objectives**

- Coordinate APPLICATE activities with EU projects;
- Coordinate APPLICATE activities with international projects (e.g. YOPP and Belmont Forum);
- Coordinate APPLICATE with WMO WWRP PPP.

**Description of work and role of partners**

**WP8 - Clustering** [Months: 1-48]

AW1, ECMWF

WP8 will be led by AWI (Thomas Jung) and ECWMF (Peter Bauer).

This WP will benefit significantly from in kind contributions of various APPLICATE PIs, especially from the coordinator Thomas Jung, through their roles in various international committees (see Part B, Table 4 for examples).

Task 8.1 – Develop draft clustering plan (AWI, ECMWF) (M1-M3)

There are a number of European and international activities that are or will be related to some of the activities planned in APPLICATE. In order to exploit synergies, APPLICATE will establish a strong clustering component. At the heart of APPLICATE’s clustering strategy, lies a draft clustering plan that will be developed at the beginning the project (D8.3).

The plan outlines:
- A list of related projects and activities, including points of contact, for which clustering is envisaged
- A proposal for forming a coordinator network
- A proposal for specific clustering activities within the coordinator network (teleconferences, joint communication activities)
- A proposal for specific clustering activities with different projects and activities (e.g. project-exchange days, invitation of coordinators to APPLICATE GAs)
- A proposal for holding the first coordination meeting in conjunction with the YOPP planning meetings that will be held from 5—9 September 2016 in Reading, UK. All coordinators of existing activities and those known to have submitted related proposals will be send a save-the-dates email by the International Coordination Office (ICO) for Polar Prediction (D8.1).

More specific elements of the draft clustering plan are outlined below for some of the most strongly related European and international activities. The clustering plan will be a living document that will be revised and updated during the project lifetime.

Task 8.2 – Specific clustering activities with EU projects

Task 8.2.1 – Projects funded under H2020-BG09-2016 and BG10-2016 (AWI) (M1-M48)

The projects funded under H2020-BG09-2016 and especially BG10-2016 are expected to have strong links to APPLICATE. It will be important therefore to strongly coordinate activities for exploiting synergies and thus increase the critical mass for delivering the expected impacts set out in the work programme and call texts. The following activities are part of the draft clustering plan and are specific to the link between APPLICATE and the projects funded under H2020-BG09-2016 and BG10-2016:
- Organize teleconferences with the project coordinators to agree on a roadmap for developing a coordinated clustering strategy.
- Invite the coordinators of collaboration projects to the GAs of APPLICATE to report on the progress and challenges of their projects and to agree on coordinated activities.
- Participation of the APPLICATE Project Coordinator or another member of the Executive Board at GAs of BG-09 and the other BG-10 project.
- Coordinators of BG-09 and other BG-10 projects will be invited to become members of the external advisory board in APPLICATE (D8.2).
- Identify common dates and places for GAs for all 3 projects and have a shared ‘project-exchange-days’.
- Develop a joint cooperation strategy and update the clustering plan accordingly (D8.4)
- It is possible that some of the APPLICATE partners will be contributing to some of the other projects. These partners will be identified and tasked to contribute to the coordination activities between the projects.
Task 8.2.2 – Projects funded under earlier calls of H2020 and FP7 (AWI, ECMWF) (M1-M48)

This task will ensure that APPLICATE activities are well coordinated with projects funded under earlier calls of H2020 and FP7 (call text: “build on other projects funded under earlier calls”):
- Compile a list of relevant projects, including points of contact. Relevant projects include PRIMAVERA, CRESCENDO and EU-PolarNet.
- Invite the coordinators of those projects to the GAs of APPLICATE to report on the progress and challenges of their projects and to agree on coordinated activities.
- Identify APPLICATE partners involved in these projects and task them to contribute to the coordination activities between the projects.
- Participation of the APPLICATE Project Coordinator or another member of the Executive Board in project meetings, if no APPLICATE partner is directly involved.
- Agree on common clustering activities with each of the projects and update clustering plan accordingly (D8.6).

Task 8.3 – Specific coordination activities with international projects

Task 8.3.1 – Year of Polar Prediction (YOPP) (AWI, ECMWF) (M1-M48)

PPP aims to enable a significant improvement in environmental prediction capabilities for the polar regions and beyond, for which YOPP represents a major milestone. Therefore, APPLICATE is very well aligned with the aims of YOPP, and there is a need to coordinate planned activities. In this context APPLICATE will strongly benefit from the fact that partners take leading roles in the preparation and implementation of YOPP, including the Project Coordinator, Thomas Jung, who is overseeing the planning and coordination of YOPP and in his role as the chair of PPP. Therefore, upcoming YOPP planning meetings and meetings of the PPP steering group will provide excellent opportunities to ensure coordination of APPLICATE with other ongoing activities.

Specific clustering activities related to YOPP include:
- If applicable, present and discuss APPLICATE at the next YOPP planning meeting that will be held from 5-9 September 2016 in Reading, UK.
- Present and discuss APPLICATE activities at annual meetings of the PPP steering group.
- Project Coordinator provides regular updates on YOPP at APPLICATE GAs.
- Exploit YOPP outreach and communication activities to disseminate APPLICATE results.
- Align stakeholder engagement activities in YOPP and APPLICATE.
- Explore the possibility for aligning the APPLICATE summer school with that planned for YOPP (D8.7).

Task 8.3.2 – Sea Ice Prediction Network (SIPN) (AWI) (M1-M48)

The Sea Ice Prediction Network (SIPN) is a collaborative network of scientists and stakeholders (mostly from the US) working to improve and communicate sea ice prediction. Coordination of SIPN and APPLICATE will be ensured as follows:
- The Co-PI of SIPN, Cecilia Bitz, has agreed to serve as a member of the external Advisory Board of APPLICATE. This will allow for regular exchanges that will be reflected in updates of respective sections of the clustering plan.
- APPLICATE partners (e.g. UCL and BSC) are actively involved in the SIPN. These partners will be tasked to contribute to the coordination activities between the projects by providing regular updates and raising potential issues.

Task 8.3.3 – Projects resulting from Belmont Forum call on climate predictability and inter-regional linkages (AWI) (M1-M48)

The Belmont Forum has recently issued a call on “Climate Predictability and Inter-Regional Linkages“. Given the nature of the call, it can be anticipated that APPLICATE and some of the Belmont Forum projects will mutually benefit from coordination. To ensure effective coordination the draft clustering plan contains the following actions:
- Identify relevant projects and establish points of contact (Project Coordinators).
- Hold meeting and agree on specific clustering activities that will feed into the APPLICATE clustering plan (D8.5).
- Invite Project Coordinator(s) of relevant projects to participate in APPLICATE GA to report on the progress and challenges of their projects and to agree on coordinated activities.
- Identify APPLICATE partners involved in these projects and task them to contribute to the coordination activities between the projects.
- Have APPLICATE representatives participate in Belmont project GAs.
- Consider inviting Belmont Project Coordinator(s) to be member of the external Advisory Board.
- Hold regular teleconferences to monitor progress and identify potential issues.

Task 8.3.4 – US CLIVAR Working Group on Arctic Change and Possible Influence on Mid-latitude Climate and Weather (AWI) (M1-M48)

The US CLIVAR Working Group has been established to further the understanding of the coupling between Arctic variability and mid-latitude climate and weather. Its aims are strongly related to that of WP3 in APPLICATE. It will
be imperative therefore to jointly develop a strong clustering concept. This activity will be led by the APPLICATE Project Coordinator, Thomas Jung, who is also a member of the US CLIVAR working group. The draft clustering plan includes the following actions:

- Agree on a joint clustering concept, including an agreement on coordinated numerical experimentation, at the next meeting of the US CLIVAR Working Group that is tentatively scheduled for 1-3 February 2017 in the US (D8.5). The meeting will be attended by the APPLICATE Project Coordinator along with the leader of WP3.
- Invite WG co-chairs to participate in APPLICATE GA to report on the progress and challenges of their projects and to agree on coordinated activities.
- Participate in upcoming meetings of the US CLIVAR Working Group.

Establish regular exchanges in the context of teleconferences of the US CLIVAR Working Group.

Task 8.4 - Monitor collaboration activities with institutions from the USA and Canada (AWI) (M1-M48)

In order to assess the success of the collaboration between APPLICATE and its collaborators from the USA and Canada, the content and extent (in terms of resources) of the collaboration activities will be reported in accordance with the reporting periods (D8.8, D8.9, D8.10).

### Participation per Partner

<table>
<thead>
<tr>
<th>Partner number and short name</th>
<th>WP8 effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - AWI</td>
<td>4.00</td>
</tr>
<tr>
<td>3 - ECMWF</td>
<td>2.50</td>
</tr>
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</table>

**Total** 6.50

### List of deliverables

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<tr>
<th>Deliverable Number14</th>
<th>Deliverable Title</th>
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<th>Type15</th>
<th>Dissemination level16</th>
<th>Due Date (in months)17</th>
</tr>
</thead>
<tbody>
<tr>
<td>D8.1</td>
<td>Invite coordinators of relevant projects to the YOPP planning meetings</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Public</td>
<td>1</td>
</tr>
<tr>
<td>D8.2</td>
<td>Invite coordinators of BG-09 and other BG-10 projects to become members of external advisory board in APPLICATE</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Public</td>
<td>1</td>
</tr>
<tr>
<td>D8.3</td>
<td>Draft clustering plan</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Public</td>
<td>3</td>
</tr>
<tr>
<td>D8.4</td>
<td>Update the clustering plan to reflect specific clustering strategy with projects funded under H2020- BG09-2016 and BG10-2016</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Public</td>
<td>3</td>
</tr>
<tr>
<td>D8.5</td>
<td>Provide report from US CLIVAR Working Group meeting including recommendations for adjustments to the WP3 part of the</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Public</td>
<td>4</td>
</tr>
</tbody>
</table>
## List of deliverables

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>D8.6</td>
<td>Update the clustering plan to reflect specific joint clustering activities with projects funded under earlier H2020 and FP7 calls</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Public</td>
<td>5</td>
</tr>
<tr>
<td>D8.7</td>
<td>Provide draft concept for a joint YOPP-APPLICATE summer school including a list of possible co-sponsors</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Public</td>
<td>7</td>
</tr>
<tr>
<td>D8.8</td>
<td>First report on the content and extent of the joint activities with collaborators from the USA and Canada</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Public</td>
<td>18</td>
</tr>
<tr>
<td>D8.9</td>
<td>Second report on the content and extent of the joint activities with collaborators from the USA and Canada</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Public</td>
<td>36</td>
</tr>
<tr>
<td>D8.10</td>
<td>Third report on the content and extent of the joint activities with collaborators from the USA and Canada</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Public</td>
<td>48</td>
</tr>
</tbody>
</table>

## Description of deliverables

D8.1 : Invite coordinators of relevant projects to the YOPP planning meetings [1]
Invitation of all coordinators of existing activities and those known to have submitted related proposals to the International Coordination Office (ICO) for Polar Prediction.

D8.2 : Invite coordinators of BG-09 and other BG-10 projects to become members of external advisory board in APPLICATE [1]
Coordinators of BG-09 and other BG-10 projects will be invited to become members of the external advisory board in APPLICATE.

D8.3 : Draft clustering plan [3]
Plan that details the clustering strategy and will be developed at the beginning of the project.

D8.4 : Update the clustering plan to reflect specific clustering strategy with projects funded under H2020-BG09-2016 and BG10-2016 [3]
Development of a joint cooperation strategy and update of the clustering plan.

D8.5 : Provide report from US CLIVAR Working Group meeting including recommendations for adjustments to the WP3 part of the APPLICATE numerical experimentation plan [4]
Agree on a joint clustering concept, including an agreement on coordinated numerical experimentation, at the next meeting of the US CLIVAR Working Group that is tentatively scheduled for 1-3 February 2017 in the US

D8.6 : Update the clustering plan to reflect specific joint clustering activities with projects funded under earlier H2020 and FP7 calls [5]

Agreement on common clustering activities with other projects and update clustering plan accordingly

D8.7 : Provide draft concept for a joint YOPP-APPLICATE summer school including a list of possible co-sponsors [7]

Concept outlining the possibility for aligning the APPLICATE summer school with that planned for YOPP

D8.8 : First report on the content and extent of the joint activities with collaborators from the USA and Canada [18]

First report on the content and extent of the joint activities with collaborators from the USA and Canada.

D8.9 : Second report on the content and extent of the joint activities with collaborators from the USA and Canada [36]

Second report on the content and extent of the joint activities with collaborators from the USA and Canada

D8.10 : Third report on the content and extent of the joint activities with collaborators from the USA and Canada [48]

Third report on the content and extent of the joint activities with collaborators from the USA and Canada

### Schedule of relevant Milestones

<table>
<thead>
<tr>
<th>Milestone number</th>
<th>Milestone title</th>
<th>Lead beneficiary</th>
<th>Due Date (in months)</th>
<th>Means of verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS17</td>
<td>Network of coordinators</td>
<td>1 - AWI</td>
<td>6</td>
<td>Network of project coordinators has been established and regular teleconference have been set up</td>
</tr>
<tr>
<td>MS18</td>
<td>Consolidated clustering plan</td>
<td>1 - AWI</td>
<td>9</td>
<td>Revised version of clustering plan after consultation with all APPLICATE key partners</td>
</tr>
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</table>
**Work package number** 9  
**Lead beneficiary** 10  
1 - AWI

**Work package title**  
Project Coordination and Management

**Start month**  
1  
**End month** 48

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**Objectives**

- Setting up, negotiate and implement the APPLICATE Consortium Agreement (CA)
- Implement the project management structure as set out in Annex I (section 3.2) of the Grant Agreement and the CA  
- Management and coordination of the projects financial and administrative terms  
- Ensuring project progress according to the project plan, deliverables and milestones  
- Identification and mitigation of possible risks related to the project  
- Overseeing and manage gender issues and balance during the project and within the consortium

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**Description of work and role of partners**

**WP9 - Project Coordination and Management [Months: 1-48]**

**AWI**

WP9 will be led by AWI (Thomas Jung).

**Task 9.1 – Administrative project management (AWI) (M1-M48)**

The administrative management of APPLICATE will be conducted by the Project Coordinator together with his Management Support Team. Its main responsibility will be to set-up and implement an efficient project management and decision making structure according to Annex I (section 3.2) of the Grant Agreement and to draft and implement the Consortium Agreement of APPLICATE.

**Task 9.1.1 – Implementation of the management and decision making structure (AWI) (M1-M48)**

The Management and decision making structure is described in section 3.2 and will be defined in more detail regarding obligations, responsibilities and rights in the project Consortium Agreement. The Management structure involves the set-up of three different levels of decision making bodies, where the General Assembly will form the highest decision making unit, the Executive Board will be responsible for the coordination and implementation of the scientific project tasks and where the Coordinator together with his Management Support Team will take care of the overall project management. Those three units will be supported by the Advisory Board. The Advisory Board is set up by external and international experts and stakeholders, providing their expert opinion and advice to the APPLICATE consortium. All decision making bodies will be established at the Kick-Off meeting in Bremerhaven. Throughout the project duration they will meet regularly as set out in section 3.2 and the Consortium Agreement. The minutes of the annual project meetings, where all decision making bodies will convene, will be send to the EC (D9.2, D9.6, D9.8, D9.10).

**Task 9.2 – Financial management of APPLICATE (AWI) (M1-M48)**

The financial management of APPLICATE will be within the responsibility of the Management Support Team of the Project Coordinator. Its main tasks will be to provide financial guidance to all members of the Consortium, to conduct the financial reporting and to distribute the EC financial contribution according to the rules set out in the project Consortium Agreement.

**Task 9.2.1 – Provide financial guidance (AWI) (M1-M48)**

To guarantee a timely and smooth financial management of APPLICATE a guide will be developed at the beginning of the project. This guide will on the one hand give a concise overview on the rules and obligations concerning the Consortium budget according to the regulations of the EC Grant Agreement and on the other hand this guide will serve as a manual on how to conduct the financial reporting. The guide will be made available to the consortium via a password protected area of www.applicate.eu website and shall serve as basis for the periodic financial reporting (D9.3).

**Task 9.2.2 – Distribution of EC financial contribution (AWI) (M1-M48)**

In addition to providing financial guidance to all partners, the distribution of the EC financial contribution will also form an integral part of the financial management. The provisions regarding the distribution of the EC financial contribution will be detailed in the Consortium Agreement according to the Grant Agreement. The distribution itself will be carried out by the Coordinator.

**Task 9.3 – Scientific Management and the coordination of work package and task leaders (AWI) (M1-M48)**

The scientific management of APPLICATE and the coordination of the work package and task leaders will be one of the main responsibilities of the Project Coordinator.
ensure that the project is implemented according to the project plan, deliverables and milestones and identify possible risks and respective mitigation measures.

Task 9.3.1 – Monitor project progress and conduct scientific reporting (AWI) (M1-M48)
In order to observe the project progress the Coordinator will be in very close contact with all WP and task leaders to ensure that deadlines are kept, deliverables are fulfilled and milestones are reached. Part of this task will be to provide the WP and task leaders with templates and guidelines on how to write deliverables, to ensure a timely and coherent submission of the deliverables to the EC. All information on the project progress, challenges and results will be gathered by the Coordinator in collaboration with all members of the Consortium and transferred into a scientific report, which will be submitted during the periodic reporting (D9.7, D9.9, D9.11, D9.12).

Task 9.3.2 – Risk Management (AWI) (M1-M48)
The risk management will form a very important part of the scientific project management. The close contact to WP and task leaders ensures that the Coordinator is always informed on the latest developments and the overall progress. Consequently the Coordinator will be able to identify possible risks and delays in due time. This will enable the Coordinator to find very early mitigation measures and to consult the EC Project Officer in case of major difficulties to seek the advice of the EC. To fulfill this task the MST will develop, monitor and maintain a risk management plan as a list of potential risks and mitigation measures (D9.4). The plan will be presented to the Executive Board during their regular meetings every three months.

Task 9.4 – Internal Project Communication (AWI) (M1-M48)
Whereas the external project communication with stakeholders, interested public, etc. will be coordinated by WP7, the internal communication of APPLICATE will be managed by WP9. The internal project communication will focus on the communication between the consortium and the communication with the European Commission.

Task 9.4.1 – Coordinating the communication of the APPLICATE consortium (AWI) (M1-M48)
The internal communication of the project consortium will be coordinated via a password protected, interactive area of the www.applicate.eu webpage designed within WP7. This area will provide the consortium with the possibility to store and exchange documents and to discuss issues online. In addition the consortium will have access through this platform to all templates, manuals and guidelines needed to ensure a proper and efficient project reporting, as well as to an updated list of the contact details of all consortium members.

Task 9.4.2 – Communication with the European Commission (EC) (AWI) (M1-M48)
The communication with the European Commission will be the sole responsibility of the Project Coordinator together with his Management Support Team. The Coordinator will maintain regular contact with the Project Officer (PO) of the EC to inform the PO on the project progress. This will be done through the regular periodic scientific and financial reporting and through regular contact to keep the PO updated and informed about the progress, arising challenges or risks to seek advice and solutions if necessary, ensuring a timely and efficient project management according to EC rules. The PO of APPLICATE will be invited to all annual General Assemblies and other important project meetings.

Task 9.5 – Management of the APPLICATE gender dimension (AWI) (M1-M48)
The Project Coordinator together with the MST will be responsible to oversee and manage gender issues and balance during the project and within the consortium. APPLICATE will endorse the principle of the European Charter for Researchers and Code of Conduct for the Recruitment of Researchers and whenever possible implement actions (such as predictable working times and travel, stimulate use of electronic meetings, etc.) to support male and female researchers with children or other dependants. The MST will gather statistics on and monitor the role of women within APPLICATE and take action if needed. Attention will be paid to how meeting programs, high profile presentations (keynote talks at conferences) on project results and educational programs are planned from a gender perspective. To fulfill this task APPLICATE will develop a Gender Strategy to be adopted by the General Assembly (D9.5).

### Participation per Partner

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<th>Partner number and short name</th>
<th>WP9 effort</th>
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## List of deliverables

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<th>Deliverable Title</th>
<th>Lead beneficiary</th>
<th>Type</th>
<th>Dissemination level</th>
<th>Due Date (in months)</th>
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<tbody>
<tr>
<td>D9.1</td>
<td>Minutes of the annual General Assemblies 1</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Confidential, only for members of the consortium (including the Commission Services)</td>
<td>2</td>
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<tr>
<td>D9.2</td>
<td>Manual, guide &amp; templates for deliverables and reporting</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Confidential, only for members of the consortium (including the Commission Services)</td>
<td>3</td>
</tr>
<tr>
<td>D9.3</td>
<td>Risk Management Plan, including potential risks and mitigation measures</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Confidential, only for members of the consortium (including the Commission Services)</td>
<td>5</td>
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<tr>
<td>D9.4</td>
<td>Gender Strategy</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Confidential, only for members of the consortium (including the Commission Services)</td>
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<tr>
<td>D9.5</td>
<td>Minutes of the annual General Assemblies 2</td>
<td>1 - AWI</td>
<td>Report</td>
<td>Confidential, only for members of the consortium (including the Commission Services)</td>
<td>18</td>
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<tr>
<td>D9.6</td>
<td>Minutes of the annual General Assemblies 3</td>
<td>1 - AWI</td>
<td>Report</td>
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<td>32</td>
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<td>D9.7</td>
<td>Minutes of the annual General Assemblies 4</td>
<td>1 - AWI</td>
<td>Report</td>
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<td>48</td>
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## Description of deliverables

D9.1 : Minutes of the annual General Assemblies 1 [2]
Minutes

Templates and guidelines for project reporting

D9.3 : Risk Management Plan, including potential risks and mitigation measures [5]
Risk management plan including a list of potential risks and mitigation measures

D9.4 : Gender Strategy [6]
Gender Strategy to be adopted by the General Assembly
D9.5 : Minutes of the annual General Assemblies 2 [18]
Minutes
D9.6 : Minutes of the annual General Assemblies 3 [32]
Minutes GA
D9.7 : Minutes of the annual General Assemblies 4 [48]
Minutes GA

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<th>Milestone title</th>
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<th>Means of verification</th>
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### 1.3.4. WT4 List of milestones

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<th>WP number</th>
<th>Lead beneficiary</th>
<th>Due Date (in months)</th>
<th>Means of verification</th>
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<tbody>
<tr>
<td>MS1</td>
<td>Enhanced version of ESMValTool available</td>
<td>WP1, WP2, WP3, WP5</td>
<td>1 - AWI</td>
<td>12</td>
<td>Metrics in ESMValTool have been incorporated, tested and accepted.</td>
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<tr>
<td>MS2</td>
<td>Coupled ocean-sea ice-atmosphere SCM ready for parameter optimisation studies</td>
<td>WP2</td>
<td>10 - SU</td>
<td>18</td>
<td>The SCM is used in a case study with at least one observational data set</td>
</tr>
<tr>
<td>MS3</td>
<td>Final design of enhanced models to be assessed in climate and prediction mode</td>
<td>WP2, WP5</td>
<td>11 - CNRS-GAME</td>
<td>36</td>
<td>Enhanced models can be used to evaluate their predictive skill in WP5</td>
</tr>
<tr>
<td>MS4</td>
<td>Final design of coordinated multi-model numerical experiments in liaison with the international community</td>
<td>WP3</td>
<td>7 - MET OFFICE</td>
<td>2</td>
<td>The numerical experimentation plan has been updated</td>
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<tr>
<td>MS5</td>
<td>Initial assessment of the value of observations for producing reanalyses and initial conditions for forecasts</td>
<td>WP4</td>
<td>3 - ECMWF</td>
<td>24</td>
<td>Draft recommendations have been formulated</td>
</tr>
<tr>
<td>MS6</td>
<td>Synoptic analysis of observational data gaps and recommendations for future observing systems</td>
<td>WP4</td>
<td>3 - ECMWF</td>
<td>48</td>
<td>Draft recommendations have been formulated</td>
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<tr>
<td>MS7</td>
<td>Database downloaded</td>
<td>WP5</td>
<td>2 - BSC</td>
<td>3</td>
<td>Databases for the atlas of prediction scores downloaded by the partners</td>
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<tr>
<td>MS8</td>
<td>Sensitivity experiments</td>
<td>WP5</td>
<td>2 - BSC</td>
<td>30</td>
<td>Sensitivity experiments to improved process representation performed</td>
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<td>MS9</td>
<td>Setup YOPP Analysis and Forecast Dataset Infrastructure</td>
<td>WP6</td>
<td>6 - MET Norway</td>
<td>15</td>
<td>Data can be archived and external access has been setup and tested</td>
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<tr>
<td>MS10</td>
<td>Start of social media campaign on Facebook and Twitter</td>
<td>WP7</td>
<td>13 - AP</td>
<td>7</td>
<td>Active accounts, regular updates, online visibility statistics</td>
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<td>MS11</td>
<td>First meeting of User Group</td>
<td>WP7</td>
<td>13 - AP</td>
<td>10</td>
<td>List of participants. Meeting minutes and conclusions of the User Group</td>
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<tr>
<td>MS12</td>
<td>1st Strategic meeting of WP7 – revision of communication and dissemination, user engagement, and training plans</td>
<td>WP7</td>
<td>13 - AP</td>
<td>17</td>
<td>Minutes of the meeting, suggestions to Project Manager</td>
</tr>
<tr>
<td>MS13</td>
<td>Summer school</td>
<td>WP7</td>
<td>14 - UiT</td>
<td>19</td>
<td>List of attendance of Summer school</td>
</tr>
<tr>
<td>MS14</td>
<td>Start of website second phase</td>
<td>WP7</td>
<td>13 - AP</td>
<td>20</td>
<td>Changes in the contents and structure of the website</td>
</tr>
<tr>
<td>MS15</td>
<td>2nd Strategic meeting of WP7 – revision of communication and dissemination, user engagement, and training plans</td>
<td>WP7</td>
<td>13 - AP</td>
<td>35</td>
<td>Minutes of the meeting, suggestions to Project Manager</td>
</tr>
<tr>
<td>MS16</td>
<td>Share outcomes of user feedbacks with key players in the C3S User Interface Platform</td>
<td>WP7</td>
<td>2 - BSC</td>
<td>41</td>
<td>Information made available from APPLICATE website</td>
</tr>
<tr>
<td>MS17</td>
<td>Network of coordinators</td>
<td>WP8</td>
<td>1 - AWI</td>
<td>6</td>
<td>Network of project coordinators has been established and regular teleconference have been set up</td>
</tr>
<tr>
<td>MS18</td>
<td>Consolidated clustering plan</td>
<td>WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8</td>
<td>1 - AWI</td>
<td>9</td>
<td>Revised version of clustering plan after consultation with all APPLICATE key partners</td>
</tr>
</tbody>
</table>
### 1.3.5. WT5 Critical Implementation risks and mitigation actions

<table>
<thead>
<tr>
<th>Risk number</th>
<th>Description of risk</th>
<th>WP Number</th>
<th>Proposed risk-mitigation measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Availability of CMIP6 model output may be delayed: Medium</td>
<td>WP1, WP2, WP3, WP5</td>
<td>CMIP5 and a subset of CMIP6 data will already be available to APPLICATE to test and refine WP1 approach.</td>
</tr>
<tr>
<td>2</td>
<td>The development of metrics in Task 1.2 includes many partners. Delays from one partner (or a partner leaving the consortium) will delay Task 1.2: Low</td>
<td>WP1, WP2, WP3, WP5</td>
<td>APPLICATE partners have broad expertise in other areas. This expertise can be made available in case of delays or a partner leaving the consortium.</td>
</tr>
<tr>
<td>3</td>
<td>Delay in provision of model enhancements from WP2: Medium</td>
<td>WP2, WP5</td>
<td>Use of a subset only of WP2 model improvements in WP5 Stream 2 experiments</td>
</tr>
<tr>
<td>4</td>
<td>Delay in guidance on optimal initialisation strategy from WP4: Medium</td>
<td>WP4, WP5</td>
<td>Selection of an initialisation strategy tested in WP4 and showing improvements in prediction performance for WP5 Stream 2 experiments</td>
</tr>
<tr>
<td>5</td>
<td>Delay in achieving deliverables or milestones / need for assignment of unanticipated tasks: Low</td>
<td>WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9</td>
<td>The Coordinator will stay in close contact to WP and task leaders. Thus he will always be informed on the latest developments and the overall progress and be able to identify possible risks and delays in due time. This will enable him to find very early mitigation measures and to consult the EC Project Officer in case of major difficulties. Mitigation measures will be discussed during the quarterly meetings of the Executive Board</td>
</tr>
<tr>
<td>6</td>
<td>Communication problems among partners. Disagreement among consortium partners: Low</td>
<td>WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9</td>
<td>Regular meetings (face to face, video- and teleconferences) among partners. The management structure provides rules for decision making and conflict resolution. This risk is also mitigated by the history of collaboration between several project partners and by the coordinator’s experience in EU project management.</td>
</tr>
<tr>
<td>7</td>
<td>Related European and international projects/ activities are reluctant to engage in the clustering process: Low</td>
<td>WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9</td>
<td>APPLICATE will take a pro-active approach offering to organize, co-lead and synthesize clustering activities. Make use of existing links with any APPLICATE partner.</td>
</tr>
<tr>
<td>8</td>
<td>Severe damage to the central data repository: Low</td>
<td>WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9</td>
<td>The data repository will be maintained to the highest level of rigour as it is a crucial infrastructure. Copies of model output will be kept at partner institutes, and backups of web pages and code repositories maintained.</td>
</tr>
<tr>
<td>9</td>
<td>Model integrations encounter fundamental technical problems such as HPC availability, stability, spin-up: Medium</td>
<td>WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9</td>
<td>Seek and share experience between groups and from external sources (ENES, ESIWACE, the centre of excellence for weather and climate); if necessary shorten integration period; look for PRACE resources whenever necessary.</td>
</tr>
<tr>
<td>Risk number</td>
<td>Description of risk</td>
<td>WP Number</td>
<td>Proposed risk-mitigation measures</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>-----------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>10</td>
<td>Key staff assigned to project become unavailable for any reason: Medium</td>
<td>WP1, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9</td>
<td>All consortium members to have appropriate succession planning, with deputies for all key roles appointed. Coordination between partners to ensure expertise is available</td>
</tr>
</tbody>
</table>
| 11         | Russian partner(s) do(es) not get funding from the Russian side: Medium              | WP1, WP2, WP3, WP6, WP7, WP8 | The Russian contribution has been developed such that it won’t jeopardize APPLICATE’s objectives, should funding for the Russian partners not materialize. More specifically the following actions would be necessary:  
• Adjust the model assessment plan in WP1 to account for the fact that some metrics/diagnostics won’t be produced.  
• Adjust the plan for numerical experimentation carried out in WP3 by removing the experiments with the Russian atmospheric model. This would reduce the number of models used but would not critically affect the multi-model approach.  
• Planning in WPs 6-8 would to be adjusted to account for the lack of Russian contributions. This would not critically affect that overall objectives of these WPs. |
### 1.3.6. WT6 Summary of project effort in person-months

<table>
<thead>
<tr>
<th>WP</th>
<th>WP1</th>
<th>WP2</th>
<th>WP3</th>
<th>WP4</th>
<th>WP5</th>
<th>WP6</th>
<th>WP7</th>
<th>WP8</th>
<th>WP9</th>
<th>Total Person/Months per Participant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - AWI</td>
<td>24</td>
<td>20</td>
<td>24</td>
<td>2</td>
<td>12</td>
<td>11</td>
<td>0</td>
<td>4</td>
<td>24</td>
<td>121</td>
</tr>
<tr>
<td>2 - BSC</td>
<td>5</td>
<td>0</td>
<td>27</td>
<td>6</td>
<td>48</td>
<td>0</td>
<td>44</td>
<td>0</td>
<td>0</td>
<td>130</td>
</tr>
<tr>
<td>3 - ECMWF</td>
<td>12</td>
<td>15</td>
<td>0</td>
<td>12</td>
<td>12</td>
<td>3</td>
<td>0</td>
<td>2.50</td>
<td>0</td>
<td>56.50</td>
</tr>
<tr>
<td>4 - UiB</td>
<td>1</td>
<td>0</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>5 - UNI RESEARCH</td>
<td>2</td>
<td>19</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>6 - MET Norway</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>0</td>
<td>25</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>59</td>
</tr>
<tr>
<td>7 - MET OFFICE</td>
<td>10</td>
<td>11</td>
<td>27</td>
<td>6</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>63</td>
</tr>
<tr>
<td>8 - UCL</td>
<td>19</td>
<td>44</td>
<td>0</td>
<td>26</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>104</td>
</tr>
<tr>
<td>9 - UREAD</td>
<td>23</td>
<td>0</td>
<td>12</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>10 - SU</td>
<td>2</td>
<td>58</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>11 - CNRS-GAME</td>
<td>18</td>
<td>34</td>
<td>4</td>
<td>0</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>74</td>
</tr>
<tr>
<td>- METEO-FRANCE</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>12 - CERFACS</td>
<td>18</td>
<td>12</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>54</td>
</tr>
<tr>
<td>13 - AP</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>52</td>
<td>0</td>
<td>0</td>
<td>52</td>
</tr>
<tr>
<td>14 - UiT</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>15 - IORAS</td>
<td>33</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>58</td>
</tr>
<tr>
<td>16 - MGO</td>
<td>25</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>58</td>
</tr>
<tr>
<td><strong>Total Person/Months</strong></td>
<td><strong>192</strong></td>
<td><strong>221</strong></td>
<td><strong>228</strong></td>
<td><strong>68</strong></td>
<td><strong>142</strong></td>
<td><strong>25</strong></td>
<td><strong>107</strong></td>
<td><strong>6.50</strong></td>
<td><strong>24</strong></td>
<td><strong>1013.50</strong></td>
</tr>
</tbody>
</table>
1.3.7. **WT7 Tentative schedule of project reviews**

<table>
<thead>
<tr>
<th>Review number</th>
<th>Tentative timing</th>
<th>Planned venue of review</th>
<th>Comments, if any</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV1</td>
<td>21</td>
<td>TBD - tentative preference for Brussels</td>
<td></td>
</tr>
<tr>
<td>RV2</td>
<td>39</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>RV3</td>
<td>48</td>
<td>TBD</td>
<td>if necessary</td>
</tr>
</tbody>
</table>
1. Project number
The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number should appear on each page of the grant agreement preparation documents (part A and part B) to prevent errors during its handling.

2. Project acronym
Use the project acronym as given in the submitted proposal. It can generally not be changed. The same acronym should appear on each page of the grant agreement preparation documents (part A and part B) to prevent errors during its handling.

3. Project title
Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date
Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry into force of the Grant Agreement (NB : entry into force = signature by the Commission). Please note that if a fixed starting date is used, you will be required to provide a written justification.

5. Duration
Insert the duration of the project in full months.

6. Call (part) identifier
The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Abstract

8. Project Entry Month
The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

9. Work Package number
Work package number: WP1, WP2, WP3, ..., WPn

10. Lead beneficiary
This must be one of the beneficiaries in the grant (not a third party) - Number of the beneficiary leading the work in this work package

11. Person-months per work package
The total number of person-months allocated to each work package.

12. Start month
Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

13. End month
Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

14. Deliverable number
Deliverable numbers: D1 - Dn

15. Type
Please indicate the type of the deliverable using one of the following codes:
- **R** Document, report
- **DEM** Demonstrator, pilot, prototype
- **DEC** Websites, patent filings, videos, etc.
- **OTHER**
- **ETHICS** Ethics requirement

16. Dissemination level
Please indicate the dissemination level using one of the following codes:
17. Delivery date for Deliverable
Month in which the deliverables will be available, month 1 marking the start date of the project, and all delivery dates being relative to this start date.

18. Milestone number
Milestone number: MS1, MS2, ..., MSn

19. Review number
Review number: RV1, RV2, ..., RVn

20. Installation Number
Number progressively the installations of a same infrastructure. An installation is a part of an infrastructure that could be used independently from the rest.

21. Installation country
Code of the country where the installation is located or IO if the access provider (the beneficiary or linked third party) is an international organization, an ERIC or a similar legal entity.

22. Type of access
- VA if virtual access,
- TA-uc if trans-national access with access costs declared on the basis of unit cost,
- TA-ac if trans-national access with access costs declared as actual costs, and
- TA-cb if trans-national access with access costs declared as a combination of actual costs and costs on the basis of unit cost.

23. Access costs
Cost of the access provided under the project. For virtual access fill only the second column. For trans-national access fill one of the two columns or both according to the way access costs are declared. Trans-national access costs on the basis of unit cost will result from the unit cost by the quantity of access to be provided.
## History of Changes

<table>
<thead>
<tr>
<th>Page</th>
<th>Concise description of changes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revision 1 – 09.08.2016</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Part A Deliverables | Change of title of D8.4 as it refers to D8.3 (Draft clustering plan)  
Formerly: Update the dissemination plan…  
Now: Update the clustering plan…                                                                                     |
| Part A Deliverables | Change of title of D8.6 as it refers to D8.3 (Draft clustering plan)  
Formerly: Update the dissemination plan…  
Now: Update the clustering plan…                                                                                     |
| Part A Deliverables | D9.1, 9.7, 9.9, 9.11, and 9.12 deleted as they are already foreseen by the Grant Agreement.  
Numbering of following Deliverables changed accordingly.                                                              |
| Part A WP9   | Subtask 9.1.1 deleted as all the work will be performed before the start of the project.  
Numbering of following subtasks changed accordingly.                                                                    |
| Part A Partner CNRS-GAME | Third Party METEO-FRANCE added  
Budget split between CNRS-GAME and METEO-FRANCE  
Person Month devided. Less Person Month, because of re-assignment of tasks from WP2, 3 and 4 to permanent staff (initially planned for post-docs). |
| Part B, Page 89, CNRS | Added sentence “Working for Third Party METEO-FRANCE” to the description of Matthieu Chevallier |
| Part B, Pages 9, 24, 26, 28 | Changed ‘ECOMS2” into ‘ClimatEurope’ |
| Part B Page 26 | Added sentence ‘The communication departments of the APPLICATE partners will support dissemination materials with national languages versions where appropriate.’ |
| Part B Page 31 | Added ‘EU and national policy makers’ to the table under the first column at ‘Public sector stakeholders’ |
| Part B Page 42 | “Other goods and services” of beneficiary 2 BSC:  
29.5000 € changed to 29.500 € |
| Part A WP1   | **Description Task 1.1:**  
Added sentence ‘Furthermore, the plan will outline how collaboration with the H2020 project CRESCENDO will be envisaged with respect to developing ESMValTool.’ |
| Part A WP1   | **Description Task 1.2.2:**  
Added ‘, benefitting from coordination with activities in WP7 Task 7.2’ |
| Part A WP1   | **Description Task 1.3.2:**  
Changed ‘M12’ into ‘M6’  
Added ‘An interim report on the assessment will be written and made available to WP2 and WP4 (D1.7).’  
**Description Task 1.3.3:**  
Added ‘(D1.8)’ |
| Part A WP2   | **Description Task 2.1.1:**  
Added ‘Recommendations on the inclusion of improved description of atmospheric processes in NWP models (D2.3) as well as an Assessment od their impact in coupled mode (D2.5) will be made.’  
**Description Task 2.1.2:**  
Deleted ‘The initialisation of snow will be performed based on the developments in WP4, Task 4.3.’  
Added ‘Recommendations on the inclusion of improved description of snow on land and sea ice in NWP models (D2.3) as well as an assessment of their impact in coupled mode (D2.5) will be made.’  
**Description of Task 2.1.3:**  
Added ‘Recommendations on the inclusion of improved sea ice properties in NWP models (D2.3) as well as an assessment of their impact in coupled mode (D2.5) will be made.’  
**Description of Task 2.1.4:**  
Added ‘Regarding the impact of resolution, APPLICATE will also build on the results from the EMBRACE project.’ |
<table>
<thead>
<tr>
<th>Part A</th>
<th>Description Task 4.3.3:</th>
<th>Changed ‘M24’ into ‘M12’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A</td>
<td>Description Task 5.2.3:</td>
<td>Typo ‘Furthermore’</td>
</tr>
<tr>
<td>WP5</td>
<td>Description Task 5.2.5:</td>
<td>Added ‘This Task will benefit from Tasks 1.2.2 and 1.2.3 (which will deliver D1.2).’</td>
</tr>
<tr>
<td>Part A</td>
<td>Description Task 6.3.3:</td>
<td>Added ‘(D6.5)’</td>
</tr>
<tr>
<td>WP6</td>
<td>Description Task 6.3.4:</td>
<td>Changed ‘D6.5’ into ‘D6.6’</td>
</tr>
<tr>
<td>Part A</td>
<td>Description Task 7.1.5:</td>
<td>Changed ‘ECOMS2’ into ‘ClimatEurope’</td>
</tr>
<tr>
<td>WP7</td>
<td>Description Task 7.2.3 and 7.2.4:</td>
<td>Added ‘D7.11, D7.12’</td>
</tr>
<tr>
<td></td>
<td>Description Task 7.3.4:</td>
<td>Added ‘. Each of the the participants’</td>
</tr>
<tr>
<td></td>
<td>Added ‘D7.13,’</td>
<td></td>
</tr>
<tr>
<td>Part A</td>
<td>Description of work:</td>
<td>Added ‘This WP will benefit significantly from in kind contributions of various APPLICATE PIs, especially from the coordinator Thomas Jung, through their roles in various international committees (see Part B, Table 4 for examples).’</td>
</tr>
<tr>
<td>WP8</td>
<td>Description Task 8.3.3:</td>
<td>Deleted ‘(D8.5)’</td>
</tr>
<tr>
<td></td>
<td>Description Task 8.3.4:</td>
<td>Deleted ‘Invite Belmont GA to be member of external advisory board.’</td>
</tr>
<tr>
<td></td>
<td>Description Task 8.4:</td>
<td>Added ‘Task 8.4 - Monitor collaboration activities with institutions from the USA and Canada (AWI) (M1-M48) In order to assess the success of the collaboration between APPLICATE and its collaborators from the USA and Canada, the content and extend (in terms of resources) of the collaboration activities will be reported in accordance with the reporting periods (D8.8, D8.9, D8.10).’</td>
</tr>
<tr>
<td>Part A</td>
<td>Description Critical Risk 11 (Russian contribution not secured):</td>
<td>Changed WP from ‘all’ to ‘1-3, 6-8’, because not all WPs are affected in case Russian Contribution is not secured. Added ‘The Russian contribution has been developed such that it won’t jeopardize APPLICATE’s objectives, should funding for the Russian partners not materialize. More specifically the following actions would be necessary:’</td>
</tr>
<tr>
<td></td>
<td>- Adjust the model assessment plan in WP1 to account for the fact that some metrics/diagnostics won’t be produced.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Adjust the plan for numerical experimentation carried out in WP3 by removing the experiments with the Russian atmospheric model. This would reduce the number of models used but would not critically affect the multi-model approach.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Planning in WPs 6-8 would to be adjusted to account for the lack of Russian contributions. This would not critically affect that overall objectives of these WPs.’</td>
<td></td>
</tr>
<tr>
<td>Part A</td>
<td>Deliverables</td>
<td>D1.7: Added Deliverable ‘Interim report from the analysis of the NWP system in support of WP2 and WP4.’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D1.8: Added Deliverable ‘Synthesis report on the growth of systematic model error across time scales.’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D5.1: Changed into ‘Simulation carried out with the models available at the beginning of APPLICATE (Task 5.2.2) and following the protocol described in Task 5.1, completed and made available within the consortium’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D5.2: Added ‘Report on the strengths’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D5.3: Added ‘Report on individual … treatment of snow, …’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D5.4: Changed into ‘Simulation carried out with the models available at the end of APPLICATE (Task 5.4) and following the protocol described in Task 5.1, completed and made available within the consortium’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D5.5: Changed into ‘Contributions to the SIPN activities through sea ice predictions produced with the forecast systems available at the end of APPLICATE’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D5.6: Added ‘Report on integrated’</td>
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<td>D6.5: Added Deliverable ‘Launch of a web portal providing an overview of the project data catalogoue’</td>
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<td>D6.6: Changed former Deliverable 6.5 into 6.6</td>
</tr>
</tbody>
</table>
|        |             | D7.11: Added Deliverable ‘First summary report of the stakeholder interaction activities including the list stakeholders reached, what feedback was received and for the benefit of which
<table>
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<tr>
<th>Part A Deliverables</th>
<th>Additional Deliverable D4.5: Interim evaluation of initialization experiments investigating the impact of novel observations in the coupled atmosphere–land–ocean–sea ice system (M24)</th>
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<tr>
<td>Part A Task 4.3</td>
<td>Deleted: Task 4.3 will produce a report recommending the initialization strategy to use in WP5. (D4.3, UCL; MS4.2). Replaced by: Task 4.3 (Subtask 4.3.1, 4.3.2 and 4.3.3) will <em>collectively</em> produce an <em>interim</em> report (D4.5, M24) and a <em>final</em> report (D4.3, M48) recommending the initialization strategy to use in WP5.</td>
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<tr>
<td>Part A Sutask 2.2.1</td>
<td>Deleted: New diagnostics for coupled processes developed in WP1, Task 1.4 will be employed. Replaced by: New diagnostics for coupled processes developed in WP1, Task 1.2 (D1.2 and D1.3) will be employed.</td>
</tr>
<tr>
<td>Part B Page 34</td>
<td>Gantt chart replaced by new version</td>
</tr>
<tr>
<td>Part B Page 114</td>
<td>Partner BSC (No. 2) In-kind contribution of Third Parties changed from NO to YES. Description of Third Party (ICREA) added.</td>
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1. Excellence

1.1 Objectives

The weather and climate of the Arctic have been changing rapidly in recent years and these profound transformations are projected to continue in the decades to come. These changes provide opportunities, such as the emergence of new, shorter shipping lanes between Europe and parts of East Asia; at the same time they expose society to major risks, such as environmental hazards associated with increased human activities in the Arctic. Climate change also poses major challenges for local communities: indigenous communities, for example, have reported a loss of weather predictive power since the 1990s (Krupnik and Jolly, 2002). This is likely associated with the fact that traditional knowledge is no longer sufficient for weather forecasting in a non-stationary climate. Furthermore, the realization that anthropogenic climate change is amplified in the Arctic has sparked concerns about a possible impact on the weather and climate in mid-latitudes, including extreme events.

Rapid Arctic changes have taken many by surprise, including the scientific and operational forecasting communities. It is therefore no coincidence that our predictive capacity in the Arctic across time scales is still limited; hampering effective decision-making processes (Jung et al. 2016). The fast pace of Arctic change may also explain why our understanding of the impact of Arctic climate change on mid-latitude weather and climate, including high-impact events, is still at a pre-consensus stage (Jung et al. 2015, Overland et al. 2015). Therefore, the overarching mission of APPLICATE is

To develop enhanced predictive capacity for weather and climate in the Arctic and beyond, and to determine the influence of Arctic climate change on Northern Hemisphere mid-latitudes, for the benefit of policy makers, businesses and society.

To achieve its mission, APPLICATE will address the following 7 top-level objectives (related work packages are given in parentheses):

**O1: Observationally constrain models using advanced metrics and diagnostics**

Achieved by: Developing a set of metrics and diagnostics that target key processes in the Arctic atmosphere, sea ice and ocean as well as user-relevant information; Applying these tools to assess, across time scales, the realism of existing models (baseline) as well as improved models developed during the project; Making advanced metrics and diagnostics available in the Earth System Model eValuation Tool (ESMValTool, Eyring et al. 2015); Exploring the concept of emergent constraints in the Arctic for narrowing the uncertainty of regional climate change projections. (WP1, WP2, WP5)

**O2: Develop enhanced weather and climate models**

Achieved by: Enhancing formulations of the atmospheric boundary layer, clouds, sea ice (rheology and thermodynamics), snow (multi-layer schemes) and Arctic Ocean (meso-scale features); Improving the representation of fluxes (mass, energy, momentum) at the atmosphere-ocean-sea ice interfaces; Exploring the benefit of horizontal resolution; Making extensive use of a hierarchy of models in conjunction with observational data. (WP2, WP1)

**O3: Determine the impact of Arctic climate change on mid latitudes through atmospheric and oceanic linkages**

Achieved by: Carrying out a set of coordinated multi-model experiments with coupled and atmospheric models in which Arctic sea ice decline is imposed; Exploring the sensitivity of the response to the background flow and the regional distribution of ice anomalies; Identifying atmospheric and oceanic pathways for polar-mid latitude linkages; Studying linkages from a prediction perspective. (WP3, WP4, WP5)

**O4: Contribute to the design of the future Arctic observing system**

Achieved by: Analysing the impact of existing data from operational model output and reanalyses; Carrying out and analysing atmospheric and coupled observing system (‘data denial’) experiments; Proposing strategies for enhanced observational capabilities; Providing a tight link to H2020 BG-9-2016 *An integrated Arctic observation system* and the Year of Polar Prediction (YOPP). (WP4, WP5)

**O5: Enhance the capacity to predict Northern Hemisphere weather and climate**

Achieved by: Analysing the skill of existing prediction systems; Assessing the impact of enhanced models and initialization strategies developed in APPLICATE in a pre-operational prediction framework; Providing recommendations for the advancements of forecasting systems from an Arctic perspective. (WP5)

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For simplicity, throughout this proposal we will use the term *prediction* to represent both predictions (daily to seasonal and decadal) and projections (decades and longer).
O6: Develop and implement APPLICATE’s research programme in coordination with external scientific partners to exploit synergies

Achieved by: Establishing close collaboration with other relevant national, European and international projects (e.g. Research and Innovation Actions under H2020, Belmont); Engaging with relevant external partners institutions (e.g. Environment and Climate Change Canada); Ensuring alignment with and contribution to relevant international activities such as YOPP and the US CLIVAR Working Group on Arctic Change and Possible Influence on Mid-latitude Climate and Weather. (WP8, WP1-7, WP9)

O7: Transfer the knowledge generated through APPLICATE to stakeholders including training of early career scientists

Achieved by: Establishing an effective dialogue with a network of key stakeholders; Disseminating APPLICATE results widely, exploiting means such as project and data portals through international (WMO, ICSU, SAON etc.) data management frameworks; Implementing enhancements in operational prediction systems and transition into Copernicus services (C3S); Involving partners from both weather and climate communities; Developing a training programme in collaboration with the Association of Early Polar Career Scientists (APECS). (WP7, WP1-6)

With APPLICATE, the Alfred Wegener Institute (AWI) is leading an experienced consortium that brings together leading European scientists from universities, research institutes and operational prediction centres. This composition ensures an effective transfer of scientific knowledge into operations, thereby reaching a plethora of different stakeholders. Moreover, APPLICATE unites experts from the weather and climate prediction communities to tackle challenges faced across time scales and considering climate as a coupled, complex system. Finally, the need for effective knowledge transfer is finally addressed by bringing together pioneers in the emerging field of climate services, a small and medium-sized enterprise (SME) with strong expertise in knowledge transfer and a network of stakeholders.

1.2 Relation to the work programme

APPLICATE responds to the call BG-10-2016: “Impact of Arctic changes on the weather and climate of the Northern Hemisphere”. The main goal of APPLICATE is well aligned with the overarching challenge of this call: “...to improve the predictability of weather and climate in the Northern Hemisphere, and of related risks”. Furthermore, all underpinning objectives outlined in the specific scope and challenge of the call will be addressed by APPLICATE (relevant APPLICATE objectives (O), as provided under section 1.1, are indicated in parentheses):

- APPLICATE will “develop innovative approaches to improving the descriptions and modelling of the mechanisms, processes and feedbacks affecting Arctic climate change” (O2). This will be achieved by targeting key processes that are important for the Arctic atmosphere, sea ice and ocean, and that are known to play a pivotal role for atmosphere-sea ice-ocean interactions. Methodologically, APPLICATE will exploit a variety of model configurations – from coupled single column models to state-of-the-art weather and climate prediction models – alongside observational data, including those taken during dedicated intensive observing periods (e.g. YOPP).
- APPLICATE will consider Arctic climate change, with a special focus on “its impacts on the weather and climate of the Northern Hemisphere” (O2, O3). More specifically, “coordinated model experiments” (coupled and atmosphere-only) will be carried out that target the impact of Arctic sea ice decline on the weather and climate of the Northern Hemisphere, including the North Atlantic Ocean. These activities will be augmented by relaxation experiments that allow Arctic-mid-latitude linkages to be evaluated in models and determine their relevance from a prediction perspective. Through the experimental setup and analysis approach employed, APPLICATE will provide new insight into models’ “ability to represent the links between polar and lower latitudes.”
- APPLICATE will “assess the performance of models” (O1, O2). More specifically, APPLICATE will develop a framework for observationally constraining weather and climate models (WP1). This framework will be used to (i) assess the performance of existing models (e.g. CMIP6), especially in the Arctic, (ii) identify

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2 In terms of knowledge transfer, operational prediction centres can be considered as ‘multipliers’. ECMWF, for example, has 20 member states and 10 cooperating states from Europe, and it operates the Copernicus Climate Change Services (C3S) and Atmospheric Monitoring (CAMS) Services on behalf of the European Commission. Any forecasting system improvements therefore, have thus potential to reach multiple ends and enhance decision making capacity across large parts of Europe.
shortcomings in existing systems, and (iii) measure the progress resulting from model development efforts made in APPLICATE.

- **APPLICATE** will “explore the potential that an improved Arctic observation system would have on the accuracy of weather, and climate forecasts in the Northern Hemisphere, including Europe and North America” (O4, O3) and “identify gaps in data and observations” through observing system experiments (O4). The design of the future Arctic observing system will be carried out in close collaboration with modellers (O2) and the project that will be funded under the topic H2020-BG-09-2016: “Integrated Arctic Observation System” (O6).

- **APPLICATE** will “further develop state-of-the-art climate models and predictions” through the above-mentioned research activities together with a strong synthesis component, resulting in a set of high-level recommendations. These recommendations will not only be beneficial for APPLICATE partners, but also the international scientific community in general.

- **APPLICATE** activities will “contribute to the Year of Polar Prediction (YOPP)” in numerous ways, including substantial contributions to the YOPP Modelling Component (O1-5). This includes the provision of the publicly available YOPP Analysis and Forecast Dataset through ECMWF, which has been proposed as a key element of YOPP in the YOPP Implementation Plan (Jung et al. 2014b). APPLICATE will also contribute to the YOPP Observing Component (O4), the YOPP Outreach and Education Component (O7), as well as the YOPP Data Component (O7). Many of the PIs engaged in APPLICATE play critical roles in the planning and implementation of YOPP, including the coordinator of APPLICATE, Thomas Jung, who leads YOPP in his role as chairman of the steering group of the Polar Prediction Project (PPP) of WMO’s World Weather Research Programme (WWRP).

- **APPLICATE** will “provide input to the improvement of short- to medium-term predictions of the Copernicus Climate Change Services (C3S)” (O4, O5). This will be achieved through the improvement of operational seasonal predictions, climate change projections, and future reanalysis efforts, which will all feed into C3S. Moreover, APPLICATE is destined to improve the quality of initial conditions and hence future reanalysis efforts. It is worth mentioning in this context that ECMWF – one of the APPLICATE partners – has the mandate from the EU to run and implement C3S.

- **APPLICATE** will implement a dedicated work package (WP8) with the goal to ”cluster with other projects financed under this topic“ and ”also under other parts of Horizon 2020“, including ”projects funded under earlier calls“ (O6, O7). Furthermore, this work package will establish ”links with projects resulting from the Belmont Forum call on climate predictability and inter-regional linkages“ to ensure synergies will be exploited (O6, O7). The key to success will lie in APPLICATE taking a pro-active approach to collaboration and in exploiting high-level activities such as YOPP that provide an international framework for collaboration.

- **APPLICATE** will ”develop relevant forms of communication with the EU (and possibly national) services to adequately disseminate results that could be used for policy action“ (O6, O7). Actions include providing input to EU-PolarNet, a coordination and support action that will develop a European polar research agenda, contributions to briefing events for policy makers (e.g. parliamentarian events in Brussels and nationally), and providing input to IPCC assessments reports.

- **APPLICATE** will ”contribute to implementing the Transatlantic Ocean Research Alliance“ through strong collaboration with coordinating bodies and numerous individual collaborators from the US (e.g. Sea Ice Prediction Network, NCAR, US CLIVAR Working Group on Arctic-Mid-latitude Linkages) and Canada (e.g. Environment and Climate Change Canada) as well as intensive research in an area outlined in the Galway scientific report: “... our common objectives are to have by 2020: ... An enhanced predictive capacity ... for interactions between the Atlantic and Arctic as well as ocean-atmosphere connections. “ APPLICATE is therefore ”in line with the strategy for EU international cooperation in research and innovation“ (O6, O7).

- **APPLICATE** will ”benefit from the inclusion of partners from the USA and from Canada“ through strong collaboration with Environment and Climate Change Canada, the US Sea Ice Prediction Network (SIPN) and the US CLIVAR Working Group on Arctic Change and Possible Influence on Mid-latitude Climate and Weather. Furthermore, APPLICATE will establish ”international cooperation with partners from other Arctic and non-Arctic third countries“ through the direct involvement of Russian partners, through its alignments with other ongoing international activities, mainly in the framework of YOPP, and through cooperation with “projects resulting from the Belmont Forum call.“ (O6)

- **APPLICATE** will ”participate in the Pilot of Open Research Data“. The Data Management is based on a metadata-driven approach where datasets are documented in a standardised manner for data discovery and this information is exposed using machine-to-machine interfaces. APPLICATE data management is linked to WMO data management through the WMO Information System (WIS) Data Collection and Production Centre (DCPC) Arctic Data Centre (ADC) hosted by the Norwegian Meteorological Institute. Through ADC and WIS,
APPLICATE data is exposed to the GEOSS Common Infrastructure. ADC is also an active participant in Arctic metadata and data interoperability efforts through the SAON/IASC Arctic Data Committee.

1.3 Concept and methodology

(a) Concept

1.3.1 Overall concept underpinning APPLICATE

APPLICATE responds to the challenges outlined in the call by moving the prediction problem into the focus. In doing so, scientific excellence and innovation can be effectively transferred into socio-economic benefit. To provide the right framework for enhancing predictive capacity in the Arctic region and beyond, APPLICATE brings together experts from academia, research institutions and operational forecasting centres.

![Image]( Attached Image on page 3 of document Ref. Ares(2016)5484127 - 21/09/2016 )

Figure 1: Survey of 22 marine stakeholders, regarding the importance of weather information in the Arctic for different prediction horizons. Data have been kindly provided by the Services Task Team of the WMO Executive Council Panel of Experts on Polar and High Mountain Observations, Research and Services (EC-PHORS).

APPLICATE aims at enhancing predictive capacity from daily to multi-decadal time scales. In doing so, APPLICATE responds to the needs of the majority of stakeholders for enhanced predictions from weather to climate time scales (Fig. 1). APPLICATE addresses this challenge by:

- Focussing research activities on daily to seasonal prediction and on tackling anthropogenic Arctic climate change including its impact on lower latitudes. Significant indirect benefits can be expected for interannual and decadal predictions due to the similarity of the systems used for seasonal and decadal prediction;
- Focussing development efforts limited to a number of key-aspects that are known to be of critical importance, across time scales, for the Arctic. More specifically, APPLICATE will address the Arctic atmospheric boundary layer physics and clouds, snow on land and sea ice, sea ice dynamics and thermodynamics, atmosphere-sea ice-ocean coupling as well as oceanic phenomena that benefit from enhanced horizontal resolution such as exchange processes at the Arctic-Atlantic gateways.

A central aspect of APPLICATE’s concept is to bring together leading experts from the weather and climate prediction communities. It is based on the premise that the same processes matter across different time scales in the Arctic. In fact, bringing the two communities together will ensure the transfer of relevant expertise for mutual benefit. For example, strong expertise in observing systems design resides within the numerical weather prediction (NWP) community; at the same time, sea ice model development is traditionally being carried out within the climate research community; while limited-area models have been used in both communities for high-resolution predictions. Therefore, bringing the weather and climate prediction communities closer together is very important to ensure progress across time scales and prediction systems.

To achieve its objectives of advancing predictive capacity in the Arctic and mid-latitudes, APPLICATE will follow a well-defined strategy (Fig. 2): It will start by developing a model assessment framework that includes existing and novel metrics and diagnostics. These tools will then be provided to all partners and used to establish the status quo (baseline), both in terms of model fidelity and prediction skill. Research efforts in APPLICATE will then lead to proposals for forecasting system enhancements, including improvements to models, initial conditions and the Arctic observing system. The proposed enhancements will be thoroughly tested across time scales, and
recommendations will be formulated and disseminated, following careful evaluation and synthesis of the results. At the end of this “value chain”, APPLICATE will deliver not only enhanced predictions, but also enhanced knowledge to design more accurate prediction systems.

![Figure 2: Schematic of APPLICATE’s strategy for the enhancement of predictive capacity across time scales.](image)

APPLICATE aims to **narrow the uncertainty of projections that are associated with Arctic climate change**. To this end, two different approaches will be followed. Firstly, the concept of emergent constraints (e.g. Klein and Hall 2015) – find physical relationships between (observable) present-day and projected future climate – will be explored by analysing statistical relationships between future and historical model runs in multi-model ensembles. Secondly, APPLICATE will carry out substantial model development efforts (see O2 above). Given that model error accounts for a substantial share of total uncertainty at multi-decadal time scales (Hawkins and Sutton, 2009), model development can potentially reduce greatly the uncertainty of regional climate change projections in the Northern Hemisphere.

APPLICATE will study the **impact of the Arctic on the weather and climate of the Northern Hemisphere** taking atmospheric and oceanic linkages into account. As pointed out by Barnes and Screen (2015), it is convenient to tackle the issue of an Arctic influence on the mid-latitude circulation by considering three central, but different questions: **Can it? Has it? Will it?** Given the short observational record along with large internal variability of the mid-latitude atmosphere, APPLICATE will **not** address the question whether recent Arctic amplification or internal variability has influenced the mid-latitude circulation; rather, the focus of APPLICATE will be on the “potentially tractable” (Barnes and Screen, 2015) questions **Can it? and Will it?**. Central to the concept of APPLICATE will be the use of both uncoupled and coupled models. By using coupled models, it will be possible to account for air-sea interactions and also determine the oceanic response to Arctic sea ice decline. APPLICATE’s concept also includes another set of numerical experiments that allow to assess atmospheric teleconnections and to assess their practical relevance from a prediction perspective.

The research carried out in APPLICATE will be **computationally demanding**. However, given that most of the partners have access to dedicated supercomputing facilities and/or have well-established cooperation with different national and international high-performance computing (HPC) providers (e.g. ECMWF special projects), APPLICATE will not strive to carrying out all numerical experimentation at one single HPC centre. The availability of these HPC resources is a major asset of the APPLICATE consortium. In addition, joint proposals for HPC resources at a European level will be pursued (e.g. Partnership for Advanced Computing in Europe, PRACE). APPLICATE’s data strategy involves three main components. Firstly, all partners will be provided access to a common data storage and analysis facility that includes compute nodes and preinstalled software tools. Secondly, part of the model data will be made publicly available and easily accessible following standard formats used by the community. Data will be made available through application servers and metadata describing the data will be searchable and exposed for harvest by relevant data management frameworks. Finally, APPLICATE will maximize the impact of these data through publications in data journals (e.g. Earth System Science Data), provision on operational centre portals, and making the data visible through the YOPP Data Portal.

APPLICATE will be addressing two (related) topics that are very high on the agenda of the international research community, namely the enhancement of predictive capacity in polar regions and the improvement of our understanding of Arctic climate change on the weather and climate in lower-latitudes. Hence, many other activities related to those proposed in APPLICATE can be expected during the coming years. Examples include Belmont Forum projects and research activities related to YOPP. In order to avoid duplication and exploit synergies,
APPLICATE includes a work package on clustering. The main element of APPLICATE’s clustering concept includes a high-level coordination meeting at the beginning of the funding period. Moreover, international coordination will be envisaged through YOPP, which provides the ideal framework regarding the polar prediction and linkages themes.

1.3.2 Positioning of APPLICATE
APPLICATE covers the whole spectrum from idea to application. In this context, the following value chains will be addressed:

- Development of advanced metrics and diagnostics ➔ thorough assessment of weather and climate models ➔ better understanding of strengths and weaknesses ➔ more trustworthy predictions
- Improved process understanding ➔ improved models ➔ improved weather and climate predictions
- Improved knowledge of the impact of observations ➔ improved reanalyses, initial conditions and predictions
- Enhanced understanding of the impact of Arctic climate change on mid-latitudes ➔ better predictions
- User-engagement ➔ identification of user-relevant parameters ➔ enhanced products

The project aims to develop and test prototype systems for weather and climate prediction, which corresponds to a Technology Readiness Level 6-7. It is possible, however, that for some of the activities, implementation in full operational systems will be achieved towards the end of the project period (Technology Readiness Level 8).

1.3.3 National and international research activities related to APPLICATE
There are numerous international, European and national projects that are related to APPLICATE (many with participation of APPLICATE partners – often in leading roles). In the following, a number of high-level projects will be discussed. The focus of the discussion will be on where these activities provide relevant input to APPLICATE, keeping in mind, however, that the relationships are strongly bidirectional in nature. Input provided by APPLICATE to other projects will be discussed in section 2 (Impact).

Related international projects include:

**Coupled Model Intercomparison Project, phase 6 (CMIP6):** All climate modelling groups participating in APPLICATE will be taking part in CMIP6. In this context, CMIP6 provides protocols that will be used by APPLICATE partners. For example, the Sea Ice Model Intercomparison Project (SIMIP) defines a list of additional variables that are saved during experiments and can be used to understand the evolution of sea ice in any experiment using the sea ice model as part of CMIP6. Furthermore, APPLICATE will exploit efforts made by the Observations for Model Intercomparison Projects (Obs4MIP) through extensive use of its observational data-base. APPLICATE will also benefit from the development of ESMValTool, a community diagnostics and performance metrics tool for the evaluation of models.

**World Climate Research Programme (WCRP):** APPLICATE will benefit from activities going on under the auspices of WCRP, especially in the area of research coordination. Examples include the WCRP Polar Climate Predictability Initiative (PCPI) in the area of model development, reanalysis and polar prediction; the Working Group on Seasonal to Interannual Prediction (WGSIP) in seasonal to interannual prediction and the Working Group on Coupled Modelling in model development and CMIP6 related activities.

**Year of Polar Prediction (YOPP):** YOPP is a high-level international activity that will provide an important mean by which APPLICATE will coordinate its research activities with other related initiatives. In this context, close collaboration with the International Coordination Office for Polar Prediction (ICO), which is hosted at AWI, will be exploited. Of particular importance will be the coordination in the framework of the YOPP Modelling Component. YOPP will also play an important role in communicating and disseminating key outcomes of APPLICATE through workshops, mailing lists, and news items on the ICO website. Moreover, YOPP will provide a framework to increase the network of stakeholders, and provide resources needed to increase the critical mass behind coordinated education activities. Hence APPLICATE is essential for a successful YOPP.

**World Meteorological Organisation (WMO):** WMO will be one of the key partners for APPLICATE, and WWRP in particular as its Polar Prediction Project is one of the flagship activities with YOPP as a key deliverable. The WMO Polar Satellite Task Group (PSTG) will provide advice on Earth Observation data in the Arctic region for use in APPLICATE. Furthermore, APPLICATE will benefit from activities in the WMO’s EC-PHORS, especially in the area of research coordination (Global Integrated Observing System, GIPPS) and services (e.g. evaluation of stakeholder needs, see Fig. 1).

**Belmont Forum:** The Belmont Forum has issued a call on Climate Predictability and Inter-Regional Linkages. Some of the funded projects are expected to contribute to the questions addressed by APPLICATE. Hence,
coordinating activities with these projects will increase the critical mass needed to make progress in addressing the overarching challenge of advancing predictive capacity.

**Related European activities include:**

**EU research projects:** APPLICATE will develop strong synergies with numerous ongoing and upcoming EU-funded projects. For example, APPLICATE will benefit from collaboration with PRIMAVERA in the area of model evaluation, model development and numerical experimentation including Arctic-mid-latitude linkages; EMBRACE will provide a base line in sea ice and ocean model development; SPECS will be key to prediction and initialization aspects; CRESCENDO will contribute to the provision of CMIP6 experiments; and COST-EOS will provide a database and tools for the evaluation of ocean analyses and reanalyses in the Arctic Ocean. The successful project that will be funded under the topic H2020-BG09-2016 ‘An integrated Arctic observation system’ presents a highly complementary effort.

**Services:** APPLICATE will benefit from EUPORIAS, which provides examples and strategies to develop end-to-end climate-to-impacts-to-decision-making services, including semi-operational prototypes. Furthermore, APPLICATE will have close links to the projects funded in the framework of the climate services (ERA-NET, ERA4CS). An important factor is that many of the APPLICATE partners are eligible for the in-kind call of ERA4CS, which is an additional opportunity to strengthen the links on the impacts of Arctic climate research among them. Along the same lines, the APPLICATE partners involved in the recently started ClimatEurope coordination and support action can ensure that the modelling and services aspects of Arctic climate and its linkages to lower latitudes are taken into account in a broader context, including in the implementation of the "European research and innovation roadmap for climate services" and the European contribution to C3S and the Global Framework for Climate Services (GFCS).

**Coordination and agenda-setting:** Regarding the coordination of Arctic research in Europe, the Arctic Programme of the European Climate Research Alliance (Arctic ECRA, co-chaired by the APPLICATE coordinator) provides an excellent framework that can be exploited by APPLICATE. Furthermore, Arctic ECRA can help to advise policy makers on APPLICATE findings of societal relevance through means such as Parliamentary Lunch Events. Furthermore, EU-PolarNet will provide a platform for communicating high-level recommendations formulated by APPLICATE.

**Related national projects include:**

**Met Office Hadley Centre Climate Programme and UK Public Weather Service Programme:** This programme will provide baseline model configurations for prediction on seasonal (GloSea5) to centennial (CMIP6) time scales. Provides guidance on the impact of sea ice model parameters and enhanced resolution.

**Meteorological Co-operation on Operational NWP (MetCoOp):** MetCoOp will provide improved versions of the limited area weather prediction model AROME tailored for Nordic weather and daily surveillance of forecast quality. MetCoOp will also provide daily ensemble predictions on a Nordic domain.

(b) Methodology

**1.3.4 Methodology**

To achieve APPLICATE’s goals, extensive use of models will be made that have been developed by APPLICATE partners. These models can be clustered into four groups: (i) climate models that participate in CMIP6; (ii) those used in operational subseasonal-to-seasonal prediction; (iii) those employed in NWP for short-range and medium-range weather prediction; and (iv) single column models that can be run in coupled mode. While some of the systems are used for specific applications only, the majority of models are used from weather to climate time scales. A more detailed overview of the model systems used in APPLICATE is given in Tab. 1.
### Table 1: Summary of the different model and forecasting systems participating in APPLICATE.

<table>
<thead>
<tr>
<th>Climate Models</th>
<th>Model</th>
<th>AWI-CM</th>
<th>EC-Earth</th>
<th>CNRM-CM</th>
<th>NorESM</th>
<th>HadGEM</th>
</tr>
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<td>Partner</td>
<td>AWI</td>
<td>BSC, UCL, SU</td>
<td>CNRS-GAME, CERFACS</td>
<td>UiB, UR, Met.no</td>
<td>MO, UREAD</td>
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<td>Atmosphere</td>
<td>ECHAM6 T127 L95</td>
<td>IFS T255/T511 L91</td>
<td>ARPEGE-Climat T127/T359 L91</td>
<td>CAM-Oslo 1°×1° L32 / L46</td>
<td>MetUM N216/N96 L85</td>
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<td>NEMO 1°, 0.25° L75</td>
<td>NEMO 1°, 0.25° L75</td>
<td>NorESM-O (extended MICOM) 1°, 0.25° L75</td>
<td>NEMO 1°×1° L75 0.25°×0.25° L75</td>
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<td>Sea ice</td>
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<td>LIM3</td>
<td>GELATO</td>
<td>CICE</td>
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<td>SURFEX</td>
<td>SURFEX</td>
<td>JULES</td>
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<td>CMIP6</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<th>Subseasonal to Seasonal Prediction Systems</th>
<th>Model</th>
<th>EC-Earth</th>
<th>CNRM-CM</th>
<th>IFS</th>
<th>HadGEM/GloSea</th>
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<tr>
<td>Partner</td>
<td>BSC, UCL, AWI</td>
<td>CNRS-GAME</td>
<td>ECMWF</td>
<td>MO, UREAD</td>
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<td>IFS T255/T511 L91</td>
<td>ARPEGE-Climat T127/T359 L91</td>
<td>IFS T511-T319 L91</td>
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<td>NEMO 1°/0.25° L75</td>
<td>NEMO 1° L75</td>
<td>NEMO 0.25°×0.25° L75</td>
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<td>GELATO</td>
<td>LIM2/3</td>
<td>CICE</td>
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<td>HTESSEL</td>
<td>JULES</td>
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<tr>
<td>Data assimilation</td>
<td>Ensemble Kalman filter</td>
<td>Extended Kalman Filter SAM2</td>
<td>4D-Var</td>
<td>4D-Var, NEMOVAR 3D-Var FGAT</td>
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<th>Numerical Weather Prediction Systems</th>
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<th>AROME</th>
<th>IFS</th>
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<td>ECMWF</td>
<td>Met.no</td>
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<td>Atmosphere</td>
<td>ARPEGE T1198, stretched HR (7.5km on grid pole), L105</td>
<td>AROME 1.3km / 500m, 90 vertical levels</td>
<td>IFS T1279 L137</td>
<td>AROME 2.5 km L65</td>
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<td>dynamical adaptation</td>
<td>4D-Var</td>
<td>3D-Var</td>
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The fact that APPLICATE will carry out comprehensive numerical experimentation with different model systems across a wide range of time scales requires a strongly coordinated approach. A draft numerical experimentation plan, that summarizes some planned numerical experiments, is presented in Tab. 2. The numerical experimentation plan will be updated throughout the project taking into account input from the WP leaders and following consultation with other related European and international activities as part of the Clustering process.
Table 2: Draft plan for the numerical experimentation carried out in APPLICATE including the level of data dissemination in WP6.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Model systems</th>
<th>Experimental design</th>
<th>Data</th>
</tr>
</thead>
</table>
| Determine the impact of model enhancements on process representation and systematic model error (WP2) | • AWI-CM  
• EC-Earth  
• CNRM-CM  
• NorESM  
• HadGEM | Baseline data: CMIP6-DECK experiments  
Implement the model changes suggested in WP2 in coupled models:  
• 200-yr pre-industrial control experiments  
• CMIP6 historical experiments  
• 1% CO₂ increase experiments | Partial Dissemination |
| Determine Arctic-lower latitude linkages in atmosphere and ocean (WP3) | Coupled models  
• AWI-CM  
• EC-Earth  
• CNRM-CM  
• NorESM  
• HadGEM | Large ensembles (50-100 members) of 12-months experiments starting June 1st with sea ice constrained to observed and projected sea ice fields  
Multi-decadal experiments with and without artificially reduced Arctic sea ice (enhanced downwelling LW radiation over sea ice); use of tracers for the ocean  
Repeat with enhanced models | Full Dissemination |
| Atmospheric models  
• ECHAM6  
• IFS  
• ARPEGE-Climat  
• CAM-OSLO  
• MetUM | Large ensembles (50-100 members) of 12-months experiments starting June 1st with sea ice constrained to observed and projected sea ice fields  
Various corresponding sensitivity experiments to explore the role of the background flow, and the prescribed sea ice pattern  
Repeat with enhanced models | Full Dissemination |
| Seasonal prediction systems  
• EC-Earth  
• CNRM-CM | Seasonal prediction experiments with and without relaxation of the Arctic atmosphere towards ERA-Interim reanalyses; 9-member ensemble forecasts with members initialized on Nov 1st, Feb 1st, May 1st and Aug 1st for the years 1979-2016 and 1993-2016 for EC-Earth and CNRM-CM, respectively. | Full Dissemination |
| Arctic observing system development (WP4) | Atmospheric model  
• IFS | Data denial experiments with the IFS for key observations (snow, surface pressure, wind, moisture) and different seasons. | Partial Dissemination |
| Seasonal prediction  
• EC-Earth  
• HadGEM  
• GloSea | - Perfect model experiments to characterize basic sensitivity of forecasts to initial conditions.  
- Different configurations of initial conditions using reanalyses, new observations, ocean reruns forced by atmospheric reanalyses.  
- Experiments focused on sea-ice thickness, snow and spatial data sampling | Partial Dissemination |
| Determine the impact of APPLICATE model enhancements on weather and climate prediction (WP5) | Atmospheric model  
• ARPEGE  
• AROME  
• IFS  
• AROME-Arctic | Test recommendations for model enhancements made in WP2 in pre-operational configurations  
Explore the impact of nesting, driving model and resolution | Partial dissemination |
| Seasonal prediction  
• EC-Earth  
• CNRM-CM  
• HadGEM | Test recommendations for model enhancements made in WP2 in pre-operational configurations | Partial dissemination |
| Climate change  
• AWI-CM  
• EC-Earth  
• NorESM | Establish the impact of model enhancements developed in WP2 on climate sensitivity by carrying out experiments using the same initial conditions and time period (1930—2050) employed in HiResMIP | Partial dissemination |

APPLICATE consists of nine work packages that can be clustered into four different groups (Fig. 3). The underlying scientific core comprises five strongly interlinked work packages that provide the scientific underpinning (WP1-5). In this context WP5 takes a central role, since this is where synthesis towards prediction systems takes place and key-recommendations will be formulated. The scientific work packages are supported by WP6, which will provide the infrastructure in the area of high-performance computing (HPC) as well as data management and dissemination needed to deliver scientific excellence. The knowledge transfer, including end-user engagement, dissemination and education will be taking place in WP7. Thus, WP7 is crucial for maximizing the impact of APPLICATE. Through the stakeholder dialogue established in WP7, important feedback will be provided to the scientific core. Finally, WP8 and WP9 will ensure coordination with related activities at the European and international level (Clustering) as well as a smooth and efficient project management of APPLICATE, respectively.
Figure 3: APPLICATE work package structure. Red arrows denote the main direction of dependencies and blue arrows indicate feedbacks.

In the following, the aims and methodology underlying the scientific core and infrastructure work packages are given:

WP1: Weather and climate model evaluation

**Aim:** WP1 will develop advanced metrics and diagnostics that will be used to observationally constrain weather and climate models.

**Approach and methodology:** To have confidence in climate projections and weather forecasts, it is essential that the models used to make such predictions are capable of capturing key physical processes in the oceans, atmosphere and cryosphere. WP1 will develop a set of metrics and diagnostics to observationally constrain and evaluate weather and climate models. The initial focus of WP1 will be on metrics, i.e. the quantitative comparison of a quantity within a model to some reference, for example, an observational data set. Several types of metrics will be developed: process-based metrics to evaluate Arctic climate processes and the linkages between the Arctic and the Northern Hemisphere, user-relevant metrics, and novel sea ice metrics based on observations from YOPP. User-relevant metrics will be co-developed with users engaged within WP7. To ensure community and user engagement, the metrics developed during APPLICATE will be made widely available through ESMValTool. The metrics developed in WP1 will be used to assess weather and climate models. This includes the existing CMIP5 data, but also the output from the forthcoming CMIP6 activity that will inform the next IPCC assessment report on climate change. The metrics will also be used to assess the ensemble weather forecasts from NWP models. To encourage the exchange of ideas between the weather and climate modelling communities, a synthesis will be made of how model errors develop across time scales in weather and climate models. A new generation of process-based heat budgets of the Arctic will be used to investigate the feedbacks and processes that lead to uncertainty in Arctic climate model projections. WP1 will also explore the potential of observational emergent constraints to reduce the uncertainty in climate model projections for the Arctic and its linkages to the whole Northern Hemisphere.

WP2: Enhanced weather and climate models

**Aim:** WP2 will improve the representation of Arctic-specific processes in weather and climate prediction models

**Approach and methodology:** The weather and climate research communities rely heavily on the availability of adequate prediction models. However, even the most advanced models still have significant shortcomings in the Arctic. This is particularly true for small-scale processes that need to be parameterised such as the formation of clouds, boundary layer mixing in ocean and atmosphere, sea ice formation/melt and the surface energy exchanges. These processes are also involved in substantial feedback mechanisms in the climate system. APPLICATE will work on improving the representation of the most critical processes for the Arctic climate system as well as on
developing methodology that can help constraining model processes by utilizing available observations. An innovative single column framework, extended from the more commonly used atmosphere-only and ocean-only framework to capture the entire system from ocean bottom, through the sea ice and snow, to the top-of-atmosphere will be developed and tested using observational data of the coupled system. The experimental cases developed within APPLICATE will be used in internationally coordinated model inter-comparison projects to continue the successful work in GEWEX Global Atmospheric System Studies (GASS) but extended to examine atmosphere-snow-sea ice-ocean interactions. Enhancement of ocean processes, especially in straits/channels and small-scale sea ice features will be explored using innovative high-resolution grids. At the end of the APPLICATE project, model enhancements will be thoroughly assessed and documented.

WP3: Atmospheric and oceanic linkages

Aim: WP3 will advance our understanding of the mechanisms by which the mid-latitude weather and climate could respond to the substantial Arctic climate change that is expected in the coming decades.

Approach and methodology: WP3 will perform a thorough assessment of the impact of Arctic climate change on the Northern mid-latitudes. This will be achieved through a suite of novel coordinated multi-model experiments. Fully coupled models will be employed since these are essential in order to properly simulate the linkages, including oceanic and atmospheric pathways and the effects of ocean-atmosphere coupling. Additional atmosphere-only experiments will be performed to further improve our understanding of the physical processes by assessing the relative roles of the ocean and atmosphere, and how the mid-latitude climate response depends on the background model state and the pattern of sea ice changes. Advanced metrics and diagnostics will be used to assess the relevant physical processes. The impact of model improvements (WP2) on atmospheric and oceanic linkages will also be assessed by repeating some key experiments with enhanced models. The improved understanding of the mechanisms linking the Arctic region and Northern mid-latitudes gained in WP3 will lead to improved climate predictions for the coming seasons to decades.

WP4: Support for Arctic observing system design

Aim: WP4 will guide the design of the future Arctic observing system in order to improve our capacity to reanalyse the Arctic climate system and enhance the predictive skill in the Arctic and beyond.

Approach and methodology: Observations are crucial for a better process understanding, model evaluation, forecast verification and for the initialization of predictions. Enhancing the existing observing system in the Arctic – one of the most undersampled regions of the planet – is a necessity. However, given the high costs associated with taking observations at high latitudes, the future of the Arctic observing system has to be planned thoughtfully. WP4 makes the best use of existing observations, reanalyses, and numerical models to provide guidance to the Arctic observational community regarding the deployment of the observational network in the Arctic. WP4 is designed to identify the most important gaps in the current Arctic observing system and to determine priorities for filling them. An assessment of current polar reanalyses will be conducted, investigating specifically the importance of the assimilation of conventional and satellite observations for capturing the variability of the coupled system, as well as their role for medium-to-seasonal prediction skill. From this, a synoptic analysis providing a consistent view of current shortcomings and requirements for observing system enhancement will be derived. WP4 will employ well-established prediction systems, a variety of model configurations (including atmosphere-only and fully coupled models) and advanced data assimilation methods and diagnostics. These tools will be used to identify key missing observation types and locations. The proposed experiments will also identify the optimal regional sampling of these observations required to best improve predictions.

WP5: Improved predictive capacity

Aim: WP5 will deliver enhanced weather and climate forecast systems with improved predictive skill for the Arctic and beyond on daily to decadal time scales.

Approach and methodology: WP5 will synthesize the results from WP 1-4 leading to enhanced weather and climate predictions. A comprehensive assessment of the existing prediction capabilities for the Northern Hemisphere will be carried out to establish a baseline. Sources of predictability will be identified by making extensive use of existing prediction dataset. Empirical forecast systems will be developed to provide a benchmark for dynamical predictions. Advanced forecasting systems will then be tested and delivered building on model enhancements (WP2), improved initialisation strategies (WP4), increased resolution, and novel ensemble generation techniques. The impact of APPLICATE on prediction skill from daily to multi-decadal time scales will
be quantified by comparing two streams of experiments: one performed with the prediction systems as available at the start of APPLICATE (stream 1) and another one performed after incorporating the developments produced by APPLICATE (stream 2). Recommendations for operational implementations in weather and climate forecast systems and for further developments will be formulated and widely disseminated.

WP6: Data and HPC management

**Aim:** WP6 will oversee all HPC activities, provide the YOPP Analysis and Forecast Dataset and ensure structured data management, simplifying data sharing, preservation and analysis.

**Approach and methodology:** WP6 will oversee HPC activities of the APPLICATE consortium and provide information about upcoming calls for HPC resources, include those at the Partnership for Advanced Computing in Europe (PRACE). Furthermore, WP6 will produce and disseminate the YOPP Analysis and Forecast Dataset. Data management APPLICATE is based on a metadata driven approach where datasets are documented in a standardised manner for sharing and preservation. This approach is aligned with relevant activities in the context of GEOSS, WMO, SAON, ICSU and EU (INSPIRE). Metadata will be exposed using machine interfaces, enabling visibility in the relevant catalogues. Through integration with the WMO Information System, information will be propagated to the GEOSS Common Infrastructure. Through application of standardised use of metadata and interfaces suitable for process oriented datasets, higher order services and simplified post-processing / analysis in a common post processing environment will be ensured. APPLICATE will use standard formats used in the weather and climate prediction communities (GRIB, NetCDF and CMOR).

1.3.5 APPLICATE gender dimension

While gender aspects are not explicitly mentioned in the call text of BG-10-2016, they are nevertheless an important aspect to be considered. The nature of the work within the core scientific work of APPLICATE is mostly gender neutral. The research carried out in APPLICATE is grounded in math and physics, subjects that generally have a large bias towards male scientists at all levels, although the situation is slowly improving with more females entering the field. APPLICATE can make a difference by employing a recruitment policy and working environment that is welcoming for female candidates. APPLICATE endorses the principles of the European Charter for Researchers and Code of Conduct for the Recruitment of Researchers. APPLICATE partners will whenever possible implement actions (such as organising predictable working times and travel, stimulating use of electronic meetings) to support male and female researchers with children or other dependants. The Project Coordinator along with the Management Support Team will gather statistics on and monitor the role of women within APPLICATE and take actions if needed. Attention will be paid to how meeting programs, high profile presentations (keynote talks at conferences) on project results and educational programs are planned from a gender perspective. The impact that APPLICATE will have on prediction tools and predictions, however, does have a gender dimension. When engaging with end-users or other target audiences, and when designing information and services, it is important to keep the gender aspects in the process. Gender aspects must therefore be constantly considered within the context of the end-users and how the project dissemination, exploitation and communication are affected. We will consult the PRIMAVERA Gender Strategy and adopt APPLICATE relevant parts.

1.4 Ambition

1.4.1 Advancement beyond the state of the art and ambition

APPLICATE will make significant advances in observationally constraining weather and climate models, especially in the Arctic: Model assessment is an important aspect in the field of weather and climate modelling because it provides insight into the trustworthiness of our prediction systems and it provides guidance for future model development efforts. The increasing importance of this area of research is reflected by numerous recent community efforts such as the dedicated chapter on evaluation of climate models in the Fifth IPCC Assessment Report (Flato et al. 2013), a move towards the development of community diagnostics and performance metrics tool for the evaluation of Earth System Models (ESMValTool, Eyring et al. 2015), and concerted efforts to run and evaluate climate models in weather prediction mode (Transpose AMIP, Williams et al. 2013). However, it can be argued that previous model evaluation had a bias towards lower latitudes, and that a coordinated approach towards ocean model evaluation is still in its infancy, especially for the Arctic (Wang et al. 2015).

APPLICATE will go beyond the state-of-the-art by developing and applying advanced metrics and diagnostics, targeting physical as well as user-relevant processes that bring the assessment of weather and climate models to a new level, especially in the Arctic. By implementing these tools in ESMValTool, APPLICATE will significantly increase the momentum behind emerging community efforts in model evaluation. Furthermore, the concept of
initial tendency and data assimilation increment diagnostics (Rodwell and Palmer, 2007) will be used in an Arctic context for the first time. This approach, which allows to determining errors in the representation of processes before they had time to interact, will provide new insights into the origin of model errors in weather and climate models in the Arctic. Moreover, APPLICATE will explore the concept of emergent constraints with an Arctic focus, which could be an extremely effective way of reducing the uncertainty of regional climate change projections for the Northern Hemisphere in the Sixth Assessment Report of the IPCC. Finally, APPLICATE will liaise with the observational community to identify, with the aid of models, new types of process-based diagnostics that are robust and stable despite the shortness of intensive observational campaigns such as YOPP.

**APPLICATE will carry out model development efforts that provide the basis for the next-generation of weather and climate models:** Model development in the Arctic has a long history. Traditionally, efforts have focussed on atmospheric or sea ice-ocean models separately. Furthermore, regional models played a relatively important role (Rinke et al. 2006, Proshutinsky et al. 2001), due to the need for locally high horizontal resolution and Arctic-specific formulations of some of the parameterisations. Despite substantial improvements over the years, however, major challenges still exit (e.g. Vihma et al., 2015). This is especially true, given that rapid Arctic climate change is associated with the emergence of new regimes (e.g. Nghiem et al. 2007). For example: the representation of stable atmospheric planetary boundary layers needs attention (Holtslag et al. 2013); the formulation of snow and sea ice models needs to be revisited (Jung et al. 2016); ocean models need to be better constrained in the Arctic (Wang et al. 2016); coupling between atmosphere, snow, sea ice and the ocean needs attention; and improved process understanding needs to feed into models.

APPLICATE will substantially increase our understanding and ability to model some of the processes thought to be essential for the prediction of the weather and climate of the Arctic and beyond. APPLICATE will take the concept of single column models (SCMs) – which have been proven very effective at constraining model parameters (e.g. Cuxart et al. 2006) – one step further, towards coupled SCMs. Using coupled SCMs will allow us to account for the full range of physical process interaction from the ocean through the ice and snow into the atmosphere. In this way, APPLICATE will be able to take into account important coupled processes and exploit the full potential of new observational capacity, such as buoys from the Ice-Atmosphere-Arctic Ocean Observing System (IAOOS, 2011-2019; Provost et al., 2015), that carry out simultaneous measurements of the coupled Arctic climate system (Figure 4). Furthermore, APPLICATE will make substantial progress in the development of next generation sea ice models following novel pathways. Firstly, the numerical efficiency of existing rheologies will be improved (e.g. Kimmritz et al. 2015) so that for the first time, long ultra-high-resolutions simulations (4.5 km) with coupled climate models will become feasible. Secondly, the novel elasto-brittle rheology (Girard et al. 2011) will be implemented and thoroughly tested. Thirdly, the representation of thermodynamic sea ice processes in models (e.g. melt ponds) will be significantly enhanced, which will improve our capacity to model important feedback processes in the Arctic. Fourthly, APPLICATE will also make significant progress in the area of snow modelling. Here the emphasis will be on harmonizing the formulation on land and sea ice by implementing multi-layer snow schemes (Lecomte et al. 2013). Finally, progress in ocean modelling will be achieved through the use of enhanced resolution. This will allow, among others, a better simulation of Arctic-Atlantic exchange processes. In this context, novel concepts such as unstructured mesh approaches, as used in AWI-CM, will be exploited (Danilov 2013, Sidorenko et al. 2015). Models formulated on unstructured meshes allow enhancing horizontal resolution – and hence focus computational resources – in dynamically active regions, and they are extremely effective at exploiting the next-generation of massively parallel HPC systems due to their excellent scalability.
APPLICATE will significantly advance our understanding of the impact of Arctic climate change on mid-latitude weather and climate: Despite substantial recent research activities, our understanding of the impact of Arctic climate change on the weather and climate of the Northern Hemisphere mid-latitudes is still at a pre-consensus state (Jung et al. 2015, Overland et al. 2016). Lack of consensus can be explained by different (related) factors: (i) the largest atmospheric changes, that have been linked to the Arctic have occurred only recently (since the early 2000s); (ii) atmospheric dynamics is known to generate sizable internal variability across a wide range of time scales (e.g. Barnes and Screen 2015); (iii) the mid latitude response may be nonlinear and thus depend on other factors such as the background flow (Harvey et al. 2014) and (iv) there has been a lack of coordinated experimentation, making it difficult to pinpoint the origin of differences between modelling studies. Finally, the recent discussion has been mostly about atmospheric linkages. However, oceanic linkages might be playing an important role in influencing the circulation and water mass characteristics of the North Atlantic Ocean, with possible implications for the blue economy (Benway et al. 2014).

APPLICATE will go beyond the state of the art by carrying out a set of coordinated experiments with some of the leading European climate models. These experiments are designed to address the question whether Arctic climate can and will influence the weather and climate of the Northern Hemisphere. In this context, APPLICATE will not only consider atmospheric but also oceanic linkages, thereby alleviating the bias of the recent discussion towards the atmosphere. Furthermore, APPLICATE will advance the field by providing further insight into important aspects such as non-linearity of the response. Importantly, all models participating in APPLICATE’s coordinated modelling efforts will contribute to CMIP6. The fact that Arctic-mid-latitude linkages will be revisited in APPLICATE with enhanced climate models – exploiting APPLICATE’s novel model development efforts mentioned above – will increase the insight into sensitivity to model formulation. APPLICATE will also exploit a completely different, and in the linkages context still largely unexplored, relaxation approach (Jung et al. 2014a). By carrying out seasonal forecasting experiments with and without relaxation of the Arctic atmosphere towards reanalysis data, it will not only be possible to assess simulated teleconnections; these experiments will also shed light on the potential that enhanced prediction capacity in the Arctic could have on mid latitude prediction skill.

APPLICATE will make novel contributions to the future design of the Arctic observing system: The polar regions are among the most sparsely observed parts of the globe, resulting in an Arctic “hole“ in the global observing system (e.g. Jung et al. 2016). This may be one explanation as to why the skill of weather forecasts in
polar regions is relatively low (Bauer et al. 2014). The relative remoteness and harsh environmental conditions of the polar regions will always provide a barrier to enhanced observations. Therefore it is important to carefully design the observing system to meet different needs. In the past, the emphasis has been on improved process understanding, model development and long-term monitoring. With an increasing need for predictive capacity, however, recently the importance of observations for improved initialization of weather and climate forecasts has been realized (e.g. Eicken 2013), and some promising initial results for the potential of additional observations for enhanced predictions have been obtained (Inoue et al. 2015).

APPLICATE will address this timely topic by focussing on two central questions: “What are the most important gaps in the existing observing system?” and “How much could predictions be improved by filling these gaps?”

APPLICATE will go beyond the state-of-the-art by applying novel diagnostic techniques that allow linking forecast improvement to the impact of individual observations, to how they are distributed in space and time, and how effectively they are assimilated in today’s systems. This will be performed by considering observational requirements across time scales and by also taking into account the needs of the model development community. APPLICATE will thus provide crucial guidance for optimizing observational data usage and for exploiting new observations to be collected during YOPP, but also for designing future reanalyses monitoring long-term climate variability in the Arctic in support of C3S.

**APPLICATE will significantly improve the fidelity of existing weather and climate prediction systems:** Traditionally, development efforts of prediction systems have focussed on lower latitudes. This is partly a result of relatively low human activities in the Arctic in the past, and the notion that sources of predictive skill mostly originate in lower latitudes (e.g., associated with ENSO). This bias led to the fact that our predictive capacity in the Arctic is still limited (e.g. Jung et al. 2016, Stroeve et al. 2012). With Arctic amplification, the perception of the relative importance of the Arctic is changing rapidly. This is reflected, among others, by the launch of major international programmes such as the PPP, YOPP and GIPPS.

APPLICATE will move the Arctic into the focus of its research efforts on prediction. Thereby it will contribute to programmes such as PPP, YOPP and GIPPS and thus close the gap that the bias of previous European and international research efforts on lower latitudes has produced. APPLICATE is ambitious in its approach by addressing the problem from a wide range of perspectives – from fundamental research on forecasting system development, covering daily to seasonal as well as multi-decadal time scales, to user-engagement and dissemination. APPLICATE will advance the field by analysing sources of predictability and by developing new empirical forecast systems that will serve as benchmarks. Furthermore, prediction systems will be enhanced by incorporating improved process representation, improved initialisation and boundary strategies, increased resolution and novel ensemble generation techniques. Finally, APPLICATE will produce a comprehensive synthesis report that will provide recommendations for the enhancements of predictions in the Arctic and beyond.

**APPLICATE will bridge between weather and climate prediction communities** by focusing on diagnostics in the coupled Earth system that target mean model errors affecting all scales and that identify error sources at process level. APPLICATE will employ a hierarchy of models to investigate their sensitivity to process parameterizations at all scales. Further examples include cross-community developments such as complex sea ice models implemented in climate models and being tested in weather prediction mode, or sensitivity experiments revealing the linkage between polar regions and lower latitudes being relevant at all forecast ranges. Long-period datasets such as CMIP-type data, different types of reanalyses and operational weather prediction model output will form a unique database benefiting the entire research community.

1.4.2 Innovation potential

APPLICATE is novel in its approach by truly addressing the prediction and linkages problem across time scales and by bringing leading experts from the weather and climate prediction communities closer together to work collaboratively on common challenges.

APPLICATE will significantly improve operational prediction in the Arctic and beyond. This will be of direct socio-economic relevance, especially in the light of the opportunities and risks that economic development will bring in a rapidly changing Arctic. Furthermore, enhanced operational predictive capacity from daily to seasonal time scales, a more user-oriented approach to model assessment, and improved trustworthiness of climate change projections will improve the foundation underlying weather and climate services. Hence, APPLICATE will support EU policy by helping to “generate economic value from available climate data and models and ongoing climate research” and by making sure that “scientific research is designed to provide demonstrable benefits and solutions to the challenges facing our society.”
APPLICATE is also at the forefront of increasing the uptake of observational data, including those generated during YOPP. This will be achieved by making effective use of available observations for model development efforts, by improving forecasting systems, and by providing guidance on the best use of observations from a prediction perspective. In summary, thus, APPLICATE will significantly enhance the return on the sizeable investments made in the global observing system.

Reanalysis products are being increasingly used for decision-making. Examples for users include commercial enterprises such as insurances. Given that the quality of reanalysis efforts hinges critically on the quality of the forecasting system used, APPLICATE research is destined to increase the fidelity of upcoming reanalyses in the Arctic, and hence the basis for decision making.

2. Impact

2.1 Expected impacts

2.1.1. Expected impact set out in work programme and text of call

**Expected Impact 1:** “Improve capacity to predict the weather and climate of the Northern Hemisphere, and make it possible to better forecast extreme weather phenomena“

The advancement of our capacity to predict the weather and climate of the Northern Hemisphere is the overarching ambition of APPLICATE. To achieve its goal, APPLICATE will concentrate on the following three key-areas: (i) Improved representation of Arctic key-processes and their linkages to lower latitudes in weather and climate models, spanning time scales from days to decades; (ii) Informing the design of the future Arctic observing system from a weather and climate prediction perspective, and (iii) Advancement of forecast initialization techniques for weather and climate models.

APPLICATE will improve of extreme weather forecasts in the Arctic, through its modelling efforts, which will advance the representation of the lower atmosphere to improve predicting near-surface weather parameters such as visibility and temperature, as well as improve exchange processes at the air-sea ice-ocean interface. APPLICATE will also address the simulation of hazardous weather including intense polar storms and cold air outbreaks. Furthermore, the development of sea ice models will be taken to the next level, through the use of new rheologies (e.g. elasto-brittle) and/or extremely high-resolution global configurations (e.g. 4 km in the Arctic Ocean), thereby laying the foundation for the prediction of extreme environmental conditions (e.g. sea-ice deformation and pressure).

APPLICATE will also contribute to the improvement of extreme weather forecasts and climate predictions in the Northern Hemisphere mid-latitudes by directly enhancing weather forecast capacity in the Arctic, which will lead to improved forecasts at lower latitudes (Jung et al. 2014a). These improvements will benefit a wide number of users through the active contribution of APPLICATE partners to information systems such as meteoalarm.info, a web-based service to warn people travelling in Europe of severe weather events. Furthermore, through comprehensive numerical experimentation, APPLICATE will provide an assessment of how Arctic climate change can impact extreme weather in the Northern Hemisphere mid-latitudes. APPLICATE partners will demonstrate how this information could be used by governments, businesses (e.g. the insurance industry) and society at large to adapt to inevitable climate variability and anthropogenic climate change.

Importantly, the APPLICATE consortium includes Europe’s leading weather and climate prediction centres, whose forecasts and services benefit the majority of European society. This is further ensured through the expected transition from research to operations and thus service-level as APPLICATE partners operate and contribute to existing C3S. The use of global prediction systems in APPLICATE, together with strong international collaboration (USA, Canada, Russia, China, Japan and South Korea), means that APPLICATE is destined to benefit non-European citizens as well.

**Expected Impact 2:** “Improve the capacity to respond to the impact of climatic change on the environment and human activities in the Arctic, both in the short and longer term“

APPLICATE will make significant contributions to the assessment of CMIP6, with a special emphasis on Arctic climate change. This assessment will update the 5th Assessment Report (AR5), taking into account recent advances in model development, observations and process knowledge.

Through its dedicated and coordinated model development efforts, APPLICATE will improve the representation of Arctic processes, using CMIP6 models as a baseline. APPLICATE will test the impact of the model enhancements (“CMIP6-Interim”) and provide a substantial contribution from Europe to the analysis of the CMIP6 experiments in
the Arctic. Furthermore, APPLICATE will provide recommendations for future coupled model intercomparison projects, especially CMIP7.

APPLICATE will develop user-relevant metrics and diagnostics that can be used for both model assessment and to determine the impact of climate change. Examples for such diagnostics include length of the growing season, ocean temperatures and boundaries of different water masses for fisheries and sea-ice-free regions for shipping.

APPLICATE will also contribute to the growing need for reliable and accurate short-term weather and environmental prediction (Fig. 1) in a changing climate. This will be achieved through the strong NWP development activities in APPLICATE that will benefit from an improved understanding of the processes governing climate time scales.

The capacity to respond to the impact of climatic change also depends on engaging the new generation of scientists, therefore APPLICATE will provide a set of training activities and materials to improve the skills and competences of those working and being trained to work within this subject. The training component will be the legacy towards the next generations of scientists.

**Expected Impact 3:** “Improve the capacity of climate models to represent Arctic warming and its impact on regional and global atmospheric and oceanic circulation“

The amplified warming in the Arctic in response to climate change is associated with the presence of stable boundary layers, which prevent vertical mixing due to turbulence and convection. Arctic warming is also associated with strong positive feedbacks involving the coupled atmosphere-sea ice-ocean system. APPLICATE will evaluate and improve the representation of these processes, which will lead to significant improvements in the ability of climate models to represent Arctic climate. Furthermore, the enhancement of sea ice models, together with increased resolution, will improve the representation of the sea ice edge. This has implications for the atmospheric response to sea ice changes, and the forecasting of cold air outbreaks, polar cyclones and other atmospheric phenomena that also affect lower latitudes.

APPLICATE will also explore the benefit of substantially increasing the horizontal resolution of ocean models in regions of strong Arctic-Atlantic exchange such as at the Fram Strait. Hence, APPLICATE has the capacity to make considerable progress in modelling the impact of Arctic climate change on the North Atlantic Ocean circulation. This will directly benefit seasonal to decadal prediction capacity and enhance the trustworthiness of longer term climate change projections. For the latter, the Arctic influence on the variability of the North Atlantic sub-polar gyre and the much-discussed stability of the North Atlantic Meridional Overturning Circulation (AMOC) will be addressed.

**Expected Impact 4:** “Improve the uptake of measurements from satellites by making use of new Earth observation assets“

APPLICATE will improve the uptake of measurements from satellites in two ways. Firstly, satellite data will play a pivotal role in APPLICATE’s model assessment and therefore development efforts. Existing and new Earth observations, such as sea ice thickness from CryoSat2 and SMOS as well as ice drift from SAR images, will be used to thoroughly evaluate the next generation of sea ice models with enhanced dynamics and thermodynamics, taking into account new approaches to introduce the observational uncertainty into the analysis. New satellite data, that turn out to be valuable for model assessment activities, will be made available to the wider scientific community through incorporation in the Observations for Climate Model Intercomparisons (Obs4MIPs) data-base.

Secondly, the model development efforts of APPLICATE will also have an indirect impact on the uptake of satellite data by operational centres, i.e. improving the representation of sea ice and snow in forecast models will improve the quality of the first guess in data assimilation. This will enable the assimilation of more high-quality satellite data, with direct benefits for predictions on daily to decadal time scales.

**Expected Impact 5:** “Lead to optimised observation systems for various modelling applications“

APPLICATE will contribute to optimised observations for various modelling applications. Firstly, a gap analysis will help to identify important shortcomings in the existing observing system. This will be achieved in APPLICATE by analysing existing data from reanalyses in the Arctic and by diagnosing current data assimilation systems using advanced diagnostics (e.g. forecasting sensitivity to observations). APPLICATE will also carry out an assessment of how much forecasts could be improved by filling the gaps in the existing observing system. This will be achieved by carrying out numerical observing system experiments with both atmosphere-only and coupled systems.
Finally, APPLICATE will synthesize the results, and make recommendations for the design of the future Arctic observing system, taking into account the needs of the prediction and model development communities, and by considering results from other related activities (e.g. H2020 BG-9, An Integrated Arctic Observation System). In this context, YOPP will be a major platform for synthesizing and disseminating the outcomes of APPLICATE, while APPLICATE will become a key European contribution to YOPP. Recommendations will also feed into the agenda-setting process of the European Commission through collaboration with the EU-PolarNet project.

**Expected Impact 6:** “Contribute to a robust and reliable forecasting framework that can help meteorological and climate services to deliver better predictions, including at sub-seasonal and seasonal time scales”

The concept of APPLICATE is strongly geared towards developing robust and reliable operational forecasting and numerical models across time scales. APPLICATE will make substantial contributions in the area of model development, forecast initialization and observing system design, cross-pollinating ideas to address the challenges faced by NWP and climate-change communities. Since leading weather and climate prediction centres in Europe are partners in APPLICATE, advances will be embedded within meteorological and climate services resulting in the much-needed improvement in Arctic predictions and subsequent linkages to other latitudes at sub-seasonal-to-decadal time scales.

It is essential to consider user requirements for developing meteorological and climate services. In this context, the User Group (UG) established by APPLICATE will play a critical role in co-designing some of the forecasting related research activities. UG will identify the relevant variables and metrics where the impact of the forecast system developments needs to be measured. The external user-specific perspective will provide feedback on the relevance of the results obtained in APPLICATE, and the way they are presented. The Group will operate following the spirit of the different frameworks for the development of climate services and conciliate them with the principles formulated by other initiatives like WWRP’s Societal and Economic Research Applications (SERA) working group. Furthermore, an online tool for harnessing user feedback and virtual consultations and surveys will strengthen user engagement and provide a wider perspective on the challenges, discrepancies, misconceptions and issues overlooked by the experts.

**Expected Impact 7:** “Improve stakeholders’ capacity to adapt to climate change”

APPLICATE will improve stakeholders’ capacity to adapt to climate change through a comprehensive analysis of the latest generation of climate models (CMIP6), which will contribute to the next IPCC assessment report. APPLICATE aims to improve the trustworthiness of climate change projections through an improved representation of important Arctic processes in next generation climate models (CMIP6–Interim, CMIP6 and CMIP7). Furthermore, APPLICATE will contribute to narrowing the uncertainty of climate change projections (CMIP5 and CMIP6) by exploiting the concept of emergent constraints, leading to a greater adaptation capacity. Importantly, APPLICATE will increase the stakeholder-relevance of its research by developing a set of user-relevant diagnostics (e.g. ocean temperatures for fisheries; sea ice free regions for shipping in the Arctic and at lower latitudes) developed after consulting key stakeholders in the Arctic and in mid-latitudes. In this context, the pro-active approach towards users will maximize the anticipated impact by continuously taking into account user needs via interactions with the User Group, workshops, meetings, interviews with key stakeholders and virtual consultations and surveys.

**Expected Impact 8:** “Contribute to better servicing the economic sectors that rely on improved forecasting capacity (e.g. shipping, mining)”

APPLICATE’s core scientific activities will feed into enhanced operational predictive capacity across time scales. The sectors targeted by APPLICATE include shipping, insurance and consulting companies, banks and investment firms, as well as tourism. A wide range of stakeholders and users will be consulted to effectively exchange the new knowledge from enhanced predictions. The operational centres involved in APPLICATE disseminate crucial forecasting information to many stakeholders within Europe and beyond (e.g. ECMWF has 22 member states and 12 cooperating states). Through its strong forecast and climate information user engagement, APPLICATE will be able to take user needs into account, and communicate the latest advances in forecasting system development to those needing trustworthy predictive information for decision making.

**Expected Impact 9:** “Contribute to the Year of Polar Prediction (YOPP) and IPCC scientific assessments, and to the Copernicus Climate Change (C3S) services”
APPLICATE will make significant contributions to the different components of YOPP (Jung et al. 2014b):

- Contribute to the YOPP Modelling Component by improving the representation of key Arctic processes in models, by providing prediction data such as the YOPP Analysis and Forecast Data Set (WP6) to the scientific community, and by determining polar-lower latitude linkages along with their relevance for prediction;
- Contribute to the YOPP Observation Component through its efforts in Arctic observation system design;
- Contribute to the YOPP Data Component through publicly delivering forecasting data in a form that is consistent with the YOPP data strategy;
- Contribute to the YOPP Education and Outreach Component (i) by developing and implementing an educational programme in collaboration with APECS that is well-aligned with the YOPP goals and (ii) by disseminating YOPP-related results, coming out of APPLICATE, widely.

The connection between APPLICATE and YOPP is strengthened by the fact that many APPLICATE partners play leading roles in the planning and implementation of YOPP: Thomas Jung (AWI) is chair of the PPP steering group and therefore responsible for the planning and coordination of YOPP; Peter Bauer (ECMWF), Trond Iversen (MET Norway), Gunilla Svensson (SU), Matthieu Chevallier (CNRS-GAME, Météo-France) and Jonny Day (UREAD) are all members of the PPP steering group; Francois Massonnet (UCL) is a CliC YOPP fellow, who plays a key role in defining WCRP-CliC’s efforts in support of YOPP; APECS is partner in the development of the YOPP educational component.

APPLICATE will also contribute to upcoming IPCC scientific assessments:

- APPLICATE will carry out a thorough assessment of CMIP6 models in the Arctic by employing novel metrics and new observational data sets. The assessment will provide insight into the fidelity of CMIP6 models in simulating Arctic key processes, an aspect that was identified in the previous IPCC report as a weakness of the models available at the time.
- Coordinated experimentation carried out in APPLICATE will, for the first time, provide robust insight into the impact that Arctic climate change will have on the weather and climate of the Northern Hemisphere, including the ocean and extreme events.
- APPLICATE will provide insight into how model enhancements will (i) improve model fidelity in the Arctic, (ii) influence the response to enhanced greenhouse gas concentrations, and (iii) influence the impact of Arctic climate on lower latitudes.
- APPLICATE will explore the concept of emergent constraints for the Arctic to reduce the uncertainty of climate change projections.

APPLICATE will make significant contributions to the C3S by contributing to the following elements of the portfolio of service products:

- **Global reanalyses** will be improved especially through analysis of strength and short-comings of existing systems; through the provision of more realistic models (e.g. representation of sea ice); and by guidance for the design of an improved Arctic observing system.
- **Multi-model seasonal forecasts** will be improved by enhancing some of Europe’s most advanced seasonal forecasting systems (Met Office, Météo-France and ECMWF) that contribute to the EUROSIP multi-model ensemble.
- **Climate projections at global and regional scales** will be considered in APPLICATE by assessing the realism of CMIP6 models; by exploring the concept of emergent constraints to narrow the uncertainty of projections; and by improving the representation of Arctic key-processes in European climate models participating in CMIP6. These activities have the potential to increase the trustworthiness of climate change projections and thus contribute to developing mitigation strategies that are in line with the outcome of Paris 2015 UN climate change conference (COP21), namely to keep a global temperature rise this century well below 2 degC and to drive efforts to limit the temperature increase even further to 1.5 degC above pre-industrial levels. On top of this, substantial efforts to support the provision of information for adaptation strategies to climate variability and change, both in the Arctic and beyond, have been planned in APPLICATE. It is hoped that these efforts will satisfy some of the adaptation recommendations raised by the participants at the COP21.

*Expected Impact 10:* “Improve the professional skills and competences for those working and being trained to work within this subject area”

APPLICATE directly contributes to the education and training of the next generation of polar scientists by developing a strong educational program in collaboration with APECS that will increase the professional skills and
competences. With its extensive experience in providing training and opportunities for early career researchers and in promoting education as an integral component of polar research, APECS is an effective channel for increasing the impacts of APPLICATE.

The APPLICATE education plan, which will be aligned with the educational component of YOPP, will:
- Provide online training materials and recordings of online activities (e.g. webinars) accumulated into an online repository serving as a legacy of APPLICATE for the next generation of scientists and early career experts
- Include an open and free online course on “Advancing predictive capacity of Northern Hemisphere weather and climate”
- Organise a unique and high-level summer school for PhD students and postdoctoral researchers and in connection to YOPP Summer School covering some of the theories and methods used within APPLICATE.

Furthermore, APPLICATE partners will incorporate relevant new knowledge in “in-house” training activities such as seminars, university lectures and courses on weather and climate prediction.

2.1.2. Any other substantial impacts not mentioned in the work programme

APPLICATE provides substantial further impacts that go well beyond the impacts mentioned in the work programme:
- Although the focus of the research will be on the Northern Hemisphere in general and the Arctic region in particular, significant indirect benefits can be expected for the Southern Hemisphere and Antarctica as well. This is especially true for the area of model development and for research activities related to the improvement of initial conditions and observing system design. Furthermore, some of the research activities could provide a blueprint for corresponding activities for the Southern Hemisphere (e.g., coordinated experiments aimed at understanding the impact on mid-latitude weather and climate).
- The use of global forecasting systems in APPLICATE opens up the opportunity for other communities to exploit the data in a different context. Perhaps one of the most prominent examples is the global YOFP Analysis and Forecast Data Set provided through APPLICATE and made available to the public already during the project. This data set will include high-resolution analysis and forecast fields (out to 14 days) for the YOFP core period from mid-2017 to mid-2019. Strong interest for using this data set has been expressed by the Science Steering Committee of the Years of the Maritime Continent (YMC) – an international programme with the goal of Observing the weather-climate system of the Earth’s largest archipelago to improve understanding and prediction of its local and global variability (see letter of commitment by the co-chairs of the YMC).

Thus, APPLICATE has not only the potential to improve mid-latitude predictions directly from an Arctic but also indirectly from a tropical perspective. In the context of the outcome of the COP21 last December in Paris, the APPLICATE partners will follow closely the developments of the new mitigation and adaptation agendas, particularly in Europe, and will be flexible to adapt its activities to the priorities identified, particularly in aspects like the illustration of the Arctic vulnerability and the additional need for adaptation to the potential influence of a changing Arctic into lower latitudes.
- The unique combination of weather and climate science experts in the consortium performing novel studies on state-of-the-art prediction systems will demonstrate the effectiveness of applying sophisticated diagnostics across time scales, common model developments and identify key elements of future seamless prediction systems. This benefit is by no means limited to polar applications but applicable to all latitudes. It also links to similar joint activities focusing on the computing and data handling aspects of weather and climate prediction that is established in the Centre of Excellence in Simulation of Weather and Climate in Europe (ESiWACE).

Several partners of APPLICATE are also involved in this project, namely ECMWF, Met Office, BSC, CERFACS.

2.1.3. Barriers/obstacles for achieving expected impacts

APPLICATE represents the first concerted effort at a European level to address the challenges of (i) enhancing predictive capacity in the Arctic and (ii) determining the impact of Arctic climate change on the weather and climate in Northern Hemisphere mid-latitudes. However, a longer-term commitment in the assessment of the impact of an improved predictive capacity can be anticipated from all stakeholders to overcome one of the biggest challenges that the weather and climate prediction communities are facing and to provide a sustained return for society – both in Europe and beyond.

Traditionally, there is lack of “open data” culture in the community, particularly when it comes to operational data. APPLICATE will apply the open policy requested by the EC and will actively look for external partners interested in exploring relevant output of the experiments performed in the framework of the project. An example for this
approach is the provision of the YOPP Analysis and Forecast Dataset, a two-year long time series covering the YOPP core period.

There is a gap in the understanding of cultural differences between local communities and the scientific community, particularly those in the natural sciences. This may pose obstacles when it comes to effectively engaging with local communities. This issue will be addressed by building on existing networks.

There is a lack of consensus on the impact of a changing Arctic on lower latitudes weather and climate. Consensus may be necessary, however, to engage some of the potentially interested parties (European energy sector, crop yield forecasters and agricultural managers etc.) in the project from the beginning. The participation of the project partners in several international fora where these issues are discussed in detail will allow the project to be kept updated on the progress in other continents and promote the conclusions reached during the project implementation. Besides, the stakeholders will be kept regularly informed, using an appropriate language, of the conclusions of the scientific community about this important issue.

Finally, there may be a possible lack of well-trained personnel on issues such as the end-user engagement in high latitudes or climate modelling to start the work at strength from the early stages of the project. The partners have a strong reputation in the field of modelling, prediction, user-engagement and education, which should help in attracting excellent personnel. Furthermore, the partners have started to identify profiles and engage with professional associations that could help to find the necessary workforce. In addition, some of the partners are increasingly engaged with student programmes at the graduate and master level (psychology, marketing, economy, etc.) where the appropriate profiles are formed.

2.2 Measures to maximise impact

To maximise the impact of the project activities and outcomes, APPLICATE has a strong emphasis on user engagement, dissemination and training. APPLICATE has selected three highly-experienced organizations with extensive experience in maximising impact: the Arctic Portal (AP), the Earth Sciences Department of the Barcelona Supercomputing Center (BSC), and the Association of Polar Early Career Scientists (APECS) represented by the UiT-Arctic University of Norway (UiT). In WP7 (User-engagement, dissemination and training), the three partners responsible for user engagement, dissemination and training and will be supported by AWI (the project coordinator).

AP has a very strong track record in communicating and disseminating the outcomes of scientific projects at local/national level (to national authorities and national associations), European level (to European institutions and associations) and circumpolar Arctic (to the Arctic Council, business community and organisations representing indigenous people). AP has extensive experience in engaging stakeholders and enabling exposure to Arctic-related information and data.

BSC is the supercomputing provider for public research in Spain with a strong programme in training in computing and big data. BSC has a dedicated communication team that has demonstrated the benefits of supercomputing to many different scientific fields, including weather, climate and air quality, and to engage with a wide range of stakeholders and users at different levels. In addition, the Earth Sciences Department hosts a team of multi-disciplinary scientists working to foster the development of climate services for both the public and private sectors, with a special focus on energy and food production and a special link to the Joint Research Centre of the European Commission. This team is pioneering the implementation of the principles of the different climate services frameworks, is involved in several C3S initiatives and is investing in the implementation of new user-engagement strategies.

APECS has an extensive experience in providing training and opportunities for career development for both traditional and alternative polar and cryosphere professions, as well as in promoting education and outreach as an integral component of polar research. By hosting a network of more than 5,000 polar researchers across disciplines and national boundaries APECS provides an effective channel for increasing the impacts of APPLICATE.

To achieve the maximum impact of APPLICATE, user engagement, dissemination and training will be developed to increase the awareness of the improved ability to predict Arctic changes and their impact on the weather and climate of the Northern Hemisphere amongst a wide range of users and stakeholders. APPLICATE will utilise modern communication tools for online facilitation and the most efficient channels for communication and dissemination of both information and data to users, stakeholders and the general public. This is augmented by tailor-made training activities to improve the professional skills and competences among those working within this subject area.
A crucial step towards maximising impact is to identify the **key, primary and secondary users**, and engage them in two-way communication and co-production of results. In order to do this effectively, the appropriate and tested structures need to be in place. Especially in the area of user identification, APPLICATE will build on previous experiences, including relevant users that have been identified in initiatives implemented by APPLICATE partners: YOPP, Polar Prediction Project, PRIMAVERA, EUPORIAS, EU-PolarNet, European Climate Research Alliance, IMO, WCRP, WWRP, RCOFs, WMO, ClimatEurope, ESCAPE, ACCESS, WISC, SECTEUR, Preparatory Action on Strategic Environmental Impact Assessment of Development of the Arctic, ICE-ARC, INTERACT, and others. APPLICATE defines users by three categories:

(i) **Key users: Scientific community and intergovernmental organisations** benefit from advancements in model development, predictive capacity and understanding of the impact of Arctic changes on the weather and climate of the Northern Hemisphere as well as from educational activities. There is a wide range of beneficiaries, from individual scientists working on related topics all the way to networks of scientists working collaboratively together in networks and projects (e.g. US Sea Ice Prediction Network and US CLIVAR Arctic-Midlatitude Working Group). Furthermore, research departments in operational weather and climate prediction centres with an interest in polar regions will directly benefit. Importantly, APPLICATE will directly support coordinated international research efforts. Enabling development of improved weather and environmental prediction services for the polar regions, on time scales from hours to seasonal, for example, will directly benefit the World Meteorological Organization's (WMO) Polar Prediction Project within WWRP. APPLICATE outputs will also be relevant to scientific community umbrella institutions and projects such as the European Climate Research Alliance (ECRA), International Arctic Science Committee (IASC), EU-PolarNet, as well as to the working groups of the Arctic Council and experts of international organisations such as the International Maritime Organisation (IMO). APPLICATE partners have strong links to these organizations and communities, with many consortium members being directly involved within their activities.

(ii) **Primary users: Private sector stakeholders** benefit from enhanced operational predictive capacity across time scales. The forecast improvements at hourly-to-decadal timescales developed by APPLICATE will lead directly to improved services for the economic sectors that rely on forecasts. Insurance, shipping, tourism, mining and fisheries industries are increasingly in need of weather and climate information on these timescales and effective transfer of new knowledge is a crucial component. APPLICATE members have strong relations with stakeholders within Europe and beyond (e.g. ECMWF has 22 European member states and 12 cooperating states). This allows not only user needs to be incorporated into the development of forecasting systems, but also the exploration of well-established two-way communication channels between the consortium and those needing trustworthy forecasts on which to make decisions. Outputs of APPLICATE will directly contribute to private sector stakeholders allowing them to adjust products and services according to science-based information. **Public sector stakeholders** benefit directly from the improved forecasting capacity provided by APPLICATE. Already established national networks of APPLICATE consortium members together with engaged national authorities will become effective co-designers of APPLICATE via workshops, the User Group and feedback tools. Active engagement in APPLICATE will help the public sector to shape the necessary actions and instruments (including financial) to address future challenges. As the accurate weather and climate predictions are of high importance to public sector stakeholders, not only in the Arctic but also in mid-latitudes, APPLICATE will communicate with targeted users on the national level with face-to-face meetings. Direct engagement of users via workshops, meetings and User Group builds trust and understanding and incorporates user requests and suggestions in APPLICATE activities, which eventually provides public sector stakeholders with the information they need to make high quality decisions. Active engagement and the two-way information exchange between APPLICATE and its key and primary users provides stakeholders with access to the expert network, serves as an additional link between science, private and public sectors, and therefore supports smart, sustainable and inclusive growth in accordance with the Europe 2020 strategy.

(iii) **Secondary users: General public/society/communities including indigenous peoples** – weather and climate change can have large impacts on the environment and human societies. Climate change and weather extremes (such as flooding, fires, storm surges, heat waves and severe snowstorms) are therefore areas of great interest to the global community. Specific communities, however, are more likely to be engaged with specific issues, e.g. indigenous peoples in the Arctic and the impacts of regional Arctic climate change. The main outcomes of APPLICATE, that is an improved ability to simulate and predict changes in the Arctic and their impacts on the
weather and climate of the Northern Hemisphere, will be of great interest to the general public and to specific communities.

a) DISSEMINATION AND EXPLOITATION OF RESULTS
APPLICATE’s dissemination strategy covers all WPs, but it is specifically addressed in WP7: User engagement, dissemination and training is implemented by AP, BSC, and APECS represented by UiT. All APPLICATE partners have a solid track record of disseminating project results and pro-actively engaging users and stakeholders. APPLICATE will actively build upon the outreach activities of related national, European and international Arctic initiatives. Importantly, APPLICATE will work closely together with YOPP, as well as the upcoming BG9 and BG11 projects funded by Horizon2020 to multiply the effect of dissemination and user engagement. This section describes the strategic approach that will be taken within APPLICATE to disseminate and maximize the impact of the project through dissemination, user engagement and training. The plan also addresses synergies with other relevant projects and initiatives, follow-up and exploitation, open research data, knowledge management, IPR and open access. More detailed plans will be produced at the beginning of the project relating to communication and dissemination (D7.2), user engagement (D7.3) and training (D7.4) to define the most relevant timeframes and sequences of interactions. These individual plans will be consistent with each other and will be revised and updated when needed to ensure their integration into the project as a whole.

The implementation of the dissemination and exploitation strategy will rely on the following critical pro-active approaches:

- Integration of dissemination and communication efforts throughout and within APPLICATE;
- Effectiveness of communication flow within APPLICATE and with users;
- Involvement of stakeholders in an active dialogue with APPLICATE to elicit user need and perspectives;
- Diversity of dissemination and two-way communication tools according to different audiences;
- Accessibility of disseminated results and project legacy;
- Co-production of outcomes and results with users and stakeholders;

The APPLICATE’s strategic approach will be flexible, innovative and user-relevant and will include the following components to develop the approaches mentioned above:

a.1) DISSEMINATION
Dissemination aims at maximizing exposure of the science produced to all audiences (scientists, end-users, stakeholders and the public at large) and aims at communicating project results, including collecting all available feedback, in order to assure knowledge sharing and knowledge exchange with stakeholders. Successful dissemination requires a comprehensive understanding of the perspective and needs of different audiences. We propose a comprehensive set of modern communication tools for online facilitation, and the most efficient channels for communication, dissemination and exploitation including:

- **APPLICATE Website:** The APPLICATE official website (we have purchased the www.appli cate.eu domain) will provide a high-level description of the project and its objectives aimed at the general public and users. The website will also contain more detailed outputs, such as links to scientific publications, public reports, general information, and news and dissemination material. Initially, the website will be set up to provide a project identify (for example, providing visual identity materials and templates for partners in their password protected area) and promote early engagement with other EU projects, international initiatives and communities. In the second phase, the structure and content will be critically revised, taking into account feedback collected from both partners and stakeholders, and modified accordingly (MS7.5) to serve more specific needs: promoting project results with high impact multimedia communication material, disseminating promotional campaigns of the project through social media (Facebook and Twitter accounts), publishing press releases and providing online feedback mechanisms to the target audiences, including the users and stakeholders contacted in Task 7.2. The website will include a compilation of strain ing resources relevant for early career researchers in the APPLICATE project. Maintenance and updates of on-line content will be outlined in the communication and dissemination plan (D7.2).

- **Social media campaign:** The social media campaign covering Facebook and Twitter will utilise the modern forms of communicating science to wide audiences across the globe. By regular updates on project progress, news and events, activities and results, as well as information related to relevant APPLICATE topics, the social media campaign will assure strong online visibility of the project. Using visual forms of communication including photos, graphs, maps etc. we intend to make APPLICATE more attractive and accessible to the
general audience. The campaign will also take advantage of all partners’ social media resources to multiply the dissemination effect and visibility of the project.

- **Visual identity materials:** APPLICATE visual identity materials including the APPLICATE logo, letterhead, report template, meeting template, and power point templates will provide consistent branding for the project.
- **Dissemination materials:** Dissemination materials will be created to present a selection of project activities and results. Material will be mainly online (although some printed material will be made available at key events) and will including brochures, leaflets, factsheets, etc. The materials will be made available in different versions to accommodate to the various levels of experience in weather and climate and needs of those audiences and will be revised regularly to accommodate the feedback provided by the three categories of users. Materials will be available in English. The communication departments of the APPLICATE partners will support dissemination materials with national languages versions where appropriate.
- **Press releases:** In addition to engagement with various users, APPLICATE proposes targeted media outreach action involving national newspapers, media outlets specialising in weather and climate (e.g. climatebrief.org), and EU policy and specialist media. Building upon media interest, APPLICATE will develop targeted press releases for both the general and specialist press to share results of the project with a wider audience. Press releases will include both information material and visual materials i.e. graphs, photos etc. The communication departments of the APPLICATE partners will support press releases with national languages versions where appropriate.
- **Project reports:** The project deliverables that are in report format and defined as public will be made openly accessible on the APPLICATE website to widely share useful results and conclusions.
- **Papers for peer-reviewed literature:** Scientific papers created within APPLICATE will be published in open access peer-reviewed literature to reach the scientific community. Scientific papers will be advertised through the website.
- **Promotion and dissemination of results in international fora of relevance:** To strengthen the role of the project as a base of cutting edge research, the project will be advertised and explained during relevant international events, particularly outside the EU. Additional promotion, dissemination of results and illustration of the implications (e.g. impact and opportunities for socioeconomic sectors) will help strengthen project recognition and role of the EU in commissioning internationally leading research. Special attention will be given to the interaction with other projects with a strong coordination and support objectives (H2020 ClimatEurope, C3S activities, and especially the contribution to YOPP).

**Table 3 First list of selected international fora of relevance**

<table>
<thead>
<tr>
<th>Event name</th>
<th>Expected audience</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>YOPP planning meetings</td>
<td>Scientists, operational prediction centres, observational community, projects and institutions that plan to make significant contributions to YOPP</td>
<td>Sep 2016</td>
</tr>
<tr>
<td>YOPP launch event</td>
<td>Scientists, national weather services, WMO member state representatives, international organizations stakeholders, general public</td>
<td>Jun 2017</td>
</tr>
<tr>
<td>Arctic Circle 2017-20</td>
<td>Stakeholders, policy makers, scientists</td>
<td>Oct 2017-20</td>
</tr>
<tr>
<td>Arctic Frontiers 2017-20</td>
<td>Stakeholders, policy makers, scientists</td>
<td>Jan 2017-20</td>
</tr>
<tr>
<td>EGU 2017-20 (scientific sessions, town-hall meetings)</td>
<td>Scientists, press</td>
<td>Apr 2017-20</td>
</tr>
<tr>
<td>Arctic Science Summit Week 2017-2020</td>
<td>Scientists, Arctic Council, press</td>
<td>Mar 2017-20</td>
</tr>
</tbody>
</table>

- **FrostBytes videos:** Production of FrostBytes videos, which are short videos (up to 60 seconds) from the Summer School that explain to the general public what research participants are conducting (public outreach activity). FrostBytes will be also posted on external websites, for instance, that of APECS.
- **On-line training material:** APPLICATE aims to promote the next generation of polar scientists. To this end an on-line repository of training materials will be created by APPLICATE jointly with APECS. This repository includes recordings of the webinar series and online courses provided as an open resource on the websites of the APPLICATE project and that of APECS.

### a.2) USER ENGAGEMENT

To maximise impact and knowledge exchange and to elicit feedback from users, it is crucial to proactively engage with groups of interest within and outside the EU. The APPLICATE partners have developed over time a network
of contacts among potential users and stakeholders. Private-sector stakeholders include companies involved in polar shipping such as the Arctic Expedition Cruise operators (Friggs, Hapag-Lloyd), shipping companies (A.P. Møller-Maersk, COSCO, Hanjin Shipping Company, Mitsui O.S.K. Lines, ICS), the insurance industry with emphasis on Shipping and Polar Code issues (DWF London, Lloyd's, GARD, Norwegian Hull CLUB, DNV GL, Marsh's Global, SKULD), research expedition logistics, etc. Furthermore, we plan to engage large consulting companies with previous experience regarding the Arctic (McKinsey & Company, the Boston Consulting Group, Bain & Company, Deloitte Consulting, Booz Allen Hamilton, PricewaterhouseCoopers Advisory Services LLC, EY LLP Consulting Practice, Accenture, KPMG LLG Consulting Practice, IBM Global Business Services). Representatives of relevant regional and global mining companies (Glencore Xtrata, BHP Billiton, Rio Tinto, Vale, Anglo American, China Shenhua Energy, Freeport McMoRan, Barrick Gold, Coal India Limited, Fortescue Metals Group) will be encouraged to participate in user engagement activities. Banks, investment firms and business analysts (PT Capital, Commerzbank Germany, Credit AgricolCIB France, HSBC Holdings PLC United Kingdom, BNP Paribas France, China International Capital Corporation, Mizuho Financial Group, Mitsubishi UFJ Financial Group, Mitsubishi UFJ Financial Group) are also potentially interested in APPLICATE results. The users will be invited to participate in the APPLICATE.

In the mid-latitudes, there is also strong interest in the impacts and opportunities of potential changes in the Arctic and related changes in lower latitudes of the Northern hemisphere from users in the energy sector. Users that have already expressed an interest include energy trading firms (EnBW, EDF trading), transmission system operators (UK National Grid, Red Eléctrica Spain, France TSO RTE), wind farm owners/investors (EDPR, GE, IBERDROLA) and energy consultants (DNV-GL, AWS Truewind, Vortex). Agriculture related stakeholders such as the Joint Research Center or private wineries (Torres, Sogrape) will also be engaged.

The full list of users that will be approached by APPLICATE will be categorized in key, primary and secondary users as described above and further detailed in the user engagement plan (D7.3) with their level of use of weather and climate information. Engaging users will be based on three main components:

- **User Group**: A group of users and stakeholders will be established. This will help support the APPLICATE by providing, i) an external user-specific perspective and feedback on the relevance and presentation of project outcomes and ii) an external perspective on user needs. The group will be composed from 7-10 representatives from private and public sector stakeholders. The WP7 co-leads will chair the group and organize its meetings. The group will meet regularly either in person or on-line.

- **Workshops, meetings at professional conferences and interviews with key stakeholders**: To illustrate the benefits of improved weather and climate forecasts to a range of stakeholders in the Arctic and mid-latitudes, APPLICATE partners will participate in relevant external events or initiatives organized by the target sectors (half-a-day events at professional conferences rather than general-purpose workshops). APPLICATE workshops and interviews will provide direct feedback from a user perspective by actors not usually linked to the weather and climate research communities. These activities will be jointly organized with other EU projects such as PRIMAVERA, IMPREX or C3S contracts such as CLIM4ENERGY, WISC and SECTEUR.

- **Virtual consultations and surveys**: An on-line user feedback tool for collecting feedback and organizing virtual consultations will improve the interaction with the stakeholders identified by the project. The virtual tools will provide additional feedback mechanisms and traceability (always respecting all due confidentiality), while providing a wider perspective on the challenges, discrepancies, misconceptions and important issues overlooked by the experts. The outcome of this task will be provided to the key players in the C3S User Interface Platform to ensure a long-lasting and wider impact of this effort.

By continuously taking into account user needs via the User Group, workshops and meetings at professional conferences, interviews with key stakeholders and virtual consultations and surveys APPLICATE will increase the stakeholder-relevance of its research and hence directly improve stakeholders’ capacity to adapt to climate change. By pro-active user-engagement the latest advances in forecasting system development can be effectively communicated to and benefit those economic sectors that rely on improved forecasting capacity. Furthermore, knowledge exchange with and feedback from users within APPLICATE will be utilized to contribute to YOPP, IPCC scientific assessments, and to the C3S.

**a.3) TRAINING**

Training aims to improve the professional skills and competences of those working and being trained to work within this subject area. We see the training component as the legacy that APPLICATE creates towards the next generations of scientists and early career experts. All training materials, recorded webinars, lectures and presentations from the summer school will be provided as an open resource on the website of APPLICATE and the
website of APECS. The tailor-made set of training activities will include:

- **On-line networking tools:** Networking tools for increasing connection and training opportunities for early career researchers will include: a) an email list, b) the compilation of a thematic website with skill training resources relevant for early career researchers in the APPLICATE and the other projects that will serve as an open resource, and c) dedicated “mentor” sessions connecting early career and senior researchers involved in the project at meetings and workshops related to the project throughout the project.

- **Webinar series:** Webinar series in connection with the APPLICATE project and directed towards early career researchers (but open to the general public) will introduce the APPLICATE project and increase the awareness about the impact of Arctic changes on the weather and climate of the Northern Hemisphere. The webinars will be recorded and provided as an open resource on the websites of the APPLICATE project and APECS.

- **On-line course:** An online three-month course on “Advancing predictive capacity of Northern Hemisphere weather and climate” will be organized for early career scientists (but open to anyone interested) with weekly interactive online sessions. Materials will be provided as an open resource on the websites of the APPLICATE project and APECS.

- **Summer school:** A Summer School for PhD students and postdoctoral researchers from APPLICATE partners organized jointly with the YOPP Summer School will provide a unique, high-level, summer school program for 30 PhD students and postdoctoral researchers, covering some of the theories and methods used within the research project. This 10-day training course will be organized by UiT and other project partners in cooperation with other external partners. Members of APPLICATE are running a Polar Prediction School in April 2016 organized by WCRP-CliC and APECS in Abisko Field Station, in Northern Sweden. The APPLICATE summer school will build on this experience and aim at including YOPP as co-sponsor for the proposed summer school. Participants of the summer school will also create short FrostBytes videos on their research projects. FrostBytes and materials from the summer school will be provided as an open resource on the websites of the APPLICATE project and APECS.

a.4) Synergies with EU projects, international committees and steering groups

Effective coordination and communication with other national, European and international activities will be a key factor for maximizing the impact of APPLICATE. As outlined in WP8 on Clustering, this will be achieved through a pro-active approach towards cooperation with relevant ongoing activities. However, APPLICATE will also exploit the fact that many of its PIs participate in relevant EU projects, international committees and steering groups (Table 2.2.2). These PIs will serve as ambassadors for APPLICATE and help to widely disseminate relevant project information to the scientific community, policy makers and stakeholders.

Table 4 **APPLICATE synergies with other initiatives through selected project ambassadors**

<table>
<thead>
<tr>
<th>Partner</th>
<th>Project/committee</th>
</tr>
</thead>
</table>
| T. Jung, AWI     | - Chair of the steering group of the Polar Prediction Project overseeing the planning and implementation of YOPP  
                  | - Co-chair of the Arctic programme of the European Climate Research Alliance (ECRA)  
                  | - Member of the WMO Executive Council Panel of Experts on Polar Observations, Research and Services (EC-PORS, since 2011)  
                  | - Coordinator of the Galway theme *Arctic-Atlantic Interplay*  
                  | - Member of the US CLIVAR Arctic-Midlatitude Working Group  |
| F. Doblas-Reyes, BSC | - Coordinator of the FP7 project SPECS  
                    | - Co-chair of the World WCRP’s Working Group on Seasonal to Interannual Prediction  
                    | - Member of the World Climate Research Programme's Modelling Advisory Council  
                    | - Member of the ENES High-Performance Computing Task Force  
                    | - Member of the H2020 ClimatEurope Coordination and Support Action  |
| P. Bauer, ECMWF   | - Coordinator of the H2020 project ESCAPE  
                    | - Co-coordinator of the H2020 project ESiWACE  
                    | - Member of the WWRP Scientific Steering Committee  
                    | - Member of the PPP steering group  
                    | - Member of the European Space Agency Scientific Advisory Committee  |
| H. Johannsson, AP | - Chair of Outreach Board of China-Iceland Aurora Observatory station  
                    | - Member of the consultancy panel of the H2020 project EU-PolarNet  
                    | - Member of the steering group of the European Polar Board  
                    | - Member of the Steering Group of SAON  |
a.5) Follow-up and exploitation

APPLICATE is committed to continue research after the end of the project funding period and to continue the exploitation of the results produced within the project. This includes, for example, the implementation of APPLICATE results into operational prediction systems and the incorporation of sea ice-ocean models in ‘weather’ prediction. Many of these exploitation activities (e.g. operational implementation and publications) will be carried out under the umbrella of the YOPP Consolidation Phase (mid-2019 to 2022, Jung et al. 2014b), whose purpose it is to generate a long-term legacy. It is also our ambition to strengthen the network that will contribute to the research on the impact of Arctic changes on the weather and climate of the Northern Hemisphere. We are convinced that our dissemination strategy approaches will be of interest to a wide audience, which will result in future opportunities to continue the research.

The consortium will closely monitor funding possibilities including the Horizon 2020 programme. Supported by the consortium and its User Group, the Project Coordinator will maintain a constant dialogue with relevant representatives from National Contact Points for the APPLICATE consortium to be able to provide input to the planned funding instruments and Horizon 2020 draft Work Programmes. Furthermore, special attention will be paid to the funding instruments for transatlantic cooperation regarding research on forecasting system development and the impacts of Arctic changes on the weather and climate globally. APPLICATE has also received commitment letters from the Korea Maritime Institute and the Polar Research Institute of China and will seek further cooperation and funding possibilities. Finally, the Project Coordinator will give annual status updates to the Advisory Board on potential follow-up and exploitation of results. Additionally, calls for proposals under national funding agencies will be monitored.

a.6) Open Research Data

The APPLICATE partners are expected to produce a large number of weather and climate simulations. These simulations are of very different character because they try to respond to various questions, which are linked between them through the Arctic focus of their origin. At the same time, the public availability of the data produced is a key part of the dissemination in a project of this type. The heterogeneity of the simulations made the partners in charge of this task to consider a holistic approach. In this approach, the documentation of the experiments, the data formatting with an appropriate documentation, the technology chosen for the dissemination, the data curation and the assurance that the methodology chosen complies with the standards of the different communities involved (both weather and climate) will be considered in a single plan for data dissemination.

The project will produce mostly model data. As indicated in Tab. 2, most of the data will be made publicly available. This is especially true for all multi-model experiments, including those designed to establish the impact of Arctic climate change on mid-latitudes. A large number of forecast experiments will be also made publicly available. This includes seasonal forecasting experiments carried out in WP5 as well as the YOPP Analysis and Forecast Data Set (produced and disseminated in WP6). Some of the observational data sets gathered for model evaluation will be considered for dissemination through the Obs4MIP data-base.

APPLICATE data management is based on a metadata driven approach through which standardised discovery metadata (compatible with GCMD DIF and ISO19115) are used to describe datasets and interfaces to these. Formatting data using NetCDF following the Climate and Forecast convention provides self-explaining datasets which relates to UNIDATAs Common Data Model allowing automated utilisation of the datasets and long term data preservation. All results will be maintained for at least 10 years. Metadata will be exposed using OAI-PMH and data using THREDDS Data Server and HTTP, OGC WMS and OPeNDAP primarily.

a.7) Knowledge management, Intellectual Property Rights and open access
The management of Intellectual Property Rights (IPR) for APPLICATE will be the responsibility of the Management Support Team. This Team will follow up publications, licensing, patents and other exploitation of the results. They will advise the Coordinator and the partners about IPR issues. The IPR and confidentiality issues will be developed in the Consortium Agreement. The Management Support Team is in charge of advising and warning the Coordinator and Partners about the management of the pre-existing know-how and knowledge. By doing so, the team will anticipate and help solving the problems of IPR shares at the start of the project, provide advice about possible extensions of the tasks that offer new patenting possibilities, and deliver a fair and efficient use of the knowledge produced by APPLICATE. All scientific publications made during the project will be made available in a project repository according to the “gold” model for open access. However, APPLICATE strongly advises all authors to consider using the “green” model for open access.

b) COMMUNICATION ACTIVITIES

Communication in APPLICATE is designed to develop and utilize the most relevant forms of communication within and outside the EU (and possibly national) services to adequately spread results that could be used for either policy or socioeconomic action. APPLICATE will update the outline provided below in the Communication and dissemination plan (D7.2) to define the goals and objectives of communication, and to provide a full framework for the development of communication tasks along the lifetime of the project detailing target audiences, communication tools and channels, key messages and practical information such as branding project style, logo, guide, templates, etc. This plan will be revised and updated during the project lifetime.

- **Internal** communication within APPLICATE will assist with timely completion of tasks and deliverables and contribute towards a better integration through and across WPs. Face-to-face and online meetings of APPLICATE teams and the yearly General Assembly will strengthen the scientific-relations between consortium members. Mailing lists and personalized user accounts on the APPLICATE website, as well as joint groups on APPLICATE’s Facebook account will contribute to the smooth implementation of the project. Communication via email, video conferencing, Skype and phone will be encouraged to contribute to the cost effectiveness, family friendliness and reduced environmental impact of APPLICATE activities (for example, through JPI-Climate Friendly Research policy). By this informal, yet effective communication approach APPLICATE promotes openness and aims at creating a flexible working environment.

- The APPLICATE **external** communication will be based on communication principles outlined in H2020’s ‘Communicating EU research and innovation guidance for project participants’ document as published on 25 September 2014. To ensure the cost effectiveness of the external communication, APPLICATE will follow the EU principles of economy, effectiveness and efficiency, as it will be described in the Grant Agreement. Specifically with regard to the communication means, online digital methods will be used whenever possible. These will be backed up by printed or physical communications tools only where necessary (including APPLICATE leaflets, roll-ups and brochures). APPLICATE consortium members rely on experienced and widely connected communication services of their institutions. Highly-experienced teams of the Arctic Portal (AP), Science Communication, Earth Sciences Department of the Barcelona Supercomputing Center (BSC), and APECS represented by the UiT-Arctic University of Norway (UIT) will be responsible for the external communication of APPLICATE. The communication will further benefit from the support of the communications service of all the consortium members, and from the experience of AWI from EU-PolarNet and other international projects and activities.

Table 5 APPLICATE communication activities by target audience

<table>
<thead>
<tr>
<th>Target audience</th>
<th>Communication measures</th>
<th>Objective</th>
<th>WPs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific community and intergovernmental organisations i.e.: WMO, PPP, WWRP, ECRA, SIPN, CLIVAR, IASC, EU-PolarNet, AC, IMO.</td>
<td>- Website <a href="http://www.apPLICATE.eu">www.apPLICATE.eu</a>&lt;br&gt;- Social Media campaign&lt;br&gt;- Visual identity materials&lt;br&gt;- Dissemination materials&lt;br&gt;- Press releases&lt;br&gt;- Project reports&lt;br&gt;- Papers for peer-reviewed literature&lt;br&gt;- Promotion and dissemination of results in international fora of relevance</td>
<td>- provide an online information repository on APPLICATE&lt;br&gt;- utilize modern forms of communicating science&lt;br&gt;- provide consistent branding/recognition of APPLICATE&lt;br&gt;- present project activities and results&lt;br&gt;- provide information to experts from topic-oriented press&lt;br&gt;- sharing result and conclusions of APPLICATE</td>
<td>7</td>
</tr>
</tbody>
</table>
| | - FrostBytes videos  
| | - On-line Training material  
| | - Workshops, meetings at professional conferences and interviews with key stakeholders  
| | - Virtual consultations and surveys  
| | - contribute to the scientific community  
| | - strengthen recognition of APPLICATE and the EU as a state-of-the-art research provider  
| | - explain what research participants are conducting  
| | - support the next generation of polar scientists  
| | - illustrate the benefits of weather and climate forecasts with improved polar representation  
| | - provide a wider perspective from scientific community  
| |  
| | - General Assemblies (GAs)  
| | - Work Package meetings  
| | - Website www.applicate.eu  
| | - Mailing lists  
| | - Password protected area of the website  
| | - internal communication  
| | - better information flow  
| | - provide central information point for APPLICATE  
| | - organized and efficient internal communication  
| | - internal area dedicated for consortium members  
| |  
| | - On-line networking tools  
| | - Webinar series  
| | - On-line course  
| | - Summer school  
| | - Website www.applicate.eu  
| | - Social Media campaign  
| | - increase connection to YOPP and other initiatives  
| | - increase training opportunities  
| | - provide education for 30 PhD students and postdoctoral researchers  
| | - provide an online information repository on APPLICATE  
| | - utilize modern forms of communicating science  
| |  
| | - User Group  
| | - Workshops, meetings at professional conferences and interviews with key stakeholders  
| | - Virtual consultations and surveys  
| | - Face-to-face meetings  
| | - Website www.applicate.eu  
| | - support the project with an external perspective  
| | - illustrate benefits of forecasts within APPLICATE and incorporate feedback from stakeholders  
| | - increase interaction with users  
| | - collect and exchange information and knowledge  
| | - general promotion and providing information  
| |  
| | - User Group  
| | - Workshops, meetings at professional conferences and interviews with key stakeholders  
| | - Virtual consultations and surveys  
| | - Face-to-face meetings  
| | - Website www.applicate.eu  
| | - support the project with an external perspective  
| | - illustrate benefits of forecasts within APPLICATE and incorporate feedback from stakeholders  
| | - increase interaction with users  
| | - collect and exchange information and knowledge  
| | - general promotion and providing information  
| |  
| | - Website www.applicate.eu  
| | - Social Media campaign  
| | - Dissemination materials  
| | - Press releases  
| | - Project reports  
| | - User Group  
| | - Workshops  
| | - FrostBytes videos  
| | - Virtual consultations and surveys  
| | - provide understanding on impacts and opportunities of potential changes in the Arctic  
| | - Raise awareness about APPLICATE  
| | - organize and maintain engagement to harness feedback from communities  

| APPLICATE consortium | 9, 7 |
| Polar Early Career Scientists | 7 |
| Private sector stakeholders (shipping, insurance industry, consulting companies, mining industry, banking and investment sector, energy sector) in the Arctic and in the mid-latitudes | 7 |
| Public sector stakeholders (EU and national policy makers, regional authorities, organizations, coast guards, ship-owners associations, chambers of commerce) | 7 |
| General public/society/communities including indigenous peoples | 7 |
### Media
- Website www.applicate.eu
- Dissemination materials
- Press releases
- FrostBytes videos
- Workshops, meetings at professional conferences and interviews with key stakeholders
- Provide an online information repository on APPLICATE
- Present project activities and results
- Provide popularized information to press
- Explain what research participants are conducting
- Illustrate the benefits of weather and climate forecasts with improved polar representation

### International fora outside the EU
- Social media campaign
- Visual identity materials
- Dissemination materials
- FrostBytes videos
- Integration with international stakeholders and projects
- Ensure project visibility

### EC Project Officer
- Project reports
- Inform on project progress and results

### Other EU bodies and projects
- Website www.applicate.eu
- Dissemination materials
- Press releases
- Understanding impacts and opportunities of potential changes in the Arctic
- Integration with other projects

### Implementation

#### 3.1 Work plan – Work packages, deliverables

The work plan builds on the iterative interaction between the different work packages centred around the central idea of using advanced metrics and diagnostics to observationally constrain weather and climate model (WP1); developing enhanced weather and climate models (WP3); determining the impact of Arctic climate change on mid-latitude weather and climate also considering linkages from a prediction perspective (WP3); providing support for the design of the future Arctic observing system (WP4); carrying our research on predictability and synthesising the results in order to deliver improved predictive capacity (WP5); supporting the scientific work packages through a strong data and HPC management component (WP6); employing effective user-engagement, dissemination of the results to a wide range of stakeholders and ensuring future recruitment opportunities by adequate education and training (WP7); ensuring effective collaboration with other ongoing and planned activities (WP8); and finally ensuring appropriate project management (WP9).

The dependencies and timings of the different work packages are presented in Figures 3 (Pert Chart) and 5 (Gantt Chart).
<table>
<thead>
<tr>
<th>WP 1</th>
<th>Task 1.1</th>
<th>Task 1.2</th>
<th>Task 1.3</th>
<th>Task 1.4</th>
<th>Task 1.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP 2</td>
<td>Task 2.1</td>
<td>Task 2.2</td>
<td>Task 2.3</td>
<td>D2.6</td>
<td></td>
</tr>
<tr>
<td>WP 3</td>
<td>Task 3.1</td>
<td>Task 3.2</td>
<td>Task 3.3</td>
<td>Task 3.4</td>
<td>Task 3.5</td>
</tr>
<tr>
<td>WP 4</td>
<td>Task 4.1</td>
<td>Task 4.2</td>
<td>Task 4.3</td>
<td>Task 4.4</td>
<td></td>
</tr>
<tr>
<td>WP 5</td>
<td>Task 5.1</td>
<td>Task 5.2</td>
<td>Task 5.3</td>
<td>Task 5.4</td>
<td>Task 5.5</td>
</tr>
<tr>
<td>WP 6</td>
<td>Task 6.1</td>
<td>Task 6.2</td>
<td>Task 6.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WP 7</td>
<td>Task 7.1</td>
<td>Task 7.2</td>
<td>Task 7.3</td>
<td>Task 7.4</td>
<td>Task 7.5</td>
</tr>
<tr>
<td>WP 8</td>
<td>Task 8.1</td>
<td>Task 8.2</td>
<td>Task 8.3</td>
<td>Task 8.4</td>
<td>Task 8.5</td>
</tr>
<tr>
<td>WP 9</td>
<td>Task 9.1</td>
<td>Task 9.2</td>
<td>Task 9.3</td>
<td>Task 9.4</td>
<td>Task 9.5</td>
</tr>
</tbody>
</table>

**Figure 5: Gantt Chart APPLICATE**
3.2 Management structure and procedures

3.2.1 Organisational Structure and decision making in the consortium

APPLICATE will bring together the expertise and know-how of 16 partners from 9 countries, forming an excellent network for advancing predictive capacity of the weather and climate of the Northern Hemisphere. Considering the size of the Consortium the organisational structure of APPLICATE has to be extremely efficient, allowing a fast and coherent decision-making process. The management structure of APPLICATE will thus be based on three levels, ensuring an efficient and success-oriented project management (Figure 6):

- **The decision making level:** This level consists of the APPLICATE General Assembly which will be the highest authority and the central body for strategic discussions within the project consortium, being responsible for the overall performance, the compliance with the Grant Agreement and its Annexes as well as with the Consortium Agreement.

- **The management level:** This level is shared by the Project Coordinator with his Management Support Team for operational management and the Executive Board for strategic management.

- **The executive level:** The WP leaders and Task Leaders within this level are responsible for carrying out all activities and tasks as described in the individual work packages, keeping close contact with the partners involved in specific tasks and WPs.

![APPLICATE Management Structure](image)

*Figure 6 APPLICATE Project Management Structure showing the reporting flows (solid arrows) and the feedback flows (dashed arrows) of the different management bodies and the decision making in APPLICATE.*

The composition, responsibilities and tasks of each Consortium body will be described in more detail below and will be formalised in the APPLICATE Consortium Agreement.

3.2.1.1 The General Assembly (GA)

The GA is the ultimate decision-making body of the consortium. It is responsible for the strategic policy and decision-making, and consists of one senior representative from all partners of the project. Guests from the Advisory Board, representing international partners and stakeholders, will assist and advise the GA in its decisions, without own voting rights.

The main role of the GA is to make sure that the strategy adopted for APPLICATE is respected and that the desired standards of excellence are achieved. The GA will decide on reorientations, validate project reviews and deal with any changes in the consortium. Further responsibilities of the GA include:

- Strategic planning and direction of the project and definition of the overall project strategy plan.
- Approval of the project deliverables in terms of quality and relevance as defined in the Grant Agreement.
- Approval of periodic and final reports to the EC.
- Review of project progress against milestones, approval of changes and recommendations for improvements in the work or dissemination plan.
- Approval of the project implementation plans and their associated financial plans and subsequent monitoring of technical and financial progress against deliverables.
- Approval of withdrawal, replacement or addition of consortium participants.
- Monitoring and implementation of any changes necessary in the Consortium Agreement.

The GA meets at least once a year, over the duration of the project. In order to facilitate the decision-making process, the GA is chaired by the Project Coordinator (PC), who consults with other members through intermediate meetings, when required by the project course.

3.2.1.2 The Project Coordinator (PC) and Management Support Team (MST)

The overall project management and coordination is the responsibility of AWI. The Project Coordinator of APPLICATE is Prof Thomas Jung, head of the Climate Dynamics Section at AWI. He has extensive experience in leading large-scale projects such as the Polar Prediction Project, which has established YOPP, and he oversees its planning and implementation. Furthermore, he is spokesperson of AWI’s research programme, PACES-II, which has an annual budget of about 140 million EUR and includes large-scale infrastructure such as the research icebreaker Polarstern.

The PC will lead the General Assembly and the Executive Board. Supported by the MST, the PC will manage the consortium as a whole and ensure that within APPLICATE all mechanisms are in place to ensure project progress and the successful achievement of all project objectives. He is the intermediary between the European Commission (EC) and the consortium in all matters, as well as in contribution-related concerns regarding allocations between participants and activities. The PC will be responsible for the day-to-day management and for collecting, reviewing and verifying consistency and submitting reports and deliverables to the EC. He will be the contact point for all disputes within the consortium and will present disputes, which cannot be resolved by mutual agreement, to the GA for final decision.

The Management Support Team will also be located at AWI to ensure the most efficient assistance to the PC in the day-to-day project management and in particular with the administrative, financial and contractual issues for APPLICATE. The MST is led by the project manager Nancy Lange, who has proven experience as a member of the management team of the FP7 collaborative project PAGE21, the H2020 coordination and support action EU-PolarNet and as project manager of the FP7 Marie Curie IRSES project IMCONet. She will be assisted by the project secretary. The responsibilities of the MST will be:

- Management of all administrative, contractual and financial aspects of the project, such as accurate scientific and financial reporting, and consortium management.
- Organisation of intra-consortium communication.
- Meeting and organisational support to the APPLICATE management bodies: GA, EB, AB and WP Leaders.
- Preparing the Grant Agreement, drafting and negotiating the Consortium Agreement and amendments.
- Setting up a quality management routine for the project management (standards of documents, proofreading, validation workflow), to be implemented from the outset of the project.
- Allocation of EC contribution to the beneficiaries in accordance with EC requirements and the Consortium Agreement.
- Advice to the Partners’ administrative and financial departments.
- Overseeing and manage gender issues and balance during the project and within the consortium.
- Development, monitoring and maintaining a risk management plan as a list of potential risks and mitigation measures.

3.2.1.3 The Executive Board (EB)

The role of the Executive Board is fundamental for the project: It will ensure the successful execution of the project by taking care of the coordination and correct implementation of the scientific project tasks. The EB reports to and is accountable to the GA. It will consist of the APPLICATE WP leaders and co-leaders and be chaired by the
Project Coordinator. International and external experts from the Advisory Board will be invited to meetings of the EB for assistance and advice as needed.

The role of the EB will be to ensure the successful implementation of all aspects of the project work plan and to formulate the overall strategy and development of the project, which will be proposed to the GA for discussion and decision. The EB’s main responsibilities will include:

- Delivery of the project work plan.
- Review of the project progress and the resources status.
- Facilitating the relationship of the project with other new and existing projects and strategic forums and initiatives related to enhancing the predictive capacity of Northern Hemisphere weather and climate.
- Ensuring the execution of the risk management plans of the project if necessary.
- Ensuring the smooth internal cooperation and relationship between consortium members as well as external project stakeholders.

The EB will meet at least quarterly, or more often as required in the course of the project. Any member of the EB can call for an extraordinary meeting by a written request. The meetings will be scheduled if possible in conjunction with other meetings such as the General Assemblies, but they will also be held via video- and teleconferences to reduce travel time and cost.

3.2.1.4 The Work Package and Task leaders

While the PC and the MST have the overall responsibility for the execution of the work plan, the work package leaders, in conjunction with the appointed task leaders, will conduct the project activities. They will collaborate closely, using a system of regular internal reporting. At least every third month, task leaders will summarise their progress towards project deliverables to the WP Leaders, who will review the activity against the work plan and, following discussion with the task leaders, consider if interim targets or measures are required. These reviews will also serve as the basis for more formal reports to the EB, PC, GA and, ultimately, the European Commission.

The WP leaders will be responsible for:

- Delivery of the WP objectives and management of tasks and deliverables.
- Management of the WP as a sub-project with regular WP meetings (video-teleconferenced/web-based virtual meetings, if appropriate).
- Frequent communication with the PC and the MST.
- Quarterly monitoring of the overall progress for each task in cooperation with the task leaders.
- Compilation and distribution of WP progress reports.
- Establishing and maintaining links with other WPs as necessary.
- Managing WP administrative issues, referring to the MST as necessary.
- Reporting to the EB, PC and MST.

The task leaders will be responsible for:

- Implementation of the individual tasks as set out in the work plan.
- Establishing and managing interactions between individual partners involved in the task.
- Reporting of task progress to WP leaders.
- Arranging individual task meetings (video-teleconferenced/web-based virtual meetings, if appropriate).
- Establishing and maintaining links to other tasks as necessary.

3.2.1.5 The Advisory Board (AB)

In addition to the Consortium bodies described above, APPLICATE will be supported by the Advisory Board. The AB comprises internationally recognised external experts in the fields of dynamics and prediction of weather and climate and representatives of the different stakeholder groups relevant to APPLICATE. In addition to those experts, the Coordinators of the funded projects under the topics H2020-BG09-2016 and H2020-BG10-2016 as well as the Coordinator(s) of the relevant projects funded under the Belmont Forum call on climate predictability and inter-regional linkages will be invited to become members of the APPLICATE AB. Due to its nature and composition, the AB will increase the international visibility of APPLICATE and strengthen the international collaboration in weather and climate predictions for the Northern Hemisphere as well as with other European initiatives and projects within this research area. Its role is to give recommendations and support to the strategic steering of the project in close collaboration with the EB and the GA. The AB will:

- Provide independent advice to the EB and the GA to support strategic decisions.
Critically review project progress (e.g. deliverables) to ensure their relevance and excellence and to provide important feedback to the APPLICATE consortium.

The members of the AB are appointed by the GA. The chair of the AB will be elected from and among the board members and recommended to the GA for approval. The following international experts have agreed to advise and support APPLICATE as members of the AB:

**Table 6 Members of the APPLICATE Advisory Board**

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cecilia Bitz</td>
<td>University of Washington</td>
<td>USA</td>
</tr>
<tr>
<td>Gilbert Brunet</td>
<td>Environment and Climate Change Canada</td>
<td>Canada</td>
</tr>
<tr>
<td>Clara Deser</td>
<td>National Centre for Atmospheric Research (NCAR)</td>
<td>USA</td>
</tr>
<tr>
<td>Veronica Eyring</td>
<td>Deutsches Zentrum für Luft- und Raumfahrt (DLR)</td>
<td>Germany</td>
</tr>
<tr>
<td>Inger Hansen-Bauer</td>
<td>Norwegian Meteorological Institute</td>
<td>Norway</td>
</tr>
<tr>
<td>Jean-Noel Thepaut</td>
<td>Copernicus Climate Change Service (C3S)</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Tero Vauraste</td>
<td>CEO Arctia Shipping</td>
<td>Finland</td>
</tr>
</tbody>
</table>

Ideally, meetings of the AB will take place adjacent to the yearly GA to give the AB members the opportunity to follow project progress most closely and to be directly involved in the discussions leading to strategic decisions. The GA and EB will seek the advice of the AB whenever it is necessary for the project course. They can call for extraordinary AB meetings or consult the AB members by video- or teleconferences and electronic communication.

### 3.2.2 Organisational structure and decision-making in relation to the project complexity and scale

APPLICATE adopts a management structure that takes into account the ambition of the project, as well as the size of its consortium. The management structure has been based on the structure used in previous projects of the participants where it has proven its effectiveness. It involves the sharing of responsibilities in both vertical and horizontal directions.

The **General Assembly** ensures that all 16 partners are represented in the decision-making process, with each of them having a voting right. The General Assembly and the Executive Board will be chaired by the **Project Coordinator**. The PC, together with the support of the **Management Support Team**, will take care of the day-to-day project management. The PC and his MST will play a key role in APPLICATE as central contact point for all project partners, the GA, EB and the European Commission. In addition we have appointed for every WP a **WP Leader** and for every task a **Task Leader**. All WP leaders (and Co-Leaders) are represented in the EB, which ensures appropriate interaction between all WPs but also an optimal flow of information on progress, potential risks or delays and necessary adaptations towards the PC and the GA. The additional appointment of task leaders supports and eases the work of the WP Leaders, especially for complex tasks involving several partners.

GA, EB, PC and WP Leaders will monitor the progress of the project along the **Milestones**.

### 3.2.3 Innovation Management

Effective innovation management within APPLICATE will require an overview of the project in its entirety. For this reason the PC will be responsible for the process of innovation management. Through the PC and within the management structure already identified above these elements will be brought together and will ensure effective innovation management.

The main innovation coming out of APPLICATE entails concrete guidance on how to improve weather and climate prediction systems for the Arctic and beyond. In this regard, innovation management will focus on two target groups: APPLICATE partners and collaborators as well as other related institutes and organisations not directly involved in APPLICATE. Regarding APPLICATE partners and collaborators, the PC will work closely with the PIs from the different partner institutions. Innovations will be closely monitored and recommendations for their implementation in operational prediction systems and climate models will be considered on a bi-annual basis. APPLICATE will also strive for sharing innovation with other institutes and organisations. In this regard, clustering (WP8) will play a pivotal role. Partners will also advocate and discuss APPLICATE innovations at a national, European and international level, taking advantage of workshops and conferences as well as of the fact that APPLICATE partners are strongly engaged in many relevant high-level committees such as the Polar Prediction Project Steering Group (overseeing YOPP), the World Climate Research Programme's Modelling Advisory Council and the World Weather Research Programme’s Scientific Steering Committee.
WPs 1-7 are designed to incorporate end-user feedback into the project, with WP7 taking a leading role in designing and implementing an effective user-engagement strategy. Incorporation of end-user feedback will be achieved through a careful timing of the deliverables and milestones of the work packages. In this way the project will be responsive to any external opportunities that are identified. The PC will also ensure that any internal opportunities are addressed and incorporated if necessary.

The Advisory Board of experts along with the User Group (see WP7) will play a very important role in delivering innovation by acting as a knowledge broker for those seeking information about the Polar Regions. If the Advisory Board or User Group cannot provide all the answers, they will be able to signpost the likely sources of the necessary knowledge.

3.2.4 Critical Risks for the project implementation and risk-mitigation measures

APPLICATE brings together a highly qualified team with proven expertise in managing large-scale European and international projects. The management structure employed by APPLICATE is similar to those of previous successful EU projects. This is a proven scheme, which is very effective at resolving any significant deviations from the project plan efficiently and transparently through dialogue with the relevant partners. If a partner encounters a problem which delays a deliverable or milestone, the WP leader will notify the MST, and together they will decide if it will be necessary to convene a conference call of the Executive Board to solve the problem. In case of a more serious delay both the Executive Board and the EC Project Officer will be notified immediately. This level of management engagement will enable efficient tactical and planning decisions to be performed with ease. The MST will be set up templates and guidelines at the outset of the project and will give clear advice on standards for deliverables, proofreading, validation and workflow.

While the project is running, the MST will develop, monitor and maintain a risk register and present this to the Executive Board at their regular meetings. The risks register contains the following information for each risk identified: risk description (fact or event which could jeopardize the correct functioning of the project), work package/task involved, likelihood (high medium, low), impact (insignificant, minor, moderate, major, catastrophic), risk response (type and description), responsibility, due date, and status (open, closed). This approach will ensure that potential risks are discovered without delay and immediate countermeasures can be applied.

Risk management will be performed at all project levels and will adopt a uniform and systematic approach across the project team to:

- Identify and evaluate risks;
- Define and plan proactive and efficient actions for risk reduction;
- Start, perform and control planned mitigation activities;
- Document the progress of risk management activities, and evaluate their results with continuity in order to implement needed corrections.

The table Critical Risks (see Part A) shows risks to project implementation that have the potential to impact the achievement of project objectives. These risks will be actively managed and monitored throughout the project. Risks that exist specifically for individual WPs are mentioned in the WP descriptions together with proposed preventative measures.

3.2.5 Conflict Resolution

The project could be affected by conflicts of various types: strategic, technical, shortage of resources, and others. WP Leaders, PC and MST will seek to anticipate the emergence of such conflicts, and discuss the best way to resolve them with the partners. The project employs a multi-level escalation strategy. Conflicts at work level should first be reported to Task leaders and then WP leaders. If not resolved at this level, problems and possible solutions will be formally discussed at the EB, moderated by the PC, where, if necessary, a vote can take place. If no decision can be found, the EB will report the issue to the GA where the final decision will be taken in a meeting moderated by the PC.
3.3 **Consortium as a whole**

### 3.3.1 Partners

The APPLICATE consortium comprises research institutions, universities, one international European organisation, national meteorological centres, one supercomputing centre and one small/medium-sized enterprise (SME). This composition ensures that the relevant expertise is well covered by the consortium:

- Scientific and technical excellence needed to make significant progress in developing predictive capacity for the weather and climate of the Northern Hemisphere;
- Representation of some of the world-leading European modelling and prediction centres providing an effective transition of APPLICATE research into operational prediction across a wide range of time scales;
- Participation of leading experts in the field of climate services, user-engagement and knowledge transfer ensuring effective stakeholder involvement and widest possible dissemination;
- Proven expertise in developing strong educational programmes.

The combination of technical and scientific excellence as well as experience will support early and sustained progress towards the overarching mission of APPLICATE – *To develop enhanced predictive capacity for weather and climate in the Arctic and beyond, and to determine the influence of Arctic climate change on mid-latitudes, for the benefit of policy makers, businesses and society.* This objective cannot be fulfilled with a less experienced team. Each partner brings a particular expertise needed for the successful development and deployment of the project’s outcome. The composition of the consortium will also be a legacy after the end of the project through the strong involvement of operational centres, and also in its support of existing Copernicus services such as C3S. Several partners have already successfully worked together, and there is substantial experience working in an international multi-disciplinary context. This ensures strong synergies within the team and with other ongoing European and international activities.

In particular:

- The consortium is coordinated by one of the world’s leading polar research organisations, AWI is embedded in a number of European Research initiatives, such as the European Polar Board (EPB) and the European Climate Research Alliance (ECRA). Furthermore, the office of the International Arctic Science Committee (IASC) and that of the International Coordination Office for Polar Prediction (ICO) are hosted by AWI. Next to the involvement in numerous EU-funded projects as a partner, AWI has a strong track record of coordinating large EU projects (e.g. PAGE21, StratoClim and EU-PolarNet).
- The project management capacity of the consortium is strengthened through the involvement of partners with experience in coordinating EU projects (e.g. BSC and ECMWF); and the coordination with other relevant ongoing European and international activities is facilitated by involving partners that take leading roles in European and international coordination programmes such as WMO, WWRP and WCRP (e.g. AWI, BSC, ECMWF and SU).
- The consortium brings together experts in the field of atmospheric modelling (SU, ECMWF, CNRS-GAME, Met Office, MET Norway), snow modelling (ECMWF, CNRS-GAME, UCL), sea ice modelling (AWI, UCL, CNRS-GAME), ocean modelling (AWI, UiB, UNI Research, Met Office, CERFACS), as well as in the field of coupling between the different climate system components (CNRS-GAME, SU, Met Office). Therefore, the consortium can draw on the expertise needed to bring the modelling of the coupled climate system to the next level, both in the Arctic and beyond.
- The consortium includes some of the leading European climate modelling groups, and all climate models that participate in APPLICATE (AWI-CM, EC-Earth, CNRM-CM, NorESM, HadGEM) will be contributing to CMIP6. It will therefore be possible to evaluate the impact of model enhancements, coming out of APPLICATE, in a CMIP framework, and to provide an interim update on the CMIP6 results (“CMIP6-Interim”).
- To make significant advances in our understanding of the impact of Arctic climate change on the weather and climate of the Northern Hemisphere – from the source region, via teleconnections, to where the impacts are felt – the consortium includes Arctic experts (AWI, BSC, SU, UiB, UNI Research, UCL, MET Norway, CNRS-GAME), experts on mid-latitude dynamics (Met Office, UREAD, BSC, CERFACS, ECMWF) as well as scientists with a track-record in research on atmospheric and oceanic teleconnections (AWI, CERFACS, Met Office, UiB, UREAD, CNRS-GAME).
- The consortium includes some of the world-leading operational prediction centres, including global (ECMWF, Met Office, Météo-France as third party of CNRS-GAME) as well as limited area (MET Norway, Météo-France) prediction systems. The involvement of these centres contributes excellent research infrastructure, such
as a framework for carrying out comprehensive experiments for designing observing systems and testing developments in full-sized prediction systems. Furthermore, this research is supported by some of the largest high-performance computing structures in Europe (e.g. ECMWF and Met Office HPC facilities). Furthermore, having operational centres involved (ECMWF, Met Office, MET Norway and Météo-France) ensures that scientific progress can be effectively translated into improved prediction services. This includes the transition from operational prediction systems to Copernicus services and their users.

- To ensure effective knowledge transfer, end-user engagement and dissemination the consortium includes one of the pioneers in the area of climate services (BSC), as well as the provider of one of the leading gateways to Arctic information and data on the internet with excellent connections to a wide network of stakeholders (AP). The consortium also benefits from the fact that many of the partners have strong outreach and dissemination facilities that can be exploited by APPLICATE.

- The educational programme will be developed and implemented in partnership with one of the leaders in the field of Arctic education APECS, hosted by the partner UiT. Furthermore, the consortium will bring together partners that have successfully developed strong educational programmes in the past (e.g. UiT/APECS, AWI, UREAD and SU).

- The consortium is augmented by distinguished partners from Russia, namely Sergey Gulev from the P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences (IORAS), and Vladimir Kattsov from the Voeikov Main Geophysical Observatory. These partners will contribute their outstanding expertise in the field of model assessment (WP1) as well as in studying the response of mid-latitude weather and climate to Arctic sea ice decline (WP3).

3.3.2 External collaborators

APPLICATE is dedicated to collaborate effectively with European and international partners. Our strategy is to actively engage with those high-level projects and organisations that coordinate activities of a wide range of relevant partners. In this context, YOPP is an excellent example of how effective coordination with a wide number of groups can be achieved by strongly engaging in a single activity. Other examples of high-level committees and projects with which the APPLICATE consortium will be engaging include the US CLIVAR Working Group on Arctic Change and Possible Influence on Mid-latitude Climate and Weather, the Sea Ice Prediction Network (SIPN) as well as EU projects such as those that will be funded under H2020-BG09-2016 and H2020-BG10-2016 as well as the ongoing H2020 project PRIMAVERA. Furthermore, there will be strong engagement with projects resulting from the Belmont Forum call on Climate predictability and inter-regional linkages. Finally, the strong engagement with EU-PolarNet will be of mutual benefit for the research planning process as well as for the process of stakeholder engagement and policy advice.

In addition to this general cooperation with projects and organisations we will also engage with some key partners on a more individual basis. Examples include Environment and Climate Change Canada (formerly Environment Canada), which has a very strong expertise in the area of model development and weather and climate prediction with coupled atmosphere-sea ice-ocean systems. Furthermore, we will engage with the International Arctic Research Centre (IARC) for coordinated experiments using coupled and uncoupled climate models on polar regional climate prediction research, the National Centre for Atmospheric Research (NCAR) for diagnosing Arctic heat budgets within model simulations. Strong collaboration is also planned with the Polar Research Institute of China (data sharing, dissemination of APPLICATE results), the Korea Maritime Museum (APPLICATE User Group), the Institute of the North in Alaska (APPLICATE User Group).

Our previous experience from EU funded projects has shown that the inclusion of international, non-EU partner organisations as full project partners is often very difficult and was in many cases impossible. The reason for this is that those partner organisations would need to sign the EC Grant Agreement as well as the Consortium Agreement if they become full partners within the project. However the EC Grant Agreement as well as the Consortium Agreement include specific clauses on intellectual property rights, liability and governing law, which are in many cases impossible to accept for international partners. Therefore the APPLICATE Consortium decided to include all International partner organisations from Canada, USA, Switzerland, China, Republic of Korea and Japan through a letter of commitment. Once the project has been chosen for funding the Project Coordinator will enter on behalf of the consortium a coordination agreement with those partner organisations in order to formalise and align the work of APPLICATE with those partner organisations. This approach of including international partner organisations has been chosen by the APPLICATE consortium on purpose in order to prevent partner organisations from withdrawing from the project once they have to sign the EC Grant Agreement and the Consortium Agreement. This will give APPLICATE a high grade of flexibility of involving international partner organisations according to the
project’s needs, whilst ensuring that all legal standards and requirements are met by signing the coordination agreement.

3.4 Resources to be committed

3.4.1 ‘Other direct cost’ items (travel, equipment, other goods and services, large research infrastructure)

Table 13 ‘Other direct cost’ items (# Table 3.4b)

<table>
<thead>
<tr>
<th>1 – AWI</th>
<th>Cost (€)</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel</td>
<td>35,000</td>
<td>Travel to General Assemblies, project meeting and outreach meetings</td>
</tr>
<tr>
<td>Equipment</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other goods and services</td>
<td>181,300</td>
<td>38,000 – for the invitation of stakeholders and end-users to project meetings 65,000 – invitation of external international experts and members of advisory board to project meetings 70,000 – to cover costs for General Assemblies and project meetings 2,500 – to cover publication costs 5,800 – to cover costs for Certificates of the Financial Statement</td>
</tr>
<tr>
<td>Total</td>
<td>216,300</td>
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</table>

<table>
<thead>
<tr>
<th>2 - BSC</th>
<th>Cost (€)</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel</td>
<td>39,000</td>
<td>Travel to General Assemblies, project meeting and outreach meetings</td>
</tr>
<tr>
<td>Equipment</td>
<td>3,000</td>
<td>Computer Hardware</td>
</tr>
<tr>
<td>Other goods and services</td>
<td>29,500</td>
<td>22,000 – To cover costs for outreach meetings targeting stakeholders and end-users 2,500 – to cover publication costs 5,000 – to cover costs for Certificates of the Financial Statement</td>
</tr>
<tr>
<td>Total</td>
<td>71,500</td>
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</tr>
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</table>

<table>
<thead>
<tr>
<th>4 - UiB</th>
<th>Cost (€)</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel</td>
<td>14,000</td>
<td>Travel to General Assemblies and project meetings</td>
</tr>
<tr>
<td>Equipment</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other goods and services</td>
<td>2,500</td>
<td>To cover publication costs</td>
</tr>
<tr>
<td>Total</td>
<td>16,500</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>6 – MET Norway</th>
<th>Cost (€)</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel</td>
<td>14,000</td>
<td>Travel to General Assemblies and project meetings</td>
</tr>
<tr>
<td>Equipment</td>
<td>100,000</td>
<td>Costs for PPI and storage capacity and costs for application server for the EGSF node/data management</td>
</tr>
<tr>
<td>Other goods and services</td>
<td>7,500</td>
<td>2,500 – to cover publication costs 5,000 – to cover costs for Certificates of the Financial Statement</td>
</tr>
<tr>
<td>Total</td>
<td>121,500</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>13 - AP</th>
<th>Cost (€)</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel</td>
<td>35,000</td>
<td>Travel to General Assemblies, project meeting and outreach meetings</td>
</tr>
<tr>
<td>Equipment</td>
<td>26,700</td>
<td>Hardware for online and communication tools necessary for WP7</td>
</tr>
<tr>
<td>Other goods and services</td>
<td>45,500</td>
<td>22,000 – outreach material (roll-ups, fact sheets, etc.) 16,000 – organisation of 4 end-user meetings 2,500 – to cover publication costs 5,000 – to cover costs for Certificates of the Financial Statement</td>
</tr>
<tr>
<td>Total</td>
<td>107,200</td>
<td></td>
</tr>
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<table>
<thead>
<tr>
<th>14 - UiT</th>
<th>Cost (€)</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel</td>
<td>14,000</td>
<td>Travel to General Assemblies, project meeting and outreach meetings</td>
</tr>
<tr>
<td>Equipment</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other goods and services</td>
<td>32,500</td>
<td>30,000 – organisation of summer school for young scientists 2,500 – to cover publication costs</td>
</tr>
<tr>
<td>Total</td>
<td>46,500</td>
<td></td>
</tr>
</tbody>
</table>
### 3.4.3 Large Research Infrastructure

APPLICA\(\text{T}\)E does not involve the use of large research infrastructures.

<table>
<thead>
<tr>
<th></th>
<th>Cost (€)</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>15 - IORAS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel</td>
<td>40,000</td>
<td>Travel to General Assemblies, project meeting and outreach meetings</td>
</tr>
<tr>
<td>Equipment</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Other goods and services</td>
<td>11,000</td>
<td>6,000 – consumables 5,000 – to cover publication costs</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>51,000</td>
<td></td>
</tr>
</tbody>
</table>

| **16 - MGO** |          |                                                    |
| Travel | 40,000   | Travel to General Assemblies, project meeting and outreach meetings |
| Equipment | 0        |                                                    |
| Other goods and services | 11,000 | 6,000 – consumables 5,000 – to cover publication costs |
| **Total** | 51,000 |                                                    |
4. Members of the consortium

4.1. Participants (applicants)

<table>
<thead>
<tr>
<th></th>
<th>Alfred-Wegener-Institut Helmholtz Zentrum für Polar- und Meeresforschung</th>
<th>AWI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The legal entity

The Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI) is one of the world’s leading polar research organisations and delivers significant contributions to the international research on climate, marine and coastal issues. AWI is a member of the Helmholtz Association of German Research Centres (HGF). It has an annual budget of more than 100 million Euros and a staff of more than 1000 employees. AWI conducts multidisciplinary research in the Arctic and Antarctic, as well as in temperate latitudes. In particular, AWI coordinates polar research in Germany and provides the necessary equipment, infrastructure, and logistics for other German institutions performing polar research. AWI keeps the German federal government updated on its research results and provides advice for the development of environmental policies. AWI conducts an extensive cooperation with numerous national and international institutions. Through memberships, AWI is embedded in a number of European Research initiatives, such as the European Polar Board (EPB), the European Marine Board (EMB), and the European Climate Research Alliance (ECRA). Furthermore, the office of the International Arctic Science Committee (IASC) and that of the International Coordination Office for Polar Prediction (ICO) are hosted by AWI.

Next to the involvement in numerous EU-funded projects as a partner, AWI is currently coordinating the FP7 collaborative research projects PAGE21 and StratoClim as well as the Marie Curie IRSES Project IMCONet. The latest AWI-coordinated Project EU-PolarNet started in March 2015 – a HORIZON 2020 coordination and support action with 22 international partners that will create a plan for an integrated European research programme for the Polar Regions. Additionally, AWI is host of one ERC Starting Grant (PETA-CARB), one ERC Advanced Grant (ABYSS) and several Marie Curie Individual Fellowships.

The infrastructure of the AWI

AWI operates the research icebreaker and supply vessel POLARSTERN, the regional research vessel HEINCKE and several smaller vessels, two research airplanes, and permanent research stations in Antarctica and on Spitsbergen. The research stations on the Northern Hemisphere are operated in close international cooperation. In Ny-Ålesund on Spitsbergen (Svalbard), AWI maintains the small, permanently staffed station AWIPEV jointly together with the French Polar Institute Paul Emile Victor (IPEV). The Siberian research station Samoylov in the Lena Delta is jointly operated with Russia. AWI together with the Centre for Marine Environmental Sciences (MARUM) of the University of Bremen operates the World Data Centre for Marine Environmental Sciences (WDC-MARE) using PANGAEA (Data Publisher for Earth & Environmental Science) as its central archive. PANGAEA is a repository for any kind of georeferenced data from Earth System research. The AWI is an associate of the German Climate Computing Centre (DKRZ). Therefore, AWI scientists have dedicated access to the supercomputing and data storage facilities at DKRZ. Furthermore, the scientific computing department of AWI provides high-performance computing facilities for model development and testing purpose. A new HPC system (CRAY CS 400 with 11.232 cores) will be installed at AWI in spring 2016.

Profile relating to the project

AWI is one of the world leaders in carrying out Arctic research. It is strongly involved in observational and process modelling studies with the aim to improve weather and climate prediction models, especially in the polar regions. The AWI scientists involved in this project are experts in climate modelling. For example, they were the first to develop a mature sea ice-ocean model (FESOM) that is based on unstructured meshes and allows using enhanced resolutions, and therefore computational resources, in areas where it matters, while keeping a coarse-resolution setup elsewhere. In a coupled version, this model will participate in CMIP6. AWI is also strongly engaged in providing services to the forecasting community. This includes providing observations data to the GTS and polar research station Neumayer III serving as a weather forecasting center for the Dronning Maud Land, Antarctica, during austral summer. Finally, AWI hosts the International Coordination Office (ICO) for Polar Prediction that coordinates all international activities related to the area of polar prediction, including the Year of Polar Prediction.
Main tasks in the project

AWI will be the project coordinator and responsible for the overall project management (WP9). In addition, AWI will lead the work package on clustering to ensure alignment of APPLICATE activities with other relevant European and international initiatives (WP8). Scientifically, AWI will take a leading role in the model assessment part (WP1); it will contribute to the development (focus on sea ice and ocean) and testing of climate model enhancements (WP2); it will be engaged in all modelling activities related to determining the impact of the Arctic on lower-latitude weather and climate (WP3); and it will contribute to synthesizing the main project results from a prediction perspective (WP5) and disseminating them widely (WP6).

Profiles of the AWI staff involved in the project

Prof. Dr. Thomas Jung
Head of Climate Dynamics Section, Male

Education

Diploma in Atmospheric Physics, Institute for Marine Research, Kiel, Germany, 1996
PhD in Atmospheric Physics, Institute for Marine Research, Kiel, Germany, 2000

Experience relating to the project

Thomas Jung is head of the Climate Dynamics section at AWI, where he is leading the climate analysis, modelling and prediction activities. He is also a full professor for physics of the climate system at the University of Bremen. Before joining the AWI, Prof. Jung worked for 10 years at the European Centre for Medium Range Weather Forecasts (ECMWF). He is spokesperson of AWI’s research programme. He acts as the chair of the Polar Prediction Project of the World Meteorological Organization’s (WMO) World Weather Research Programme. In this role, he coordinates the planning and implementation of the Year of Polar Prediction (YOPP). Since 2012, he is co-chair of the Arctic programme of the European Climate Research Alliance (ECRA). In this role, he has been appointed coordinator for the theme Arctic-Atlantic Interplay in support of the implementation of the Galway statement. Prof. Jung is also member of WMO’s EC Panel of Experts on Polar Observations, Research and Services (EC-PORS), which oversees the implementation of the Global Integrated Polar Prediction System (GIPPS). He is the (co)-author of more than 75 publications in the peer-reviewed literature.

Publications / achievements relevant for this project


Participation in research projects

2011 – 2015 Federal Ministry of Education and Research in Germany (BMBF) – Miklip: Lead scientist
2014 – 2018 Programme oriented research at AWI (PACES-II): Spokesperson
Dr. Sergey Danilov
Principal research scientist, Male

Education

Diploma in Physics, Moscow Institute of Physics and Technology, Moscow, Russia, 1982
PhD in Physics and Mathematics, Acoustical Institute of Russian Academy of Sciences, Moscow, Russia, 1986

Experience relating to the project

Sergey Danilov is a principal research scientist of the Climate Dynamics section at AWI. He is leading the development of Finite-Element Sea ice – Ocean circulation model (FESOM) and its sea-ice component FESIM, the first multi-resolution models worldwide that are practically used for climate research. His major expertise lies in numerical methods on unstructured meshes, applied mathematics and geophysical turbulence, with particular focus on mathematics and physics related to modelling high-resolution dynamics. His recent work involves questions of stability and convergence of sea-ice dynamics solvers, which present a challenge at high resolution. Before joining AWI in 2001, Dr. Danilov worked at A.M. Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences (since 1985). He is the author of about 100 papers and book contributions. Since 2012 he is also Associate Editor of Ocean Modelling.

Publications / achievements relevant for this project


Participation in research projects

2013 – 2016 German Research Foundation (DFG) – Anisotropic limiter techniques for simulating ocean flows on unstructured meshes: Principal Investigator
2015 – 2017 German Research Foundation (DFG) – CONTIM: Lead Scientist

Dr. Tido Semmler
Senior Scientist in the Climate Dynamics Section, Male

Education

Diploma in Meteorology, Institute for Meteorology Free University Berlin, Berlin, Germany, 1998
PhD in Meteorology, Meteorological Institute of Hamburg University, Hamburg, Germany, 2002

Experience relating to the project

Tido Semmler is a senior scientist in the Climate Dynamics section at AWI. He has experience in the development of coupled climate models (EC-Earth, AWI-CM) and through the participation in Coupled Model Intercomparison Projects (CMIP5). In this context, he was in charge of preparing, carrying out and analysing the model simulations and delivering the data to the CMIP5 database. Dr. Semmler has actively contributed to various international
climate modelling projects funded by the European Union such as PRUDENCE, BALANCE, and ENSEMBLES. In his position at AWI, he is currently involved in the final testing of the AWI climate model for the simulations necessary for the next Coupled Model Intercomparison Project CMIP6. Furthermore, Dr. Semmler has extensive experience in the fields of polar-lower latitude linkages including a number of publications and supervision of Master and PhD theses.

**Publications / achievements relevant for this project**


**Participation in research projects**

2004 – 2009 EU – ENSEMBLES: scientist
2011 – 2015 BMBF – MIKLIP: scientist

**Dr. Felix Pithan**

Postdoctoral Researcher, Male

**Education**

M.Sc. in Climate Change, University of East Anglia, Norwich, UK, 2010
PhD in Meteorology, Max Planck Institute for Meteorology / University of Hamburg, Hamburg, Germany, 2014

**Experience relating to the project**

Felix Pithan has used a combination of single-column modelling, observational data and climate model output to expose weaknesses in the representation of Arctic boundary-layer clouds in state-of-the-art climate models. Based on this research, he has developed and led a GASS (Global atmospheric boundary-layer studies) single-column model intercomparison. He also implemented and evaluated a new boundary-layer scheme in the Max Planck institute’s climate model ECHAM and investigated the effects of boundary-layer and mountain drag on the large-scale circulation in climate models. He has experience in running and modifying climate models, specifically for ECHAM/ICON, CAM and the UM.

**Publications / achievements relevant for this project**


Pithan, F., Ackerman, A., Angevine, WA., Hartung, K., Ickes, L., Kelley, M., Medeiros, B., Sandu, I., Steeneveld, G.J., Sterk, HAM., Svensson, G., Vaillancourt, P.A., & Zadra, A. Strengths and biases of models in representing the Arctic winter boundary layer: the Larform 1 single column model intercomparison submitted to JAMES
Participation in research projects
2015 – 2016 ERC Marie-Curie Fellowship UACSURF: Researcher (Marie-Curie Fellow)

Dr. Helge F. Goessling
Senior scientist

Education
Diploma (M.Sc. equivalent) in Theoretical Biophysics, Humboldt University Berlin, Berlin, Germany, 2008
PhD in Climate Science, Max Planck Institute for Meteorology / University of Hamburg, Hamburg, Germany, 2013

Experience relating to the project
Helge F. Goessling is working with coupled and uncoupled climate models since 2008, focussing during his PhD on moisture transports in the atmosphere. Since 2012, he is working on various aspects of polar prediction, with a focus on sea ice. He is contributing to the development of a new type of climate model that exploits unstructured mesh approaches (AWI-CM) and that also constitutes one of his main research tools. He has participated in, and contributed simulation data to, the Arctic sea-ice predictability model-intercomparison project APPOSITE, developed new verification metrics for sea-ice predictions, and investigated the potential predictability of Arctic sea ice, including aspects of scale-dependent predictability. Since 2014 he is strongly engaged in the planning and coordination of the Year of Polar Prediction (mid-2017 to mid-2019) in his role as Director of the International Coordination Office for Polar Prediction (ICO).

Publications relevant for this project

Participation in research projects
2016 – present PI of ERA.Net-RUS consortium project NAtMAP: Amendind North Atlantic Model Biases to Improve Arctic Predictions
2014 – present Polar Prediction Project (PPP) and Year of Polar Prediction (YOPP) – Director of the International Coordination Office
The legal entity

The Barcelona Supercomputing Center – Centro Nacional de Supercomputación (BSC-CNS) combines unique high performance computing facilities and in-house research departments on computer, life, and Earth sciences, and computational applications, counting more than 350 researchers and students from more than 40 different countries. BSC-CNS has been accredited as one of the first eight Severo Ochoa Centers of Excellence. This award is given by the Spanish Government as recognition for leading research centers in Spain that are internationally well known institutions in their respective areas. Established in 2006, the Earth Sciences Department (ESD) of the BSC, worked on atmospheric composition modelling. The designation of Professor Francisco J. Doblas-Reyes as Director of the ESD in 2014 initiated the merging of the Climate Forecast Unit of the Institut Català de Ciències del Clima (IC3-CFU), which he was leading and that in a short time became a main European actor in the development of climate predictions and climate services into the ESD. The newly merged department is structured around four groups, two of which will be involved in APPLICATE, with more than 50 employees, including technical and support staff. It is a highly productive scientific entity that has published more than 300 research articles in peer-reviewed journals over the last 5 years, including 5 in prestigious high-impact journals. (For a complete list of the publications of the department: https://earth.bsc.es/wiki/doku.php?id=publications:publications). The climate prediction group aims at developing a climate forecast system based on the EC-Earth model and performs regular assessments of the characteristics of this forecast system compared to all other operational and quasi-operational systems available in the world. The Earth system services group ensures that the outcomes of the department reach society, both in the public and private sectors, and continuously sample the needs of a range of users in the insurance, agriculture and renewable energy sectors. The climate prediction and services groups involved in APPLICATE, participate in seven European projects and three national projects. Of special interest for APPLICATE are the national PICA-ICE (CGL2012-31987) project coordinated by Virginie Guemas which focuses on improving Arctic sea ice prediction and their role on the Northern Hemisphere climate and European EUPORIAS project which focuses on developing prototypes for different of end-to-end climate-to-impacts-to-decision-making services operating on seasonal to decadal time scales. The BSC-ES international activity includes the participation in climate services initiatives like the Climate Services Partnership (CSP).

The infrastructure of BSC

BSC-CNS is the National Supercomputing Facility of Spain and hosts a range of high-performance computing (HPC) systems, including MareNostrum III, one of the most powerful supercomputers in Europe with 48,128 cores and 1.1 Pflops capacity. The BSC-CNS is a key element of and coordinates the Spanish Supercomputing Network, which is the main framework for granting competitive HPC time to Spanish research institutions. Furthermore, BSC-CNS is one of six hosting nodes in France, Germany, Italy and Spain that form the core of the Partnership for Advanced Computing in Europe (PRACE) network. PRACE provides competitive computing time on world-class supercomputers to researchers in the 25 European member countries.

Profile relating to the project

BSC is one of the world leaders in the development of climate prediction capability and climate services. These objectives rely on expanding the understanding of the climate predictability mechanisms through tailored and comprehensive forecast quality assessment, on the development of the EC-Earth climate forecast system through the testing of new model parameterisations/components as well as the development of innovative initialization strategies, on identifying user needs that will partly guide BSC research and on quantifying the impact of weather and climate upon socio-economic sectors through the development of user-oriented services that ensure the transfer of the technology developed and the adaptation to a rapidly changing environment, especially of those highly vulnerable. The BSC members involved in this project are expert on polar climate modelling and its impact on the mid-latitudes and/or experts on the development of user-tailored climate products.
Main tasks in the project

BSC will lead the work package dedicated to improve prediction and projection capability on weather to climate change timescales (WP5) as well as the work package dedicated to bridging the gap between scientific knowledge production within APPLICATE and end-user understanding and optimal exploitation of this knowledge (WP7). BSC will also contribute to the development of prediction-specific metrics within WP1, the development of a breaking-ground resolution configuration of its in-home climate forecast system within WP2, participate to coordinated experiments organized within WP3 to advance our understanding of the mechanisms linking the polar and mid-latitude weather and climate and the development of new initialisation strategies for climate prediction systems within WP4. BSC will also liaise with the INTRAROS proposal submitted to the “BG-09-2016: An integrated Arctic observation system” call if funded.

Profiles of the BSC staff involved in the project

Prof. Francisco Doblas Reyes
Head of the Earth Sciences department, male

Education

PhD in atmospheric physics dynamics, Universidad Complutense de Madrid, Madrid, Spain, 1996

Experience relating to the project

Prof. Doblas-Reyes is a worldwide expert in the development of seasonal-to-decadal climate prediction systems and has more than 20 years of experience in weather and climate modeling, climate prediction, as well as the development of climate services. For his work in seasonal forecasting, he was awarded the Norbert Gerbier-Mumm International Award from the UN World Meteorological Organization (WMO) in 2006. He serves in several panels of the World Climate Research Programme (WCRP) and the World Weather Research Programme (WWRP) under the UN WMO (among them the steering group of the Polar Prediction Project), is a member of the European Network for Earth System modelling HPC Task Force and has participated in numerous national and European FP4, FP7 and H2020 projects. Currently, Prof. Doblas-Reyes is the principal investigator (PI) or co-investigator in 6 FP7 and H2020 European projects, is coordinator of the FP7 collaborative SPECS project and supervises numerous postdoctoral scientists and software engineers. He has won 50 Million hours of computing time for the High Resolution Ensemble Climate Modeling project through the PRACE network. He is a lead author of the IPCC and member of the steering group of the Polar Prediction Project. Overall, Prof. Doblas-Reyes has authored and co-authored more than 100 peer-reviewed papers on climate modeling and prediction, as well as climate services, and currently has a total of 6103 citations with a h-index of 39.

Publications / achievements relevant for this project


Participation in research projects

2012 – 2017 EU – SPECS: Coordinator
2012 – 2017 EU – EUPORIAS: Principal Investigator (PI)
2014 – 2017 MINECO (Spanish government) – RESILIENCE: PI
2014 – 2015 EU – EUCLEIA: PI

Dr Virginie Guemas
Head of the climate prediction group, female

Education
Master in climate physics, Paul Sabatier University, Toulouse, France, 2006
PhD in climate physics, Paul Sabatier University, Toulouse, France, 2009

Experience relating to the project

Dr Virginie Guemas is an expert on seasonal to decadal climate prediction, with a particular emphasis on polar climate predictability and its linkages with the mid-latitudes. She was awarded the 2010 Adrien Gaussail PhD prize, granted every two years to a scientific PhD. She is member of the WCRP (World Climate Research Program) CLIVAR (Climate and Ocean Variability, Predictability, and Change) SSG (Scientific Steering Group). She has participated in 13 national and international research projects. Currently, she is Principal Investigator (PI) or co-investigator of six European projects and the PICA-ICE national project focused on Arctic climate predictions. She contributed to the IPCC (Fifth Assessment Report). She is author of 33 articles on climate modelling and predictions in international peer-reviewed journals, among which six in high-impact journals. She has supervised one PhD student and several post-doctoral scientists.

Publications / achievements relevant for this project


Participation in research projects

2013 - 2016 MINECO (Spanish Government) – PICA-ICE: Principal Investigator (PI)
2014 – 2017 European Space Agency (ESA) – CMUG2
2015 – 2016 EU – EUCLEIA: PI

Dr Isadora Christel Jiménez
Communication specialist at the Earth Sciences department, female

Education

Dr Virginie Guemas
Head of the climate prediction group, female

Education
Master in climate physics, Paul Sabatier University, Toulouse, France, 2006
PhD in climate physics, Paul Sabatier University, Toulouse, France, 2009

Experience relating to the project

Dr Virginie Guemas is an expert on seasonal to decadal climate prediction, with a particular emphasis on polar climate predictability and its linkages with the mid-latitudes. She was awarded the 2010 Adrien Gaussail PhD prize, granted every two years to a scientific PhD. She is member of the WCRP (World Climate Research Program) CLIVAR (Climate and Ocean Variability, Predictability, and Change) SSG (Scientific Steering Group). She has participated in 13 national and international research projects. Currently, she is Principal Investigator (PI) or co-investigator of six European projects and the PICA-ICE national project focused on Arctic climate predictions. She contributed to the IPCC (Fifth Assessment Report). She is author of 33 articles on climate modelling and predictions in international peer-reviewed journals, among which six in high-impact journals. She has supervised one PhD student and several post-doctoral scientists.

Publications / achievements relevant for this project


Participation in research projects

2013 - 2016 MINECO (Spanish Government) – PICA-ICE: Principal Investigator (PI)
2014 – 2017 European Space Agency (ESA) – CMUG2
2015 – 2016 EU – EUCLEIA: PI

Dr Isadora Christel Jiménez
Communication specialist at the Earth Sciences department, female

Education
Experience relating to the project

Dr Christel Jiménez has a Master’s degree in Science communication and a PhD in offshore wind energy Impact assessment. During eight years of research experience she was in direct contact and interaction with wind energy stakeholders. Her awareness on Arctic research topics grew during her PhD stages in Norway (at NINA in Trondheim and the IMR in Tromsø) where she still has academic networks. As a science communication specialist at BSC her role is to enhance user-engagement activities and knowledge transfer of the research on climate services carried out in the Earth Sciences Department. She is the WP leader of the user-engagement workpackage of PRIMAVERA and she is involved in dissemination tasks and the interaction with stakeholders in European funded projects (e.g. EUPORIAS, RESILIENCE, IMPREX…).

Publications / achievements relevant for this project

Coordination of Project Ukko, a visualisation tool providing semi-operational seasonal wind speed predictions for the energy sector stakeholders (www.project-ukko.net).

Event coordinator of the 9th Barcelona-Pittsburgh conference with more than 400 participants and 30 invited speakers: Communication manager of the conference before, during and after the event.


Participation in research projects

2012 – 2017 EU – EUPORIAS: WP41 leader (climate information for decision-making processes)
2014 – 2017 MINECO (Spanish government) – RESILIENCE: User-engagement coordinator
2015 – 2019 COPERNICUS C3S – CLIM4ENERGY: participant in WP1 (user-engagement)

Dr Javier García-Serrano
Junior Researcher (H2020 MSCA-IF-EF fellow), male

Education

Degree on Physics, Universidad Complutense de Madrid (UCM), Madrid, Spain, 2005
Master on Geophysics and Meteorology, UCM, Madrid, Spain, 2007
PhD on Climate Variability and Dynamics, UCM, Madrid, Spain, 2010

Experience relating to the project

During his scientific career, Dr García-Serrano has worked on exploring teleconnection dynamics for climate prediction, thoroughly building a bridge between his theoretical background in atmospheric dynamics and the practical requirements of climate forecasting. The former dates from his PhD stage at UCM, Madrid. The latter started out during his post-doc on the pioneering field of decadal climate prediction, first hired at IC3 (Barcelona) and then via his own funding at the University of Tokyo (AORI; private grant from the CANON Foundation in Europe). More recently, at LOCEAN/IPSL (Paris), Dr García-Serrano merged both research lines and showed broad capabilities to develop and lead the tasks undertaken by his institution in the EU-FP7 NACLIM project. The investigation focused on the teleconnections between Arctic sea-ice changes and European climate. García-Serrano et al. (2015) developed for the first time empirical predictions of interannual variability in Europe based on Arctic sea-ice concentration. He has led the project’s multi-model assessment (García-Serrano et al. 2016, currently under review).
Publications / achievements relevant for this project


Participation in research projects

2013 – 2017 EU – NACLIM: participant in WP1.2
2013 – 2016 MINECO (Spanish Government) – PICA-ICE: Work Team member
2015 – 2015 Severo Ochoa mobility grant (Spanish Government) – ‘Polar/non-polar linkages in EC-EARTH and NorESM’ to host Dr M. P. King (UniRes/BCCR, Norway) at BSC-CNS: recipient

Dr. Neven S. Fučkar
Juan de la Cierva postdoctoral fellow, male

Education

M.S. in Oceanography, Texas A&M University, College Station, TX, USA, 2003
M.A. in Atmospheric and Oceanic Sciences, Princeton University, Princeton, NJ, USA, 2006
Ph.D. in Atmosphere and Oceanic Sciences, Princeton University, Princeton, NJ, USA, 2010

Experience relating to the project

Dr. Neven Stjepan Fučkar has substantial knowledge of sea ice, ocean and coupled climate dynamics as well as extensive experience with numerical models with different levels of complexity (from idealized models to the state-of-the-art general circulation models). After obtaining a Ph.D. in Atmospheric and Oceanic Sciences at Princeton University with thesis research focused on ocean dynamics and ocean role in climate he continued his carrier by working on coupled climate dynamics, climate prediction and large-scale teleconnections at the University of Hawaii. After Honolulu, Dr. Fučkar moved to Barcelona where he focused on Arctic sea ice dynamics, climate prediction, and model verification and bias correction, first at the Catalan Institute of Climate Sciences and now at the Earth Sciences Department of the Barcelona Supercomputing Center. He is participating in PICA-ICE national project focused on Arctic climate variability and prediction, EU FP7 SPECS and H2020 PRIMAVERA focused on seasonal-to-decadal climate prediction and impact of increased model resolution on prediction skill, respectively. Dr. Fučkar is Principal Investigator of two RES (Spanish Supercomputing Network) grants and author of 10 articles in international peer-reviewed journals with 336 citations on Google scholar. He is also the convener of a skeleton EGU session on Polar Climate Predictability and Prediction.

Publications / achievements relevant for this project


Participation in research projects
2013 – 2016 MINECO (Spanish Government) – PICA-ICE: postdoctoral scientist
2012 – 2017 EU – SPECS: postdoctoral scientist
2015 – 2019 EU – PRIMAVERA: postdoctoral scientist
2015 RES (Spanish Supercomputing Network) - AECT-2015-1-0014: PI
2015 RES (Spanish Supercomputing Network) - AECT-2015-2-0003: PI
European Centre for Medium-Range Weather Forecasts

The legal entity

The European Centre for Medium-Range Weather Forecasts (ECMWF) is an international organisation supported by 34 European and Mediterranean States. ECMWF’s longstanding principal objectives are the development of numerical methods for medium-range weather forecasting, the operational delivery of medium-to-seasonal range weather forecasts for distribution to the meteorological services of the Member States, to lead scientific and technical research directed to the improvement of these forecasts, and the collection and storage of appropriate meteorological data.

ECMWF has extensive competence in operating complex global forecasting suites on high-performance computers and in transitioning top-level science from research to operations exploiting innovative approaches in computing science to fulfil the tight runtime and delivery constraints required by Member States.

The infrastructure of ECMWF

ECMWF's computer facility includes supercomputers archiving systems and networks. ECMWF’s multi-petaflops supercomputer facility is designed for operational resiliency featuring two Cray XC30 systems and independent Cray Sonexion storage systems. The system comprises two independent sub-systems located in separate halls. It has separate resilient power and cooling systems to protect against a wide range of possible failures. Each sub-system consists of 19 Cray XC30 cabinets equipped with Intel Ivy Bridge processors and around 3500 dual-socket compute nodes per system, a number of Cray development and log-in nodes and more than 6 petabytes of Lustre storage with the ability to cross mount the Lustre file systems between the halls.

ECMWF produces operational forecasts, archives and disseminates global model output to member states under tight schedules employing its computing and data handling infrastructure. ECMWF also operates a large-scale data handling system, in which all ECMWF users can store and retrieve data that is needed to perform weather modelling, research in weather modelling and mining of weather data.

Profile relating to the project

ECMWF has a wide-ranging programme of research and development directed at improving the quality and variety of forecast products for the medium-range and beyond. Approximately 95 staff work in the Research Department on all aspects of the forecast and data assimilation systems. The result of this research effort is one of the most comprehensive Earth-system models available anywhere.

ECMWF is the leading medium-range weather prediction centre worldwide and operates a set of analysis and forecast suites to produce medium-to-seasonal range forecasts globally. These employ a vast amount of observational data and both high-resolution (16km) and coupled ensemble (32/64km) prediction capability up to the sub-seasonal range. ECMWF, through its partnerships with EUMETSAT, ESA, the EU and the international science community, has also established a leading position for operational seasonal forecasting with coupled atmosphere-ocean-land models, and for reanalyses supporting climate monitoring. Recently, ECMWF has developed a sea-ice initialization capability, which will be implemented operationally in 2016, at the same time that an active sea-ice model will become part of the operational coupled forecasting system.

ECMWF has been engaged in polar prediction for some time now, has organized a number of seminars and workshops on this topic3 and participates actively in the WWRP Polar Prediction Project.

Main tasks in the project

ECMWF will co-lead the work package on the observing system (WP4), guiding the work on the assessment of current forecasting systems and their sensitivity to the initial conditions, on performing observing system experiments, for establishing a gap analysis indicating observational needs in the Artic and for producing

3 http://www.ecmwf.int/en/learning/workshops-and-seminars/past-workshops/ecmwf-wwrp/thorpex-workshop-polar-prediction
recommendations how to overcome these gaps. ECMWF will also take the lead on developing diagnostics to target the surface interface in the coupled ocean–atmosphere–snow–sea-ice system, and contribute to diagnostics for characterizing the role of individual physical processes in the coupled system, to develop ensemble data assimilation diagnostics and demonstrate an observational monitoring and evaluation framework (WP1). ECMWF will lead the implementation of a multi-layer snow model over land and contribute to the investigation of cloud, boundary layer, snow, sea-ice model options for the ECMWF model (IFS) (WP2). It will lead numerical experiments investigating the attribution of extreme events, and contribute to the generation of an ensemble forecast performance atlas representing Arctic variability. ECMWF will also assess the impact of enhanced sea-ice models and snow, assess the impact of WP-2 model improvements (WP5). Lastly, ECMWF will prepare and disseminate the YOTC-type dataset for the YOPP period (WP6), contribute to the clustering plan, and initiate collaboration with other H2020 projects, and the Year of Polar Prediction (WP8).

Profiles of the staff involved in the project

Dr Peter Bauer
Deputy Director of Research, male

Education
PhD Meteorology, Institute for Meteorology, University Hamburg, 1992, Thesis: ‘Water-vapour, total water and rain rates derived from passive microwave data over oceans’.

Experience relating to the project
Peter Bauer joined ECWMF in January 2000. Before becoming Deputy Director of Research he headed the Model Division that comprises the physical and numerical aspects of numerical weather prediction. Before joining ECMWF, he was leading a DLR research team on satellite meteorology in Cologne, Germany. His background covers physical modelling, data assimilation and satellite remote sensing. During his career, he was awarded research fellowships by NOAA and NASA, and a science award by DLR. He is the author and co-author of 100 peer-reviewed scientific journal papers, and his publications have an h-index of 33. He is a member of several scientific advisory committees at the international level (WMO, ESA, EUMETSAT) and has extensive experience with managing international research projects. At ECMWF, his current duties also include the management of the transition of new model cycles from research to operations and he is the manager of the recently launched Scalability Programme.

Publications / achievements relevant for this project

Participation in research projects
Peter Bauer has participated in a number of field campaigns, also related to arctic processes (ARKTIS ’88, 1988); other projects related to APPLICATE are:
2010 – 2011 EUCOS, 'Space-terrestrial observing system experiments'
2011 – 2012 ESA, 'Estimating the optimal number of GNSS radio occultation measurements for numerical weather prediction and climate reanalysis applications'
2015 – 2019 European Commission, 'Centre of Excellence in Simulation of Weather And Climate in Europe (ESiWACE)'

Dr. Gianpaolo Balsamo
Senior scientist in Earth System Modelling Section, male

Education
Diploma of Computer Science, Institute G. Peano, Turin, Italy, 1994
Master degree in General Physics, (speciality in Atmospheric Physics), University of Turin, Italy, 1999
PhD in Meteorology, University Paul Sabatier, Toulouse, France, 2003
Habilitiation in Meterology, University Paul Sabatier, Toulouse, France, 2012

Experience relating to the project
Research scientist responsible for the development of the Earth surface components (e.g. soil, vegetation, snow, water-bodies) within the ECMWF Integrated Forecasting System (ESM/PA sections, 2006-present), previously affiliated with the Meteorological Research Branch of the Meteorological Service of Canada (RPN team, 2004-2005) and with Météo-France/CNRM (GMAP team, 2000-2003) developing the modelling and data assimilation components for representing continental surfaces in weather forecasting and climate applications.

Publications / achievements relevant for this project

Participation in research projects

Dr. Linus Magnusson
Scientist in Evaluation Section, Male

Education
Master degree in Physics (speciality in meteorology), Uppsala University, Uppsala, Sweden, 2005
PhD in Atmospheric Science and Oceanography, Stockholm University, Stockholm, Sweden, 2009

Experience relating to the project
Research scientist in the diagnostic team in the Evaluation Section at ECMWF, with main focus on evaluating forecast performance and investigating sensitive regions for forecast quality, diagnostics on extreme weather events and diagnostics of coupled ocean-atmosphere models (both regarding average performance and during extreme events). From earlier projects experience in sea-ice modelling and initial strategies of seasonal and decadal forecasts.
Publications / achievements relevant for this project


Participation in research projects

The legal entity

The University of Bergen (UiB) is a young, modern university with about 14 000 students and 3,400 faculty and staff, making it a medium sized European University. The University is engaged in the European Union’s Framework programmes for research and technological development and has been designated as a European Research Infrastructure and a Research Training Site in several scientific fields. Since 1997 more than 500 European researchers (professors, senior researchers, post docs and PhD candidates) have visited Bergen on EU grants, making Bergen one of the most international universities, setting out to attract both established and junior scientists to contribute to research teams and work in multidisciplinary research groups. UiB has completed more than 150 EU research projects, about 20% of them as coordinator. UiB is currently involved in 29 H2020 collaborative research projects, 8 of which it coordinates. UiB currently hosts 5 Marie Curie projects, 7 ERC Advanced Grants, 2 ERC Starting Grants, 2 ERC Consolidator Grants and 1 ERC Synergy Grant.

The Geophysical Institute (UiB-GFI) is an internationally acknowledged contributor in the areas of marine and climate research. The institute’s research strategy rests upon theoretical studies and modelling, as well as use of own cutting edge measurement techniques developed in collaboration with technology partners. Polar research is one of the institute’s four interdisciplinary focus areas.

GFI has completed a series of collaborative EU projects, many of them as coordinator, and currently coordinates the collaborative EU projects PREFACE and SEAMAN, the Marie Curie projects COCLIMAT, STEPS, HIMWARC, and SOCCLI, and one ERC consolidator grant (STERCP). GFI is currently partner in 10 collaborative EU projects (ECO2, FixO3, GEOCARBON, GROOM, INGOS, IS-ENES 2, NAACLIM-2, SUMO, AtlantOS, CRESCENDO).

The infrastructure of the UiB-GFI

UiB-GFI is involved in extensive field programs in oceanography, sea ice dynamics/thermodynamics and meteorology in the Arctic and in Antarctica, and is frequent user of research vessels like G.O. SARS and HÅKON MOSBY. UiB-GFI coordinates the Norwegian Research School in Climate Dynamics (ResClim; http://www.uib.no/rs/resclim) and it’s successor, Changing Climates in the Coupled Earth System (CHESS; http://www.uib.no/en/rs/chess).

UiB-GFI is active in the Bjerknes Centre for Climate Research, a collaboration between the four Bergen partners UiB, the Uni Research, the Institute of Marine Research and the Nansen Environmental and Remote Sensing Center. The Bjerknes Centre has a staff of about 200 persons from 36 nationalities, and conducts research of past, present and future climates, using field observations, theory and numerical models.

The Bjerknes Centre coordinates the national climate modeling effort, with the Norwegian Earth System Model (NorESM; https://wiki.met.no/noresm/start) being a data provider for CMIP5 and IPCC. UiB-GFI has access to the Norwegian e-infrastructure for high-performance computing, data storage and support organized under SIGMA2 (https://www.sigma2.no). A new HPC system will be available in Norway in late 2016/early 2017.

Profile relating to the project

The research in APPLICATE is in full compliance with the research strategy of University of Bergen where marine sciences and climate are one of three prioritised areas. It is also in full compliance with the research strategy of the UiB-GFI, which emphasises the particular responsibility of the institute to ensure knowledge building in meteorology, oceanography and climate, and identifies Atmosphere-ocean-ice interaction / Climate variability as a prioritized cross-disciplinary research effort. The Norwegian Earth System Model will participate in CMIP6. UiB-GFI hosts the Norwegian Research School in Climate Dynamics (ResClim; http://www.uib.no/rs/resclim) and it’s successor, Changing Climates in the Coupled Earth System (CHESS; http://www.uib.no/en/rs/chess).
Main tasks in the project

UiB-GFI will co-lead the Atmospheric and oceanic linkages work package (WP3) and will here contribute to determining the impact of the Arctic on lower-latitude weather and climate. UiB-GFI will in addition be involved in defining the model metrics in WP1 with particular focus on the ocean, and will contribute in-kind to the development and testing of climate model enhancements (WP2) with focus on the high-resolution ocean part of NorESM.

Profiles of the UiB-GFI staff involved in the project

Prof. Helge Drange
Lecturer/researcher, Head of the Program Board, Male

Education
PhD in Climate Modelling, University of Bergen/the Nansen Environmental and Remote Sensing Center, Bergen, Norway, 2004

Experience relating to the project

Helge Drange has wide experience in the use of basin to global scale isopycnal ocean models and coupled physical-biogeochemical models for climate research, environmental studies and process studies. Drange was board member of the Official Norwegian Report Norwegian climate adaptation committee (2009-2010), and the Governmental appointed Klima21 (Climate21) committee in 2010 and the Hav21 (Ocean21) committee in 2011-12. Drange contributed to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) and the Arctic Climate Impact Assessment Report (ACIA). Drange has been co-leader of the CLIVAR Working Group for Ocean Model Development (CLIVAR, 2007-2014). Drange was one of the initiative takers for the establishment of the Bjerknes Climate Center for Research (BCCR) that awarded status as a Center of Excellence by the Research Council of Norway for the period 2002-2011. Drange is (co-)author of 90 peer reviewed articles, including two articles in Nature, one in Science and one in Nature Geosciences, and he has edited one book on the past, present and future climate of the Nordic Seas. As of January 2016, there are about 2700 citations to Drange’s publications. Drange was in 2010 awarded the University of Bergen’s Meltzer Prize for outstanding public outreach.

Publications / achievements relevant for this project


Participation in research projects

2005 – 2008 EU FP6 – DYNAMITE, Understanding the Dynamics of the Coupled Climate System: Coordinator

2007 – 2010 NorClim – Norwegian multi-institutional, coordinated climate research project: Coordinator

2011 – 2014 EarthClim – Norwegian multi-institutional, coordinated climate research project: Coordinator

Dr. Svetlana A. Sorokina
Post-doctoral researcher, Female

Education
PhD in Climate Variability, University of Bergen/the Nansen Environmental and Remote Sensing Center, Bergen, Norway, 2014
Experience relating to the project

Svetlana Sorokina has focused her research on Arctic climate variability, sea ice processes and Arctic-mid latitude linkages since beginning of graduate studies. She is currently analyzing observations and CMIP5 modelling experiments to investigate regional and global temperature changes in relation of the recent decadal shifts in the Atlantic and the Pacific Oceans, paying special attention to atmospheric teleconnection patterns. Previous projects included analysis of Arctic sea ice, ocean-to-atmosphere heat fluxes and various large-scale atmospheric fields in reanalysis and satellite-based products on seasonal to interannual timescales.

Publications / achievements relevant for this project

Dr. Paul Hezel
Post-doctoral researcher, Male

Education
PhD in Atmospheric Sciences, University of Washington, Seattle, Washington, USA, 2012.

Experience relating to the project
Paul Hezel has focused on sea ice and the Arctic and Antarctic climate systems since beginning his graduate studies. He is currently running atmosphere-only (CAM5) modelling experiments to investigate large scale atmospheric circulation variability associated with Laurentide ice sheet reconstructions and other plausible prescribed Arctic and sub-Arctic boundary condition scenarios. Previous projects included analysis of sea ice and other Arctic fields in CMIP5. Hezel was also a contributing author to the Summary for Policy Makers and Ch. 12 (Cryosphere) of the IPCC WG1 Fifth Assessment (AR5) report.

Publications / achievements relevant for this project
Stern, H., R. Lindsay, C. Bitz, and P. Hezel (2008), What is the Trajectory of Arctic Sea Ice?, in Arctic Sea Ice Decline: Observations, Projections, Mechanisms, and Implications, Geophysical Monograph Series 180, American Geophysical Union, doi:10.1029/180GM03.
The legal entity

**Uni Research AS (UNI Research)** is a non-profit research company in which the University of Bergen owns 85% of the shares. Uni Research Climate is the climate research division of UNI Research. Uni Research Climate has particular strengths in understanding climate dynamics across multiple spatial and temporal scales, dynamical modelling of the climate system and understanding past-future climate variability and change. Uni Research Climate has extensive experience coordinating and leading large national and international projects (it is for example the coordinator of the European Research Council – funded project nr.610055, Ice2Ice). Uni Research Climate is also one of four partners in the Bjerknes Centre for Climate Research (BCCR). The BCCR is the largest climate research centre in the Nordic countries with a focus on the natural science aspects of climate change and established expertise in complex research projects (e.g. BCCR Centre of Excellence; EVA, the national Norwegian Earth System Modelling project). Uni Research Climate has a leading role in Norway for the use and further development of the Norwegian Earth System Model (NorESM), with expertise in global climate, atmosphere and ocean modelling, decadal prediction, regional downscaling and climate dynamics. Uni Research Climate played an instrumental role in delivering future Earth system model projections to the CMIP5 project.

The infrastructure of UNI Research

UNI Research has access to the Norwegian national infrastructure of super-computing and long-term storage facilities (NOTUR and NorStore).

Profile relating to the project

Although Uni Research Climate has an international profile, the main focus is on Northern Europe and the Polar regions. UNI Research is involved in several projects addressing high northern latitude climate science questions. It is strongly involved in the modelling of climate processes, projections and prediction and much of the climate model development carried out at UNI Research is motivated by improving the representation of polar regions. UNI Research will play an active role in providing experiments to CMIP6, and the national contribution to several CMIP6 endorsed Model Intercomparison Projects (MIPs) are lead by UNI Research personnel.

Main tasks in the project

UNI Research will contribute to develop ocean metrics in WP1. In WP2, UNI Research will contribute to the improvement of the simulated representation of oceanic circulation and sea ice conditions and to the assessment of model enhancements in coordinated experiments. In WP3, UNI Research will carry out coupled experiments to assess the impact of Arctic sea ice changes on the ocean and contribute to the analysis of the formation, transport and decay of water masses that are exchanged between the Arctic Ocean and surrounding seas.

Profiles of the UNI Research staff involved in the project

**Dr. Mats Bentsen**
Senior research scientist, Male

*Education*

Cand. scient. in plasma dynamics, University of Bergen, Bergen, Norway, 1997
Dr. scient. in climate modelling, Nansen Environmental and Remote Sensing Center and University of Bergen, Bergen, Norway, 2002

*Experience relating to the project*

Mats Bentsen is co-leading the research group on Climate Model Development and Climate Projections at the BCCR, Bergen, Norway. He has been strongly involved in the development of coupled climate modelling
capability in Norway and had an active role in the development of the NorESM that contributed to CMIP5 and will contribute to CMIP6. Bentsen is the main developer of the NorESM ocean component that is one of a few CMIP models using isopycnic vertical coordinate. Bentsen is a member of the CLIVAR Ocean Model Development Panel and responsible for the Norwegian contribution to the CMIP6 endorsed Ocean MIP. He has extensive experience in the simulation and interpretation of North Atlantic and Arctic climate state, circulation and variability. He is the author/co-author of more than 40 peer-reviewed publications with an h-index of 19.

**Publications / achievements relevant for this project**


**Participation in research projects**

2014 – 2017  RCN – Enhancing seasonal-to-decadal Prediction Of Climate for the north Atlantic Sector and Arctic (EPOCASA): Scientist
2014 – 2019  European Research Council (ERC) – Arctic Sea Ice and Greenland Ice Sheet Sensitivity (Ice2Ice): Lead scientist of Task 1.3, Task 2.2 and Task 3.1

**Dr. Mehmet Ilicak**

Senior research scientist, Male

**Education**

M.S. in Mechanical Engineering, Bogazici University, Istanbul, Turkey, 2003
PhD in meteorology and physical oceanography, University of Miami, Miami, USA, 2009

**Experience relating to the project**

Mehmet Ilicak is a physical oceanographer focusing on the combination of theory and modelling. His research focuses on small scale mixing processes and their representation in climate models. In particular, he has a great experience in gravity currents and exchange flows. He uses combination of theory, process-oriented numerical simulations, and global climate models to understand subgrid scale processes in the ocean and their impact on the global circulation and climate. Mehmet Ilicak is currently working on developing the Norwegian Earth System Model that will participate in CMIP6. He has authored and co-authored 19 peer review publications. Ilicak is the first author in 11 of these papers. According to ISI Web of Knowledge, 12 of these publications have been cited a total of 99 times, with an average citation rate of 9, and an h-index of 6. He has worked extensively with climate models. In particular, he published one of the most influential papers about numerical spurious mixing in ocean models (Ilicak et al. 2012), and has published in other relevant areas: gravity currents, horizontal convection, exchange flows and Arctic Ocean.
Publications / achievements relevant for this project


Ilıcak, M., S. Legg, A. Adcroft, and R. Hallberg, 2011: Dynamics of a dense gravity current flowing over a corrugation. Ocean Modelling, 38, 71-84.

Participation in research projects

2014 – 2019 European Research Council (ERC) – Arctic Sea Ice and Greenland Ice Sheet Sensitivity (Ice2Ice): task leader in WP3

The legal entity

The Norwegian Meteorological Institute (MET Norway; also referred to as METNO in the project plan) is the national public meteorological service in Norway. The institute provides information to public authorities, businesses and the general public to secure life and property and in support of economic activity, societal planning and environmental protection. This includes operational monitoring and forecasting for large North Atlantic and Arctic areas. MET Norway represents Norway in international meteorological organizations such as ECMWF, EUMETSAT, EUMETNET, WMO and other international forums. MET Norway also participates in national and international research projects funded by EU and other bodies on climate, atmospheric and marine research including the application of remote sensing techniques and air pollution research. MET Norway employs about 400 persons, in addition to about 600 observers, including staff at Arctic stations.

The infrastructure of the MET Norway

MET Norway operates an extensive operational meteorological observation network that covers parts of the Arctic, including manned stations on the islands Jan Mayen, Bjørnøya and Hopen, as well as a network on the Svalbard archipelago. MET Norway has access to national supercomputer facilities for doing research and running predictive models, and also cooperates with the Swedish national meteorological service on running joint operational models on Swedish supercomputer resources.

MET Norway supports and implements a free and open data policy. Official data and products from the institute are regarded as public sector information and are freely available to the public for use, distribution and processing. Channels for public distribution of weather forecasts include the website and the mobile application yr.no (with 5-10 million unique users weekly – the largest weather website in the world outside the US) as well as various lower level download services.

MET Norway is connected to WMO data exchange, both through WMO Information System and through the Global Telecommunication System. Data management is based on a metadata driven approach where datasets are documented including the interfaces for accessing them. In addition to close linkages to national High Performance Computing and Storage systems, MET Norway has also local HPC and HPS systems that scales for future needs.

Profile relating to the project

Around 80 scientists do research within numerical weather prediction, ocean modelling, remote sensing, air pollution, product development, instrumentation, climatology and climate research. Numerical models for atmospheric, oceanographic and sea-ice forecasting are continuously improved. In situ and remote sensing observations and data assimilation techniques are used in the work on forecast modelling. Considerable R&D is also centred on environmental models (air pollutants, oil spills, etc.). MET Norway has extensive experience in developing methods and operational applications that have led to innovation and value addition in both the private and public sector.

In recent years our climate research included development and running of a full-scale global Earth System Model (NorESM), which is done as a part of a national co-operation, in particular with the UniResearch Bjerknes Centre and University of Bergen. Other contributions include co-operation with the Stockholm University and to a lesser extent University of Helsinki. NorESM provided full-scale climate projection data for the CMIP5 intercomparison and to IPCC AR5. Almost 500 peer reviewed publications refer to NorESM and NorESM-generated data. NorESM-work, presently in preparation for CMIP6 and IPCC AR6, is partly funded by a nationally co-ordinated project from the Research Council of Norway (EVA) and a recently initiated project under EU H2020 (CRESCENDO). NorESM is also associated with the IS-ENES2 and several project under the Nordic Council of Ministres, NordForsk (CRAICC, eSTICC). MET Norway’s scientific contributions to NorESM are mainly in aerosol-cloud-climate interactions, sea-ice processes, and dynamic response in the climate system to forcing agents. MET Norway is a core institution together with UniResearch Bjerknes Centre for setting up and running the model for full-scale climate simulations in line with the CMIP-protocols.
MET Norway takes part in the joint development in the multi-national HARMONIE cooperation on advancing a state-of-the-art high-resolution numerical weather prediction (NWP) system, in particular with contributions in the field of data assimilation, ensemble predictions, verification and system set-up. In support of Arctic forecasting, MET Norway runs operationally a version of the AROME NWP model: AROME-Arctic. This model is convection permitting with 2.5 km horizontal resolution and covers a region comprising parts of Arctic Ocean and Greenland and Barents seas. The system is updated through three-dimensional variational data assimilation, using both conventional meteorological observations and polar-orbiting satellite data, which are very important in these regions, such as microwave and infrared sounders, scatterometer winds and atmospheric motion vectors. MET Norway does not intend to run AROME-Arctic in ensemble mode operationally so far.

MET Norway runs the Norwegian Ice Service, which is part of MET Norway’s Forecasting Division for Northern Norway in Tromsø. The Ice Service provides daily (working day, Monday-Friday) ice charts for the European sector of the Arctic, with an emphasis on Spitsbergen (Svalbard) which is covered in detail using different synthetic aperture radar satellites including the Copernicus Sentinel-1 SAR. The analysts study the current conditions primarily from satellite data and provide ice charts, ice-edge information and an overview of sea surface temperatures.

MET Norway co-leads (together with the Danish Meteorological Institute) the High Latitude production centre of the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF), which delivers operational global sea ice products to world's weather centres, including the ECMWF. MET Norway also leads the Ocean and Sea Ice Thematic Assembly Centre (OSI TAC), a sub-system of the EU Copernicus Marine Environment Monitoring Service (CMEMS).

MET Norway operates a WMO Information System approved Data Collection and Production Centre, the Arctic Data Centre. This is a legacy of the International Polar Year (IPY) when MET Norway was coordinating data management nationally and operational data streams internationally. The Arctic Data Centre attempts to bridge operational and scientific communities in a region where observations are sparse. This activity is closely linked to a number infrastructure projects nationally and internationally where MET Norway has a prominent role in data management. This includes WMO Global Cryosphere Watch and YOPP data management, the Norwegian Satellite Earth Observation Database for Marine and Polar Research and the emerging Svalbard Integrated Arctic Earth Observing System.

Main tasks in the project

In the present proposed project MET Norway tasks include both contributions to research into short-range numerical weather prediction (NWP), and into climate system research of potential changes in mid-latitude atmospheric flows associated with reduction of Arctic sea-ice. MET Norway will be co-leading the synthesis of main progress in the project with relevance for improved predictive capacity associated with the Arctic at large (WP5), and will be a central contributor to climate system experiments focusing on the impact of Arctic sea-ice reductions (WP3). There is strong relevance with YOPP and with C3S.

The short-range NWP-research will predominantly take place through defining experimental set-ups to diagnose predictive capacities in the beginning (stream 1) and towards the end (stream 2) of the project. Systematic experiments with different set-ups of the 2.5km AROME-Arctic, emphasizing domain-size, forecast lead time, and representation of sea-ice, are planned. The main aim is to improve the prediction and diagnose predictability of severe weather associated with the sea-ice edge in the Euro-Atlantic sector of Arctic. This field of research will also involve comparisons with the even finer-resolution version of AROME run by CNRM, and with ECMWF concerning the use of larger-scale boundary data.

The work on potential climate impacts associated with Arctic sea-ice reduction, will be made with a recent version of NorESM. The experiments will follow a protocol designed in WP3 in line with several model teams, and thus, considerably more certain understanding of these possible links between the Arctic and mid-latitudes is expected to emerge.

MET Norway will co-ordinate data management (WP6) with emphasis of integrating real time data streams with WMO (YOPP etc) and SAON needs.

Profiles of the MET Norway staff involved in the project

Professor Dr. Trond Iversen
Deputy Research Director at MET Norway, Male
Education
Dr. Scient. (PhD), Dynamic Meteorology, University of Oslo, 1981.
Cand Real (MSc), Dynamic Meteorology, University of Oslo, 1979

Experience relating to the project
Over more than the 20 later years Iversen has been leading or co-leading several nationally co-ordinated research projects in the field of climate modeling and the understanding and numerical representation of physicochemical processes in global climate and earth system models. Emphasis has been on aerosol lifecycling and the interactions between aerosols and radiation and clouds. Also the relations between forcing, climate sensitivity and response has been studied. Many scientific publications and the NorESM climate model system has been produced in a wide co-operation nationally and internationally. Before this, Iversen contributed scientifically to fields in NWP and transport of air pollution, including Arctic haze.
During 2006-2012, Iversen was in the project management for the HIRLAM NWP consortium in Europe, with responsibility for developing a new limited-area ensemble prediction system. As a leader of the team of scientists from several national weather services in Europe, Iversen lead the development of the pan-European system called GLAMEPS, which proved to show considerably better probabilistic scores than the ECMWF ENS. This system has run operationally since 2011, and has since been subject to two major upgrades. Iversen has also been involved in regional climate modeling.

Publications / achievements relevant for this project
In addition to scientific publications, Iversen has been instrumental on the management side in establishing the NorESM climate model system, and a research group centred around NorESM, with international co-operation. The Grand Limited-Area Model Ensemble Prediction System (GLAMEPS) for short-range NWP, which is run operationally as an international co-operation, was also developed from scratch under his leadership. Iversen was Guest Editor for three special issues (two times Tellus A, on time Geoscientific Model Development) in connection with these two major achievements.


Participation in research projects
1997 – 2006  RegClim, Research Council of Norway: Project Manager
2014  ongoing  EVA, Research Council of Norway: Co-leader and PI for NorESM and contact for CMIP6.
2006  2012  HIRLAM Project Leader for predictability and ensemble prediction system GLAMEPS.

Dr. Morten Ø. Køltzow
Head Division for Numerical Weather Prediction and Researcher (2016-), Male
Assistant Head Division for Numerical Weather Prediction and Researcher (2012-2015), Male
Education
PhD in meteorology, University of Oslo, Norway, 2012,
Cand Scient in meteorology, University of Oslo, Norway, 1998.

Experience relating to the project
Morten Ø. Køltzow has a wide approach to the field of meteorology. His PhD is titled “Abilities and limitations in the use of Regional Climate models” and is related with the use of limited-area models for climate simulations. At the same time he has been working in all parts of the METNO production chain for NWP from model development, verification and diagnostics, post-processing, forecast presentation/communication and end user contact. Similarities between the climate and NWP work is the use of limited-area models. Earlier he has also been working on the parameterization of sea ice and snow albedo in models and coupling of atmosphere and ocean models.

Publications / achievements relevant for this project
Leader for Development MetCoOp, the operational NWP cooperation between METNO/SMHI, 2014–2015
Leader of METNO project for implementation of operational forecasts with AROME, 2013
Leader of geophysical development for the web portal Yr.no, 2010-2014.

Participation in research projects
2002 – 2007 Norwegian Research Council - REGCLIM, Researcher
2002 – 2005 EU – GLIMPSE, Researcher
2001 – 2005 EU – EUROCLIM, Researcher

Dr. Øyvind Seland
Research Scientist

Education
Cand. Scient. in Meteorology, University of Oslo, Oslo, Norway, 1994
PhD in Meteorology, University of Oslo, Oslo, Norway, 2001

Experience relating to the project
Experience with modelling of physical properties and climate effects of aerosols from 1997 and up til now. Have in close collaboration with Professor Trond Iversen and Dr. Alf Kirkevåg developed a unique aerosol-climate interaction parameterisation with high focus on processes. With increasing complexity of parameterisation these ideas have been worked on and included in several generations of the NCAR-CAM model. After 2008 my focus has switched towards Earth System modelling and had together with Dr Mats Bentsen and Dr. Ingo Bethke the main responsibility for creating and running CMIP 5 experiments for Norwegian Climate Centre (NorESM model) Special interest areas are representation of physical processes in climate and meteorological models, and coupling and feedbacks in Earth System Models.

Publications / achievements relevant for this project
Outten, S., P. Thorne, I. Bethke, and Ø. Seland (2015), Investigating the recent apparent hiatus in surface


Participation in research projects

2015 – 2019 EU-Crescendo: Task leader in WP3 and WP6
2013 – 2017 EU–IS-ENES2: Institution scientific contact

Dr. Jens Boldingh Debernard
Research Scientist

Education

Cand. Scient. in Physical Oceanography, University of Oslo, Oslo, Norway, 1994
PhD in Physical Oceanography, University of Oslo, Oslo, Norway, 2001

Experience relating to the project

Main research experiences relevant for this project covers development of sea ice models, global and regional climate modelling, development of regional and global atmosphere-sea ice-ocean models, climate change in the Arctic. He is a core member of the NorESM development team, with main responsibility for the sea ice component, and has experience from the CMIP5-production with this model, and use of the model for typical Arctic questions (EU-FP7 ACCESS). He has also experience with nudging or relaxation of sea ice models towards observations. Special interest areas are representation of physical processes in sea ice and climate models, sea ice as a part of the climate system, and general coupling and feedbacks in Earth System Models.

Publications / achievements relevant for this project


Participation in ongoing research projects

2014 – 2018 Norwegian Research Council – EVA
2015 – 2020 EU-Crescendo
2016 – 2020 Norwegian Research Council – SPARSE, Task leader
Dr. Øystein Godøy
Senior Scientist, male

**Education**

Dr. Scient. in Oceanography from University of Bergen, 1998.

**Experience relating to the project**

Øystein Godøy has been involved in a number of national and international projects. He was chairing data management activities in the EU FP6 project DAMOCLES, EU FP7 project ACCESS, was International Operational Data Coordinator during IPY, is chairing the data portal team in WMO Global Cryosphere Watch, is member of the WMO Integrated Global Observing System – Task Team on metadata, participated in drafting the technical specifications of WMO Information System, seats the combined SAON/IASC Arctic Data Committee, representing WMO and the national resource allocation committee for high performance computing and storage. He is leading a number of national e-infrastructure projects on data management.

**Publications / achievements relevant for this project**


**Participation in research projects**

Øystein Godøy has participated in EU FP6 and FP7 projects DAMOCLES and ACCESS, participates (or leads) in the EUMETSAT Ocean and Sea Ice SAF, Norwegian Satellite Earth Observation Database for Marine and Polar Research, Norwegian Marine Data Centre, Svalbard Integrated Arctic Earth Observing System, Norwegian Scientific Data Network and GeoAccess.

Dr. Eivind Støylen
Research Scientist at NWP division, male

**Education**

Master in meteorology and oceanography, University of Oslo, Oslo, Norway, 2008
PhD in oceanography, University of Oslo, Oslo, Norway, 2013

**Experience relating to the project**

Eivind Støylen has four years experience on arctic processes in the ocean, numerical modelling and observations, during his Ph.D. Since joining MET Norway in 2013 he has worked primarily on two projects, funded by BarentsWatch and NVE (The Norwegian Water Resources and Energy Directorate) respectively. The BarentsWatch project involves tracking of Polar Lows using a high resolution convection-permitting NWP EPS covering parts of the Barents and Norwegian Seas. He has led the work on the development of the tracking algorithm as well as the evaluation and verification of the results. In the NVE project he has worked on post processing of (deterministic and EPS) high resolution NWP data for preparation for hydrological models. He has also worked on verification
and analysis of NWP data for flooding events. Furthermore, he has contributed in the preparation and setup of the NWP model AROME-Arctic to be run operationally at MET Norway.

**Publications / achievements relevant for this project**


**Participation in research projects**

2013 – 2015 BarentsWatch – Polar Low tracking: project leader
2013 – 2016 NVE – Facilitate NWP forecasts for flood models: project leader
2015 – 2016 MET (internally funded) – Arome-Arctic: employee

**Dr. Lise Seland Graff**
Researcher, female

**Education**
PhD in meteorology, University of Oslo, Oslo, Norway, 2015
Master in meteorology, University of Oslo, Oslo, Norway, 2009
Bachelor in meteorology, University of Oslo, Oslo, Norway, 2007

**Experience relating to the project**

Graff has a PhD in atmospheric dynamics, specializing in extratropical storm tracks and synoptic-scale mixing. She is currently working on atmospheric feedback using the radiative kernel method from Soden et al. (2008).

**Publications / achievements relevant for this project**


**Participation in research projects**

2014 – 2016 EU – EVA: participant WP3, task 3.1

**Dr. Ivar A. Seierstad**
Researcher at the Division for Numerical Weather Prediction, Male

**Education**
Cand. Scient Meteorology, University of Bergen 2002
PhD in Meteorology, University of Bergen 2008

**Experience relating to the project**

Seierstad is a meteorologist with main research focus on understanding the the internal and forced variability of extratropical storm tracks and associated circulation patterns. His interests include diagnostic analysis of both observed and simulated climate variability in the coupled atmosphere-ocean-ice system. He is currently co-leading

**Publications / achievements relevant for this project**


**Participation in research projects**


2014 – 2017 Research Council of Norway - *EVA* - Earth system modelling of climate Variations in the Anthropocene: Co-leader WP3 (Variability and feedback analysis)

**Dr. Andrew Singleton**

Ensemble Prediction Scientist, Male

**Education**

PhD in Meteorology, University of Cape Town, Cape Town, South Africa, 2005

MSc in Atmospheric Sciences, University of East Anglia, Norwich, United Kingdom, 1999

**Experience relating to the project**

Currently working in the development of the Harmonie Ensemble Prediction System (HarmonEPS) under the HIRLAM consortium. The emphasis is on developing methods to perturb surface parameters, including snow, ice and sea surface temperature, in order to better quantify the forecast uncertainty. Further experience related to the development, use and verification of probabilistic weather forecasts as well as research in extreme weather.

**Publications / achievements relevant for this project**


**Participation in research projects**

2016 – 2020 HIRLAM – HIRLAM C: Ensemble Prediction scientist


ONGOING EU-JRC – DESERT ACTION: Ensemble forecasting post-doctoral researcher (2010-2013)
The legal entity

The Met Office, founded in 1854, is the National Meteorological Service (NMS) for the United Kingdom and one of the world's foremost weather, climate service and operational oceanography providers. It is a UK government trading fund employing around 1,800 staff including meteorologists, hydrologists, climate scientists, oceanographers, IT and support staff. A world renowned centre of excellence in meteorological and oceanographic modelling, forecasting and climate prediction, the Met Office supports a large number of customers globally including governments, civil aviation, defence, commerce and industry. It provides essential services 24/7, 365 days a year, in many aspects of business, social and political life in the UK without which these organisations operations would be severely restricted. The Met Office supplies data, products, training and capability building services to many countries throughout the world.

The Met Office has always been at the forefront of meteorological science and is a recognised world leading organisation in climate science and climate services through the Met Office Hadley Centre (MOHC) for Climate Science and Services. MOHC leads the production of a number of key global climate datasets (e.g. HadISST), and its climate models in the HadCMx and HadGEMx families have been widely regarded as at the forefront for many years. The top-level aims of the MOHC include monitoring global and national climate variability and change, attribution of recent changes in climate, and projection of future climate change. Many MOHC scientists have made major contributions to scientific literature and to the assessment reports of the Intergovernmental Panel on Climate Change (IPCC).

The MOHC also has a strong activity in seasonal and decadal climate prediction. Recent advances in modelling systems have increased the capabilities of its monthly to decadal prediction systems, which bridge the gap between short-term weather forecasts and long-term climate projections. These forecasts have a range of applications throughout the world. The Met Office's interannual to decadal prediction system (DePreSys) was the first in the world. From 2016 both the seasonal (GloSea5) and decadal (DePreSys3) forecast systems will be based on a new, high-resolution climate model, HadGEM3, which has been shown to provide increased realism, for example in its representation of Atlantic/European weather patterns.

The Met Office is in a rare, if not unique position, of having cutting edge expertise in weather forecasting, seasonal to decadal prediction and climate change under the same roof, using prediction systems that are based on the same underlying model (the Met Office Unified Model) for all timescales. For APPLICATE this will allow insights gained from predictions on one timescale to be easily transferred to other timescales.

The infrastructure of the Met Office

The Met Office operates a powerful High Performance Computing facility based on a CRAY XC40 supercomputer system. From around March 2016 this will have approximately 6000 user nodes, with a further ~6000 nodes due to be added around March 2017. The computing engine is supported by the Met Office’s MASS-R storage system, which uses the IBM HPSS (High Performance Storage System: http://www.hpss-collaboration.org/) to provide hierarchical storage management of IBM disk and tape hardware, and services for very large storage requirements. It enables high data transfer rates to move large files between storage devices and computers, and an environment that can scale to multiple petabytes ($10^{15}$ bytes).

Access to these facilities will allow the Met Office to perform a large suite of modelling and ensemble climate prediction experiments, to deliver its planned contributions to the science work packages of APPLICATE. A wide suite of additional model runs (e.g. CMIP6 DECK) performed outside APPLICATE will also be available for analysis, forming a substantial in-kind contribution.

Profile relating to the project

The Met Office will contribute internationally recognised expertise to APPLICATE in the areas of seasonal and decadal climate prediction, climate change projections, and climate model development and evaluation. Examples of recent advances of particular relevance to APPLICATE include:
• Demonstrating skilful seasonal prediction of the September Arctic sea ice minimum from spring conditions (Peterson et al. Clim. Dyn. 2014)
• Developing the world’s first decadal climate prediction system and demonstration of skill in predicting European winter climate anomalies (Smith et al. Quart. J.R.M.S 2014)
• Demonstrating the key roles of meltponds and ocean heat exchange in the retreat of Arctic sea ice under climate change (Keen et al. Clim. Dyn. 2013)
• Development of global coupled models suitable for prediction of Arctic sea ice across all timescales (Hewitt et al. Phil. Trans. Roy. Soc. 2015).

The Met Office’s modelling and climate prediction contributions to APPLICATE will build upon the above systems. The Met Office will also contribute to the wider reach of APPLICATE through extensive links to the international research community, including membership of the CLIVAR Ocean Model Development Panel, WCRP Grand Challenge Panel on near-term climate prediction, CLIVAR Global Ocean Synthesis and Observations Panel, and coordination of the annual inter-institutional exchange of decadal forecasts.

Main tasks in the project

The Met Office’s contributions to APPLICATE will focus on: innovative process-based model metrics to reduce uncertainty in projections of Arctic climate change (WP1), model developments to improve representation of Arctic ocean and sea ice processes (WP2), improved quantification of the links between Arctic and European climate (WP3 – Met Office lead), evaluation of the potential for sea ice thickness observations to improve climate predictions (WP4), understanding sources of seasonal predictability and assessing the impact of APPLICATE developments on seasonal prediction and climate change projections (WP5).

Profiles of the staff involved in the project

Dr Richard Wood
Head of Oceans, Cryosphere and Dangerous Climate Change, Male

Education
BA in Mathematics, University of Cambridge, Cambridge, UK, 1980
PhD in Geophysical Fluid Dynamics, University of Exeter, Exeter, UK, 1988

Experience relating to the project

Richard Wood is Head of Oceans, Cryosphere and Dangerous Climate Change at the Met Office Hadley Centre, where he leads the Met Office’s research on the role of the oceans and polar regions in climate, as well as its ocean and sea ice model development activities. He was a founder member of the Met Office Hadley Centre in 1989, and before this was Lecturer in Applied Mathematics at Southampton University. From 2009-2013 Richard worked part-time for the UK’s Natural Environment Research Council as its Theme Leader (Climate System), playing a science leadership role in the development of fifteen NERC strategic research programmes in climate science (with values between 3-20 M GBP). He is author/co-author of around 50 peer-reviewed publications, and was Lead Author/Coordinating Lead Author of the Climate Model Evaluation chapters in the IPCC Third and Fourth Assessment Reports.

Publications / achievements relevant for this project


Participation in research projects

1990 present UK Departments of Environment (Defra) and Energy & Climate Change (DECC), Met Office Hadley Centre Climate Programme: long term research programme. At various times, leader of Oceans and Climate science theme, Climate Thresholds and Vulnerabilities science theme, and Climate Model Development science theme
2003 present NERC RAPID programme. Member of Programme Executive Board
2008 – 2012 EU – THOR: leader, Core Theme 2 (Assessing sources of uncertainty in reanalyses and forecasts) and Met Office lead scientist
2015 – 2019 EU – AtlantOS: Task leader in WP 1 and WP8, and Met Office lead scientist

Dr Doug Smith
Manager of Predictability Research Group and Met Office Science Fellow, Male

Education
PhD, Computational Fluid Dynamics, Imperial College, UK, 1990
BSc (1st class) Mechanical Engineering, Imperial College, UK, 1984

Experience relating to the project
Dr Smith developed the first decadal climate prediction system to show improved skill through initialisation with observations (Smith et al. 2007), subsequently using it to demonstrate skillful predictions of the North Atlantic ocean and related climate impacts (Smith et al. 2010; Robson et al. 2012, 2013, 2014; Pohlmann et al. 2013; Hermanson et al. 2014). He currently leads a research team investigating climate predictability on seasonal to decadal timescales (Smith et al. 2012), with a particular focus on the North Atlantic Oscillation (Smith et al. 2014; Eade et al. 2014) and the potential impacts of Arctic sea ice decline on the mid-latitudes (Smith et al. 2016). As co-chair of the WCRP Decadal Climate Prediction Panel Dr Smith played a leading role in designing coordinated decadal prediction experiments for the upcoming sixth Coupled Model Intercomparison Project. He also coordinates an annual exchange of international real-time decadal forecasts (Smith et al. 2012b), and as a member of the panel coordinating the WCRP Grand Challenge on near term climate prediction he is well placed to ensure that APPLICATE research will feed through into actual forecasts for the user community.

Publications / achievements relevant for this project
Smith, D. M., N. J. Dunstone, A. A. Scaife, E. K. Fiedler and D. Copsey, 2016: Atmospheric response to reduced Arctic sea ice simulated in HadGEM3, to be submitted to J. Climate

Participation in research projects and panels
2009 – 2013 EU - COMBINE: Work package co-leader
2012 – 2016 EU – SPECS: Scientist
2009 – 2011 US CLIVAR Working group on decadal prediction: member
Dr Helene Hewitt  
Manager of Ocean Modelling Group and Met Office Science Fellow, Female

**Education**

PhD, Physical Oceanography, University of Southampton, UK, 1996  
BA (1st class) Mathematics, Fitzwilliam College, University of Cambridge, UK, 1993

**Experience relating to the project**

Dr Hewitt (nee Banks) successfully led the development of the HadGEM3 coupled model (Hewitt et al., 2011) which for the first time coupled the Unified Model to the shared ocean and sea ice models NEMO and CICE using the OASIS coupler. The infrastructure developed in the HadGEM3 project continues to underpin the Met Office Global Coupled model. She has led work to develop both ocean and sea ice models (e.g., Johns et al., 2006; Rae et al., 2015; Storkey et al., in prep.) and is an internationally recognised expert in this area (Griffies et al., 2009; Belcher et al., 2015; Member of CLIVAR Ocean Model Development Panel). She currently manages the UK Joint Weather and Climate Research Programme ocean modelling work. Dr. Hewitt has worked on exploiting the capability to simulate sea ice in the coupled system for seasonal prediction (e.g., Keen et al., 2013; Peterson et al., 2014; Hewitt et al., 2015) and developed techniques to evaluate ocean and sea ice models against observations (e.g., Gordon et al., 2000; Pardaens et al., 2003; McLaren et al., 2006). Her work looking at ocean observations in the context of climate model output has guided understanding of observational error as well as the likelihood of an anthropogenic cause (e.g., Banks et al., 2000; Banks and Bindoff, 2003; Gregory et al., 2004). In 2010, she was a member of the programme advisory group for the UK NERC Arctic Research programme.

**Publications / achievements relevant for this project**


**Participation in research projects**

2008 – 2013 Hadley Centre Climate Programme: Manager of Polar Climate group  
2011 – 2014 NERC - TEA-COSI: External collaborator  
2015 – 2019 EU – PRIMAVERA: Scientist

Dr Ed Blockley  
Manager of Polar Climate Group, Male

**Education**

MMath - Masters in mathematics with 1st class hours in mathematics, University of Exeter, UK, 2003  
PhD in applied mathematics, University of Exeter, UK, 2008
Experience relating to the project

Dr. Ed Blockley manages the Polar Climate Group of the Met Office Hadley Centre – a group with considerable experience of developing and evaluating coupled climate models and with a focus on understanding climate change in polar regions. Ed has experience of ocean and sea ice modelling and assessment within the framework of the Met Office's global climate models and operational short-range and seasonal forecasting systems. Within the UK, under the auspices of the UK's Joint Weather and Climate Research Programme, Ed leads development of the Global Sea Ice (GSI) configurations that are used within all the Met Office/Hadley Centre physical models and the UK Earth System Model. These GSI configurations are used for forecasting and prediction across all timescales from hours to seasons as well as for climate projections. Prior to taking on the leadership of the Polar Climate Group in 2015, Ed worked in the Ocean Forecasting Research and Development team where he led development and evaluation of the Met Office’s near-real-time operational ocean-sea ice forecasting system FOAM. During this time he was heavily involved, including as work package leader, with the (EU) MyOcean series of projects.

Publications / achievements relevant for this project


Participation in research projects

2014 – present Hadley Centre Climate Programme: Manager of Polar Climate group
2013 – 2015 Copernicus MyOcean2: leader WP7 (European Northwest Shelf Seas Monitoring and Forecasting Centre)
2012 – 2015 Copernicus MyOcean2: Service Manager for Met Office production/dissemination unit
2015 – 2019 EU – PRIMAVERA: Scientist (involvement with sea ice model development activities in WP3)

Ms Ann Keen
Senior Sea Ice Scientist, Female

Education

BSc in Mathematical Physics, Nottingham University, 1982
MSc in Numerical Analysis, Brunel University, 1989

Experience relating to the project

Ann Keen is a Senior Research Scientist at the Met Office Hadley Centre (MOHC). Since 2002 she has specialised in the development and assessment of the representation of sea ice within climate models, with the aim of increasing confidence in projections of polar climate change. She contributed to the development and evaluation of the models HadGEM1 and HadGEM2. She has recently spent 18 months managing the Polar Climate Group at the MOHC, including leading the development of the CICE sea ice component of HadGEM3, which will form the basis of the MOHC’s contribution to CMIP6. She is currently working to understand the processes driving variability and decline in modelled Arctic sea ice.
Publications / achievements relevant for this project


Dr Tim Graham
Senior ocean modelling research scientist, male

Education
BSc (Hons) in Meteorology & Oceanography with a year in continental Europe, School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom, 2004
PhD in coupled ocean atmosphere modelling, School of Mathematics, University of East Anglia, Norwich, United Kingdom, 2008

Experience relating to the project
Tim has worked with the NEMO model since starting at the Met Office in 2008. He is a member of the NEMO systems team and actively contributes to development and maintenance of the NEMO model code. He has been involved in the development of the Met Office configuration of the Global Ocean Model (GO5; Megann et al., 2014) and version GC2 of the HadGEM3 coupled climate model (Williams et al., 2015). His past research includes analysis of the Arctic Ocean heat budget in coupled GCMs (HadCM3 & HadGEM; Graham and Vellinga 2013). More recently, Tim has worked with the AGRIF (Adaptive Grid Refinement In Fortran) nested modelling configuration in NEMO and, in collaboration with other members of the systems team, is developing capability for vertical grid refinement.

Publications / achievements relevant for this project
Hewitt, H. et al., 2012: Assessment of Possibility and Impact of Rapid Climate Change in the Arctic. Hadley Centre Technical Note 91.
Williams K., et al., 2015: The Met Office Global Coupled model 2.0 (GC2) configuration, Geoscientific Model Development, 8 (5).

Participation in research projects
2008 – 2015 Met Office Hadley Centre Climate Programme: Ocean model evaluation and development scientist
2015 – 2015 EU – MyOcean follow on project: Development of the NEMO ocean model

Dr Kenneth Andrew (Drew) Peterson
Senior Scientist Operational Systems, male

Education
BSc (Hons) in Physics, University of Saskatchewan, Canada, 1984
MSc in theoretical physics, University of Alberta, Canada, 1987
PhD in theoretical physics, University of Alberta, Canada, 1991

Experience relating to the project
Drew works in the Monthly to Decadal Variability and Prediction team at the Met Office who are responsible for developing the seasonal forecast system. His primary responsibility is to produce the ocean and sea ice analyses required to initialize the coupled seasonal (re-)forecasts. This entails using data assimilation techniques (NEMOVAR) to best fit the available observations into the ocean and sea ice model (NEMO/CICE) in a dynamically balanced fashion. Drew is a member of the ORA-IP project which has made significant advances in the use of ocean analyses as a tool to study the ocean and climate system – something he will continue with his involvement in the Evaluating Ocean Synthesis EU COST project. Drew is responsible for the long range seasonal forecasts of Arctic sea ice that the Met Office provide to the, US funded, Sea Ice Prediction Network (SIPN) Sea Ice Outlook (SIO) each year. He has also led an international multi-model study to determine the effects of sea ice initialization in seasonal forecast models.

Publications / achievements relevant for this project


Participation in research projects

2012 – 2016 EU–SPECS: Scientist
2015 – 2016 CSSP-China: Scientist
The legal entity

Building on almost 600 years’ experience, the Université catholique de Louvain (UCL; www.uclouvain.be) is today a multisite university in Belgium (Louvain-la-Neuve, Brussels Woluwe, Mons, Tournai, Brussels Saint-Gilles and Charleroi) at the forefront of innovation and excellence in education and research. The university involves more than 28,000 students of 127 different nationalities and a staff of about 5,700 teachers, researchers and administrative and technical collaborators. UCL is responsible for the education of nearly one out of two French-speaking academics in Belgium and proposes courses in all possible disciplines. Research is one of UCL’s main activities. More than 1000 research contracts are signed every year with universities, public institutions and private companies. UCL actively participates in the R&I programmes of the European Union. It is notably involved in 176 projects within FP7 and in already 40 Horizon 2020 projects. UCL proposes a variety of services to society and the academic community: 3 science parks (Louvain-la-Neuve, Brussels, Seneffe), 2 university hospitals (Saint-Luc Brussels and Mont-Godinne), 2 museums and 8 main libraries.

The research conducted at the Georges Lemaître Centre for Earth and Climate Research (TECLIM; www.uclouvain.be/teclim; around 80 staff members) of UCL aims at understanding the functioning of the Earth system, with a focus on its climate component, and the interactions between human activities and their natural environment. The current research activities concern (1) past environmental and climate changes, (2) the present state of the Earth and solar systems, (3) human-environment interactions and (4) modelling tools. Next to its involvement in numerous national and European projects, UCL-TECLIM hosts or has hosted 2 ERC Starting Grants, 2 ERC Advanced Grants and several Marie Curie Individual Fellowships.

The infrastructure of UCL

The CISM (Centre de Calcul et de Stockage de Masse; www.uclouvain.be/cism) is a high-performance computing facility integrated inside UCL’s structure. It offers to researchers an access to a high-computing power and mass storage. The whole infrastructure consists of 3 clusters containing up to 3830 cores, corresponding to a total peak performance of 42 Tflops, and 261 TB of secure mass storage. Thanks to the Consortium des Equipments de Calcul Intensif (CECI; www.ceci-hpc.be) supported by the Belgian Fund for Scientific Research – FNRS, UCL’s researchers have also access to clusters located in the other universities of the Wallonia-Brussels Federation (PRACE Tier2 level), representing together up to 6100 additional cores and 77.7 Tflops. Finally, this collaboration gives UCL’s researchers a privileged access to the PRACE Tier1 level Zénobe cluster hosted and operated by Cenaero (www.cenaero.be). This computer features a total of 11,496 cores, with up to 64 GB of RAM per node, interconnected with a QDR/FDR mixed infiniband network and sharing a fast 350 GPFS parallel filesystem. Its total peak performance is 217.53 Tflops.

Profile relating to the project

The positive reputation of UCL-TECLIM in the area of global climate modelling is well established. The sea ice model (LIM) it has built is considered to be essential in the community of climate and ocean modellers and is used in many countries. A large number of original process studies were performed with this model coupled to various oceanic general circulation models. These studies have notably highlighted the key role played by sea ice–ocean interactions in controlling the circulation of the World Ocean. LIM is also increasingly used in the context of seasonal-to-interannual climate prediction, for optimal estimation of initial sea ice state and the calibration of sea ice parameters. Members of UCL-TECLIM have also developed a hierarchy of Earth system models, one of them (LOVECLIM) being utilized worldwide. The group has carried out seminal studies on the last glacial–interglacial cycles, the abrupt climate change that occurred 8,200 years ago, climate variability and changes during the Holocene (including the last millennium), interannual climate variability over the last decades and future climate changes.
Main tasks in the project

With a wealth of experience in sea ice and polar climate modelling behind it, UCL-TECLIM will co-lead and actively contribute to the work package on the support for the design of the Arctic observing system (WP4). It will also take an important role in (1) the model evaluation part (WP1), (2) the improvement (focus on sea ice and coupling processes) and testing of climate models (WP2) and (3) the analysis of the influence of sea ice model improvements on climate forecast quality (WP5).

Profiles of UCL’s staff involved in the project

Prof. Dr. Thierry Fichefet
Full Professor, Male

Education

Master Degree in Physics, UCL, Louvain-la-Neuve, Belgium, 1983
PhD in Sciences, UCL, Louvain-la-Neuve, Belgium, 1988

Experience relating to the project

Thierry Fichefet is a Full Professor at UCL. He has 32 years’ experience in global climate modelling, with a focus on climate-cryosphere interactions. At UCL-TECLIM, he is leading the development of LIM. He was principal investigator for about 40 national and European research projects. He is author or co-author of about 120 scientific papers published in international peer-reviewed journals or books, and of 70 other publications. He is frequently invited to give talks and chair sessions in international scientific meetings, and to give popular conferences on climate change in schools and societies. He is also deeply involved in national and international research programmes and organisations. In particular, he was member of the Scientific Steering Group of the Climate and Cryosphere (CliC) programme of the World Climate Research Programme (WCRP) up to 2008. He was Lead Author of the Fourth and Fifth Assessment Reports of Working Group 1 of the Intergovernmental Panel on Climate Change (IPCC), which shared the Nobel Peace Prize 2007 with Al Gore. He is member of the Academia Europaea and was awarded the Adolphe Wetrems Prize 2004 (Mathematical and Physical Sciences) of the Classe des Sciences de l’Académie Royale des Sciences, des Lettres et des Beaux-arts de Belgique, the Gérard Mégie Prize 2008 of the Académie des Sciences of the Institut de France and the Louis Agassiz Medal 2016 of the Division on Cryospheric Sciences of the European Geophysical Union.

Publications / achievements relevant for this project


Participation in research projects

2009 – 2013 EU – COMBINE: task leader in WP4, WP5, WP6 and WP7
2010 – 2015 Belgian Science Policy – Constraining long-term climate and sea level projections using the Last
Interglacial (iCLIPS): leader of several tasks
2011 – 2016 EU – EMBRACE: task leader in WP2
2015 – 2019 EU – PRIMAVERA: task leader in WP1 and WP2
2016 – 2020 Belgian Fund for Scientific Research – FNRS – Influence of small-scale processes on the dynamics of the coupled atmosphere-cryosphere-ocean system on daily to seasonal timescales in the region of Adélie Land, Antarctica: coordinator

Prof. Dr. Hugues Goosse
Head of UCL-TECLIM, Male

Education
Civil Engineer, Université de Liège, Liège, Belgium, 1993
PhD in Applied Sciences, UCL, Louvain-la-Neuve, Belgium, 1997

Experience relating to the project
Hugues Goosse is a Research Director at the Belgian Fund for Scientific Research – FNRS, a Part-time Professor at UCL and the Head of UCL-TECLIM. He has more than 20 years of experience in global climate modelling. His research interest is presently focused on decadal-to-centennial climate variability in mid- and high latitudes, on the evaluation of climate models using process-oriented diagnostics and on the evolution of climate over the last millennia. He is theme leader of the WCRP Polar Climate Predictability Initiative and member of the Steering Committee of the PAGES (Past Global Changes) programme. He is author or co-author of more than 140 scientific papers published in international refereed journals and was Contributing Author of the Fourth and Fifth Assessment Reports of Working Group 1 of IPCC.

Publications / achievements relevant for this project

Participation in research projects
2010 – 2014 EU – Past4Future: task leader in WP1 and WP4
2010 – 2015 Belgian Science Policy – Understanding and predicting Antarctic sea ice variability at the decadal timescale (PREDANTAR): coordinator
2014 – 2018 Belgian Fund for Scientific Research – FNRS – Improving the representation of Antarctic sea ice in climate models thanks to a better understanding of the processes governing its mean state and variability: coordinator

Dr. François Massonnet
Post-doctoral researcher, Male

Education
Civil Engineer, Université catholique de Louvain, Louvain-la-Neuve, Belgium, 2009
PhD in Sciences, Université catholique de Louvain, Louvain-la-Neuve, Belgium, 2014

Experience relating to the project
François Massonnet is a young and already very active researcher in the community of polar climate prediction. During his PhD, he developed various metrics to evaluate sea ice models used in the framework of climate reconstructions, predictions and projections. He participated as a Contributing Author to the Fifth Assessment Report of Working Group 1 of IPCC and was involved in several national and international research projects about climate prediction and predictability. He also implemented data assimilation methods in large-scale sea ice models for state and parameter estimation. François Massonnet is now undertaking a post-doctoral stay at the Barcelona Supercomputing Center (BSC, Barcelona, Spain), where he is actively interacting with future members of the APPLICATE project (F. Doblas-Reyes, V. Guemas, J. García-Serrano and N. Fuckar). At BSC, he is looking in particular at polar predictability using the EC-Earth climate model, with focus on the role of sea ice. He is a WCRP/CLIVAR/CliC fellow for the Year of Polar Prediction (YOPP). As a member of the Sea Ice Prediction Network (SIPN) Action Team, he has also established close contacts with the sea ice forecasting community, and has been invited to comment on modelling contributions twice. He is also a member of the WCRP/CLIVAR/CliC Southern Ocean Region Panel.

Publications / achievements relevant for this project


Participation in research projects

2009 – 2013 EU – COMBINE: contributor
2010 – 2015 Belgian Science Policy – Understanding and predicting Antarctic sea ice variability at the decadal timescale (PREDANTAR): contributor
2012 – 2016 EU – SPECS: contributor
2014 – 2018 WCRP/CLIVAR/CliC: member of the Southern Ocean Region Panel and fellow for YOPP
The legal entity

The University of Reading (UREAD) is a public research university based in Reading in the United Kingdom. The University of Reading is ranked in the top 1% of universities in the world and enjoys a world-class reputation for teaching, research and enterprise. Its Department of Meteorology is Europe’s largest with a world-leading reputation in research focusing on the fundamental science of weather and climate. In the 2014 Research Evaluation Framework assessment, we were graded the third highest Environmental and Earth Science department in the UK for Research Power. The Department hosts three Natural Environment Research Council funded research centres (including the Climate directorate of the National Centre for Atmospheric Science) and several Met Office research groups. The NCAS-Climate group at Reading provides a strategic programme in modelling and understanding the climate. NCAS-Climate has strong links with the Met Office and works closely with them on many aspects of climate model development and evaluation, and applications to understanding climate variability and change, and predictability and prediction.

The infrastructure of the University of Reading

The University of Reading has access to the UK’s National Supercomputing Facility (ARCHER) which it uses extensively for climate modeling. ARCHER comprises of a Cray XC30 MPP supercomputer with 4920 compute nodes with two 12-core Intel Ivy Bridge series processors giving a total of 118,080 processing cores. The University of Reading also has access to the UK’s JASMIN super-data cluster, which offers 15 Petabytes of disk storage.

Profile relating to the project

The Department of Meteorology at the University of Reading has a global reputation in weather and climate science, and makes substantial contributions to international assessments such as the IPCC reports on climate change. The Department has extensive experience in coupled ocean-atmosphere modelling, both in terms of numerical experimentation and in climate model assessment and evaluation. The University of Reading also has global reputation for data assimilation and the analysis of atmospheric and the oceanic reanalyses.

Main tasks in the project

The University of Reading will co-lead WP1 on advanced metrics for weather and climate models (and in particular lead Task 1.2.3 and Task 1.3). This will draw upon the University’s extensive experience in climate model assessment and evaluation. The University of Reading’s experience in climate modelling and data assimilation will also be essential for its participation in the numerical experiments in WP3 (Task 3.6) and the numerical experiments and the assessment of ocean reanalyses in WP4 (Tasks 4.1 and 4.2; UREAD will lead Task 4.2).

Profiles of UREAD’s staff involved in the project

Dr. Len Shaffrey
Senior Scientist, Male

Education

BSc in Maths/Physics, University of Manchester, Manchester, UK, 1994
PhD in Meteorology, University of Reading, Reading, UK, 1997

Experience relating to the project

Dr Shaffrey is Senior Scientist at the National Centre for Atmospheric Science in the University of Reading. His research focuses on how extremes such as storms, floods and droughts might respond to climate change and Arctic
Dr. Shaffrey is the Lead Principal Investigator for the national-funded IMPETUS and TEMPEST projects on drought and storm risk and a PI for nationally funded TEA-COSI project on Arctic climate change. External links include being a member of the Willis Research Network, a partnership between academia and the reinsurance industry, the Lead Scientist at the University of Reading for the XWS Extreme European Windstorms Catalogue and the Lead Academic for a Knowledge Transfer Partnership with BP on wind and wave risk to offshore oil and gas platforms.

Publications / achievements relevant for this project


Participation in research projects

2014 – 2018 UK IMPETUS consortium project for Droughts & Water Scarcity: Lead PI
2013 – 2016 EU FP7 EUCLEIA project on attributing of extreme climate events: Partner in WP5, WP6 and WP7
2011 – 2015 UK NERC TEA-COSI consortium project for the Arctic programme: PI at UREAD
2010 – 2014 UK TEMPEST consortium project for the Storm Risk programme: Lead PI

Prof. Keith Haines

BMT Professor, Male

Education

MA in Natural Sciences, University of Cambridge, Cambridge, UK, 1984
PhD in Meteorology, Imperial College, London, UK, 1987

Experience relating to the project

Keith Haines is the BMT (British Maritime Technology) Professor of Marine Informatics and Joint Head of the Meteorology Dept. Until recently he was Co-chair of the CLIVAR Global synthesis and Observations panel. He has lead pioneering work in the field of ocean data assimilation, including contributions to data assimilation algorithms now used at several operational centres. He is currently Co-I on the ERACLIM2 project developing the next generation of coupled reanalyses at ECMWF, and he leads several NERC projects on ocean and coupled model assimilation and forecast error analysis. He has been a Co-I in several national and EU funded projects focussing on the Arctic using ocean reanalyses products. He was recently involved in the International Ocean Reanalysis Intercomparison project, contributing to 9 publications on different aspects of ocean reanalyses. In this APPLICATE project Prof Haines role is in WP4 will focus on using reanalyses as a means to synthesise Arctic observations and to infer heat and freshwater exchanges with mid-latitudes.

Publications / achievements relevant for this project

Melia, N., K. Haines and E. Hawkins, 2015: Improved Arctic sea ice thickness projections using bias corrected...
CMIP5 simulations. The Cryosphere, 9, 2237-2251

Participation in research projects

<table>
<thead>
<tr>
<th>Year</th>
<th>Project Description</th>
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<tr>
<td>2007 – 2011</td>
<td>UK NERC Arctic Synoptic Basin-wide Observations (ASBO): Co-I (supporting 1 PDRA)</td>
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<tr>
<td>2009 – 2012</td>
<td>EU Developing Arctic modeling and observing capabilities for long-term environmental studies (DAMOCLES): Co-I (supporting 1 PDRA 12 months)</td>
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<tr>
<td>2012 – 2016</td>
<td>UK NERC APPOSITE on sea ice predictability: Co-I (Supervising tied studentship)</td>
</tr>
<tr>
<td>2011 – 2015</td>
<td>CLIVAR Ocean ReAnalysis Intercomparison Project ORA_IP: Data Provider and Lead Analysis of Air-Sea Fluxes</td>
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Dr. Jonathan Day
AXA Research Fellow, Male

Education
MSci in Maths, Kings College London, London, UK, 2007
PhD in Geographical Sciences, University of Bristol, Bristol, UK, 2011

Experience relating to the project
Dr Day is a Research Fellow in NCAS-Climate division of the Department of Meteorology in the University of Reading. He is funded by an AXA Research Fellowship investigating Arctic storm risk. Before this Dr. Day worked on the NERC-funded APPOSITE project at the University of Reading, analysing sea ice variability and predictability in climate models and observations. He is a Steering Group member of the Polar Prediction Project, which is an initiative of the World Meteorological Organisation designed to promote international research enabling the development of environmental prediction services for the Polar Regions.

Publications / achievements relevant for this project

Participation in research projects

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<tr>
<td>2015 – 2017</td>
<td>AXA Research Fund, How will Arctic Meteorological Hazards change over the Coming Decades? Personal Research Fellowship</td>
</tr>
<tr>
<td>2012 - 2016</td>
<td>UK NERC APPOSITE on Arctic sea ice predictability: Post Doctoral Research Assistant</td>
</tr>
</tbody>
</table>
The legal entity

Stockholm University (SU) is the largest university in Sweden, with over 64,000 students and 5,000 staff. The Department of Meteorology (MISU, www.misu.su.se) is the leading meteorological department in Sweden, established 1947 and first lead by the renowned professor Carl-Gustaf Rossby, one of the fathers of modern dynamic meteorology, and later by professor Bert Bolin; father of the Intergovernmental Panel on Climate Change (IPCC). Today research at the department spans four specialties: Dynamic Meteorology, Physical Oceanography, Atmospheric Physics and Chemical Meteorology. In particular, within Dynamic Meteorology and Chemical Meteorology there is substantial experience in Arctic research in both modelling and observations.

The department belongs to the Mathematics and Physics sub-faculty of the Faculty of Sciences, and has about 80 staff: ~30 scientists and ~30 PhD students, while the rest are technical and administrative support staff. Among the scientists ten are professors/lecturers, five Assistant Professors (or similar) and the rest are postdoctoral scholars. Two educational programs are given at MISU, a bachelor program in Meteorology and a Master program in Atmospheric sciences, Oceanography and Climate. MISU is a strong partner in the Bolin Centre for Climate Research (www.bolin.su.se).

The infrastructure of SU

MISU is a partner in the European consortium that develops and uses EC-Earth, as well as the Nordic collaboration on NorESM. These two models are used extensively at the department to study climate and climate change, and technical support is provided for these activities by scientific programmers at the university and Application Experts through the strategic initiative SeRC (Swedish e-science Research Centre). HPC for these activities is provided through the national resources allocated by SNIC (Swedish National Infrastructure for scientific Computing).

The Swedish research icebreaker Oden has been used in a series of Arctic expeditions (AOE-2001, ASCOS 2008 and ACSE 2014) with atmospheric programs lead by MISU scientists in collaboration with the Swedish Secretariat for Polar Research. Currently, there are collaborative efforts that aim to instrument the icebreaker with a suit of instruments to probe the vertical structure of the atmosphere, including cloud and cloud properties. The leading idea is that Oden will take observations whenever navigating the Arctic Ocean regardless of the specific science targets of the expeditions.

The Arctic research at MISU is world leading on observations of atmospheric processes in the Arctic Ocean region. The observational work is complemented with modelling activities using a hierarchy of models: Direct and Large Eddy Numerical Simulations (DNS and LES), Single Column Models (SCM) and Earth System Models. Both observational and numerical modelling studies are performed in national and international collaborations. Much of the national collaboration is within the Bolin Centre for Climate Research, where the Rossby Centre at SMHI is partner and within the Climate community of SeRC. MISU was responsible for a share of the CMIP5 simulations within the EC-Earth consortium and will be so for CMIP6 as well. MISU was also one of the first users of OpenIFS and have through that, as well as other collaborations on parameterized processes, strong links to the research at the ECMWF.

Main tasks in the project

MISU will undertake to improve the description of atmospheric processes and of the atmosphere – sea ice – ocean coupling, as well as taking the leading role for the work package that concentrates on model enhancement (WP2). MISU will provide observational data for model testing and development as well as work on methodology on model improvement. MISU will also be involved in model assessment (WP1) of atmospheric processes in CMIP6 models.
Profiles of the staff involved in the project

Prof. Dr. Gunilla Svensson
Professor of Meteorology, Female

Education
PhD in Meteorology, Uppsala University, Uppsala, Sweden, 1995
Associate Professor, Stockholm University, Stockholm, Sweden, 2003
Professor, Stockholm University, Stockholm, Sweden, 2008

Experience relating to the project
Gunilla Svensson has more than 20 years of research experience as an expert on numerical modelling from process scale to global scales. Her main interest is in understanding, modelling and parameterization of boundary layer processes, surface exchange and clouds and their effect on the general circulation and global climate. She has extensively evaluated global climate model performance in Arctic and elsewhere (CMIP3 and CMIP5 models), develop new parameterization for turbulent boundary layers, and lead a model inter-comparison project within GABLS. She is involved in international coordination of research as member of the SSGs for GEWEX Global System Studies, WWRP Polar Prediction Project and WCRP Polar Climate Predictability Initiative. She has published about 60 research articles in peer review journals. She has substantial administrative and leadership experience for example as the coordinator of the strategic initiative on climate modelling within the Bolin Centre for Climate Research.

Publications / achievements relevant for this project

Participation in research projects
2010 – 2014 EU – EUCLIPSE: task leader
2010 – 2016 Swedish Space Board – Clouds in global climate models: PI
2015 – 2018 Swedish Research Council – The role of surface friction for midlatitude climate: PI
2015 – 2018 Swedish Research Council – The role of atmospheric moist intrusions in Arctic climate: Co-PI

Prof. Dr. Michael Tjernström
Professor of Boundary Layer Meteorology, Male

Education
PhD in Meteorology, Uppsala University, Uppsala, Sweden, 1988
Associate Professor, Uppsala University, Uppsala, Sweden, 1994
Professor, Stockholm University, Stockholm, Sweden, 2000

Experience relating to the project
Michael Tjernström has over 30 years of research experience and is an expert in atmospheric dynamics with experience on both experimental and numerical modelling meteorology, dealing with mesoscale and boundary-layer processes, in particular in the Arctic. He has published over 100 scientific peer-review papers and led three Arctic research missions on the Swedish icebreaker Oden (AOE-2001, ASCOS 2008 and ACSE 2014). He is Sweden’s representative on the IASC Atmospheric Working Group and has recently served as Chair for the Department of Meteorology, on the Bolin Centre for Climate Research board, as Chair of the International Study of Arctic Change and on the ECMWF Science Advisory Committee.

Publications / achievements relevant for this project

Participation in research projects
2009 – 2014 Swedish FORMAS – Advanced Simulation of Arctic climate change and impact on Northern regions (ADSIMNOR): Work Package Leader
The legal entity

The Centre National de la Recherche Scientifique – Groupe d’études de l’Atmosphère Météorologique (CNRS-GAME, France) is part of the National Meteorological Research Centre (CNRM) of Météo-France (the French national meteorological service), accredited to the National Centre for Scientific Research (CNRS) as a mixed research unit (UMR3589). CNRS-GAME is a leading institute in the field of atmospheric sciences and related disciplines.

As CNRS-GAME is affiliated to Météo-France, its mission is primarily driven by the need for protecting people and property, especially through coordinating high-level research and developments in numerical weather forecast, avalanche prediction, historical data rescue or wave and storm surge forecasting. CNRS-GAME has also a strong climate research department and is among the 20 centres worldwide that contribute to the international Climate Model Intercomparison Project (CMIP) used as a basis for the IPCC Assessment Reports. Several GAME scientists have served as authors or reviewers for these reports issued by the Intergovernmental Panel on Climate Change (IPCC), which has been awarded the Nobel Peace Prize in 2007. Besides providing global and regional climate scenarios, many GAME scientists contribute to the analysis of such projections, especially focusing on extreme climate events (heat waves, cold spells, droughts, heavy rains and floods, tropical cyclones, extratropical storms).

Research is conducted in close cooperation, at the national level with geoscience laboratories from other institutions and agencies (Universities, CNRS) and, at the international level, with many different foreign and European research laboratories. This collaboration involves: participation to multidisciplinary research programmes such as WCRP, WWRP, THORPEX, French national programmes from the Institut National des Sciences de l’Univers (INSU-CNRS), including the French Arctic Initiative (“Chantier Arctique”), or of the National Research Agency (ANR); participation in the management of heavy infrastructures (atmospheric research aircraft, massively parallel computer machines); coordination of and involvement in numerous national and international research projects such as CRESCendo (Horizon 2020), COMBINE (FP7), EUCLIPSE (FP7), SPECS (FP7), IRCAAM (ANR), CLASSIQUE (ANR), Greenland (ANR), CECILE (ANR) and Copernicus Atmosphere, Marine and Climate Change services, among many others.

About 225 permanent employees work at CNRS-GAME, including 86 researchers (evaluated following a peer-review procedure). Currently there are about 94 PhD students and post-doc researchers. In 2013, GAME researchers have produced around 172 high-rank publications (impact factor>1) peer-reviewed journals.

The infrastructure of CNRS-GAME

The computer centre at Météo-France is based on two BULL computers, each with a total of 1000 nodes of 24 “Ivy Bridge” cores. In 2016, both computers will upgrade to “Broadwell” cores, with an increase in the number of cores (about 1800 nodes of 40 cores in each. Part of one computer is devoted to operations (NWP), while a full computer is devoted to research. Since March 2010, CNRS-GAME hosts and maintains a node of the Earth System Grid Federation (ESGF).

Profile relating to the project

CNRS-GAME develops different models: Crocus and ISBA-ES snow pack models, Gelato sea ice model, SURFEX platform of marine and land surface models, and the ARPEGE/ARPEGE-Climat and AROME atmospheric models. CNRS-GAME also contributes to focused developments in the NEMO model, in collaboration with other CNRS institutes and Mercator Océan. CNRS-GAME tightly cooperates with the European Centre for Medium-Range Weather Forecasts (ECMWF) and with other European meteorological services (ALADIN network). The NWP models are developed at CNRS-GAME jointly with ECMWF for the global model ARPEGE-IFS and the ALADIN Group for a small-scale numerical limited area model ALADIN and recently for the non-hydrostatic model AROME.

CNRS-GAME has assembled the CNRM-CM5 global coupled model in close collaboration with CERFACS (Toulouse, France) to participate to the Coupled Model Intercomparison Project phase 5, and will contribute to...
CMIP6 with an upgraded version, CNRM-CM6. The model is developed and maintained by a total of about 12 full-time permanent researchers and engineers from CNRS-GAME and CERFACS, plus post-docs. Alongside the development of CNRM-CM, CNRS-GAME contributes to the study of climate variability, of the projection of climate at global and regional scales, of atmospheric chemistry, ocean-air interactions and global carbon cycle. CNRS-GAME has a long history within the climate research community and contributes to the successive IPCC reports.

CNRS-GAME contributes to the international efforts in seasonal forecasting as one of the partners of the EUROSIIP consortium (with MetOffice, ECMWF and NCEP) who delivers each month a 7-month range forecast based on a multi-model approach. Since January 2016, CNRS-GAME is a subcontractor of ECMWF for the delivery of seasonal forecasts with the Copernicus Climate Change Service (C3S). Seasonal forecasting systems operated at CNRS-GAME are based on CNRM-CM.

Main tasks in the project

CNRS-GAME will contribute to several tasks in APPLICATE, including analyses of CMIP6 simulations with respect to atmospheric linkages and the definition of advanced metrics in WP1, model enhancements in their various models in WP2 (atmosphere/surface interactions, snow and sea ice modelling, coupling methodology and increased resolution), coordinated experiments in WP3, coordinated analyses of reanalyses in the Arctic in WP4, and tests of various enhancements in CNRS-GAME climate prediction and numerical weather prediction systems in WP5. CNRS-GAME will co-lead WP2 on model developments, and lead tasks 2.1.3, 4.1.1 and 5.1.1.

Profiles of the staff involved in the project

Dr Matthieu Chevallier (working for Third Party METEO-FRANCE)
Research scientist, male

Education

PhD in Environmental Sciences, Université Paris-Est, Marne-la-Vallée, France, 2012
MSc Degree in Physics of Ocean and Atmosphere, Université Pierre et Marie Curie, Paris, France, 2009
Degree of engineering from the "grande école" Ecole des Ponts ParisTech, Marne-la-Vallée, France, 2009
Degree of engineering from the "grande école" Ecole Polytechnique, Palaiseau, France, 2009

Experience relating to the project

Matthieu Chevallier is a researcher in charge of developments related to the ocean-sea ice component of CNRM-CM, with experience of working in polar research since 2007. He is a member of the steering group of the Polar Prediction Project (WWRP/PPP), and a member of the scientific committee of the ANR EQUIPEX IAOOS project. During his PhD, he studied the predictive capacity of CNRM-CM5.1 in producing seasonal forecasts of the Arctic sea ice cover. His research mainly focuses on Arctic climate predictability and coupled processes at the air-ice-sea interface. He has experience of field campaigns in Greenland, the Beaufort Sea and the Canadian Arctic Archipelago.

Publications / achievements relevant for this project


Participation in research projects
2013 – 2015 CLIVAR-GSOP/GODAE OceanView Ocean ReAnalyses Intercomparison Project (ORA-IP) : scientist, coordinator of the sea ice intercomparison
2013 EU – MyOcean2 : scientist
2015 – 2019 EU – CRESCENDO : scientist

Dr Lauriane Batté
Research scientist, female

Education
PhD in Environmental Sciences, Université Paris-Est, Marne-la-Vallée, France, 2013
MSc Degree in Physics of Ocean and Atmosphere, Université Pierre et Marie Curie, Paris, France, 2009
Degree of engineering from the "grande école" Ecole des Ponts ParisTech, Marne-la-Vallée, France, 2009
Degree of engineering from the "grande école" Ecole Polytechnique, Palaiseau, France, 2009

Experience relating to the project
Lauriane Batté designed and implemented an original technique to address model inaccuracy in the seasonal forecasting system based on CNRM-CM5 during her PhD (2009-2012). Her research focuses on ensemble climate forecasting at sub-seasonal to seasonal time scales. She has experience in assessing seasonal forecast quality in several multi-model databases (DEMETER, ENSEMBLES) and has worked on stochastic perturbation techniques in both CNRM-CM and EC-Earth as part of a collaboration with BSC.

Publications / achievements relevant for this project

Participation in research projects
2013 EU – SPECS : scientific visitor at IC3/CFU (now part of BSC-ES)
2014 – 2016 EU – SPECS: research scientist at CNRS-GAME
2014 – 2017 ANR – ACASIS: research scientist
2016 – 2018 EU – C3S “seasonal forecasting”: scientist

Dr Julien Cattiaux
Research scientist, male

Education
PhD in Climate Sciences, Université Pierre et Marie Curie, Paris, France, 2010
MSc Degree in Physics of Ocean and Atmosphere, Université Pierre et Marie Curie, Paris, France, 2007
Degree of engineering from the "grande école" ENSTA ParisTech, Paris, France, 2007

Experience relating to the project
During his PhD done at the LSCE (2007-2010), he studies the physical mechanisms involved in European
temperature extremes, as well as their response to climate change. He develops a strong expertise in both statistical analysis and regional modelling. In 2014, he obtains a permanent position as a Research Scientist at the CNRS, and keeps working at the CNRS-GAME on the detection and attribution of changes in the climate variability and extremes, with a particular focus on changes in the North-Atlantic / European atmospheric dynamics. Julien Cattiaux has published 21 articles as a first author or co-author in peer-reviewed scientific journals.

**Publications / achievements relevant for this project**

Cassou, C. and J. Cattiaux, 2016: Disruption of the European climate seasonal clock in a warming world, accepted in Nature Climate Change.


**Participation in research projects**

2014 – 2017 ANR – MORDICUS: research scientist

2013 – 2016 MEDDE – EXTREMOSCOPE: research scientist

2011 – 2013 EU – Climate-KIC “Extreme Events for Energy Providers” (E3P): post-doc and research scientist


**Mr Eric Bazile**

Senior scientist, male

**Education**

Degree of engineering from the Ecole Nationale de la Météorologie, Toulouse, France, 1988

**Experience relating to the project**

Eric Bazile is senior scientist at CNRS-GAME since 1991. He has several years of experience in the fields of surface data assimilation, surface and boundary layer parameterization for NWP. He has been involved in several projects and collaborates with both the HIRLAM and ALADIN consortia since 1993, in particular during the development and the operational implementation of the soil moisture assimilation and the ISBA scheme. He implemented the Turbulent Kinetic Energy scheme in the Météo-France global NWP model ARPEGE/ALADIN. From 2013 onwards, he initiates and leads the GABLS4 international project (GEWEX/GLASS/GASS) for the study on the stable boundary layer Antarctic Plateau.

**Publications / achievements relevant for this project**


**Participation in research projects**

2012 – present GEWEX – GABLS: principal investigator and Project leader for the GABLS4 exercise (GEWEX/GLASS/GASS)

2010 – 2013 EU – EURO4M: principal scientist for CNRS-GAME

2014 – 2017 EU – UERRA: principal scientist for CNRS-GAME

2005 – 2007 NetFAM project (Nordic Network on Fine-scale Atmospheric Modelling) principal scientist

**Dr David Salas y Mélia**

Head of the climate research group, male

**Education**

PhD in Atmospheric and oceanic physics, Université Paul Sabatier, Toulouse, France, 2000

Degree of engineering from the Ecole Nationale de la Météorologie, Toulouse, France, 1996

Degree of engineering from the Ecole Polytechnique, Palaiseau, France, 1994

**Experience relating to the project**

David Salas y Mélia is the coordinator of CNRS-GAME’s contributions to CMIP. He has 20 years of experience in sea ice and coupled climate modelling. He is the author of the Gelato sea ice model included in CNRM-CM. He is the author or co-author of more than 40 peer-reviewed articles.

**Publications / achievements relevant for this project**

Wang, Q, et al., An assessment of the Arctic ocean in a suite of interannual CORE-II simulations. Part I: Sea Ice and solid freshwater, Ocean Modelling, accepted.


**Participation in research projects**

2015 – 2019 EU – CRESCENDO: scientist

2009 – 2014 EU – COMBINE: principal scientist for CNRS-GAME

2006 – 2016 LEFE – MISSTERRE: research scientist


2004 – 2005 CMIP3: principal scientist for CNRS-GAME

**Dr Hervé Douville**

Senior scientist, male

**Education**

Habilitation from the Institut National Polytechnique, Toulouse, France, 2008

PhD in Atmospheric physics, Université Paul Sabatier, Toulouse, France, 1995

Degree of engineering from the Ecole Nationale de la Météorologie, Toulouse, France, 1991

Degree of engineering from the « grande école » Institut National Agronomique, Paris-Grignon, France, 1990

**Experience relating to the project**
Hervé Douville has been conducting research since 1995 in the field of global climate modelling and the understanding of both natural climate variability and climate change. Since 2009, he has been the head of a research team at CNRS-GAME, whose main objective is to study climate variability from intraseasonal to climate change timescales with a particular focus on atmospheric teleconnections, land surface feedbacks, extreme events and model uncertainties in global climate projections. The team is also in charge of developing the global land surface hydrology to be used in CNRM-CM. Hervé Douville has published about 90 scientific articles. He was a member of the WCRP Working Group on Seasonal to Interannual Prediction (WGSIP) from 2009 to 2015.

Publications / achievements relevant for this project


Participation in research projects

2007 – 2010 ANR – IRCAAM: principal investigator

Dr Michel Déqué
Senior scientist, male

Education

Habilitation from the Institut National Polytechnique, Toulouse, France, 2006
Degree of engineering from the Ecole Nationale de la Météorologie, Toulouse, France, 1979
Degree of engineering from the Ecole Polytechnique, Palaiseau, France, 1977

Experience relating to the project

Michel Déqué is the head of the ARPEGE-Climat group, a research team in charge of developing and maintaining a climate version of the Météo-France ARPEGE model. He has led the developments of long-range numerical prediction at Météo France since the early 1980s. He has been member of several WCRP international working groups, and now represents Météo-France at the Technical Advisory Committee of EUROSIM.

Publications / achievements relevant for this project


Participation in research projects

2013 – 2017 EU – SPECS : principal scientist for CNRS-GAME
2016 – 2018 EU – C3S “seasonal forecasting”: principal investigator for CNRS-GAME contribution
The legal entity

CERFACS (http://www.cerfacs.fr), established in 1987 in Toulouse (France), is currently one of the world's leading research institutes working on efficient algorithms for solving large-scale scientific problems. The CERFACS Climate Modelling and Global Change (GLOBC) team (about 20 researchers and engineers) conducts fundamental scientific research and high-level technical developments in the field of climate studies. In particular, the team develops the OASIS coupler currently used by more than 35 climate-modelling groups in Europe and around the world. Significant resources are devoted to develop and offer user support for this community software. CERFACS activities in high performance computing encompass assembling high-resolution coupled climate based on state-of-art component models, porting and optimising them on a variety of platforms, including PRACE tier-0 machines such as those of TGCC and BSC. CERFACS is also getting involved in building new approaches to deal with large data volumes produced in climate science together with large data centres in Europe, through its participation to EU-FP7 projects such as EUDAT, CLIPC and IS-ENES2. CERFACS undertakes research activities aimed to a better understanding of the world climate variability, predictability and change at regional to global spatial scales and seasonal-to-decadal time scales. CERFACS researchers have made pioneering contributions to a better understanding and description of European climate variability and change with a specific focus on the ocean influence at various time scales. CERFACS in partnership with CNRM/Météo-France develops the CNRM-CM suite of global coupled models such as CNRM-CM5 that was used for the CMIP5 exercise and CNRM-CM6 that will be used in the upcoming CMIP6.

CERFACS/GLOBC is currently involved in several FP7 projects (SPECS, EUDAT, IS-ENES2, PREFACE, CLIPC, ERACLIM, PRIMAVERA), many nationally-funded projects (MORDICUS, OCCIPUT, CONVERGENCE) and two computing projects granted by PRACE (HighResClim, SPRUCE) focusing on high-resolution climate predictions at decadal and seasonal time scales. Note also that the GLOBC team is part of a joint Cerfacs/CNRS laboratory (CECI UMR5318) and that several CNRS researchers are part of the team.

The infrastructure of CERFACS

CERFACS develops the OASIS coupler https://verc.enes.org/models/software-tools/oasis that allows to couple climate models on a wide range of platforms in a uniform and highly parallel way. CERFACS has its own computing platform based on Bull, HP and IBM clusters delivering 80 TeraFlops/s.

Main tasks in the project

CERFACS will contribute to the model assessment of the climate models described in APPLICATE WP1. CERFACS will be strongly engaged in the development and testing of model enhancements, specifically for the ocean component (WP2). CERFACS will exploit its expertise in climate modelling and process studies of climate variability in particular that related to the detection and attribution of climate change signals relative to internal variability to identify the impact of the Arctic on climate, through both atmospheric and oceanic linkages (WP3).

Profiles of the CERFACS staff involved in the project

Dr. Laurent Terray
Head of the GLOBC Climate group, Male

Education

Master in gas and plasma physics, University of Orsay, 1983
PhD in laser fusion and plasma physics, Université Pierre et Marie Curie, Paris, France, 1985
HDR, Climate variability and change, from the Institut National Polytechnique de Toulouse, Toulouse, France, 2002

Experience relating to the project
Laurent Terray is a worldwide expert in the studies of climate variability and change. He was involved in the initial development of the OASIS coupler since its inception. He is an IPCC contributor and reviewer for both the Fourth and Fifth Assessment Reports. He served in numerous national and WCRP scientific panels and has participated in a large number of FP4 to FP7 projects. He is author of more than 70 peer-reviewed papers. He has served as a member and then co-chair for the CLIVAR Atlantic Implementation Panel.

Publications / achievements relevant for this project


Participation in research projects

2012 – 2016 FP7 SPECS
2015 – 2019 H2020 PRIMAVERA

Dr. Rym Msadek
Reseach scientist, Female

Education

Master in Applied Mathematics and numerical modelling, University of Bordeaux, France, 2005
PhD in Physical Oceanography and Climate, Université Pierre et Marie Curie, Paris, France, 2009

Experience relating to the project

Rym Msadek is a research scientist who recently joined CERFACS as a CNRS scientist. Her research mainly focuses on North Atlantic and Arctic ocean-atmosphere processes that contribute to climate predictability. Before joining CERFACS, Rym Msadek worked for 6 years at the Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, USA where she was leading GFDL activities on North Atlantic decadal predictability and seasonal Arctic sea ice predictions. In this role she contributed to the Sea Ice Prediction Network (SIPN) outlooks. She was also the chair of the US CLIVAR task team on AMOC variability and predictability and is a member of the CLIVAR working group on decadal climate variability and predictability (DCVP). She was a contributing author and an expert reviewer of the IPCC Fifth Assessment report and is in charge of designing some of the CMIP6 decadal predictability experiments (DCPP component C). She is the (co)-author of more than 25 publications in the peer-reviewed literature.

Publications / achievements relevant for this project


Participation in research projects
2015 – 2018 NOAA CPO project on Arctic Variability and Predictability: lead PI
2014 – 2017 NOAA CPO project on AMOC variability and predictability: co-PI
2014 – 2017 WGCM-WGSIP Decadal Climate Prediction Project (DCPP) Panel: member
2012 – 2015 APPOSITE project: contributor

Dr. Sophie Valcke
Leader of the OASIS coupler development, Female

Education
Master degree in Sciences, California Institute of Technology, Pasadena, USA, 1991
PhD in Mechanics, Speciality in Oceanography, Université Joseph Fourrier, Grenoble, France, 1995

Experience relating to the project
Sophie Valcke holds a "highly qualified" research engineer position at CERFACS. Dr Valcke is currently leading a team of about 4 engineers for the developments of the OASIS coupler. Through the user support provided for the OASIS coupler, Dr Valcke established working contacts with many climate- modelling groups in Europe. Dr Valcke is CERFACS Principal Investigator for the current IS-ENES2 project and was CERFACS PI in METAFOR project. These projects also favor Dr Valcke's interaction with other groups developing coupling framework internationally, such as the USA-led ESMF project, the USA NCAR Community Earth System Model 1 (CESM1), and Earth System Grid (ESG).

Publications / achievements relevant for this project
Valcke, S., "First review report on the enes earth system model resources," CERFACS/CNRS 2015.

Participation in research projects
2013 – 2017 FP7 IS-ENES-2, WP9 co-leader
2015 – 2019 H2020 PRIMAVERA

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The legal entity

The Arctic Portal, www.arcticportal.org, is the Arctic Gateway, providing a comprehensive gateway access to the Arctic related information on the internet. AP provides access to Arctic data, information and organizations across the Arctic, facilitating information sharing and cooperation between public and private parties. The portal is based in Akureyri, Iceland, managed as a non-profitable organization under an international board of directors. The principal functions of AP are: (1) the Gateway to Arctic information includes features such as: news from around the Arctic; information on the Arctic Council and other Arctic stakeholders; sections on science, societies and business; topic related portals; document and project database; virtual library; up-coming events; collection of relevant links; multimedia material including web casts, virtual conferences and videos; interactive mapping portal; webcams and weather in the Arctic; acronyms interpretation. AP has facilitated numerous important events with virtual presence through web casting and further being the venue where presentations, documents, pod-casts and other multimedia material are saved and made accessible for the generations to come. (2) Communication and outreach, support and hosting - providing consultation, technical and content support and web hosting to numerous Arctic organizations and projects i.e. APECS – The Association of Polar Early Career Scientists; the Arctic Yearbook; Sustaining Arctic Observation Networks – SAON; Strategic Environmental Impact – Assessment of Development of the Arctic (arcticinfo.eu), IASC - International Arctic Science Committee; ICR - The International Centre for Reindeer Husbandry; the Iceland Arctic Cooperation Network, NF – the Northern Forum, PAGE21 – Changing Permafrost and its Global Effects in the 21st Century, IPA – International Permafrost Association, IASSA, – International Arctic Social Science Association; IPS – Indigenous Peoples Secretariat; Pacific Arctic Group – PAG; IPY – the International Polar Year. (3) Arctic Data Interface – the Central Database for the Arctic – developing the central database for the Arctic and designing a methodology, producing and facilitating an interoperable and scalable interfacing technology that allows retrieval and interfacing of observational metadata and consequently interpretation of data accessing tools with emphasis on Iceland as a service provider to the international Circumpolar Sustained Arctic Observing Networks (SAON) and its tasks - www.arcticobserving.org. (4) Participation in international projects of Arctic importance and relevance incl.: (i) VLT – Virtual Learning Tools http://vlt.is higher education, e- learning platform, jointly created by the University of the Arctic, AP, the Association of Polar Early Career Scientists and the International Center for Reindeer Husbandry. (ii) PAGE21 – http://page21.eu a large-scale integrating collaborative project under the ENV call topic "Vulnerability of Arctic permafrost to climate change and implications for global GHG emissions and future climate" where the Arctic Portal has been responsible for: - The Project’s website - Communication and outreach strategy and tools - Social media - Design and distribution of promotional material to include brochures, posters, bookmarks, project videos etc. - GTN – P Database and the Mapping http://gtnp.arcticportal.org/ (iii) EU Arctic Information Center http://arcticinfo.eu the EU – funded project that aims to compile stakeholders’ knowledge and perspectives on the scientific information about the development of the Arctic as well as increase awareness about the Arctic and its changing political, economic and environmental landscape, and the impact of EU policies. (iv) Interactive Mapping System http://portal.inter-map.com. (v) Northern Forum http://thenorthernforum.org composed of sub-national or regional governments from eight northern countries. The Arctic Portal has been acting as a creator and managing partner of the website and its internal platform as well as business database. It has been a subject responsible for hosting and organizing Northern Forum’s international events, workshops and conferences. (5) Participation in organizing events, workshops and conferences incl. The Arctic Circle 2013, 2014 and 2015, Arctic Energy Summit 2013 and 2015, the EU in the Arctic, stakeholders consultations for the EU Arctic Information Centre in 2013 and 2014, the Arctic in the EU in 2014.
The infrastructure of AP

AP has used the Joomla content management system for 9 years for all its websites. It has numerous qualities, especially its easy customization and access for users. The access is easily controlled and users can have their own login and access given to certain sectors of the proposed portal. AP has extensive experience and knowledge on the system. AP provides a selection of data management solutions. ePrints database for large amounts of diverse formats of publications. It allows wide range of customization opportunities and interface development to fit the visual image of the project. The ePrints archive can store publications and data in all major formats varying from texts and images to video and audio recordings and links as well as exhibition and artefact products. Currently, AP uses ePrints database in its own Publications Library: www.library.arcticportal.org Joomla based publications archive integrated into the website for small and medium size archiving needs. AP has four members in their IT team and responds to problems within 24 hours, providing web accessibility according to the WAI guidelines and a step by step tutorial as well as helpdesk services, when problems/ malfunctions possibly arise. We host our material on an IBM server facilitated with state-of-the-art backup facilities.

Profile relating to the project

AP is one of the most-established organizations in carrying out Arctic-related outreach and communication. It is strongly involved in organizing and providing communication on Arctic issues. We provide services to over 50 international organisations and institutions of high Arctic relevance including: IPY, IASC, PAG, APECS, SAON, IPS, ICR, Northern Forum, ICARC, CNARC, AMATII. AP is involved in organizing active stakeholder engagement at local, regional and international levels. Additionally, AP has experience in collecting and visualizing complex scientific data and information and developed the first standardized global data sets for Permafrost Temperature and Active Layer thawing depths. Data Management system for permafrost developed by AP is seen as a case for integrating Essential Climate Variables (ECVs) from In situ terrestrial Networks into Earth System Models.

Main tasks in the project

AP will be the leader of end-user engagement, dissemination and training (WP7) and responsible for the overall implementation of the workpackage. AP will lead communication and dissemination task and co-lead end-user/stakeholder engagement task; it will furthermore contribute to synthesizing the main project results from a prediction perspective (WP5) and disseminating them widely (WP6).

Profiles of the staff involved in the project

Halldor Johannsson
Executive Director, Male

Education
Diploma in Landscape Architecture and Urban and Site Planning, University of Toronto, Canada, 1984

Experience relating to the project

Halldor Johannsson is Director of all business, consultation, communication and outreach activities in Arctic Portal. Halldor Johannsson has 30 years of experience in design and planning, and more than 15 years in communication activities related to the Arctic. He is a member of numerous committees and projects on Arctic issues i.e.: board member of Sustainable Arctic Observation Networks - SAON, Iceland Arctic Cooperation Network, member of the Arctic Data Committee, member of the steering group of the European Polar Board, member of the consultancy panel of the EU-PolarNet, member of the board of the EU Arctic Information Centre, UArctic Council member, Aurora Observatory vice chair, leading expert of the China-Iceland Aurora Observatory outreach activities. He served as SAON steering group representative of Iceland 2008-2012, as leading communication and outreach expert in the EU 7 project PAGE21, as senior communication expert – EU Arctic Information Centre, co-chair of the Arctic Energy Summit 2013. Halldor Johannsson is involved in most of the Arctic Council SAO and ministerial meetings since 2004.

Publications / achievements relevant for this project

under conditions of climate change, post-cold war geopolitics and globalization/power transition. Journal of Environmental Studies and Sciences, 1-17.


Dahlbäck, B., L-M. van der Watt, K. Jagodziński, P. Kankaanpää, 2014: European Arctic Initiatives Compendium. Arctic Centre of the University of Lapland/European Commission. Contributor

Participation in research projects

2011 – 2013 Arctic Marine and Aviation Transportation Infrastructure Initiative (AMATII): Data Analysis Expert
2009 – 2011 Virtual Learning Tools: Leading Designer of outreach and communication tools

Kamil Jagodziński
Senior Project Manager

Education

Master of Arts in Political Sciences, Adam Mickiewicz University, Poland, 2007
Diploma in International Project Management, Rovaniemi University of Applied Sciences, Finland, 2008

Experience relating to the project

Kamil Jagodziński’s background spans the fields of project management, science communication, and political marketing. His specific interest is in executing complex projects in the Arctic and converting strategies into actions. Drawing on a broad range of experience including strategic planning and management within the EU Arctic Information Centre initiative, project planning and training in the Barents Euro-Arctic Region, organizational change management the Balkans and Central Asia, he has also been involved in stakeholder management, mentoring innovation labs and teaching activities in Finland, Russia, Poland, Slovenia and Kazakhstan. A graduate of Adam Mickiewicz University with a masters in political sciences and specialization studies in international project management from Rovaniemi University of Applied Sciences, he holds a number of certifications in project management. Currently, he is a part of Stanford Advanced Project Management programme.

Publications / achievements relevant for this project


Chapter coauthor of European Arctic Initiatives: Capacities, Gaps and Future Opportunities


Participation in research projects

2015 – 2018 HUMAN-ANimal Relations Under Climate Change in NORT hern Eurasia: Main Planner
application in Arctic Regions of Finland and Russia: Main Planner and project management Advisor

2013 – 2014 Barents Studies: Peoples, Economies and Politics: Main Planner
**UiT - The Arctic University of Norway** is the northernmost university of the world. UiT’s key research focuses on the polar environment, climate research, indigenous people, peace and conflict transformation, telemedicine, medical biology, space physics, fishery science, marine biosprospecting, linguistics and computational chemistry. 15500 students and 3300 staff study and work at the University of Tromsø. Teaching is research-based. UiT’s seven faculties offer, in spite of a dedication to Northern issues, a broad range of study programmes. The academic community in Tromsø is highly international. More than 20% of the academic staff and 10% of the student body are from abroad. The Faculty of Biosciences, Fisheries and Economics (BFE) is responsible for development of scientific knowledge within all areas of marine research in Norway. BFE has systematically developed competence, facilities and equipment related to marine and fishery biology, including population structure and dynamics. Teaching and research is primarily focused on the fields of freshwater and marine ecology, fisheries biology, assessment, aquaculture, resource management, spatial planning governance. The faculty hosts competence in multidisciplinary studies and in implementing results.

**Profile relating to the project**

UiT The Arctic University of Norway is the northernmost university of the world and its location on the edge of the Arctic implies its mission. The Arctic is of increasing global importance. Climate change, the exploitation of Arctic resources and environmental threats are topics of great public concern, and which the University of Tromsø takes special interest in. Its strong investment in the training of the next generation of Arctic researchers is also demonstrated by it hosting the International Directorate of the Association of Polar Early Career Scientists (APECS) (www.apecs.is) which will be responsible for completing the UiT tasks of the APPLICATE project. APECS is an international and interdisciplinary organization for undergraduate and graduate students, postdoctoral researchers, early faculty members, educators and others with interests in Polar Regions and the wider cryosphere with currently about 5500 members in more than 75 countries. Its aims are to stimulate interdisciplinary and international research collaborations, and develop effective future leaders in polar research, education and outreach. With its Arctic-focused background, the profile of UiT ideally matches its tasks set aside as part of the APPLICATE project.

**Main tasks in the project**

UiT will be a partner to WP7 (“User engagement, dissemination and training”) leading the training tasks (7.3.) as well as contributing to the production of FrostBytes (7.1.4.)

**Profiles of the UiT staff involved in the project**

**Dr. Gerlis Fugmann**

Project leader APECS / Executive Director APECS, female

*Education*

PhD in Geography, Justus Liebig University Giessen, Germany, 2011

Magister Artium / Master of Arts (M.A.) in Geography (Minors: Anthropology and Prehistoric Archaeology), Rheinische Friedrich-Wilhelms University Bonn, Germany, 2005

*Experience relating to the project*

Dr. Gerlis Fugmann has been project leader at the UiT The Arctic University of Norway responsible for projects of the Association of Polar Early Career Scientists (APECS) since October 2013, serving parallel as the Executive Director of the APECS International Directorate Office hosted at UiT. Before, she had been involved in the APECS leadership already as a volunteer since 2009. In her current role as Executive Director, she provides support, mentorship, coordination, management, and leadership for APECS activities, projects and committees around the
world, and serves as the main contact point for APECS members and partners. As part of her work, Dr.
Fugmann has organized numerous training activities as well as education and outreach events for early career
researchers, schools and other audiences. This includes, for example, workshops, panels and online webinars for
early career researchers on topics such as data management, community-based research, working with policy
makers, communicating science and communicating with the media (e.g. at the APECS World Summit 2015). It
also includes education and outreach events such as presentations in schools around the APECS International Polar
Weeks, Antarctica Days or Arctic Frontiers Science for Schools (Tromsø, Norway). She serves on several
international committees including the Steering Committee of the Arctic Frontiers conference and the Steering
Committee of the US National Science Foundation sponsored “EarthCube Research Coordination Network for
High-Performance Distributed Computing in the Polar Sciences”, and has previously served on the International
Advisory Committees for the Polar Data Forum II 2015 and the Arctic Biodiversity Congress 2014, as well as the
International Organizing Committee of the International Polar Year 2012 “Knowledge to Action” Conference.
Before joining UiT and the APECS International Directorate Office, she completed her PhD in Geography in 2011
at the University of Giessen (Germany) and worked from 2012-2013 as a postdoctoral researcher at the
International Centre for Northern Governance and Development (ICNGD) at the University of Saskatchewan in
Canada. Her research focused on projects in the Canadian Arctic and Sub-Arctic as well as Northern Scandinavia,
addressing questions of comparative economic development, entrepreneurship, tourism, resource development and
Northern engagement and participation in innovation and the knowledge economy.

Publications / achievements relevant for this project

Xavier, J.C., Fugmann, G., Beck, I., Huffmann, L. and E. Jensen (n.d): Education on biodiversity of the polar
regions. In: Castro P, Azeiteiro UM, Bacelar Nicolau P, Leal Filho W and AM Azul (eds): Biodiversity and
Education for Sustainable Development (ESD). Springer. (accepted).

97, doi:10.1029/2016EO042993. Published on 8 January 2016. https://eos.org/meeting-reports/focus-on-the-
future-of-polar-research.


Skills. *Eos, Transactions American Geophysical Union* 95, no. 24 (June 17, 2014): 204.

Sharp, L., Paquin, K., Fugmann, G. and the APECS Nordic Project Team (2015): APECS Nordic Project 2013-

Participation in research projects

2014 – 2016 Where are they now? A Case Study of International Travel Support for Early Career
Researchers (APECS, CliC, IASC – ICARP III): project participant

2013 – 2016 Association of Polar Early Career Scientists (APECS) International Project Office –
Shaping the Future of Polar Research (Research Council of Norway; UiT The Arctic
University of Norway; Norwegian Polar Institute): project manager


in Nordic Countries (Nordic Council of Ministers Arctic Cooperation Programme):
project manager

2012 – 2013 Comparative Economic Development in the Circumpolar North (International Centre
for Northern Governance and Development, University of Saskatchewan): Post-
Doctoral Fellowship
The legal entity

P.P.Shirshov Institute of Oceanology of the Russian Academy of Sciences (IORAS) is one of the world’s largest ocean research centres covering all aspects of multidisciplinary ocean and climate research, including ocean physics and air-sea interaction, marine geology, marine biology and ocean engineering. As a national centre, IORAS has its headquarters in Moscow with 6 branches located in St. Petersburg, Kaliningrad, Gelengik, Archangelsk and Astrahan. IORAS is a large scientific center with 900 research associates and over-all staff of more than 2,000 members (crews of research vessels included). Its total funding amounts to about 65 million US dollars of which 30 million USD constitute the ground funds and about 35 million are the project funds. The Institute is capable of conducting theoretical and experimental research into a variety of processes and phenomena in the World Ocean. IORAS leads several National Federal Research Programmes, associated with diagnostics and predictability of abrupt climate changes, extreme climate events and the oceanic mechanisms governing their occurrence. In particular, IORAS develops climate diagnostics and parameterizations, used by Russian National Hydrometeorological Center and climate assessments for Ministry of Emergency and Catastrophes. Of a special importance are the studies of sea-air interaction, which provide comprehensive description of climate signals associated with the ocean. IORAS is deeply involved in the international ocean and climate research worldwide. In particular, IORAS conducts large ocean observing projects in the sub-polar North Atlantic in co-operation with IFREMER (France) and also participates as a partner in the TIE-OHF (Towards Improving Estimates of the Ocean Heat Flux) initiative funded by ESA. During 2011-2014 IORAS conducted a joint Russian-German project (in partnership with GEOMAR) on European climate extremes co-funded by the Helmholtz Association and Russian Foundation for Basic Research. IORAS is also deeply involved as a funded partner in GREENICE project (Collaboration on Green Growth in an Era of Climate Change) funded by the Arctic Consul through the Nordforsk agency in Norway. Importantly, IORAS is also a partner at the "ARCTIC-Era (Arctic climate change and its impact on Environment, infrastructures and Resource Availability)" project funded by Belmont Forum Fund. In 2015-2015 IORAS awarde large-scale institutional research grant and 5 grants for medium size research groups from the Russian Science Foundation, as well as 7 projects funded by Russian Ministry of Education and Science. During the last years IORAS awarded two SCAR fellowships and one POGO fellowship. More information about institute can be accessed at www.ocean.ru and www.sail.msk.ru.

The infrastructure of the IORAS

IORAS operates 8 ocean research vessels and 2 research submersibles. Of these 3 research vessels (ACADEMICIAN IOFFE, ACADEMICIAN SERGEY VAVILOV, ACADEMICIAN KELDYSH) operate in the North Atlantic and Antarctic waters and 3 smaller ships conduct the research in the Arctic and marginal seas. To conduct oceanographic and meteorological research IORAS has wide spectrum of instruments including ocean and atmospheric profiling units, radars and lidars as well as necessary laboratory equipment. To facilitate ocean and climate diagnostics and modelling activities IORAS maintains powerful computer network in its Moscow building and has also an access to the Academy computer facilities. Sea-Air Interaction Laboratory is equipped with powerful computer cluster and data storage devices.

Profile relating to the project

IORAS is strongly involved in the long-term monitoring of the heat and mass exchanges between the Atlantic and the Arctic, conducting starting from 1997 post-WOCE full depth transect at 60N along with detailed surveys in the GIN sea. In the area of air-sea interaction IORAS develops both advanced scale-dependent parameterizations of air-sea turbulent and radiative fluxes as well as methods of reconstruction of long term surface flux are-integrated time series, specifically relevant to this project. On a modelling side, IORAS is deeply involved in the development of forcing functions for ocean general circulation models, including those developed by the NEMO modelling consortium. For targeting regionalization of global climate model results IORAS operates the non-hydrostatic prognostic system WRF, developed by NCAR. Atmospheric diagnostic capabilities include numerical algorithms of cyclone tracking and analysis of cyclone life cycles, including also algorithms for building cyclone composites.
These methods were extensively tested under international intercomparison experiment MILAST and are now implemented at a number of research institutions world wide. Using these methodologies IORAS develops and regularly updates cyclone climatologies based on all available reanalyses products and some of climate models.

**Main tasks in the project**

IORAS will contribute the analysis of the Atlantic –Arctic exchanges using 60N section monitored from 1992 (the longest post-WOCE sections) in conjunction with the analysis of variability of surface heat fluxes in the subpolar North Atlantic using VOS data and reanalyses (WP1, WP6). These data will be used also for the validation of model results developed under APPLICATE. Further IORAS will adopt numerical analysis of atmospheric cyclones and will implement relevant methodologies into SMValTool planned to be extensively used under the project (WP1, WP3). IORAS will also be responsible for consolidated analysis of cyclone activity and energy and moisture transports in high latitudes in the model simulations under APPLICATE (WP1, WP6).

**Profiles of the IORAS staff involved in the project**

**Prof. Dr. Sergey Gulev**
Head of the Air-Sea Interaction and Climate Lab, Male

**Education**

Diploma in Oceanography, Moscow State University, Moscow, Russia, 1980  
PhD in Physical Oceanography, State Oceanographic Institution, Moscow, Russia, 1985  
DSC in Oceanography and Meteorology, P.P. Shirshov Institute of Oceanology, Moscow, Russia, 1996

**Experience relating to the project**

Sergey Gulev is head of the Air-Sea Interaction and Climate Lab, leading air-sea interaction and climate research at IORAS. He is also full professor of oceanography and meteorology at Moscow State University. Before joining IORAS in 1994, Prof. Gulev worked for 12 years at the State Oceanographic Institution of Russian Hydrometeorological Service and was a Humboldt Fellow at the Institut fuer Meereskunde (Keil, Germany, now GEOMAR). He then continued co-operation with GEOMAR as a visiting professor during 1990s-2010s. Sergey Gulev served as a co-chair of Air-Sea Flux Working Group of WCRP in 1996-2002. In 2001-2008 he was a member and officer of the JSC for WCRP. In 2010-2015 he served as a member of SOLAS and CLIVAR Scientific Steering Groups. Currently he is a member of the WCRP Panel on CONCEPT-HEAT activity of WCRP, targeting long-term ocean heat content changes, particularly important for APPLICATE. Sergey Gulev was lead author of the 4th and 5th IPCC Assessment Reports (WG1). Sergey Gulev is Associate Editor of International Journal of Climatology. He is the (co)-author of more than 80 publications in the peer-reviewed literature.

**Publications / achievements relevant for this project**


**Participation in research projects**

2015 – 2017  "ARCTIC-ERA (Arctic climate change and its impact on Environment, infrastructures and Resource Availability)" Belmont Forum Fund (5 partners) (Co-PI)  

2014 – 2016  “Impact of Future Cryospheric Changes on Northern Hemisphere Climate, Green Growth and Society”. The Arctic Consul (partner co-PI)


Ms. Natalia Tilinina
Staff research scientist, Female

Education
Diploma in Meteorology, Moscow State University, Moscow, Russia, 2009
PhD in Physics and Mathematics (expected in April 2016), P.P. Shirshov Institute of Oceanology

Experience relating to the project
Natalia Tilinina is a staff research scientist of the Air-Sea Interaction and Climate Lab at IORAS. She joined IORAS in 2011 after 2 years work at Russian Metoffice as a research engineer. She develops and maintains the algorithmic system associated with cyclone activity analysis. Her major experience is in the dynamical meteorology and numerical diagnostics of the subpolar and Arctic atmosphere. She developed one of the most comprehensive comparative assessments of cyclone characteristics in all available reanalyses and also performed the first diagnostics of cyclone activity in the Arctic System Reanalysis. In 2013 she awarded SCAR felowship. She is (co) - author of 8 peer reviewed papers.

Publications / achievements relevant for this project
Tilinina, N., S.K. Gulev, I.Rudeva, and K.P. Koltermann, 2013: Comparing cyclone life cycle characteristics and their interannual variability in different reanalyses. J. Climate, 26, 6419-6438, DOI: 10.1175/JCLI-D-12-00777.1

Participation in research projects

Dr. Sergey Gladyshev
Senior Scientist at IORAS, Male

Education
Diploma in Oceanography, Moscow State University, Moscow, Russia, 1981
PhD in Physical Oceanography, Pacific Oceanological Institution, RAS, Vladivostok, Russia, 1990

Experience relating to the project
Sergey Gladyshev is a senior scientist at IORAS. He has experience in the analysis of ocean circulation using in-
situ data, ARGO floats, AVISO measurements and long-term data bases of hydrographic data. Before joining IORAS, he worked for many years at the Pacific Oceanological Institution in Vladivostok and then spent 4 years (1998-2002) at the University of Hokkaido as a visiting researcher. His experience in the analysis of long-term ocean changes will be highly relevant for the project. He currently leads Work Package at an Arctic-oriented project funded by Russian Foundation for Basic Research. He is (c0)-author of more than 30 publications in peer reviewed literature.

Publications / achievements relevant for this project


Participation in research projects


The legal entity

Voeikov Main Geophysical Observatory (MGO) – the oldest Russian meteorological institute (founded in 1849) – currently belongs to the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet). MGO has a staff of about 250. MGO preserves a wide scope of activities and responsibilities, including fundamental climate research, applied climatology, methodical guidance of Russian observational networks, air pollution research and monitoring, metrology, radiometeorology, atmospheric electricity, etc. MGO consists of 6 scientific departments, the WMO’s World Radiation Data Centre, and the Roshydromet Climate Centre. Over past two decades, MGO has a significant record of international collaborations in the field of climate research (particularly, Arctic climate research), inter alia under US NSF and EU INTAS joint projects. MGO climate research is also supported currently by a number of grants of the Russian Foundation for Basic Research, Russian Foundation for Humanities, Russian Science Foundation. MGO co-led the two Russian National Climate Assessments (2008 and 2014). MGO experts at the level of lead authors contributed to all IPCC WGI reports, and other international assessments, such as the Arctic Climate Impact Assessment (2005). MGO led drafting of the Climate Doctrine of Russian Federation (signed by the President in 2009). More information about MGO can be found at http://www.voeikovmgo.ru and (in its capacity as the Roshydromet Climate Centre) at http://www.cc.voeikovmgo.ru.

The infrastructure of MGO

MGO has the main building located in St.Petersburg and the field experimentation base consisting of a number of multipurpose facilities over an extensive territory disposed in the countryside near St.Petersburg. MGO maintains a computer network and has an access to Roshydromet’s computer facilities.

Profile relating to the project

MGO is one of Russia’s leaders in climate change and variability research by means of comprehensive state-of-the-art climate models. A set of original GCMs and RCMs (focussed at different regions) has been developed by MGO scientists. MGO has been participating in a number of major international model intercomparison projects (either experimental, or diagnostic components), starting from the earliest one – first AMIP (Atmospheric Model Intercomparison Project) – to one of the most recent – CORDEX (with the MGO pan-Arctic regional climate model). For about quarter a century, research priorities of the MGO climate modelling group include high-latitude climate dynamics, climate sensitivity to anthropogenic forcing, and model evaluation. MGO scientists initiated or participated in a number of “Arctic” diagnostic subprojects of CMIP2, CMIP3 and CMIP5.

Main tasks in the project

In APPLICATE, MGO will contribute to the analysis of CMIP5 and CMIP6 global model results (WP1), particularly, the state-of-the-art model evaluation based on their ability to reproduce the ocean climate and its variability. MGO will also participate in the research of atmospheric and oceanic linkages (WP3), inter alia through experimentation with MGO GCM.

Profiles of the MGO staff involved in the project

Dr. Vladimir Kattsov
Director, Male

Education

Diploma (M.Sc.) in oceanology, Leningrad Hydrometeorological Institute, Leningrad (St.Petersburg), USSR, 1983
Diploma (M.A.) in philology (English literature), Kalinin State University, Kalinin (Tver), USSR, 1989
Diploma (M.Sc.) in mathematics, St.Petersburg State University, St.Petersburg, Russian Federation, 1992
PhD (Candidate of Sciences) in oceanology, Leningrad Hydrometeorological Institute, Leningrad (St.Petersburg), USSR, 1989
DSC in physics of atmosphere and hydrosphere, Voeikov Main Geophysical Research Observatory, St.Petersburg, Russian Federation, 2007

Experience relating to the project

Vladimir Kattsov is in his 28th year as a research scientist and the 10th year as the director at the Voeikov Main Geophysical Observatory (MGO, St.Petersburg). His research includes global climate 3D modelling with a focus on the polar climate dynamics and model evaluation (author or co-author of about 100 papers in peer-reviewed journals, books, and reports). He was a lead author of the IPCC 3rd (2001), 4th (2007), and 5th (2013, 2014) Assessment Reports, as well as of the Arctic Climate Impact Assessment (ACIA, 2005) and the two Russian national climate assessments (Roshydromet, 2008 and 2014). Since 2000, Dr. Kattsov has been with the WMO/ICSU/IOC of UNESCO’s World Climate Research Programme (WCRP) as a member of the Working Group on Numerical Experimentation (WGNE, 2000-2005); “Climate and Cryosphere” project’s Scientific Steering Group (CliC SSG, 2007-2008); and currently – Joint Steering Committee (WCRP JSC, since 2009; as its vice-chair since 2013). He is also a member of the Scientific Advisory Committee, Asia-Pacific Economic Cooperation Climate Center (APCC SAC, since 2006). He is a member of editorial boards of a number of Russian scientific journals.

Publications / achievements relevant for this project


Participation in research projects

2016 – 2018 “Development of probabilistic regional climate projection technique for Russian territory and building scenarios of climate impacts on efficiency, reliability and security of functioning of the energy systems, transport and construction infrastructure, agriculture and forest industry” Russian Science Foundation: PI
2015 – 2017 “Socio-economic impacts of Arctic climate change” Russian Foundation for Humanities: PI
2014 – 2016 “A study of regional climate change impact on air pollution over the territory of Russia through the 21st century.” Russian Foundation for Basic Research: PI
2011 – 2013 “Study of climate change over the territory of Russia and adjacent countries through the 21st century projected by a superensemble of climate models of the new generation (CMIP5).” Russian Foundation for Basic Research: PI
2009 – 2010 “Investigation of changes in climate extremes over the territory of Russian Federation in 21st century and possibilities of quantitative estimate of their impacts on the economy” Russian Foundation for Basic Research: PI

Dr. Igor Shkolnik
Head of Regional Climate Modeling Laboratory, Male

Education

Diploma in Meteorology, State Hydrometeorological Institute, Leningrad, USSR, 1991
PhD in Physics and Mathematics, Voeikov Main Geophysical Observatory, St.Petersburg, Russia, 2004
Experience relating to the project

Igor Shkolnik is the head of the Regional Climate Modeling Laboratory, Voeikov Main Geophysical Observatory. He will bring expertise in climate modelling and analysis. He developed the Russian regional climate model (RRCM) which has been extensively used for studies over the regions of northern Eurasia and Arctic. Igor is the leading author of the First (2008) and Second (2014) Assessment Report on Climate Change and Its Consequences in Russian Federation and co-author of the AMAP’s Adaptation Actions for a Changing Arctic (AACA) report. He is a member of the WCRP Working Group on Regional Climate (WGRC) whose mission is to prioritize and coordinate regional climate research. A key project within WGRC is CORDEX (RRCM is a member of Arctic-CORDEX ensemble) which provides global coordination of regional climate downscaling for improved climate change adaptation and impact assessment.

Publications / achievements relevant for this project

Participation in research projects
2016 – 2018 “Development of probabilistic regional climate projection technique for Russian territory and building scenarios of climate impacts on efficiency, reliability and security of functioning of the energy systems, transport and construction infrastructure, agriculture and forest industry” Russian Science Foundation: co-PI
2014 – 2016 “A study of regional climate change impact on air pollution over the territory of Russia through the 21st century.” Russian Foundation for Basic Research: WP leader
2014 – 2016 “Change of atmospheric and hydrologic patterns in northern Eurasia due to the expected global climate warming in the 21st century” Russian Foundation for Basic Research: participant

Ms. Anastasia Pikaleva
Research Associate, Female

Education
Diploma (M.Sc.) in Climatology, St.Petersburg State University, St. Petersburg, Russia, 2011

Experience relating to the project
Anastasia Pikaleva is a research associate in the Regional Climate Modeling Laboratory, Voeikov Main Geophysical Observatory. Her scientific interest is focused on regional and local climate modelling and analysis in the context of atmosphere-cryosphere interaction and carbon cycle evolution.

Publications / achievements relevant for this project

Participation in research projects

2016 – 2018 “Development of probabilistic regional climate projection technique for Russian territory and building scenarios of climate impacts on efficiency, reliability and security of functioning of the energy systems, transport and construction infrastructure, agriculture and forest industry” Russian Science Foundation: participant

2014 – 2016 “Change of atmospheric and hydrologic patterns in northern Eurasia due to the expected global climate warming in the 21st century” Russian Foundation for Basic Research: participant


2012 – 2013 “Investigation of methane emission over the territory of Northern Eurasia using multiscale system of climate models” Russian Foundation for Basic Research: PI
4.2. Third parties involved in the project (including use of third party resources)

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<th>1 – AWI</th>
<th>2 – BSC</th>
<th>3 – ECMWF</th>
<th>4 – UiB</th>
<th>5 – UNI Research</th>
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<td><strong>Does the participant plan to subcontract certain tasks</strong> (please note that core tasks of the project should not be sub-contracted)</td>
<td><strong>Does the participant envisage that part of its work is performed by linked third parties</strong></td>
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BSC applies a Third Party modality where the third party is making its resources available to the beneficiary under *Article 12 of the Grant Agreement - Use of in-kind contributions provided by third parties free of charge*. According to this situation, the third party, the Institut Català de Recerca i Estudis Avançats (ICREA) will not carry out any part of the work and just lends resources to the beneficiary. These resources are directly used by the beneficiary, the work is performed in its premises and there is no reimbursement by the beneficiary to the third party. The third party makes available some of its resources to the beneficiary, which does not reimburse the third party, but which charges the costs of the third party as an eligible cost of the project. Its costs will be declared by the beneficiary in its Form C but must be recorded in the accounts of the third party. In that context, ICREA resources corresponding to dedicated time of Prof. Francisco J. Doblas-Reyes (ICREA personnel) will be available for the whole duration of the project, mainly for RTD activities. Prof. Francisco J. Doblas-Reyes is the Director of the Earth Science Department which brings together around 50 people working on the prediction of global weather, climate and air quality, as well as in the analysis of the computational efficiency of Earth science codes.
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<td>Does the participant envisage that part of its work is performed by linked third parties</td>
<td>No</td>
</tr>
<tr>
<td>Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)</td>
<td>No</td>
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<th>8 – UCL</th>
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<td>Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)</td>
<td>No</td>
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<th>11 – CNRS-GAME</th>
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<td>Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)</td>
<td>No</td>
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<td>Yes</td>
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</table>
If yes, please describe the third party, the link of the participant to the third party, and describe and justify the foreseen tasks to be performed by the third party.

Meteo France will be involved as a linked Third Party to CNRS-GAME. The work in APPLICATE will be carried out at the National Centre for Meteorological Research – Research group for atmospheric meteorology which is a Joint Research Unit between CNRS and Meteo France. Scientists from Meteo France will be involved in all tasks carried out by CNRS-GAME in WP2, WP3, WP4 and WP5.

<table>
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<td>N o</td>
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</tbody>
</table>
5. Ethics and Security

5.1 Ethics

The APPLICATE project does not involve any ethic issues.

5.2 Security

The APPLICATE project does not involve:
- activities or results raising security issues
- 'EU-classified information' as background or results

References


Jung, T., and co-authors (2016). Advancing polar prediction capabilities on daily to seasonal time scales. Bull. Amer. Meteor. Soc., doi.10.1175/BAMS-D-14-00246.1


Vihma, T., and co-authors, 2014: Advances in understanding and parameterization of small-scale physical processes in the marine Arctic climate system: a review. Atmos. Chem. Phys., 14, 9403–9450, doi:10.5194/acp-14-9403-2014


## ESTIMATED BUDGET FOR THE ACTION (page 1 of 2)

<table>
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<tr>
<th>Form of costs(b)\</th>
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<td>G. M.R.</td>
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<td>Total consortium</td>
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## Additional information

- **Form of costs\(b)**: The form of costs includes actual, indirect, and flat-rate costs.
- **Unit\(c)**: The unit of the cost depends on the nature of the cost (e.g., employees, personnel costs, travel costs).
- **Unit\(d)**: The unit of the cost used on premises.

### Information for auditors

- **Estimate of costs under Project D.4**: Estimated costs of beneficiaries linked third parties not receiving EU funding.
- **Declaration of costs**: Declaration of costs for auditors.
(1) See Article 6 for the eligibility conditions.

(2) The indirect costs covered by the operating grant (received under any EU or Euratom funding programme; see Article 6.5(b)) are ineligible under the GA. Therefore, a beneficiary that receives an operating grant during the action's duration cannot declare indirect costs for the year(s)/reporting period(s) covered by the operating grant (see Article 6.2.E).

(3) This is the theoretical amount of EU contribution that the system calculates automatically (by multiplying all the budgeted costs by the reimbursement rate). This theoretical amount is capped by the 'maximum grant amount' (that the Commission/Agency decided to grant for the action) (see Article 5.1).

(4) The 'maximum grant amount' is the maximum grant amount decided by the Commission/Agency. It normally corresponds to the requested grant, but may be lower.

(5) Depending on its type, this specific cost category will or will not cover indirect costs. Specific unit costs that include indirect costs are: costs for energy efficiency measures in buildings, access costs for providing trans-national access to research infrastructure and costs for clinical studies.

(6) See Article 5 for the forms of costs.

(7) Unit : hours worked on the action; costs per unit (hourly rate) : calculated according to beneficiary's usual accounting practice.

(8) See Annex 2a ‘Additional information on the estimated budget’ for the details (costs per hour (hourly rate)).

(9) Flat rate : 25% of eligible direct costs, from which are excluded: direct costs of subcontracting, costs of in-kind contributions not used on premises, direct costs of financial support, and unit costs declared under budget category F if they include indirect costs.

(10) See Annex 2a ‘Additional information on the estimated budget’ for the details (units, costs per unit).

(11) See Annex 2a ‘Additional information on the estimated budget’ for the details (units, costs per unit, estimated number of units, etc).

(12) Only specific unit costs that do not include indirect costs.

(13) See Article 9 for beneficiaries not receiving EU funding.

(14) Only for linked third parties that receive EU funding.
ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION (BSC), E4A82CE203194C3C, established in Calle Jordi Girona 31, BARCELONA 08034, Spain, VAT number ESS0800099D, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

(to become beneficiary No (‘2’)

in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and Linkages associated with Arctic Climate change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Mateo VALERO with ECAS id rvalerme signed in the Participant Portal on 13/10/2016 at 14:15:41 | transaction id Sjgld-356607-D044WQd0zov/FgzcOOMNk1uT0IPQgVbopm=Z4Ut1saeApjHnuU
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ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS (ECMWF), established in SHINFIELD PARK, READING RG2 9AX, United Kingdom, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘3’) in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and Linkages associated with ArctiC ClimATe change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary
ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITETET I BERGEN (UiB), 874789542, established in Museplassen 1, BERGEN 5007, Norway, VAT number NO874789542MVA, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘4’)

in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and Linkages associated with ArctiC ClimATE change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Inger GJESDAHL with ECAS id ngjesing signed in the Participant Portal on 14/10/2016 at 09:47:42 (transaction id SigId-364818- yCZY9AyXZyZd2dVQHwKoJSBiQlyyPE1gKvPdhxKqFOnsHgbzIDlygRqia1KVZvAJ1cD28lPGULJ66y-3J7KzY8ggvryyGUXixsv0- gBEmsAzFslGKzxyyDWeO9BNMwuN4E7TD1SECMYGYW).

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ACCESSION FORM FOR BENEFICIARIES

UNI RESEARCH AS (UNI RESEARCH) AS, 985827117, established in THORMOHLENS GATE 55, BERGEN 5008, Norway, VAT number NO985827117MVA, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘5’)

in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and LInkages associated with ArctiC ClimATE change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary
METEOROLOGISK INSTITUTT (MET Norway), 971274042, established in HENRIK MOHNS PLASS 1, OSLO 0313, Norway, VAT number NO971274042MVA, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘6’)
in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and LInkages associated with ArctiC ClimATE change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

(timestamp information)
ACCESSION FORM FOR BENEFICIARIES

MET OFFICE (MET OFFICE), established in FitzRoy Road, EXETER EX1 3PB, United Kingdom, VAT number GB888805362, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned, hereby agrees

to become beneficiary No (‘7’) in Grant Agreement No 727862 (‘the Agreement’) between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’), for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and Linkages associated with Arctic Climate change (APPLICATE)’.

and mandates the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Sandra PEARSON with ECAS id npeasand signed in the Participant Portal on 14/10/2016 at 14:27:51 (transaction id SigId-1985-yfJbSRO4LMcWjLyLOvqgqH8d7ApCaEe9XEdz1Gq8p12xIaEg5IE3 by7GWbb2zWvBY5P2d859CgwVym-PHJUyMYXYCwB6qQjPh748-xZzXxQ5U1aXhH05HqiftIyyI4gJ3x6WkGTRGzqKU8D). Timestamp by third party at Fri Oct 14 15:27:59 CEST 2016
ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITE CATHOLIQUE DE LOUVAIN (UCL) BE6, 419052272, established in PLACE DE L UNIVERSITE 1, LOUVAIN LA NEUVE 1348, Belgium, VAT number BE0419052272, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned, hereby agrees

to become beneficiary No (‘8’)
in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and Linkages associated with ArctiC ClimATE change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Fabienne KINARD with ECAS id nikinarca signed in the Participant Portal on 13.10.2016 at 13:40:42 (transaction id sigdld:353756-jPLjFguOodkv6s5bWdFwDDdZzKqUjJbwHbszOfRzCoyj276RavPzr2OyP
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Thu Oct 13 14:40:51 CEST 2016
ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

THE UNIVERSITY OF READING (UREAD) GB22, n/a, established in WHITEKNIGHTS CAMPUS WHITEKNIGHTS HOUSE, READING RG6 6AH, United Kingdom, VAT number GB200012659, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘9’)

in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and LInkages associated with ArctiC ClimATE change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Mark VANVEEN with ECAS id rvanvmar signed in the Participant Portal on 13/10/2016 at 11:57:53 (transaction id SigId-353810- lIEoC2Tnxq2NBWkprghhr143dux0dMgftbtsd5vCZkx7u0WQ6T8F 0om11gZjRqoe3vFs1PgoQT9iplY-J7ixY8byYyiGUXlxsv0- d45Mro2xZ2mx3maux28zXT3idhGWbzyHLuC78XVRe5m).
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ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

STOCKHOLMS UNIVERSITET (SU), 2021003062, established in Universitetsvägen 10, STOCKHOLM 10691, Sweden, VAT number SE202100306201, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘10’)
in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and Linkages associated with Arctic Climate change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary
ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS (CNRS-GAME),
180089013, established in RUE MICHEL ANGE 3, PARIS 75794, France, VAT number FR40180089013, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘11’)

in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and LInkages associated with ArctiC ClimATE change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Jean-Paul SWERTS with ECAS id nswertje signed in the Participant Portal on 14/10/2016 at 17:35:26 (transaction id Signd-5542- VpJXY6U66LxLxVw52d2Q0Xh54bfSAhMgPfPzge4MULXlpq4vppWgxgFyjynU OVJ3Q4WLVvzdp9F4VZcY1Y0ppQ7UI-h4lUMlXUXYDwil6cQ3H478- xkillvkJzgeryUwFpg2ezczpmsjLAERzSnzer9X7o6m). Timestamp by third party at Fri Oct 14 18:35:33 CEST 2016
ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

CENTRE EUROPEEN DE RECHERCHE ET DE FORMATION AVANCEE EN CALCUL SCIENTIFIQUE (CERFACS) FR13, 407875434, established in Avenue Gaspard Coriolis 42, TOULOUSE 31057, France, VAT number FR26407875434, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘12’)

in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and Linkages associated with Arctic Climate change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary
ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

NORDURSLOÐAGATTIN EHF (AP) EHF, 6203720569, established in KRISTNIBRAUT 87, REYKJAVIK 113, Iceland, VAT number IS11790, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘13’)
in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and Linkages associated with Arctic Climate change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

halldor JOHANNSSON with ECAS id njohanhr signed in the Participant Portal on 12/10/2018 at 16:15:20 (transaction id Sigid:345596:99edHzqSjJHVee9g0Ngbw0x14zZ/0L95E3dn2Vq0pV0t1w5NsOWMBVzpo d2kGd7btxpQ3pa3OFvqdpL3d77CmpzBTLn9kUw-3T7jXxYbbyYvYguGjGouV0 ly2bqpx78Fh933UHes4F561Y9e4kJ7b2zUy2c9UHPh6m)/. Timestamp by third party Bl
ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITETET I TROMSOE (UiT) NO11, 970422528, established in HANSINE HANSENS VEG 14, TROMSO 9019, Norway, VAT number NO970422528MVA, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘14’)
in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and LInkages associated with ArctiC ClimATE change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Christian HANSEN with ECAS id rhansec signed in the Participant Portal on 16/10/2016 at 13:56:31 (transaction id SigId-65510- gYDyKszzqa5DadCJaqCCwO3tYxhTh5ROBNGQzbwXX6NhMrJaQf5Hog bMjCAyLbDz7G6VsnF5mG02UP0xSGxK-PhtsUMV5XYCw8ap7q59kX74b- VmIcAkJF2zKv5S0aO5Q8BiHJ6vEYEdVLsZtLM), Timestamp by third party at Sun Oct 16 14:56:39 CEST 2016
ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

P.P. SHIRSHOV INSTITUTE OF OCEANOLOGY OF RUSSIAN ACADEMY OF SCIENCES (IORAS), 1037739013388, established in NAKHIMOVSKY PROSPECT 36, MOSKVA 117997, Russian Federation, VAT number RU7727083115, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘15’)

in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and LInkages associated with ArctiC ClimATE change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary
ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

THE FEDERAL STATE BUDGETARY INSTITUTION VOEI Kov MAIN GEOPHYSICAL OBSERVATORY (MGO), 1027801554604, established in KARBYSHEV 7, SAINT PETERSBURG 194021, Russian Federation, VAT number RU7802031006, (‘the beneficiary’), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No (‘16’)

in Grant Agreement No 727862 (‘the Agreement’)

between ALFRED-WEGENER-INSTITUT HELMHOLTZ- ZENTRUM FUER POLAR- UND MEERESFORSCHUNG and the Executive Agency for Small and Medium-sized Enterprises (EASME) (‘the Agency’), under the power delegated by the European Commission (‘the Commission’),

for the action entitled ‘Advanced Prediction in Polar regions and beyond: Modelling, observing system design and Linkages associated with Arctic Climate change (APPLICATE)’.

and mandates

the coordinator to submit and sign in its name and on its behalf any amendments to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary
**MODEL ANNEX 4 FOR H2020 GENERAL MGA — MULTI**

**FINANCIAL STATEMENT FOR [BENEFICIARY [name]/ LINKED THIRD PARTY [name]] FOR REPORTING PERIOD [reporting period]**

<table>
<thead>
<tr>
<th>Eligible costs (per budget category)</th>
<th>Receipts</th>
<th>EU contribution</th>
<th>Additional information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total costs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### A. Direct personnel costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Eligible costs</th>
<th>Flat-rate</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1 Employees (including students)</td>
<td></td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>A.2 Natural persons under direct contract</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.3 Seconded persons</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.4 SME owners without salary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.5 Beneficiaries that are natural persons without salary</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B. Direct costs of subcontracting

<table>
<thead>
<tr>
<th>Description</th>
<th>Eligible costs</th>
<th>Flat-rate</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1 Travel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2 Equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.3 Other goods and services</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### C. Direct costs of financial support

<table>
<thead>
<tr>
<th>Description</th>
<th>Eligible costs</th>
<th>Flat-rate</th>
<th>Unit</th>
</tr>
</thead>
</table>

### D. Other direct costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Eligible costs</th>
<th>Flat-rate</th>
<th>Unit</th>
</tr>
</thead>
</table>

### E. Indirect costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Eligible costs</th>
<th>Flat-rate</th>
<th>Unit</th>
</tr>
</thead>
</table>

### F. Costs of large scientific research infrastructure

<table>
<thead>
<tr>
<th>Description</th>
<th>Eligible costs</th>
<th>Flat-rate</th>
<th>Unit</th>
</tr>
</thead>
</table>

### G. Other direct costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Eligible costs</th>
<th>Flat-rate</th>
<th>Unit</th>
</tr>
</thead>
</table>

### H. Additional information

- Costs of in-kind contributions not used on premises
- Information for indirect costs:
  - Receipts of the action, to be reported in the last reporting period according to Article 5.3.3
  - Costs of the indirect costs claimed must be free of any amounts covered by an operating grant (received under any EU or Euratom funding programme; see Article 6.2.E). If you have received an operating grant during this reporting period, you cannot claim any indirect costs.
  - The indirect costs claimed must be free of any amounts covered by an operating grant (received under any EU or Euratom funding programme; see Article 6.2.E). If you have received an operating grant during this reporting period, you cannot claim any indirect costs.

The beneficiary/linked third party hereby confirms that:
- The information provided is complete, reliable and true.
- The costs declared are eligible (see Article 6).
- The costs can be substantiated by adequate records and supporting documentation that will be produced upon request or in the context of checks, reviews, audits and investigations (see Articles 17, 18 and 22).
- The amount you request (in the column ‘requested EU contribution’) may have to be less (e.g. if you and the other beneficiaries are above budget, if the 90% limit (see Article 21) is reached, etc).

For the last reporting period: that all the receipts have been declared (see Article 5.3.3).

### Please declare all eligible costs, even if they exceed the amounts indicated in the estimated budget (see Annex 2). Only amounts that were declared in your individual financial statements can be taken into account lateron, in order to replace other costs that are found to be ineligible.

1. See Article 6 for the eligibility conditions
2. The indirect costs claimed must be free of any amounts covered by an operating grant (received under any EU or Euratom funding programme; see Article 6.2.E). If you have received an operating grant during this reporting period, you cannot claim any indirect costs.
3. This is the theoretical amount of EU contribution that the system calculates automatically (by multiplying the reimbursement rate by the total costs declared). The amount you request (in the column ‘requested EU contribution’) may have to be less (e.g. if you and the other beneficiaries are above budget, if the 90% limit (see Article 21) is reached, etc).
4. See Article 5 for the form of costs
5. Flat rate: 25% of eligible direct costs, from which are excluded: direct costs of subcontracting, costs of in-kind contributions not used on premises, direct costs of financial support, and unit costs declared under budget category F if they include indirect costs (see Article 6.2.E)
6. Only specific unit costs that do not include indirect costs
ANNEX 5

MODEL FOR THE CERTIFICATE ON THE FINANCIAL STATEMENTS

- For options [in italics in square brackets]: choose the applicable option. Options not chosen should be deleted.
- For fields in [grey in square brackets]: enter the appropriate data

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TERMS OF REFERENCE FOR AN INDEPENDENT REPORT OF FACTUAL FINDINGS ON COSTS DECLARED UNDER A GRANT AGREEMENT FINANCED UNDER THE HORIZON 2020 RESEARCH FRAMEWORK PROGRAMME.......................................................... 2

INDEPENDENT REPORT OF FACTUAL FINDINGS ON COSTS DECLARED UNDER A GRANT AGREEMENT FINANCED UNDER THE HORIZON 2020 RESEARCH FRAMEWORK PROGRAMME
........................................................................................................ 7
Terms of Reference for an Independent Report of Factual Findings on costs declared under a Grant Agreement financed under the Horizon 2020 Research and Innovation Framework Programme

This document sets out the ‘Terms of Reference (ToR)’ under which

[OPTION 1: [insert name of the beneficiary] (‘the Beneficiary’)] [OPTION 2: [insert name of the linked third party] (‘the Linked Third Party’), third party linked to the Beneficiary [insert name of the beneficiary] (‘the Beneficiary’)]

agrees to engage

[insert legal name of the auditor] (‘the Auditor’)

to produce an independent report of factual findings (‘the Report’) concerning the Financial Statement(s)\(^1\) drawn up by the [Beneficiary] [Linked Third Party] for the Horizon 2020 grant agreement [insert number of the grant agreement, title of the action, acronym and duration from/to] (‘the Agreement’), and

to issue a Certificate on the Financial Statements’ (‘CFS’) referred to in Article 20.4 of the Agreement based on the compulsory reporting template stipulated by the Commission.

The Agreement has been concluded under the Horizon 2020 Research and Innovation Framework Programme (H2020) between the Beneficiary and [OPTION 1: the European Union, represented by the European Commission (‘the Commission’)][ OPTION 2: the European Atomic Energy Community (Euratom,) represented by the European Commission (‘the Commission’)][OPTION 3: the [Research Executive Agency (REA)] [European Research Council Executive Agency (ERCEA)] [Innovation and Networks Executive Agency (INEA)] [Executive Agency for Small and Medium-sized Enterprises (EASME)] (‘the Agency’), under the powers delegated by the European Commission (‘the Commission’).]

\(^1\) By which costs under the Agreement are declared (see template ‘Model Financial Statements’ in Annex 4 to the Grant Agreement).
1.1 Subject of the engagement

The coordinator must submit to the [Commission][Agency] the final report within 60 days following the end of the last reporting period which should include, amongst other documents, a CFS for each beneficiary and for each linked third party that requests a total contribution of EUR 325 000 or more, as reimbursement of actual costs and unit costs calculated on the basis of its usual cost accounting practices (see Article 20.4 of the Agreement). The CFS must cover all reporting periods of the beneficiary or linked third party indicated above.

The Beneficiary must submit to the coordinator the CFS for itself and for its linked third party(ies), if the CFS must be included in the final report according to Article 20.4 of the Agreement.

The CFS is composed of two separate documents:

- The Terms of Reference (‘the ToR’) to be signed by the [Beneficiary] [Linked Third Party] and the Auditor;
- The Auditor’s Independent Report of Factual Findings (‘the Report’) to be issued on the Auditor’s letterhead, dated, stamped and signed by the Auditor (or the competent public officer) which includes the agreed-upon procedures (‘the Procedures’) to be performed by the Auditor, and the standard factual findings (‘the Findings’) to be confirmed by the Auditor.

If the CFS must be included in the final report according to Article 20.4 of the Agreement, the request for payment of the balance relating to the Agreement cannot be made without the CFS. However, the payment for reimbursement of costs covered by the CFS does not preclude the [Commission][Agency,] the European Anti-Fraud Office and the European Court of Auditors from carrying out checks, reviews, audits and investigations in accordance with Article 22 of the Agreement.

1.2 Responsibilities

The [Beneficiary] [Linked Third Party]:
must draw up the Financial Statement(s) for the action financed by the Agreement in compliance with the obligations under the Agreement. The Financial Statement(s) must be drawn up according to the [Beneficiary’s] [Linked Third Party’s] accounting and book-keeping system and the underlying accounts and records;

must send the Financial Statement(s) to the Auditor;

is responsible and liable for the accuracy of the Financial Statement(s);

is responsible for the completeness and accuracy of the information provided to enable the Auditor to carry out the Procedures. It must provide the Auditor with a written representation letter supporting these statements. The written representation letter must state the period covered by the statements and must be dated;

accepts that the Auditor cannot carry out the Procedures unless it is given full access to the [Beneficiary’s] [Linked Third Party’s] staff and accounting as well as any other relevant records and documentation.

The Auditor:


[Option 2 if the Beneficiary or Linked Third Party has an independent Public Officer: is a competent and independent Public Officer for which the relevant national authorities have established the legal capacity to audit the Beneficiary].

[Option 3 if the Beneficiary or Linked Third Party is an international organisation: is an [internal] [external] auditor in accordance with the internal financial regulations and procedures of the international organisation].

The Auditor:

must be independent from the Beneficiary [and the Linked Third Party], in particular, it must not have been involved in preparing the [Beneficiary’s] [Linked Third Party’s] Financial Statement(s);

must plan work so that the Procedures may be carried out and the Findings may be assessed;

must adhere to the Procedures laid down and the compulsory report format;

must carry out the engagement in accordance with this ToR;

must document matters which are important to support the Report;

must base its Report on the evidence gathered;

must submit the Report to the [Beneficiary] [Linked Third Party].

The Commission sets out the Procedures to be carried out by the Auditor. The Auditor is not responsible for their suitability or pertinence. As this engagement is not an assurance engagement, the Auditor does not provide an audit opinion or a statement of assurance.

1.3 Applicable Standards
The Auditor must comply with these Terms of Reference and with:

- the International Standard on Related Services (‘ISRS’) 4400 *Engagements to perform Agreed-upon Procedures regarding Financial Information* as issued by the International Auditing and Assurance Standards Board (IAASB);
- the *Code of Ethics for Professional Accountants* issued by the International Ethics Standards Board for Accountants (IESBA). Although ISRS 4400 states that independence is not a requirement for engagements to carry out agreed-upon procedures, the [Commission][Agency] requires that the Auditor also complies with the Code’s independence requirements.

The Auditor’s Report must state that there is no conflict of interests in establishing this Report between the Auditor and the Beneficiary [and the Linked Third Party], and must specify - if the service is invoiced - the total fee paid to the Auditor for providing the Report.

1.4 Reporting

The Report must be written in the language of the Agreement (see Article 20.7).

Under Article 22 of the Agreement, the [Commission] [Agency], the European Anti-Fraud Office and the Court of Auditors have the right to audit any work that is carried out under the action and for which costs are declared from [the European Union] [Euratom] budget. This includes work related to this engagement. The Auditor must provide access to all working papers (e.g. recalculation of hourly rates, verification of the time declared for the action) related to this assignment if the [Commission] [Agency], the European Anti-Fraud Office or the European Court of Auditors requests them.

1.5 Timing

The Report must be provided by [dd Month yyyy].

---

2 Supreme Audit Institutions applying INTOSAI-standards may carry out the Procedures according to the corresponding International Standards of Supreme Audit Institutions and code of ethics issued by INTOSAI instead of the International Standard on Related Services (‘ISRS’) 4400 and the Code of Ethics for Professional Accountants issued by the IAASB and the IESBA.
1.6 Other terms

[The [Beneficiary] [Linked Third Party] and the Auditor can use this section to agree other specific terms, such as the Auditor’s fees, liability, applicable law, etc. Those specific terms must not contradict the terms specified above.]

[legal name of the Auditor] [legal name of the [Beneficiary][Linked Third Party]]

[name & function of authorised representative] [name & function of authorised representative]

[dd Month yyyy] [dd Month yyyy]

Signature of the Auditor Signature of the [Beneficiary][Linked Third Party]
Independent Report of Factual Findings on costs declared under Horizon 2020 Research and Innovation Framework Programme

(To be printed on the Auditor’s letterhead)

To

[ name of contact person(s)], [Position]

[ Beneficiary’s] [Linked Third Party’s] name

[ Address]

[ dd Month yyyy]

Dear [Name of contact person(s)],

As agreed under the terms of reference dated [dd Month yyyy]

with [OPTION 1: [insert name of the beneficiary] (‘the Beneficiary’)] [OPTION 2: [insert name of the linked third party] (‘the Linked Third Party’), third party linked to the Beneficiary [insert name of the beneficiary] (‘the Beneficiary’)],

we

[name of the auditor] (‘the Auditor’),

established at

[full address/city/state/province/country],

represented by

[name and function of an authorised representative],
have carried out the procedures agreed with you regarding the costs declared in the Financial Statement(s)\(^3\) of the [Beneficiary] [Linked Third Party] concerning the grant agreement [insert grant agreement reference: number, title of the action and acronym] (‘the Agreement’),

with a total cost declared of [total amount] EUR,

and a total of actual costs and ‘direct personnel costs declared as unit costs calculated in accordance with the [Beneficiary’s] [Linked Third Party’s] usual cost accounting practices’ declared of [sum of total actual costs and total direct personnel costs declared as unit costs calculated in accordance with the [Beneficiary’s] [Linked Third Party’s] usual cost accounting practices] EUR

and hereby provide our Independent Report of Factual Findings (‘the Report’) using the compulsory report format agreed with you.

**The Report**

Our engagement was carried out in accordance with the terms of reference (‘the ToR’) appended to this Report. The Report includes the agreed-upon procedures (‘the Procedures’) carried out and the standard factual findings (‘the Findings’) examined.

The Procedures were carried out solely to assist the [Commission] [Agency] in evaluating whether the [Beneficiary’s] [Linked Third Party’s] costs in the accompanying Financial Statement(s) were declared in accordance with the Agreement. The [Commission] [Agency] draws its own conclusions from the Report and any additional information it may require.

---

\(^3\) By which the Beneficiary declares costs under the Agreement (see template ‘Model Financial Statement’ in Annex 4 to the Agreement).
The scope of the Procedures was defined by the Commission. Therefore, the Auditor is not responsible for their suitability or pertinence. Since the Procedures carried out constitute neither an audit nor a review made in accordance with International Standards on Auditing or International Standards on Review Engagements, the Auditor does not give a statement of assurance on the Financial Statements.

Had the Auditor carried out additional procedures or an audit of the [Beneficiary’s] [Linked Third Party’s] Financial Statements in accordance with International Standards on Auditing or International Standards on Review Engagements, other matters might have come to its attention and would have been included in the Report.

**Not applicable Findings**

We examined the Financial Statement(s) stated above and considered the following Findings not applicable:

*Explanation (to be removed from the Report):*

If a Finding was not applicable, it must be marked as ‘N.A.’ (‘Not applicable’) in the corresponding row on the right-hand column of the table and means that the Finding did not have to be corroborated by the Auditor and the related Procedure(s) did not have to be carried out.

The reasons of the non-applicability of a certain Finding must be obvious i.e.

i) if no cost was declared under a certain category then the related Finding(s) and Procedure(s) are not applicable;

ii) if the condition set to apply certain Procedure(s) are not met the related Finding(s) and those Procedure(s) are not applicable. For instance, for ‘beneficiaries with accounts established in a currency other than euro’ the Procedure and Finding related to ‘beneficiaries with accounts established in euro’ are not applicable. Similarly, if no additional remuneration is paid, the related Finding(s) and Procedure(s) for additional remuneration are not applicable.

List here all Findings considered not applicable for the present engagement and explain the reasons of the non-applicability.

*...

**Exceptions**

Apart from the exceptions listed below, the [Beneficiary] [Linked Third Party] provided the Auditor all the documentation and accounting information needed by the Auditor to carry out the requested Procedures and evaluate the Findings.
**Explanation (to be removed from the Report):**

- If the Auditor was not able to successfully complete a procedure requested, it must be marked as ‘E’ (‘Exception’) in the corresponding row on the right-hand column of the table. The reason such as the inability to reconcile key information or the unavailability of data that prevents the Auditor from carrying out the Procedure must be indicated below.
- If the Auditor cannot corroborate a standard finding after having carried out the corresponding procedure, it must also be marked as ‘E’ (‘Exception’) and, where possible, the reasons why the Finding was not fulfilled and its possible impact must be explained here below.

**List here any exceptions and add any information on the cause and possible consequences of each exception, if known. If the exception is quantifiable, include the corresponding amount.**

... 

**Example (to be removed from the Report):**

1. The Beneficiary was unable to substantiate the Finding number 1 on ... because ....
2. Finding number 30 was not fulfilled because the methodology used by the Beneficiary to calculate unit costs was different from the one approved by the Commission. The differences were as follows: ...
3. After carrying out the agreed procedures to confirm the Finding number 31, the Auditor found a difference of___________ EUR. The difference can be explained by ...

**Further Remarks**

In addition to reporting on the results of the specific procedures carried out, the Auditor would like to make the following general remarks:

**Example (to be removed from the Report):**

1. Regarding Finding number 8 the conditions for additional remuneration were considered as fulfilled because ...
2. In order to be able to confirm the Finding number 15 we carried out the following additional procedures: ....

**Use of this Report**

This Report may be used only for the purpose described in the above objective. It was prepared solely for the confidential use of the [Beneficiary] [Linked Third Party] and the [Commission] [Agency], and only to be submitted to the [Commission] [Agency] in connection with the requirements set out in Article 20.4 of the Agreement. The Report may not be used by the [Beneficiary] [Linked Third Party] or by the [Commission] [Agency] for any other purpose, nor may it
be distributed to any other parties. The [Commission] [Agency] may only disclose the Report to authorised parties, in particular to the European Anti-Fraud Office (OLAF) and the European Court of Auditors.

This Report relates only to the Financial Statement(s) submitted to the [Commission] [Agency] by the [Beneficiary] [Linked Third Party] for the Agreement. Therefore, it does not extend to any other of the [Beneficiary’s] [Linked Third Party’s] Financial Statement(s).

There was no conflict of interest\(^4\) between the Auditor and the Beneficiary [and Linked Third Party] in establishing this Report. The total fee paid to the Auditor for providing the Report was EUR [ ] (including EUR [ ] of deductible VAT).

We look forward to discussing our Report with you and would be pleased to provide any further information or assistance.

[legal name of the Auditor]

[name and function of an authorised representative]

[dd Month yyyy]

Signature of the Auditor

\(^4\) A conflict of interest arises when the Auditor’s objectivity to establish the certificate is compromised in fact or in appearance when the Auditor for instance:
- was involved in the preparation of the Financial Statements;
- stands to benefit directly should the certificate be accepted;
- has a close relationship with any person representing the beneficiary;
- is a director, trustee or partner of the beneficiary; or
- is in any other situation that compromises his or her independence or ability to establish the certificate impartially.
H2020 Model Grant Agreements: General MGA — Multi: June 2014

Agreed-upon procedures to be performed and standard factual findings to be confirmed by the Auditor

The European Commission reserves the right to i) provide the auditor with additional guidance regarding the procedures to be followed or the facts to be ascertained and the way in which to present them (this may include sample coverage and findings) or to ii) change the procedures, by notifying the Beneficiary in writing. The procedures carried out by the auditor to confirm the standard factual finding are listed in the table below.

If this certificate relates to a Linked Third Party, any reference here below to ‘the Beneficiary’ is to be considered as a reference to ‘the Linked Third Party’.

The ‘result’ column has three different options: ‘C’, ‘E’ and ‘N.A.’:

- ‘C’ stands for ‘confirmed’ and means that the auditor can confirm the ‘standard factual finding’ and, therefore, there is no exception to be reported.
- ‘E’ stands for ‘exception’ and means that the Auditor carried out the procedures but cannot confirm the ‘standard factual finding’, or that the Auditor was not able to carry out a specific procedure (e.g. because it was impossible to reconcile key information or data were unavailable),
- ‘N.A.’ stands for ‘not applicable’ and means that the Finding did not have to be examined by the Auditor and the related Procedure(s) did not have to be carried out. The reasons of the non-application of a certain Finding must be obvious i.e. i) if no cost was declared under a certain category then the related Finding(s) and Procedure(s) are not applicable; ii) if the condition set to apply certain Procedure(s) are not met then the related Finding(s) and Procedure(s) are not applicable. For instance, for ‘beneficiaries with accounts established in a currency other than the euro’ the Procedure related to ‘beneficiaries with accounts established in euro’ is not applicable. Similarly, if no additional remuneration is paid, the related Finding(s) and Procedure(s) for additional remuneration are not applicable.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Procedures</th>
<th>Standard factual finding</th>
<th>Result (C / E / N.A.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>ACTUAL PERSONNEL COSTS AND UNIT COSTS CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Auditor draws a sample of persons whose costs were declared in the Financial Statement(s) to carry out the procedures indicated in the consecutive points of this section A.

(The sample should be selected randomly so that it is representative. Full coverage is required if there are fewer than 10 people (including employees, natural persons working under a direct contract and personnel seconded by a third party), otherwise the sample should have a minimum of 10 people, or 10% of the total, whichever number is the highest)

The Auditor sampled ______ people out of the total of ______ people.

### A.1 PERSONNEL COSTS

For the persons included in the sample and working under an employment contract or equivalent act (general procedures for individual actual personnel costs and personnel costs declared as unit costs).

To confirm standard factual findings 1-5 listed in the next column, the Auditor reviewed following information/documents provided by the Beneficiary:

- a list of the persons included in the sample indicating the period(s) during which they worked for the action, their position (classification or category) and type of contract;
- the payslips of the employees included in the sample;
- reconciliation of the personnel costs declared in the Financial Statement(s) with the accounting system (project accounting and general ledger) and payroll system;
- information concerning the employment status and employment conditions of personnel included in the sample, in particular their employment contracts or equivalent;

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<td></td>
<td>The Auditor draws a sample of persons whose costs were declared in the Financial Statement(s) to carry out the procedures indicated in the consecutive points of this section A. (The sample should be selected randomly so that it is representative. Full coverage is required if there are fewer than 10 people (including employees, natural persons working under a direct contract and personnel seconded by a third party), otherwise the sample should have a minimum of 10 people, or 10% of the total, whichever number is the highest) The Auditor sampled ______ people out of the total of ______ people.</td>
<td>1) The employees were i) directly hired by the Beneficiary in accordance with its national legislation, ii) under the Beneficiary’s sole technical supervision and responsibility and iii) remunerated in accordance with the Beneficiary’s usual practices.</td>
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<tr>
<td></td>
<td>A.1 PERSONNEL COSTS</td>
<td>2) Personnel costs were recorded in the Beneficiary's accounts/payroll system.</td>
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<td></td>
<td>For the persons included in the sample and working under an employment contract or equivalent act (general procedures for individual actual personnel costs and personnel costs declared as unit costs)</td>
<td>3) Costs were adequately supported and reconciled with the accounts and payroll</td>
<td></td>
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</table>
The Auditor also verified the eligibility of all components of the retribution (see Article 6 GA) and recalculated the personnel costs for employees included in the sample.

**Further procedures if ‘additional remuneration’ is paid**

To confirm standard factual findings 6-9 listed in the next column, the Auditor:

- reviewed relevant documents provided by the Beneficiary (legal form, legal/statutory obligations, the Beneficiary’s usual policy on additional remuneration, criteria used for its calculation...);
- recalculated the amount of additional remuneration eligible for the action based on the supporting documents received (full-time or part-time work, exclusive or non-exclusive dedication to the action, etc.) to arrive at the applicable FTE/year and pro-rata rate (see data collected in the course of carrying out the procedures under A.2 ‘Productive hours’ and A.4 ‘Time recording system’).

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<td></td>
<td>o the Beneficiary’s usual policy regarding payroll matters (e.g. salary policy, overtime policy, variable pay); o applicable national law on taxes, labour and social security and o any other document that supports the personnel costs declared.</td>
<td>records.</td>
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<td>4) Personnel costs did not contain any ineligible elements.</td>
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<td>5) There were no discrepancies between the personnel costs charged to the action and the costs recalculated by the Auditor.</td>
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<td>6</td>
<td>The Beneficiary paying “additional remuneration” was a non-profit legal entity.</td>
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<td>7</td>
<td>The amount of additional remuneration paid corresponded to the Beneficiary’s usual remuneration practices and was consistently paid whenever the same kind of work or expertise was required.</td>
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</table>
**Procedures**

If any part of the remuneration paid to the employee is not mandatory according to the national law or the employment contract ("additional remuneration") and is eligible under the provisions of Article 6.2.A.1, this can be charged as eligible cost to the action up to the following amount:

- **(A)** If the person works full time and exclusively on the action during the full year: up to EUR 8,000/year;
- **(B)** If the person works exclusively on the action but not full-time or not for the full year: up to the corresponding pro-rata amount of EUR 8,000, or
- **(C)** If the person does not work exclusively on the action: up to a pro-rata amount calculated in accordance to Article 6.2.A.1.

**Standard factual finding**

8) The criteria used to calculate the additional remuneration were objective and generally applied by the Beneficiary regardless of the source of funding used.

9) The amount of additional remuneration included in the personnel costs charged to the action was capped at EUR 8,000 per FTE/year (up to the equivalent pro-rata amount if the person did not work on the action full-time during the year or did not work exclusively on the action).

**Additional procedures in case “unit costs calculated by the Beneficiary in accordance with its usual cost accounting practices” is applied:**

Apart from carrying out the procedures indicated above to confirm standard factual findings 1-5 and, if applicable, also 6-9, the Auditor carried out following procedures to confirm standard factual findings 10-13 listed in the next column:

10) The personnel costs included in the Financial Statement were calculated in accordance with the Beneficiary’s usual cost accounting practice. This methodology was consistently used in all H2020 actions.
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<td></td>
<td>o obtained a description of the Beneficiary's usual cost accounting practice to calculate unit costs.;</td>
<td>11) The employees were charged under the correct category.</td>
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<td></td>
<td>o reviewed whether the Beneficiary's usual cost accounting practice was applied for the Financial Statements subject of the present CFS;</td>
<td>12) Total personnel costs used in calculating the unit costs were consistent with the expenses recorded in the statutory accounts.</td>
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<td></td>
<td>o verified the employees included in the sample were charged under the correct category (in accordance with the criteria used by the Beneficiary to establish personnel categories) by reviewing the contract/HR-record or analytical accounting records;</td>
<td>13) Any estimated or budgeted element used by the Beneficiary in its unit-cost calculation were relevant for calculating personnel costs and corresponded to objective and verifiable information.</td>
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<td>o verified that there is no difference between the total amount of personnel costs used in calculating the cost per unit and the total amount of personnel costs recorded in the statutory accounts;</td>
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<td>o verified whether actual personnel costs were adjusted on the basis of budgeted or estimated elements and, if so, verified whether those elements used are actually relevant for the calculation, objective and supported by documents.</td>
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<td></td>
<td>For natural persons included in the sample and working with the Beneficiary under a direct contract other than an employment contract, such as consultants (no subcontractors). To confirm standard factual findings 14-18 listed in the next column the Auditor reviewed following information/documents provided by the Beneficiary:</td>
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<td>o the contracts, especially the cost, contract duration, work description, place of work, ownership of the results and reporting obligations to the Beneficiary;</td>
<td>14) The natural persons reported to the Beneficiary (worked under the Beneficiary's instructions).</td>
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<td></td>
<td>15) They worked on the Beneficiary’s premises (unless otherwise agreed with the Beneficiary).</td>
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### Ref | Procedures | Standard factual finding | Result (C / E / N.A.)
--- | --- | --- | ---
- | o the employment conditions of staff in the same category to compare costs and;  
o any other document that supports the costs declared and its registration (e.g. invoices, accounting records, etc.). | 16) The results of work carried out belong to the Beneficiary. | 
- |  | 17) Their costs were not significantly different from those for staff who performed similar tasks under an employment contract with the Beneficiary. | 
- |  | 18) The costs were supported by audit evidence and registered in the accounts. | 
- |  | 19) Seconded personnel reported to the Beneficiary and worked on the Beneficiary’s premises (unless otherwise agreed with the Beneficiary). | 
- |  | 20) The results of work carried out belong to the Beneficiary. | 

**For personnel seconded by a third party and included in the sample (not subcontractors)**

To confirm standard factual findings 19-22 listed in the next column, the Auditor reviewed following information/documents provided by the Beneficiary:

- their secondment contract(s) notably regarding costs, duration, work description, place of work and ownership of the results;
- if there is reimbursement by the Beneficiary to the third party for the resource made available (in-kind contribution against payment): any documentation that supports the costs declared (e.g. contract, invoice, bank payment, and proof of registration in its accounting/payroll, etc.) and reconciliation of the Financial Statement(s) with the accounting system (project accounting and general ledger) as well as any proof that the amount invoiced by the third party did not include any profit;

- |  | 21) The costs declared were supported with documentation and recorded in the |
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|         | o if there is no reimbursement by the Beneficiary to the third party for the resource made available (in-kind contribution free of charge): a proof of the actual cost borne by the Third Party for the resource made available free of charge to the Beneficiary such as a statement of costs incurred by the Third Party and proof of the registration in the Third Party's accounting/payroll;  
   o any other document that supports the costs declared (e.g. invoices, etc.). | Beneficiary’s accounts. The third party did not include any profit. |                          |
|         |                | **If personnel is seconded free of charge:**  
   22) The costs declared did not exceed the third party’s cost as recorded in the accounts of the third party and were supported with documentation. |                          |
| **A.2** | **PRODUCTIVE HOURS** | 23) The Beneficiary applied method [choose one option and delete the others]  
   [A: 1720 hours]  
   [B: the ‘total number of hours worked’]  
   [C: ‘annual productive hours’ used correspond to usual accounting practices] |                          |
|         | To confirm standard factual findings 23-28 listed in the next column, the Auditor reviewed relevant documents, especially national legislation, labour agreements and contracts and time records of the persons included in the sample, to verify that:  
   o the annual productive hours applied were calculated in accordance with one of the methods described below,  
   o the full-time equivalent (FTEs) ratios for employees not working full-time were correctly calculated. |                          |
If the Beneficiary applied method B, the auditor verified that the correctness in which the total number of hours worked was calculated and that the contracts specified the annual workable hours.

If the Beneficiary applied method C, the auditor verified that the ‘annual productive hours’ applied when calculating the hourly rate were equivalent to at least 90% of the ‘standard annual workable hours’. The Auditor can only do this if the calculation of the standard annual workable hours can be supported by records, such as national legislation, labour agreements, and contracts.

**Beneficiary’s Productive Hours’ for persons working full time shall be one of the following methods:**

A. **1720 Annual Productive Hours (pro-rata for persons not working full-time)**

B. **The total number of hours worked by the person for the Beneficiary in the year (this method is also referred to as ‘total number of hours worked’ in the next column). The calculation of the total number of hours worked was done as follows: annual workable hours of the person according to the employment contract, applicable labour agreement or national law plus overtime worked minus absences (such as sick leave or special leave).**

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<td>24</td>
<td>Productive hours were calculated annually.</td>
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<td>25</td>
<td>For employees not working full-time the full-time equivalent (FTE) ratio was correctly applied.</td>
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<td>26</td>
<td>The calculation of the number of ‘annual workable hours’, overtime and absences was verifiable based on the documents provided by the Beneficiary.</td>
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<td>27</td>
<td>The calculation of the number of ‘standard annual workable hours’ was verifiable based on the documents provided by the Beneficiary.</td>
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<td>A.3</td>
<td><strong>HOURLY PERSONNEL RATES</strong></td>
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<td></td>
<td><strong>1)</strong> For unit costs calculated in accordance to the Beneficiary's usual cost accounting practice (unit costs):</td>
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<td></td>
<td>If the Beneficiary has a &quot;Certificate on Methodology to calculate unit costs &quot; (CoMUC) approved by the Commission, the Beneficiary provides the Auditor with a description of the approved methodology and the Commission’s letter of acceptance. The Auditor verified that the Beneficiary has indeed used the methodology approved. If so, no further verification is necessary.</td>
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<td></td>
<td>If the Beneficiary does not have a &quot;Certificate on Methodology&quot; (CoMUC) approved by the</td>
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28) The ‘annual productive hours’ used for calculating the hourly rate were consistent with the usual cost accounting practices of the Beneficiary and were equivalent to at least 90% of the ‘annual workable hours’.

29) The Beneficiary applied [choose one option and delete the other]:

[Option I: “Unit costs (hourly rates) were calculated in accordance with the Beneficiary’s usual cost accounting practices”]

[Option II: Individual hourly rates were applied]
**Procedures**

Commission, or if the methodology approved was not applied, then the Auditor:

- reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates;
- recalculated the unit costs (hourly rates) of staff included in the sample following the results of the procedures carried out in A.1 and A.2.

II) For individual hourly rates:

The Auditor:

- reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates;
- recalculated the hourly rates of staff included in the sample following the results of the procedures carried out in A.1 and A.2.

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|     | Commission, or if the methodology approved was not applied, then the Auditor:  
  - reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates;  
  - recalculated the unit costs (hourly rates) of staff included in the sample following the results of the procedures carried out in A.1 and A.2. | For option I concerning unit costs and if the Beneficiary applies the methodology approved by the Commission (CoMUC):  
  30) The Beneficiary used the Commission-approved methodology to calculate hourly rates. It corresponded to the organisation's usual cost accounting practices and was applied consistently for all activities irrespective of the source of funding. | |
|     | II) For individual hourly rates:  
  The Auditor:  
  - reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates;  
  - recalculated the hourly rates of staff included in the sample following the results of the procedures carried out in A.1 and A.2. | For option I concerning unit costs and if the Beneficiary applies a methodology not approved by the Commission:  
  31) The unit costs re-calculated by the Auditor were the same as the rates applied by the Beneficiary. | |

*UNIT COSTS CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICES*:

It is calculated by dividing the total amount of personnel costs of the category to which the employee belongs verified in line with procedure A.1 by the number of FTE and the annual total productive hours of the same category calculated by the Beneficiary in accordance with procedure A.2.

**HOURLY RATE FOR INDIVIDUAL ACTUAL PERSONAL COSTS:**

It is calculated by dividing the total amount of personnel costs of an employee verified in line with
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<td>PROCEDURE A.1 BY THE NUMBER OF ANNUAL PRODUCTIVE HOURS VERIFIED IN LINE WITH PROCEDURE A.2.</td>
<td>32) The individual rates re-calculated by the Auditor were the same as the rates applied by the Beneficiary.</td>
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<td>A.4</td>
<td>TIME RECORDING SYSTEM</td>
<td>33) All persons recorded their time dedicated to the action on a daily/ weekly/ monthly basis using a paper/computer-based system. (delete the answers that are not applicable)</td>
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<td></td>
<td>To verify that the time recording system ensures the fulfilment of all minimum requirements and that the hours declared for the action were correct, accurate and properly authorised and supported by documentation, the Auditor made the following checks for the persons included in the sample that declare time as worked for the action on the basis of time records:</td>
<td>34) Their time-records were authorised at least monthly by the project manager or other superior.</td>
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<td></td>
<td>o description of the time recording system provided by the Beneficiary (registration, authorisation, processing in the HR-system);</td>
<td>35) Hours declared were worked within the project period and were consistent with the presences/absences recorded in HR-records.</td>
<td></td>
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<td>o its actual implementation;</td>
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<td></td>
<td>o time records were signed at least monthly by the employees (on paper or electronically) and authorised by the project manager or another manager;</td>
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<td></td>
<td>o the hours declared were worked within the project period;</td>
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<td>o there were no hours declared as worked for the action if HR-records showed absence due to holidays or sickness (further cross-checks with travels are carried out in B.1 below);</td>
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### Procedures

- the hours charged to the action matched those in the time recording system.

*Only the hours worked on the action can be charged. All working time to be charged should be recorded throughout the duration of the project, adequately supported by evidence of their reality and reliability (see specific provisions below for persons working exclusively for the action without time records).*

If the persons are working exclusively for the action and without time records

For the persons selected that worked exclusively for the action without time records, the Auditor verified evidence available demonstrating that they were in reality exclusively dedicated to the action and that the Beneficiary signed a declaration confirming that they have worked exclusively for the action.

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<td>o the hours charged to the action matched those in the time recording system.</td>
<td>36) There were no discrepancies between the number of hours charged to the action and the number of hours recorded.</td>
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<td></td>
<td><em>Only the hours worked on the action can be charged. All working time to be charged should be recorded throughout the duration of the project, adequately supported by evidence of their reality and reliability (see specific provisions below for persons working exclusively for the action without time records).</em></td>
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<td></td>
<td>If the persons are working exclusively for the action and without time records</td>
<td>37) The exclusive dedication is supported by a declaration signed by the Beneficiary's and by any other evidence gathered.</td>
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<tr>
<td></td>
<td>For the persons selected that worked exclusively for the action without time records, the Auditor verified evidence available demonstrating that they were in reality exclusively dedicated to the action and that the Beneficiary signed a declaration confirming that they have worked exclusively for the action.</td>
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### B COSTS OF SUBCONTRACTING

**B.1** The Auditor obtained the detail/breakdown of subcontracting costs and sampled **10** cost items selected randomly *(full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest).*

To confirm standard factual findings 38-42 listed in the next column, the Auditor reviewed the

38) The use of claimed subcontracting costs was foreseen in Annex 1 and costs were declared in the Financial Statements under the subcontracting category.
following for the items included in the sample:

- the use of subcontractors was foreseen in Annex 1;
- subcontracting costs were declared in the subcontracting category of the Financial Statement;
- supporting documents on the selection and award procedure were followed;
- the Beneficiary ensured best value for money (key elements to appreciate the respect of this principle are the award of the subcontract to the bid offering best price-quality ratio, under conditions of transparency and equal treatment. In case an existing framework contract was used the Beneficiary ensured it was established on the basis of the principle of best value for money under conditions of transparency and equal treatment).

In particular,

i. if the Beneficiary acted as a contracting authority within the meaning of Directive 2004/18/EC or of Directive 2004/17/EC, the Auditor verified that the applicable national law on public procurement was followed and that the subcontracting complied with the Terms and Conditions of the Agreement.

ii. if the Beneficiary did not fall under the above-mentioned category the Auditor verified that the Beneficiary followed their usual procurement rules and respected the Terms and Conditions of the Agreement.

For the items included in the sample the Auditor also verified that:

- the subcontracts were not awarded to other Beneficiaries in the consortium;

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<td>following for the items included in the sample:</td>
<td>39) There were documents of requests to different providers, different offers and assessment of the offers before selection of the provider in line with internal procedures and procurement rules. Subcontracts were awarded in accordance with the principle of best value for money. (When different offers were not collected the Auditor explains the reasons provided by the Beneficiary under the caption “Exceptions” of the Report. The Commission will analyse this information to evaluate whether these costs might be accepted as eligible)</td>
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<td>o the use of subcontractors was foreseen in Annex 1;</td>
<td>40) The subcontracts were not awarded to other Beneficiaries of the consortium.</td>
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### Procedures

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|     | o there were signed agreements between the Beneficiary and the subcontractor;  
     | o there was evidence that the services were provided by subcontractor; | 41) All subcontracts were supported by signed agreements between the Beneficiary and the subcontractor.  
     |                                             | 42) There was evidence that the services were provided by the subcontractors. |

### C COSTS OF PROVIDING FINANCIAL SUPPORT TO THIRD PARTIES

#### C.1

The Auditor obtained the detail/breakdown of the costs of providing financial support to third parties and sampled ___ cost items selected randomly **(full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest).**

The Auditor verified that the following minimum conditions were met:

- a) the maximum amount of financial support for each third party did not exceed EUR 60 000, unless explicitly mentioned in Annex 1;
- b) the financial support to third parties was agreed in Annex 1 of the Agreement and the other provisions on financial support to third parties included in Annex 1 were

43) All minimum conditions were met
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<td>respected.</td>
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### D OTHER ACTUAL DIRECT COSTS

#### D.1 COSTS OF TRAVEL AND RELATED SUBSISTENCE ALLOWANCES

The Auditor sampled _____ cost items selected randomly *(full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is the highest).*

The Auditor inspected the sample and verified that:

- travel and subsistence costs were consistent with the Beneficiary's usual policy for travel. In this context, the Beneficiary provided evidence of its normal policy for travel costs (e.g. use of first class tickets, reimbursement by the Beneficiary on the basis of actual costs, a lump sum or per diem) to enable the Auditor to compare the travel costs charged with this policy;

- travel costs are correctly identified and allocated to the action (e.g. trips are directly linked to the action) by reviewing relevant supporting documents such as minutes of meetings, workshops or conferences, their registration in the correct project account, their consistency with time records or with the dates/duration of the workshop/conference;

- no ineligible costs or excessive or reckless expenditure was declared.

44) Costs were incurred, approved and reimbursed in line with the Beneficiary's usual policy for travels.

45) There was a link between the trip and the action.

46) The supporting documents were consistent with each other regarding subject of the trip, dates, duration and reconciled with time records and accounting.

47) No ineligible costs or excessive or reckless expenditure was declared.

#### D.2 DEPRECIATION COSTS FOR EQUIPMENT, INFRASTRUCTURE OR OTHER ASSETS

The Auditor sampled _____ cost items selected randomly *(full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is the highest).*

For “equipment, infrastructure or other assets” [from now on called “asset(s)’"] selected in the

48) Procurement rules, principles and guides were followed.

49) There was a link between the grant agreement and the asset charged to the action.
sample the Auditor verified that:

- the assets were acquired in conformity with the Beneficiary's internal guidelines and procedures;
- they were correctly allocated to the action (with supporting documents such as delivery note invoice or any other proof demonstrating the link to the action);
- they were entered in the accounting system;
- the extent to which the assets were used for the action (as a percentage) was supported by reliable documentation (e.g. usage overview table);

The Auditor recalculated the depreciation costs and verified that they were in line with the applicable rules in the Beneficiary's country and with the Beneficiary’s usual accounting policy (e.g. depreciation calculated on the acquisition value).

The Auditor verified that no ineligible costs such as deductible VAT, exchange rate losses, excessive or reckless expenditure were declared (see Article 6.5 GA).

| 50) | The asset charged to the action was traceable to the accounting records and the underlying documents. |
| 51) | The depreciation method used to charge the asset to the action was in line with the applicable rules in the Beneficiary's country and the Beneficiary's usual accounting policy. |
| 52) | The amount charged corresponded to the actual usage for the action. |
| 53) | No ineligible costs or excessive or reckless expenditure were declared. |

### D.3 COSTS OF OTHER GOODS AND SERVICES

The Auditor sampled [ ] cost items selected randomly (full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest).

For the purchase of goods, works or services included in the sample the Auditor verified that:

- the contracts did not cover tasks described in Annex 1;

| 54) | Contracts for works or services did not cover tasks described in Annex 1. |
| 55) | Costs were allocated to the correct action and the goods were not placed in the inventory of durable equipment. |
Grant Agreement number: [insert number] [insert acronym] [insert call/sub-call identifier]

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56) The costs were charged in line with the Beneficiary's accounting policy and were adequately supported.

57) No ineligible costs or excessive or reckless expenditure were declared. For internal invoices/charges only the cost element was charged, without any mark-ups.

58) Procurement rules, principles and guides were followed. There were documents of requests to different providers, different offers and assessment of the offers before selection of the provider in line with internal procedures and procurement rules. The purchases were made in accordance with the principle of best value for money.

(When different offers were not collected the Auditor explains the reasons provided by the Beneficiary under the

<table>
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<th>Table Content</th>
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<tbody>
<tr>
<td>o they were correctly identified, allocated to the proper action, entered in the accounting system (traceable to underlying documents such as purchase orders, invoices and accounting);</td>
</tr>
<tr>
<td>o the goods were not placed in the inventory of durable equipment;</td>
</tr>
<tr>
<td>o the costs charged to the action were accounted in line with the Beneficiary's usual accounting practices;</td>
</tr>
<tr>
<td>o no ineligible costs or excessive or reckless expenditure were declared (see Article 6 GA).</td>
</tr>
<tr>
<td>In addition, the Auditor verified that these goods and services were acquired in conformity with the Beneficiary's internal guidelines and procedures, in particular:</td>
</tr>
<tr>
<td>o if Beneficiary acted as a contracting authority within the meaning of Directive 2004/18/EC or of Directive 2004/17/EC, the Auditor verified that the applicable national law on public procurement was followed and that the procurement contract complied with the Terms and Conditions of the Agreement.</td>
</tr>
<tr>
<td>o if the Beneficiary did not fall into the category above, the Auditor verified that the Beneficiary followed their usual procurement rules and respected the Terms and Conditions of the Agreement.</td>
</tr>
<tr>
<td>For the items included in the sample the Auditor also verified that:</td>
</tr>
<tr>
<td>o the Beneficiary ensured best value for money (key elements to appreciate the respect of this principle are the award of the contract to the bid offering best price-quality ratio, under conditions of transparency and equal treatment. In case an existing framework contract was used the Auditor also verified that the Beneficiary ensured it was established on the basis of the principle of best value for money under conditions of transparency and equal treatment);</td>
</tr>
</tbody>
</table>

Such goods and services include, for instance, consumables and supplies, dissemination (including open access), protection of results, specific evaluation of the action if it is required by the
**AGREEMENT, CERTIFICATES ON THE FINANCIAL STATEMENTS IF THEY ARE REQUIRED BY THE AGREEMENT AND CERTIFICATES ON THE METHODOLOGY, TRANSLATIONS, REPRODUCTION.**

### D.4 AGGREGATED CAPITALISED AND OPERATING COSTS OF RESEARCH INFRASTRUCTURE

The Auditor ensured the existence of a positive ex-ante assessment (issued by the EC Services) of the cost accounting methodology of the Beneficiary allowing it to apply the guidelines on direct costing for large research infrastructures in Horizon 2020.

**In the cases that a positive ex-ante assessment has been issued** (see the standard factual findings 59-60 on the next column),

The Auditor ensured that the beneficiary has applied consistently the methodology that is explained and approved in the positive ex ante assessment;

**In the cases that a positive ex-ante assessment has NOT been issued** (see the standard factual findings 61 on the next column),

The Auditor verified that no costs of Large Research Infrastructure have been charged as direct costs in any costs category;

| 59) The costs declared as direct costs for Large Research Infrastructures (in the appropriate line of the Financial Statement) comply with the methodology described in the positive ex-ante assessment report. |
| 60) Any difference between the methodology applied and the one positively assessed was extensively described and adjusted accordingly. |
| 61) The direct costs declared were free from any indirect costs items related to the Large Research Infrastructure. |
**In the cases that a draft ex-ante assessment report has been issued with recommendation for further changes** (see the standard factual findings 61 on the next column),

- The Auditor followed the same procedure as above (when a positive ex-ante assessment has NOT yet been issued) and paid particular attention (testing reinforced) to the cost items for which the draft ex-ante assessment either rejected the inclusion as direct costs for Large Research Infrastructures or issued recommendations.

---

**E USE OF EXCHANGE RATES**

**E.1 a) For Beneficiaries with accounts established in a currency other than euros**

The Auditor sampled **_______** cost items selected randomly and verified that the exchange rates used for converting other currencies into euros were in accordance with the following rules established in the Agreement (full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest):


*If no daily euro exchange rate is published in the Official Journal of the European Union for the currency in question, conversion shall be made at the average of the monthly accounting rates established by the Commission and published on its website ([http://ec.europa.eu/budget/contracts_grants/info_contracts/inforeuro/inforeuro_en.cfm](http://ec.europa.eu/budget/contracts_grants/info_contracts/inforeuro/inforeuro_en.cfm)),*
<table>
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<tr>
<th><strong>DETERMINED OVER THE CORRESPONDING REPORTING PERIOD.</strong></th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>b) For Beneficiaries with accounts established in euros</strong></td>
<td></td>
</tr>
<tr>
<td>The Auditor sampled _____ cost items selected randomly and verified that the exchange rates used for converting other currencies into euros were in accordance with the following rules established in the Agreement (full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest):</td>
<td></td>
</tr>
<tr>
<td>COSTS INCURRED IN ANOTHER CURRENCY SHALL BE CONVERTED INTO EURO BY APPLYING THE BENEFICIARY’S USUAL ACCOUNTING PRACTICES.</td>
<td></td>
</tr>
</tbody>
</table>

63) The Beneficiary applied its usual accounting practices.

[legal name of the audit firm]

[name and function of an authorised representative]

[dd Month yyyy]

<Signature of the Auditor>
MODEL FOR THE CERTIFICATE ON THE METHODOLOGY

- For options *in italics in square brackets*: choose the applicable option. Options not chosen should be deleted.
- For fields in [grey in square brackets]: enter the appropriate data.

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TERMS OF REFERENCE FOR AN AUDIT ENGAGEMENT FOR A METHODOLOGY CERTIFICATE IN CONNECTION WITH ONE OR MORE GRANT AGREEMENTS FINANCED UNDER THE HORIZON 2020 RESEARCH AND INNOVATION FRAMEWORK PROGRAMME..............................................................2

INDEPENDENT REPORT OF FACTUAL FINDINGS ON THE METHODOLOGY CONCERNING GRANT AGREEMENTS FINANCED UNDER THE HORIZON 2020 RESEARCH AND INNOVATION FRAMEWORK PROGRAMME
........................................................................................................7
Terms of reference for an audit engagement for a methodology certificate in connection with one or more grant agreements financed under the Horizon 2020 Research and Innovation Framework Programme

This document sets out the 'Terms of Reference (ToR)' under which

[OPTION 1: [insert name of the beneficiary] ('the Beneficiary')] [OPTION 2: [insert name of the linked third party] ('the Linked Third Party'), third party linked to the Beneficiary [insert name of the beneficiary] ('the Beneficiary')]

agrees to engage

[insert legal name of the auditor] ('the Auditor')

to produce an independent report of factual findings ('the Report') concerning the [Beneficiary's] [Linked Third Party's] usual accounting practices for calculating and claiming direct personnel costs declared as unit costs ('the Methodology') in connection with grant agreements financed under the Horizon 2020 Research and Innovation Framework Programme.

The procedures to be carried out for the assessment of the methodology will be based on the grant agreement(s) detailed below:

[title and number of the grant agreement(s)] ('the Agreement(s)')

The Agreement(s) has(have) been concluded between the Beneficiary and [OPTION 1: the European Union, represented by the European Commission ('the Commission')][ OPTION 2: the European Atomic Energy Community (Euratom,) represented by the European Commission ('the Commission')][OPTION 3: the [Research Executive Agency (REA)] [European Research Council Executive Agency (ERCEA)] [Innovation and Networks Executive Agency (INEA)] [Executive Agency for Small and Medium-sized Enterprises (EASME)] ('the Agency'), under the powers delegated by the European Commission ('the Commission').]
The [Commission] [Agency] is mentioned as a signatory of the Agreement with the Beneficiary only. The [European Union] [Euratom] [Agency] is not a party to this engagement.

1.1 Subject of the engagement

According to Article 18.1.2 of the Agreement, beneficiaries [and linked third parties] that declare direct personnel costs as unit costs calculated in accordance with their usual cost accounting practices may submit to the [Commission] [Agency], for approval, a certificate on the methodology (‘CoMUC’) stating that there are adequate records and documentation to prove that their cost accounting practices used comply with the conditions set out in Point A of Article 6.2.

The subject of this engagement is the CoMUC which is composed of two separate documents:

- the Terms of Reference (‘the ToR’) to be signed by the [Beneficiary] [Linked Third Party] and the Auditor;

- the Auditor’s Independent Report of Factual Findings (‘the Report’) issued on the Auditor’s letterhead, dated, stamped and signed by the Auditor which includes: the standard statements (‘the Statements’) evaluated and signed by the [Beneficiary] [Linked Third Party], the agreed-upon procedures (‘the Procedures’) performed by the Auditor and the standard factual findings (‘the Findings’) assessed by the Auditor. The Statements, Procedures and Findings are summarised in the table that forms part of the Report.

The information provided through the Statements, the Procedures and the Findings will enable the Commission to draw conclusions regarding the existence of the [Beneficiary’s] [Linked Third Party’s] usual cost accounting practice and its suitability to ensure that direct personnel costs claimed on that basis comply with the provisions of the Agreement. The Commission draws its own conclusions from the Report and any additional information it may require.

1.2 Responsibilities

The parties to this agreement are the [Beneficiary] [Linked Third Party] and the Auditor.

The [Beneficiary] [Linked Third Party]:
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- is responsible for preparing financial statements for the Agreement(s) (‘the Financial Statements’) in compliance with those Agreements;
- is responsible for providing the Financial Statement(s) to the Auditor and enabling the Auditor to reconcile them with the [Beneficiary’s] [Linked Third Party’s] accounting and bookkeeping system and the underlying accounts and records. The Financial Statement(s) will be used as a basis for the procedures which the Auditor will carry out under this ToR;
- is responsible for its Methodology and liable for the accuracy of the Financial Statement(s);
- is responsible for endorsing or refuting the Statements indicated under the heading ‘Statements to be made by the Beneficiary/ Linked Third Party’ in the first column of the table that forms part of the Report;
- must provide the Auditor with a signed and dated representation letter;
- accepts that the ability of the Auditor to carry out the Procedures effectively depends upon the [Beneficiary] [Linked Third Party] providing full and free access to the [Beneficiary’s] [Linked Third Party’s] staff and to its accounting and other relevant records.

The Auditor:

- [Option 2 if the Beneficiary or Linked Third Party has an independent Public Officer: is a competent and independent Public Officer for which the relevant national authorities have established the legal capacity to audit the Beneficiary].
- [Option 3 if the Beneficiary or Linked Third Party is an international organisation: is an [internal] [external] auditor in accordance with the internal financial regulations and procedures of the international organisation].

The Auditor:

- must be independent from the Beneficiary [and the Linked Third Party], in particular, it must not have been involved in preparing the Beneficiary’s [and Linked Third Party’s] Financial Statement(s);
- must plan work so that the Procedures may be carried out and the Findings may be assessed;
- must adhere to the Procedures laid down and the compulsory report format;
- must carry out the engagement in accordance with these ToR;
- must document matters which are important to support the Report;
- must base its Report on the evidence gathered;
- must submit the Report to the [Beneficiary] [Linked Third Party].

The Commission sets out the Procedures to be carried out and the Findings to be endorsed by the Auditor. The Auditor is not responsible for their suitability or pertinence. As this engagement is not an assurance engagement the Auditor does not provide an audit opinion or a statement of assurance.
1.3 Applicable Standards

The Auditor must comply with these Terms of Reference and with¹:

- the International Standard on Related Services (‘ISRS’) 4400 *Engagements to perform Agreed-upon Procedures regarding Financial Information* as issued by the International Auditing and Assurance Standards Board (IAASB);
- the *Code of Ethics for Professional Accountants* issued by the International Ethics Standards Board for Accountants (IESBA). Although ISRS 4400 states that independence is not a requirement for engagements to carry out agreed-upon procedures, the Commission requires that the Auditor also complies with the Code’s independence requirements.

The Auditor’s Report must state that there was no conflict of interests in establishing this Report between the Auditor and the Beneficiary [*and the Linked Third Party*] that could have a bearing on the Report, and must specify – if the service is invoiced - the total fee paid to the Auditor for providing the Report.

1.4 Reporting

The Report must be written in the language of the Agreement (see Article 20.7 of the Agreement).

Under Article 22 of the Agreement, the Commission, [*the Agency*], the European Anti-Fraud Office and the Court of Auditors have the right to audit any work that is carried out under the action and for which costs are claimed from [*the European Union*] [*Euratom*] budget. This includes work related to this engagement. The Auditor must provide access to all working papers related to this assignment if the Commission, [*the Agency*], the European Anti-Fraud Office or the European Court of Auditors requests them.

1.5 Timing

The Report must be provided by *[dd Month yyyy]*.

¹ Supreme Audit Institutions applying INTOSAI-standards may carry out the Procedures according to the corresponding International Standards of Supreme Audit Institutions and code of ethics issued by INTOSAI instead of the International Standard on Related Services (‘ISRS’) 4400 and the Code of Ethics for Professional Accountants issued by the IAASB and the IESBA.
1.6 Other Terms

[The [Beneficiary] [Linked Third Party] and the Auditor can use this section to agree other specific terms, such as the Auditor’s fees, liability, applicable law, etc. Those specific terms must not contradict the terms specified above.]

[legal name of the Auditor] [legal name of the [Beneficiary] [Linked Third Party]]

[name & title of authorised representative] [name & title of authorised representative]

[dd Month yyyy] [dd Month yyyy]

Signature of the Auditor Signature Signature of the [Beneficiary] [Linked Third Party]
Independent report of factual findings on the methodology concerning grant agreements financed under the Horizon 2020 Research and Innovation Framework Programme

(To be printed on letterhead paper of the auditor)

To

[ name of contact person(s)], [Position]
[[Beneficiary’s] [Linked Third Party’s] name]
[ Address]
[ dd Month yyyy]

Dear [Name of contact person(s)],

As agreed under the terms of reference dated [dd Month yyyy]

with [OPTION 1: [insert name of the beneficiary] (‘the Beneficiary’)] [OPTION 2: [insert name of the linked third party] (‘the Linked Third Party’), third party linked to the Beneficiary [insert name of the beneficiary] (‘the Beneficiary’)],

we

[ name of the auditor] (‘the Auditor’),

established at

[full address/city/state/province/country],

represented by

[name and function of an authorised representative],
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have carried out the agreed-upon procedures (‘the Procedures’) and provide hereby our Independent Report of Factual Findings (‘the Report’), concerning the [Beneficiary’s] [Linked Third Party’s] usual accounting practices for calculating and declaring direct personnel costs declared as unit costs (‘the Methodology’).

You requested certain procedures to be carried out in connection with the grant(s)

[title and number of the grant agreement(s)] (‘the Agreement(s)’).

The Report

Our engagement was carried out in accordance with the terms of reference (‘the ToR’) appended to this Report. The Report includes: the standard statements (‘the Statements’) made by the [Beneficiary] [Linked Third Party], the agreed-upon procedures (‘the Procedures’) carried out and the standard factual findings (‘the Findings’) confirmed by us.

The engagement involved carrying out the Procedures and assessing the Findings and the documentation requested appended to this Report, the results of which the Commission uses to draw conclusions regarding the acceptability of the Methodology applied by the [Beneficiary] [Linked Third Party].

The Report covers the methodology used from [dd Month yyyy]. In the event that the [Beneficiary] [Linked Third Party] changes this methodology, the Report will not be applicable to any Financial Statement\(^2\) submitted thereafter.

The scope of the Procedures and the definition of the standard statements and findings were determined solely by the Commission. Therefore, the Auditor is not responsible for their suitability or pertinence.

Since the Procedures carried out constitute neither an audit nor a review made in accordance with International Standards on Auditing or International Standards on Review Engagements, we do not

\(^2\) Financial Statement in this context refers solely to Annex 4 of the Agreement by which the Beneficiary declares costs under the Agreement.
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give a statement of assurance on the costs declared on the basis of the [Beneficiary’s] [Linked Third Party’s] Methodology. Had we carried out additional procedures or had we performed an audit or review in accordance with these standards, other matters might have come to its attention and would have been included in the Report.

Exceptions

Apart from the exceptions listed below, the [Beneficiary] [Linked Third Party] agreed with the standard Statements and provided the Auditor all the documentation and accounting information needed by the Auditor to carry out the requested Procedures and corroborate the standard Findings.

List here any exception and add any information on the cause and possible consequences of each exception, if known. If the exception is quantifiable, also indicate the corresponding amount.

.....

Explanation of possible exceptions in the form of examples (to be removed from the Report):

i. the [Beneficiary] [Linked Third Party] did not agree with the standard Statement number … because…;

ii. the Auditor could not carry out the procedure … established because …. (e.g. due to the inability to reconcile key information or the unavailability or inconsistency of data);

iii. the Auditor could not confirm or corroborate the standard Finding number … because …. 

Remarks

We would like to add the following remarks relevant for the proper understanding of the Methodology applied by the [Beneficiary] [Linked Third Party] or the results reported:

Example (to be removed from the Report):

Regarding the methodology applied to calculate hourly rates …

Regarding standard Finding 15 it has to be noted that …

The [Beneficiary] [Linked Third Party] explained the deviation from the benchmark statement XXIV concerning time recording for personnel with no exclusive dedication to the action in the following manner:

.....

Annexes
Please provide the following documents to the auditor and annex them to the report when submitting this CoMUC to the Commission:

1. Brief description of the methodology for calculating personnel costs, productive hours and hourly rates;
2. Brief description of the time recording system in place;
3. An example of the time records used by the [Beneficiary] [Linked Third Party];
4. Description of any budgeted or estimated elements applied, together with an explanation as to why they are relevant for calculating the personnel costs and how they are based on objective and verifiable information;
5. A summary sheet with the hourly rate for direct personnel declared by the [Beneficiary] [Linked Third Party] and recalculated by the Auditor for each staff member included in the sample (the names do not need to be reported);
6. A comparative table summarising for each person selected in the sample a) the time claimed by the [Beneficiary] [Linked Third Party] in the Financial Statement(s) and b) the time according to the time record verified by the Auditor;
7. A copy of the letter of representation provided to the Auditor.

Use of this Report

This Report has been drawn up solely for the purpose given under Point 1.1 Reasons for the engagement.

The Report:

- is confidential and is intended to be submitted to the Commission by the [Beneficiary] [Linked Third Party] in connection with Article 18.1.2 of the Agreement;
- may not be used by the [Beneficiary] [Linked Third Party] or by the Commission for any other purpose, nor distributed to any other parties;
- may be disclosed by the Commission only to authorised parties, in particular the European Anti-Fraud Office (OLAF) and the European Court of Auditors.
- relates only to the usual cost accounting practices specified above and does not constitute a report on the Financial Statements of the [Beneficiary] [Linked Third Party].

No conflict of interest exists between the Auditor and the Beneficiary [and the Linked Third Party] that could have a bearing on the Report. The total fee paid to the Auditor for producing the Report was EUR [_____] (including EUR [_____] of deductible VAT).

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3 A conflict of interest arises when the Auditor’s objectivity to establish the certificate is compromised in fact or in appearance when the Auditor for instance:

- was involved in the preparation of the Financial Statements;
We look forward to discussing our Report with you and would be pleased to provide any further information or assistance which may be required.

Yours sincerely

[legal name of the Auditor]
[name and title of the authorised representative]
[dd Month yyyy]
Signature of the Auditor

- stands to benefit directly should the certificate be accepted;
- has a close relationship with any person representing the beneficiary;
- is a director, trustee or partner of the beneficiary; or
- is in any other situation that compromises his or her independence or ability to establish the certificate impartially.
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Statements to be made by the Beneficiary/Linked Third Party (‘the Statements’) and Procedures to be carried out by the Auditor (‘the Procedures’) and standard factual findings (‘the Findings’) to be confirmed by the Auditor

The Commission reserves the right to provide the auditor with guidance regarding the Statements to be made, the Procedures to be carried out or the Findings to be ascertained and the way in which to present them. The Commission reserves the right to vary the Statements, Procedures or Findings by written notification to the Beneficiary/Linked Third Party to adapt the procedures to changes in the grant agreement(s) or to any other circumstances.

If this methodology certificate relates to the Linked Third Party’s usual accounting practices for calculating and claiming direct personnel costs declared as unit costs any reference here below to ‘the Beneficiary’ is to be considered as a reference to ‘the Linked Third Party’.

Please explain any discrepancies in the body of the Report.

<table>
<thead>
<tr>
<th>Statements to be made by Beneficiary</th>
<th>Procedures to be carried out and Findings to be confirmed by the Auditor</th>
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</thead>
<tbody>
<tr>
<td><strong>A. Use of the Methodology</strong></td>
<td><strong>Procedure:</strong></td>
</tr>
<tr>
<td>I. The cost accounting practice described below has been in use since [dd Month yyyy].</td>
<td>✓ The Auditor checked these dates against the documentation the Beneficiary has provided.</td>
</tr>
<tr>
<td>II. The next planned alteration to the methodology used by the Beneficiary will be from [dd Month yyyy].</td>
<td><strong>Factual finding:</strong></td>
</tr>
<tr>
<td></td>
<td>1. The dates provided by the Beneficiary were consistent with the documentation.</td>
</tr>
<tr>
<td><strong>B. Description of the Methodology</strong></td>
<td><strong>Procedure:</strong></td>
</tr>
<tr>
<td>III. The methodology to calculate unit costs is being used in a consistent manner and is reflected in the relevant procedures.</td>
<td>✓ The Auditor reviewed the description, the relevant manuals and/or internal guidance documents describing the methodology.</td>
</tr>
<tr>
<td>[Please describe the methodology your entity uses to calculate personnel costs, productive hours and hourly rates, present your description to the Auditor and annex it to this certificate]</td>
<td><strong>Factual finding:</strong></td>
</tr>
<tr>
<td></td>
<td>2. The brief description was consistent with the relevant manuals, internal guidance and/or other documentary evidence the Auditor has reviewed.</td>
</tr>
<tr>
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<td>3. The methodology was generally applied by the Beneficiary as part of its usual costs accounting practices.</td>
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</table>
### Please explain any discrepancies in the body of the Report.

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<tr>
<td><strong>Factual Findings:</strong></td>
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<tr>
<td>C. Personnel costs</td>
<td></td>
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<tr>
<td>General</td>
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<tr>
<td>IV. The unit costs (hourly rates) are limited to salaries including during parental leave, social security contributions, taxes and other costs included in the remuneration required under national law and the employment contract or equivalent appointing act;</td>
<td>Procedure:</td>
</tr>
<tr>
<td>V. Employees are hired directly by the Beneficiary in accordance with national law, and work under its sole supervision and responsibility;</td>
<td>The Auditor draws a sample of employees to carry out the procedures indicated in this section C and the following sections D to F.</td>
</tr>
<tr>
<td>VI. The Beneficiary remunerates its employees in accordance with its usual practices. This means that personnel costs are charged in line with the Beneficiary’s usual payroll policy (e.g. salary policy, overtime policy, variable pay) and no special conditions exist for employees assigned to tasks relating to the European Union or Euratom, unless explicitly provided for in the grant agreement(s);</td>
<td>[The Auditor has drawn a random sample of 10 full-time equivalents made up of employees assigned to the action(s). If fewer than 10 full-time equivalents are assigned to the action(s), the Auditor has selected a sample of 10 full-time equivalents consisting of all employees assigned to the action(s), complemented by other employees irrespective of their assignments.]. For this sample:</td>
</tr>
<tr>
<td>VII. The Beneficiary allocates its employees to the relevant group/category/cost centre for the purpose of the unit cost calculation in line with the usual cost accounting practice;</td>
<td>✓ the Auditor reviewed all documents relating to personnel costs such as employment contracts, payslips, payroll policy (e.g. salary policy, overtime policy, variable pay policy), accounting and payroll records, applicable national tax, labour and social security law and any other documents corroborating the personnel costs claimed;</td>
</tr>
<tr>
<td>VIII. Personnel costs are based on the payroll system and accounting system.</td>
<td>✓ in particular, the Auditor reviewed the employment contracts of the employees in the sample to verify that:</td>
</tr>
<tr>
<td>IX. Any exceptional adjustments of actual personnel costs resulted from relevant budgeted or estimated elements and were based on objective and verifiable information. [Please describe the ‘budgeted or estimated elements’ and their relevance to personnel costs, and explain how they were reasonable and based on objective and verifiable information, present your explanation to the Auditor and annex it to this certificate].</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. they were employed directly by the Beneficiary in accordance with applicable national legislation;</td>
</tr>
<tr>
<td>X. Personnel costs claimed do not contain any of the following ineligible costs: costs related to return on capital; debt and debt service charges; provisions for future losses</td>
<td></td>
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</thead>
<tbody>
<tr>
<td>or debts; interest owed; doubtful debts; currency exchange losses; bank costs charged by the Beneficiary’s bank for transfers from the Commission/Agency; excessive or reckless expenditure; deductible VAT or costs incurred during suspension of the implementation of the action.</td>
<td>into account when calculating the personnel costs;</td>
</tr>
<tr>
<td>XI. Personnel costs were not declared under another EU or Euratom grant (including grants awarded by a Member State and financed by the EU budget and grants awarded by bodies other than the Commission/Agency for the purpose of implementing the EU budget).</td>
<td>✓ the Auditor numerically reconciled the total amount of personnel costs used to calculate the unit cost with the total amount of personnel costs recorded in the statutory accounts and the payroll system.</td>
</tr>
<tr>
<td>If additional remuneration as referred to in the grant agreement(s) is paid</td>
<td>✓ to the extent that actual personnel costs were adjusted on the basis of budgeted or estimated elements, the Auditor carefully examined those elements and checked the information source to confirm that they correspond to objective and verifiable information;</td>
</tr>
<tr>
<td>XII. The Beneficiary is a non-profit legal entity;</td>
<td>✓ if additional remuneration has been claimed, the Auditor verified that the Beneficiary was a non-profit legal entity, that the amount was capped at EUR 8,000 per full-time equivalent and that it was reduced proportionately for employees not assigned exclusively to the action(s).</td>
</tr>
<tr>
<td>XIII. The additional remuneration is part of the beneficiary’s usual remuneration practices and paid consistently whenever the relevant work or expertise is required;</td>
<td>✓ the Auditor recalculated the personnel costs for the employees in the sample.</td>
</tr>
<tr>
<td>XIV. The criteria used to calculate the additional remuneration are objective and generally applied regardless of the source of funding;</td>
<td><strong>Factual finding:</strong></td>
</tr>
<tr>
<td>XV. The additional remuneration included in the personnel costs used to calculate the hourly rates for the grant agreement(s) is capped at EUR 8,000 per full-time equivalent (reduced proportionately if the employee is not assigned exclusively to the action).</td>
<td>4. All the components of the remuneration that have been claimed as personnel costs are supported by underlying documentation.</td>
</tr>
<tr>
<td></td>
<td>5. The employees in the sample were employed directly by the Beneficiary in accordance with applicable national law and were working under its sole supervision and responsibility.</td>
</tr>
<tr>
<td></td>
<td>6. Their employment contracts were in line with the Beneficiary’s usual policy;</td>
</tr>
<tr>
<td></td>
<td>7. Personnel costs were duly documented and consisted solely of salaries, social security contributions (pension contributions, health insurance, unemployment fund contributions, etc.), taxes and other statutory costs included in the remuneration (holiday pay, thirteenth month’s pay, etc.);</td>
</tr>
<tr>
<td></td>
<td>8. The totals used to calculate the personnel unit costs are consistent with those registered in the payroll and accounting records;</td>
</tr>
<tr>
<td></td>
<td>9. To the extent that actual personnel costs were adjusted on the basis of budgeted or estimated elements, those elements were</td>
</tr>
</tbody>
</table>
**Please explain any discrepancies in the body of the Report.**

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<thead>
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<td><strong>Factual Findings:</strong></td>
<td>relevant for calculating the personnel costs and correspond to objective and verifiable information. The budgeted or estimated elements used are: — (indicate the elements and their values).</td>
</tr>
<tr>
<td></td>
<td>10. Personnel costs contained no ineligible elements;</td>
</tr>
<tr>
<td></td>
<td>11. Specific conditions for eligibility were fulfilled when additional remuneration was paid: a) the Beneficiary is registered in the grant agreements as a non-profit legal entity; b) it was paid according to objective criteria generally applied regardless of the source of funding used and c) remuneration was capped at EUR 8,000 per full-time equivalent (or up to up to the equivalent pro-rata amount if the person did not work on the action full-time during the year or did not work exclusively on the action).</td>
</tr>
</tbody>
</table>

**D. Productive hours**

XVI. The number of productive hours per full-time employee applied is [delete as appropriate]:

A. 1720 productive hours per year for a person working full-time (corresponding pro-rata for persons not working full time).

B. the total number of hours worked in the year by a person for the Beneficiary

C. the standard number of annual hours generally applied by the beneficiary for its personnel in accordance with its usual cost accounting practices. This number must be at least 90% of the standard annual workable hours.

**If method B is applied**

XVII. The calculation of the total number of hours worked was done as follows: annual workable hours of the person according to the employment contract, applicable labour agreement or national law plus overtime worked minus absences (such as sick leave and special leave).

XVIII. ‘Annual workable hours’ are hours

**Procedure (same sample basis as for Section C: Personnel costs):**

- The Auditor verified that the number of productive hours applied is in accordance with method A, B or C.
- The Auditor checked that the number of productive hours per full-time employee is correct and that it is reduced proportionately for employees not exclusively assigned to the action(s).
- If method B is applied the Auditor verified i) the manner in which the total number of hours worked was done and ii) that the contract specified the annual workable hours by inspecting all the relevant documents, national legislation, labour agreements and contracts.
- If method C is applied the Auditor reviewed the manner in which the standard number of working hours per year has been calculated by inspecting all the relevant documents, national legislation, labour agreements and contracts and verified that the number of productive hours per year used for these calculations was at least 90% of the standard number of working hours per year.
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<td>during which the personnel must be working, at the employer’s disposal and carrying out his/her activity or duties under the employment contract, applicable collective labour agreement or national working time legislation. XIX. The contract (applicable collective labour agreement or national working time legislation) do specify the working time enabling to calculate the annual workable hours. If method C is applied</td>
<td>Factual finding: General 12. The Beneficiary applied a number of productive hours consistent with method A, B or C detailed in the left-hand column. 13. The number of productive hours per year per full-time employee was accurate and was proportionately reduced for employees not working full-time or exclusively for the action. If method B is applied 14. The number of ‘annual workable hours’, overtime and absences was verifiable based on the documents provided by the Beneficiary and the calculation of the total number of hours worked was accurate. 15. The contract specified the working time enabling to calculate the annual workable hours. If method C is applied 16. The calculation of the number of productive hours per year corresponded to the usual costs accounting practice of the Beneficiary. 17. The calculation of the standard number of workable (working) hours per year was corroborated by the documents presented by the Beneficiary. 18. The number of productive hours per year used for the calculation of the hourly rate was at least 90% of the number of workable (working) hours per year.</td>
</tr>
<tr>
<td>XX. The standard number of productive hours per year is that of a full-time equivalent; for employees not assigned exclusively to the action(s) this number is reduced proportionately. XXI. The number of productive hours per year on which the hourly rate is based i) corresponds to the Beneficiary’s usual accounting practices; ii) is at least 90% of the standard number of workable (working) hours per year. XXII. Standard workable (working) hours are hours during which personnel are at the Beneficiary’s disposal preforming the duties described in the relevant employment contract, collective labour agreement or national labour legislation. The number of standard annual workable (working) hours that the Beneficiary claims is supported by labour contracts, national legislation and other documentary evidence.</td>
<td></td>
</tr>
</tbody>
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If certain statement(s) of section “D. Productive hours” cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor:
- ...

<table>
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<tr>
<th>E. Hourly rates</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>The hourly rates are correct because: XXIII. Hourly rates are correctly calculated since they result from dividing annual personnel</td>
<td>✓ The Auditor has obtained a list of all personnel rates calculated by the Beneficiary in accordance with the methodology used. ✓ The Auditor has obtained a list of all the relevant employees, based on which the</td>
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<td>costs by the productive hours of a given year and group (e.g. staff category or department or cost centre depending on the methodology applied) and they are in line with the statements made in section C. and D. above.</td>
<td>personnel rate(s) are calculated. For 10 full-time equivalent employees selected at random (same sample basis as Section C: Personnel costs):</td>
</tr>
<tr>
<td>If the statement of section ‘E. Hourly rates’ cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor: ...</td>
<td>✓ The Auditor recalculated the hourly rates. ✓ The Auditor verified that the methodology applied corresponds to the usual accounting practices of the organisation and is applied consistently for all activities of the organisation on the basis of objective criteria irrespective of the source of funding. Factual finding: 19. No differences arose from the recalculation of the hourly rate for the employees included in the sample.</td>
</tr>
</tbody>
</table>

F. Time recording

XXIV. Time recording is in place for all persons with no exclusive dedication to one Horizon 2020 action. At least all hours worked in connection with the grant agreement(s) are registered on a daily/weekly/monthly basis [delete as appropriate] using a paper/computer-based system [delete as appropriate];

XXV. For persons exclusively assigned to one Horizon 2020 activity the Beneficiary has either signed a declaration to that effect or has put arrangements in place to record their working time;

XXVI. Records of time worked have been signed by the person concerned (on paper or electronically) and approved by the action manager or line manager at least monthly;

XXVII. Measures are in place to prevent staff from:
   i. recording the same hours twice,
   ii. recording working hours during absence periods (e.g. holidays, sick leave),
   iii. recording more than the number of productive hours per year used to calculate the hourly rates, and

Procedure

✓ The Auditor reviewed the brief description, all relevant manuals and/or internal guidance describing the methodology used to record time. The Auditor reviewed the time records of the random sample of 10 full-time equivalents referred to under Section C: Personnel costs, and verified in particular:

✓ that time records were available for all persons with not exclusive assignment to the action;
✓ that time records were available for persons working exclusively for a Horizon 2020 action, or, alternatively, that a declaration signed by the Beneficiary was available for them certifying that they were working exclusively for a Horizon 2020 action;
✓ that time records were signed and approved in due time and that all minimum requirements were fulfilled;
✓ that the persons worked for the action in the periods claimed;
✓ that no more hours were claimed than the productive hours used to calculate the hourly
### Please explain any discrepancies in the body of the Report.

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<td>iv. recording hours worked outside the action period.</td>
<td>• that internal controls were in place to prevent that time is recorded twice, during absences for holidays or sick leave; that more hours are claimed per person per year for Horizon 2020 actions than the number of productive hours per year used to calculate the hourly rates; that working time is recorded outside the action period;</td>
</tr>
<tr>
<td>XXVIII. No working time was recorded outside the action period;</td>
<td>• the Auditor cross-checked the information with human-resources records to verify consistency and to ensure that the internal controls have been effective. In addition, the Auditor has verified that no more hours were charged to Horizon 2020 actions per person per year than the number of productive hours per year used to calculate the hourly rates, and verified that no time worked outside the action period was charged to the action.</td>
</tr>
<tr>
<td>XXIX. No more hours were claimed than the productive hours used to calculate the hourly personnel rates.</td>
<td></td>
</tr>
</tbody>
</table>

[Please provide a brief description of the time recording system in place together with the measures applied to ensure its reliability to the Auditor and annex it to the present certificate].

[If certain statement(s) of section “F. Time recording” cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor:  

...]

### Factual finding:

20. The brief description, manuals and/or internal guidance on time recording provided by the Beneficiary were consistent with management reports/records and other documents reviewed and were generally applied by the Beneficiary to produce the financial statements.

21. For the random sample time was recorded or, in the case of employees working exclusively for the action, either a signed declaration or time records were available;

22. For the random sample the time records were signed by the employee and the action manager/line manager, at least monthly.

23. Working time claimed for the action occurred in the periods claimed;

24. No more hours were claimed than the number productive hours used to calculate the hourly personnel rates;

The description of the time recording system must state among others information on the content of the time records, its coverage (full or action time-recording, for all personnel or only for personnel involved in H2020 actions), its degree of detail (whether there is a reference to the particular tasks accomplished), its form, periodicity of the time registration and authorisation (paper or a computer-based system; on a daily, weekly or monthly basis; signed and countersigned by whom), controls applied to prevent double-charging of time or ensure consistency with HR-records such as absences and travels as well as it information flow up to its use for the preparation of the Financial Statements.
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<td>personnel rates;</td>
</tr>
<tr>
<td>25. There is proof that the Beneficiary has checked that working time has not been claimed twice, that it is consistent with absence records and the number of productive hours per year, and that no working time has been claimed outside the action period.</td>
<td></td>
</tr>
<tr>
<td>26. Working time claimed is consistent with that on record at the human-resources department.</td>
<td></td>
</tr>
</tbody>
</table>

[official name of the Beneficiary] [Linked Third Party]

(name and title of authorised representative)

[dd Month yyyy]

<Signature of the Beneficiary>

[official name of the Auditor]

(name and title of authorised representative)

[dd Month yyyy]

<Signature of the Auditor>
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