H2020 - Research and Innovation Action

APPLICATE

Advanced Prediction in Polar regions and beyond: Modelling, observing system design and LInkages associated with a Changing Arctic climaTE

Grant Agreement No: 727862

Deliverable No. 7.11

First summary report of stakeholder interaction activities

Submission of Deliverable

Work Package	**WP7 User engagement, dissemination and training**		
Deliverable No	7.11		
Deliverable title	First summary report of stakeholder interaction activities		
Version	1		
Status	**Draft**		
Dissemination level	**PU - Public**		
Lead Beneficiary	**2 - BSC**		
Contributors	X 1 – AWI	X 2 – BSC	☐3 - ECMWF
	☐ 4 – UiB	☐ 5 – UNI Research	☐ 6 – MET Norway
	☐ 7 – Met Office	☐ 8 – UCL	☐ 9 - UREAD
	☐ 10 – SU	☐ 11 – CNRS-GAME	☐ 12 - CERFACS
	☐ 13 – AP	☐ 14 – UiT	☐ 15 - IORAS
	☐ 16 - MGO		
Due Date	**30 April 2018**		
Delivery Date	**23 April 2018**		

This project has received funding from the European Union's Horizon 2020 Research & Innovation programme under grant agreement No. 727862.

Table of Contents

Table of Contents 3
EXECUTIVE SUMMARY 4
1. INTRODUCTION 5
1.1. Background and objectives 5
1.2. Organisation of this report 5
2. METHODOLOGY 5
2.1. User Group meetings 5
UG online meeting 6
UG meeting at Arctic Circle Assembly 6
UG meeting at the APPLICATE General Assembly 6
2.2. Stakeholder interactions in relevant events 7
2.3. Blog 7
3. STAKEHOLDERS DISCUSSION 7
3.1. User group discussion 7
3.2. Mapping of relevant topics and sectors 9
3.3. Lessons learnt from stakeholders interactions 13
3.4. Does 'Polar Prediction Matter'? 13
2. CONCLUSIONS AND OUTLOOK 16
3. REFERENCES 17
4. ACRONYMS 17
5. ANNEX 18

EXECUTIVE SUMMARY

The main objective of the APPLICATE project 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 the Northern Hemisphere. To produce usable and trustworthy predictive information for decision-making, APPLICATE actively engages with stakeholders, including representatives of various economic sectors and local communities.

This deliverable describes the different stakeholder interaction activities that have been undertaken to date, including the meetings with the APPLICATE User Group, the interactions with stakeholders when attending relevant events and the participation in the blog Polar Prediction Matters (PPM).

The User Group is composed of representatives from all the APPLICATE targeted stakeholder groups, including the scientific community and international organisations, the public and private sectors, and the society at large including the general public and local communities. The first and second User Group meetings were held with the main aim for the project WP7 partners and the participants to get to know each other, learn about the project and start a discussion about Arctic priority issues and sectors where enhanced predictive capacity is needed. The first virtual meeting in September 2017 was an introduction to the second face-to-face User Group meeting that took place in October during the Arctic Circle Assembly in Reykjavik. After that, User Group participants were invited to attend the APPLICATE General Assembly in January 2018 in Barcelona. The aim of this third meeting was to introduce the User Group to the APPLICATE partners and vice versa, and to give them the chance to follow project developments. In a specific round-table session devoted to the User Group meeting, participants mapped the most urgent issues and sectors affecting the Arctic.

Other chances to interact with stakeholders were provided through attendance to relevant events about the Arctic. Beside the Arctic Circle Assembly, WP7 partners also attended the ArcticNet conference Arctic Change held in Québec (Canada) in December 2017 and the Arctic Frontiers conference in Tromsø (Norway) in January 2018. In addition, the participation of APPLICATE in the PPM blog, run by the Year of Polar Prediction (YOPP), also provides the project a unique chance to interact with other stakeholders.

All the described stakeholder interaction activities are key to identify and gather information on knowledge gaps in the Arctic. This is important in order to define what are the user-relevant variables and metrics that the APPLICATE project should focus its efforts on.

The complexity of the Arctic was one of the main outcomes of the user consultations. It is clear that the APPLICATE project cannot address all the topics discussed, but we can ensure that the information gathered is shared further and addressed by other Arctic projects and initiatives.

1. INTRODUCTION

1.1. Background and objectives

This report summarizes the different stakeholder-interaction activities that have been undertaken by the APPLICATE user engagement team in WP7. It expands on the first meeting of the User Group previously described in MS11. The deliverable also includes a description of the second and third User Group meetings as well as additional activities that were conducted to obtain stakeholder's feedback on the relevance of the results generated and the way they were presented to relevant audiences. Interactions with stakeholders external to the project are expected to serve the project as an additional advisory mechanism.

1.2. Organisation of this report

The main activities in which APPLICATE has participated to gather stakeholder's feedback are described in the Methods section. The Stakeholder discussion section summarizes the obtained feedback. The Conclusions and outlook section includes the main messages and the next steps that APPLICATE will follow to complete the User Group with participants from all relevant sectors, that are expected to guide the project's research.

2. METHODOLOGY

APPLICATE uses different approaches to interact with relevant stakeholders, with the aim of engaging, informing and empowering them to adapt to Arctic changes and their far-reaching impacts on the environment and communities. In turn, stakeholders provide the project with an external perspective and feedback, ensuring that the products generated are tailored to user needs, and maximising their relevance and usability. Applied activities for stakeholder interaction are user group meetings, attendance to relevant events and a blog.

2.1. User Group meetings

The APPLICATE User Group applies the focus group technique, a set of procedures to collect and analyse qualitative data that allows a guided discussion between a small but diverse group of stakeholders (Merton, 1987). A focus group involves usually a group of 6-12 participants who share a common interest, or are similar in some other way, and discuss together an issue of specific interest to research. This technique relies on a group interaction and dynamics to stimulate discussion, thinking and contributions from the participants, providing perspectives that could not be obtained with other participatory techniques (Asbury, 1995). In a focus group, the role of the facilitator is to study the reactions and answers of the participants and keep the discussion at the same time dynamic and balanced, allowing all the participants to express their views.

Recruiting focus group participants and finding a suitable place and time for the meeting can be time-consuming and expensive, particularly when participants come from different geographical regions – such as the case with the APPLICATE UG. For that reason, APPLICATE decided to hold UG meetings both online and in person.

The first step was to carefully identify participants. The aim is to have representatives from all different sectors with the stake in the topic at hand – enhanced climate predictions in the Arctic. It is also recommendable to have a balanced group, when it comes to gender, geographical location, and professional position.

Three UG meetings have been held to date: an online meeting (September 2017), a meeting at the Arctic Circle Assembly (October 2017) and a meeting at the APPLICATE General Assembly (GA) (January 2018).

UG online meeting

Initially, APPLICATE listed 12 stakeholders, all from different institutions or companies spreading from Alaska to Korea, who were invited to take part in the UG and to attend this first online meeting. The first task was to find the time that would fit in office hours in so many different time zones. We thus proposed three different time slots in two different days. The invitation letter contained a link to the doodle poll that let participants select the date and the time they preferred. As a result, the first UG meeting was composed of two sessions, one with the representatives from North America and the other with participants from Europe, Russia and Asia.

The meeting was composed of the two online sessions. Two stakeholders from Alaska, WP7 partners from AP and BSC and the project coordinator participated in the first session on 26 September. Three other stakeholders, from Norway, Russia and China participated in the second session, facilitated by the WP7 partners from AP and BSC, on 27 September.

The first UG meeting had three components:

1. Participants introduction and project presentation
2. Discussion about participants' expectations from the project and their anticipated contribution
3. Discussion about knowledge gaps, priority topics and sectors for the project

UG meeting at Arctic Circle Assembly

Some UG participants attended the Arctic Circle Assembly last October 2017 in Reykjavik, Iceland. A meeting breakfast was organised between the UG participants that attended the event and the APPLICATE WP7 user-engagement team. The meeting was a good opportunity to get to know each other personally, to address the participants' questions about the project and start identifying topics for which a better prediction of Arctic weather and climate would be an asset.

UG meeting at the APPLICATE General Assembly

UG members were invited to the 2nd APPLICATE GA, a 3-day meeting that took place on the 15-17 January 2018, in Barcelona, Spain. This gave the UG members the chance to meet the project team, closely follow the project developments, and share their experiences regarding the challenges and opportunities that climate change is posing to Arctic regions. On day 1, UG participants had the opportunity to give a short talk about issues in the Arctic that were relevant for their life and/or businesses. Day 2 was devoted to the official UG meeting where, using a round table format, participants discussed about the most urgent issues and topics affecting the Arctic. The meeting was recorded and participants were asked to give their consent by filling a form. A few scientists from the APPLICATE project, the project coordinator and the project manager also took part in the discussion.

During the UG meeting, participants helped to develop a map of the different Arctic sectors affected by the variability of Arctic weather and climate. The group agreed to take the following next steps: 1) update the mapping of sectors by integrating the feedback received from the UG session, and 2) share the updated document with the UG again, giving them the chance to complete it and provide new information regarding geographical regions and/or institutions or actors for which the particular topic/sectors are relevant.

The list of APPLICATE UG participants to date is provided in section 3.1. The project will however keep the composition of the group flexible to changes and enlarging. If some sectors or user groups are underrepresented in the project / such as fisheries, aviation, nature

conservation, oil&gas and tourism), while their feedback might be valuable, we will invite new members to join the UG.

2.2. Stakeholder interactions in relevant events

There are many relevant events that provide chances to interact with stakeholders. Some of the attended events are:

- **Arctic Circle Assembly**, Reykjavik, Iceland, October 2017: this annual event provides an excellent platform for networking, since it gathers a plethora of stakeholders representing different types of organizations, ways of life – from big city dwellers to reindeer herders and nomads, and regions all over the Arctic and beyond. Relevant projects and initiatives focusing on the Arctic are there. In this occasion, the projects from the European Arctic Cluster shared a booth at the event.

- **Arctic Change**, Quebec, Canada, December 2017: international conference organised by the ArcticNet network of centres of excellence that allowed interaction with stakeholders and presentation of the APPLICATE project in an oral session entitled „APPLICATE: a project within the EU Arctic Cluster for advanced prediction in Polar regions and beyond“.

- **Arctic Frontiers**, Tromsø, Norway, January 2018: international conference on sustainable development in the Arctic that allowed interaction with APPLICATE UG members and other stakeholders and presentation of the APPLICATE project in a poster session entitled „Engaging, involving and empowering: triple approach to stakeholders‘ collaboration on the production of enhanced Arctic climate prediction“.

Additionally, APPLICATE is participating in the **User engagement task group of the EU Arctic Cluster**, a network of different EU-funded H2020 projects with focus in the Arctic. This initiative has the aim to enhance the user engagement strategy of the individual projects through an effective coordination that allows to exploit synergies between the projects and to avoid user fatigue. It also facilitates the joint organisation of side events and participation in conferences.

2.3. Blog

The Polar Prediction Matters (PPM) blog was launched in September 2017. The blog aims to become a discussion forum that helps foster the dialogue between forecasters and climate data users. It hosts articles for and by stakeholders on the scientific outputs of Arctic research and how these can be transferred to other societal sectors beyond academia. In addition, it is a tool to engage with users and to gather information that helps define user-relevant metrics to develop within APPLICATE.

3. STAKEHOLDERS DISCUSSION

The discussion of the three UG meetings is summarised together in this section, providing first a presentation of each of the participants, their expectations from the project and anticipated contribution, as well as the identification of the knowledge gaps, priority topics and sectors in the Arctic that need further research. A mapping of the different sectors of relevance, which constitutes the main result of the UG held in the APPLICATE GA, is provided in the section 3.2.

3.1. User group discussion

A list of UG participants, with their expectations and possible contribution to the project follows:

- **Nils Andreassen** (Director) and **Veronica Slajer**, Institute of the North, Alaska, USA. They can provide links with different Arctic Council activities related to renewable energy, such as the Arctic Energy Conference, that they will organise in Iceland in 2019. The Institute of the North is in charge of the project management of the Arctic Council's Sustainable Development Working Group work on the Arctic Renewable Energy Atlas (AREA). The atlas collects renewable energy resource potential data and develops visualisations to map renewable resources in collaboration with Arctic Portal (APPLICATE partner) and various Arctic national bodies. Nils and Veronica are also involved in other projects dealing with energy efficiency and sustainable development.

- **Cindy Dickson**, Executive Director of the Arctic Athabaskan Council, Canada. The Council is established to defend the rights and further the interests of American and Canadian Athabaskan member First Nation governments in the Arctic Council and other international fora. The Council also provides the opportunity to Athabaskan communities to participate in research projects that are of their interest. They are interested in a stronger collaboration between researchers and local communities that allow to translate complex changes happening in the Arctic in examples that everyone can understand (e.g. what does climate change mean for reindeer in the Arctic).

- **Justin Kim**, Director of the Korean Maritime Institute (KMI). The institute is a think tank and research centre interested in developing policies on marine affairs for Korea. Justin focuses on filling the gap between science and policy; developing an Arctic research roadmap together with the government. He is also interested in understanding the links between the Arctic and mid-latitudes.

- **Michael Kingston**, Managing Director, Michael Kingston Associates, London. He has had long-term collaboration with insurance companies such as Lloyd's. He also contributed to the Arctic Marine Best Practice Declaration.

- **Anders Oskal**, Director of the International Centre for Reindeer Husbandry (ICRH), Norway, and member of the Association of World Reindeer Herders. The ICRH could support the project with their network composed of all reindeer communities across the Arctic and the national states, including China, Mongolia, Scotland, UK, and eight Arctic states. In addition, the Centre has some scientific capacity, involving science-related initiatives.

- **Mikhail Pogodaev**, Director of the Northern Forum and chair of the board of the Association of World Reindeer Herders, Russia. The Northern Forum is an organisation of regional cooperation and an observer to the Arctic Council. It has a working group on climate change, which unites representatives of the Northern region governments and experts in climate change, with the main purpose to develop guidelines for climate change adaptation in northern regions. He can provide expertise on the effects of the changing climate and their influences on the life of Northern people at the local and regional levels. Reindeer herders were among the first who faced climate change due to their day-to-day proximity to nature, and their observations and traditional knowledge can be beneficial to the project.

- **Mead Treadwell**, President of PT Capital, Alaska, USA. He is a former Lieutenant of Alaska and chair of the US Arctic Commission. PT Capital works on Arctic shipping, where there is a strong need for expertise and reliable climate and ice forecasts.

- **Jie Zhang / Cheng Wenfang**, associates of the Polar Research Institute of China (PRIC). PRIC is interested in collaborating closely with WP6 of APPLICATE, since they are developing the Arctic Observation Centre, and increasing their collaboration with the Sustainable Arctic Observing Networks (SAON) for interoperable Arctic data management. They are operating research stations and vessels in the Arctic and the Antarctic.

Participants in the first online meeting identified some priority topics in the Arctic for which appropriate weather and climate information would be of use, such as rescue activities, food security, reindeer herding, clean energy or emergency preparedness. Participants agreed in the need to perform a gap analysis in order to know which type of information is missing to

adapt to the new Arctic situation. The results of this gap analysis will help identify which other stakeholders we need to engage in our UG to get their feedback.

Users mentioned that gaps exist in processes occurring both in the short and in the long term, and that the regional factor is very important because depending on where you are in the Arctic, climate change can have very diverse impacts and there is no single solution that fits all. This involves that when addressing the capacity of the different sectors to adapt to changes, there is a need to distinguish between different geographical regions.

Another gap identified by users is the availability of observational data series in the Arctic, which are needed to make robust models and allow statistical downscaling. Although in some cases this data exists, often it is not digitised and therefore not accessible. In addition, the way in which information is given is something to keep in mind since annual averages, for example, are not relevant for situations that can change drastically on a daily basis.

The importance to integrate research and traditional knowledge is a gap often pointed out by local communities: „*Reindeer herders observe the nature every day, they see the changes, and they can provide important information"*. In fact, some work has been going on in this direction, such as the dissertation of Inger Marie Gaup Eira (2012) developed within the framework of the EALÁT project.

3.2. Mapping of relevant topics and sectors

Relevant topics and sectors that are of the most importance for the Arctic stakeholders and could take advantage of enhanced weather and climate predictions were mapped in the interactions with the UG group. The main contribution comes from the two-hour round table discussion during the APPLICATE GA. The mapping of key sectors and issues is summarised in Table1 contained in Annex, whereas the main topics identified in the discussion are described in this section and grouped under the following seven themes: (i) weather and climate data use, (ii) knowledge communication and integration (iii) food security (iv) biodiversity, (v) relevant economic sectors, (vi) climate change and natural hazards (vii) mid-latitude linkages.

Weather and climate data use

The Arctic is a large and very diverse region, with different weather conditions – that can abruptly change, occurring simultaneously in different places. Also, climate change can have various impacts, depending on where you are in the Arctic. "There is no one solution for all". Having climate data for regions facing different weather challenges would be very important and a plethora of activities would benefit from this information. One example is the need for weather and climate data for guiding the response in rescue activities and making sure that coast guards and search and rescue teams are able to respond appropriately over a big area.

Besides the strong geographical differences across the Arctic, there are also significant seasonal differences. In spring and autumn, with melting and freezing periods, a good planning is crucial and often high-frequency data is needed (e.g. daily). This applies to regional activities like reindeer herding, but also to day-to-day activities, such as commuting within Arctic towns or communities.

The UG participants are of the opinion that end users, such as local and regional governments, need tailored information. They do not have capacity nor time to analyse the data, and scientific organisations should thus help them with this aspect. Another concern is that scientific data, reports and recommendations are not well implemented at the regional and local levels.

One recommendation from the UG was that the project should provide climate data in a format

compatible with the models already used by the engineering and/or planning communities. This would allow a seamless information flow, a functional input-output system that would facilitate the integration of this new data.

What is a useful forecast type will be determined by each particular sector's characteristics and needs. Shipping companies need real-time forecasts for operational activities and navigation, while seasonal and annual forecasts could be useful for planning. Then again, the infrastructure sector would benefit from annual and decadal forecasts for their development planning.

Relating our work to global trends and challenges, e.g. food security, ocean acidification, droughts, or migrations, could enhance interest in the produced climate data and predicted impacts, according to our participants. If we manage to connect to these main global trends, our work would be more informative. In addition, highlighting the relevance of climate data for the regional strategies is also very important.

Sea ice data was pointed out as crucially important for various sectors, including shipping, mining, oil & gas, and hunting & fishing, among others. An interesting observation was that scientists should move ahead of a simple binary attitude of ice vs no-ice. From the shipping industry perspective, there will always be ice, because even if you don't have ice you need to be prepared for the ice conditions. The question for the ships is rather how manageable the ice is and what one needs to be prepared for.

When it comes to the barriers to using climate data and information, digital divide and lack of stable and strong telecommunication infrastructure stuck out. This makes the access to, as well as uploading and downloading of information, difficult. Communication in the Arctic is hence another recognised and very important topic.

Knowledge communication and integration

UG members emphasised the importance of the information flow, e.g. national meteorological services provide information to the regional and municipal level, which should be further communicated to the individual users. We should however also ensure the information flow from other sources, such as scientific projects.

Local knowledge and citizen science were other very important topics for UG members. They were understood as a way to build capacity within the community, providing data for and by the users. "Users are the source of information. E.g. reindeer herders observe the nature every day, they see the changes, and they can provide important information." However, traditional knowledge is a different system of information, a "different way of knowing and understanding", and its integration in the conventional knowledge system is not always straightforward. Sometimes this knowledge is not recognised or acknowledged. Hence, some of this knowledge may disappear, and thus we need to put efforts to preserve it and develop it further. In reindeer husbandry, for instance, every herder relies on traditional knowledge and can predict what to expect in different situations. Reindeer herders also learn from animals and from the environment about what will happen. Actually, the co-production and co-design paradigm, so necessary to ensure useful and usable information tailored to user needs, assumes integrating different types of knowledge.

Food security

Food security is an important challenge for the Arctic. Local communities are concerned about the melting permafrost and the freezing and melting of lakes and rivers that is becoming ever more irregular. Fishers and hunters often cross frozen lakes and rivers while looking for preys,

and need to do it safely. Seasonal climate data, particularly about precipitation, temperature and snow cover, can help planning fishing and hunting activities, allowing local communities to make more reliable estimations for winter food and animal feed supply.

Reindeer herding well reflects the complexity of the Arctic region. It extends over all the Arctic nations except in Iceland, meaning that it is composed of a wide variety of topographical, geographical, and climatically different settings and contexts. Therefore, different climate change adaptation strategies will be needed to adapt each of these settings. Still, one of the common challenges for most reindeer herders today is the difficulty to secure feed for their animals. If the ground freezes and thaws continuously, it is hard for reindeers to dig for food. The changing season is another challenge, particularly the changing precipitation and temperature patterns.

For reindeer husbandry both short and longer term – particularly seasonal – data is useful. High-resolution data is important, since different weather conditions occur on relatively short distances, and local data is essential for looing after a herd.

Biodiversity

Arctic fish species could be affected by Arctic changes in different ways, from an increased plankton production to a change of habitat conditions due to sea temperature rise and sea ice withdrawal. The change in habitats may displace local fish species northwards, often in favour of an 'invasion' of southern species. The sea ice change also affects water acidity, which can have a cascading effect on the whole sea food chain.

We have already witnessed regime shifts of certain fisheries systems in the recent past. Some users expect a dramatic drop in cod production. A shifting ecological pattern often implies a sudden collapse of a certain industry or a fish stock in a particular area, but the opening up in another area. These changes can mean that fishing fleets will start operating in new areas in the future. These new areas might have a lack of climate data and practical experience thus new climate and sea ice data would be crucial there to avoid accidents.

Reliable Arctic climate data could support blue growth and species conservation. In order to improve fish management and conservation, sea ice models or other data outputs should be compatible with the fish productivity models that are already in place. In particular, salmon movement has been directly linked to weather. From the UG discussion, information on the weather and on the development of plankton would be useful to manage hatcheries (i.e. to decide the release dates).

Relevant economic sectors

Shipping, infrastructure, energy, insurance, reindeer herding and commercial fishery were the most frequently mentioned economic sectors that need enhanced Arctic climate forecast.

An important issue in the Arctic is transport and re-supply. In some regions, items like construction materials and fuel are only supplied once per year. In the same way, fish catch and other local goods are taken out with the same frequency. One of the questions raised in the UG meeting was: "what combination of climate change, technology change and change in habits will actually reduce the cost of living in Arctic communities". In fact, the economy of re-supply is already changing with the changing ice conditions. A big advantage for many Arctic communities would be moving from the winter-summer transport schedule to a year-round schedule. The availability of winter roads is also very relevant for goods re-supply. While this possibility of shipping out products the whole year round is also relevant for the mining industry.

The renewable energy field is well advancing in the Arctic. However, there are certain concerns that these new technologies are still too expensive and that local communities cannot afford them; communities from Northern Canada were mentioned as an example. The efficiency of these technologies under extreme polar conditions is another concern. In addition, many places, including some communities in Yukon are only connected with the rest of the world by air, and flying renewable energy equipment in is very expensive. That is the reason why many Northern communities still rely on the use of diesel even though they would like to move to cleaner options.

Energy efficiency should be considered together with renewable energy. This aspect is currently lagging behind in some areas, such as Siberia. The energy losses are very high in many parts of the Arctic due to large distances, and in places with a central heating system these losses are even larger. Low temperatures can also increase losses from electricity grids.

Another relevant opportunity for the Arctic development is liquid natural gas (LNG). For shipping LNG to the consumer market advanced climate data, the sea ice data in the first place, is very important.

Prosperity of sustainable energy and infrastructure projects is closely related to the insurance sector. Critical to insurance is the modelling of risk. Besides renewable energy projects, the field of action of insurance companies extends also to ports, properties and other projects involving the finance sector. The decision to underwrite a new development is based on the prediction of the future conditions regarding many factors, including future climate. Without reliable climate data available to the insurance market, insurers will not underwrite the risk, and new projects will not be bankable. Enhanced climate data is thus key to unlock large renewable energy projects and other investments.

Climate change and natural hazards

Flooding is a big issue in some Arctic regions such as Siberia. Taking in consideration the size of Siberian rivers (e.g. the Lena River) flooding can have severe effects on large areas. In addition, the increase of flooding in the last years has obliged some communities to seek for better protection of their settlements.

Besides flooding, another challenge is ice on rivers. Arctic rivers are not only used for shipping but also as winter roads. Melting and freezing of these “roads” is an important aspect to consider, especially when planning seasonal transport and re-supply. Precipitation can also affect winter roads. An example of that was last year’s intensive precipitation that did not allow the ice to create and some Siberian communities could not use winter roads until April.

Some parts of the Arctic, Iceland in the first place, are strongly affected by high winds and waves. Natural hazards are responsible for some of the experienced problems. For example, currents are bringing silt to some Icelandic harbours, making them too shallow and causing risks to navigation. Coastal security is also a very important issue in other parts of the Arctic, such as Alaska.

Enhanced climate data on precipitation, wind and waves could support disaster risk reduction and climate change adaptation measures.

Mid-latitude linkages

The APPLICATE UG also includes participants from beyond the Arctic region to allow the discussion to tackle the links between Arctic change and mid-latitudes. There is still a lack of understanding of the impact of Arctic changes on Europe and North America. Improving this

understanding with enhanced climate data could help implement better policy decisions, including decisions dealing with where to build houses, how to protect areas from flooding or how to manage land and livestock.

3.3. Lessons learnt from stakeholders interactions

Many different topics were identified at attended events to be relevant in the Arctic. Important topics included sea ice and user engagement, and luckily, here APPLICATE has a role to play. User engagement was seen happening as a trend towards decentralized platforms which are community or user-generated and in which users are not passive receivers any more, becoming more and more producers of information. An example of that is the SIKU project, a social media mapping platform and mobile app designed with and for Inuit combining traditional knowledge and tools with cutting-edge technology. Information shared on the platform contributes to a living wiki of Inuit knowledge to be used by communities for their own benefit.

In addition, as the sea ice declines in the Arctic, it becomes less predictable. Therefore, one cannot talk about 'sea ice predictability' in general, but rather for a specific time scale, region or parameter considered. Knowledge of baseline sea ice and the ocean state is key to be able to perform skilful predictions. This aspect links to the need of reliable observations in the Arctic, that is approached by projects such as INTAROS, INTERACT, the Year of Polar Prediction (YOPP), or initiatives with the participation of the World Meteorological Organization (WMO) and the US National Science Foundation.

Relevant topics discussed in the attended events are, among others:

- Governance of the Arctic marine environment taking into account the new activities that will develop
- Integration of local knowledge and scientific knowledge. Empowering of local communities
- Permafrost and waves impact on construction stability
- Effects of ocean temperature and acidification on fisheries and biodiversity. Application of the agreement on unregulated fishing in the Arctic Ocean
- Development of future scenarios together with shipping companies that include sea ice projections, different types of cargos and policy options. Need of water and sea ice forecasts for implementation of the new Polar Code
- Coastal protection under risk from the occurrence of bigger waves due to thinner ice. Critical (safe) ice thickness mentioned as a useful parameter to assess coastal protection
- Reindeer herding faces different challenges in different regions in the Arctic. Therefore, it is important to consider the temporal and spatial resolution of data
- Opening of an Arctic food market that brings new opportunities for business
- Food security is compromised by ice melting, both sea and on-shore ice, which reduces the ice infrastructure that local communities use for fishing,hunting and commuting
- Energy barriers for the integration of renewables in Northern communities
- Influence of weather and climate factors on the wellbeing of local communities (health effects)

3.4. Does 'Polar Prediction Matter'?

The answer to that question is 'yes', and the PPM blog has already a few examples of that. On the 1st September 2017 the blog was officially launched with a welcome to Polar Prediction

Matters written by Helge Göβling, director of the International Coordination Office for Polar Prediction, and a first stakeholder article. Articles published so far have a focus on safe Arctic shipping. A list and a summary of these articles is provided below:

1. Breaking the ice (September 2017) by Uwe Pahl, master of the German research icebreaker RV Polarstern from 1996 to 2014. Since 2014, he has been the team leader of the construction supervision team of Reederei F. Laeisz for the new Polarstern II. In this article, he shares his personal view on how challenging is to navigate such a large vessel through the polar seas. He points at the easy access to real-time ice images to be of crucial importance for a safe navigation. He describes three levels of voyage track planning, for which real-time information is used:

- Strategic planning: all available sources used to find the most convenient passage through the ice with respect to the scientific programme of the expedition (e.g. written reports on the ice conditions and ice charts based on satellites processed and submitted data).
- Long-range tactical ice and weather assessment: medium-scale radar ice charts. Helicopter flights are often used to explore the current ice situation. 2 to 3 months in advance of a cruise, ice charts already indicate how the sea-ice situation might develop during the coming voyage.
- Short-range tactical observations: for immediate navigation decisions, high-resolution ice-radar charts obtained with instruments aboard the ship are used, complemented with helicopter reconnaissance flights around the vessel and direct observations from the ship's crow's nest.

However, after learning about activities aiming at improved ice forecasts presented in the annual meeting of the International Ice Charting Working Group (IICWG), the article author is convinced that in the near future sea-ice forecast methods based on numerical models will play an important role for the navigation in ice-covered waters.

2. Polar Prediction Matters to the Icelandic coast guard (October 2017) by Snorre Greil, project officer and Soley Kaldal, risk management and safety engineer, Department of Operations, Icelandic Coast Guard. They explain that increased traffic in the Arctic puts pressure on national capabilities, and all responsible nations want to do their best to ensure an acceptable level of operational safety. This is logistically complicated and expensive, and no single nation is expected to undertake the challenges of dealing with complex large-scale emergencies alone. Weather and environmental observations, forecasting and prediction matter to the Icelandic Coast Guard. In-situ observations (deploying state-of-the-art instruments to measure waves, currents, atmospheric pressure, and sea surface temperature) provide situational awareness for safer at-sea operations and coast guard missions. And these observations improve Arctic prediction and forecasting capabilities. The authors mentioned that for the purpose of informing a long term strategy and proactive operations, the interest is not only in short-term forecasting, but also in climate change predictions and consequences thereof.

3. To turn or not to turn (November 2017) by Dr Jan Lieser and Dr Tomas Remenyi, researchers at the Antarctic Climate & Ecosystems Cooperative Research Centre (ACE CRC) of the University of Tasmania in Hobart, Tasmania, Australia. They point at not only sea ice and its various geophysical characteristics (thickness, concentration, drift or state of development) to be of concern to polar mariners but also at sea ice of land origin (icebergs). Due to the different properties of frozen sea water versus snow compacted over hundreds and thousands of years, even small fragments of largely submerged ice can inflict substantial damage to a ship's hull and consequently compromise its intergrity. To access harbours or stations, a sea-ice passage has to be planned carefully, but for other operations in the proximity of sea ice (e.g. blue-water research or commercial interests near the sea-ice edge) advice on sea-ice avoidance is needed. Under the recentyly implemented Polar Code for the regulation

of the world's shipping, ships operating in polar waters have to meet certain requirements with respect to safety and the environment. Ships will be required to receive and interpret information on ice conditions and other environmental conditions that affect the ice and navigation in sea ice. A framework to create sea-ice analyst and forecaster competency standards is currently under development. It aims to establish consistent levels of know-how and procedures for service providers, so that the receiver of sea-ice advice can be assured to get a consistent message regardless of the provider. For the Arctic, the Sea-Ice Prediction Network (SIPN) has coordinated a Sea-Ice Outlook, a seasonal summer sea-ice prediction exercise, for ten years. With this, SIPN produced an incentive to develop a reliable forecasting capacity within the research community, which can be transferred to operational use.

4. Sailing frozen oceans (January 2018) by Tero Vauraste, president and CEO of Arctia Ltd, a Finnish Polar Maritime Services company. The company provides ice management services, including icebreaking, oil spill response and other polar maritime assistance with a fleet of eight icebreakers and 300 professionals. Tero Vauraste has worked as a vessel master and in several other positions at the Finnish Coast Guard. Recently, he has been elected Chair of the Arctic Economic Council for the term 2017—2019. He identified forecast elements and time scales that are necessary for a safe Arctic shipping. In terms of ice forecasting, important elements include thickness, area, age, salinity, movement, compression, ridging, icebergs and berg bits and their movement. Weather forecasting is also critical for temperature, wind and spraying (leading to structural sea ice formation). Forecasts of these elements at different time scales can help guiding different types of decisions. Thus, considering that the lifespan of an icebreaker can be as long as thirty to fifty years, foreseeing the climatic and business developments in the Arctic some decades ahead is one of the main variables that is going to impact the fleet renewal plan. Seasonal forecasts are valuable for fleet and crew planning and mangement. At even shorter scales, monthly forecasts of temperature and wind, as well as forecasts of the movement, compression, thickness and ice extent are used for fleet usage and definition of the operational area. Daily forecasts are used to appoint the correct fleet and to inform decisions when it comes to managing the risk of exceptional situations. Finally, online or nowcast information is a central element of the everyday operational decision-making of an icebreaker.

5. Engaging users of sea ice forecasts (April 2018) by Lawrence Hislop, executive director of the global Climate and Cryosphere project (CliC) of the WMO World Climate Research Programme. In his contribution to Polar Prediction Matters he outlines the format, implementation and key outcomes of a recent workshop aimed at exploring the needs of sea ice forecast users. Paramount for all industries was ensuring the safety of the crew and ships operating in ice-covered waters, complying with the Polar Code, and following related international standards and regulations. The benefits of accurate sea ice forecasts were highly valued for safeguarding the passage of vessels, improved logistics planning and overall efficiency. Participants noted the importance of forecasts and the help they can provide in saving fuel and time as well as in reducing costs of maintenance and insurance. Moreover, the need for real-time information on the current sea ice state and for small-scale and high-resolution products was highlighted. Companies ultimately need to know if they can get through a very specific area, e.g. straits, bottlenecks and essential gateways. An overarching need identified by many participants centred around improved communication, both on the technical side and regarding human capacity. North of 79 degrees the main form of telecommunications is with Iridium technology and the data transfer is only 30kb/s – which can be very limiting (especially for high-resolution and real-time information). Any new forecast products or services will need to consider these limitations. Companies would also like more standards and agreement among forecasters for defining important information such as the ice edge, first-year vs multi-year ice and overall quality of ice. The human aspect of interpreting and conveying information in the right ways could dramatically improve these issues going forward.

2. CONCLUSIONS AND OUTLOOK

APPLICATE has had a fruitful collaboration with various stakeholders so far. User consultation and engagement activities included the meetings with the APPLICATE User Group, the interactions with stakeholders when attending relevant events and the participation in the Polar Prediction Matters blog. Most of the findings related to the user needs for enhanced polar predictions can be sorted in two groups: (i) needs of Arctic communities and (ii) needs of economic sectors, with some of the issues and needs for climate data overlapping for the two groups. Next steps will consider the inclusion of a third group related to the linkages of Arctic changes with mid-latitudes, which have been already pointed out during the various user consultations.

Stakeholder interactions conducted so far have provided a comprehensive overview of the needs and challenges from the vast and complex Arctic region. Still, we will continue working on enlarging the UG, in order to cover the sectors that are not represented at the moment, such as fisheries, oil and gas, conservation, aviation and tourism.

Among the plethora of relevant topics and challenges identified, APPLICATE will select those where its expertise and the project capacity can bring the biggest added value. Some of these contributions have already been recognised and include:

- Enhancing sea ice prediction that will benefit shipping and many other economic activities in the Arctic;
- Improving understanding and prediction of the freezing and melting cycle and snow cover, that will support reindeer herding, hunting, commuting and many other aspects relevant for local communities;
- Climate data of ocean parameters that can support nature conservation, fishery and blue growth;
- Understanding of the Arctic change linkages with mid-latitudes

Although not all the relevant aspects identified through the stakeholder interactions can be covered by the APPLICATE project, other Arctic projects and initiatives may address some of these challenges. The first step will thus be sharing these results and the table developed during the UG meeting with the EU Arctic Cluster.

The results from the stakeholder engagement activities have direct benefit for the Task: Co-development of the user-relevant impact metrics and implementation in ESMValTool of the project`s WP1. However, other scientific WPs can also benefit from the knowledge gained about user needs, making the project results more relevant, usable and useful. Finally, the results will be shared and commented with the rest of the Arctic research community, primarily through the collaboration within the EU Arctic Cluster and presentations at conferences. This will enhance the clustering work of the project, lead by WP8.

Next steps in the APPLICATE interaction with stakeholders will consist in continuing our meetings with the UG every 3-4 months. Next meeting will take place in May/June 2018. The project will also be presented at the Polar 2018 meeting in Davos, Switzerland in June 2018, with the talk ‘Engaging, involving and empowering stakeholders for Arctic climate prediction’ and in the Adaptation Futures in Cape Town, in June 2018, with the talk ‘A changing Arctic – dialogues from the North’. New blog articles are going to be prepared monthly to evidence the diverse views and needs from Arctic stakeholders.

3. REFERENCES

- Asbury, Jo-Ellen (1995) Overview of Focus Group Research, Qualitative Health Research, 5 (4): 414-420
- Inger Marie Gaup Eira (2012) The silent language of snow. Sámi traditional knowledge for snow in a time of climate change, PhD Dissertation.
- Merton, R. K. (1987) The focused interview and focus groups. Public Opinion Quarterly, 51: 550-566

4. ACRONYMS

UG: User Group

PPM: Polar Prediction Matters

YOPP: Year Of Polar Prediction

GA: General Assembly

LNG: Liquid Natural Gas

5. ANNEX

Table 1. Relevant Arctic sectors and issues

Topic	Sector	Main issues
Food security	Reindeer husbandry	Thawing and rain-on-snow events create ice cover on vegetation making food access difficult for animals Habitat succession and availability Pest and diseases Change in migration patterns, difficulty to reach the mating areas
	Agriculture	Opportunities for new crops and longer growing season but risk of wetter conditions that hamper harvest and the day-length limitation
	Fisheries (ocean/freshwater)	Impacts on habitat availability and fish stocks Shifting of the fishing areas Shifts in ecological patterns
	Hunting and gathering	Ice cover as infrastructure for local communities to go fishing and hunting Permafrost melting
Water	Water supply	Algal blooms contaminating water supply
	River floods	If the ice gets stuck in the rivers it can cause floods

Nature protection	Biodiversity	Risk of extinction of high Arctic zone habitats Loss of some species (e.g. ice associated algae Trend towards browning Arctic Processes depending on sea ice - biological processes Invasive sp. Spread of pests and diseases Outlet of fresh water from Arctic changes salinity
Natural resources	Oil and gas	Longer drilling seasons, lower shipping costs (in ice free waters) and bergy bits that can provide a risk Reduced stability of infrastructure (pipelines, roads…) due to thawing permafrost Sea ice level presents risk for LNG
	Renewable energy and Energy efficiency	Challenges in reducing diesel in favor of clean energy Difficulty in transporting renewable energy equipement (e.g. solar panels) and their resistance to extreme temperature Huge losses in energy transportation to households
	Forestry	Limitation of winter logging due to a lack of frozen winter roads Increased tree growth Risk from pests and diseases Risk from fires and droughts
	Mining	Risk of seepage and flood-spread pollutants
Transport and Supply	Shipping	More logistically efficient and cheaper alternatives, but risk of premature increase in activity; Need for real time information
	Aviation	Fog affecting visibility
	River transport	Rivers represent natural infrastructure (winter roads) in some areas

	Supply	Resupply (food, fuel stock, construction materials…); What combination of climate change, technology change and change in habits could reduce the cost of living
Infrastructure and safety	Coastal protection	Protection from waves due to strong winds Sea level rise and more severe winds in the future (what type of shore protection will we need in the future?) Early warning system
	Urban development/ housing	Melt of permafrost and ground subside Need for longterm planning and climate projection
	Communication infrastructure	Lack of internet coverage in some areas - digital divide
	Technology, monitoring and early warning	Monitoring system Satellites Crowdsourcing Real-time information useful for early-warning
	Search and rescue	New opportunities (for shipping and exploitation) increase exposure and brings new risks Mobile sea-ice increases risks from ice-related hazards
Health	Human health	Impact on human wellbeing and injuries due to unreliable ice cover Air and marine pollution
Population and social aspects	Population change	Climate change opens new possibilities for immigration in the Arctic region. Can this affect other sectors? (food security, nature protection, natural resources…) Pollution forcing emigration from mid-latitudes?
	Local knowledge and use of local languages	Geographical differences How to include local knowledge and knowledge systems? Co-production of knowledge Potential from crowdsourcing and knowledge collected from local businesses

Finance and insurance	Financial services and insurance	Identifying and reducing risk Modelling information critical for the insurance sector Cross-sectoral (affect all sectors)
Tourism	Tourism	Shorter winter season and unpredictable snow cover Most of the tourism is ship-based (increased presence of large cruise vessels) and there is a risk from mobile ice (bergy bits)