# Inter-comparison of the mass budget of Arctic sea ice and snow in CMIP6 models: format for data submission

Ann Keen & Ed Blockley, February 2019

Thank you for your interest in this inter-comparison of CMIP6 models. Here we provide further information about the data required, and the format for submitting data.

Please aim to submit your ASCII data files by email to Ed Blockley & Ann Keen, by June 2019. Please prioritise contributions from SSP5-8.5 scenario and HIST runs.

For the sea ice mass budget, we are asking participants to supply monthly mean values of ice area, ice mass, and components of the ice mass budget, summed over a defined domain of the Arctic. The domain is defined using the NSIDC Arctic regional masks (https://nsidc.org/data/polar-stereo/tools_masks.html#region_masks), where we include the following regions (image courtesy of NSIDC):
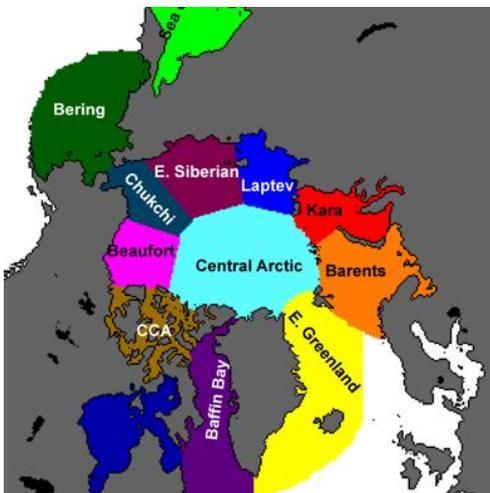
- Central Arctic Ocean
- Beaufort Sea
- Chukchi Sea
- East Siberian Sea
- Laptev Sea
- Kara Sea
- Barents Sea

We have provided a mask of the domain on the NSIDC 25km resolution polar stereographic grid, and also on the two grids that we at the Met Office are using for our model runs: eORCA1 and eORCA025:
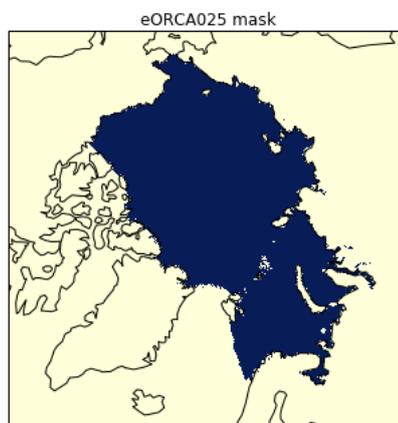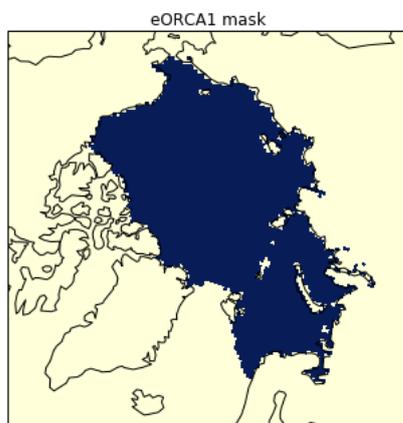
Required data

Please supply the following quantities, in the units specified. We have indicated how these values should be calculated from the SIMIP diagnostics. If your model does not explicitly represent a particular process, then please keep the column in your data file but populate it with zero values. In each case, the data should be summed over all grid points within the domain shown above.

- Sea ice area (km^2): sum of *siconc**grid-cell-area
- Sea ice mass (kg): sum of *simass**grid-cell-area
- Mass budget components ($kg\ s^{-1}$): sum of *sidmass**grid-cell-area for each of:
  - *sidmassgrowthbot* (*rate of change of s*ea ice mass due to growth at the base of existing ice/grid-cell-area $kg\ m^{-2}\ s^{-1}$)
  - *sidmassgrowthwat* (rate of change of sea ice mass due to frazil ice formation/grid-cell-area $kg\ m^{-2}\ s^{-1}$)
  - *sidmassmelttop* (rate of change of sea ice mass due to melting at the top surface/grid-cell-area $kg\ m^{-2}\ s^{-1}$)
  - *sidmassmeltbot* (rate of change of sea ice mass due to melting at the bottom surface/grid-cell-area $kg\ m^{-2}\ s^{-1}$)
  - *sidmasslat* (rate of change of sea ice mass due to lateral melting/grid-cell-area $kg\ m^{-2}\ s^{-1}$)
  - *sidmasssi* (rate of change of sea ice mass due to transformation of snow to sea ice/grid-cell-area $kg\ m^{-2}\ s^{-1}$)
  - *sidmassevapsubl* (rate of change of sea ice mass due to evaporation and sublimation/grid-cell-area $kg\ m^{-2}\ s^{-1}$)
  - *sidmassdyn* (sea ice mass change from dynamics/grid-cell area $kg\ m^{-2}\ s^{-1}$)
  - *total:* the sum of all the *sidmass**grid-cell-area terms ($kg\ s^{-1}$)

Filename and data format

The filename should be of the following format:
ModellingCentre_ModelConfiguration_Scenario_XXX_ice.txt, where

- *ModellingCentre* is the centre supplying the data
- *ModelConfiguration* is a name that uniquely identifies the model (so should include information about the resolution if appropriate)
- *Scenario* describes the forcing, and should be either "HIST" for the historical period, or one of the CMIP6 SSP scenarios (for example "SSP5-8.5")
- *XXX* denotes the ensemble number, which should be "001" for a single realisation.
- *"ice"* indicates that the data is for the mass budget of the sea ice. The other option is "*snow*", for the mass budget of snow on sea ice.
- [For example: "MetOffice_UKESM1N96ORCA1_HIST_001_ice.txt"]

File contents
The file should be in standard ASCII format.
The 1st line of the file should contain the name and email address of the person(s) supplying the data.
The 2nd line of the file should indicate which file contains the HIST data that the scenario continues from (if appropriate), or n/a otherwise (for example if file contains data for the historical period).
The 3rd line describes the data, including a confirmation of the units,
The 4th line is the column headings – using SIMIP variable names for the budget terms
The 5th line onwards contains the data.

Example file and demo programs

We have supplied an example file *MetOffice_UKESM1-N96ORCA1_HIST_001_ice.txt*, which contains two years of sea ice budget data for our model UKESM1. These data were calculated using the Python program *SIMIP_ice_mass_budget_calculate.py*. We have also supplied a program *SIMIP_ice_mass_budget_read_plot_write_demo.py* that will read in a data file and demonstrate that the budget balances (for the first year of data in the file). It also writes the data out again, producing a file identical to the original input file. For the supplied data file, the program produces the following plots:
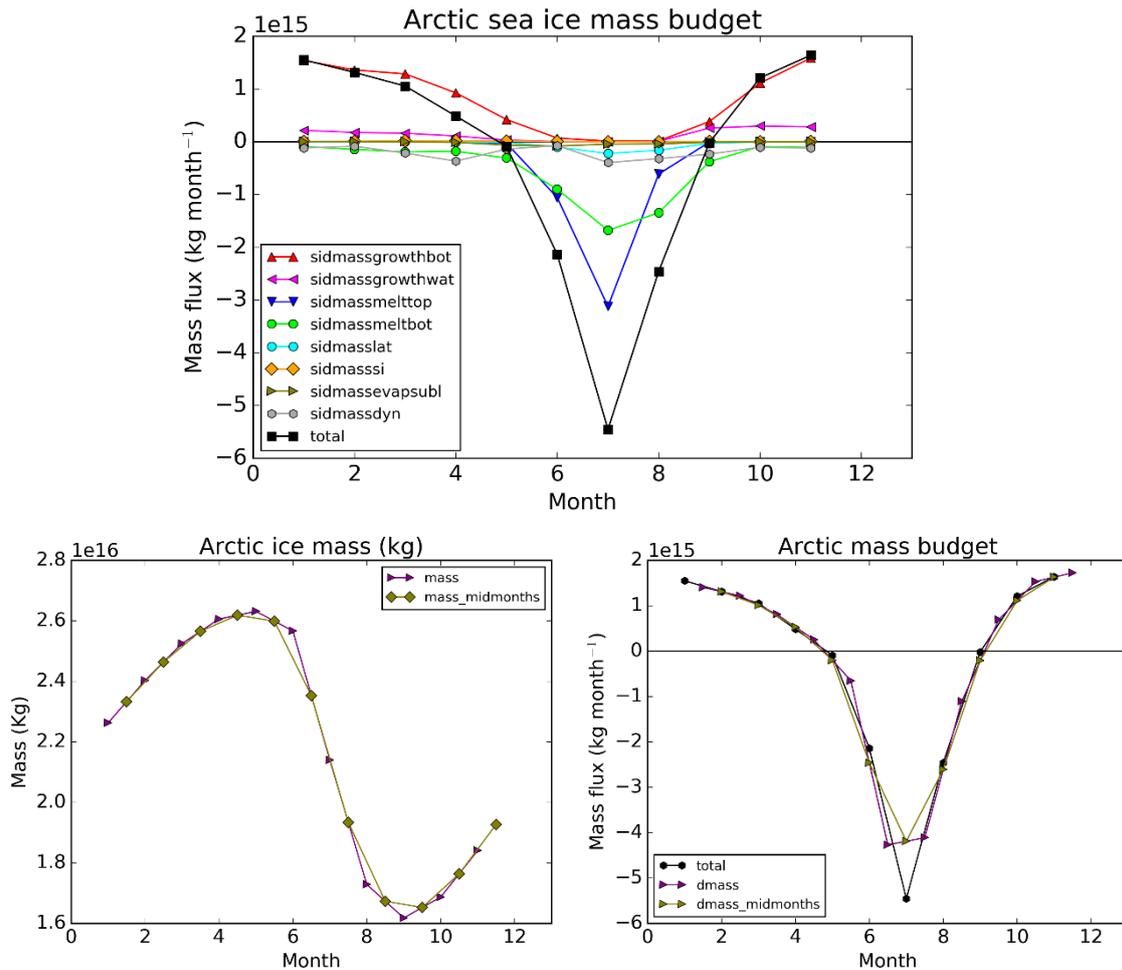
In the final plot, the total of the mass budget terms is compared to the actual change in ice mass each month, as for a closed budget these should broadly agree. For exact agreement, we would require the instantaneous ice mass at the beginning and end of each month. Here the instantaneous values are approximated by interpolated values of the monthly mean. This approximation will work best when the rate of change of ice mass does not vary too much during the period of interest. This comparison is only supposed to provide a rough test to ensure that you have included – and correctly calculated – all the relevant terms for your model's budget.

Snow on sea ice

The example data plotted above is that required for the mass budget of the sea ice. We also plan to compare the mass budget of the snow on sea ice, and possibly also the combined budget for the sea ice and snow. The terms required for the snow budget are as follows:

- Snow on sea ice area (km^2): sum of *snowfrac*siconc*grid-cell-area
- Snow mass (kg): sum of *sisnmass*grid-cell-area
- Mass budget components (kg s^{-1}): sum of *sndmass*grid-cell-area for each of:
  - *sndmasssnf* (mass of solid precip falling onto sea ice/grid-cell-area kg m^{-2} s^{-1})
  - *sndmassmelt* (rate of change of snow mass through melt/grid-cell-area kg m^{-2} s^{-1})
  - *sndmasssi* (rate of change of snow mass through snow ice conversion/grid-cell-area kg m^{-2} s^{-1})
  - *sndmasswindrif* (rate of change of snow mass through wind drift (into ocean)/grid-cell-area kg m^{-2} s^{-1})
  - *sndmasssubl* (rate of change of snow mass through sublimation/grid-cell-area kg m^{-2} s^{-1})
  - *sndmassdyn* (rate of change of snow mass through advection/grid-cell-area kg m^{-2} s^{-1})
  - *total*: the sum of all the sisnmass*grid-cell-area terms (kg s^{-1})

We have supplied an example data file *MetOffice_UKESM1-N96ORCA1_HIST_001_snow.txt* containing data for our snow mass budget, which can be generated using an adapted version of *SIMIP_ice_mass_budget_calculate.py.* The output formatting code for writing the snow budget files can be found in the script *SIMIP_ice_mass_budget_read_plot_write_demo.py.* For the supplied data file, the program produces the following plots: