REQUEST FOR A SPECIAL PROJECT 2021–2023

MEMBER STATE: Denmark

Principal Investigator[1]: Prof. Peter L. Langen

Affiliation: Aarhus University

Address: Frederiksborgvej 399

DK-4000 Roskilde, Denmark

Other researchers: Senior Researcher Shuting Yang, DMI

Project Title: EC-Earth3 contribution to Polar Amplification Intercomparison Project (PAMIP)

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** _____	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2021	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2021-2023: (To make changes to an existing project please submit an amended version of the original form.)		**2021**	**2022**	**2023**
High Performance Computing Facility	(SBU)	10 million	10 million	
Accumulated data storage (total archive volume)[2]	(GB)	25,000	50,000	

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.

[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.

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Extended abstract

The completed form should be submitted/uploaded at https://www.ecmwf.int/en/research/special-projects/special-project-application/special-project-request-submission.

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used.

Following submission by the relevant Member State the Special Project requests will be published on the ECMWF website and evaluated by ECMWF as well as the Scientific Advisory Committee. The evaluation of the requests is based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, disciplinary relevance, and justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

Requests asking for 1,000,000 SBUs or more should be more detailed (3-5 pages). Large requests asking for 10,000,000 SBUs or more might receive a detailed review by members of the Scientific Advisory Committee.

Background

Polar amplification is the tendency for high-latitude climate change to be larger than the global average. This is found in paleo-reconstructions of past warming and cooling, in modern records of current climate change and in model projections of future warming.

The ice-albedo feedback, where melting snow and ice leads to larger surface absorption of sunlight, is often claimed to be responsible for polar amplification, but the causes are, in fact, many-fold and not fully understood. Particularly the relative roles of sea surface temperature (SST) changes and sea ice concentration (SIC) changes in producing the magnitude and pattern of polar near-surface air temperature (SAT) changes is unclear.

Likewise, the hemispheric- and global-scale impacts of high-latitude changes in temperature and sea ice are debated. It is clear that polar warming has impacts on global sea level through modification of high-latitude glacier and ice sheet mass balance and on global greenhouse gas concentrations through cpntrols on surface carbon fluxes. However, impacts on atmospheric and ocean circulations are less clear and it is, for instance, widely debated whether, when, where, how and how much Arctic sea ice loss influences European weather and climate.

Many studies have attempted, through analyses of observational or reanalysis products or through dedicated model experiments, to answer these questions. However, confounding impacts of many simultaneous ongoing changes affect the observed, real-world polar amplification leaving a clear

decomposition of the response near impossible. On the other hand, differences between model formulations, background climates and experimental protocols have made clear conclusions difficult to draw from the modelling literature.

The Polar Amplification Intercomparison Project (PAMIP; Smith et al., 2019) has been designed to remedy this by supplying detailed experimental protocols and input datasets to allow for proper intercomparability between model results. PAMIP is part of the overall framework of the sixth Coupled Model Intercomparison Project (CMIP6) and makes data available through the CMIP6 infrastructure. The PAMIP thereby allows researchers worldwide to access data from across the many models.

Experiments

The full PAMIP suite comprises three tiers of experiments, ordered by priority. This special project covers only the Tier 1 experiments (plus two experiments from Tier 2), consisting of a set of atmosphere-only experiments designed to allow analyses of the relative roles of SST and SIC changes in the past and future in determining Arctic temperatures and Arctic-midlatitude-communication.

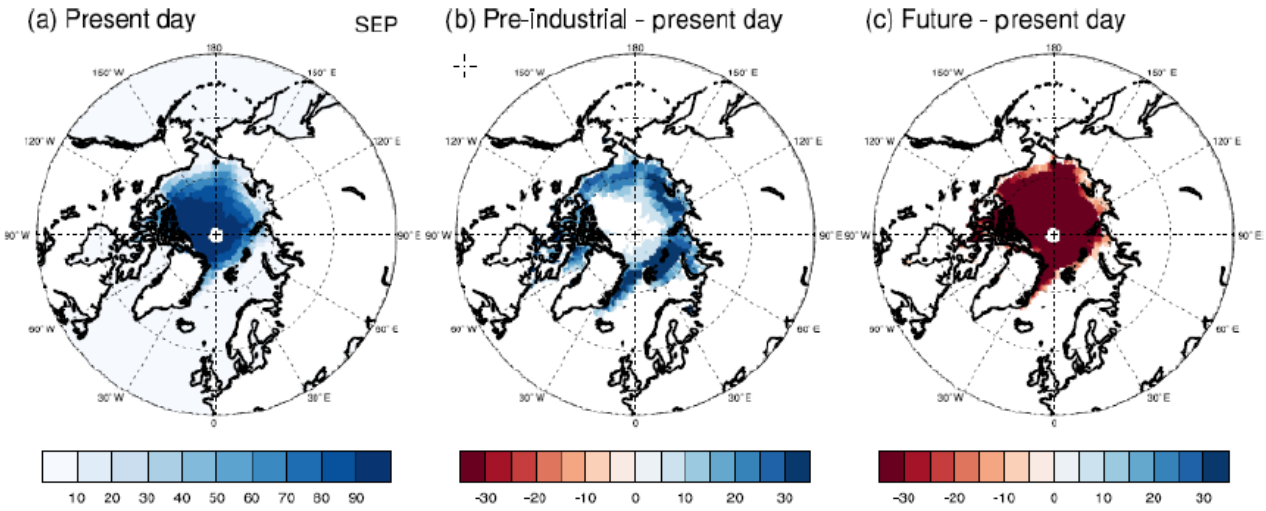

Figure 1. (a) Present day SIC, and anomaly therefrom in (b) pre-industrial and (c) future conditions. Units are in percent. Shown are September conditions but the climatology consists of all 12 months (Source: Smith et al., 2019).

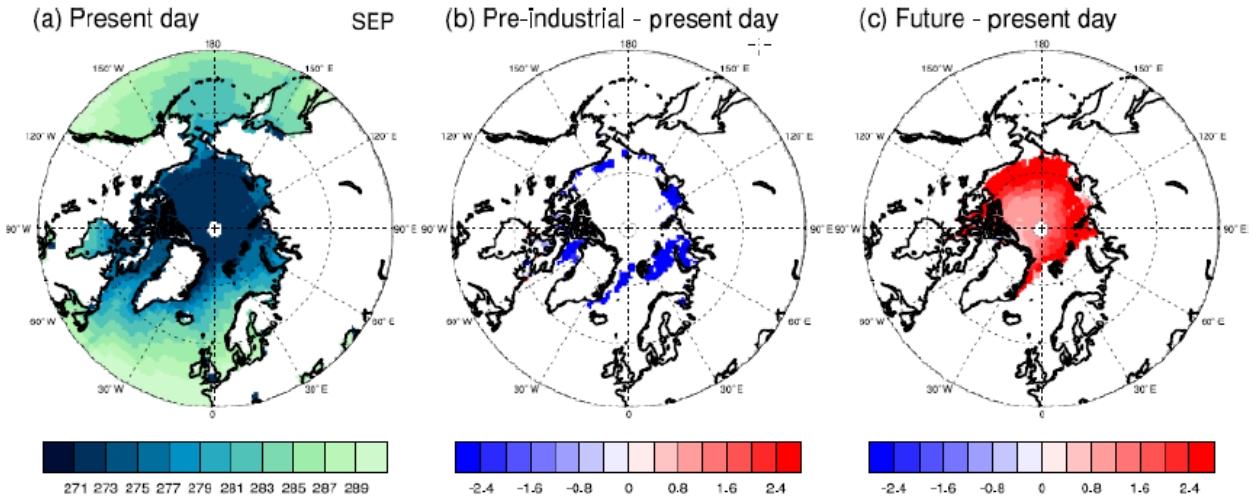

Figure 2. As in Figure 1 but for SST (Source: Smith et al., 2019).

The starting point is a collection of climatological SSTs and SICs for preindustrial (pi), present day (pd) and future (fut) conditions (see figures 1 and 2 for September conditions; the climatology consists of 12 monthly fields). The future is designed as an average over a number of coupled climate model states at the time when global warming has reached 2°C. These pi, pd, and fut SSTs and SICs are then combined in various ways. All Tier 1 experiments consist of 100 ensemble members of one climatology year-run, where each run covers 14 months to allow 2 months disposable spinup for each.

Table 1 shows an overview over the PAMIP experiments covered in this special project, i.e., all six Tier 1 experiments (1.1, 1.3, 1.5-1.8) plus 1.2 and 1.4 from Tier 2.

No.	Experiment name	Description	Notes	Tier	Start year	Number of years	Minimum ensemble size
1. Atmosphere-only time slice experiments							
1.1	pdSST-pdSIC	Time slice forced by climatological monthly mean SST and SIC for the present day (pd)[1,2]	Present-day SST and SIC	1	2000	1[2]	100
1.2	piSST-piSIC	Time slice forced by climatological monthly mean SST and SIC for pre-industrial (pi) conditions[3]	Pre-industrial SST and SIC	2	2000	1	100
1.3	piSST-pdSIC	Time slice forced by pi SST and pd SIC[3]	Different SST relative to 1.1 to investigate the role of SSTs in polar amplification	1	2000	1	100
1.4	futSST-pdSIC	Time slice forced by pd SIC and future SST representing 2° global warming (fut)[3]		2	2000	1	100
1.5	pdSST-piArcSIC	Time slice forced by pd SST and pi Arctic SIC[3]	Different Arctic SIC relative to 1.1 to investigate the impacts of present-day and future Arctic sea ice and the role of Arctic SIC in polar amplification	1	2000	1	100
1.6	pdSST-futArcSIC	Time slice forced by pd SST and fut Arctic SIC[3]		1	2000	1	100
1.7	pdSST-piAntSIC	Time slice forced by pd SST and pi Antarctic SIC[3]	Different Antarctic SIC relative to 1.1 to investigate the impacts of present-day and future Antarctic sea ice and the role of Antarctic SIC in polar amplification	1	2000	1	100
1.8	pdSST-futAntSIC	Time slice forced by pd SST and fut Antarctic SIC[3]		1	2000	1	100

Table 1. Overview over some of the coordinated PAMIP experiments. All six Tier 1 experiments (1.1, 1.3, 1.5-1.8) along with 1.2 and 1.4 from Tier 2 are shown (Source: Smith et al., 2019).

Resources

We will use the EC-Earth3 model for the experiments. This is the CMIP6 version of the EC-Earth model and is already set up and tested on the cca cluster. Experience shows that atmosphere-only experiments such as those outlined above require about 20 kSBUs per simulation year.

Each of the eight experiments consist of 100 members of each 14 months. This gives a total of 933 simulation years. With setup and testing of this particular experimental setup it is prudent to budget with 1000 simulation years, giving a total of 20 M SBUs.

A best estimate for necessary storage of output is 50 GB per simulation year, giving a total of 50 TB. We expect to run the experiments over the two-year duration of the special project, giving the resources applied for in the table above.

References

Smith, D.M., et al., 2019. The Polar Amplification Model Intercomparison Project (PAMIP) contribution to CMIP6: investigating the causes and consequences of polar amplification. Geosci. Model Dev., 12, 1139–1164, 2019, https://doi.org/10.5194/gmd-12-1139-2019