REQUEST FOR A SPECIAL PROJECT 2023–2025

MEMBER STATE: Denmark…………………….………………………………………

Principal Investigator[1]: Dr Jose Abraham Torres Alavez...…………………………….……

Affiliation: Danish Meteorological Institute

Address: Sankt Kjelds Plads 11, Copenhagen, 2100, Denmark

Other researchers:
Ruth Mottram, Senior Scientist
Ole Bøssing Christensen, Senior scientist
Fredrik Boberg, Senior scientist
Martin Olesen, scientist

Project Title:

250 years of Antarctic climate: Transient projections with HCLIM

If this is a continuation of an existing project, please state the computer project account assigned previously.	___________________	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2024	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2024-2026: (To make changes to an existing project please submit an amended version of the original form.)		**2024**	**2025**	**2026**
High Performance Computing Facility	(SBU)	45000000	45000000	45000000
Accumulated data storage (total archive volume)[2]	(GB)	100000	100000	100000

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.

Principal Investigator: Dr Jose Abraham Torres, Researcher, DMI

Project Title: 250 years of Antarctic climate: Transient projections with HCLIM

Extended abstract

Overview

We are requesting a large number of computational resources for a special project to run very high-resolution regional-dynamical downscaling over the pan-Antarctica domain. Danish Meteorological Institute (DMI) is part of the Horizon Europe project PolarRES, which will provide a novel set of simulations over both Polar Regions. For this initiative, DMI will run the Harmonie Climate model at a resolution of ~11km, providing climate projections based on transient 120-year simulations (1980-2100) under the shared socio-economic pathway 3-7.0 (SSP3-7.0). This simulation will be driven by the general circulation model (GCM) MPI-ESM1-2-LR, which showed a best representation of the current climate and a more realistic projection of the processes that the project tries to investigate.

Previous special project applications have focused on optimising the set-up of HCLIM over the Antarctica ice sheet. With the tests in last proposal, we can produce this long simulation set. Resources from this special project will be used completely for running the cycle 43 model set-up with HCLIM43 over Antarctica. The total of the budget requested will be used to run climate simulations during 2024, with additional optional simulations investigated in subsequent years. An application for an amendment to an existing special project, submitted alongside this one by colleague Dr Ruth Mottram will run a near-identical second set of the 120 years forced with the global climate model CESM2 in 2024. Additional simulations, downscaling other GCMs (likely EC-Earth) are planned for 2025.

We aim to assess future changes in snowfall (snow-cover fraction, depth, various indexes for length of snow season, etc.) from an ERA-5 hindcast and to compare with projections forced by MPI-ESM1-2-LR, with subsequent years including simulations forced with other ESMs as required. We plan to use weather station and satellite data for evaluation of runs and all outputs will be made open access and CORDEX compliant. and CESM2

Science Plan

Antarctica is the coldest, driest, windiest continent on earth with the largest potential source of future sea level rise, currently locked up in the vast ice sheets. In this project, we will examine the likely future of Antarctica climate under the scenarios SSP3-7.0 to 2100, as well as future snow changes.

1. The first six months will be mostly used to run long simulations for PolarRES, using the set-up determined in the previous spdkmot project.
2. The second six months will focus on completing outstanding simulations and evaluating the simulations and calculating future changes of snow characteristics using our simulations and the simulations performed by partners at different international institutes in connection with CMIP6, as well as the PolarRES project.

The Antarctic domain (Figure 1) is complicated, as the continent covers a large area but experiments show the current CORDEX domain is too small to adequately represent synoptic scale systems. However, a much larger domain is computationally expensive, while impact studies planned in the PolarRES project cover an area that extends well beyond what is required to capture the continent alone. This project will also focus on evaluating the simulations driven by the GCM, using in-situ and satellite observations.

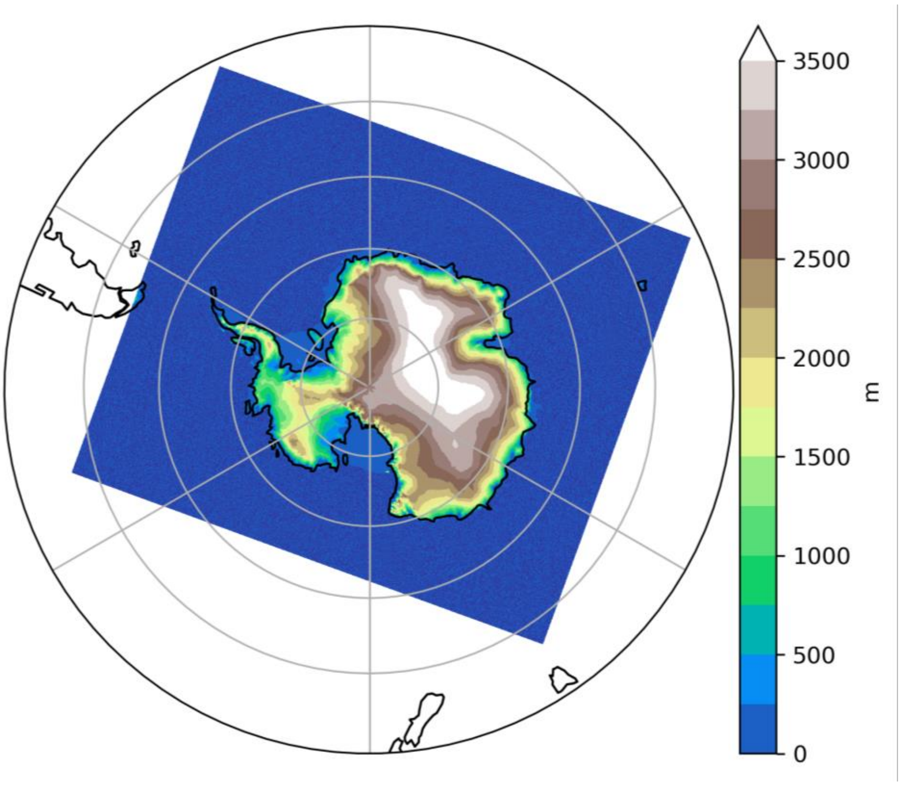

Figure 1: Final Antarctic domain within the PolarRES project. Figure by A. Torres.

We have calculated the SBUs required in this special project as:

HCLIM with ALADIN physics at 11km resolution and including sea-ice modelling:

ANT11_MPI-LR_SICE: one transient simulation (1x120 yr) for Antarctic: 120yr * 0.37 MSBUs/yr = 45.2 MSBUs.

For a one-year special project. This is augmented with 4.8 extra million SBUs to account for process studies, with a total of 50 MSBU.

Storage:

HCLIM uses approximately 1.5TB per simulated year for 11-km pan-Antarctic (most fields one hour).

1.5TB/yr * 120 yr = 180 TB

This special project application augments the previously granted spdkmott project, which is also requesting an extension and will ensure we can meet the aims of the project. We will supplement where necessary with national quota.

Science Outcomes

The proposed simulations will be processed according to the prescribed formats in CORDEX and made available via the ESGF server nodes as part of Polar CORDEX contributions to regional climate modelling in the polar regions.

In addition, the outputs from HCLIM will be used to force an offline SMB model developed at DMI to provide present day and future projections of surface mass budget (SMB), an important component of sea level rise that is also used to force dynamical ice sheet models (e.g. Mottram et al., 2021). These will contribute to the IMBIE (Ice sheet Mass Budget Intercomparison Exercise, 2018) dataset aiming to assess the present contribution to sea level from the ice sheets. We also expect the simulations will be used to analyze important weather and climate processes and therefore contribute to a number of scientific publications.

Simulations will also be analyzed at a summer school for early-career researchers planned for 2024 within the PolarRES project and will form the basis of other scientific analysis in a range of projects including the Horizon Europe funded OCAEN:ICE project on Antarctic freshwater fluxes.

References

The IMBIE team. Mass balance of the Antarctic Ice Sheet from 1992 to 2017. Nature 558, 219–222 (2018). https://doi.org/10.1038/s41586-018-0179-y

Mottram, R., Hansen, N., Kittel, C., van Wessem, J. M., Agosta, C., Amory, C., Boberg, F., van de Berg, W. J., Fettweis, X., Gossart, A., van Lipzig, N. P. M., van Meijgaard, E., Orr, A., Phillips, T., Webster, S., Simonsen, S. B., and Souverijns, N.: What is the surface mass balance of Antarctica? An intercomparison of regional climate model estimates, The Cryosphere, 15, 3751–3784, https://doi.org/10.5194/tc-15-3751-2021 , 2021.