SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2023
Project Title:	Antarctic regional climate modelling: developing and running the HCLIM Polar High Resolution Regional Climate Model
Computer Project Account:	spdkmott
Principal Investigator(s):	Dr Ruth Mottram
	Dr Ole Bøssing Christensen, Dr Jose Abraham Torres Alavez, Dr Martin Olesen, Dr Fredrik Boberg, DMI.
Affiliation:	Danish Meteorological Institute
Name of ECMWF scientist(s) collaborating to the project (if applicable)	…… ……
Start date of the project:	01/01/2023
Expected end date:	31/12/2025

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)			9.5 million	10786062
Data storage capacity	(Gbytes)				

Summary of project objectives (10 lines max)

In this project we will examine the likely future evolution of Antarctica under climate scenarios out to 2100, as well as performing process studies, using a regional climate model. The project focuses on developing and optimising the HARMONIE-Climate (HCLIM) model for simulations in Antarctica, a region it has not previously been tested or run for, using a combination of in-situ and satellite data to test performance. Outputs will be used as part of the Horizon 2020 project PolarRES and will contribute to the Polar CORDEX regional climate model ensemble. Process studies focused on extreme precipitation in West Antarctica at high resolution (2km) and an experiment using a new sea ice dataset provided by the ESA CCI are also planned.

Summary of problems encountered (10 lines max)

Our most important problem currently is that we have used all our resources on this project for the whole of the year by June. This has been due to somewhat heavier than initially anticipated simulations and the necessity to test multiple combinations of different scheme to optimise the model set-up in Antarctica. Compared to our initial estimates, the domain is bigger, the resolution higher and spectral nudging has been introduced, as has a dynamic sea ice component, all of which consume more resources than originally assessed. We have therefore this year requested more resources in an amended application. Note that our storage use is still relatively small, but this will change as the production runs get underway. Although the model currently runs stably, we note that we still have some biases in near surface air temperature and relative humidity, possibly related to issues in the boundary layer and or cloud schemes. These parts of the code will continue to be optimised.

Summary of plans for the continuation of the project (10 lines max)

Model set-up and tuning has advanced well this year and the new HCLIM Antarctic set-up performs stably, though still with some biases, possibly related to the cloud /radiation scheme as well as difficulties related to deep stable boundary layers over the Antarctic plateau. An operational hindcast downscaling ERA-5 will start from August in order to deliver outputs to users focused on impact studies. Boundary file preparation for downscaling the climate simulations will focus on CESM2 and MPI-ESM1-2-LR global models from the CMIP6 archive on ESGF initially, followed by EC-Earth3. Other models may be considered if resources are available.

The focus in the last few months of this year will be on process studies using a high resolution (2km) set-up in west Antarctica to examine the impact of extreme precipitation. 2024 will be mostly used running long simulations for PolarRES using the set-up finalised this year. Our third and final year will focus on completing outstanding simulations and running the process studies agreed on with partners at different international institutes in relation not only to the PolarRES project but also within SCAR (Scientific Committee on Antarctic Research) action groups ANTClimNOW and Antarctic RINGS (Matsuoka et al., 2022)

List of publications/reports from the project with complete references

Publications from this project are still in preparation but results were initially shown at the EGU Spring meeting and will be presented more fully at the IUGG meeting in Berlin. Papers in preparation include a model experimental protocol including evaluation of simulations from this project plus a publication looking at melt events over the Ross Ice Shelf and extreme precipitation in West Antarctica. In addition we aim to look at the effect of polar clouds on the surface energy budget.

Summary of results

This year we have set-up the HCLIM model over a Pan-Antarctic domain. A series of test simulations to optimise parameterisation schemes, as well as evaluate the model against data have been carried out. We have also tested the impact of different physical schemes AROME and ALADIN and we have finalised the set-up of the model to be used in the operational downscaling. Below are some plots showing performance of the model at this stage and illustrating some of the climate model biases that we would still like to improve.

In summary, building on the work with HCLIM in Greenland, we feel the project is progressing well. We have however identified areas for improvement in the model. We are confident that the project will be delivered on time as planned, assuming sufficient additional computer resources can be assigned to us.

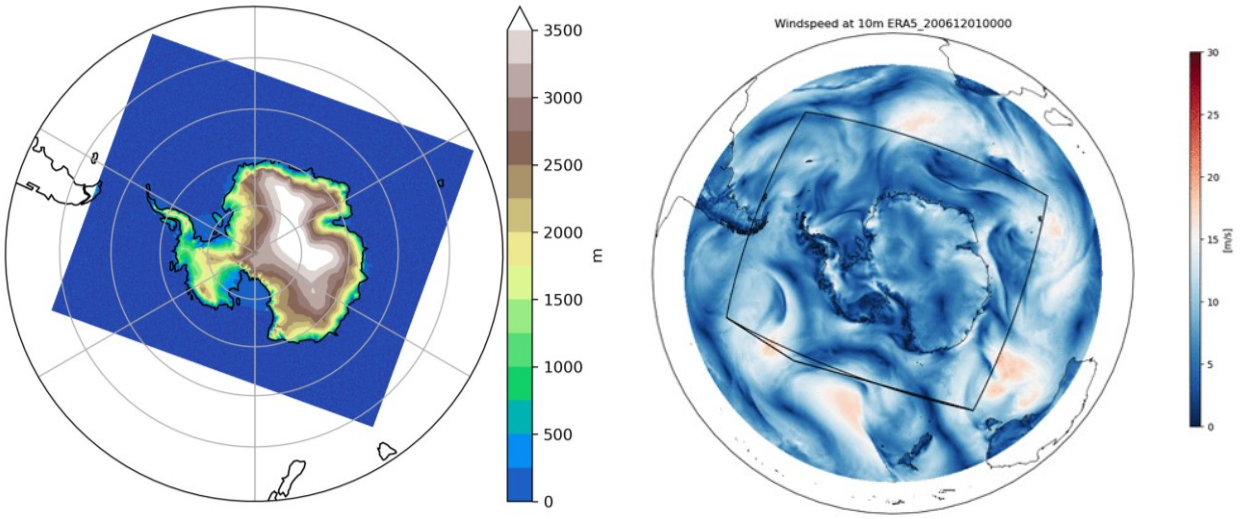

Figure 1. (left) Antarctic domain: 739x637 grid points. (Right) 10m wind speed over the domain for a single timestep. Outside the square box is the driving ERA5 data, inside is the data downscaled to 11km with HCLIM.

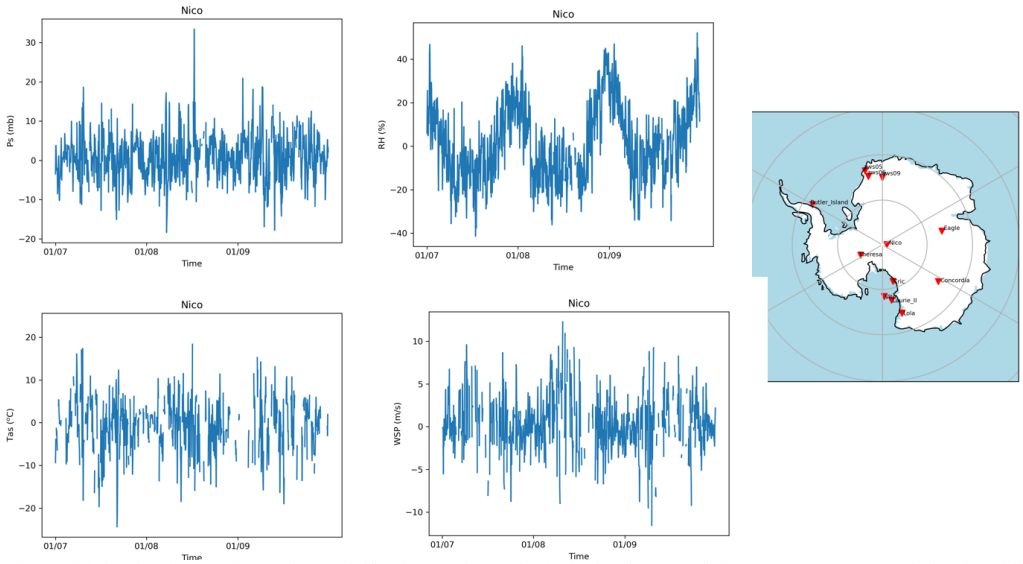

Figure 2. Comparison with in-situ observation. Bias on daily observations of (clockwise from top left) surface pressure, relative humidity, 2m air temperature and wind speed at the Nico AWS close to the south pole, shown in the inset map (right). Data is for 3 test years from 2007 to 2010. The annual cycle in bias of relative humidity and wind speeds suggest the model may not be resolving the deep stable boundary layer sufficiently. Coastal AWS show temperature biases suggestive of bias in mixed phase clouds.

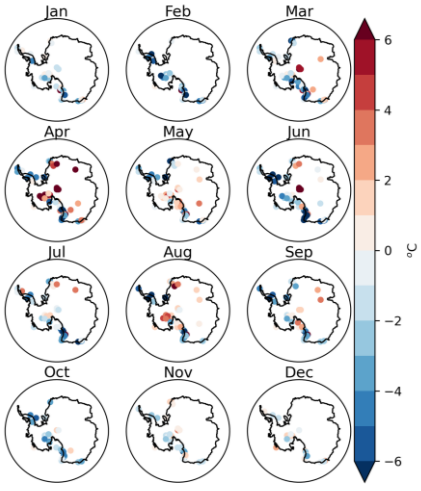

Figure 2. Bias in monthly mean 2m air temperature at AWS over Antarctica in the first version of HCLIM run over Antarctica. Data is only for 2000.