Danmarks Meteorologiske Institut

DMI Report 22-20
Harmonie Climate - Greenland

Final scientific report of the 2021 National Centre for Climate Research Work Package 2.1.1, HCLIM - Greenland

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Indhold

1. Scientific summary

Short description

Prepare the regional climate model HCLIM (Harmonie Climate) for polar downscaling experiments and finish test simulations.

Overall results

The regional climate model HCLIM cycle 38 has now been set up both for the large domain covering Greenland, Iceland and Svalbard and for a small domain over southern Greenland. Both experiments have been set up to downscale the reanalysis dataset ERA5 from ECMWF at 30 km resolution. For the large domain ERA5 has been downscaled to 5 km and to 2.5 km for the smaller domain.

HCLIM cycle 43 which as of today is the newest version has been set up to downscale ERA5 for the large domain at 5 km for 2019. The simulation is compared with a regional climate model HIRHAM5 simulation for the same year and with the same boundaries. The first comparisons show that HCLIM is representing precipitation better than HIRHAM5 especially over steep mountains.

Next steps

HCLIM simulations will be used as input in the two offline surface mass balance (SMB) models: The SMB model allowing refreezing /retention (Langen et al. 2017) and the CICCEMBEL model. SMB output will be compared with the reanalysis product CARRA (Copernicus Arctic Regional ReAnalysis) for the period 1979-2020 and with the standard datasets used in Fettweis et al. 2020. If the SMB output is good enough, we will prepare to replace HIRHAM SMB climatology on Polarportal.

2. Scientific reporting

Purpose

The purpose is to set up and test downscaling experiments of reanalysis data over Greenland with the non-hydrostatic regional climate model Harmonie Climate (HCLIM), enabling production of detailed input fields to further SMB modelling. This includes preparing HCLIM for polar modelling and finish test runs at different resolutions and time steps.

Setting up HCLIM for Greenland is closely linked to work package 1.1.1 with focus on Denmark. Model experiments with HCLIM for Greenland will be highly relevant for two H2020 projects, where FU is involved: PolarRES and Protect.

The overall objective of PolarRES is to improve understanding of key local to regional scale physical processes for atmosphere-ocean-ice interactions in the Arctic and Antarctic and influence on projected changes in the global circulation and the implications of their consequences for society and the environment in the polar regions and beyond. PolarRES will use the HCLIM model, together with others, in the Arctic region, and our analysis thus helps to optimise the use of HCLIM in the polar regions for different modelling purposes. The objective of Protect is to Project sea-level rise from ice sheets to local implications.

Results

HCLIM Cycle 38 (not the newest version) has been set up to downscale the reanalysis dataset from ECMWF (ERA5) from 31 km to 2.5 km for the southern part of Greenland shown in figure 1. Figure 2 shows a zoom of the southern tip of Greenland to get an idea of the resolution where even small fjords are resolved realistically.

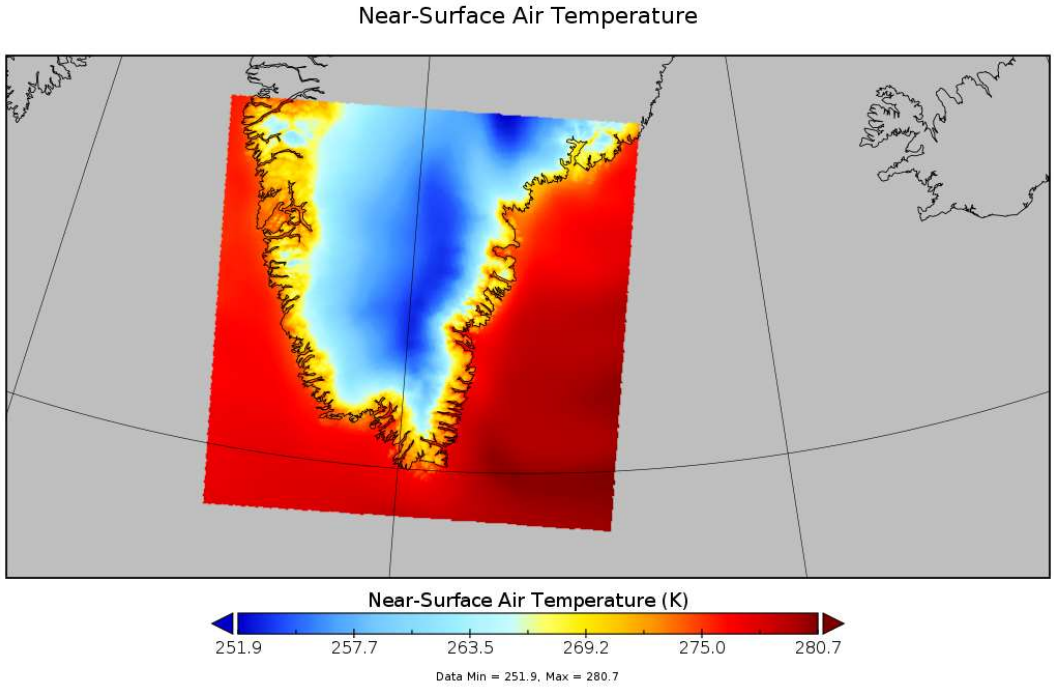

Figure 1. Near surface temperature for the southern Greenland domain.

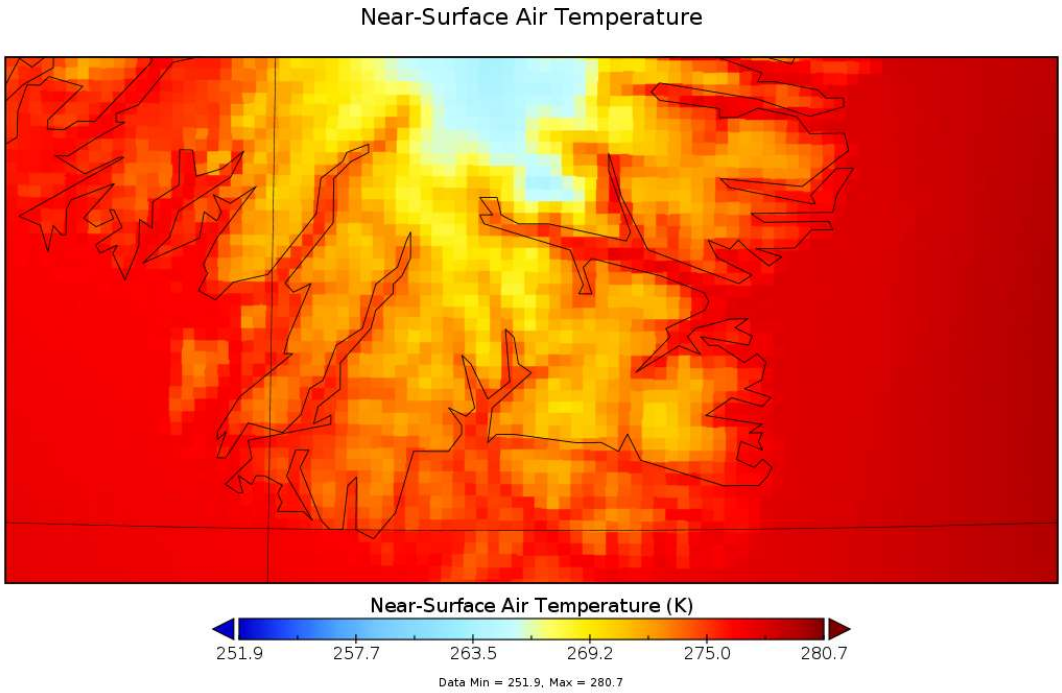

Figure 2. Zoom of figure 1 showing the southern tip of Greenland.

Upgrade to HCLIM Cycle 43

To work closer together with colleagues within the Harmonie Climate consortium and in projects like the Horizon2020 project PolarRES, we decided to switch to the latest updated version of HCLIM, cycle 43. This version is now also installed and running at the IMO/DMI supercomputer.

With HCLIM cycle 43 we have tested different resolutions, domains and time steps enabling downscaling of the entire Greenland domain shown in figure 1.

It is notet that ERA5 has already been downscaled with the regional climate model HIRHAM5 for 2019. HIRHAM5 is a hydrostatic regional climate model co-developed and used at DMI for more than a decade. To evaluate the HCLIM simulation we have downscaled ERA5 for 2019 and compared it corresponding HIRHAM5 experiment. The results show that HIRHAM5 releases too much precipitation over certain areas in Greenland. In figure 3 the accumulated annual precipitation downscaled with HIRHAM5 from ERA5 is shown to exceed 25 meters in some of the mountains on the south east coast in Greenland. This amount of annual precipitation has never been observed in Greenland and may be considered as unrealistic.

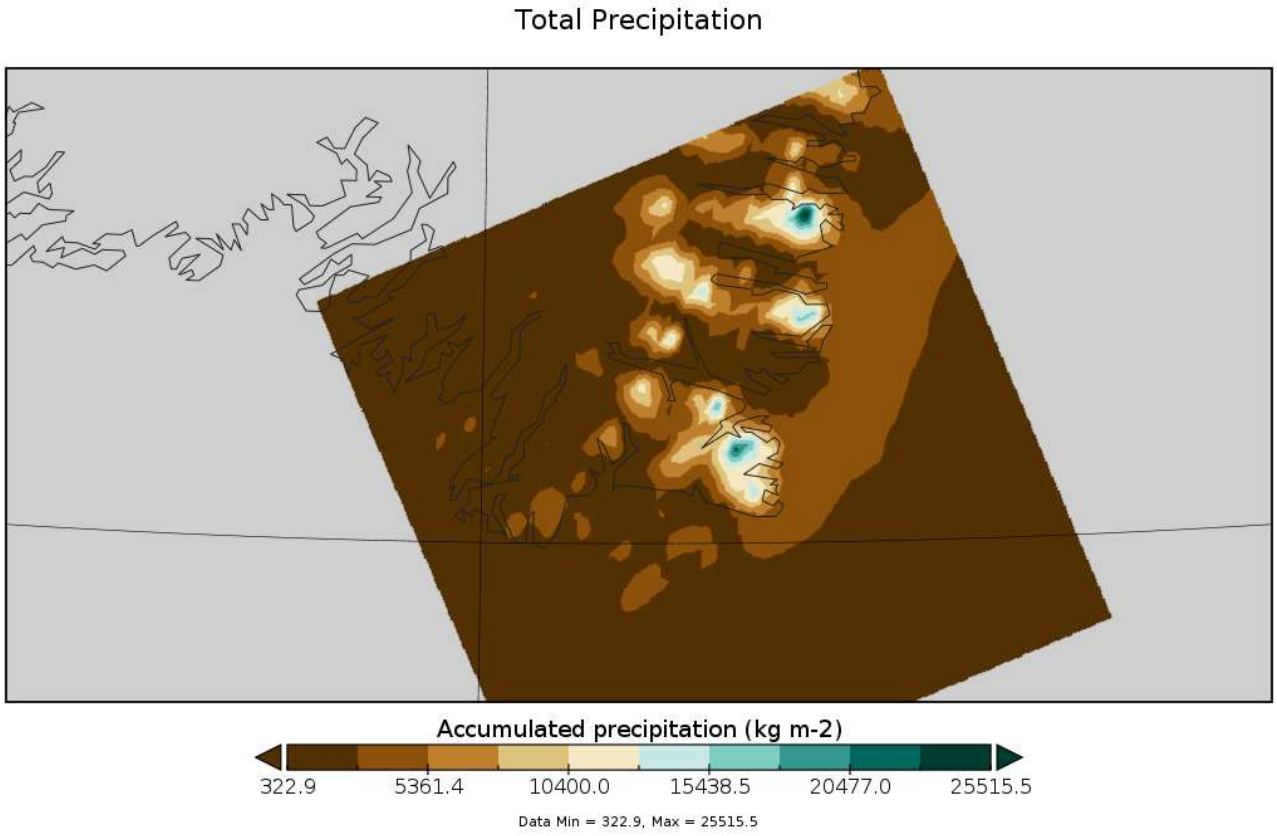

Figure 3. Accumulated precipitation (mm/yr) for 2019 simulated with HIRHAM5 forced with ERA5 on the boundaries.

With HCLIM, the downscaling of ERA5 for 2019 results in a more realistic amount of precipitation on the south-eastern coast, as shown in figure 4.

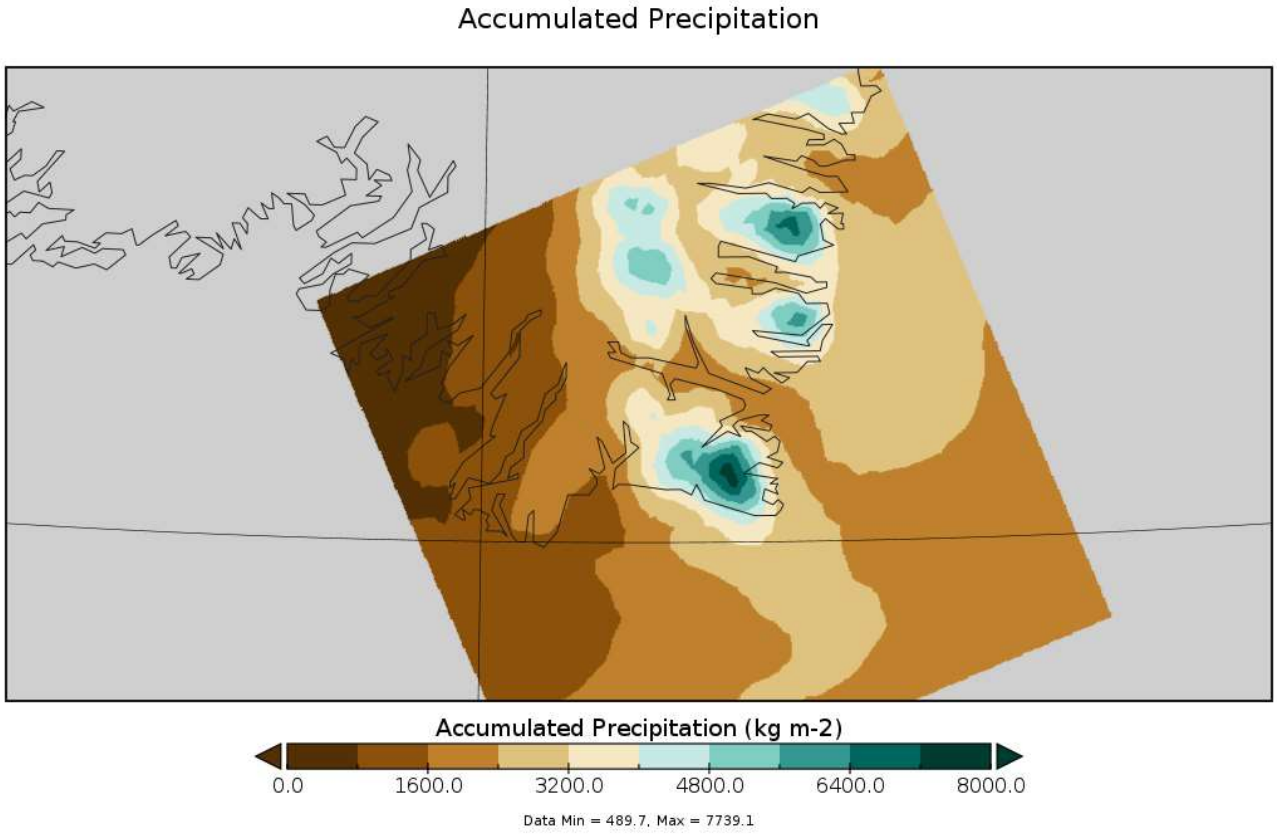

Figure 4. Accumulated precipitation (mm/yr) for 2019 simulated with Harmonie Climate forced with ERA5 on the boundaries.

An outstanding issue is still that the simulation at 2.5 km resolution, which is what we aim for, is relatively time consuming.

One year of simulation takes 12 days. Increasing the time steps to more than 60 seconds will of course reduce the computer time, but it also introduces some instability issues due to the time step compared to the grid sice (the Courant number). The model time step of the ERA5 data assimilation is 12 minutes (and also adjusted to cope with instabilities) and the horizontal resolution is 31 km. It corresponds to at 50 seconds time step at a 2.5 km resolution.

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