Various Aspects of Numerical Simulations of Atmosphere over Greenland

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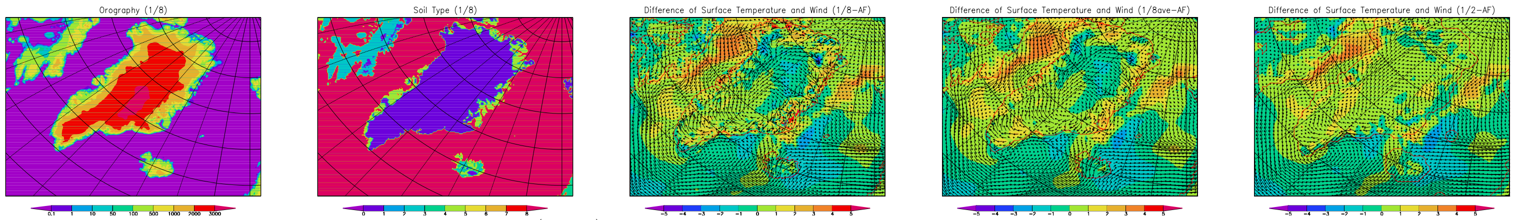
The hydrological cycle over polar regions plays a central role in global climatic change and variability and in the rise of mean sea level. Numerical simulation of 40 years over Greenland is planned to study various aspects of the atmospheric component of the hydrological cycle. A preliminary study of one month is carried out using the operational Numerical Weather Prediction high resolution nonhydrostatic Limited-Area Model ‘ Lokal-Modell ’ (LM) of the German Weather Service (DWD).
The effect of resolution (ca. 14 km und 50 km) on the regional variability is investigated here for obtaining reliable simulations of crucial processes of the atmospheric hydrological cycle. The simulation results are compared with the analyzed data to validate LM over Greenland.

Introduction

As a part of an interdisciplinary project to quantify past, present and future sea level changes (SEAL), a 40 year hindcast of atmospheric state over Greenland is currently under preparation. The seasonal and annual variations of snow accumulation over the ice sheet would be considered in particular.
In this preliminary study, the effect of model resolution on the main parameters of interest such as surface temperature, surface wind and precipitation is being investigated. The difference of the simulated from the observed state for various fields will be considered next.

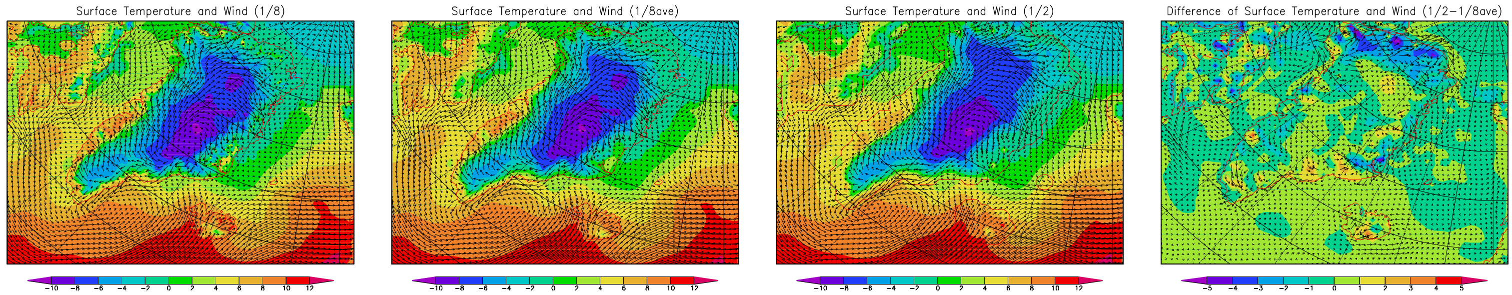
Model Description

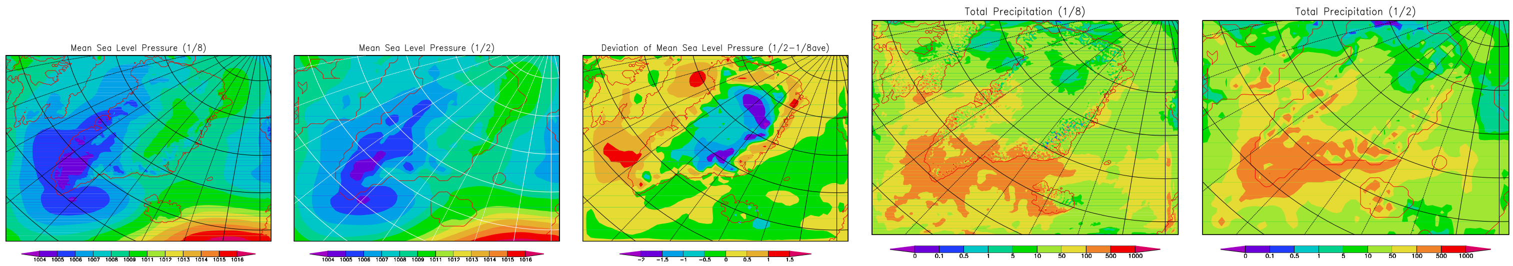
LM is used for monthly simulations of atmosphere over the model domain shown below for horizontal resolutions of 0.5×0.5 and 0.125×0.125 in rotated coordinates (South Pole at 32.5 S 170 W) with 20 and 35 vertical layers respectively. The latitudes extend from 55 to 85 N in intervals of 5 degrees and logitudes extend from 80 W to 40 E in intervals of 10 degrees. The physical parameterization and the soil model has to be improved further to carry out annual or decadal simulations.



The orography and the extent of the ice sheet and glaciers (violet) over Greenland is shown in the first 2 figures. The analyzed data from August 1995 prepared by DWD for the PIDCAP period (Aug-Oct 1995) for validating simulations of precipitation over BALTEX region is used to initialize and to drive the model at the lateral boundaries. The differences of monthly averaged surface temperature and wind to the corresponding analyzed fields for both resolutions are shown above. Averaging for comparison the finer resolution (over 4×4 points) smoothens the results and difference to the analyzed fields (AF) and to the coarser resolution. Futher validation with respect to data from coastal stations would be desirable.

The model simulation for finer resolution shows more variability in surface fields along the steep orography of Greenlands coast. Even the averaged fine resolution fields still deviates quite considerably along the coast from the coarser resolution. The mean sea level fields for both resolutions is shown below along with their difference (over the averaged fine resolution field). The total precipitation for the simulation month is also shown. The fine resolution has again visible orographic influence. The orographic feature visibly affect the distribution of precipitation over the domain.





Proposed modifications for 40 year hindcast

Many physical processes can not be resolved at the computational scales of the current atmospheric models. The initial state of the atmosphere is only inadequately known. The errors occuring are further aggravated by the chaotic dynamics of fluid motion. Ensemble calculations are a means of assessing uncertainties but require enormous computational resources. An alternative sophisticated technique of spectral nudging for hindcast simulations becomes desirable which reduces the internal model variabilty at the better known synoptic scale bringing the model simulations closer to observed state.(3)
The parameterizations in model (LM) must be improved to model processes in polar regions, such as katabatic winds, and include e.g. ice clouds, sea ice, subgrid scale heterogeneity. The added value of finer (e.g. 1/8 degree) resolution using a highly resolved orography should be further investigated. A higher vertical resolution close to the surface would be useful to improve the simulation of katabatic winds.

The model would also be compared with other models such as hydrostatic model REMO (with ECHAM 4 physics) and HRM to investigate the effect of dynamics and parameterization. It has been observed that results improved in HIRLAM using the ECHAM 4 parameterization package.(4)

Literature:

1 Bromwich, D. H. et al, 2000, Interannual variations of snow accumulation on the Greenland Ice Sheet (1985-1996): new observations versus model predictions, J Geophys Res-atmos 105(D3):4039-4046.
2 Dethloff, K. et al, Greenland Precipitation from Ice Core Estimates and Regional Climate Model Simulations, preprint.
3 Storch, H. v. et al, 2000, A spectral nudging technique for dynamical downscaling purposes.
4 Rinke, a. et al, 1997, Simulation and validation of Artic clouds in a regional climate model.J Geophys. Res. 102, 29833-29847.