Project: **967**

Project title: **PalMod-KIT**

Project lead: **Gerd Schädler**

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Model development:

KIT contributes to two working packages of the BMBF funded project PalMod. In WG1-2 the limited-area model COSMO-CLM (CCLM) will be used for deriving improved parametrizations of ice sheet physics. In WG3-3-TP3 an isotope-enabled version of CCLM (CCLMiso) will be developed and employed for on optimal comparison between climate simulations and paleo archives.

a) WG1-2: Regional ice sheet modelling: sensitivity of results to set up of CCLM

In order to improve the modelling of ice sheet related processes which are subgrid scale for the global models, and to provide suitable parameterizations, we adapted and set up the regional climate model COSMO-CLM for simulations of the Arctic, especially the Greenland ice sheet. Sensitivity tests concerning the convection scheme, orography, time steps, the modeling domain, the resolution and the impact of sea ice were performed. Four different modeling domains (Fig.1) and two different resolutions (0.44° and 0.22°) and 50 vertical levels were analyzed. The model was driven with ERA-Interim data for the period 2001-2010.

Results were validated with different observation and reanalysis datasets, for example the Willmot-Matsura database for Greenland. This was also done for different subregions of Greenland. Seven regions were defined: north, northwest, southwest, northeast, southeast, south and central Greenland. The characteristics and climate of the regions differ. For example the amount of precipitation is highest in the southeast, while it is low in the north. The focus of the validation was on parameters which mainly contribute to the surface mass balance of the Greenland ice sheet: precipitation, temperature and wind.

Results show a sensitivity to the chosen area, with best results for the CORDEX-Arctic region (blue in Fig. 1) and a resolution of 0.22°. This region and resolution will be used for further validation runs for present day data to asses an added value of the higher resolution compared to GCMs and to parametrize subgrid scale processes.

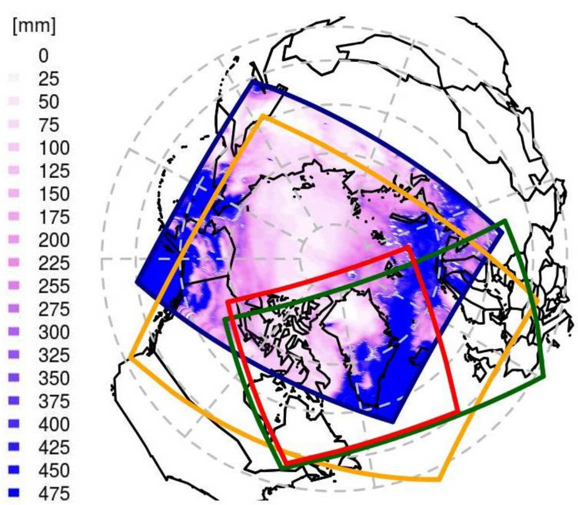

Fig.1: Investigated regions and an example for the monthly precipitation for January 2001 in mm for the CORDEX-Arctic region. Red: excluding the North Pole and Europe; green: excluding North Pole but including parts of Europe; orange: including North Pole and extending towards Europe, blue: CORDEX-Arctic region.

b) WG3-3-TP3:

Implementing water isotopes into CCLM

Concentration ratios of the stable water isotopes H216O, H218O, and HD16O are closely related to temperatures and recorded in paleo archives such as ice cores and speleothems. Enabling climate models to simulate stable water isotopes therefore allows to directly compare simulations to the archives and to assess uncertainty of paleo simulations.

Based on earlier work of Pfahl et al., 2012, who already implemented water isotopes into the atmospheric component of the weather forecast version of COSMO, we implemented water isotopes into the atmospheric component of the climate version of COSMO (CCLM 4.8). In addition, we added the description of isotope physics to the multi-layer soil module TERRA-ML. Finally, a restart mechanism necessary for simulations of long time periods was adapted for the use of water isotopes.

For debugging and testing the new CCLMiso we performed several short simulation runs (0.5°×0.5° horizontal resolution, 50 vertical levels, about 2000 node-hours).

Sensitivity runs with CCLMiso

To validate the isotope simulations with CCLMiso, we performed one 15-year model run with CCLMiso for Europe (2000-2014, horizontal resolution 0.5°×0.5° horizontal resolution, 50 vertical levels, about 1800 node-hours). We found good agreement between the modeled isotope fields and isotope observations of the Global Network of Isotopes in Precipitation, in situ observations of isotope ratios of near-surface water vapor in Karlsruhe, and remote sensing observations of isotope ratios of water vapor in the free troposphere over Karlsruhe.

For a first assessment of model sensitivity on different isotope processes (isotope fractionation during soil evaporation, sensitivity on the treatment of snow melt, condensate evaporation below cloud base (sub-cloud processes), sensitivity on initialization and spin up time of the soil model), we complemented the validation study by short sensitivity runs (about 700 node-hours). For summer, we found a high sensitivity of the modeled isotope ratios in precipitation on sub-cloud processes implying that not only temperature but also the strength of sub-cloud processes is reflected by the isotopic composition of precipitation under warm conditions. This will be further characterized and considered when comparing the climate simulations to the paleo archives.