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The importance of land surface schemes in regional models for simulating the Arctic climate

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In order to better understand the Arctic climate system, quantitative assessments of the magnitude of potential changes in this region are needed. Regional Climate Models (RCM) provide a more detailed representation of the physical processes relevant to the Arctic climate than Global Circulation Models (GCMs). Additionally, the ability of RCMs to run at very high horizontal and vertical resolutions allows capturing of fine-scale details of climate processes related to complex topography and small-scale weather features leading to the development of, for instance, polar lows.

An adequate representation of the surface energy balance over ocean and land, of clouds and precipitation processes, planetary boundary layer turbulence, the snow/ice albedo feedback, and sea-ice processes is critical to understand and assess the implications of changes in these processes for climate studies in the Arctic. Land Surface Models (LSMs) coupled to RCMs have become more comprehensive and evolved into the third generation of models now representing a large number of interactions and feedbacks between physical, biological, and chemical processes.

The purpose of this work is to evaluate systematic model errors related to the choice of the LSM schemes currently available in the Weather Research and Forecast model (WRF v3.5) in the Arctic region and implications to the structure of the Arctic boundary layer. Sensitivity analyses include simulations using three land surface models Noah, NoahMP and CLM4 for a three months period in a two-way nested domain at 45km and 9km horizontal resolution. The Noah scheme is currently the most widely used LSM in the WRF modeling community. The more recent NoahMP scheme was specifically designed to improve snow processes allowing more detailed simulations of the diurnal variations of the snow skin temperature, which is critical for estimating the energy available for melting processes. NCAR's Community Land Model version 4 (CLM4) LSM has been coupled to the latest version of WRF includes the most sophisticated snow, soil, and vegetation physics among the three LSM schemes allowing an improved characterization of land surface processes.

The WRF model simulations are confronted with meteorological variables from observational data generated by automated weather stations and from the Arctic System Reanalysis (ASR). The ASR uses a high-resolution suite of data assimilation systems that have been optimized for the Arctic. Preliminary results show that the model is able to reproduce the diurnal cycle and vertical structure of the Arctic boundary layer reasonably well. The model is, however, sensitive to the choice of the land surface scheme with significant biases in simulated moisture and temperature profiles. This factor might have implications to simulated anthropogenic emissions and dynamical processes and the projected changes in the Arctic.