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Sensitivity of high-resolution Arctic regional climate model projections to changed land surface conditions

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The work presented here discusses the effects of vegetation cover and soil parameters on the climate change projections of a regional climate model over the Arctic domain. Different setups of the land surface model of the regional climate model HIRHAM were realized to analyze differences in the atmospheric circulation caused by (1) the incorporation of freezing/thawing of soil moisture, (2) the consideration of top organic soil horizons typical for the Arctic and (3) a vegetation shift due to a changing climate.
The sensitivity of the 2m air temperature projections to changes in land surface conditions ranges from -2°C to 2°C among all experiments and seasons. The strongest influence on the climate change signal is found for changes of vegetation cover, especially over regions where tundra vegetation is replaced by forest. This sensitivity is mainly driven by changes in surface albedo and in winter by changes in roughness length.
An equally distinct sensitivity is found for turbulent heat fluxes (THF); the strongest response among the experiments occurs again for changing vegetation (THF increases in the cold seasons by up to 19 W/m2). This response is again partly driven by changes in roughness length, which lead to a less stable stratification of the lower atmosphere.
Though there are distinct differences in the magnitude of the sensitivity in 2m air temperature and turbulent heat fluxes, all experiments show changes in mean sea level pressure and geopotential height of similar magnitudes. These responses are triggered by the non-linear feedbacks within the atmospheric system. The spatial patterns of the sensitivity in mean sea level pressure strongly depend on experiment and season and range between -1.6 hPa and 2.4 hPa. Changes in geopotential height are found throughout the troposphere and range between -15 gpm to 5 gpm.
The results of this analysis point to the importance of dynamical feedbacks within the atmosphere-land system. Land and soil processes have a distinct remote influence on large scale atmospheric circulation patterns in addition to their direct, regional effects. All processes discussed should therefore be included in an update of the land surface model used with HIRHAM.