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Atmosphere and permafrost in the Arctic: results from a new regional coupled atmosphere-land model

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Frozen ground is one of the key components of the land part of the Arctic climate system. A reliable representation of the exchanges of energy, water and gases (CO_2 and CH4) between frozen ground and the atmosphere is essential for simulating the present day Arctic coupled climate system realistically and its future changes with some confidence. Regional atmosphere-snow-permafrost interactions can be best studied with Regional Climate Models (RCMs) due to their high horizontal resolution compared to Global Climate Models.
For this purpose, the sophisticated land model CLM4 was integrated into the Arctic regional climate model HIRHAM5 (HIRHAM5-CLM4). To validate this model, it was run over the ERAInterim period (1979-2014) and the model results were compared to a similar simulation of HIRHAM5, using the inbuilt land model, as well as to station observations. The comparison focuses on the models ability to represent observations on permafrost like permafrost extent, active layer thickness (ALT) and soil temperature profiles, as well as on the representation of the Arctic atmosphere.
The representation of ALT and soil temperature profiles is significantly improved in HIRHAM5-CLM4 compared to HIRHAM5. Averaged over the period 2000-2011, the bias to station observations of ALT is reduced from -1.3 m to -0.3 m, the Arctic wide winter soil temperature root mean square is reduced from up to 14.4K to a maximum of 5K.
Arctic climatology of 2m air temperature and mean sea level pressure are well represented in both HIRHAM5-CLM4 and HIRHAM5, HIRHAM5-CLM4 reduces the air temperature bias averaged over 1979-2014 over Eastern and Central Siberia in winter by 0.5K. Using CLM4 in HIRHAM5 impacts the simulation of local circulation patterns and influences the occurrence of baroclinic cyclones.