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Air temperature variability and soil heterogeneity affect large-scale permafrost temperature

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Meteorological variables, such as air temperature and precipitation will not only change gradually into the future but also their short-term variability and frequency of extreme events is projected to change. For instance, for northern high-latitude regions, climate models project an increase of the annual maximum of the daily maximum temperature by 4 °C at the end of the century. At the same time, northern high latitude terrestrial ecosystems show a large spatial heterogeneity of soil properties.

This study investigates the effects of the short-term temporal variability of meteorological variables on land-atmosphere coupling and ultimately permafrost temperature in northern high latitude regions using the land surface model JSBACH and artificial meteorological forcing data as well as soil property distributions.

The impacts of climate variability on insulating surface layers (snow, lichens and bryophytes) substantially alter the heat exchange between atmosphere and soil. As a result, soil temperature is 0.1 to 0.8 °C higher when climate variability is reduced under a conserved long-term average. In addition, sub-grid heterogeneity of soil thermal and hydrological properties leads to differences in sensible and latent heat flux of up to 10 % which also has consequences for soil state variables, such as soil temperature, ice content or active layer thickness.

Our results demonstrate the need to account for temporal and spatial variation of environmental factors in terrestrial ecosystem modelling.