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Towards operational permafrost modeling for Norway

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In the course of the 21st century, thawing of permafrost is expected to occur in large areas as a consequence of climate change, which could trigger a number of climatic feedback mechanisms on the local to global scale. As the vast and remote permafrost areas cannot be sufficiently covered by ground-based monitoring of soil temperatures in boreholes alone, it is desirable to exploit the wealth of multi-sensor-multi-source data to assess the thermal ground conditions on large scales. In Norway, permafrost conditions range from mountain permafrost over organic-rich wetlands to high-arctic permafrost in Svalbard. Furthermore, the availability of gridded data sets from various sources makes it a well-suited test region to evaluate the performance of soil thermal models run with different input data, which facilitates comparing and benchmarking requirements on data quality.

Soil temperatures can be modeled using Fourier's law of heat conduction, so that the key challenge is to supply accurate time series of three key input variables at suitable spatial and temporal resolutions: 1. land surface temperature, 2. snow depth, and 3. soil and snow thermal properties. We developed a framework for transient and distributed modeling the ground thermal regime in Norway, CryoGRID 2.0. In the model, the subsurface heat flow is treated in terms of 1D heat conduction using the land or snow surface temperature as upper boundary condition. The model features a dynamical representation of the snow cover and explicitly accounts for the heat flux through the snow pack.

The spatio-temporal distribution of ground temperatures is calculated for a spatial resolution of 1 km for mainland Norway. The model is driven by operationally gridded data of daily air temperature and snow depth available at http://senorge.no. These datasets are available for the period 1957 to date having a spatial resolution of 1 km2. Spatial distributions of the ground thermal properties (e.g. heat conductivity), surface cover (e.g. vegetation, block fields) were derived from geological maps, borehole measurements and remotely-sensed data.

We present preliminary results from model runs to demonstrate the capacity of the approach to simulate permafrost distribution, and duration of seasonal frost and discuss strategies to reduce computational cost, hence to make the model applicable to large datasets.