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From Snow Depth Distribution to Small-Scale Variability of Soil Temperatures

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Permafrost is a temperature phenomenon on the local scale. Soil temperatures are not only influenced by atmospheric conditions varying on scales of kilometers, but are also determined by the land cover and soil properties, which display large variability on the meter-scale in many permafrost areas. In mountain areas the seasonal snow cover is crucial for the ground thermal regime, and the redistribution of snow by wind can create a pattern of different snow depths, which results in spatially variable permafrost temperatures. Existing permafrost models (CryoGRID1.0 and CryoGRID2.0) are implemented at 1x1km spatial resolution for Norway, and have proven to capture the regional distribution of permafrost. One of the principal uncertainties of these models is the effect of sub-grid variability in snow cover, and downscaling approaches for snow are therefore required to get a satisfactorily representation of the ground thermal regime.

An extensive dataset including ground temperatures of 7 boreholes and data of 5 stations measuring snow depth and air/ground surface temperature is available from Juvflye, a high-mountain site in central southern Norway (1800-1900m a.s.l.). The area has a rough topography and a seasonal snow cover dominated by heavy wind redistribution. A Ground Penetration Radar (GPR) survey of snow depth was conducted in March 2012, covering an 8km2 area including the 7 boreholes. This GPR-survey will be repeated in 2013. The measured snow depths form the basis for probability density functions (PDFs) of snow cover within each 1x1km grid cell for this area.

A 1-D numerical model including both a soil thermal model and snow pack scheme are calibrated for all 7 boreholes. Several model runs are performed for different snow depths, intended to cover the range of observed values. We present the effects of different snow depths on the thermal regime of the underlying permafrost, based on this model attempt. Furthermore, we outline a probabilistic approach for including sub-grid variability of snow depth in grid-based permafrost models.