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Distributed snow modelling integrating ground penetrating radar data for improved runoff predictions in a Swedish mountain basin

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Operational forecasts of snow melt runoff in Sweden are currently running with precipitation and temperature as the main input variables and calibrated with runoff data, and there is an interest to make better use of new measurement systems for distributed snow data. At the same time, various data assimilation techniques are becoming more frequently used in hydrological modeling, in order to reduce uncertainties related to both model structure errors and errors in input and calibration data. Thus, it is important to address not only what type of snow data that can be used to improve the model predictions, but also what type of input data and model structures that are optimal in relation to the available snow data.

The objective of this study is to investigate to what extent the runoff predictions can be improved by assimilation of temporal and spatially distributed snow data, and if the improvements depend on the choice of model structures, for instance the use of energy balance or day-degree snow models. In order to achieve these objectives a new distributed snow model has been implemented into the hydrological modeling framework HYSS/HYPE. This model can easily be setup with either an energy balance model or a day-degree model for the snow pack calculations, and it is easy to run the model with different spatial resolutions. In the fully distributed case, snow drift processes are implicitly included in the model through a precipitation distribution model, based on topographical information and wind direction.

The model was applied to a mountain basin in northern Sweden used for hydropower production, where extensive snow measurements were taken during the last two winters 2007-2009. A climate station is located at the outlet of the regulation lake, including automated point measurements of snow depth, snow mass (snow pillow), snow wetness and snow temperature. Distributed snow cover data was sampled using ground-penetrating radar from snow mobiles. Measurements were taken at the time of the maximum snow cover, providing a data set with snow depth, snow density, snow water equivalent along 20 km long transects in representative areas of the basin. The precipitation distribution model was calibrated using the distributed SWE data from the GPR measurements. Application of the calibrated model to previous years without available snow data show that the runoff predictions was improved compared to calibrations without the distributed snow data, however the improvements were larger for the energy balance compared to the day-degree model. Further developments will include assimilation of the temporal and spatial snow data to adjust the distribution of various input variables, for instance air temperature and wind speed.