Assimilation of in-situ and satellite snow data for hydrological forecasting in Sweden - a hydropower case study

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Abstract

Snow melt runoff predictions provide valuable information for hydropower reservoir management in regions dominated by snow. The forecasting skill may be improved by adjusting the initial snow storage in the models by assimilation of in-situ and satellite based snow observations. However, in many situations the uncertainties in initial conditions are less important compared to the uncertainties in the seasonal meteorological forecast used to force the hydrological model.

The objective of this study is thus to make a systematic evaluation of the improvement in seasonal spring melt forecast skill by assimilation of various types of snow data - in-situ observations and/or satellite remote sensing data for a number of hydropower reservoir basins in Sweden representing different amount of snow domination. Data assimilation methods such as Ensemble Kalman filter was used to update the simulated water storages in snow and soil during the initialization period before forecast issued at different times through the winter and melt season. In here, we evaluate methods for updating hydrological models by use of: 1) operational snow depth measurements from SMHI, 2) satellite based data on snow water equivalent and snow cover area from EU FP7 project CryoLand, and 3) pre-operational manual observations of snow depth, snow density and snow water equivalent located close to hydropower reservoirs in the Swedish mountain area, operated by hydropower management company Vattenregleringsföretagen AB. Results show that assimilation of snow information improved spring melt forecasts in most of the study areas and study years. It was mainly manual observations of snow water equivalent and satellite based data on fractional snow cover area that where useful for improving the forecasts. However, model updating with snow data does not always lead to improved simulations of river discharge and reservoir inflow probably due to: 1) the uncertainty in the weather forecast/climatological forecast is more important than the uncertainty in the snow conditions at the start of the forecast, 2) the updating methods do not take into account systematic representation errors in the assimilated snow information in an adequate way, and 3) the manual snow observations are most sparse and the satellite based data is most uncertain in the mountain areas that are most interesting for spring melt runoff predictions from a hydropower management perspective.

This study is part of a project aiming for an integrated meteorological-hydrological forecasting system with the objective to make progress in km-scale numerical weather prediction (NWP) and hydrological forecasting by enhancing the land surface data assimilation (DA) system through introduction of satellite radiance and backscatter data together with modern DA methods. Cross fertilization of meteorological and hydrological competences will result in synergy effects on the development of data assimilation methods as well as the use of remote sensing satellite data in the respective modelling systems.

Keywords: snow observations, remote sensing, data assimilation, spring melt runoff forecasts