Influence of assimilating surface snowpack observations to snowpack simulation by a physically based hydrological model

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Data assimilation (DA) can be used to improve snowpack simulations by supplementing uncertain model forcing data with more certain snowpack observations. Here measured snow water equivalent (SWE) and daily snow depth (ds), and estimates of snowpack density (ρ) were assimilated into a physically based snow hydrology model using an ensemble Kalman filter (EnKF). The Cold Regions Hydrological Modelling platform (CRHM) was forced by Global Environmental Multiscale (GEM) model 2.5 km output. Multiple DA experiments were conducted in the well instrumented Marmot Creek Research Basin, Canadian Rockies, which is subject to snow interception and blowing snow redistribution. Assimilating frequent ds measurements alone improved SWE very little due to the sometimes-poor prediction of ρ by the CRHM snowpack module. Assimilating SWE alone generally improved the accuracy of the SWE simulation, but due to infrequent SWE observations, the improvement was small during the early accumulation and late melt periods and in dry years. A combined DA approach using both SWE and ds provided better results than assimilating ds alone but was not as good as assimilating SWE alone, indicating that assimilating more information doesn't always lead to better results. Assimilation of ds and historical or simulated snowpack density together was close to the performance of assimilating SWE alone in parts of the basin where CRHM simulated ρ poorly, suggesting an alternative when SWE measurements are not available. Poor correlations were observed between SWE and ds with other state variables of Snobal (CRHM snow module), therefore no significant difference was found when updating these state variables using EnKF or not. The DA experiments strongly suggest that data assimilation is beneficial when using numerical weather prediction model output to force CRHM.