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Ensemble-Based Snow Data Assimilation for Improved Operational Streamflow Predictions

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The National Weather Service (NWS) is the agency responsible for flood forecasting in the U.S. NWS primarily uses the SNOW17 model for operational forecasting of snowmelt, which then serves as an input to rainfall-runoff models for streamflow forecasts in snow-affected areas. To improve snowmelt estimates and therefore streamflow forecasts, a principle component regression (PCR) technique is typically adopted to produce areal Snow Water Equivalent (SWE) data from point SWE measurements (e.g., from SNOTEL sites) in operations. While this method is parsimonious and easy to use in operations, it does not capitalize on the full capabilities offered by advanced data assimilation techniques to quantify, reduce, and propagate forecast uncertainty in a statistically and dynamically consistent fashion. This study investigates assimilating point SNOTEL SWE observations and PCR-based areal SWE estimates into the SNOW17, via direct insertion and an ensemble Kalman filter (EnKF). The performance of SWE assimilation strategies is evaluated for streamflow predictions using the NWS operational rainfall-runoff model, the Sacramento Soil Moisture Accounting model (SAC-SMA) at a snow-dominated basin in the western U.S. Results indicate that SWE observations from three SNOTEL sites are significantly related to SNOW17-simulated SWE, with correlation coefficients varying from 0.87 to 0.96. Assimilating SNOTEL SWE using the direct insertion method improves the accuracy of streamflow forecasts over assimilating PCR-derived SWE. The corresponding Nash-Sutcliffe coefficients are 0.91 and 0.63, respectively, for the period studied. Preliminary test of the EnKF illustrates that it outperforms the direct insertion method during low flow periods, while their performances in high flow periods are comparable.