How complex should a snow model be?

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Abstract

Snow is an important component of the land surface energy and water budgets. In the western U.S., mountain snowmelt accounts for 70-90% of the annual streamflow. The ability to describe and predict mountain snowpack is critically important to hydrologic and atmospheric predictions, especially under changing climates in the western U.S. where snow is a critical component of the regional water supply.

Understanding snow processes in high mountains is challenging due to the lack of information and potentially large uncertainties associated with the observations and forcing data as well as the complex snow accumulation and melting processes. When a snow model does not perform well, we tend to ask ourselves a fundamental question: have we reached the limit of the snow model? How much improvement would we gain if the model was more complex? Since our models perform well sometimes, and not so well at other times, we tend to believe that we would improve our model performance by having better model parameters, including more physical processes, and improving numerical solutions. So, this leads to an open question: how complex should a model be? In this poster, we investigate the potential of complex physical processes on snow accumulation and melting simulations in high altitudes and the impacts of the uncertainties in the meteorological forcing data on snow water equivalent (SWE). We have taken a two step approach: (1) to develop a more complex snow model, through a bottom-up approach, which incorporates more physical processes and better numerical structures that are not available in a simple snow model; and (2) to apply a Multiscale Kalman Filtering (MKF)-based data assimilation paradigm which is an extension of the MKF framework to fuse SWE data and use it as an input to the snow model. Our initial results from Valdai, Russia and Ebbetts Pass, CA show that (1) there is a limitation on what a complex snow model can do given the typical uncertainty ranges associated with the meteorological forcing data; (2) the 2-layer (2-L) snow module in the Variable Infiltration Capacity (VIC) land surface model captures the main physical processes related to the snow accumulation and melting processes; (3) it is important to fuse SWE data which can significantly reduce the huge uncertainty involved in the meteorological forcing data; and (4) great efforts are necessary to obtain adequate SWE products through multiple remote sensing techniques.