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Advances in operational snow water resources monitoring using physically-based snow models in conjunction with data assimilation

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National services have developed very different approaches to tackle the challenges of snow water resources monitoring. Switzerland is a comparably small country and can rely on a very dense network of snow monitoring stations. This is why Swiss operational services have successfully adopted methods that dynamically assimilate available snow monitoring data into snow hydrological models. Today, an increasing number of flood events are associated with complex weather situations such as rain-on-snow. These circumstances require more complex modelling approaches compared to conceptual models typically used by operational services in the past. More complex approaches, such as physically-based snow models, however are increasingly dependent on a wider scope of meteorological forcings and incorporating data assimilation techniques in these models is not straightforward.

Here we present our latest model framework set up to monitor snow water resources and forecast snowmelt rates across Switzerland. For this end, the physically-based snow model JIM is coupled to the numerical weather prediction (NWP) system COSMO providing input fields at 1km spatial resolution. While COSMO, as well as other NWPs, have largely improved over past predecessors, some biases remain that affect the accuracy of resultant simulations. Apart from stationary debiasing, we employ a dynamic, bias correcting model ensemble which additionally accounts for transient errors in the meteorological model forcings. The procedure involves particle filter data assimilation of station data, which contrary to alternative data assimilation techniques allows for physically consistent model simulations throughout the modeling domain. We demonstrate that these approaches effectively improve depictions and forecasts of snow states and melt fluxes compared to simulations that don't include debiasing or data assimilation procedures.