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Multiphysics snowpack simulations over 10 contrasted local sites around the world

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The most detailed snowpack models solve the heat diffusion equation in a stratified snowpack with an accurate vertical discretization. However, even these detailed models are affected by significant uncertainties in a number of empirical parameterizations including fresh snow properties, parameterizations of albedo and turbulent fluxes, compaction, liquid water percolation, snow thermal conductivity, snow metamorphism, etc. In order to quantify this uncertainty in ensemble forecasting systems and in data assimilation algorithms applied to snowpack modelling, a multiphysics version of the Crocus snowpack model has recently been developed (ESCROC, Lafaysse et al, 2017, TC). However, the ensemble members were only selected in order to adequately quantifiy the uncertainty at Col de Porte, a mid-altitude grassy meadow in French Alps.

The availability of meteorological and snow dataset at 10 contrasted local sites around the world in the context of the ESM-SnowMIP initiative gives the opportunity to evaluate the ability of ESCROC to depict the model uncertainty in a wide range of climate conditions. The dataset includes 3 forest sites and 7 clear sites. Over the 3 forest sites, the ESCROC multiphysics system was coupled with the Multiple Energy Balance model (MEB, Boone et al, 2017, GMD) including an explicit layer of high vegetation and an explicit layer of litter. We compare the relative impact of including snow-vegation interactions with the uncertainties in the other processes affecting the snowpack. Over the 10 sites, we illustrate that in many cases, the ensemble system is more reliable than the deterministic version of the model. We also show that the most classical probabilistic scores (spread skill and Continous Ranked Probability Score applied on several snow variables) can be significantly improved by a multi-sites calibration of the ensemble. Finally, we illustate that there is equifinality between several physical processes at most sites with for instance possible error compensations between turbulent fluxes and absorption of solar radiation.