Multiphysical ensemble snowpack simulations at Col de Porte site (French Alps)

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The snow and meteorological dataset of the Col de Porte experimental station (French Alps, 1325 m asl) provides all the variables required to drive snow numerical models at a hourly time step and to evaluate them over a 21-year long period. Detailed snowpack models used for instance for avalanche hazard forecasting suffer for various modeling errors which should be better quantified. In this work, the Col de Porte dataset is used to drive and evaluate a multiphysical ensemble of 7776 members based on the implementation of new options for several physical processes of the SURFEX-Crocus snow model (fresh snow density, metamorphism, radiative transfer, turbulent fluxes, thermal conductivity, liquid water holding capacity, compaction, ground surface heat capacity). The individual skill of each member as well as the ability of the ensemble to correctly capture the uncertainty associated to modeling errors are assessed for snow depth, snow water equivalent, bulk density, snow albedo, snow surface temperature, and ground temperature. The instrumental errors of the evaluation data and their spatial variability in the meadow are used to test the significativity of the differences between members. Although a large number of model configurations have scores similar to the standard version, the ensemble needs to integrate significantly biased members to exhibit a sufficient dispersion for ensemble forecasting and ensemble data assimilation applications. However, even at this well instrumented site, it is very difficult to discriminate the model errors from the forcing data errors. Snow models are for instance very sensitive to biases in measured longwave incident radiations and precipitation amount.