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A computational framework to advance hydrometeorological prediction capabilities in cold regions.

Many different modeling groups recognize the need for new computational frameworks for use as both (i) a model development tool to evaluate competing process representations; and (ii) a predictive tool to reliably represent model uncertainty. Here we describe a computational framework to explore different approaches for modeling the hydrology and thermodynamics of snow and partially frozen soils. The framework has two main features: it has a “numerically agile” structural core to support evaluating the impact of different numerical approximations (e.g., vertical discretization, linearizations, etc.), and it has the modularity to support experimenting with different constitutive functions and boundary conditions. The broad flexibility of the framework facilitates constructing multiple equally plausible model realizations – these realizations can be used either as ensembles to represent model uncertainty, or examined in a systematic way to isolate the impact of individual model components on model predictions and hence facilitate a controlled approach to hypothesis testing. Application of the framework in different snow environments emphasizes the impact of (and interactions among) different modeling decisions. The approaches used to parameterize turbulent heat fluxes, parameters controlling the storage of liquid water in the snowpack, and the lower boundary conditions for hydrology were especially important in the case studies examined. In one-dimensional simulations results show that the impacts of differences in model structure are often overwhelmed by uncertainty in a-priori estimates of model parameters, and suggest that careful specification of probability distributions of model parameters can be used to represent model uncertainty.