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Representing Spatial Variability of Snow Water Equivalent in Hydrological and Land-surface Models: A Review

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This paper evaluates the use of field data on the spatial variability of snow water equivalent (SWE) to guide the design of distributed snow models. Model design strategies are gleaned from an extensive re-analysis of results from previous field studies in different snow environments around the world, and from analysis of field data on spatial variability of snow collected in the headwaters of the Jollie River basin, a rugged mountain catchment in the Southern Alps, New Zealand. In addition, the choice of the spatial scale for the model is evaluated based on snow simulations using different degrees of spatial discretization. This study emphasizes the importance of spatial variability at the hillslope scale, as evident in a large number of previous field studies and in the data collected in the Jollie River basin. Explicitly resolving such hillslope-scale variability in simulation models requires an extremely fine horizontal grid, and hence large computational resources, whereas sub-grid probability distributions produce effective simulations of the aggregate impact of hillslope-scale processes. This study also demonstrates that while sub-grid probability distributions are effective at the hillslope scale, they may not adequately represent all important processes at the watershed scale. Spatial variability at the watershed scale must be explicitly resolved through spatial discretization of the model domain into smaller computational elements such as elevation bands and aspect classes. While such modeling recommendations are clearly case-specific, the results presented in this paper are intended to guide the design suitable modeling strategies for a multitude of different applications.