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Is There Really a Tension between Parsimony and Predictive Power? Lessons on Validation Using a Snow Model with Variation in Complexity

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Mechanistic snow models are commonly applied to assess changes to snowpacks in a warming climate. Such assessments involve a number of assumptions about details of weather at daily to sub-seasonal time scales. Models of season-scale behavior can provide contrast for evaluating behavior at time scales more in concordance with climate warming projections. Such top-down models, however, involve a degree of empiricism, with attendant caveats about the potential of a changing climate to affect calibrated relationships. We estimated the sensitivity of snowpacks from 497 Snowpack Telemetry (SNOTEL) stations in the western U.S. based on differences in climate between stations (spatial analog). We examined the sensitivity of April 1 snow water equivalent (SWE) and mean snow residence time (SRT) to variations in Nov-Mar precipitation and average Nov-Mar temperature using multivariate local-fit regressions. We tested the modeling approach using a leave-one-out cross-validation as well as targeted two-fold non-random cross-validations contrasting, for example, warm vs. cold years, dry vs. wet years, and north vs. south stations.

Nash-Sutcliffe Efficiency (NSE) values for the validations were strong for April 1 SWE, ranging from 0.71 to 0.90, and still reasonable, but weaker, for SRT, in the range of 0.64 to 0.81. From these ranges, we exclude validations where the training data do not represent the range of target data. A likely reason for differences in validation between the two metrics is that the SWE model reflects the influence of conservation of mass while using temperature as an indicator of the season-scale energy balance; in contrast, SRT depends more strongly on the energy balance aspects of the problem. Model forms with lower numbers of parameters generally validated better than more complex model forms, with the caveat that pseudoreplication could encourage selection of more complex models when validation contrasts were weak. Overall, the split sample validations confirm transferability of the relationships in space and time contingent upon representation of validation conditions in the calibration data set. The ability of the top-down space-for-time models to predict in new time periods and locations lends confidence to their application for assessments and for improving finer time scale models.