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Assessment of Large-Scale Reanalysis Forcing on Winter Simulations in the Boreal Forest Using the Canadian Land Surface Scheme

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Historically, biases in simulated winter albedo and regional climate have been shown to be closely related in global climate and Earth system models (ESMs). Two decades ago, a cold bias in the boreal forest region in the ECMWF (European Centre for Medium-Range Weather Forecasts) model was corrected by eliminating a large positive winter albedo bias. However inaccurate representation of vegetation distribution and parameters have persisted resulting in biases in the simulated winter albedo in the boreal forest in many CMIP5 (Coupled Model Intercomparison Project Phase 5) models, with subsequent effects on regional temperatures and the snow albedo feedback. More recent studies have shown that the rate of unloading of intercepted snow on forest canopies is related to meteorological conditions, and the snow albedo feedback in the Community Climate System Model was found to be sensitive to interception-related albedo errors.

The advancement of parameterizations in land surface schemes (LSSs) for use in ESMs typically involves site-level testing followed by regional or global off-line testing forced with a large-scale product [e.g. ESM climate, CRUNCEP (Climatic Research Unit National Centers for Environmental Prediction), GSWP3 (Global Soil Wetness Project Phase 3), WATCH (WATer and global CHange)], prior to coupled simulations. Site level experiments can provide a high degree of accuracy in both forcing and validation data, whereas larger-scale off-line forcing offers land surface variability akin to that in a coupled ESM, but without the computational expense of an atmospheric model. Given the interdependence of biases in snow-related albedo and surface temperature, there is a need for assessments of how large scale products compare with local forcing to understand the effects of scale on the simulated surface properties in LSSs, especially albedo and snow properties. The amalgamation of atmospheric properties as scale or grid-cell size increases introduces bias in that smaller scale effects such as local warming over forested fractions of a grid-cell are averaged out. Also the aforementioned off-line data products provide temperature and humidity at a height of 2 m and wind speed at 10 m, whereas LSSs require these above the vegetation canopy.

We compare biases in CRUNCEP V8 and GSWP3 relative to site-level forcing and present off-line simulations conducted with the Canadian Land Surface Scheme (CLASS V3.6.2) at boreal forest sites in Saskatchewan, Canada, with forcing at scales from site level to T63 ($\sim$2.8°). Neither product was better for all forcing parameters; incoming longwave radiation and wind speed were biased low in CRUNCEP V8; the diurnal range in air temperature was more exaggerated and wind speed was biased high in GSWP3, while precipitation bias varied seasonally and from site to site. As the scale of forcing increases, the number of days with snow on the ground at forest sites increases, possibly caused by a negative temperature bias as the local forest heat island is lost. The average monthly albedo also increases with scale but is less variable compared with site-level forcing. We examine the effect of these different forcing biases on snowpack properties and the simulated albedo.