Topographical Controls on Hydrology and Microwave Behavior of Seasonal Snowpacks: Modeling Framework and Scaling Analysis

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ABSTRACT

Seasonal mountain snowpacks exhibit high spatial and temporal variability due to complex topography, heterogenous land-cover, and weather patterns. A coupled distributed snow hydrology-radiative transfer modeling framework with explicit vegetation parameters, forced by downscaled and topography-corrected reanalysis datasets and albedo at high spatio-temporal resolution (30-m, 15-min), was applied to the Senator Beck Basin (SBB), Colorado between September 1st, 2016 and July 28th, 2017. The high-resolution atmospheric forcing was evaluated against tower observation from two locations with intensive automated instruments in the SBB. Manual observations of SWE and snow depth, as well as streamflow were used to assess the seasonal march of snow accumulation and melt. The results show that the model captured the snow accumulation and melt processes over the basin well with simulated snowpack evolution and streamflow predictions consistent with the observations. Scaling analysis was subsequently applied to seasonal backscatter and brightness temperature fields at L-, C-, X-, Ku-, and Ka-bands and to snow depth and SWE toward synthesizing the signature of key topographic controls on snow hydrology and microwave behavior. Under uniform surface roughness conditions, the snowpack exhibited robust scaling behavior as measured by the time-varying spectral slope with a scale between 0.1 – 1 km independent of location within the watershed (and thus elevation) for both passive and active microwave emissions at all frequencies. To separate contributions of volumetric scattering from surface one at different frequencies and different seasons, a large sensitivity experiment was conducted using synthetically generated surface roughness patterns. A joint analysis of passive and active microwave hysteresis vis-à-vis fractional volume scatter provides guidance for SWE retrieval.

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