The Use of Detailed Forest Structure to Explain Plot Scale Snowmelt Patterns in a Conifer Forest: Improving Physically Based Model Representation of Sub-Canopy Hydrometeorology

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ABSTRACT

We present the use of detailed canopy structure as measured by hemispherical photographs taken at locations coinciding with 24 ultrasonic snow depth sensors to explain plot scale ablation patterns in a forested basin of Sequoia National Park. Coupled with above canopy radiation measurements, the detailed canopy structure data are used to estimate sub-canopy solar irradiance. We relate both the sky view factor (SVF) and simulated direct beam fluxes to three years of measured sub-canopy snow dynamics recorded by the automated depth sensors and repeated density measurements (i.e. SWE ablation indicators). The direct beam flux explains >60% and 0% of the observed seasonal SWE ablation rates during different spring seasons dominated by clear and cloudy conditions, respectively. Conversely, SVF explains <30% and 86% of the seasonal ablation during the same clear and cloudy seasons, respectively. The findings imply that the explanatory value of the two forest structure metrics, direct beam transmissivity and SVF, varies with meteorology. Direct beam transmissivity explicitly addresses the probability that the solar beam is incident on the sub-canopy surface, while SVF is implicitly correlated with mechanisms governing melt during cloudy conditions (i.e. diffuse and longwave radiation, and turbulent exchange). Together the two metrics may be used to explain much of the interannual plot-scale snow ablation patterns. The relationships observed at the scale of our forested research sites serve to inform optimal treatment of canopy structure in physically based snow models as well as to guide the use of increasingly available LiDAR data for basin level hydrological applications.

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