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A Detailed and in Situ Assessment of the Snowpack Physical Properties in a Discontinuous Humid Boreal Forest

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Boreal forests occupy a large fraction of the continental surfaces and receive a lot of solid precipitation in winter. Evergreen canopies are often represented as a single and homogeneous layer in hydrological and weather forecasting models. However, in reality, boreal canopies are composed of a rather complex mosaic of trees unevenly spaced apart, with gaps of various sizes. Therefore, mass and energy inputs to the snowpack show remarkable variability at small scales resulting not only in strong spatial heterogeneity in snow depth (SD) and snow water equivalent (SWE), but also in the vertical temperature gradient in the snow column ($\partial T/\partial z$). Unlike SD and SWE, $\partial T/\partial z$ has been little documented in discontinuous needleleaf forests, despite its impact on snow cover metamorphism and on a range of physical properties of snow such as density (ρ_s), specific surface area (SSA) and effective thermal conductivity (k_{eff}). This work investigates the snowpack underneath the canopy and inside small forest gaps using continuous measurements of SD and k_{eff} and weekly snow pit surveys during winter 2018-19 in a juvenile balsam fir stand of eastern Canada (47°17’18”N, 71°10’05”W). This site receives an average of almost 1600 mm of precipitation annually, including 40 % falling as snow. Snow cover typically lasts over 6 months. Observations show that less snow accumulates in the subcanopy and therefore $\partial T/\partial z$ is more pronounced than inside the gaps. Moreover, ρ_s and SSA are lower underneath the canopy where faceted crystals are observed. Large $\partial T/\partial z$ in that environment results in a decreasing k_{eff} over time. Overall, kinetic grain growth takes place in the subcanopy whereas settlement and isothermal conditions prevail inside the gaps. This research provides accurate observations of the snowpack in forested environments needed for a better representation of SWE, heat fluxes and ground thermal regime in hydrological and meteorological models.