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Ground-based and airborne measurements over forests for understanding canopy radiation balance during snowmelt

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The radiation budget at the snow surface is often the main driver of spring snowmelt in forested environments. The shading, absorption, reflection and emission of longwave and shortwave radiation by vegetation cause significant spatial and temporal variation of net radiation at the snow surface. This variability is markedly different from adjacent unforested areas, and is largely controlled by canopy structure and temperature. Commonly, understanding of the forest radiation budget has been limited to point-based measurements either above or below the canopy. These measurements are subsequently assumed to be representative of forests across larger spatial scales, so far constraining understanding of the canopy radiation budget to the point scale. As an alternative method, this study presents spatially distributed ground-based and airborne measurements, collected across a discontinuous forest site near Davos, Switzerland during the snowmelt period. Repeat flights, coupled with ground-based measurements demonstrated both spatial and temporal variations in the canopy radiative regime. In particular, thermal imagery demonstrated changes in the spatial distributions of forest temperatures that are consistent with canopy warming from direct solar radiation. In shaded areas, average canopy temperature increased with increasing height along the vertical profile, reaching air temperature close to the top of the canopy. Sun-lit edges along canopy discontinuities as well as sun-lit areas in closed canopies were both shown to be consistently warmer than air temperature. These results provide evidence for the strong spatial and temporal variations in the controls on the canopy radiation budget. The novel combination of ground-based and airborne measurements provide valuable contribution to improving radiation transfer models for spatially distributed applications.