EGU21-5541
https://doi.org/10.5194/egusphere-egu21-5541
EGU General Assembly 2021

Impact of above and below canopy air temperatures in simulation of sub-canopy longwave radiation in snow-covered boreal forests

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Above canopy air temperatures, as simulated prognostic variables in earth system models or as driving data in snow-physics models, are used as a basis to calculate energy transfers through forest canopies and down to the snow surface. Consequently, simulations of absorption of solar radiation, emission of longwave radiation and coupling between canopy and air temperatures become critical. Parts of the forest canopy, especially the shaded downward-facing elements, are often in equilibrium with sub-canopy air temperatures.

Measurements of sub-canopy incoming longwave radiation, air temperatures, and forest canopy structure were made in a snow-covered boreal forest, March through April 2012 in Sodankylä, Finland. Accurate simulations of longwave radiation to the snow surface were enabled by using measured sub-canopy air temperatures as a proxy for downward-facing forest canopy temperatures. However, there was a notable decoupling of measured above and below forest canopy air temperatures in stable conditions (air temperatures warmer above the canopy than below), which was enhanced during night-time. Hence, here we present results of an experiment using a multi-physics snow model including a forest canopy (FSM2.1.1) to investigate the impact of above and below canopy air temperature decoupling on simulations of sub-canopy longwave radiation. Simulations compare the use of 1- and 2-layer canopy models, and application of Monin–Obukhov similarity theory across a wide range of forest densities.