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Year-round observation of energy balance components within a permafrost black spruce forest in interior Alaska

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Black spruce is one of the most abundant forest types in the North American boreal forest, also occupying approximately 44 % of the forest cover in interior Alaska. In this study, energy balance components such as radiation and eddy covariance fluxes were observed year-round in 2011, within a black spruce forest underlain by permafrost at the University of Alaska Fairbanks Poker Flat Research Range, located in interior Alaska. This research was conducted under the JAMSTEC-IARC Collaboration Study, with funding provided by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) under a grant to the International Arctic Research Center (IARC).

Here, if ground heat flux was observed using the default value of thermal conductivity, the sum of sensible and latent heat flux exceeded the available energy in summer. By multiplying the correction factor of 0.74 by ground heat flux, the deficit of energy balance was minimal. This 0.74 value was consistent with the thermal conductivity of the heat flux plate (HFP01SC) value of 0.8 W m^{-1} K^{-1}, whereas the maximum Sphagnum thermal conductivity has been reported to have ranged from 0.5 to 0.6 W m^{-1} K^{-1} at high volumetric water content. As a result, the energy balance of this black spruce forest was almost closed in summer, and ground heat flux was proven to play an important role in energy balance, explaining 26.5 % of the net radiation in summer.

On the other hand, a large energy balance deficit was observed in spring. The energy balance deficit during the snowmelt season was mostly explained by the latent heat energy of fusion consumed by snowmelt, which was calculated from the observed snow water equivalent.

The mean daily evapotranspiration of this forest in summer was 1.37 mm day^{-1}, considered typical for boreal forests. Further, the annual evapotranspiration and sublimation amounted to 207.3 mm $year^{-1}$, which was much smaller than the annual precipitation, and sublimation accounted for 8.8 % (18.2 mm $year^{-1}$) of this annual total value. Thus, sublimation is *not* negligible in the annual water balance for boreal forests.

Keywords: energy balance, black spruce, permafrost, ground heat flux, evapotranpiration, sublimation