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Radiation budget and soil heat fluxes in different Arctic tundra vegetation types

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While solar radiation is one of the primary energy sources for warming and thawing permafrost soil, the amount of shortwave radiation reaching the soil is reduced by vegetation shading. Climate change has led to greening, shrub expansion and encroachment in many Arctic tundra regions and further changes are anticipated. These vegetation changes feed back to the atmosphere and permafrost as they modify the surface energy budget. However, canopy transmittance of solar radiation has rarely been measured or modelled for a variety of tundra vegetation types. We assessed the radiation budget of the most common vegetation types at the Kytalyk field site in North-East Siberia (70.8°N, 147.5°E) with field measurements and 3D radiative transfer modelling and linked it to soil heat fluxes. Our results show that Arctic tundra vegetation types differ in canopy albedo and transmittance as well as in soil heat flux and active layer thickness. Tussock sedges transmitted on average 56% of the incoming light and dwarf shrubs 27%. For wet sedges we found that the litter layer was very important as it reduced the average transmittance to only 6%. Model output indicated that both, albedo and transmittance, also depend on the spatial aggregation of vegetation types. We found that permafrost thaw was more strongly related to soil properties than to canopy shading. The presented radiative transfer model allows quantifying effects of the vegetation layer on the surface radiation budget in permafrost areas. The parametrised model can account for diverse vegetation types and variation of properties within types. Our results highlight small scale radiation budget and permafrost thaw variability which are indicated and partly caused by vegetation. As changes in species composition and biomass increase can influence thaw rates, small scale patterns should be considered in assessments of climate-vegetation-permafrost feedbacks.