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The impact of vegetation type on the shortwave radiation balance of the Arctic tundra

Inge Juszak and Gabriela Schaepman-Strub
Institute of Evolutionary Biology and Environmental Studies, University of Zurich, Switzerland (inge.juszak@ieu.uzh.ch)

Profound changes in vegetation composition in the Arctic tundra have been observed and are predicted in a warmer future climate. Shrub expansion may positively feed back to climate warming by decreasing the shortwave albedo. On the other hand, permafrost protection through soil shading by shrubs has been discussed in literature. Several studies compared the average radiation balance across vegetation zones. However, variation within vegetation zones may be as important as differences between vegetation zones. The lowland tundra ecosystem at the Kytalyk research site (NE Siberia) is dominated by two vegetation types (dwarf shrub (Betula nana) and wet sedge (Eriophorum angustifolium)) organised in patches at a scale of about 10m. We investigated the shortwave radiation balance of both types separately and related it to the 11 year data set of the fluxtower with a mixed footprint. In addition to canopy albedo, we measured canopy transmittance below dwarf shrubs and wet sedges to quantify the often discussed effect of soil shading. Our results show that at our field site, wet sedge vegetation is shading the soil more efficiently than dwarf shrubs due to multi-year standing litter. While we measured an average transmission of 36% of the incoming shortwave radiation below dwarf shrubs, the transmission of wet sedge was 28%. Wet sedge summer albedo was on average 16% higher than dwarf shrub albedo. Additionally, the snow melted 10 days later in the sedge patches, leading to large albedo differences in the second half of May 2014. Our analysis shows, that cloud cover is the second most important control on albedo and transmittance of both vegetation types. Clouds reduced the summer albedo of both vegetation types across all zenith angles. On average, the growing season albedo was about 11% higher on clear sky days as compared to overcast days whereas the transmittance was about 23% lower. As cloud cover is expected to change with climate change, field studies of the cloud effects on the surface radiation balance are important to assess potential climate feedbacks. The results of our study reveal considerable variation of the shortwave energy balance at the local scale depending on vegetation type and cloud cover. Such detailed measurements at the local scale are important to complement satellite data in the parameterisation and validation of land-surface and climate models. They are contributing to a better understanding of the impact of vegetation type on the land surface and permafrost energy and carbon cycle in highly patterned tundra wetlands.