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

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Vegetation and radiation

Our research is about the effect of vegetation type and canopy density on the surface energy budget. In particular we look at common cottongrass (*Eriophorum angustifolium*), which dominates wet areas, and dwarf birch (*Betula nana*), the main species on drier patches at the Kytalyk site in N-E Siberia. Depending on vegetation characteristics more or less solar radiation is absorbed, reflected or transmitted to the soil or moss layer. Ultimately, we are interested in the influence of vegetation type on permafrost and atmosphere through local warming and soil shading.

Fig. 1: Station for measuring radiative and soil heat fluxes, soil and air temperature (growing seasons 2013 and 2014); study site in the Arctic tundra (extent by ***Walker et al.* (2005)**)

Shrubs reflect less & transmit more than sedges

On dwarf shrubs plots more solar radiation is absorbed than on sedge plots. Cloud cover reduces albedo and increases transmittance.

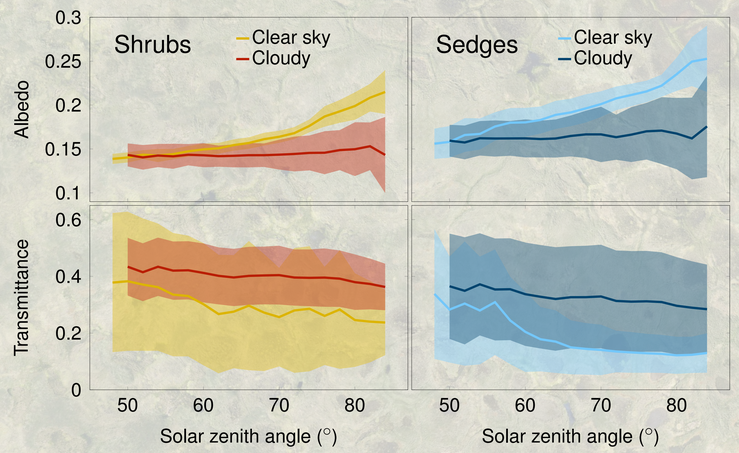
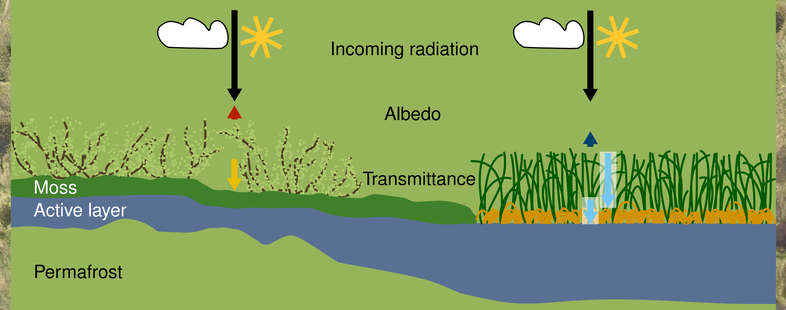
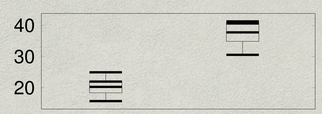


Fig. 2: Albedo and transmittance depending on sun zenith angle and cloud cover; transmittance data include spatial variation.

Sedges shade more than shrubs

In agreement with literature we found that dwarf shrub albedo was lower than sedge albedo. However, sedges shaded the soil more efficiently than dwarf shrubs, especially through multi-year litter. As we observed deeper active layers and higher soil heat fluxes below the sedge canopy, transmittance is not the major driver.



	Shrubs	Sedges
Main Species	*Betula nana*	*Eriophorum angustifolium*
		
Leaf (wood) area ($m^2\ m^{-2}$)		
Top soil thermal conductivity	0.08 $W\ m^{-1}\ K^{-1}$	0.44 $W\ m^{-1}\ K^{-1}$
Top soil heat capacity	0.5 $MJ\ m^{-3}\ K^{-1}$	3.3 $MJ\ m^{-3}\ K^{-1}$
End of season active layer thickness (cm)		
Summer albedo	0.15	0.17
Summer transmittance	0.35	0.27
Snowmelt date	24/05/2014	03/06/2014

Tab. 1: Overview of canopy and plot properties; boxplots for spatial variability on 8 plots per vegetation type.

Transmittance does not control soil heat flux

The soil temperature below sedges is lower and less variable than below shrubs. However, the soil heat flux is consistently higher below sedges. As transmittance is higher below shrubs, other factors are more important for the heat flux and thus the active layer thickness. The soil thermal properties may be more relevant for the soil thermal budget.

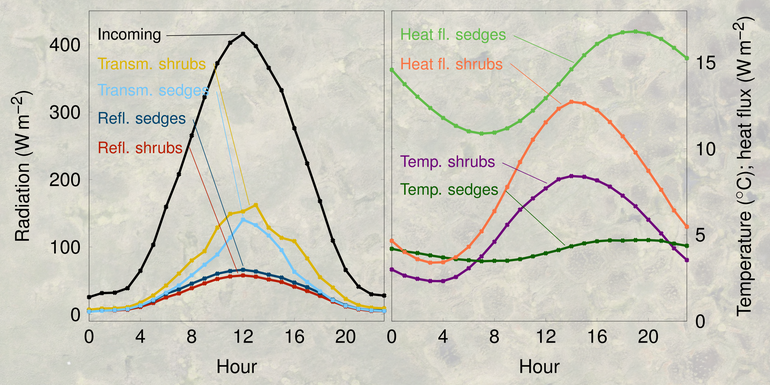


Fig. 3: Shortwave radiative fluxes, soil heat flux and soil temperature, growing season average diel cycle (2013 and 2014).

For shrubs, the wood matters

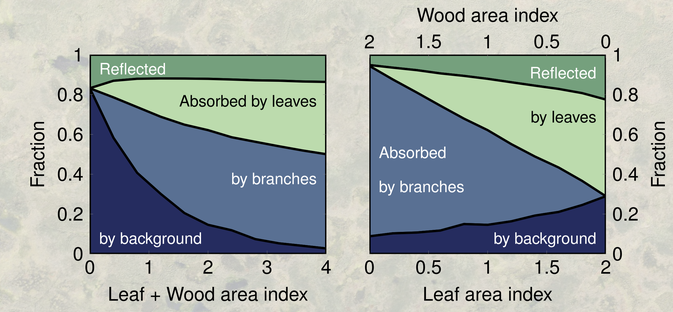


Fig. 4: Solar energy partitioning depending on dwarf birch leaf and wood area ($m^2\ m^{-2}$), 3D radiative transfer model (DART) results (***Juszak et al.*, 2014**).

References

Juszak, I., A. M. Erb, T. C. Maximov, and G. Schaepman-Strub (2014), Arctic shrub effects on NDVI, summer albedo and soil shading, *Remote Sensing of Environment*, *153*, 79–89.

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Acknowledgements

Thanks to

- Trofim C. Maximov and the Siberian Branch of the Russian Academy of Science (Yakutsk)
- Swiss National Science Foundation (project grant 140631)
- University research priority programme on Global Change and Biodiversity (URPP GCB)