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Biogeosciences Discussions

Interactive comment on "Contrasting radiation and soil heat fluxes in Arctic shrub and wet sedge tundra" *by* I. Juszak et al.

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General comments:

The study explores vegetation controls on surface radiation budget and soil heat flux in Arctic tundra ecosystem in Siberia. The topic is interesting and timely, since it has direct connection to permafrost dynamics and climate feedbacks of vegetation changes in the Arctic region. The topic fits also well into the scope of Biogeosciences.

This is a solid experimental study which novelty arises from subject of the study, not from the study design. The field experiment and measurements seem to be designed and performed carefully, and data-analysis and discussion is adequate. To gain further understanding, the experimental results need to be considered together / analyzed with soil-vegetation-atmosphere transfer models. Inclusion of relatively simple model

schemes (e.g. canopy radiative transfer, soil heat balance) would allow explaining the empirical findings using theoretical grounds. I understand this may be unrealistic for the current study, and thus encourage the authors to publish the dataset to allow its use by the modeling community. From modeling perspective, it is unfortunate that e.g. soil surface temperature, wind speed, and turbulent heat fluxes from the combined shrub/sedge ecosystem were not measured at the study site?

The manuscript is transparent and well written, and I consider it as useful contribution to our understanding of controls of soil thermal regime in Arctic tundra. I recommend the paper to be published in Biogeosciences after minor revisions.

Specific comments:

P7 L9-11: Please clarify: 'In order to reduce the solar angle influence, we took daily average fluxes of K and L to compute Rn, alpha and T for the analysis of vegetation type and cloud cover effect.' Later, you show how you calculate e.g. cloud cover for each 10min period, and show In the solar angle dependency of above parameters separately for clear-sky and cloudy conditions (Figs. 5, 7 &8) so is there a mistake in text?

As Reviewer 1, I would expect to see e.g. ensemble diurnal cycles of Rn/Kdn, Lnet, alpha and T. Such a figure could replace Fig. 8 which I consider unnecessary since same information is given already in Fig. 7.

P8 L 15 – 25: Please clarify: What are the total LAI's & WAI (woody area index) above sub-canopy radiation sensors for shrub and sedge –sites. These are needed to interpret canopy transmittance (T). Does the LAI of sedge (1.4 +/- 0.3 m2m-2) include the dead standing leaves? If not, what is their LAI?

P10 L 18-19: The differences in transmittance (clear-sky vs. cloudy) can be explained by different plant-area index (LAI+WAI) of shrubs and sedges, and partly by different leaf orientation (spherical vs. vertical leaf angle distribution).

P11 Fig 5: Maybe consider showing Rn relative to incoming global radiation (Kdn)? Now you compare apples and oranges since global radiation varies strongly between cloudy and clear-sky conditions, and with solar zenith angle.

P12 L5: Would be interesting to see ensemble diurnal cycles of soil heat flux, soil-air temperature gradient and radiation (net short- and longwave) for core growing season. See also later comment.

P14 L9 and P15 L30-31: Plant-area index (PAI) is the main control of light extinction within canopies, not canopy height. Of course, taller canopies have often high PAI, and also more complex architecture (at shoot, branch, canopy levels) that enhance absorption of solar radiation compared to shallow vegetation.

This is a section where use of a simple canopy radiation models (e.g. Spitters, 1986; Zhao & Qualls, 2005) would have been beneficial to back up the discussion.

P17 L3 – 18: This is a section where use of soil heat transfer models could be of great help. You arrive into conclusion that net radiation at the soil surface is not a major cause of shrub/sedge plot difference in soil heat flux. So, one could use same upper forcing for both plots (shrub/sedge) and ask how much the different soil properties (thermal conductivity, heat capacity that are measured) explain the observed difference in soil heat flux at 10 cm depth.

Deeper non-saturated layer and 5 cm thick moss cover at shrub site are likely to act as an insulating media. This restricts heat conduction to deeper layers reducing the heat flux measured at 10cm depth. As consequence, the diurnal variability of top soil temperature (measured at 4cm depth?) and top soil heat storage change at shrub site should be much greater than at the sedge site.

If this is not the case, then it is the soil surface energy budget that explains the difference. Since you think net radiation is not significantly different, this would mean that net turbulent energy transfer (sensible + latent heat) should be stronger at the shrub

site. Because shrub canopy is sparser than sedge canopy, I would expect that eddy diffusivity (exchange coefficient) is larger for shrub. Without detailed model it is not easy to speculate what happens to latent heat flux from moss-dominates soil surface (shrub-site) vs. moist peat/litter surface at the sedge sites. The analysis of soil – air temperature difference and its seasonal / diurnal variability should, however, give some indication of possible differences in the sensible heat exchange.

See e.g. Stoy et al. (2012) if interested on possibly significant impacts of moss cover /moss type on soil heat flux and temperature, and Launiainen et al. (2015) for an example of modeling soil-moss-air energy exchange below plant canopies.

Technical corrections:

P2 L15: ‘Vegetation alters the radiation budget and turbulent energy fluxes at the soil surface…’

P4 L 7: ‘volumetric soil moisture’

P4 L8 – P5 L4: Please note here that you measured the thermal conductivities and heat capacities at the sites.

P4 L5: At first read I was expecting ‘energy fluxes’ to include also sensible and latent heat. Please be more exact in the 1st sentence of the chapter; you measured only radiation above and below the canopy, and soil heat flux at 10cm depth.

P13 L9: Include definition of active layer depth for a general reader?

P16 L 22: Spatial variability of transmissivity is thus related to spatial inhomogeneity of canopy structure.

P16 L31: drivers of processes but causes of differences

P17 L2: … and activity, and by soil processes (not or)

References:

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