Spatial variation and linkages of soil and vegetation in the Siberian Arctic tundra – coupling field observations with remote sensing data

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Abstract. Arctic tundra ecosystems will play a key role in future climate change due to intensifying permafrost thawing, plant growth and ecosystem carbon exchange, but monitoring these changes may be challenging due to the heterogeneity of Arctic landscapes. We examined spatial variation and linkages of soil and plant attributes in a site of Siberian Arctic tundra in Tiksi, northeast Russia, and evaluated possibilities to capture this variation by remote sensing for the benefit of carbon exchange measurements and landscape extrapolation. We distinguished nine land cover types (LCTs) – bare soil, lichen tundra, shrub tundra, flood meadow, graminoid tundra, bog, dry fen, wet fen and water – and to characterize the LCTs, sampled 92 study plots for plant (biomass and leaf area index, LAI) and soil (organic matter OM%, bulk density, moisture, pH, litter layer depth, litter mass loss, temperature and active layer depth) attributes in 2014. Moreover, to test if variation in plant and soil attributes can be detected using remote sensing, we produced a normalized difference vegetation index (NDVI) and topographical parameters for each study plot using three very high spatial resolution multispectral satellite images, portraying vegetation at 180, 220 and 750 growing degree days, DD (with 0 °C threshold), and a digital elevation model (DEM). We found that soils ranged from mineral soils in bare soil and lichen tundra to soils of high OM% in graminoid tundra, bog, dry fen and wet fen. OM content of the top soil was on average 14 g dm^{-3} in bare soil and lichen tundra and 89 g dm^{-3} in other LCTs. Total moss biomass varied from 0 to 820 g m^{-2}, total vascular shoot mass from 7 to 112 g m^{-2} and vascular LAI from 0.04 to 0.95 among LCTs. In late summer, soil temperatures at 15 cm depth were on average 14 °C in bare soil and lichen tundra, and varied from 5 to 9 °C in other LCTs. On average, depth of the biologically active, unfrozen soil layer doubled from early July to middle August. When contrasted across study plots, moss biomass was positively associated with soil OM% and OM content and negatively with soil temperature, explaining 14–34 % of the variation. Vascular shoot mass and LAI were also positively associated with soil OM content, and LAI with active layer depth, but only explained 6–15 % of the variation. NDVI captured variation in vascular LAI better than in moss biomass, but while this difference was significant with late season 750-DD NDVI, it was minimal with early season 180-DD NDVI. For this reason, soil attributes associated with moss mass were better captured by early season NDVI. Topographic attributes were related to LAI and many soil attributes, but not to moss biomass and could