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High-resolution mapping and spatial variability of soil organic carbon storage of permafrost-affected soils

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Permafrost-affected soils store large amounts of soil organic carbon (SOC). Mapping of this SOC provides a first order spatial input variable for research that relates carbon stored in permafrost regions to carbon cycle dynamics. High-resolution satellite imagery is becoming increasingly available even in circum-polar regions. The presented research highlights findings of high-resolution mapping efforts of SOC from five study areas in the northern circum-polar permafrost region. These study areas are located in Siberia (Kytalyk, Spasskaya Pad /Neleger, Lena delta), Northern Sweden (Abisko) and Northwestern Canada (Herschel Island).

Our high spatial resolution analyses show how geomorphology has a strong influence on the distribution of SOC. This is organized at different spatial scales. Periglacial landforms and processes dictate local scale SOC distribution due to patterned ground. Such landforms are non-sorted circles and ice-wedge polygons of different age and scale. Palsas and peat plateaus are formed and can cover larger areas in Sub-Arctic environments. Study areas that have not been affected by Pleistocene glaciation feature ice-rich Yedoma sediments that dominate the local relief through thermokarst formation and create landscape scale macro environments that dictate the distribution of SOC. A general trend indicates higher SOC storage in Arctic tundra soils compared to forested Boreal or Sub-Arctic taiga soils. Yet, due to the shallower active layer depth in the Arctic, much of the SOC may be permanently frozen and thus not be available to ecosystem processes. Significantly more SOC is stored in soils compared to vegetation, indicating that vegetation growth and incorporation of the carbon into the plant phytomass alone will not be able to offset SOC released from permafrost.

This contribution also addresses advances in thematic mapping methods and digital soil mapping of SOC in permafrost terrain. In particular machine-learning methods, such as support vector machines, artificial neural networks and random forests show promising results as a toolbox for mapping permafrost-affected soils. Yet, these new methods do not decrease our dependency from soil pedon data from the field. In contrary, soil pedon data represents an urgent research priority. Statistical analyses are provided as an indication for best practice of soil pedon sampling for the quantification and the model representation of SOC stored in permafrost-affected soils.