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Ground thermal variability and landscape dynamics in a northern Swedish permafrost peatland

A. Britta K. Sannel[1,2]
[1]Department of Physical Geography, Stockholm University, Stockholm, Sweden (britta.sannel@natgeo.su.se)
[2]Bolin Centre for Climate Research, Stockholm University, Stockholm, Sweden

Permafrost peatlands cover extensive areas in subarctic regions, and store large amounts of soil organic carbon that can be remobilized as active layer deepening and thermokarst formation is expected to increase in a future warmer climate. In northern Fennoscandia peatland initiation started soon after the last deglaciation, and throughout most of the Holocene the peatlands were permafrost-free fens. Colder conditions during the Little Ice Age resulted in epigenetic permafrost aggradation (Kjellman et al., 2018; Sannel et al., 2018). Today, these ecosystems are characterized by a complex mosaic of different landscape units including elevated peat plateaus and palsas uplifted above the surrounding wetlands by frost heave, and collapse features such as fens and thermokarst lakes formed as a result of ground-ice melt. This small-scale topographic variability makes the local hydrology, and possibly also the ground thermal regime very variable. In a peat plateau complex in Tavvavuoma, northern Sweden, ground temperatures and snow depth have been monitored within six different landscape units; on a peat plateau, in a depression within a peat plateau, along a peat plateau edge (close to a thermokarst lake), at a thermokarst lake shoreline, in lake sediments and in a fen. A thermal snapshot from 2007/08 shows that permafrost is present in all three peat plateau landscape units, and the mean annual ground temperature (MAGT) at 2 m depth is around -0.3 °C. In the three low-lying and saturated landscape units taliks are present and the MAGT at 1 m depth is 1.0-2.7 °C. Small-scale topographic variability is a key parameter for ground thermal patterns in this landscape affecting both local snow depth and soil moisture. Wind redistribution of snow creates a distinctive pattern with thin snow cover on elevated landforms and thicker cover in low-lying landscape units. Permafrost is present in peat plateaus where the mean December-April snow cover is shallow (<20 cm). In a small depression on the peat plateau permafrost exists despite a 60-80 cm mean December-April snow cover, but here the maximum annual ground temperature at 0.5 m depth is 8-9 °C warmer than in the surrounding peat plateau and the active layer is deeper (100-150 cm compared to 50-55 cm). In recent years, 2006-2019, the depression has experienced continued ground subsidence as a result of permafrost thaw, and the dominant vegetation has shifted from *Sphagnum* sp. to *Cyperaceae*. This transition could be the initial stage in collapse fen or thermokarst pond formation. In the same time period extensive block erosion and shoreline retreat has occurred along sections of the peat plateau edge where the mean December-April snow cover is deep (>80 cm). In a future warmer climate, permafrost thaw will have a continued impact on landscape changes, shifts in hydrology, vegetation and carbon exchange in this dynamic and climate-sensitive environment.

References

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