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Detecting lowland thermokarst development by UAV remote sensing in the Stordalen mire, Abisko, Sweden

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In situ field studies in thawing permafrost regions have shown that C emissions resulting from organic carbon (OC) decomposition depend among others on the variability in soil water content, which can be directly related to microtopography. A more precise assessment of the evolution of permafrost C emissions as a function of thermokarst development requires high-resolution quantification of thermokarst-affected areas, as lowland thermokarst development induces fine-scale spatial variability (~ 50 – 100 cm). Here, we investigate a gradient of lowland thermokarst development at Stordalen mire, Abisko, Sweden, from well-drained undisturbed palsas to inundated fens, which have undergone ground subsidence. We produced orthomosaics and digital elevation models from very-high resolution (10 cm) UAV photogrammetry as well as a spatially continuous map of soil electrical conductivity (EC) based on Electromagnetic Induction (EMI) measurements performed in September 2021. In conjunction, we measured in situ the soil water content from the different stages of thermokarst development at the same period. The soil EC values are contrasted along the gradient in line with contrasts observed in the landscape classification derived from the orthomosaics and digital elevation models: palsas are flat areas with low soil EC (drier), whereas fens are subsided areas with higher EC (water-saturated). Areas in the course of degradation (transition zones) are well identified based on their higher slope, and broad range of EC. Importantly, these transition zones are only detected using a very fine spatial scale (i.e., 10 cm) coupled to information on the microtopography. Compared to a set of previously collected orthomosaics and digital elevation models, our results show an acceleration of thermokarst development in this area with a rate of palsa decline 4 to 10 times greater in 2019-2021 than in 2000-2014.