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Measuring and modelling thermal erosion patterns of peat plateaus in northern Norway

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Abstract

Peat plateaus are a major type of permafrost landscape in Arctic and Siberian lowlands. They represent a substantial pool of several hundreds of petagrams of organic carbon that has the potential to contribute to the Permafrost Carbon Feedback. The thermal response of these soils to the climate signal is complex and implies the interaction of various surface and subsurface processes operating at a very small spatial scale involving water, snow and heat fluxes and surface subsidence. As these processes have the ability to generate feedbacks between each other and trigger non-linear evolutions of the landscape, they challenge our abilities to measure and model them.

Peat plateaus in Northern Norway have been actively degrading over at least the last 60 years. They thus offer a precious opportunity to measure and model the degradation patterns they exhibit. We present new topographical observations derived from drone-based photogrammetry that we acquired for one site in Northern Norway. Over a period of 3 years, these Digital Elevation Models allows quantifying precisely the surface subsidence and resulting lateral degradation of the peat plateaus. In a second time, we use the land surface model CryoGrid to model the observed patterns. The model is able to (i) simulate the snow fluxes and the water and heat sub-surface fluxes within the plateau and between the plateau and the surrounding wet mire and to (ii) represent the soil surface subsidence due to excess ice melt in the soil. We implement a set up that discretize the interface between the peat plateaus and the wet mire and force the Surface Energy Balance module of the model with climatic data derived from regional atmospheric modelling.

Our simulations manage to reproduce the degradation speed we observe in our topographical data. We also present a sensitivity analysis of the degradation speed to snow cover and to the geometry of the peat plateaus and show how the feedbacks between the dynamical topography and the lateral fluxes of snow and water can trigger rapid permafrost thawing and fast degradation of permafrost landscapes.