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Investigating peat soil carbon and methane emissions with a new process-based model and new data from Nuuk (Greenland)

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Permafrost soils and arctic wetlands methane emissions represent an important challenge for modeling the future climate. We present a new process-based model designed to represent the main thermal, hydrological, and biogeochemical processes related to these emissions for general land surface modeling, and a new soil carbon dataset from a greenlandic peatland, close to Nuuk.

The multilayer scheme, embedded in the ISBA land-surface model, represents carbon pools, vertical carbon dynamics (advection and cryoturbation processes), and both oxic and anoxic organic matter decomposition. It also represents the soil gas processes for CH4, CO_2, and O_2 through the soil column.
Although this model has been validated on three climatically distinct arctic sites - two in Greenland (Nuuk and Zackenberg) and one in Siberia (Chokurdakh) - where it realistically reproduces methane and carbon dioxide emissions from both permafrosted and non-permafrosted sites, the modeled soil carbon stocks and profiles were not evaluated due to the lack of soil carbon data on these sites. This shortcoming had to be adressed, as carbon profiles are one of the primary drivers for CO_2 and CH4 soil production.

Hence, we measured for the first time soil carbon stocks and profiles at the Nuuk peatland. These new measurements are in the range of those encountered in arctic peatlands. Comparing these stocks and profiles with the modeled carbon stocks shows some shortcomings of the new discretized soil carbon model, in particular for the soil carbon vertical dynamics processes. Sensitivity experiments on the vertical dynamics and the soil carbon decomposition rates show that our model is able to reproduce fairly well both carbon profiles and greenhouse gases emissions from the Nuuk peatland.