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Deglacial permafrost carbon dynamics simulated with JSBACH

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Glacial-interglacial climate dynamics are strongly affected by concurrent changes in atmospheric greenhouse gas concentrations. During recent years, many studies have underlined that permafrost soils might have stored vast amounts of carbon during the glacial period and that these soils could have played an important role in deglacial carbon dynamics by having released large amounts of carbon to the atmosphere following post-glacial thaw.

We have used the land-surface model JSBACH in an offline configuration driven by climate forcings from the MPI Earth System model (T31 resolution) to explore the role of permafrost carbon in contributing to past changes in CO_2 concentrations following deglacial warming. For this purpose we have modelled soil carbon build-up under glacial boundary conditions, accounting for altered glacial vegetation, ice sheets and permafrost extent. Our simulations are based on the YASSO soil carbon model with a newly developped module to account for soil carbon accumulation in permafrost regions and for transfer of carbon between active (thawed) and inert (frozen) pools. By describing deglacial temperature rise and ice-sheet history (based on transient simulations of the CLIMBER-2 model) we capture the dynamic nature of the frozen carbon inventory through changes in permafrost extent and active layer deepening, as well as through climate-affected changes in soil litter input and soil carbon respiration loss.

Our results reveal pronounced patterns of spatio-temporal changes of northern hemisphere land carbon accumulation and release for the transition from the Last Glacial Maximum to the Holocene. We also explore the role of labile carbon which has accumulated in permafrost soils due to a strong reduction of respiration loss under harsh glacial climate conditions. Once thawed under future climate warming, this old soil carbon could get quickly mineralized and released to the atmosphere in the 21st century and beyond.