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Modelling carbon in permafrost soils from preindustrial to the future

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The carbon release from thawing permafrost soils constitutes one of the large uncertainties in the carbon cycle under future climate change. Analysing the problem further, this uncertainty results from an uncertainty about the total amount of C that is stored in frozen soils, combined with an uncertainty about the areas where soils might thaw under a particular climate change scenario, as well as an uncertainty about the decomposition product since some of the decomposed C might result the release of CH_4 as well as CO_2.

We use the land surface model JSBACH, part of the Max Planck Institute Earth System Model MPI-ESM, to quantify the release of soil carbon from thawing permafrost soils. We have extended the soil carbon model YASSO by introducing carbon storages in frozen soils, with increasing fractions of C being available to decomposition as permafrost thaws. In order to quantify the amount of carbon released as CH_4, as opposed to CO_2, we have also implemented a TOPMODEL-based wetland scheme, as well as anaerobic C decomposition and methane transport.

We initialise the soil C pools for the preindustrial climate state from the Northern Circumpolar Soil Carbon Database to insure initial C pool sizes close to measurements. We then determine changes in soil C storage in transient model experiments following historical and future climate changes under RCPs 2.6, 4.5, and 8.5. Based on these experiments, we quantify the greenhouse gas release from permafrost C decomposition, determining both CH_4 and CO_2 emissions, as well as the feedback resulting from these emissions.