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The permafrost carbon-climate feedback simulated by a coupled global climate model: feedback strength and sensitivity

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The permafrost soils of the northern high latitudes are estimated to contain 1700 Pg of carbon, most of it sequestered below the active layer in perennially frozen soils. This pool of carbon has been incorporated into the UVic Earth System Climate Model (ESCM) by prescribing historically permanently frozen soil layers with a uniform permafrost carbon density in the top 3.35 m of soil. When these layers thaw the permafrost carbon within them is transferred to the active soil carbon pool and the carbon is subjected to heterotrophic soil respiration. The UVic ESCM is forced under four emissions pathways diagnosed from representative concentration pathways 2.6, 4.5, 6.0, and 8.5. An uncertainty envelope for the likely strength of the permafrost carbon-climate feedback is established by varying permafrost carbon density between 16 and 26 kg m^{-3} and varying the equilibrium climate sensitivity (to a doubling of CO_2) of the model between 2 and 4.5 °C. The strength of the permafrost carbon-climate feedback is estimated to be 0.25 (0.1 to 0.7) °C (relative to control runs with no permafrost carbon) by the end of the 21st century regardless of emission scenario followed. By the end of the 23rd century the strength of the feedback diverges by emission pathway. Notably the upper bound of the feedback strength (in terms of additional warming) is highest for the two emission pathways with the lowest cumulative anthropogenic CO_2 emissions. This counterintuitive result is linked to the lower radiative efficiency of a unit of CO_2 at higher atmospheric CO_2 concentrations. That is, the CO_2 released by the permafrost has a greater ability to warm the Earth under scenarios where there is less CO_2 already in the atmosphere. If these model simulations are accurate humanity may have already set into motion a positive climate system feedback beyond our ability to mitigate with reductions in carbon emissions.