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Projecting the release of carbon from permafrost soils using a perturbed physics ensemble modelling approach

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The soils of the northern hemisphere permafrost region are estimated to contain 1100 to 1500 Pg of carbon. A substantial fraction of this carbon has been frozen and therefore protected from microbial decay for millennia. As anthropogenic climate warming progresses permafrost soils are expected to thaw. Here we conduct perturbed physics experiments on a climate model of intermediate complexity, with an improved permafrost carbon module, to estimate with formal uncertainty bounds the release of carbon from permafrost soils by year 2100 and 2300. We estimate that by year 2100 the permafrost region may release between 56 (13 to 118)Pg C under Representative Concentration Pathway (RCP) 2.6 and 102 (27 to 199) Pg C under RCP 8.5, with substantially more to be released under each scenario by 2300. A subset of 25 model variants is projected 8000 years into the future under continued RCP 4.5 and 8.5 forcing. Under the high forcing scenario the permafrost carbon pool decays away over several thousand years. Under the moderate forcing scenario a remnant near-surface permafrost region persists in the High-Arctic, which develops a large permafrost carbon pool, leading to a global recovery of the pool beginning in mid third millennium of the common era. Overall our simulations suggest that the permafrost carbon cycle feedback to climate change will make a significant but not cataclysmic contribution to climate change over the next centuries and millennia.