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Estimating the permafrost-carbon-climate response in the CMIP5 climate models using a simple modelling framework

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Permafrost soils contain ∼1672 Pg of organic carbon, much of which is relatively inert and not currently included within the global carbon cycle. Under increased temperatures permafrost degrades and a proportion of this old permafrost carbon becomes more vulnerable to decomposition and subsequent release into the climate system. Like fossil fuel burning this is an irreversible process which will cause a further increase in greenhouse gases in the atmosphere and hence have a positive carbon climate response. The permafrost carbon response is defined here as the additional permafrost carbon made vulnerable to decomposition per degree of global temperature increase. This paper adopts a simple modelling framework to estimate the permafrost carbon climate response that might have been calculated if permafrost carbon were included within the CMIP5 set of global climate models. The increase in the maximum active layer thickness was quantified from the soil temperatures output by the climate model simulations. This increase was then combined with an estimate of the distribution of organic carbon in permafrost soils along with its quality to assess the amount of carbon that might be released and hence the permafrost carbon response. There are large uncertainties in this estimate which are explored using an ensemble of Monte Carlo simulations. The dominant uncertainty is caused by differences in the simulated permafrost extent between the different CMIP5 models. Some models simulate a very low permafrost extent when compared with the observations and their response is very small because there is little frozen soil carbon present initially. However, for other model simulations, the response is comparable to the land carbon-climate feedback.