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Response of permafrost to projected climate change: Results from global offline model simulations with JSBACH

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Permafrost or perennially frozen ground is an important part of the terrestrial cryosphere; roughly one quarter of Earth's land surface is underlain by permafrost.
As it is a thermal phenomenon, its characteristics are highly dependent on climatic factors.
The impact of the currently observed warming, which is projected to persist during the coming decades due to anthropogenic CO_2 input, certainly has effects for the vast permafrost areas of the high northern latitudes.
The quantification of these effects, however, is scientifically still an open question.
This is partly due to the complexity of the system, where several feedbacks are interacting between land and atmosphere, sometimes counterbalancing each other.
Moreover, until recently, many global circulation models (GCMs) lacked the sufficient representation of permafrost physics in their land surface schemes.

In order to assess the response of permafrost to projected climate change for the 21st century, the land surface scheme of the Max-Planck-Institute for Meteorology, JSBACH, has recently been equipped with the important physical processes for permafrost studies, and was driven globally with bias corrected climate data, thereby spanning a period from 1850 until 2100.
The applied land surface scheme JSBACH now considers the effects of freezing and thawing of soil water for both energy and water cycles, thermal properties depending on soil water and ice contents, and soil moisture movement being influenced by the presence of soil ice.
To address the uncertainty range arising through different greenhouse gas concentrations as well as through different climate realisations when using various climate models, combinations of two Representative Concentration Pathways (RCPs) and two GCMs were used as driving data.
In order to focus only on the climatic impact on permafrost, effects due to feedbacks between climate and permafrost (namely via carbon fluxes between land and atmosphere) are excluded in the experiments.
Differences between future time slices and today's climate are analysed.
The effect in relevant variables, such as permafrost extent, depth of the Active Layer, ground temperature, and amount of soil carbon, is investigated.

The experiments (as well as the development of JSBACH with respect to permafrost soil physics) are part of the European project PAGE21, where a focus is set on interactions between the changing climate and its impact on permafrost, especially for the 21st century.