



EMS Annual Meeting Abstracts

Vol. 21, EMS2024-363, 2024, updated on 16 Jan 2025

<https://doi.org/10.5194/ems2024-363>

EMS Annual Meeting 2024

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Long-term responses to changes in Arctic soil hydrology

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Global warming is particularly intense in the Arctic, where temperature trends are up to four times higher than those observed globally. This results in Arctic permanently frozen soils, known as permafrost, being particularly vulnerable to climate change. Permafrost degradation due to warming is a critical element for Earth's climate stability, as it leads to the release of substantial amounts of carbon into the atmosphere, acting as a positive feedback mechanism for climate change. Additionally, the permafrost retreat leads to changes in the landscape, loss of resources, and damage to infrastructure, posing an economic challenge for populations inhabiting the Arctic. However, the increase in temperatures is not the only factor affecting permafrost degradation. Changes in water availability in the Arctic, induced by decadal and centennial changes in general atmospheric circulation, significantly alter soil moisture and the presence of ice, and thus the thermal structure of the soil in permafrost regions. This, in turn, may have global feedbacks through Arctic Amplification processes.

The representation of Arctic hydrological and thermodynamical processes and their interactions is still limited in current ESMs, hindering the understanding of Arctic permafrost dynamics. This work explores the response of the Max Planck Institute for Meteorology's ESM (MPI-ESM) to changes in hydrological and thermodynamic characteristics of its Land Surface Model, JSBACH, in permafrost-affected regions. A set of ongoing experiments covering the past2k (0-1850), the historical period (1850-2014), and different climate change scenarios (SSPs, 2015-2100) with variations in soil depth and vertical resolution under two hydro-thermodynamic coupling configurations generating comparatively drier or wetter conditions in the Arctic allows for assessing climate sensitivities to Arctic hydroclimate.

How to cite: García-Pereira, F., González-Rouco, J. F., Meabe-Yanguas, N., Jungclaus, J., de Vrese, P., and Lorenz, S.: Long-term responses to changes in Arctic soil hydrology, EMS Annual Meeting 2024, Barcelona, Spain, 1–6 Sep 2024, EMS2024-363, <https://doi.org/10.5194/ems2024-363>, 2024.