



## Long term influence of changing soil hydrology in an Earth System Model on Arctic Amplification

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The Arctic's enhanced response to global warming, driven by sea-ice and lapse-rate feedbacks, among other processes, has significant implications for the climate system, ecosystems, and society. Known as Arctic Amplification (AA), this phenomenon accelerates permafrost thawing, influencing carbon soil emissions and hydrology. However, the physics of permafrost-related processes remain poorly understood. Additionally, Earth System Models (ESMs) exhibit significant uncertainties in projecting future Arctic hydrology, making it difficult to determine whether this region will become wetter or drier. A better representation of soil thermodynamics and hydrology within ESMs allows for assessing uncertainties related to permafrost processes. This study uses a modified version of the MPI-ESM, where soil hydro-thermodynamics is improved in permafrost regions. With the tuning of parameters in these modifications we create the WET and DRY versions of the model. This allows for evaluating how these changes affect Earth's climate and, in particular, AA until 2300. Simulations, reveal that the AA factor converges to a value of 2–3 when external forcing outperforms the influence of internal variability. Furthermore, differences in climate backgrounds and the availability of sea ice and snow result in feedback processes of different magnitudes. Thus, accurately representing Arctic hydrology is crucial to better understand and predict the region's future changes. The feedback mechanisms explored here not only shape Arctic climate, but also have the potential to affect the global climate via a series of teleconnections.