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Internal variability of Arctic surface air temperatures at different levels of global warming

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Surface temperatures in the Arctic are increasing more than twice as fast as the global average due to Arctic amplification. This warming gives rise to new types of extreme events that can have particularly large impacts. Here, we study the interplay of mean warming and changes in internal variability to better understand and constrain the intensity and frequency of temperature extremes in the Arctic, both regionally and seasonally.
For this study, we analyze projected mean and extreme surface air temperatures in the Arctic for different levels of global warming based on output data from multiple single-model initial-condition large ensembles, with the Max Planck Institute Grand Ensemble (MPI-GE) at the core of the analysis. We use a time-slice approach to construct representative samples of the pre-industrial climate and the climate at different levels of global warming, including the Paris Agreement targets of 1.5 °C and 2 °C.
Considering pan-Arctic temperatures, we find that the mean warming is strongest in winter (~3.5 times annual mean global warming) and lowest in summer (~1.05 times annual mean global warming), which leads to a weakening of the Arctic seasonal cycle with global warming. Moreover, the change in the return levels of extreme temperatures is particularly strong for cold extremes, rendering extremely cold temperatures seldom in a warming Arctic. The level of global warming is strongly impacting the frequency of extreme events. For example, warm extremes that occur every 100 years at 1.5 °C of global warming, occur more than once in 10 years at 2 °C of global warming, and cold extremes that occur every 10 years at 1.5 °C global warming, occur only about every 200 years at 2 °C of global warming (based on MPI-GE data). The response of Arctic mean temperatures to global warming results from a local temperature response that varies substantially for different regions and types of surfaces (land, ice sheet, open ocean, sea ice). We find the most drastic warming, accompanied by a strong reduction of variability, in winter temperatures over the northern Barents Sea linked to its 'Atlantification'. Lastly, we also note a considerable difference in the Arctic temperature response for the same level of global warming in a transient versus a quasi-equilibrium climate state.
The results of our study allow us to quantify expected changes in the Arctic temperature range with global warming and also to determine when and where, for example, climate mitigation measures are most likely to be visible.