EGU22-8788
https://doi.org/10.5194/egusphere-egu22-8788
EGU General Assembly 2022

Temperature and precipitation distribution changes in response to global warming – results from transient simulations of the Last Deglaciation from a hierarchy of climate models

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Projections of anthropogenic climate change suggest possible surface temperature increases similar to those during past major shifts of the mean climate like the Last Deglaciation. Such shifts do not only affect the mean but rather the full probability distributions of climatic variables such as temperature and precipitation. Changes to their distributions can thus be expected for the future as well and need to be constrained.

To this end, we examine transient simulations of the Last Deglaciation from a hierarchy of climate models, ranging from an energy balance model to state-of-the-art Earth System Models. Besides the mean, we use the higher moments of variability – variance, skewness, and kurtosis – to characterize changes of the distribution. The analysis covers annual to millennial timescales and examines how patterns vary with timescale and region in response to warming. Furthermore, we evaluate how the changes of the distributions affect the occurrence of extremes.

To analyze the influence of forcings on the distributions, we compare the patterns of the fully-forced simulations to those in sensitivity experiments that isolate the effects of individual forcings. In particular, the effect of volcanism is examined across the hierarchy, as well as changes in ice cover, freshwater input, CO_2, and orbit. While large-scale global patterns can be found, there are significant regional differences as well as differences between simulations, relating for example to

differences in the modelling of ice cover changes and freshwater input. Finally, we investigate whether climate model projections show the same trends with respect to the change in moments as those found in the deglacial simulations and thus whether the patterns found might hold for future climate.