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Comparing temperature trends and variability over the Holocene in climate models of low and high complexity

Christian Wirths[1], Elisa Ziegler[1], Matthew Toohey[2], Julie Christin Schindlbeck-Belo[3], Steffen Kutterolf[3], Heather Anders[4], and Kira Rehfeld[1]

[1]Institute of Environmental Physics, Heidelberg University, Germany
[2]University of Saskatchewan, Faculty of Physics & Engineering Physics, Canada
[3]GEOMAR, Helmholtz Centre for Ocean Research, Germany
[4]Memorial University of Newfoundland, Department of Physics and Physical Oceanography, Canada

Modeled and observed temperature trends over the Holocene disagree. Proxy reconstructions suggest global cooling during the late Holocene. Model simulations, on the other hand, show a warming trend for the entire Holocene, a contradiction known as the Holocene temperature conundrum.

A recent study by Bader et. al. (2020) introduced a new approach to the question by proposing the coexistence of a cooling and warming climate mode. While the warming mode is proposed to be related to changes in greenhouse gas concentrations, the physical process behind the cooling mode might be a change in the seasonal cycle of Arctic sea-ice. It's unclear to what extent this process is responsible for the observed climate response. Depending on their strength and location these modes have strong implications for proxy data interpretation and location selection when calculating global mean temperatures.

Here, we investigate if similar modes and temperature trends can be found in models of different complexity. Therefore, we use a 2D Energy Balance Model (EBM), with solar, volcanic, ice-sheet and greenhouse gas forcing, for transient simulations of the Holocene climate. We analyze these Holocene climate simulations in terms of global and regional temperature trends, modes and variability patterns. We conduct sensitivity tests to examine the influence of the forcings on those trends and modes. In particular, we are interested in the influence of volcanic eruptions on the Holocene climate. Furthermore, we compare our model results with temperature reconstructions and simulations from Earth System Models.

Altogether, we comprehensively analyze Holocene climate as simulated by a conceptual EBM, a state-of-the-art Earth System Model and proxy reconstructions. The results provide insight into whether models of different complexity produce similar modes and trends and whether these

occur due to climate forcing rather than internal processes of the earth system. Finally, we will provide a better understanding of Holocene cooling and warming and the interpretation of differences between Holocene temperature proxy reconstructions and climate model simulations.

References:

Bader, J., Jungclaus, J., Krivova, N. et al. Global temperature modes shed light on the Holocene temperature conundrum. Nat Commun 11, 4726 (2020). https://doi.org/10.1038/s41467-020-18478-6