EGU21-4304, updated on 06 Jul 2022
https://doi.org/10.5194/egusphere-egu21-4304
EGU General Assembly 2021

Contribution of forcings to Holocene climate evolution

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The climate evolution of the past few thousand years is essential for understanding the context in which civilisation arose and for understanding the natural background of anthropogenic influence. Proxy-inferred records show a complex picture of earlier warming and later cooling during the Holocene depending on region and reconstruction method. In contrast climate model simulations almost uniformly show warming throughout the past 10,000 years and for example also fail to reproduce a major advance of rainbelt over the Sahara. These discrepancies raise questions about the reliability of climate models on longer-time scales.

We present a suite of four new transient Holocene simulations covering the last 8500 years using the HadCM3B-M21aD coupled general circulation. We use an optimised version of this model which is able to replicate the greening of the Sahara through changes to the atmospheric convection and vegetation schemes. We apply transient changes in Earth's orbit, ice-sheets and sea-level and greenhouse gases, and optionally solar output, volcanic eruptions and anthropogenic land-use change. The simulations without land-use show a warming throughout the Holocene, albeit with significantly higher variability once volcanic eruptions are included. With the inclusion of land-use change temperature trends in Northern Hemisphere are reversed from around 4000 years before present.

We explore the contribution of different forcings to the regional trends in the model ensemble and we compare the simulations against the Holocene reconstructions to evaluate the relative importance of each forcing. We also use the model ensemble to quantify the terrestrial coverage of proxy locations that is required to reliably infer global mean temperature variations.