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Simulation of the mid-Pliocene Warm Period using HadGEM3-GC31-LL: Pliocene climate relative to the pre-industrial era, previous model versions, other climate models and proxy data

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To better understand the processes contributing to future climate change, palaeoclimate model simulations are an important tool because they allow testing of the models' ability to simulate very different climates than that of today. As part of CMIP6/PMIP4, the latest version of the UK's physical climate model, HadGEM3-GC31-LL (hereafter, for brevity, HadGEM3), was recently used to simulate the mid-Holocene (~6 ka) and Last Interglacial (~127 ka) simulations and the results were compared to the preindustrial era, previous versions of the same model and proxy data (see Williams et al. 2020, *Climate of the Past*). Here, we use the same model to go further back in time, presenting the results from the mid-Pliocene Warm Period (~3.3 to 3 ma, hereafter the "Pliocene" for brevity). This period is of particular interest when it comes to projections of future climate change under various scenarios of CO₂ emissions, because it is the most recent time in Earth's history when CO₂ levels were roughly equivalent to today. In response, albeit due to slower mechanisms than today's anthropogenic fossil fuel driven-change, during the Pliocene global mean temperatures were 2-3°C higher than today, more so at the poles.

Here, we present results from the HadGEM3 Pliocene simulation. The model is responding to the Pliocene boundary conditions in a manner consistent with current understanding and existing literature. When compared to the preindustrial era, global mean temperatures are currently ~5°C higher, with the majority of warming coming from high latitudes due to polar amplification from a lack of sea ice. Relative to other models within the Pliocene Modelling Intercomparison Project (PlioMIP), this is the 2nd warmest model, with the majority of others only showing up to a 4.5°C increase and many a lot less. This is consistent with the relatively high sensitivity of HadGEM3, relative to other CMIP6-class models. When compared to a previous generation of the same UK model, HadCM3, similar patterns of both surface temperature and precipitation changes are shown (relative to preindustrial). Moreover, when the simulations are compared to proxy data, the results suggest that the HadGEM3 Pliocene simulation is closer to the reconstructions than its predecessor.

