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Modelling the climate and ice sheets of the mid-Pliocene warm period: a test of model dependency

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The mid-Pliocene warm period (MPWP; c. 3.0 – 3.3 million years ago) has been the subject of a large number of published studies during the last decade. It is an interval in Earth history, where conditions were similar to those predicted by climate models for the end of the 21st Century. Not only is it important to increase our understanding of the climate dynamics in a warmer world, it is also important to determine exactly how well numerical models can retrodict a climate significantly different from the present day, in order to have confidence in them for predicting the future climate.

Previous General Circulation Model (GCM) simulations have indicated that MPWP mean annual surface temperatures were on average 2 to 3°C warmer than the pre-industrial era. Coastal stratigraphy and benthic oxygen isotope records suggest that terrestrial ice volumes were reduced when compared to modern. Ice sheet modelling studies have supported this decrease in cryospheric extent. Generally speaking, both climate and ice sheet modelling studies have only used results from one numerical model when simulating the climate of the MPWP. However, recent projects such as PMIP (the Palaeoclimate Modelling Intercomparison Project) have emphasised the need to explore the dependency of past climate predictions on the specific climate model which is used.

Here we present a comparison of MPWP climatologies produced by three atmosphere only GCMs from the Goddard Institute of Space Studies (GISS), the National Centre for Atmospheric Research (NCAR) and the Hadley Centre for Climate Prediction and Research (GCMAM3, CAM3-CLM and HadAM3 respectively). We focus on the ability of the GCMs to simulate climate fields needed to drive an offline ice sheet model to assess whether there are any significant differences between the climatologies. By taking the different temperature and precipitation predictions simulated by the three models as a forcing, and adopting GCM-specific topography, we have used the British Antarctic Survey thermomechanically coupled ice sheet model (BASISM) to test the extent to which equilibrium state ice sheets in the Northern Hemisphere are GCM dependent. Initial results which do not use GCM-specific topography suggest that employing different GCM climatologies with only small differences in surface air temperature and precipitation has a dramatic effect on the resultant Greenland ice sheet, where the end-member ice sheets vary from near modern to almost zero ice volume.

As an extension of this analysis, we will also present results using a second ice sheet model (Glimmer), with a view to testing the degree to which end-member ice sheets are ice sheet model dependent, something which has not previously been addressed. Initially, BASISM and Glimmer will be internally optimised for performance, but we will also present a comparison where BASISM will be configured to the Glimmer model setup in a further test of ice sheet model dependency.