Modelling the mid-Pliocene with HadAM3:

UK Contribution to PlioMIP

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PRISM Pliocene Research, Interpretation and Synoptic Mapping
PlioMIP

SGPC Sellwood Group for Palaeo-Climatology

(1) INTRODUCTION

In 2008 the temporal focus of the Palaeoclimate Modelling Intercomparison Project (PMIP) was expanded to include a model intercomparison for the mid-Pliocene warm period (3.29–2.97 million years ago). This project is referred to as PlioMIP (Pliocene Model Intercomparison Project). Two experiments have been agreed upon and comprise phase 1 of PlioMIP. The first (Experiment 1) is performed with atmosphere-only climate models, the 2nd with fully coupled atmosphere-ocean mdoels. This poster presents the results for Experiment 1 from the UK Met Office AGCM, HadAM3.

(2) BOUNDARY CONDITIONS

The boundary conditions for PlioMIP are descibed in Haywood et al (2010), and shown below:

land-sea mask/orography:

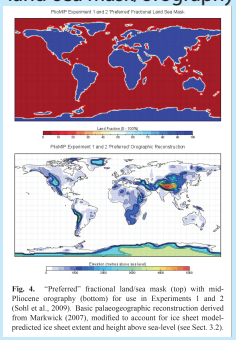
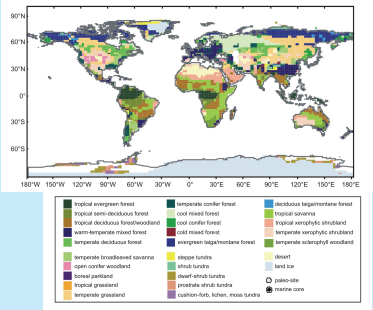


Fig. 4. "Preferred" fractional land/sea mask (top) with mid-Pliocene orography (bottom) for use in Experiments 1 and 2 (Sohl et al., 2009). Basic palaeogeographic reconstruction derived from Markwick (2007), modified to account for ice sheet model-predicted ice sheet extent and height above sea-level (see Sect. 3.2).

vegetation:



SST:

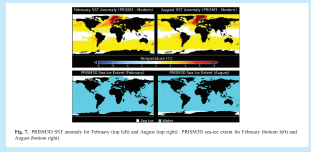
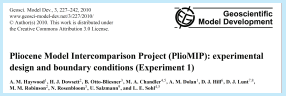


Fig. 7. PRISM3D SST anomaly for February (top left) and August (top right). PRISM3D sea-ice extent for February (bottom left) and August (bottom right).



Geoscientific Model Development

Pliocene Model Intercomparison Project (PlioMIP): experimental design and boundary conditions (Experiment 1)

ice:

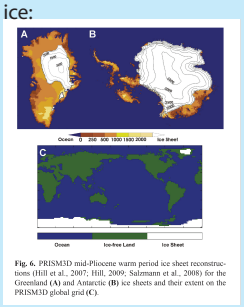
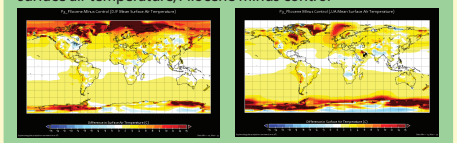


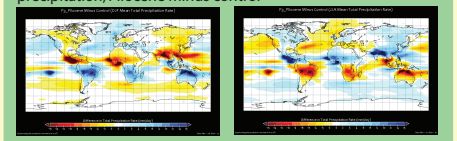
Fig. 6. PRISM3D mid-Pliocene warm period ice sheet reconstructions (Hill et al., 2007; Hill, 2009; Salzmann et al., 2008) for the Greenland (A) and Antarctic (B) ice sheets and their extent on the PRISM3D global grid (C).

(3) RESULTS

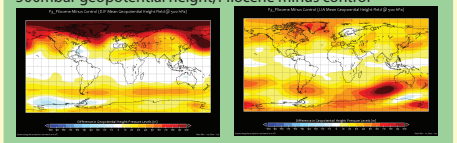
surface air temperature, Pliocene minus control



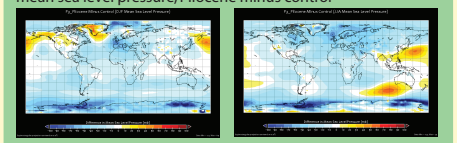
precipitation, Pliocene minus control



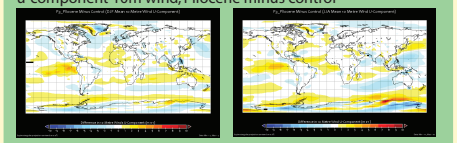
500mbar geopotential height, Pliocene minus control



mean sea level pressure, Pliocene minus control



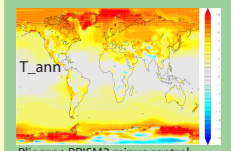
u-component 10m wind, Pliocene minus control



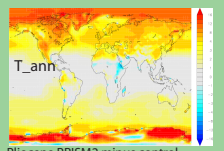
The figures above show the anomlaies, Pliocene minus control, as simulated by the UK Met Office model, HadAM3. HadAM3 runs at a resolution of 3.75 x 2.5 degrees, and has 19 vertical layers in the atmosphere.

(4) ANALYSIS 1 - Impact of PRISM3 vs. PRISM2 boundary conditions

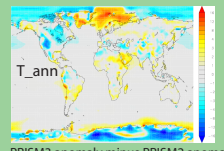
The PlioMIP boundary conditions are based on the USGS PRISM3 reconstructions. An earlier version of the boundary conditions, PRISM2, has been used in several previous works. The new reconstructions use an extended database of SSTs including multiproxy estimates where available, a new vegetation database based on a greatly increased number of sites, new reconstructions of the ice sheets based on more recent models, and an updated orography. The impact of these new boundary conditions is shown below.



Pliocene PRISM3 minus control



Pliocene PRISM2 minus control

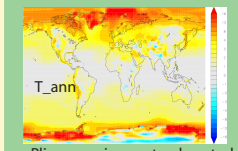


PRISM3 anomaly minus PRISM2 anomaly

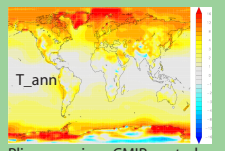
(5) ANALYSIS 2 - Role of the control 'pre-industrial' climate

In the PlioMIP experimental design, some care is taken in describing the control simulation, aswell as the Pliocene simulation. There was some discussion about the control - in the end it was decided to use the same definitions as CMIP and PMIP pre-industrial simulation. This includes prescribed vegetation which includes land-use change and does not represent the 'natural' unperturbed vegetation.

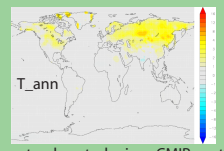
Below, we show the difference in climate anomaly if a 'natural' vegetation dataset is used in the control, instead of the CMIP standard. Comparison with the natural vegetation highlights just the non-anthropogenic component. The comparison of the two controls also allows an assessment of the climatic effect of anthropogenic land-use change.



Pliocene minus natural control



Pliocene minus CMIP control



natural control minus CMIP control

(6) CONCLUSIONS

The new SSTs in PRISM3 are characterised by greater warming in the North Atlantic compared to PRISM2. There is a cooling in the Rockies due to the higher mountain range in PRISM3. Furthermore, the higher Antarctic ice sheet in PRISM3 is also clearly impacting the temperature anomaly. The important question is whether the improvements in boundary conditions have led to an improvement in modelled climate. This remains to be tested. Clearly, the PRISM3 SSTs can not be used as a validation dataset. The vegetation dataset could be used to assess the model response in terms of temperature and precipitation, but again there is an issue of circularity in that the vegetation is also used as a boundary condition.

The role of the control is also interesting. The impact of land-use change is apparent in the temperature anomaly, in particular in the Northern Hemisphere. This indicates that some of the difference normally attributed to natural climate variations between the Pliocene and modern are actually due to land-use change.

However, there is another possibility for both the above effects. In both cases (PRISM3 vs PRISM2 and CMIP vs natural) the vegetation datasets are inconsistent in that they use different schemes to describe the vegetation.