Paleoclimate modeling: an integrated component of climate change science

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Past climates provide an opportunity to examine the working of the Earth system under a much wider range of forcing than those experienced during the historical period. The Paleoclimate Modelling Intercomparison Project (PMIP) is an ongoing program tasked with the systematic comparison of models and observations of past climate. Over the last 20 years, through the definition of model experimental designs and the syntheses of paleoenvironmental data, PMIP has made significant progress in the understanding of a number of key periods of the past. Previous PMIP experiments have included the mid-Holocene (MH) and the Last Glacial Maximum (LGM). For the latest iteration, PMIP3, the last millennium (LM), the Eemian (last interglaciation) and the mid-Pliocene warm period (approximately three million years ago) have been added. Three of these PMIP3 experiments (MH, LGM, LM) have been included as high-priority simulations in the Coupled Model Intercomparison Project (CMIP5; Taylor et al. 2012), which provides the framework for coordinated climate change experiments used in the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5).

In May 2012 over 80 scientists from more than 30 institutions gathered at Crewe Hall, a former Jacobean mansion in the English county of Cheshire, for the second general meeting of PMIP3. For the first time, model results for the PMIP3 experiments were shown. Over the course of five days many different aspects of paleoclimatology were examined, from the causes of temperature changes over the last 1000 years to a data-model comparison for the Eocene (56-34 Ma); from changes in Arctic sea ice to tropical Pacific El Niño teleconnections; from multi-model temperature patterns to global climate reconstructions based on pollen data. PMIP has identified some key paleoclimate features, which are relevant to each of the time periods by varying degrees and are also relevant to future climate change. These include climate variability, climate/Earth system sensitivity, polar amplification, and data-model comparison. Significant time was devoted to discussing these topics in break out groups, and new working groups were established to examine these topics in detail through the lifetime of PMIP3.

Integrated quantitative analysis of paleoclimate model simulations and climate reconstructions show that global scale climate models are generally capable of reproducing past climate change. However, many questions remain about the abilities of these models on regional scales. Can they reliably reproduce the large Arctic changes seen in the past? Why does the Atlantic Meridional Overturning Circulation respond differently in different models given the same forcing? Why do the simulated climates of the continental interiors change so little? Discrepancies between model simulations and paleoclimate reconstructions based on observations can arise from a combination of uncertainties in the interpretation of paleoenvironmental observations, uncertainties in the model physics and problems with the experimental design. The PMIP philosophy is that a better understanding of past climates and the workings of the Earth System can only be achieved by addressing each of these sources of uncertainty in an integrated way.

A special issue highlighting many results of the PMIP3 meeting is being prepared for the journal Climate of the Past. The Crewe meeting was hosted by the Universities of Leeds and Bristol, and sponsored by PAGES, SCAR (Scientific Committee on Antarctic Research), NCAS (UK National Centre for Atmospheric Science), The Royal Meteorological Society, The Geological Society, and the UK Meteorological Office.

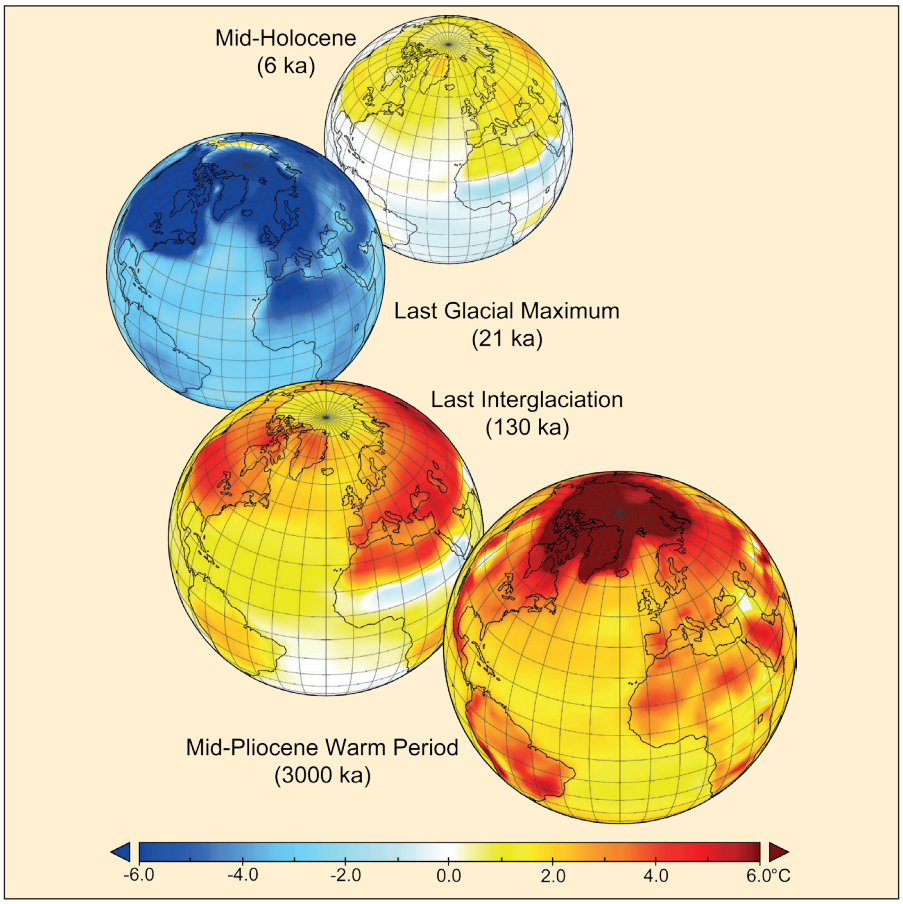

Figure 1: Multi-model mean summer (JJA) warming in the main Paleoclimate Model Intercomparison Project (PMIP3) equilibrium time periods, mid-Holocene, Last Glacial Maximum (Braconnot et al. 2012), Last Interglacial (Lunt et al. 2012) and the mid-Pliocene Warm period (Haywood et al. 2012).

References

Braconnot P et al. (2012) *Nature Climate Change* 2: 417-424

Haywood AM et al. (2012) *Climate of the Past Discussions* 8: 2969-3013

Lunt DJ et al. (2012) *Climate of the Past* 8: 1717-1736

Taylor KE, Stouffer RJ, Meehl GA (2012) *Bulletin of the American Meteorological Society* 93: 485-498