Palaeoclimate Modelling PMIP Intercomparison Project

An international project for coordinating palaeoclimate modelling activities designed to understand the mechanisms of climate change and test whether climate models can represent a climate state different from the present day

http://pmip2.lsce.ipsl.fr

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PROJECT INTRODUCTION

Palaeoclimate Modelling PMIP Intercomparison Project

The **Palaeoclimate Modelling Intercomparison Project (PMIP)** began in the early 1990s to provide an efficient mechanism for coordinating palaeoclimate modelling activities. The key aims of the project are to:

Understand the mechanisms of climate change

Identify the different climatic factors that shape our environment

Evaluate the capability of state-of-the-art models to reproduce different climates

Climate models have changed over the past decade from atmosphere-only models to coupled ocean-atmosphere and ocean-atmosphere-vegetation models. Models have also been developed to include the coupling between the physical climate and biogeochemical cycles (e.g. the carbon cycle), and the subsequent feedbacks.

The increase in model complexity poses:

Challenges - because these 'Earth-system models' (ESMs) require benchmarking against observations to be sure they can simulate radically different climates.

Opportunities - because these models can now address aspects of climate change with direct societal relevance, such as changes in short-term climate variability, in climate extremes such as droughts or storms, and in important biogeochemical cycles.

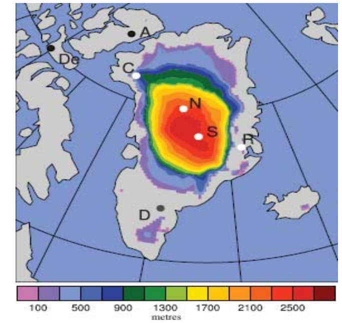
PMIP facilitates regular use of PMIP diagnostics and data sets for model benchmarking by the community, by making these resources easy to use and freely available (http://pmip2.lsce.ipsl.fr). PMIP's success is due largely to maintenance of close synergies between the modelling and observational community.

PMIP ACHIEVEMENTS

Accomplishments

PMIP has

- facilitated production of data syntheses and model-data comparisons for the benchmark periods of the mid-Holocene (MH: ~6000yr BP) and Last Glacial Maximum (LGM: ~21,000yr BP),
- published over 100 peer reviewed articles on past climates,
- provided results for the IPCC's 3rd and 4th Assessment Reports.



Annual minimum ice thickness and extent for Greenland and western arctic glaciers for the LIG from a multi-model and multi-proxy synthesis (Jansen *et al.* 2007 In: IPCC 4th AR)

PMIP Modelling activities have demonstrated that:

- the ability to simulate the present-day is not a sufficient test of model capability and the ability to simulate future climate changes,
- the ability to simulate response to a change in forcing improves with increased model resolution or better physical parameterisation,
- vegetation feedbacks are important in the climate system, which has led to incorporating vegetation as a dynamic component of climate models,
- increased model complexity is needed to simulate past and future climate changes, which has promoted ESM development.

PMIP Data-Model comparison activities

PMIP has involved hundreds of scientists in simulations of the LGM and MH and promoted synergies within the palaeo-data community, leading to the development of:

- regional and continental syntheses of palaeoclimate and palaeo-environmental data (e.g. BIOME 6000, DIRTMAP, MARGO),
- improved methods of reconstructing climate parameters from palaeo-observations,
- forward models (e.g. vegetation models) for model evaluation and for coupling in a climate-model framework,
- rigorous statistical approaches to comparing simulated and observed climates.

PMIP ACTIVITIES

PMIP have identified 3 activity streams as the focus of their future plans:

1. Benchmarking

Models that perform equally well for present-day may produce very different responses to likely changes in forcing in the future. This makes it vital to evaluate and benchmark models, by comparing simulations of past climates against palaeo-observations. PMIP will take the lead in palaeo-benchmarking of models, by defining experimental protocols, assembling evaluation data sets and undertaking quantitative assessment of simulations.

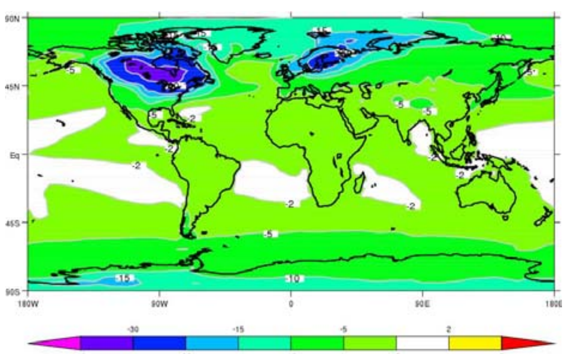
2. Climate Analysis

PMIP's strengths lie in the ability to examine multi-model ensembles and to analyse the causes of differences in model ability to reproduce observed climate changes in the past. The project will continue to focus on the analysis of the mechanisms of past climate change, specifically during:

- past interglacials and warm periods;
- intervals when there have been abrupt changes in the climate system;
- intervals when land-surface or ocean circulation feedbacks have played an important role.

3. Exploration

There are palaeo-dimensions to several emerging issues and uncertainties, including feedbacks through ice-sheet melting and sea-level rise, the influence of vegetation changes on trace gas and aerosol emissions to the atmosphere, and the frequency of extreme weather events. PMIP will continue to provide a discussion forum which includes both modellers and observationalists, and is therefore very well placed to identify how emerging issues in global change science can be addressed through models and data.



Annual mean LGM changes in temperature (°C) for the ensemble mean of PMIP2 simulations (Braconnot et al, 2007a)

THEME 1

Evaluation of ESMs at 6ka and 21ka

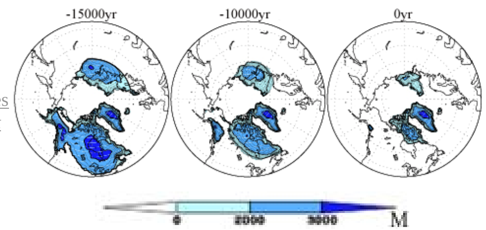
PMIP will promote the use of palaeo-benchmarks for model testing with focus on the LGM (21kyr BP) and MH (6kyr BP), where there are a number of existing palaeodata syntheses for evaluation. Benchmarking will ascertain whether the inclusion of new components (vegetation, biochemical cycles, chemistry and ice-sheets) and feedbacks (carbon cycle) produces an improvement in the simulation of regional climates.. The strategy will involve:

New data set: Existing datasets need to be complemented by datasets addressing both previously unevaluated aspects and new components of the simulations.

New diagnostic techniques: Specific diagnoses need to be developed for the different climate indicators and to overcome the mismatch in temporal scales between simulations and palaeo-environmental models.

Model-data comparison: PMIP will continue to promote model-data comparison in both forward and inverse mode, with a strong focus on comparison and development of forward models.

Ice sheet distribution at different stages (Abe-Ouchi *et al*, 2007)



THEME 2

Interglacials and Warm Periods

PMIP will initiate new simulations, data syntheses and data-model comparisons for 'warm periods' other than the MH. In the first instance, these foci are likely to be the last interglacial (LIG: ~129-116kyr BP) and the mid-Pliocene (~3.3-3.0Myr BP). These simulations will allow PMIP to address key issues including:

Polar Amplification: Is polar amplification characteristic and of a similar magnitude during all warm periods? Do the amplification mechanisms differ between models?

Tropical Response: How does the strength and nature of the initial forcing impact on the simulation of global monsoons? How constant are the relationships between El Nino and monsoon changes?

Climate Sensitivity: Are key feedback processes similar between the MH, LIG, mid-Pliocene? What do simulations of other warm periods imply about climate sensitivity?

THEME 3

Abrupt Climate Changes

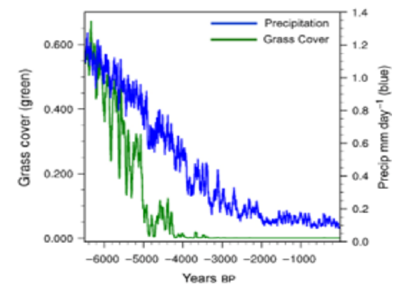
PMIP will move towards transient experiments with coupled climate models, focusing on the LGM to present, to estimate the likelihood of abrupt climate changes. Key questions are:

Deglaciation: What are the leads and lags between insolation forcing, climate response, ice sheets, and greenhouse gases? What are the mechanisms and feedbacks that govern the changes in atmospheric CO_2 and CH_4 during the deglaciation? What are the rates of ice sheet decay, and how is this influenced by ice sheet dynamics and feedbacks with the climate system?

Abrupt meltwater events: What is the thermohaline (THC) response to changes in freshwater inputs to the ocean, and does this response vary depending on whether the climate is in a warm or cold state? How does the climate respond to changes in the THC and what determines the abruptness of the response and recovery?

Other abrupt thresholds: Are there abrupt thresholds during the deglaciation and Holocene that are controlled by terrestrial feedbacks? What are the mechanisms that produce these abrupt thresholds?

Changes in annual precipitation (blue) & grass cover (green) for northern Africa from a 6500-year long transient simulation with FOAM-LPJ (Notaro *et al*, 2008)



THEME 4

Uncertainties: Characterisation & Understanding

PMIP will explore the extent to which weighting models according to their ability to reproduce past climate changes can reduce the uncertainty in future climate projections. This activity will build on the development of an array of metrics that gauge the model performance in PMIP benchmark experiments against available palaeoclimate data and will lead to development of a **palaeoclimate skill index** for weighting models. Several aspects will be considered, including:

- an **assessment** of uncertainties in the palaeoclimate boundary conditions,
- an **estimate** of uncertainty in palaeoclimate reconstructions and the **development** of metrics that quantify model performance in simulating palaeoclimates,
- the **determination** of the relationship between skill in simulating past and present observed climate and skill in projecting climate change.