Insights into climate mechanisms and process of a warmer world

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Thanks to careful and detailed palaeoenvironmental studies carried out over many years, it is widely acknowledged that observational and instrumental climate records only partially constrain the behaviour of the global climate system. The study of Earth's climate history provides the means to assess climate response over a variety of temporal and spatial scales, and a variety of forcing mechanisms of different magnitudes. Earth's climate history is the undeniable natural laboratory in which we can explore and understand a broader range of Earth system behaviour. This is an intellectually stimulating and highly challenging endeavour in its own right. In the context of the "great climate experiment" (anthropogenic modification of the climate system) currently underway, it is a highly relevant adventure. Much has been said and written about geological templates for 21st Century climate. However, the penetrating light provided by objective assessment shows us that there are no geological analogues. Although disappointing on one level, the study of Earth's climate history enables us to understand the mechanics and process of the climate system in a way which is impossible using other approaches. This, in a nutshell, is the importance of our science.

While geological analogues do not exist our quest to understand processes in the climate system have been facilitated by a focus on contrasting climatic states in Earth history. The Pliocene epoch, and in particular the mid-Pliocene Warm Period (mPWP), has seen an explosion of scientific study over the past 20 years. New palaeoceanographic records using multiple techniques in ever increasing temporal resolution have played an important part in the entire science, from reconstructing local to global patterns of climate and environmental change to providing new insights into atmospheric concentrations of CO2.

In this presentation I will briefly review the development of palaeoceanographic constraints on oceanographic conditions during the mPWP, and demonstrate how these data have been used thus far to evaluate the predictive abilities of numerical climate models. Such studies have highlighted potential weaknesses in model representation of climate response to specific forcing (e.g. the well-known polar amplification problem), but have also been instrumental in highlighting uncertainty in model experimental design and geological boundary conditions. These are now being addressed within the context of internationally co-ordinated model inter-comparison exercises. Combined data and modelling approaches are shedding new light on the oceanographic response to CO2 and ice sheet variation, in new and innovative ways, and novel application of proxies in the context of the mPWP is allowing multi-model predictions of critical aspects of the climate system to be examined more robustly (e.g. model representations of Pliocene sea-ice behaviour). Finally the talk will address the issue of Pliocene climate sensitivity and sensitivity to base-state, as well as highlighting current limiting factors in the relationship between data and models, specifically for the purpose of model evaluation.