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Pliocene climate variability and tipping elements

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The Pliocene (5.3 to 2.6 million years ago) was the last epoch of Earth History when the climate was warmer than modern and atmospheric CO2 was at or higher than present concentrations. As such, it remains one of the best time intervals for investigating the potential future response of the climate system to elevated greenhouse gas concentrations in the long term. The processes driving Pliocene warmth and climate variability remain only partially understood.

Here we examine some of the key components of the climate system and climate variability in numerical model simulations of the Pliocene. Due to their implication in Pliocene warmth and their identification as potential policy-relevant climate tipping elements the following four Earth System components are examined: 1) ice sheets, 2) thermohaline circulation, 3) the El Niño Southern Oscillation (ENSO), 4) the North Atlantic Oscillation (NAO).

The mean state and, where appropriate, the variability in the different Earth System components is examined within simulations of Pliocene climate. If possible the results are compared to palaeo-data that provides evidence of their state during the Pliocene.

During warm 'interglacial' events of the Pliocene climate and ice sheet models indicate reduced ice volumes. However, orbital forcing was capable of generating significant variability in ice sheet size and distribution. Thermohaline circulation strength appears to have been the same or slightly weaker than model predictions for the modern. The ENSO was in operation but with an increase in amplitude and frequency. Finally NAO variability was significantly decreased, but only in Pliocene simulations set up with lowered elevations over the western cordillera of North America.