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North Atlantic / Arctic Oscillations in the Pliocene: A Mechanism for Regional Warming?

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Pliocene climate is significantly warmer than modern globally, but particularly so in the North Atlantic and adjacent portions of the Arctic. In order to fully understand these changes we must examine not only the mean climate state, but also changes to the significant oscillatory modes of regional climate. The Arctic and North Atlantic Oscillations (AO/NAO) are the primary atmospheric oscillatory modes in the North Atlantic / Eastern Arctic region, observed mainly in mean sea level pressure, but accounting for typically a third of all climate variability in the Northern Hemisphere. Advanced General Circulation Models (GCMs) of both the modern and Mid-Pliocene Warm Period (MPWP) enable the study of AO/NAO changes between the two intervals and the examination of the causes and significance of any changes.

Models show that there is a large change in the mean state of the pressure systems in the North Atlantic, on which the NAO index is based. While the mean Azores High remains relatively constant throughout Pliocene and modern simulations, the mean Icelandic Low is much deeper in MPWP models. By changing the various parameters that are different between the modern and Pliocene simulations, the cause of this change can be examined. The observed changes in mean AO/NAO state can be largely attributed to changes in the orography of the Rocky Mountains. Changes in the Pliocene NAO also include the seasonal and interannual variability seen in the indexes.

While the Hadley Centre GCM, used in this study, consistently performs well in studies of regional climate change and atmospheric phenomenon, different GCMs have been shown to produce different NAO responses to climate change. Multiple models can be used to find patterns that are robust between different GCMs, which should be possible in the new PlioMIP study. Secondly, comparison with palaeoclimate proxy data can be used to ground truth the modelled changes. Although this will always be difficult with an interannual atmospheric phenomenon operating in the geological past, annually resolved tree-ring records from the Pliocene have been developed from sub-fossil wood in the Canadian high Arctic Islands. These should allow comparison between variability in the model and in climate sensitive isotopic data to see if Pliocene changes in AO/NAO had a significant climatic impact and can be observed in the geological record.