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Pliocene Climate, ENSO and Equifinality

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Information regarding the behaviour of ENSO (El Niño-Southern Oscillation) during past climate states can be found within the geological proxy climate record. This resource can provide important clues on the variability of ENSO, during periods where climates were radically different from that seen today as well as providing data with which to test palaeoclimate models. During the Pliocene (∼5-1.8 Ma BP), it has been suggested that an El Niño condition existed as a permanent feature. This is based upon a number of palaeoceanographic studies which have examined the development of the thermocline and SST gradient in the tropical Pacific over the last five million years. However, since ENSO events occur over decadal to sub-decadal timescales, the low temporal resolution of the palaeoceanographic data means that current palaeoceanographic records are not capable of proving whether a permanent El Niño-like state existed during the Pliocene. An independent line of investigation has been to compare teleconnections associated with modern El Niño events to Pliocene proxy data collected in the extratropics. The primary assumption here being that Pliocene boundary conditions were sufficiently similar to modern to allow regional differences in seasonal precipitation and surface temperature (reconstructed by geological proxies) to be attributed to climate/weather teleconnections patterns associated with a permanent El Niño during the Pliocene.

Using the UK Met Office GCM, we examine this assumption by comparing outputs from a suite of Pliocene climate simulations which do not exhibit a permanent El Niño state, to observed patterns of regional precipitation and surface temperature change

associated with modern ENSO events. We also examine regional patterns of climate change associated with changes in the model boundary conditions, moving from the climate of the pre-industrial to that of the mid Pliocene in a series of incremental steps (vegetation, orography, ice sheets, and CO_2 concentration), and compare these to observed ENSO teleconnection patterns.

Our results indicate that a significant proportion of the proposed permanent El Niño surface temperature and precipitation patterns are observable in the Pliocene climate model simulations that display variability in tropical Pacific SSTs over ENSO timescales (i.e. permanent ENSO rather than El Niño). The sensitivity experiments, in which boundary condition changes are made incrementally, highlight the importance of equifinality in reconstructed patterns of regional Pliocene climates.