Geophysical Research Abstracts
Vol. 12, EGU2010-329, 2010
EGU General Assembly 2010

Evolution of the tropical Pacific climate using HadCM3: from the mid-Pliocene warm period to the pre-industrial

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The mid-Pliocene Warm Period (MPWP; 3.3-3.0 Ma) is the most recent interval of geological time where global mean temperatures were considerably warmer than pre-industrial for a prolonged period of time (ca. 2-3 oC greater) and has therefore been identified as a climate potentially similar to estimates for the late 21st Century. Palaeoceanographic proxy data from the tropical Pacific have shown that MPWP surface and subsurface ocean temperatures in the eastern equatorial Pacific (EEP) were much warmer than today, indicating a deeper thermocline and a west-to-east temperature gradient in the equatorial Pacific that was considerably reduced. This has led to the MPWP being characterised as showing a permanent El Niño-like mean state or El Padre. Recently, it has been suggested that this low temperature gradient may not have been caused by a permanent El Niño condition, but rather a change in the frequency and magnitude of ENSO. Modelling studies of the MPWP, using fully coupled ocean-atmosphere general circulation models, have demonstrated that this would not be inconsistent with a mean SST warming in the EEP.

This work will examine the behaviour and characteristics of ENSO, using the UK Meteorological Office GCM (HadCM3), in a MPWP coupled simulation compared with a control pre-industrial run. The results presented will include an analysis of El Padre conditions over the tropical Pacific and its implications for the EEP upwelling and mid-Pliocene ENSO. We will then expand on this analysis, examining the contribution from changes in the boundary conditions (CO2, ice sheets, orography and vegetation) to the differences observed in ENSO behaviour. Initial results suggest that the largest contributor to the warmer surface temperatures in the EEP comes from a higher atmospheric CO2 concentration. An analysis of potential temperature and vertical currents across the equatorial Pacific shows that despite warmer ocean temperatures, the upwelling in the EEP was still present. The source of these warmer intermediate waters is complex, however global plots of potential temperature at 2000 m indicate that the warmer subsurface waters originate from the Southern Ocean; potentially linking observed changes in the tropical Pacific to changes in high latitude ocean temperatures.