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A permanent El Niño-like state during the Pliocene & the onset of Northern Hemisphere glaciation

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Recent palaeoceanographic studies reconstructing sea surface temperature (SST) gradients across the tropical Pacific via Mg/Ca and δ^{18}O analyses of planktonic foraminifera, as well as alkenone palaeothermometry, have indicated that the gradient in SST across the Pacific during the Early and Middle Pliocene ($\sim$5.2 to 2.6 million years before present) was substantially lower than it is today (only $\sim$1.5 ºC) and that mean SSTs in the eastern equatorial Pacific (EEP) were $\sim$3 ºC warmer. This scenario of warmer EEP SSTs and a reduced SST gradient across the tropical Pacific is akin to what occurs during a modern El Niño event, thus the Early and Middle Pliocene have been characterised as geological stages exhibiting perennial El Niño-like conditions. Barreiro et al. (2005) prescribed this condition in an atmosphere-only GCM initialised with present-day boundary conditions and in doing so find that the trade winds along the equator, and hence the Walker Circulation, collapse. Low-level stratus clouds in the low latitudes greatly diminish reducing the albedo of the planet and increase global temperatures. The atmospheric concentration of water vapour also increases, further contributing to the global warming. Philander & Fedorov (2003) hypothesise that as surface temperatures warm due to anthropogenic emissions of greenhouse gasses (GHG's), the thermocline in the tropical Pacific may deepen leading to reversion to a permanent El Niño-like state potentially akin to that of the Pliocene. Philander & Fedorov (2003) also argue that the transition from uniformly warm tropics to tropics with zonal SST gradients, after 3 million years ago, provided important positive feedbacks for the amplification of glacial cycles and the onset of Northern Hemisphere Glaciation (NHG).

Here we use the HadCM3 GCM to examine the role of the oceans and ocean structure on Pliocene warmth. A permanent El Niño-like state is not predicted. Annual

mean SSTs in the EEP increase by 1 to 3˚C and the model-predicted SST gradient across the Pacific is approximately 1.9 ºC in agreement with palaeoceanographic data. However, El Niño Southern Oscillation events are clearly expressed by the model. Sensitivity tests indicate that a prescribed permanent El Niño-like condition increases global mean annual surface temperatures by a maximum of 0.6 ˚C. Tropical warming is in part, or wholly, compensated for by high-latitude cooling. Therefore, if the Pliocene were characterised by a permanent El Niño-like state, it is questionable that it provided a significant contribution to global warmth at that time and, therefore, it us uncertain that the termination of this state contributed significantly to the onset of NHG.