Glacial-Interglacial Pattern of Variation in the Eastern Equatorial Pacific Cold Tongue-ITCZ Complex

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Wind-driven upwelling in the eastern equatorial Pacific (EEP) forms a characteristic tongue of cold waters centered just south of the equator, which extends westward from the Peruvian coastal upwelling zone toward the dateline. The upwelled waters displace the region of warmest sea surface temperature (SST) to the north of the equator, roughly coincident with the Intertropical Convergence Zone (ITCZ). The frontal zone between the cold tongue and ITCZ features one of the steepest tropical SST gradients with a seasonal maximum exceeding 1°C per degree of latitude. The dynamics of this front are linked to the coupled ocean-atmosphere interactions that modulate the intensity of upwelling over seasonal, interannual and longer timescales. Cold tongue-ITCZ dynamics are therefore of central importance for the equatorial circulation in the tropical Pacific and hence for global climate.

Here we use oxygen isotope ($\delta^{18}O$) and Mg/Ca ratios measured on planktonic foraminifera from nine EEP sites to investigate the glacial-interglacial pattern of variation in this system from the Last Glacial Maximum (LGM) through the Holocene. $\delta^{18}O$ of foraminiferal calcite records hydrographic variability due to a combination of surface temperature and salinity, while Mg/Ca is predominantly a temperature proxy. Both indicators suggest that the cross-equatorial hydrographic front separating the cold tongue and ITCZ was attenuated to approximately half its present strength during the LGM. Because the strength of this front is presently related directly to the intensity of upwelling in the cold tongue, we infer reduced upwelling in glacial times, most likely associated with a weakening of the southeast trade winds. Reduced southeasterly surface winds imply a weakening of the southern hemisphere Hadley cell in the vicinity of the EEP, in agreement with terrestrial evidence from South America. We suggest that the dominant mean climate mode in the glacial EEP resembled a quasi-El Niño state, with a weaker cold tongue, more symmetric SST distribution about the equator, and southward shift of the mean ITCZ position.