Ocean Heat Transport Variability in the Western Pacific Warm Pool During the Last Deglaciation: Insights from TraCE-21ka

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As a primary engine of the global climate system, the Western Pacific Warm Pool (WPWP) undergoes profound thermal reorganization during major climatic transitions. While modern dynamics are well-documented, the mechanisms governing its heat budget during past warming periods remain poorly constrained. In this study, we utilize the TraCE-21ka simulation to resolve the evolution of the WPWP heat budget and its drivers throughout the last deglaciation (21–9 ka).

Our analysis reveals that horizontal Ocean Heat Transport (OHT) dominates the WPWP heat budget on both deglacial and millennial scales. While the overall deglacial OHT intensification primarily reflects a thermodynamic response to broad ocean warming, millennial-scale variations are modulated by more complex atmospheric-driven oceanic adjustments. During Northern Hemisphere cold intervals, the southward migration of the Intertropical Convergence Zone (ITCZ) shifts the equatorial current bifurcation point, typically strengthening northward-flowing branches and leading to coupled increases in velocity and OHT (up to 16.0%). Crucially, a distinct decoupling occurs in the southern tropical Pacific during Heinrich Stadial 1. While the ITCZ shift weakened the South Equatorial Current and left regional flow nearly stagnant (-1.4%), the northward OHT paradoxically rose by 7.5%. This anomaly suggests that the increased OHT likely stemmed from current warming rather than mechanical strengthening, potentially reflecting a potent Southern Ocean warming signal propagated via Antarctic Intermediate Water and South Pacific Mode Water that may have counterbalanced the regional mechanical weakening.

These findings reveal a dual decoupling in heat dynamics: a shift from thermodynamic to dynamic dominance across scales, and a millennial-scale divergence between temperature and velocity. Such complexity implies that velocity proxies alone may be insufficient for resolving heat budget evolution. Ultimately, by bridging ocean–atmosphere and high-to-low latitude coupling, this study provides a robust framework for interpreting regional paleoclimate records and the tropical Pacific’s role in global climate.

Keywords: Millennial-scale Variability, Deglaciation, Ocean Heat Transport, TraCE-21ka, Western Pacific Warm Pool, Western Boundary Currents

