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Insights into Longwave Feedback over the Tropical Warm Pool from Upper-tropospheric Humidity and Cloud Regimes

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Longwave (LW) feedback is a key mechanism regulating the Earth's energy balance. LW feedback is modulated by how temperature, water vapor, and clouds respond to warming. Over the Tropical Warm Pool (TWP), vigorous convective activity sensitive to local sea surface temperature (SST) variations modifies both the radiative responses and coverage of LW feedback components. To capture those simultaneous variations that shape LW feedback in the TWP, this study employed a regime-based approach that combines warming-driven changes within five distinct regimes: moist-upper-cloudy, dry-lower-cloudy, moist-lower-cloudy, dry-clear, and moist-clear. Using GEO-KOMPSAT-2A (GK2A) observations (2020–2024), we classified regimes based on upper-tropospheric humidity and cloud characteristics, then estimated changes in outgoing longwave radiation (OLR) and area-fraction in response to SST warming within each regime. Our approach suggested that the LW feedback in the TWP can be expressed through the current OLR and area-fraction of each regime, combined with the changes under warming in these two factors. Through statistically significant warming-driven changes in OLR and area-fraction across regimes, we developed a simplified equation that captured the observed negative LW feedback, with estimated energy loss of 15.21 W m^{-2} K^{-1} falling within the 99% confidence interval. These findings underscore that understanding LW feedback requires integrated approach, as the regime-based analysis reveals the combined influence of radiative and spatial changes drives negative LW feedback over the TWP.

Keywords: Tropical Warm Pool, Longwave Feedback, Outgoing Longwave Radiation, Sea Surface Temperature