A Mechanism for the Maintenance of Sharp Tropical Margins

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The deep tropics characterized by moist air and deep convection are separated from the dry, quiescent subtropics often by a sharp horizontal gradient of moisture only loosely tied to SST or other geographical constraints. Mapes et al. (GRL, 2018) showed that this margin of the moist tropics is a true PDF minimum (a regime separatrix), along a column water vapor (CWV) contour around 48 mm in instantaneous data. Quasi-meridional statistical composites of observations across the poleward-most excursion of this sinuous contour retain the sharpness of the margin while increasing signal to noise ratio. Observations primarily from a suite of the A-Train satellites show the meridional structure of thermodynamic state and budget terms across the margin of the moist tropics. Composites are computed around the PDF-minimum CWV value of 48 mm as well as a range of other thresholds from 35 mm to 60 mm for comparison. Major findings are summarized as follows. (1) CWV increases equatorward from the subtropics for all CWV thresholds but eventually converges to 48 mm deep into the tropical side. Precipitation abruptly intensifies on the tropical side of the margin but declines equatorward to 85 W/m2 regardless of the CWV thresholds. (2) The diabatic forcing to the atmosphere (radiative heating plus surface heat fluxes) changes its sign across the CWV=48 mm border, being positive on the tropical side and negative on the subtropics. This contrast is owing to the meridional gradient of radiative heating, principally the longwave effect of high clouds. (3) Vertical mode decomposition reveals a transition from bottom-heavy to top-heavy subsidence on the subtropical side of the margin. These observed features are interpreted in terms of a simple theory from the moisture and heat budget perspectives. The model explains the abrupt moistening at the margin as a singularity where the vertical displacement of air costs little energy within a column.

Keywords: Tropical dynamics, Satellite data analysis, Conceptual theory

