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Tropical Cold-Point Tropopause: Climatology, Seasonal Cycle and Intraseasonal Variability derived from COSMIC GPS Radio Occultation Measurements

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The fine-scale structure of the tropical cold-point tropopause (CPT) is examined using high-resolution temperature profiles derived from COSMIC GPS radio occultation measurements for four years from September 2006 to August 2010. The climatology, seasonal cycle and intraseasonal variability are analyzed for three CPT properties: temperature (T-CPT), pressure (P-CPT) and sharpness (S-CPT). Their relationships with tropospheric and stratospheric processes are also discussed.

The climatological P-CPT is largely homogeneous in the deep tropics, whereas T-CPT and S-CPT exhibit local minima and maxima, respectively, at the equator in the vicinity of deep convection regions. All three CPT properties, however, show coherent seasonal cycle everywhere in the tropics; the CPT is colder, higher (lower in pressure) and sharper during boreal winter than during boreal summer. This seasonality is consistent with the seasonal cycle of tropical upwelling, which is largely driven by stratospheric and near-tropopause processes, although the amplitude of the seasonal cycle of T-CPT and S-CPT is modulated by tropospheric circulations. On intraseasonal time scales, P-CPT and T-CPT exhibit homogeneous variability in the deep tropics, whereas S-CPT shows pronounced local variability and seasonality. The wavenumber-frequency spectra reveal that intraseasonal variability of CPT properties is primarily controlled by Kelvin waves, with a non-negligible contribution by Madden-Julian Oscillation convection. The Kelvin waves, which are excited by deep convection but often propagate along the equator freely, explain the homogeneous P-CPT and T-CPT variabilities. On the other hand, vertically-tilted dipole temperature anomalies, which are associated with convectively-coupled equatorial waves, determine the local structure and seasonality of S-CPT variability.