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Convectively-driven tropopause-level cooling and its influences on stratospheric moisture

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Characteristics of the tropopause-level cooling associated with tropical deep convection are examined using CloudSat radar and Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) GPS radio occultation measurements. Extreme deep convection is sampled based on the cloud top height (>17 km) from CloudSat, and co-located temperature profiles from COSMIC are composited around the deep convection. Response of moisture to the tropopause-level cooling is also examined in the upper troposphere and lower stratosphere using microwave limb sounder (MLS) measurements.

The composite temperature shows a warming in the troposphere and a significant cooling near the tropopause (at 16-19 km) when deep convection occurs over the western Pacific, particularly during periods with active Madden-Julian Oscillation (MJO). The composite of the tropopause cooling has a large horizontal scale (∼6,000 km in longitude) with minimum temperature anomaly of ∼-2 K, and it lasts more than two weeks with support of mesoscale convective clusters embedded within the envelope of the MJO. The water vapor anomalies show a strong correlation with the temperature anomalies (i.e. dry anomaly in the cold anomaly), showing that the convectively-driven tropopause cooling actively dehydrates the lower stratosphere in the western Pacific region. The moisture is also affected by anomalous Matsuno-Gill-type circulation associated with the cold anomaly, in which dry air spreads over a wide range in the TTL. These results suggest that convectively-driven tropopause cooling and associated transient circulation play an important role in the large-scale dehydration process in the TTL.