Intraseasonal Temperature Variability in the Upper Troposphere and Lower Stratosphere from the GPS RO and AIRS Measurements

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The thermodynamic structure of the upper troposphere and lower stratosphere (UTLS) plays an important role in stratosphere-troposphere exchange, stratospheric dehydration and water vapor trends, and the formation of tropical thin cirrus clouds. In this study, we examine the detailed spatial and temporal patterns and vertical structure of the intraseasonal temperature variability in the UTLS associated with the Madden-Julian Oscillation (MJO) using temperature profiles from the recent Global Positioning System radio occultation (GPS RO) measurements including the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) mission. The MJO-related temperature anomalies in the UTLS are small near the equator (<0.6 K) but large (>1.2 K) over the subtropics. Near the equator, the temperature anomalies exhibit an eastward tilt with height from the UT to the LS and their magnitudes and signs are determined by the strength of convective anomalies and vertical level. The subtropical temperature anomalies have similar magnitudes and patterns between the UT (250 hPa to 150 hPa) and the LS (150 hPa to 50 hPa) except for opposite signs which changes occur around 150 hPa. The subtropical warm (cold) anomalies in the UT and cold (warm) anomalies in the LS are typically collocated with the subtropical positive (negative) tropopause height anomalies and flank or lie to the west of equatorial enhanced (suppressed) convection. These results indicate that the subtropical cyclones/anticyclones in the UTLS generated by the MJO are responsible for these subtropical temperature anomalies in the UTLS.

We also compare the intraseasonal temperature variability in the UTLS between the GPS and Atmospheric Infrared Sounder (AIRS) measurements to evaluate the quality of the AIRS temperature profiles in the UTLS. Our comparison indicates that both AIRS and GPS show a similar spatial and temporal pattern and vertical structure of the intraseasonal temperature anomalies in the UTLS. The magnitudes of the subtropical temperature anomalies are also very similar between AIRS and GPS, but the equatorial temperature anomalies are about 50% underestimated in AIRS in comparison to GPS likely due to the limited sampling of AIRS in the optically thick cloud regions and/or the coarser vertical resolution of AIRS. These results indicate that AIRS is a reliable data set to study the intraseasonal temperature variability in the UTLS over the subtropics and is also a useful data set for a similar purpose near the equator but with a caution of sampling biases.