The Tropical Cold-Point Tropopause derived from the COSMIC GPS measurements

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1. Introduction

Temperature of the tropical cold-point tropopause (T-CPT) has a significant role controlling the amount of water vapor in the lower stratosphere (Mote et al., 1996; Randel et al., 2004). Because of its importance in radiative budget, it has widely been examined in the recent past (Randel et al., 2000; Seidel et al., 2001; Fueglistaler et al. 2009). Most studies have utilized either radiosonde or reanalysis data whose spatial coverage and quality are somewhat questionable.

In this study, we use high-resolution global observations from COSMIC mission for better understanding the climatology, seasonal cycle and intraseasonal variability of T-CPT.

By updating and extending previous studies, it is hope to gain better insights are expected on the spatio-temporal structure of T-CPT and its maintenance mechanism.

COSMIC GPS/RO data

COSMIC is a GPS radio occultation (RO) mission jointly launched by Taiwan and US. It provides high-resolution temperature profiles over the globe: it has been providing ~1800 temperature profiles per day evenly distributed over the globe and ~500 profiles over the tropics since its launch at April 2006.

This study uses recent 4 years of COSMIC data (Sep. 2006 – Aug. 2010)

2. Climatology

In the deep tropics, both CPT temperature (T-CPT) and pressure (P-CPT) are largely homogeneous.

T-CPT shows weak zonal asymmetry which correspond to geographical distribution of deep convections.

T-CPT and P-CPT derived from COSMIC measurements are quantitatively similar to those from radiosonde observations.

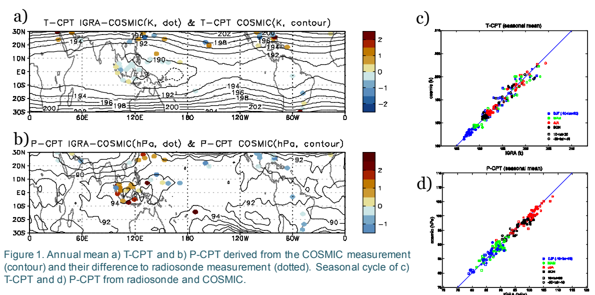

Figure 1. Annual mean a) T-CPT and b) P-CPT derived from the COSMIC measurement (contour) and their difference to radiosonde measurement (dotted). Seasonal cycle of c) T-CPT and d) P-CPT from radiosonde and COSMIC.

3. Seasonal variation

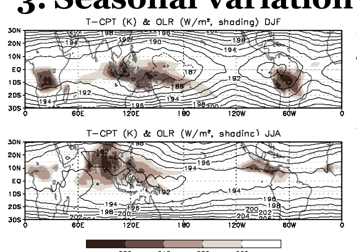

Figure 2. Seasonal mean of T-CPT (contour) and OLR (shaded) in a) DJF and b) JJA.

Seasonal mean T-CPT

The seasonal migration of the regions of minimum T-CPT is largely co-incident with that of minimum OLR.

While spatial pattern of T-CPT is closely related with that of OLR, they are not exactly matched especially during DJF. In fact, three regions of minimum T-CPT are located few degrees north of those of minimum OLR. It indicates that T-CPT is not solely controlled by deep convections.

Seasonal cycle of T-CPT at two seasonal minima (DJF, JJA)

The Seasonal cycles of T-CPT at the western Pacific and Indian monsoon regions are qualitatively similar although convections in the two regions exhibit out-of-phase relationship. It indicates that seasonal cycle of T-CPT is not determined by deep convection. It is instead controlled by zonally homogeneous processes.

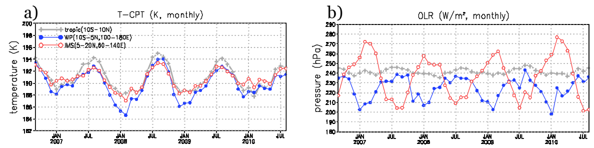

Figure 3. Monthly a) T-CPT and b) OLR averaged over the deep tropics (10°S-10°N), western Pacific (10°S-5°N, 100°-180°E) and Indian monsoon region (5°-20°N, 60°-140°E).

Seasonal cycle of zonal-mean T-CPT

Zonal-mean CPT is generally colder and higher in the boreal winter (DJF) than in the summer (JJA)

This seasonality is likely associated with stratospheric circulation: temperature anomaly in the deep tropics is extended to the stratosphere, contrasting to the possible temperature anomaly driven by synoptic-scale wave forcing in the tropical lower stratosphere.

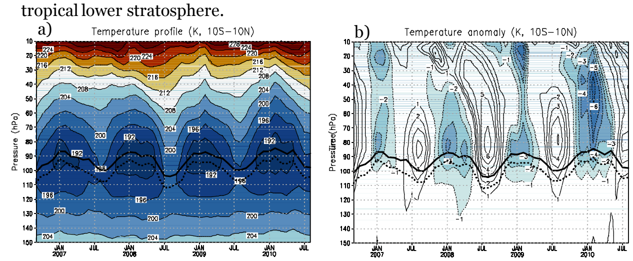

Figure 4. Monthly mean a) temperature and b) temperature anomaly averaged over 10°S-10°N as a function of month and pressure. Thick solid and dotted lines denote cold point tropopause and lapse rate tropopause, respectively.

Locality of the seasonal cycle

T-CPT over eastern Pacific is typically warmer than other regions.

This locality is mostly due to large-scale zonal circulation in the tropical troposphere. A similar locality, however, does not appear in P-CPT.

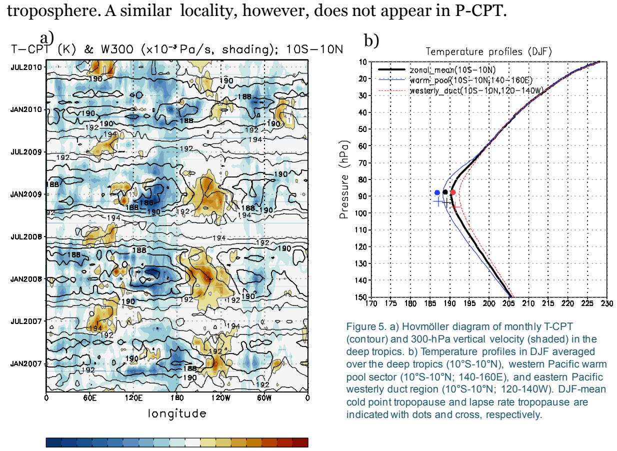

Figure 5. a) Hovmöller diagram of monthly T-CPT (contour) and 300-hPa vertical velocity (shaded) in the deep tropics. b) Temperature profiles in DJF averaged over the deep tropics (10°S-10°N), western Pacific warm pool sector (10°S-10°N; 140-160E), and eastern Pacific westerly duct region (10°S-10°N; 120-140W). DJF-mean cold point tropopause and lapse rate tropopause are indicated with dots and cross, respectively.

4. Intraseasonal variation

Intraseasonal variation of T-CPT is highly associated with the Madden-Julian Oscillation (MJO) and Kelvin waves (e.g. Zhou and Holton, 2002).

The MJO signal is generally weaker than Kelvin waves; wavenumber-frequency spectrum shows pronounced power in Kelvin wave bands.

Kelvin wave signal in T-CPT is likely associated with both free and convectively-coupled waves.

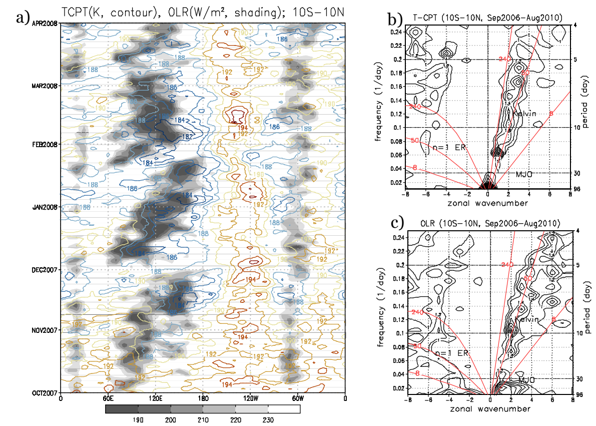

Figure 6. a) Hovmöller diagram of daily T-CPT (contour) and OLR (shaded) in the deep tropics (10°S-10°N) from October 2007 to April 2008. Wavenumber-frequency spectra of b) T-CPT and c) OLR for the whole analysis period (September 2006 – August 2010). Daily data are obtained using 3-day running mean.

5. Conclusions

- COSMIC measurements provide reliable CPT characteristics.
- Geographical distribution of T-CPT is controlled by localized deep convection and large-scale zonal circulation in the tropical troposphere.
- However, its seasonal cycle is largely driven by stratospheric circulation.
- Intraseasonal variability of T-CPT is dominated by MJO convection and Kelvin waves (both free and convectively-coupled waves.
- These results are largely consistent with previous studies based on radiosonde and reanalysis data.

References

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