Impact of Quasi-Biennial Oscillation (QBO) on cold point tropopause temperature and its height in tropics: A COSMIC FORMOSAT-3/GPS study from 2007-2011

by

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Introduction

- The annual cycle of tropical tropopause temperatures and its height is an important feature of the atmosphere.
- QBO effect under its different phases could also be the important aspects to investigate the significant changes in temperature and its height in the tropopause region and can effect this annual cycle.
- We will present effect of QBO on annual tropopause cycle.
- The studies in the past have used various techniques for instance Radar, Radiosonde NCEP re-analysis data. But these observations are dense enough only over land, not over sea, except for few weather balloons launched from ship. Therefore current satellite observations are important.
Unlike radiosonde, the satellite measurements provide us information over land as well as over sea and oceans at a fine spatio-temporal resolution.

**Motivation of the current study:**

- There are various study that have shows the effect of QBO on tropopause temperature but we will present how the QBO can effect the tropopause height and its property in tropics.

- A study of the occurrences of coldest temperature in stratosphere and the temperature structure from pole to pole are presented.
Data Used and Method of Analysis
We use the COSMIC/FORMOSAT-3 Satellite Data from 2007 to 2011.

The mission is called the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) in the United States and the Formosat Satellite Mission 3 (FORMOSAT-3) in Taiwan. It was launched on April 14, 2006 Vandenberg AFB CA.
Characteristics of GPS RO Data

- With the ability of performing both rising and setting occultation, COSMIC/FORMOSAT-3 has been producing approximately 2,500 soundings per day. Such remarkable near-real time data with wide spatial coverage, high vertical resolution (100m), high accuracy (equivalent to <1 K; average accuracy <0.1 K) and almost uniform global coverage over the globe have never been available to atmospheric scientists before.

- COSMIC have good validation with (NCEP), (JRA-25), and the United Kingdom Met Office (MetO) data sets [P. Kishore et al., 2009, JGR]

- Global 3-D coverage of data between surface and 40 km.

- No satellite-to-satellite bias
Results and discussion

Zonal mean seasonal variation of T-CPT over tropics (30°N-30°S):

- We will discussed about the zonal averaged contours of the temperature of cold point tropopause (T-CPT) and height of cold point tropopause (H-CPT) confined between 30°N and 30°S during 2007-2011.

- All occultation are averaged each day over 0-5°N, 5-10°N, 10-15°N, 15-20°N, 20-25°N, 25-30°N latitude bands. Similarly this has been repeated in Southern Hemisphere (SH) up to 30°S.

- Then monthly mean is constructed using daily values.

- The left panels of all Fig. denote the T-CPT starting from 2007 to 2011 while the right panels denotes the H-CPT in respective years.
At each lat. band the coldest T-CPT can be observed during NH winter (DJF).

For all latitude band the maximum height can be observed during NH winter (DJF).

While minimum height can be observed during summer monsoon (JAS).

The warmest T-CPT can be observed during monsoon season (JAS).

The maximum tropopause height can be observed off-equatorial region beyond 15°N and 15°S in both hemispheres with steeper slope (~0.6-1.0km) during winter time in comparison to monsoon season (~0.2-0.5km).

The annul cycle of tropopause temperature is warmer by 6°C-8°C from DJF to JAS and height decreases by .8 to 1.0 Km for the same.
The similar features of annual cycle of tropopause temperature and height can be observed during 2008 and 2009. But the interesting point to be noted is that during 2008 monsoon (JAS) when the T-CPT is warmer by 2°C and height decreased by .5 Km in comparison to 2007, 2009 and other years 2010, 2011 that shown later.
During 2010 summer monsoon season the T-CPT cools by 2°C and corresponding increase in height by .5 km can be observed in left panel.

The interesting point to be noted is that off-equatorial maxima property disappears during summer season when T-CPT cool by 2°C.

Another interesting point to be noted is that during 2011 that tropopause height of winter and monsoon season are same and summer season is colder in comparison to winter.
The point to be noted from above results

1. The annual cycle of tropopause temperature is warmer by 6°C-8°C and from winter (DJF) to (JAS) and height is decreases by .8 to 1.0 Km.

2. The decreases in H-CPT from DJF to JAS shows that wave motion from surface side (equatorial planetary Rossby waves Kerr-Munslow and Norton [2006] or BDC circulation Ueyama and Wallace (2010) but it yet to conclude what is possible causes for this tropical tropopause annual cycle ) is stronger during winter (DJF) in compression to monsoon (JAS).

3. This tropopause annual cycle of H-CPT is increased by .5 km during 2008 monsoon when T-CPT warmed by 2°C
5. The off-equatorial property of tropopause height is disappears during 2010 monsoon (JAS) when the tropopause temperature cool by 2°C in comparison to other years. Any other motion may be available during this period and effecting this off-equatorial maxima property.

6. During 2011 the H-CPT is almost same as in winter and monsoon season. The annul variation of H-CPT is corresponding to .2 km. There may be any motion from stratospheric side that cancelling the effect of surface side motion those are responsible for increasing the H-CPT during winter. The strength of both motion is almost same.

QBO effect may be one of the key components, that responsible for above variation. we calculate the QBO from 2007-2011 in same temperature data at equatorial region(10°N-10°S) because QBO is most effective in this region.
Parabolic structure of T-CPT during different years from 30° N to 30° S.

The inter-seasonal variability (annual cycle) in T-CPT and H-CPT is examined in the presence of westerly and easterly phases of QBO signature.
The control of T-CPT and H-CPT operates via mechanism suggested by Collimore et al. [2003] and shown in blow fig. The westerly and easterly phases of QBO in the meridional direction constitutes a secondary circulation; westerly (easterly) phase over equator suppresses (expands) the H-CPT through convergence (divergence) process and as a result the off-equator H-CPT shifts upward (downward).

Adapted from collimore et al. 2003

Deceases in tropopause height by .5km can be observed during 2008 and 2011 when QBO westerly phase hit the Tropopause.

This results during 2011 shows that the strength of QBO from upward side is almost same as downward motion those are responsible for increasing the height during winter times. So upwards motion is as well as strong as downward motion. Before conclude anything about the tropopause annul cycle we should consider QBO phase.

During 2011 when westerly phase hit tropopause in winters times the tropopause height at equator is almost same during winter and monsoon and off equatorial maxima is steeper by .5 Km in winter.
Easterly phase can decrease tropopause height at equatorial region and produces unfavorable condition for off-equator maxima.

Increase in tropopause height by 0.5 km can be observed during 2010 monsoon when easterly phase of QBO hit the tropopause.

Figure Adapted from Collimore et al. 2003

During 2010 when easterly phase hit tropopause in monsoon (JAS) the off-equatorial maxima property disappears and same H-CPT can be observed from equator to tropics region.
The concluded points are:

1. The annual cycle of T-CPT and H-CPT is found to be influenced by QBO in which westerly (easterly) phase favors warm (cool) T-CPT with a decrease (increase) in H-CPT. It is concluded that the QBO induces the changes in T-CPT by as much as 2°C and in H-CPT by 0.5 km.

2. Before concluding anything about the annual cycle of tropopause we should consider QBO phases.

3. The QBO strength from stratospheric side is equivalent to the wave motion from surface side which are responsible for increasing the tropopause height during winter times.
4. The QBO westerly (easterly) can produce favorable (unfavorable) condition for off-equatorial maxima not responsible for this property. This property disappears during easterly phase and increases its amplitude during westerly phase. These are first unique observational results that discussing about this off-equatorial property variation.

5. The QBO has a remarkable strength (almost .5 Km) at equatorial region. So that before concluding about the increasing trends of global tropopause height that is reported by 4–7 m/yr, we should count the QBO effect.

6. These are unique observed results of QBO on tropopause height that is observed by COSMIC data which shows the demonstrational potential of COSMIC mission.
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