◆ Analysis of the Tropical Tropopause Layer using the global nonhydrostatic atmospheric model

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Introduction

- Stratospheric water vapor mixing ratio is determined by both dynamics and transport in the TTL [Tropical Tropopause Layer]. Various scales processes control the dehydration in the TTL.

We attempt to understand the effective processes with small to planetary scales controlling the TTL dynamics and dehydration using the **'global'** and **'nonhydrostatic'** cloud resolving atmospheric model, **NICAM**.
various dynamical processes

- convection [> 3.5 km]
- organized convection [planetary scale]
- gravity waves
- equatorial Kelvin waves

Topics …

1. Cloud top Height Statistics.
2. Major Disturbances in the TTL.
3. Water vapor in the TTL.

NICAM

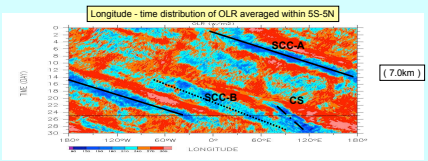
[Nonhydrostatic Icosahedral Atmospheric Model]
Explicit W calc.; No cumulus parameterization.
Cloud microphysical scheme : (Grabowski, 1998)

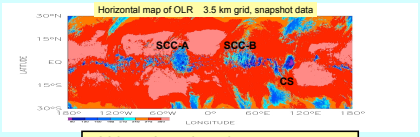
- Horizontal spacing : 3.5 km,7.0km,14.0km
  Vertical spacing : 700 m in the upper troposphere.
- Aqua planet condition
- Radiation : Equinox condition
- SST : Neale and Hoskins (2000)
  - uniform in zonal
  - 27 ℃ at the equator and decreasing with latitude

In this study…

- 3.5km [snapshot data]

Initial condition of 3.5 km grid were interpolated from 7.0 km grid results on 20th day. 3.5 km snapshot data consist with 7.0 km grid data on 25th day.
7.0km [time series data, 3hr mean , interval of 3hr, during 30 days]

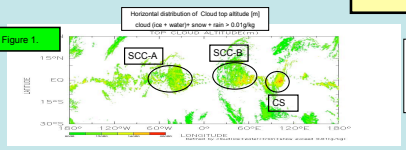




- SCC – B [Super Cloud Cluster] is consisted of CCs [Cloud Cluster] with 500 km scales.
  ※ hierarchic structure
  [Nasuno et al. 2008, using the same data]
- The zonal phase speed is SCC-A for 17 m/s, and SCC-B for 17 m/s and CS [Convective System] for 12 m/s.

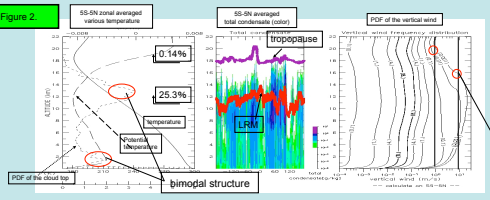
1. Cloud Top Height Statistics

Figure 1.



- Deep convection is mainly found in the 5°S – 5°N.
- The highest cloud top altitude of SCC – A reaches 14 km
- The highest cloud top altitude of SCC – B reaches 16 km
- The highest cloud top altitude of CS reaches 18 km.
  CS overshoot the tropopause [not shown].

Figure 2.



- Mean tropopause height is 18.2 km
- Mean TTL bottom boundary [LRM] is 11.2 km.
- Bimodal structure is found in cloud top distribution.
- Frequency of cloud top altitude higher than 11.2 km is 25.3 %.
- Frequency of cloud top altitude higher than 18.2 km is 0.14%.
- Cumulus clouds often penetrate the bottom of the TTL (LRM)
- Strong vertical winds rarely exist above 16km.

TTL bottom boundary

Figure 3.

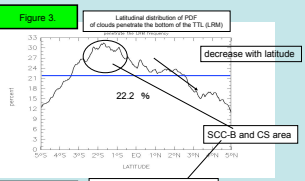
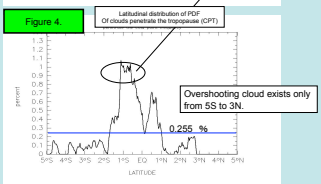


Figure 4.



2. Major Disturbances is in the TTL.

3.5 km snapshot data

Figure 5.

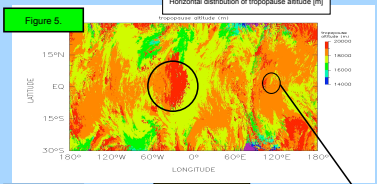


Figure 6. Kelvin waves

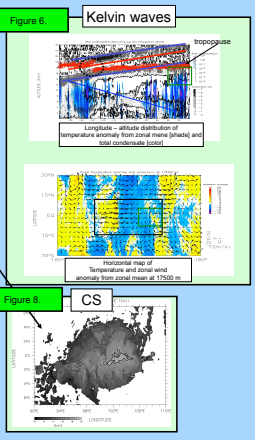


Figure 7. gravity waves

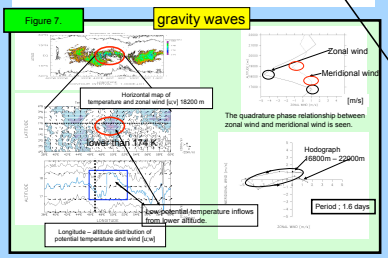
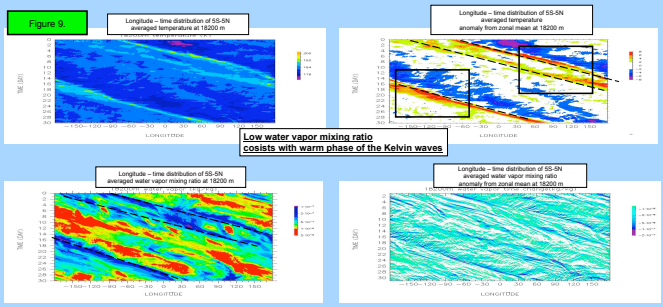


Figure 8. CS

7.0 km time-series data

Figure 9.



Low water vapor mixing ratio cosists with warm phase of the Kelvin waves

3. Water Vapor is in the TTL

3.5 km snapshot data

Figure 10.

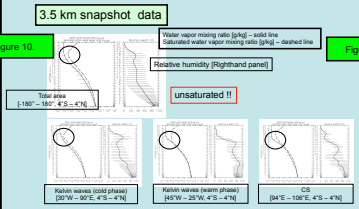
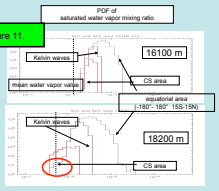
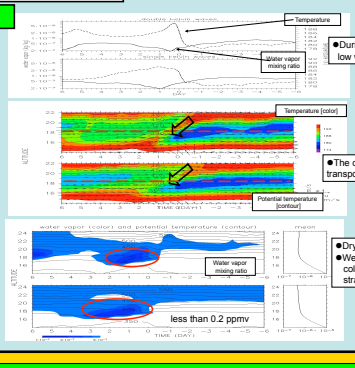


Figure 11.



7.0 km time-series data

Figure 12.



- During the warm phase of the Kelvin waves, low water vapor mixing ratio is found.
- The downward displacement of the Kelvin waves transports the dry air into the TTL.
- Dry air is transported from 22 km into 16km.
- We can't estimate the dehydration effect of the cold phase of the Kelvin waves, because dry stratospheric air has mixed with air in the TTL.

Summary

We investigated the cloud top height statistics, major disturbances in the TTL and water vapor in the TTL, using the nonhydrostatic atmospheric model, NICAM.

- 22.2 % of clouds overshoot the TTL bottom boundary, and 0.14 % overshoot the tropopause. (For reference, Fig. 2, 3, 4)
- Major disturbances in the TTL are the Kelvin waves, gravity waves and CS. The large-scale deformation of the tropopause is associated with the Kelvin waves. (Fig. 5, 6, 7, 8)
- Gravity waves superimposed on the cold phase of the Kelvin waves are one of the important dehydration process. (Fig. 6, 7)
- Storatospheric air in this model is too dry. The stratospheric air may not attain the equilibrium. [cf. Mote 1995] (Fig. 10, 11.)
- Kelvin waves transport dry air from the lower stratosphere into the TTL (Fig. 9, 12).
- Air transport, water variation in the TTL are all mainly caused by the Kelvin waves. The Kelvin waves excited by organized convection are prominent process in the TTL in this model. (Fig 6, 9, 12)