Role of Equatorial Kelvin Waves, Organized Convections, and Cumulonimbus Clouds in the Tropical Tropopause Layer

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Introduction

• Equatorial Kelvin waves affect TTL (Obs.)
  Cold-point-temperature modulation (Tsuda et al., JGR, 1994)
  Ozone transport (Fujiwara et al., JGR, 1998)
  Cirrus clouds modulation (Boehm and Verlinde, GRL, 2000)
  Water vapor control ("dehydration pump") (Fujiwara et al., GRL, 2001)
  Turbulence generation (Fujiwara et al., GRL, 2003)

• Kelvin waves are dominant around the tropical tropopause
  (Madden and Julian, JAS, 1972; Parker, QJRMS, 1973)

• There is a strong connection between
  Organized Cumulus Clouds and the
  Large-scale Tropopause-level Disturbances

• → Two Global Model Experiments
Experiments

(1) CCSR/NIES AGCM  (Fujiwara and Takahashi, JGR, 2001)
T42 (~2.8 x 2.8 deg.), 60 vertical layers (550 m spacing in UT-LS)
Realistic Topography and Annual Cycle of SST
Arakawa-Schubert Cumulus Parameterization
Simplified Ozone Photochemistry
Analyzed data: Daily averages, 4 years

(2) NICAM (Nonhydrostatic ICosahedral Atmospheric Model) for the Earth Simulator
Global cloud-resolving calculations
3.5-km horizontal spacing (in this study), 54 layers
Aqua planet (in this study); SST (Neale and Hoskins, 2000)
Microphysics Parameterization (Grabowski, 1998; Lin et al., 1983)
Analyzed data: Snap shot
A case over the Indian Ocean in northern summer:
Kelvin wave around the tropopause coupled with organized convection
Latitude: 1.3953N (equator)  [Fujiwara and Takahashi, JGR, 2001]
Latitude: 1.3953N

[Fujiwara and Takahashi, 2001]
• Seasonal and longitudinal characteristics:
  Large-scale, eastward-moving disturbances are dominant around the tropical tropopause
[Fujiwara and Takahashi, 2001]
NICAM 3.5-km Aqua Planet 1/3

- 3.5-km horizontal spacing; 700-m vertical spacing in TTL
- Aqua planet; SST (Neale and Hoskins, 2000)
- Microphysics Parameterization (Grabowski, 1998; Lin et al., 1983)
- Analyzed data: Snap shot
NICAM Aqua-Planet Experiment

Initial Conditions (Day 0): CCSR/NIES/FRCGC AGCM climatology

Spin-up time NICAM

Data for Analysis

Day 0

Day 60

Day 90

14km grid

7km grid

3.5km grid

interpolation

30-day period

interpolation

10-day period

3.5-km data on DAY 85 (Snapshot) is analyzed in this presentation
NICAM 3.5-km Aqua Planet 2/3

• Cloud Maps (OLR, total condensate) and Cold-point Tropopause Distribution
TOP CLOUD ALTITUDE (m)

LATITUDE

15°S

30°S

LONGITUDE

180° 120°W 60°W 0° 60°E 120°E 180°

Defined by cloud(ice+water)+rain+snow exceed 0.01(g/kg)
• Impact on TTL: Kelvin-wave Generating Clouds vs. Penetrating Clouds

• Definition of the TTL Lower Boundary: Temperature Profile vs. Vertical Wind vs. Total Condensate
Summary

• Various tropical cloud organizations → different impact on TTL
• Large-scale Kelvin wave signals vs. Locally penetrating clouds

• Definition of the TTL lower boundary: Temperature profile vs. vertical wind vs. total condensate
• Vertical wind data is a good indicator for the TTL lower boundary