1. Introduction

- Vertically thin layers
  - Reported by radiosondes and airborne observations
  - Right panel: An example over the tropical eastern Pacific (Shiotani et al. 2002)
- Water vapor in the tropics
  - Important for convectons and radiation
  - Limited in-situ observations over ocean
- Formation of thin layered structures
  - Study using minor constituents (e.g., a) and

2. Formation of moist layers by advection

- Necessary condition at the central altitude of the layers: $q'' < 0$
- When $q''$ is a positive tracer, $0 < q'' < 0$ or $q'' > 0$
- Thus, $Dq'' < 0$

3. Model description

- NGAR/PSU MM5 Version 3.6:
  - 2-way nesting
  - Input:
    - NCEP Final Analysis (1° x 1°)
    - 62 levels from surface to 10 hPa
- Duration:
  - Case 1: Calculation period: 1.5 days (26-29 Sep 1999)
  - Case 2: Calculation period: 2 years (1 Jan 2005 - 31 Dec 2006)

4. Case 1 (26-29 Sep 1999)

- Horizontal distribution of the source terms, Streamlines, and the thin moist layers
  - $t = 45$ h (27 September 1999 21:00 UTC)
  - $a = 0.151 (a \sim 5 km)$
  - Red: formation of the layers / Blue: destruction


- Frequency of extreme values for $\delta RH/\delta z$ and sum of the source terms
- Frequency of extreme values of source terms
  - Threshold: $-5\times10^{-4} \text{ m}^2 \text{s}^{-1}$
  - Vertical distribution
  - Each season
  - Compression term contains wavy motions.
  - Vertical-advection term and radiation term are not dominant.

6. Summary

- Diagnosis on formation of thin moist layers
  - Formation of the layers by advection is classified to four types
  - Formation of new layers: Intrusion and Linear shear
  - Enhancement and maintenance: Compression
  - Application to the numerical experiments over equatorial eastern Pacific:
    - Intrusion: dominant at 5 and 15 km in altitude
    - Linear shear: dominant at 15 and 9.5 km in altitude
    - Detrainment from cumulus convolutions and the distribution of water vapor may be responsible.

- References:

7. Analysis method

- Necessary condition at the central altitude of the layers: $\partial^2 q''/\partial z^2 < 0$
- When $q''$ is a positive tracer, $0 < q'' < 0$ or $q'' > 0$
- Thus, $\partial^2 q''/\partial z^2 < 0$

- A layer can be formed if the value above is negative.
- We used relative humidity (RH) instead of mixing ratio $q$. 

8. Vertical distribution

- Study using minor constituents (e.g., a) and

9. Intrusion

- Vertical advection

- Source terms in RH

- Vertical advection

- Compression

- Intrusion

- Linear shear

- Compression

- Intrusion - Linear shear

- Linear shear

- Compression

- Layered structure

- Schematic image of the shear flow in this case.

- RH & winds

- Intrusion (S)

- Vertical advection (S)

- Linear shear (S)

- Compression (S)

- Layered structure

- Schematic diagrams of vertical cross sections. Colors show humidity.

- Linear

- Green circles

- Intrusion

- Compression

- Linear shear

- Intrusion - Linear shear

- Linear shear

- Compression

- Layered structure

- Schematic diagrams of vertical cross sections. Colors show humidity.