Tropospheric Relative Humidity and Tropical Cumulus Congestus Clouds as viewed in Collocated AIRS/CloudSat data

Sean P.F. Casey, Andrew E. Dessler and Courtney Schumacher
Department of Atmospheric Sciences
Texas A&M University

AIRS Science Team Meeting
May 06, 2009
Johnson et al. (1999)
Kikuchi and Takayabu (2004) found distinct MJO stages in convection over the west Pacific, including:

- Shallow convection stage
  - Low cloud-top heights
  - Low middle and upper tropospheric humidity
- Developing stage, dominated by congestus
  - Cloud-top heights predominantly in the middle troposphere
  - Midtroposphere moistening
- Mature stage, dominated by deep clouds
  - High cloud tops
  - High middle and upper tropospheric humidity
The Big Question: What is the interplay between tropical convection and atmospheric relative humidity?

Implications for:
• Water Vapor amounts/feedbacks
• Cloud parameterizations within GCMs
• Many more fields of study
CloudSat provides a 2B-GEOPROF-LIDAR product which allows easy use of collocated CloudSat/CALIPSO data to view all clouds, from subvisible cirrus to deep convection.

Stephens et al. (2002)
New AIRS/CloudSat collocated product

- Collocates 172 variables of AIRS L2 Standard data with CloudSat 2B-GEOPROF
- January 2007 completed; used here
- Connects relative humidity values to observed clouds
Advantages/Disadvantages of:

**AIRS**
- Wide swath width
- ~45 km\(^2\) footprint
- Maximum of two cloud layers

**CloudSat**
- Nadir-only view
- ~1 km\(^2\) footprint
- Total column view of clouds available

Casey et al. 2007
Determining Convective Features

1. Cloud identified as “cloud certain” (cloud mask = 40) for entire depth of cloud

2. Maximum reflectivity ≥ 10 dBZ (proxy for convection [Luo et al. 2008])

3. CALIPSO-measured cloud-top height (CTH) within 1 km of Cloudsat-measured cloud-top height (proxy for optically-thick cloud [Luo et al. 2008])
However, Cloudsat provides a *snapshot* of cloud height.
However, Cloudsat provides a *snapshot* of cloud height

Me, today
Luo et al. 2009

Transient Congestus

Terminal Congestus
Conversion from Snapshot to Final Cloud Heights using Geostationary Satellites

- NCEP/AWS Global Infrared Geostationary Composite (from GHRC)
- Combines geostationary satellites (with exception of GMS; data gap around 70° E)
- 14-km resolution, 30-minute time intervals
Using this, we noted that ~25% of observed congestus are transient.
Including AIRS Data

• Using observed geometric heights and minimum $T_B$, separate identified convective features into:
  – Shallow
  – Terminal Congestus
  – Transient Congestus
  – Deep

• Determine mean RH in the presence of each cloud type
  – Only regions where Qual_H2O=0 or (Qual_H2O = 1 and PBest > 600 hPa)
- Notable difference in terminal, transient congestus curves
- Virtually no difference between transient congestus, deep curves...because they describe the same cloud!
Shallow Convection Stage:
- Moist below 850 hPa
- Dry middle, upper troposphere
Developing (Congestus) Stage:
- RH increases to 60% at 600-700 hPa level
- 10% increase in upper troposphere
Mature (Deep) Stage:
- Further moistening of atmosphere above 600 hPa
- Little change below 600 hPa from developing (congestus) stage
With Just One Month (and a lot of quality flags)

- Demonstrated the need to separate terminal from transient congestus clouds
  - Transient congestus = deep clouds
- Identified cloud types with given relative humidity profiles (in agreement with Kikuchi and Takayabu [2004])
Future Work

An expansion of the AIRS/CloudSat collocated dataset will allow for a variety of other studies, including:

• Seasonal, regional variations of
  – Cloud amount
  – Cloud type
  – Relation to upper tropospheric relative humidity

• Backtrajectory analysis of sources of drier air aloft, similar to midtropospheric dry air analysis in Casey et al. [2009; in publication]
Any Questions?