



National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

A Multi-Sensor Water Vapor Climatology

**Eric J. Fetzer, Evan F. Fishbein, Brian H. Kahn, Bjorn
Lambrigtsen, Joao Teixeira, Bill Read and Brian D. Wilson**

Jet Propulsion Laboratory, California Institute of Technology

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Eric.J.Fetzer@jpl.nasa.gov



Our MEaSUREs Proposal

ROSES 2006

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MEaSUREs

WATER VAPOR CLIMATE RECORD

A Multi-Sensor Water Vapor Climate Data Record Using Cloud Classification

Eric J. Fetzer, Evan F. Fishbein, Brian D. Wilson, Joao Teixeira, Brian H. Kahn, Bjorn H. Lambrechtsen, William G. Read and Tim Barnett

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What

- **Create a merged, reconciled record of water vapor from all sensors, but relating clouds and water vapor.**
- **We are coordinating with the NVAP project.**
 - ***We will provide a 'seamless' record between earlier sensors (TOVS, SSM/I) and A-Train.***
 - ***Our Grand Goal:*** Extend back into the disco-era TOVS data.



Some Questions

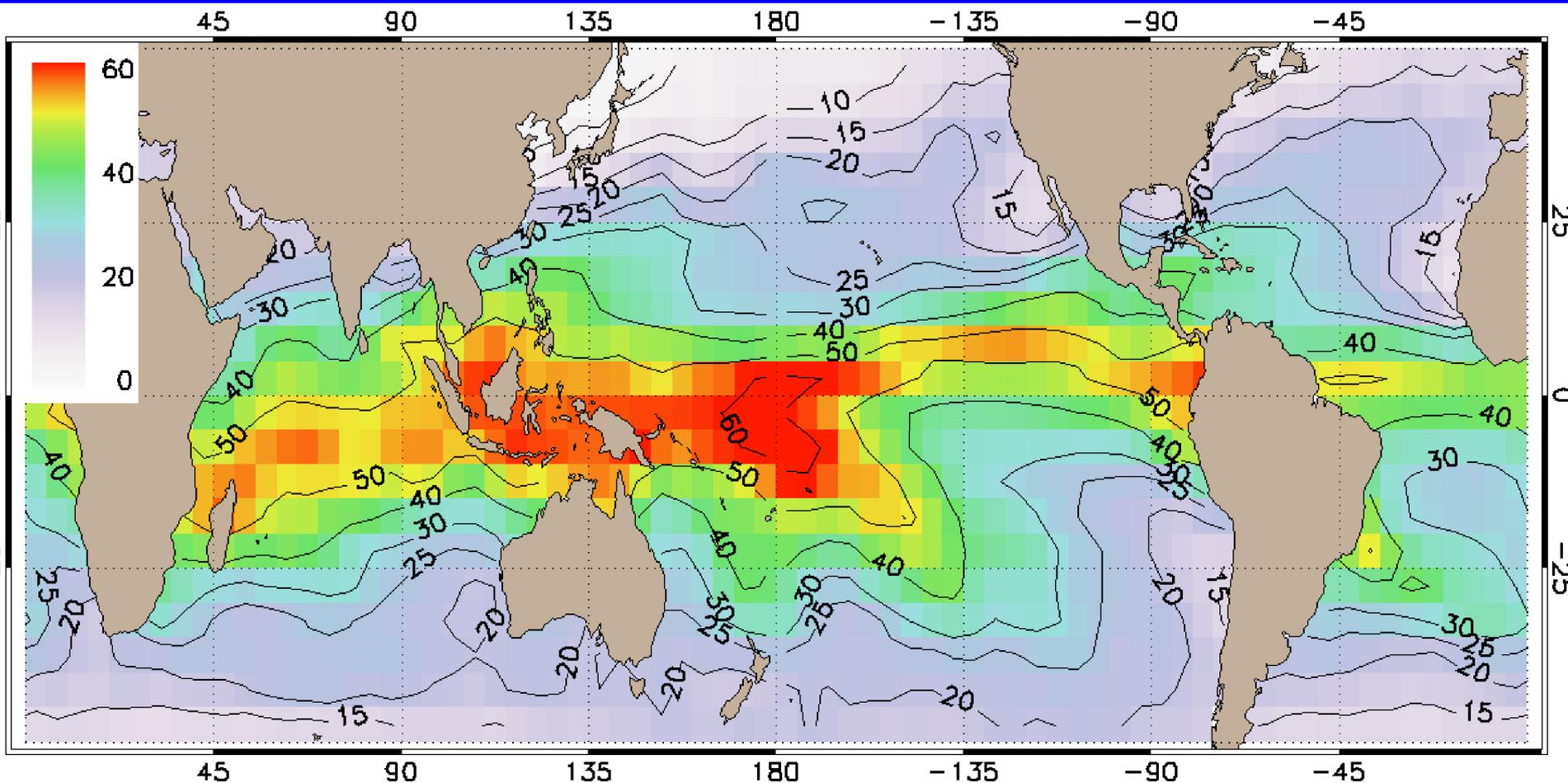
- **Can we simultaneously monitor water vapor and changes in its viewing conditions (due to clouds in the IR, precip in the MW), over years to decades?**
- **How do moist thermodynamics vary with cloud state?**
 - *Climate model physics is regime dependent.*
- **Is the relationship between cloud state and water vapor universal?**
- **How dominant are effects in the radiatively important middle and upper troposphere?**
- **How precise and accurate should earlier sounders be to separate trends in water vapor by cloud state?**
 - *Assuming cloud state can be well characterized by ISCCP or similar observations.*



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Background: AIRS Mean Total Water Vapor 25 Dec 02-9 Jan 03



Fetzer, E. J., et al., 2006: Biases in total precipitable water vapor climatologies from Atmospheric Infrared Sounder and Advanced Microwave Scanning Radiometer, *J. Geophys. Res.*, 111, D09S16, doi:10.1029/2005JD006598.

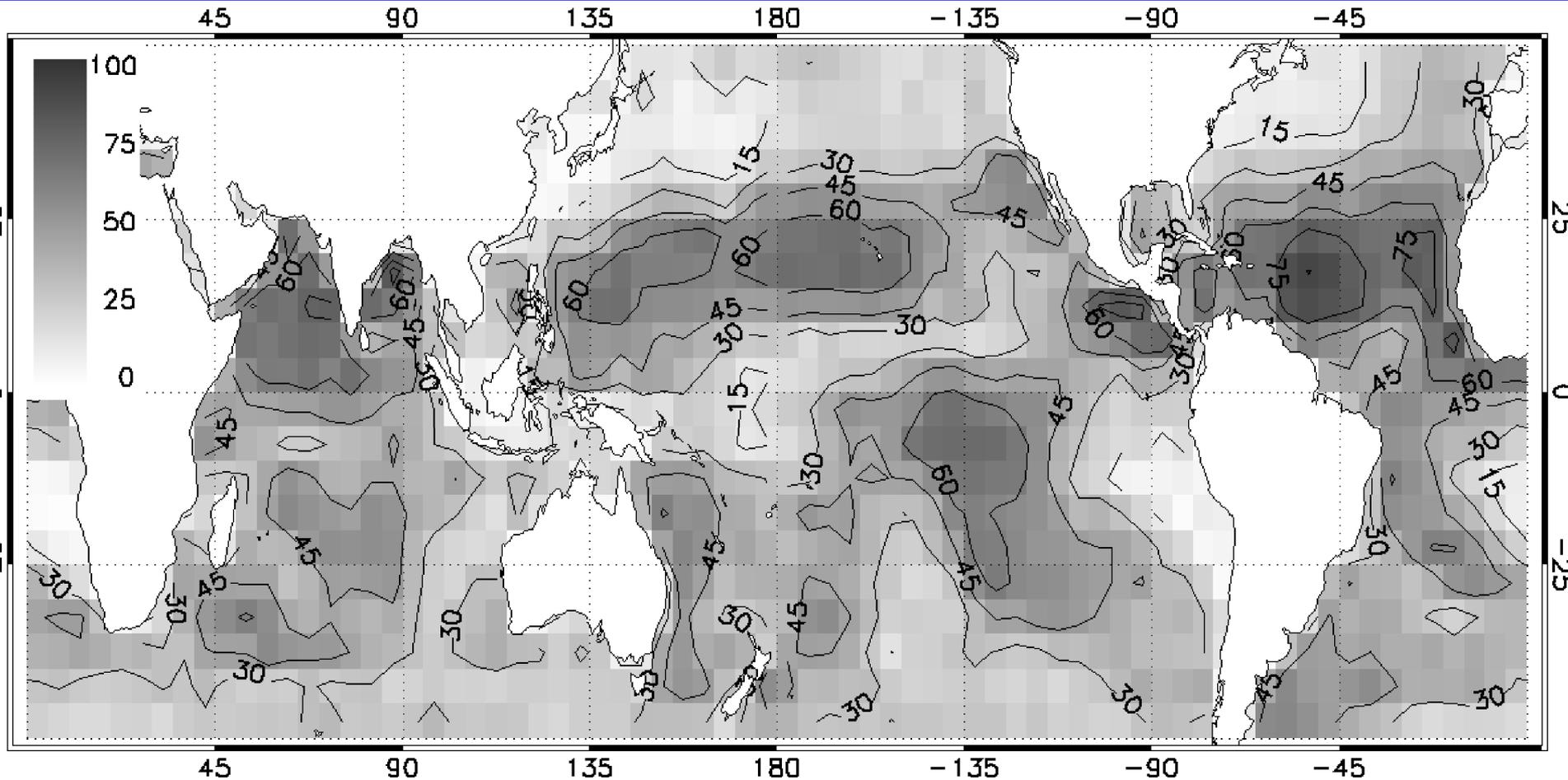


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Fraction of AIRS Profiles in Mean (Yields)

25 Dec 02-9 Jan 03



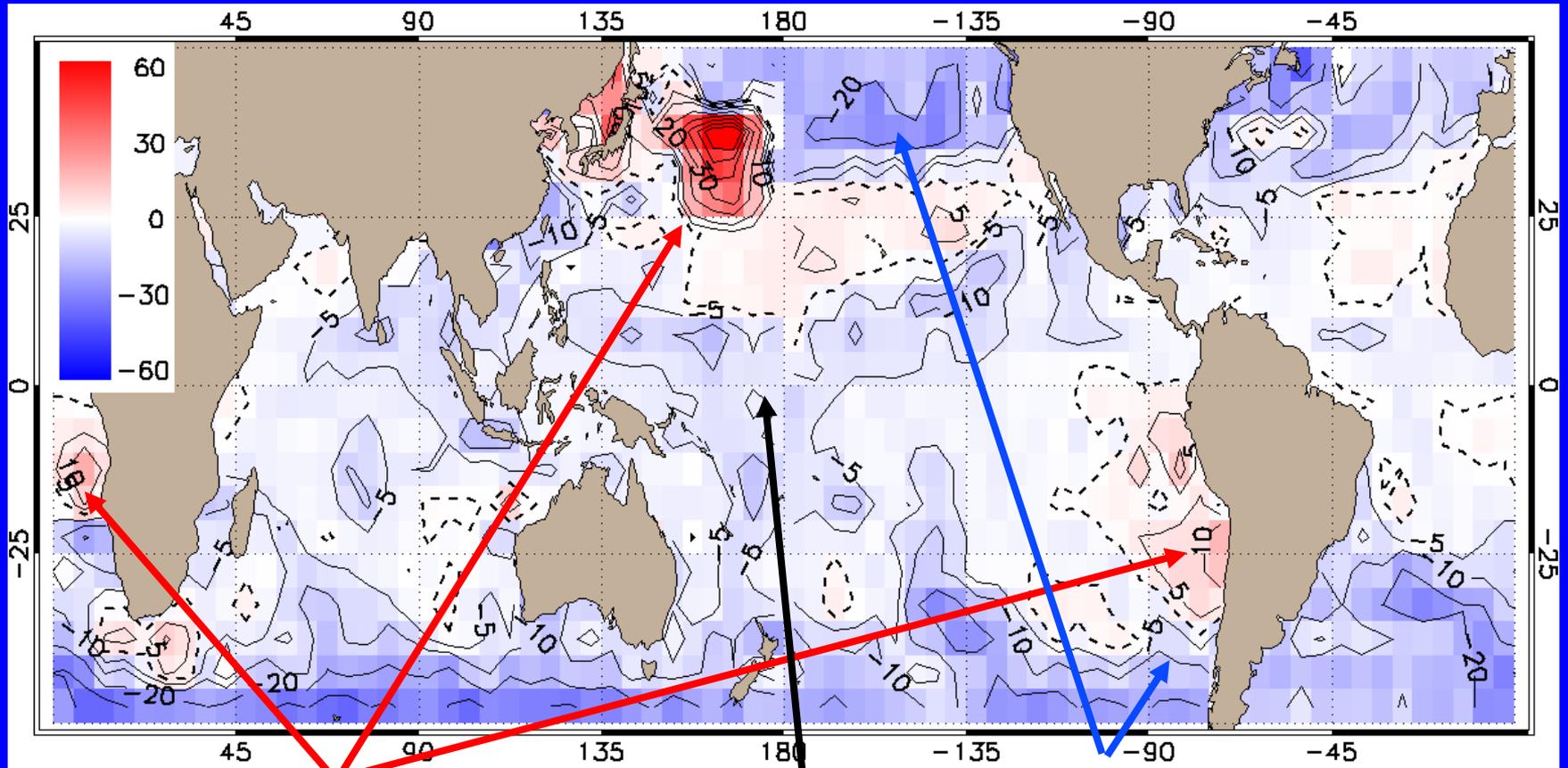
Fetzer, E. J., et al., 2006: Biases in total precipitable water vapor climatologies from Atmospheric Infrared Sounder and Advanced Microwave Scanning Radiometer, *J. Geophys. Res.*, 111, D09S16, doi:10.1029/2005JD006598.



Percent Differences in Mean Water Vapor Climatologies

**AIRS can be drier OR wetter than AMSR-E
because of cloud-induced sampling effects**

25 Dec 2002 to 15 Jan 2003



AIRS climatology is *wetter*
than AMSR-E in stratus regions

Small difference
in tropics !!??

AIRS climatology is *drier*
than AMSR-E at high latitudes



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What the AMSR-E comparison suggested.

- **At high latitudes, AIRS is biased dry because clouds imply more water vapor.**
- **For extensive low clouds, AIRS samples wet because clouds imply *less* water vapor.**
- **In the tropics, AIRS sampling is unbiased**
 - *Because wet, cloudy scenes are infrequent?*
 - *Because clouds imply neither dry nor wet?*

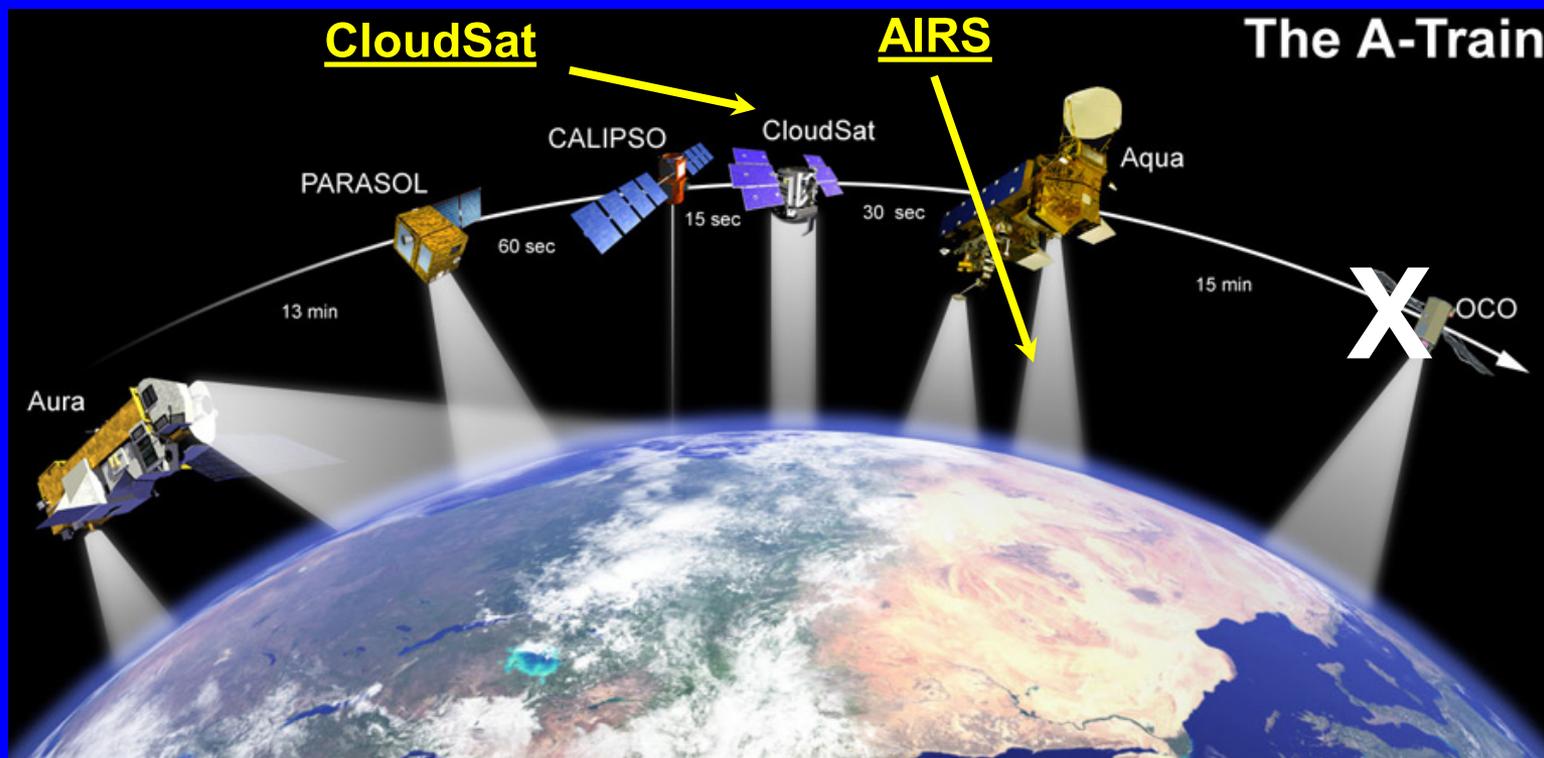


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Showing Data from Two *Independent* Instruments (Same data was shown by Sean Casey yesterday)

1. Atmospheric Infrared Sounder (AIRS) water vapor profiles.
2. CloudSat cloud classes overlie AIRS near nadir.





Relate Cloud State and Water Vapor Tropics 15S-15N, Oceans Only

Combining CloudSat cloud classes and AIRS water vapor observations.

- ***Traditional***
 - space time summaries from single instrument.
- ***Our approach***
 - *summaries of AIRS water vapor based on CloudSat cloud classes.*

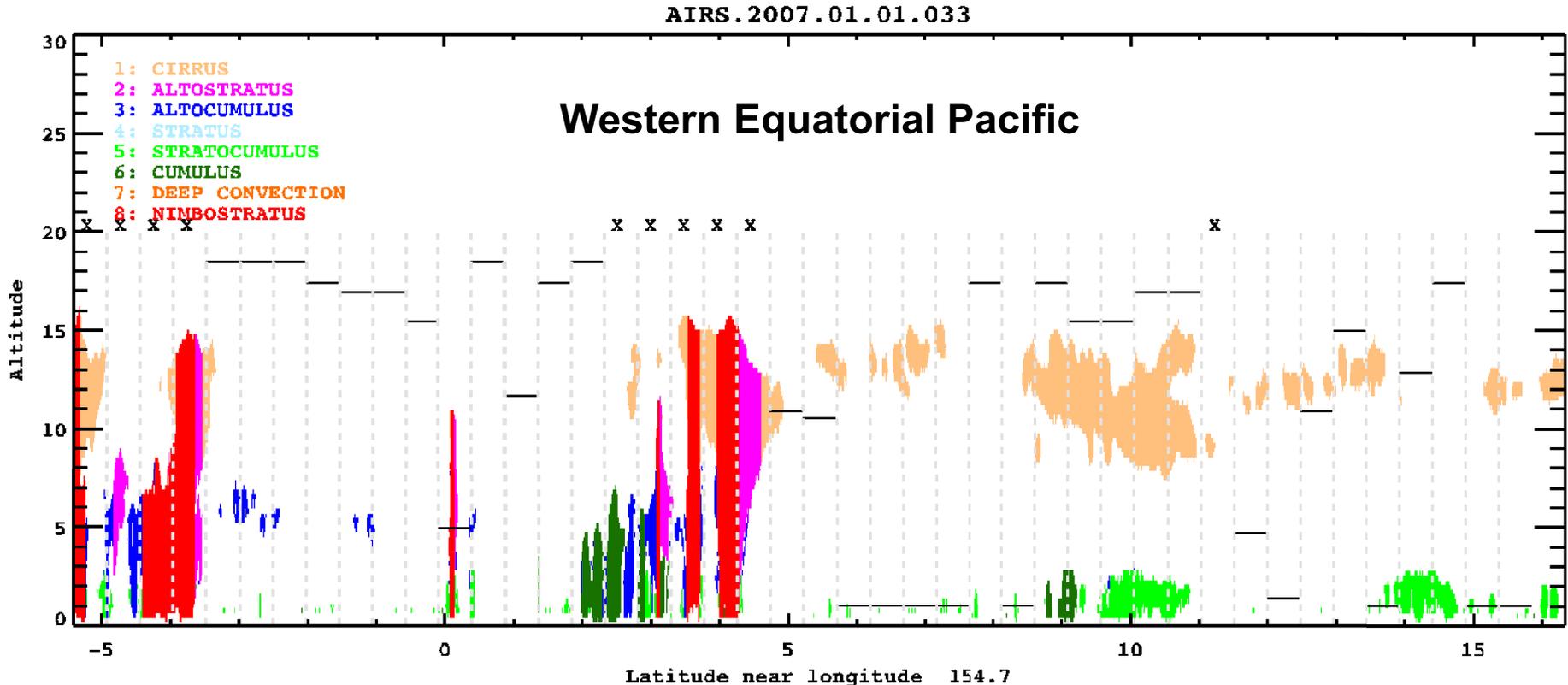
Why only the tropics?

- **Water vapor feedbacks strongest there.**
- **The following CloudSat groupings easily account for most AIRS scenes in the deep tropics:**
 - ***Shallow convection (three classes).***
 - ***Deep convection (five classes).***
 - ***Few unclassified scenes remain.***



AIRS-CloudSat Matched Data

Color fill = CloudSat Class (Sassen and Wang, 2008, GRL)



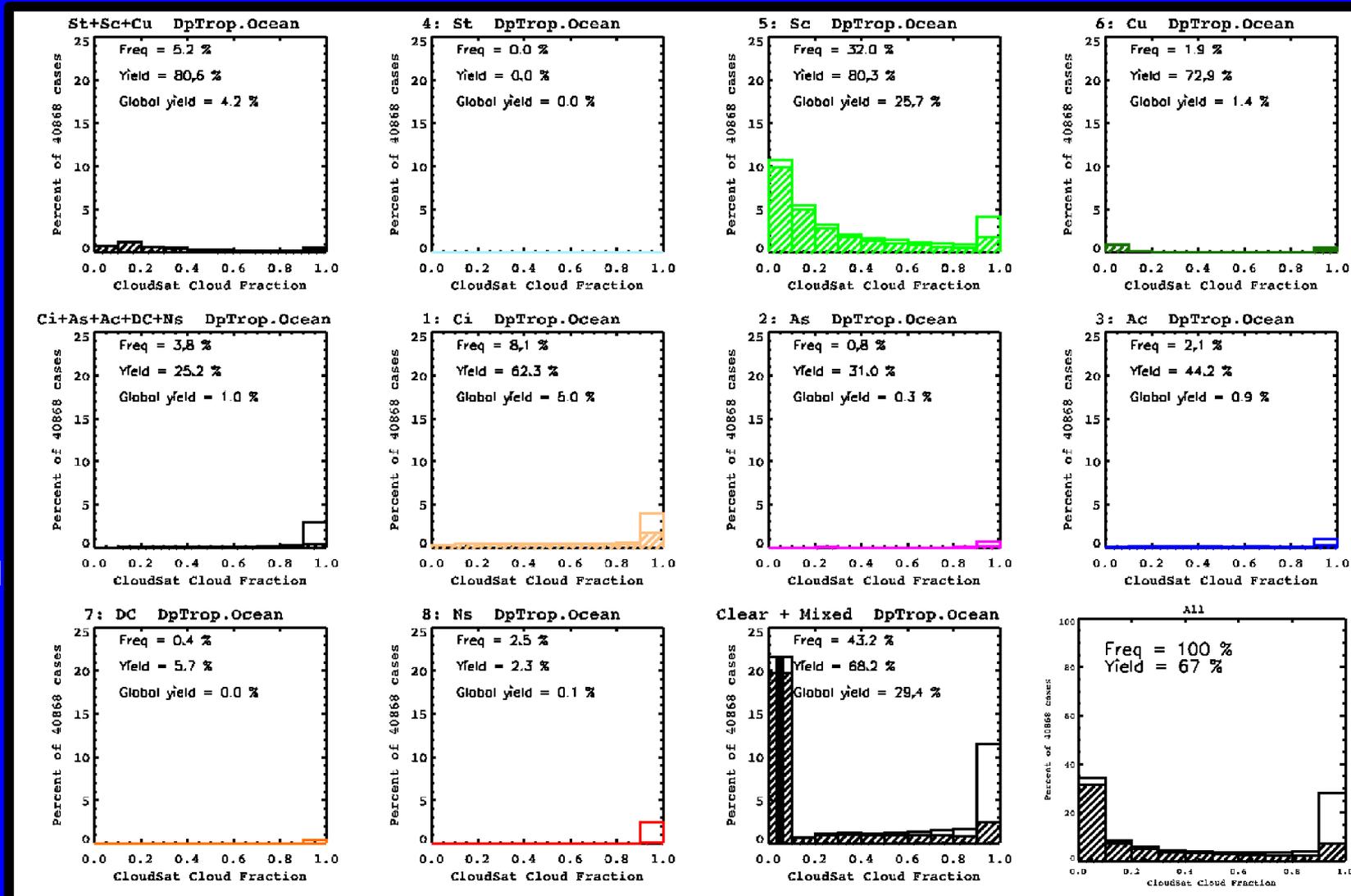
Black lines: AIRS 'best' retrieval altitude
X: no AIRS tropospheric profiling.



Relating AIRS retrieval performance to CloudSat cloud class and fraction *January 2007, 15S-15N, Ocean only*

No Fill:
percent of
AIRS scenes
of that
CloudSat
cloud type &
fraction.

Fill:
percent of
AIRS scenes
with retrieval
to surface.





Confirming AIRS Retrieval Performance Varies with CloudSat Cloud Class

1) Shallow Clouds

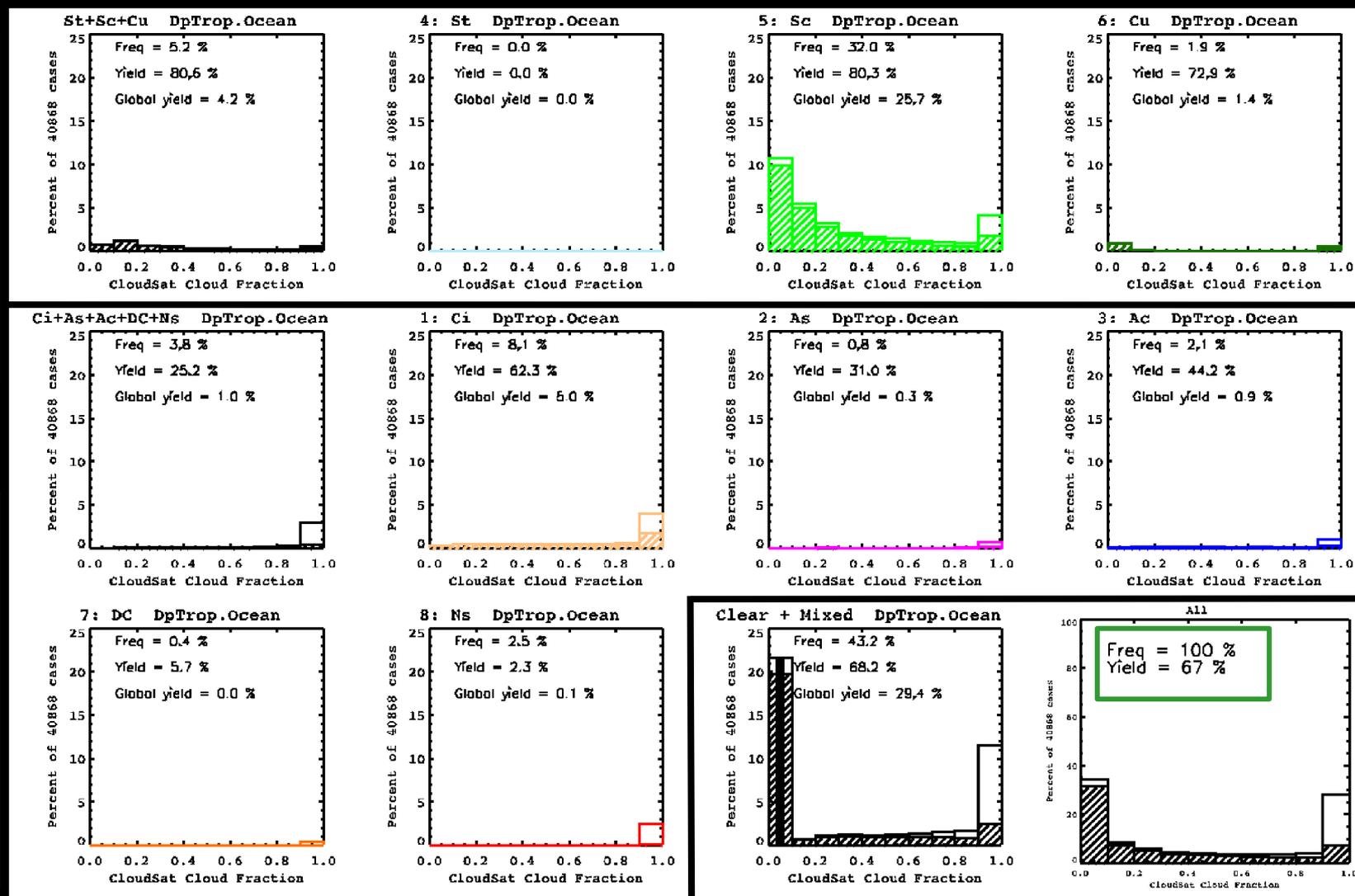
40% of all scenes

Yields are ~80%.

2) Deep Clouds

17% of all scenes

Yields are ~2 to 63%.



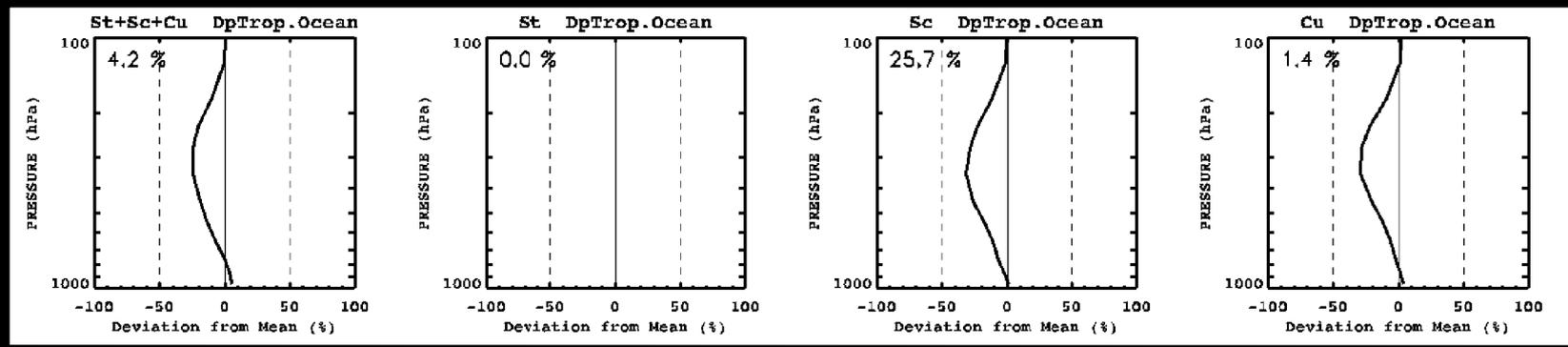
3) Clear & Mixed; ~43% of scenes; Yield is 68%.



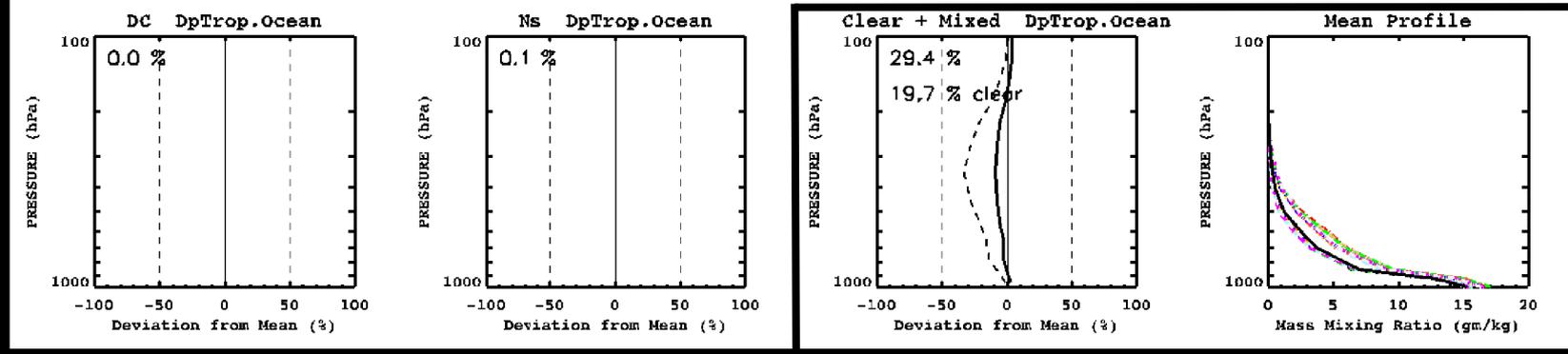
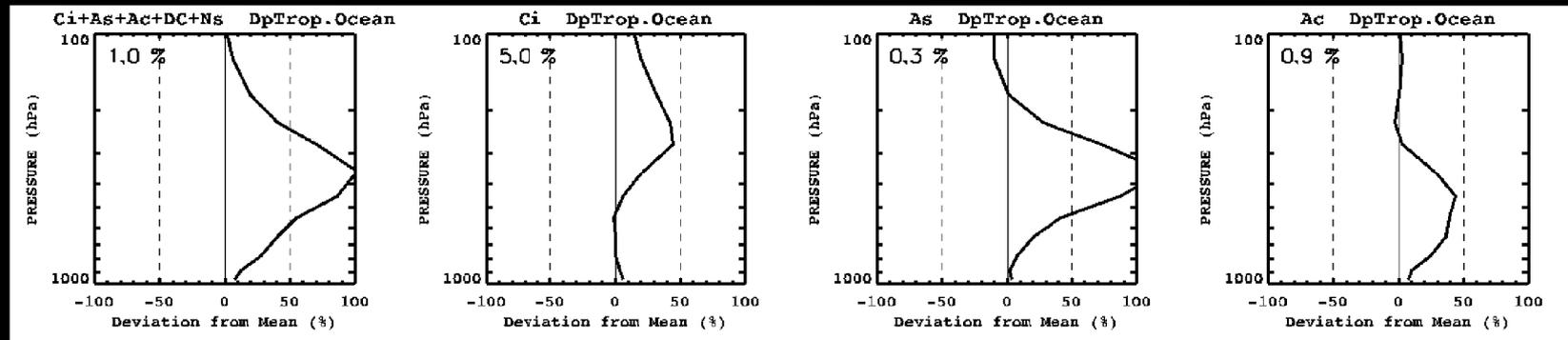
AIRS Mean Water Vapor by Classes

January 2007, 15S-15N, Ocean only

1) Shallow Clouds



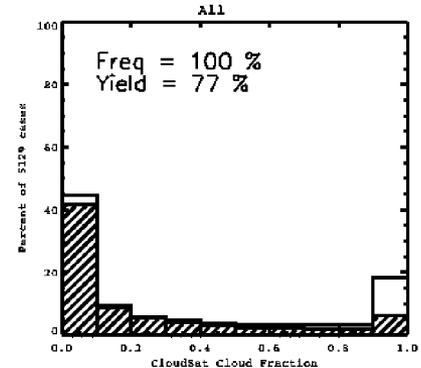
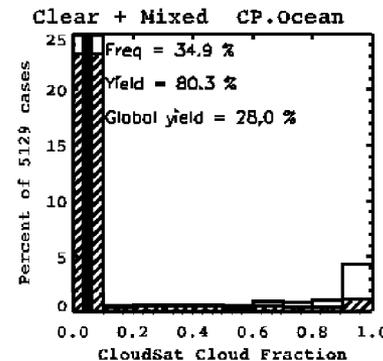
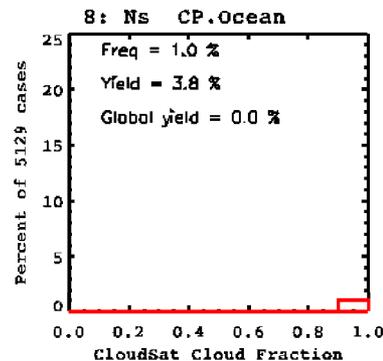
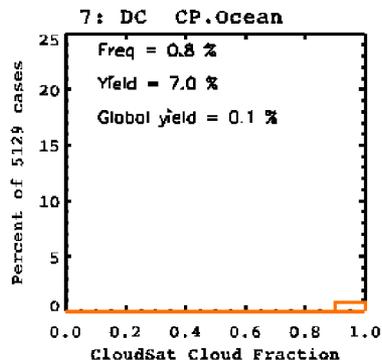
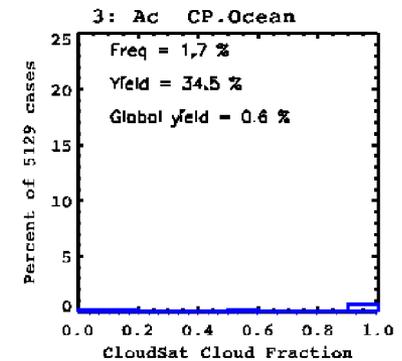
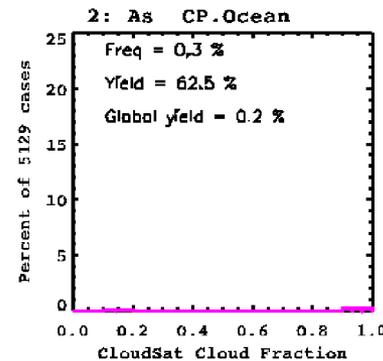
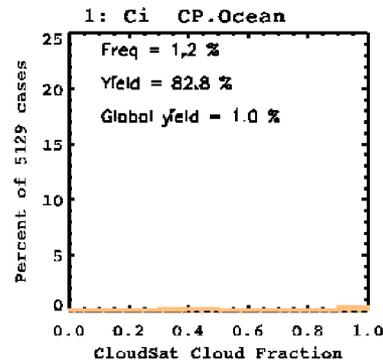
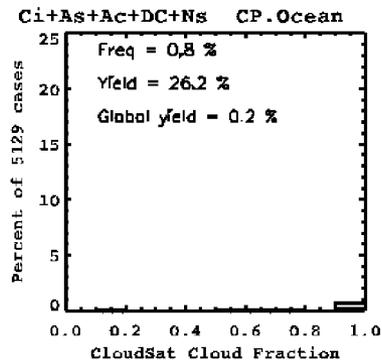
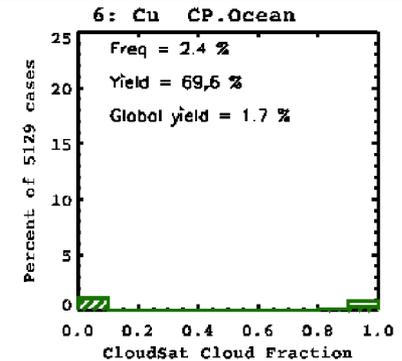
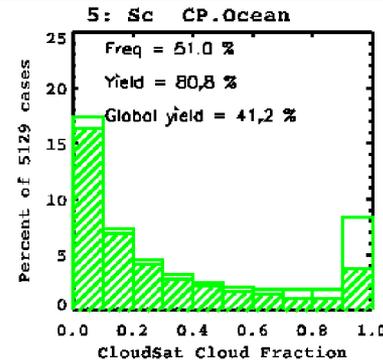
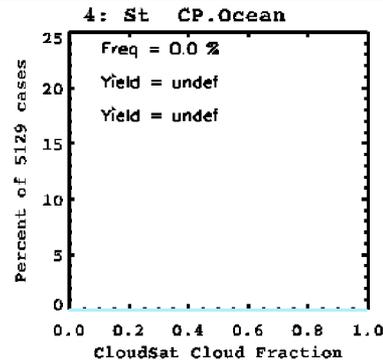
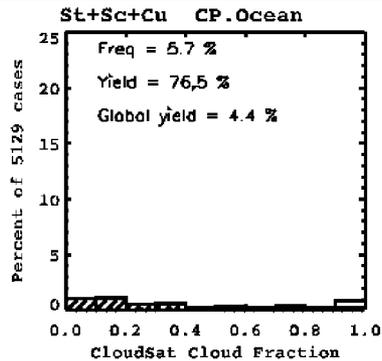
2) Deep Clouds



3) Clear & Mixed

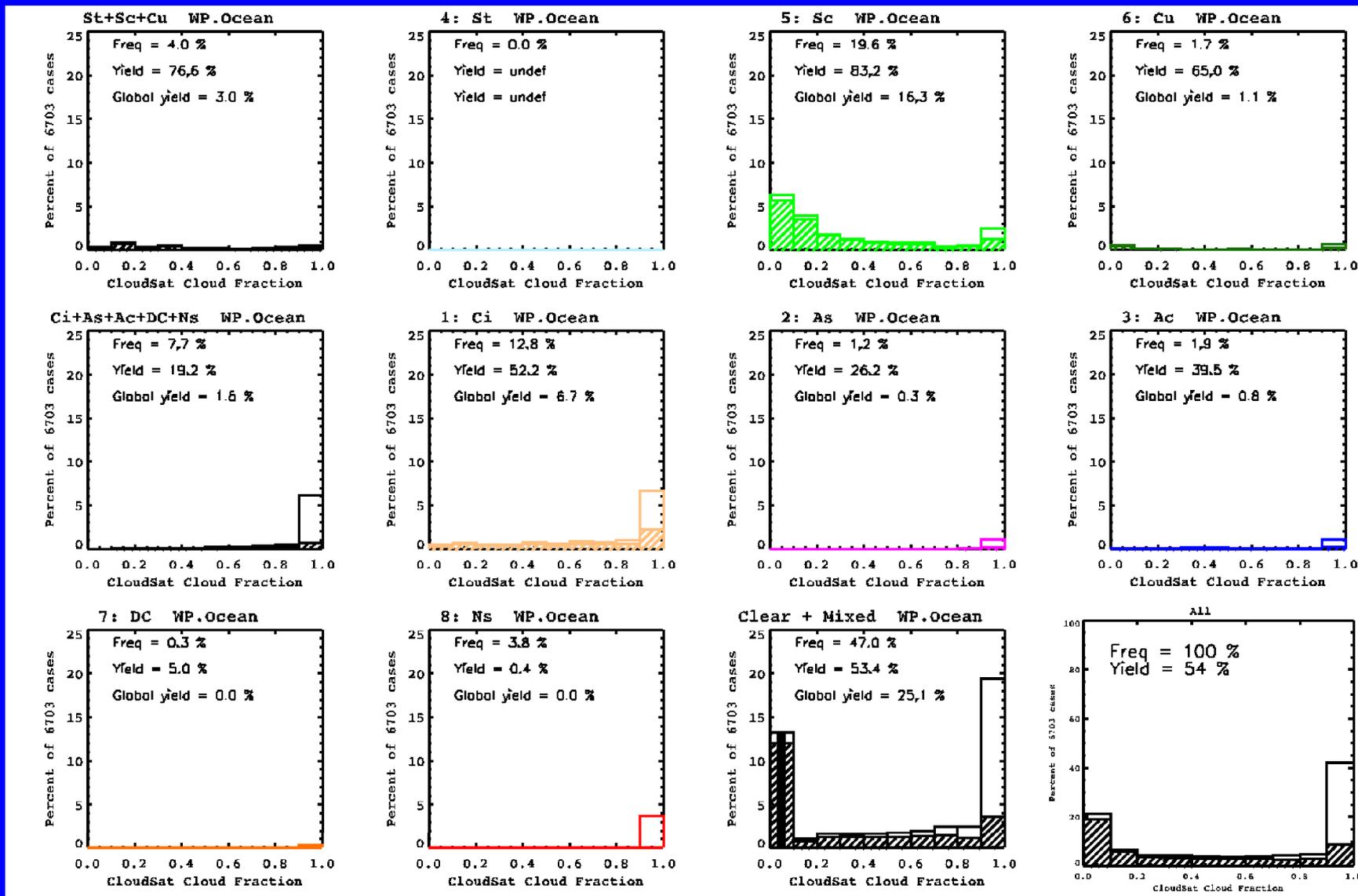


Moving to E. Pacific Cool Pool





W. Pacific Warm Pool

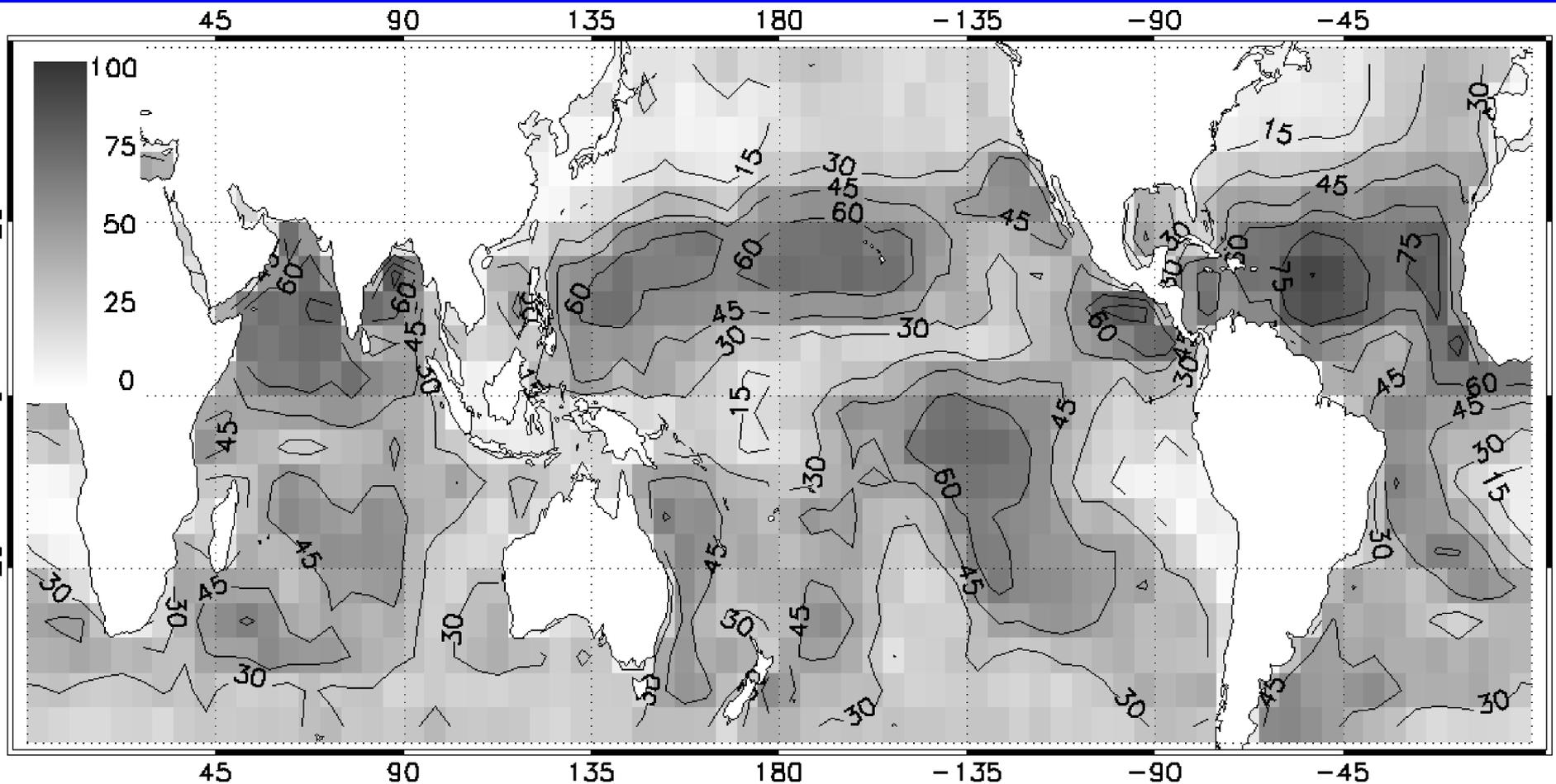




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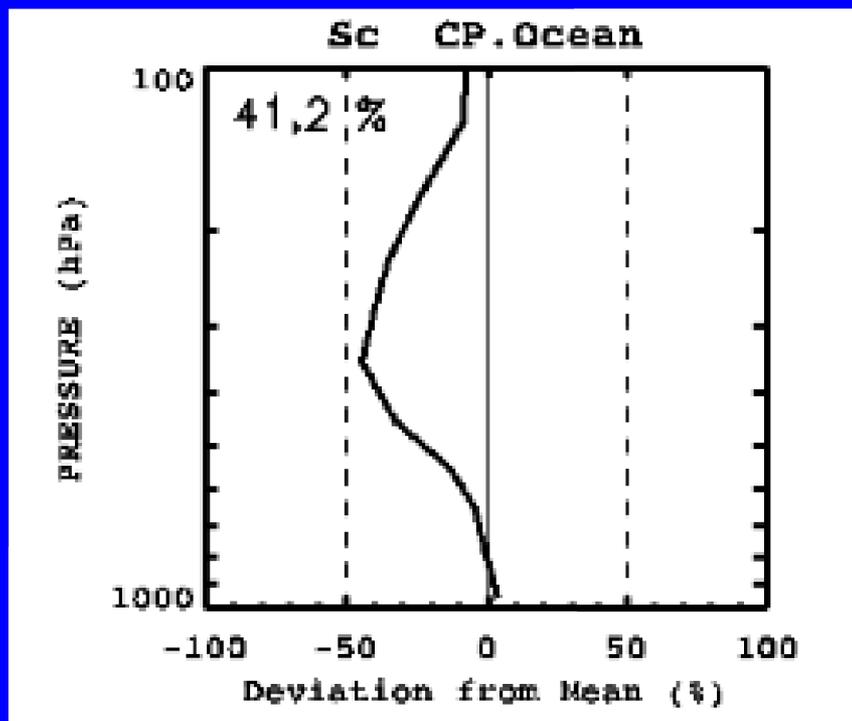
High yields in the E. Pacific due to prevalence of shallow, broken clouds.
Low yields in W. Pacific due to prevalence of deep, thick clouds.



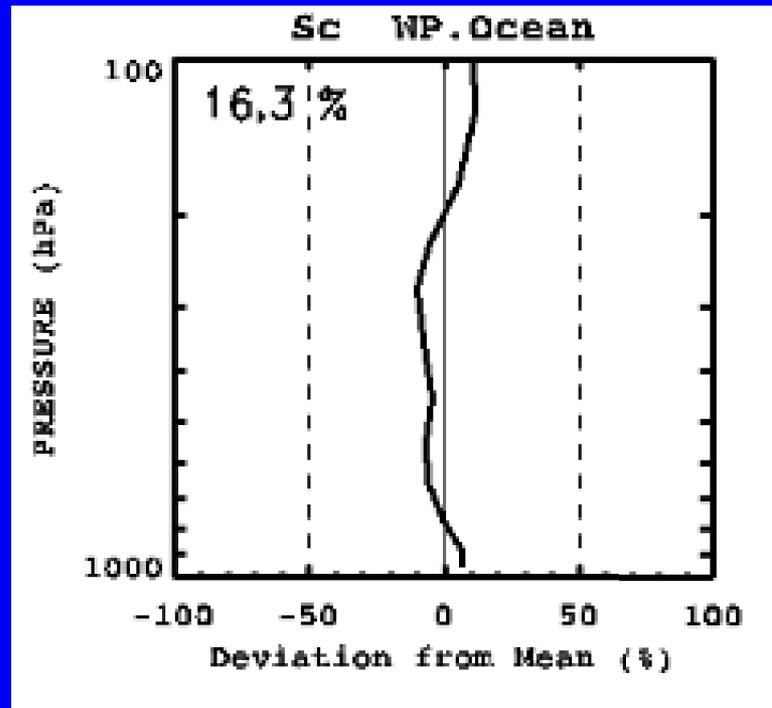


No Universal Water Vapor Profile by Cloud State

Mean AIRS water vapor profiles for CloudSat
Stratocumulus class, relative to the tropical mean



E. Pacific Cool Pool



W. Pacific Warm Pool



Answering Today's Questions

- **Can we simultaneously monitor water vapor and changes in its viewing conditions (imposed by clouds in the IR)?**
 - ***Yes, with deep convection most challenging in the tropics.***
- **How do moist thermodynamics vary with cloud state?**
 - ***Water vapor varies up to 200% between states.***
- **Is the relationship between cloud state and water vapor universal?**
 - ***No. Example: shallow convection in the Warm Pool has a wetter free troposphere than shallow convection in the Cool Pool.***
 - Surface humidity is trivially universal: roughly constant.



Answering Some Questions (cont'd)

- **How dominant are effects in the radiatively important middle and upper troposphere?**
 - ***Most of the water vapor variations between cloud states occur in the middle and upper troposphere.***
- **How precise and accurate do earlier sounders need to be to separate trends in water vapor by cloud state? Assuming cloud state can be well characterized by ISCCP or similar observations.**
 - ***Don't know, yet, but distinguishing deep and shallow convection may require ~25% biases.***



Next Steps

- **Analyze entire CloudSat record matched to AIRS.**
 - *Look at T, RH, etc.*
- **Match CloudSat to Microwave Limb Sounder & AMSR-E.**

These data will become publicly available through our MEaSUREs project via the Goddard DAAC.

