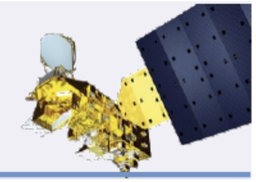

AIRS and Climate

Bjorn Lambrigtsen, Joao Teixeira, Eric Fetzer & the AIRS Team

Jet Propulsion Laboratory, California Institute of Technology

2012 Eumetsat Conference

September 3, 2012

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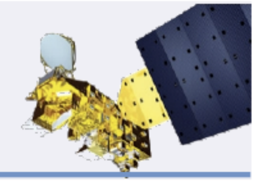
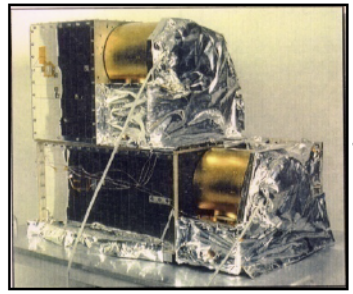
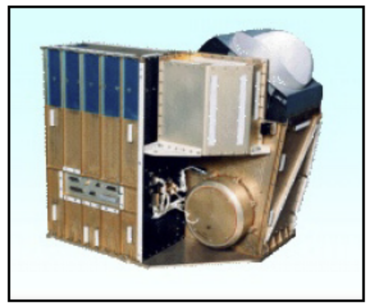
AIRS/AMSU/HSB on Aqua



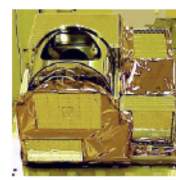
- Aqua Spacecraft
  - Launched May 4, 2002
  - Orbit: 705.3 km
  - Expected Life: 2016+
- AIRS
  - ~15 km IFOV
  - 2378 IR Channels 3.74-15.4 μm
  - 4 Vis/NIR Channels
- AMSU
  - ~45 km IFOV
  - 15 Microwave Channels 23-89 GHz
- HSB
  - ~15 km IFOV
  - 4 Microwave Channels 150-183 GHz
  - No Longer Operational

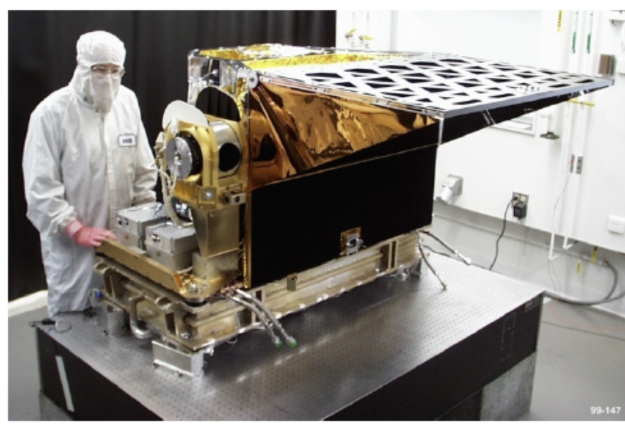


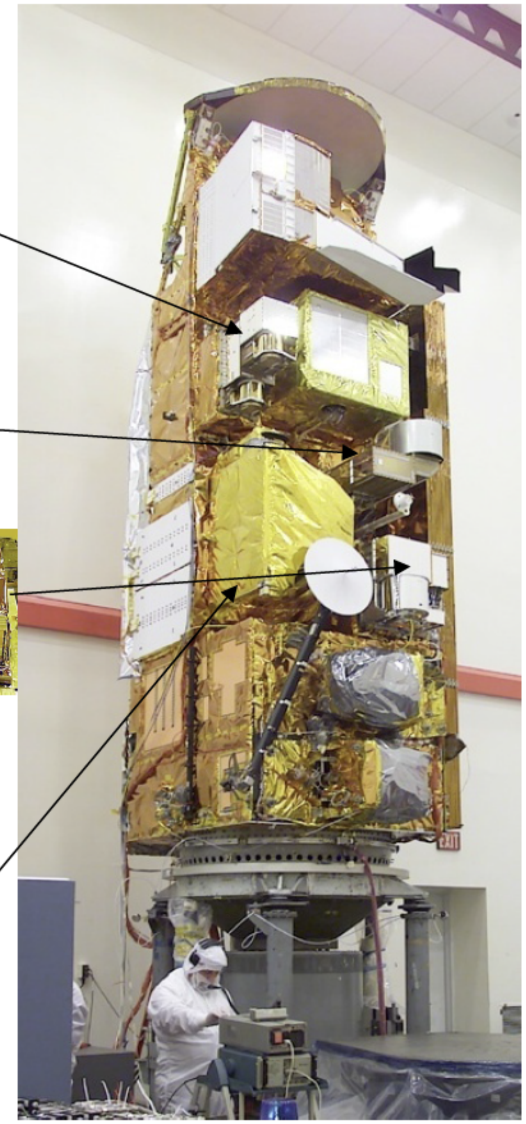
AMSU



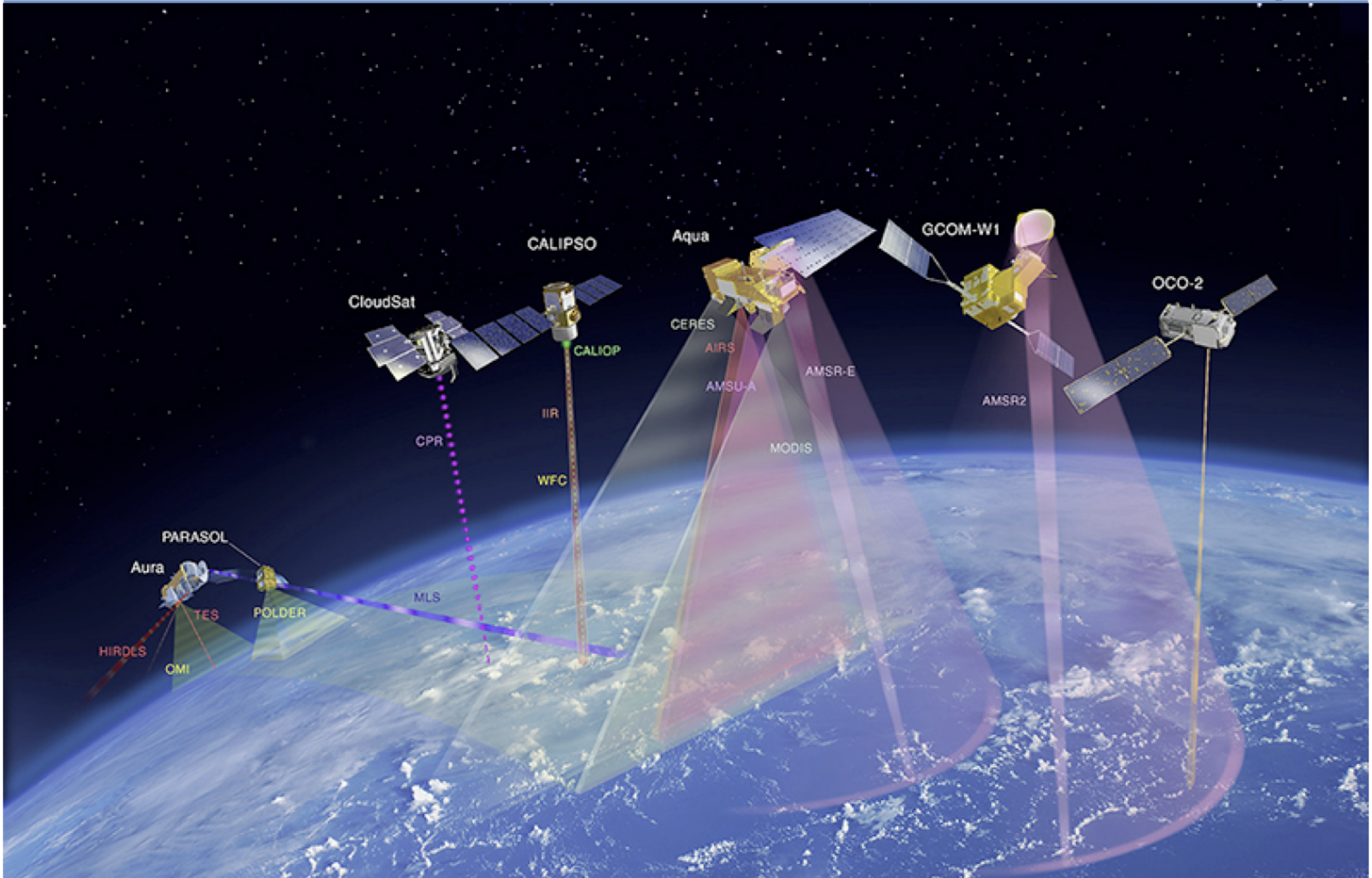
HSB



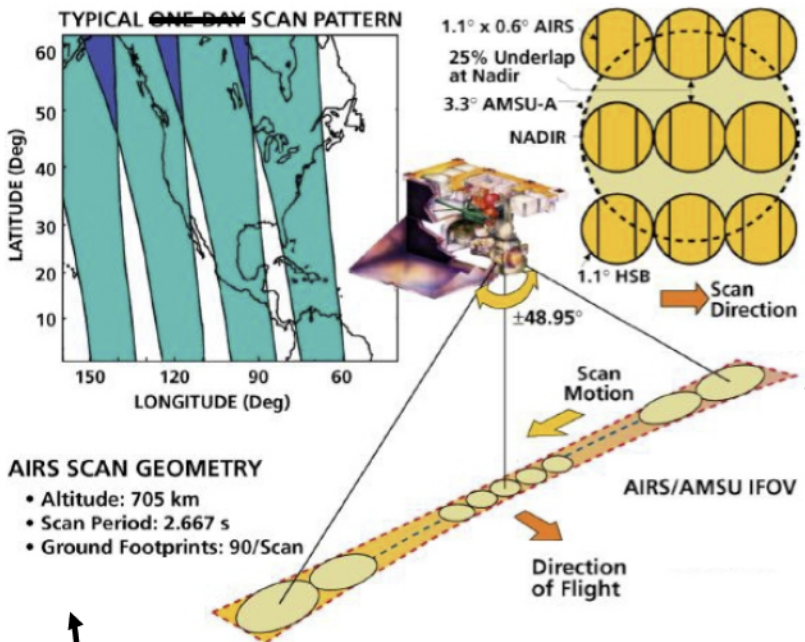




Aqua in the A-Train



Combined IR and MW Observations



1. AMSU footprint, 45 km across at nadir, contains 9 AIRS spectra
   – THIS IS THE RETRIEVAL GRANULARITY.
2. Viewing swath 30 AMSU footprints or ~1650 km wide.
3. The result: 2,916,000 IR spectra and 324,000 retrievals per day

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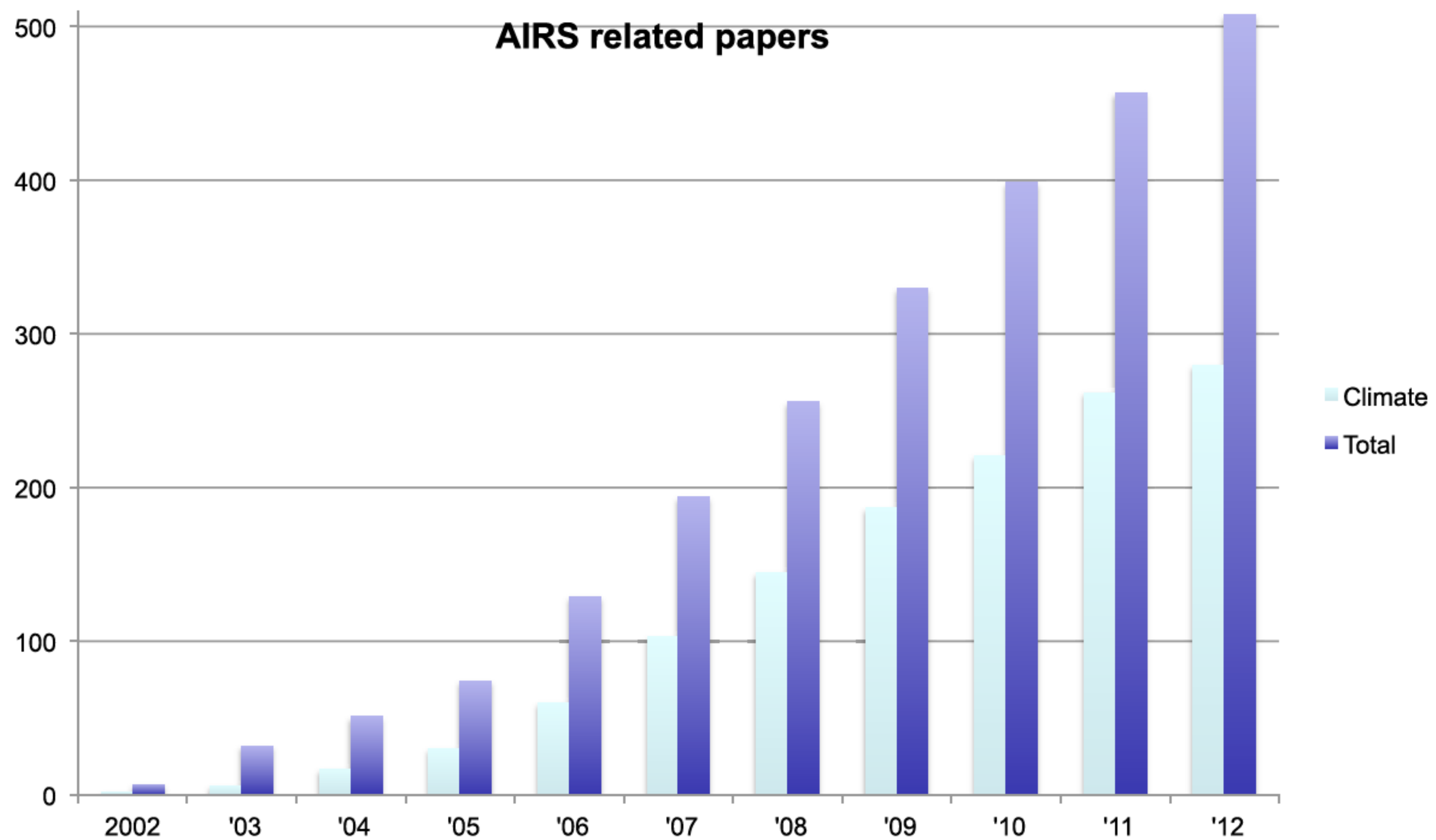
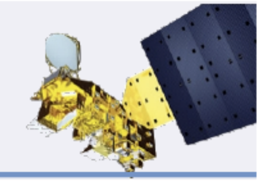
AIRS Peer Reviewed Publications Growing

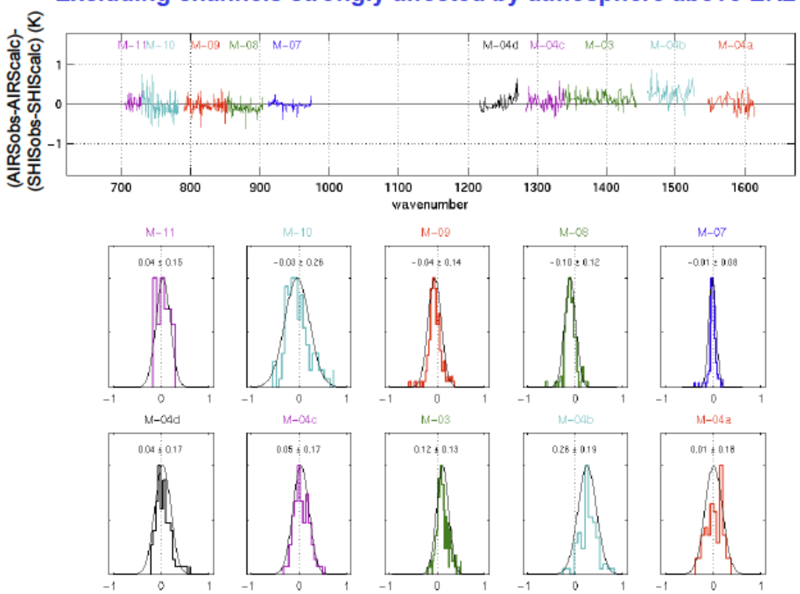


Climate Quality Instrument and Products

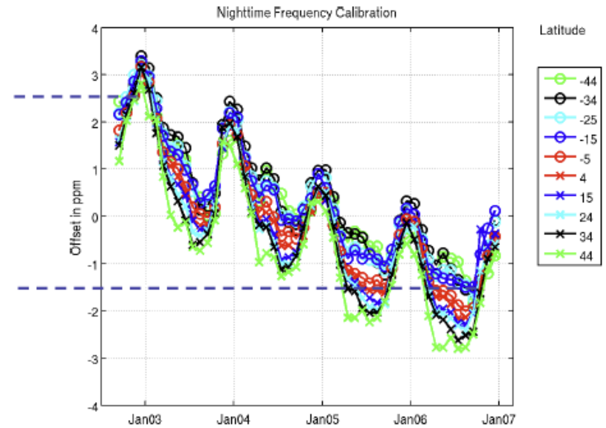


Radiometric Accuracy: 0.2 K

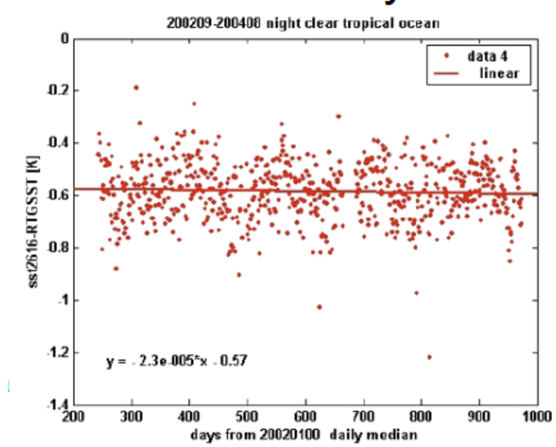
Final "Comparison 2" (21 November 2002)
Excluding channels strongly affected by atmosphere above ER2



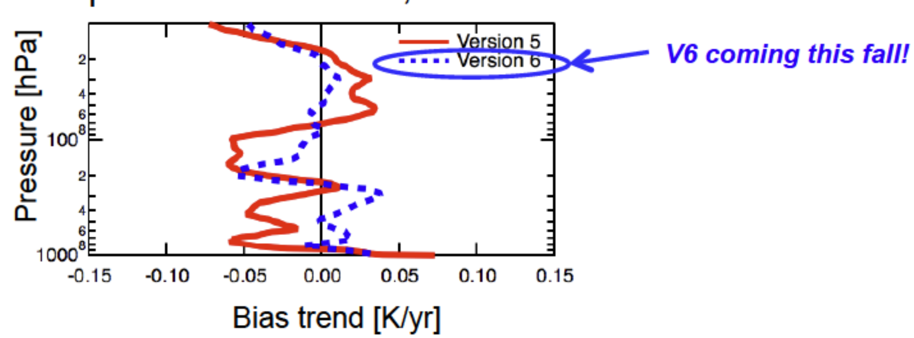
Spectral Accuracy/Stability: < 1 ppm/yr



Radiometric Stability: < 8 mK/yr



Product stability: Mean bias-trend ~ 0



AIRS and Climate Sensitivity

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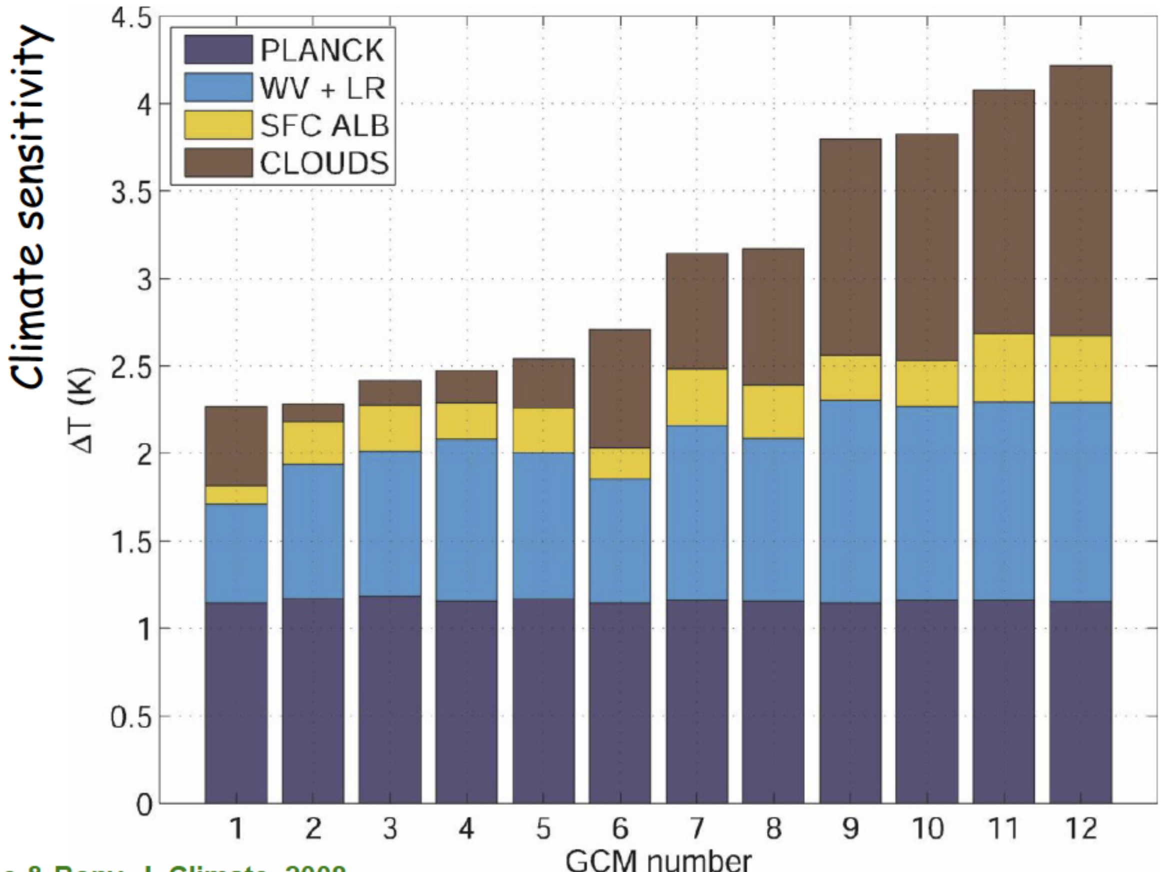
California Institute of Technology

AIRS makes essential observations of the processes controlling climate feedbacks: temperature, water vapor, clouds, CO2, ….

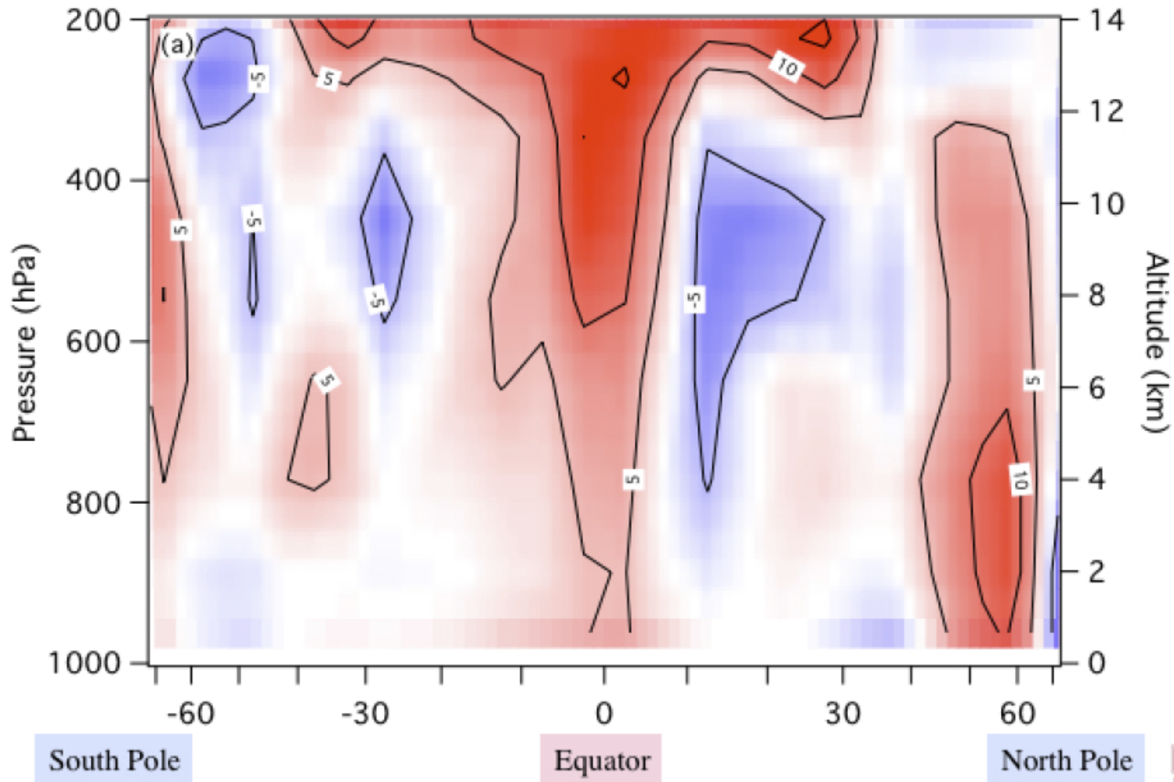


Dufresne & Bony, J. Climate, 2008

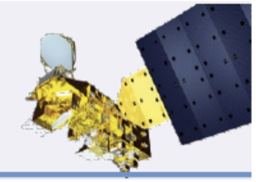
Climate Change: Using El Niño as Proxy for Global Warming

Percent change in specific humidity between El Niño and La Niña

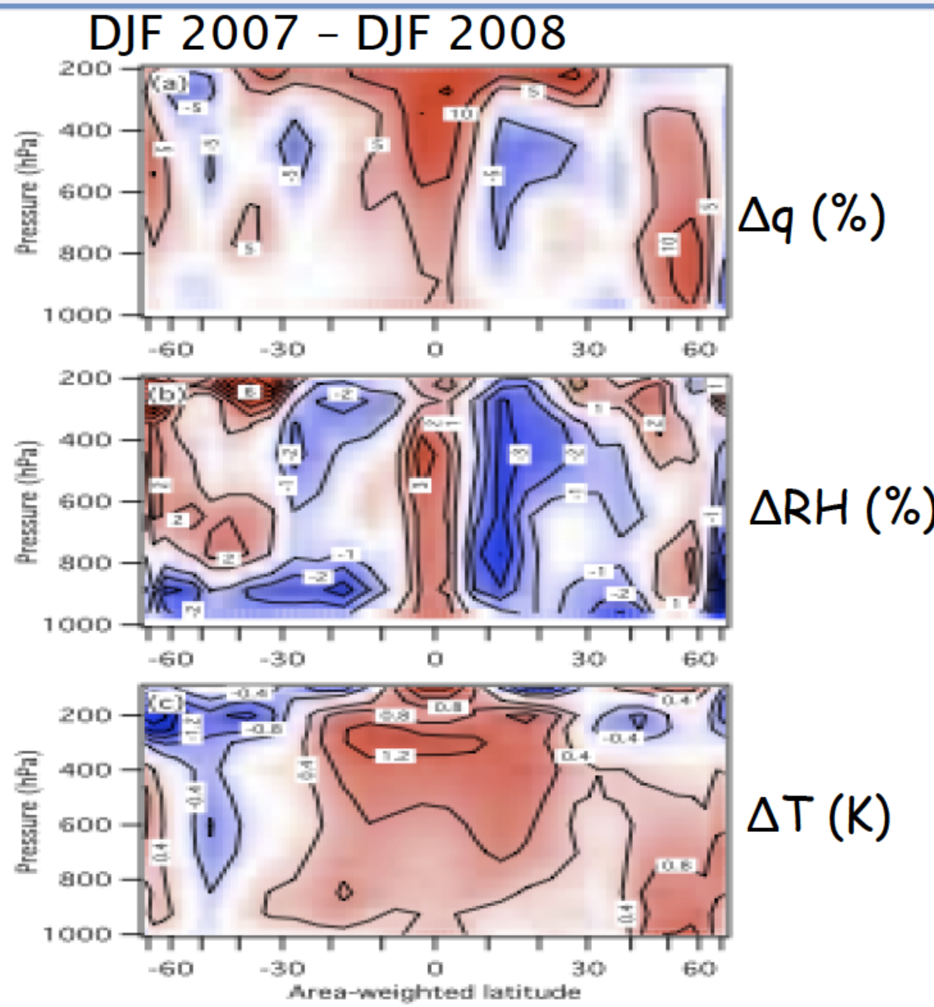
(Change in surface temperature = 0.6 degrees Celsius)



Dessler & al, GRL, 2008



AIRS and Water Vapor Feedback

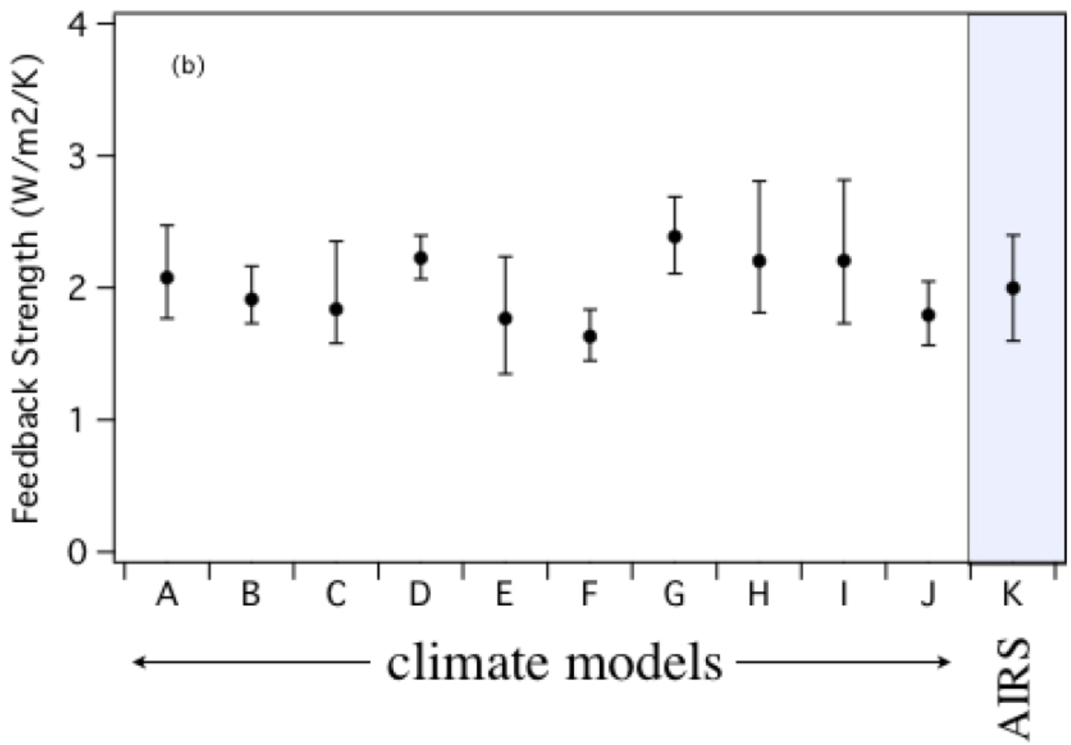


Dessler & al, GRL, 2008

AIRS confirms estimates of water vapor feedback strength: $\lambda q \sim 2\ \ W.m^{-2}.K^{-1}$

Feedback Strengths in Climate Models vs. AIRS

Calculated values of the water vapor feedback



Dessler, personal communication, 2008

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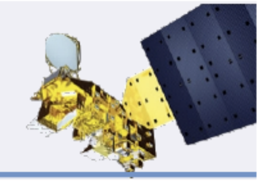
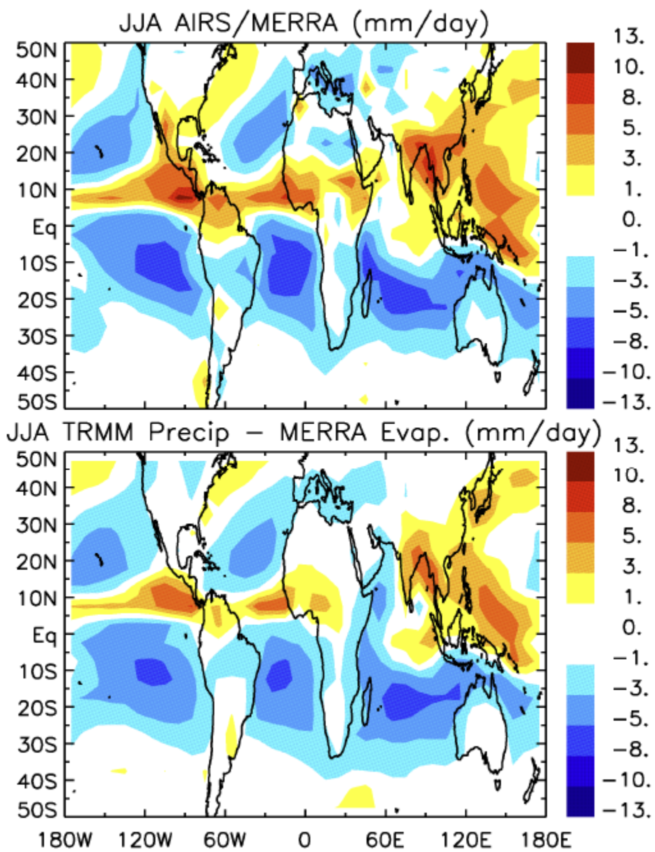
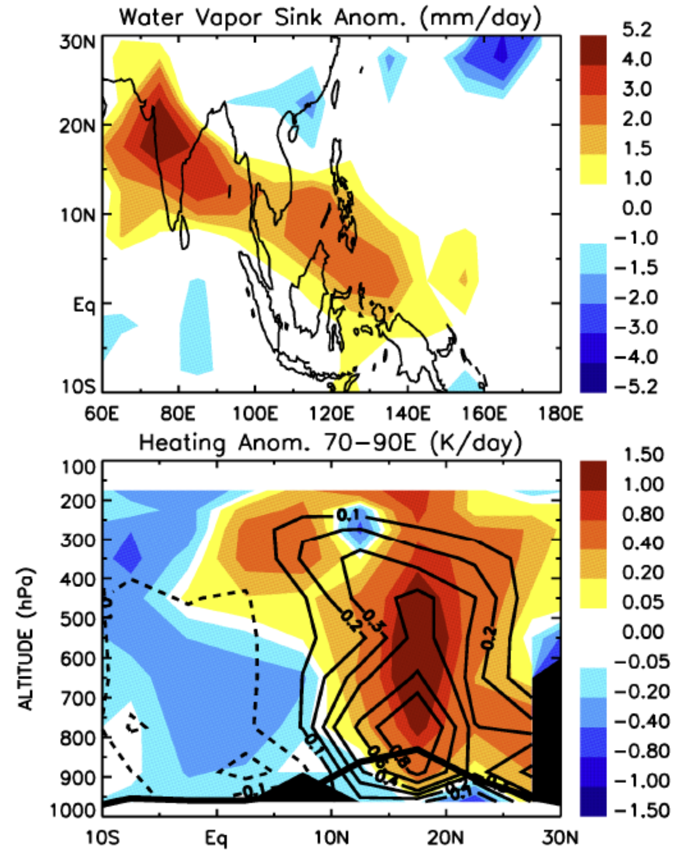
Water and Energy Budgets



Global



Indian monsoon

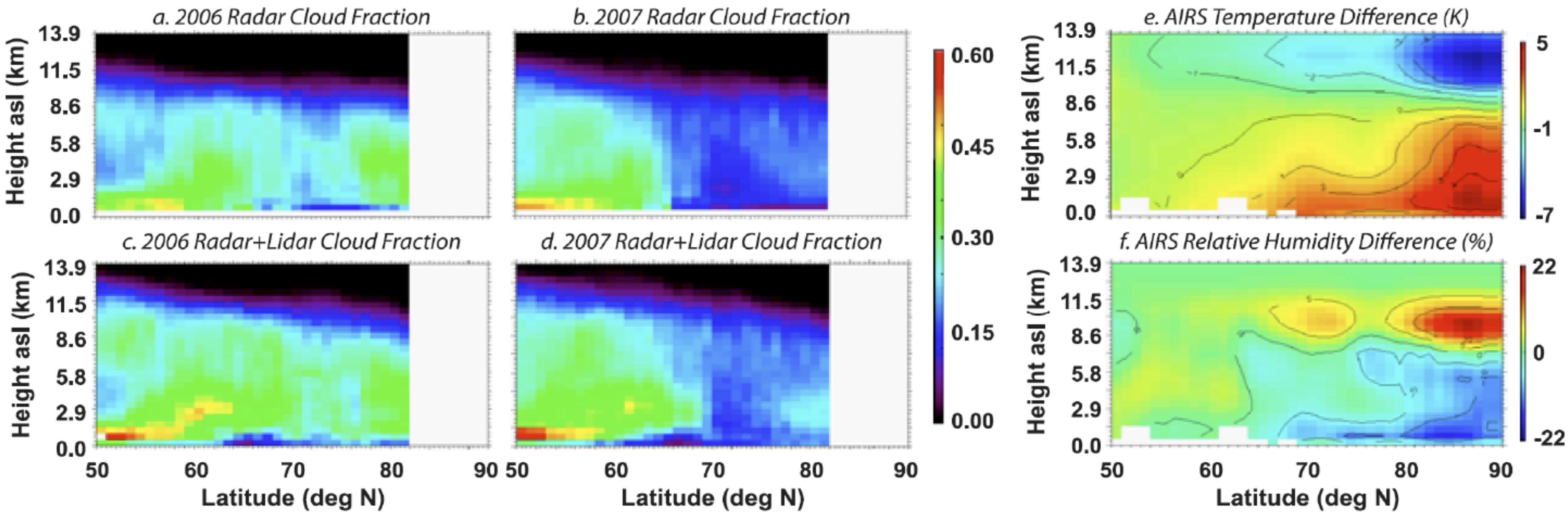


Top: Vertical sum of water vapor convergence from observed AIRS water vapor and modeled MERRA winds. Should equal precip-evap.
Bottom : Difference between observed TRMM rainfall and modeled MERRA evaporation.

Wong & al., J. Climate, 2011

Top: Column integrated water vapor loss anomalies at monsoon peaks.
Bottom: Heating anomalies at monsoon peaks (color); water vapor loss anomalies (contours); and precipitation anomalies (the thick line at the bottom).

Arctic Warming: Summer of 2007

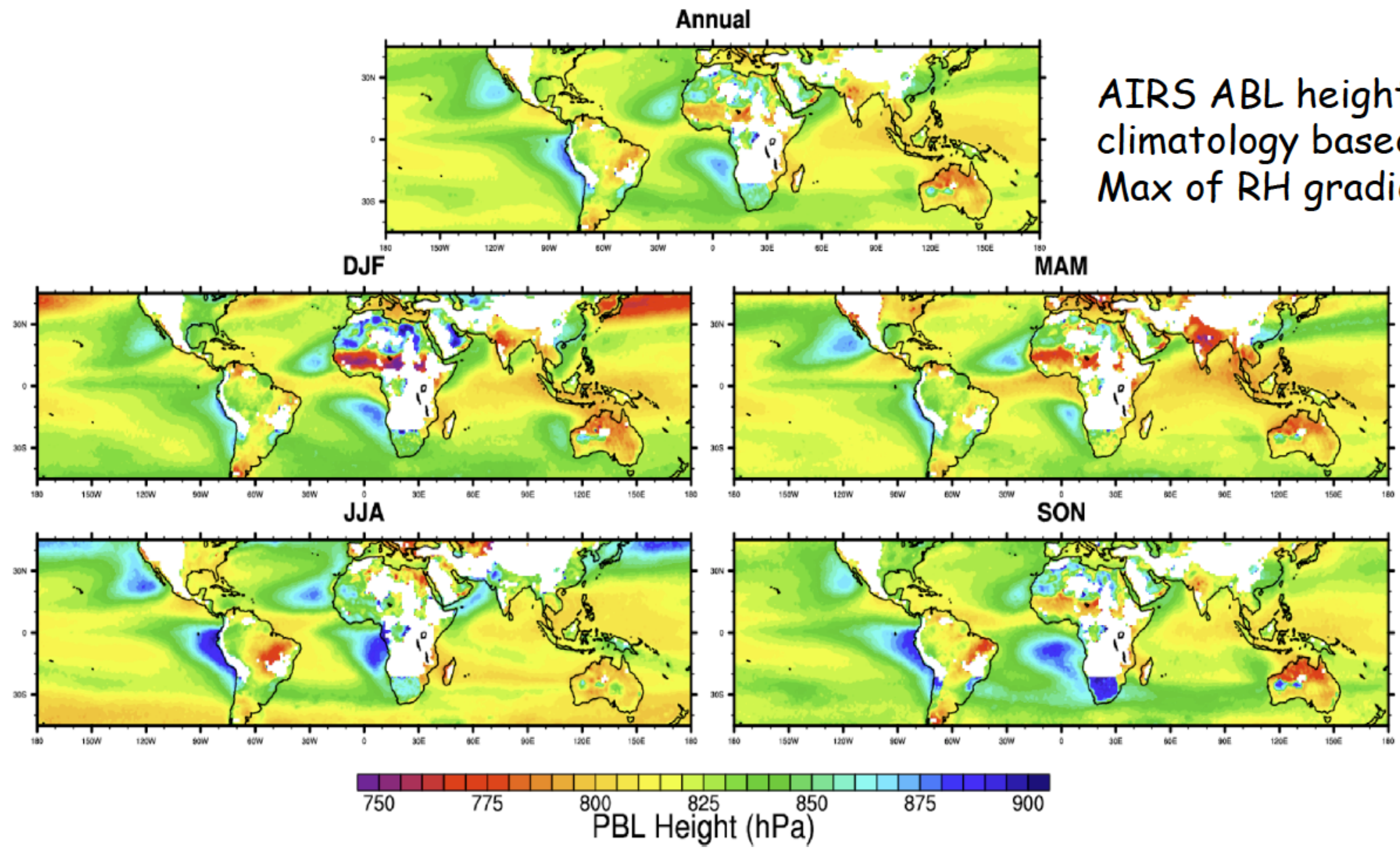


- AIRS T and q profiles + CALIPSO, CloudSat, and MODIS
- Increase in downwelling solar radiation of $32W/m^2$ ➔ 2.4K surface warming
- Increased T and decreased RH explain reduction in cloudiness

Kay & al., GRL, 2008

The Atmospheric Boundary Layer

Global and smooth boundary layer height climatology from space (1st time):



AIRS ABL height climatology based on Max of RH gradient

Martins & al., JGR, 2012

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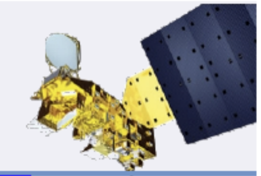
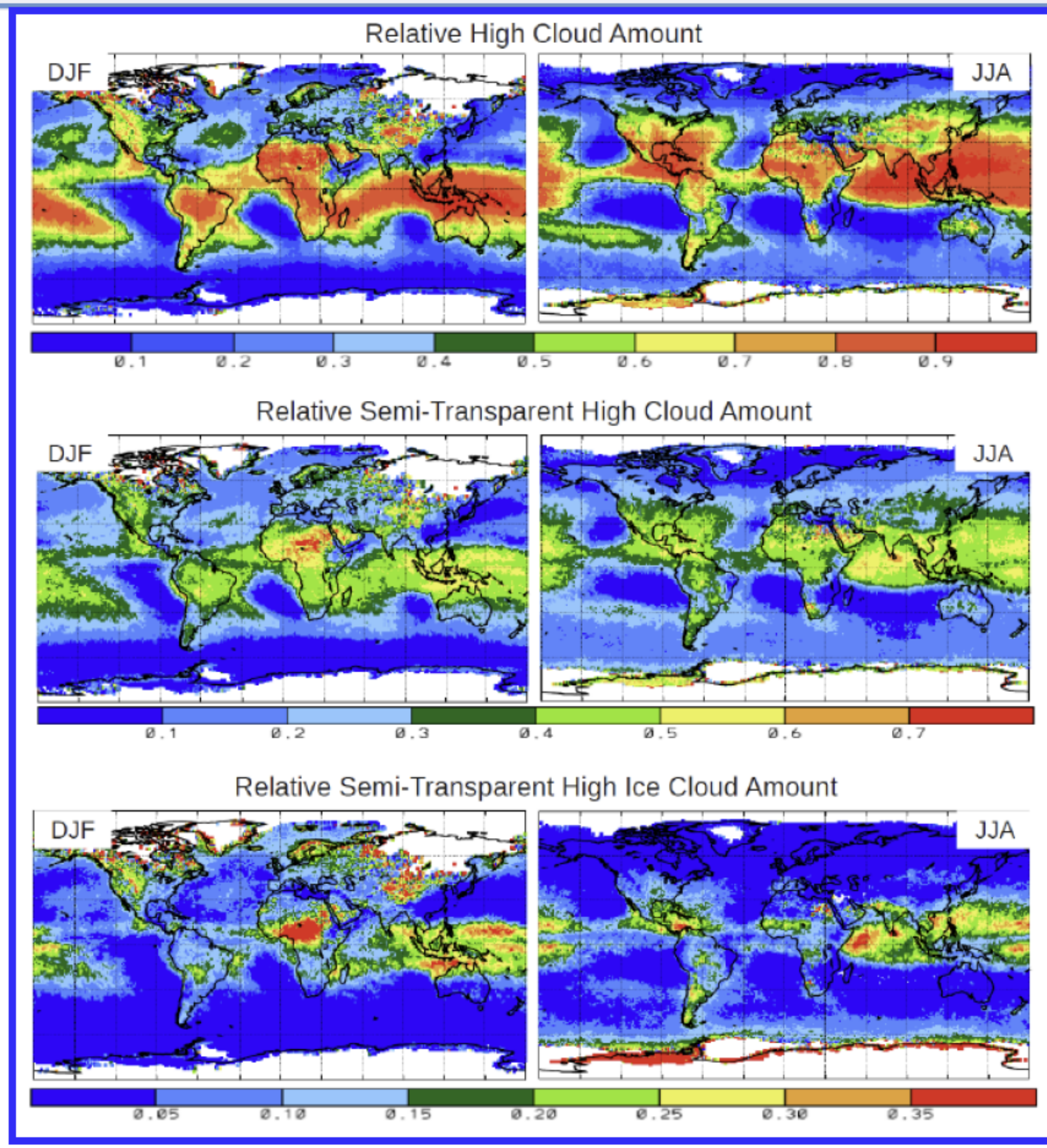
Cirrus Cloud Climatologies



Six Years of Thin Clouds from AIRS and CloudSat/ CALIPSO

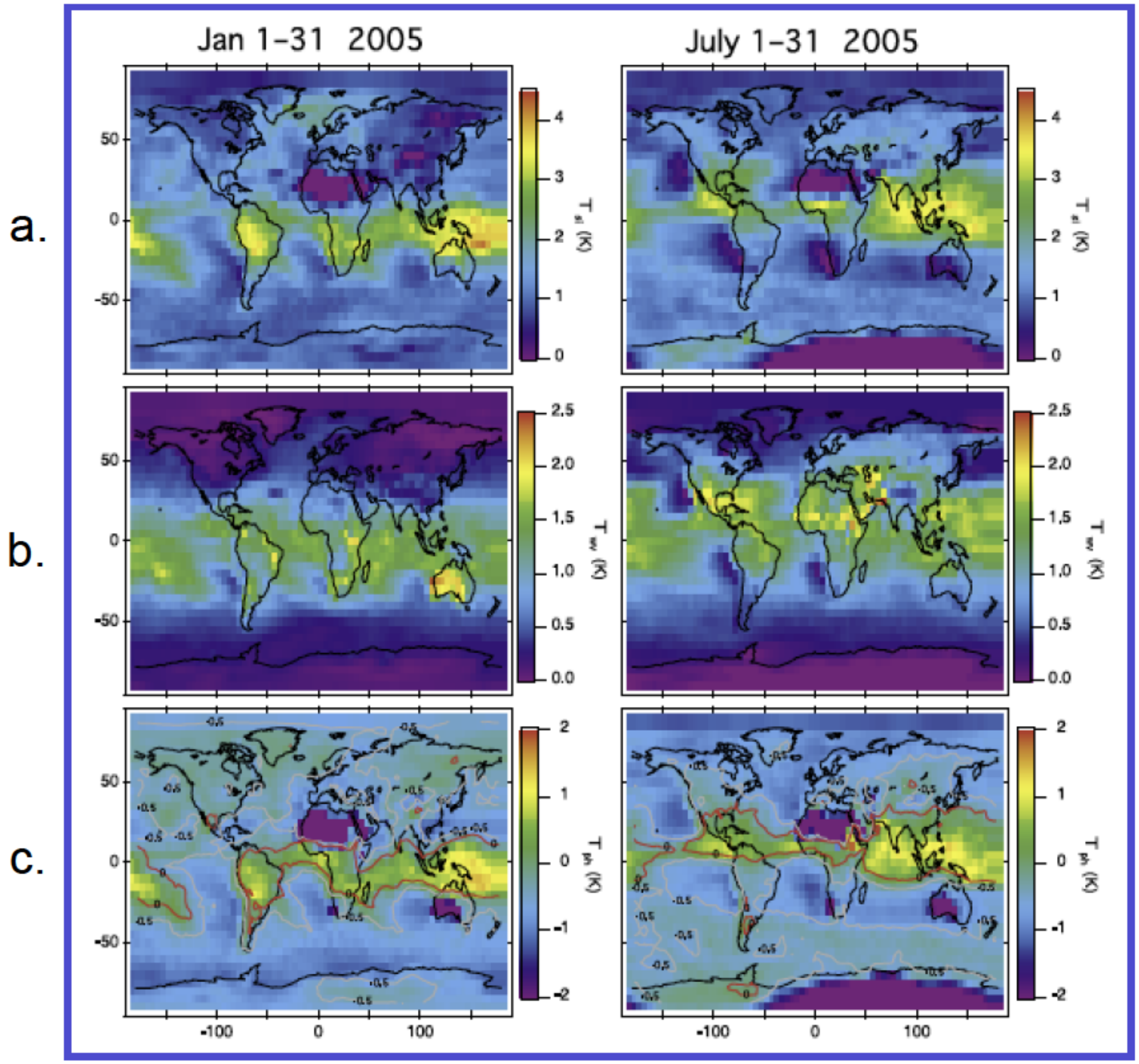


Guignard & al., ACP, 2012

Ice Cloud Microphysics

Four AIRS channels were combined to form three different ΔT_b that are primarily sensitive to

a. ice cloud particle size
b. water vapor
c. cloud phase



Kahn & al., JGR, 2011

Monsoon Signal in AIRS CO2

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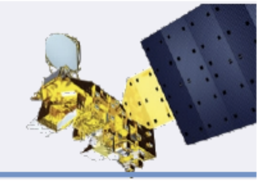
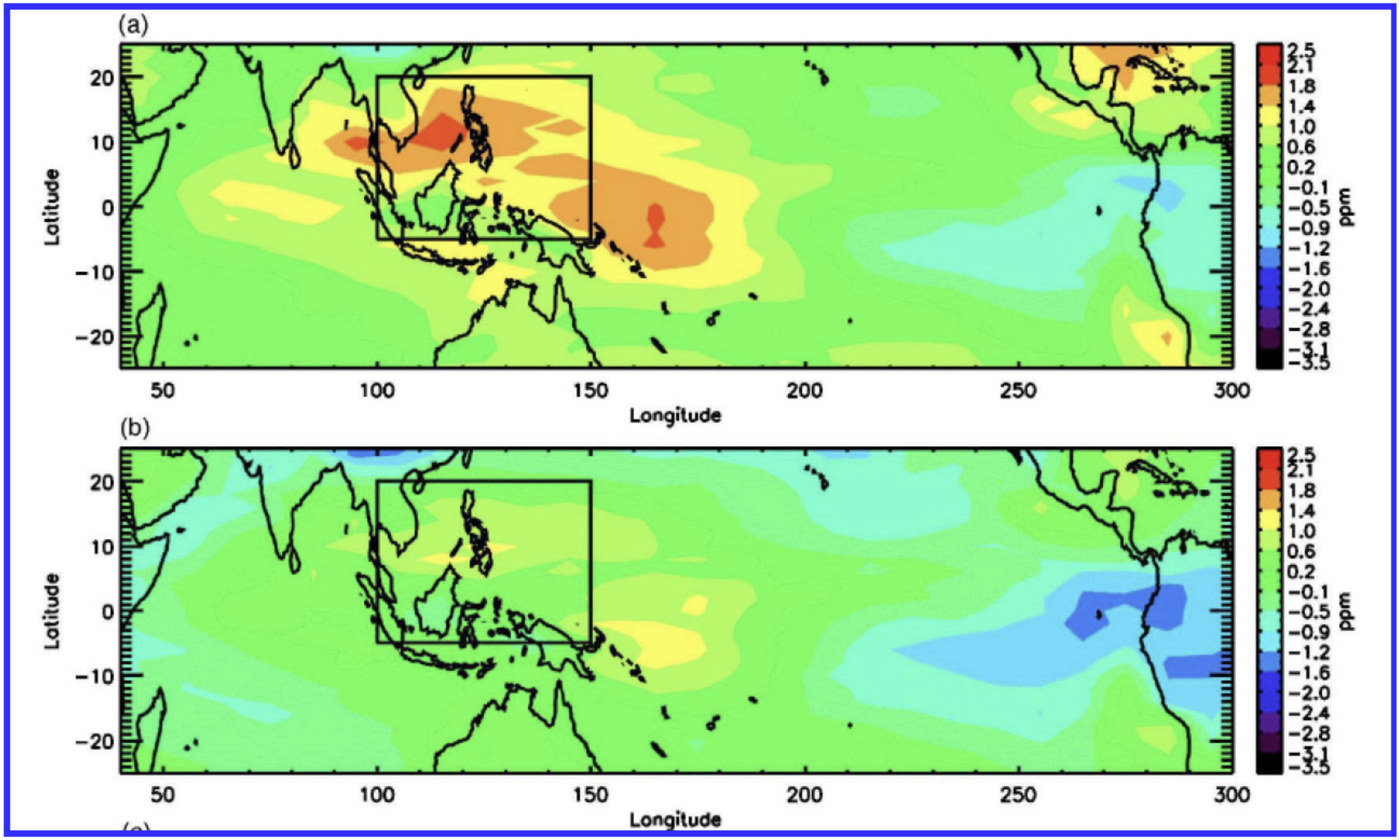


Strong Monsoon
2003,
2005,
2007,
2010

Weak Monsoon
2004,
2006,
2008



Wang & al., GRL, 2011

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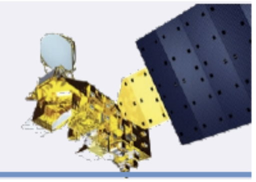
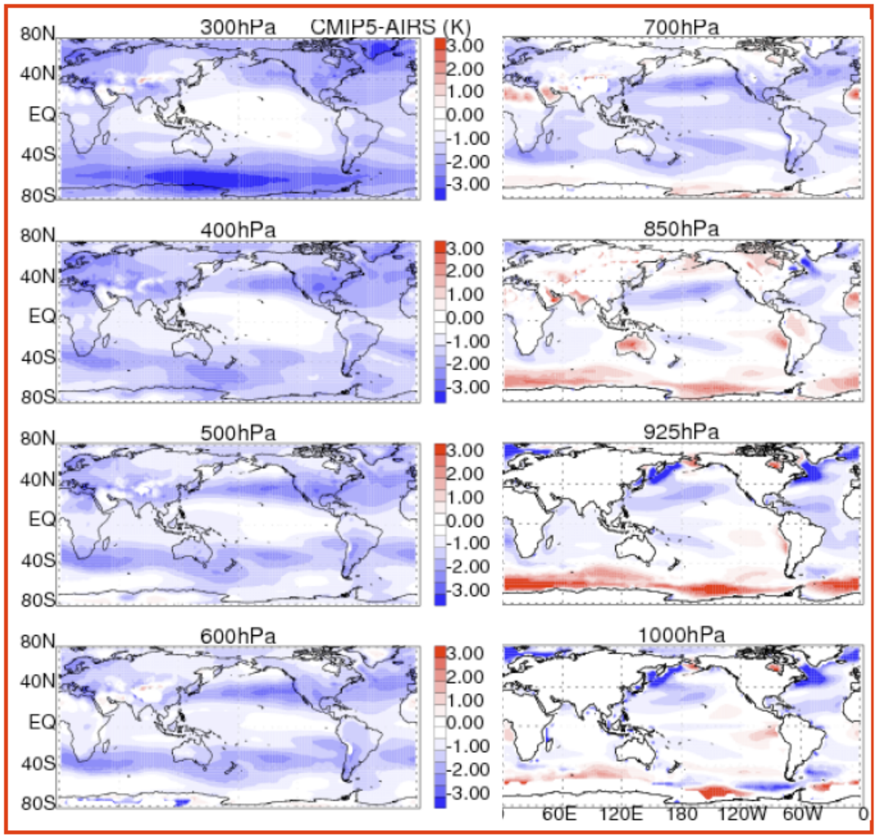
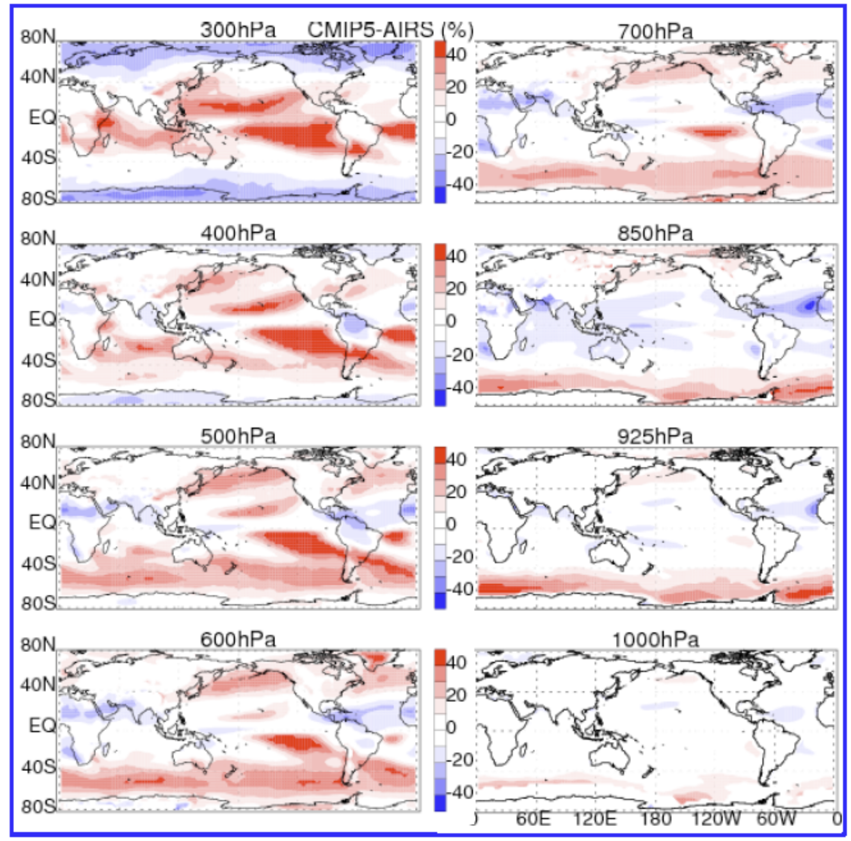
Model Evaluation for CMIP5



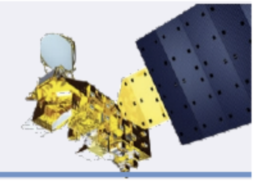
AIRS climatology vs. 16 CMIP5 models (mean)





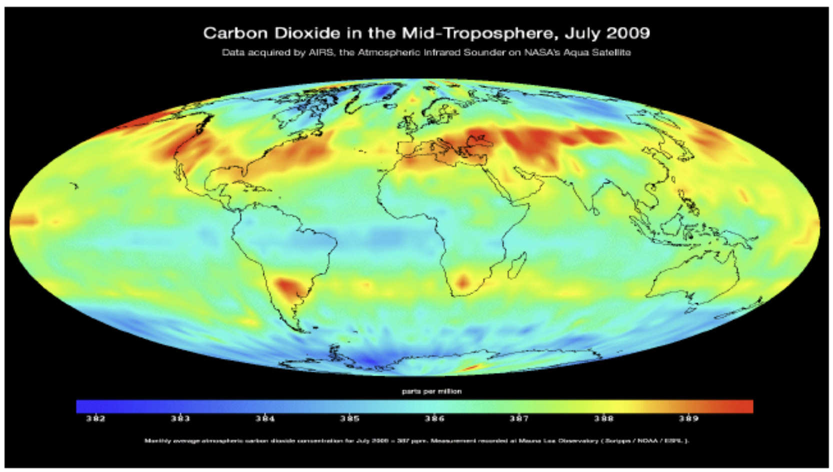
In comparison to AIRS, the 16 CMIP5 models can generally simulate the climatological features of tropospheric air temperature and specific humidity well. However, the majority (at least 13) of the models have an upper tropospheric cold bias (around 2 K), especially in the extratropics, and the double-ITCZ syndrome in the troposphere from 1000 hPa to 300 hPa, i.e., the models are too dry at the equatorial convective regions while too moist over both off-equatorial sides especially in the tropical Pacific.

Tian & al., JGR, 2012



Summary

- Unprecedented accuracy and stability of AIRS radiances
- AIRS is central to understanding climate and climate change
- AIRS confirms water vapor feedback strength
- AIRS is being used to investigate PBL clouds and climate interactions
- AIRS helps explain key climate events - 2007 Arctic ice minimum
- First global maps from space of mid-tropospheric CO2



"Always Make Progress"
Mous Chahine (1935-2011)

http://airs.jpl.nasa.gov