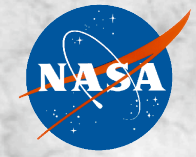

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An A-Train Water Vapor Thematic Climate Data Record Using Cloud Classification

Eric J. Fetzer, Qing Yue, Alexandre Guillaume, Van T. Dang, Calvin Liang, Brian H. Kahn, Brian D. Wilson, Bjorn H. Lambrigtsen and Evan F. Fishbein

Jet Propulsion Laboratory, California Institute of Technology

NOAA Workshop on Climate Data Records from Satellite Passive Microwave Sounders

College Park, Maryland

3 March 2011

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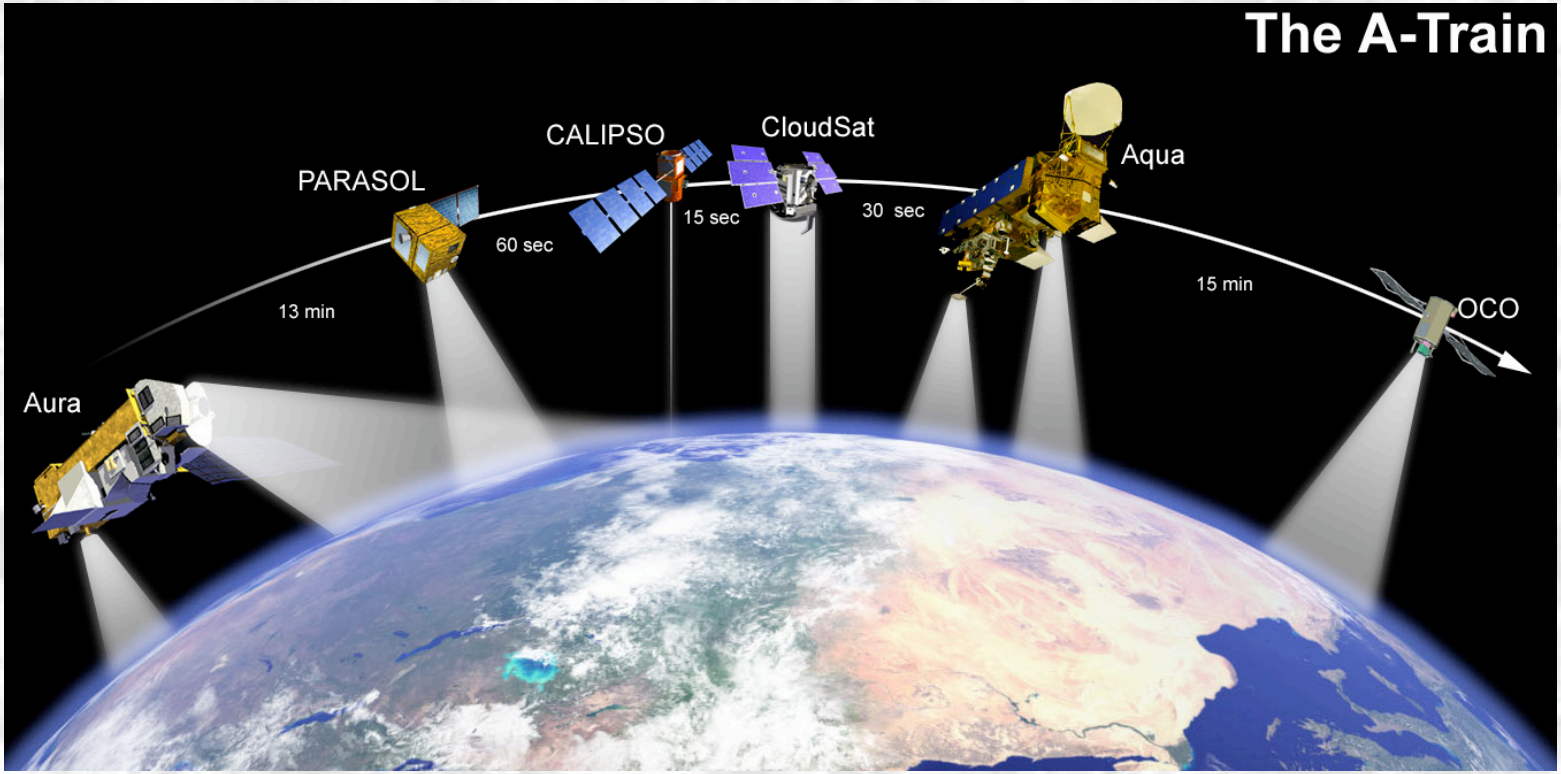
The Grand Challenge: An *Integrated* Picture Including non-A-Train Instruments

Multiple sensors, often identical quantities:

- **Temperature from AIRS, MLS, TES, MODIS.**
- **Water vapor from AIRS, AMSR-E, TES and MODIS.**
- **Clouds from CloudSat/CALIPSO, MODIS, AIRS and AMSR-E.**



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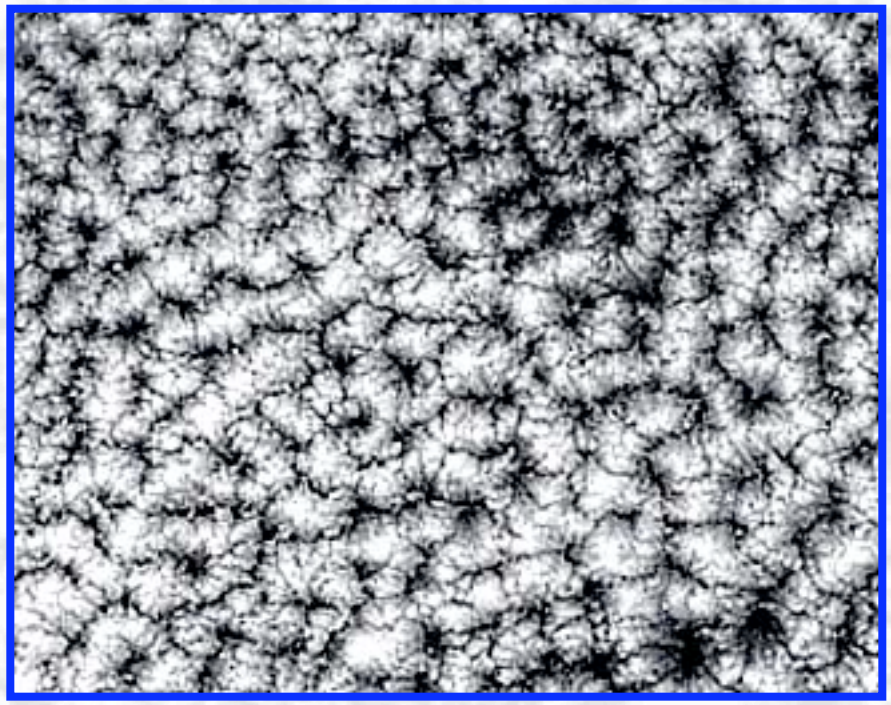
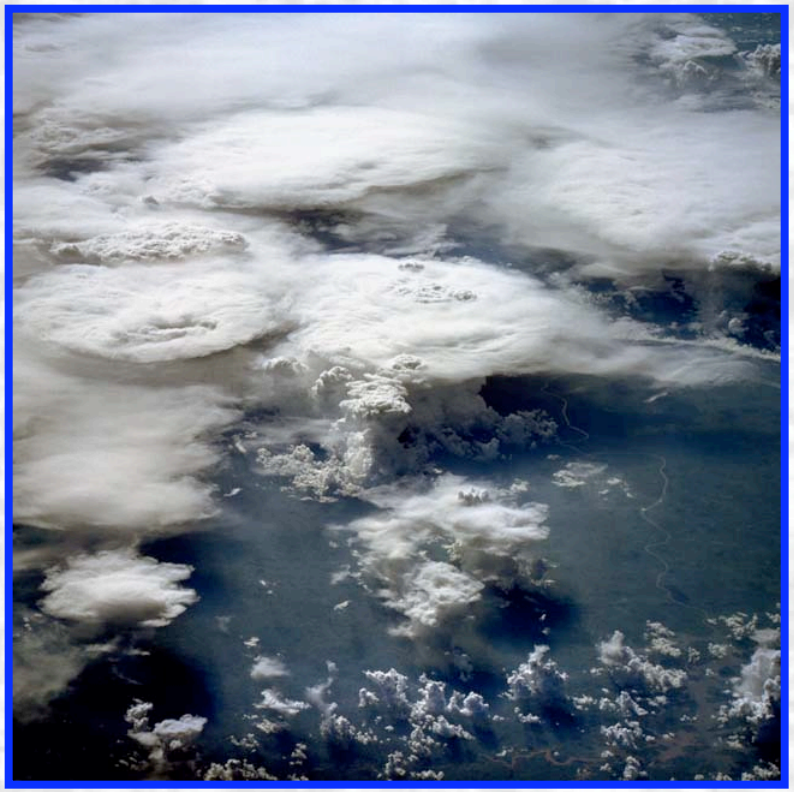
A General Philosophy

Emphasize Level 2 quantities, matched along the A-Train orbit track.

- **Focus on 'fast' processes.**
- **Focus on 'point-by-point' comparisons.**
- **Interested in global picture of *local* variability like this:**





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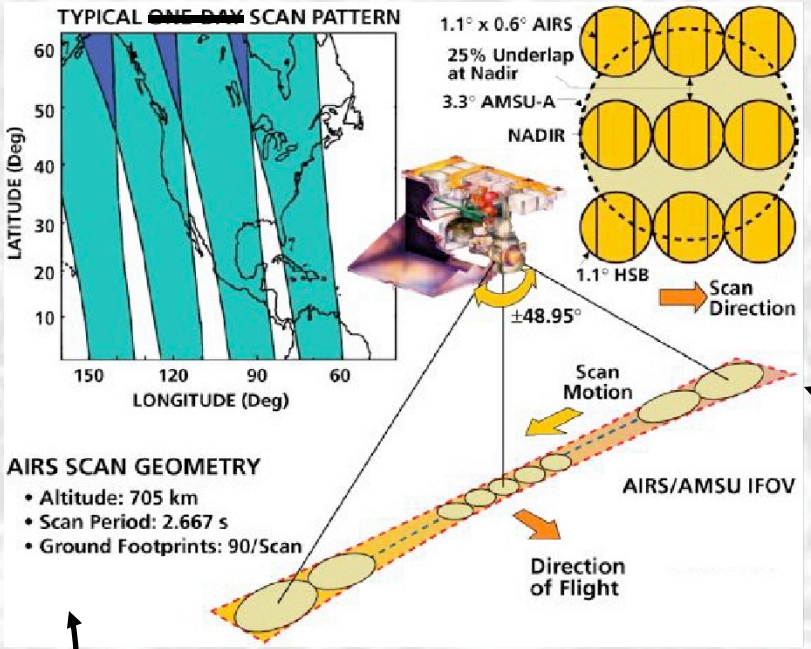
AIRS/AMSU Geometry and Sampling



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 microwave spectra & retrievals per day**

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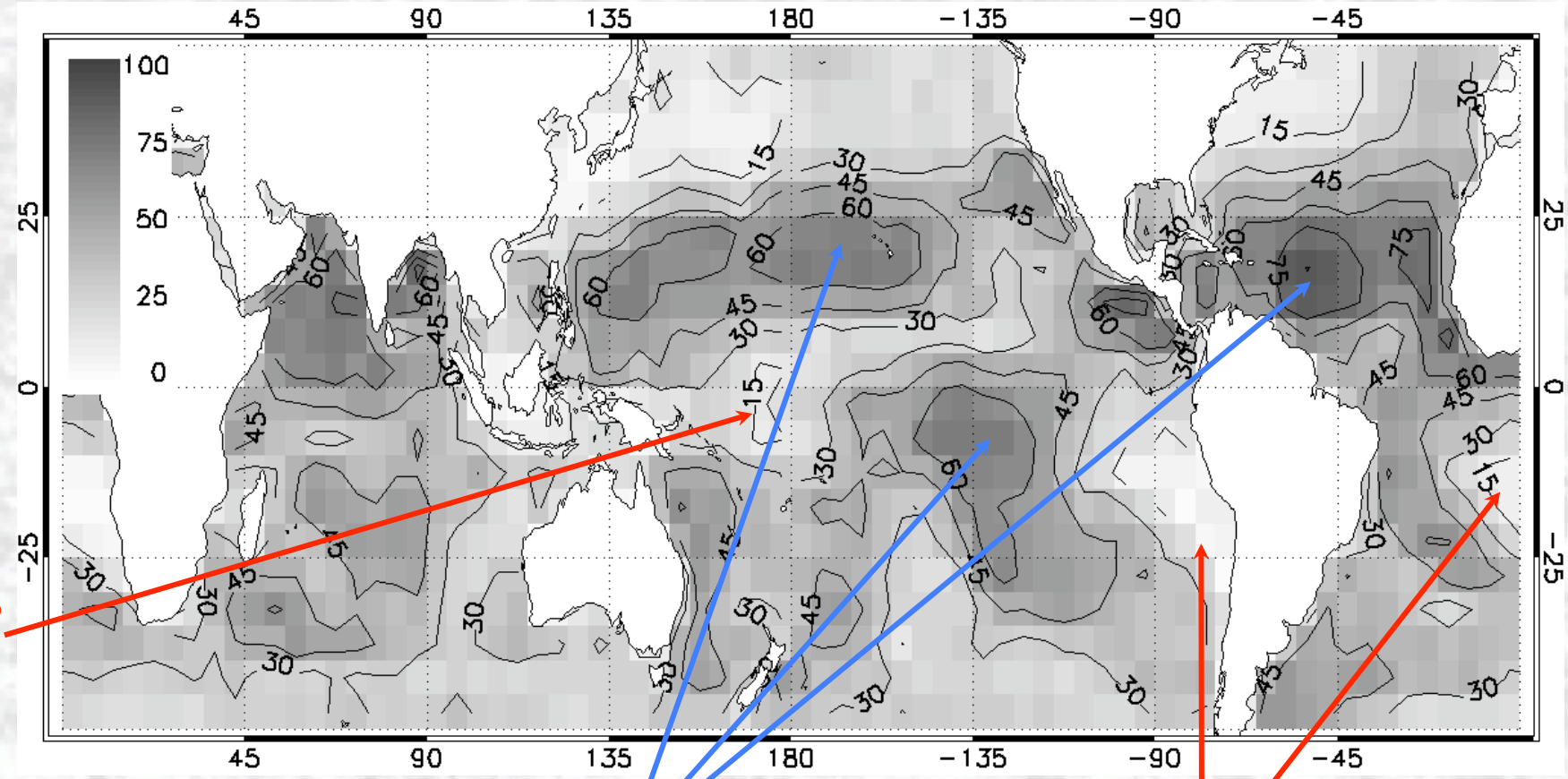
AIRS/AMSU retrieval yields vary with location

Fraction of 'good' retrievals (percent)

25 Dec 2002 to 15 Jan 2003



!!??

Highest yields in trade cumulus.

Poorer coverage in stratocumulus.

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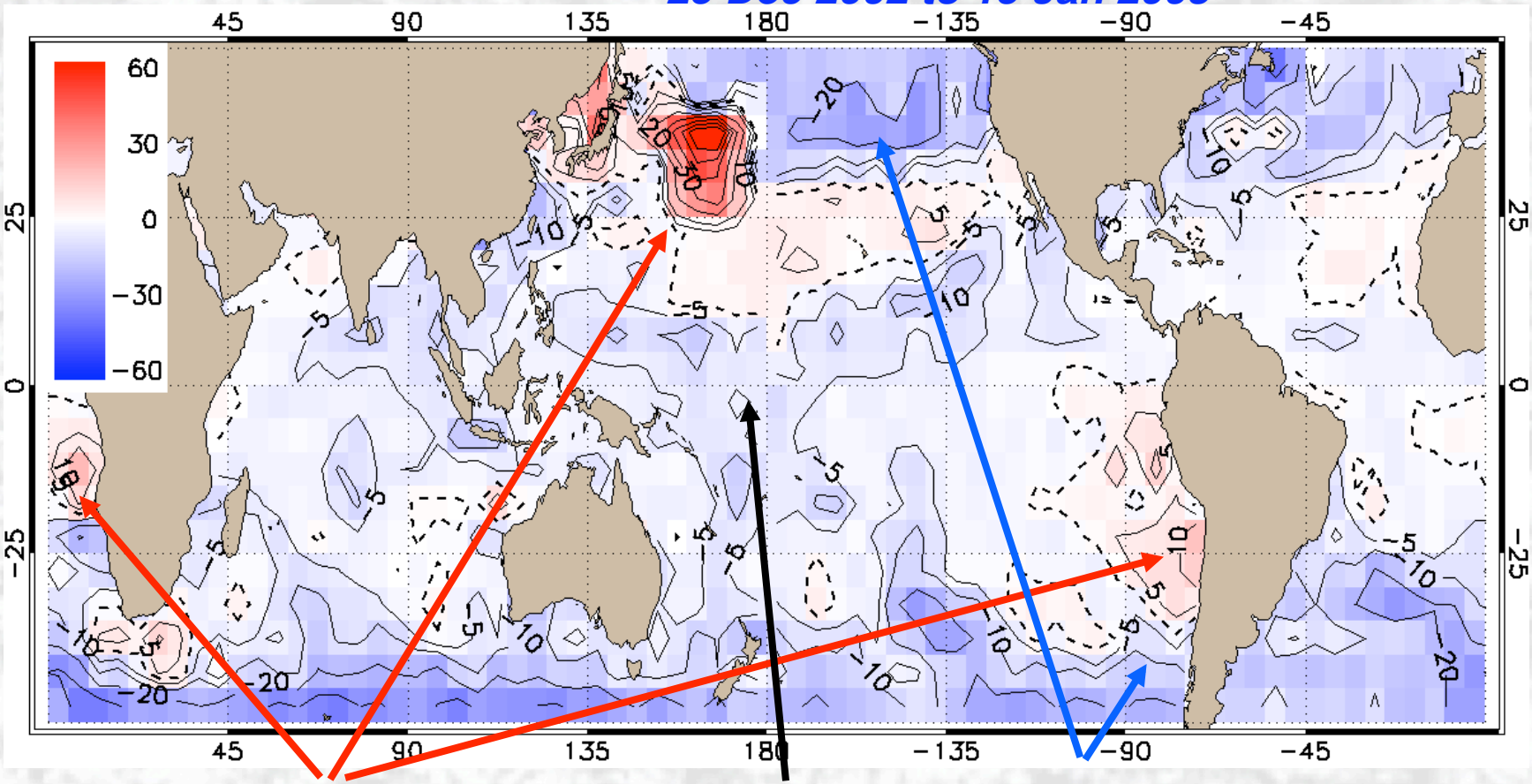
Percent Differences in Mean Water Vapor Climatologies

AIRS/AMSU 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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Summary of yields and sampling biases in AIRS total water vapor *using AMSR-E as a diagnostic*

Climate Regime	AIRS-AMSR-E total bias (%)	AIRS Full Retrieval yields (%)
Mid-latitude storm belts	-10 to -30	15 to 30
Cold air outbreaks	+30 to +70	<15
Subtropical stratus	-5 to -15	15 to 50
Trade wind cumulus	-5 to +5	50 to 90
Tropical deep convection	-5 to +5	15 to 50

From: Fetzer et al., 2006.

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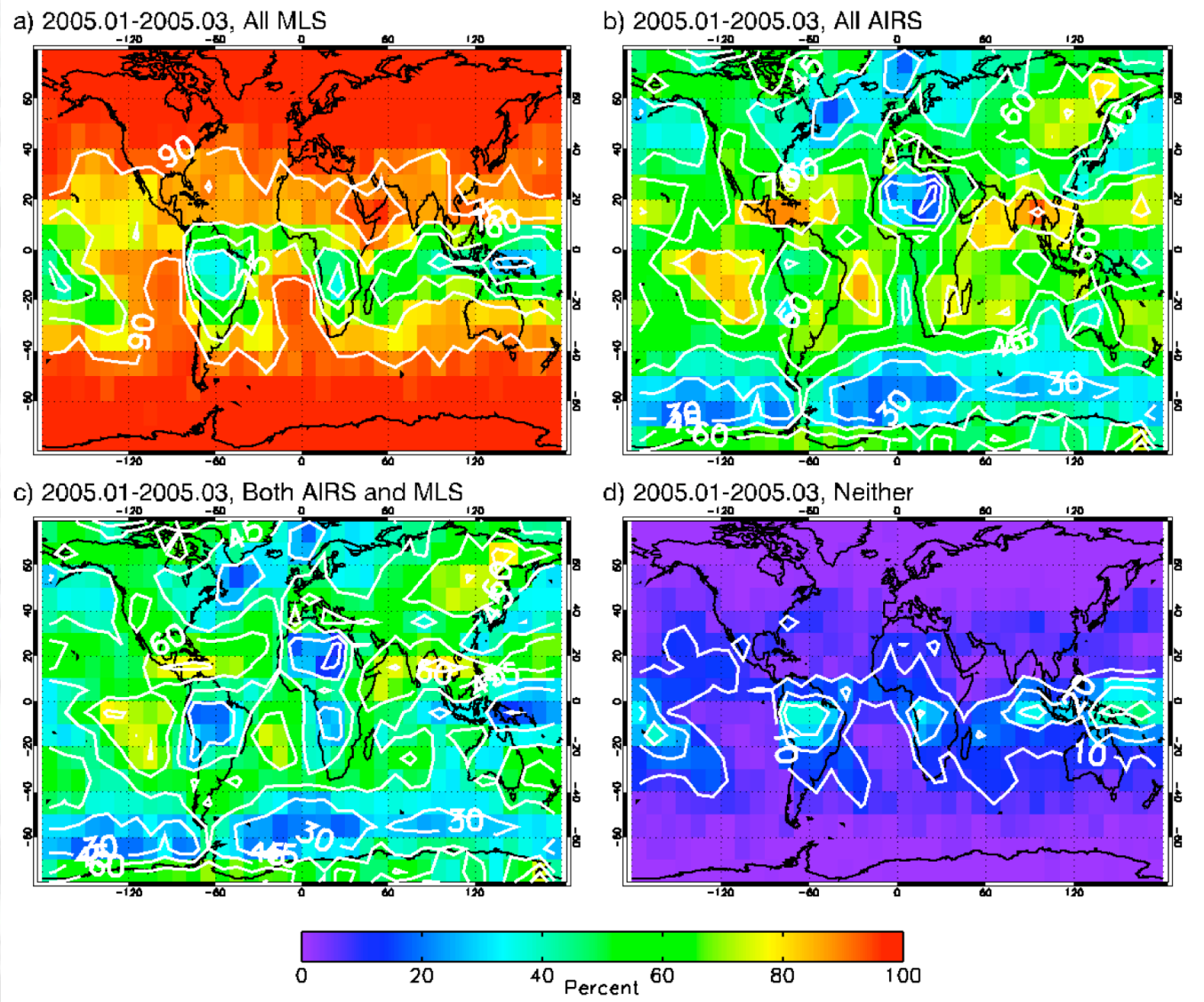
Good instruments don't always have good coverage
AIRS and MLS at 300 hPa



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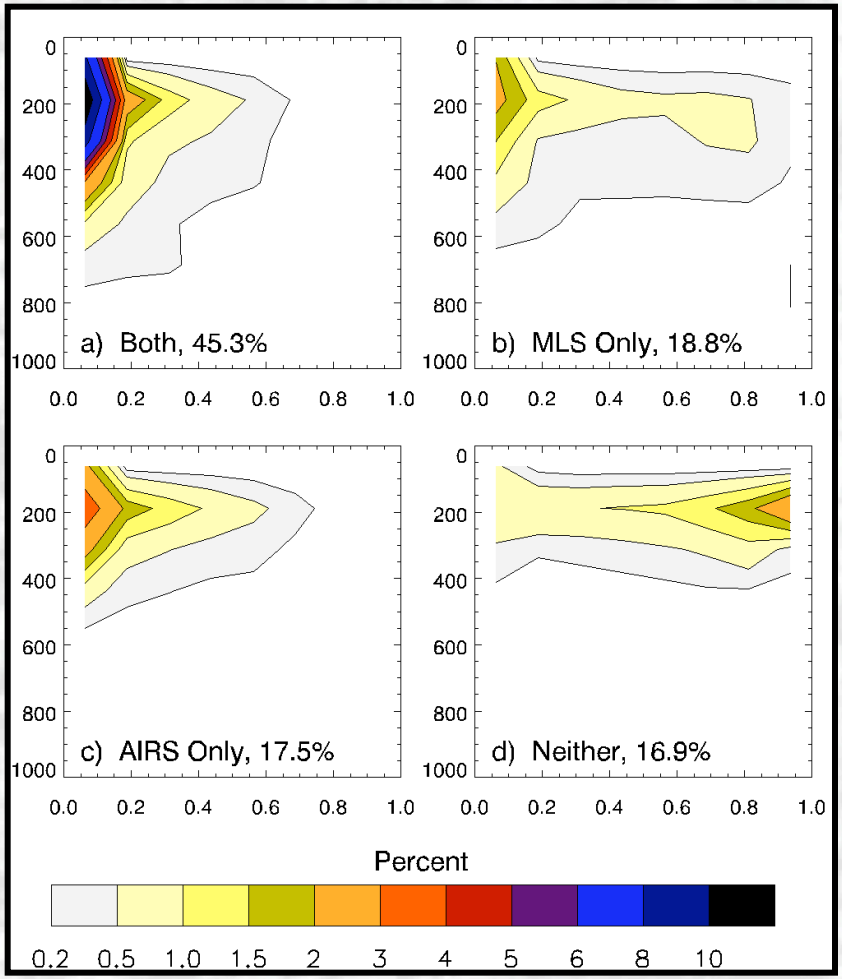
AIRS/AMSU and MLS sampling affected by clouds in Tropics.

PDF of AIRS/AMSU cloud top pressure and fraction by retrieval state, 15S-15N.

Both instruments sound most often in clearer conditions, while unsuccessful soundings are most frequent at higher cloud fraction.



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Reconciling water vapor observations is a challenge.

Manuscript prepared for Atmos. Meas. Tech. Discuss.
with version 2.2 of the LaTeX class copernicus_discussions.cls.
Date: 11 June 2010

Characterization of Merged AIRS and MLS Water Vapor Sensitivity Through Integration of Averaging Kernels and Retrievals

Calvin K. Liang[1,2], Annmarie Eldering[2], Frederick Irion[2], William G. Read[2], Eric Fetzer[2], Brian H. Kahn[2], and Kuo-Nan Liou[1]

[1]Joint Institute for Regional Earth System Science and Engineering, Los Angeles, California, USA
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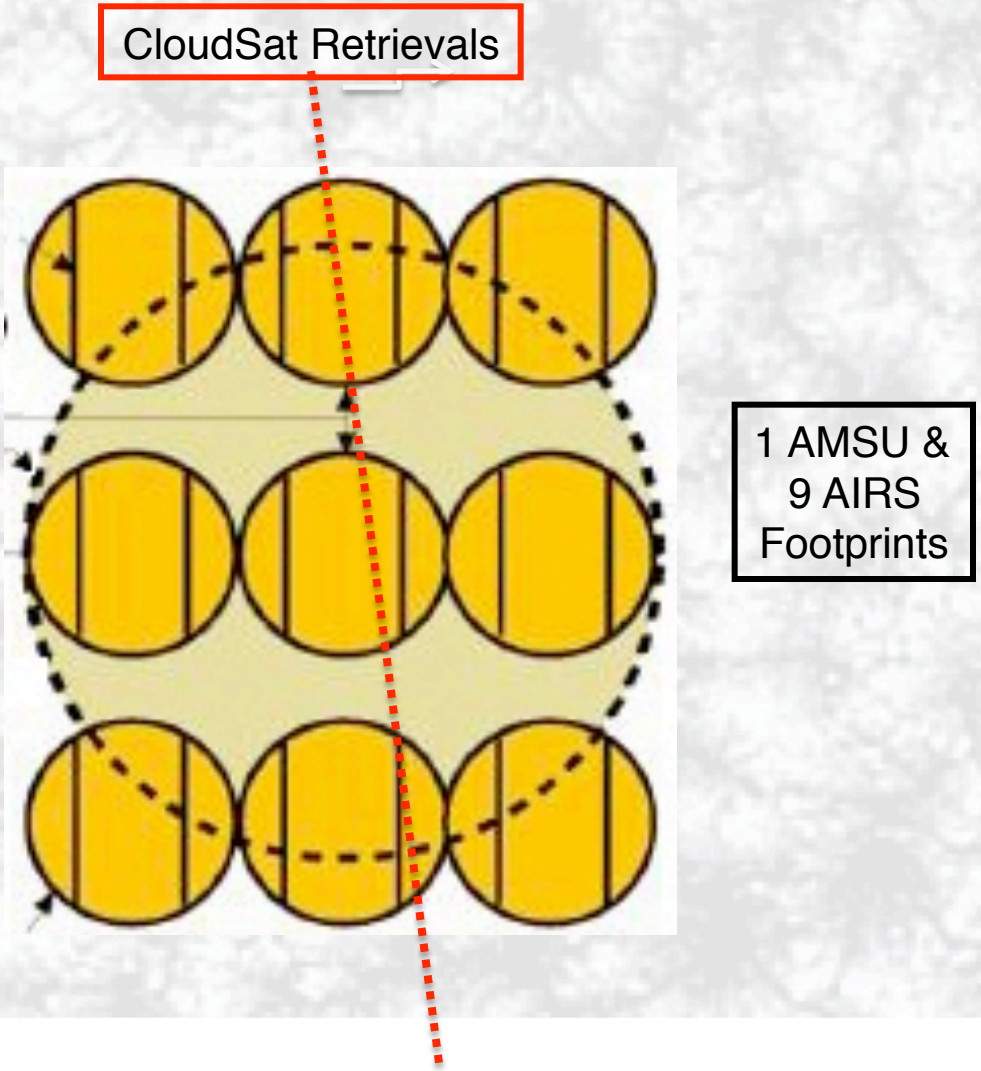
Use CloudSat to Characterize AIRS.
Co-registering Level 2 data sets
Example: AIRS / CloudSat Matching

Compute Overlaps:

- **Look up geometry**
- **Intersect CloudSat strip with ellipses (nearest neighbor)**
- **Save matchup indices**
- **Use indices later to subset temp., water, and cloud data**



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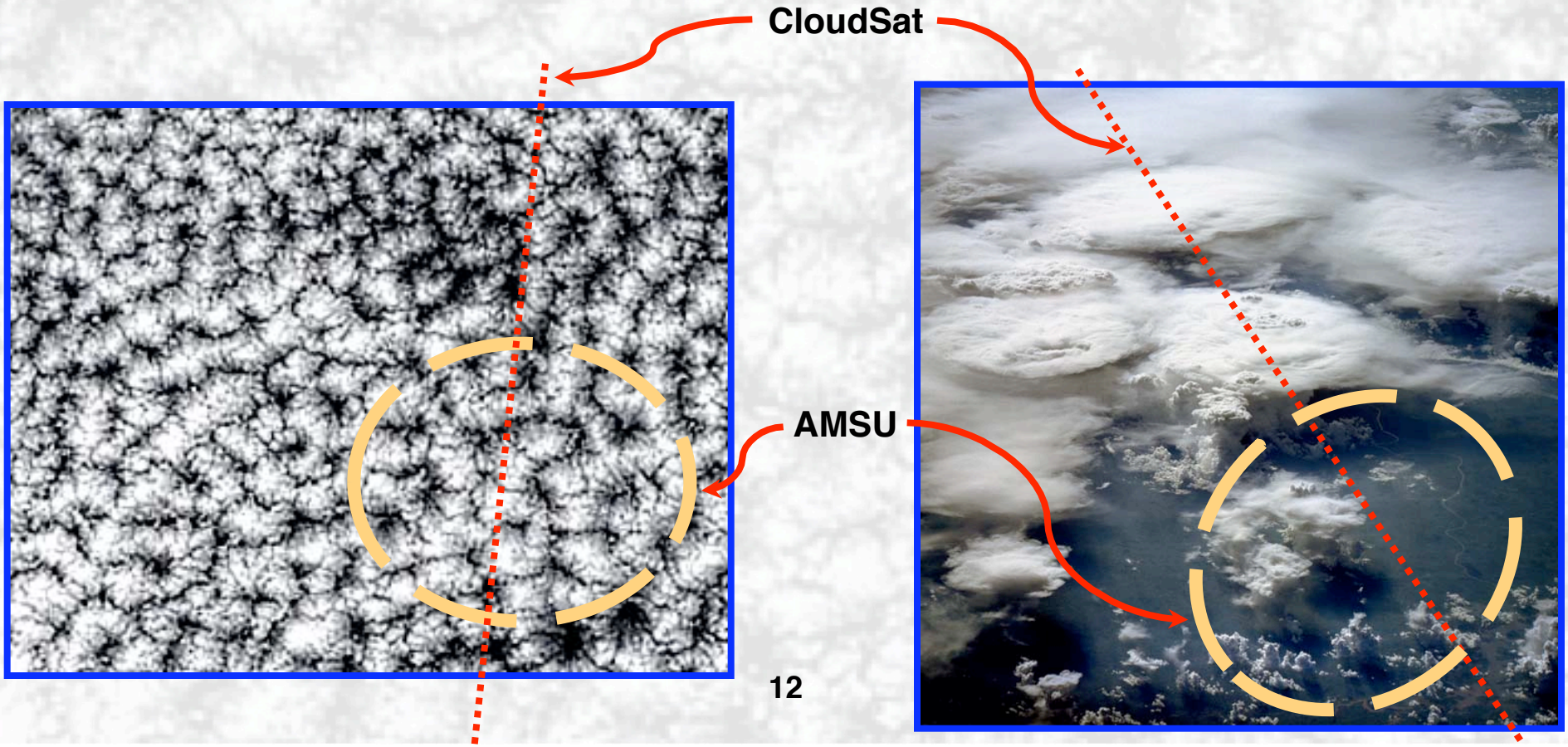
Schematically, this is what's happening in millions of scenes per month.

(Geometry is best guest).



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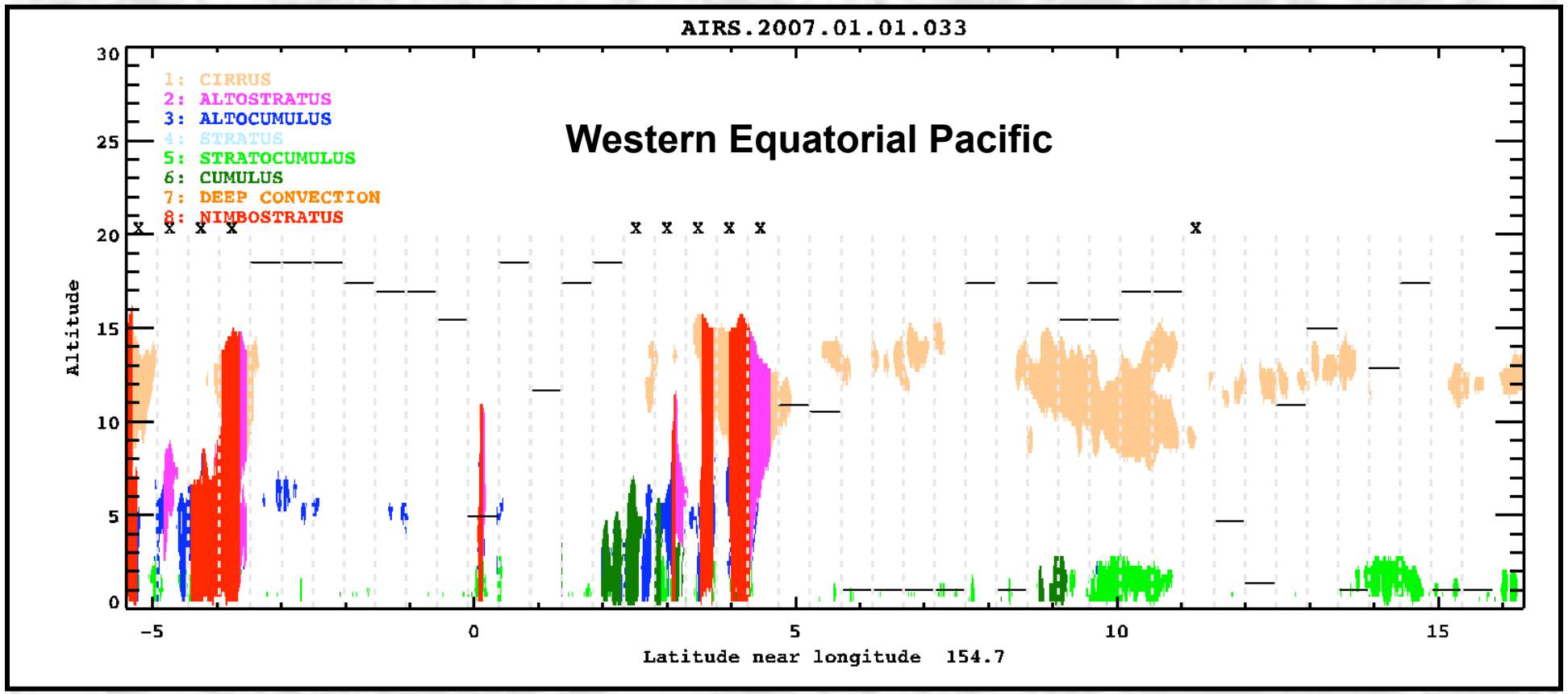
AIRS-CloudSat Matched Data

Color fill: CloudSat Classes (Sassen and Wang, 2008, GRL)

Gray verticals: matched AIRS profile boundaries.
Black horizontals: AIRS 'best' retrieval altitude (from 'PBest').
X: no AIRS tropospheric profiling.



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Dominant *CloudSat* Cloud Classes in *AIRS* Scenes Indep't of AIRS ret.

scene code	count	proportion [%]	scene
264	1057776	27.14	{"nc", "Sc"}
256	703439	18.05	{"nc"}
384	258885	6.64	{"nc", "ci"}
320	217153	5.57	{"nc", "AlSt"}
296	179918	4.62	{"nc", "Alcu", "Sc"}
392	128973	3.31	{"nc", "ci", "Sc"}
268	124975	3.21	{"nc", "Sc", "Cu"}
448	104261	2.68	{"nc", "ci", "AlSt"}
258	92868	2.38	{"nc", "Ns"}
288	70978	1.82	{"nc", "Alcu"}
64	56502	1.45	{"AlSt"}
328	51229	1.31	{"nc", "AlSt", "Sc"}
322	50914	1.31	{"nc", "AlSt", "Ns"}
300	44125	1.13	{"nc", "Alcu", "Sc", "Cu"}

- **Only 327 combinations exist (of 512 possible).**
- **Fourteen scene types in this table explain 80.6% of scenes GLOBALLY for August 2006.**
- **The prevalence of the clear sky scenario ("nc") as well as the absence of deep convection ("DC") and stratocumulus ("St") is striking.**
- **Some classes will have very few AIRS soundings.**

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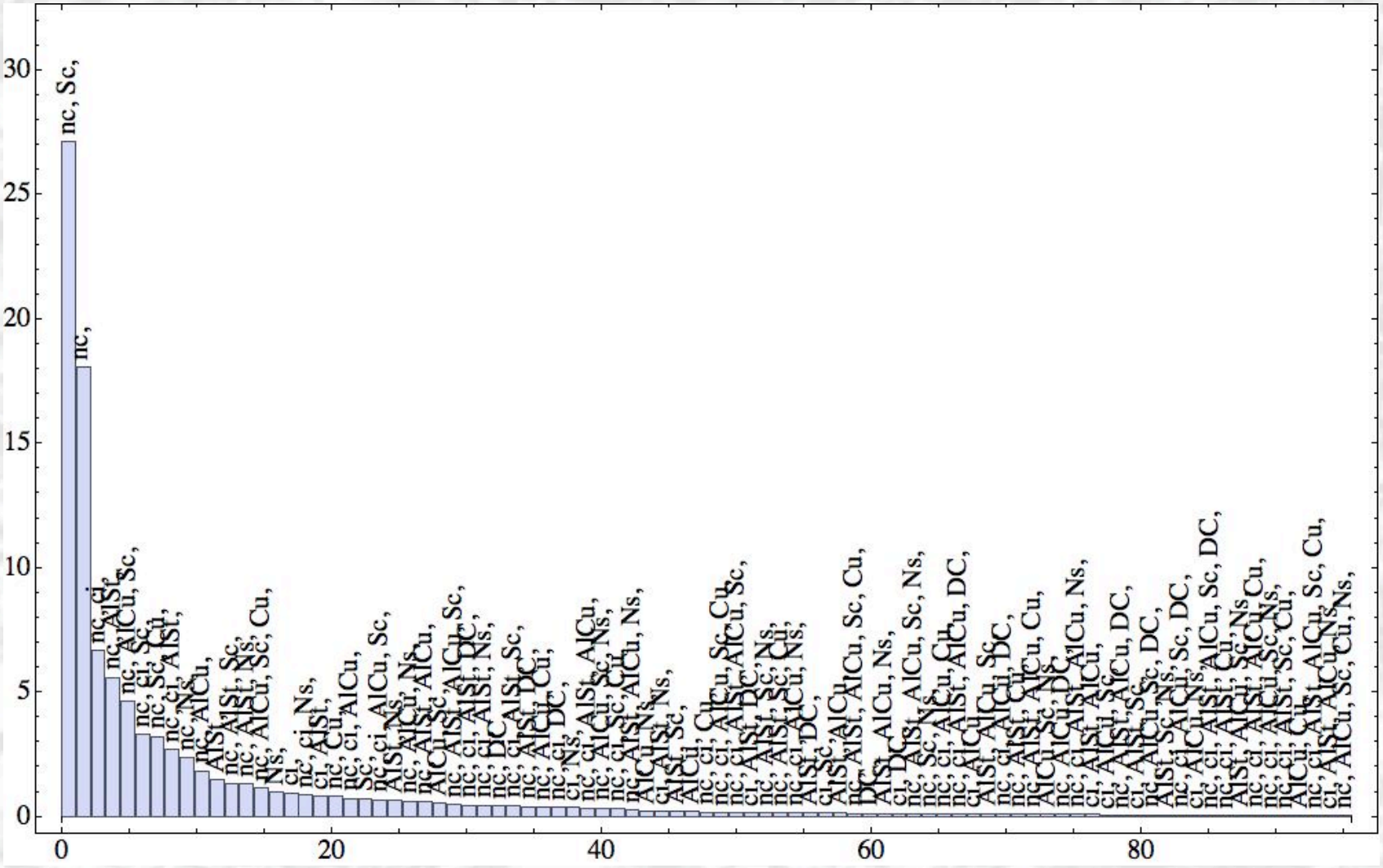
Dominant Scene in AIRS AIRS FOVs
Independent of AIRS Retrieval



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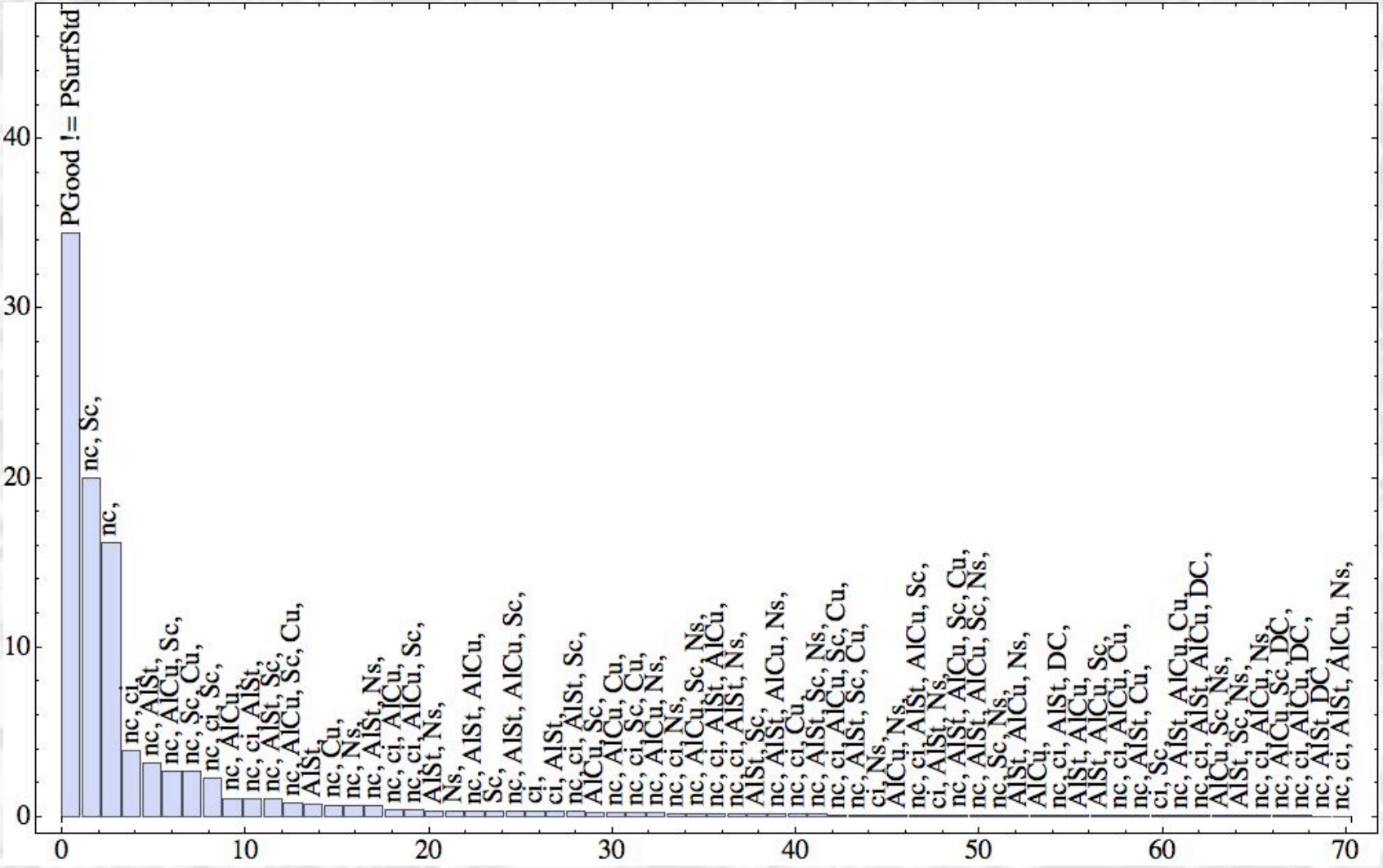
Dominant Scenes
When AIRS Retrieves to Surface



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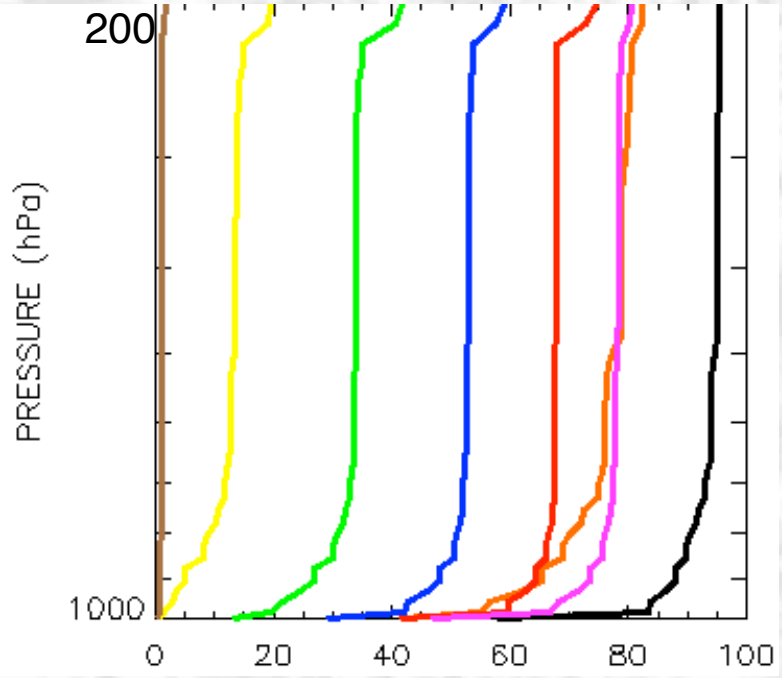
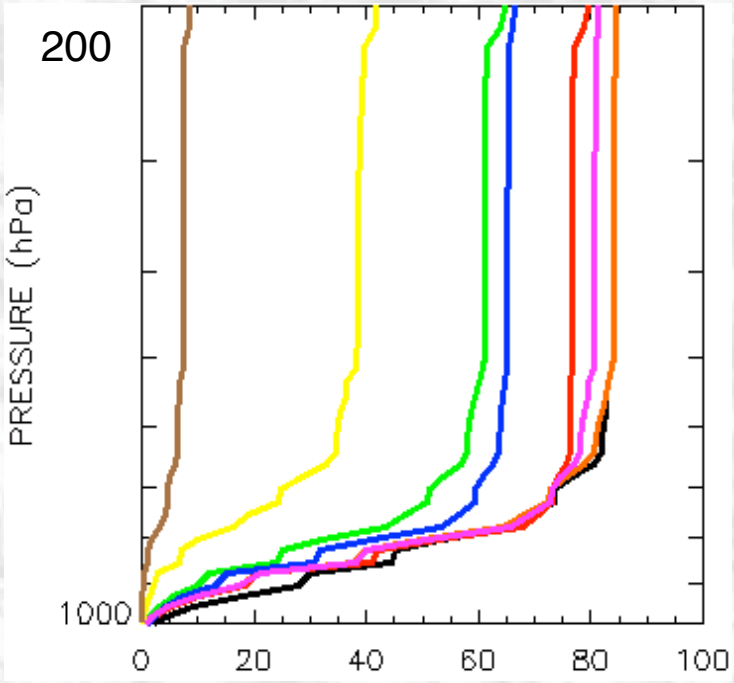
AIRS Yield by Cloud Class

Yield= percentage of PBest ≤ Pressure(z)

Ocean



Land



Ns
DC
Cu
Ac
As
Ci
Sc
Clear

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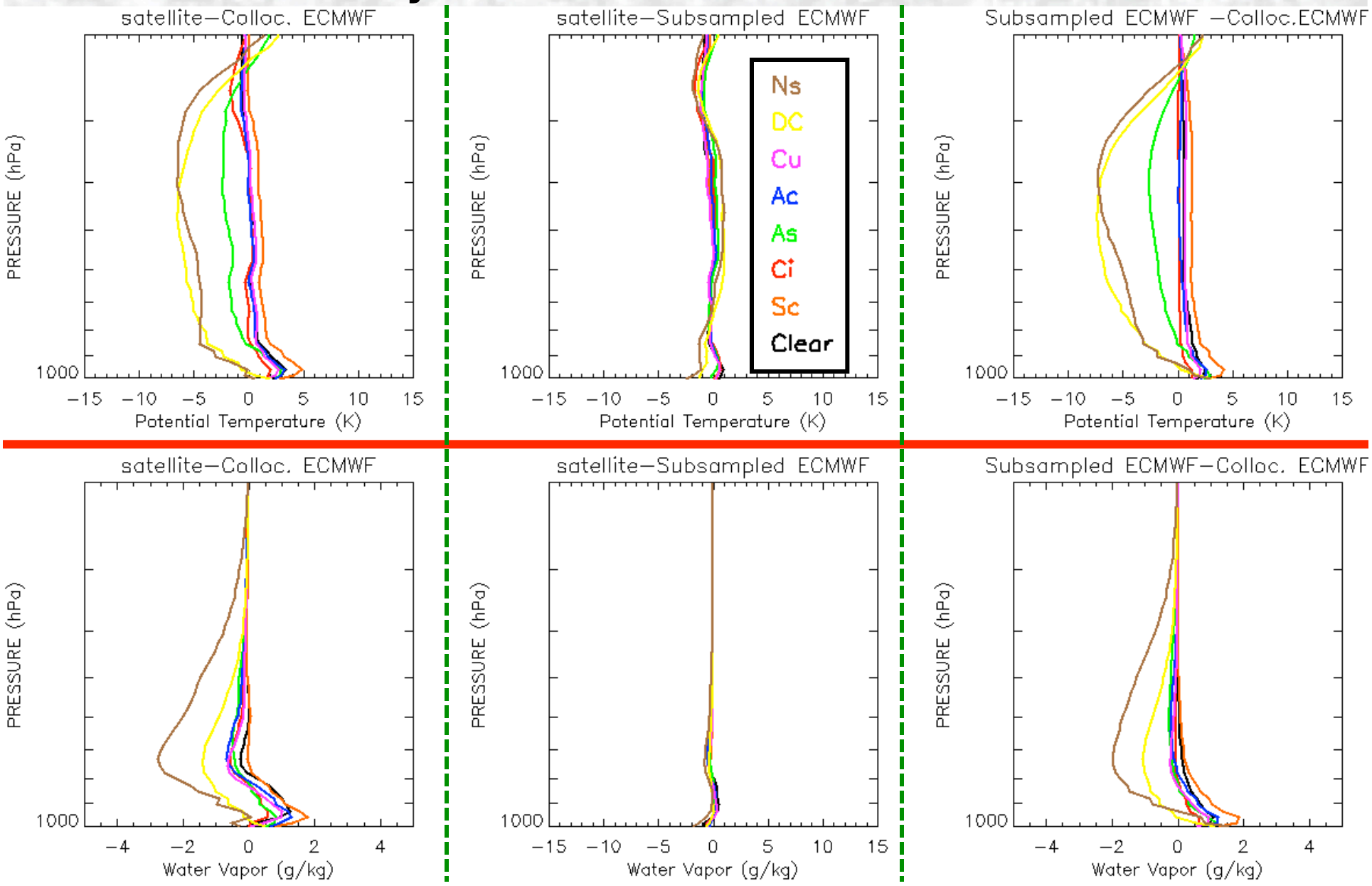
Comparison of θ, q profiles

By Cloud Class over Ocean



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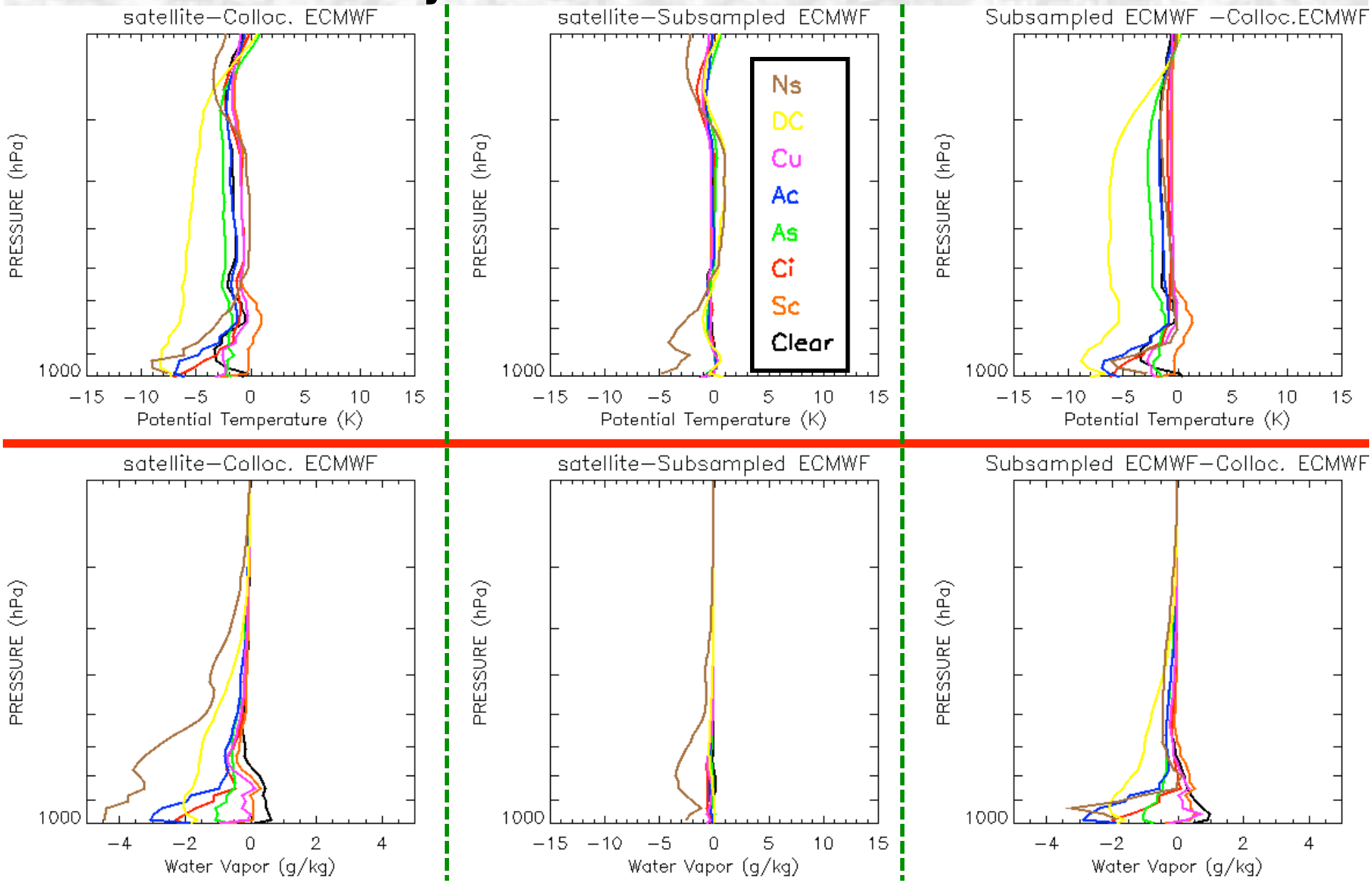
Comparison of θ, q profiles

By Cloud Class over Land



CloudSat Marine BL Cloud Types

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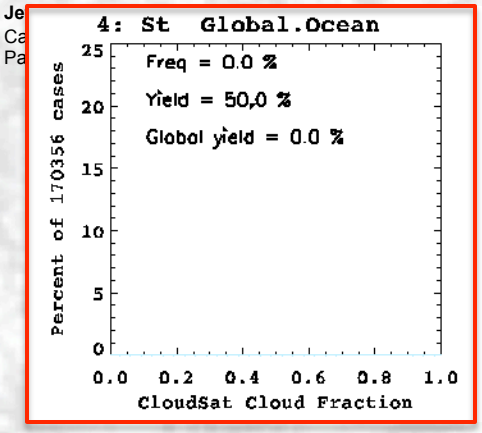
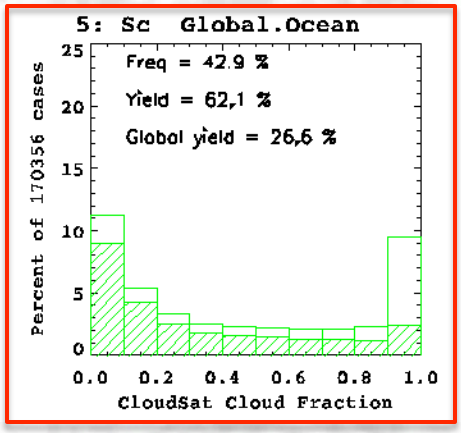
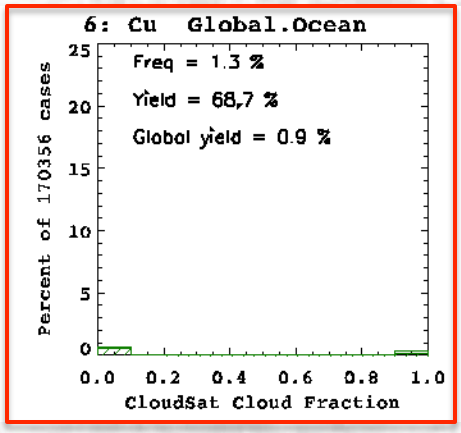
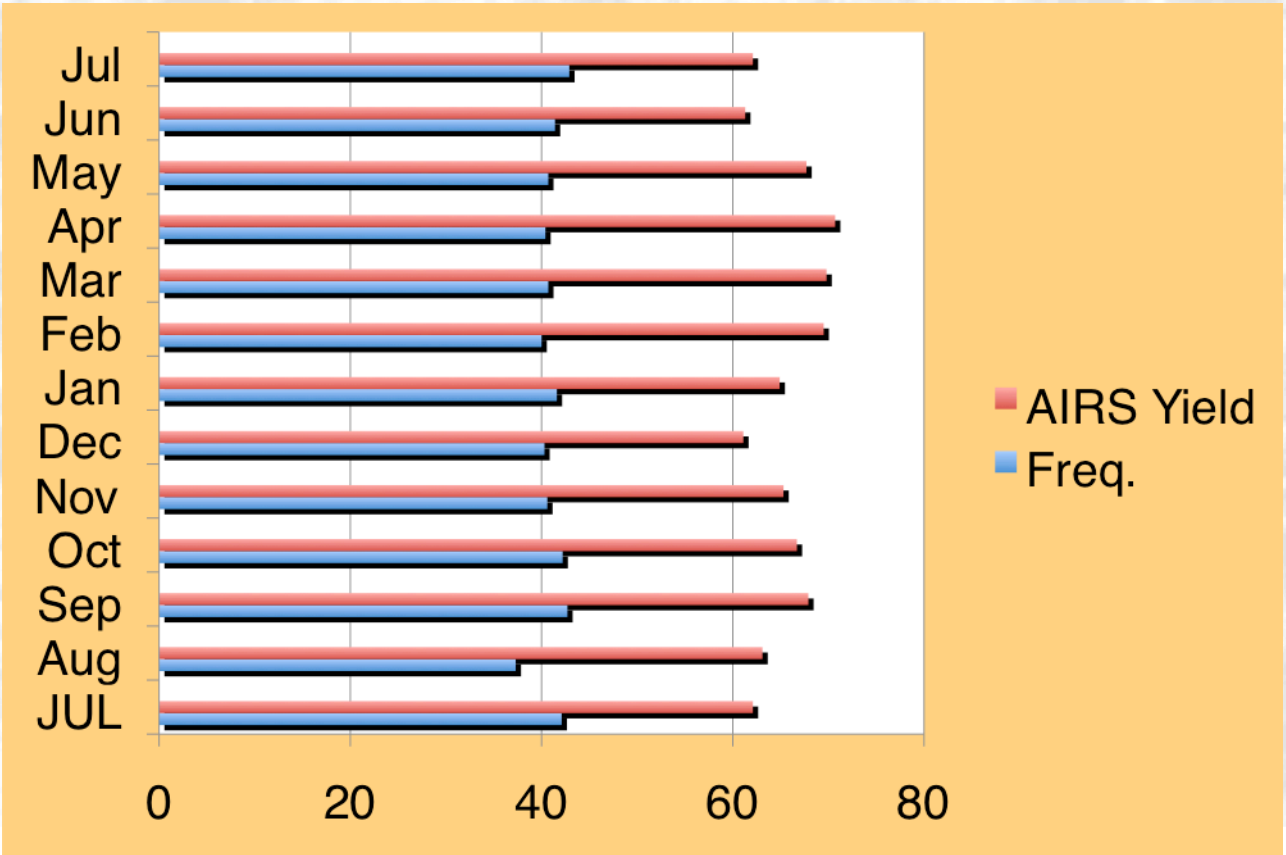
Je
Ca
Pa







2007 July 01~31, Global Ocean



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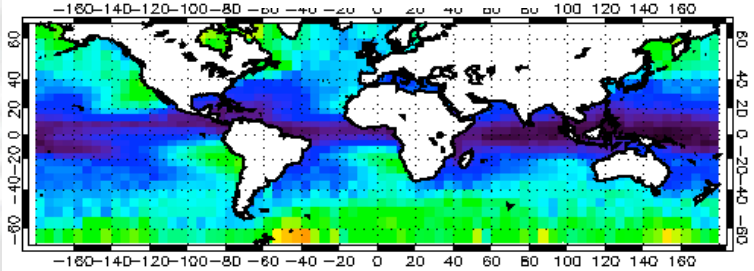
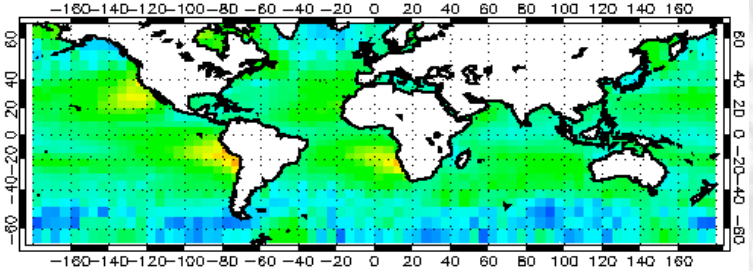
Annual EIS and LTS over Global Ocean

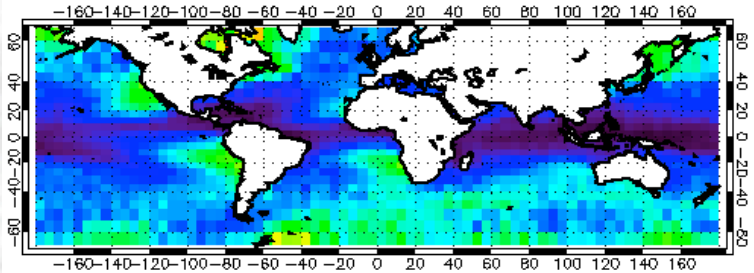
Satellite EIS



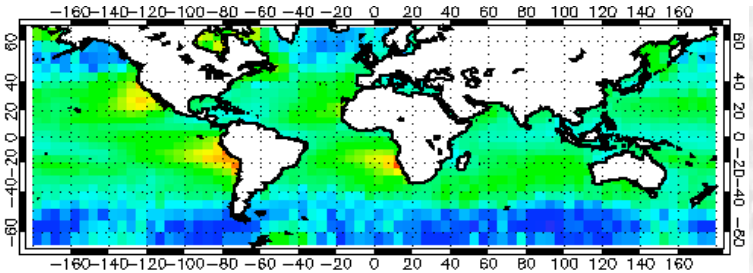
Satellite LTS



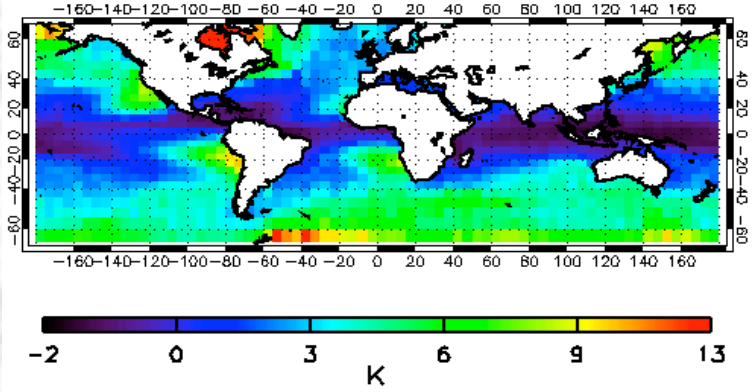
PBest Collocated ECMWF Analysis EIS



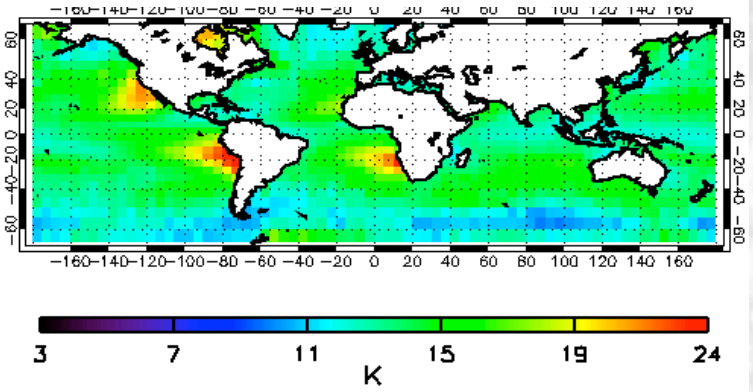
PBest Collocated ECMWF Analysis LTS



Collocated ECMWF Analysis EIS



Collocated ECMWF Analysis LTS



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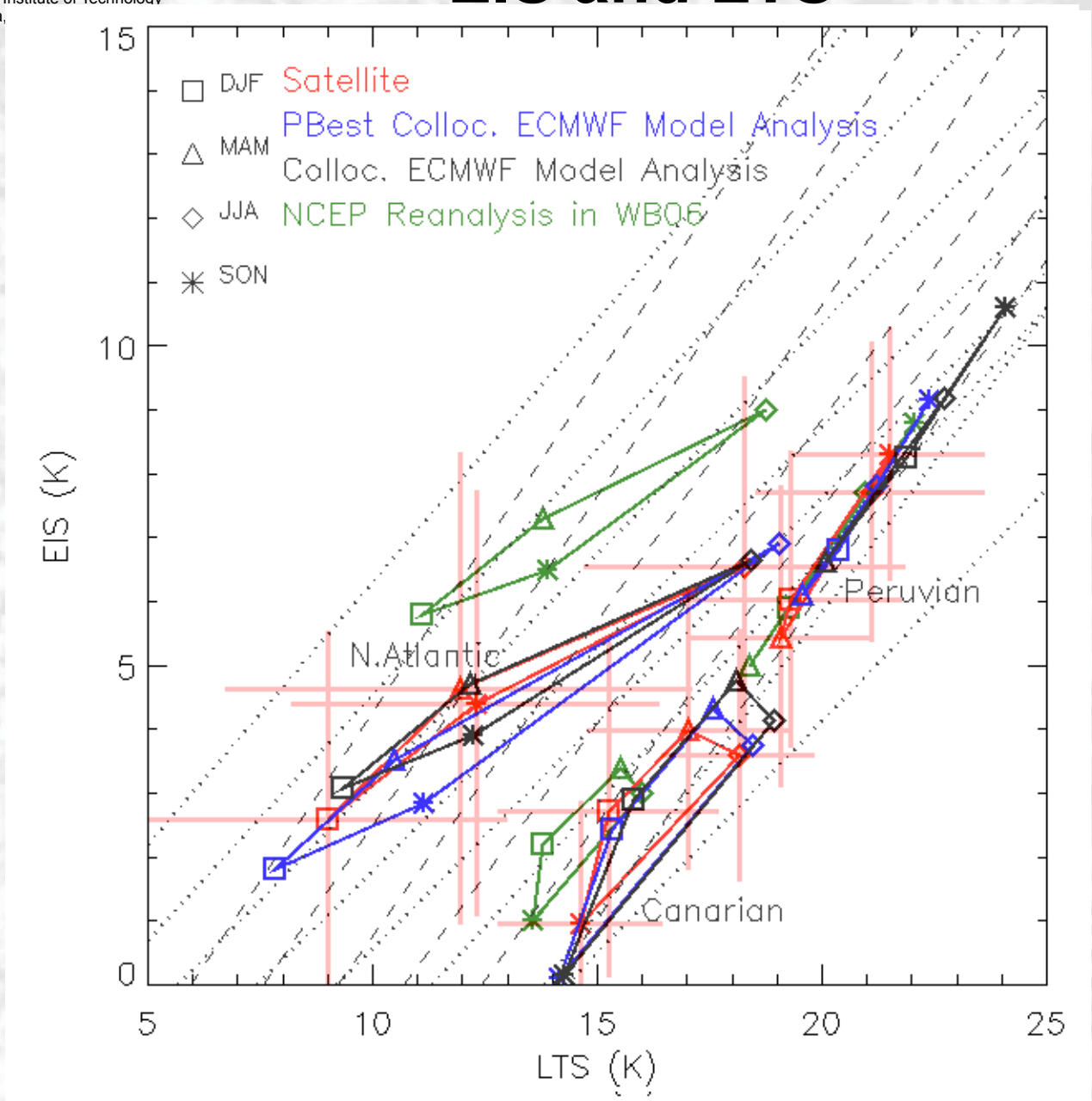
Regional Relationships Between EIS and LTS



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Summary

Combined data sets from the A-Train offer much potential for understanding climate phenomena. Challenges:

- **Matching L2 quantities.**
- **Reconciling similar observations, including sampling issues (which can only be resolved at L2).**
- **Interpreting the resulting combined data sets.**

We are currently creating a climatology conditioned on CloudSat cloud classes, using AIRS, MLS and AMSR-E water vapor and temperature.

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A true multi-decadal record requires reconciling the A-Train with earlier (NVAP-MEaSUREs).

Instrument	Satellite	Product	Operational Period	Data Archive
EOS Data Sets				
MODIS	Aqua	Clouds	Aug 2002 –	LAADS
MLS	Aura	Upper tropospheric water vapor, cloud path	Sep 2004 –	JPL
AIRS	Aqua	Water vapor, temperature, cloud amount and height	Sep 2002 –	GDAAC
AMRS-E	Aqua	Total water vapor and cloud path	Jun 2002 –	RSS
AMSU MHS	POES Aqua METOP-A	Water vapor, temperature and cloud path	Jan 1999 –	CLASS
Pre-EOS Data Sets				
NVAP	DMSP POES	Water vapor	Jan 1988-Dec 1999	LDAAC
MLS	UARS	Upper tropospheric water vapor, cloud path	May 1992 – Jul 1999	JPL
ISCCP D1/DX	GOES POES GMS Met	Cloud height, amount and type	Jan 1983 – Jun 2005	JPL
SSM/I	DMSP	Total water vapor	Jul 1987 -	RSS