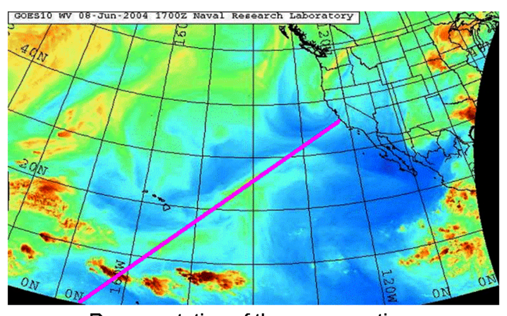
Preliminary validation of GPCI simulations with observational data from NASA's A-Train Aqua, CloudSat and Calipso satellites.

S. Cardoso(1,2), J. Teixeira(3), P. Rasch(1), P. Miranda(2)
A. Gettelman(1), Y. Zhang(4), S. Klein(4), G. Mace(5), C. Hannay(1), M. Koehler(6), M. Zhao(7)
P. Siebesma(8), P. Marquet(9), A. Lock(10), C. Jakob(11), C. DeMott(12), H. Kitagawa(13), D. Mironov(14)

(1) NCAR, USA; (2) CGUL, Portugal; (3) JPL, USA; (4) LLNL, USA; (5) University of Utah, USA; (6) ECMWF, UK; (7) GFDL, USA
(8) KNMI, The Nederlands; (9) MeteoFrance, France; (10) UKMO, UK; (11) BMRC, Australia
(12) CSU, USA; (13) JMA, Japan; (14) DWD, Germany

GPCI (Gewex cloud system study Pacific Cross-section Intercomparison) is a working group of GCSS.
Models and data are analyzed along a Pacific cross-section from stratocumulus, to cumulus and to deep convection.



Representation of the cross-section.

GPCI motivation

- To evaluate models and observations in the (sub)tropics in terms of the atmospheric hydrologic cycle.
- To include 3D NWP/Climate models in the GCSS framework.
- To utilize a new generation of satellite datasets.
- To create a database of models and observations for future studies of the (sub)tropics.

GPCI participating models

8 Countries
20 Institutions
22 Models
7 US Institutions

Organization	Model	Type
BMRC (Aus)	BAM 4.0.21	Global
CMC (Can)	GEM	Regional
CSU/MMF (US)	MMF	Global/MMF
DWD (Ger)	GME	Global
GFDL (US)	AM2p12b	Global
GKSS (Ger)	CLM	Regional
JMA (Jap)	GSM0412	Global
KNMI (Ned)	RAC	Regional
MeteoFrance (Fra)	ARPEGE	Global
NASA/GISS (US)	GISS III 3.3	Global
NCAR (US)	CAM 3.0	Global
NCEP (US)	GFS&MOM3	Global Coupled
ECMWF (UK)	ECMWF	Global
UKMO (UK)	HadGAM	Global
UQM (Can)	CRCM	Regional
NCEP (US)	GFS	Global
JAMSTEC (Jap)	AFES2	Global
CCC (Can)	CCCma	Global
CSU/BUGS (US)	BUGS	Global
UCSD (US)	RSM	Regional
ETH (Ger)	ECHAM5	Global
UCLA (US)	UCLAtm7.3	Global

17 Global
1 MMF
1 Coupled
5 Regional

GPCI model data characteristics

When?
June-July-August 1998 and 2003.

Time resolution:
0, 3, 6, 9, 12, 15, 18, 21 UTC.

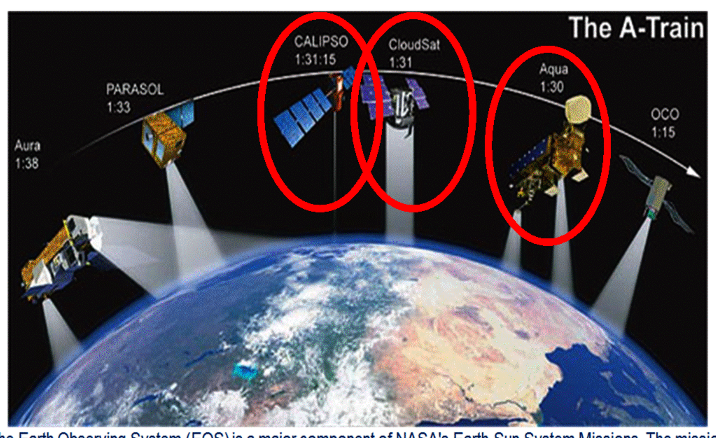
Where?
NE Pacific.

Boundary Conditions:
prescribed sea surface temperature.

Cross-section:
13 locations starting at 35 N, 125 W and moving southwestwards at 4 deg longitude and 3 deg latitude steps until 1 S, 173 W.

2D map:
locations every 5x5 degrees within the following grid: latitude from 5 S to 45 N, longitude from 160 E to 120 W.

Aqua, CloudSat and Calipso



The Earth Observing System (EOS) is a major component of NASA's Earth-Sun System Missions. The mission includes a series of satellites, a science component, and a data system supporting a coordinated series of polar-orbiting and low inclination satellites for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans.

http://www-airs.jpl.nasa.gov/Technology/

Coverage:
pole-to-pole, covers the globe two times a day (daytime and nighttime).

Orbit:
438 miles (705.3km) polar, sun synchronous, 98.2+/- .1 degrees inclination, ascending node 1:30pm +/- 15 minutes, period 98.8 minutes.

Repeat cycle:
exact 16-day (233 orbits).

http://www-airs.jpl.nasa.gov/Technology/

Aqua leads the constellation with an equatorial crossing time of about 1:30 PM. CloudSat and CALIPSO lag Aqua by 1 to 2 minutes and are separated from each other by 10 to 15 seconds, so that both instrument suites view the same cloud area at nearly the same moment. This capability is crucial for studying clouds, which have lifetimes often less than 15 minutes.

http://www-calipso.larc.nasa.gov/about/

Instruments of interest here:

AIRS
Atmospheric InfraRed Sounder
(Aqua)

Aimed at obtaining highly accurate temperature and humidity profiles throughout the atmosphere.

Measures the Earth's outgoing radiation at 0.4 to 1.0 μm and 3.7 to 15.4 μm (4 visible/near-infrared and 2378 infrared channels).

Swath: 1650 km.
Resolution: 13.5 km at horizontal at nadir, 1 km vertical.
Accuracy: 1 K temperature retrieval accuracy per 1 km layer in the troposphere, 0.05 emissivity accuracy.

CPR
Cloud Profiling Radar
(CloudSat)

The primary CloudSat instrument, it is a 94-GHz nadir-looking radar which measures the power backscattered by clouds as a function of distance from the instrument.

The purpose of mission is to measure the vertical structure of clouds from space and, for the first time, simultaneously observe cloud and precipitation.

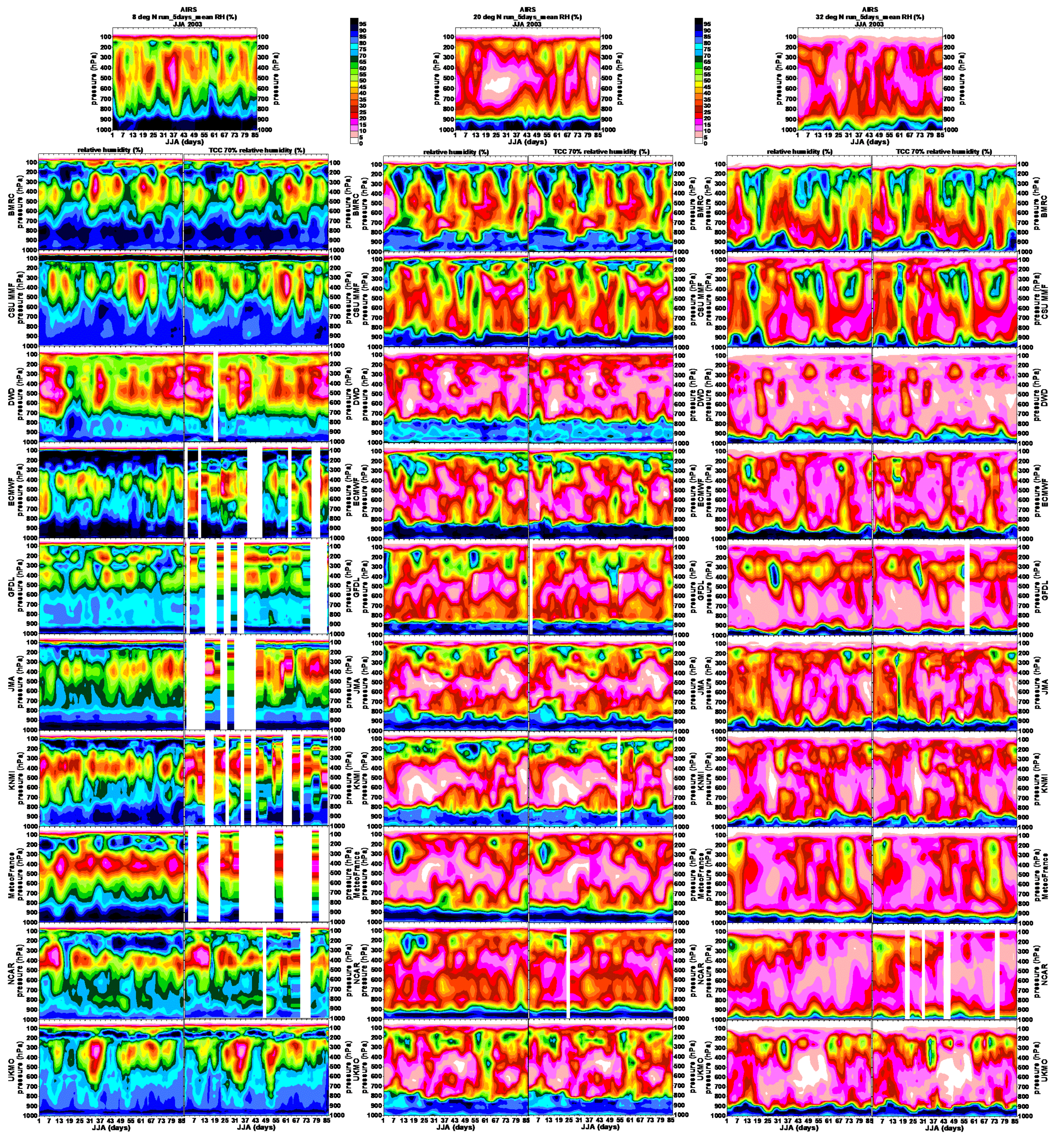
Resolution: 1 profile generated every 1.1 km along track, with 125 vertical "bins" (each one 240m thick), 1.4km (across-track) by 2.5 km (along-track) footprints.

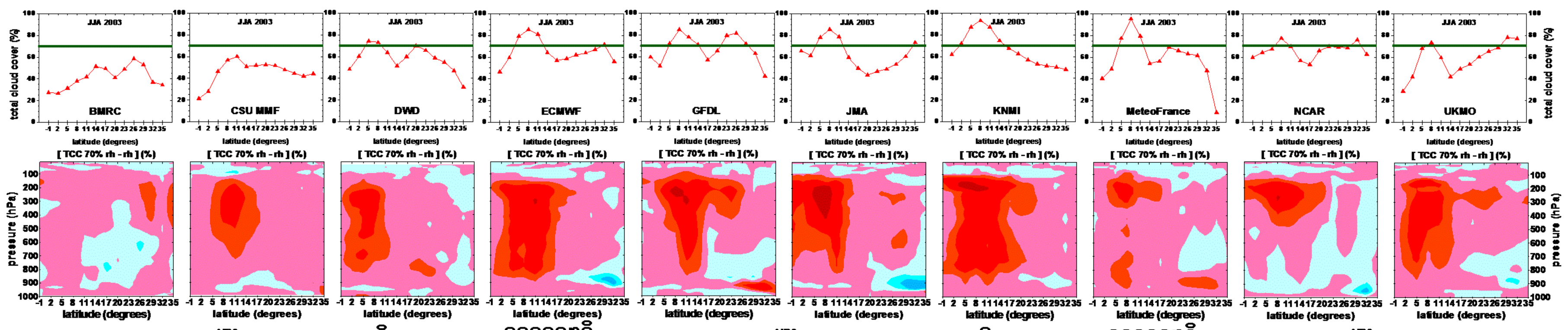
CALIOP
Cloud-Aerosol Lidar with Orthogonal Polarization
(Calipso)

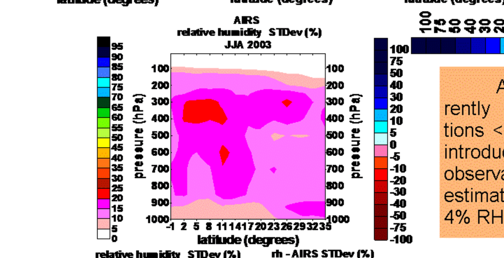
These observations, combined with passive imagery, will lead to improved understanding of the role aerosols and clouds play in regulating the Earth's climate.

CALIOP utilizes three receiver channels: one measuring the 1064 nm backscatter intensity and two channels measuring orthogonally polarized components of the 532 nm backscattered signal.

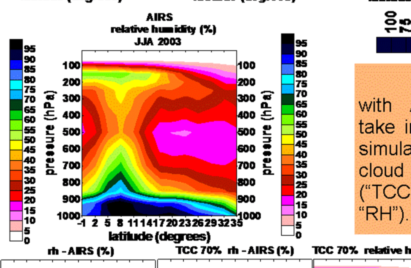
Footprint: 100 m.
Resolution: 30-60 m vertical, 333 horizontal.



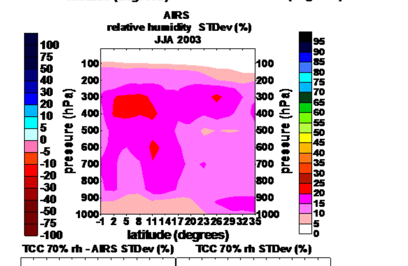


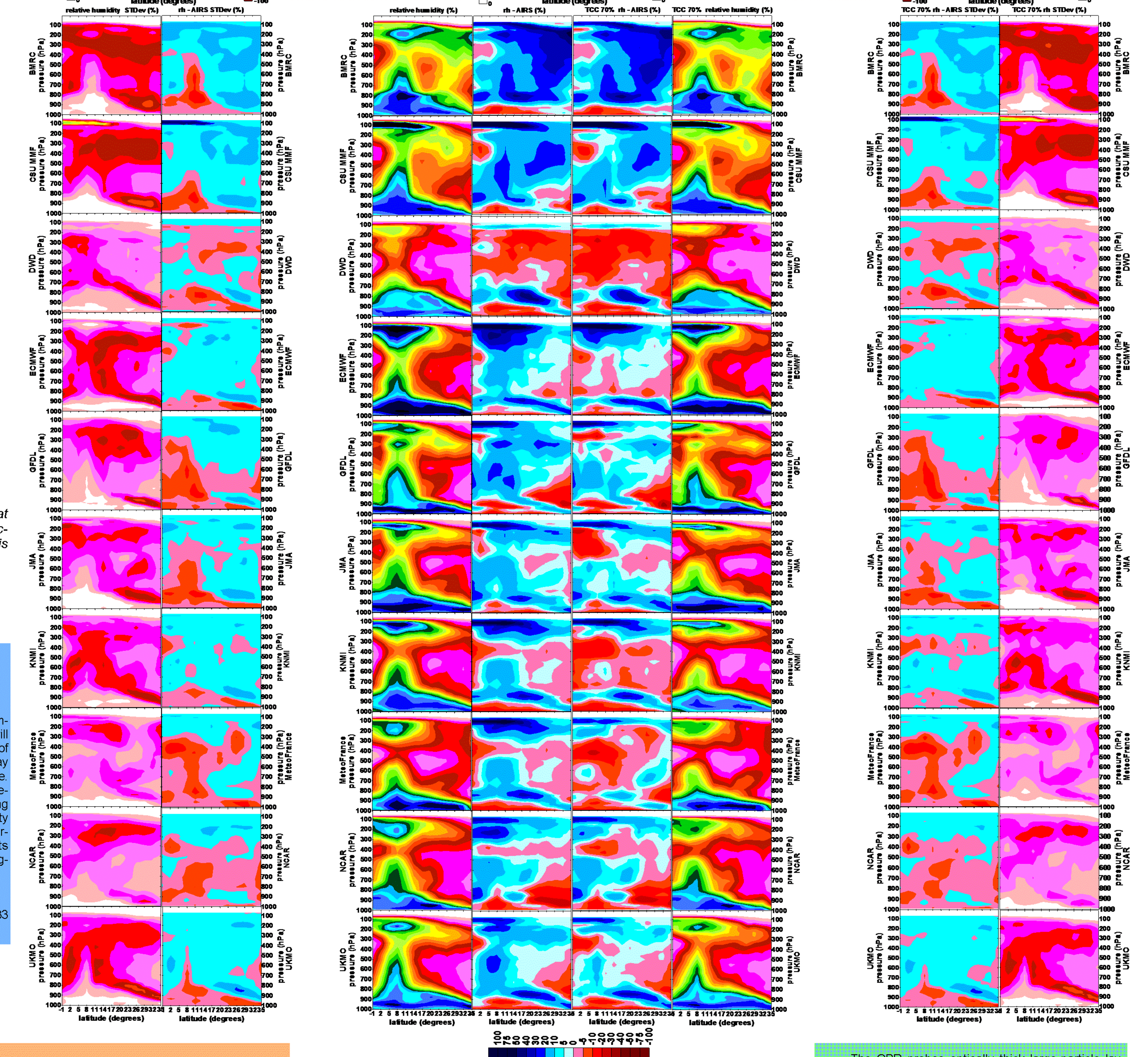


AIRS profiles are currently available for cloud fractions < 0.7. This is believed to introduce a dry bias in these observations (which has been estimated to be of the order of 4% RH).



To facilitate comparisons with AIRS observations, we take into account those model simulated profiles with total cloud cover less than 70% ("TCC 70% RH" as opposed to "RH").



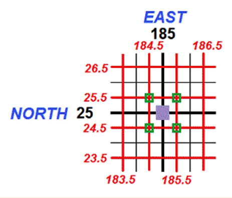


AIRS standard Level 2 retrieved profiles of water vapor and temperature were used to derive relative humidity.

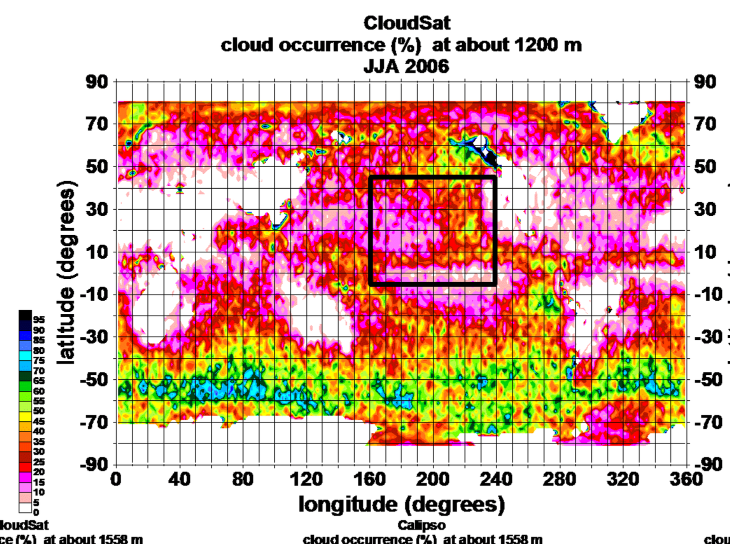
The profiles of relative humidity were binned into a 1 degree by 1 degree latitude longitude grid.

13 levels in the vertical from 1000 hPa to 70 hPa were used here.

< We thank A. Gettleman for providing the AIRS data ! >



The "nearest grid point" to each one of the 13 locations along the GPCI cross-section was identified, resulting in the average of 4 (green above) values of RH from the original 1 deg x 1 deg grid.



The CPR probes optically thick large-particle layers, and the CALIOP senses optically thin layers and tenuous cloud tops.

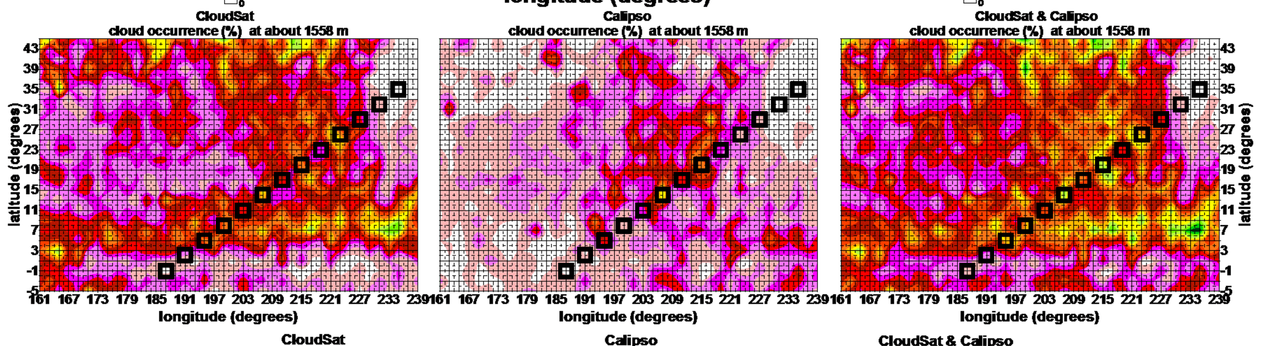
Due to the radar detection threshold and surface contamination, the lidar data can complement the information on cloud fields from the radar data.

This combination has the potential of providing as complete a picture of the occurrence of cloud and aerosol as has been compiled to date.

2B-GEOPROF and 2B-GEOPROF-LIDAR (a mapping of the CALIOP cloud mask onto the CPR footprint) data were used to generate the combined cloud/precipitation (hydrometeor) mask data.

<Thanks to Jay Mace, Yuying Zhang, and Jennifer Kay for providing the CloudSat and Calipso data !>

The original 2 degree by 2 degree latitude longitude grid was interpolated bilinearly to a 1 deg x 1 deg grid and the values for the 13 locations along the GPCI cross-section were obtained by using a 2 degrees averaging radius. Also, for plotting purposes, we converted the original heights (~250m resolution) to a regular grid of pressure in the vertical.

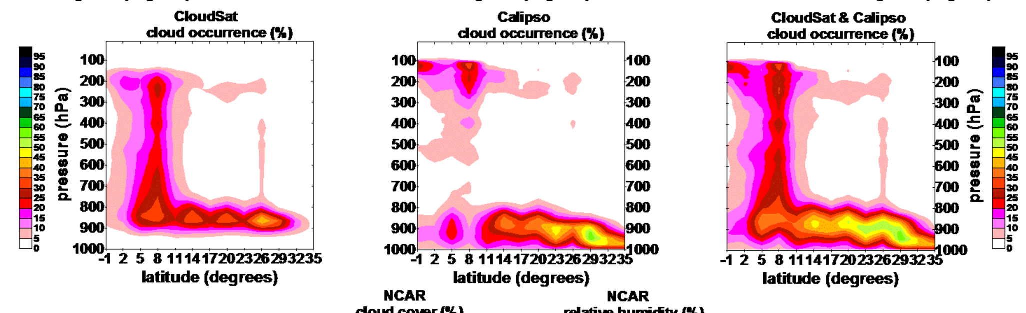


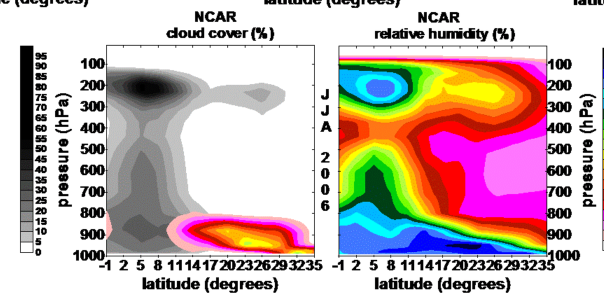
? Questions and/or Comments !

João Teixeira
(joao.teixeira@jpl.nasa.gov)

&

Sambingo Cardoso
(sambingo@ucar.edu)





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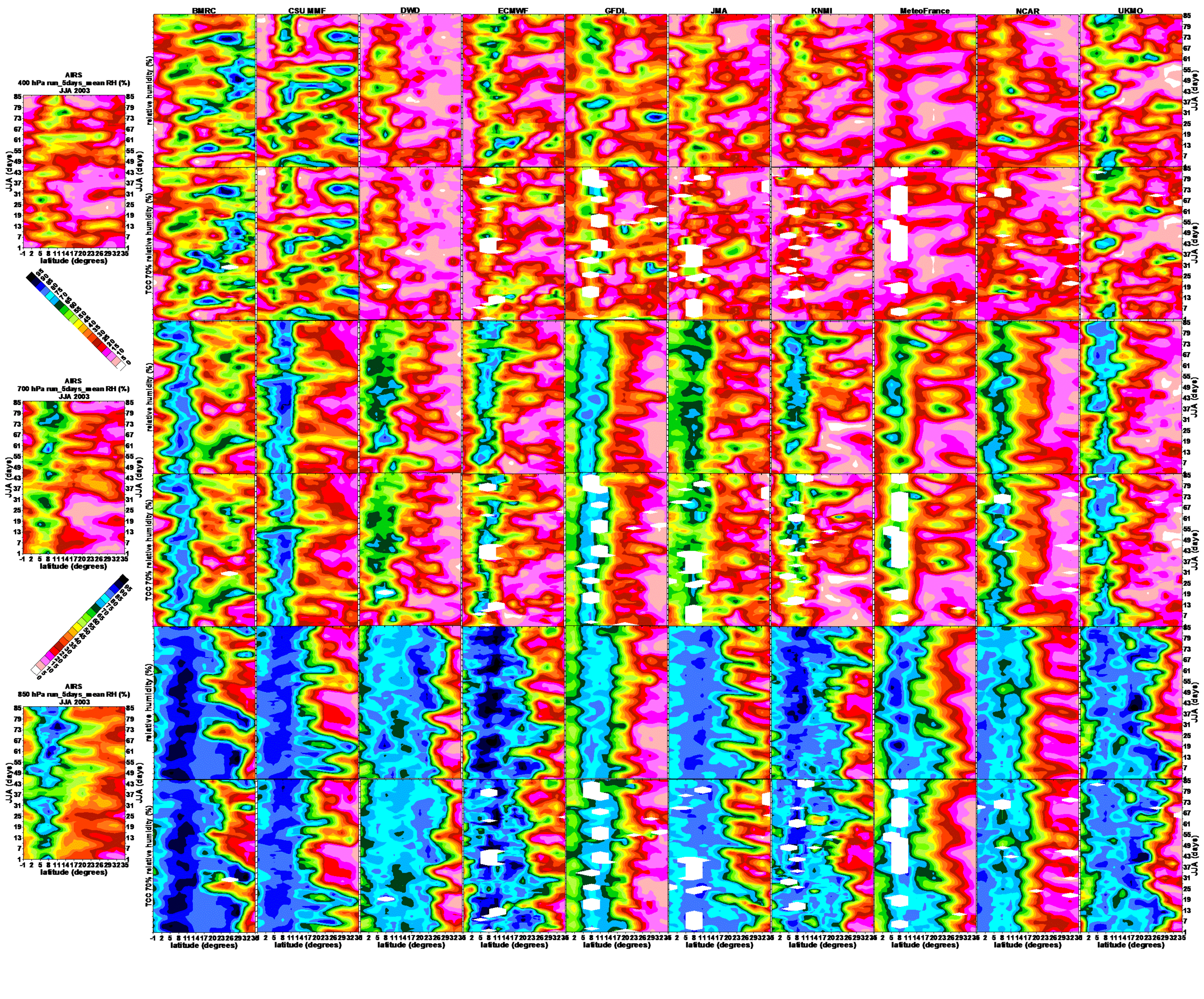
http://www.gewex.org/gcss.html
< for general information on GCSS >
—
http://gcss-dime.giss.nasa.gov/
< all about the ongoing efforts of the DIME >
—
http://gcss-dime.giss.nasa.gov/gpci/gpci.html
< observations, software, etc, for GPCI >
—
http://gcss-dime.giss.nasa.gov/gpci/modsim_gpci_models.html
< for the first set of GPCI results for JJA 1998 and JJA 2003 >

http://www-calipso.larc.nasa.gov/about/atrain.php
< for general information on NASA's A-Train >
—
http://aqua.nasa.gov/index.php
< all about Aqua and AIRS >
—
http://cloudsat.atmos.colostate.edu/
< all about CloudSat and CPR >
—
http://www-calipso.larc.nasa.gov/
< all about Calipso and CALIOP >



SUMMARY:

• In order to assess the impact of constraining the model averages to the situations of total cloud cover (TCC) < 70% (to comply with the limitation that is the inability of AIRS to provide profiles when cloud coverage is above 70%), it was decided that the unconstrained model results should also be made available for analysis.
• With that in mind, an overview of the mean cross-sections of TCC is presented ("total cloud cover (%)" plots). In general, the models show an agreement in the location of the ITCZ, with the main differences being the value of the maximum TCC in the ITCZ and in the stratocumulus (Sc) regions (North of 26 degrees N), and the way it transitions between these two regions.
• It is expected that the higher the values of TCC at a given location, the maximum the number of profiles with TCC > 70% (note the green line at 70% in the plots) !
• Observational studies concluded that this AIRS dataset should be regarded as being biased by about 4% (drier).
• Out of curiosity, we investigated what would be the case for the model simulations and it was concluded that the difference between the constrained and the unconstrained seasonally averaged ("[TCC 70% rh -rh] (%)" plots) cross-sections presented a general dry bias (specially between levels 800mb and 200mb) in a band (2 to 17 degrees N) centered in the ITCZ region. Interestingly enough, the models with the higher TCCs in the Sc area show, in these plots, a wet bias above the boundary layer (PBL) in the region (North of 26 degrees N).
• Confronting the cross-sections of relative humidity (RH) for the models against AIRS ("rh -AIRS (%)" and "TCC 70% rh - AIRS (%)" plots) leads to the broad conclusion that there is a wet bias above the boundary layer in the tropical regions (interrupted by a dry layer centered at 400mb), as opposed to a dry bias above the Sc in the subtropics. The models from the BMRC and the DWD clearly differ from the rest in opposite directions (general wetter and general drier biases, respectively). The same conclusions stated above for the impact of the "TCC < 70%" constrain on model results hold here.
• As for the standard deviation (STDev) of RH ("relative humidity STDev (%)" and "TCC 70% rh SDTev (%)" plots), we first note that the general structure of the constrained and the unconstrained cross-sections compare very well, with a slight decrease in variability in the constrained ("TCC 70 % rh") plots. Can we infer that the same would be expected for AIRS, i.e., is the variability of humidity in (the currently available) AIRS datasets less than in the real picture ? Note also the differences between some of the models (e.g., UKMO, NCAR, MeteoFrance). Comparing with AIRS, the conclusion is that, in the models, there is a lack of variability in RH in the PBL along the cross-section, and in the deep convection region up to about 300mb. A feature common to most models is the positive bias in the variability in a relatively thin layer immediately above the Sc in the subtropical region that extends as far South as 17 degrees N (see UKMO, for instance).
• OBS: for the models we calculated the STDev of the daily means as the AIRS data was available in a daily temporal resolution.
• For the hovmollers of RH we used a 5-day running mean. Again, we present the constrained and the unconstrained results. Note that periods with no data available (more than 5 consecutive days of model simulations with TCC > 70%) show in the plots as white geometric shapes. The same conclusions (see above) apply, i.e., a general drier picture for the constrained results.
• In the hovmollers for a given location along the cross-section, we can notice that models and AIRS agree when it comes to the behaviour/evolution of RH. As one progresses to the North, the PBL shallows and the upper levels become drier. Also, drier periods tend to be felt throughout the entire profile, at 32 degrees N, as opposed to being caped by higher RH values at the upper levels (e.g., at 20 degrees N).
• Most models compare better with AIRS at 32 degrees N (in the Sc region). In the other positions (8 and 20 degrees N) they tend to "lack" RH below 900mb, while being "moister" above 350mb.
• For these profiles there seems to be a better spatio-temporal correlation between any two given models than between the models and AIRS (further analysis is needed).
• In order to investigate how the RH evolves along the entire cross-section, hovmollers for a given level (400, 700, and 850 mb) were investigated. Note that care should be taken as this analysis may be misleading. A single cross-section is clearly insufficient to study the broader GPCI region (other window spans for the running mean should also be tried).
• That said, and keeping in mind some of the above conclusions/notes, it is apparent that for AIRS there is a relatively high degree of correlation along the entire cross-section when it comes to an increase in the RH (specially South of 29 degrees N). For the models, however, there seems to be a different behaviour when we compare the 3 levels shown. At 400mb, some models (ECMWF, GFDL, JMA, KNMI) show a northward propagation of higher values of RH. At 700mb, the average model situation is probably best depicted by UKMO, that shows periods of northward propagation of higher RH values and also periods of southward propagation of lower values of RH (specially to the North of 17 degrees N). At 850mb, the main feature is a southward intrusion of "drier" air from the subsidence regions.
• Finally, the CloudSat and Calipso results. We present a global map of cloud occurrence at about 1200m for JJA 2006 as derived from CloudSat CPR retrievals. This gives a perspective of the location of the GPCI region (enclosed by the black rectangle). Also included are 3 maps of cloud occurrence at about 1558m in which we show the 13 locations that comprise the GPCI cross-section. These maps for CloudSat, Calipso, and their combination show the expected differences briefly discussed in the text box to the right of the global map, which are also noticeable in the vertical profiles along the cross-section shown (see the deep convection and the Sc regions, for instance).
• Taking the combined profile (CloudSat & Calipso "cloud occurrence (%)" cross-section plot) as the "truth", we can conclude that NCAR cloud coverage ("cloud cover (%)" plot) compares fairly well with it, the bigger difference being the level of the maximum values to the North of 29 degrees N. We plan on having GPCI model simulations for JJA 2006 for more models.

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