Progress Report at the JCSDA 08 Annual Meeting

Evaluating the NCEP Global Forecast System Cloud Vertical Structure against MODIS, CloudSat/Calipso Retrievals

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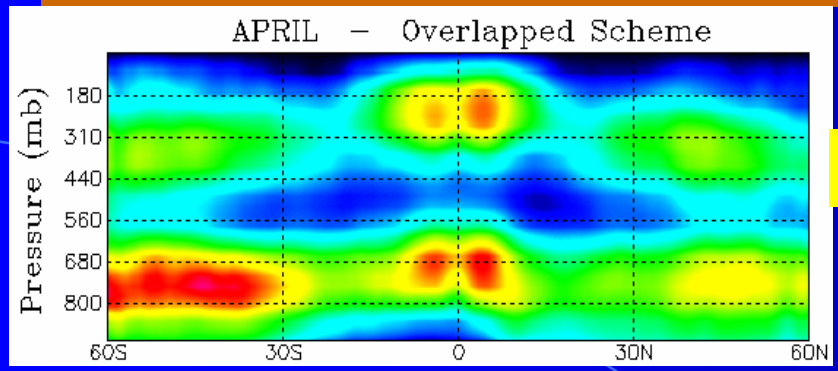
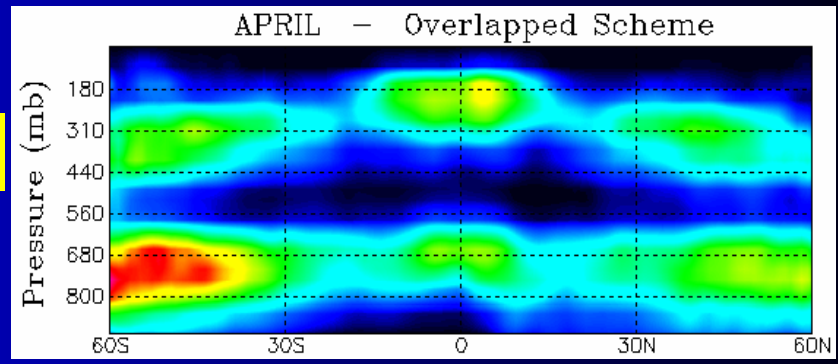
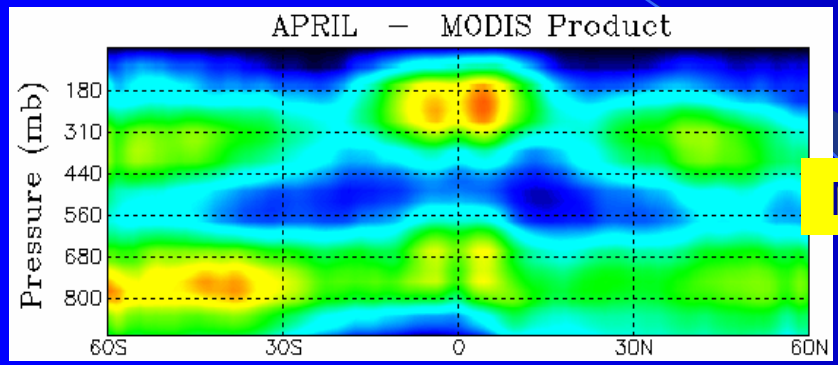
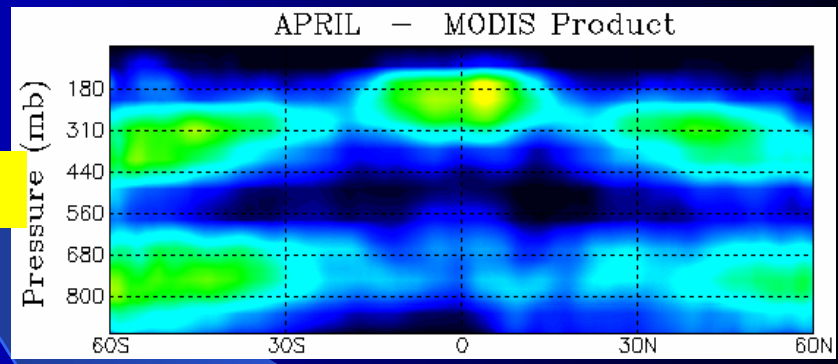
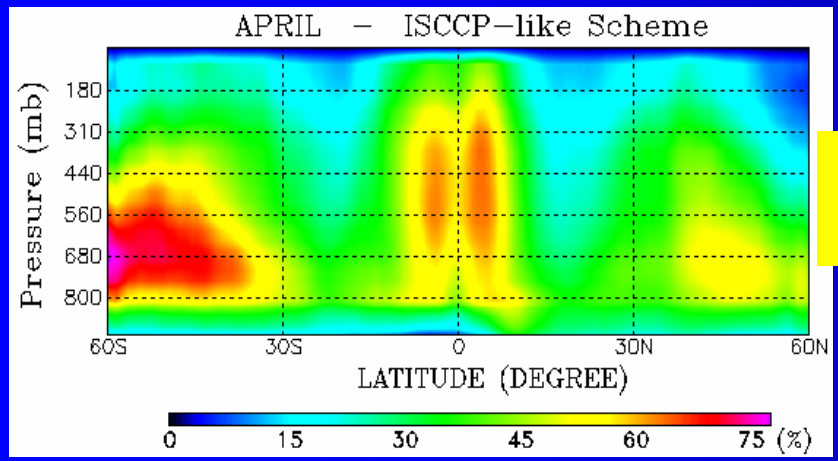
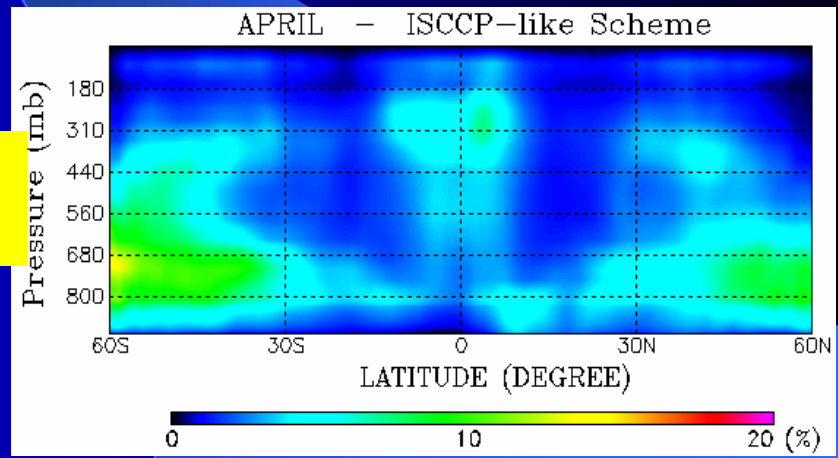
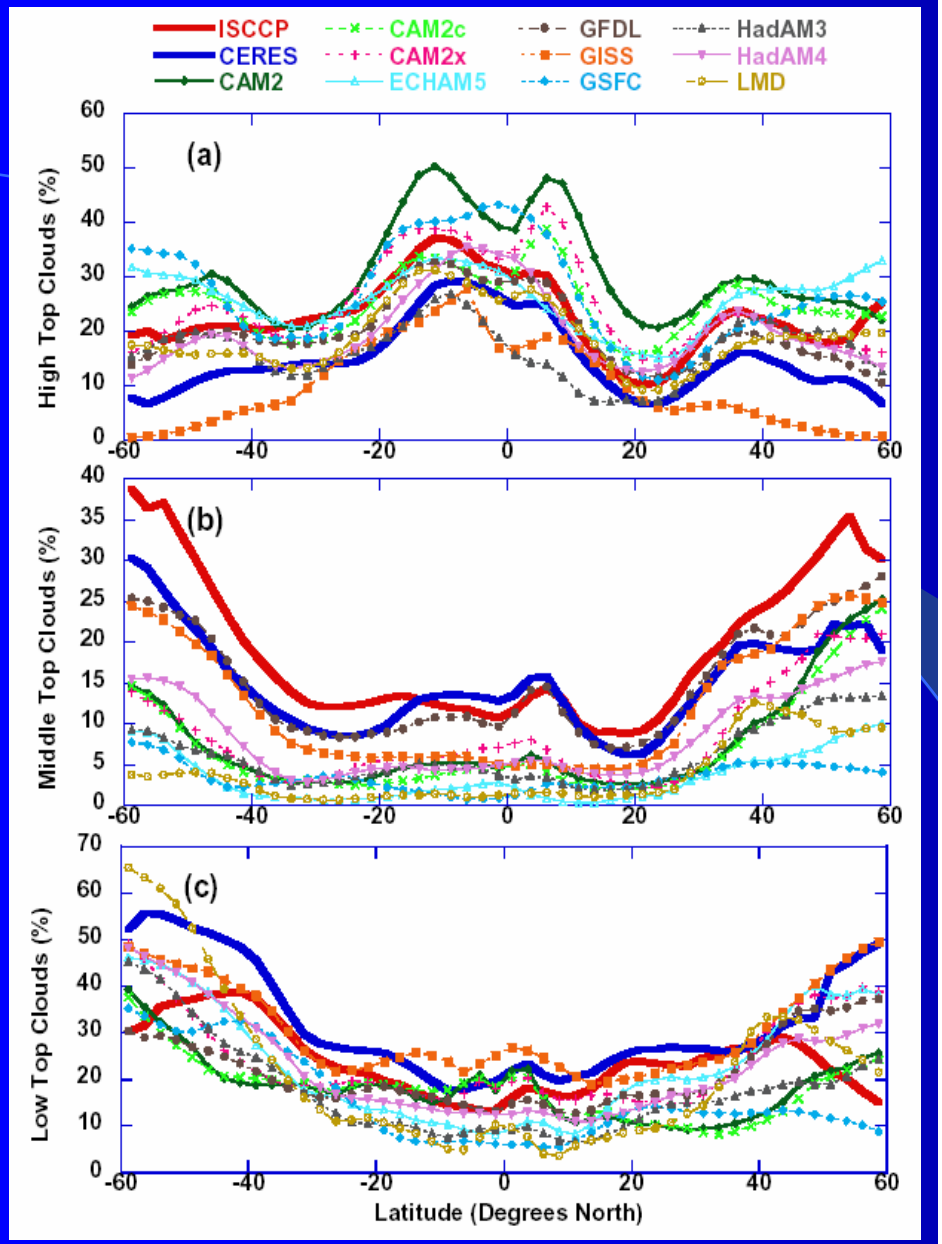
J. Mace (UT)

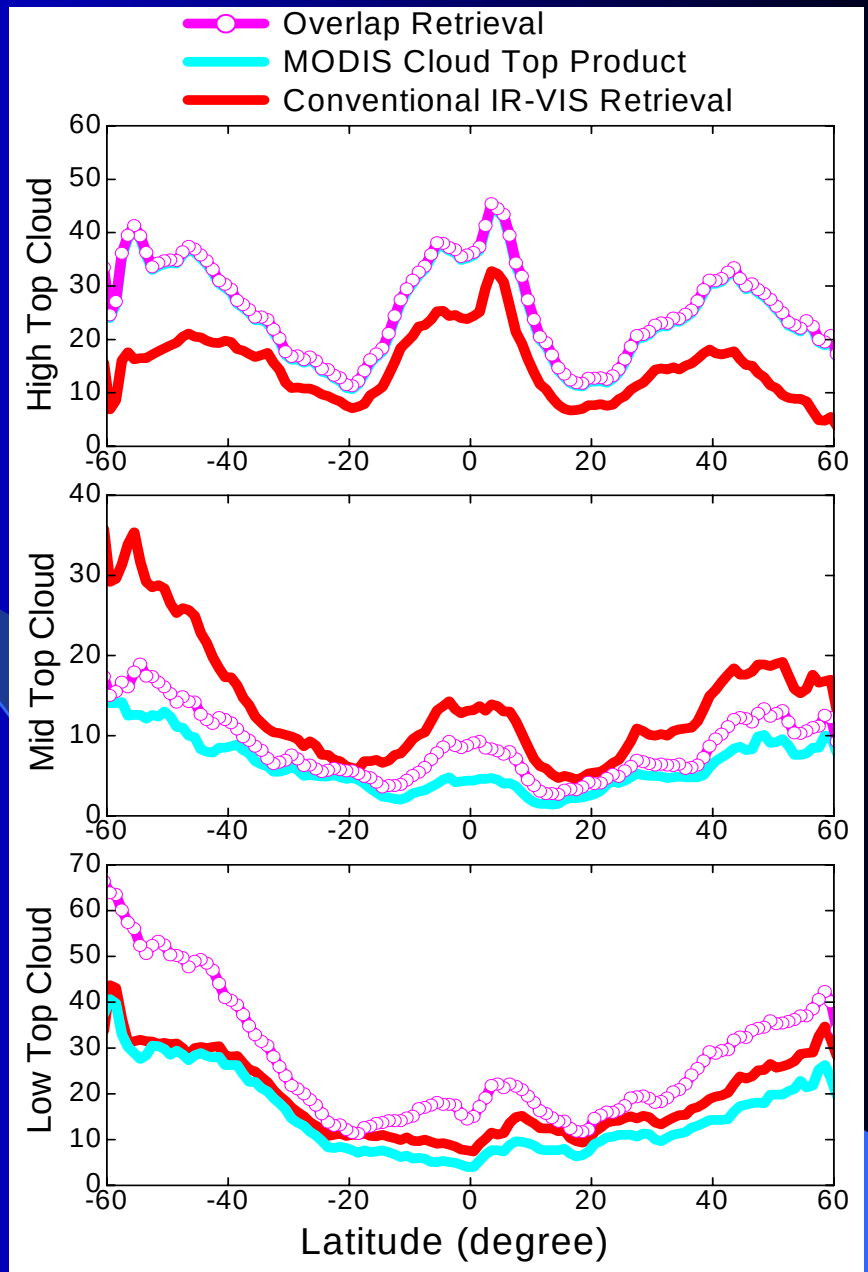
How much do we know about cloud vertical structure ?

Comparing Ours, MODIS and ISCCP Cloud Layer Structures

Probability of Cloud Occurrence		Layer Cloud Amount
	Ours	
	MODIS	
	ISCCP like	

Comparisons of High, Mid, Low Cloud Amounts





Data Sources

Three sources of cloud information used in this study:

- Official MODIS and our own MODIS products
- NCEP Global Forecast System model output
- CloudSat/CALIPSO merged radar/lidar product

Years/Dates chosen for study: January, April, July, October 2006 and 2007

Sampling: days 2, 6, 10, 14, 18, 22, 26, 30 in each month

Chang and Li (2005) Algorithm

novel approach toward retrieval of single-layer and overlapped clouds and optical properties using MODIS satellite data

- takes full advantage of multi-spectral channels available from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the Terra and Aqua platforms

- combines the MODIS CO2-slicing method with traditional IR and VIS techniques to overcome some limitations due to single-layer cloud assumptions used by conventional satellite cloud retrieval methods

NCEP Global Forecast System (grid 003)

- Global Latitude/Longitude 1 deg Resolution
- Control time chosen: 00Z
  Forecast times chosen: 03, 06, 09, 12, 15, 18, 21, 24Z
- Variables extracted:
  high, middle, and low cloud cover
  cloud-top and cloud-base pressures
  - converted to km using relation:
    $44307.693\ [1-(\text{pressure}/1013.25)^{0.190284}]/1000$
- Data availability (daily) : off-line Feb. 15, 2005 to May 31, 2007
  on-line June 1, 2007 to current date

http://nomads.ncdc.noaa.gov/cgi-bin/ncdc-ui/define-collection.pl?model_sys=gfs-hi&model_name=gfs&grid_name=3

CloudSat/Calipso

- As part of the A-train constellation, CloudSat is the first satellite-based millimeter-wavelength cloud radar
  - 94-GHz nadir-looking
  - 4 km (along-track) by 1.4 km (cross-track) footprint
  - 0.5 km vertical resolution between the surface and 25 km
- Goal is to obtain cloud profile information, liquid & ice water content profiles and precipitation information to aid in the quantitative evaluation ofglobal atmospheric circulation models
- In operation collecting data since May 2006

Credit: Alex McClung

Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)

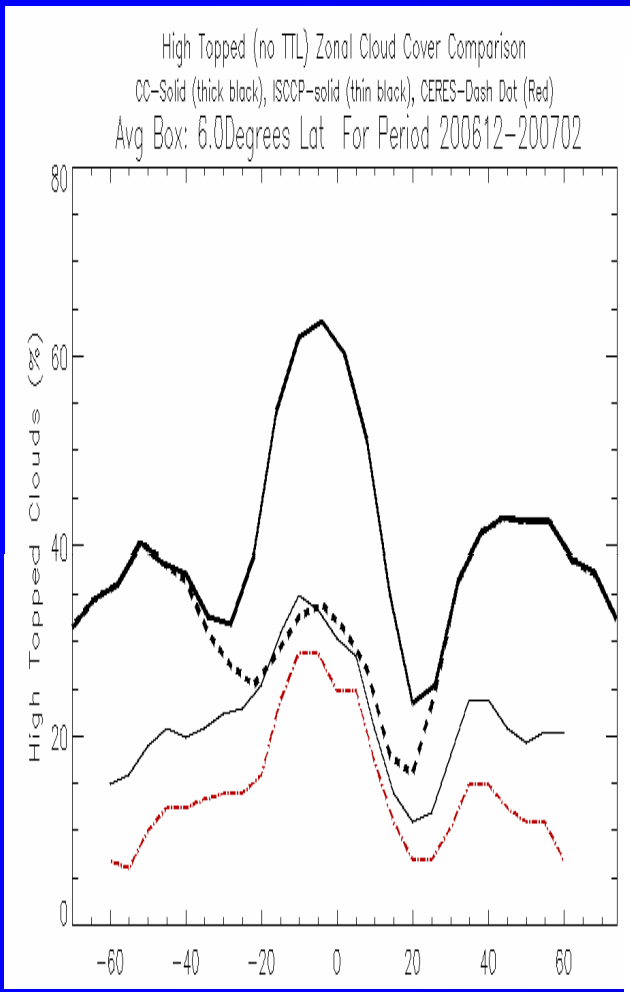
Primary objective is to make a global survey of the vertical structure of clouds and aerosols and their physical properties

- Comprised of three instruments:
  - Cloud-Aerosol Lidar with Orthogonal Polarization
    provides information re: composition of clouds, abundance and sizes of aerosols, altitudes of cloud and aerosol layers
  - Imaging Infrared Radiometer
    measures outgoing radiation (at 8.65, 10.6, and 12.0 μm) to determine cloud emissivity and particle size
  - Wide-Field Camera
    nadir-viewing, taking images of the region around the CALIOP and IIR measurements at 645nm

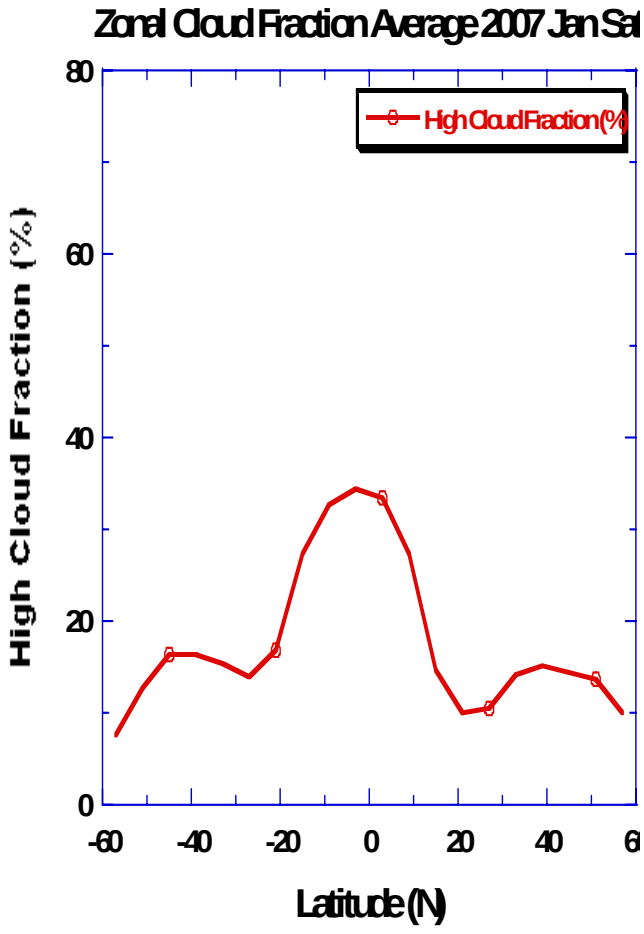
Overall Comparison

Comparison of High-Level Clouds

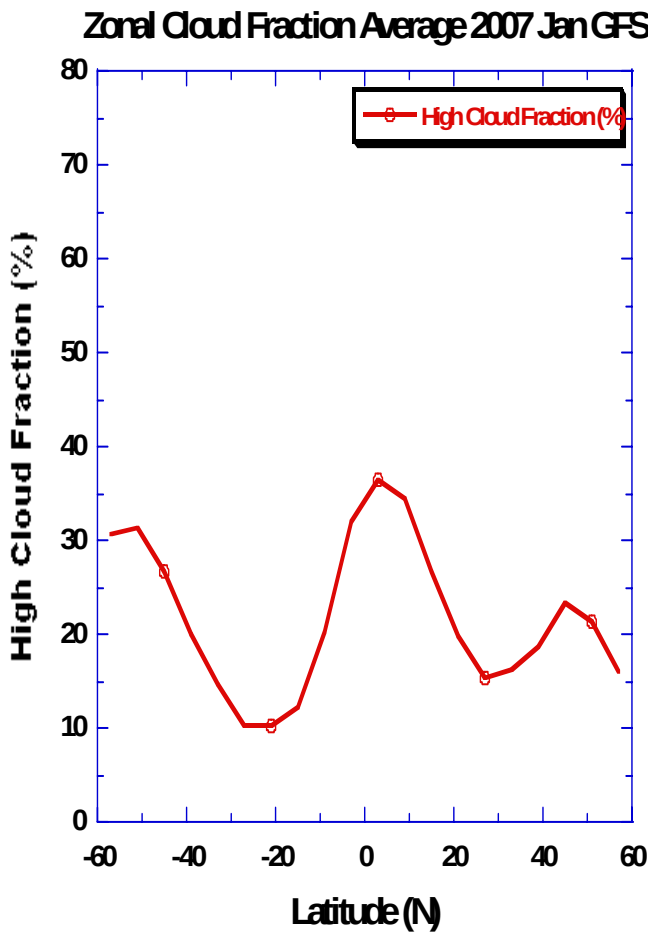
CloudSat + Calipso



Satellite_Our_retrieval

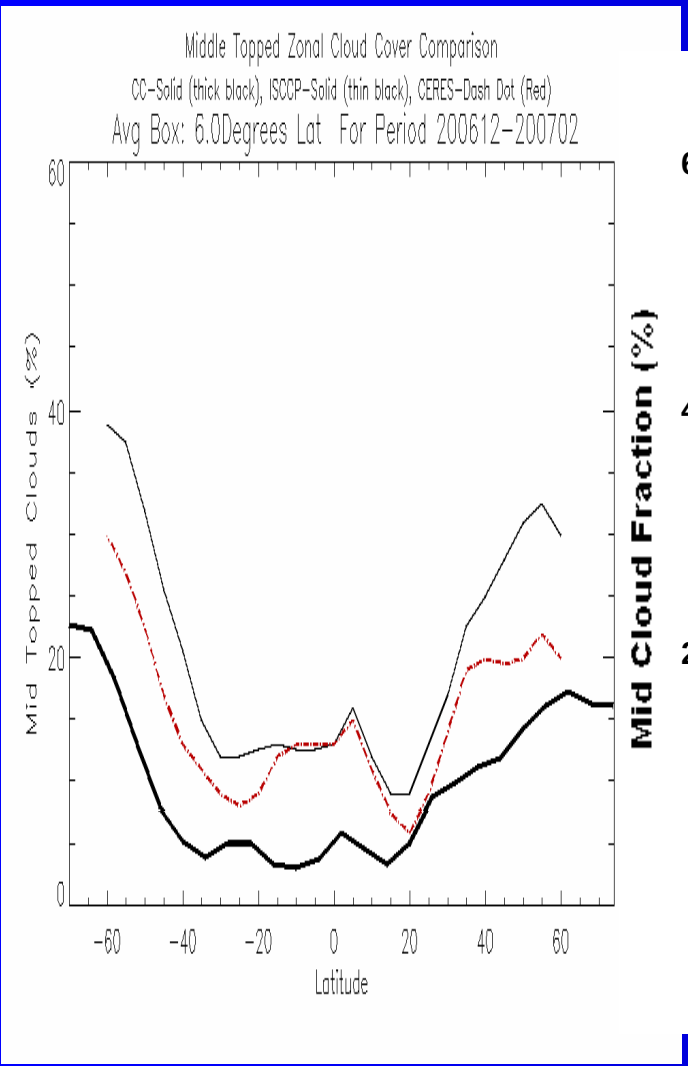


GFS_Model

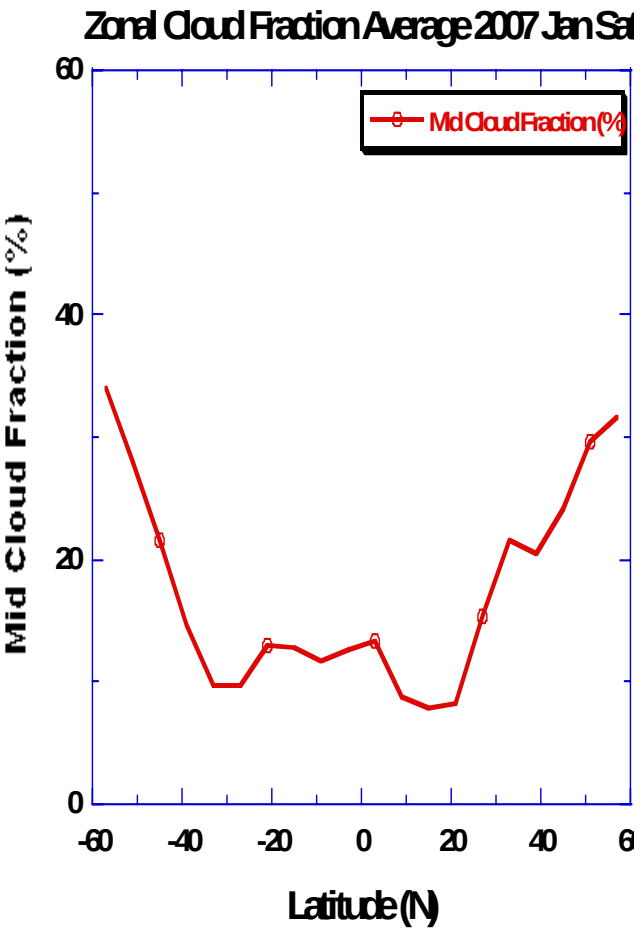


Comparison of Middle-Level Clouds

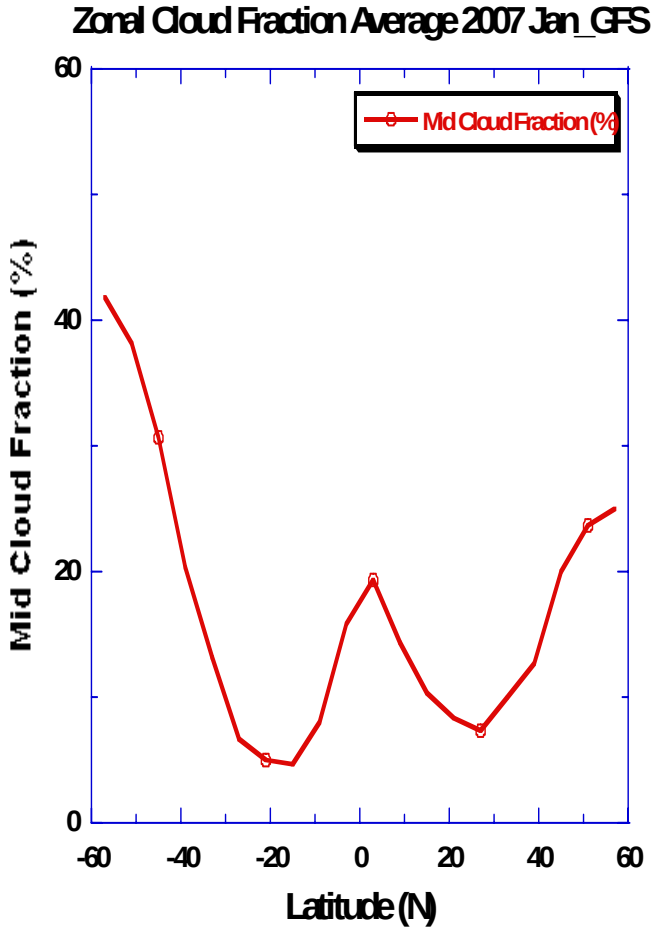
CloudSat + Calipso



Satellite_Our_retrieval

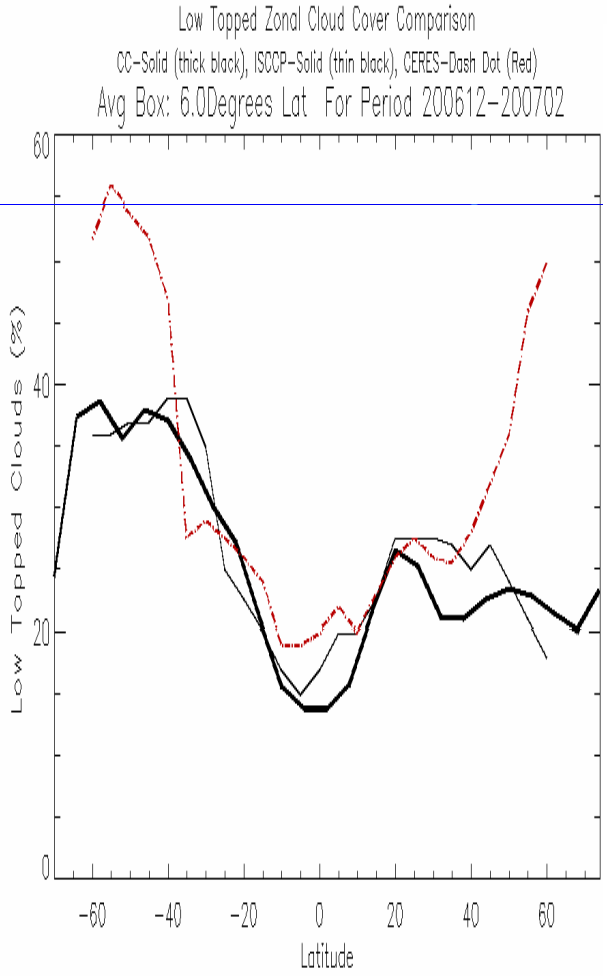


GFS_Model

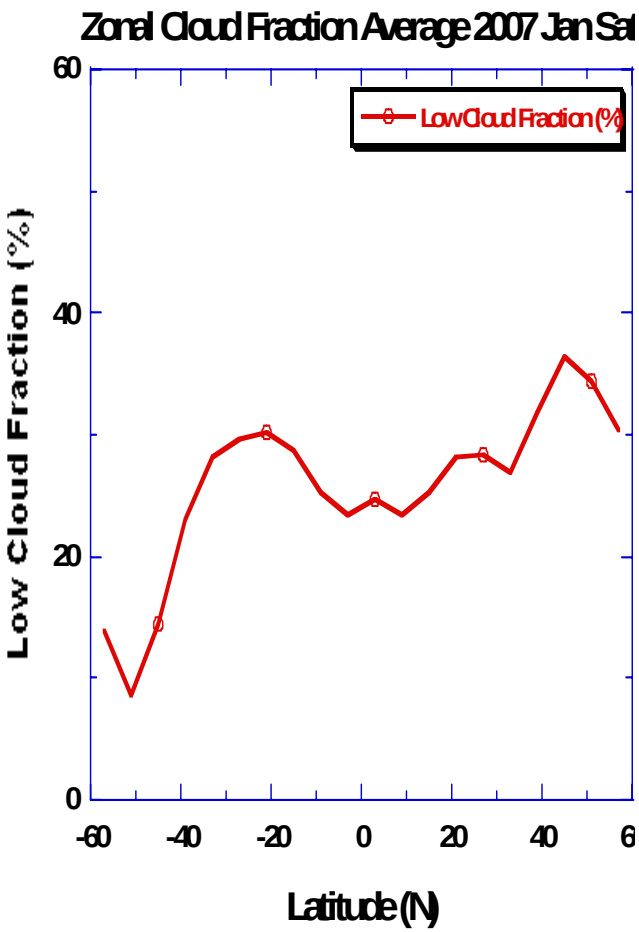


Comparison of Low-Level Clouds

CloudSat + Calipso



Satellite_Our_retrieval



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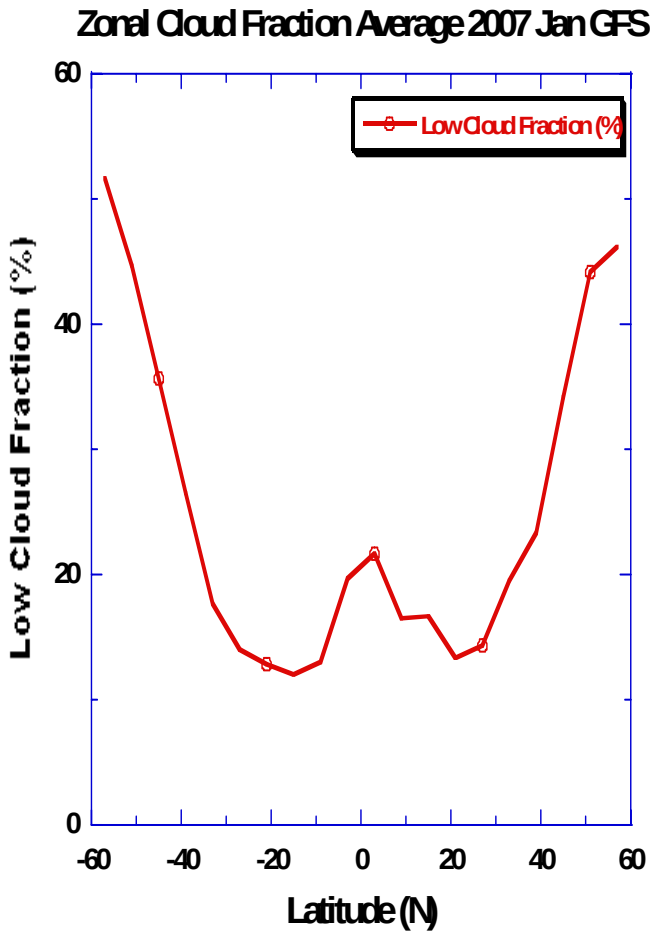
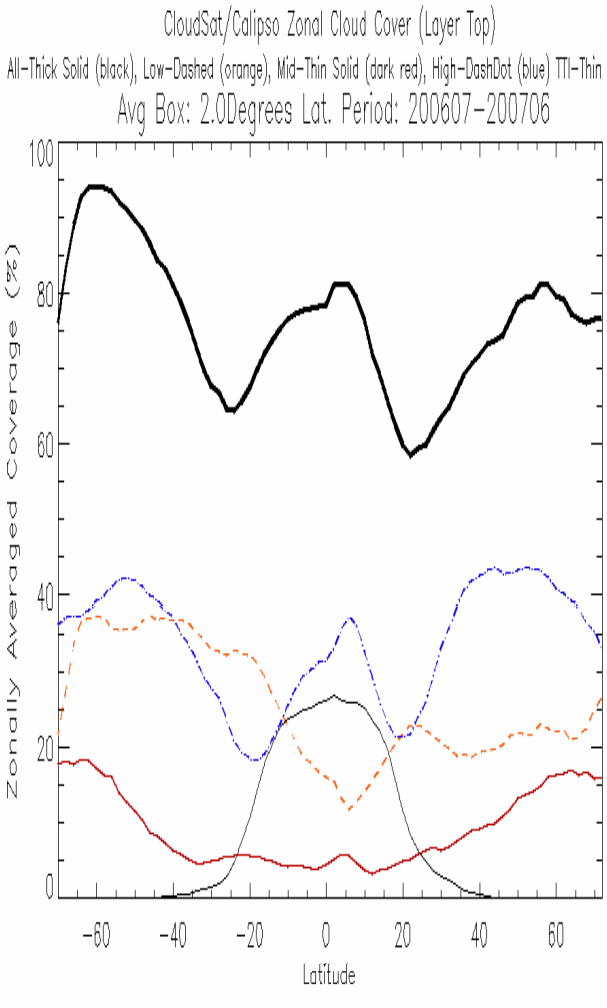
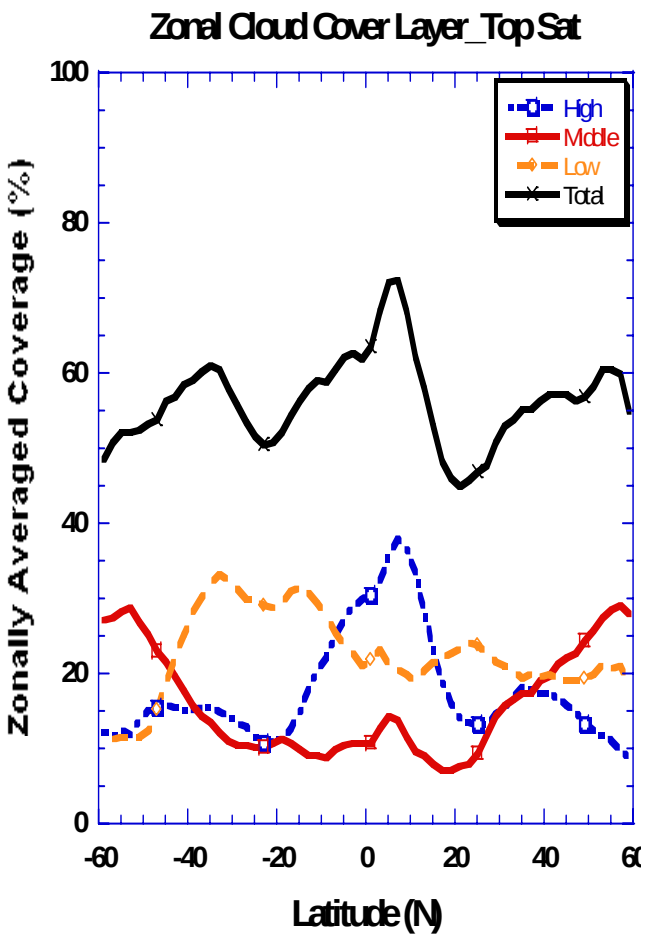


Comparison of All Clouds

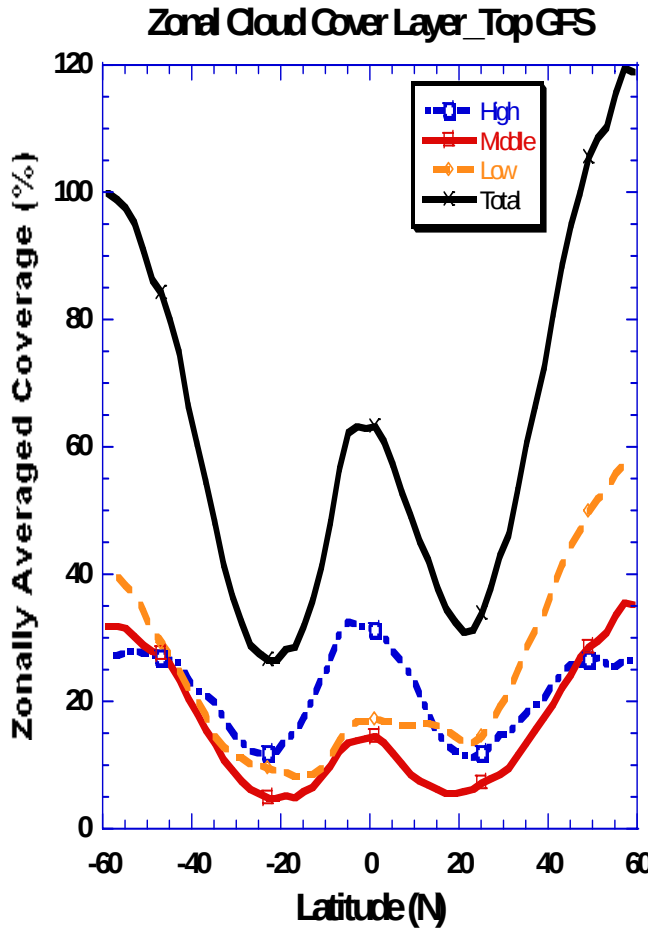
CloudSat + Calipso



Satellite_Our_retrieval



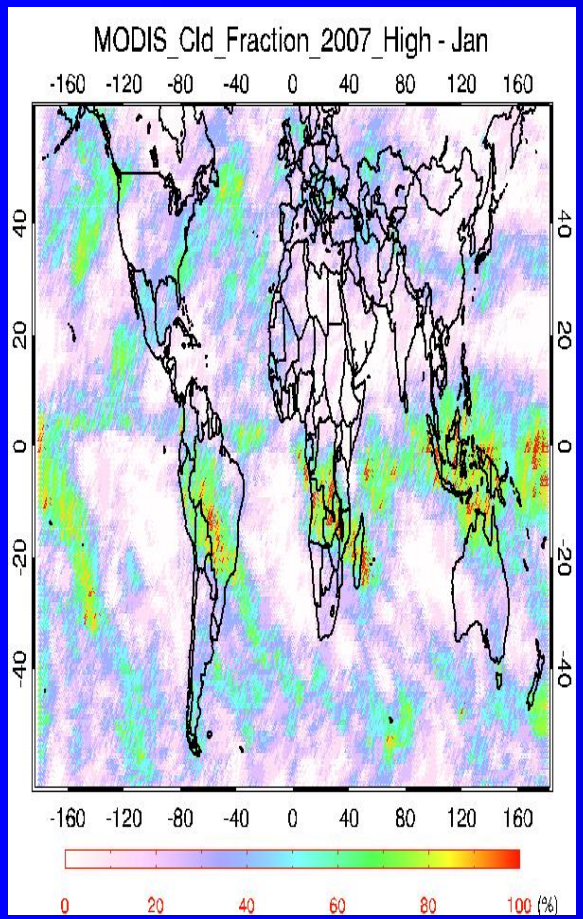
GFS_Model



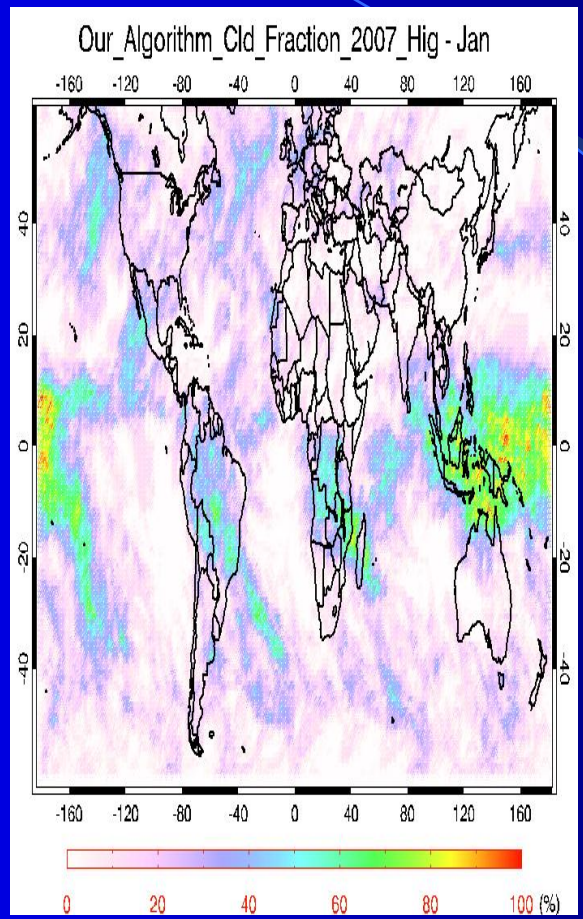
Comparison with Cloud Retrievals from MODIS

Comparison of High-Level Clouds in Jan

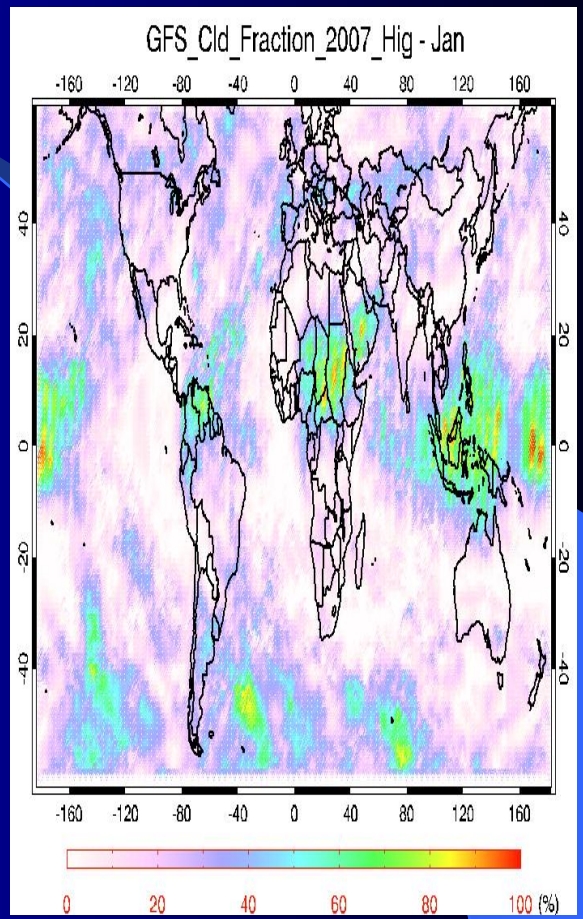
2007_January_High_MODIS



2007_January_High_Ours

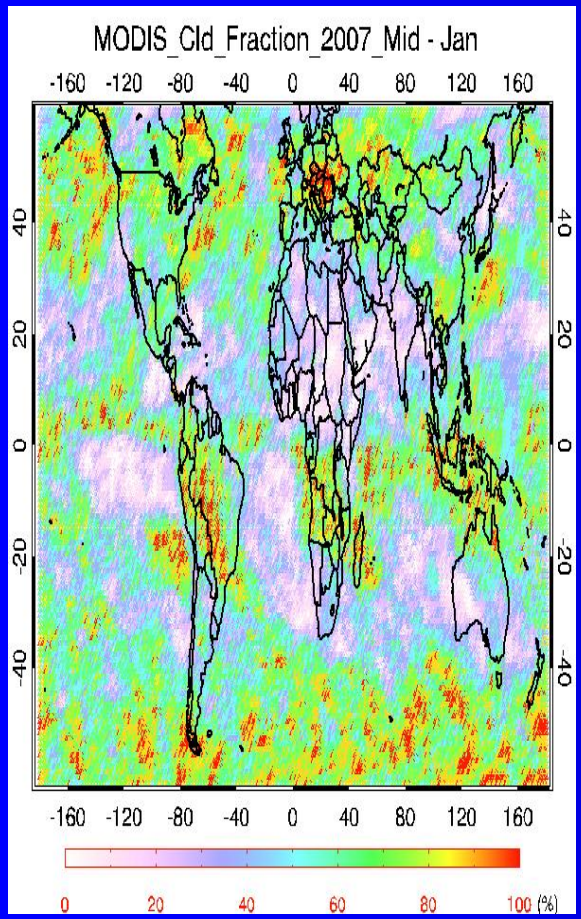


2007_January_High_GFS

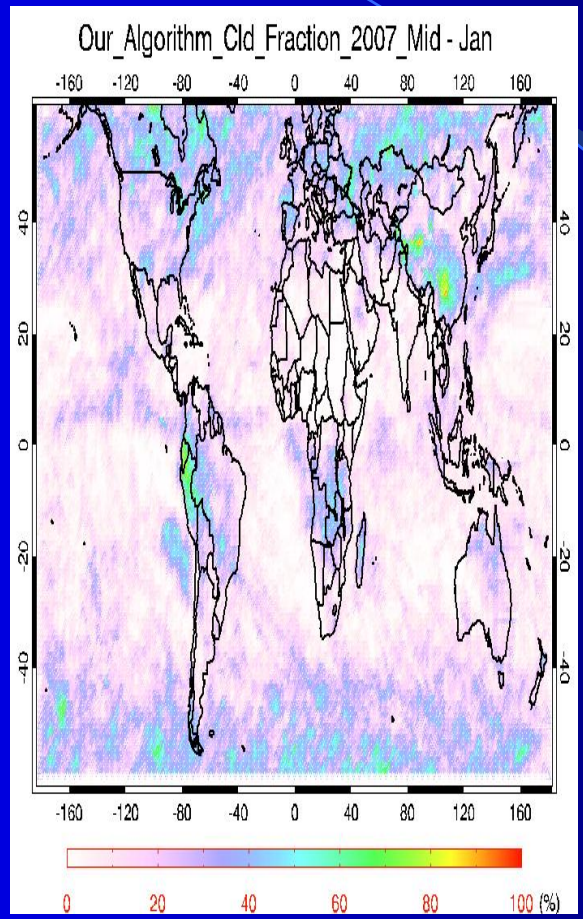


Comparison of Mid-Level Clouds in Jan

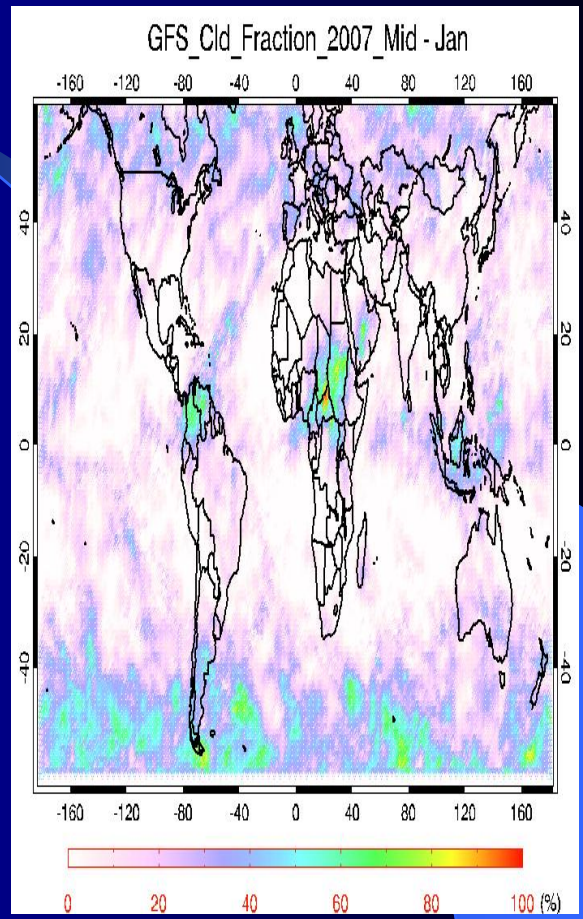
2007_January_Mid_MODIS



2007_January_Mid_Ours

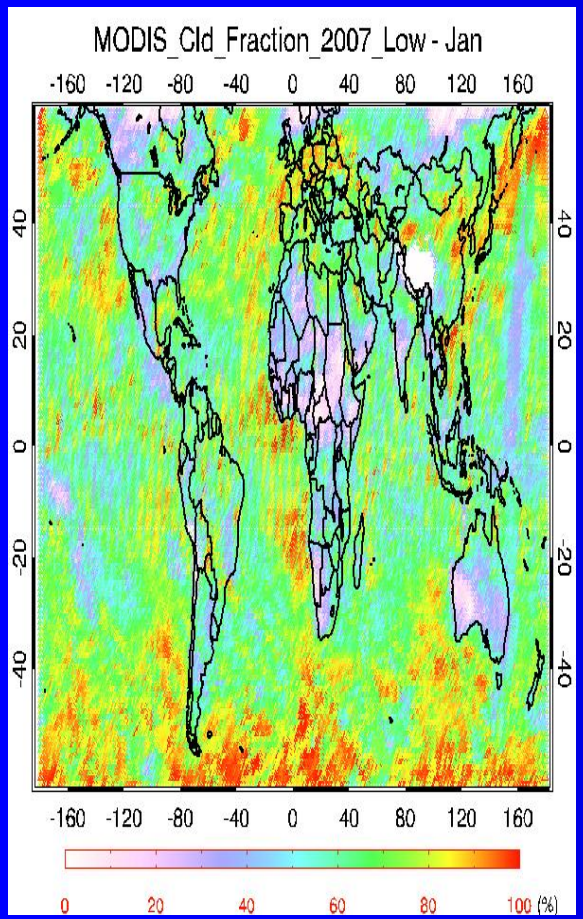


2007_January_Mid_GFS

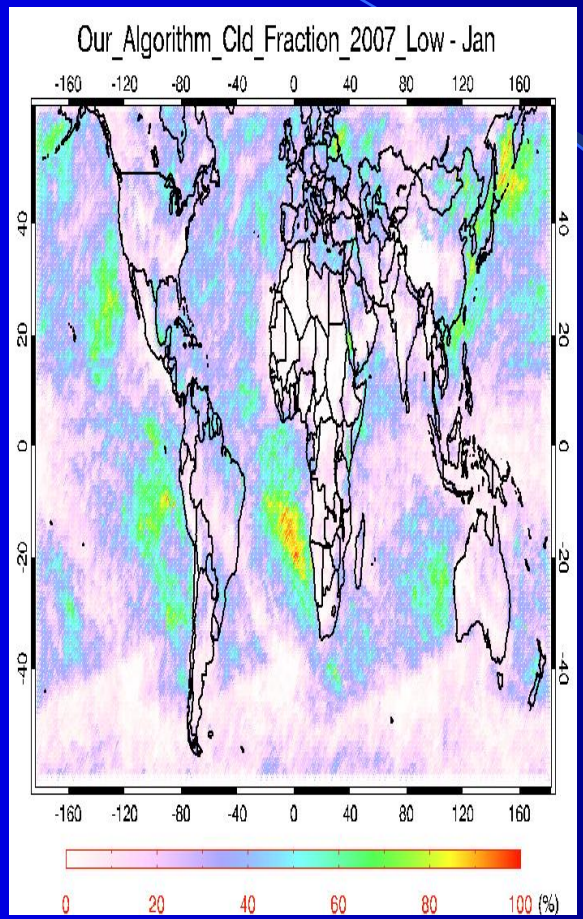


Comparison of Low-Level Clouds in Jan

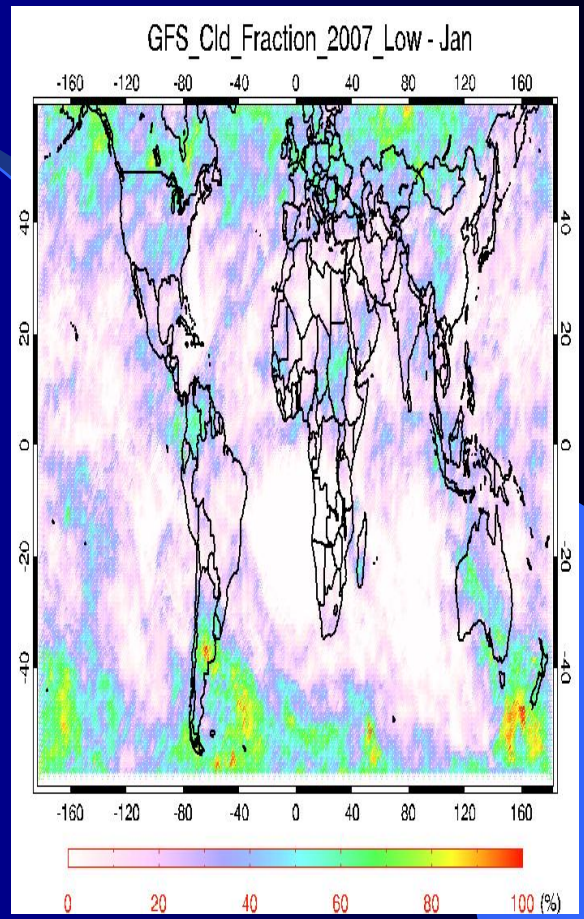
2007_January_Low_MODIS



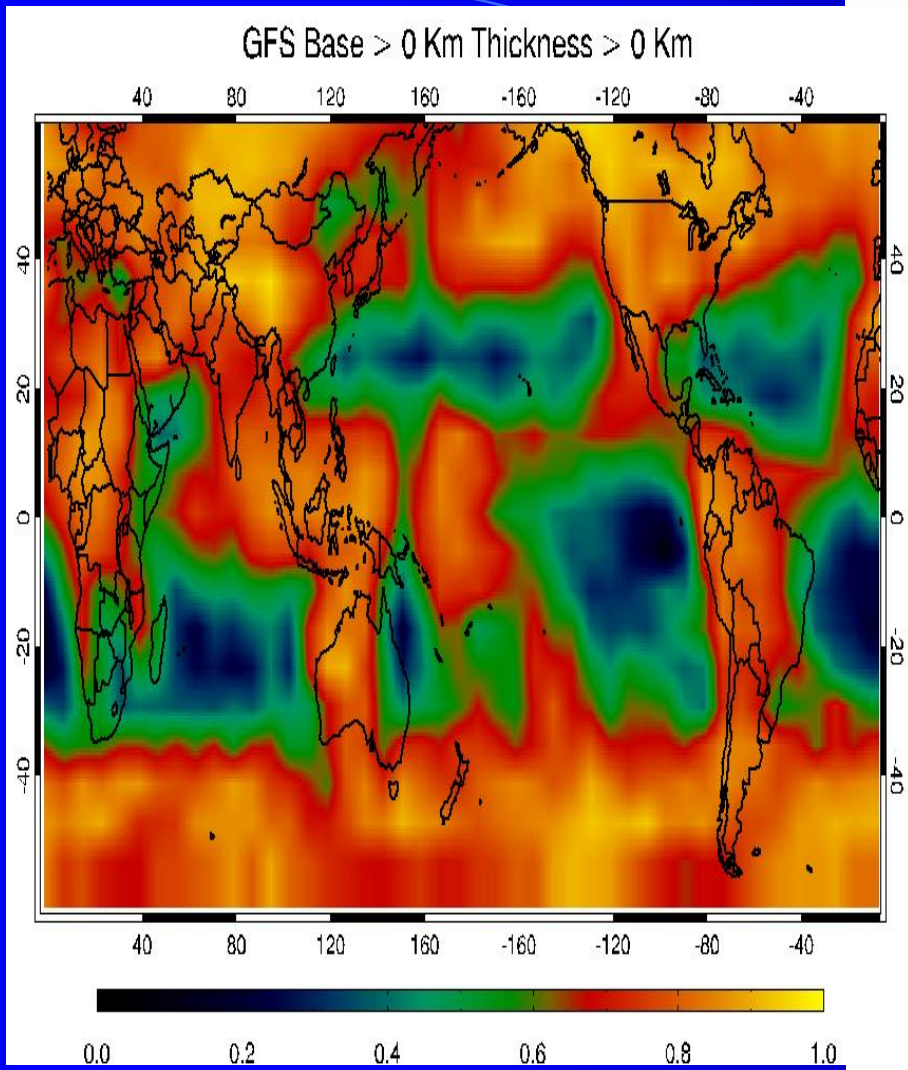
2007_January_Low_Ours

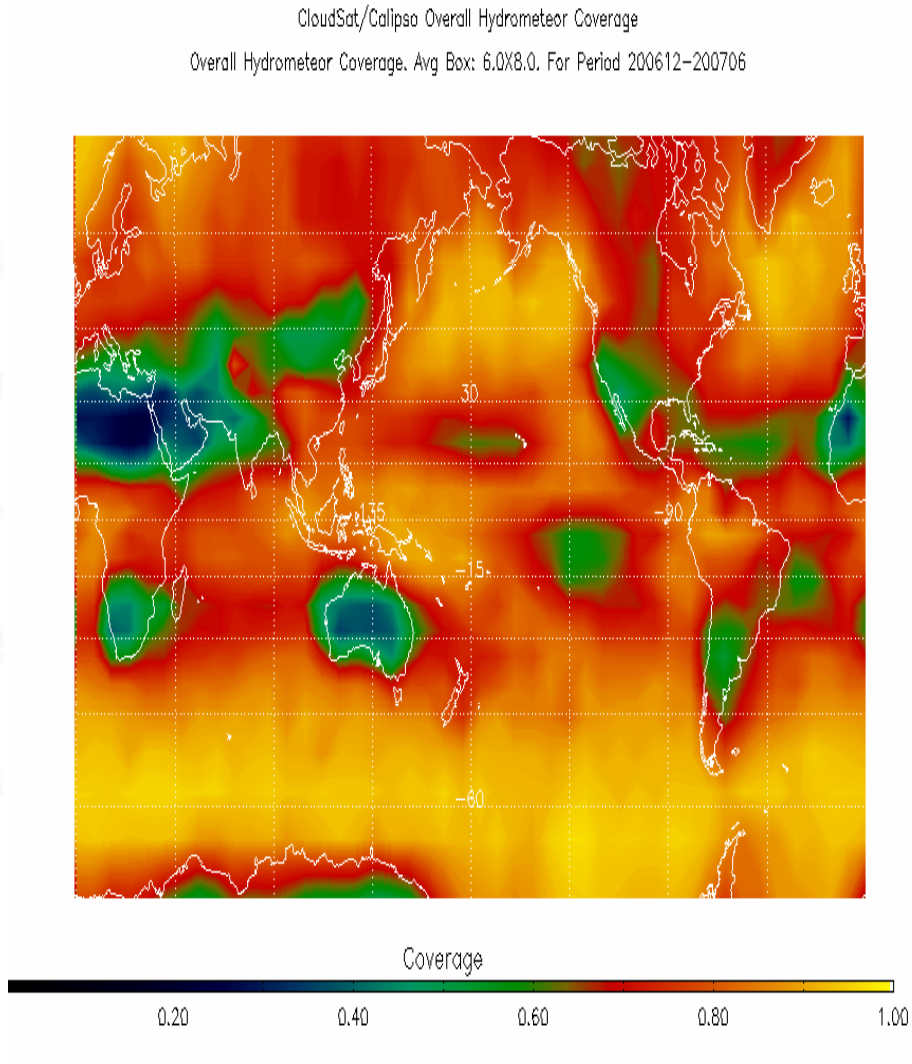


2007_January_Low_GFS



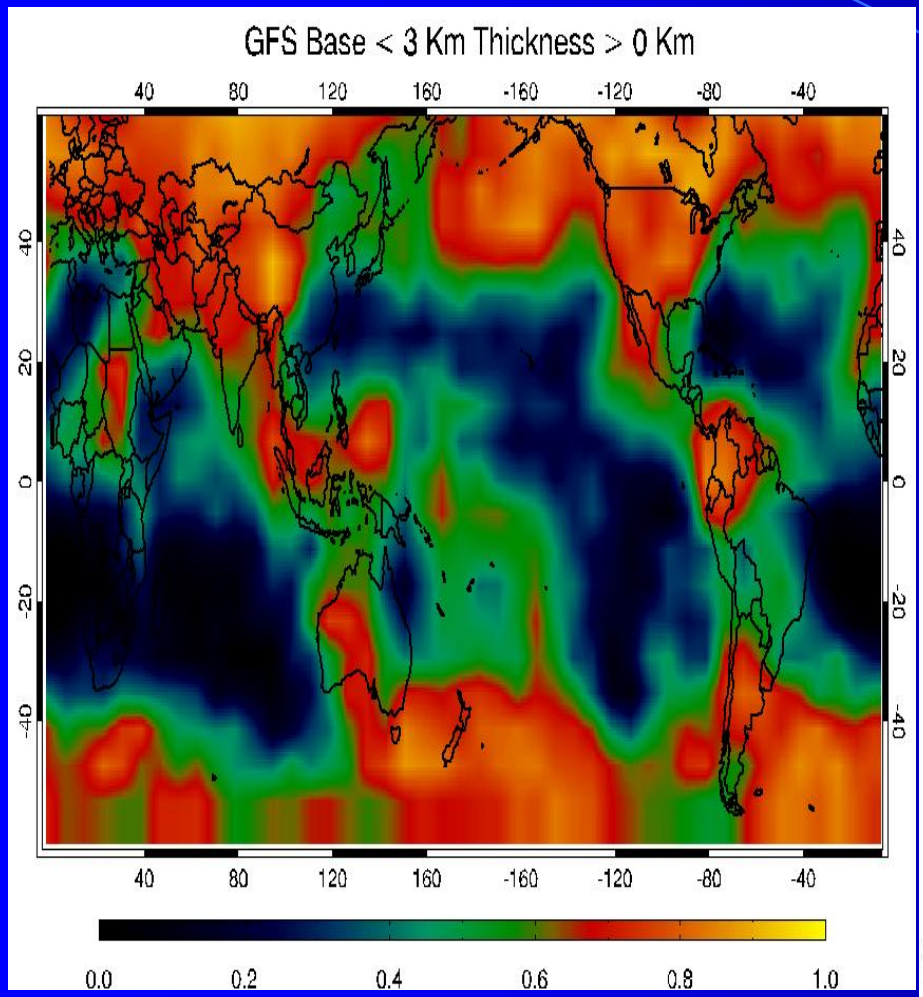
Comparison with Cloud Retrievals from CloudSat/Calipso

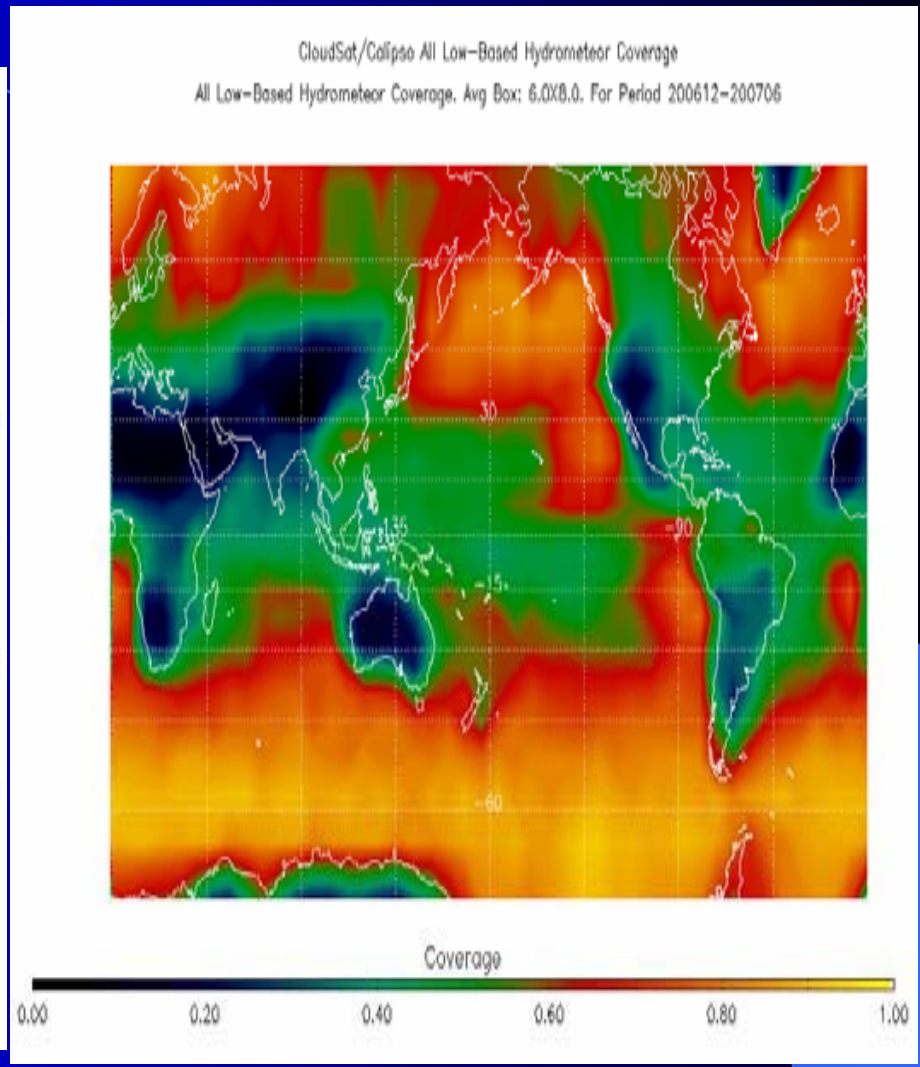




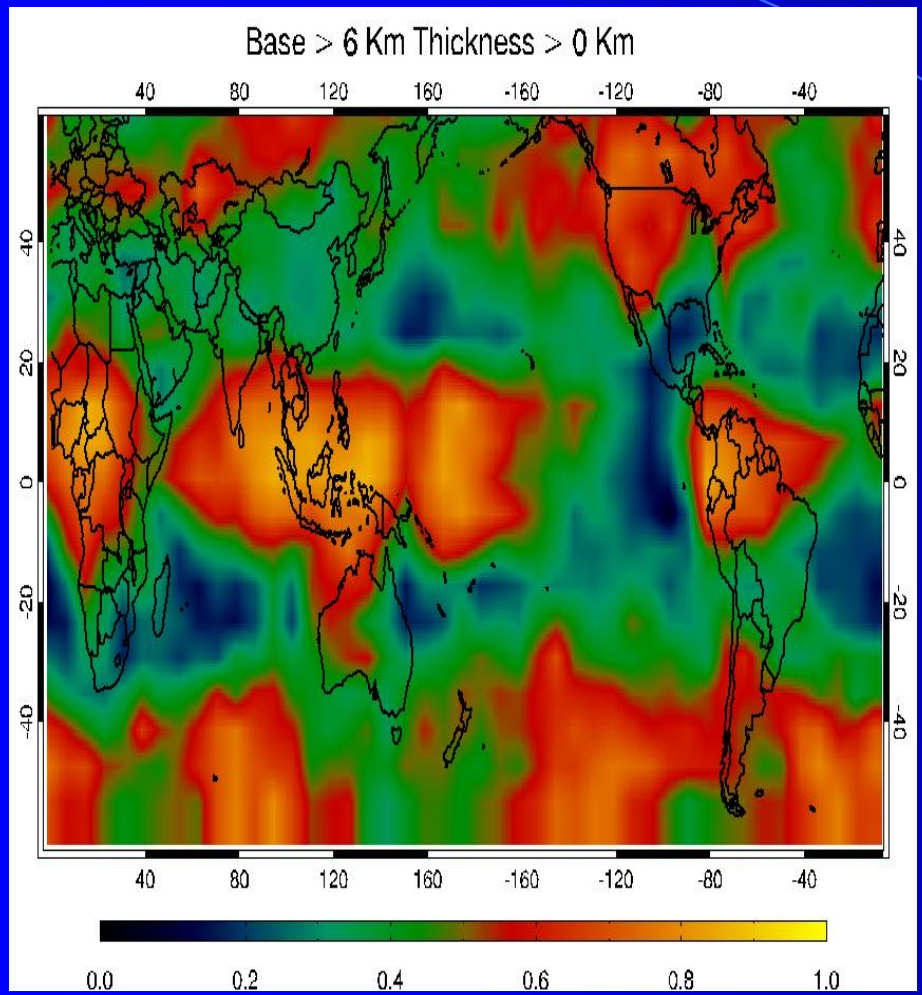
Total cloud cover from GFS and CloudSat.

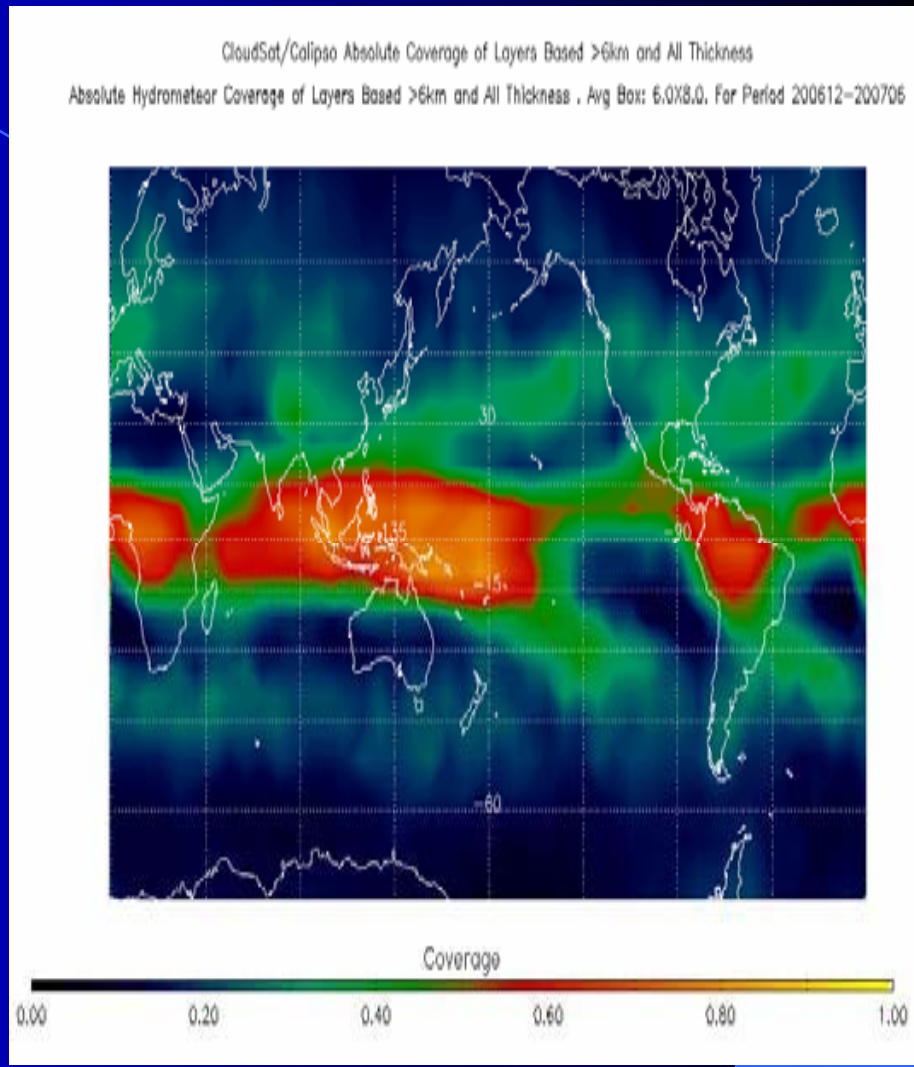
The averaging period id from December, 2006 to June, 2007 for CloudSat.
The averaging period id from Jan, Apr, early of July, 2007 for GFS.



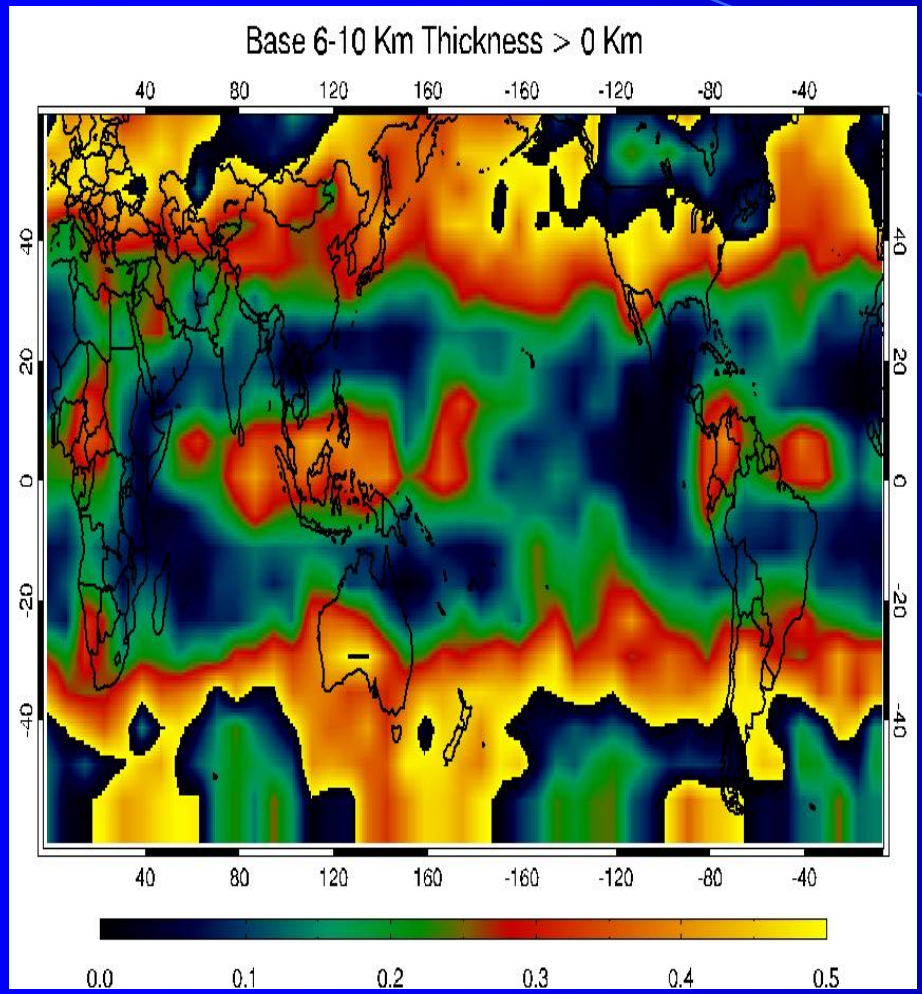


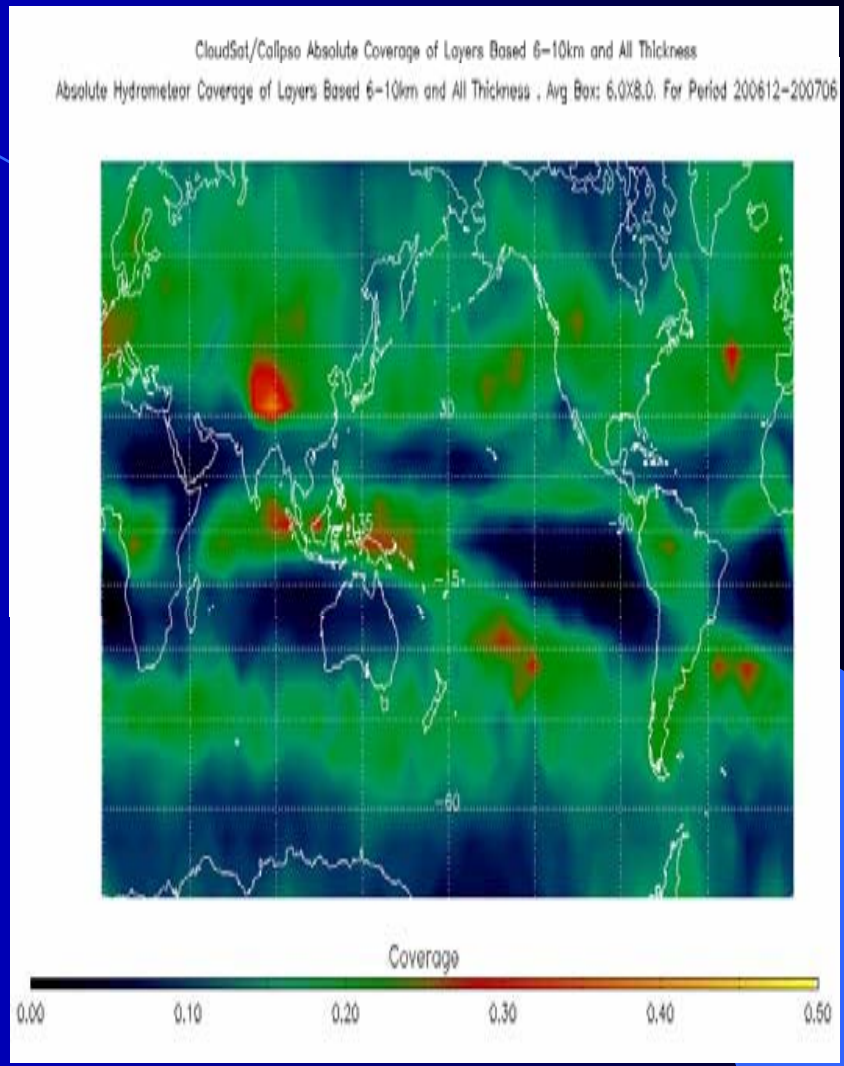
Comparison of Low Clouds between GFS and CC



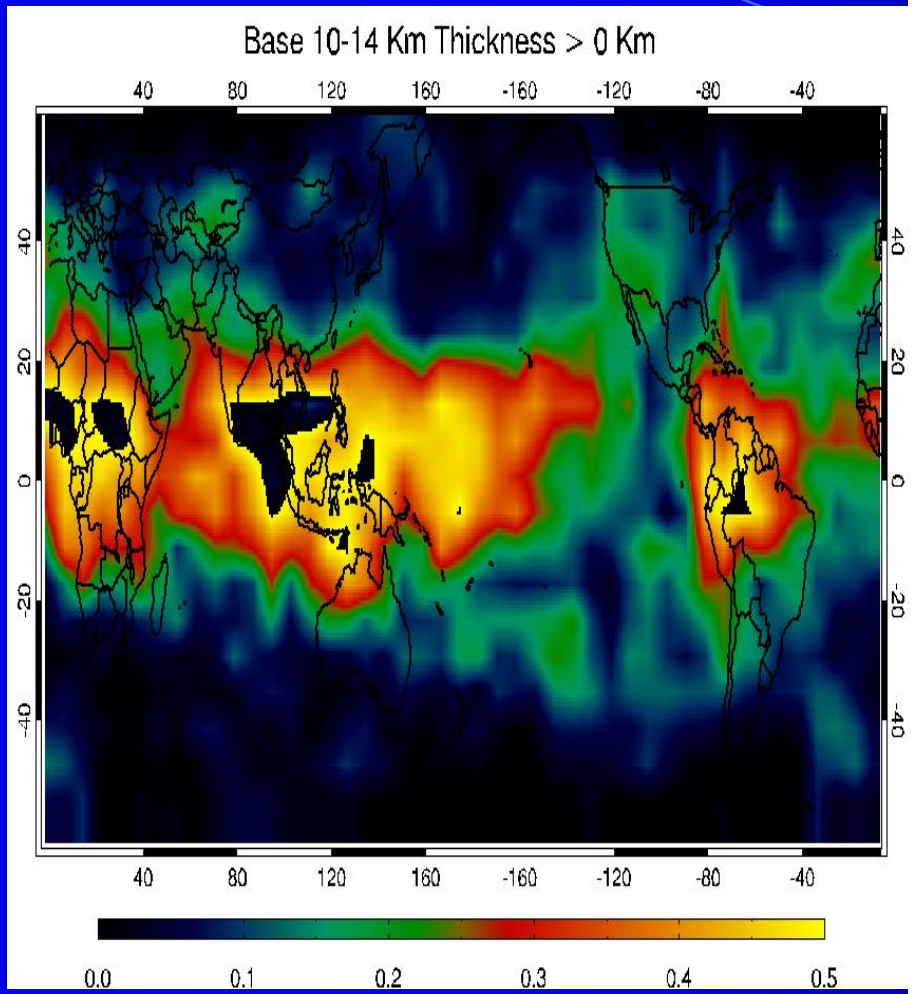


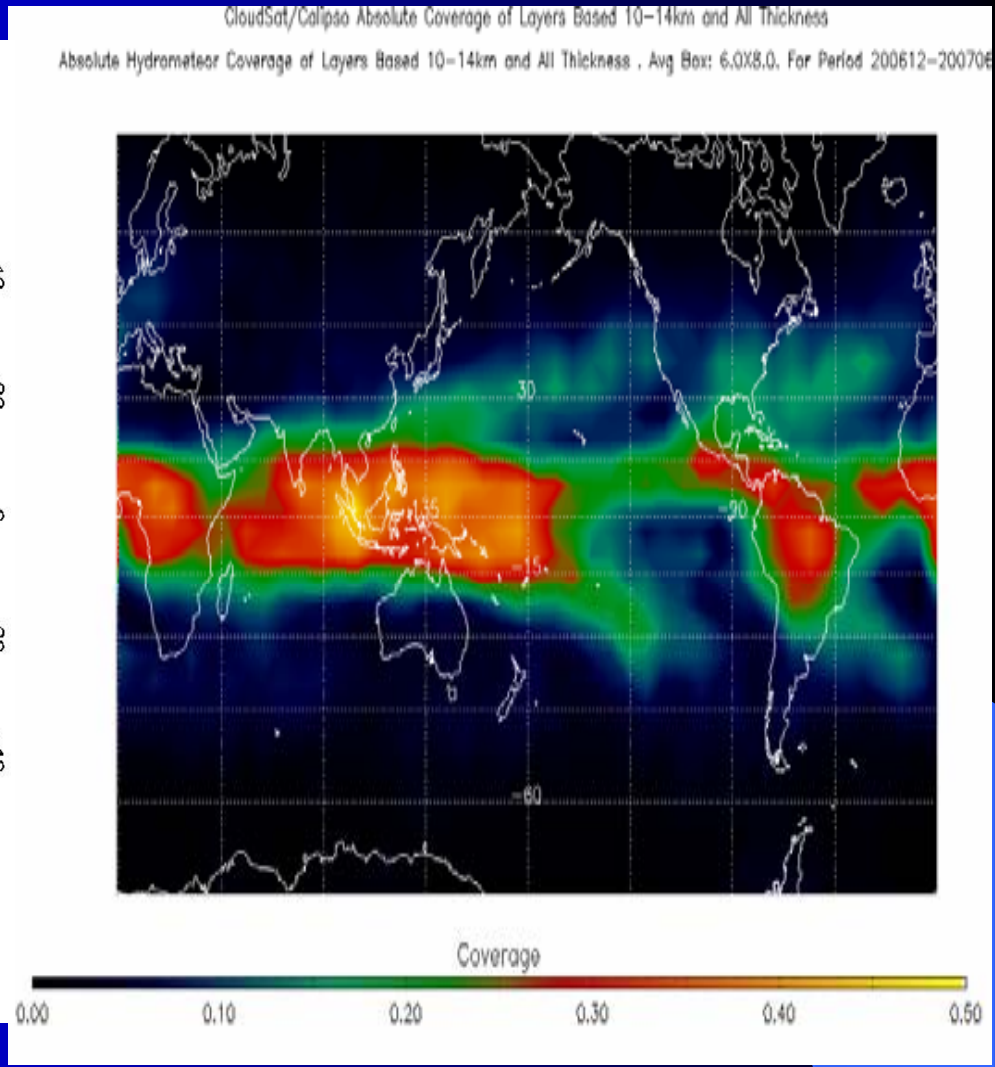
Comparison of Mid-high Clouds between GFS and CC



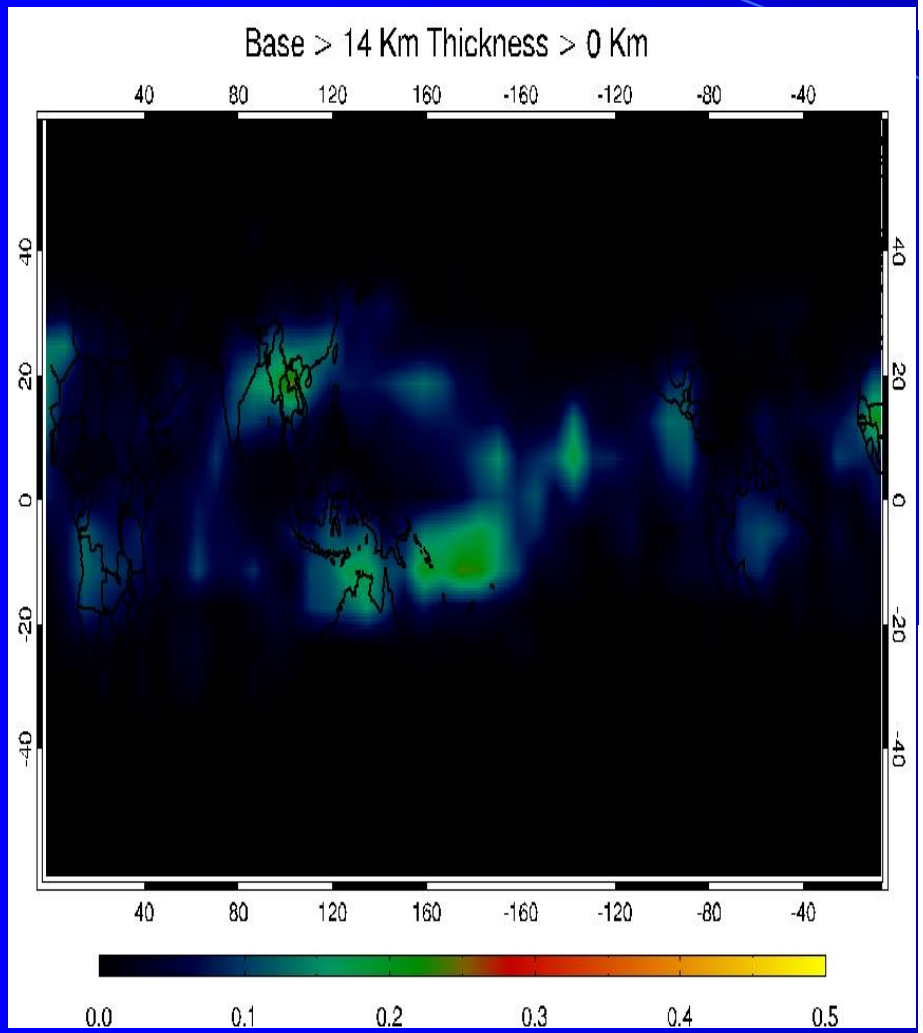


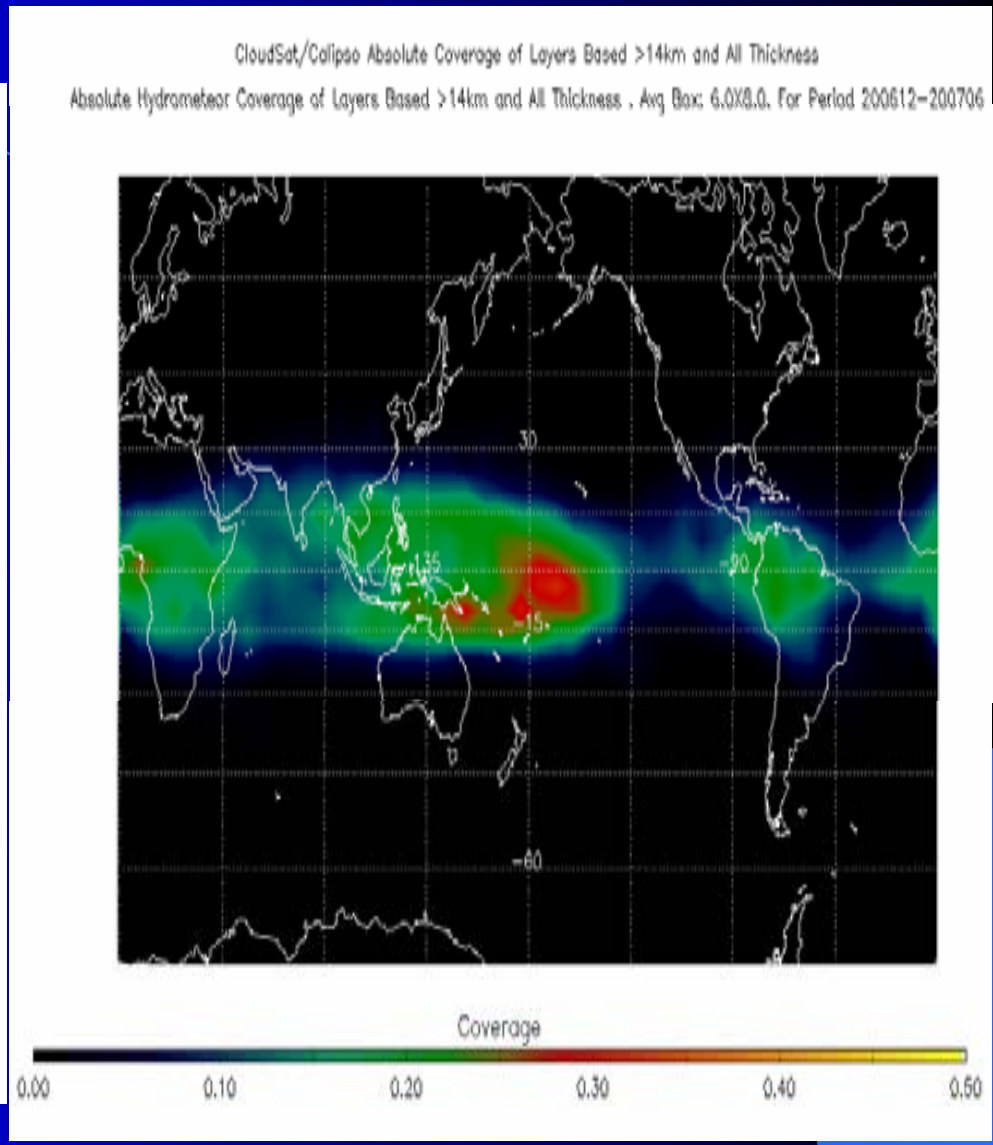
Comparison of mid-high Clouds between GFS and CC



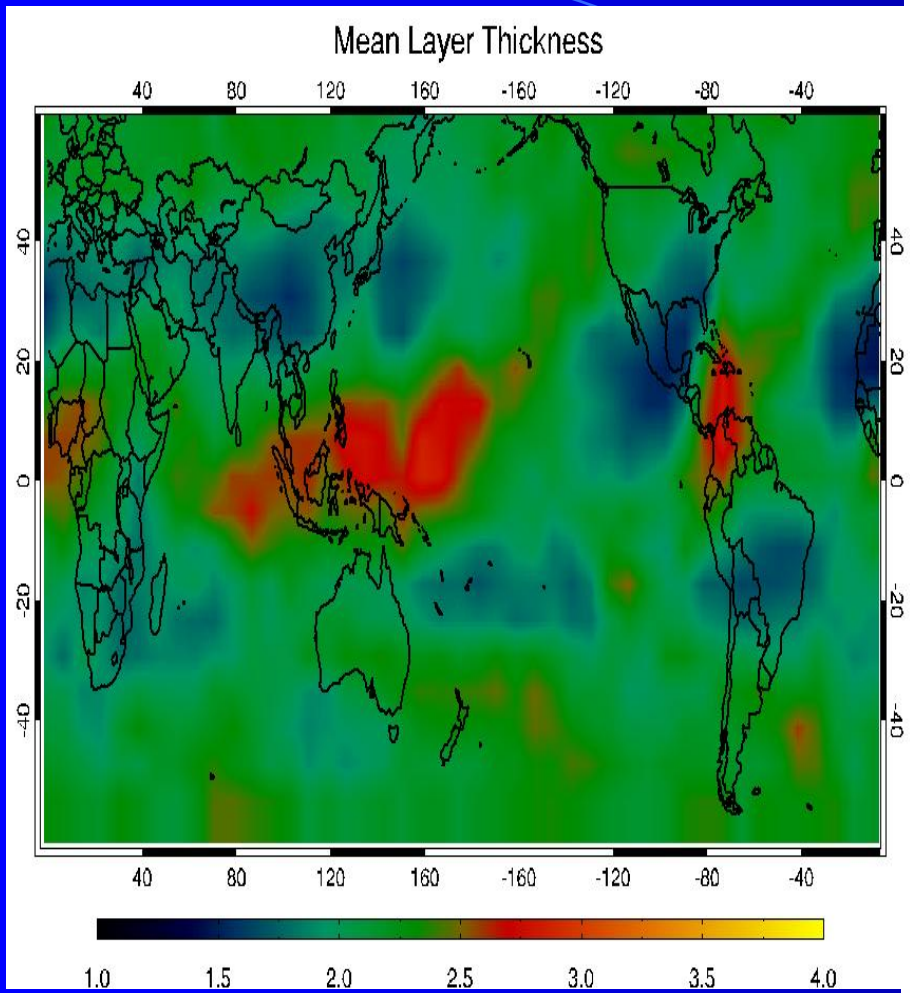


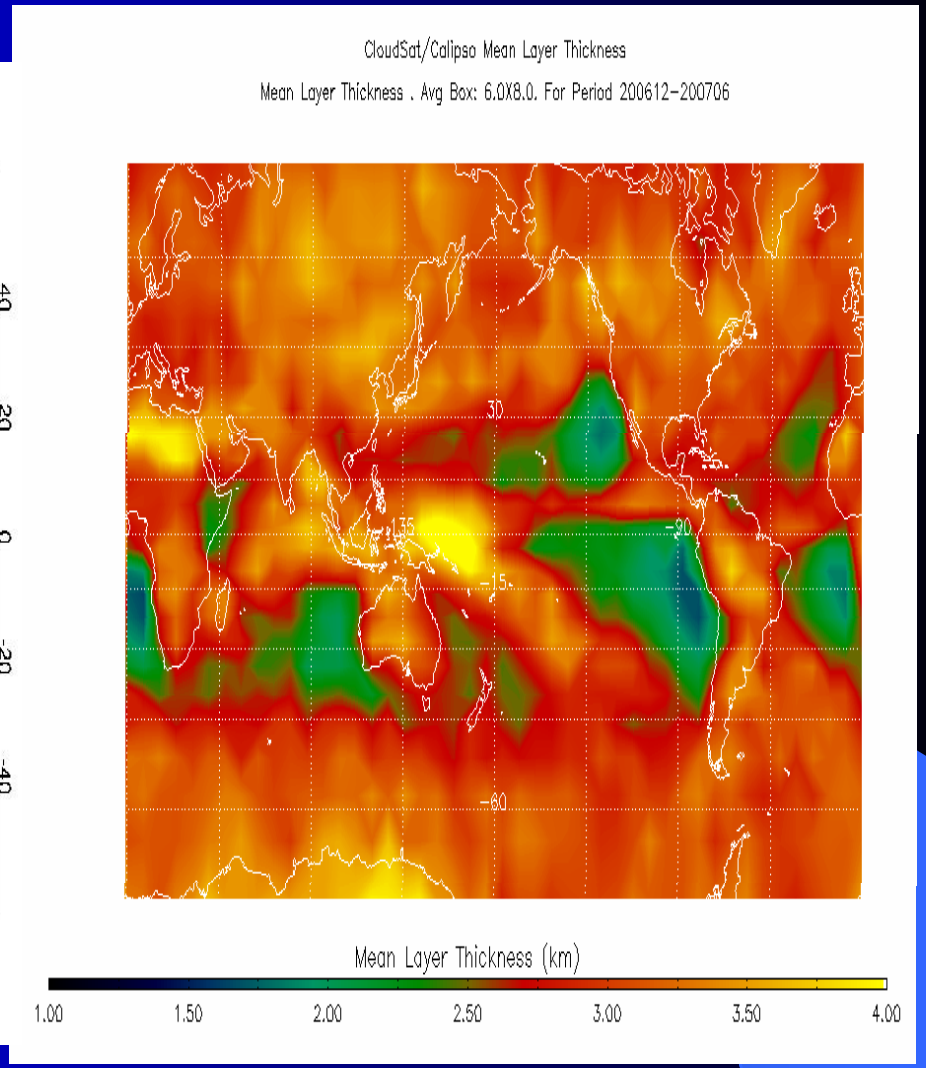
Comparison of High Clouds between GFS and CC



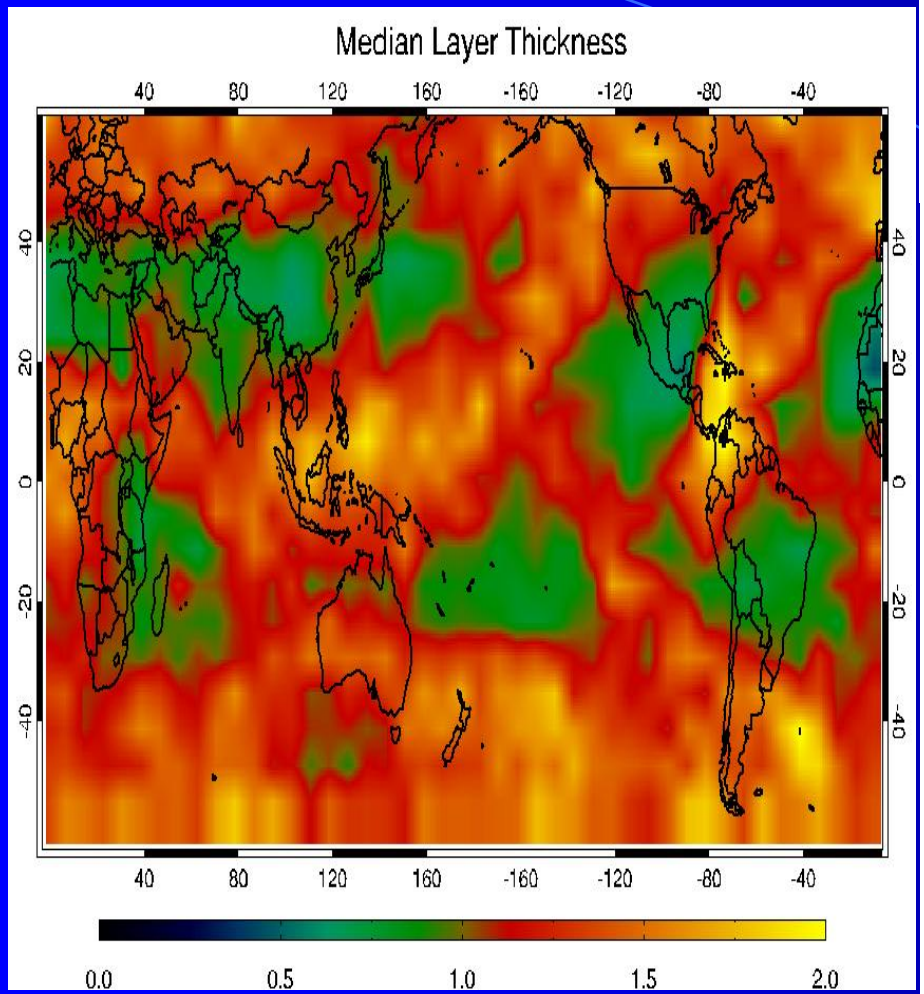


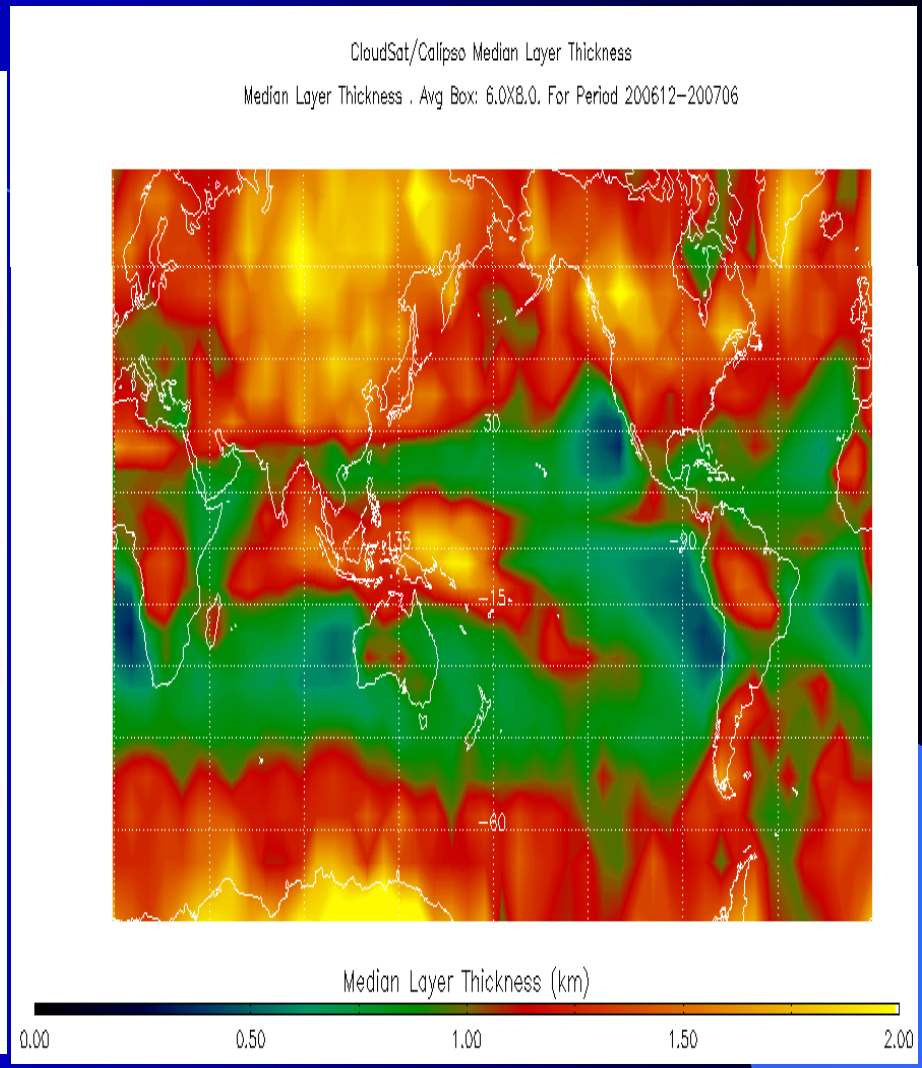
Comparison of Very-high Clouds between GFS and CC





Comparison of Mean Cloud Thickness between GFS and CC





Comparison of Median-Layer Thickness between GFS and CC

Major findings

- The spatial patterns and latitudinal variation of cloud from all three sources bear great resemblance
- Large discrepancies exist among all three products
- In general, the GFS modeled clouds are more similar to the MODIS retrieved clouds than to CC clouds
- The GFS model tends to generate less high clouds, more middle clouds and less low clouds than C-C clouds
- The GFS produces far less cirrus cloud in the tropics
- The GFS clouds are generally too thin by about 50%
- Many regional features are yet to be explored,e.g. too much clouds over deserts, too little over cold oceans, …

Future plan

- We shall continue to validate MODIS clouds against CC clouds, and between the two MODIS-based products
- We shall continue to evaluate the GFS model to find any dependence of the discrepancies on atmospheric and surface environments and weather regimes
- We shall gain further insights into the causes of the discrepancies by working closely with the modelers
- We shall match and analyze more datasets to fully understand the problems.
- Finally, we shall take a little break especially for Maureen and Hyelim !