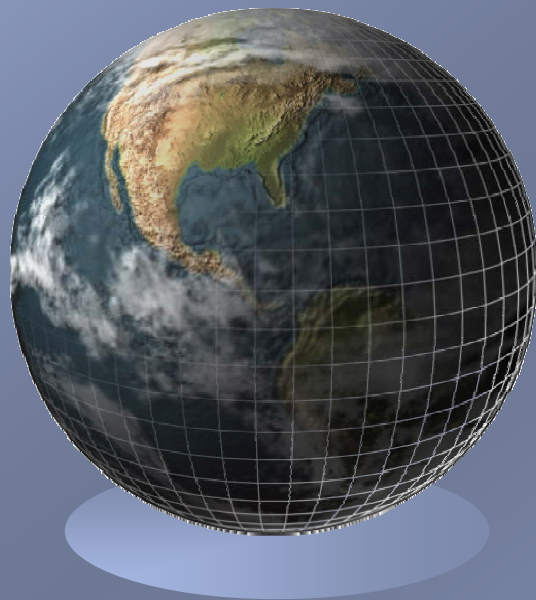


USING MICROWAVE LIMB SOUNDER (MLS) DATA TO EVALUATE MODEL CLOUD ICE FIELDS

Workshop on Parametrization of Clouds in Large-scale Models,
ECMWF, Nov 2006



Duane Waliser/JPL

Frank Li/JPL

MLS Team/J. Jiang/JPL

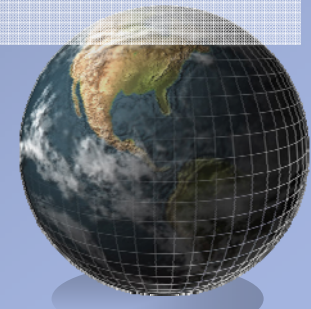
A. Tompkins/ECMWF

A Number of GCM Modelers/Modeling Groups

e.g., CSU/Kharitondov, GFDL/Donner, GISS/DelGenio, GSFC/Chern, Tao

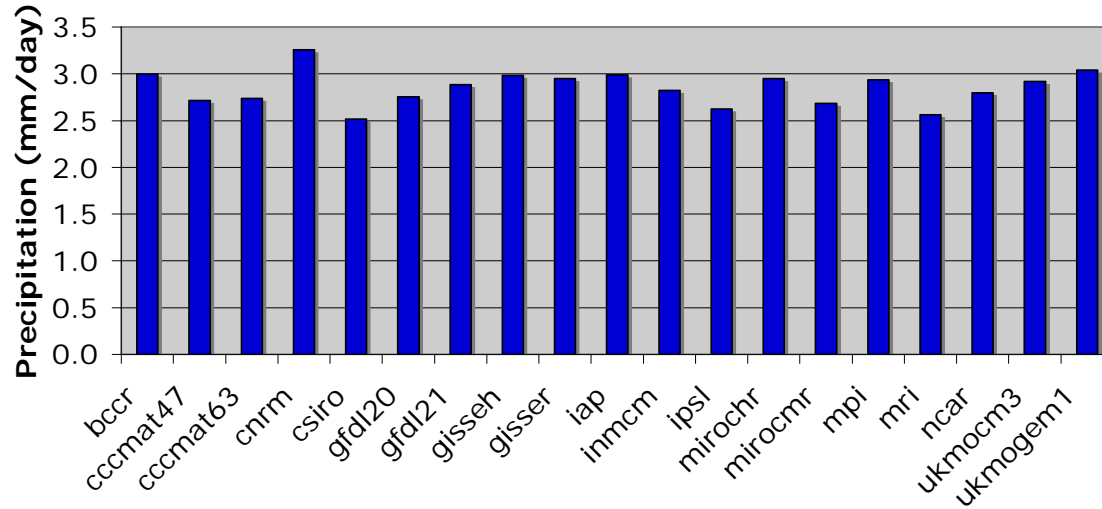
CLOUD ICE: SCIENCE MOTIVATION

- Critical link between upper tropospheric hydrological and energy cycles.
- Key attribute of clouds/climate that arises from both large-scale and microphysical processes.
- Rainfall, cloud fraction and TOA radiation observations leave many unconstrained quantities in model clouds/convection (e.g., cloud water/ice, particle size).
- *Height-resolved, global data for cloud ice water content (IWC) has been very limited.*



MODELING IMPLICATIONS: IPCC GCMS

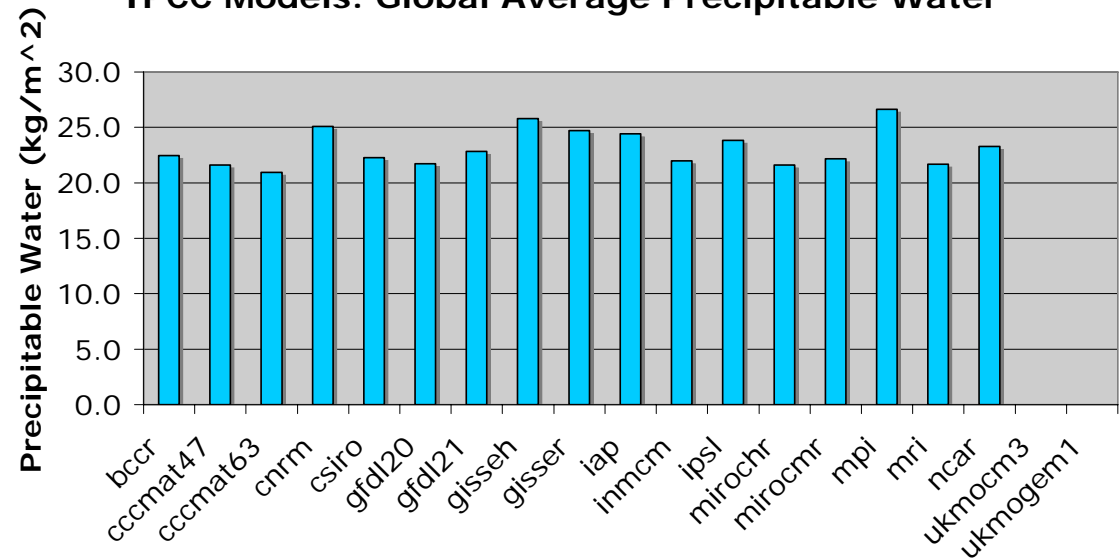
IPCC Models: Global Average Precipitation



Global Average
Precipitation
Multi-Model
Agreement to
within ~ +/-10%

Global Average
Precipitable Water
Multi-Model
Agreement to
within ~ +/-10%

IPCC Models: Global Average Precipitable Water



OBSERVING CLOUD ICE

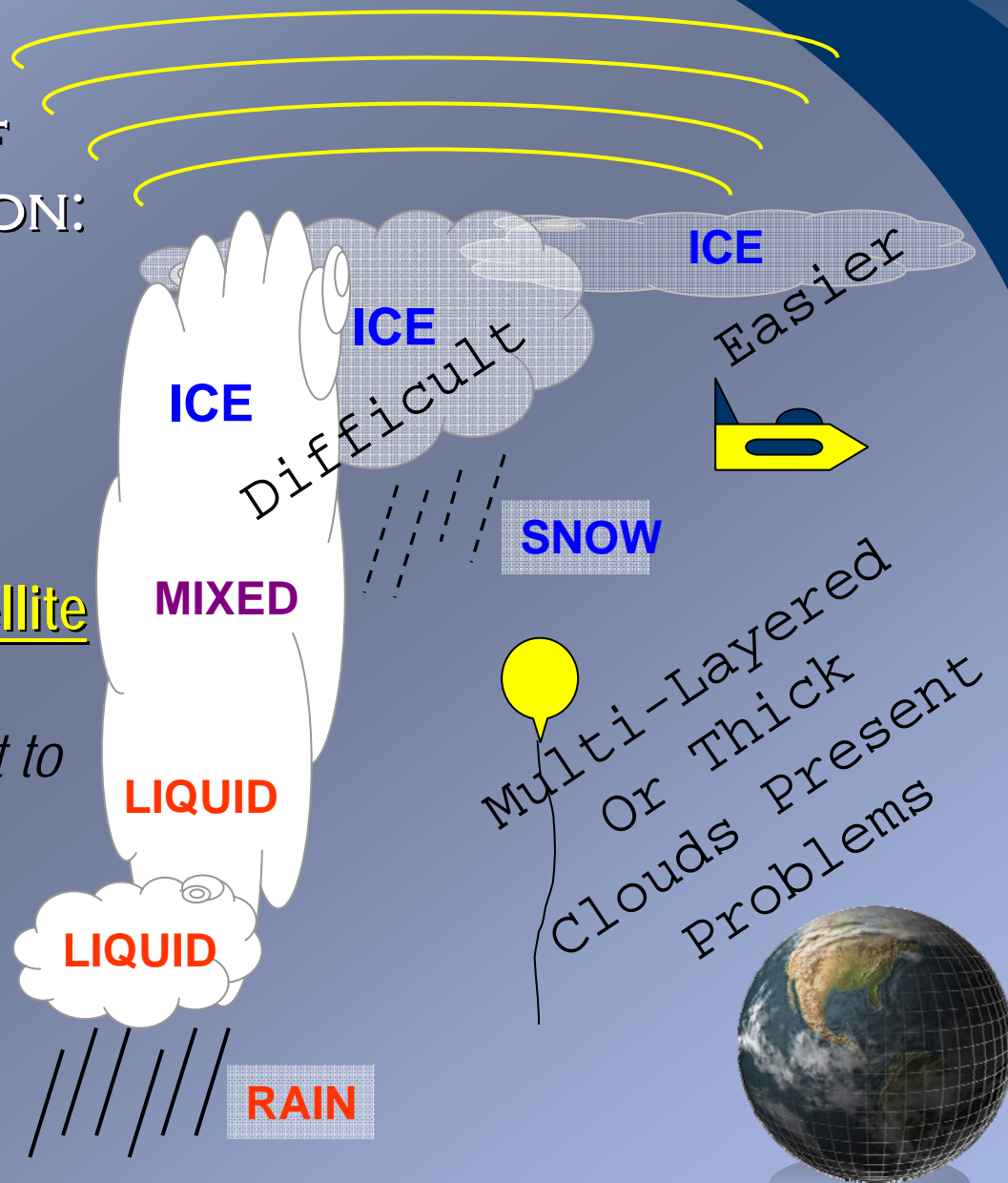
PREVIOUS ESTIMATES OF IWC HAVE BEEN BASED ON:

In-Situ:

Sparse in Time & Space
e.g. McFarquhar et al. 1999

Nadir-Viewing Passive Satellite Remote Sensing:

Path Estimate Only & Subject to Considerable Uncertainty
e.g., Rossow and Gardner 1993



MLS CLOUD ICE MEASUREMENT FEATURES

Resolutions:
~ 3.5 km
vertical

~ 200 km
horizontal

Data pressure levels:

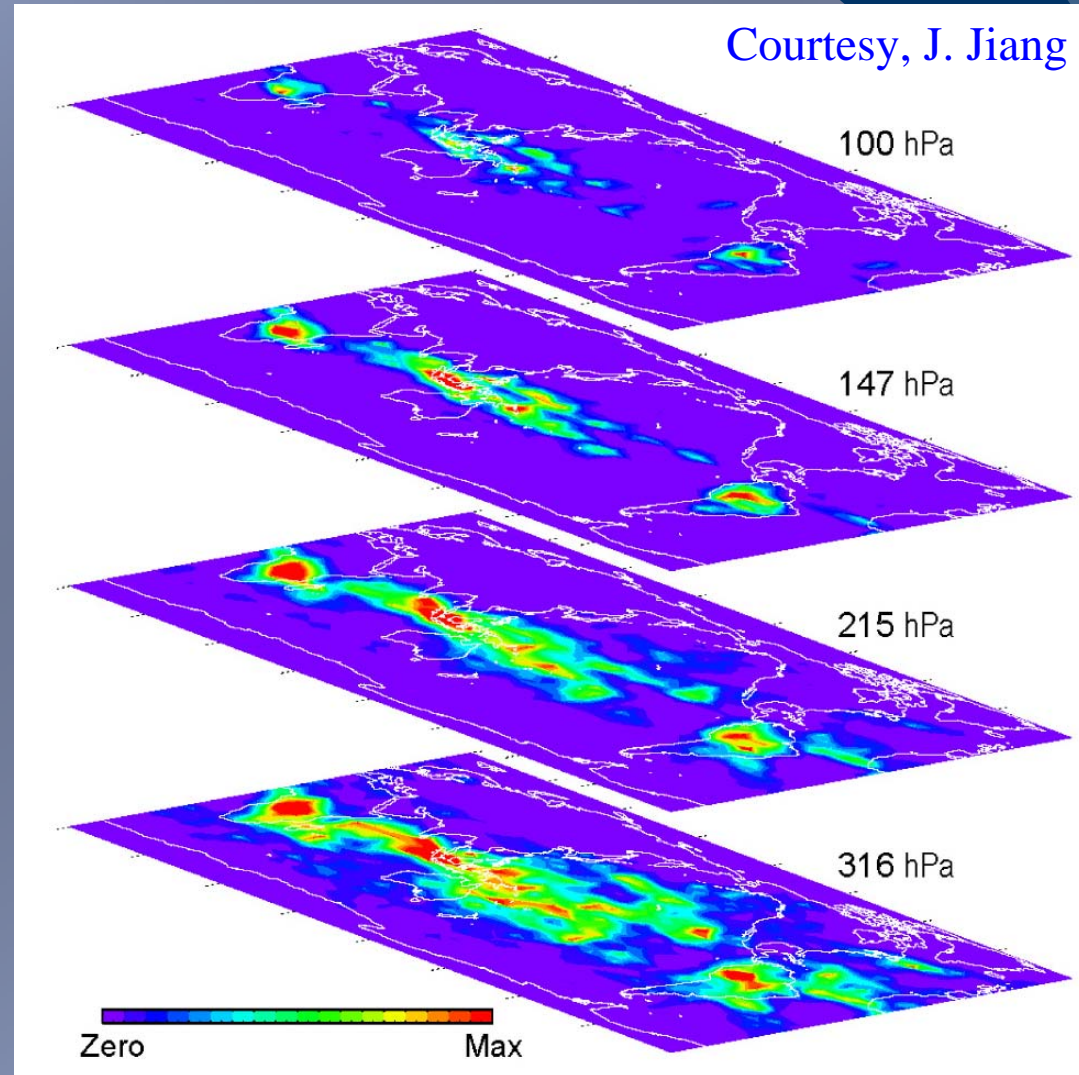
46 hPa
56 hPa
68 hPa
83 hPa
100 hPa
121 hPa
147 hPa
178 hPa
215 hPa
261 hPa
316 hPa

Standard Products

Research Products

Retrieval Scheme

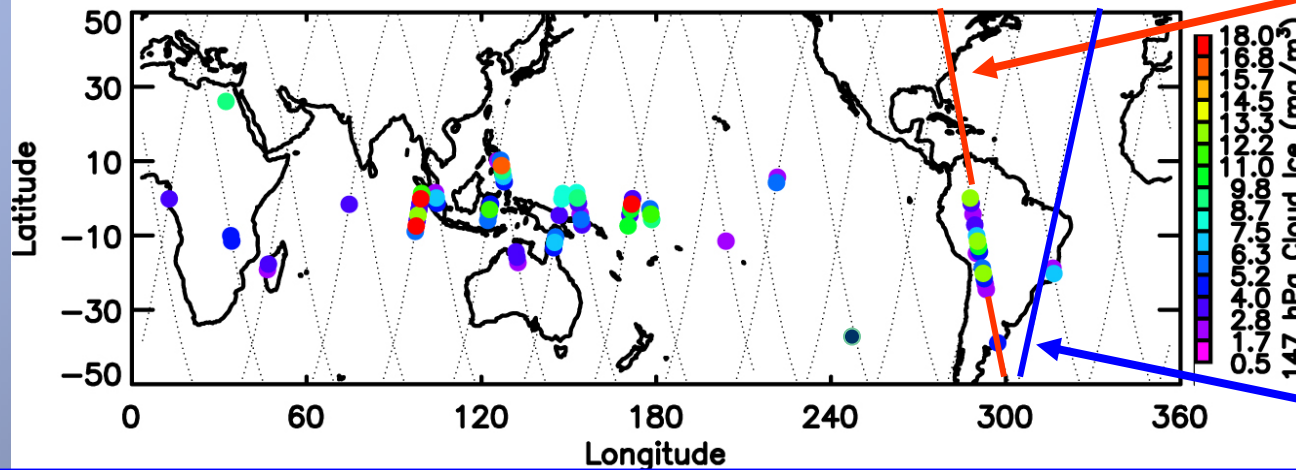
1. Retrieve T, q, Chem
2. Compute Clr-Sky Rad
3. Obs-Clr -> Clouds



MLS IWC maps for December 2004 at four pressure levels.

MLS IWC AT 147 hPa FOR JANUARY 2ND 2005

MLS IWC Jan 2nd 2005



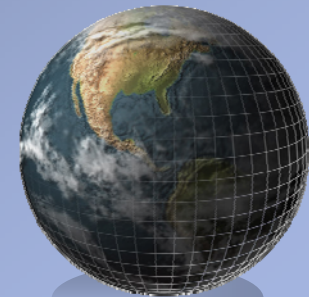
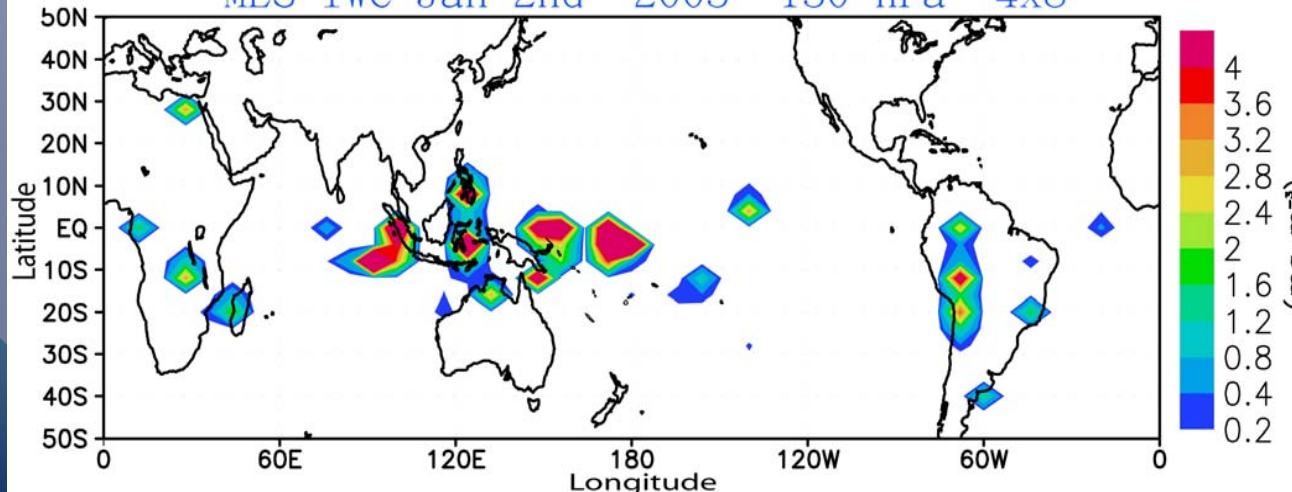
small black dots:
-measurement tracks

colored dots:
-non-zero individual IWC measurements

~1:30 AM

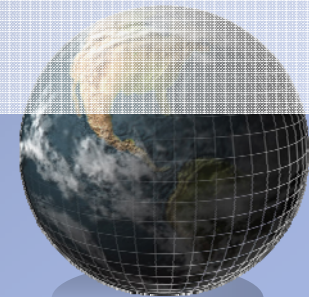
IWC amounts divided by the total number of measurements (including cloud free conditions) at each 4°× 8° lat-lon MLS grid.

MLS IWC Jan 2nd 2005 150 hPa 4x8



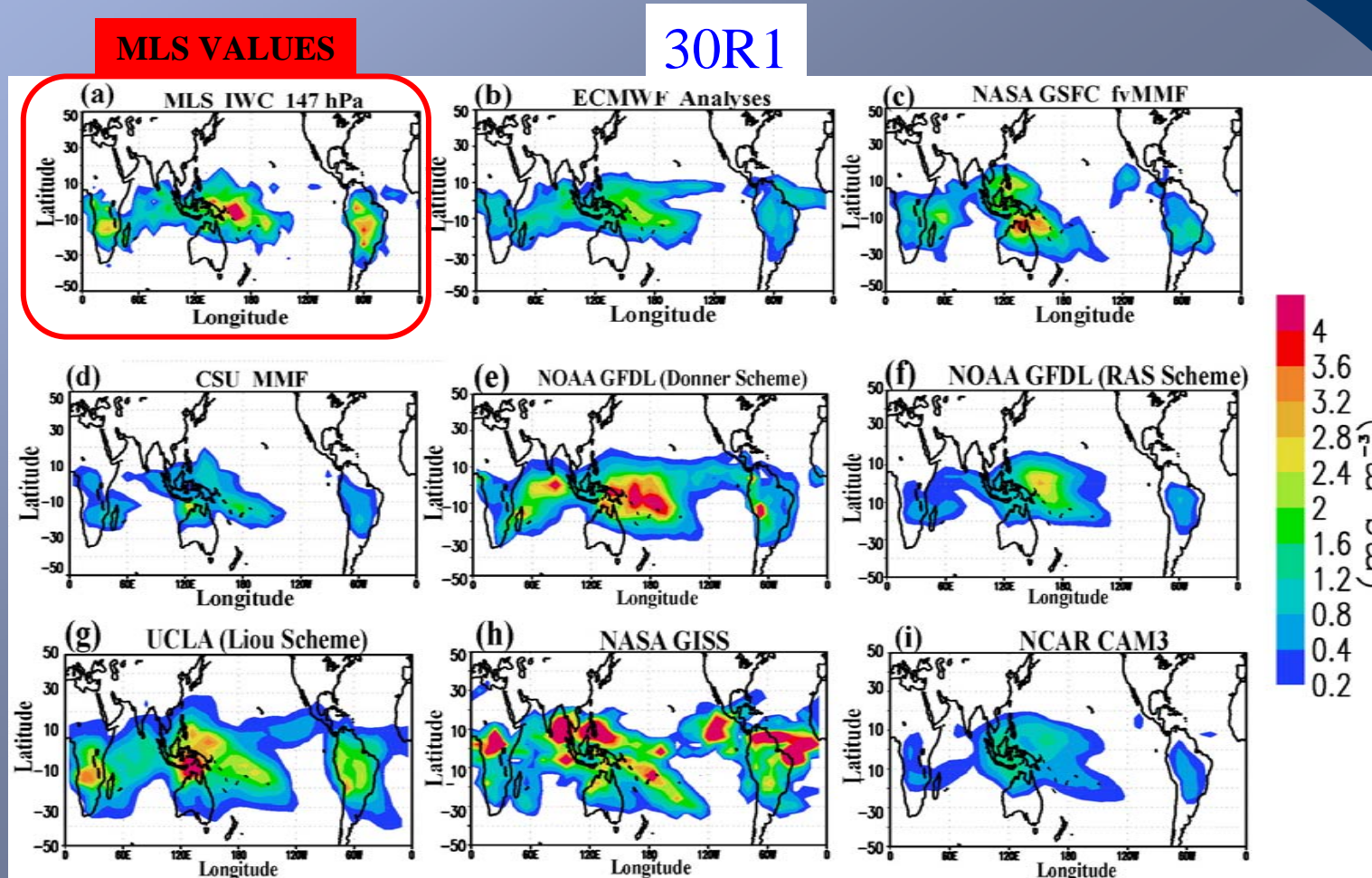
MLS ESTIMATES & MODEL VALUES

- ECMWF analyses (0 and 12Z) and forecasts (up to 10 days):
Both from 30R1 and 31R1
- GCM Values
 - ✓ Multi-year values from GCMs with conventional prognostic cloud parameterization. Such as:
 - **GFDL-RAS and -Donner** convection schemes
 - **NASA GISS**
 - **UCLA-Liou** cloud-radiation scheme
 - **NCAR CAM3**
 - ✓ GCMs using Multiscale-Modeling Framework (MMF).
 - **CSUMMF**
 - **GSFC fvMMF**



UPPER-TROPOSPHERIC CLOUD ICE: MLS vs MODELS

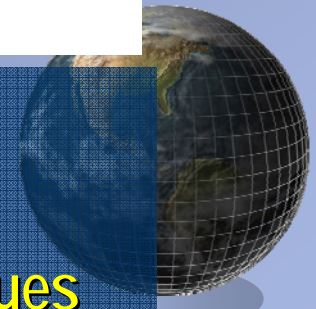
PRELIMINARY COMPARISON: LI ET AL. 2005



Observers: Models are doing terrible.

GCM Modelers: Hey, not as bad as I thought.

Need More Careful Analyses: Consider Sampling Issues



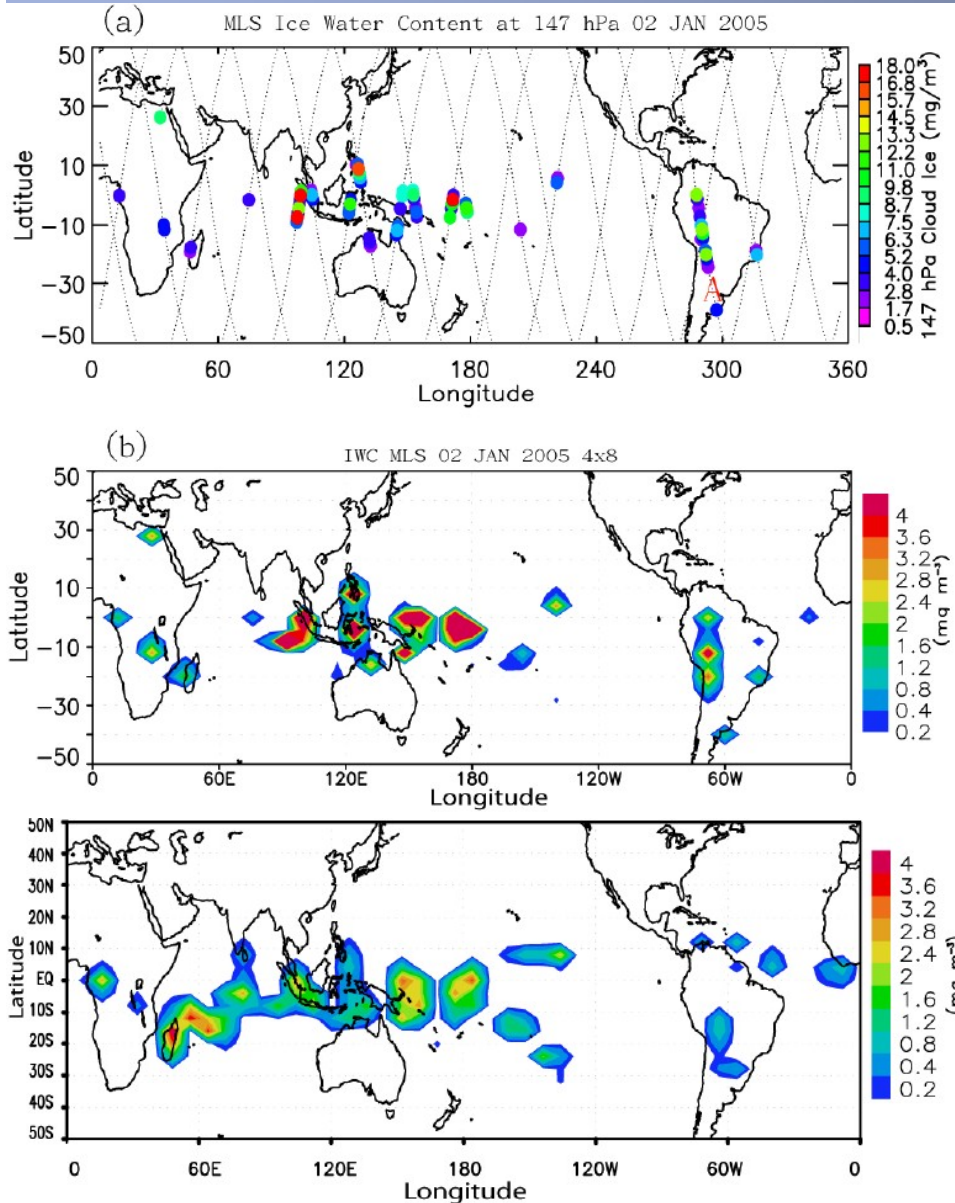
CLOUD ICE: MLS vs ECMWF ANALYSES

147 hPa; Jan 2, 2005

MLS Orbits + Retrievals

MLS Averaged to 4x8 Grid

ECMWF Sampled Along Track

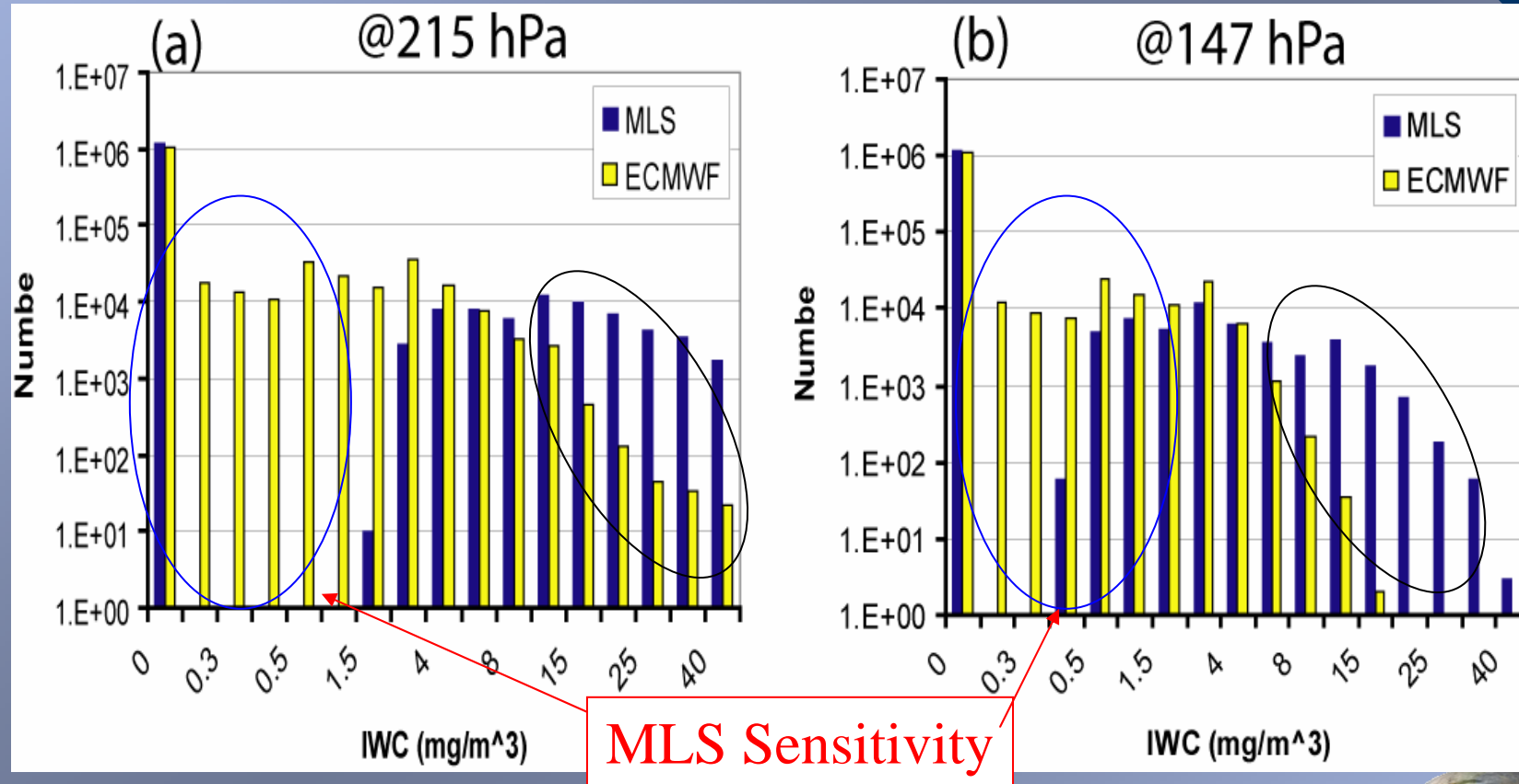


30R1

MLS vs SAMPLED ECMWF ANALYSES

30R1

Aug 2004 - Jul 2005; PDF of Instantaneous Values



ECMWF and MLS disagree at high values.

Low value representation needs to be accounted for.

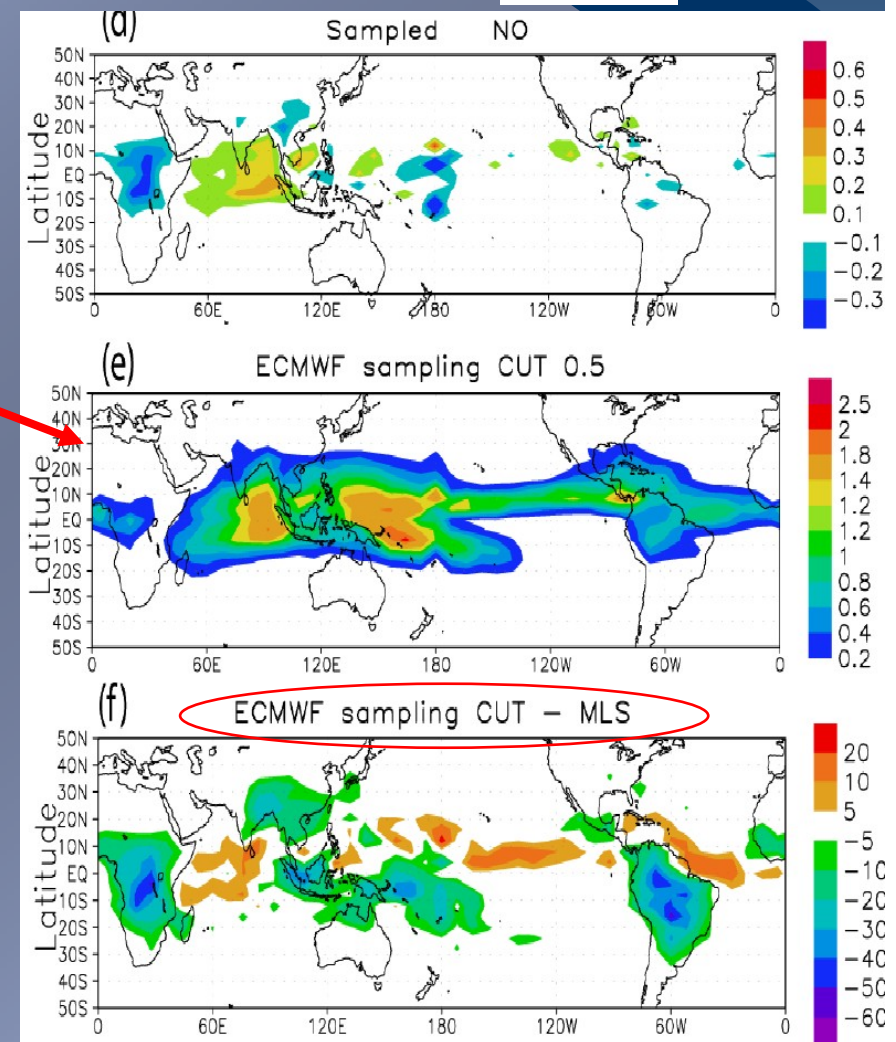
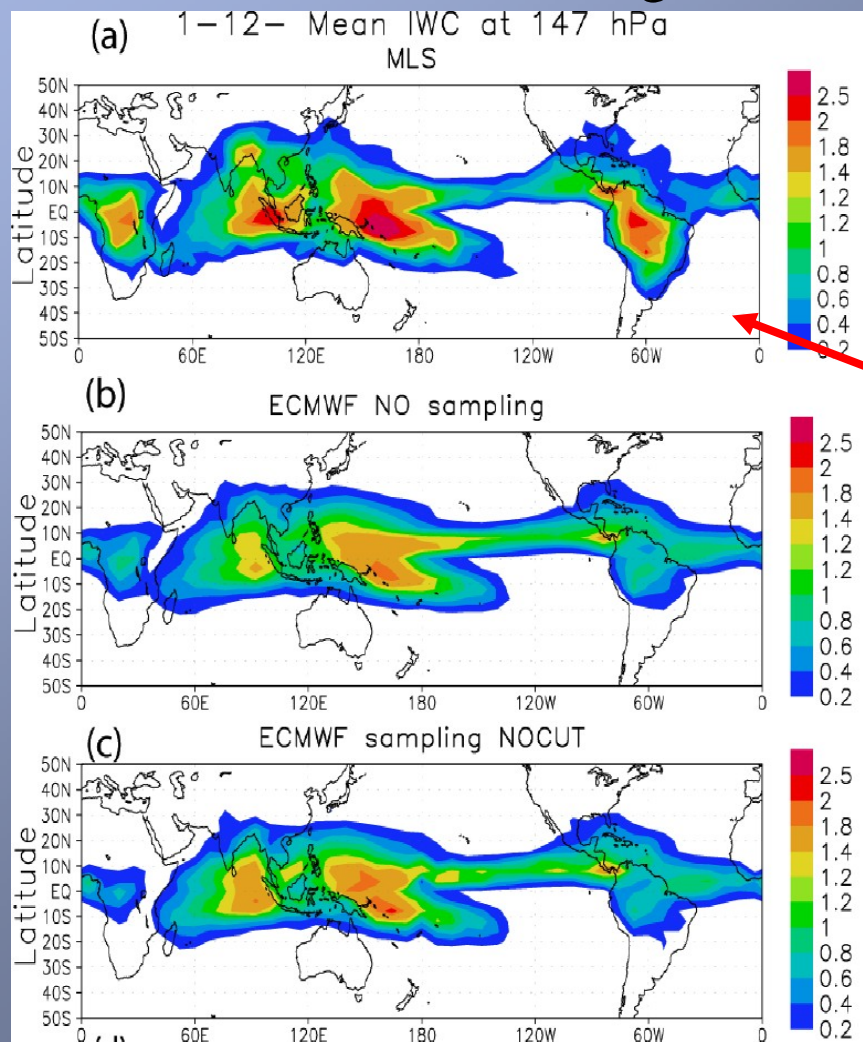
CloudSat (Calypso) will provide low+high (low) value data



MLS vs SAMPLED, FILTERED ECMWF ANALYSES

Aug 2004 - Jul 2005; 147 hPa

30R1



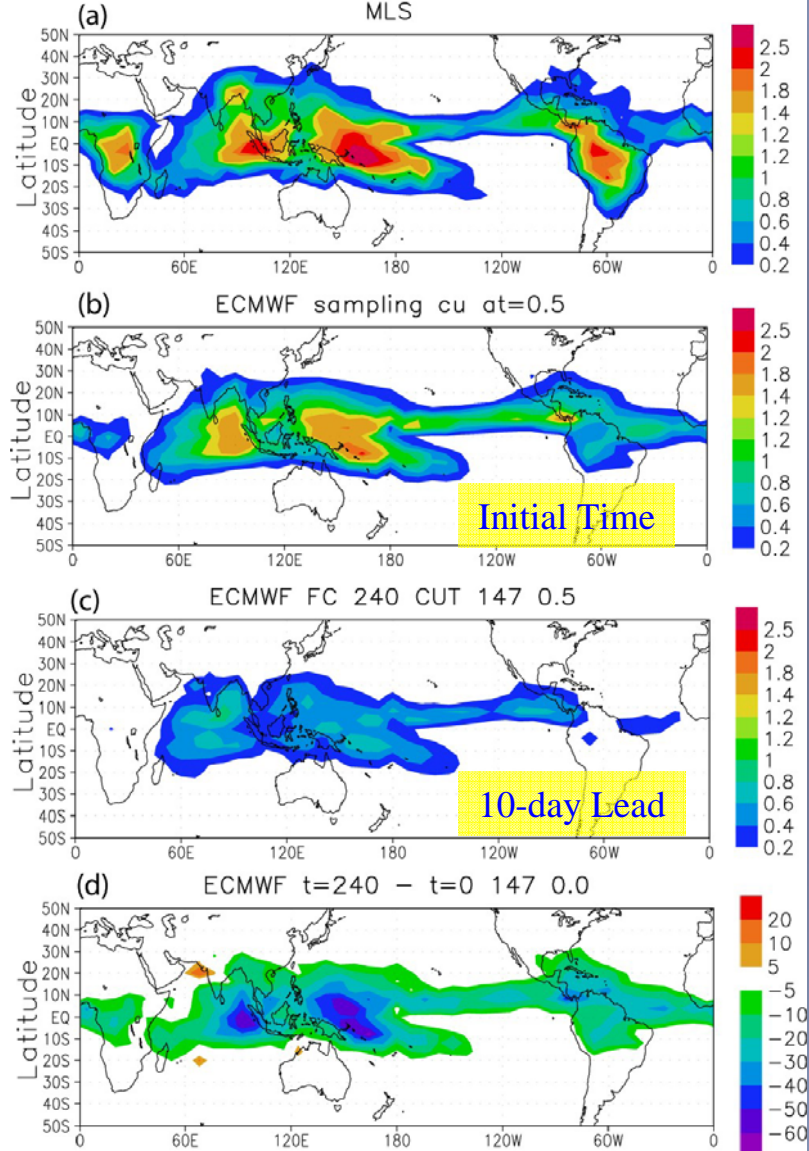
- Over the strongest convective regions, ECMWF is about 50% or less than MLS.
- In many ITCZ regions, ECMWF is about 20% larger than MLS.
- Similar results found for other levels.

MLS vs SAMPLED, FILTERED ECMWF FORECASTS

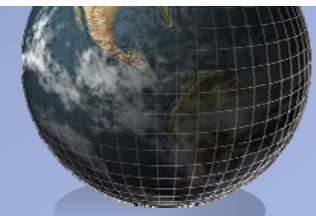
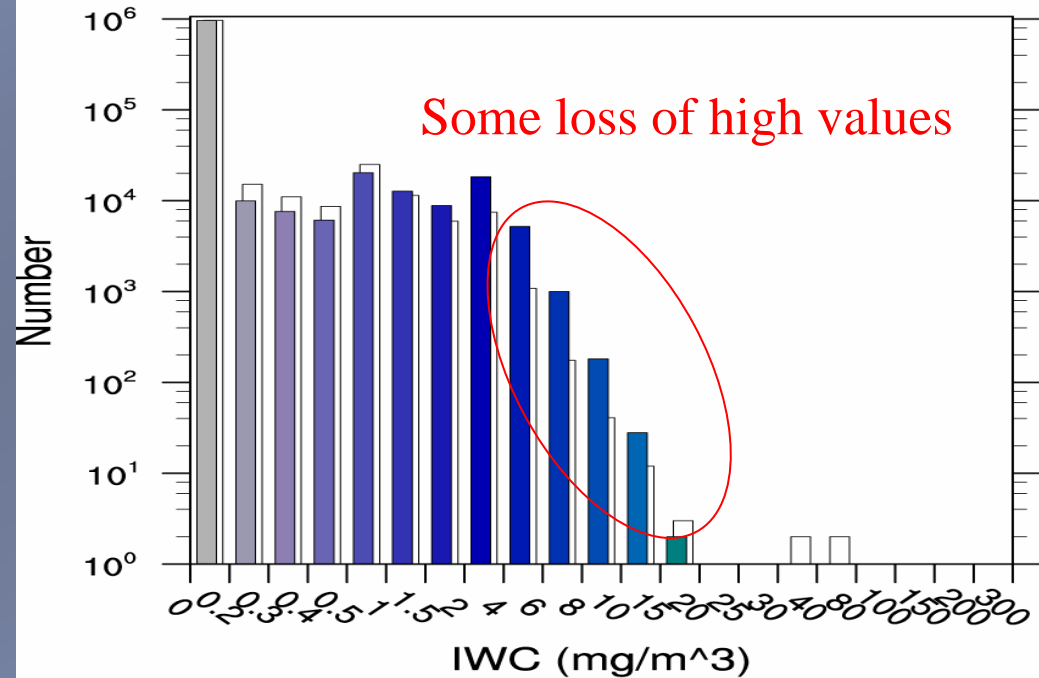
Aug 2004 - Jul 2005; 147 hPa

30R1

1-12- Mean 0.5 IWC at 147 hPa
MLS



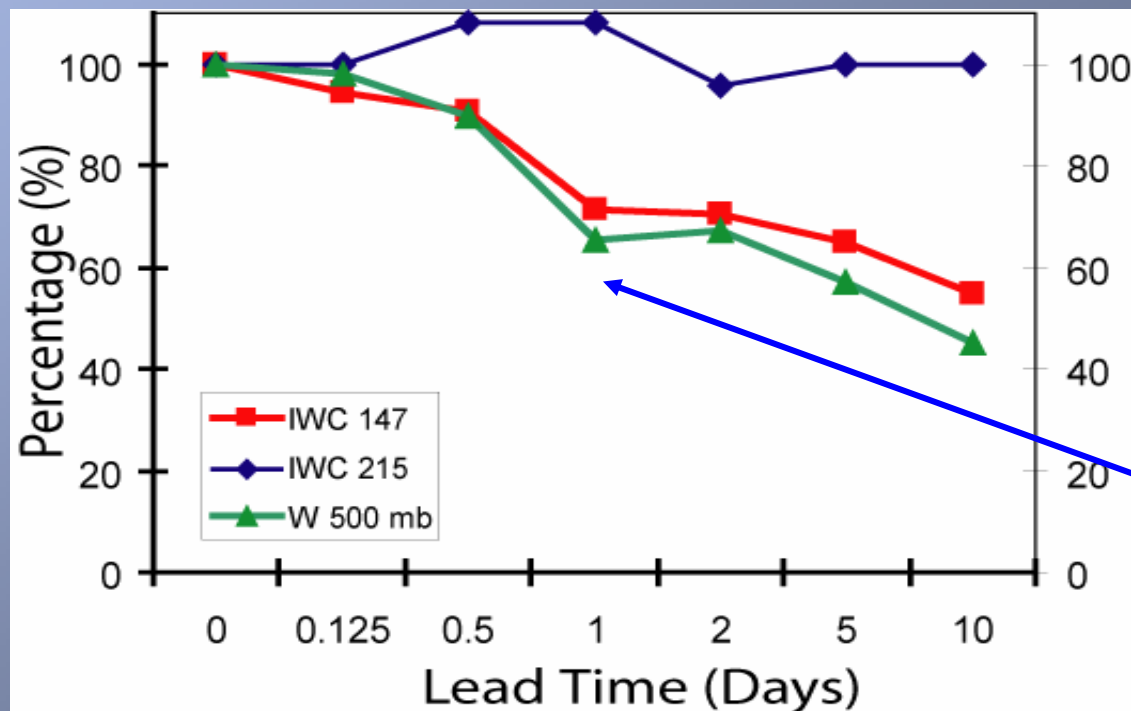
EC FC=0.COLOR vs. EC FC = 240 hrs



FORECAST OF GLOBAL MEAN ECMWF IWC

(initial hour to day-10 forecast)

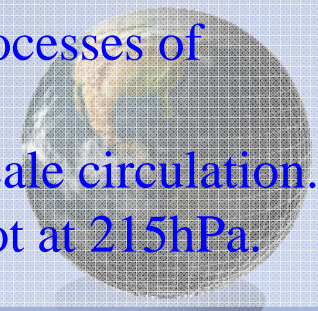
30R1



Significant
Drop in 1 Day

Some systematic bias development, particularly at highest levels:

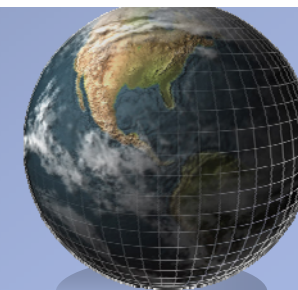
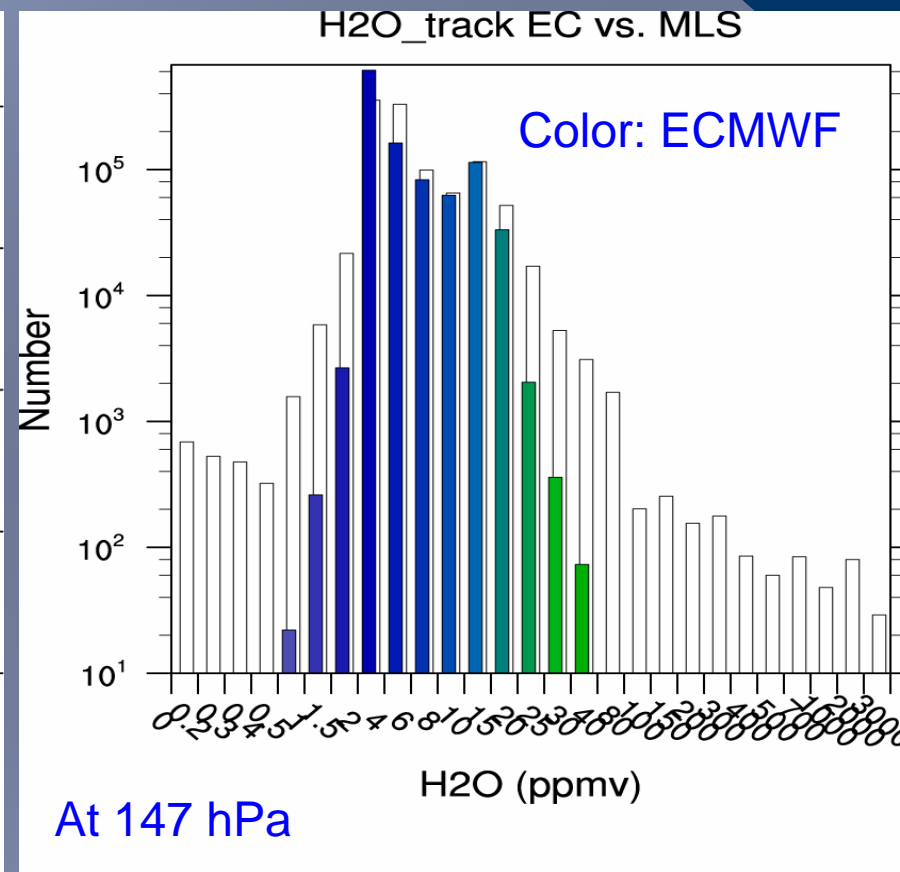
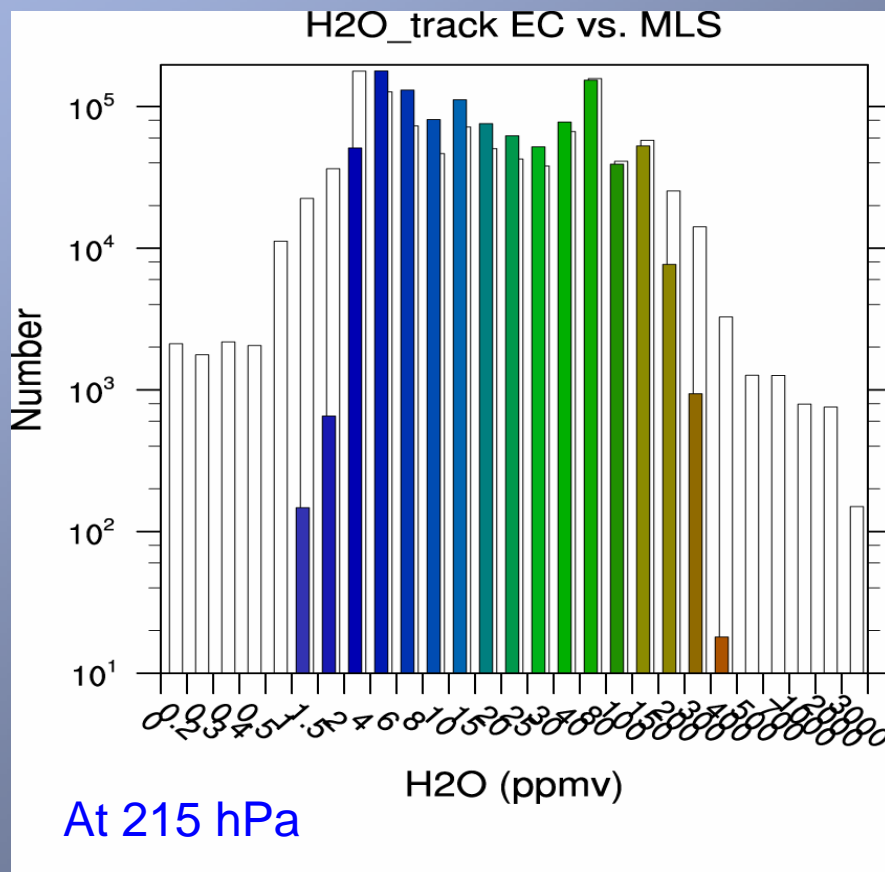
- Indicating convective strength erosion or changes in upper level stratification
- Possible shortcomings in the parameterizations of moist physical processes of clouds and convection
- Impact may be through local effects and/or feedbacks to the large-scale circulation.
- Preliminary look shows cloud detrainment rate decreasing at 147, not at 215hPa.



WATER VAPOR: MLS vs ECMWF ANALYSIS

1 Year of Data - Sampled Along MLS Tracks

30R1



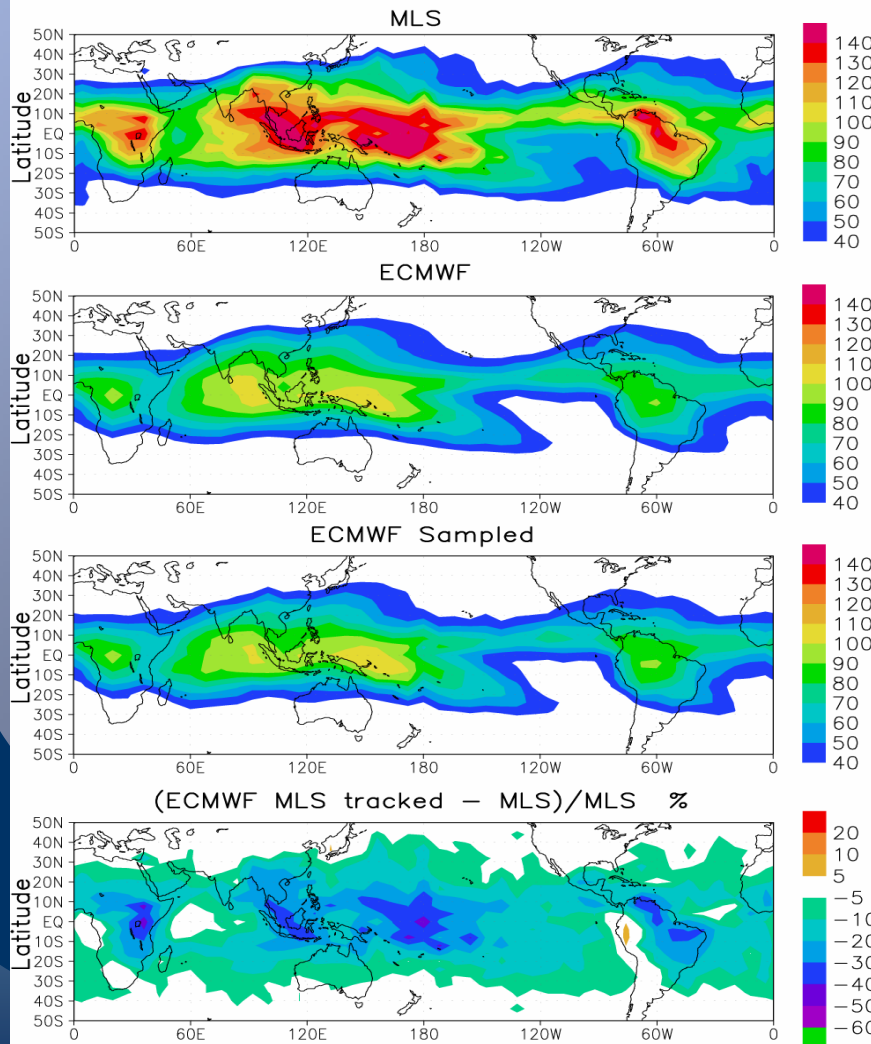
WATER VAPOR: MLS VS ECMWF ANALYSIS

1 Aug04 ~ Jul05 - Sampled Along MLS Tracks

30R1

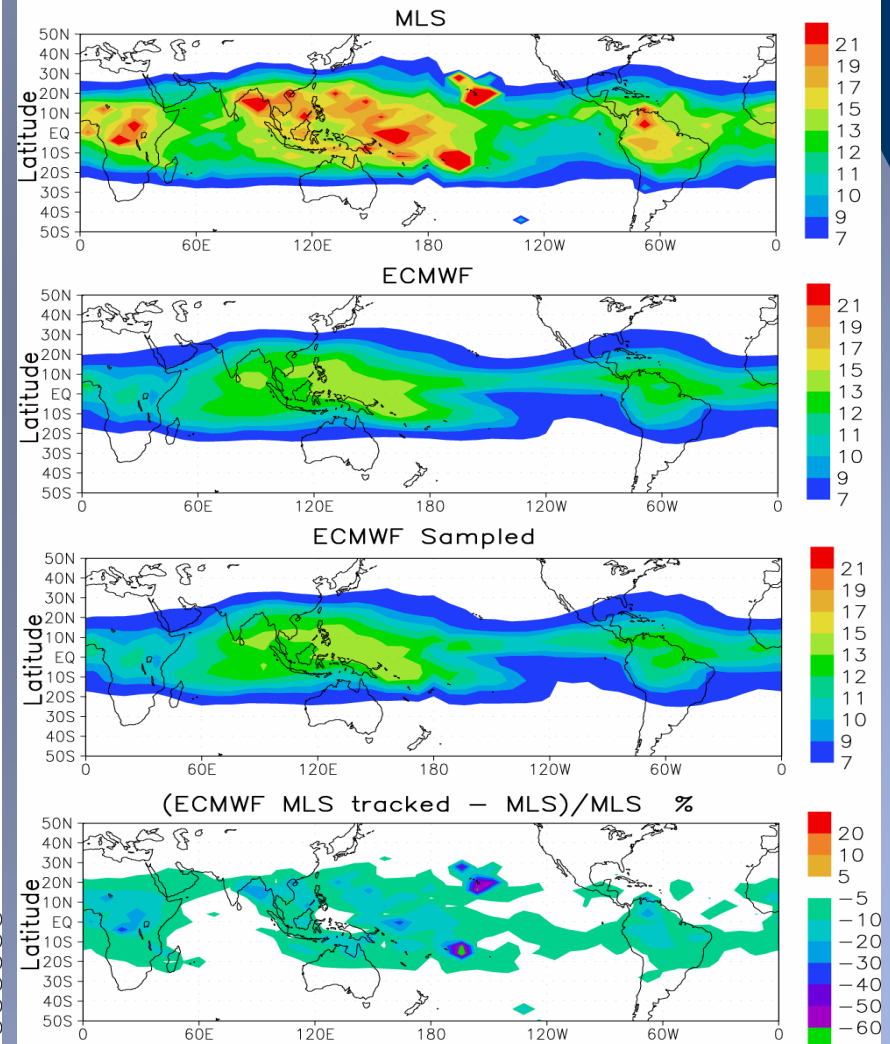
215 hPa

Annual Mean (1004–0705) H₂O at 215 hPa



147 hPa

Annual Mean (1004–0705) H₂O at 147 hPa



RECENT UPDATES TO ECMWF FORECAST SYSTEM

Moist Package Revisions

Operational Versions

- OLD -> ECI : 30R1: up to Sep 12th 2006 (ECI).
- NEW -> ECII: 31R1: starting operational on Sep 13th 2006.

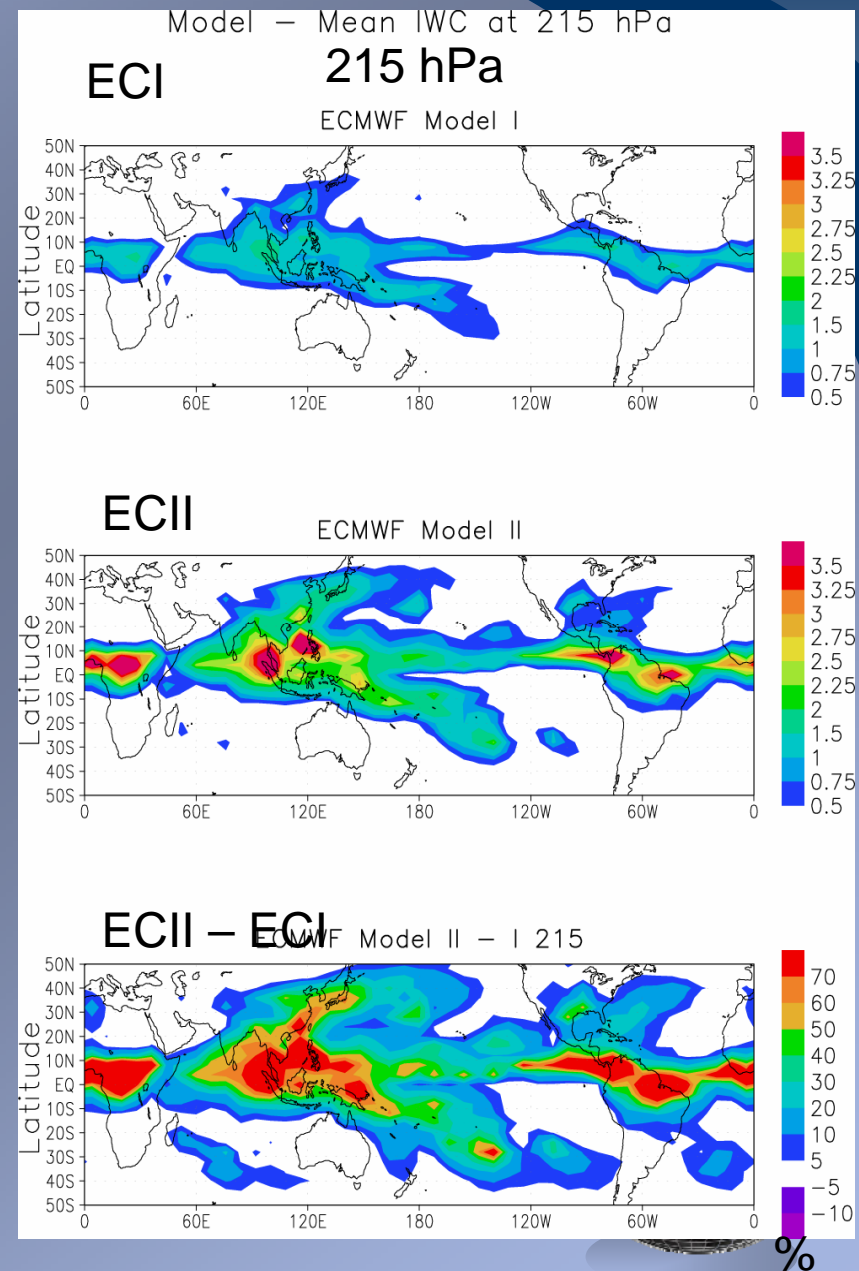
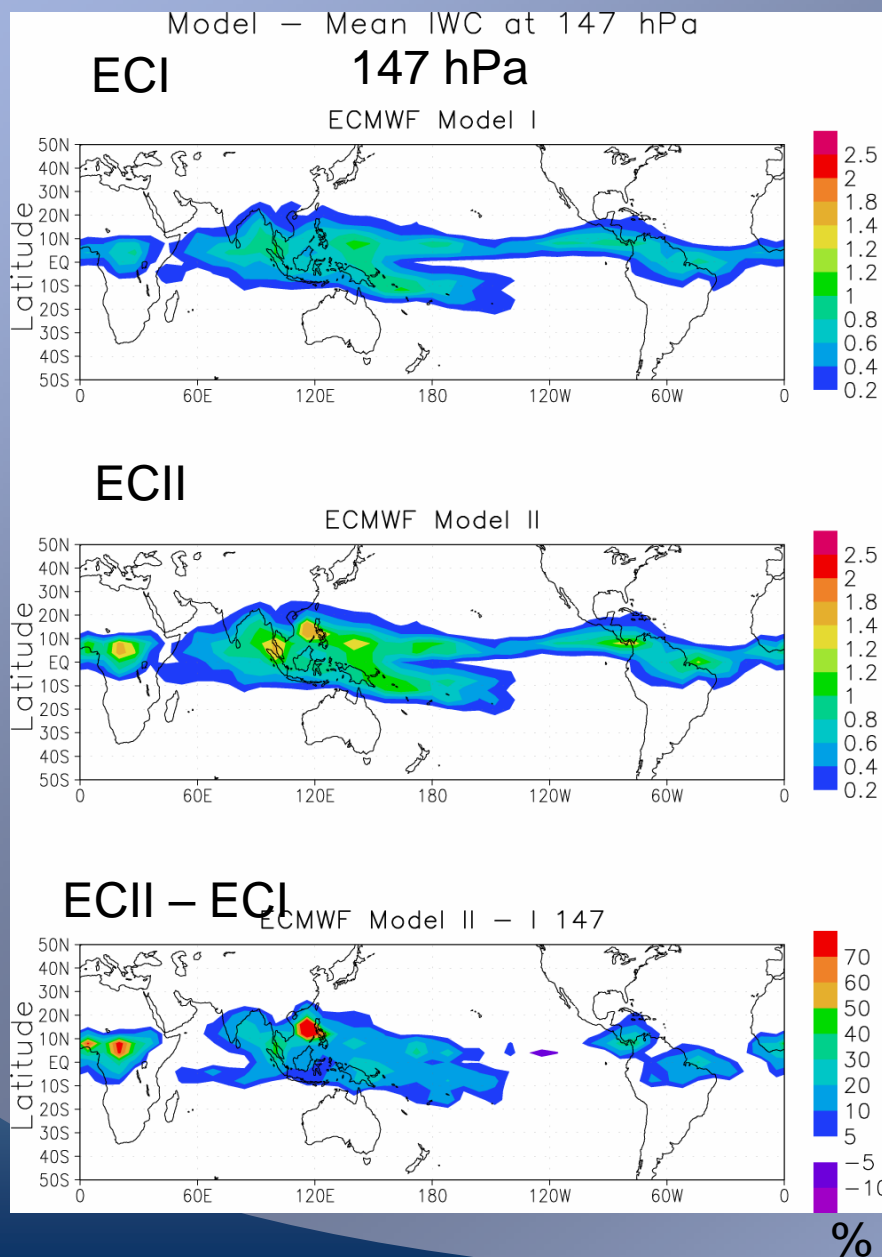
The changes in the moist processes are:

- a) New parameterization to allow ice-phase supersaturation
- a) Revised ice crystal sedimentation and snow autoconversion



ECI vs. ECII

Mean IWC May~July 2006

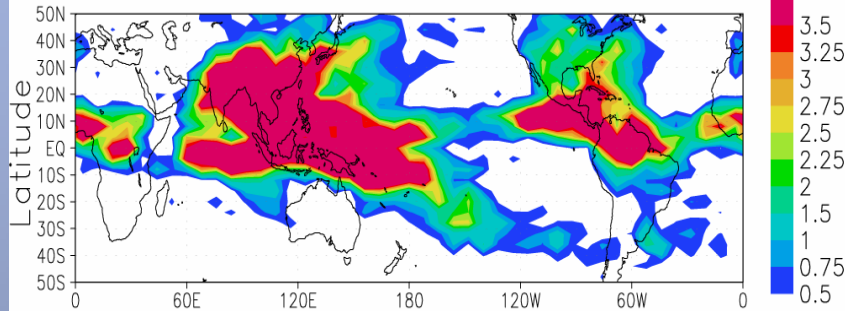


ECMWF DAY-10 FORECAST MEAN IWC MAY~JULY 2006

215 hPa

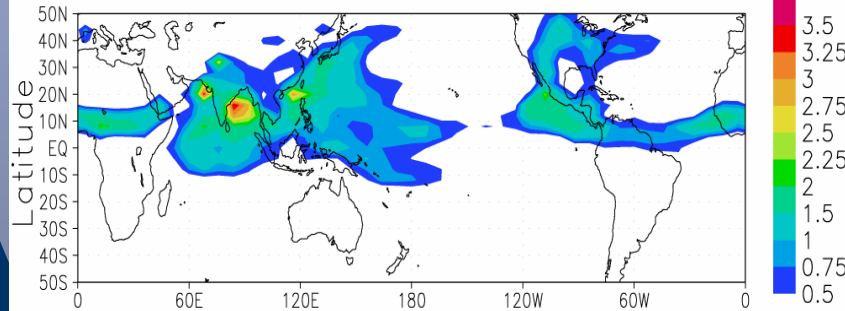
147 hPa

Model FC vs. MLS 5-7 Mean IWC at 215 hPa
MLS



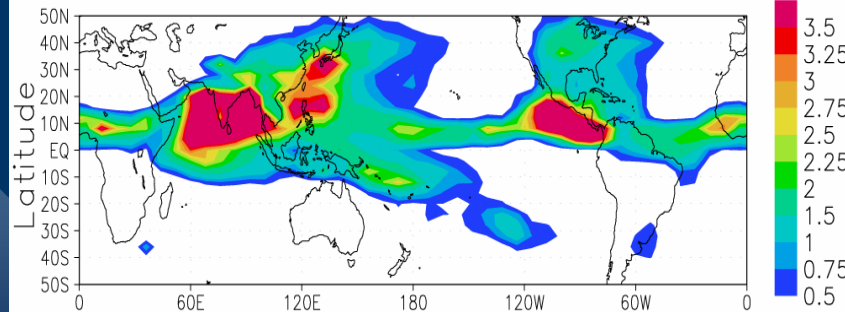
MLS

ECMWF Model I FC



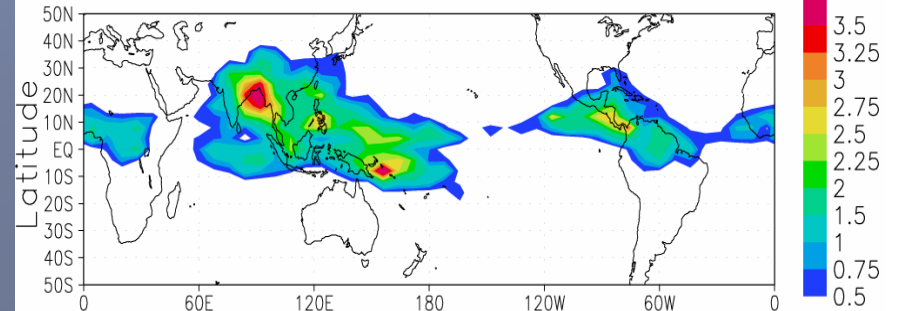
EC_I

ECMWF Model II FC

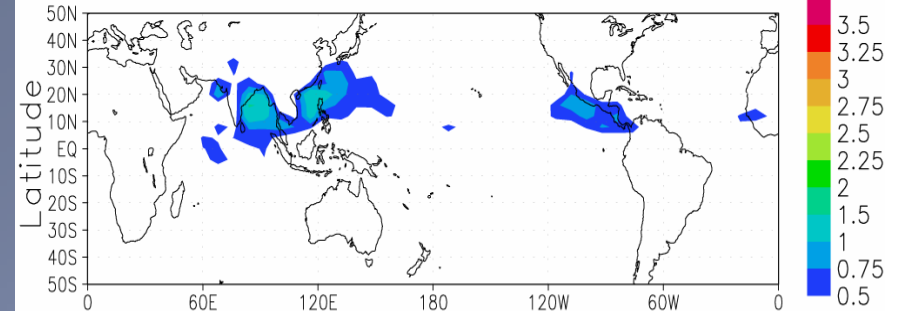


EC-II

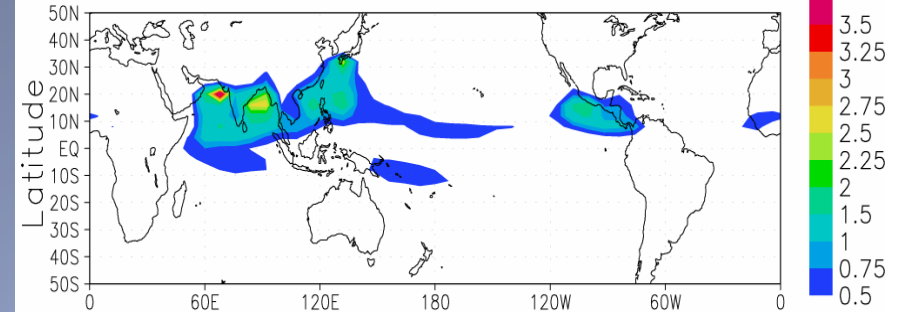
Model FC vs. MLS 5-7 Mean IWC at 147 hPa
MLS



ECMWF Model I FC

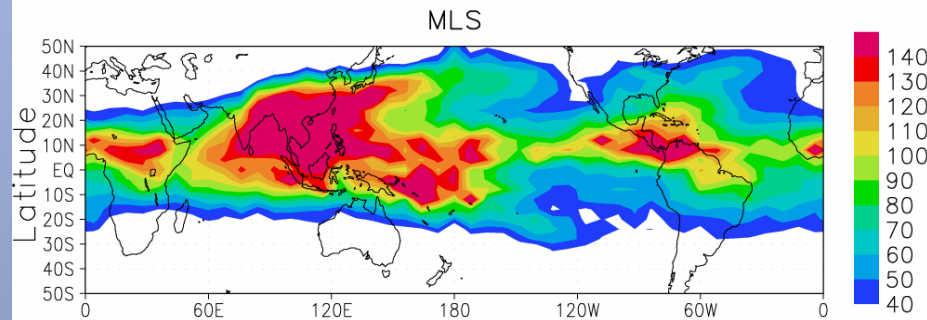


ECMWF Model II FC

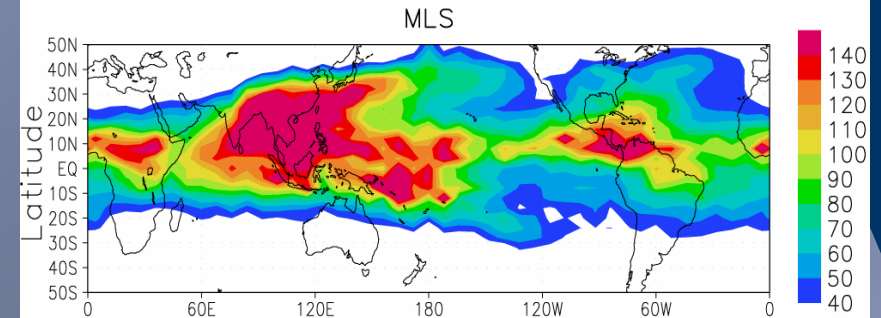


H2O: MLS VS ECMWF MEAN @ 215 MAY~JULY 2006

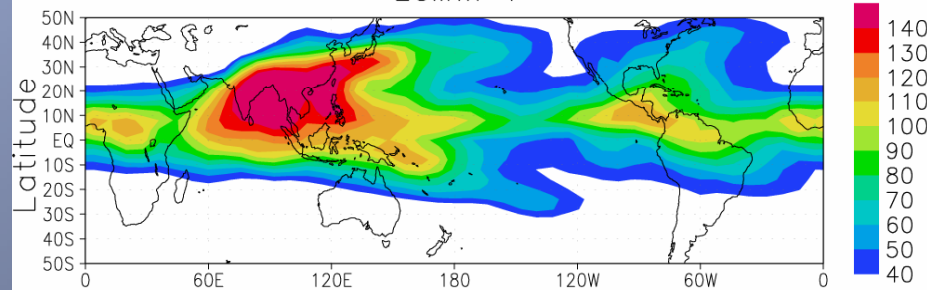
Model I vs. II 567 Mean H2O at 215 hPa



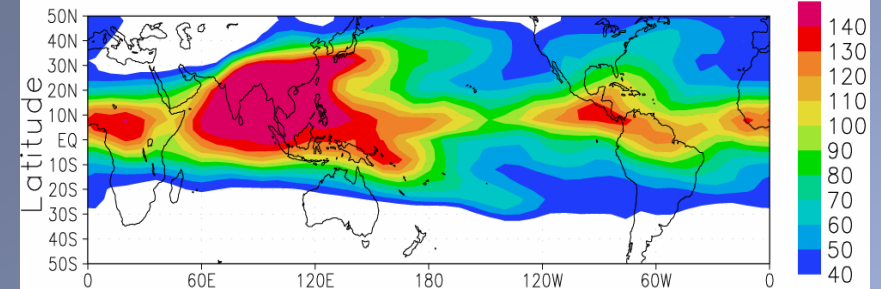
Model I vs. II 567 Mean H2O at 215 hPa



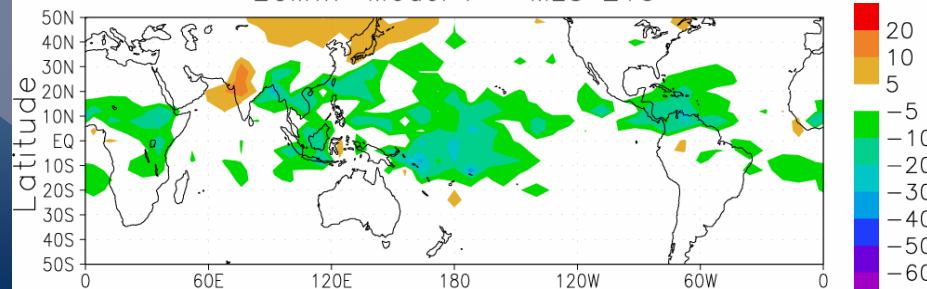
ECMWF I



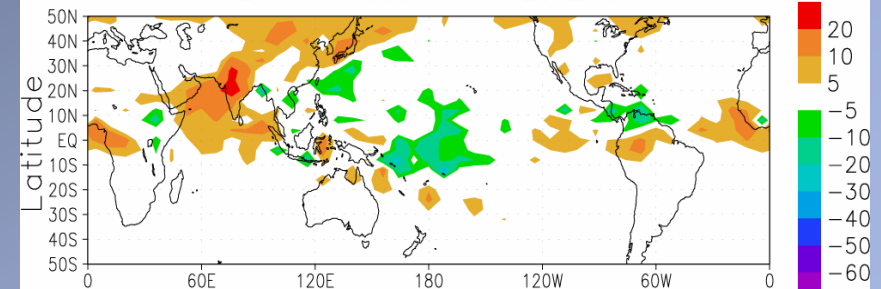
ECMWF II



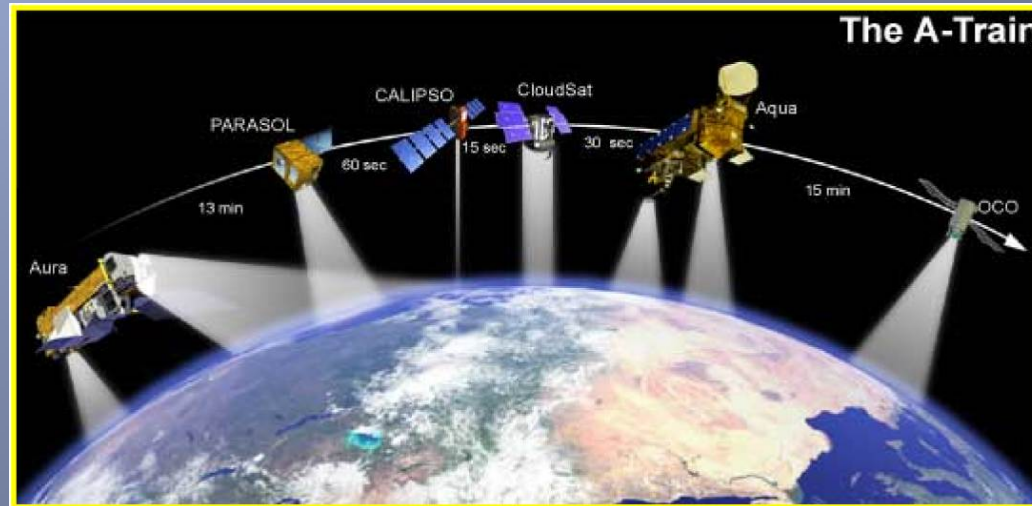
ECMWF Model I - MLS 215



ECMWF Model II - MLS 215

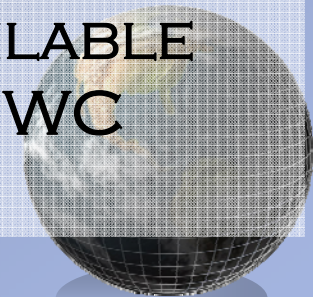


ADDITIONAL IWC INFORMATION/ CO-VALIDATION: CLOUDSAT



OFFICIAL IWC FROM CLOUDSAT STILL PENDING.

JUST TO EXAMINE MLS VS CLOUDSAT IWC
MORPHOLOGY => CONVERT CLOUDSAT AVAILABLE
LEVEL 1 B CLOUD REFLECTIVITY INDEX TO IWC
(HOGAN ET. AL., 2006)



IWC AT 14 KM 8X4 GRID @ 14KM - 5 WEEKS

CloudSat-derived

Not official product

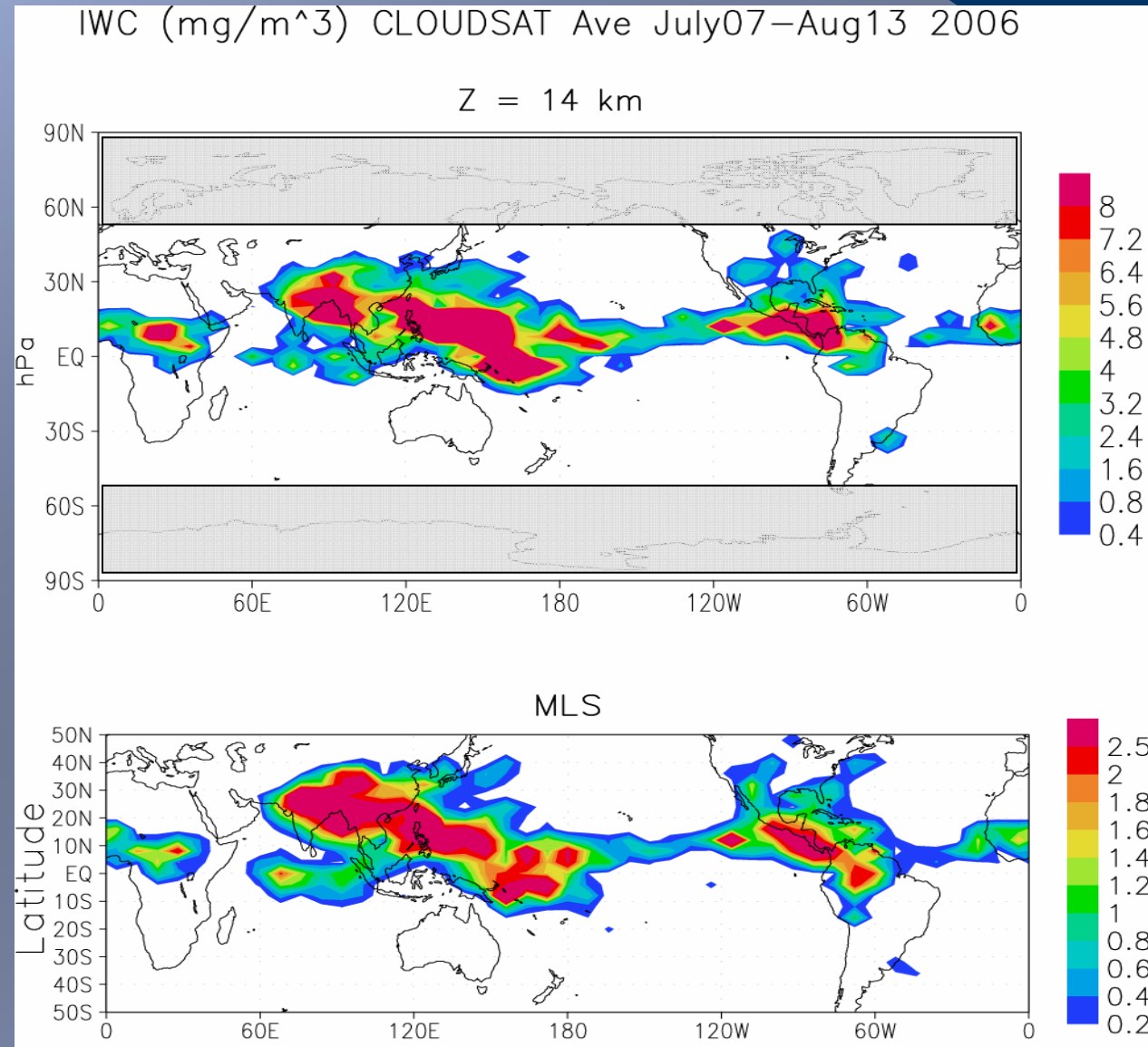
Morphology

Agreement - Good

Magnitude

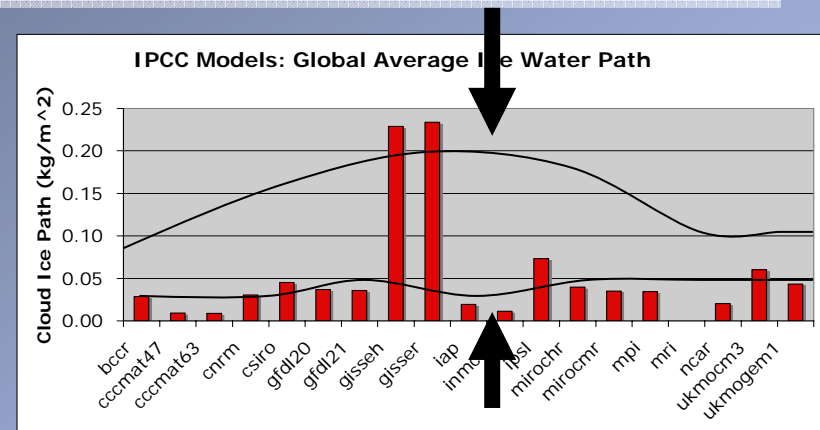
Agreement - ??

MLS



FUTURE WORK

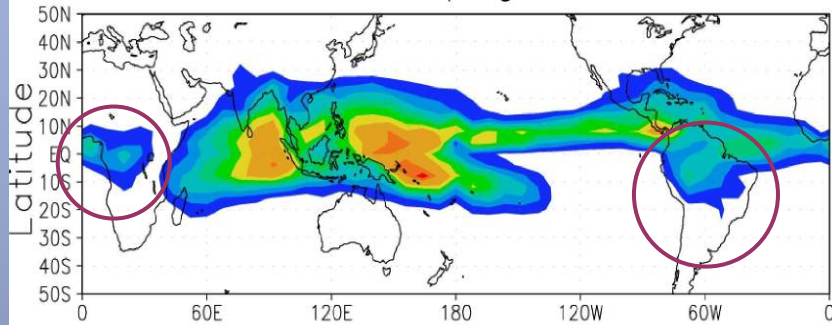
- Continue MLS vs ECMWF & GCMs comparisons - IWC as well as factor in implications of Water Vapor & Temperature comparisons.
- Integrate CloudSat LWC/IWC/Cloud Mask&Type into our Analyses. Taking advantage of higher vertical resolution and active sensing capabilities.
- Investigate and try to Reduce the Development of Biases in ECMWF forecasts and GCM Simulations as they relate to cloud ice/liquid and thermodynamics.



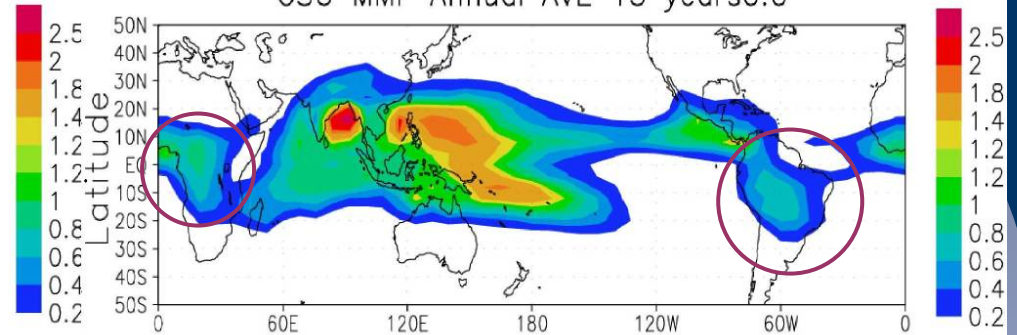
HOW ABOUT IWC & MMF GCMS?

1-12- Mean 0.0 IWC at 147 hPa

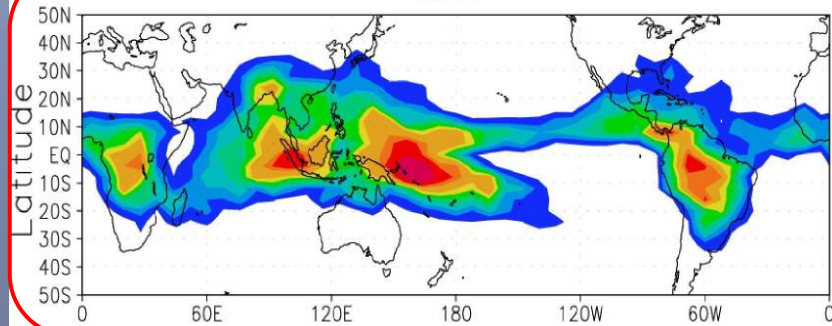
ECMWF sampling NOCUT



CSU MMF Annual AVE 15 years 0.0



MLS



fvMMF ANNUAL AVE (98+99) years 0.0

