STATUS OF CERES CLOUD PRODUCTS

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CERES Cloud Products

- Validation & Assessment Continues
  - calibration
  - comparison with MODIS team products
  - surface comparisons
  - other instrument comparisons
    - GLAS & CALIPSO

- Edition 3 will start in spring 2007
  - delays from computer problems, summer leaves, additional study
  - improved mask
  - new products

CALIBRATION MONITORING

- **Paper comparing VIS (0.64 *μ*m) channels on Aqua & Terra MODIS with each other and TRMM VIRS and CERES FM-1/FM-4 SW going to *JTech***
- **Main points**

  - used direct matching, DCC albedo,
  - VIRS V6 has 1.15% y^{-1} degradation, V5 flat
  - Terra MODIS flat except for 1.21% gain change in November 2003
  - Terra MODIS and VIRS reconcilable to 0.1%y^{-1}
  - FM-1 has trend relative to MODIS < 0.1% y^{-1}
  - Aqua MODIS may have 0.3% y^{-1} degradation ambiguous
  - Aqua MODIS ~ 1% brighter than Terra
  - Aqua MODIS vs VIRS closer to theory, 1.045 ratio
  - Aqua MODIS and VIRS have relative trends
  - FM-4 SW shows 0.3 y^{-1} degradation compared to Aqua MODIS

NASA Clouds and Earth's Radiant Energy System (CERES)

Monitor Earth's radiation budget (ERB) w/*TRMM, Terra, & Aqua*

- Relate cloud properties to the radiation budget

need cloud properties coincident w/ERB data

- Develop new bidirectional reflectance models for interpreting broadband radiance measurements

cloud properties affect BRDF (Loeb et al., 2004,5)

- Derive surface and atmospheric radiation budgets & the top-of-atmosphere ERB

with aerosol data, good for direct & indirect effect estimates

- Provide data to initialize & validate climate & weather prediction models

clouds & radiation data are consistent

CERES Matched Cloud-Radiation Data

Single-Scanner Footprint (SSF)

Broadband Radiances:

FOV = 10 - 20 km

Cloud Properties:

FOV = 2 km (VIRS)

1 km (MODIS)

Convolved in 2 layers (max)

Clear radiances saved

Aerosol Properties:

AVHRR-like

MODIS MOD04

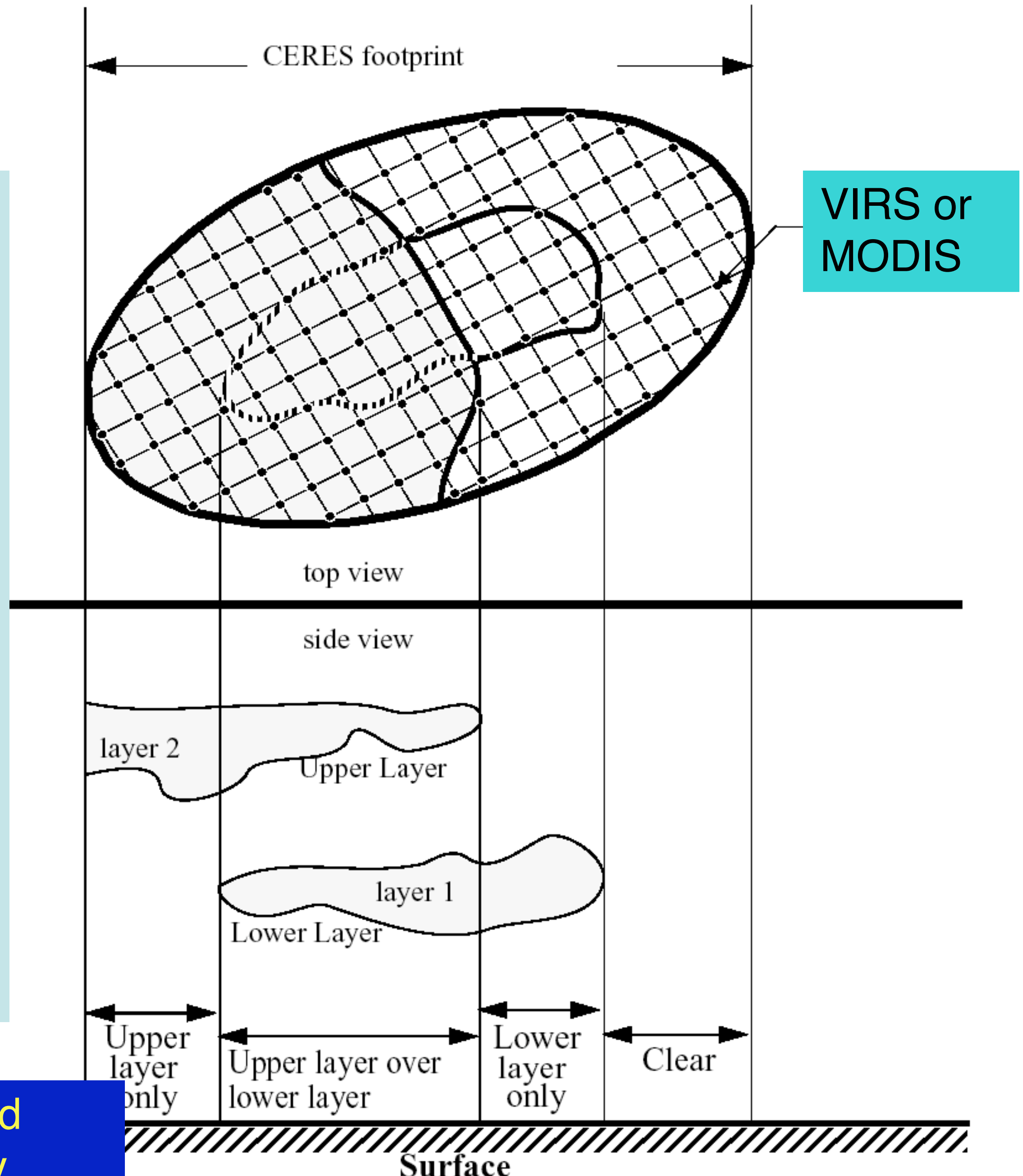


Figure 4-10. CERES Clear/layer/overlap illustration

Have albedo, cloud properties and aerosol properties simultaneously

No need to compute albedo!

CERES CLOUD PROPERTIES

1 SSF PIXEL w/CERES FLUXES
(SSF = Single Scanner Footprint)

AMOUNT	F
EFFECTIVE RADIATING TEMP	Tc
EFFECTIVE HEIGHT, PRESSURE	Zc, pc
TOP PRESSURE	p_t
THICKNESS	h
EMISSIVITY	ε
PHASE (0 - 2)	P
WATER DROPLET EFFECTIVE RADIUS	re
OPTICAL DEPTH	τ
LIQUID WATER PATH	LWP
ICE EFFECTIVE DIAMETER	De
ICE WATER PATH	IWP

STATUS

CERES-*TRMM:* broadband radiometer took 9 - 10 months of data:

January - August 1998, March - April 2000

Cloud properties derived for life of VIRS (1/98 ->)

(Edition 2, Jan. 1998 - July 2001 available now)

CERES-*Terra:* 2 broadband radiometers since Feb 2000 (1030/2230 LT)

Cloud properties derived for life of MODIS (2/00 ->)*

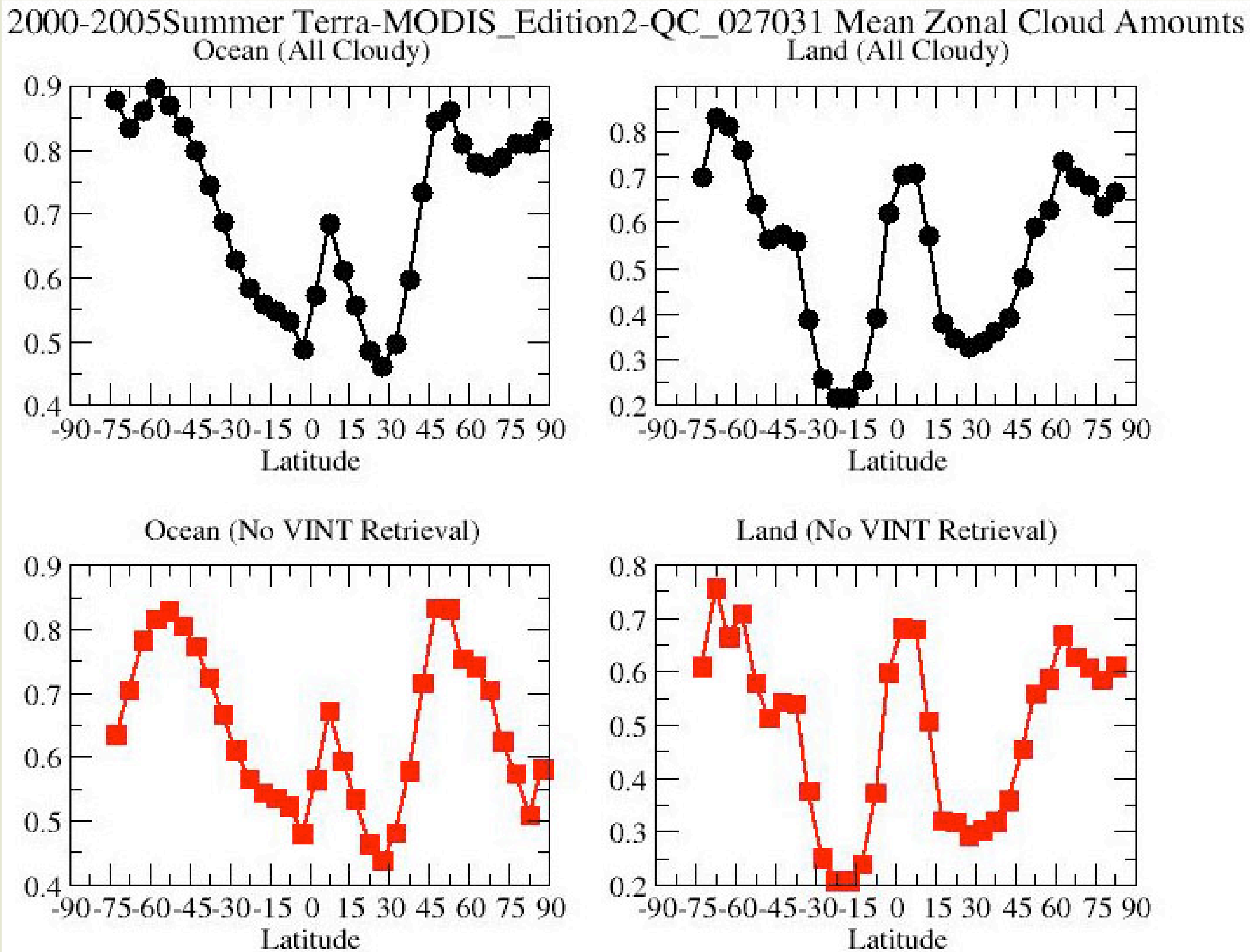
(Edition 2a, March 2000 - December 2005, collection 4)

CERES-*Aqua:* 2 broadband radiometers since June 2002 (0130/1330 LT)

Cloud properties will be derived for life of MODIS (7/02 ->)*

(Edition 1a, July 2002 - December 2005, collection 4)

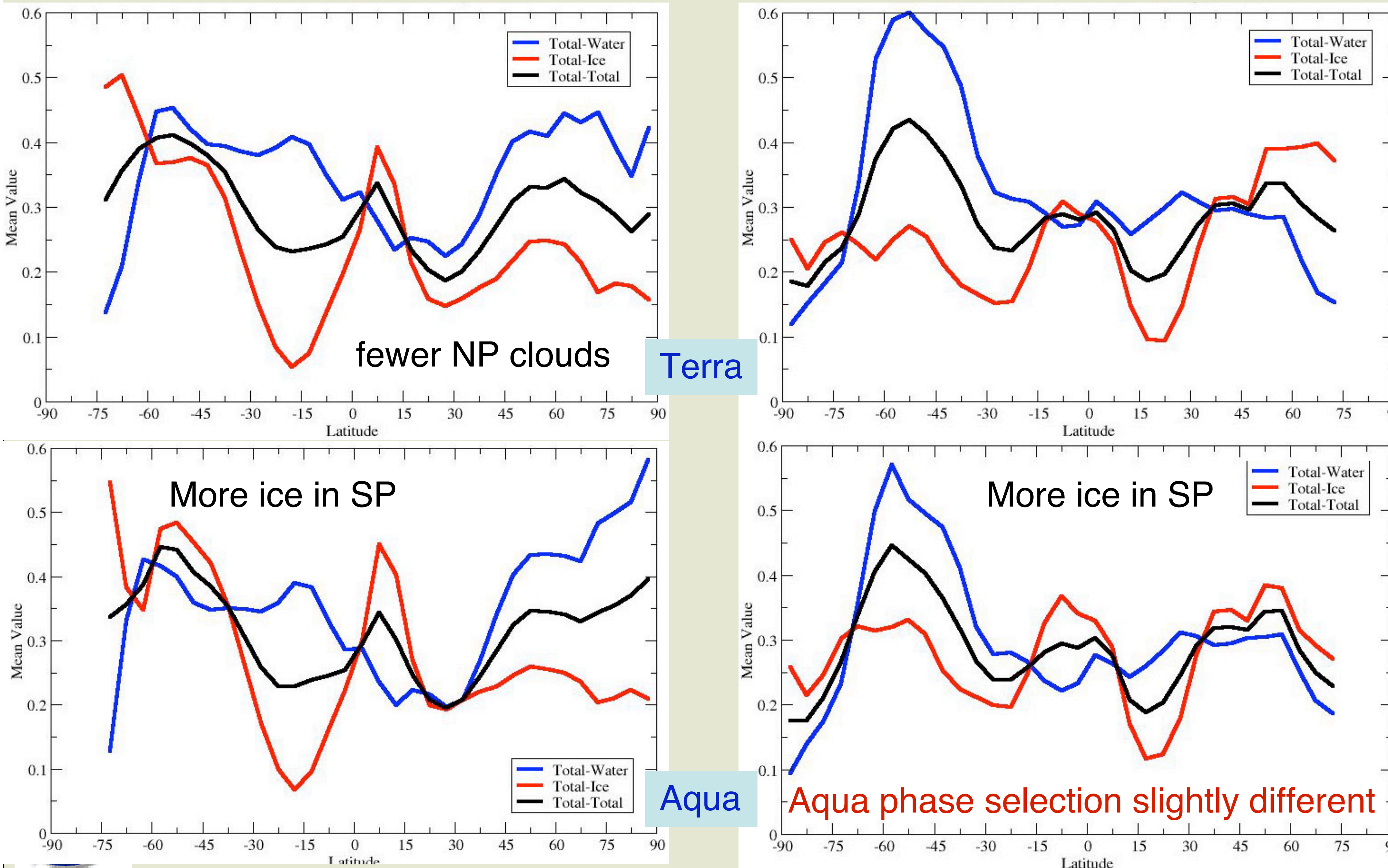
* Will start on collection 5 data in 2007



Properties derived for most cloudy pixels, worst cases over polar ice & high SZA

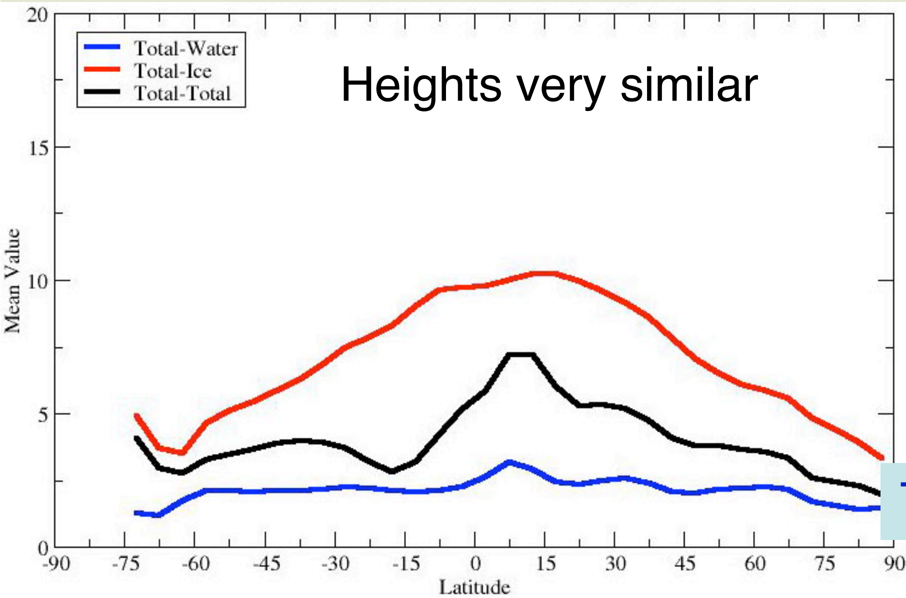
Zonal Distribution of Cloud Amount by Phase
Daytime (2000-2005 or 2002 -2005)

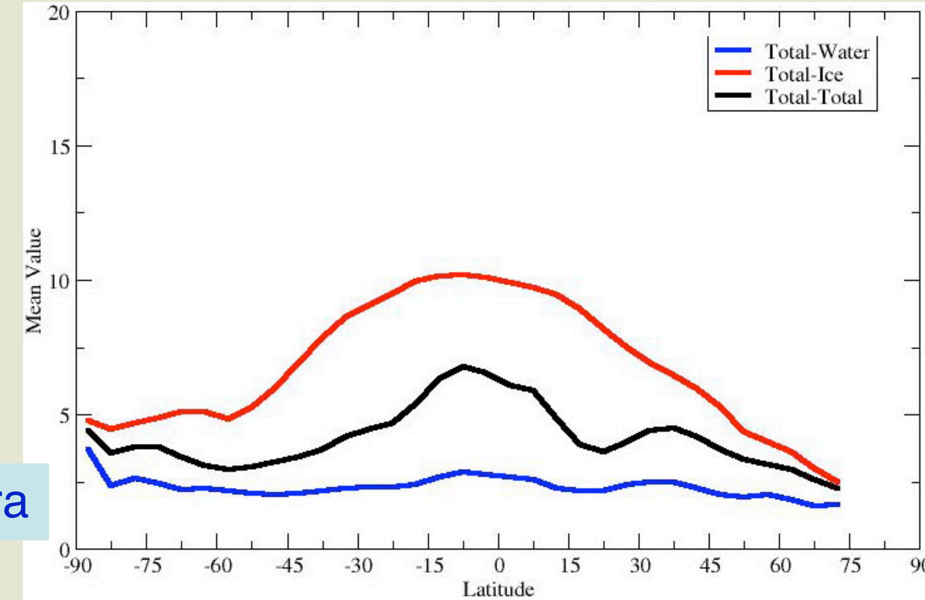
JJA **DJF**



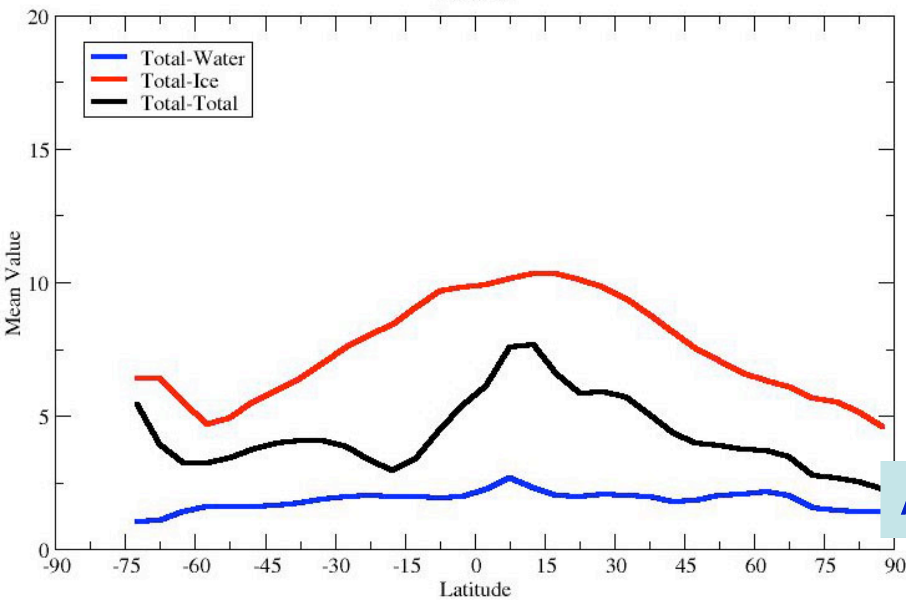
Zonal Distribution of Cloud Height, Daytime (2000-2005 or 2002 -2005)

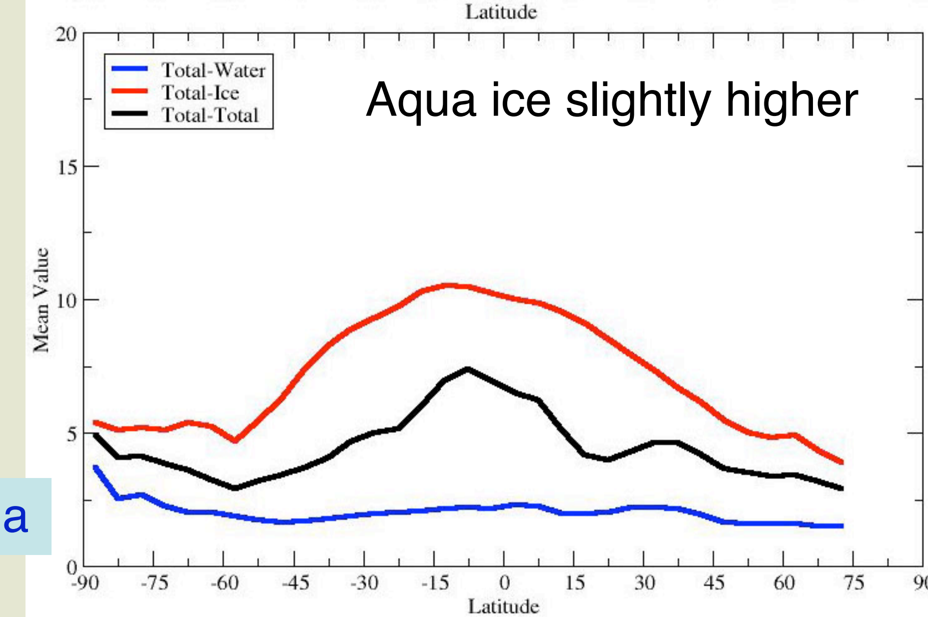
JJA **DJF**





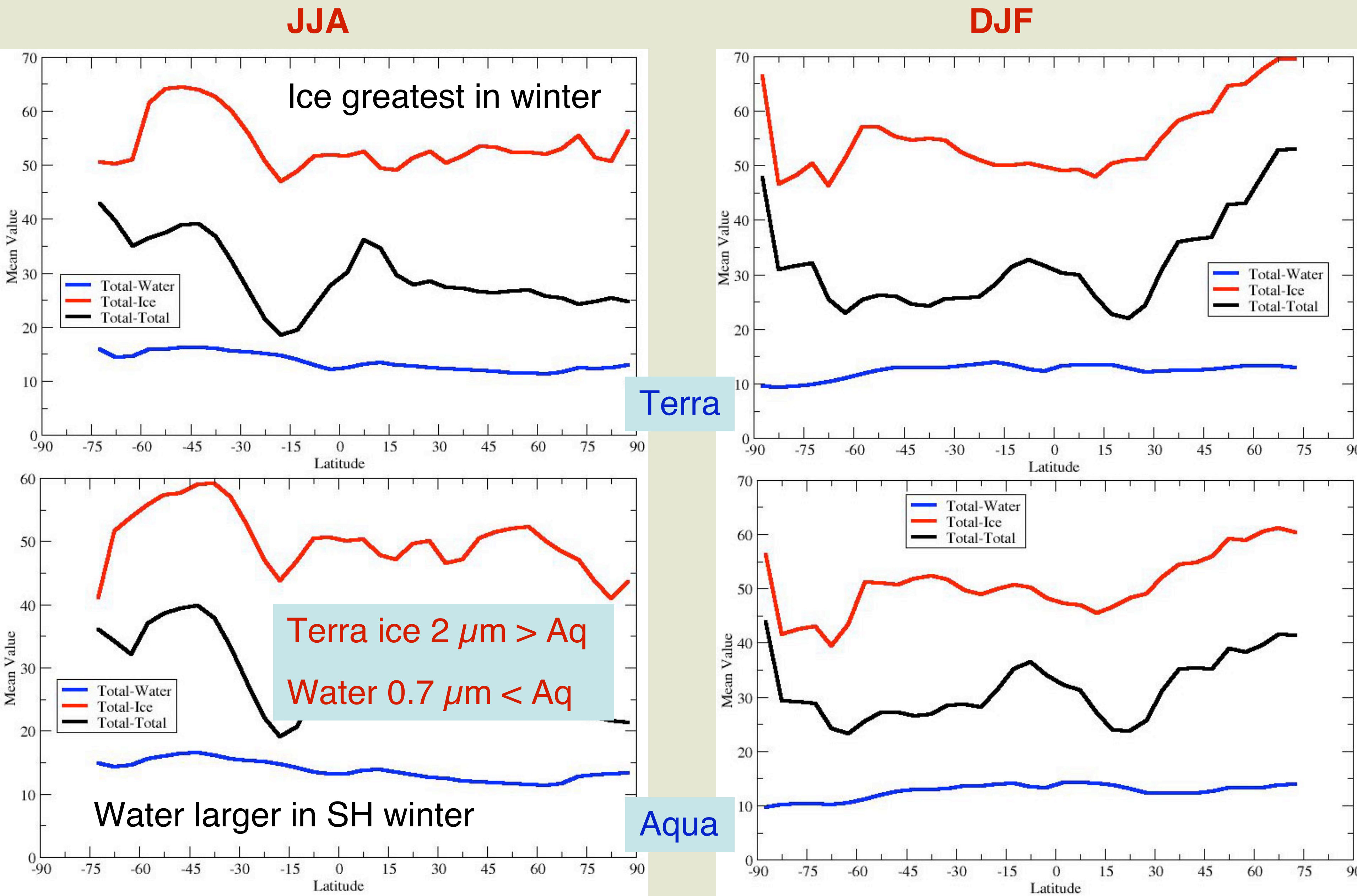
Terra





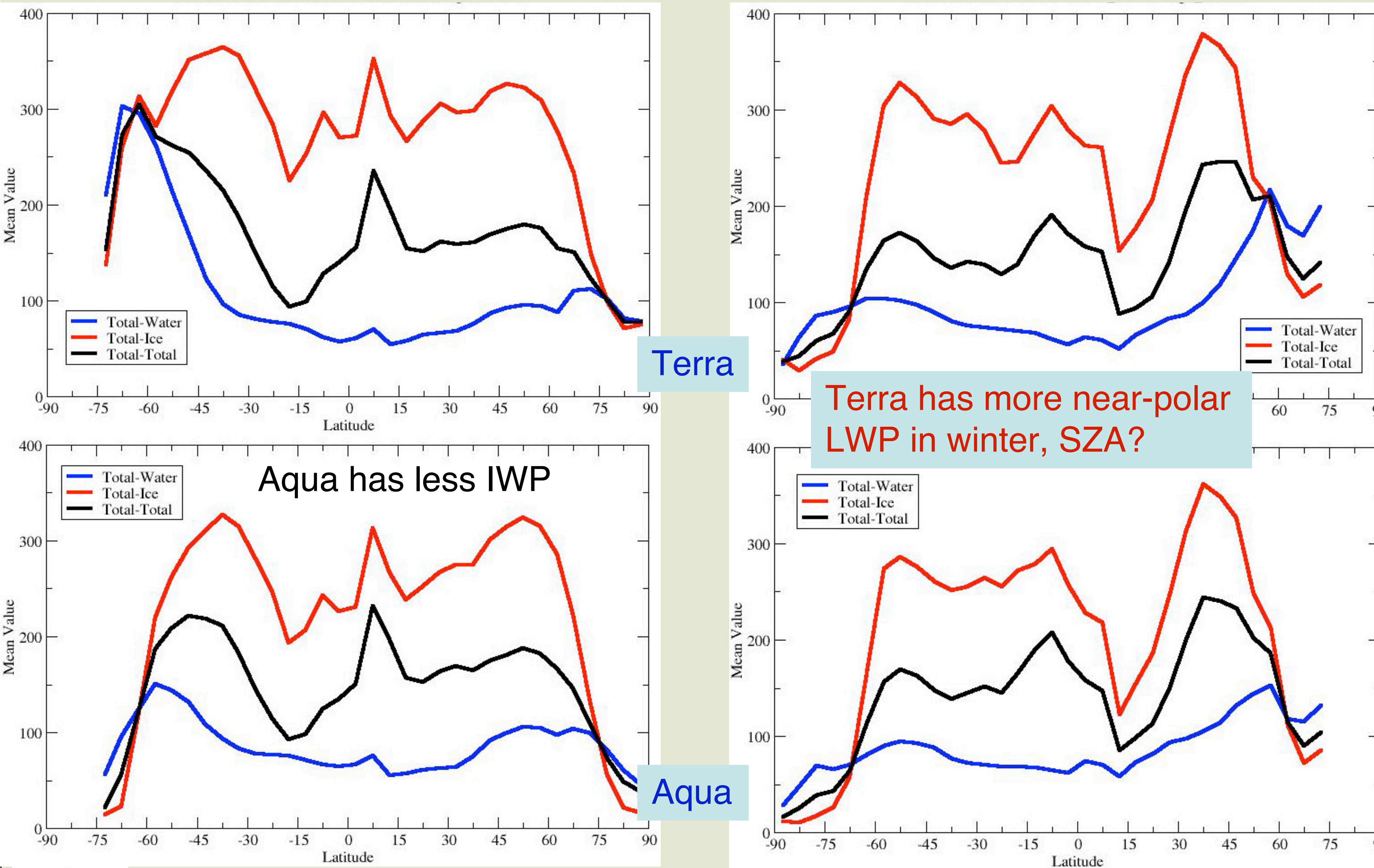
Aqua

Zonal Distribution of Cloud Particle Size (μm)
Daytime (2000-2005 or 2002 -2005)



Zonal Distribution of Cloud Water Path (gm^{-2})
Daytime (2000-2005 or 2002 -2005)

JJA | **DJF**



- CERES *Terra* & *Aqua* cloud properties generally very consistent
  - discrepancies over poles in cloud fraction, % retrieved
  - 1-5% discrepancy in phase selection, Aqua more thin Ci
  - Aqua ice water path smaller (extra thin Ci?)
  - Terra LWP (opt depth) dependence in high SZA
  - some uncorrected calibration differences in 3.7 and 0.64 µm

- CERES day-night cloud fractions differ by 1-3%
  - *different ice & water fractions, more ice at night*

CERES MODIS CLOUD PRODUCTS ARE DIFFERENT THAN THE MODIS TEAM PRODUCTS

- Different masks
  - different channels, thresholds, etc.

- Different radiative transfer
  - *different ice/water models*
  - *different atmospheric properties*
  - *different interpretive models*

- Different processing systems
  - maybe differences in calibration/solar constants

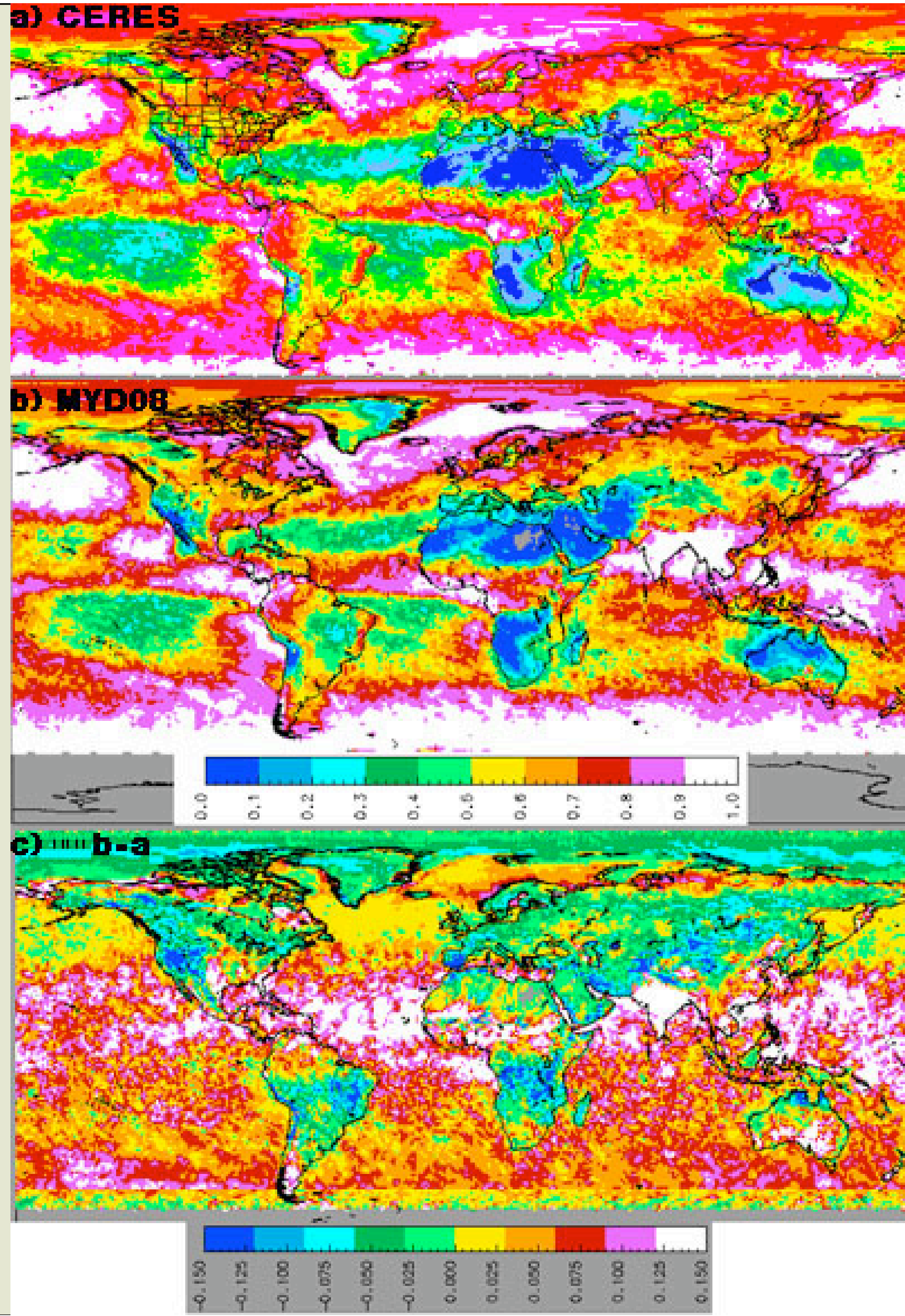
=> differences in products

COMPARISONS & VALIDATION

Previous Validation Efforts

- Cirrus optical depth, height, particle size, IWP
  - *Mace et al. (JAM, 2005)*
- Cirrus optical depth, height, and particle size
  - *Chiriaco et al. (JAM, 2006)*
- Anvil particle size
  - *Garrett et al. (JAS, 2005)*
- Continental stratus microphysics
  - *Dong et al. (JAS, 2002)*
- Those & many other parameters
  - *many conference papers*

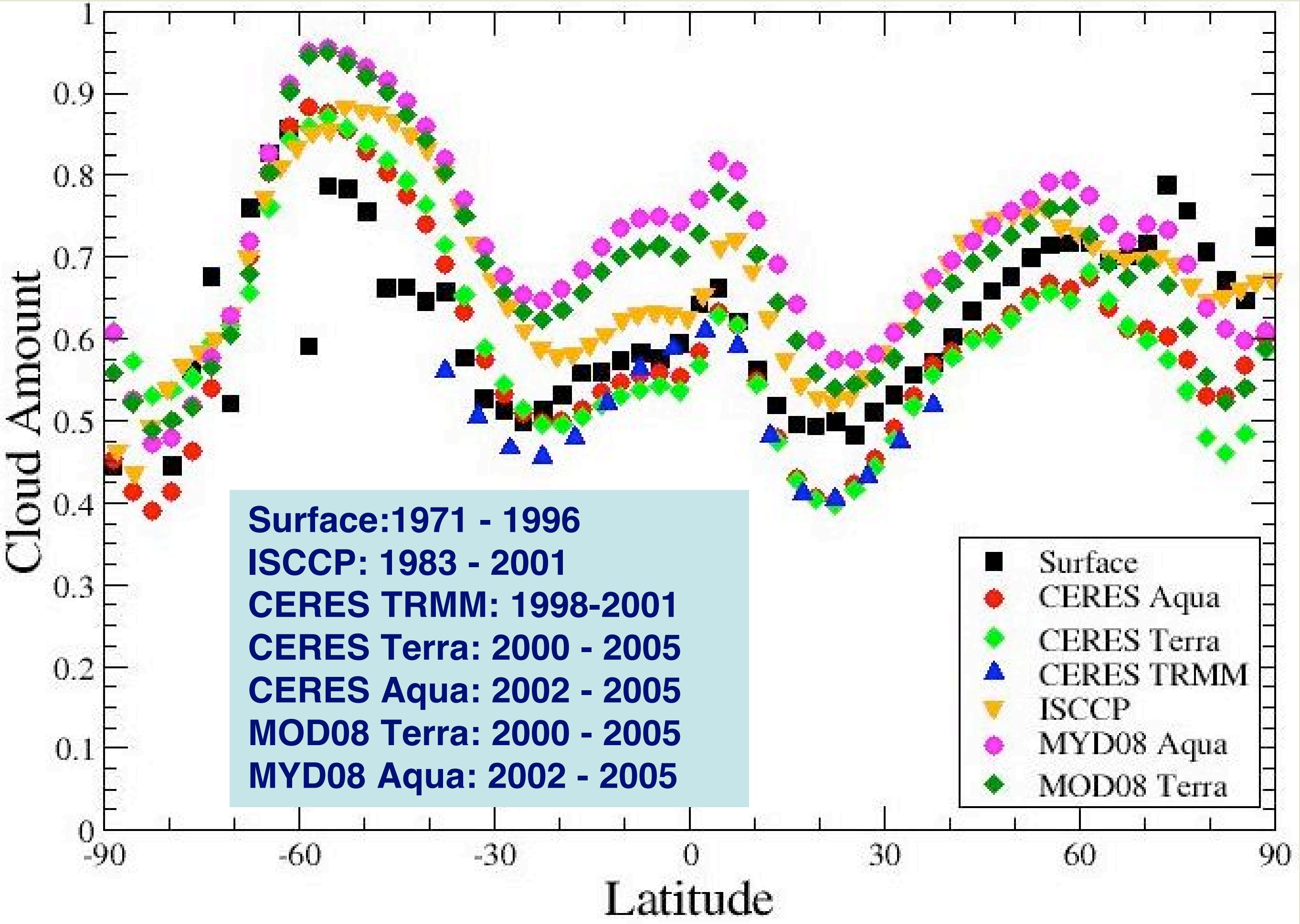
Mean daytime cloud amounts from Aqua MODIS from CERES & MODIS AST algorithms, June 2004.



CERES > in Arctic & some land areas

MYD08 > in Tropics & southern ocean

Mean Total Cloud Amount



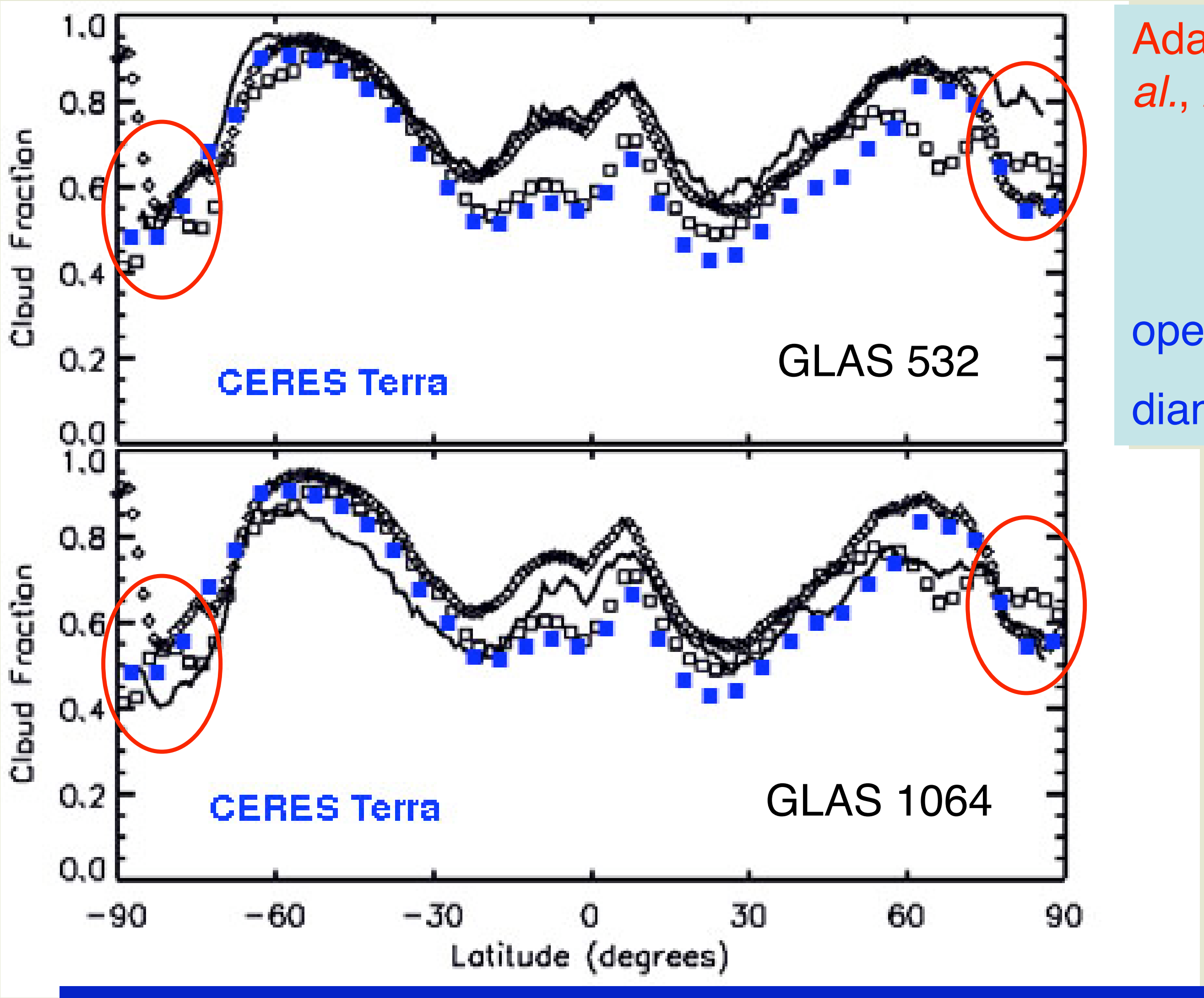
- All three CERES track surface values except Terra in Antarctica(CERES 5-20% more)
- CERES Aqua, surface and ISCCP agree well near South Pole
- Arctic: CERES 3-20% less than the surface and ISCCP
- MOD08 and MYD08 have most cloud cover

	GLOBAL MEAN	37.5 S - 37.5 N MEAN
Surface:	0.614	0.554
CERES Aqua:	0.618	0.545
CERES Terra:	0.603	0.538
ISCCP:	0.666	0.628
MYD08 MODIS:	0.715	0.692
MOD08 MODIS:	0.686	0.660

CERES mean day-night difference:

-0.01 to 0.02

Comparison with IceSat GLAS, October 2003



Adapted from *Hart et al.*, AMS ATRAD 06

open square: ISCCP

diamond: MOD08

- **CERES Global mean = 62%**
- **Missing optically thin clouds in Arctic night and in Tropics**
  - **- CERES mask does not detect $\tau < 0.3$**

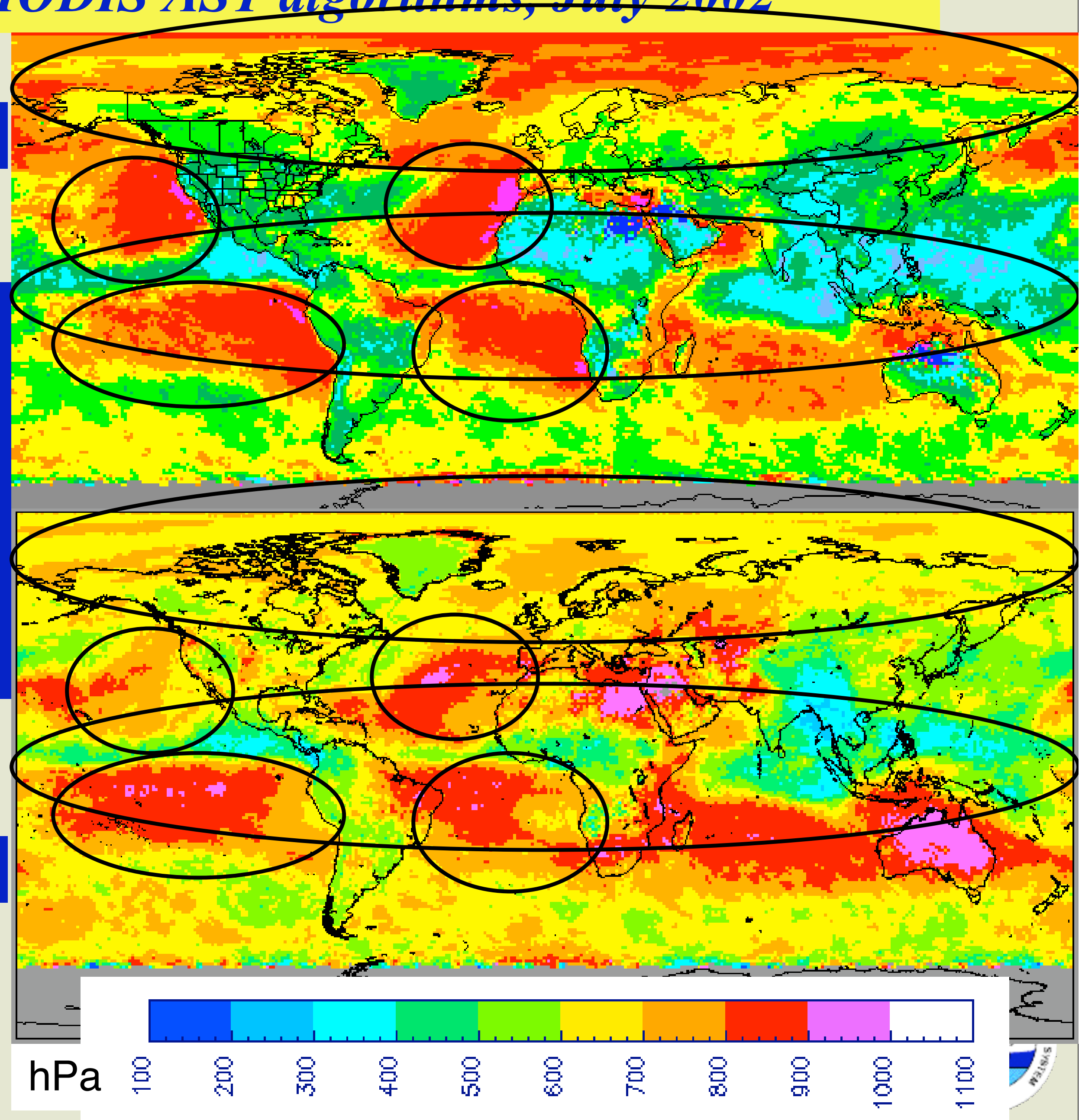
Mean daytime cloud pressure from Terra MODIS from CERES & MODIS AST algorithms, July 2002

CERES > in Arctic & Antarctic

MOD08 < in coastal marine stratus, pressure increases with increasing distance from coast

MOD08 > Tropics and Africa

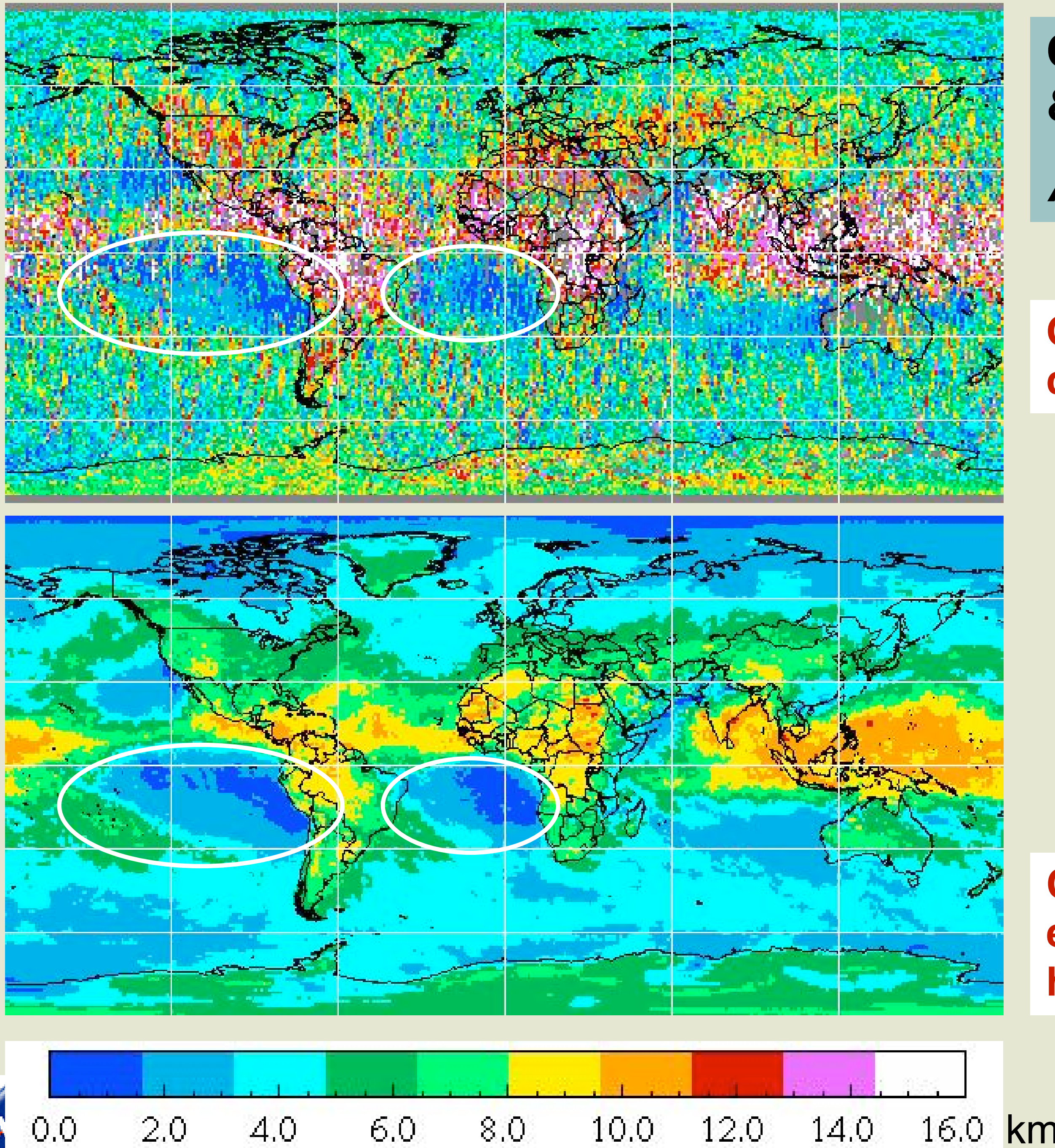
CERES



MOD08

Comparison of CERES & GLAS Cloud Heights

***Aqua*, October 2003**

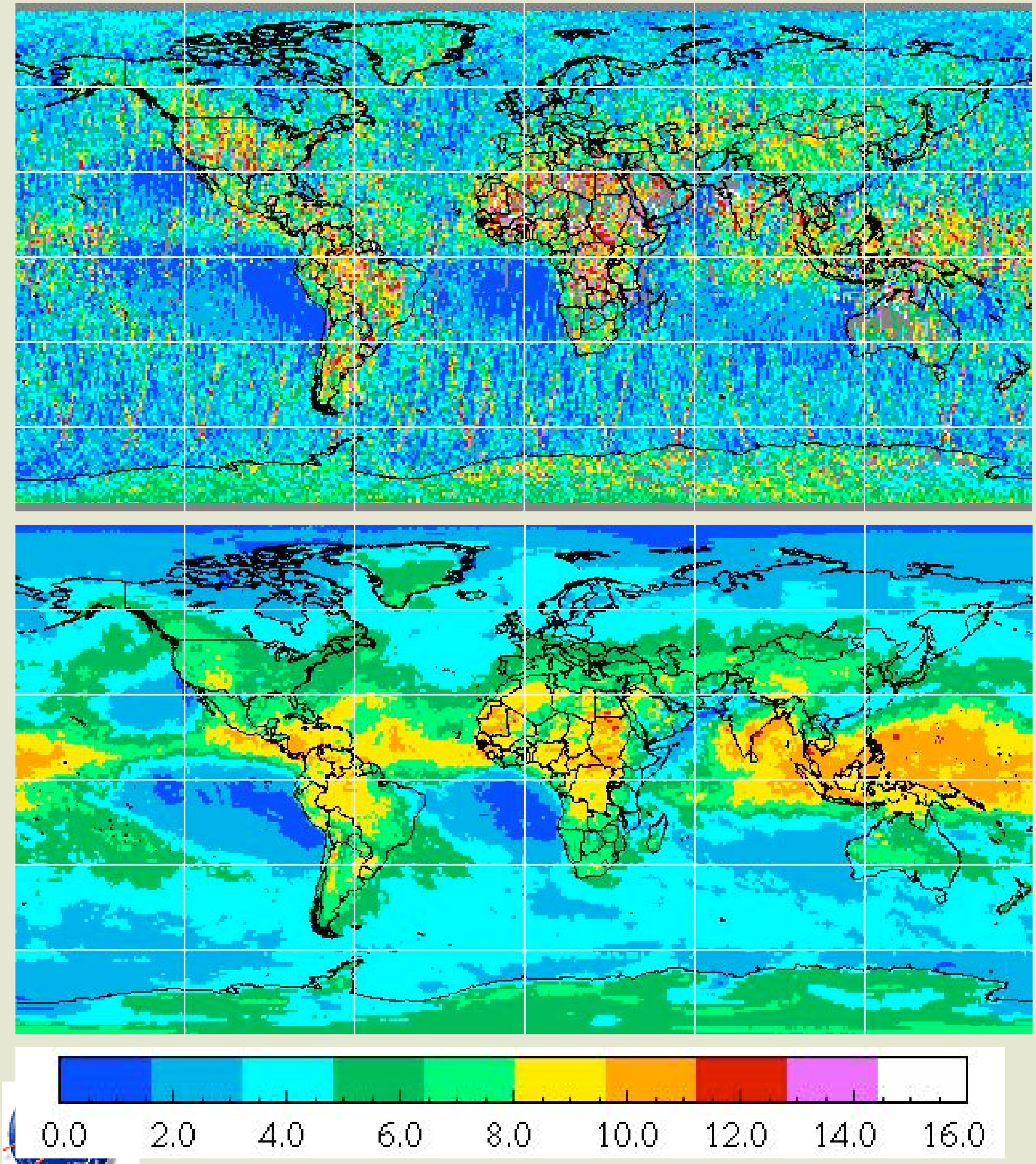


GLAS uppermost cloud height

CERES average effective cloud height

Comparison of CERES & GLAS Cloud Heights

Aqua, October 2003

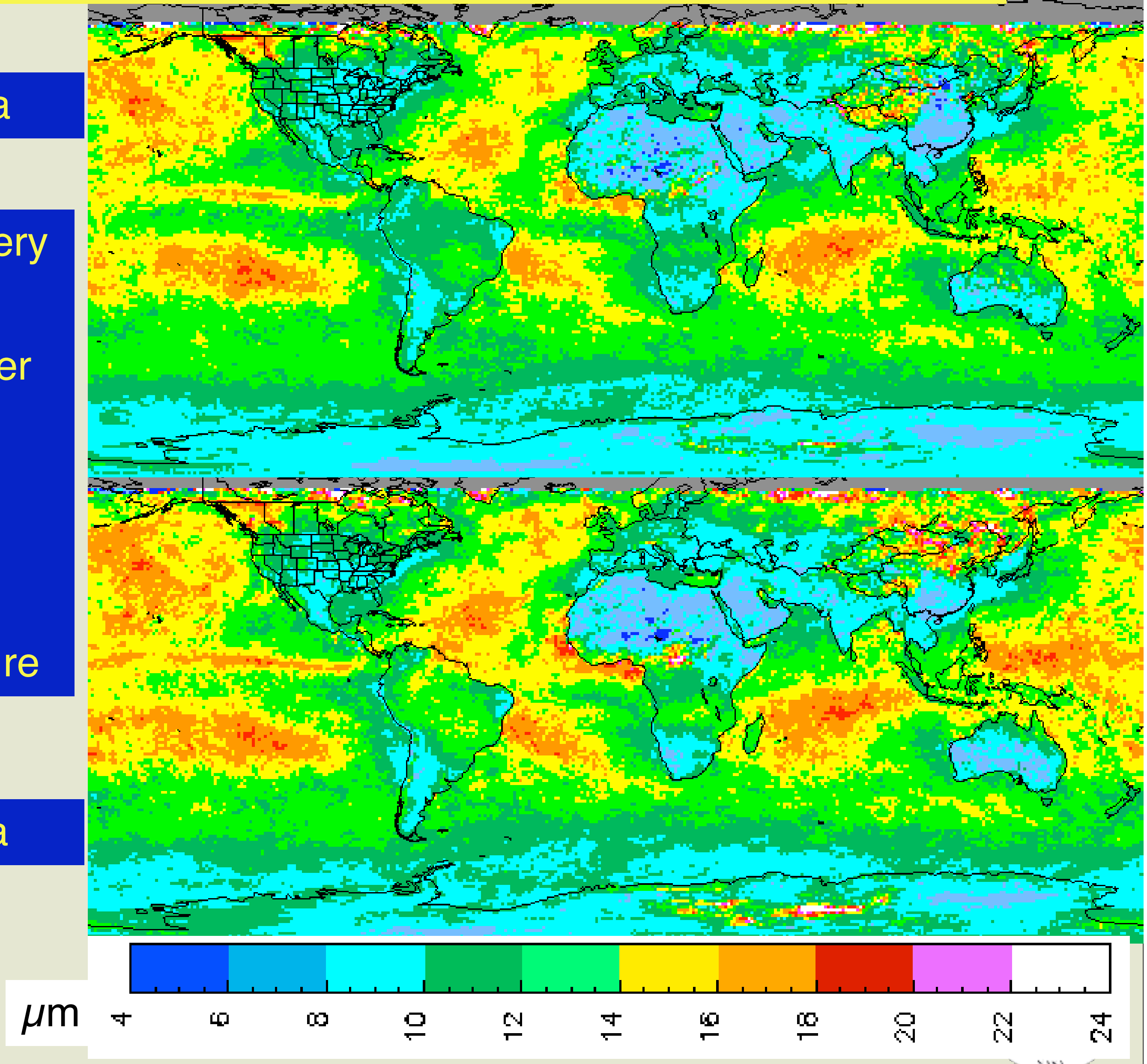


Mean daytime cloud effective droplet radius from Terra Aqua MODIS from CERES algorithms, January 2002

Terra

- Aqua & Terra patterns very similar
  - some discrepancies over snowy regions
- Aqua re is 0.6-μm larger than Terra - calibration difference at 3.8 μm
- Land re ~ 4 μm < ocean re

Aqua

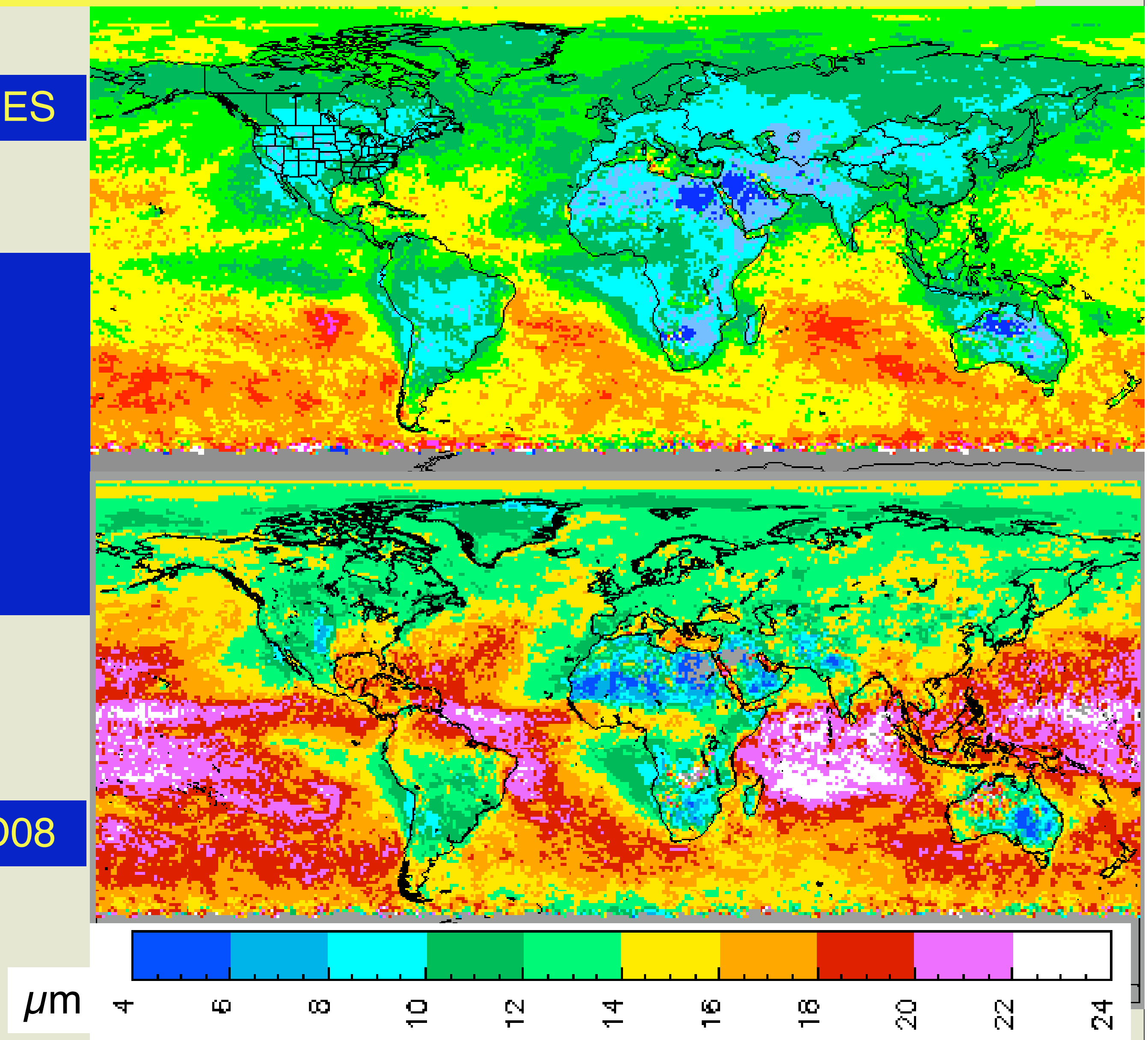


Mean daytime cloud effective droplet radius from Terra MODIS from CERES & MODIS AST algorithms, July 2002

CERES

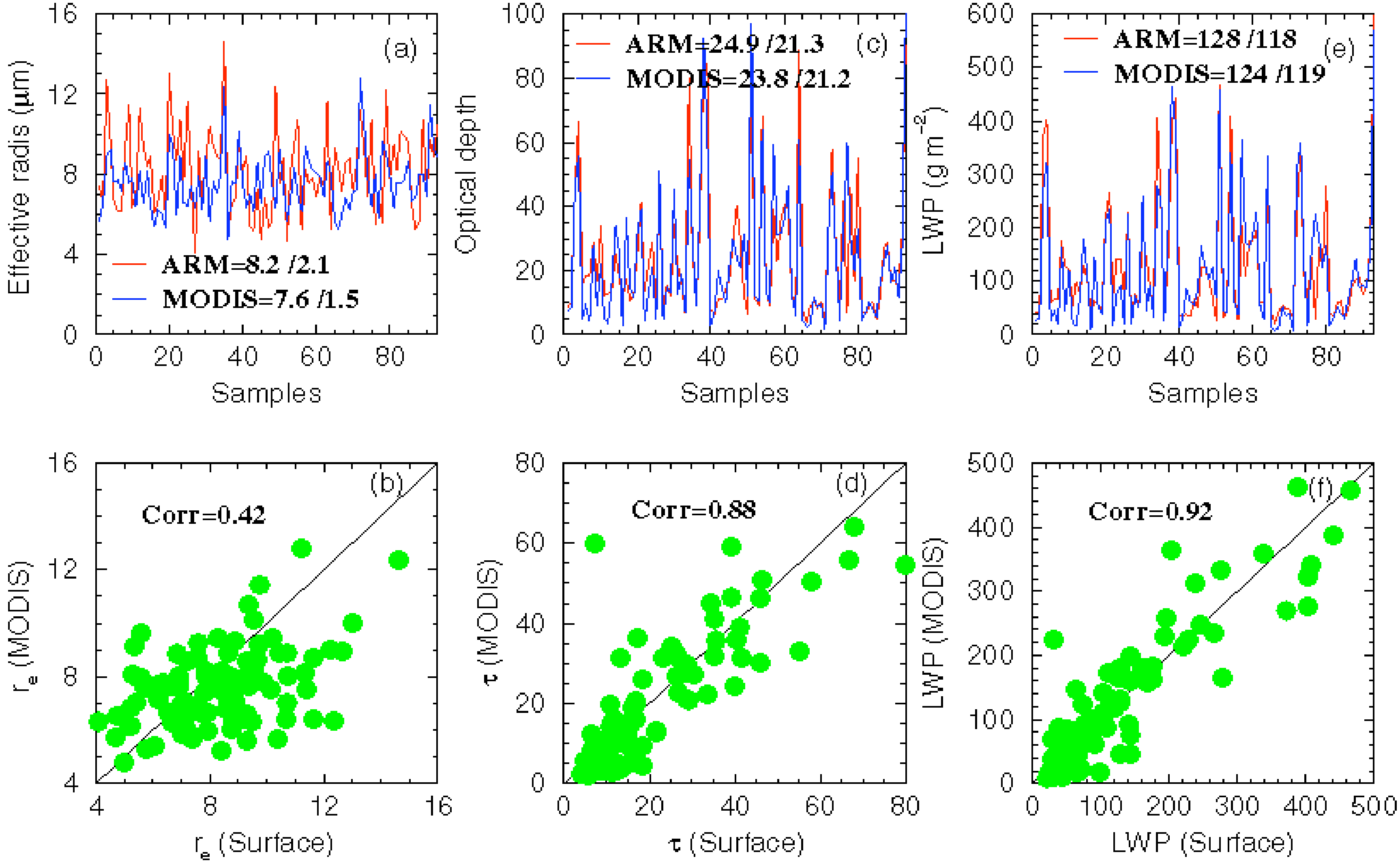
- CERES < MOD08 most places
- Some resemblance in patterns
- MOD08 6 μm > in many open marine areas

MOD08

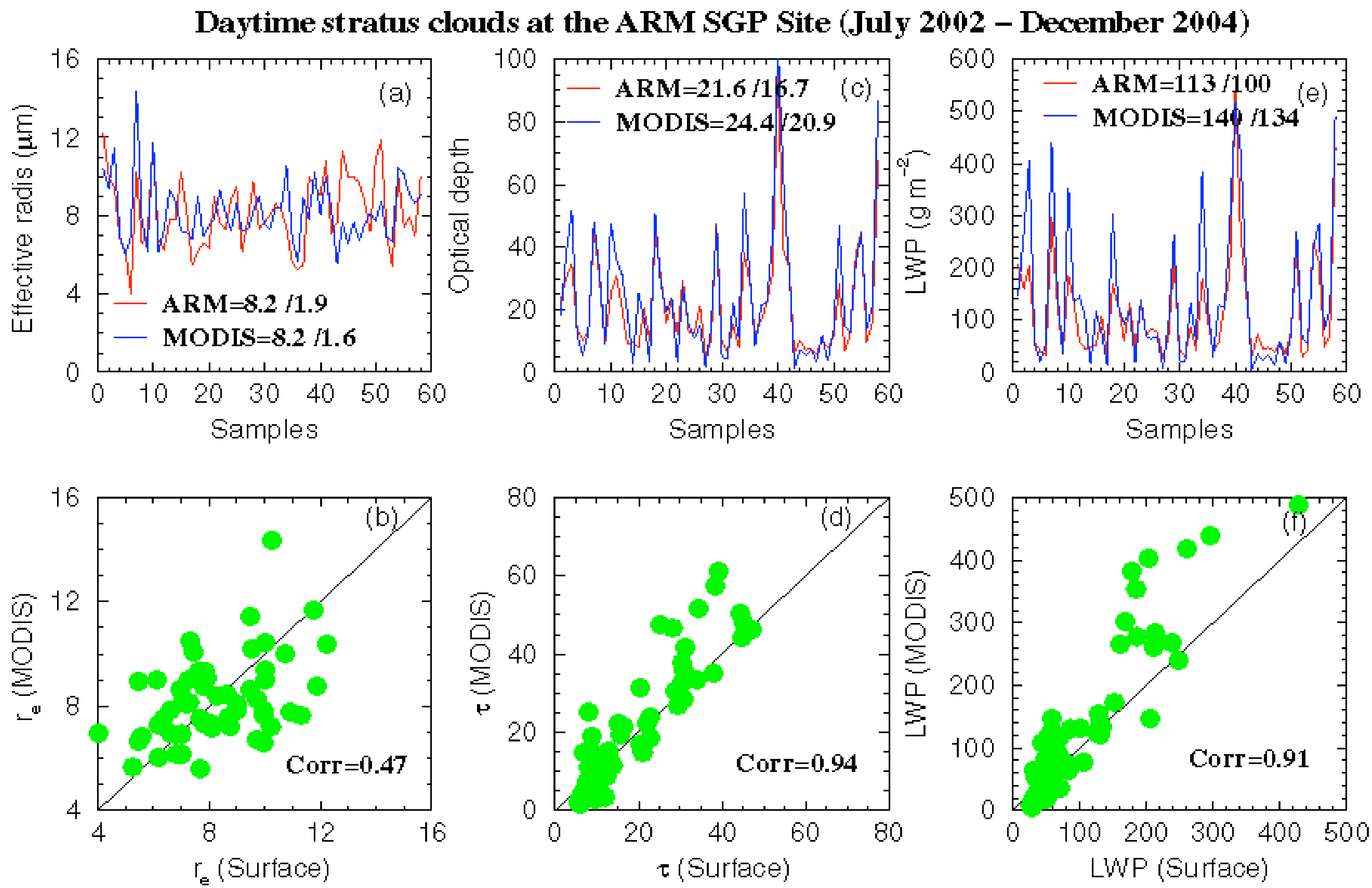


Terra Daytime Stratus μ-physics

Daytime stratus clouds at the ARM SGP Site (March 2000 – December 2004)



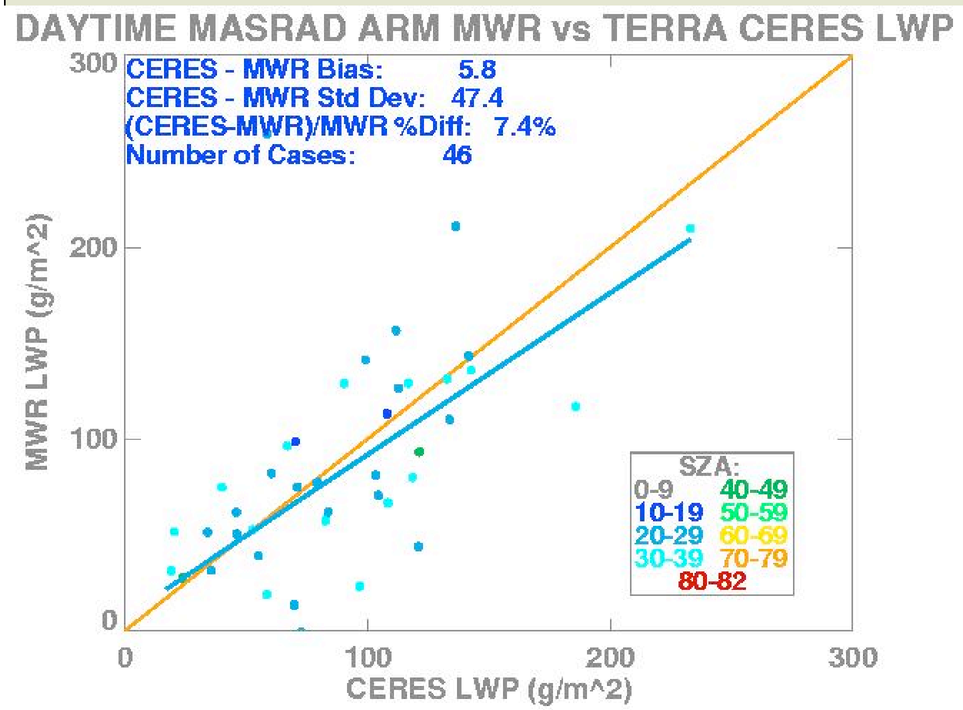
Aqua Daytime Stratus μ-physics

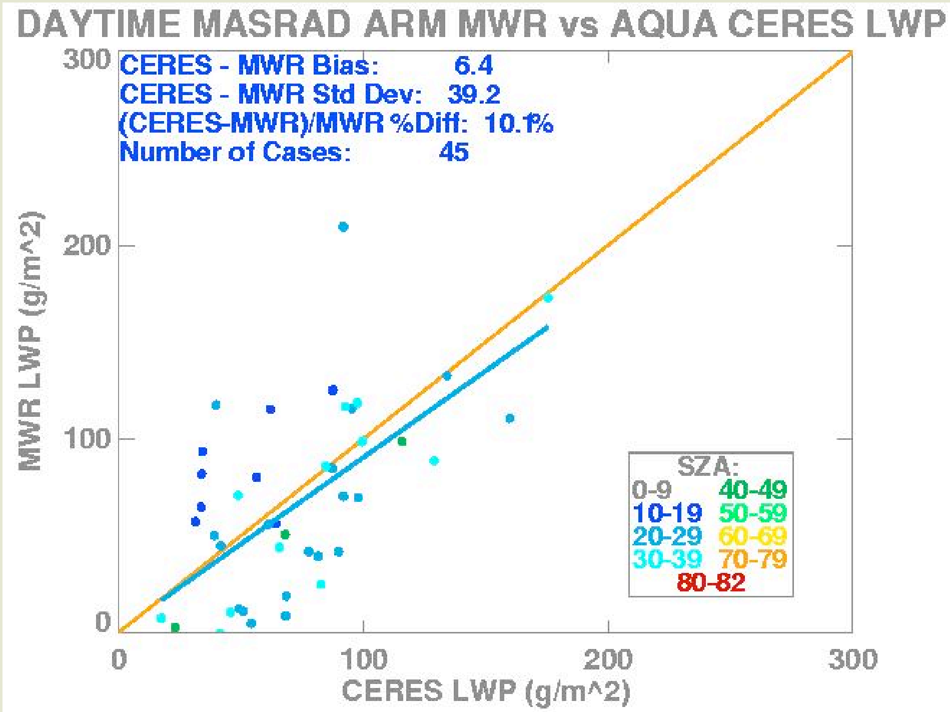


Terra Validation over Ocean (beach) Site

LWP over ARM AMF site, Pt. Reyes, CA

Feb 2005-September, 2005





CERES very consistent with marine surface data

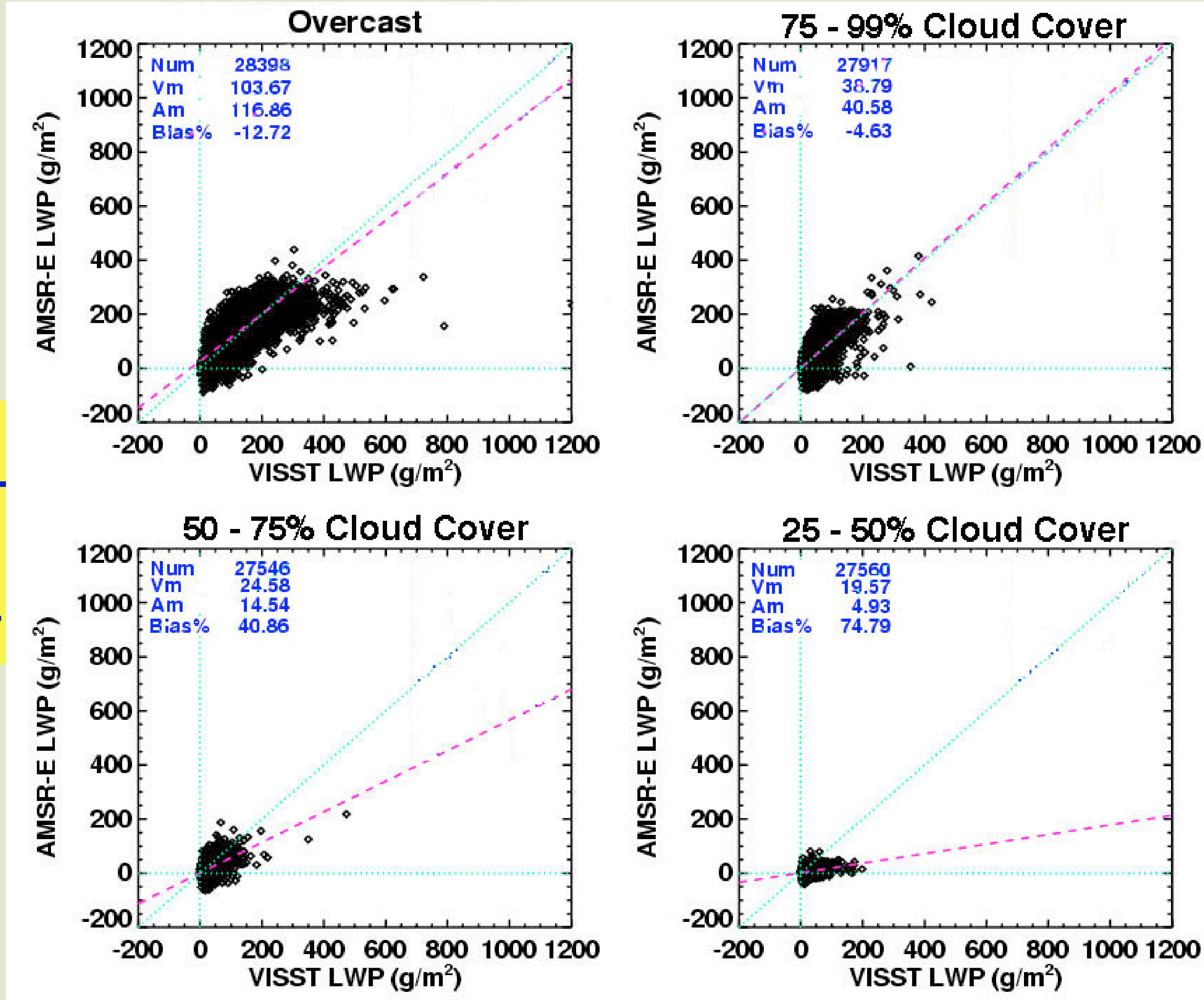
Aqua AMSR-E vs. CERES MODIS LWP, February 2005

Water only; SZA < 78°; Lin et al. (1998) retrieval; ocean only; 1° daily avg

Means (gm^{-2})

CERES: 47.1

AMSRE: 44.7



SUMMARY

- **CERES SSF product is a unique resource for studying clouds & their interactions with aerosols and radiation**

- **Large differences with Collection-4 MODIS products**

  - do not detect or retrieve clouds with $\tau < 0.3$

- **Vary favorable validation results to date, many more are needed**

  - 4-5% of cloudy pixels have no retrievals (mostly snow/desert)

  - do not detect or retrieve clouds with $\tau < 0.3$

  - caveats in AMS conferences & Data Quality Summaries

- **Time-space averaged data also available, if SSF too high res**

- **Results are not perfect, so…**

Edition 3 Cloud Algorithm Changes

- Account for MODIS Collection 5 radiance changes

  - and other calibration biases

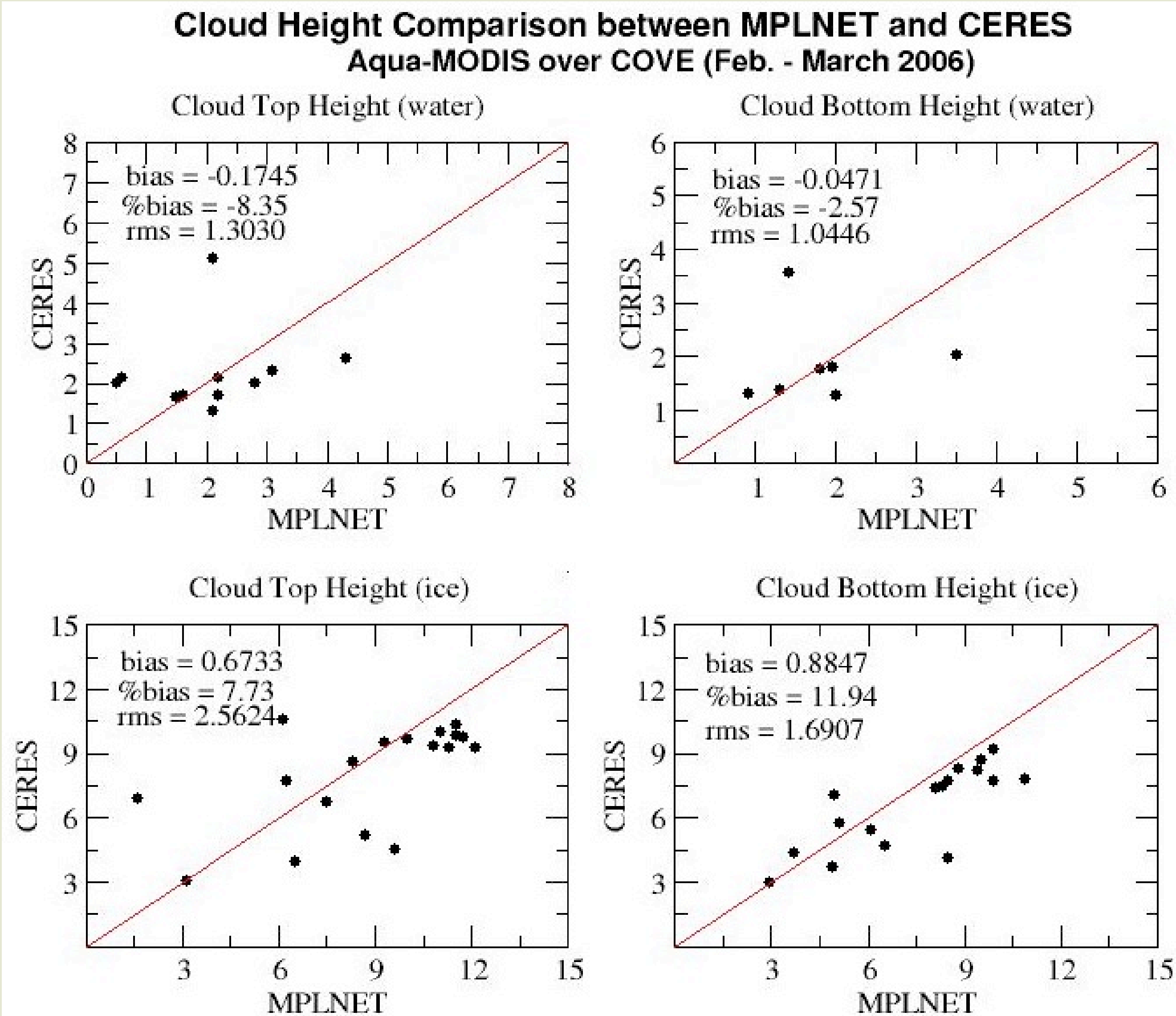
- Improved cloud mask, better dust/cloud detection
- Improved thin cloud opt depth, phase, and heights
- Refined thin cirrus detection & dust/cloud discrimination
- Hi-res cloud detection and retrieval for low clouds (250-m into 1 km)
- Multilayer cloud detection & retrieval
- Multiple particle size retrievals (3.8 and 2.1 μm)

Edition 3 will start in early 2007

VALIDATION

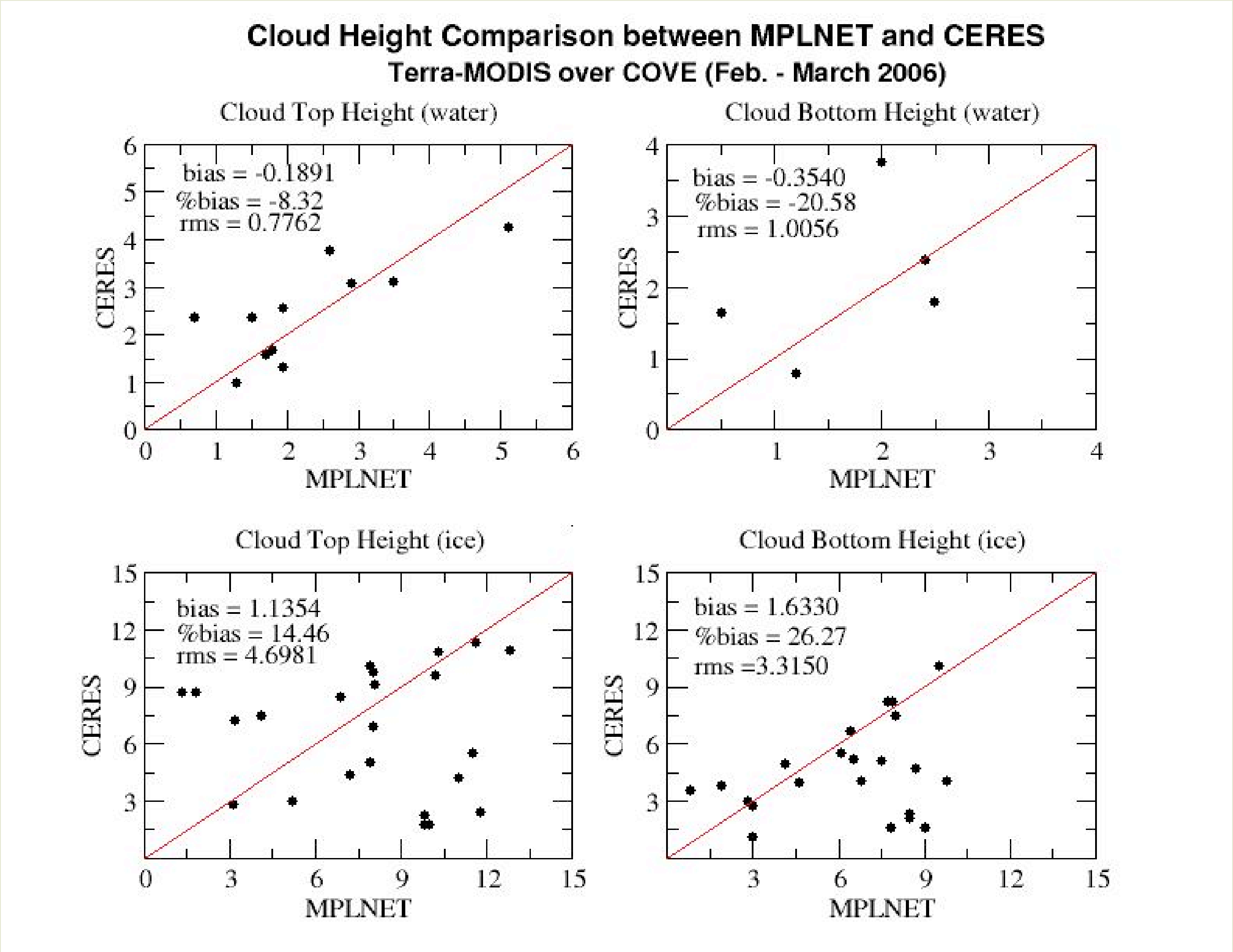
- Results at COVE site
- More proxy comparisons
- Other satellite instruments

Summary of Aqua-COVE Height Comparison



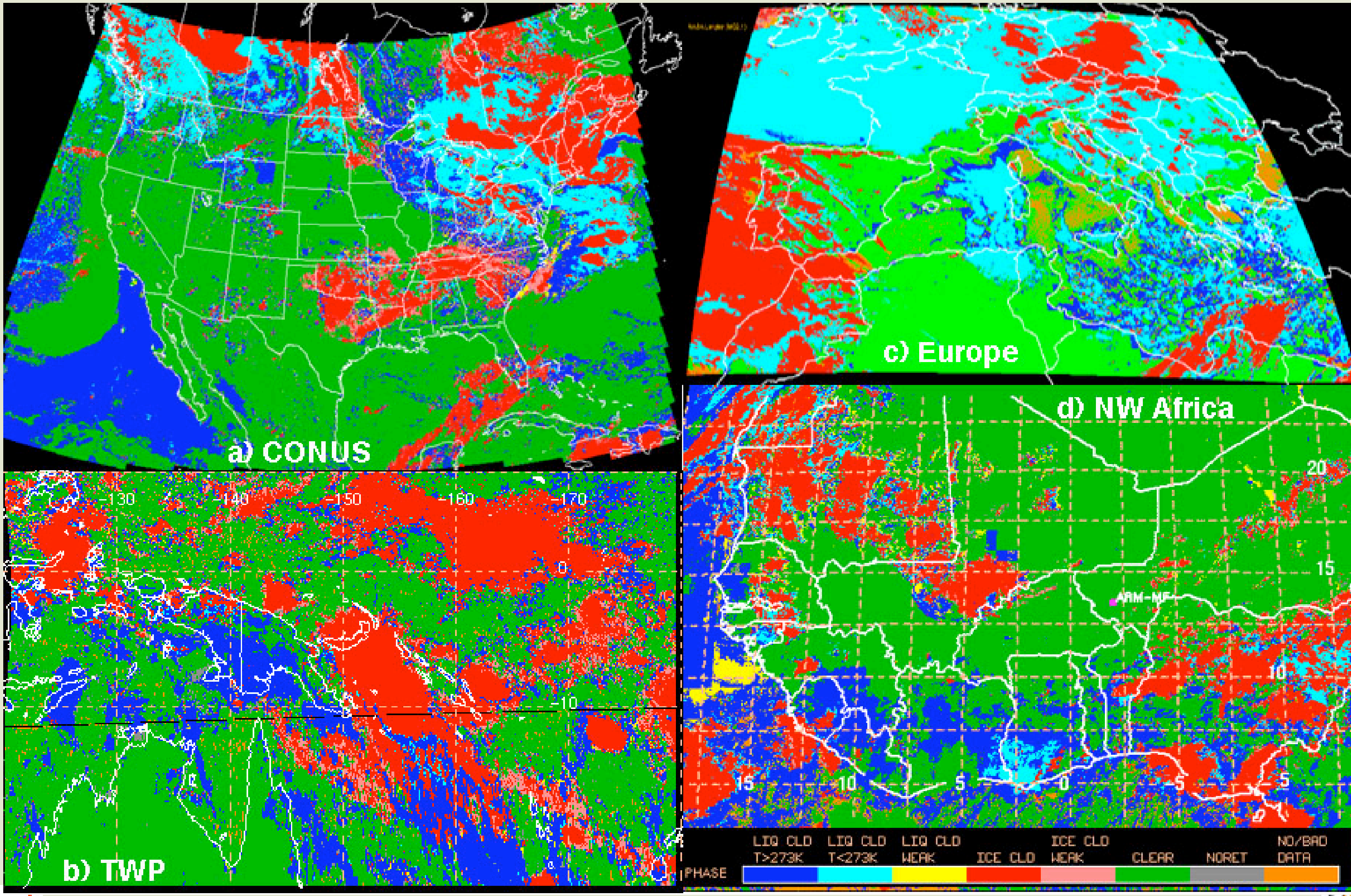
- Low clouds essentially unbiased on average
- Ice clouds a little better than over land sites

Summary of Terra-COVE Height Comparison



- Low clouds essentially unbiased on average
- Ice cloud errors similar to land sites

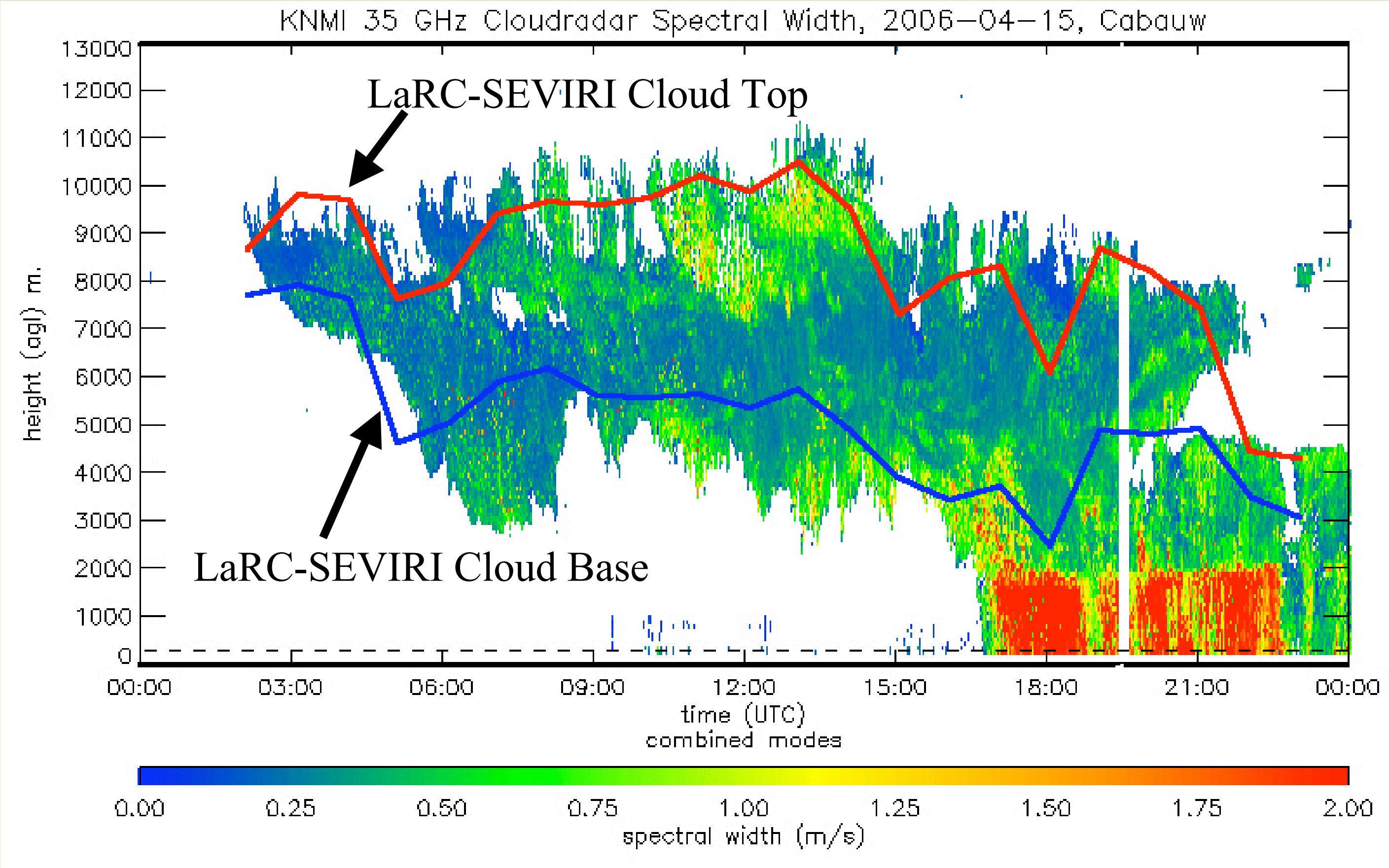
Examples of cloud phase retrievals from geostationary satellites for arbitrarily selected times during 2005



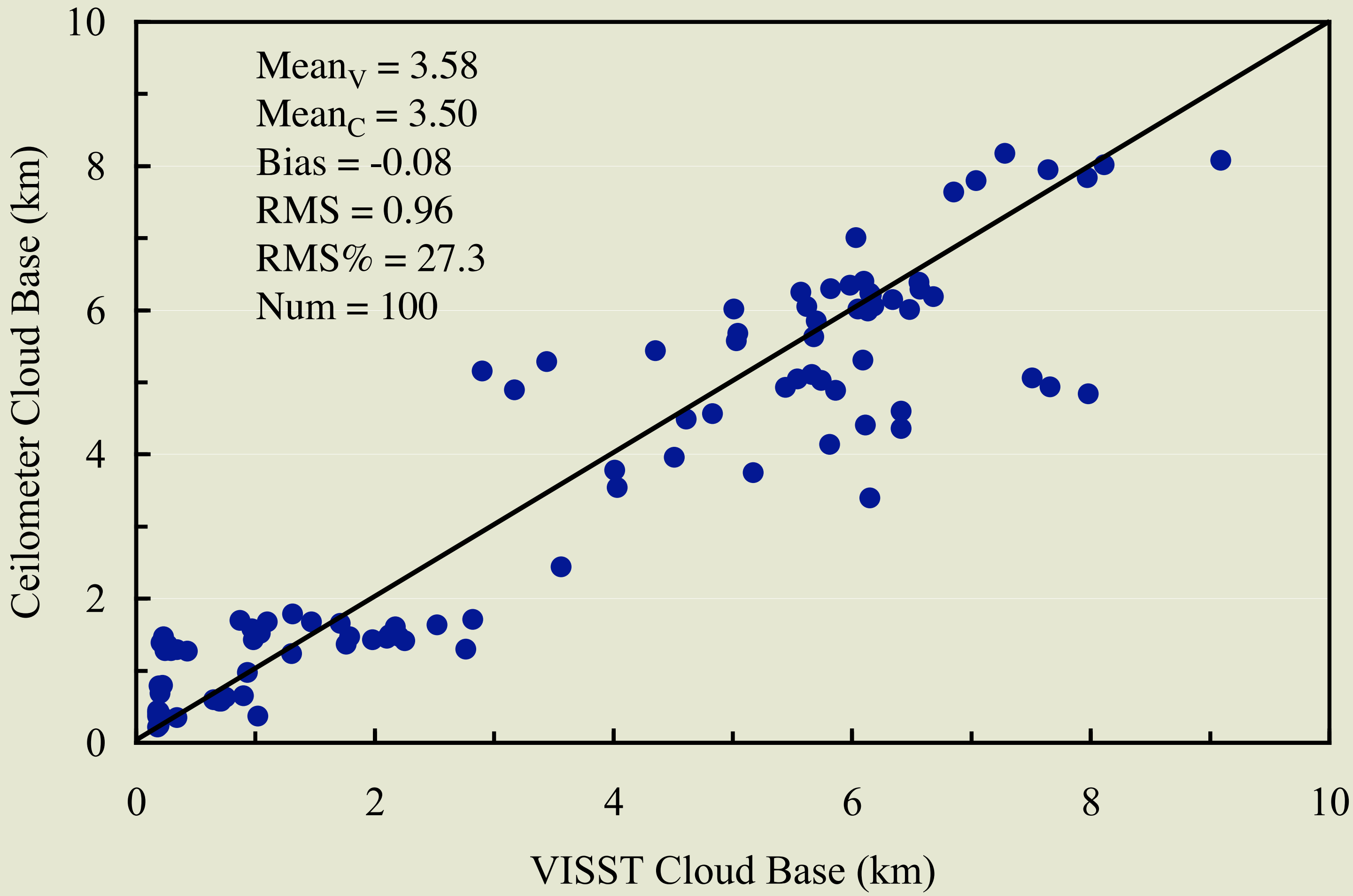
GEO data available each 1/2 - 1 hour

SEVIRI (CERES Algorithm) vs Surface Radar Cloud Heights

Cabauw, Netherlands Radar Comparison (4/15/2006)



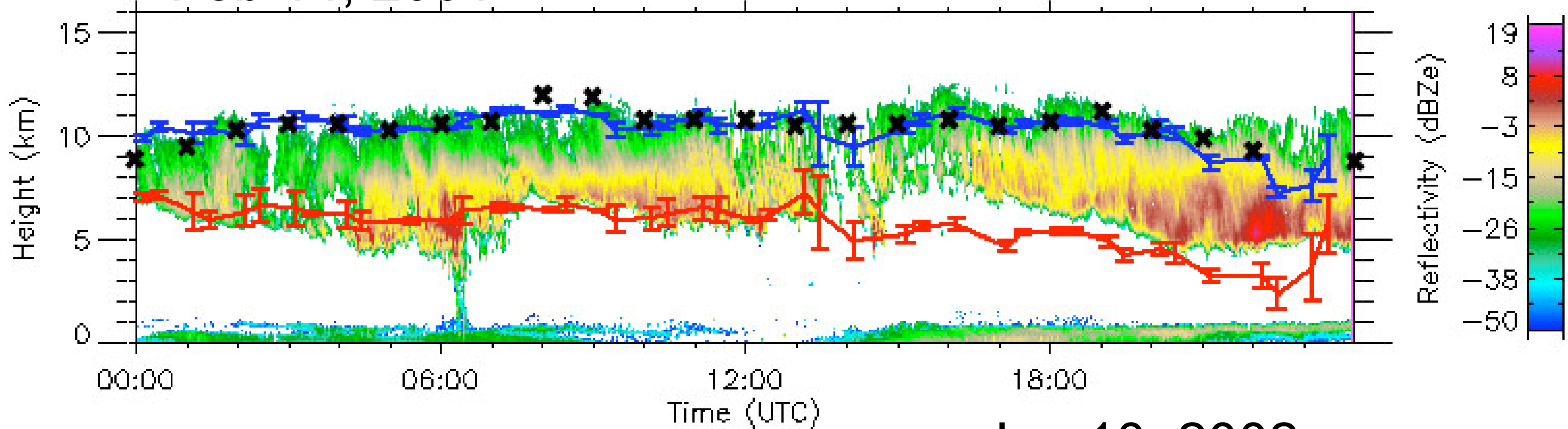
SEVIRI (CERES algorithm) comparison to ceilometer cloud base heights
Chilbolton, UK (January - March, 2006)



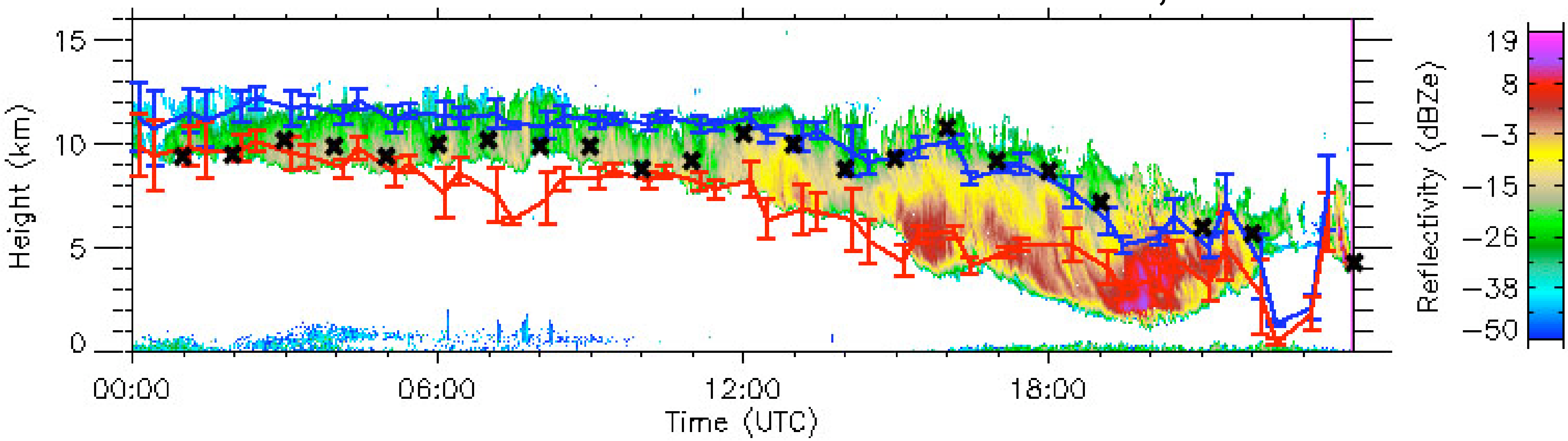
- Repeat comparisons with matched CERES MODIS products
- Expect to include Cabauw & SIRTA + Chilbolton

Examples of GOES-radar Cloud Height Comparisons
ARM SGP, Lamont, OK

Feb 14, 2001



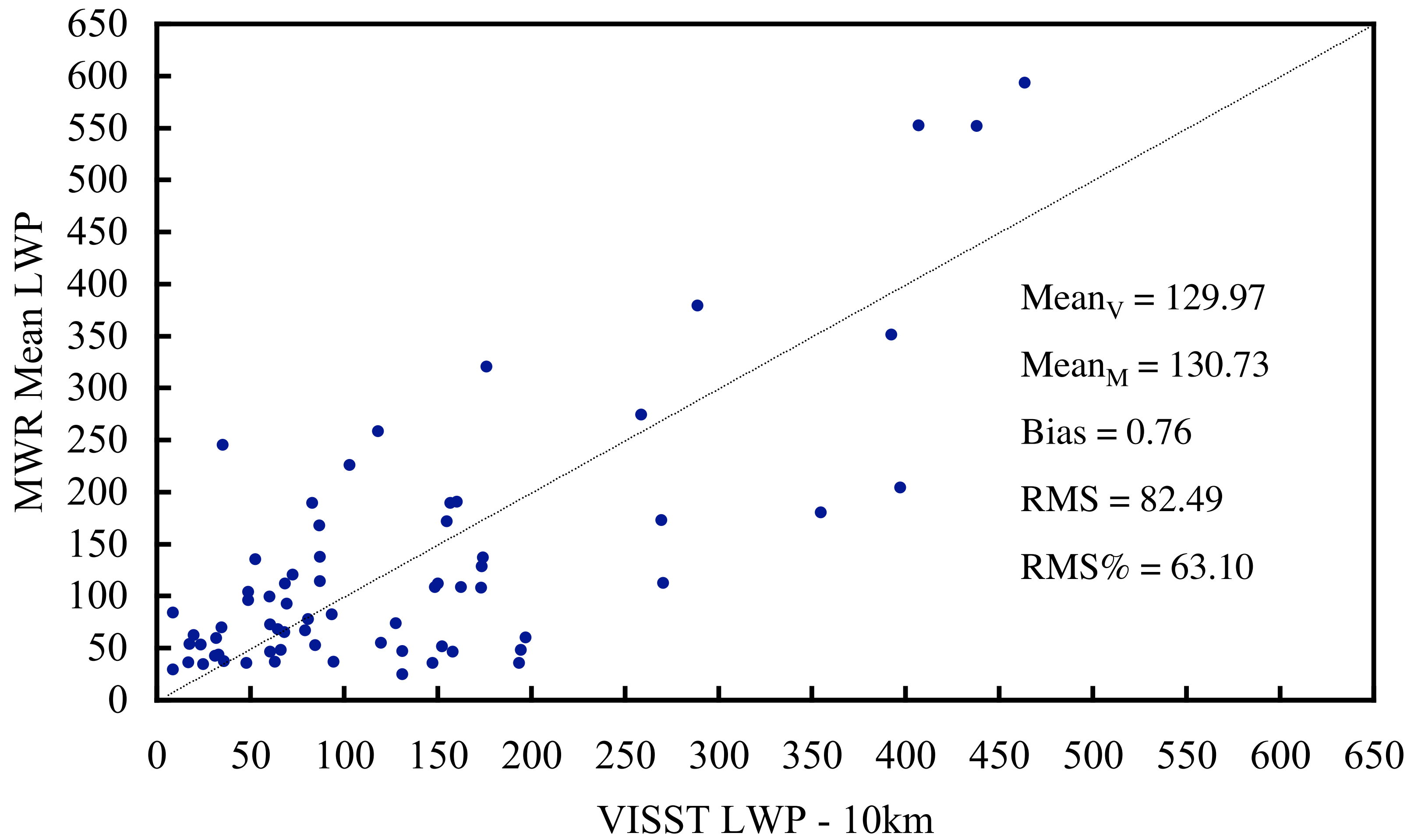
Jan 10, 2002



x - co2 slicing

Blue and red, LaRC cloud top and base

SEVIRI (CERES Algorithm) vs MWR LWP
Chilbolton, UK (April, 2005)



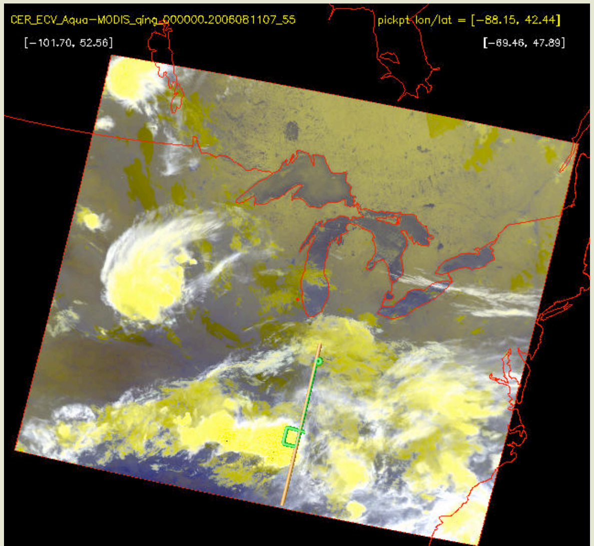
VISST avg for 10-km radius circle around site, no parallax correction

*LWP data provided by the Radiocommunications Research Unit at the Rutherford Appleton Laboratory

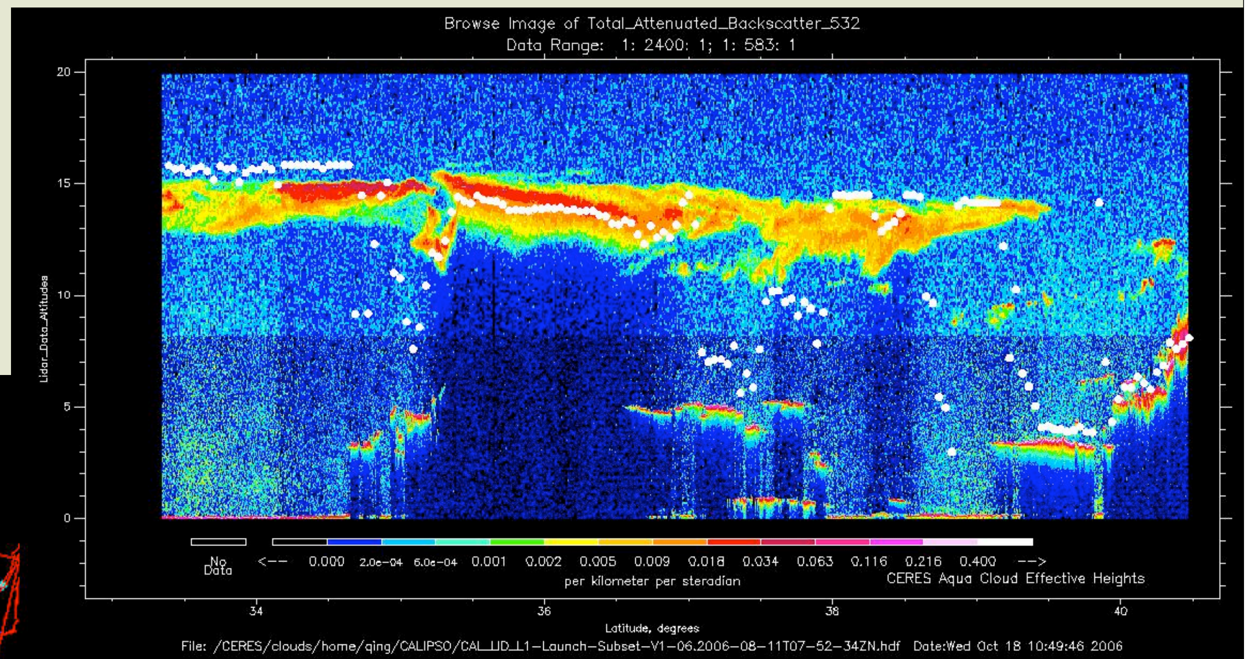
CALIPSO

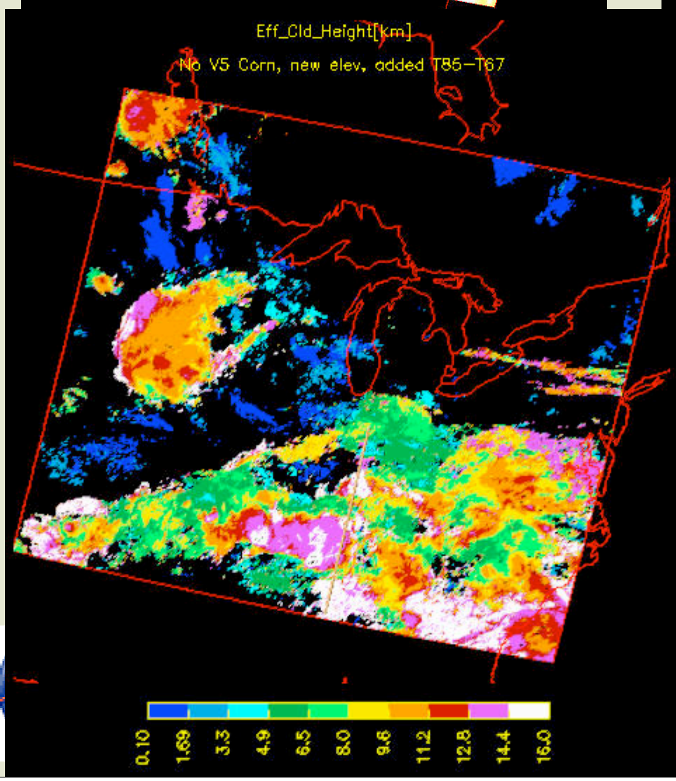
- In Aqua orbit -
  - Instantaneous, well-matched comparisons possible
  - Coordinated with CloudSat radar, more cloud parameters
- Cloud detection and analysis scheme
  - Facilitates automated comparisons
  - Discriminates aerosols from clouds
- Validate:
  - cloud occurrence
  - cloud-top height and phase
  - cloud-base height and optical depth for thin clouds
  - multilayered cloud detection

CloudSat-CALIPSO Validation Experiment (CCVEX)
July - August 2006



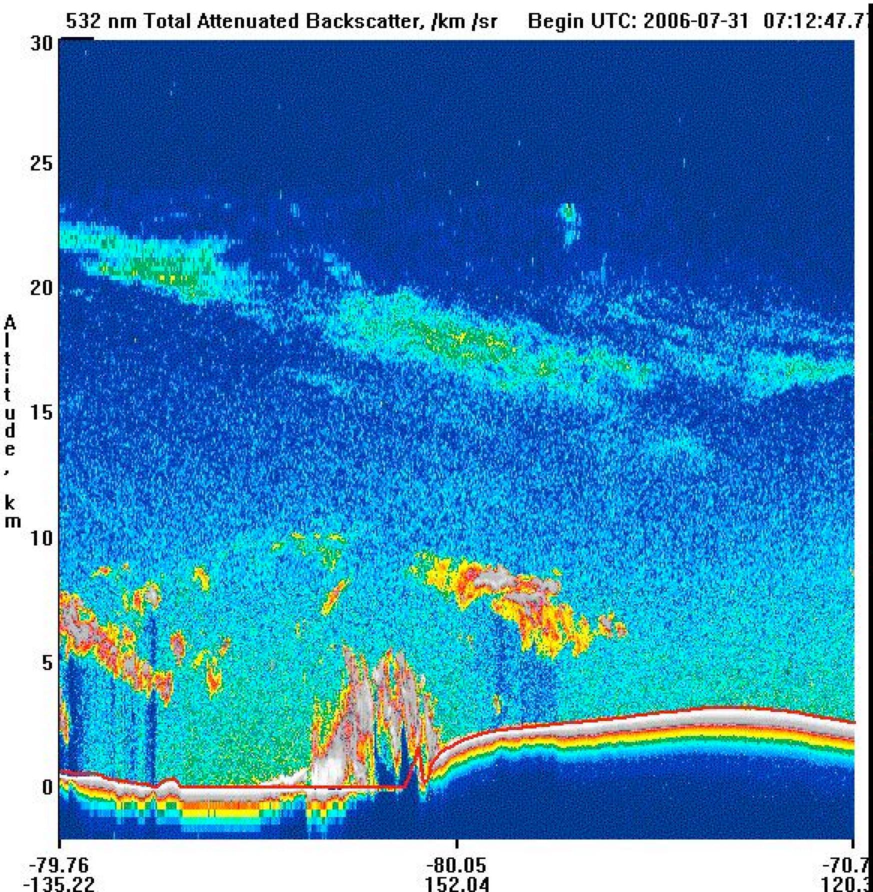
Example: August 11 night flight

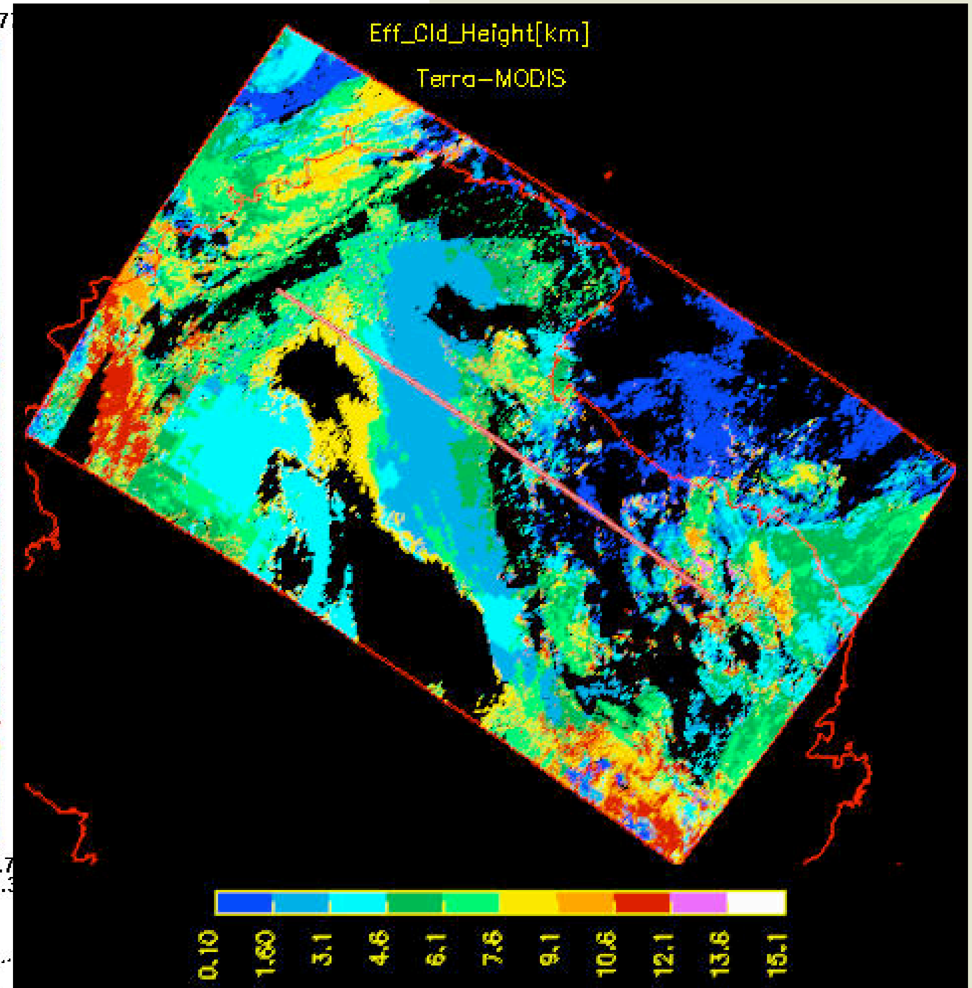


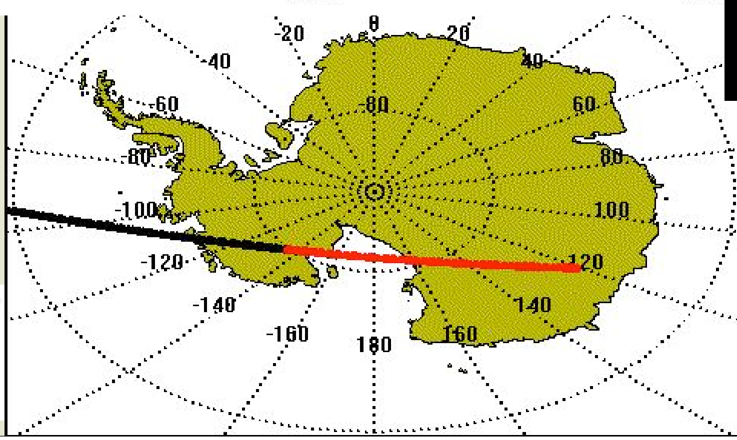


- For optically thick Cb tops, T(11μm) corresponds to ~ 2 km below physical top
- ML clouds cause expected effect

CERES & CALIPSO over Antarctica

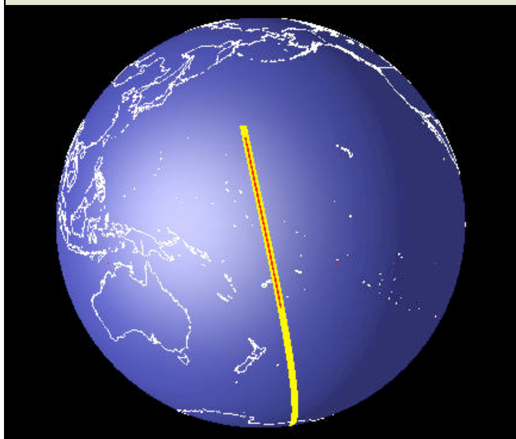




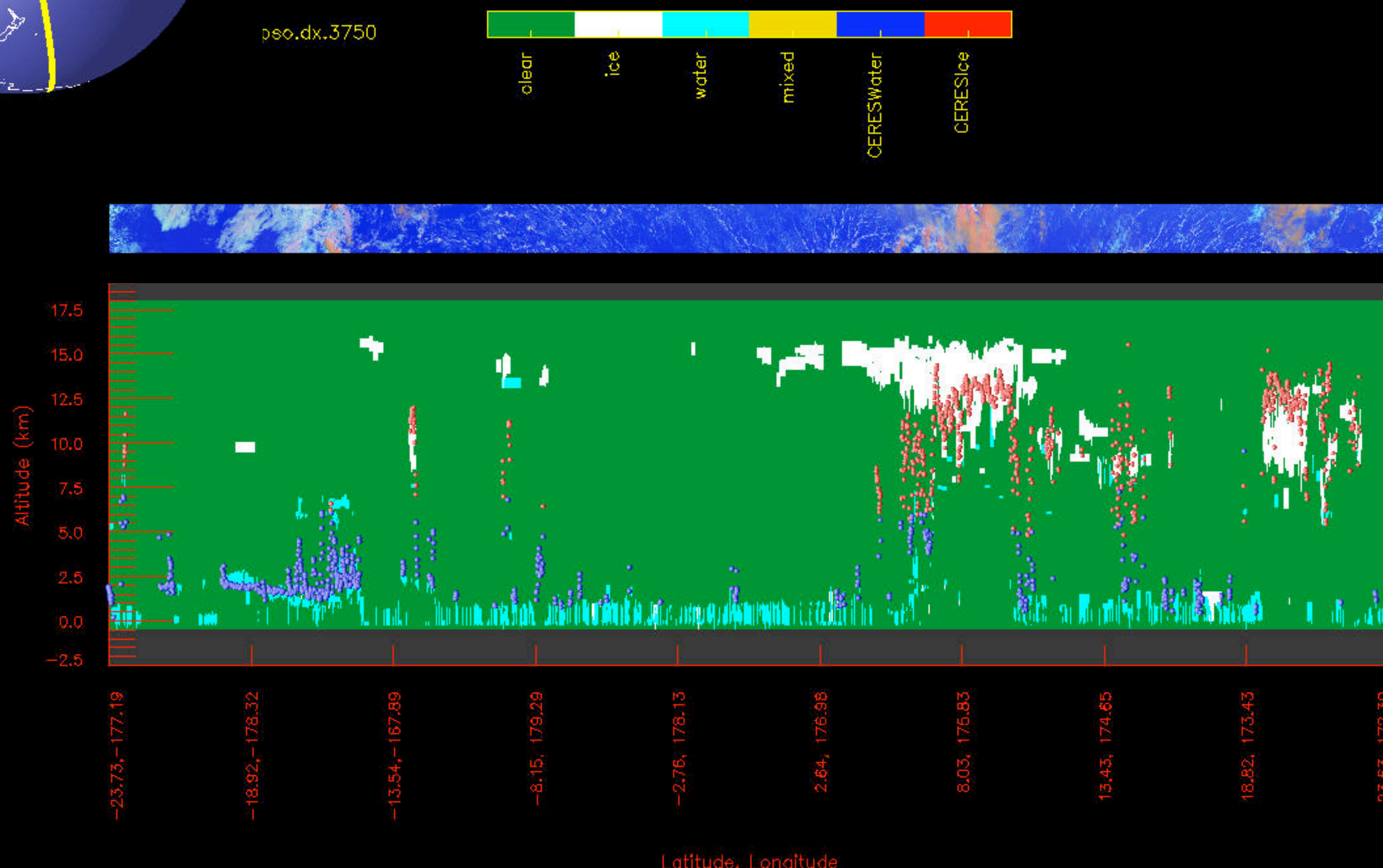


CALIPSO will be invaluable for improving polar cloud detection at night

Comparison of CERES & CALIPSO Cloud heights 8/8 over western Pacific



- Generally good agreement, thick ice Ztop too low as usual
- Highlights need for ML cloud detection/retrieval
- Automated matching process described in PI report



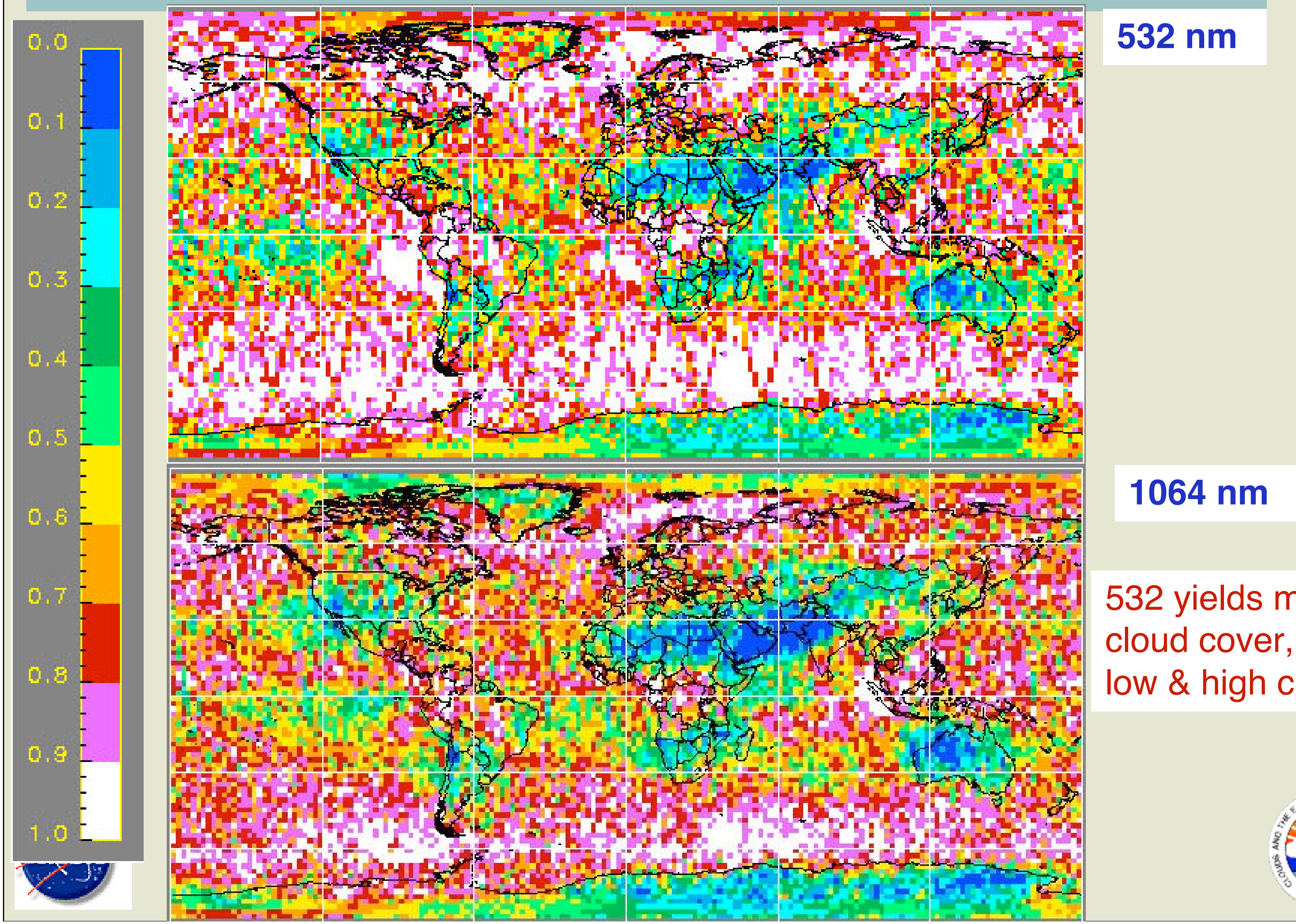
ICESat GLAS

- ICESat in a gradually precessing polar orbit
  - rarely coincides with Aqua or Terra orbits
- GLAS has two lasers
  - 532 nm: most sensitive
  - 1064 nm: most robust
  - used to automatically define cloud & aerosol layers
- For comparisons with CERES
  - use monthly means instead of instantaneous matches
  - regional means
- For comparisons with GEO:
  - use instantaneous & monthly means, hi-resolution
- Focus on 10/2003: Both lasers available

  ICESat overpasses early evening/morning

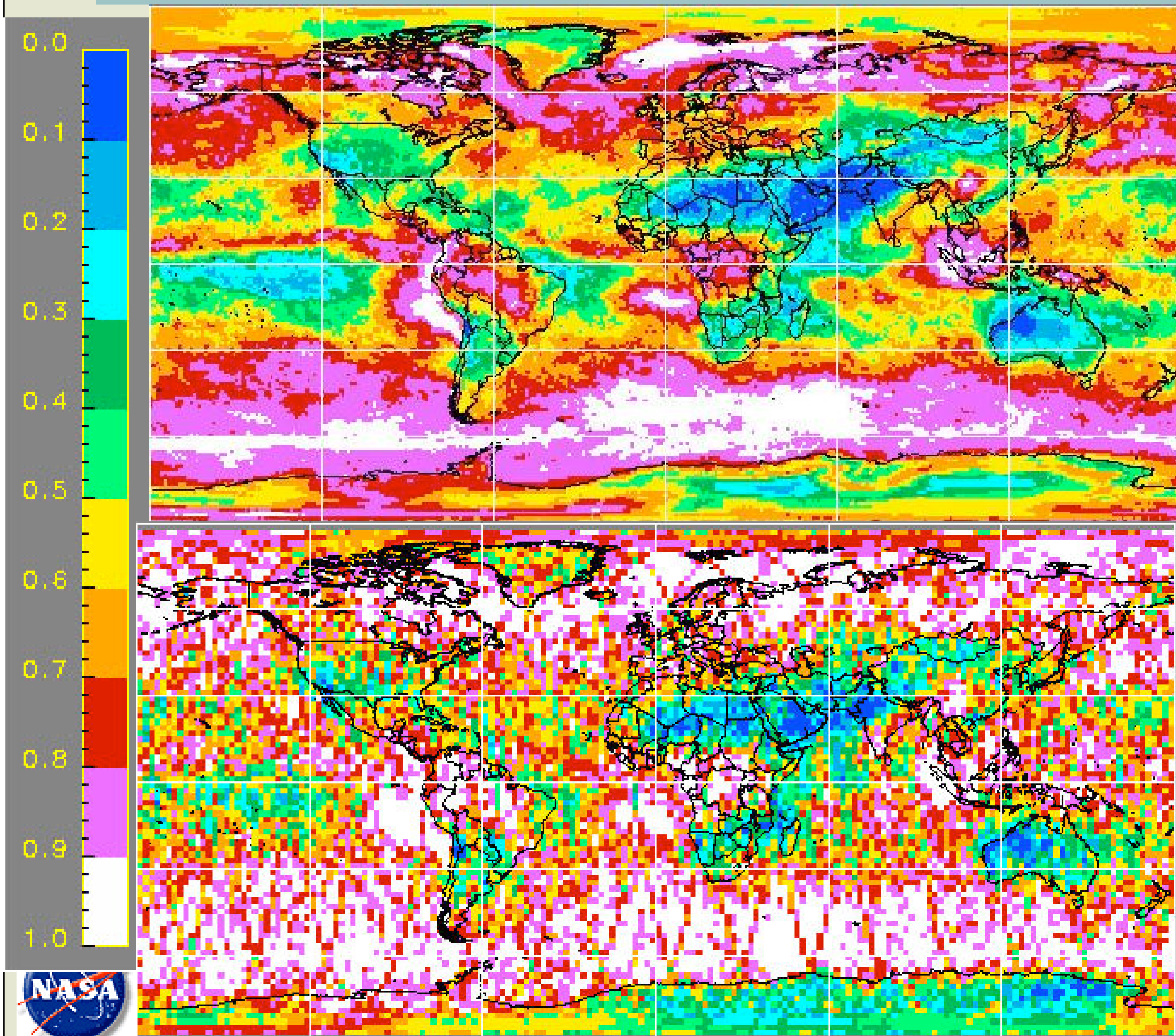
GLAS 532 vs 1064 Total Cloud Fraction, 2-deg avg, October 2003

Mid-Res data



532 yields more cloud cover, both low & high clouds

CERES Aqua MODIS vs GLAS 532 Total Cloud Fraction
Mid-Res, October 2003

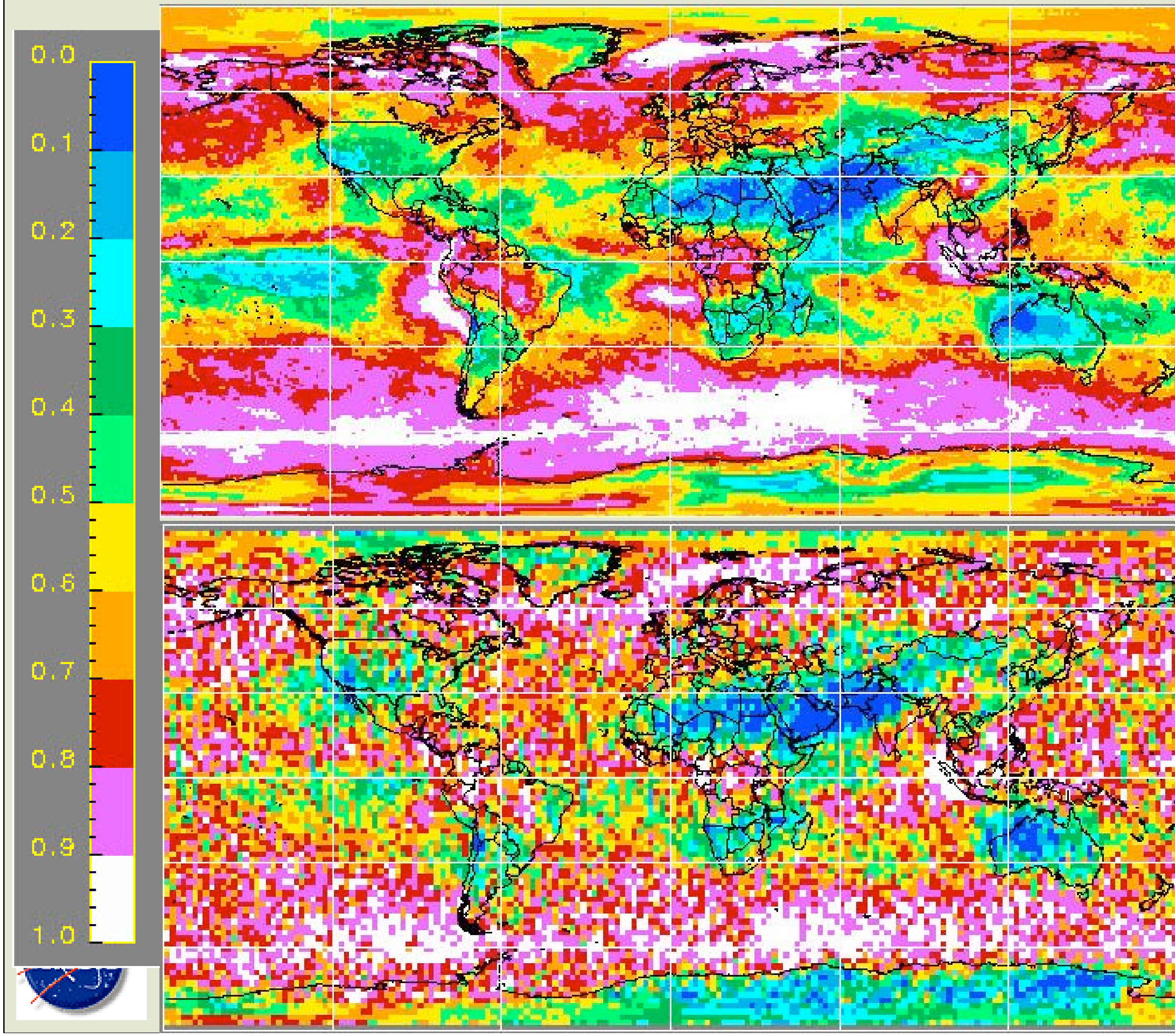


CERES

532 nm

CERES yields less low & high cloud cover than GLAS 532

GLAS 1064 vs CERES Aqua Total Cloud Fraction
2-deg avg, October 2003 Mid-Res data

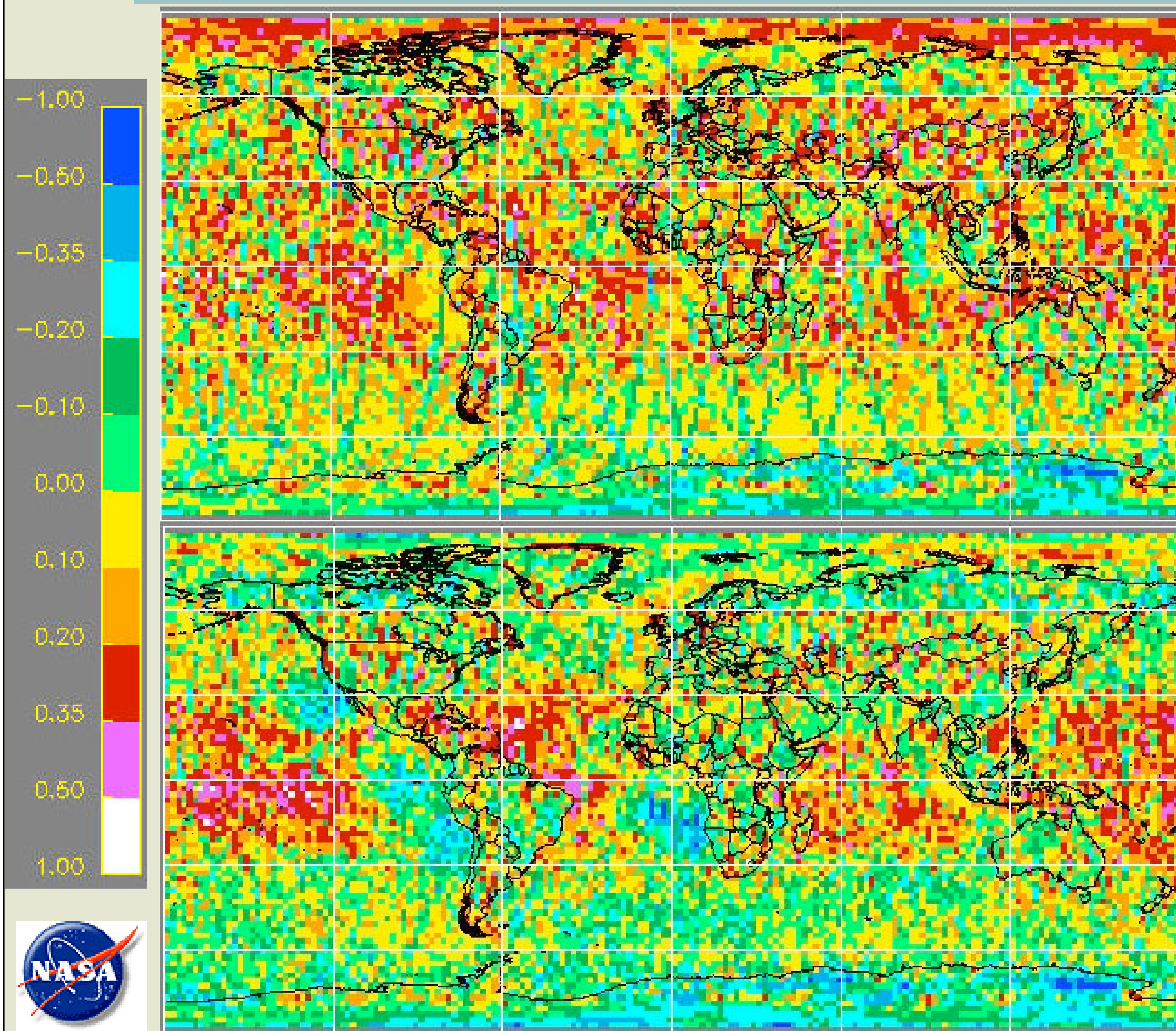


CERES

1064 nm

CERES yields more low cloud cover than 1064

GLAS - CERES Aqua Total Cloud Fraction Difference
October 2003 Mid-Res data



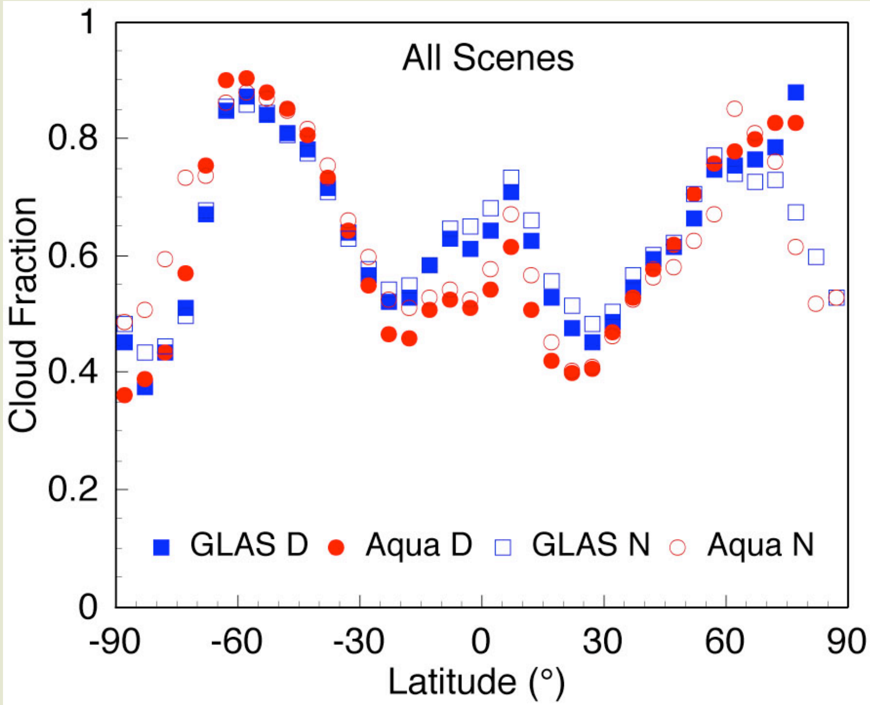
532 nm

532 yields more red, especially in Arctic

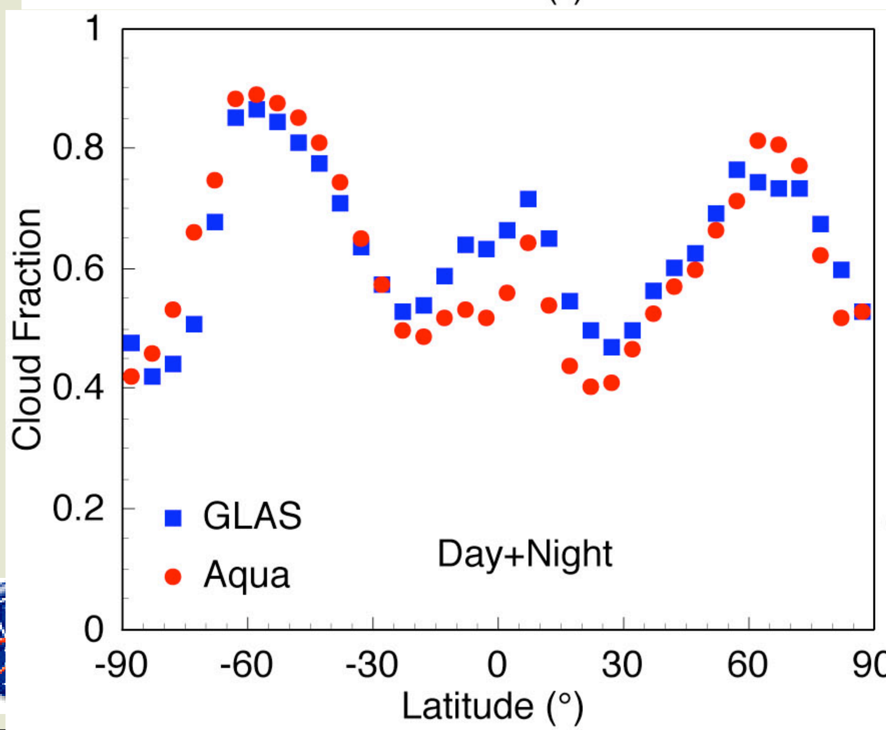
1064 nm

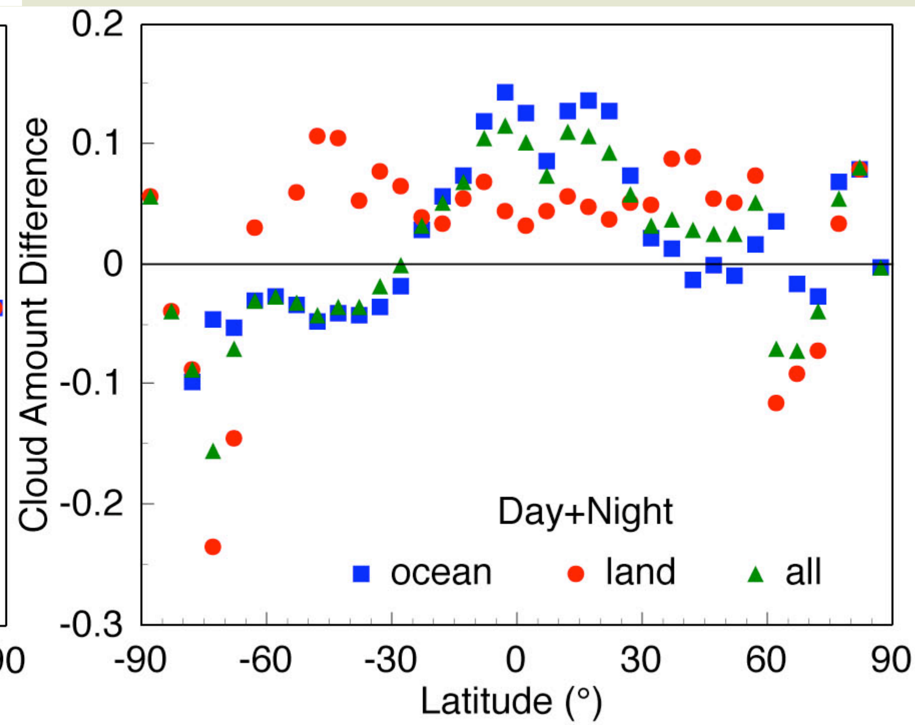
1064 yields more blue, especially in Arctic land and Sc regions

GLAS 1064 vs CERES Aqua Total Cloud Fraction October 2003 Mid-Res data



- 0.06 low over nonpolar land
- 0.05-0.25 high over polar land
- 0.10 low over tropical ocean
- 0.04 high over temperate south ocn
- too much cloud at night in Antarc.





Preliminary Cloud Fraction Comparison Summary

	Day	Night	Total
Aqua	64.7	65.5	65.1
Terra	61.6	64.5	63.8
G53low	67.6	76.1	73.1
G53mid	63.2	74.4	70.3
G10low	74.4	75.7	75.5
G10mid	62.8	64.4	64.0

- Global means are very similar for mid-resolution data, particularly daytime
- Daytime 532 cover much less than nighttime; loses sensitivity in sunlight

GLAS - CERES Cloud Fraction Differences

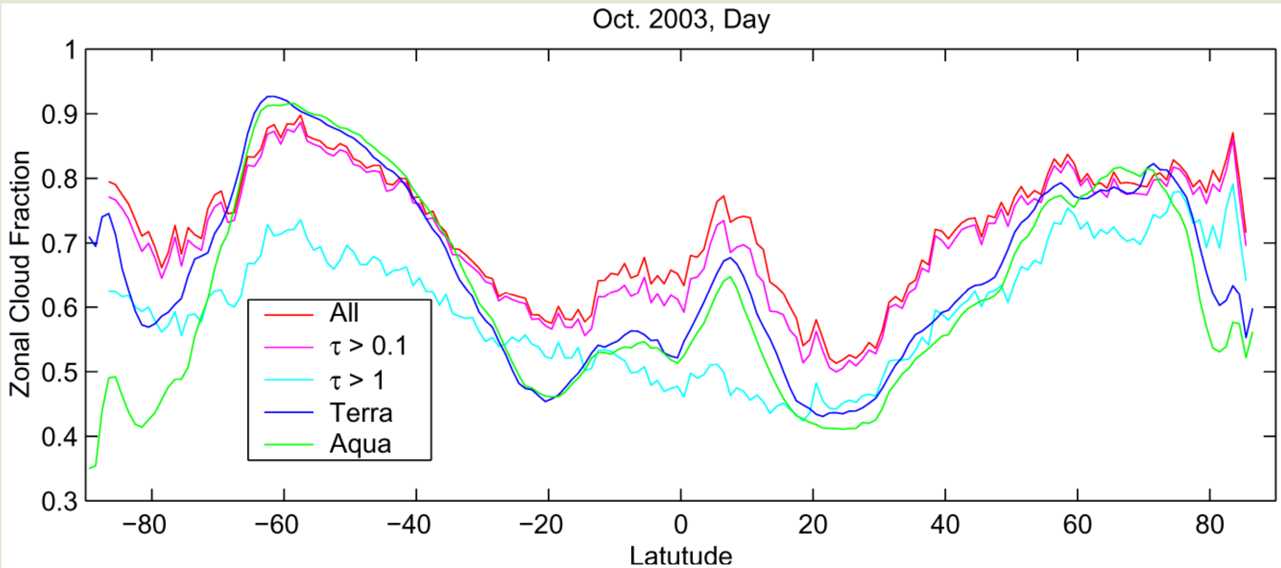
- Depends on background & GLAS product

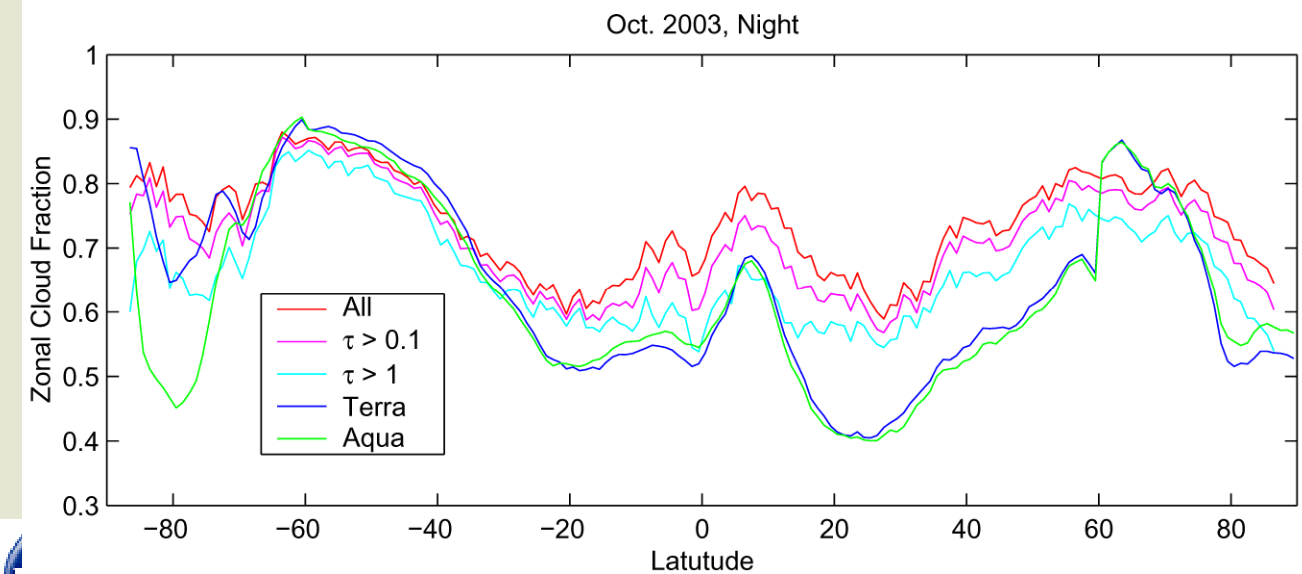
- Why the big difference in 532 & 1064 nm clouds?

    - optical depth? height?

- Clear that CERES misses some clouds in tropics & Arctic

Breakdown of Clouds by Optical Depth, 532 nm low



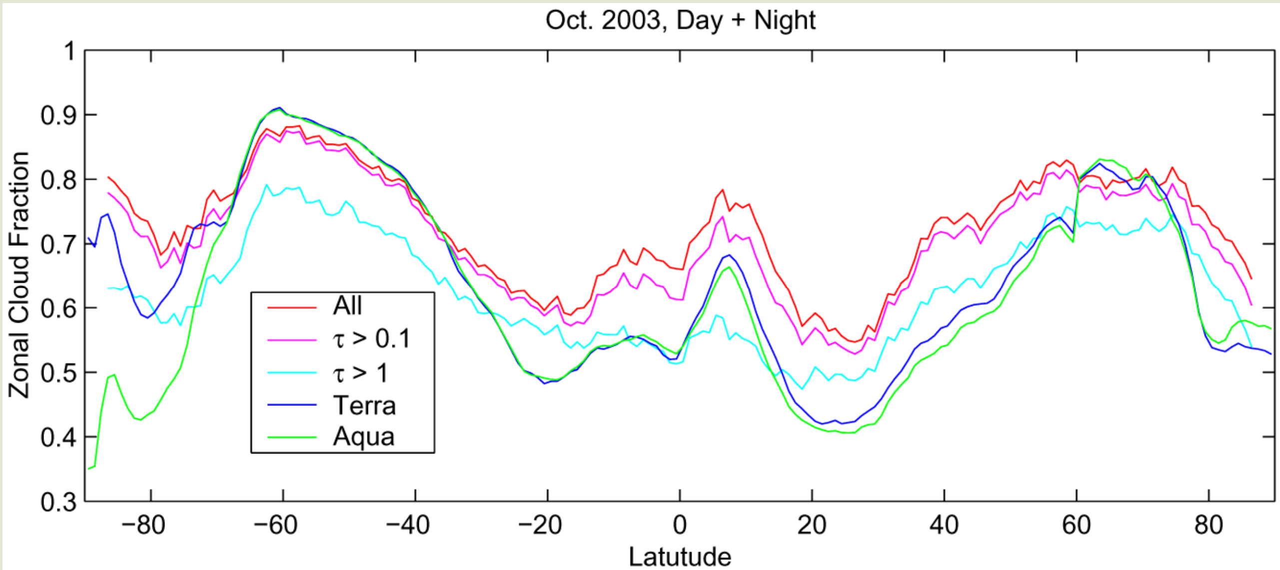


- ~0.04 cloud cover in tropics is $\tau < 0.1$,
- ~0.15 in tropics, $\tau < 1$
- ~ 0.10 elsewhere, $\tau < 1$

- more $\tau < 0.1$ in Tropics in early evening
- $\tau > 1$ greater everywhere at night?
- Aqua too low in poles
- Terra ok over Antarctica

Thanks to Seiji Kato for this analysis!

Breakdown of Clouds by Optical Depth, 532 nm low-res



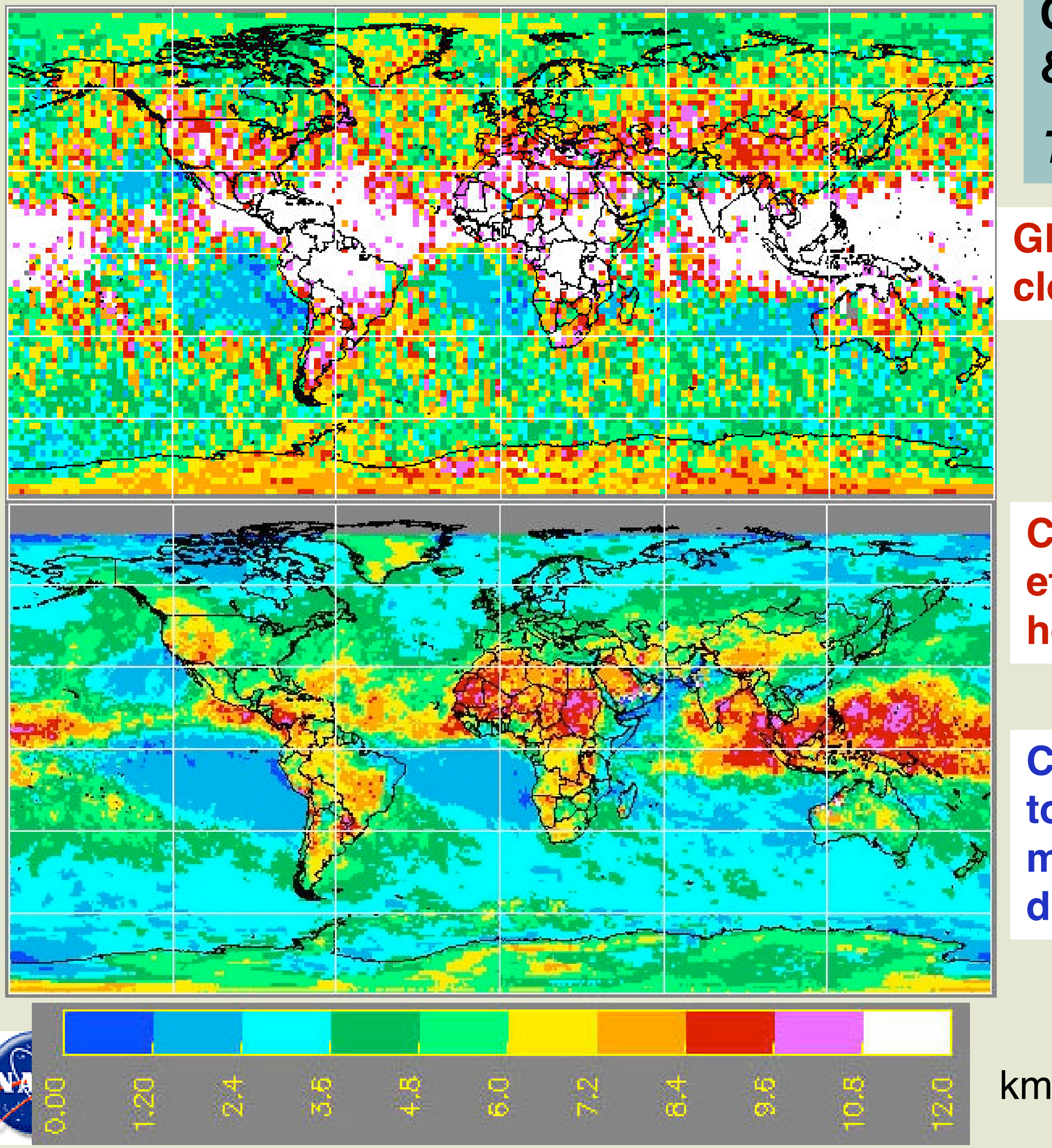
- Clear that Aqua algorithm needs work in polar regions
- Terra has some issues in Arctic
- Need better thin cloud detection
- Redo with mid-res data

Comparison of CERES & GLAS Cloud Heights

Terra, October 2003

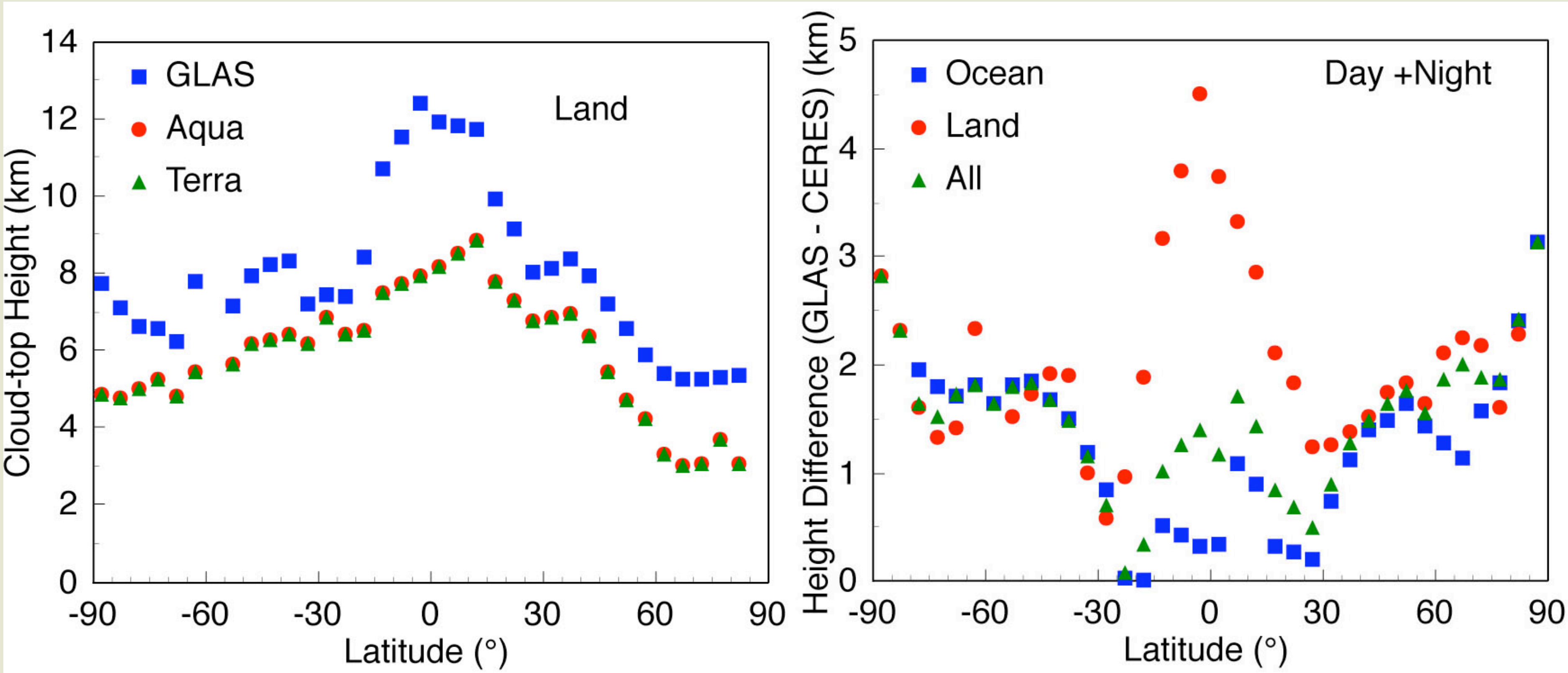
GLAS uppermost cloud height

CERES average effective cloud height



CERES heights generally too low except where marine stratocumulus dominates

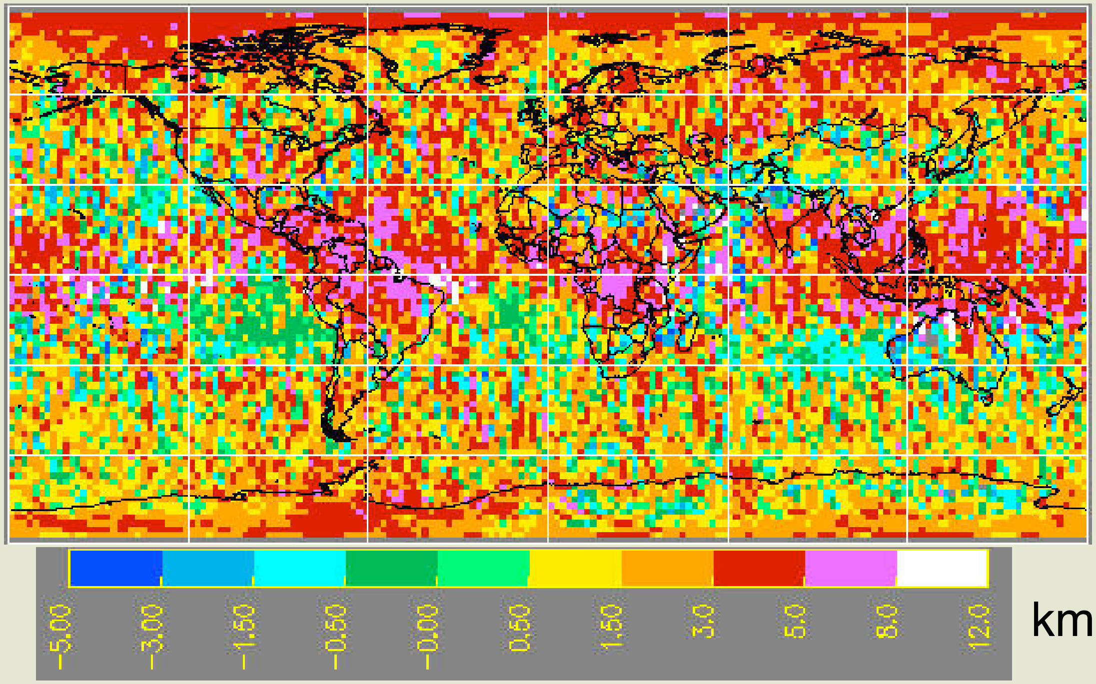
Zonal comparison, CERES & GLAS 532 mid-res cloud heights
Terra, October 2003



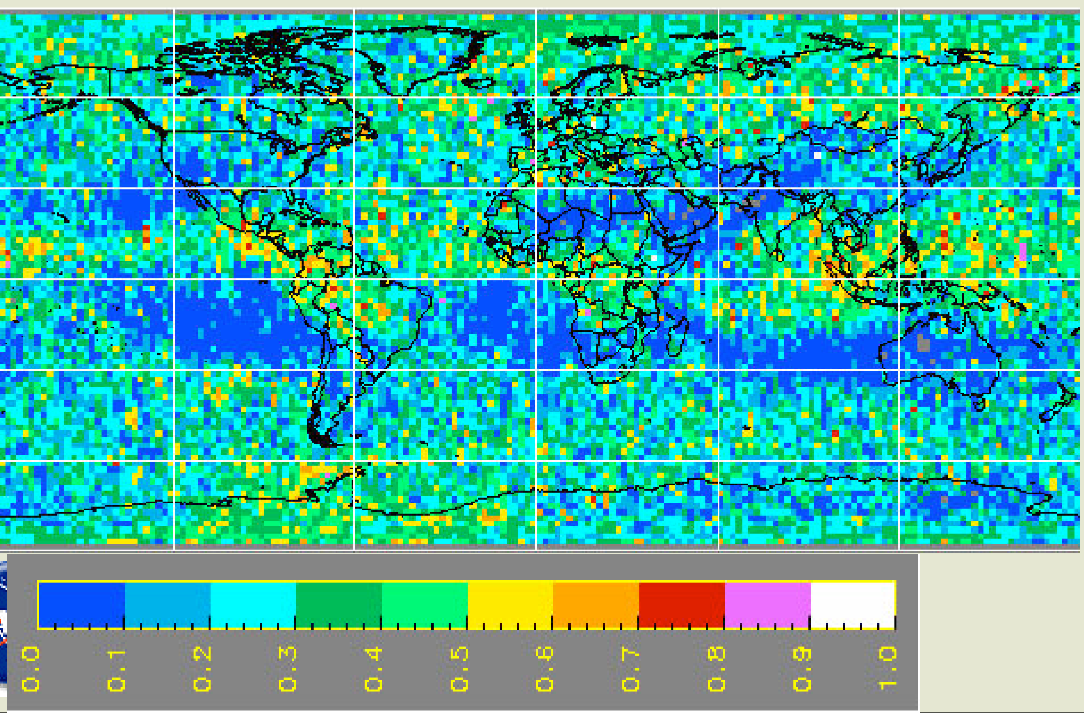
- **CERES heights not bad over tropical ocean**
- **Too low over tropical land where thin cirrus fraction highest**
- **Far too low over midlats & polar regions particularly**

Comparison of CERES & GLAS Cloud Heights

Terra, October 2003



GLAS uppermost - CERES cloud height

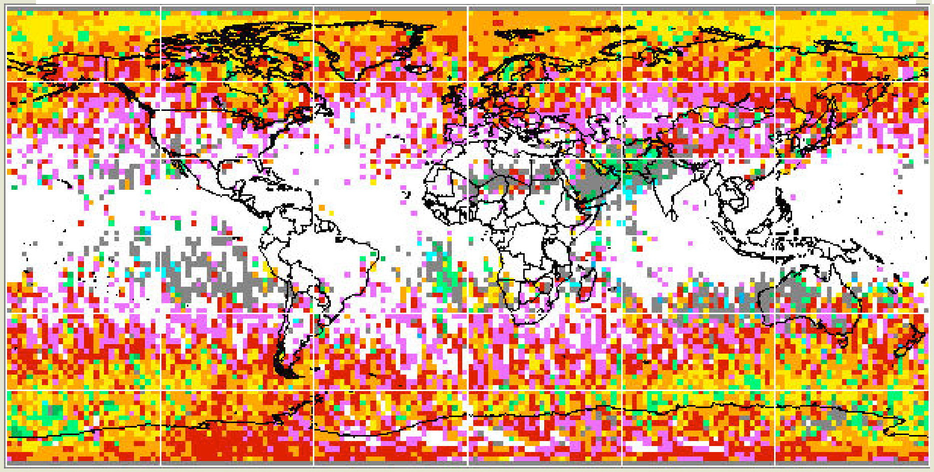


Fraction of multilayered clouds from GLAS

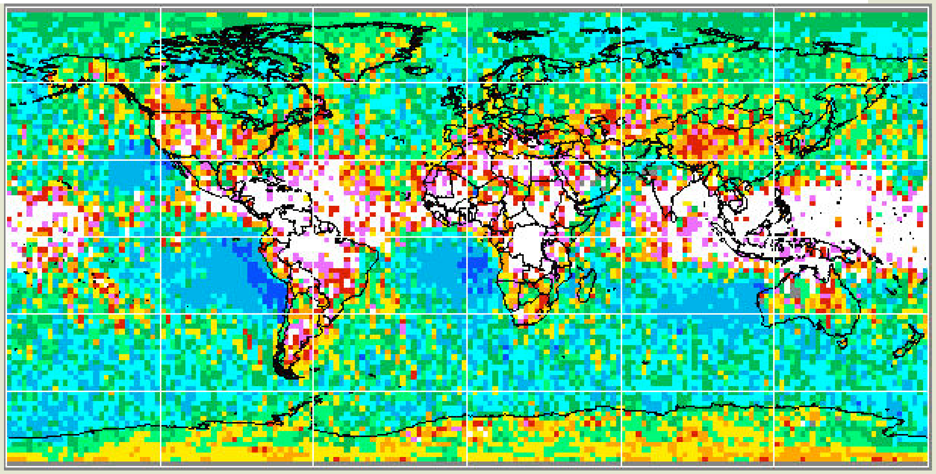
CERES heights too low where multilayered clouds dominate

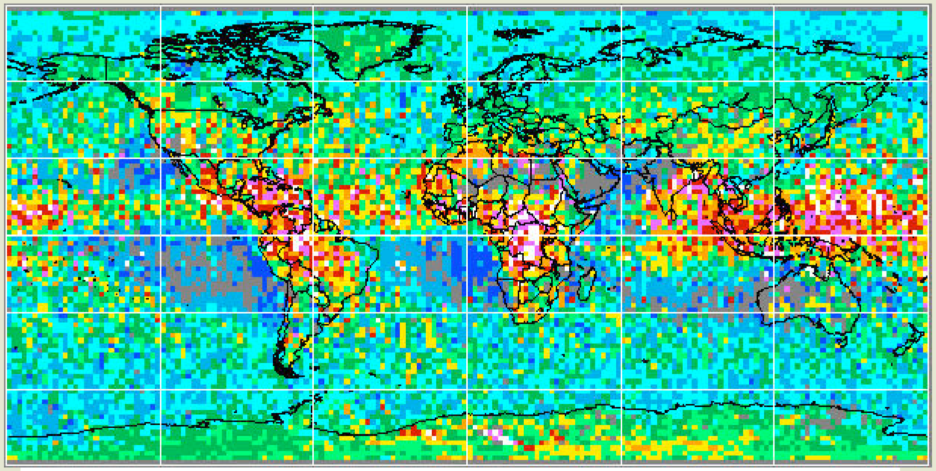
Comparison of CERES & GLAS 532 mid-res Cloud Heights
Terra, October 2003

Highest layer of multilayered clouds

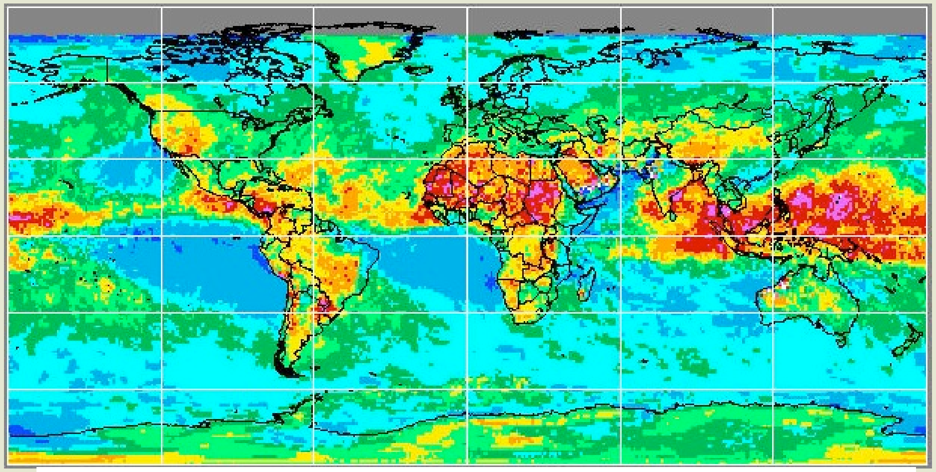


Single-layered clouds





Lowest layer of multilayered clouds



CERES average height

CERES heights look like combination of single & lowest layers

CERES vs. GLAS Global Cloud Top Heights

➢ ***ALL Clouds***	***6.46 (7.29) km (532 nm)***
➢ ***Terra (Aqua) (all SL)***	***5.18 (5.83) km***
➢ ***highest layer ML clouds***	***10.8 (10.9) km***
➢ ***lowest layer ML clouds***	***4.05 (5.13) km***
➢ ***single layer clouds***	***5.77 (6.24) km***

- CERES heights between average for lowest and highest GLAS cloud-tops
  - *- GLAS sees through clouds with OD < 2*
  - *- overlapped cloud method should improve comparison*
- CERES characterization of stratus regimes very similar to GLAS
- CERES heights over land too low? patterns OK
- CERES high cloud patterns very similar to uppermost clouds,but low
- IR-based techniques generally underestimate top heights of thick ice clouds
  - *- additional corrections required*

Comparisons of GLAS With LaRC Geostationary Satellite Cloud Products

- **Validation source for operational weather/aviation products**
  - aid improvement of products
  - set uncertainties for modelers & end users

- **Useful for calibrating POES comparisons to account for diurnal cycle changes**
  - GEO samples all hours, POES imagers have fixed hours (e.g., *Aqua* ECT = 0130, 1330 LT)

Hi-res cloud detection and retrieval for low clouds (250-m into 1 km)

- Apply VIS threshold to 250-m subpixels within 1-km pixel to estimate fractional cloud cover in pixel (16 subpixels, 4 x 4)

- Need alignment of 250-m pixels with 1-km pixels
  - assumes 1-km VIS aligned with all other 1-km channels

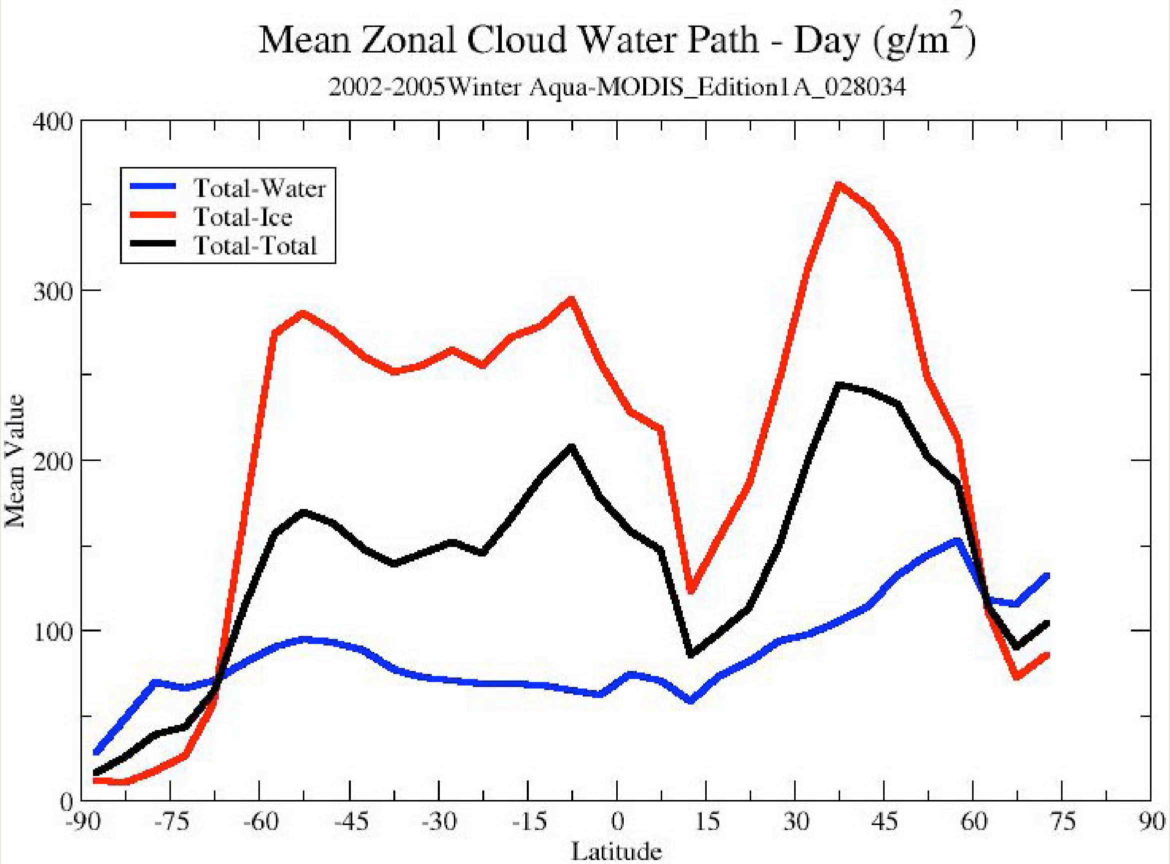
- Set up operational code and run examples
  - apply only over dark surfaces, no coasts
  - no ice clouds
  - no overlap

- Use examples to tune VIS thresholds

- Iterate on refinement, criteria for application

Multilayered Cloud Cover

- Very large mean IWP values (> 250 gm^{-2}) seen in many areas

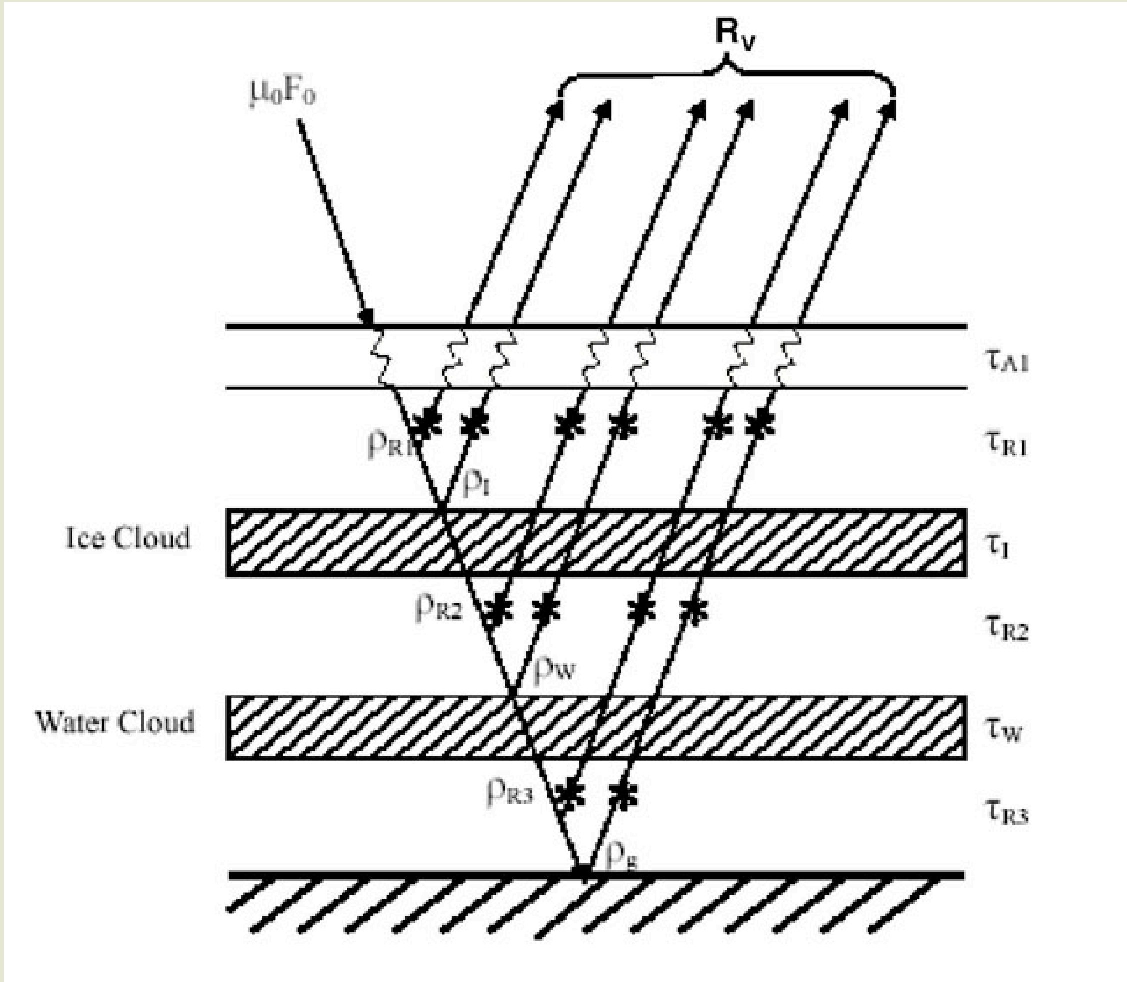


- Large IWP may be due to ML clouds

Multilayer cloud detection and retrieval

- Edition 3 will use upgrade of Chang & Li (2005) CO_2-slicing/VISST overlapped cloud detection and retrieval method
  - only detects and analyzes ML clouds when upper cloud $\tau < 4$
  - no snow surfaces or nighttime
- Mechanics of method currently operational
  - refinement is ongoing using sfc, GLAS, CALIPSO, MCRS
  - validation planned using same datasets
- Offline studies using MW & VISST (MCRS) over ocean for thicker clouds
  - complementary to CO_2 method, but can be used to validate CO_2 method for many conditions
  - 2 papers in press/accepted
  - proposal submitted to test combining MCRS/CO_2 techniques

Multilayer VISST (ML-VISST)

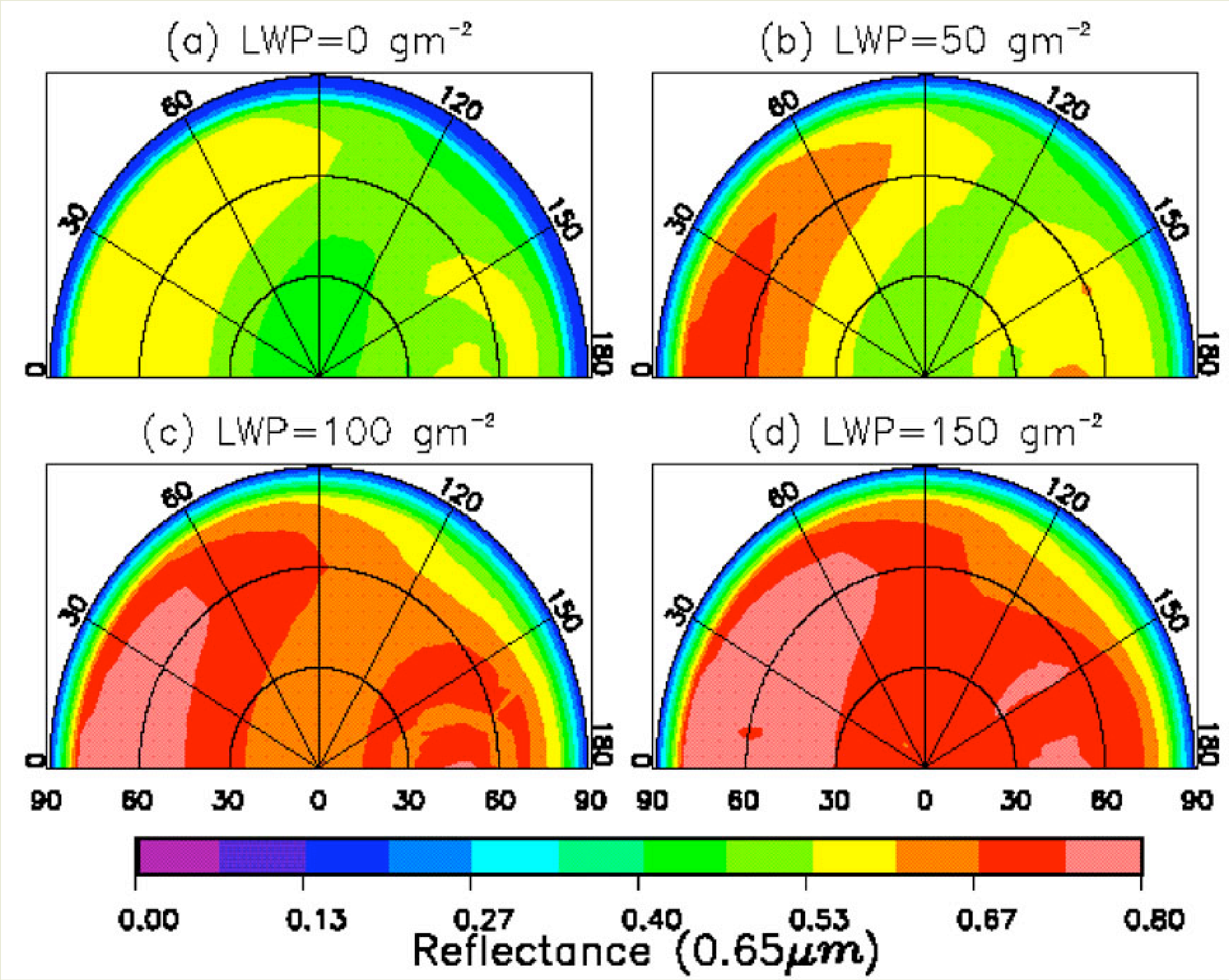


- Single-layer (SL) VISST uses LUTs based on AD calcs for SL cloud in vacuum

- ML-VISST uses LUTs combining 2 cloud layers with sfc & 2 enclosed atmospheric layers

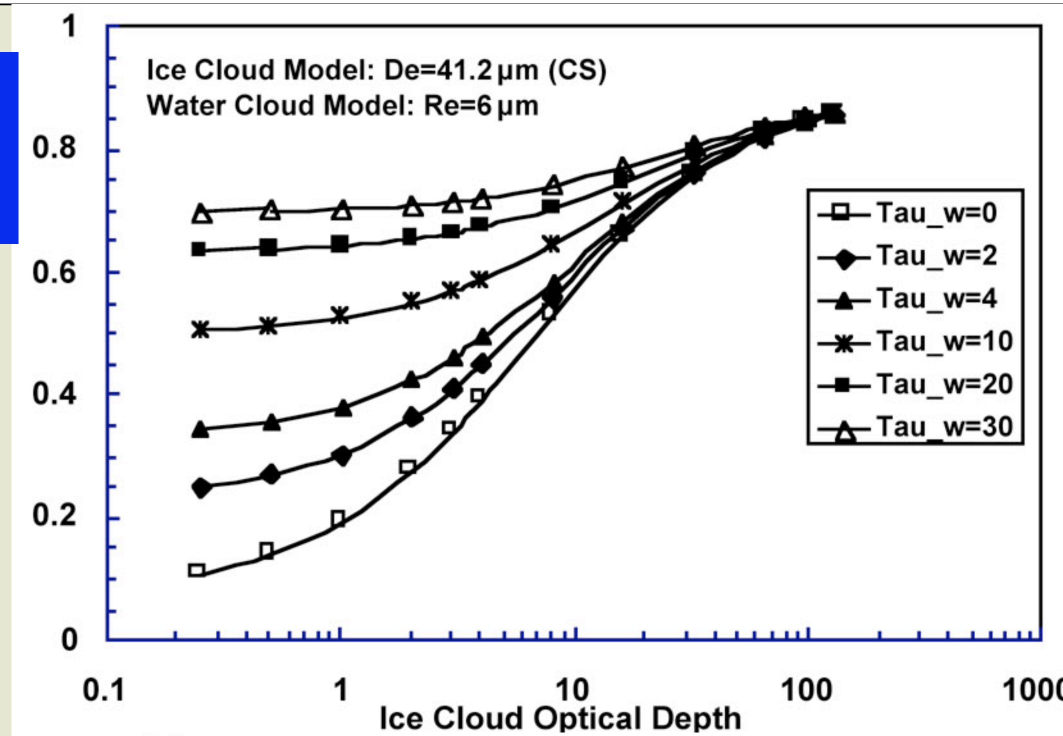
2-Layer Reflectance Fields

SZA = 45°, α_{sfc} = 0.04, TWP = IWP + LWP

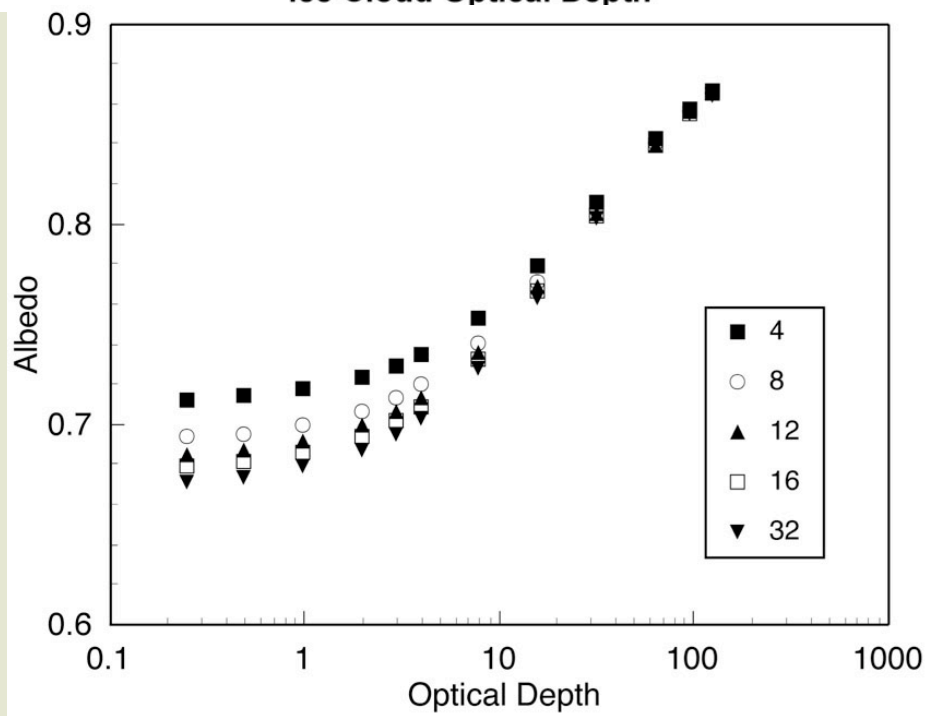


2-Layer Diffuse Albedo

$\alpha_{sfc} = 0.04$



Fixed r_e, τ_w varies



Fixed τ_w, r_e varies

Albedo more sensitive to τ_w than to r_e

MCRS Method

- Uses VISST to estimate TWP, T_c, τ, and Zc (for ML cloud IWP = TWP)
  MW to estimate LWP and T_L of lower cloud

- Compares T_c and T_L to detect ML clouds when 100% IWP

When ML,

- Use LWP to estimate τ_L and r_e of lower cloud, T_L to get Z_L

- Uses ML-VISST to estimate τ_U, IWP, T_U, Z_U, and D_e of upper cloud

Results:

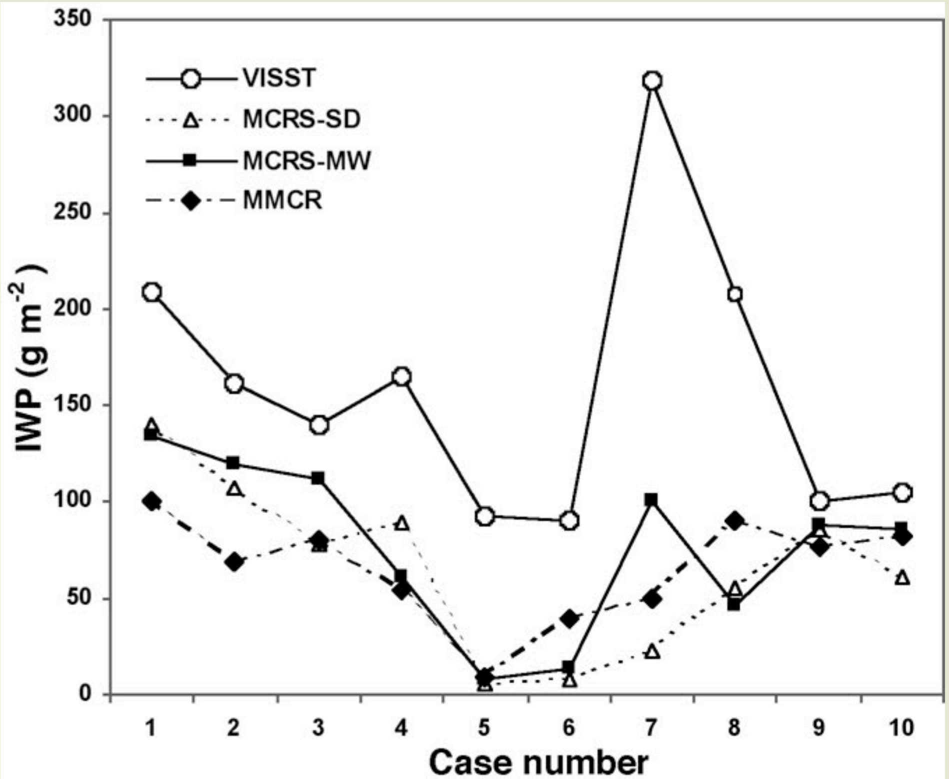
- Both IWP and TWP decrease

- Distribution of τ(ice, ML) ~ τ(ice,SL)

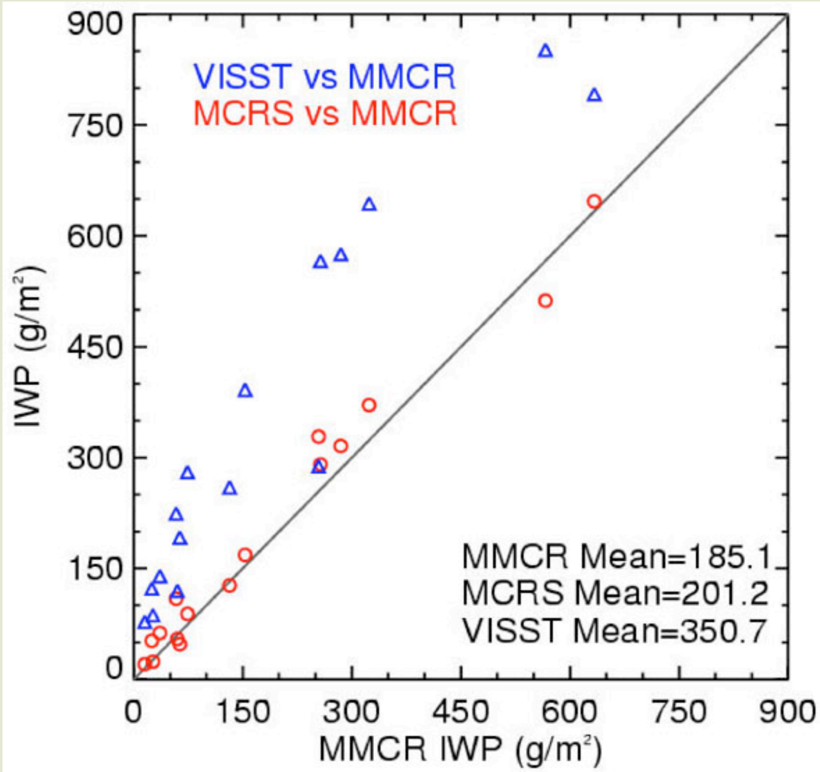
Validation of MCRS over ARM sites

Use sfc MWR for MW LWP

ARM SGP (GOES)

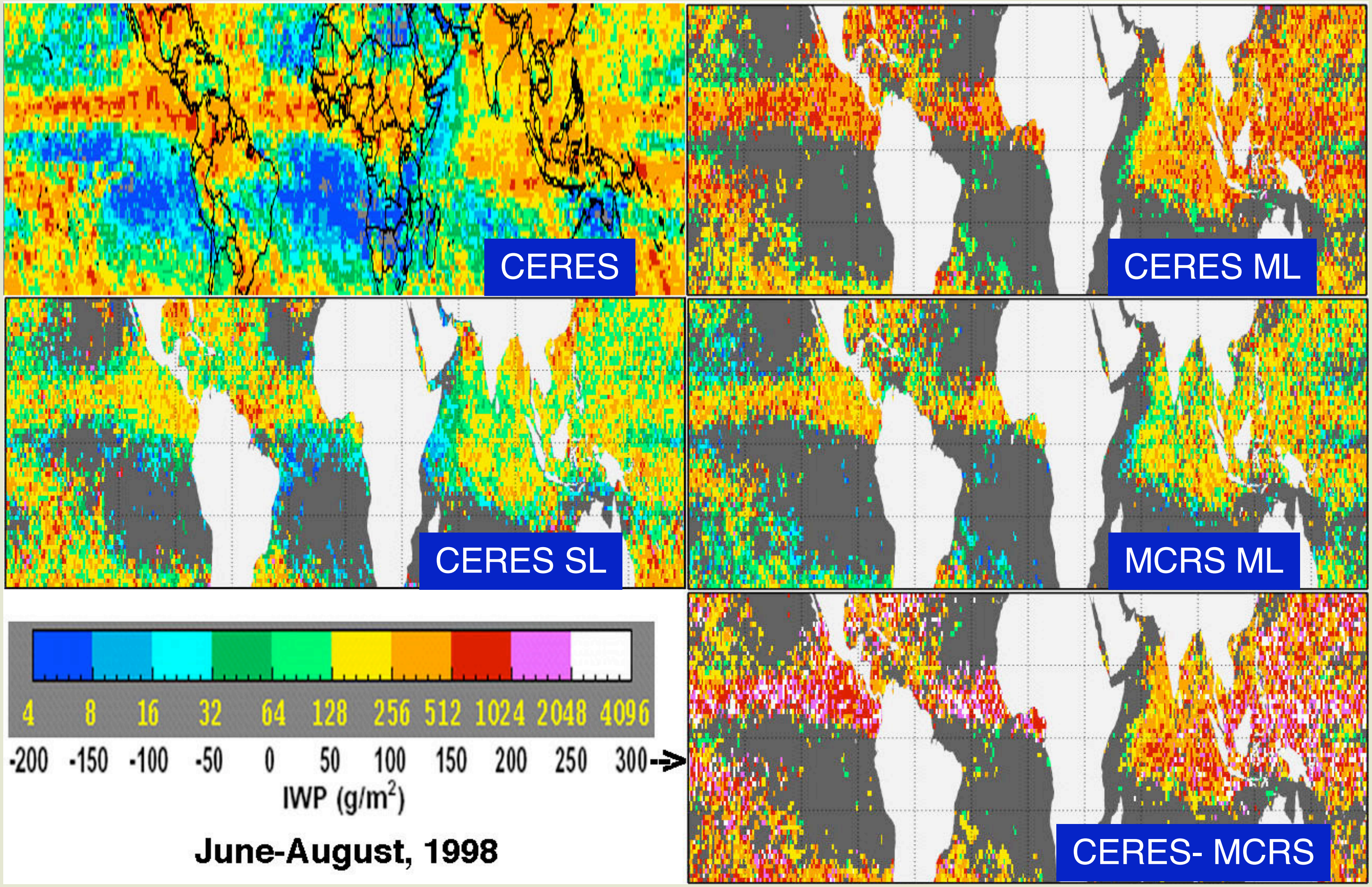


ARM TWP (Aqua)



Mean MCRS results within 10% of surface radar retrievals

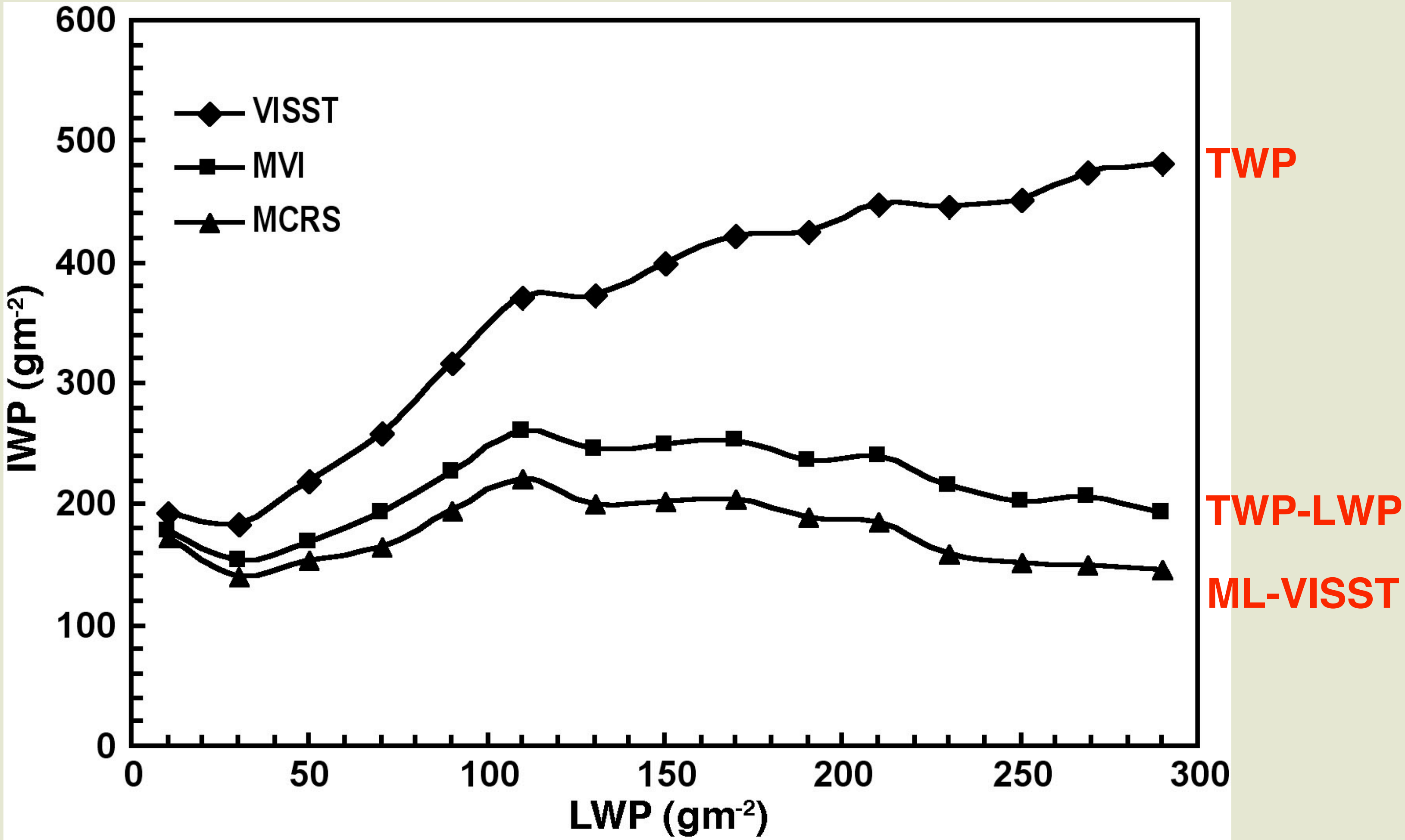
Example: MCRS applied to TRMM VIRS & TMI data



- MCRS ML distribution similar to CERES SL
- MCRS ML IWP > CERES SL

MCRS applied to 1998 TRMM VIRS & TMI data

Dependence of ML IWP on LWP



- IWP + LWP < TWP

explicit radiance modeling reduces total water path!

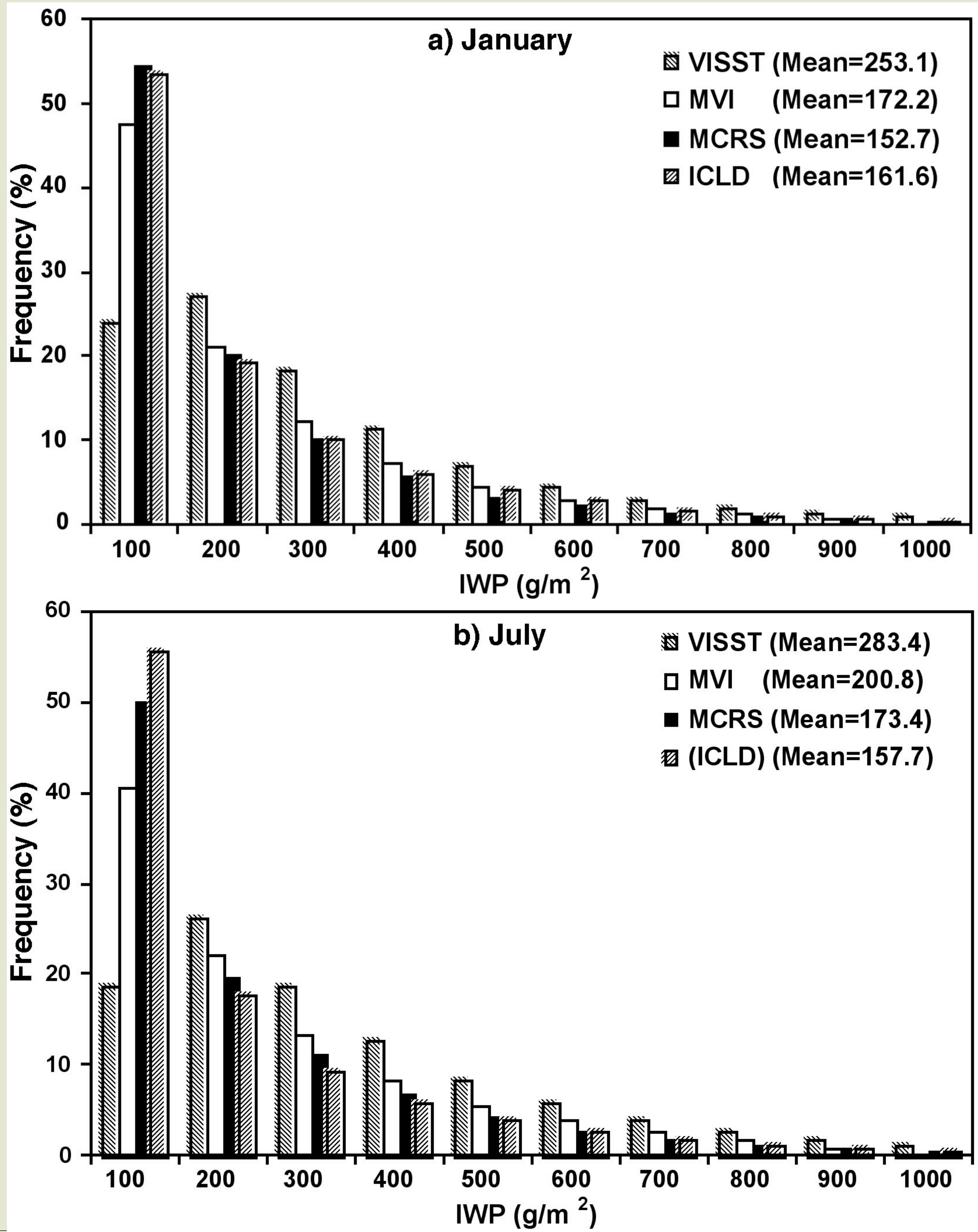
Example

MCRS applied to 1998 TRMM VIRS & TMI data

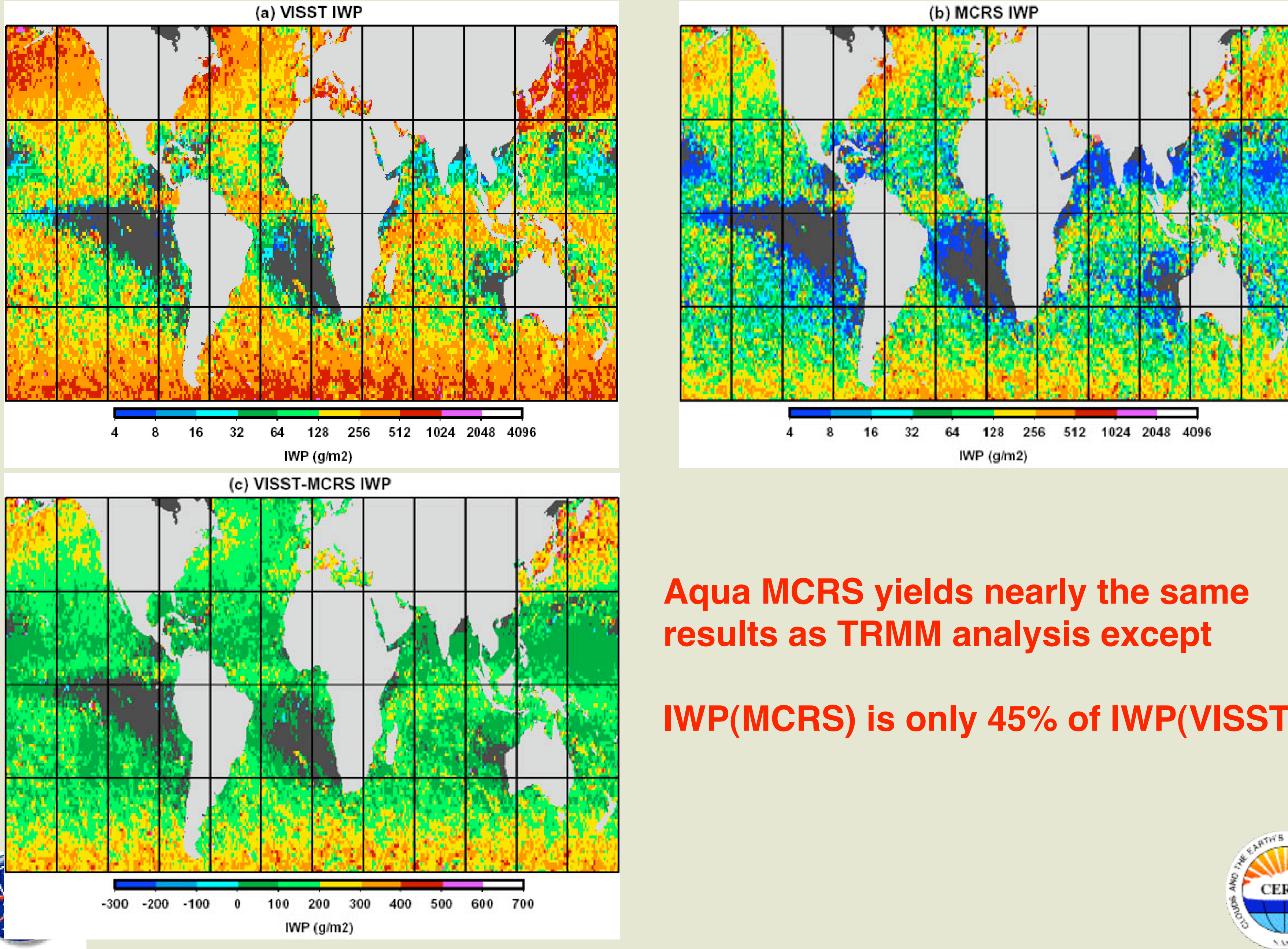
IWP Histograms

Accounting for overlap with MCRS yields nearly the same frequency of thin ice clouds (IWP < 100) as the single layer ice clouds (ICLD).

IWP(MCRS) ~10% > IWP(ICLD)



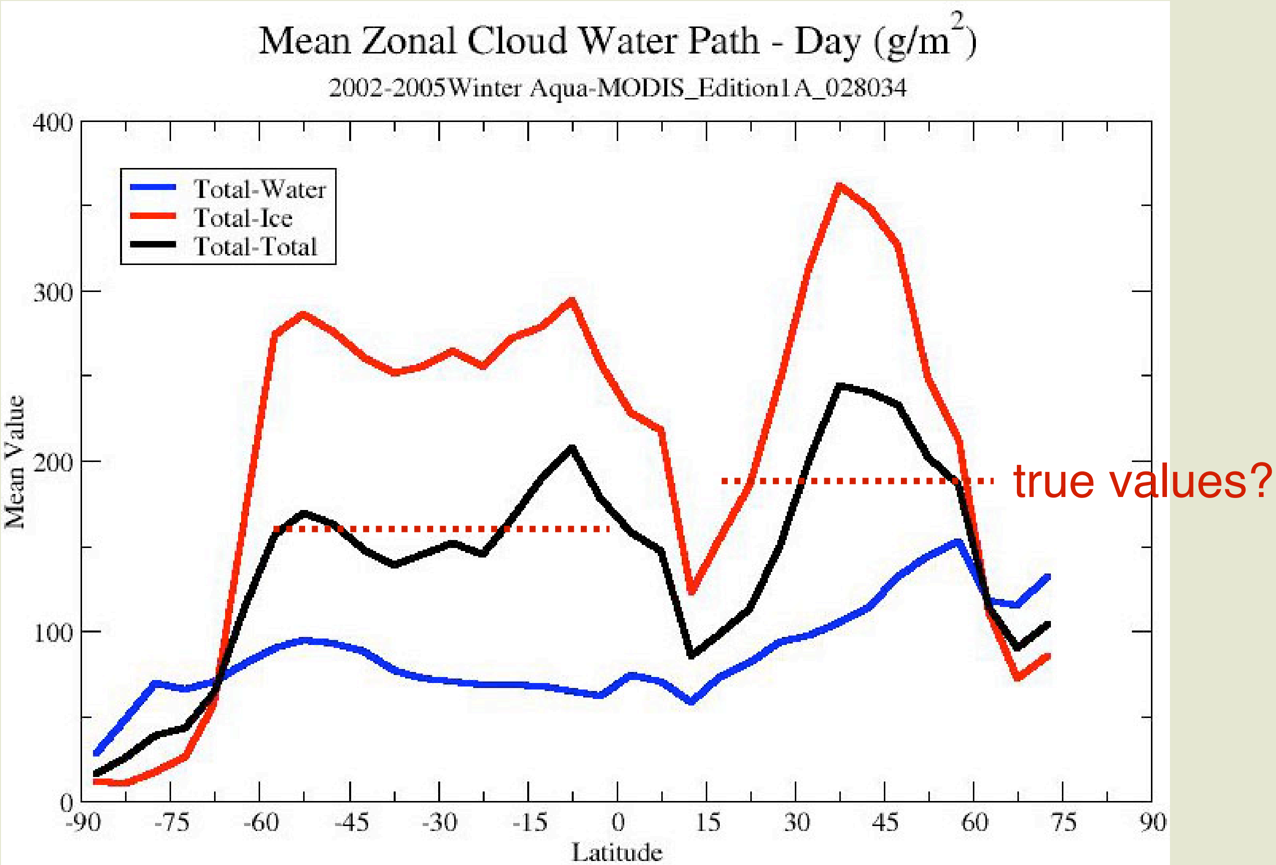
MCRS applied to Aqua MODIS & AMSR-E data (DJF, 04-05)



Aqua MCRS yields nearly the same results as TRMM analysis except

IWP(MCRS) is only 45% of IWP(VISST)

• Very large mean IWP values (> 250 gm^{-2}) seen in many areas are likely due to ML clouds



• Actual IWP could be around 50-60% less than current estimates

• Overall, WP is smaller than SL estimates

CERES Edition 3 ML Detection Method

Chang & Li (2005) CO2-slicing overlapped cloud detection and retrieval method

- only detects and analyzes ML clouds when upper cloud $\tau < 4$
- no snow surfaces or nighttime, works over land & ocean
- altered to use ML-VISST

• Uses CO2-slicing to estimate T_u, τ_u, and Z_u
VISST to estimate T_c, τ and De

• Compares T_c and T_u & τ and τ_u to detect ML clouds

When ML,

• Use adjacent SL areas to estimate T_L and r_e of lower cloud, T_L to get Z_L

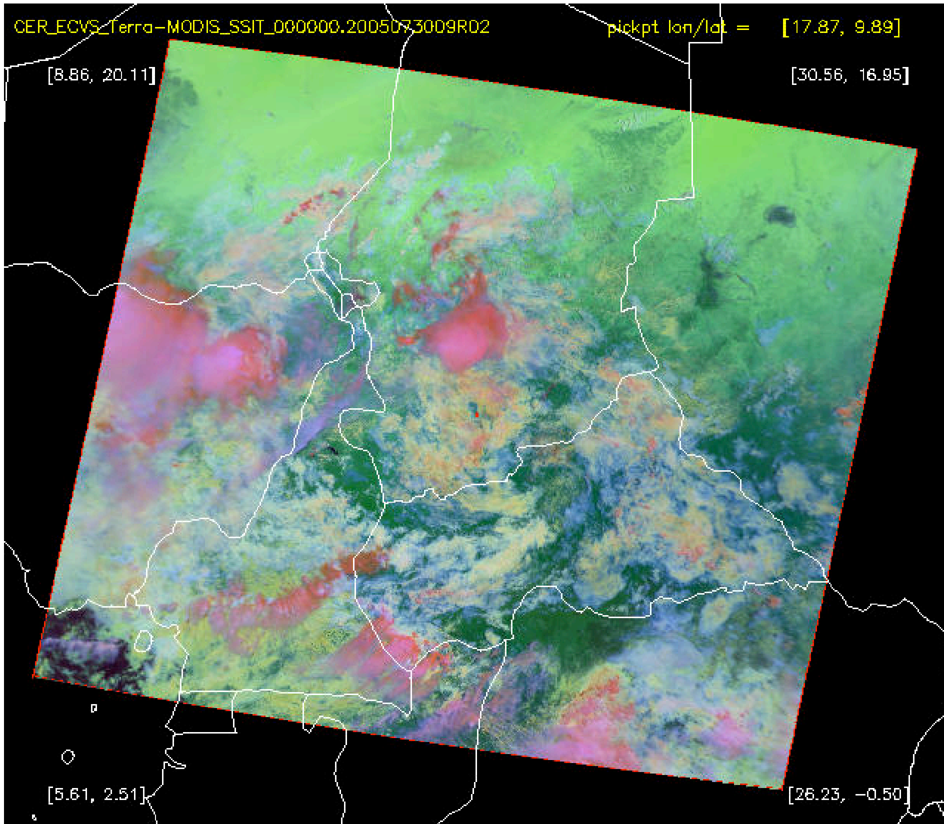
• Uses ML-VISST to estimate τ_L and LWP of lower cloud

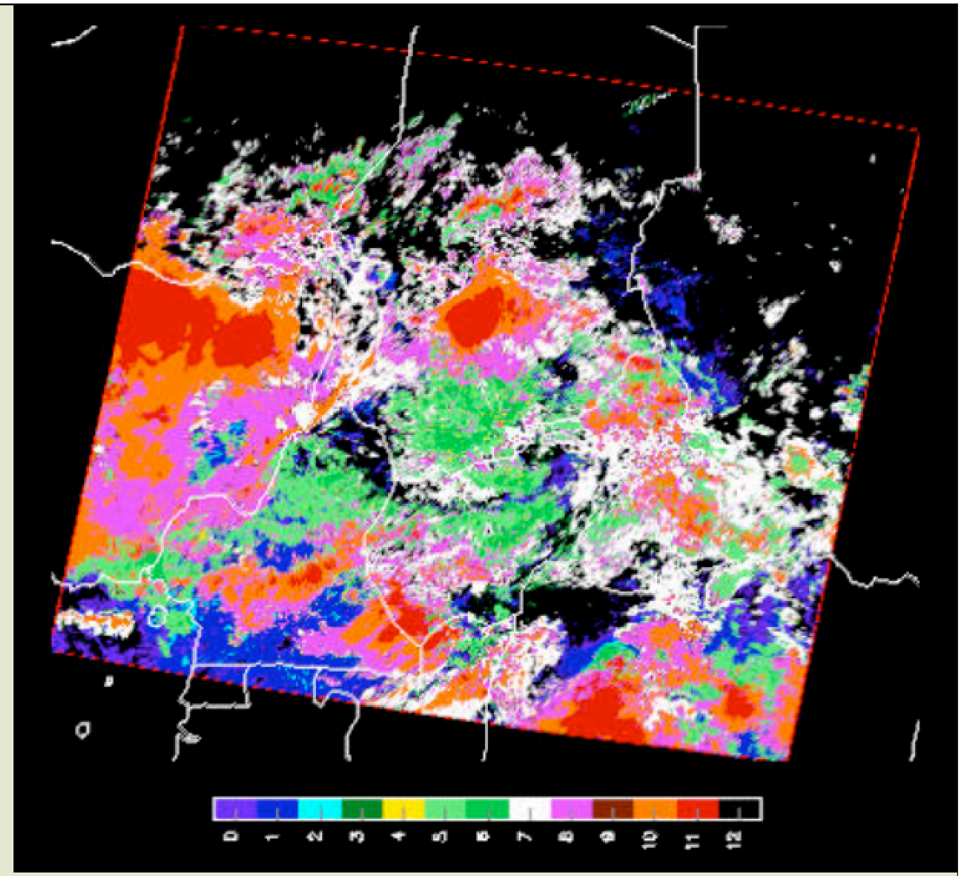
• Iterate first three steps to refine all values

* Technique denoted as the CO2-slicing Multilayered Approach (COMA)

Classification of updated CO2-slicing Multi-layer Cloud Mask

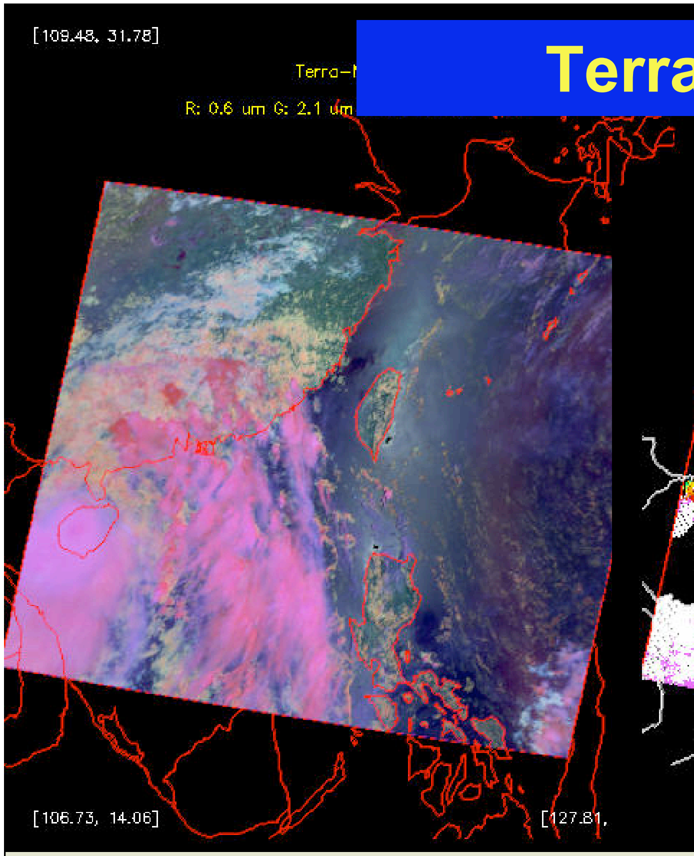
	Code	Code Description
Pc < 440 mb IR ε > 0.85	3 3 3 3 3 2 3 3 1 3 3 0	High cloud, High**3**, with adjacent mid+low High cloud, High**3**, with adjacent mid High cloud, High**3**, with adjacent low High cloud, High**3**, without adjacent mid or low
Pc < 440 mb IR ε < 0.85	3 2 3 3 2 2 3 2 1 3 2 0	High cloud, High**2**, overlap with mid+low High cloud, High**2**, overlap with mid High cloud, High**2**, overlap with low High cloud, High**2**, marginal overlap/uncertain
Pc < 440 mb IR ε < 0.85	3 1 0	High cloud, High**1**, no overlap
Pc = 440-680 mb IR ε > 0.85	2 3 1 2 3 0	Mid cloud, Mid**3**, with adjacent low Mid cloud, Mid**3**, without adjacent low
Pc = 440-680 mb IR ε < 0.85	2 2 1 2 2 0	Mid cloud, Mid**2**, overlap with low Mid cloud, Mid**2**, marginal overlap/uncertain
Pc = 440-680 mb IR ε < 0.85	2 1 0	Mid cloud, Mid**1**, no overlap
Pc > 680 mb	1 1 0	Low cloud, Low**1**, no overlap



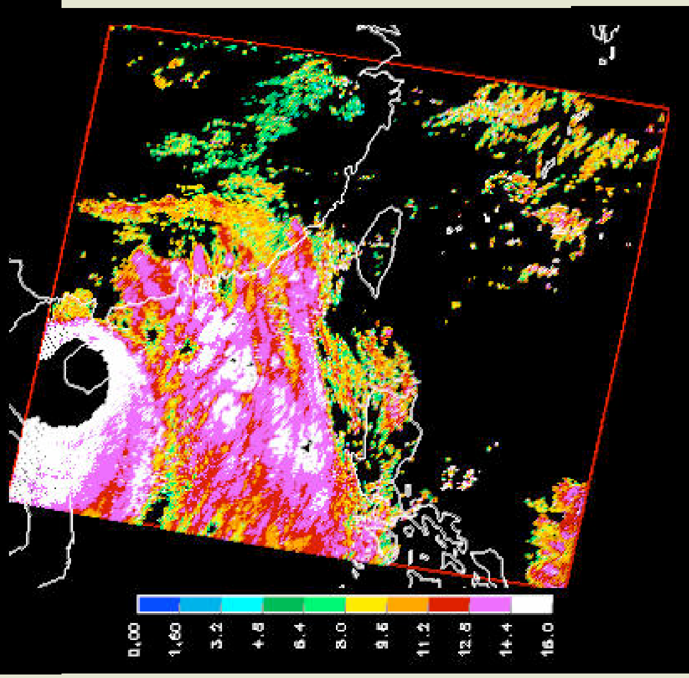


Low Cloud		Mid Cloud		High Cloud	
0 (110)	$0 < \tau < 3.6$	3 (210)	$0 < \tau < 3.6$	7 (310)	$0 < \tau < 3.6$
1 (110)	$3.6 < \tau < 23$	4 (220-221)	overlap	8 (321-323)	overlap
2 (110)	$\tau > 23$	5 (230-231)	$3.6 < \tau < 23$	9 (320)	marginal
		6 (230-231)	$\tau > 23$	10 (330-333)	$3.6 < \tau < 23$
				11 (330-333)	$\tau > 23$

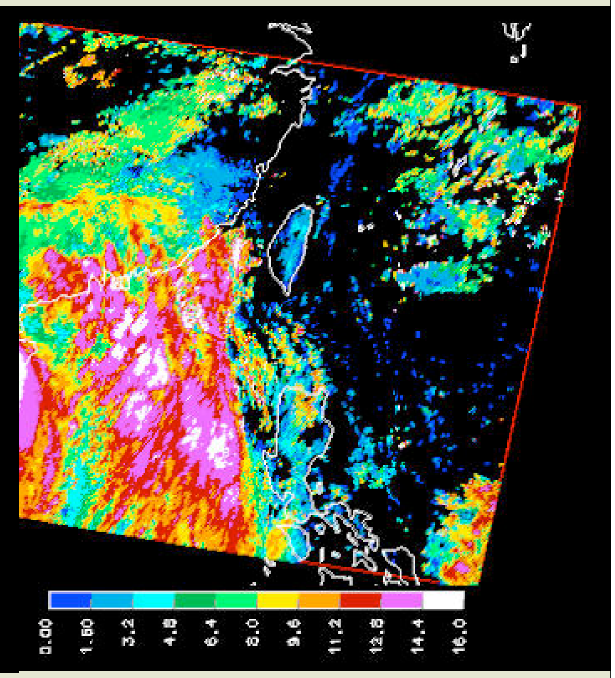
Terra CO2-Slicing Example



July 30, 2005

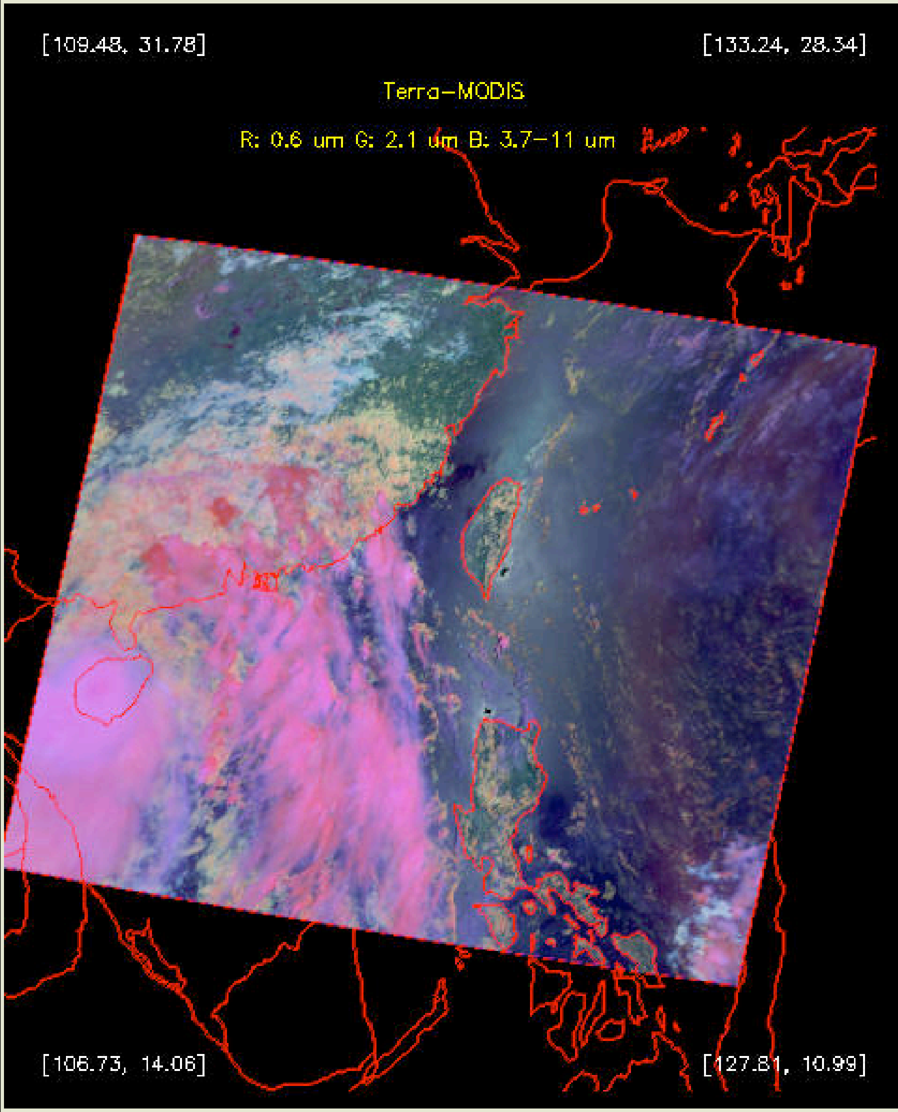


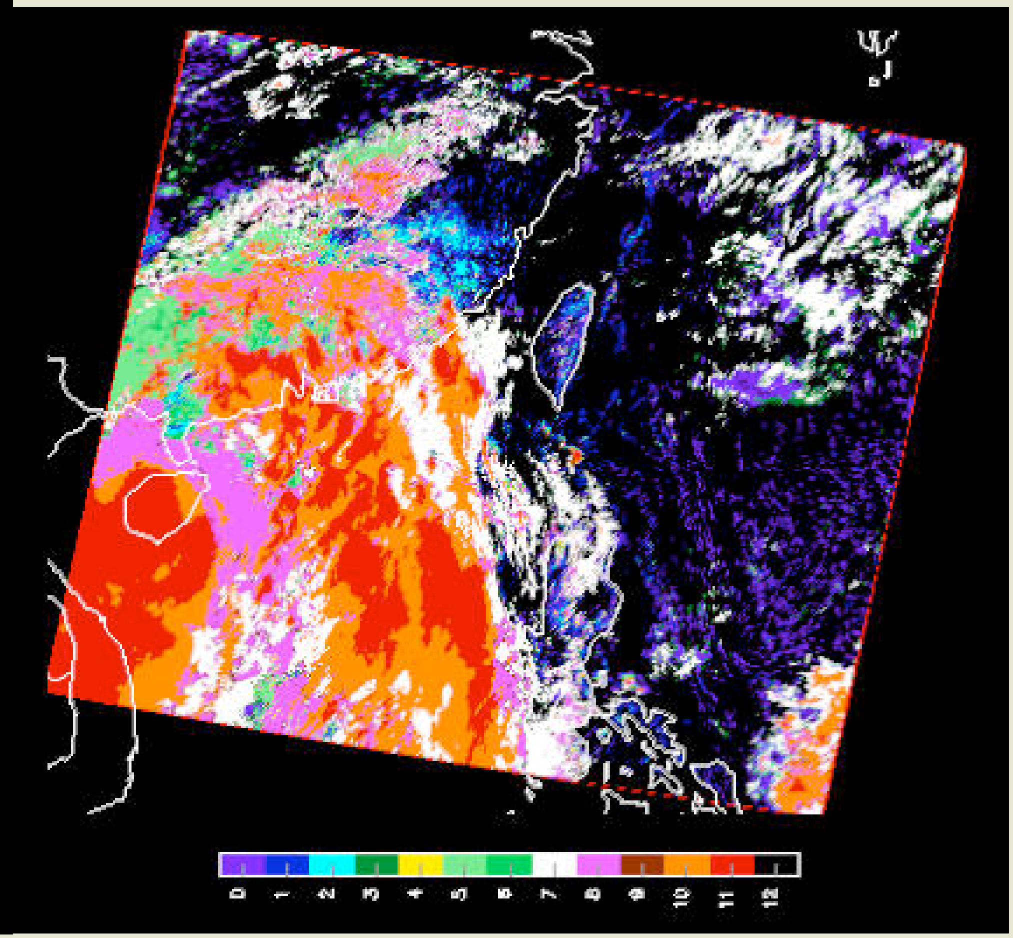
CO2 Cloud Top Ht



VISST Eff Ht

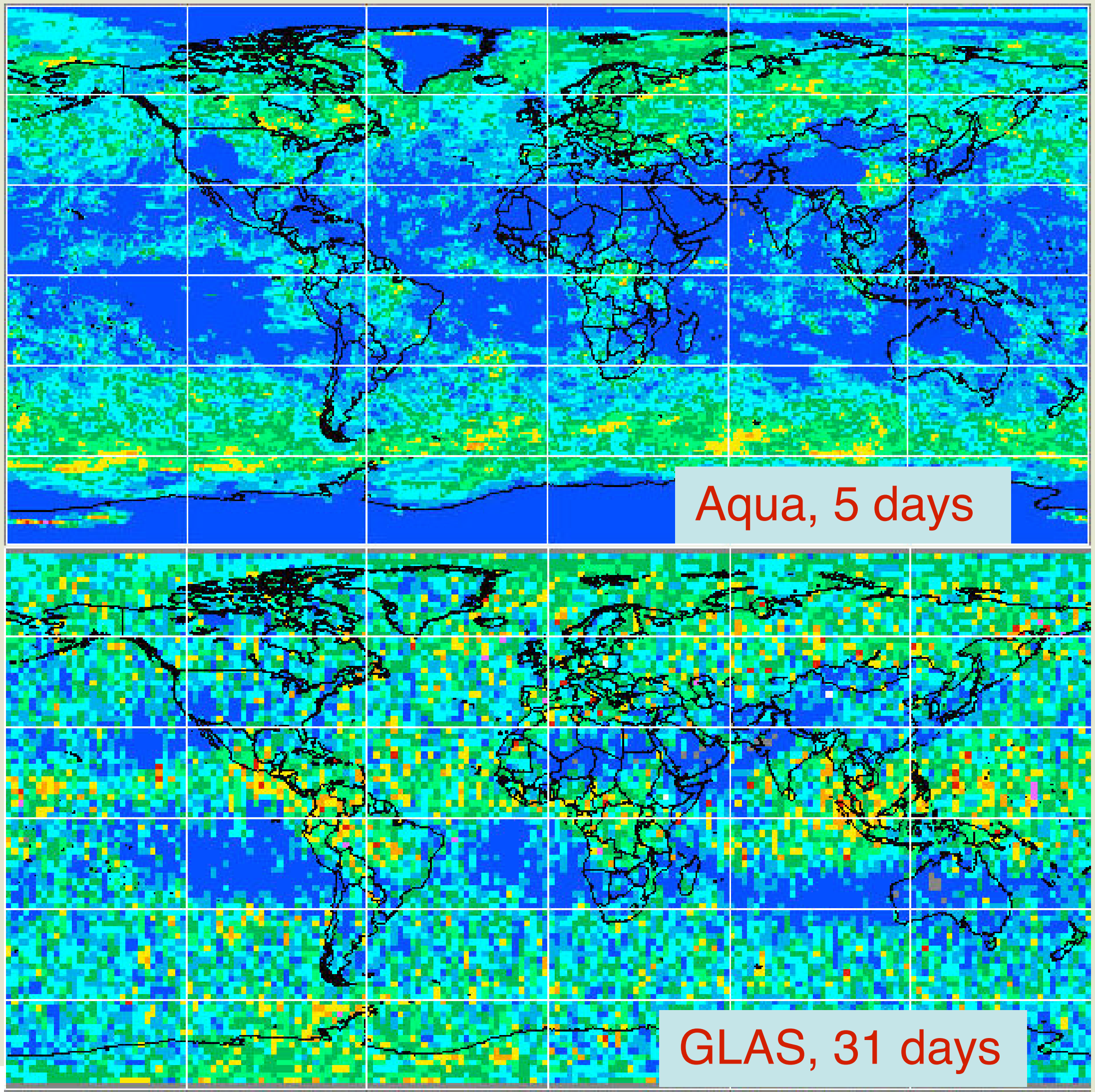
Terra COMA Example





Pink & yellow are overlapped

Testing of COMA with October 2003 data



- General patterns mostly similar
- ML missed in maritime cont
  - ice/ice GLAS?
  - Cu too small for COMA
- Less ML in many convective regions
- More ML in SH midlat
  - thicker ice/water?

These issues and more will be addressed in the coming months using GLAS, MCRS, & CALIPSO

Multispectral particle size retrieval

- Two wavelengths will be used to retrieve reff or Deff in Ed3 VISST
  - not over ice/snow
  - 2.1, 3.8 μm
- Retrieval yields new size and τ, which will be added to SSF
- Results should give information about precipitation & cloud structure
- Better estimates of LWP/IWP are possible
- Possible feedback to alter phase

OTHER ISSUES TO BE HANDLED IN ED3

- Smoother polar transition
- mixed phase clouds in Arctic (flag only)
- General mask/retrieval & calibration upgrades
  - fix lapse rate approach in midlevel inversion cases
- 1.6 vs 2.1 µm: 2.1 only for Terra SINT?
- Improved clear-sky
  - better updating of our maps
  - code changes in VIS parameterization
- Streamline code=> faster

CERES cloud-related papers published/accepted/submitted since last STM

1. Huang, J., B. Lin, P. Minnis, T. Wang, X. Wang, Y. Hu, Y. Yi, and J. K. Ayers, 2006: Satellite-based assessment of possible dust aerosols semi-direct effect on cloud water path over east Asia. *Geophys. Res. Lett.,* **33**, L19802, doi:10.1029/2006GL026561.

2. Kato, S., N. G. Loeb, P. Minnis, J. A. Francis, T. P. Charlock, D. A. Rutan, and E. E. Clothiaux, 2006: Seasonal and interannual variations of top-of-atmosphere irradiance and cloud cover over the Arctic derived from the CERES data set. *Geophys. Res. Lett.,* **33**, L18904, doi:10.1029/2006GL026685.

3. Ignatov, A., P. Minnis, W. Miller, B. Wielicki, and L. Remer, 2006: Consistency of global MODIS aerosol optical depths over ocean on Terra and Aqua CERES SSF datasets. J. *Geophys. Res*., **111**, D14202, doi:10.1029/2005JD006645.

4. Chiriaco, M., et al., 2006: Comparison of CALIPSO-like, LaRC, and MODIS retrievals of ice cloud properties over SIRTA in France and Florida during CRYSTAL-FACE. In press, *J. Appl. Meteorol. Climatol.*

5. Lin, B., B. A. Wielicki, P. Minnis, L. Chambers, K. Xu, Y. Hu, and A. Fan, 2006: The effect of environmental conditions on tropical deep convective systems observed from the TRMM satellite. In press, *J. Climate*.

6. Chepfer, H., P. Minnis, P. Dubuisson, M. Chiriaco, S. Sun-Mack, and E. D. Riviere, 2006: Nitric acid particles in cold thick ice clouds observed at global scale: Link with lightning, temperature, and upper tropospheric water vapor. In press, *J. Geophys. Res.*

7. Huang, J., P. Minnis, B. Lin, Y. Yi, T.-F. Fan, S. Sun-Mack, and J. K. Ayers, 2006: Determination of ice water path in ice-over-water cloud systems using combined MODIS and AMSR-E measurements. In press, *Geophys. Res. Lett.*, doi:10.1029/2006GL027038.

7 Papers submitted/ready related to CERES Clouds since last STM

8. Verlinde, H., et al., 2006: The Mixed-Phase Arctic Cloud Experiment (M-PACE). In press, *Bull. Am. Meteorol. Soc.*

9. Minnis, P., J. Huang, B. Lin, Y. Yi, R. F. Arduini, T.-F. Fan, J. K. Ayers, and G. G. Mace, 2006: Ice cloud properties in ice-over-water cloud systems using TRMM VIRS and TMI data. Accepted, *J. Geophys. Res.*, 10.1029/2006JD007626.

10. Spangenberg, D. A., P. Minnis, M. D. Shupe, M. R. Poellot, and Z. Wang, 2006: Mixed-phase cloud detection over the Atmospheric Radiation Measurmeent North Slope of Alaska site from MODIS 6.7 - 12.0 µm data. Submitted to *J. Atmos. Oceanic Technol.*

11. Chepfer, H., P. Dubuisson, M. Chiriaco, P. Minnis, S. Sun-Mack, and E. D. Riviere, 2006: Negative brightness temperature differences (11-12 µm) in cold thick ice clouds: A signature of nitric acid. Submitted to *Remote Sens. Environ.*

12. Chepfer, H., P. Dubuisson, P. Minnis, A. Hauchecorne, M. Chiriaco, and S. Sun-Mack, 2006: Observations of nitric acid particles in cloudy conditions in polar regions by passive remote sensing. Submitted to *J. Appl. Meteorol. Climatol.*

13. Minnis, P., D. R. Doelling, L. Nguyen, and W. F. Miller, 2006: Intercalibration of the visible channels on the TRMM VIRS and MODIS on Terra and Aqua. Submitted, *J. Atmos. Oceanic Technol.*

CERES cloud-related conference papers published since last STM

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