CERES Ed4 Cloud Properties

P. Minnis, D. Doelling (calibration), W. L. Smith (offline val)

NASA Langley Research Center, Hampton, VA, USA

S. Sun-Mack (QB), Q. Trepte (mask), F-L. Chang (CO2, ML), T. Chee (web, DM), R. Arduini (RTM), K. Bedka (OT tops), S. Bedka (SIST), R. Brown (QC), Y. Chen (clr props, test runs), S. Gibson (graphics), E. Heckert (web, IG), G. Hong (night tau), M. Khaiyer (val), R. Palikonda (offline testing), R. Smith (web, NPP), D. Spangenberg (polar), Y. Yi (thickness), C. Yost (phase)

SSAI, Hampton, VA, USA

P. W. Heck (retrieval algo)

CIMSS, U. Wisconsin, Madison, Wi, USA

P. Yang, Y. Xie (ice cloud models)

Texas A&M Univ., College Station, TX, USA

CERES Edition 2 Algorithms & Result Summaries

Minnis, P., Q. Z. Trepte, S. Sun-Mack, Y. Chen, D. R. Doelling, et al., 2008: Cloud detection in non-polar regions for CERES using TRMM VIRS and Terra and Aqua MODIS data. *IEEE Trans. Geosci. Remote Sens.*, **46**, 3857-3884.

Minnis, P., S. Sun-Mack, D. F. Young, P. W. Heck, D. P. Garber, et al., 2010: CERES Edition-2 cloud property retrievals using TRMM VIRS and Terra and Aqua MODIS data, Part I: Algorithms. Submitted to *IEEE Trans. Geosci. Remote Sens., in revision*

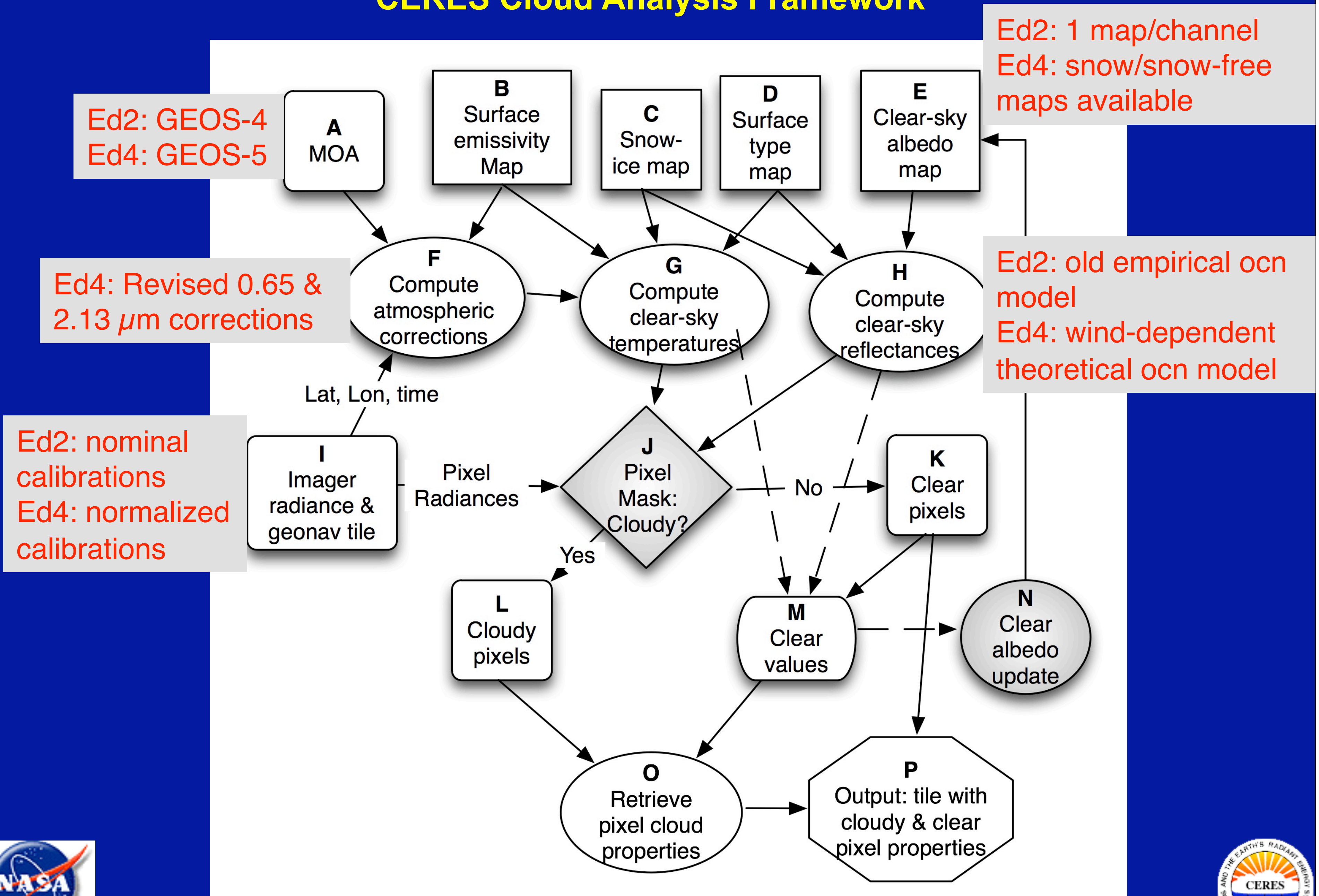
Minnis, P., S. Sun-Mack, Y. Chen, M. M. Khaiyer, Y. Yi, et al., 2010: CERES Edition-2 cloud property retrievals using TRMM VIRS and Terra and Aqua MODIS data, Part II: Examples of average results and comparisons with other data. Submitted to *IEEE Trans. Geosci. Remote Sens., in revision*

Chen, Y., S. Sun-Mack, P. Minnis, D. F. Young, and W. L. Smith, Jr., 2004: Seasonal surface spectral emissivity derived from Terra MODIS data. *Proc. 13th AMS Conf. Satellite Oceanogr. and Meteorol.*, Norfolk, VA, Sept. 20-24, CD-ROM, P2.4.

Trepte, Q., P. Minnis, and R. F. Arduini, 2002: Daytime and nighttime polar cloud and snow identification using MODIS data. *Proc. SPIE 3rd Intl. Asia-Pacific Environ. Remote Sensing Symp. 2002: Remote Sens. of Atmosphere, Ocean, Environment, and Space*, Hangzhou, China, October 23-27, Vol. 4891, 449-459.

Chen, Y., S. Sun-Mack, P. Minnis, and R. F. Arduini, 2006: Clear-sky narrowband albedo variations derived from VIRS and MODIS data. *Proc. AMS 12th Conf. Atmos. Radiation*, Madison, WI, July 10-14, CD-ROM, 5.6.

CERES Cloud Analysis Framework

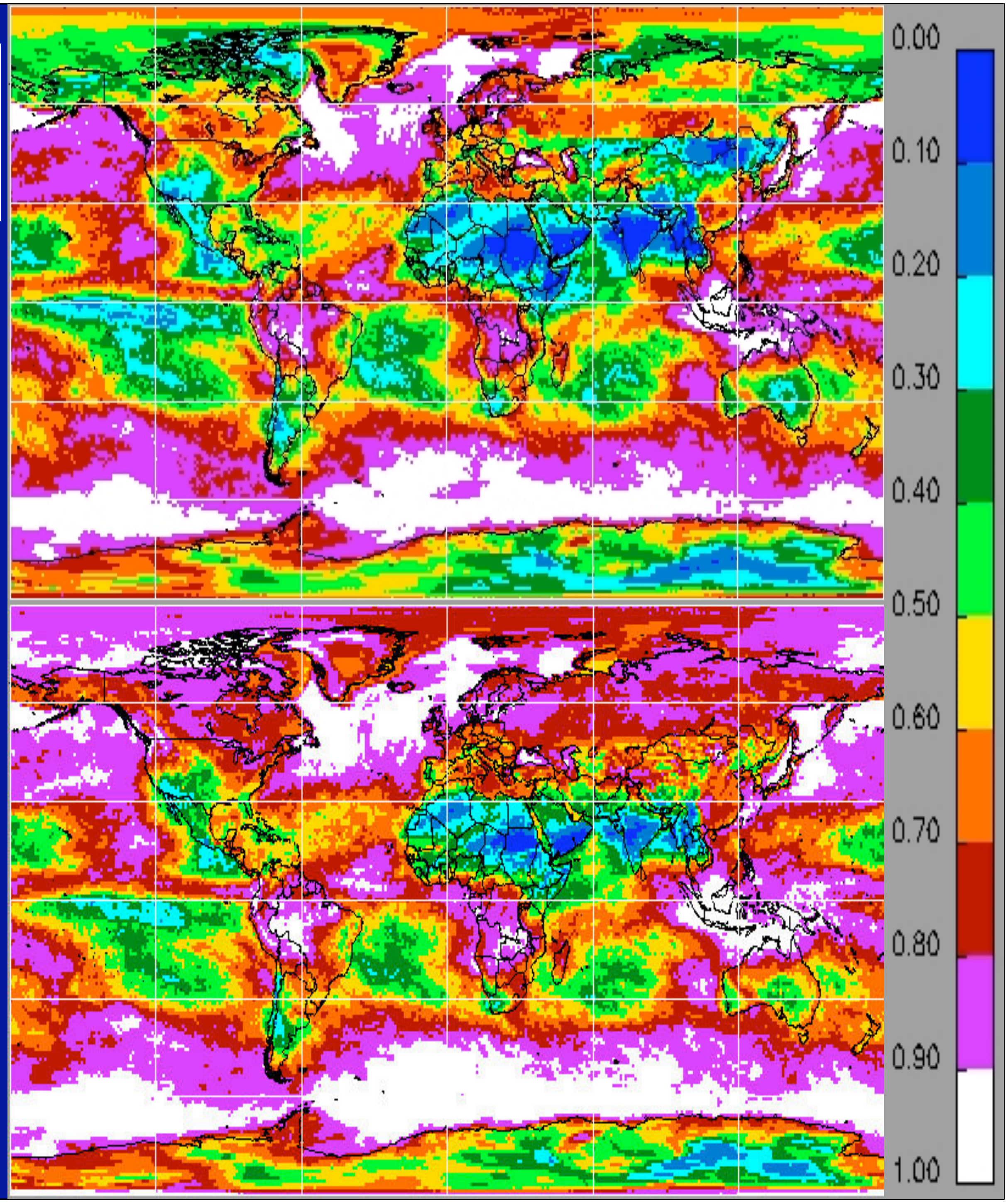


Evaluation of Ed3β Cloud Mask

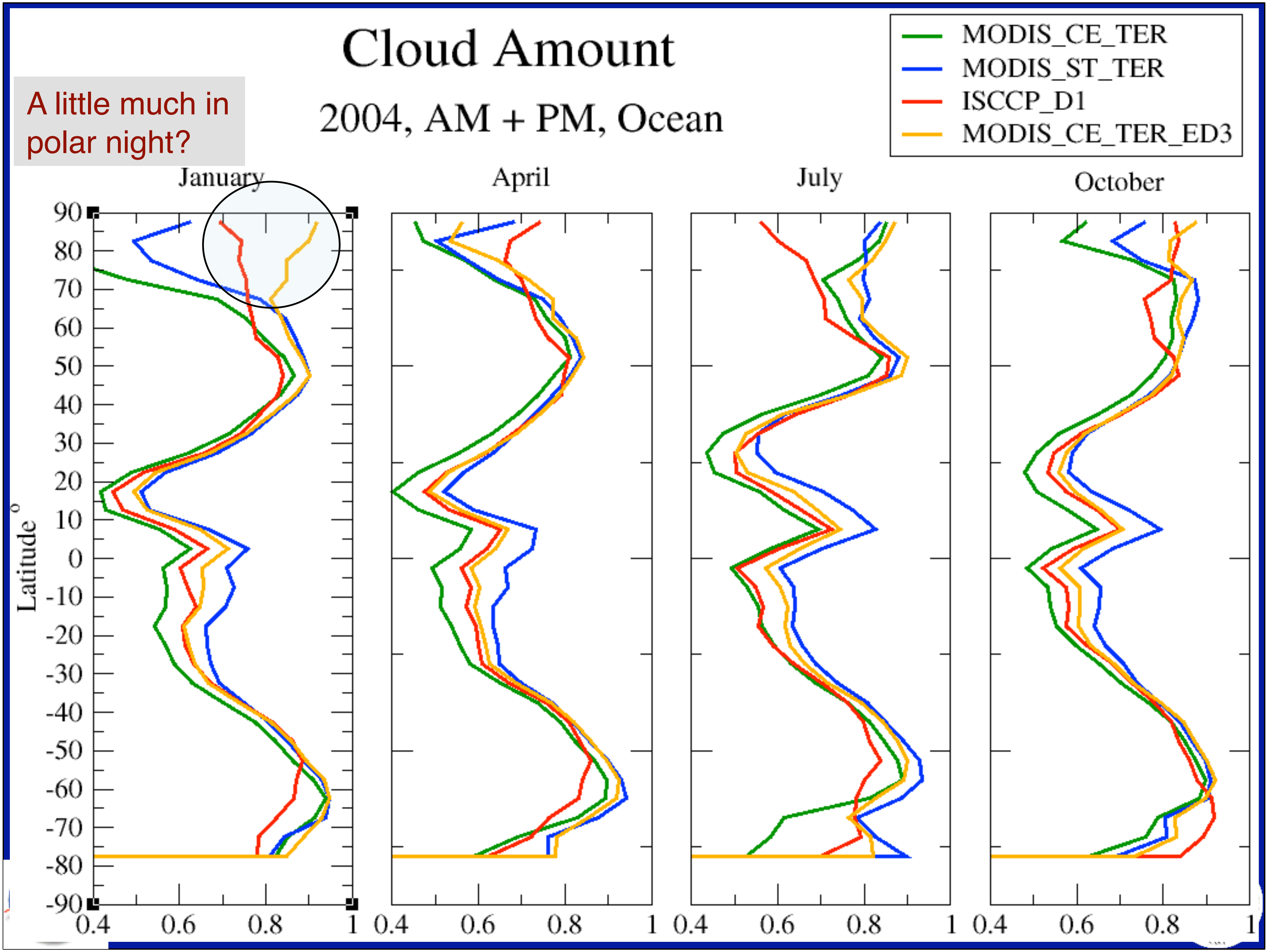
Mean Cloud Amounts from
Terra MODIS
January 2006

CERES Ed2

CERES Ed3

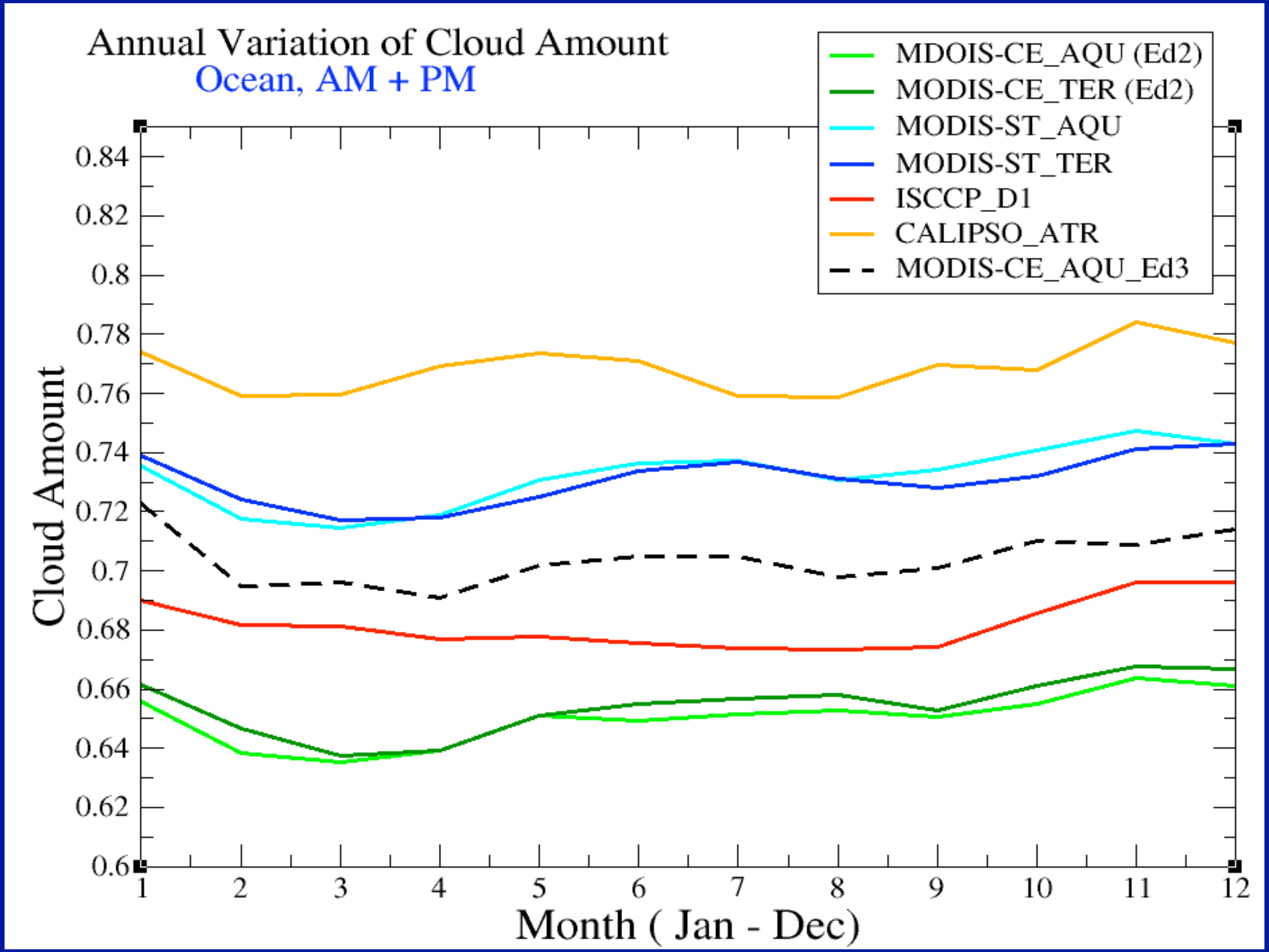


Cloud amounts generally increased at all locations, especially small cumulus



Cloud Amount
2004, AM + PM, Ocean
MODIS_CE_TER
MODIS_ST_TER
ISCCP_D1
MODIS_CE_TER_ED3
A little much in polar night?
January
April
July
October
Latitude °
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
0.4
0.6
0.8
1

Comparison of Monthly Mean Global Cloud Amounts



- CERES Ed2 less than others, ~0.11 less than CALIPSO
  - over land, 0.15 less
- CERES Ed3 > ISCCP, ~0.06 less than CALIPSO, V2
  - over land, 0.10 less

CERES (Ed4) Cloud Mask Changes since Apr 2010 STM

Highlights:

1. Added Terra VIS reflectance adjustment using Aqua VIS as reference

2. Tested adjusted Terra 3.8-μm brightness temperature calibration

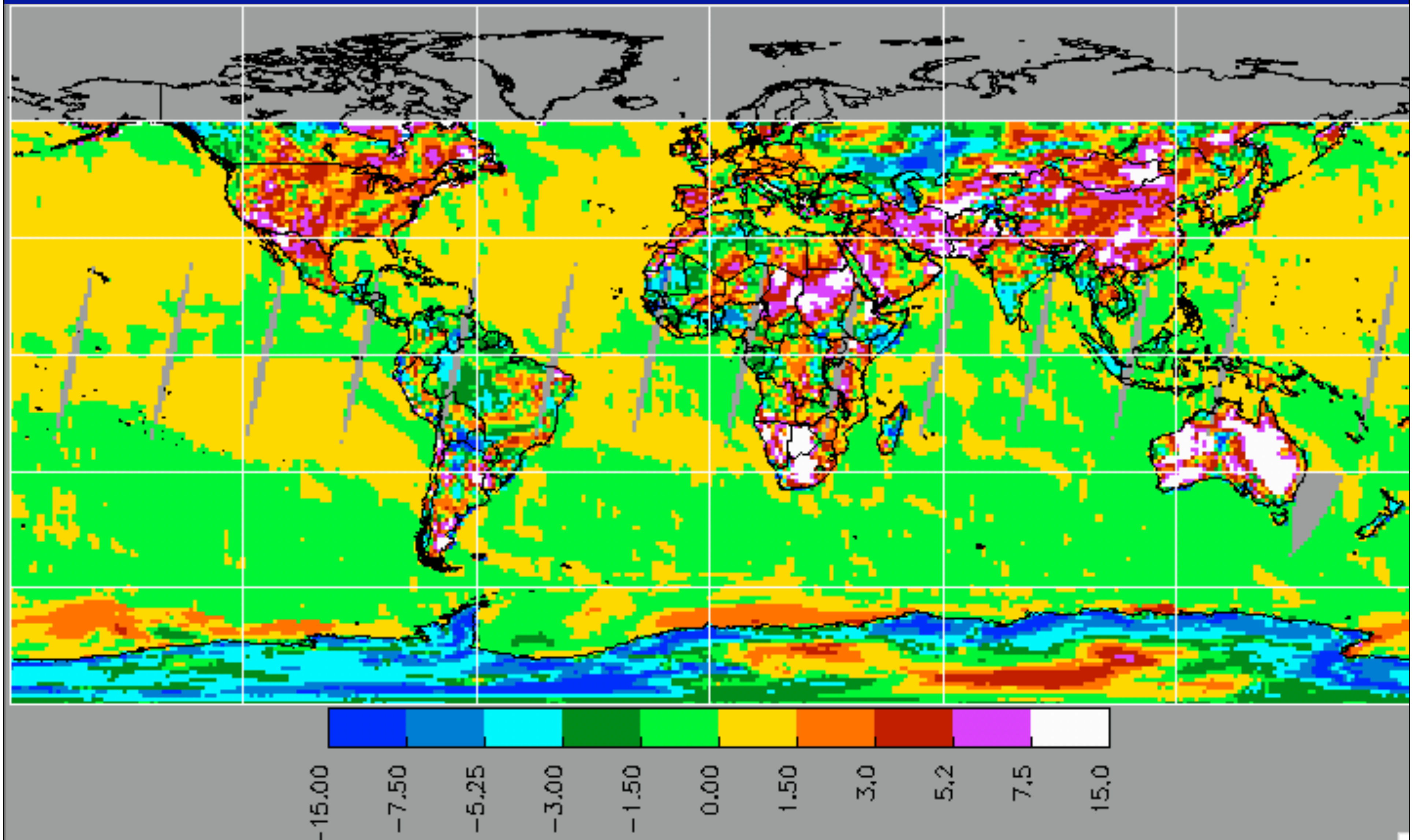
3. Reduced false clouds in various areas:

    - Polar night
    - Sun Glint ocean
    - Thin Cirrus

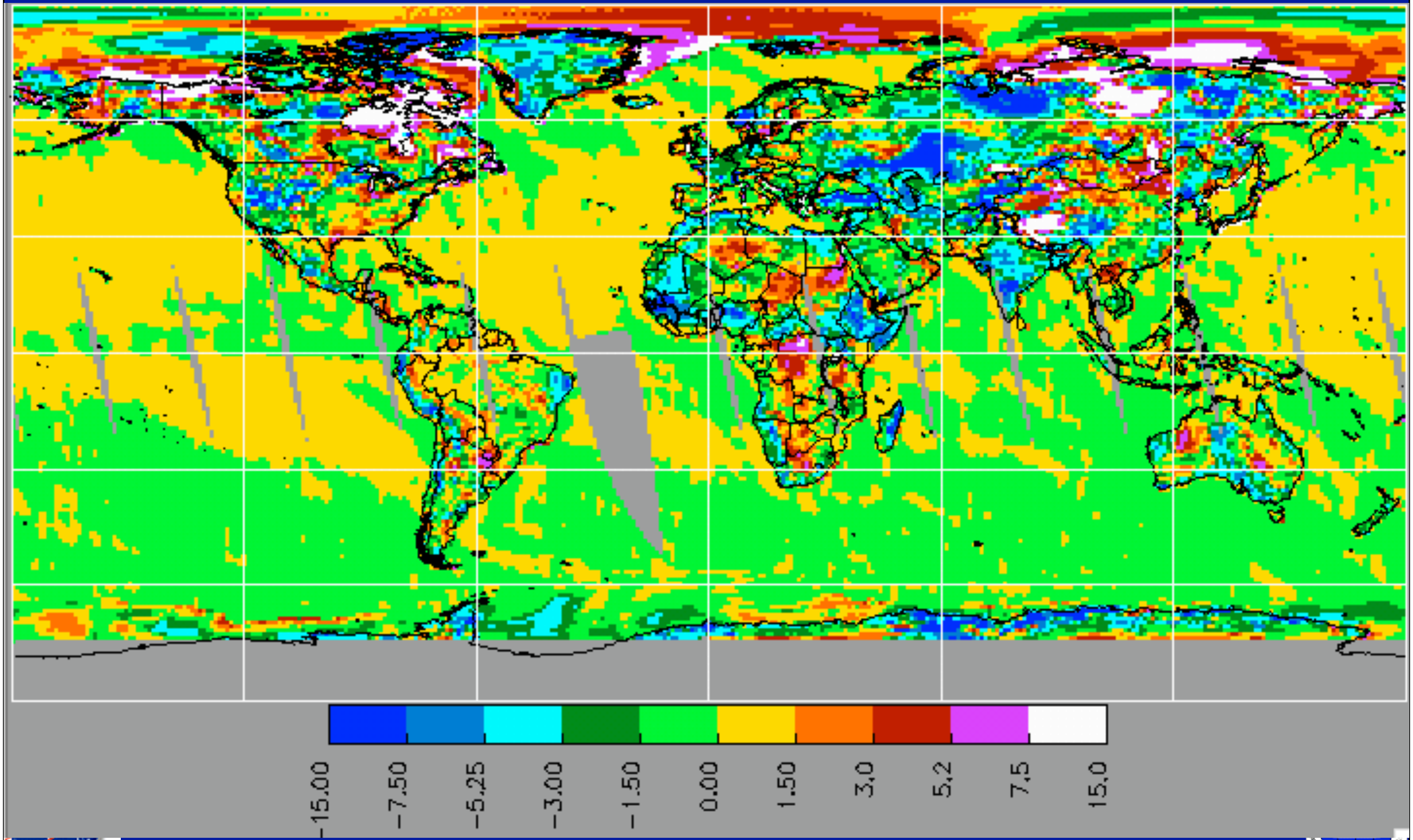
4. Tested impact of replacing GEOS4 MOA with “final” G5 MOA in CERES Ed4 cloud mask

Impact of using “final” G5 MOA
in CERES Ed4 cloud mask

Skin Temperature Difference (K), T(G5) – T(G4), 15 Dec 2007
Daytime

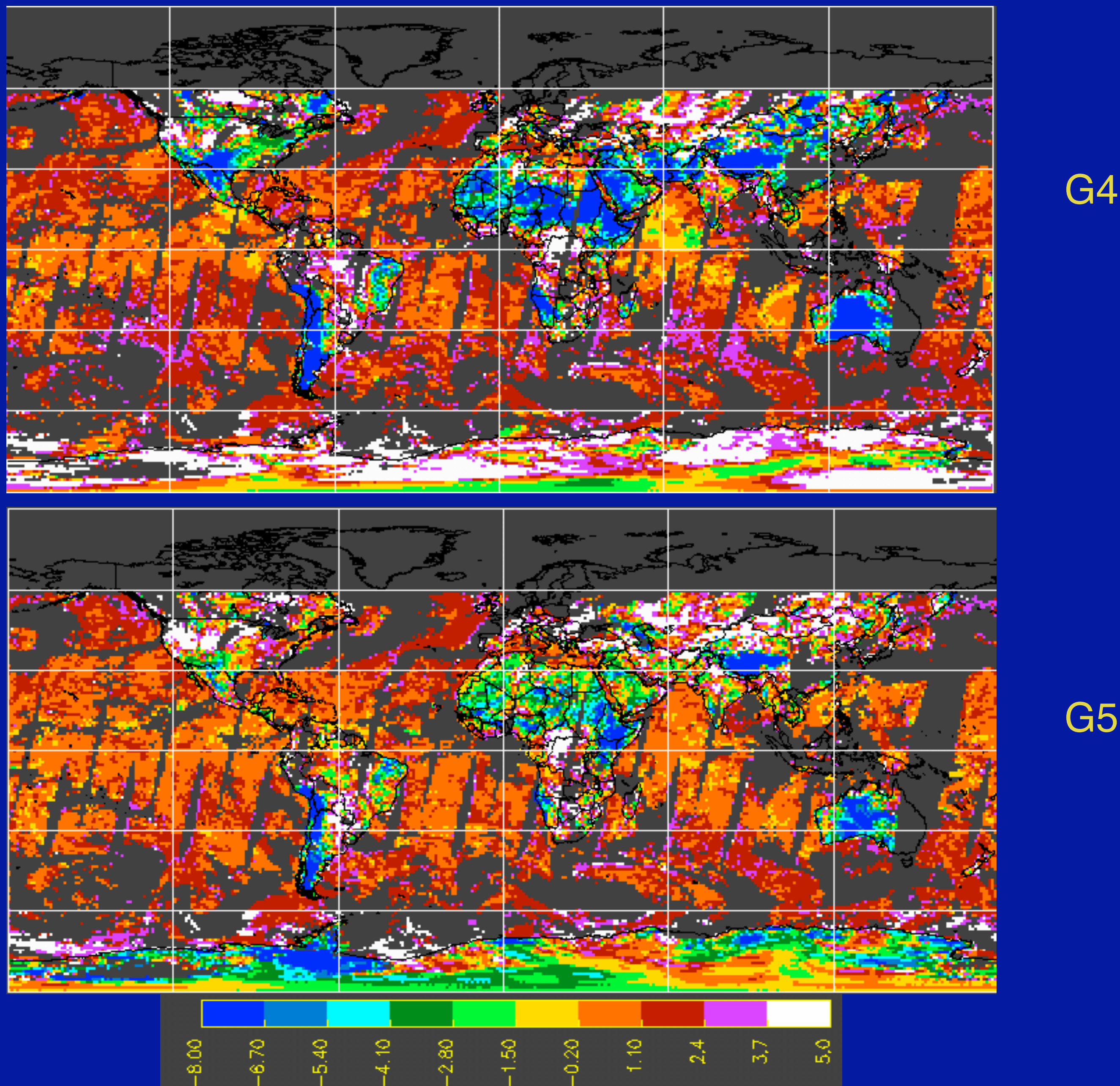


Skin Temperature Difference (K), T(G5) – T(G4), 15 Dec 2007
Night



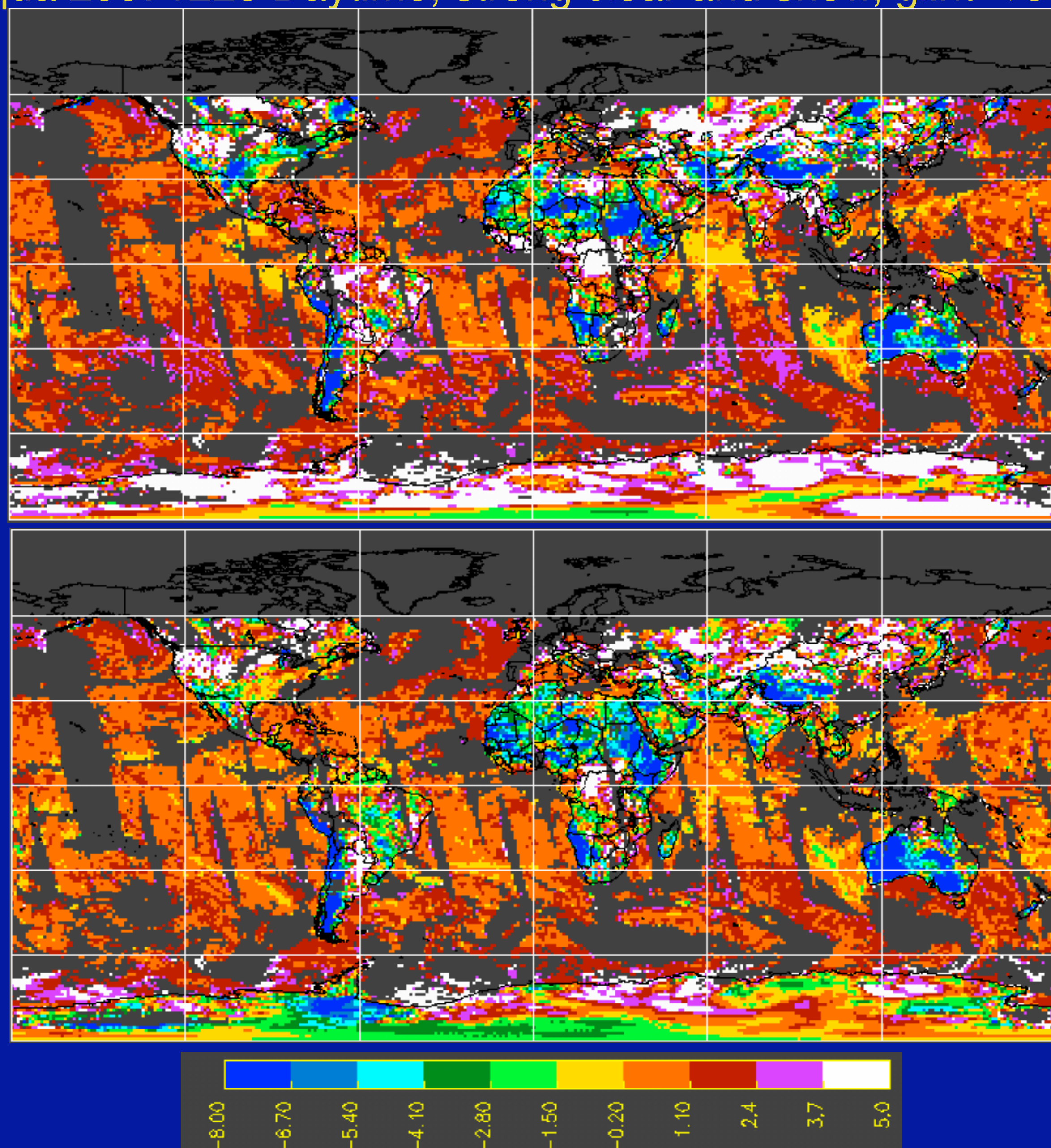
TOA 11 um Clear Sky T - MODIS obs. T11

Terra 20071225 Daytime, strong clear and snow, glint < 50%



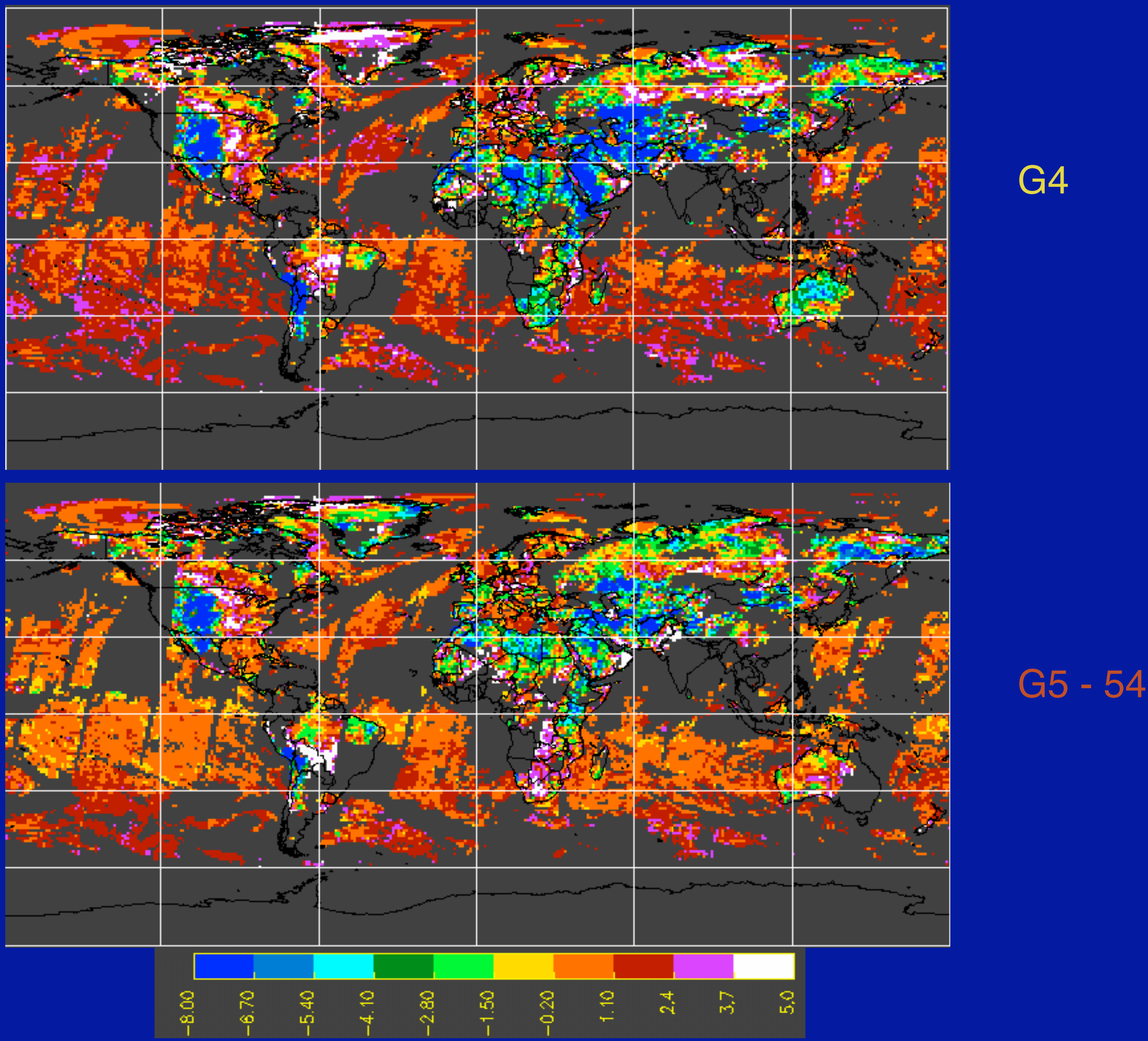
TOA 11 um Clear Sky T - MODIS obs. T11

Aqua 20071225 Daytime, strong clear and snow, glint < 50%



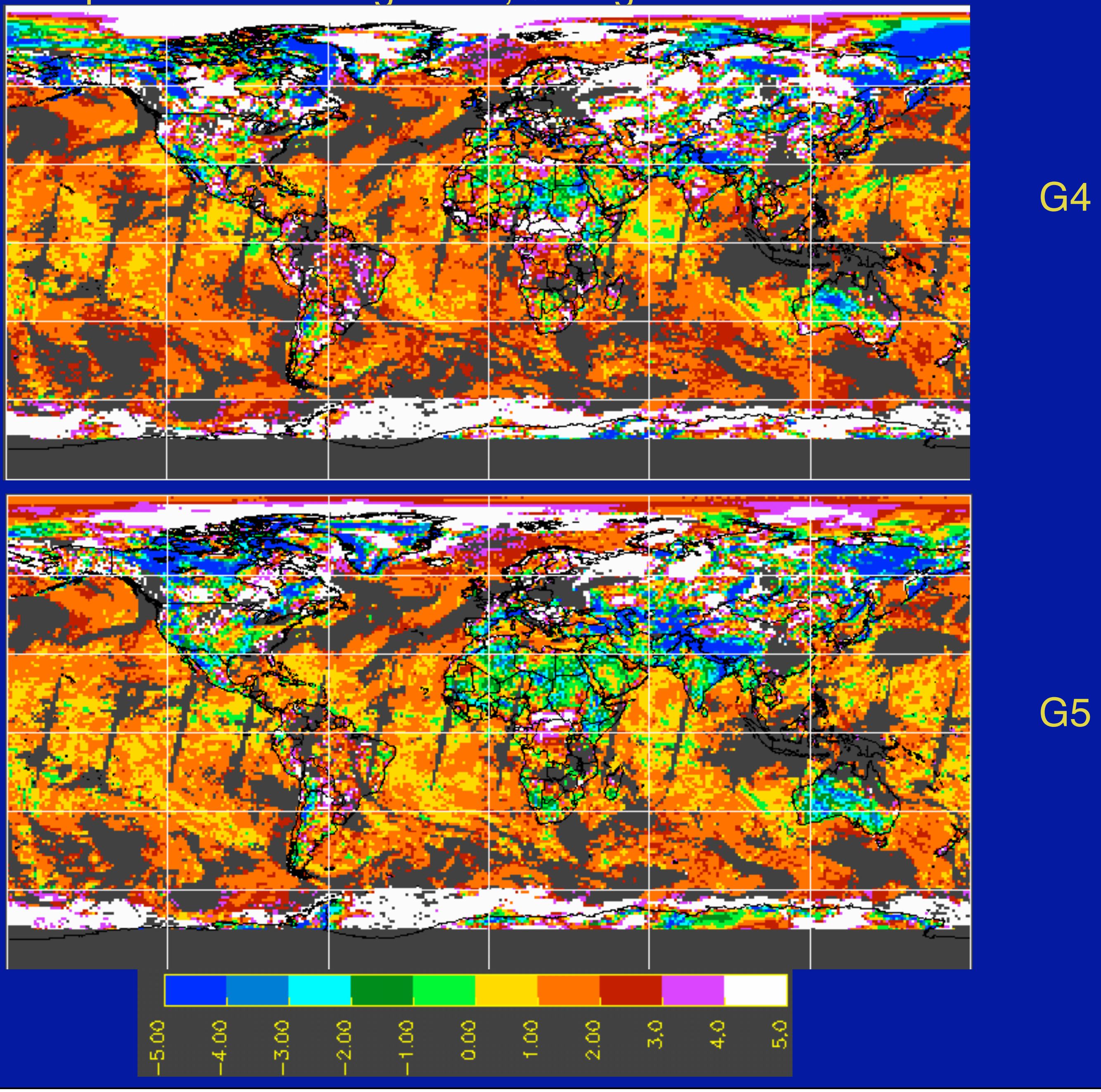
TOA 11 um Clear Sky T - MODIS obs. T11

Terra 20060715 Daytime, strong clear and snow, glint < 50%, Clr Percent > 10%

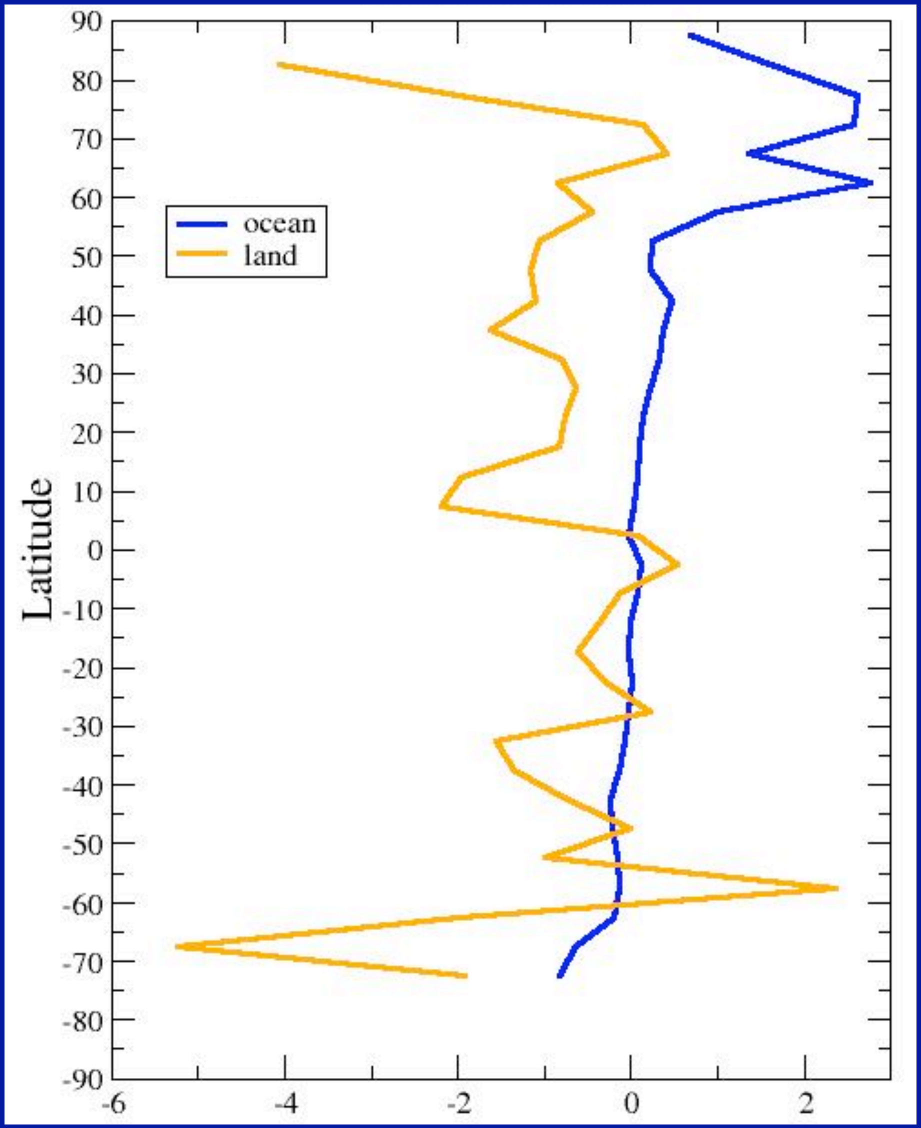


TOA 11 um Clear Sky T - MODIS obs. T11

Aqua 20071225 Nighttime, strong clear and snow

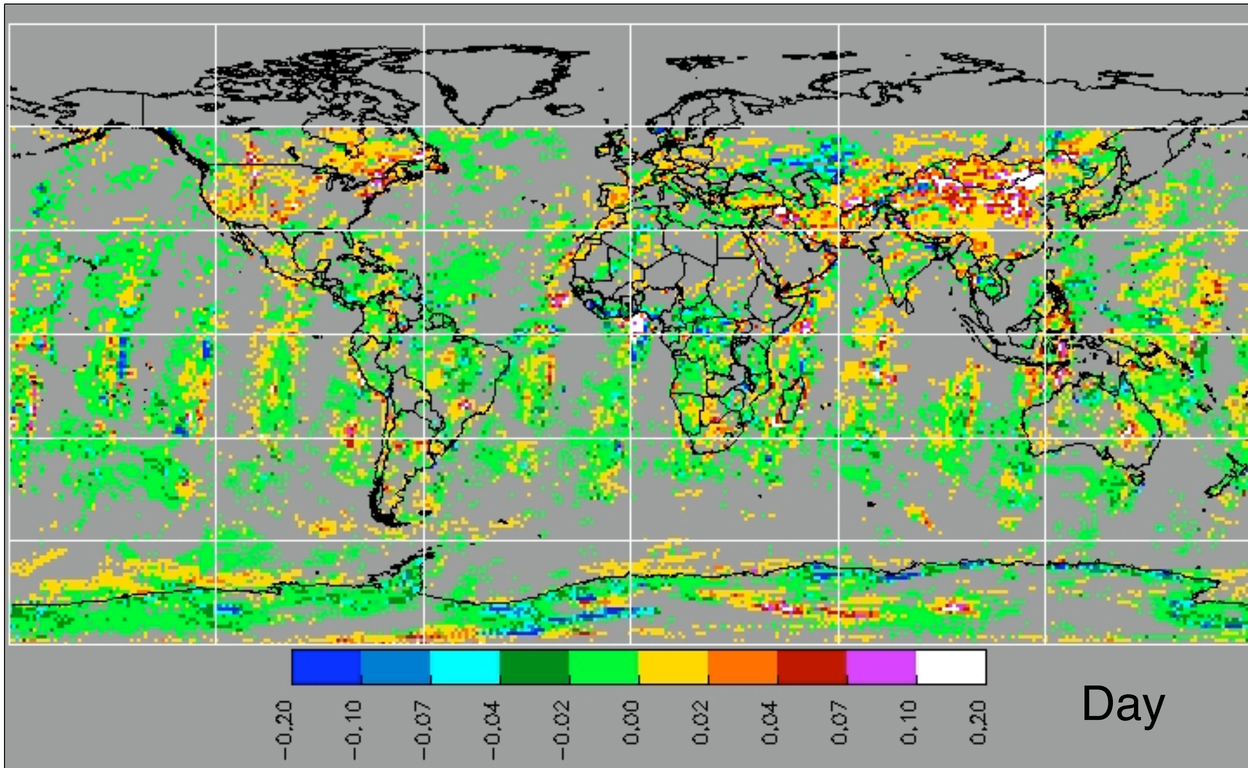


Mean Zonal Temperature Difference (K), Night, 15 Dec 2007

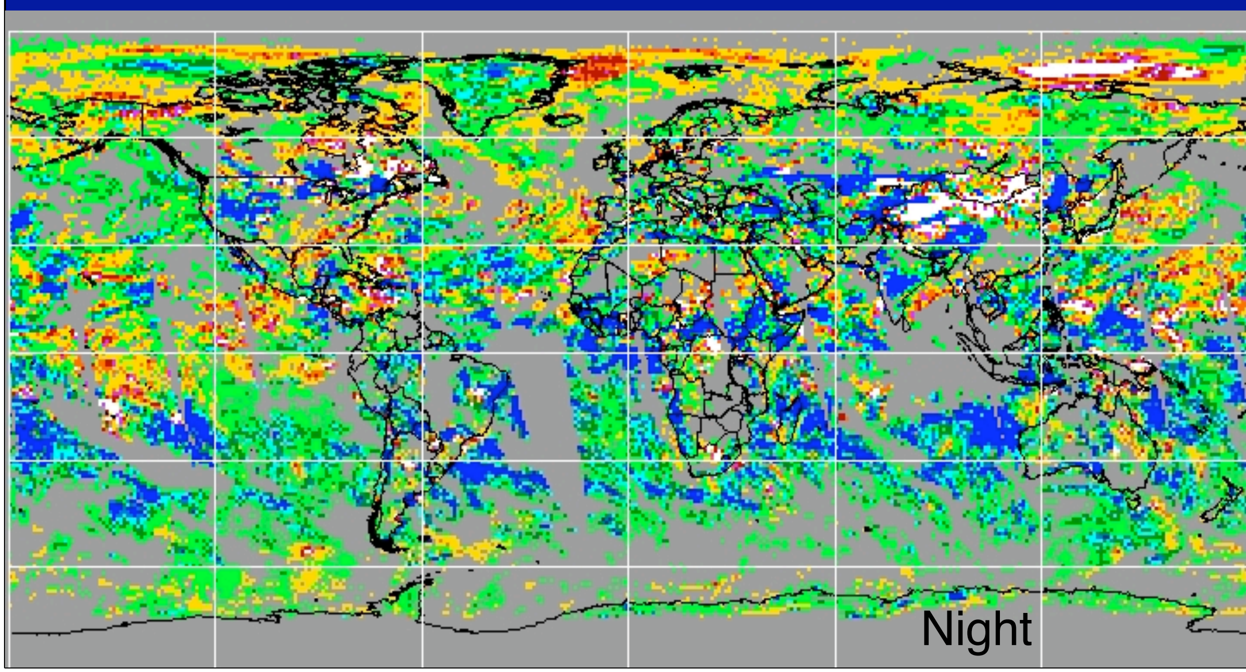


Greatest changes over sea ice, minimal changes over most ocean areas.

Cloud Fraction Difference, C(G5) – C(G4)
Dec 15, 2007

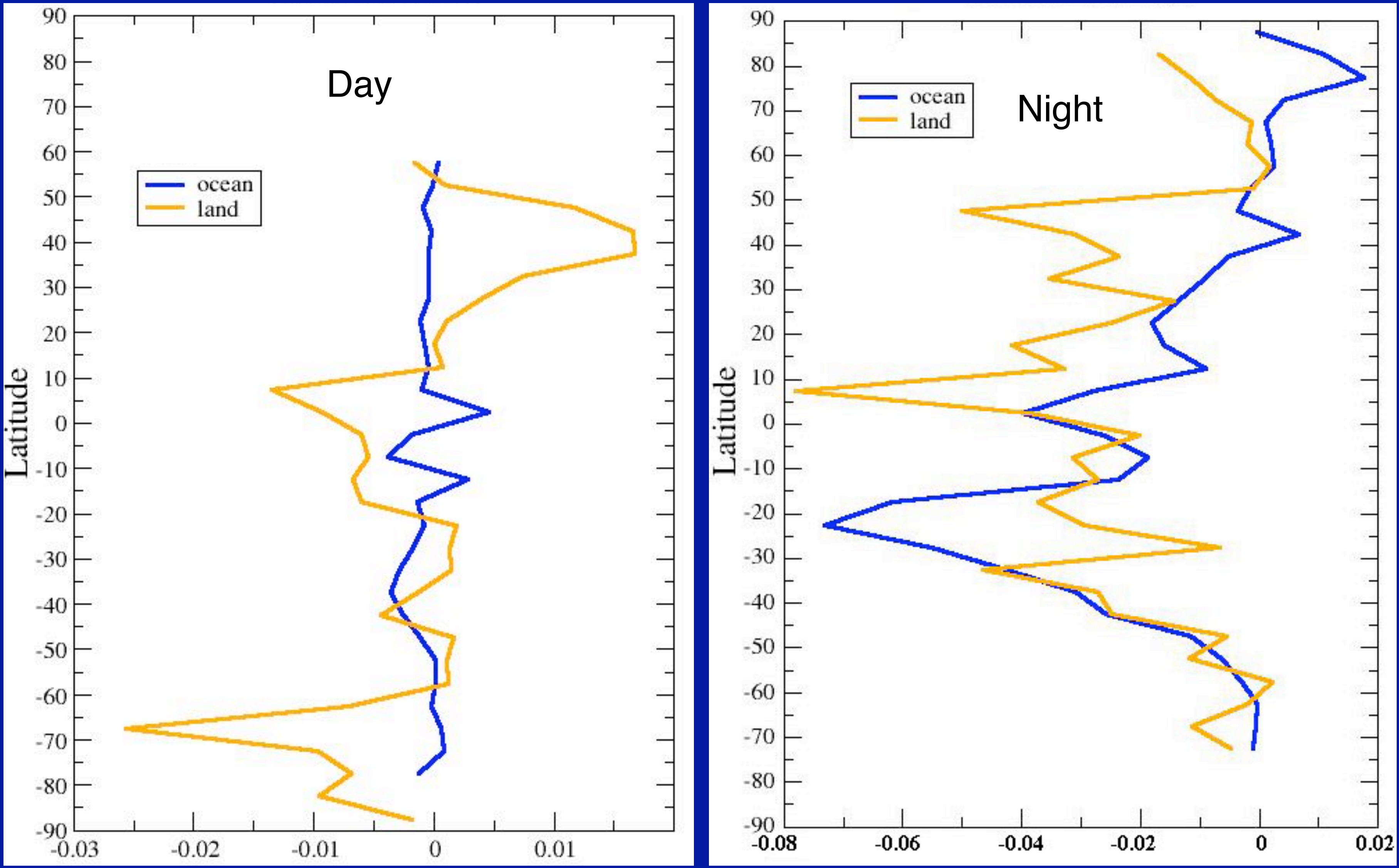


Greatest differences over land at night



Greatest differences over ocean at night

Zonal Average Cloud Fraction Differences, 15 Dec 2007



Zonal Average Cloud Fraction Differences, Dec 15, 2007

Cloud Fraction Difference, C(G5) - C(4), Terra
Dec 15, 2007

Day	land	ocean	total
Global:	-0.0007	-0.0008	-0.0003
Polar:	0.0001	-0.0135	-0.0041
NonPolar:	-0.0007	-0.0000	-0.0001
Night			
Global:	-0.0204	-0.0267	-0.0229
Polar:	0.0027	-0.0061	-0.0000
NonPolar:	-0.0235	-0.0291	-0.0260

Introducing GEOS-5 reduces cloud fraction by a noticeable amount at night

MODIS Correction of V5 Terra and Aqua Normalization to Aqua by Cross-Calibration

0.65 & 3.75 μm

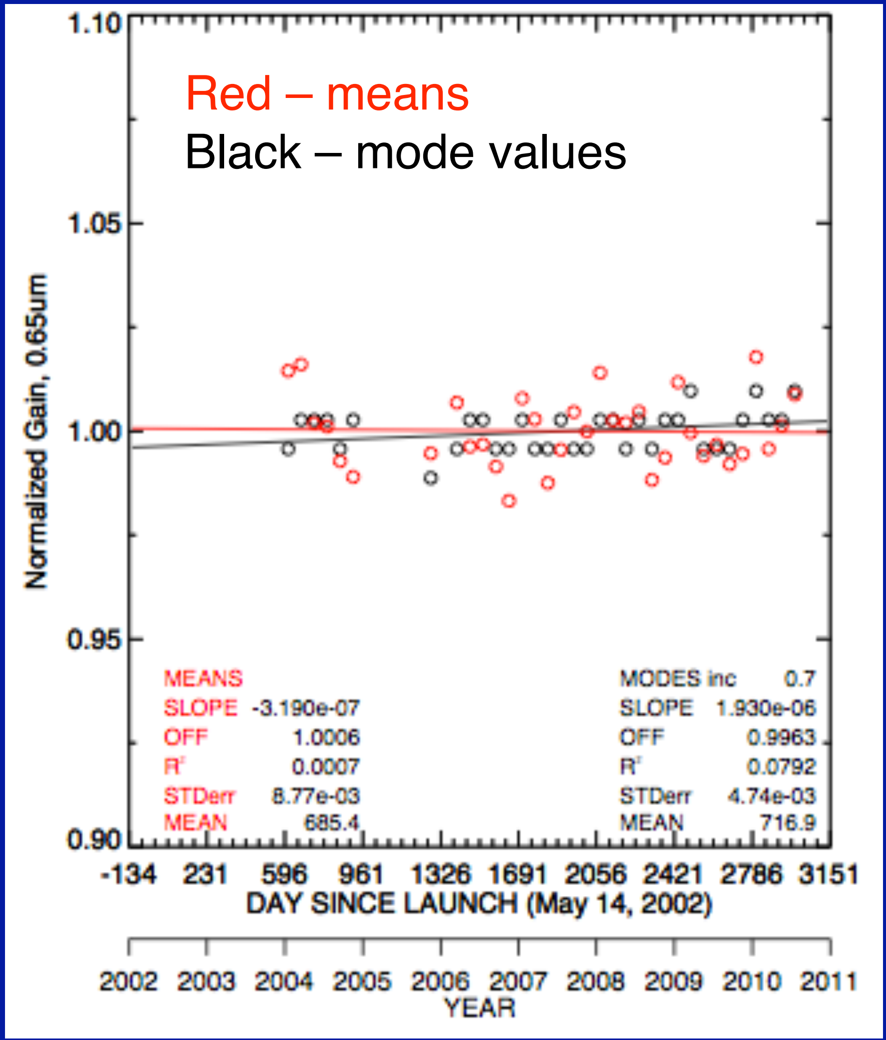
VIS Channel Normalizations

- From earlier study*
  - Aqua 0.65-μm gain = 1.01 * Terra gain
  - After Nov 2003, Aqua gain = 1.027 * Terra gain

- New
  - Aqua gain stable from launch to present
  - After June 2009, Aqua gain = 1.004* Terra gain
  - Terra has 1.3% linear change in response across scan angle
    - *corrected in MODIS Collection 6*

*Minnis, P., D. R. Doelling, L. Nguyen, W. F. Miller, and V. Chakrapani, 2008: Assessment of the visible channel calibrations of the TRMM VIRS and MODIS on *Aqua* and *Terra*. *J. Atmos. Oceanic Technol.*, **25**, 385-400.

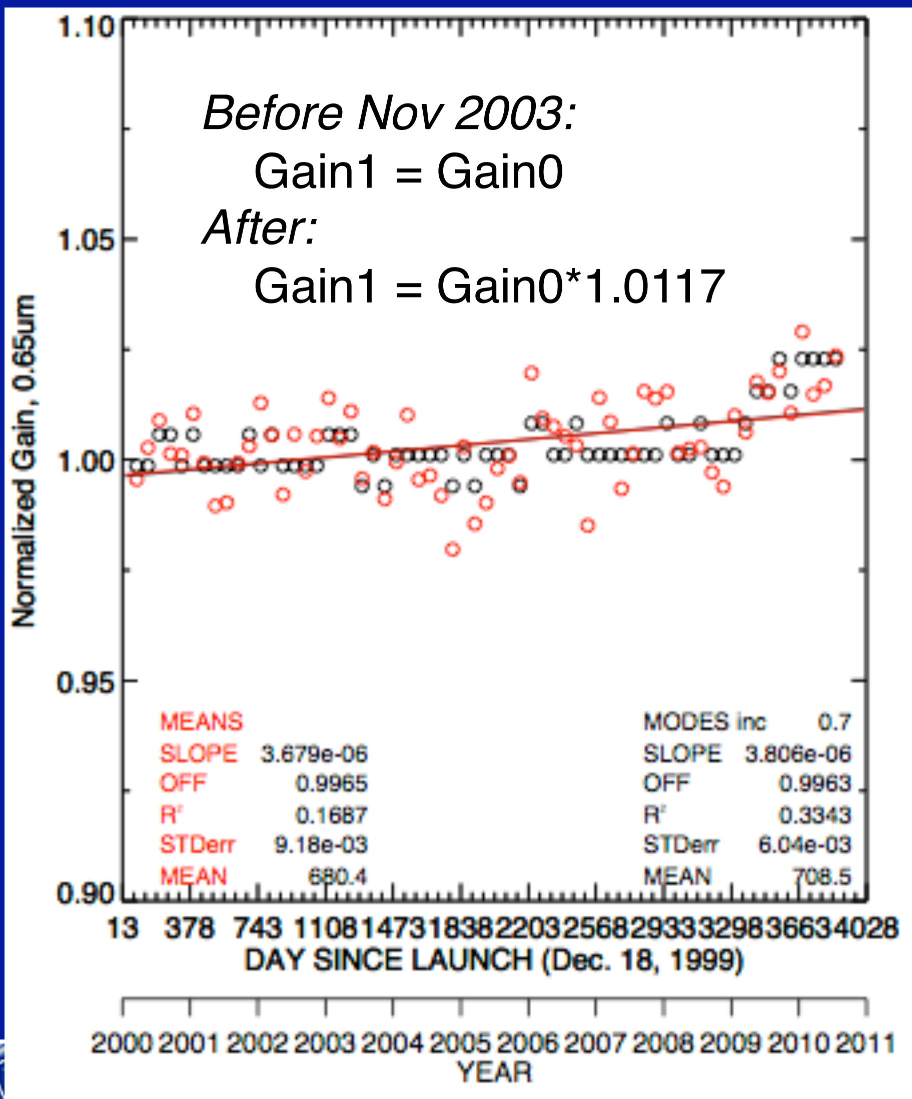
Normalized Aqua Deep Convective Cloud (DCC) VIS Albedo Trends 2002 - 2010

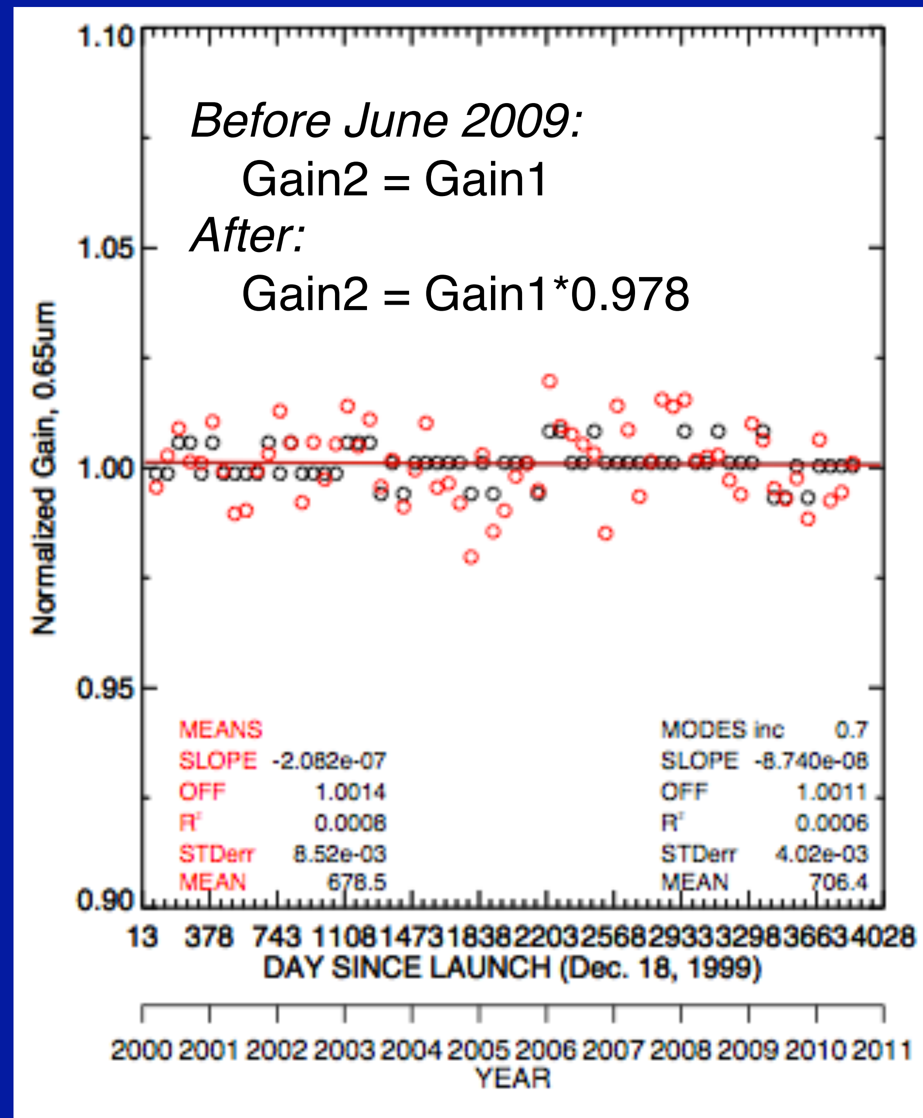


- DCC mean albedo trend ~ -0.01%/year
- DCC mode albedo trend ~ 0.07%/year

=> Aqua very stable

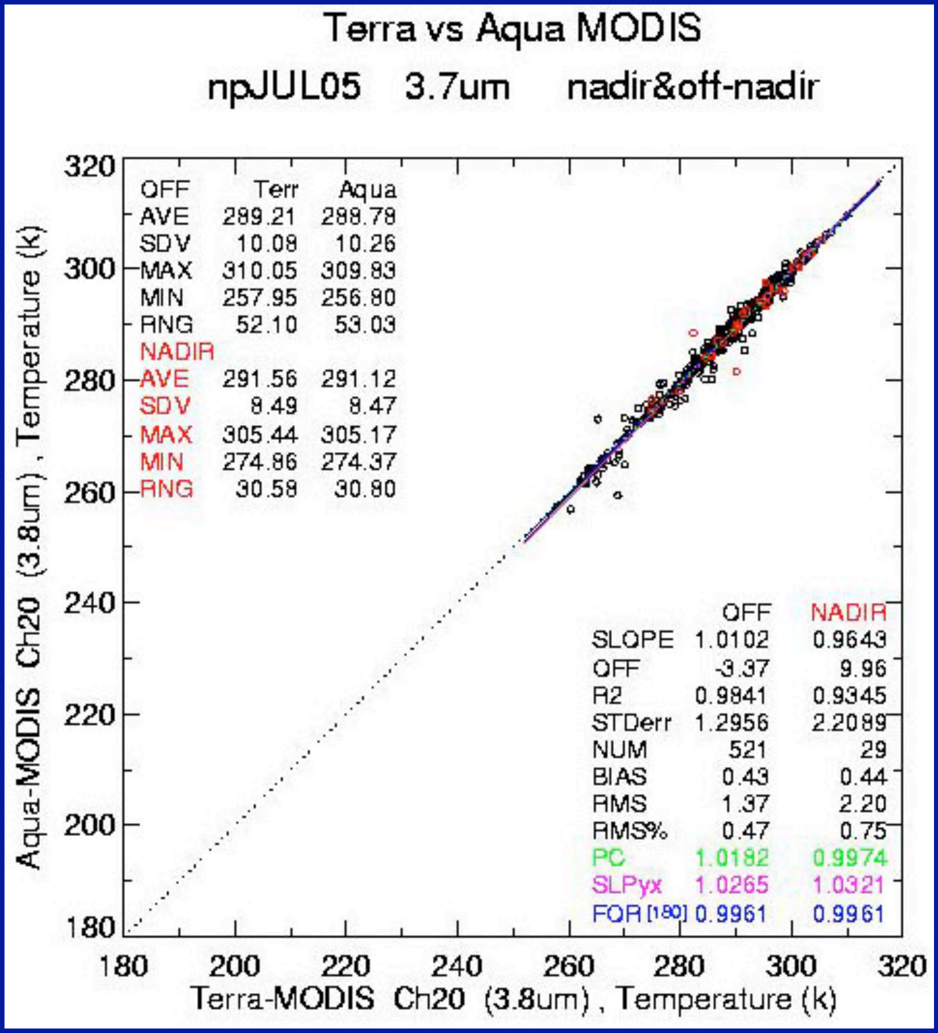
Normalized Terra Deep Convective Cloud (DCC) VIS Albedo Trends 2002 - 2010



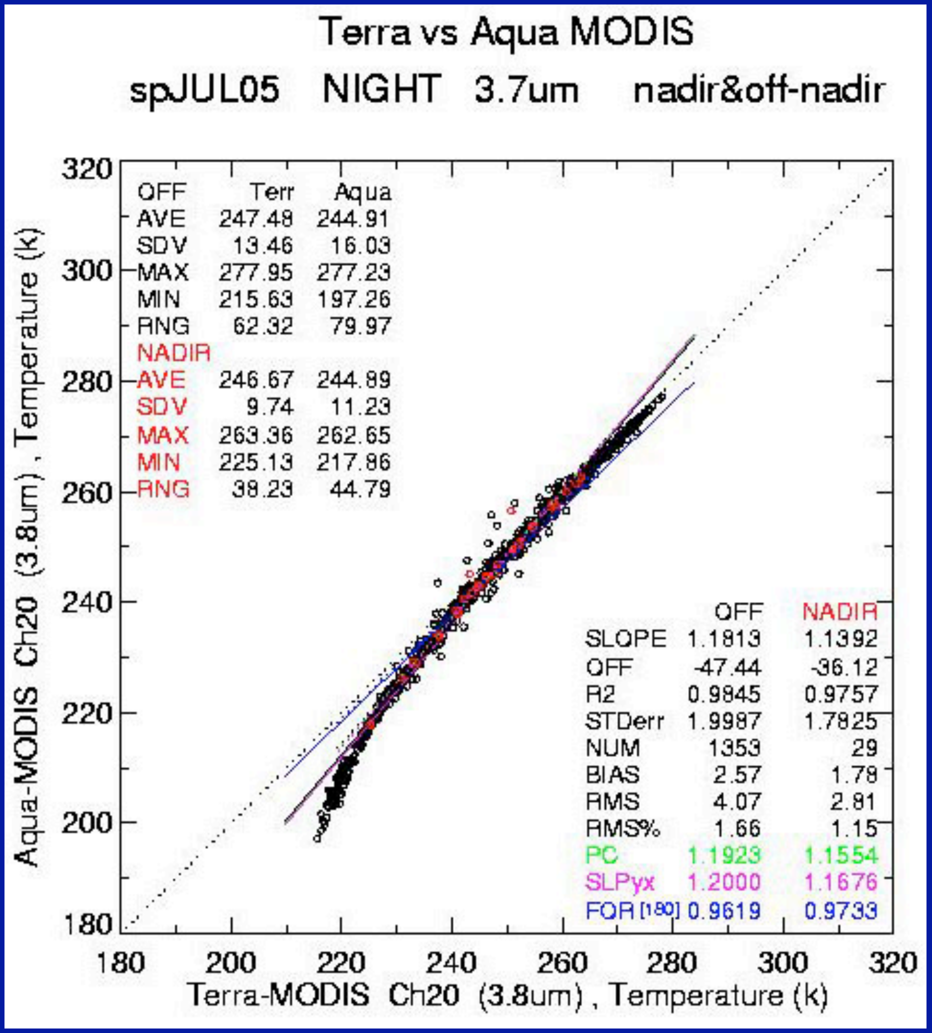


Shortwave Infrared (3.8 µm) Channels

Daytime slope



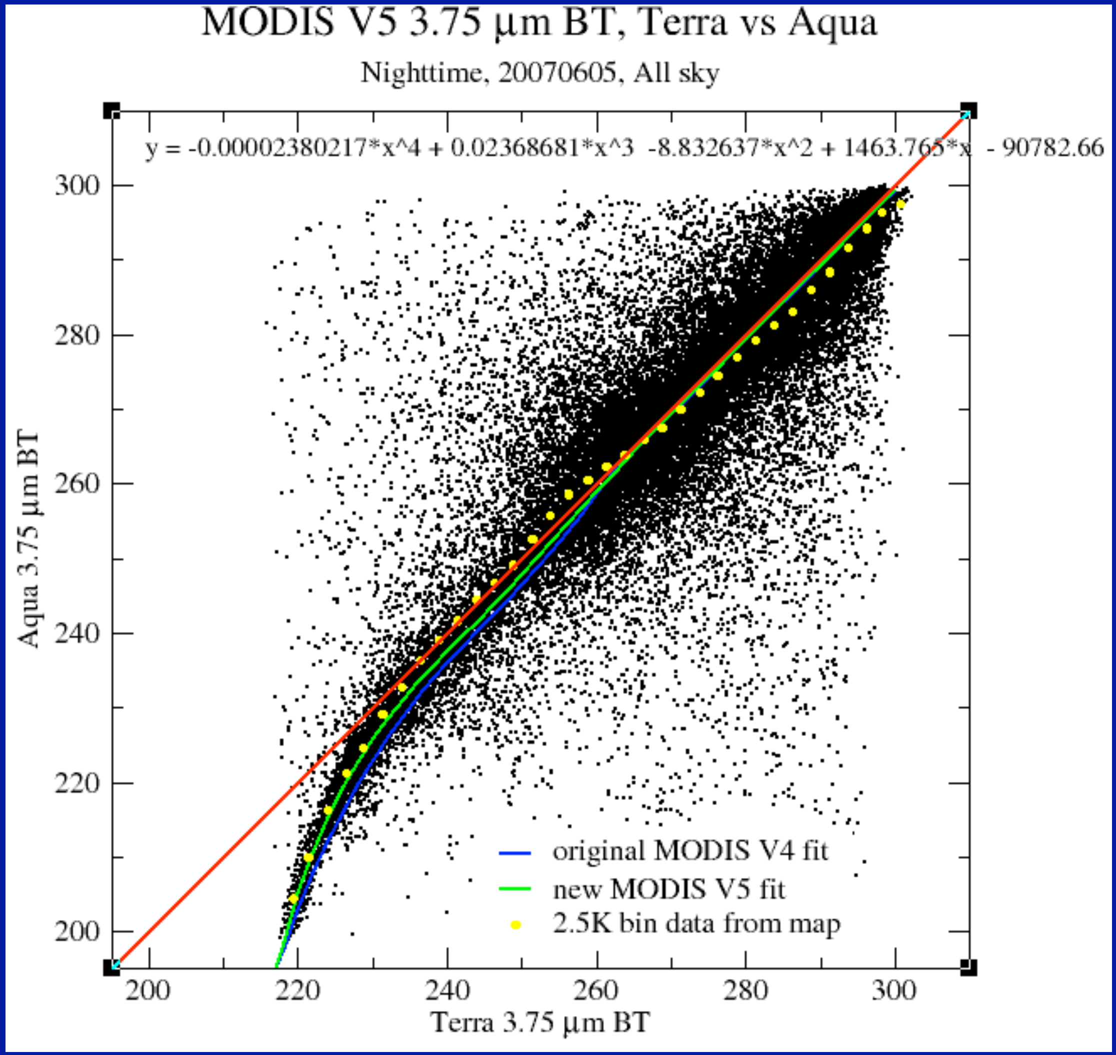
Night slope



- **Aqua 0.57 K warmer than Terra during daytime**
- **Nonlinear difference at night at low temperatures**

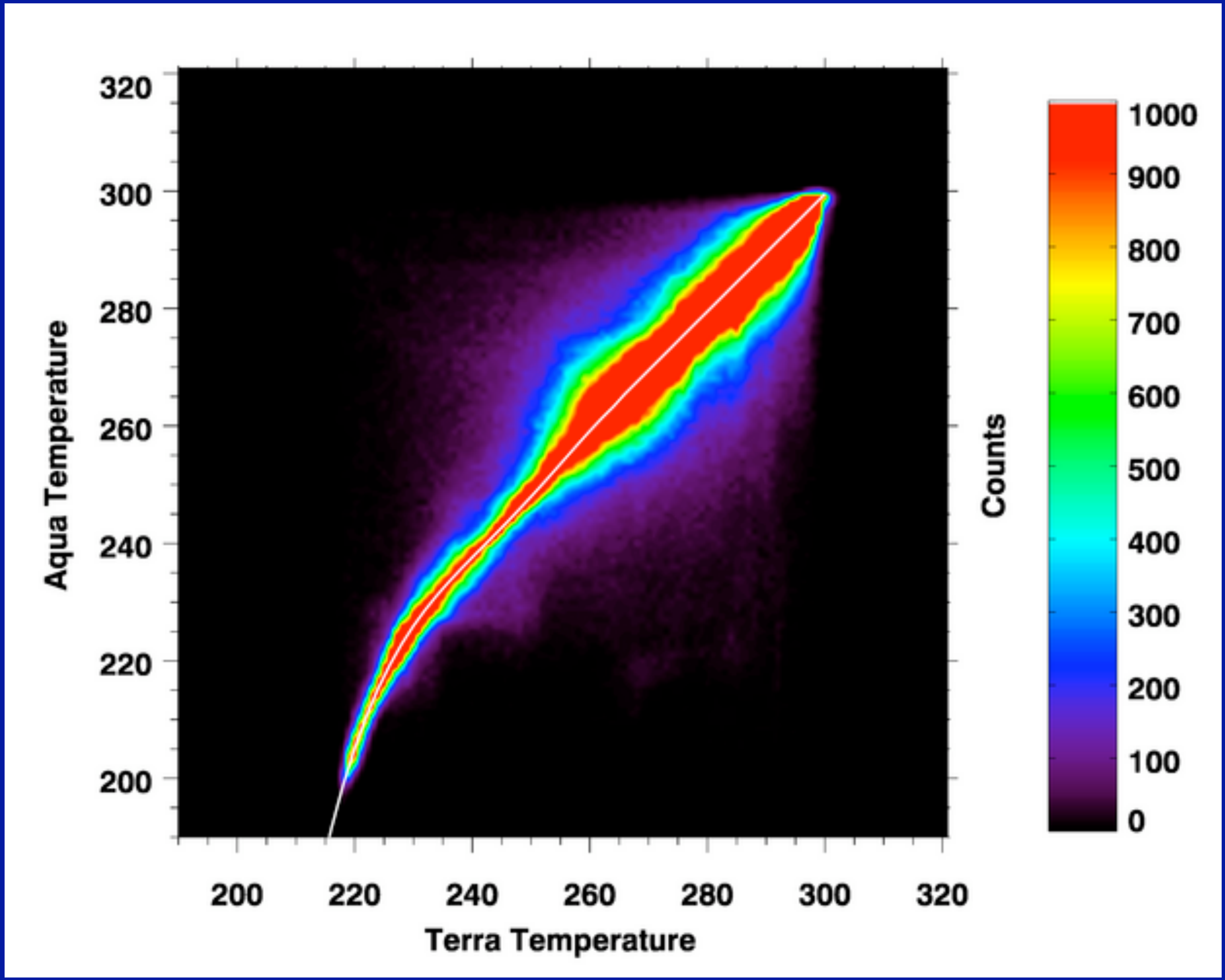
Spatially Matched Aqua and Terra V5 Data, 5 June 2005

- 10' averages
- sample every 50 points



New fit to slightly to left of V4 fit from ray-matched data

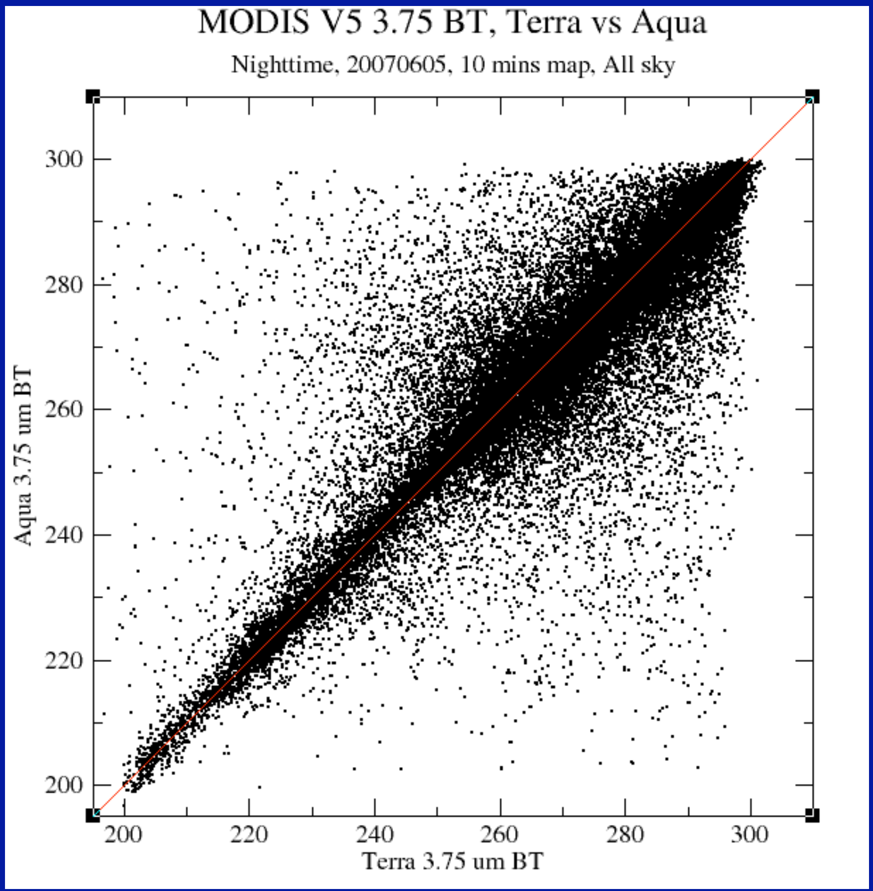
MODIS V5 3.75 μm BT, Terra vs Aqua, Denisty Plot
Nighttime, 20070605, all sky



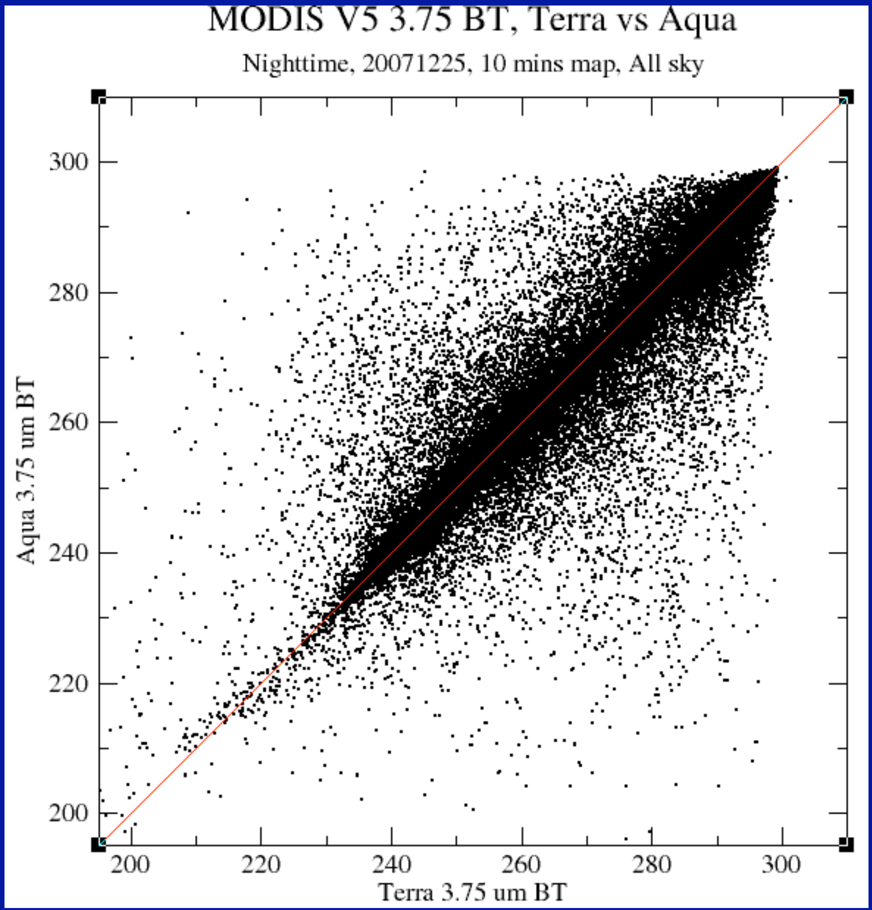
MODIS V5 3.75 μm BT, Terra vs Aqua

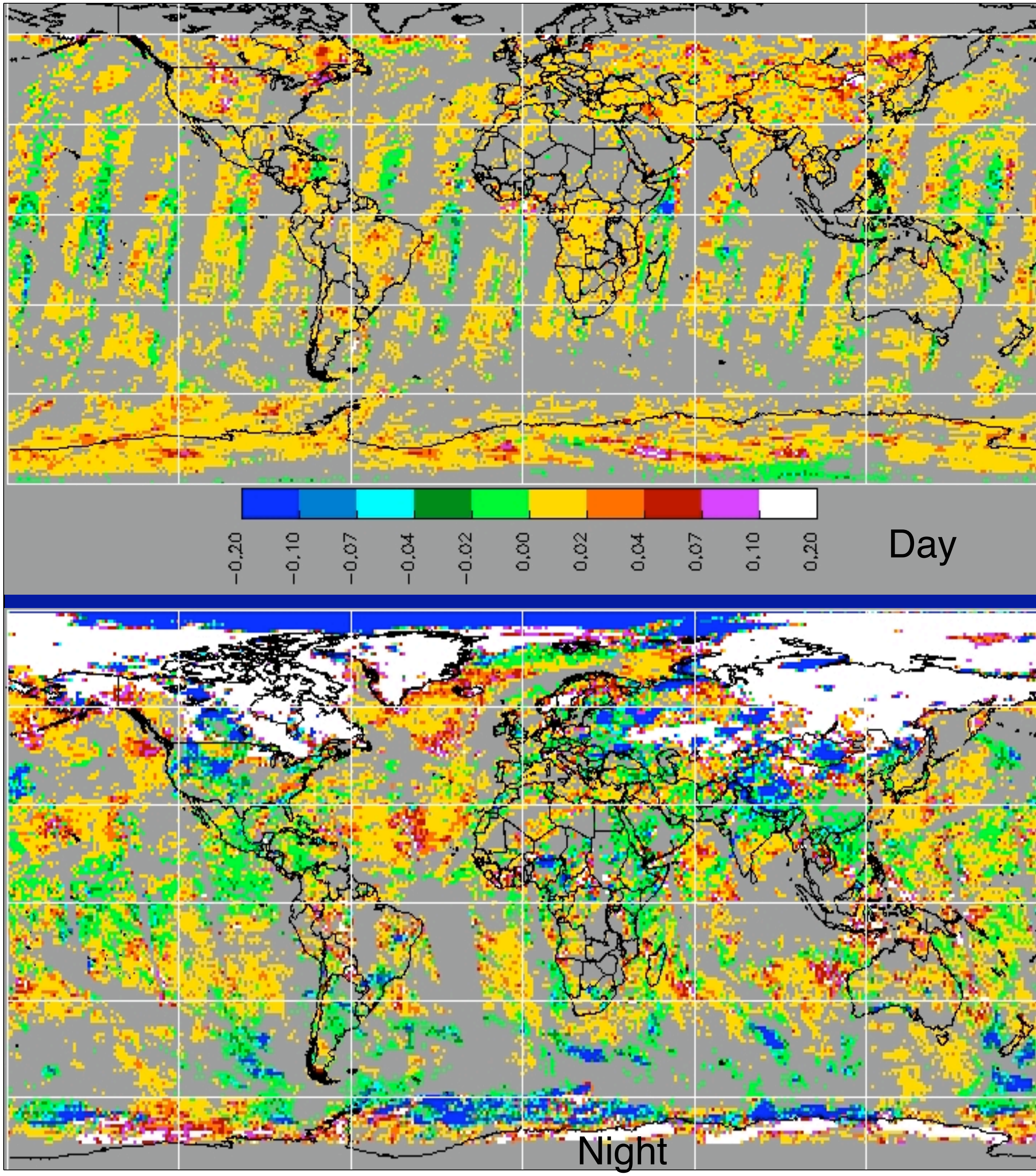
After New Correction

20070605



20071225



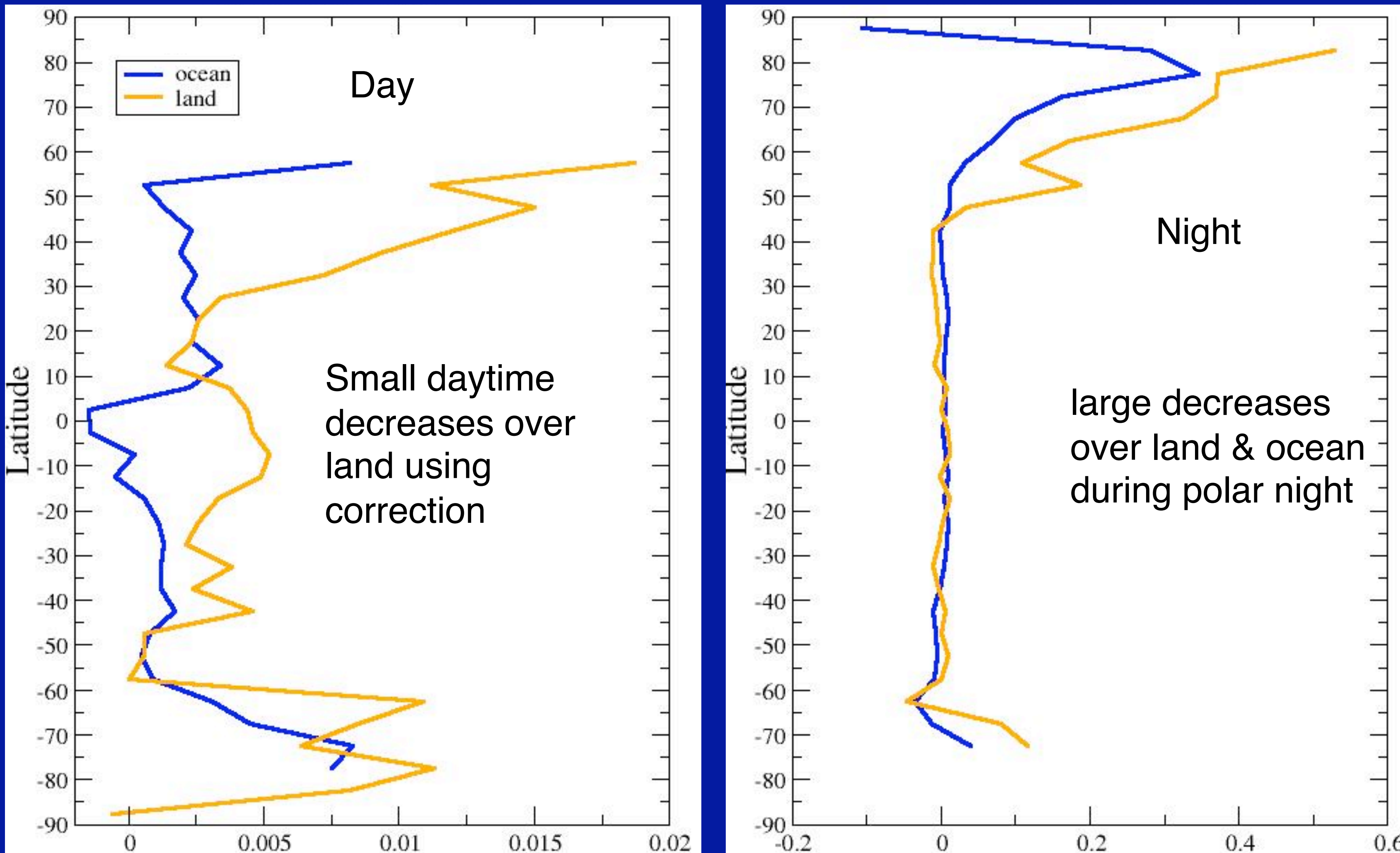


Cloud Fraction Difference,
C(nom) - C(corr)
Terra
Dec 15, 2007

Small differences due to viewing angle changes during daytime

Large differences over polar night areas

Zonal Average Cloud Fraction Differences, C(nom) – C(corr)
Terra 15 Dec 2007



Cloud Fraction Difference, C(nom) - C(corr), Terra
Dec 15, 2007

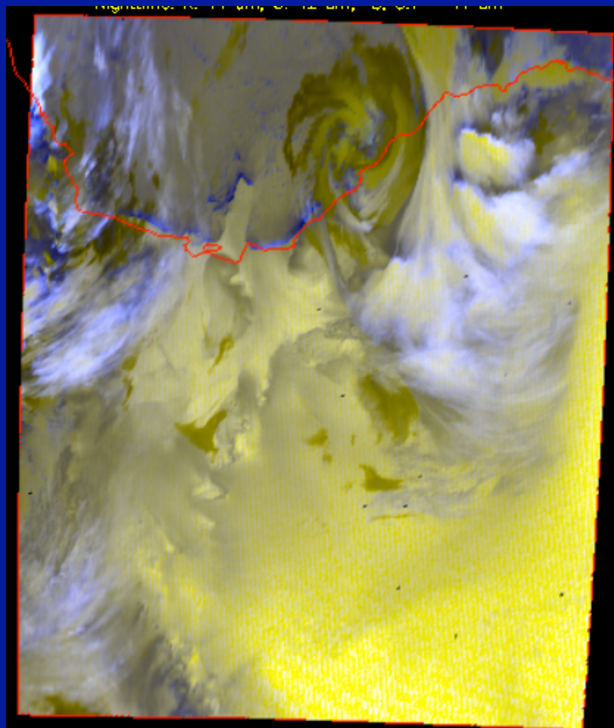
Day:	land	ocean	total
Global:	0.0016	0.0052	0.0029
Polar:	0.0052	0.0085	0.0058
NonPolar:	0.0014	0.0050	0.0027

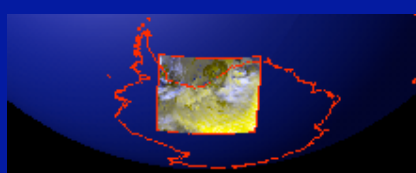
Night:			
Global:	0.0133	0.0317	0.0232
Polar:	0.0808	0.2225	0.1389
NonPolar:	0.0042	0.0093	0.0075

Introducing 3.7-μm calibration change reduces cloud fraction slightly during daytime, but by a large amount at night over areas where it is too large from Ed3

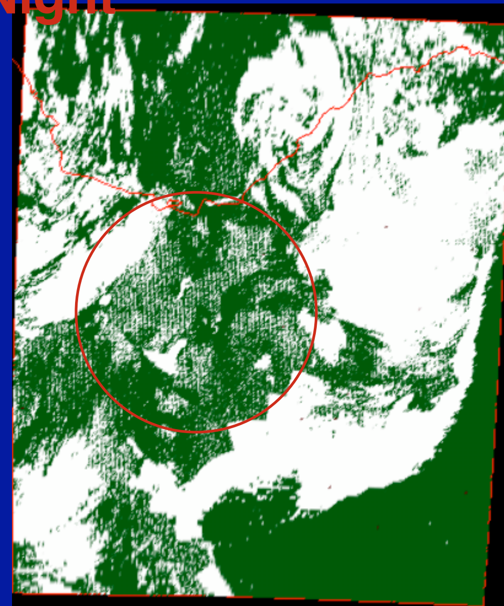
Reduce False Clouds in Polar Night

Terra 2007050106R59

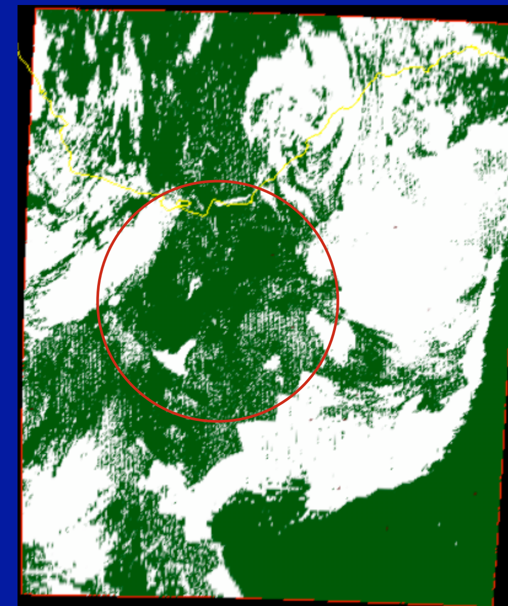




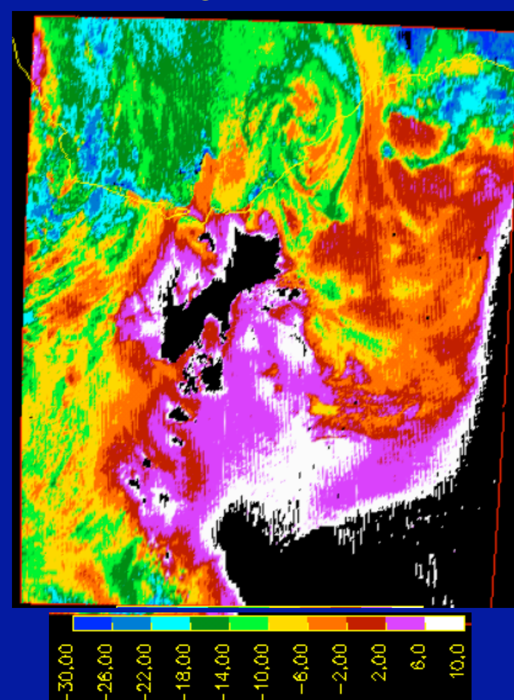
Mask Before



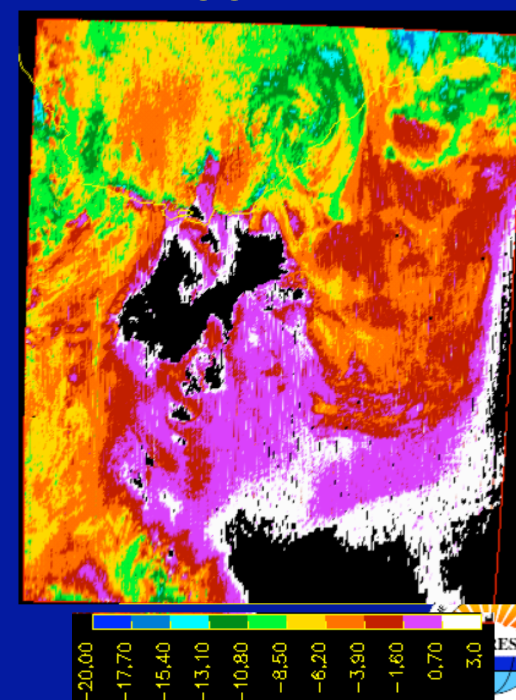
Mask After



T6.7 - T11



T13.3 - T11



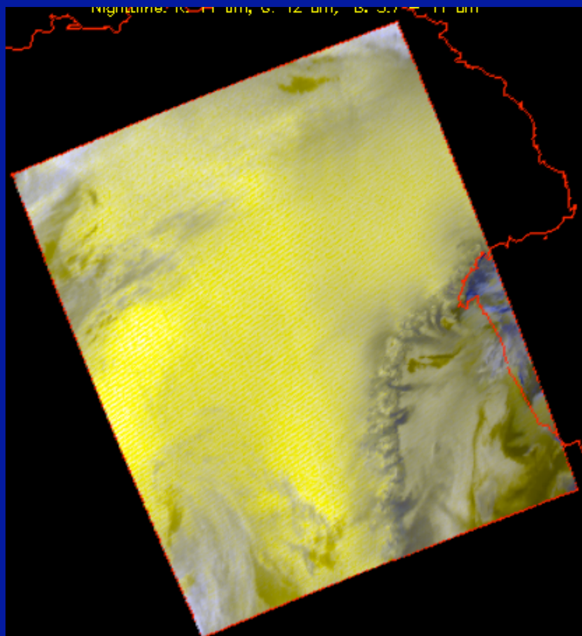
Clear Sky Restoral

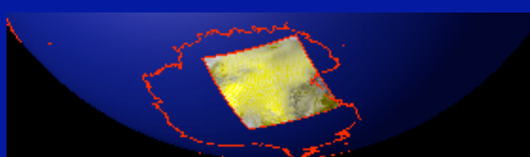
T6.7 - T11 > 10K

T13.3 - T11 > 3K

Reduce False Clouds in Polar Night

Terra 2007050121R66





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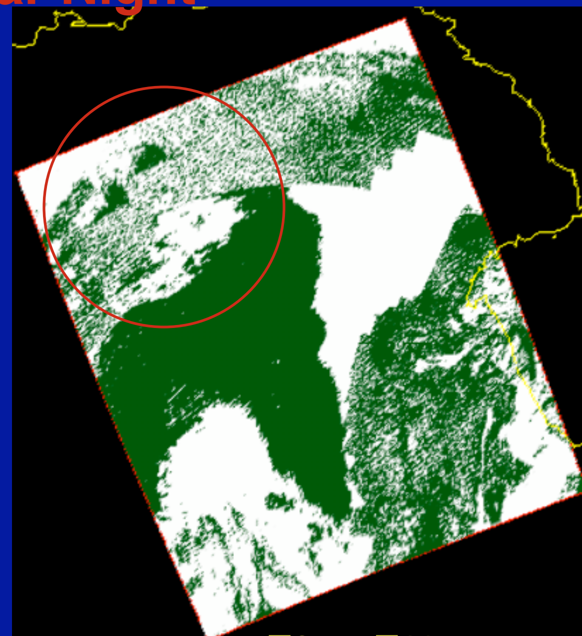
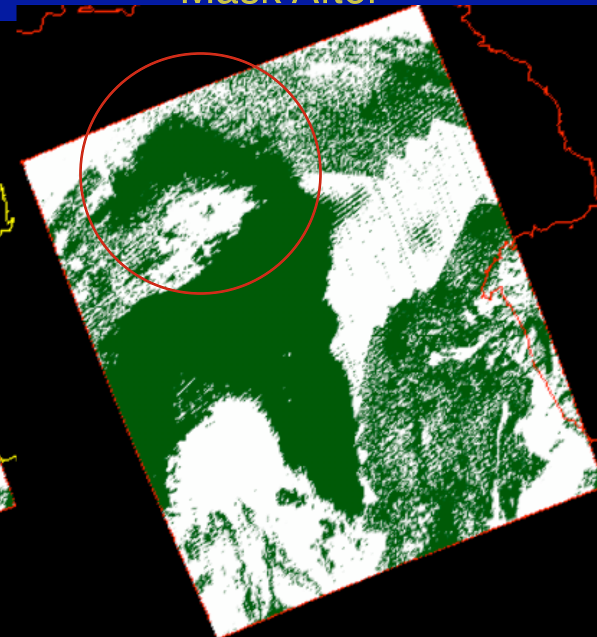
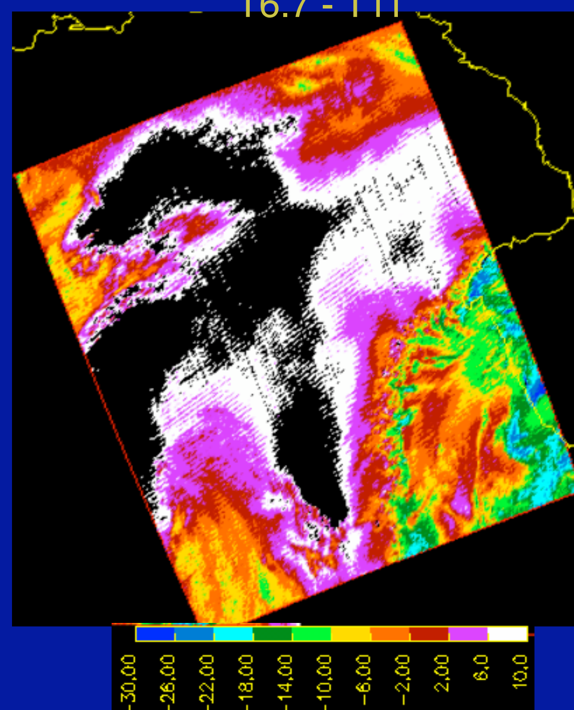


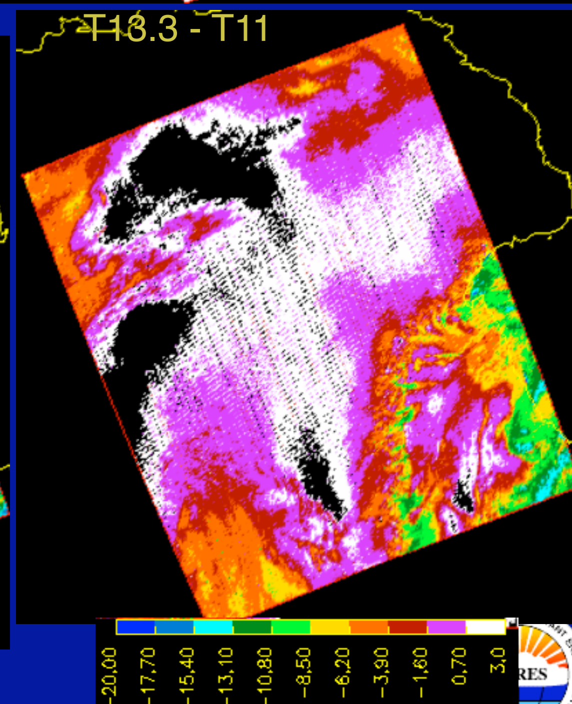
Mask After



T6.7 - T11



T13.3 - T11



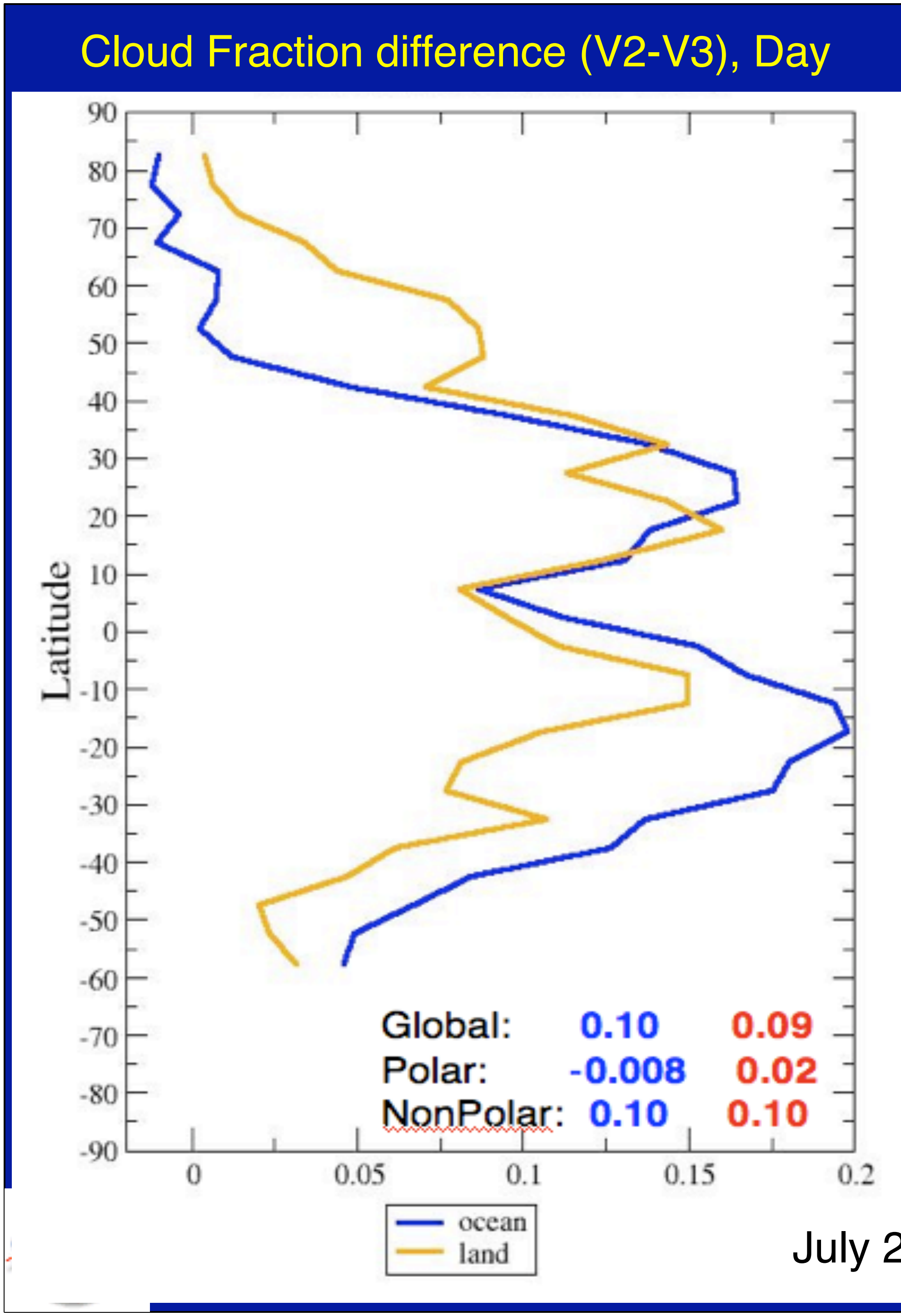
Clear Sky Restoral

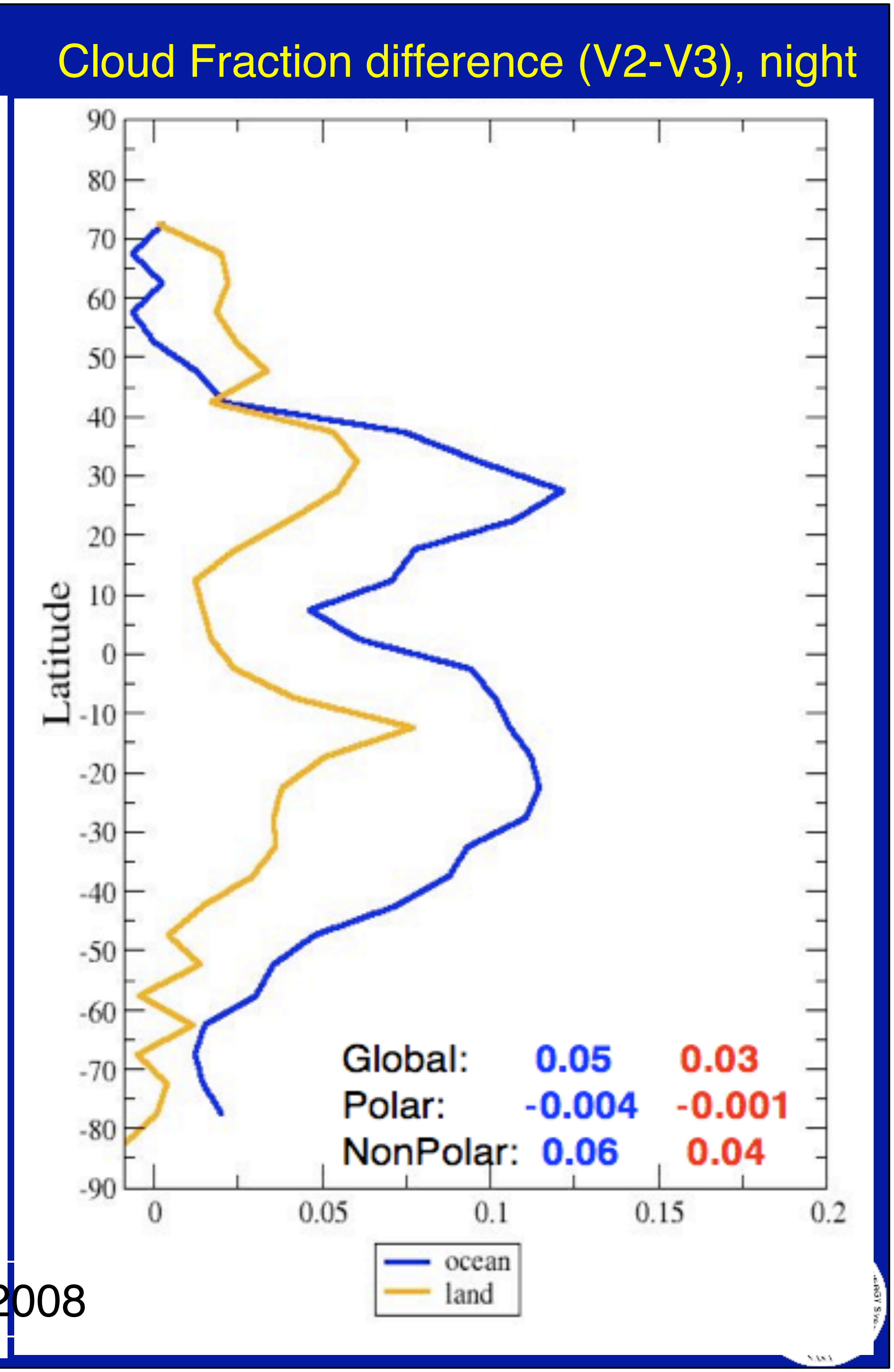
T6.7 - T11 > 10K

T13.3 - T11 > 3K

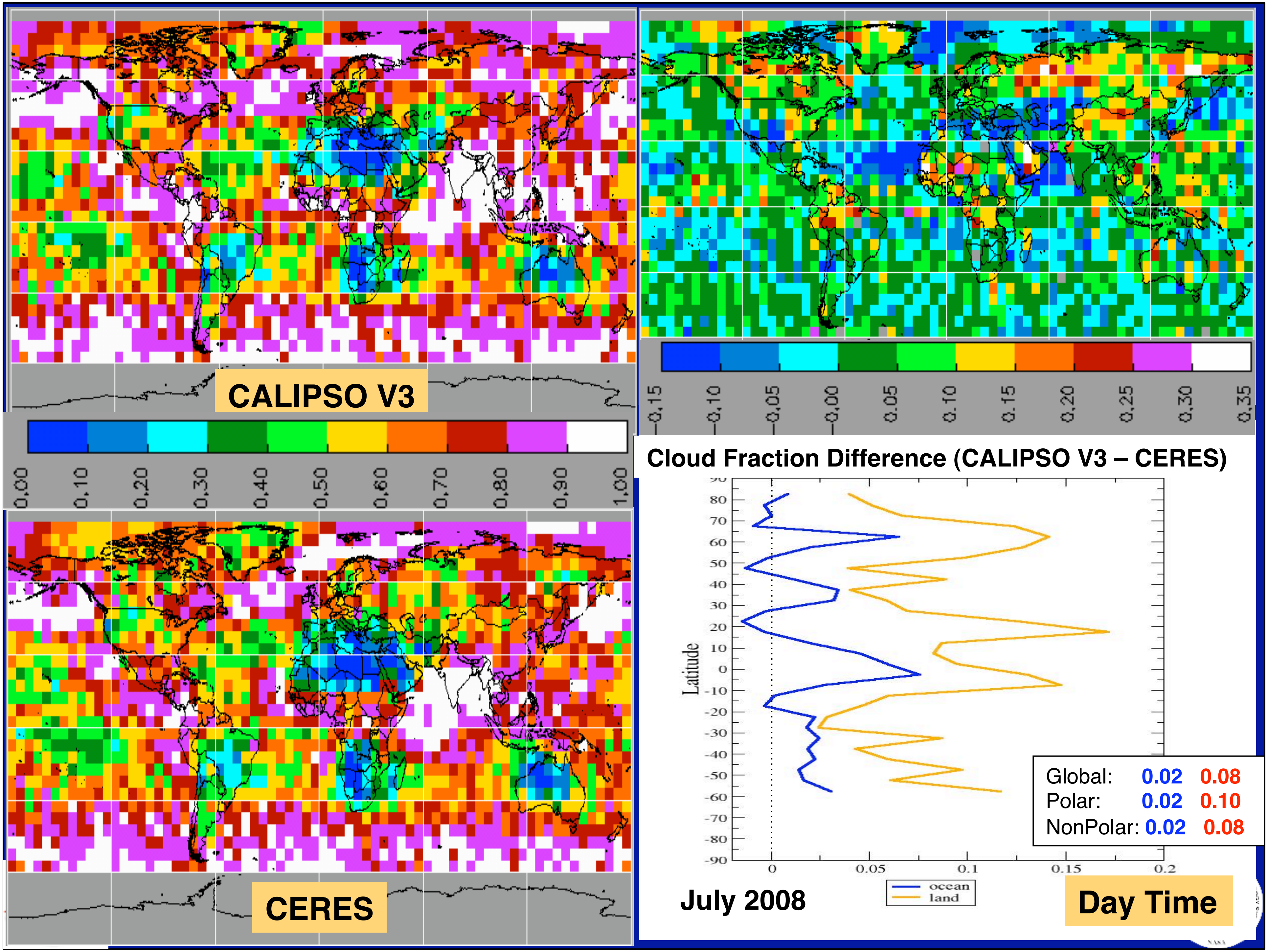
Do not get rid of all false clouds!

Comparisons with CALIPSO V3 Cloud Fractions

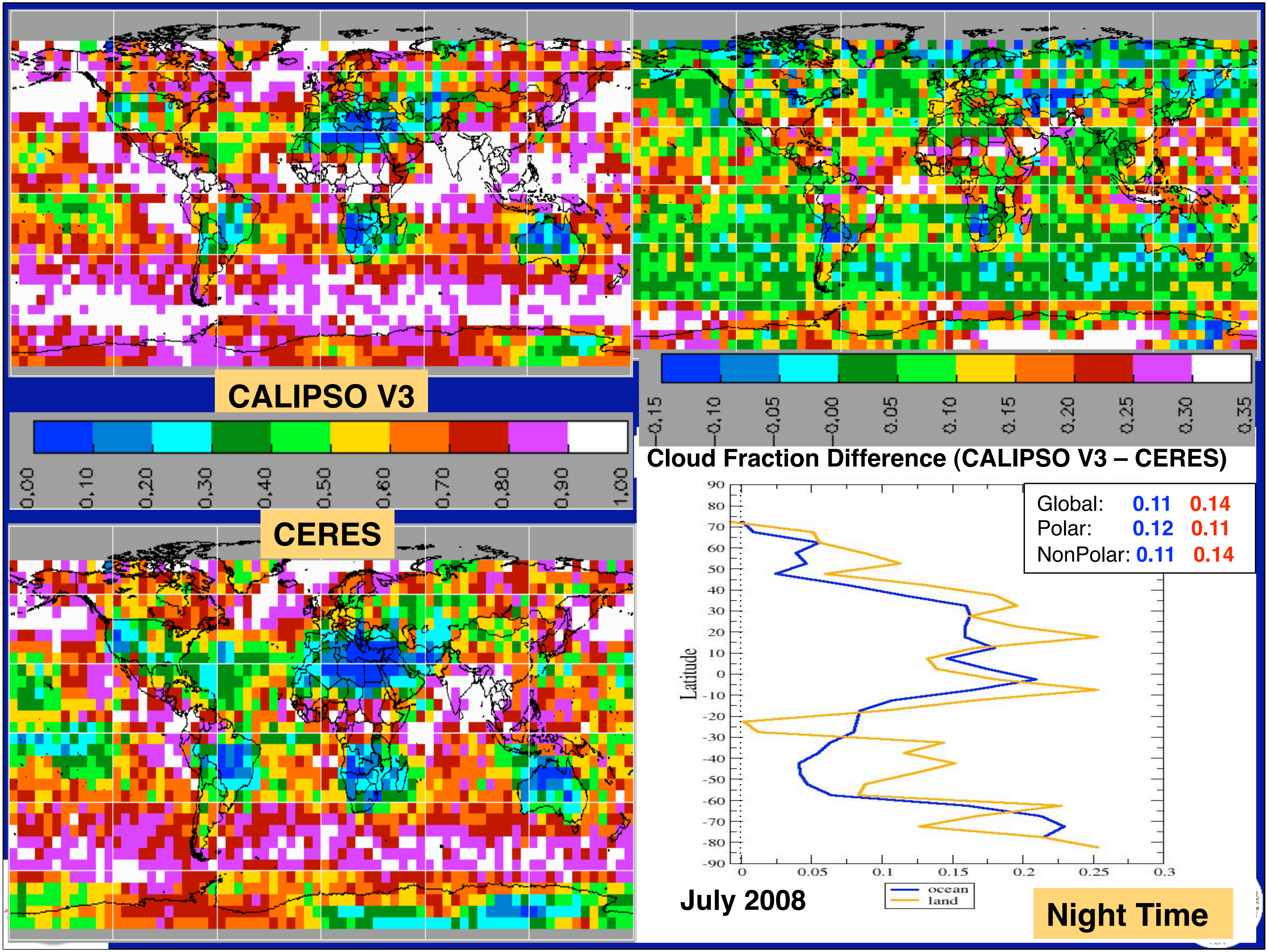

Cloud Fraction difference (V2-V3), Day
Latitude
Global: 0.10 0.09
Polar: -0.008 0.02
NonPolar: 0.10 0.10
ocean
land


Cloud Fraction difference (V2-V3), night
Latitude
Global: 0.05 0.03
Polar: -0.004 -0.001
NonPolar: 0.06 0.04
ocean
land

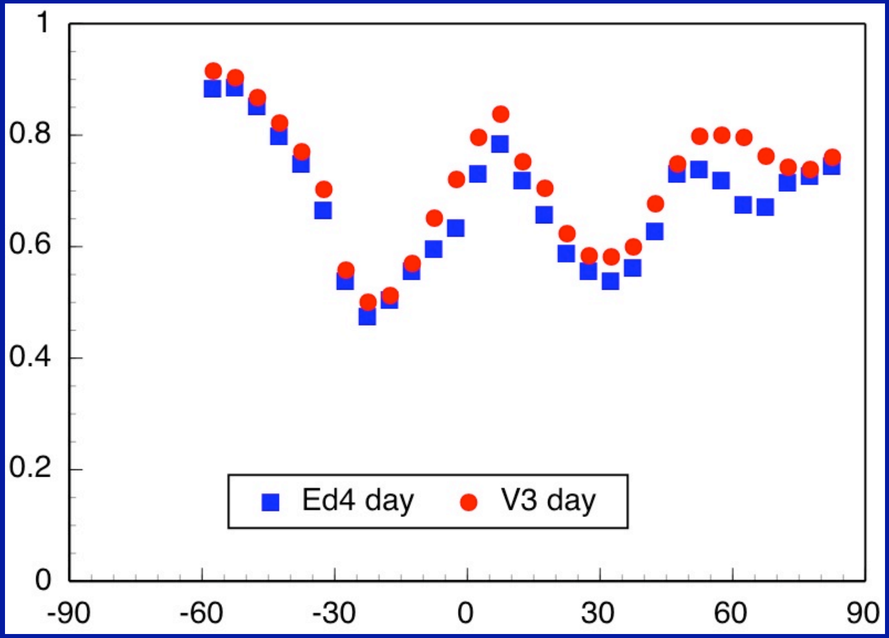
July 2008

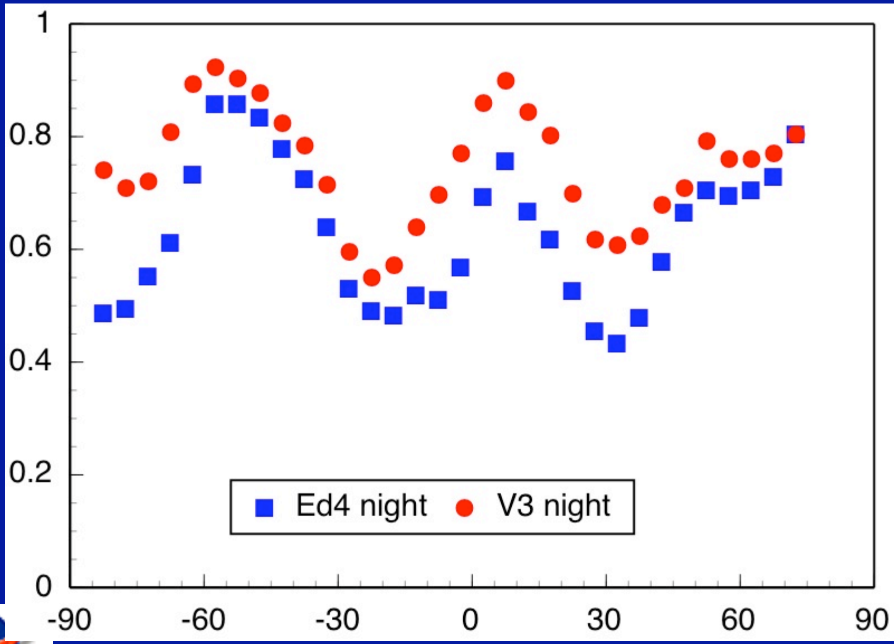


CALIPSO V3
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
CERES
-0.15 -0.10 -0.05 -0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35
Cloud Fraction Difference (CALIPSO V3 – CERES)
Latitude
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90
0 0.05 0.1 0.15 0.2
ocean
land
Global: 0.02 0.08
Polar: 0.02 0.10
NonPolar: 0.02 0.08
July 2008
Day Time



CALIPSO V3
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
CERES
-0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35
Cloud Fraction Difference (CALIPSO V3 – CERES)
Global: 0.11 0.14
Polar: 0.12 0.11
NonPolar: 0.11 0.14
Latitude
ocean
land
July 2008
Night Time





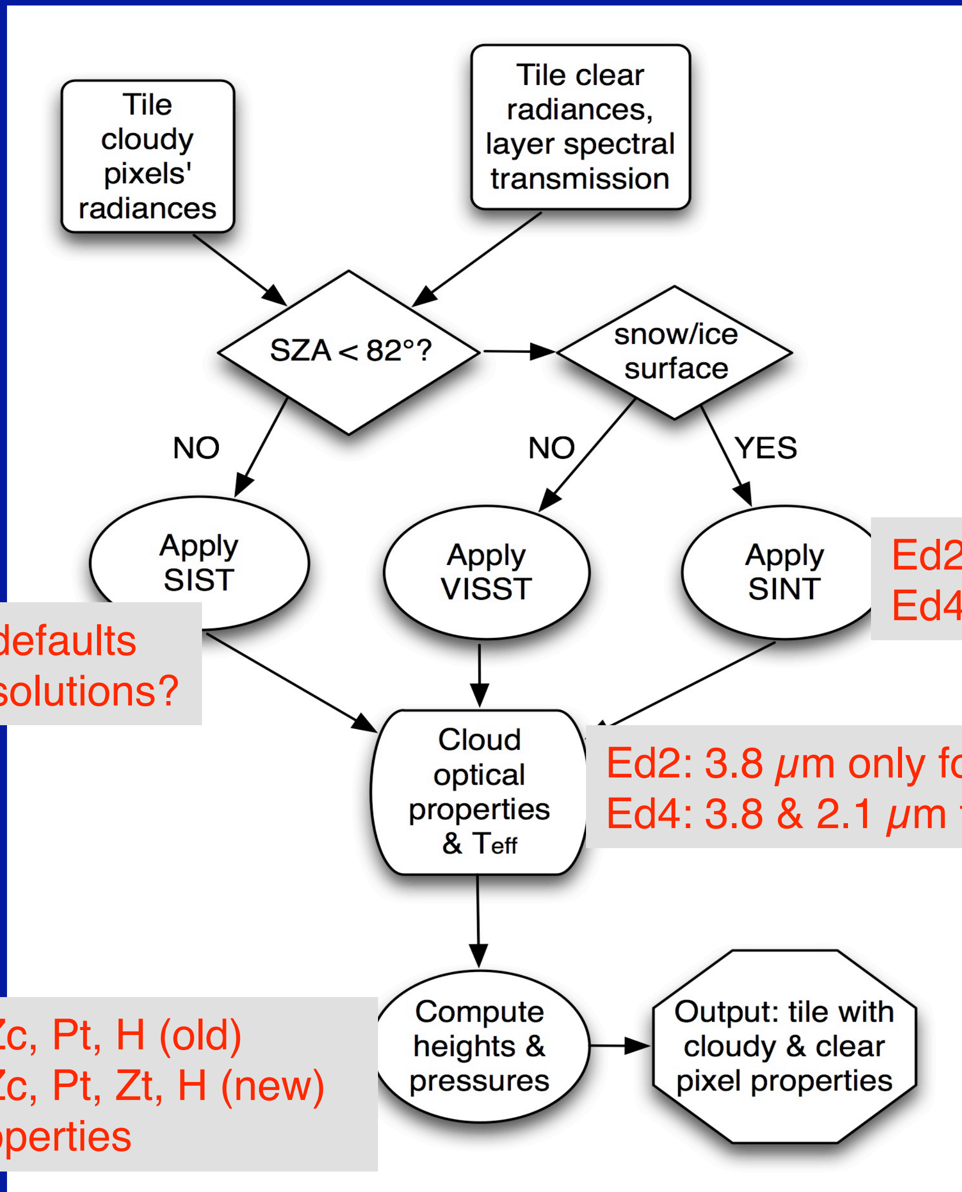
Comparison of Cloud Fraction
CALIPSO Version 3
CERES Ed4 preliminary
July 2008

- Daytime in much better agreement than in past

- Nighttime Ed4 too low
  - *- likely due to new G5*
  - *- thresholds must be tuned*

Cloud Retrievals

- Retrieve T_c, phase, tau, R_e from radiances
- Compute LWP or IWP
- Determine Z_c & p_c from T_c
- Estimate Z_t, p_t, T_t, H from empirical models



Ed2: 1.6/2.1 μm for tau over snow
Ed4: 1.24 μm for tau over snow

Ed2: Thick cloud defaults
Ed4: Thick cloud solutions?

Ed2: 3.8 μm only for Re, smooth hex xtals
Ed4: 3.8 & 2.1 μm for Re, rough hex xtals

Ed2: Pc, Tc, Zc, Pt, H (old)
Ed4: Pc, Tc, Zc, Pt, Zt, H (new)
+ ML properties

Effective cloud height/pressure retrieval

- Z_c from $T(Z)$) [p_c from $T(p)$], height (pressure) corresponding to Tc where the temperature profile is $T(Z)$ [$T(p)$].

- For $p < p_h$, $T(Z) = T(Z_{nwa})$

- For p > 700 hPa, $T(Z) = T(Z_{lap})$, where

$$T(Z_{lap}) = T(z + z_o) = T_o - \Gamma * (z - z_o)$$

T_o = skin temperature

- For $p_h < p < 700$ hPa,

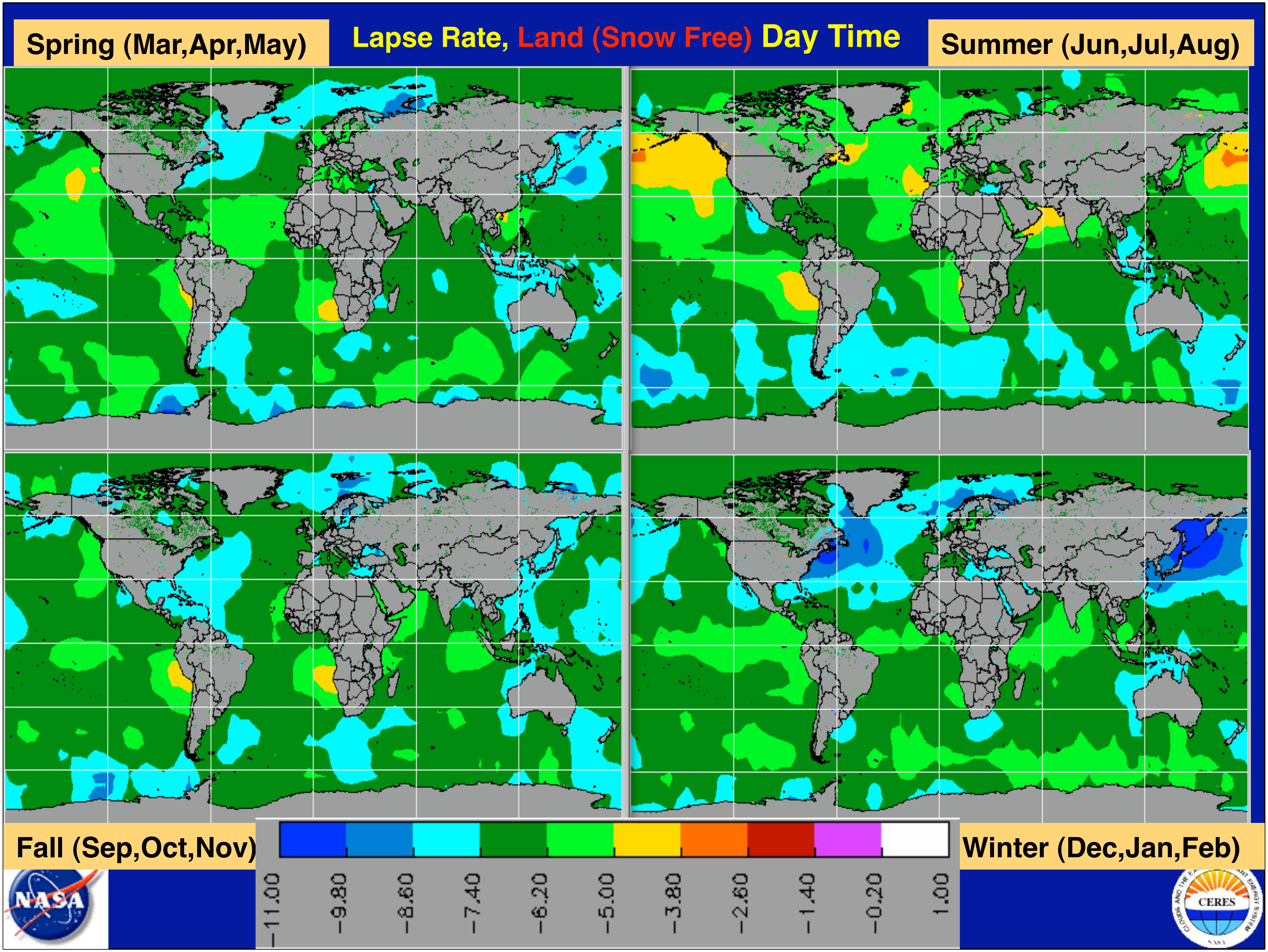
$$T(Z) = \{(p - p_h) * T(Z_{lap}) + (700 - p) * T(Z_{nwa})\} / (700 - p_h)$$

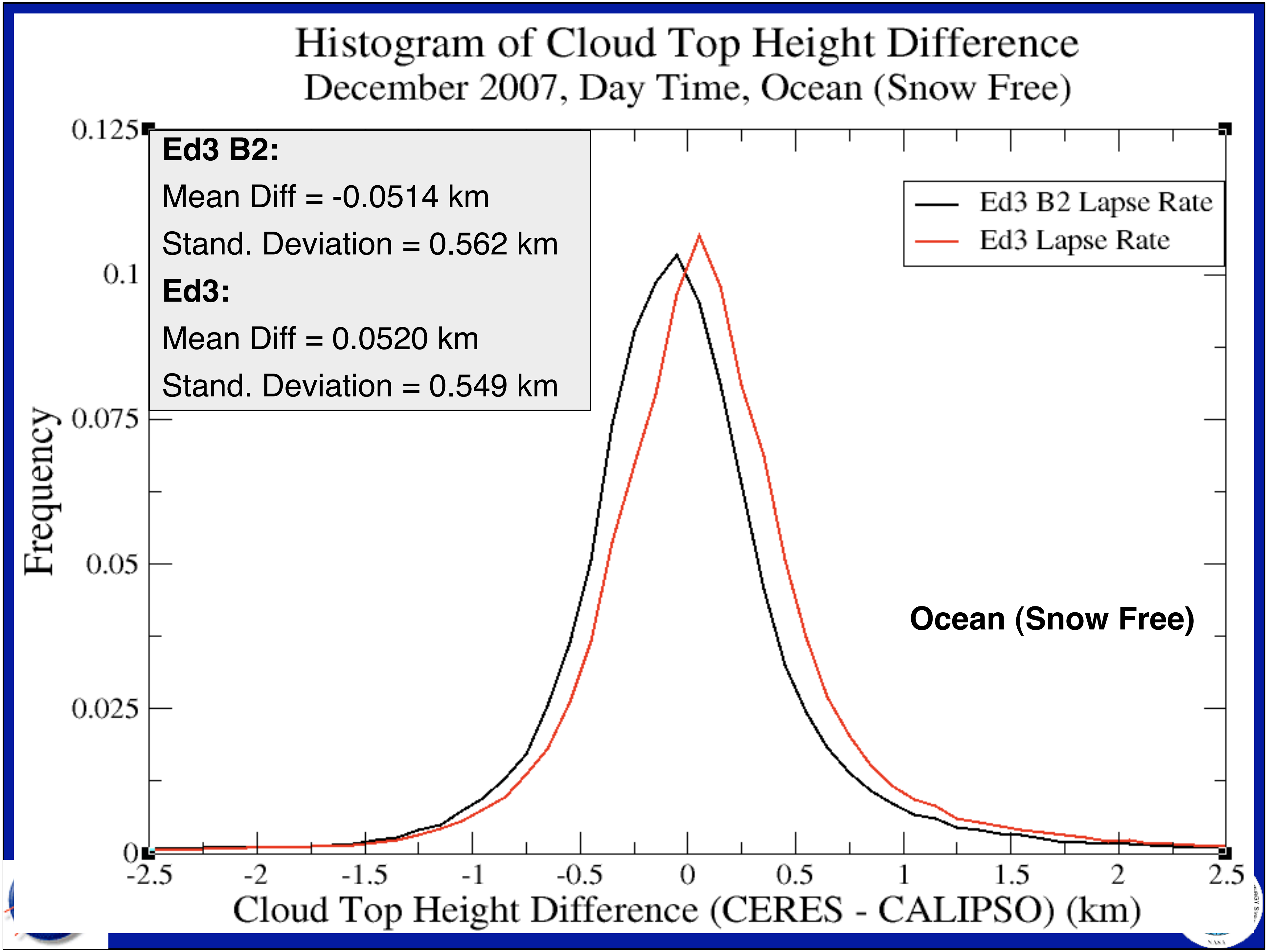
- For Ed2, $p_h = 500$ hPa, $\Gamma = 7.1$ K km^{-1}

- For Ed4, $p_h = 600$ hPa, Γ is regionally & seasonally dependent

Cloud Height Changes

- Regionally and seasonally dependent lapse rate for low clouds
  - year of Aqua & CALIPSO data analyzed
  - see Sun-Mack talk for more detail
- Overshooting convective cloud heights included in output
  - overshooting tops identified
  - lapse rate used to take top higher
  - tropopause height no longer cap on CERES cloud tops
- Changes in CO_2 retrievals
  - Chang talk


Spring (Mar,Apr,May)
Lapse Rate, Land (Snow Free) Day Time
Summer (Jun,Jul,Aug)
Fall (Sep,Oct,Nov)
Winter (Dec,Jan,Feb)
-11.00
-9.80
-8.60
-7.40
-6.20
-5.00
-3.80
-2.60
-1.40
-0.20
1.00
NASA
CERES

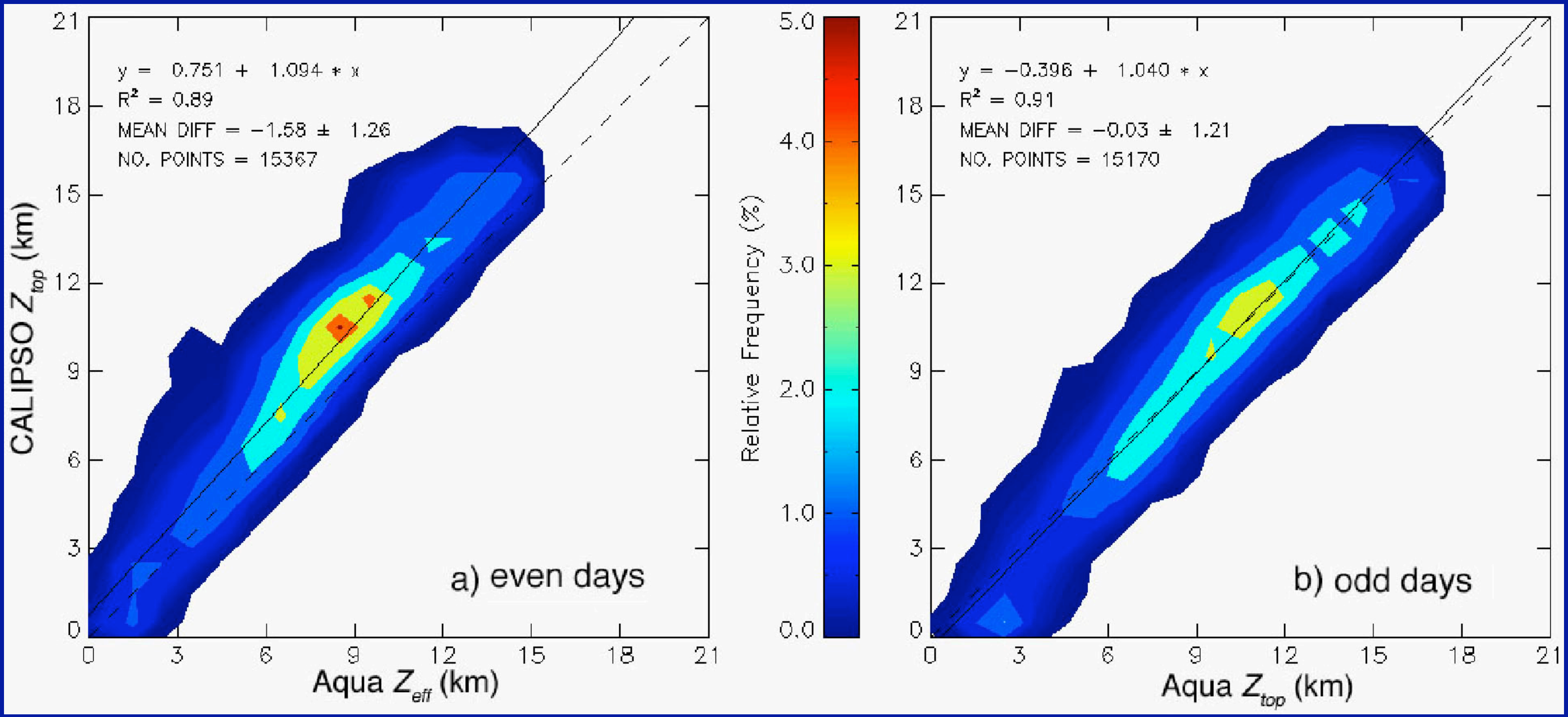


Histogram of Cloud Top Height Difference
December 2007, Day Time, Ocean (Snow Free)
Ed3 B2:
Mean Diff = -0.0514 km
Stand. Deviation = 0.562 km
Ed3:
Mean Diff = 0.0520 km
Stand. Deviation = 0.549 km
Ed3 B2 Lapse Rate
Ed3 Lapse Rate
Ocean (Snow Free)
Frequency
0.125
0.1
0.075
0.05
0.025
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
Cloud Top Height Difference (CERES - CALIPSO) (km)

Thick Ice Cloud Top Height Changes

- Ice cloud $T_t = T_c - T(\varepsilon)$, little change for $\varepsilon > 0.99$
- T_t and T_c are different thick ice clouds; not much difference for water

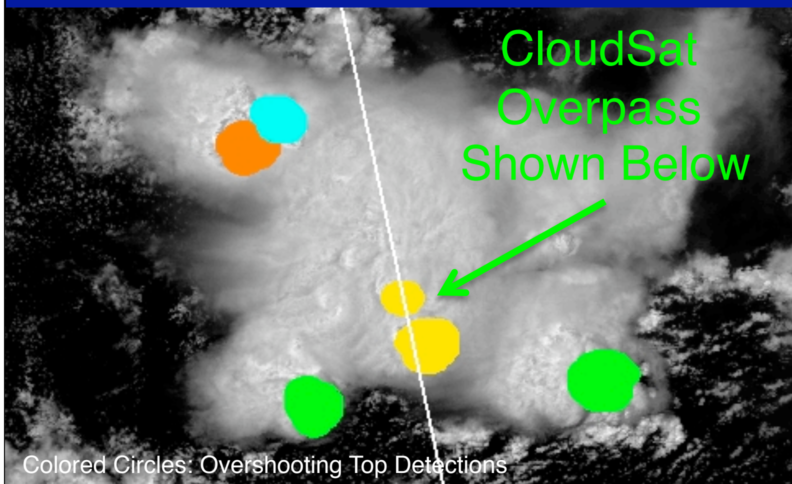
Cloud-top vs effective height April 2007 CERES MODIS & CALIPSO



Empirical corrections included in Ed4 for tau > 10, ice only

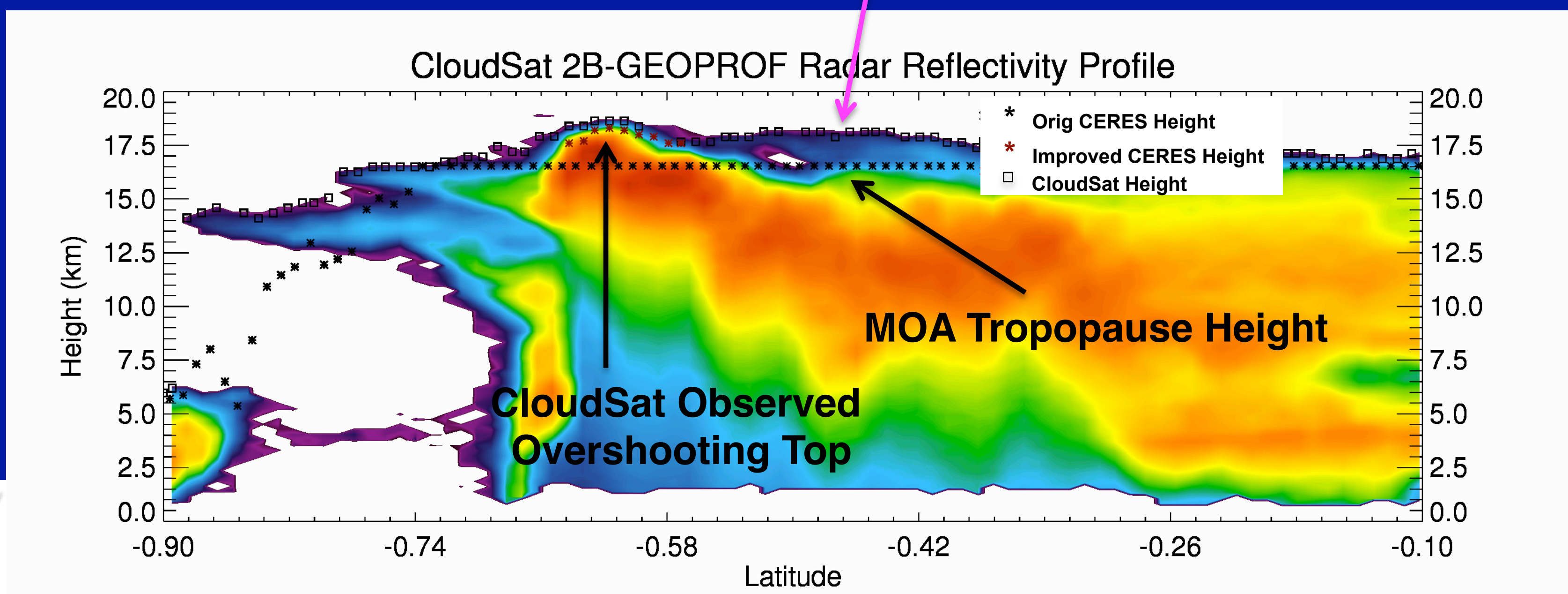
Minnis, P., C. R. Yost, S. Sun-Mack, and Y. Chen, 2008: Estimating the physical top altitude of optically thick ice clouds from thermal infrared satellite observations using CALIPSO data. *Geophys. Res. Lett.*.

Using Objective Overshooting Top Detections To Improve CERES Convective Cloud Top Height



- Height adjustment in overshooting top (OT) regions integrated into CERES Ed3 cloud algorithms
  - OT algorithm utilizes gradients in 11-μm channel temperatures for detection (Bedka et al., *JCAM*, 2010)
  - OT algorithm validated using 1.5 yrs of CloudSat OT observations: POD=75% FAR: 16%

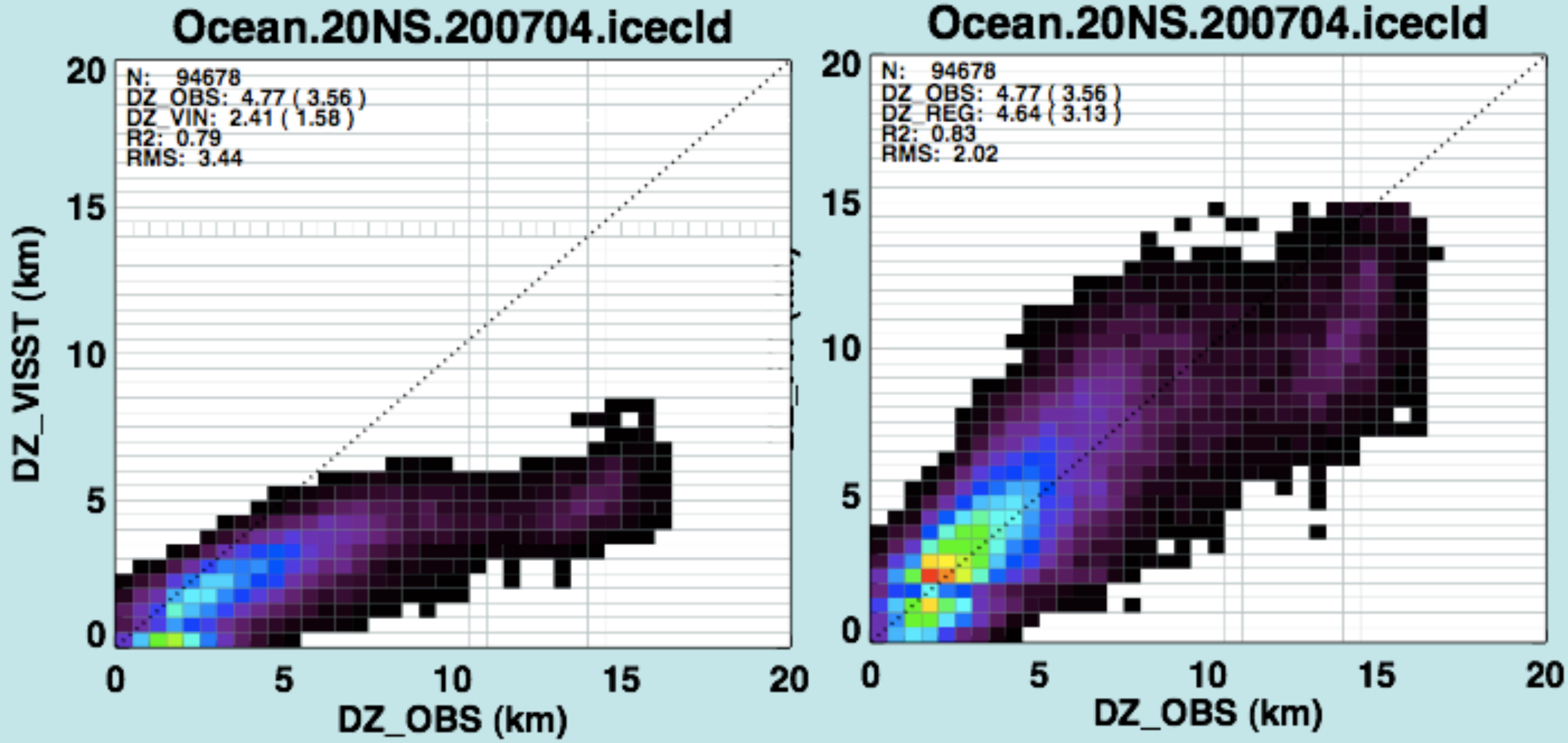
- Example below shows new height adjustment to Z_c better matches CloudSat heights
  - Additional 0.5-km increase will be applied to estimate Z_t



Improvements in Cloud Thickness Parameterizations

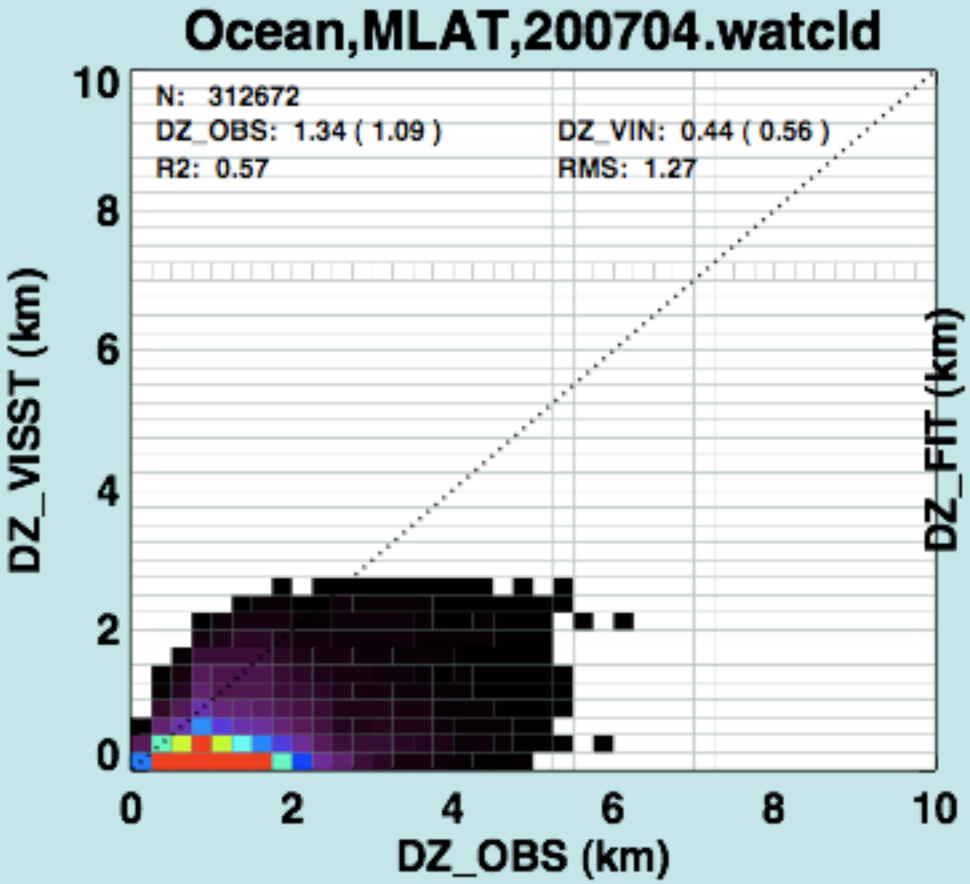
- Ed4 using CALIPSO/CloudSat-based thickness parameterizations

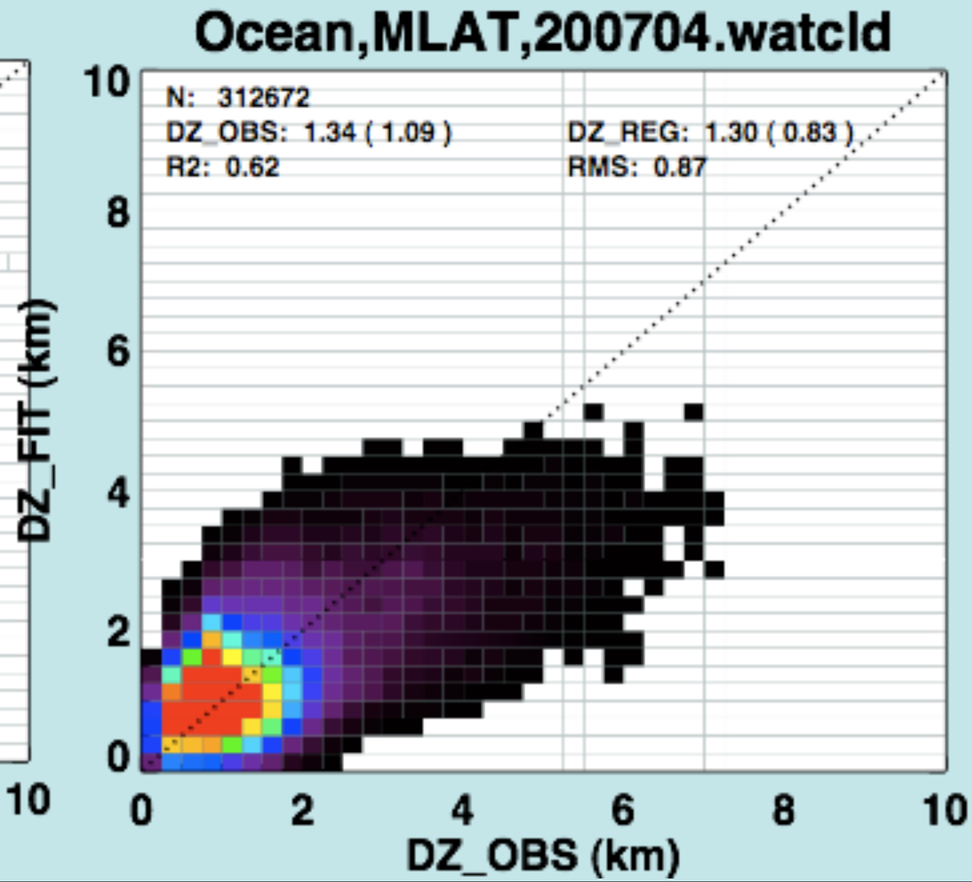
Ice Clouds over Ocean
Tropical (20N-20S)



Bias reduced from 2.36km to 0.13km
rms reduced 1.42km

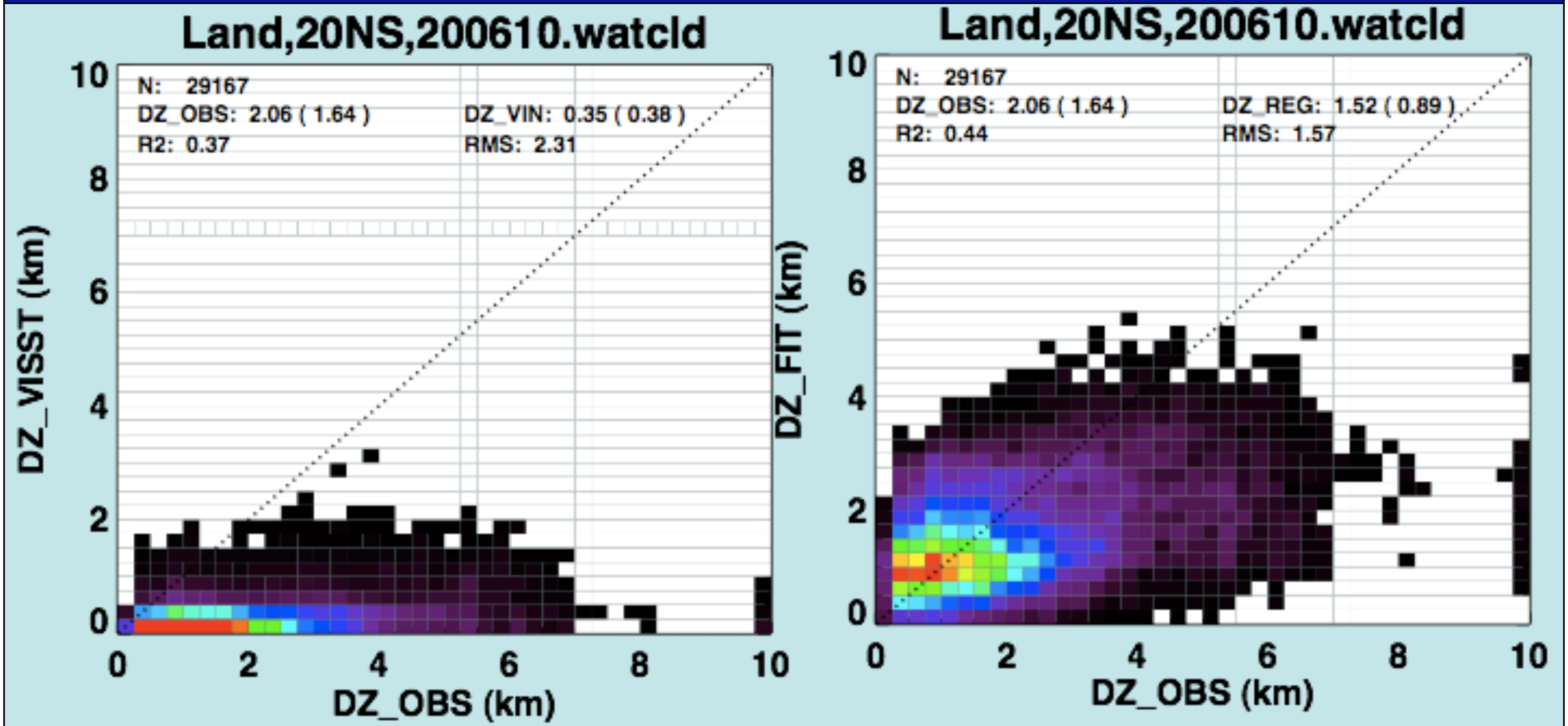
Water Clouds over Ocean
Mid Lat (50-20 N/S)





Bias reduced from 0.9 to 0.04km
rms reduced 0.4km

Water Clouds over Land
Tropical (20N-20S)



Bias reduced from 1.7 to 0.5 km
rms reduced by 0.7 km

Cloud Thickness Summary

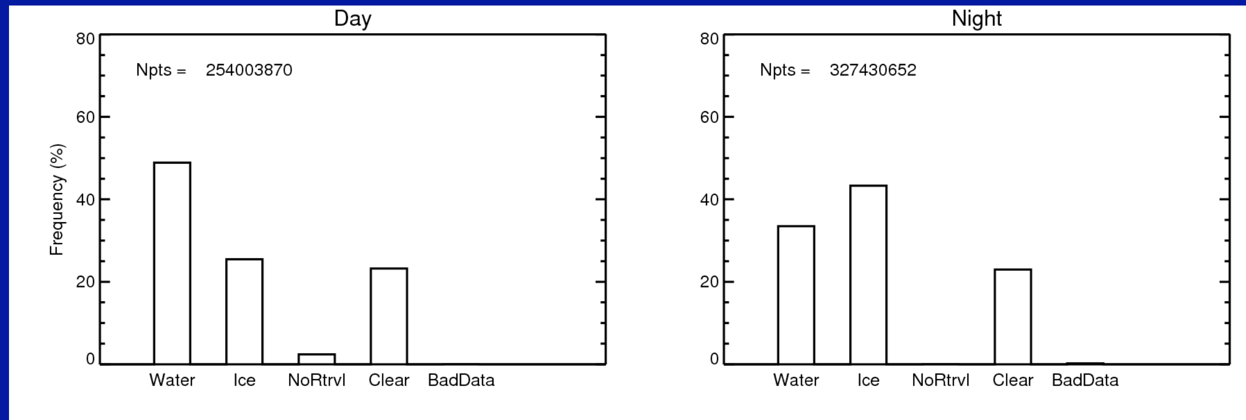
- New parameterizations for Ed4 dramatically decrease thickness biases found in Ed2 results

- Parameterization based on single-layer clouds
  - can be applied *post facto* to multilayered clouds

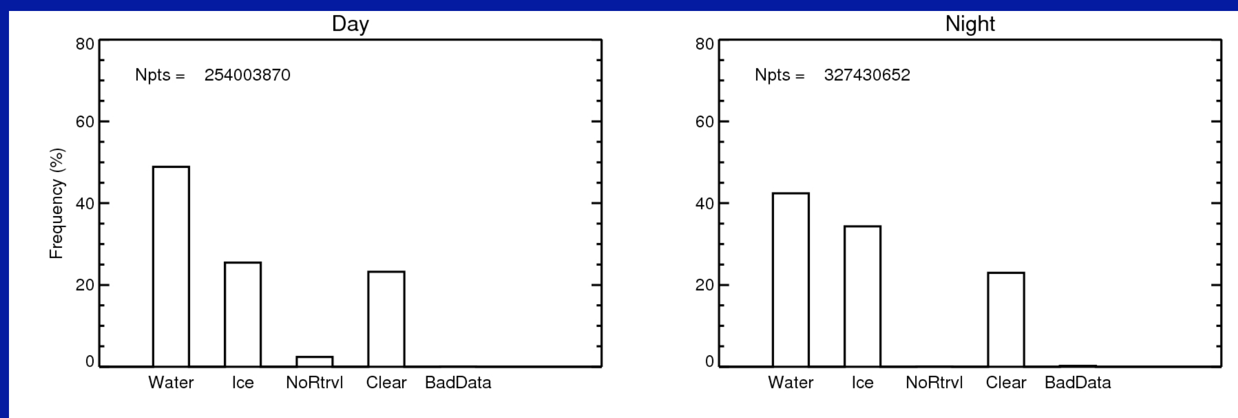
- Additional improvements possible
  - reduce rms by modeling as function of cloud type
  - not until Ed5

SIST / BSM Cloud Phase

Without BTD fits (original data)



With BTD fits



- Applied fits to Ice/Water and Ice/NoRtrvl cases for nighttime pixels over ocean
- More (supercooled) water cloud, less ice cloud, over ocean using fits to guide phase selection process; more realistic distributions

Nocturnal Phase Classification Summary

- Diurnal difference in ice cloud percentage reduced
  - remainder may be due to overlapped clouds
- Final testing this week

New Roughened Surface Ice Crystal Models for Ice Cloud Retrievals

• Goal: Use a simple ice crystal model that minimizes angular dependencies and still yields IWP values comparable to those of Ed2.

• Ed2: uses smooth hexagonal columns
  Ed4: use smooth, rough, or bubbled hexagonal columns

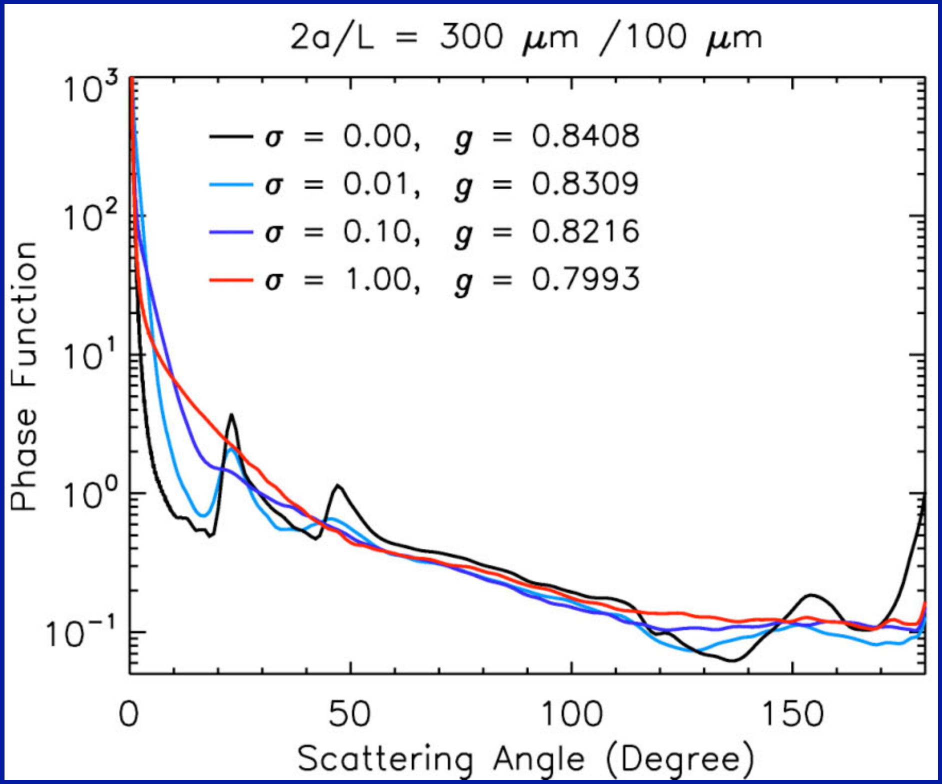
• Test models using MODIS & MISR data (similar to POLDER approach)

- Xie et al., TGRS, 2010, to be submitted
- Rough model yields lowest variation of tau with scattering angle

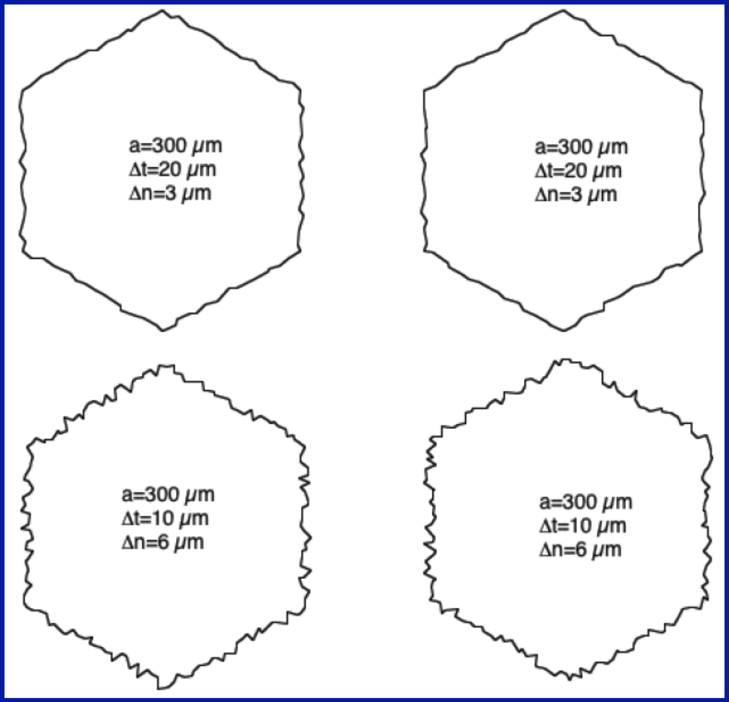
• Ed4 will use rough models for 0.65, 1.24, 1.61, and 3.8 μm
  smooth models for infrared channels

Ice Clouds

• Ice cloud model uses smooth hexagonal column distributions to retrieve ice cloud properties (black curve)



Progressive xtal roughening

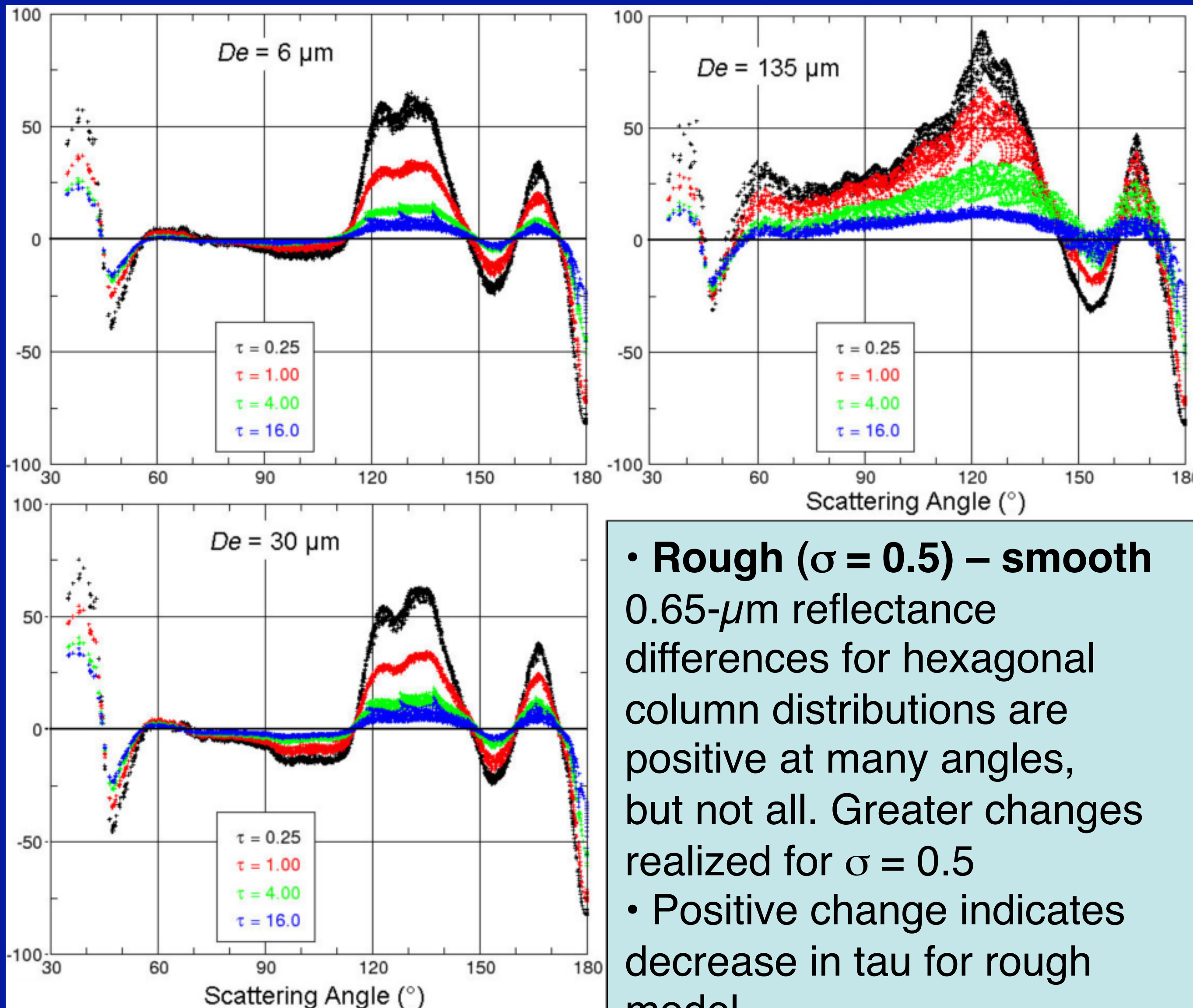


• Roughened crystals yield smoother phase functions, smaller asymmetry factors, g

from *Yang et al.* (2008, TGRS)

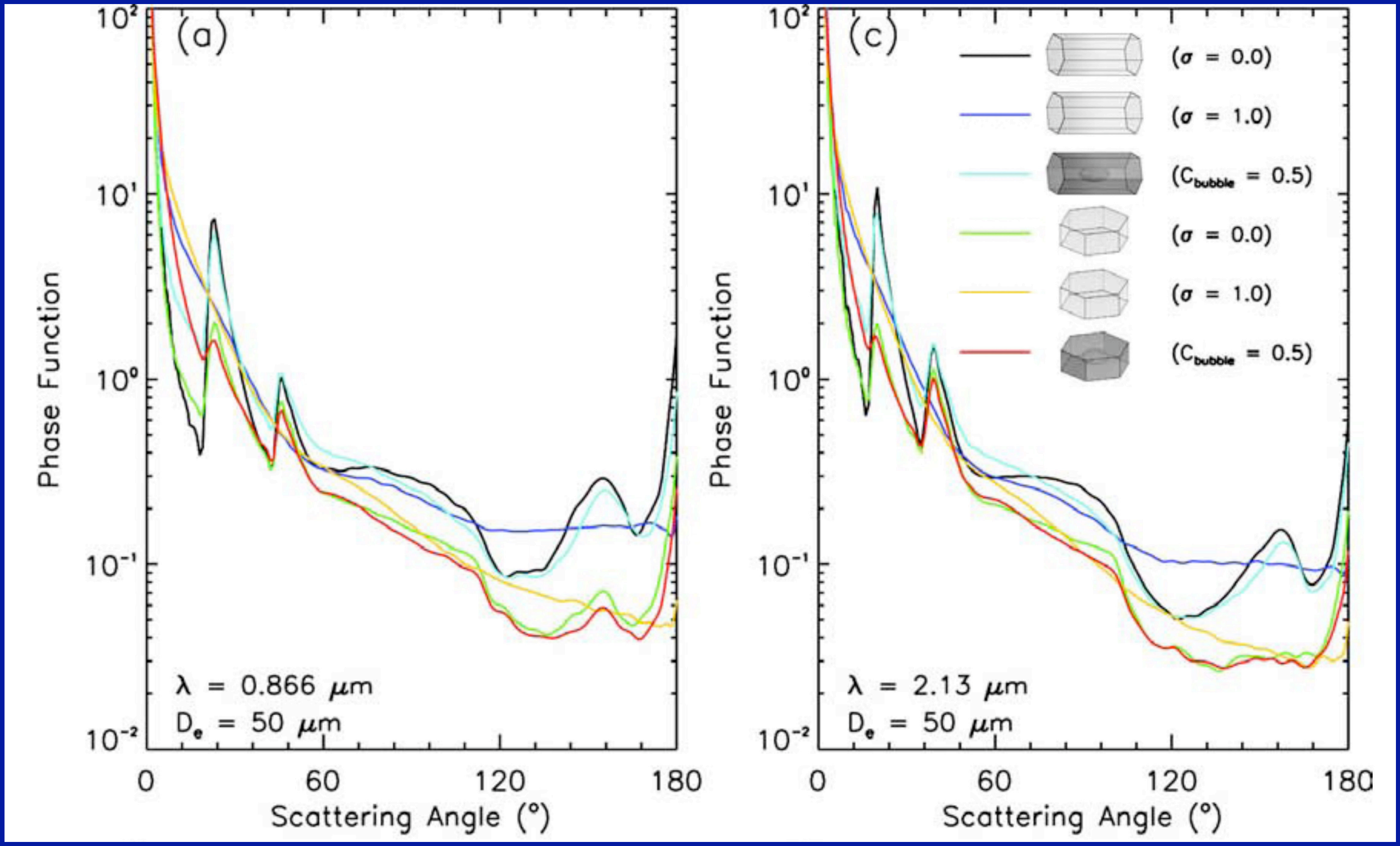
Reflectance fields for smooth & roughened ice hexagonal columns

Change in reflectance depends on De and τ



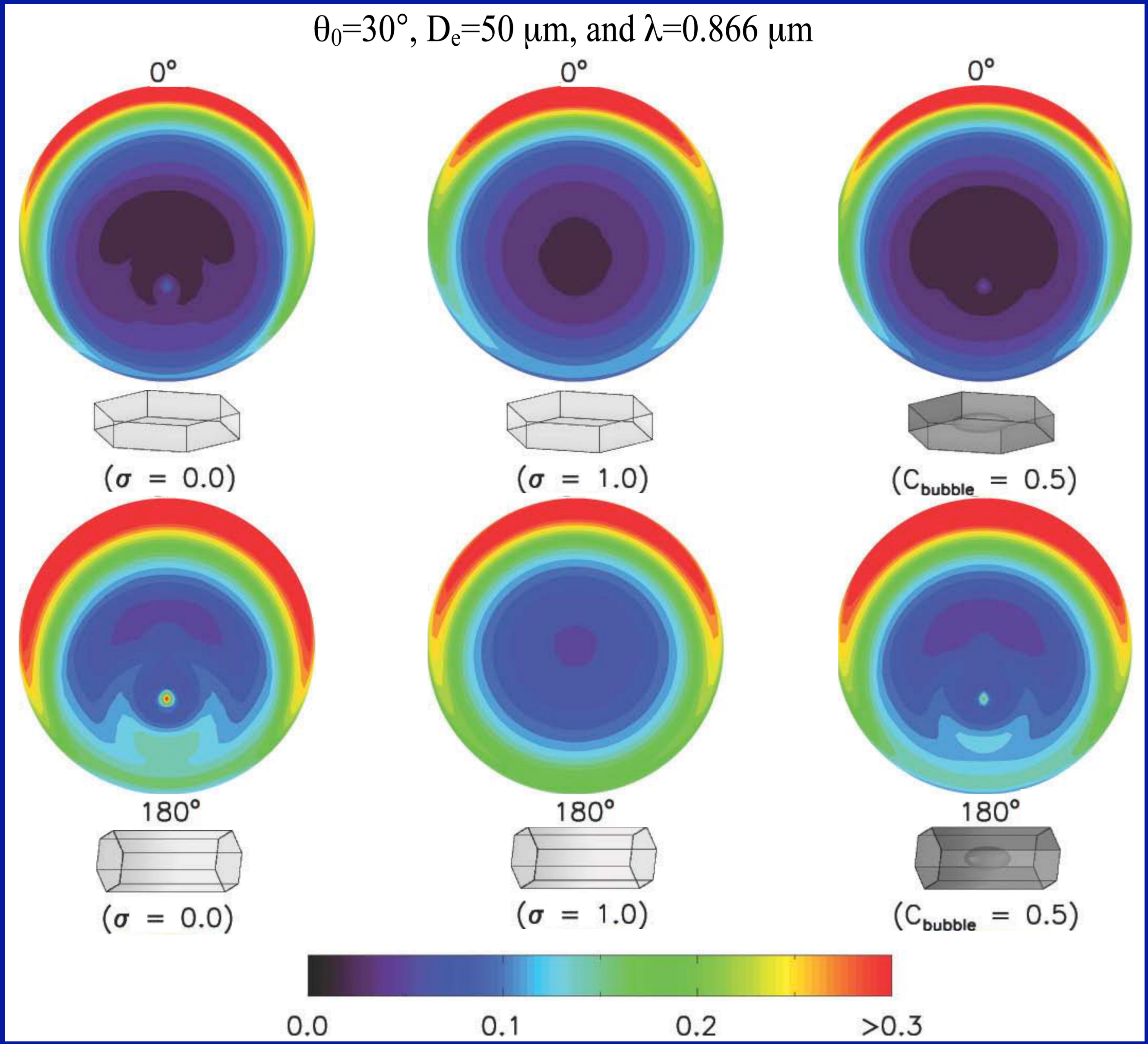
- **Rough (σ = 0.5) – smooth** 0.65-μm reflectance differences for hexagonal column distributions are positive at many angles, but not all. Greater changes realized for σ = 0.5
- Positive change indicates decrease in tau for rough model.

Scattering Phase Functions for Various Hexagonal Plate & Column Habit Configurations for Distributions Yielding De = 50 μm

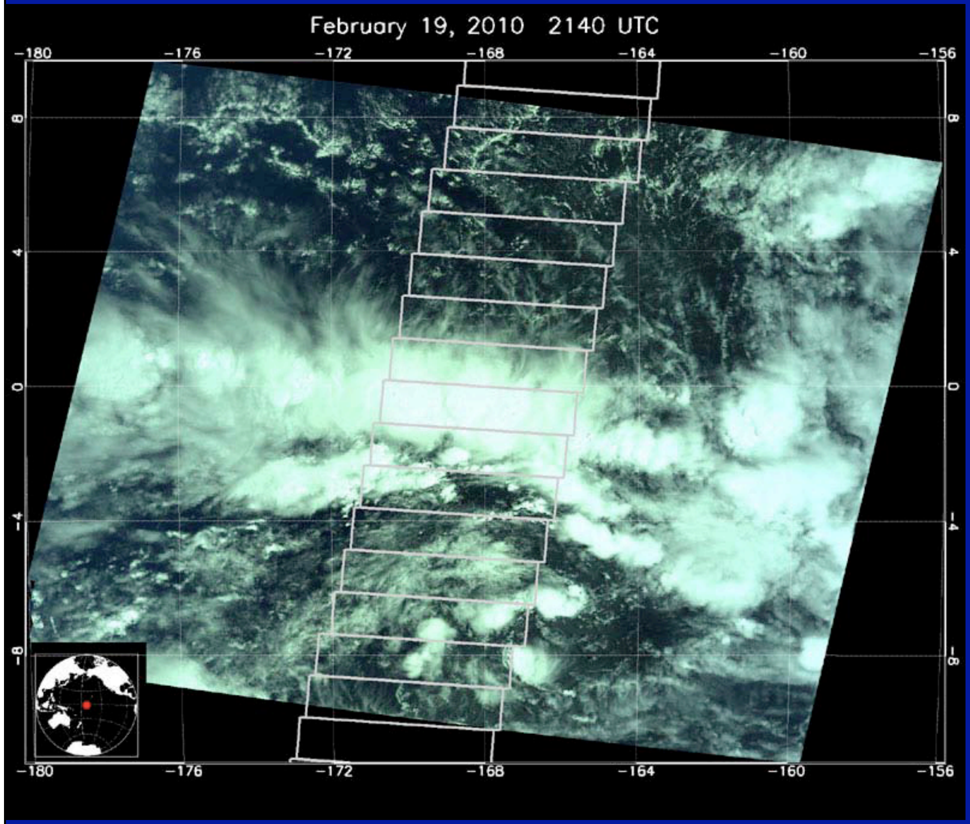


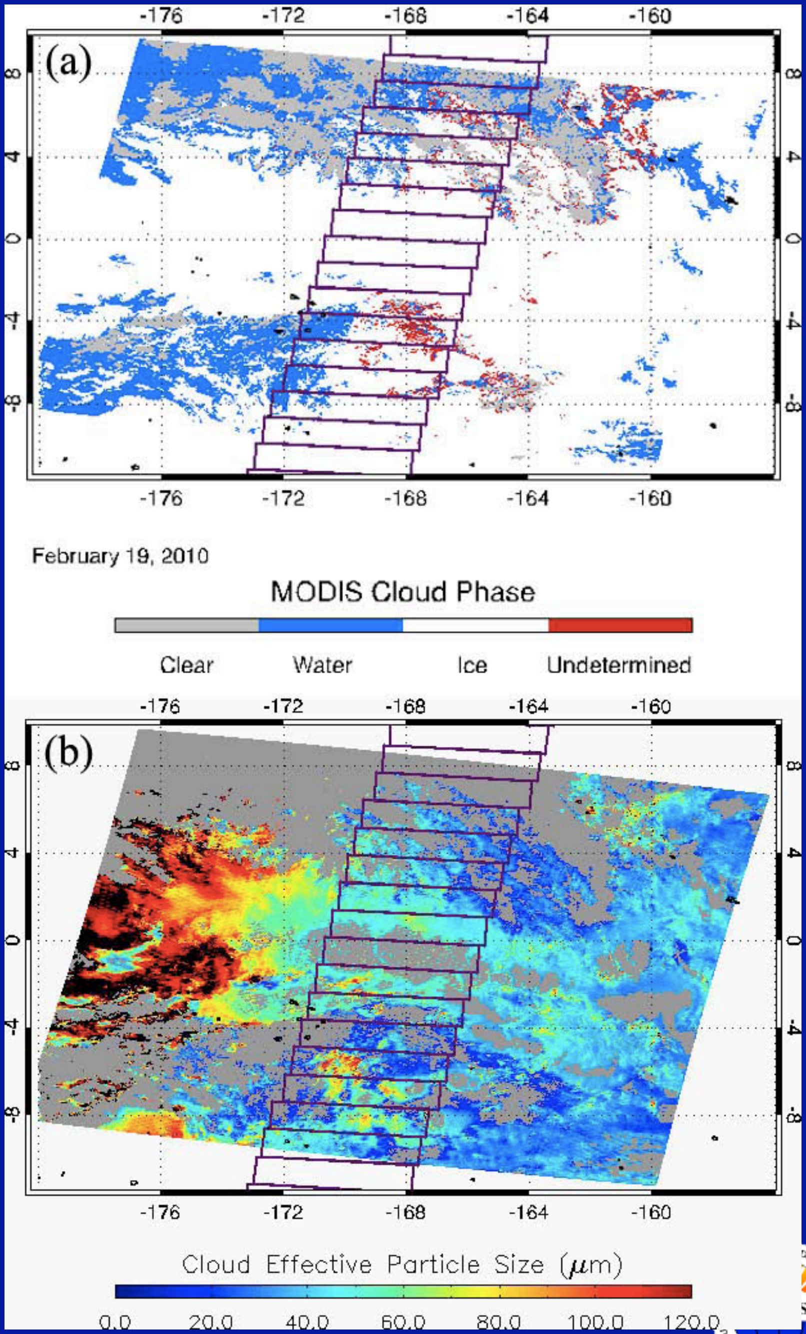
- Homogeneous plate (HP) or Column (HC), smooth, no bubble
- Rough (RP or RC), σ = 1.0, no bubble
- Inhomogeneous (IP or IC), C_{bubble} = 0.5, smooth

Bidirectional Reflectances for Various Hexagonal Plate & Column Habit Configurations for Distributions Yielding De = 50 μm



Retrieval of Optimal Tau Using MISR and Matched MODIS Data, 2140 UTC, 19 Feb 2010





- Retrieve tau using all 9 MISR views with a given Habit
- Find De from MODIS yielding minimum error in all 9 views

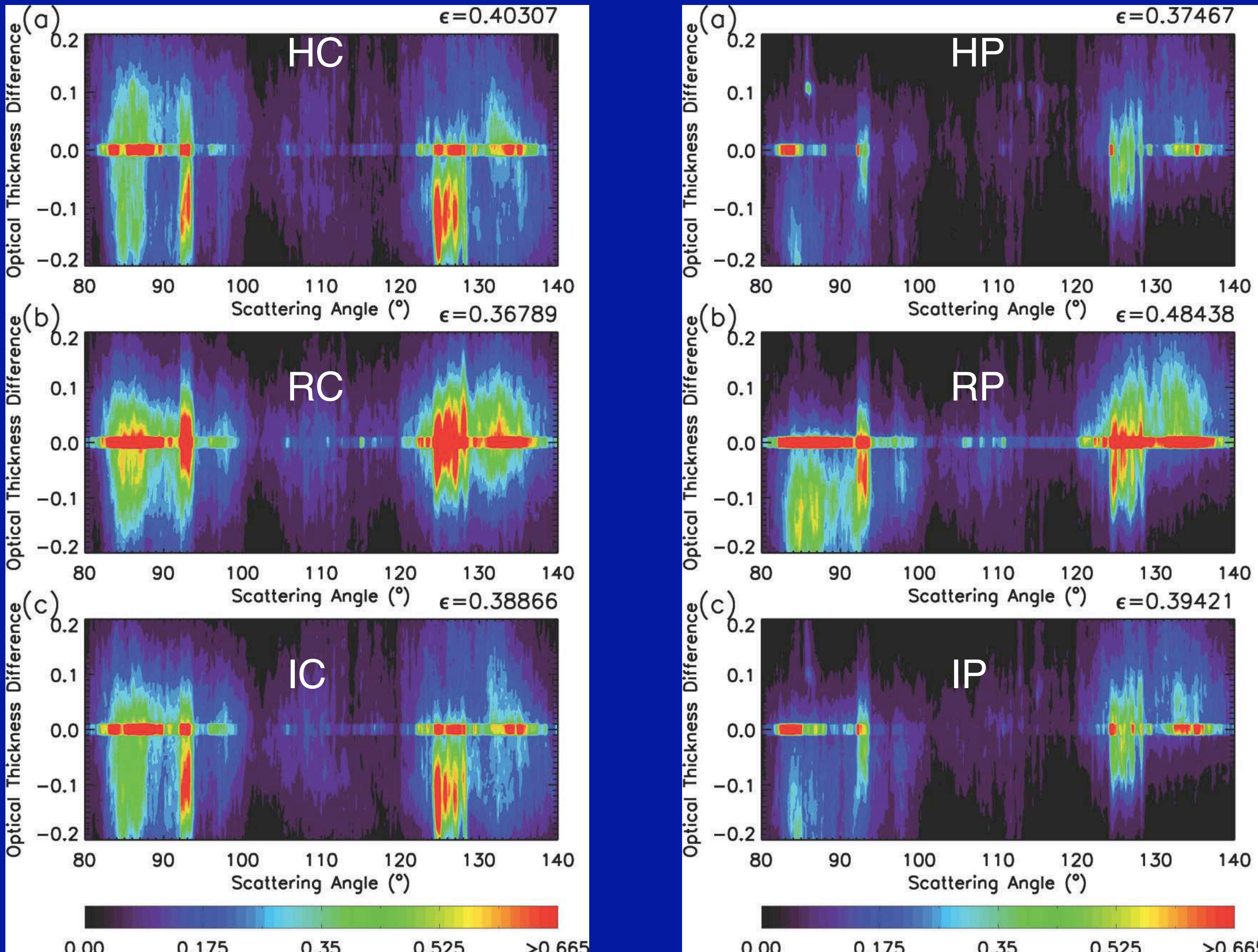
Ice cloud models and standard deviations of cloud optical thickness for MODIS and MISR granules for 5-minute intervals 2 July 2009 and 19 February 2010

Ice cloud model	ε	
HC	0.24471	
RC	0.17645	1
IC	0.25578	
HP	0.25722	
RP	0.23708	
IP	0.24435	3

Ice cloud model	ε	
HC	0.19793	
RC	0.16843	4
IC	0.19520	
HP	0.16284	
RP	0.16645	
IP	0.15526	1

- RC yields best average std dev = 0.173
- IP second with std dev = 0.204

Normalized Density of Ice Cloud Tau Differences for Various Habit Configurations for Terra/MISR Data, 2 July 2009



- RC yields best average std dev = 0.368

Ice cloud models and standard deviations of cloud optical thickness for MODIS and MISR granules for 2 July 2009

MX are habit mixtures of various proportions

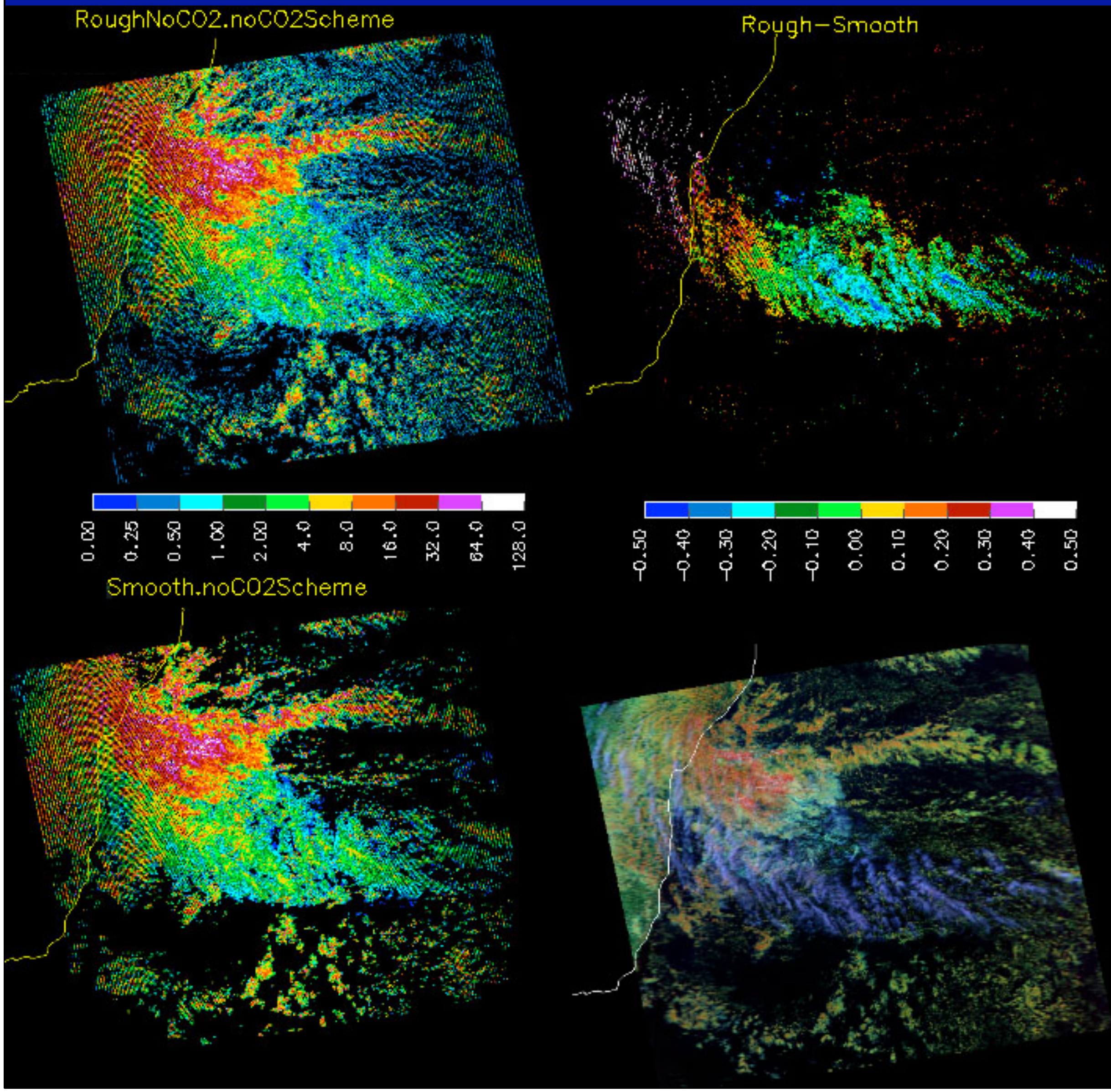
Ice cloud model	C_{HC}	C_{RC}	C_{IC}	C_{HP}	C_{RP}	C_{IP}	ε
HC	1.0	0.0	0.0	0.0	0.0	0.0	0.40307
RC	0.0	1.0	0.0	0.0	0.0	0.0	0.36789
IC	0.0	0.0	1.0	0.0	0.0	0.0	0.38866
HP	0.0	0.0	0.0	1.0	0.0	0.0	0.37467
RP	0.0	0.0	0.0	0.0	1.0	0.0	0.48438
IP	0.0	0.0	0.0	0.0	0.0	1.0	0.39421
M1	0.0001	0.9974	0.0014	0.0009	0.0002	0.000	0.36720
M3	0.0423	0.8913	0.0004	0.0115	0.0063	0.0482	0.36494
M5	0.0353	0.7963	0.0390	0.0598	0.0158	0.0538	0.36589
M7	0.0589	0.6987	0.0361	0.0710	0.0374	0.979	0.36867
M9	0.0701	0.5217	0.0191	0.0779	0.1609	0.1503	0.38807
M11	0.0091	0.4818	0.0066	0.0254	0.2528	0.2243	0.40737

- M3 yields best average std dev = 0.365
- RC not much worse, std dev = 0.368

** Xie et al., 2010 submitted*

Impact of Rough Ice Crystal Model on τ Retrieval, Aqua MODIS, 15 July 06, 15 UTC

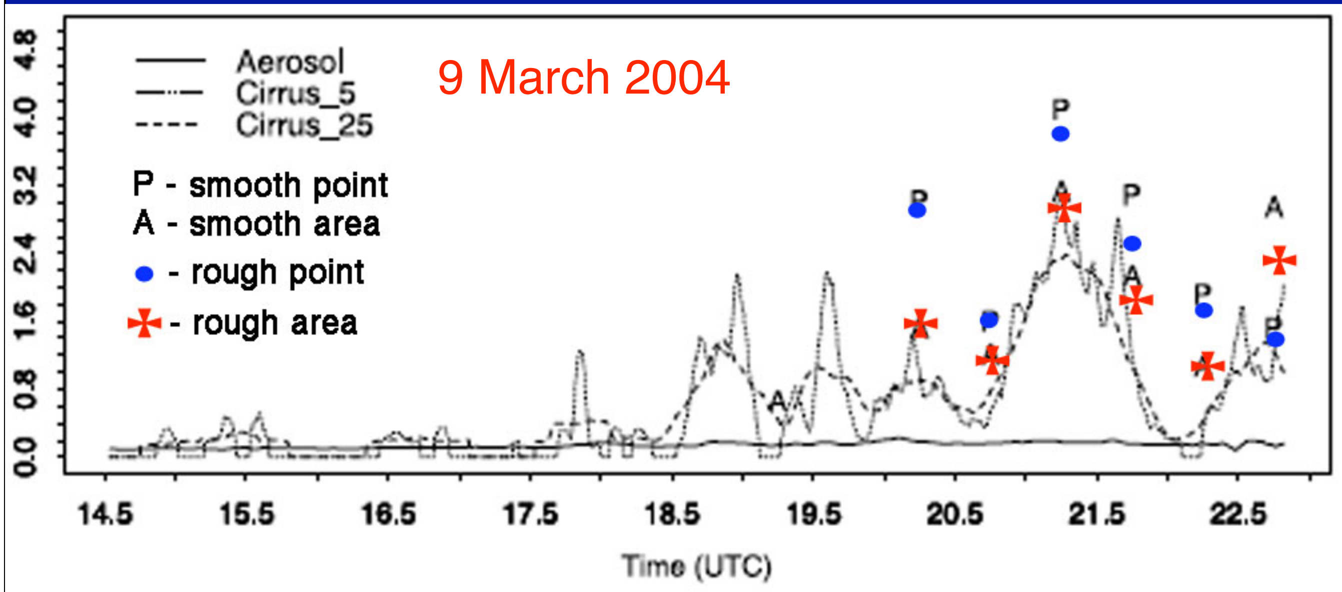
σ = 1.0

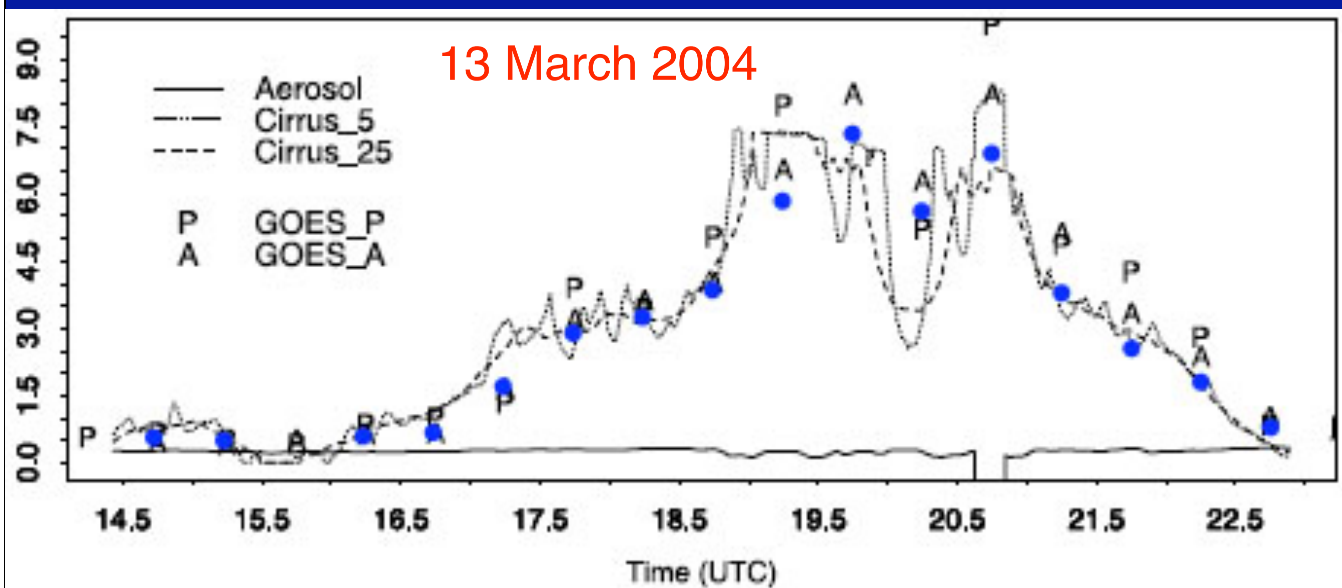


- Scan angle changes from > 90° to < 90° near center of image going right to left

- tau decreases on right side & increases on left, except near edges of cloud

Impact of Using Rough Ice Crystal Model on τ Retrieval, GOES-12 over ARM SGP





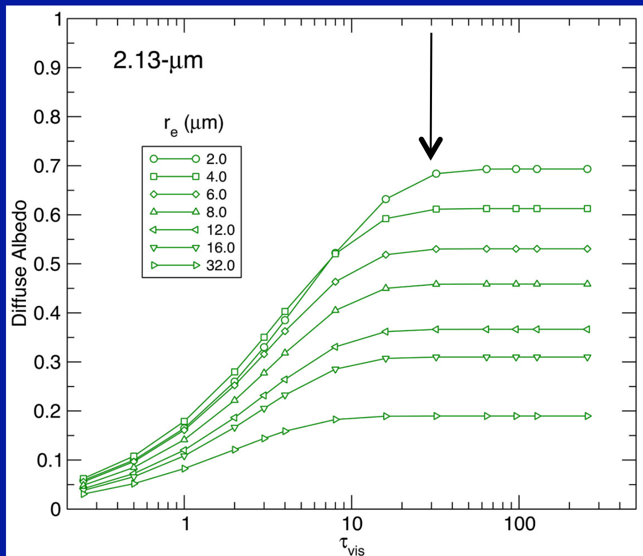
- roughened crystal, σ = 1.0, yields better agreement for these cases
- τ decreases in afternoon, not morning
- Z_e is steady or increases (not shown)

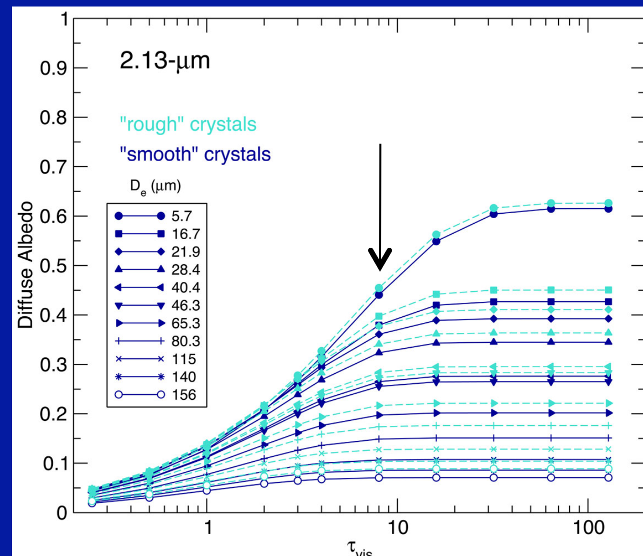
Original results from *Min et al.* (2004, JGR)

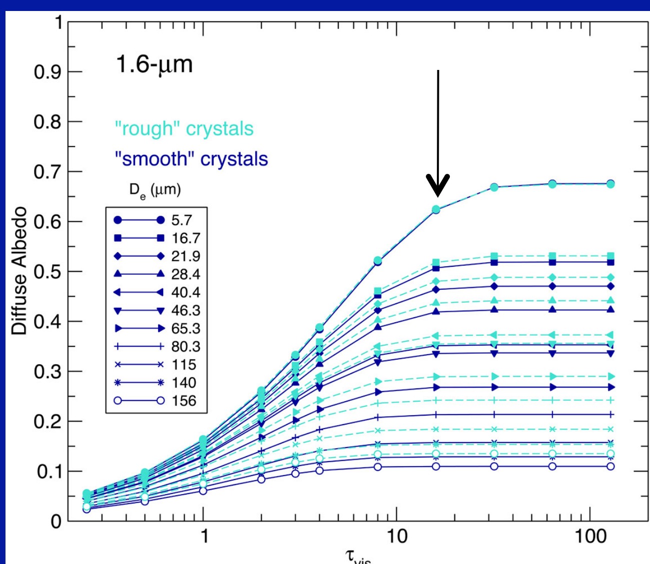
Retrieval of Properties over Snow

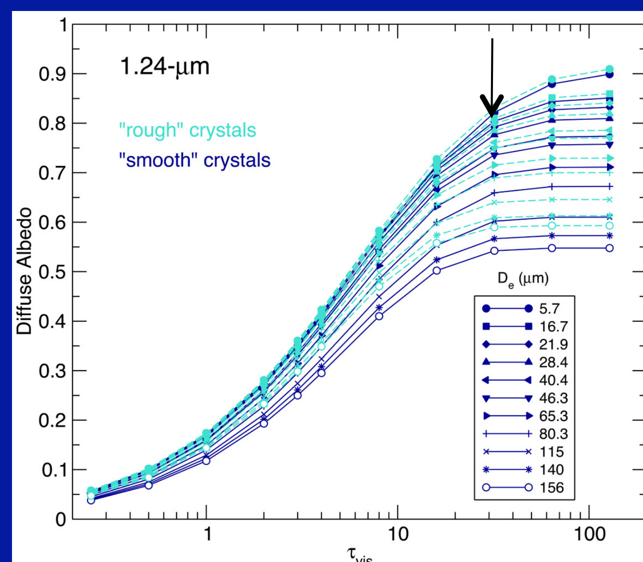
- For optical depth, Ed2 used 1.6 μm for Terra & 2.1 μm for Aqua
    - $\tau(2.1) < \tau(1.6)$ because of coding error and 2.13-μm limits
- 2.13-μm channel only good for small optical depth clouds
- 1.24-μm channel will be used for Ed4
    - used by MODIS Atmosphere Team (e.g., MOD06)?
- Requires good estimates of background albedos
    - need both snow-covered & snow-free monthly albedo maps

Diffuse Cloud Albedos from Adding-Doubling Computations









2.13-*µ*m

- water limit: $\tau = 16$
- ice: $\tau < 8$

1.6 *µ*m

- ice limit: $\tau = 16$

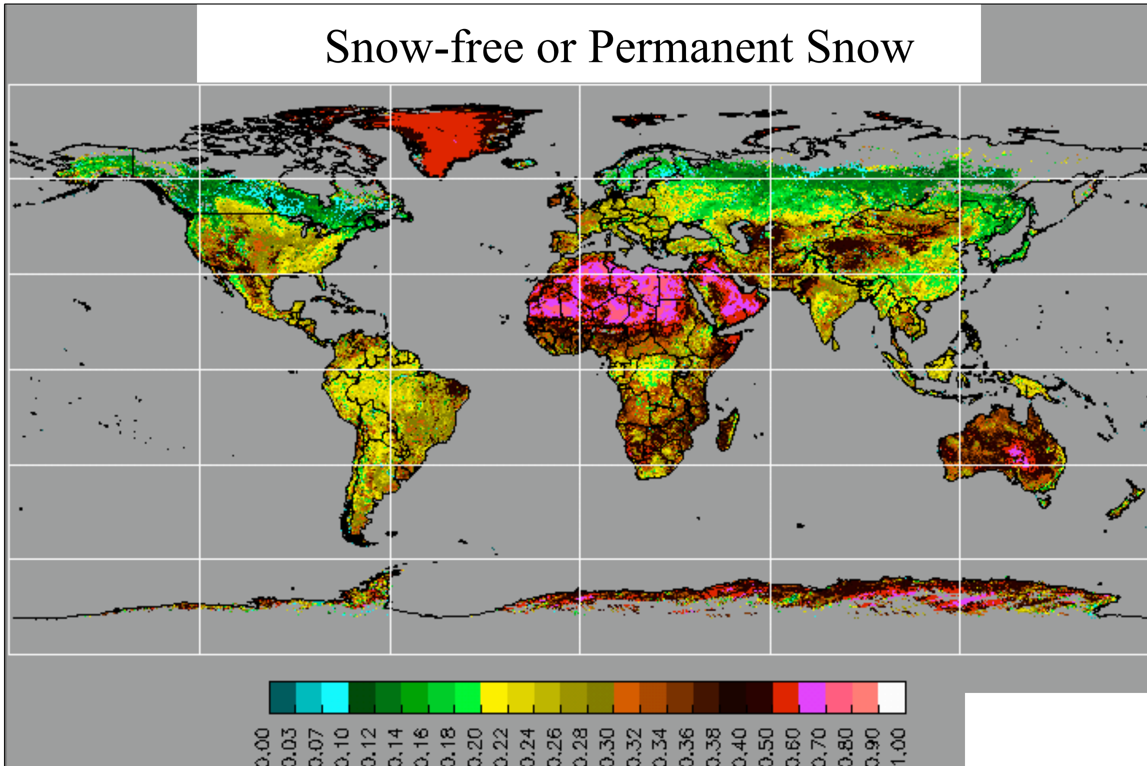
1.24 *µ*m

- ice limit: $\tau > 32$

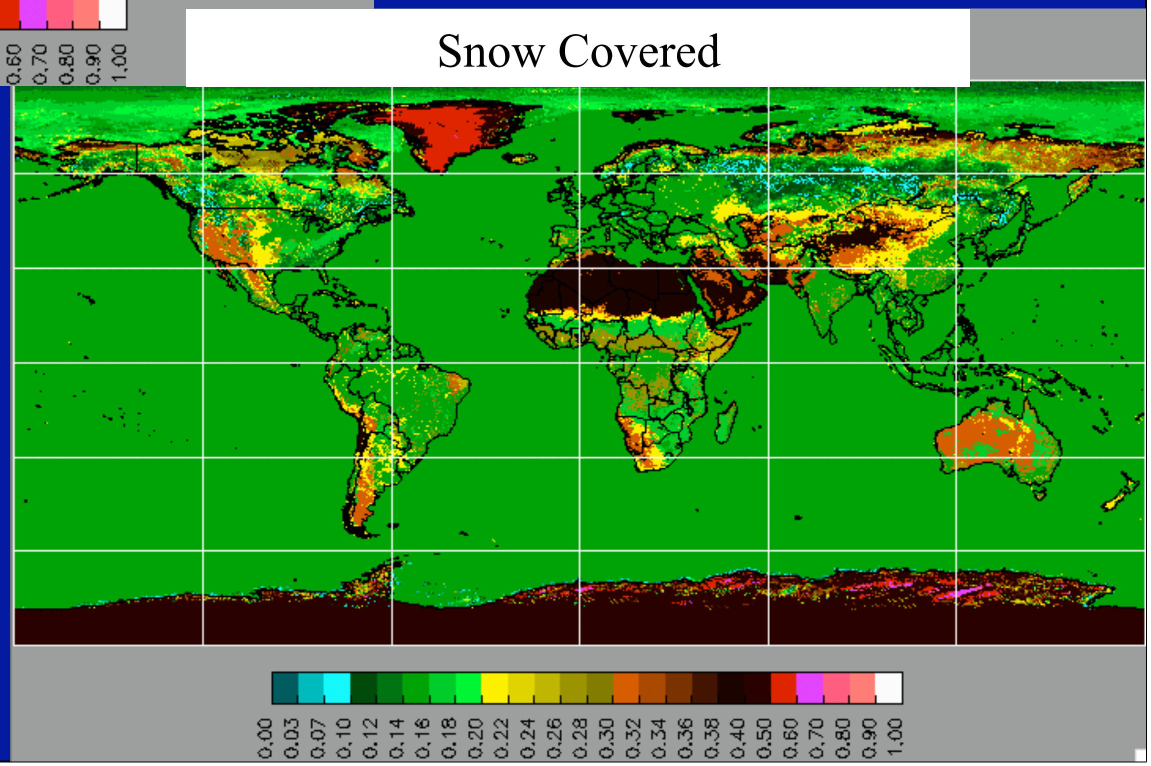
1.24 *µ*m channel has more promise for getting most of full range of τ

- MODIS team using 1.24 µm over snow

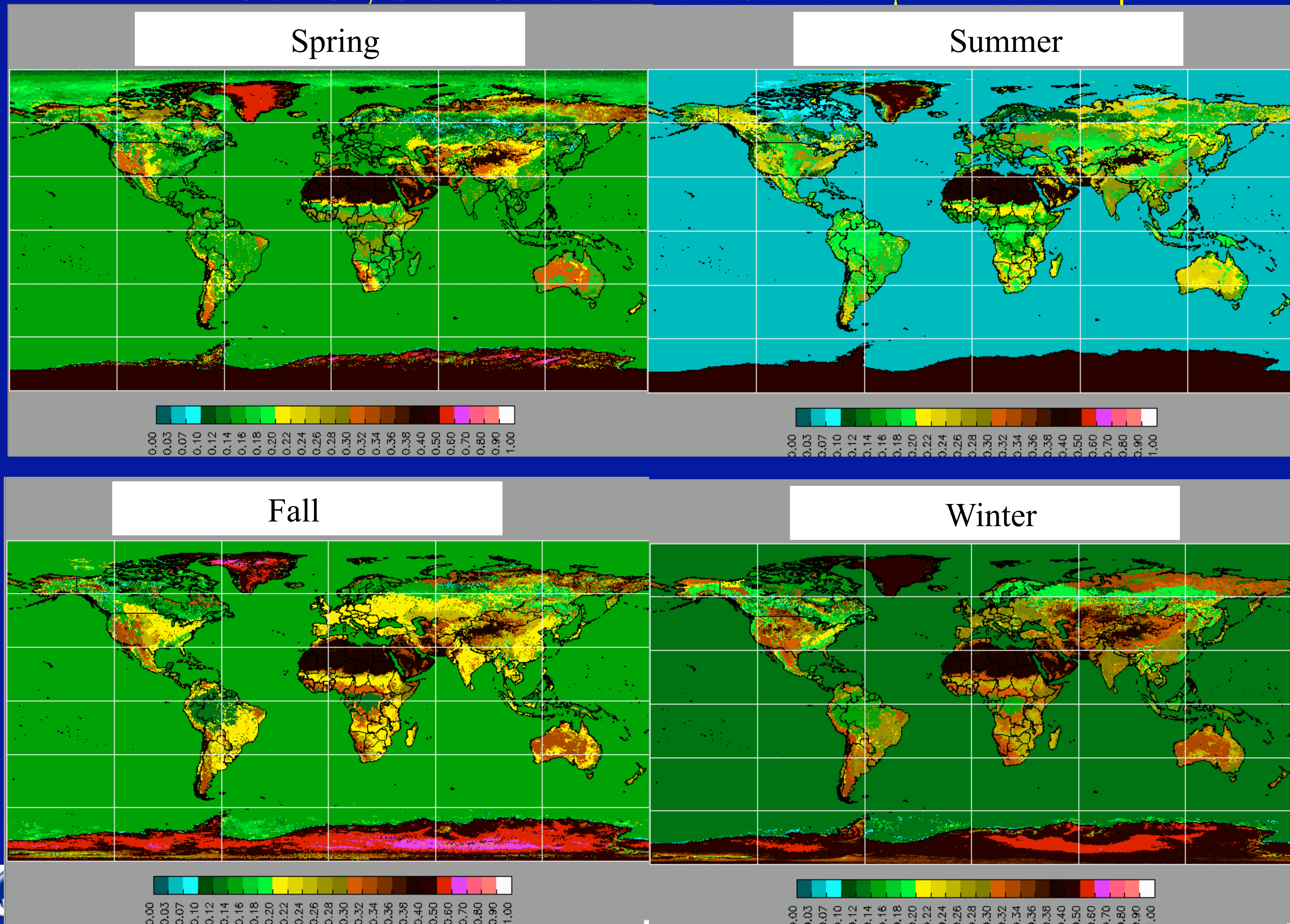
Clear-sky Overhead-Sun, 1.24-μm Albedo April 2007



• snow albedos nearly equal to or slightly greater than snow-free albedos



Final Clear Sky Snow Cover Overhead Sun 1.24 -µm Albedo Maps



Retrieval Clouds over Snow Summary

- 2.13-μm channel only good for small optical depth clouds
- Observations confirm 1.24-μm channel as the best option
- Requires good estimates of background albedos
  - use both snow-covered & snow-free albedo maps
  - monthly dependent
- Final implementation testing ongoing
  - complete retrieval code

Cloud Particle Size

- new definition for particle size, $R_e = D_{eg}/2 = f(D_e)/2$
  - $R_e = (7.918*1.0E\text{-}9*D_e*D_e + 1.0013*1.0E\text{-}3*D_e + 0.4441)*D_e$

- 2.1-μm particle sizes being retrieved now along with 3.8-μm Re

Modified CO2 Absorption Technique (MCO2) Cloud Heights

• MCAT simultaneously solves for cloud and background (cloud or surface) radiating temperatures & pressures using 10.8 and 13.3 μm channels

- Chang et al., JGR, 2010a,b

• CERES multilayer algorithm uses VISST/SIST to estimate tau & MCAT to estimate emissivity

- if tau too large to explain emissivity, ML ID applied
- various levels of confidence result

• If ML ID positive, properties for both low and high clouds are retrieved

• Final tuning performed for Ed4

- full explanation in Chang talk

Illustration of Terra MCAT Retrievals, 15 Aug 2007

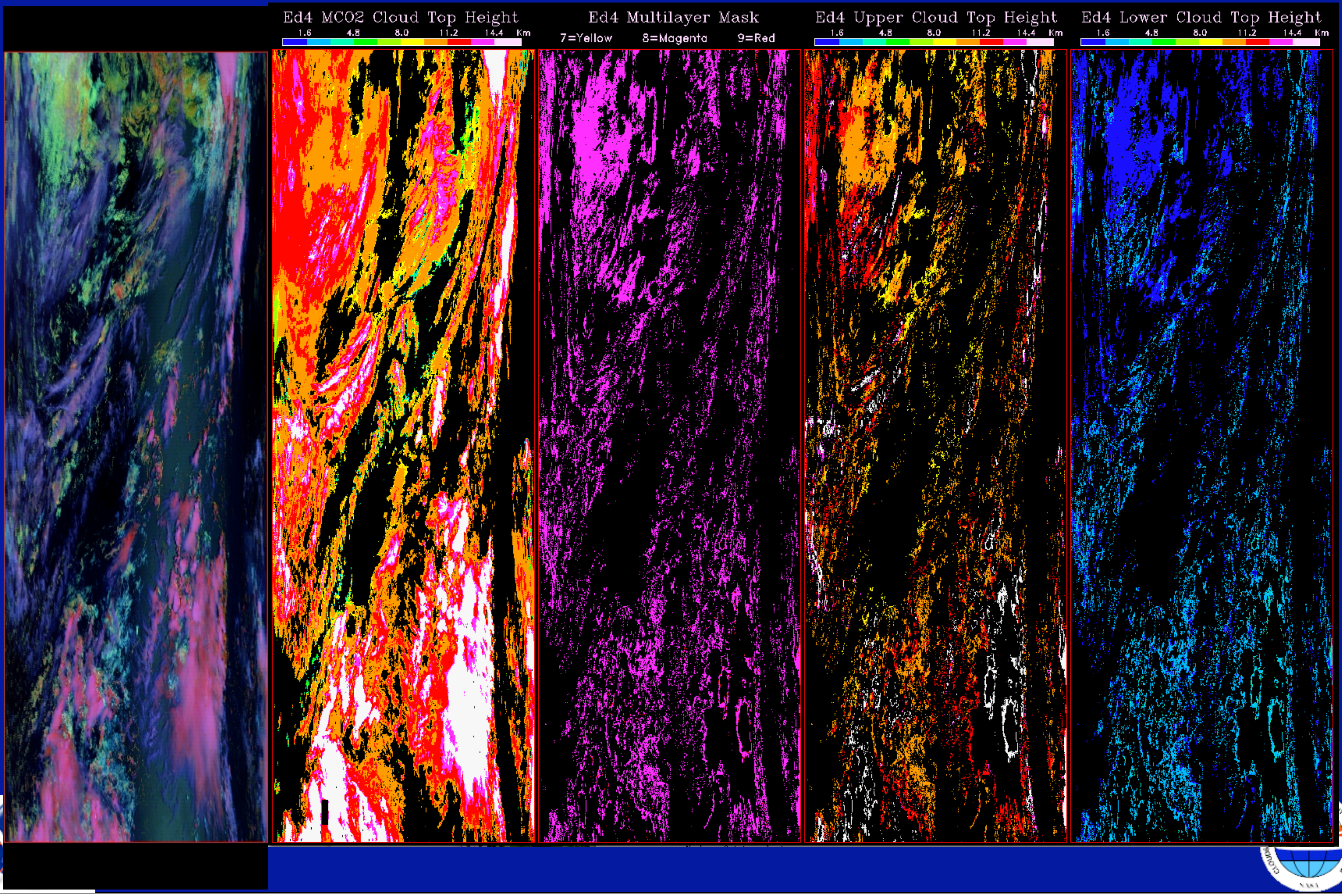
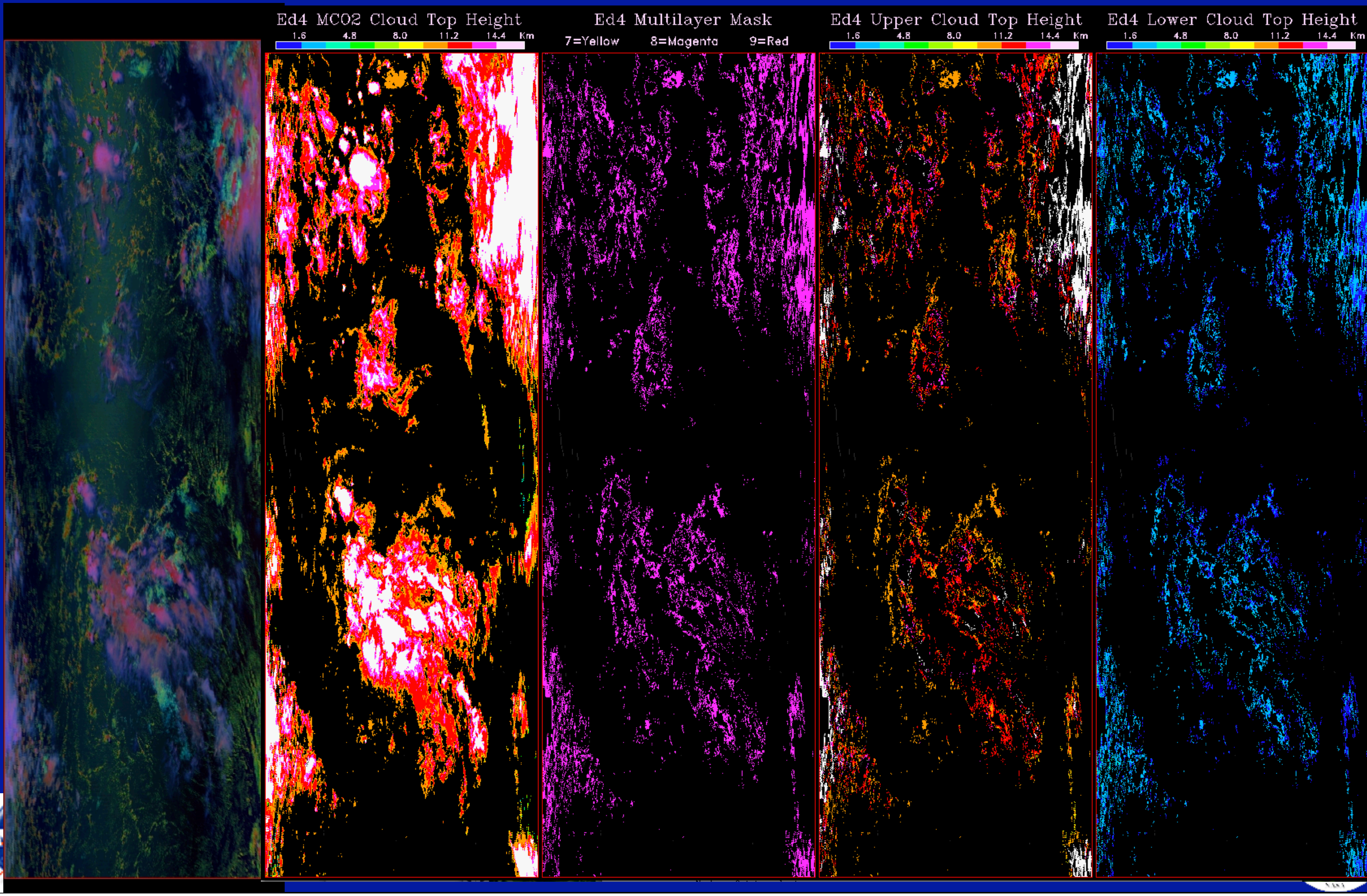


Illustration of Aqua MCAT Retrievals, 15 Aug 2007



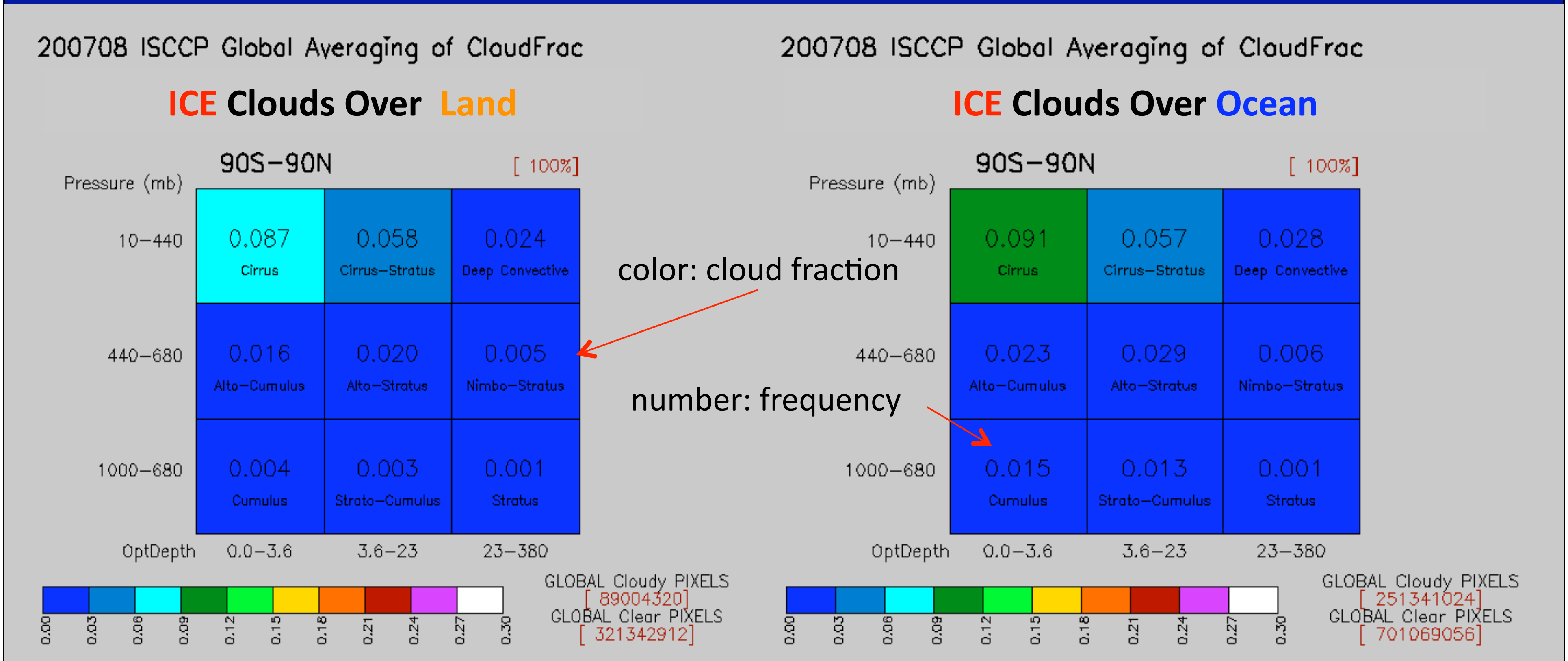
Ed3 Cloud Properties on SSF

- All Ed2 parameters
- SSF-79, 79a: CWG Tskin, CWG PW
- SSF-94a, b: Cloud top temperature, height
- SSF 102a: Mean cloud base temperature
- SSF 108-110: re(1.6), Re(1.6), log[tau(1.6)]
- SSF 110a-c: re(2.1), Re(2.1), log[tau(2.1)]
- SSF 111: CO2 layer coverage
- SSF 111a-c: emissivity, pc, Tc for CO2
- SSF 112: CO2 Zc
- SSF 114a-l: multilayer, single-layer properties (n x 4)

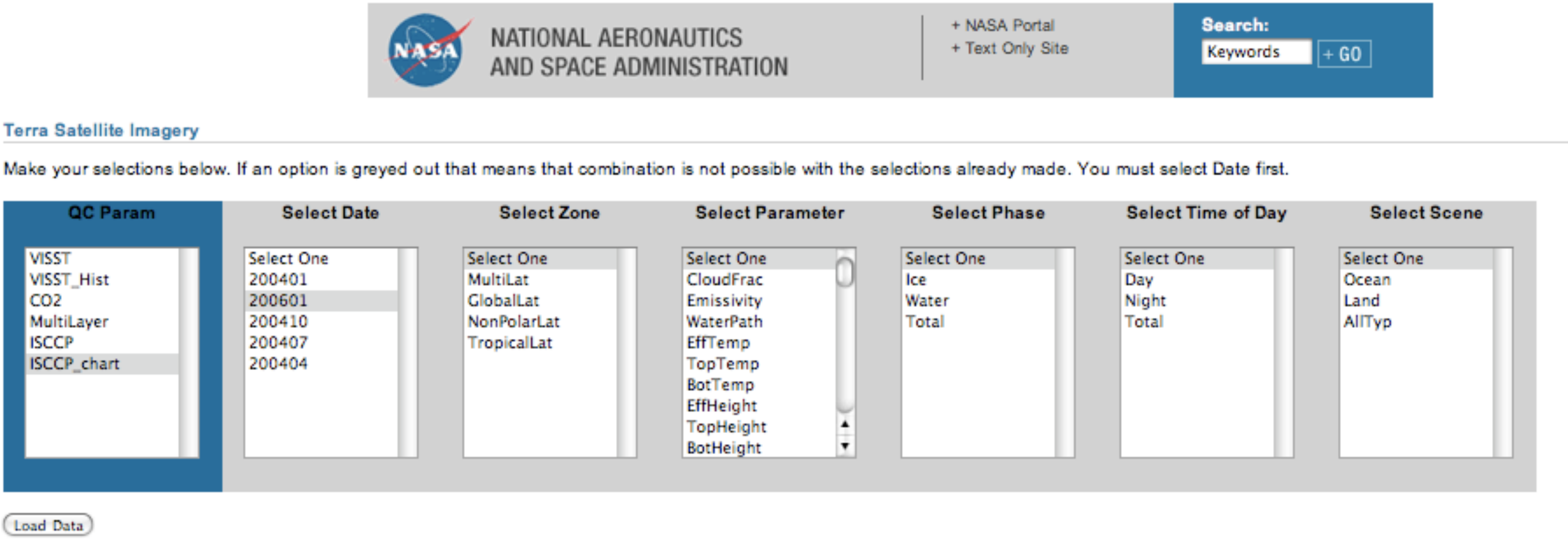
  coverage, OD, log(OD), emissivity, pt, Tt, Zt
  Rere(3.7), re(3.7), Re(3.7)
  Rere(2.1), re(2.1), Re(2.1)

New Product, ISCCP Simulator

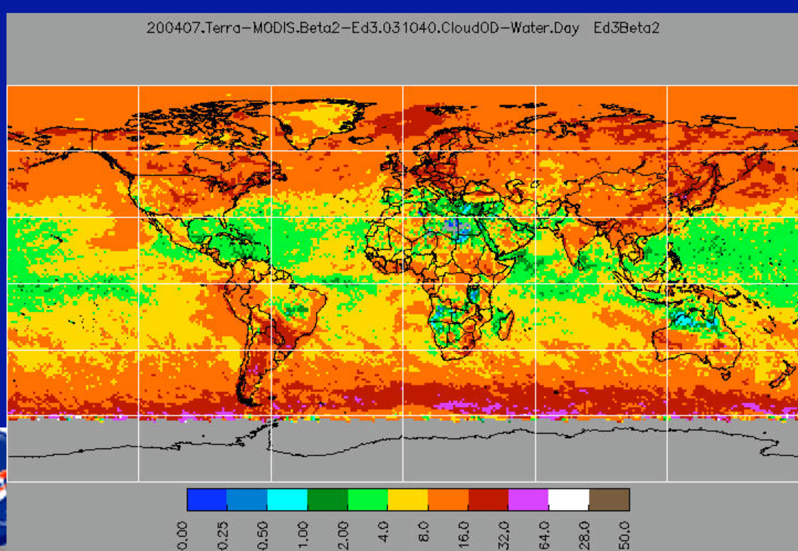
200708 Terra, CERES ISCCP Cloud Fraction, Day Time, ICE Clouds (Ed3-Beta2)



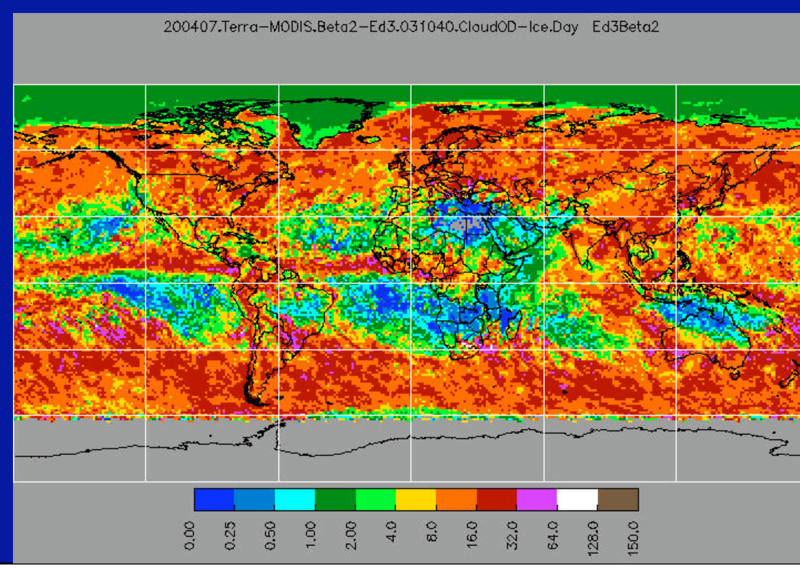
New Display Interface and Parameters



Water OD



Ice OD



Wrap-up Work for Final Ed4

- 0.64-μm Terra-Aqua differences: which is reference channel? Aqua
- Mask: test impact of 3.8 (night polar) & 0.64-μm (tau increase) calib changes
  impact of final GEOS-5? decreases nocturnal clouds, tuning needed
- Cloud phase
  - finalize nocturnal BSM/TSM algorithm & test; testing now
  - tweak daytime phase selection to properly detect altocumulus liquid
- Rough models? Final testing; rough selected, global tests this week
- Using CO2: do not apply cloud-top height correction for thin cirrus? No change
- Cloud-top heights
  - test for potential ML clouds first to prevent overcorrecting No change
  - test seasonal lapse rates, Reduces std dev (Sun-Mack talk)
- ML algorithm see Chang talk
  - use only two most certain categories? Decide when to perform retrieval
  - use only over non-snow sfcs?
- 2.13-μm saturation & models
  - test 1.24-μm retrievals over snow; clr albedos defined, testing this week
  - test 2.1-μm ice cloud Re retrievals, using Yang models

Bottom line: final testing underway for next 3 weeks