CERES Edition 3 Cloud Algorithm Status

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CERES Science Team Meeting, Newport News, VA

May 6-8, 2008

CERES Cloud Activities & Plans

- Prepared & submitted papers on algorithms, validation, calibration, science

- Examined impacts of changes from GEOS-4 to GEOS-5

- Completed Terra Ed2A and Aqua Ed1B through 2006

  - Dealt with Collection 4 and 5 differences: ignore

  - GEOS-4 ended December 2007

  - Ed2 & Ed1 to continue through 2008 with GEOS-5

- Edition 3

  - Delivered Beta 1, evaluate

  - Refine Beta 1, add new changes, deliver Beta 2

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

- Cho, H.-M., P. Yang, G. W. Kattawar, S. L. Nasiri, Y. Hu, P. Minnis, C. Trepte, and D. Winker, 2007: Depolarization ratio and attenuated backscatter for nine cloud types: analyses based on collocated CALIPSO lidar and MODIS measurements. *Opt. Express*, **16**, 3931-3948.
- 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.
- Dong, X., P. Minnis, B. Xi, S. Sun-Mack, and Y. Chen, 2008: Comparison of CERES-MODIS stratus cloud properties with ground-based measurements at the DOE ARM Southern Great Plains site. Accepted, *J. Geophys. Res.*, **113**, D03204, doi:10.1029/2007JD008438.
- Yang, P., G. W. Kattawar, G. Hong, P. Minnis, and Y. X. Hu, 2008: Uncertainties associated with the surface texture of ice particles in satellite-based retrieval of cirrus clouds: Part I. Single-scattering properties of ice crystals with surface roughness. *IEEE Trans. Geosci. Remote Sens.*, in press.
- Yang, P., G. W. Kattawar, G. Hong, P. Minnis, and Y. X. Hu, 2008: Uncertainties associated with the surface texture of ice particles in satellite-based retrieval of cirrus clouds: Part II. Effect of particle surface roughness on retrieved cloud optical thickness and effective particle size. *IEEE Trans. Geosci. Remote Sens.*, in press.
- 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. Accepted, *Geophys. Res. Lett.*, doi:10.1029/2008GL033947.
- Su, J., J. Huang, Quang Fu, P. Minnis, J. Ge, and J. Bi, 2008: Estimation of Asian dust aerosol effect on radiation forcing using Fu-Liou radiative model and CERES measurements. Submitted, *Atmos. Chem. and Phys.*
- Minnis, P., Q. Z. Trepte, S. Sun-Mack, Y. Chen, D. R. Doelling, D. F. Young, D. A. Spangenberg, W. F. Miller, B. A. Wielicki, R. R. Brown, S. C. Gibson, and E. B. Geier, 2008: Cloud detection in non-polar regions for CERES using TRMM VIRS and Terra and Aqua MODIS data. Submitted, *IEEE Trans. Geosci. Remote Sens.*

CERES cloud-related papers submitted or in preparation

• Dong, X., B. A. Wielicki, B. Xi, Y. Hu, G. G. Mace, S. Benson, F. Rose, S. Kato, T. Charlock, and P. Minnis, 2008: Using observations of deep convective systems to constrain atmospheric column absorption of solar radiation in the optically thick limit. Accepted, *J. Geophys. Res.*

• Minnis, P., S. Sun-Mack, Y. Chen, and Y. Yi, 2008: Comparison of CERES-MODIS and ICESat GLAS cloud amounts. Submitted, *Geophys. Res. Lett.*

• Smith, W. L., P. Minnis, H. Finney, R. Palikonda, and M. M. Khaiyer, 2008: An evaluation of operational GOES-derived single-layer cloud top heights with ARSCL over the ARM Southern Great Plains site. *Geophys. Res. Lett.*, Submitted.

• Lin, B., P. Stackhouse, P. Minnis, B. A. Wielicki, Y. Hu, W. Sun, T.-F. Fan, and L. Hinkelman, 2008: Assessment of global annual energy balance from satellite observations. Submitted to *J. Geophys. Res.*

• Waliser, D., F. Li, C. Woods, R. Austin, J. Bacmeister, J. Chern, A. DelGenio, J. Jiang, Z. Kuang, H. Meng, P. Minnis, S. Platnick, W. B. Rossow, G. Stephens, S. Sun-Mack, W. K. Tao, A. Tompkins, D. Vane, C. Walker, and D. Wu, 2008: Cloud ice: A climate model challenge with signs and expectations of progress. Submitted to *J. Geophys. Res.*

• Sun-Mack, P. Minnis, Y. Chen, R. F. Arduini, and D. F. Young, 2008, Visible clear-sky and near-infrared surface albedos derived from VIRS and MODIS data for CERES. *IEEE Trans. Geosci. Remote Sens.*, in preparation.

• Trepte, Q. Z, P. Minnis, D. A. Spangenberg, R. F. Arduini, S. Sun-Mack, and Y. Chen, 2008: Polar cloud and snow discrimination for CERES using MODIS data. *IEEE Trans. Geosci. Remote Sens.*, in preparation.

•Minnis, P., S. Sun-Mack, D. F. Young, P. W. Heck, D. P. Garber, Y. Chen, D. A. Spangenberg, B. A. Wielicki, and E. B. Geier, 2008: Cloud property retrievals for CERES using TRMM VIRS and Terra and Aqua MODIS data, *IEEE Trans. Geosci. Remote Sens.*, in preparation.

• Minnis, P., Sunny Sun-Mack, Y. Yi, and Y. Chen, 2008: Comparison of cloud heights derived from CERES-MODIS retrievals and the IceSat GLAS, October 2003. In preparation, *Geophys. Res. Lett.*

CALIBRATION

- Mask paper includes 1.6 and 3.7-μm changes for Ed3

- Calibration studies continue

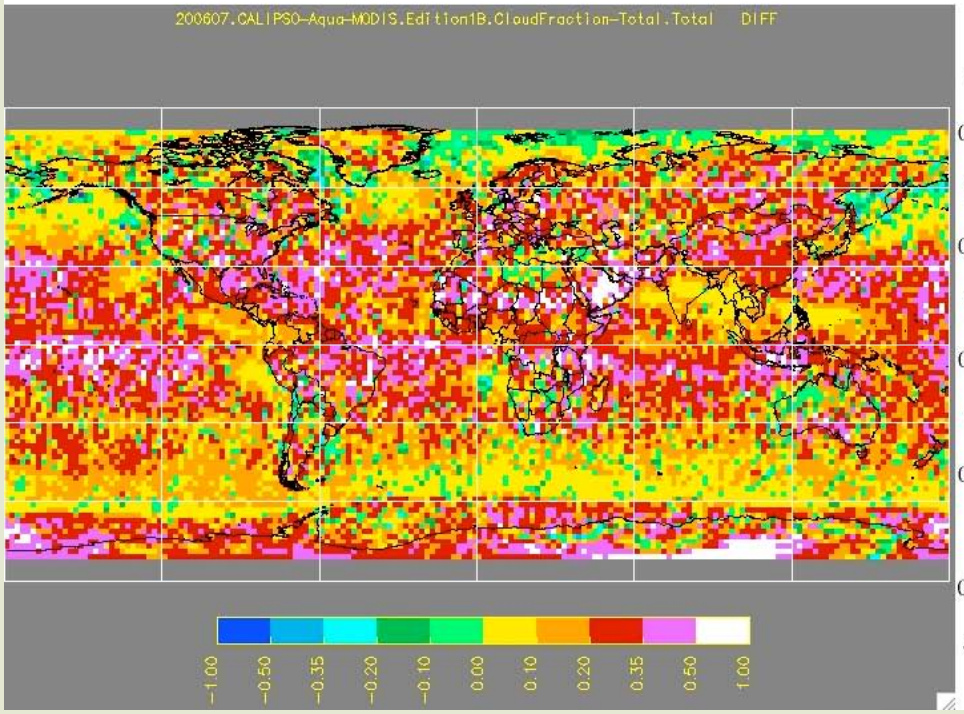
- Work with CERES, MODIS, VIRS, & GEOsats led to inclusion of Langley researchers in the international GSICS and CEOS meteorological and NPP research satellite calibration programs

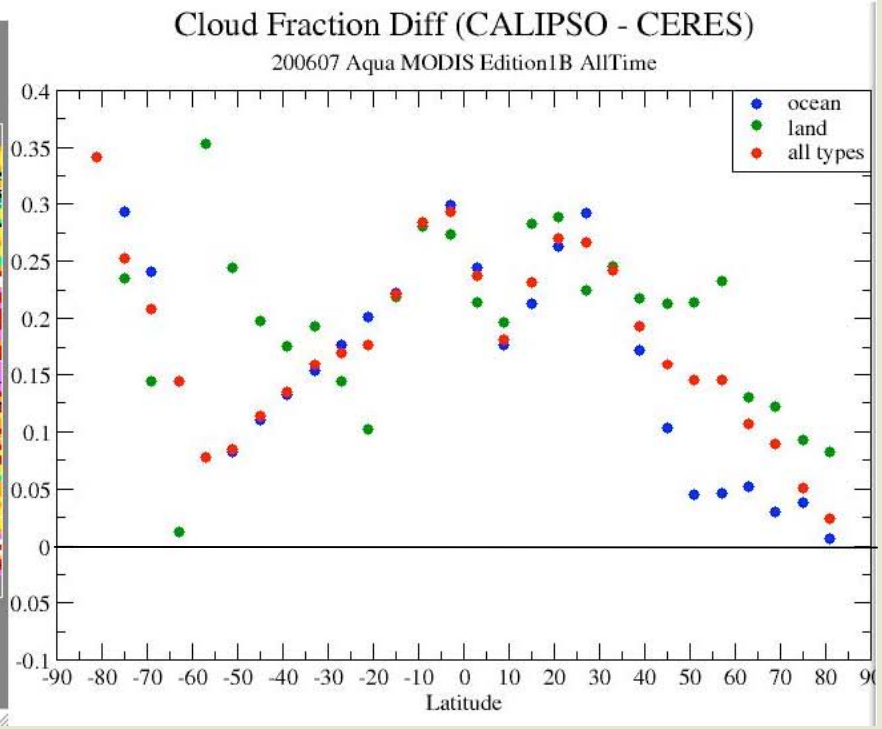
  - Doelling: DCC
  - Nguyen: GEO-LEO
  - Minnis: reference to MODIS

GEOS-4 versus GEOS-5

BACKGROUND

Cloud Fraction Difference, July 2006: CALIPSO - CERES

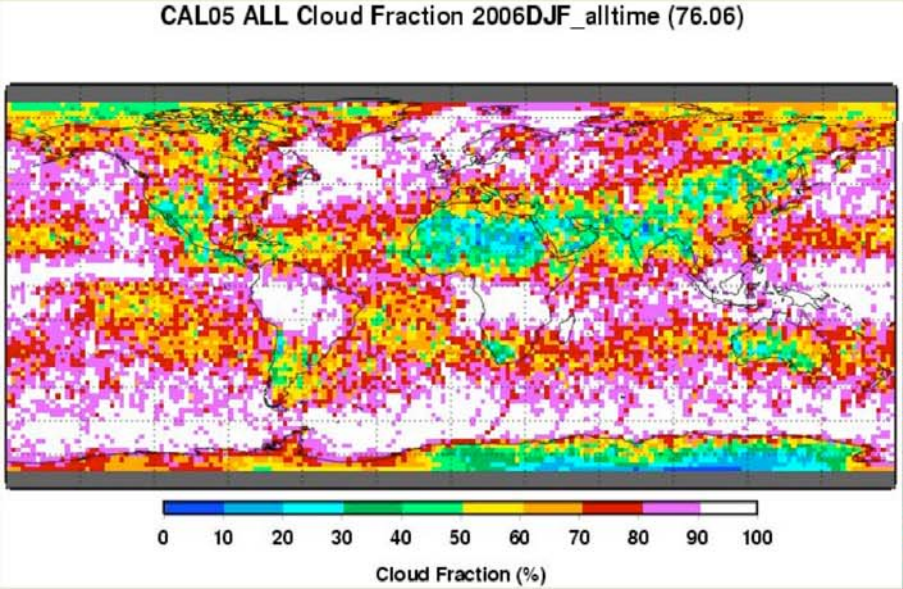


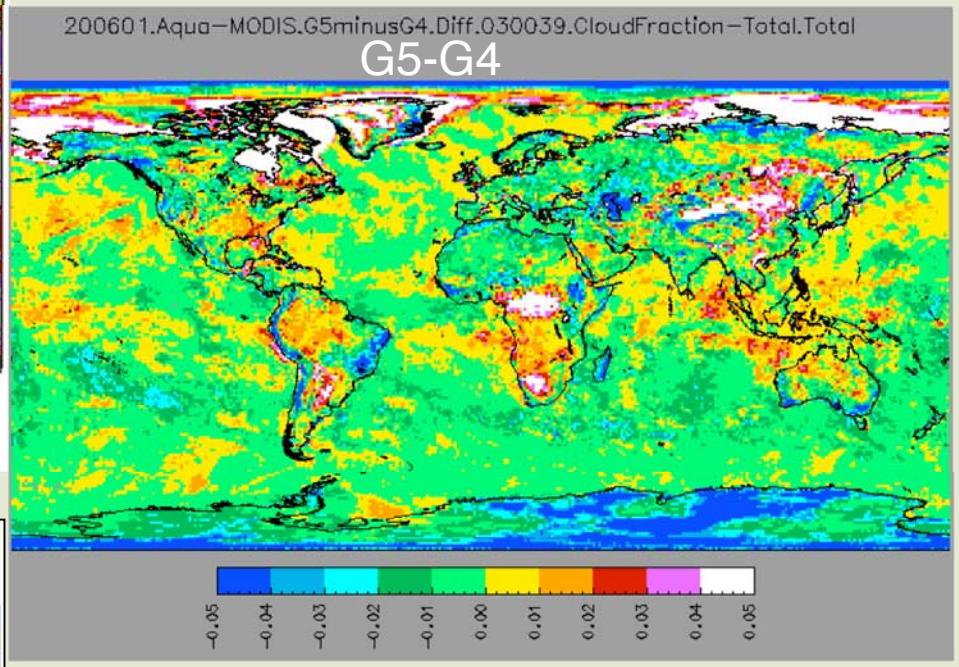


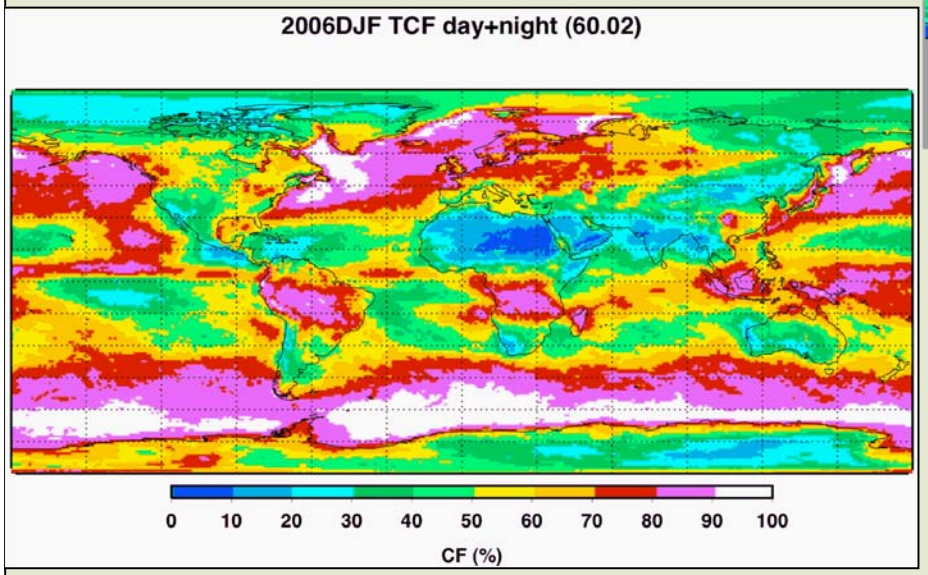
In general, CERES needs more clouds -

Mostly polar night & tropics (high & low)

CALIPSO/CERES Clouds, Jan 2006





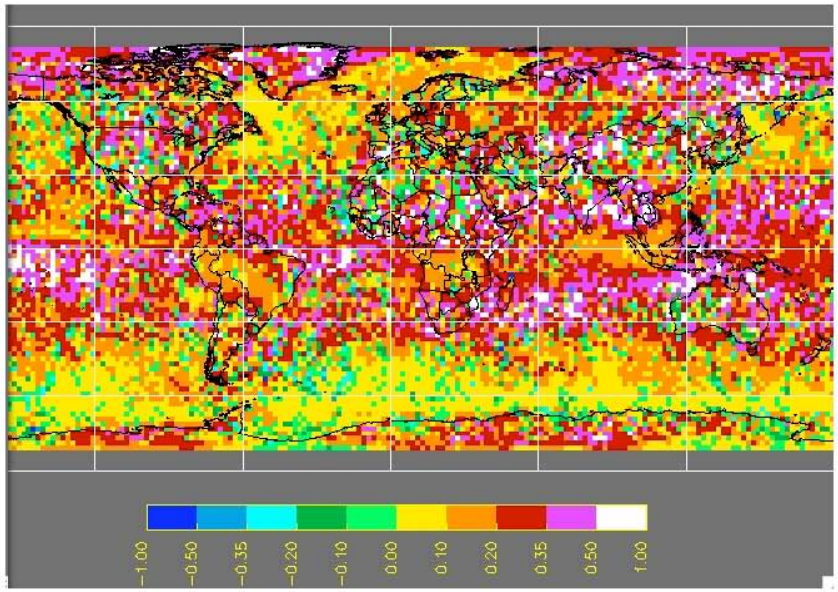


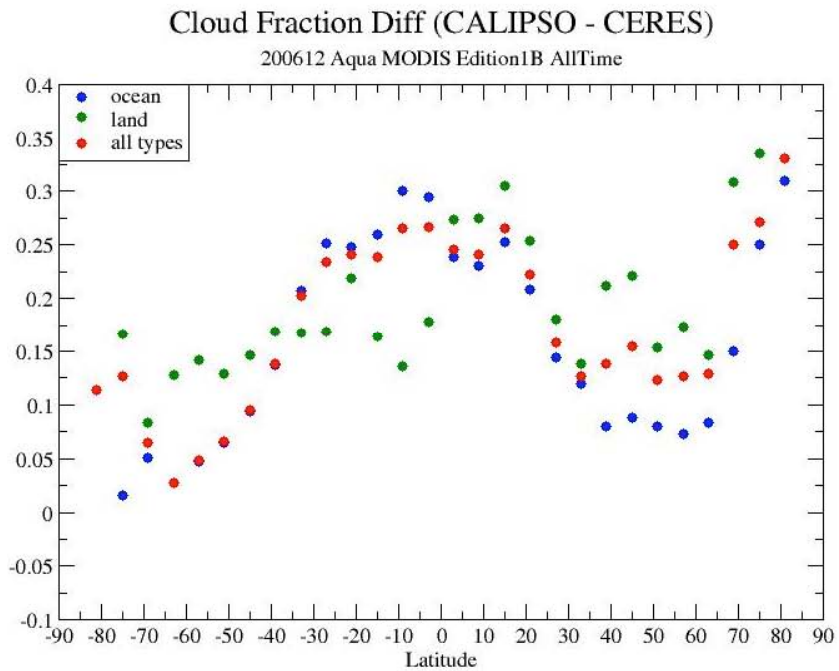
G5 worse in Antarctic day

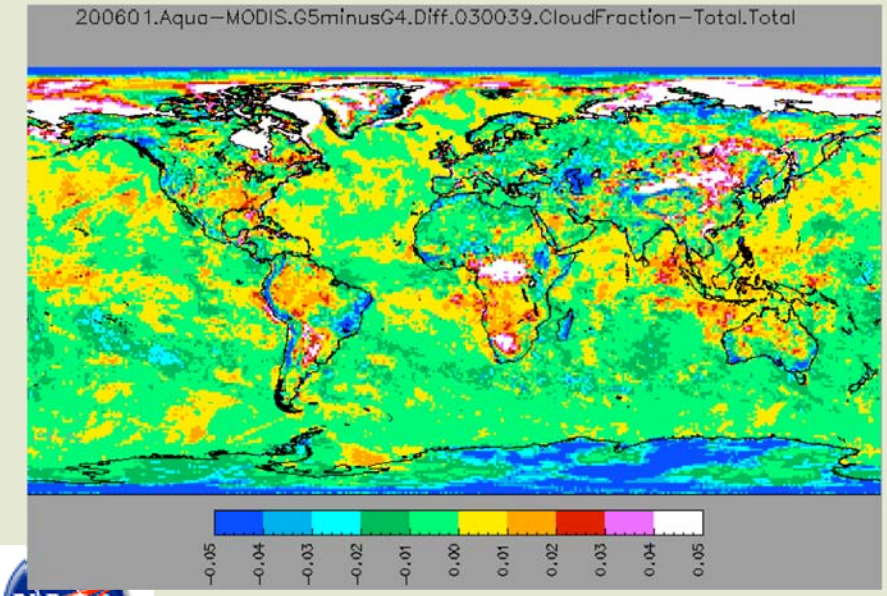
Better in tropical Africa, TradeCu areas, & Arctic night

Other areas difficult to assess because of different time periods

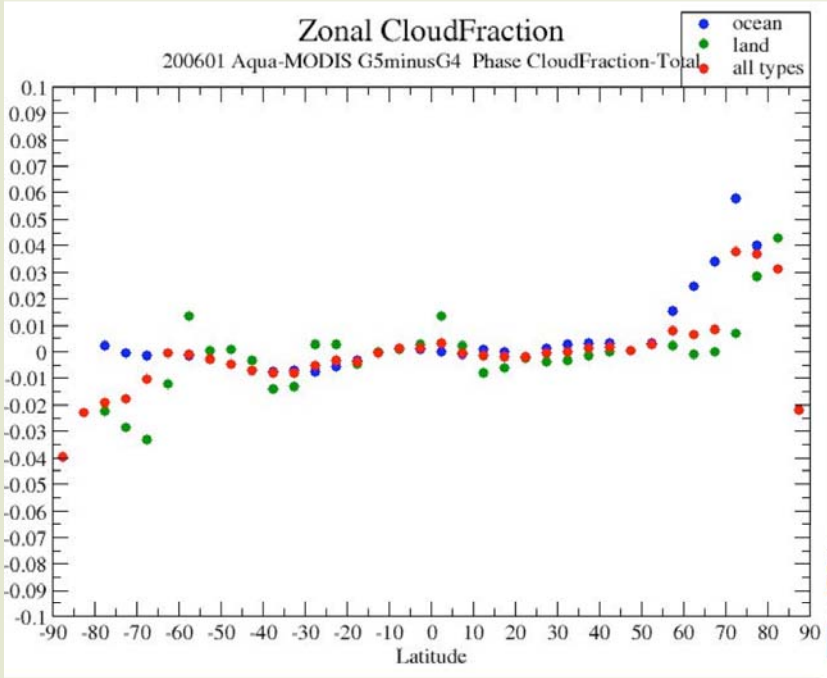
CALIPSO-CERES CF 12/06







G5-G4



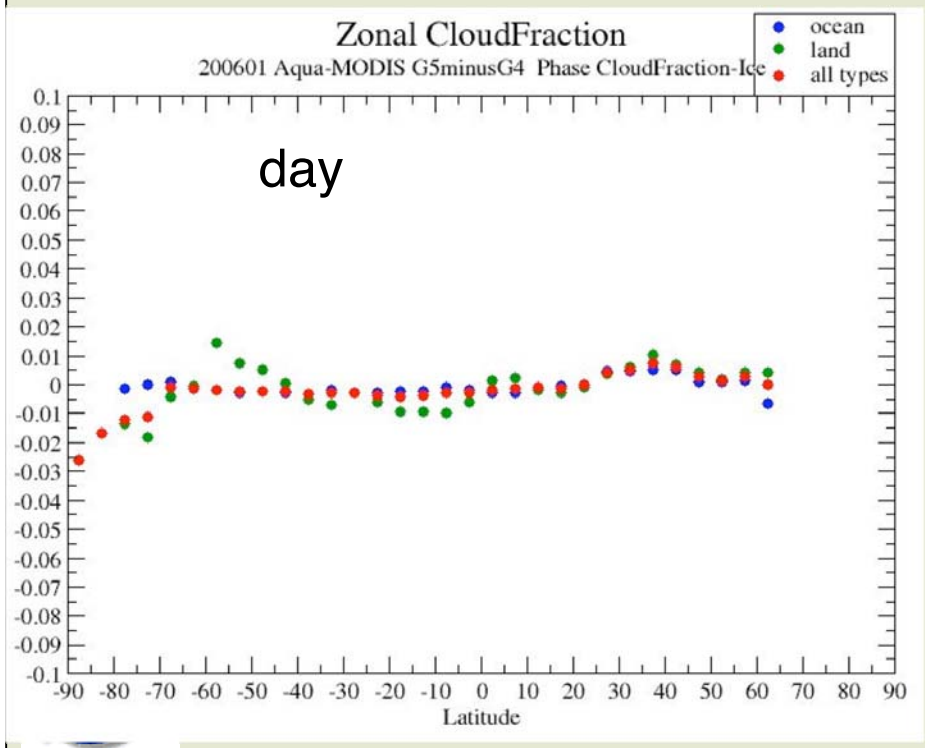
G5 vs G4: January 2006

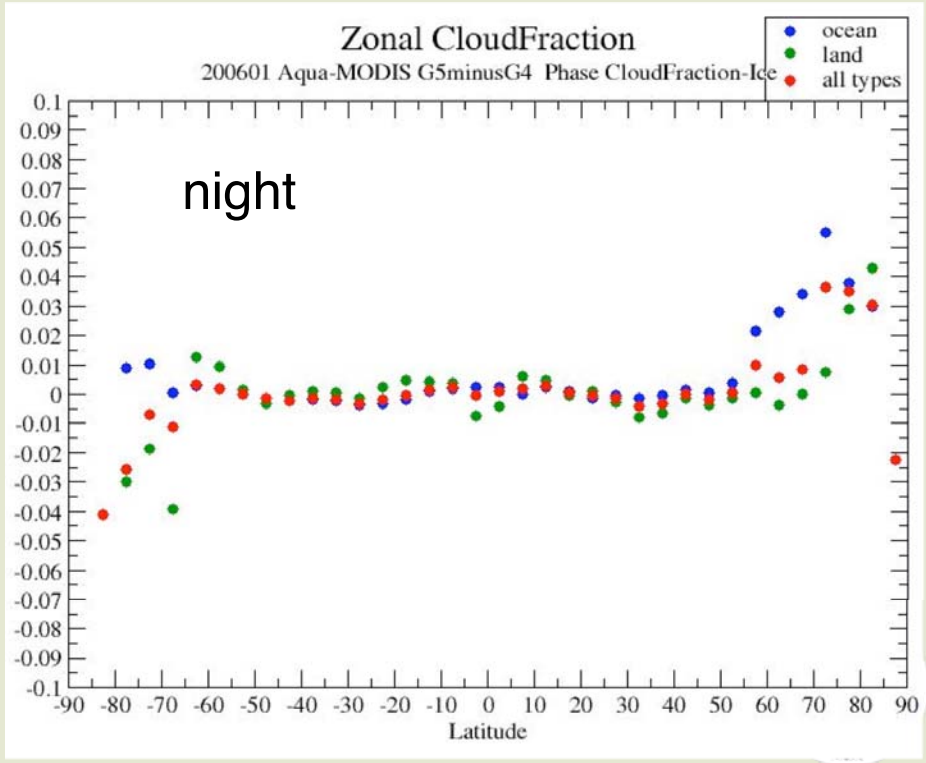
G5 worse in Antarctic day

Better in tropical Africa, TradeCu areas, & Arctic night

A wash everywhere but polar regions

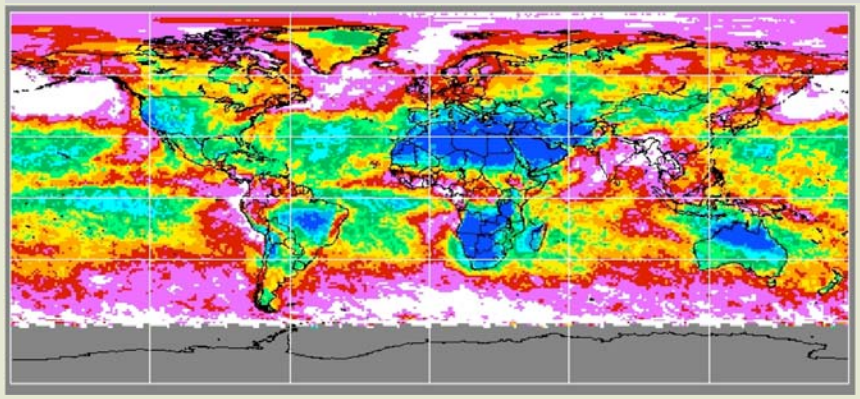
- tropics increase & decrease
- midlatitudes have no improvement



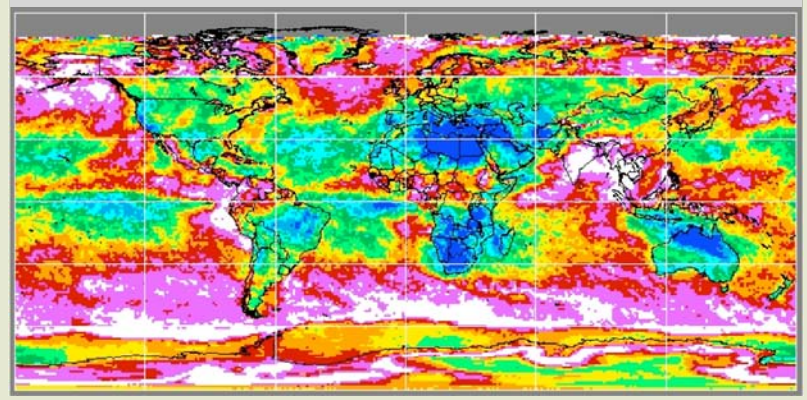


Cloud Fractions, July 2004

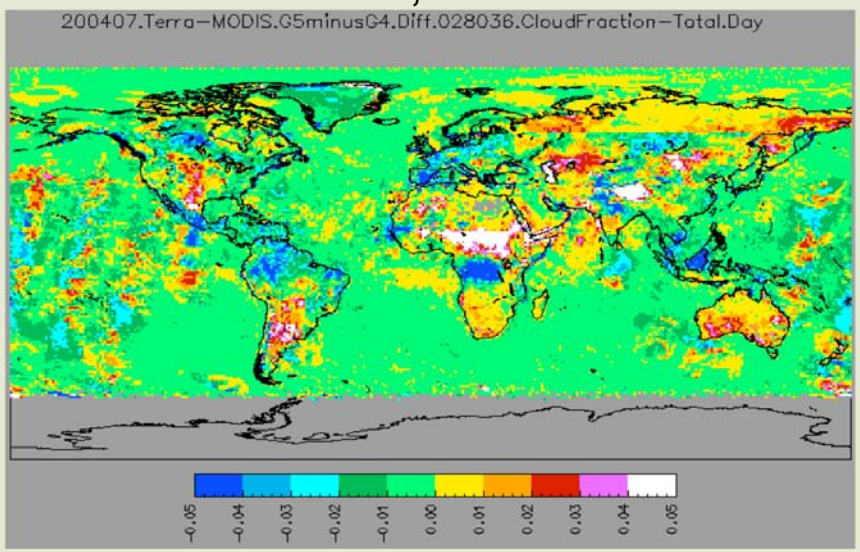
Ed2 G4 Day



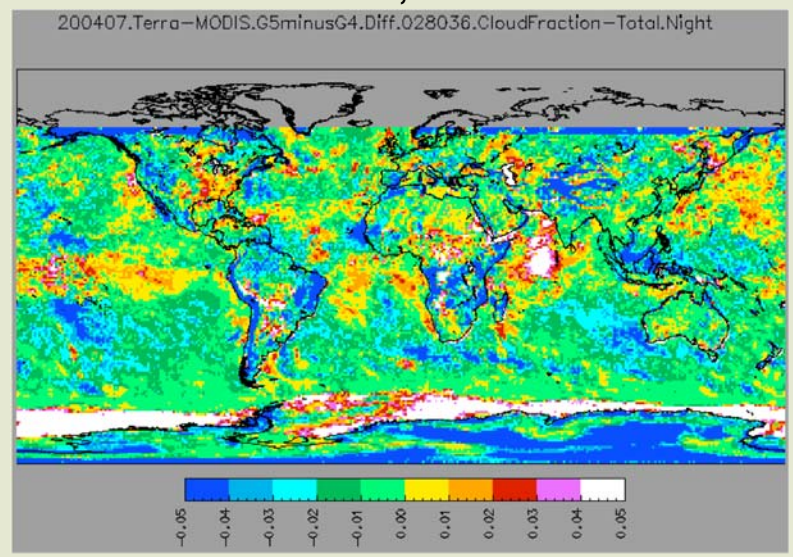
Ed2 G4 Night



Difference, G5 – G4



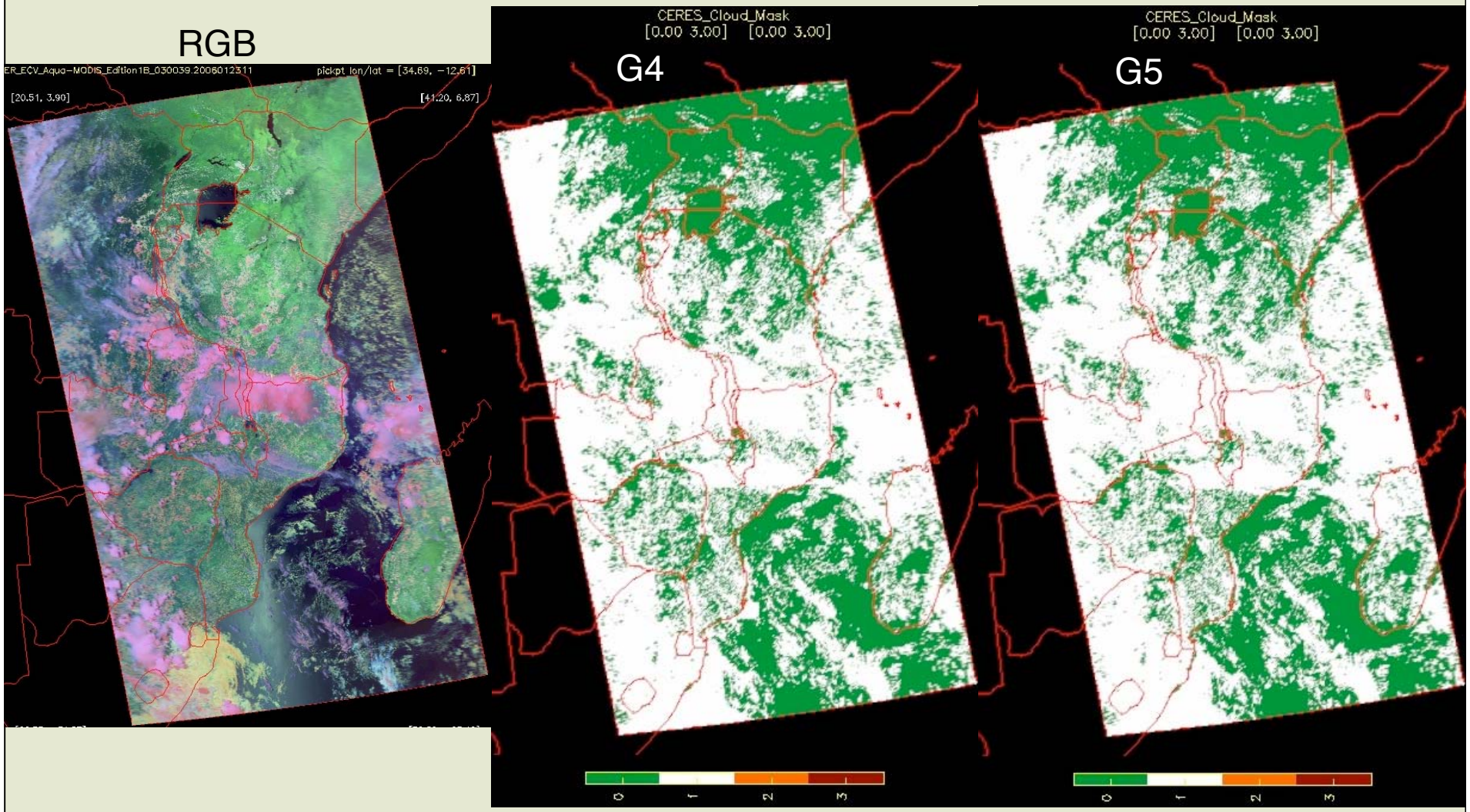
Difference, G5 – G4



G5 looking better in Antarctic night & tropical Africa, TradeCu

Other areas difficult to assess because of different time periods

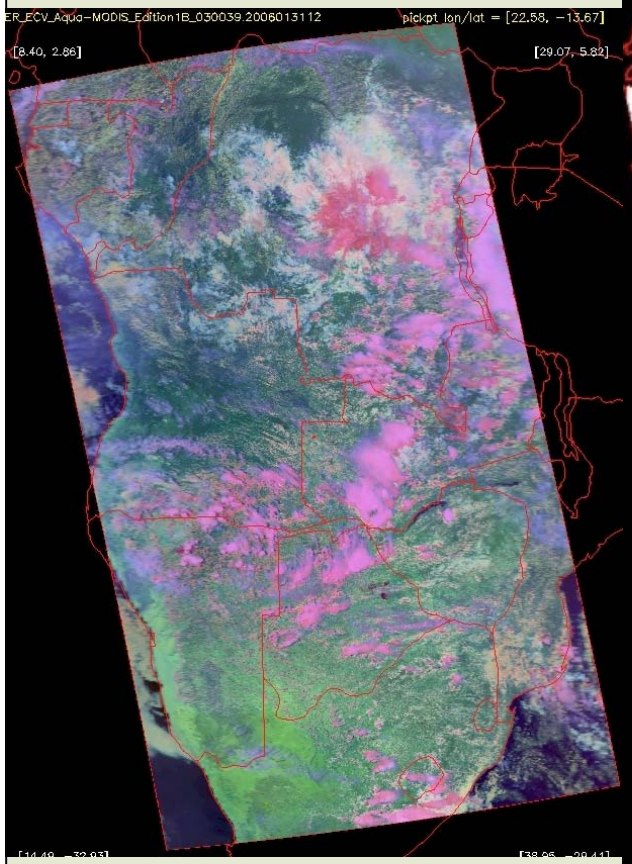
GEOS-4 vs GEOS-5, East Africa, 1/23/06

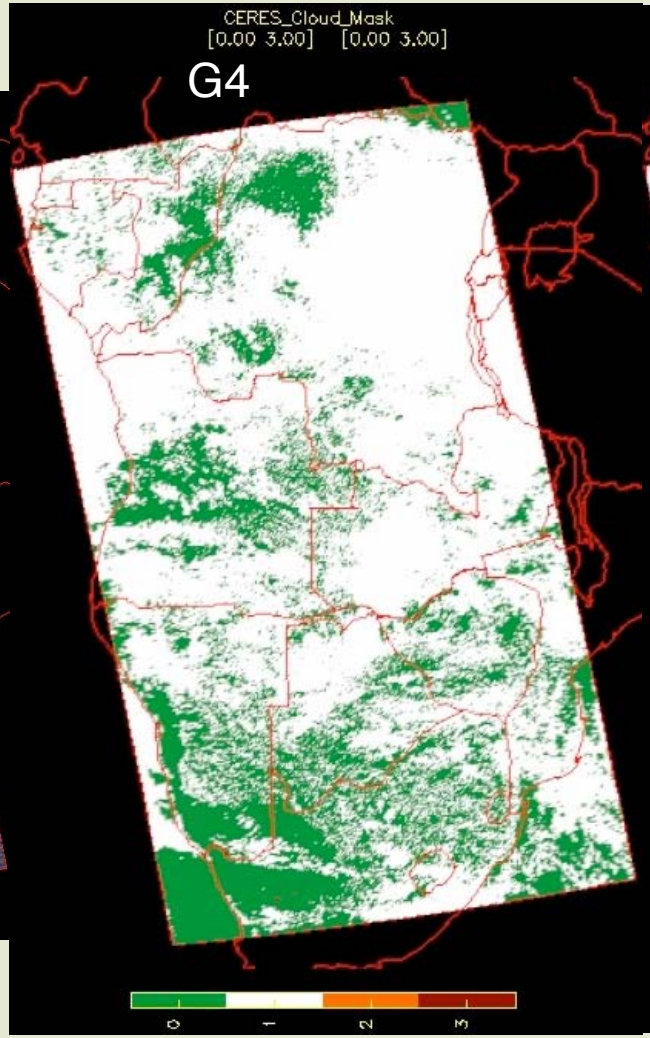


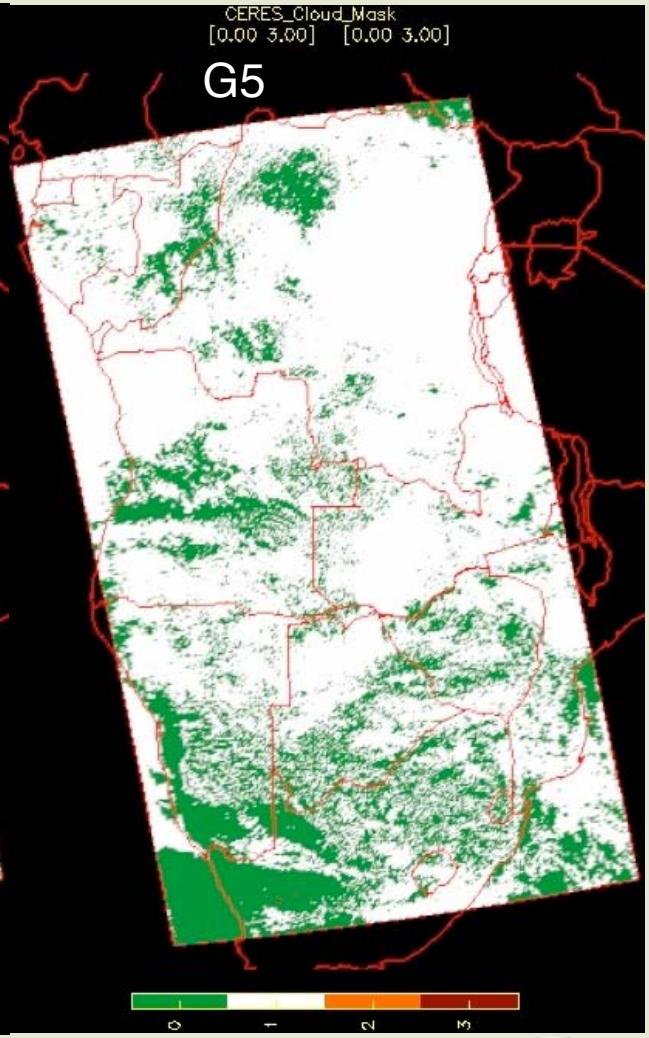
G5 picks up more cumulus clouds, especially along edges of fields

GEOS-4 vs GEOS-5, East Africa, 1/13/06

RGB







G5 picks up more cumulus clouds, especially along edges of fields

CONCLUSIONS

- G5 represents an improvement for polar night and cumulus clouds, areas needing improvement

- Mixed bag otherwise

  - eyeball evaluations of granule results to determine if better or worse

- Will probably have to change thresholds to get desired effect

  - need assessment of clouds that are being missed

Ed3 Beta1 Cloud Code Changes

- **Cloud Mask Changes**

Non-polar Day

- added dust detection using IR BTDs, ref ratios
- additional low cloud check for SZA > 70°
- better snow tests for high elevation/melting snow
- refined cloud shadow tests
- reduced misclassifications along coasts
- sunglint definition changed from prob > 2% to prob > 10%
- new warm cloud tests in sunglint

Non-polar Night

- attempted reduction in polar-nonpolar discontinuity
- added low/inversion cloud detection test based on sfc emis thresholds
- reduced T3.7-T11 STD (threshold) by 0.5 K
- refined snow & thin cirrus detection tests

- **Cloud Mask Changes**

Polar Day

- Theoretical 2.1-μm snow models used for both Terra & Aqua
- improved classification of TBD pixels
- refined cloud & snow tests over super-cold plateau

Polar Night

- improved cloud detection over super-cold plateau
- enhanced mini-mask for TBD pixels

Twilight

- added visible channel tests to smooth day-night transition
- added new thin cirrus and low-cloud tests

Thin cirrus

- CO2 retrievals complement standard CERES mask

- **Cloud Retrieval Changes**

Single-layer

- CO_2 algorithms: Standard 4-channel; Chang 2-channel (C2C: 11 & 13.3 μm)
  - if VISST/SIST no retrieval, force VISST values to C2C Tcld
- 2.1-μm used for SINT & VINT retrievals for both Aqua & Terra
- zonally averaged ocean/land lapse rates from CALIPSO used for low clouds
- improved thick ice-cloud top heights
- implemented IGBP-dependent snow albedo models
- extended optical depth range to 512
- initial 2.1-μm particle size retrieval algorithm (VINT)
- phase tweaked

Auxiliary data

- updated IGBP map to be delivered
- updated elevation map to be delivered

- **Cloud Retrieval Changes**

Multi-layer

- C2C (11 & 13.3 μm) ML detection
- BTD (T11 – T12) algorithm delivered
- Initial C2C ML retrieval algorithm: no iteration on Deff

Edition 3 CERES mask changes since Aqua Edition 1

Framework Level

• Decided not do adjustments from MODIS V004 to V005, for both Terra and Aqua, after studies performed over polar night where largest impact presents.

• In Terra Ed3 cloud detection algorithms, 1.6 um is replaced by 2.1 um. Terra and Aqua cloud masks are consistent using the same algorithms.

• Replaced theoretically 2.1 snow reflectance models with IGBP-dependent snow model - only impacts daytime polar regions.

• New 3.7 μm calibration for Terra MODIS data - Terra Ed3 needs retune.

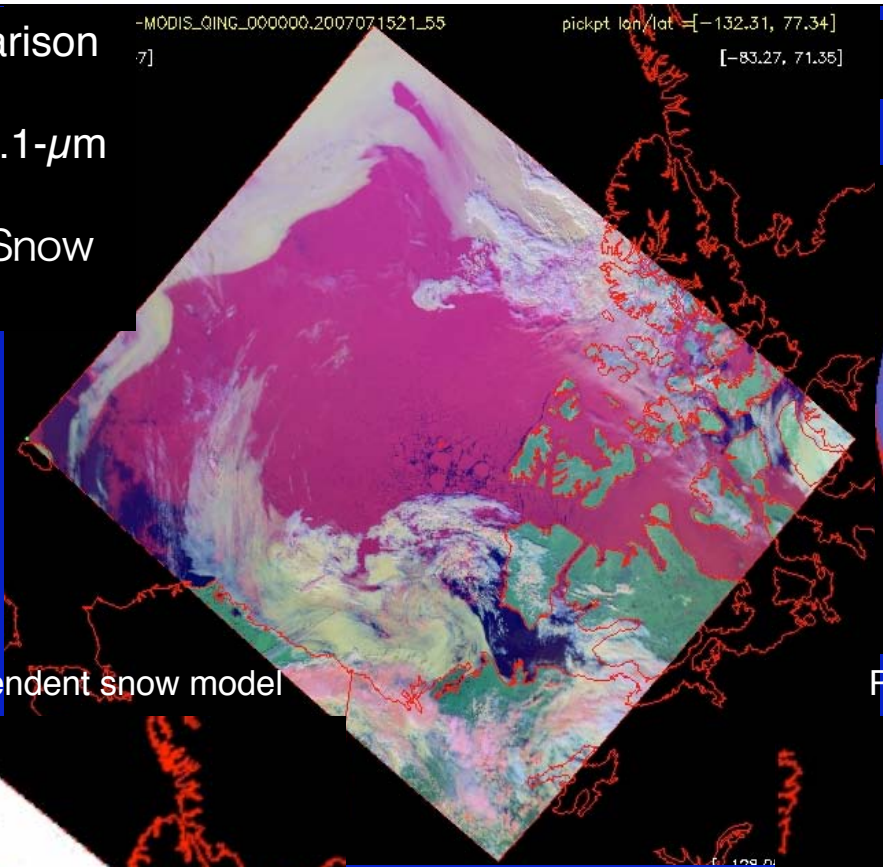
• CO2 clouds overwrite CERES clear pixels except for polar regions.

• Restrict clear sky 11 um STD to max value 6 K for land.

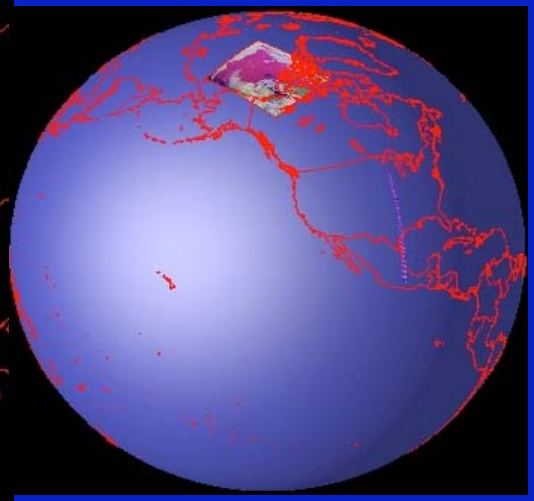
• New elevation map - impacts super-cold plateau.

IGBP Snow Model vs Theoretical Snow Model

Polar Mask Comparison between IGBP-dependent 2.1-μm Snow Model and Theoretical Snow Model

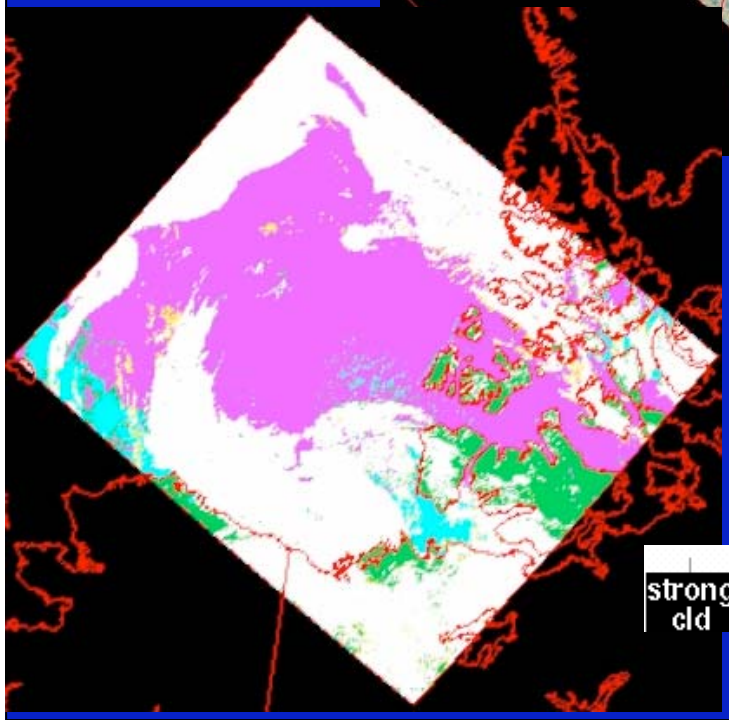


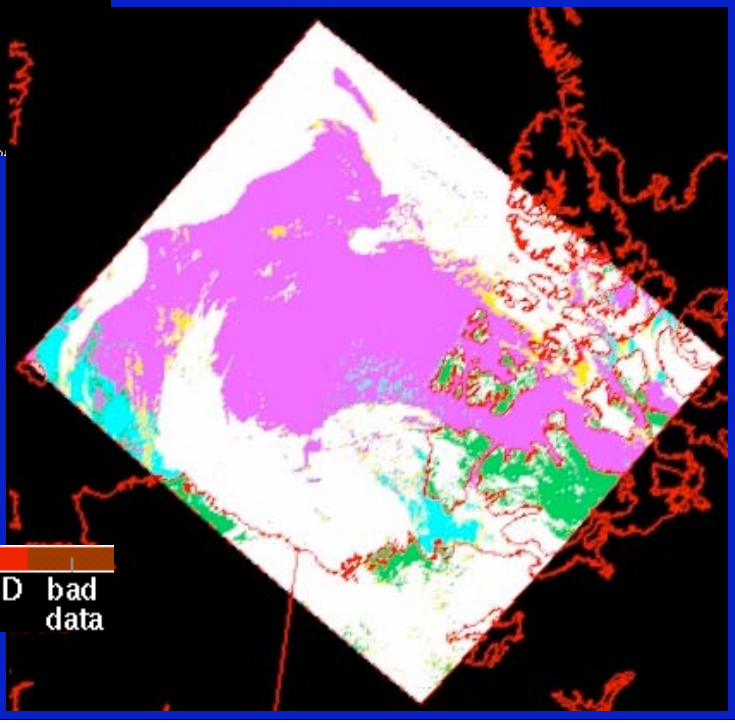
Terra MODIS, 15 July 2007, 2155



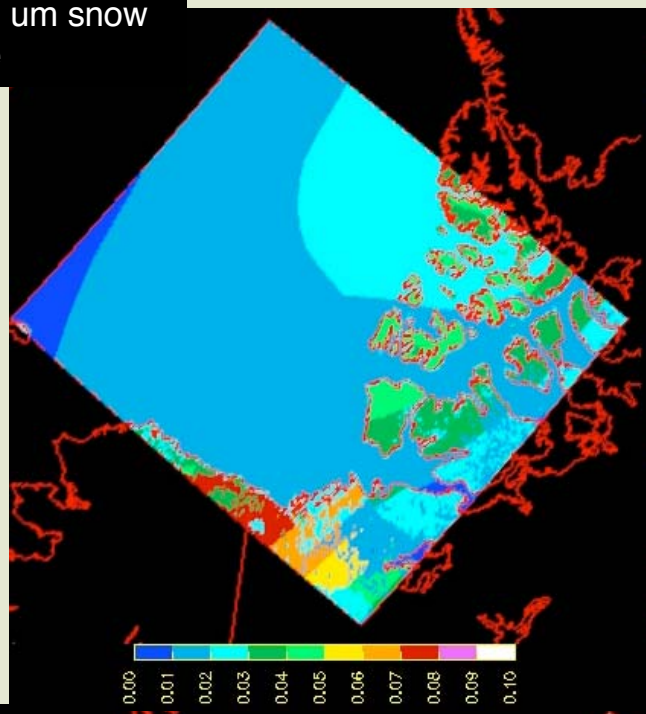
Polar Mask : IGBP-dependent snow model

Polar Mask : Theoretical snow model

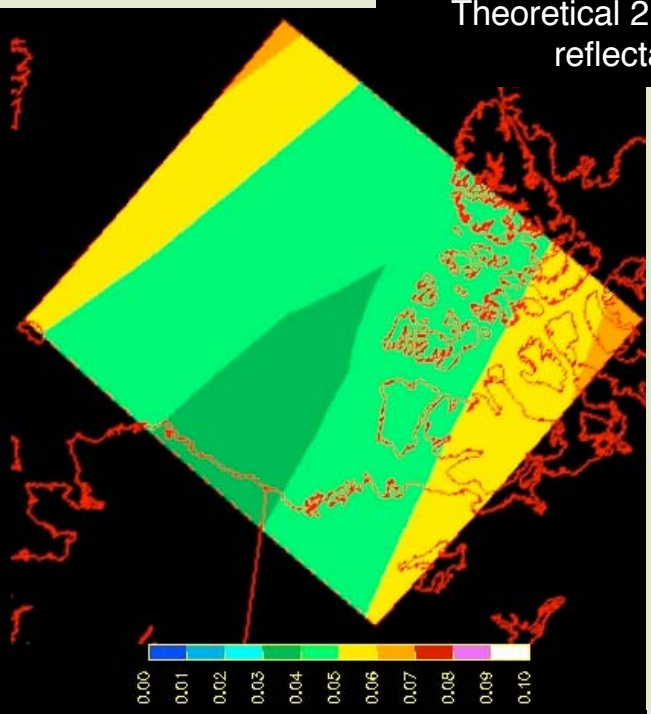




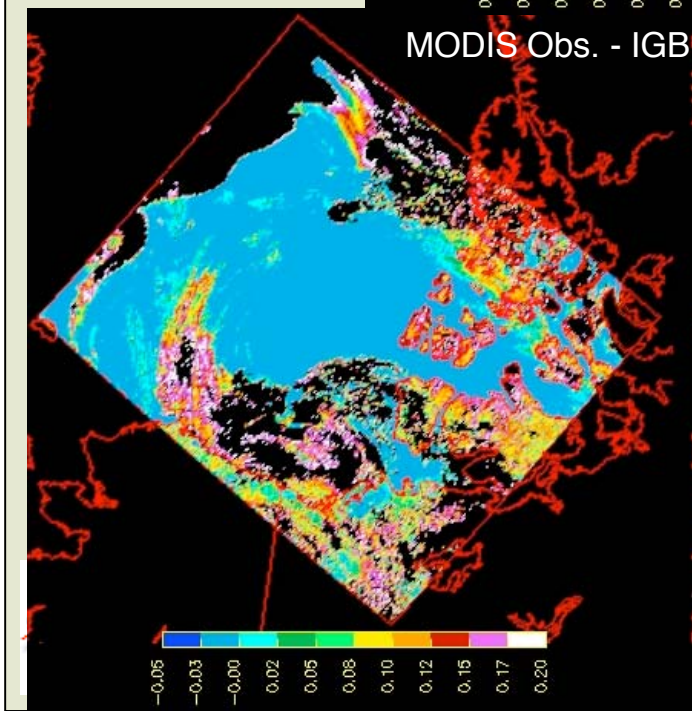
IGBP-dependent 2.1 um snow reflectance



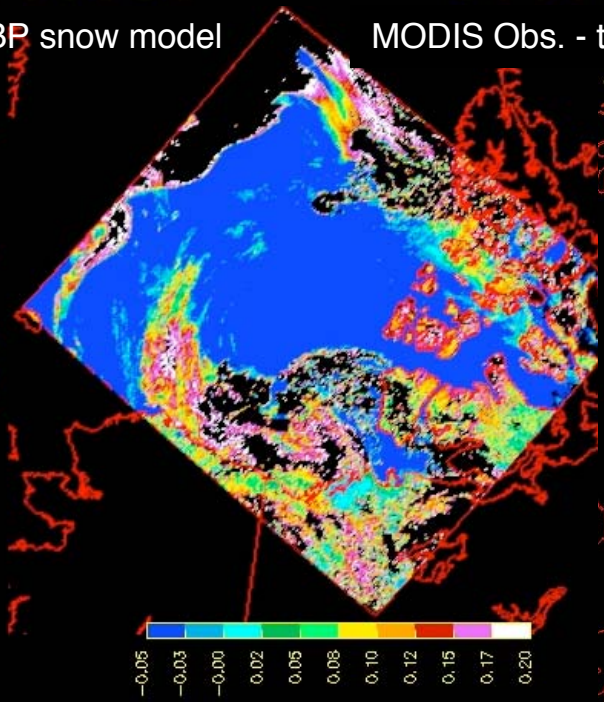
Theoretical 2.1 um snow reflectance

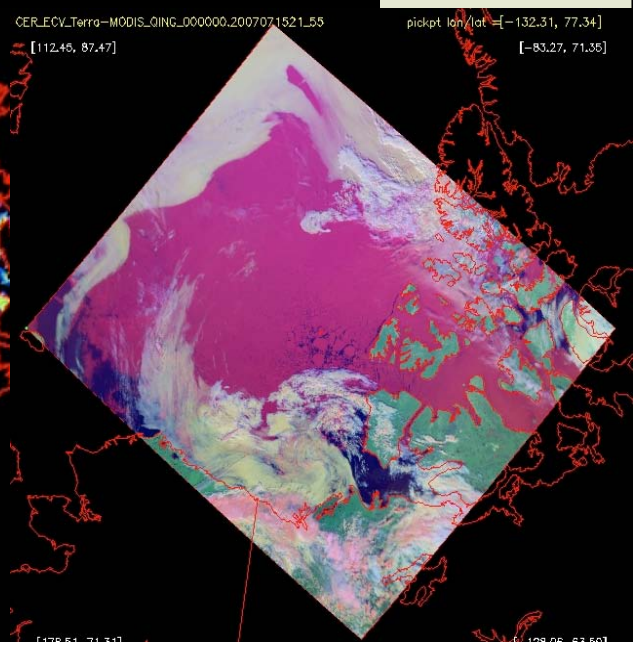


MODIS Obs. - IGBP snow model

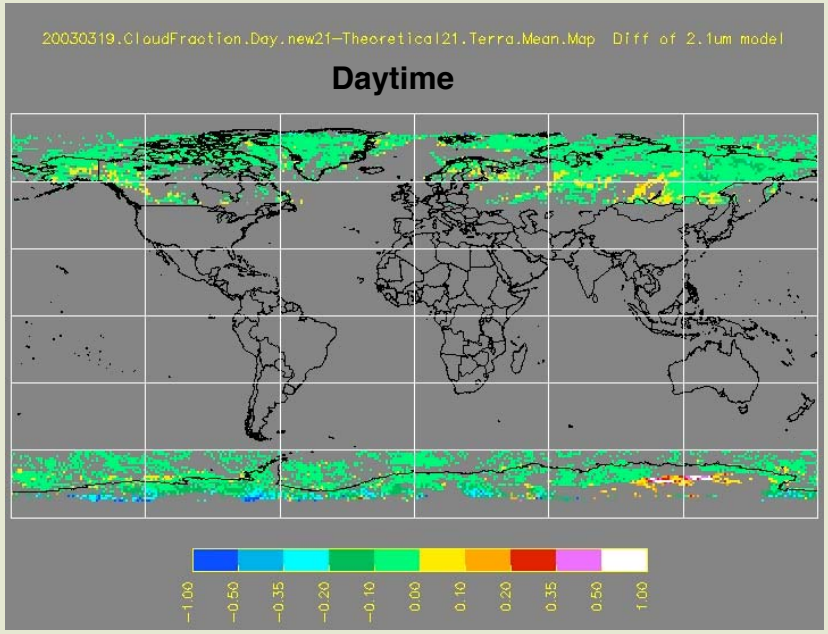


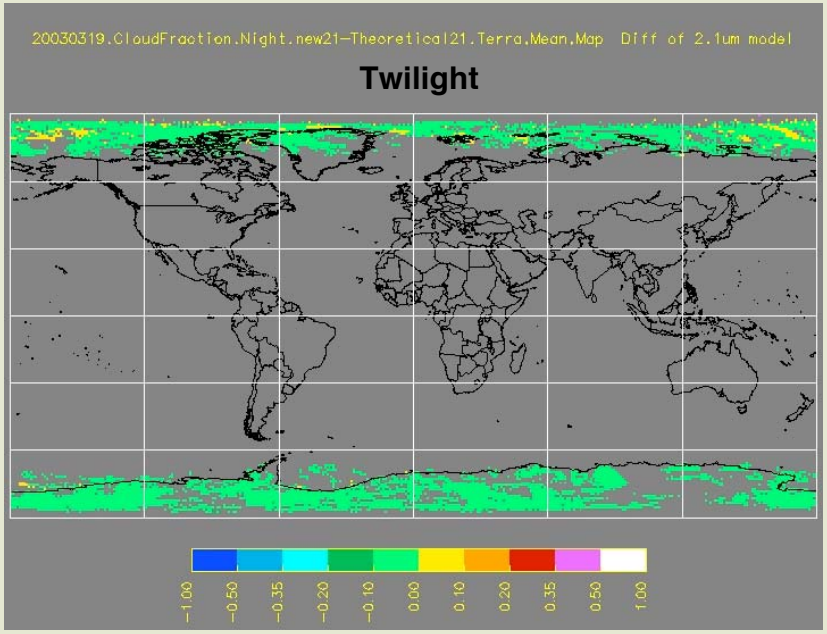
MODIS Obs. - theoretical snow model

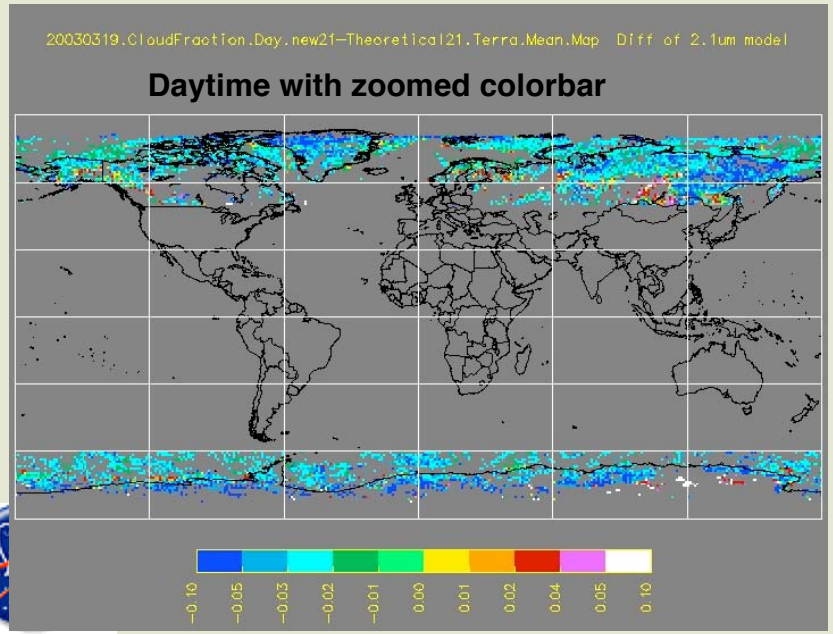


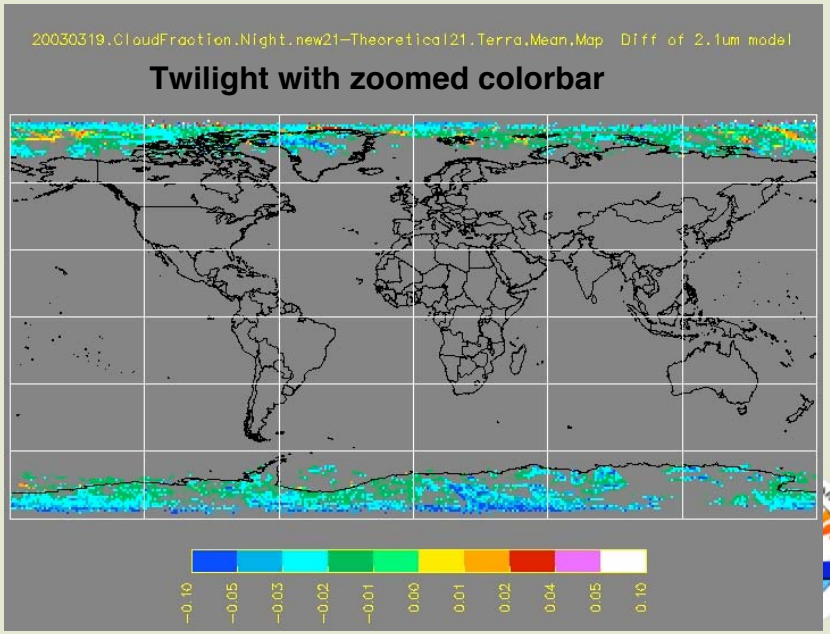


Cloud Fraction Differences between 2.1 um IGBP Snow Directional Model and Theoretical Model

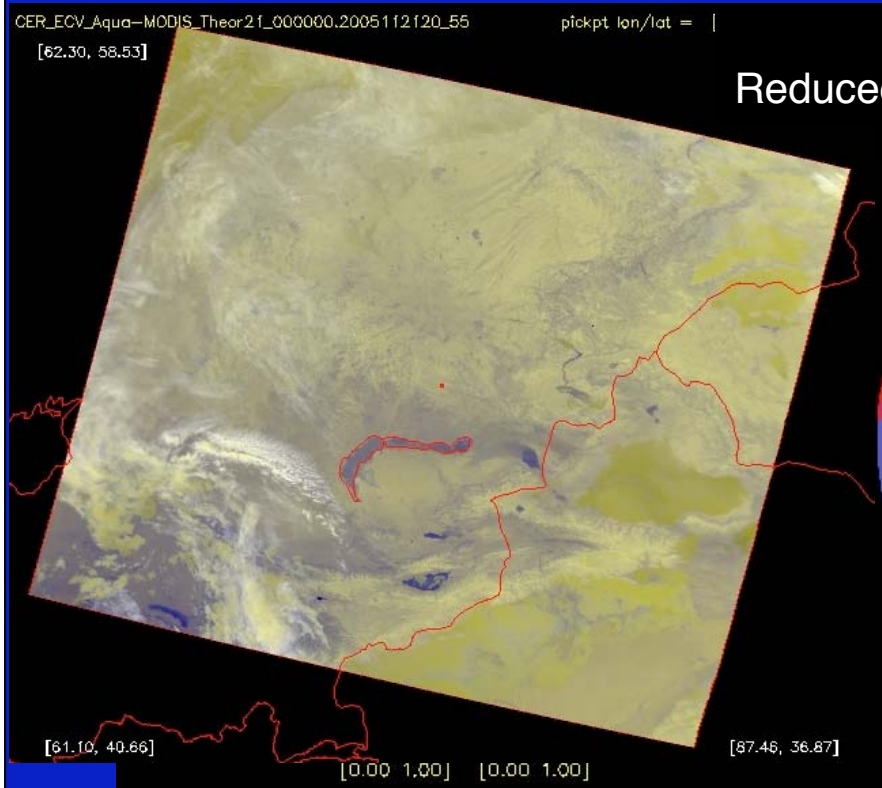


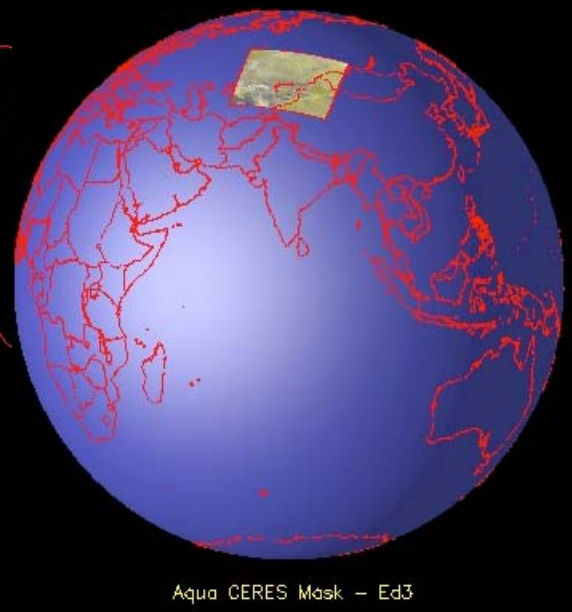




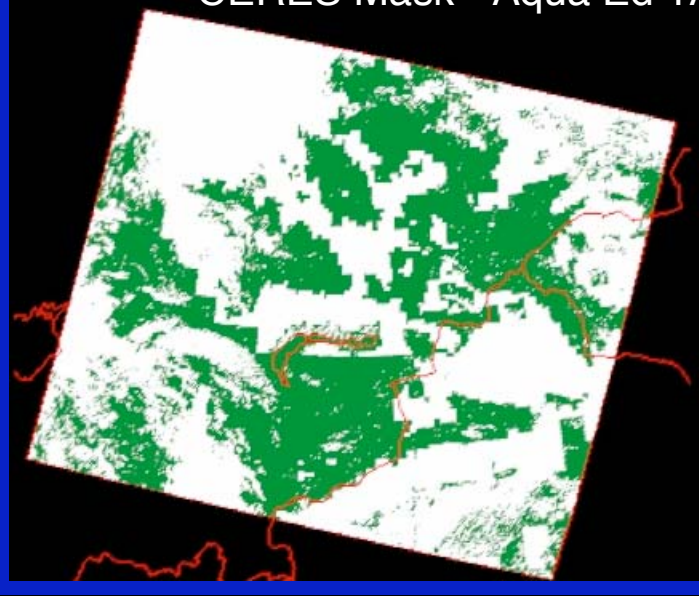


Aqua MODIS, Nov. 21, 2005, UTC 2055
Reduced false clouds over nighttime polar transition regions

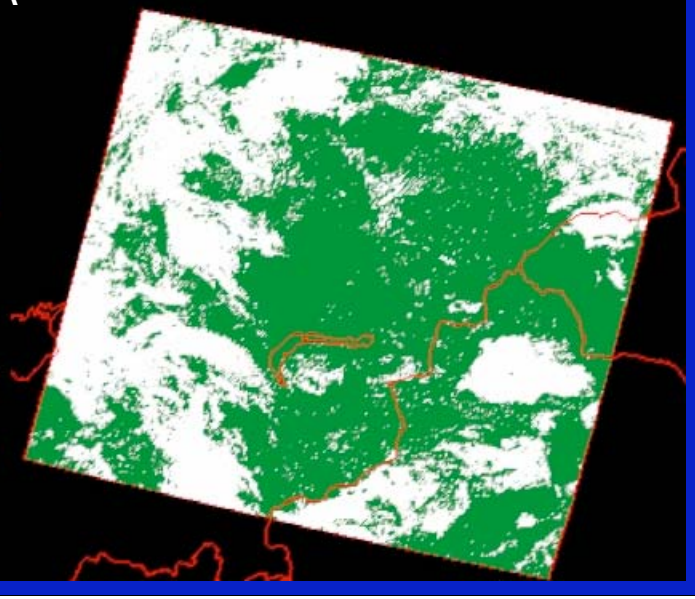




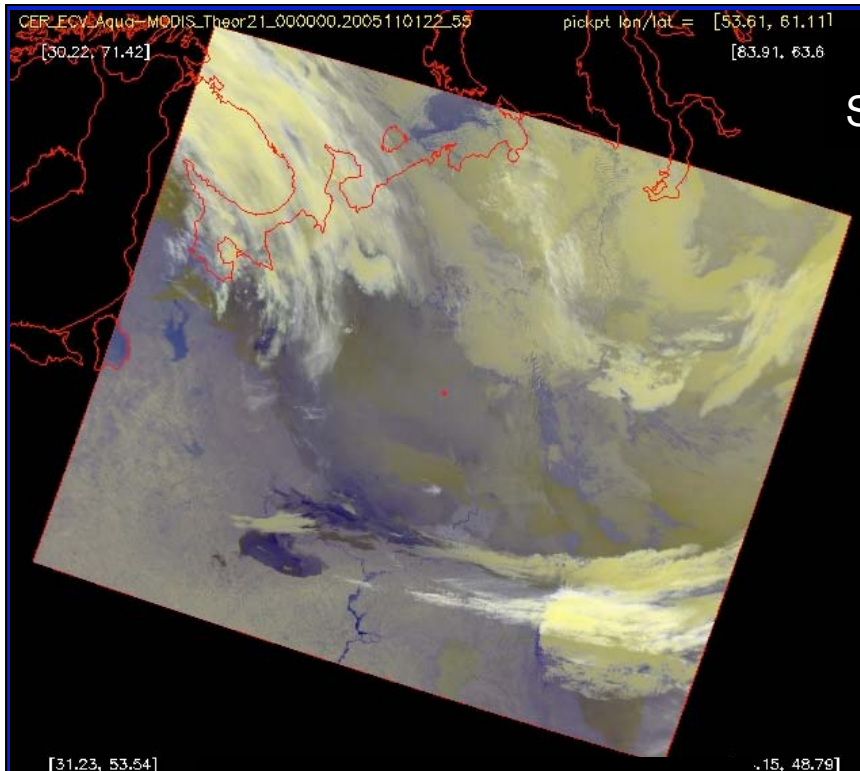
CERES Mask - Aqua Ed 1A

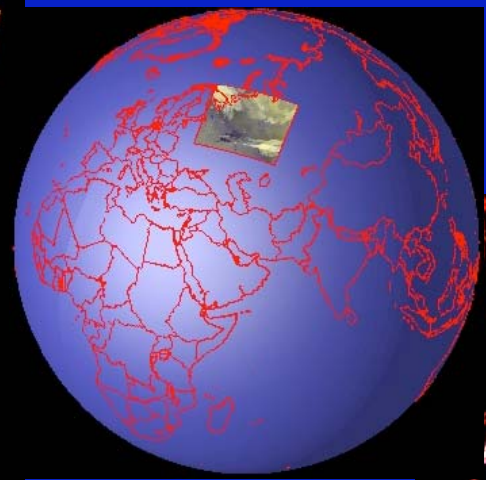


CERES Mask - Ed3

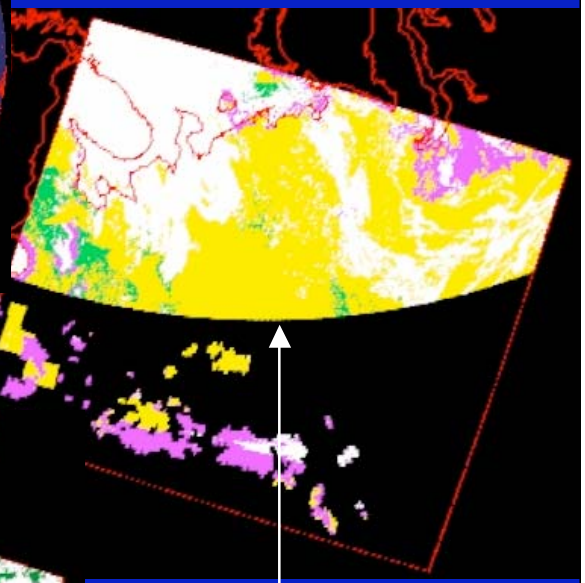


Aqua MODIS, Nov. 1, UTC 2255, 2005
Smoothed nighttime discontinuity line, but it is stubborn



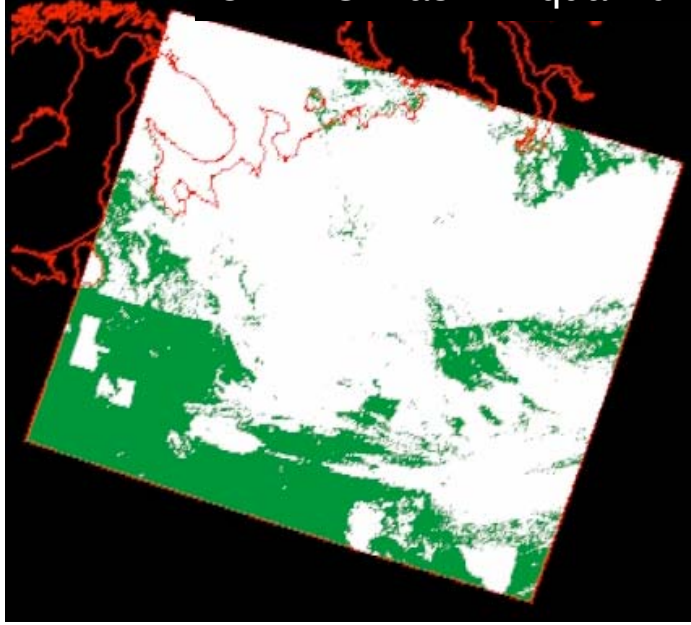


CERES Polar Mask

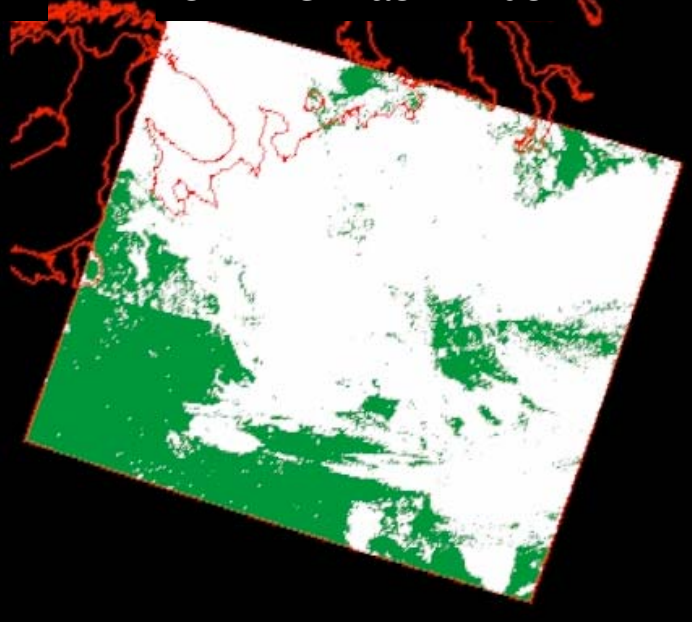


Polar Regions

CERES Mask - Aqua Ed 1A

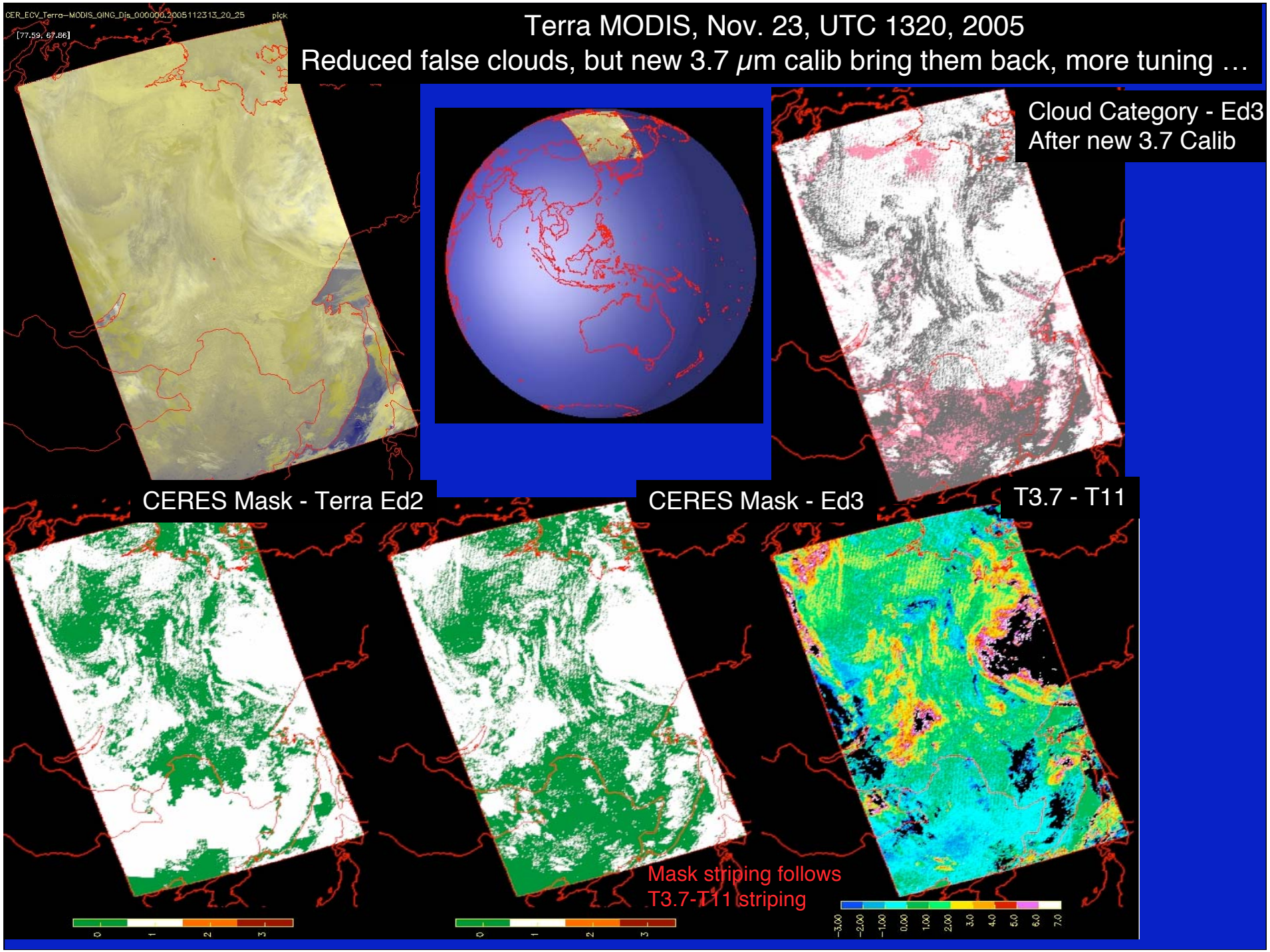


CERES Mask - Ed3

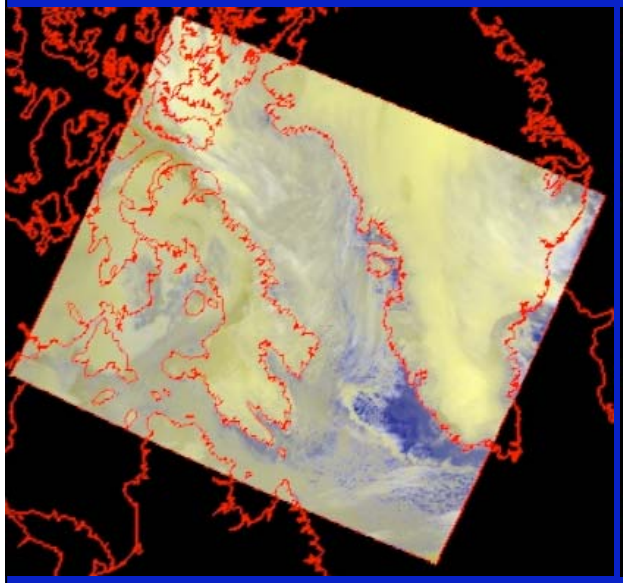


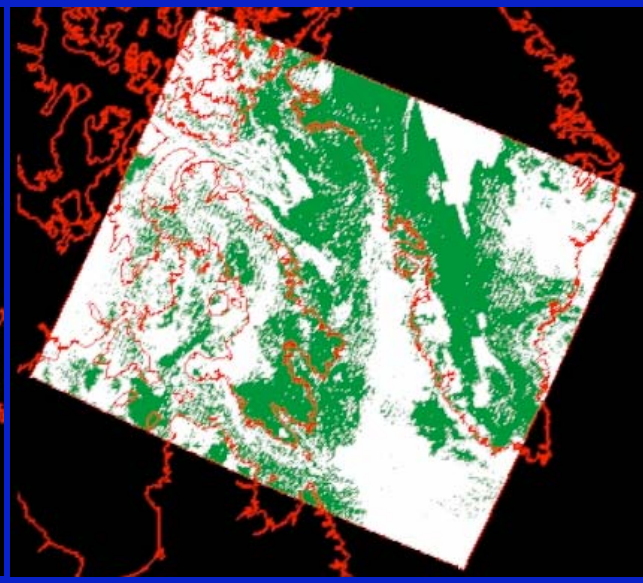
Terra MODIS, Nov. 23, UTC 1320, 2005

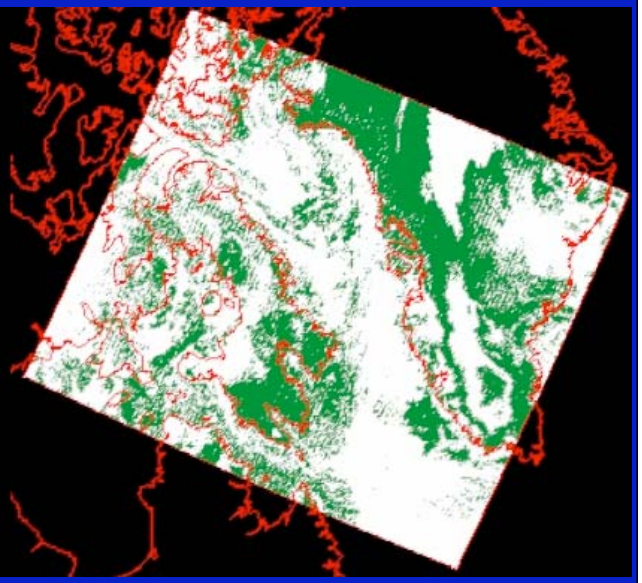
Reduced false clouds, but new 3.7 μm calib bring them back, more tuning …

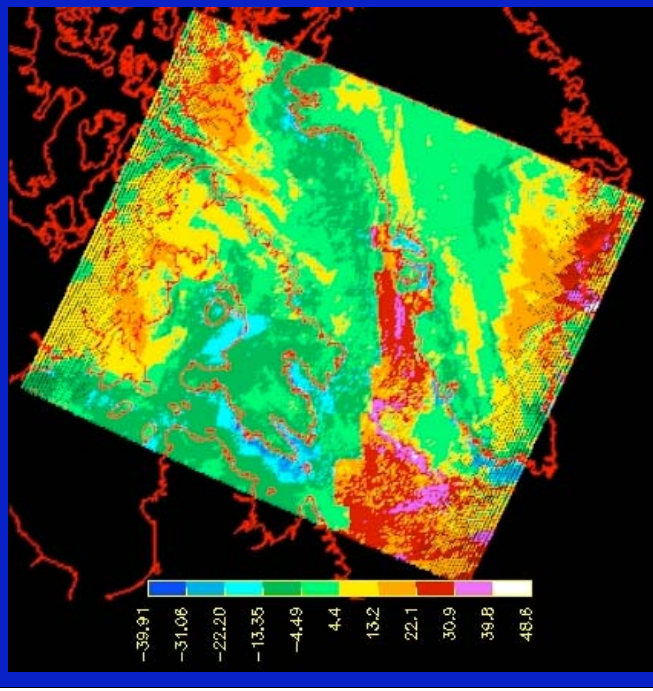


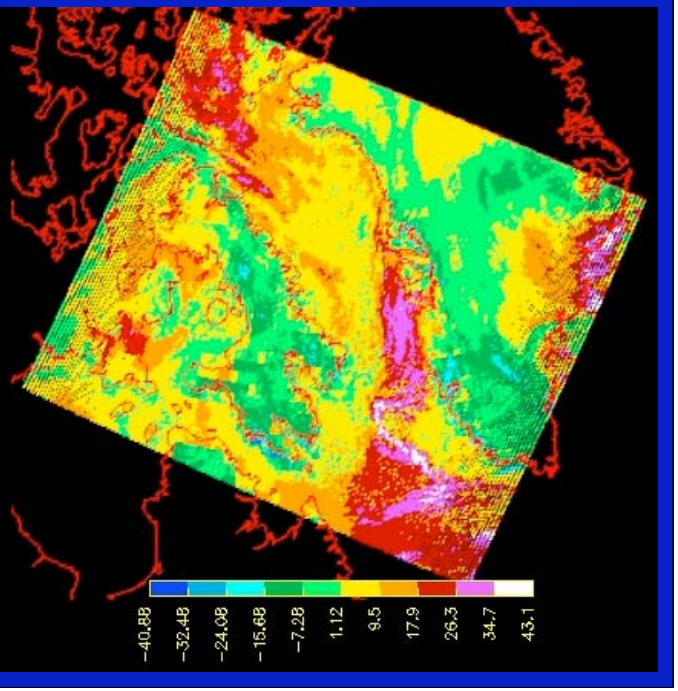
G4 and G5 Comparison - nighttime Greenland, G5 picks up more clouds, false & otherwise
Aqua MODIS, Jan. 5, 2006, UTC 07



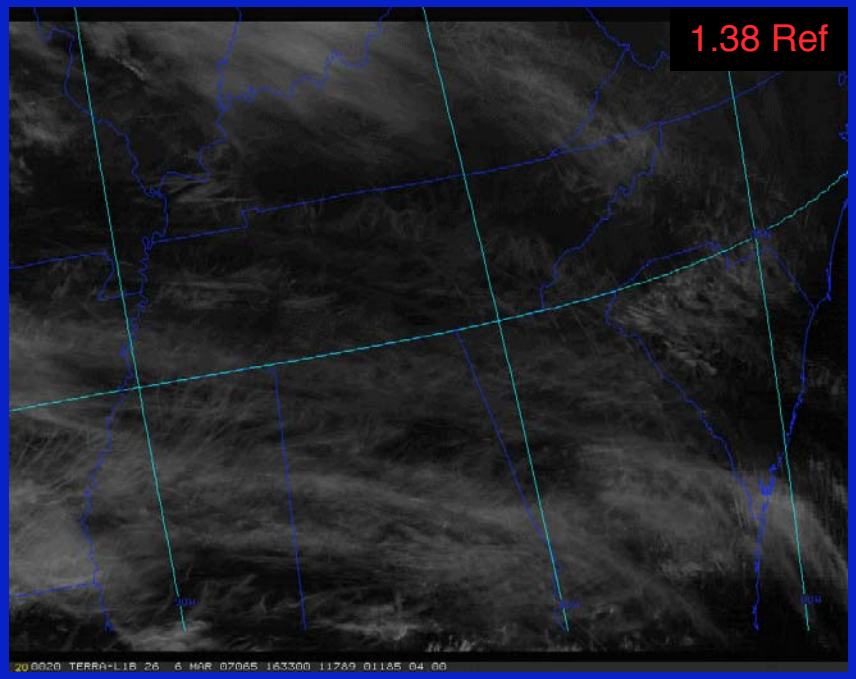


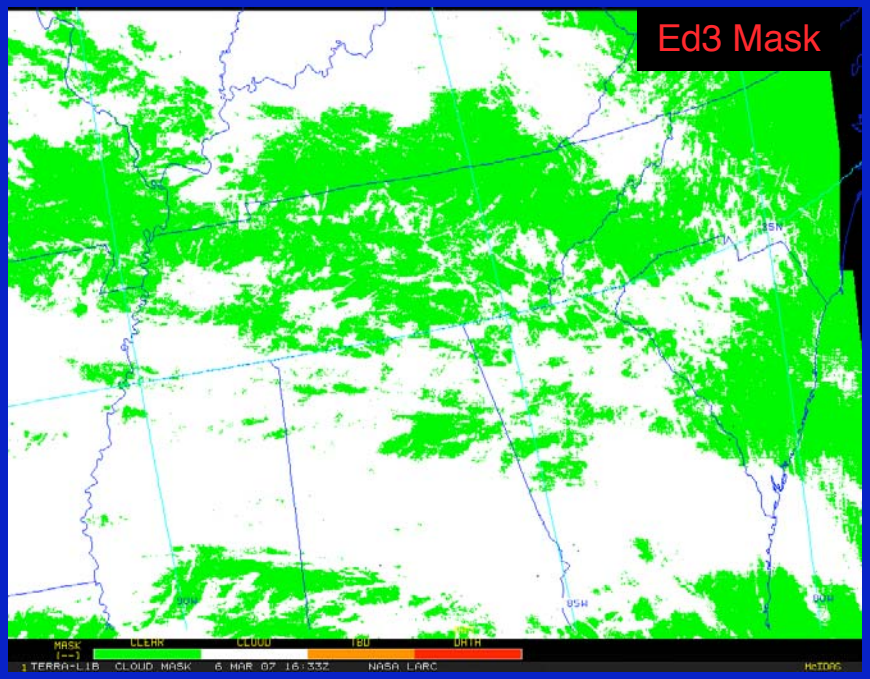


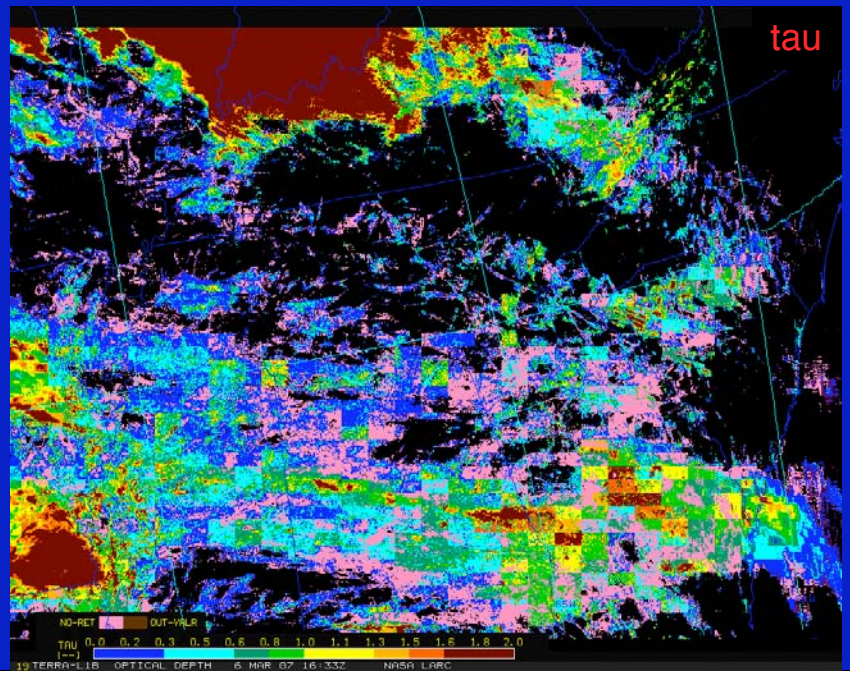


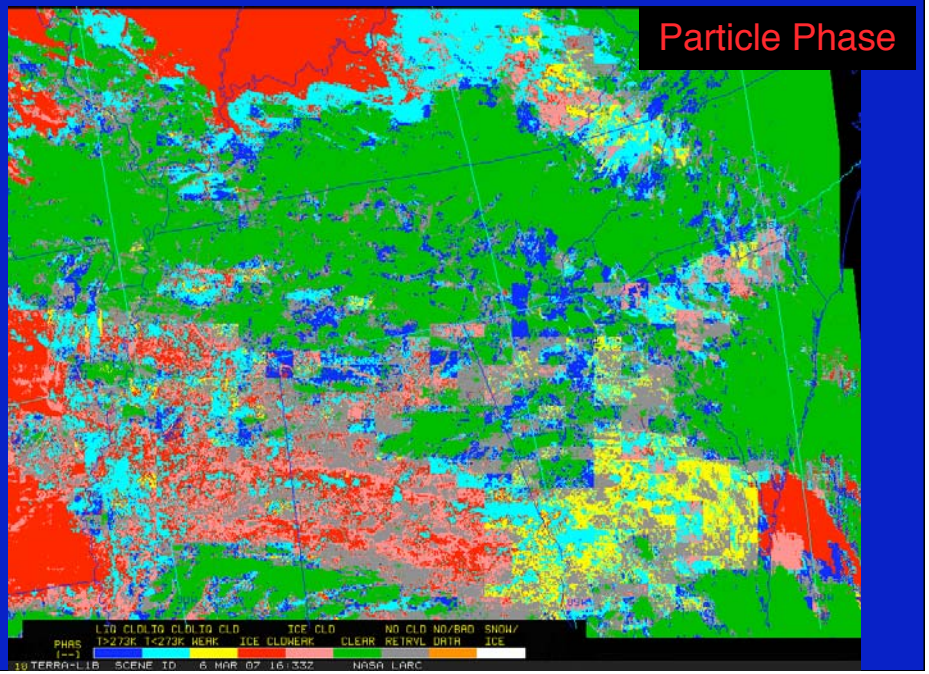


Terra 1km MODIS, March 6, 2007 UTC 1633, Thin cirrus/contrail detection







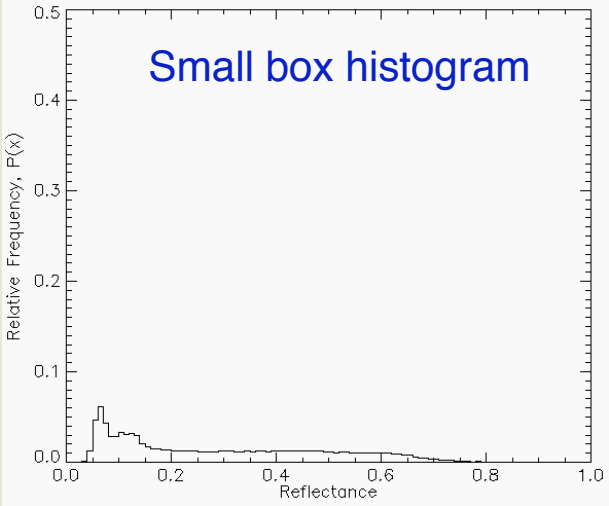


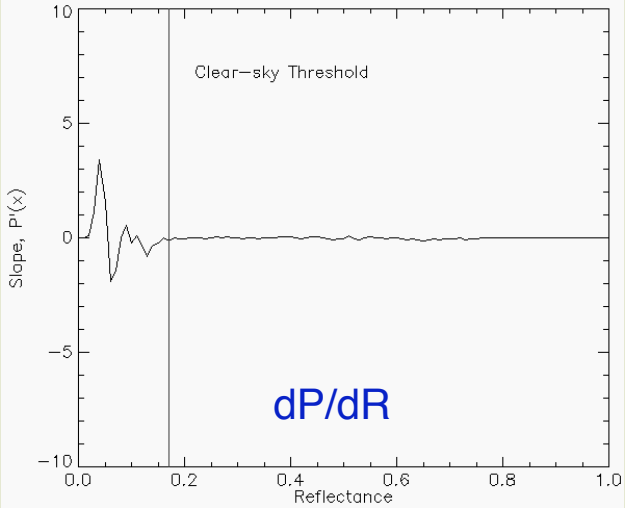
Future Work for Ed3 Beta2

- Polar cloud fraction discontinuity
- Cloud mask over Super Cold Plateau
  - G5 yields more false clouds, need tuning
- Tune Terra mask to new 3.7 calibration
- Revise use of IGBP models - theo over perm snow?
- Examine & tune impact of CO2 retrievals
  - take care of no retrieval cirrus
- Define lower tau limit of detection w/CALIPSO data
- Integrate hi-res VIS retrieval results

Using Hi-Res VIS to Detect Pixel-Level Fractional Cloudiness

VIS reflectance over ocean

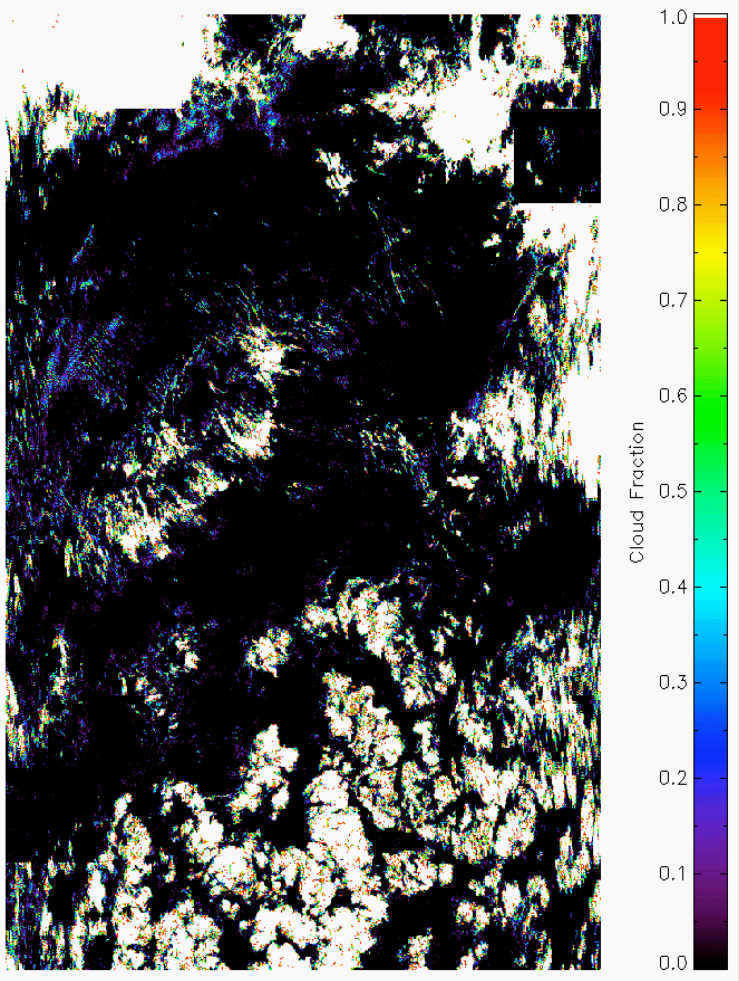




Using Hi-Res VIS to Detect Pixel-Level Fractional Cloudiness

VIS reflectance over ocean

Cloud fraction

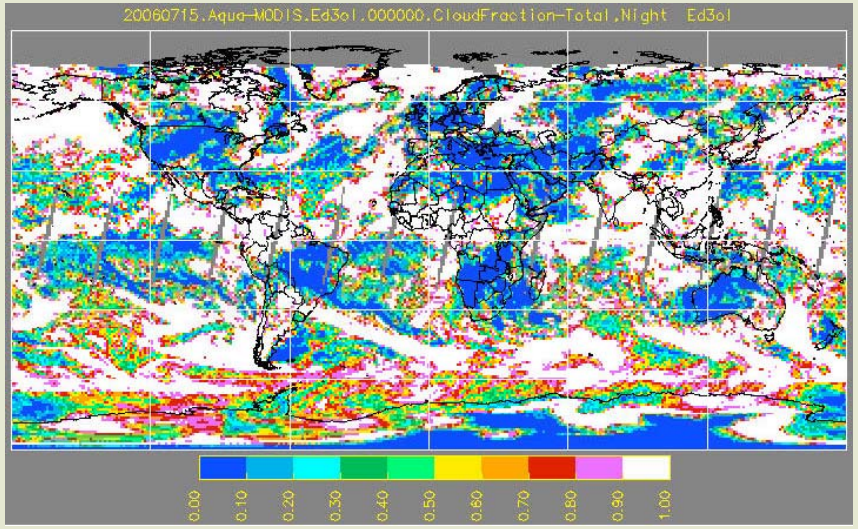


- Picks up more clouds, but smaller fractions
- No apparent problems with multi-thickness clouds
- Kinks to be rubbed out in next few months

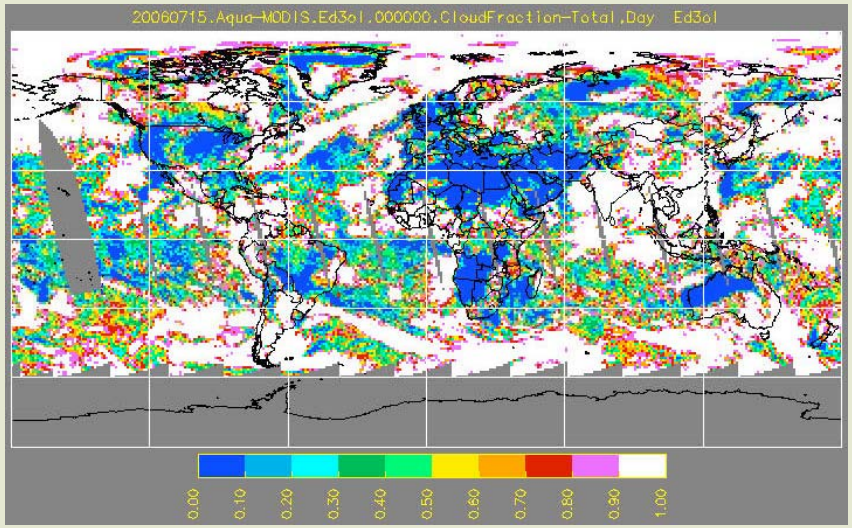
Comparison of Ed3 and Previous Edition Cloud Mask

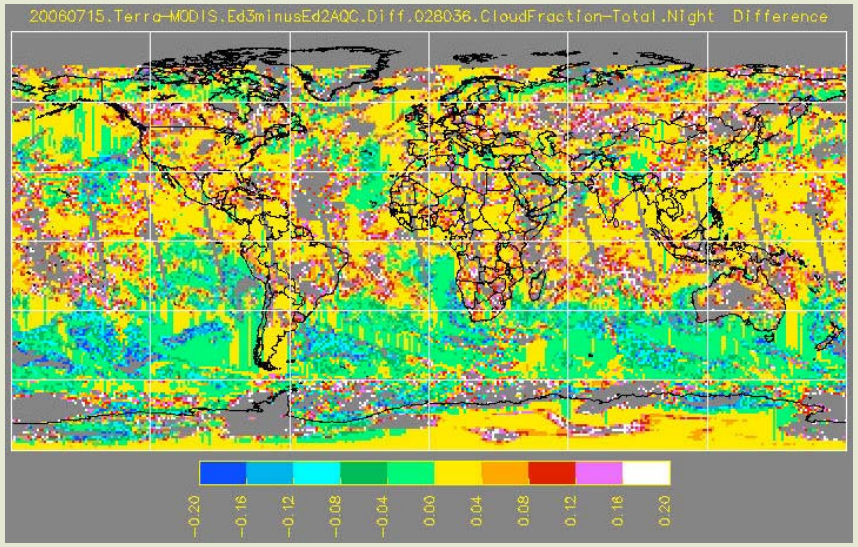
Aqua Mean Cloud Fraction & Differences, 15 July 2006

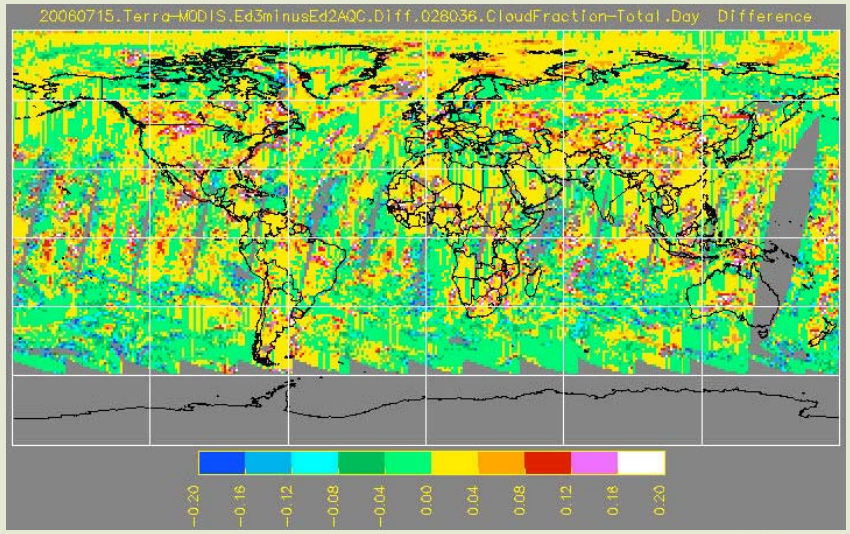
Night



Day





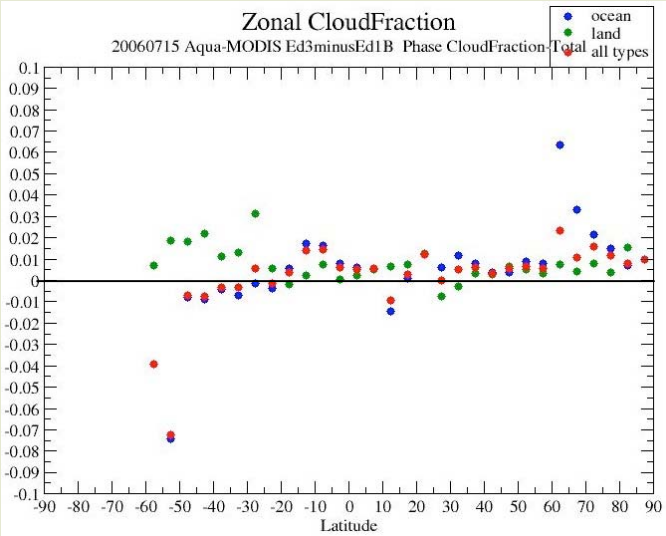


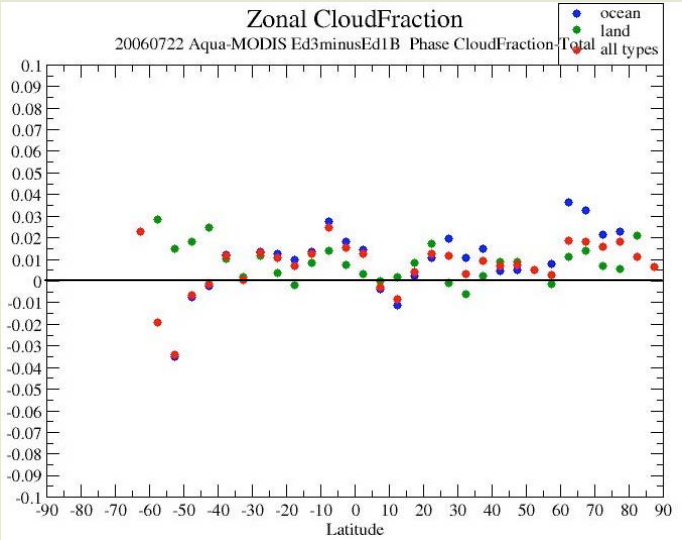
Cloud amount mostly increases at night, up & down during day

Aqua Mean Cloud Fraction & Differences, July 2006

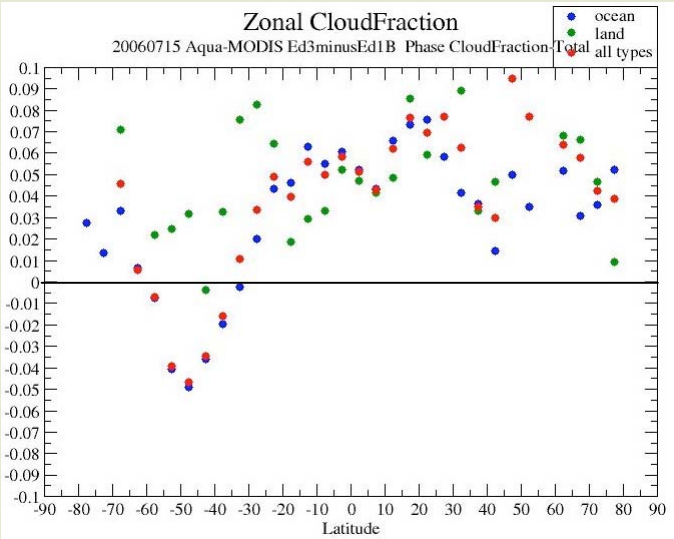
15 July

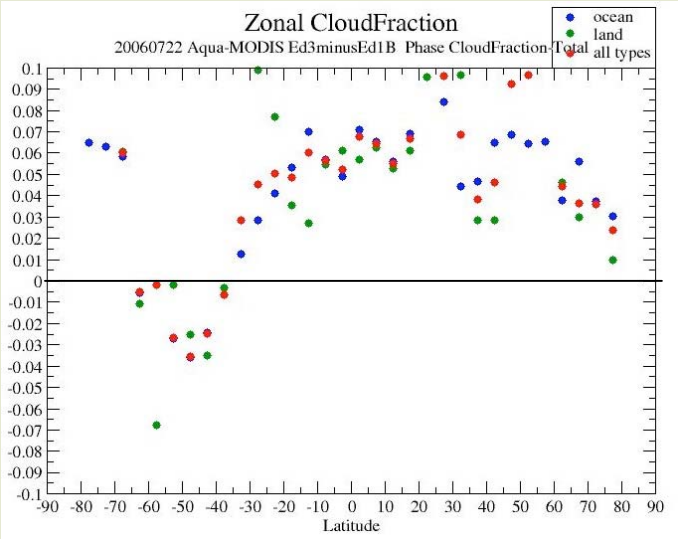
22 July





Day



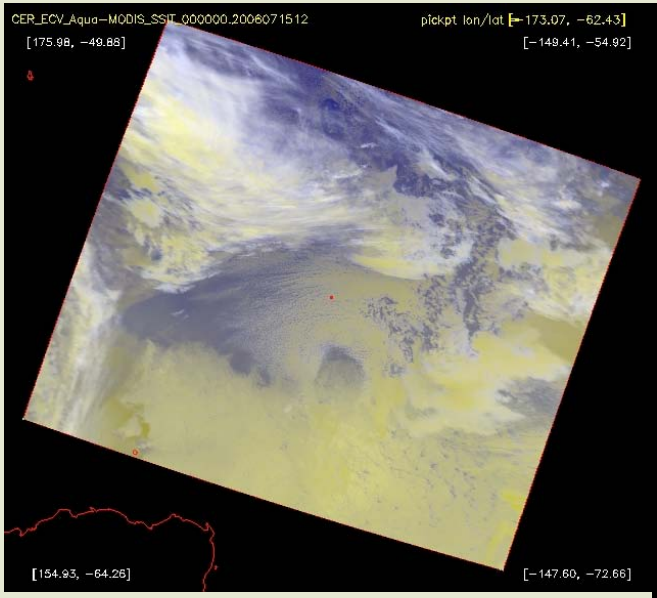


Night

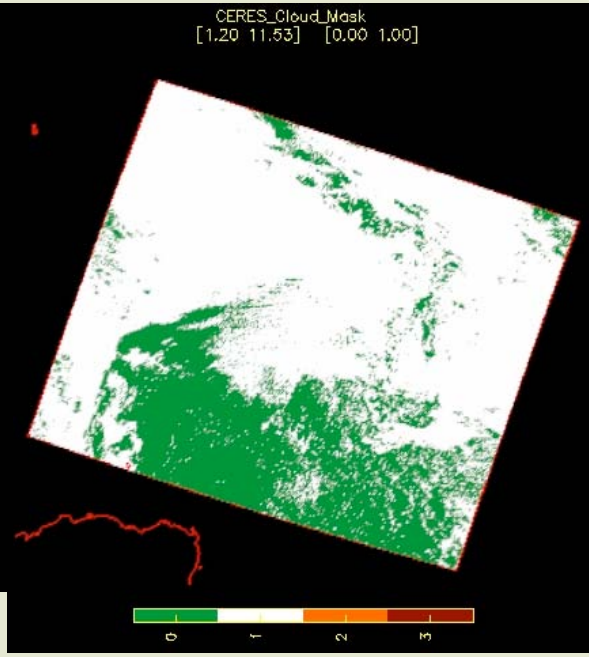
Cloud fraction higher at night by ~6%, twilight drops over oceans
Daytime CF up by 0.5%

Aqua Ed3 vs Ed1 Mask, Antarctic Night

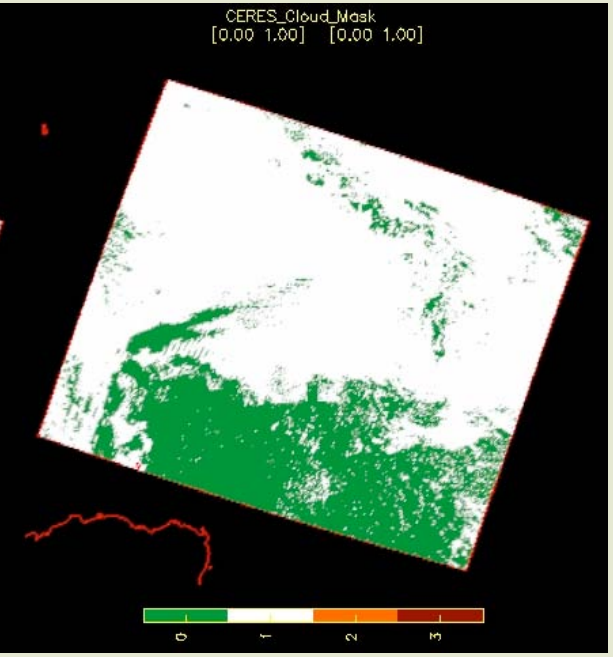
RGB



Ed3



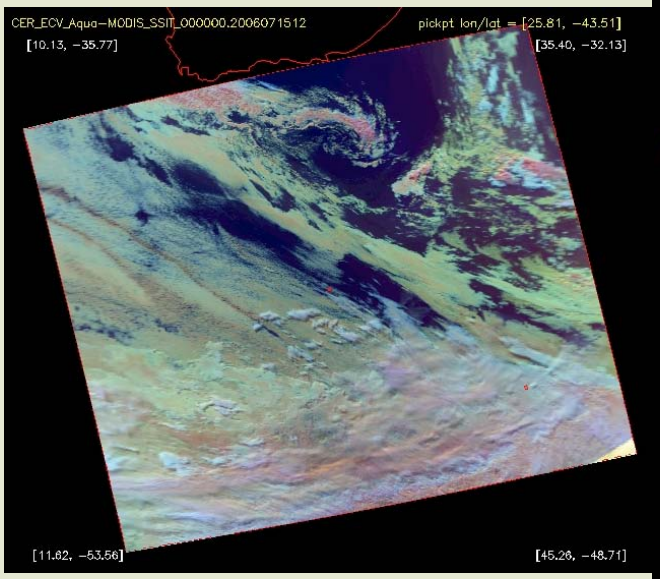
Ed1



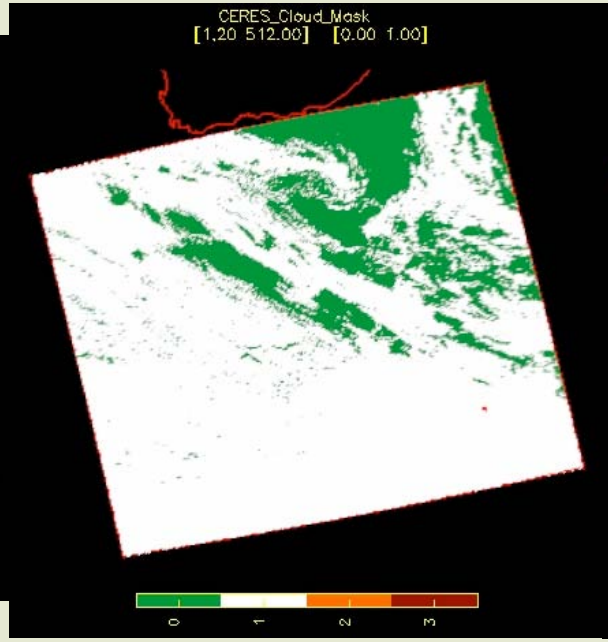
Ed3 looking more realistic here

Aqua Ed3 vs Ed1 Mask, Off South Africa

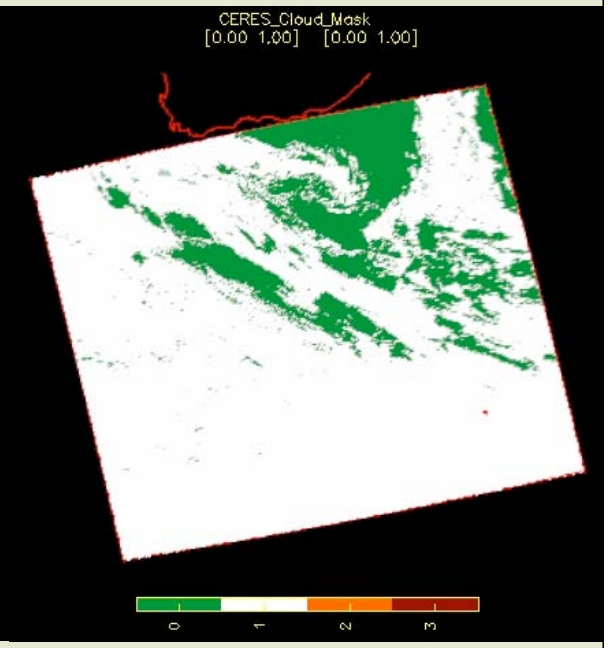
RGB



Ed3



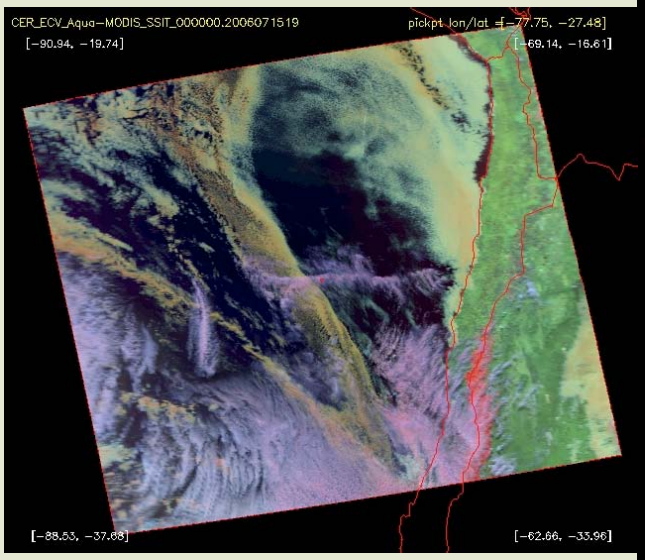
Ed1



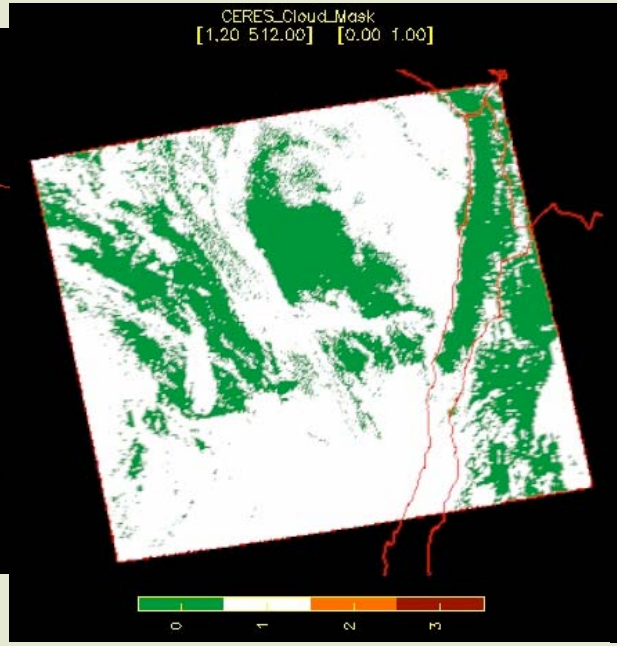
Ed3 looking more realistic here, fewer clouds in glint area

Aqua Ed3 vs Ed1 Mask, Off Chile

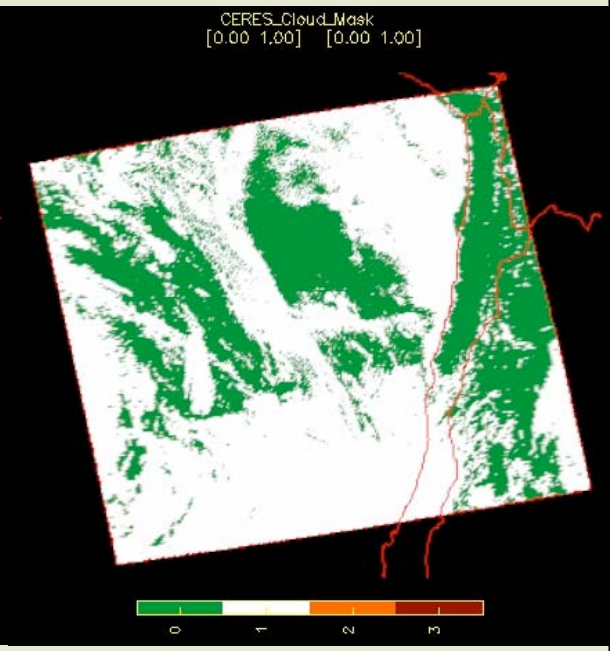
RGB



Ed3



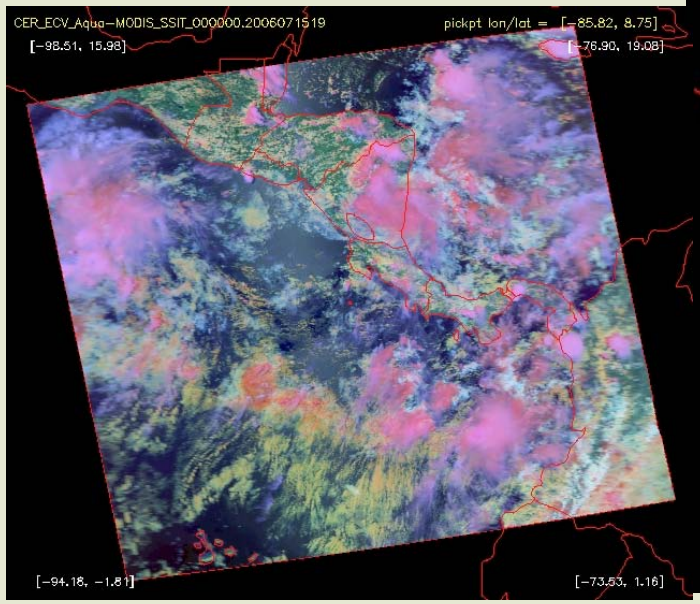
Ed1



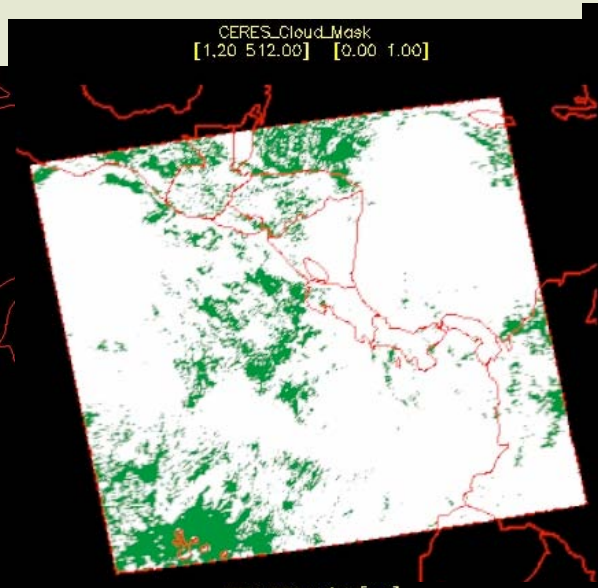
Ed3 picks up more clouds where re is small, fewer for greater re

Aqua Ed3 vs Ed1 Mask, Central America

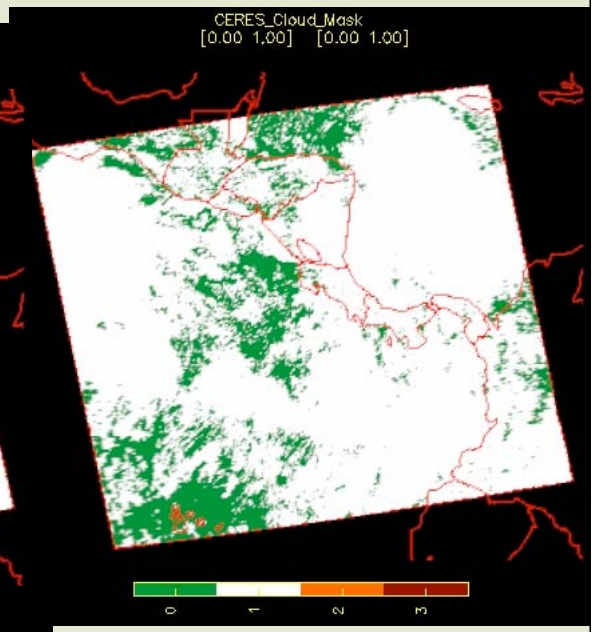
RGB

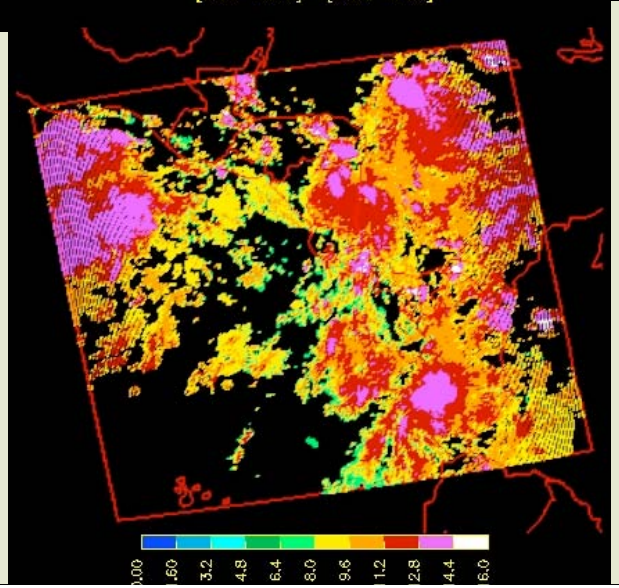


Ed3



Ed1



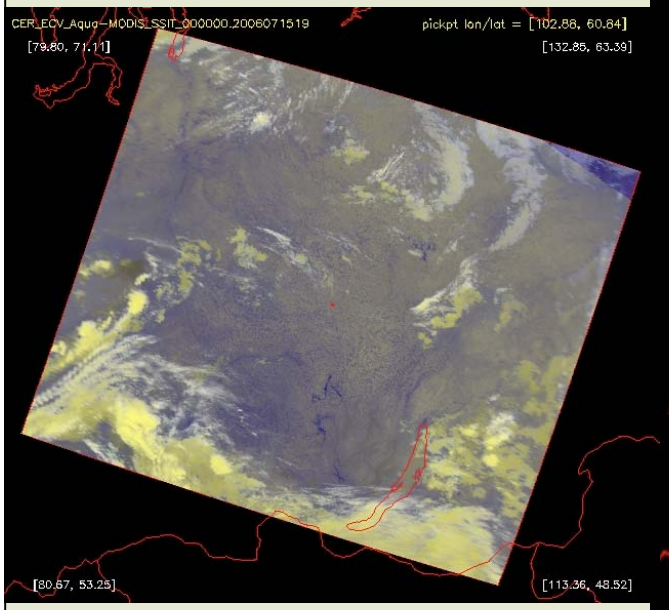


Ed3 picks up more clouds in sun glint – image and height suggest too much

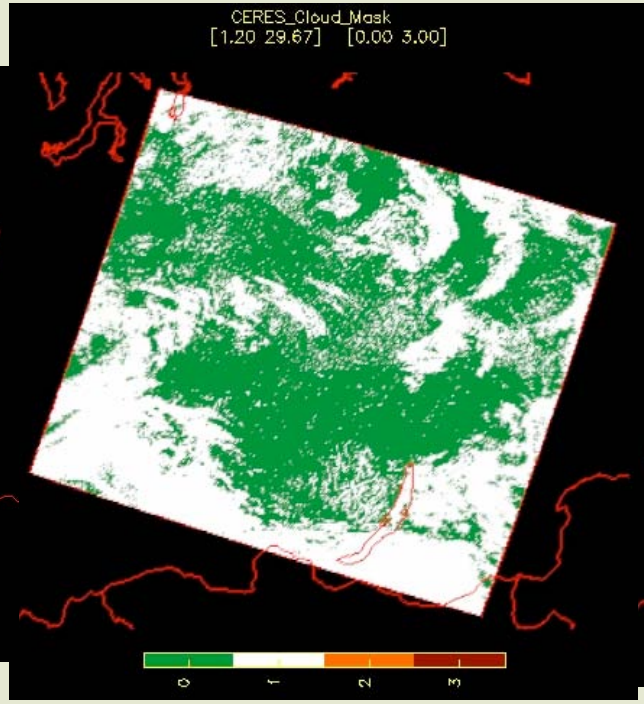
Ed 3 picks up more in streaks- probably more realistic

Aqua Ed3 vs Ed1 Mask, Siberian Night

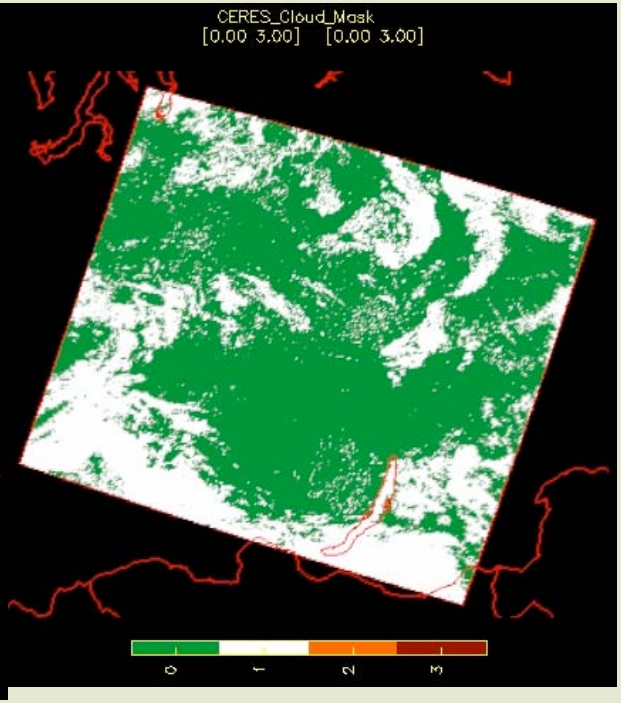
RGB



Ed3



Ed1

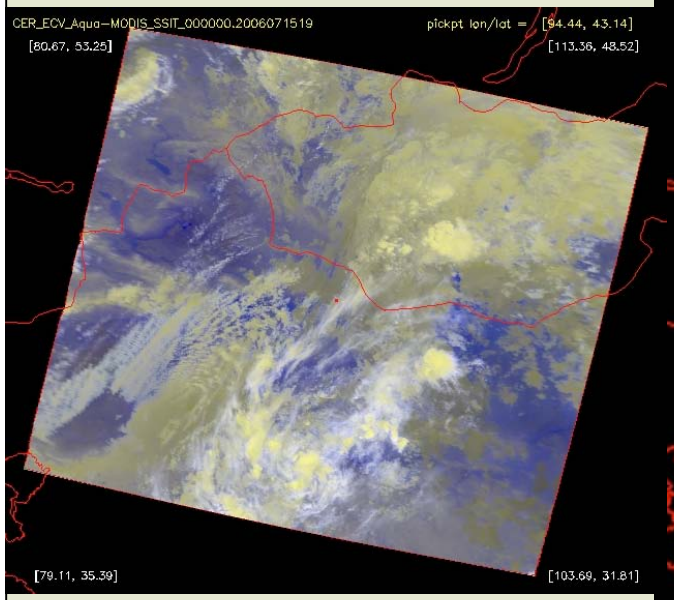


Ed1 looking more realistic here, extra night clouds may not be actual clouds, on average.

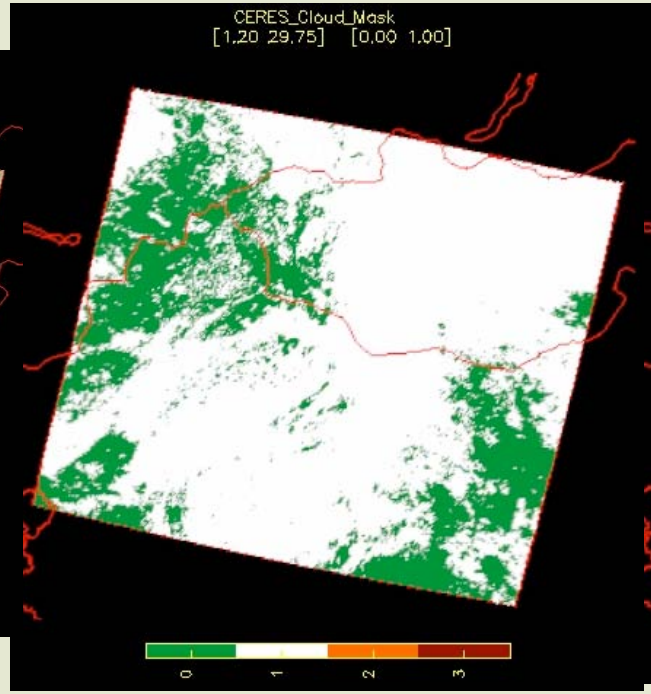
None of extra clouds are high

Aqua Ed3 vs Ed1 Mask, Western China Night

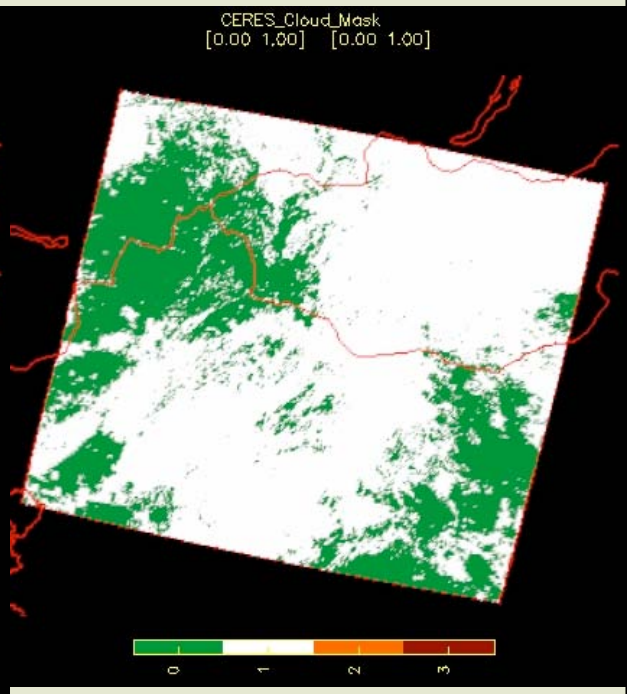
RGB



Ed3

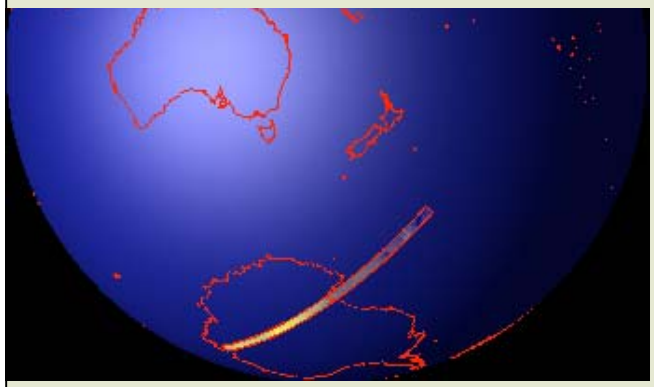


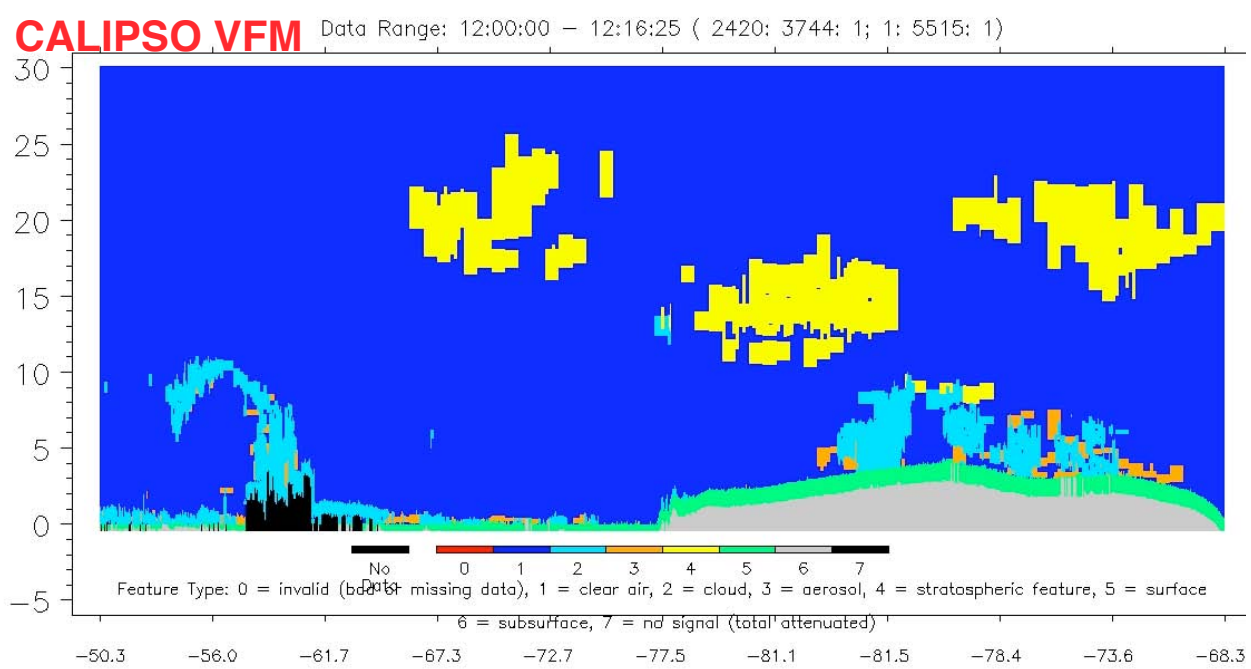
Ed1

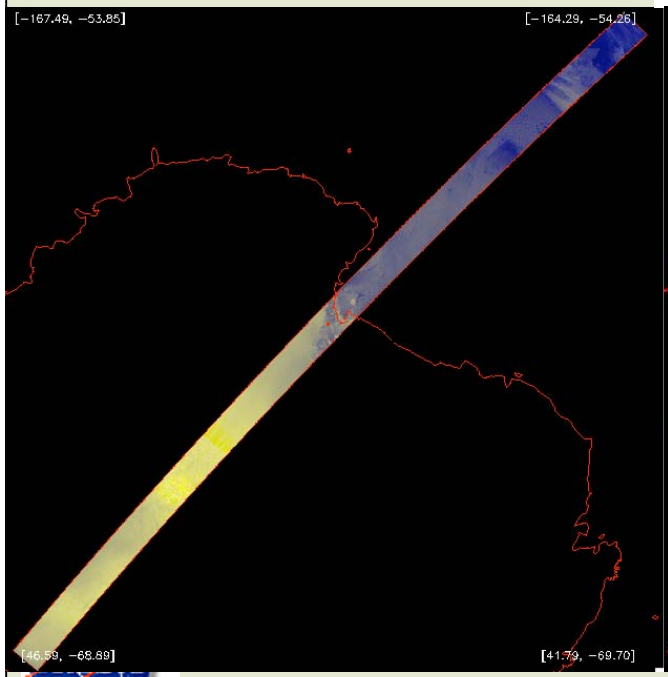


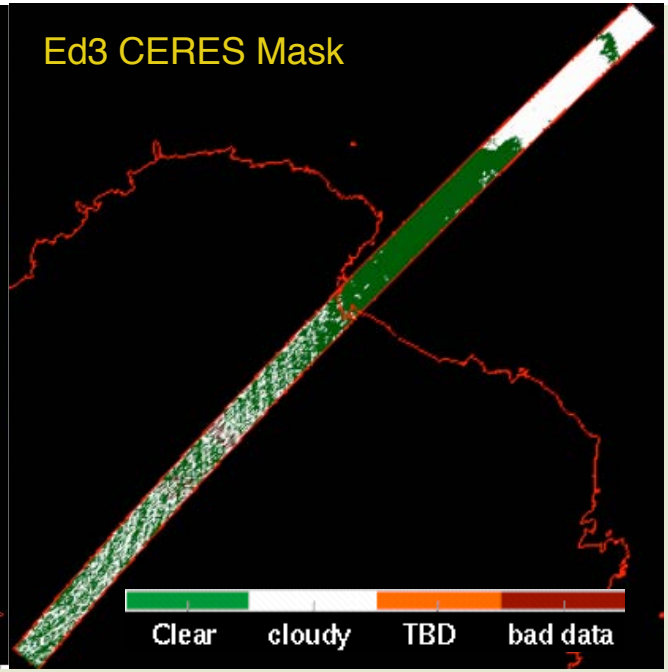
Ed3 looking more realistic here, picks up more altocumulus/stratus

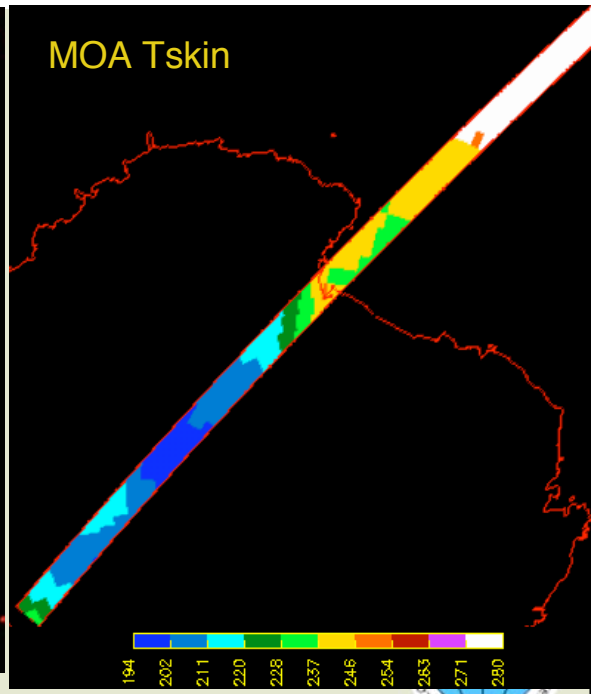
Nighttime Antarctica
Aqua and CALIPSO VFM
20060715 UTC 12









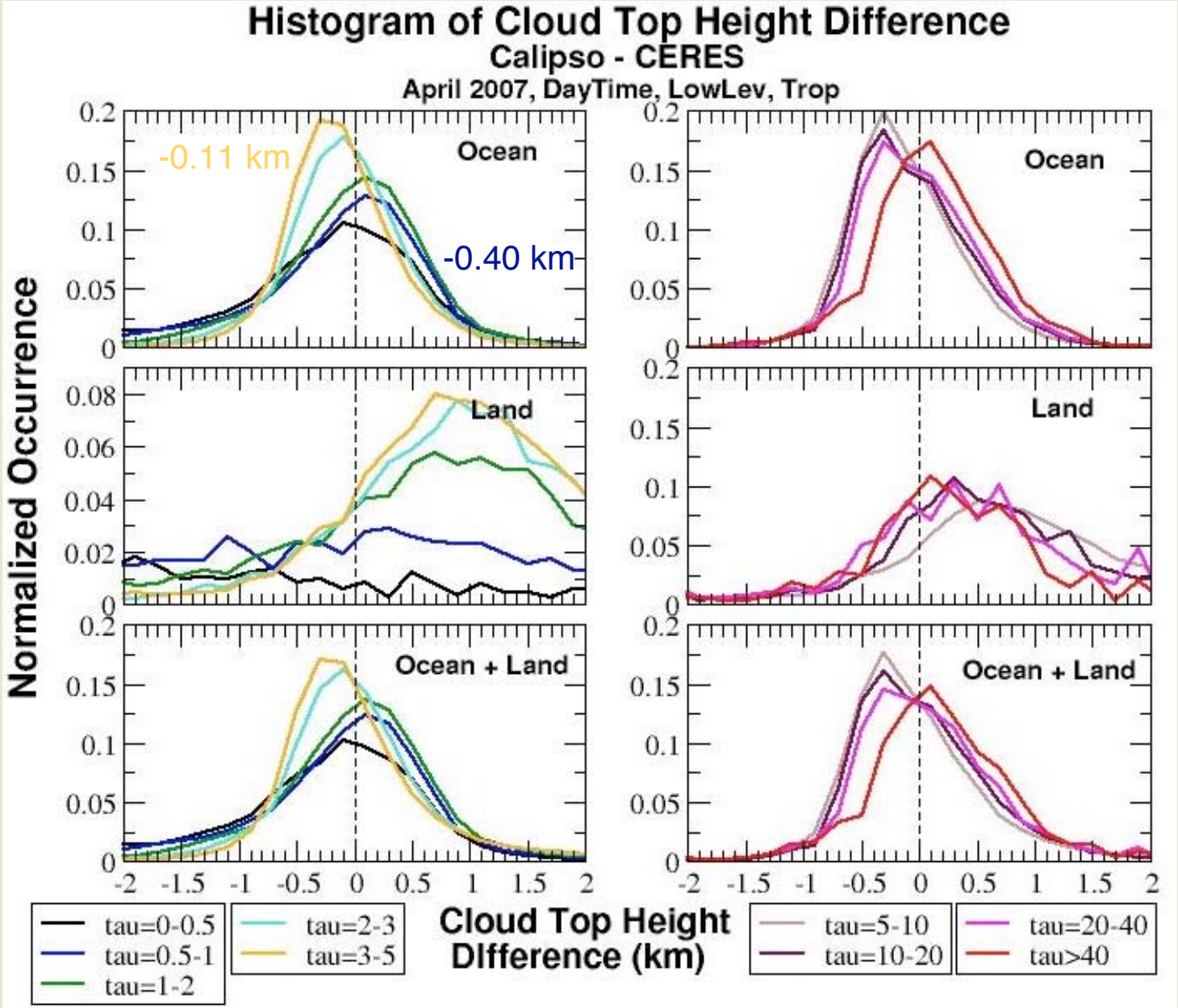


Ed 3 Mask Summary

- Considerable number of changes made
  - some made things worse, some better
  - increase in nighttime cloudiness may/may not be accurate
    - need more CALISPO matches
    - if realistic, need increase in daytime

- Beta 2 will have additional changes plus refinements
  - Hi-res VIS
  - adjusted thresholds
  - final CO2 detection
  - altered polar for transition

RETRIEVALS



- Different lapse rates needed over land (5.5/km?) and water (8.0/km?)
- Correction for effective to top?

Lapse Rate Calculation

For Merged CALIPSO and CERES Clouds

CALIPSO Clouds:

(1) Single Layer

(2) Transparent Clouds

(3) Cloud Top Height: Z_{top}

Surface Height: Z_{sfc}

$Z_{top} - Z_{sfc} < 4$ km

CERES Clouds:

(1) Water Clouds

(2) Cloud Top Temp: T_{top}

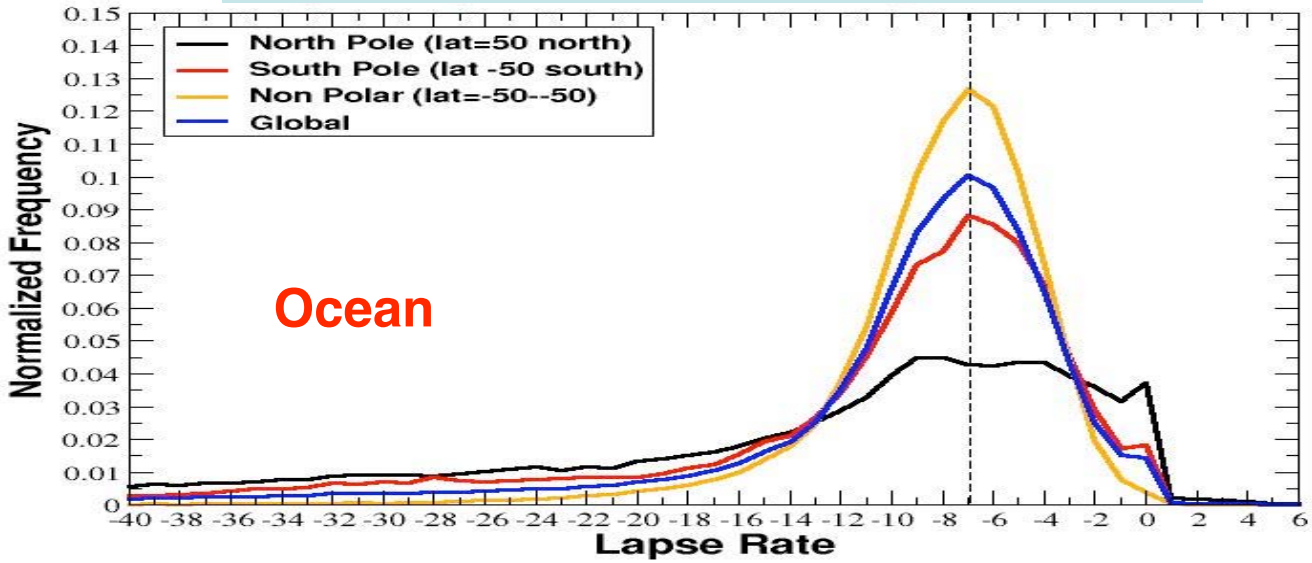
(3) For Ocean: T_{skin}

(4) For Land: $T_{sfc\text{-}24h\text{-}mean}$

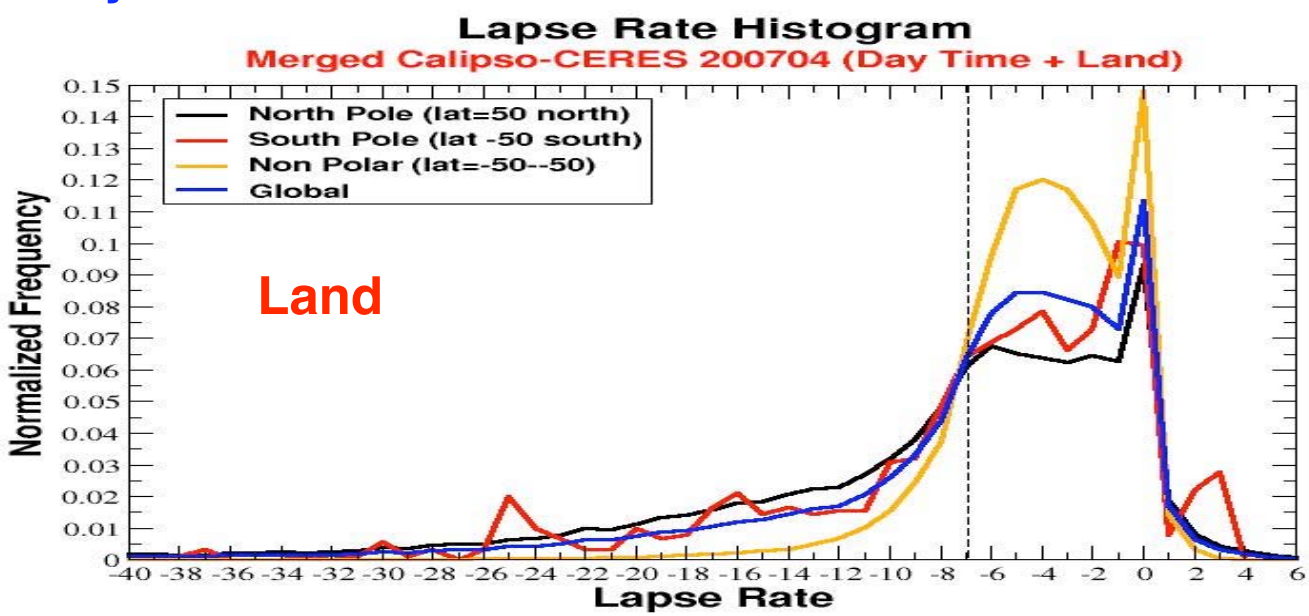
Lapse Rate $= (T_{top} - T_{skin}) / (Z_{top} - Z_{sfc})$ <------ For Ocean

Lapse Rate $= (T_{top} - T_{sfc\text{-}24h\text{-}mean}) / (Z_{top} - Z_{sfc})$ <------ For Land

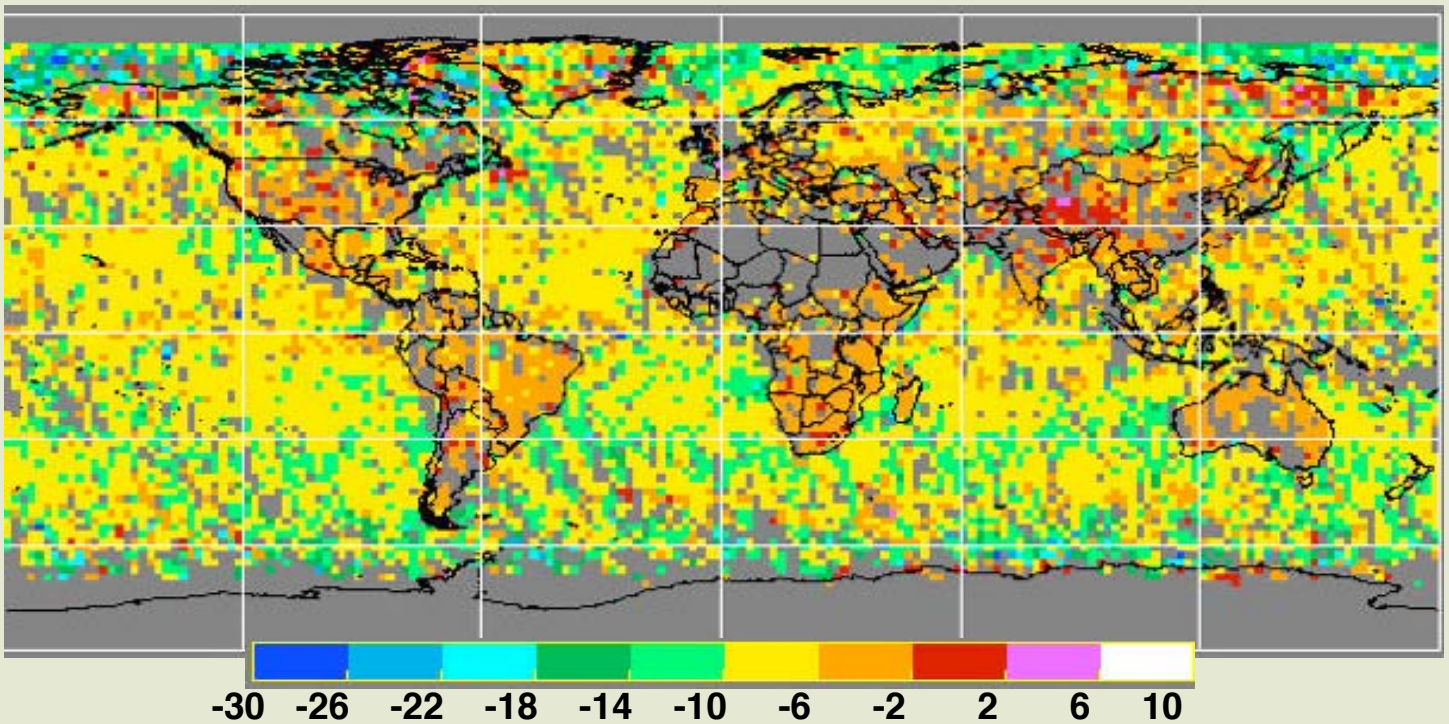
Lapse Rate Histogram (April 2007)



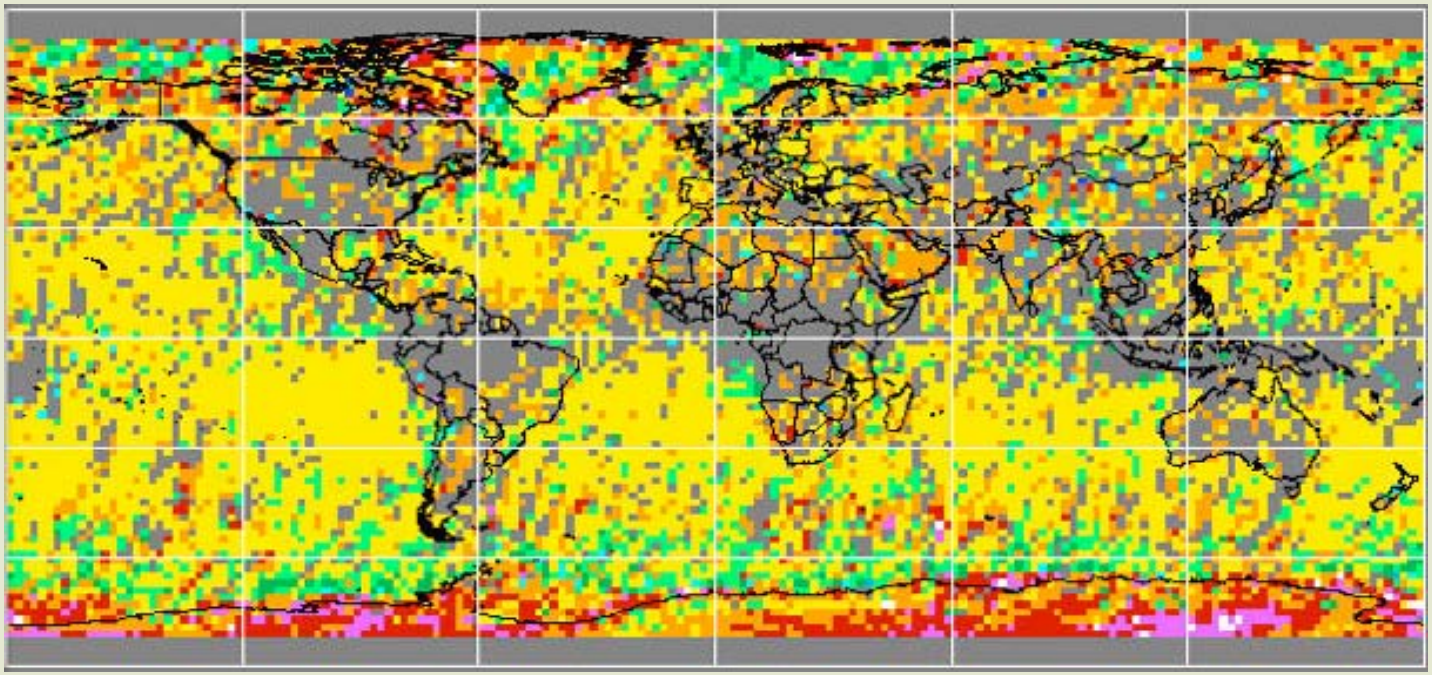
Day Time



Global Maps of Lapse Rate (April 2007)

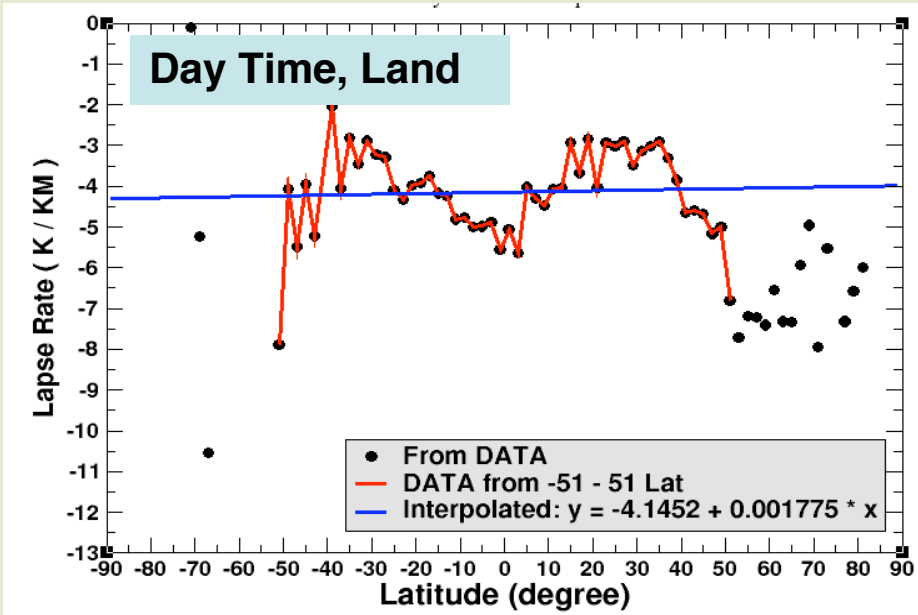


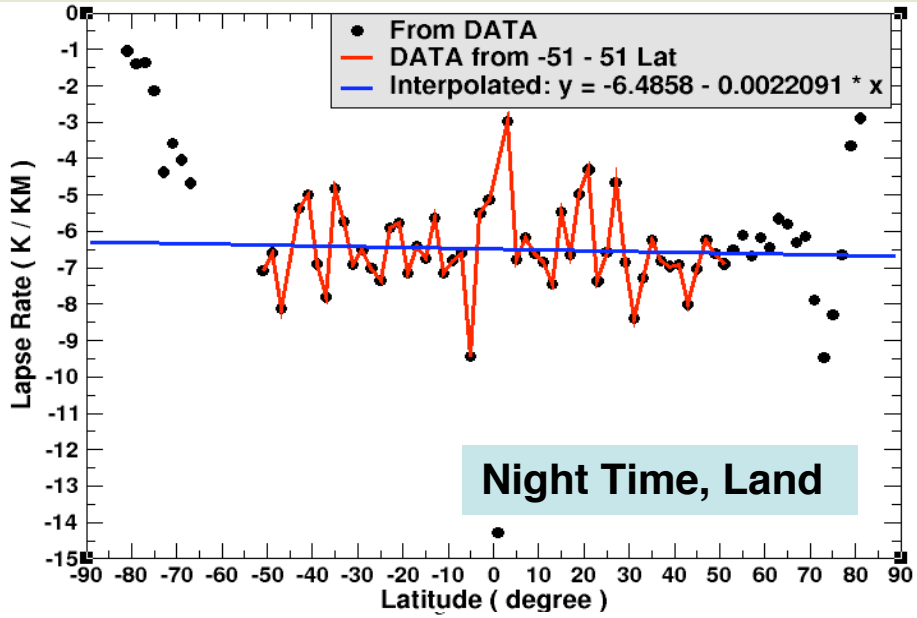
Day Time

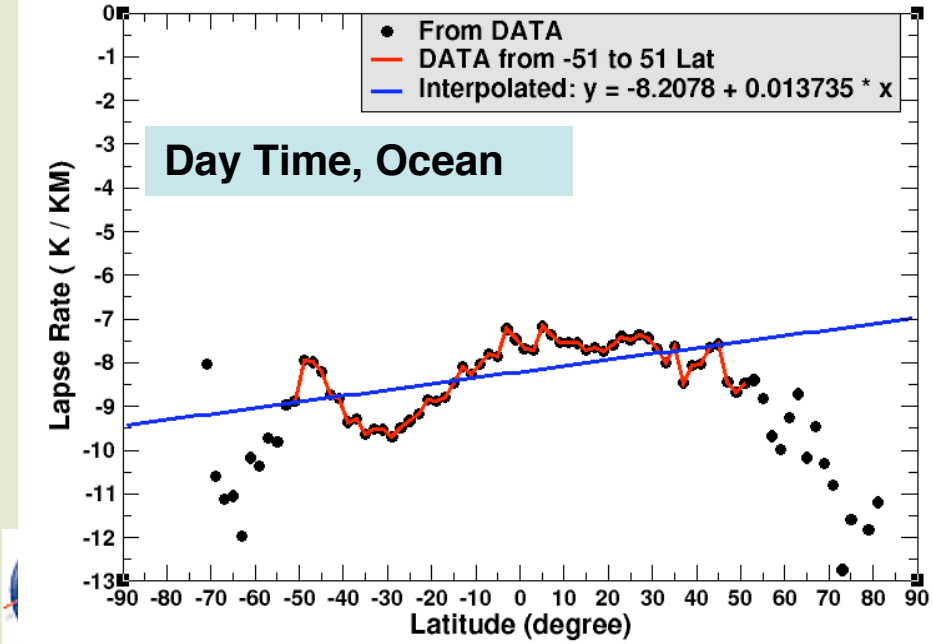


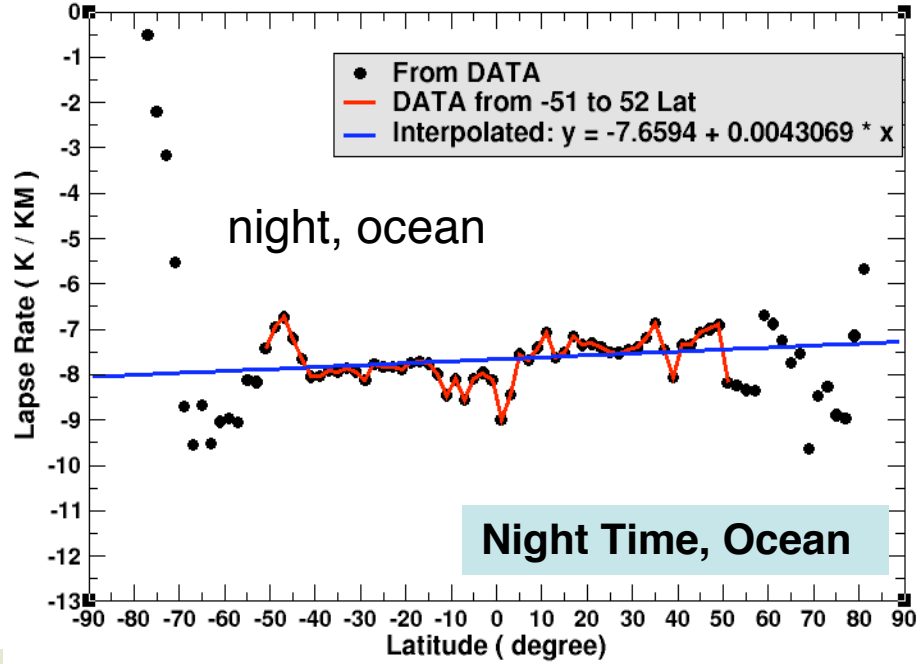
Night Time

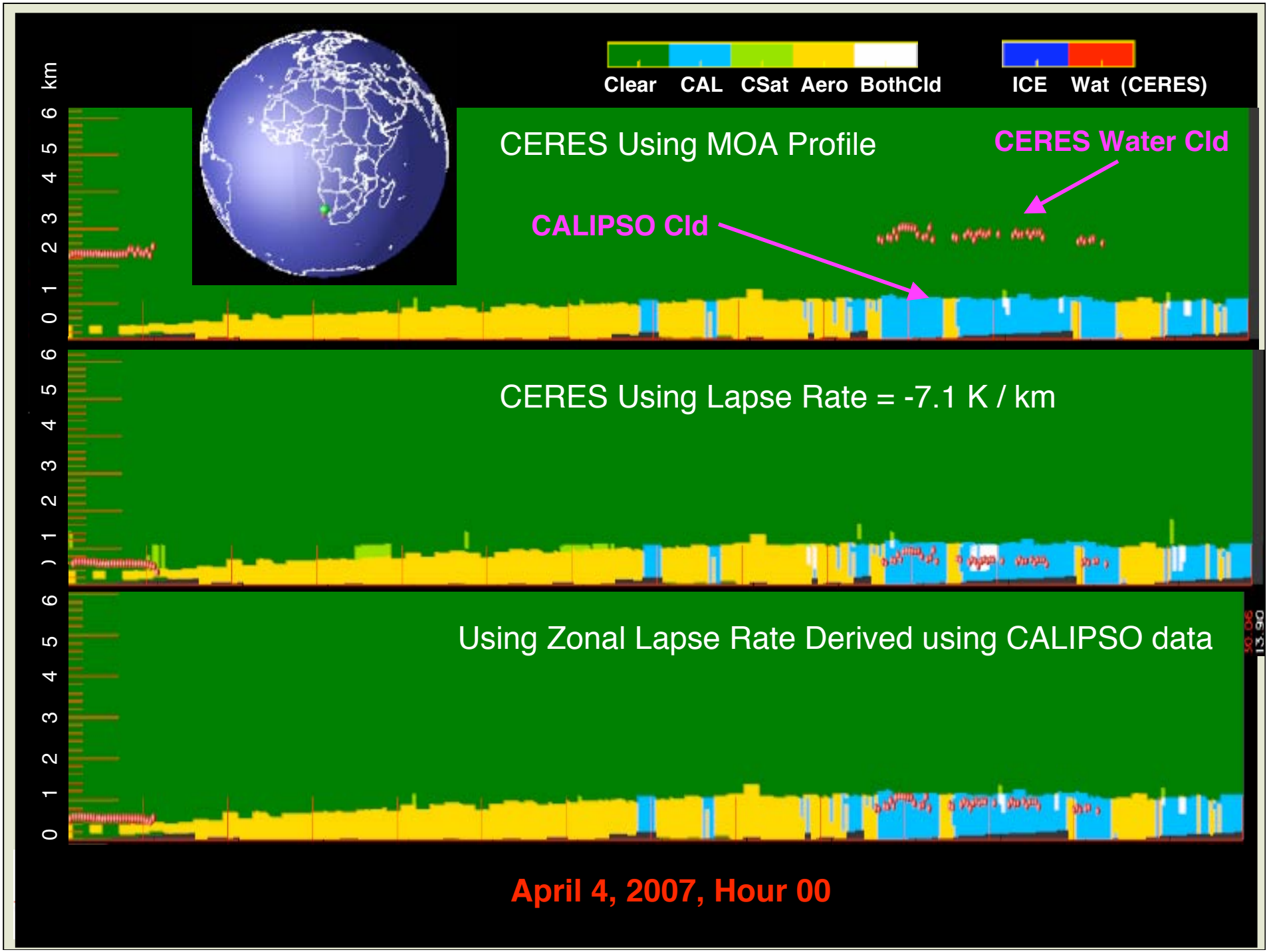
Zonal Lapse Rate (April 2007)

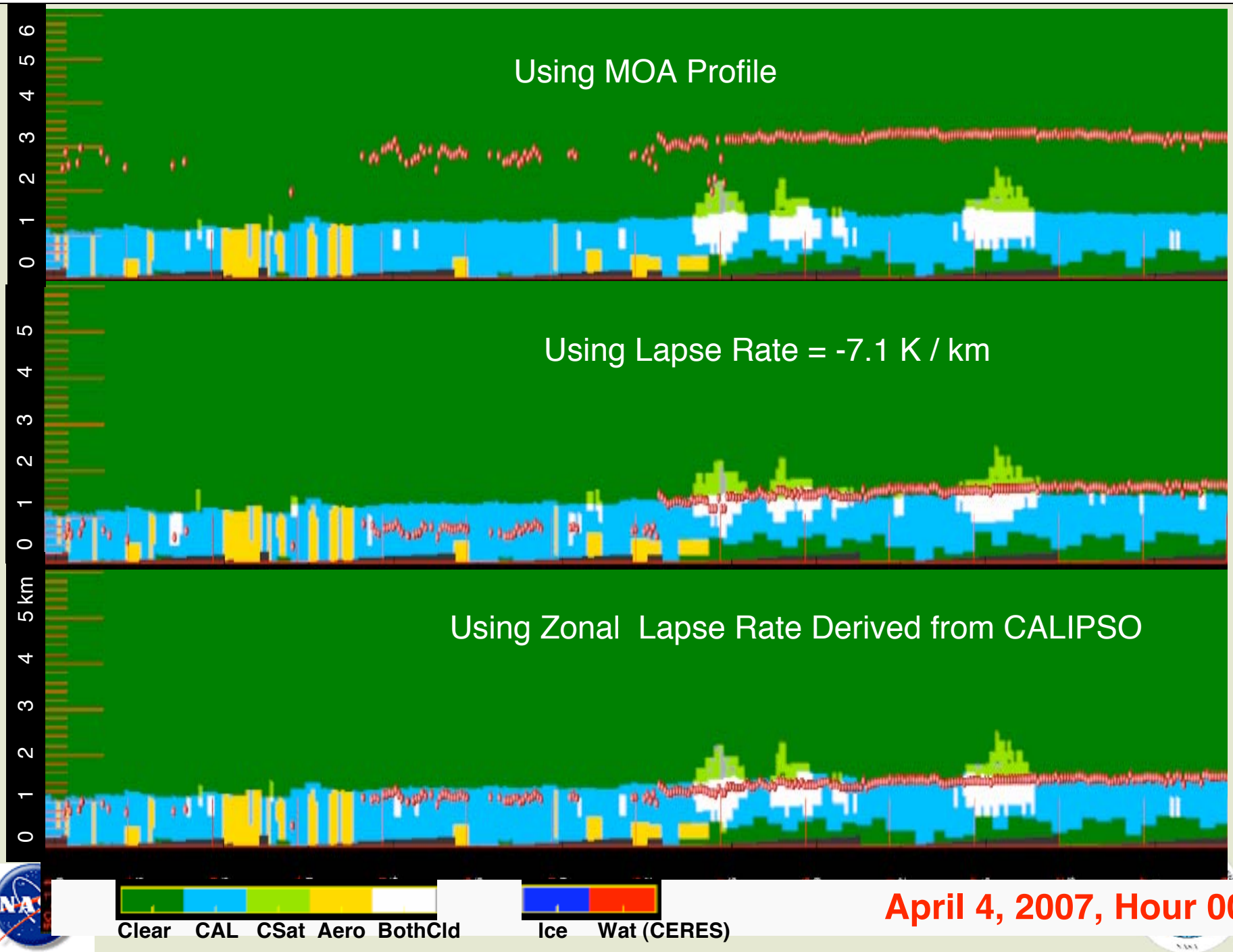




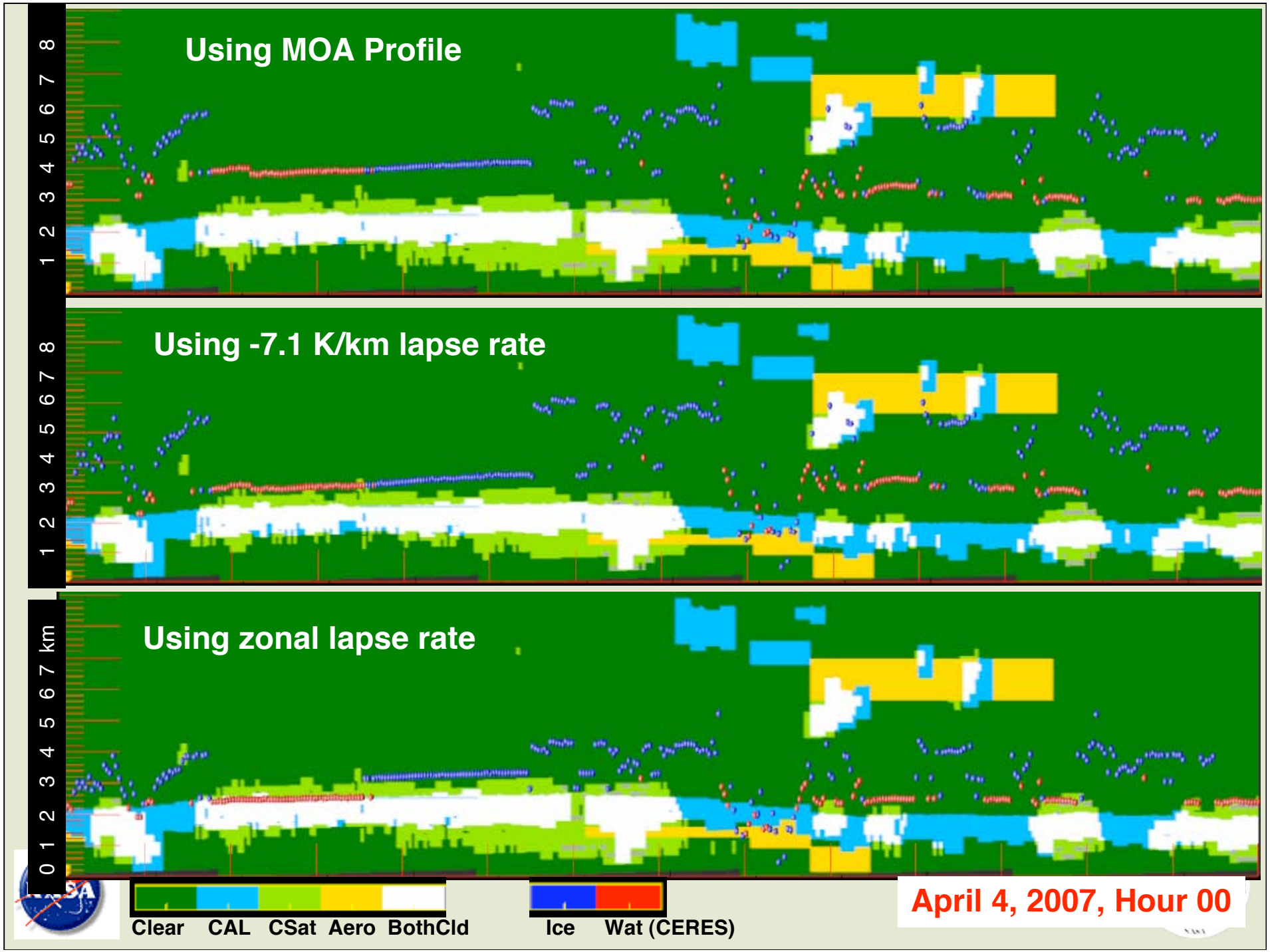


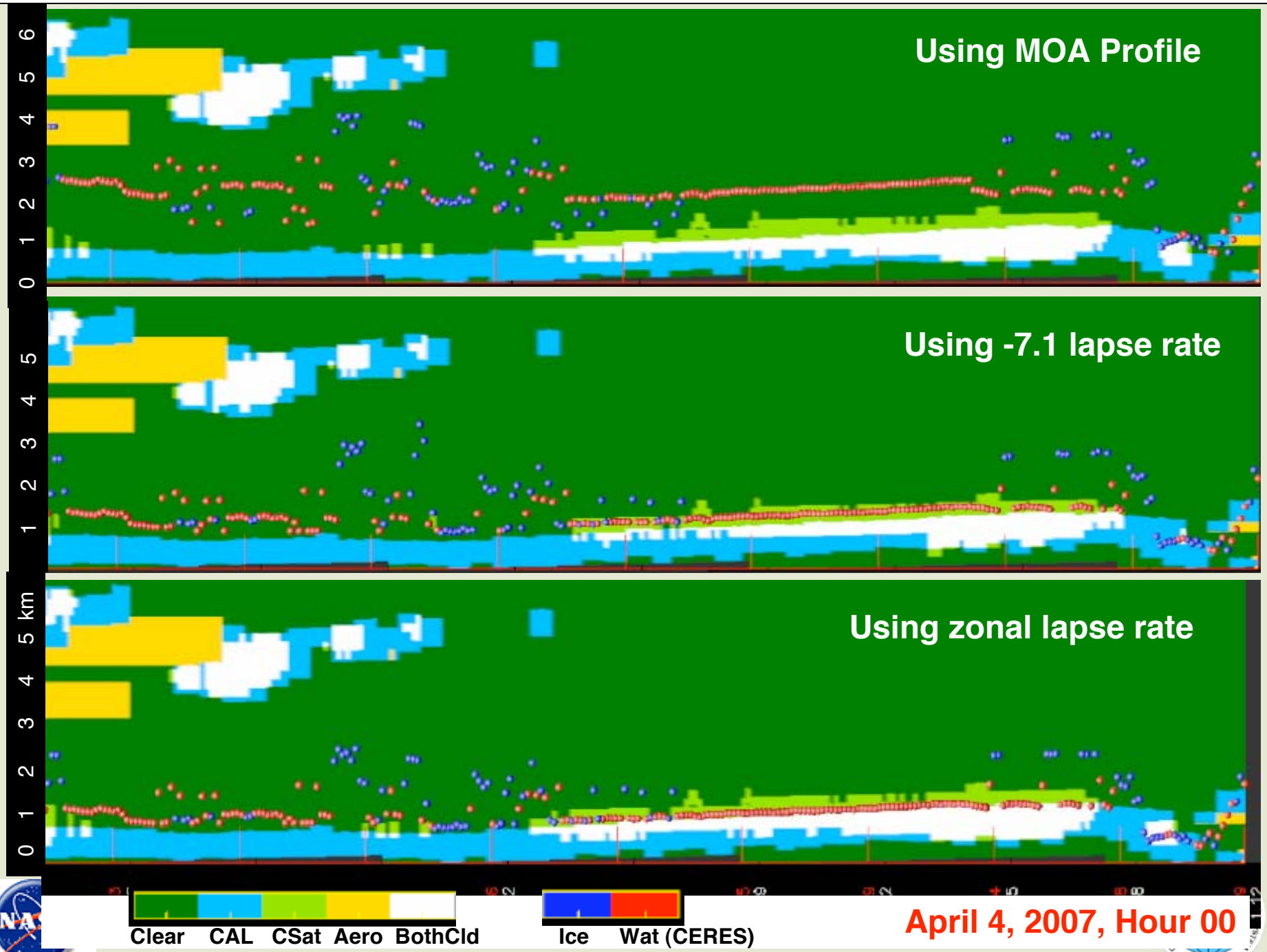



km
6 5 4 3 2 1 0
Clear CAL CSat Aero BothCld
ICE Wat (CERES)
CERES Using MOA Profile
CERES Water Cld
CALIPSO Cld
CERES Using Lapse Rate = -7.1 K / km
Using Zonal Lapse Rate Derived using CALIPSO data
April 4, 2007, Hour 00



April 4, 2007, Hour 00


Using MOA Profile
Using -7.1 K/km lapse rate
Using zonal lapse rate
0 1 2 3 4 5 6 7 km
1 2 3 4 5 6 7 8
Clear
CAL
CSat
Aero
BothCld
Ice
Wat (CERES)
April 4, 2007, Hour 00


Using MOA Profile
Using -7.1 lapse rate
Using zonal lapse rate
0 1 2 3 4 5 6
0 1 2 3 4 5
0 1 2 3 4 5 km
Clear
CAL
CSat
Aero
BothCld
Ice
Wat (CERES)
April 4, 2007, Hour 00

Lapse rate summary

- **need close examination of cloud temperatures and lapse rates over polar regions.**
- **Need to process more months to get seasonal lapse rates – beta 2**
- **potential land-to-ocean issues, e.g., discontinuities**

Edition 3 Retrievals of Thin Cirrus Cloud Properties, Daytime

- Perform VISST & CO_2-slicing retrievals

  => T_{eff}, τ_{sm}, p_{eff}, D_{sm} + T_{co2}, p_{co2}, τ_{co2}

- If single-level and $\tau_{sm} < 6$, then

  - if $p_{eff} - p_{co2} > 50$ mb, then attempt to find new ice crystal model

- Perform retrieval with VISST-R, where nominal models replaced with roughened models, $\sigma = 1.0$: => T_{reff} , g_{ro}, τ_{ro}, D_{ro}

- If $T_{co2} \leq T_{reff}$, then use results of VISST-R, otherwise

$$\tau = (\tau_{sm} - \tau_{ro})/(T_{eff}-T_{reff}) + \tau_{ro}$$

And so forth for g, D_{eff}

- Retrieval structure has been implemented without the models

  - now force τ to yield τ_{co2}

Edition 3 Improvement of SIST Retrievals, Night/Twilight

- Perform SIST & CO_2-slicing retrievals

  => T_{eff}, τ_{sm}, p_{eff}, D_{sm} + T_{co2}, p_{co2}, τ_{co2}

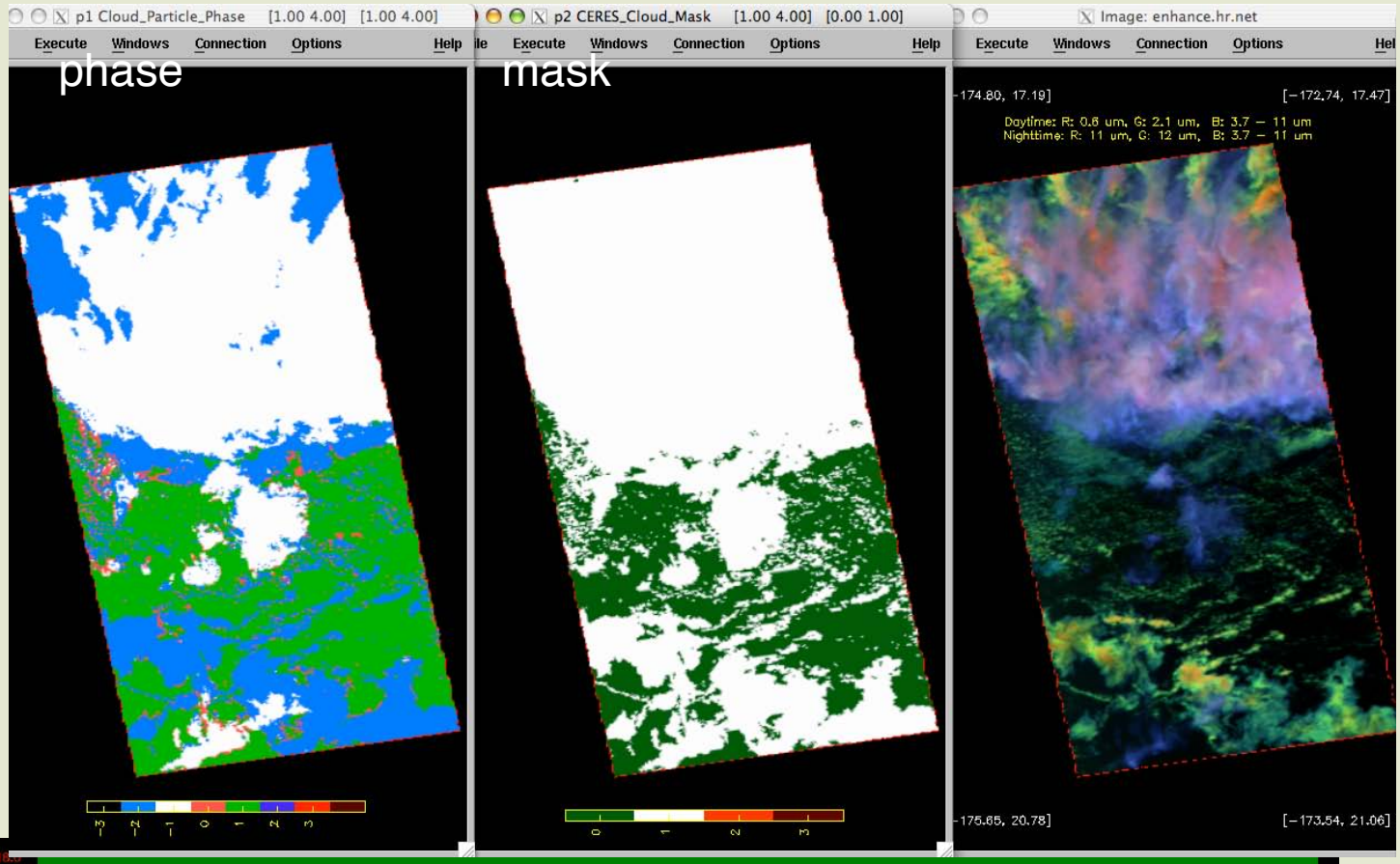
- If single-level and $\tau_{sm} < 6$, then

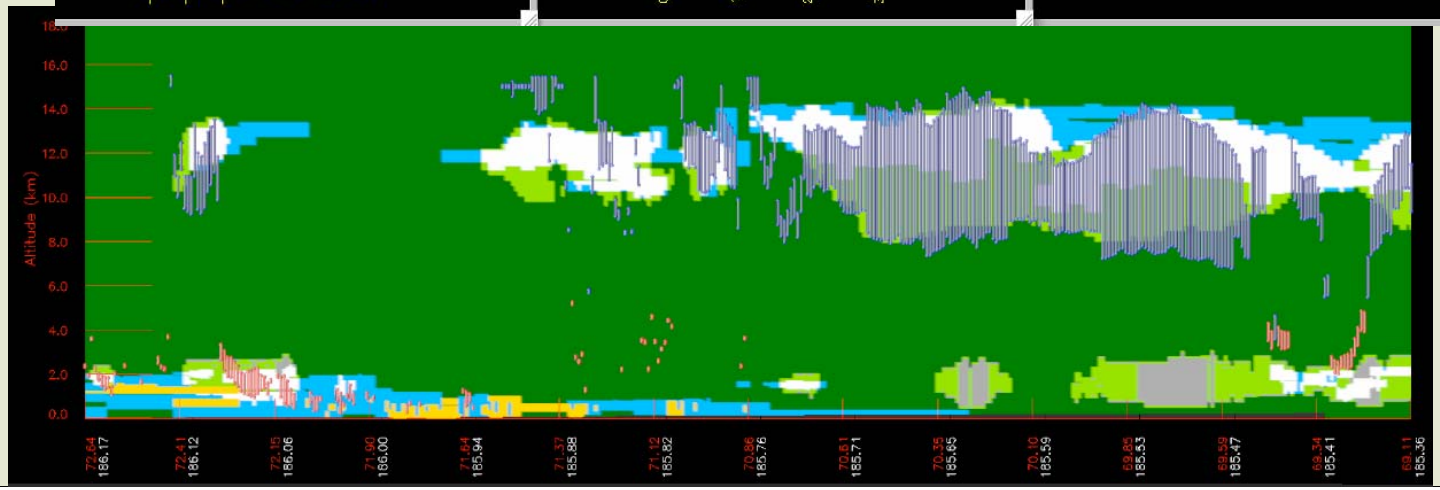
  - if $p_{eff} - p_{co2} > 50$ mb, then attempt to find new ice crystal model

- Perform retrieval with SIST-C, where $T_{reff} = T_{co2}$, solve for τ, D_{eff}

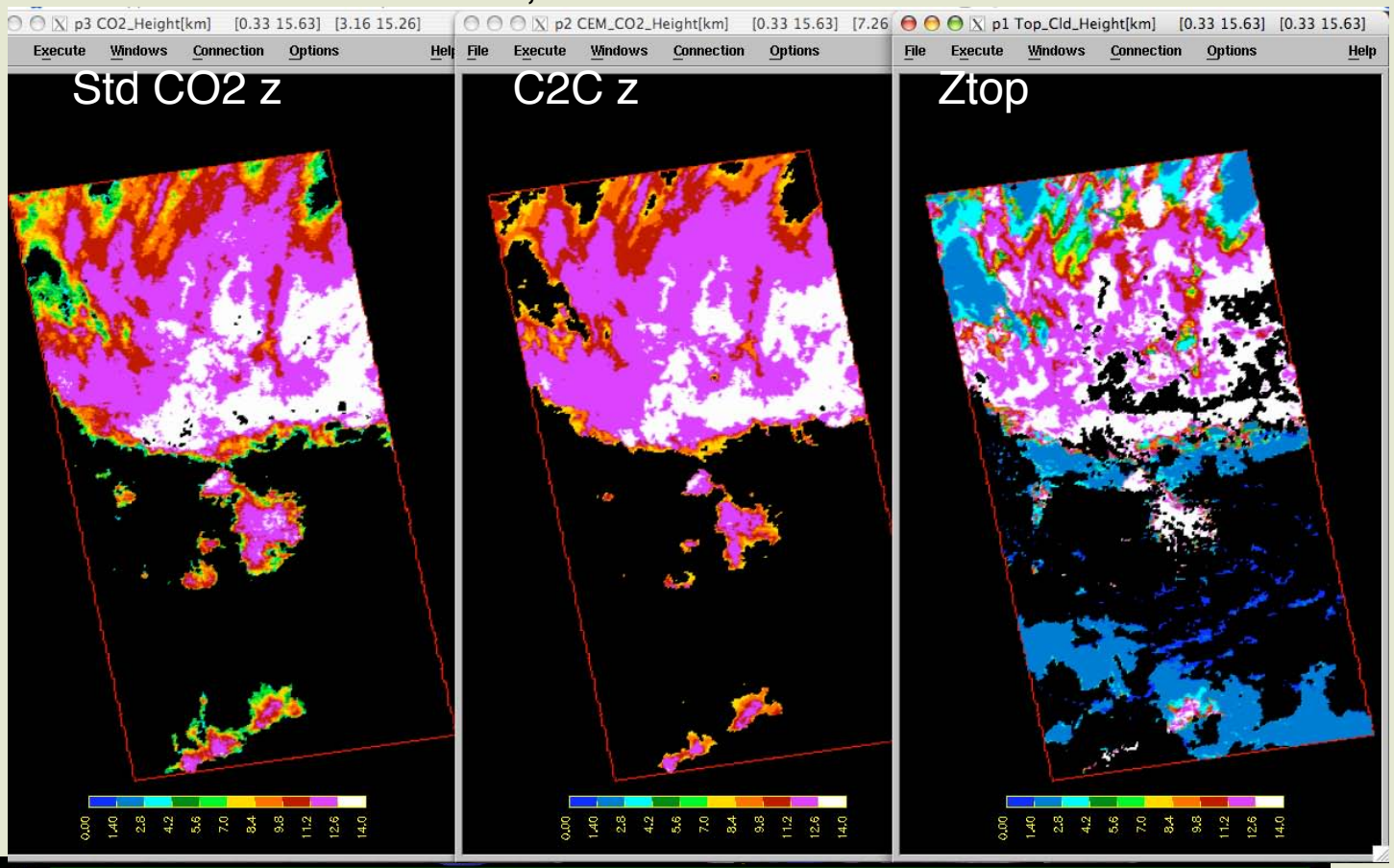
- Retrieval structure has been developed and is in Ed3 Beta 1

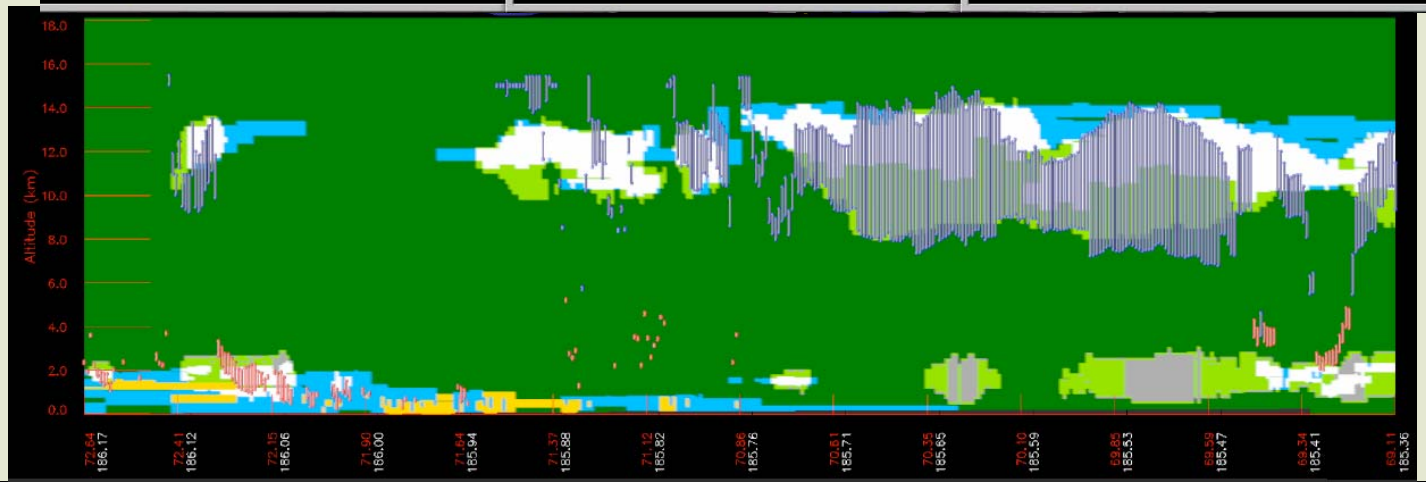
Clouds over North Pacific, Case 1



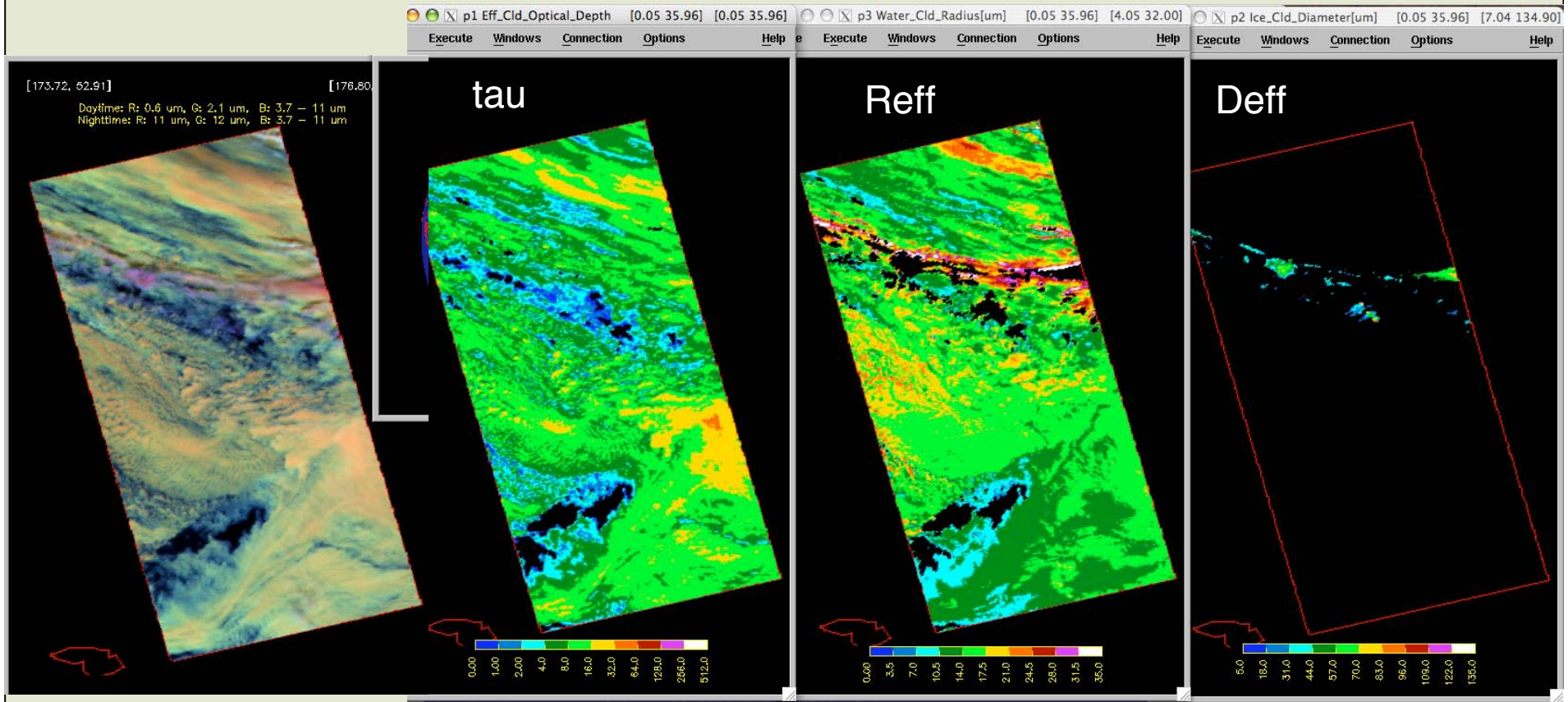


Clouds over North Pacific, Case 1

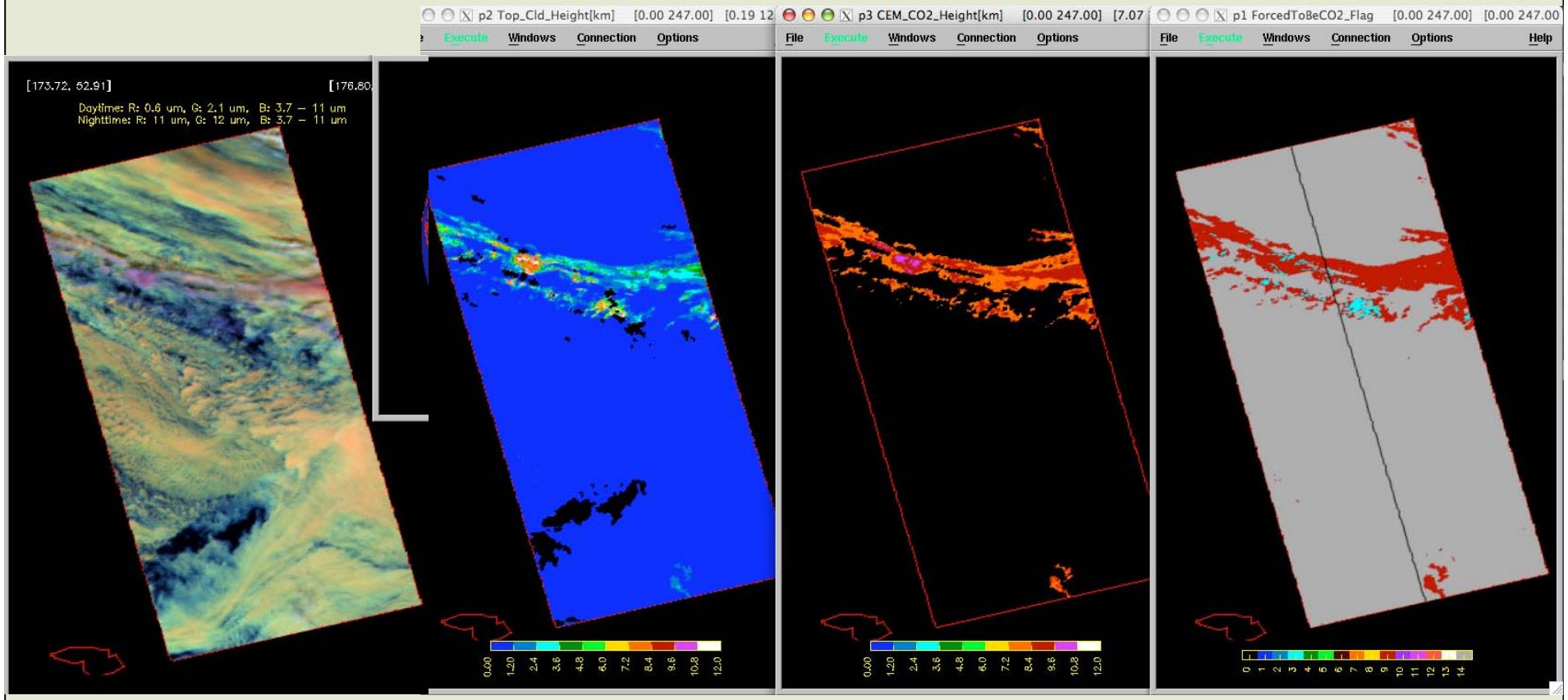




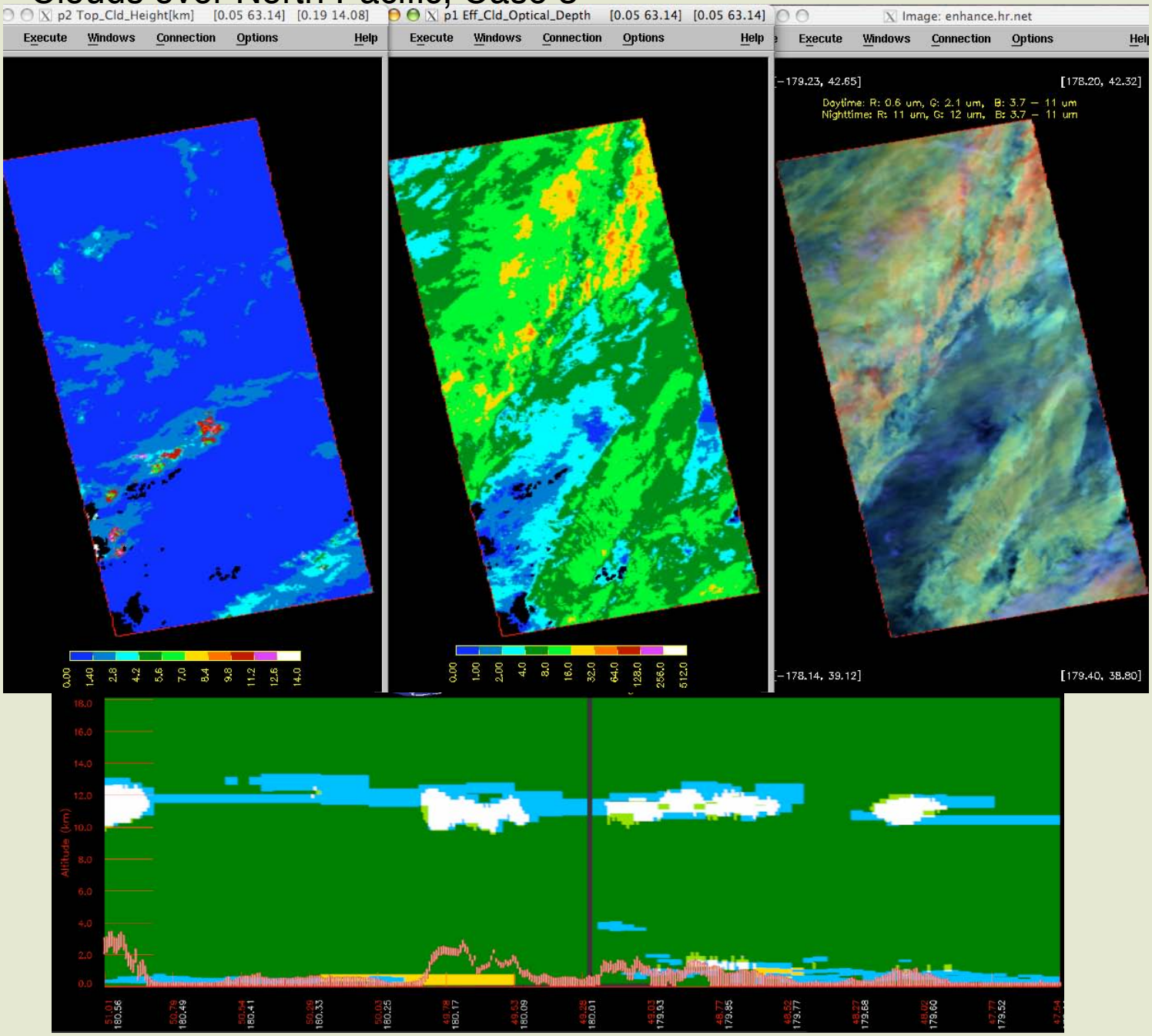
Clouds over North Pacific, Case 2



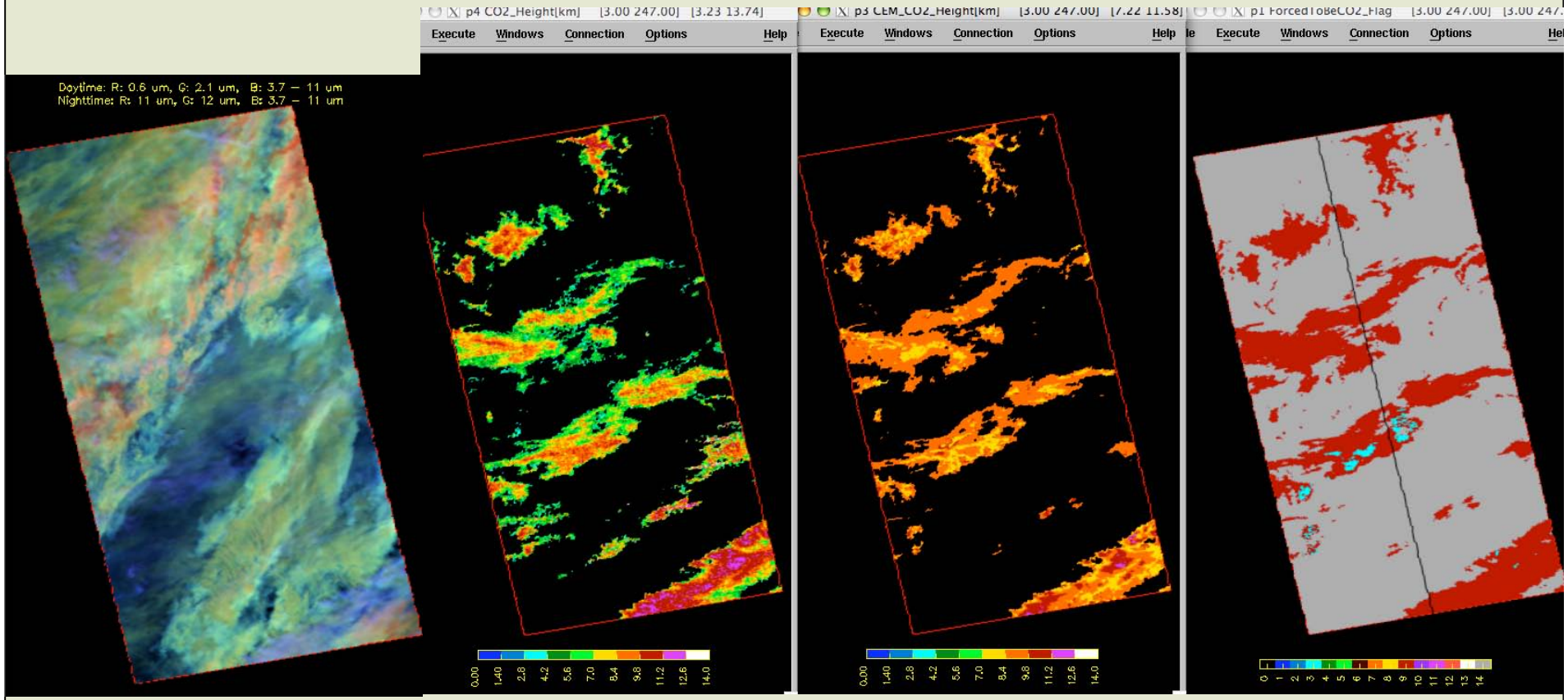
Clouds over North Pacific, Case 2

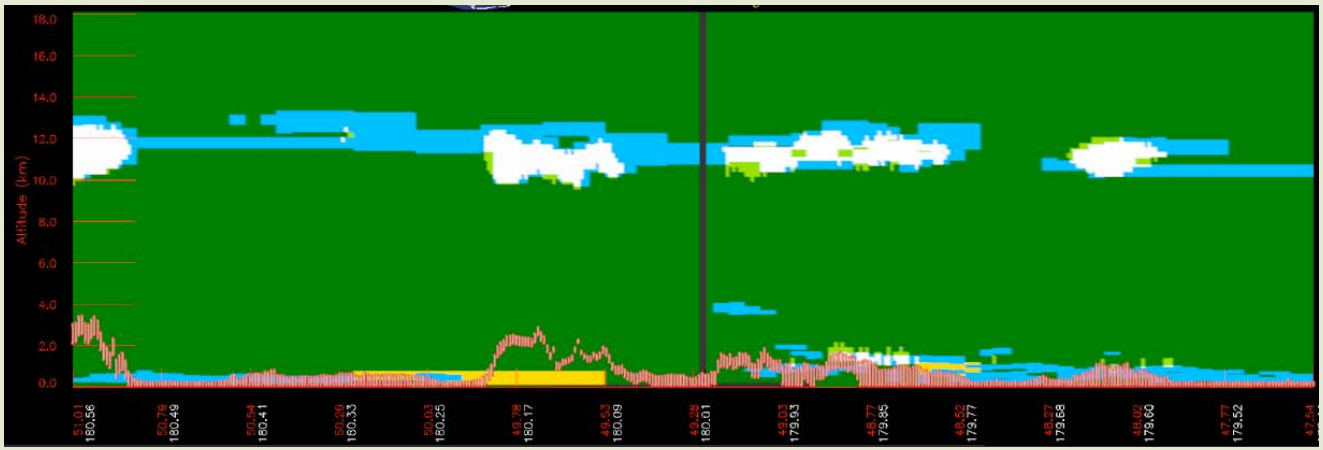


Clouds over North Pacific, Case 3

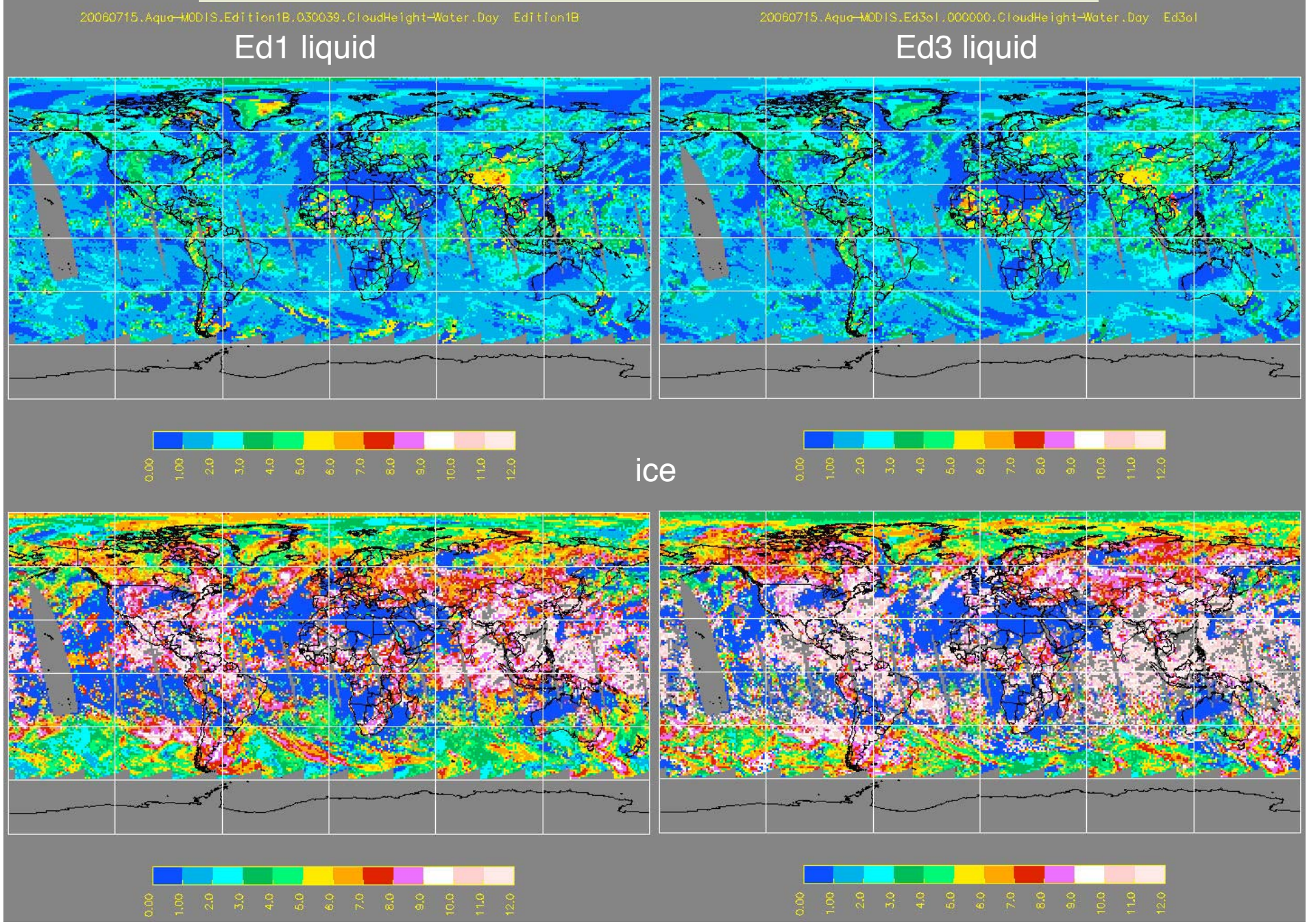


Clouds over North Pacific, Case 3



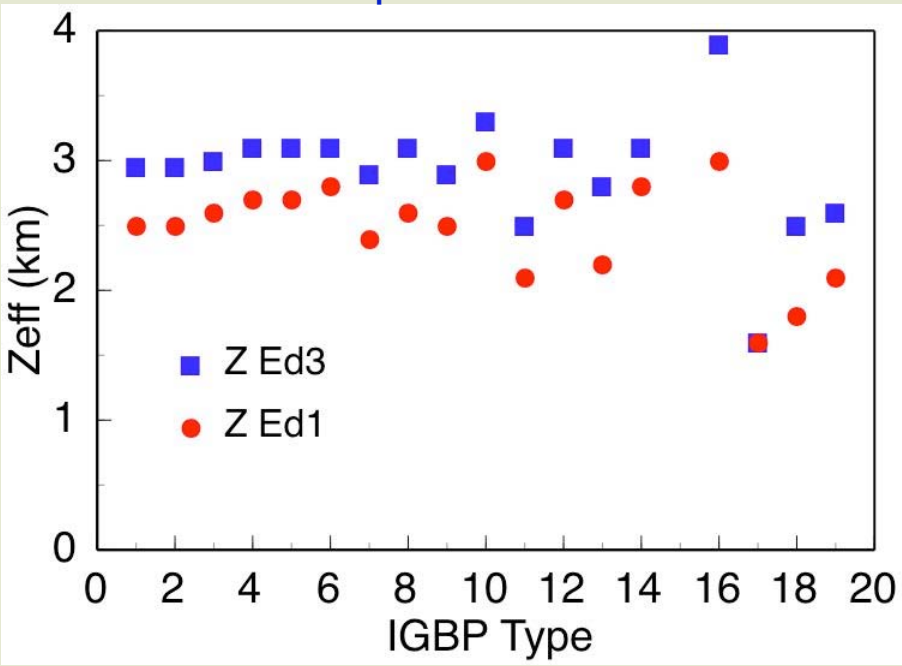


Zeff, Ed3 vs Ed 1, 15 July 2006

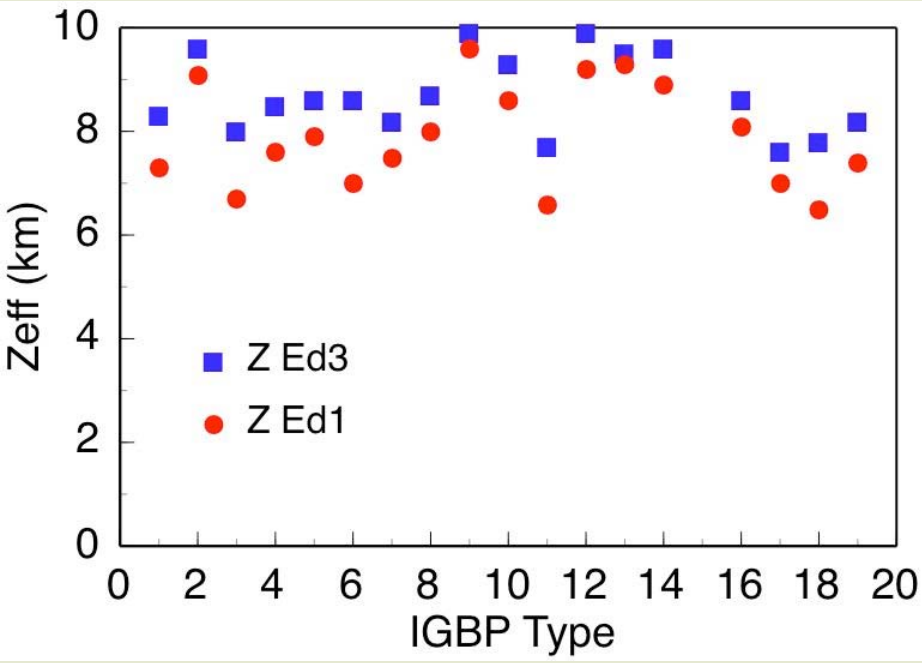


Zeff, Ed3 vs Ed 1, 15 July 2006

Liquid Clouds



Ice Clouds



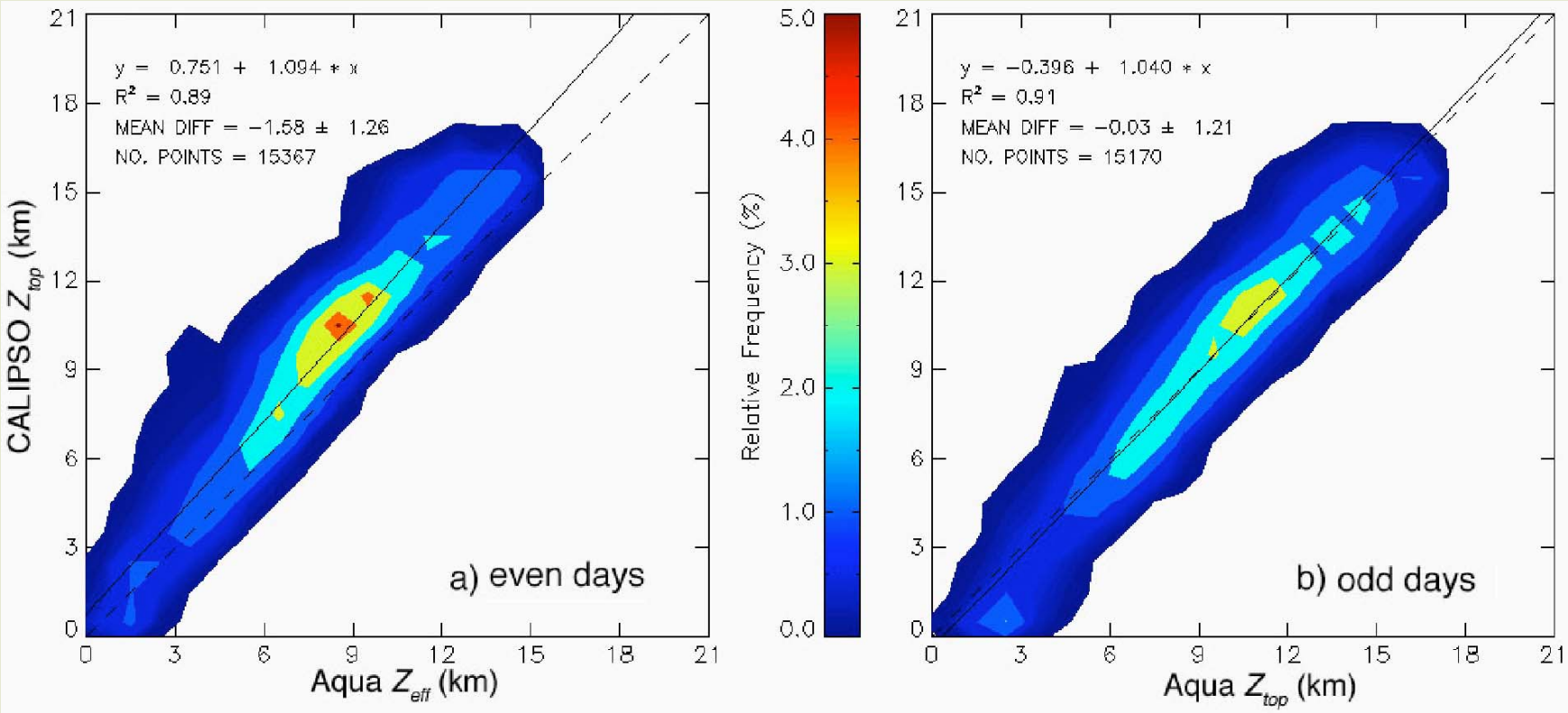
Water cloud heights increase by 0.5 km over land

Ice cloud heights increase by 0.2 - 1.3 everywhere

Correcting Cloud-Top Heights for Optically Thick High Clouds Using April 2007 CERES MODIS & CALIPSO Data

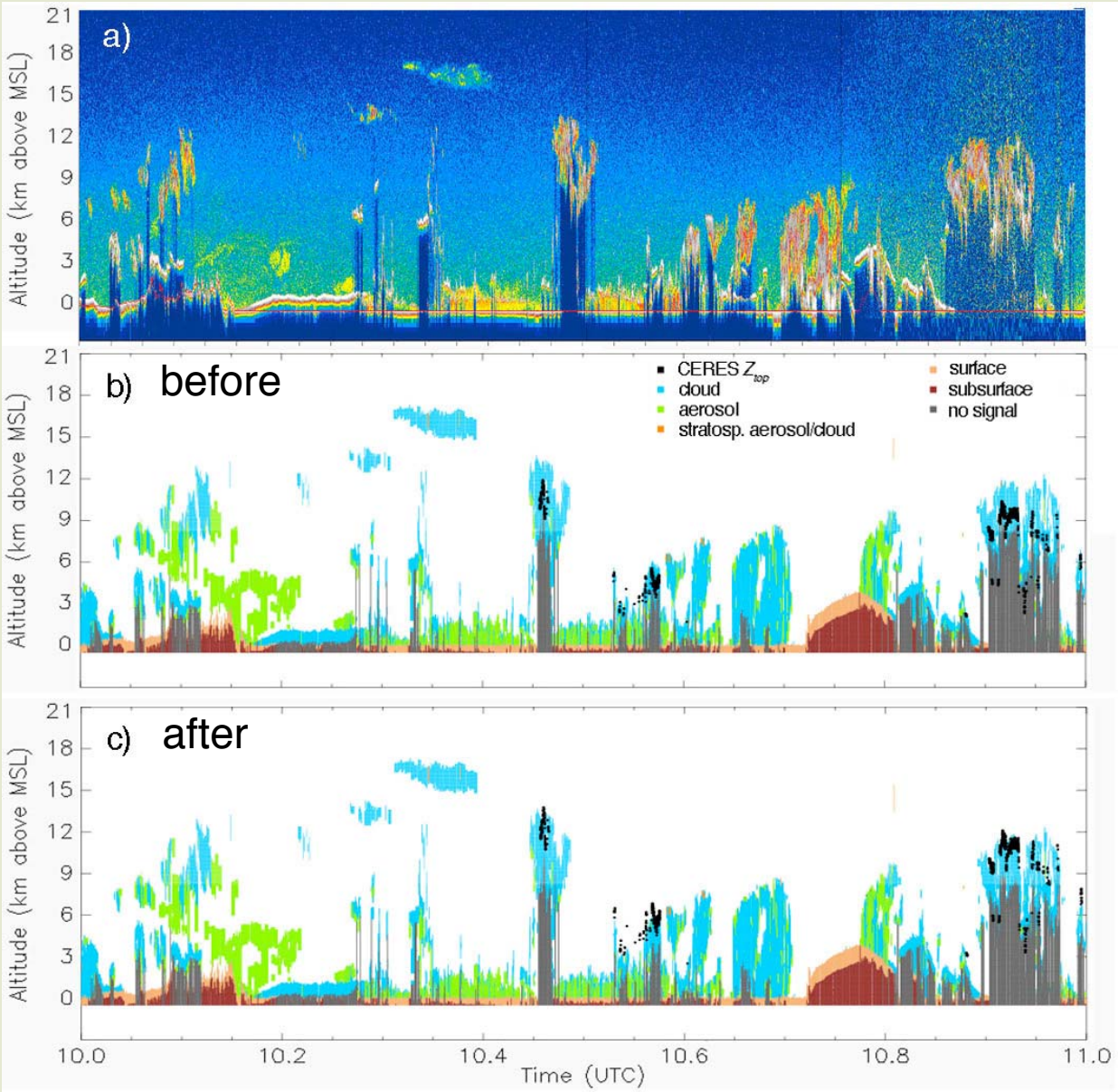
Data for even days to make fit

Data for odd days to test fit

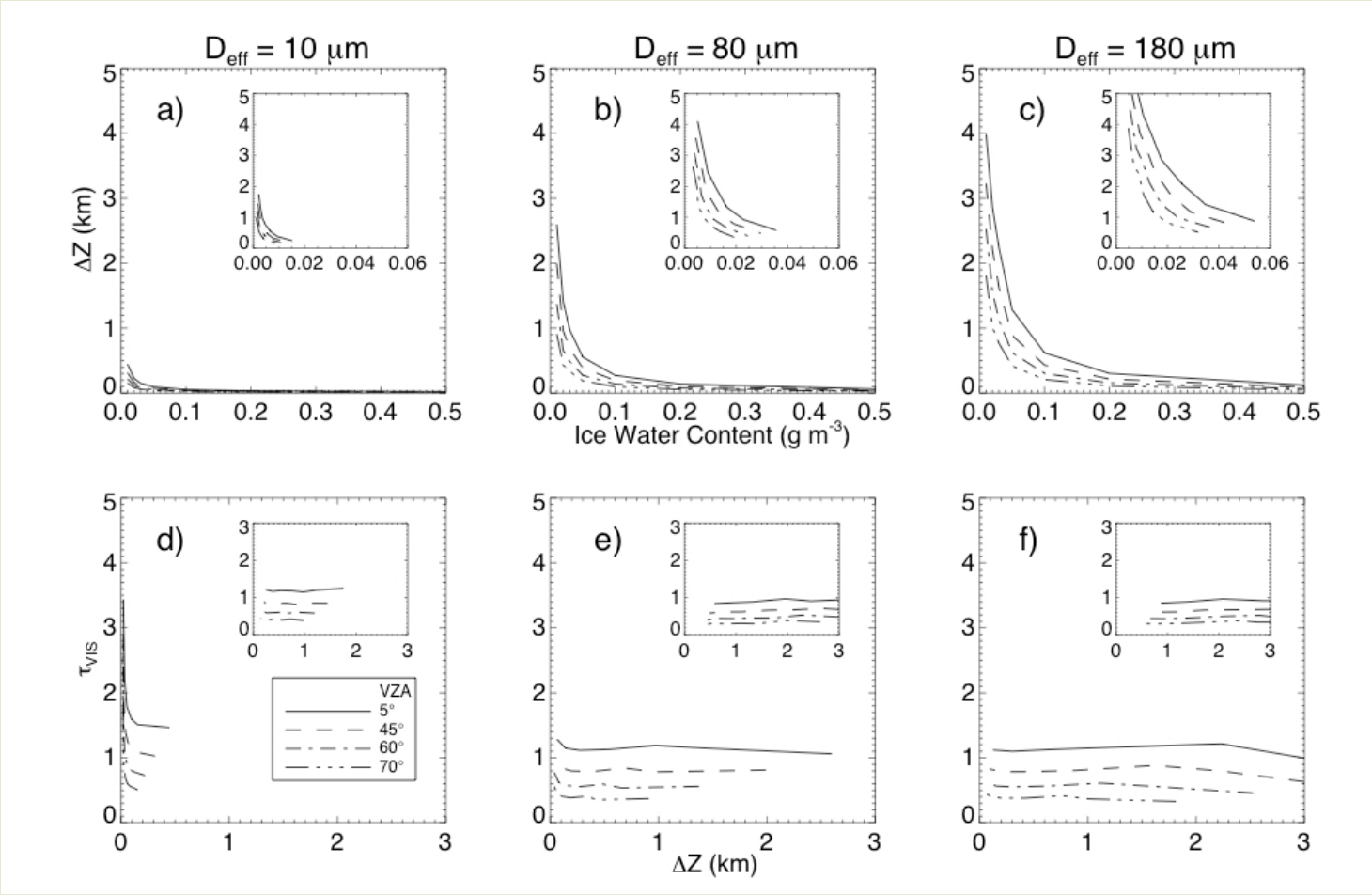


Empirical corrections has been included in Ed3 to improve accuracies of physical cloud top height for thick ice clouds

Example of improved cloud-top heights



Correction to Cloud-top Height Must Account for VZA Dependence

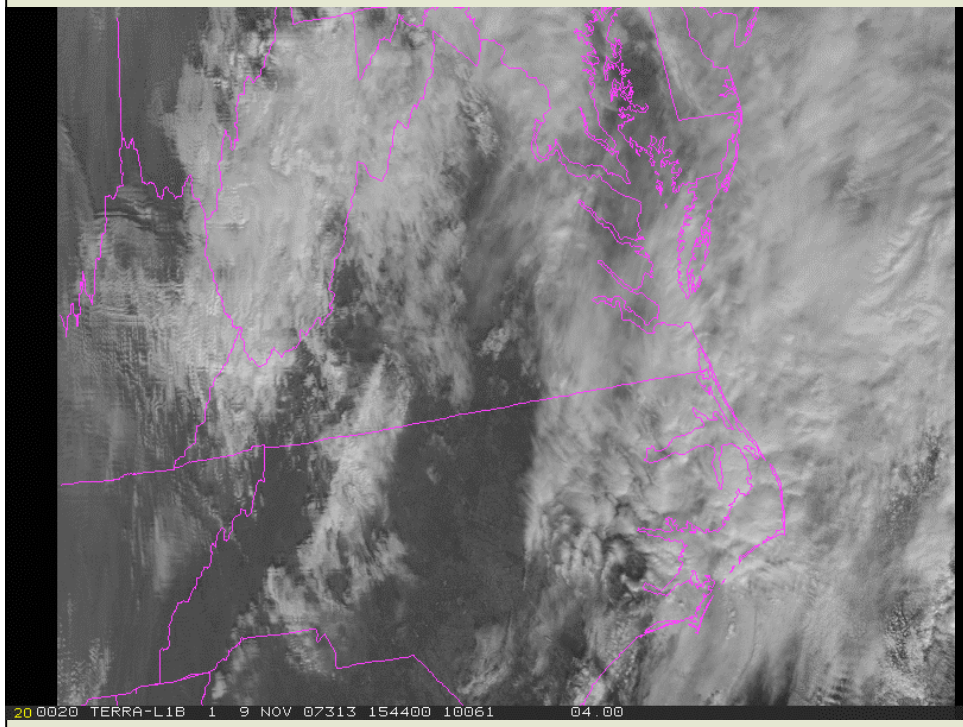


Expanded Optical Depth Models

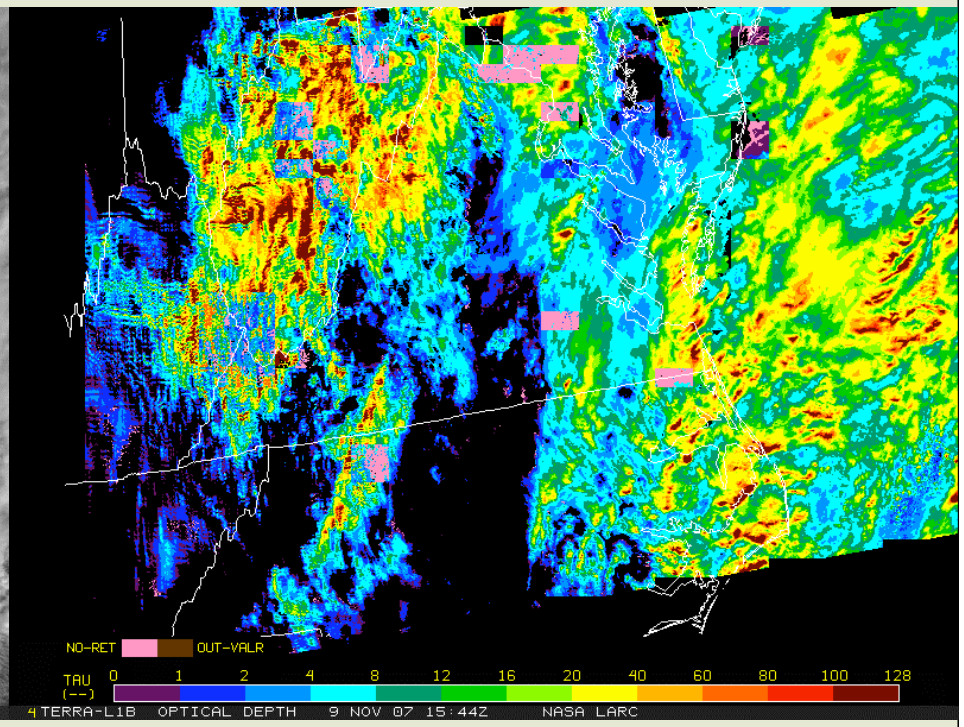
Range in retrieved cloud optical depth increased from 128 to 512

=> increase in LWP & IWP

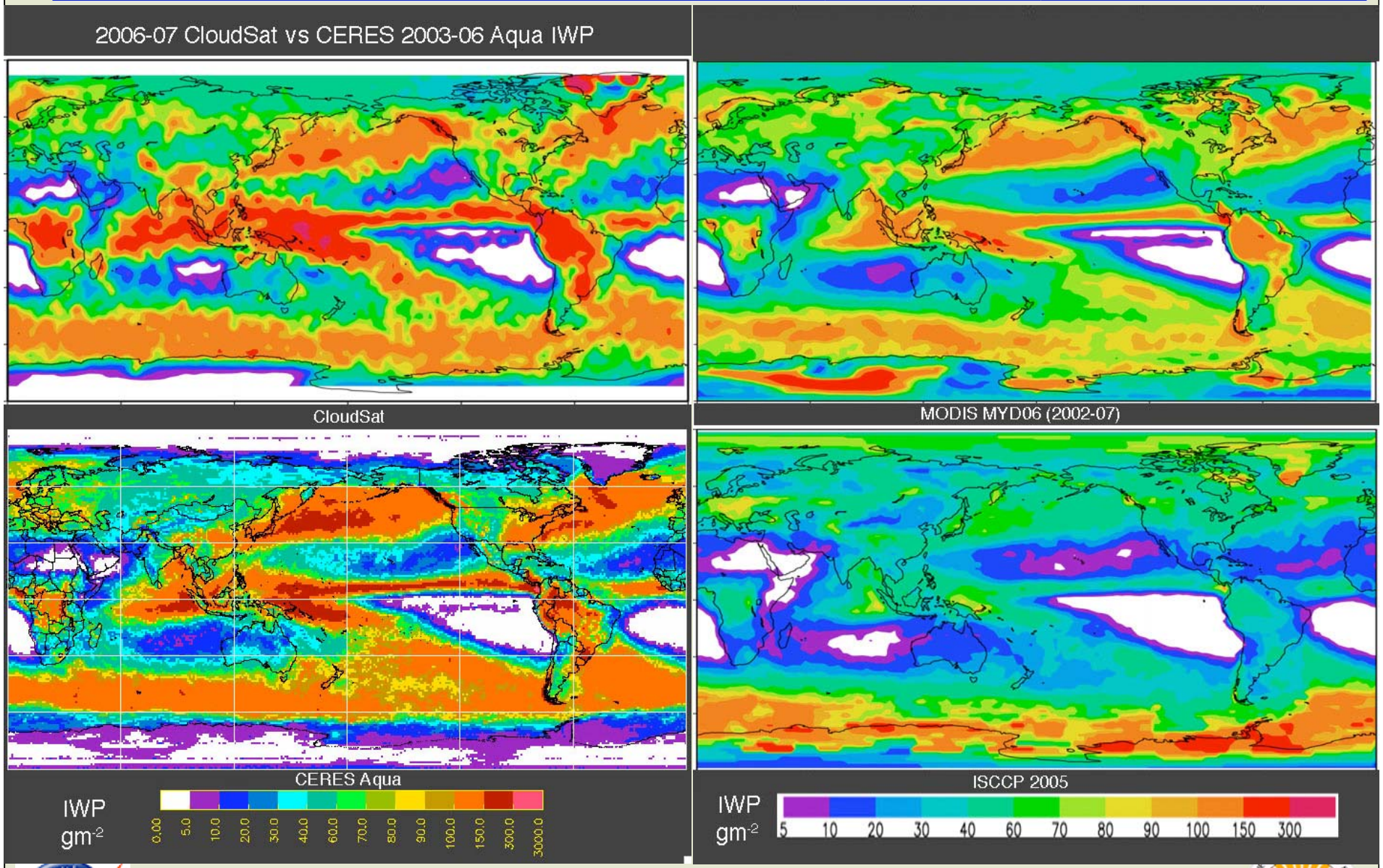
Terra MODIS VIS, 9 Nov 2007



Optical Depth



Cloud Ice Water Path (From Waliser et al. 2008)

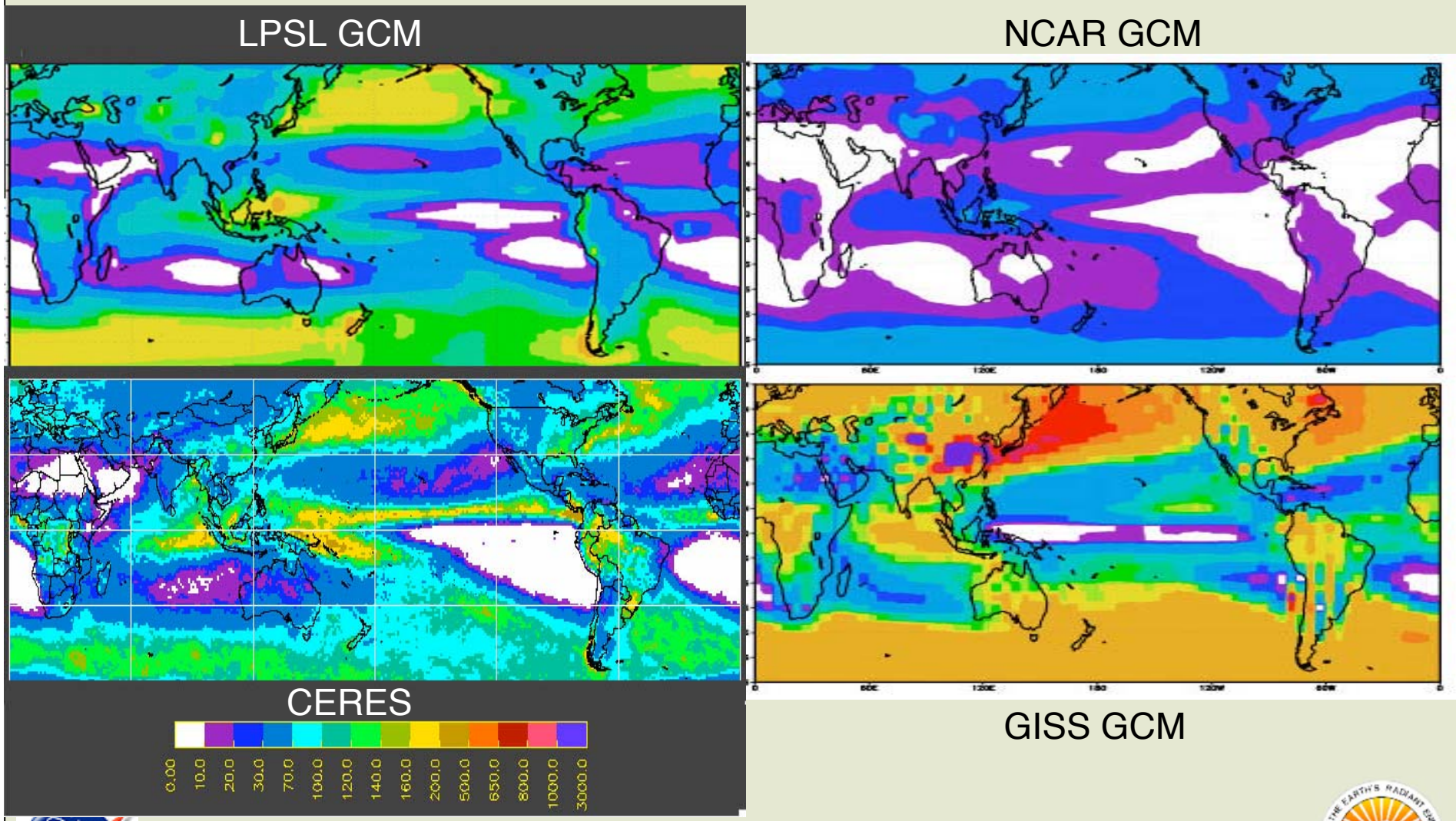


CERES most similar to CloudSat values, but less than, on average

CloudSat suspected of being high – effects of going to τ_{max} = 512?

Comparison of model & CERES GCM IWP

Waliser et al., JGR, 2008

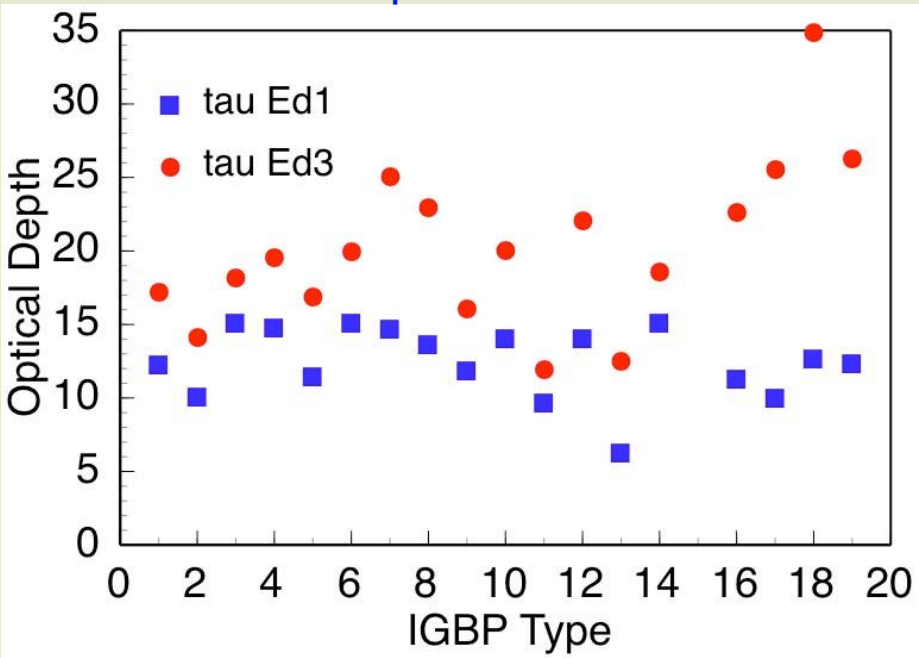


Important to get IWP correct

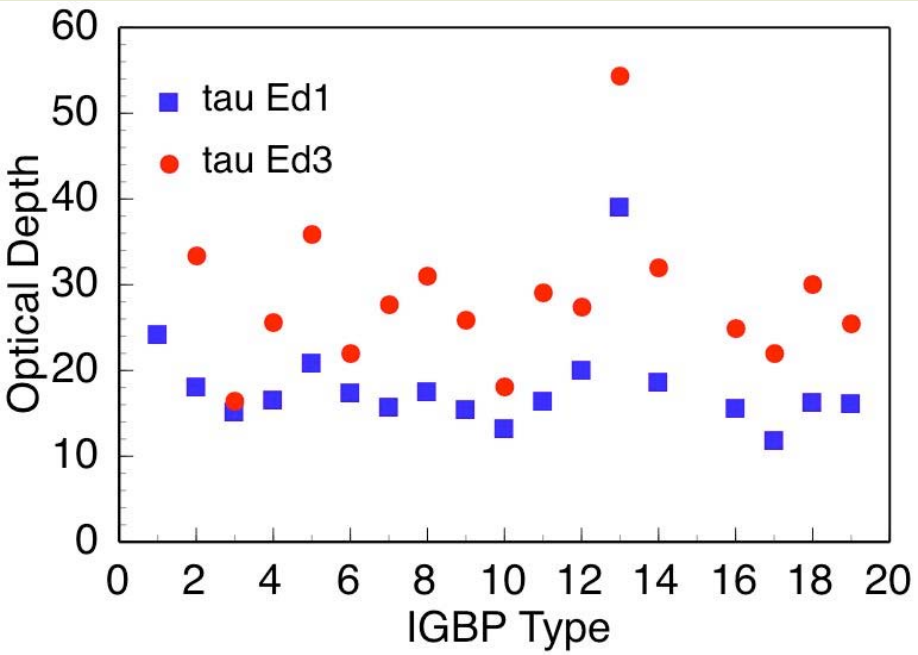
Cloud Optical Depth Average as Function of Ecotype

17 July 2006

Liquid Clouds



Ice Clouds



Increasing to 512 almost doubles the average optical depth for Aqua

Ed3 Ice Water Path

- Increased opt depths => give a better match with CloudSat
  - CloudSat IWP not yet validated, do not know the error
    - Mace suspects overestimate
  - CERES IWP is actually smaller because of ML clouds
    - => ~ 42% less in ML clouds
    - => ~85% overall if 35% ML cover

- Users will need to interpret large taus with caution
  - small error in reflectance, big error in tau
    - do we want 256, 150 limit? SZA dependent?
  - 1% reflectance difference between Aqua & Terra!
    - normalize Aqua to Terra?

No Retrieval Minimization

- CERES Ed2 no retrieval percentage is ~4% for nonpolar areas
  - retrieved cloud fraction = 0.58
  - compare to 0.54 for MODIS products (less for 1.6, 2.1 μm)
- To reduce no retrievals in Ed3
  - use LBTM (VIS & IR only, assume particle size)
  - use IR (CO_2) techniques for thin clouds
- Test runs indicate LBTM reduces no retrievals to < 1%
  - IR techniques (SIST/CO_2) needed for remainder
    - recalculate clear sky reflectances/sfc temps?

New CO_2 Method

- Applicable to SL & ML clouds both day and night
- Faster than 4-channel method
- Applicable to many satellites (any imager with 11 and 13.3 μm)
- Details - wait for Chang Co-I Report

Previous

- BTD & CO2 technique - ~85% accurate in detecting SL clouds
  - minimal skill at detecting ML clouds

Multilayer cloud detection and retrieval

• Edition 3 will use new CO2-slicing/VISST & BTD overlapped cloud detection methods

- only detects ML clouds when upper cloud $\tau < 4$

- uses C2C retrieval technique (see Chang talk for details)

Improving CERES Thin and Multi-layered Cloud Retrievals

Satellite data & model inputs

LaRC cloud mask & retrievals

Improved CERES single- & multi-layered cloud properties

Improve cloud top properties:
Zc, Pc, Tc, & Ec

Determine multi-layered cloud properties:
Zc1, Pc1, Tc1, & Ec1
Zc2, Pc2, Tc2, & Ec2

Determine multi-layered cloud particle sizes:
De1/Re1 at 3.7, 2.1, 1.6μm
Re2 at 3.7, 2.1, 1.6μm

Improving CERES Cloud Top Locations

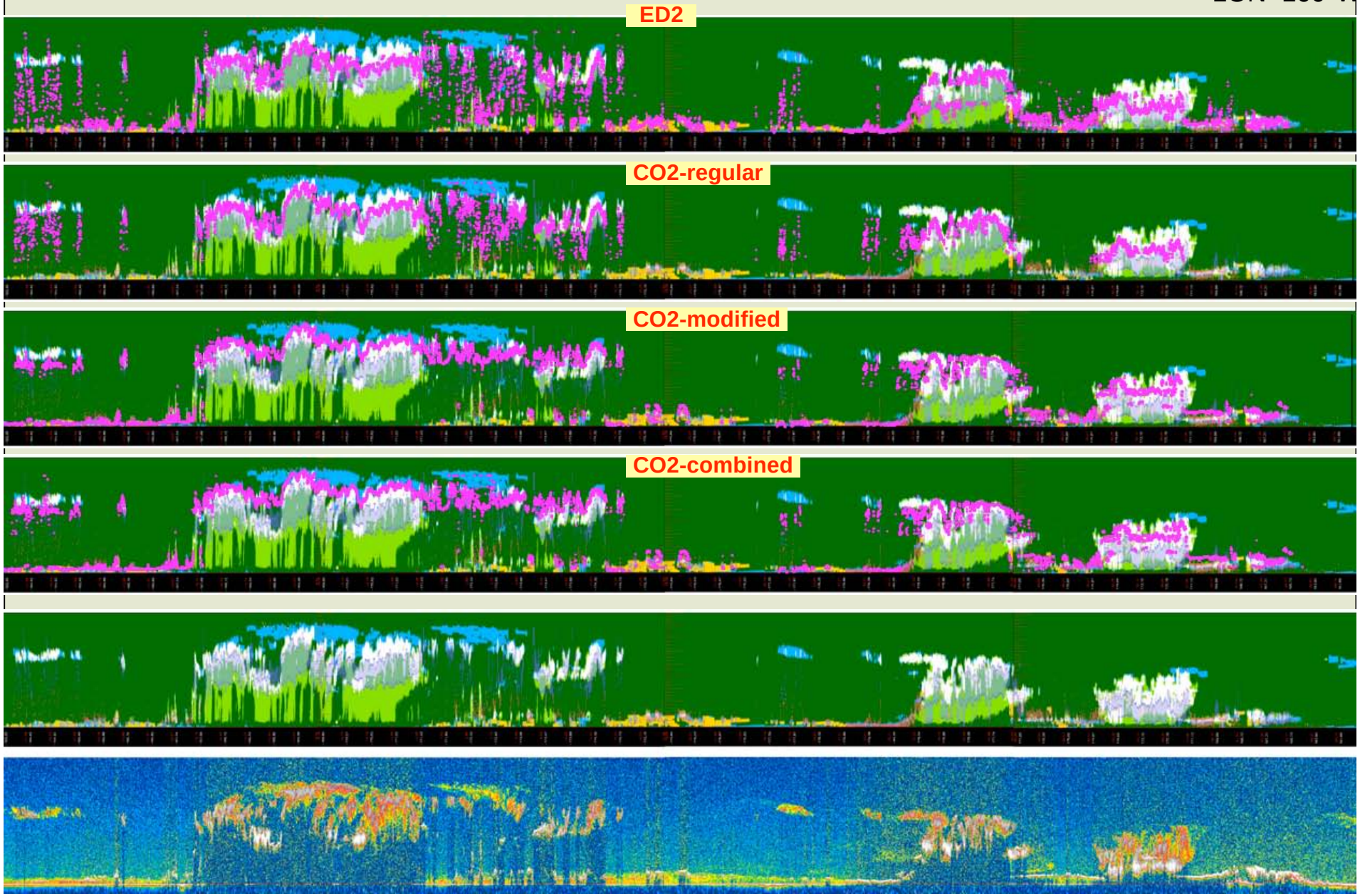
SZA=48°
LAT=34°S
LON=168°E

LAT= 8°S
LON=170°E

SZA=25°

LAT=45°N
LON=177°W

SZA=65°
LAT=70°N
LON=160°W



Improving CERES Cloud Top Locations

SZA=65°
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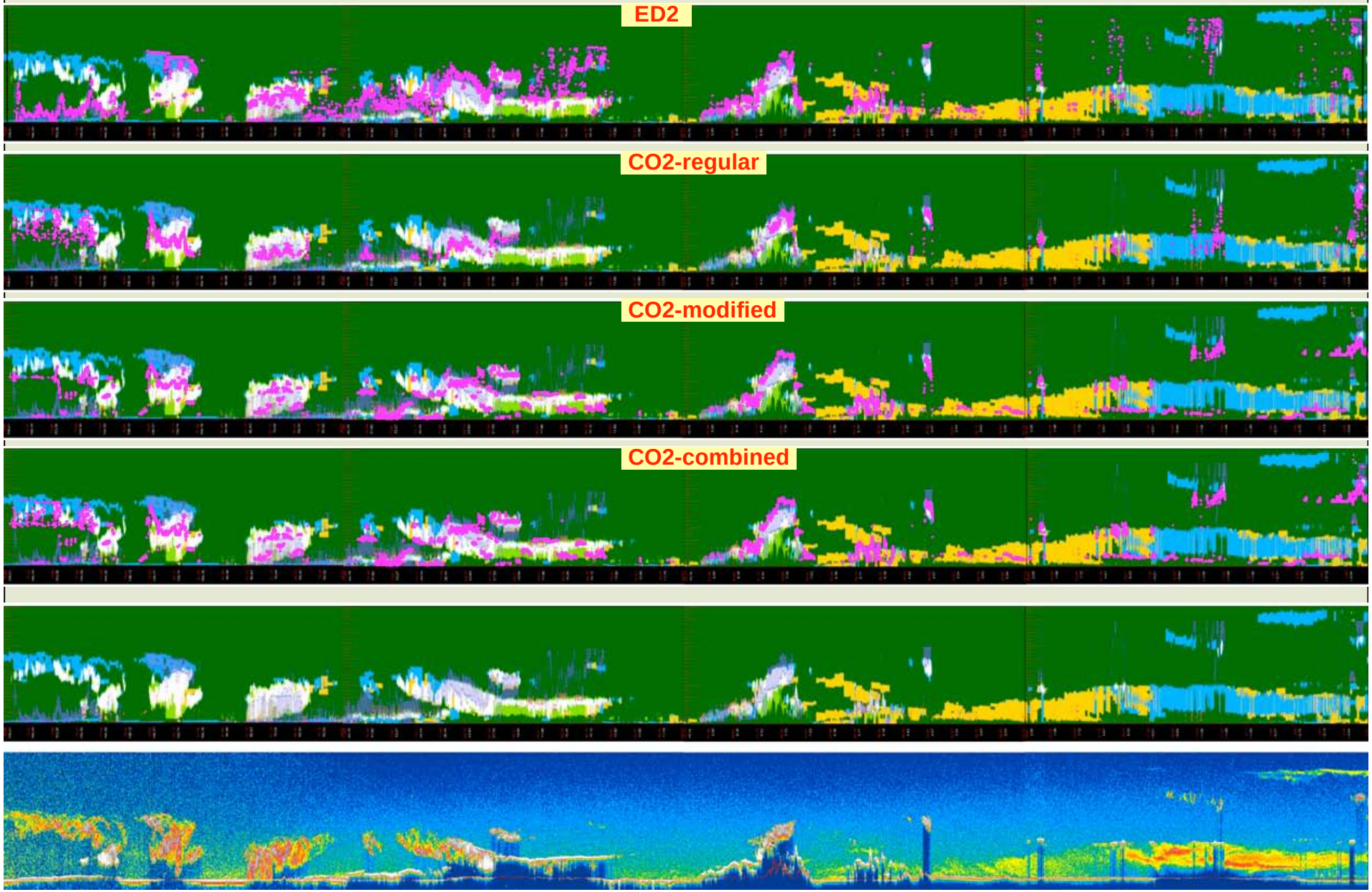
LON=160°W

LAT=82°N
LON=98°W

SZA=114°

LAT=27°N
LON= 2°W

SZA=154°
LAT= 0°S
LON= 4°E



Determine Multiple Cloud Layers

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LAT=34°S
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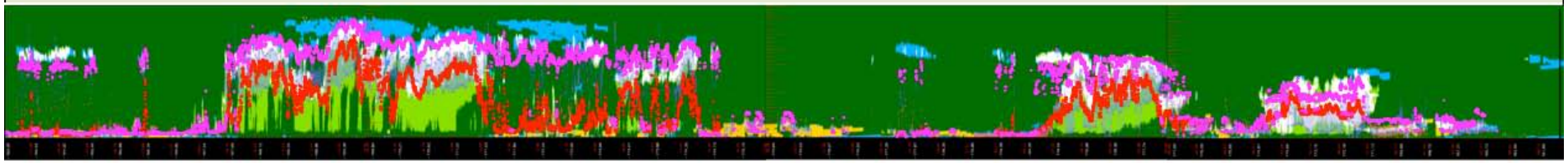
SZA=25°

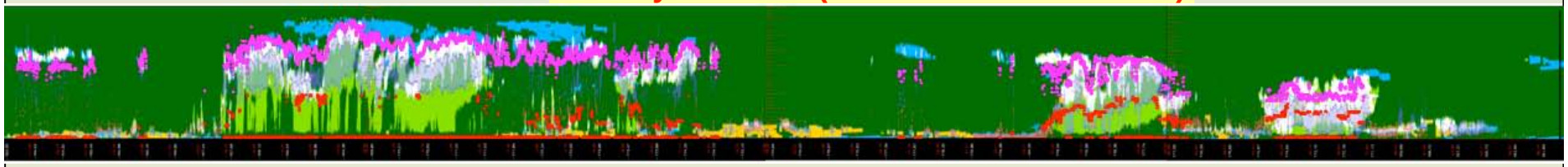
LAT=45°N
LON=177°W

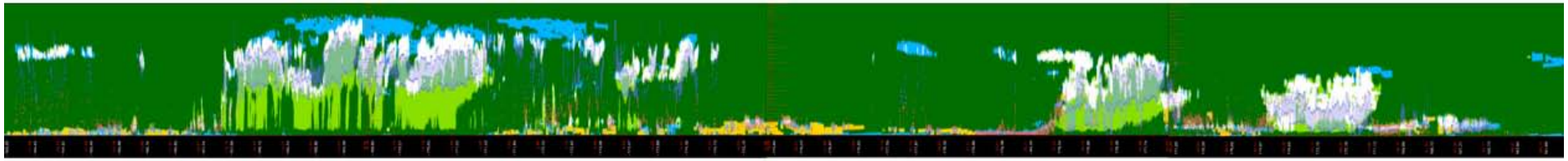
SZA=65°
LAT=70°N
LON=160°W

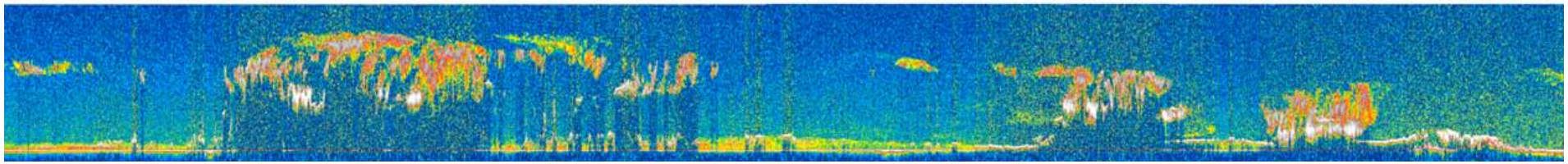
CO2-modified



Multilayer Clouds (CO2-Infrared-Shortwave)







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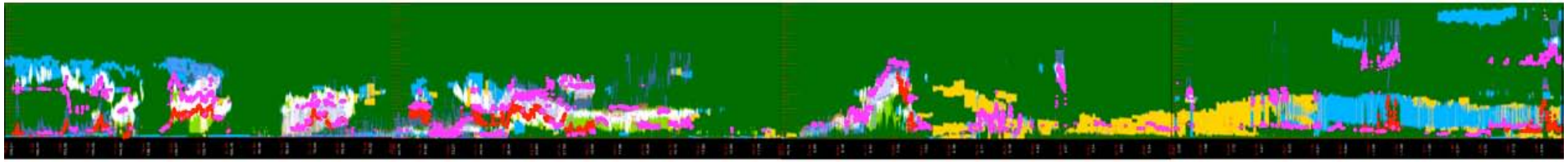
CO2-modified



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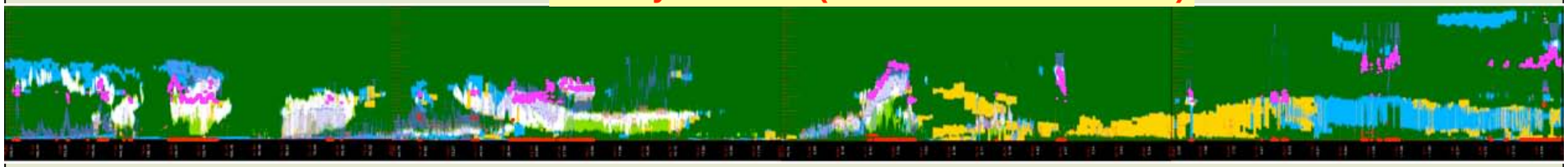

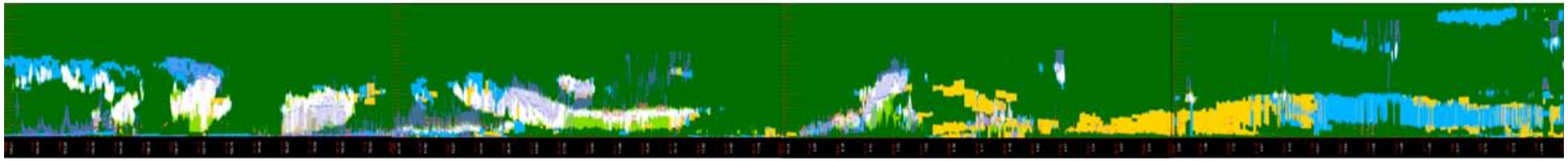

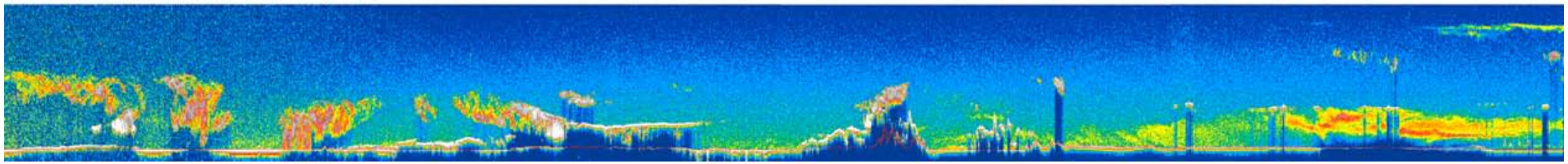

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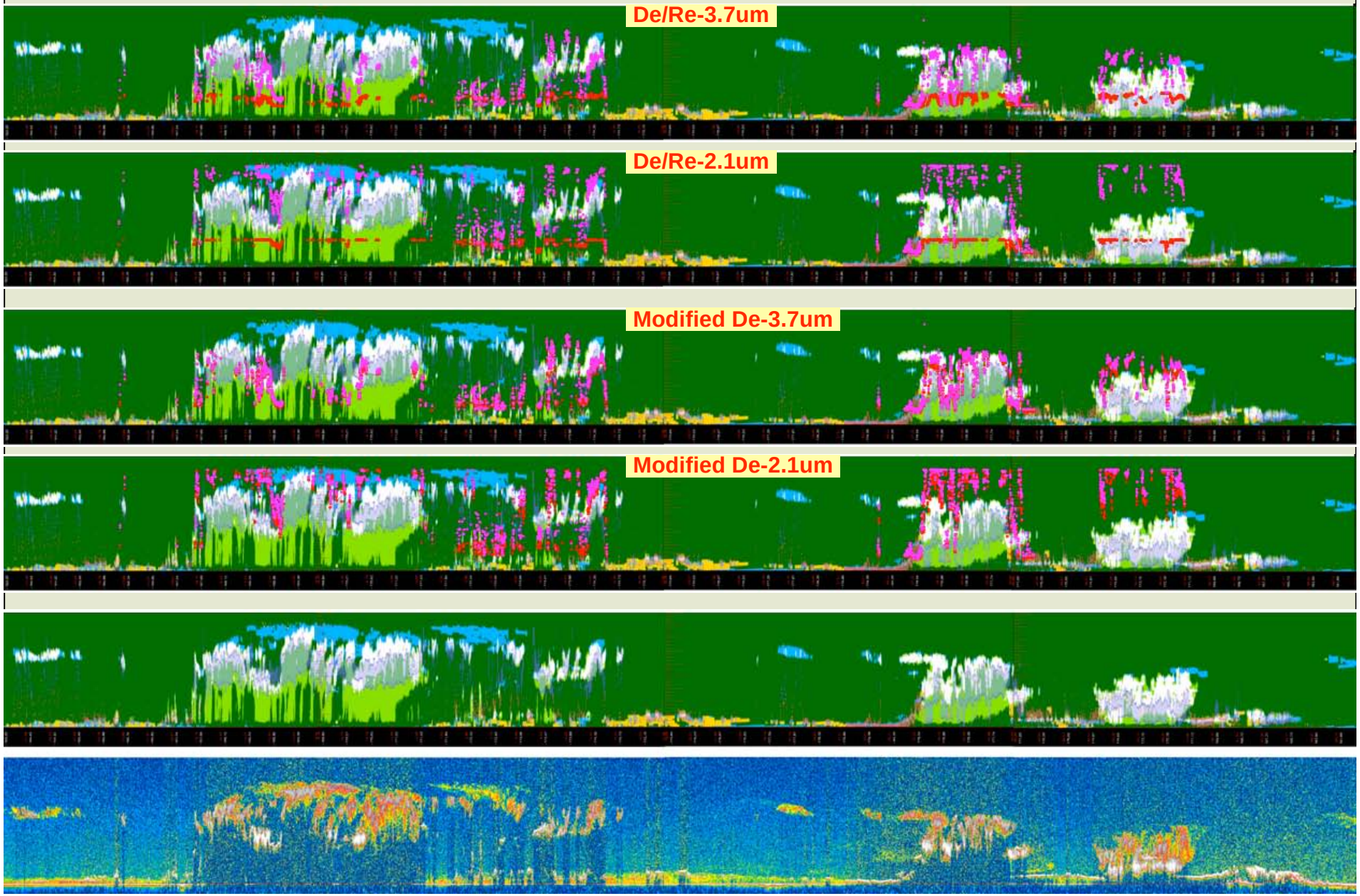

Determine Multiple Cloud De/Re

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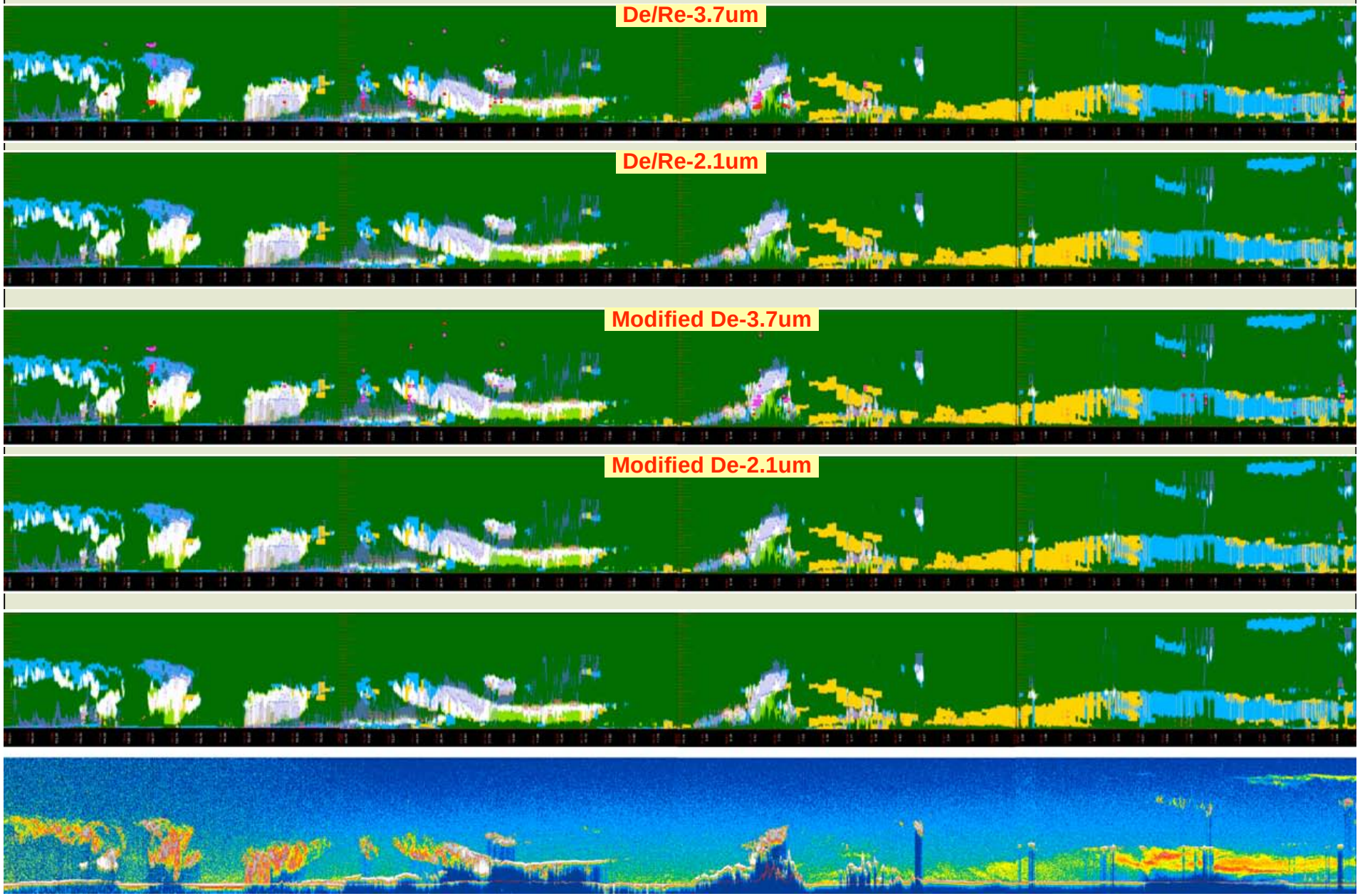
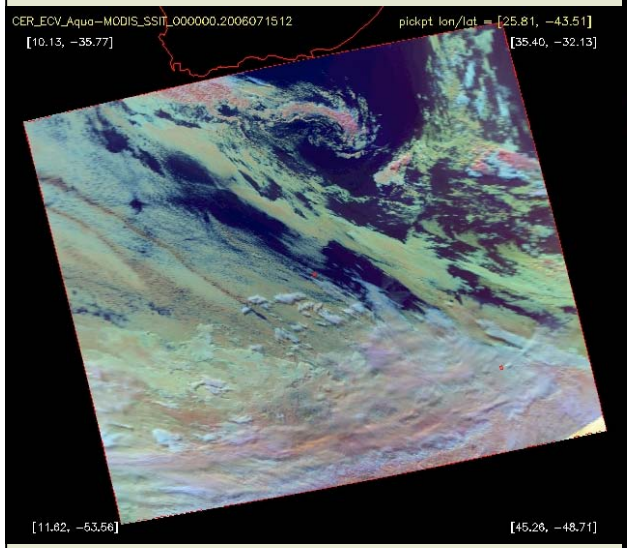
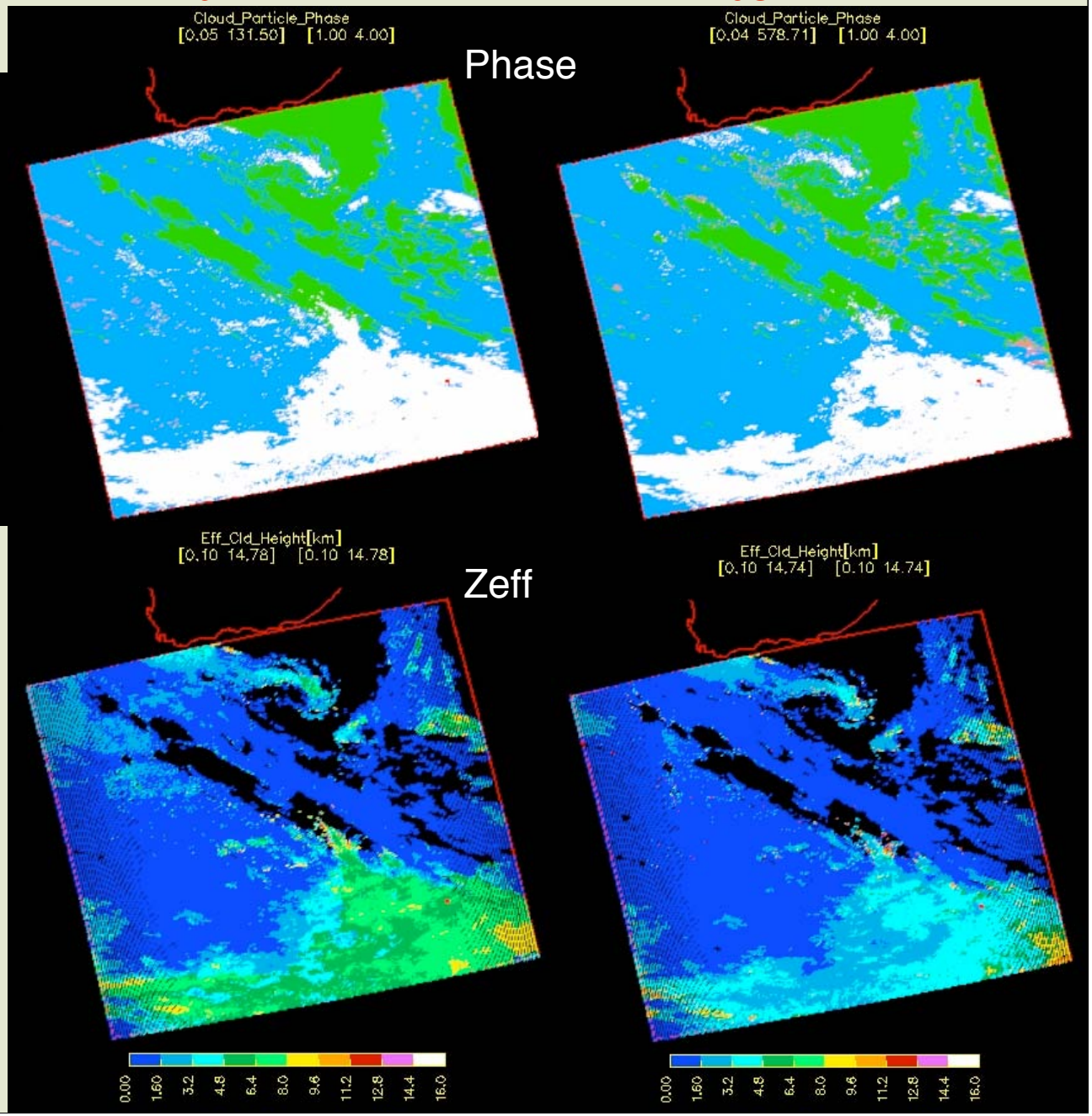


Ed3 vs Ed1, Aqua, 15 July 2006, off S. African Coast



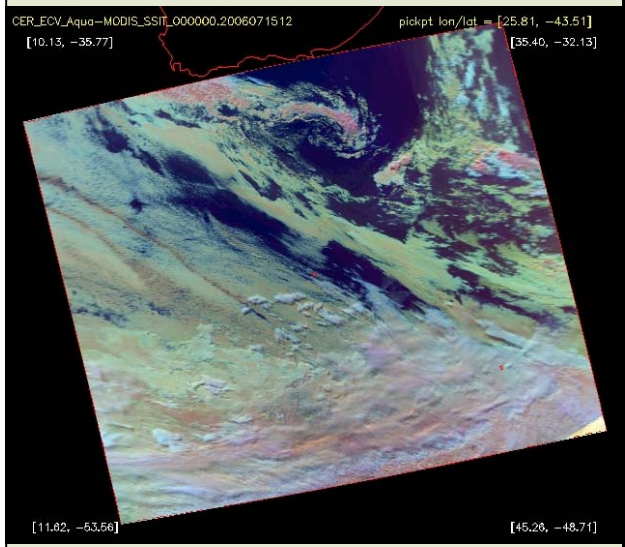


Ed3 - Less ice for low cloud edges, but also for ice clouds

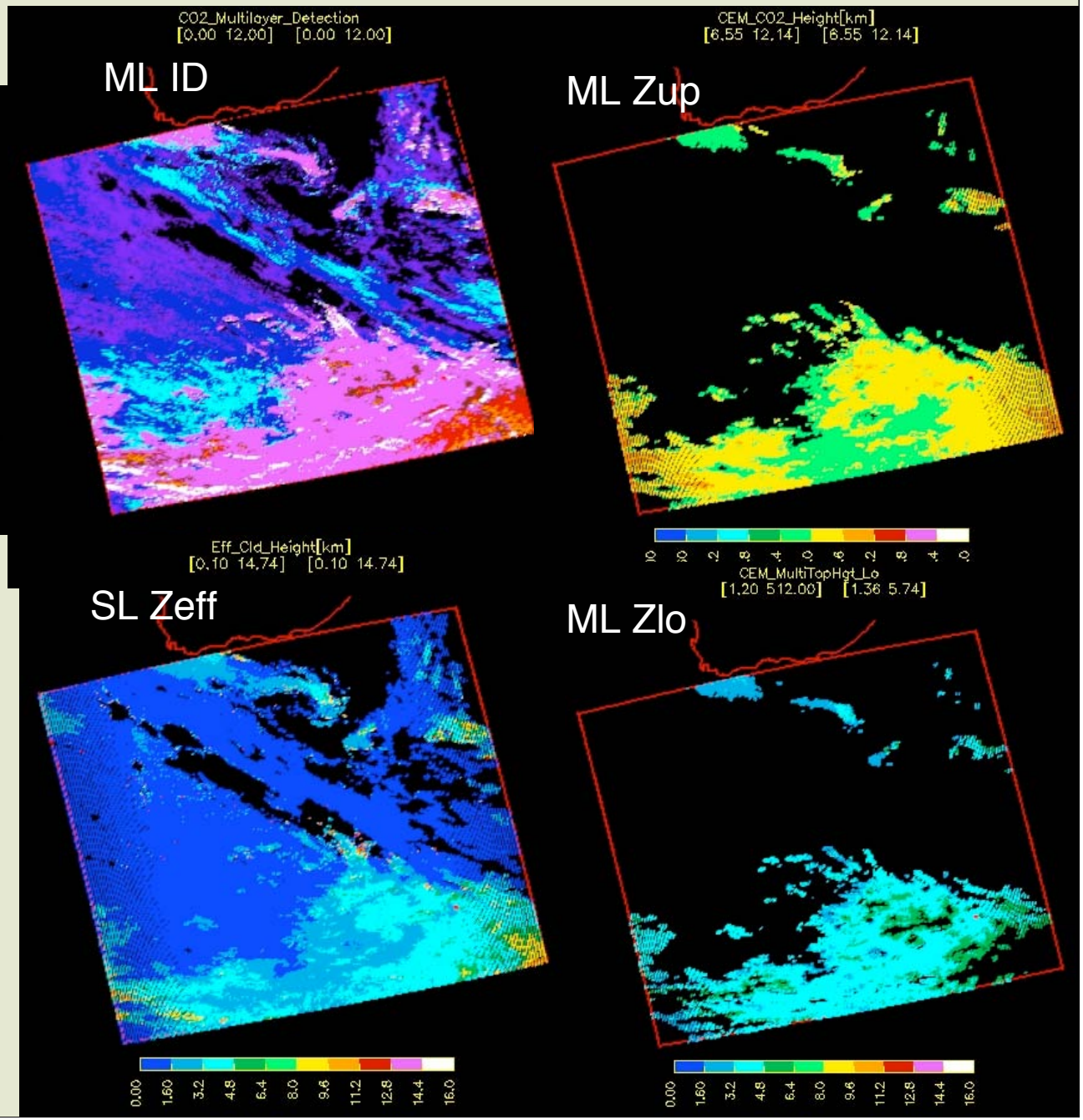
Ed3 - Zeff less because of new lapse rates

- must reconsider transition method

Ed3 vs Ed1, Aqua, 15 July 2006, off S. African Coast



Ed3



Ed3 - Less ice for low cloud edges, but also for ice clouds

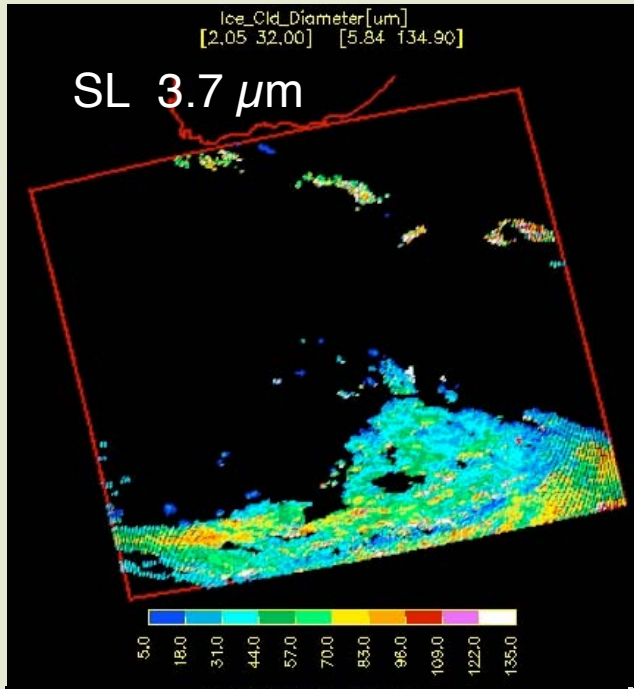
Ed3 - Zeff less because of new lapse rates

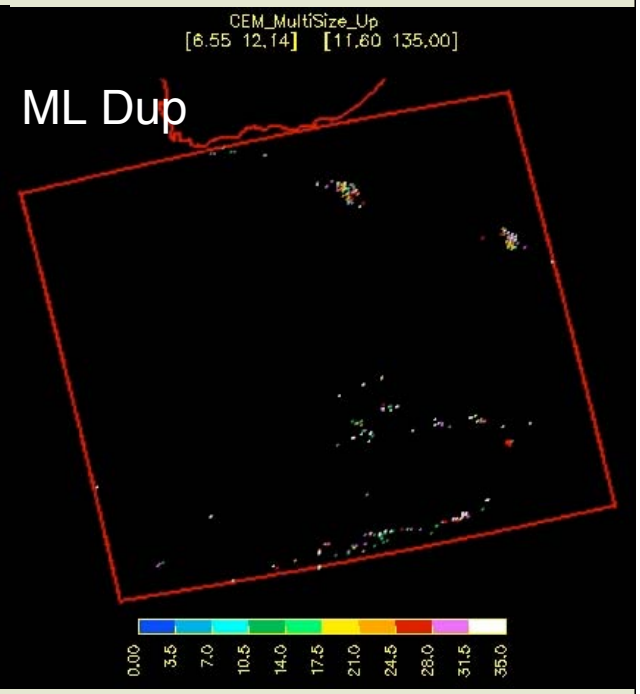
- must reconsider transition method

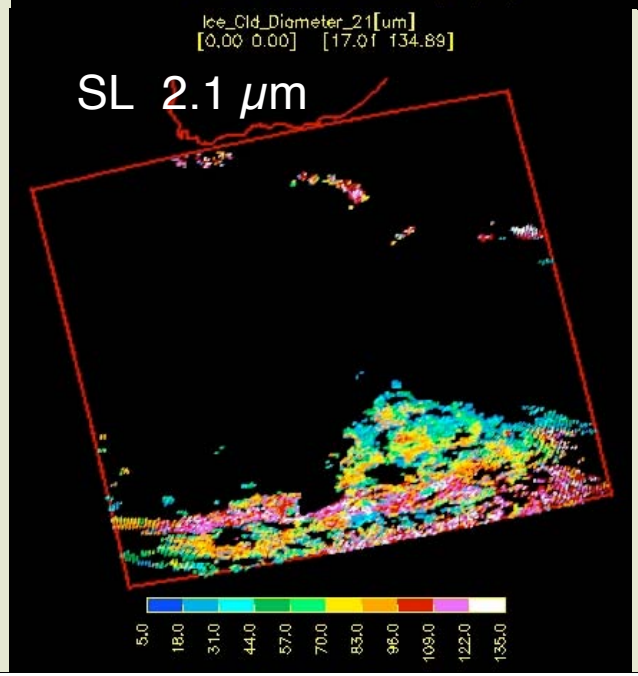
Ed3 vs Ed1, Aqua, 15 July 2006, off S. African Coast

3.7-μm smaller than 2.1 μm Deff.

Deff





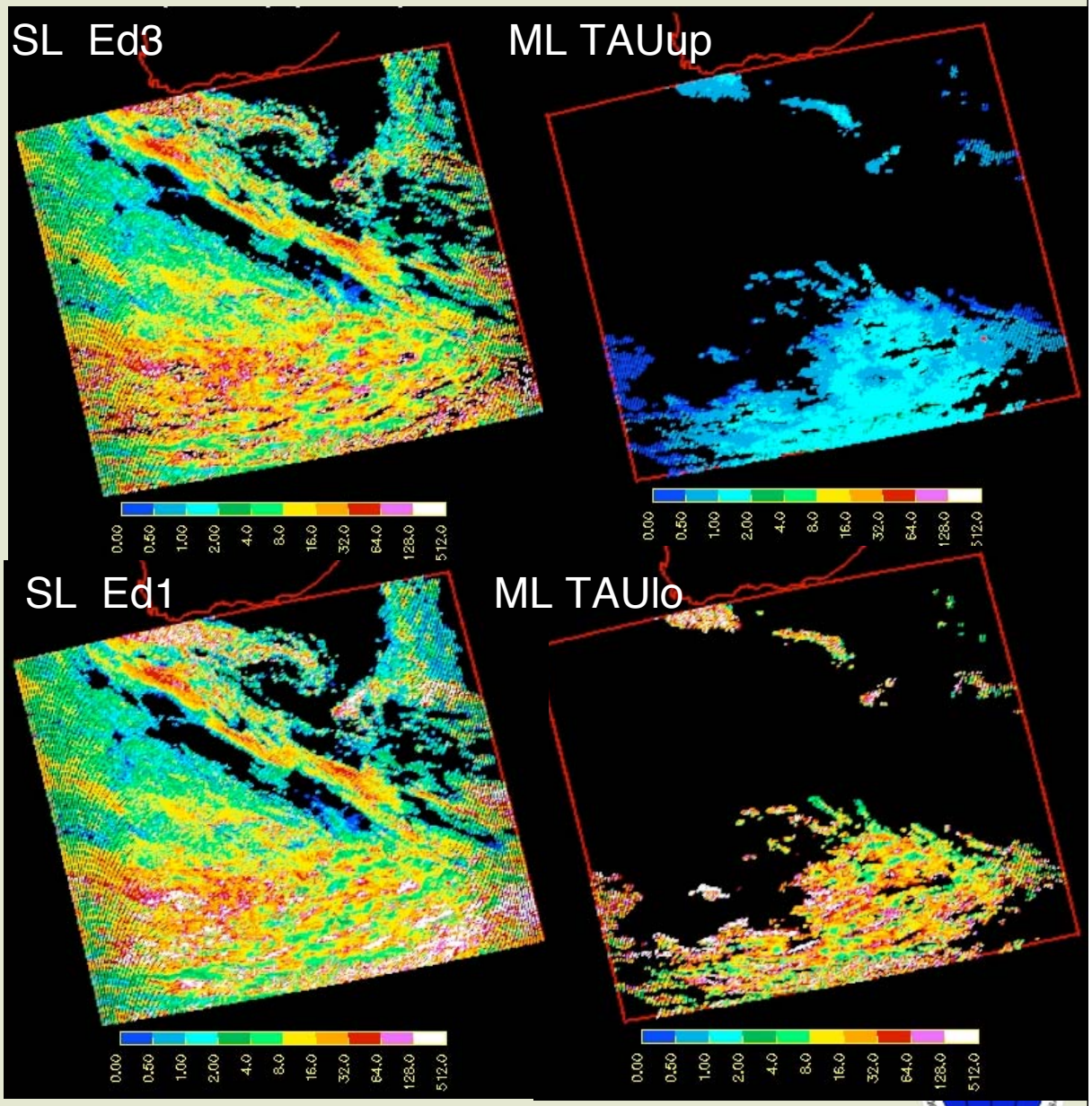


ML Dup plotted in reff, not valid

Ed3 vs Ed1, Aqua, 15 July 2006, off S. African Coast

Ed3 greater than Ed1

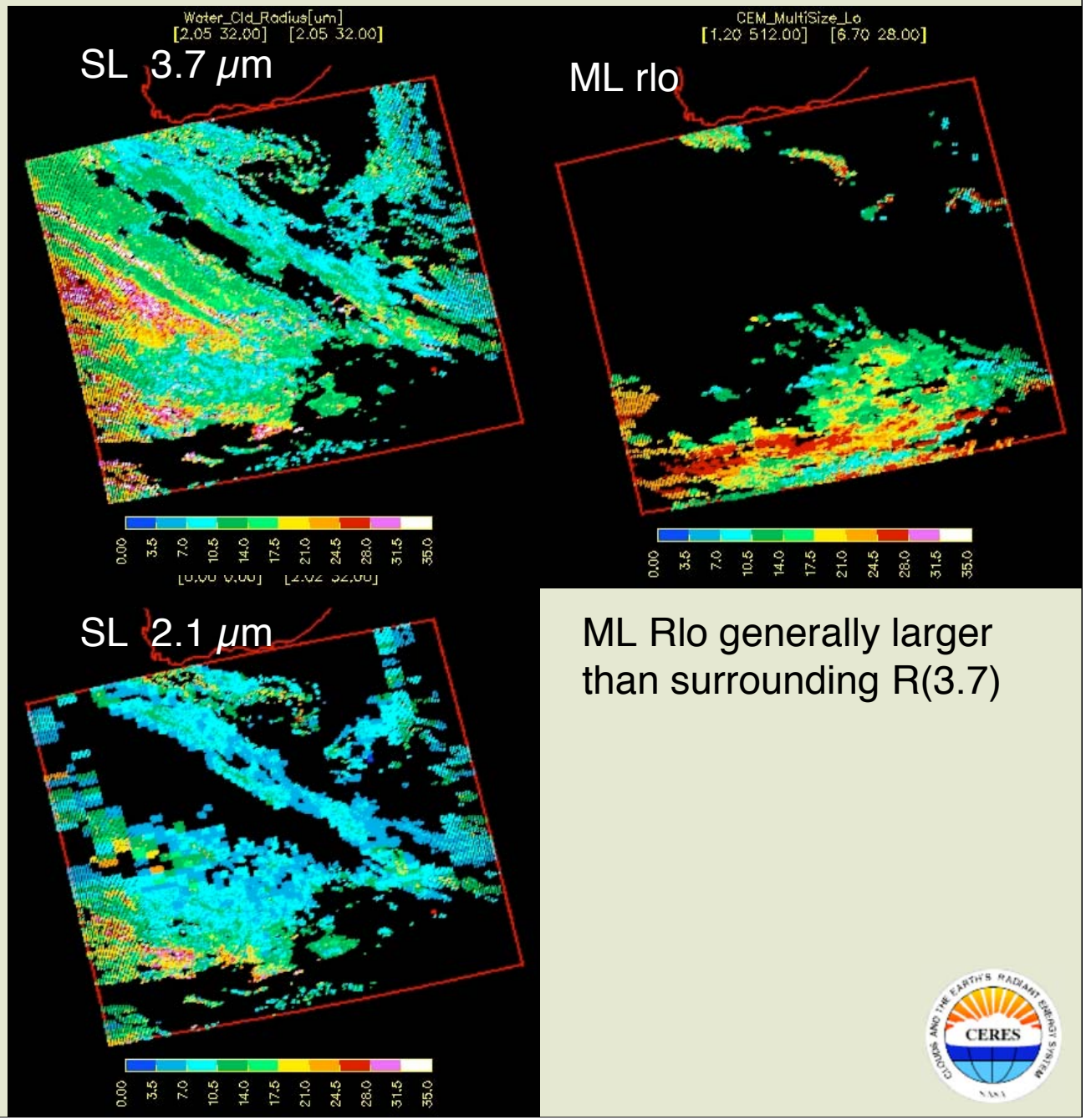
TAU



Ed3, Aqua, 15 July 2006, off S. African Coast

3.7-μm larger than 2.1 μm Reff.

Reff



ML Rlo generally larger than surrounding R(3.7)

- Particle sizes now coming out in expected spectral ratios
    - r(2.1) < r(3.7)
    - D(2.1) > D(3.7)
- Multilayer cloud detection looking better
    - stats with more CALIPSO comparisons needed
- Multilayer heights need some fine tuning
    - updated technique will help
- Multilayer retrievals
    - top tau looking good
    - lower reff may need some help

Edition 3 Betas

- **Cloud mask improvements**
  - C2C method working; *rough xtals in Beta 2*
  - clear-sky model, threshold, polar transition improvements
    - *more work needed, need eval of CALIPSO CFs*
- **Cloud retrieval improvements**
  - multipsectral retrievals *look good*, fewer no retrievals
  - improved lapse rates w/ blended C2C heights => *better heights*
  - new ice cloud phase functions: *Beta 2*
  - expanded tau range: *cut back to a smaller max?*
  - polar retrievals: *turn on SINT*
- **Multilayer cloud detection & retrieval**
  - New code working: *Beta 2 update*
  - CALIPSO opt depth now available for assessment
- **Hi-res cloud detection/retrieval of low clouds (250 m - 1 km):** *Beta 2*
- **New thickness parameterization**: *Beta 2*
- **Continue work on BTD ML method**: *NPP (no CO2 on VIIRS)*