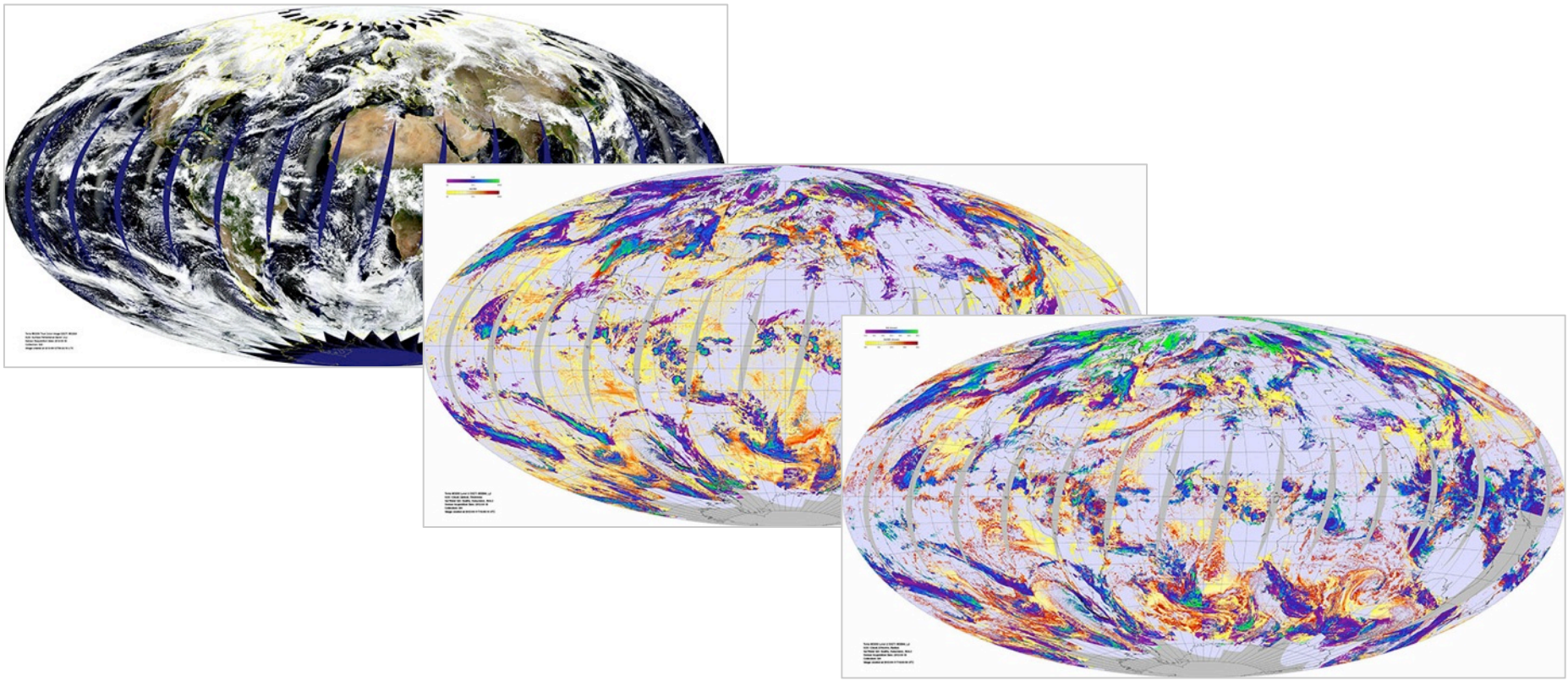
Collection 6 Update:

L2 MODIS Cloud Optical Properties (part of MOD/MYD06) + MYD02 Band 1/2 1km "re-registration" + L3 Atmosphere Team (MOD/MYD08) + Joint L2 Product (MOD/MYDATML2)

- MOD06: S. Platnick, G. Wind, N. Amarasinghe, B. Marchant, G. T. Arnold, K. Meyer, M. D. King, Z. Zhang, R. Holz, P. Yang., S. A. Ackerman
- MOD08: P. Hubanks, S. Platnick, B. Ridgway, R. Pincus
- MYD02 1km re-registration: R. Bennartz, R. Wolfe, B. Ridgway, S. Platnick

with thanks to MODAPS and the Atmosphere PEATE at U. Wisconsin-Madison

Level-2 Cloud Optical Properties (MOD06) Collection 6



MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

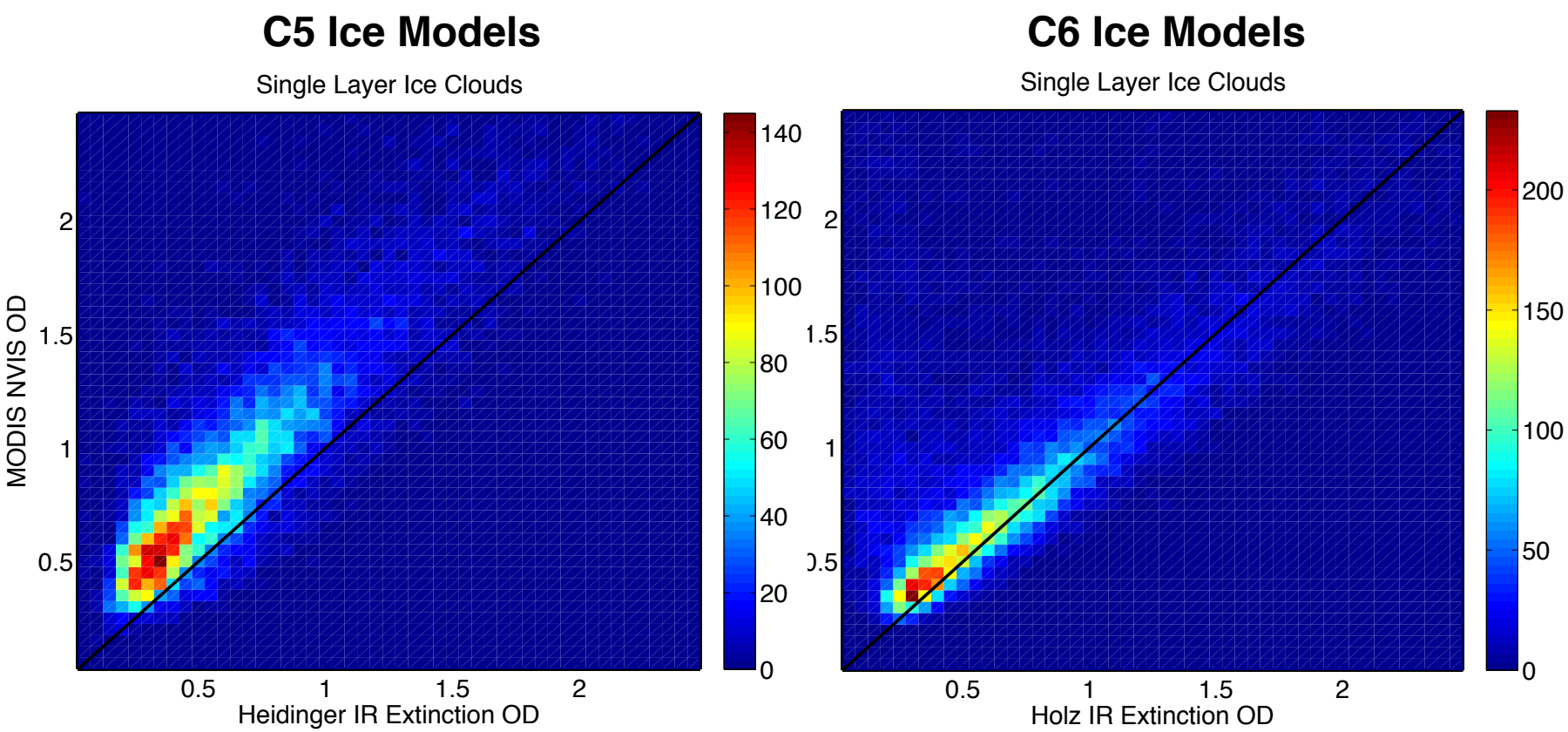
MOD06 Collection 6 Change Highlights (1)

Radiative Transfer

- New LUTs
  - Full LUT across retrieval space/geometry (no asymptotic parameters, easier maintenance of retrieval routines)
  - New ice cloud models: Severely roughened aggregated columns. Analytic distribution (gamma, 0.10 effective variance) + P. Yang particle scattering database. Extensive evaluation vs. IR and CALIOP retrievals by R. Holz et al. (including A. Heidinger, CALIPSO IIR and CALIOP team).
  - LUTs include reflectance sensitivity associated with selected model parameters for use in quantifying pixel-level model retrieval uncertainties
- Ocean spectral surface BRDF
  - Wind speed-interpolated Cox-Munk (3 separate LUTs)
- Land spectral surface albedo
  - New gap-filled dataset derived Aqua/Terra C5 product (MCD43B3)

Example MOD06 C6 Changes Since 2012 STM: Ice Models

New ice radiative models achieve closure with IR observations of single layer cirrus



analysis from R. Holz

MOD06 Collection 6 Change Highlights (2)

Algorithm

- Retrievals
  - Effective radius: absolute size retrievals derived from 1.6 and 3.7 μm bands (instead of difference relative to the 2.1 μm retrieval). Allows for L3 aggregations and improved spectral retrieval comparisons.
  - Cloud-Top: Use new 1km MODIS cloud-top retrievals, incorporate cloud emissivity into window IR retrievals for use in optical property code.
  - Numerous science and code performance improvements.
- Changes related to pixel populations and filtering
  - Thermodynamic Phase: SWIR/VNIR ratio tests replaced w/separate ice and liquid water retrievals (CALIOP, POLDER validation).
  - Attempt retrievals on pixels expected to be partly cloudy.
  - Provide solution space metrics on failed retrievals (separate SDSs).
  - Updated multilayer detection and algorithm for removal of heavy aerosol (smoke, dust) and glint from cloud population.

MOD06 Collection 6 Change Highlights (3)

Algorithm (cont.)

- Pixel-level Uncertainties (not incl. deviations from 1D radiative model)
  - Calibration uncertainty: uses new L1B scene-dependent pixel-level uncertainty indices improved for C6.
  - New model error sources included as LUT entries (size distribution effective variance for liquid and ice cloud reflectances, wind direction for ocean surfaces)
  - 3.7 μm band effective radius retrievals now include emission error sources (effective cloud and surface emissivity, T_{cloud}, T_{sfc}, including dependences on ancillary water vapor)

Example MOD06 C6 Changes Since 2012 STM: Ice Models

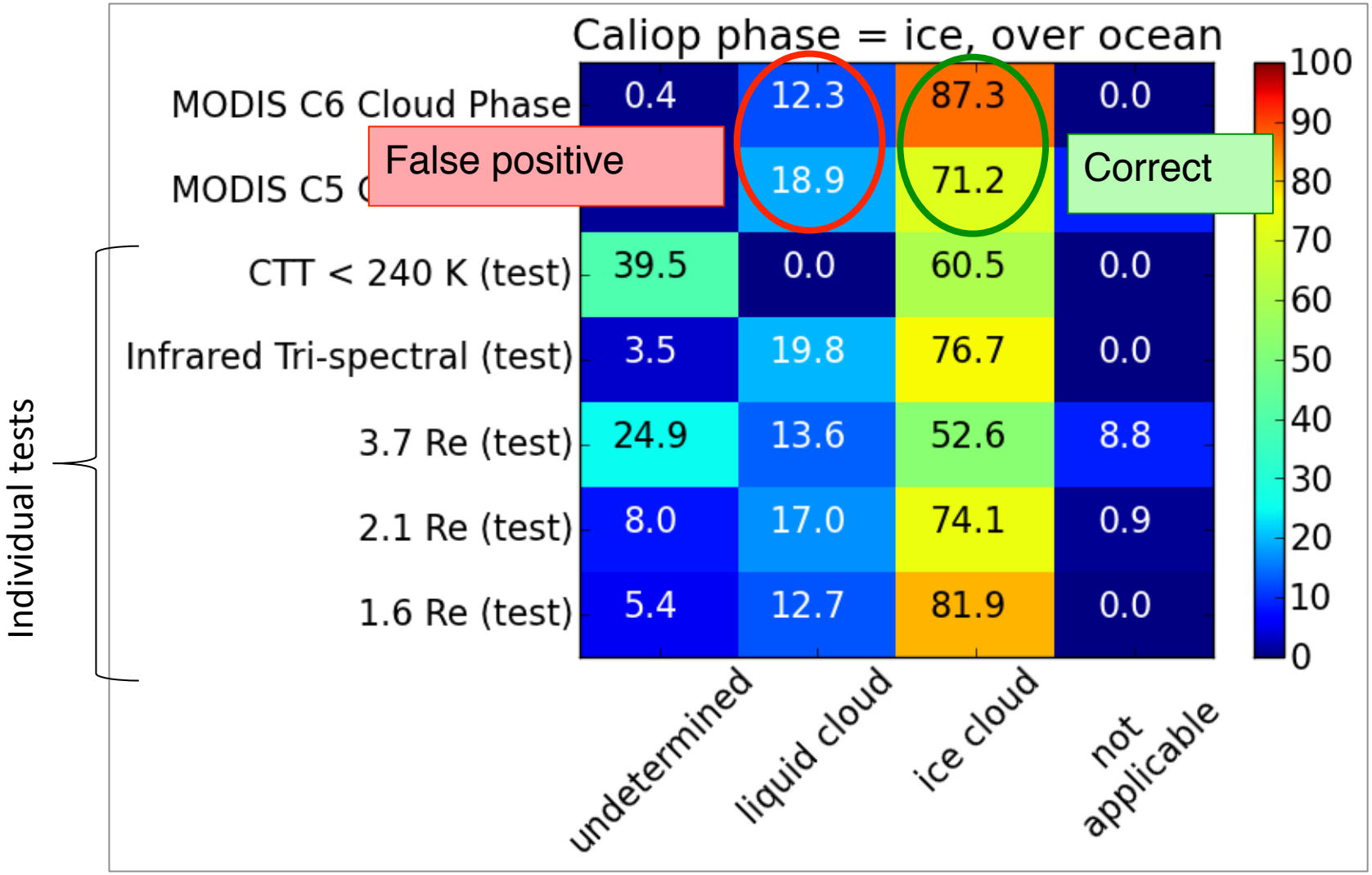
Radiative Transfer

- Finalized ice cloud radiative model, lowers retrieved optical thickness
  - uses severely roughened aggregated columns
  - analytic distribution (gamma, 0.10 effective variance) + P. Yang particle scattering database
  - extensive evaluation vs. IR and CALIOP retrievals by R. Holz et al. (including A. Heidinger, CALIPSO IIR and CALIOP team)
  - MOD06 file include g_λ, $\tilde{\omega}_{0,\lambda}$, $Q_{e,\lambda}$ arrays for both ice and water models so users can compare/scale retrievals to their own radiative assumptions.

C6, C5 Phase Comparisons vs. CALIOP: May 2007

CALIOP Phase = Ice

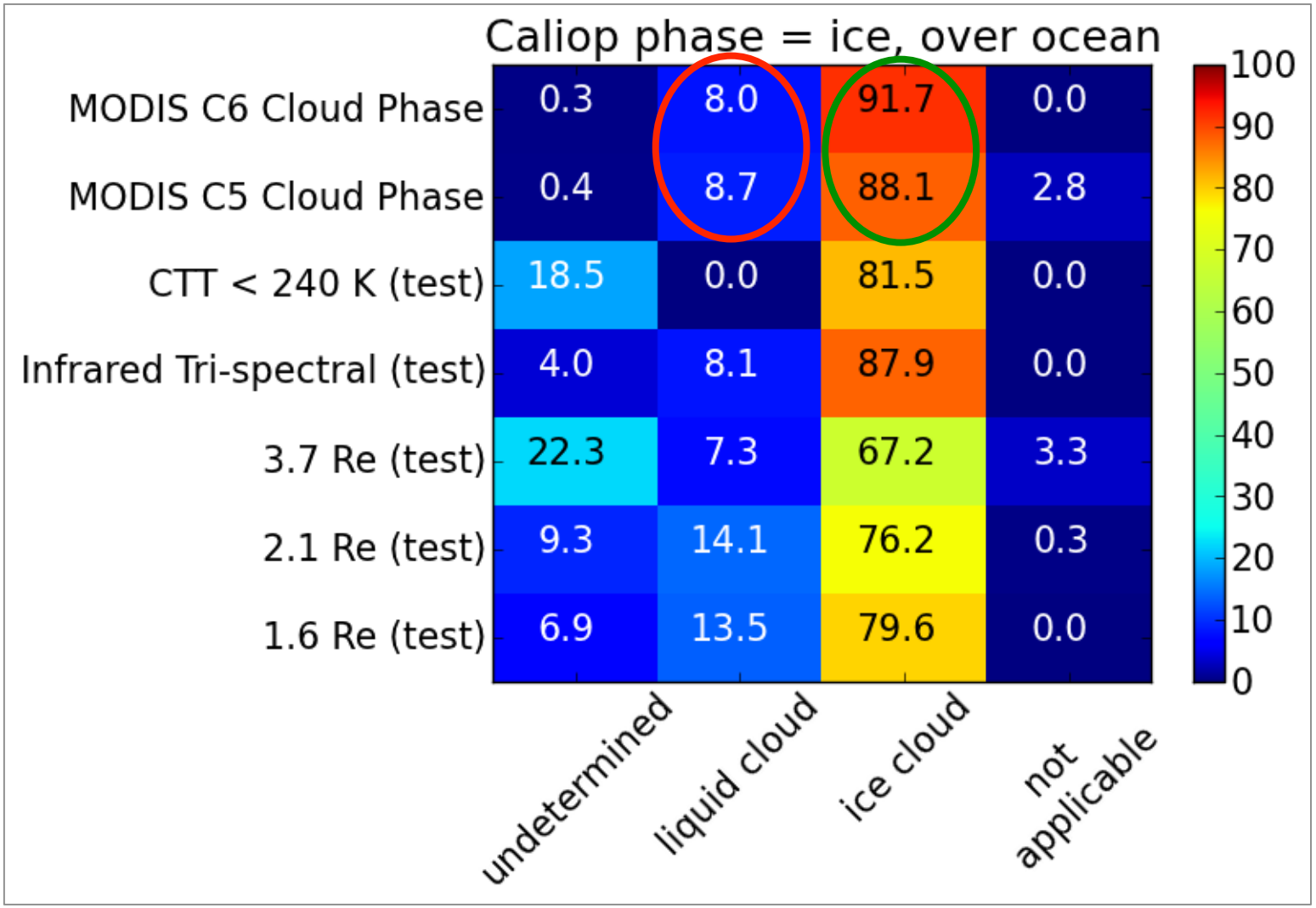
(ocean, 1 km, tau<5 - w/lidar single column phase)



C6, C5 Phase Comparisons vs. CALIOP: May 2007

CALIOP Phase = Ice

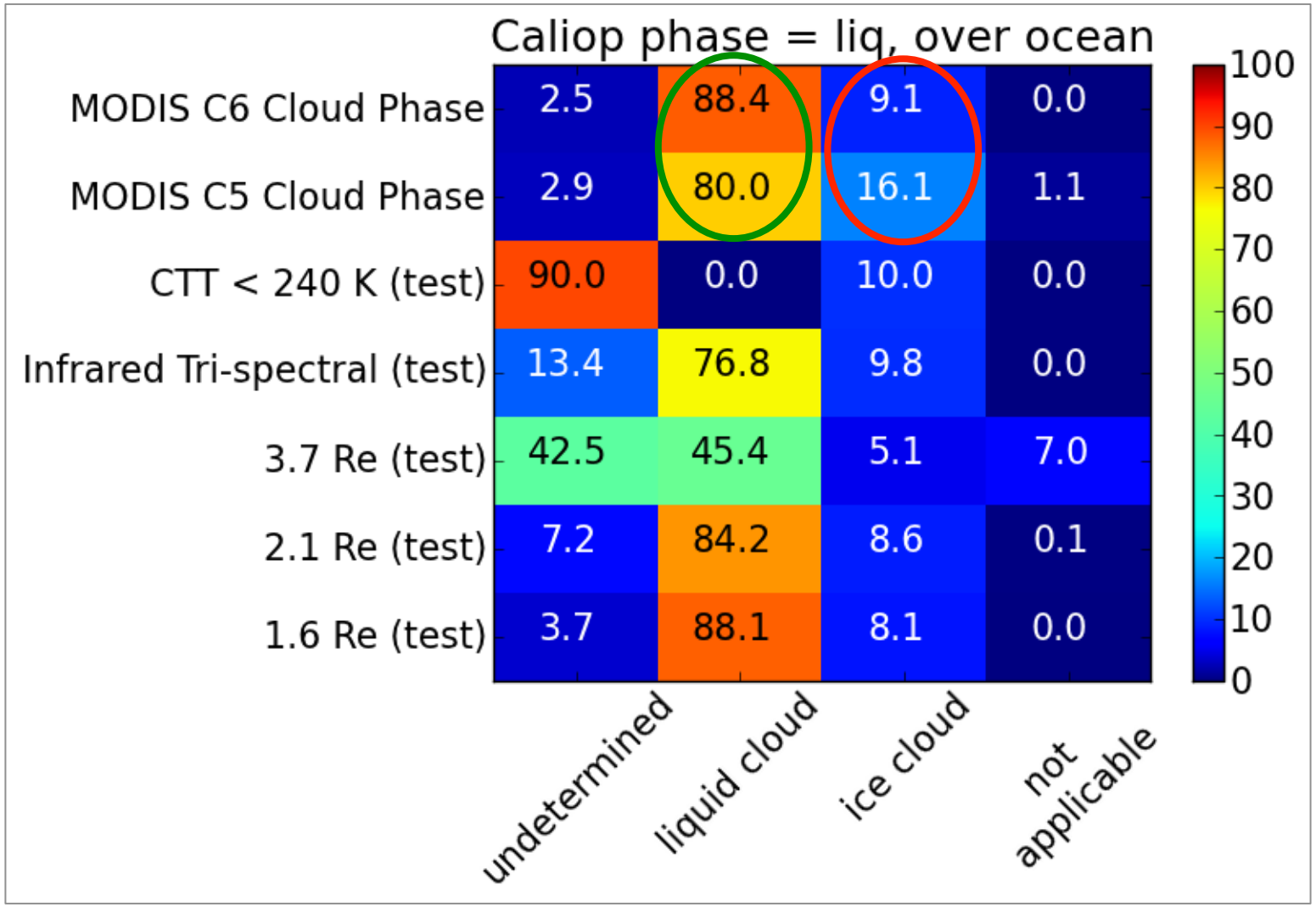
(ocean, 1 km, all tau - w/lidar single column phase)



C6, C5 Phase Comparisons vs. CALIOP: May 2007

CALIOP Phase = Liquid Water

(ocean, 1 km, all tau - w/lidar single column phase)



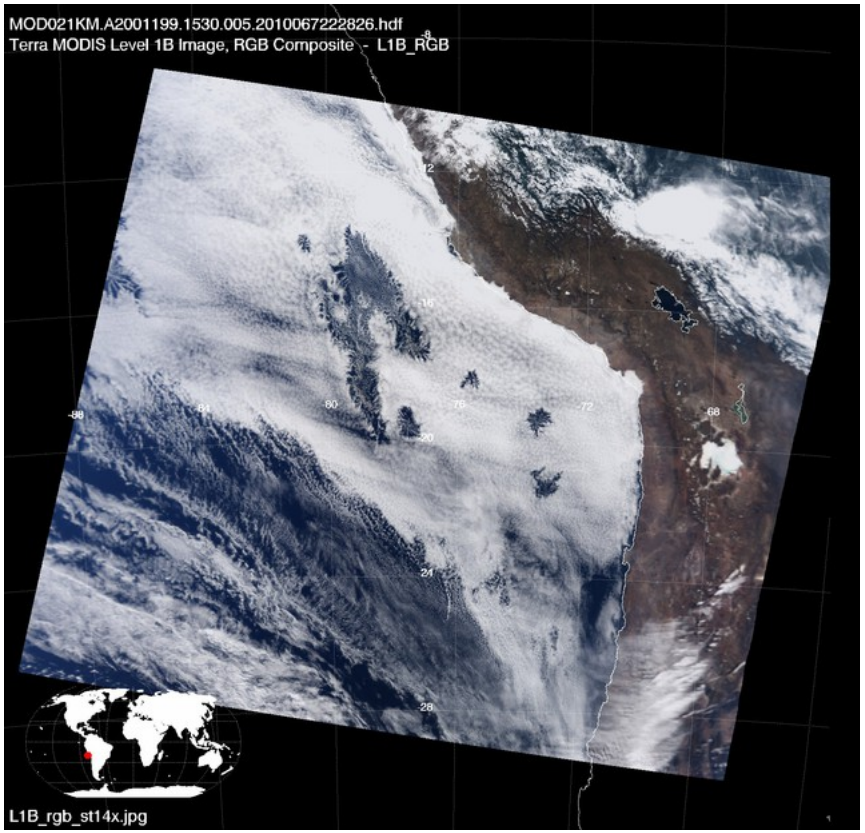
Example MOD06 C6 Changes Since 2012 STM: QA

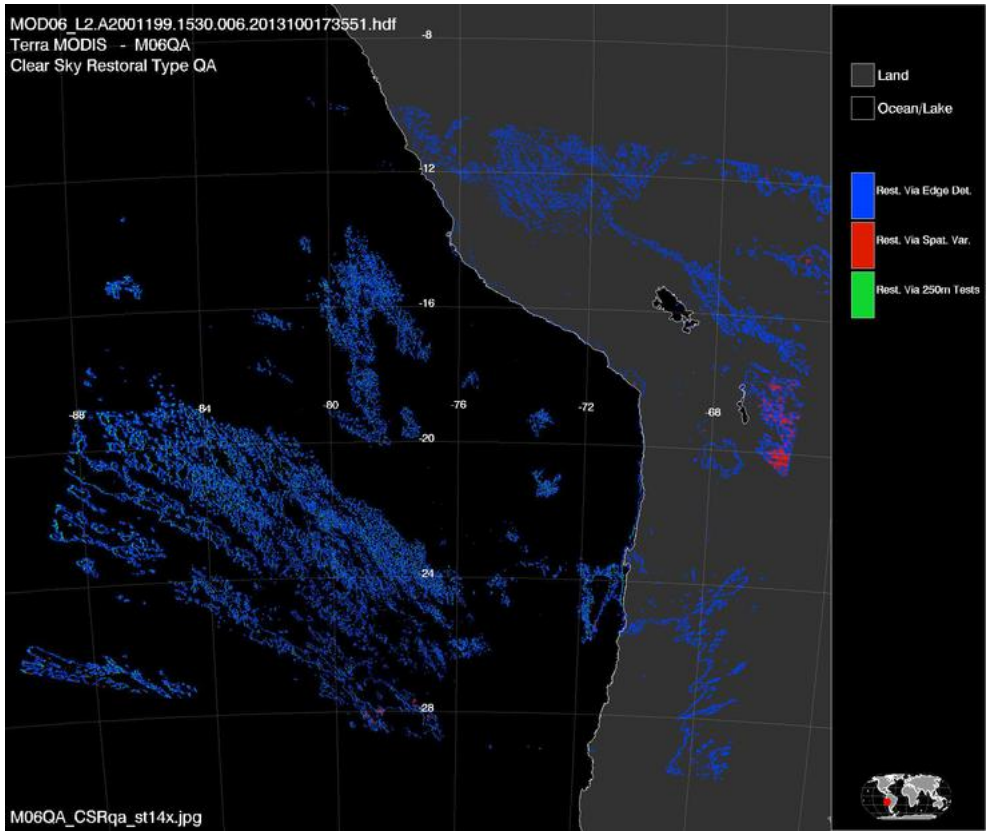
Algorithm

- No longer assign Confidence QA (2 bits)
  - Confusing to users, source of data misuse, no consistency across products, etc.
  - Previously used for general assessment of retrieval accuracy (replaced by pixel-level uncertainty) and QA-weighted L3 aggregations. User directed to L3 “Uncertainty of Mean” SDSs based on pixel-level uncertainty calculations.
  - Original C6 plan was to use Confidence QA to indicate partly cloudy pixels, but anticipated user confusion. Now provided in separate SDS.
  - For compatibility with C5 QA structure, Confidence QA remain but have trivial assignments.
- For potential use in assessing retrieval quality, have added band 1 and 2 250m reflectance heterogeneity information ($\sigma_R/\langle R \rangle$) using reflectance information added to cloud mask.

Example MOD06 C6 Changes Since 2012 STM: QA

Terra MODIS, 199/2001, 1530 UTC

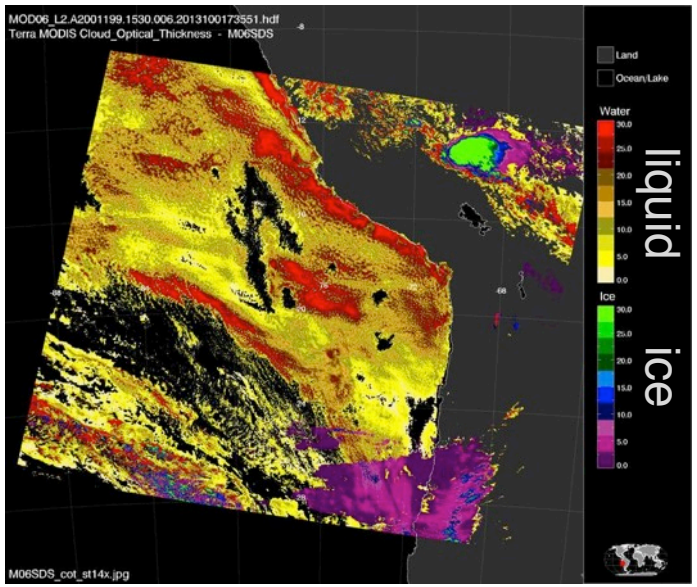


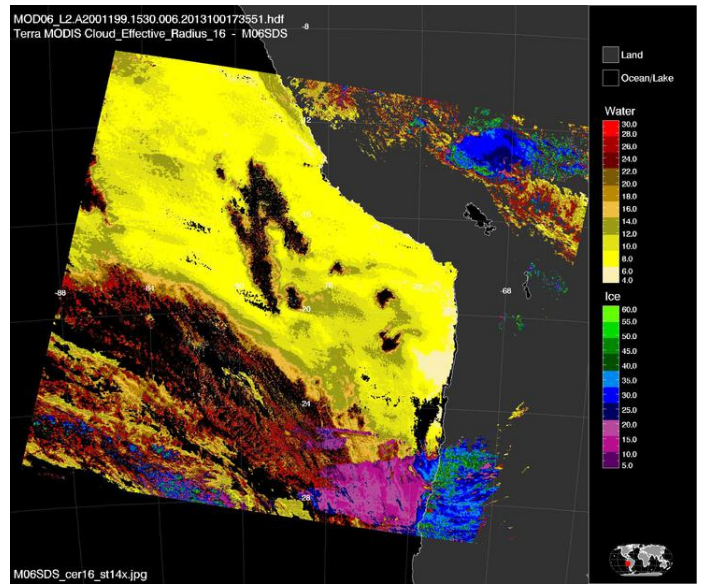


"Partly Cloudy" pixels (blue=cloud edges)
make up ≈ 9% of all cloudy pixels

Example MOD06 C6: “Overcast” Retrievals

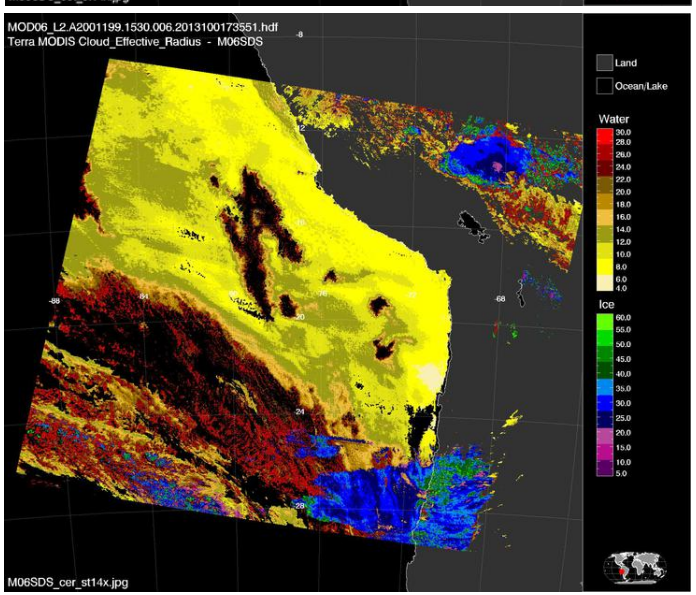
COT
(0-30
liq. & ice
color bars)

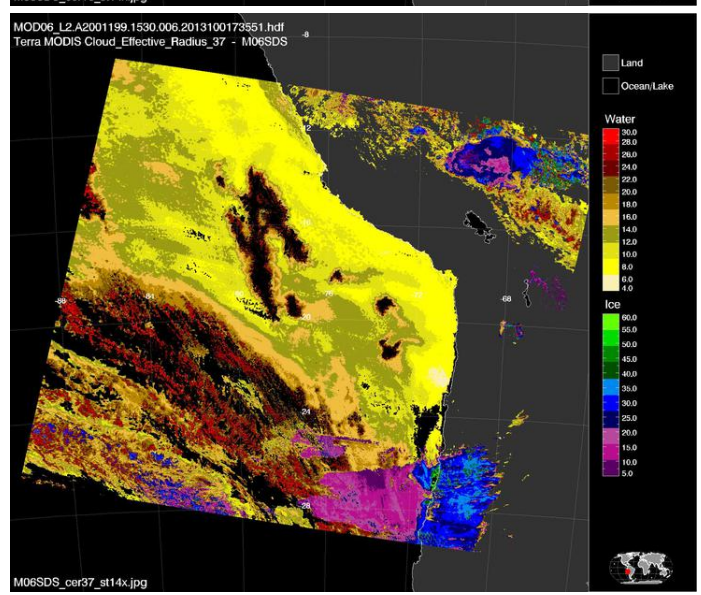




CER
1.6μm

CER
2.1μm
(liq: 4-30,
ice: 5-60)



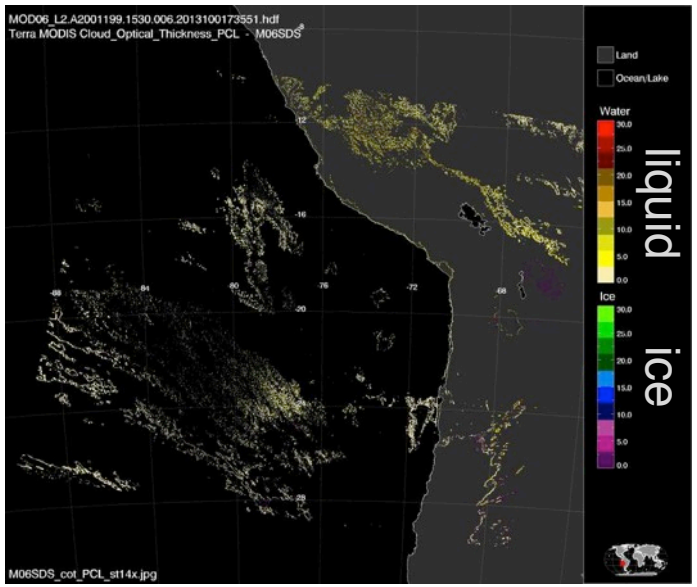


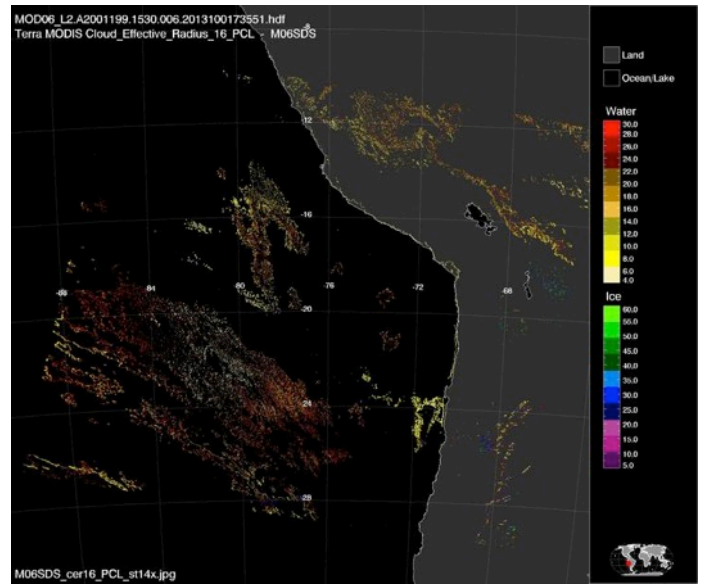
CER
3.7μm

MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

Ex. MOD06 C6: “Partly Cloudy” Retrievals

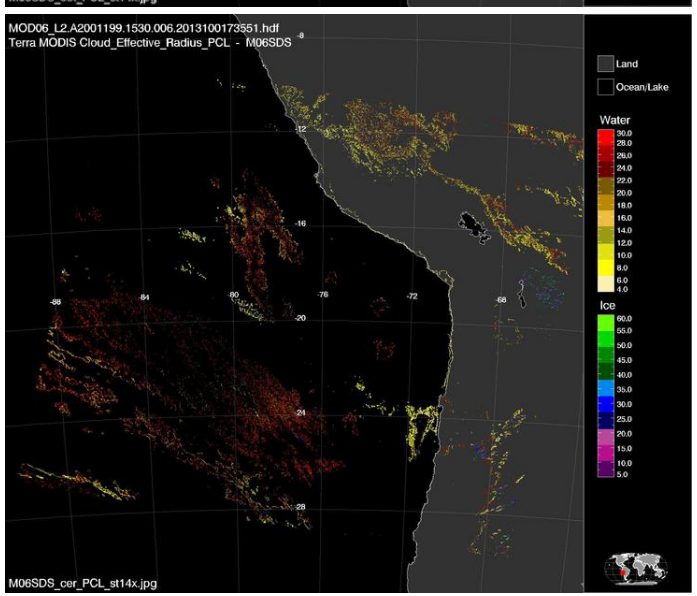
COT
(0-30
liq. & ice
color bars)

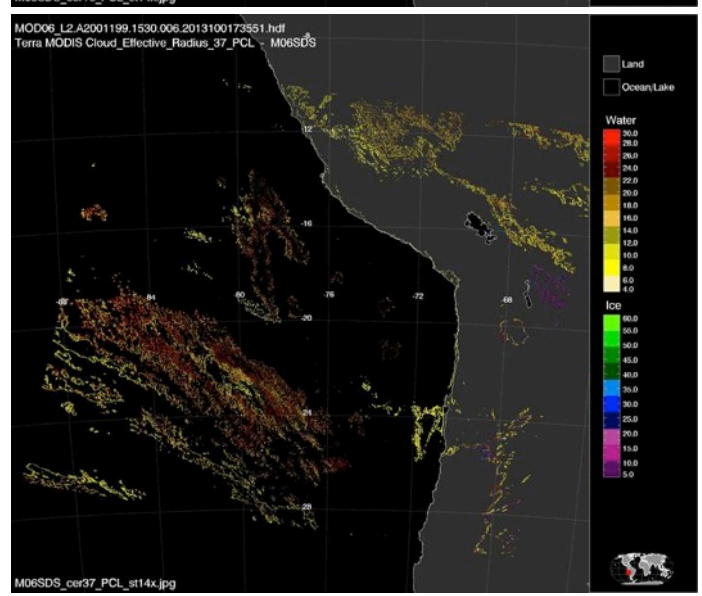




CER
1.6μm

CER
2.1μm
(liq: 4-30,
ice: 5-60)





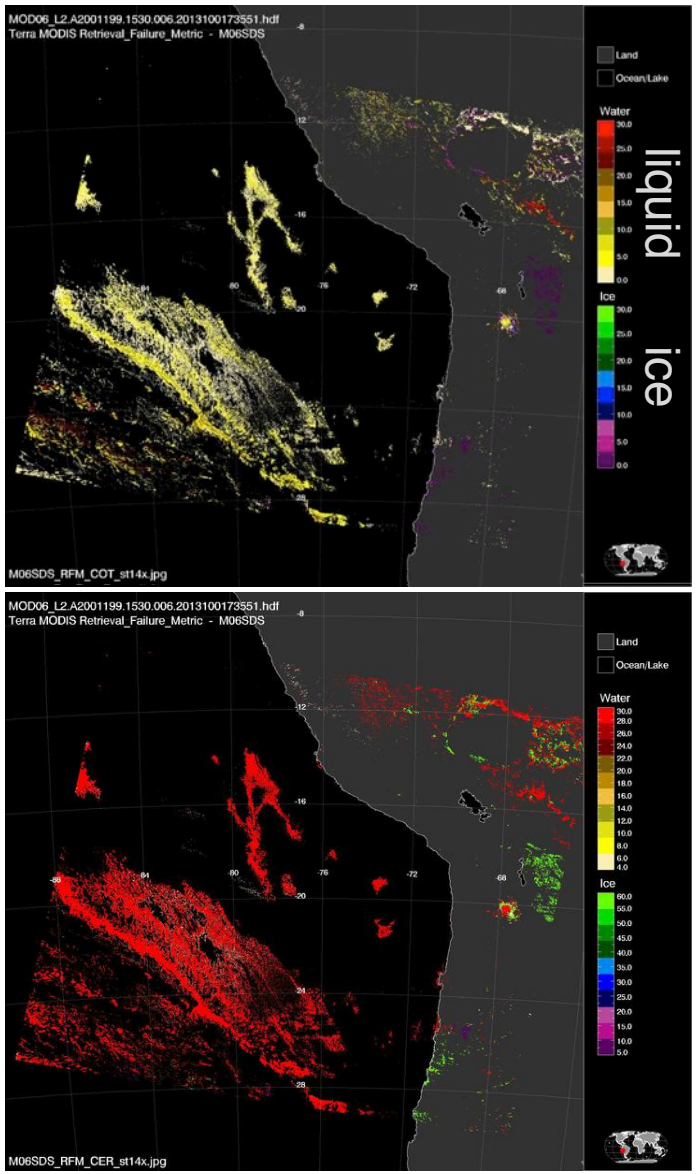
CER
3.7μm

MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

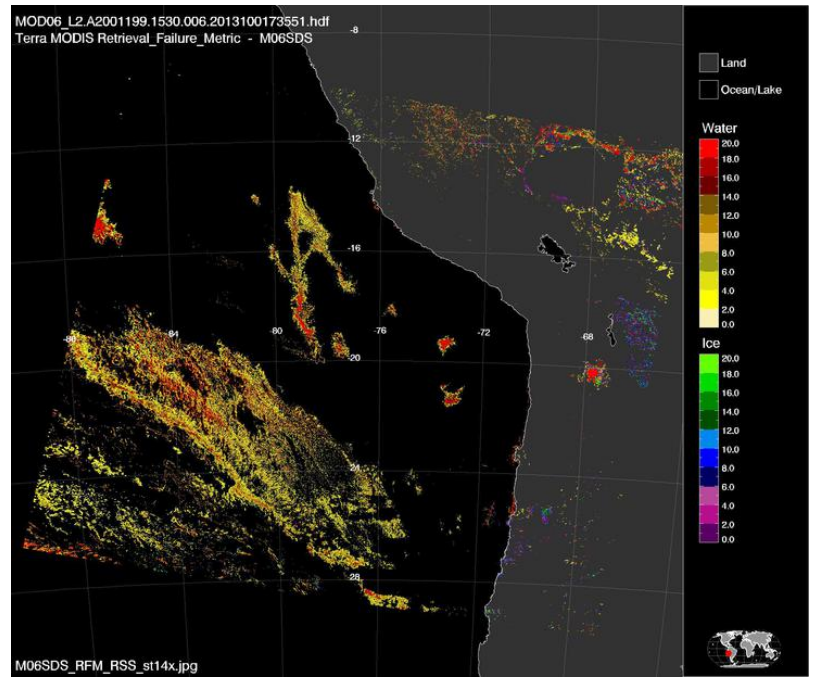
Ex. MOD06 C6: Retrieval Failures (Outside Solution Space)

COT failures
(<5 for liq.)

CER 2.1μm failures
(>30μm for liq.)



~14.6% of 2.1 μm retrievals fail

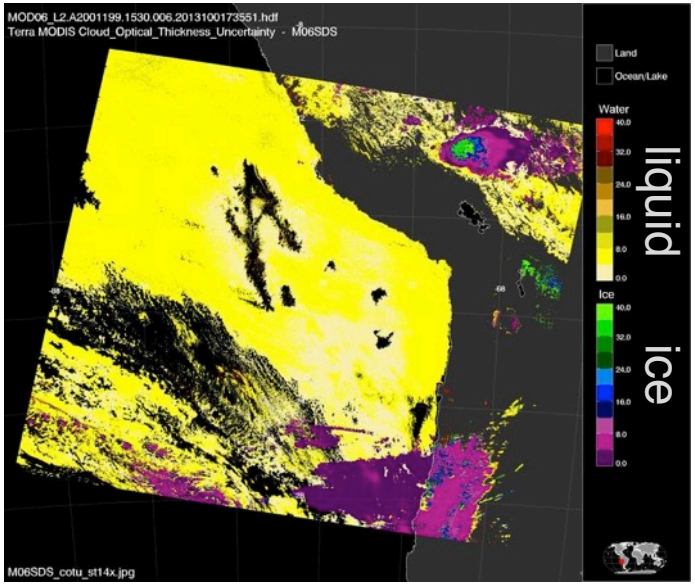


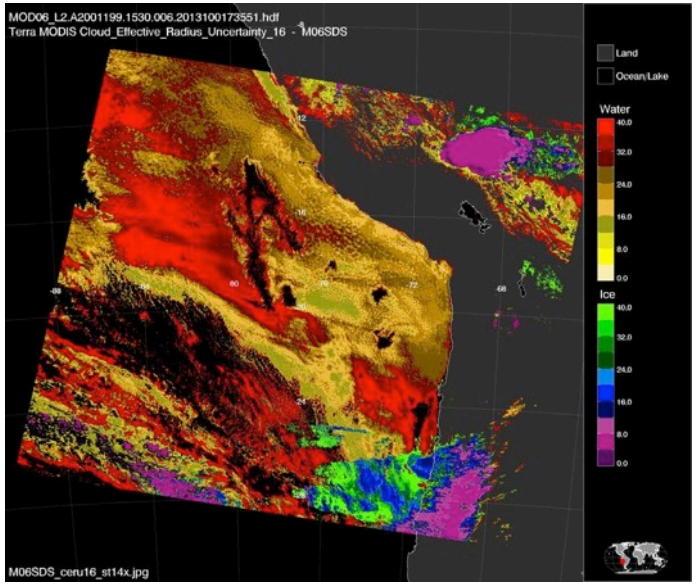
Failure magnitude:
Distance to Solution Space rel. to measurement vector
(0-20%)

MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

Ex. MOD06 C6: Uncertainties

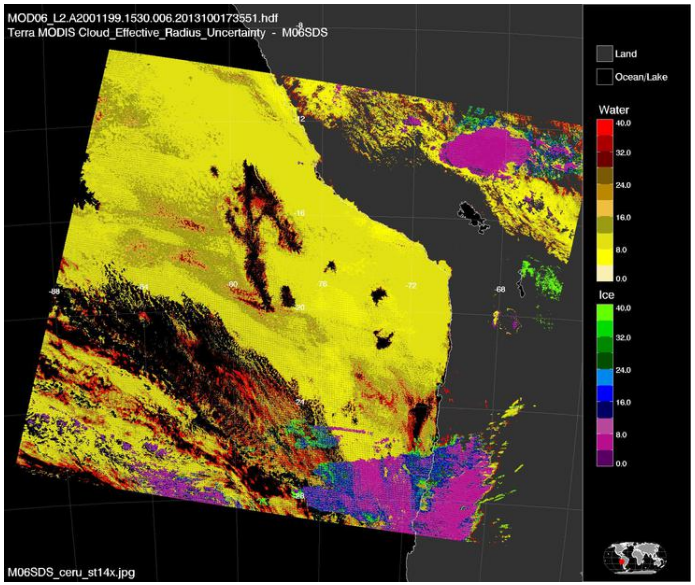
COT Uncert. (0-30%)

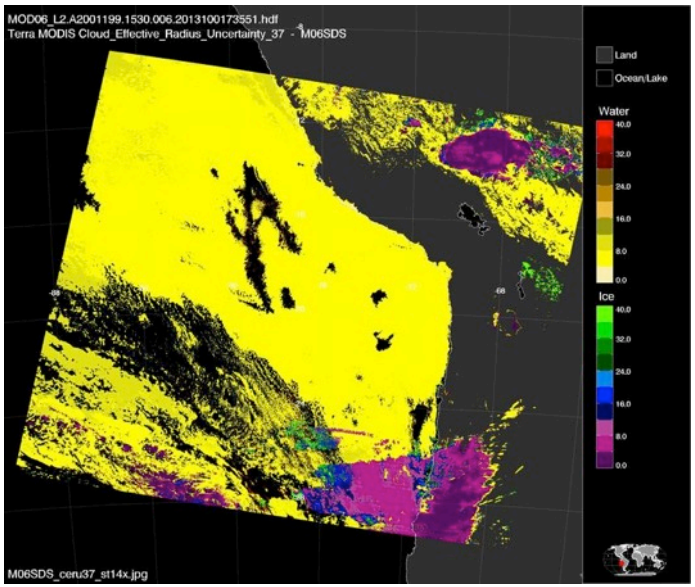




CER 1.6 μm Uncert.

CER 2.1μm Uncert. (0-30%)

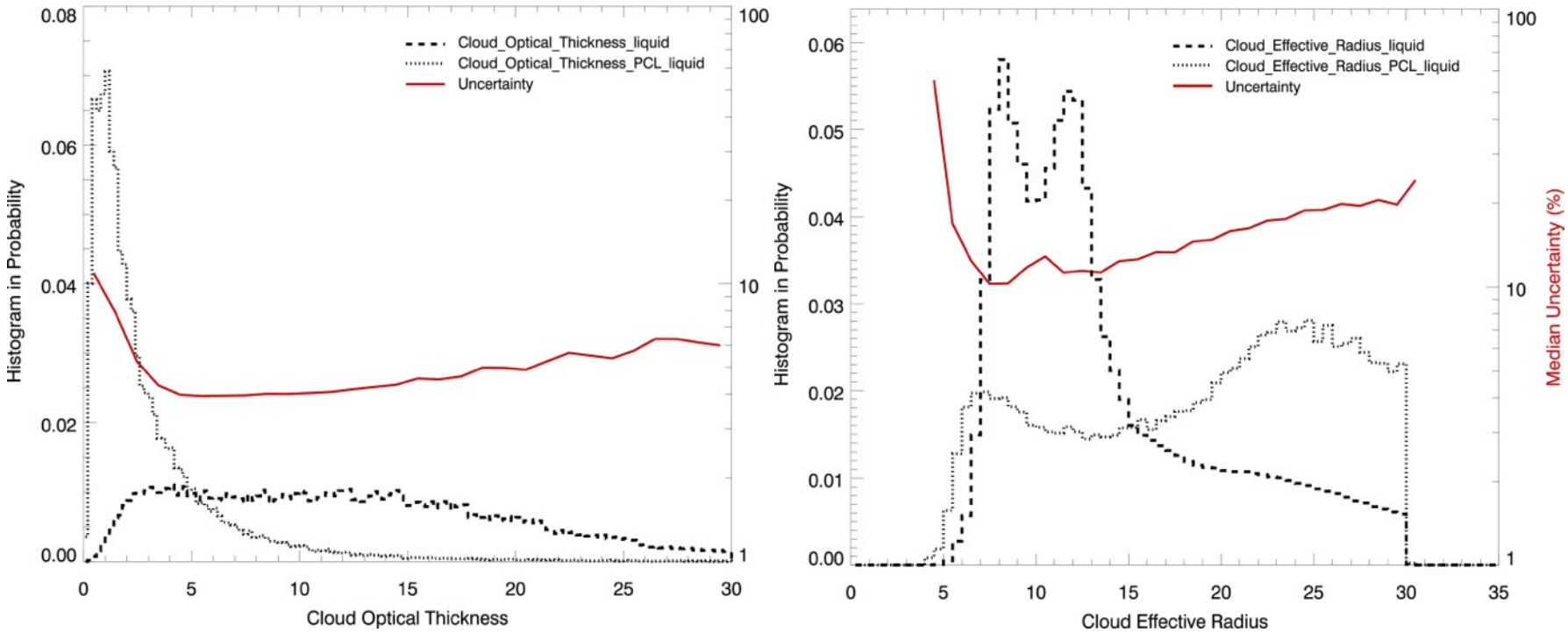




CER 3.7μm Uncert.

MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

Example MOD06 C6:
Overcast vs. Partly Cloudy Distributions & Uncertainties

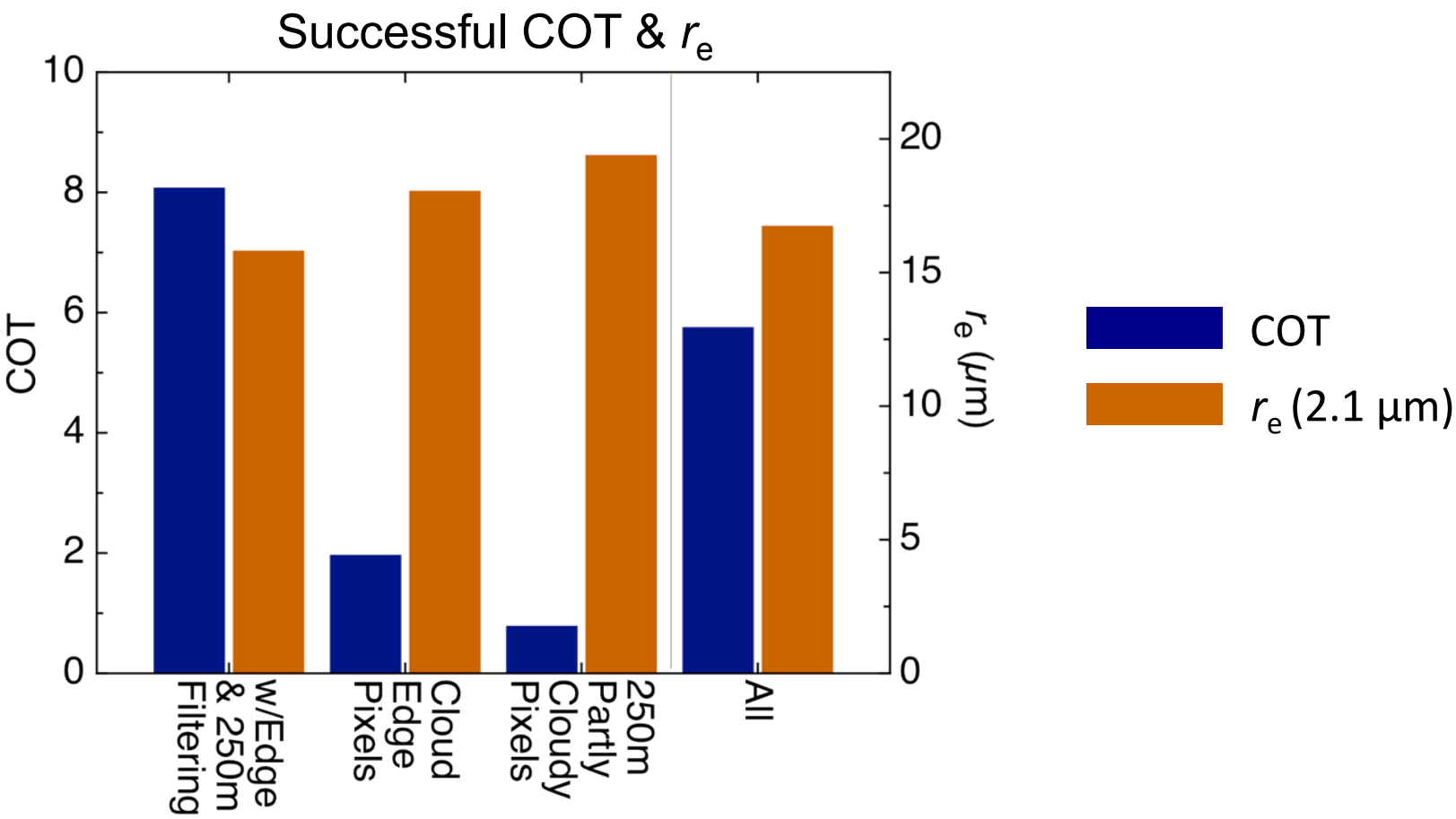


MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

Pixel Filtering: Retrieval Outcome

Terra MODIS April 2005, maritime water clouds

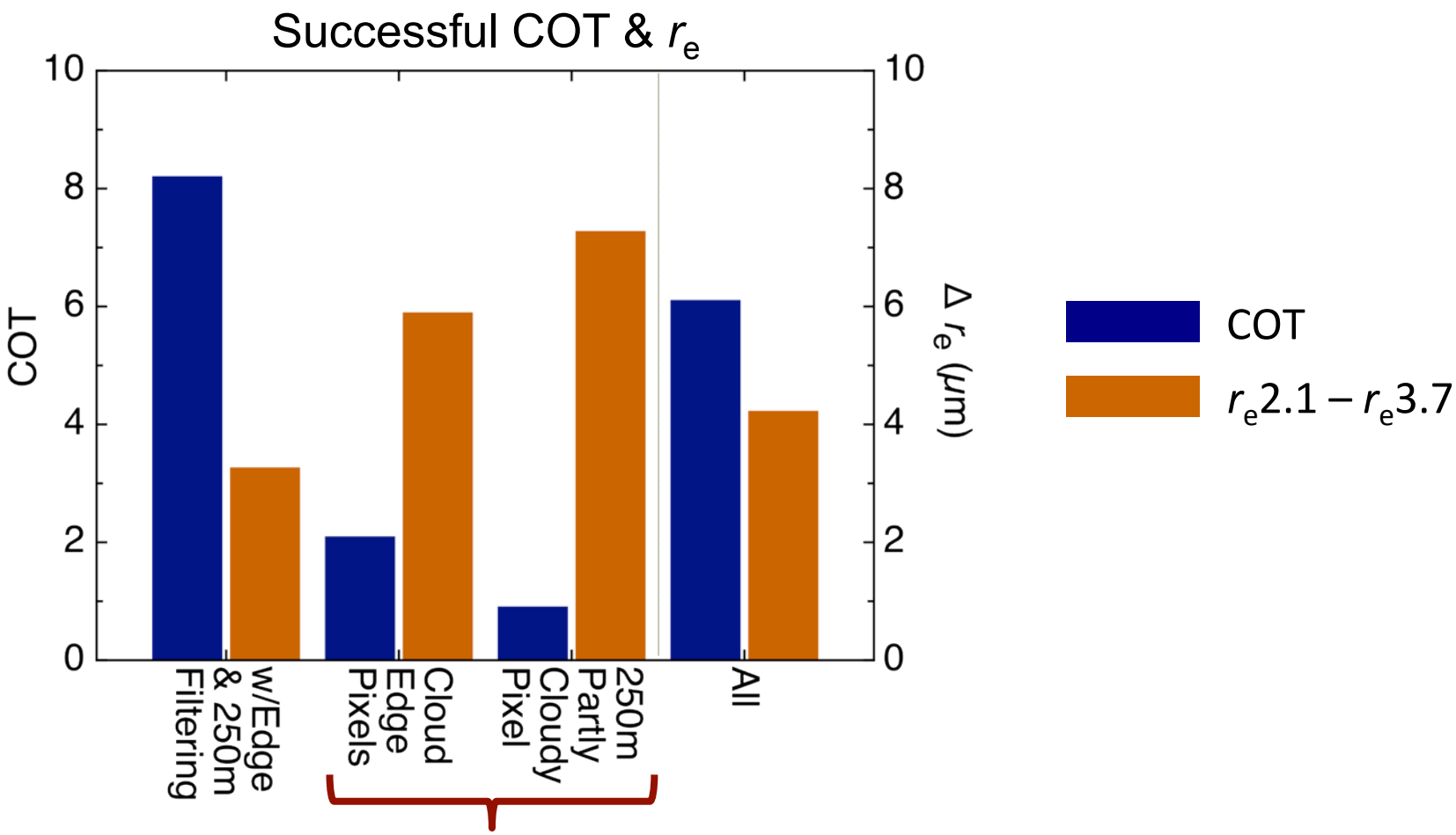
CTP ≥ 680mb, ±30° latitude



Pixel Filtering: Retrieval Outcome

Terra MODIS April 2005, maritime water clouds

CTP ≥ 680mb, ±30° latitude

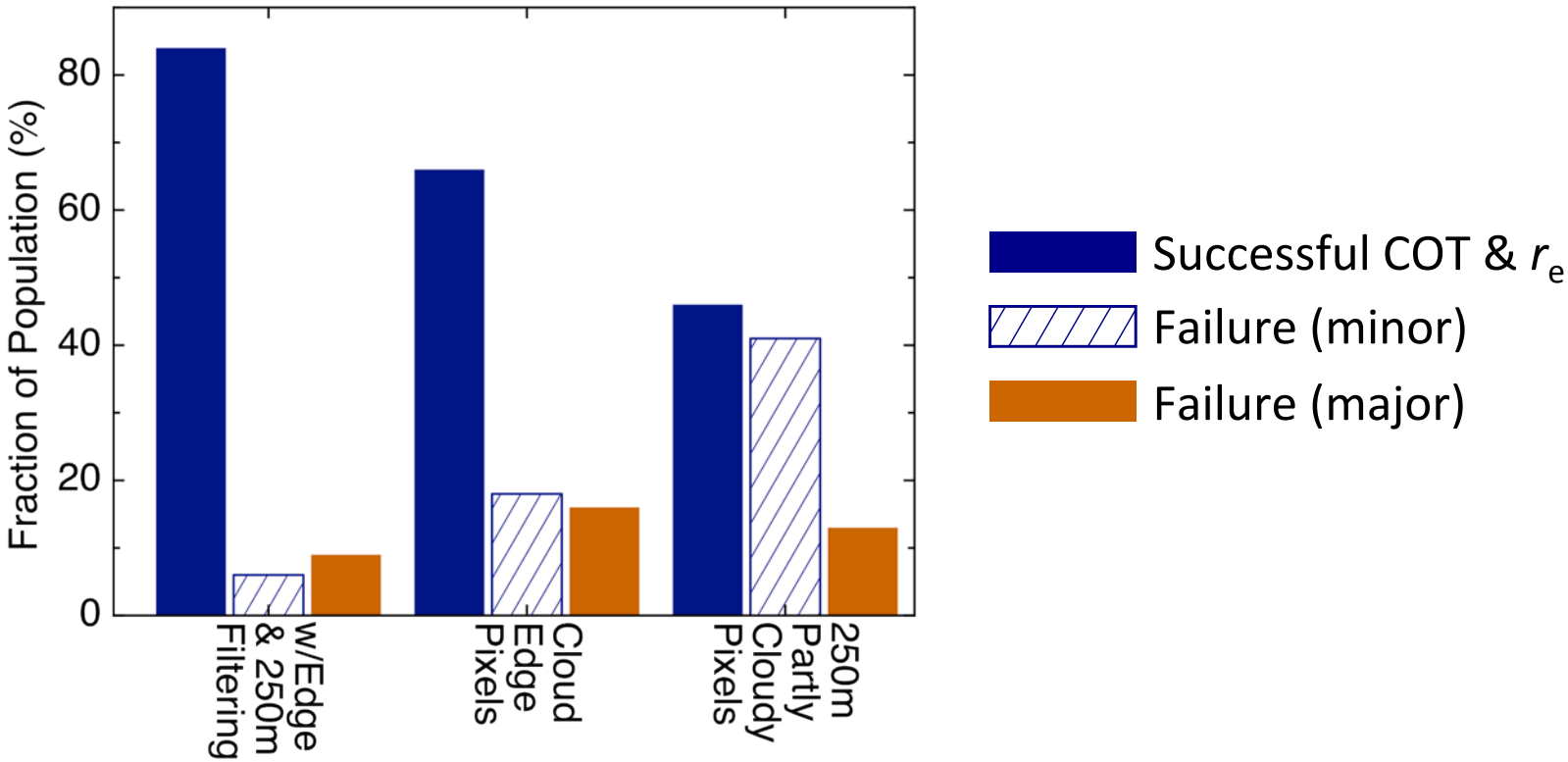


Retrievals consistent w/breakdown of 1D forward model

Pixel Filtering: Sampling Statistics

Terra MODIS April 2005, maritime water clouds

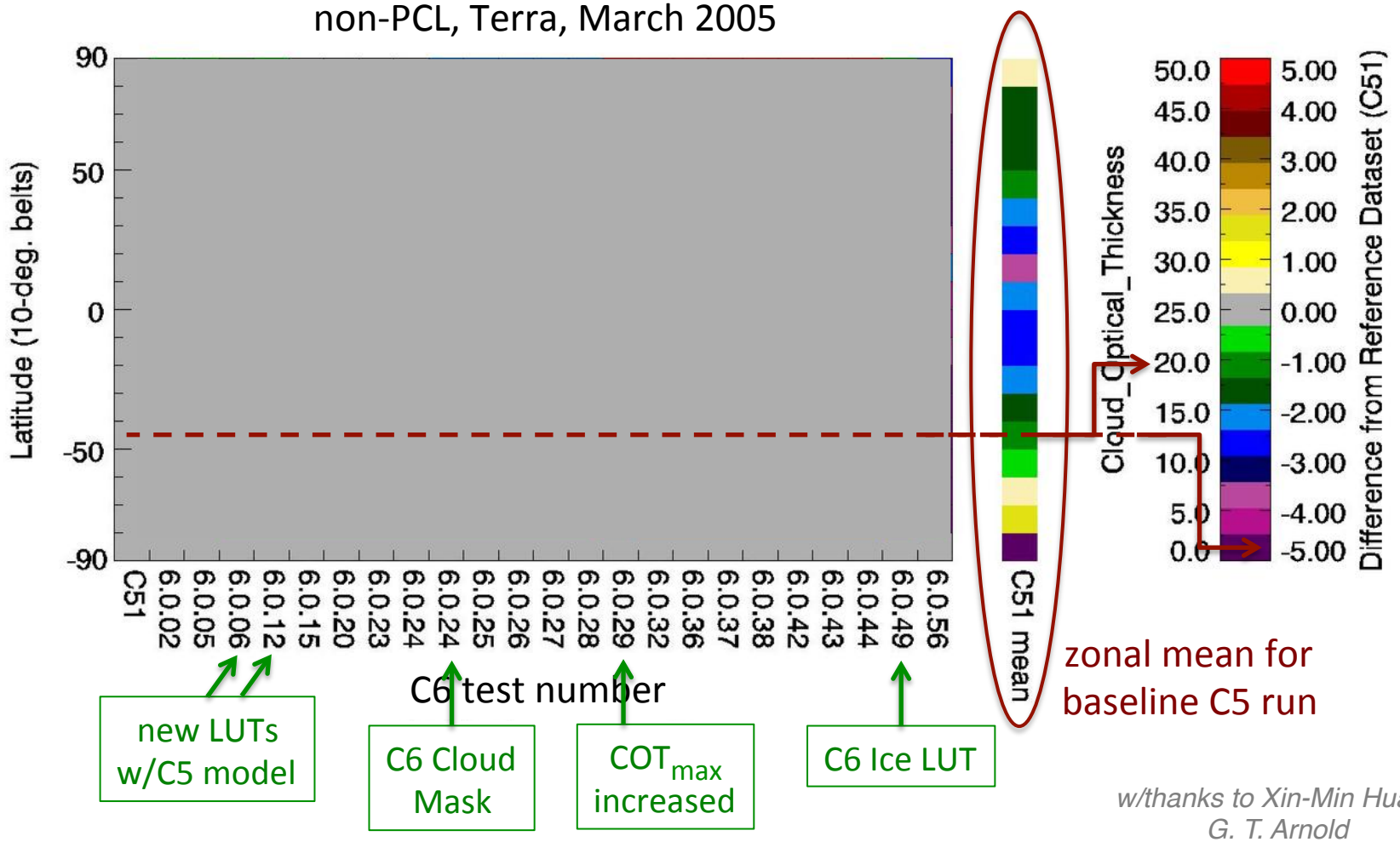
CTP ≥ 680mb, ±30° latitude



- 44% of cloudy pixels are associated w/edges or designated as partly cloudy by the 250m cloud mask
- 40% of edge/partly cloudy pixel retrievals fail (simultaneous COT and r_e solution fall outside LUT space)

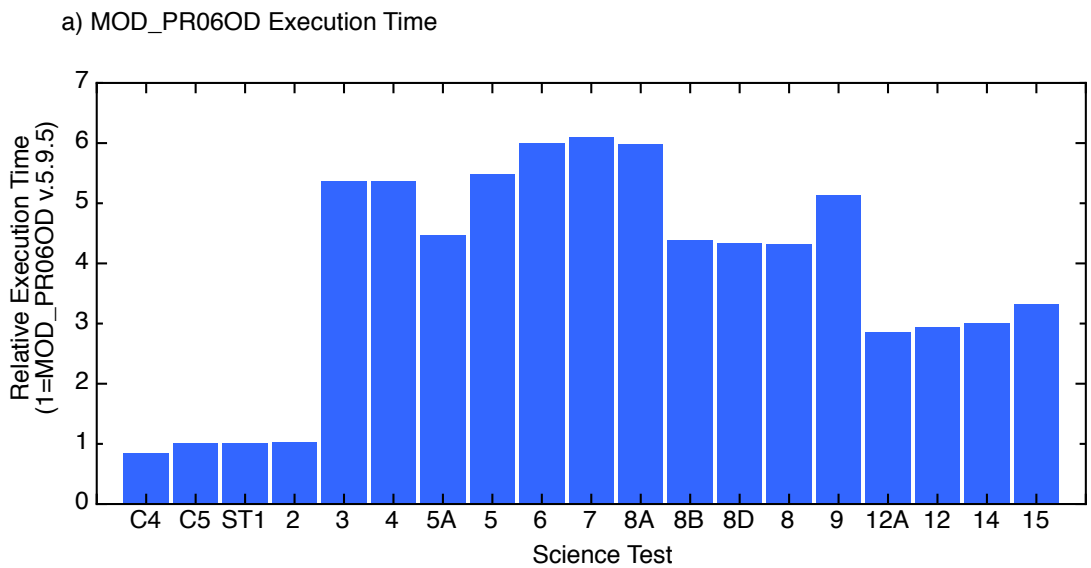
Example MOD06 C6 Changes Since 2012 STM: Zonal Means vs. MODAPS Archive Tests

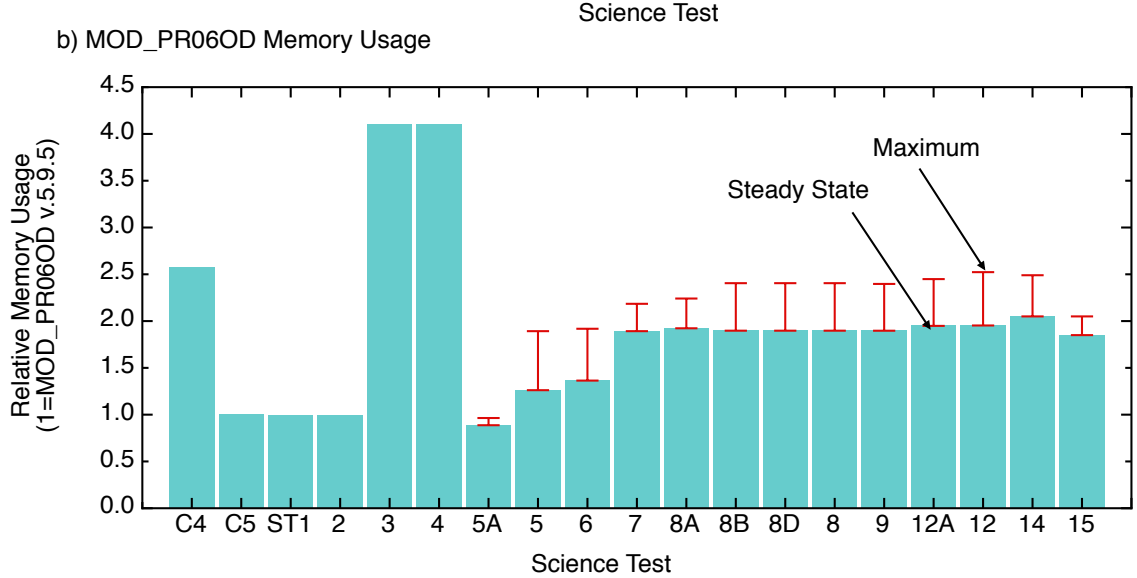
Ice Cloud Optical Thickness over ocean, non-PCL, Terra, March 2005



w/thanks to Xin-Min Hua & G. T. Arnold

MOD06 C6 Processing/Memory Stats



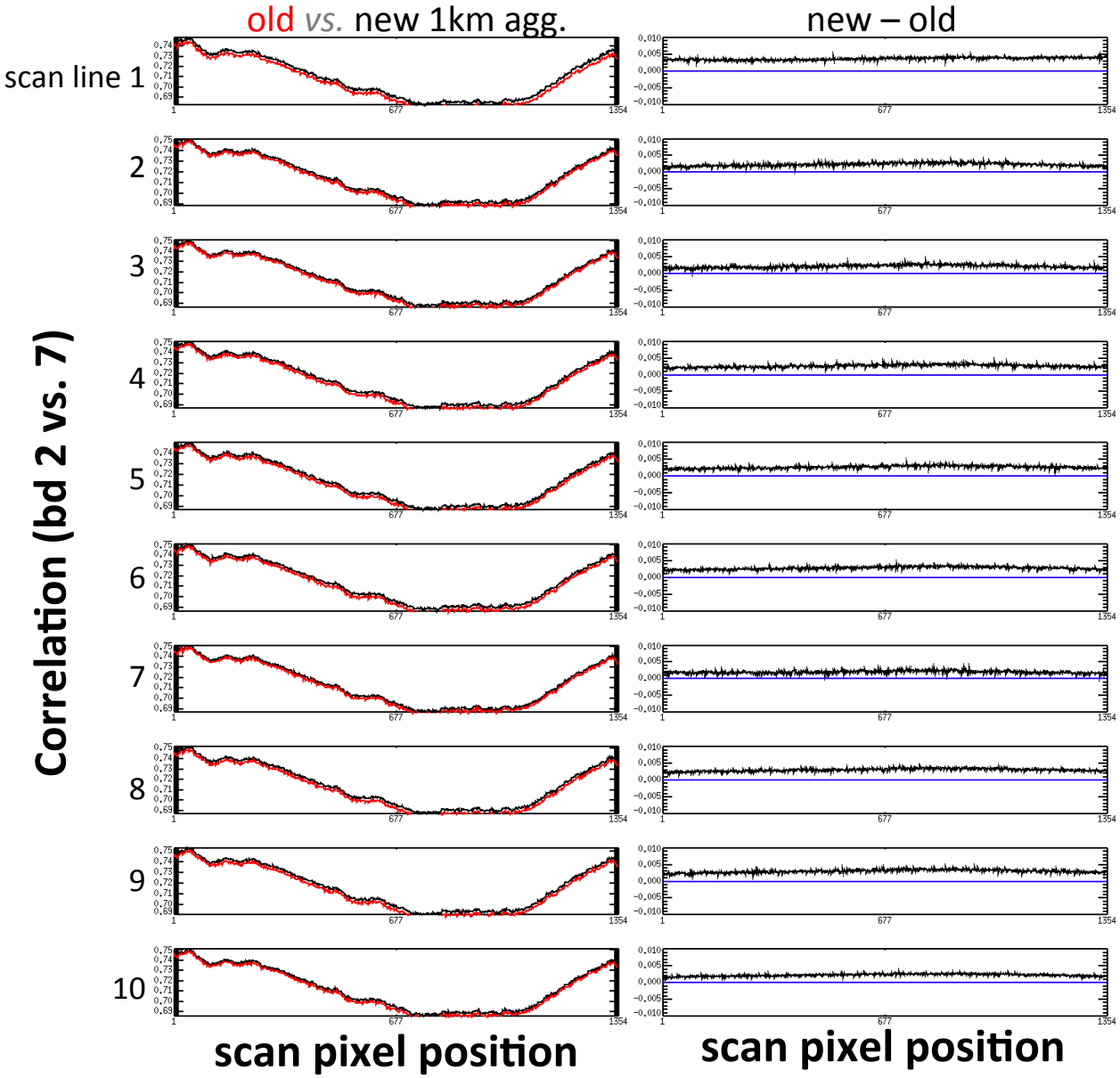


MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

MYD02 Band 1/2 Re-registration Status (1)

- Problem
  - Aqua VNIR focal plane misregistered w.r.t. other focal planes (~few hundred meters, see MCST reports)
  - Cloud mask and optical products and use bands from all focal planes. Could impact retrievals for heterogenous cloud scenes/cloud edges.
    - Investigated empirical correlations between bands 1, 2 and SWIR bands in 2010. Significant differences found between MODIS Terra and Aqua. [Ralf Benartz]
    - "Misregistered" Terra MODIS MYD02 1km aggregation test file resulted in noticeable differences in optical properties distributions. [Platnick, Kuiper]
- Re-registration history
  - Aqua correlations improve using empirical 1km aggregation kernel for bands 1/2. [Bennartz]
  - Been working with R. Wolfe since early 2013 and recently tested kernel based on MCST characterization (similar results).
  - Empirical correction approach and status reported in previous MODIS cal meetings (2010/11/12).

MYD02 Band 1/2 Re-registration Status (2)



R. Wolfe
kernel

MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

MYD02 Band 1/2 Re-registration Status (3)

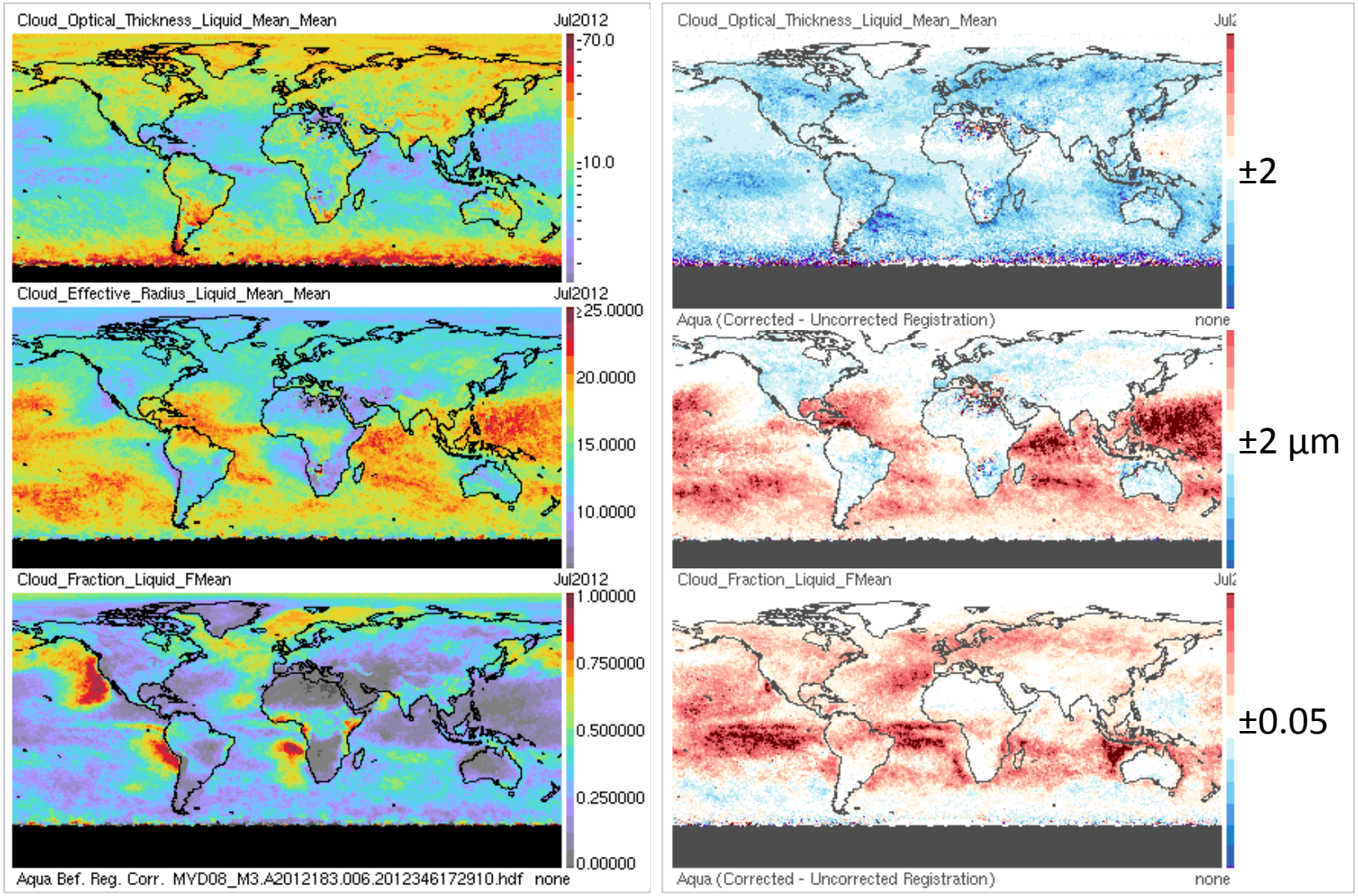
liquid cloud means, July 2012, Bennartz kernel: vDec. 2012

uncorrected mean | **corrected – uncorrected**

Optical Thickness

Effective Radius (µm)

Retrieval Fraction

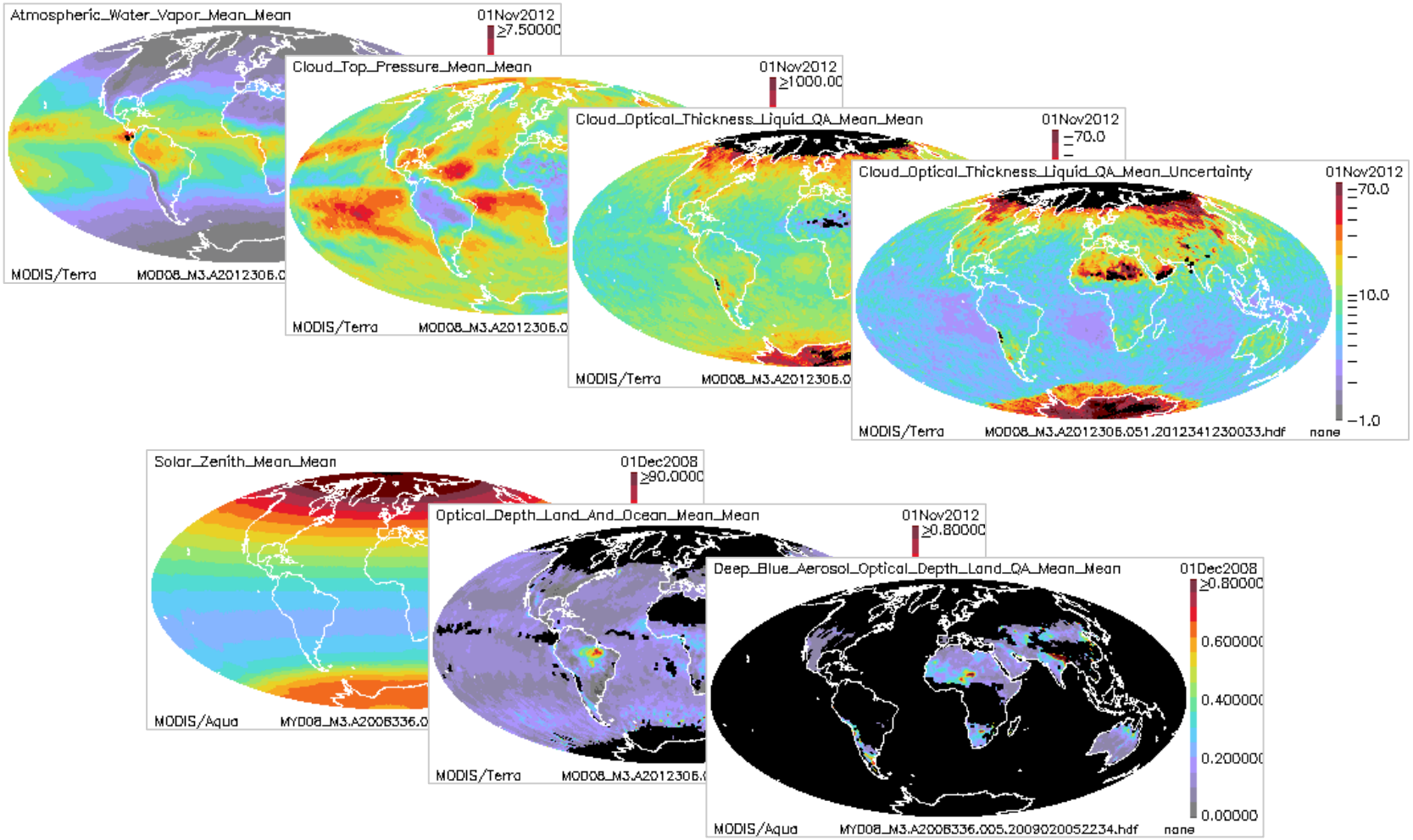


MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

MYD02 Band 1/2 Re-registration Status (4)

- Status
  - In testing: Re-registered MYD02 1km –> MYD35 cloud mask –> MYD06 cloud product
    - New MYD02 and MYD35 files used as intermediate files for cloud product processing only.
  - TBD: Use of new MYD02 1km and/or MYD35 files by other teams
    - Atmosphere MYD04/07 products haven't seen any impact in previous re-registration tests.
    - Land? Any algorithms use 1km b1/2 aggregation or MYD35 tests that use b1/2?

Atmosphere Team Level-3 (MOD08) Collection 6



MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

MOD08 Collection 6 Change Highlights

- Notable SDS Change Summary
  - Aerosols (MOD04): Addition of 2D aerosol histograms, SDS deletions and renaming, non-pixel count multiday weightings.
  - Cloud-top (MOD06): Addition of cloud-top stats by restricted Sensor ZA limits. Addition of sfc. type fraction. Improved bin resolution for calculation of means vs. pressure height (high, middle, low). Cloud-top height SDSs.
  - Cloud optical properties (MOD06): Addition of cloud optical property SDSs (e.g., 1.6 & 3.7 μm-derived parameters), removal of QA SDSs.
- Definition of Day
  - UTC definition results in discontinuities in tropics/midlatitudes
  - Inconsistent with other instrument team approaches. Can impact daily gridded comparisons but makes no difference to monthly analysis.
- Expect to begin production <u>after</u> L2 code processing has begun

MOD08 C6 SDS Change Summary

Product	SDSs Added/ Modified	SDSs Renamed	SDSs Deleted
Aerosol: Dark Target	19	10	24
Aerosol: Deep Blue	8	–	–
Cloud-Top Properties	60	–	–
Cloud Optical Properties	54	10	Numerous (incl. all QA-weighted)
Solar/View Geometry Stats	12	–	–

** each SDS changed needs to be implemented in 4 files (tile, daily, 8-day, & monthly)*

MOD08 C6 SDS Change Summary (2)

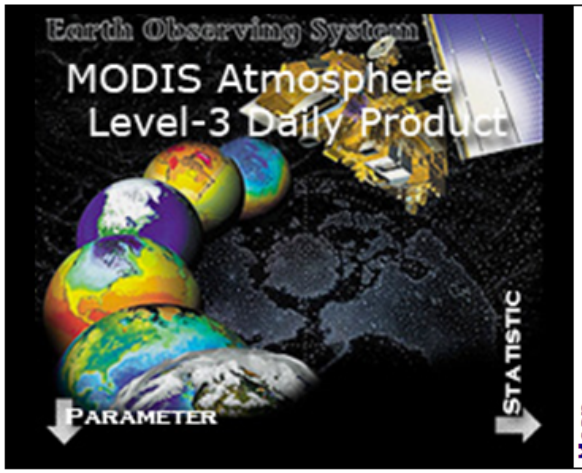
http://modis-atmos.gsfc.nasa.gov/_docs/L3_Statistics_Table_2013_04_13.pdf

L3 Daily Global (08_D3) Statistics

Collection 006 Updates

http://modis-atmos.gsfc.nasa.gov/products_C006update.html

= Added = Renamed = Deleted = Modified



Angles Derived from L2 Cloud (06_L2)

Angles	Mean	Standard_Deviation	Minimum	Maximum	QA_Mean	QA_Standard_Deviation	Histogram_Counts (n)	Confidence_Histogram (4)	Fraction	Pixel_Counts	Mean_Uncertainty	QA_Mean_Uncertainty	Log_Mean_Uncertainty	QA_Log_Mean_Uncertainty	Log_Mean	Log_Standard_Deviation	QA_Log_Mean	QA_Log_Standard_Deviation	Regression_Slope	Regression_Intercept	Regression_R-Squared	Regression_Mean_Square_Error	Joint_Histo_vs_Opt_Depth (nxn)	Joint_Histo_vs_Effect_Radius (nxn)	Joint_Histo_vs_Temperature (nxn)	Joint_Histo_vs_Emissivity (nxn)	Joint_Histo_vs_Pressure (nxn)
01. Solar_Zenith (changed to D+N)	•	•	•	•						•																	
02. Solar_Zenith_Day	•	•	•	•						•																	
03. Solar_Zenith_Night	•	•	•	•						•																	
04. Solar_Azimuth (changed to D+N)	•	•	•	•						•																	
05. Solar_Azimuth_Day	•	•	•	•						•																	
06. Solar_Azimuth_Night	•	•	•	•						•																	
07. Sensor_Zenith (changed to D+N)	•	•	•	•						•																	
08. Sensor_Zenith_Day	•	•	•	•						•																	
09. Sensor_Zenith_Night	•	•	•	•						•																	
10. Sensor_Azimuth (changed to D+N)	•	•	•	•						•																	
11. Sensor_Azimuth_Day	•	•	•	•						•																	
12. Sensor_Azimuth_Night	•	•	•	•						•																	

MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

MOD08 Collection 6 QA Plans

http://modis-atmos.gsfc.nasa.gov/products_C006update.html

MODIS Atmosphere

HOME PRODUCTS IMAGES DATA ISSUES NEWS STAFF FORUM REFERENCE TOOLS HELP

AEROSOL H_2O VAPOR CLOUD PROFILE CLD. MASK JOINT (Level-2 Products)

DAILY EIGHT DAY MONTHLY (Level-3 Products) | ALBEDO NDVI ECOSYSTEM (Level-3 Ancillary)

PRODUCTS

VERVIEW
VAILABILITY CALENDAR
OLLECTION 006
OLLECTION 051
OLLECTION 005
CQUISITION
NOWN PROBLEMS
OF FILENAMES
OW DIAGRAM

Collection 006 Update

The documents below describe Collection 006 changes to all L2 and L3 MODIS data. The next generation of MODIS data products, tagged *Collection 006*, is expected to began production in late Spring 2013.

QA Plan for Collection 006

MODIS-Atmosphere QA Plan (Interim C006 Version, Not Final)

- MODIS-Atmosphere QA Plan C006 Update (04/14/2013, v4.5) View PDF View DOC

Level-2 Collection 006 Change Summary Documents

Level-2 "Prior to Release" Documentation

- Profiles (07_L2) (v1, 06/22/2012) View PDF
- Cloud Mask (35_L2) (v1, 06/22/2012) View PDF

Level-2 Change Documentation

- Aerosol (04_L2) (v28, 04/08/2011) View PDF View DOC
- Water Vapor (05_L2) (v27, 01/11/2010) View PDF View DOC
- Cloud Optical (06_L2) (v29, 04/21/2011) View PDF View DOC
- Cloud Top (06_L2) * (v28, 04/11/2011) View PDF View DOC
- Profiles (07_L2) (v28, 04/08/2011) View PDF View DOC
- Cloud Mask (35_L2) (v28, 04/13/2011) View PDF View DOC
- Joint L2 (ATML2) (v28, 04/22/2010) View PDF View DOC

Level-2 Addendums

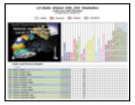
- * Cloud Top (06_L2) Spec Guide for L3 (v05, 01/03/2013) View PDF View DOC

Level-2 CDL File Specifications (Interim C006 Version, Not Final)

- CDL File Spec for Aerosol Product (04_L2) (03/21/2013) View TXT
- CDL File Spec for Cloud Product (06_L2) (03/28/2013) View TXT

Level-3 Collection 006 Change Summary Documents

Level-3 Change Documentation



- Global (08) - SDS Change Table (04/13/2013, v33) View PDF View DOC
- Global (08) High-Level L3 Change Summary/Status (04/13/2013, v10) View PDF View DOC
- Global Aerosol (04->08) Parameter Mapping (03/23/2013, v05) View PDF View DOC
- Global (08) - Preliminary (Early) Change Summary (01/21/2011, v28) View PDF View DOC

Level-3 CDL File Specifications (Interim C006 Versions, Not Final)

- MOD08_TL & MOD08_D3 - CDL File Spec for Tile and Daily (04/13/2013, v1060) View TXT
- MOD08_E3 & MOD08_M3 - CDL File Spec for Eight Day and Monthly (04/13/2013, v1060) View TXT

MOD06, MOD08, etc.: Platnick et al., MODIS STM, 15 April 2013

MOD08 Collection 6 Change Details: Aerosol

Aerosol combined Land and Ocean: completed

- Renamed parameters using Aerosol prefix [3 parameters renamed]
- Deleted some parameters [2 parameters deleted]
- Added Avg. Distance from the Aerosol Retrieval to the nearest Cloud [1 parameter added]
- Changed all Multiday averages from Pixel Count Weighted to Unweighted [3 parameters modified]

Aerosol over Land: completed

- Renamed parameters using Aerosol prefix [2 parameters renamed]
- Deleted many parameters [12 parameters deleted]
- Added Avg. Number of L2 Pixels used in Retrieval [1 parameter added]
- Changed all Multiday averages from Pixel Count Weighted to Unweighted [2 parameters modified]

MOD08 Collection 6 Change Details: Aerosol, cont.

Aerosol over Ocean: completed

- Renamed parameters using Aerosol prefix [5 parameters renamed]
- Many parameters deleted [10 parameters deleted]
- Added Avg. Number of L2 Pixels used in Retrieval [1 parameter added]
- Added three Joint Histograms (AE1, AE2, & AODRSO) vs. AOD [3 parameters added]
- Changed all Multiday averages from Pixel Count Weighted to Unweighted [8 parameters modified]

Aerosol Deep Blue: completed

- Added Avg. Number of L2 Pixels used in Retrieval [1 parameter added]
- Added AOD Dark Target & Deep Blue Combined [1 parameter added]
- Changed all Multiday averages from Pixel Count Weighted to Unweighted [6 parameters modified]

MOD08 Collection 6 Change Details: Clouds

Cloud-Top: completed (95%)

- Added Near Nadir versions of CTP, CTT, CEE, CF, and CTH (all aggregated by Day only, Night only, and Combined Day and Night) [15 parameters added]
- Added Low (>680mb), Middle(680-440 mb), & High Cloud (<440 mb) separation of CTP, CTT, CEE, CF, and CTH through finely binned Histograms (for CTP) and Joint Histograms vs. CTP (for remaining 4 parameters). Note that this was done for both the near nadir aggregation as well as the heritage (full view angle) parameters. Also, all were aggregated by Day only, Night only, and Combined Day and Night [24 joint histograms added & 6 marginal histograms added]
- Added eleven new Surface Type Fractions and Pixel Counts in the Cloud Top Property retrieval space. [11 parameters added]
- Added Joint Histogram of Cloud Phase (Baum) vs. CTP Near Nadir for Day and Night. [2 joint histograms added]
- Added Joint Histogram of Near Nadir CTP (5 km avg) vs. CTP (1 km sampled) for Day and Night. [2 joint histograms added]

MOD08 Collection 6 Change Details: Clouds, cont.

Cloud Optical Properties: ongoing

- Delete all QA Confidence Flag related statistics from all Cloud Optical Property parameters. [many SDS's deleted]
- Add Partly Cloudy (PCL) versions of COT, CER, CWP, CF (for primary 2.1 µm retrieval) for Liquid, Ice, Undetermined, and Combined. [14 parameters added]
- Delete all Combined Effective Radius and Combined Water Path parameters. [2 parameters deleted]
- Change all "Cloud_Fraction_(Phase)" parameters to "Cloud_**Retrieval_**Fraction_(Phase)" [10 parameters renamed]
- Add Partly Cloudy (PCL) versions of COT, CER, CWP, CF (for 1.6/2.1 retrieval) for Liquid & Ice only. [8 parameters added]
- Add Standard and Partly Cloudy (PCL) versions of COT, CER, CWP, CF (for 1.6 µm retrieval) for Liquid & Ice only. [16 parameters added]
- Add Standard and Partly Cloudy (PCL) versions of COT, CER, CWP, CF (for 3.7 µm retrieval) for Liquid & Ice only. [16 parameters added]

MOD08 Collection 6 Change Details: Other

Solar and Sensor Geometry: completed

- Added Solar and Sensor Angles aggregated using Cloud Top Properties definitions of Day and Night. [8 new parameters added]
- Modified the heritage Solar and Sensor Angle parameters to be a true combined D+N so comparison can be made with combined D+N products in L3. [4 parameters modified]

Water Vapor

- No Changes

Cirrus Reflectance

- No Changes

Atmospheric Profiles

- No Changes

Collection 6 Schedule

- MYD02 1km re-registration test w/Wolfe kernel in process
- Science Test 15 submitted to MODAPS
  - All test descriptions and results posted to public site http://modis-atmos.gsfc.nasa.gov/team/pge06_test_details.html
- MOD06 Remaining Science Test
  - Cloud retrieval thermodynamic phase (Science Test 16)
  - User guide to C6 changes in development. Webinar rollout.
- MOD08
  - All SDS code updates other than MOD06 optical properties have been completed (MOD06 CT requires testing).
  - Change in 'Definition of Day' algorithm determined, to be implemented
- MODATML2
  - TBD

C6 Level 1 & Atmosphere Algorithm Status

PGE02 L1B radiances	Full reprocessing complete; running in parallel with C5 Reviewing Aqua 1km aggregation / deregistration fix
PGE03 cloud mask & profiles	Full reprocessing complete; running in parallel with C5 Would be impacted if (Aqua) MYD021KM updated
PGE85/55/81 clear-sky radiance	C6 codes tested and ready
PGE04/05 aerosols & water vapor	Deep Blue ready (Aqua) ; testing continues (Terra) Dark Target final testing; 3 km product is ready
PGE06 cloud properties, cirrus	Cloud Top properties code tested and ready Cloud Optical properties final testing continues
PGE83 L2 subsets & browse	Minimal changes, parameter name updates
PGE107/108 L2 global browse	C6 parameter updates complete, enhancing post-processing system to produce 5-10TB C6 archive
PGE69/56/70/57 Level 3	Cloud Top, Aerosol parameter updates complete Cloud Optical parameter updates in process Definition-of-day change: coding in process Browse post-processing updates in process