

# What to expect from the Collection 6 MODIS aerosol products

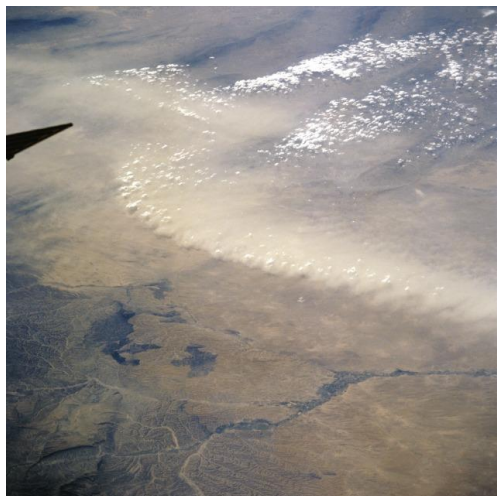
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ICAP-2013



Tsukuba City, Ibaraki, Japan, November 2013

## MODIS aerosol: Relationship with ICAP

- We count ICAP investigators as our product “super-users”.
- Between NRL, GMAO and ECMWF, your teams know our product very well.
- So when you tell us we have biases and weaknesses in our product, we try to fix.

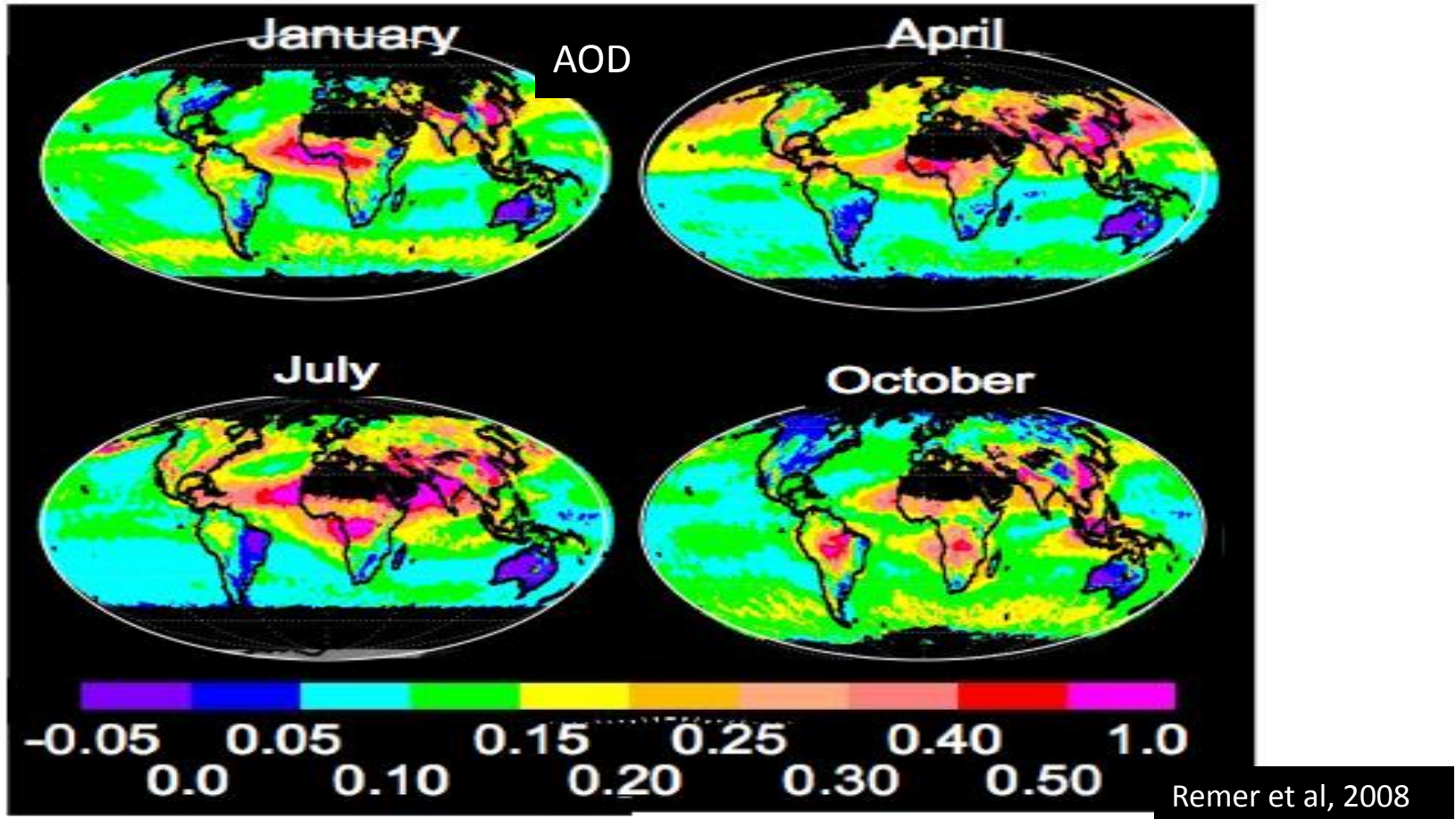


# A MODIS view of global aerosol system (over dark targets)

## Collection 5

As envisioned by Y. Kaufman and D. Tanré

And produced by the MODIS-aerosol team at NASA GSFC



We have two sophisticated sensors (aboard Terra and Aqua), with stable orbits, excellent calibration teams and validated aerosol retrievals.

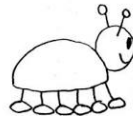
But we always want to do better.

# What was the original C6 plan?

- Even before 2010, our “super-users” complained. Based on Collection 5:
  - MODIS bias was unacceptably large over many regions (southern oceans, western US)
  - There were trends in MODIS-derived AOD over the globe that were not confirmed in other datasets
  - Other than “global comparison against AERONET”, product uncertainties were not well understood.
- We planned to fix these and other issues for C6.

# Why has C6 production been so difficult?

- We have been discussing C6 development for over three years now
- It was proposed as a “maintenance and modest refinement”
- Yet, three years later, still not operational ☹️
- At least there are some good excuses
  - All MODIS science teams must be satisfied
  - Terra re-calibration has been extra tricky
  - Other “upstream” products (geo-location/cloud mask) have been revised
  - Operational architecture/infrastructure/politics/people has been changed.
  - There are always bugs.
  - Government shutdown



Trying to get C6 product finished is like...:



Video found on You-Tube  
Note: no harm to cat

# Overall Dark target algorithm updates

In proof for AMT!

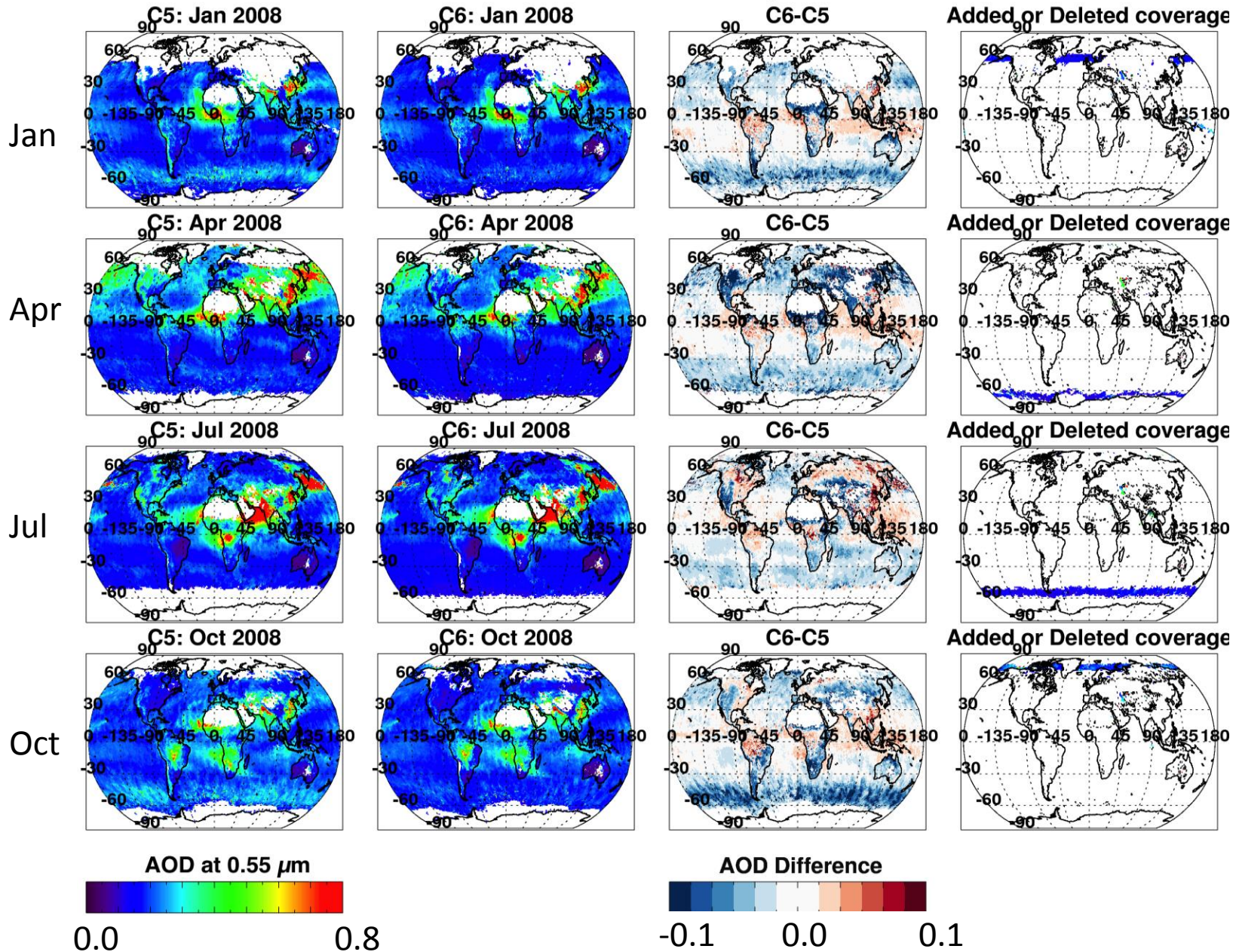
- [Levy, R., S. Mattoo, L.A. Munchak, L.A. Remer, A.M. Sayer, and N. Hsu](#) (2013). The Collection 6 MODIS Aerosol Products over Land and Ocean *Atmos. Meas. Tech. Disc.* (6), 159-259



# Outline

- “Overall” changes (C6 versus C5)
- “incremental” updates (and rationale behind)
- Ocean versus Land
- Some preliminary validation (for Aqua)
- Terra versus Aqua
- Level 3 protocol
- Loose ends

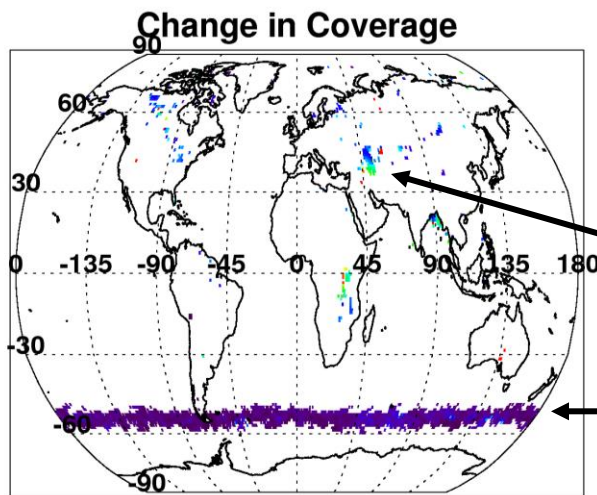
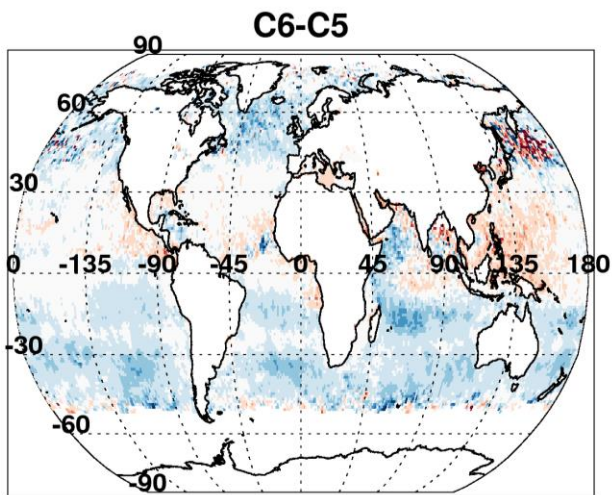
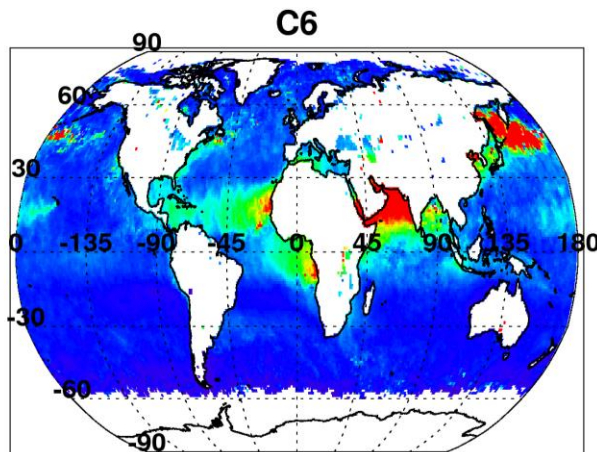
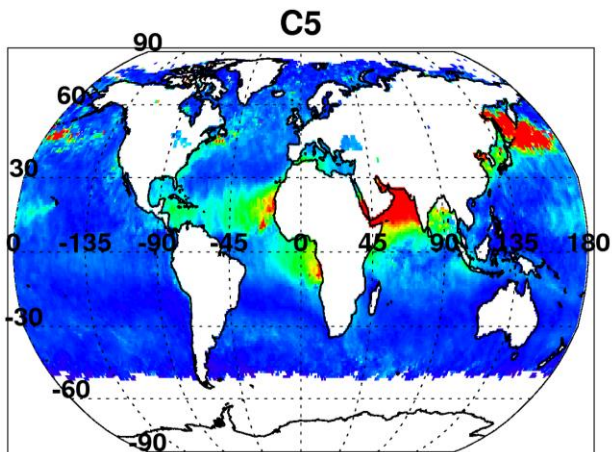
# Overall changes (C6 vs C5): Aqua, 2008



# Aerosol over ocean

# Dark target over ocean

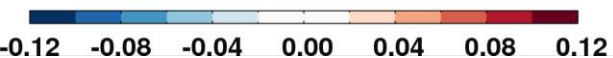
## Overall changes to products (Aqua, Jul 2008)



- Overall decrease of AOD in mid-latitudes
- Strong decrease in “roaring 40s” (even stronger in other months)
- Overall increase in tropics

- “New” coverage over inland lakes
- Increase in coverage toward poles

AOD Difference



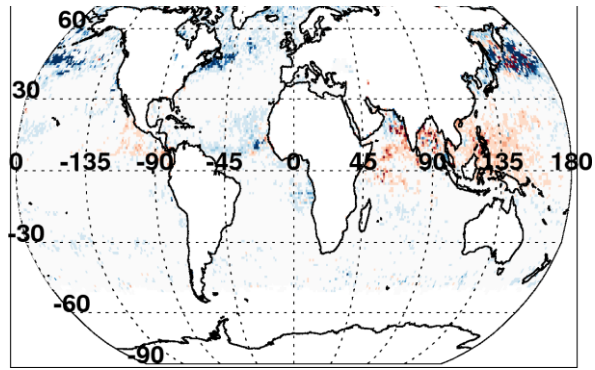
AOD at 550 nm



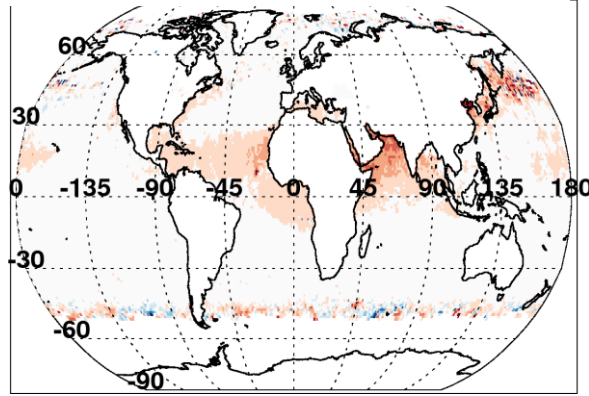
Why the changes?

# C6-C5 ocean: Due to many incremental changes (Aqua, July 2008)

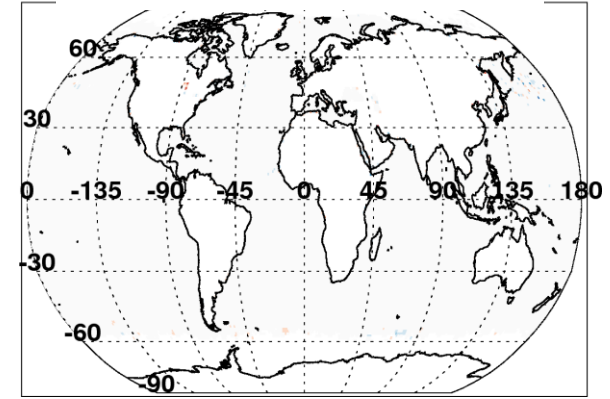
New reflectance, geo-location inputs, Wisconsin cloud mask



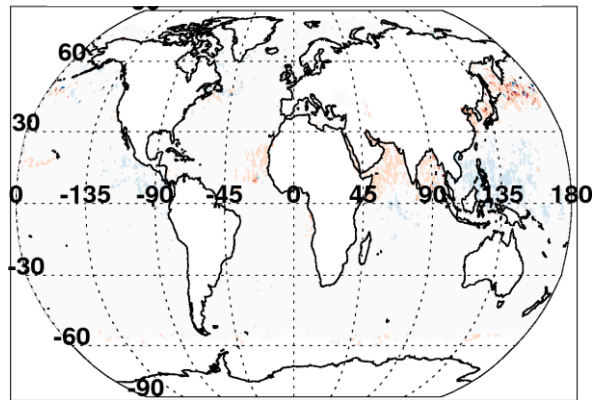
Updated radiative transfer



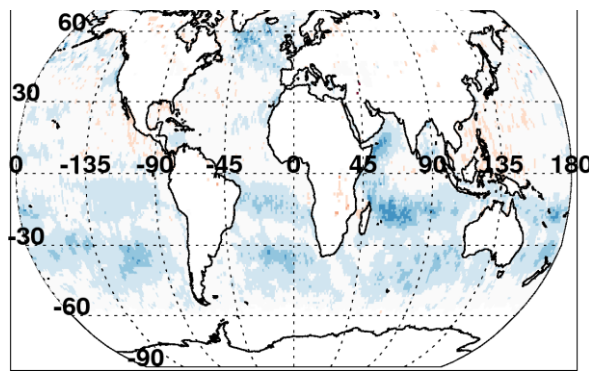
Re-define land and sea



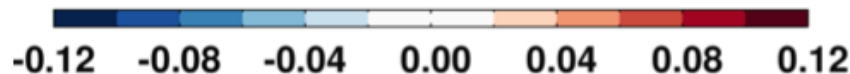
Improved cloud mask



Account for wind speed impact on surface

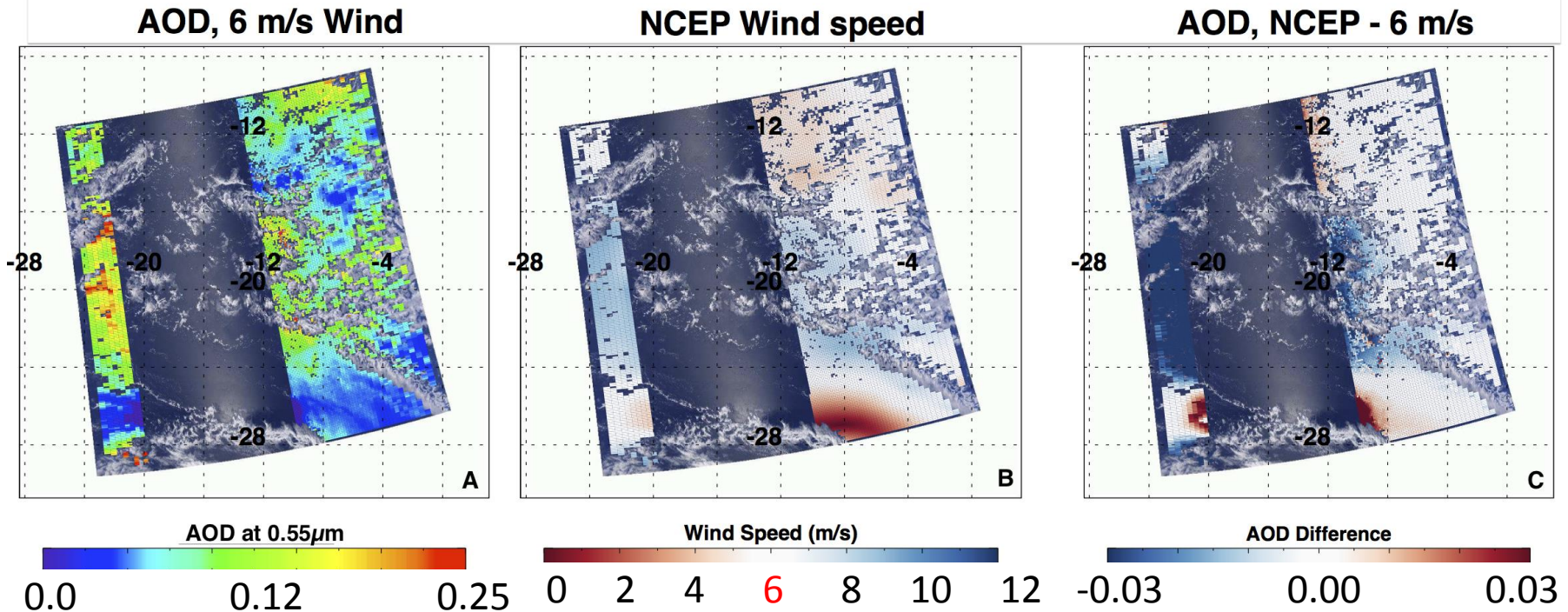


AOD Difference



- Also changed “Quality Assurance” Filtering
- Changed aerosol definitions of land and sea
- Etc

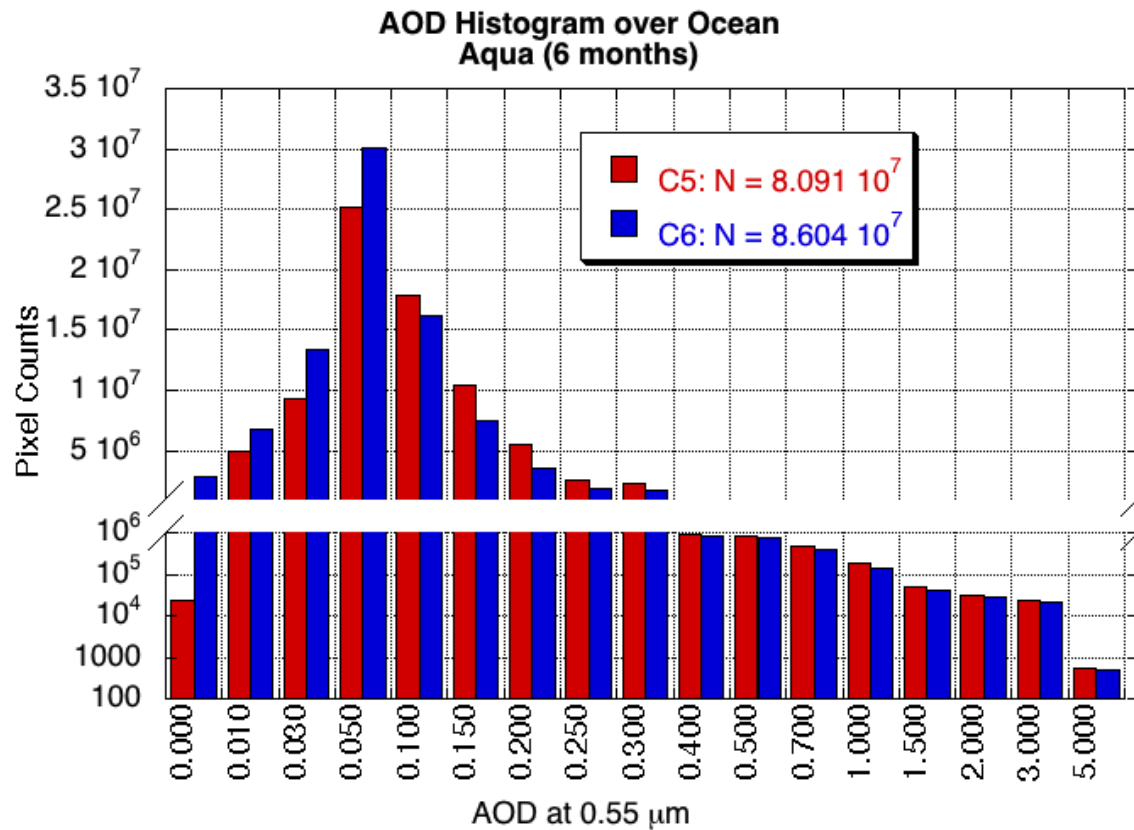
# Biggest “science” change for C6: Introduce wind speed dependence (ocean)



- Higher wind speeds  $\rightarrow$  more ocean foam and diffused glitter pattern
- C5: Aerosol LUT calculated for 1 wind speed (6 m/s).
- C6: LUT calculated for 4 wind speeds ( $v=2, 6, 10, 14$  m/s)
- Retrieved AOD is reduced when  $v > 6$  (increased when  $v < 6$ )
- Reduces AOD near  $40^\circ$  glint mask edges and in “Roaring 40s” of south Oceans.
- MODIS now in line with other satellite algorithms (VIIRS, SOAR on SeaWiFS)<sup>15</sup>

# Example of “minor” update with major impact

## Quality assurance over ocean



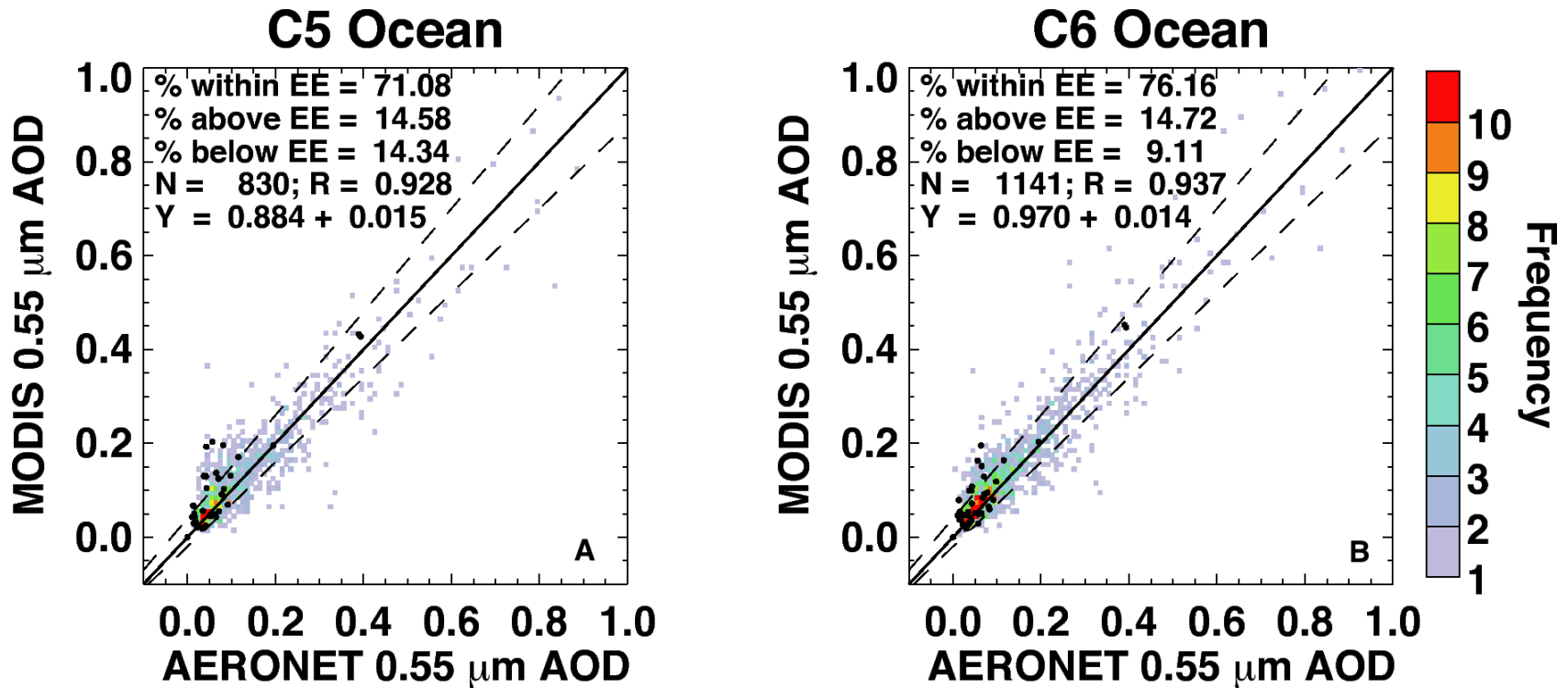
- Old (C5): Quality assurance depends on success of a retrieval solution. If aerosol signal is too small, then do not include in daily/monthly statistics.

New (C6) : Sometimes signal is small, but we are confident that it is small. Include in daily/monthly statistics.

- But “major” influence on estimating regional and global mean AOD

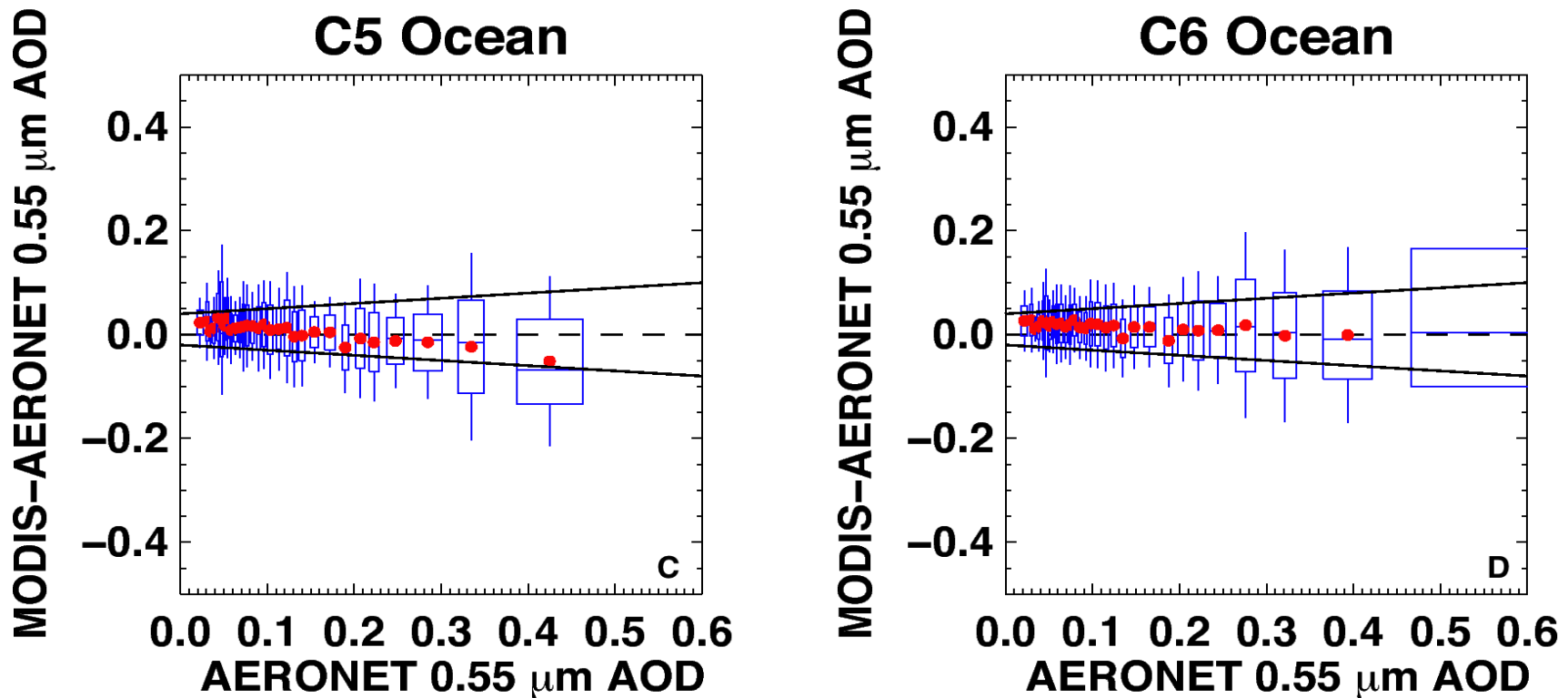


# Comparison with AERONET and MAN



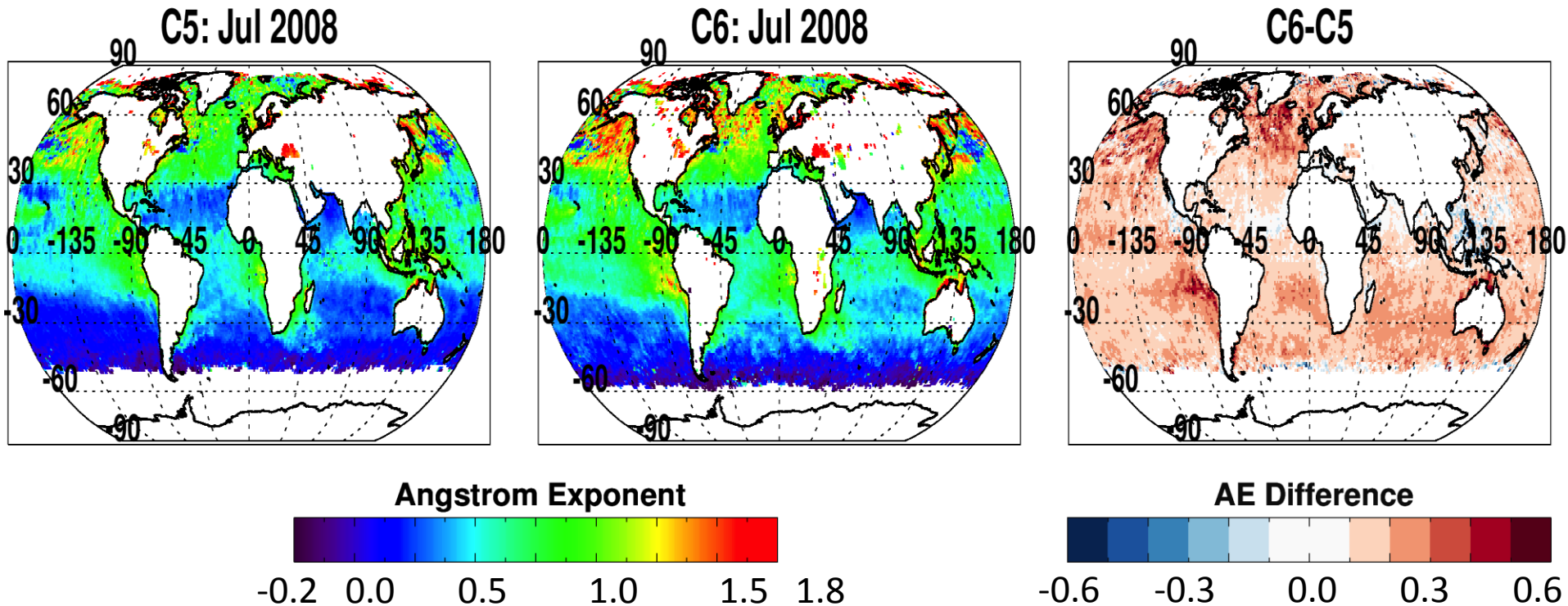
- Aqua for 8 months (Jan + July, 2003, 2008 and 2010; Apr + Oct 2008).
- Overall, not much change over ocean (slope, intercept, correlation)
- But 30% more valid points to compare with (1141 versus 830).
- AERONET are gray and colored, MAN are black dots

# Better way to see MODIS improvement



- MODIS error (MODIS-AERONET) versus AERONET; zero “error” is dashed line
- Boxes represent middle 67% of each dataset, whiskers are middle 95% of MODIS-AERONET
- Solid lines are “expected error” (EE) envelope; note asymmetry (new definition for C6).
- Note that in C6, that the MODIS error is within EE for nearly all bins of AOD
- C5 EE =  $\pm(0.03 + 5\%)$ . C6 EE =  $(-0.02 - 10\%), (+0.04 + 10\%)$

# Impact on Ångström Exponent

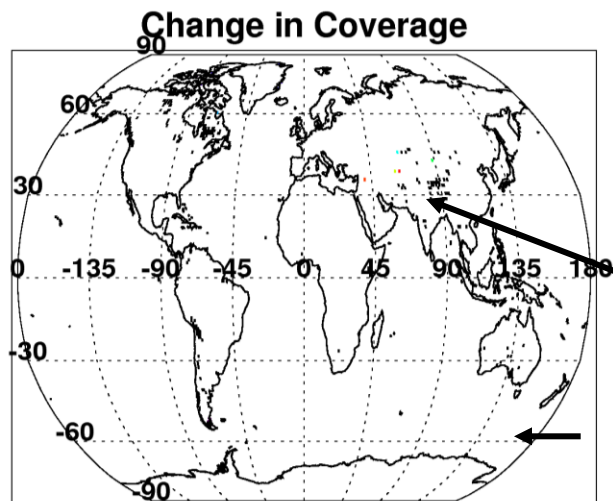
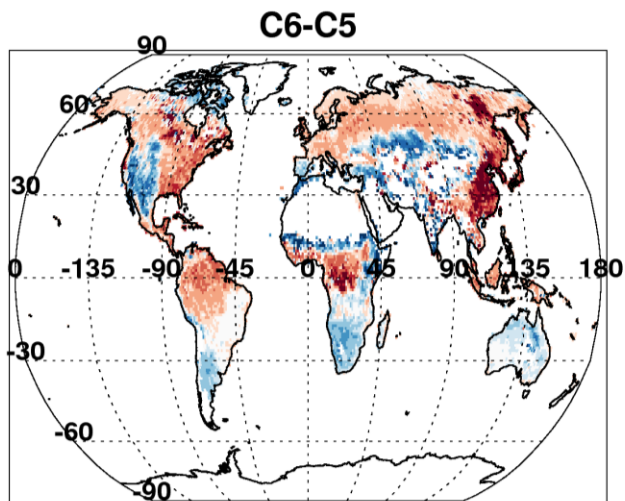
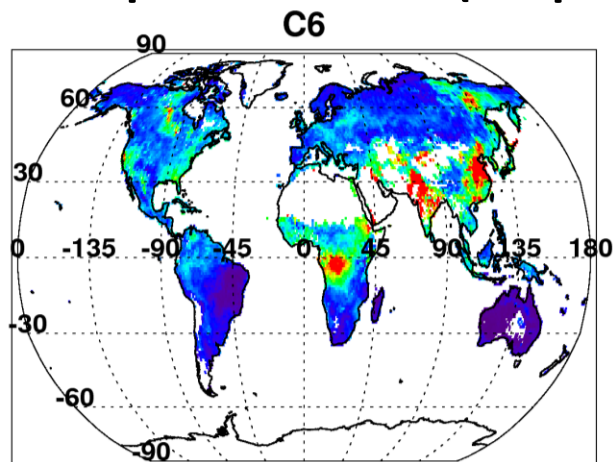
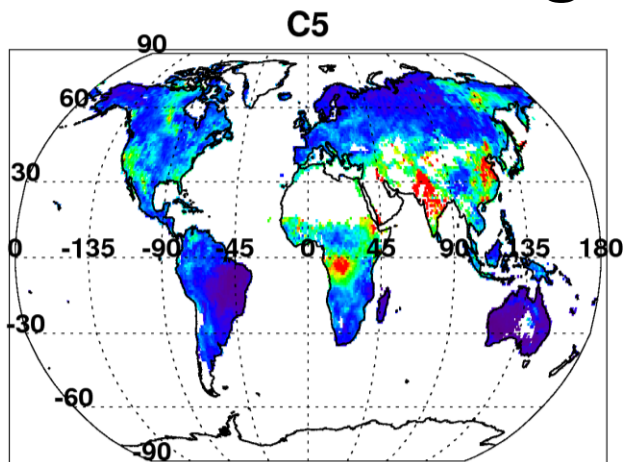


- Comparison is for Aqua
- Overall increase of global AE (+0.18).

# Aerosol over land

# Dark target over land

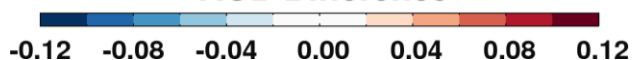
## Overall changes to products (Aqua, Jul 2008)



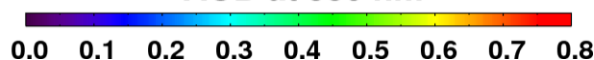
- Overall decrease of AOD in semi-arid
- Overall increase over vegetation
- Strong increase over Eastern Asia

- Slight change in coverage here and there

AOD Difference



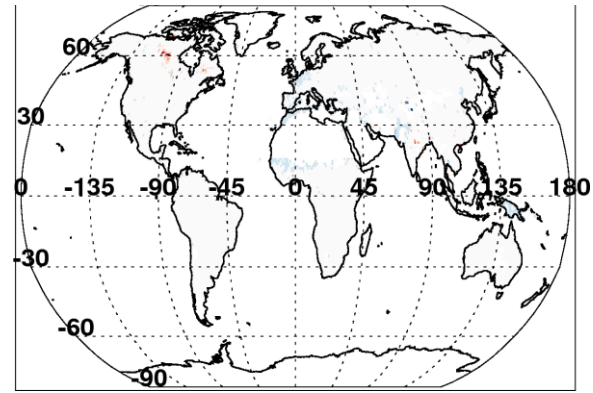
AOD at 550 nm



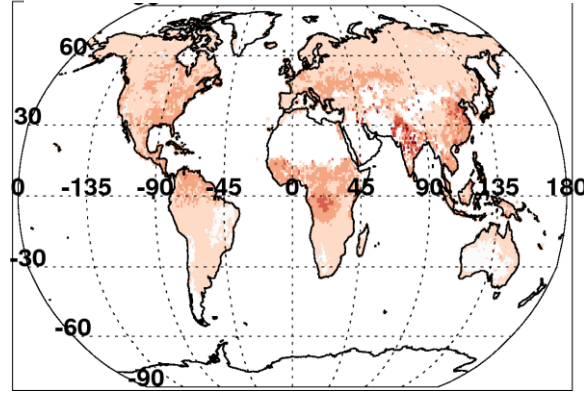
Why the changes?

# C6-C5 land: Due to many incremental changes (Aqua, July 2008)

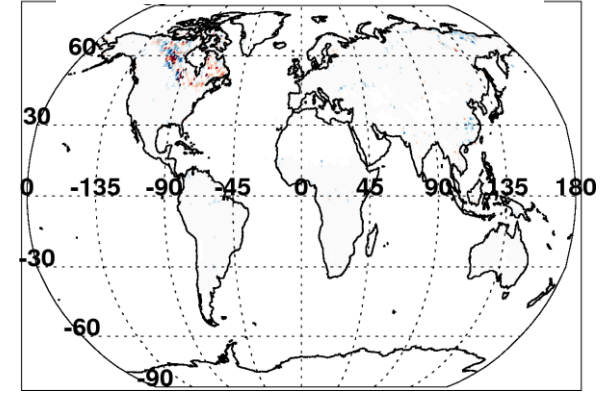
New reflectance and geo-location inputs



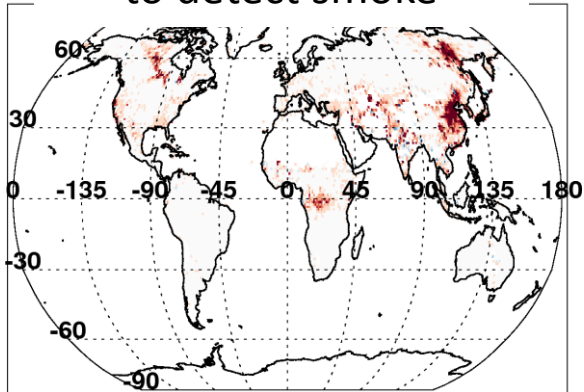
Updated radiative transfer



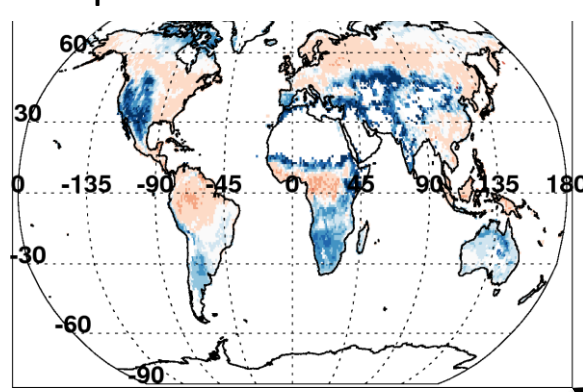
Re-define land and sea



Improved cloud mask to detect smoke

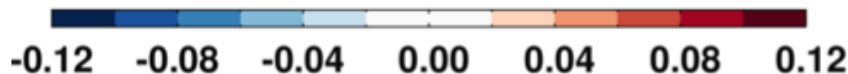


Fixed surface reflectance dependence on TOA NDVI



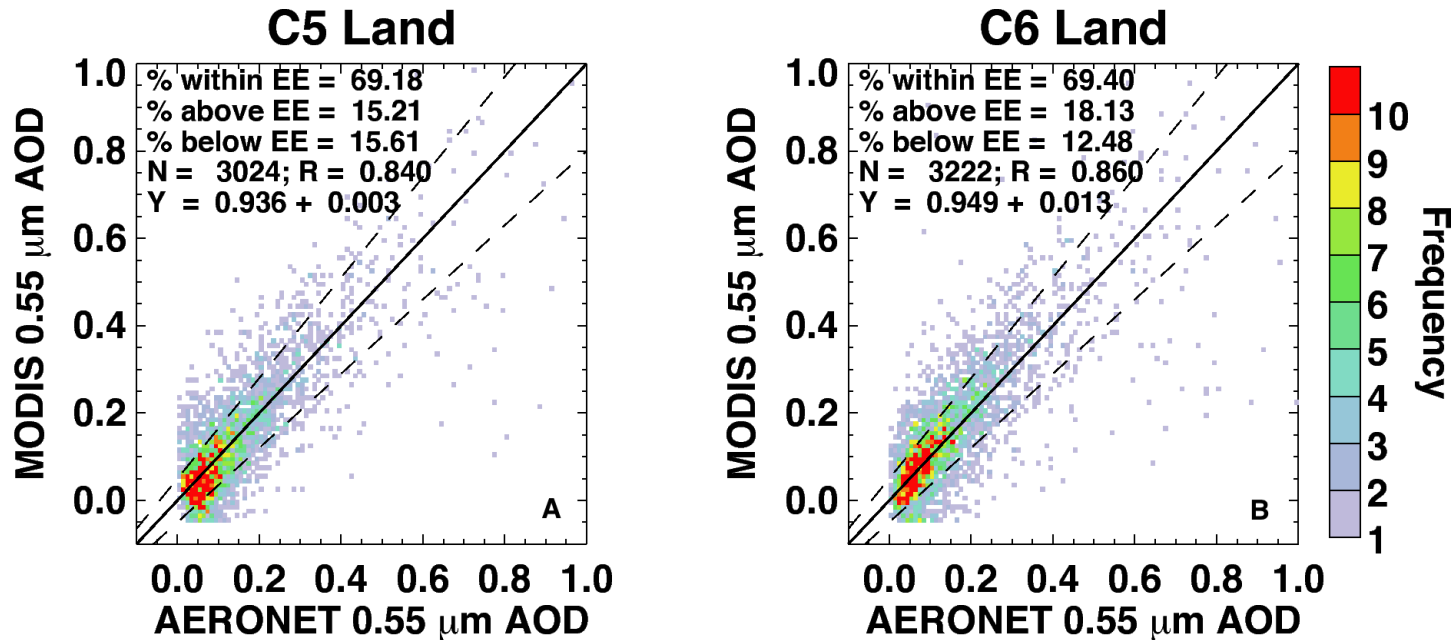
- Also changed “Quality Assurance” Filtering
- Changed aerosol definitions of land and sea
- Etc

AOD Difference



This was a major bug!

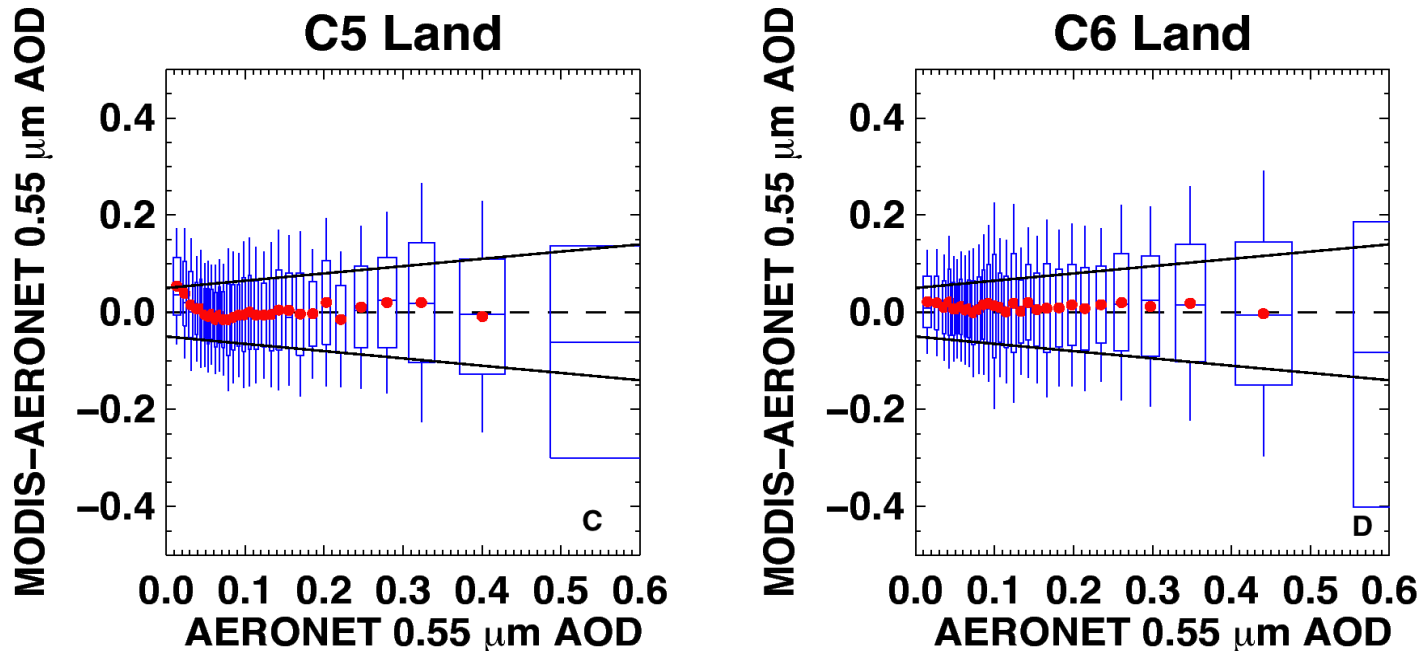
# Comparison with AERONET



- Aqua for 8 months (Jan + July, 2003, 2008 and 2010; Apr + Oct 2008).
- Overall, not much change over land (slope, intercept, correlation)
- 8% more valid points to compare with (3222 versus 3024).
- More “spread out” along 1-1 line near zero.



# Better way to see MODIS improvement

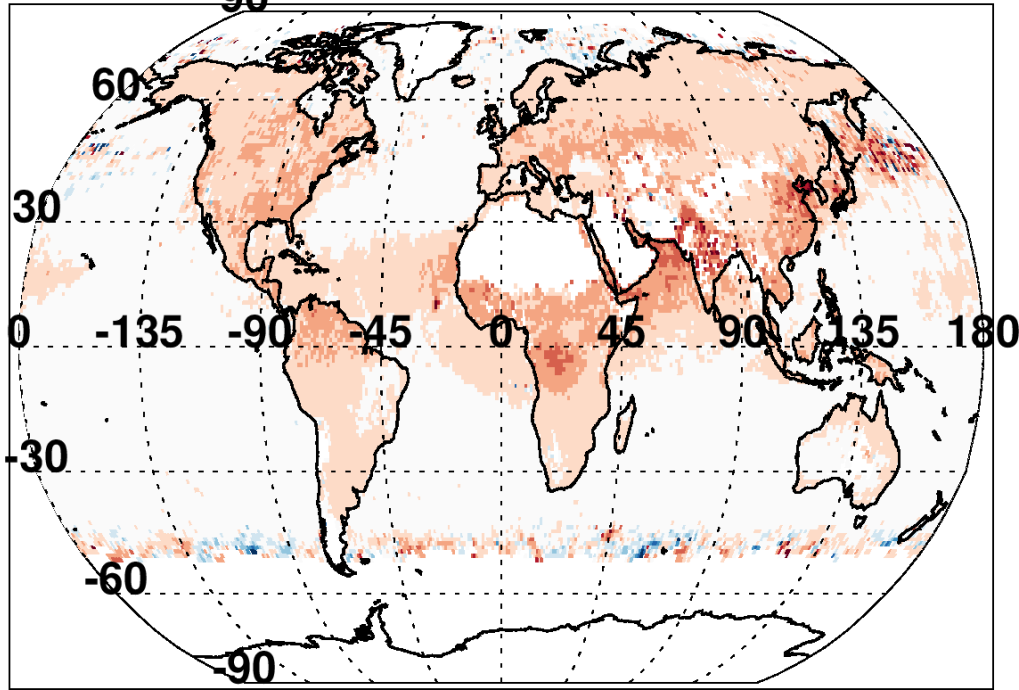


- MODIS error (MODIS–AERONET) versus AERONET; zero “error” is dashed line
- Boxes represent middle 67% of each dataset, whiskers are middle 95% of MODIS-AERONET
- Solid lines are “expected error” (EE) envelope; no asymmetry
- C6 MODIS error is within EE for nearly all bins of AOD (even at low values)
- C5 EE =  $\pm(0.05 + 15\%)$ . Keep definition for C6.

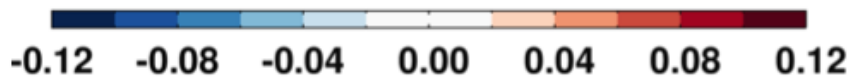
# Other details

# What do we mean by RT updates?

## C6Gas&LUT - C5Gas&LUT

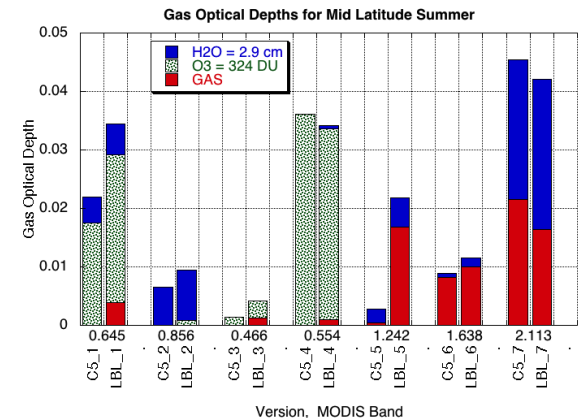


### AOD Difference



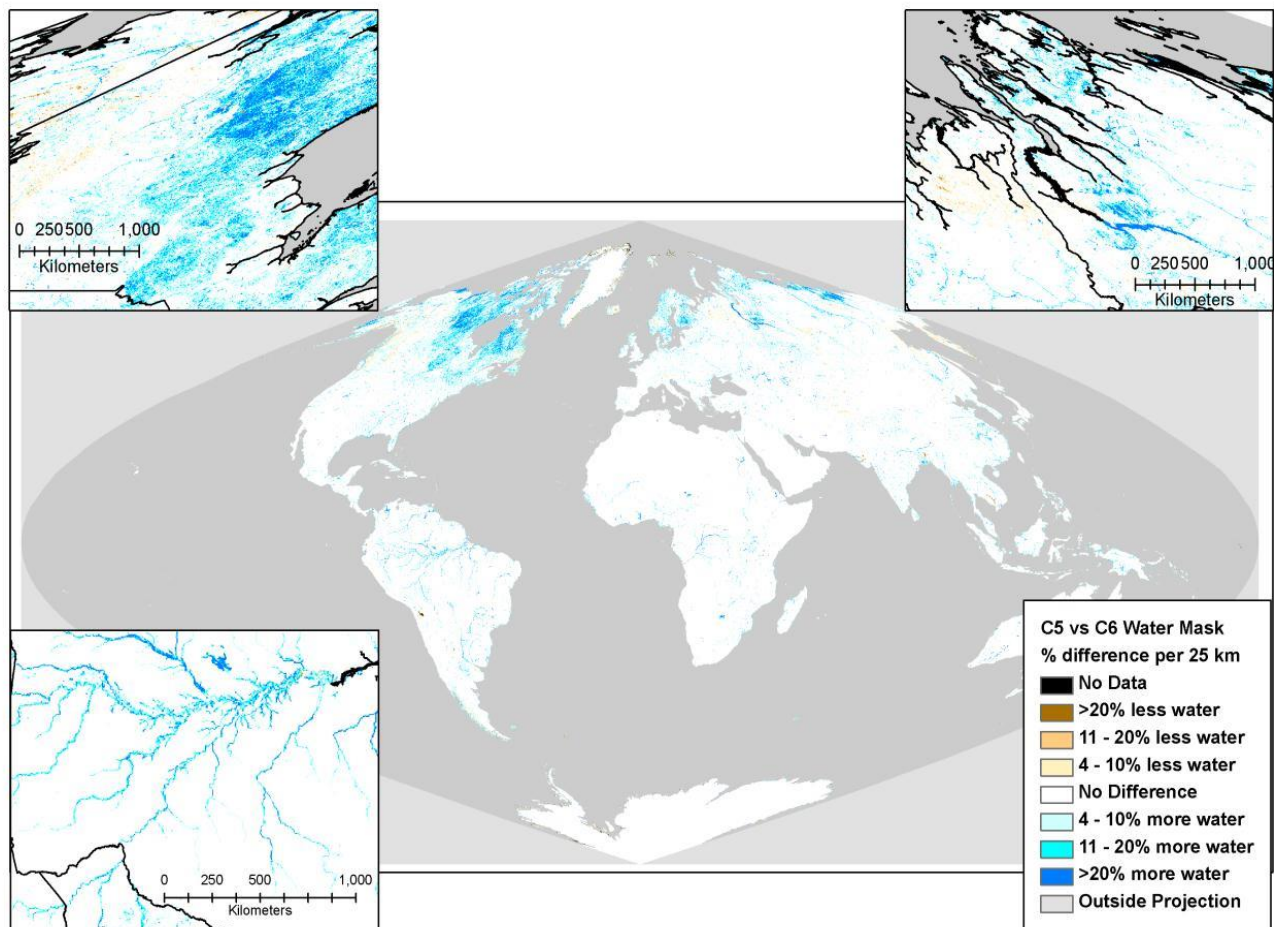
C5: Center wavelengths: pre-launch assumptions (1999)  
 C5: Gas correction: circa 1997 (no documentation)

- Recalculate “center wavelengths” from MODIS filter functions
- Ensure consistency between land and ocean retrievals
- Recalculate gas absorption coefficients and optical depths for H<sub>2</sub>O, O<sub>3</sub>, CO<sub>2</sub>, NH<sub>3</sub>, O<sub>2</sub>, etc.
- (now use LBL-AER code)
- Extend valid solar zenith angle from 72° to 84°.



# What do we mean by re-define Land/Sea ?

## Differences between C5 and C6 water mask for MODIS

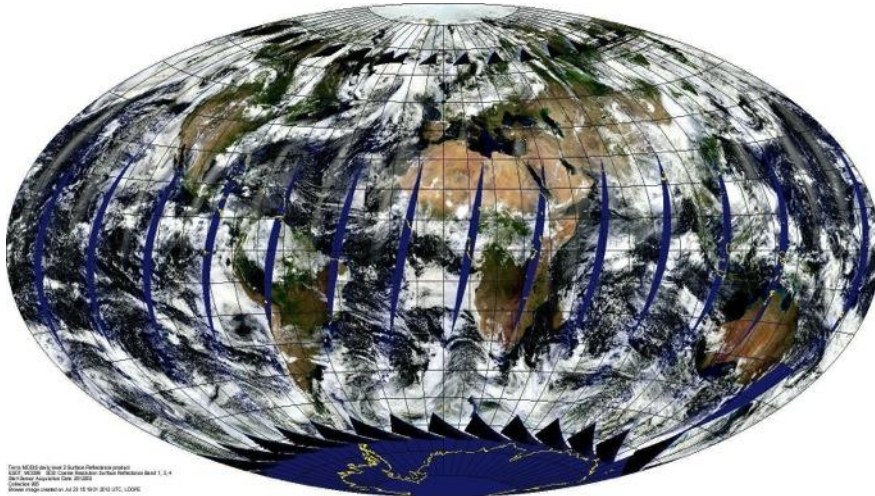


- Aerosol retrieval reads flags from “upstream” files, to guess whether land or ocean
- In C5, “coastal” was rare. It was treated as land, and NDVI test was used to deselect water pixels
- C6 uses much higher resolution database
- For C6, “coastal” is ubiquitous, especially near high-latitude lakes.

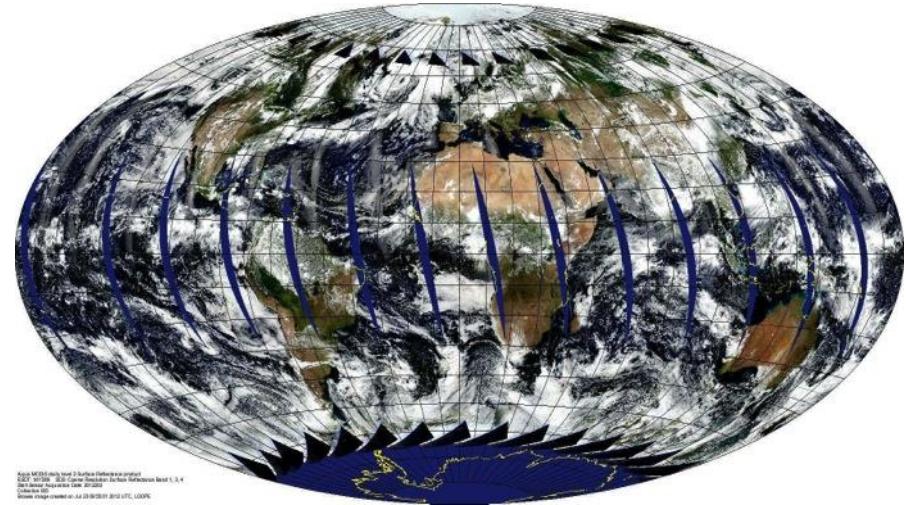
Finally, calibration issues

# MODIS instruments = “identical twins”

Terra (10:30 Local Time, Descending)



Aqua (13:30 Local Time, Ascending)

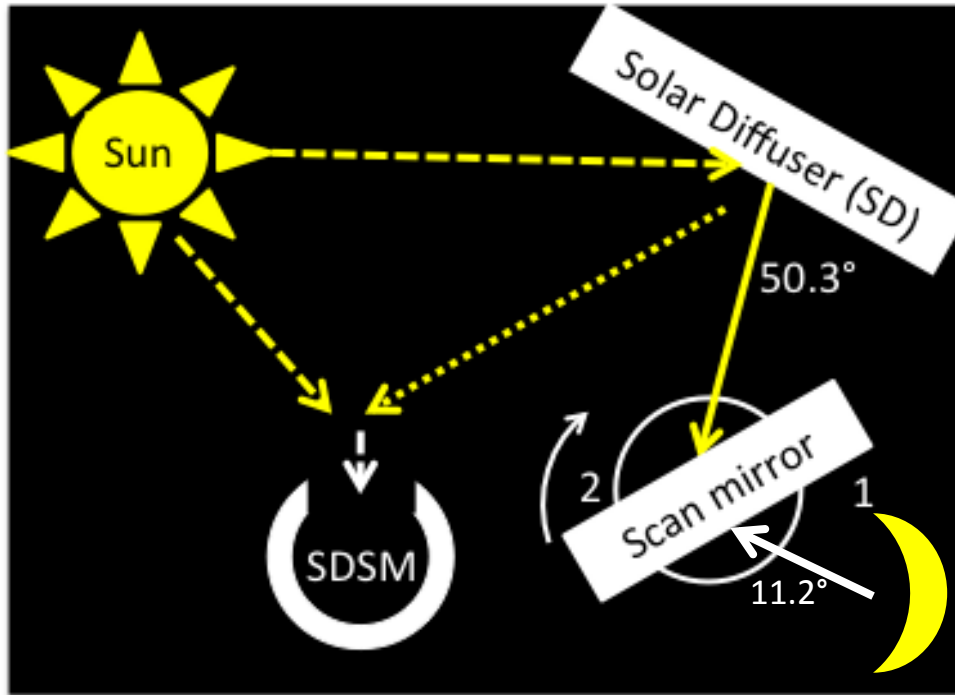


Like human twins:

- Each instrument has had a different life experience (pre-launch, during-launch, during orbit)
- They see the same world, but from different perspective
- Different *aging* patterns (for optics, sensor characteristics, electronics)

MODIS Calibration & Support Team (MCST) works very hard!<sup>30</sup>

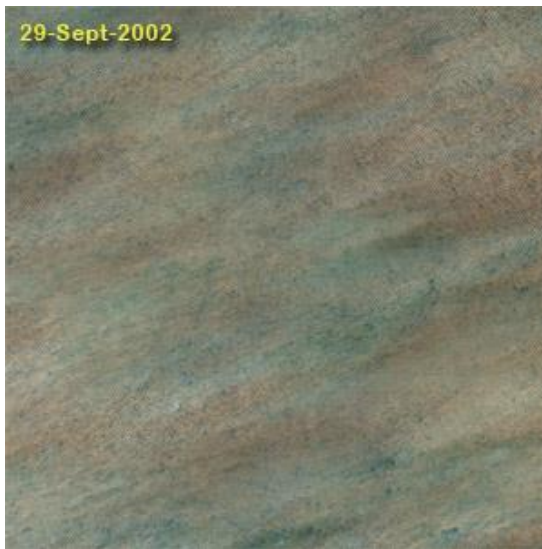
# Instrument calibration tied to pre-launch assumptions



- The BRFs of the Solar Diffuser (SD) and mirrors were characterized pre-launch.
- The Solar Diffuser Stability Monitor (SDSM) views the SD at a fixed angle.
- What if the BRF of Terra's SD/mirrors has changed? (Accumulation of "junk").
- Viewing only one angle would not be sufficient to monitor changing BRF.



# MODIS reflectance trends over desert sites



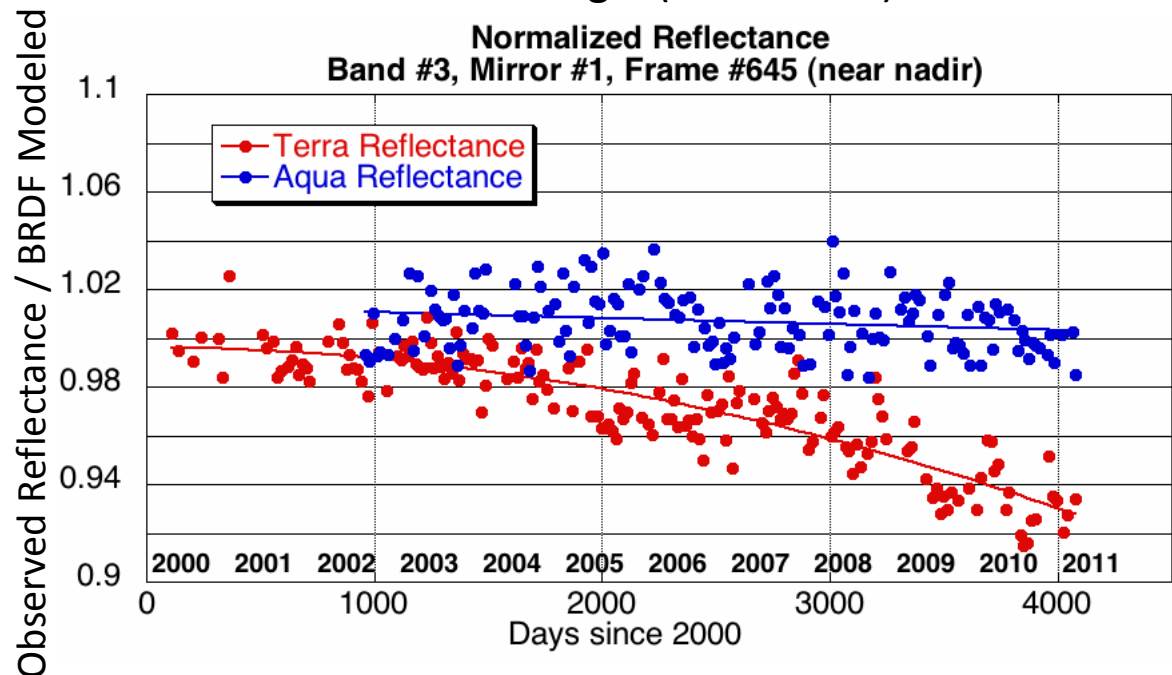
desert test sites



MCST (Sun, Xiong et al)

- (1) Collect clear-sky MODIS data over desert sites
- (2) Develop site-specific BRDF from first 3 years of mission
- (3) Over time, compare “observed” reflectance with BRDF modeled reflectance, for different view angles

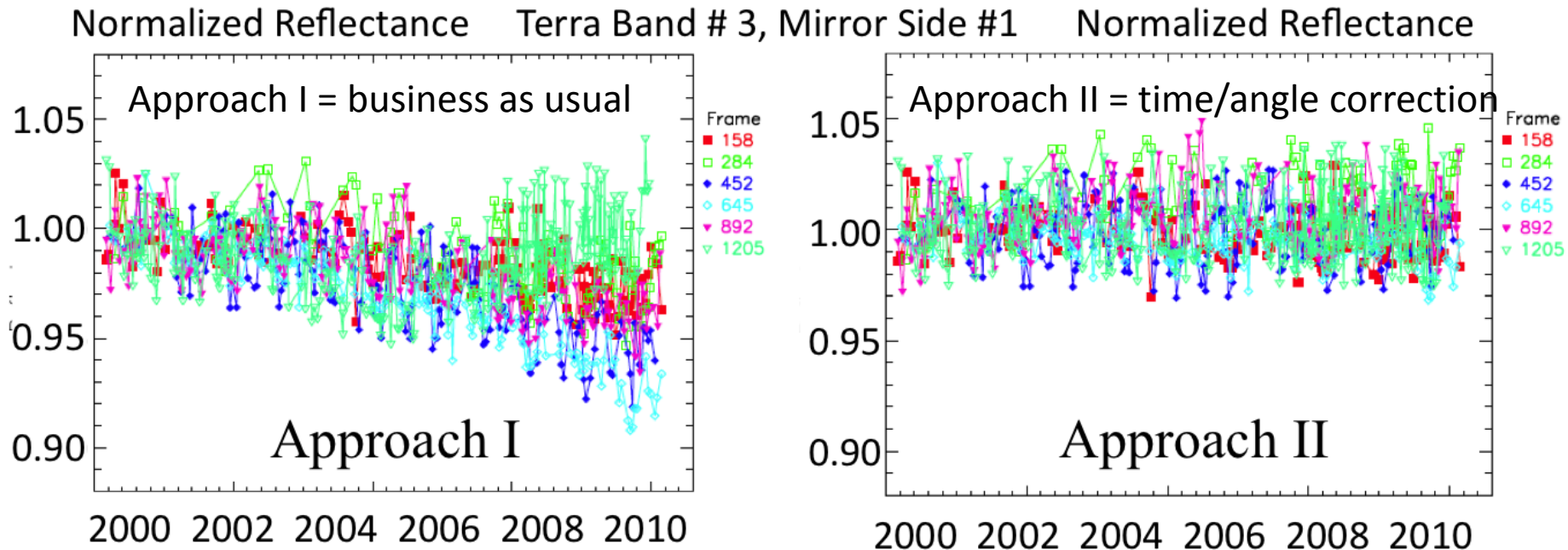
- Trends in Terra Band #3 ( $0.47 \mu\text{m}$ ). No trend for Aqua
- Trend varies with Scan Angle (or Frame #)



- (4) Apply de-trending algorithm to MODIS observations



# De-trend applied to C6: Removes the temporal/angular reflectance trends

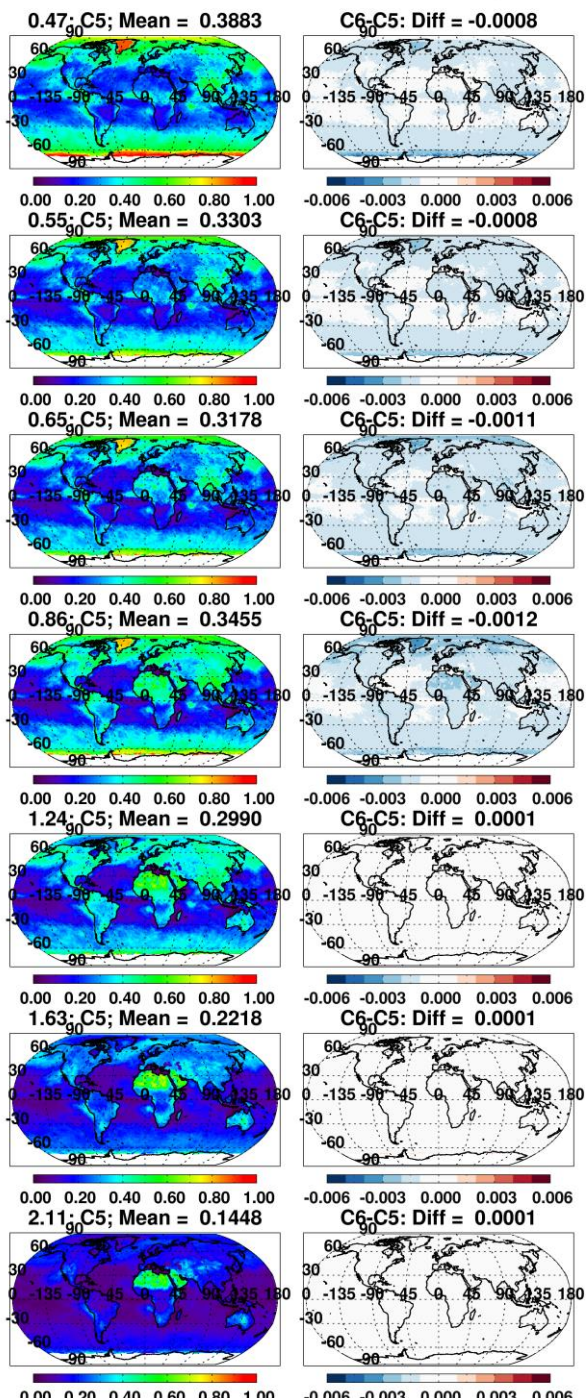


- B3 (466 nm)
  - 7% decrease near nadir
  - 0% change on right (near Moon)
  - 3% increase on left

MCST: Junqiang Sun

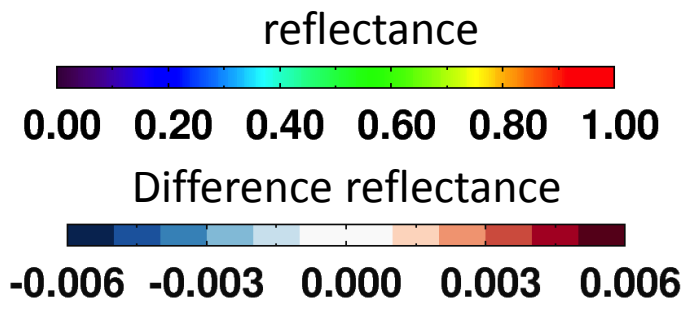
(5) Apply de-trended observations to aerosol retrieval algorithm

# L1B Reflectance: Jul 2008 Aqua

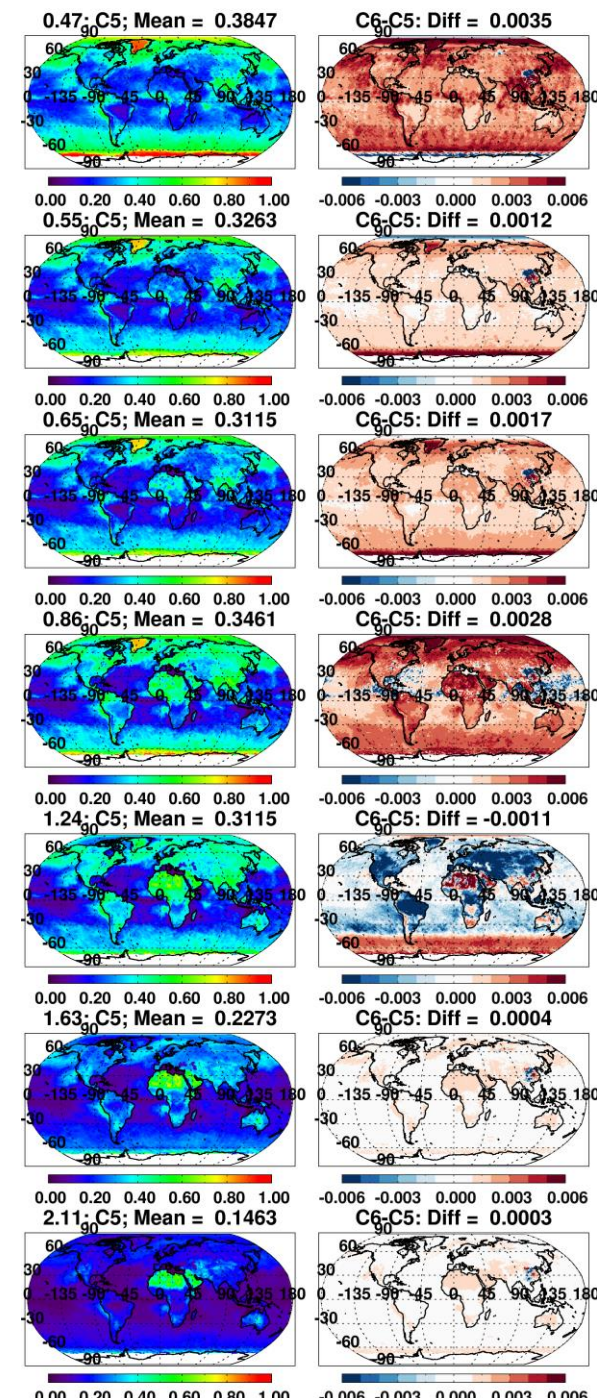


# Impact to “observed” reflectance

- “Global” Aqua changes in visible bands by -0.001 or less
- “Global” Terra changes in visible bands by +0.002 or more
- Overall Aqua changes are relatively stable, but Terra’s changes vary over time.

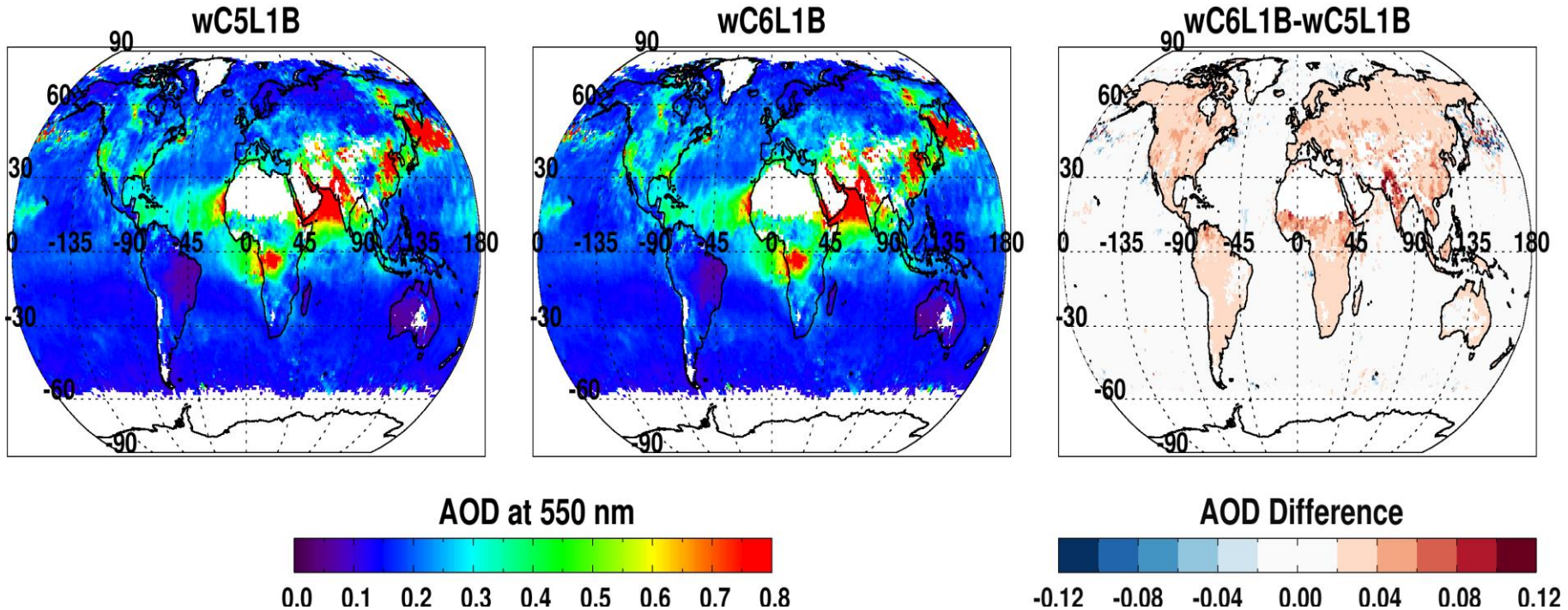


# L1B Reflectance: Jul 2008 Terra



# Impact of New Terra calibration

Jul 2008: Terra



- Big changes to blue and red bands
- Biggest impacts over land
  - Global increase by 0.02 (for this particular month). 10% of global mean!
- Smaller impacts over ocean
  - Global increase by 0.004 (for this particular month)

# MODIS: Climate Data Records (CDRs)?

“A time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change.”



From: Climate Data Records from Environmental Satellites: Interim Report (2004)

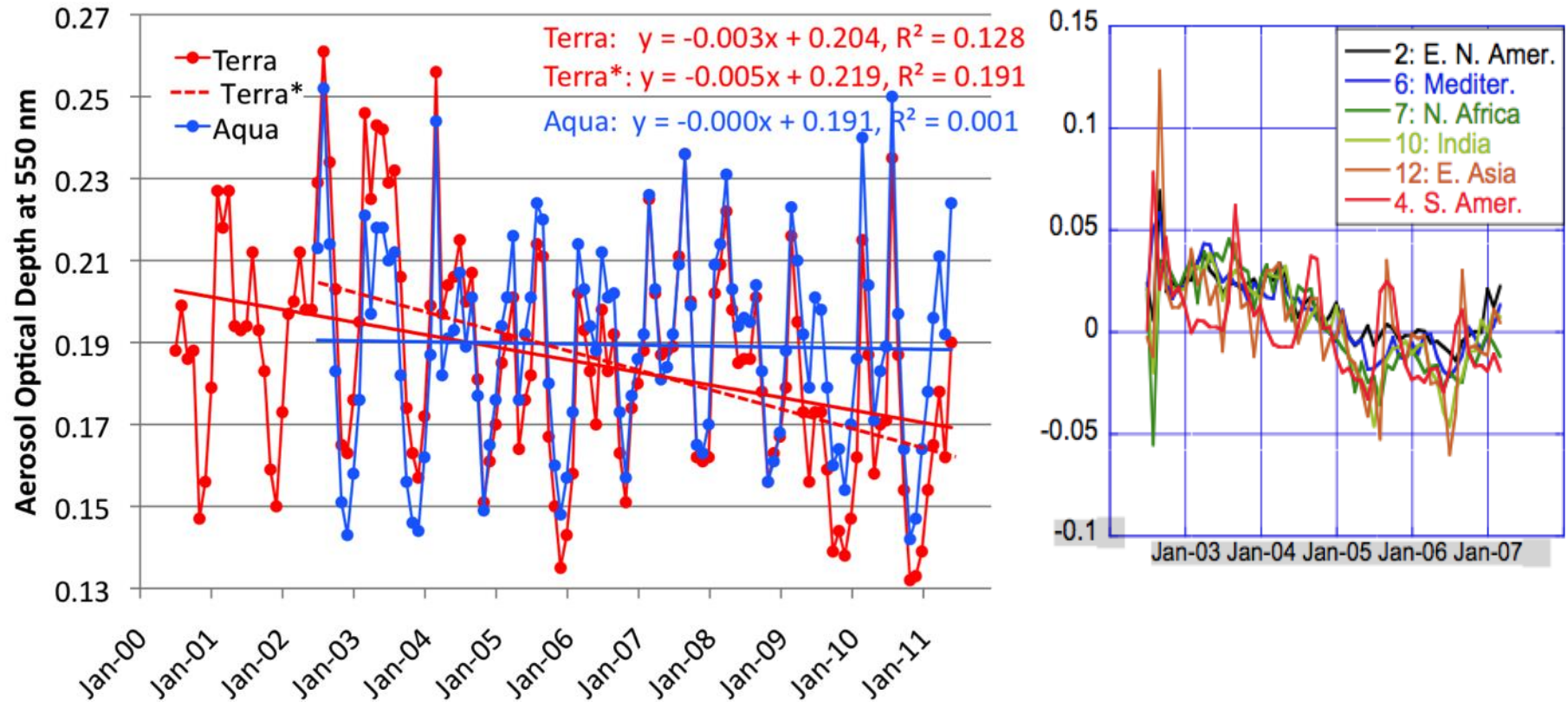
## Some requirements

- Measurements sustained over decades
- Measurement of measurement performance (e.g. calibration, stability)
- Acquired from multiple sensors / datasets

*Have we sufficiently characterized the MODIS aerosol product?*

# If we had used Collection 5

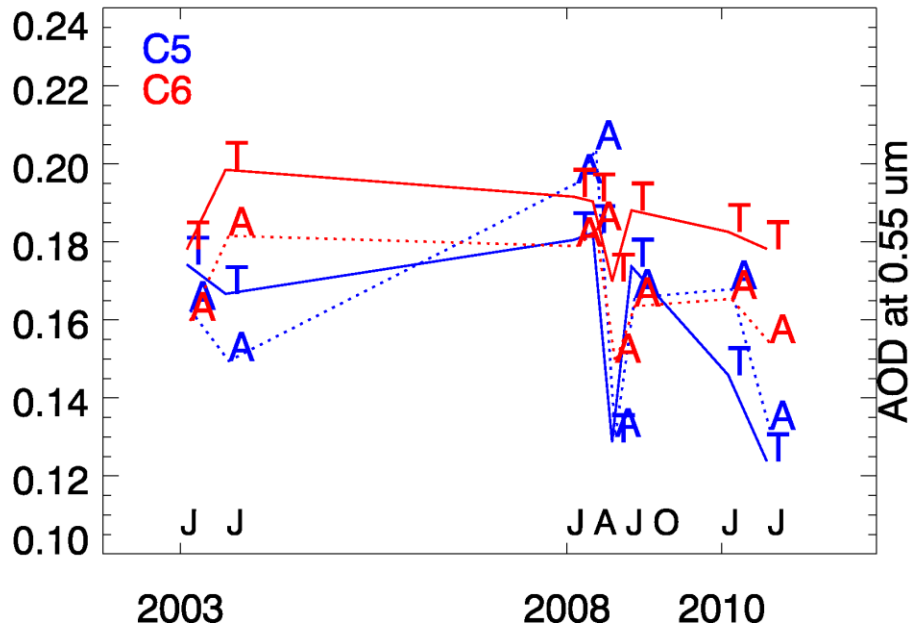
## MODIS AOD Monthly Mean - Land Only



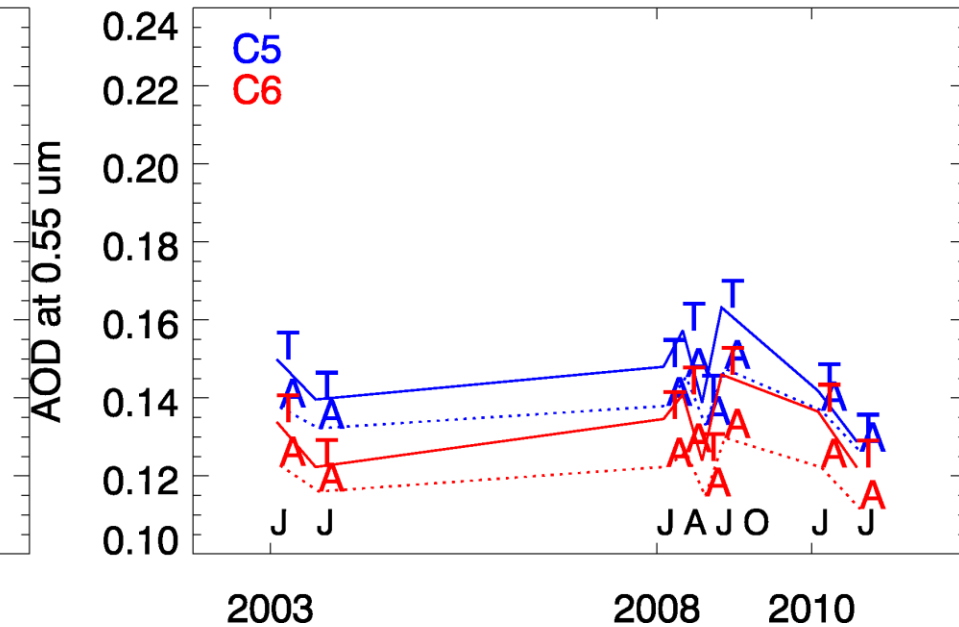
- Over land, **Terra** decreases (-0.04/decade), **Aqua** constant
- **Terra** / **Aqua** divergence is the same everywhere on the globe!
- In NH, observations are 1.5 hours apart, while SH are 4.5 hours
- So, probably not due to diurnal cycle of aerosol

# Impact of new calibration on trend

Global mean AOD: land



Global mean AOD: ocean

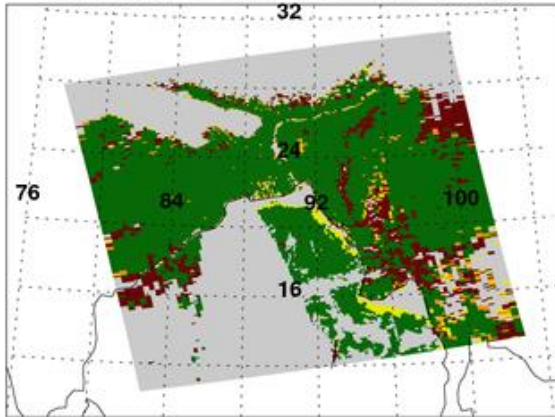


- 8 months processed with same dark-target aerosol algorithms
- Terra (T) Approach II now “in sync” with Aqua (A) time series
- (Terra-Aqua) offset remains 0.01 (ocean) and 0.015 (land)
- Aqua AOD reduced from 0.14 to 0.12 over ocean
- **New calibration → Terra/Aqua divergence removed for C006!**<sup>38</sup>

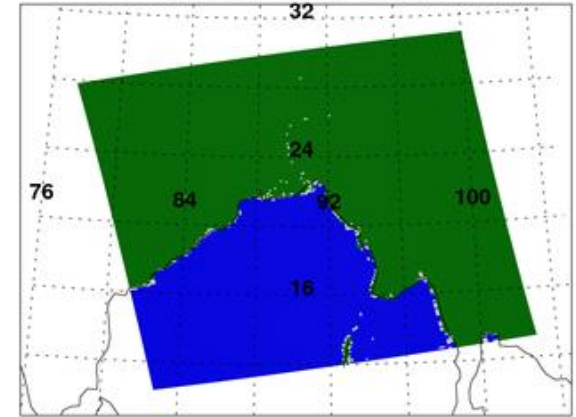
# What else for C6 Level 2?

# Diagnostic SDSs

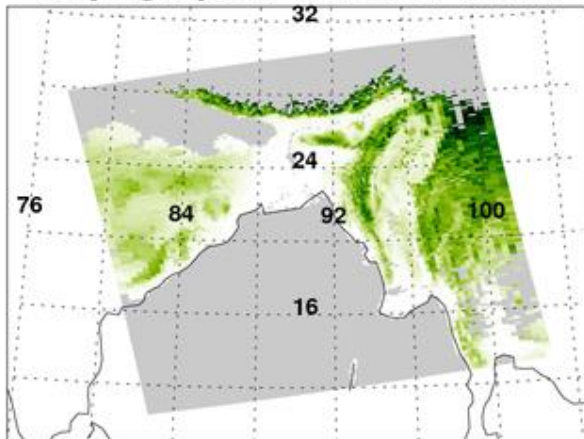
## Land\_Ocean\_Quality\_Flag



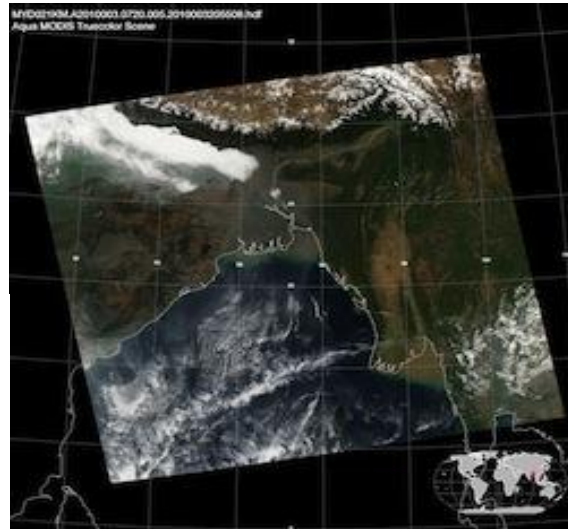
## Land\_Sea\_Flag



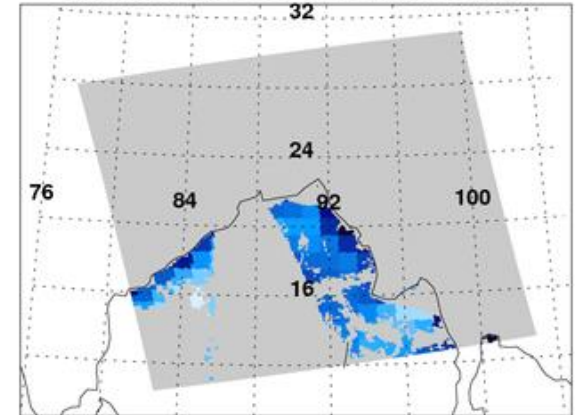
## Topographic\_Altitude\_Land



Surface Height [km]



## Wind\_Speed\_Ncep\_Ocean



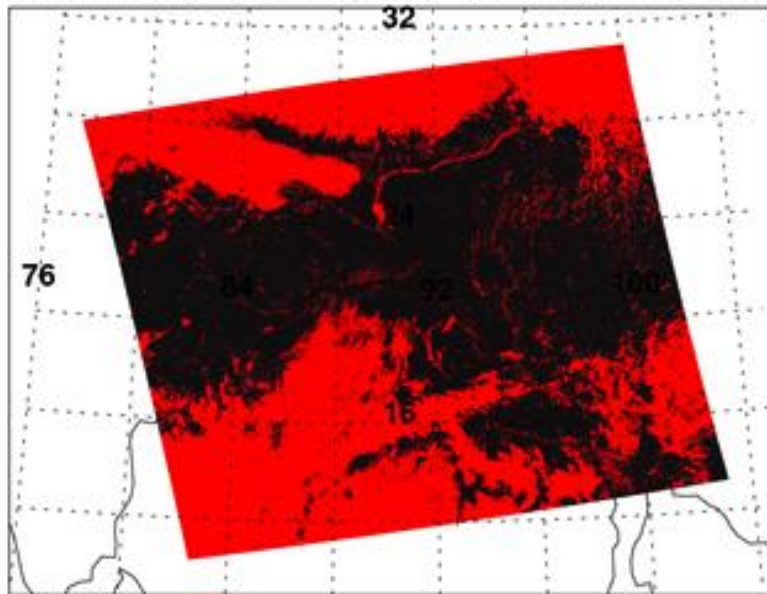
Wind Speed [m/s]





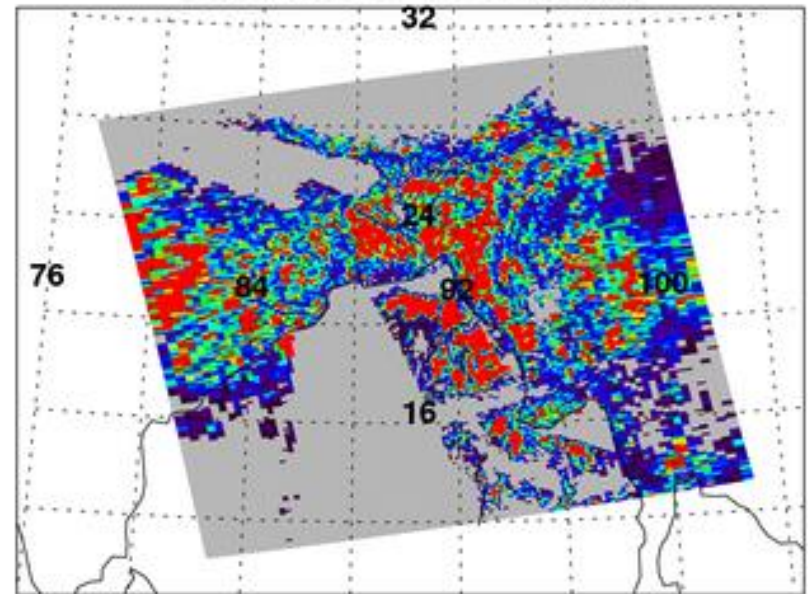
# Cloud and Aerosol SDSs

## Aerosol\_Cldmask\_Land\_Ocean



500 meter resolution cloud mask used in aerosol retrieval. Can be (at times, significantly) different than MOD35

## Distance to Cloud



Number of pixels between an aerosol retrieval and the closest cloud. Not validated yet.

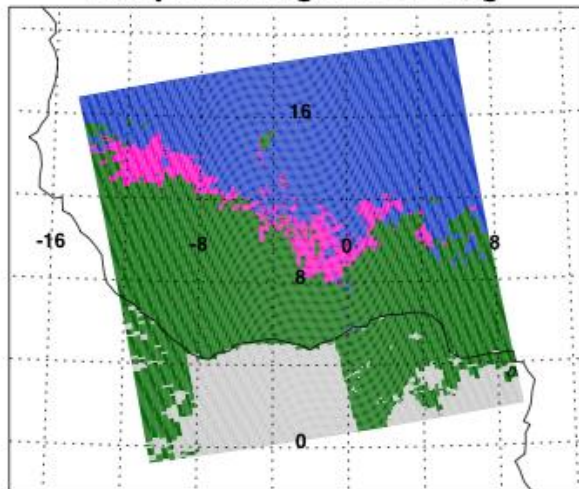
Jan 21 2010 at 13:40 UTC



# The Dark/Deep merge

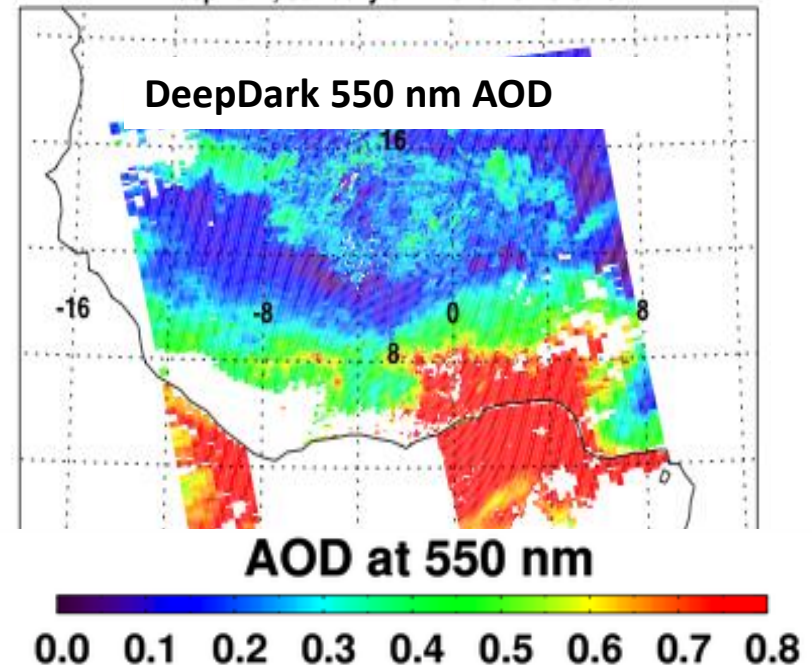
- **Dark**, **bright**, and **transitional** regions are identified by monthly mean NDVI
- In **Dark** regions, value from dark-target retrieval is used
- In **bright** regions, value from deep-blue is used
- In **transition** regions, AOD is merged, dependent on QA of retrievals

DeepDark Algorithm Flag



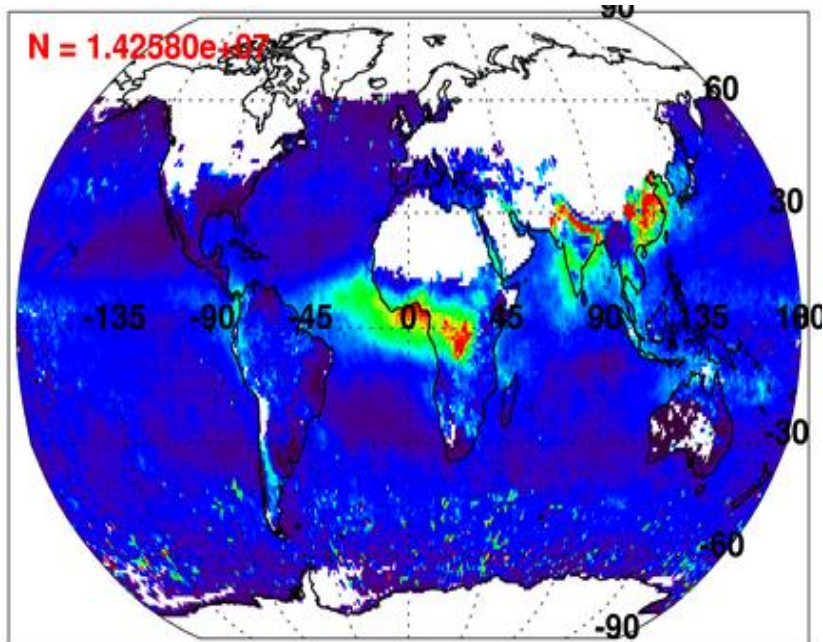
0: Dark Target 1: Deep Blue 2: Mixed

DeepDark, January 021 2010 13:40 UTC



# Monthly mean AOD for Aqua, January 2010

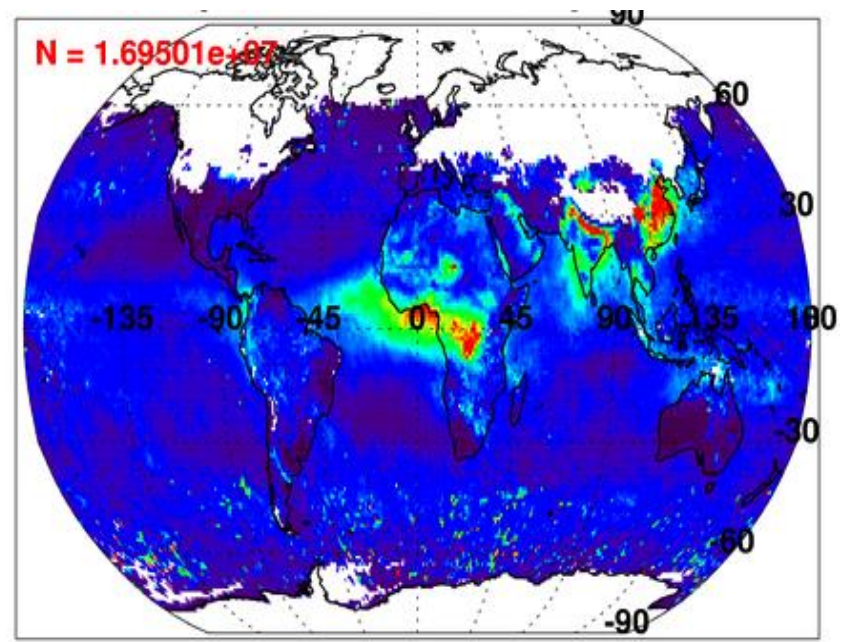
Dark Target AOD



AOD at 550 nm



DeepDark AOD



AOD at 550 nm



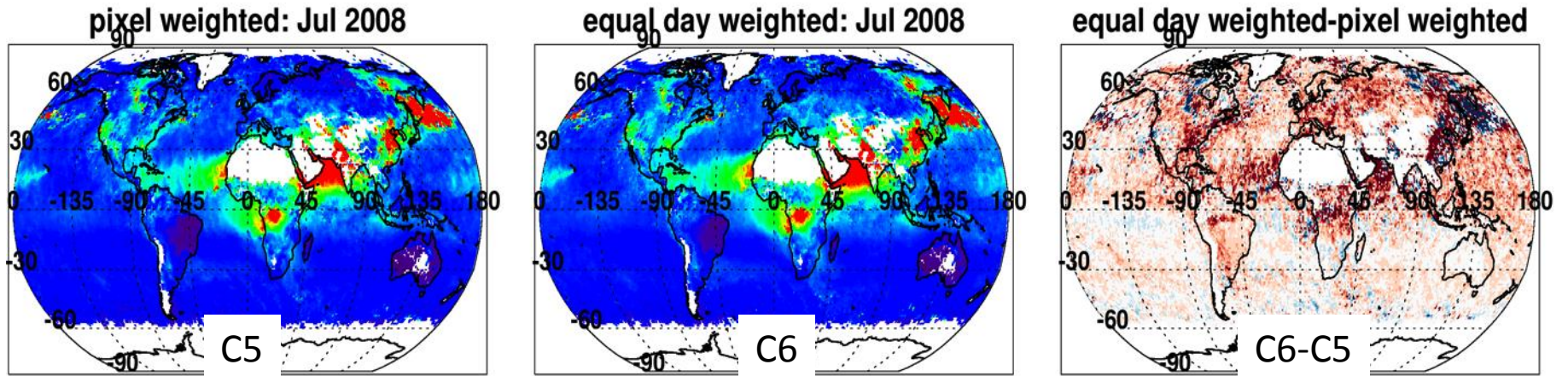
Merging deep blue & dark target produces best global coverage

- Deep blue is land-only; need dark target for oceans
- Deep blue introduces coverage over Australian outback, Sahara desert and Arabian peninsula
- Still no coverage over snow (see: most of Northern Hemisphere).

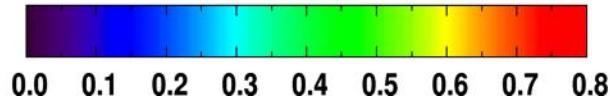
**LOOKS REASONABLE, BUT NOT VALIDATED YET!!!!**

# Beyond MxD04\_L2

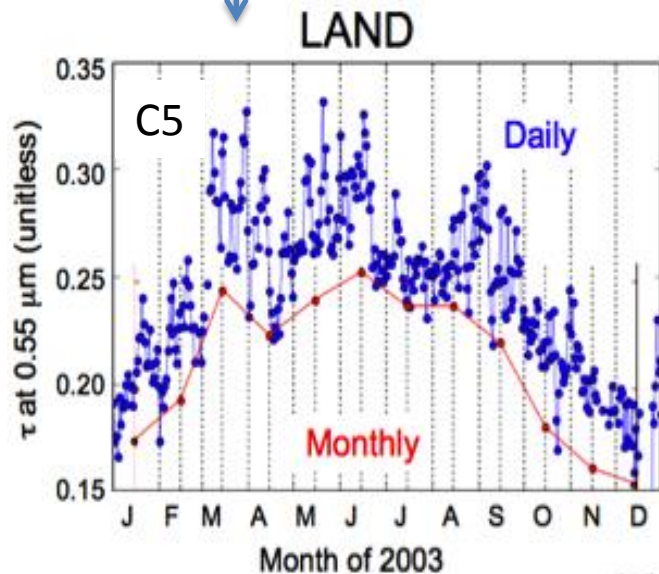
# Changes to Level 3 (MxD08\_M3)



AOD at 550 nm



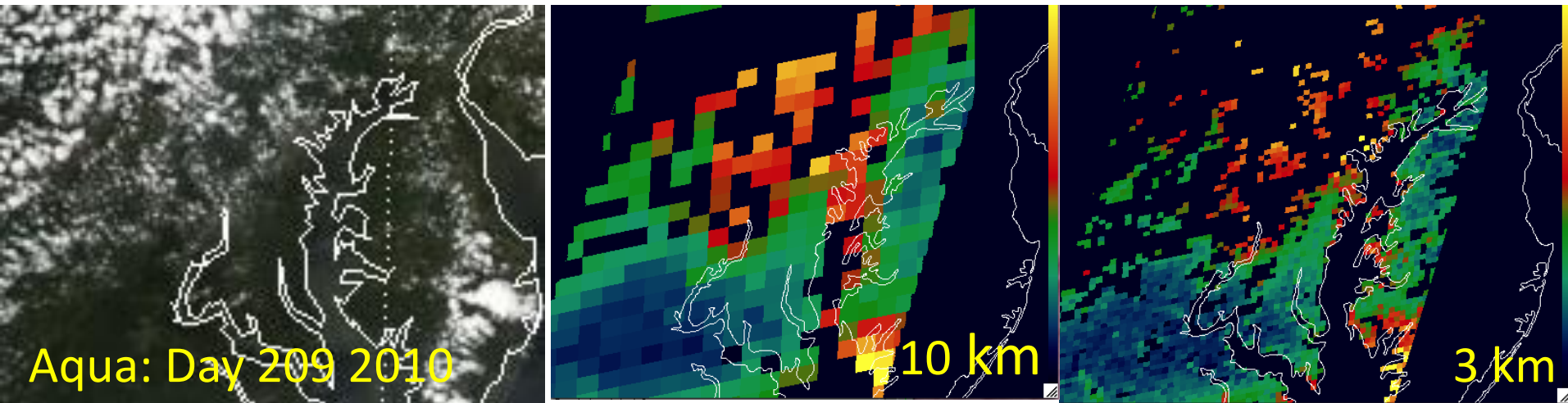
AOD Difference



- In C5, averaging daily data did not look like monthly data (left, from Giovanni web application)
- C5 monthly was “pixel weighted”. A day with 100 retrieved pixels was worth 10 times more than one with 10. It was clear-sky biased.
- C6 monthly is “equal day” weighted. If at least five pixels in a day, than that day counts.
- → Increases monthly mean AOD over land, and ocean. Less clear sky biased?

# MxD04\_3K (a new 3 km aerosol product)

- Driven by air quality community,
- Maybe also some applications to aerosol/clouds.
- Currently Dark target only



Munchak, L., R.C. Levy, S. Mattoo, L.A. Remer, B.N. Holben, J.S. Schafer, C.A. Hostetler, and R.A. Ferrare (2013). MODIS 3km Aerosol Product: applications over land in an urban/suburban region *Atmos. Meas. Tech*, 6, 1747-1759, doi:10.5194/amt-6-1747-2013

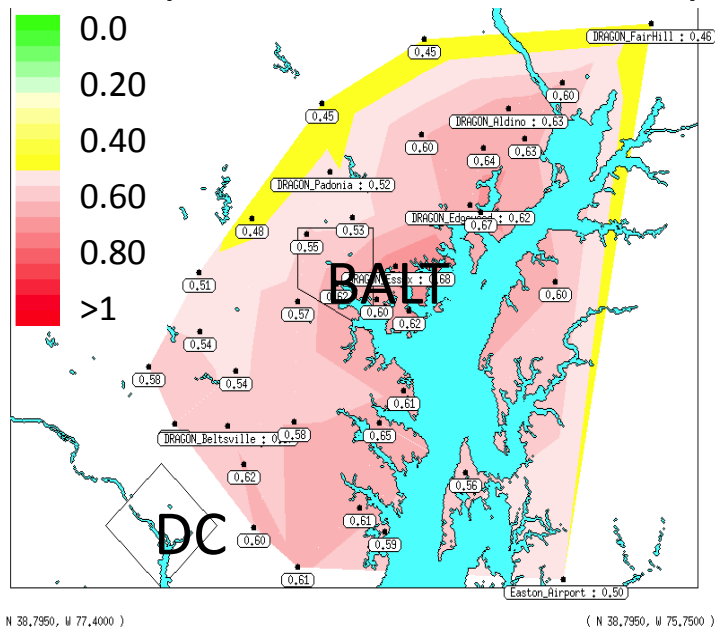
Remer, L., S. Mattoo, R.C. Levy, and L. Munchak (2013). MODIS 3km Aerosol Product: Algorithm and Global Perspective *Atmos. Meas. Tech*, 6, 1829-184, doi:10.5194/amt-6-1829-2013

J. M. Livingston, J. Redemann, et al, (2013). Comparison of MODIS 3-km and 10-km resolution aerosol optical depth retrievals over land with airborne Sunphotometer measurements during ARCTAS summer 2008, *Atmos. Chem. Phys. Disc*,

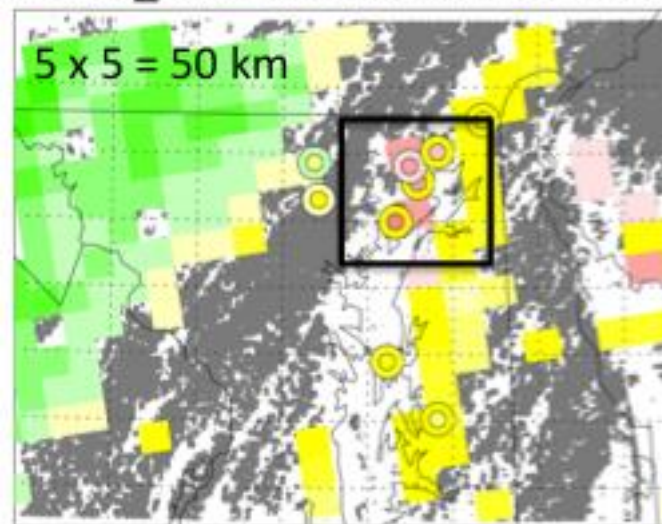
# MODIS vs DRAGON

## July 21, 2011

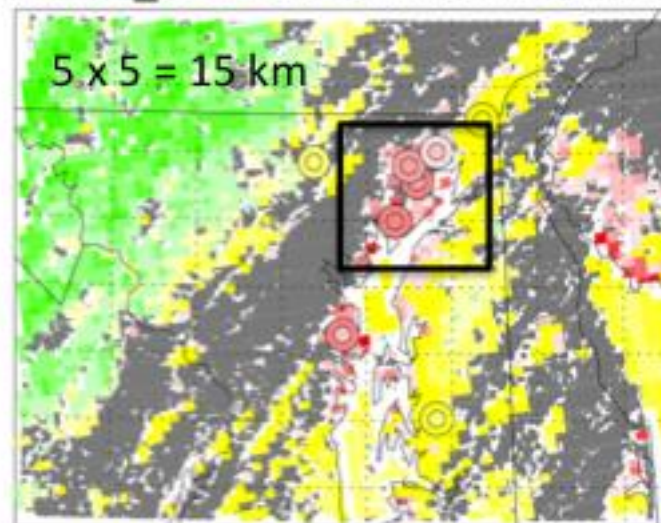
### AOD (AERONET: DRAGON)



MYD04\_10km 550 um 2011202 18:30



0.0 0.25 0.8  
MYD04\_03km 550 um 2011202 18:30



0.0



- DRAGON = Many AERONET over Maryland during DISCOVER-AQ, July 2011
- Gray is MODIS-Aerosol cloud mask
- 3km (bottom) resolves Baltimore maxima
- 3km also resolves aerosol over Ches. Bay

## From MxD06 (clouds) 5 km:

- Latitude
- Longitude
- Cloud\_Optical\_Thickness
- Cloud\_Optical\_Thickness\_Uncertainty
- Cloud\_Optical\_Thickness\_PCL
- Cloud\_Optical\_Thickness\_16
- Cloud\_Optical\_Thickness\_16\_PCL
- Cloud\_Optical\_Thickness\_37
- Cloud\_Optical\_Thickness\_37\_PCL
- Cloud\_Optical\_Thickness\_Uncertainty\_16
- Cloud\_Optical\_Thickness\_Uncertainty\_37
- Cloud\_Effective\_Radius
- Cloud\_Effective\_Radius\_Uncertainty
- Cloud\_Effective\_Radius\_PCL
- Cloud\_Effective\_Radius\_16
- Cloud\_Effective\_Radius\_16\_PCL
- Cloud\_Effective\_Radius\_37
- Cloud\_Effective\_Radius\_37\_PCL
- Cloud\_Effective\_Radius\_Uncertainty\_16
- Cloud\_Effective\_Radius\_Uncertainty\_37
- Cloud\_Water\_Path
- Cloud\_Water\_Path\_Uncertainty
- Cloud\_Water\_Path\_PCL
- Cloud\_Water\_Path\_16
- Cloud\_Water\_Path\_16\_PCL
- Cloud\_Water\_Path\_37
- Cloud\_Water\_Path\_37\_PCL
- Cloud\_Water\_Path\_Uncertainty\_16
- Cloud\_Water\_Path\_Uncertainty\_37
- Cloud\_Optical\_Thickness\_1621
- Cloud\_Optical\_Thickness\_Uncertainty\_1621
- Cloud\_Effective\_Radius\_1621
- Cloud\_Effective\_Radius\_Uncertainty\_1621
- Cloud\_Water\_Path\_1621
- Cloud\_Water\_Path\_Uncertainty\_1621
- Cloud\_Phase\_Optical\_Properties
- Cloud\_Quality\_Assurance
- Cirrus\_Reflectance
- Cloud\_Top\_Pressure
- Cloud\_Top\_Temperature
- Cloud\_Top\_Height
- Cloud\_Height\_Method
- Cloud\_Top\_Pressure\_1km
- Cloud\_Top\_Temperature\_1km
- Cloud\_Top\_Height\_1km
- Surface\_Temperature\_1km
- OS\_Top\_Flag\_1km
- Infrared\_obs\_minus\_calc
- Cloud\_Mask\_SPI
- Cloud\_Multi\_Layer\_Flag
- Cloud\_Fraction
- Cloud\_Phase\_Infrared
- Cloud\_Phase\_Infrared\_1km

## From MxD04 (aerosol) 10 km:

- Latitude\_10km
- Longitude\_10km
- Solar\_Zenith\_10km
- Viewing\_Zenith\_10km
- Relative\_Azimuth\_10km
- Aerosol\_Optical\_Depth
- Aerosol\_Angstrom\_Exponent\_Ocean
- Aerosol\_Land\_Sea\_Flag
- Aerosol\_Cloud\_Pixel\_Distance\_Land\_Ocean
- Aerosol\_Cloud\_Fraction\_Ocean
- Aerosol\_Cloud\_Fraction\_Land
- Aerosol\_Land\_Ocean\_Quality\_Flag
- AOD\_550\_Dark\_Target\_Deep\_Blue\_Combined
- AOD\_550\_Dark\_Target\_Deep\_Blue\_Combined\_QA\_Flag
- AOD\_550\_Dark\_Target\_Deep\_Blue\_Combined\_Algorithm\_Flag
- Deep\_Blue\_Aerosol\_Optical\_Depth\_550\_Land
- Deep\_Blue\_Angstrom\_Exponent\_Land
- Deep\_Blue\_Single\_Scattering\_Albedo\_412\_Land
- Deep\_Blue\_Aerosol\_Optical\_Depth\_550\_Land\_Best\_Estimate
- Deep\_Blue\_Aerosol\_Optical\_Depth\_550\_Land\_QA\_Flag
- Deep\_Blue\_Aerosol\_Optical\_Depth\_550\_Land\_Uncertainty
- Aerosol\_Quality\_Assurance\_Land
- Aerosol\_Quality\_Assurance\_Ocean

## From MxD05 (precip water) 10 km:

- Precipitable\_Water\_Infrared\_ClearSky
- Precipitable\_Water\_Near\_Infrared\_ClearSky

## From MxD35 (Cloud Mask) 5 km:

- Cloud\_Mask

## From MxD07 (Profiles) 5 km:

- Total\_Ozone
- Lifted\_Index
- K\_Index
- Total\_Totals\_Index

# MxDATML2 product

- Combines the “best of” MxD04\_L2 (10 km) aerosol, MxD06\_L2 (5 km) cloud products, and other atmosphere prods
- For joint analyses of aerosols and clouds (at granule level)

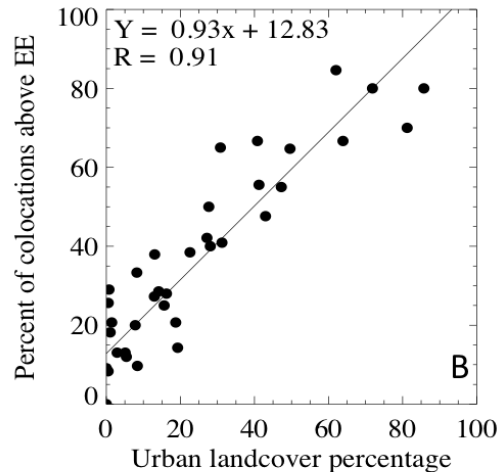
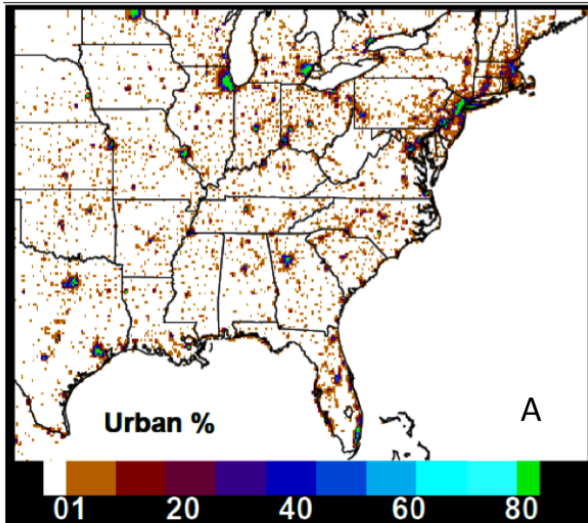
Platnick, King, Hubanks,...



# Towards collection 7

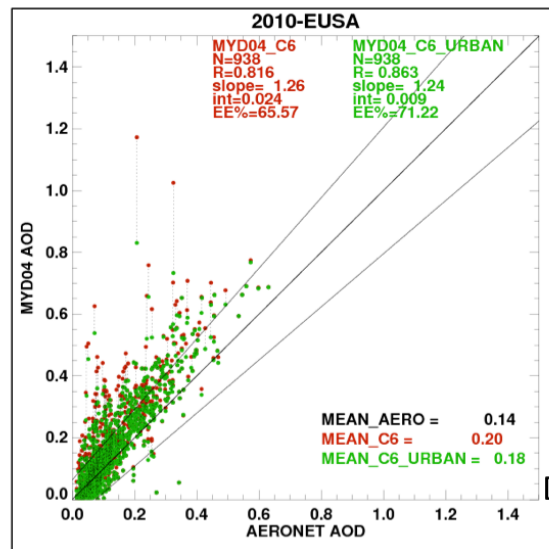
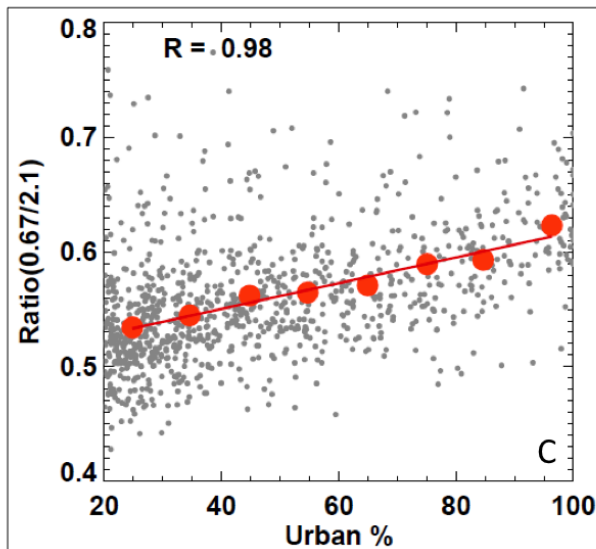
- Accounting for bias over urban areas
  - Determining per-retrieval uncertainty
  - Residual calibration/polarization errors
- 
- This is where we can use YOUR help!

# Accounting for Urban bias



More urban -->  
higher bias

Over MD/DC  
during  
DISCOVER-AQ



Looking at  
possible  
corrections

Applied to E-USA  
over 2010

- Can we reduce artificial urban hotspots without impacting surrounding rural areas

# Characterizing uncertainty in Aerosol Optical Depth Retrieval

There are **two** broad error sources :

## 1. Measurement / Input Uncertainties

- Calibration Uncertainty [**1 – 2%**]
- Standard Deviation of reflectance in 10 x 10 km retrieval box [**1 – 2%**]
- Uncertainty in the Ancillary data used for atmospheric correction [**~3.5%**]
- Cloud contamination [  $\tau$  Bias of **+0.04** (Terra) and **+0.01** (Aqua), *Hyer et al., 2011*]
- Snow contamination

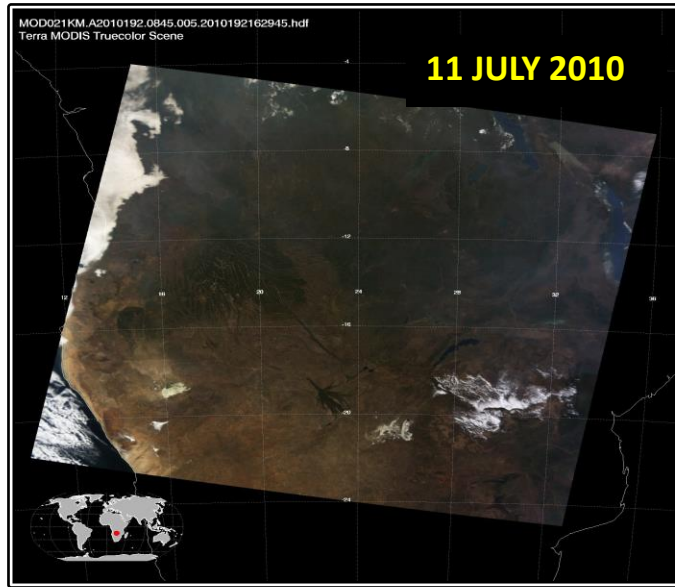
## 2. Retrieval Assumptions

- Surface reflectance
- Aerosol models

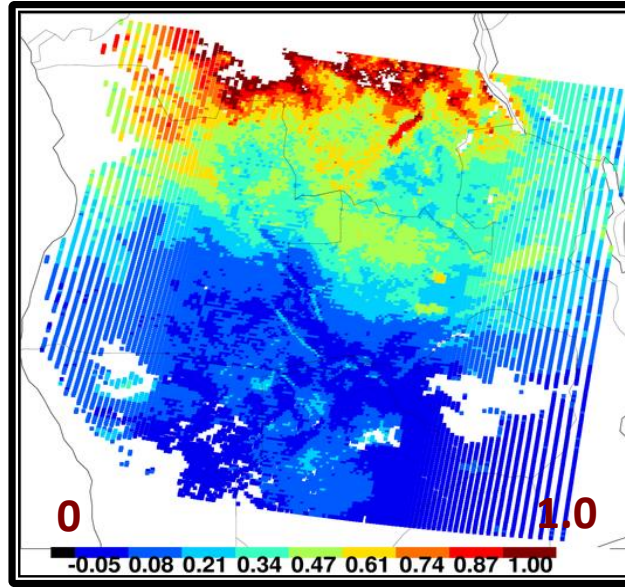
- The numbers in red are derived from test case shown in following slide
- We plan to look at the uncertainties related to input data first

# Example : Uncertainty in AOD retrieval from Reflectance Standard Deviation

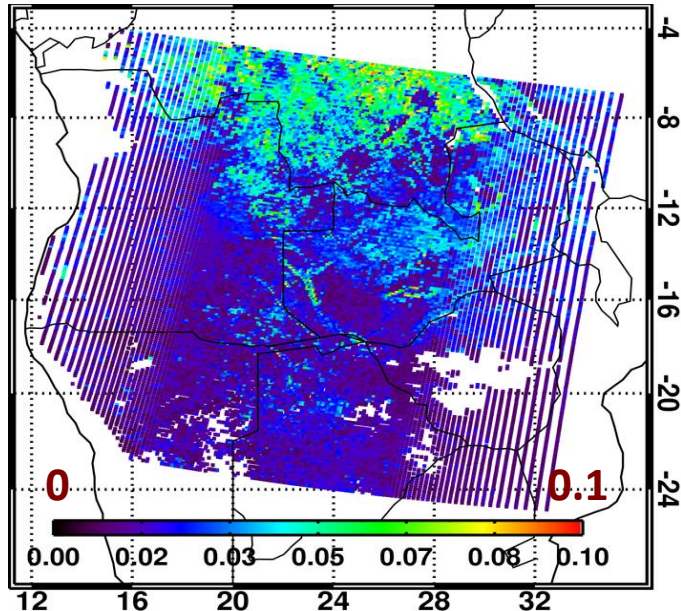
MODIS L1B RGB Image over Central Africa



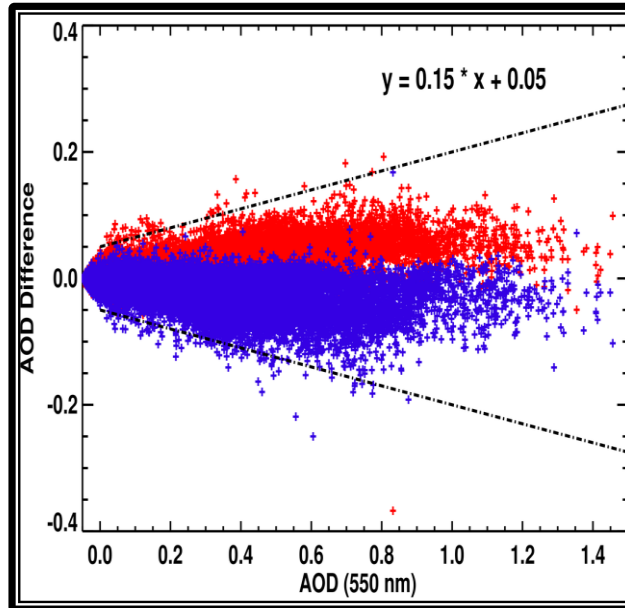
MODIS AOD (554 nm)



Absolute Error in AOD



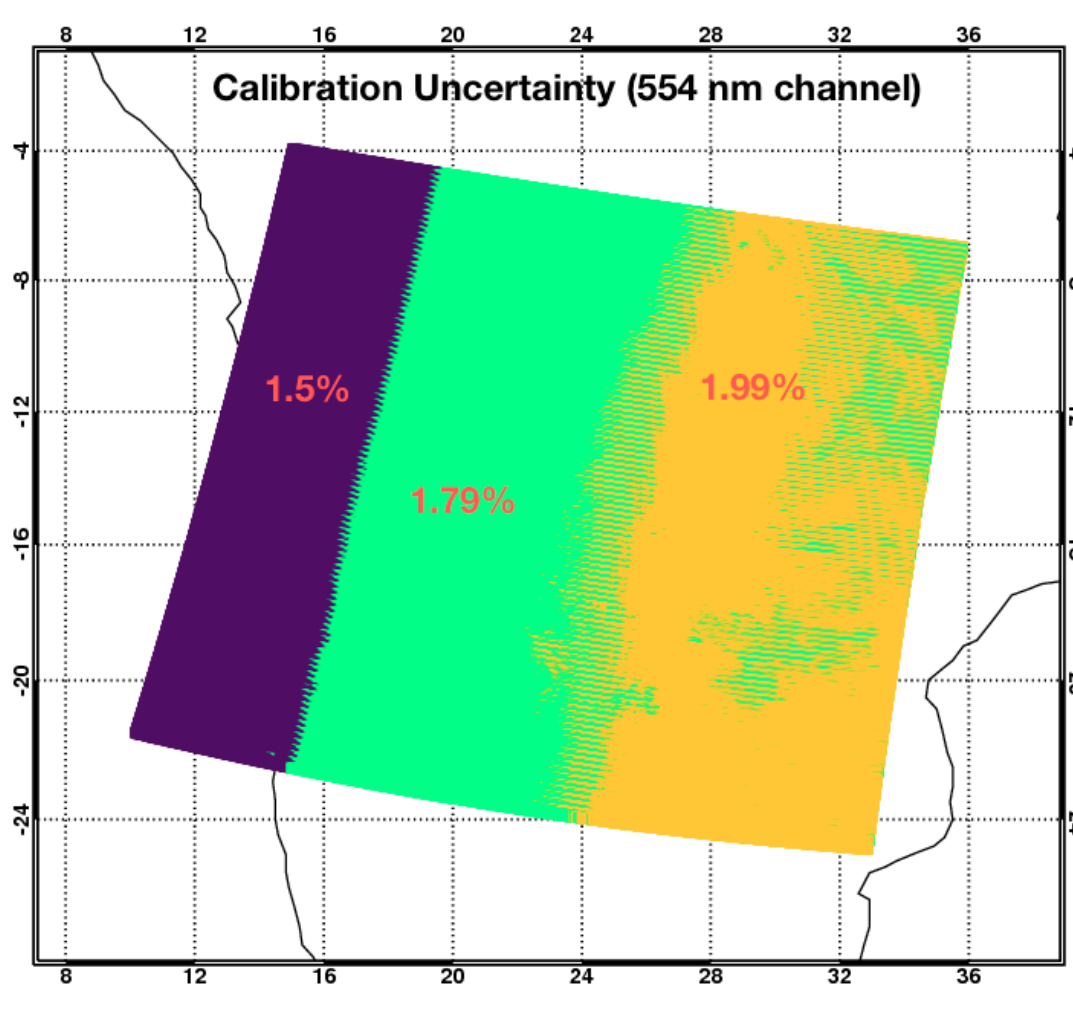
Absolute AOD Error Relative to AOD



AOD differences due to standard deviation of reflectance within 10 X 10 km box

Compared to EE envelope

# Understanding Level 1 Uncertainties

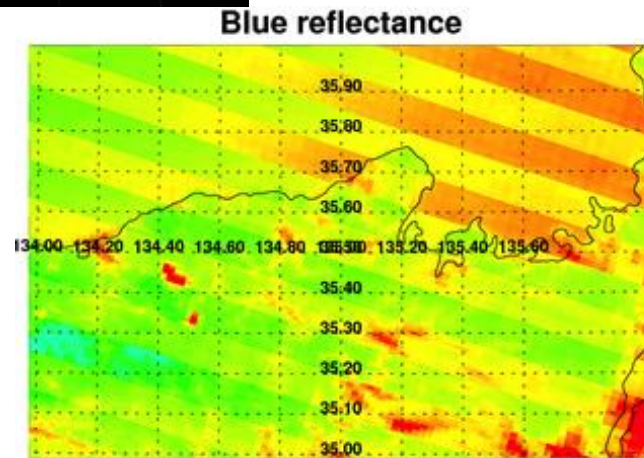
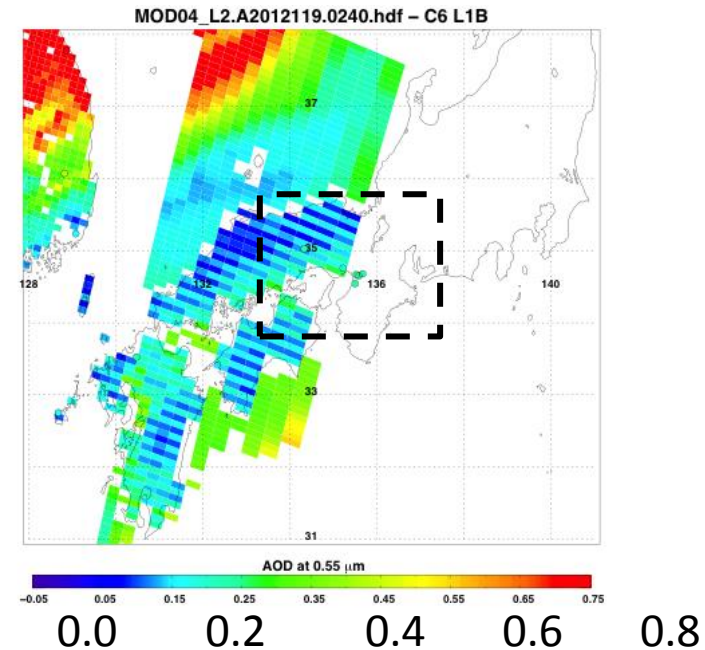
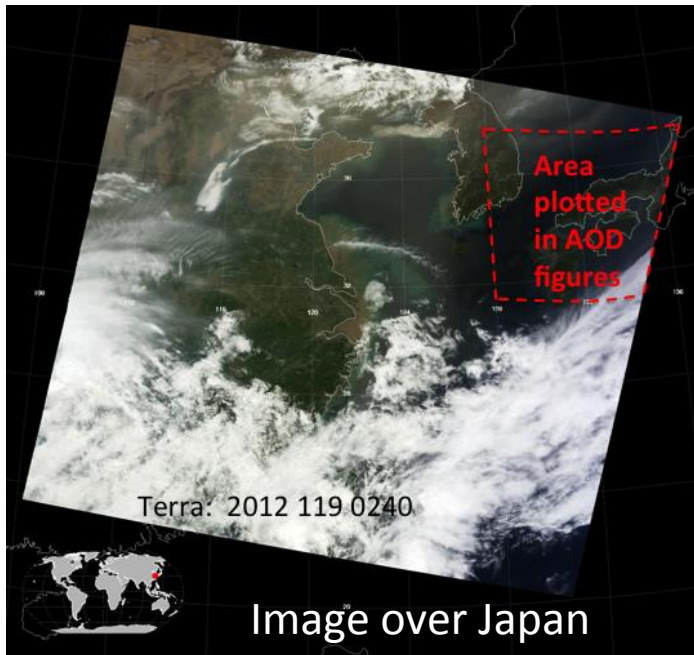


Interesting across track step functions

We don't understand what it means yet.

- How do we account for measurement uncertainties in our products?

# But also noting that calibration still not perfect

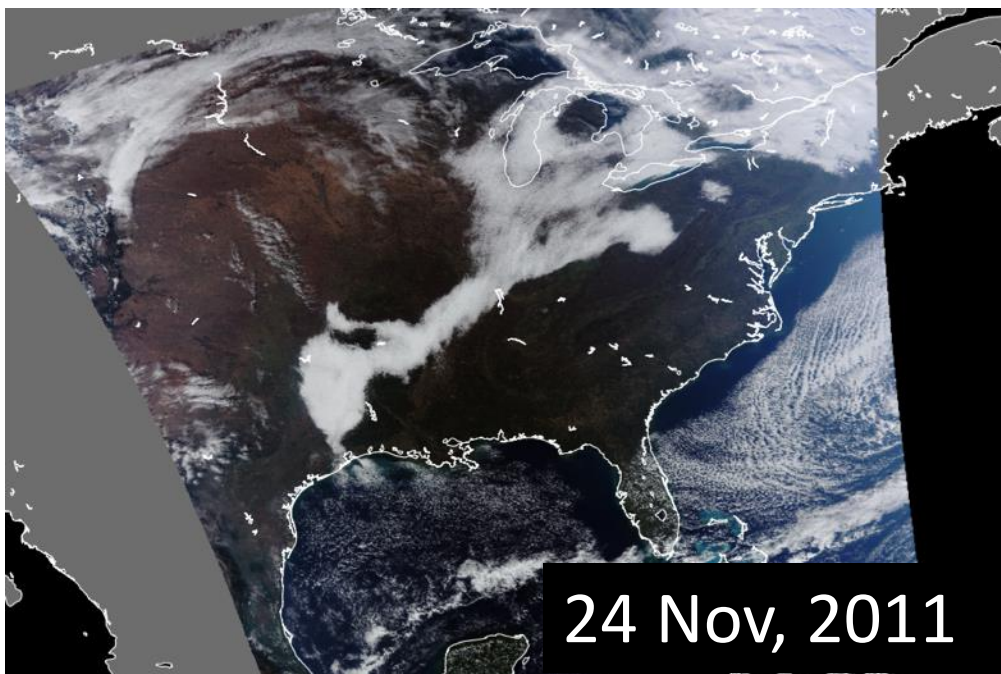


- Dealing with “striping” of 0.1 AOD in recent (post 2012) Terra data
- Seems to be a mirror polarization sensitivity issue.

# Dark-target aerosol retrieval: Beyond MODIS

# Suomi-NPP VIIRS

Visible Infrared Imager Radiometer Suite



Multiple VIIRS granules stitched. Image by Geoff Cureton, CIMSS

- Different instrument, resolution, sampling, cloud masking, algorithms, etc.
- Will VIIRS “continue” the MODIS aerosol data record?



# VIIRS versus MODIS

**Orbit:** 825 km (vs 705 km), sun-synchronous, over same point every 16 days

Equator crossing: 13:30 on Suomi-NPP, since 2012 (versus on Aqua since 2002)

**Swath:** 3050 km (vs 2030 km)

**Spectral Range:** 0.412-12.2 $\mu\text{m}$  (22 bands versus 36 bands)

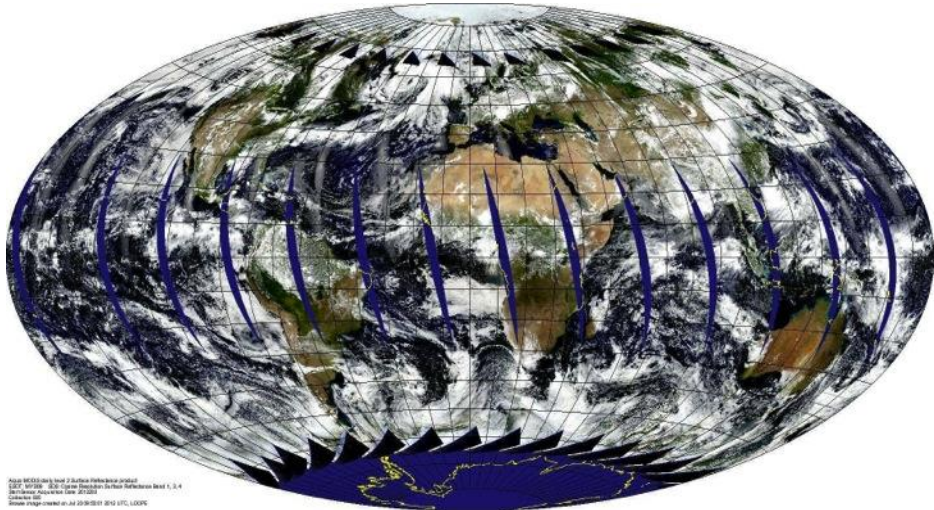
**Spatial Resolution:** 375m (5 bands) 750m (17 bands): versus 250m/500m/1km

**Wavelength bands (nm) used for DT aerosol retrieval:** 482 (466), 551 (553) 671 (645), 861 (855), 2257 (2113)  $\rightarrow$  differences in Rayleigh optical depth, surface optics, gas absorption.

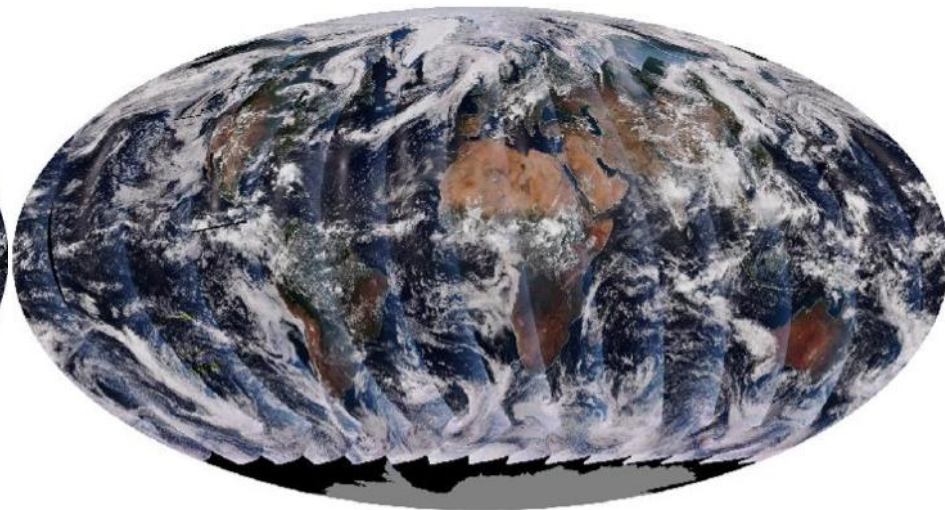
**Aerosol Retrieval:** Created and maintained by scientists partnered with NOAA (NASA), with a strategy of maximizing environmental data record - EDR (climate data record – CDR)

**ALSO:** Different cloud masks, different aggregation techniques, different pixel selections.

Aqua (13:30 Local Time, Ascending)



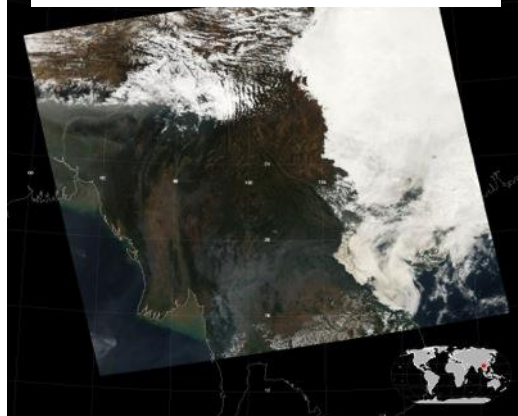
Suomi-NPP (13:30 Local Time, Ascending);



Aqua MODIS Level 2 Surface Reflectance product  
©2012 NASA. All rights reserved. Aqua MODIS Level 2, 3, 4  
Data are provided under the NASA Open Data Policy.  
Image usage limited to: All 2010-2011 810 1110 100%

# MODIS-like algorithm on VIIRS data for climate continuity (on hold until C6 has started)

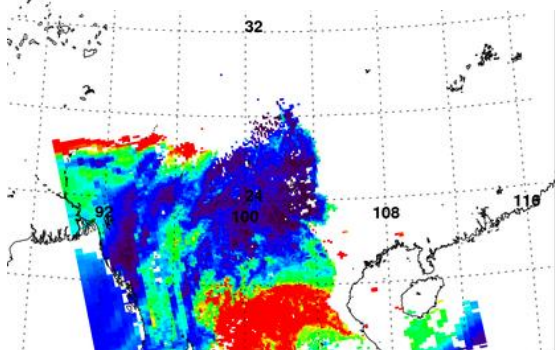
RGB image for MODIS



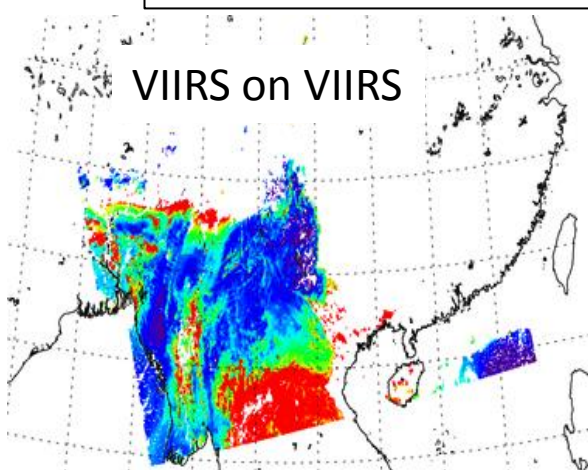
Both satellites overpass within minutes

- Preparation of “5 minute” VIIRS granule
  - Create MODIS-like cloud mask, gas corrections, pixel selection/averaging, quality assurance, etc
- Using MODIS algorithm on VIIRS looks much more like MODIS
- More processing, including entire months of data are forthcoming
- Necessary for continuation of other data (e.g. CERES records!)

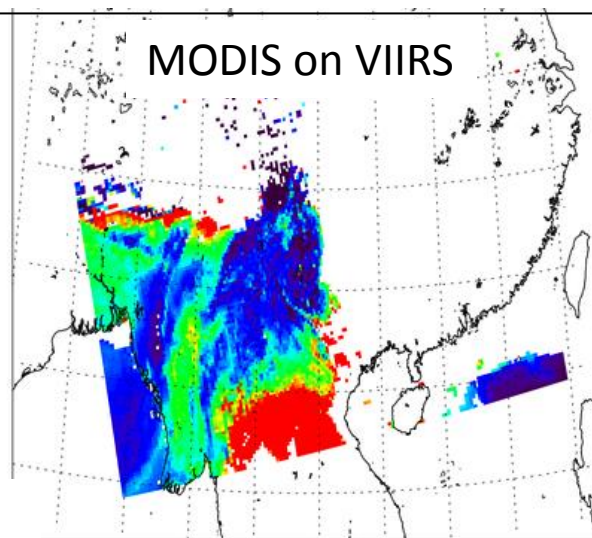
MODIS on MODIS-Aqua



VIIRS on VIIRS



MODIS on VIIRS

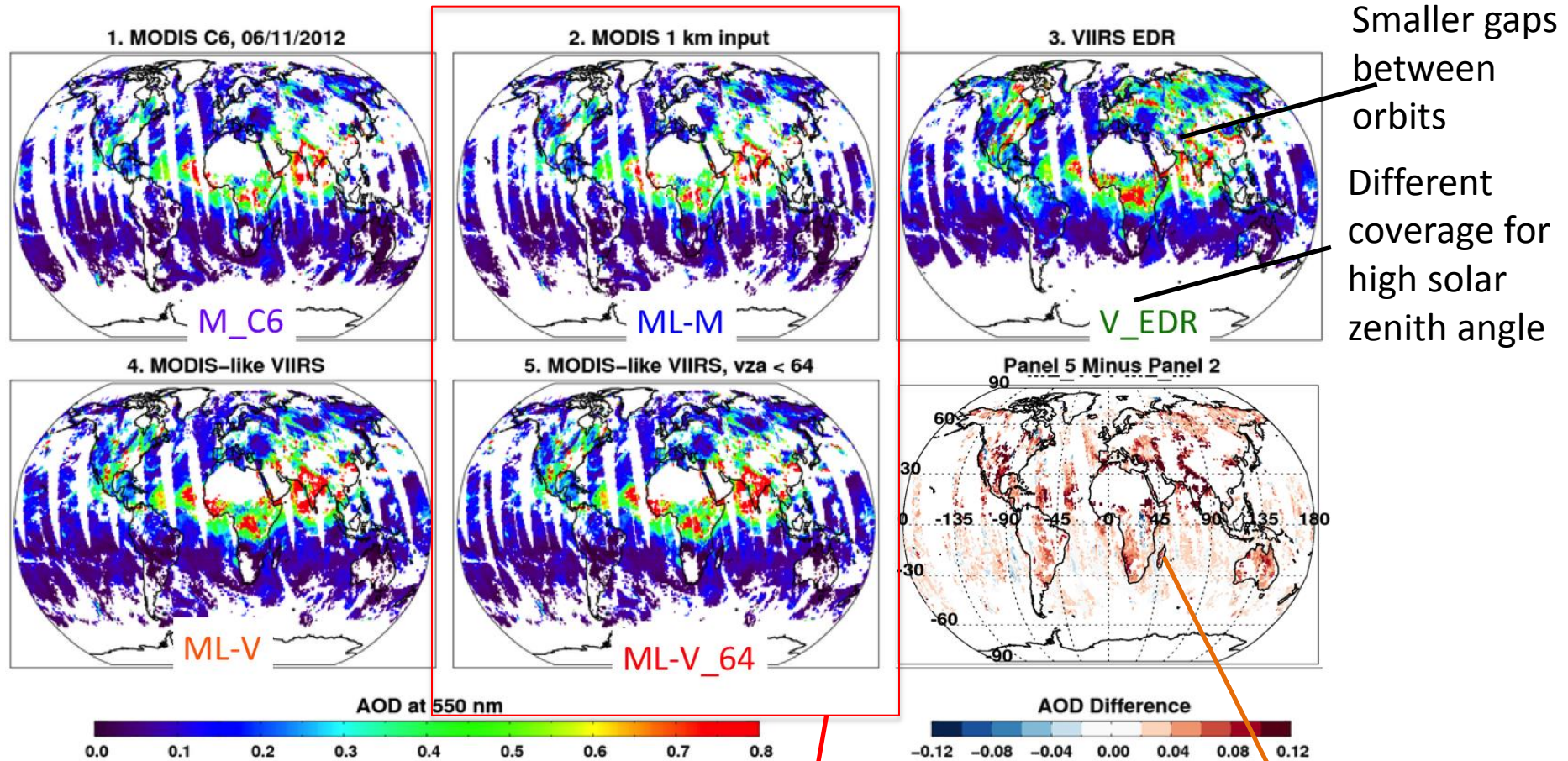


AOD at 550 nm



(with help from UW-PEATE) 58

# Applied for single day (June 11, 2012)



Much more similar looking

Still positive bias for ML on VIIRS over land

# Histograms (June 11, 2012)

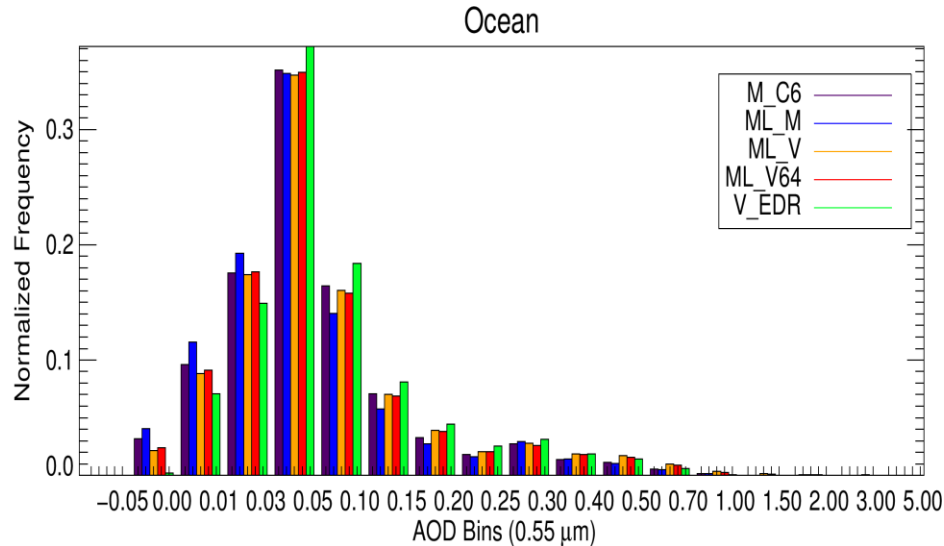


Table 6: Granule statistics for AOD over ocean, for June 11, 2012.

Version	Granule Count	Total pixels attempted	QAC-filtered pixel count	QAC-filtered Mean AOD
M_C6	131	2313053	460357	0.1086
ML_M	150	2364192	327765	0.1031
ML_V	152	7677777	1244976	0.1245
ML_V64	152	6726560	1084340	0.1201
V_EDR	151	11045900	1341926	0.1212

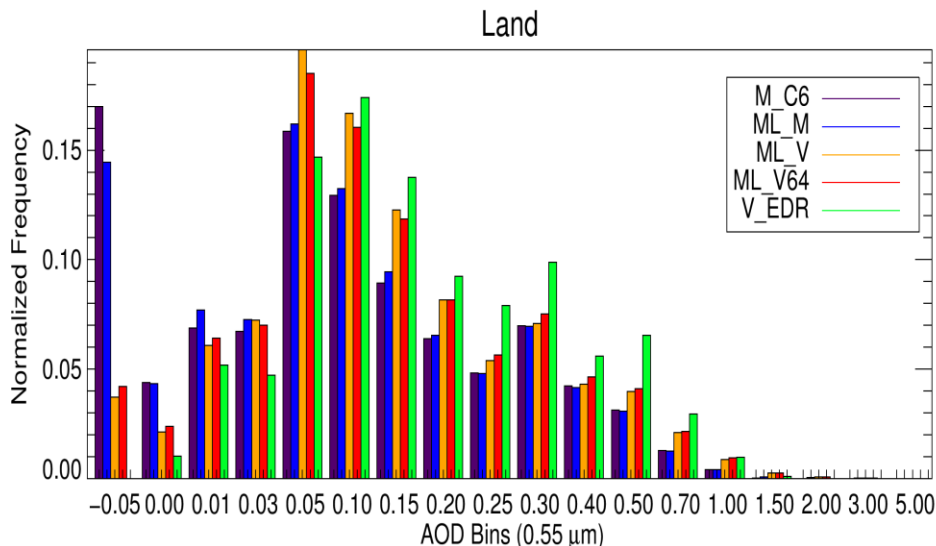


Table 7: Granule statistics for AOD over land, for June 11, 2012.

Version	Granule Count	Total pixels attempted	QAC-filtered pixel count	QAC-filtered Mean AOD
M_C6	131	1160502	133837	0.1473
ML_M	150	1196077	159091	0.1533
ML_V	152	3781527	561976	0.1953
ML_V64	152	3274176	493534	0.1988
V_EDR	151	4530845	820357	0.2367

- No zeros or negatives in VIIRS-EDR, but included for MODIS-Like on VIIRS
- High bias over land reduced by half when application of common algorithm

# MODIS-like algorithm on ANY sensor!

## For climate continuity

- MODIS
- VIIRS
- MAS/E-MAS/AMS (Airborne spectrometers and historical experiment data)
- International sensors
- Future sensors (e.g. PACE / ACE) as a baseline for testing new ideas

Opens up many cans of worms ..... (and makes our programmer Shana very unhappy).

Okay: summary time

# Summary (1)

- There are many ways to retrieve aerosol properties from MODIS, and there is more than one set of algorithms/products
- Dark-target algorithm/products are updated for C6
- Changes are “modest” but lead to significant changes in retrieved global aerosol
- Dark-target and Deep-blue products are merged, leading to more global coverage
- Documentation is still under development. Some papers have been published; my “overall” paper accepted to AMT.
- **According to my latest sources, Collection 6 processing is expected to begin sometime during October. It will start with Aqua Level 2, then Terra, then Level 3. WE WILL BLAST ICAP EMAIL WHEN IT HAPPENS!**

# Summary (2)

- The MODIS aerosol products have matured over the last 13 years.
  - They are well characterized (striving for better)
  - We understand the strengths and limitations
  - Our products are “useful” and in a useful format.
  - The global community (both research and operational) depends on the MODIS aerosol products



# Summary (3)

- MODIS aerosol retrieval was intended for global *climate* applications
  - MODIS aerosol products → climate data records?
  - Not yet
  - but artificial trends can be removed by reformulating instrument calibration and quality assurance
  - More evaluation is needed.

# Summary (4)

- MODIS aerosol retrieval was intended for *global* climate applications
  - Air quality events are sometimes on urban and local scales
  - Aerosol properties change near clouds
  - → The MODIS dark-target team is offering 3 km operational aerosol data.
  - There are two published papers, and one accepted.

# Summary (5)

- MODIS is not the only thing
  - NPP-VIIRS is online
  - VIIRS is “similar”, yet different than MODIS
  - TBD: How different?
  - More evaluation is needed.
  - Now that MODIS Collection 6 is delivered, we can focus on NPP-VIIRS.
- Onward towards Collection 7 !!!
  - Includes reporting per-retrieval uncertainty
  - Correction for bias over urban areas

[thank you](#) [の画像検索結果](#)