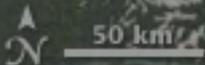


Updates on aerosol remote sensing with the dark target algorithm for C006

Leigh Munchak, Robert Levy, Shana Mattoo,
Lorraine Remer, Bill Ridgway, Richard Kleidman,
Steve Platnick

See also Collection 6 dark target update poster &
MODIS 3 km aerosol poster



Outline

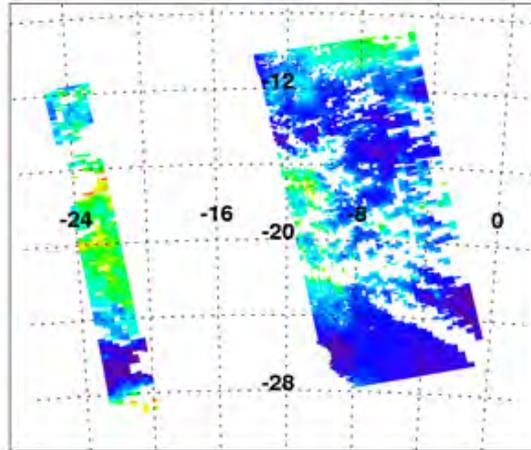
- Major changes to Level 2 algorithm
 - See poster for all changes...
- “New” products and SDSs
 - Diagnostic & Scientific
- Expected changes to AOD & FMF
- New monthly averaging scheme for level 3 aerosol products
- Operational 3 km resolution product, including initial validation

Variable wind speed LUTs over ocean

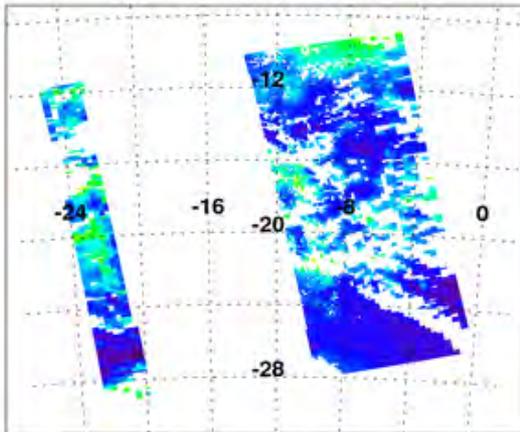
MYD04_L2.A2010018.1440.hdf



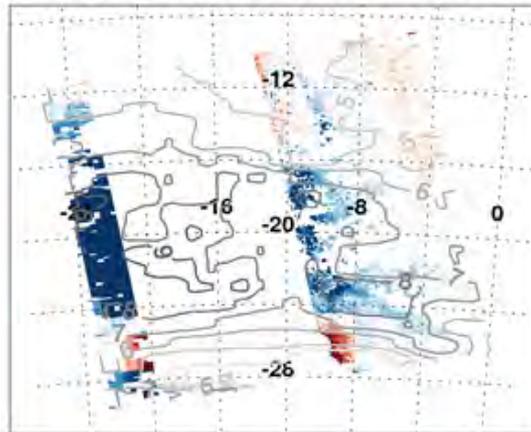
6 m/s winds



NCEP winds



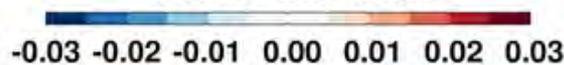
NCEP winds - 6 m/s winds



AOD at 550 nm



AOD Difference



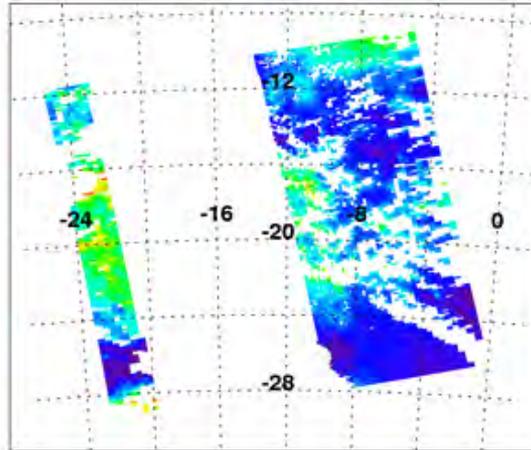
- C005 bias related to wind speed
- C006 calculates ocean surface as function of wind speed.
- Biggest change near glint edges

Variable wind speed LUTs over ocean

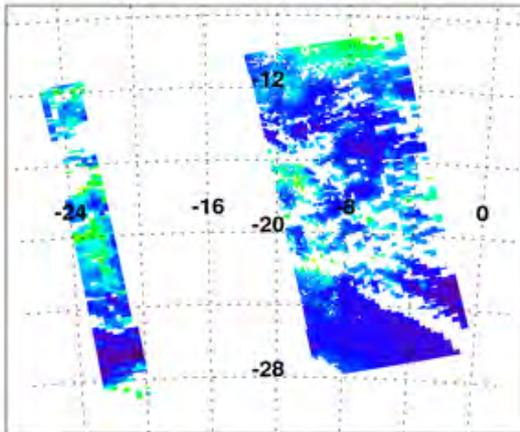
MYD04_L2.A2010018.1440.hdf



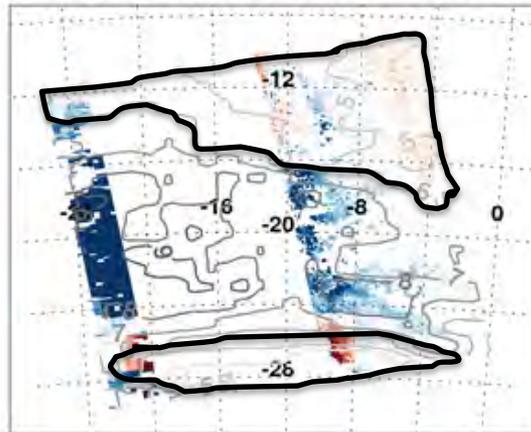
6 m/s winds



NCEP winds



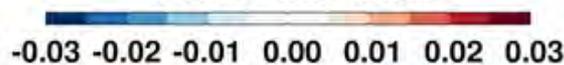
NCEP winds - 6 m/s winds



AOD at 550 nm



AOD Difference



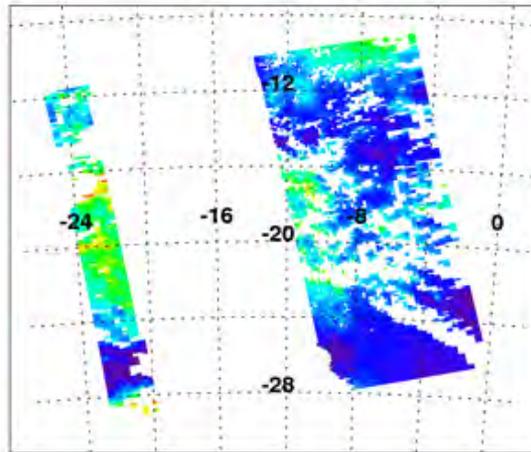
- C005 bias related to wind speed
- C006 calculates ocean surface as function of wind speed.
- Biggest change near glint edges

Variable wind speed LUTs over ocean

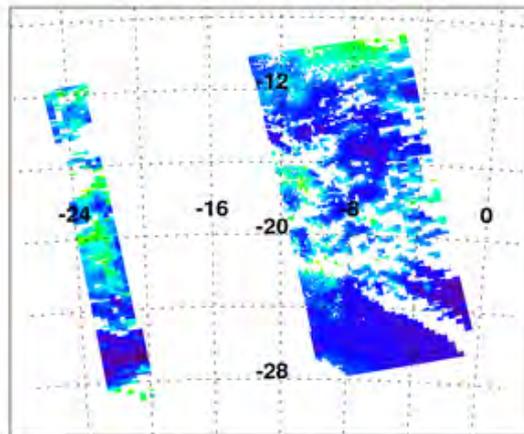
MYD04_L2.A2010018.1440.hdf



6 m/s winds



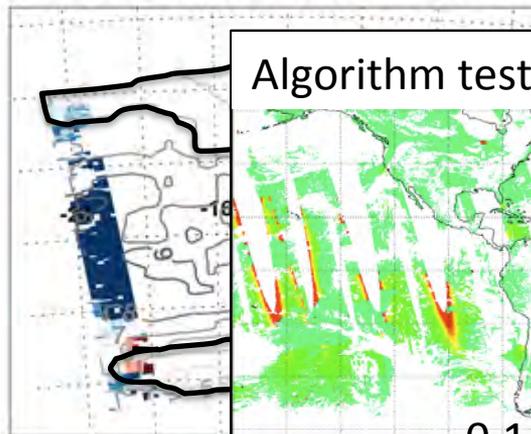
NCEP winds



AOD at 550 nm

0.00 0.10 0.20 0.30

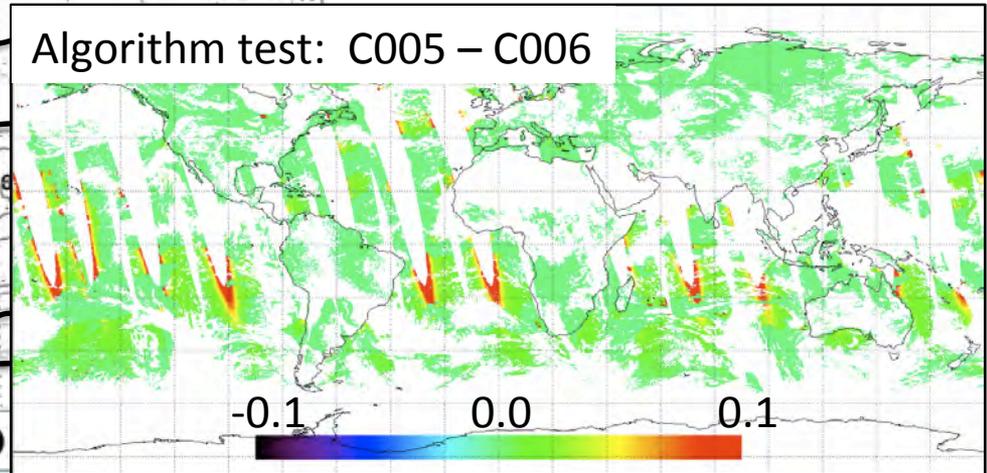
NCEP winds - 6 m/s winds



AOD

-0.03 -0.02 -0.01 0.00 0.01 0.02 0.03

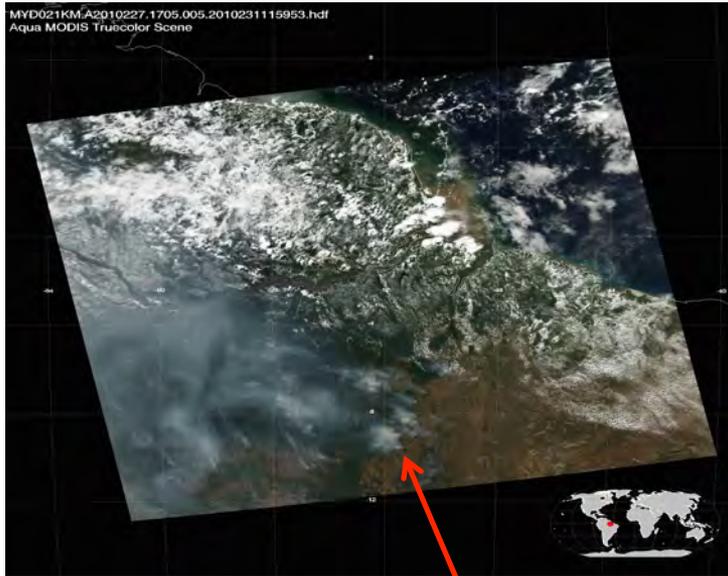
Algorithm test: C005 - C006



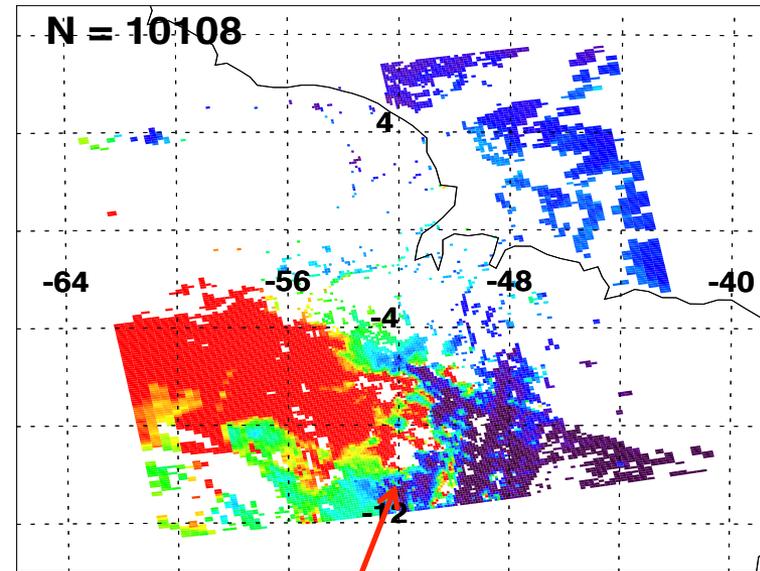
- C005 bias related to wind speed
- C006 calculates ocean surface as function of wind speed.
- Biggest change near glint edges

Land cloud masking is less conservative

MYD04_L2.A2010227.1705.hdf



With old cloudmask

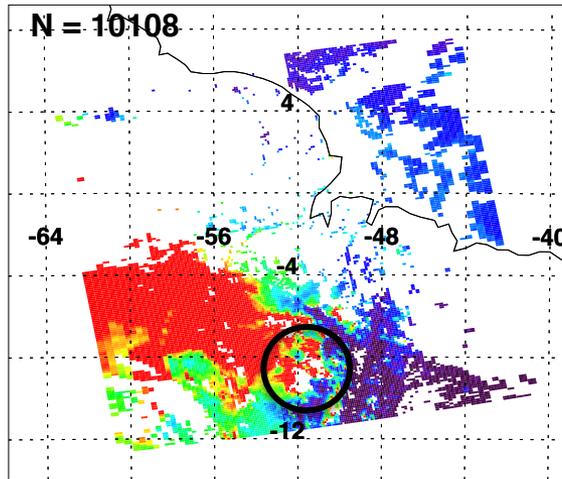


Heaviest smoke is flagged as cloud

MYD04_L2.A2010227.1705.hdf

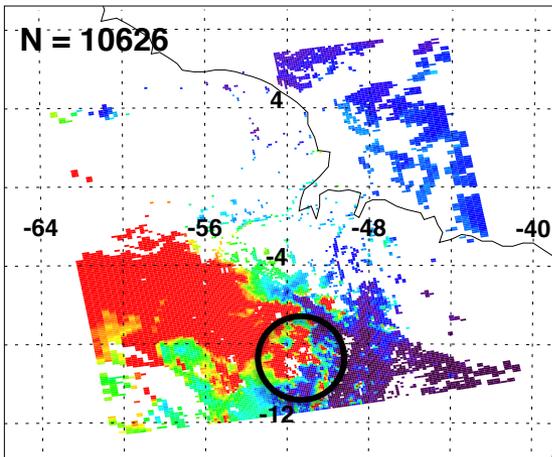


With old cloudmask

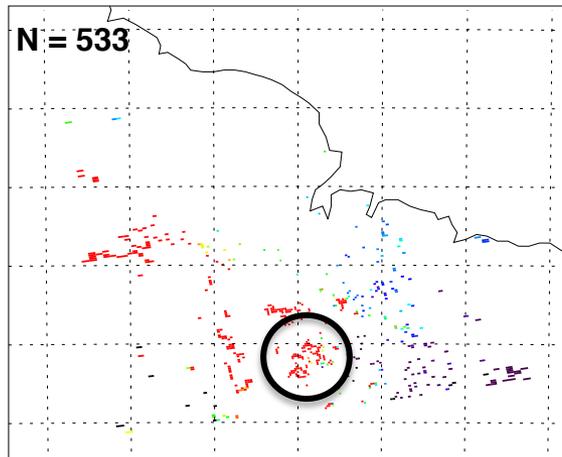


1. New cloudmask brings back some, but not all, dense smoke plumes
2. Cloudmask brings back some cloud free pixels over bright or inhomogeneous terrain.

With new cloudmask

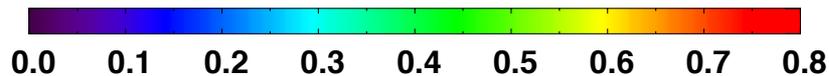


New Pixels



3. New cloudmask does not bring back clouds!
(Very important!)

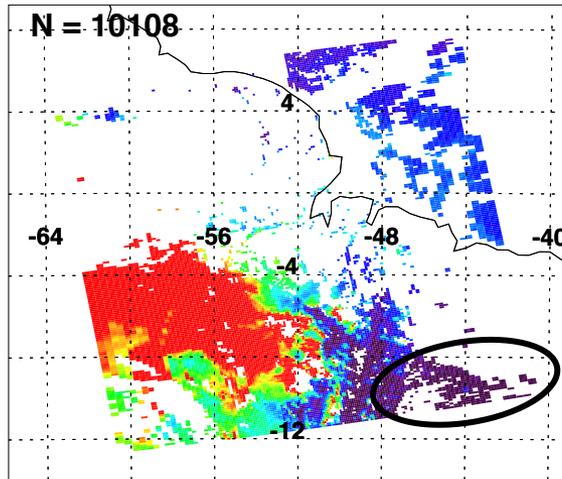
AOD at 550 nm



MYD04_L2.A2010227.1705.hdf

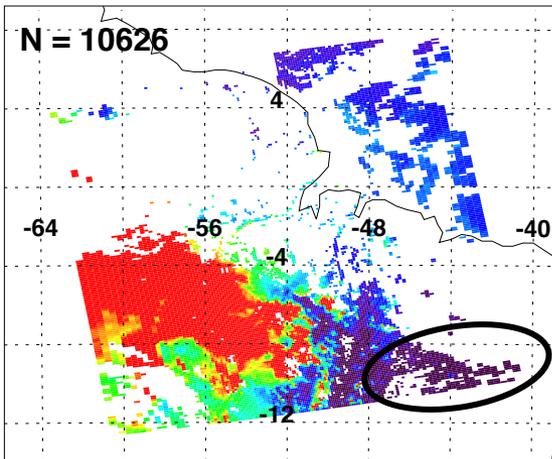


With old cloudmask

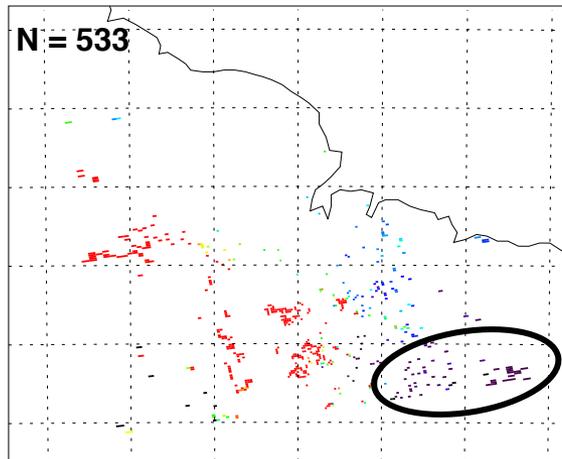


1. New cloudmask brings back some, but not all, dense smoke plumes
2. Cloudmask brings back some cloud free pixels over bright or inhomogeneous terrain.

With new cloudmask

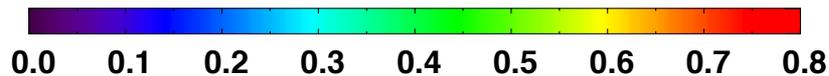


New Pixels

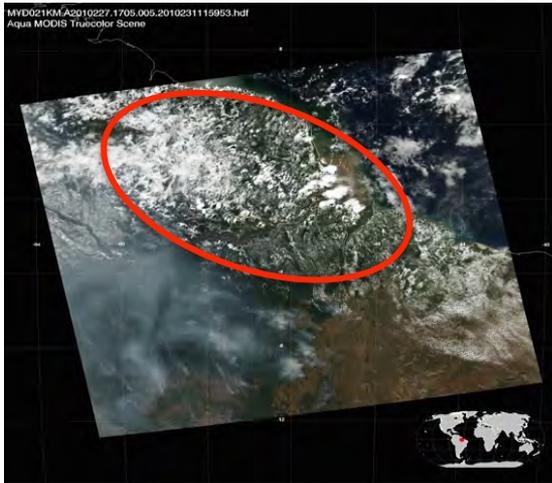


3. New cloudmask does not bring back clouds!
(Very important!)

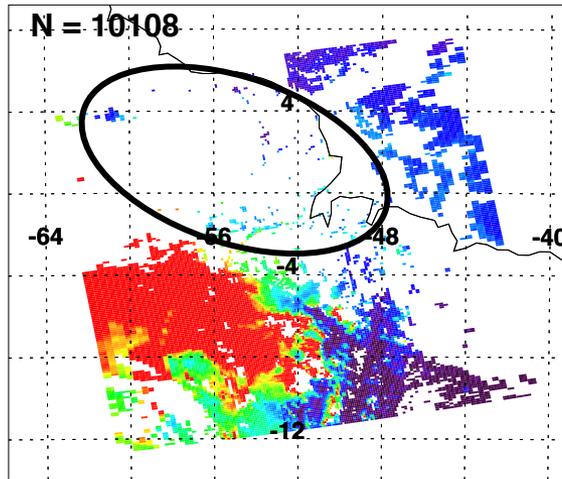
AOD at 550 nm



MYD04_L2.A2010227.1705.hdf

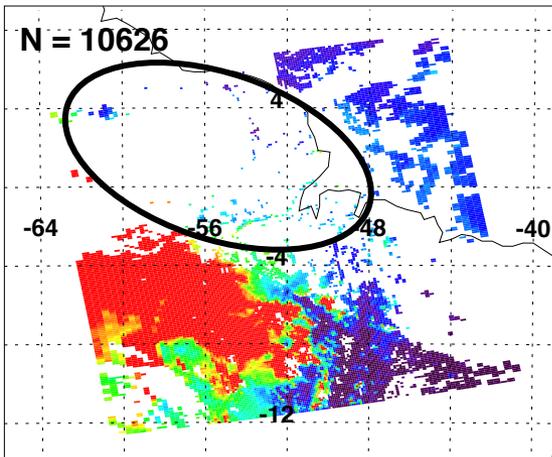


With old cloudmask

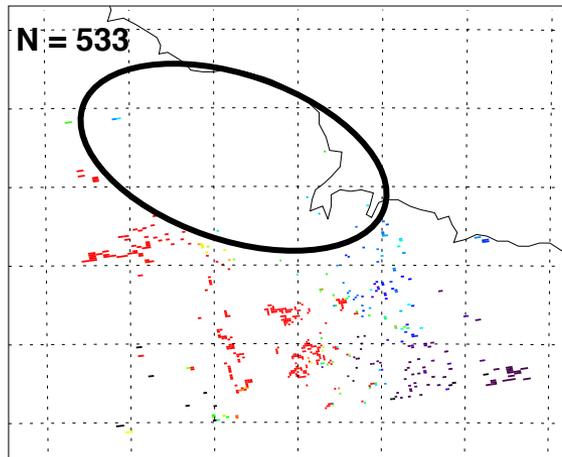


1. New cloudmask brings back some, but not all, dense smoke plumes
2. Cloudmask brings back some cloud free pixels over bright or inhomogeneous terrain.

With new cloudmask

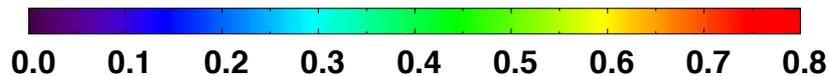


New Pixels



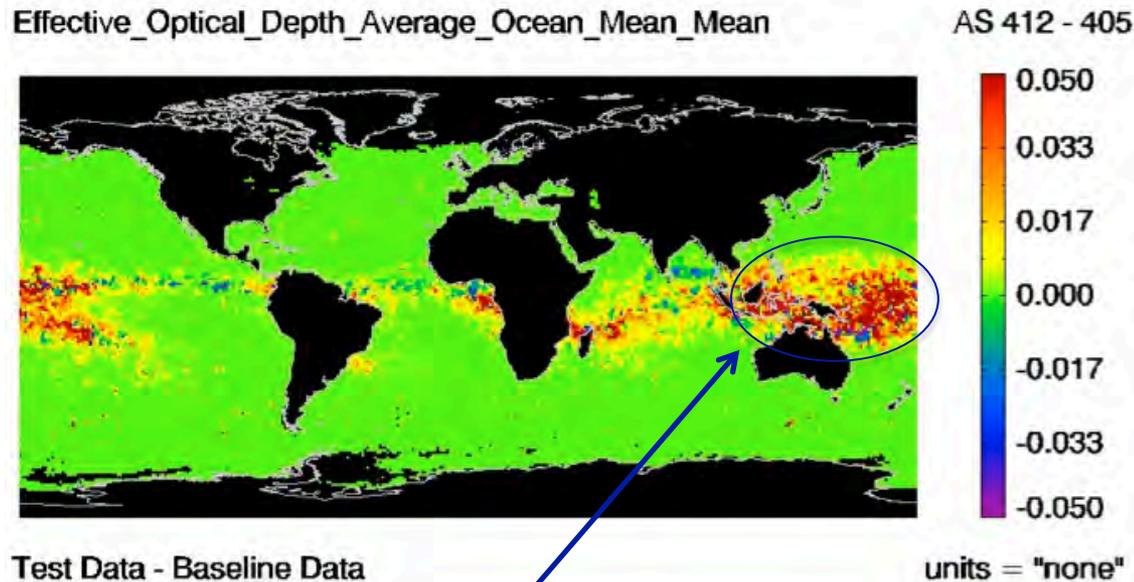
3. **New cloudmask does not bring back clouds!
(Very important!)**

AOD at 550 nm



Ocean cloud masking

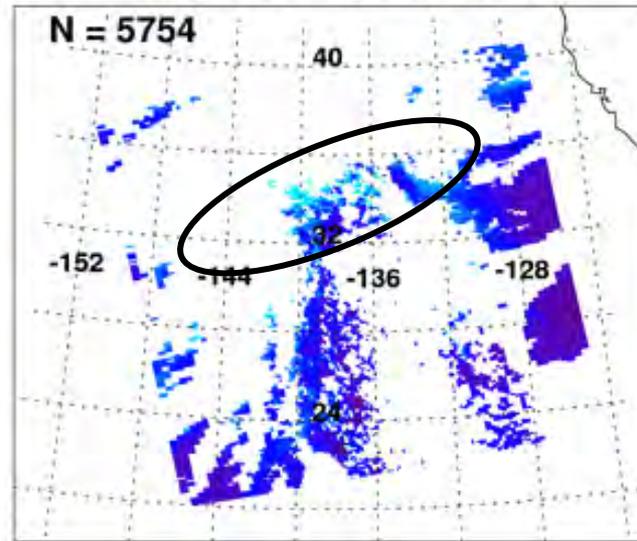
AOD with C6 MOD35 input minus AOD with C5 MOD35 input



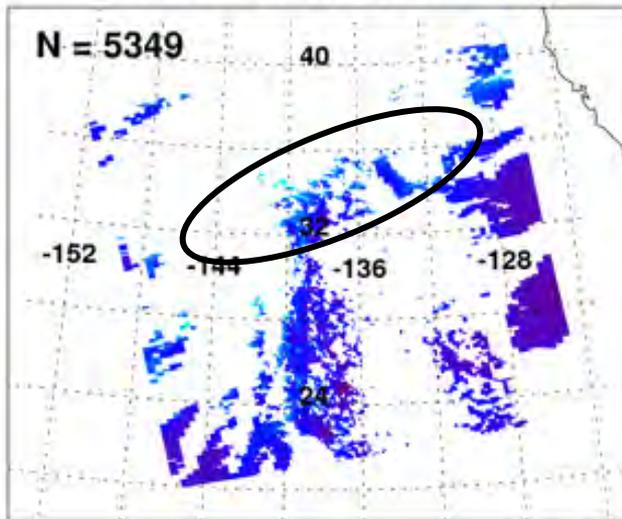
New MOD35 bit 18 test is less conservative in tropics, sometimes introducing cirrus cloud. Impetus to revisit ocean cloud mask.

MYD04_L2.A2010001.2225.hdf

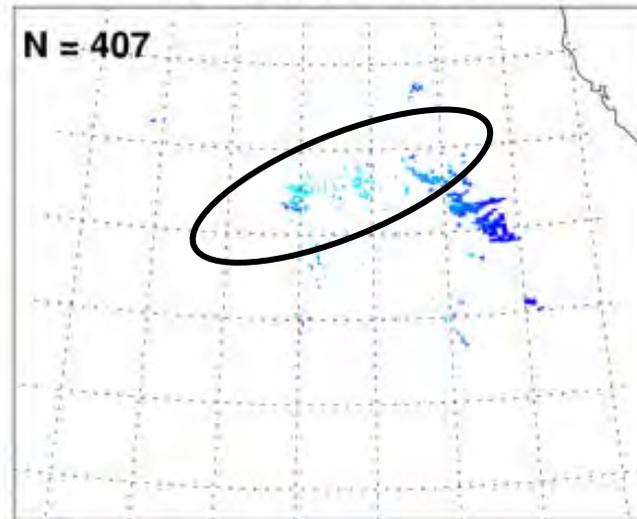
With old cloudmask



With new cloudmask



Deleted Pixels

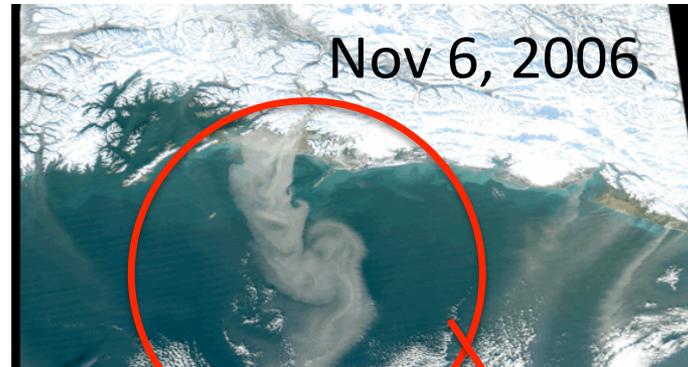


AOD at 550 nm

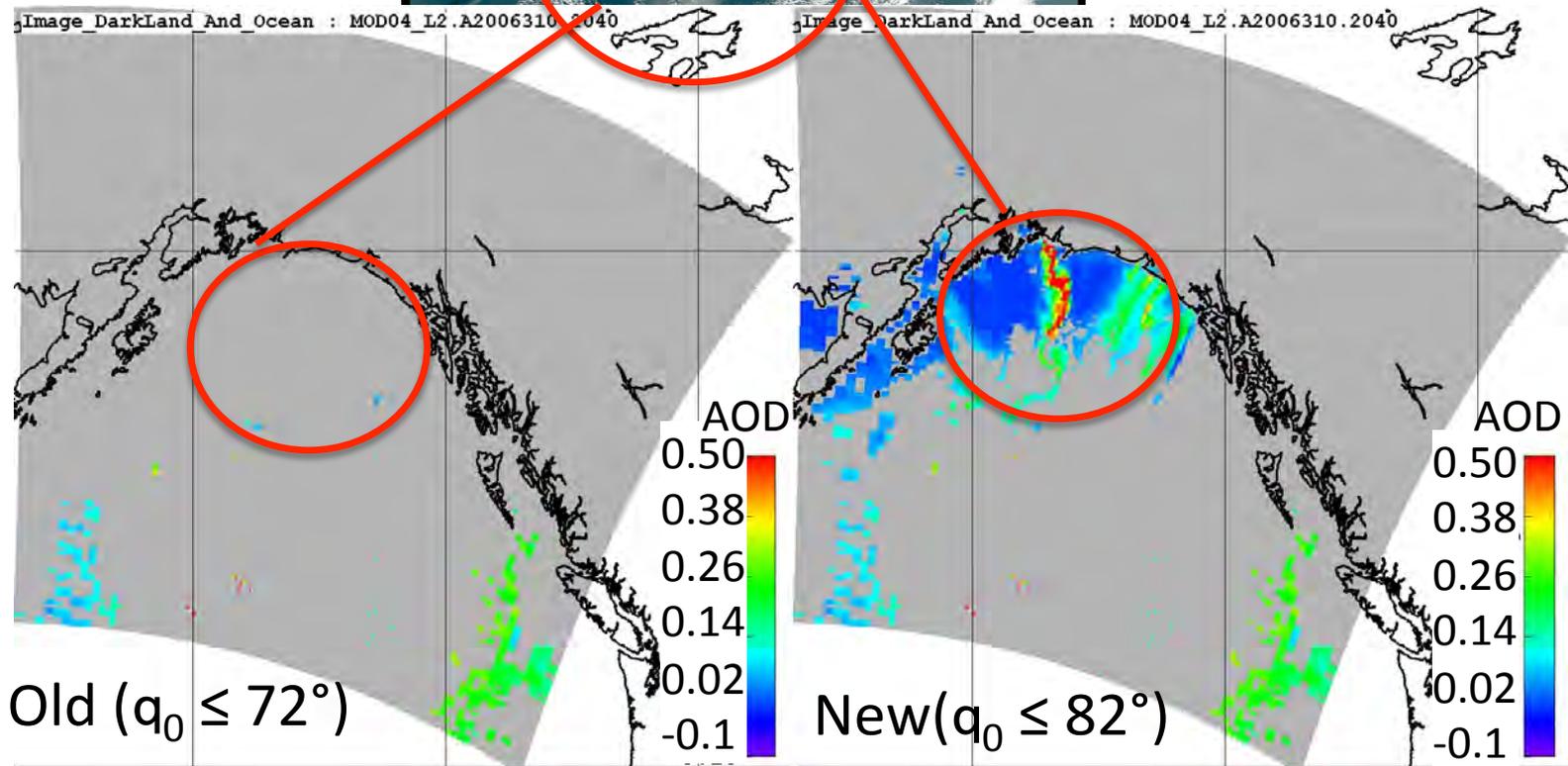


C006 will increase coverage in high latitudes

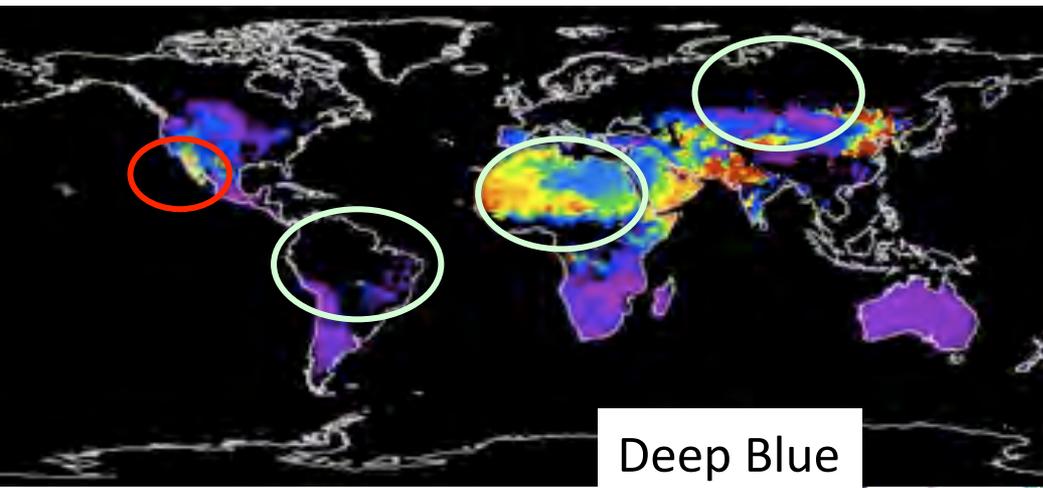
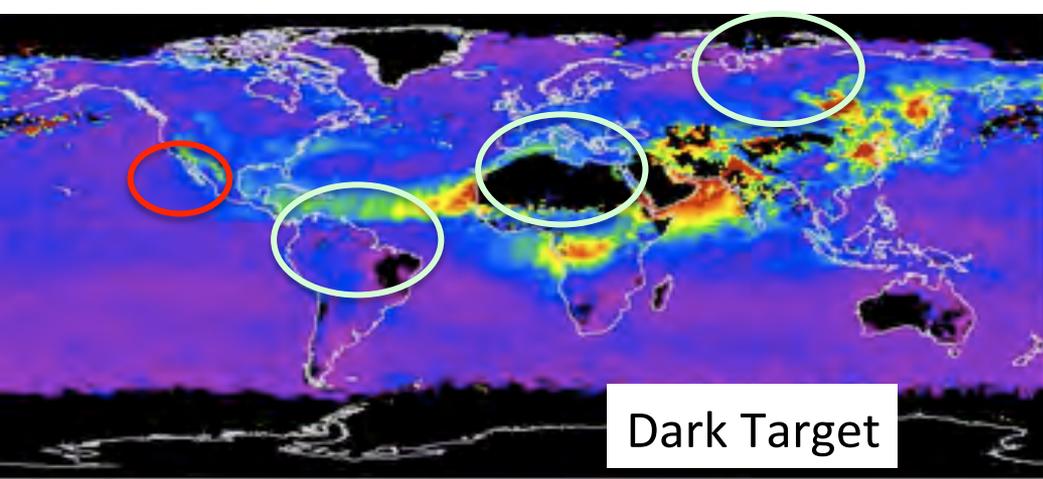
Dust event
Copper River
Gulf of Alaska



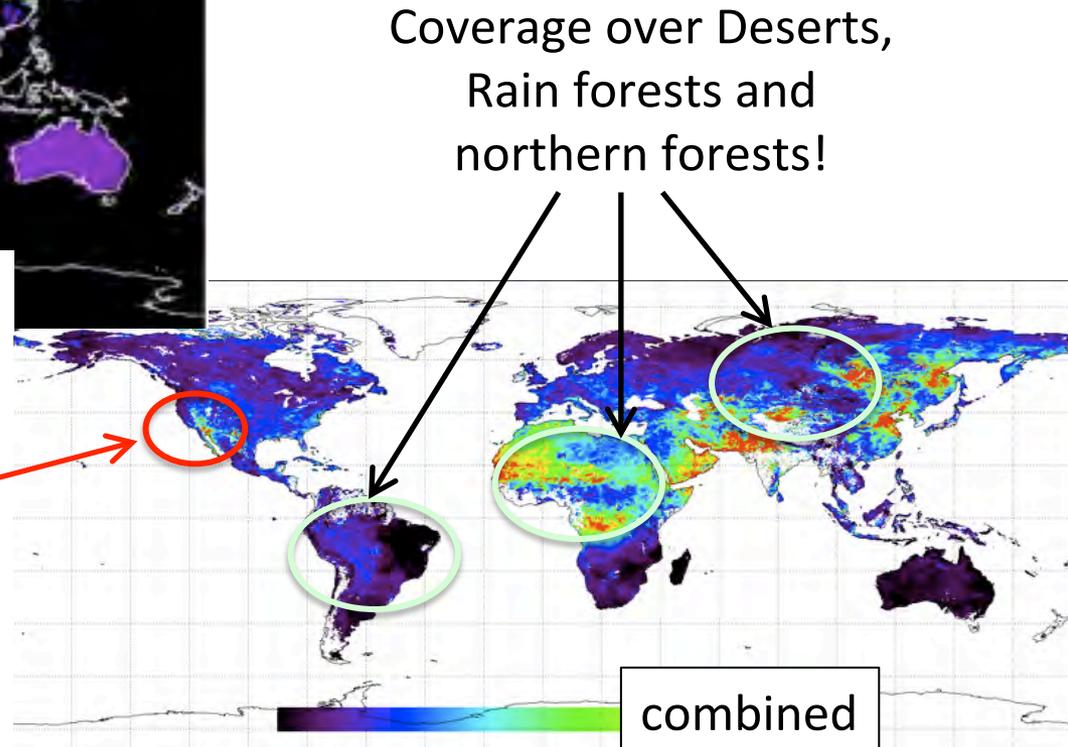
Relaxing threshold for
valid solar zenith angle
increases coverage and
“discovers” NEW DUST
SOURCE!



Terra July 2003 New combined DB/DT AOD

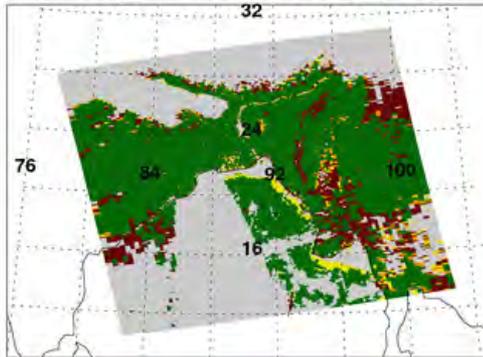


Some "suspicious" extremes are mitigated



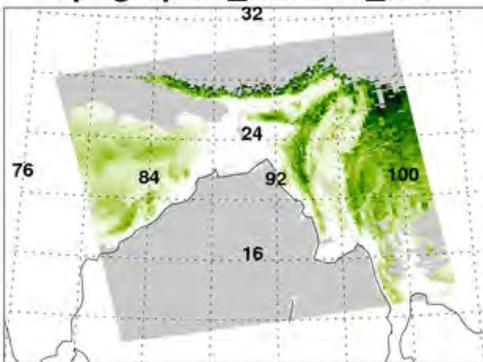
Diagnostic SDSs

Land_Ocean_Quality_Flag



0: Poor 1: Marginal 2: Good 3: Very Good

Topographic_Altitude_Land

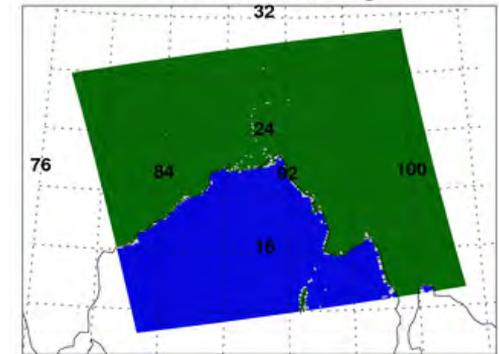


Surface Height [km]

0 1 2 3

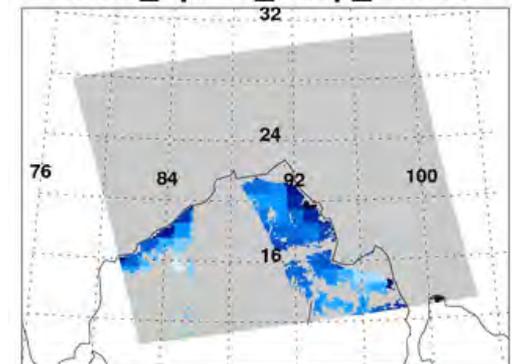


Land_Sea_Flag



Ocean Land

Wind_Speed_Ncep_Ocean

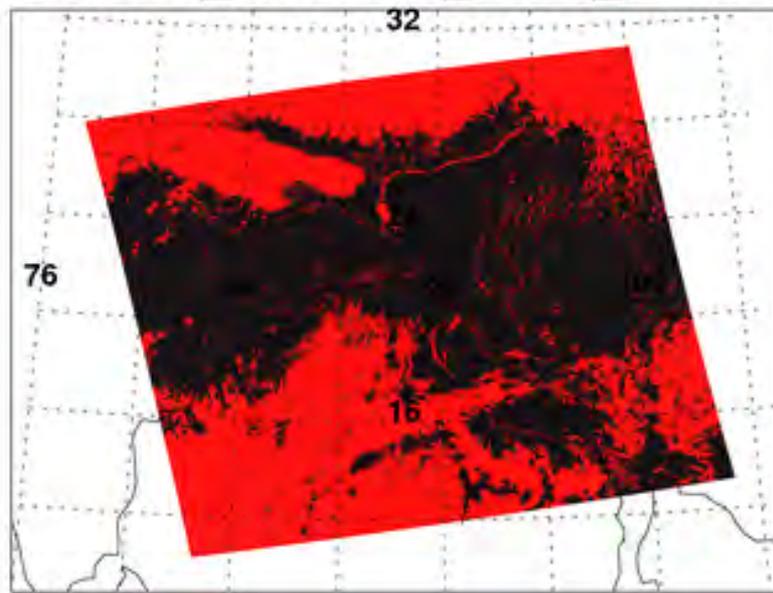


Wind Speed [m/s]

0 1 2 3 4 5 6 7 8

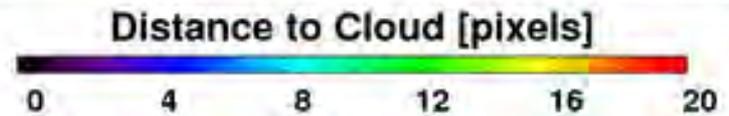
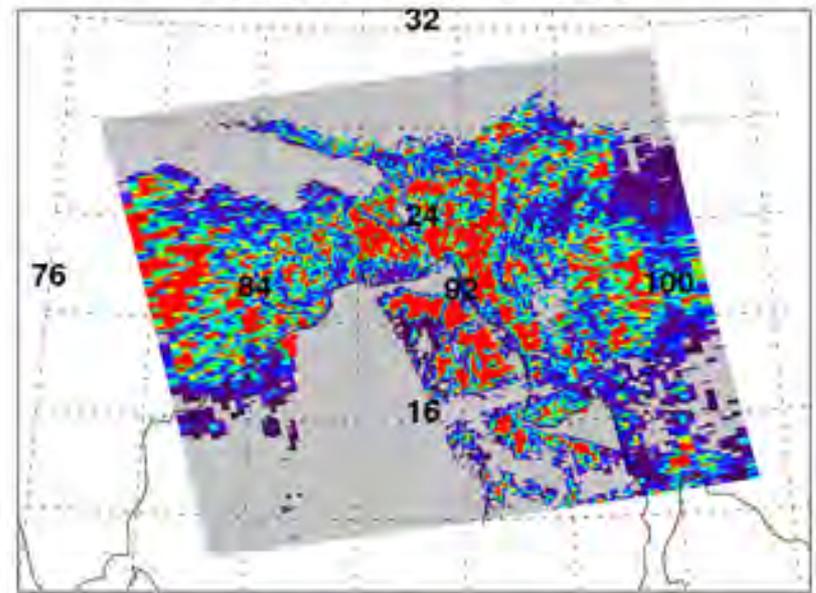
Cloud and Aerosol SDSs

Aerosol_Cldmask_Land_Ocean



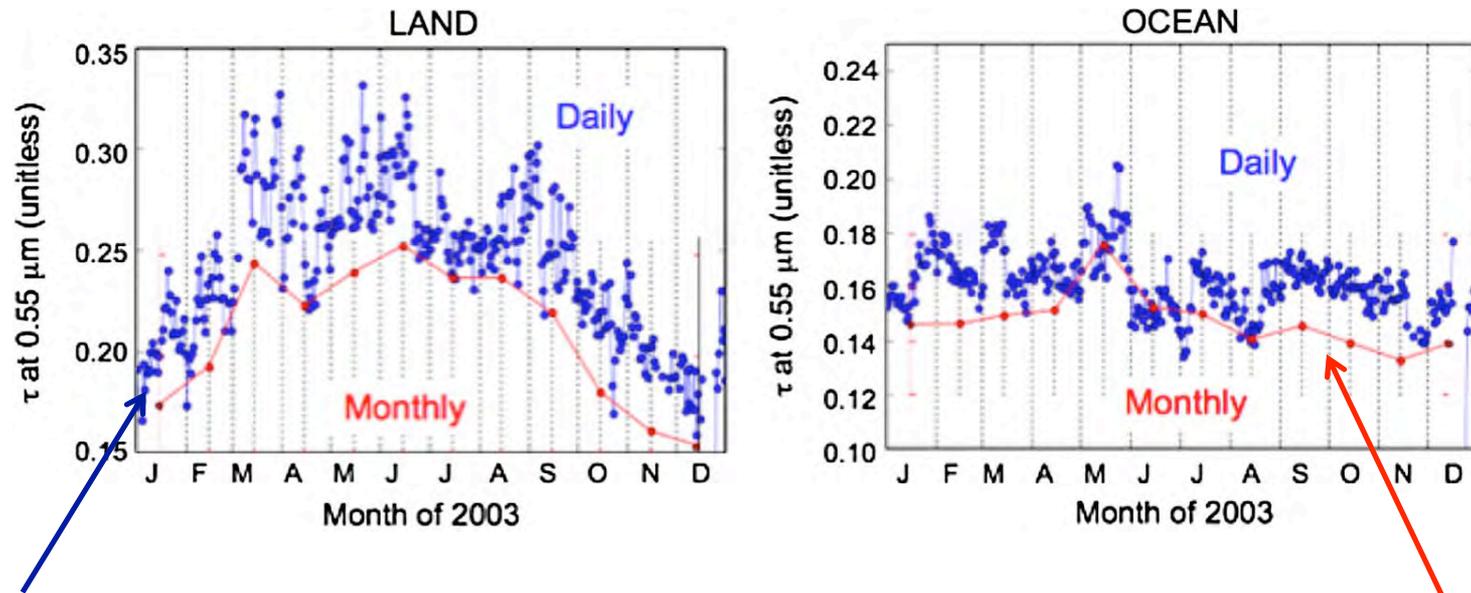
500 meter resolution cloud mask used in aerosol retrieval. Can be (at times, significantly) different than MOD35

Distance to Cloud



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

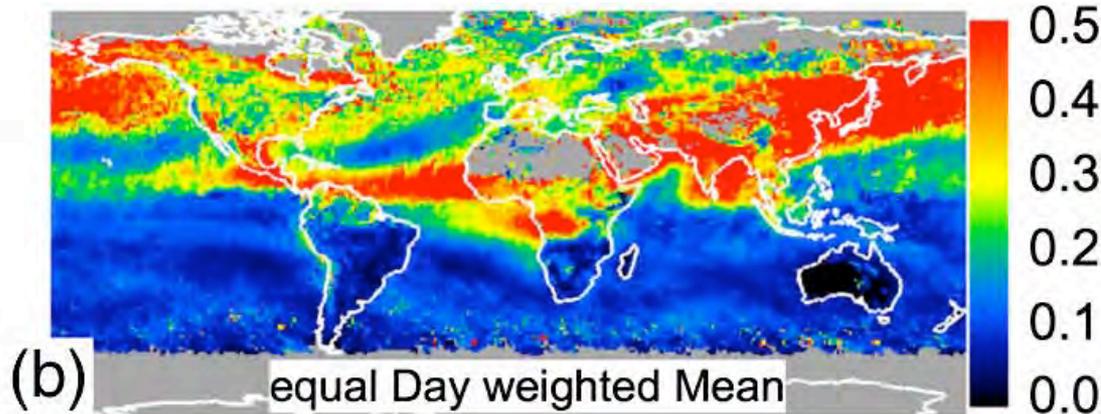
Changes to monthly aggregation (MOD08 world)



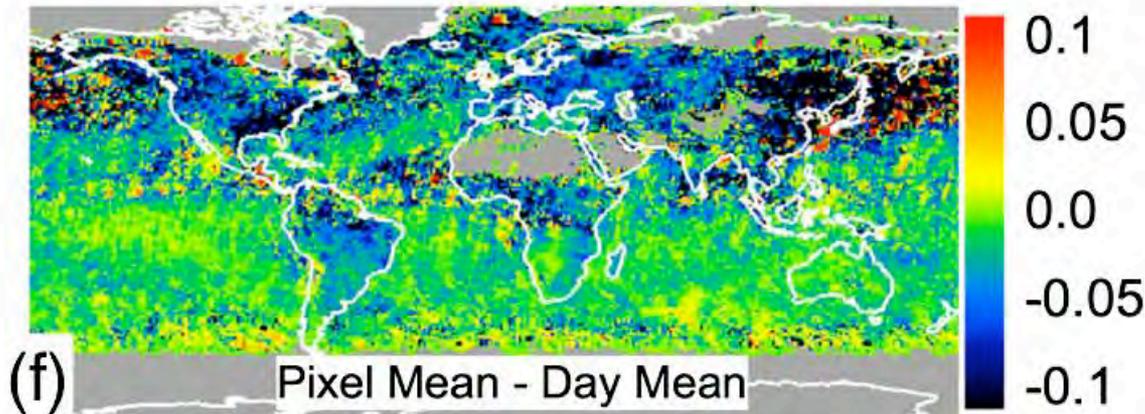
Daily average: Spatial average of 1x1 degree grid cell AOD, created from L2 granules

Monthly average: Average of the daily grid cell AOD averages, weighted by the number of pixels in each cell

Changes to monthly aggregation (MOD08 world)



Collection 6 method

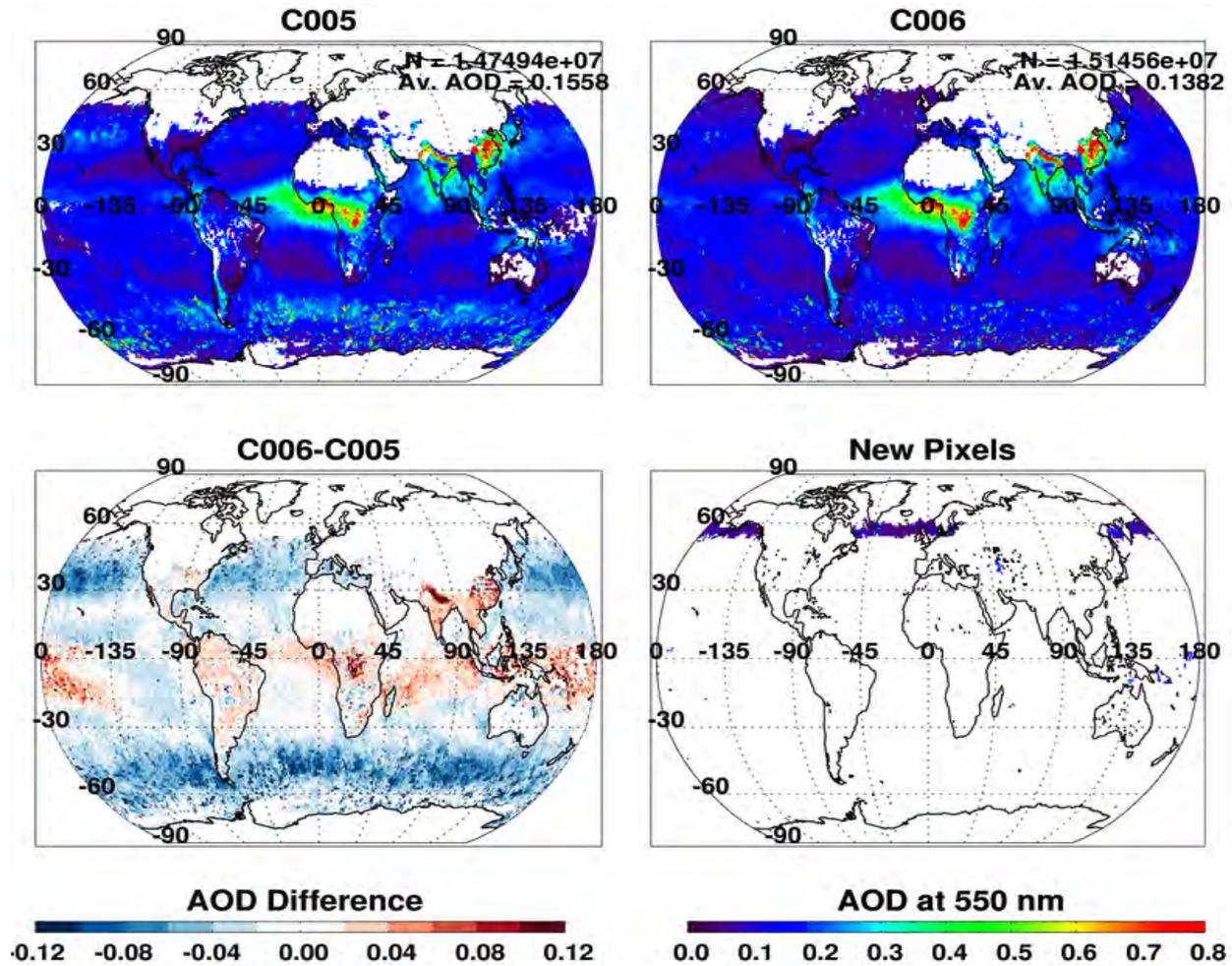


**Difference between
collection 5 method
and collection 6
method**

What is the total expected change?

Algorithm changes + L1B calibration
...for one month of data...

AOD changes



AOD changes

Global Correction of Rayleigh optical depth:

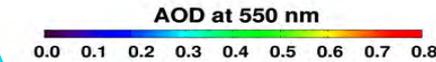
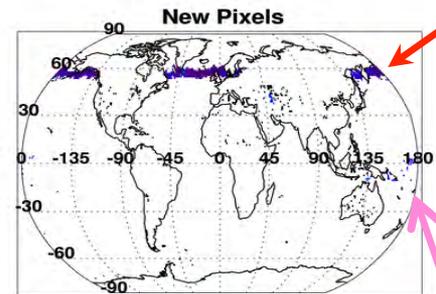
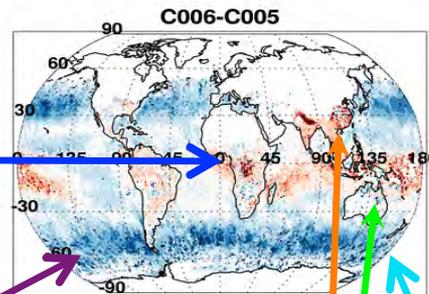
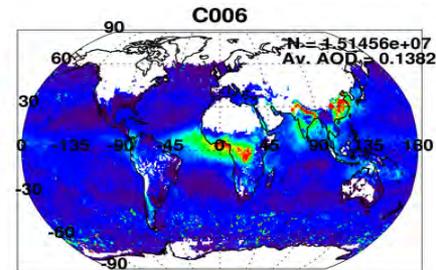
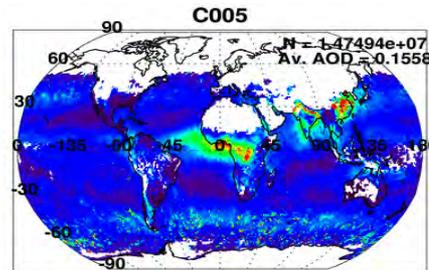
- 0.01 increase over land
- 0.01 decrease over ocean

Land cloud masking changes:

Nearly no change to global AOD, but large local AOD increases

Multiple wind speed LUT over ocean:
AOD decrease near glint and where large wind speeds exist (e.g. roaring 40s in SH)

Preliminary comparisons with MAN data for low AOD cases show significantly reduced bias in AOD in collection 6 (Sayer et al, in prep)



New aerosol model map boundaries over land:

- increase over SE Asia and N. American plains
- decrease over parts of Brazil savanna and Australia

Allowing SZA up to 84°:
high latitude coverage

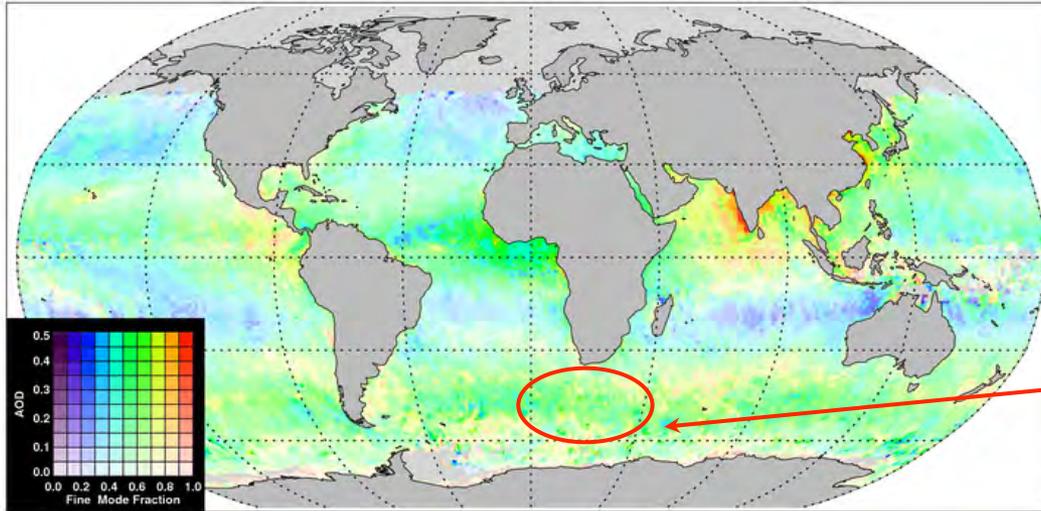
Ocean cloudmasking changes:

- more pixels retrieved over tropical oceans (changes in C6 MOD35)
- AOD decreases in extratropics due to removal of cloud contamination

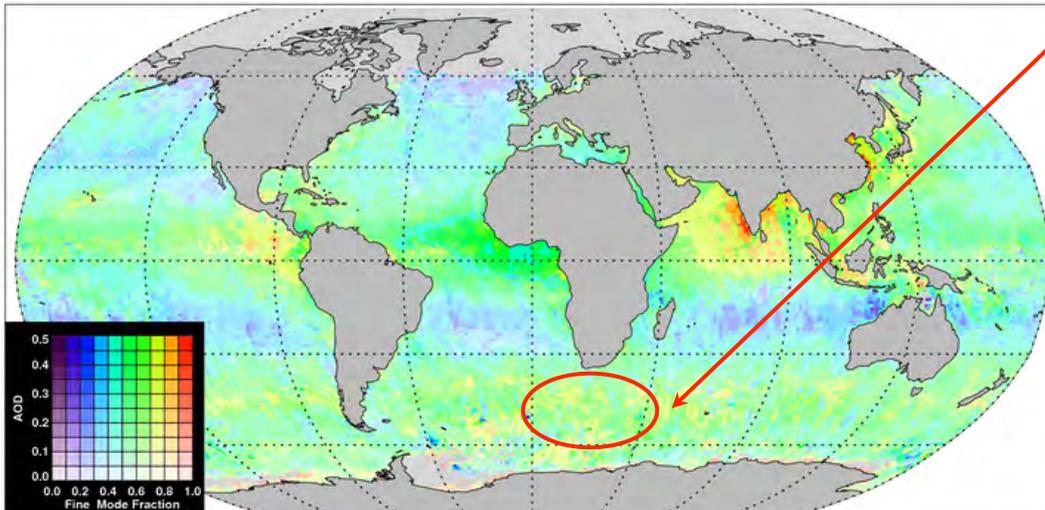
Monthly average, AQUA, January 2010

Fine Mode Fraction Changes

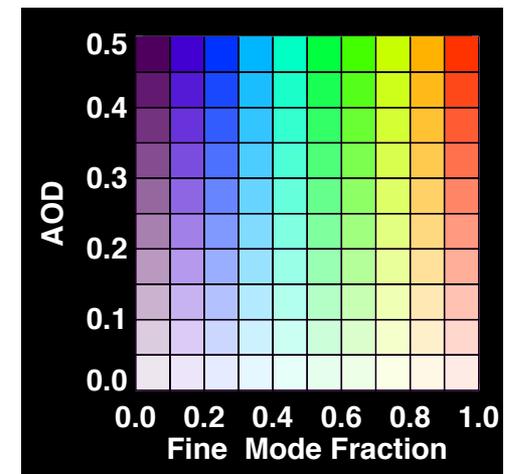
C005



C006



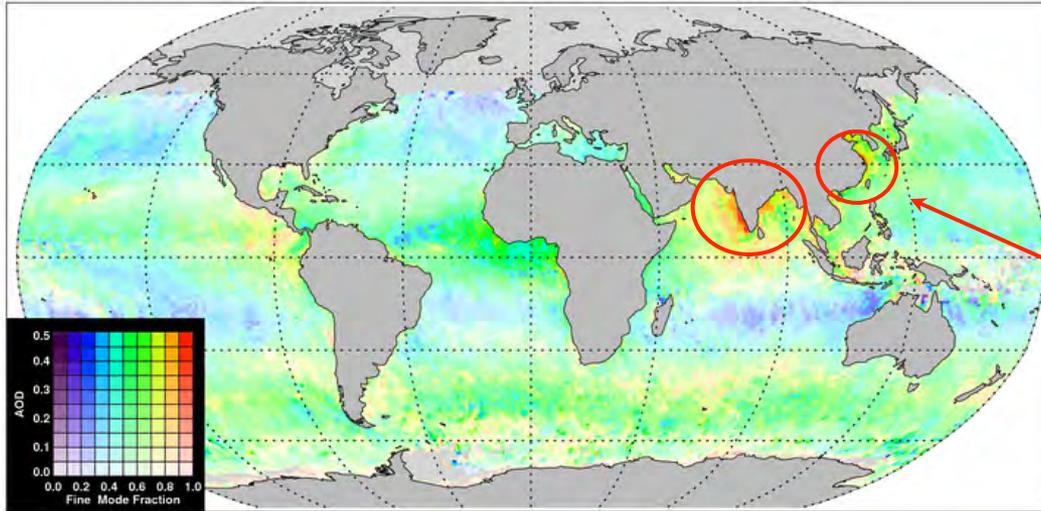
smaller particles in
'roaring 40s'



Monthly average, AQUA, January 2010

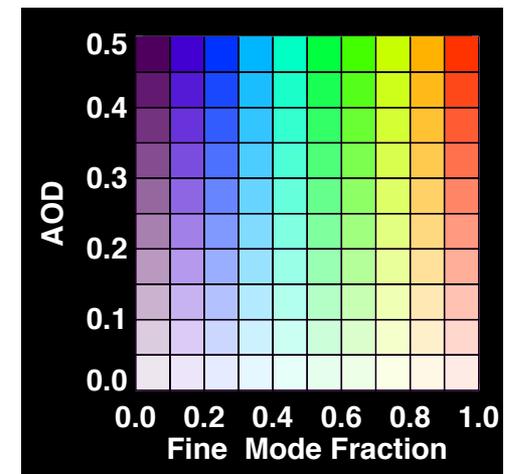
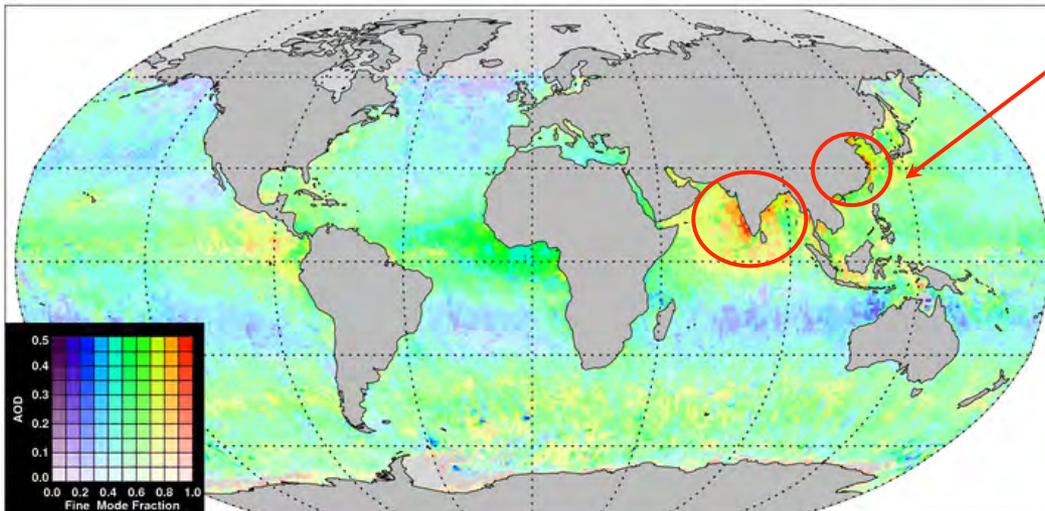
Fine Mode Fraction Changes

C005



smaller particles for biomass burning regions near Africa and polluted areas near India and China

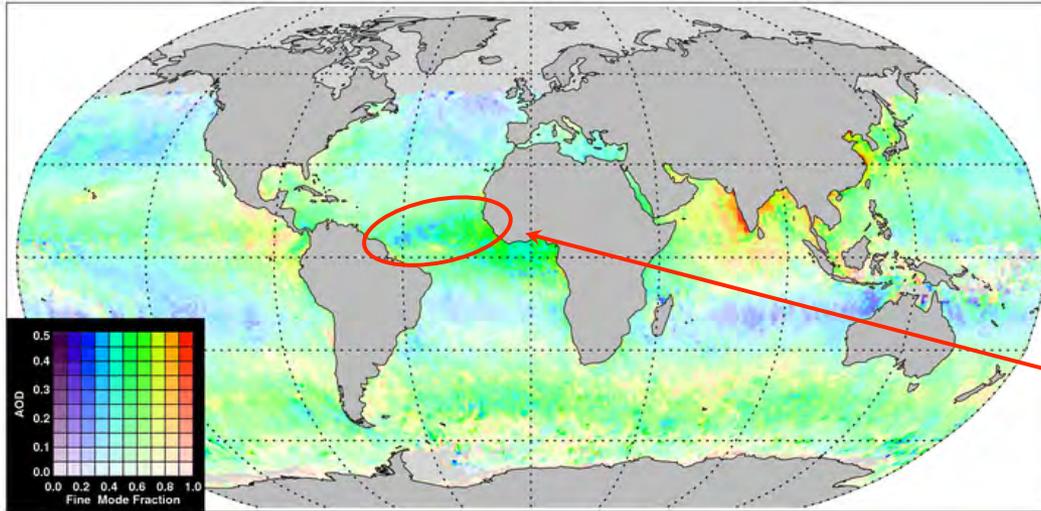
C006



Monthly average, AQUA, January 2010

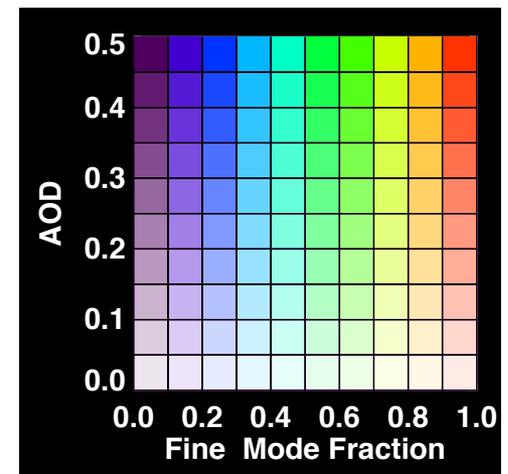
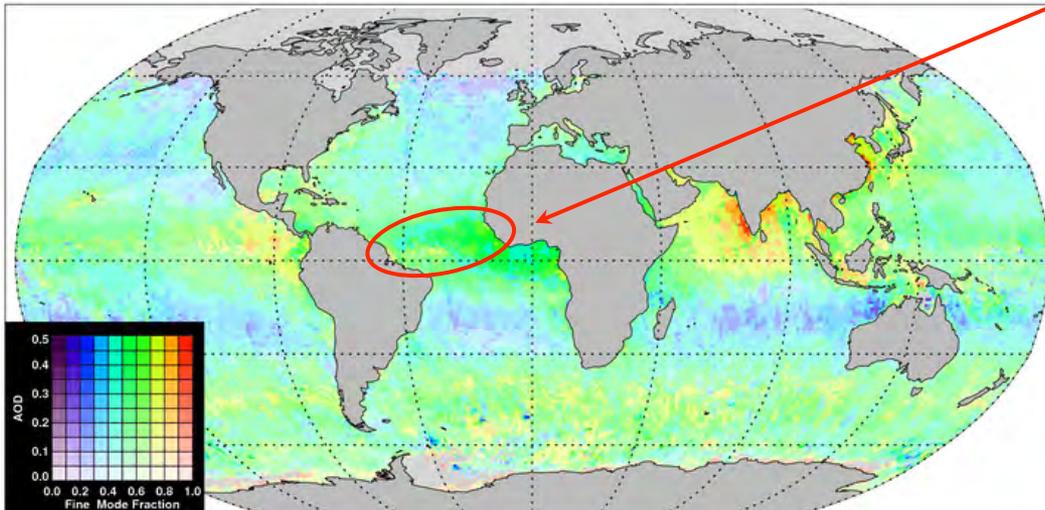
Fine Mode Fraction Changes

C005



smaller particles in the Saharan dust belt

C006

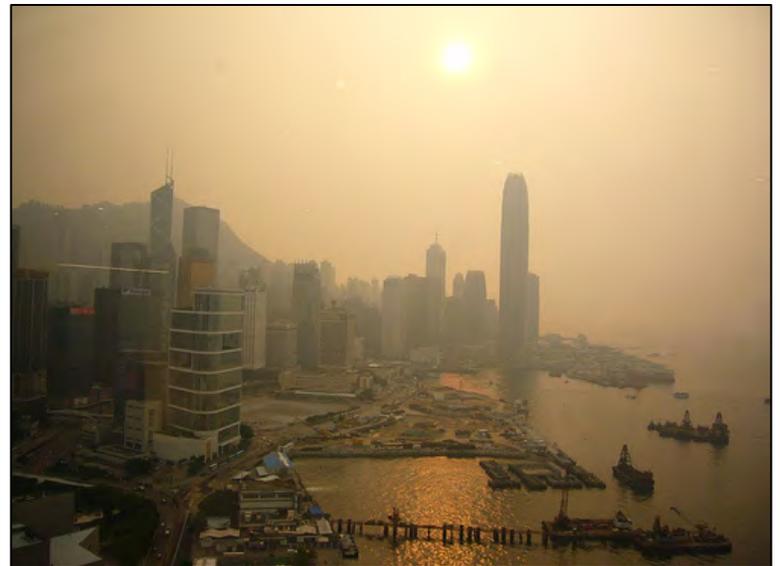


Monthly average, AQUA, January 2010

Initial validation of 3 km aerosol product

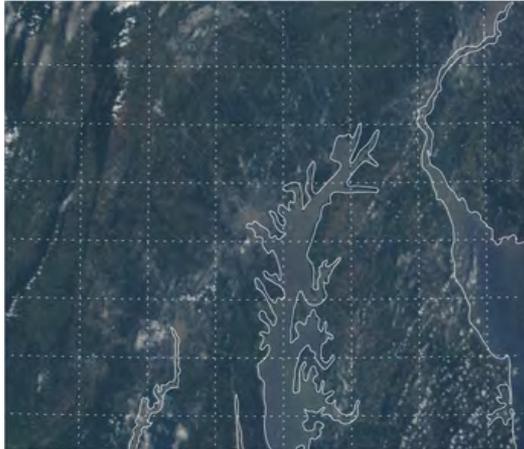
In response to user requests, MODIS Collection 6 will include a 3 km aerosol product over land and ocean.

Attempting to bridge the scales from climate to air quality.

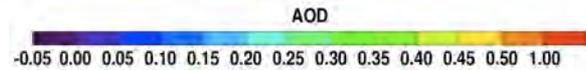
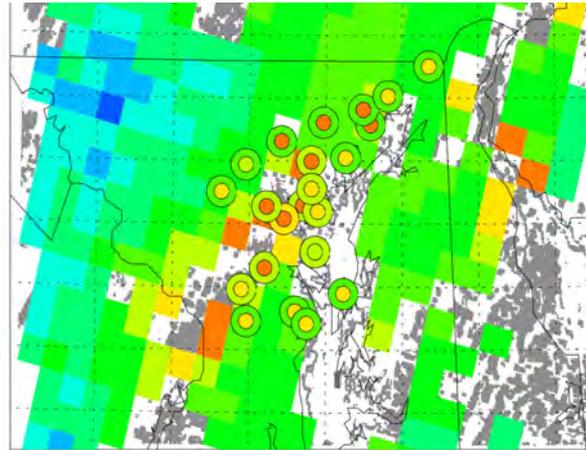


Testing of 3 km product in DISCOVER-AQ (summer 2011)

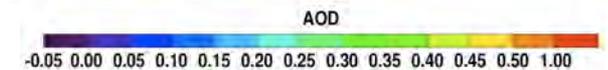
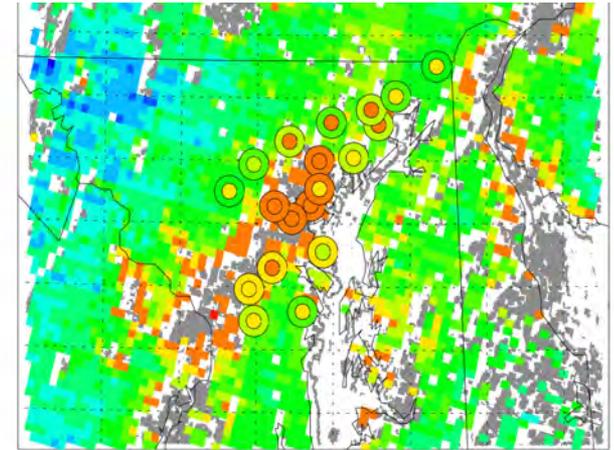
Terra: July 11, 2011



10 km retrieval



03 km retrieval

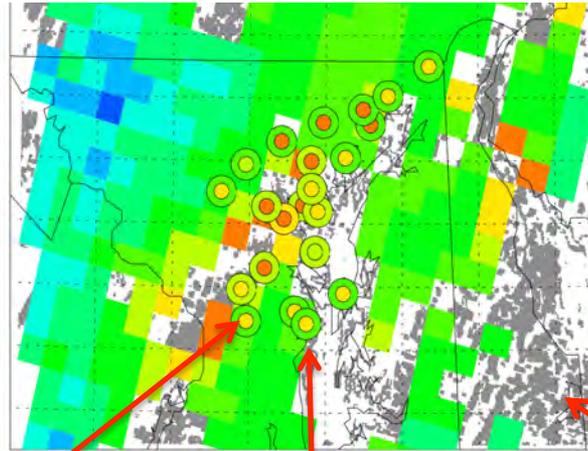


Testing of 3 km product in DISCOVER-AQ (summer 2011)

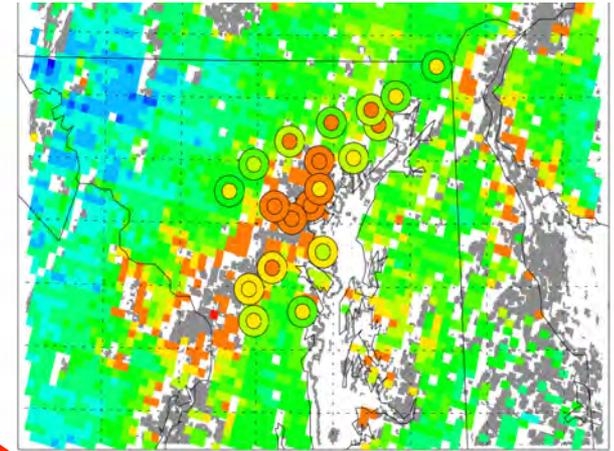
Terra: July 11, 2011



10 km retrieval



03 km retrieval



Inner circle: AERONET collocation
(+/- 30 minutes of satellite overpass)

Outer circle: MODIS collocation
(average of 5x5 pixel box surrounding
AERONET observation)

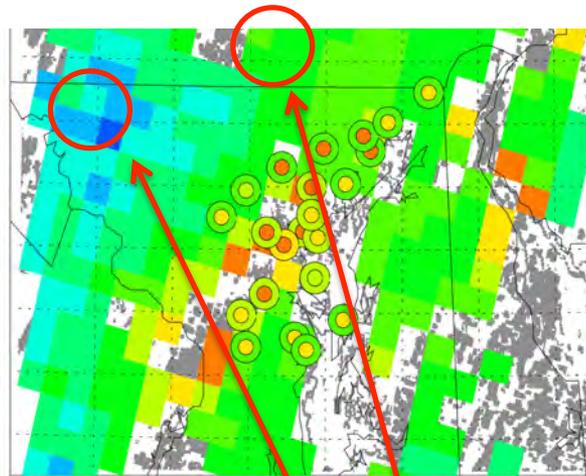
500 meter resolution
aerosol cloud mask

Testing of 3 km product in DISCOVER-AQ (summer 2011)

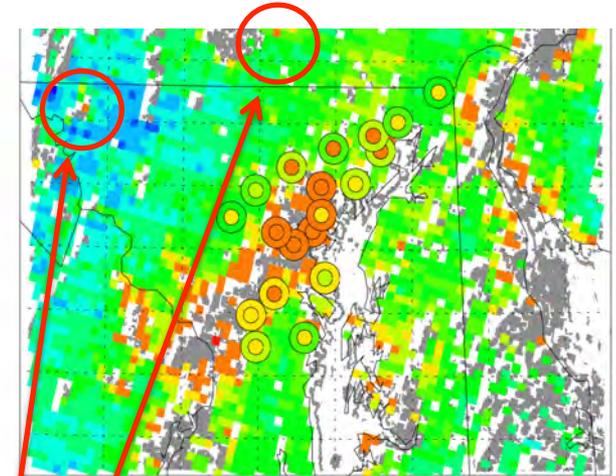
Terra: July 11, 2011



10 km retrieval



03 km retrieval



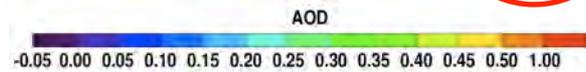
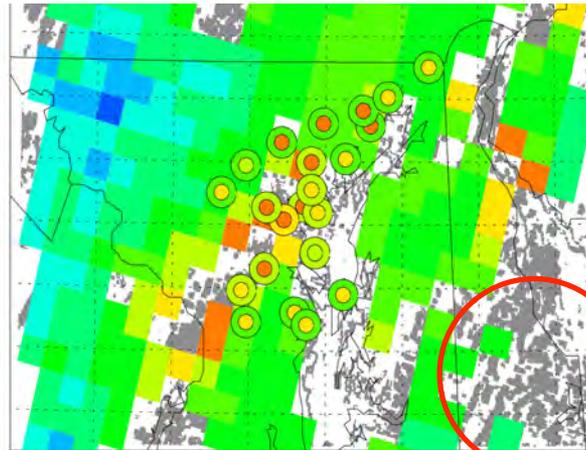
3 km product has more
noise than 10 km
product

Testing of 3 km product in DISCOVER-AQ (summer 2011)

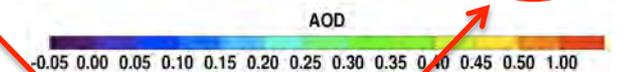
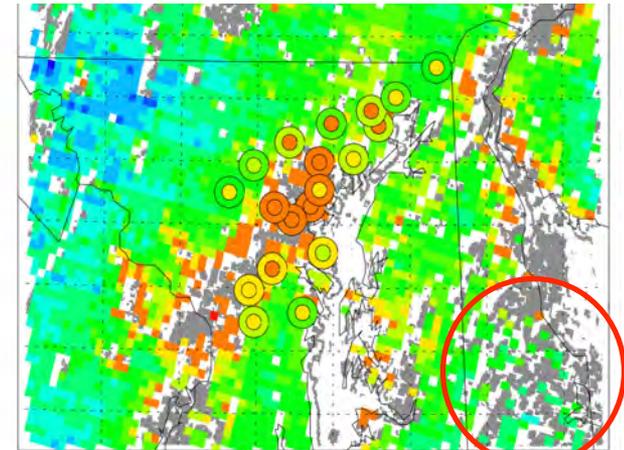
Terra: July 11, 2011



10 km retrieval



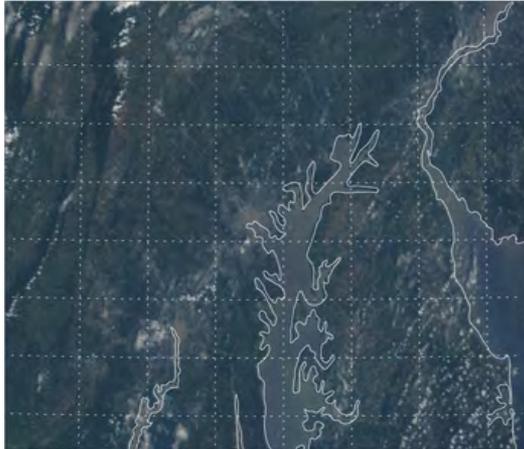
03 km retrieval



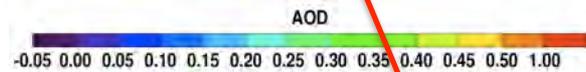
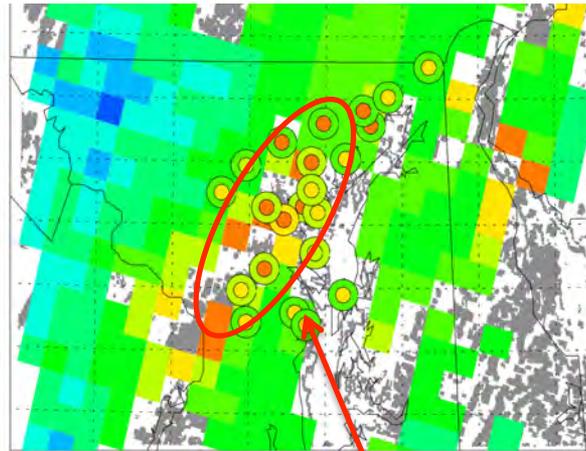
3 km product is able to retrieve closer to cloud edges

Testing of 3 km product in DISCOVER-AQ (summer 2011)

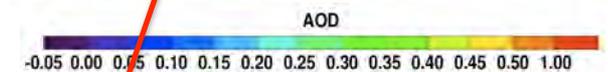
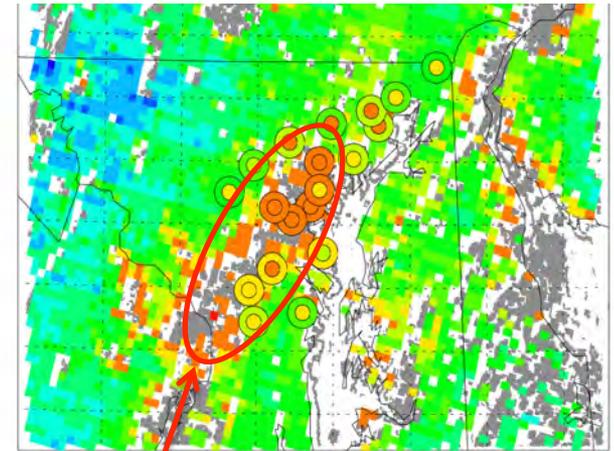
Terra: July 11, 2011



10 km retrieval



03 km retrieval

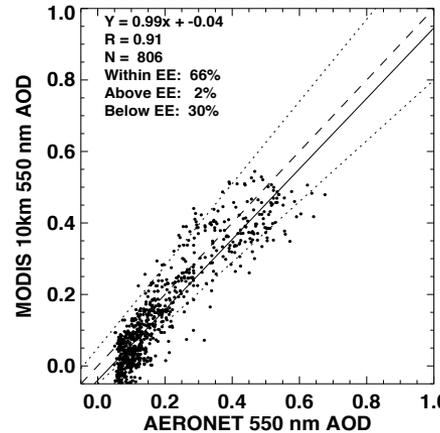


3 km resolves the high AOD concentrated over the urban corridor while the 10 km product misses it.

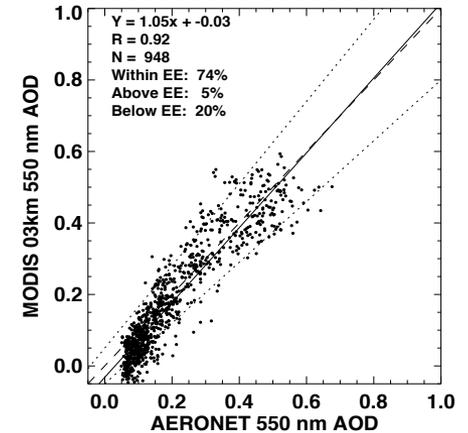
Validation statistics

Validation during DISCOVER-AQ:
74% of 3 km match-ups are within
expected error (vs. 66% of 10 km)

10 km data



03 km data



Initial validation of 6 months of global data looks good,
detailed global validation effort is ongoing

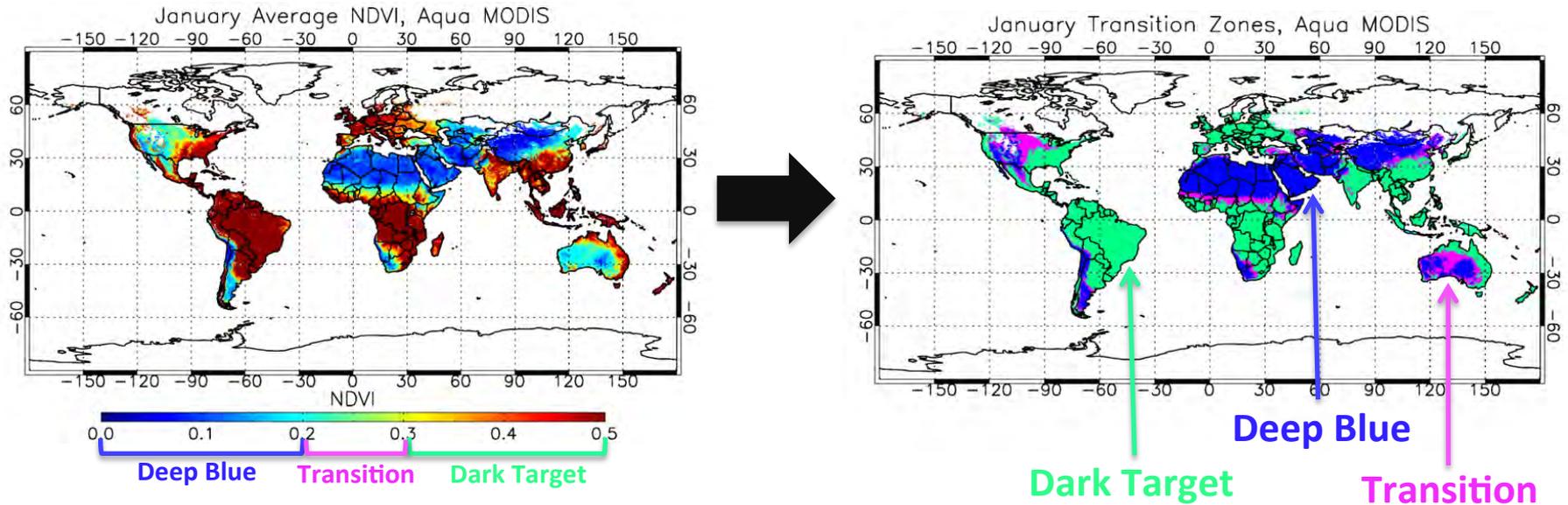
- Significant algorithm changes since C005 (but no algorithm overhauls).
- New diagnostic & aerosol-cloud SDSs.
- Better global coverage – SZA & combined Deep Blue/Dark Target product
- C006 will have a separately produced 3km product (in addition to 10km) that is validating well
- We have some testing before C006 becomes “operational”
 - Assess impacts of new C006 L1B calibration, especially to AOD trends
 - Run 6 months of MOD04 with full C006 inputs
 - Begin validation with AERONET/MAN

Thank you

Changes for C006 product

- Major changes to Level 2 algorithm
 - Changes to cloud mask over both land and ocean
 - Variable wind speed LUTs
 - Allow SZA up to 84° (high latitude coverage)
 - Over land, aerosol model map is updated (new boundaries).
 - Over ocean, sediment mask logic is updated.
 - LUT consistency (adjustments in wavelengths, Rayleigh optical depth).
 - QA consistency: Make sure QA is assigned correctly
- “New” products and SDSs
 - Useful “integer” values and diagnostics for QA, land/sea flag
 - Diagnostic SDS parameters: elevation, glint angle, wind speed
 - Combined Deep Blue/Dark Target retrieval
 - 500 m resolution “aerosol” cloud mask and “distance” to nearest cloud.
- New monthly averaging scheme for level 3 aerosol products
- Operational 3 km resolution product

Combining algorithm



Divide world into three zones based on NDVI thresholds from monthly gridded climatology

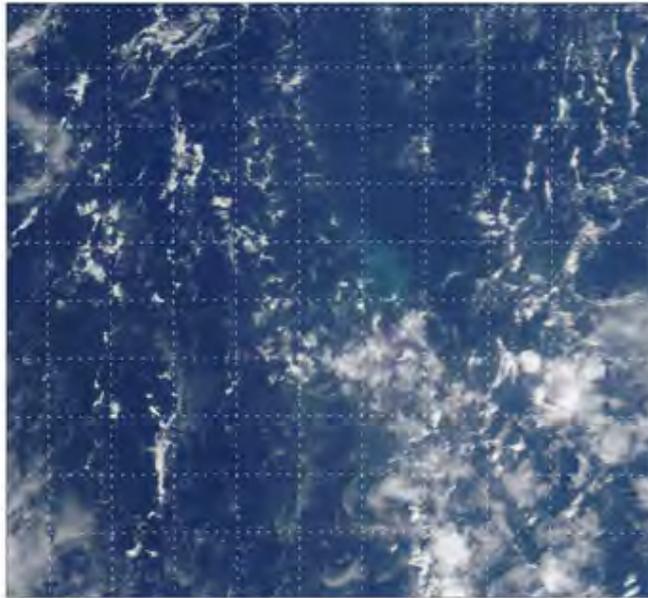
In transition regions...

if $QA_{DT} > QA_{DB}$, then use dark target

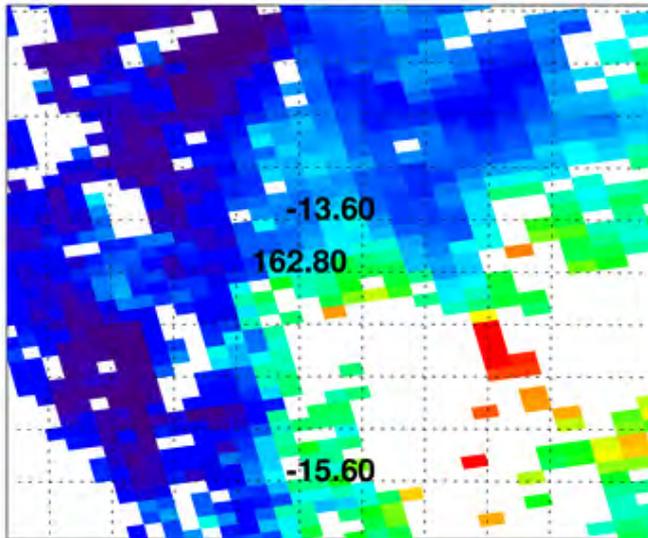
if $QA_{DT} < QA_{DB}$, then use deep blue

if $QA_{DT} = QA_{DB}$, then average ($0.5 * DB + 0.5 * DT$)

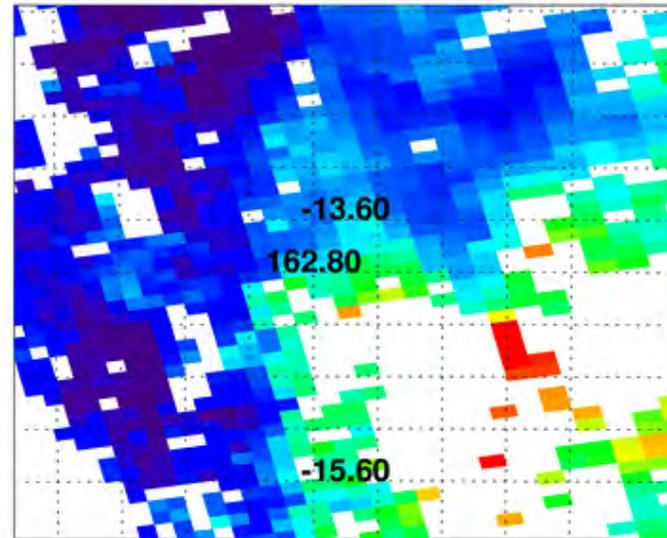
Test 405



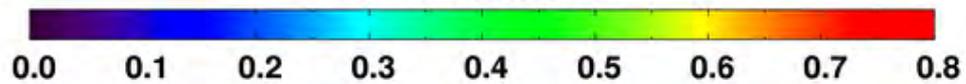
Test 412



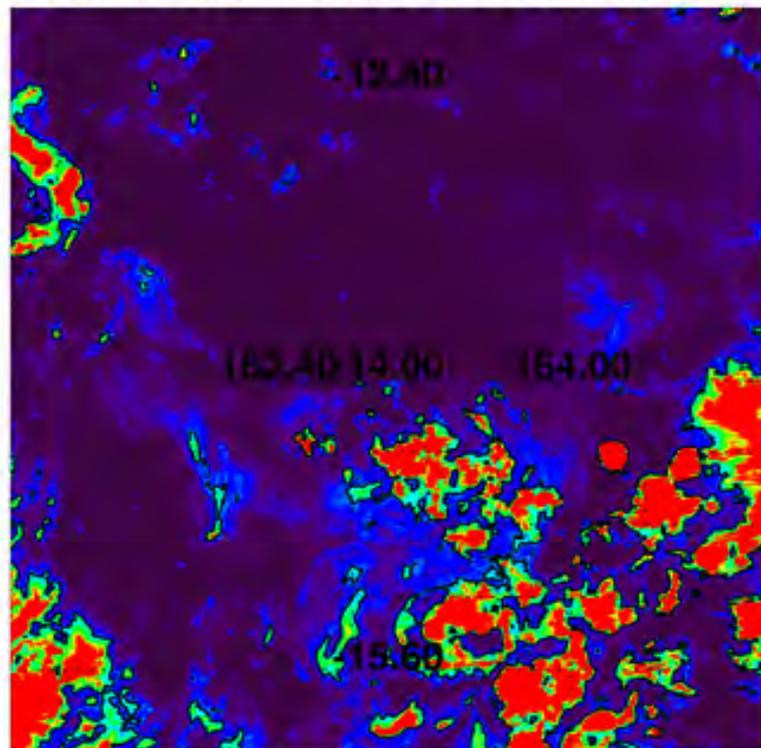
New Pixels



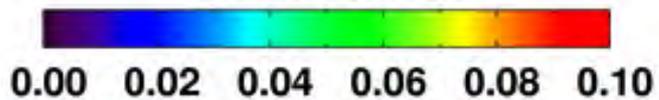
AOD at 550 nm



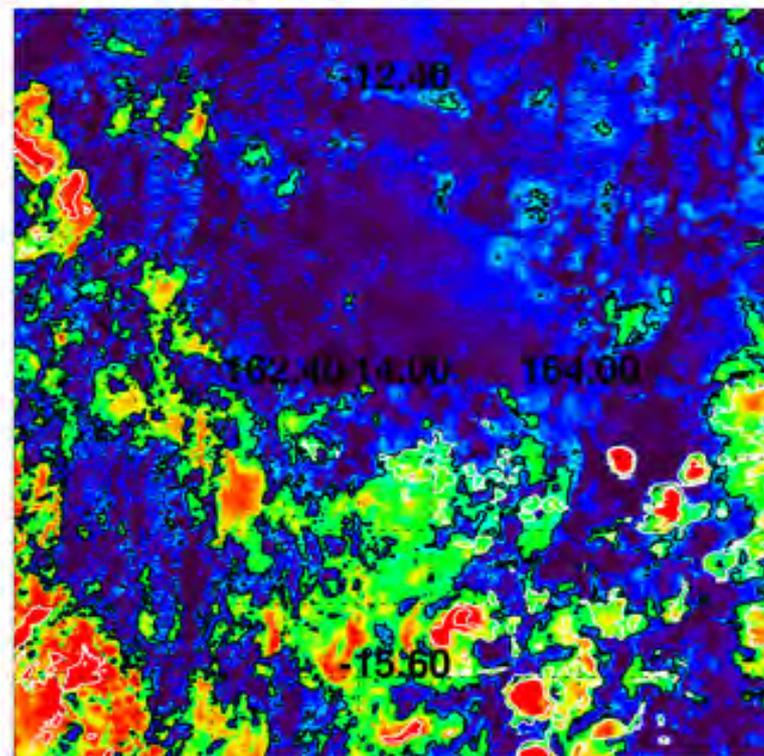
C006L1B - 1.38 um reflectance



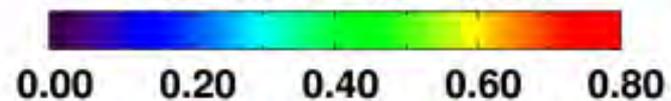
Reflectance

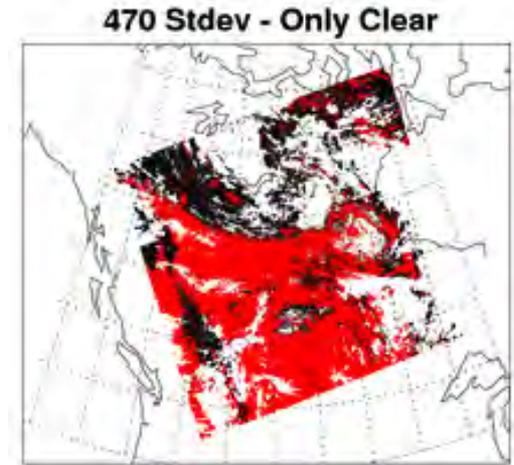
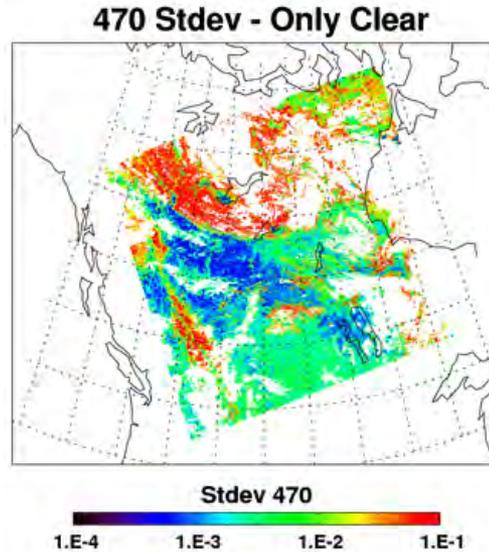
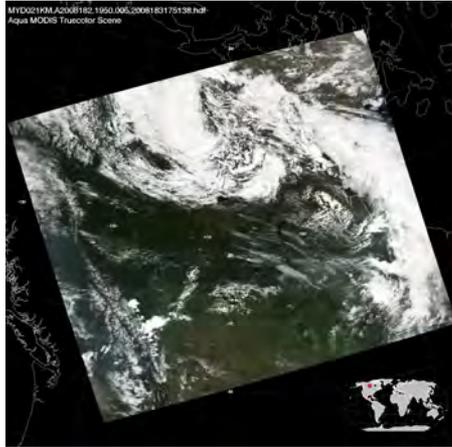


C006L1B - 1.38/1.24 um Reflectance



Reflectance Ratio

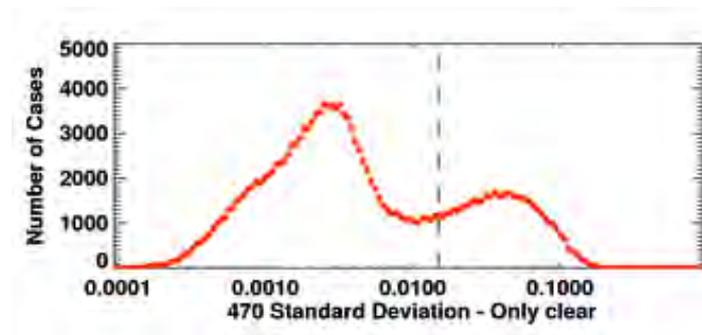




Original mask: .47 standard deviation (Martins, 2002)

...somewhere along the way... .47 standard deviation times .47 reflectance

New mask: .47 standard deviation times .47 reflectance with a .47 standard deviation callback



Less conservative cloud masking over land

A. van Donkelaar et al. / Atmospheric Environment 45 (2011) 6225–6232

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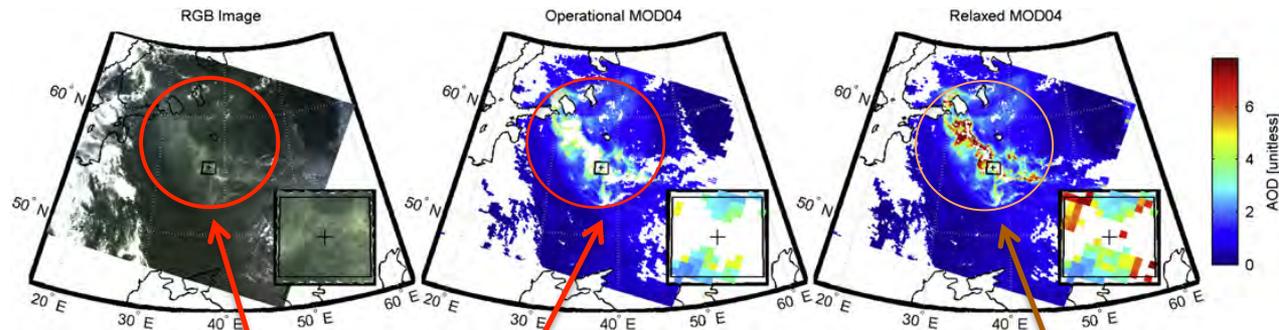
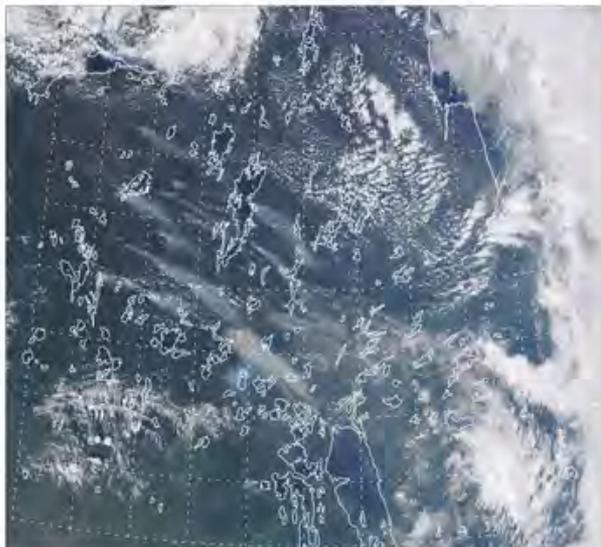


Fig. 2. The MODIS Terra granule from August 8, 2010 08:50 UTC. From left to right, the RGB image, the operational 550 nm AOD retrieval and the relaxed criteria 550 nm AOD retrieval are shown. The black crosshair and box identify Moscow and the Moscow Region, respectively, and are enlarged within the lower right subplot of each panel.

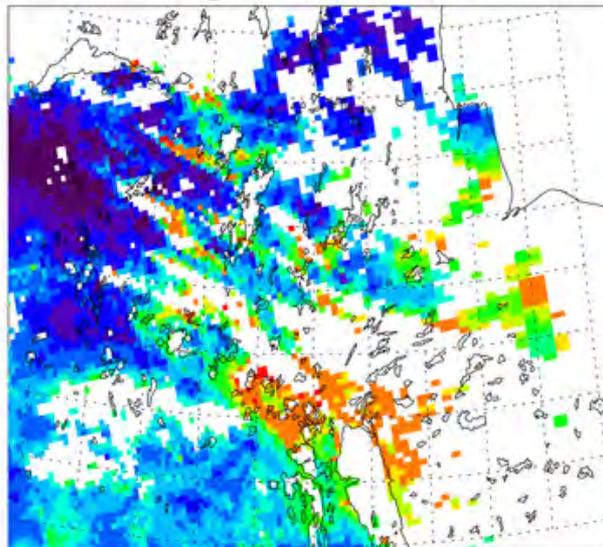
Regions of heaviest smoke are masked out in operational product

Relaxed cloud masking criteria allows some of the pixels to be retrieved

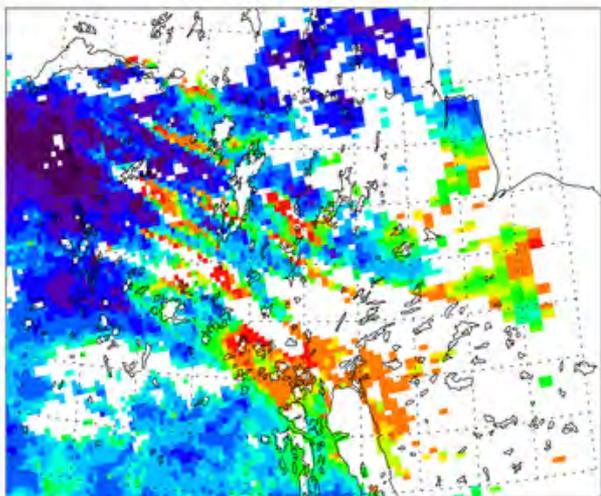
MYD04_L2.A2008182.1950.hdf



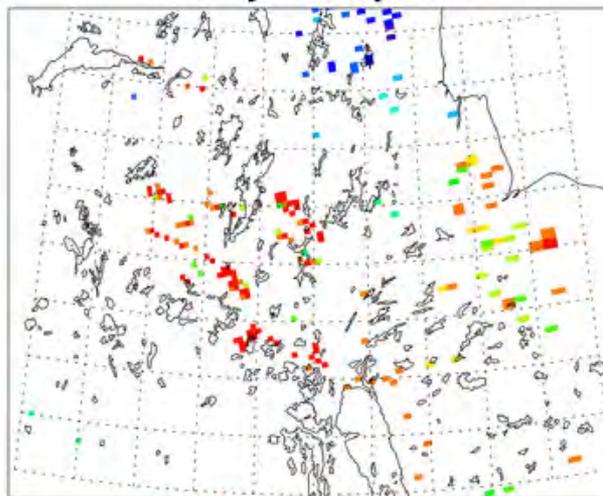
Original cloudmask



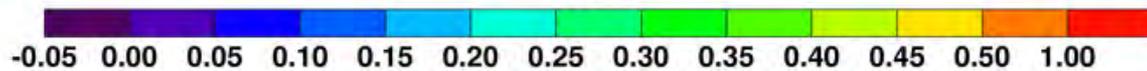
New Cloudmask



Newly ID'ed pixels



AOD

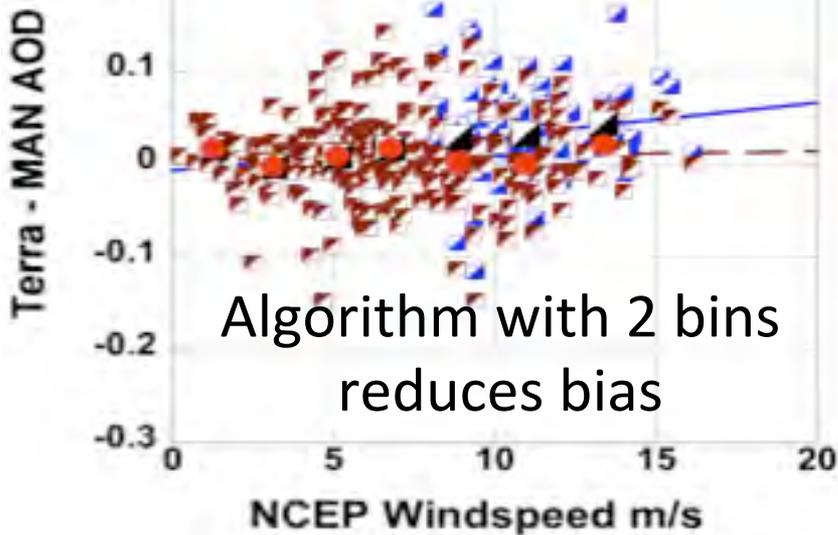


C006 will be more accurate near ocean glint



Regression equations for the scatter plot:

- Blue line: $y = -0.007 + 0.004x$ $R = 0.25$
- Red line: $y = 0.005 + 0.0004x$ $R = 0.03$



- C005 bias related to wind speed
- C006 calculates ocean surface as function of wind speed.
- Biggest change near glint edges

Algorithm test: C005 – C006

