

# Collection 6 update: MODIS 'Deep Blue' aerosol

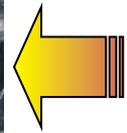
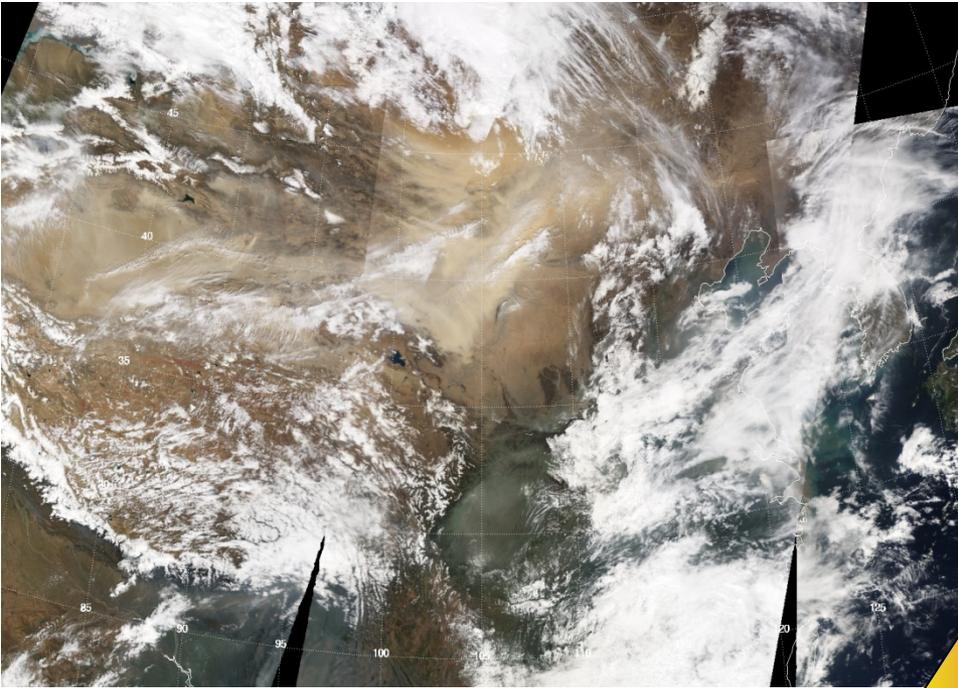
N. Christina Hsu & team:

C. Bettenhausen, R. Gautam, R. Hansell, J. Huang, M. J. Jeong,  
R. Limbacher, **A. M. Sayer**, C. Seftor, J. Warner

Related poster: A. M. Sayer et al.



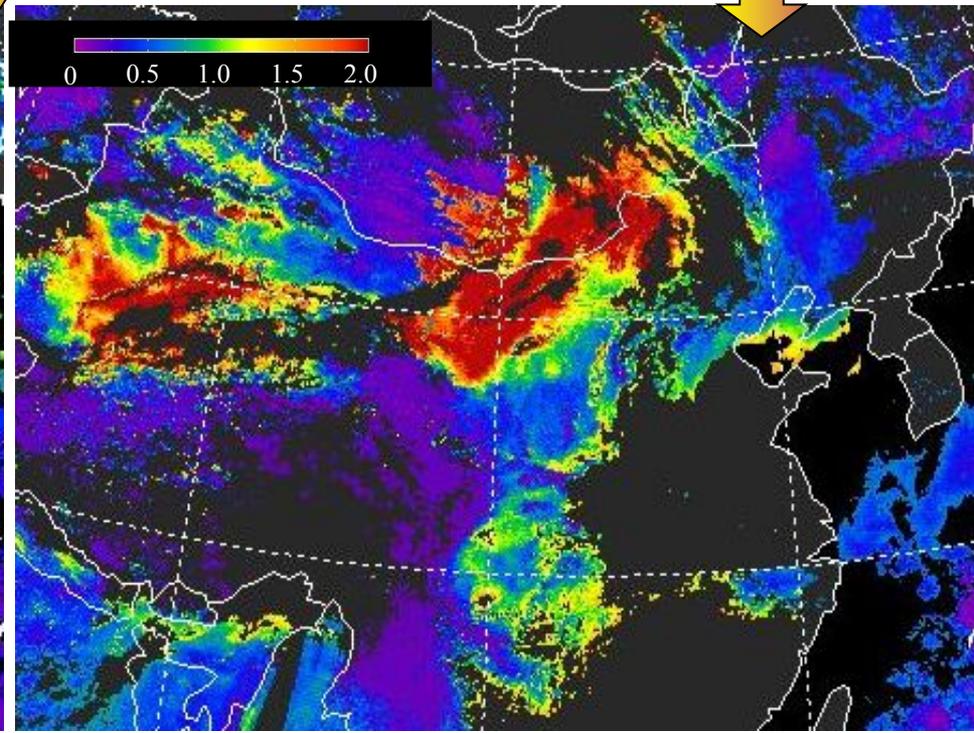
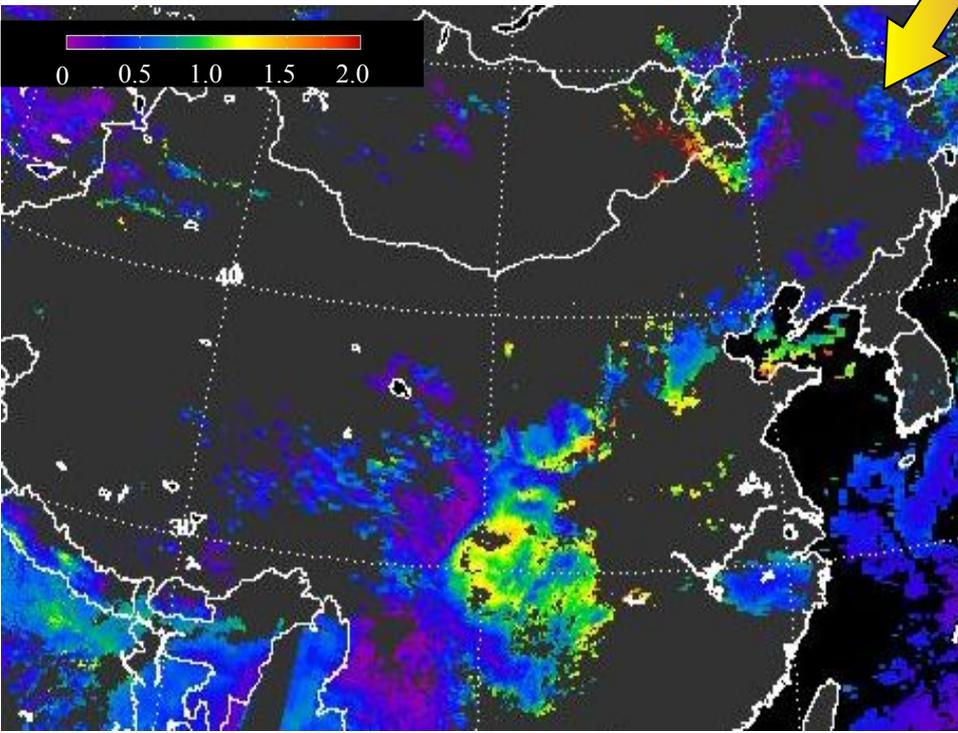
# Dust storm: 6<sup>th</sup> April 2001



MODIS *Red-Green-Blue*  
composite

MODIS *Dark Target*  
AOD

MODIS *Deep Blue*  
AOD



# Main developments

- Collection 5 introduced the Deep Blue algorithm for retrieval of aerosol optical depth (AOD) over bright arid surfaces (Hsu *et al.*, 2004, 2006)
- Collection 6 will include various refinements to Deep Blue, chiefly:
  1. Extended coverage to vegetated surfaces, as well as bright land.
  2. Improved surface reflectance models.
  3. Improved aerosol microphysical models.
  4. Improved cloud screening (reduced false positive and false negatives).
  5. Simplified quality assurance (QA) flags (integer; note bitwise will also still be present).
  6. Calibration improvements will mean that Deep Blue can be applied to the whole MODIS record (previously the Terra record ended in 2007).
  7. Merged Deep Blue – Dark Target aerosol SDS, to provide a more gap-free (aside from clouds and snow) product.
- Many of these improvements developed during our recent application of Deep Blue to SeaWiFS data

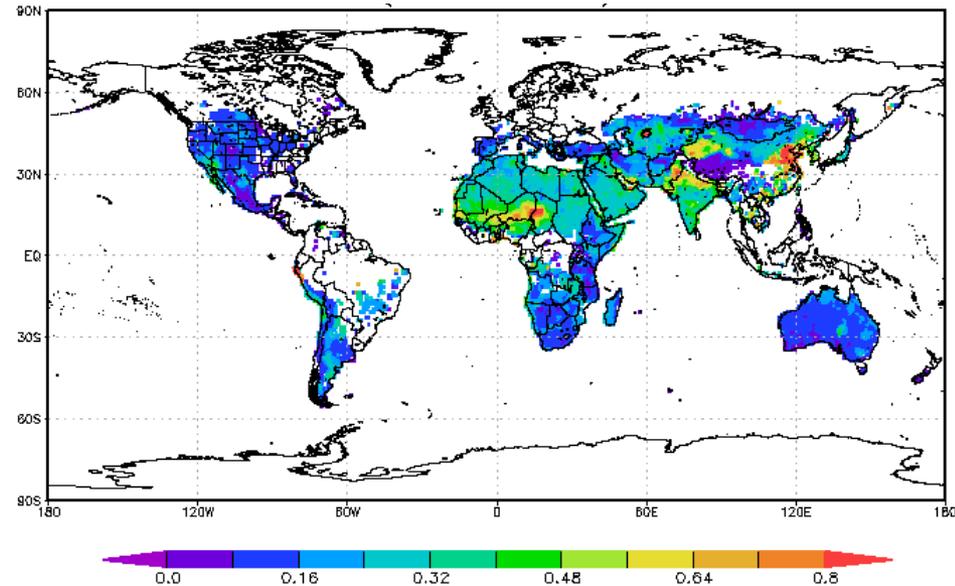
# SDS changes specific to Deep Blue

- New datasets:
  - Deep\_Blue\_Aerosol\_Optical\_Depth\_550\_Land\_QA
    - Integer QA flags
  - Deep\_Blue\_Aerosol\_Optical\_Depth\_550\_Land\_Best\_Estimate
    - 550 nm AOD with quality flag mask applied
  - Deep\_Blue\_Algorithm\_Flag\_Land
    - Information on which algorithm type (related to channels used) was applied
- Renamed datasets (mostly to avoid potential confusion):
  - Deep\_Blue\_Spectral\_Aerosol\_Optical\_Depth\_Land
  - Deep\_Blue\_Spectral\_Single\_Scattering\_Albedo\_Land
  - Deep\_Blue\_Spectral\_Surface\_Reflectance\_Land
  - Deep\_Blue\_Spectral\_TOA\_Reflectance\_Land
  - Deep\_Blue\_Number\_Pixels\_Used\_550\_Land

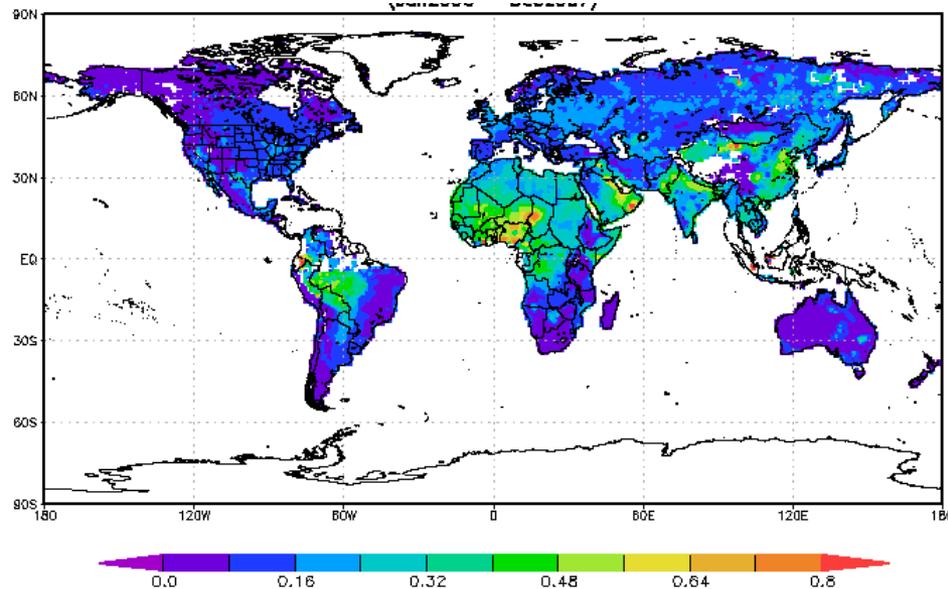
# Extended spatial coverage

- We are applying 'Deep Blue' over all non-snow land surfaces
  - Upper right: coverage of MODIS Deep Blue for Aqua Collection 5.1
  - Lower right: coverage of MODIS Dark Target and ocean for Aqua Collection 5.1
  - Bottom left: over-land coverage of SeaWiFS Deep Blue (from Giovanni); MODIS Collection 6 Deep Blue coverage should match this
- All images from Giovanni monthly instances

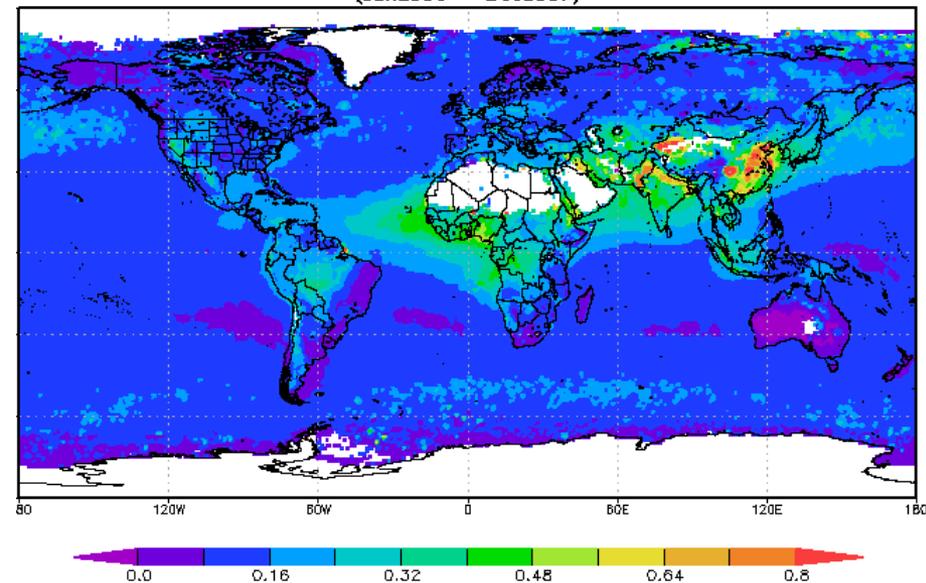
MODIS Deep Blue C5



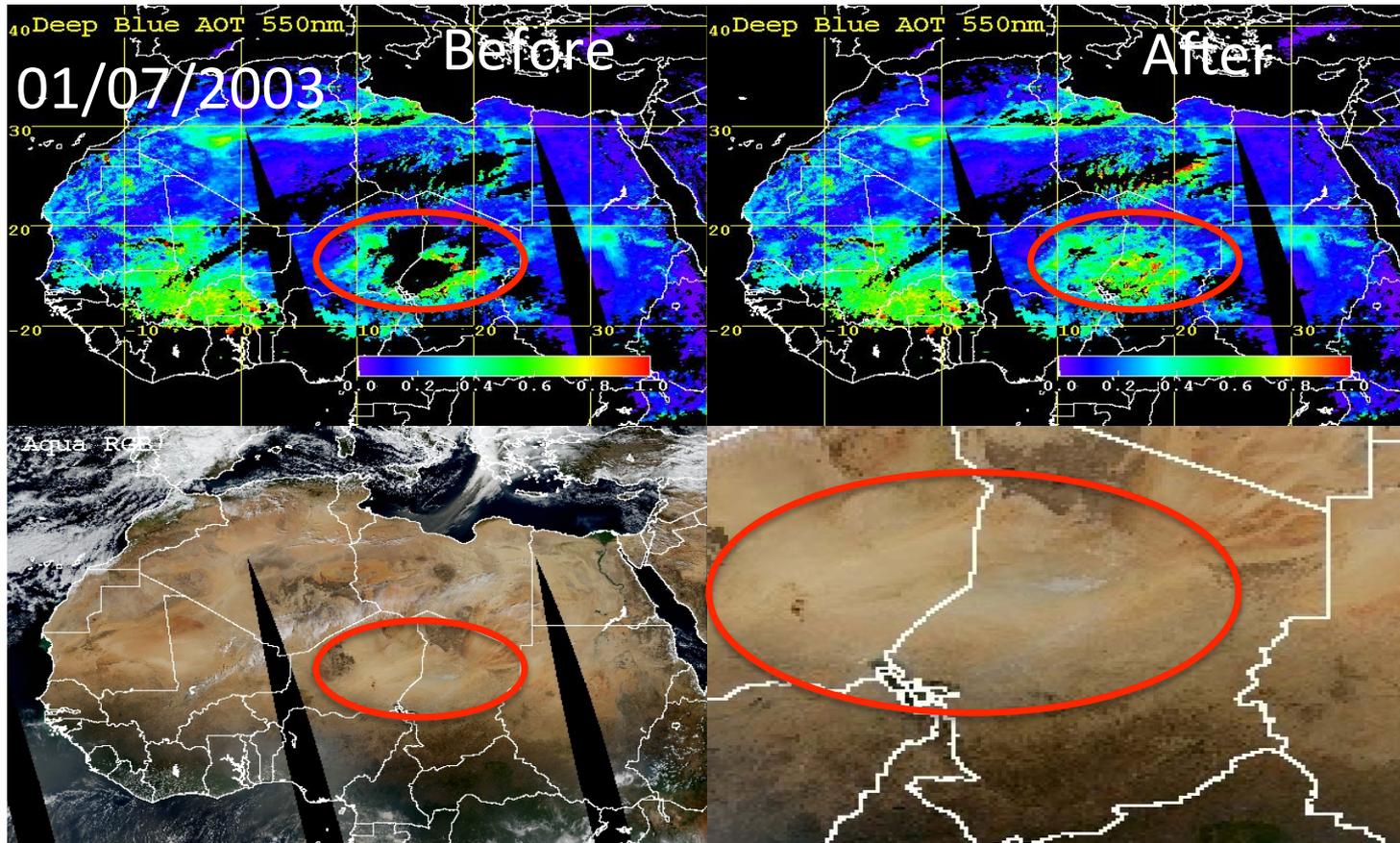
SeaWiFS Deep Blue, expected MODIS Deep Blue C6



MODIS ocean/Dark Target C5

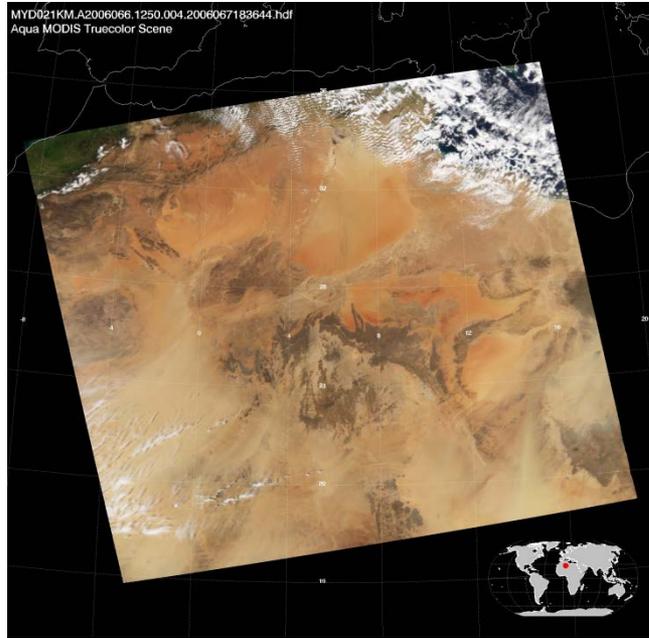


# Cloud screening



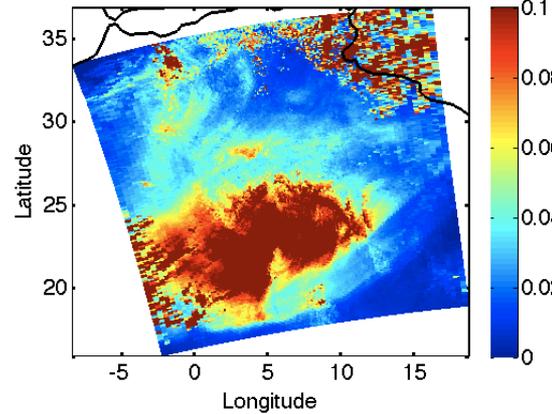
- In Collection 5, some cloud-free areas were flagged as cloudy by the 1.38 micron (cirrus/high cloud) test
  - Combination of high surface reflectance, aerosol, and low columnar water vapor
  - Developed several tests to reduce these false negatives: typically gives more high-AOD events
- False positives also decreased through refinement of other cloud tests and QA flags

# Thin Cirrus Over-Screening over the Sahara, March 7<sup>th</sup> 2006



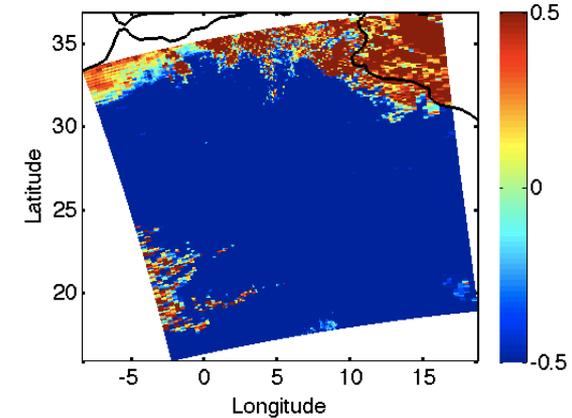
**RR1.38/0.66**

RR1.38/0.66



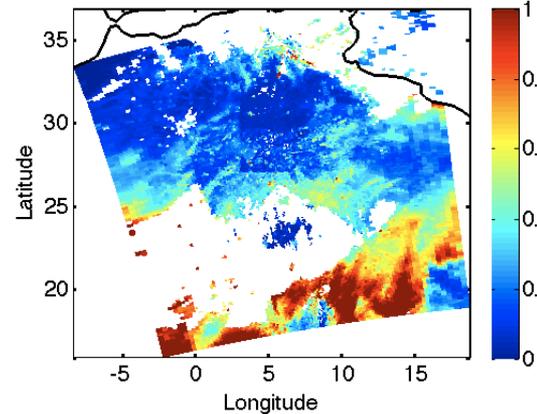
**BTD11-12**

Brightness Temperature Difference 11-12



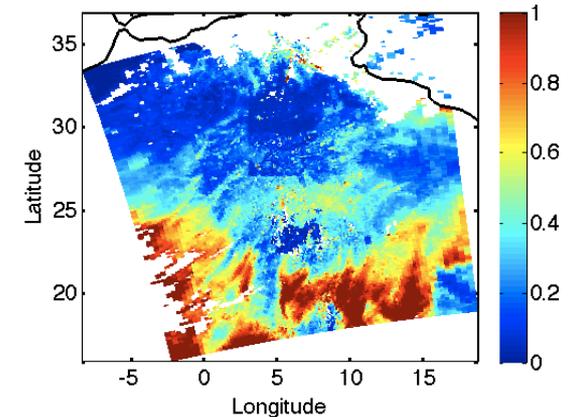
**AOT C5.1**

MOD04-DT&DB2006066.1250

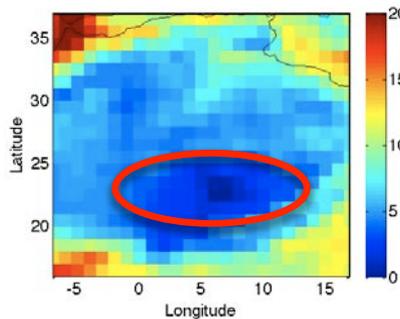


**AOT C6**

MOD04-DT&DB 2006066.1250

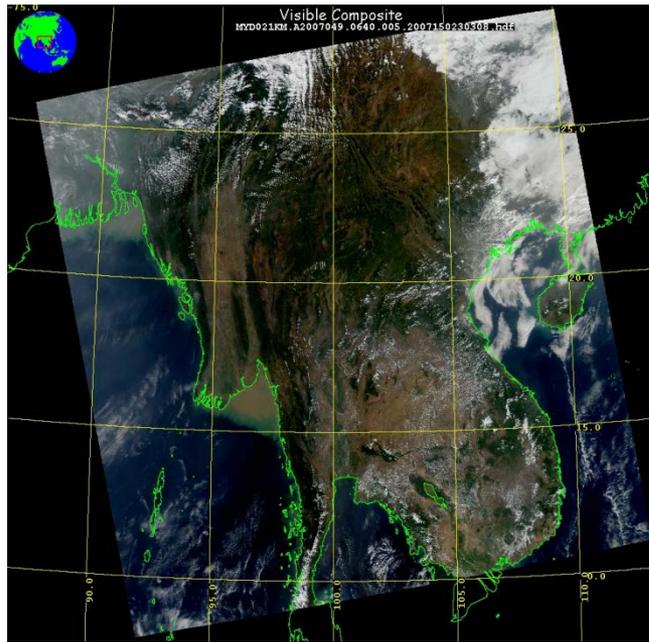


**NCEP TPW (mm)**

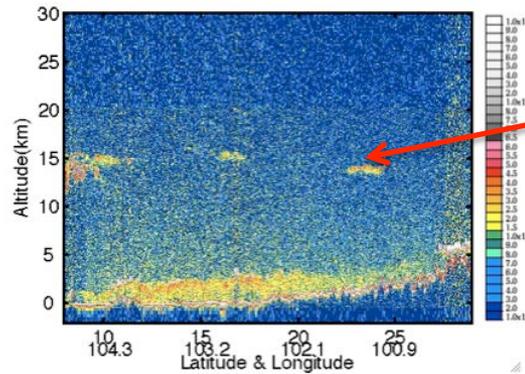


- Bright 1.38 micron reflectance caused cirrus test to be flagged.
- Low total precipitable water (TPW, <4 mm) in part of granule meant transmitted aerosol & surface reflectance was higher than expected
- Not apparent in thermal IR confirms cirrus unlikely
- Significant portion of dust plume regained, no adverse effect elsewhere

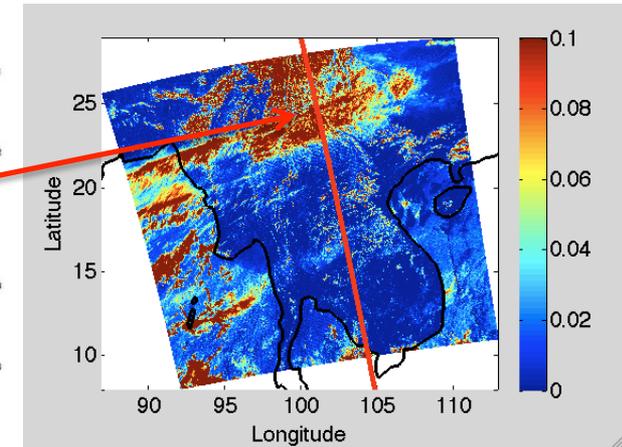
# Thin Cirrus Under-Screening over Southeast Asia, February 18<sup>th</sup> 2002



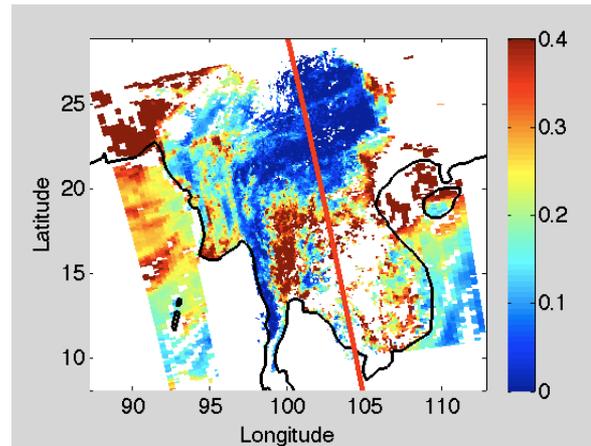
**CALIOP TAB, 532**



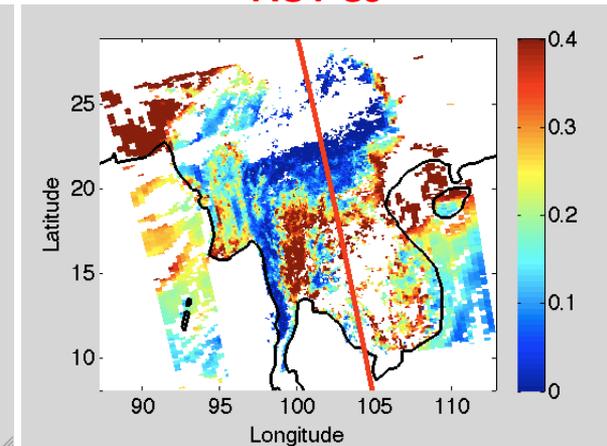
**RR1.38/0.66**



**AOT C5.1**



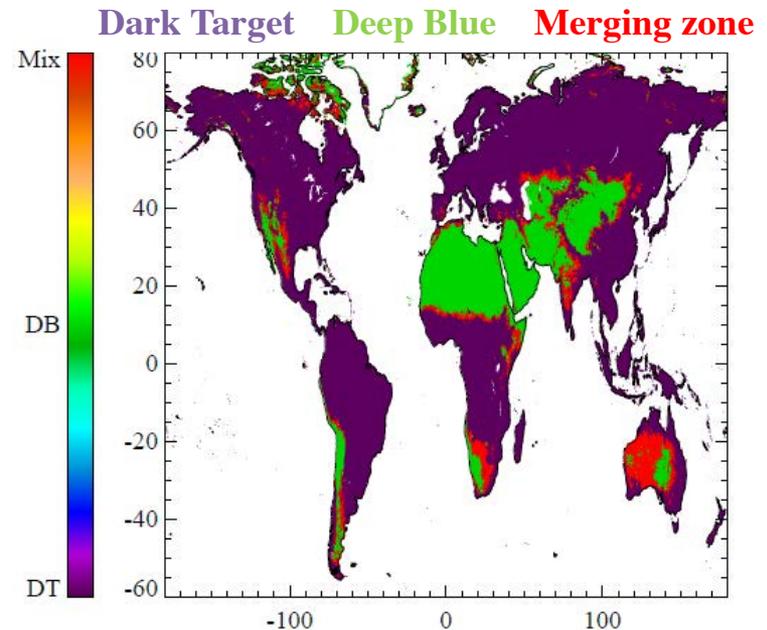
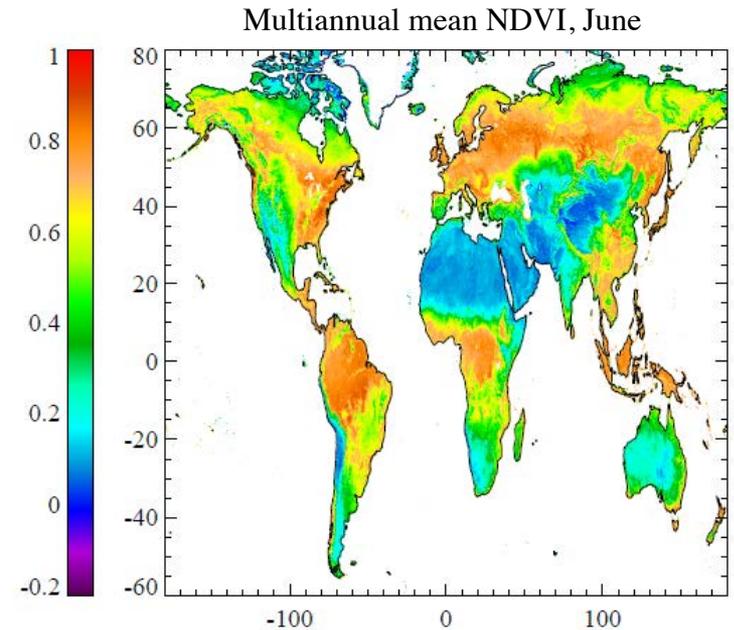
**AOT C6**



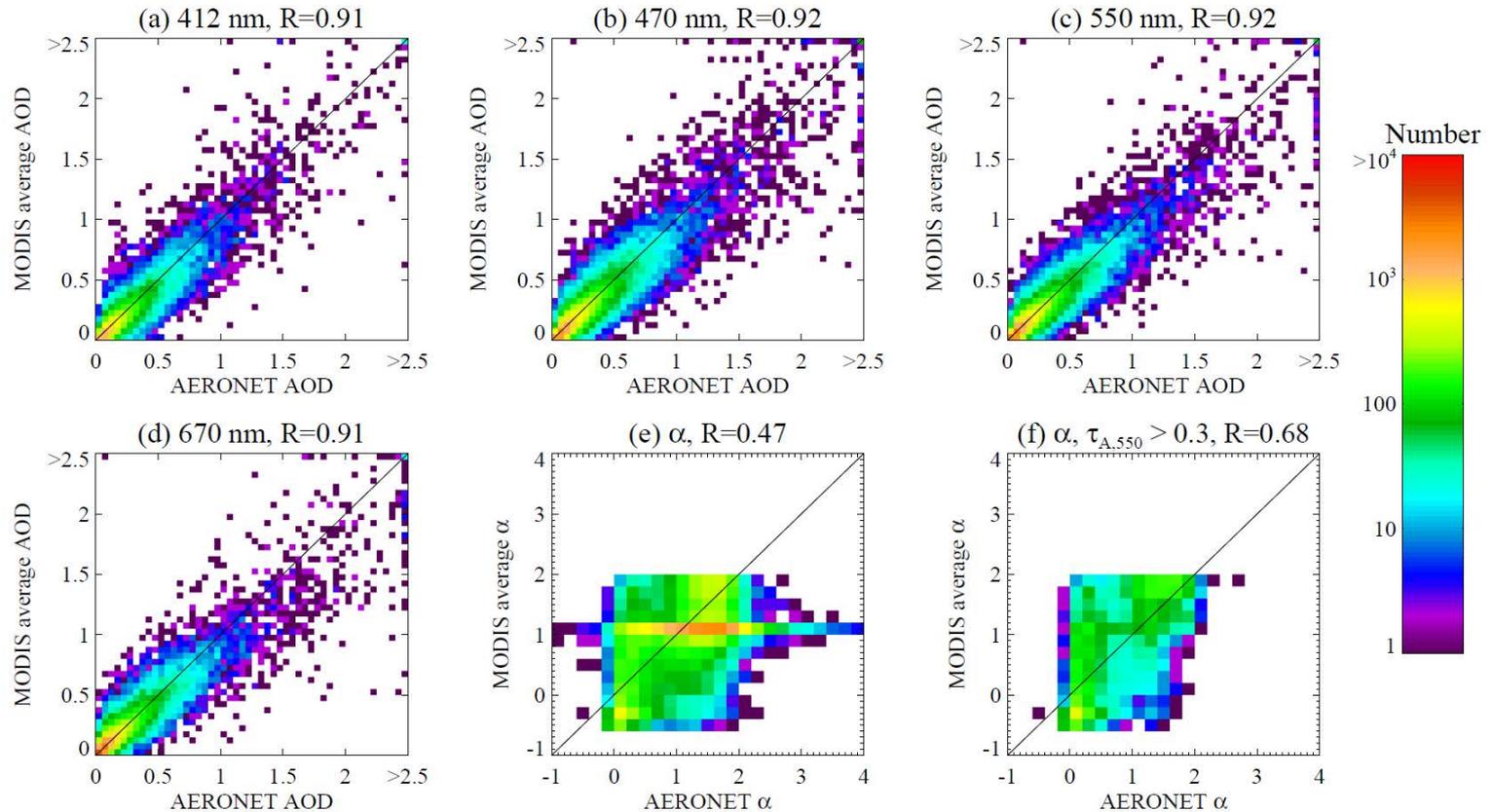
- Converse of previous case: undetected cirrus, visible in CALIOP, let to contamination of C5.1 retrieval
- New reflectance ratio and tests identify this, removing the retrievals from Collection 6
- Not found to introduce significant false negatives

# Merged dataset

- C6 will include a new SDS of merged 550 nm AOD from the Deep Blue and Dark Target algorithms.
- To minimize pixel-level discontinuities and for simplicity/clarity, pixels will be assigned to either algorithm based on climatological values of (atmospherically corrected) NDVI for each month
  - Only Deep Blue is available for bright barren surfaces, while Dark Target may be more reliable for greenest surfaces
  - Note SDS will also include the ocean algorithm retrievals
  - Will be an interim ‘transition zone’ where retrievals will either be averaged (if the same QA) or that with higher QA flag chosen
  - Final criteria still being tested
- Example shown to the right for June

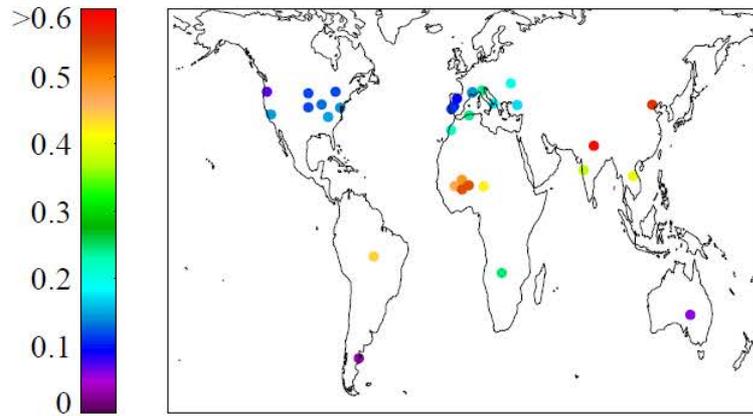


# Preliminary validation

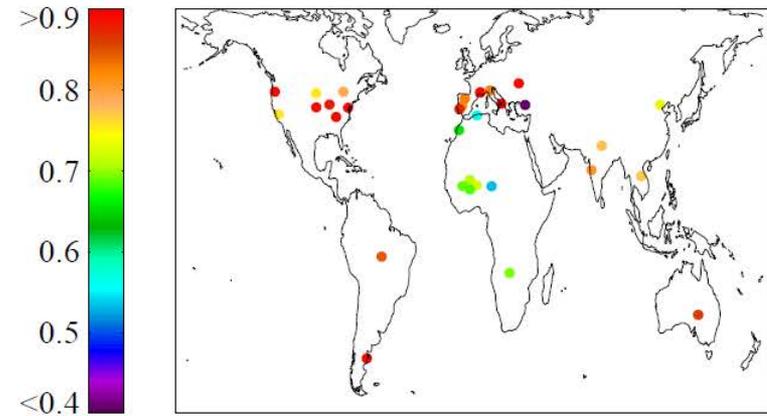


- QA flags are still being refined, but we have performed a preliminary validation against AERONET using MODIS Aqua
  - See also poster by A. M. Sayer *et al.*
- Define one-sigma absolute expected error (EE) of  $0.05+20\%$  at each wavelength
- Current (albeit limited) testing suggests this goal is being achieved, although some regional variation in performance

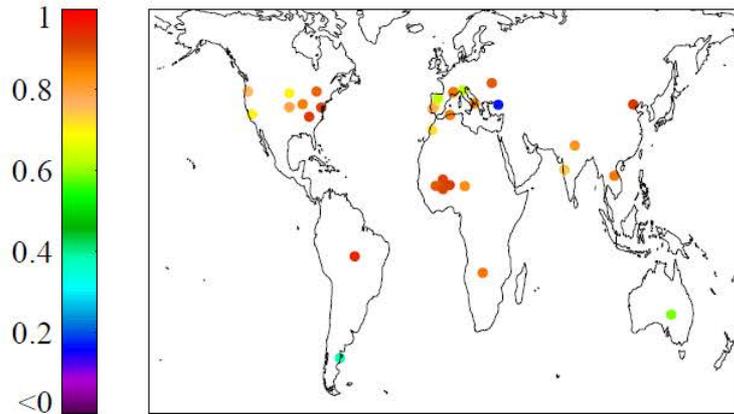
(a) Mean AERONET 550 nm AOD



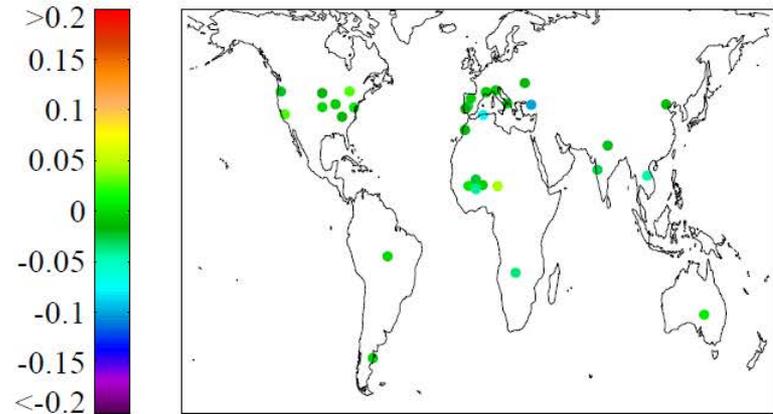
(b) Fraction within expected error, 550 nm



(c) Correlation coefficient, 550 nm



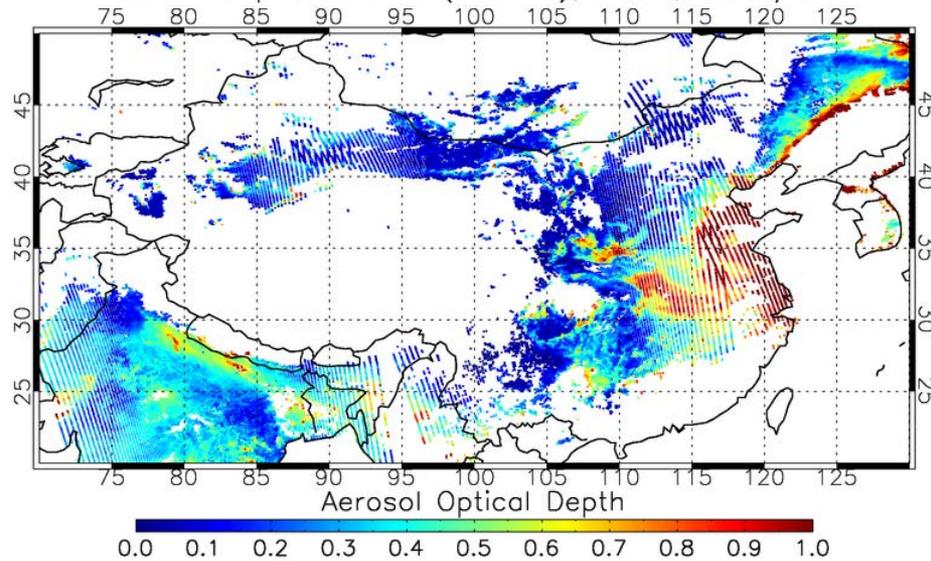
(d) Median bias, 550 nm



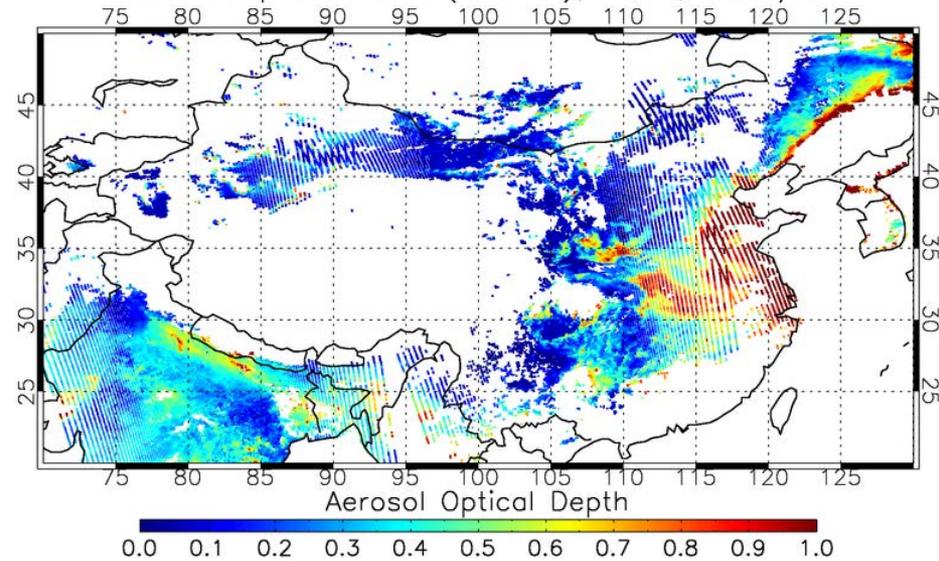
- Generally, correlations are high: capture variability at individual sites well
- Most sites have 68% or more of matchups within expected error, and small biases

# C5 vs. C6 L1bs: Central/Eastern Asia

MODIS Deep Blue AOD (550nm), AQUA, 2003/083

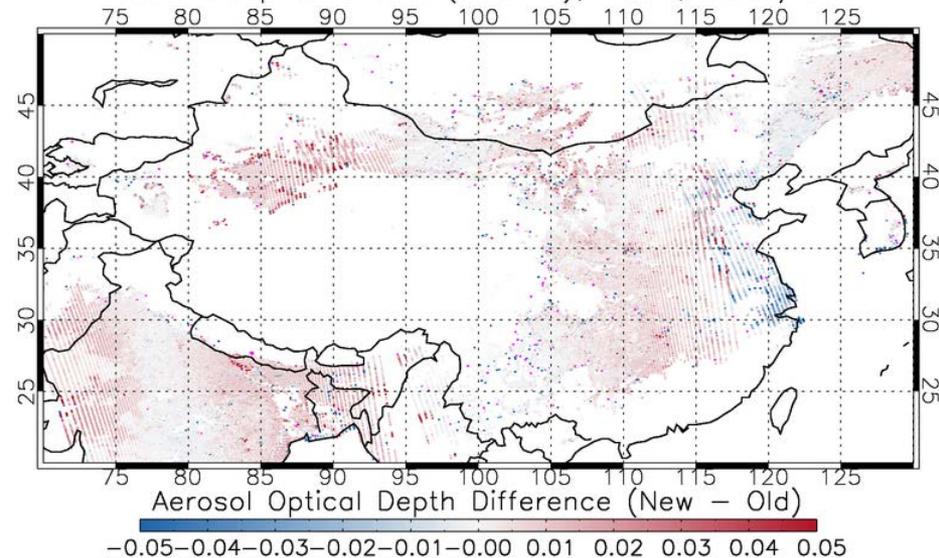


MODIS Deep Blue AOD (550nm), AQUA, 2003/083

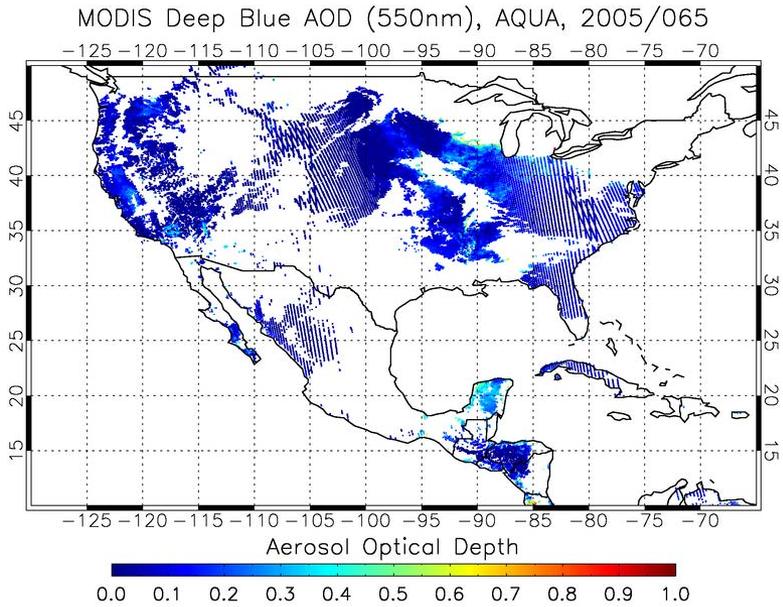
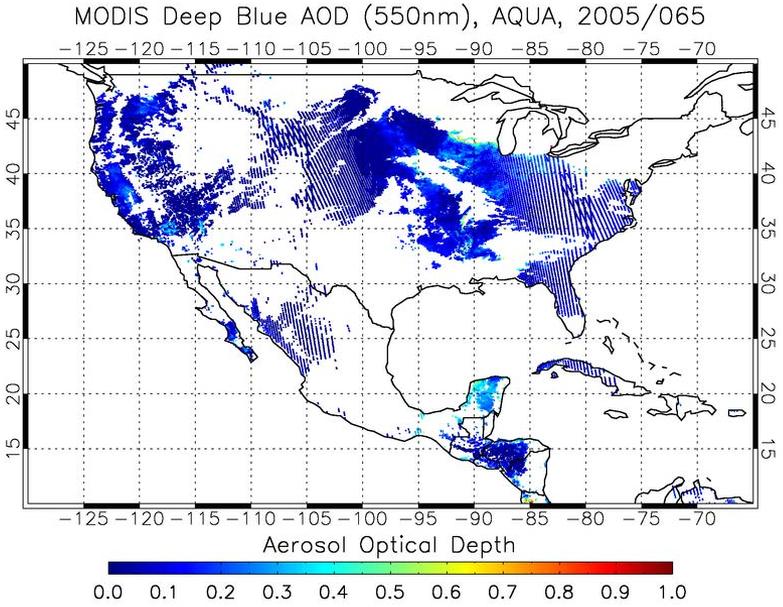


- So far most testing of the C6 algorithm has been carried out with C5 L1b files. We have processed a small amount of data using the C6 L1bs
- Changes mostly of order  $\pm 0.01$  in AOD at 550 nm, for this region and time
- Spatial patterns and continuity unchanged

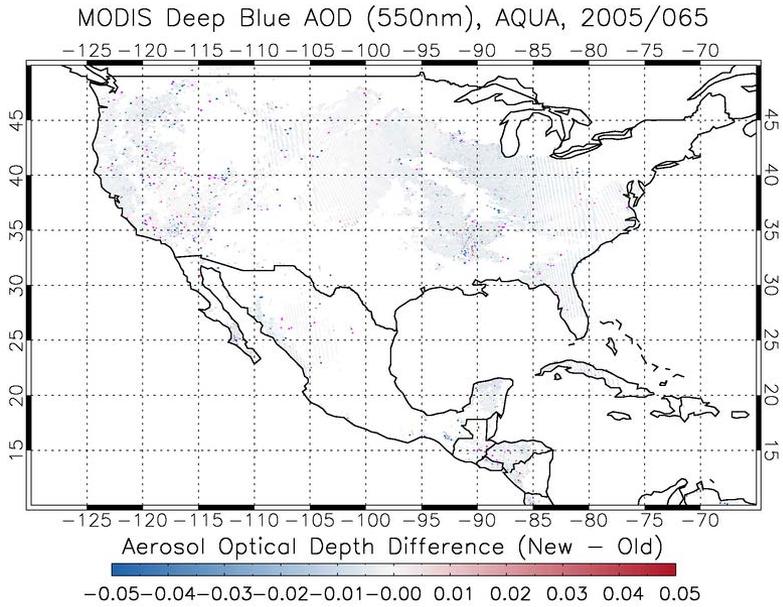
MODIS Deep Blue AOD (550nm), AQUA, 2003/083



# C5 vs. C6 L1bs: Central/North America

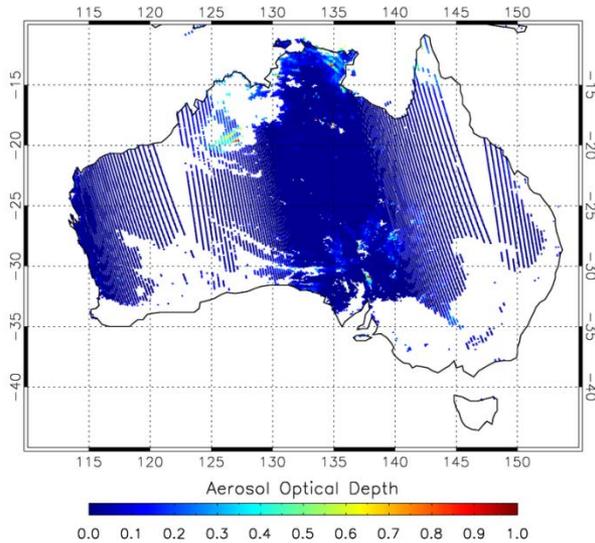


- This time a tendency for small decrease in 550 nm AOD
- Smaller than -0.01 most of the time
- Pink spots in the difference image are where the C6 L1bs result in retrievals the C5 ones didn't (i.e. change in cloud flagging)

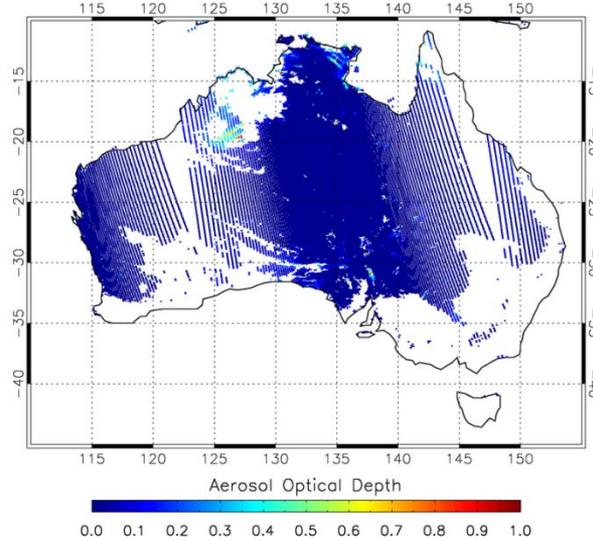


# C5 vs. C6 L1bs: Australia

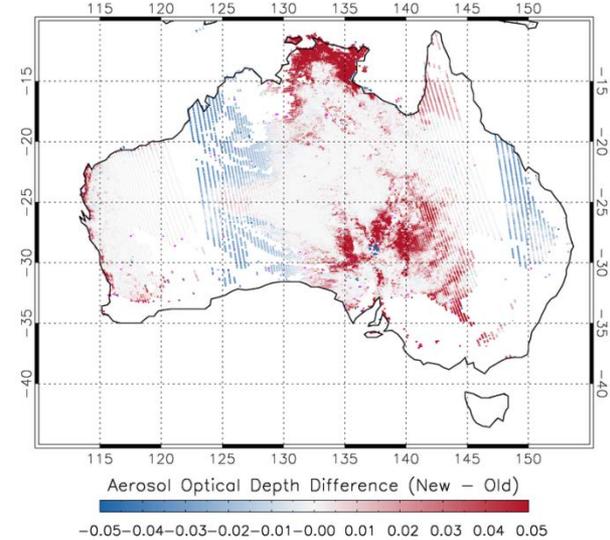
MODIS Deep Blue AOD (550nm), AQUA, 2009/278



MODIS Deep Blue AOD (550nm), AQUA, 2009/278



MODIS Deep Blue AOD (550nm), AQUA, 2009/278



- More extreme changes in this example
  - Some apparent dependence on position across track
- Larger absolute changes mostly seen in more recent Aqua years
  - Consistent with earlier years being well-characterised in C5 and later years showing more degradation, which has also been characterised better in C6
- Note again spatial patterns tend to stay the same