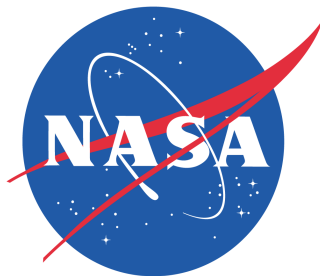
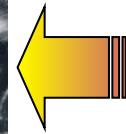


# Collection 6 update: MODIS 'Deep Blue' aerosol

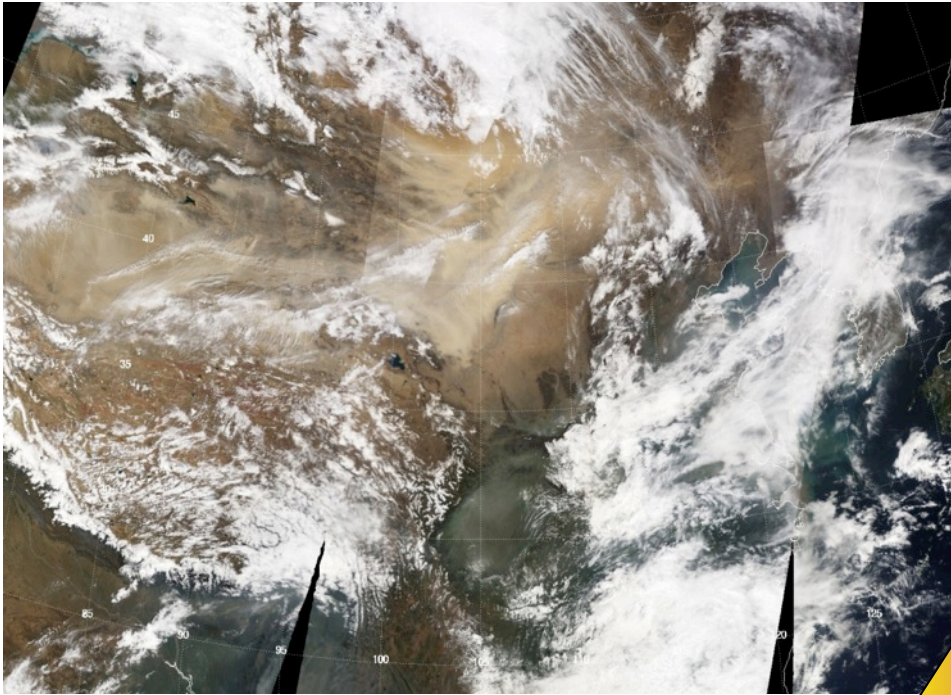
Andrew M. Sayer, N. Christina Hsu, Corey Bettenhausen, Myeong-Jae Jeong, Jaehwa Lee



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

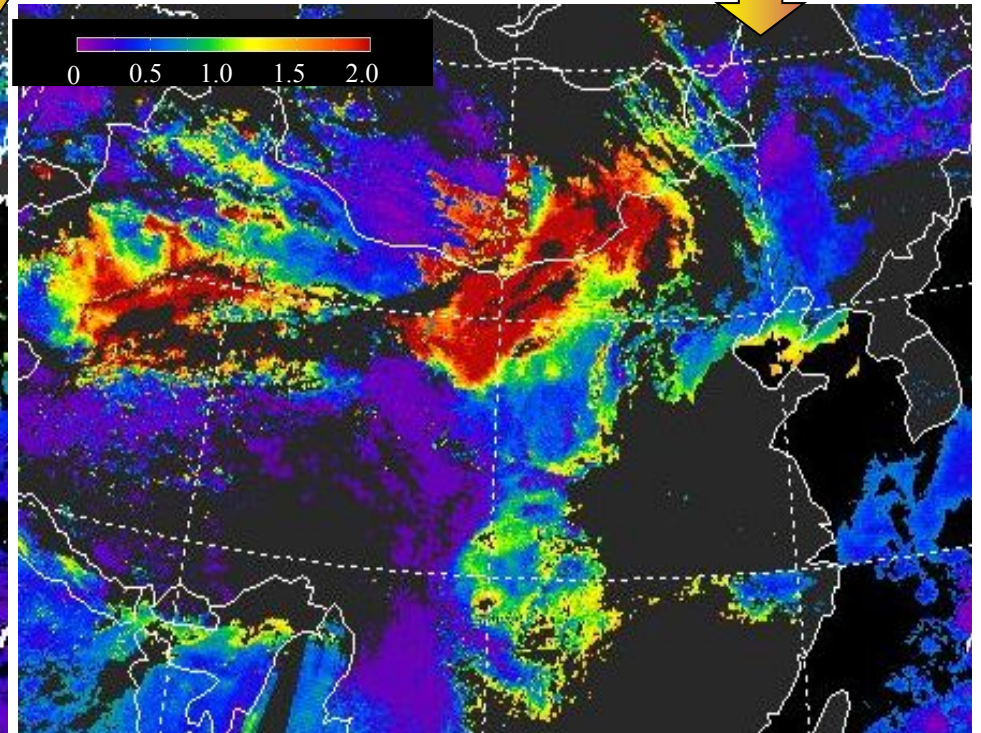
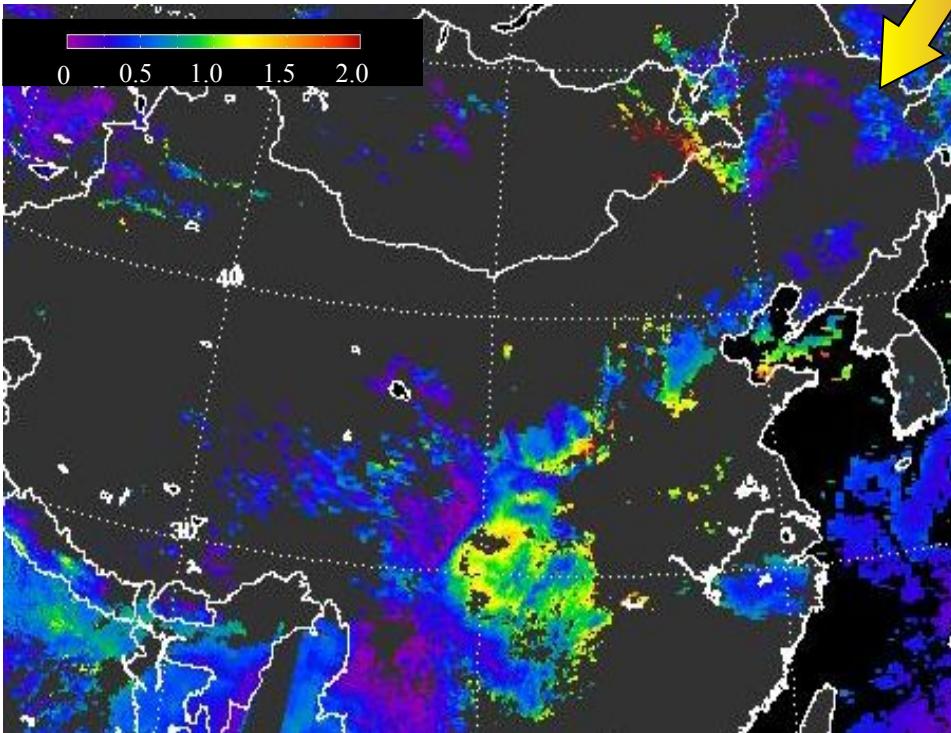


MODIS *Red-Green-Blue*  
composite

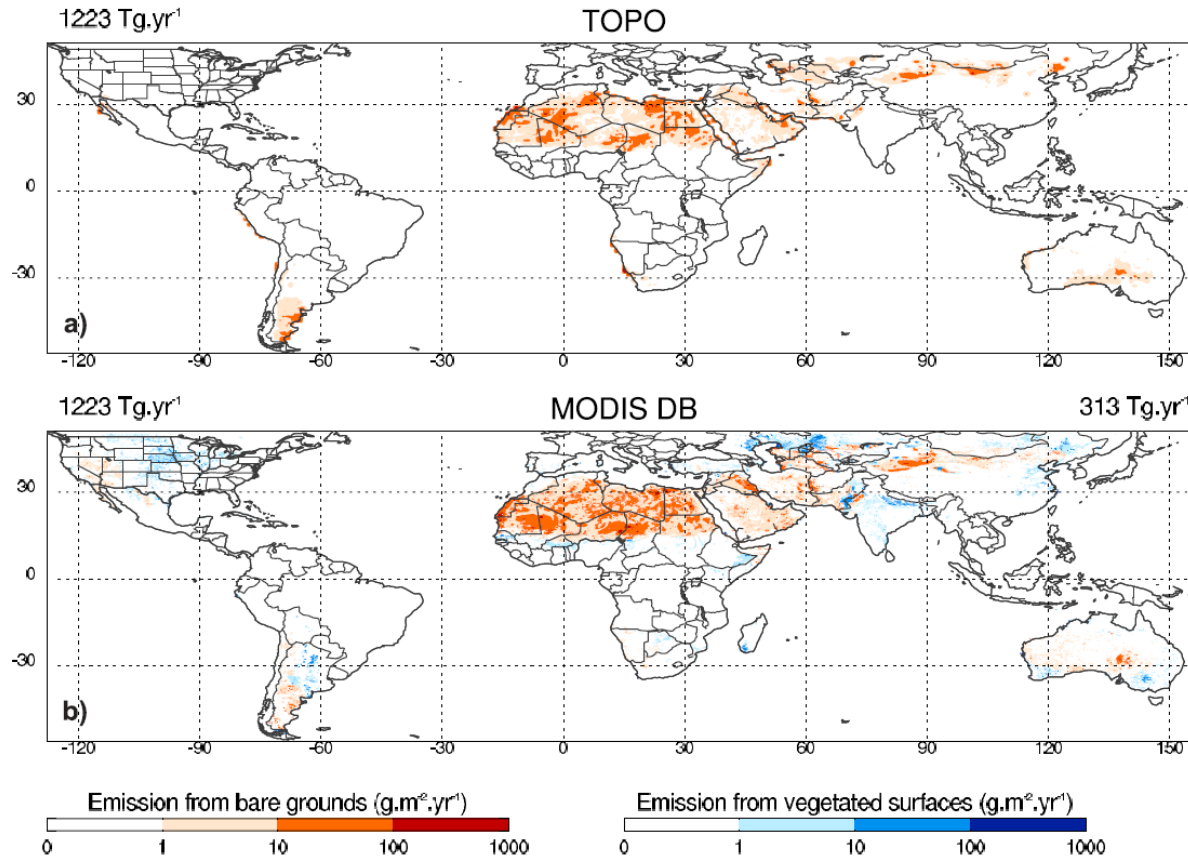


MODIS *Dark Target*  
AOD

MODIS *Deep Blue*  
AOD



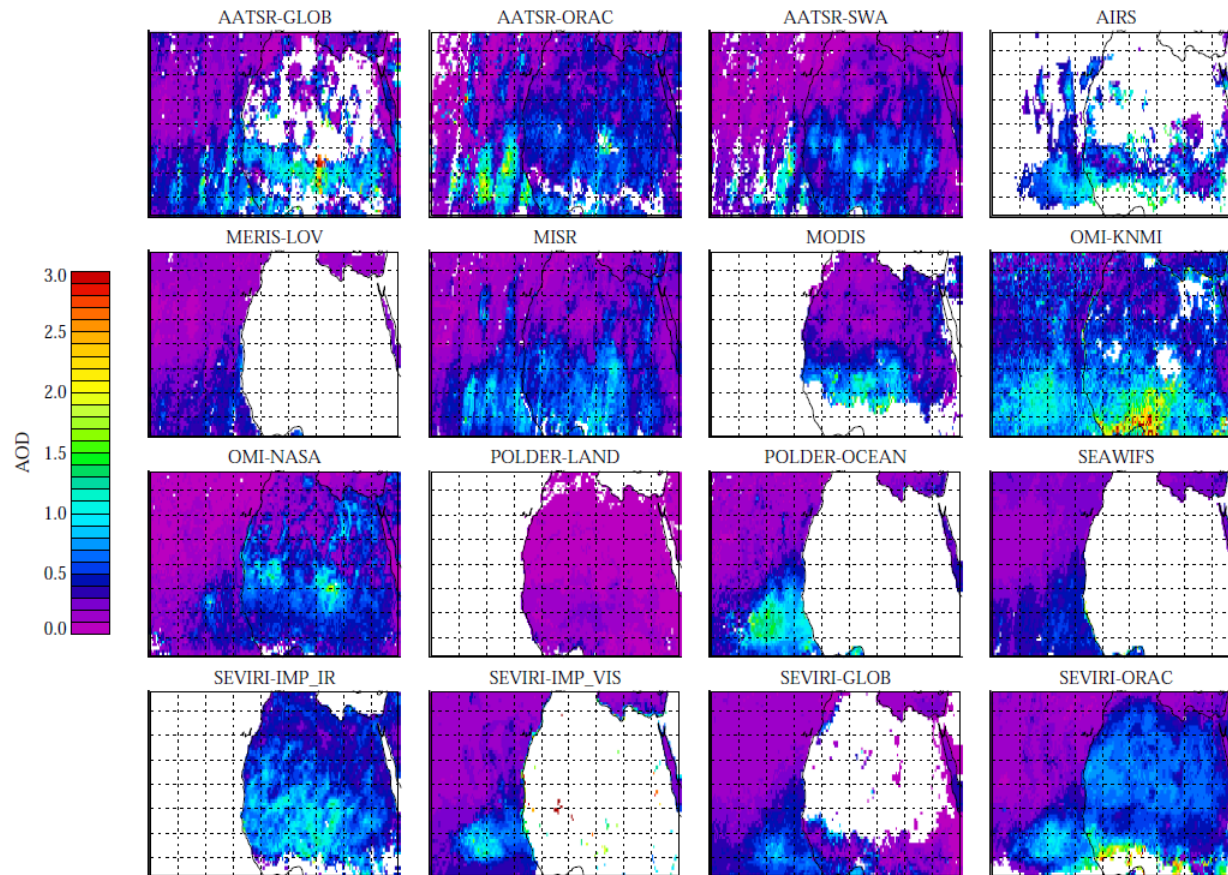
# Some applications of Deep Blue data... (1)



**Figure 15.** Annual mean dust emission using (a) topographic depression sources and (b) M-DB2 FoO that DOD > 0.2. The M-DB2 emissions are colored in blue or red shadings if they are within or outside topographic depression coverage, respectively.

- Global dust source mapping
- Ginoux et al. (2012) Global-scale attribution of anthropogenic and natural dust sources and their emission rates based on MODIS Deep Blue aerosol products, *Rev. Geophys.*, 50, RG3005, doi:10.1029/2012RG000388.

# Some applications of Deep Blue data... (2)



- Comparison of aerosol optical depth from multiple satellite datasets during an intense Saharan dust storm in March 2006
- Carboni et al. (2012), Intercomparison of desert dust optical depth from satellite measurements, *Atmos. Meas. Tech.*, 5, 1973-2002, doi:10.5194/amt-5-1973-2012.

# Some applications of Deep Blue data... (3)

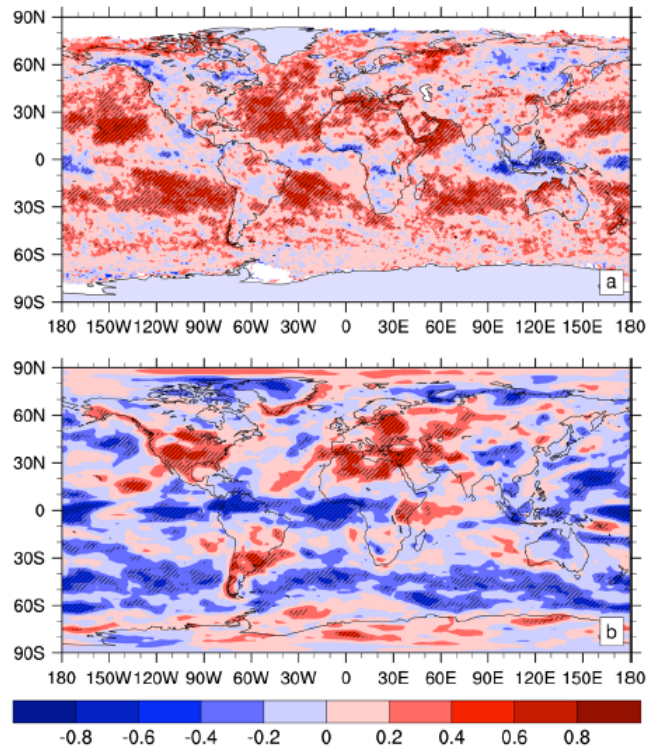


Fig. 6 Regression coefficient between AOD and cloud fraction: (a) Aqua MODIS AOD and cloud fraction; and (b) CAM5 simulated AOD and cloud fraction.

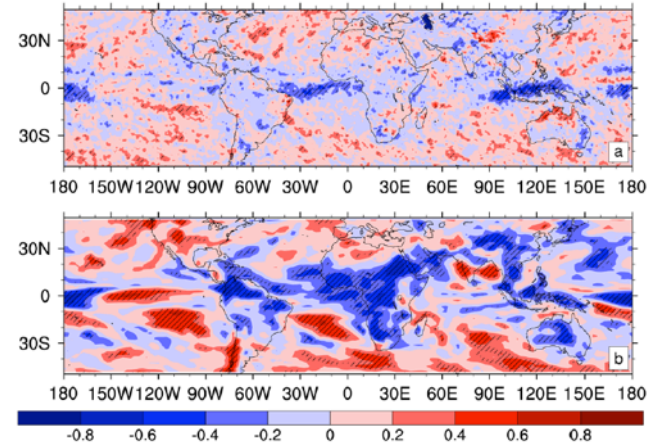
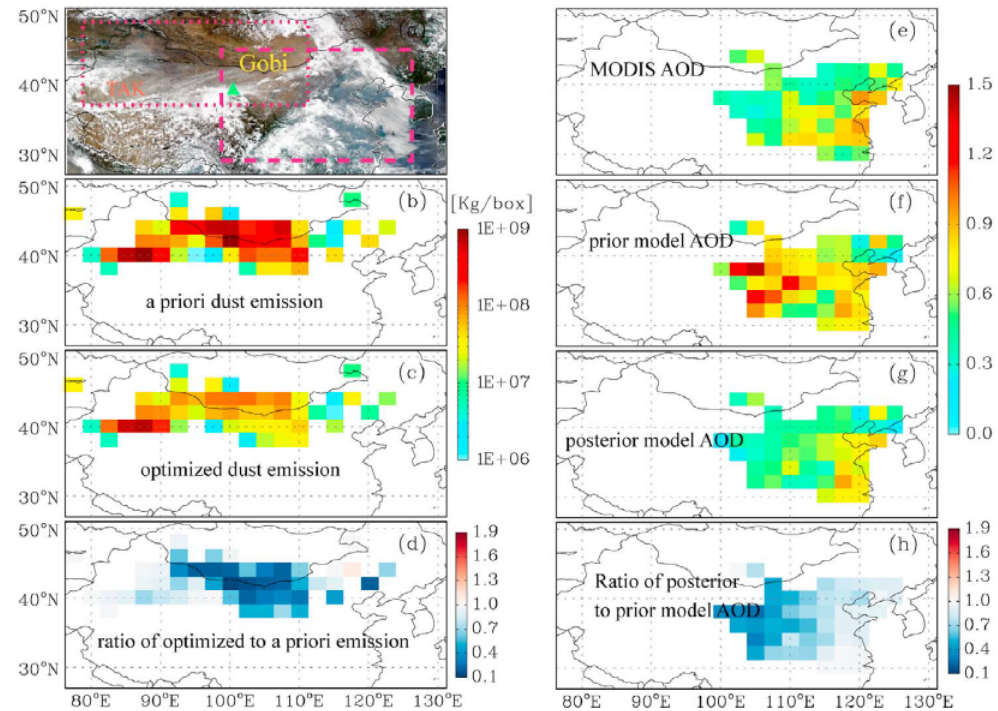


Fig. 7 Regression coefficient of MODIS Aqua Combined AOD and TRMM precipitation rate (a) as compared with CAM5 model simulation (b).

- Combination with Dark Target aerosol data to compare aerosol/cloud/precipitation relationships between models and satellite observations
- Yi et al. (2012), Aerosol-cloud-precipitation relationships from satellite observations and global climate model simulations, *J. Appl. Remote Sens.* 6(1), 063503, doi:10.1117/1.JRS.6.063503

# Some applications of Deep Blue data... (4)

- Constraints on mineral dust aerosol emission in the Gobi and Taklamakan deserts through combination with MISR data and the Geos-Chem model
- Wang et al. (2012), Top-down estimate of dust emissions through integration of MODIS and MISR aerosol retrievals with the GEOS-Chem adjoint model, *Geophys. Res. Lett.*, 39, L08802, doi: 10.1029/2012GL051136

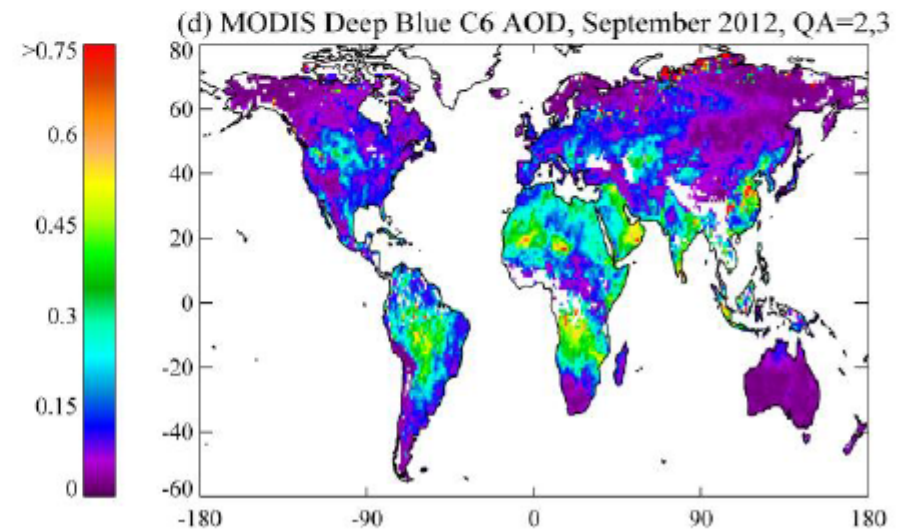
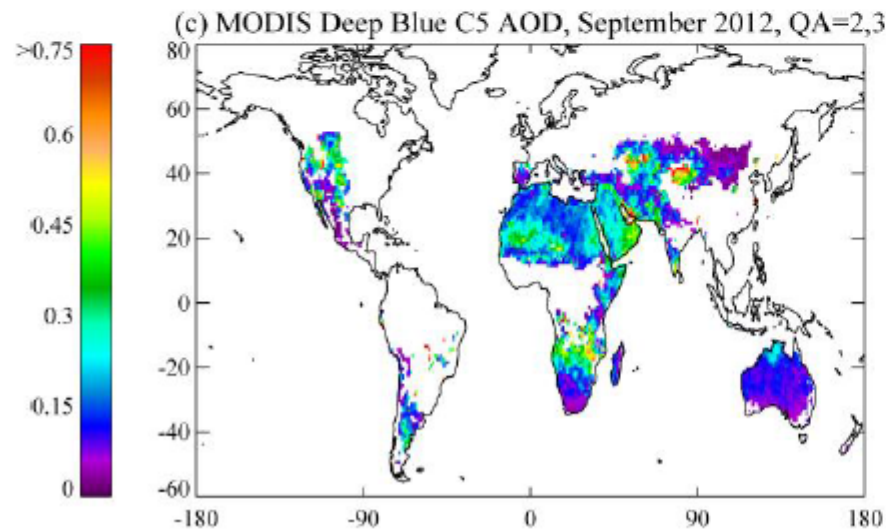
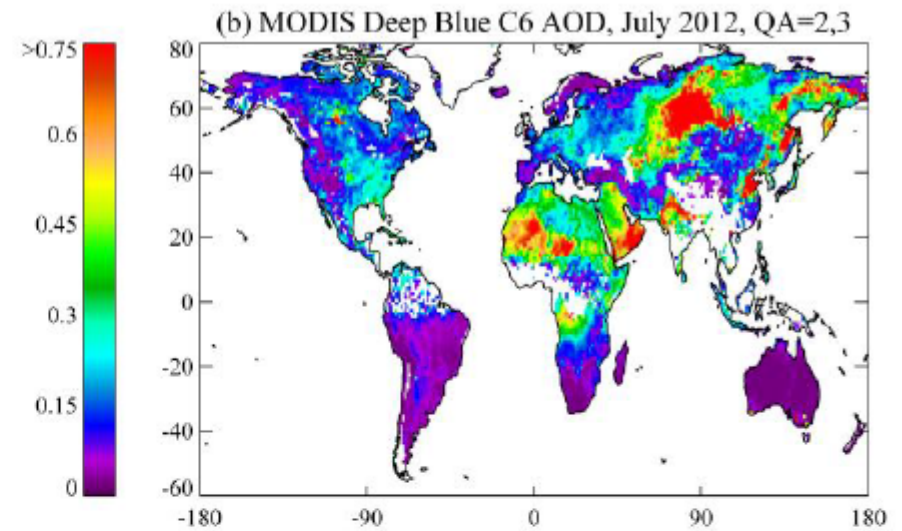
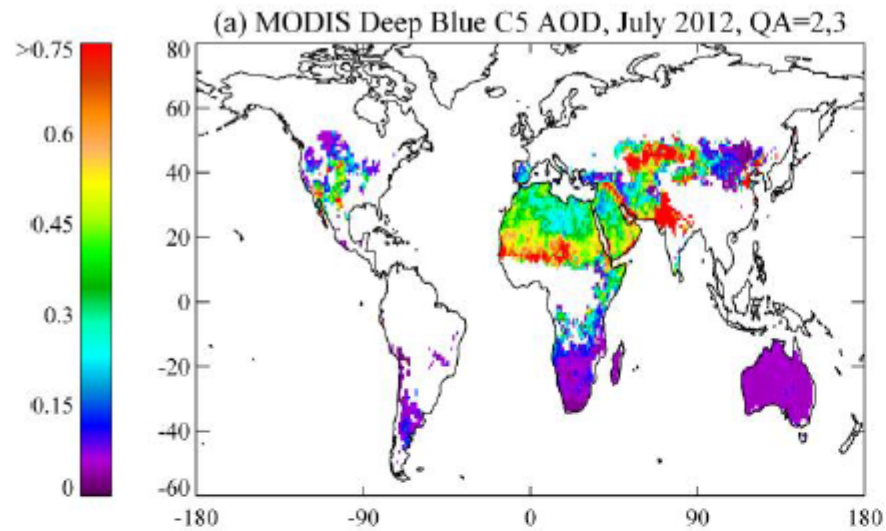


**Figure 1.** (a) True color image from MODIS/Aqua on 27 May 2008. The region within the rectangle of dashed line is the downwind plume region where the observational data are used. The region within the rectangle of dotted line is used for validation. (b) The prior mineral dust emission for the period of 25–28 May 2008. (c) Same as Figure 1b but for optimized dust emission. (d) The ratio of the optimized to prior dust emission. (e) MODIS AOD at  $0.67 \mu\text{m}$  aggregated to GEOS grid box and averaged for the period of 25–28 May 2008, which served as observational constraint for the adjoint inverse modeling of dust emission. (f) GEOS-chem total AOD at  $0.67 \mu\text{m}$  simulated with prior dust emission averaged over satellite overpass time period (see text for details). (g) Same as Figure 1f but for the AOD simulated with optimized emission. (h) Ratio between Figures 1f and 1g.

# Main developments

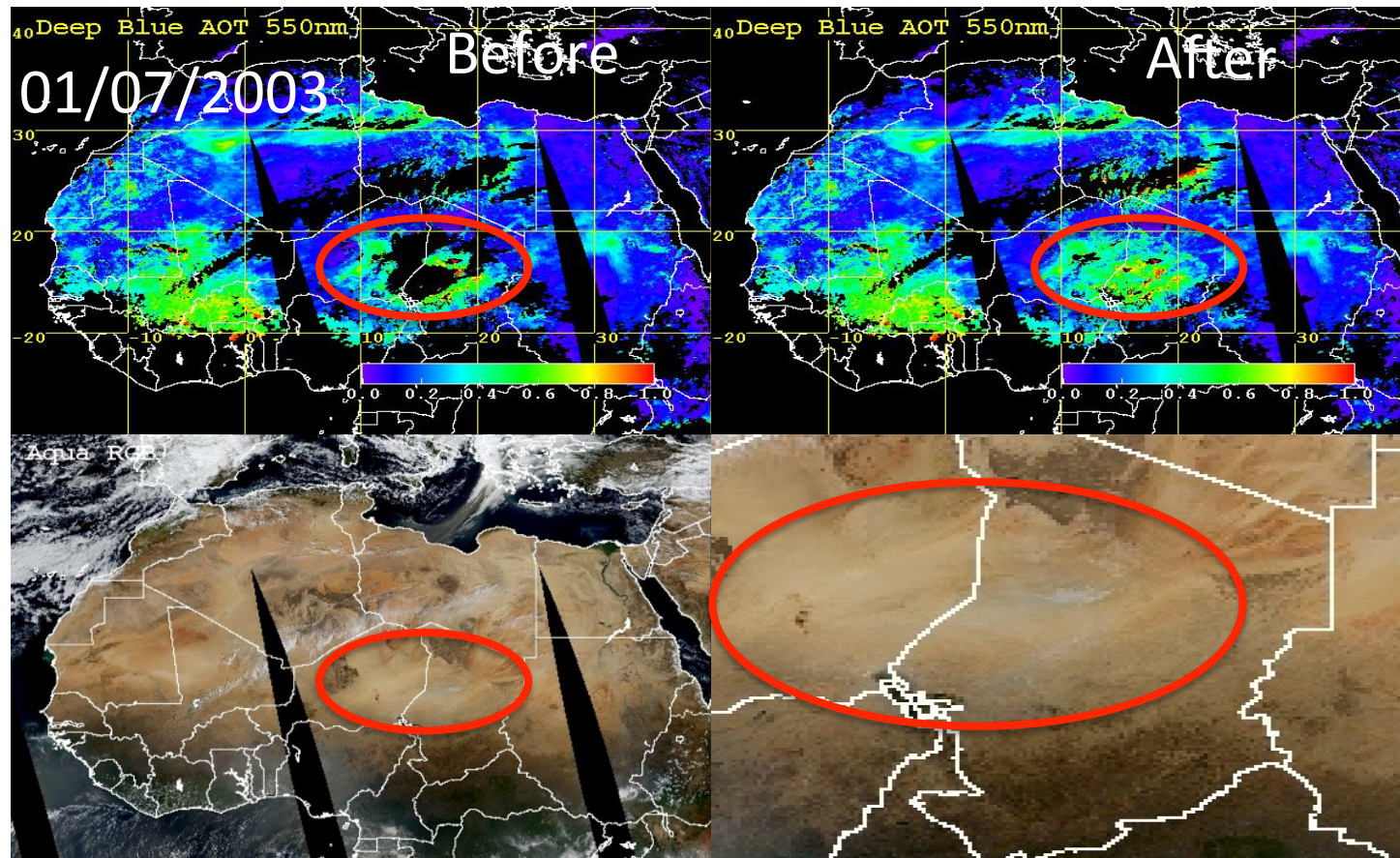
- Collection 6 will include various refinements to Deep Blue:
  1. Extended coverage to vegetated surfaces, as well as bright land.
  2. Improved surface reflectance models.
  3. Improved aerosol microphysical models
  4. Improved cloud screening
  5. Simplified quality assurance (QA) flags
  6. Calibration improvements will mean that Deep Blue can be applied to the whole MODIS record
  7. Merged Deep Blue – Dark Target aerosol SDS, to provide a dataset with fewer gaps, for visualisation purposes

# Extended spatial coverage



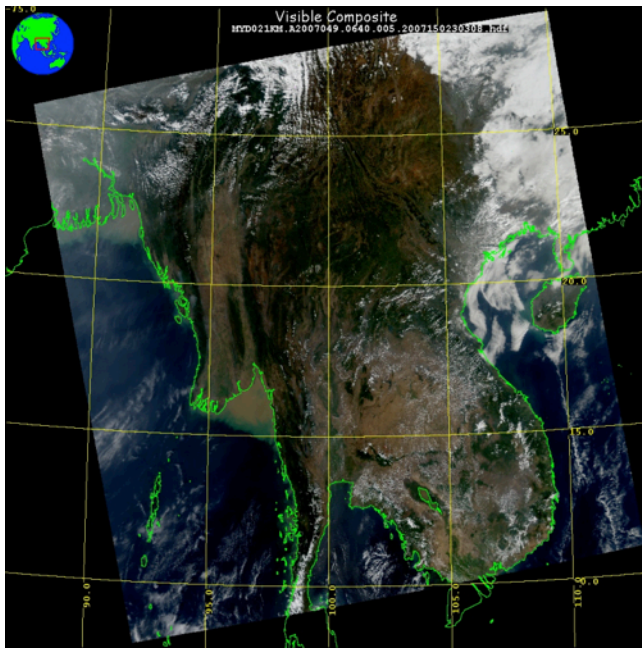


# Cloud screening

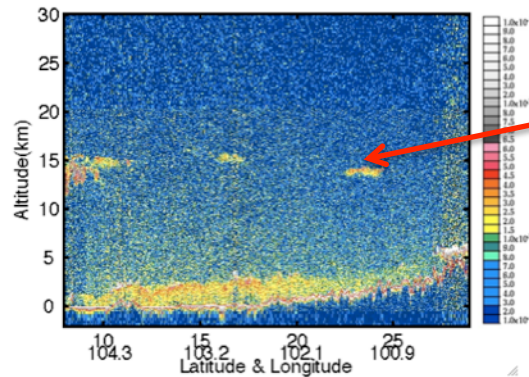


- In Collection 5, some cloud-free areas were flagged as cloudy by the 1.38 micron (cirrus/high cloud) test
  - Combination of high surface reflectance, aerosol, and low columnar water vapor
  - Developed several tests to reduce these false negatives: typically gives more high-AOD events
- False positives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

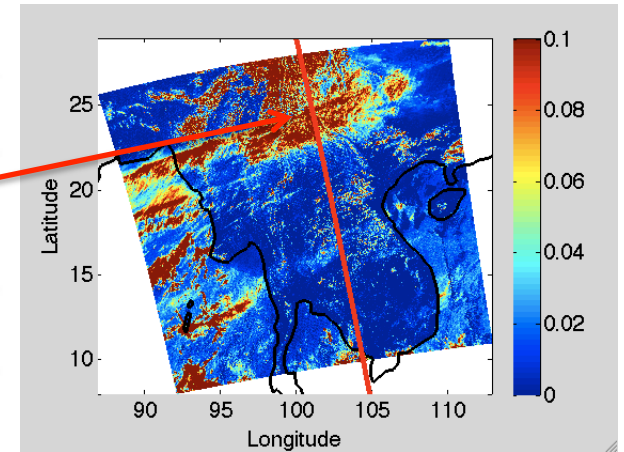
# Thin Cirrus Under-Screening over Southeast Asia, February 18<sup>th</sup> 2002



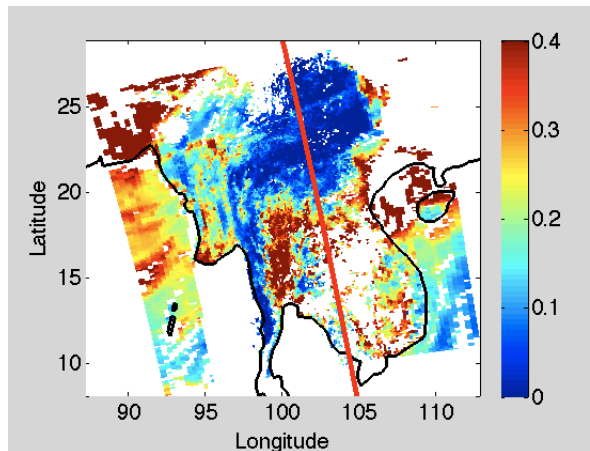
**CALIOP TAB, 532**



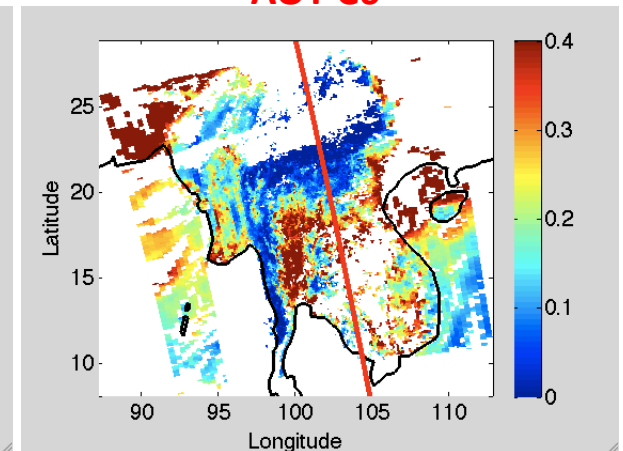
**RR1.38/0.66**



**AOT C5.1**



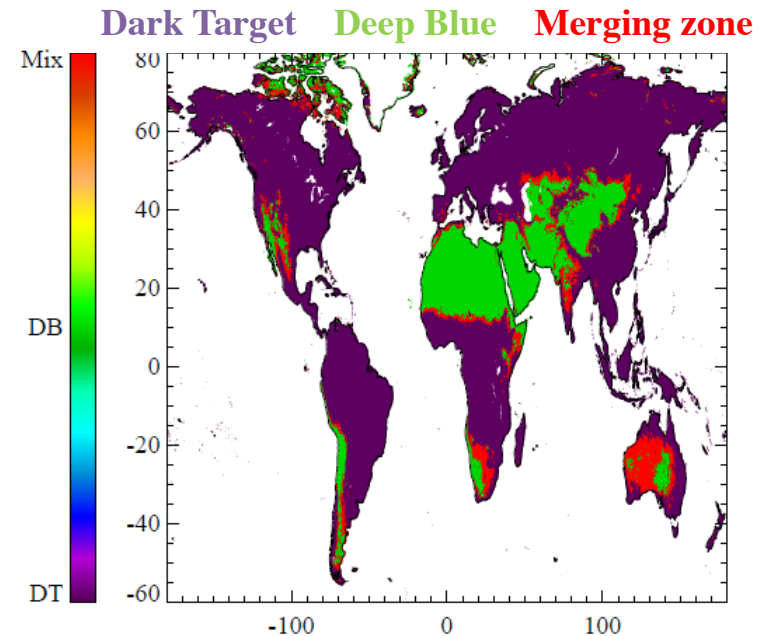
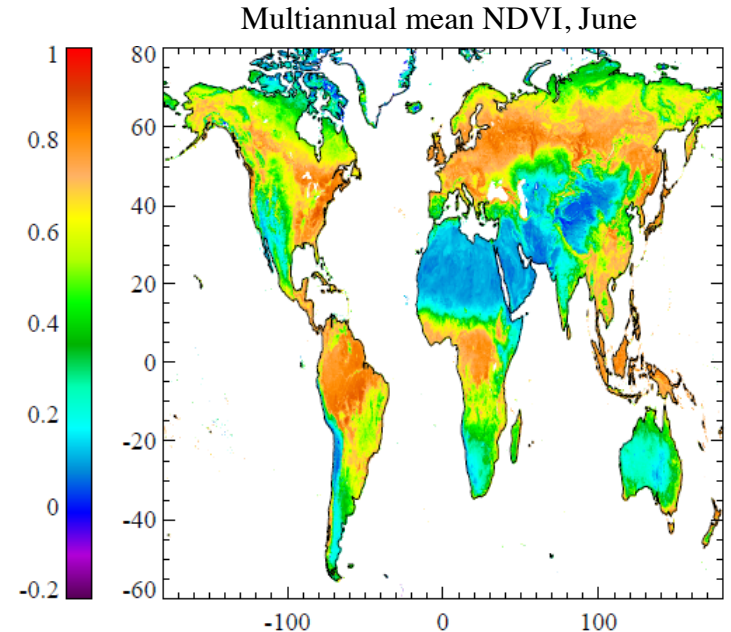
**AOT C6**



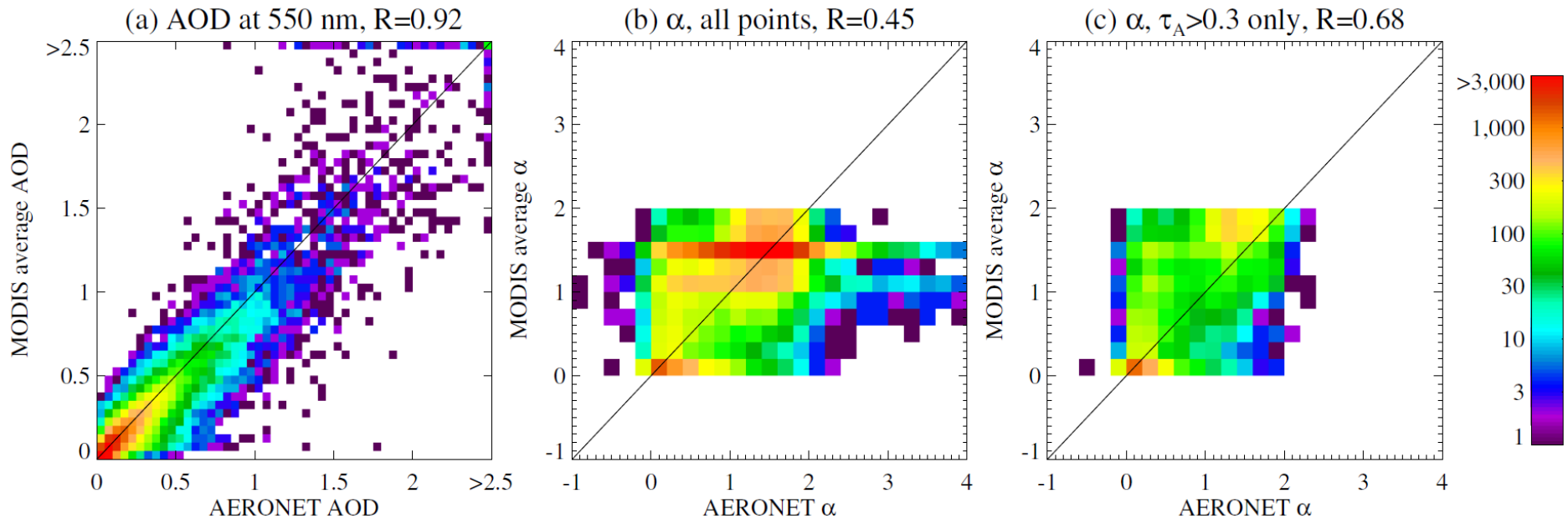
- Converse of previous case: undetected cirrus, visible in CALIOP, led to contamination (high biases) in C5.1 retrieval
- New reflectance ratio and tests identify this, removing the retrievals from Collection 6
- Not found to introduce significant false negatives
- See poster here by Jaehwa Lee et al

# 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 climatology of atmospherically corrected NDVI
  - Only Deep Blue is available for bright barren surfaces
  - Dark Target has longer heritage for vegetated 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
- Example shown to the right for June

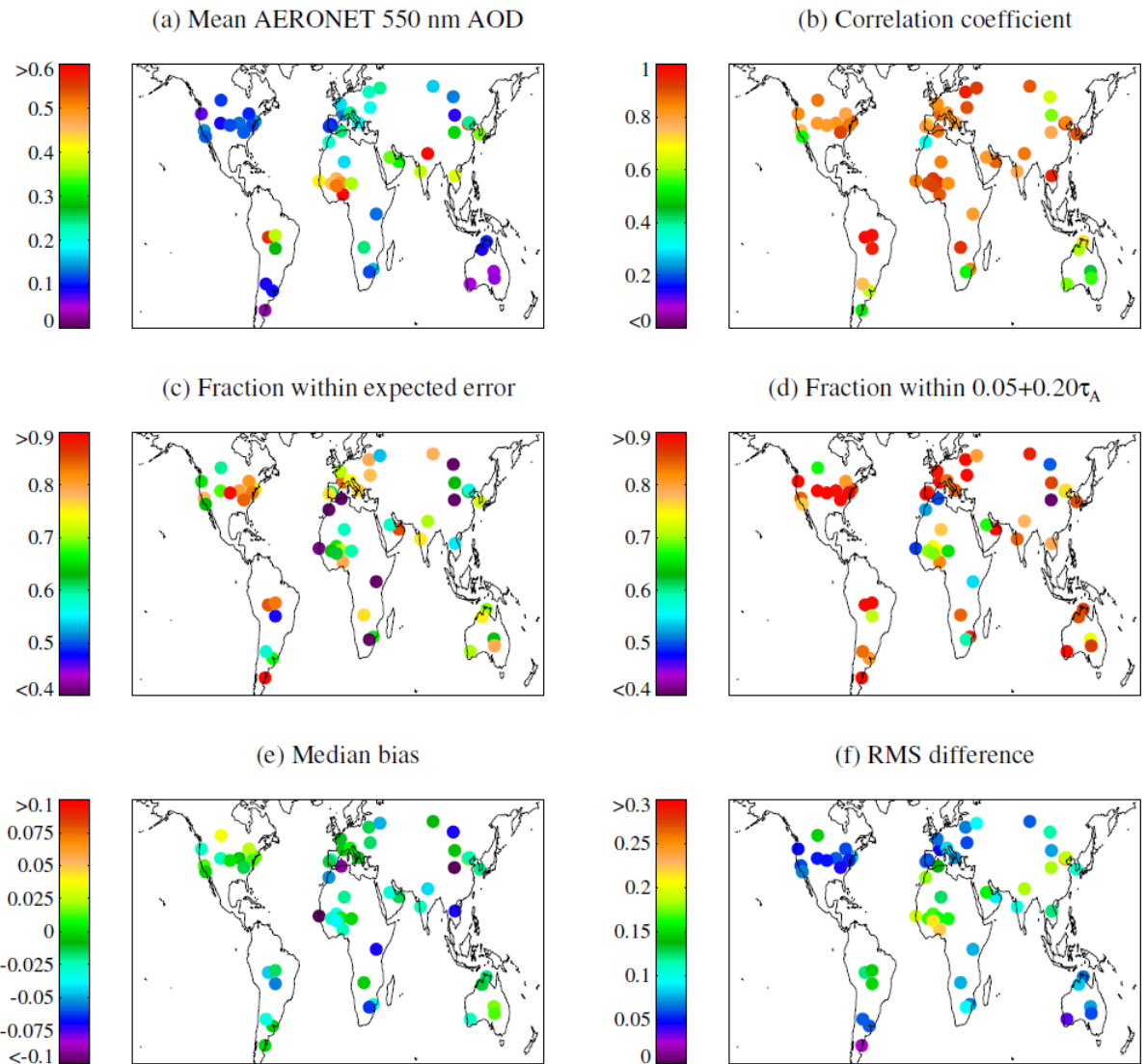


# Validation

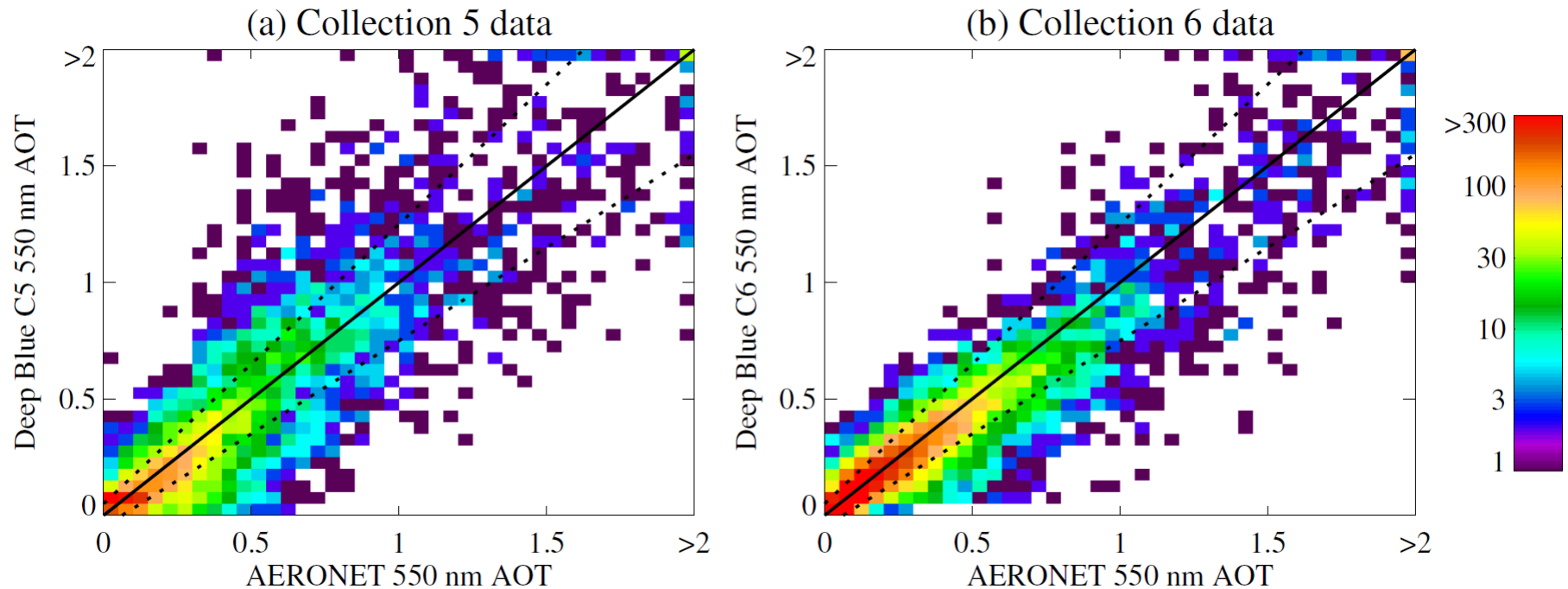


- Validated Aqua data against AERONET
  - See also poster by A. M. Sayer *et al.*, and a paper has been submitted to JGR
- One-sigma absolute uncertainty estimates provided for each pixel, dependent on viewing geometry and AOD
- For typical geometries, expected error (EE) approximately  $0.03+20\%$
- Similar at other wavelengths (412 nm, 470 nm, 670 nm)

- Correlations are high: capture variability at individual sites well
- Most sites have 68% or more of matchups within expected error, and small biases
- Performance poorer for spatially heterogeneous sites, and complex aerosol mixtures (typically parts of Africa and SE Asia)



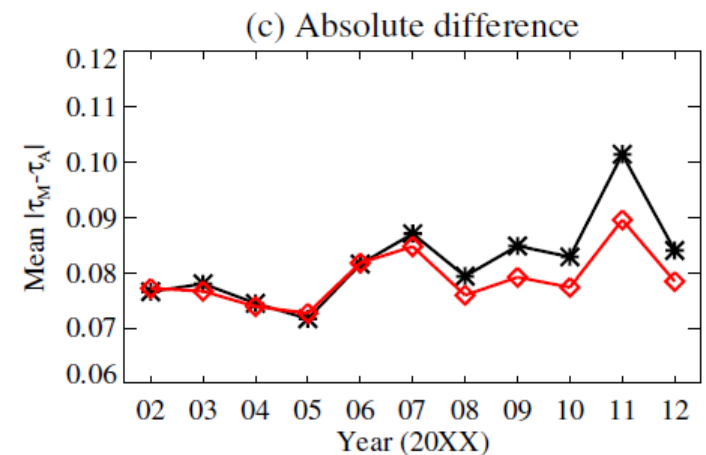
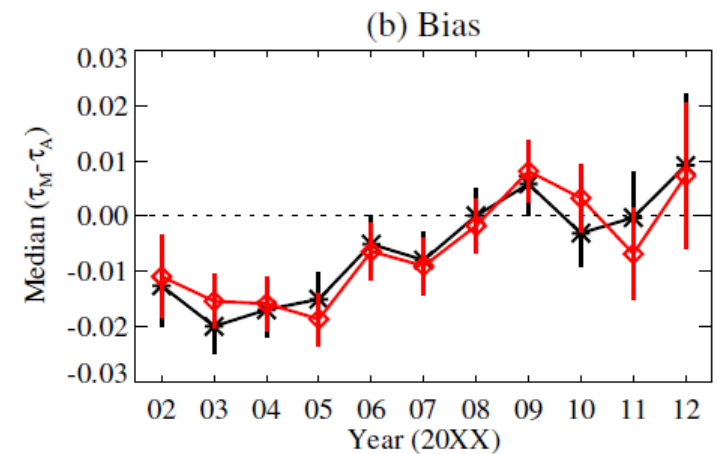
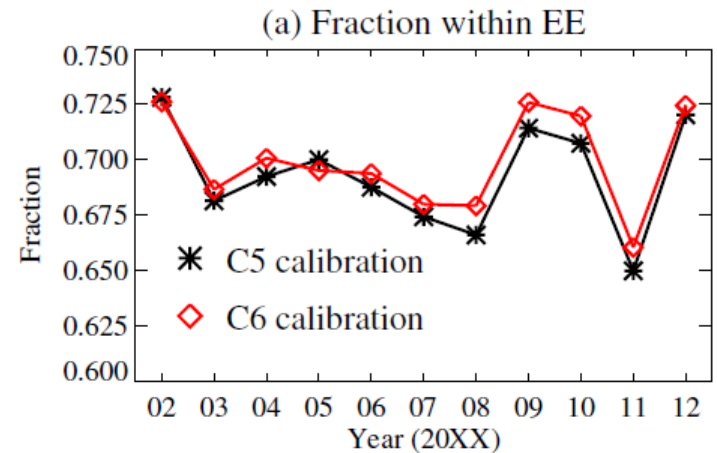
# Comparison to C5



- Have validated C5 and C6 against AERONET for 10 sites where both perform retrievals
- C6 has a better data volume (~ double the number of matchups), better correlation with AERONET (0.93 vs. 0.86), and smaller errors on retrieved AOD (bias ~halved, RMS error decrease by ~30%)

# Effect of L1b changes

- Ran C6 algorithm through C5 and C6 L1bs for long-term AERONET sites, to evaluate effect of radiometric calibration change
  - Note 2002 and 2011/2012 are incomplete due to Aqua and AERONET respectively
  - Differences become stronger in later years
- C6 L1bs result in better retrievals
  - Effect is smaller than that of algorithmic improvements
- Small trend in biases in retrievals for both calibration coefficients
  - Unknown whether this is coincidental, algorithmic, or calibration-related
- Thank you MCST!



# Summary

- Quality:
  - The C6 Deep Blue dataset will have better spatial coverage (including vegetated land surfaces) and smaller uncertainties than C5
  - We will be providing uncertainty estimates on an individual-retrieval basis, to aid quantitative analysis and facilitate applications such as data assimilation
- Status:
  - Aqua is ready to go
  - Terra testing is underway; the delay is due to the extra calibration efforts required for Terra
  - Algorithm and validation papers have been prepared
- Thanks to MCST and the Ocean Colour group for their extensive efforts in maintaining the high radiometric quality of MODIS data, and to the AERONET PIs for creation and stewardship of this invaluable resource for validation