MAIAC Update: Synergistic Approach to Cloud Detection, Aerosol Retrievals and Atmospheric Correction from MODIS

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MODIS STM, Land
May 7, 2012

MAIAC = *Time Series + Spatial Analysis*

Towards a Complete Physical Model of RT:

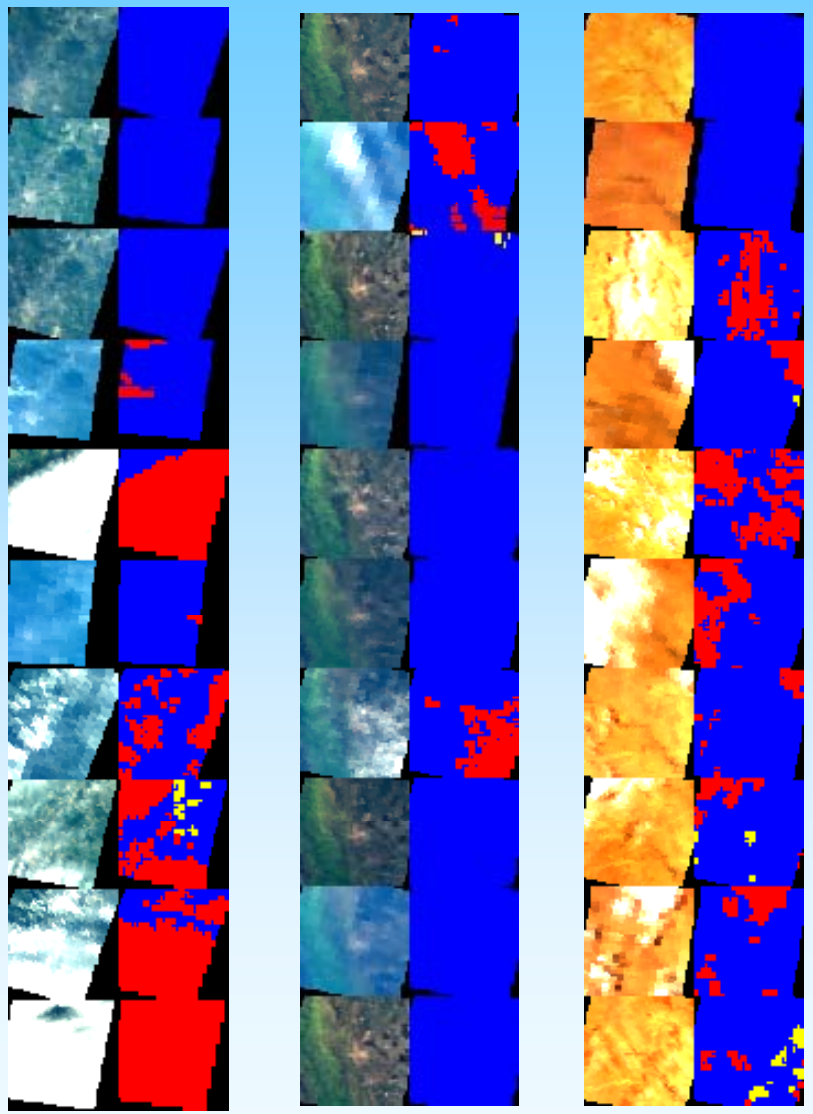
- *Anisotropic surface;*
- *Retrieval of Spectral Regression Coefficient:* $\rho^{\lambda} = b^{\lambda}\rho^{2.1}$
- *Detection and accommodation of seasonal and rapid surface change;*
- *Synergy among WV, CM, aerosol and AC algorithms.*

New Developments

- *Latest Work on Cloud Mask;*
- *Discrimination of Aerosol Type;*
- *Aerosol Retrievals and Atmospheric Correction over Bright Surfaces;*
- *Schedule.*

Cloud Mask

Left – MODIS TERRA RGB, 2003 (50×50km²), Right – MAIAC CM



GSFC, USA *Mongu, Zambia* *Solar Village*

- ***Basis*** *- covariance analysis (identifies stable pattern in the time series) & reference clear-sky image of surface (B. Rossow)*

- ***High covariance - CLEAR****. Ephemeral clouds disturb the pattern and reduce covariance.*

- *Algorithm maintains a dynamic clear-skies reference surface image in B1, B7, used as a comparison target in cloud masking.*

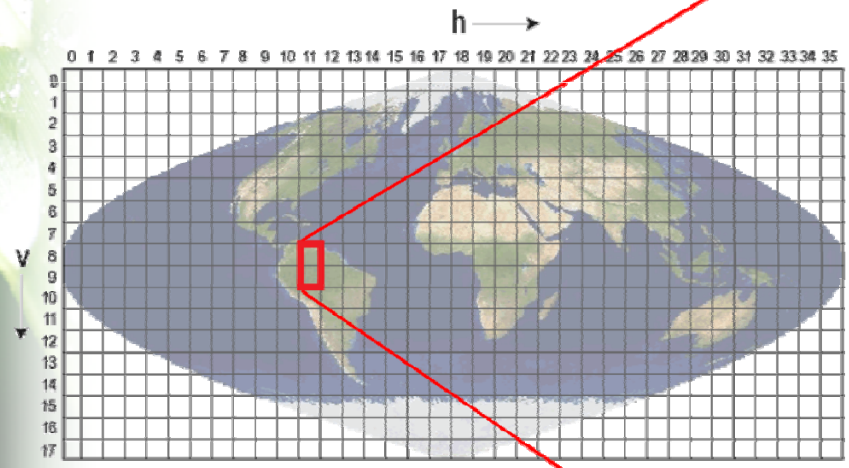
CM Legend:

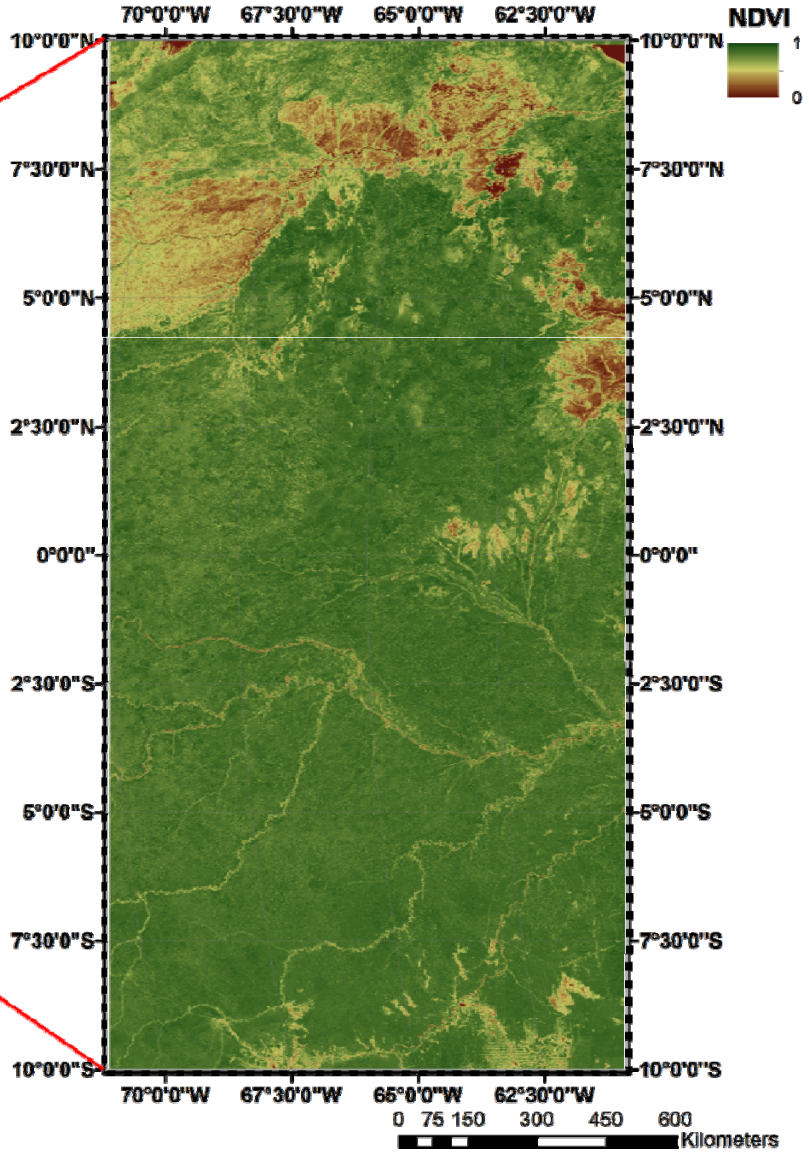
Blue *(Clear),* ***Red*** ***&*** ***Yellow*** *(Cloudy).*

from T. Hilker, A. Lyapustin, J. Tucker, P. Sellers, F. Hall

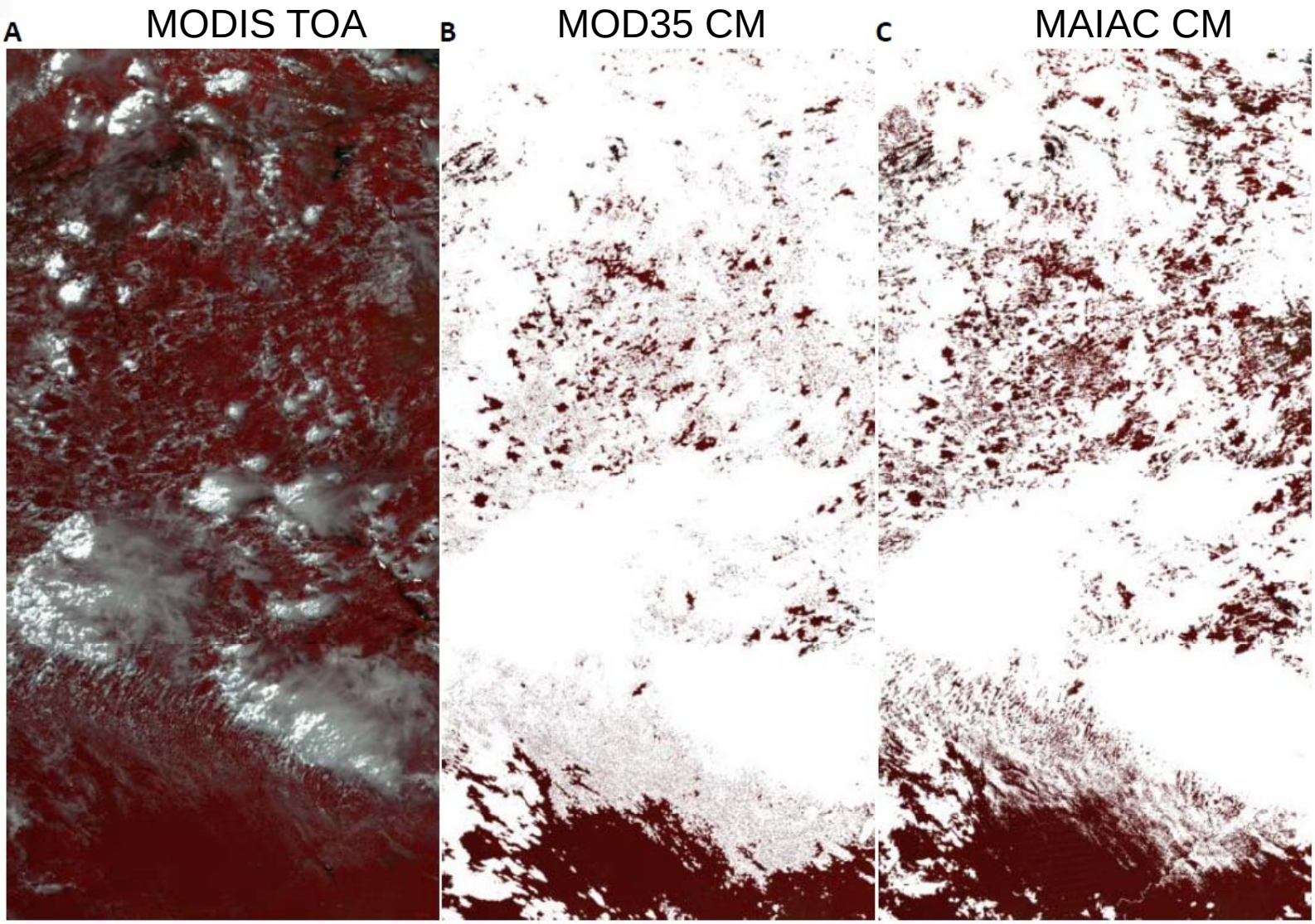
Study area

MAIAC NDVI

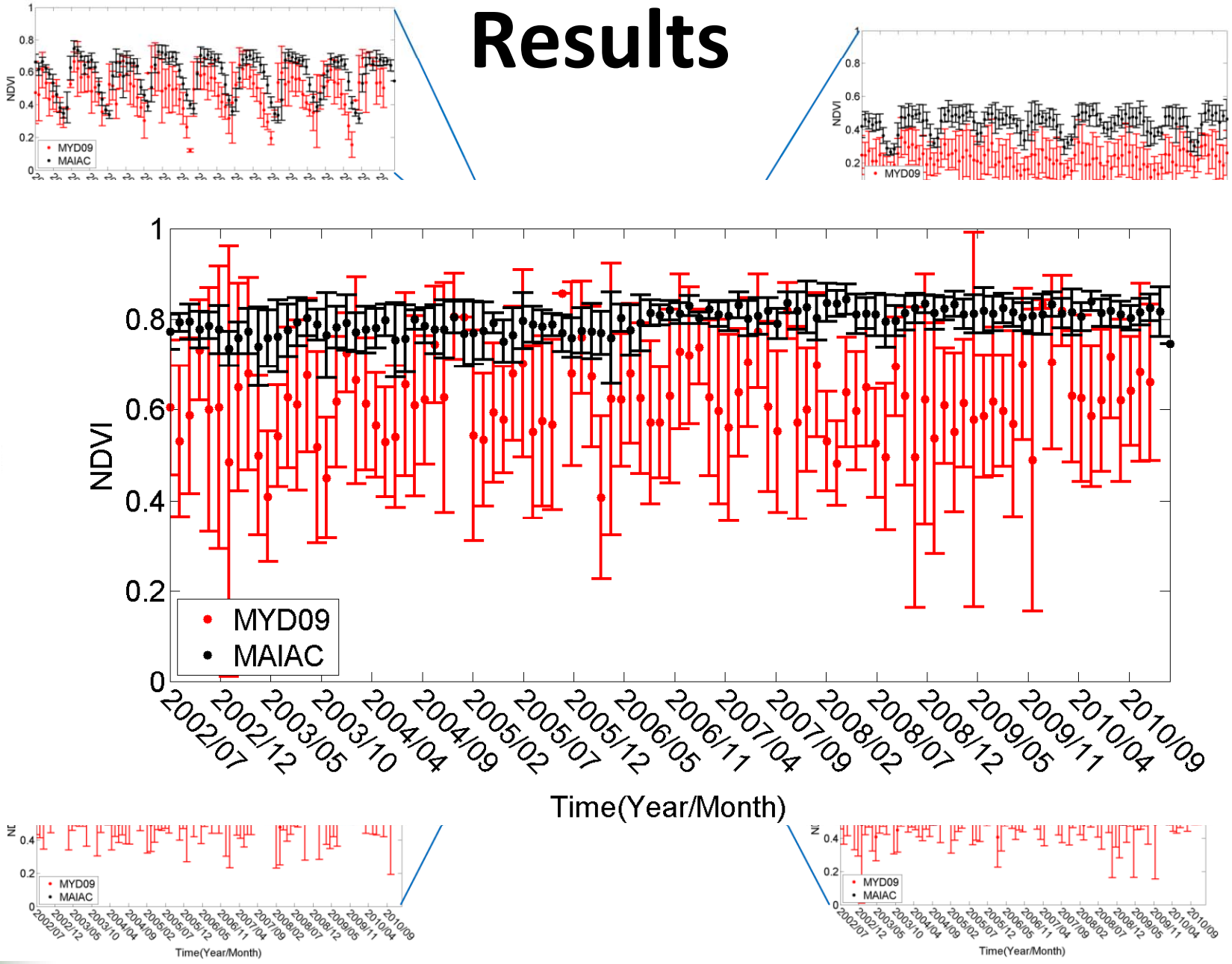




Cloud mask

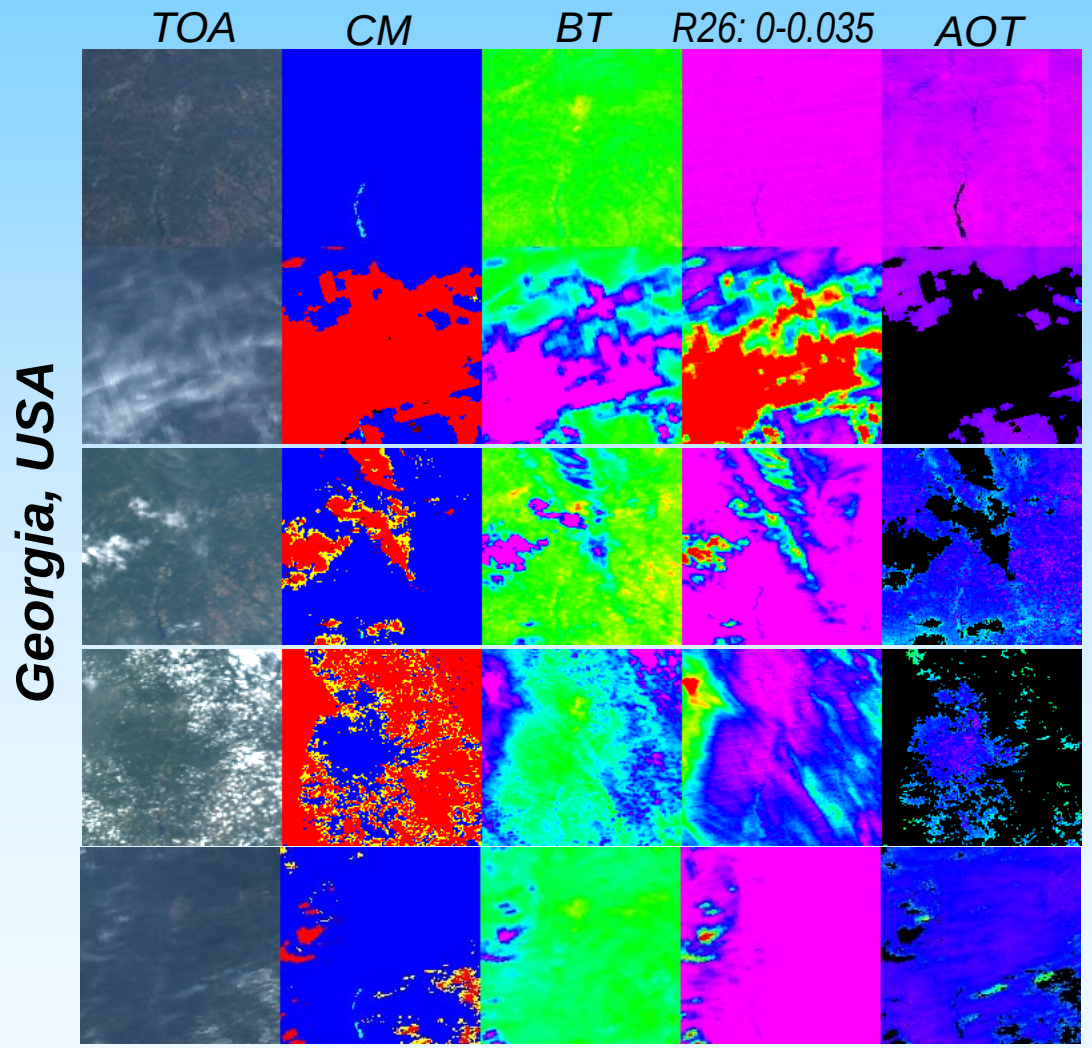


Results

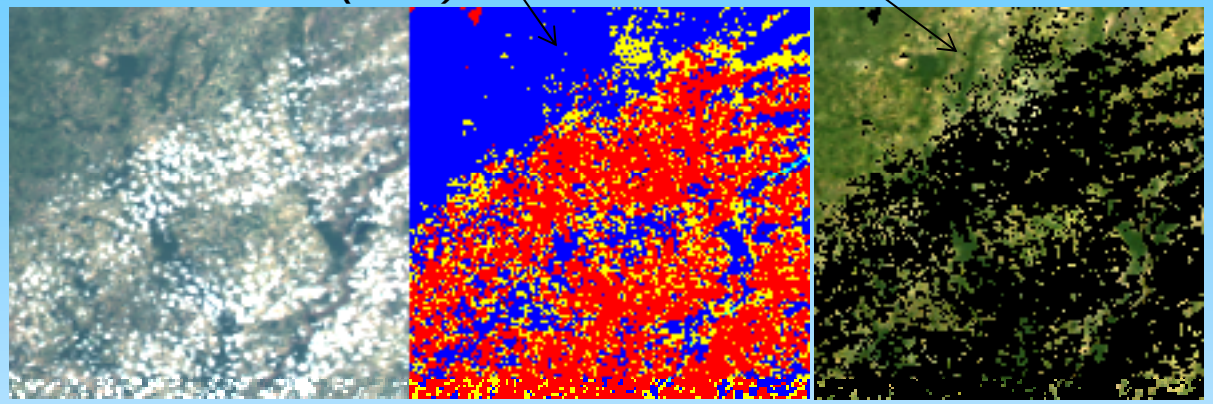

NDVI
MYD09
MAIAC
Time(Year/Month)
2002/07
2002/12
2003/05
2003/10
2004/04
2004/09
2005/02
2005/07
2005/12
2006/05
2006/11
2007/04
2007/09
2008/02
2008/07
2008/12
2009/05
2009/11
2010/04
2010/09

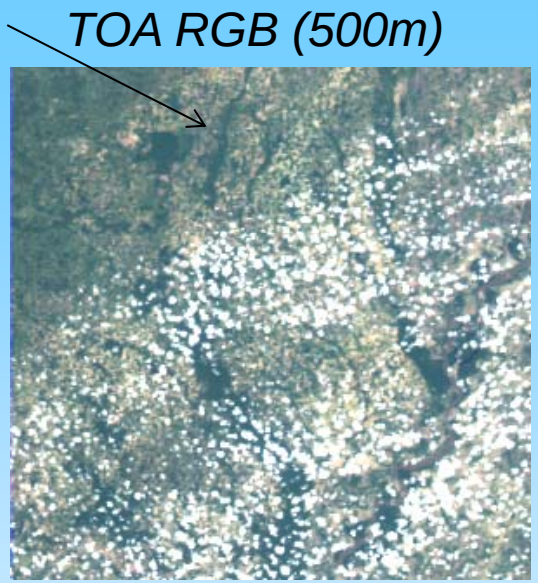
1. Enhanced Detection of Cirrus Clouds

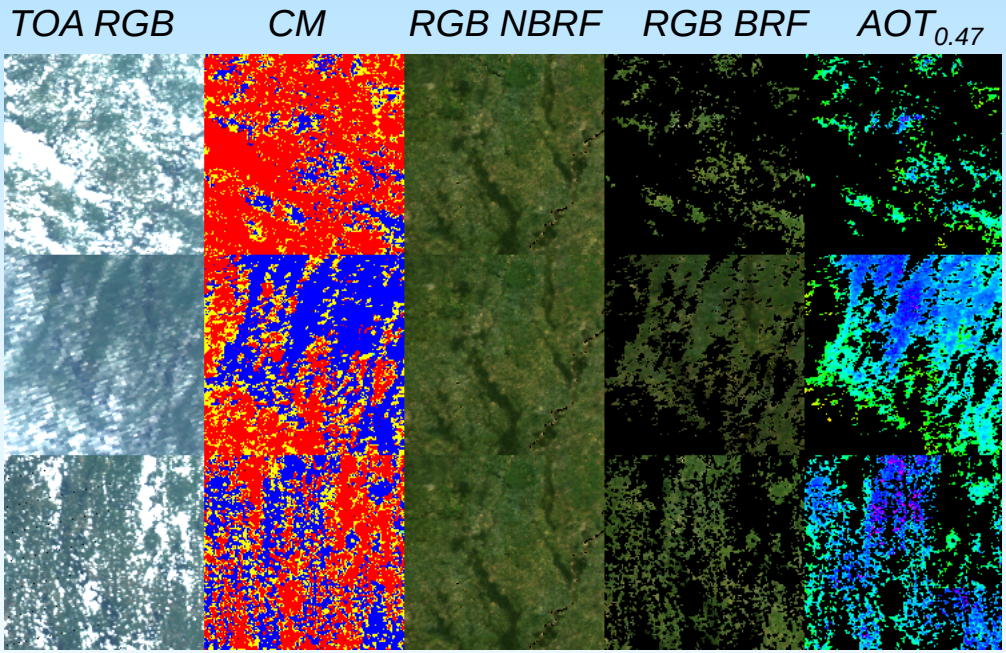
- *MOD35: $R_{1.38}$ > 0.035, not used if H>2km*
- *MAIAC: a) Threshold is f(WV): 0.01 (WV>1cm), and 0.035 (WV>0.3 cm)*



2. Sub-Pixel Clouds: Using 500m Grid

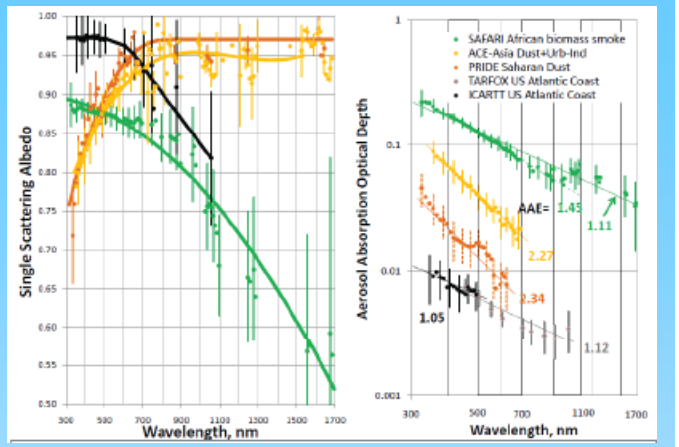






Smoke Test

- *Smoke is mostly fine mode aerosol (Eck et al., 2008)*
- *Smoke is more absorbing than the background aerosol, plus OC enhances absorption at short wavls. (Blue to UV)*



Russell et al., ACP, 2010

Absorption Parameter (~ OMI AI)

1. *Compute aerosol reflectance in Red, Blue and DB:*

$$R_\lambda^{Aer} = R_\lambda^{Meas} - R_\lambda^{Molec} - R_\lambda^{Surf}(\tau^a)$$

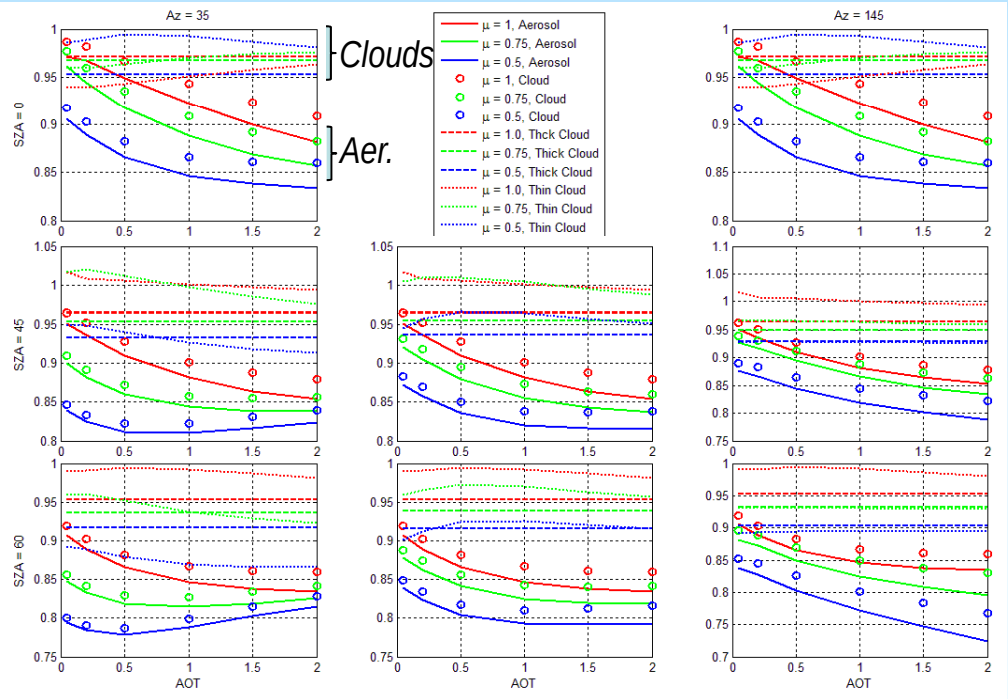
2. *Assume* $R_\lambda^{Aer} \sim \lambda^{-b}$ *and get AE from Red and Blue.*

3. *Compute AP as ratio of measured and predicted aer. reflectance in DB:*

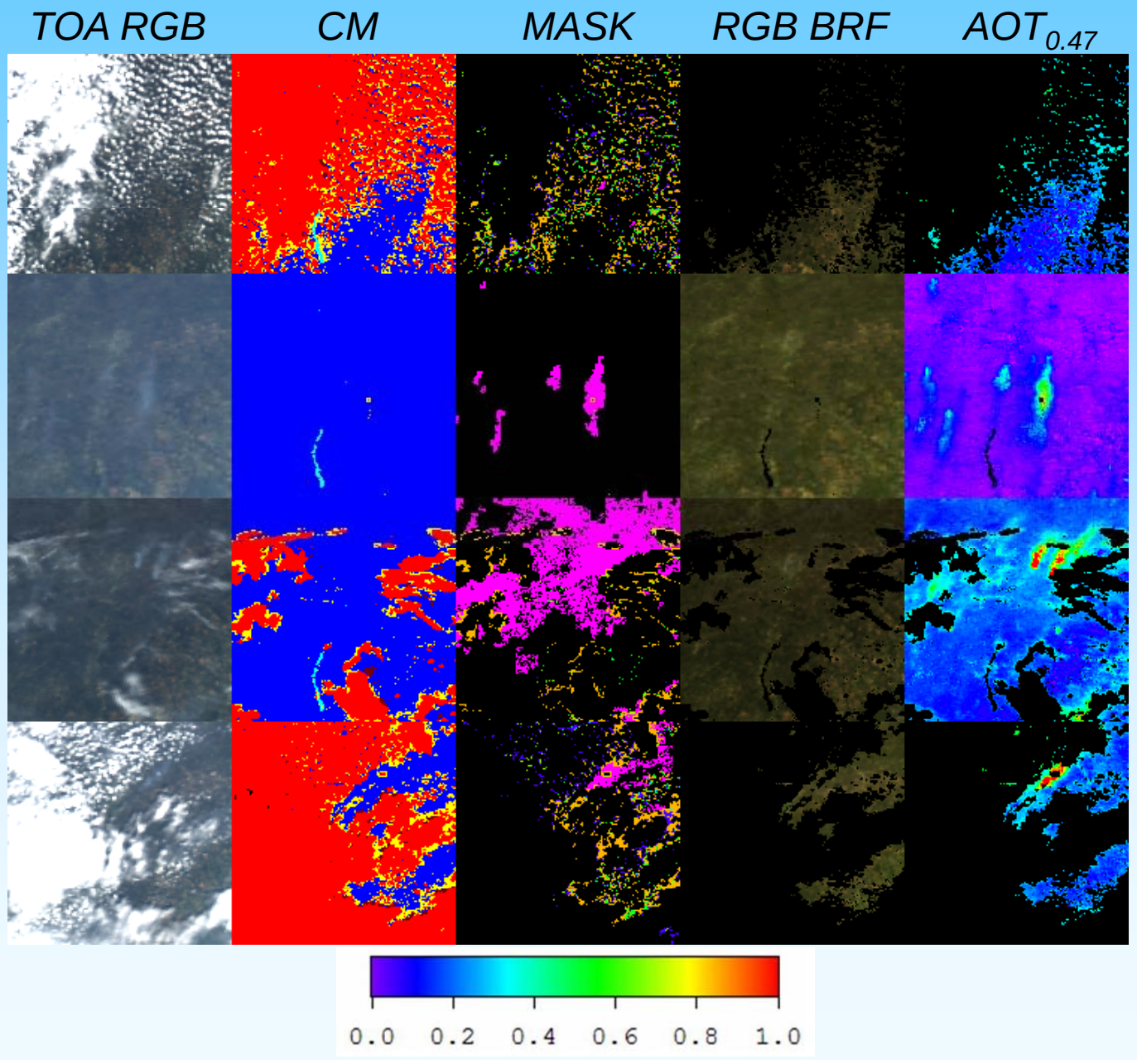
$$AP = R_{0.412}^{Aer,Meas} / R_{0.412}^{Aer,Pred}, \text{ where}$$

$$R_{0.412}^{Aer,Pred} = R_{0.466}^{Aer}\left(\frac{0.466}{0.412}\right)^{-b}$$

Absorption Parameter (n_i~0.01)



Smoke Test at Work



Georgia, USA
Summer, 2003

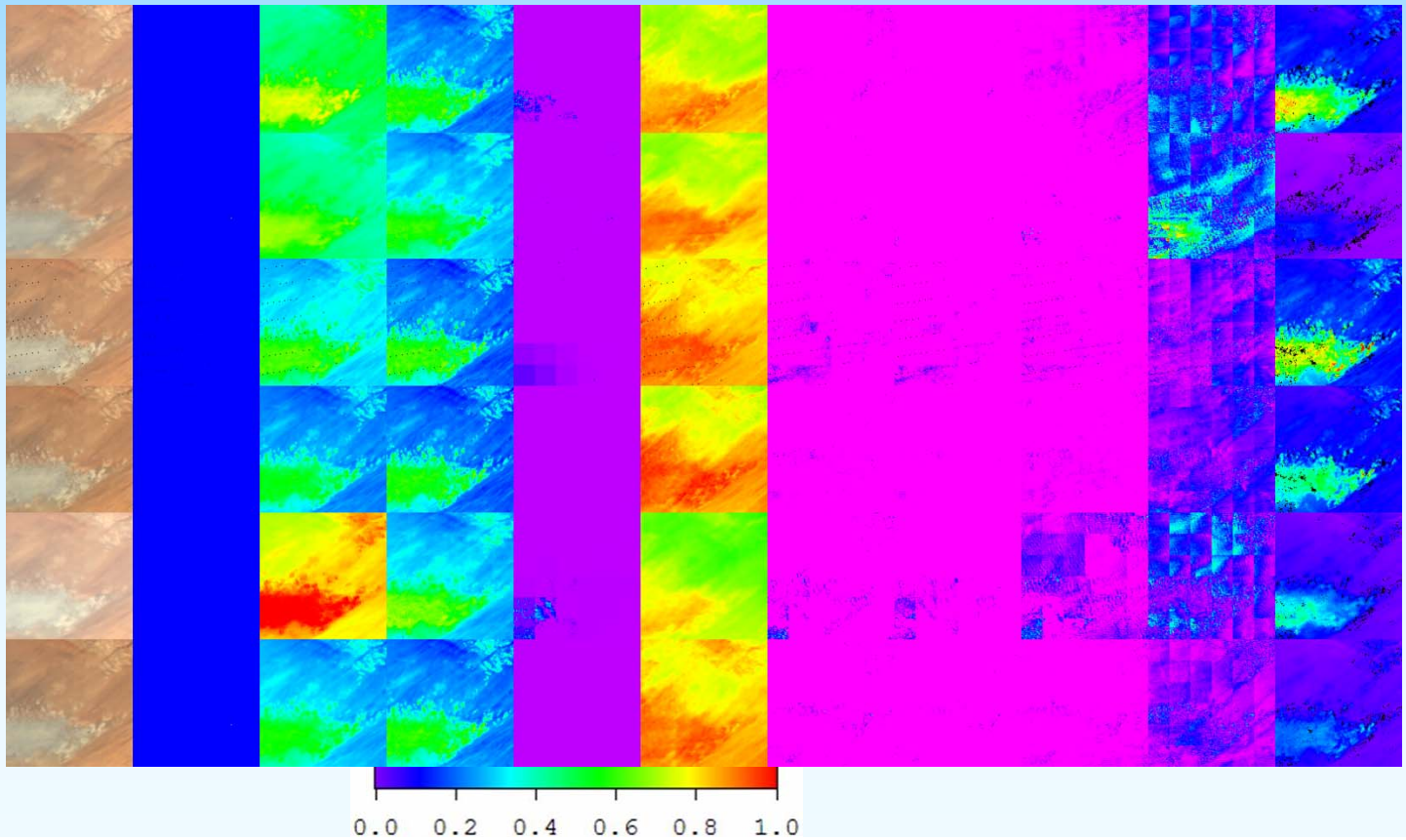
Bright-I: Surface Characterization

Analysis for 25×25 km² blocks (includes both magnitude and contrast)

$$\delta_{\lambda;i,j} = \frac{R^{M}_{\lambda;i,j} - R^{T}_{\lambda;i,j}}{\sigma_{\lambda;i,j}}; \quad \chi_{i.j} = \sum_{\lambda} \delta^{2}_{\lambda;i,j}; \quad rmse = \sum_{i,j} \chi^{2}_{i,j} = \min_{\tau<0.3}\{\tau\} \Rightarrow$$

Accept if Cov>HIGH & rmse<1

Example for Bodele Depression (150×150 km²: DOY 344-351, 2007)



$$\Delta\tau_{\lambda;i,j} = \frac{\mu_0 \sigma_{\lambda;i,j}}{L'_{\lambda;i,j}};$$

- AOT uncertainty

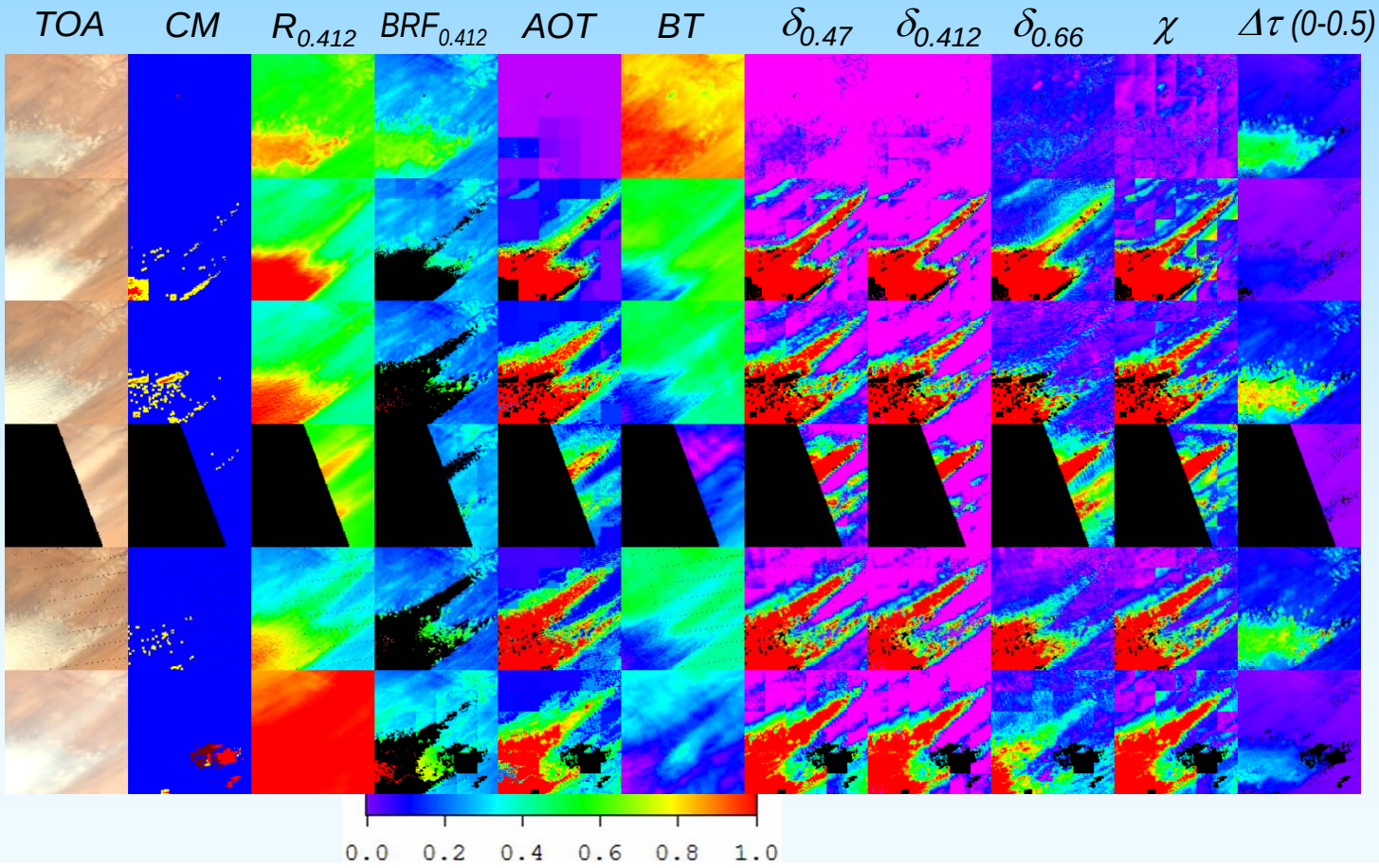
Bright-II: Aerosol Retrieval

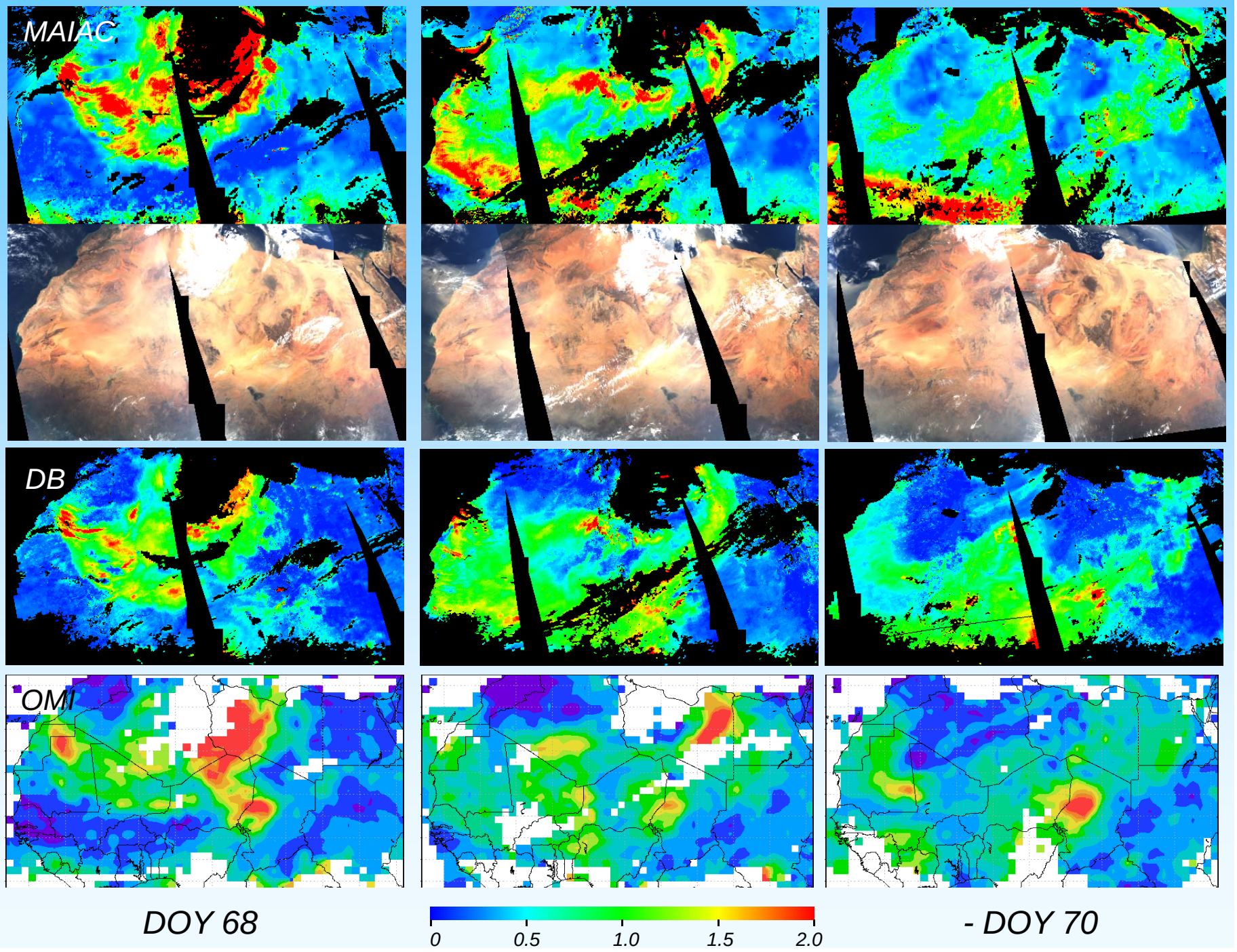
Pixel Analysis

$$\delta_{\lambda;i,j} = \frac{R^{M}_{\lambda;i,j} - R^{T}_{\lambda;i,j}}{\sigma_{\lambda;i,j}}; \qquad \chi_{i,j} = \sum_{\lambda} \delta^{2}_{\lambda;i,j} = \min\{\tau; Model\}$$

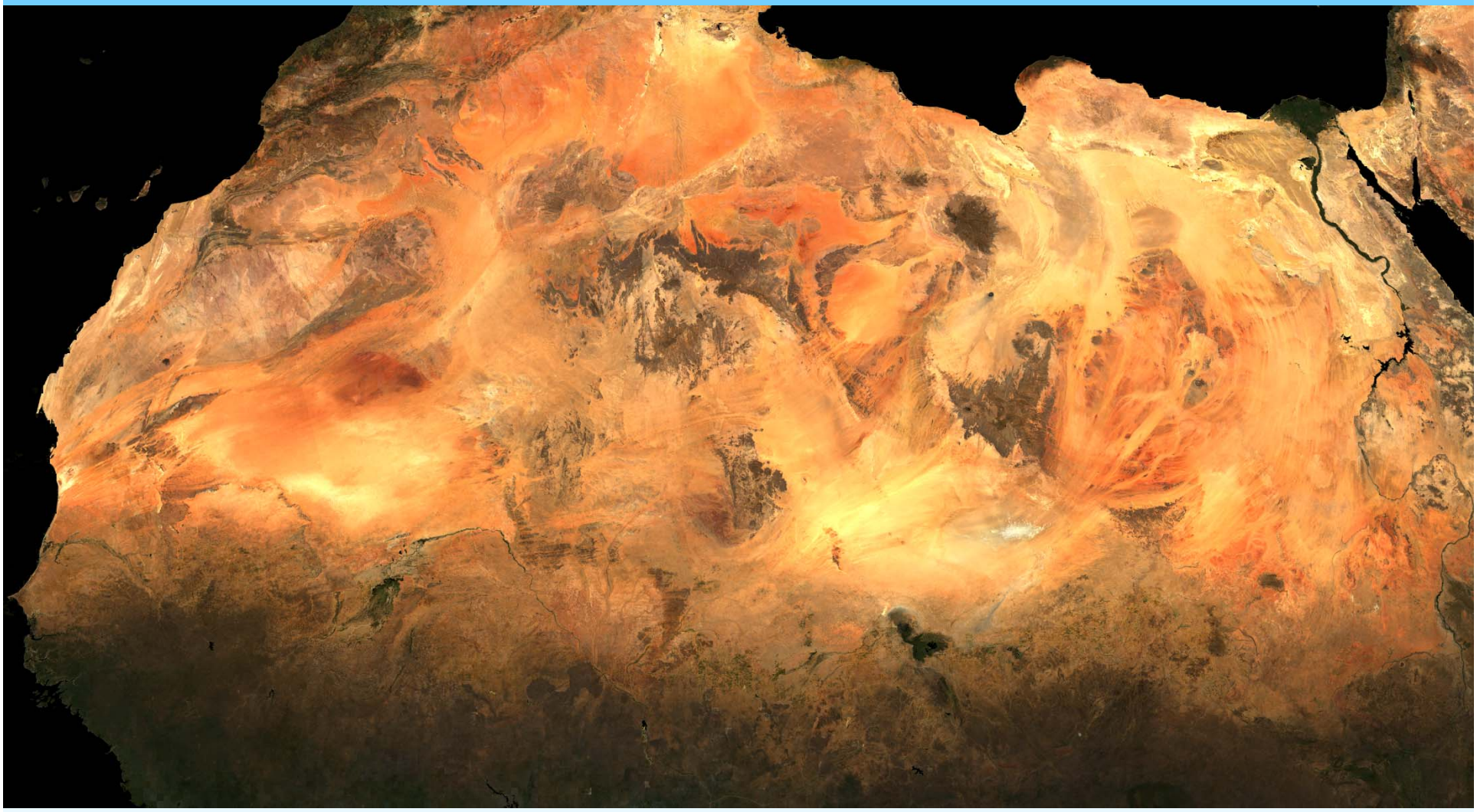
for every pixel with χ>0.5

… Bodele Depression (*DOY 352-358, 2007 – Dust Storm)*




MAIAC
DB
OMI
DOY 68
- DOY 70
0
0.5
1.0
1.5
2.0

RGB NBRF, 5500×3000 km², 2007



MAIAC NBRF (SZA=45°, VZA=0°), end of 2007

To Do List for the Next 6 Months

- *Finalize Bright Surface Algorithm and Integrate with Standard MAIAC;*
- *Plug-in Winter (Snow) Processing and Validate: Snow Grain Size and Sub-Pixel Snow Fraction;*
- *MODAPS Testing (working with MODAPS group):*
  - *HDF format output is fully compatible with current MOD09 product (need to define QA);*
  - *Limited Testing Completed;*
  - *Global Testing Planned;*
  - *Peer Review of the Comparison Results (HQ).*
- *Full re-processing of MODIS Terra and Aqua data by MAIAC is expected after MODIS Collection 6 re-processing.*