Current Status of Algorithm MAIAC

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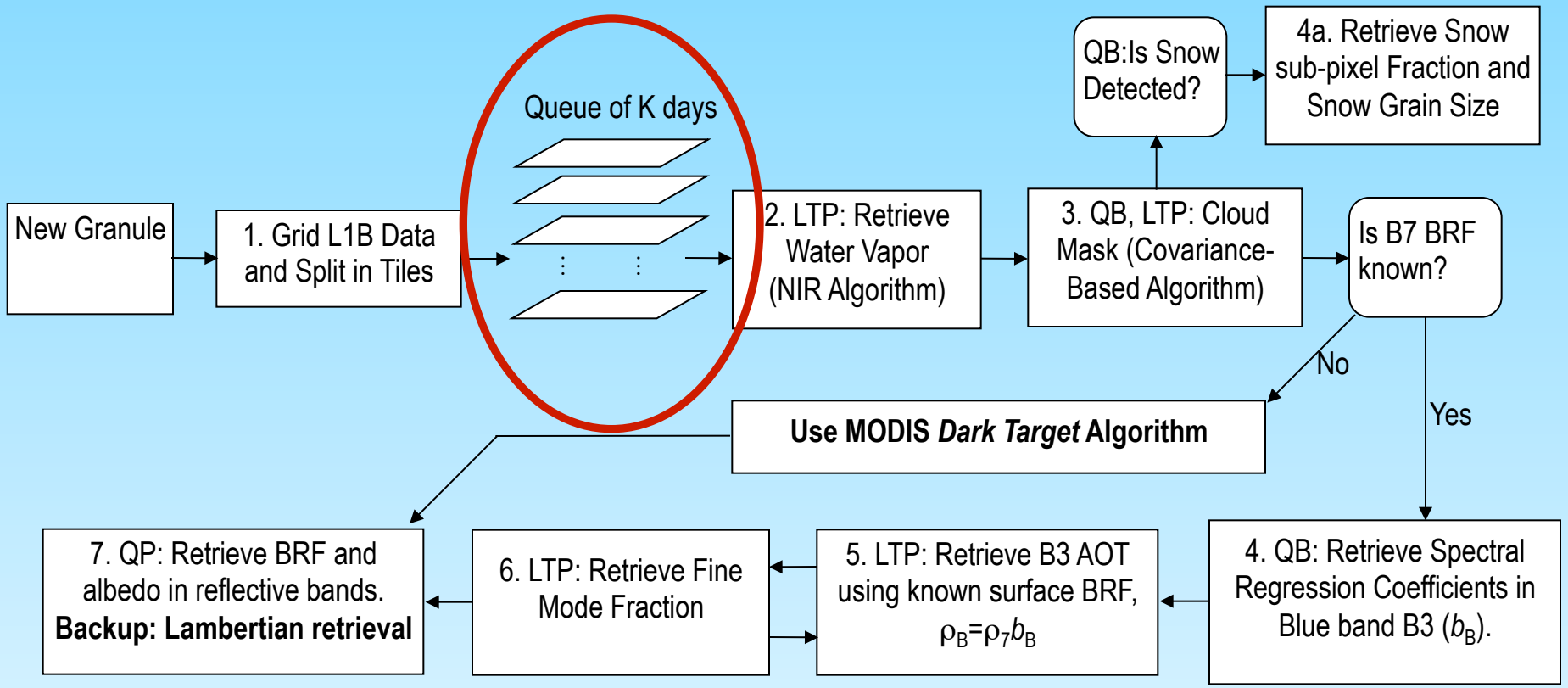
"Observations and modeling of aerosol and cloud properties for climate studies"

September 12-14, 2011, Paris

Multi-Angle Implementation of Atmospheric Correction (MAIAC)



MAIAC Products (1 km, gridded)

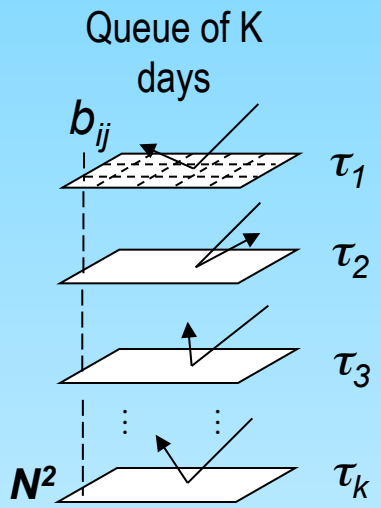
Atmosphere:

- *Cloud Mask;*
- *Water Vapor;*
- *AOT & fine mode fraction;*

Surface:

Parameters of RTLS BRF model;
Surface Reflectance (BRF)/ Albedo;
Dynamic Land-Water-Snow Mask.

Generic Retrieval of SpectralRegressionCoefficient



$$\{\rho_{ij}^{\lambda} \propto (k_L, k_{go}, k_v)_{ij}^{\lambda} \propto b_{ij}^{\lambda}\}$$

Basis:

- *surface is spatially variable and stable in short time intervals;*
- *aerosols are variable in time and have a mesoscale (60-100 km) range of global variability.*

Approach:

- *Derive shape of BRF from 2.1 μm, and use spectral scaling:* $\rho_{ij}^{Blue} = b_{ij}\rho_{ij}^{B7}$

- *Process K days for area N×N pixels simultaneously :*

$$KN^2 \text{ (measurements)} > K_{\{\tau_k\}} + N^2_{\{b_{ij}\}}$$

MISR heritage:

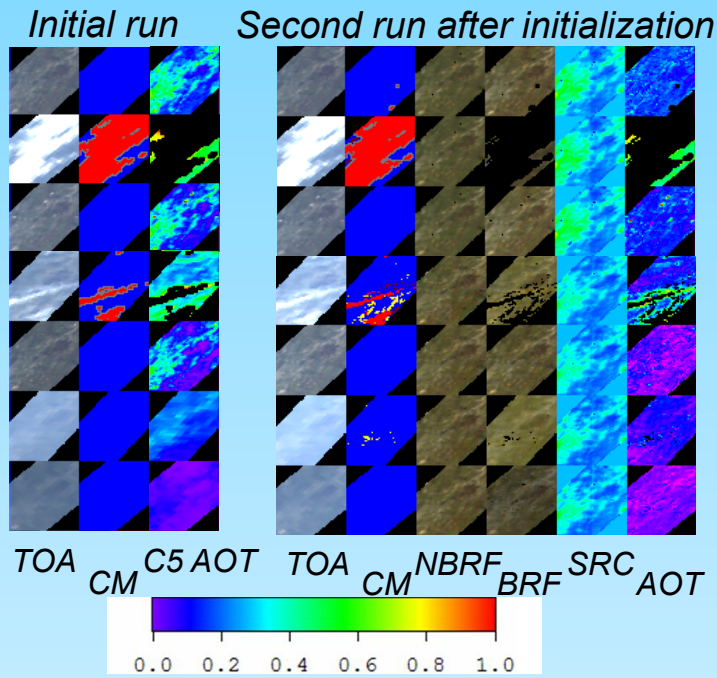
-Using spatial and angular structure of imagery for aerosol retrievals (Martonchik et al., IEEE TGARS 1998);

-Using angular and spectral shape similarity constraints in aerosol retrievals over land (Diner et al., *RSE*, 2004).

MODIS heritage:

- RTLS BRF retrieval algorithm (Schaaf et al., 2002)
- Gridding algorithm (Wolfe et al., 1998)
- Cloud Mask (Ackerman et al., 1998)
- Regional Aerosol Models (Levy et al., 2007)

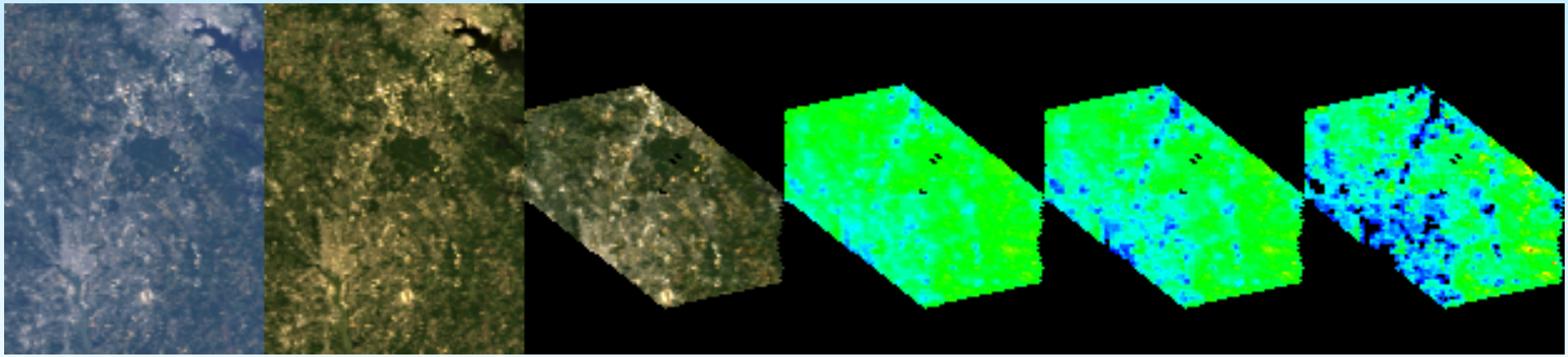
SRC & Aerosol-AC Bias Over Bright Pixels



1. *In standard MOD04 retrievals, AOT correlates with surface brightness (left). This explains reflectance reduction over bright pixels (below).*
2. *MAIAC removes artificial correlation by means of SRC retrieval (right).*

Difference Image: ***MOD09-ASRVN*** *(GSFC, 2005, day 264. Scale (-0.02, 0,02))*

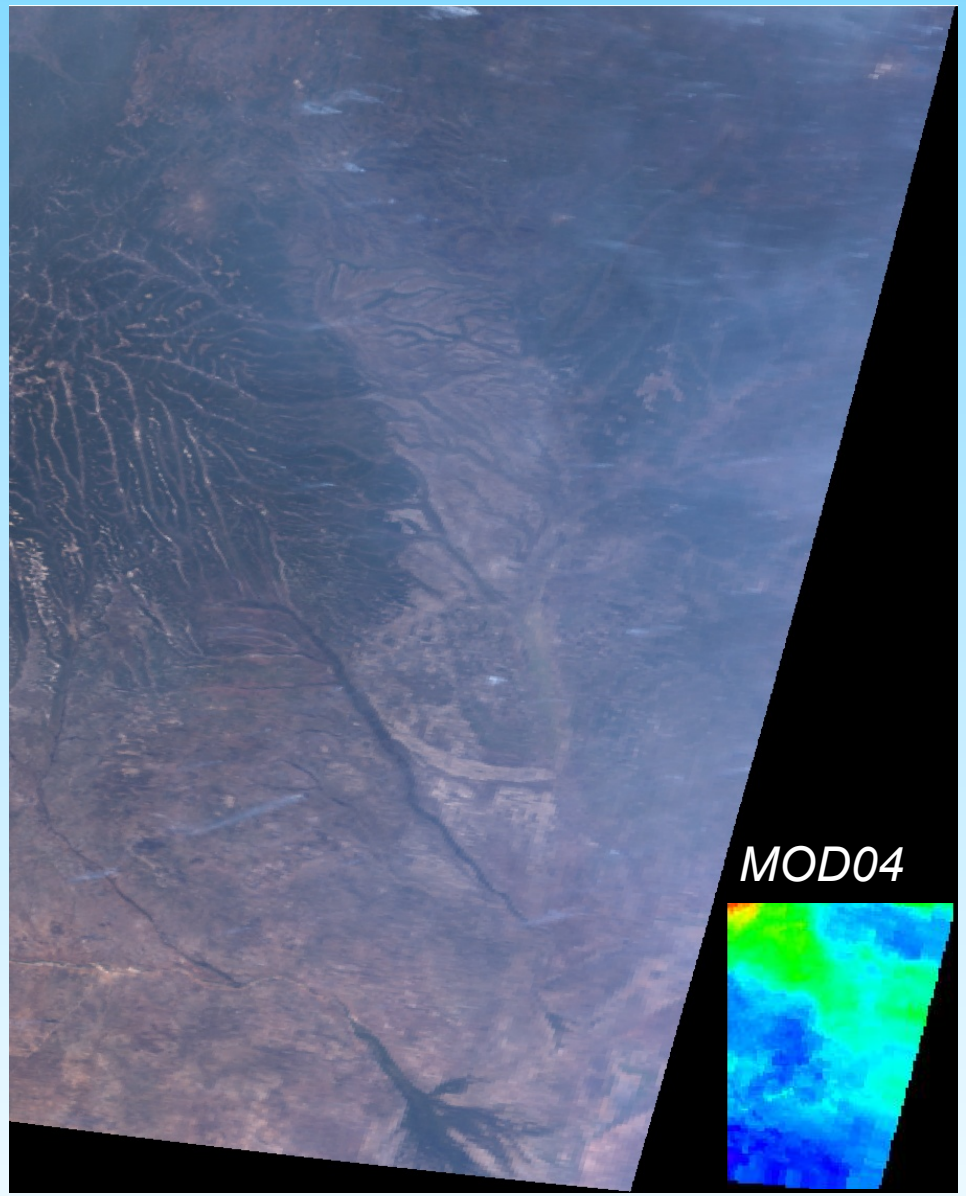
Blue/Black-Underestimation
Green – Agree
Yellow/Red - Overestimation

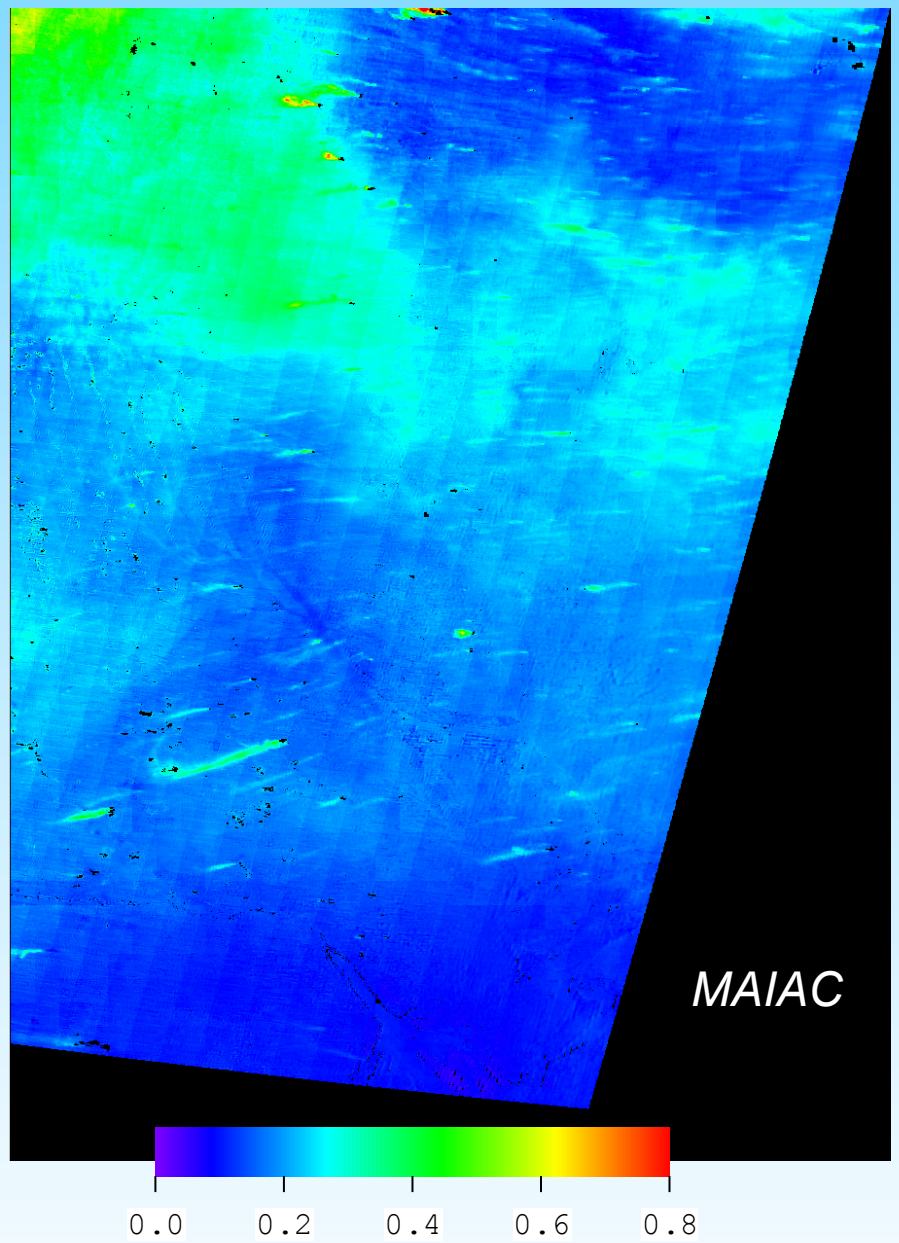


TOA *MOD09* *ASRVN* *Diff-Red* *diff-Green* *diff-Blue.*

Aerosol Retrievals: Biomass Burning

Fires: Zambia, day 205, 2005. 1 km resolution of AOT allows tracing smoke plumes

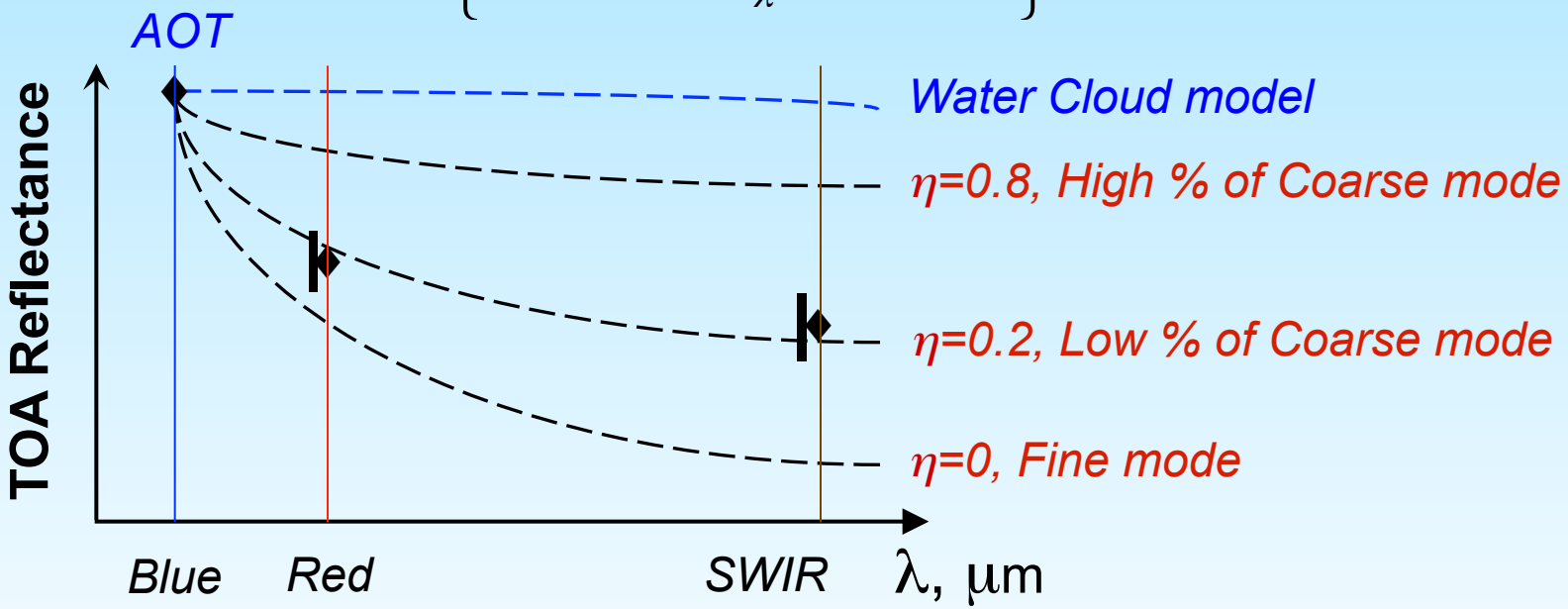




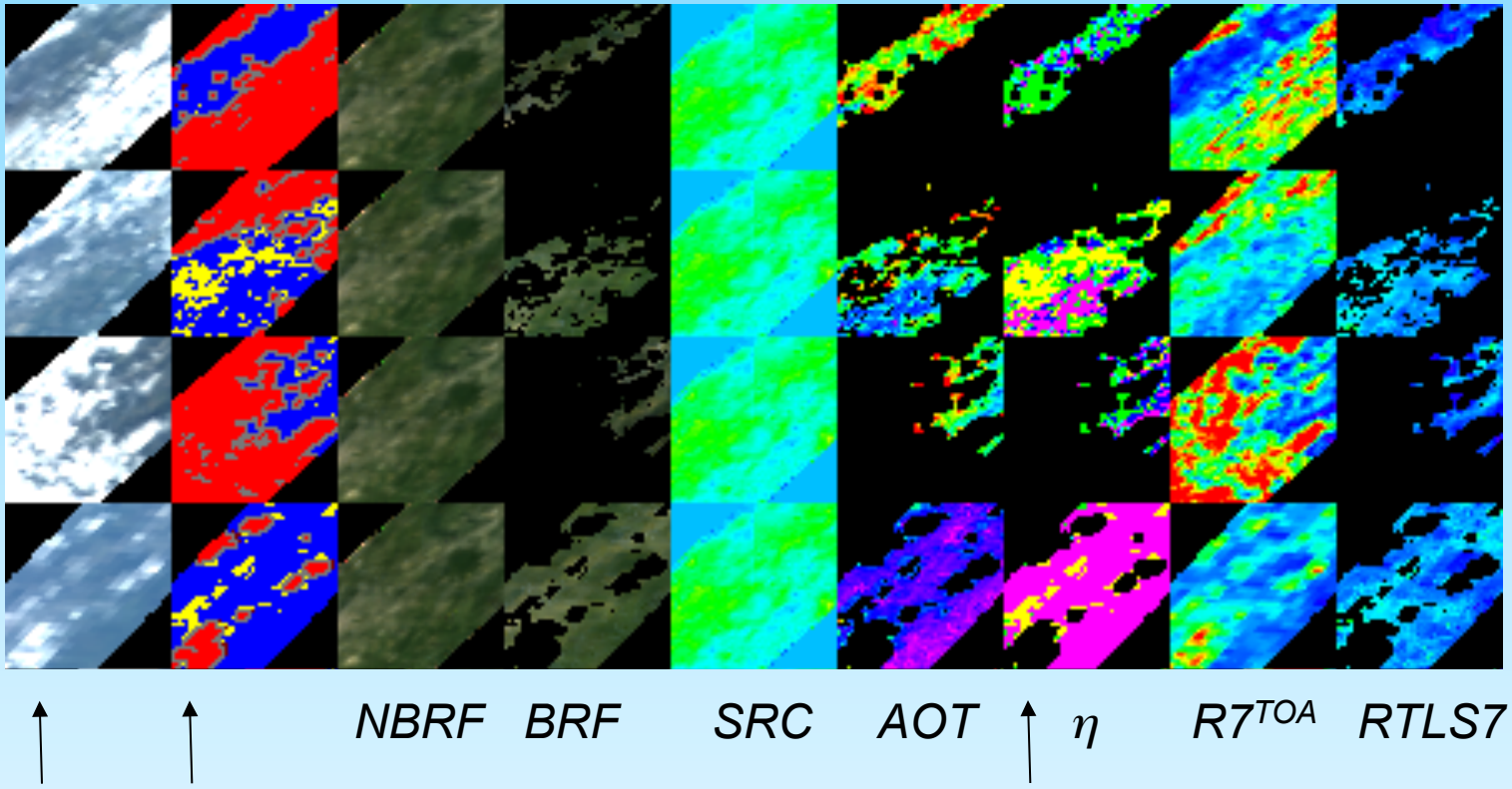
Aerosol Retrieval Algorithm

- Compute AOT_B and coarse mode fraction η using Blue (B3), Red (B1), SWIR (B7) bands.
- Surface BRF: use SRC in blue band, $\rho_{ij}^{Blue} = b_{ij}\rho_{ij}^{B7}$. BRF in B1 and B7 is known from previous retrieval with uncertainty $\sigma_{ij}(\lambda)$.
- Algorithm: Fit Blue band to find AOT_B for given η, and find η by minimizing

$$rmse = \frac{1}{2}\sum\left\{\frac{R_\lambda^{Meas} - R_\lambda^{Theor}(AOT_B,\eta)}{\sigma_\lambda}\right\}^2 \le 1$$



Cloud Mask Enhancement from Aerosol Retrievals



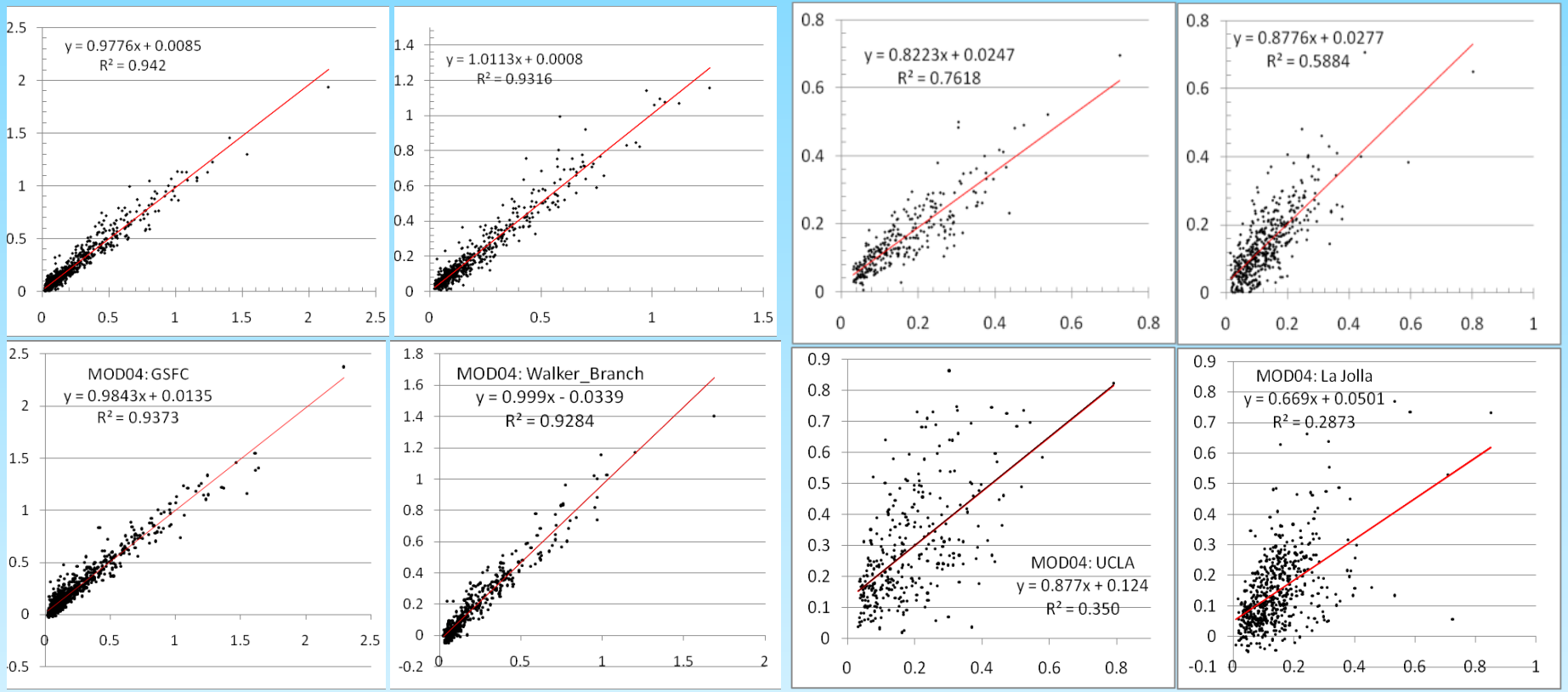
Resolving thin clouds using Cloud Model (yellow color)

AERONET Validation, 9 yrs. of TERRA Data

East Coast USA *West Coast USA*

MAIAC

MOD04

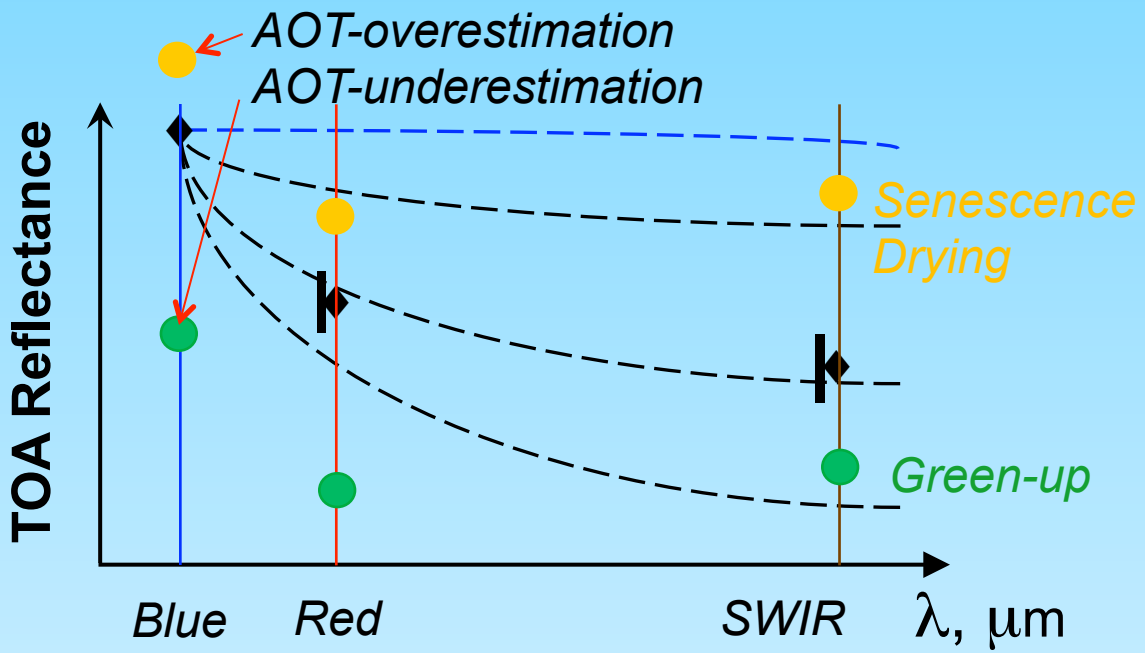


AERONET

- *The accuracy of MAIAC (1km) and MOD04 (10km) is generally similar over green and relatively dark parts of the world.*
- *Over brighter surfaces, MAIAC has a better accuracy and smaller bias than MOD04 due to SRC retrievals and explicit BRF characterization.*

Lyapustin, A., Y. Wang, I. Laszlo, R. Kahn, S. Korkin, L. Remer, R. Levy, J. Reid, 2011: MAIAC:-2. Aerosol Algorithm, JGR, 116, D03211, doi:10.1029/2010JD014986.

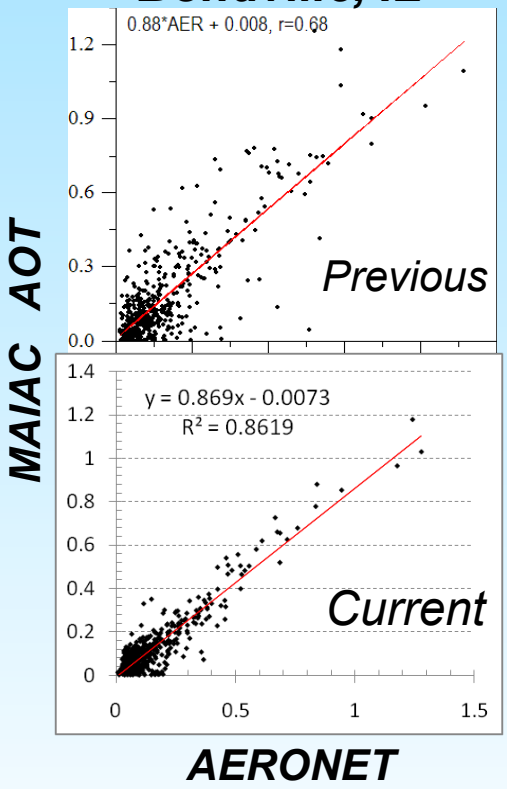
Changing Surface



OLD PROBLEM

- *Aerosol alg. assumes a stable surface: AOT and particle size are biased;*
- *AC alg. gives "old" reflectance;*
- *Change detection post-AC does not help.*

Bondville, IL



SOLUTION

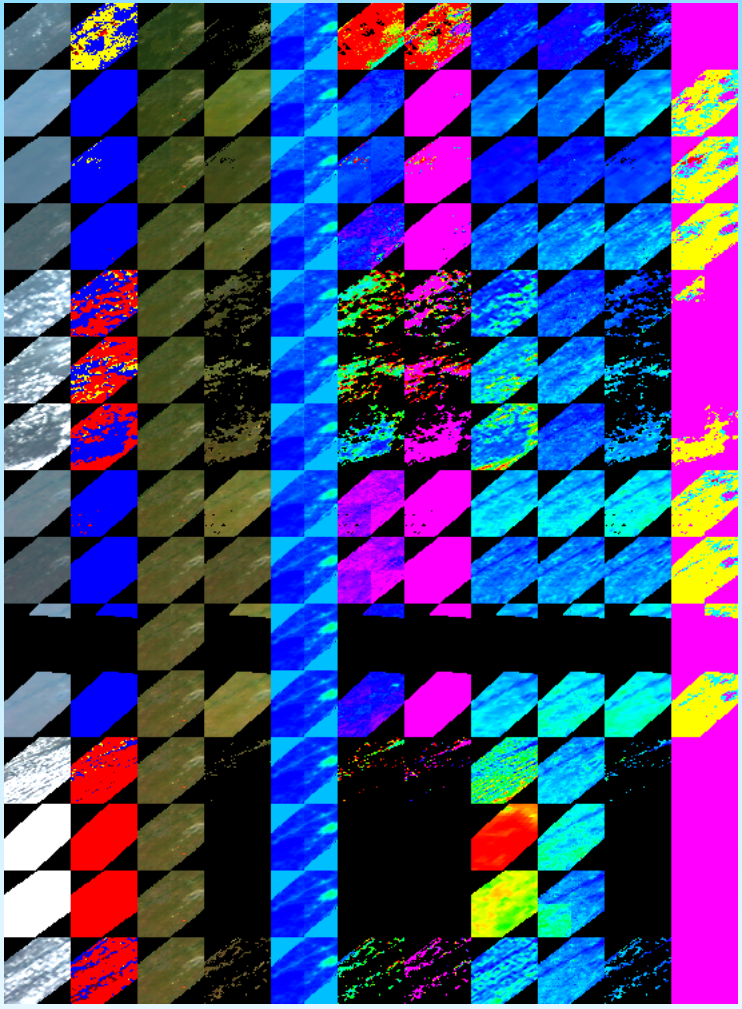
- *Introduced Change Detection in Aerosol alg.*
- *Change Detection is based on Red-NIR BRF_n*

$$\rho_n = \rho(\theta_0,\theta,\varphi)\frac{RTLS(45^0,0^0)}{RTLS(\theta_0,\theta,\varphi)}$$

- *Criterion separating BIG_CHANGE (scaling) and regular CHANGE (RTLS-inversion):* $\Delta\rho_n / \rho_n > 15\%$

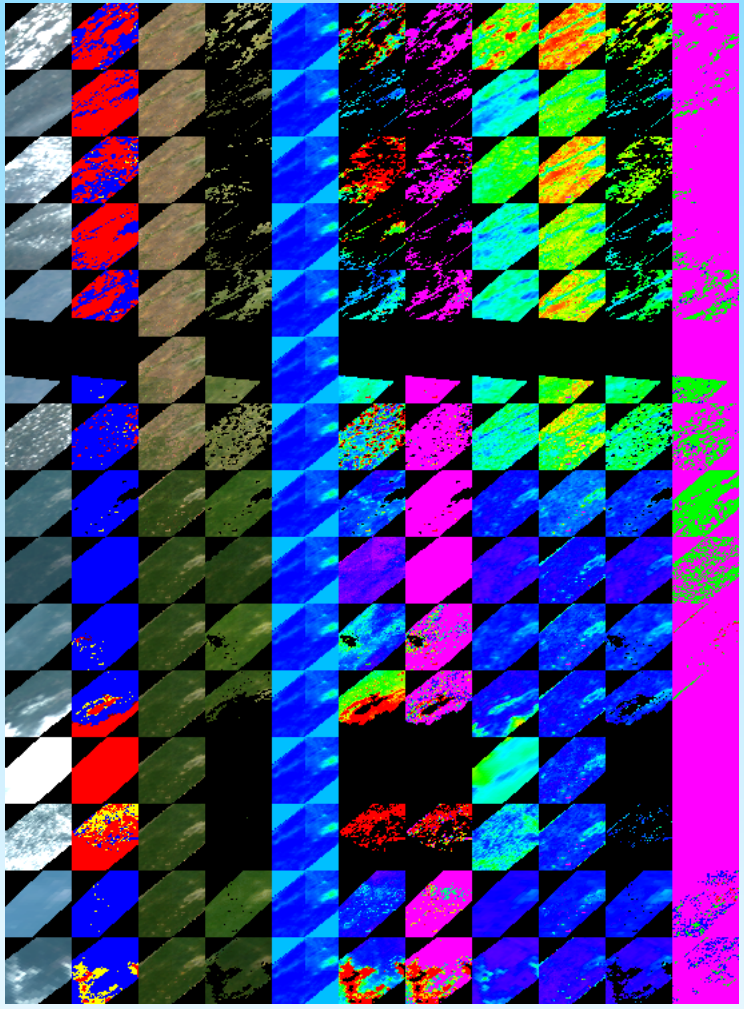
Example: Bondville, Senecsence

DOY: 243-255, 2000



TOA NBRF SRC η RTLS7 CHNG
CM BRF AOT $R7^{TOA}$ P7

DOY: 160-191, 2001



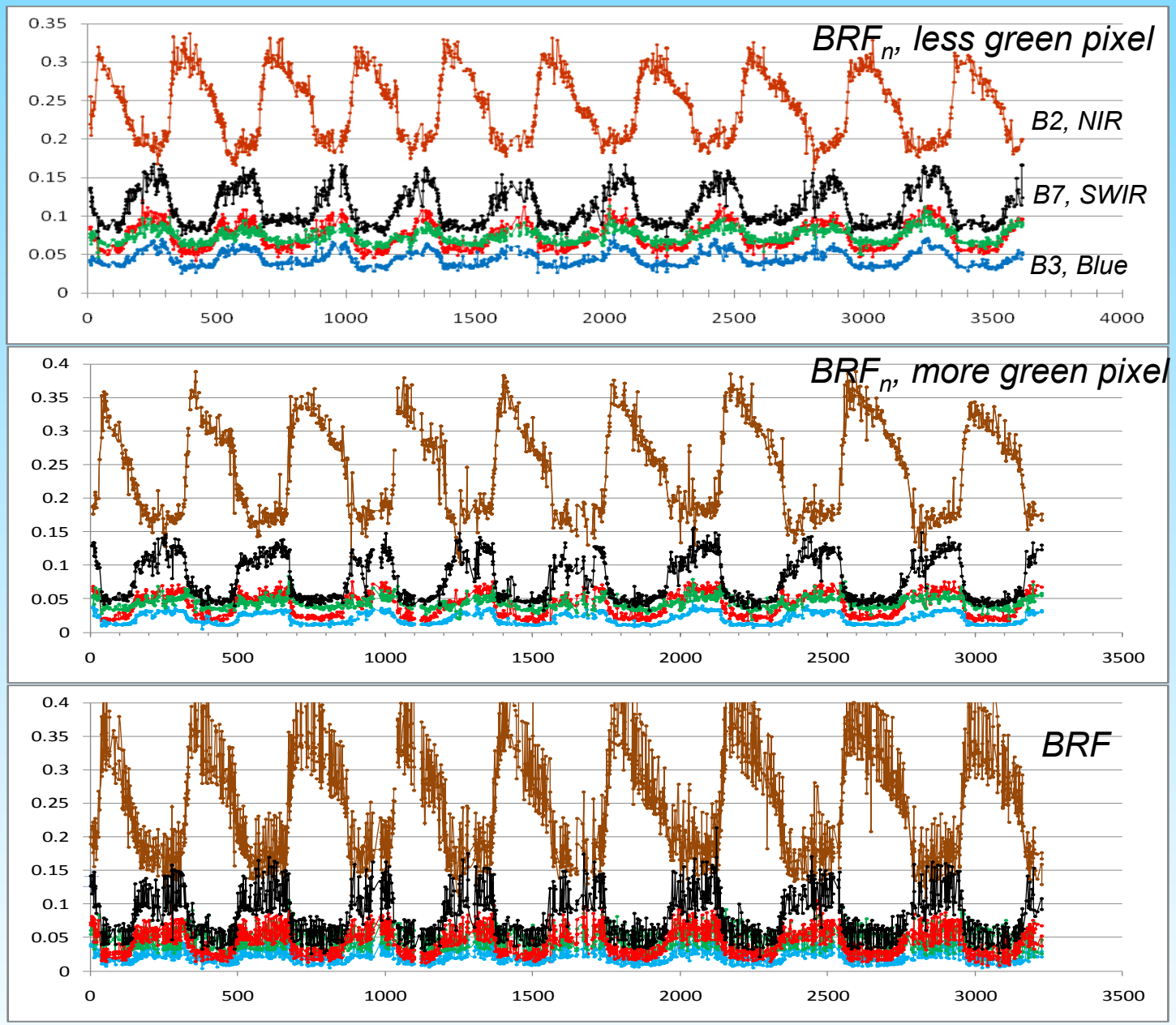
TOA NBRF SRC η RTLS7 CHNG
CM BRF AOT $R7^{TOA}$ P7

Legend

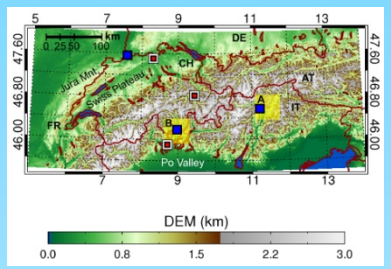
Green-Up
Change
Big-Change

Senescence
Change
Big_Change

Examples of BRF_n and BRF



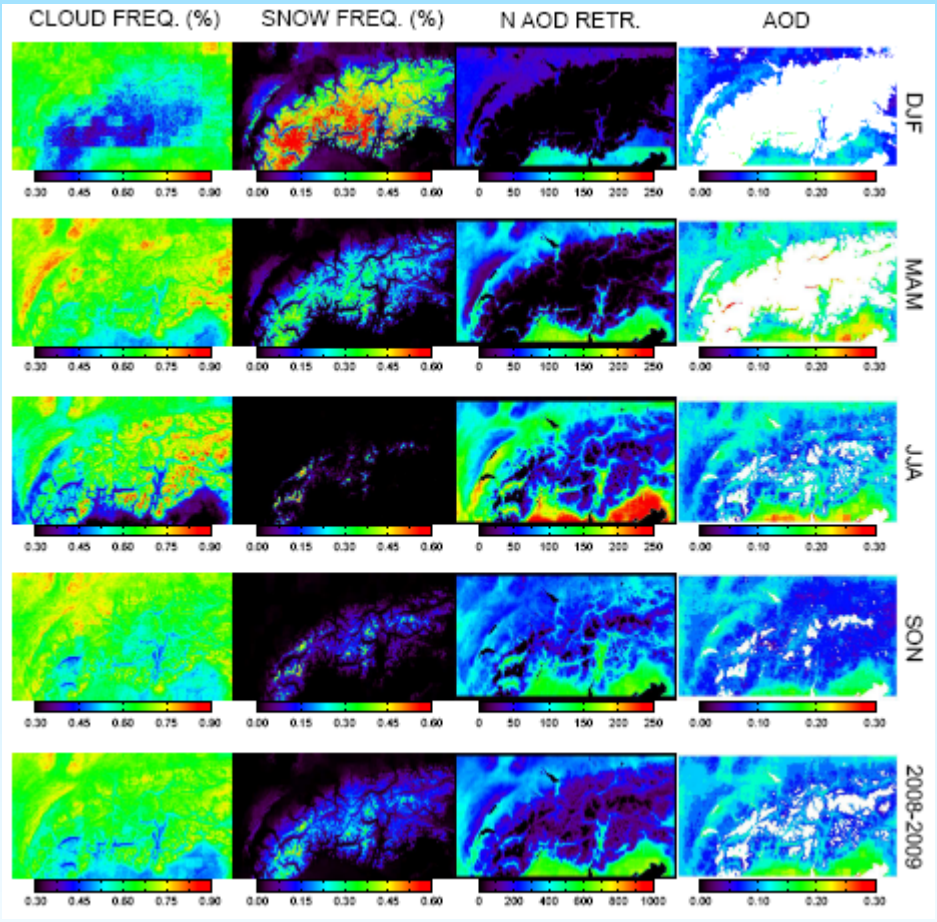
MAIAC Analysis for Alpine Region

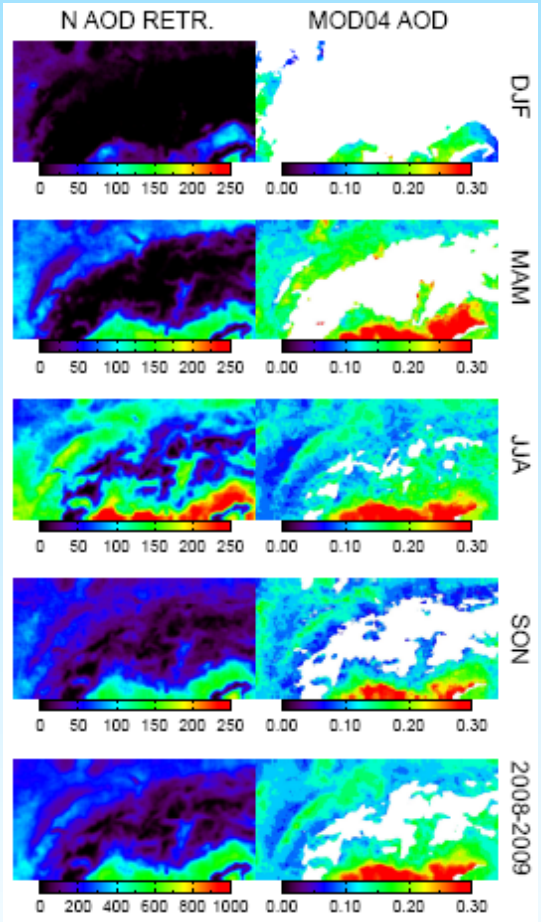


High spatial resolution aerosol retrieval with MAIAC: application to mountain regions, *JGR, in review, by E. Emili, M. Petitta (EURAC), … A. Lyapustin*

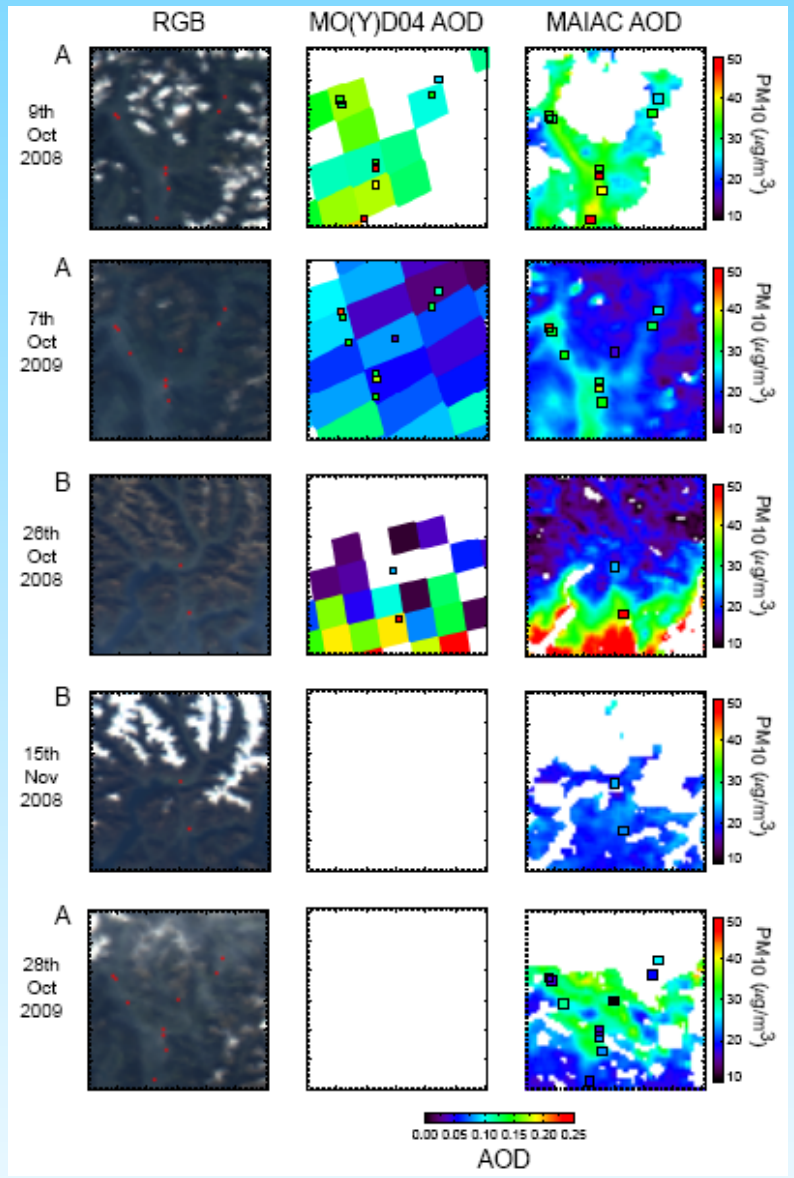
- *50% more retrievals than MOD04*
- *Residual cloud/snow contamination: 3×3 spatial variance filter (σ>0.05)*

Comparison of quarterly and 2-year average climatology for 2008-2009

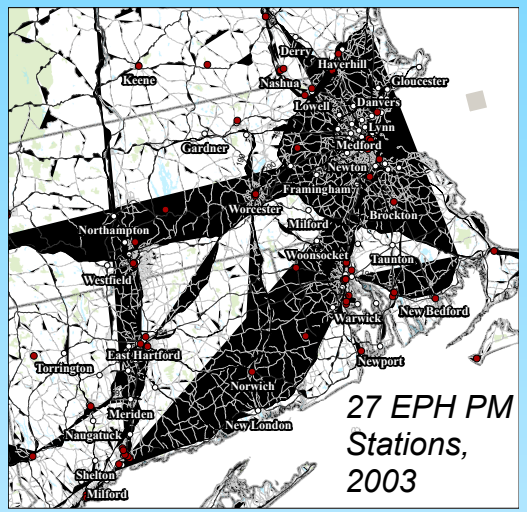


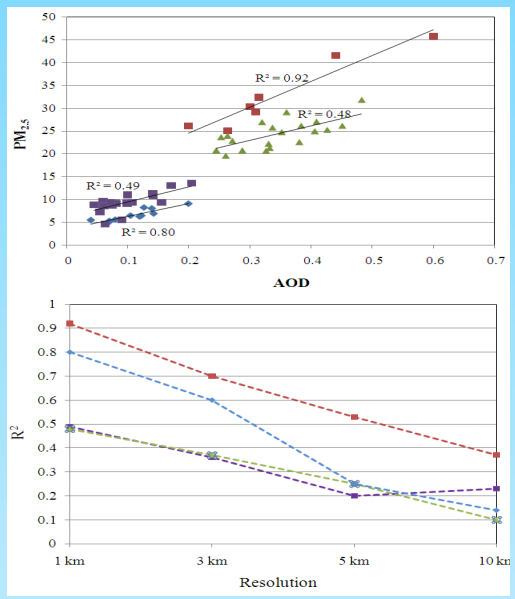


Air Quality: Comparison with PM

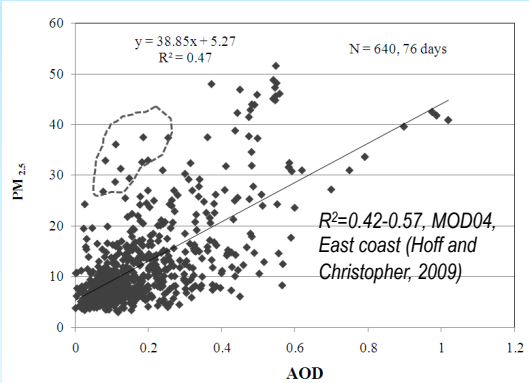


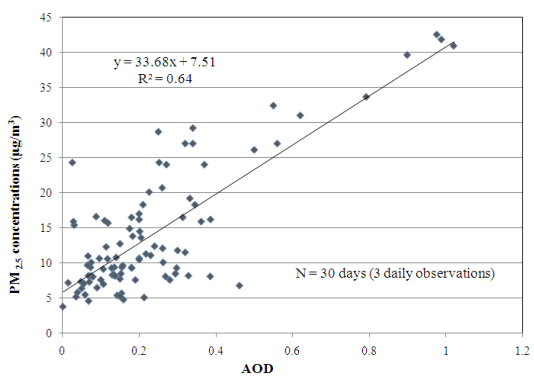
From *Emili et al.*





AOD-$PM_{2.5}$ spatial correlation and its degradation with decreased resolution





Regional and local (10km, 5 PM stations) AOD-$PM_{2.5}$ correlation

From *A. Chudnovsky et al. (Harvard School of Public Health), EHP*, in review