Adapting MAIAC algorithm for synergistic ABI-TEMPO processing

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MAIAC: General Information

Status:

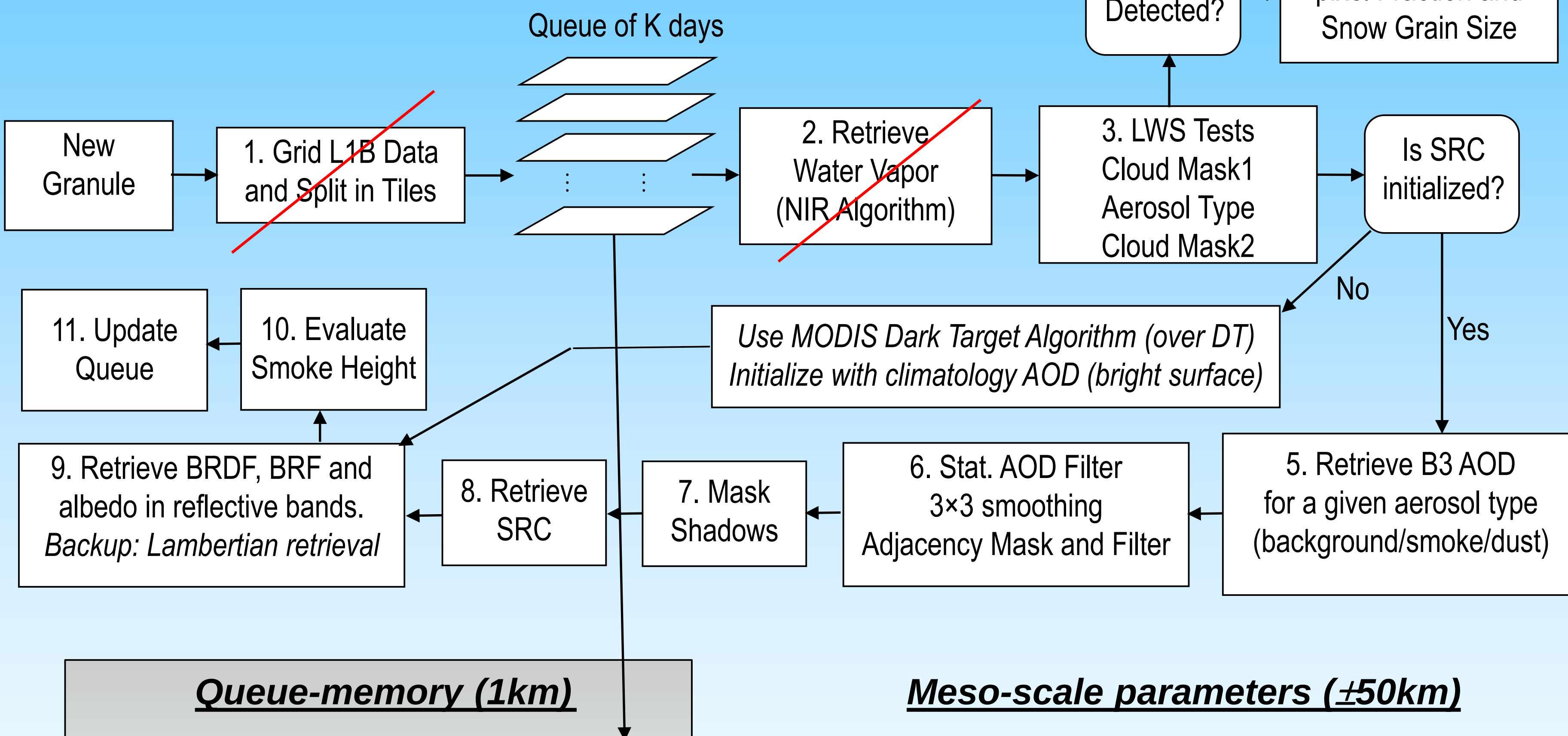
- *MODAPS started C6+ re-processing of MODIS with MAIAC (MCD19)*

Products (gridded):

- ***Atmosphere****: WV, CM, AOD, aerosol type (background/smoke/dust), FMF (over water) @1km resolution;*
- ***Land Surface****: spectral BRDF (RTLS model, naturally gap-filled), BRF (surface reflectance) @1km and 500m in bands 1-12, albedo;*
- ***Detected Snow****: snow grain size, and sub-pixel snow fraction (1km);*

Processing Diagram: Leo→Geo

Sliding window algorithm:
Store: 4-16 days (MODIS), 2-4 days (Geo)



Queue-memory (1km)

- *BT_{11}, $dTb = Tb_4 - Tb_{11,wv}$;*
- *SRC: SR Ratios ($\rho_{0.47}/\rho_{0.55}$, $\rho_{0.47}/\rho_{2.13}$);*
- *$\sigma_{500}(0.66), \sigma_{500}(0.47)$;*
- *RTLS(λ);*
- *LWS mask, Memory of snow etc.*

Meso-scale parameters (±50km)

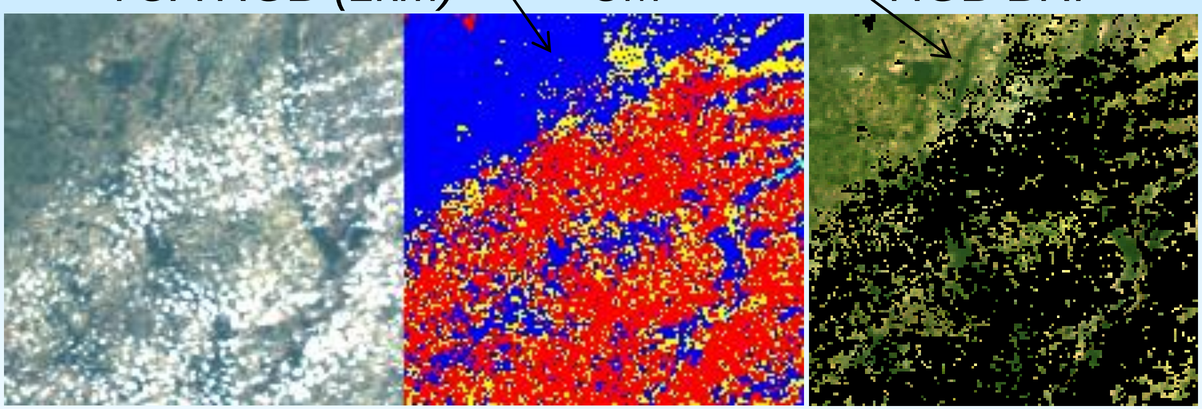
- *Tb_{11}, WV, $R_{1.38}$(min, max);*
- *nHot-Spot;*
- *nSnow.*

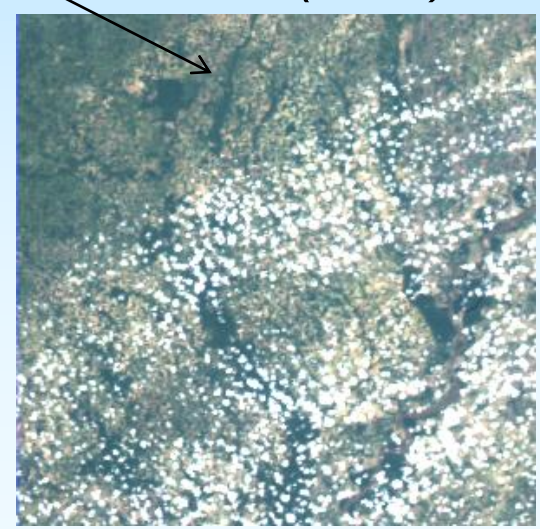
Cloud Mask

- *Land-Water-Snow Classification;*
- *Reliable Clouds:*
  - *Bright;*
  - *Cold (q.Tb_{11}-Tb_{11}>30° & high $R_{1.38}$ or dTb): assumes smoke <4.5km*
  - *σ_{500} test;*
- *Smoke/Dust test;*
- *$R_{1.38}$ - dTb_{4-11} test;*
- *…*

σ_{500} (500m sub-pixel variability)

TOA RGB (1km) *CM* *RGB BRF* *TOA RGB (500m)*





*Lyapustin, A. et al., 2012: Improved cloud screening in MAIAC aerosol retrievals using spectral and spatial analysis, **AMT**, 5, 843–850.*

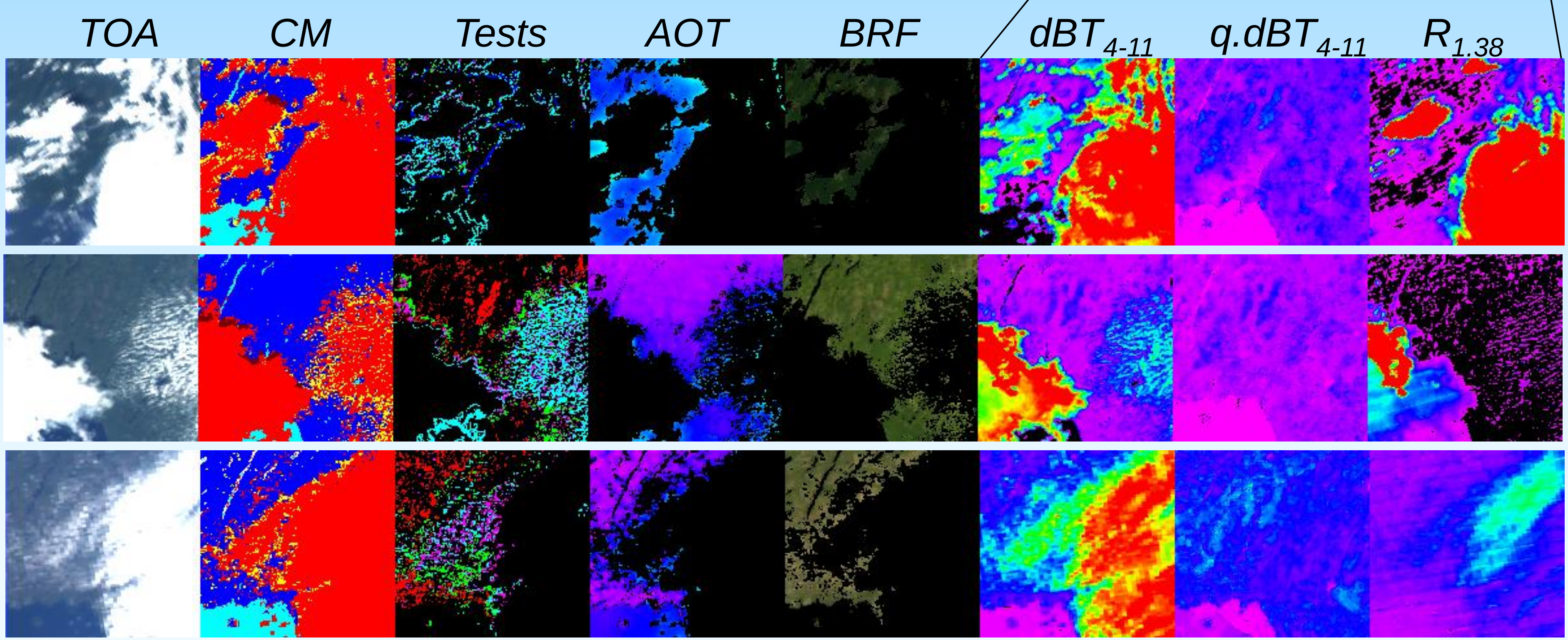
Cloud Mask, cont.

<u>Post Aerosol Retrievals</u>:

- *Filter upper AOT>70% at 25km (depending on cloud fraction)*
- *3x3 AOD outlier test (original idea of E. Emili, A.Lyapustin et al., 2011: High spatial res. aerosol retrieval with MAIAC: Application to mountain regions, JGR, 116, D23211)*
    - *In 3x3, filter outlier (max) if $\tau_{max}-\tau_{av}> 0.2$. Iterate;*

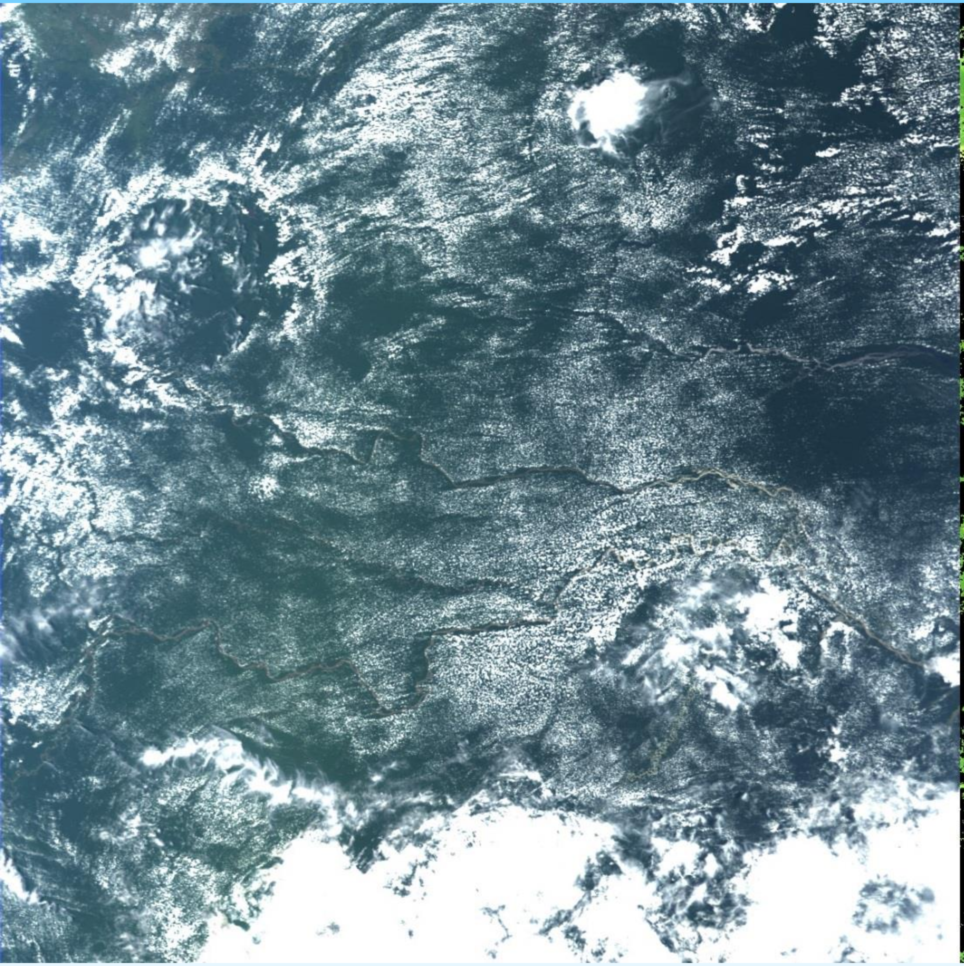
<u>Post Atmospheric Correction</u>:

- *Additional shadow detection based on low BRF/BRDF*

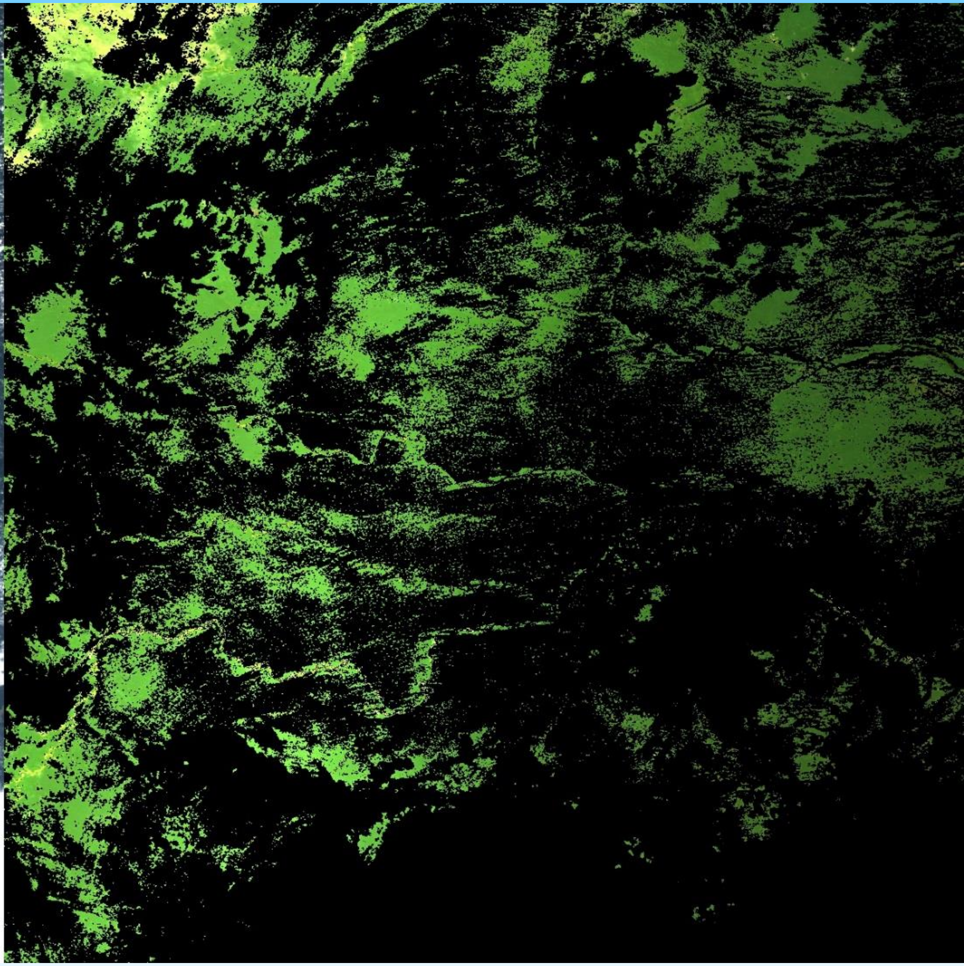


Quality of Atmospheric Correction: Central Amazon

TOA RGB



BRF RGB



1200 km

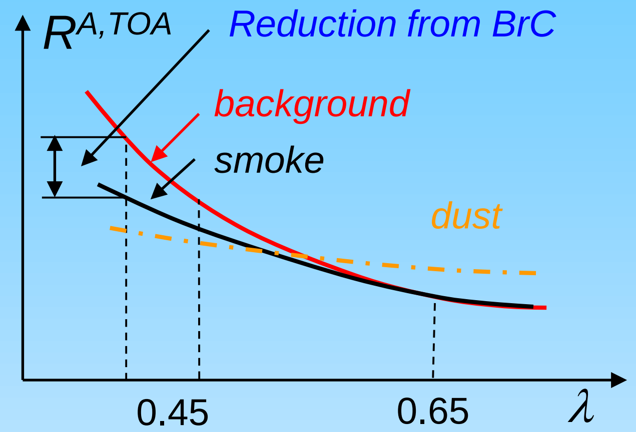
Decreasing brightness – moving from backscattering towards forward scattering

MAIAC Aerosol Type (Smoke/Dust)

Lyapustin, A. et al., 2012: Discrimination of biomass burning smoke and clouds in MAIAC algorithm, **ACP**, 12, 9679–9686.

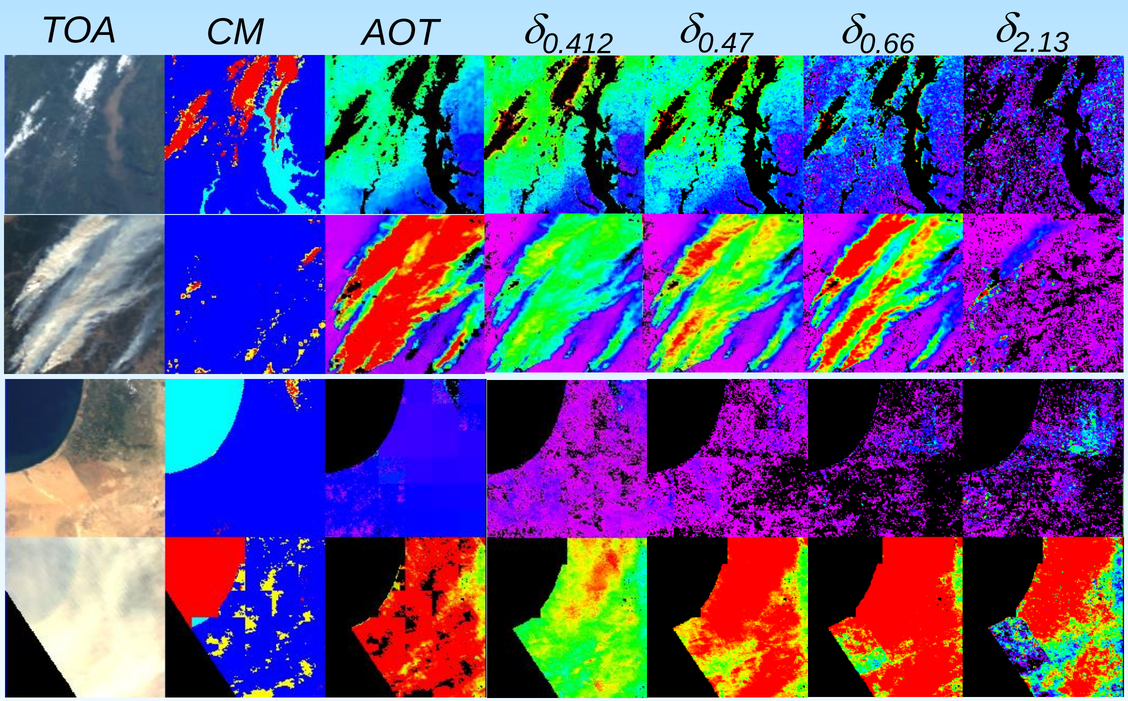
*Phys. principles (~OMI) – **enhanced shortwave absorption** (Red →Blue →DB)*

$$R_\lambda^{Aer} = R_\lambda^{Meas} - R_\lambda^{Molec} - R_\lambda^{Surf}(\tau^a)$$ *- proxy of aerosol reflectance*



1) n_i increases R→DB for OC (smoke) and dust;

2) Multiple scattering, for absorbing aerosols.

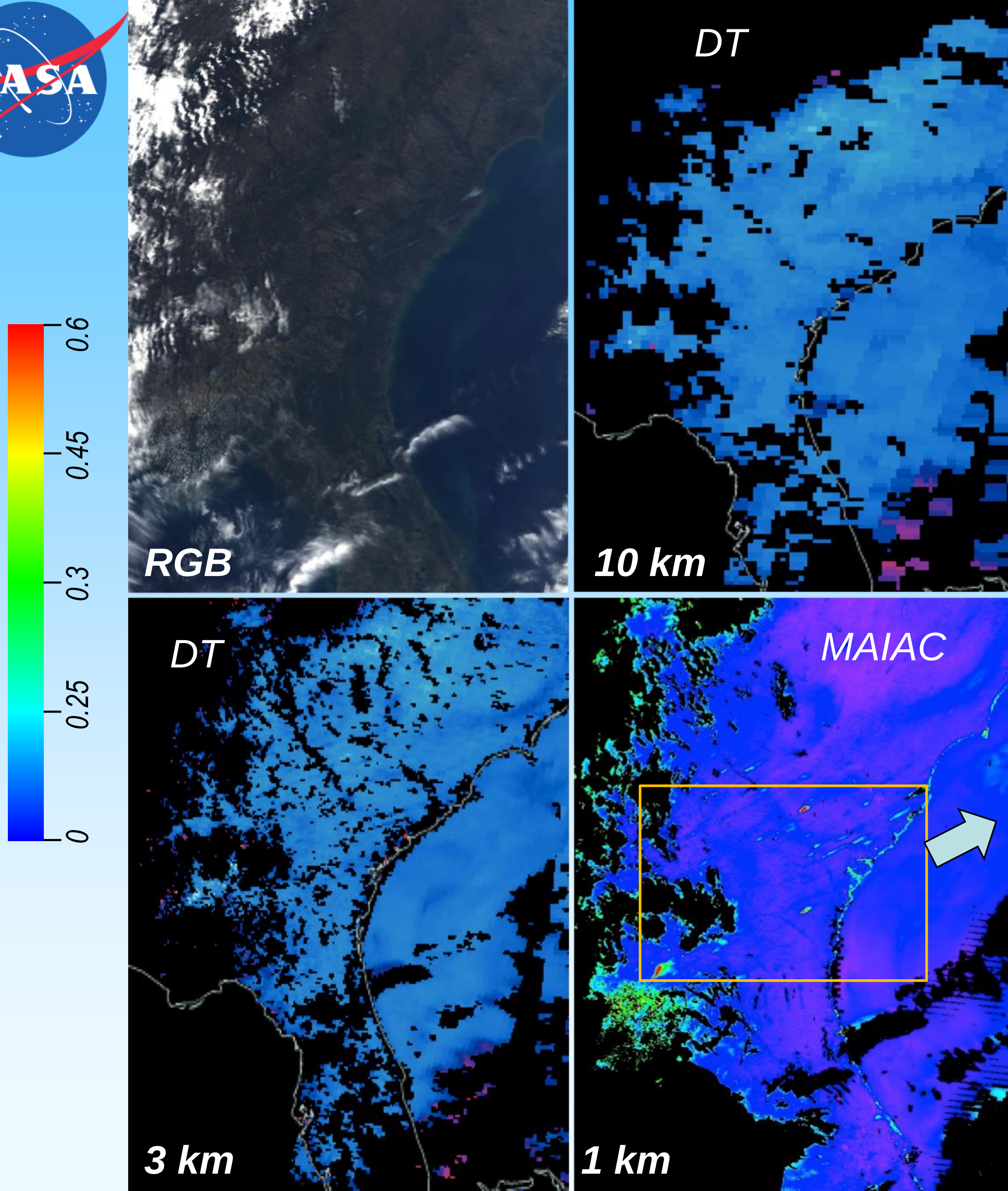


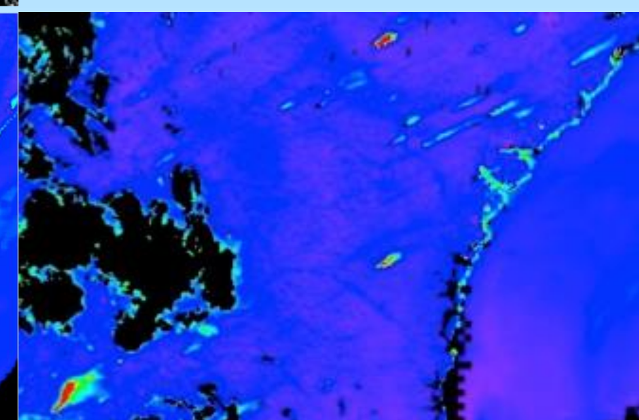
Backgr./Smoke/Dust

$$\delta_\lambda = R_\lambda^M - R_\lambda^T(\tau_{0.47}^a = 0.05)$$

Model	Abs.	Size
Backgr.	No	Small
Smoke	Yes	Small
Dust	Yes	Large

MAIAC and 3km DT





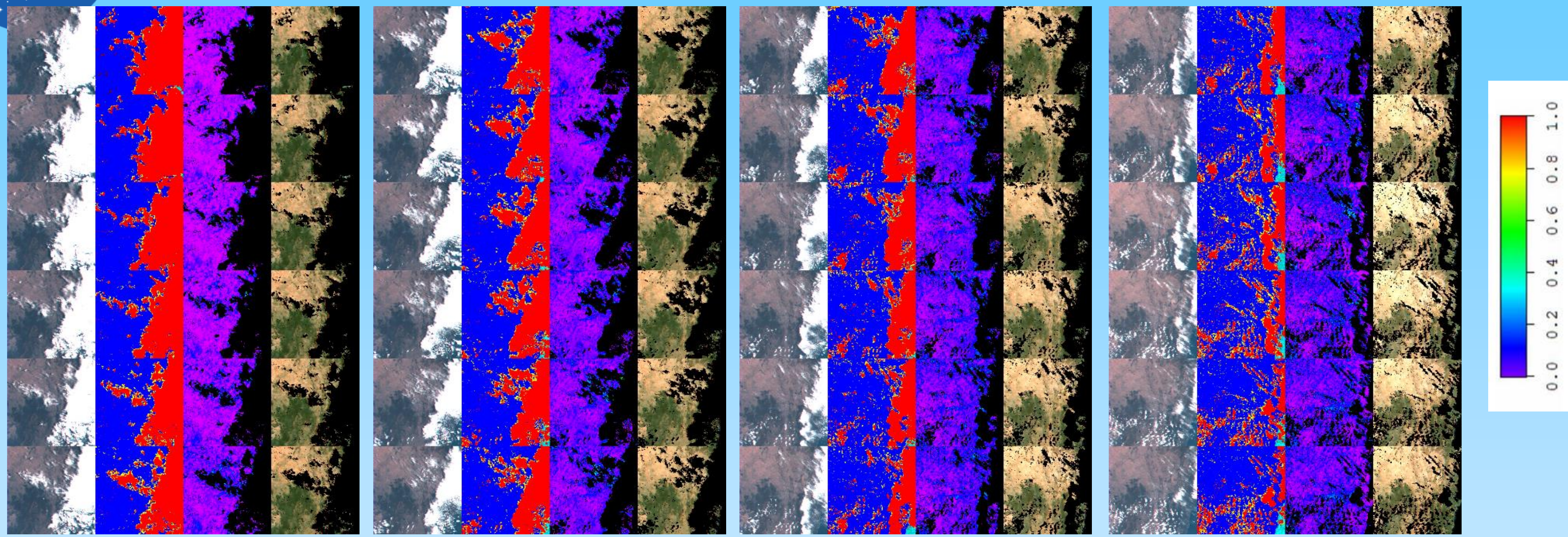
Detection of absorbing aerosol is critical for high-res. AOD

(from Pawan Gupta, NASA Applications Air Quality Program)

ABI – TEMPO Synergy

- *Need 400-412nm TEMPO data gridded to ABI grid;*
- *This will allow to run "standard" MAIAC with good cloud/snow mask and Smoke/Dust detection;*
- *MAIAC can include window TEMPO bands for the atmospheric correction ($BRDF_\lambda$) – will help TEMPO gas retrievals;*
- *Use 340 – 390nm to derive absorption (imaginary refractive index k_λ / SSA_λ)*

MAIAC Adapted for AHI-8 HIMAWARI



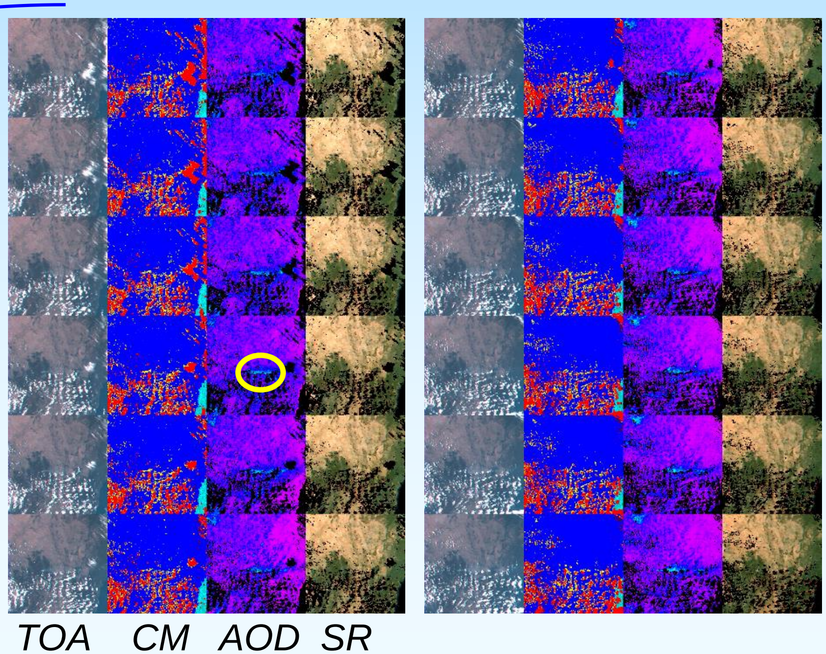


Figure 1. *MAIAC processing of HIMAWARI-8 AHI data on day 93, 2016 over 250km area of Australia, centered on capital Canberra. Shown are retrievals from early morning till mid-evening. The 4 columns show 1) TOA RGB from AHI, 2) MAIAC cloud mask (Blue-clear-land; light Blue – clear-water; Red/Yellow – cloud); 3) aerosol optical depth at 0.47μm; 4) atmospherically corrected RGB surface reflectance.*

Aerosol Absorption From GLI

- ***Funding from NASA GeoCAPE project***
- ***Idea: study synergy between GOES-R and TEMPO***
  - *GOES-R provides high spatial resolution and VIS-SWIR-TIR bands (CM/snow, surface change, AOT, BRF/BRDF/Albedo surface suite etc. from MAIAC)*
  - *TEMPO gives a hyperspectral coverage in UV-VIS at 2x4km^2;*
  - *Opportunity for retrieval of AOT, SW absorption, and H_{eff}.*
- ***Started with GLI on ADEOS-II:***
  - *10:30am orbit; 1600km swath (VZA<45°), 4 days global coverage*
  - *Almost MODIS-like spectrally (for 1km bands):*
    - *Lacks NIR WV bands at 0.94μm; adds 399.7, 388nm;*
    - *Lacks 500m bands; Some bands at 250m, LAC mode;*
  - *Launched in Dec. 2002; Data available Feb.-October 2003.*

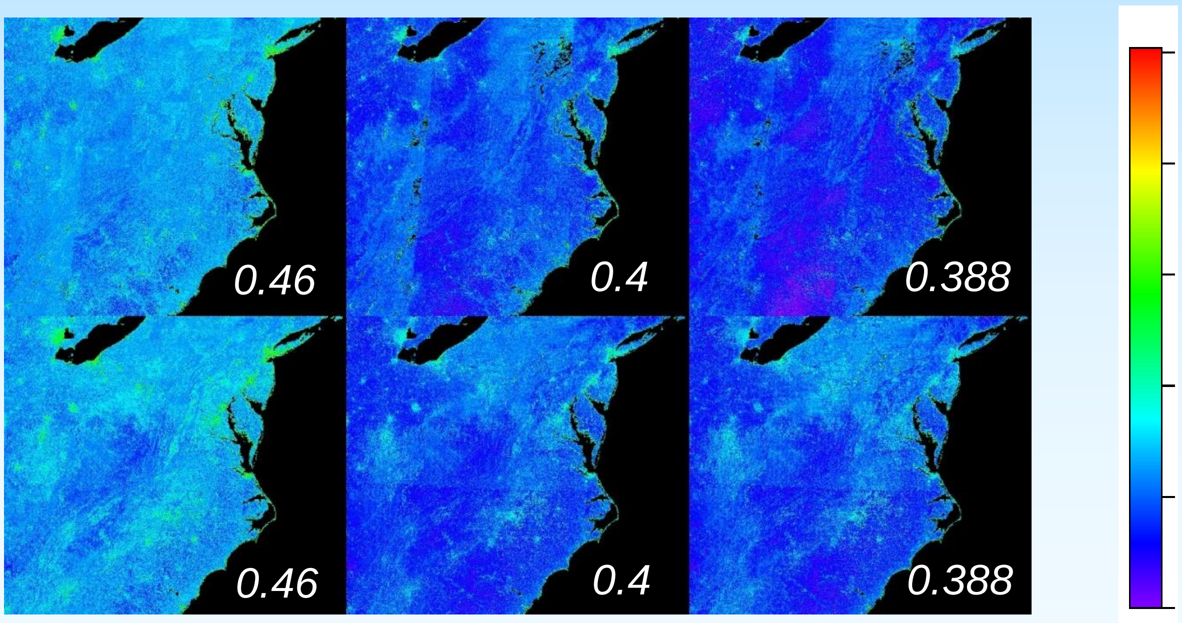
Algorithm and Assumptions

- *MAIAC has a dynamic characterization of SRC,* $b_{0.46}=\rho_{0.46}/\rho_{2.2}$ using min reflectance method. *For GLI, also compute* $b_{0.40}$, $b_{0.388}$
- *Run standard MAIAC* $\rightarrow$ *cloud mask,* $AOT_{0.46}$*, aer. type (smoke), spectral surface BRDF etc.*
- *Assuming aerosol model (SD, (n,k), profile and* $AOT_{0.46}$*), retrieve k (SSA) at 0.4 and 0.388*μ*m independently using separate LUT with variable refIM (5 values, k=0.001-0.02) by matching measured radiance.*
- *Evaluate AAE:* $k_{\lambda}=k_{0.55}(\lambda/0.55)^{-AAE}$*. Given AAE, repeat joint inversion for* $(AOT, k)_{0.46}$ *by best fit to measurements at 0.46, 0.4 and 0.388* μ*m.*

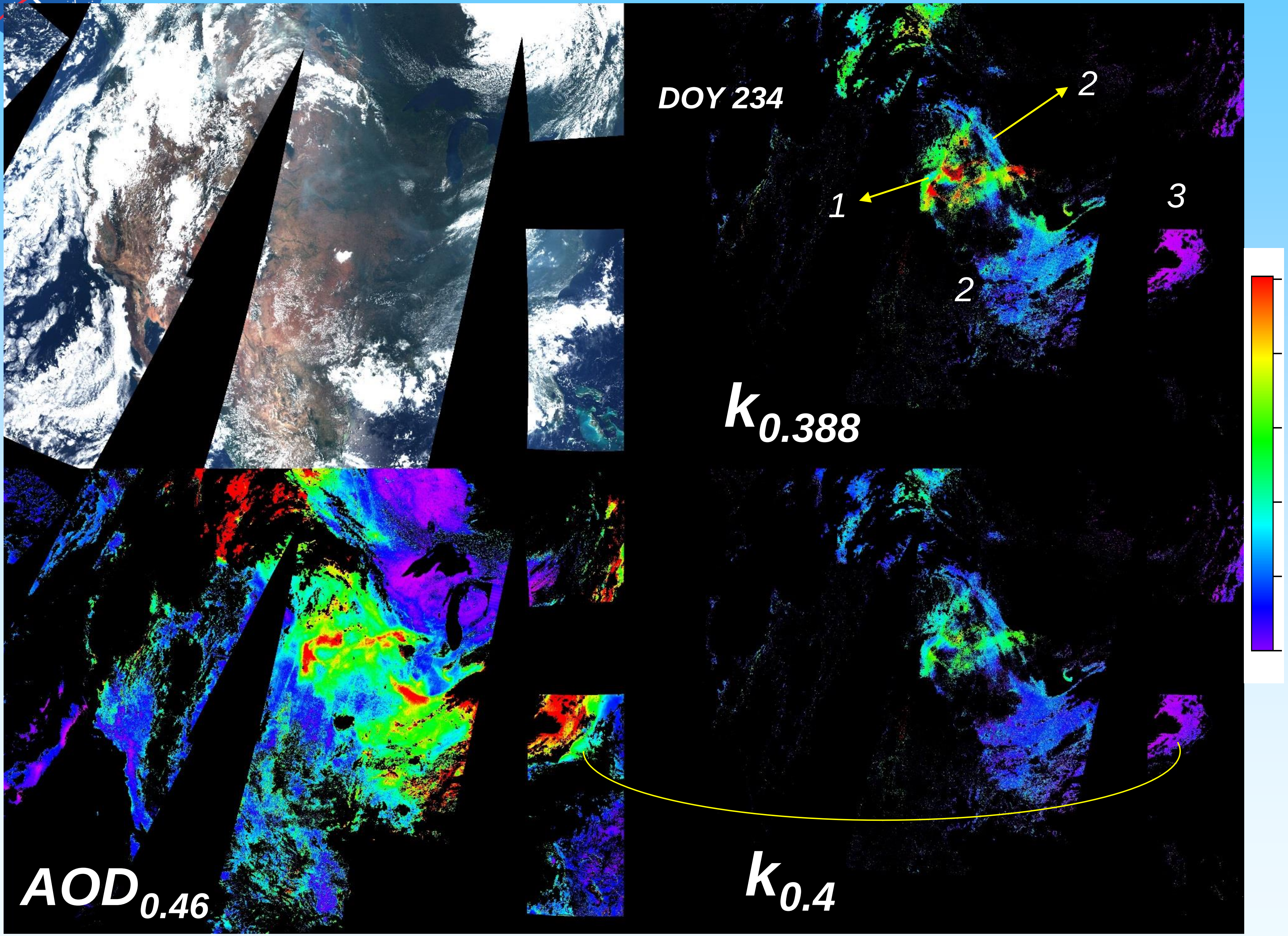
SRC, _FS

SRC for the East Coast USA

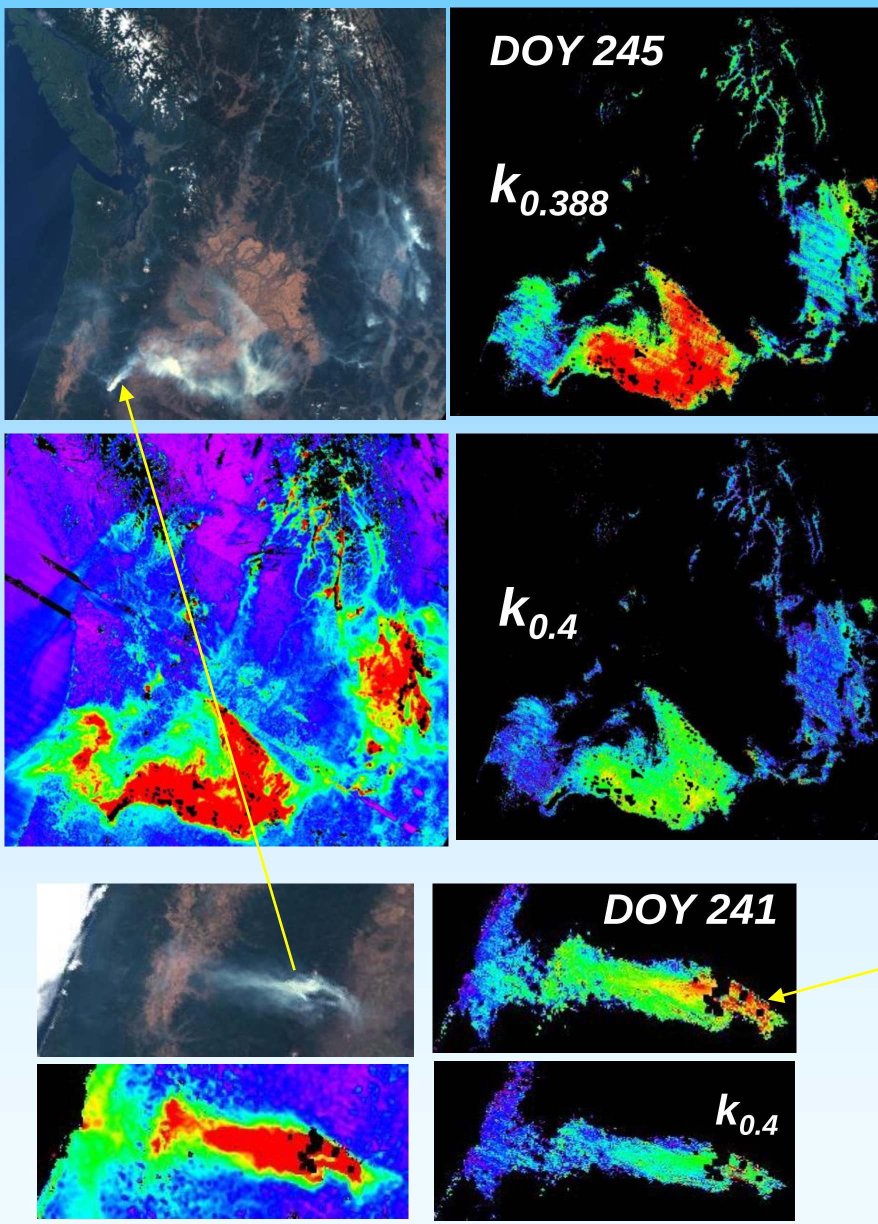
SRC, _BS

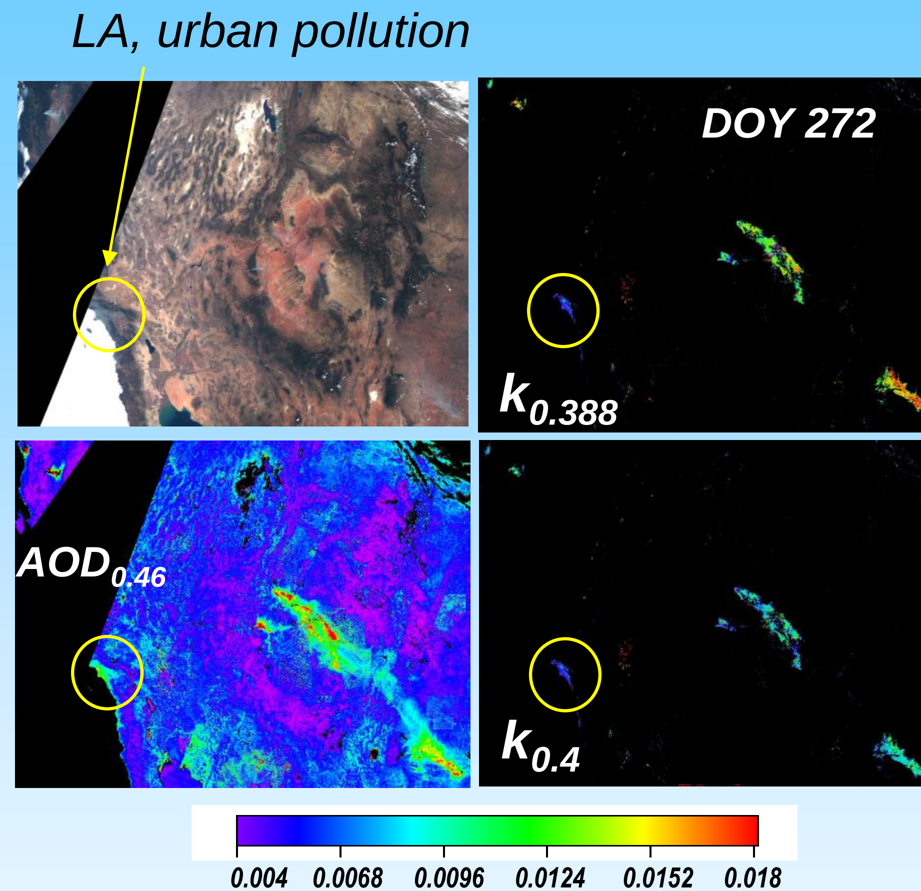


High, Moderate and Low Absorption



At High Resolution, Near Sources





1 Absorption is often higher at the epicenter of fire

2 Urban pollution shows low absorption and low AAE