Status of versatile GRASP retrieval algorithm

Towards "the universal" retrieval approach

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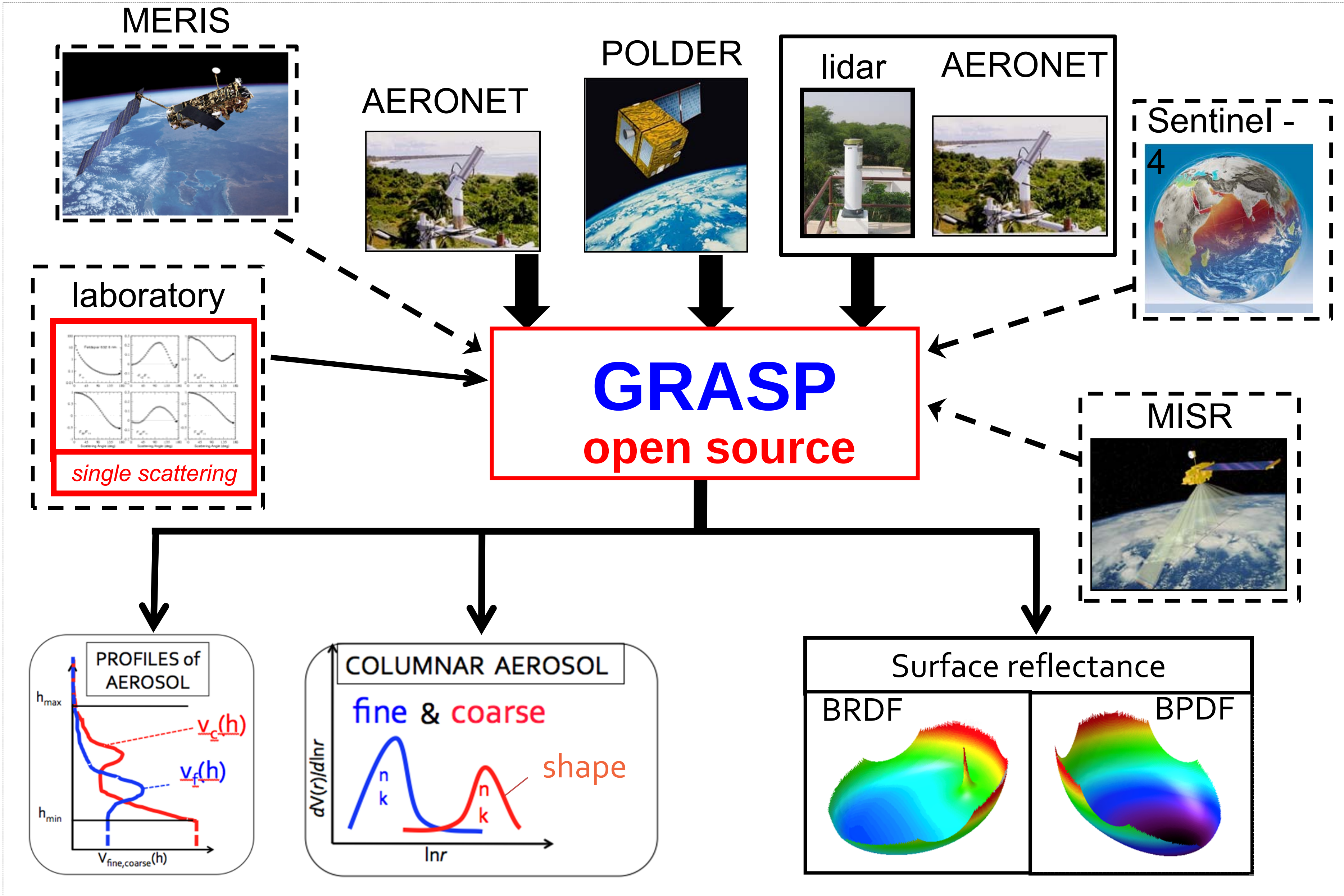
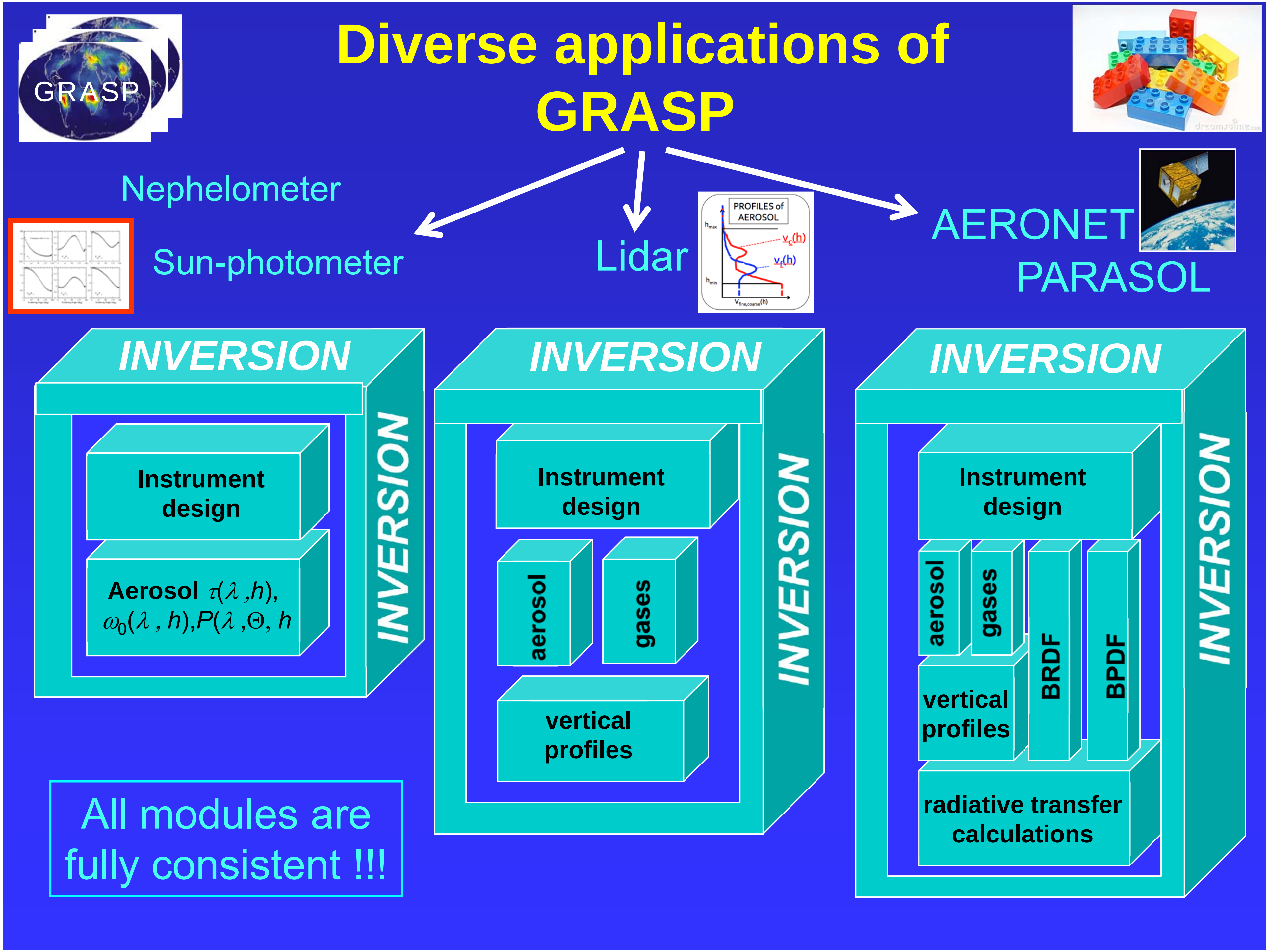
9-th ICAP, Lille, France, 26 – 28 June, 2017

GRASP: Generalized Retrieval of Aerosol and Surface Properties




Diverse applications of GRASP
GRASP
Nephelometer
Sun-photometer
Lidar
PROFILES of AEROSOL
AERONET
PARASOL
INVERSION
Instrument design
Aerosol τ(λ,h), ω0(λ, h),P(λ,Θ, h
INVERSION
INVERSION
Instrument design
aerosol
gases
vertical profiles
INVERSION
INVERSION
Instrument design
aerosol
gases
BRDF
BPDF
vertical profiles
radiative transfer calculations
INVERSION
All modules are fully consistent !!!

Multi-Source LSM approach:

$$\boldsymbol{P}_{1,2,3} = \boldsymbol{P}_1 \boldsymbol{P}_2 \boldsymbol{P}_{3\ldots} \sim \exp\left(-\frac{1}{2\sigma_1^2} \sum_i \frac{\sigma_1^2}{\sigma_i^2} \left(\Delta \boldsymbol{f}_i^T \Delta \boldsymbol{f}_i \right) \right) = max \longrightarrow \sum_i \frac{\sigma_1^2}{\sigma_i^2} \left(\Delta \boldsymbol{f}_i^T \Delta \boldsymbol{f}_i \right) = min$$

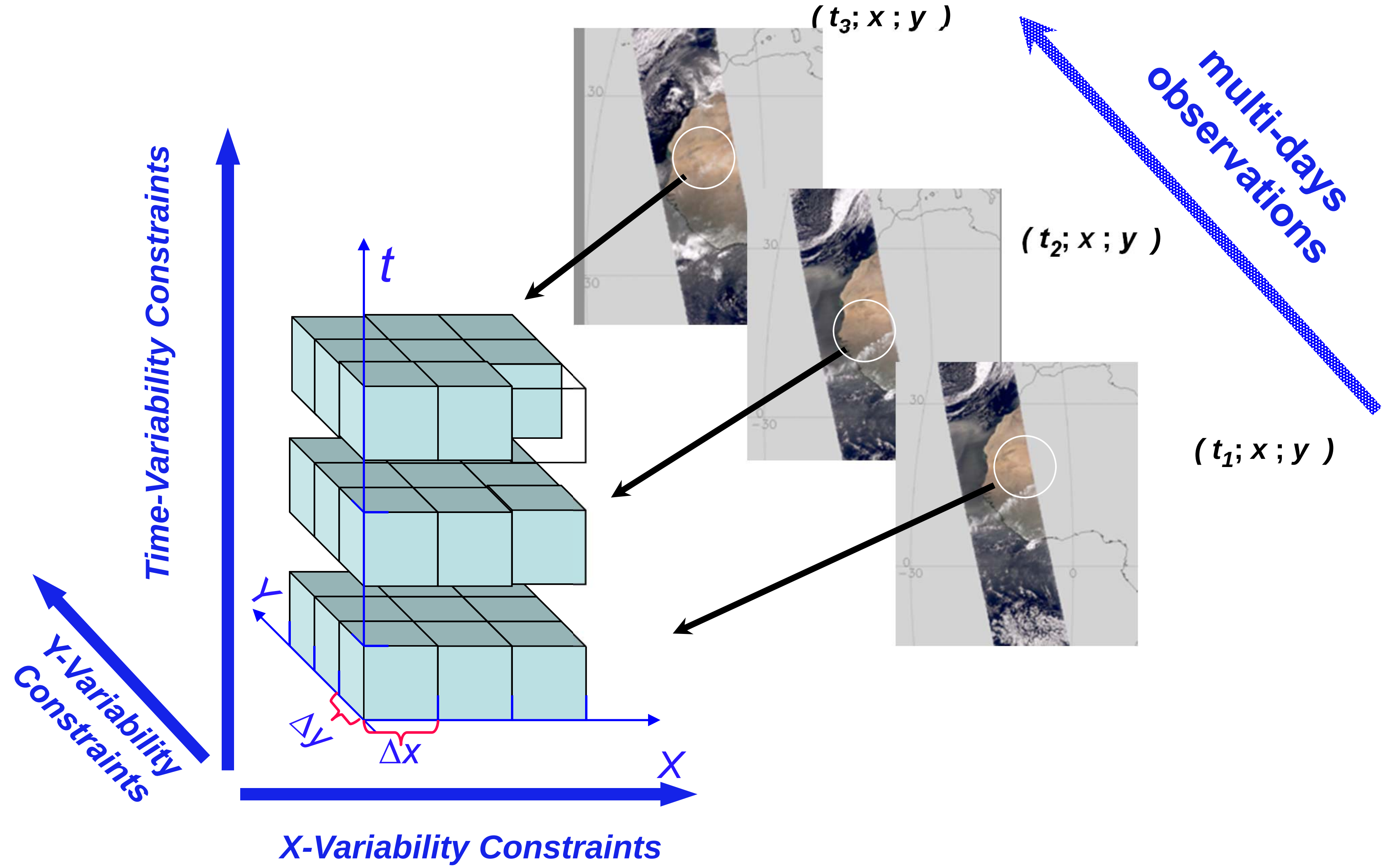
where $\Delta_i = \boldsymbol{f}_i^* - \boldsymbol{f}_i(\boldsymbol{a})$ and $\boldsymbol{f}_i^*$ - measurements or *a priori data*

P (...) - *Probability Density Function (**Likelihood**)*

- Optimum data combination
- Optimum use of a priori information
- Continuous solution space
- Rigorous error estimations
- Large number of retrieved parameters with less assumption

- More "sophisticated"
- Generally more time consuming

The concept of multi-pixel retrieval



Multi-term LSM **Multi-Pixel Solution:**

$$\begin{pmatrix} \boldsymbol{a}_1 \\ \boldsymbol{a}_2 \\ \boldsymbol{a}_3 \end{pmatrix} = \left[\begin{pmatrix} \mathbf{F}_1^T \mathbf{W}_1^{-1} \mathbf{F}_1 & 0 & 0 \\ 0 & \mathbf{F}_2^T \mathbf{W}_2^{-1} \mathbf{F}_2 & 0 \\ 0 & 0 & \mathbf{F}_3^T \mathbf{W}_3^{-1} \mathbf{F}_3 \end{pmatrix} + \begin{pmatrix} \gamma_1 \Omega_1 & 0 & 0 \\ 0 & \gamma_2 \Omega_2 & 0 \\ 0 & 0 & \gamma_3 \Omega_3 \end{pmatrix} + \gamma_x \Omega_x + \gamma_y \Omega_y + \gamma_t \Omega_t \right]^{-1} \begin{pmatrix} \mathbf{F}_1^T \mathbf{W}_1^{-1} \Delta \boldsymbol{f}_1^{\boldsymbol{p}} \\ \mathbf{F}_2^T \mathbf{W}_2^{-1} \Delta \boldsymbol{f}_2^{\boldsymbol{p}} \\ \mathbf{F}_3^T \mathbf{W}_3^{-1} \Delta \boldsymbol{f}_3^{\boldsymbol{p}} \end{pmatrix}$$

$$\Omega_x = \mathbf{s}_x^T \mathbf{s}_x; \; \Omega_y = \mathbf{s}_y^T \mathbf{s}_y; \; \Omega_t = \mathbf{s}_t^T \mathbf{s}_t;$$

$$\begin{pmatrix} \boldsymbol{a}_v \\ \boldsymbol{a}_n \\ \boldsymbol{a}_n \\ a_h \\ a_{sph} \\ a_{Vc} \\ \boldsymbol{a}_{brdf,1} \\ \boldsymbol{a}_{brdf,2} \\ \boldsymbol{a}_{brdf,3} \\ \boldsymbol{a}_{bpdf} \end{pmatrix}$$

$$\gamma_\Delta \Omega = \begin{pmatrix} \gamma_{\Delta,1}\Omega_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \gamma_{\Delta,2}\Omega_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \gamma_{\Delta,3}\Omega_3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \gamma_{\Delta,4}\Omega_4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \gamma_{\Delta,5}\Omega_5 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \gamma_{\Delta,6}\Omega_6 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \gamma_{\Delta,7}\Omega_7 \end{pmatrix}$$

$$\mathbf{s}_y^T \mathbf{s}_y = \begin{pmatrix} \begin{pmatrix} \mathbf{I}_{d_{11}} & \mathbf{I}_{d_{12}} & \mathbf{I}_{d_{13}} \\ \mathbf{I}_{d_{21}} & \mathbf{I}_{d_{22}} & \mathbf{I}_{d_{23}} \\ \mathbf{I}_{d_{31}} & \mathbf{I}_{d_{32}} & \mathbf{I}_{d_{33}} \end{pmatrix} & \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} & \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} \\ \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} & \begin{pmatrix} \mathbf{I}_{d_{11}} & \mathbf{I}_{d_{12}} & \mathbf{I}_{d_{13}} \\ \mathbf{I}_{d_{21}} & \mathbf{I}_{d_{22}} & \mathbf{I}_{d_{23}} \\ \mathbf{I}_{d_{31}} & \mathbf{I}_{d_{32}} & \mathbf{I}_{d_{33}} \end{pmatrix} & \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} \\ \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} & \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} & \begin{pmatrix} \mathbf{I}_{d_{11}} & \mathbf{I}_{d_{12}} & \mathbf{I}_{d_{13}} \\ \mathbf{I}_{d_{21}} & \mathbf{I}_{d_{22}} & \mathbf{I}_{d_{23}} \\ \mathbf{I}_{d_{31}} & \mathbf{I}_{d_{32}} & \mathbf{I}_{d_{33}} \end{pmatrix} \end{pmatrix};$$

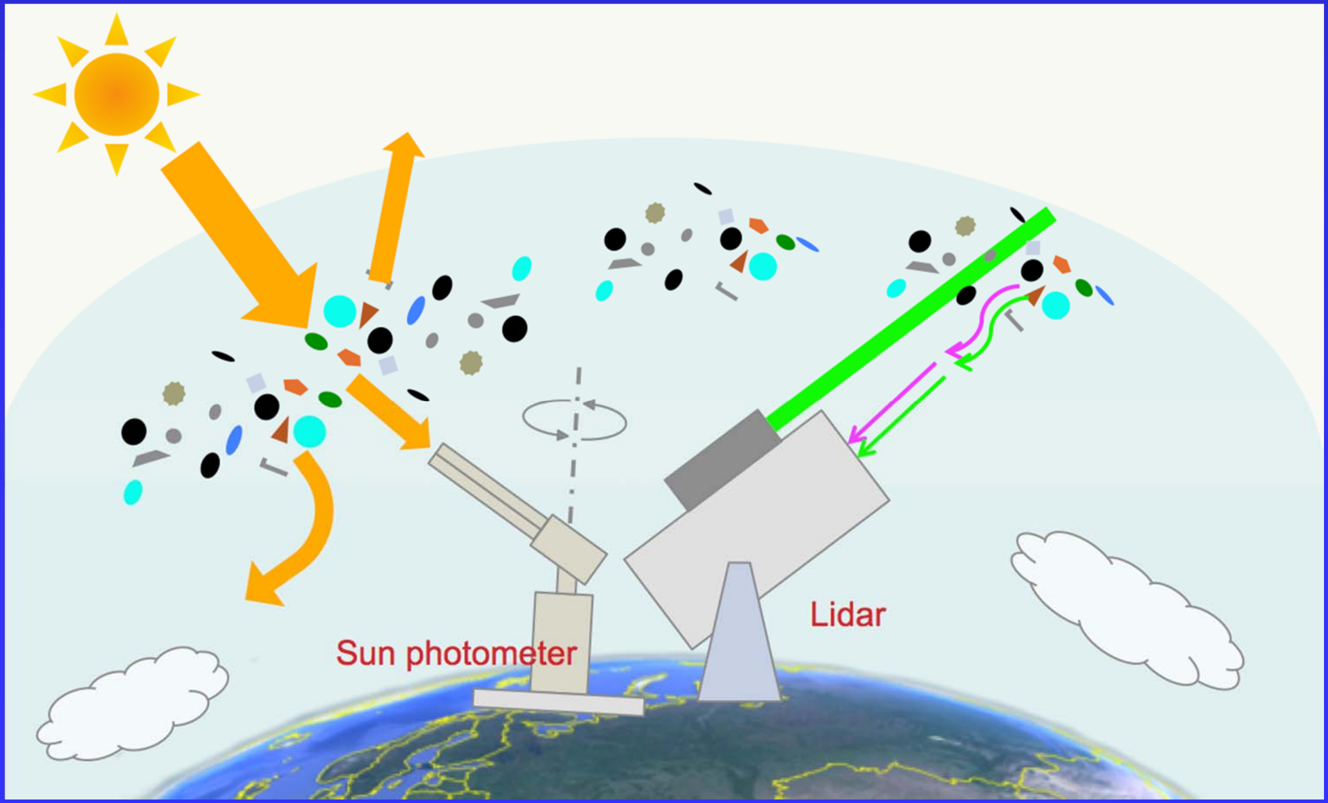
$$\mathbf{s}_y^T \mathbf{s}_y = \begin{pmatrix} \begin{pmatrix} \mathbf{I}_{d_{11}} & \mathbf{I}_{d_{12}} & \mathbf{I}_{d_{13}} \\ \mathbf{I}_{d_{21}} & \mathbf{I}_{d_{22}} & \mathbf{I}_{d_{23}} \\ \mathbf{I}_{d_{31}} & \mathbf{I}_{d_{32}} & \mathbf{I}_{d_{33}} \end{pmatrix} & \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} & \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} \\ \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} & \begin{pmatrix} \mathbf{I}_{d_{11}} & \mathbf{I}_{d_{12}} & \mathbf{I}_{d_{13}} \\ \mathbf{I}_{d_{21}} & \mathbf{I}_{d_{22}} & \mathbf{I}_{d_{23}} \\ \mathbf{I}_{d_{31}} & \mathbf{I}_{d_{32}} & \mathbf{I}_{d_{33}} \end{pmatrix} & \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} \\ \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} & \begin{pmatrix} \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix} & \begin{pmatrix} \mathbf{I}_{d_{11}} & \mathbf{I}_{d_{12}} & \mathbf{I}_{d_{13}} \\ \mathbf{I}_{d_{21}} & \mathbf{I}_{d_{22}} & \mathbf{I}_{d_{23}} \\ \mathbf{I}_{d_{31}} & \mathbf{I}_{d_{32}} & \mathbf{I}_{d_{33}} \end{pmatrix} \end{pmatrix};$$

$$\mathbf{s}_t^T \mathbf{s}_t = \begin{pmatrix} \begin{pmatrix} \mathbf{I}_{d_{11}} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{I}_{d_{11}} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}_{d_{11}} \end{pmatrix} & \begin{pmatrix} \mathbf{I}_{d_{12}} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{I}_{d_{12}} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}_{d_{12}} \end{pmatrix} & \begin{pmatrix} \mathbf{I}_{d_{13}} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{I}_{d_{13}} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}_{d_{13}} \end{pmatrix} \\ \begin{pmatrix} \mathbf{I}_{d_{21}} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{I}_{d_{21}} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}_{d_{21}} \end{pmatrix} & \begin{pmatrix} \mathbf{I}_{d_{22}} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{I}_{d_{22}} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}_{d_{22}} \end{pmatrix} & \begin{pmatrix} \mathbf{I}_{d_{23}} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{I}_{d_{23}} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}_{d_{23}} \end{pmatrix} \\ \begin{pmatrix} \mathbf{I}_{d_{31}} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{I}_{d_{31}} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}_{d_{31}} \end{pmatrix} & \begin{pmatrix} \mathbf{I}_{d_{32}} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{I}_{d_{32}} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}_{d_{32}} \end{pmatrix} & \begin{pmatrix} \mathbf{I}_{d_{33}} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{I}_{d_{33}} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{I}_{d_{33}} \end{pmatrix} \end{pmatrix}.$$

43 parameters

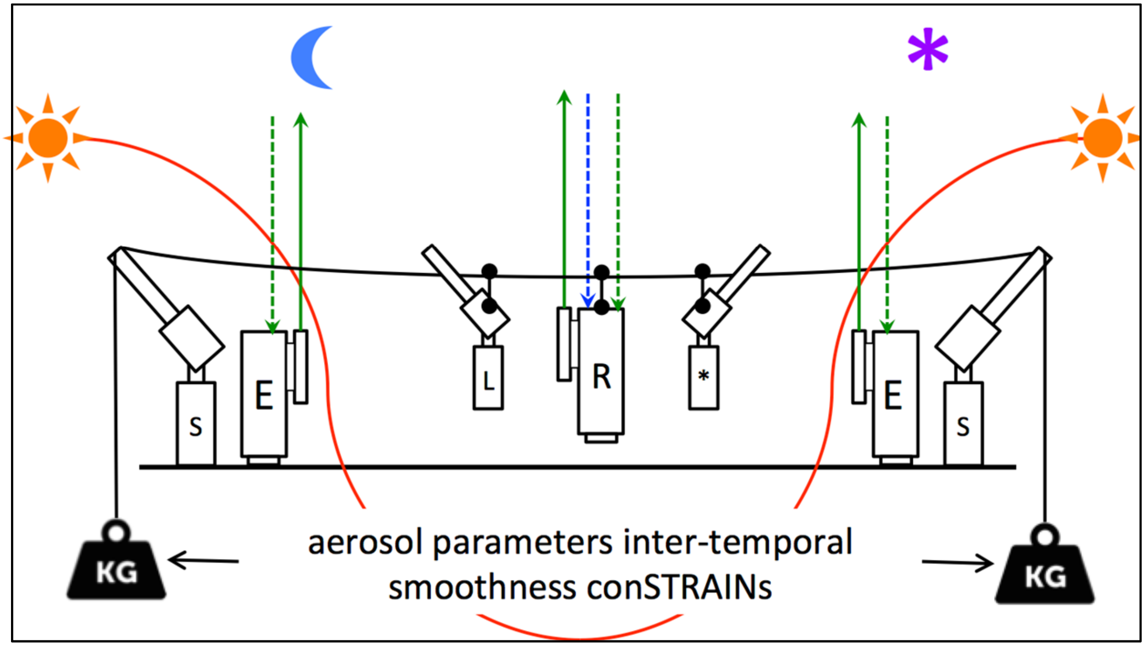
Priorities in GRASP development for ground-based and in situ observations:

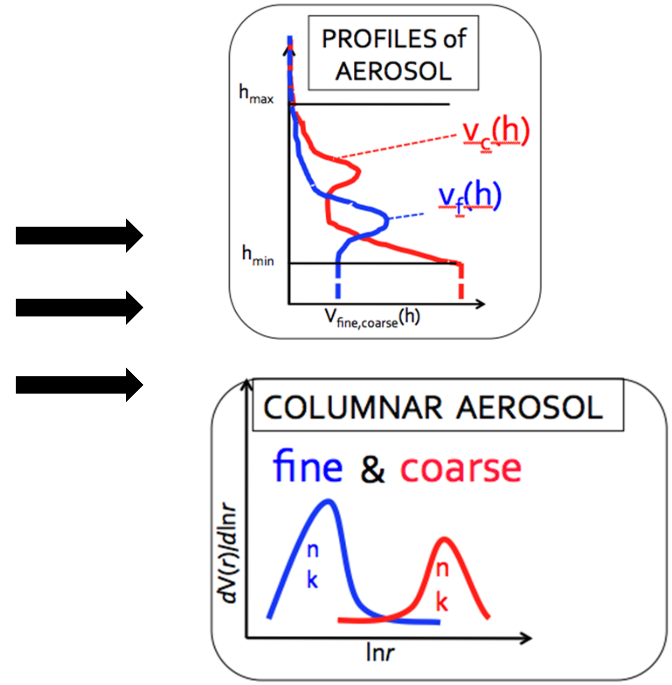
- *multi-instrument combination,*
- *diversity of observations,*
- *consistency of observations*



Multi-temporal multi-instrumental retrievals concept

ACTRIS Project





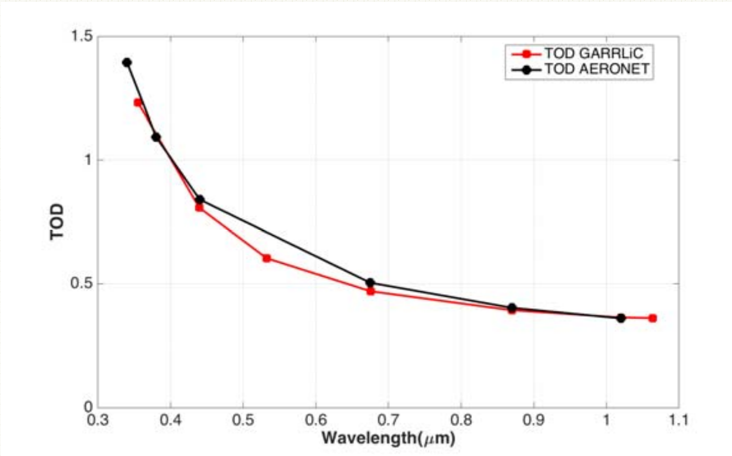
Advanced processing of ground-based observations using GRASP:

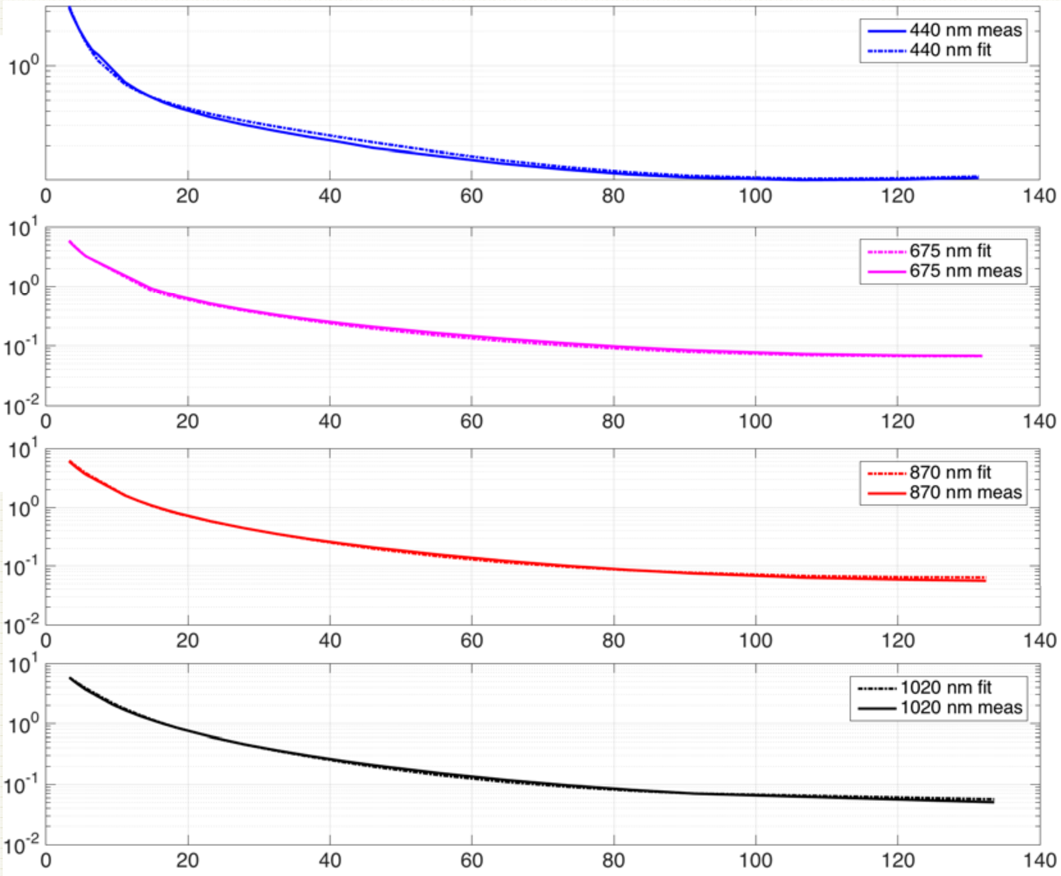
- combining observation during **several days**;
- combining **day and night** observations;
- combining **passive** (photometric) **and active** (lidar);
- combining **ground-based and satellite** observations;
- retrieving as many parameters as possible;

Expectations: more accurate and more complete validation data set

LIDAR + AERONET

Fitting AERONET by AERONET/lidar GRASP retrieval



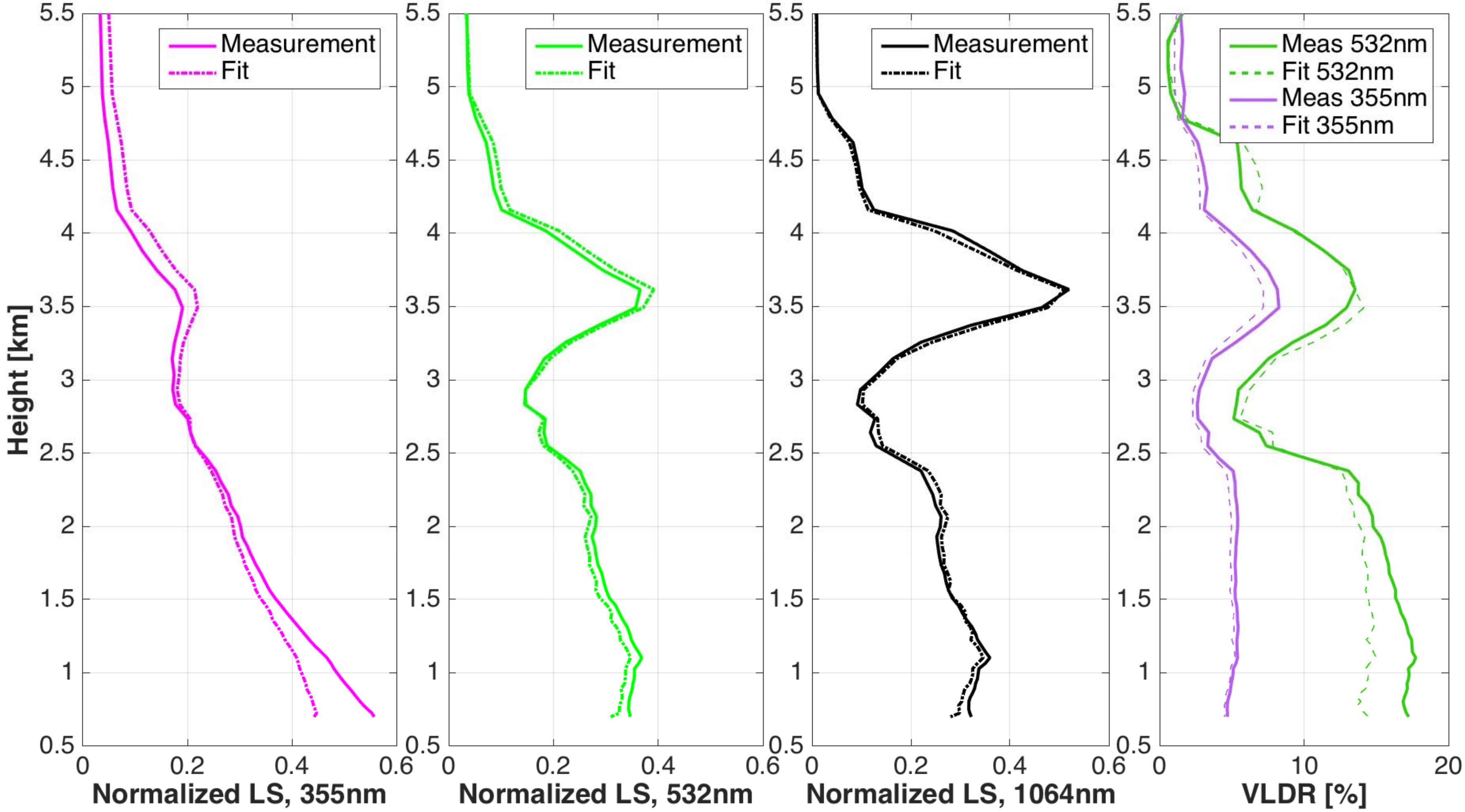


20 Jan 2016, M'bour

Qiaoyun HU, Anton Lopatin, etc.

LIDAR + AERONET

Fitting lidar observations by AERONET/lidar GRASP retrieval

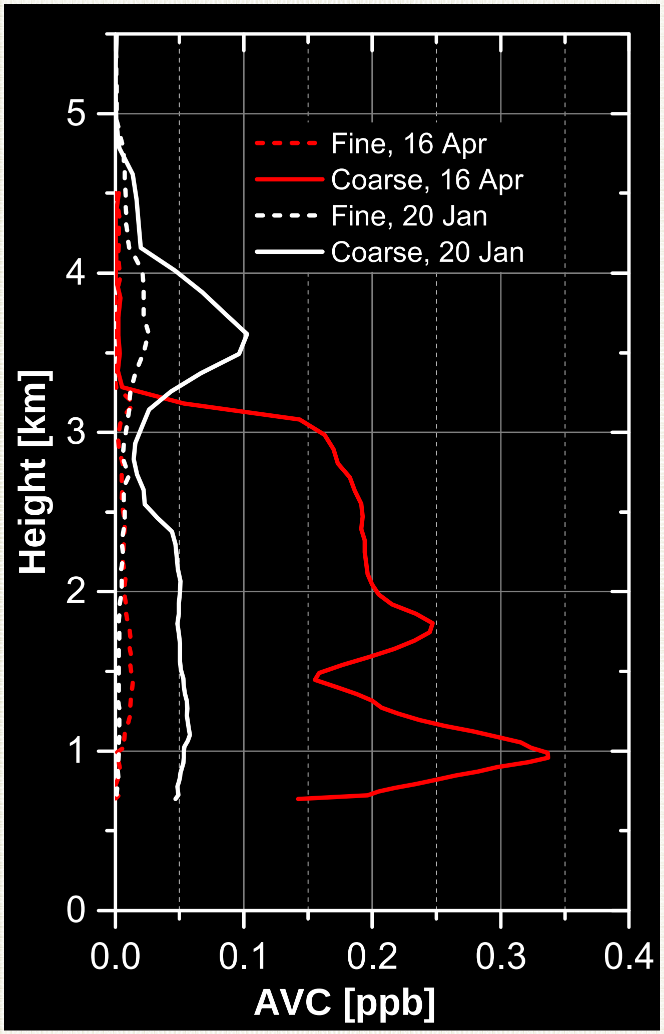


3 Backscattering + 2 Depolarizations

Qiaoyun HU, Anton Lopatin, etc.

LIDAR + AERONET – GRASP retrievals

• Vertical concentration



• Size distribution

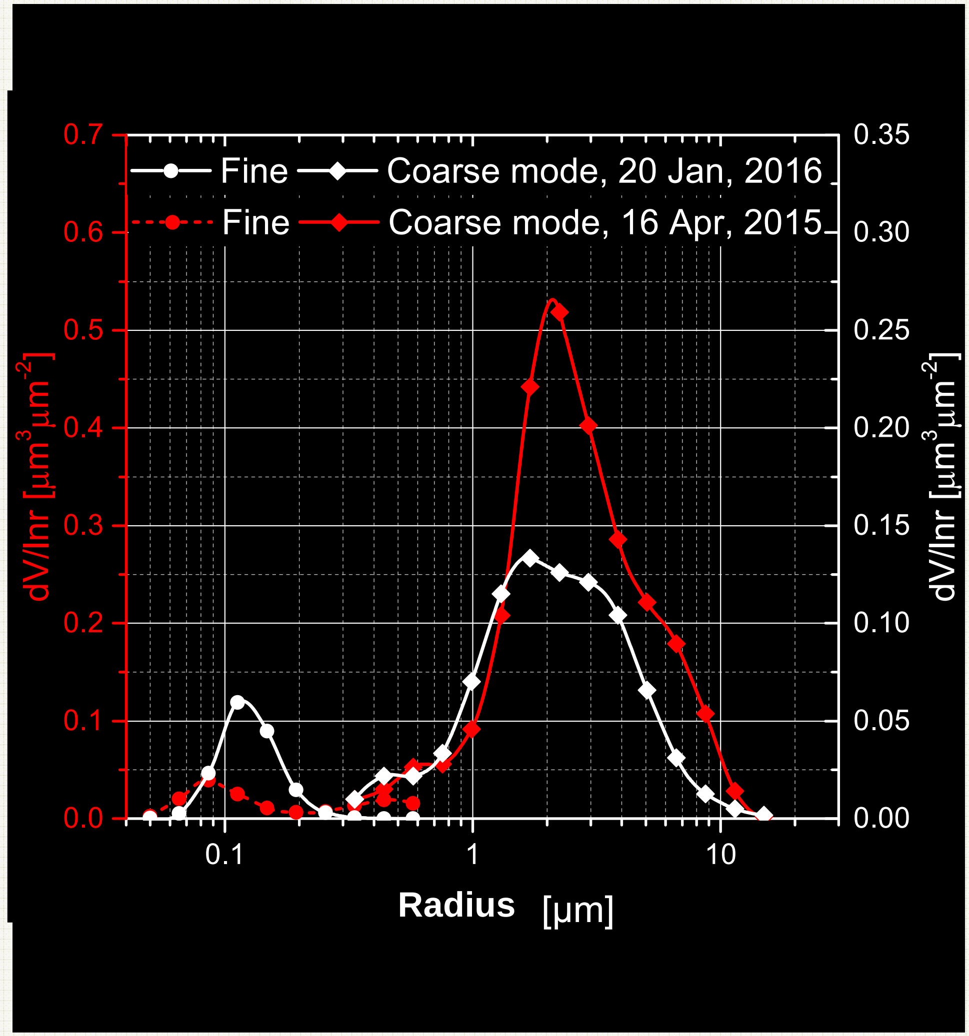


Fig 3. Retrieval of aerosol vertical concentration and size distribution for 16 Apr, 2015 (09:04,) and 20 Jan, 2016 (09:15).

Qiaoyun HU, Anton Lopatin, etc.

Polar- Nephelometer (Martins et al.), GRASP

Espinosa et al. 2017

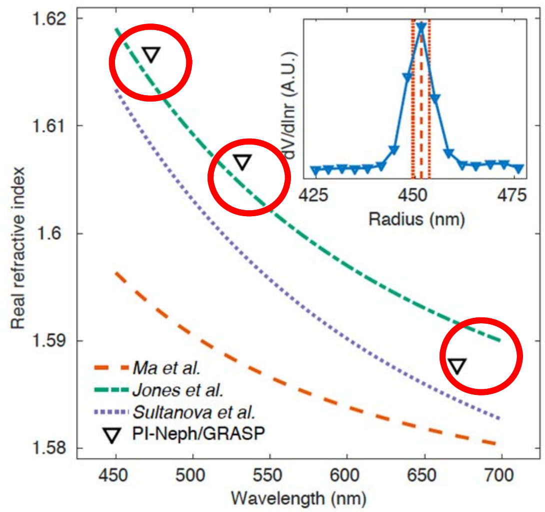


Figure 9. Retrieved real part of the refractive index for PSL spheres, alongside three previous, modern measurements of polystyrene refractive indices (Ma et al., 2003; Jones et al., 2013; Sultanova et al., 2003). The subplot shows the retrieved size distribution (blue) along side the manufacturer's specified central radius (red dashes) and FW67 (red dots).

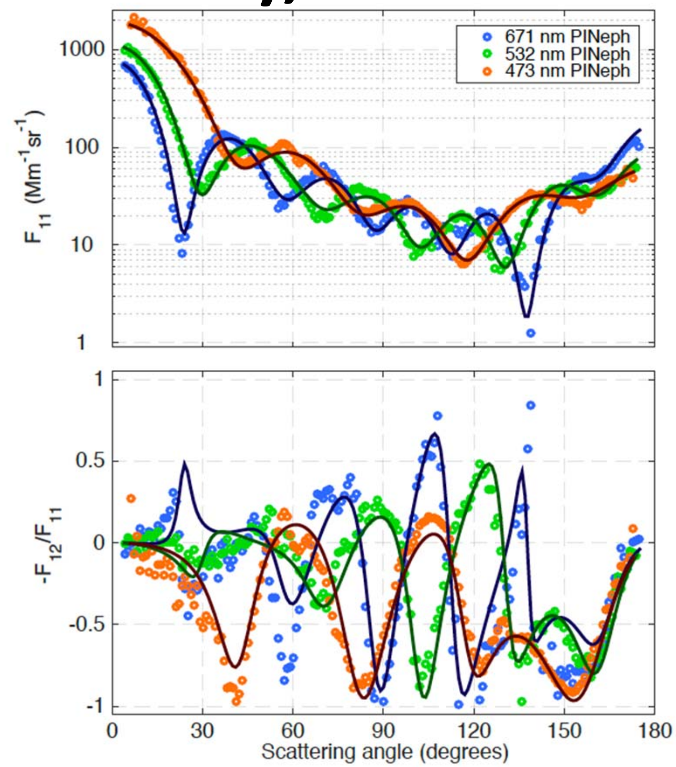


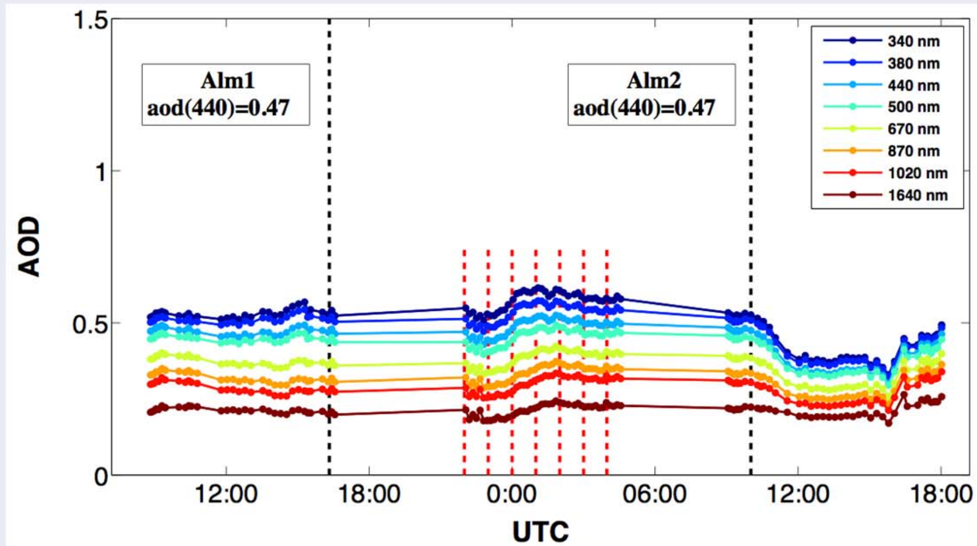
Figure 8. Scattering matrix elements at 473 nm (blue), 532 nm (green) and 671 nm (red) for 903 nm diameter PSL sample along with the corresponding GRASP fits (solid lines).

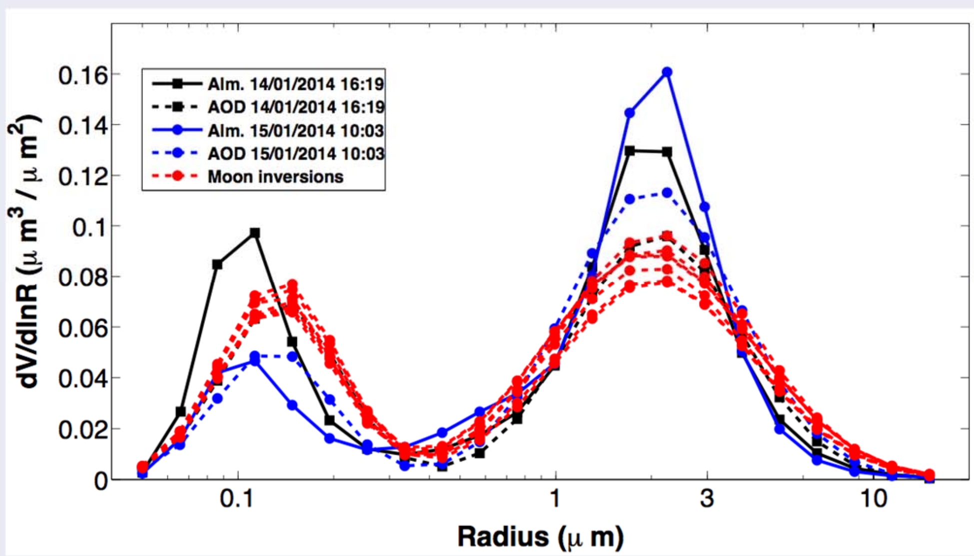
Compound	DRH (%)	Measured RH (%)	κ	r_{50}^{GRASP} (nm)	Sphere (%)	n_{dry}	n_{wet}^{GRASP}	$n_{wet}^{\kappa\text{Köhler}}$
NaCl	80	83.7 ± 2	0.91–1.33	144	100	1.544	1.395	1.353–1.372
$(NH_4)_2SO_4$	75	82.6 ± 2	0.33–0.72	120	100	1.530	1.383	1.370–1.414
NH_4NO_3	62	83.5 ± 2	0.58–0.75	129	54	1.554	1.392	1.371–1.393

Lunar Photometer: Night GRASP/AOD inversions

Dakar - 14/01/2014 and 15/01/2014 - Ph#714

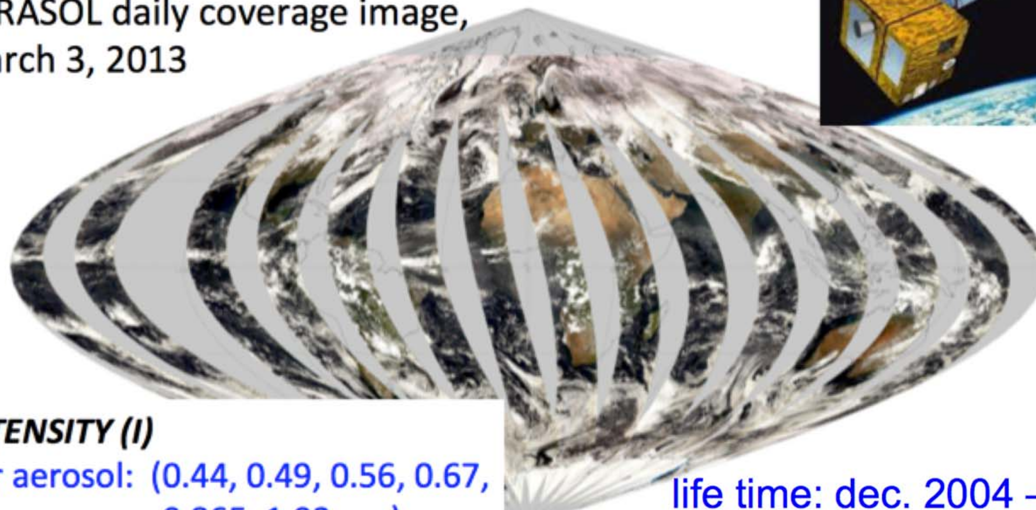
Torres et al., 2017





PARASOL: the space–borne instrument most suitable for enhanced aerosol/surface characterization

PARASOL daily coverage image, March 3, 2013



INTENSITY (I)

for aerosol: (0.44, 0.49, 0.56, 0.67, 0.865, 1.02 μm)

for gas absorption): (0.763, 0.765, 0.910 μm)

POLARIZATION (Q, U): (0.49, 0.67, 0.865 μm)

life time: dec. 2004 – 2013

Swath: about 1600 km cross-track

Global coverage: every 2 days

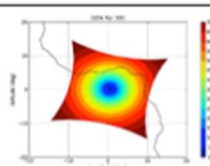
1 pixel spatial resolution: 5.3km × 6.2km

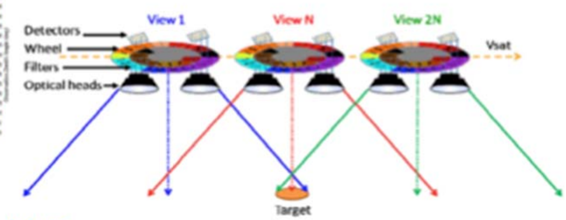
Viewing directions: 16: (80^0 – 180^0)

Multi- Angular Polarimetric imagery:

What is a real value?

3MI:





Swath: ~ 2200 km

Global coverage: every :

Pixel spatial resolution: ~ 4 km

Viewing direction: 10 – 14 (80^0 – 180^0);

for aerosol (0.41, 0.44, 0.49, 0.56, 0.67, 0.87, 1.37, 1,65, 2,13);

for gas absorption (0.763, 0.765, 910);

polarization (0.41, 0.44, 0.49, 0.56, 0.67, 0.87, 1.37, 1,65, 2,13);

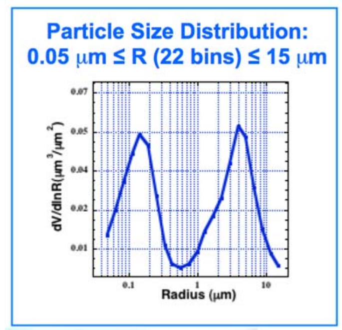
PARASOL:

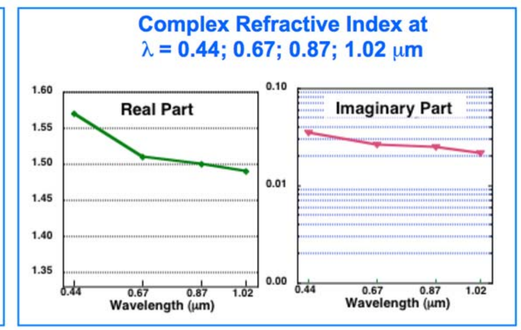
- radiances: *(443, 490, 560, 670, 870, 1020 nm)*
- polarization: *(490, 670, and, 870 nm)*
- up to 16 viewing directions

144 measurements

AEROSOL:

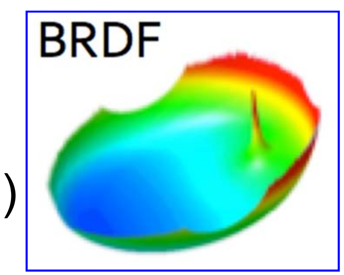
- size distribution (5 or more bins)
- spectral index of refraction (8 λ)
- sphericity fraction;
- aerosol height

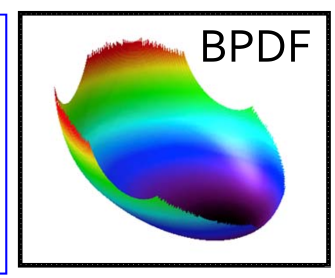




SURFACE:

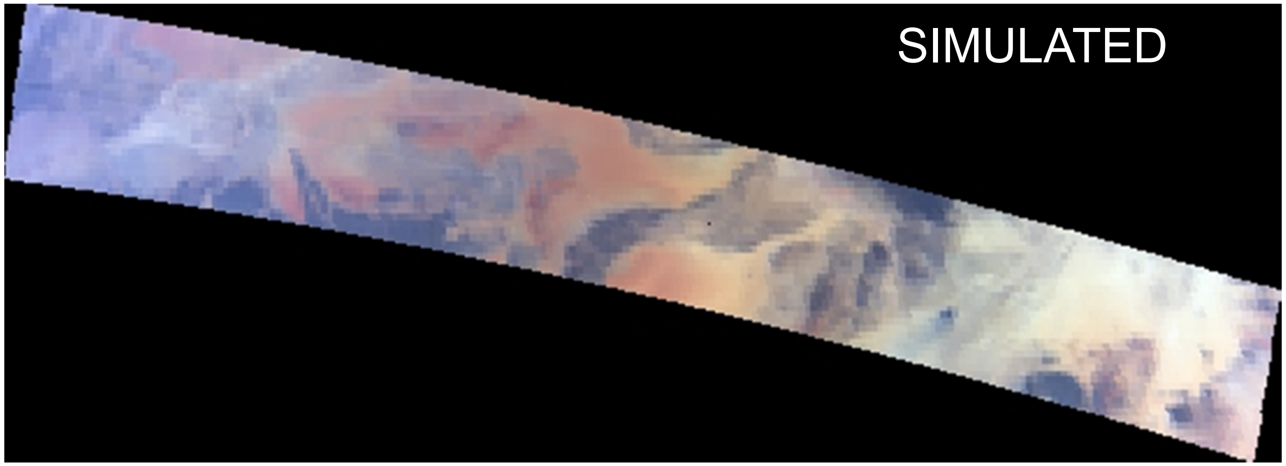
- BRDF (3 spectrally dependent parameters)
- BPDF (1 or 2 spectrally dependent parameters)

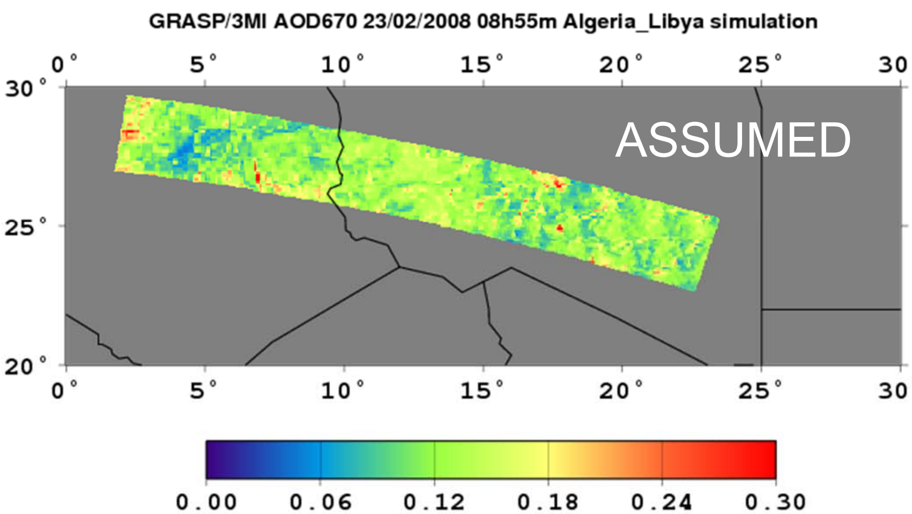


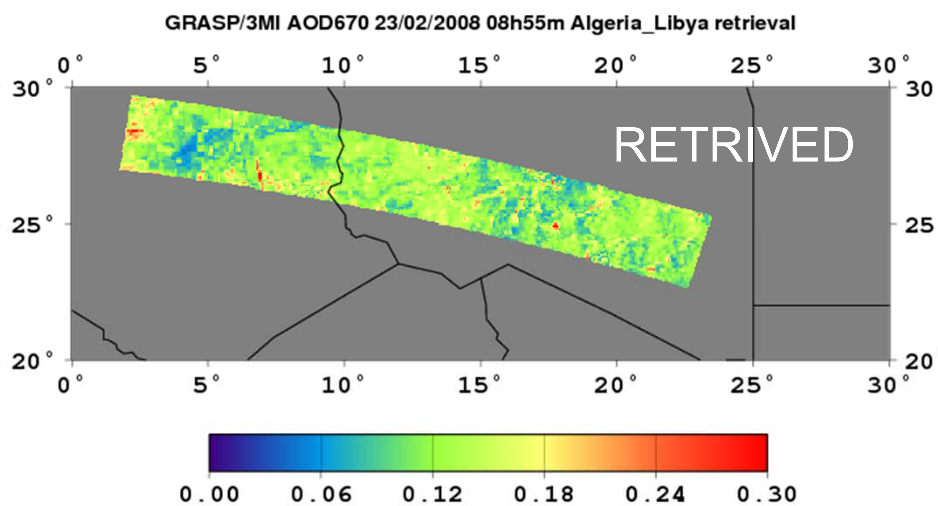


43 = (5 (SD) +12 (ref. ind.) + 1 (nonsp.) + 18 (BRDF) +6 (BPDF) + 1 (height)

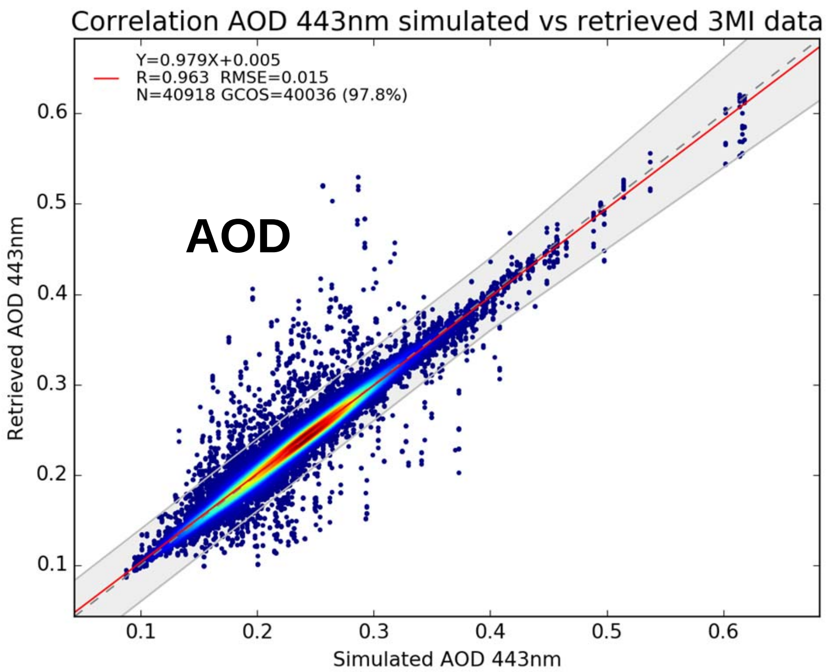
3MI / Metop

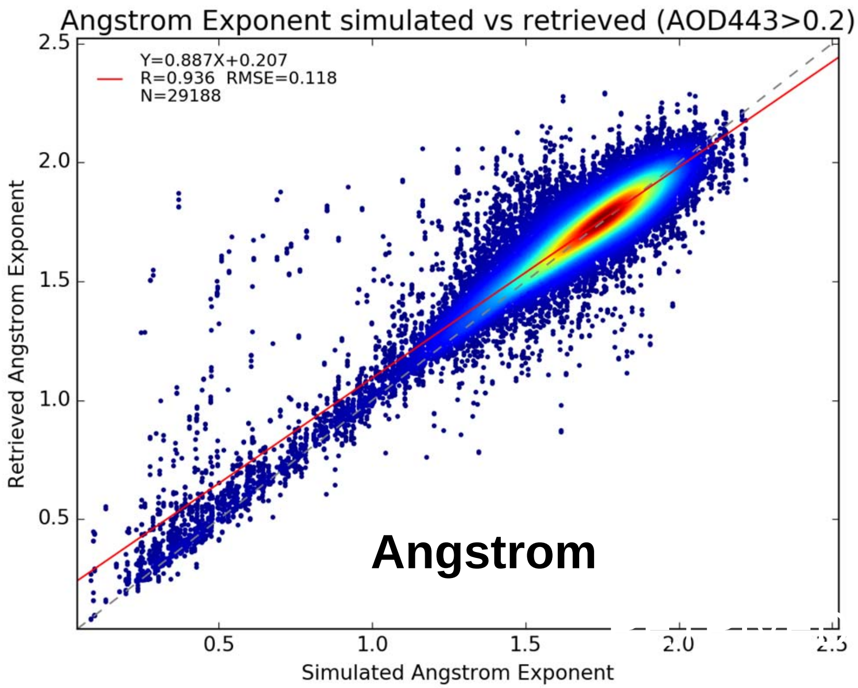

SIMULATED


GRASP/3MI AOD670 23/02/2008 08h55m Algeria_Libya simulation
ASSUMED
0° 5° 10° 15° 20° 25° 30°
30° 25° 20°
0.00 0.06 0.12 0.18 0.24 0.30


GRASP/3MI AOD670 23/02/2008 08h55m Algeria_Libya retrieval
RETRIVED
0° 5° 10° 15° 20° 25° 30°
30° 25° 20°
0.00 0.06 0.12 0.18 0.24 0.30

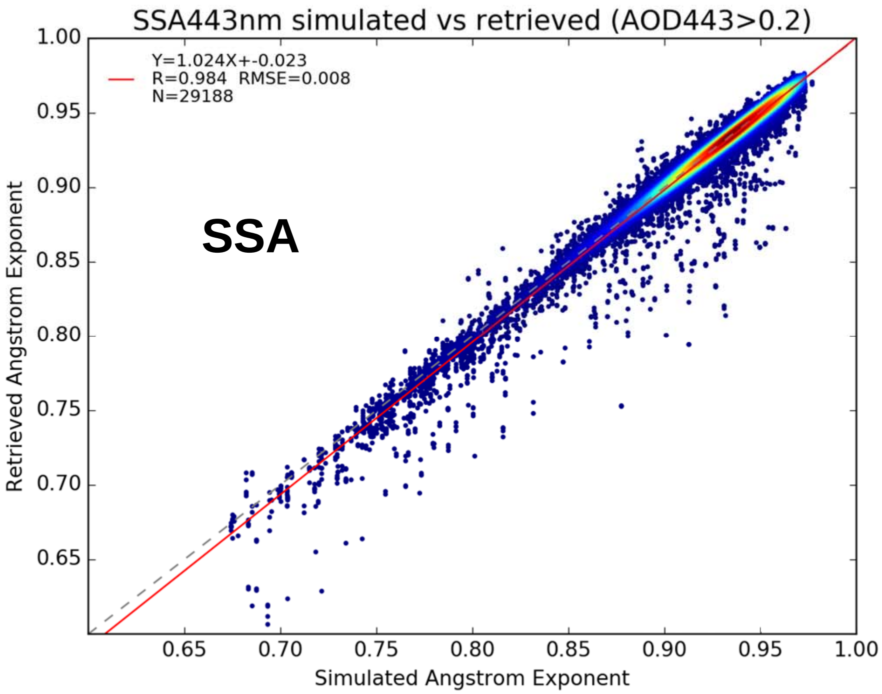
3MI / Metop

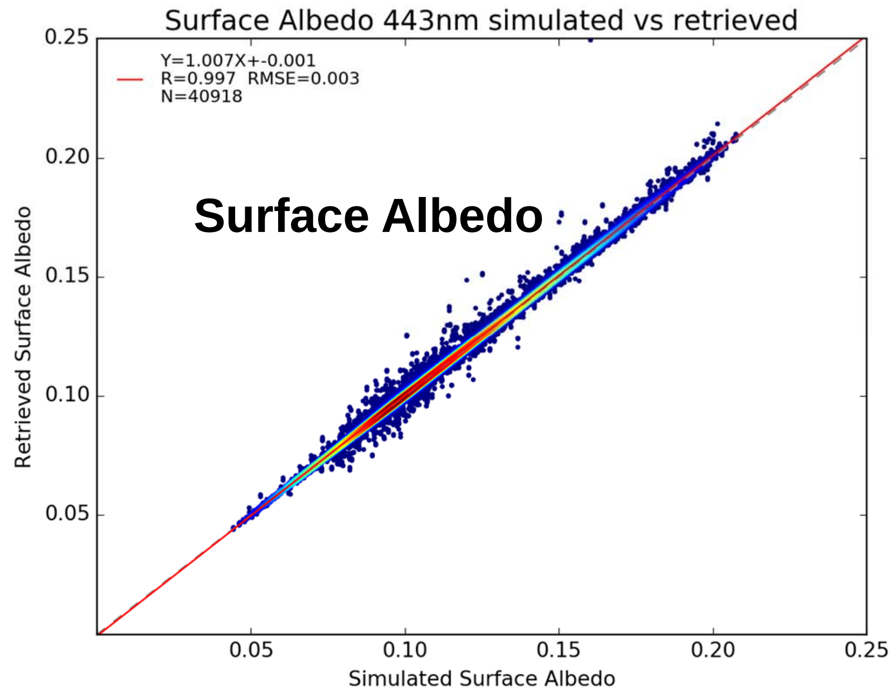

Correlation AOD 443nm simulated vs retrieved 3MI data
Y=0.979X+0.005
R=0.963 RMSE=0.015
N=40918 GCOS=40036 (97.8%)
AOD
Retrieved AOD 443nm
Simulated AOD 443nm


Angstrom Exponent simulated vs retrieved (AOD443>0.2)
Y=0.887X+0.207
R=0.936 RMSE=0.118
N=29188
Angstrom
Retrieved Angstrom Exponent
Simulated Angstrom Exponent

GRASP
In principle, yes!

3MI / Metop





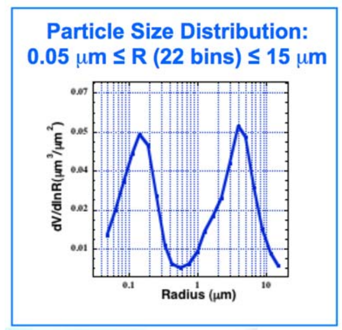
PARASOL:

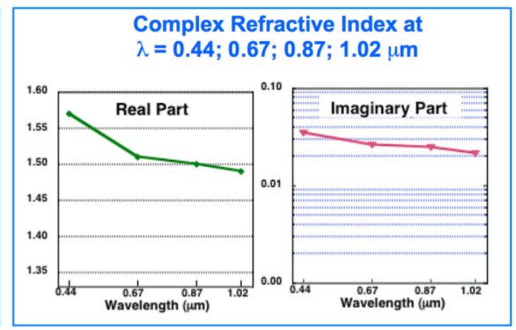
- radiances: *(443, 490, 560, 670, 870, 1020 nm)*
- polarization: *(490, 670, and, 870 nm)*
- up to 16 viewing directions

144 measurements

AEROSOL:

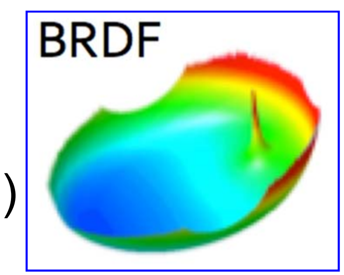
- size distribution (5 or more bins)
- spectral index of refraction (8 λ)
- sphericity fraction;
- aerosol height

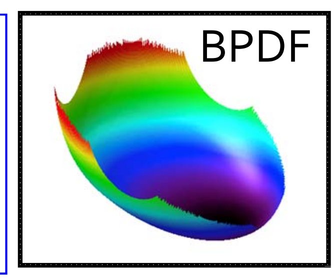




SURFACE:

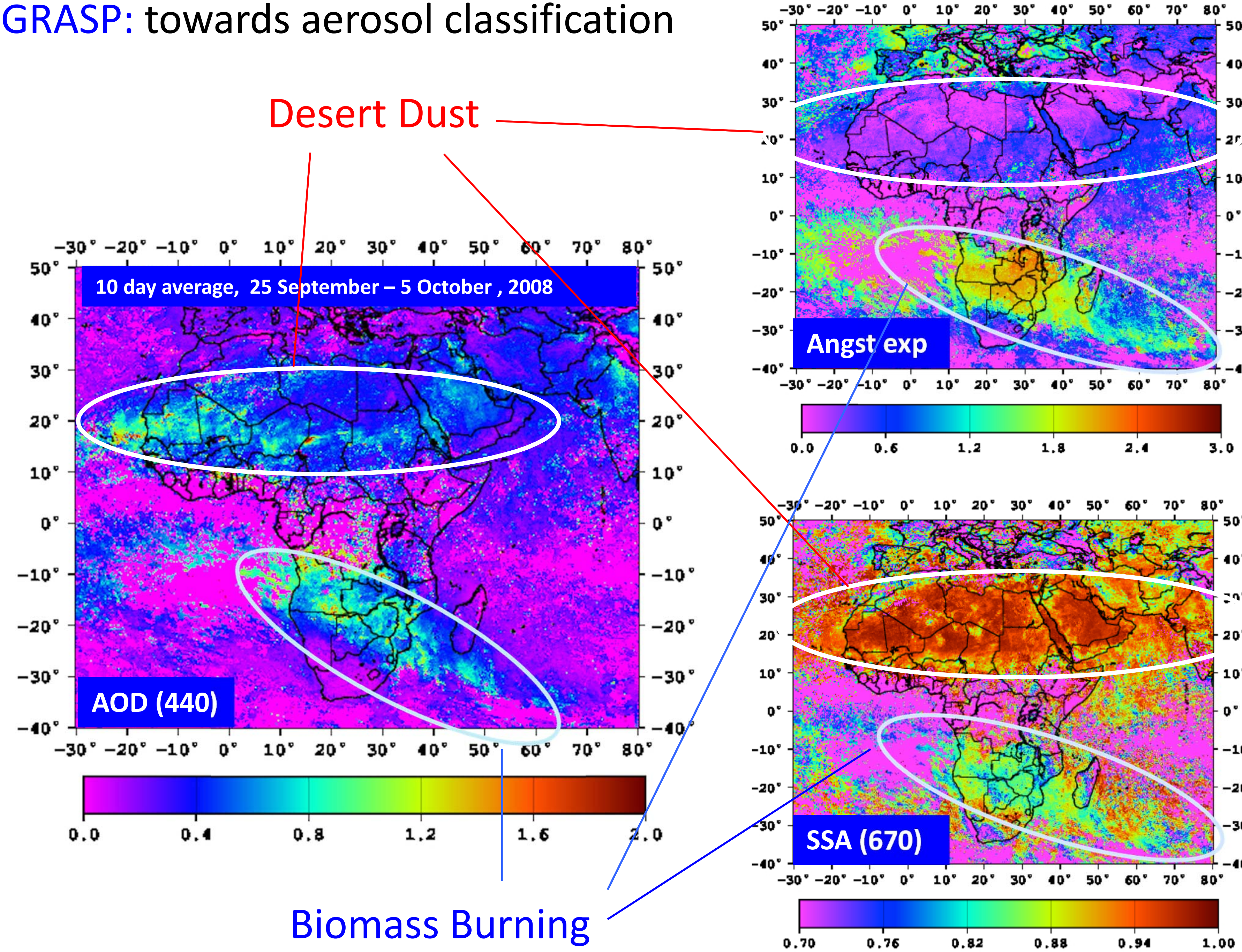
- BRDF (3 spectrally dependent parameters)
- BPDF (1 or 2 spectrally dependent parameters)



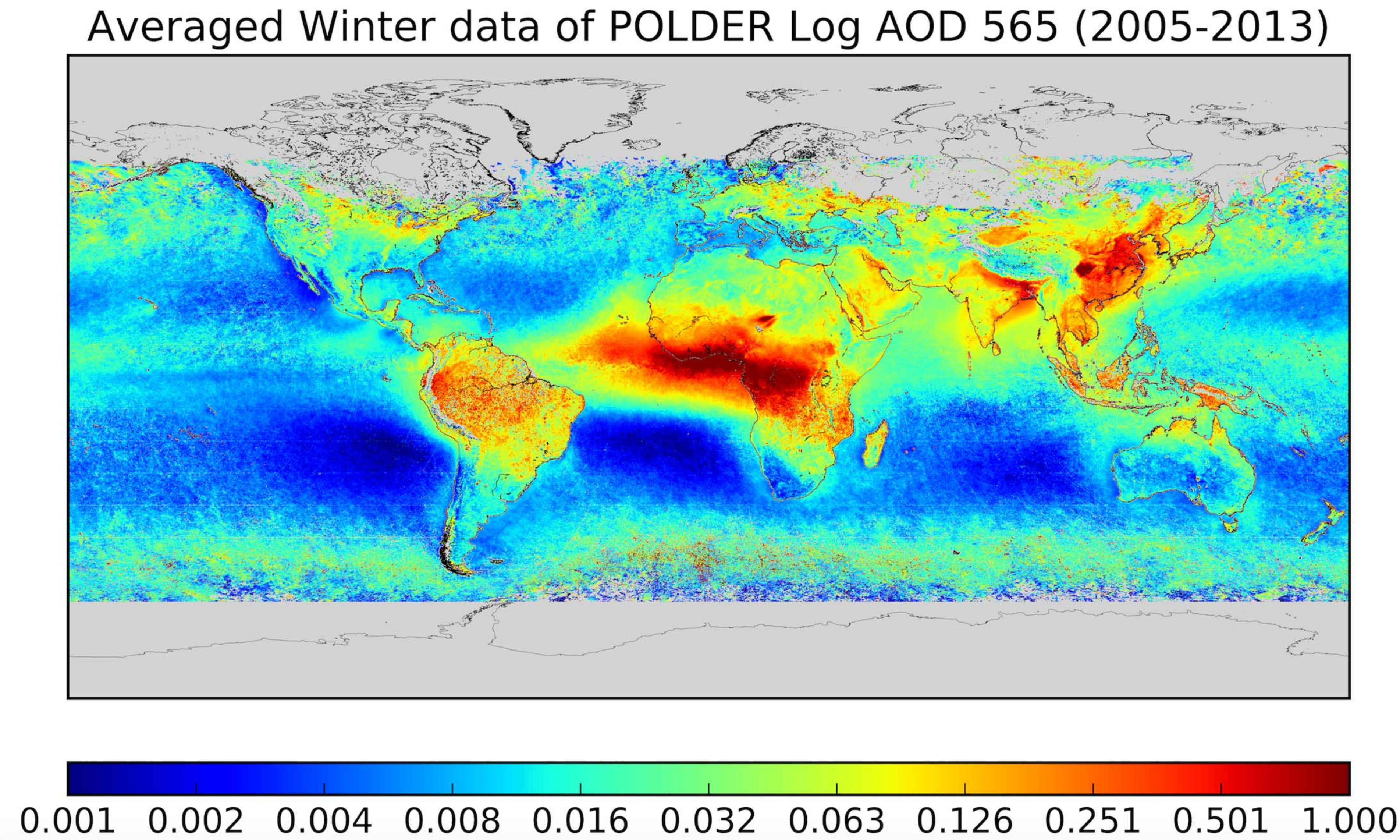


43 = (5 (SD) +12 (ref. ind.) + 1 (nonsp.) + 18 (BRDF) +6 (BPDF) + 1 (height)

GRASP: towards aerosol classification

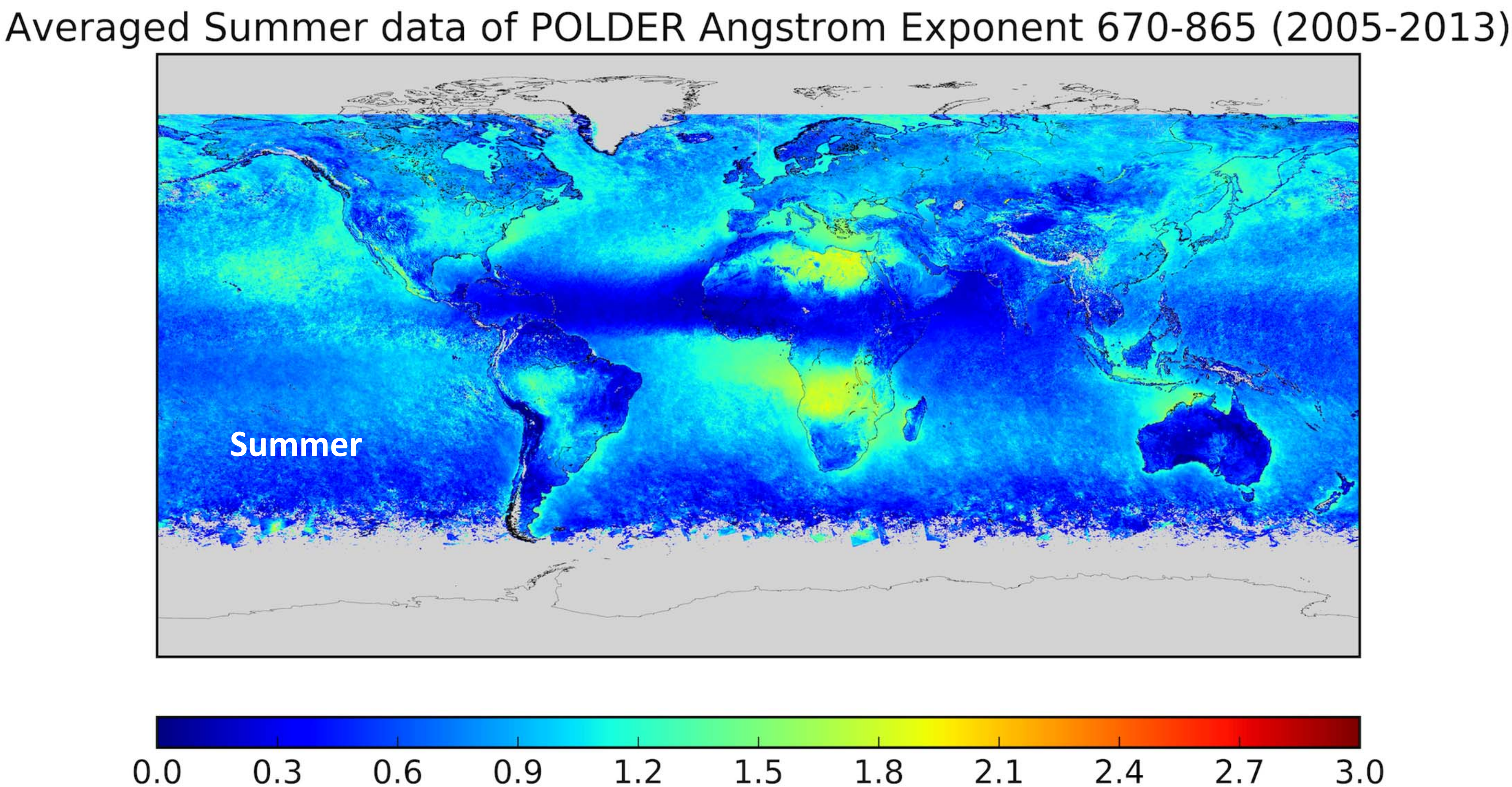


AOD (565), Winter (PARASOL archive average)



Amount of aerosol

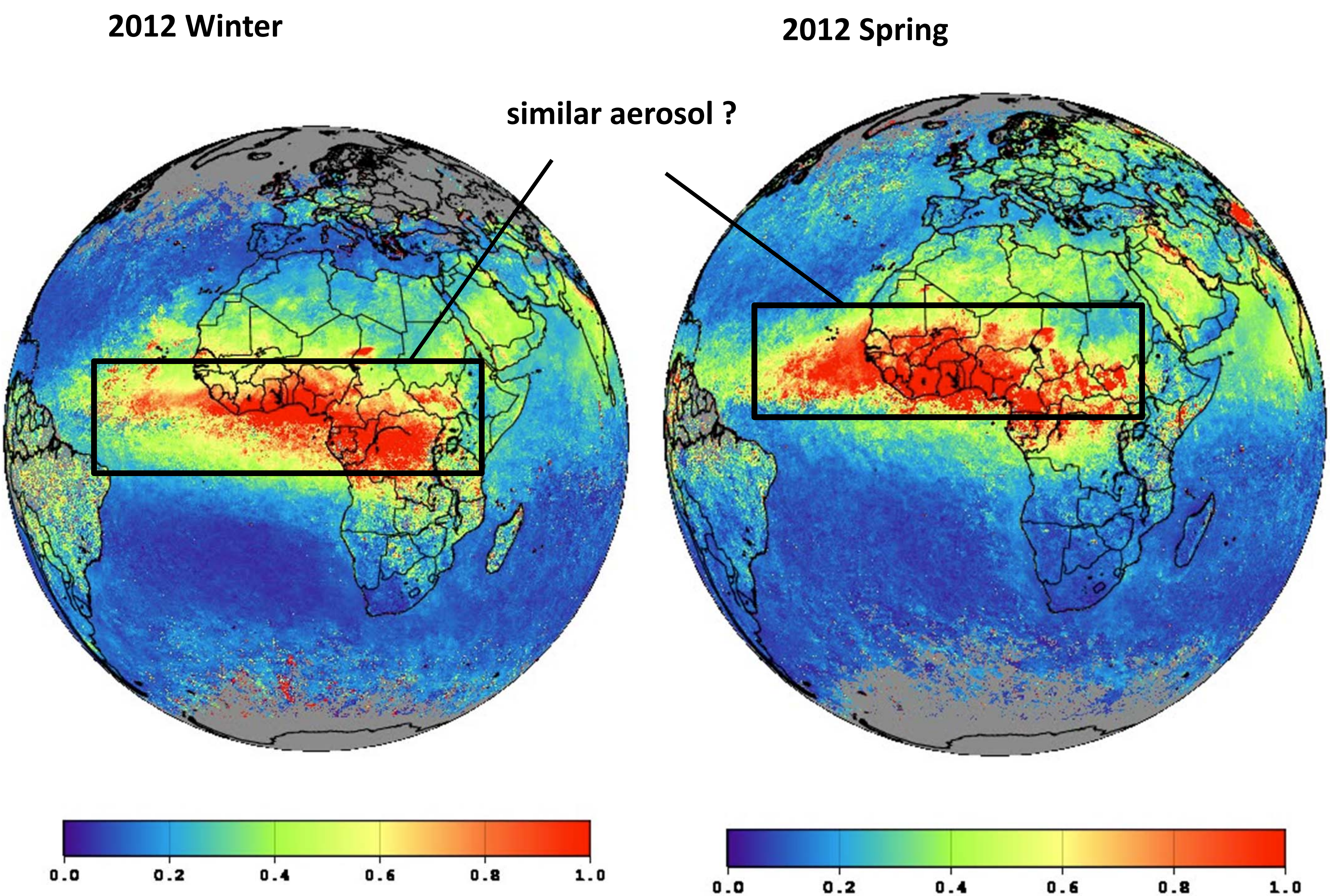
Angstrom exponent, Summer (PARASOL archive average)



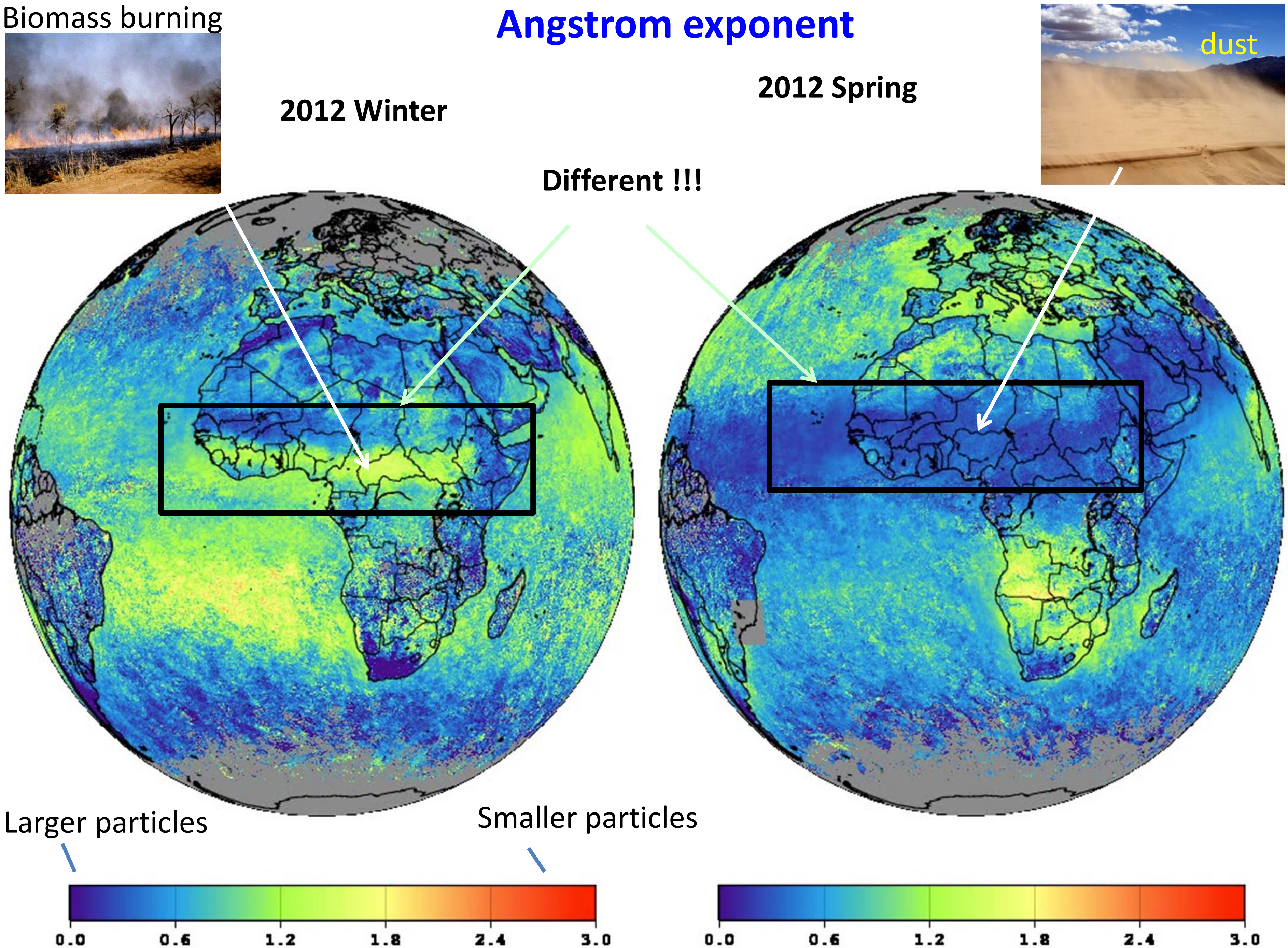
Large particles

Small particles

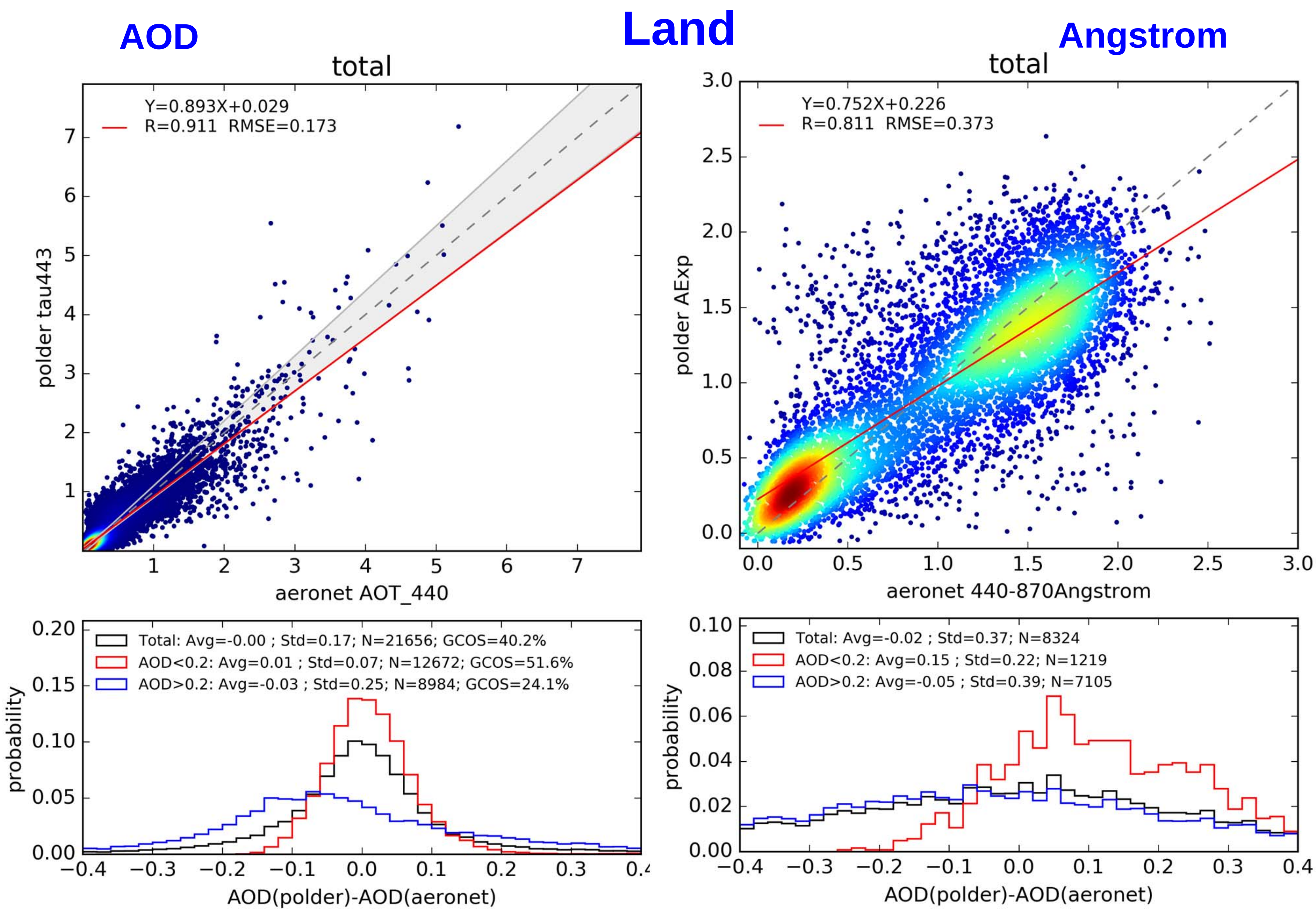
AOD(565) – aerosol loading



Angstrom exponent



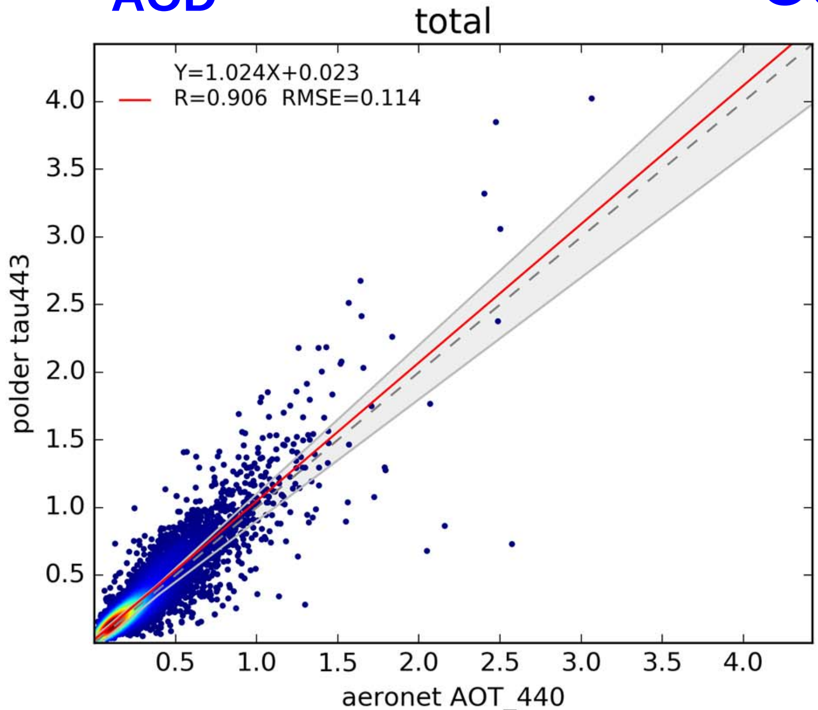
Validation vs AERONET 2004 - 2013

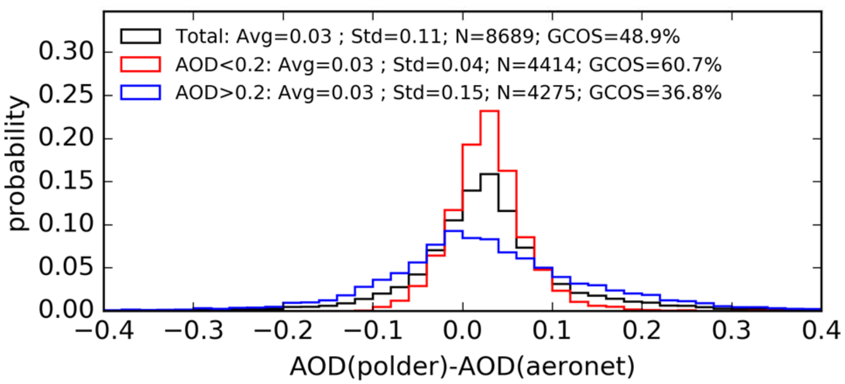


PARASOL Validation vs AERONET 2004 - 2013

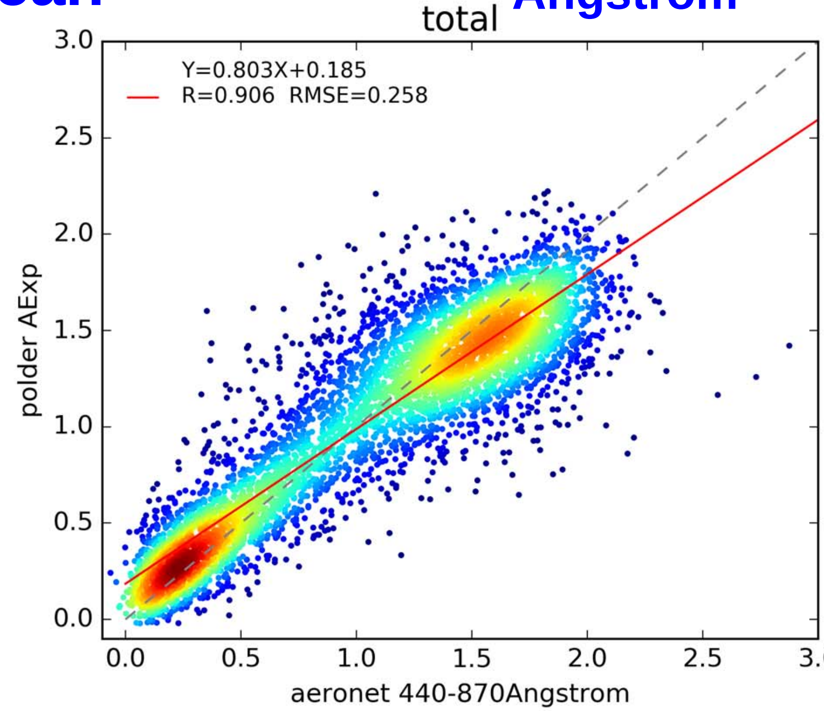
Ocean

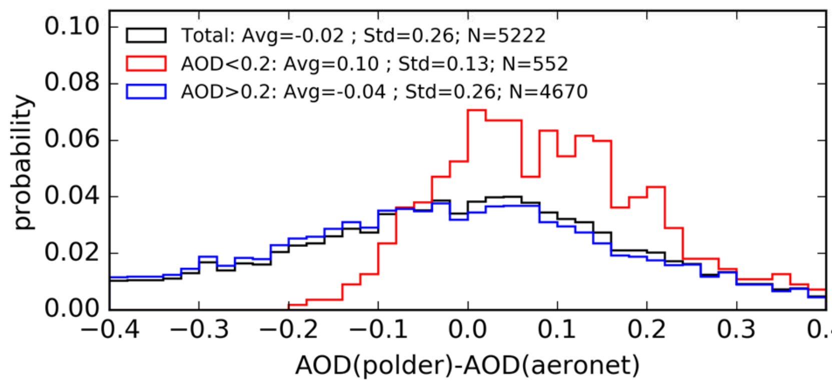
AOD





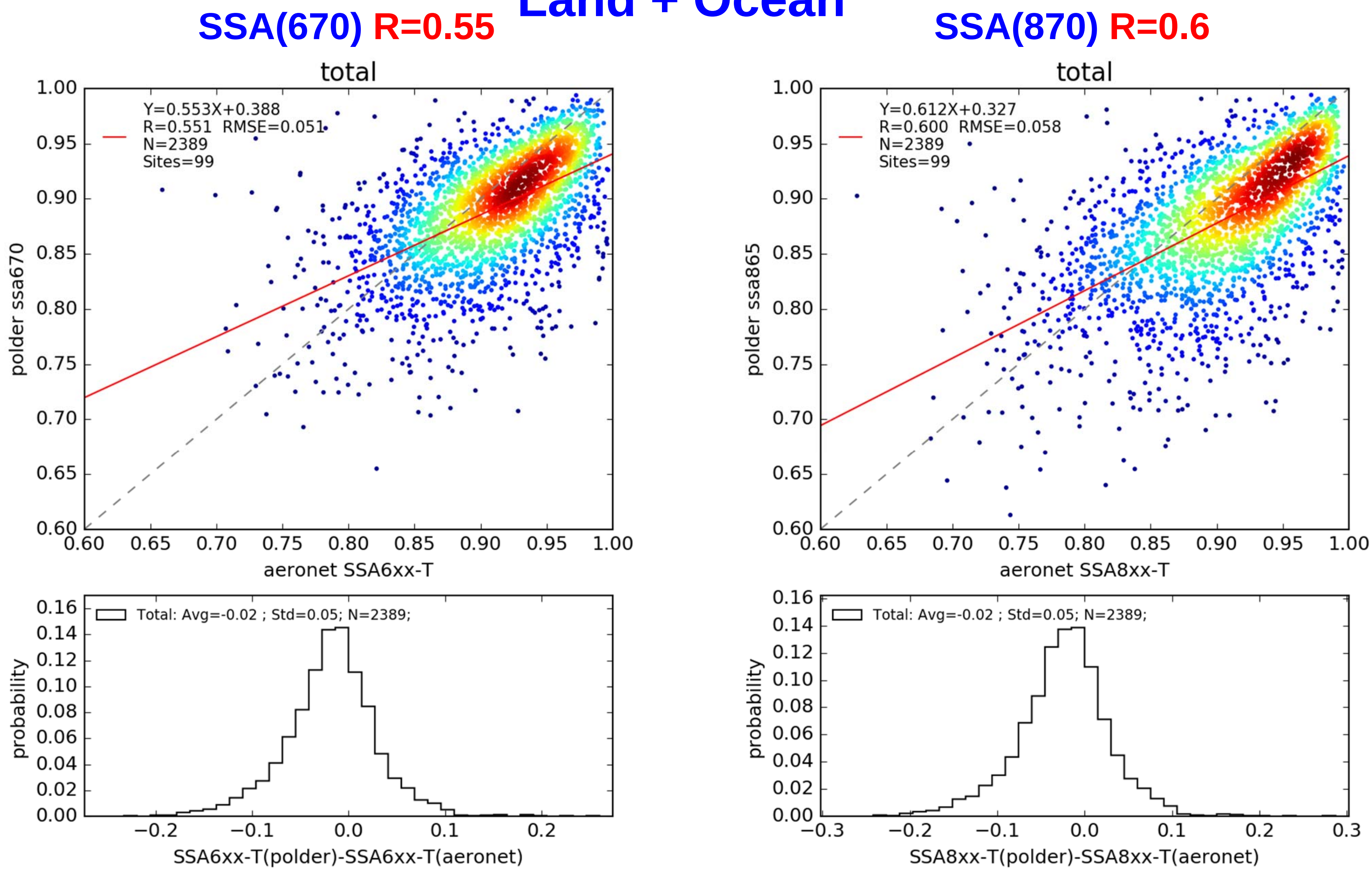
Angstrom





PARASOL Validation vs AERONET 2004 - 2013

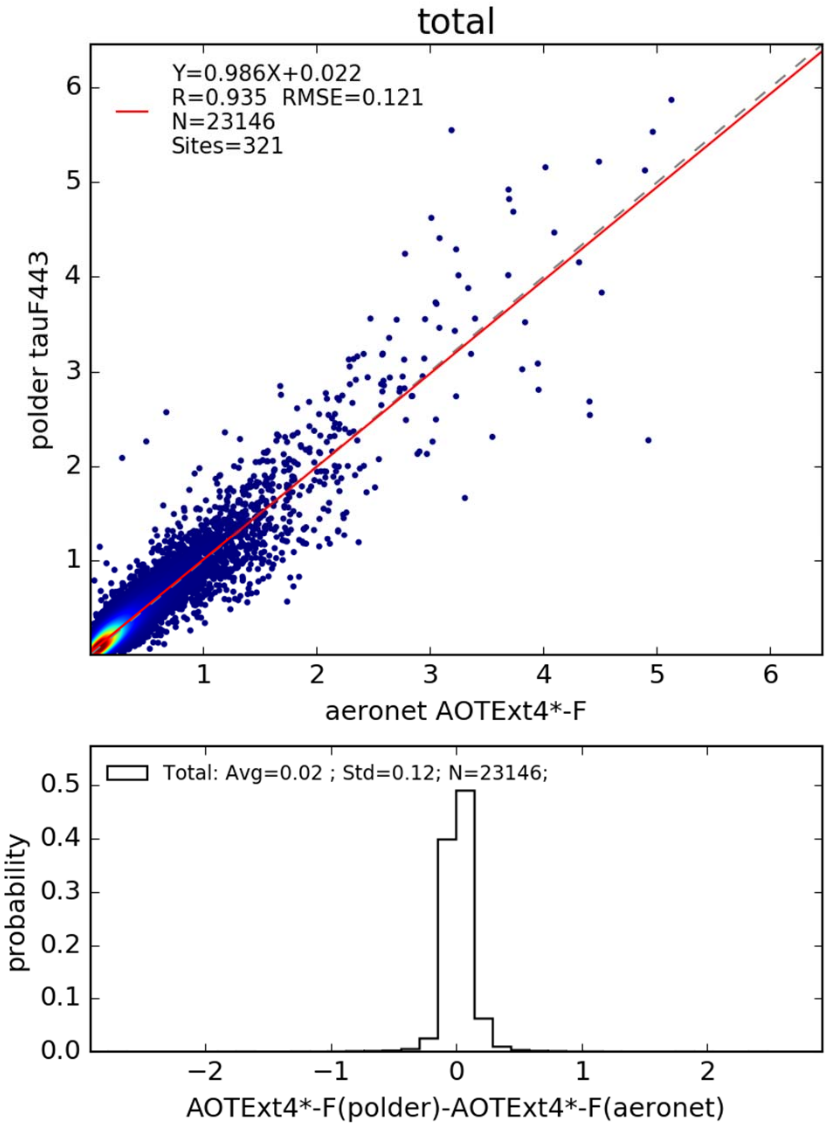
Land + Ocean



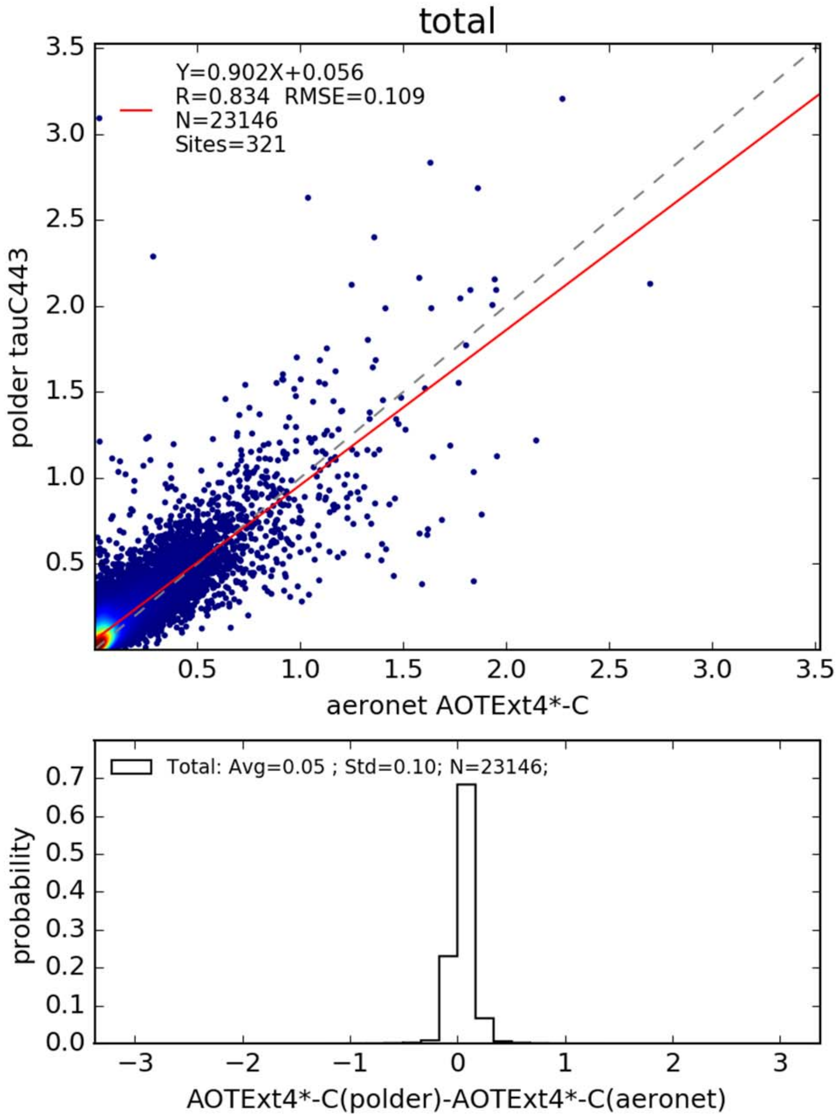
PARASOL Validation vs AERONET 2004 - 2013

Land + Ocean

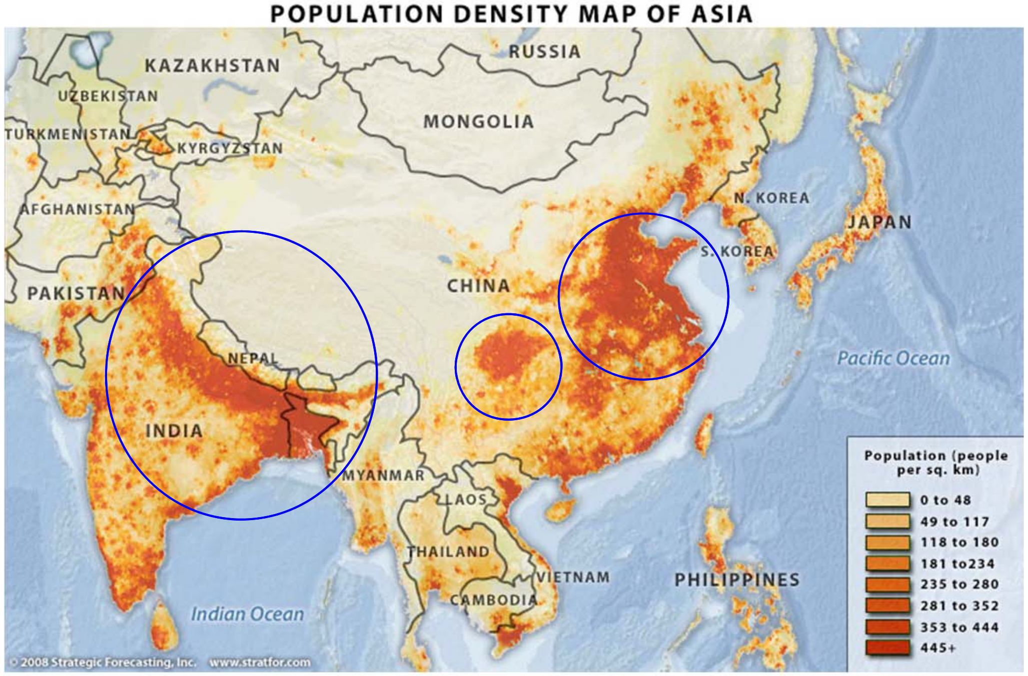
AOD Fine mode



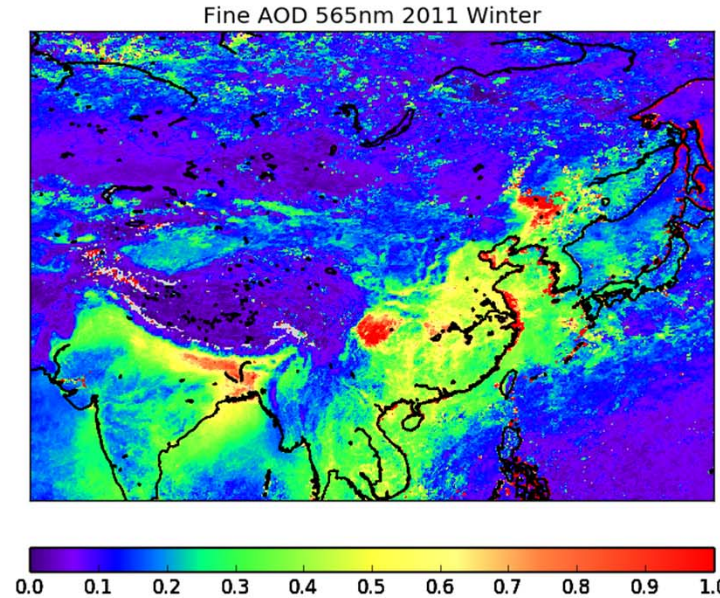
AOD Coarse mode

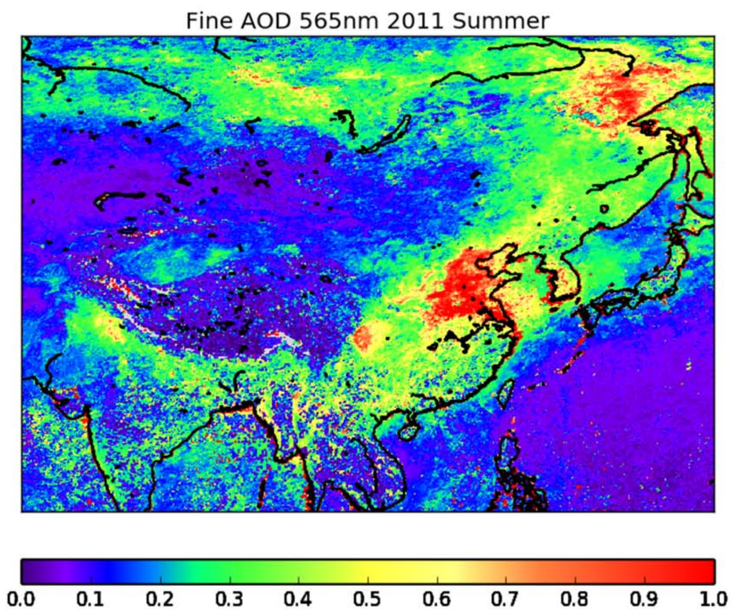


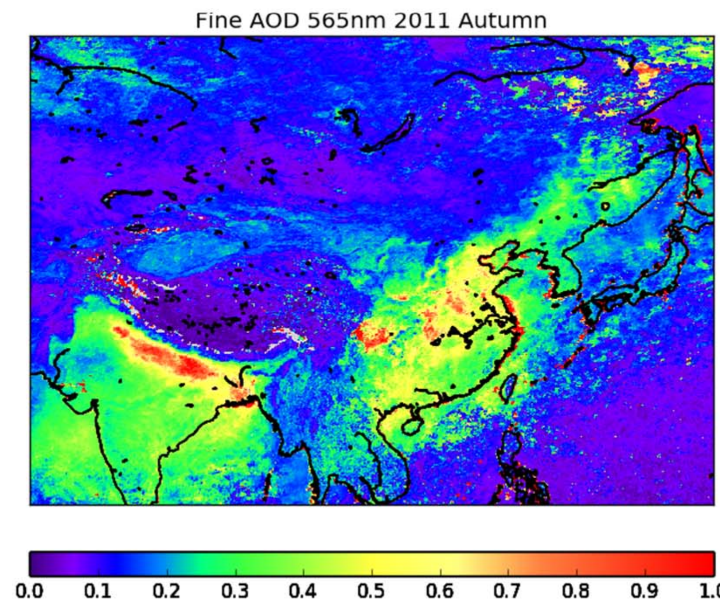
Correlation of population density and pollution



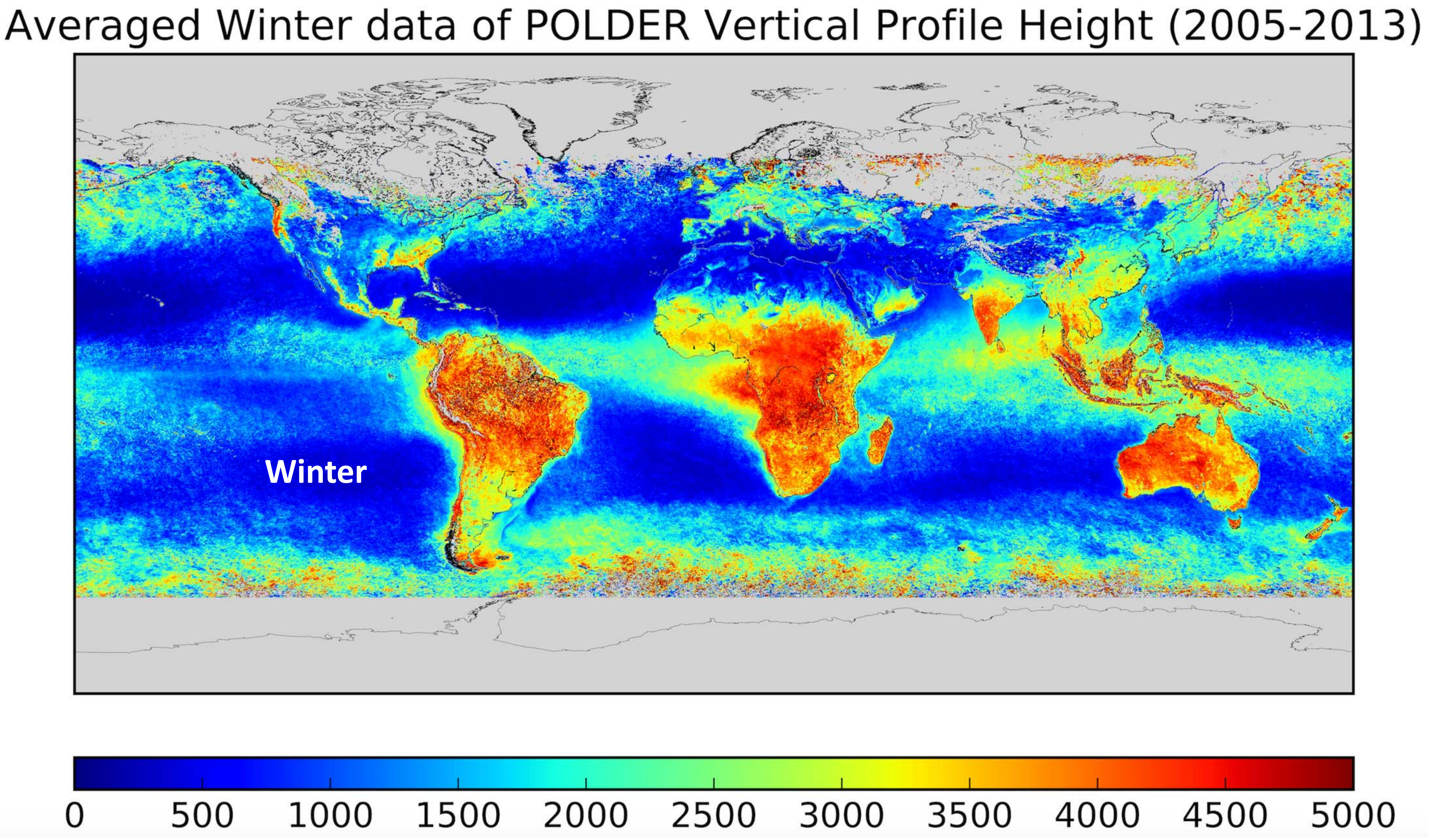
$AOD_{fine}(565)$





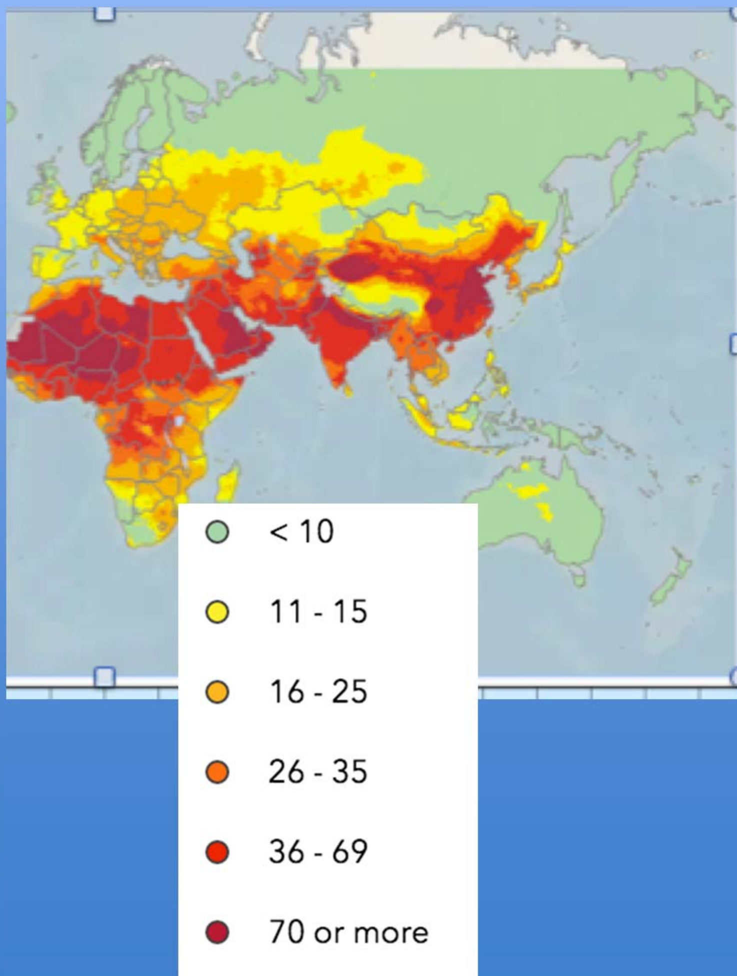


Scale height (m), Winter (PARASOL archive average)

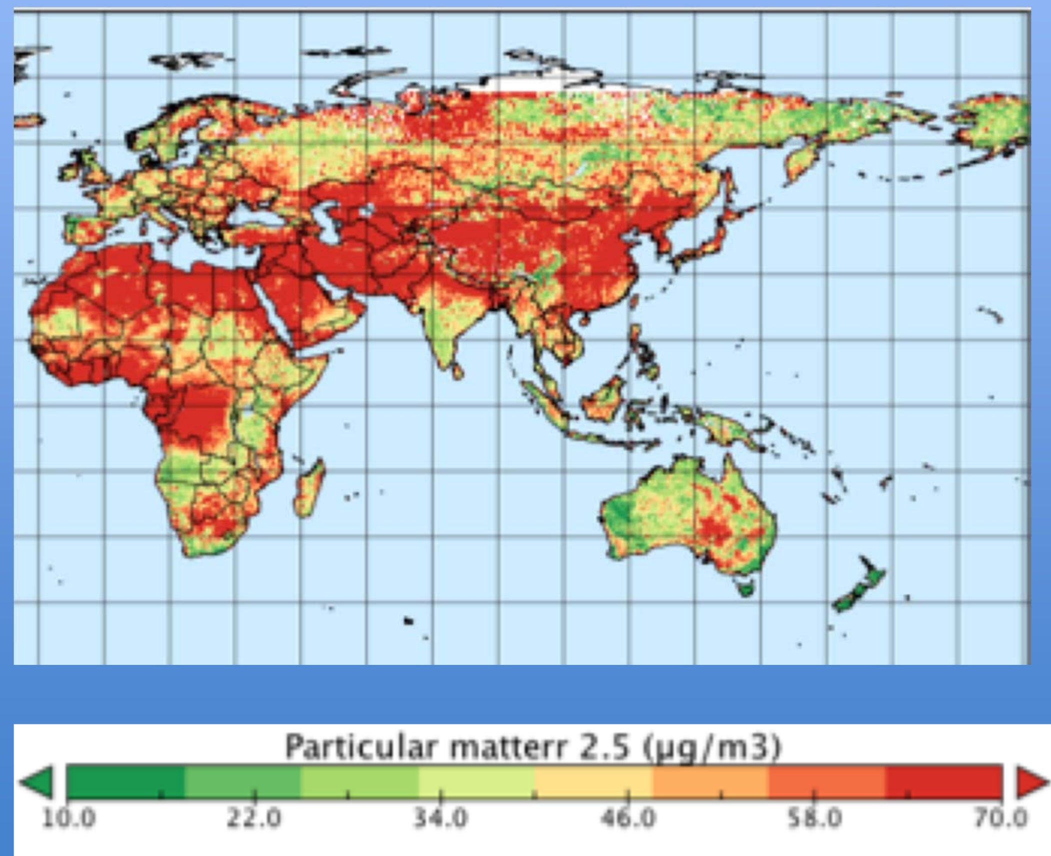


PM2.5 climatology

WHO Global Urban Ambient Air Pollution Database

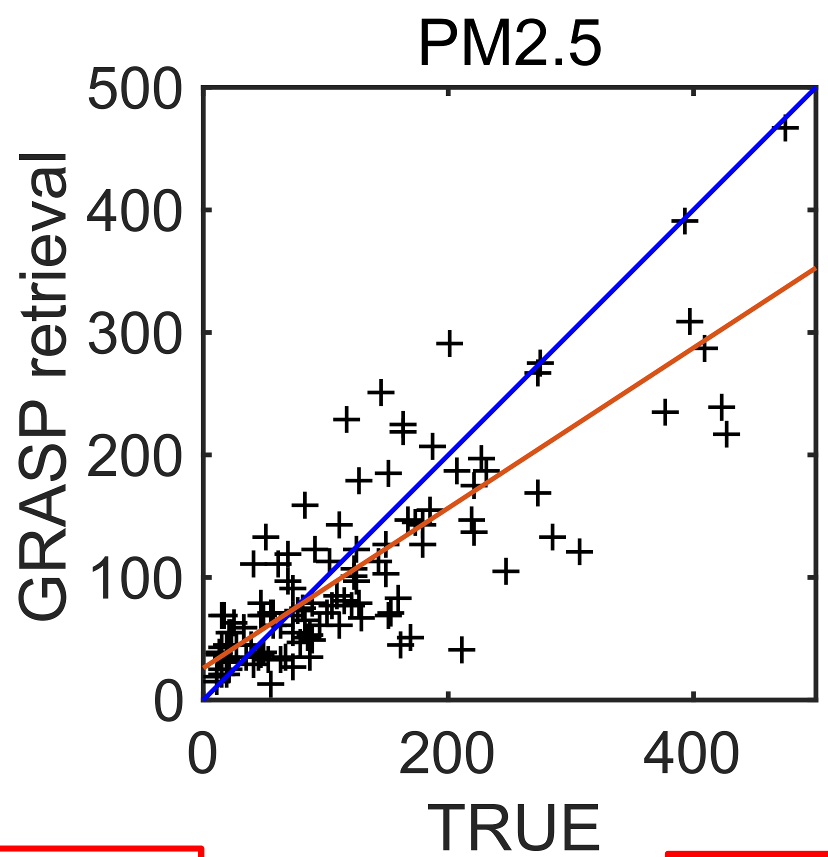


PARASOL/GRASP 2008



A. Lopatin

PARASOL/GRASP PM2.5 over Beijing 2009–2012

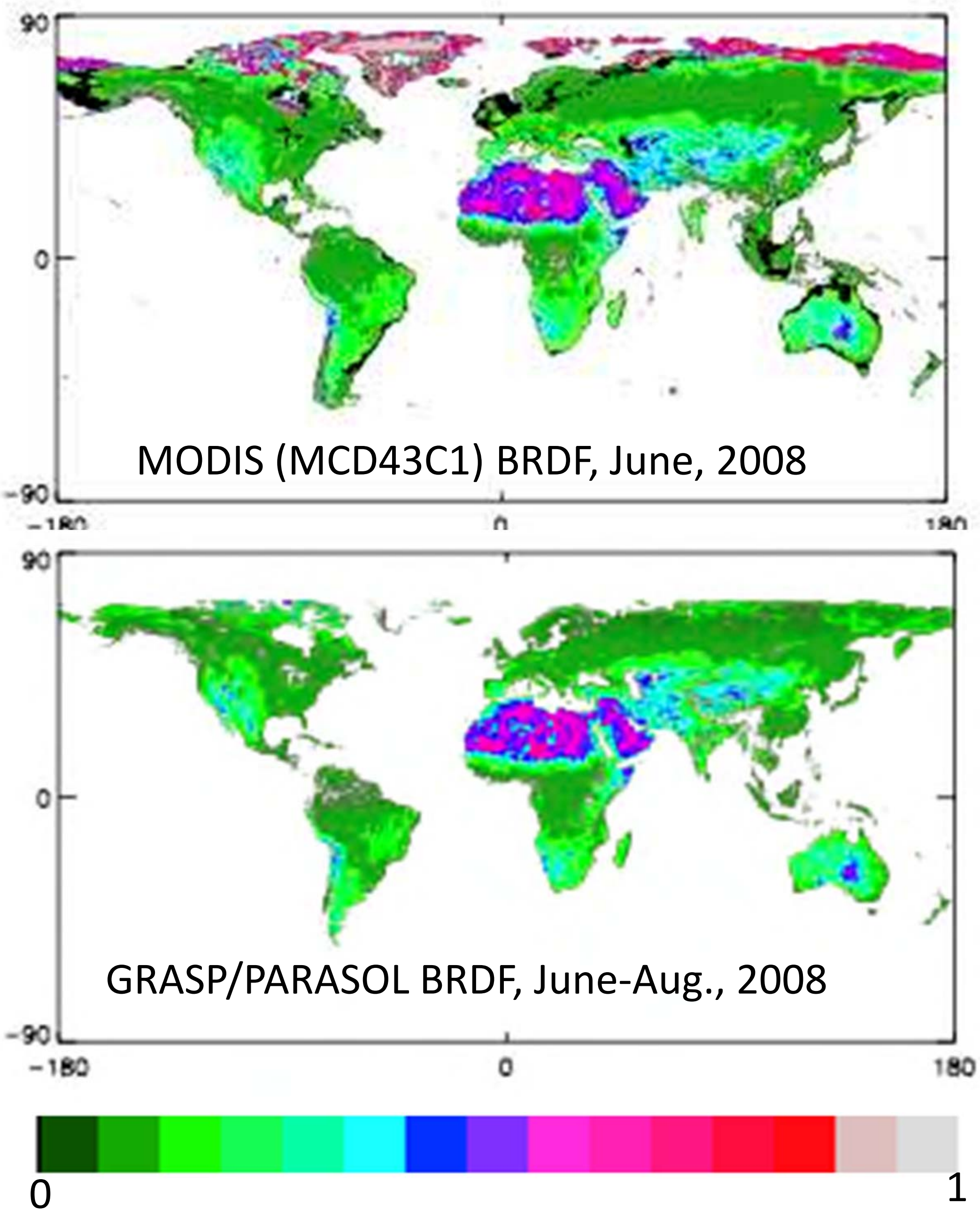


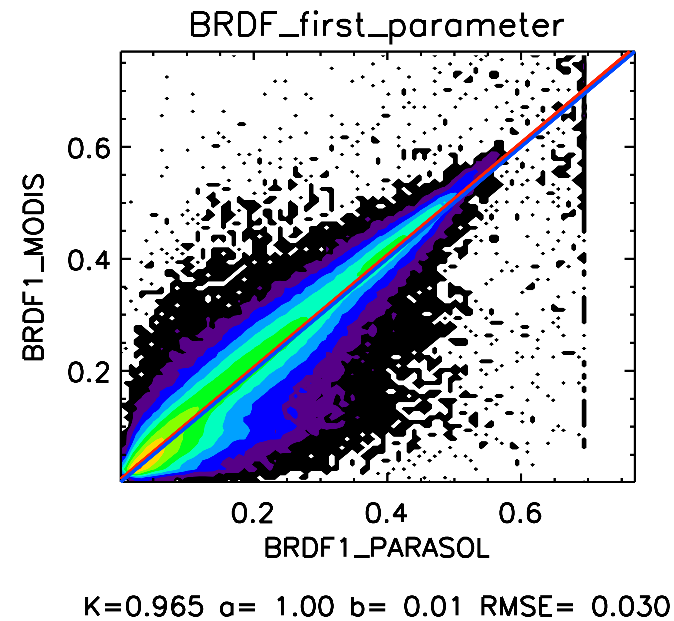
K=0.821 a=0.65 b=26.00 RMSE=60.957
N=115 Aver.=121.513

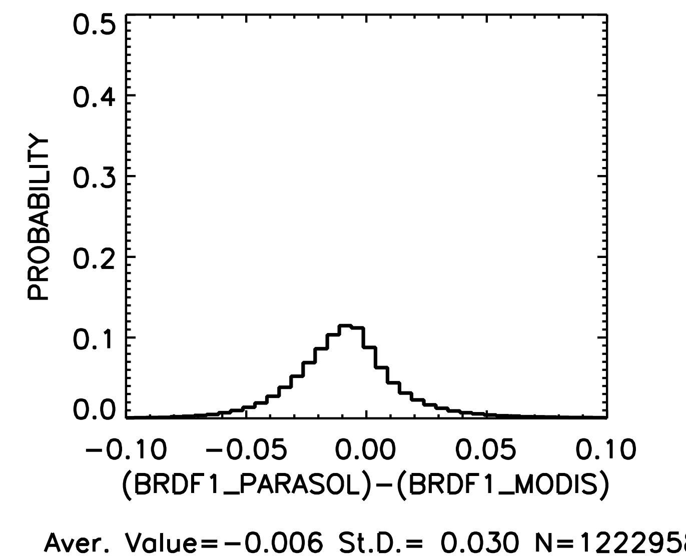
AOT>0.3, residual<3%

A. Lopatin

First parameter (670 nm) of Ross-Li BRDF, 2008

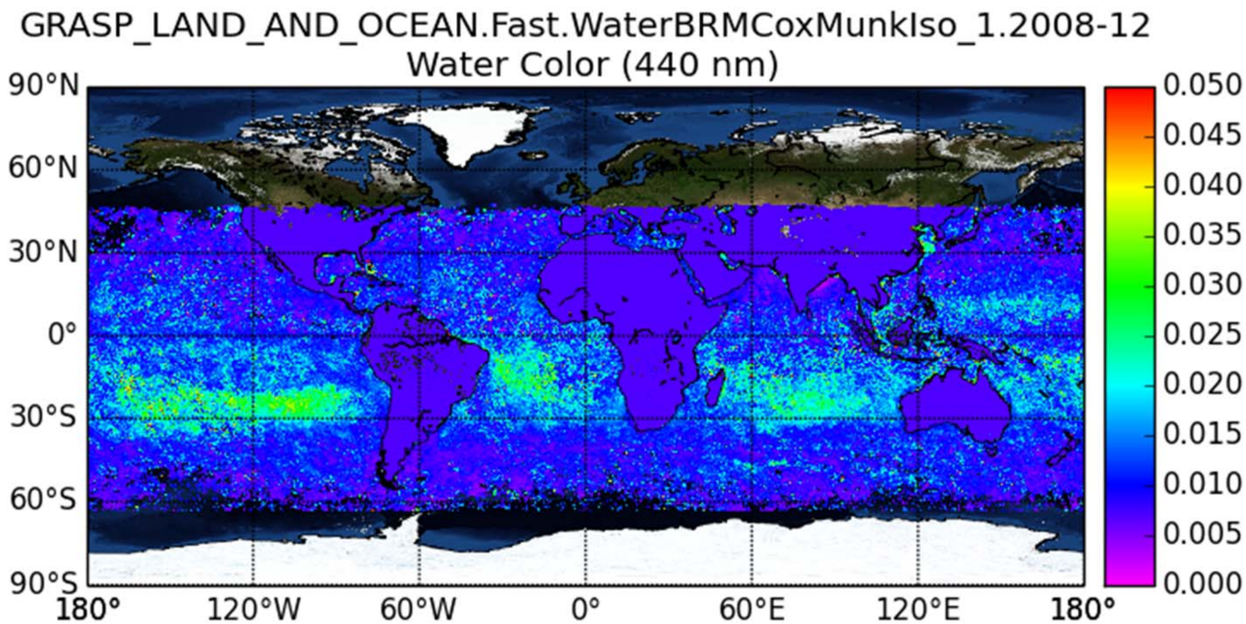






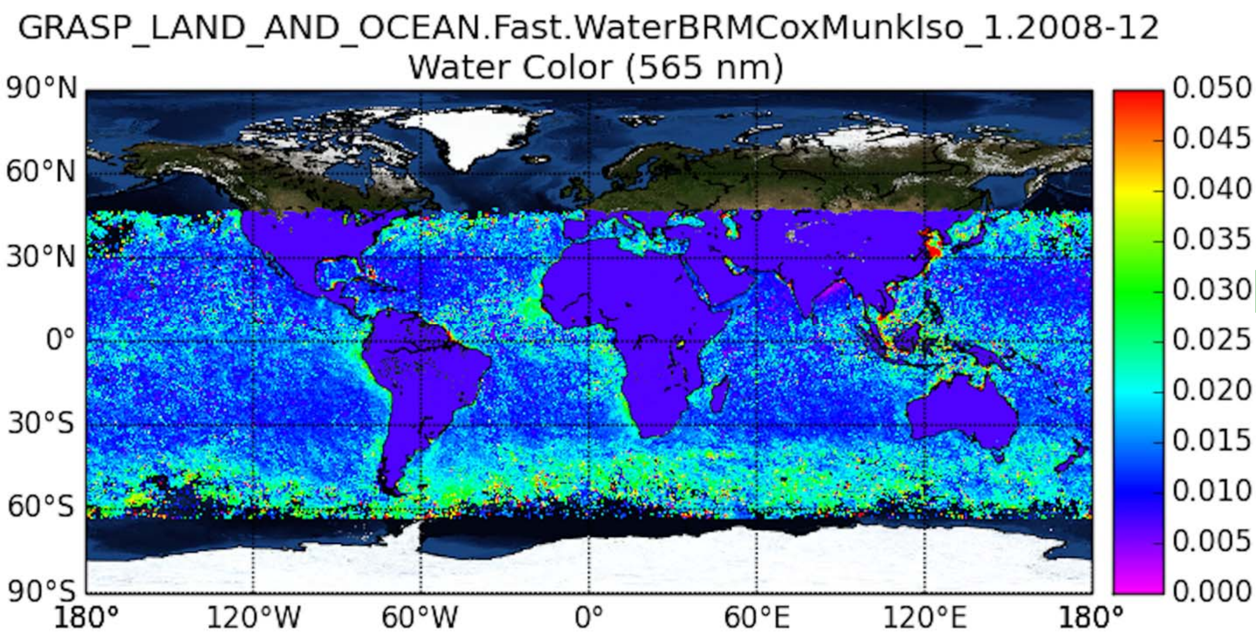
PARASOL water living radiance

December 2008,



« Blue » water

« clean »



« Green » water

« bio active »,

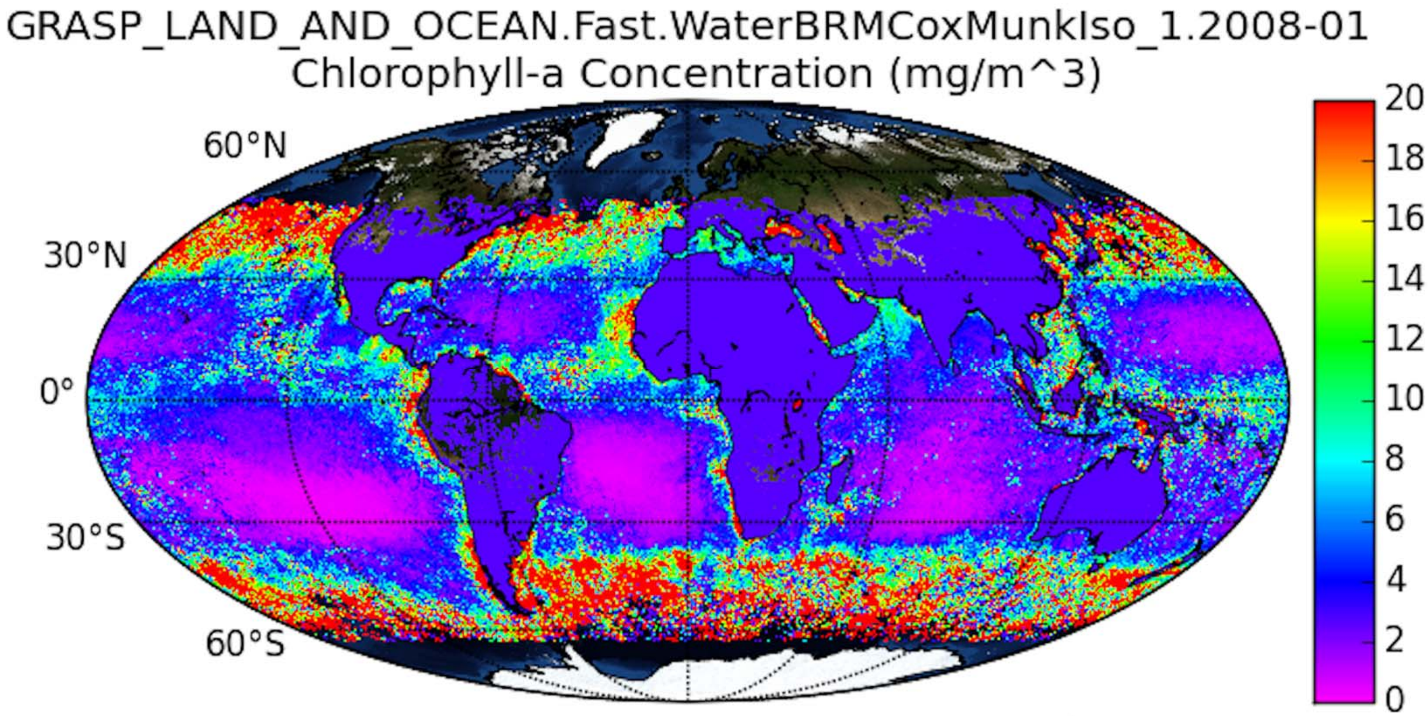
bio-active (phytoplankton), etc.

PARASOL 2008

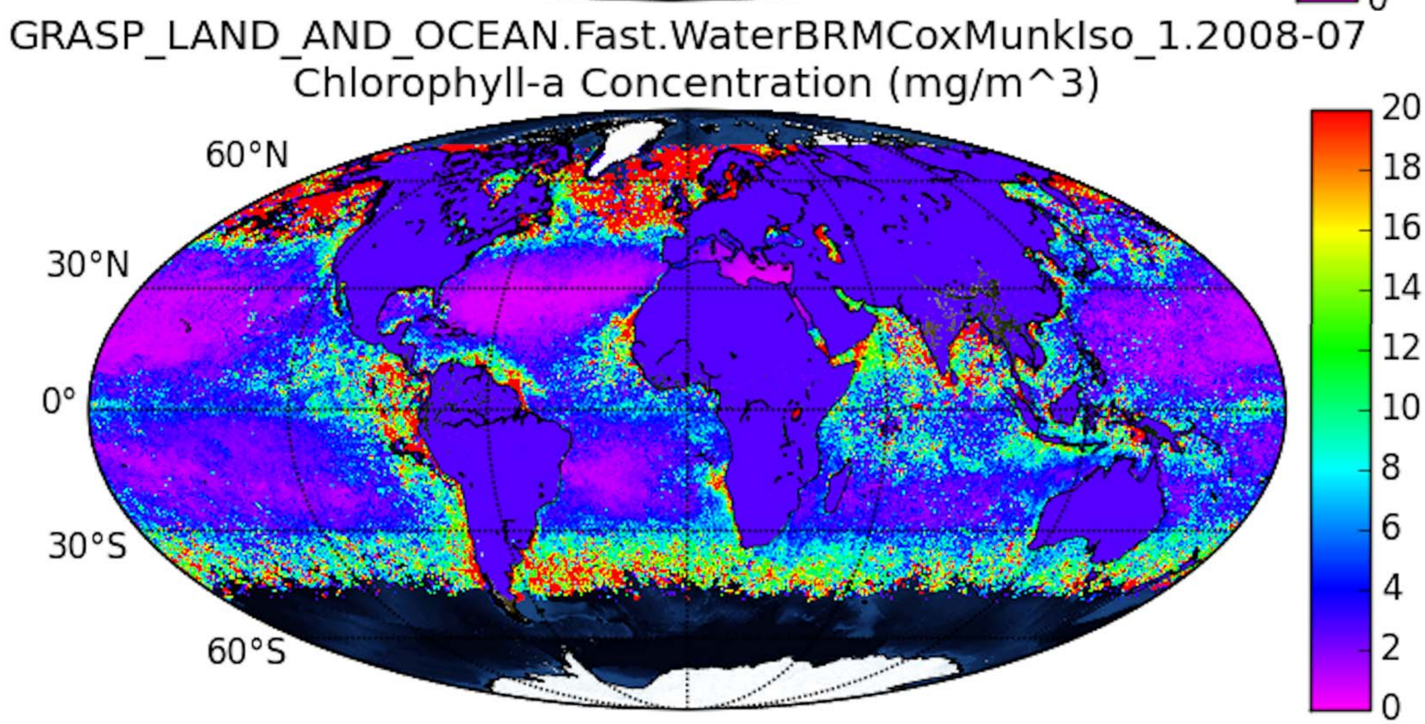
Chlorophyll

Preliminary result…

January

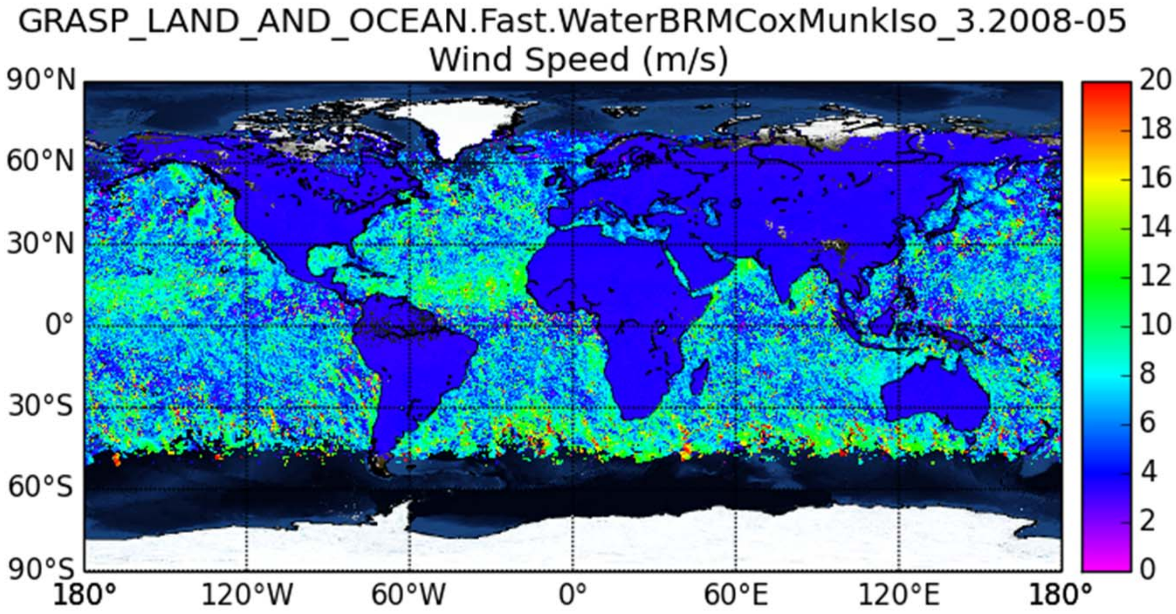


July

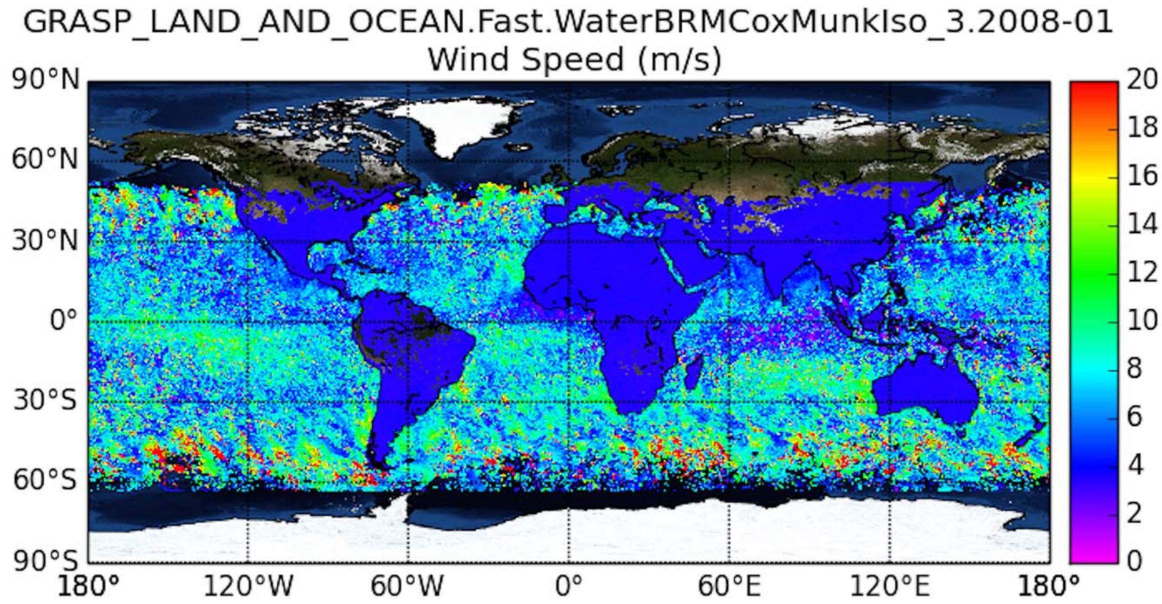


PARASOL # 2008

May



January



PARASOL:

- radiances: *(443, 490, 560, 670, 870, 1020 nm)*
- polarization: *(490, 670, and, 870 nm)*
- up to 16 viewing directions

144 measurements

≠

MERIS:

- radiances: *(413, 443, 490, 510, 560, 665, 755, 870)*
- 1 viewing direction

8 measurements

What are the differences in the results?

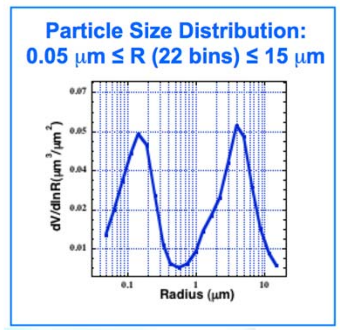
MERIS:

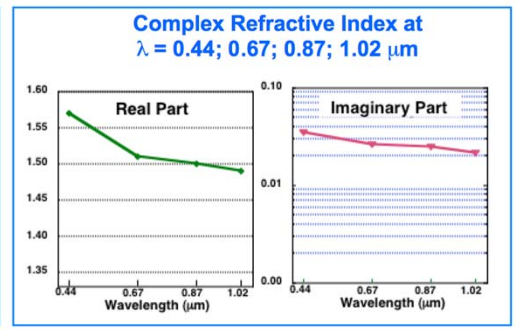
- radiances: *(413, 443, 490, 510, 560, 665, 755, 870)*
- 1 viewing direction

8 measurements

AEROSOL:

- size distribution (5 or more bins)
- spectral index of refraction (8 λ)
- sphericity fraction;



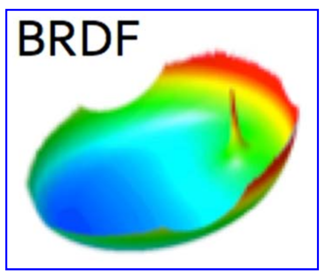


$$\tau^{aerosol}(\lambda) = C_i \sum_{i=1,\ldots,5} \int_{r_{min}}^{r_{max}} K_\tau^i(k_i;n_i;\varepsilon_i;r)V_i(r)dr$$

SURFACE:

- BRDF

(3 parameters)



43 = (5 (SD) +16 (r. ind.) + 1(nonsp.) + 21 (BRDF)) ⟶ 25 = (4 (aer. comp.) + 21 (BRDF))

GRASP/MERIS 2002- 2012 product has been generated

10 km resolution

GRASP/MERIS:
year 2008 averages

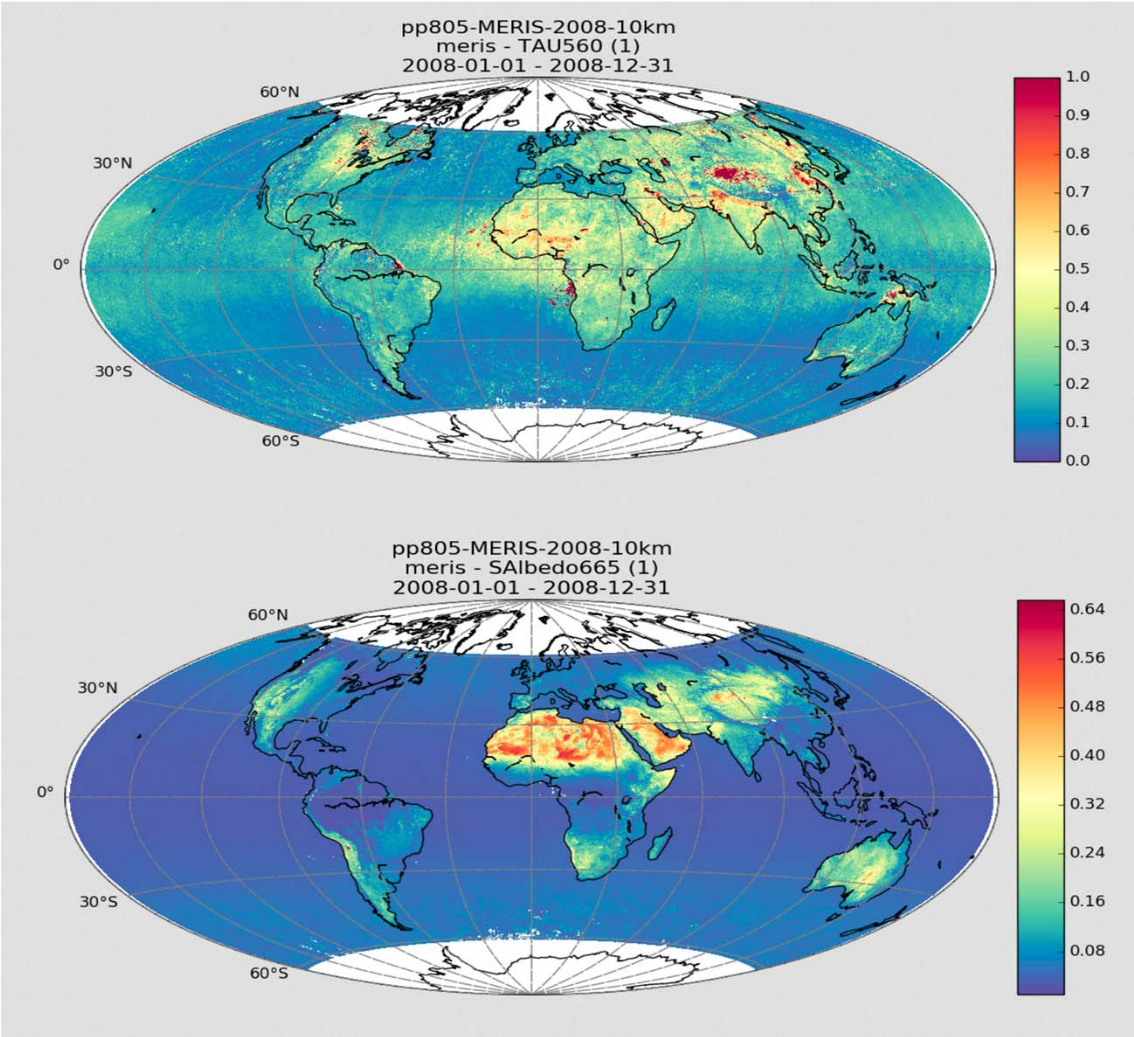
AOD(560 nm)

No location specific assumptions !!!

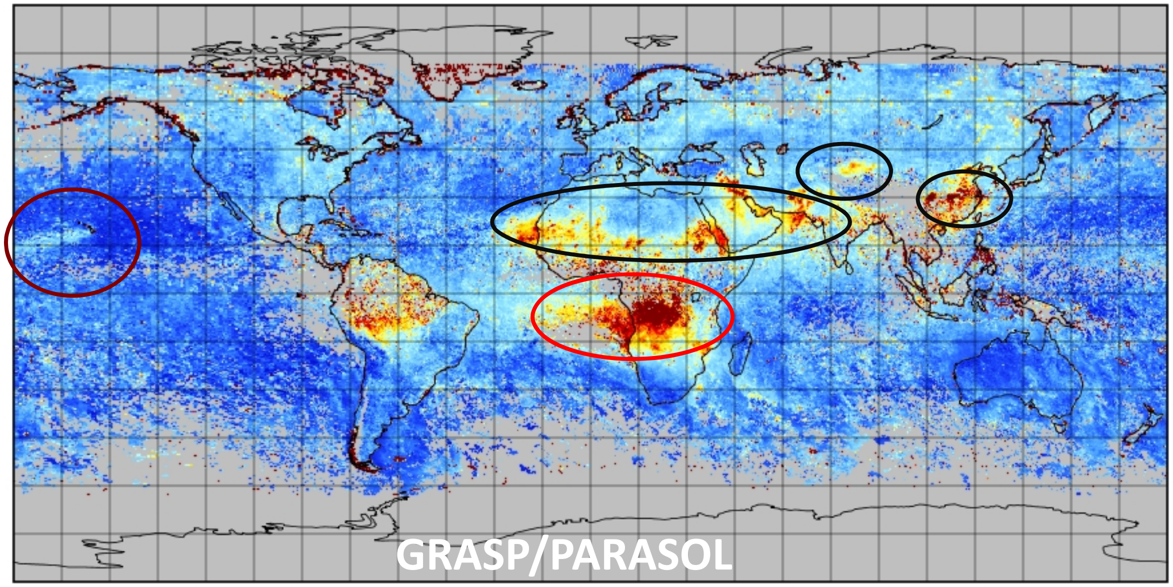
No climatologies!

Surface Albedo (670 nm)

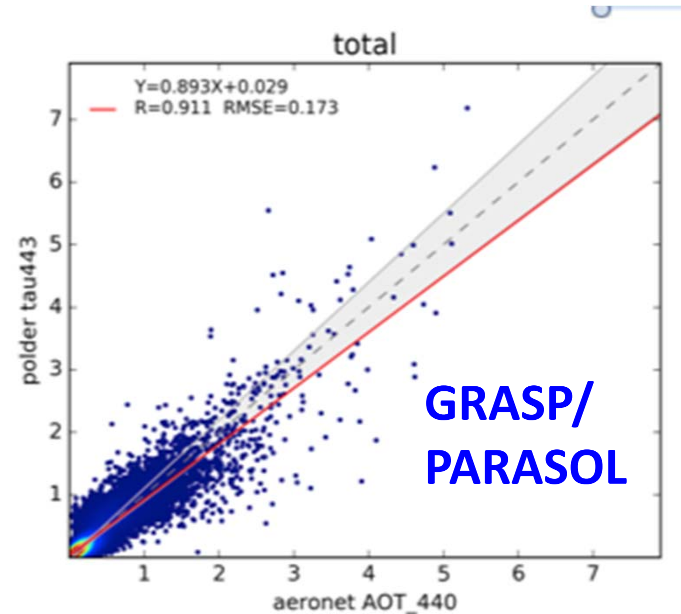
ESA CAWA project

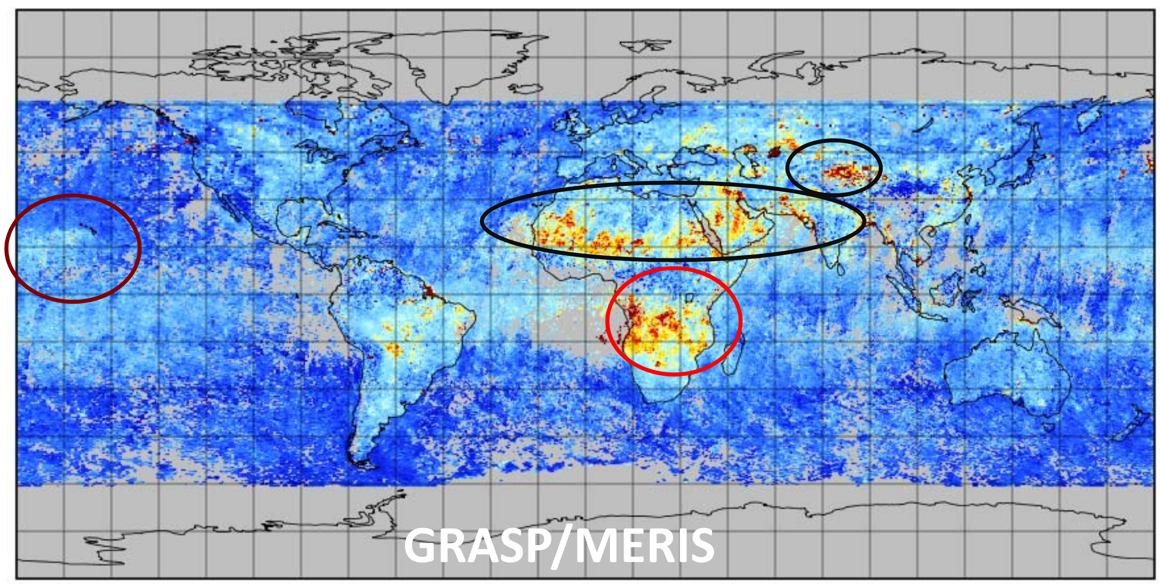


September, 2008

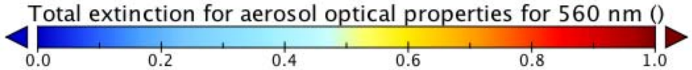


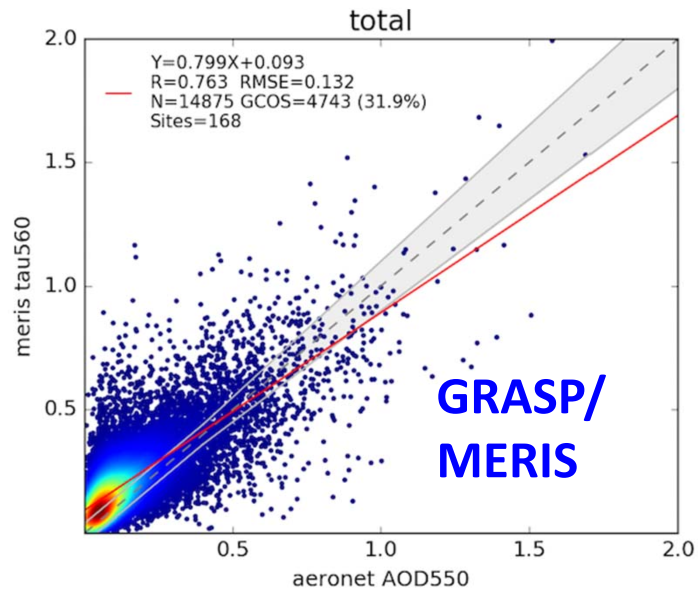
Total extinction for aerosol optical properties for 560 nm



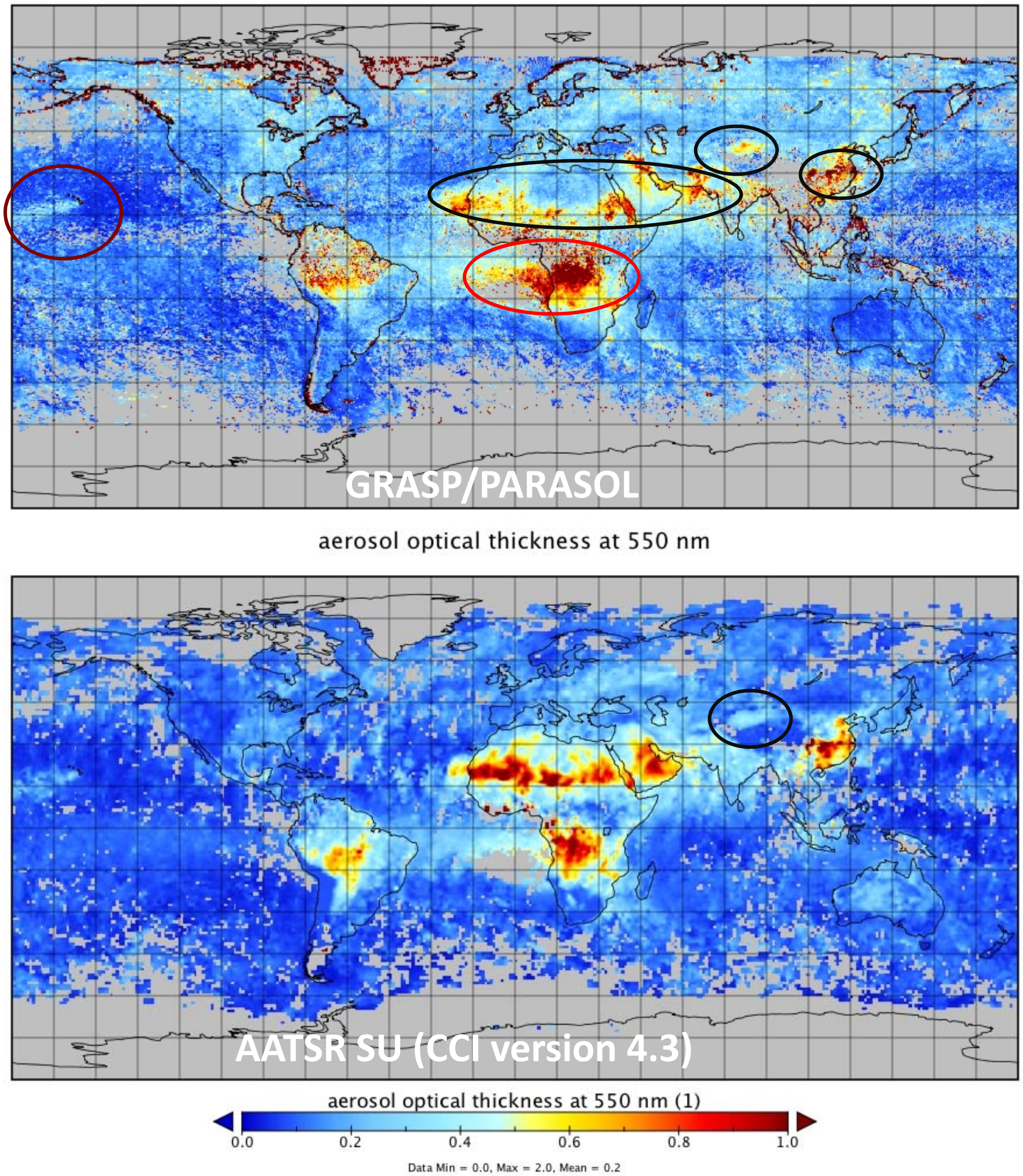


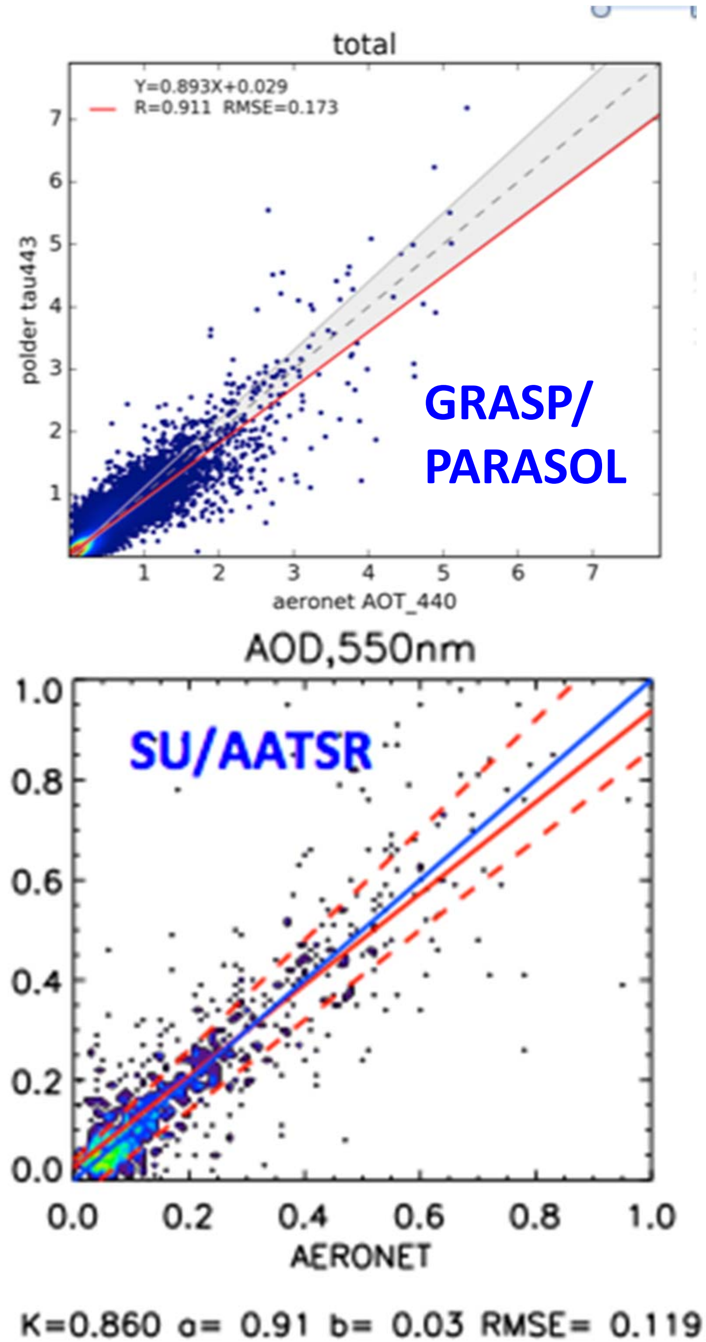
Total extinction for aerosol optical properties for 560 nm ()





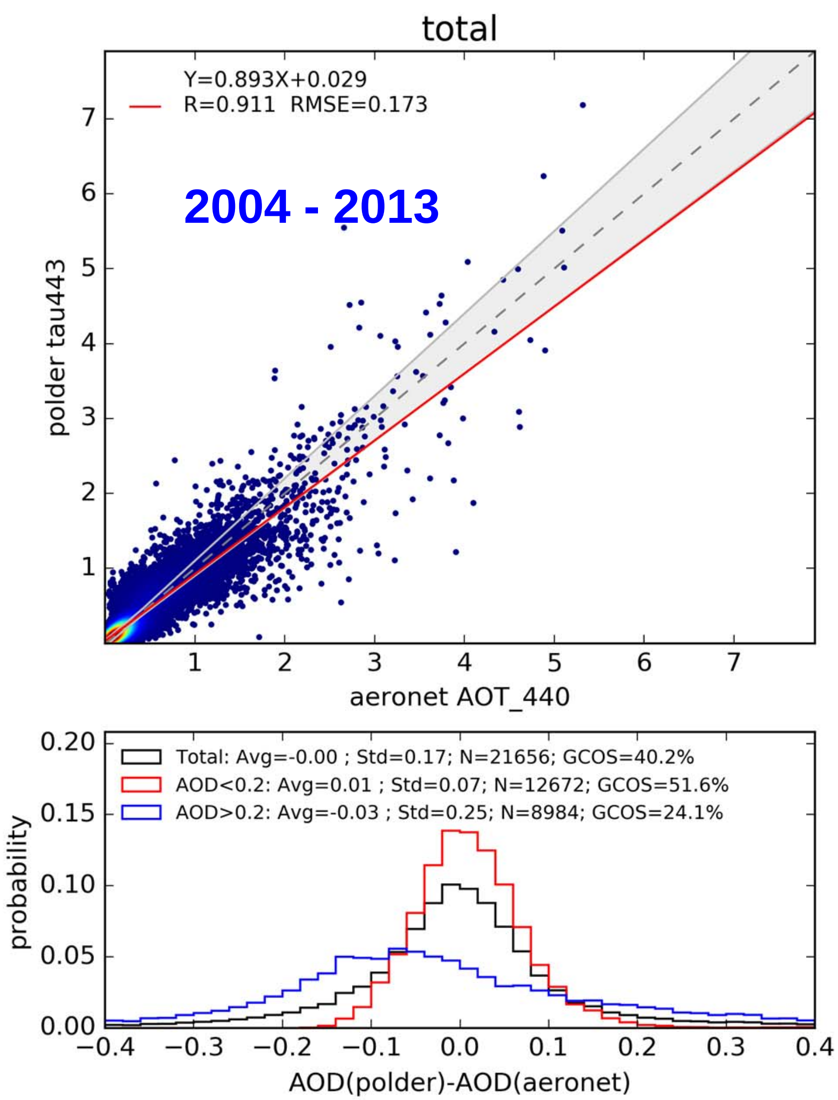
September, 2008 September, 2008



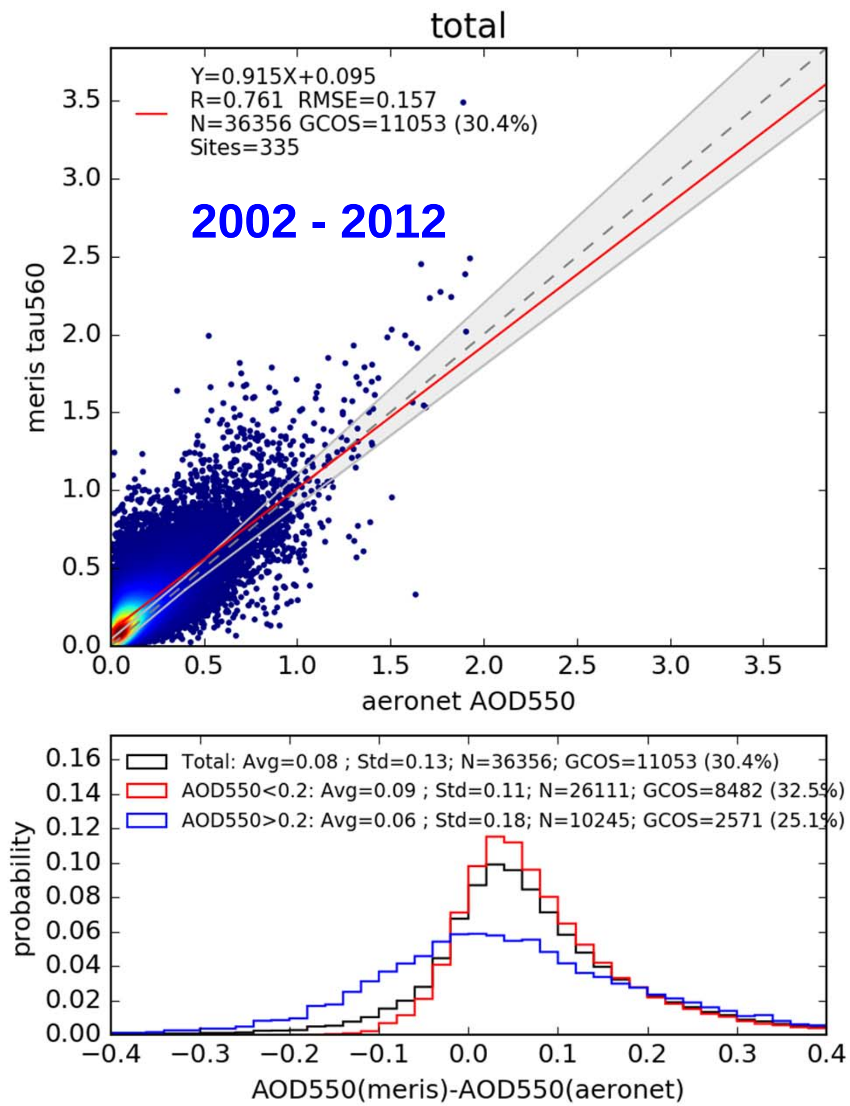


Validation vs AERONET, AOD over land

PARASOL/GRASP, R=0.91



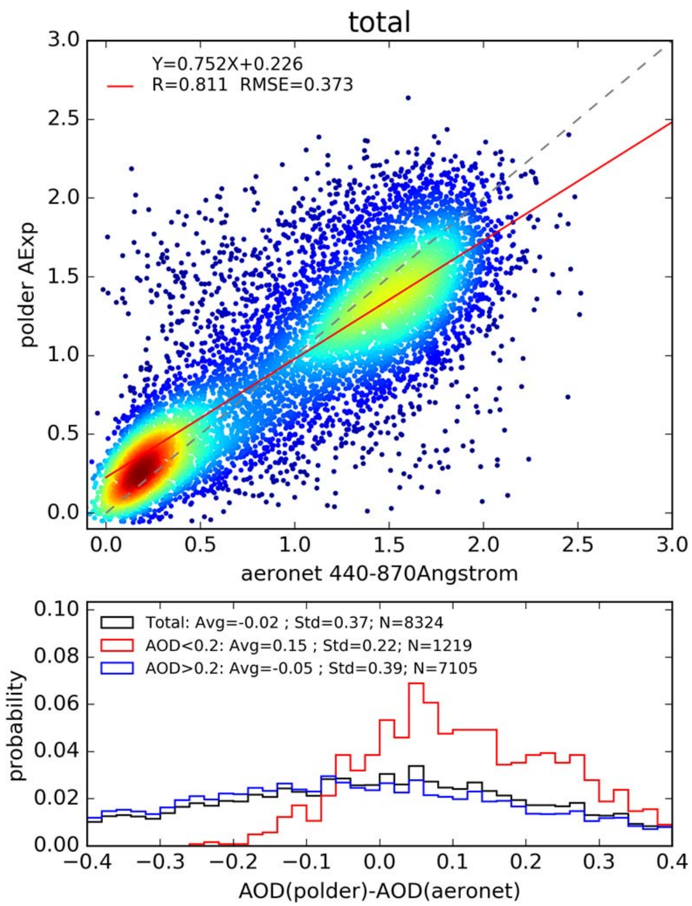
MERIS/GRASP, R=0.76



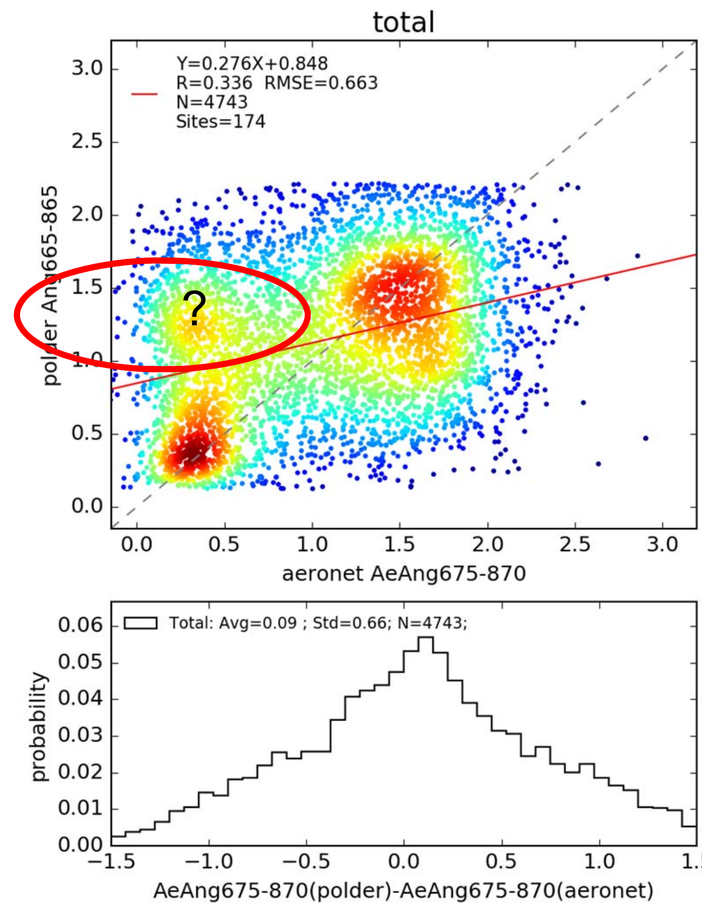
Validation vs AERONET over land

Angstrom

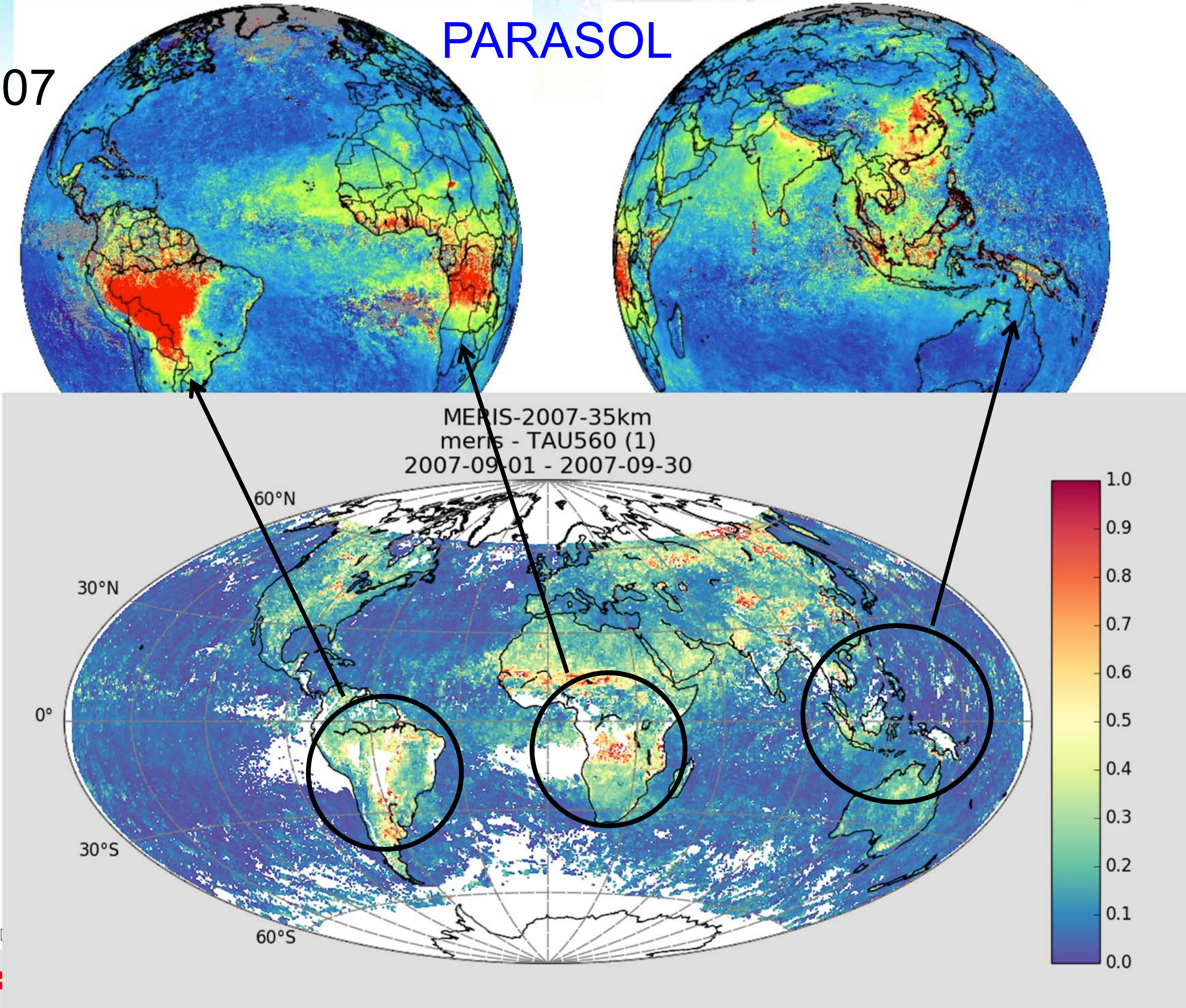
GRASP/PARASOL



GRASP/MERIS



Fall, 2007


PARASOL
MERIS-2007-35km
meris - TAU560 (1)
2007-09-01 - 2007-09-30
60°N
30°N
0°
30°S
60°S
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0

Mongu, 1200x 1200 zone.

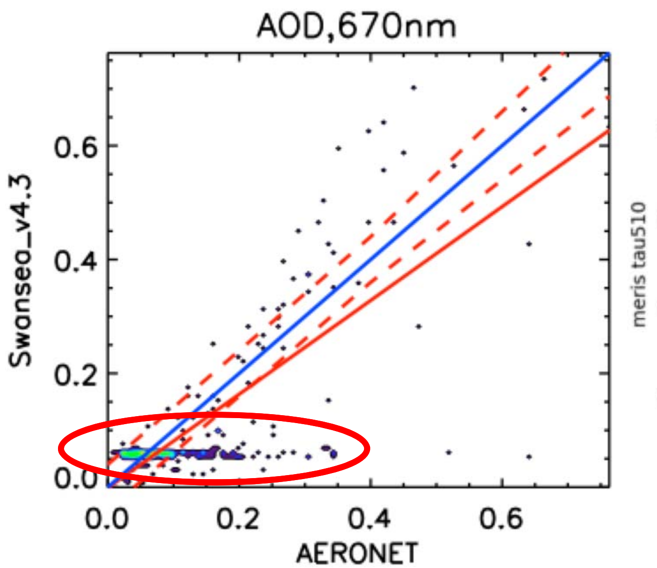
2002-2012

AATSR / SU, R=0.76

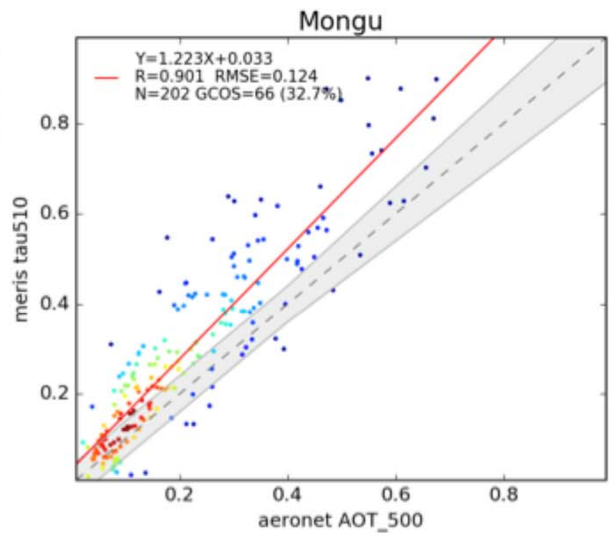
MERIS / GRASP, R=0.91

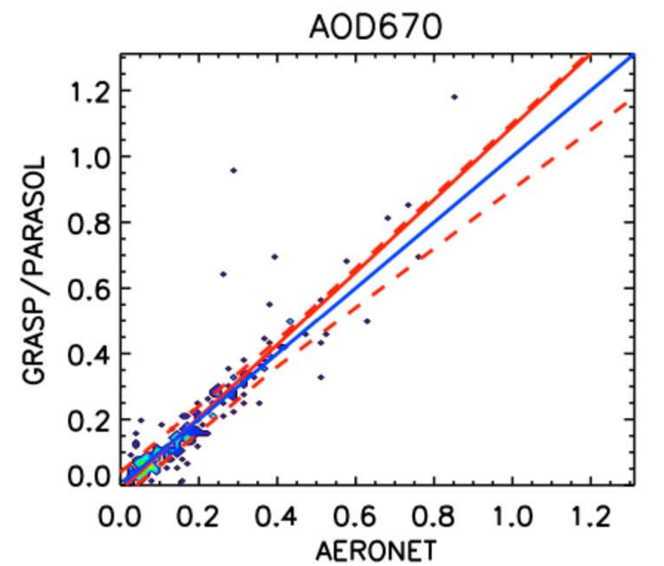
2004-2013

PARASOL / GRASP, R=0.91



K=0.760 a= 0.82 b=-0.00 RMSE= 0.101





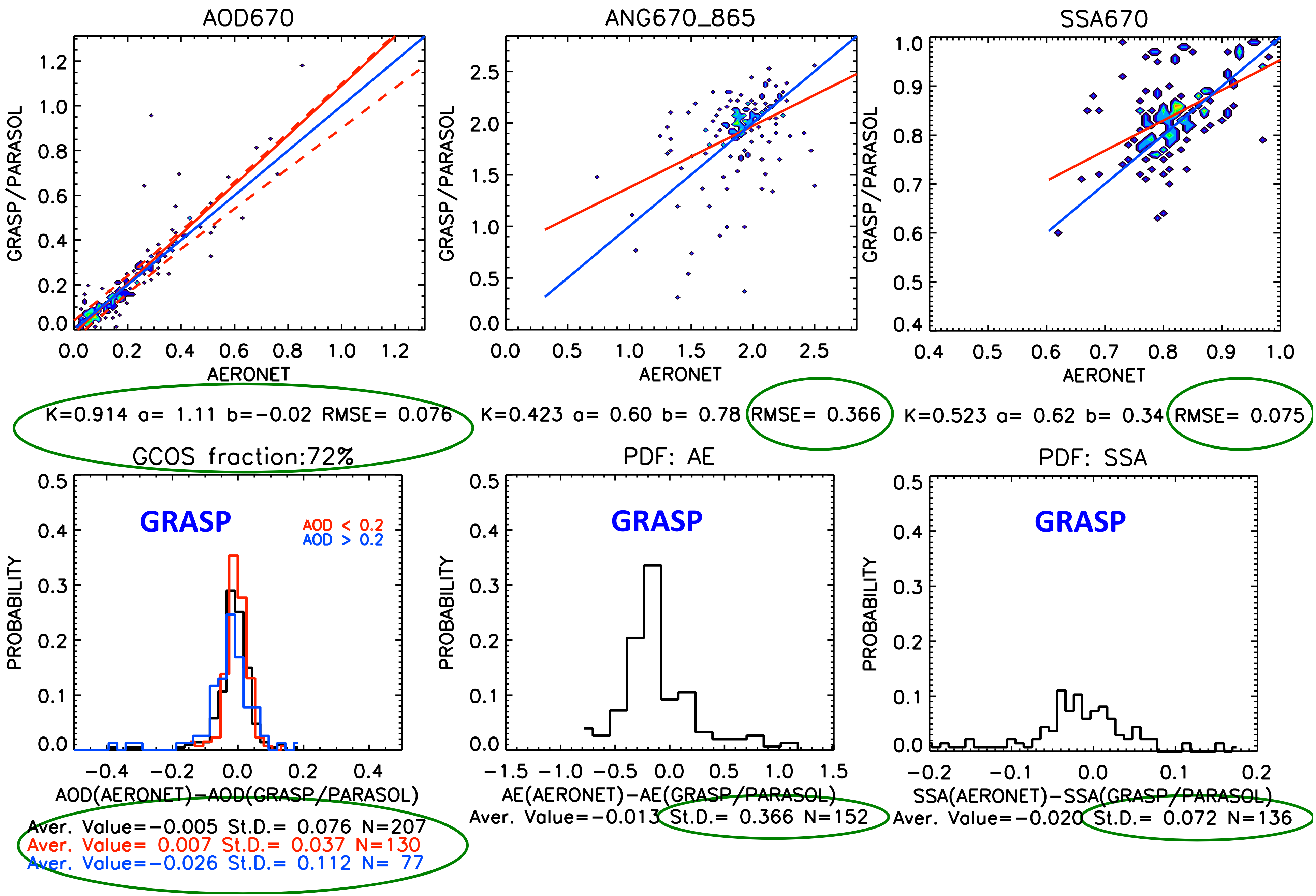
K=0.914 a= 1.11 b=-0.02 RMSE= 0.076

AATSR - fails with aerosol model ???

MERIS is surprisingly good with R, but slope is wrong ???

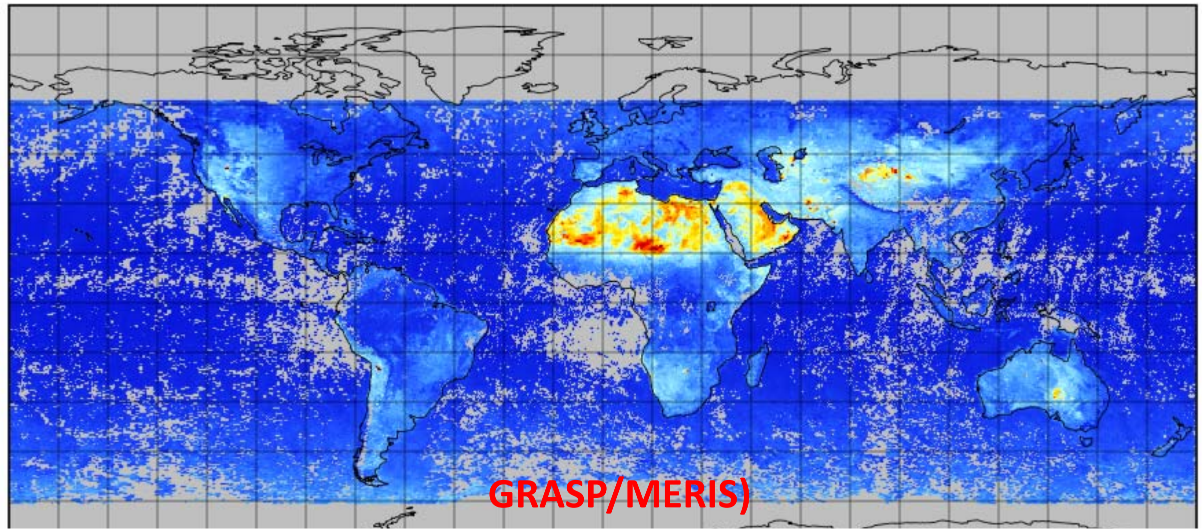
PARASOL could be better???

Mongu, 1200x 1200 zone. 2005-2013. 2 sites. GRASP

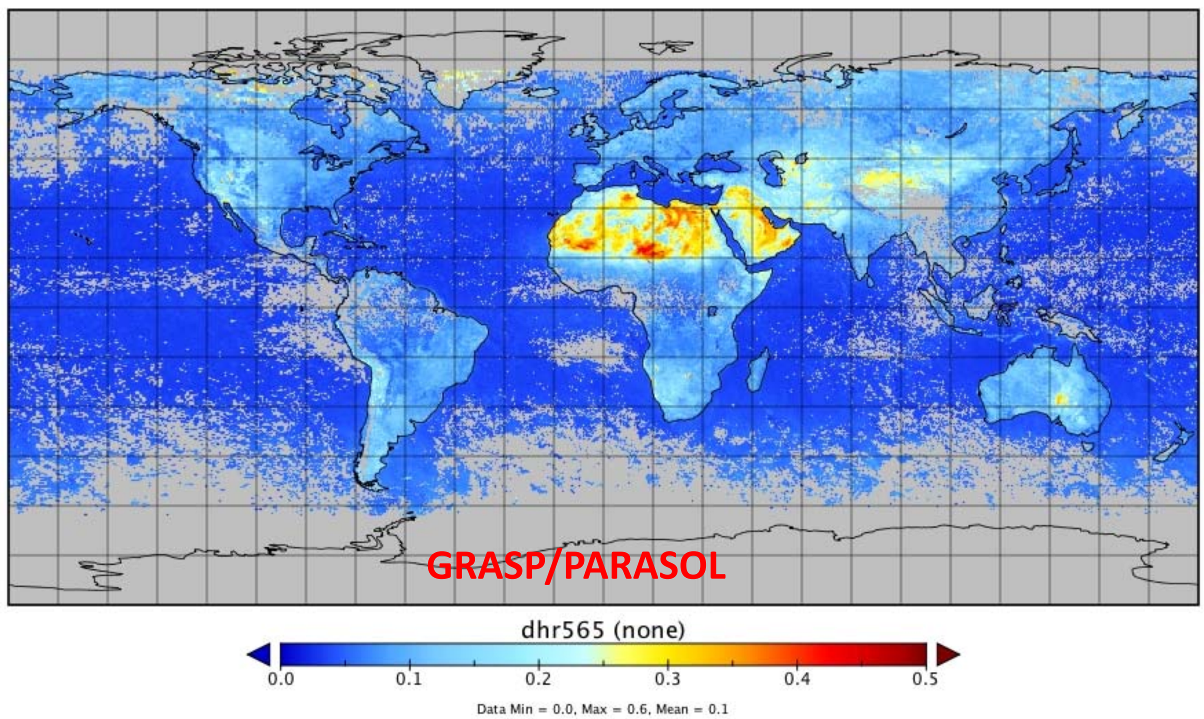


Comparison of surface reflectance

September, 2008

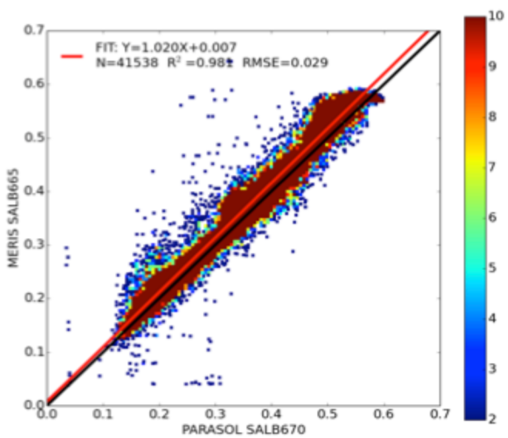


dhr565

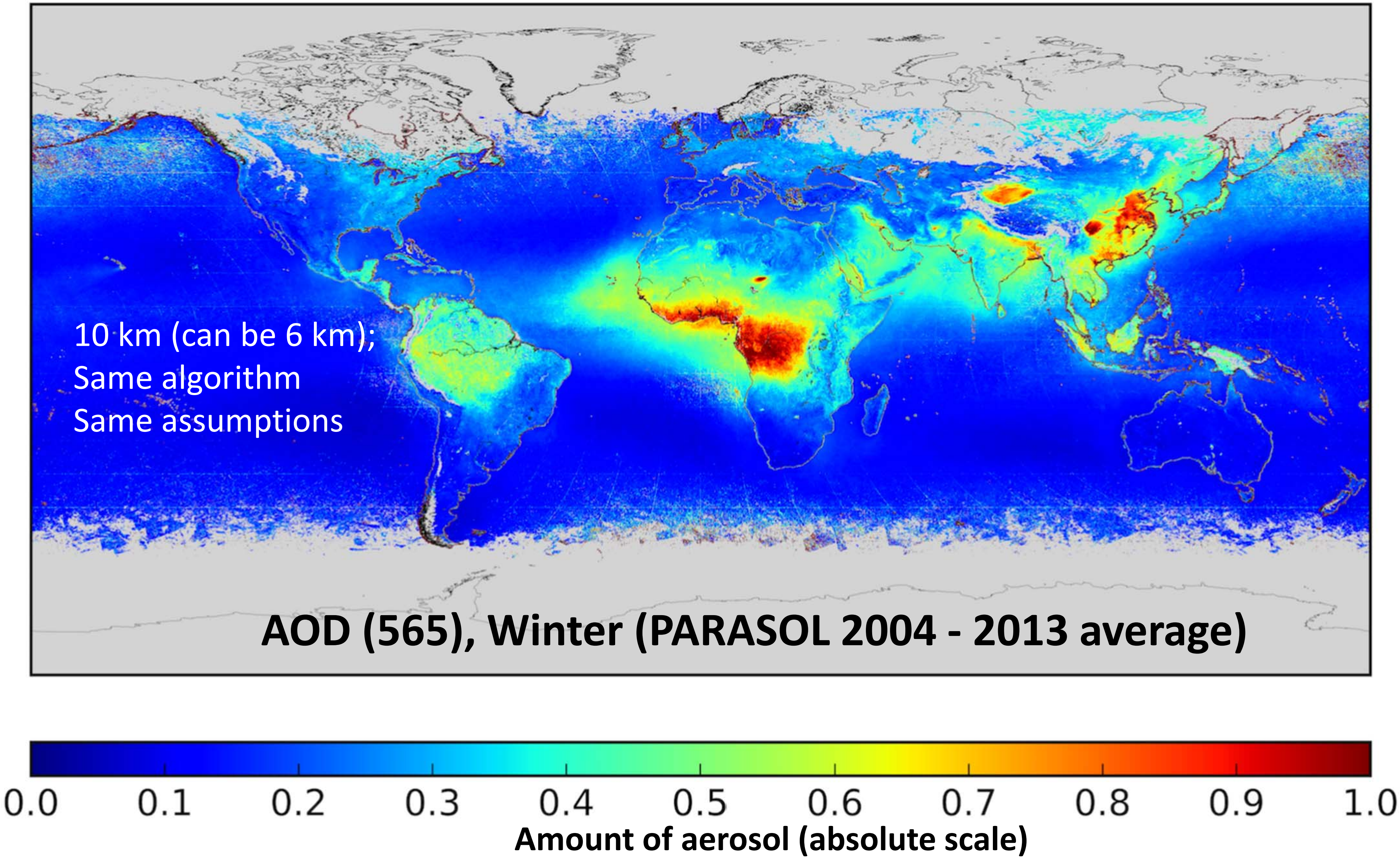


Good agreement !

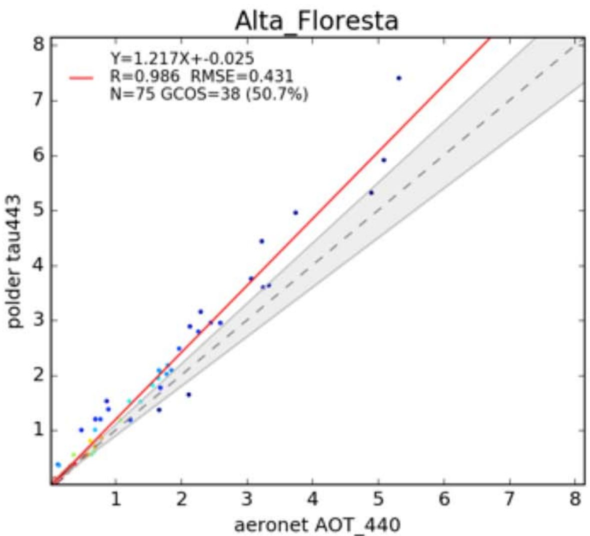
MERIS vs. PARASOL

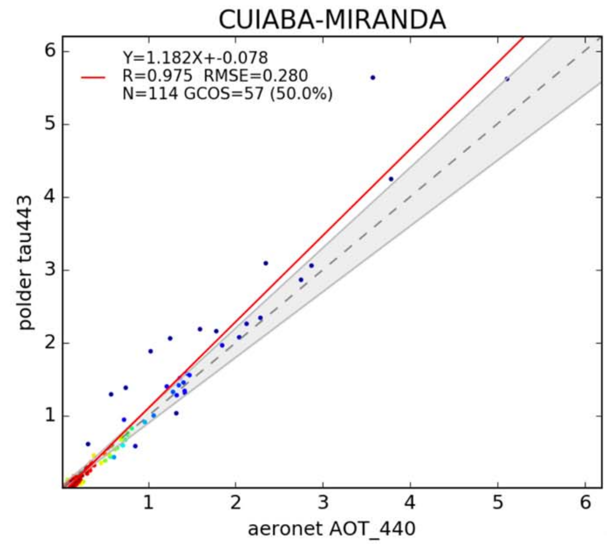


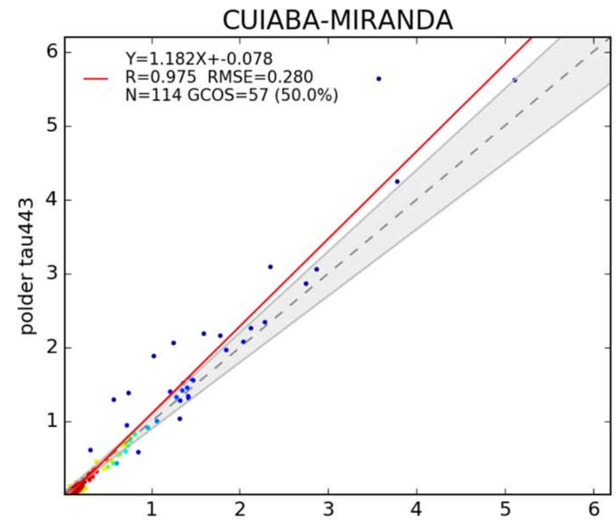
PARASOL/GRASP 2004- 2013 product has been generated

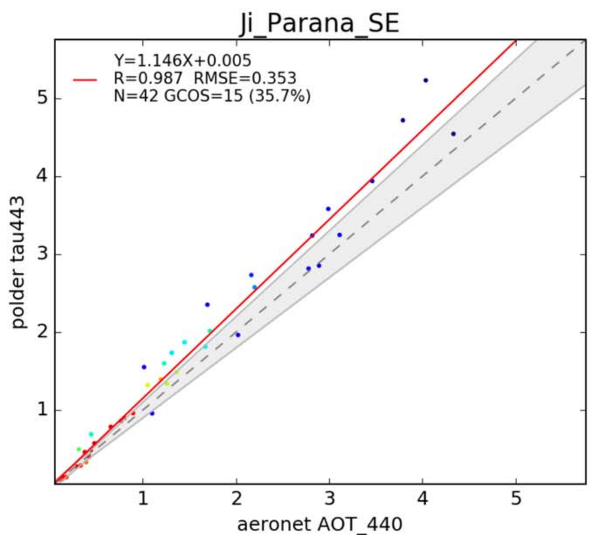


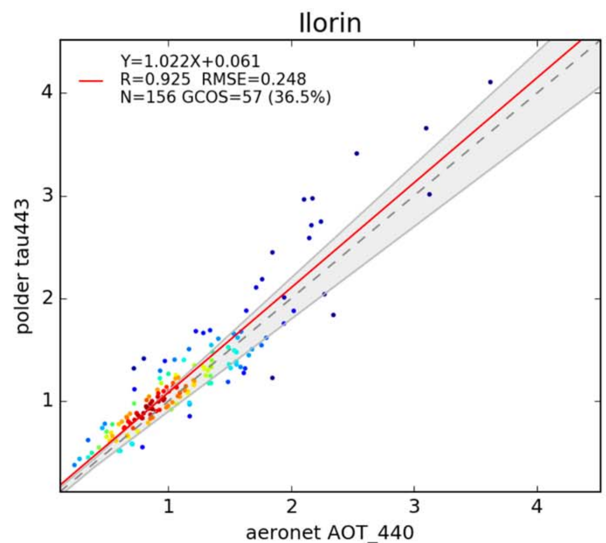
Validation against AERONET for high AOD biomass cases

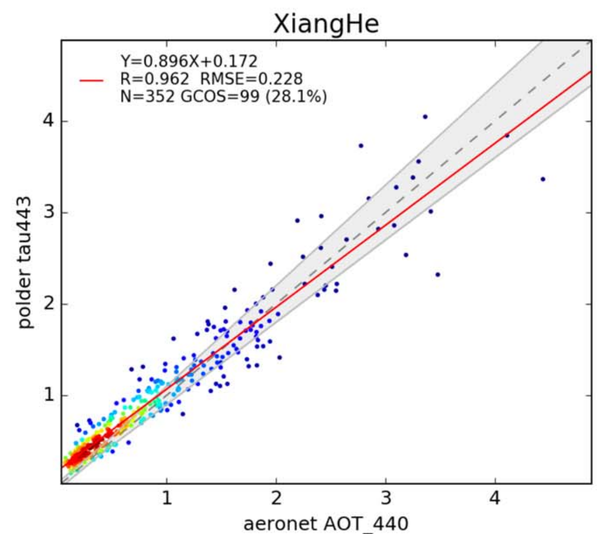




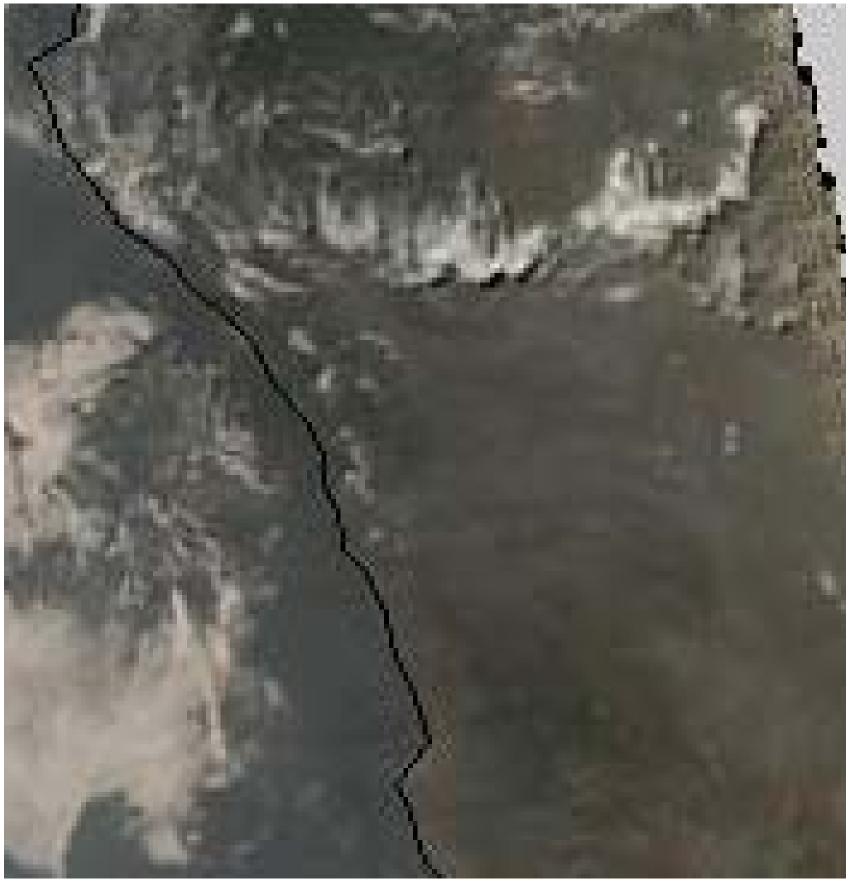


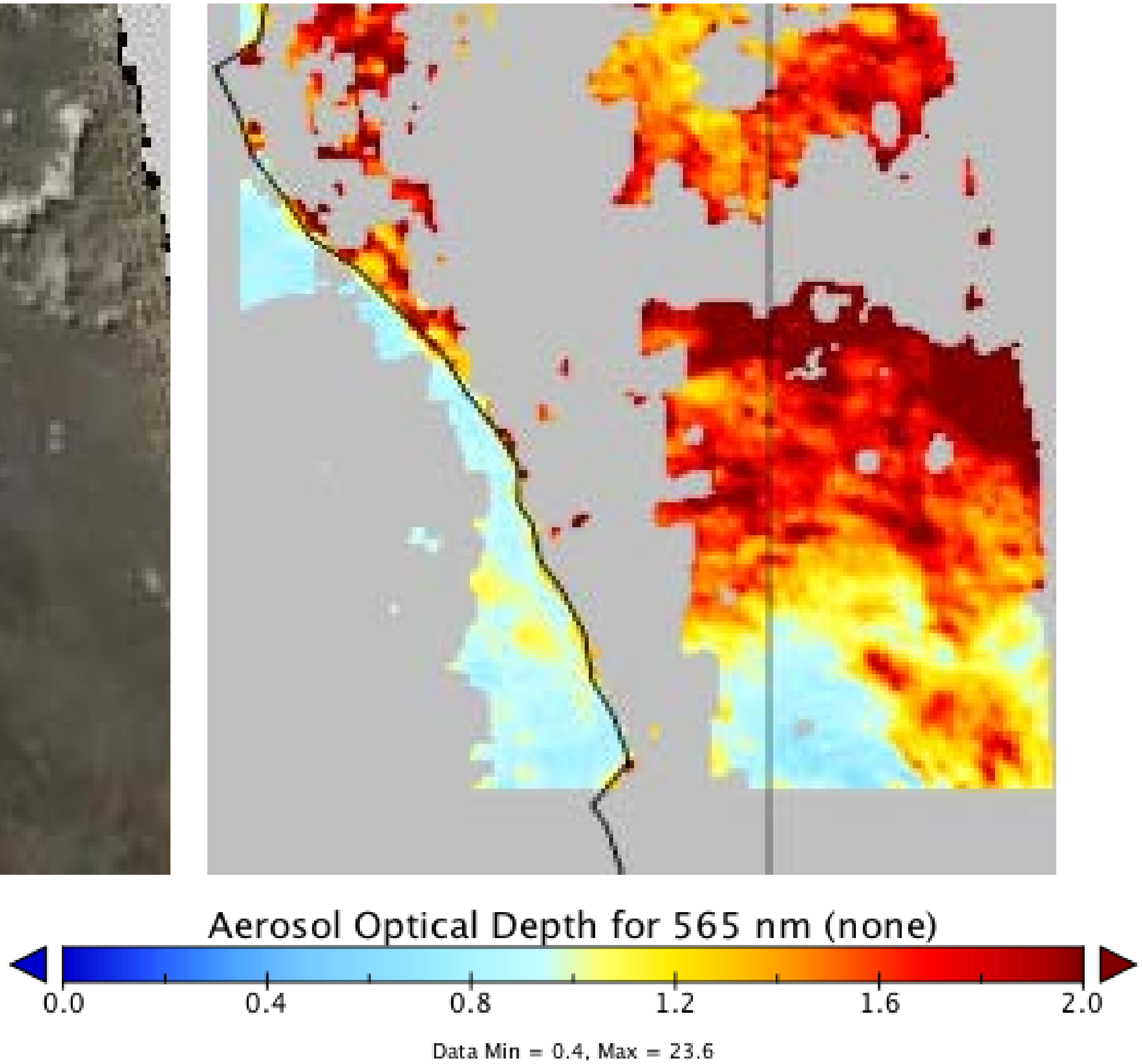






Biomass burning. Mongu region, August, 3, 2013

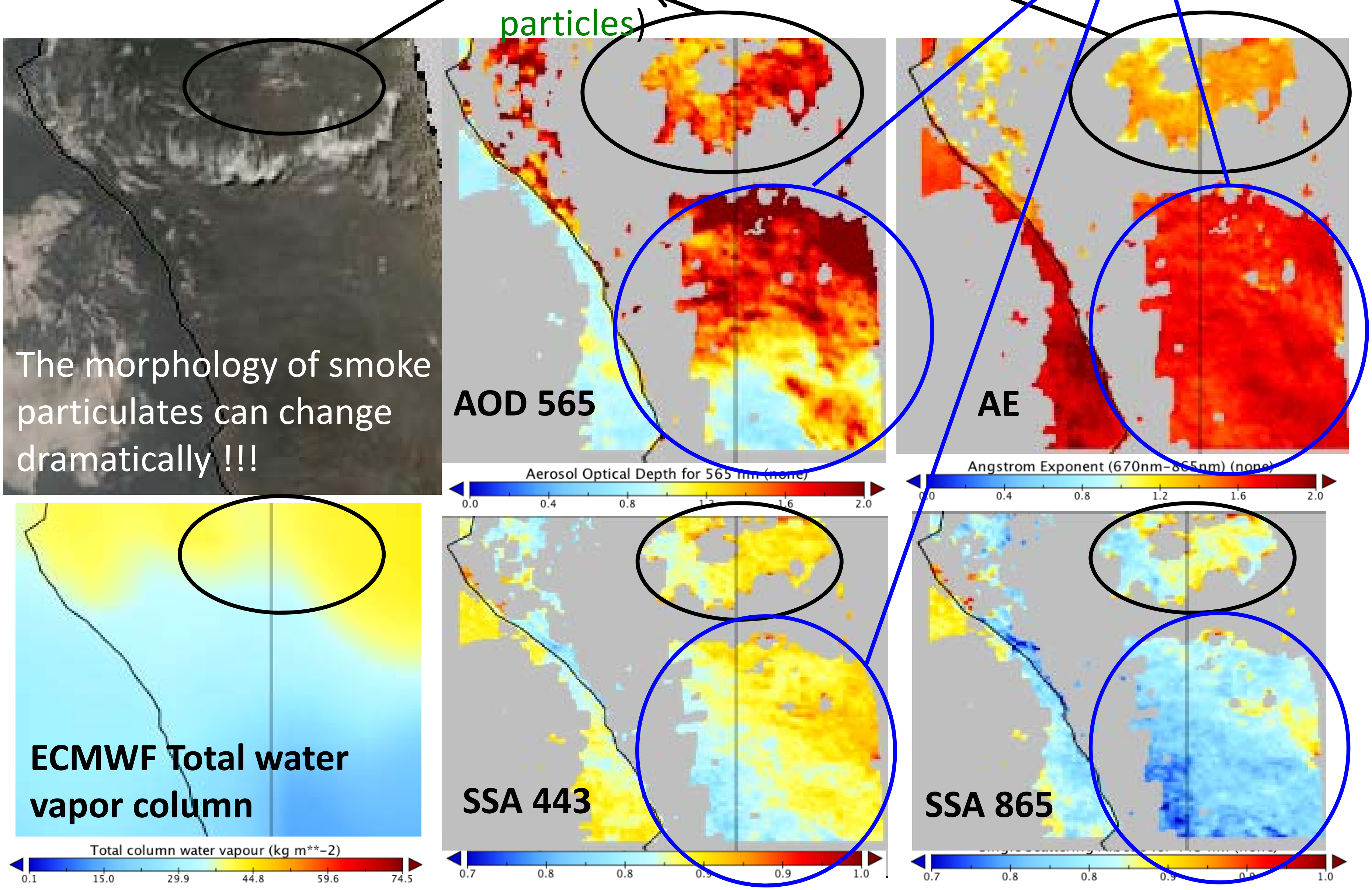




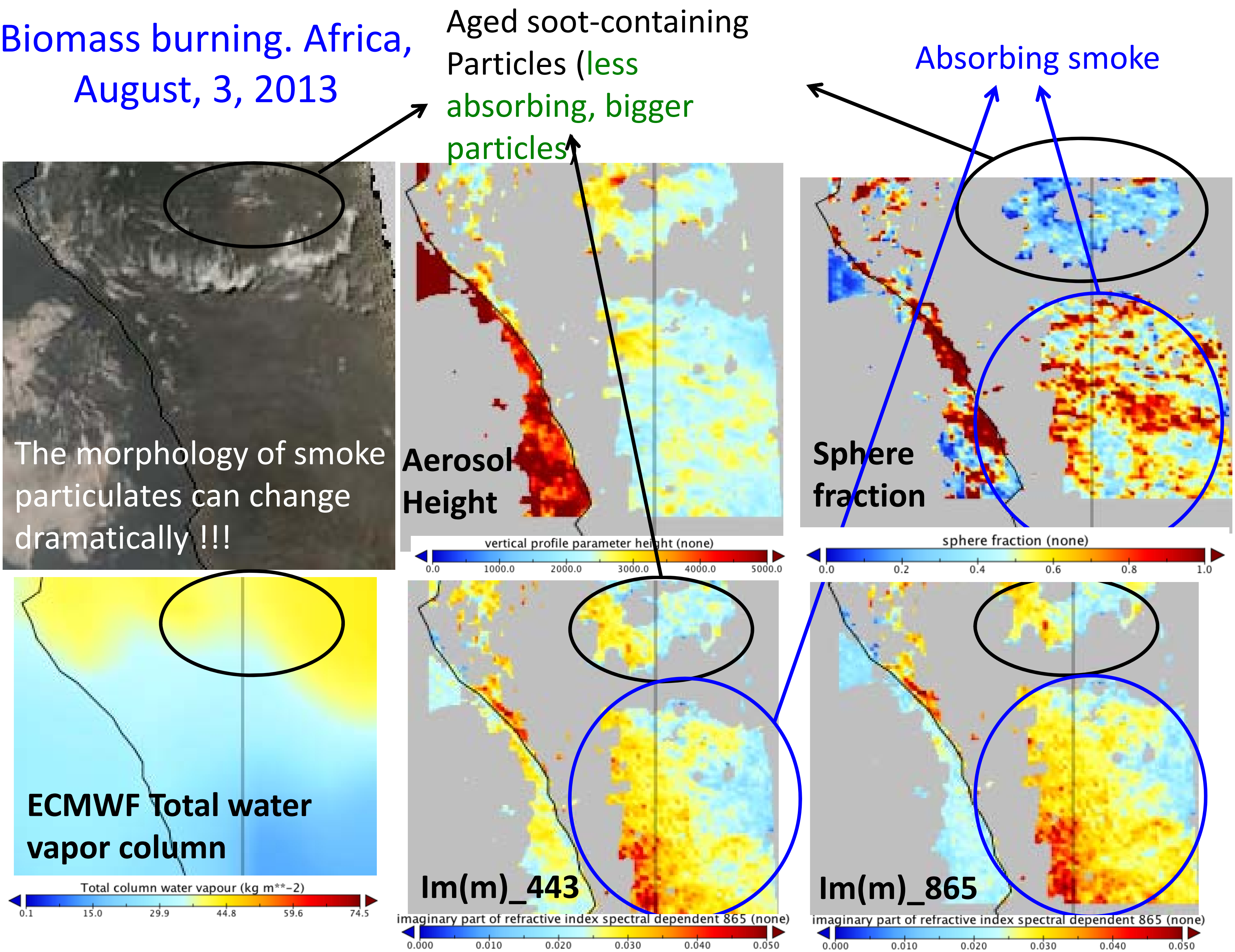
Biomass burning. Africa, August, 3, 2013

Aged soot-containing Particles (less absorbing, bigger particles)

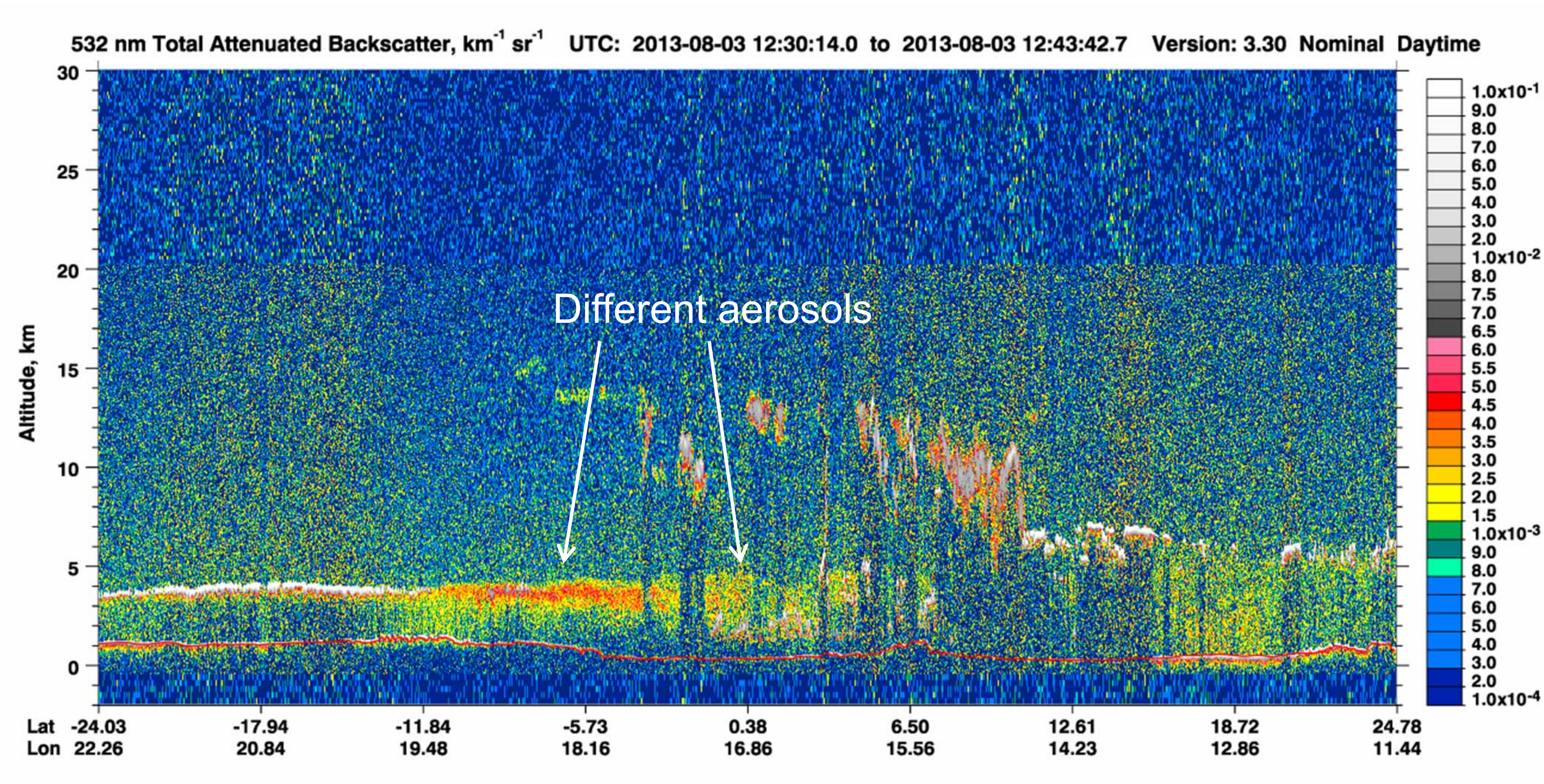
Absorbing smoke



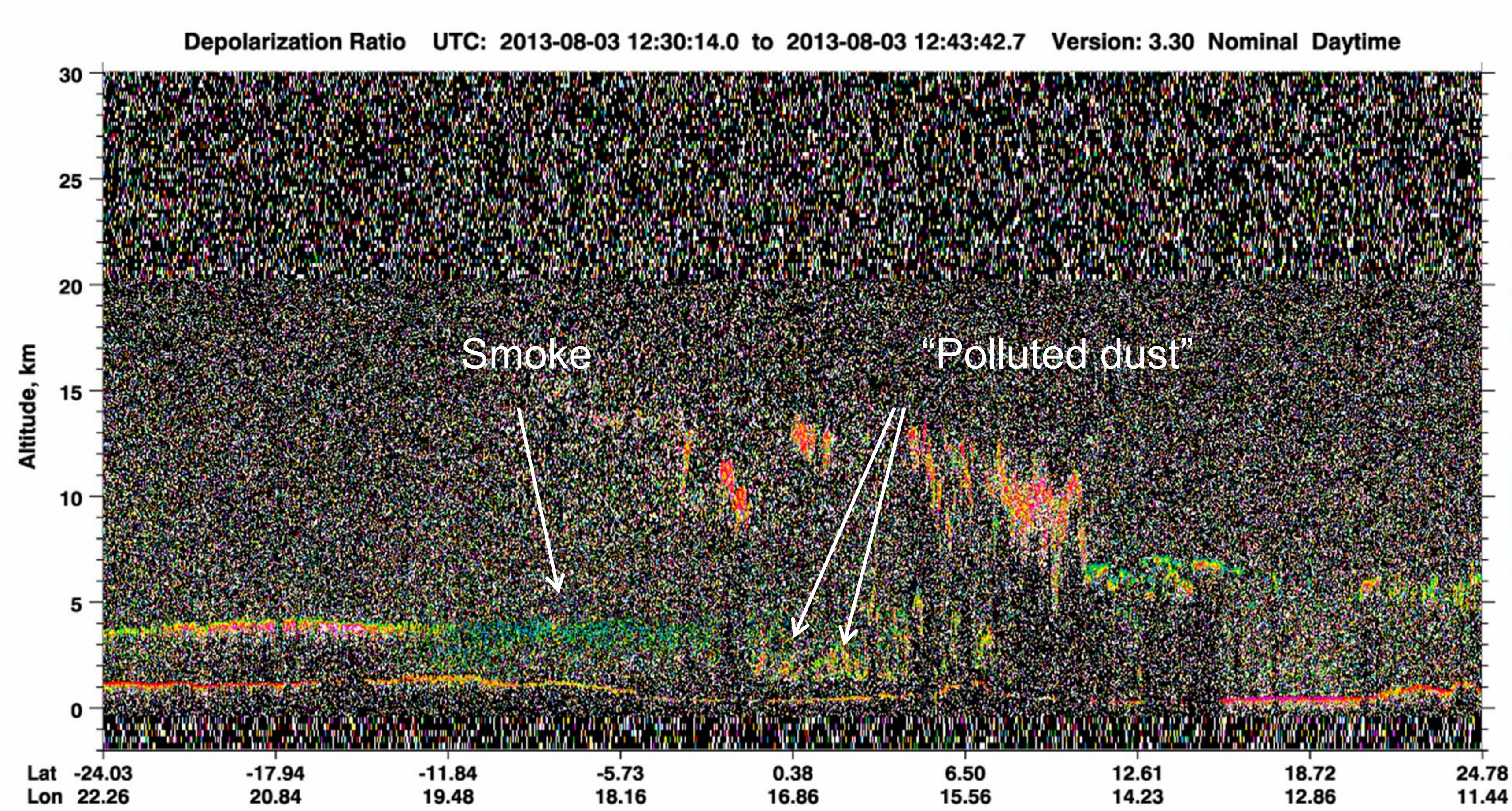
Biomass burning. Africa, August, 3, 2013



CALIPSO backscattering



CALIPSO depolarization



1st International Workshop on

Advancement of POLarimetric Observations

Calibration and improved aerosol retrieval

APOLO 2017

October 24-27, 2017   Hefei · China

- Welcome Letter
- Important Dates
- Organizing Committee
- Agenda
- Invited Speakers
- Registration
- Abstract Submission
- Venue
- Booking Hotel
- Sponsorship
- Tours Information
- Useful Information
- Contact Us

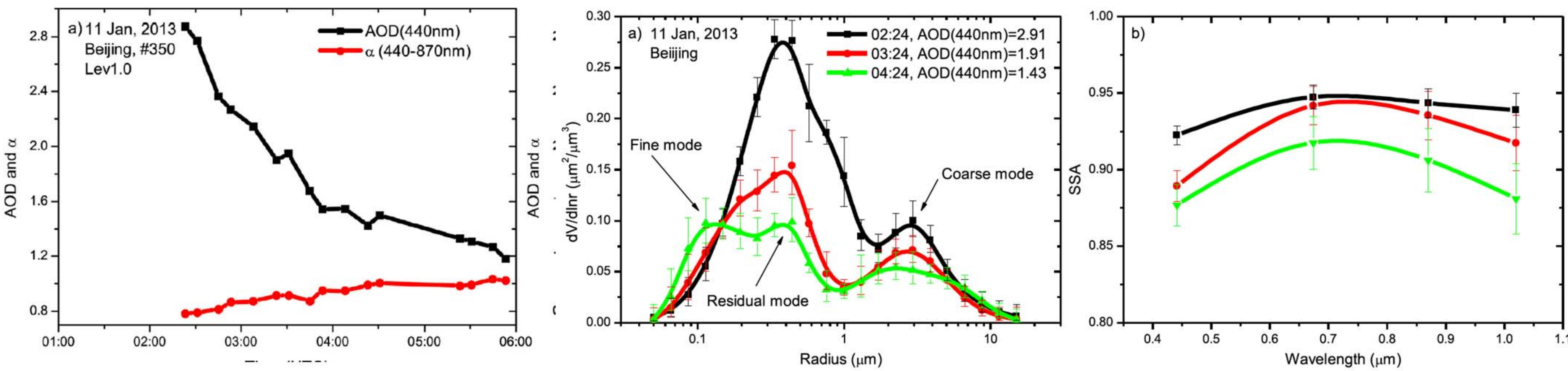
Welcome Letter

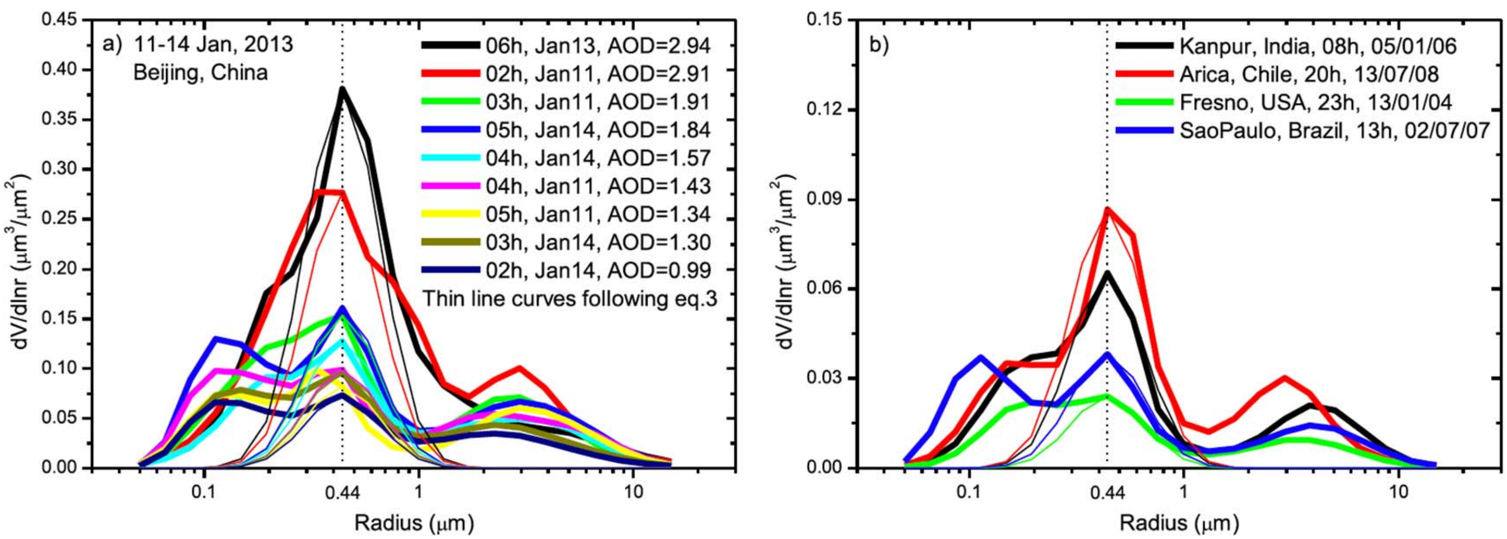
Dear colleagues,

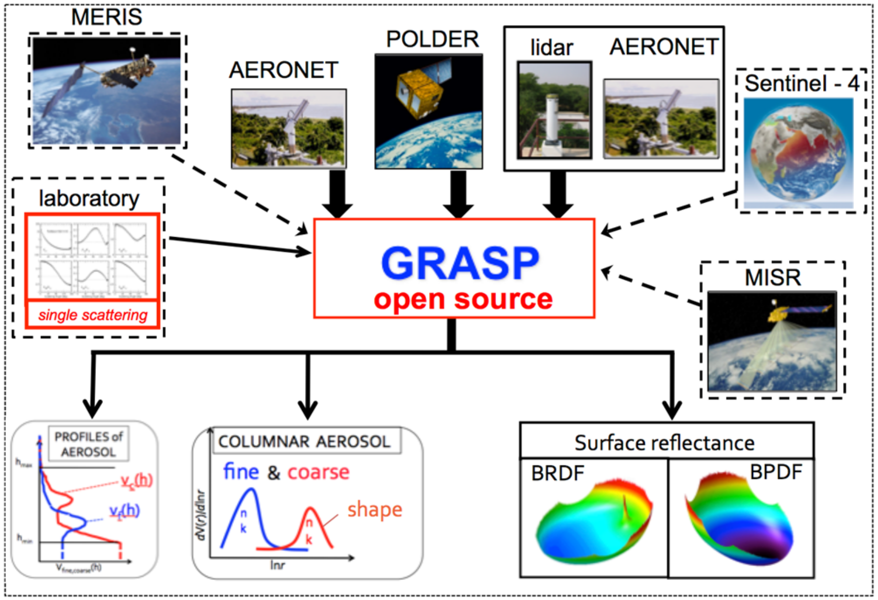
We are glad to announce that the 1st International Workshop on "Advancement of polarimetric observations: calibration and improved aerosol retrievals" (APOLO2017) will be held in Hefei, China from October 24 to 27, 2017. This is the first workshop of a series of polarimetry workshops (http://www-loa.univ-lille1.fr/workshops/APOLO-2017).

Several polarimetric missions are scheduled for launch in the coming years by international and national space agencies. Satellite polarimetry is one of the most promising and, at the same time, largely underexploited fields of aerosol remote sensing. This is the 1st meeting of the planned series of workshops on satellite polarimetry. These scientific workshops aim to promote international collaboration as well as in-depth exchange of ideas and experiences on diverse aspects of polarimetric remote sensing, in particular: advances in the theory of polarimetric remote sensing, optimisation of strategies of polarimetric Earth observations, improvement of polarimetric observation quality and information content, advancement of retrieval algorithms and data processing, and long-term Cal/Val.

Climatology (Beijing, China) Li et al. 2014







Strength of GRASP algorithm concept:

- ✓ Based on accurate rigorous physics and math;
- ✓ Versatile (applicable to different sensors and retrieval of different parameters);
- ✓ Designed for multi-sensor retrieval (satellite, ground-based, airborne; polar and geostationary,);
- ✓ Not-stagnant (different concept can be tested and compared within algorithm);
- ✓ Flexible:
  - generalizable (to IR, hypo spectral, to retrieval of gases and clouds, etc.);
  - or degradable (to less accurate but fast solution, LUT,…);
- ✓ Practical (rather fast and easy to use for given level fundamental complexity);

Current and potential applications:

Satellite instruments:

polar: POLDER/PARASOL, 3MI/MetOp-SG, MERIS/Envisat, Sentinel-3 (OLCI, SLSTR), etc.

geostationary: Sentinel-4, FCI, GOCO, Himawari-8, etc.

Ground-based, airborne and laboratory instruments:

passive: AERONET radiometers, sun/luna/star-photometers, etc.

active: multi-wavelength elastic and non-elastic lidars; *airborne and laboratory*: *polar nephelometers,*

Multi-instrument synergy:

ground-based: lidar + radiometers + photometers , sun/luna/star-photometers, etc.

satellite: OLCI + SLSTR, polarimeter + lidar (e.g. PARASOL + CALIPSO)

Support: **CNES** (TOSCA, RD), **ANR** (CaPPA), **ESA** (S-4, MERIS/S-3, GPGPU, CCI, CCI-2,CC+); **EUMETSAT** (3MI NRT), **FP6-7** (ACTRIS 1-2), Catalysts GmbH, etc.

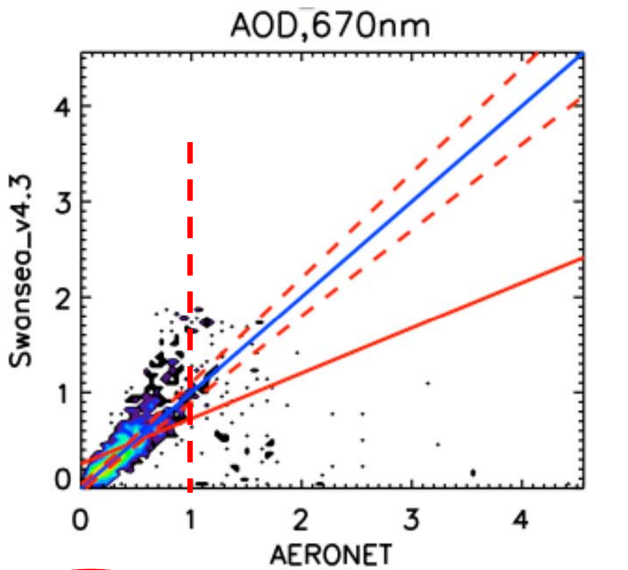
Collaborations: NASA/JPL, NASA/GSFC, NASA/GISS, NASA/Langley KNMI, JAXA, Catalysts GmbH (Austria), Chinese Academy of Science and Space Agency, Belarus, Ukraine, etc.

Banizoumbou 1200x 1200 zone

2002-2012

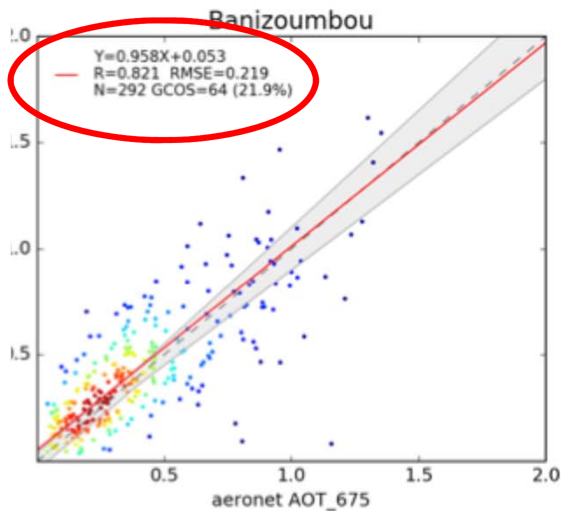
2004-2013

AATSR / SU, R=0.54

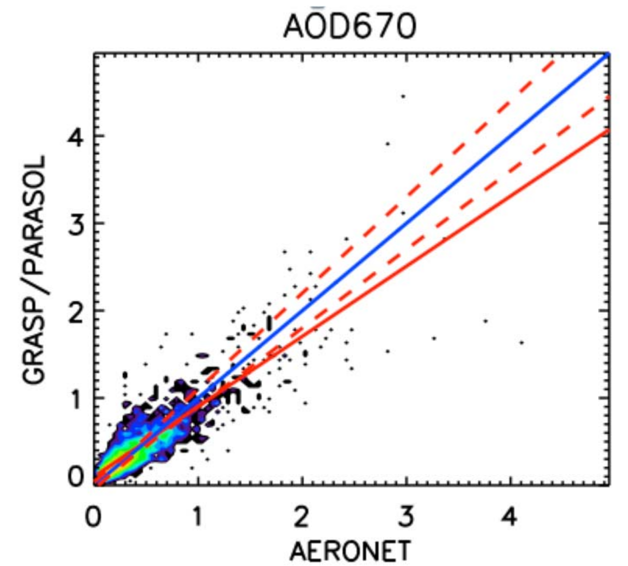


K=0.540 a= 0.47 b= 0.25 RMSE= 0.392

MERIS / GRASP, R=0.82



PARASOL / GRASP, R=0.87



K=0.867 a= 0.80 b= 0.10 RMSE= 0.227

AATSR- fails for AOD > 1.0 ???

PARASOL fails with the slope ???

MERIS is surprisingly good ???

Aged soot-containing aerosol. LIDER depolarization measurements and theoretical modeling (Mischenko et al., Applied Optics, 2016)

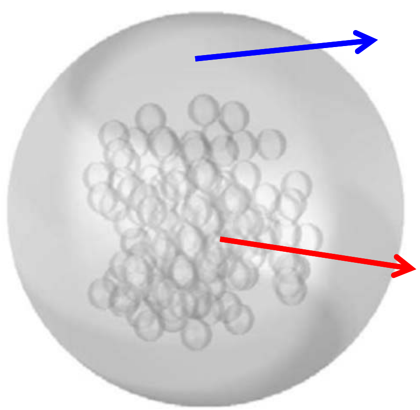
Burton et al., Atmos. Chem. Phys. 2015:

Table 1. Measured Spectral Values of the Linear Depolarization Ratio and Their Ranges [20]

	δ (355 nm)	δ (532 nm)	δ (1064 nm)
Measured	0.203 ± 0.036 (0.017)	0.093 ± 0.015 (0.011)	0.018 ± 0.002 (0.007)
Range	[0.150, 0.256]	[0.067, 0.119]	[0.009, 0.027]

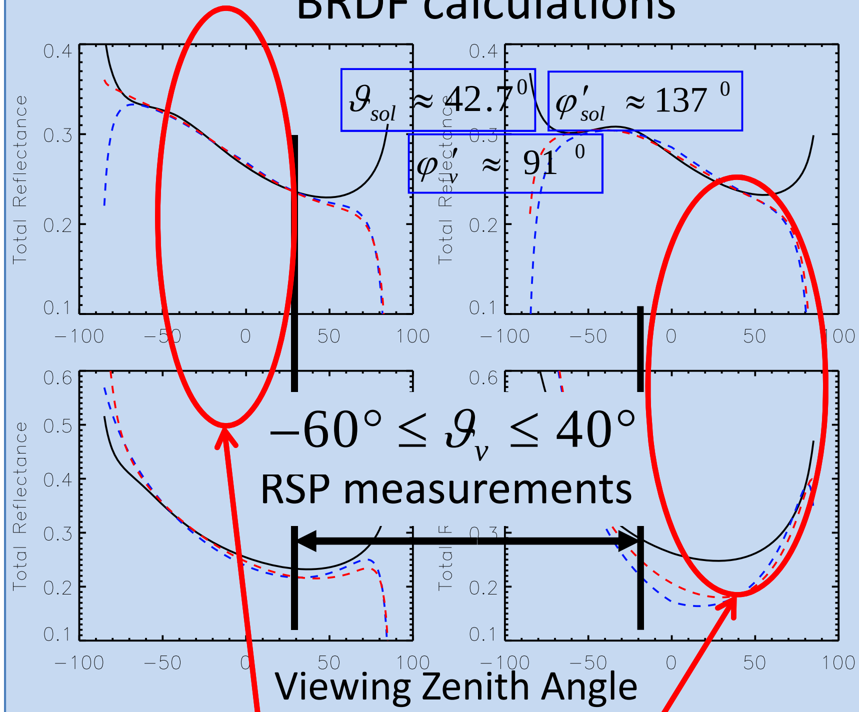
Mischenko et al., Applied Optics, 2016:

Complex morphologies of aged soot-containing aerosols can reproduce the spectral dependence of linear depolarization observed for an aged smoke plume by Burton et al.



BRDF models uncertainties.

BRDF calculations



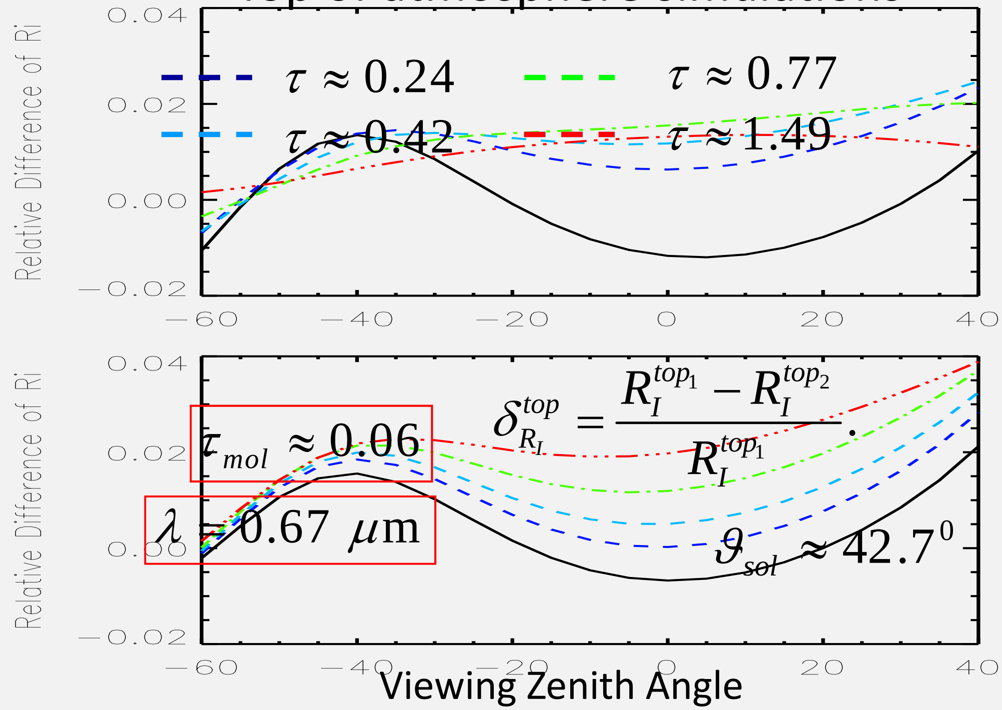
BRDF models uncertainties!

Black curves: **RPV model**

Blue curves: **Ross-Roujean model**

Red curves: **Ross-Li model**

Top of atmosphere simulations

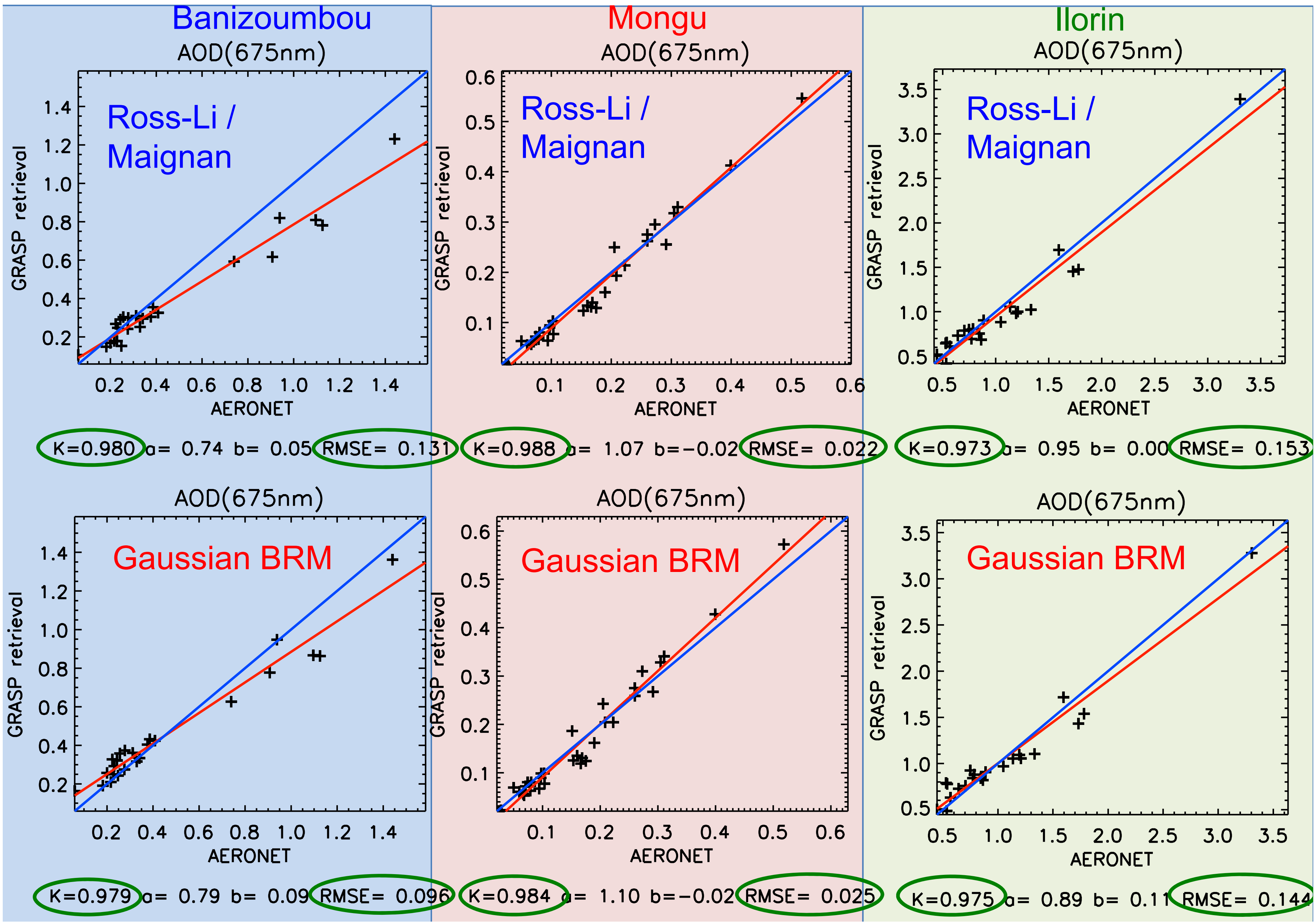


Black curves: **the relative differences of the BRDF models (RPV and Ross-Li models)**

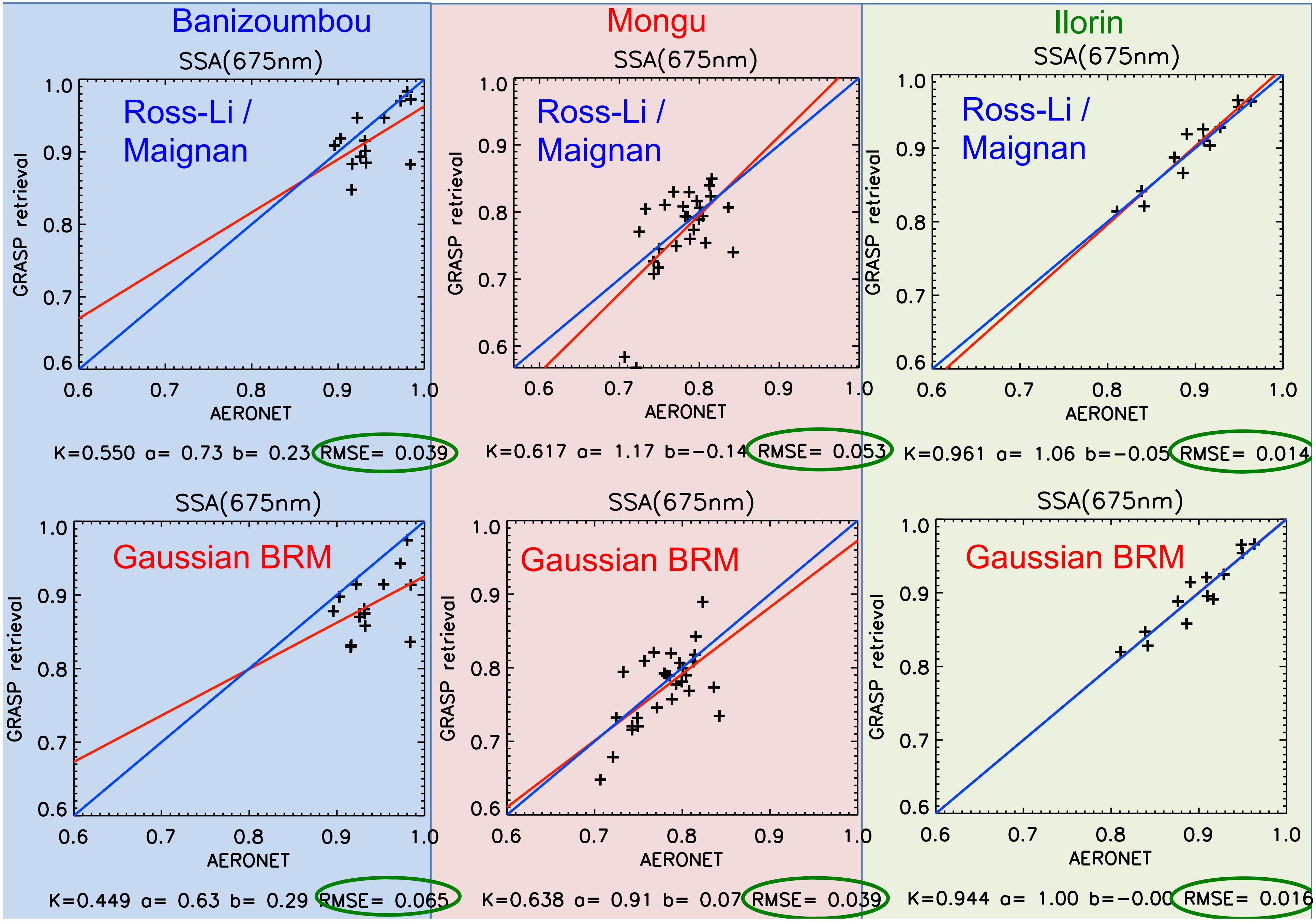
Color curves: **the relative differences of the top of atmosphere total reflectances (RPV and Ross-Li model, the same aerosol model)**

BRDF models uncertainties can provide up 2- 5% systematic error in top of atmosphere signal! (Litvinov et al., RSE, 2011)

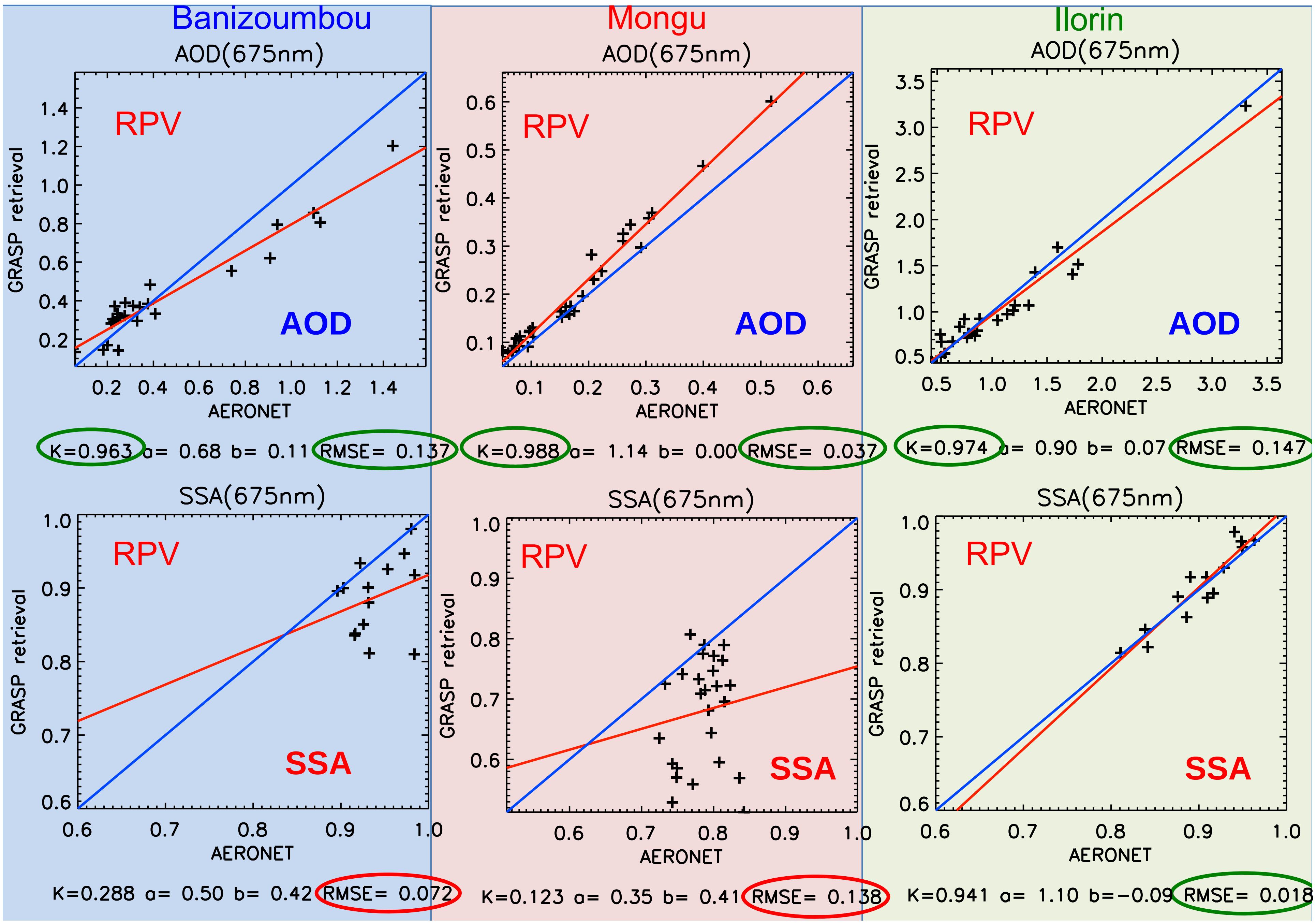
Surface BRM effect (Ross-Li and Gaussian BRDF). AOD.



Surface BRM effect (Ross-Li and Gaussian BRDF). SSA.



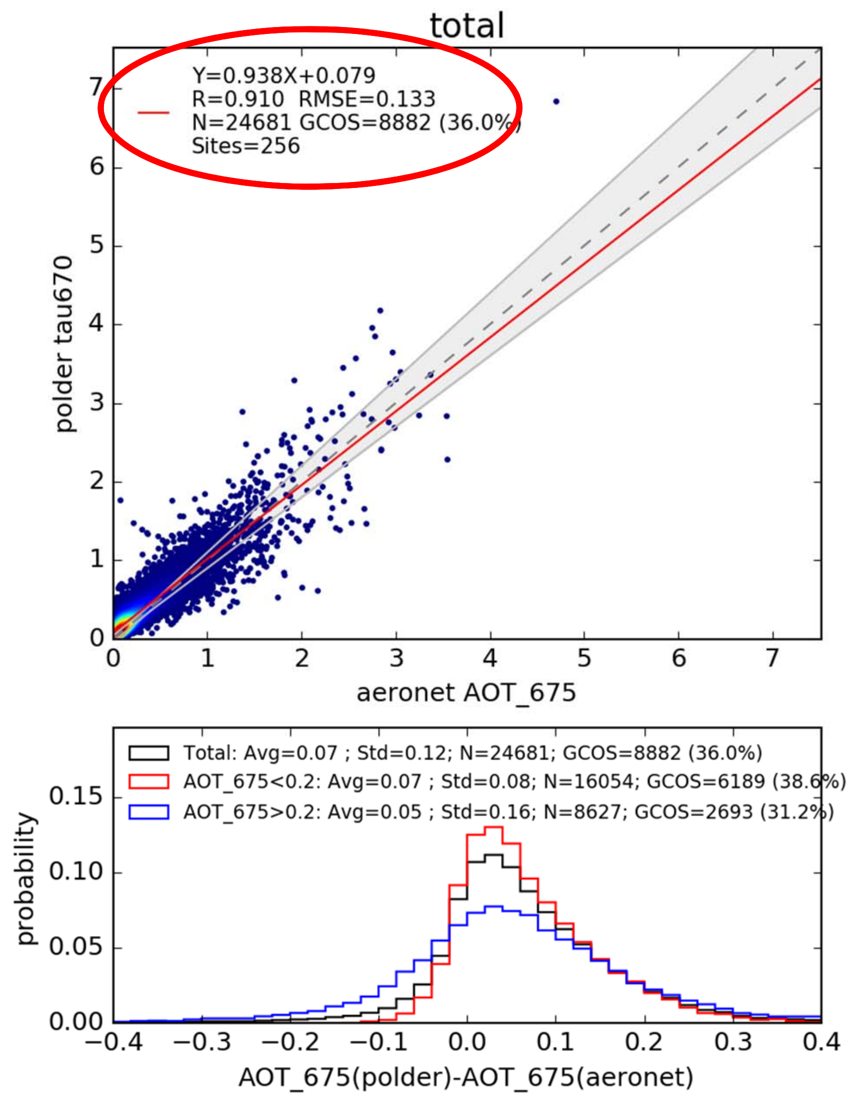
Surface BRM effect (RPV BRDF). **AOD and SSA.**



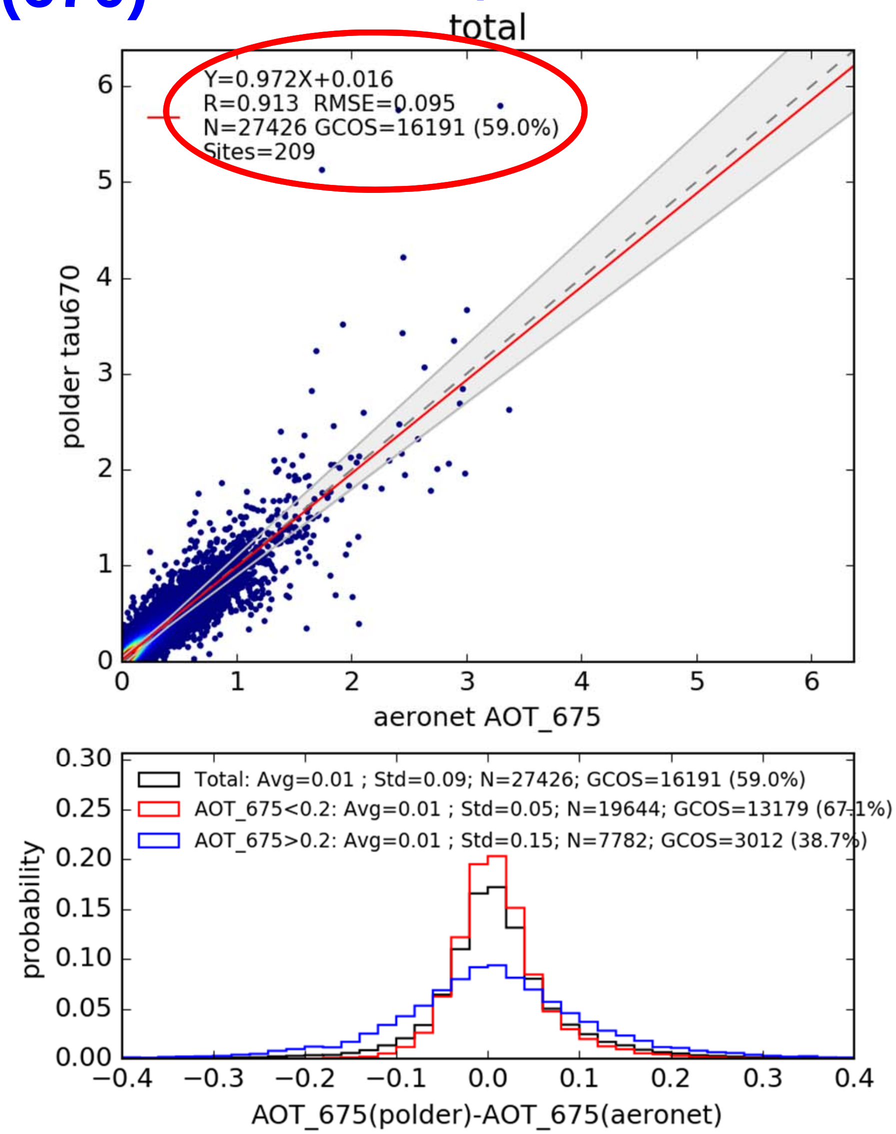
Validation vs AERONET 2004 - 2013

AOD(670)

Reference version



Component mixture

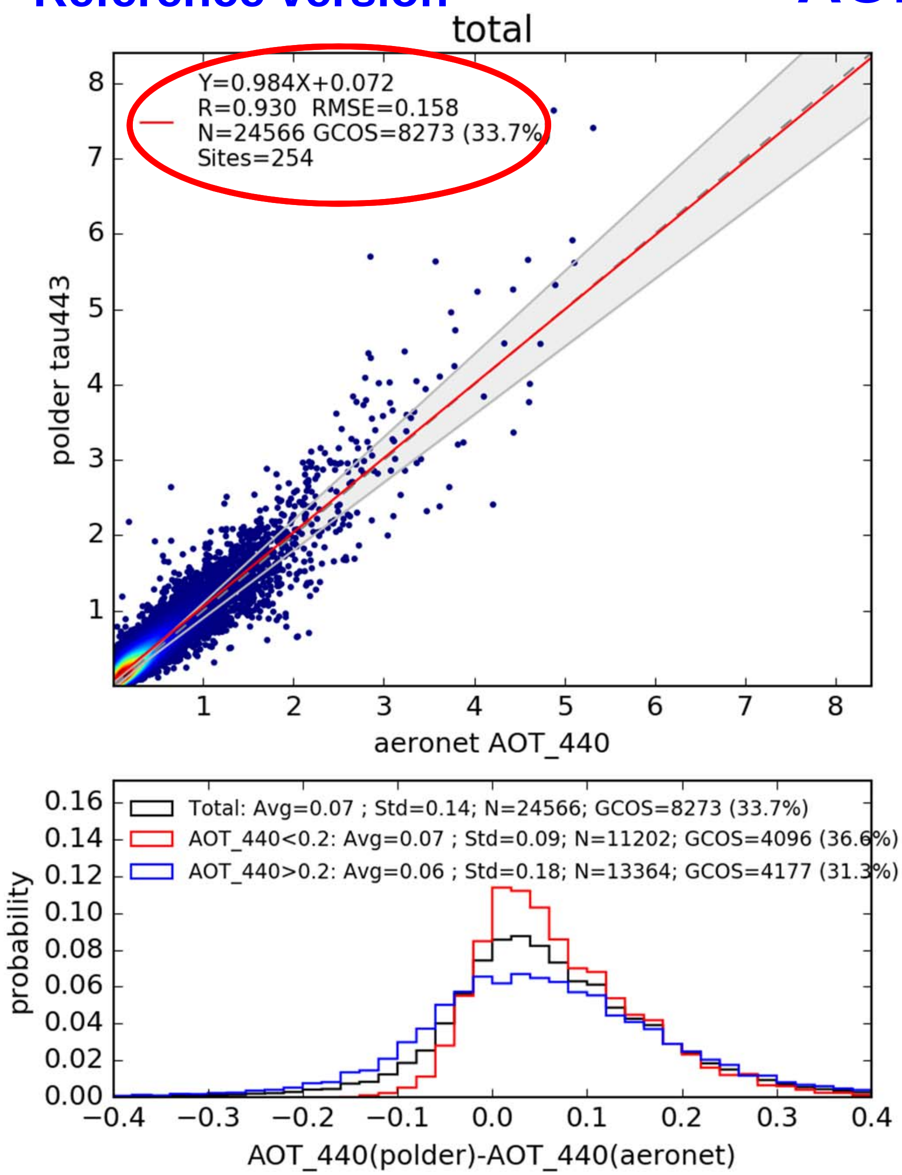


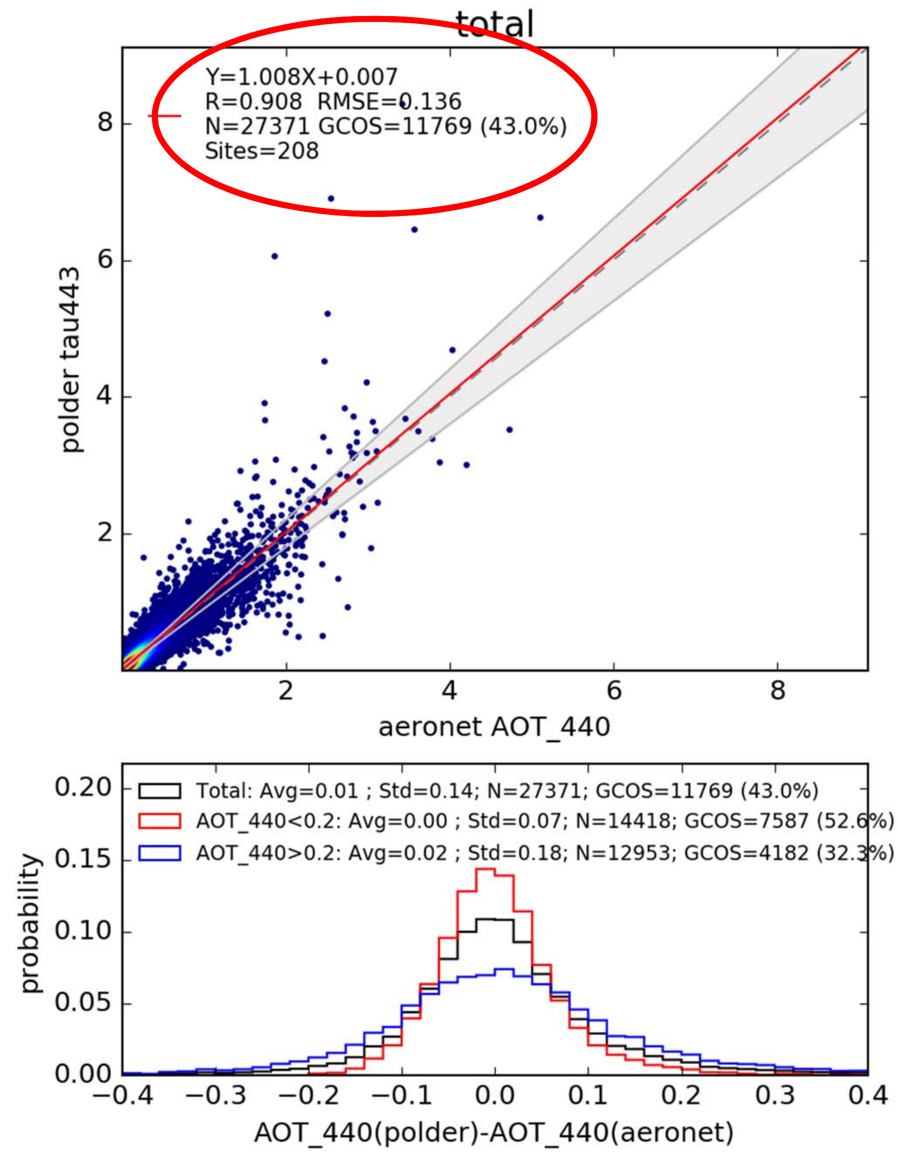
Validation vs AERONET 2004 - 2013

Reference version

AOD(440)

Component mixture

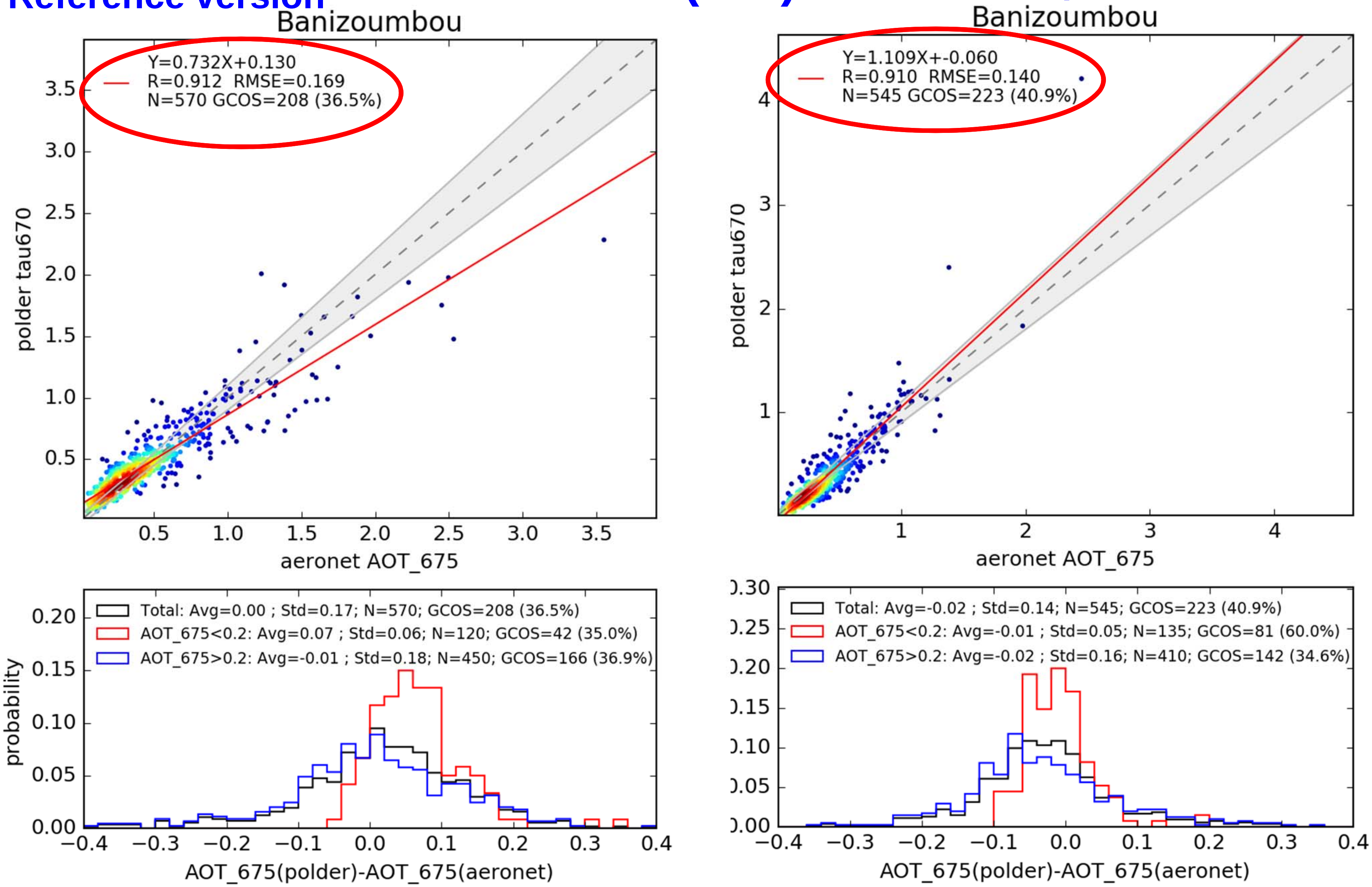




Validation vs AERONET 2004 - 2013

AOD(670)

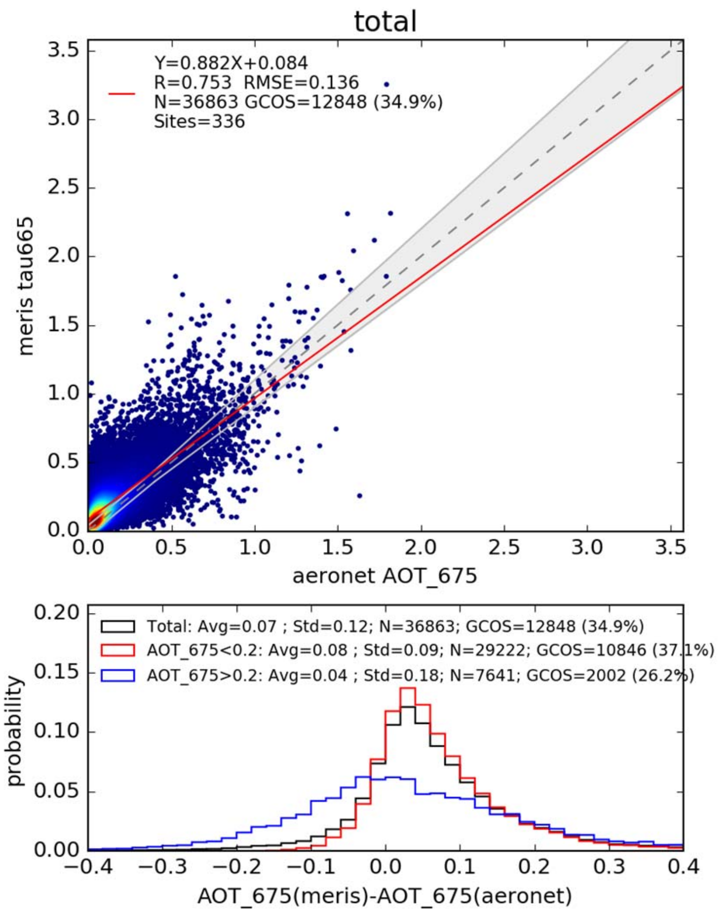
Reference version | **Component mixture**



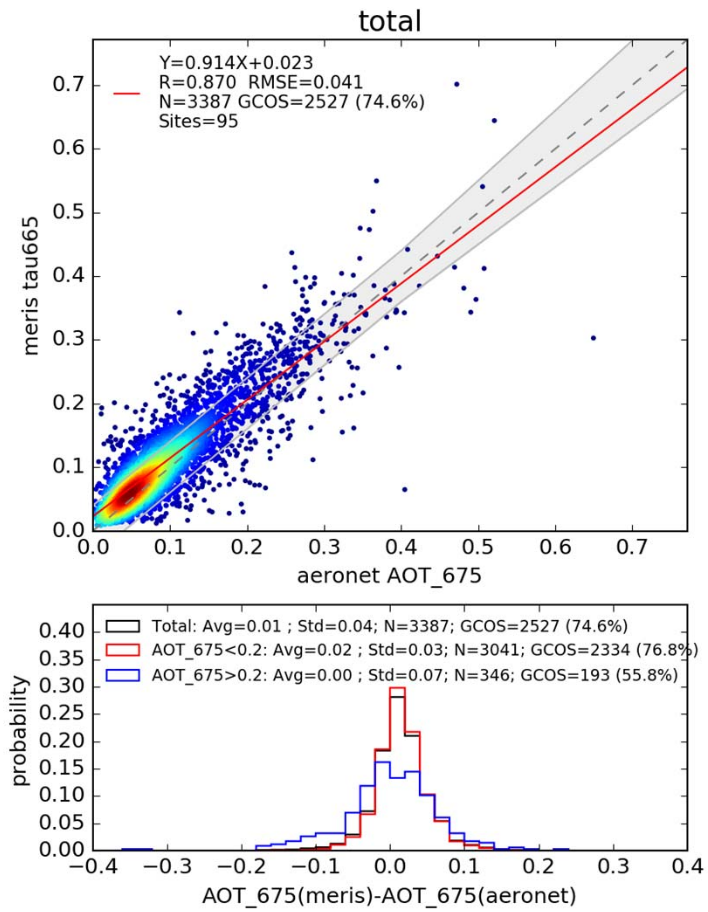
Validation vs AERONET 2002 - 2012

MERIS/GRASP - AOD

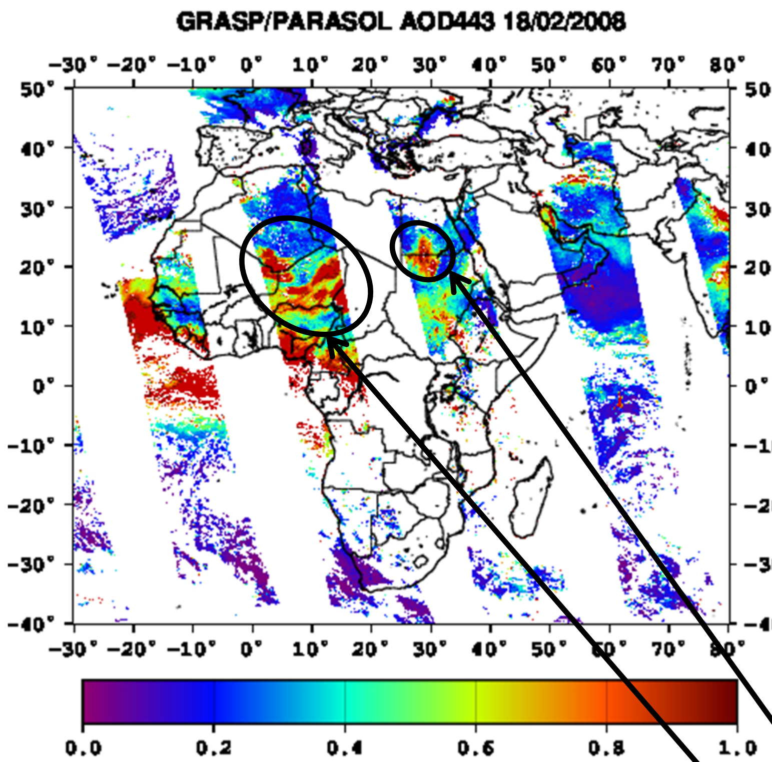
Land

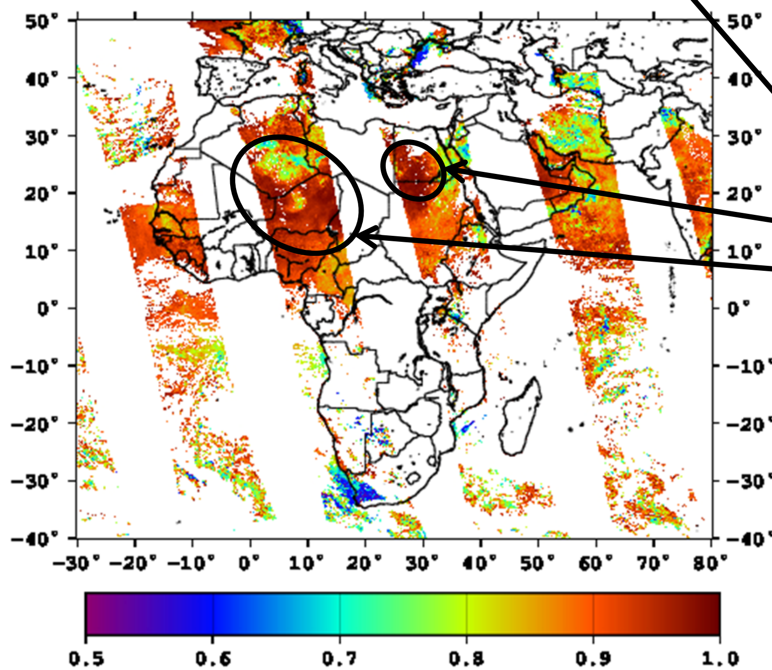


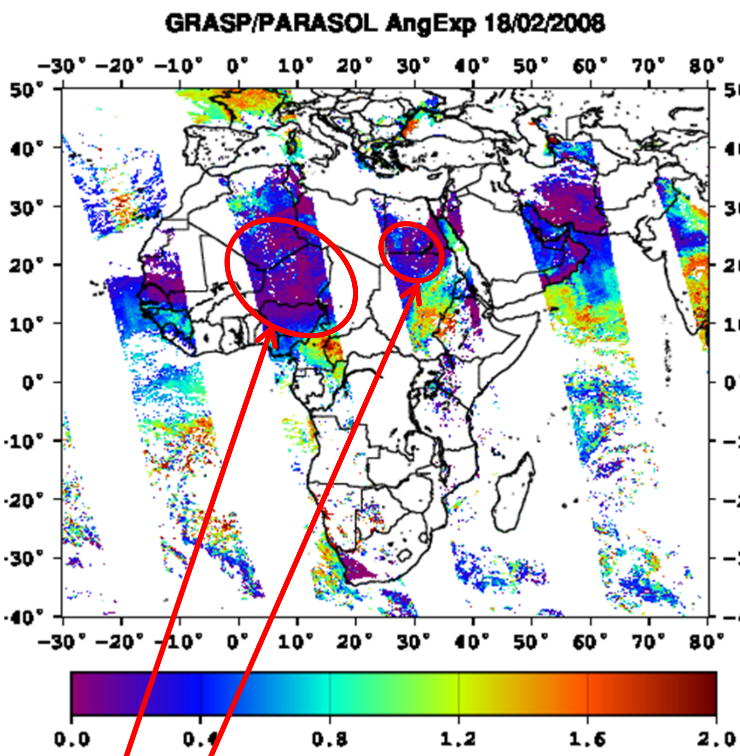
Ocean



Dust detection with GRASP







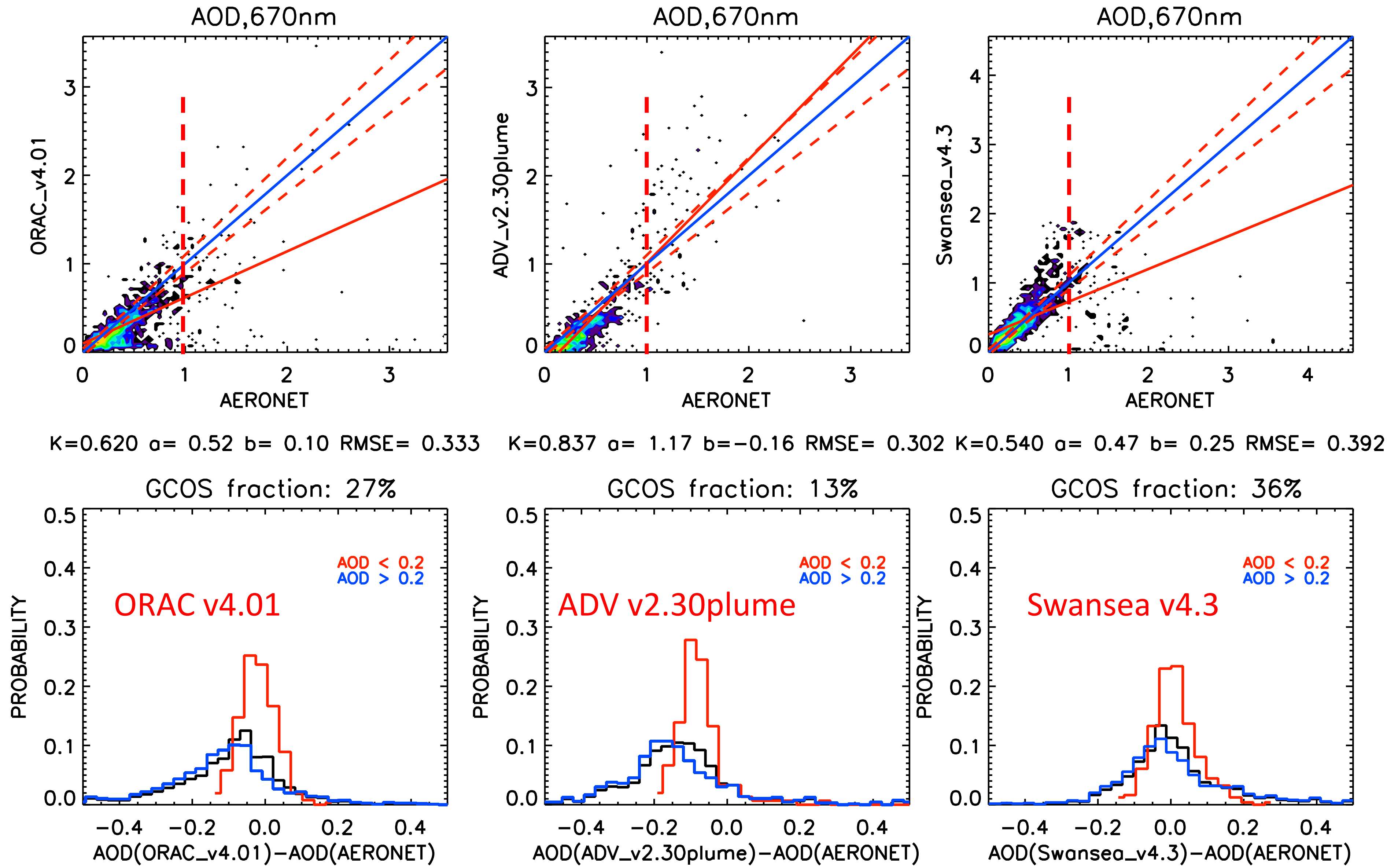
Dust events:

✓High AOD

✓Angstrom Exponent < 0.5

✓SSA (440 - 1020) > 0.9

Banizoumbou 1200x 1200 zone. 2002-2012. **AATSR**.

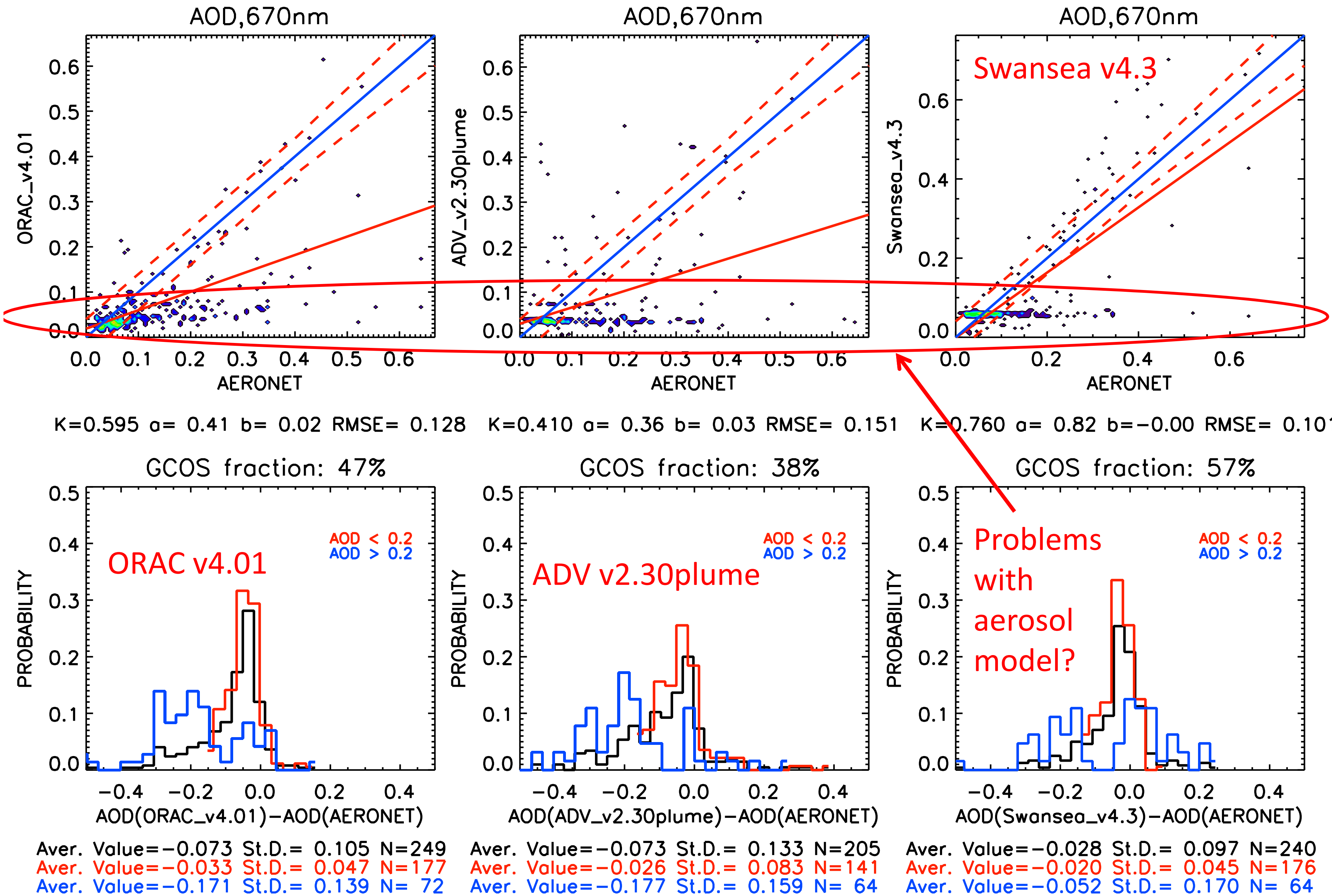


Aver. Value=−0.126 St.D.= 0.309 N=1310
Aver. Value=−0.006 St.D.= 0.051 N=258
Aver. Value=−0.156 St.D.= 0.337 N=1052

Aver. Value=−0.077 St.D.= 0.292 N=812
Aver. Value=−0.055 St.D.= 0.108 N=151
Aver. Value=−0.082 St.D.= 0.319 N=661

Aver. Value=−0.011 St.D.= 0.392 N=1345
Aver. Value= 0.028 St.D.= 0.063 N=248
Aver. Value=−0.020 St.D.= 0.432 N=1097

Mongu 1200x 1200 zone. 2002-2012. **AATSR**.



Real Part of Ref. Index (565), Summer (PARASOL archive average)