Aerosol absorption above clouds from combined OMI and MODIS hyperspectral measurements

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TUDelft
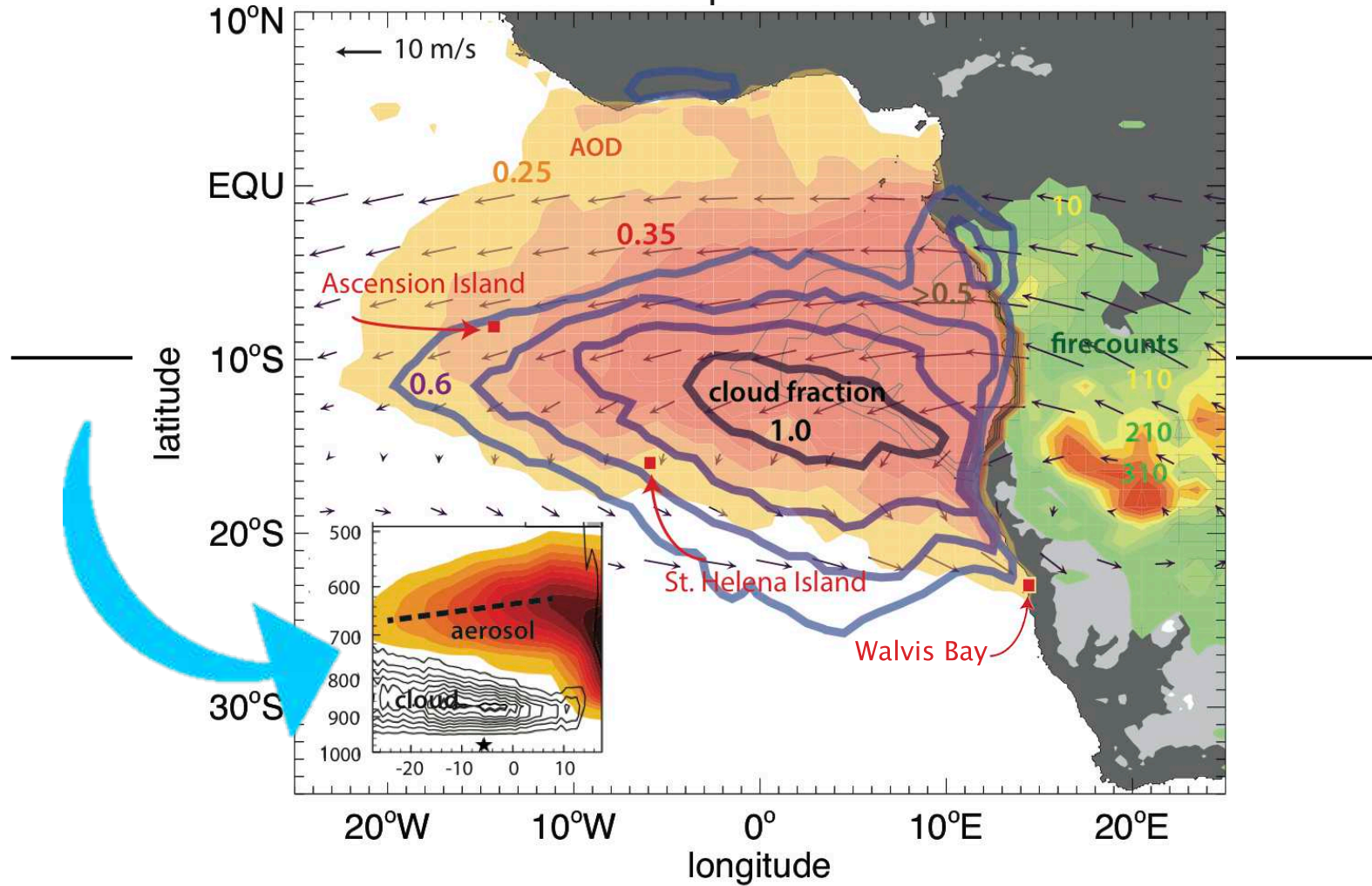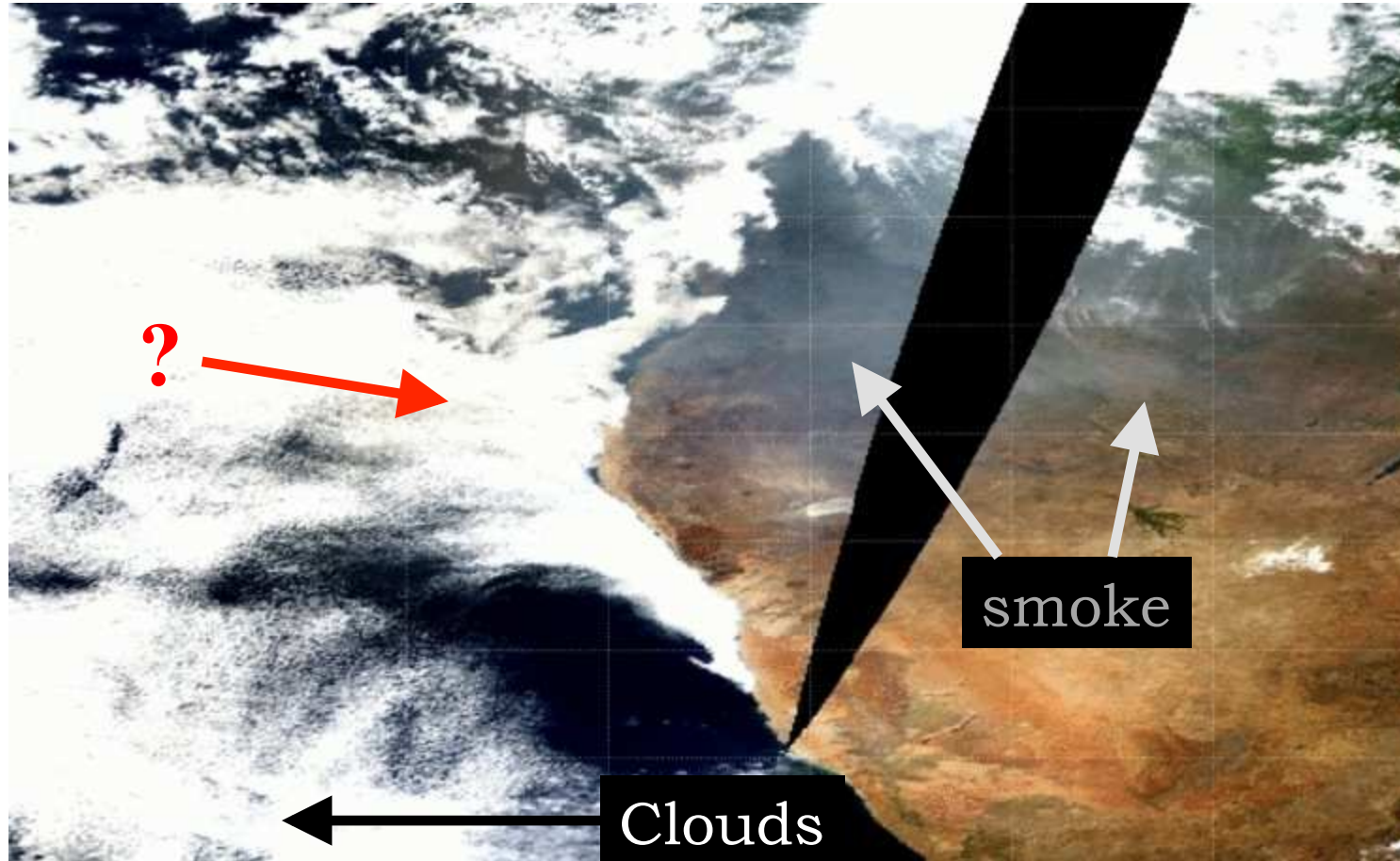
Aerosol absorption over clouds

- **South East Atlantic Ocean**

- **Differential Aerosol Aborption (DAA)**

- **Comparison with model results**

- **OMI/MODIS retrievals**

- **Conclusions**

Southeast Atlantic Ocean during dry season: a laboratory for aerosol-cloud-radiation interactions
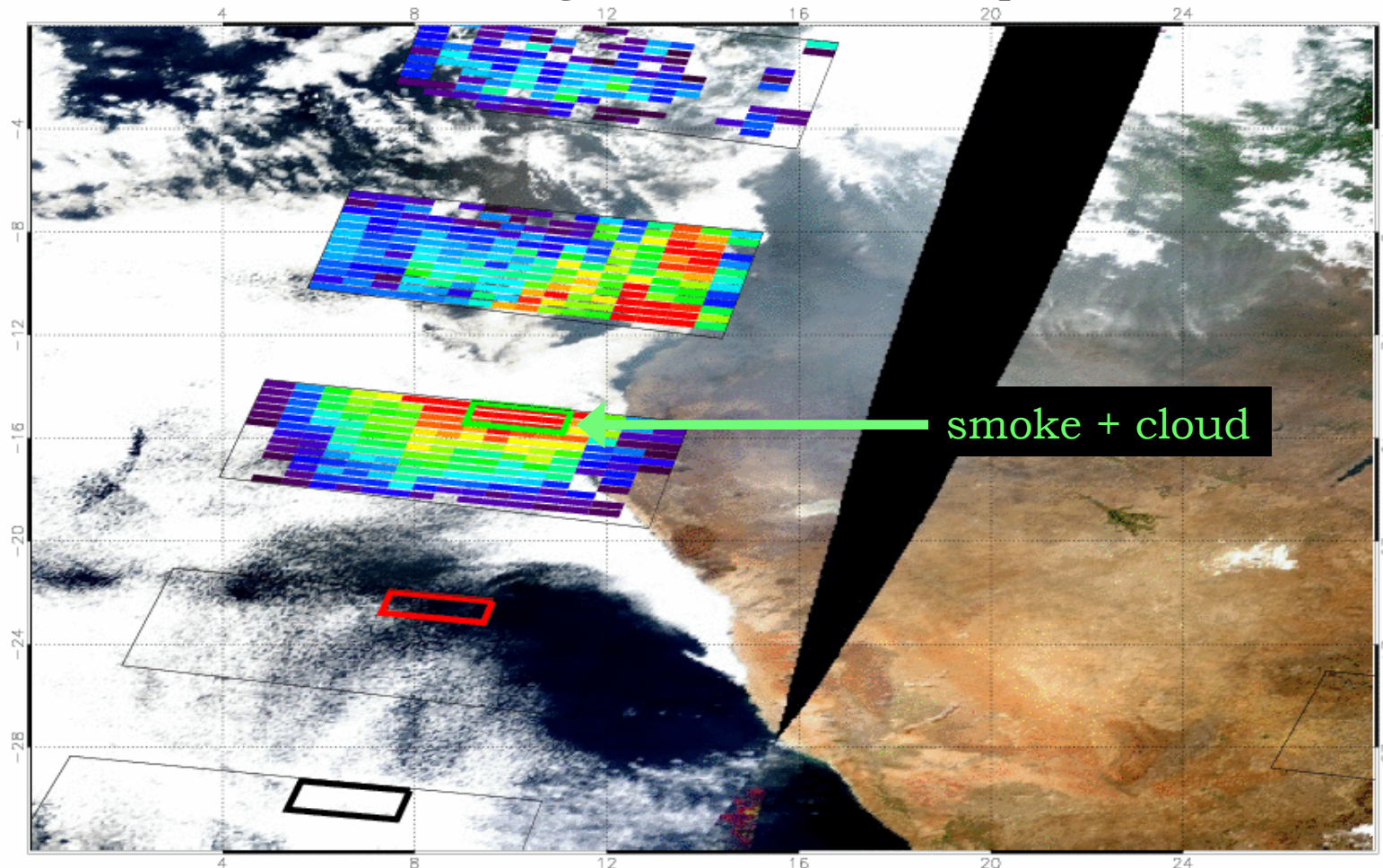

September

Figure courtesy of P. Zuidema

Biomass burning in SW Africa, 09 September 2004

Biomass burning in SW Africa, 09 September 2004

smoke + cloud

[SCIAMACHY AAI]

0.0   0.6   1.2   1.8   2.3   2.9   3.5

TUDelft
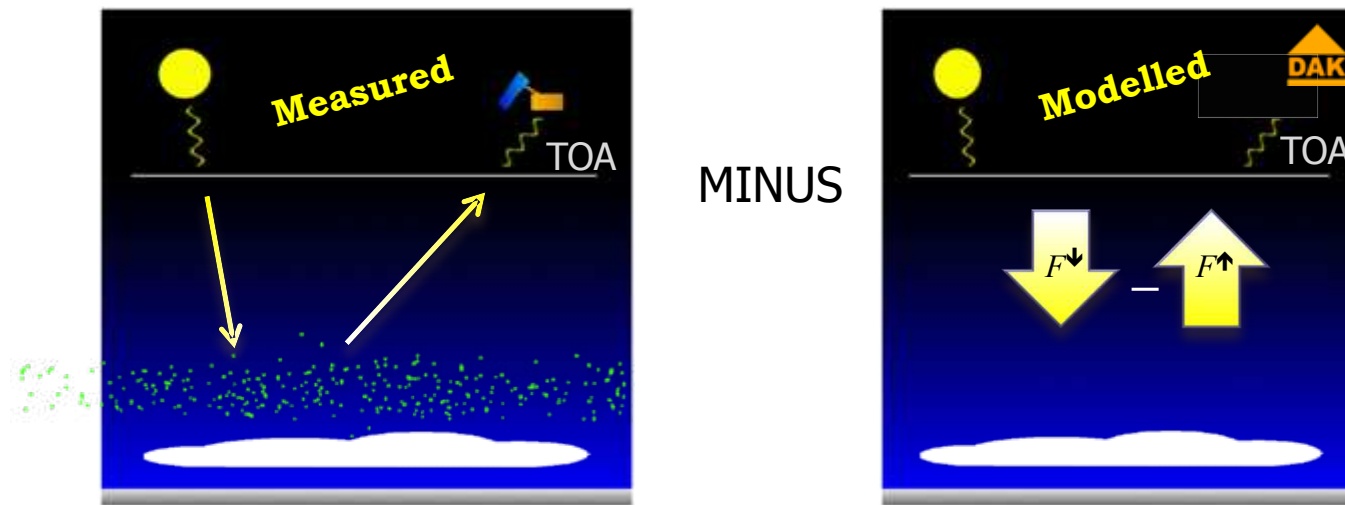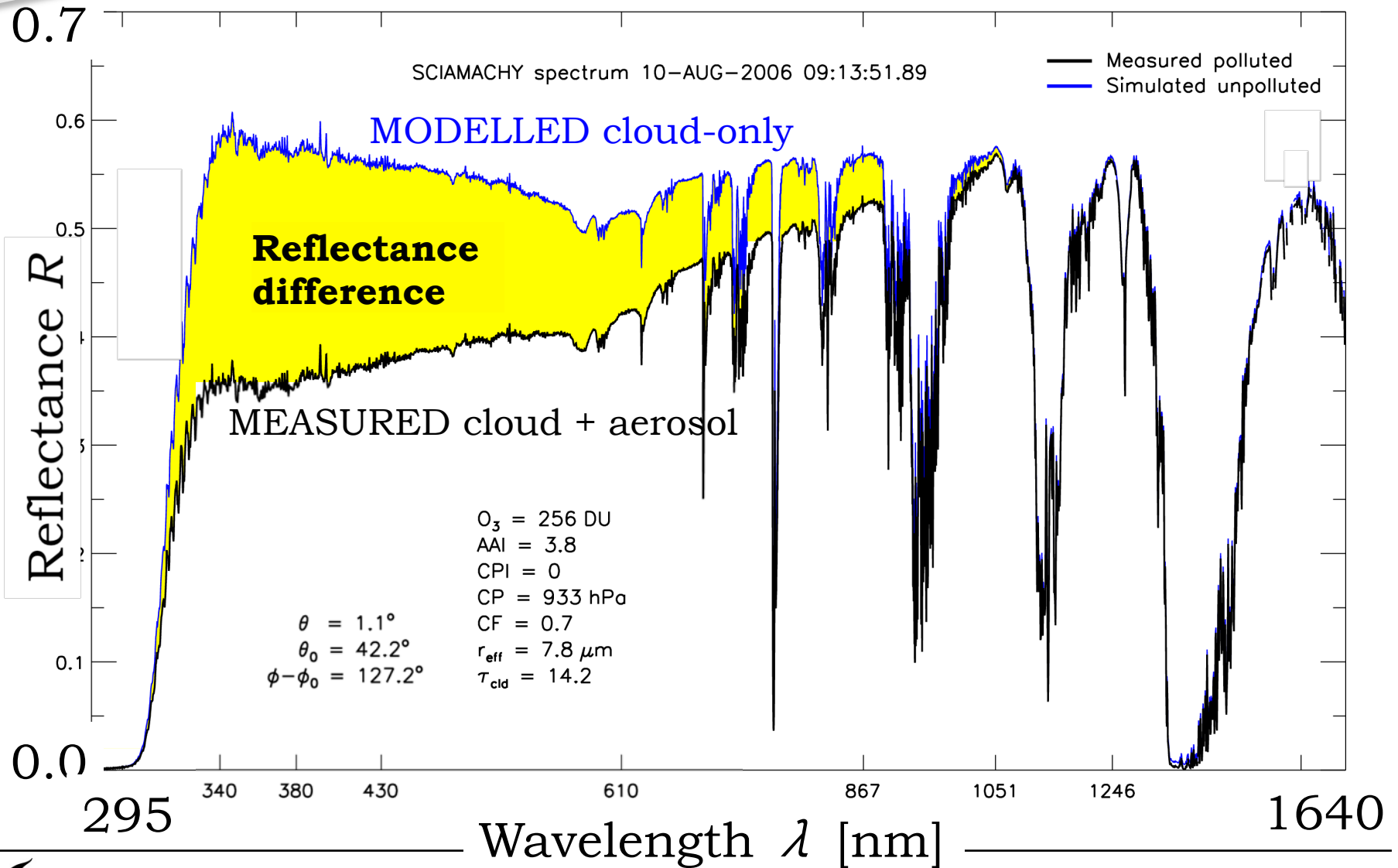
Aerosol absorption over clouds

- **Differential Aerosol Aborption (DAA)**

DAA method uses spectral information to retrieve aerosol absorption (in the UV) and cloud information in the SWIR simultaneously to determine aerosol Direct Radiative Effect (DRE) over clouds. Aerosol DRE is the difference between the measured aerosol+cloud flux and the simulated aerosol-free cloud flux
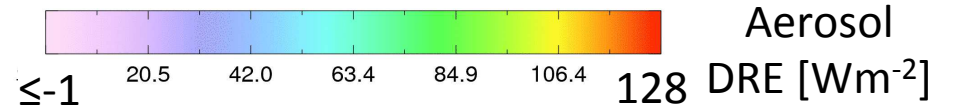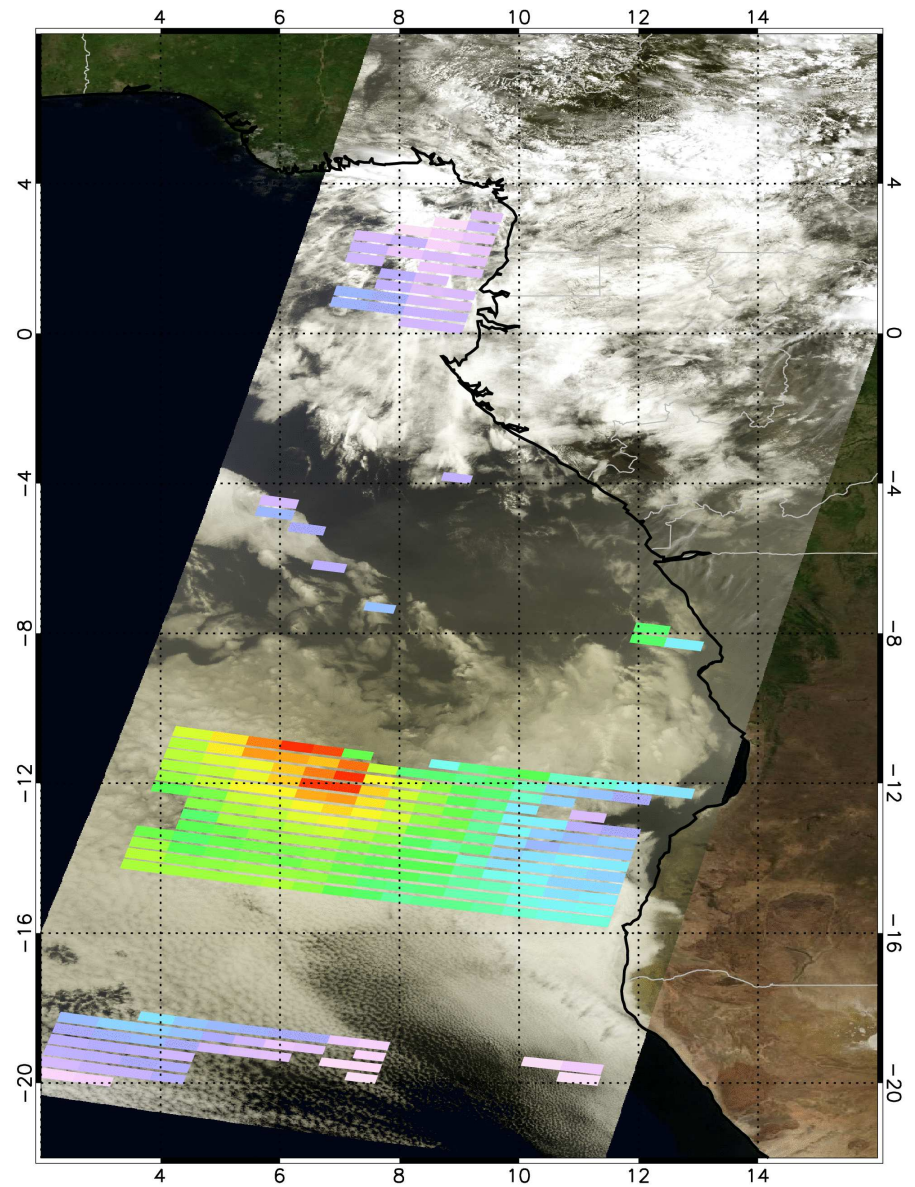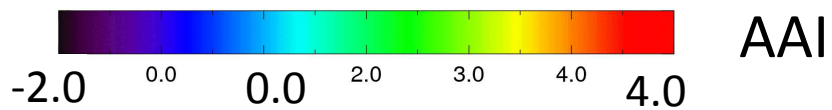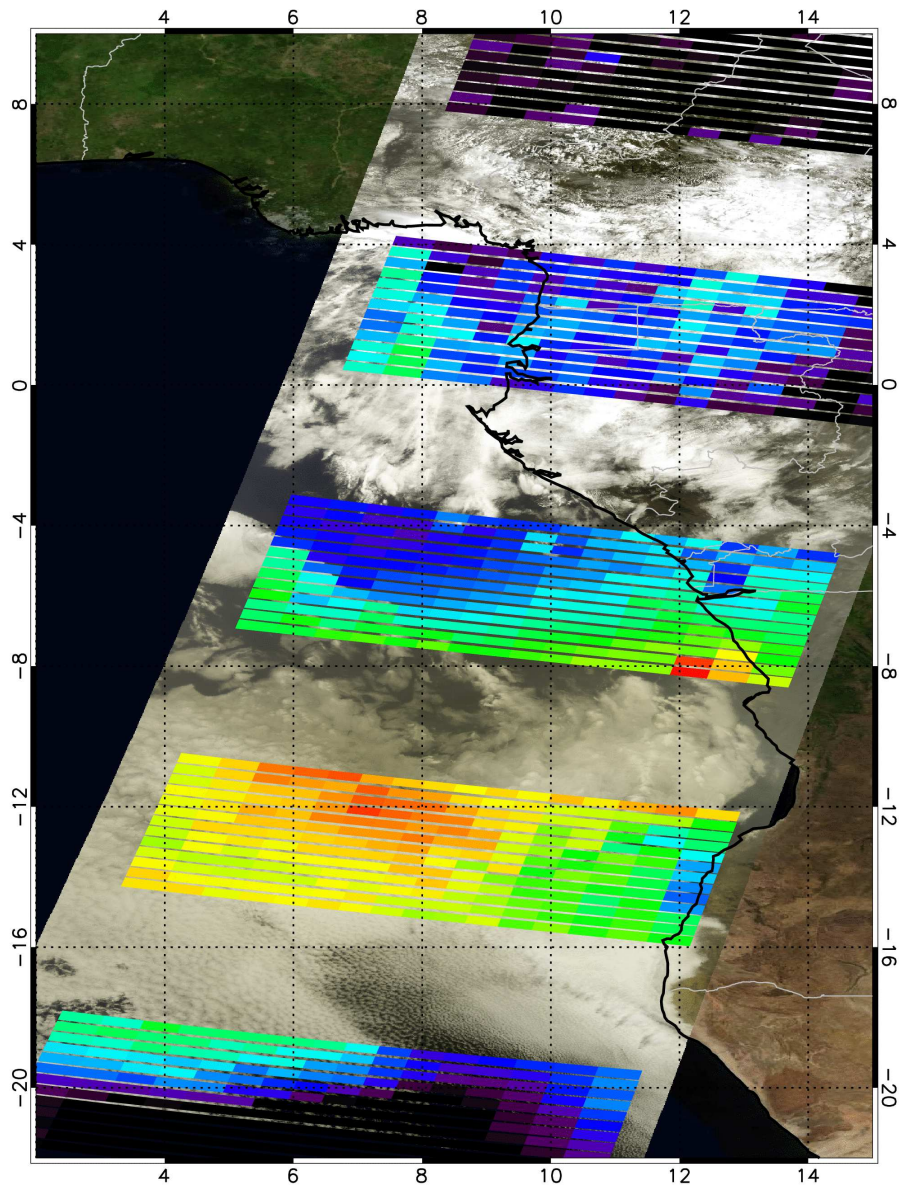
Differential Aerosol Absorption

De Graaf *et al.*, **2012**. JGR

SCIAMACHY spectrum 10-AUG-2006 09:13:51.89

Measured polluted
Simulated unpolluted

0.7

0.6

MODELLED cloud-only

0.5

Reflectance difference

Reflectance R

MEASURED cloud + aerosol

O_3 = 256 DU
AAI = 3.8
CPI = 0
CP = 933 hPa
CF = 0.7
r_{eff} = 7.8 μm
τ_{cld} = 14.2

θ = 1.1°
θ_0 = 42.2°
$\phi - \phi_0$ = 127.2°

0.1

0.0

295   340   380   430   610   867   1051   1246   1640

Wavelength λ [nm]

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ENVISAT track 13 Aug 2006 09:13:27 – 09:22:48 UTC

AAI

-2.0   0.0   0.0   2.0   3.0   4.0   4.0

Aerosol
DRE [Wm⁻²]

≤-1   20.5   42.0   63.4   84.9   106.4   128
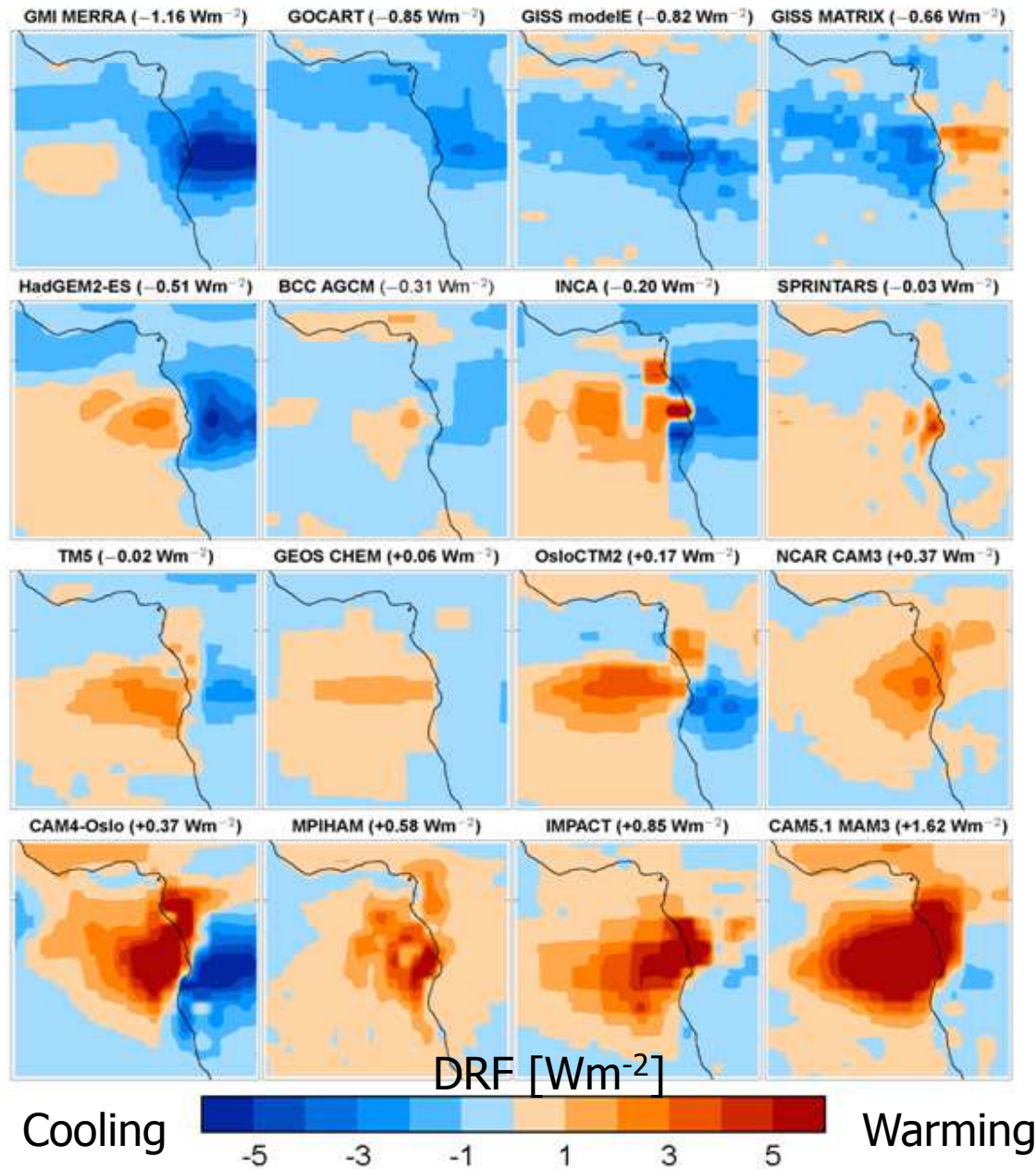
Aerosol absorption over clouds

- South East Atlantic Ocean

- Differential Aerosol Aborption (DAA)

- **Comparison with model results**

- OMI/MODIS comparisons

- Conclusions
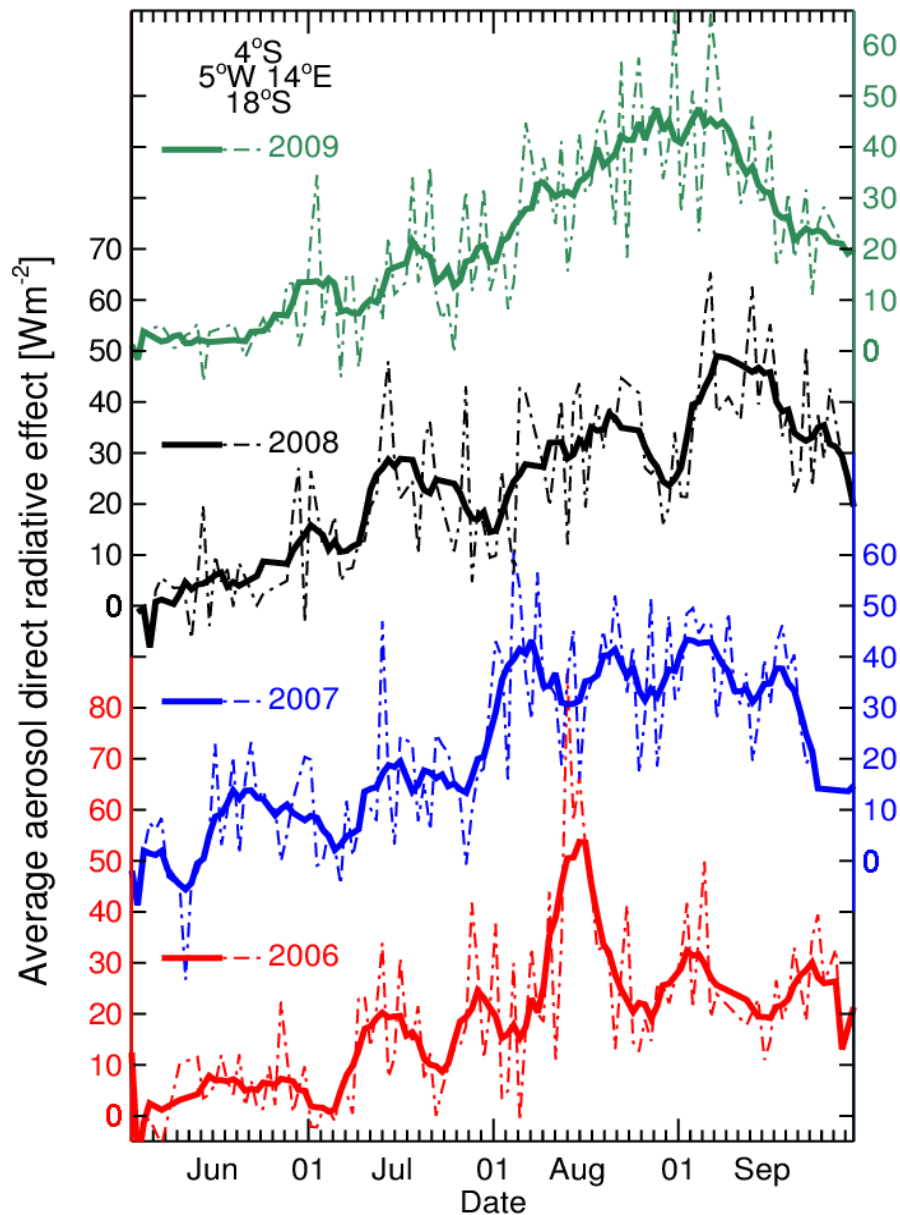
De Graaf et al., **2014** GRL **41**

Aerosol DRE from SCIAMACHY averaged over the southeast Atlantic Ocean:

- 2006 was anomalous with extreme events
- High observed values are **not reproduced** by climate models

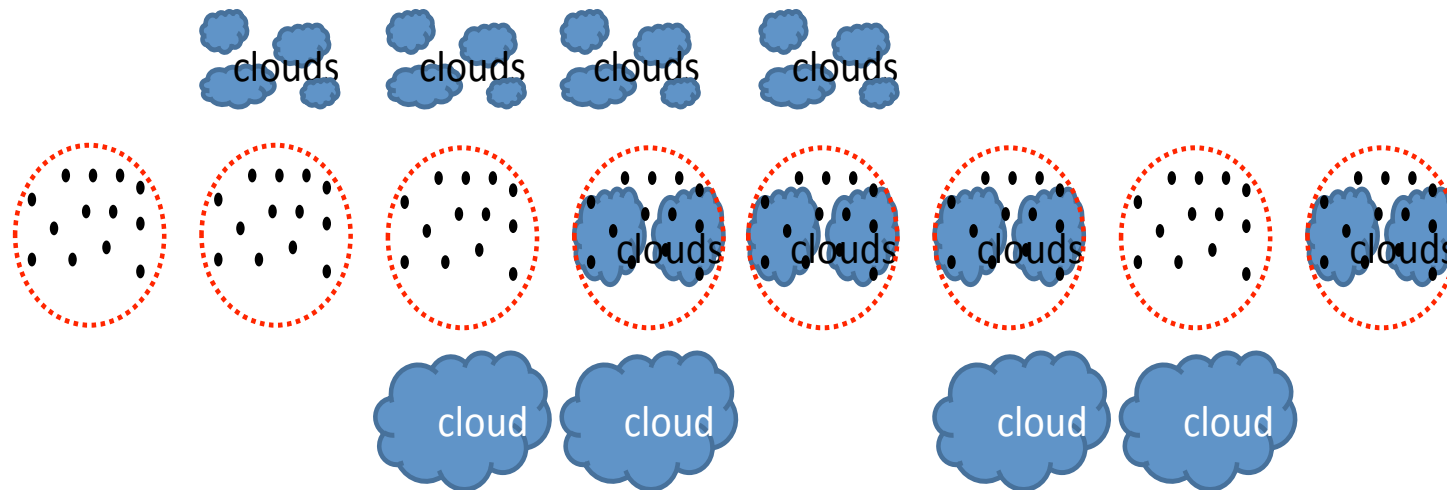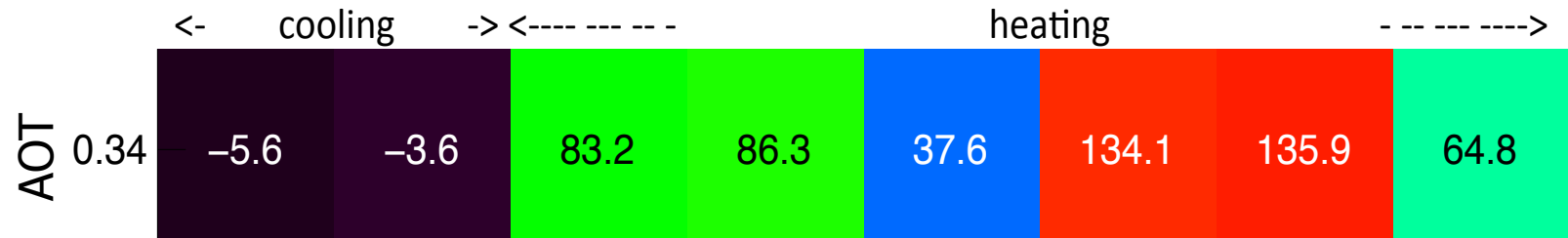AERCOM model comparison of aerosol direct **forcing** (now-1750):

Large discrepancies between models

<u>Possible causes</u>
Differences in:

- cloud properties
- cloud fraction and location
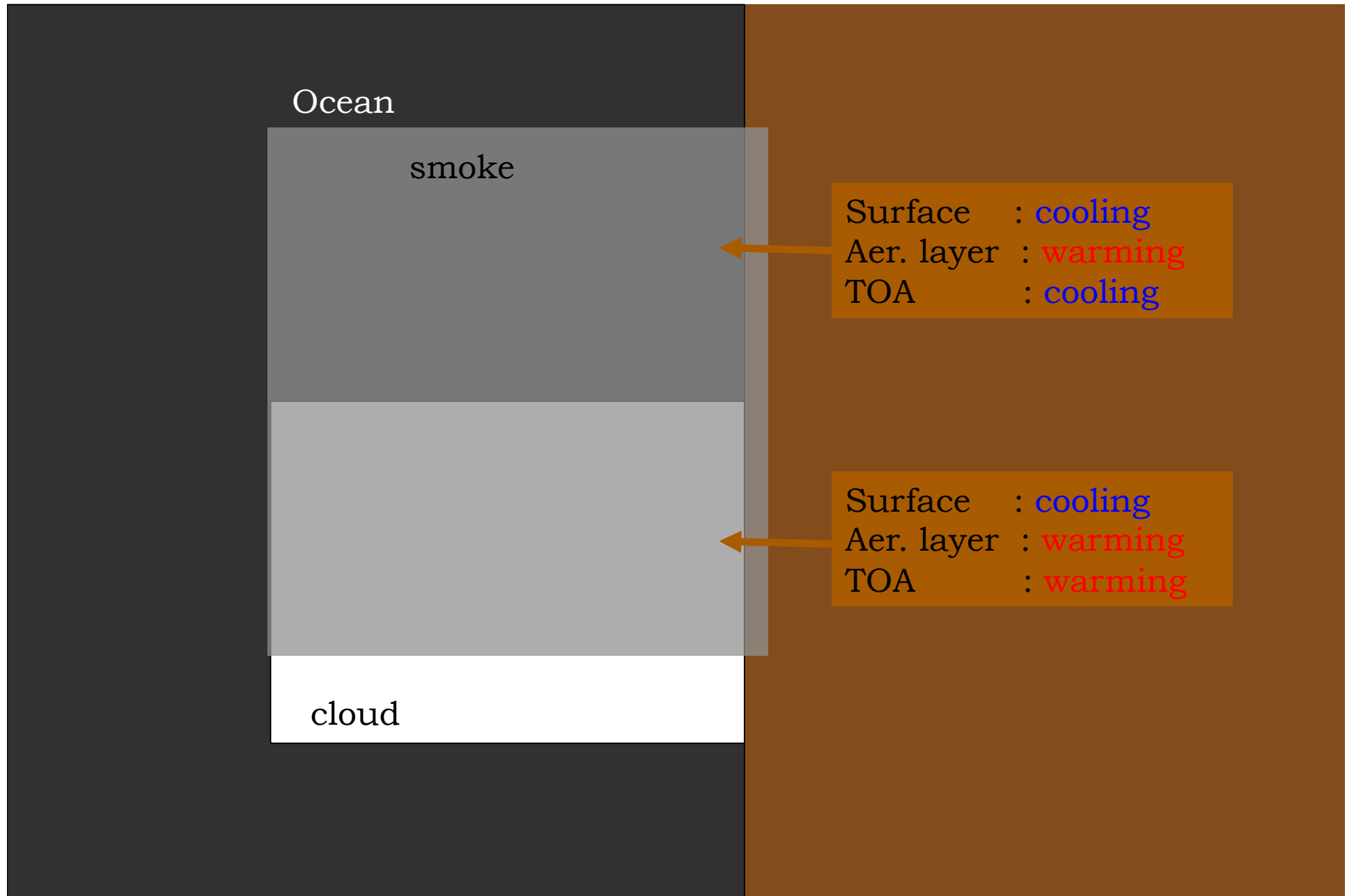- aerosol properties
- smoke dispersion
- ?

Aerosol direct effect at top of atmosphere in shortwave spectrum

Clouds strongly change the effect of absorbing aerosol

Ocean

smoke

cloud

Surface   : cooling
Aer. layer : warming
TOA   : cooling

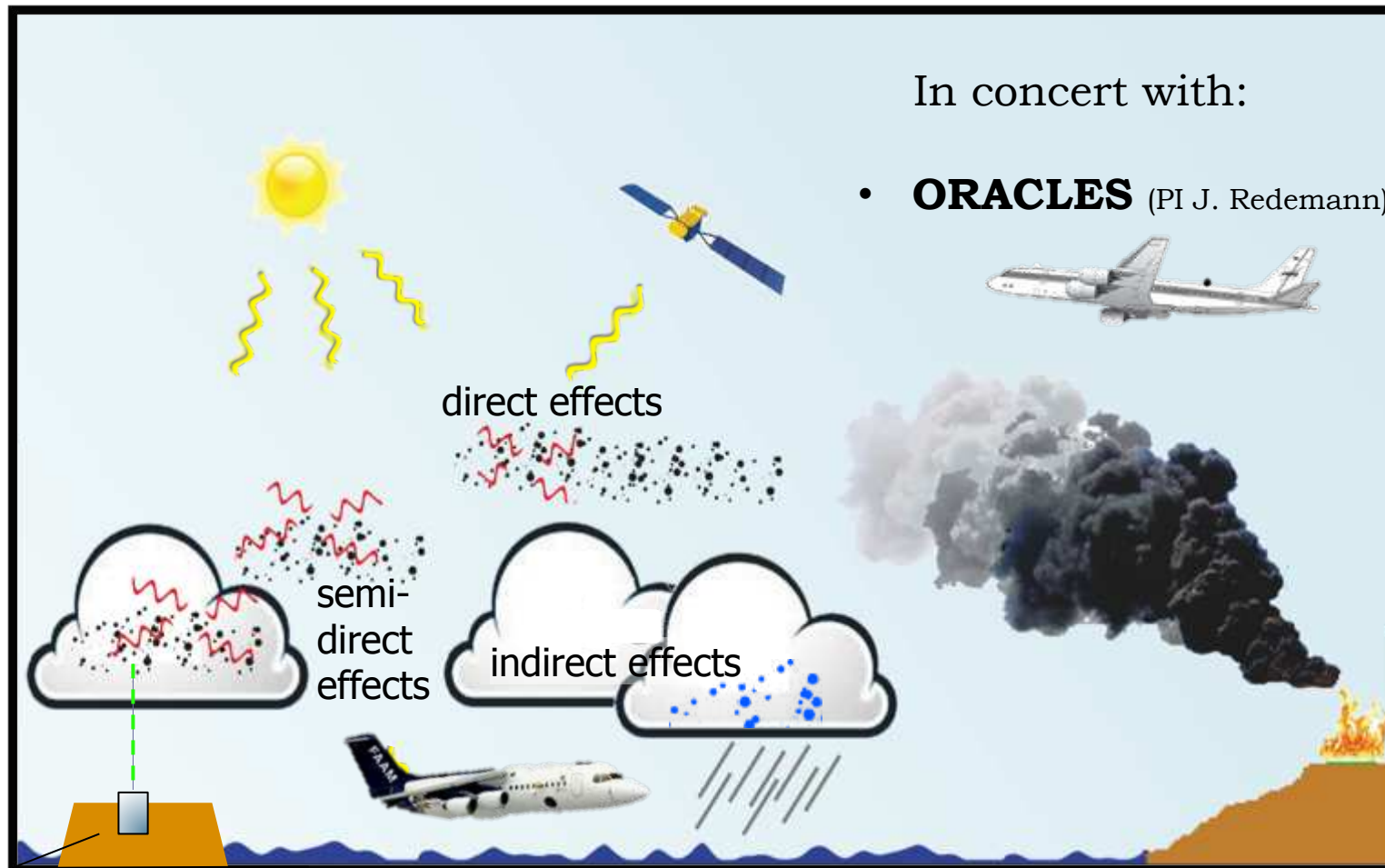Surface   : cooling
Aer. layer : warming
TOA   : warming

Aerosol absorption over clouds

- South East Atlantic Ocean

- Differential Aerosol Aborption (DAA)

- Comparison with model results

- **OMI/MODIS retrievals**

- Conclusions

Observation campaign CLARIFY – 2016 (Sept.) (PI J. Haywood)

CLouds and Aerosols Radiative Impacts and Forcing: Year 2016
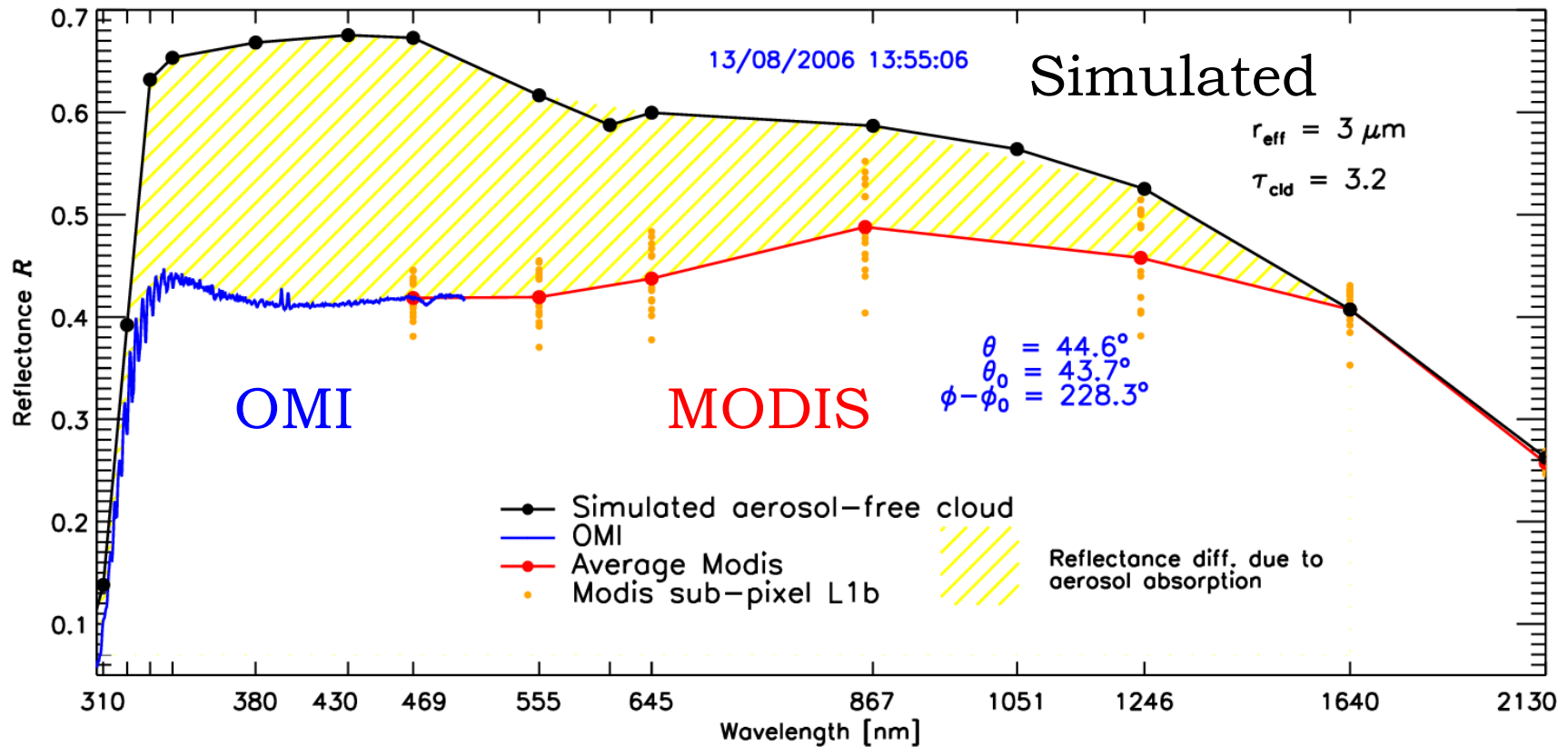
In concert with:
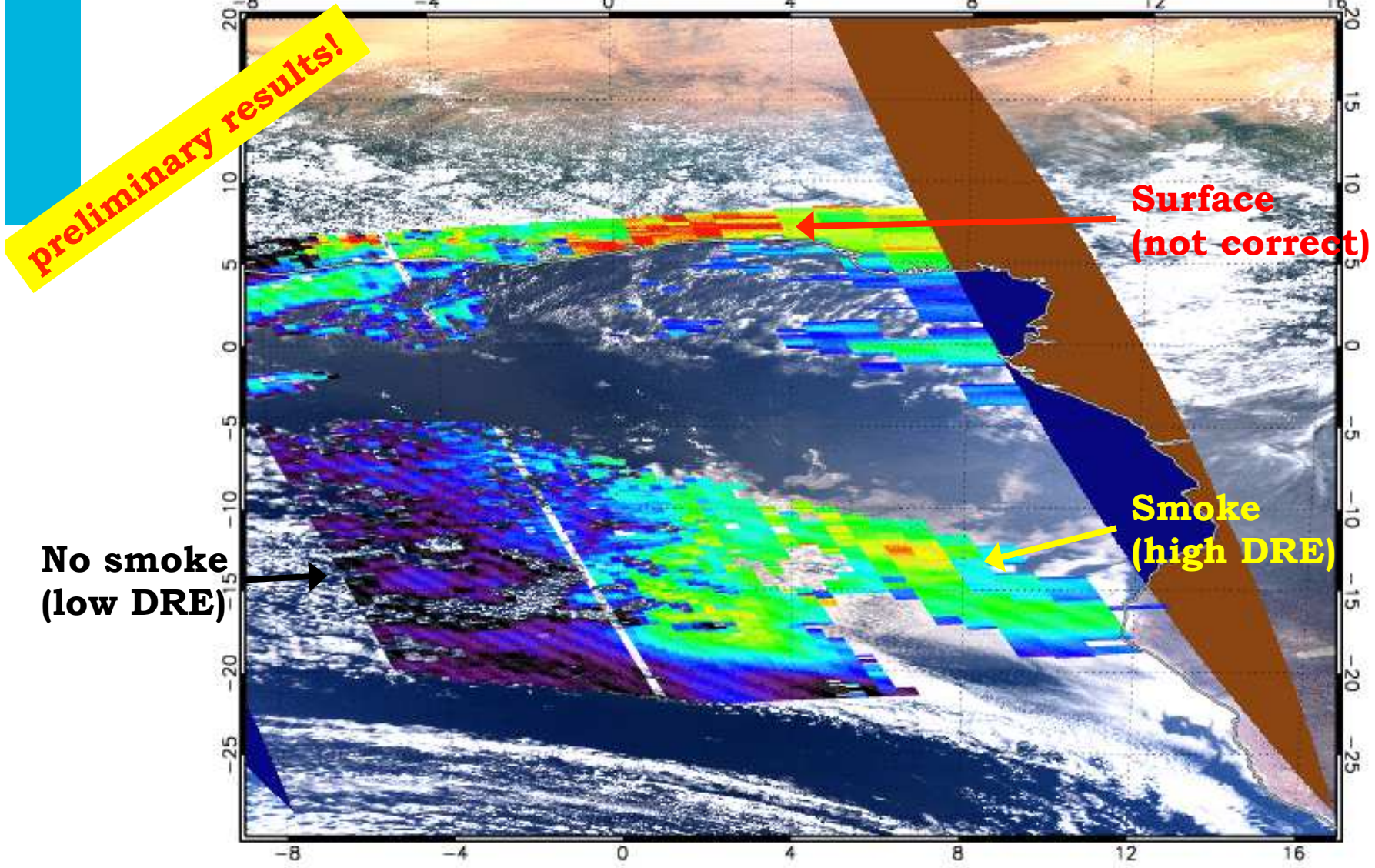
- **ORACLES** (PI J. Redemann)

direct effects

semi-direct effects

indirect effects

&
- **LASIC** (PI P. Zuidema)
- **ASCII** (PI M. de Graaf)

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CLARIFY – 2016

Aerosol DRE from current (OMI+MODIS) and upcoming satellite missions (TROPOMI)

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OMI + MODIS DRE 13 Aug. 2006 se Atlantic Ocean

preliminary results!

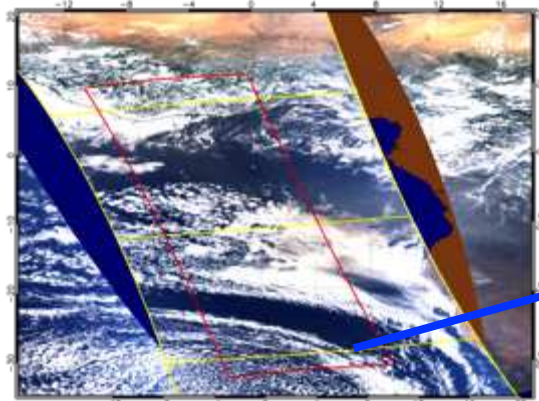Surface (not correct)

Smoke (high DRE)
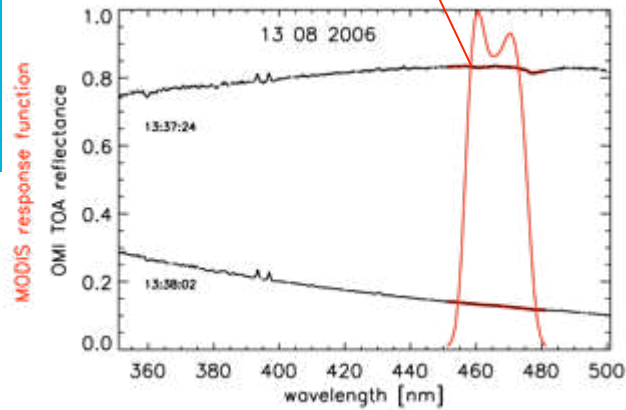
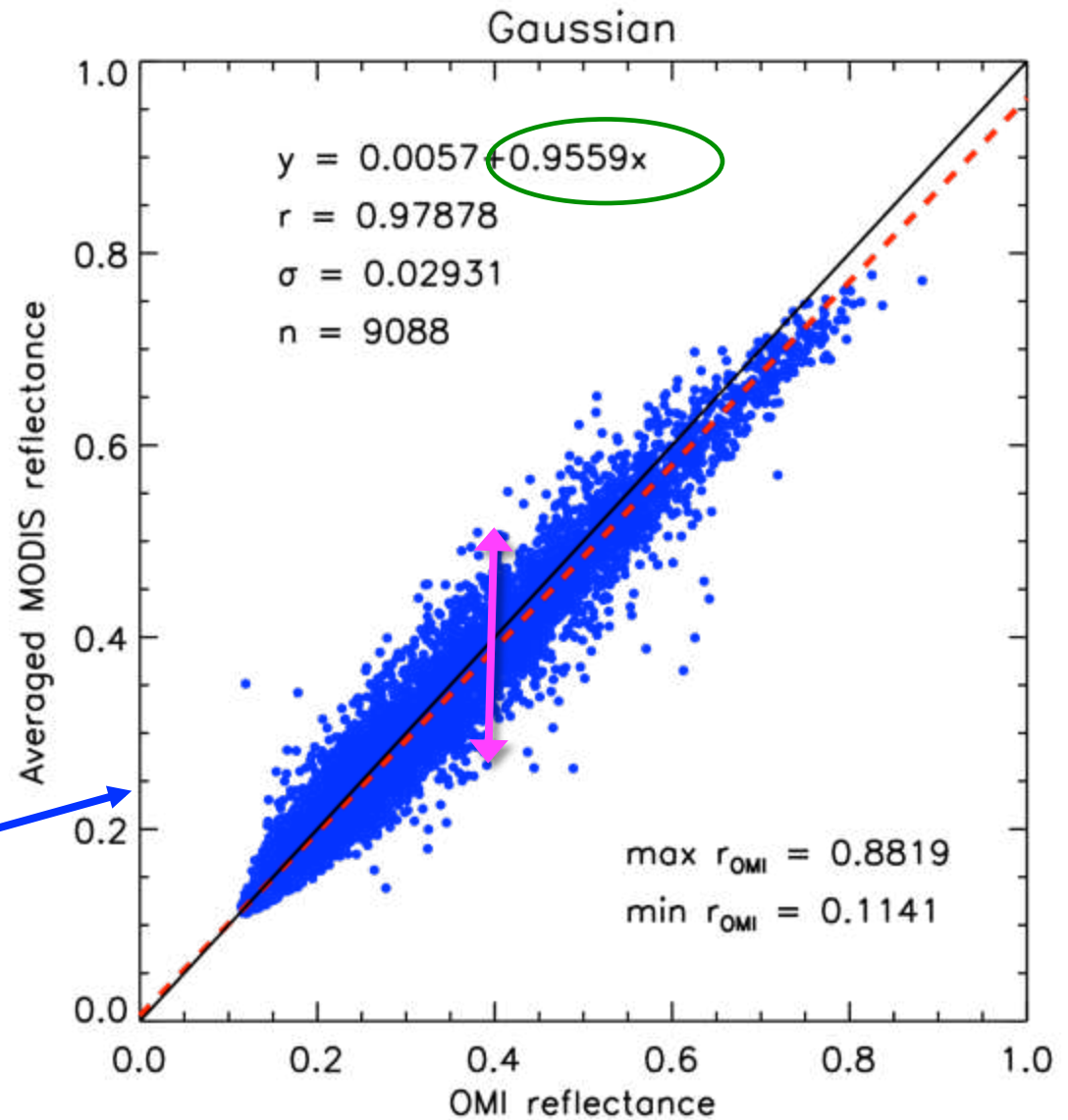No smoke (low DRE)

Combining OMI and MODIS reflectances
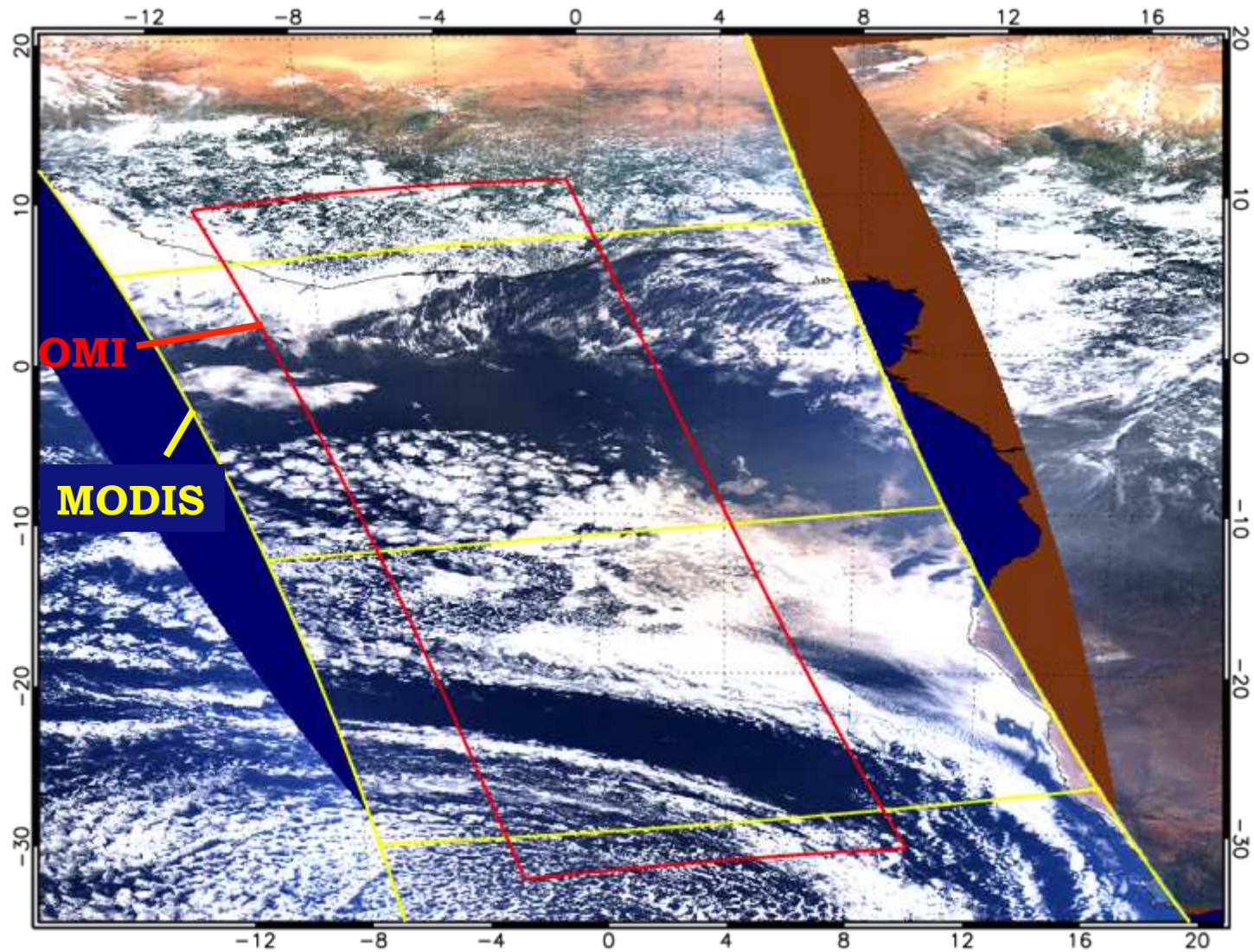
Combining OMI and MODIS reflectances

OMI and MODIS
overlap around 469 nm

Good correlation between OMI
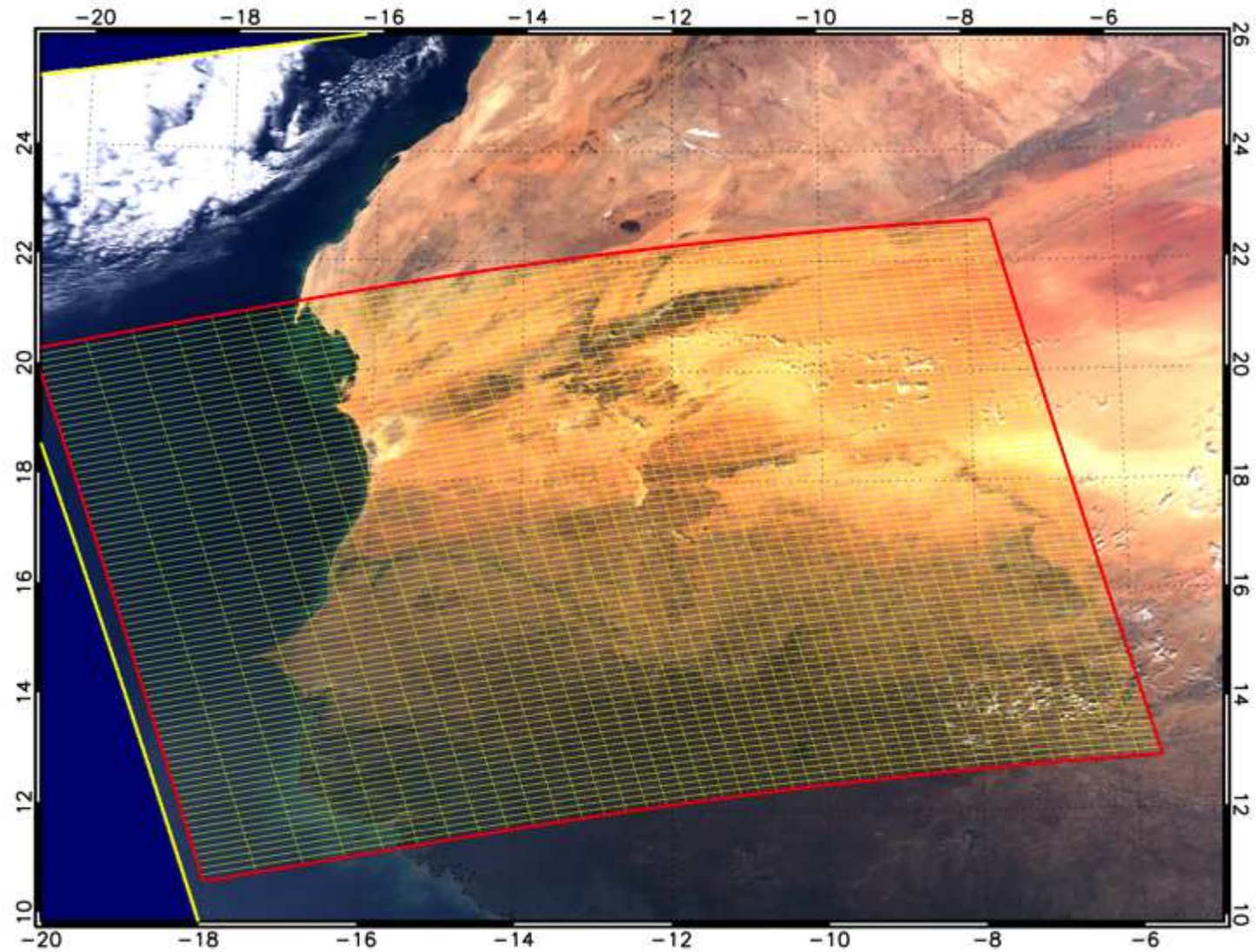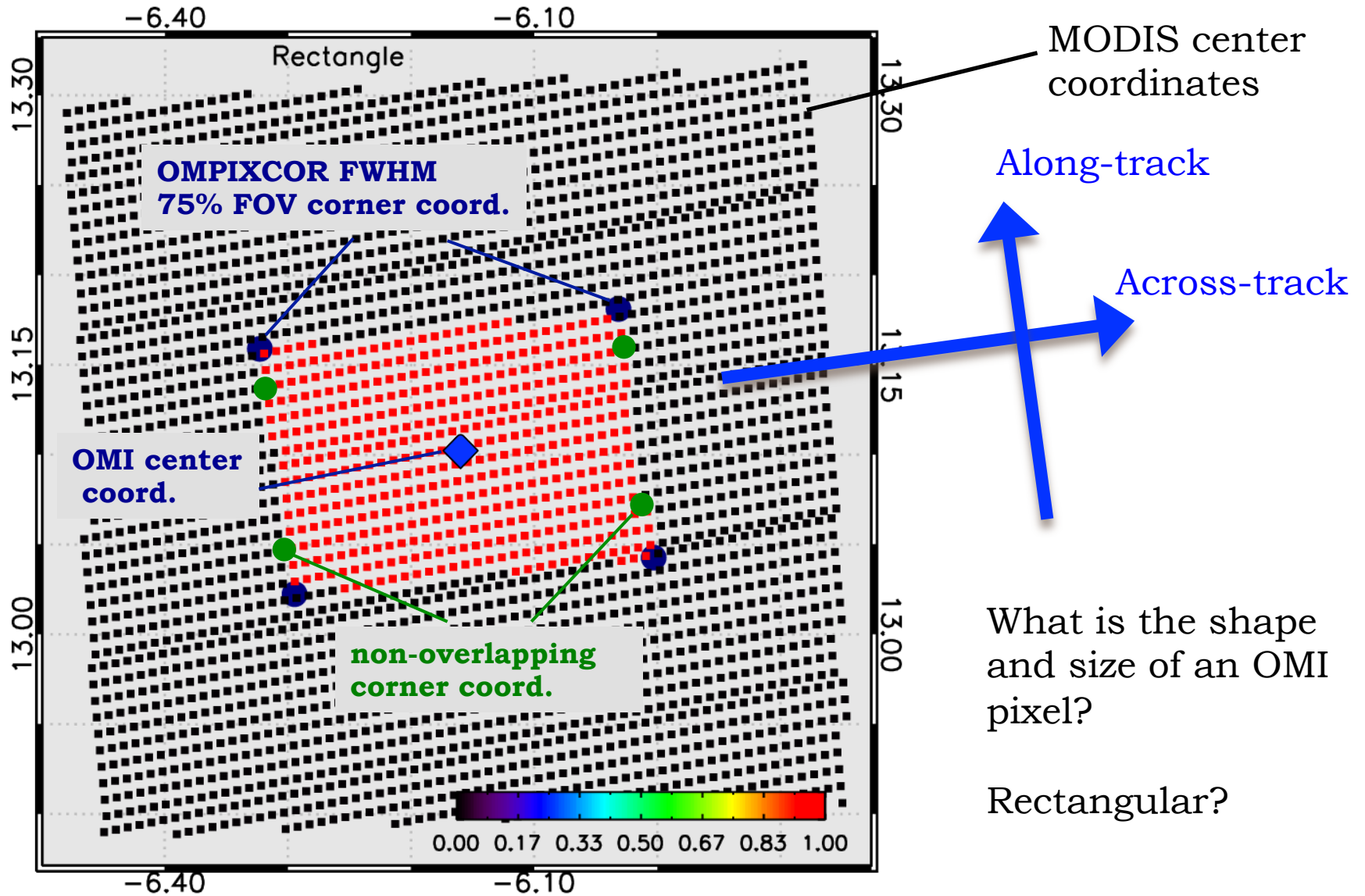and MODIS reflectances, but
large spread

Gaussian

$y = 0.0057 + 0.9559x$

$r = 0.97878$

$\sigma = 0.02931$

$n = 9088$

$\max r_{OMI} = 0.8819$

$\min r_{OMI} = 0.1141$

Combining OMI and MODIS reflectances

If the spread is due to clouds, then how about cloud-free scenes?

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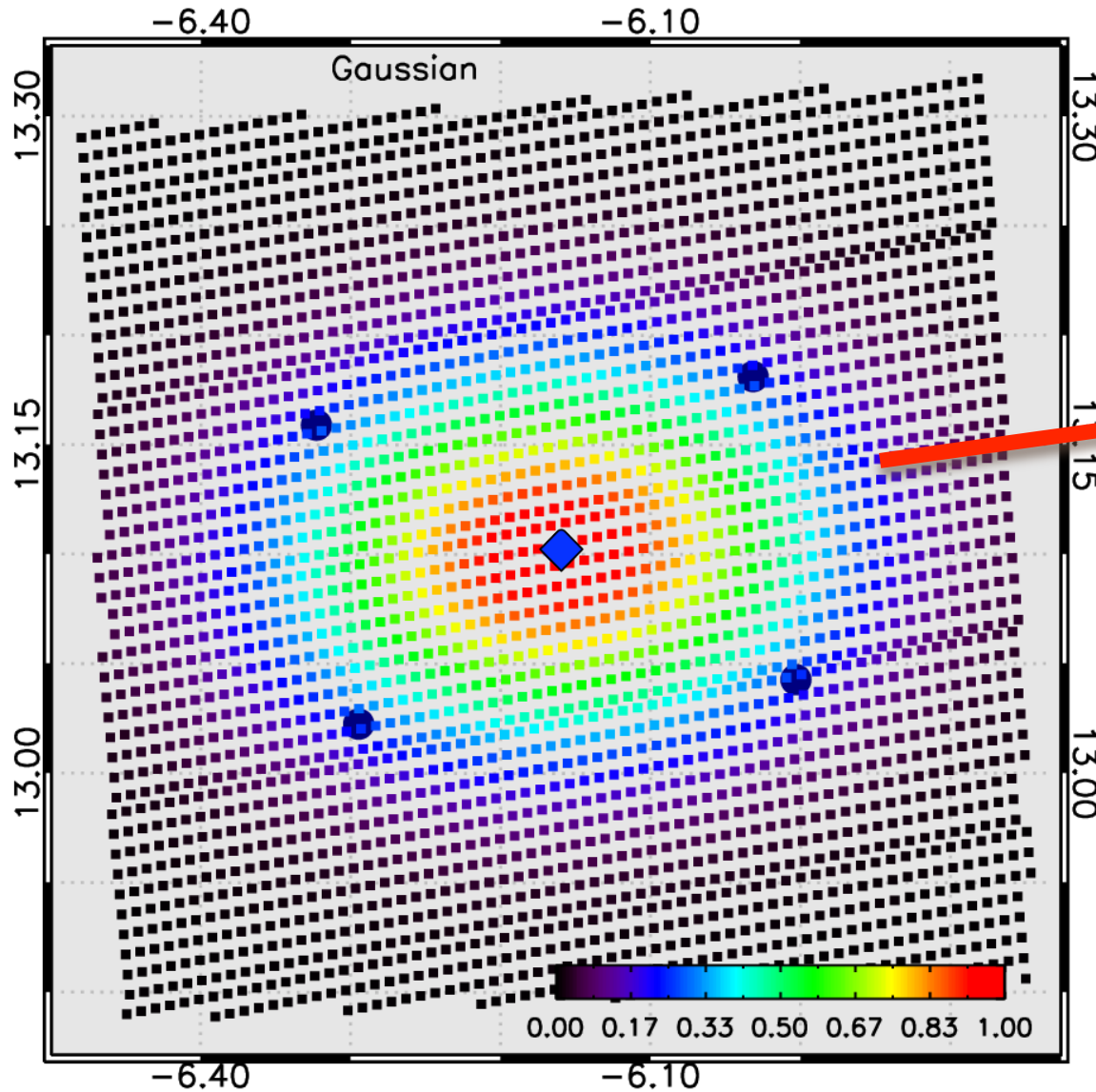
Combining OMI and MODIS reflectances

MODIS center coordinates

Along-track

Across-track

What is the shape and size of an OMI pixel?

Rectangular?

TU Delft

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Combining OMI and MODIS reflectances

Along-track

Across-track
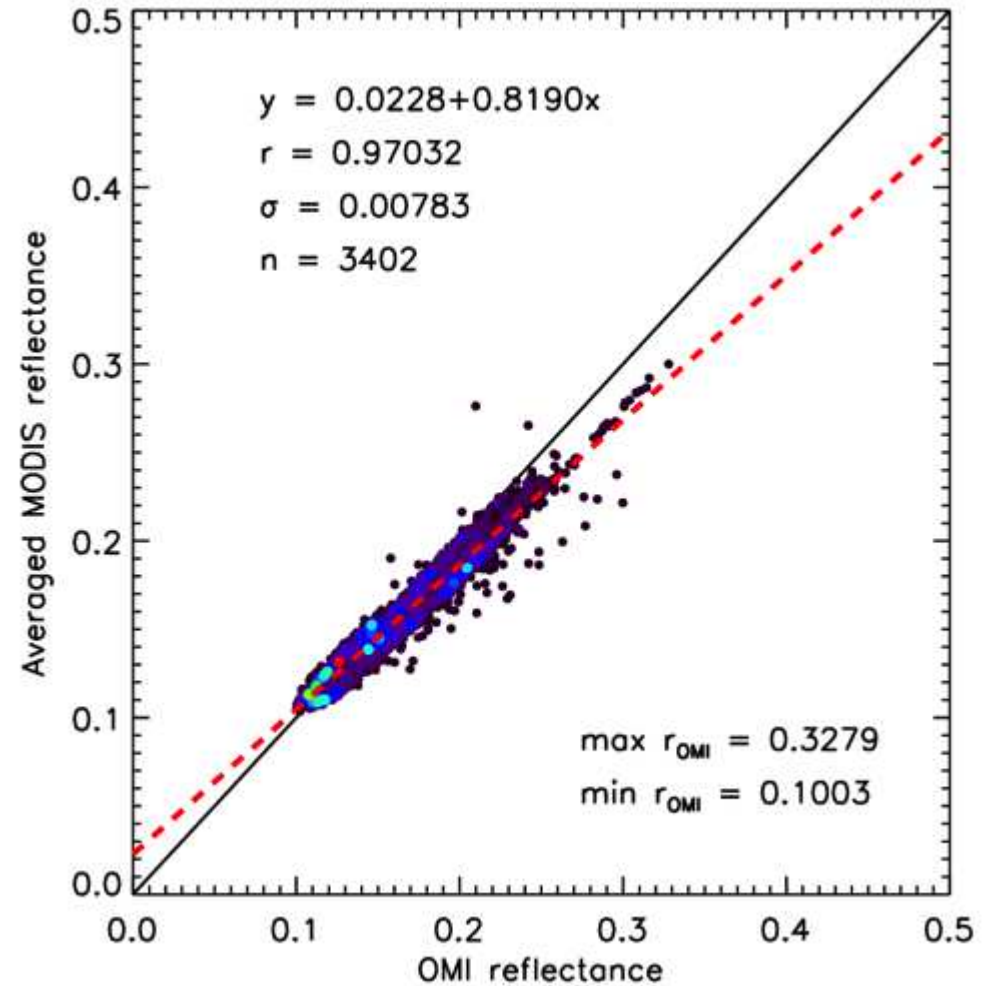
What is the shape and size of an OMI pixel?

Gaussian?

Combining OMI and MODIS reflectances

How does the correlation
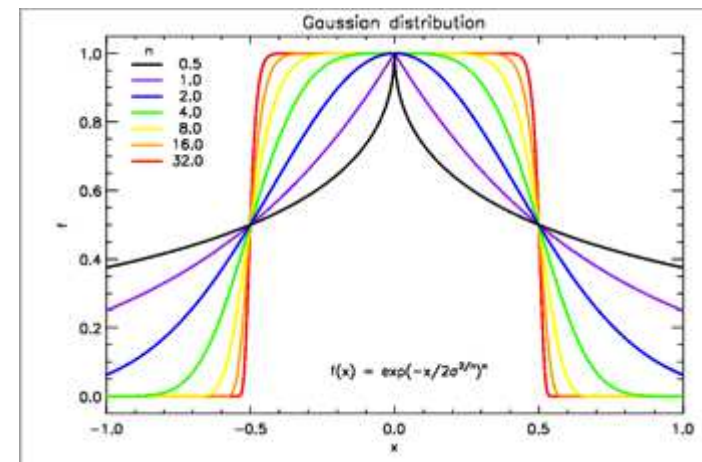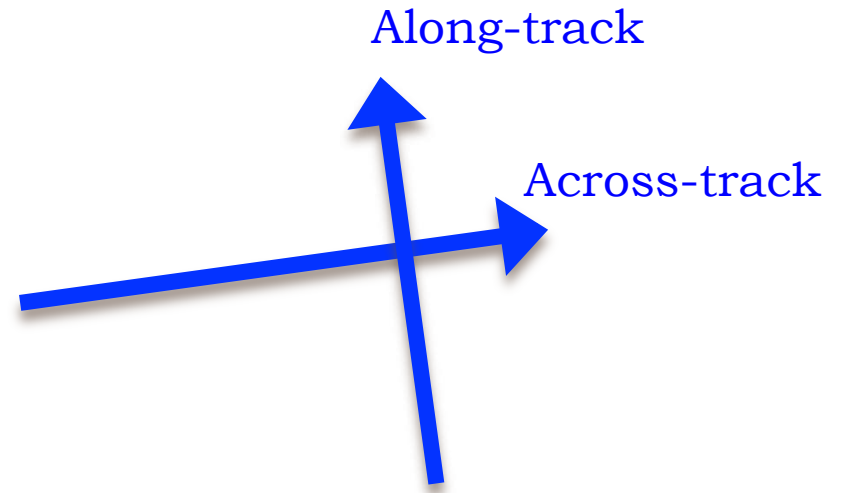change if the OMI pixel
shape and size is changed?

GAUSSIAN

RECTANGLE

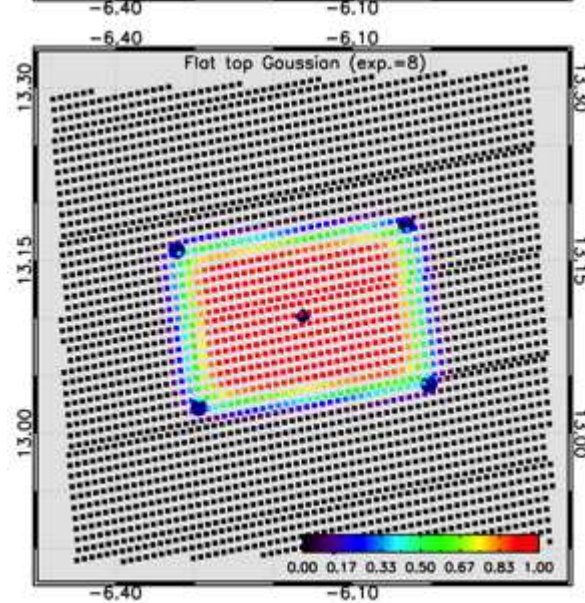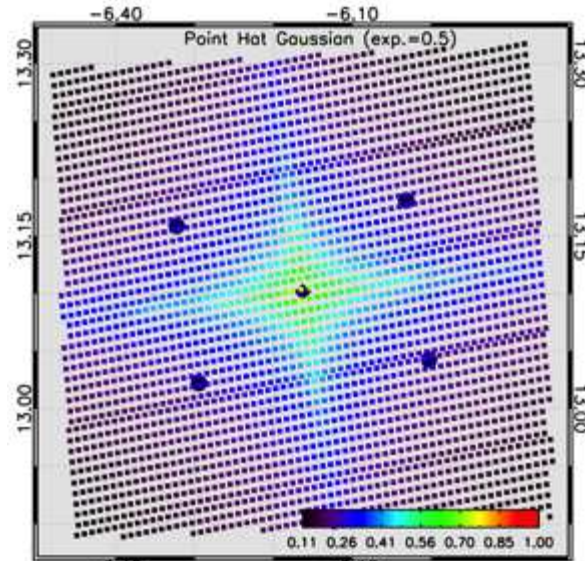

RECTANGLE plot:
Averaged MODIS reflectance (y-axis) vs OMI reflectance (x-axis)
y = 0.0217+0.8257x
r = 0.96660
σ = 0.00841
n = 3402
max r_{OMI} = 0.3279
min r_{OMI} = 0.1003

GAUSSIAN plot:
Averaged MODIS reflectance (y-axis) vs OMI reflectance (x-axis)
y = 0.0228+0.8190x
r = 0.97032
σ = 0.00783
n = 3402
max r_{OMI} = 0.3279
min r_{OMI} = 0.1003

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Combining OMI and MODIS reflectances

Along-track

Across-track
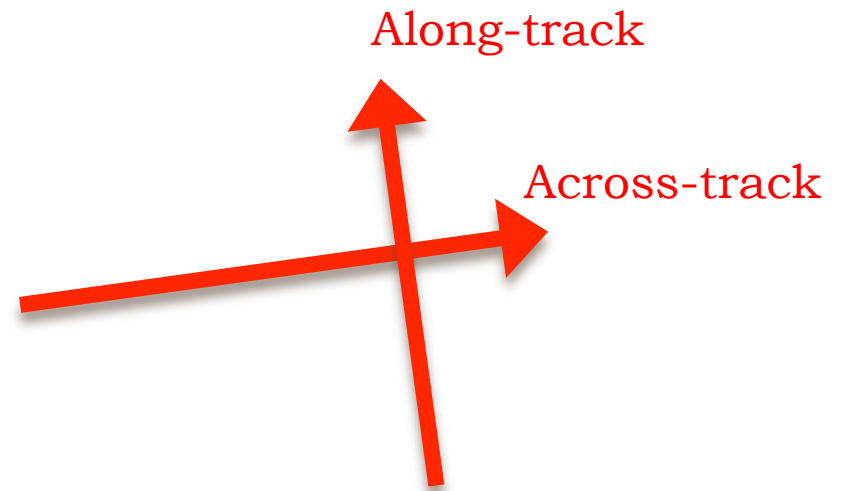
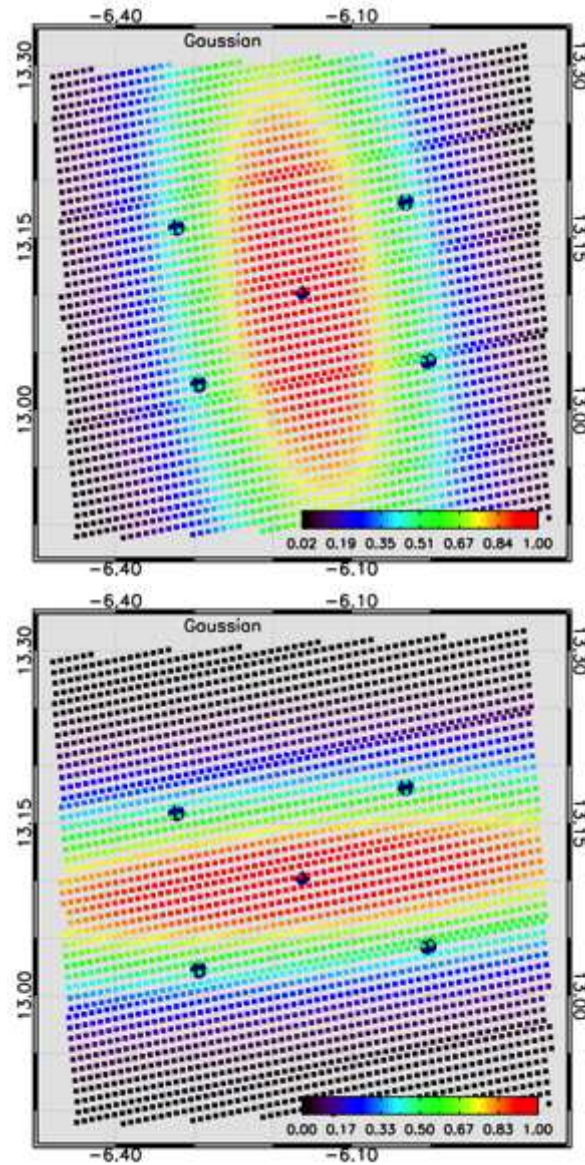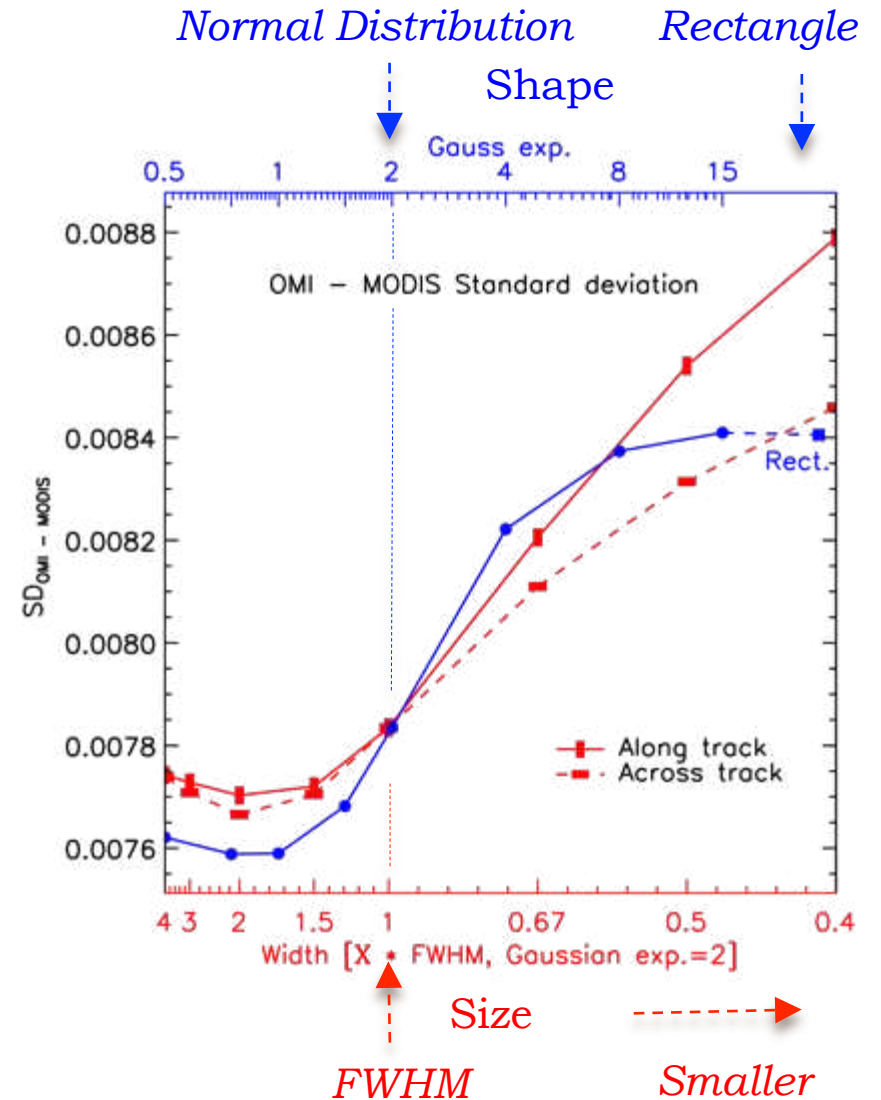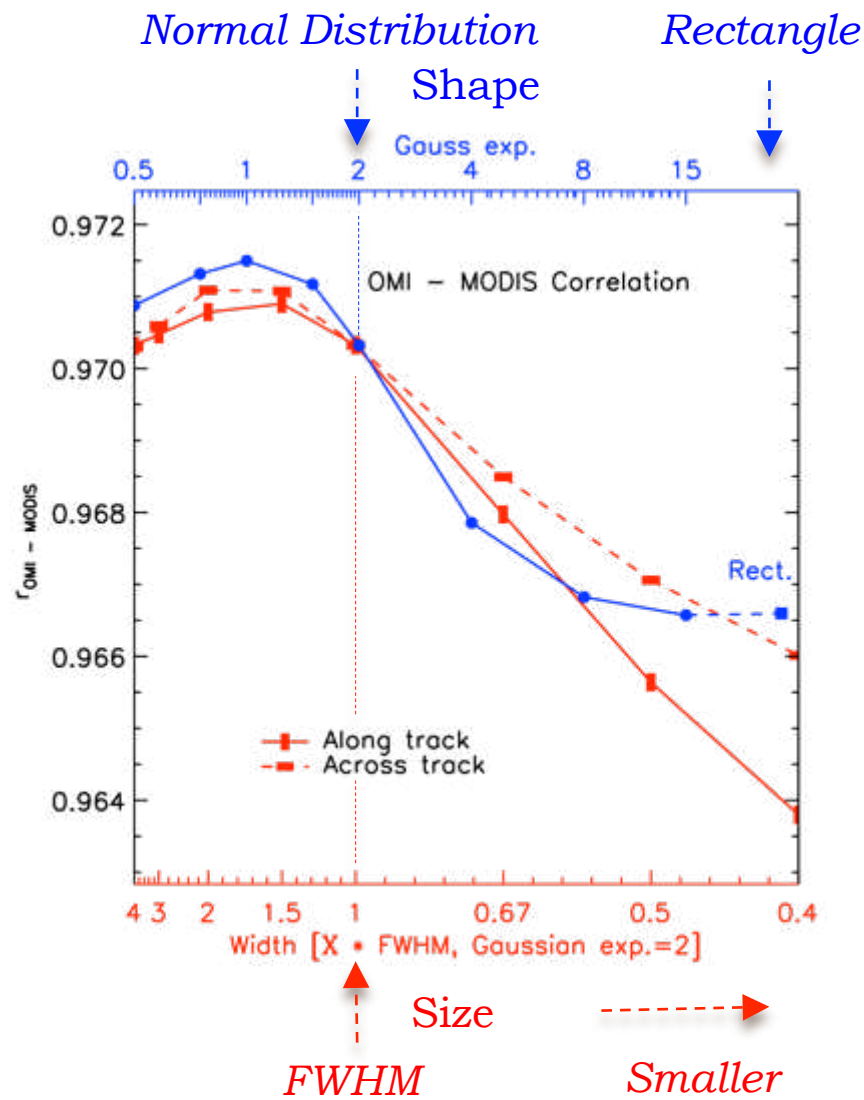# Combining OMI and MODIS reflectances

Along-track

Across-track

Combining OMI and MODIS reflectances
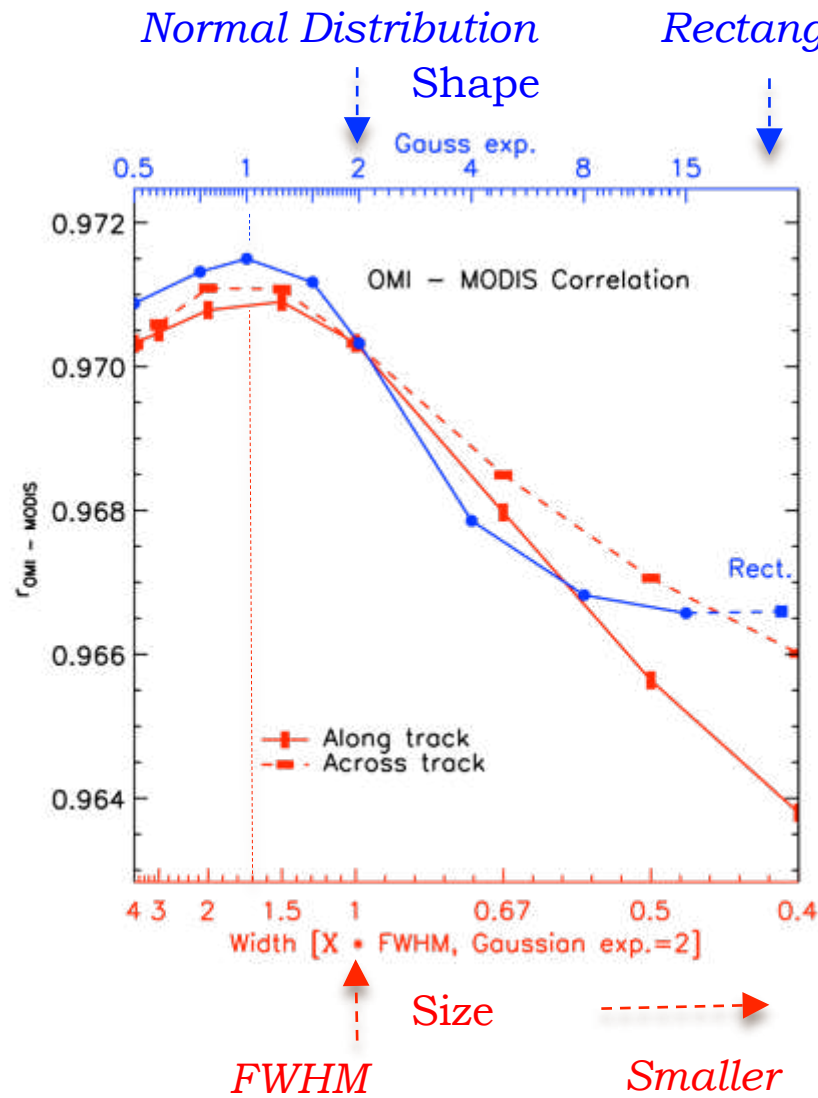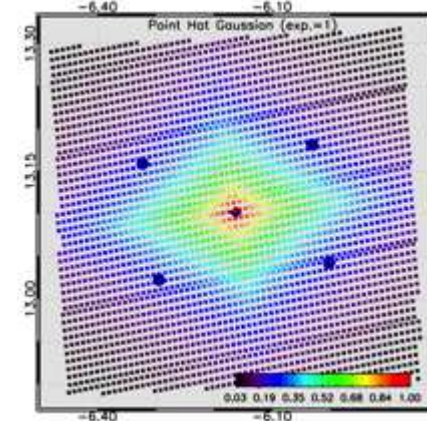
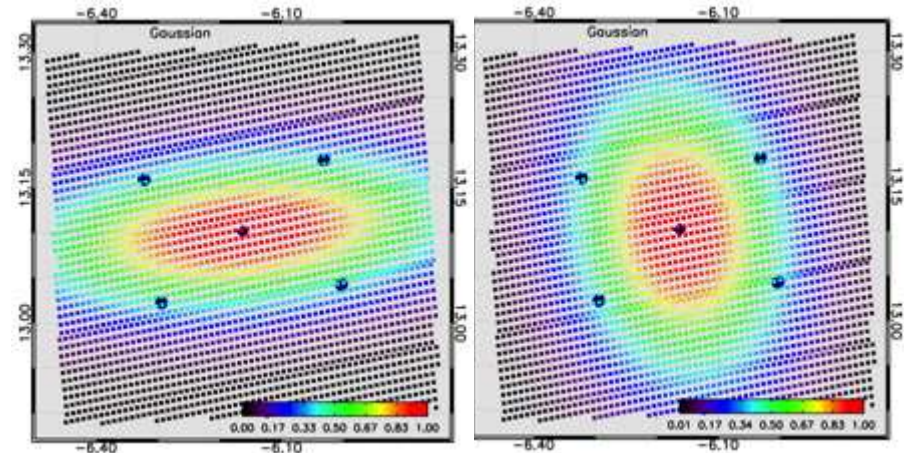# Combining OMI and MODIS reflectances

Combining OMI and MODIS reflectances

Spread is much smaller for cloud-free scenes
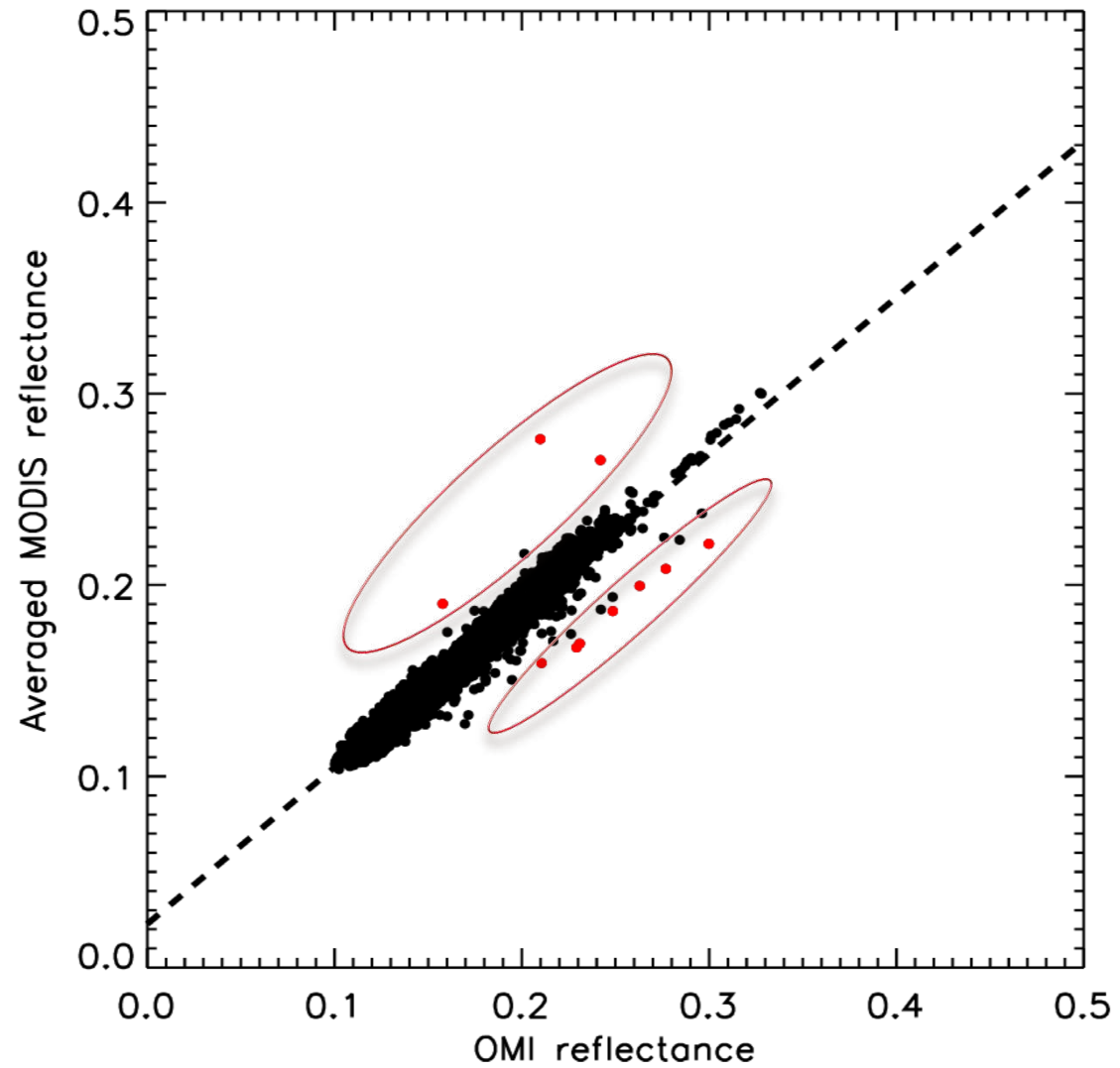

Gaussian

$y = 0.0228 + 0.8190x$

$r = 0.97032$

$\sigma = 0.00783$

$n = 3402$

max $r_{OMI} = 0.3279$

min $r_{OMI} = 0.1003$
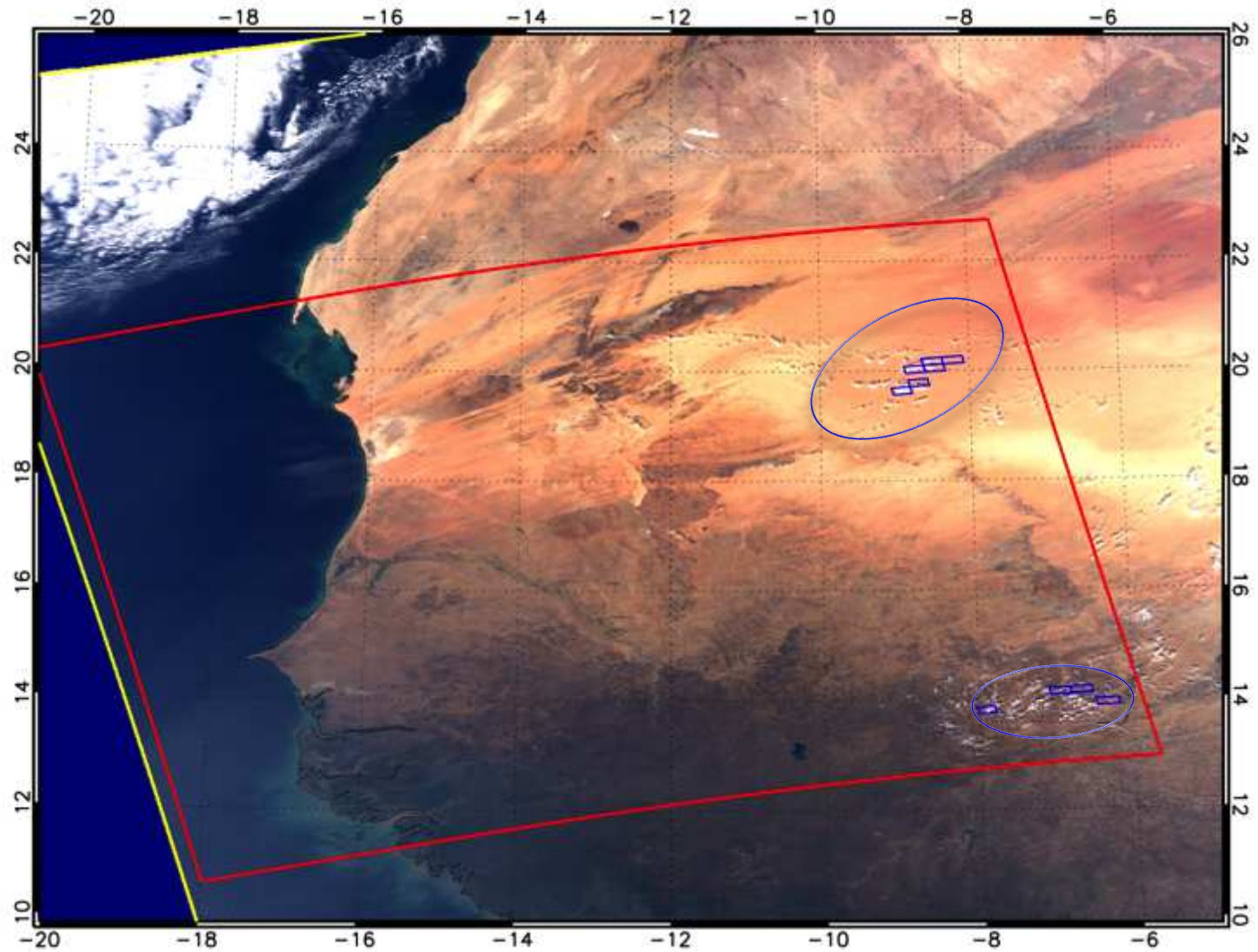
Averaged MODIS reflectance
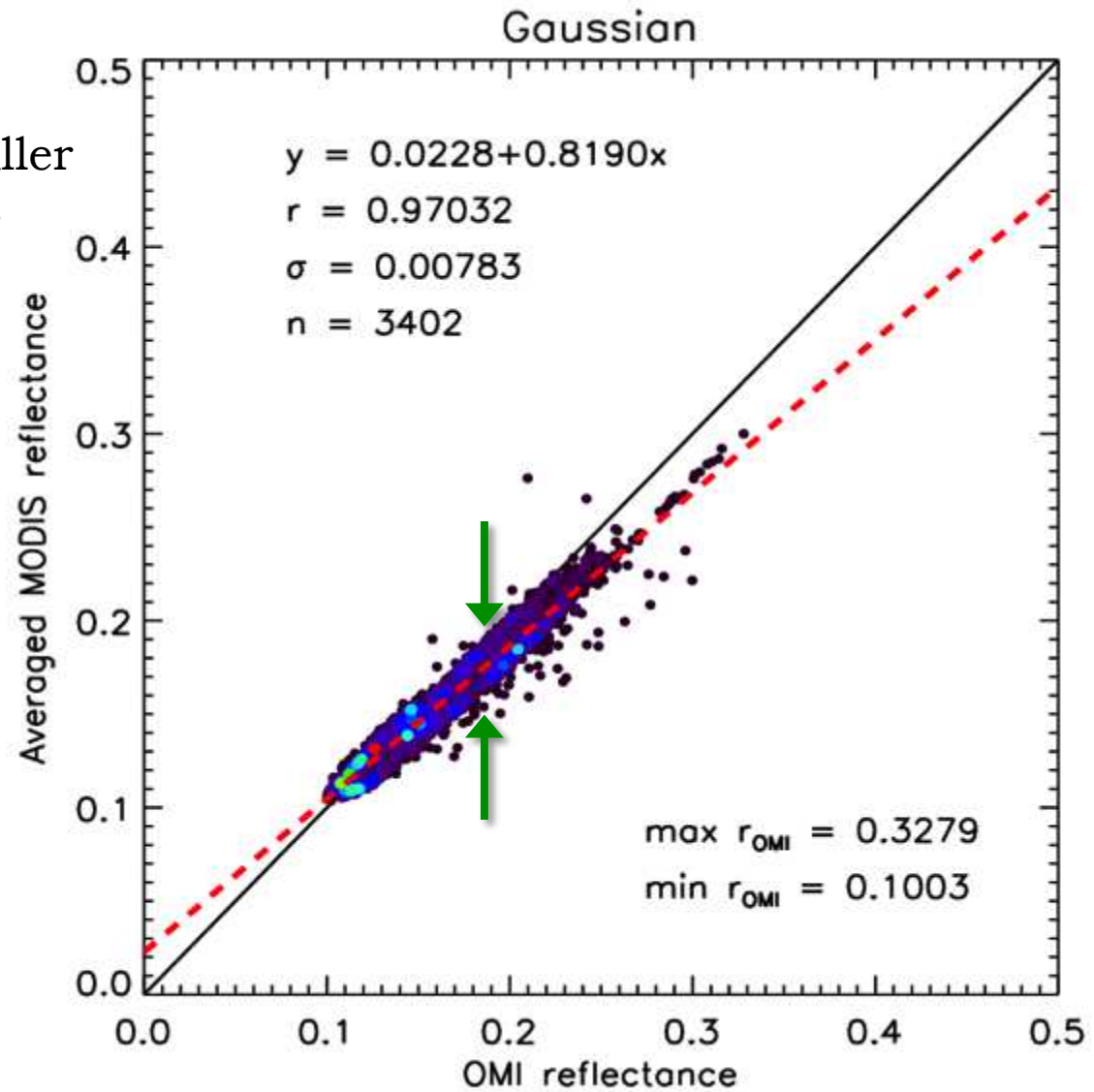
OMI reflectance

Combining OMI and MODIS reflectances

So what about these outliers?

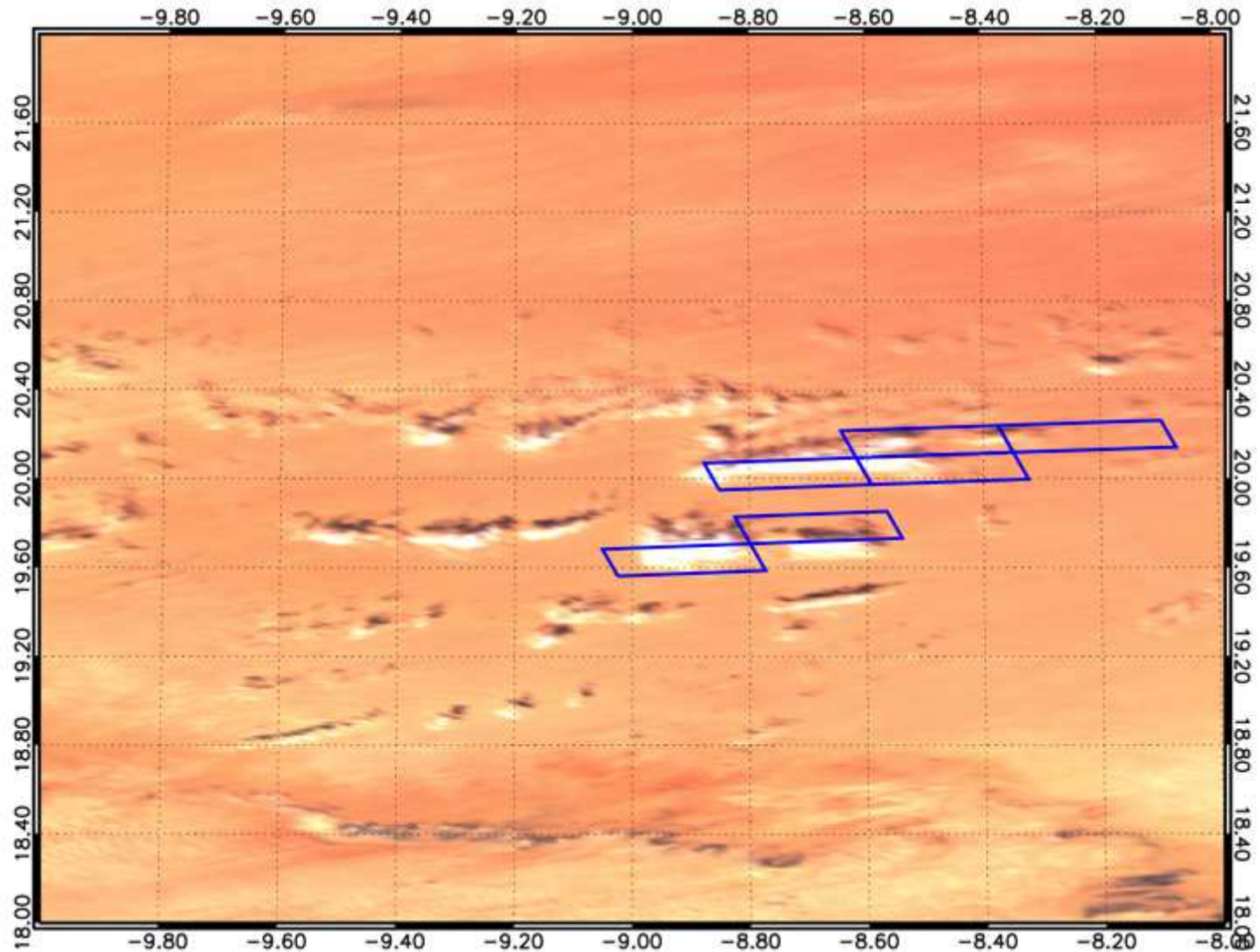# Combining OMI and MODIS reflectances

Outliers
correspond to
broken cloud
fields

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Combining OMI and MODIS reflectances

Outliers correspond to broken cloud fields:

The scene reflectance changes considerably between Aqua and Aura overpasses.

Aerosol absorption over clouds

Conclusions

- OMI + MODIS reflectances can be combined to shortwave spectra for DAA retrieval, but..

- OMI footprint is not (well) defined. Footprint is not rectangular and information outside corner coordinates also plays a role. Also holds for TROPOMI..

- Clouds scenes change significantly in the 8-15 minutes between Aqua and Aura overpasses, reducing the accuracy of the combined spectra.