Aerosol and cloud parameters from UV-visible spectrometers

GOME-2, SCIAMACHY, OMI

Piet Stammes

and colleagues at KNMI

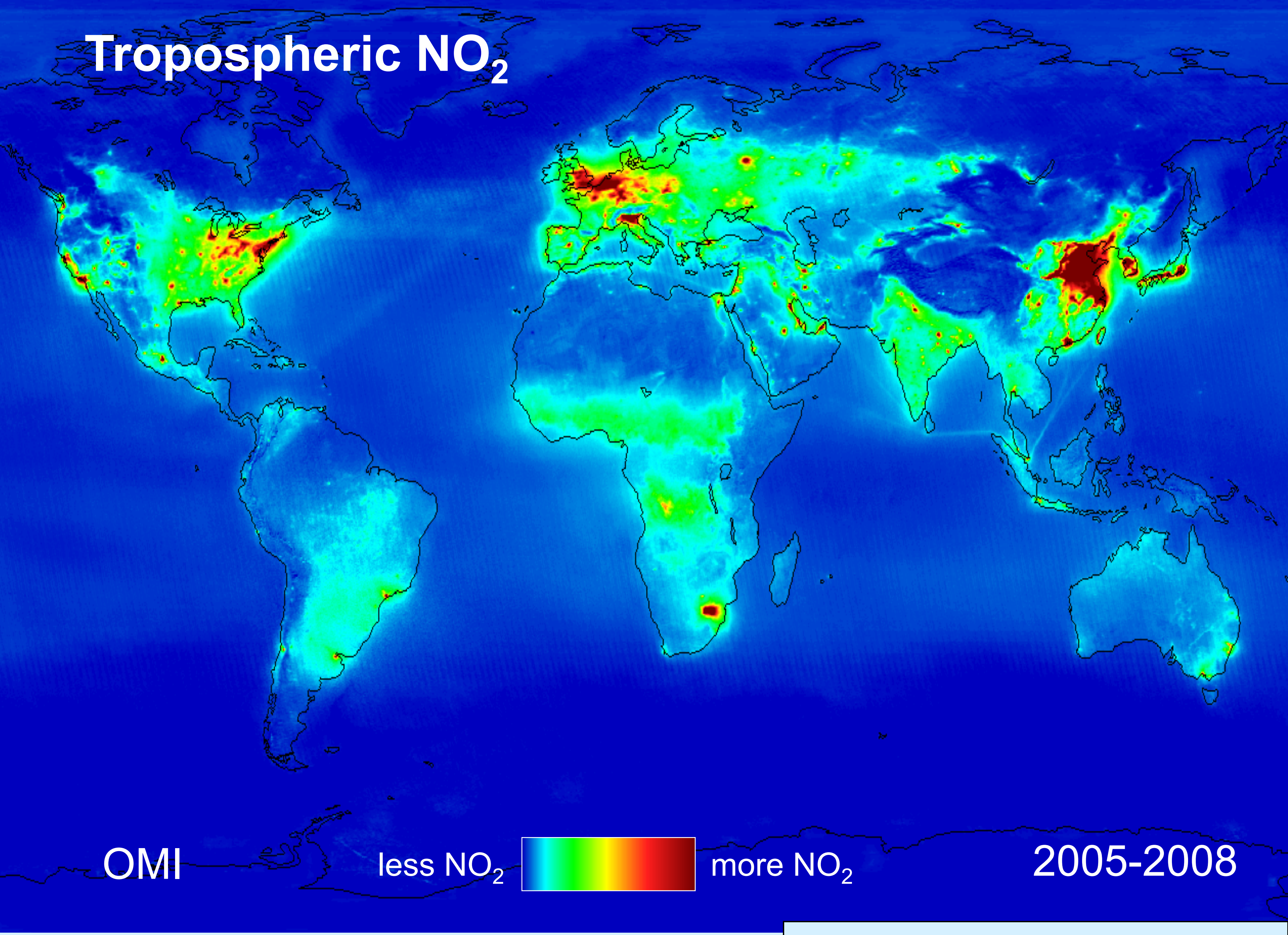
Aerosol-Clouds-Climate workshop

Paris, 12-14 September 2011

“The Antropocene”

(Paul Crutzen)

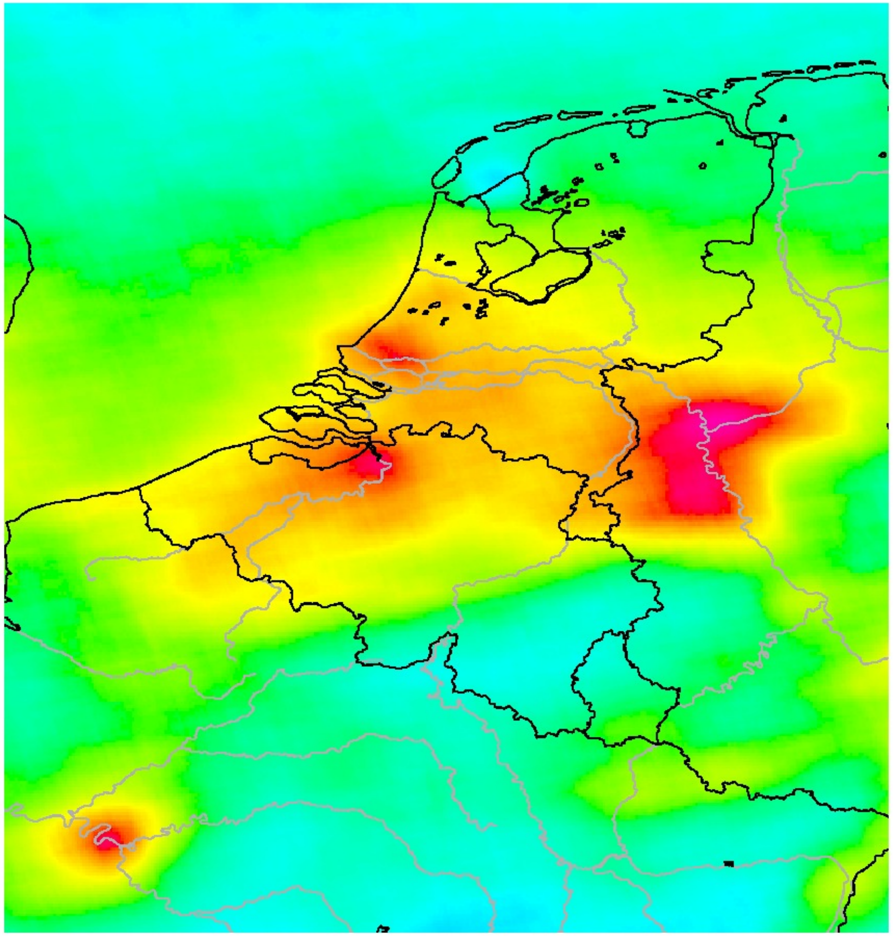
- Growing world population (9 billion in 2050)
- Growing energy demand, especially in developing countries
- Growing use of fossil fuel
- Growing air pollution
- Growing greenhouse effect



Mijling, Boersma, Van der A, KNMI

OMI tropospheric NO_2

2005 - 2008



Vinken, Boersma, Van der A, KNMI/TUE

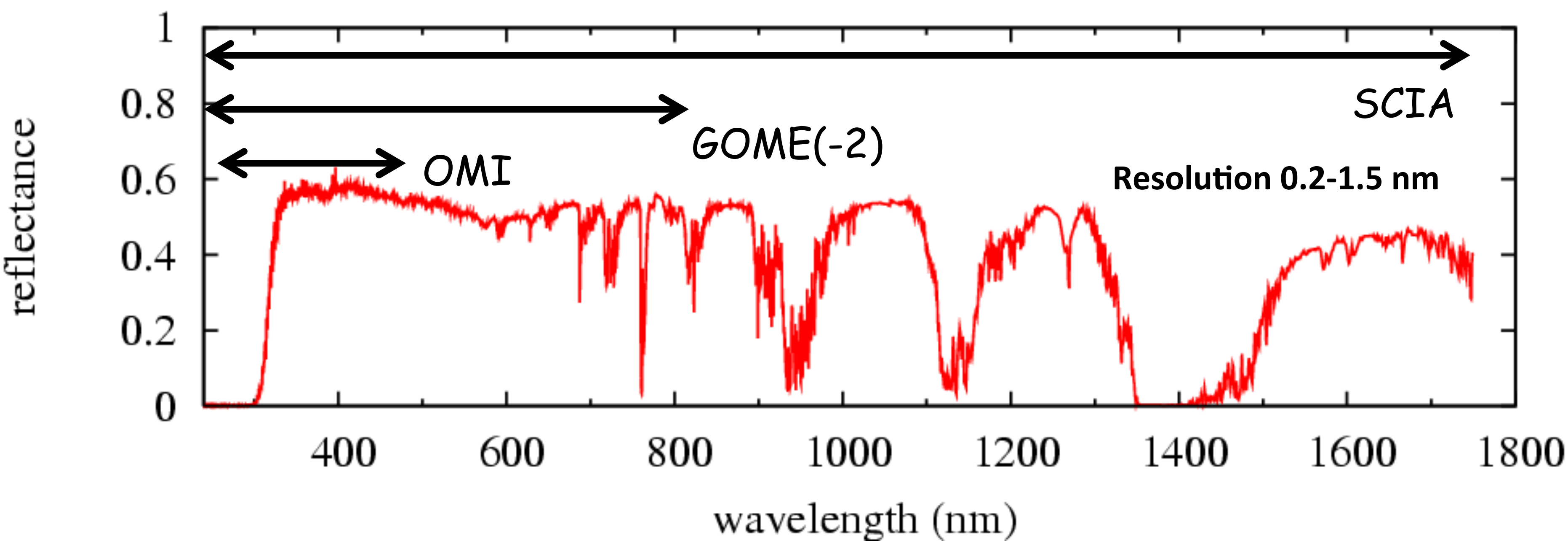
10^{15} mol/cm^2

Satellite UV-visible spectrometers

• GOME	ERS-2	240 – 800 nm
• SCIAMACHY	Envisat	240 – 1750 nm
• OMI	EOS-Aura	270 - 500 nm
• GOME-2	Metop-A	240 – 800 nm

GOME-2/SCIAMACHY/GOME overpass at 9:30/10:00/10:30 LT

OMI overpass at 13:30 LT



Strong and weak points of spectrometers

Strong points:

- Differential absorption spectroscopy for trace gases (O_3, NO_2, SO_2, HCHO)
- Absorbing aerosols from UV spectrum

  - AOT is large; surface is dark; AAI works with aerosols + clouds
- Cloud height (even aerosol height) from O_2 A-band spectrum

  - cloud height down to the surface, independent of temperature.

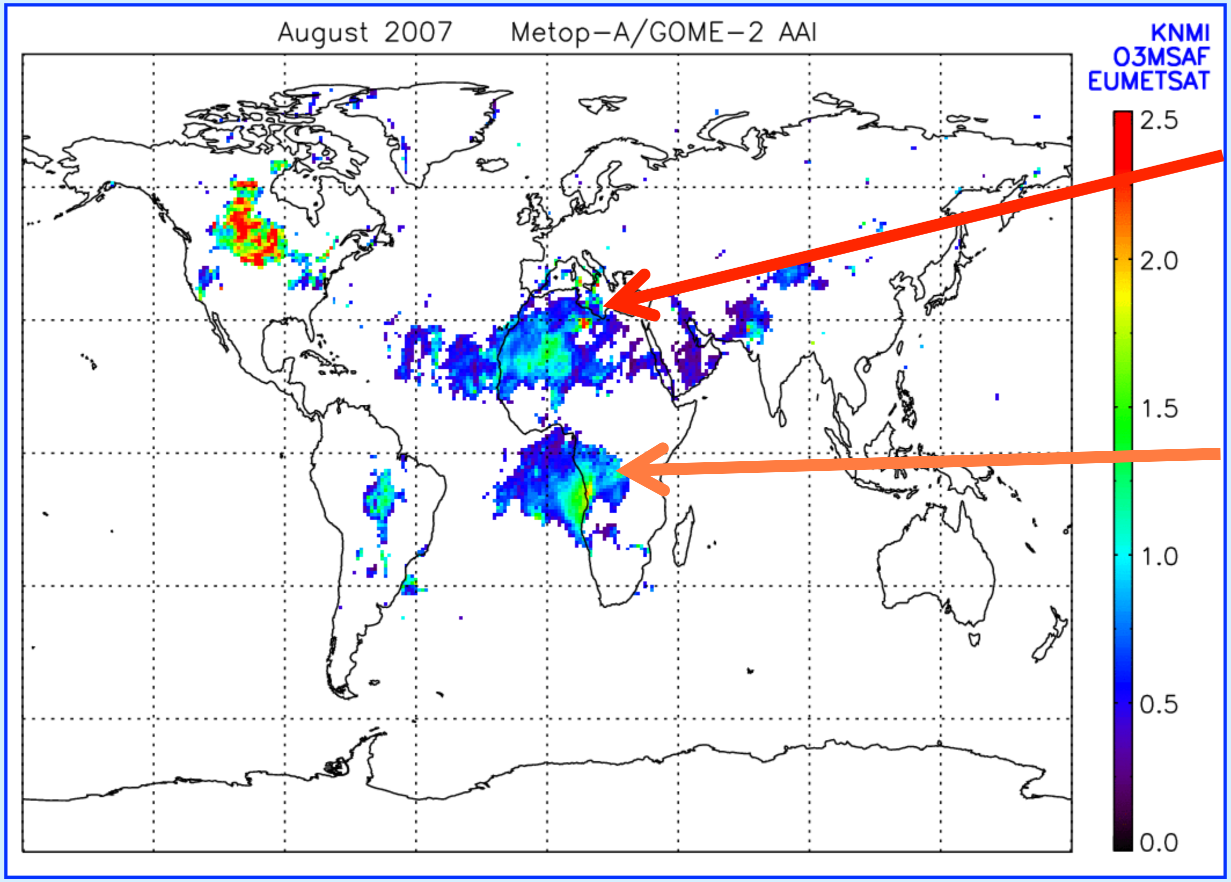
Weak points:

- Single view
- Limited spatial resolution

Pixel sizes

- GOME
- GOME-2
- SCIAMACHY
- OMI
- **TROPOMI** on ESA S5P

Absorbing aerosol distribution from AAI

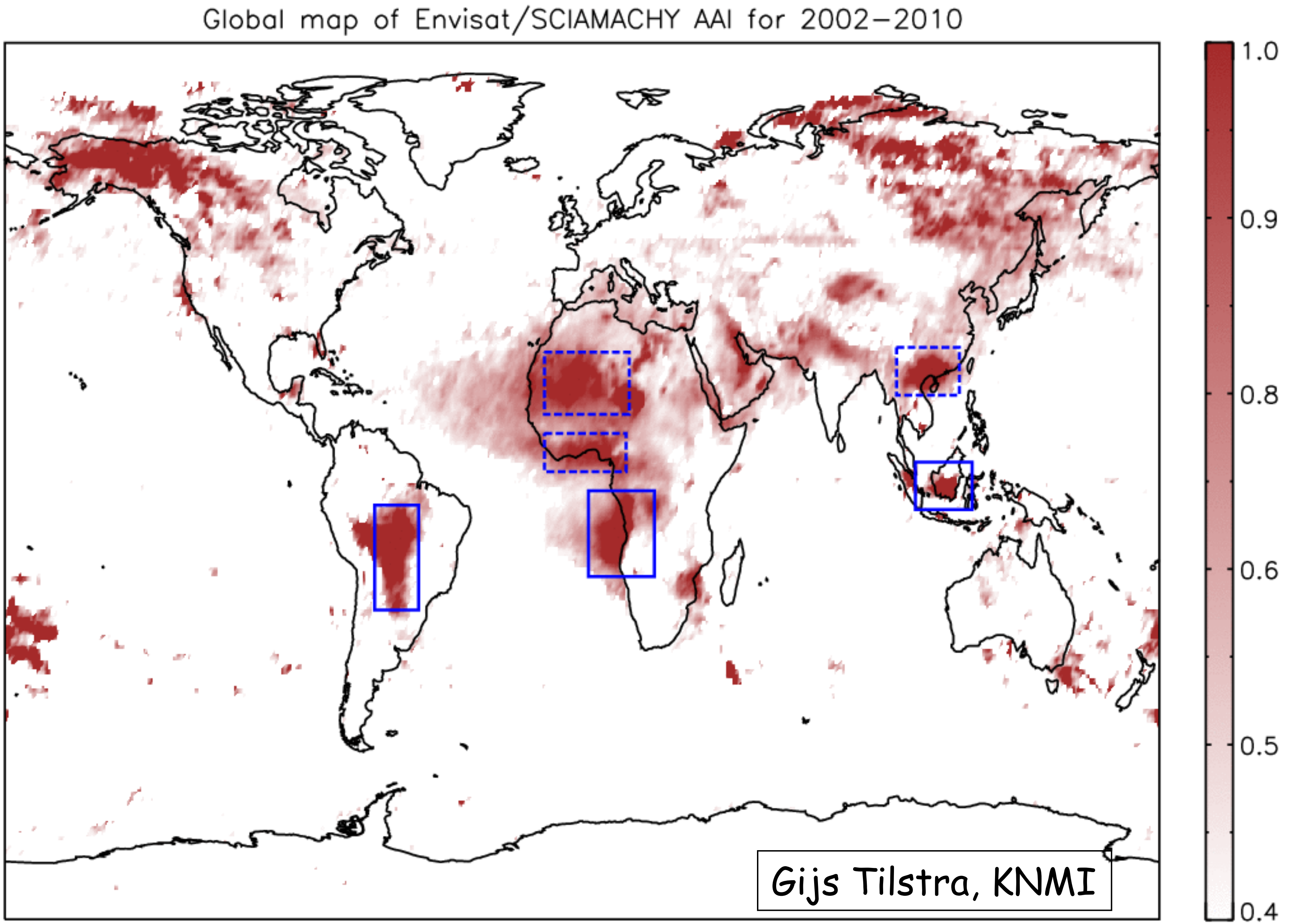


Desert Dust Aerosols

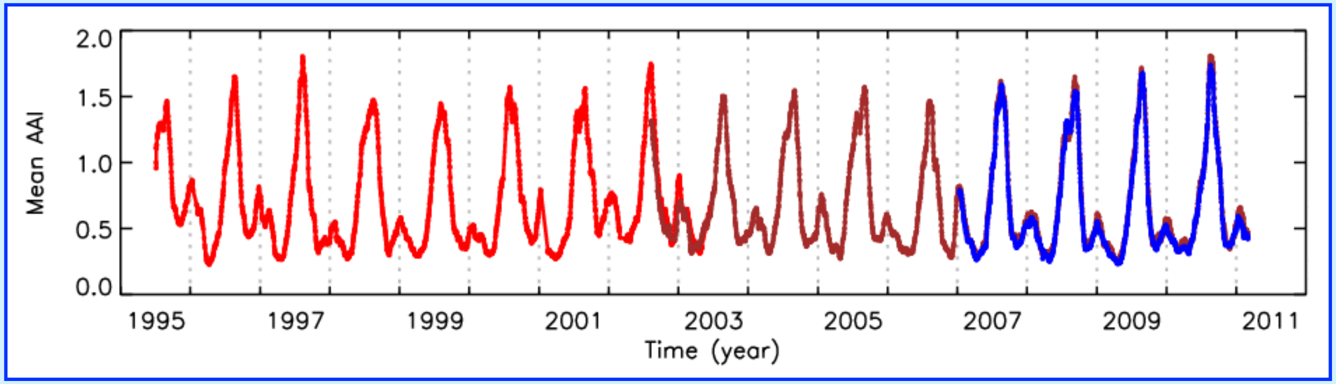
Biomass Burning Aerosols (dry season, anthropogenic)

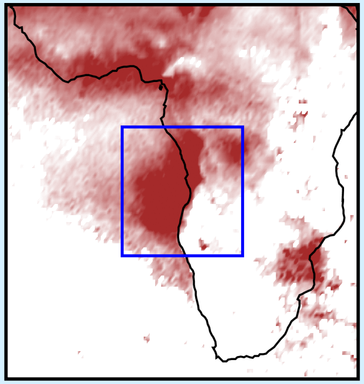
There are more than three decades (1978–2011) of satellite AAI data.

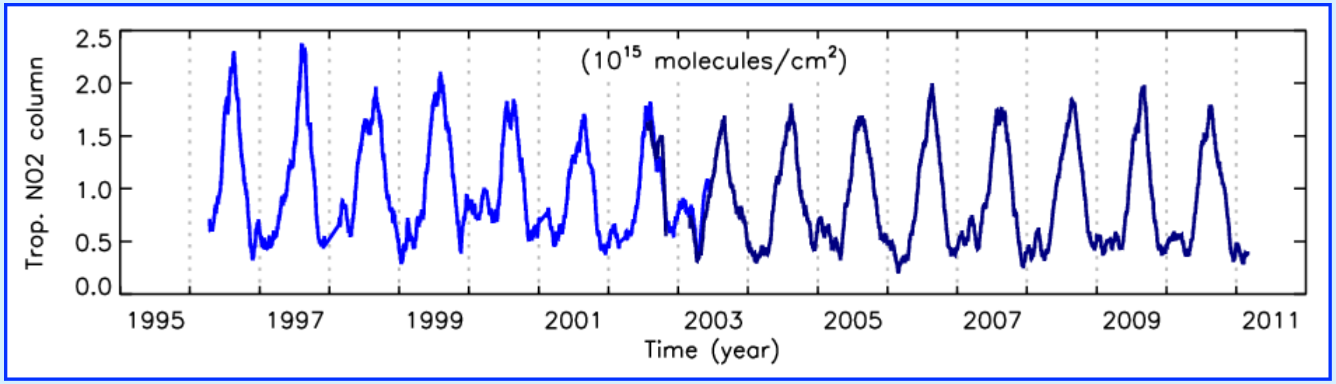
Gijs Tilstra, KNMI


Global map of Envisat/SCIAMACHY AAI for 2002–2010
1.0
0.9
0.8
0.6
0.5
0.4
Gijs Tilstra, KNMI

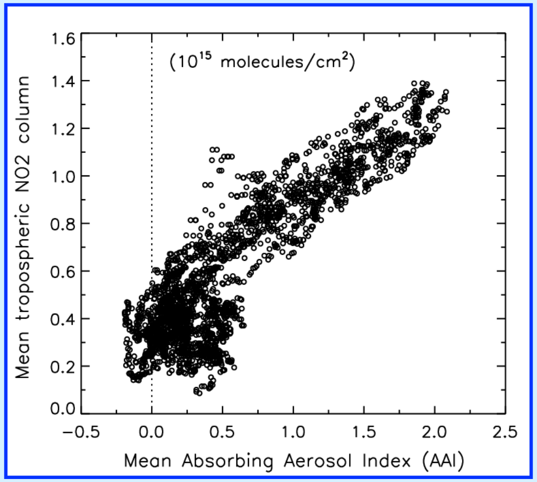
Times series for south-west Africa







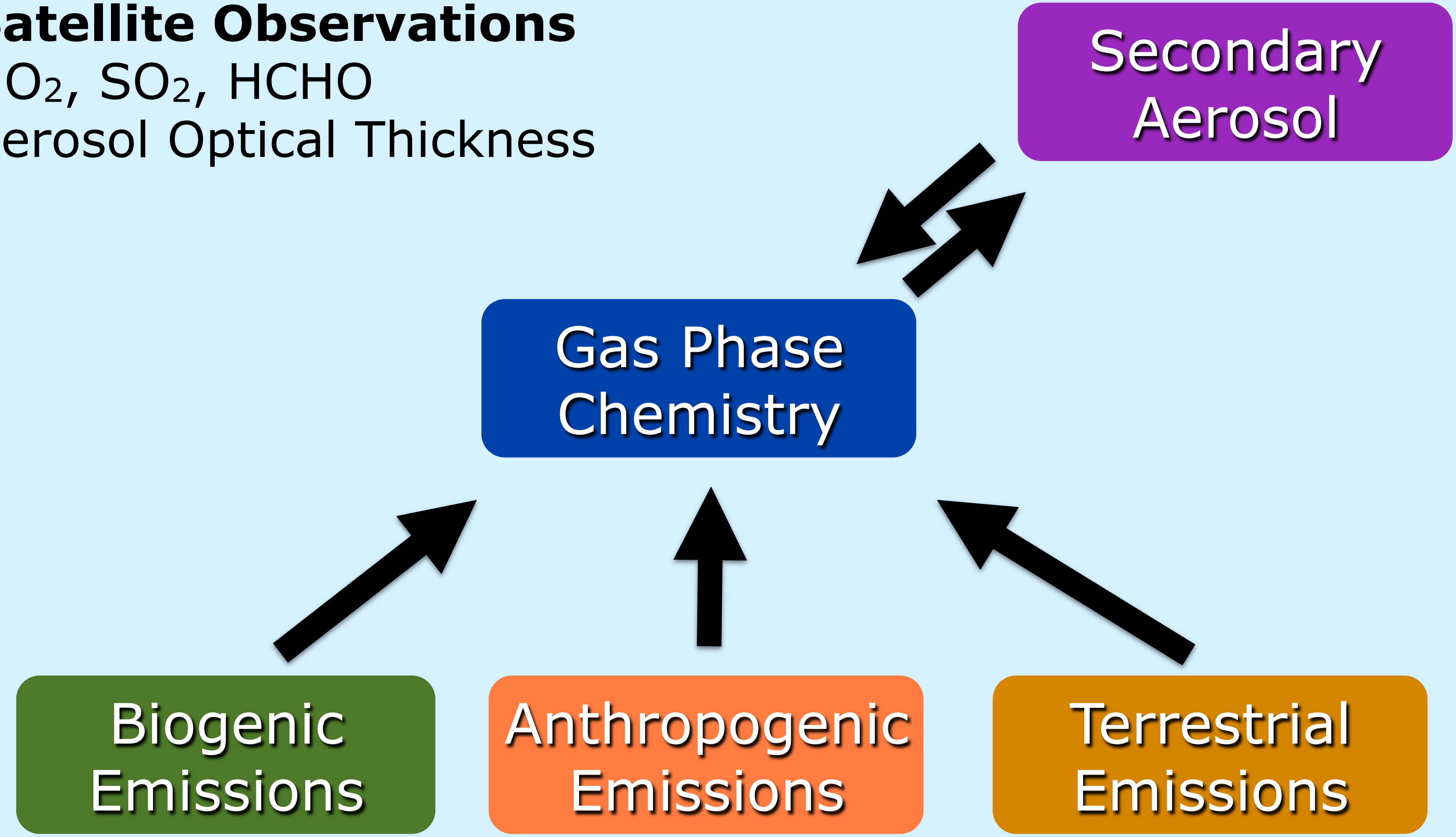
Tropospheric NO_2 column: good correlation with AAI. No clear trend in AAI visible.



Regional averages of tropospheric NO_2 and AAI correlate rather well.

Gijs Tilstra, KNMI

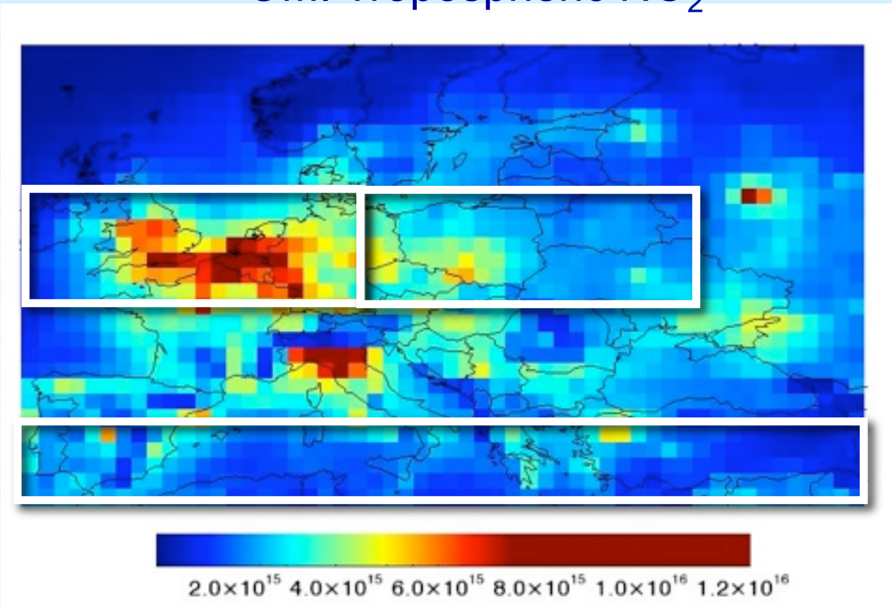
Satellite Observations
NO_2, SO_2, HCHO
Aerosol Optical Thickness



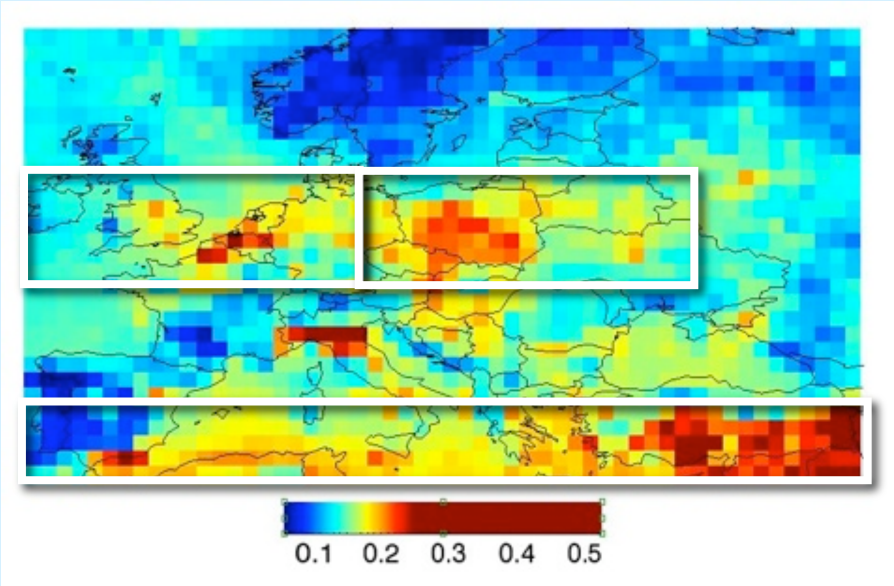
Pepijn Veefkind, KNMI

OMI NO_2 and MODIS AOT

OMI Tropospheric NO_2



MODIS AOT at 550 nm



Time period 2005-2007
Gridded 1x1 degree

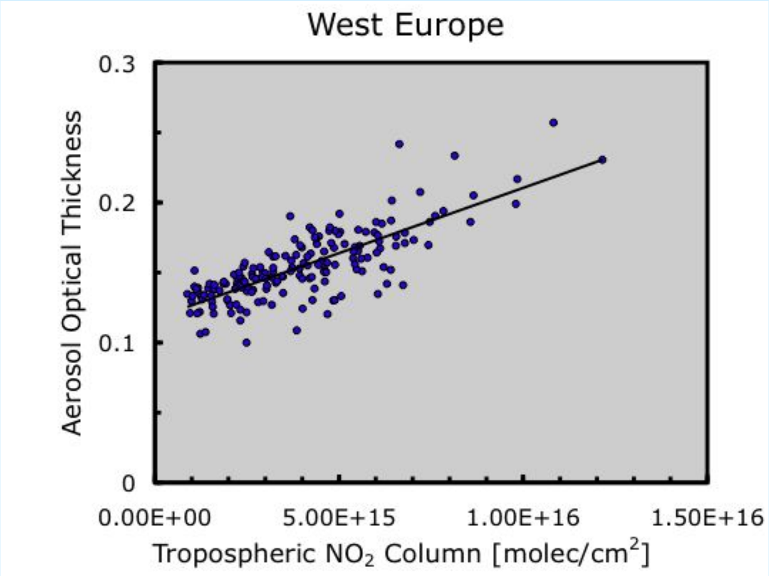
West Europe

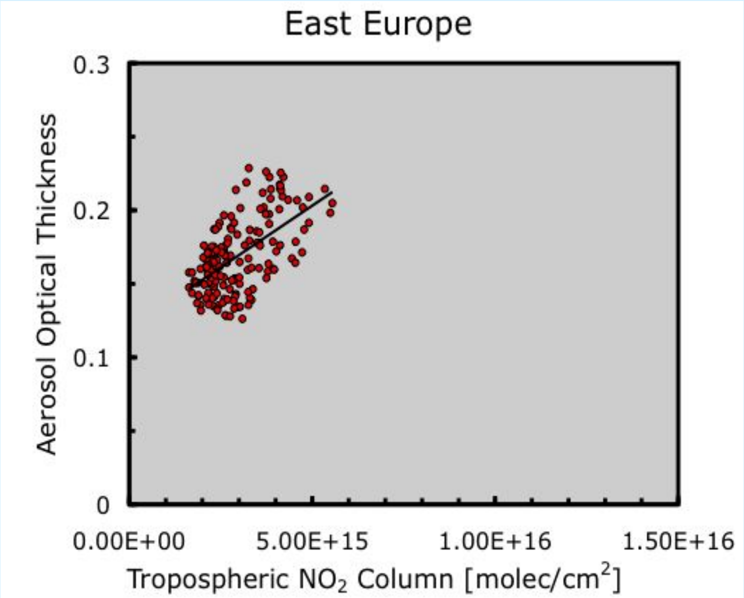
East Europe

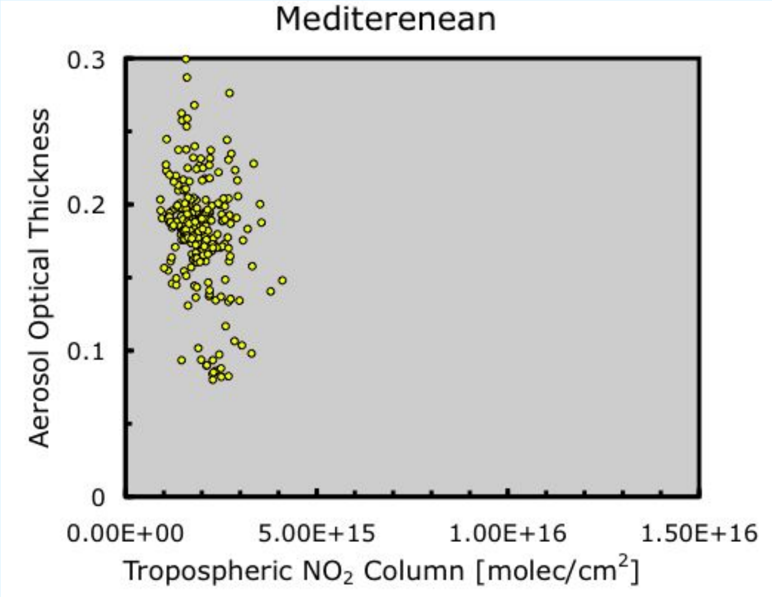
Mediterranean

Veefkind et al., ACP, 2011

AOT - NO_2 Spatial Correlation





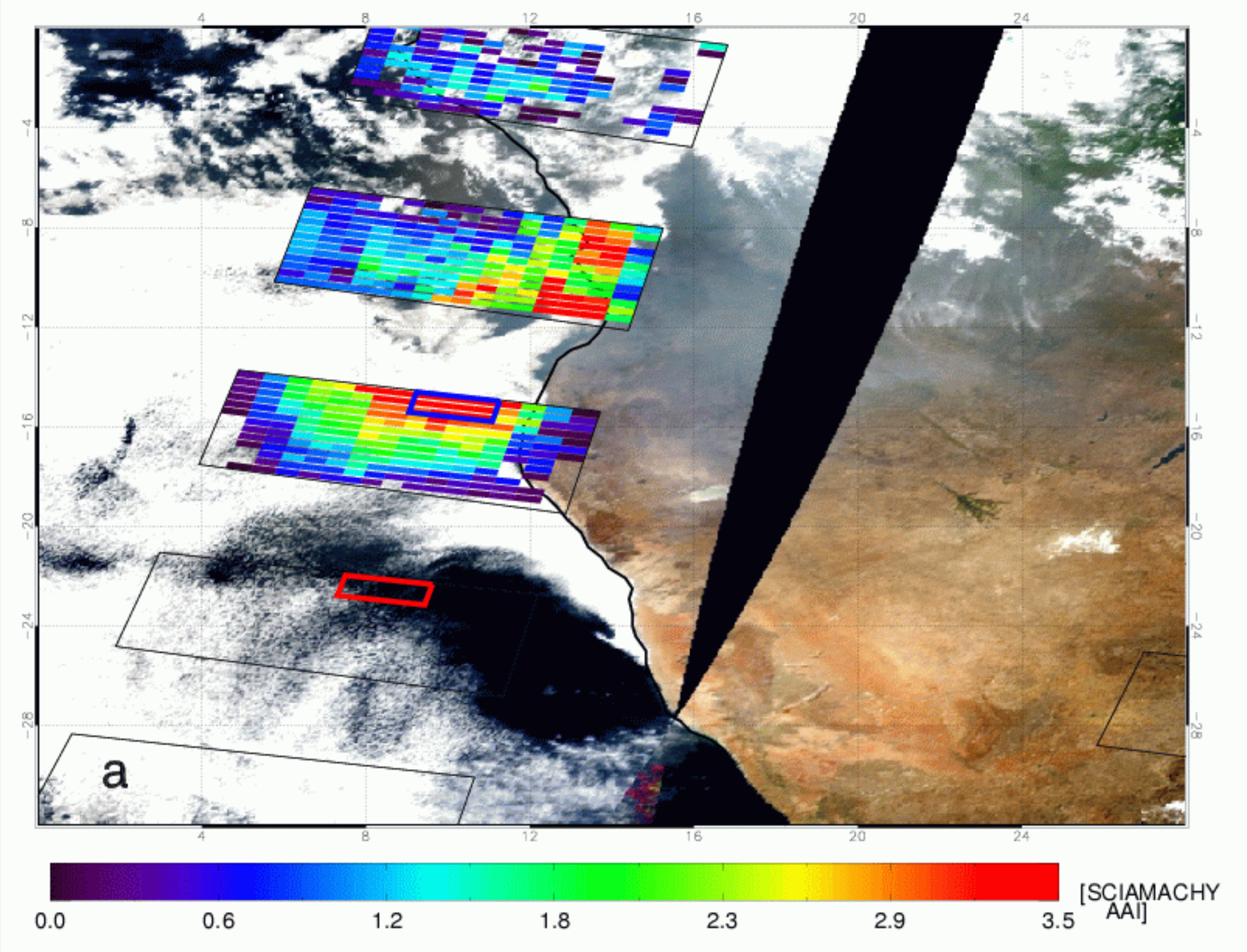


Region	Correlation	Slope
West Europe	0.79	$0.93\ 10^{-17}$
East Europe	0.58	$1.68\ 10^{-17}$
Mediterranean	-0.20	N/a

Veefkind et al., ACP, 2011

AAI detects smoke over clouds

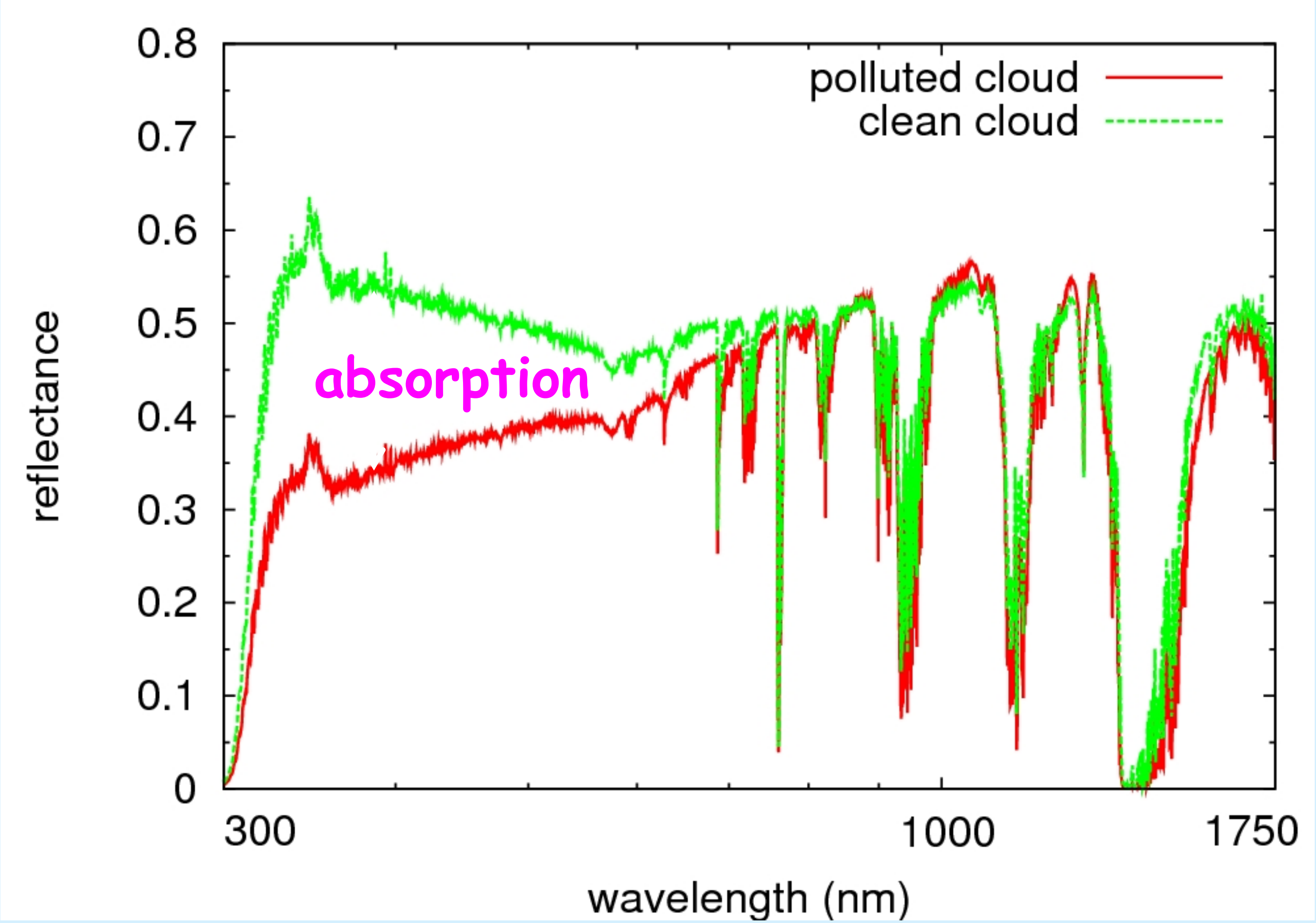
SCIAMACHY AAI overlayed on MODIS image



West of Angola, 9 Sept 2004

De Graaf et al., JGR, 2007

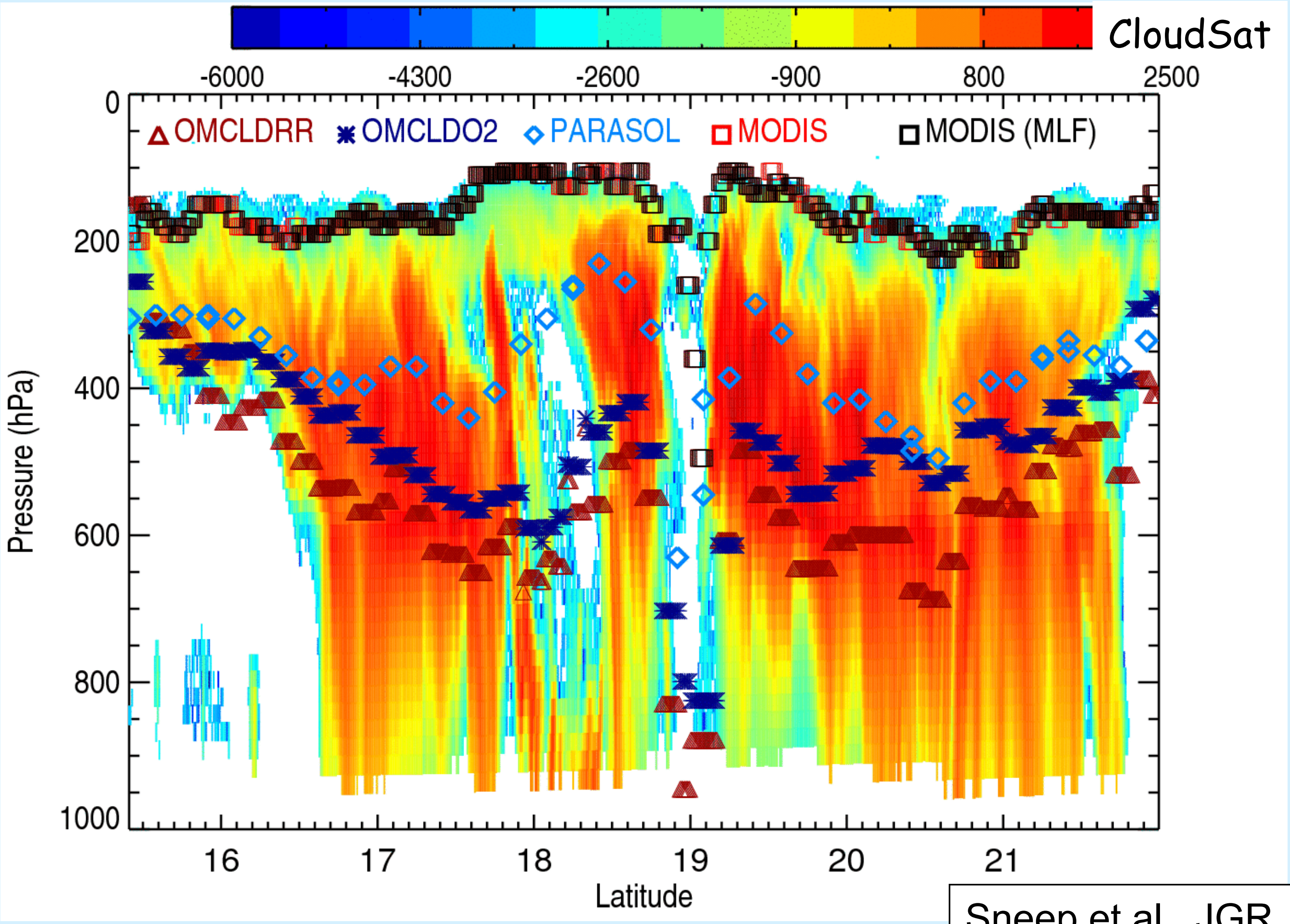
Reflectance spectra of smoke over clouds



SCIAMACHY data, SW Africa

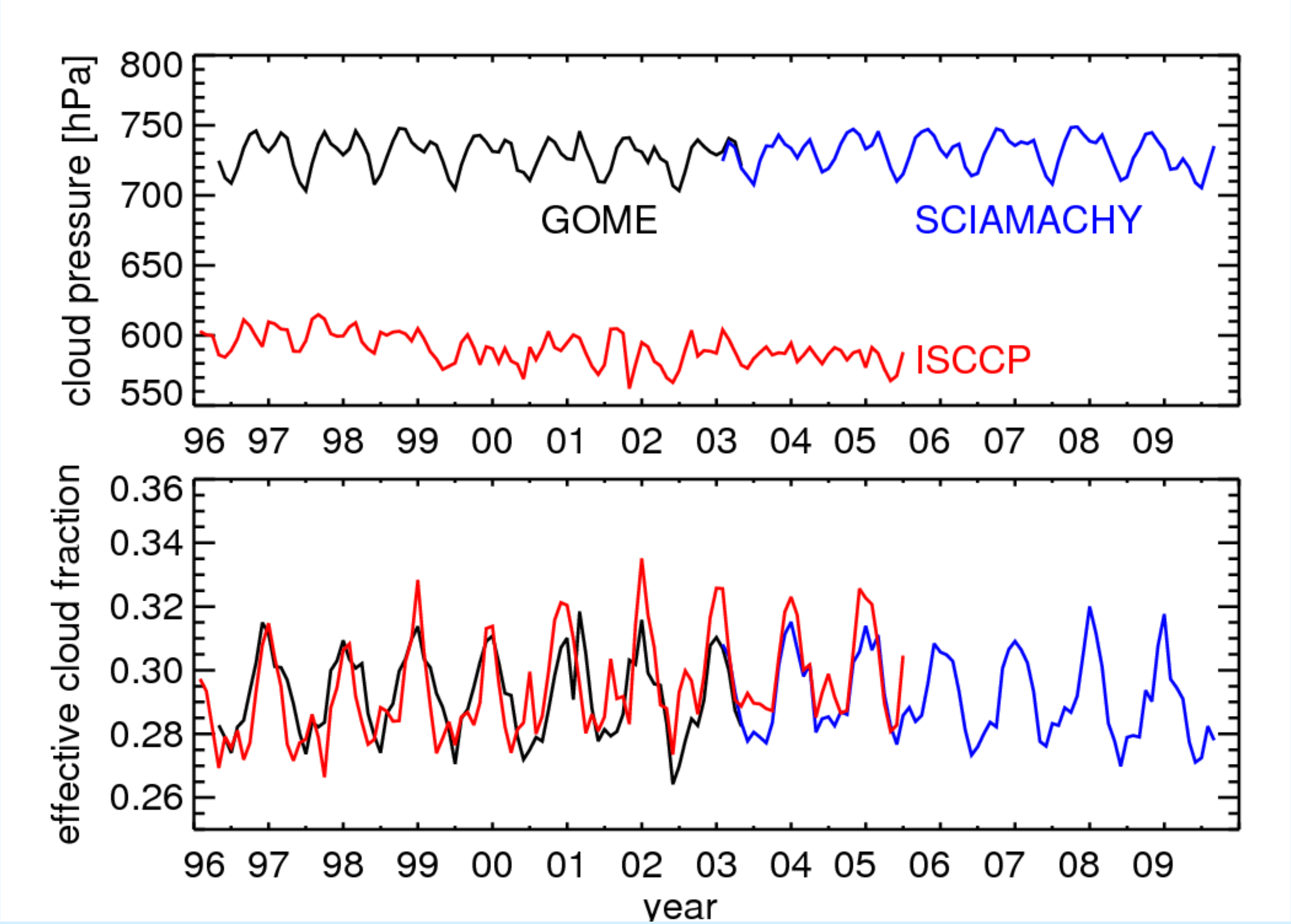
Stammes et al., Proc. IRS 2008

Oxygen absorption gives pressure inside cloud



Sneep et al., JGR, 2008

Global mean time series of O_2 cloud pressure



Ping Wang, KNMI

Conclusions

1. Combining satellite observations of trace gases and aerosols provides a wealth of information on secondary aerosols.

2. The AOT/NO_2 ratio varies strongly globally. This ratio may be used as indicator for combustion efficiency.

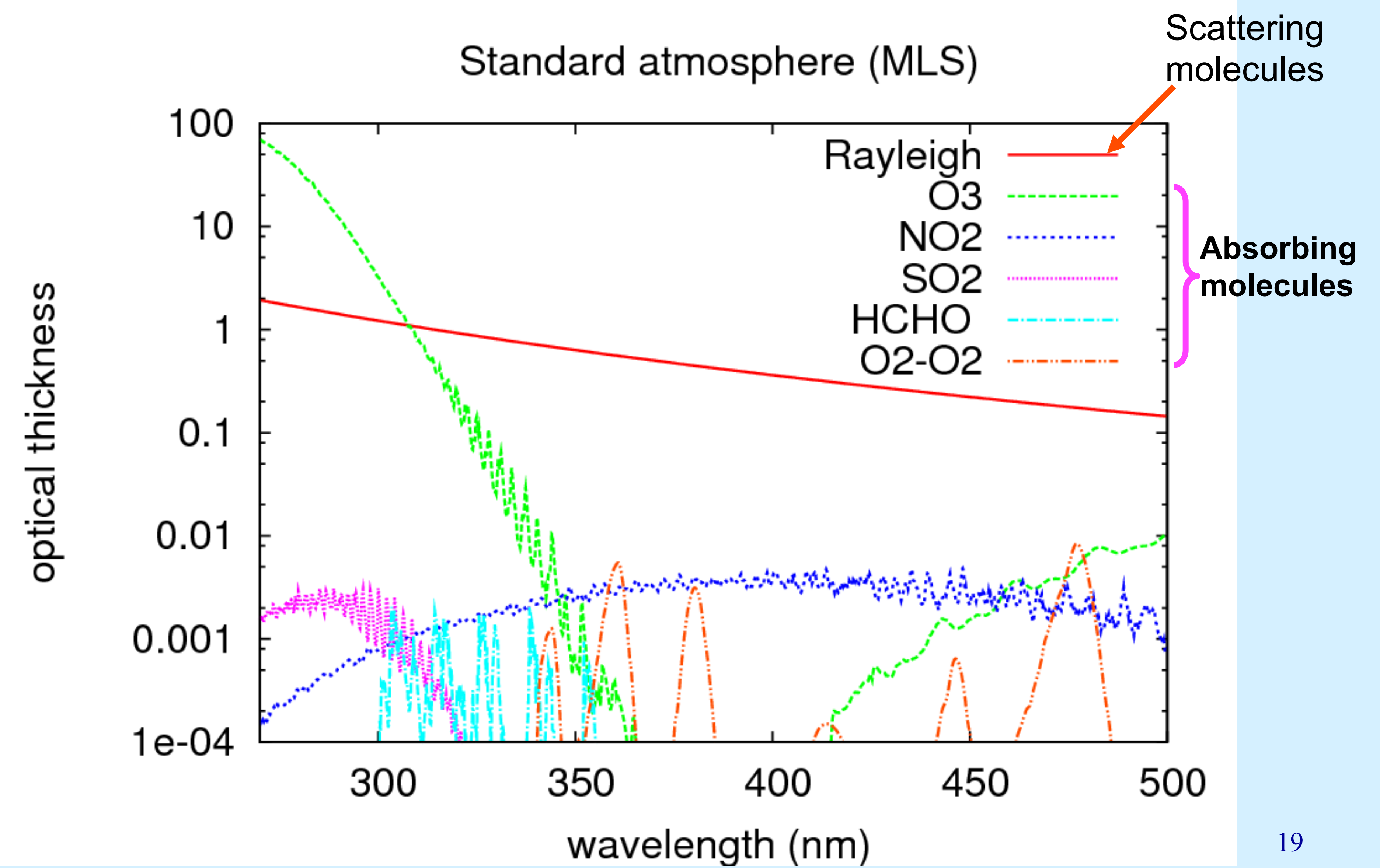
3. UV spectra are powerful for detecting absorbing aerosols.

4. Oxygen absorption gives independent information for detecting cloud (midlevel) height and aerosol height.

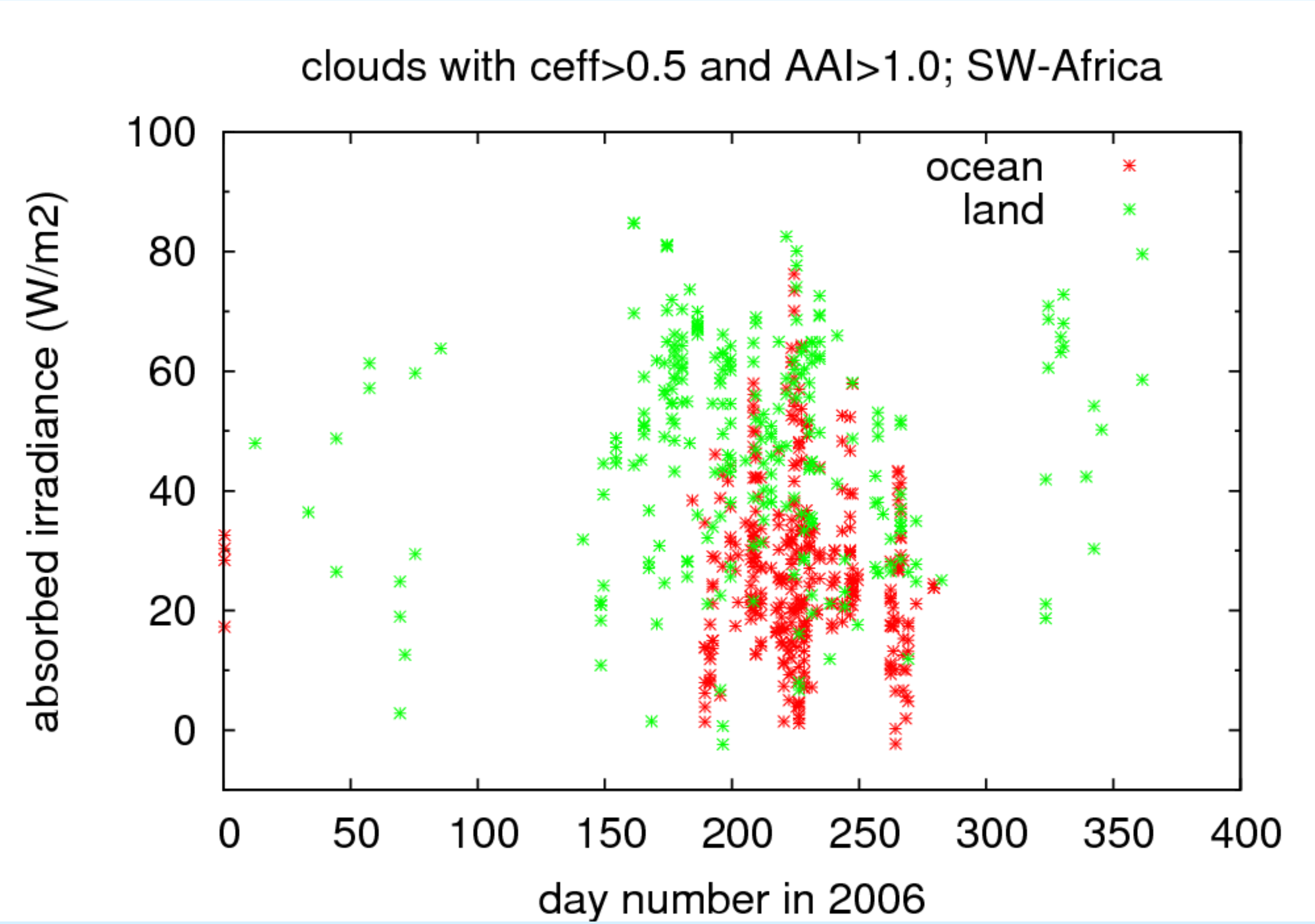
5. Combining trace gas and aerosol information from satellite is essential to study chemical cycles.

6. GOME-2, SCIAMACHY and OMI products are produced and published near-real-time; see www.temis.nl.

Optical thickness in UV and visible



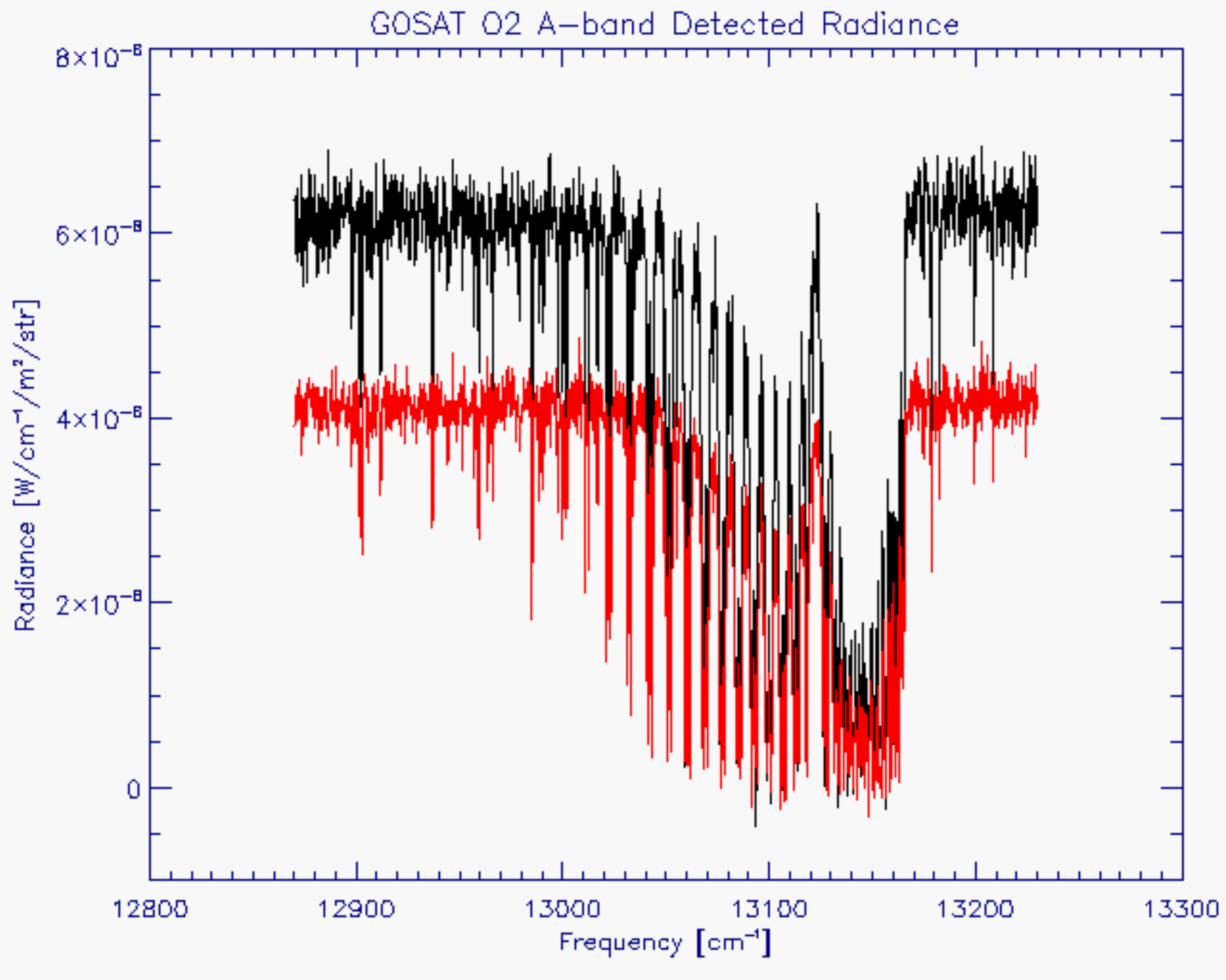
Absorbed irradiance (polluted–clean clouds)



SCIAMACHY data, SW Africa

Stammes et al., Proc. IRS 2008

GOSAT – O2 A-band spectra



Ofelia Vieitez, KNMI

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OMI *OMAERUV* Aerosol Algorithm

Products:

-Extinction and absorption Optical Depth (354, **388**, 500 nm), AOD, AAOD

-Single Scattering Albedo (SSA)

-Absorbing Aerosol Index (AAI)

Recent Upgrades:

-New carbonaceous aerosol Model

-CALIOP Aerosol Height Data

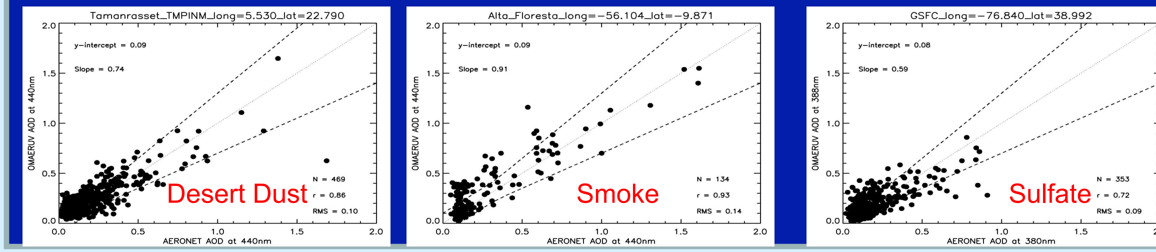
-Aerosol type: AIRS CO data

Accuracy estimates:

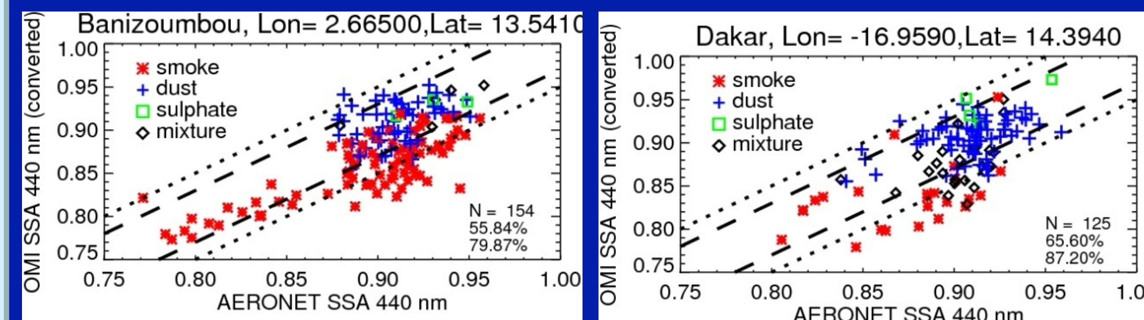
-SSA: 0.05

-AOD: 0.1 or 30%

AOD Validation (2005-2008)

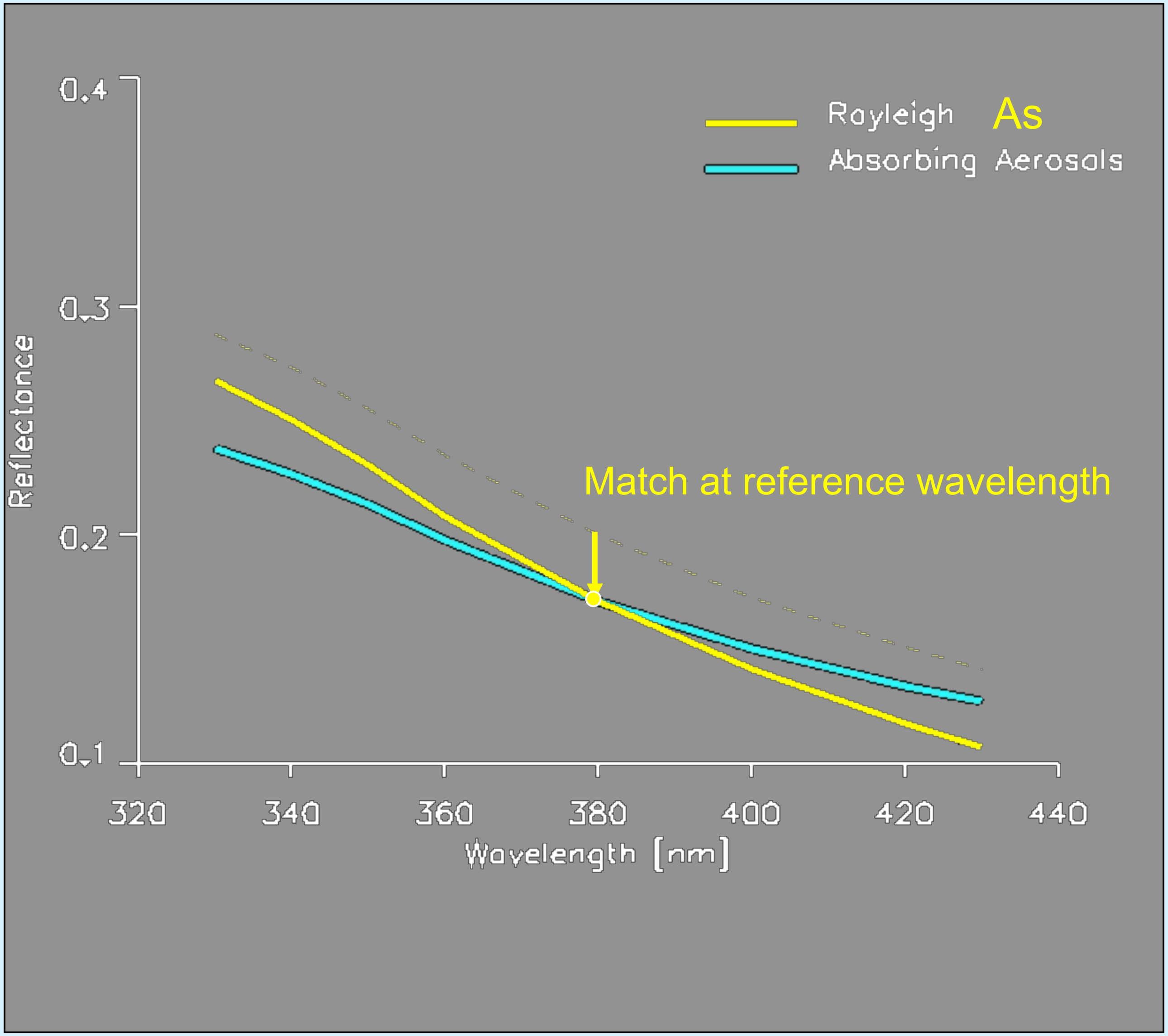


SSA Evaluation (2005-2008)

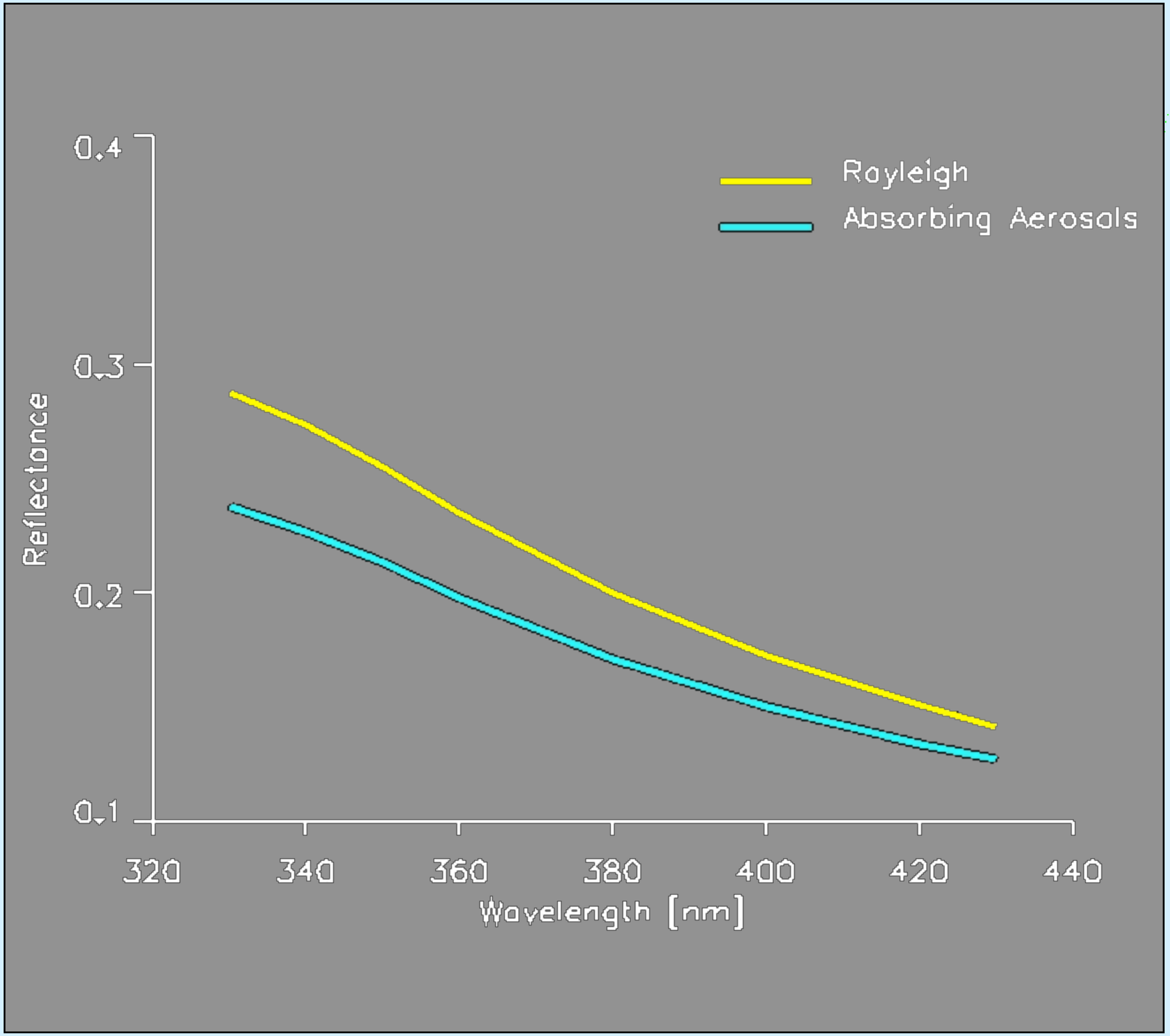


Omar Torres, NASA/GSFC

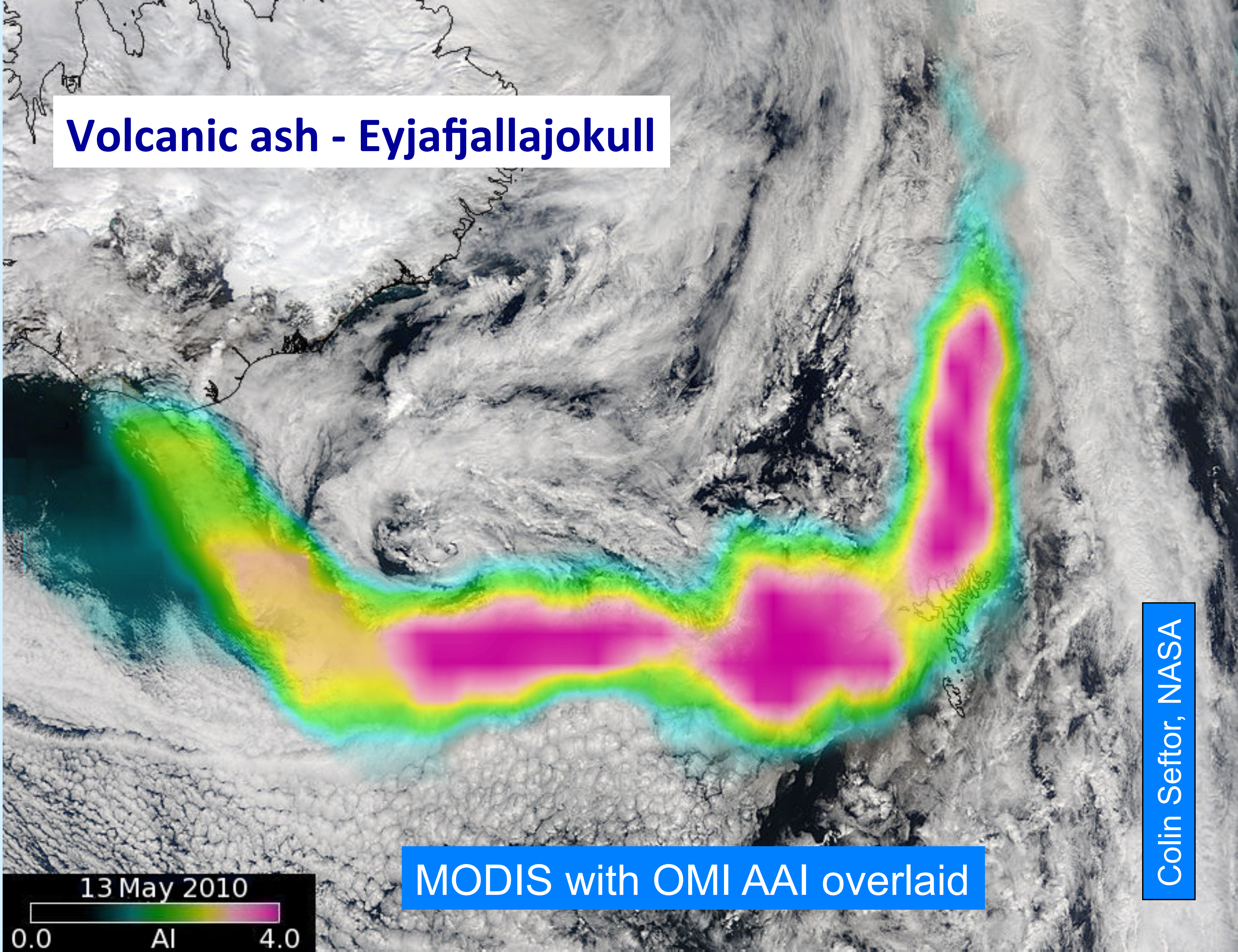
Reflectance at TOA with absorbing aerosols and matched Rayleigh reflectance



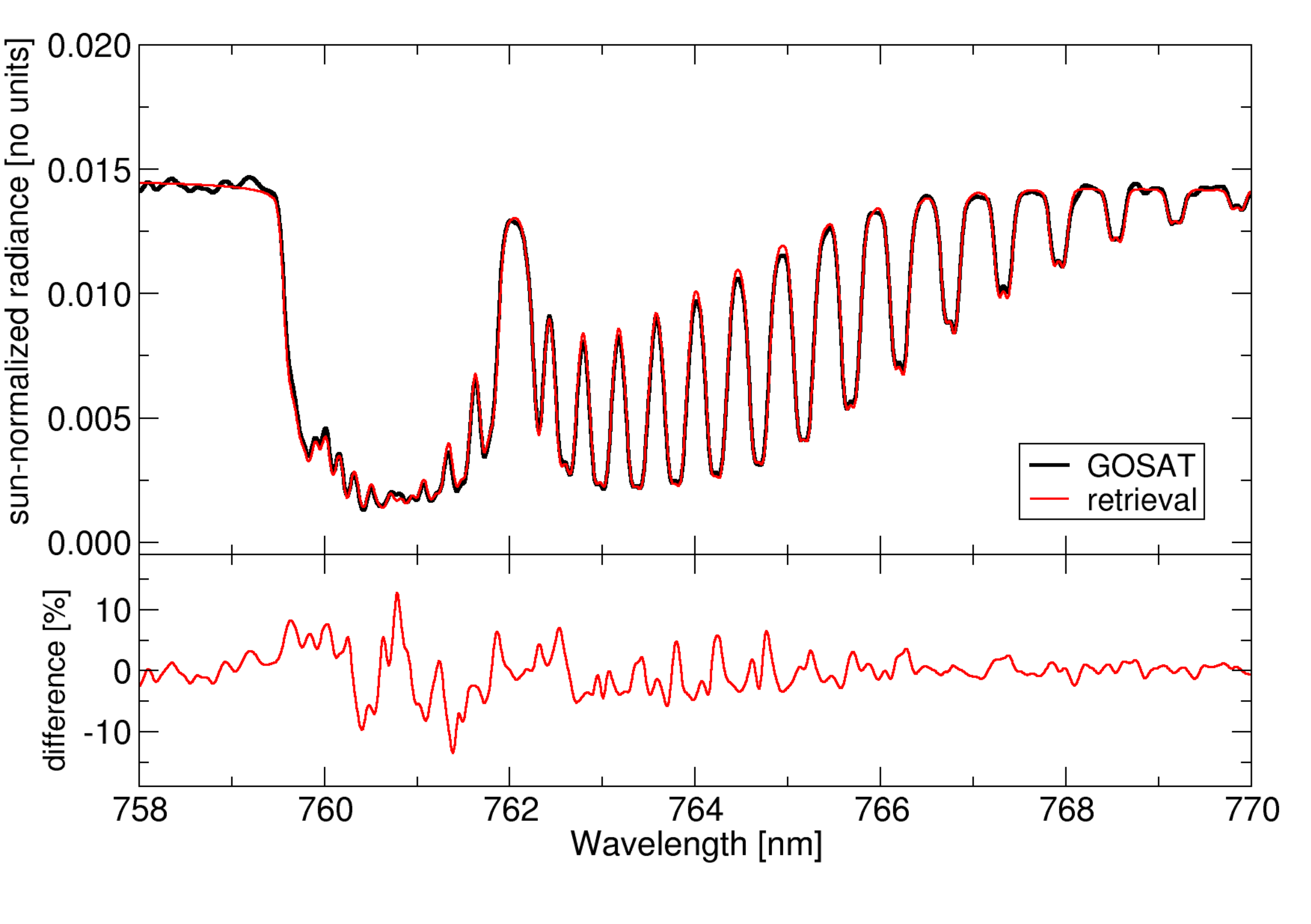
Reflectance at TOA with absorbing aerosols



Volcanic ash - Eyjafjallajokull



Retrieval of aerosol parameters from GOSAT spectra



Retrieved parameters @ ssa 0.95:

AOT = 0.189 ± 0.015

surf. alb.@758 nm = 0.06015 ± 0.0012

z_{top}= 7.2 ± 0.6 km
z_{top}= 384 ± 35 hPa

Δz= 0.4 km (25 hPa)

Scene type:
dark ocean

Vieitez, Sanders, De Haan, KNMI

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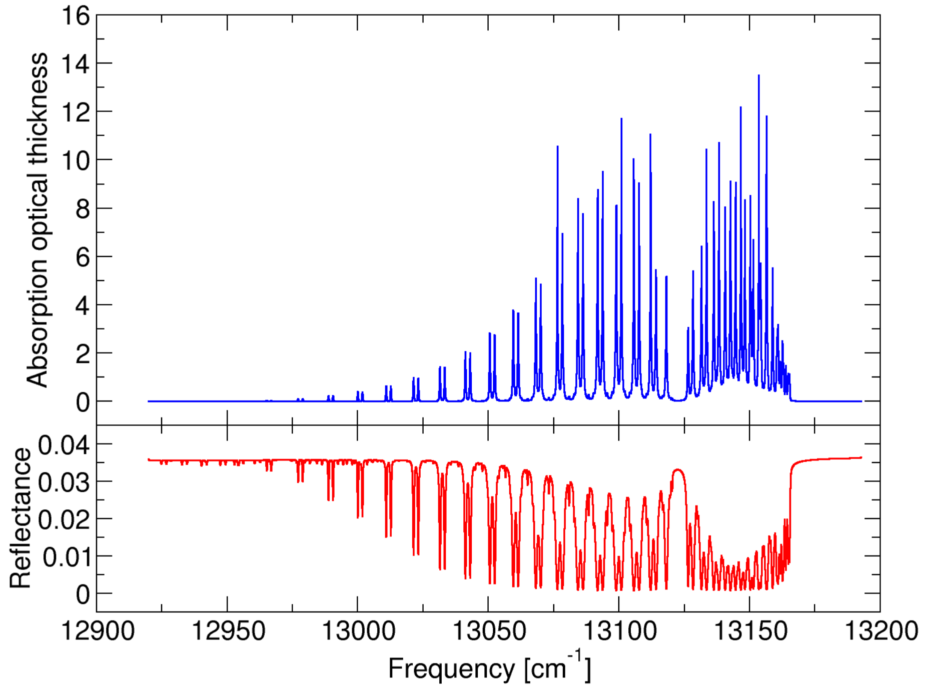
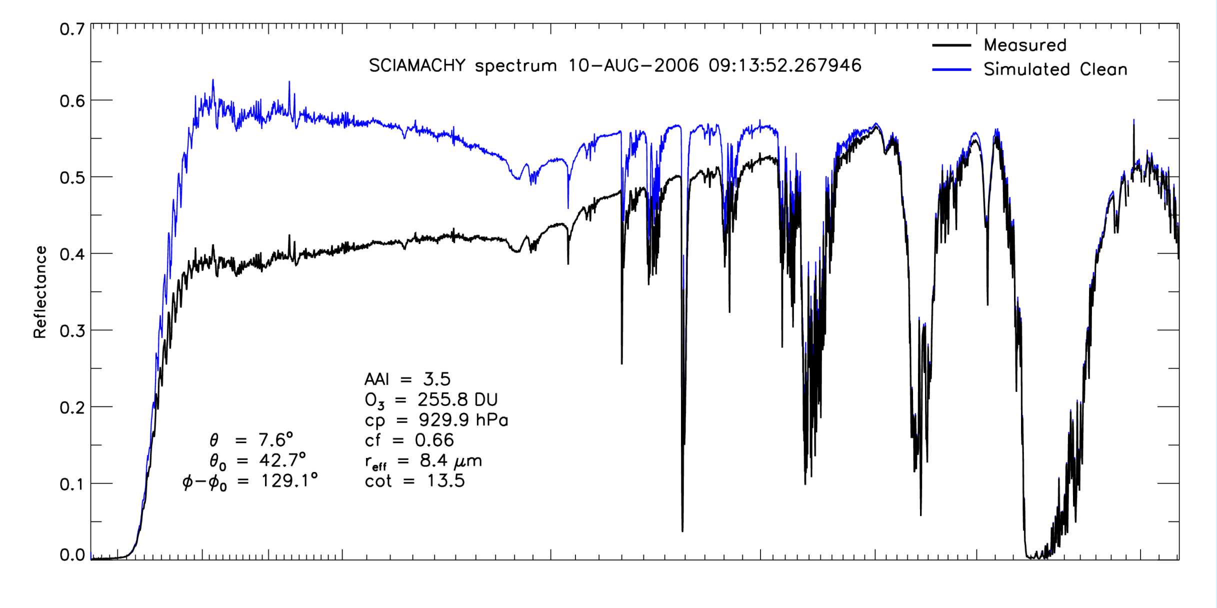
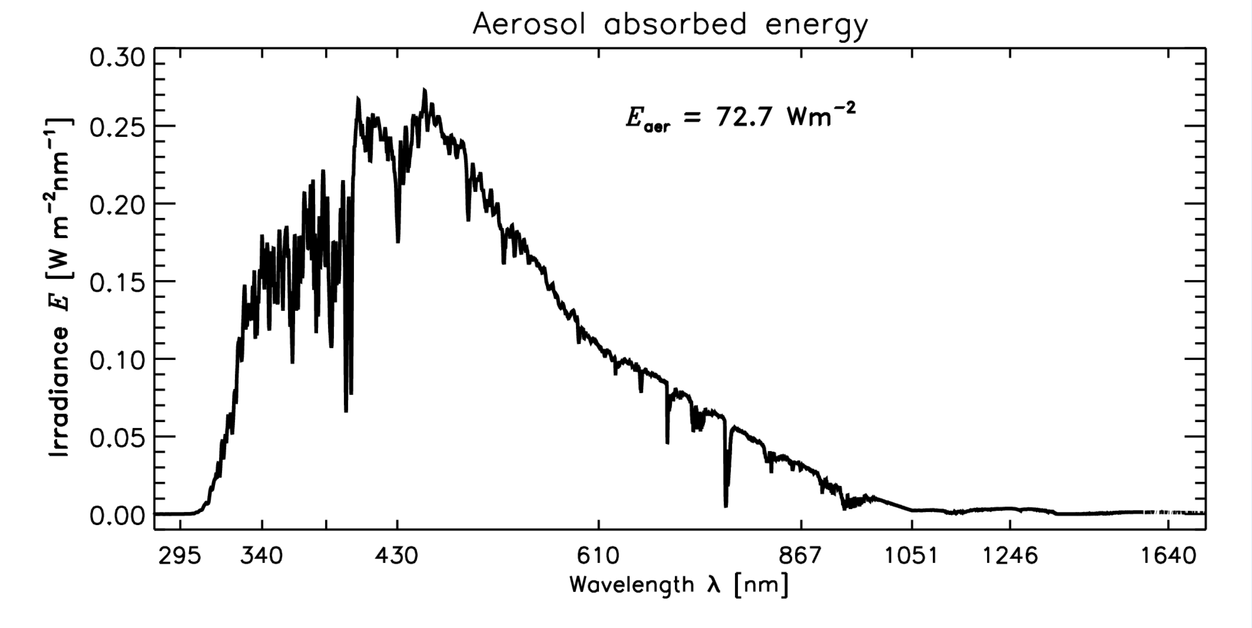
Absorption optical thickness



High values of abs. opt. thick.
strong absorption lines
Low values of abs. opt. thick.
continuum





De Graaf et al., 2011