Tropospheric Aerosols

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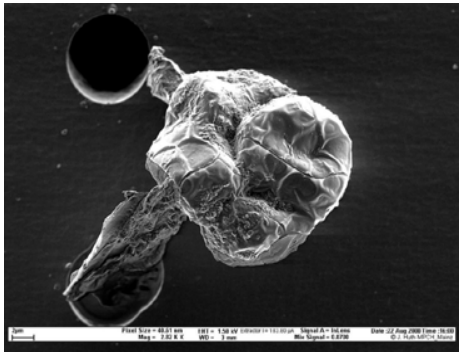
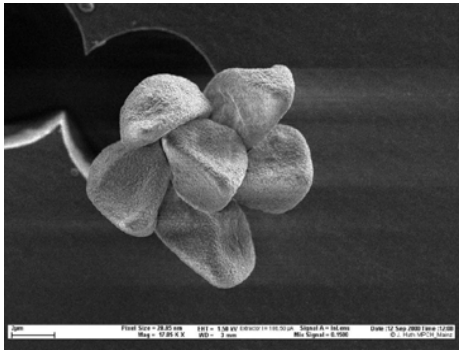
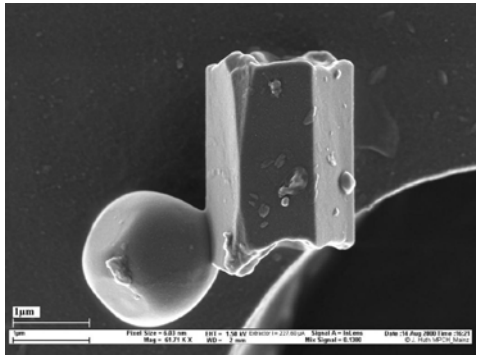
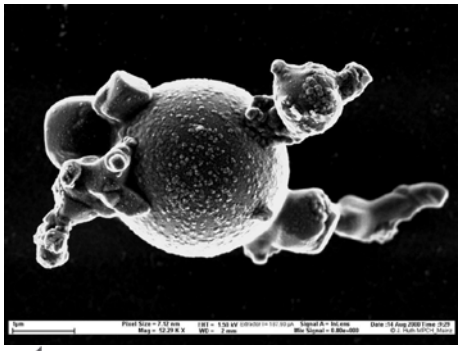
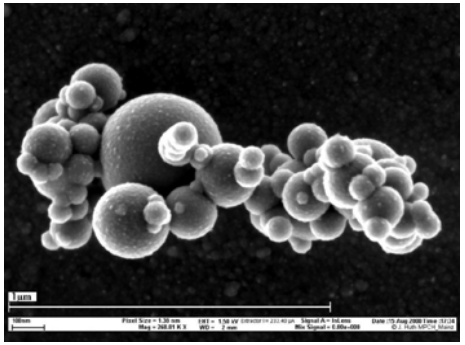
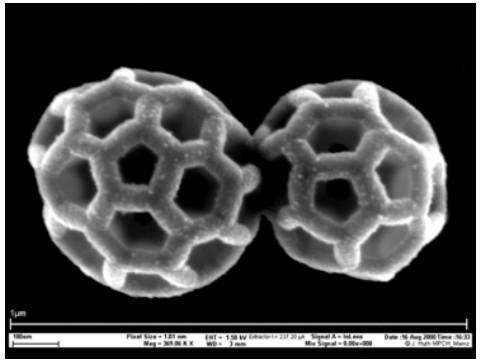
atmospheric aerosols

aerosol:
liquid or solid particles (other than cloud droplets) suspended in the atmospheric column which cause increased turbidity of the atmosphere and affect meteorology, visibility and human health

aerosol sources





many different sources for atmospheric aerosol

five main aerosol classes:
water soluble, soot, mineral dust, sea salt, biogenic

external and internal mixing of aerosol species

vertically seperated aerosol layers (e.g. dust and soot)



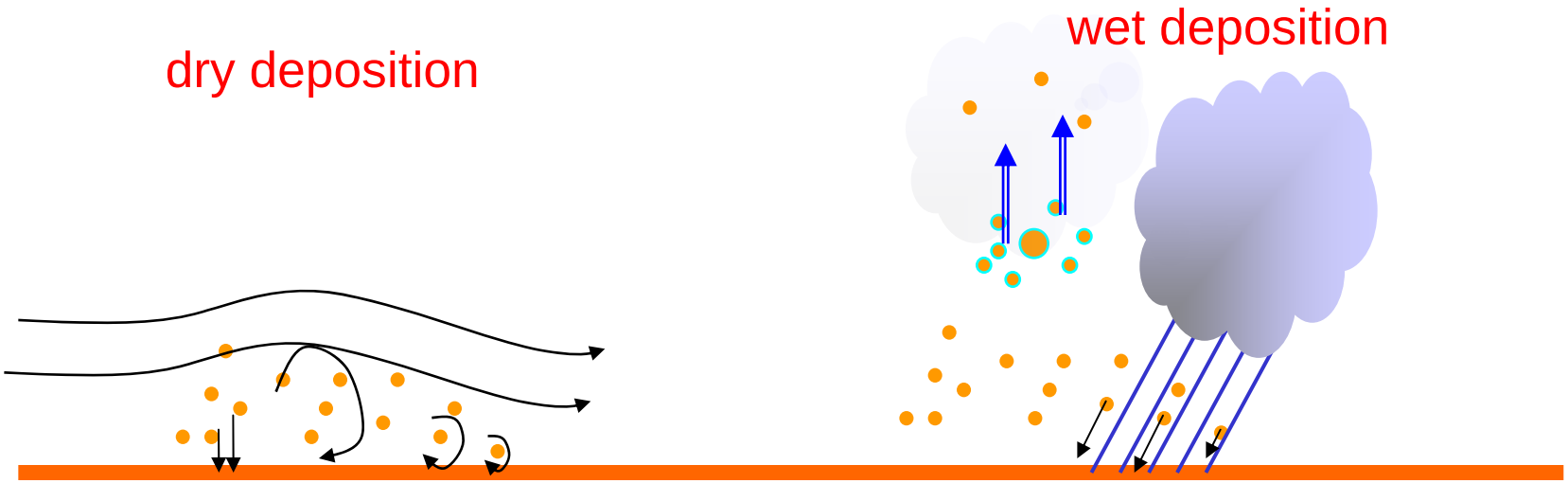


aerosol deposition

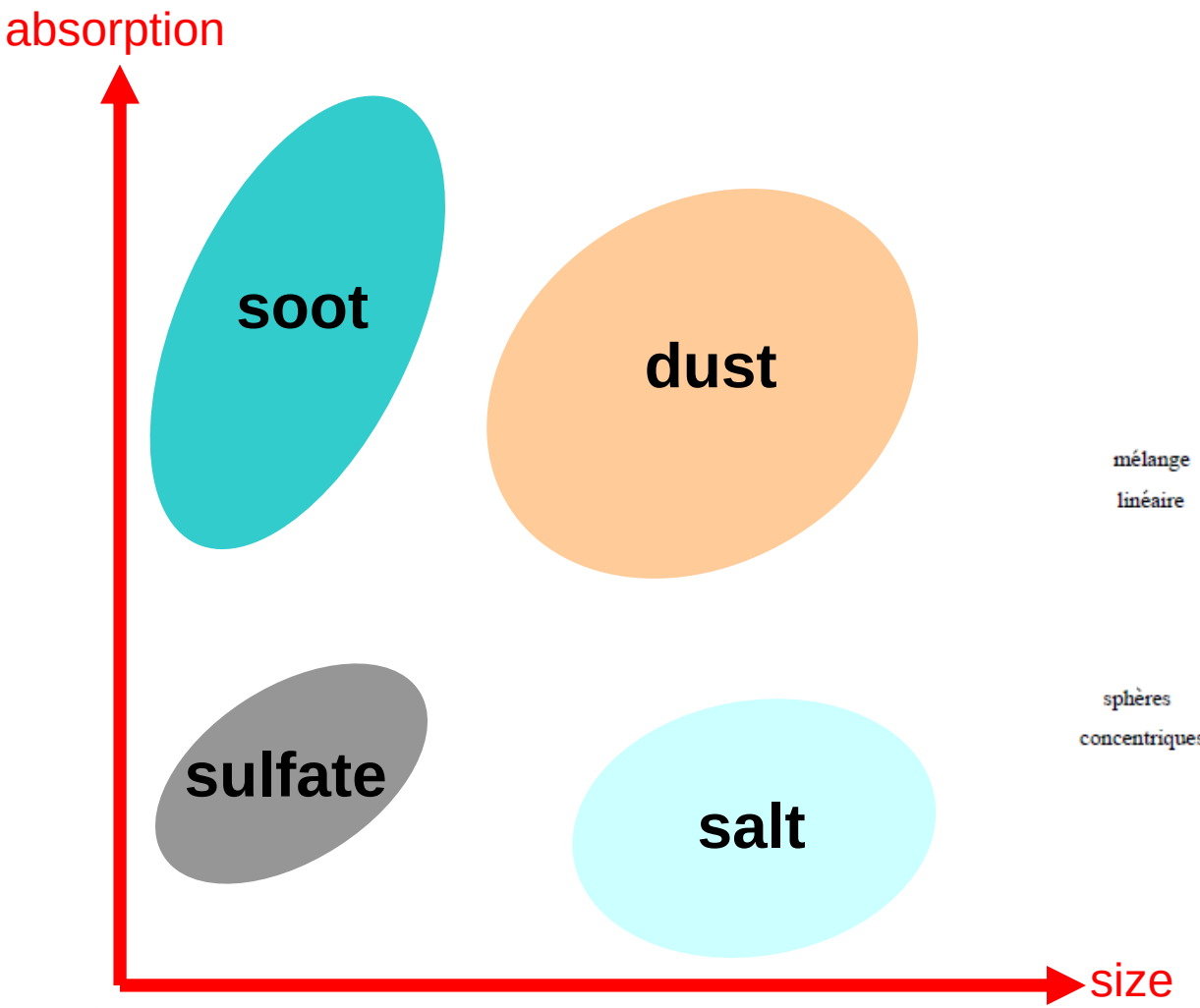
mainly two deposition mechanisms for atmospheric aerosols

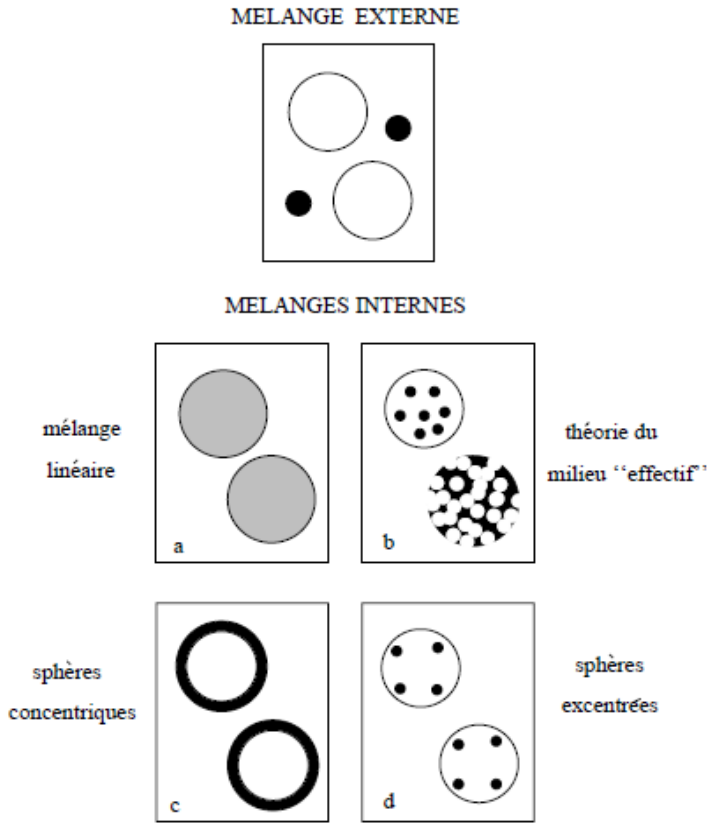
- *dry deposition*:
  gravitational settling, turbulent down-mixing, breakdown of turbulent momentum fluxes at night

- *wet deposition*:
  „wash out“ by precipitation, aerosol particles acting as cloud condensation nuclei and in-cloud transport throughout the atmosphere



atmospheric aerosol

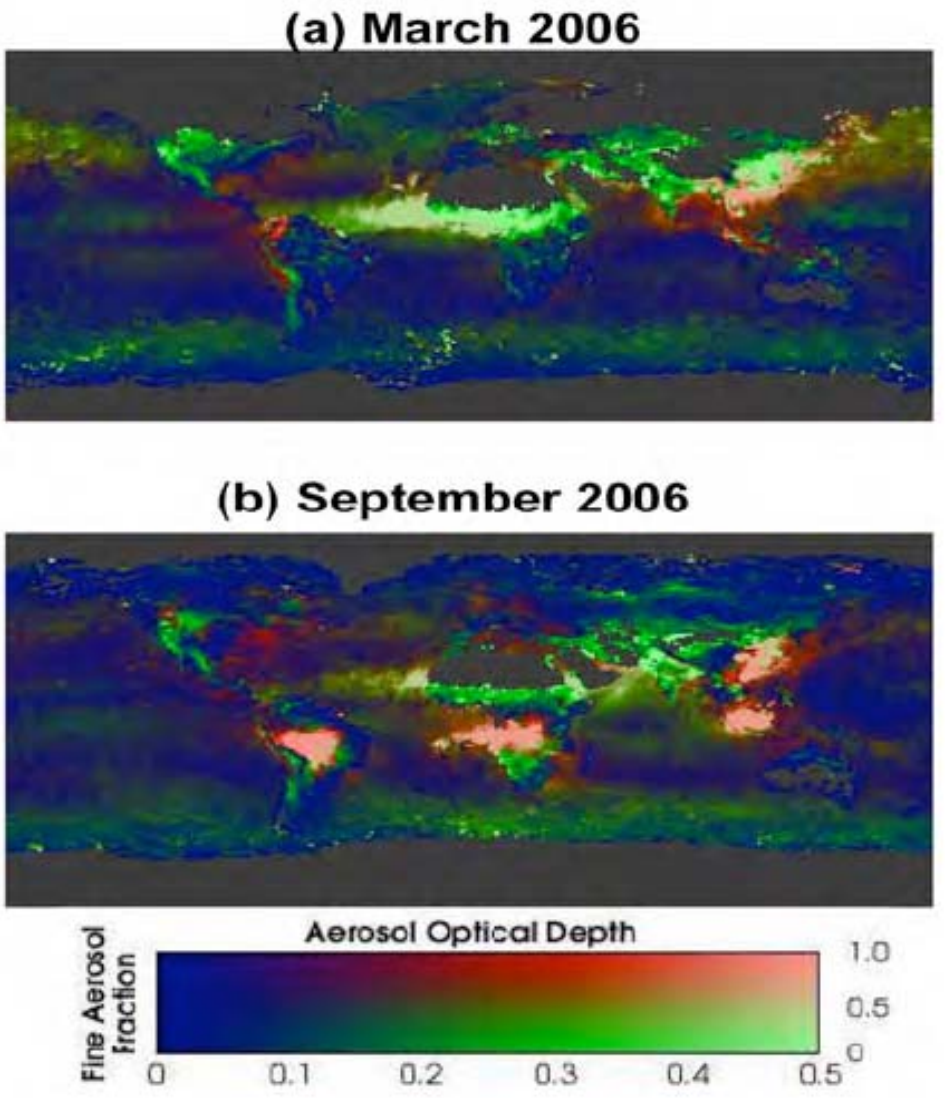




global aerosol

In „hot-spot“ areas tropospheric aerosols have distinct seasonal cycles, which also control aerosol type predominance.

Especially over Africa the seasonal cycles of mineral dust activity and dry season biomass burning are very evident in the MODIS observations and fine mode aerosol differentiation.



NASA, 2009

Aerosol Optical Depth

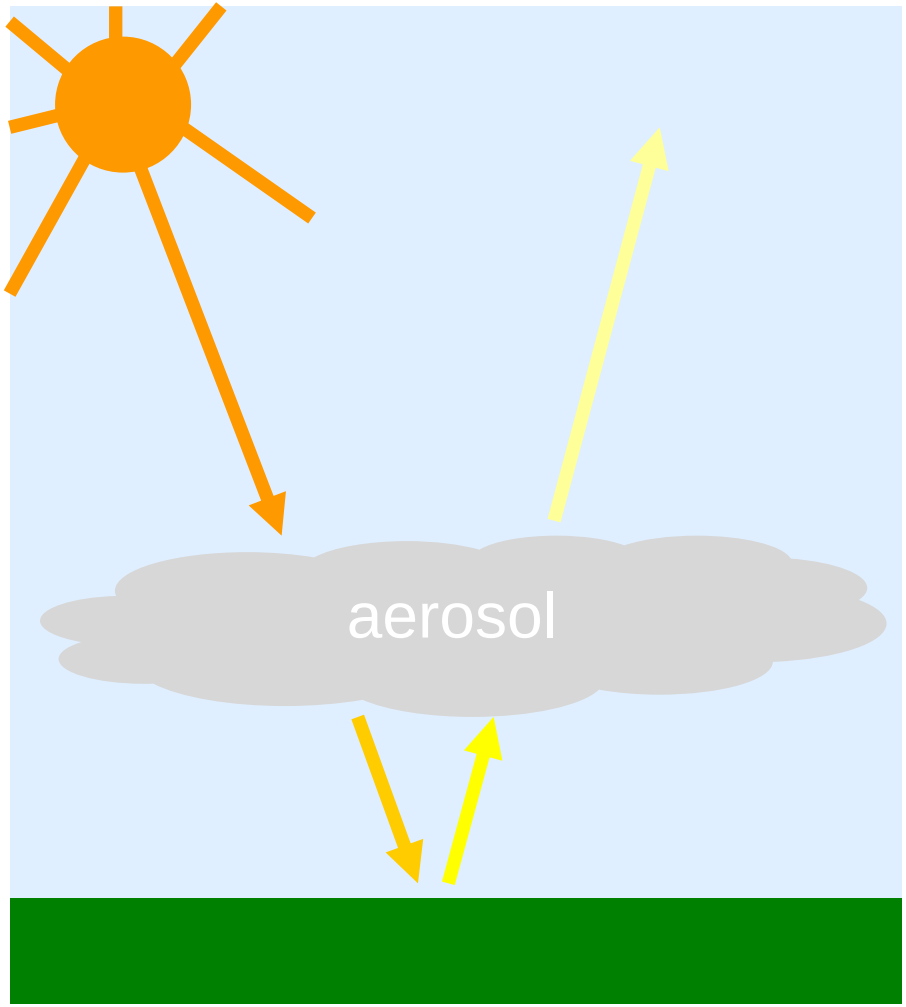
Aerosol Optical Depth is a quantity which describes the reduction of radiative intensity (extinction) by scattering and absorption within an aerosol plume

$$I_1 = e^{-AOD/\cos\Theta} I_0$$

and is defined as

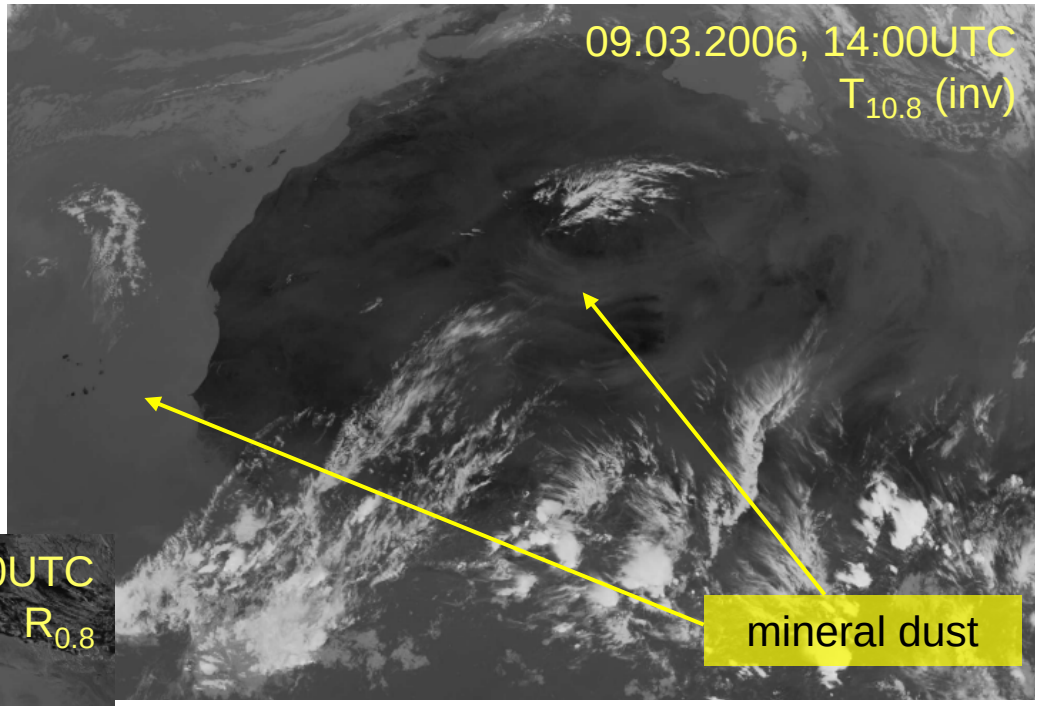
$$AOD = \int \beta_e dz$$

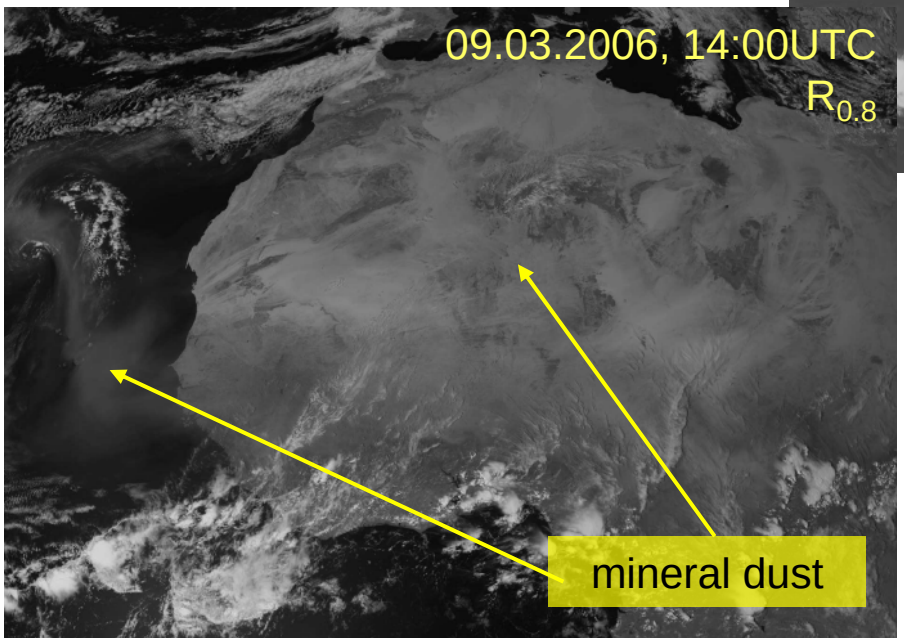
for one pass (either top to bottom or bottom to top) through the aerosol



radiative properties

Tropospheric aerosols can be observed from space with different remote sensing instruments and techniques.





aerosols reflect solar (shortwave) and some of them also reduce outgoing thermal (longwave) radiation

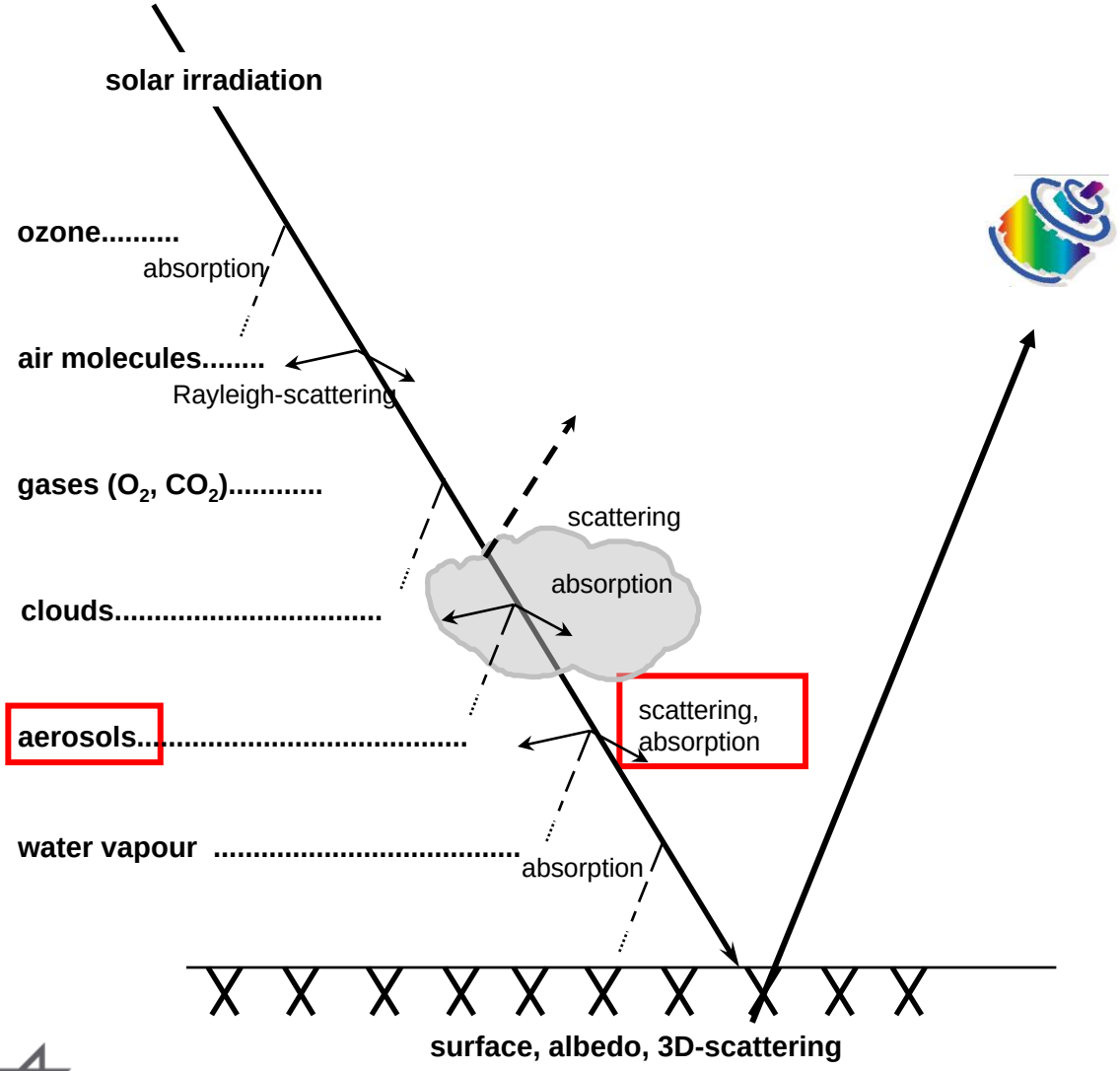
aerosol remote sensing mostly retrieves aerosol optical depth (AOD) from reflected shortwave radiation

aerosols and air quality

Pollution Level	*Concentration [mg m-3]*	*Frequency*	*Weather Conditions*	*Composition*
low	5-40	28%	during and after rain	black carbon, minerals
medium	35-65	45%	summer smog, high inversion	sulphates, black carbon, sea spray, nitrates, minerals
high	65-150	24%	winter smog, low inversion	black carbon, salts of sulphates and nitrates, heavy metals, minerals
very high	100-3000	3%	dust storms	pollen, minerals, sea spray

pollution levels, frequencies and their conditions

satellite remote sensing of aerosols



charakteristical change of the solar spectrum

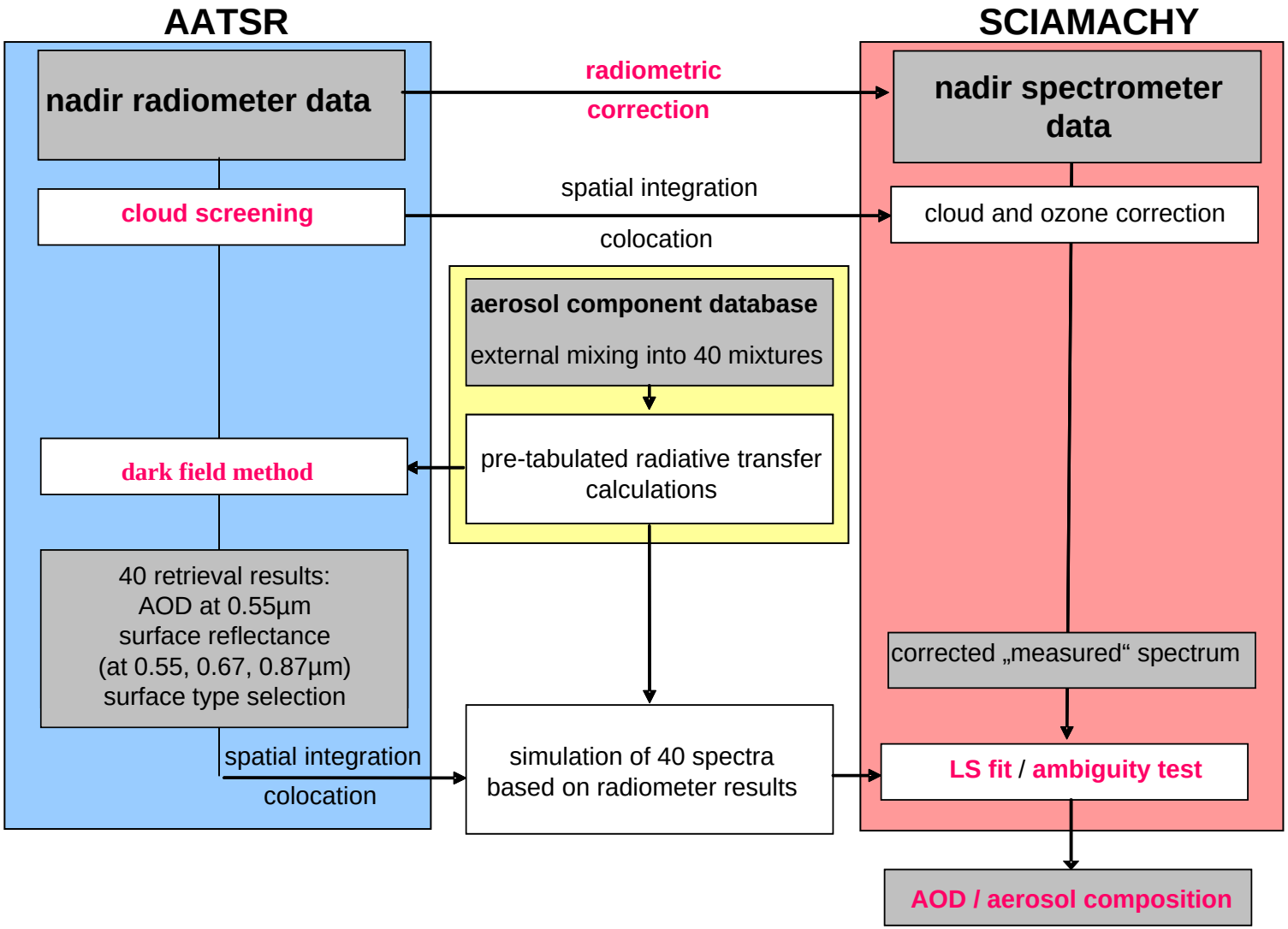
= ‚footprint' of aerosol within spectrum as identification attribute

problem:
extraction of the aerosol signal from a large variety of influencing parameters

atmosphere + surface

cloud screening as precondition

SYNAER: synergistic aerosol retrieval from ENVISAT



SYNAER basic aerosol components

Component	Species	Refract. Index at 550 nm	Mode radius [μm]	Stand. Dev. of size distribution	Particle density [g/cm^3]	Extinction coefficient for 1 particle per cm^3 at 550 nm [km^{-1}]	Single scattering albedo	source
WASO, rH = 70%	Sulfate/nitrate	1.53 – 0.0055 i	0.028	2.24	1.33	7.9 e-6	0.981	Hess, et al. 1998
INSO	Mineral dust, high hematite content	1.53–0.008i	0.471	2.51	2.0	8.5 e-3	0.73	Hess, et al. 1998
INSL	Mineral dust , low hematite content	1.53 – 0.0019 i	0.471	2.51	2.0	8.5 e-3	0.891	Dubovik 2002, Sinyuk et al. 2003, Hess `98
SSAM, rH = 70%	Sea salt, accumulation mode	1.36 – 0 i	0.378	2.03	1.2	3.14 e-3	1.0	Hess, et al. 1998
SSCM, rH = 70%	Sea salt, coarse mode	1.36 – 0 i	3.17	2.03	1.2	1.8 e-1	1.0	Hess, et al. 1998
BISO	Biomass burning soot	1.63-0.036i	0.0118	2.0	1.0	1.5 e-7	0.698	Dubovik 2002 Hess et al, 1998
DISO	Diesel soot	1.49 – 0.67i	0.0118	2.0	1.0	7.8 e-7	0.125	Schnaiter, et al. 2003, Hess `98
MITR	Transported minerals, high hematite content	1.53 – 0.0055 i	0.5	2.2	2.6	5.86 e-3	0.837	Hess, et al. 1998
MILO	Transported minerals, low hematite content	1.53 – 0.0019 i	0.5	2.2	2.6	5.86 e-3	0.93	Dubovik 2002, Sinyuk et al. 2003, Hess `98

SYNAER pre-defined aerosol mixtures

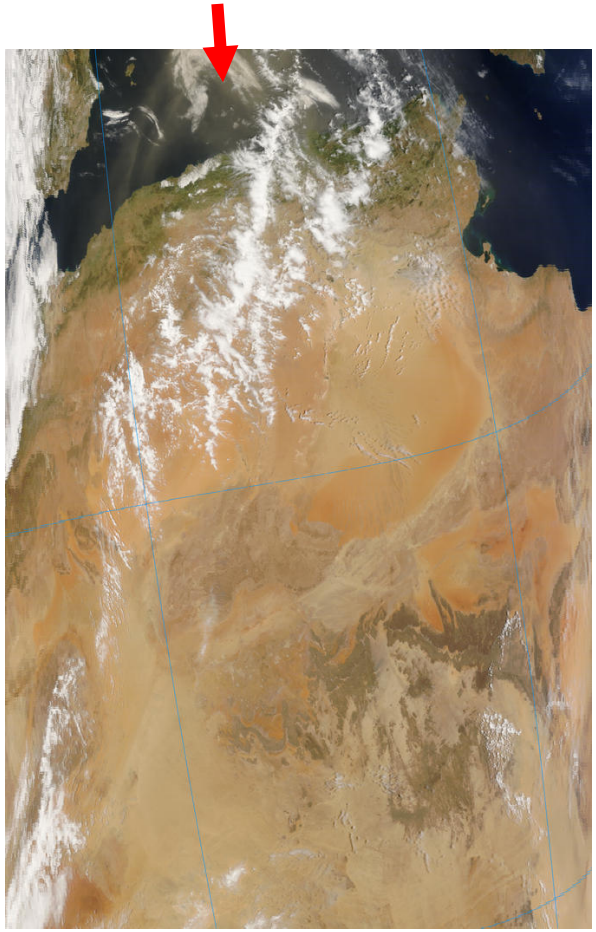
No.		Name	Rel. hum. [%]	Vert. Prof. [km]	Component contributions to AOT550 [%] WASO	INSO	INSL	SSAM	SSCM	BISO	DISO	MITR	MILO
1	21	Pure watersoluble	50/80	2	100								
2	22	Continental	50	2	95	5	5						
3	23				90	10	10						
4	24				85	15	15						
5	25	Maritime	50/80	2	30			70					
6	26				30			65	5				
7	27				15			85					
8	28				15			75	10				
9	29	Polluted watersoluble	50/80	2	90						10		
10	30				80						20		
11	31	Polluted Continental	50	2	80	10	10				10		
12	32				70	10	10				20		
13	33	Polluted Maritime	50/80	2	40			45	5		10		
14	34				30			40	10		20		
15	35	Desert Outbreak	50	2 - 4	25							75	75
16	36			3 - 5	25							75	75
17	37			4 - 6	25							75	75
18	38	Biomass Burning	50/80	3	85					15			
19	39				70					30			
20	40				55					45			

WASO = watersoluble, INSO = insoluble, INSL = insoluble / low hematite, SSAM = sea salt accummul. mode, SSCM = sea salt coarse mode, BISO = biomass burning soot, DISO = diesel soot, MITR = mineral transported, MILO = mineral transported / low hematite

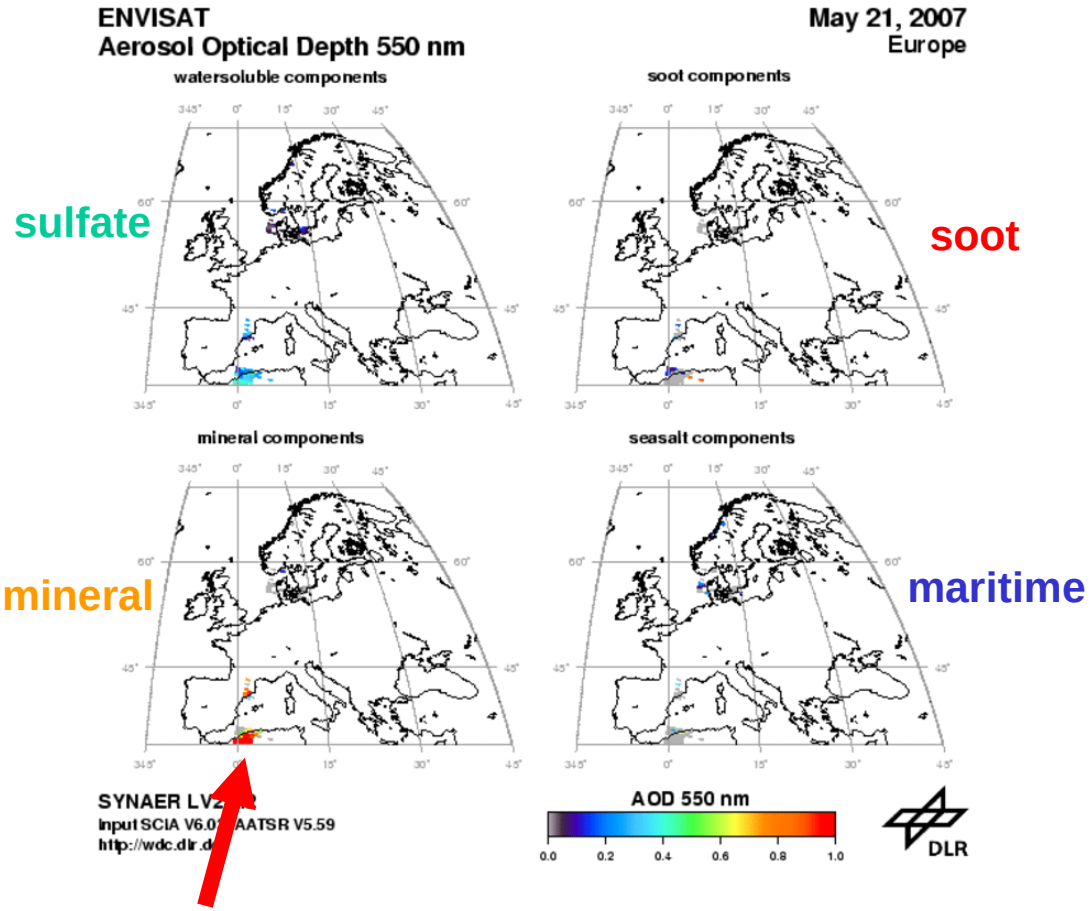
Mixture number N and mixture number N + 20: alternative humidity or mineral composition, respectively

SYNAER/ENVISAT Episodes

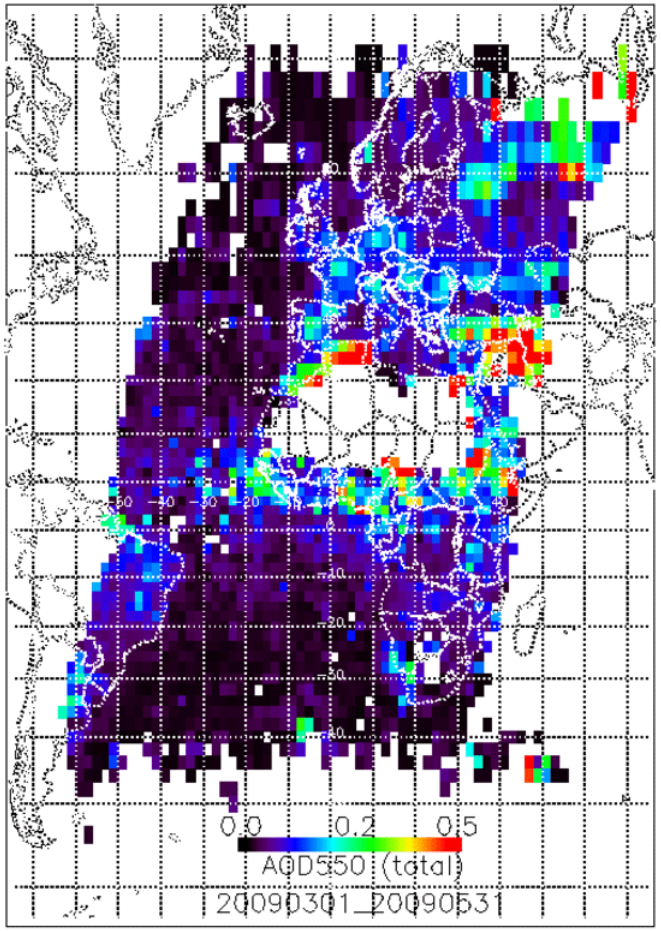
Dust Outbreak, 21 May 2007



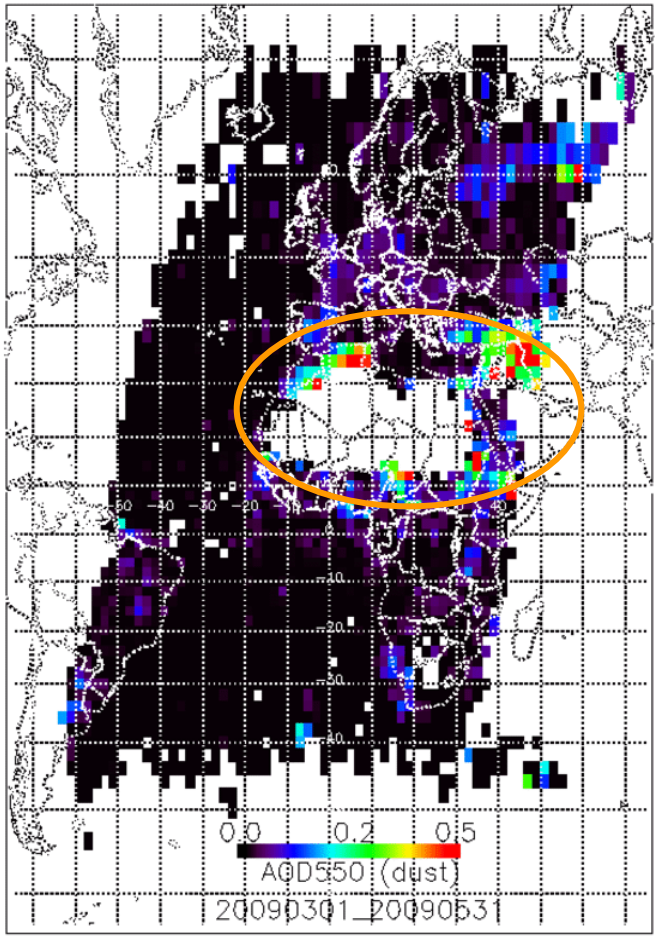
MODIS RGB



SYNAER / ENVISAT v2 – seasonal AOD550 (MAM 2009)



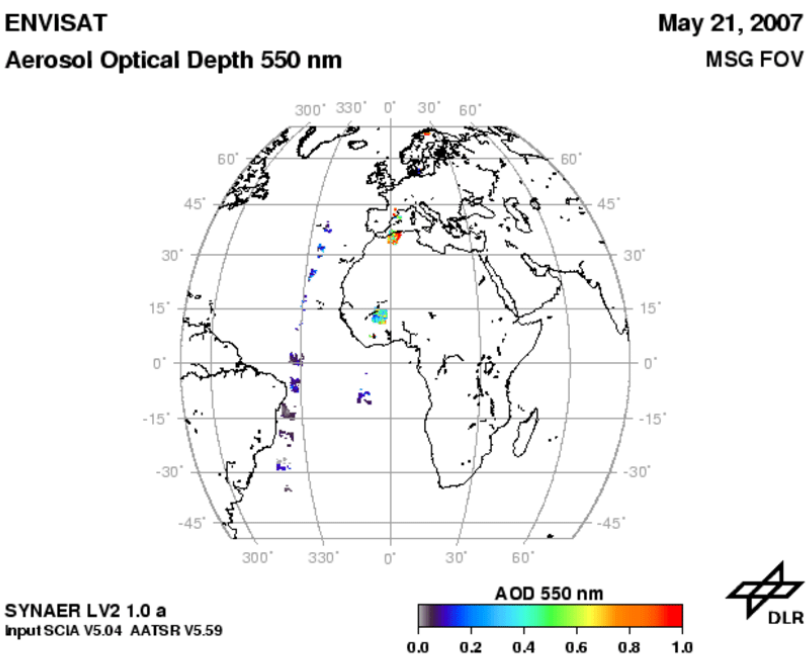
total



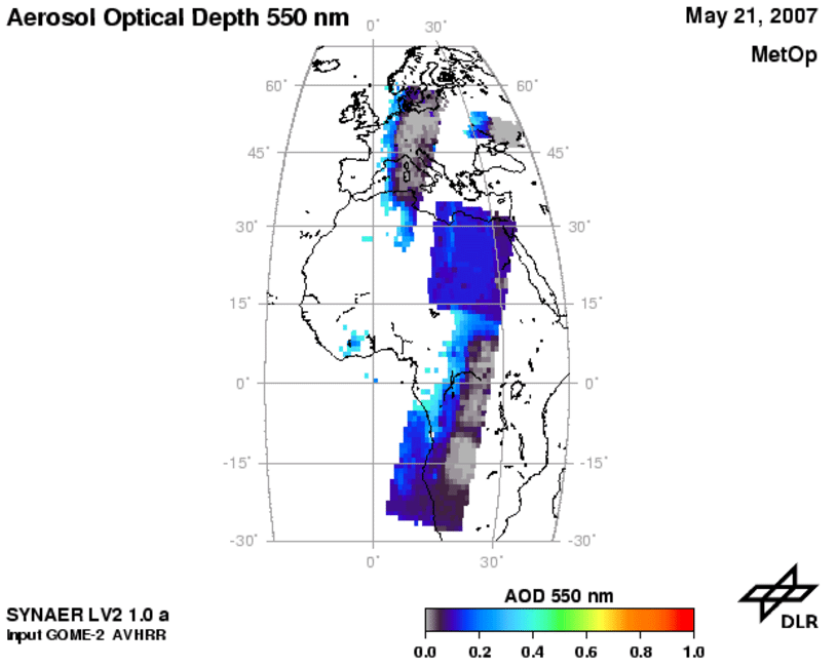
mineral dust

outlook: SYNAER/METOP: GOME2 + AVHRR

- largely improved spatial coverage due to swath widths of GOME-2 and AVHRR
- no limb-scanning mode of GOME-2



SYNAER/ENV



SYNAER/METOP

summary

- aerosol: solid or liquid phase particles suspended in the air
- aerosols are emitted by a large variety of sources
- many different types of atmospheric aerosols
- aerosols have many effects on the atmosphere and its circulation
- SYNAER:
  DLR aerosol retrieval for ENVISAT
  capable of type separation
  40 aerosol mixtures, 4 classes of aerosols
  transfer to Metop improves spatial coverage

- dedicated talks on particulate matter and mineral dust!