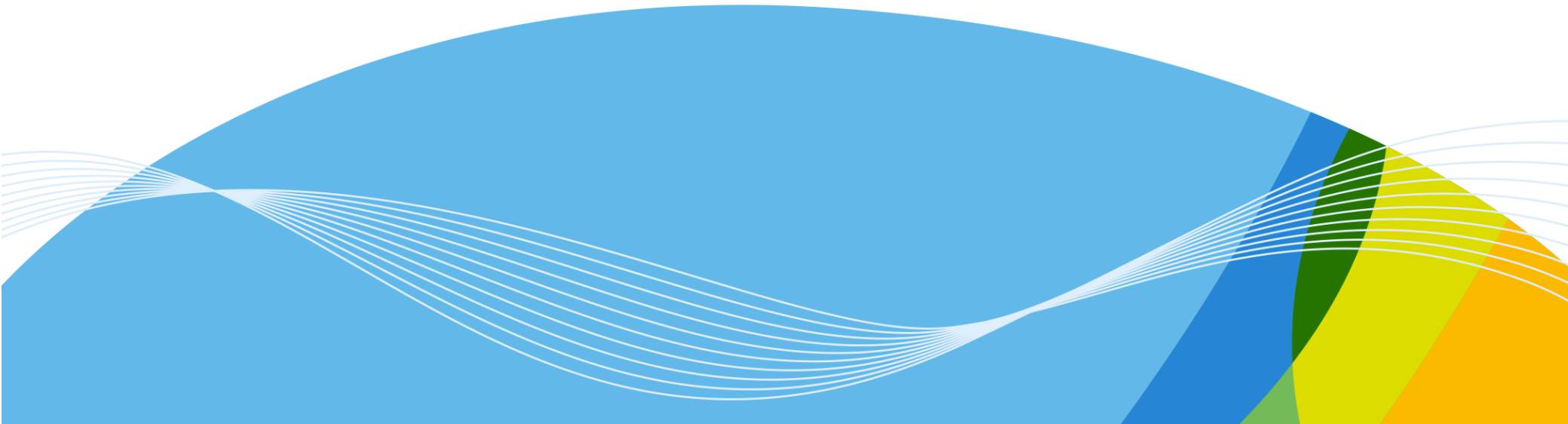
FINNISH METEOROLOGICAL INSTITUTE

Aerosol-climate model validation with in-situ and satellite retrieval data

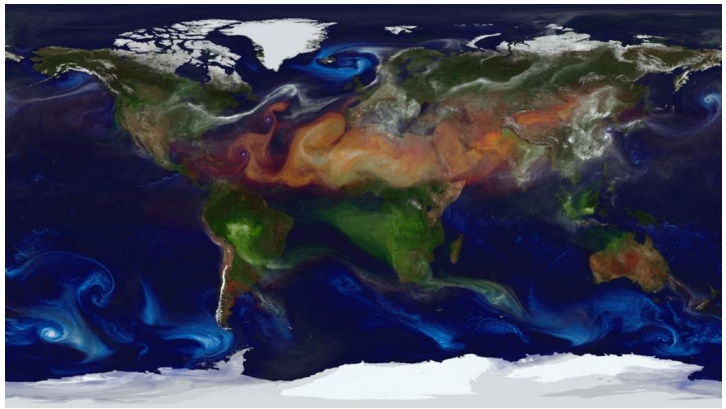


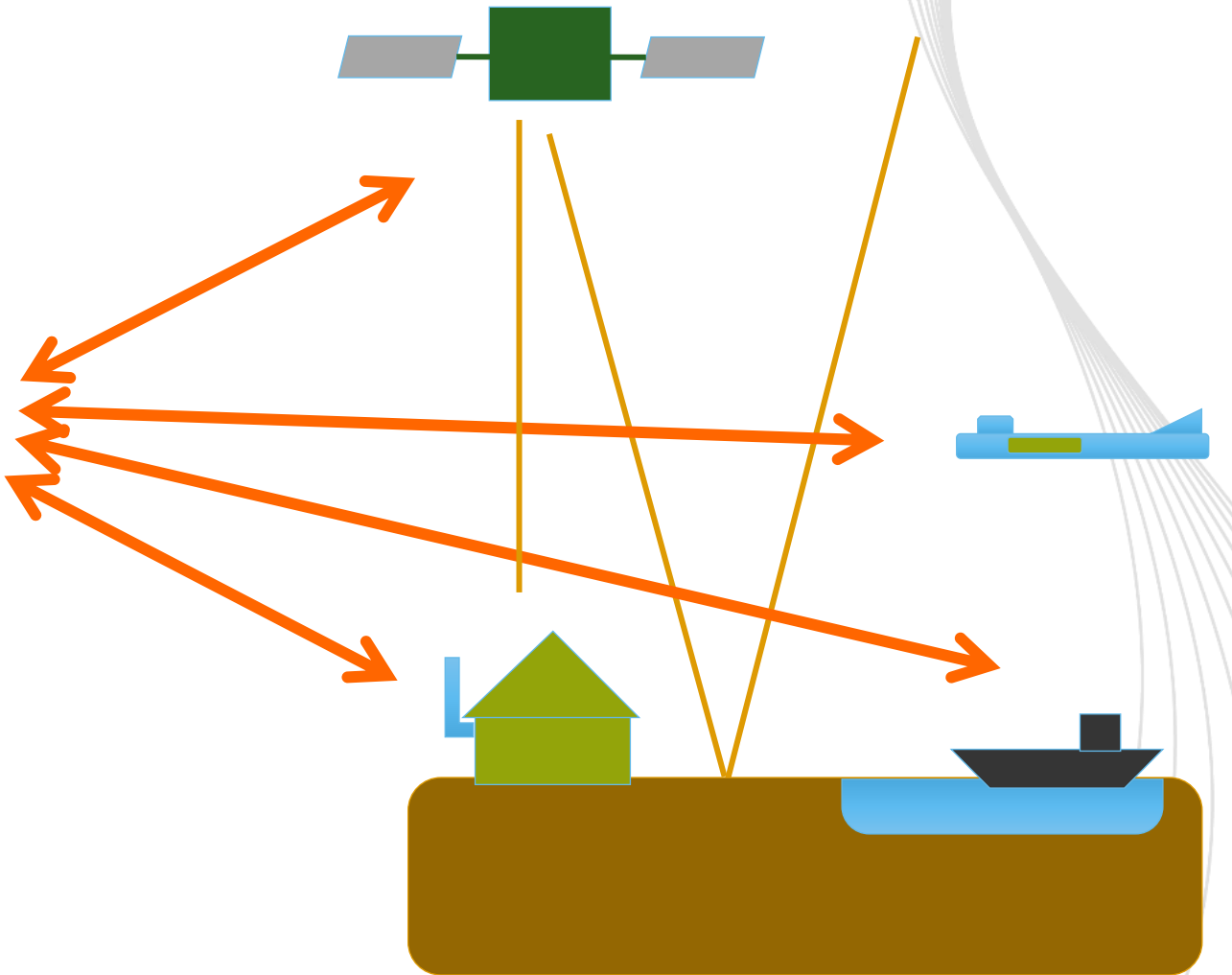
Who am I?

- Tommi Bergman
  - FMI -30.4.2016
  - KNMI 1.5.2016-30.4.2019
- Living in Vantaa, Finland

- PhD in global climate model develepment and validation last year

Model validation with observations





Aerosols

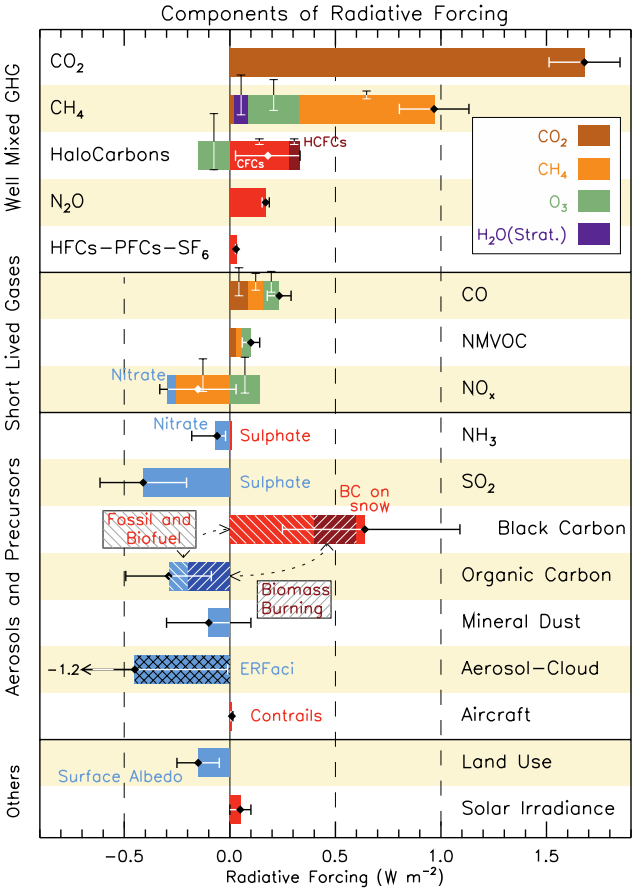
Good Visibility Day
Visual Range: 147 miles

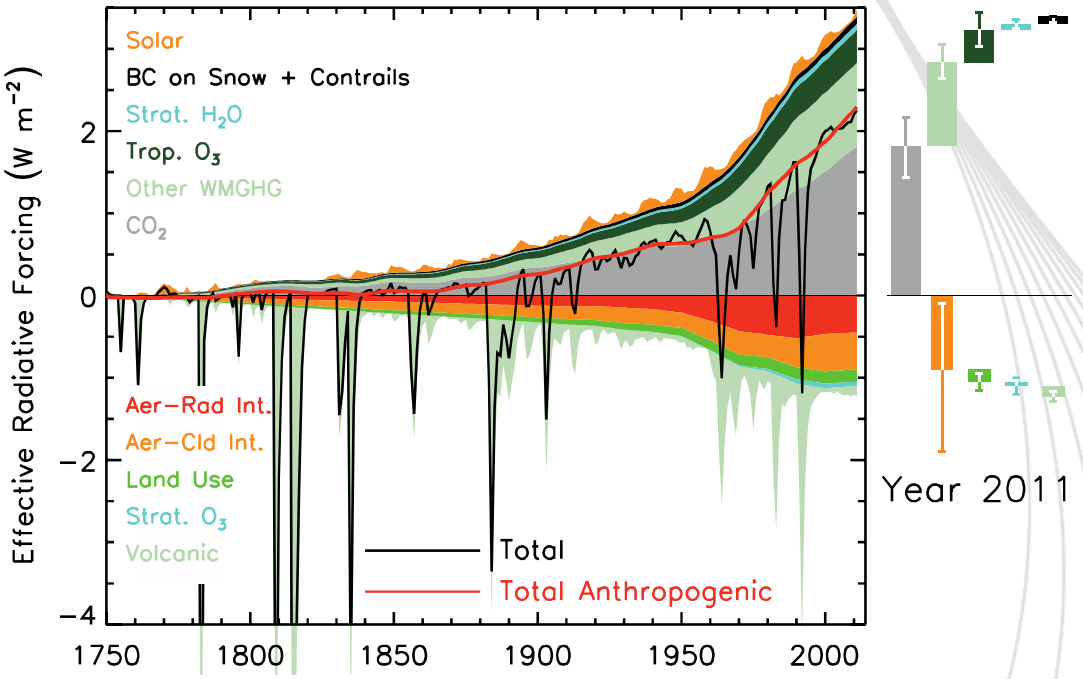
Bad Visibility Day
Visual Range: 9 miles

http://alg.umbc.edu/usaq/archives/005177.html

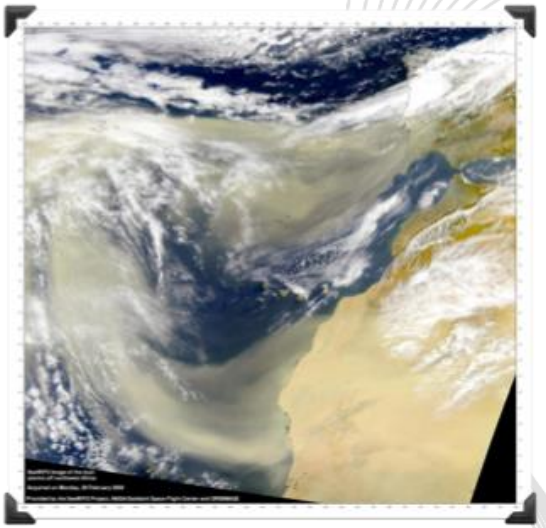
Why aerosols are important

- Intergovernmental panel on climate change



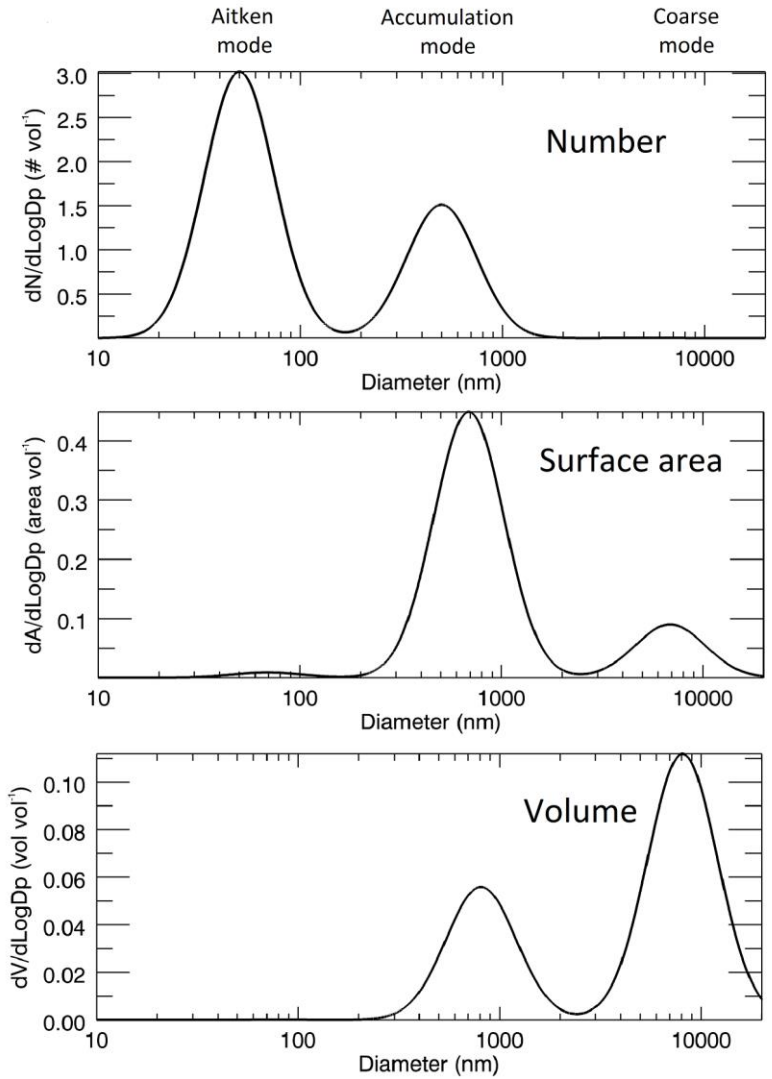


Sources and types



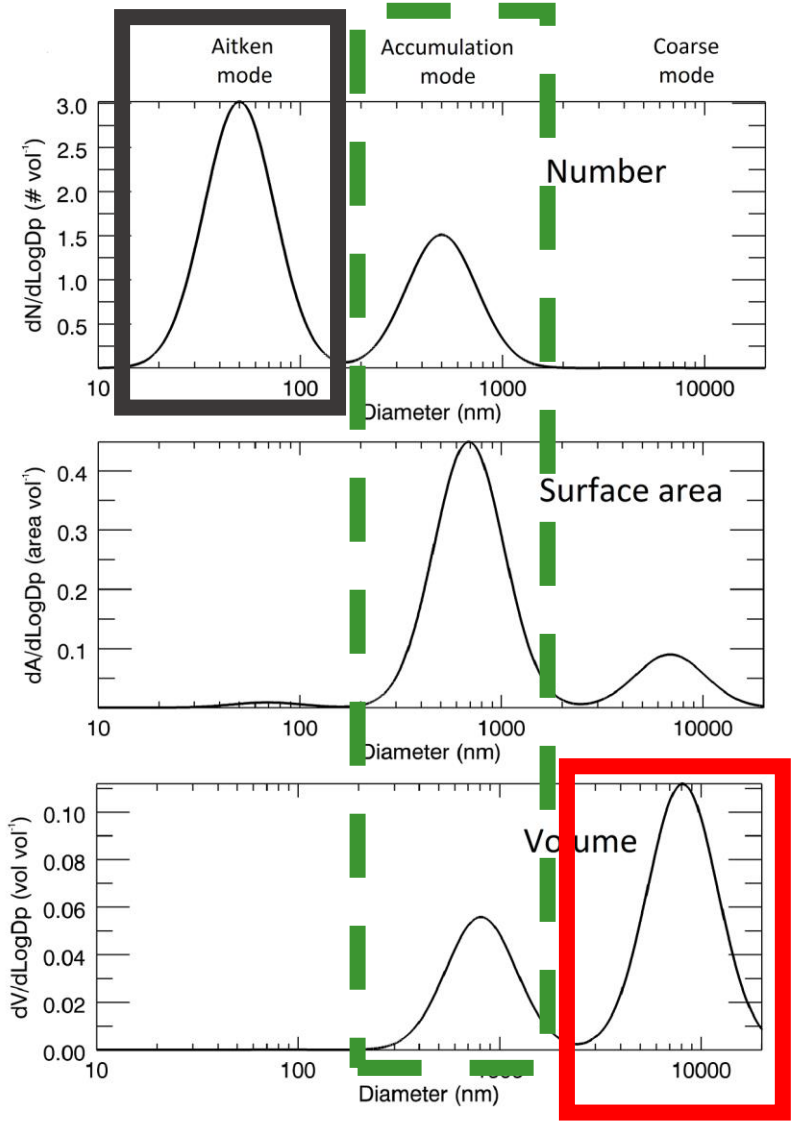
Anthropogenic sources

Size distribution



- Idealized aerosol concentrations
- Highest number with smallest
- Highest volume/mass in largest
  - PM-values
- Most radiative effect in between

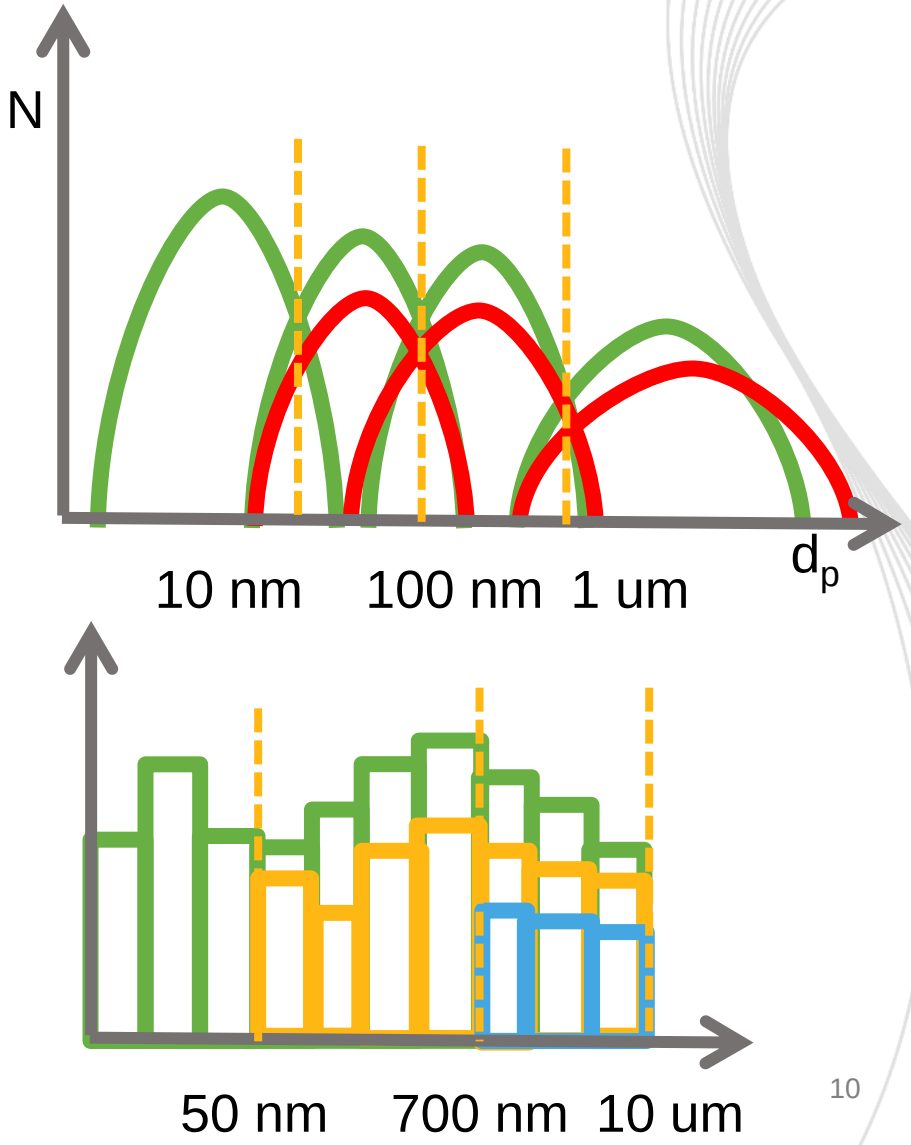
Size distribution



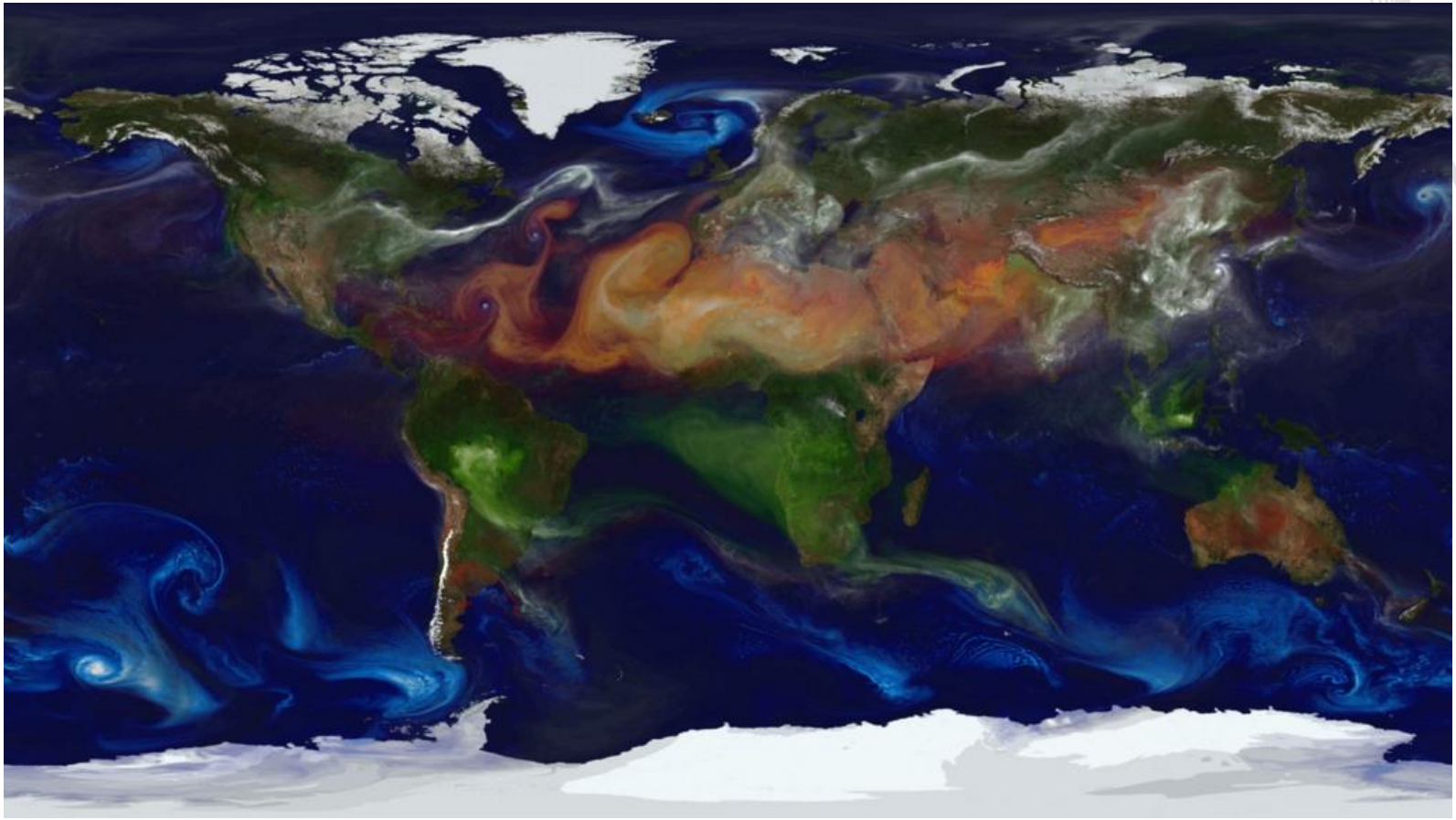
- Idealized aerosol size distribtuions
- Highest number with smallest
- Highest volume/mass in largest
  - E.g. PM2.5
- Most SW radiative effect in between

Modelling aerosols

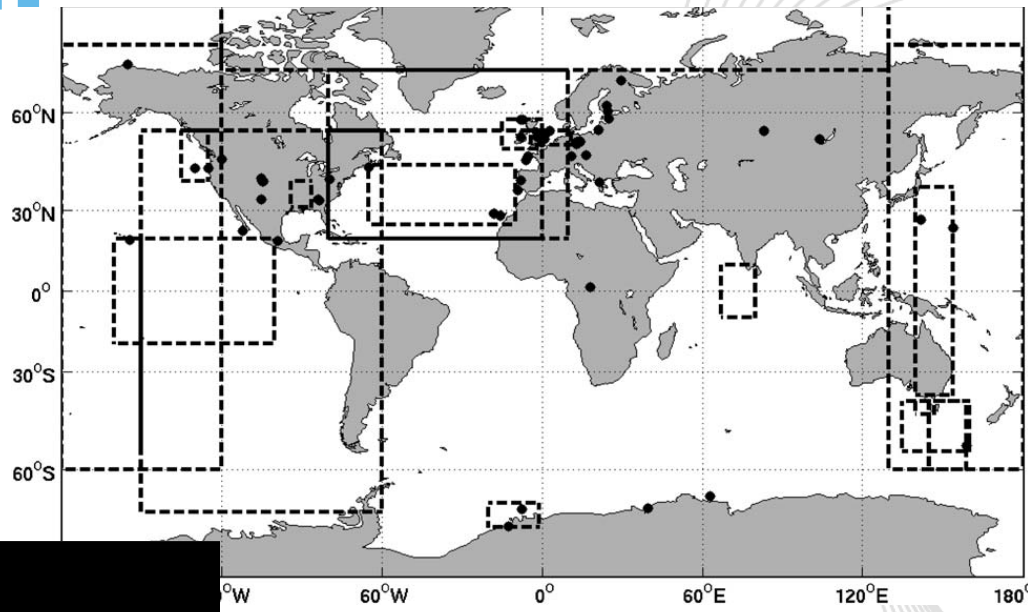
- Modeled aerosols mostly simulated with two methods
  - Modal
  - Sectional
- Aerosol models simulate
  - Condensation
  - Coagulation
  - Emission
  - New particle formation
  - Removal

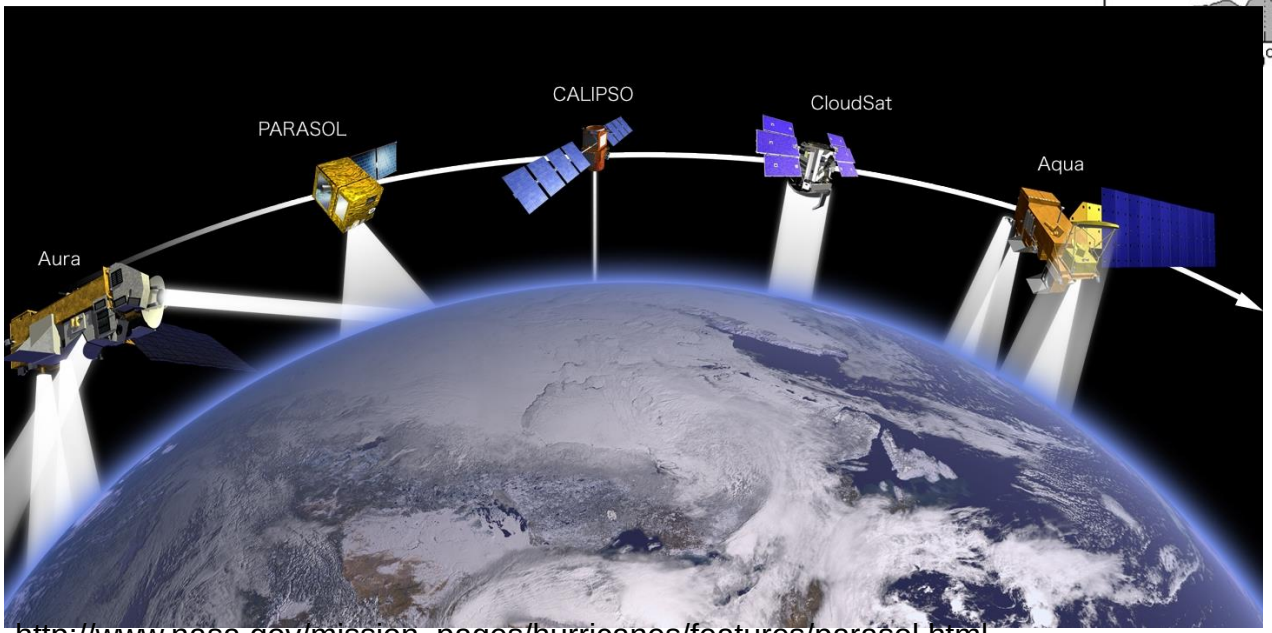


Aerosol-climate models



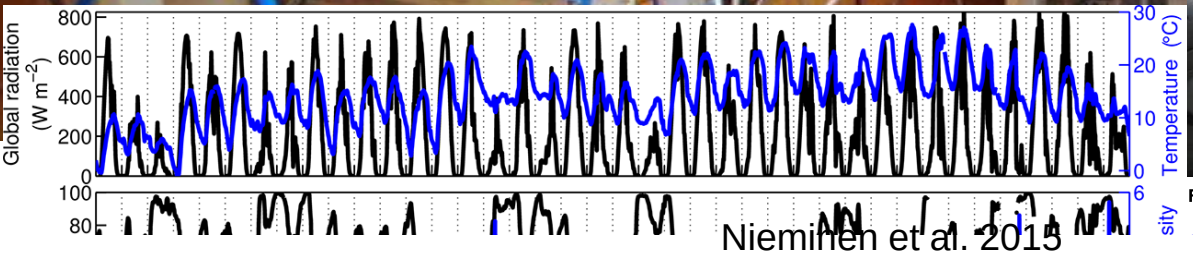
Model validation





http://www.nasa.gov/mission_pages/hurricanes/features/parasol.html

In-situ observations



Nieminen et al. 2015

Fig. 1. Photographs of the inlet mounted on the right wing of the measurement aircraft.

Schobesberger et al. 2013

In situ observations

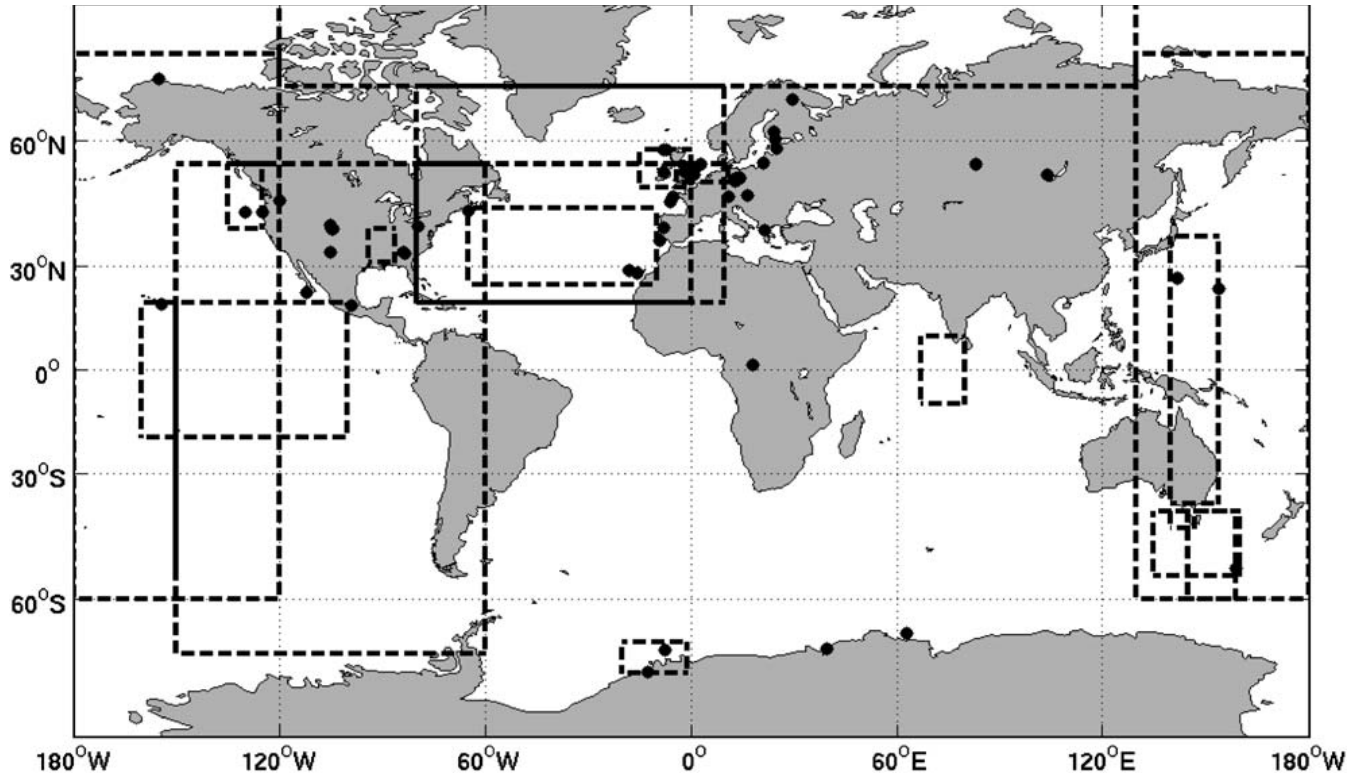
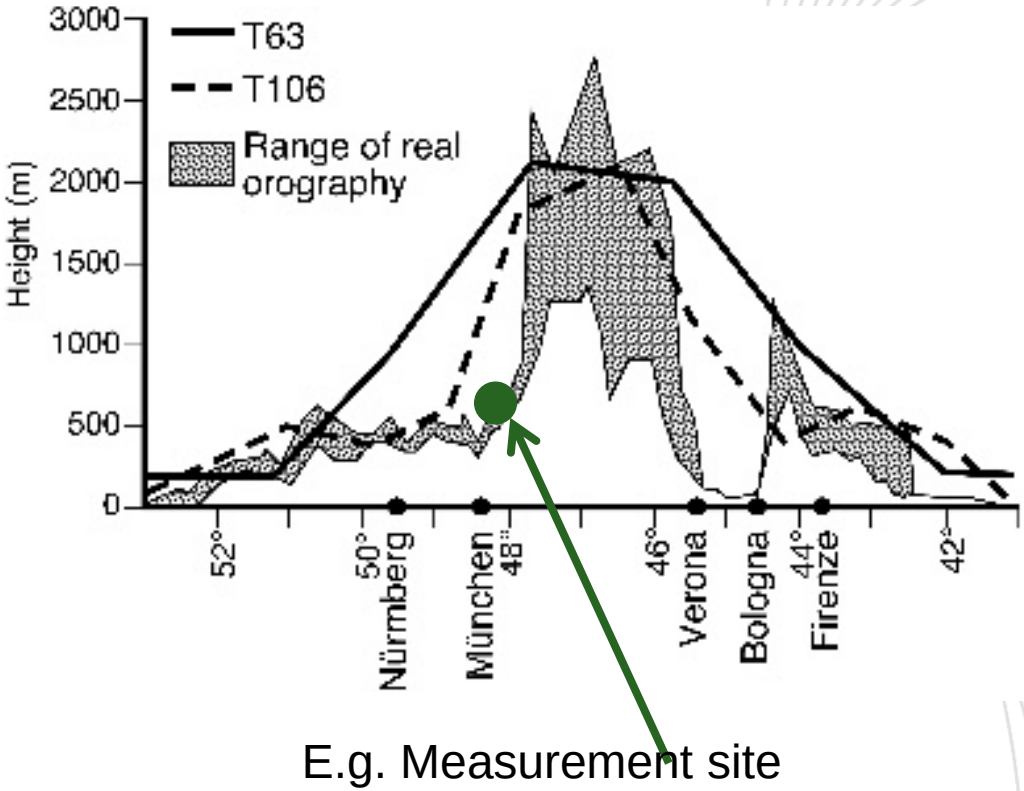


Fig. 1. Global map. The dots indicate observation sites, the dashed lines and rectangles indicate regions where airborne or ship observations have been made.

Kulmala et al. 2004

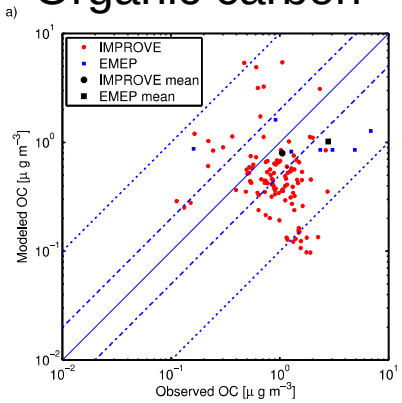
Resolution effects

- Global model resolution
  - ~200km (T63)
- Emissions of particulate matter in global general circulation models
- Representativeness of site

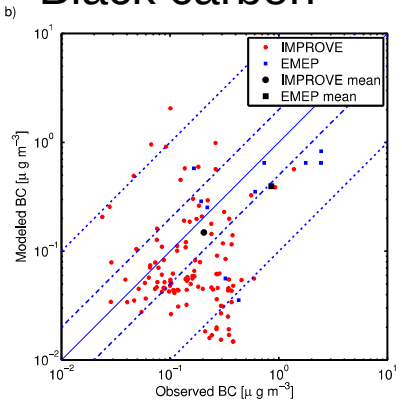


In-Situ observations

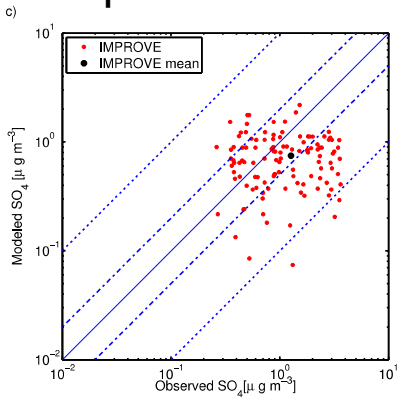
Organic carbon



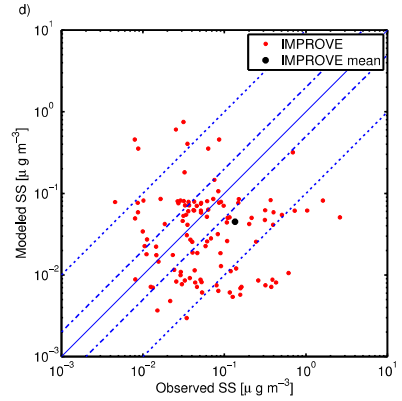
Black carbon



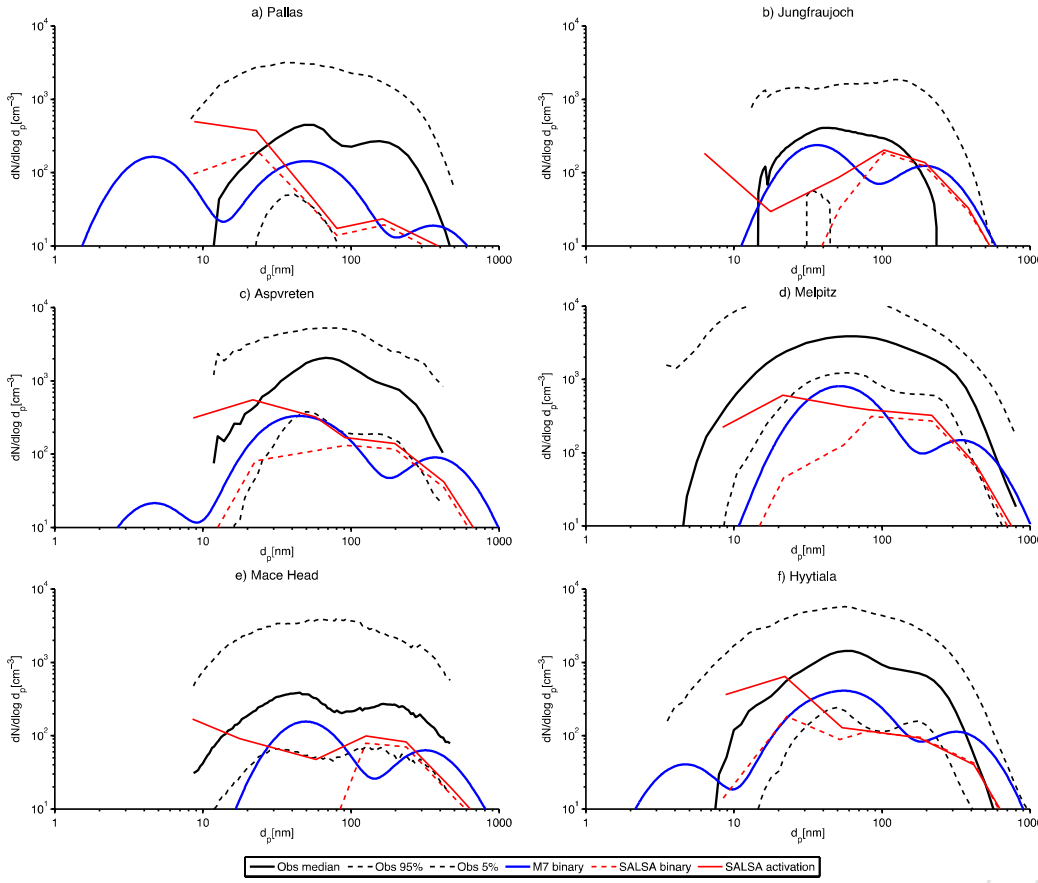
Sulphate



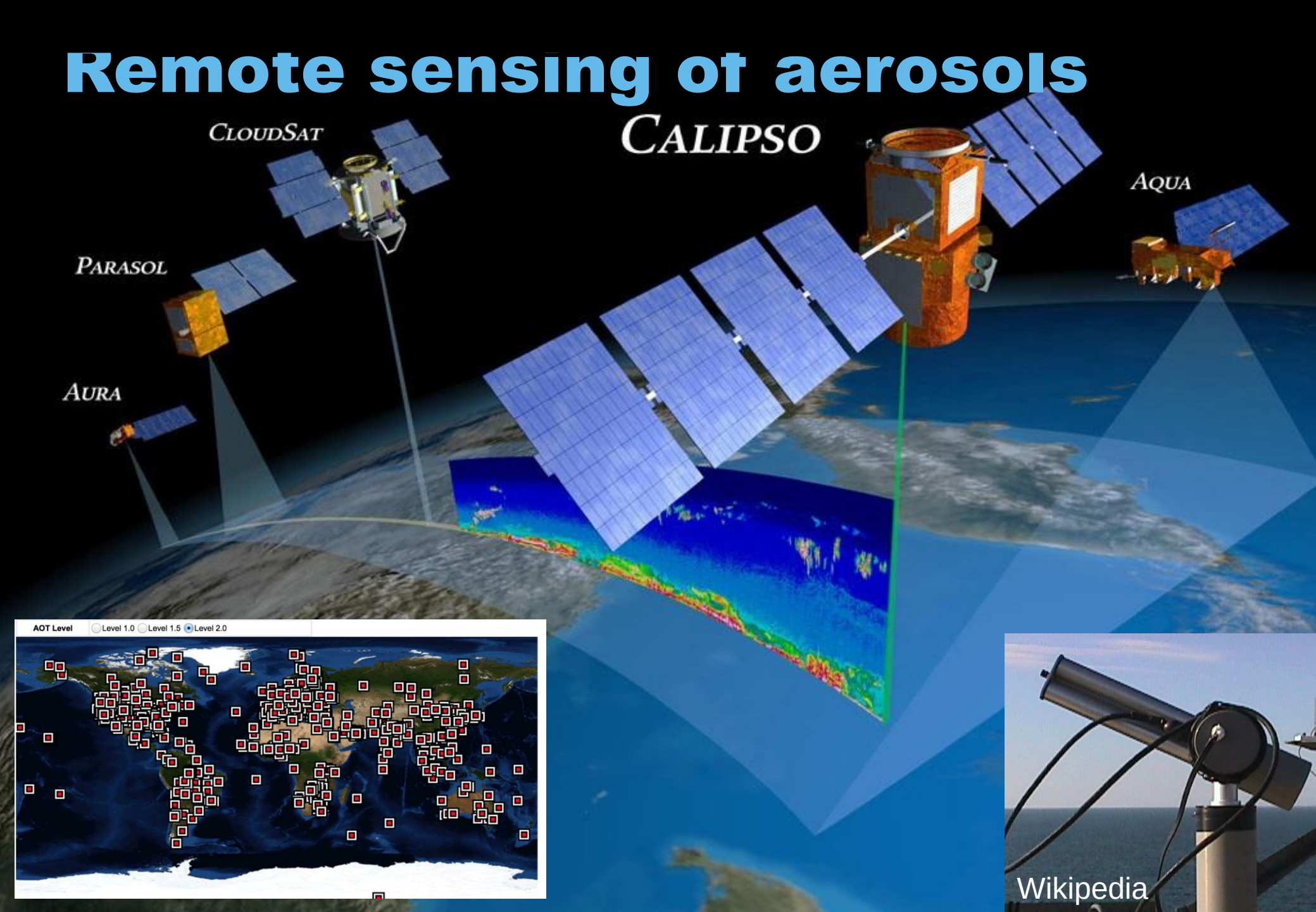
Sea salt



Number concentration



Remote sensing of aerosols

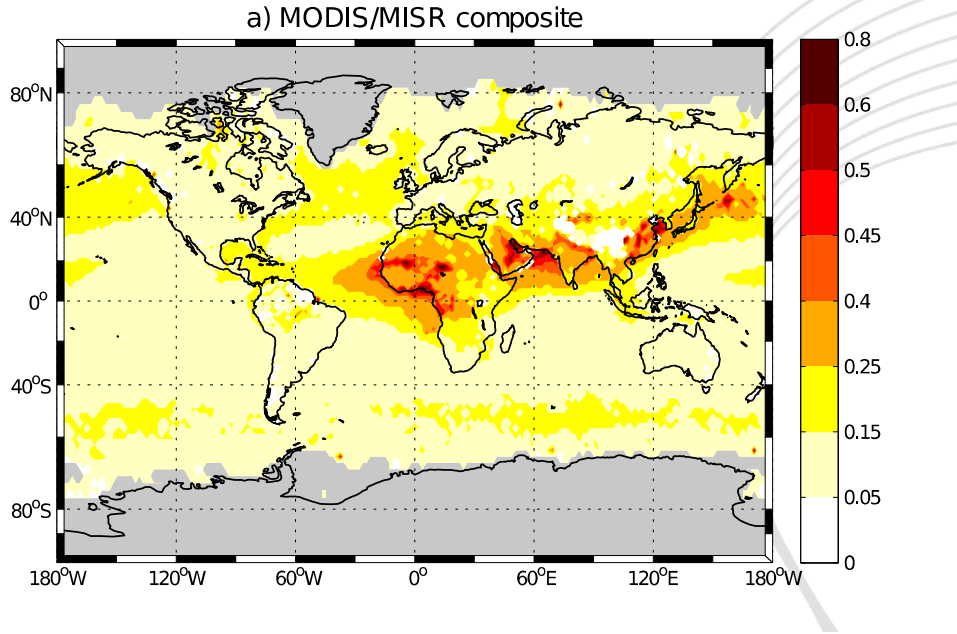


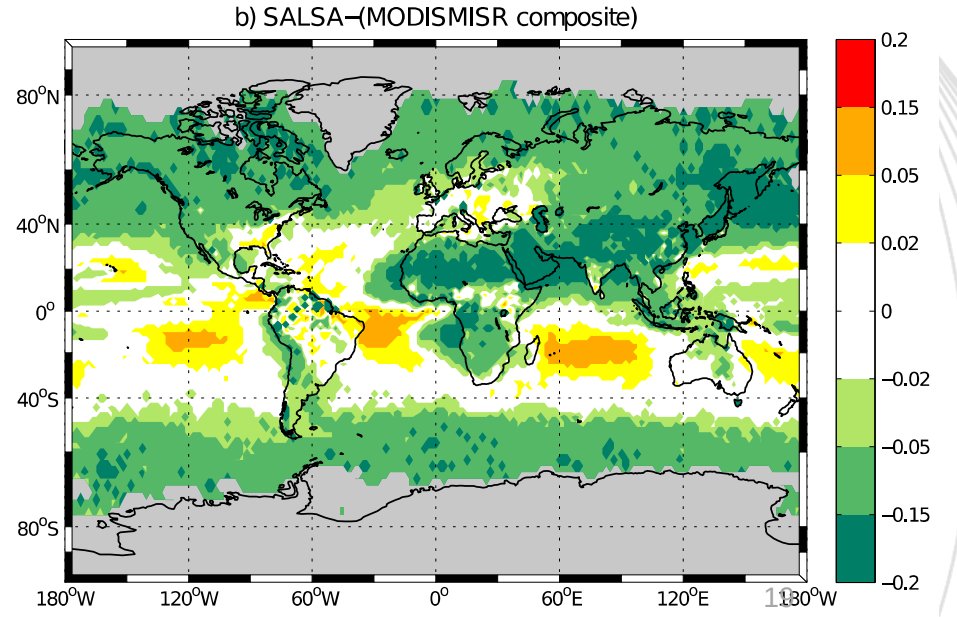
Remote sensing of Aerosols

Instrument	Satellite/time of measurement	Swath (km)	Channels	Spatial resolution	Multi-angle observation
MERIS	ENVISAT 10:00 UTC	1150	15 bands 0.4–1.05 μm (0.41,0.44,0.49,0.51,0.56, 0.62,0.665,0.681,0.705,0.754, 0.76,0.775,0.865,0.89,0.9 μm)	0.3 × 0.3 km^2	No
AATSR	ENVISAT 10:00 UTC	512	7 bands 0.55,0.66, 0.87, 1.6, 3.7, 10.85, 12.0 μm	1 × 1 km^2	Yes, 2 angles from the ranges 0–21.732 and 55.587–53.009 degrees
SCIAMACHY	ENVISAT 10:00 UTC	916	8000 spectral points 0.24–2.4 μm	30 × 60 km^2	No
MISR	TERRA 10:32 UTC	400	4 bands 0.446, 0.558, 0.672, 0.866 μm	0.25 × 0.25 km^2 at nadir and at 0.672 μm 1.1 × 1.1 km^2 in the remaining channels	Yes, 9 angles 0, 26.1, 45.6, 60.0, 70.5°
MODIS	TERRA 10:32 UTC AQUA 13:30 UTC	2300	36 bands 0.4–14.4 μm (1):0.659,0.865 (2):0.47,0.555,1.24,1.64,2.13 (3):0.412,0.443,0.488,0.531,0.551, 0.667,0.678,0.748,0.869,0.905,0.936, 0.94,1.375+MWIR(6)/LWIR (10) channels	(1): 0.25 × 0.25 km^2 (2): 0.5 × 0.5 km^2 (3):1 × 1 km^2	No
POLDER	PARASOL 13:33 UTC	1700	8 bands 0.443,0.490*,0.565,0.670*, 0.865*,0.763,0.765,0.91	5.3 × 6.2 km^2	Yes, channels marked with* have a capability to measure polarization

ECHAM-SALSA validation

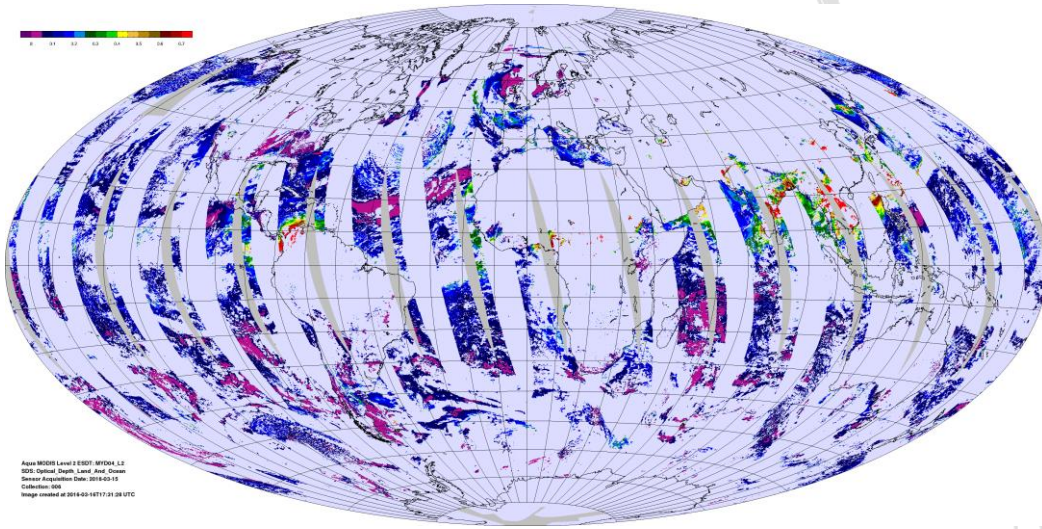
- MISR AOD for land
- MODIS AOD for oceans
- Modeled differences with two aerosol models
  - Sectional model (SALSA)
  - Modal model (M7)





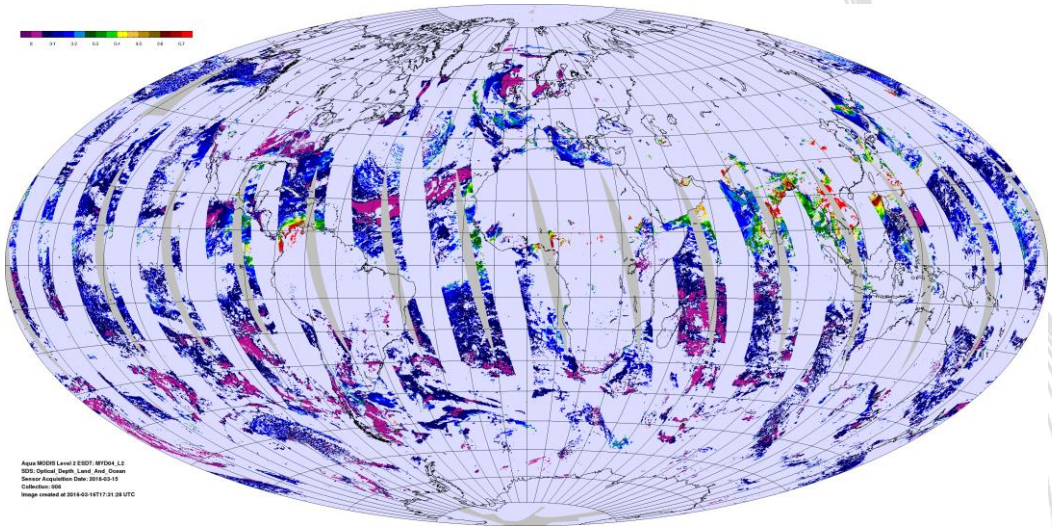
MODIS one day AOD

- Patchy
- All stripes at different times
- Same location will be observed in 1 or 2 days time
- Lot of gaps due to e.g. clouds
- Monthly mean



Factors limiting remote sensing of aerosols

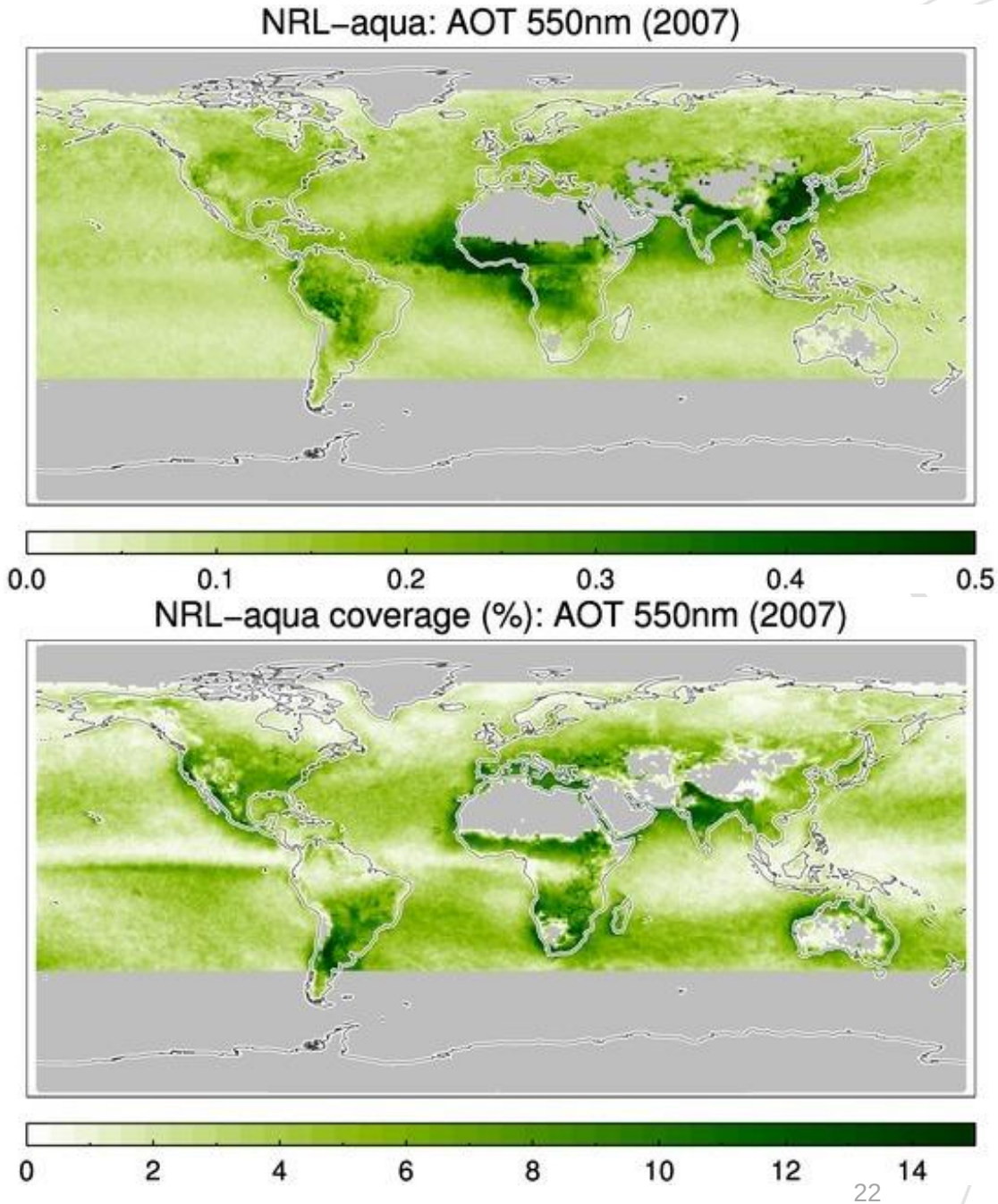
- Cloudiness
- Reflectivity of surface
- Low aerosol amount
- Solar zenith angle
- Trajectory of platform
- Model AOD from all timesteps



Data coverage of AOD from MODIS

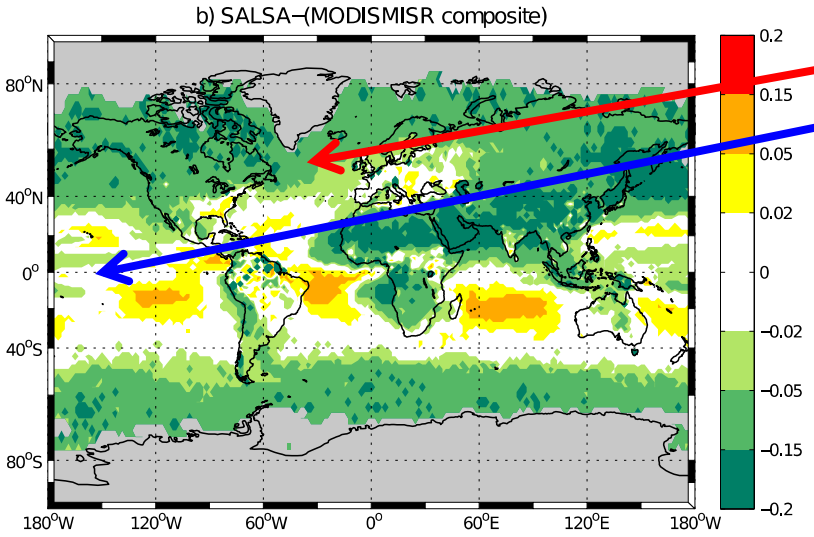
- Global AOT from MODIS aboard aqua

- Frequency of available data over one year



Problems with AOD from MODIS

- Poor agreement due to sampling
- Good agreement, but sampling mismatch



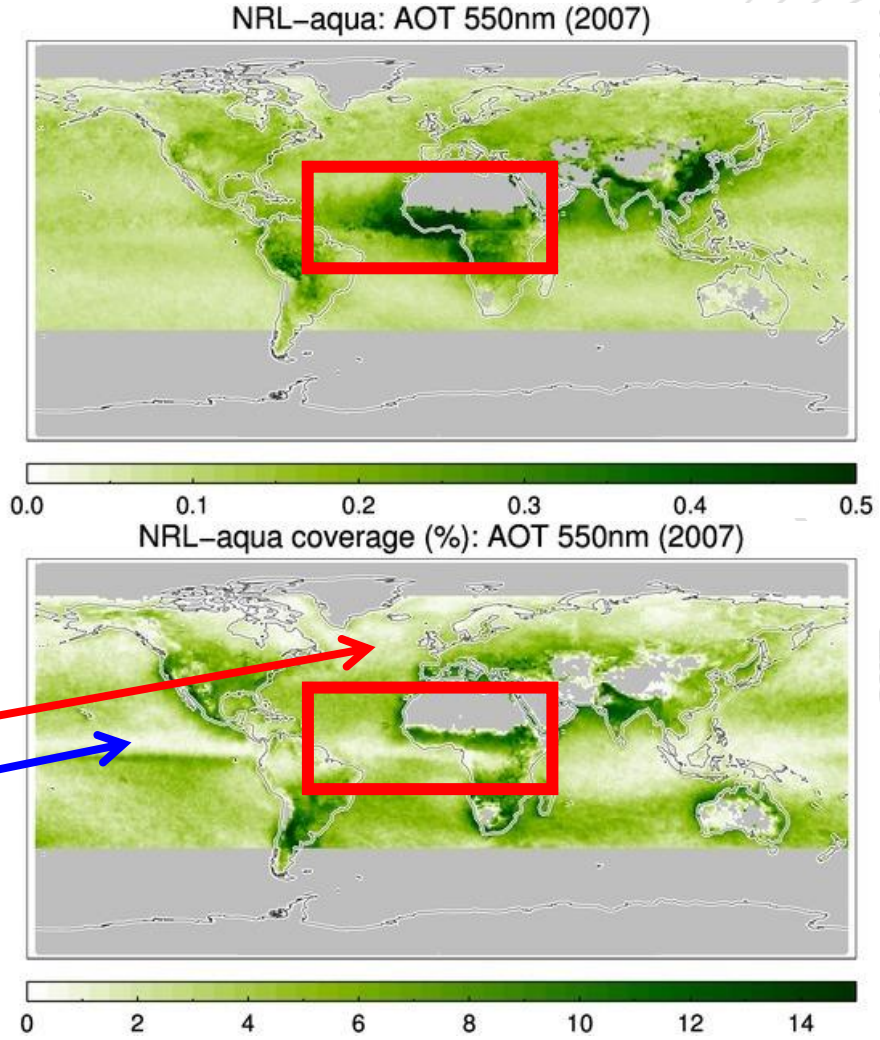
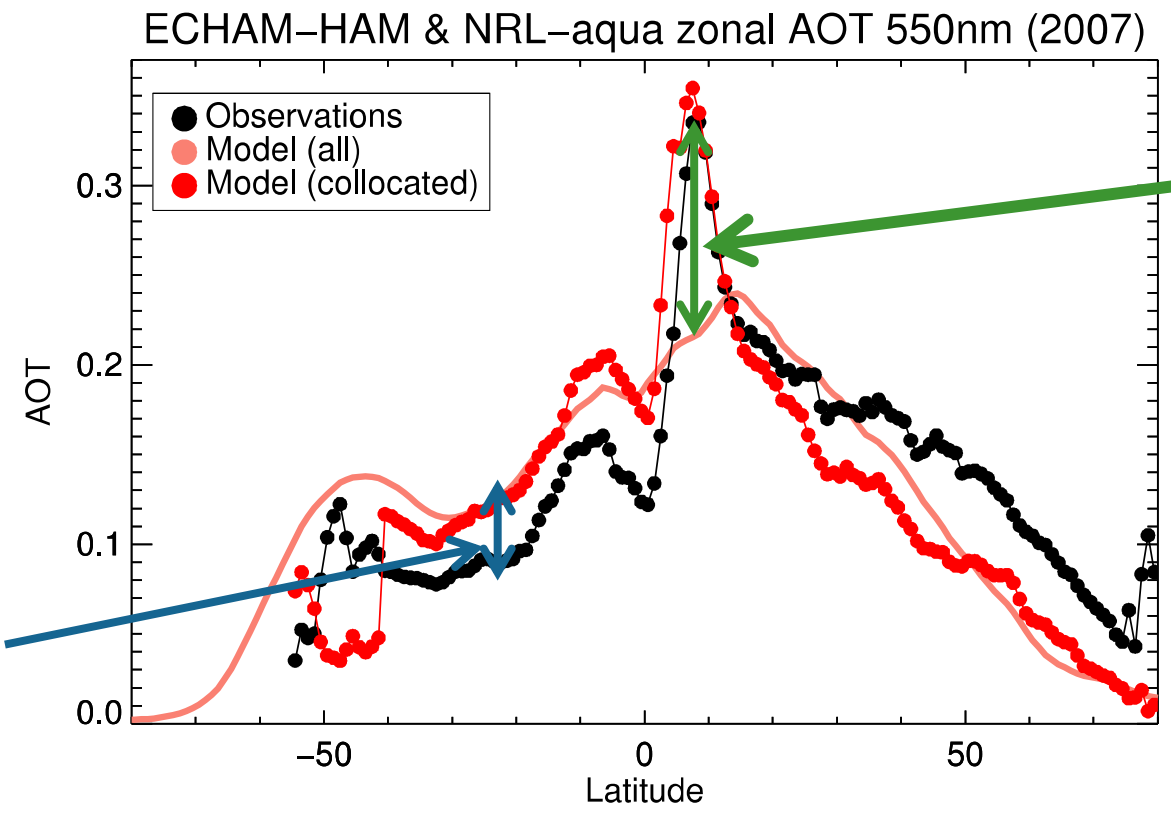


Figure 7. Top panel shows the 2007 yearly mean AOT of MODIS-NRL Aqua. Bottom panel shows the temporal coverage (%) of observations during that year. Grey colours indicate no observations available at all.

Schutgens et al. 2016

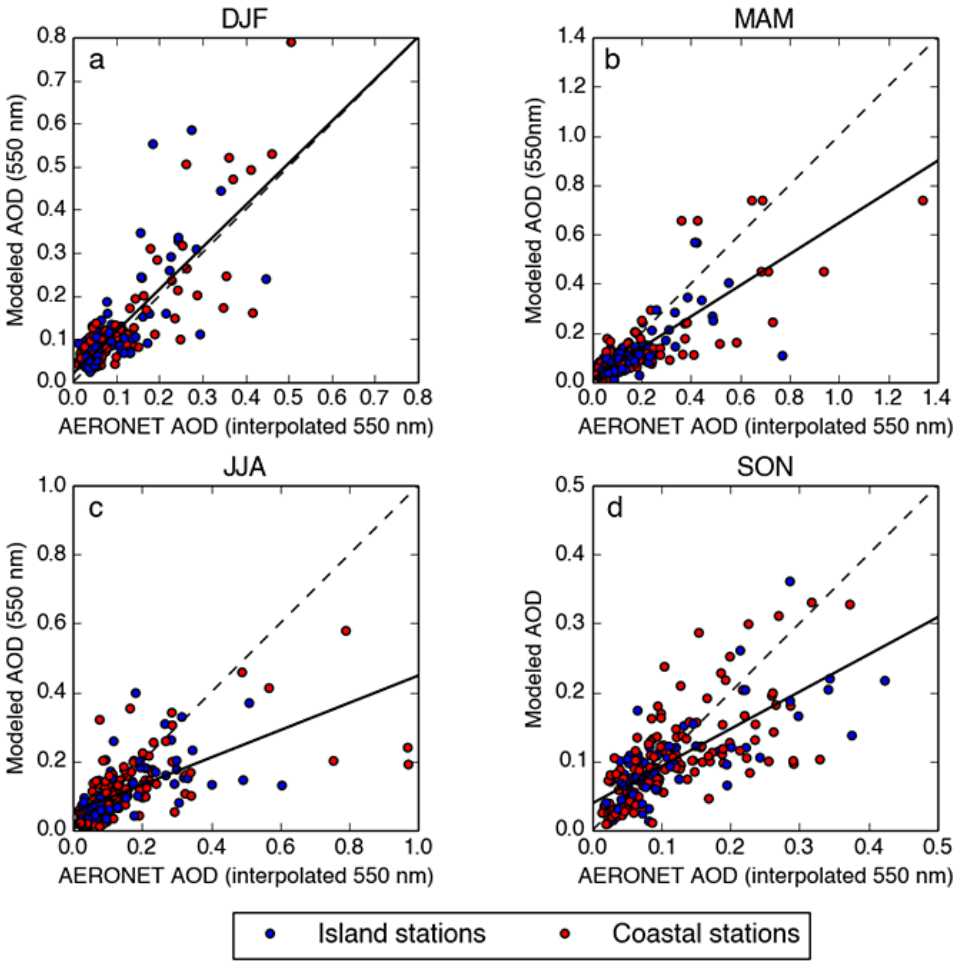
Errors within models and colocation



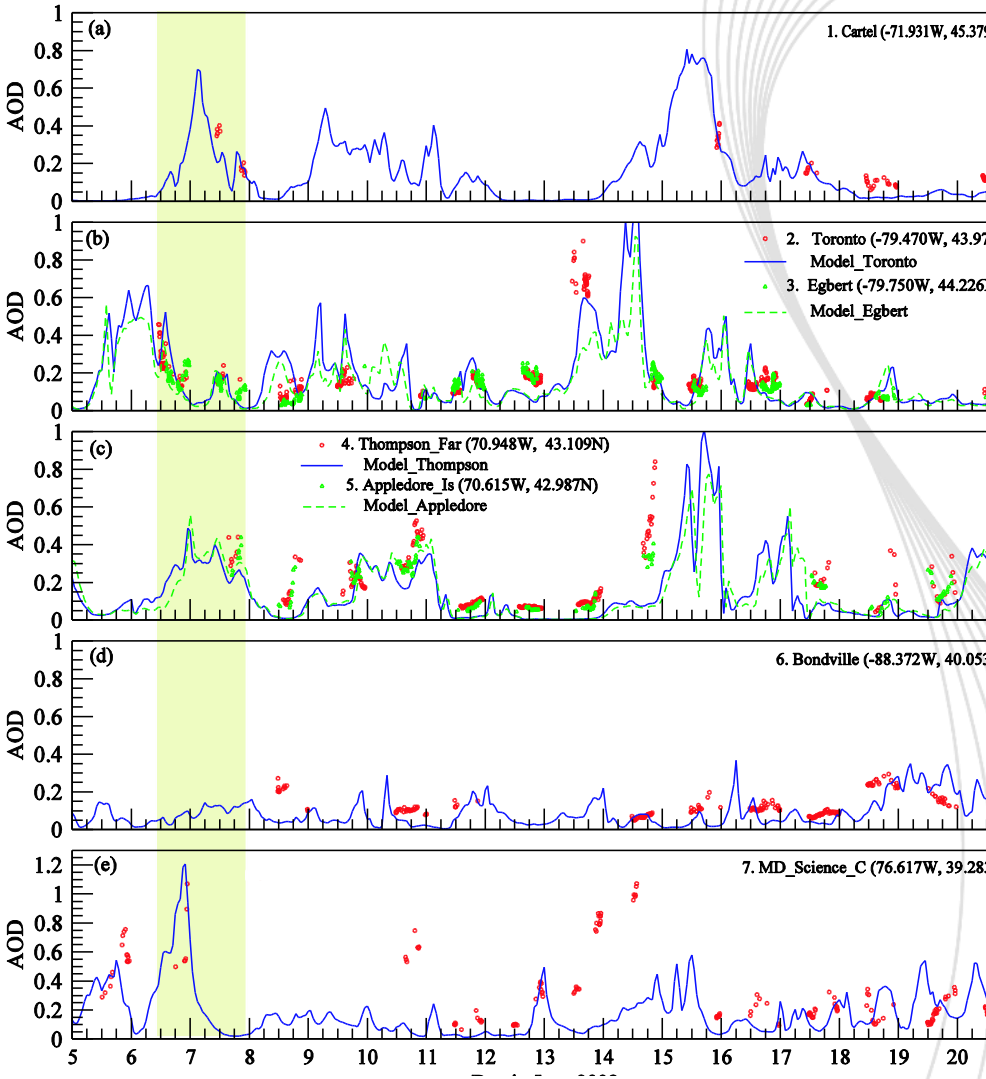
Sampling error

Model error

Aeronet vs. Model



Partanen et al. 2014



Yu et al. 2012

Ångström exponent

- Angström Exponent shows relation between large and small particles
  - Smaller value -> more larger particles
- ~0.6 difference in AE due to minimum AOT requirement
  - (Schutgens et al.2016)

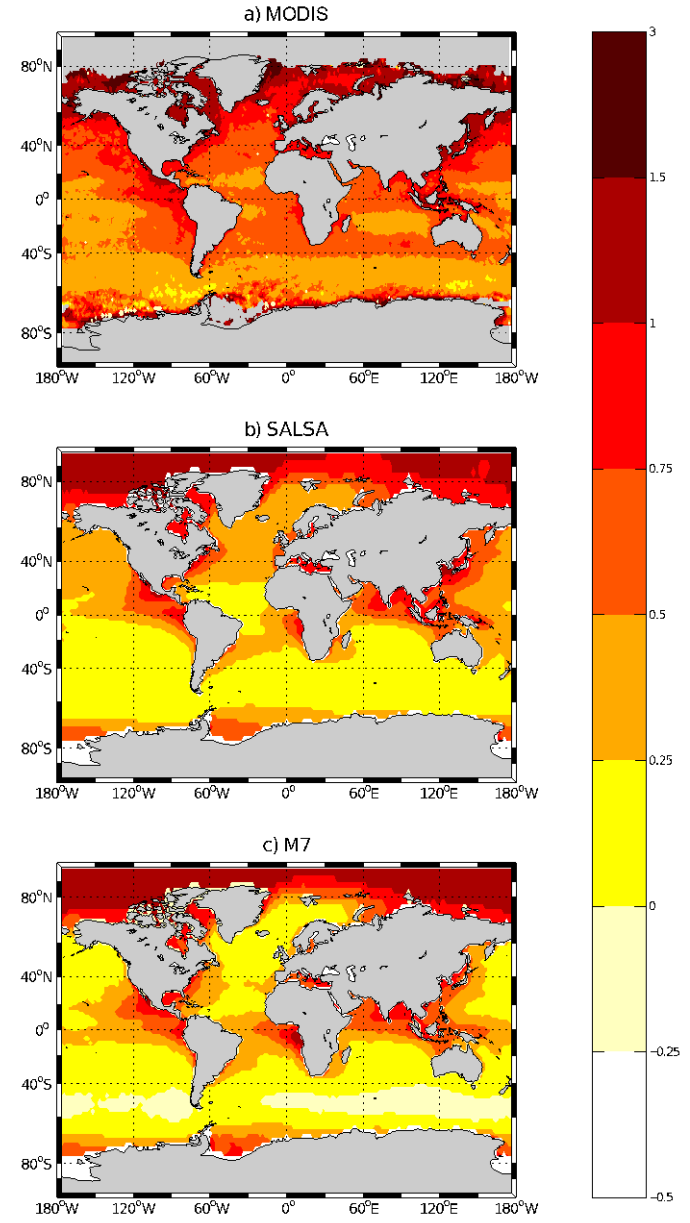


Fig. 11. Simulated and satellite retrieved annual mean Ångström exponent of MODIS (550/865 nm), SALSA (550 nm/825 nm) and M7 (550 nm/825 nm) for year 2008. Gray areas either have no data or have been omitted.

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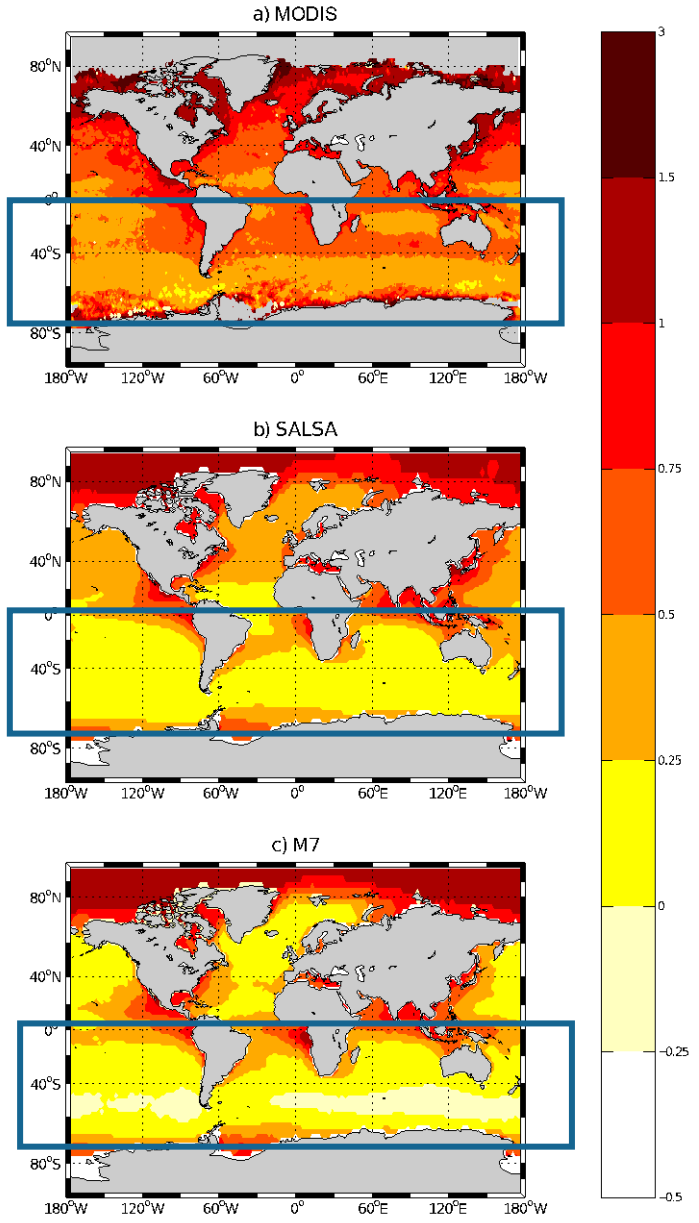
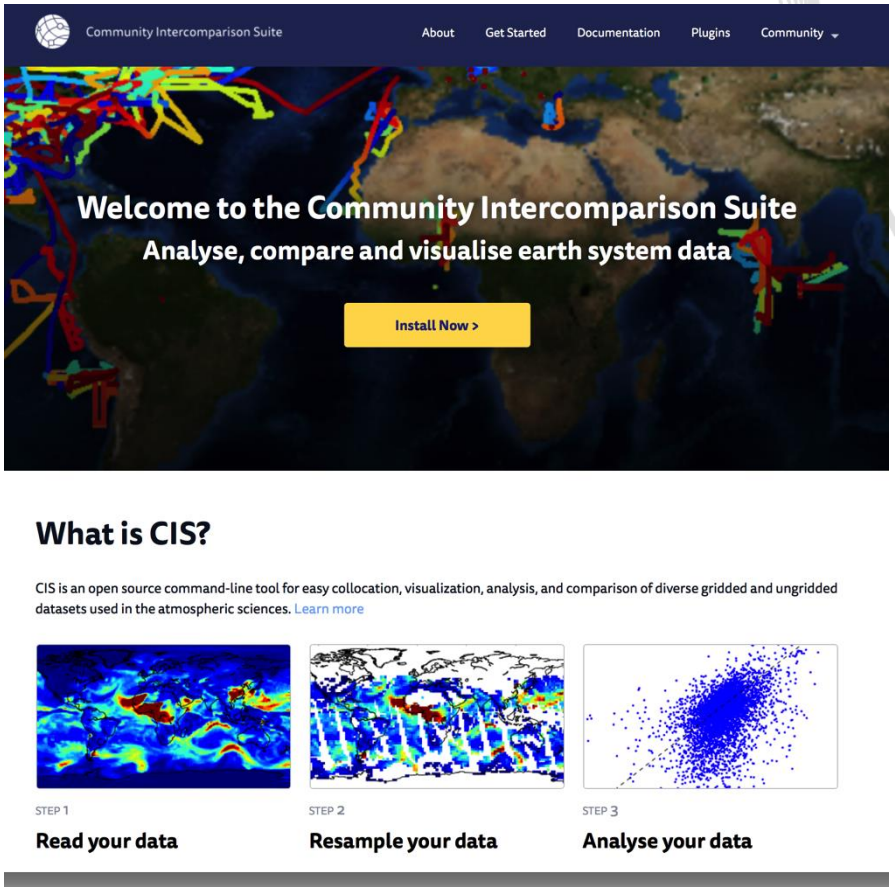


Fig. 11. Simulated and satellite retrieved annual mean Ångström exponent of MODIS (550/865 nm), SALSA (550 nm/825 nm) and M7 (550 nm/825 nm) for year 2008. Gray areas either have no data or have been omitted.

Automatic colocation

- Satellite simulators in models
- High resolution output of models
- Community intercomparison suite
  - AERONET
  - MODIS
  - CALIPSO
  - Flight campaign data
  - EUSAAR



Conclusions

- When comparing model and observed quantities
  - Temporal and spatial co-location of data very important
  - Significant reduction of errors
  - Both satellite and in-situ data
- Model resolution enforces limitations
  - How well low global model resolution grid box and point-like observations correlate
- Novel tools can alleviate the problems by allowing automatic co-location
  - Community intercomparison suite