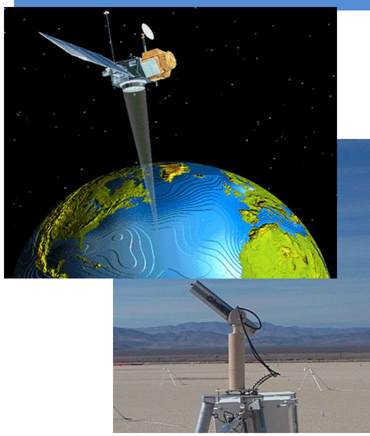
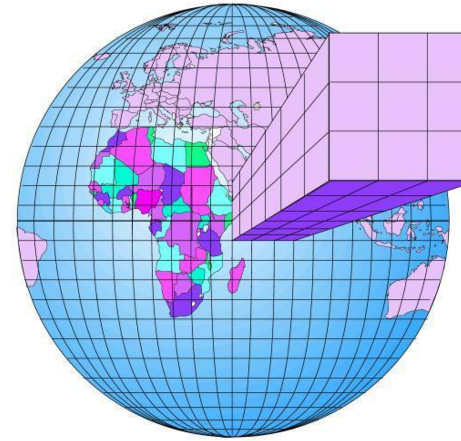
SATELLITE AEROSOL COMPOSITION RETRIEVAL USING NEURAL NETWORKS



$\tau(\lambda), \omega(\lambda), g(\lambda), m(\lambda), dV/d\log(r), \ldots$



Gabriele Curci [1,2]

Del Frate, F. [3], Di Noia, A. [4], Sist, M. [3], Tirelli, C. [1]

[1] CETEMPS

[2] Dept. Physical and Chemical Sciences University of L'Aquila

[3] University of Tor Vergata

[4] SRON Netherlands Institute for Space Research, Utrecht, The Netherlands

gabriele.curci@aquila.infn.it

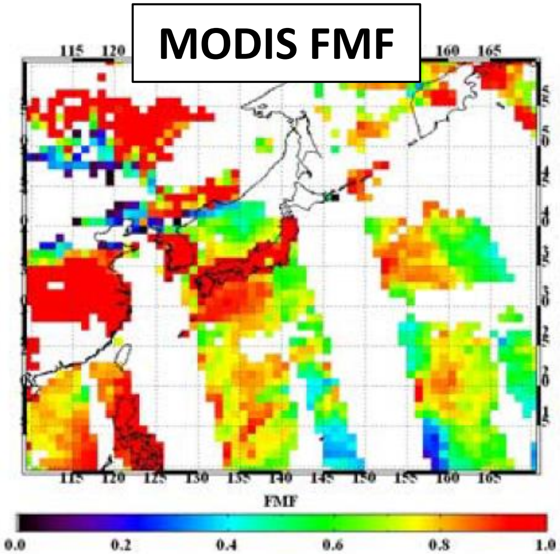
ROMA 1-3 Marzo 2017

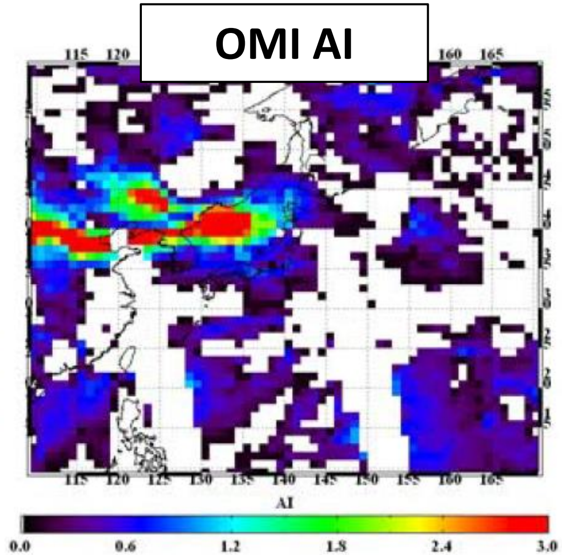
Data Exploitation della missione PRISMA, precursore delle missioni iperspettrali nazionali

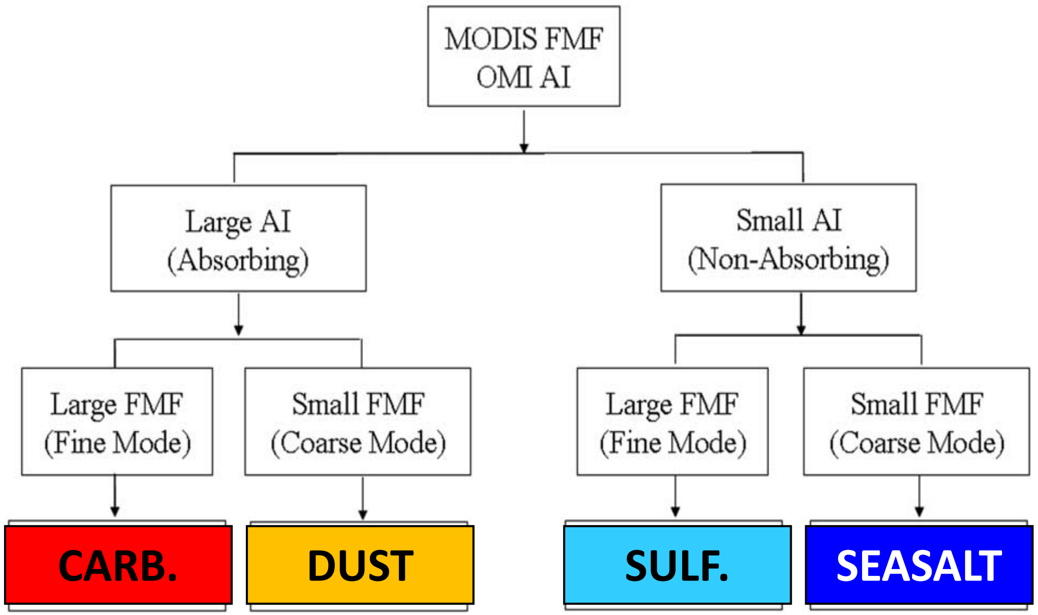
AEROSOL COMPOSITION REMOTE SENSING: MASK

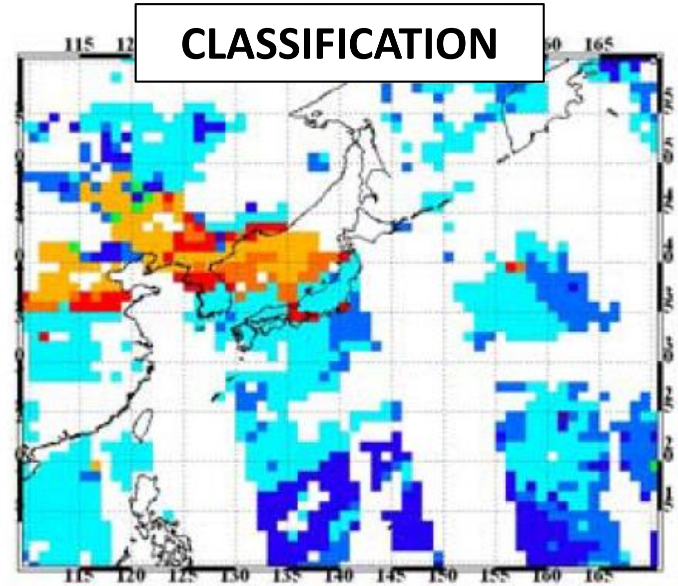
Simple mask based on MODIS Fine Fraction and OMI AI products

Absorption adds info





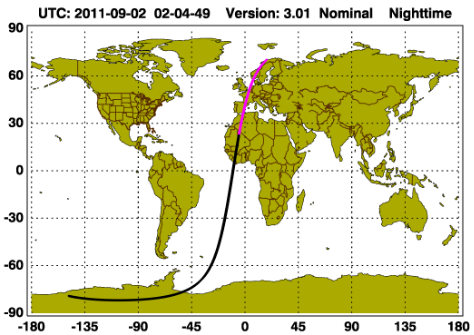


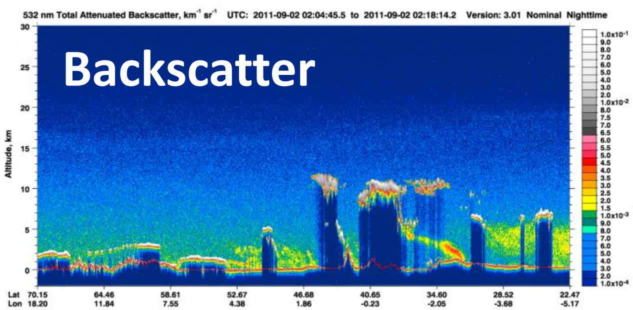


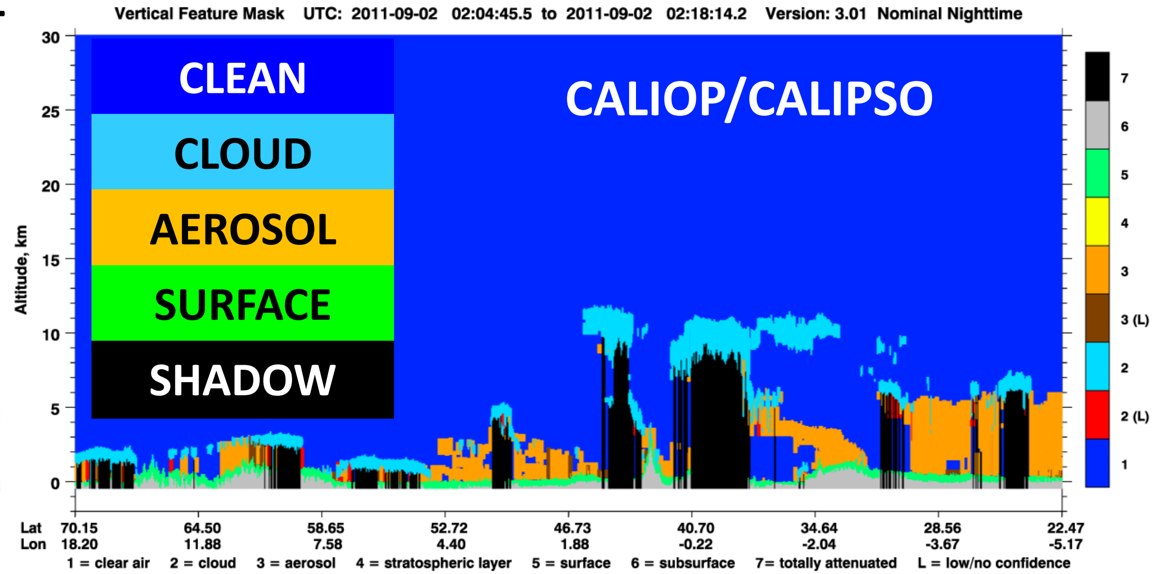
[Kim et al., 2007]

AEROSOL COMPOSITION REMOTE SENSING: LIDAR

Saharan dust event Sep. 2011







MARITIME

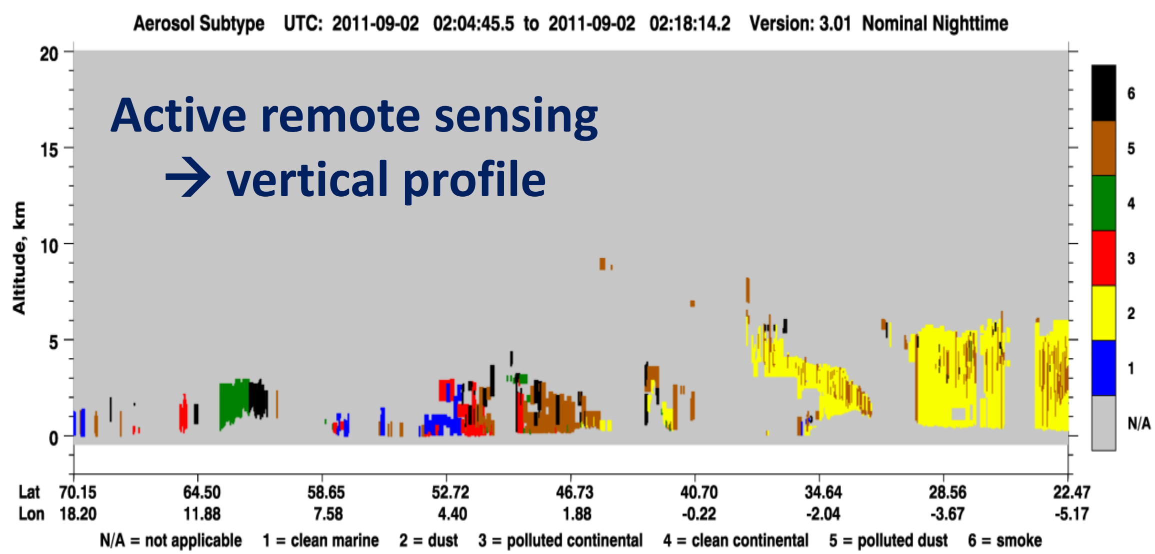
DUST

POLLUTED

CLEAN CONT.

POLL. DUST

SMOKE



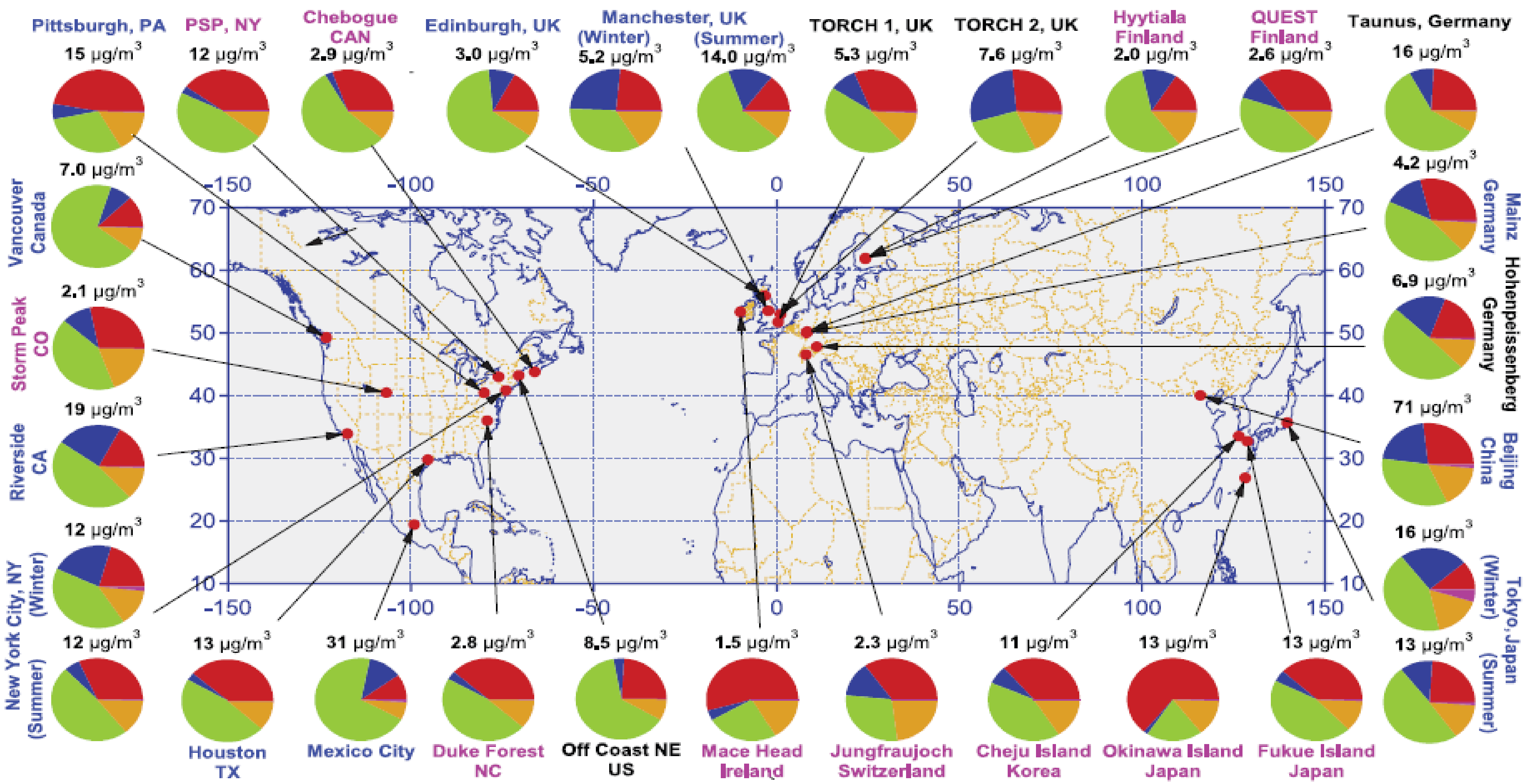
AEROSOL CHEMICAL COMPOSITION IN MODELS

SULFATE | NITRATE
AMMONIUM | ORGANIC

This is what we (attempt to) simulate in Chemistry-Transport Models (CTM)

also:

SEASALT
DUST
BC (SOOT)

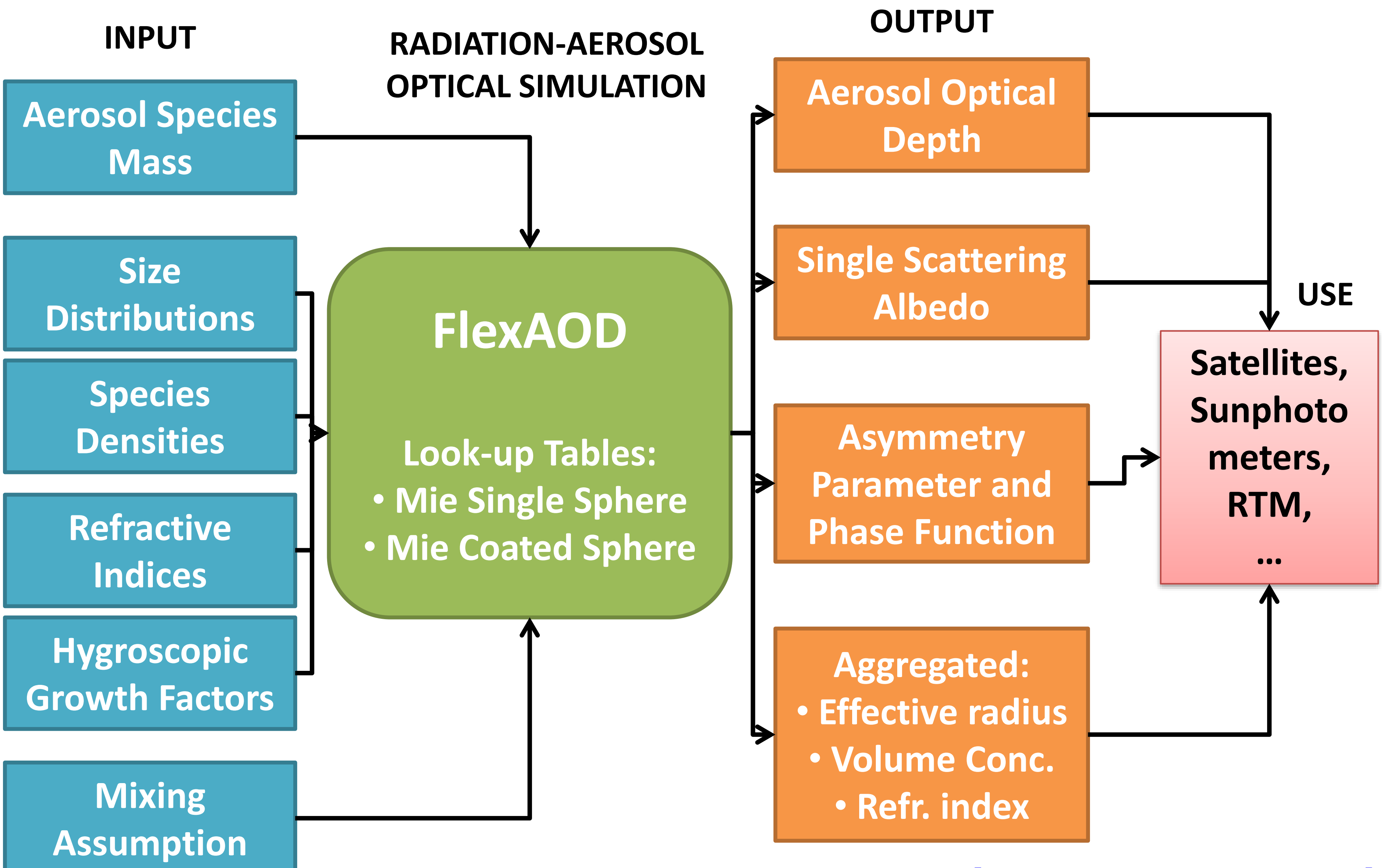


[Zhang et al., 2007]

QUESTION AND METHOD

- Question:
  - Can we retrieve a «model-like» aerosol composition from satellites?
- Method:
  - We **simulate one year** (2006) of **aerosol composition** over the globe with the **GEOS-Chem** chemistry-transport model (www.geos-chem.org) at 2° x 2.5° horizontal resolution
  - We **calculate optical properties** associated to aerosol fields using the **FlexAOD** post-processor
  - We use the **libRadtran** radiative trasfer model (www.libradtran.org) to calculate **Top of Atmosphere reflectaces** arising from about 6000 aerosol scenes randomly selected over the ocean (dark surface)
  - We train **Neural Networks** to associate the **TOA reflectances** to the **underlying aerosol chemical species** column abundance

FlexAOD WORKING DIAGRAM

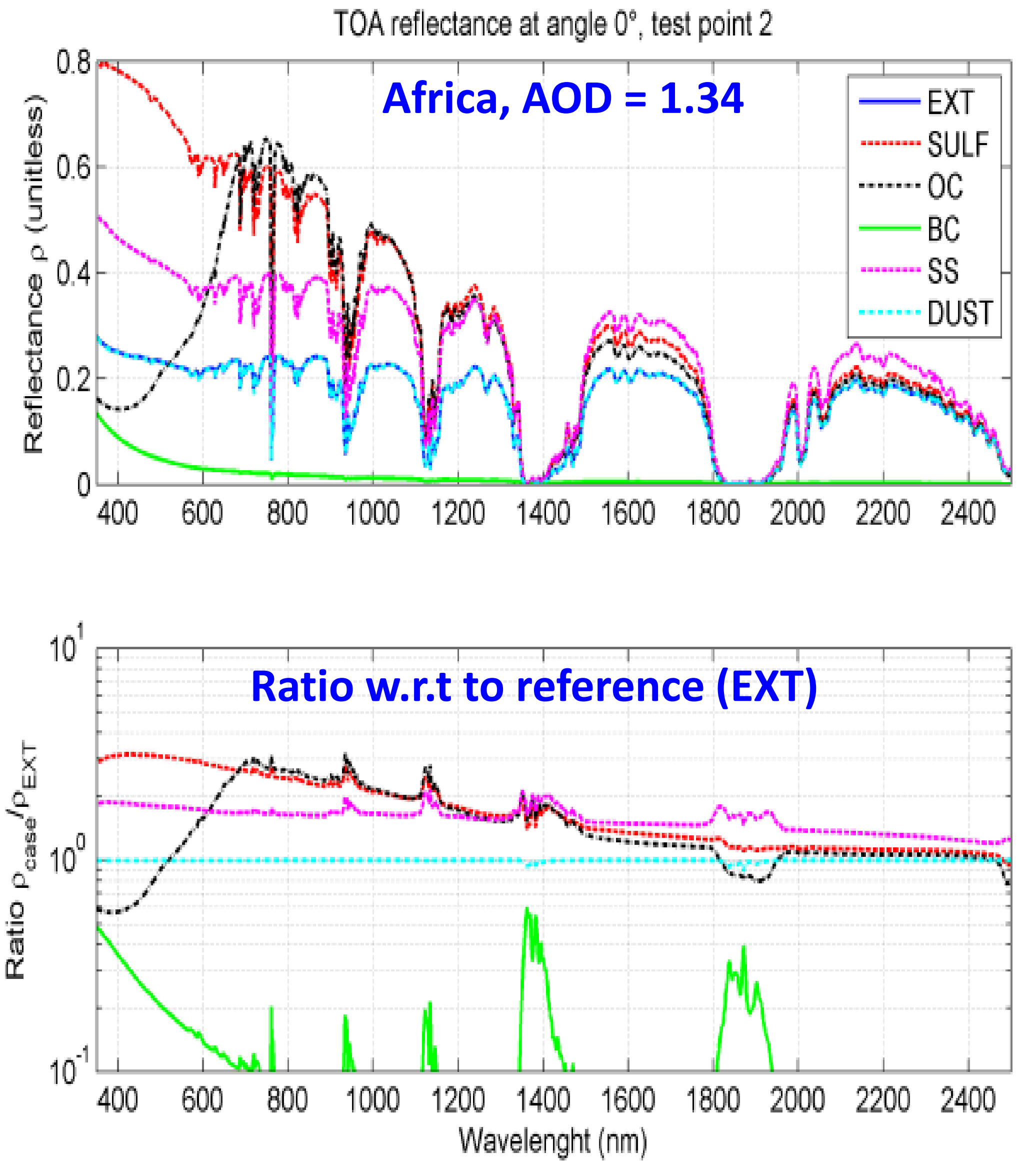


[Curci et al. Atm. Env. 2015]

PHYSICAL AND CHEMICAL PROPERTIES OF SIMULATED AEROSOL SPECIES

	SIA	OCPO	OCPI	BCPO	BCPI	SSA	SSC	DUST
Description	Inorganic secondary aerosol (sulfate like)	Hydrophobic Organic Carbon (primary)	Hydrophillic Organic Carbon (aged primary and secondary	Hydrophobic Black Carbon	Hydrophillic Black Carbon (aged BC)	Sea Salt accumulatio n mode	Sea Salt Coarse mode	Dust from soil erosion
Density (g/cm^3)	1.77	1.47	1.3	1.8	1.8	2.2	2.2	2.5-2.65
Modal radius (µm)	0.05	0.12	0.095	0.012	0.012	0.085	0.4	-
Sigma	2	1.3	1.5	2	2	1.5	1.8	-
Growth RH 90%	1.64	-	1.64	-	1.4	2.37	2.39	-
Refind species	AMSU	ORGC	SOAH	BCME	BCME	Accum.	Coarse	SINYUK
Real refind 550 nm	1.53	1.63	1.43	1.85	1.85	1.5	1.5	1.56
Im refind 550 nm	1e-7	0.021	0	0.71	0.71	1e-8	1e-8	0.0014

ARE THE SIMULATED AEROSOL SPECIES (ENOUGH) OPTICALLY DIFFERENT?

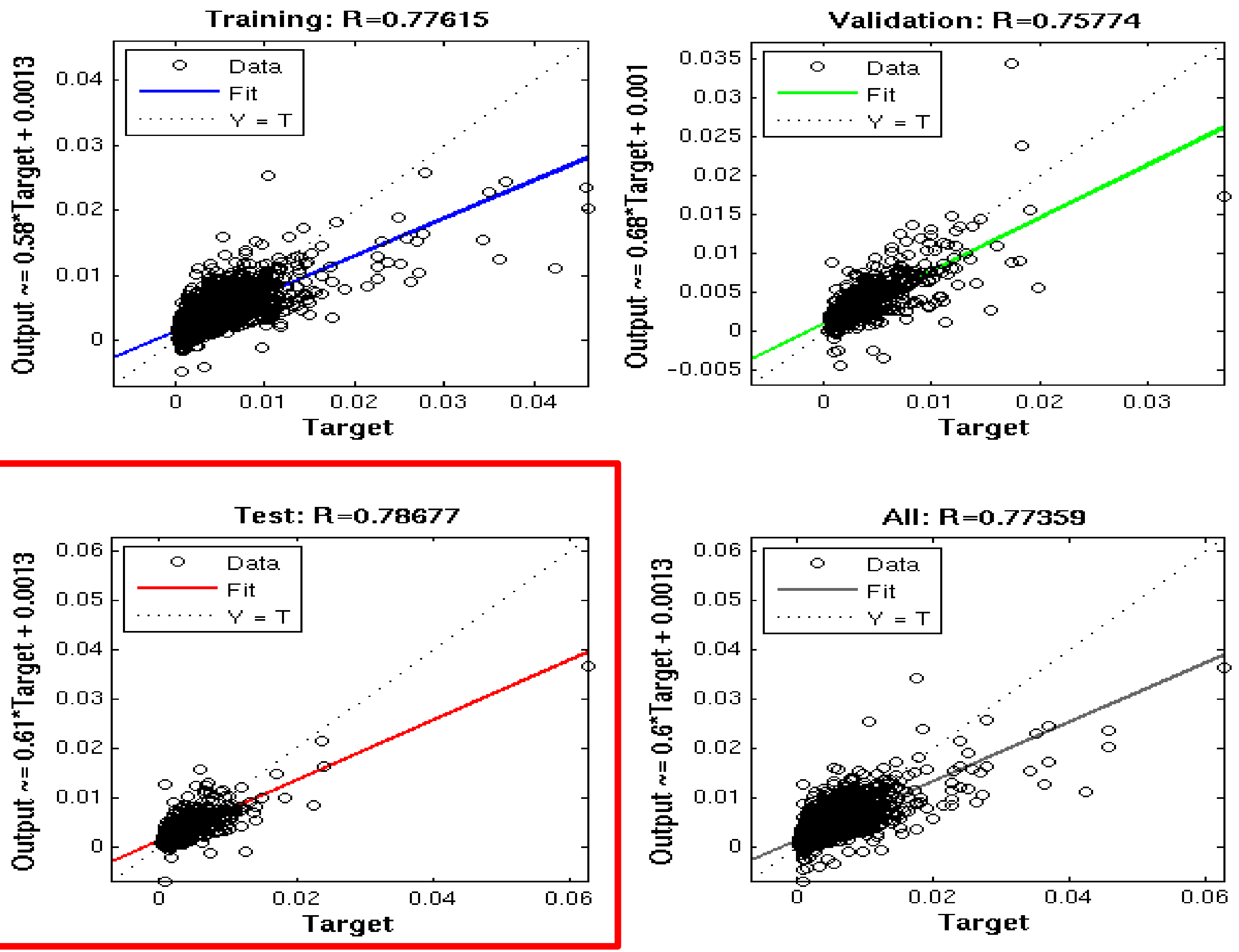


- The ratio of reflectances of sensitivity tests with that of the reference case display different and distinctive trends for the selected species.
- Dust is the dominant optical species in this test point. Its ratio with the reference case is near 1.
- Sulfate and sea salt have a ratio almost monotonically decreasing with wavelength. The slope of sulfate is usually steeper than sea salt.
- The ratio of black carbon is always below 1 (high absorbtion of radiation). The slope of the ratio with wavelength is very steep in the UV-VIS, then it is almost constant.
- The ratio of organic carbon increases with wavelength in the visible than monotonically decreases.
- These features are similar among selected test points, but change in magnitude (increasing with the aerosol load)
- This features varies in magnitude for different solar and viewing angles, but are conserved
- Higher surface albedo decreases the differences among cases

ARTIFICIAL NEURAL NETWORK SETUP

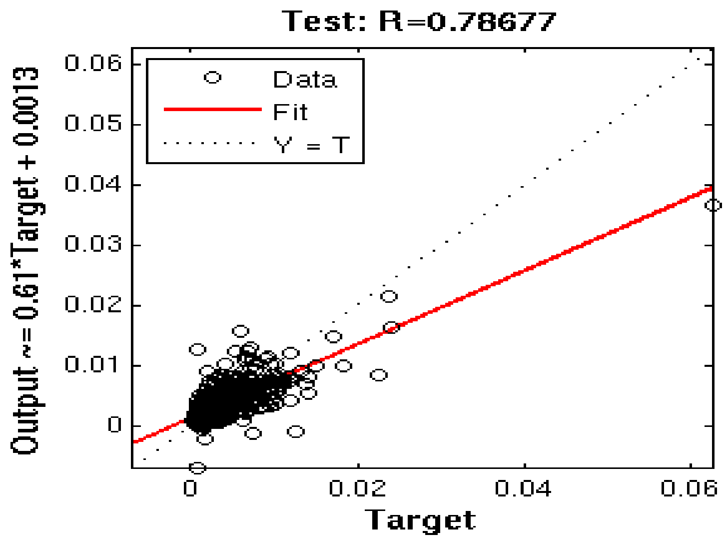
- 5 ANN were trained, one for each aerosol component
- INPUT (12 nodes): Solar zenith and azimuth angles, latitude, longitude, Aerosol Optical Depth at 550 nm, 7 most significant components of the spectral TOA reflectance
- HIDDEN LAYER: One with 40 nodes
- OUTPUT (1 node): One aerosol component among SIA, BC, OC, Sea Salt, Dust

RESULTS: SECONDARY INORGANICS RETRIEVAL

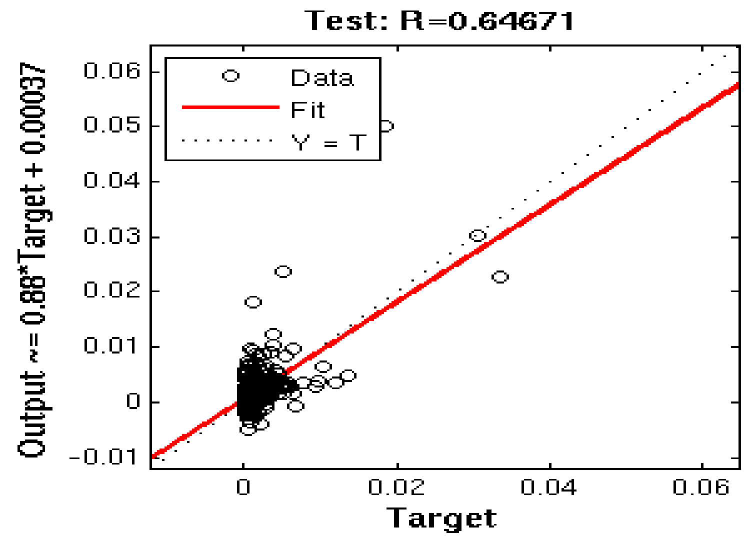


RESULTS: SIA, ORGANICS, DUST, SEA SALT

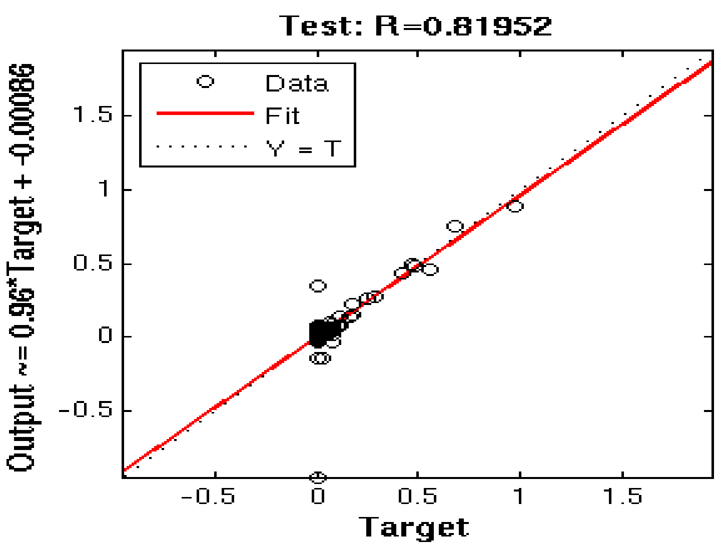
Inorganics secondary



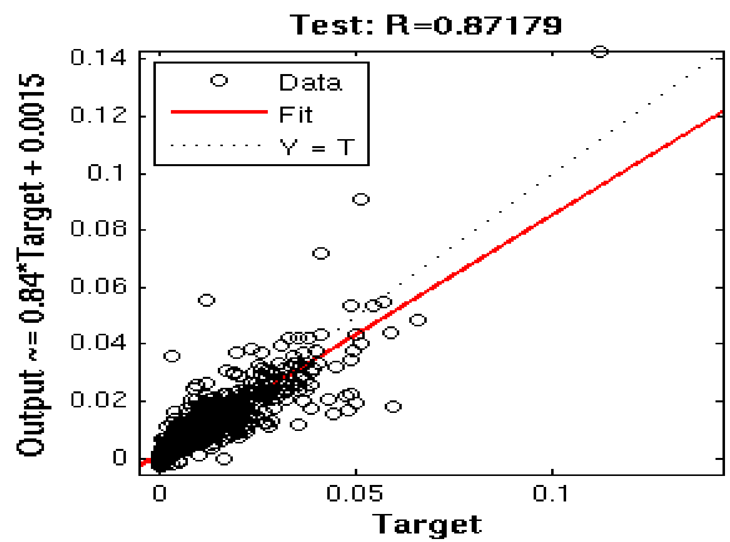
Organic Carbon



Dust

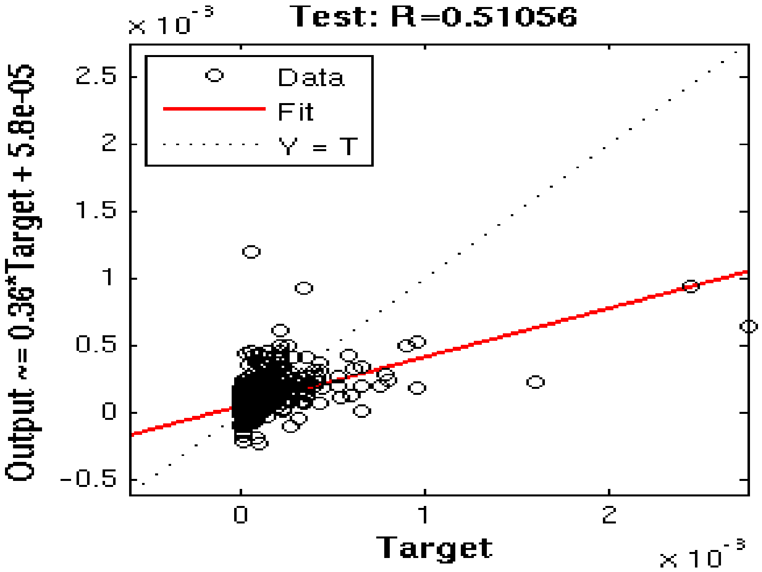


Sea Salt

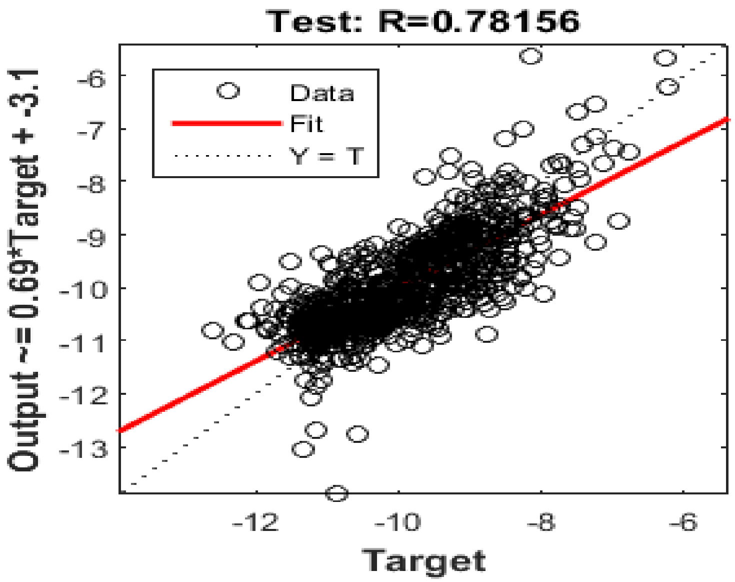


RESULTS: BLACK CARBON

BC (linear conc.)



BC (log conc.)



CONCLUSIONS

- These preliminary results show the potential for the quantitavive retrieval of the aerosol composition from space
- Dust, sea salts and secondary inorganic fractions are retrieved by the Neural Network with a correlation coefficient in the test phase between 0.87 and 0.78
- Organic fraction is retrieved with a correlation of 0.64
- Black carbon is retrieved with a correaltion of 0.51, which increases to 0.78 when using log concentrations
- More work is needed: introduction of observational noise, much larger training dataset, application to a real case (undergoing …)

REFERENCES

Curci, G. et al. (**2015**), ***Uncertainties of simulated aerosol optical properties induced by assumptions on aerosol physical and chemical properties: an AQMEII-2 perspective***, ***Atmos. Environ.,*** 115, 541-552, doi: 10.1016/j.atmosenv.2014.09.009

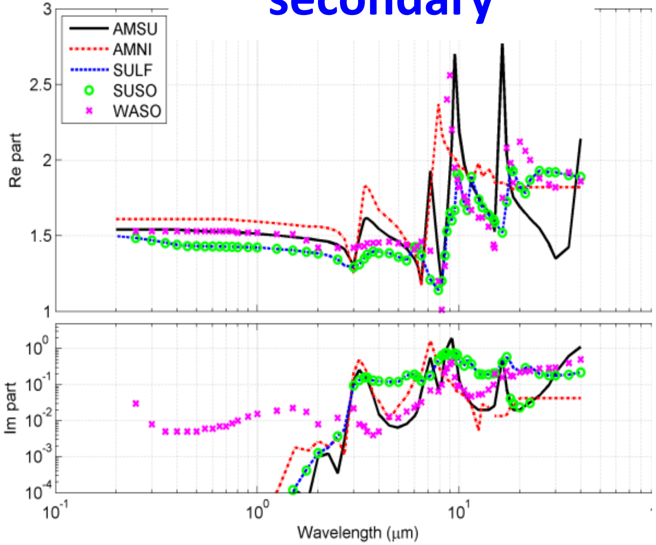
Kim, J. et al. (**2007**), ***Consistency of the aerosol type classification from satellite remote sensing during the Atmospheric Brown Cloud–East Asia Regional Experiment campaign***, ***J. Geophys. Res.,*** 112, D22S33

Zhang, Q., et al. (**2007**), ***Ubiquity and dominance of oxygenated species in organic aerosols in anthropogenically-influenced Northern Hemisphere midlatitudes***, ***Geophys. Res. Lett.,*** 34, L13801

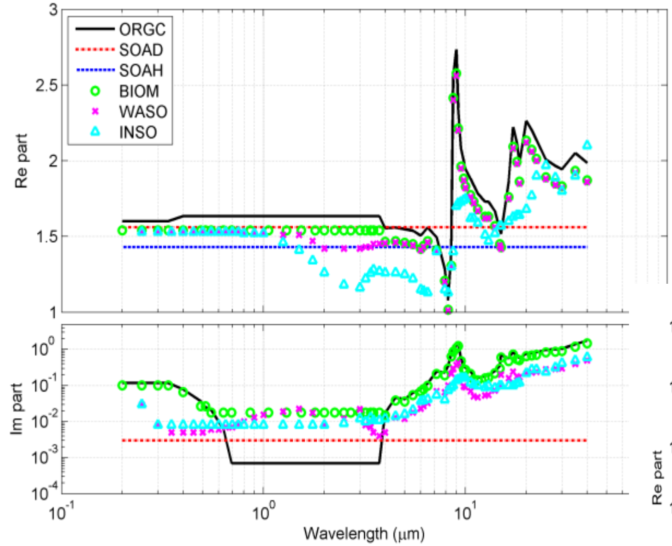
EXTRA SLIDES

REFRACTIVE INDICES OF SIMULATED AEROSOL SPECIES

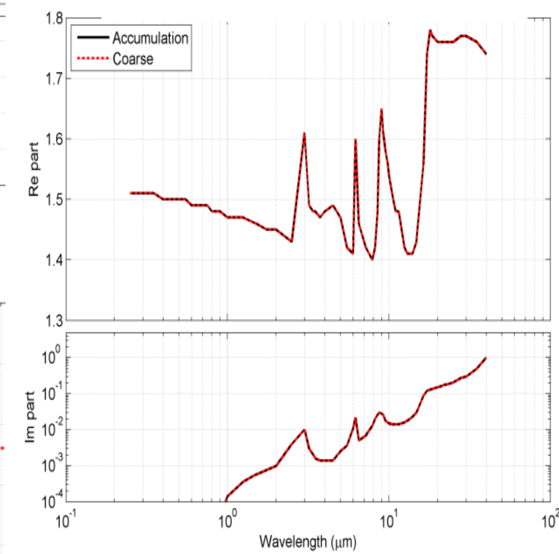
Inorganics secondary



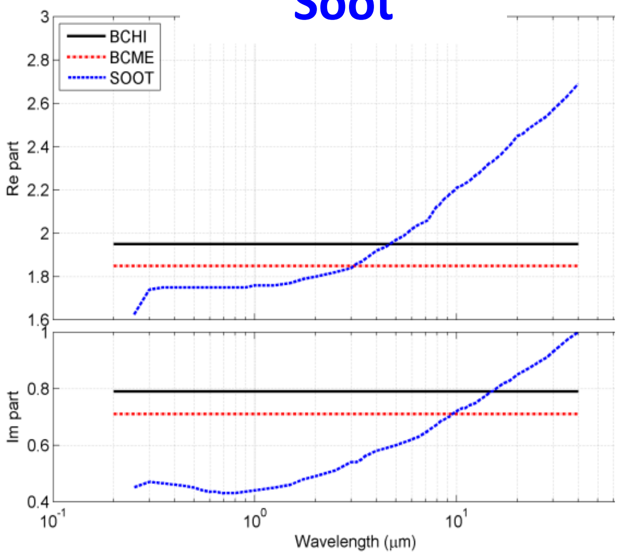
Organic Carbon



Sea Salt



Soot



Dust