# Joint retrieval of Aerosol Properties and Surface Reflectance from Meteosat First, Second and Third Generation Observations with an Optimal Estimation Method

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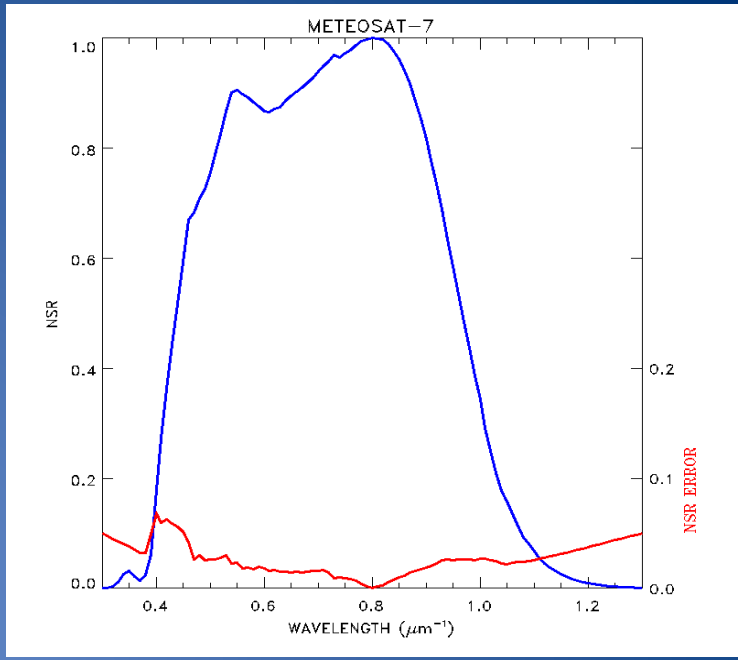
# OVERVIEW

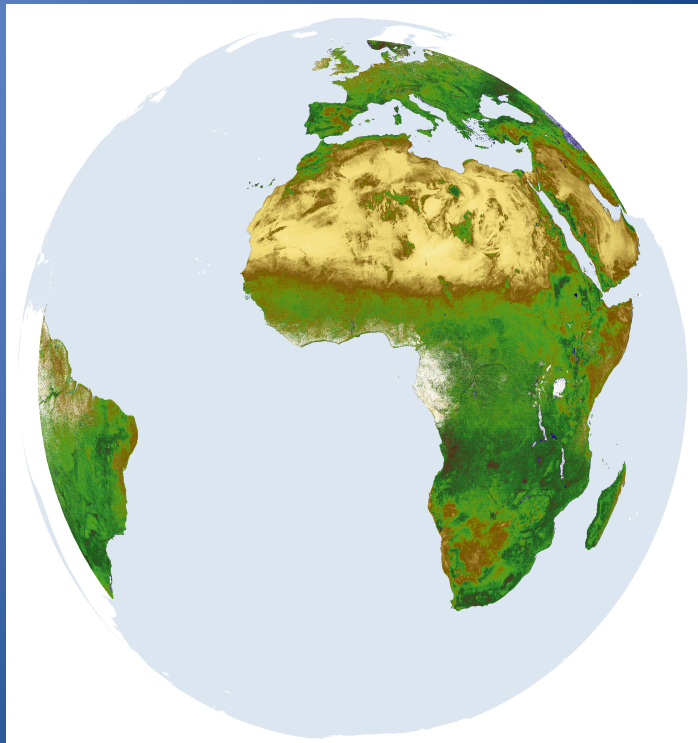
Aerosol retrieval: from Meteosat First Generation to Meteosat Third Generation:

1. Heritage from Meteosat First Generation
2. Benefit from MSG/SEVIRI
3. Potential of MTG/FCI
4. Conclusions

# HERITAGE FROM MFG

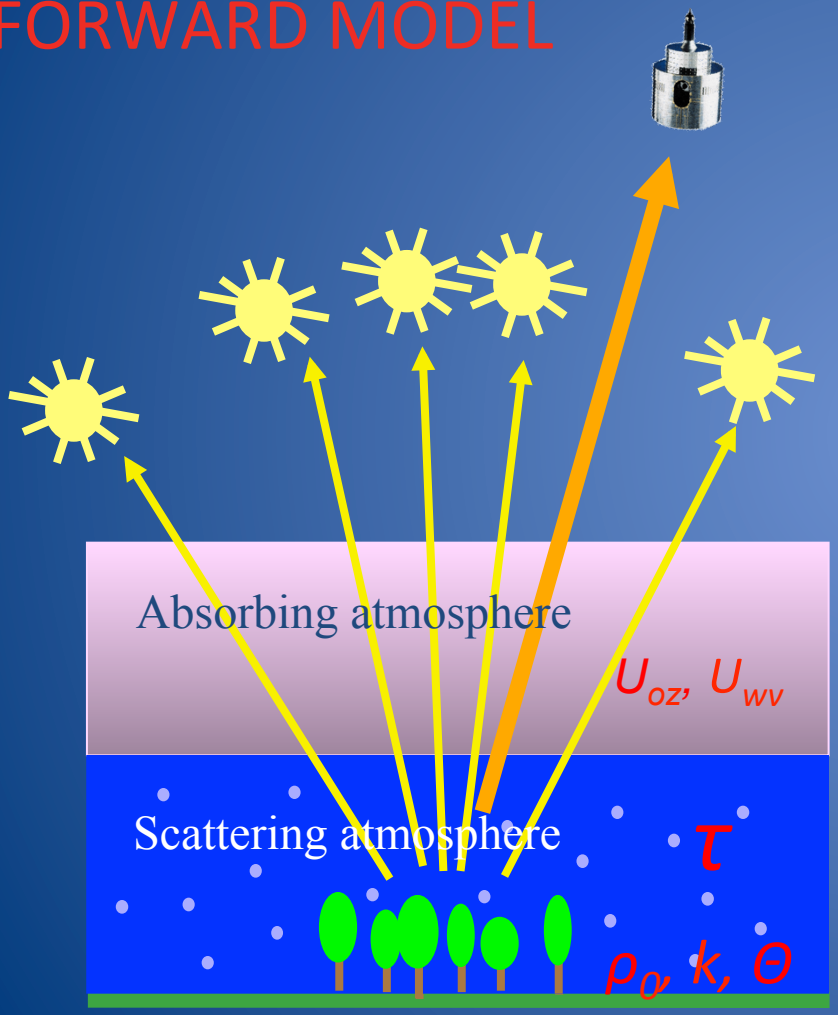
- Development of an algorithm (GSA) for the retrieval of surface albedo from archived MFG observations (1997)
- Simultaneous retrieval of surface reflectance and aerosol optical thickness (by-product).
- Daily accumulation of the observations to characterise the surface anisotropy.
- 10-day composite to minimise the cloud effects.



# HERITAGE FROM MFG

## FORWARD MODEL




Forward model *y*
- Atmosphere is composed of one absorbing gas layer and one scattering layer
- Atmospheric and surface scattering properties are constant along the day
- Surface scattering properties can be represented by the RPV BRF model

State variables *x of y*
Model :
- ozone $U_{oz}$ (TOMS)
- Water vapour $U_{wv}$ (ECMWF)

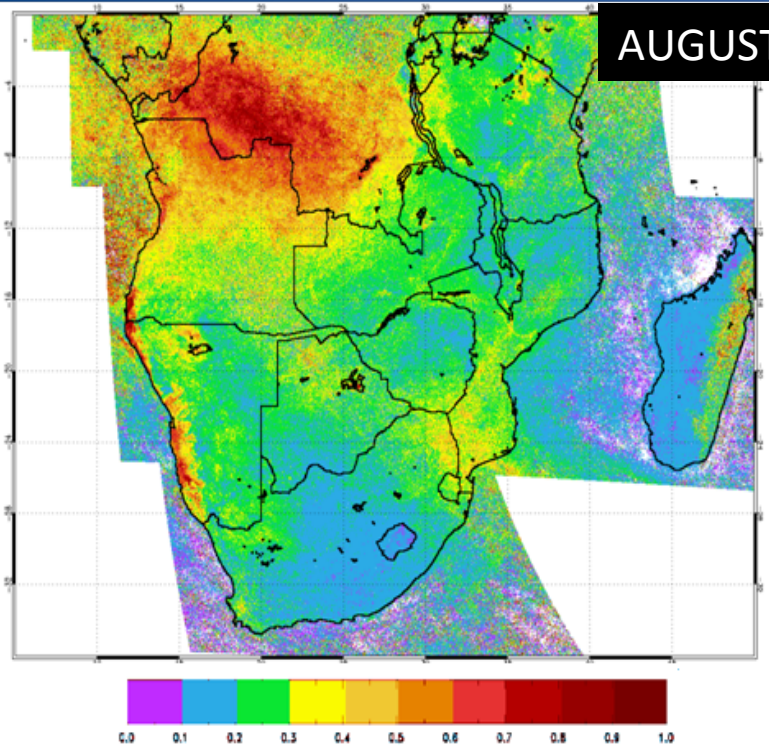
Retrieved :
- aerosol optical thickness $\tau$
- surface reflectance level $\rho_0$
- surface anisotropy $k$, $\Theta$

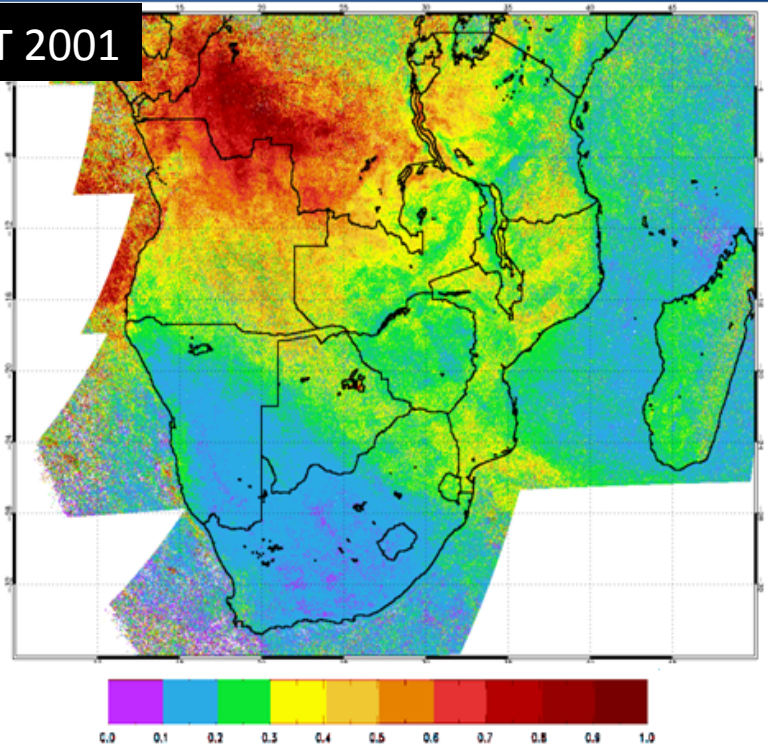
Pinty, B., Roveda, F., Verstraete, M.M., Gobron, N., Govaerts, Y., Martonchik, J.V., Diner, D.J., and Kahn, R.A. (2000) Surface albedo retrieval from Meteosat: Part 1: Theory, *Journal of Geophysical Research*, 105, 18099-18112.

AUGUST 2001

MET-7

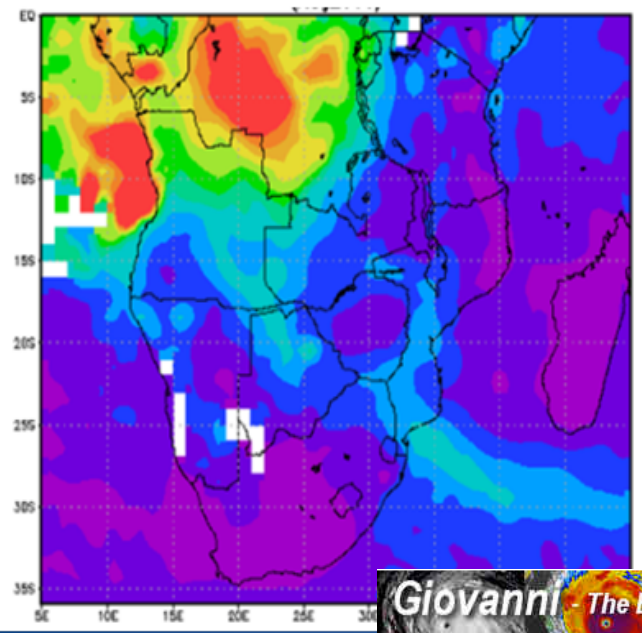
MET-5

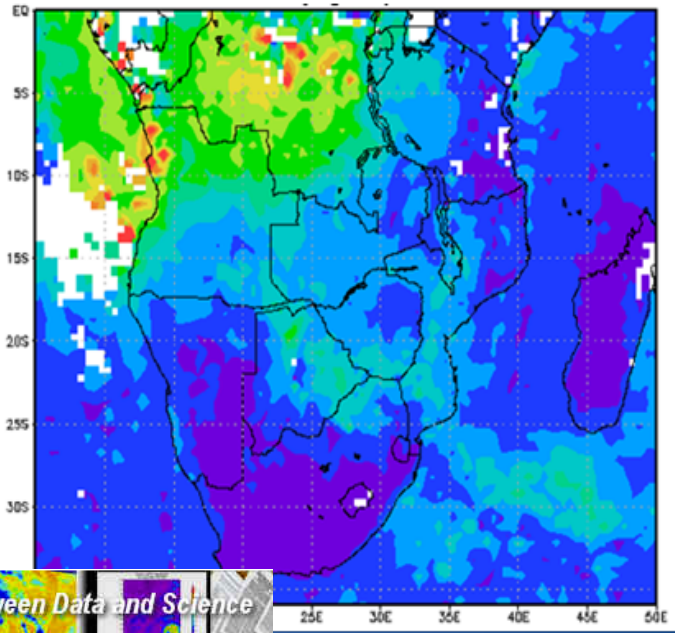



MODIS

MISR

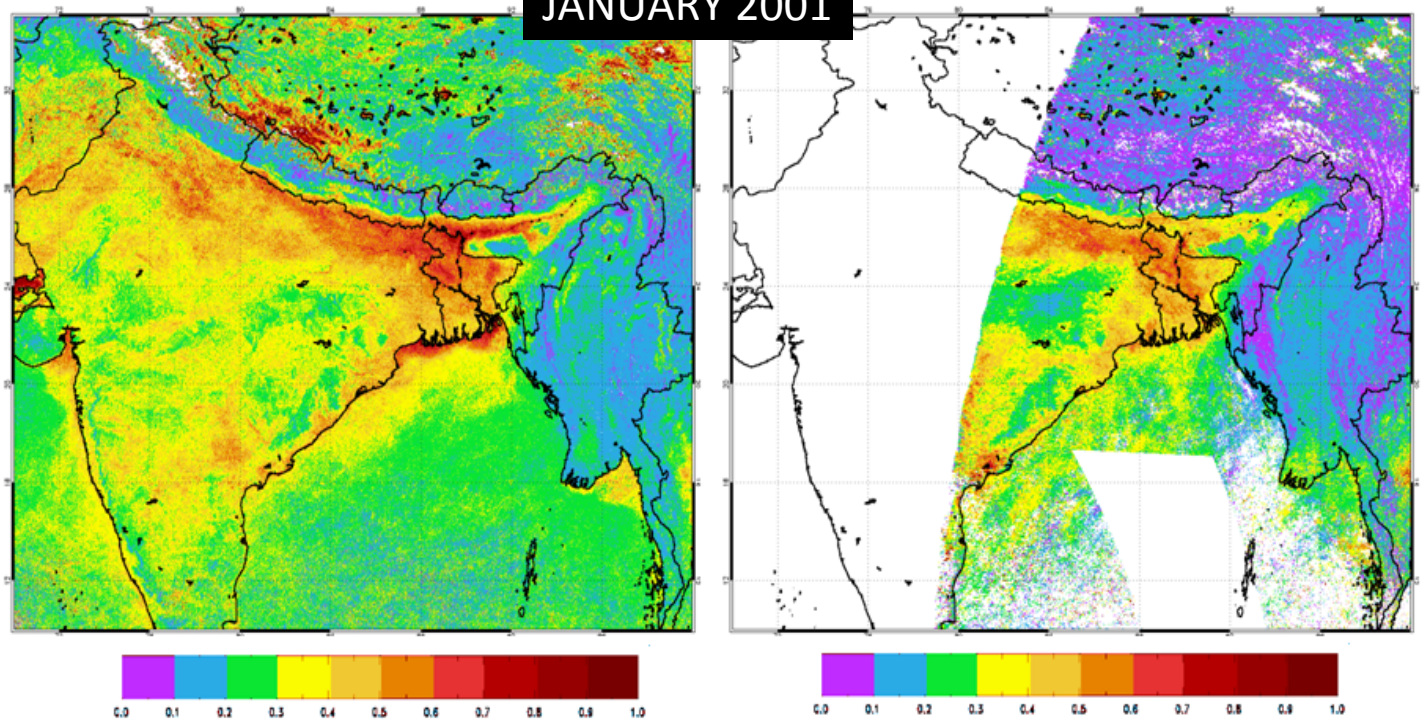


# JANUARY 2001

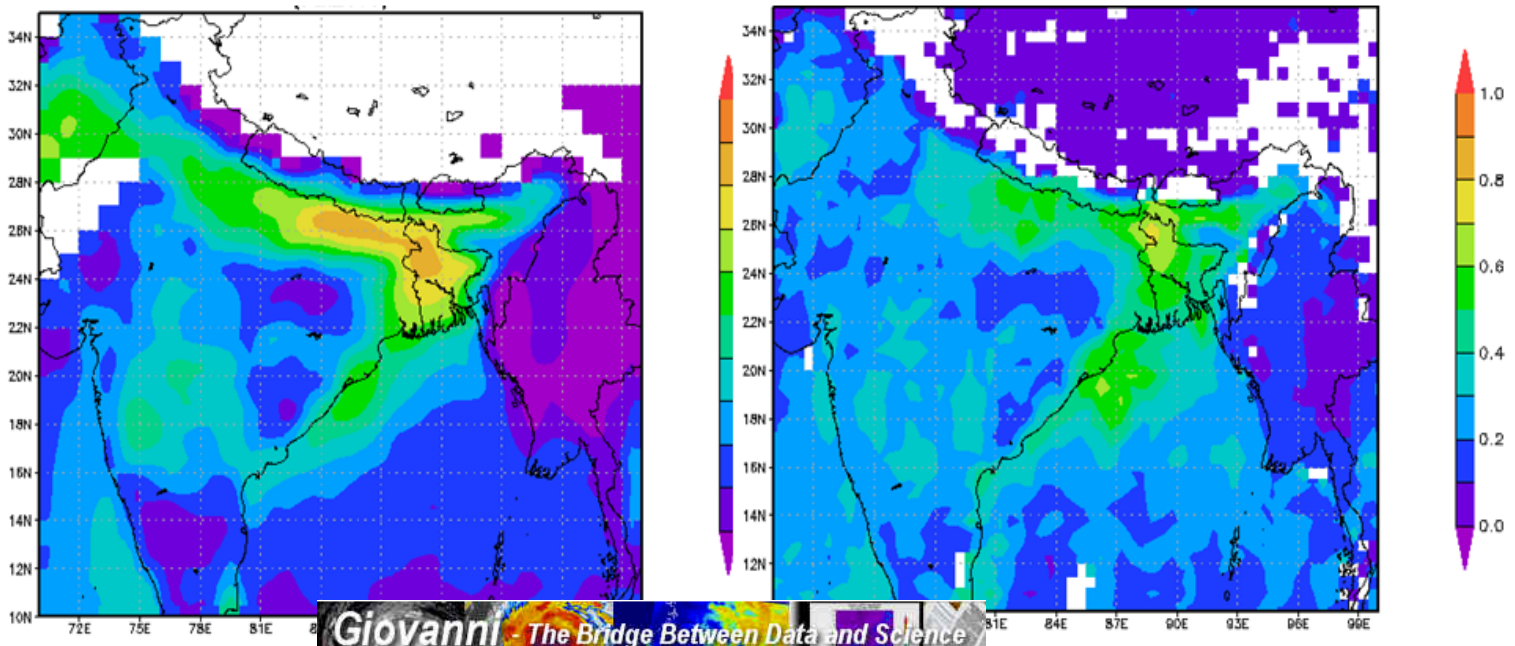
MET-5

GMS-5



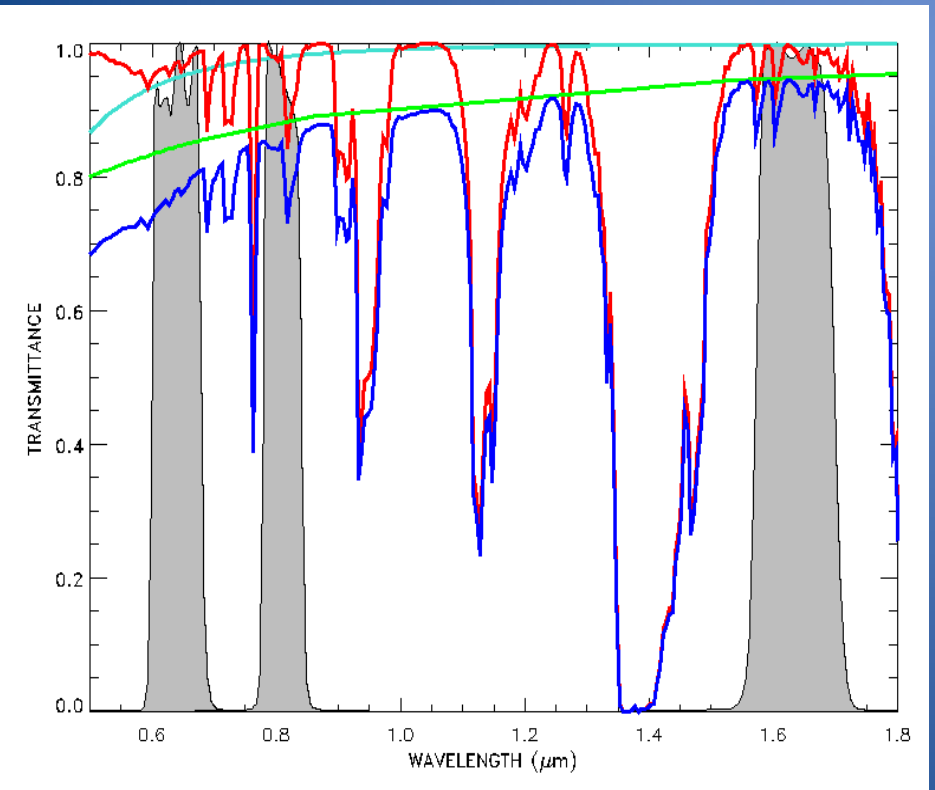

MODIS

MISR



# BENEFIT FROM SEVIRI

- Improved spectral resolution
- 3 solar channels
- 15 min repeat cycle



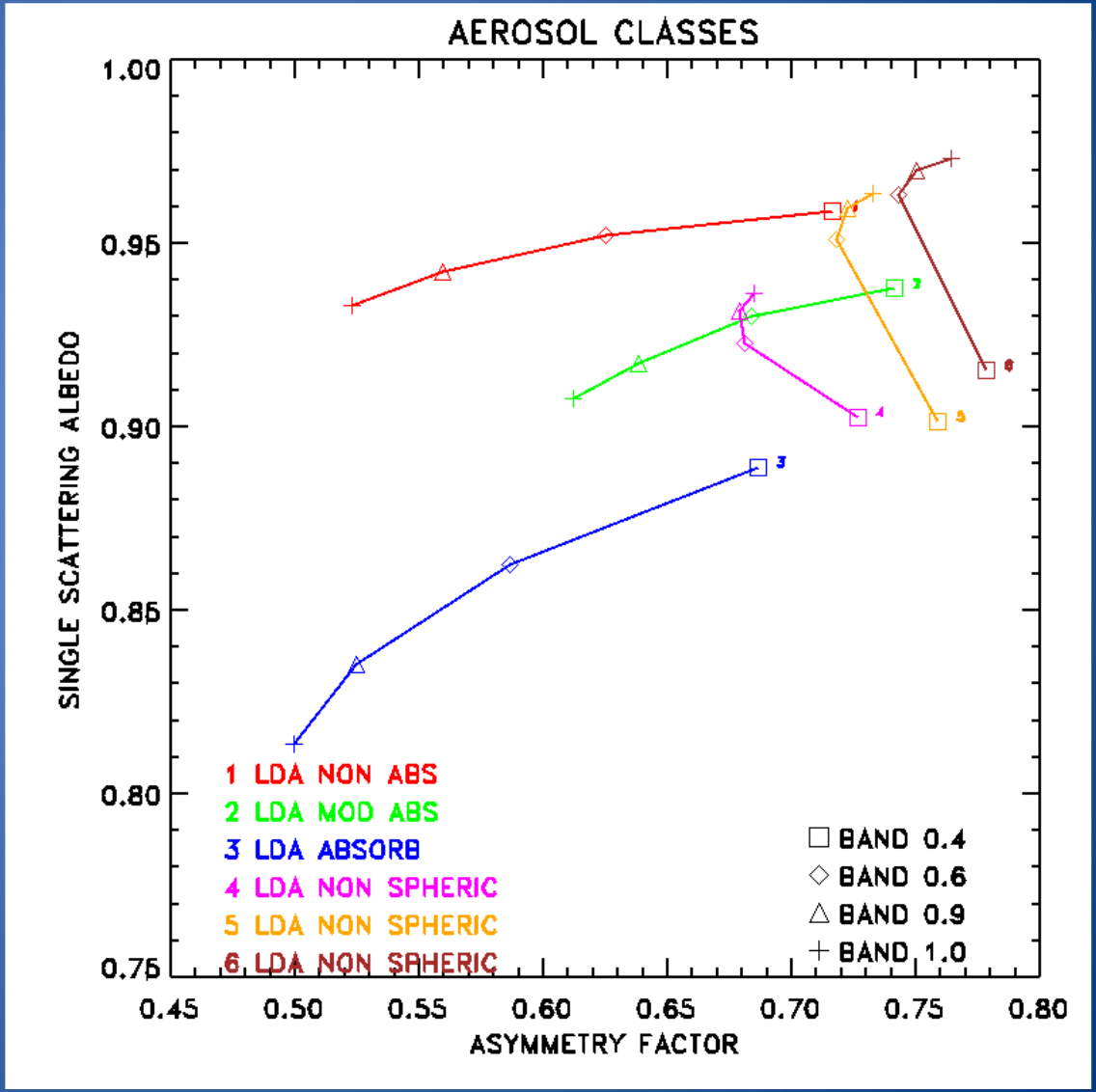

The major improvements with respect to the GSA algorithm are:

- Inversion based on optimal estimation with surface prior information based on its temporal invariance.
- Estimation of the daily mean aerosol optical thickness and estimated error.
- Use of 6 different aerosol classes including non-spherical particles derived from AERONET.

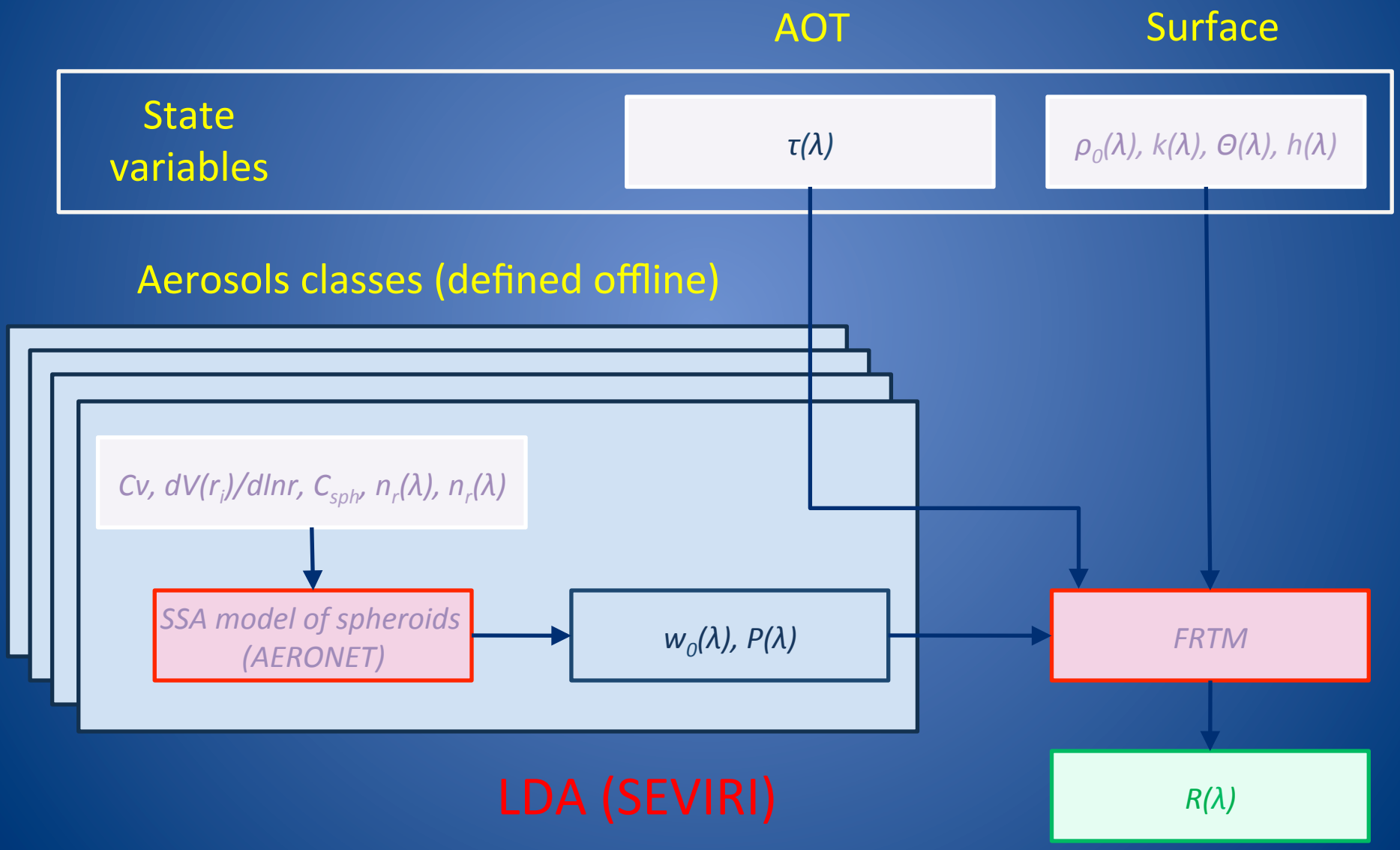
# LAND DAILY AEROSOLS: AEROSOL CLASSES

- Non-spherical classes: organised according to the asymmetry parameter
- ➔ determined by the ratio between large and small particles

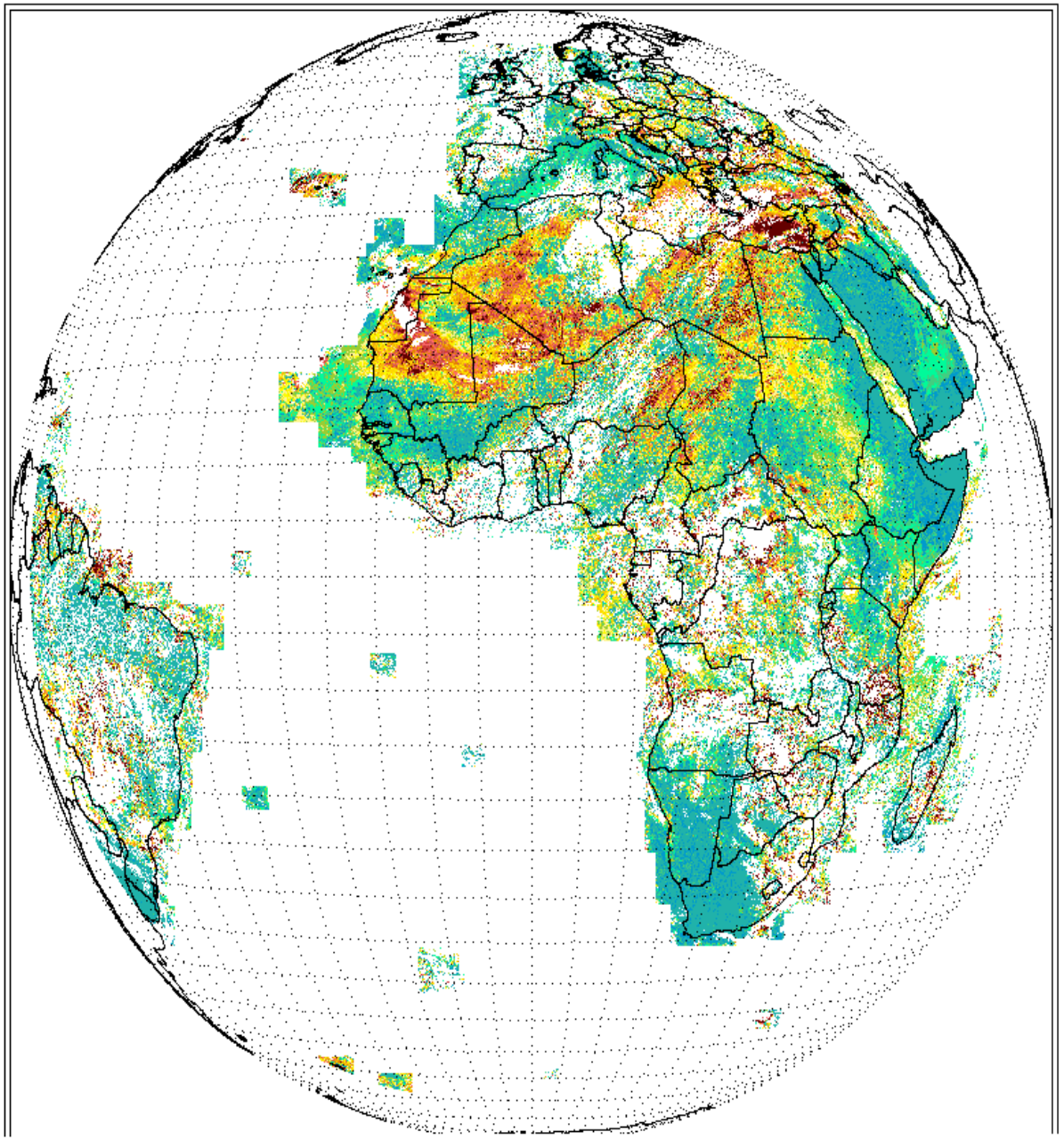
- Spherical classes: organised according to the single scattering albedo
- ➔ determined by the imaginary part of refractive index



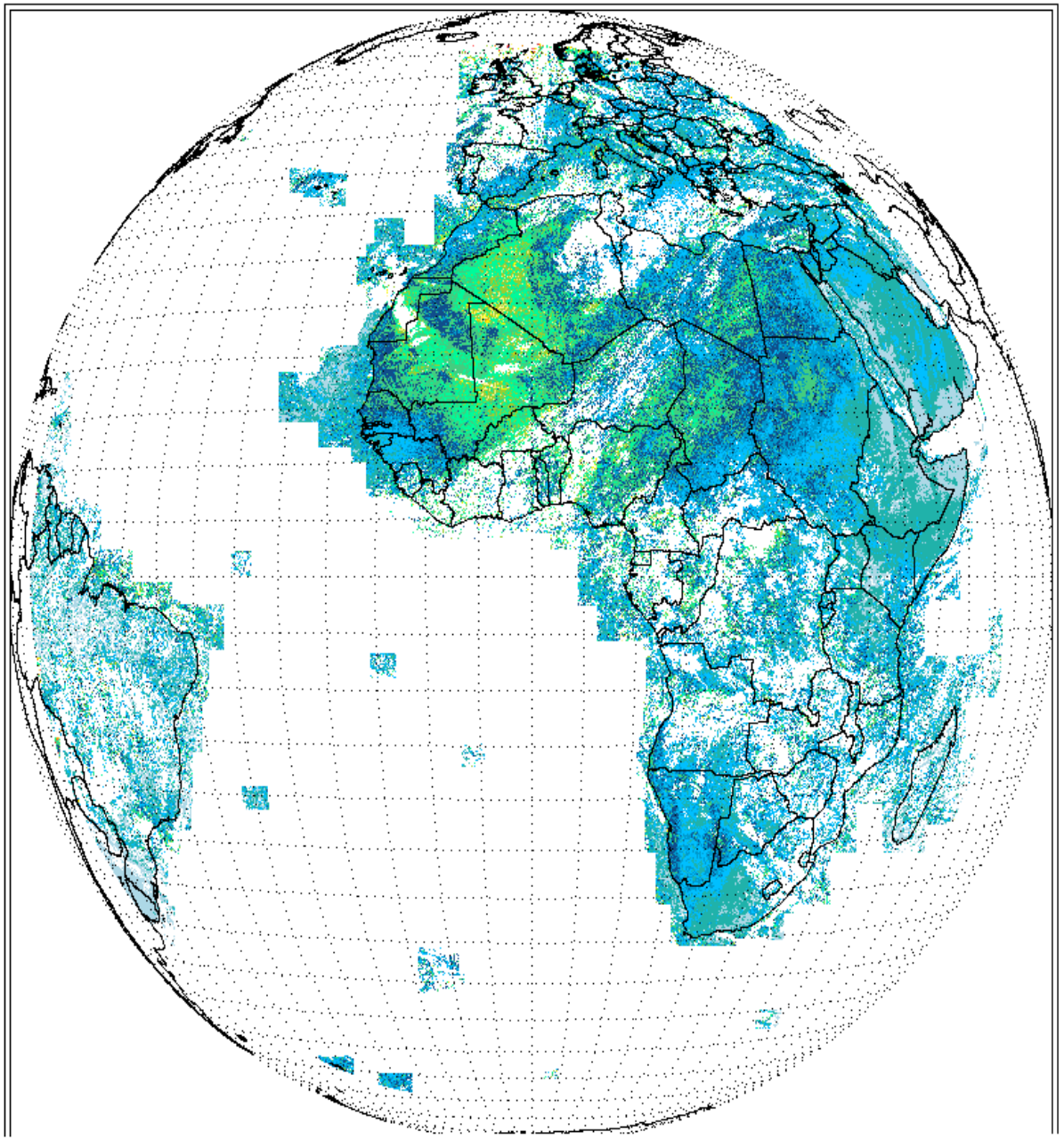
# LAND DAILY AEROSOLS: FORWARD MODEL



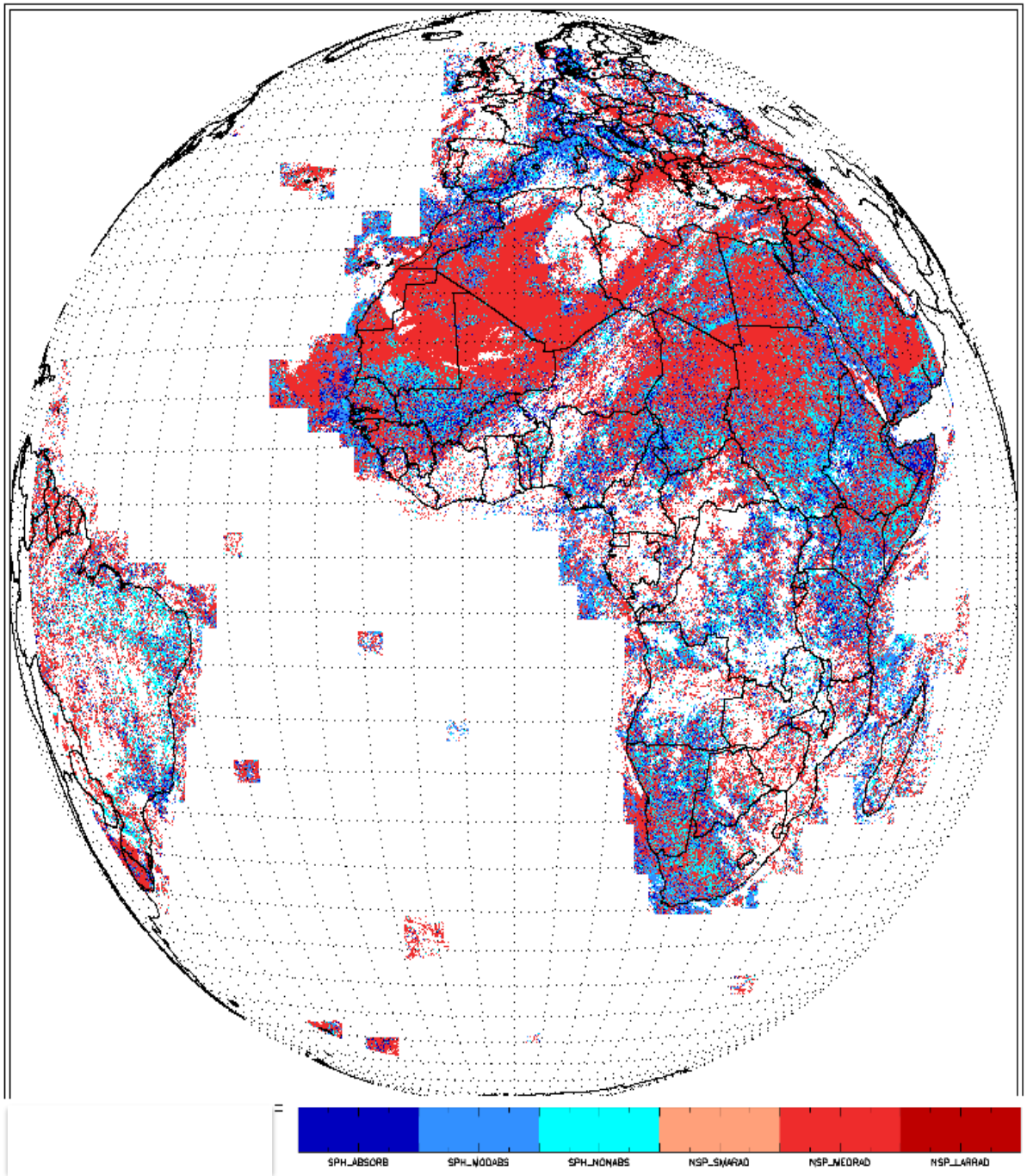
# AOT

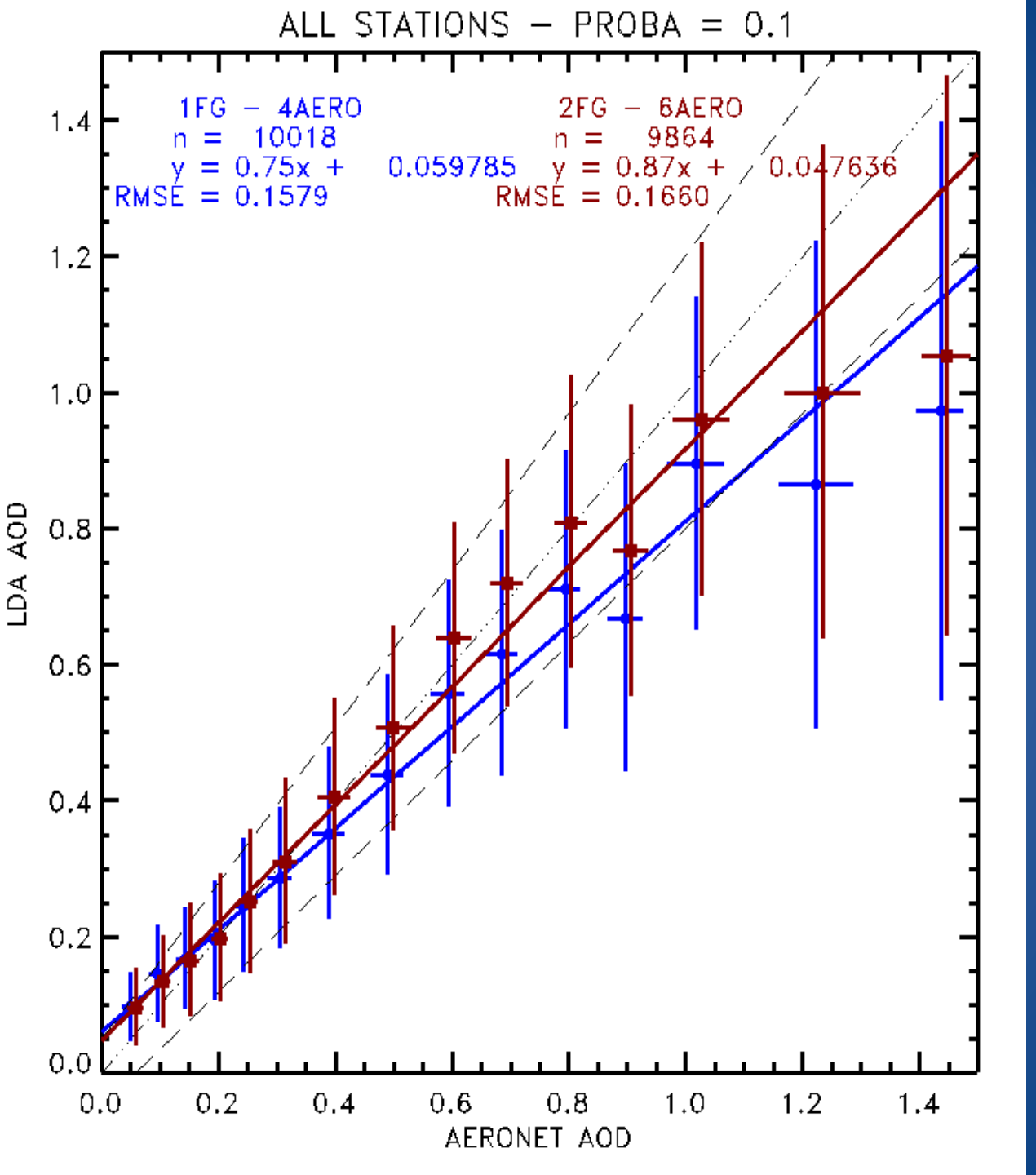


# AEROSOL AOT ESTIMATED ERROR



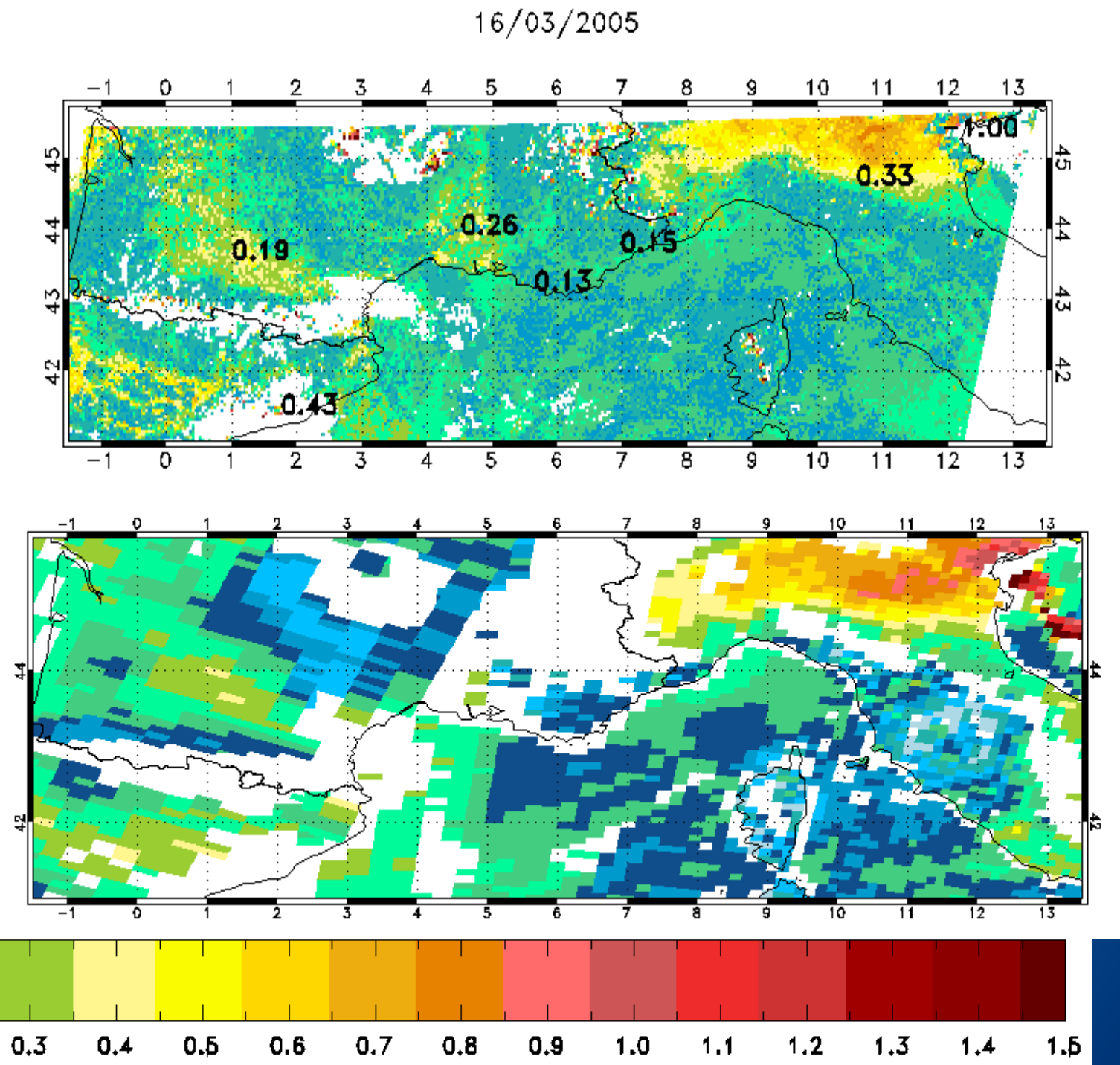
# AEROSOL SIZE DISTRIBUTION




ALL STATIONS – PROBA = 0.1
1FG – 4AERO
n = 10018
y = 0.75x + 0.059785
RMSE = 0.1579
2FG – 6AERO
n = 9864
y = 0.87x + 0.047636
RMSE = 0.1660
LDA AOD
AERONET AOD
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4

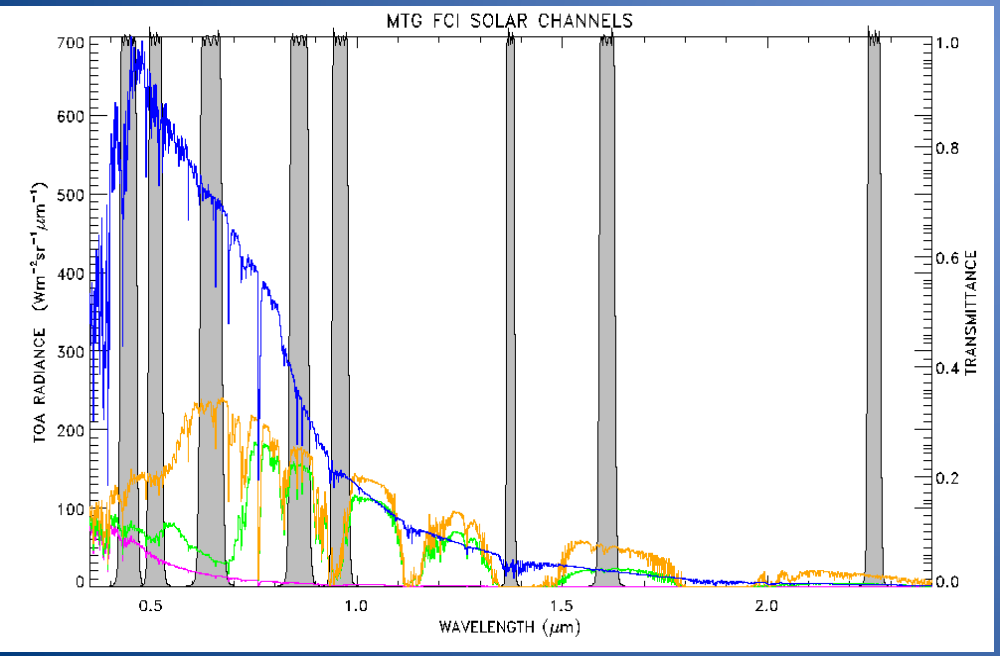
SEVIRI

MODIS L2 C5



# MTG/FCI AEROSOL POTENTIAL

- Improved spectral resolution
- 6 window solar channels
- 10 min repeat cycle

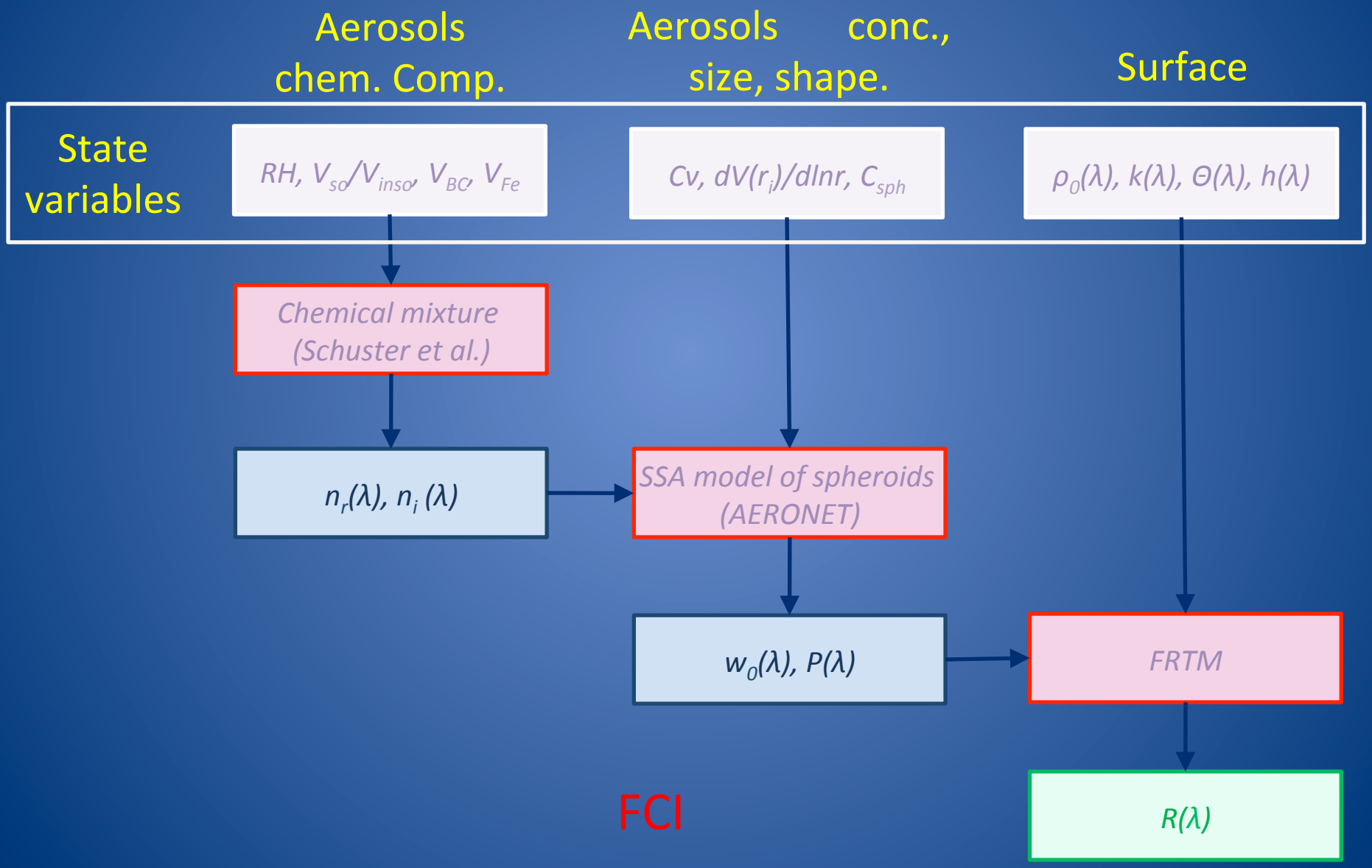



- Aerosol classes is a limitation to the application of the OE as it does not allow a continuous variation of the state variables in the solution space.
- For FCI aerosol retrieval, it should be possible to explicitly represent the aerosol microphysical properties in the state vector.
- Aerosol optical thickness could be retrieved on an hourly basis while micro-physical properties should be assumed constant during the course of the day.

# MTG/FCI AEROSOL POTENTIAL

- It should be possible to derive additional information (not limited to pre-defined aerosol classes) about aerosol properties including aerosol sizes, shape, absorption and chemical composition (BC, iron, quarts, soluble – Ammonium Nitrate) with a multi-pixel Optimal Estimation retrieval approach.
- Use of physical model (Shuster et al. [2005, 2009]) that allows calculation of spectrally dependent complex refractive index considering aerosol particles as a mixture of several chemical components.
- The model assumes that aerosols are homogeneous particles composed by internally mixed components
- The model is driven by only few parameters describing BC, Iron, liquid water content and ratio soluble to insoluble components.
- The ammonium nitrate is assumed as a soluble component "hosting" the mixture

# MTG/FCI AEROSOL : FORWARD MODELS



# CONCLUSIONS

- Geostationary satellites have proven their ability to provide relevant information on aerosol load and composition.
- The joint retrieval of surface reflectance and aerosol load allows to retrieve aerosol properties over any types of surface, providing that enough angular information is available.
- The new aerosol retrieval method developed at LOA which is capable of deriving information about aerosol micro-physical properties thanks to a multi-pixel optimal estimation retrieval approach, is versatile enough to be adapted to any satellite observations providing enough independent peaces of information.
- The combination of this approach with the one proposed by Shuster allows to derive information about chemical composition (BC, iron, quarts, soluble – Ammonium Nitrate).