WP3.2 Preparation and Harmonization of aerosol satellite data set

Task 3.2a Tropospheric (column) aerosol products

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Objective

- Preparation of the aerosol satellite data to be assimilated in the ECMWF model
  - Harmonization of the dataset
    - Intercomparison/ validation
  - Evaluation of the error associated with the satellite products for a given pixel
    - Quantification of the main sources of uncertainty
    - Evaluation of the sensitivity of retrieved products

Error estimation

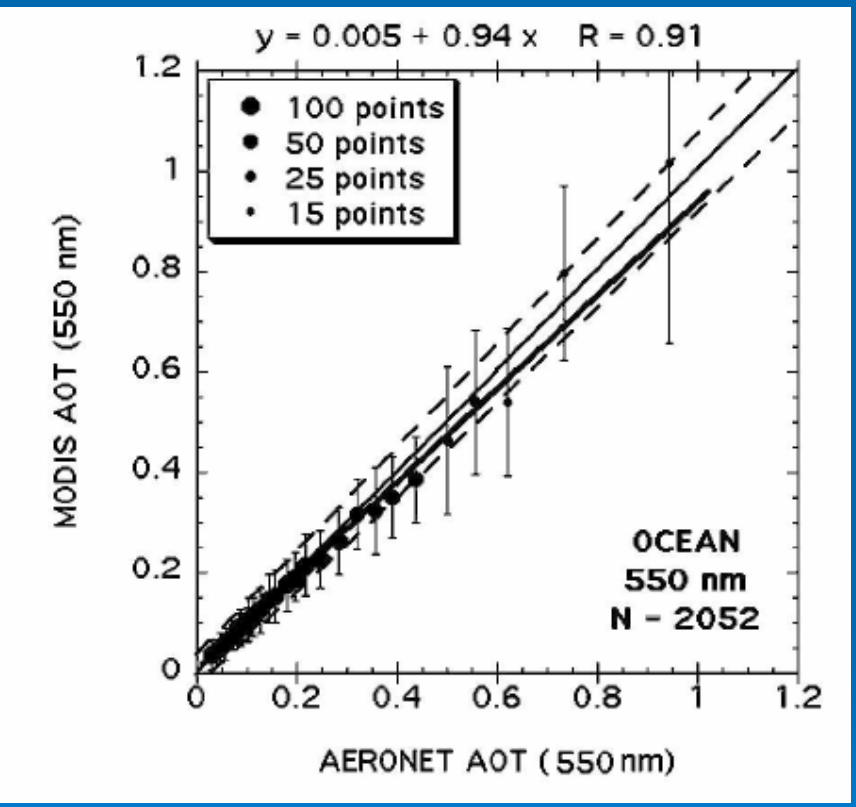
- Basic quantity is the radiance measured at the satellite level
  - Radiometric performance of the sensor
- The product is derived according to a scientific algorithm (e.g ATBD04 for MODIS)
  - Cloud screening algorithm
  - Many hypothesis in the retrieval algorithm (retrieval scheme, aerosol models, radiative transfer model, surface contribution,…)
  - No straightforward bottom-up estimate of the observational error

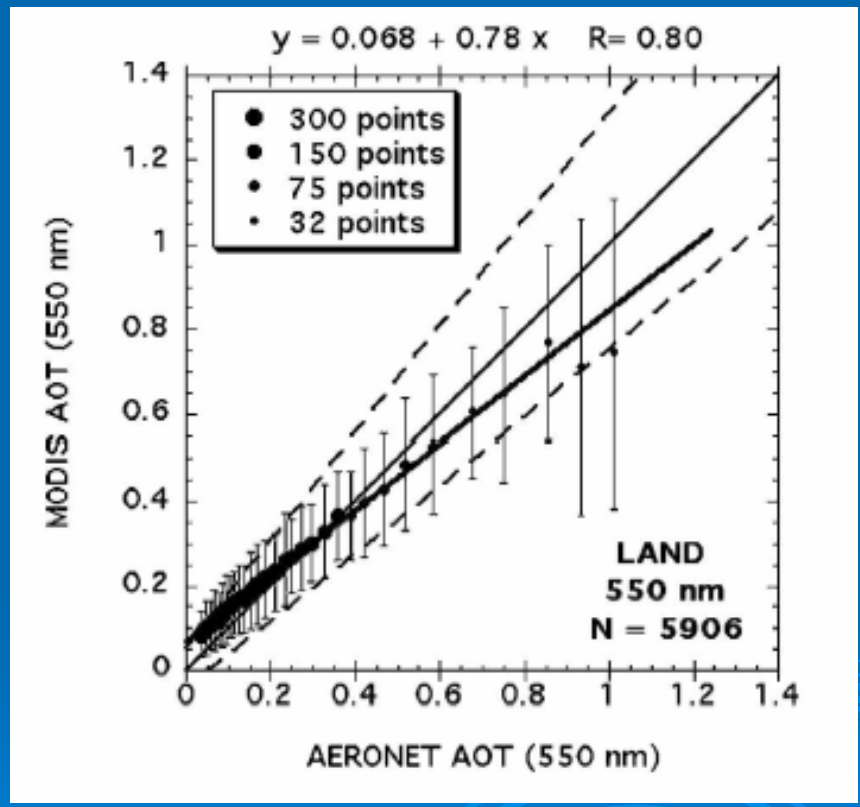
Satellite dataset

Table 2.7.3 Satellite Data on Aerosols to be used in GEMS				
Agency	**Mission**	**Instruments**	**Species**	**Estimated transfer to ECMWF per day of satellite life (MB/day)**
ESA	ENVISAT	MERIS	Aerosol Optical Depth at 865 nm Aerosol Epsilon Factor Radiances	TBD (target ~250MB/day maximum)
ESA	ATSR AATSR	ERS-2 ENVISAT	Radiances used in GLOBAER project	TBD
EUMET	MSG	SEVIRI	Radiation budget Radiances for inversion	TBD low-moderate volume
	MSG	GERB	Radiation budget Radiances for inversion	TBD low-moderate volume
NASA	TERRA	MODIS	Aerosol optical depth / Type / Size Distribution Radiances	600
NASA	AQUA	MODIS	AsTERRA	600
NASA	AURA	HIRDLS	Aerosol Optical Depth (4 wavelengths)	TBD low-moderate volume
NASA	SAGE-II		Aerosol optical depth (8 wavelengths)	low volume, available on web
NASA	SAGE-III		Aerosol optical depth (8 wavelengths)	low volume, available on web

- Focus on MODIS sensors aboard AQUA and TERRA
  - One of the more accurate aerosol product (AOT and size parameters)
  - Global daily coverage
  - Long-term dataset (since 2000)
  - Absolute availability of data (Levels 1 & 2)
  - Scientific support from NASA PI's

Statistical approach: validation vs. AERONET





- bin average (from Remer et al., 2005)
  - $\Delta\tau = \pm 0.05 \pm 0.15\tau$ over land
  - $\Delta\tau = \pm 0.03 \pm 0.05\tau$ over ocean

Observational errors

- Validation vs. AERONET data gives a good estimate of the overall accuracy of the product but not for a single observation
  - Error analysis for a given inversion : use of the Quality assurance flags
  - Assessment of the impact on the product : sensitivity studies

Quality of the inversion : use of the quality flags
from MODIS atmosphere QA plan

- Over oceans

		10	All Channels do not have valid data
Part II: Aerosol over Ocean Retrieving Condition when inversion IS performed. *Note: τ (550 nm) retrieved value will be output.on conditions 0 through 10.* *Confidence Flag Notes:* • *If Retrieving Condition = 0, then Confidence. Flag is set to Very Good.* • *If = 7, then Confidence Flag is set to Good.* • *If = 1, 3, 4, 6, 8 or 10, then Confidence Flag is set to Marginal.* • *If = 2, 5, or 9, then Confidence Flag is set to No Confidence.*	4	0 1 2 3 4 5 6 7 8 9 10 11	Retrieval performed normally Number of useful pixels within 10 x 10 km box is < 10% *R* (0.865 μm) low but large enough for retrieving optical thickness; the size distribution is questionable; η = fill value 1.65 μm channel not used 2.13 μm channel not used 1.65 and 2.13 μm channels not used Aerosol type as well as aerosol content are variable There is variability in aerosol content but the spectral dependence is stable The best value of Ɛ is larger than the threshold value (5%) τ (550 nm) < 0 to avoid bias in level 3 product Glint angle between 30° and 40° Glint; Store only Refl., SD, and Number of Pixels Used

Quality of the inversion : use of the quality flags

from MODIS atmosphere QA plan

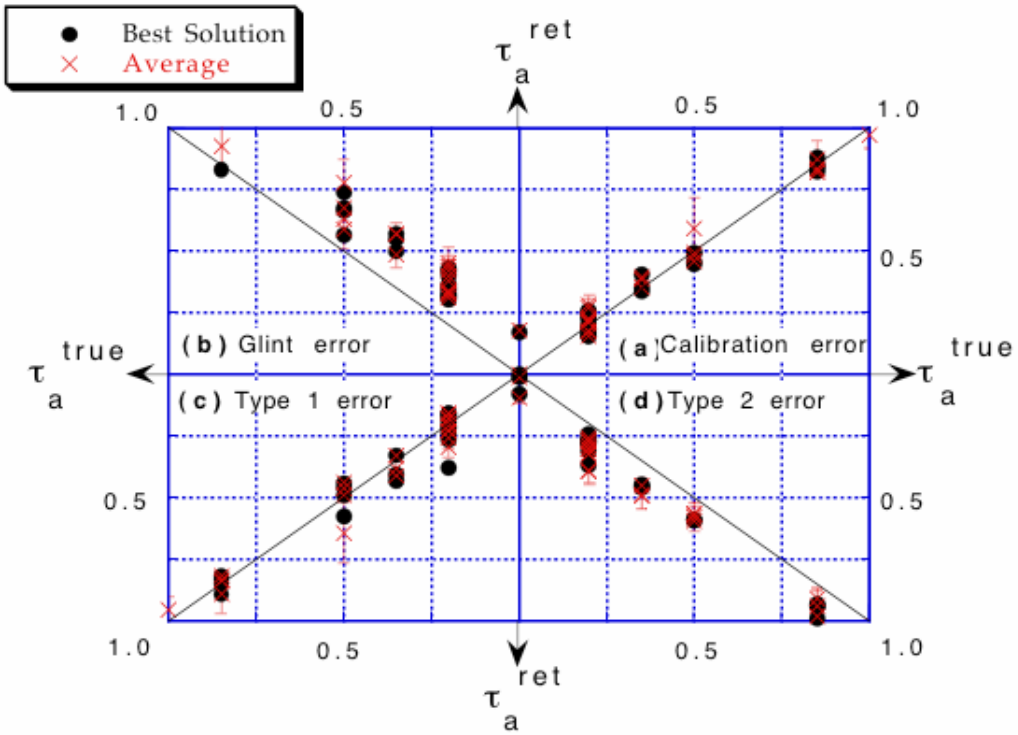
- Over the land, use of the 2.1 µm channel to give the surface reflectance according to $\rho^{s}_{0.47} = 0.25\ \rho_{2.13}; \rho^{s}_{0.66} = 0.50\ \rho_{2.13},$

processing path flags

Dark Target Criteria used in retrieval	3	0	not met (Fill Value)
		1	0.01 < *Ref* (2.1 µm) ≤ 0.05
		2	0.05 < *Ref* (2.1 µm) ≤ 0.10
		3	0.10 < *Ref* (2.1 µm) ≤ 0.15
		4	0.15 < *Ref* (2.1 µm) ≤ 0.25
		5	0.25 < *Ref* (2.1 µm) ≤ 0.40

AOT sensitivity study

example from Kaufman and Tanré, 1998



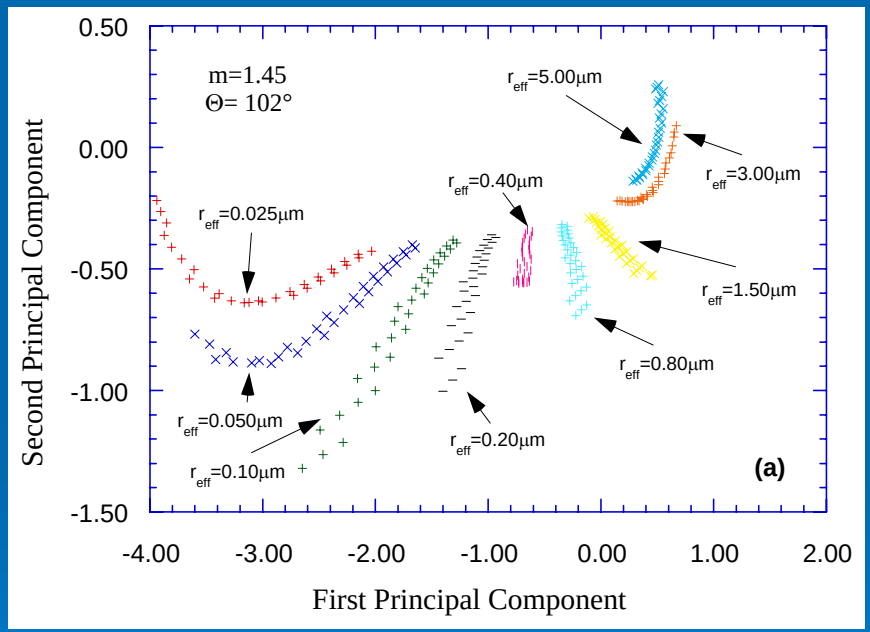
AOT and aerosol model is retrieved to minimize

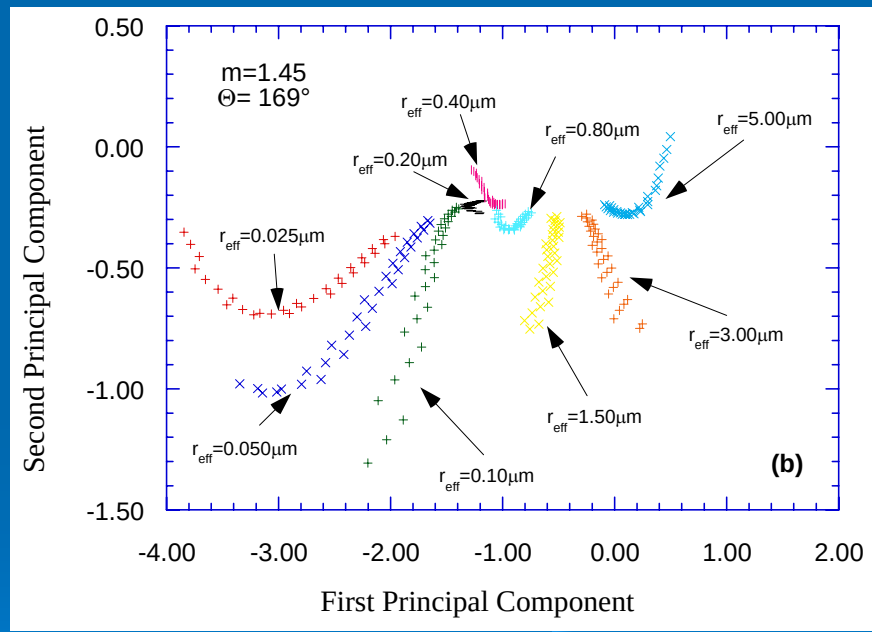
$$\varepsilon = \sqrt{\frac{\sum_{\lambda=1}^{6} N_\lambda \left(\frac{\rho_\lambda^{m} - \rho_\lambda^{LUT}}{\rho_\lambda^{m} + 0.01} \right)^2}{\sum_{\lambda=1}^{6} N_\lambda}},$$

Error due random calibration error, glint contamination, random error on the surface contribution, error on the spectral behavior of the surface

Sensitivity of the retrieval of size parameters (ocean) to the scattering geometry

from Tanré et al., 1996





- Forward scattering favorable for small particle while backward scattering for large particles (Polder-like instrument needed)

Conclusions

- Methodology to derive error at the pixel resolution to be finalized and implemented
  - Recruitment of Bertrand Crouzille in Jan. 06 will boost up
- Apply the same kind of approach to the overall set of satellite data (Globaer data ??)