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Comparing aerosol types in climate models and satellite retrievals

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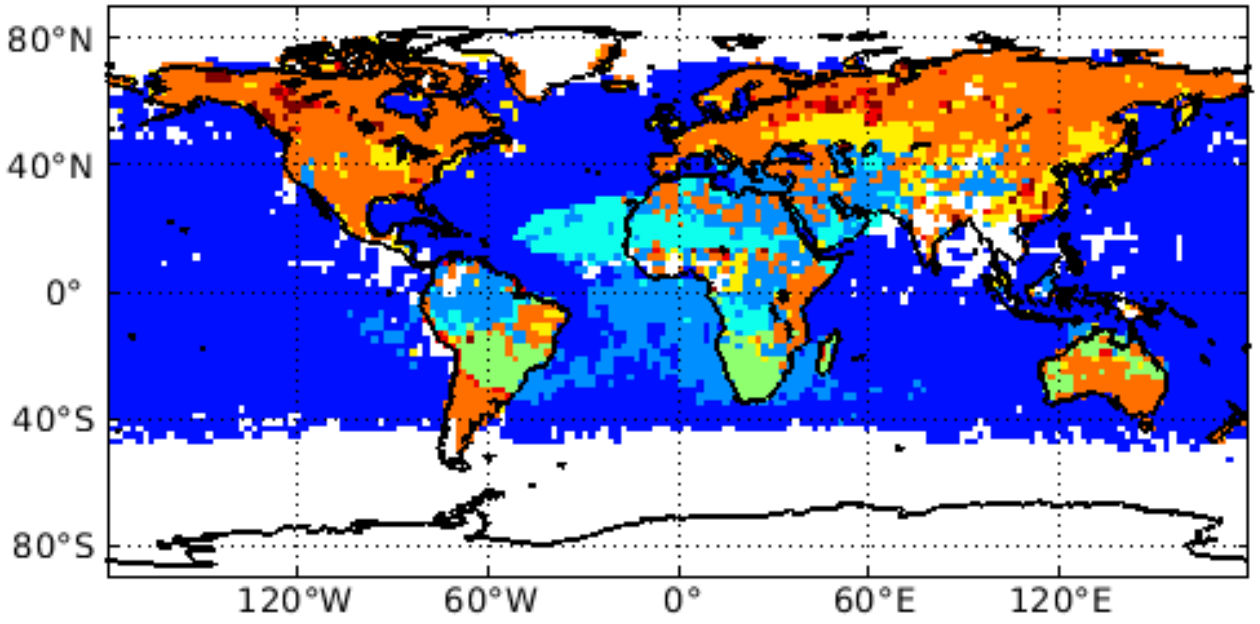
Typical types in **satellite retrievals**		Typical ”types” in **climate models**
Maritime		Sea salt
Mixed Maritime		Dust
Dust	≠	Black Carbon
Biomass Burning		Organic Carbon
Fine absorbing		Sulphate
Fine non-absorbing		Water



How to compare apples and oranges?

- As aerosol types in satellite retrievals are predefined, it is straighforward to calculate the frequency of each type in different regions
  - Each type has specific Ångström exponent (α) and single scattering albedo (SSA) range

    → Similar calculation can be done with simulated aerosol data using spectral aerosol optical depth (AOD) and absorption AOD

    → Then we can compare directly the frequencies of different types in observations and models

Model simulations used

- From the AeroCom CTRL2016 experiment
- AOD at 3 wavelengths 440, 550 and 870 nm, and absorption AOD at 550 nm to calculate α and SSA
- 5 models had the required parameters
  - ECHAM-HAM
  - ECHAM-SALSA
  - ECMWF-IFS
  - HadGEM3
  - SPRINTARS
- Daily averages from July-August 2010 used in the comparison with satellite data

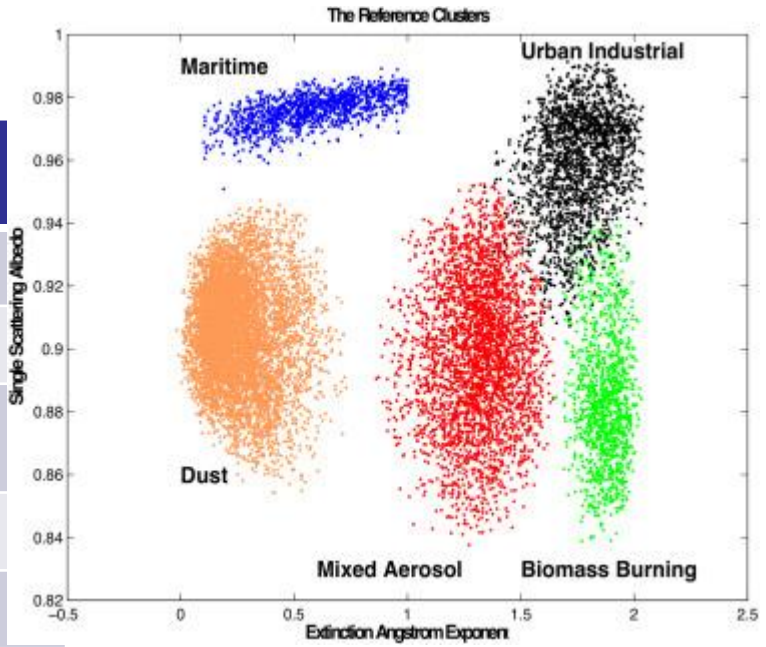
FMI aerosol retrieval

- The FMI dual-view algorithm using ATSR-2, AATSR, and SLSTR data
- The algorithm retrieves an *aerosol model* together with aerosol loading (AOD)
- The model is a mixture of four (Aerosol CCI) aerosol components
  - Weakly absorbing fine particles
  - Strongly absorbing fine particles
  - Sea salt coarse particles
  - Non-spherical mineral dust coarse particles
- Three external mixtures form the retrieved aerosol model
  - Mixture of the two fine particle components (a priori initial condition from a climatology)
  - Mixture of the two coarse particle components (dust fraction from a climatology)
  - Mixture of the fine and coarse particles
- The mixtures can be used to obtain information about any of the aerosol properties included within the components, such as asymmetry, SSA, etc.
- The Ångström exponent is derived from the retrieved multispectral AOD.

Holzer-Popp, T., de Leeuw, G., Griesfeller, J., et al., **Aerosol retrieval experiments in the ESA Aerosol_cci project**, *Atmospheric Measurement Techniques*, 6, 1919-1957, 2013.
Kinne, S., O'Donnel, D., Stier, P., et al., MAC-v1: **A new global aerosol climatology for climate studies**, *J. Adv. Model. EarthSyst.*, 5, 704-740, 2015.
Kolmonen, P., Sogacheva, L., Virtanen, T. H., et al., **The ADV/ASV AATSR aerosol retrieval algorithm: current status and presentation of a full-mission AOD dataset**, *International Journal of Digital Earth*, 9, 545-561, 2016.

Typing based on retrieved aerosol optical properties

Tentative name	Ångström exponent α	SSA at 550 nm	AOD
1. Maritime	α < 1.00	SSA > 0.94	AOD(550 nm) > 0.10
2. Mixed Maritime	0.50 < α < 1.20	SSA < 0.94	AOD(550 nm) > 0.10
3. Dust	α < 0.50	SSA < 0.94	AOD(550 nm) > 0.10 AOD(1610 nm) > 0.30
4. Biomass Burning	α > 1.70	SSA < 0.89	AOD(550 nm) > 0.10
5. Background/Rural	1.20 < α < 1.90	SSA > 0.90	AOD(550 nm) > 0.10
6. Background/Urban	α > 1.90	SSA > 0.89	0.10 < AOD(550 nm) < 0.30
7. Absorbing Urban	α > 1.90	0.89 < SSA < 0.94	AOD(550 nm) > 0.30
8. Non-Absorbing Urban	α > 1.90	SSA > 0.94	AOD(550 nm) > 0.30



For example:

Hamill, P., Piedra, P., and Giordano, M., Simulated polarization as a signature of aerosol type, *Atm. Environ.,* 224, 2020.

- Typing is based on several previous studies, the experience of the assigning person, and nice-looking global maps
- The 0.1 AOD is set for large enough TOA signal

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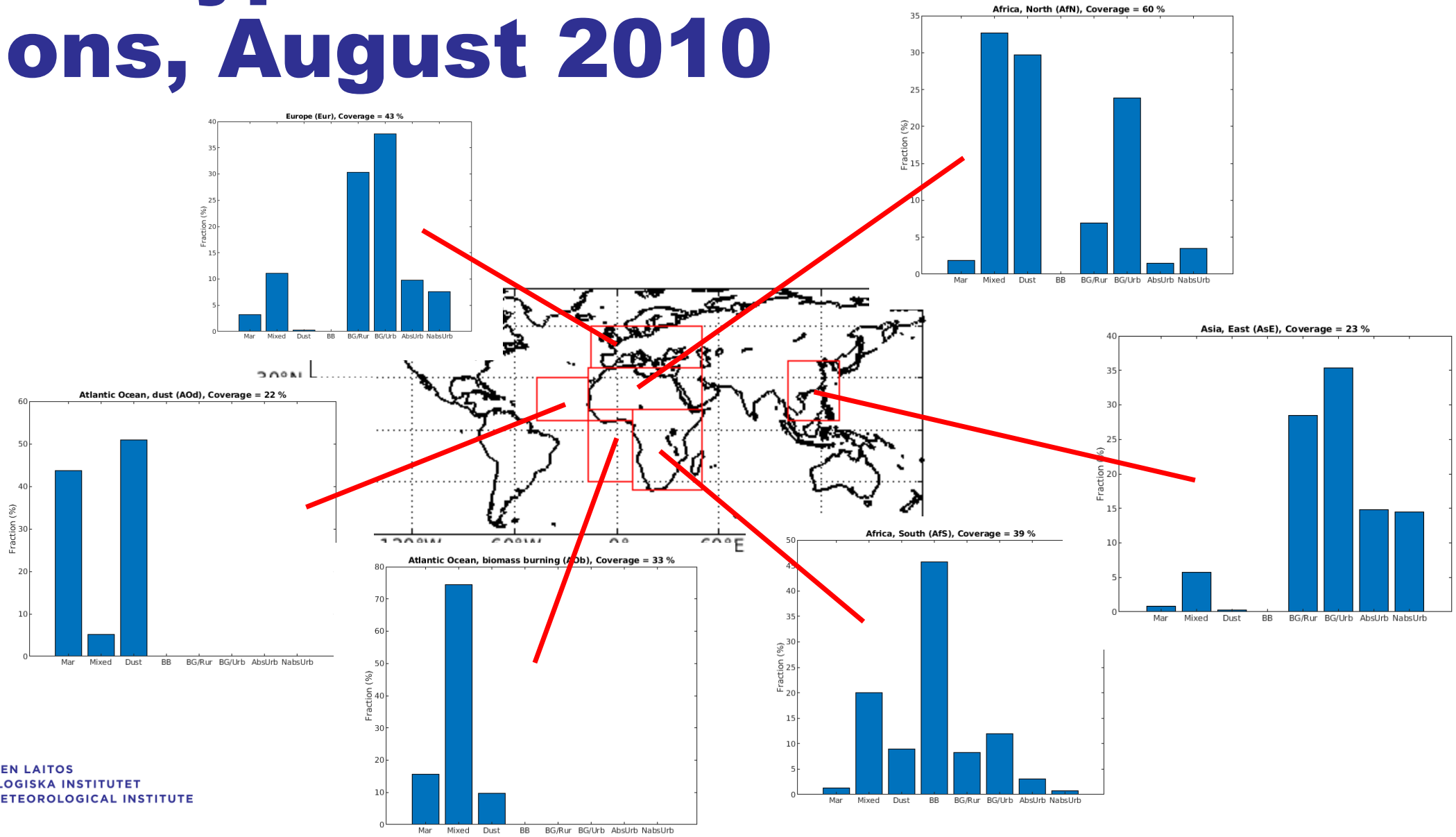
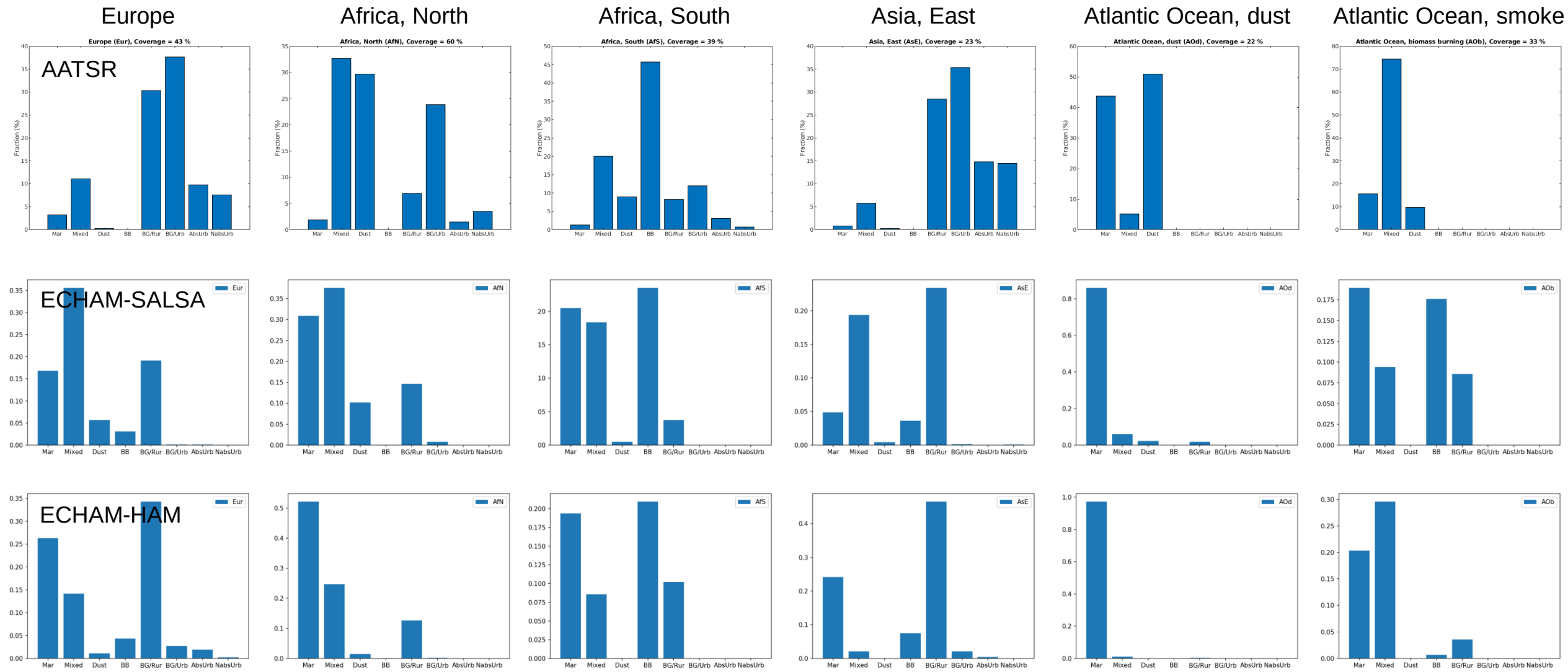
AATSR type distributions for selected regions, August 2010



Comparison of type distributions for selected regions, July-August 2010



Discussion

- The model and satellite comparisons showed some agreement for some types in some regions
- But there are large differences, even between similar models!
  - The differences are evident even with simpler aerosol typing (small abs., small non-abs., large abs., large non-abs.)
  - Model biases in AOD, SSA and α are one reason for the discrepansies
- What are the best parameters to compare – should we turn to the microphysical/chemical parameters (size distribution, refractive index)?
- What is the effect of vertical profiles?

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Thank you!

5.10.2020 **Tero Mielonen**