Aerosol type – how to use the information from satellites for models???

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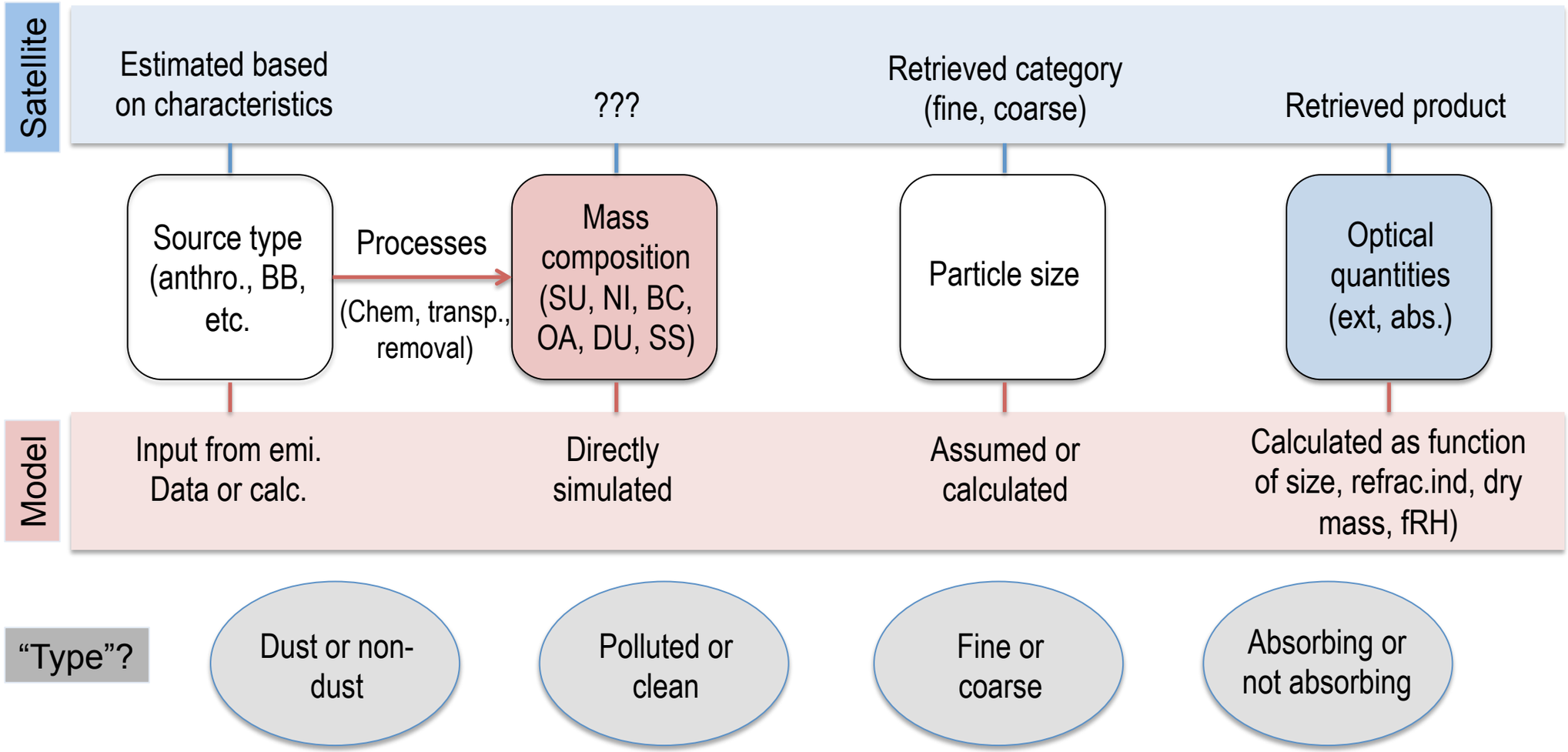
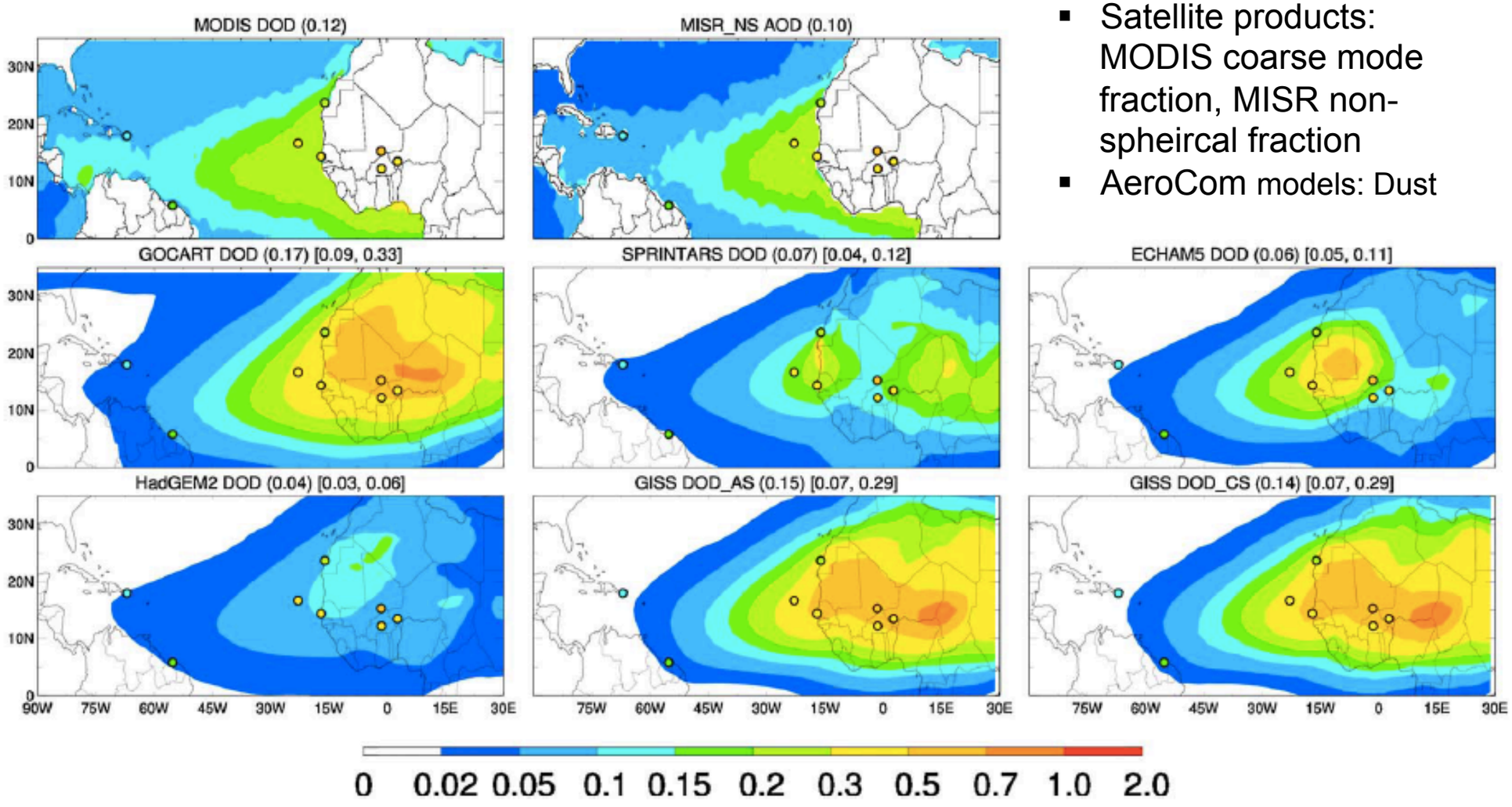
What does “type” mean?



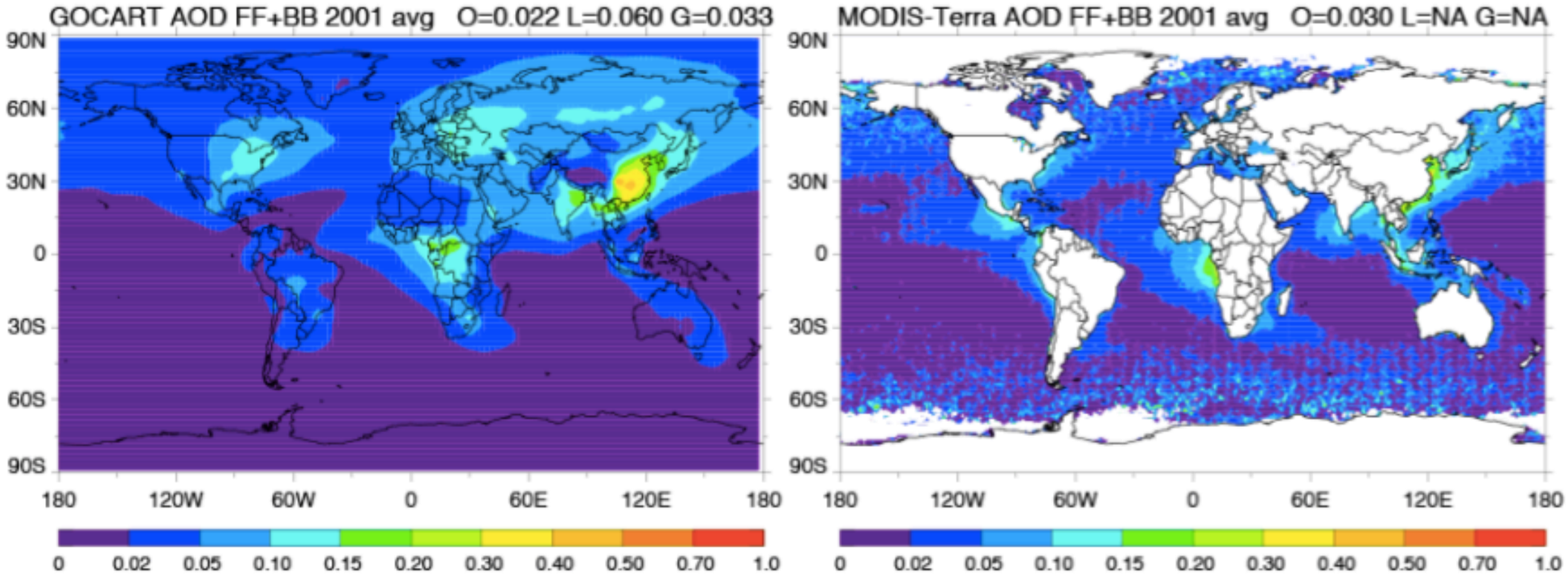
Dust AOD from MODIS, MISR, and models



- Satellite products: MODIS coarse mode fraction, MISR non-spheircal fraction
- AeroCom models: Dust

Kim et al., 2014

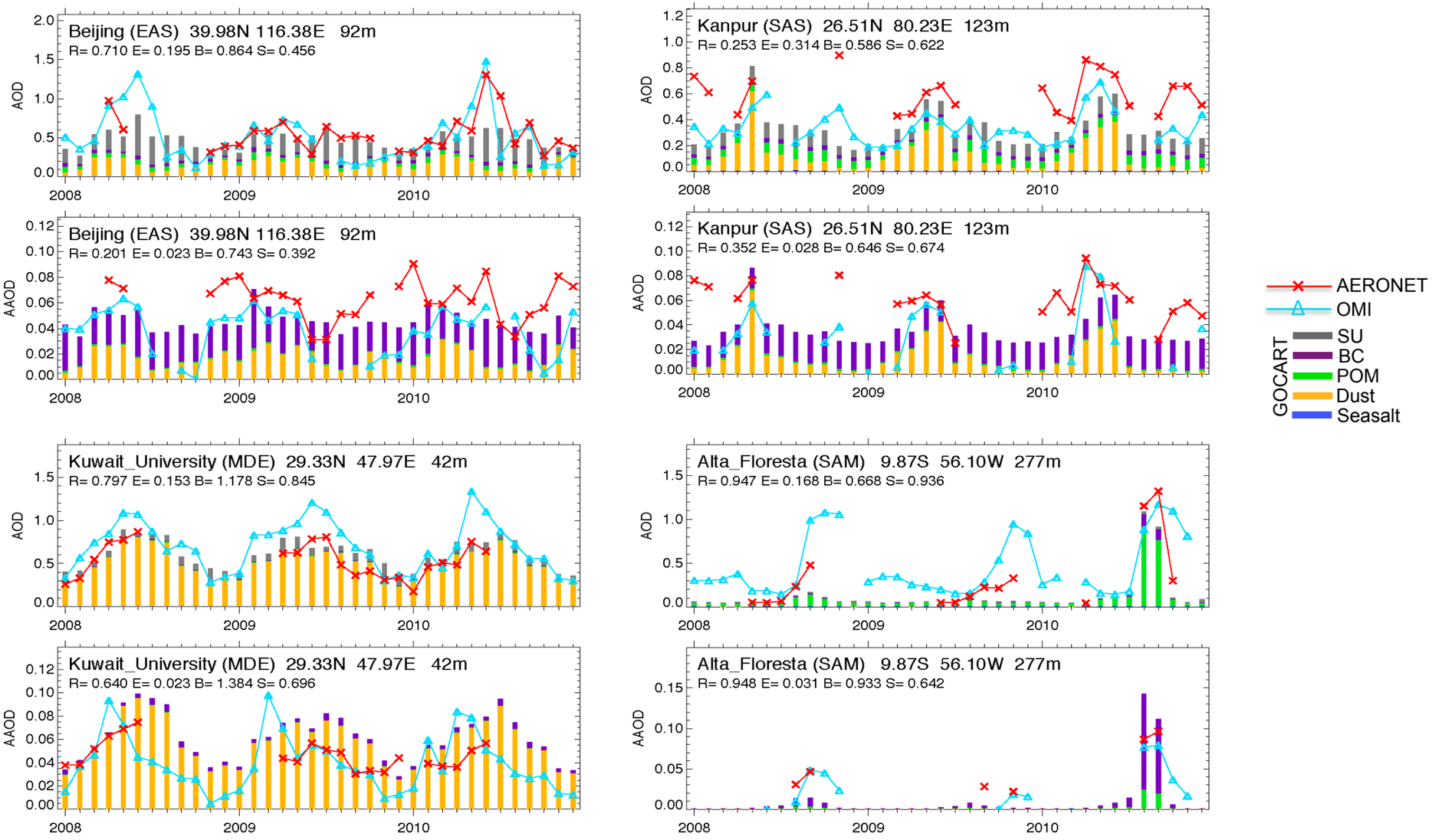
Pollution (anthropogenic + biomass burning)



- MODIS-based fossil fuel and biomass burning (FF+BB) AOD: Derived empirically from the MODIS AOD and fine mode fraction, with corrections to exclude fine mode natural dust and marine aerosols (Kaufman et al., 2005; Yu et al., 2009)
- AeroCom models: AOD from FF and BB source only

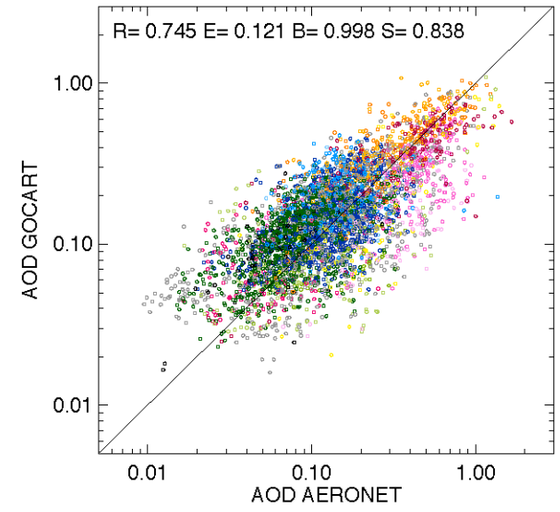
Chin et al., 2014

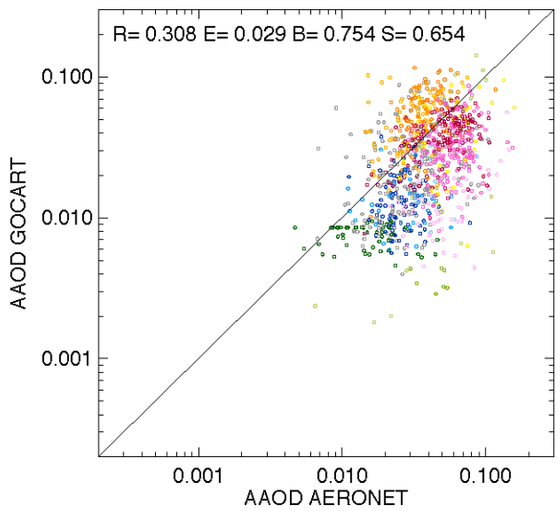
Total and absorbing aerosols from OMI and GOCART



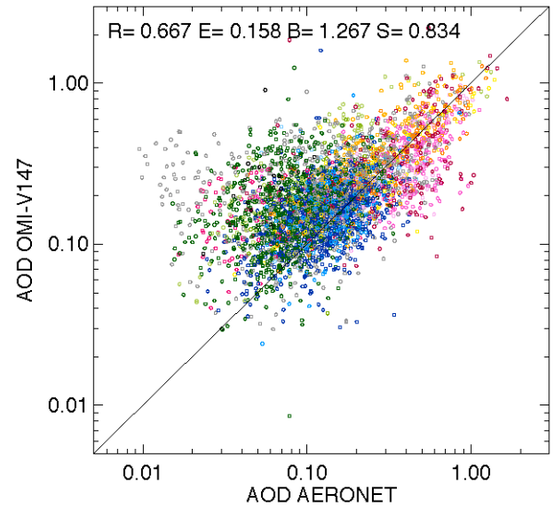
Model vs. AERONET and OMI vs. AERONET – Hmmm…

Model vs. AERONET





OMI vs. AERONET



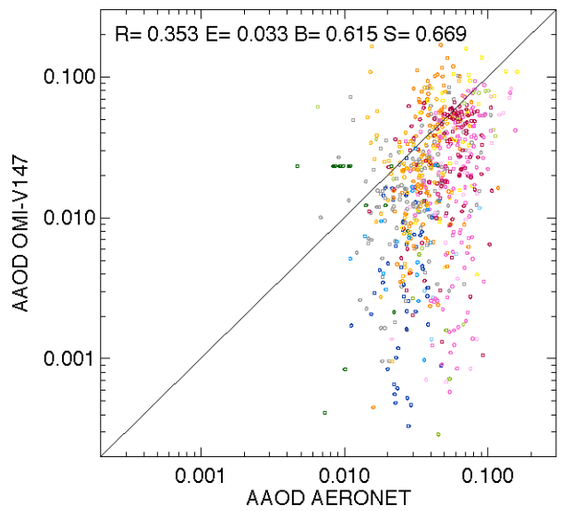


Table 1. Comparisons of CALIOP and GOCART aerosol type selection schemes and type-dependent lidar ratios.

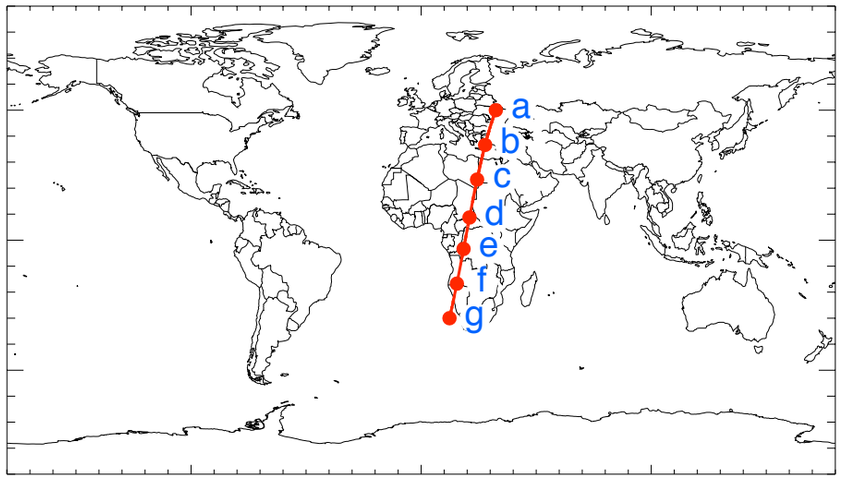
Type		Selection Criteria*	Lidar Ratio at 532 nm
Polluted Continental (PC)	CALIOP	(1) Over land: $\gamma > 0.0005$, $\delta' \leq 0.075$, layer not elevated (2) Over ocean: $\gamma \leq 0.01$, $0.75 \geq \delta' \geq 0.05$ (3) Over snow/ice or tundra: $\gamma > 0.0005$, $\delta' \leq 0.075$	70
	GOCART	σ(pollution) /σ(total) ≥ 0.55	70.0 ± 11.1
Smoke (SM)	CALIOP	(1) Over land: $\delta' \leq 0.075$, $\gamma > 0.0005$, elevated layer (2) Over ocean: $\delta' \leq 0.075$, elevated layer	70
	GOCART	σ(smoke) /σ(total) ≥ 0.55	67.7 ± 6.3
Dust (DU)	CALIOP	$\delta' > 0.075$, $\gamma > 0.2$	40
	GOCART	σ(dust) /σ(total) ≥ 0.55	54.0 ± 3.5
Polluted Dust (PD)	CALIOP	(1) Over all surface: $\delta' > 0.075$, $\gamma \leq 0.2$ (2) If (1) does not meet: over desert $\delta' \leq 0.075$, $\gamma \leq 0.005$	65
	GOCART	σ(dust) /σ(total) = 0.4 – 0.55 and σ(pollution +smoke) /σ(total) = 0.15 – 0.4	55.8 ± 6.2
Clean Marine (CM)	CALIOP	(1) Over ocean, layer not elevated, $\delta' \leq 0.075$, $\gamma > 0.01$ (2) Over ocean, $\gamma \leq 0.01$, $\delta' < 0.05$	20
	GOCART	σ(sea salt) /σ(total) ≥ 0.55	22.8 ± 2.8
Clean Continental (CC)	CALIOP	(1) Over land, non-desert surface: $\delta' \leq 0.075$, $\gamma \leq 0.0005$ (2) Over snow/ice or tundra: $\delta' \leq 0.075$, $\gamma \leq 0.0015$	35
	GOCART	σ(total) < 0.002 km^{-1} and σ(sea salt) /σ(total) < 0.4	64.3 ± 9.7
Biogenic / Volcanic (BV)	CALIOP	N/A	
	GOCART	σ(biogenic +volcanic) /σ(total) ≥ 0.55	69.7 ± 3.9
Other (OT)	CALIOP	N/A	
	GOCART	Mixture with σ fractions not meet the criteria for the above	59.2 ± 17.1

*γ = attenuated backscatter at 532 nm; σ = extinction (km^{-1}) at 532 nm; δ' = corrected depolarization ratio (or estimated particle depolarization ratio, which is corrected from the volume depolarization ratio to account for the molecular contribution. See Omar et al., 2009).

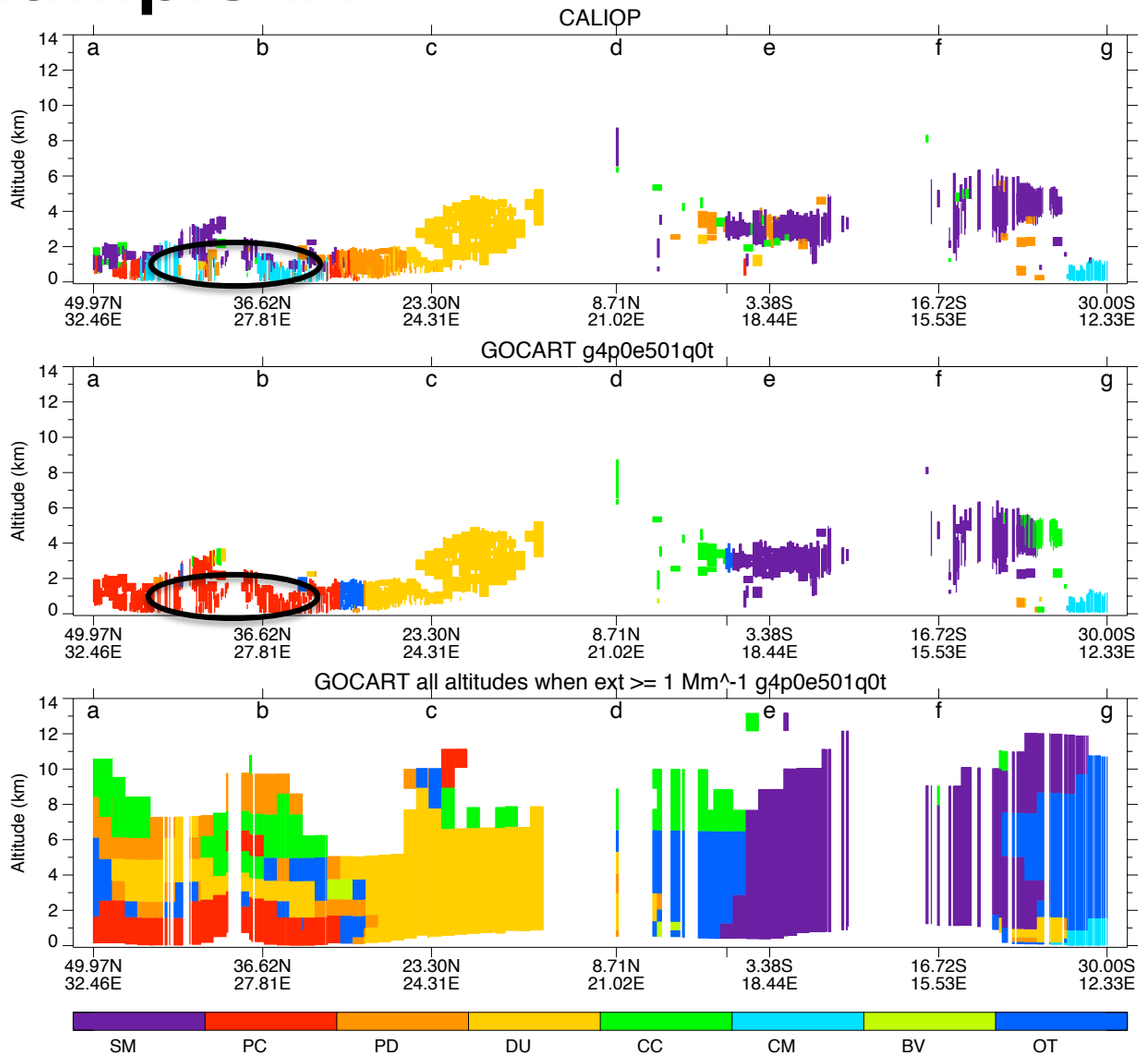
Aerosol type from CALIOP and GOCART

- Model simulations with sources tagged to group the speciation according to the sources: anthropogenic (sulfate, BC, OC), biomass burning (sulfate, BC, OC), volcanic (sulfate), biogenic (OC), dust, sea salt
- Type is determined by the highest fraction of aerosol from a particular source

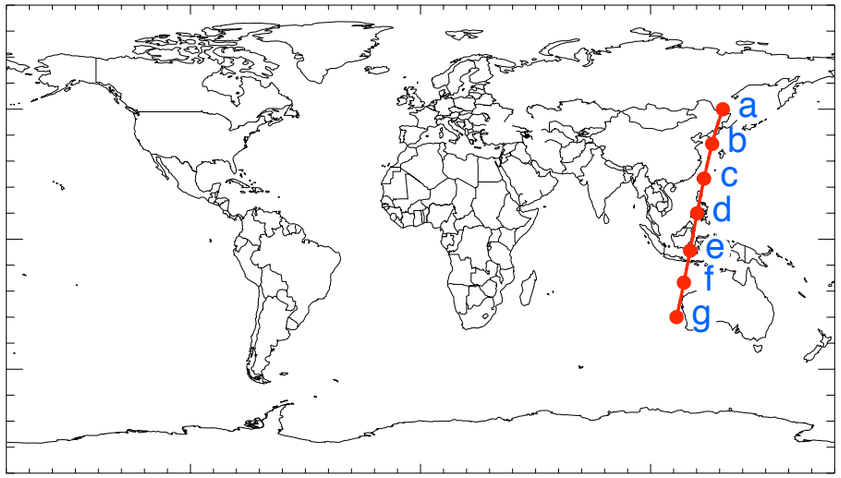
Aerosol type from CALIOP and GOCART: Example #1

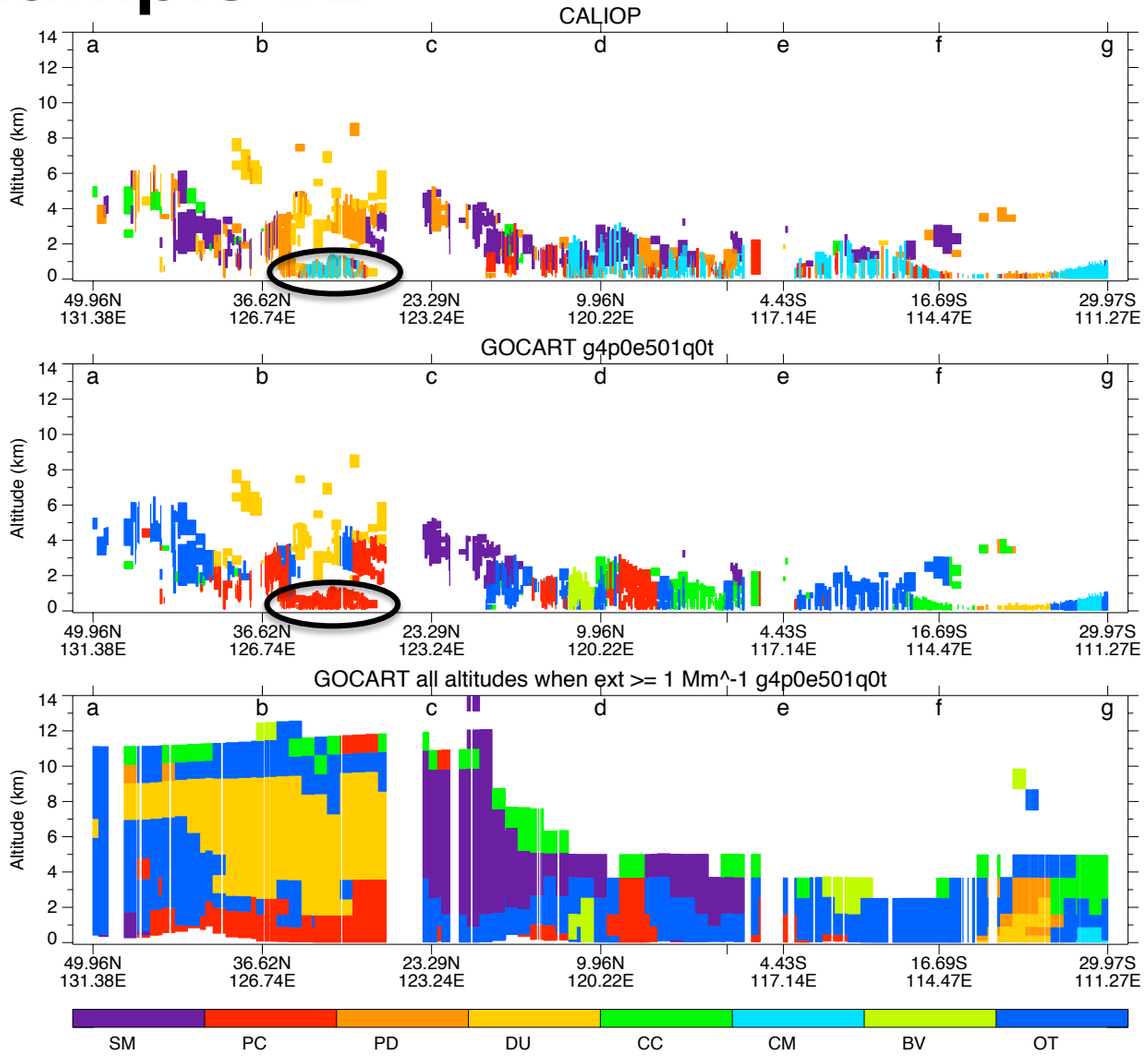


- Best agreement between CALIOP and GOCART aerosol type: Dust
- Worst agreement: Coastal water

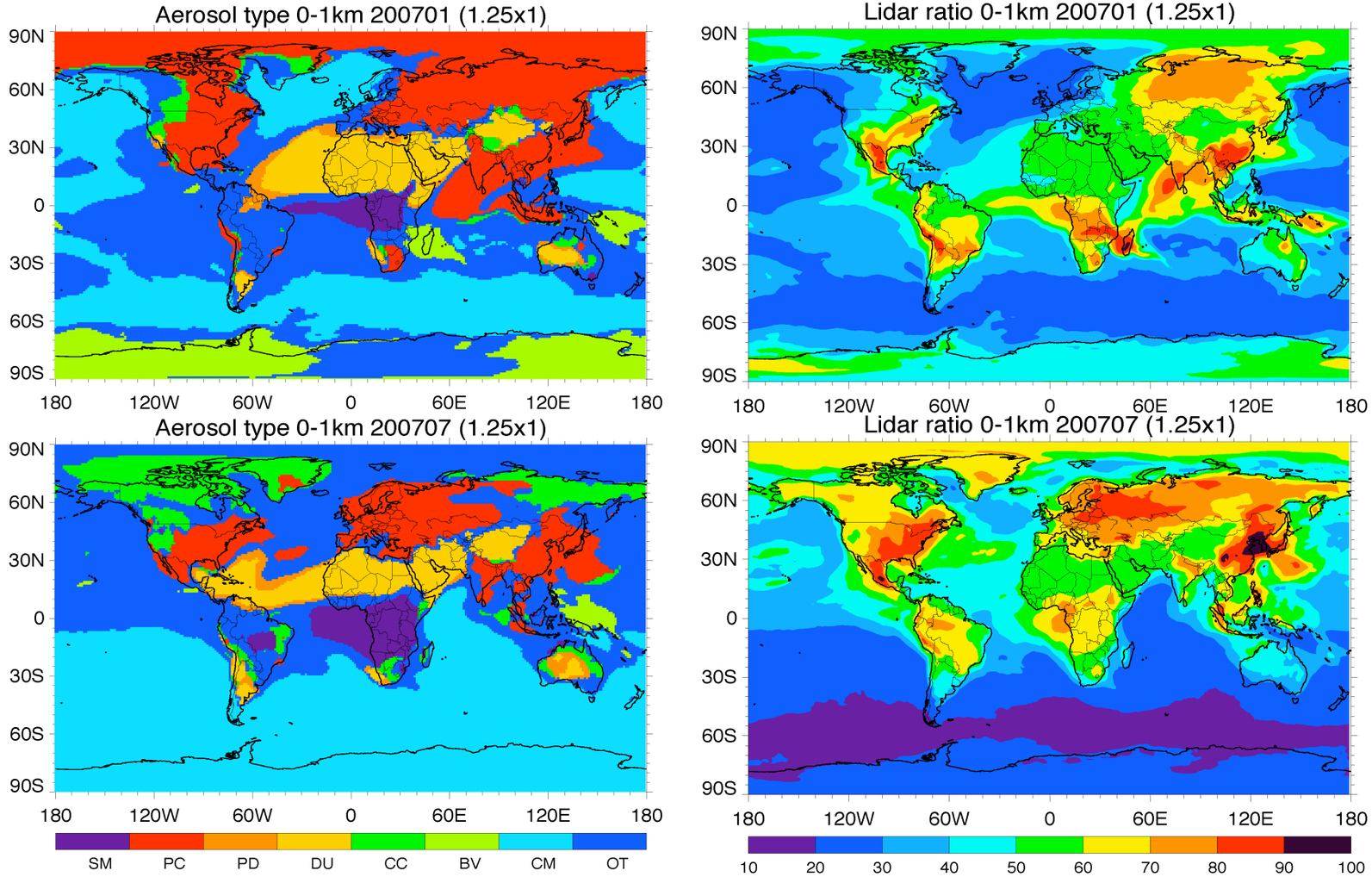


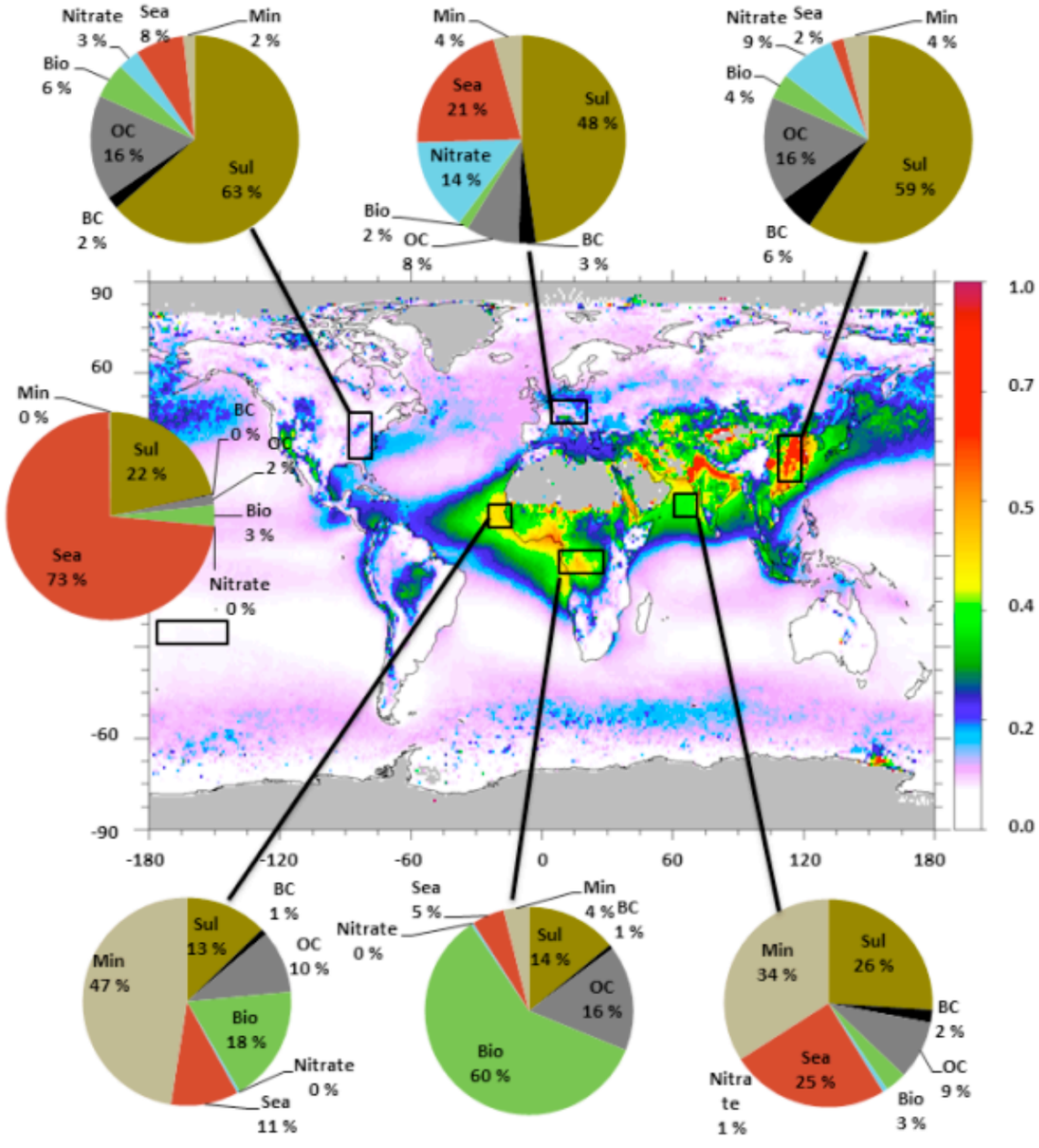
Aerosol type from CALIOP and GOCART: Example #2





GOCART CALIOP-like aerosol type near the surface





AOD composition

MODIS 550 AOD averaged over the 10-year period 2001–2010 (Remer *et al*. 2008). Pie charts show how various aerosol types contribute to the total AOD for different regions, as estimated by a global aerosol model (Myhre *et al*. 2009). Aerosol types are Sul (sulphate), BC and OC from fossil fuel usage, Bio (OC and BC from biomass burning), Nitrate, Sea (sea salt), and Min (mineral dust). Gray areas indicate lack of MODIS data. Some aerosol types, e.g. sulphate, have enhanced contributions to AOD due to hygroscopic growth. The contribution from OC is likely underestimated as in most of the global aerosol models (Zhang *et al*. 2007).

(Figure from Myhre et al., 2013)

Surface Aerosol Composition

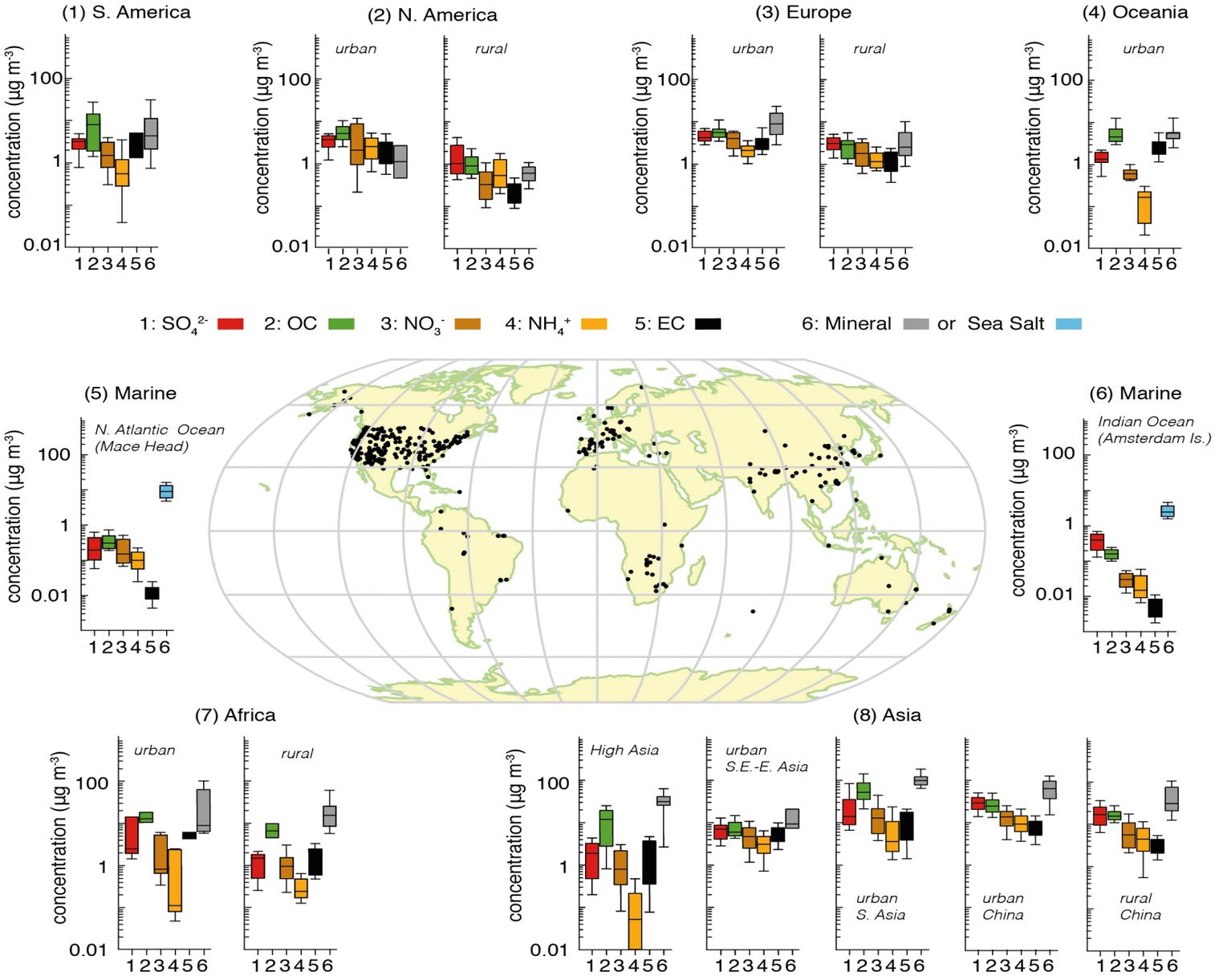


Fig.7-13 from IPCC AR5 Chapter 7, Clouds and Aerosols, by Boucher et al.

Remarks and questions regarding aerosol type

- How can satellite estimated aerosol types be used to evaluate/ constrain the models?
  - My experience: Dust (or fine/coarse) is the most useful product that can be used quantitatively to evaluate models, but it is only relatively reliable over the ocean
  - Absorbing/non-absorbing is also useful, but data quality needs to be much improved
  - CALIOP-type: Useful information but difficult to quantitatively constrain the models
- How quantitative the remote sensing derived aerosol type should be in order to be useful?
- No aerosol specie composition can be retrieved from remote sensing, leaving models unconstrained

- All models (and satellite retrievals) are wrong, but some are useful