Evaluations of seasonal and spatial variations of global aerosol optical depth in GEOS-Chem-APM based on multiple-platform observations

Xiaoyan Ma[12] and Fangqun Yu[2]

[1]Key Laboratory for Aerosol Cloud-Precipitation of China Meteorological Administration, Nanjing University of Information Science and Technology, China,

[2]Atmospheric Sciences Research Center, State University of New York at Albany, Albany, New York, USA,

15th CAS-TWAS-WMO Forum
15th AeroCom / 4th AeroSAT workshops

Beijing, China, September 22, 2016

Advanced Particle Microphysics (APM) model

Turco et al., 1979; Jacobson et al., 1994; Yu and Turco, 1998; Yu, 1998; Yu and Luo, 2009; Yu, 2010; Luo and Yu, 2011; Ma et al., 2012; Yu et al., 2012, 2013

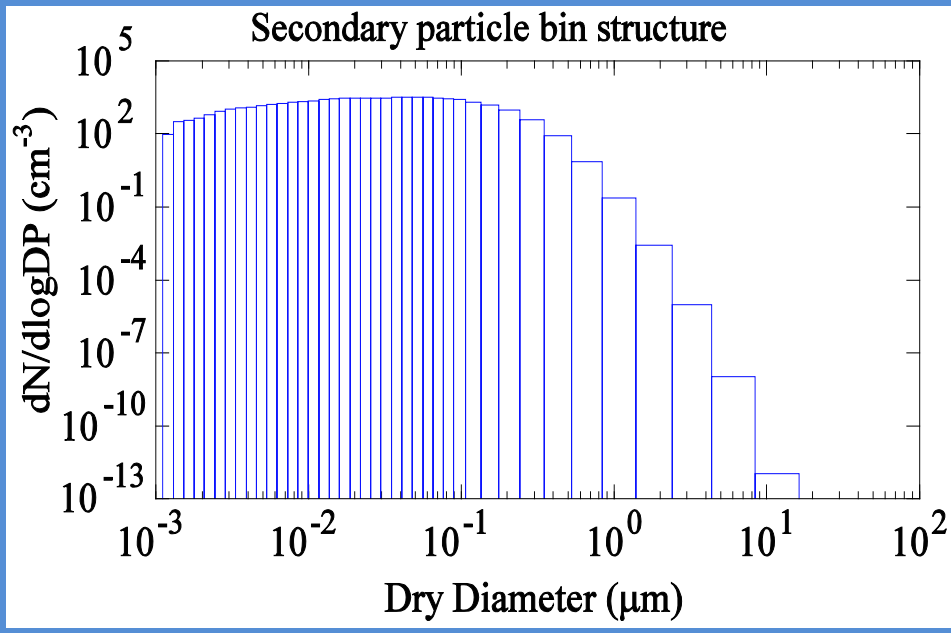
Secondary particles (SP) : **40** bins
(composed of SO4, NO3, NH4, SOA)

Sea salt particles: 20 bins

Dust: 15 bins

BC: two log-normal modes (one for fossil fuel, the other for biomass burning)

Primary OC: two log-normal modes

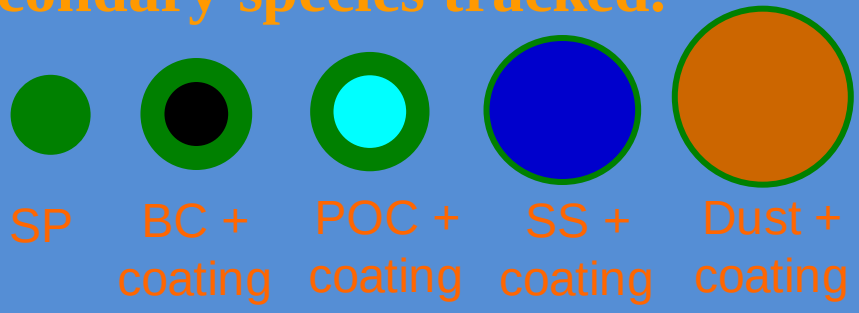


Computing cost (8-core workstation)

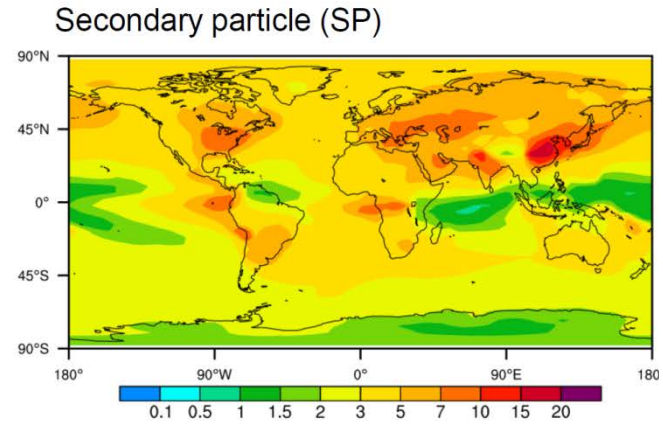
GEOS-Chem (4°x5° , 47 layers, **1 yr**)

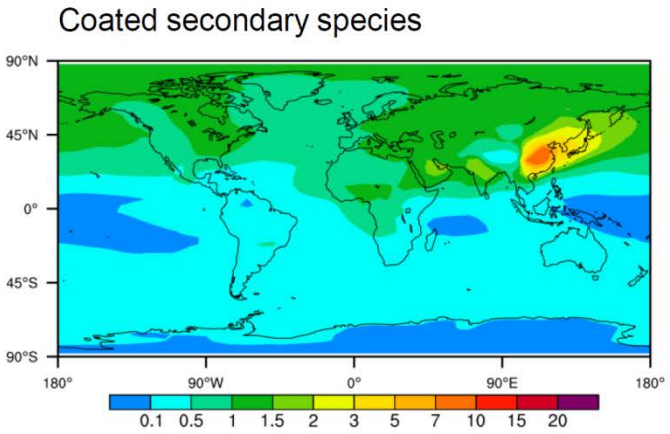
Original model	With APM
59 tracers	59+88= 147 tracers
~ 1 day	~ 2 days

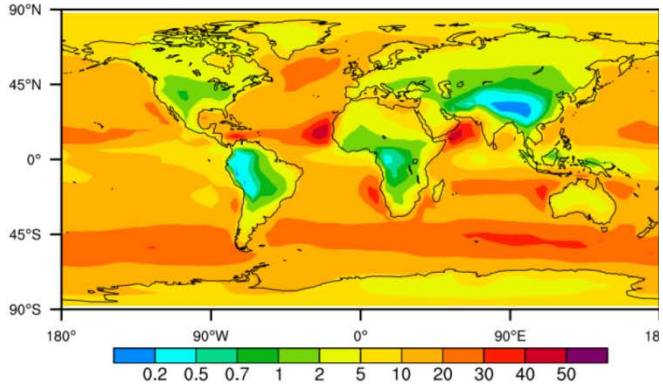
Coating of primary particles by secondary species tracked.

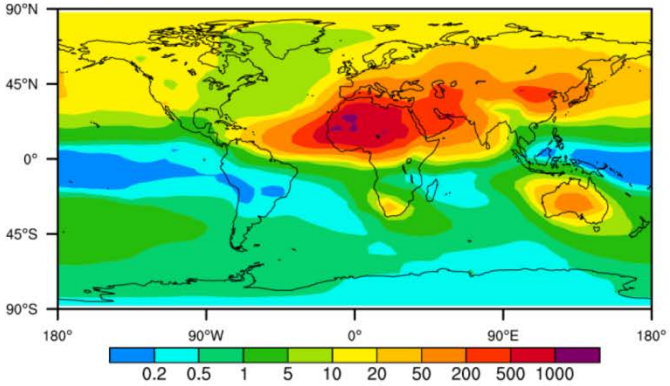


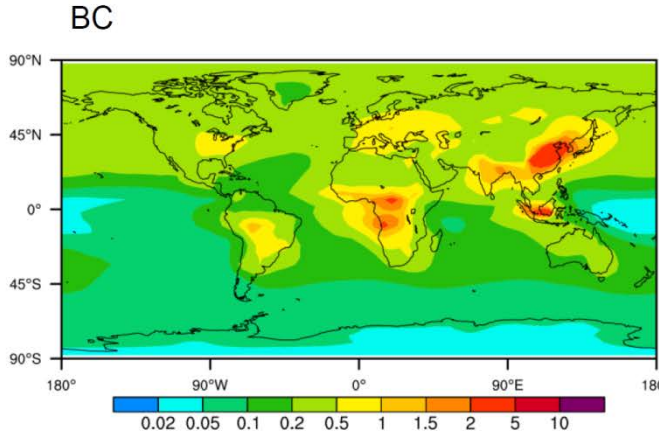
Modeled aerosol burden from GEOS-Chem-APM

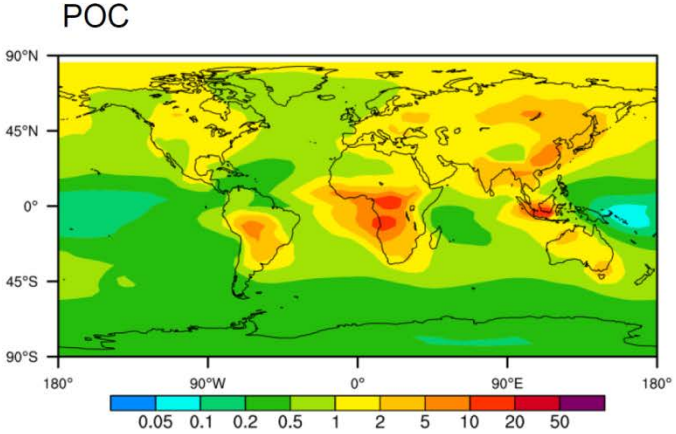


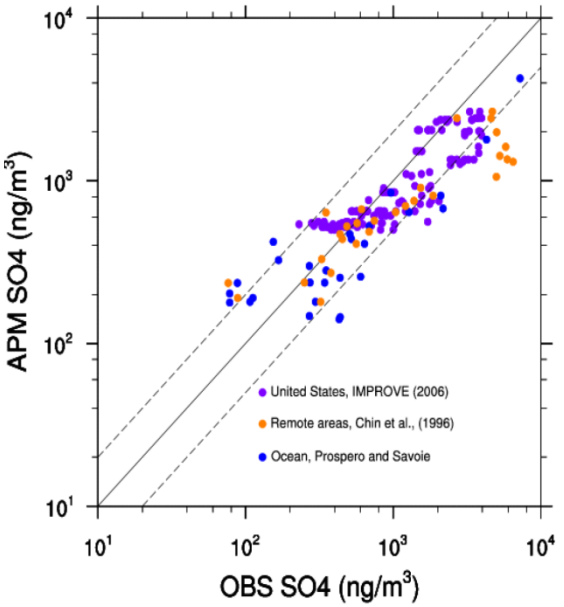


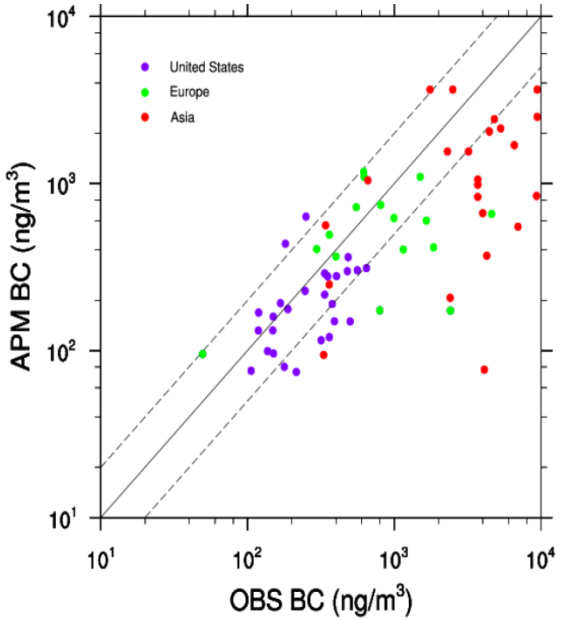












Ma et al. (ACP, 2012)

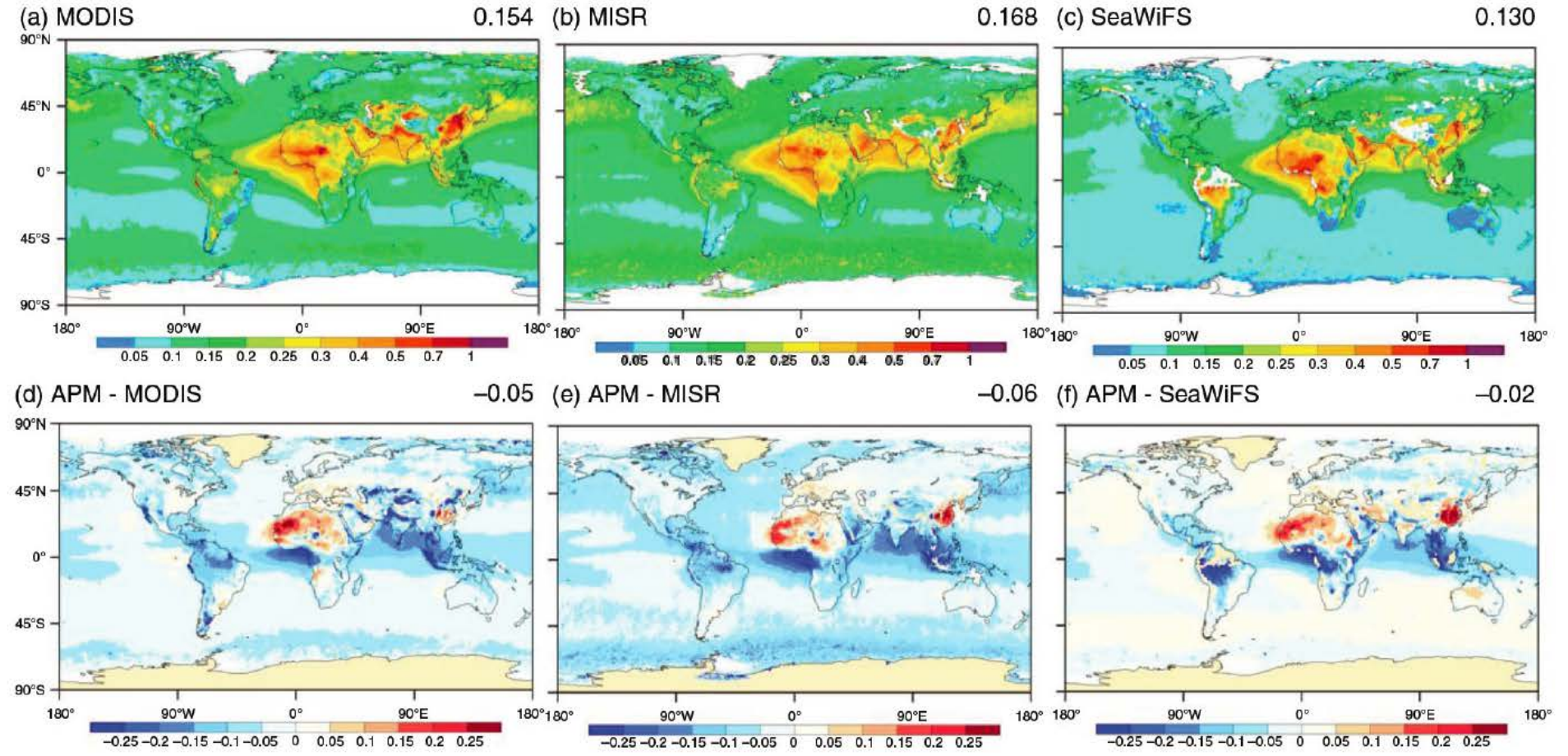
GEOS-Chem/APM

mass and number
size distribution
compositions
mixing state
hygroscopic growth

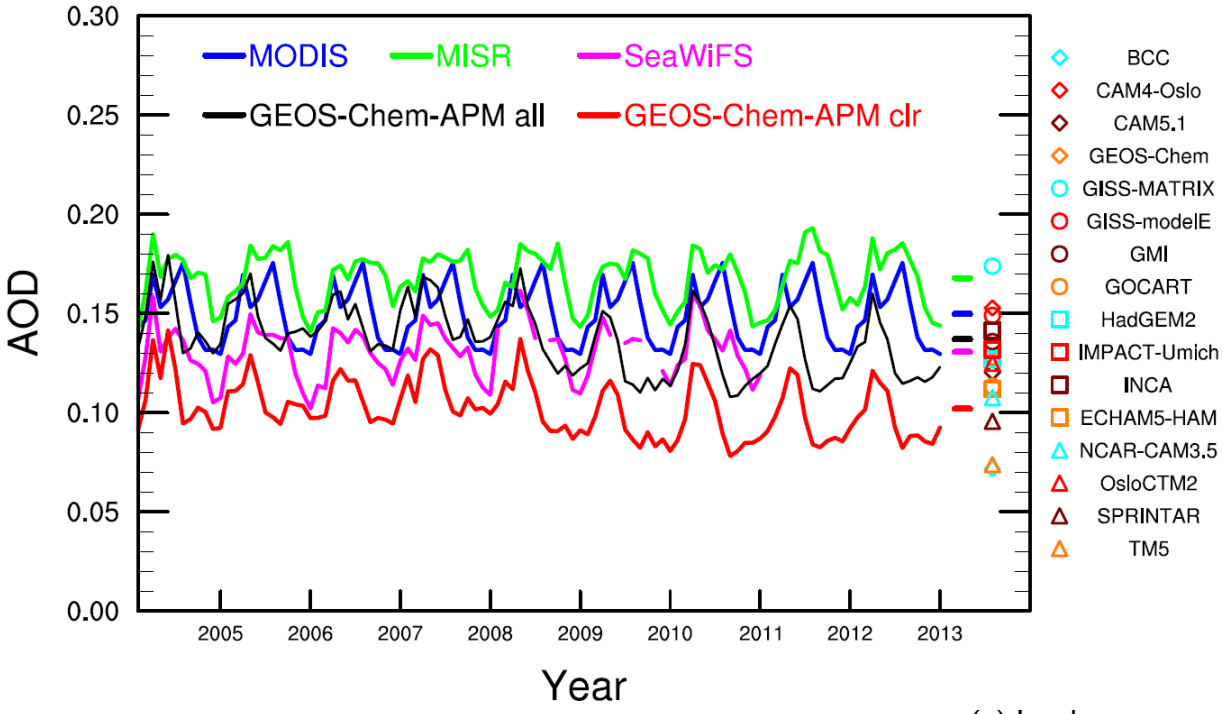
Refractive index

Mie Code
core-shell

Aerosol optical properties



(a) Global

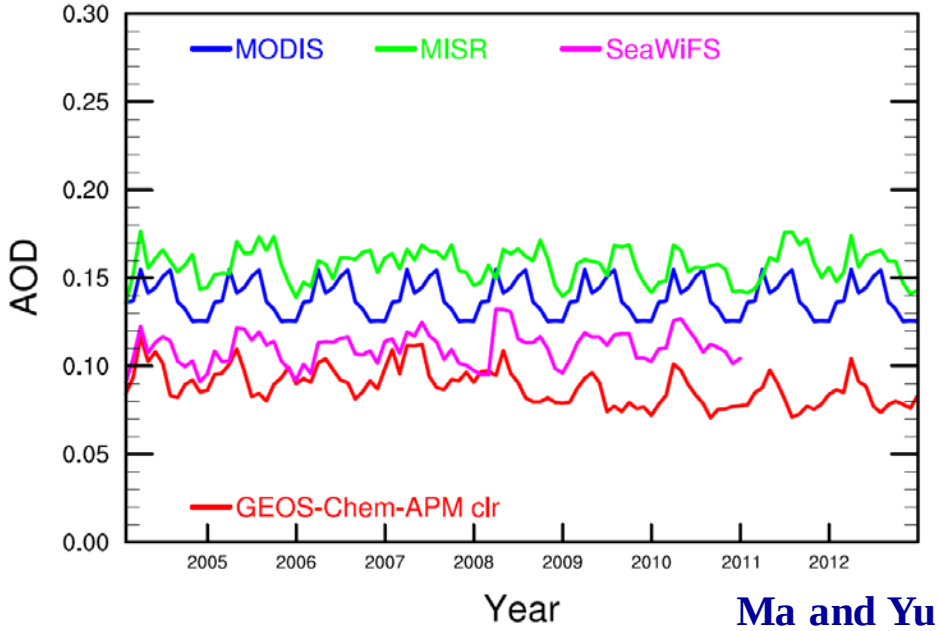


- Satellite: clear sky, daytime
- APM clear sky: cloud cover <0.25
- 16 other models: all sky AODs for year 2006

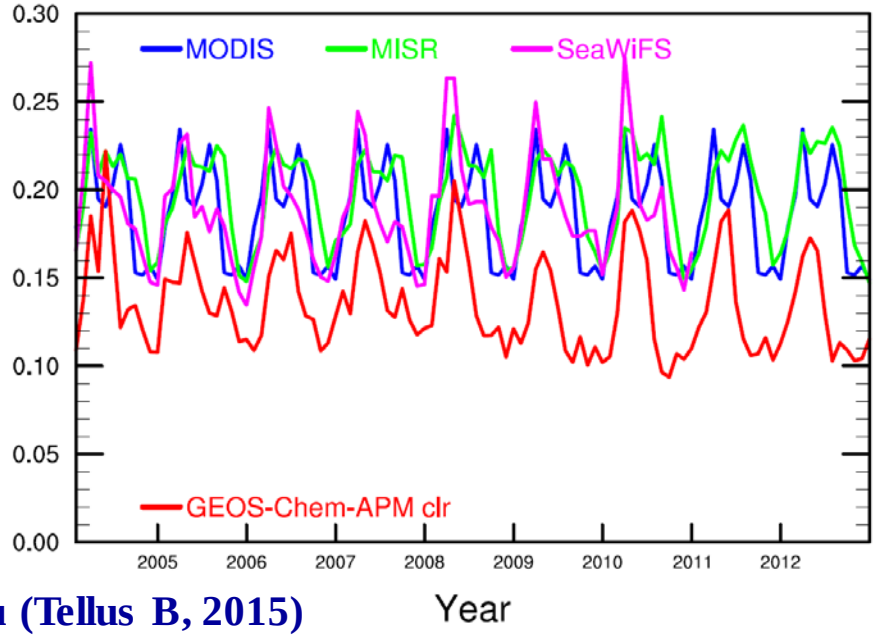
AODs all sky is ~30% higher than clear sky according to the GEOS-Chem-APM simulations

AODs from most global models are lower than satellite

(b) Ocean



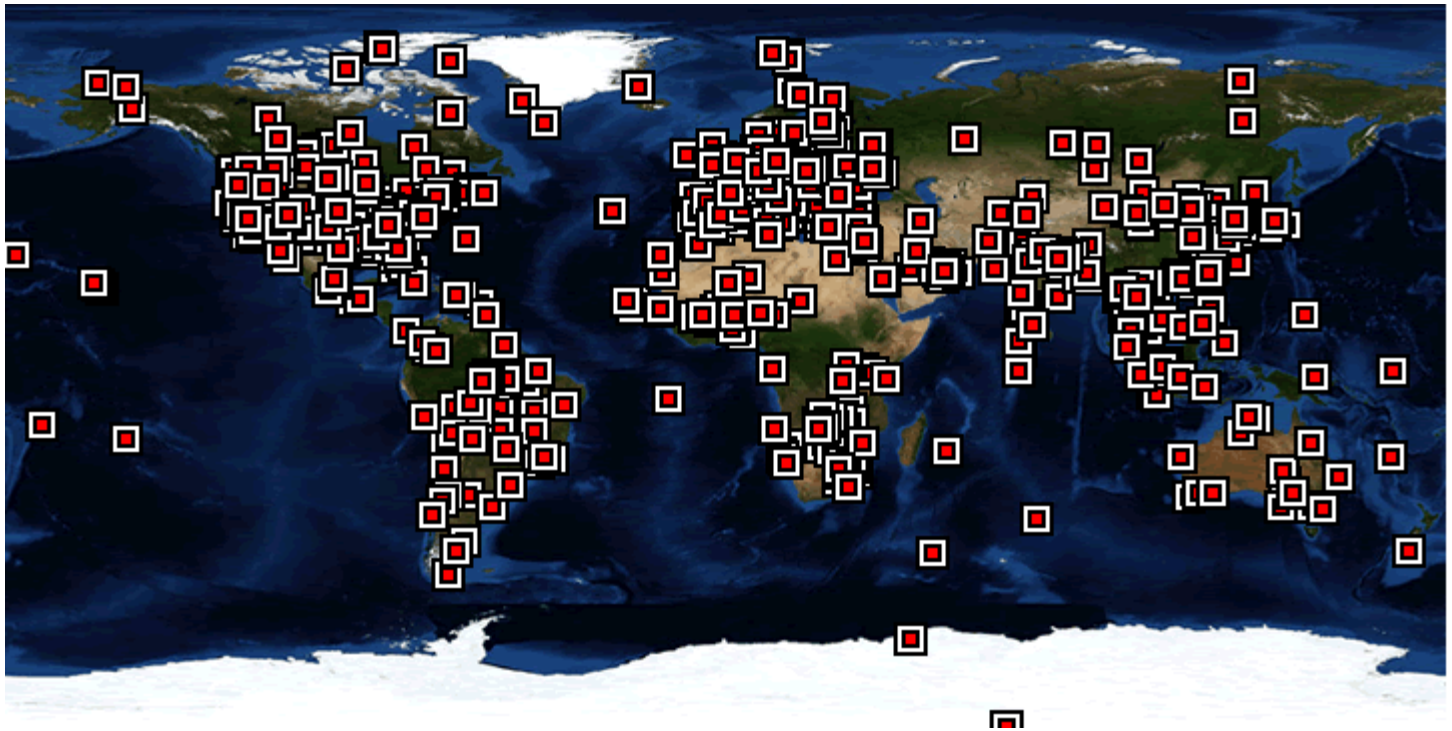
(c) Land



Ma and Yu (Tellus B, 2015)

Global AERONET Sites

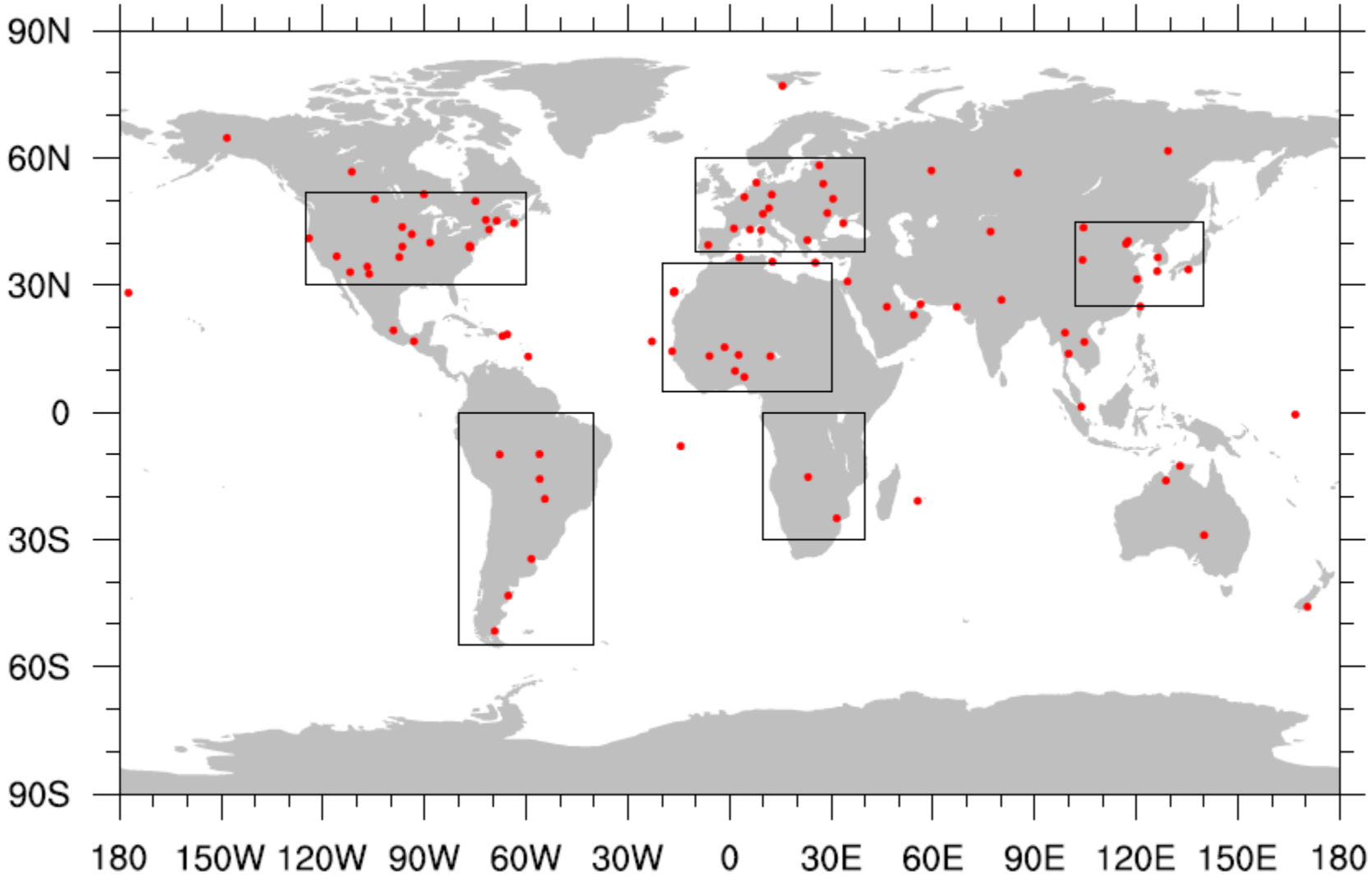
Level 2.0 Quality Assured Data, over 600 sites around the world



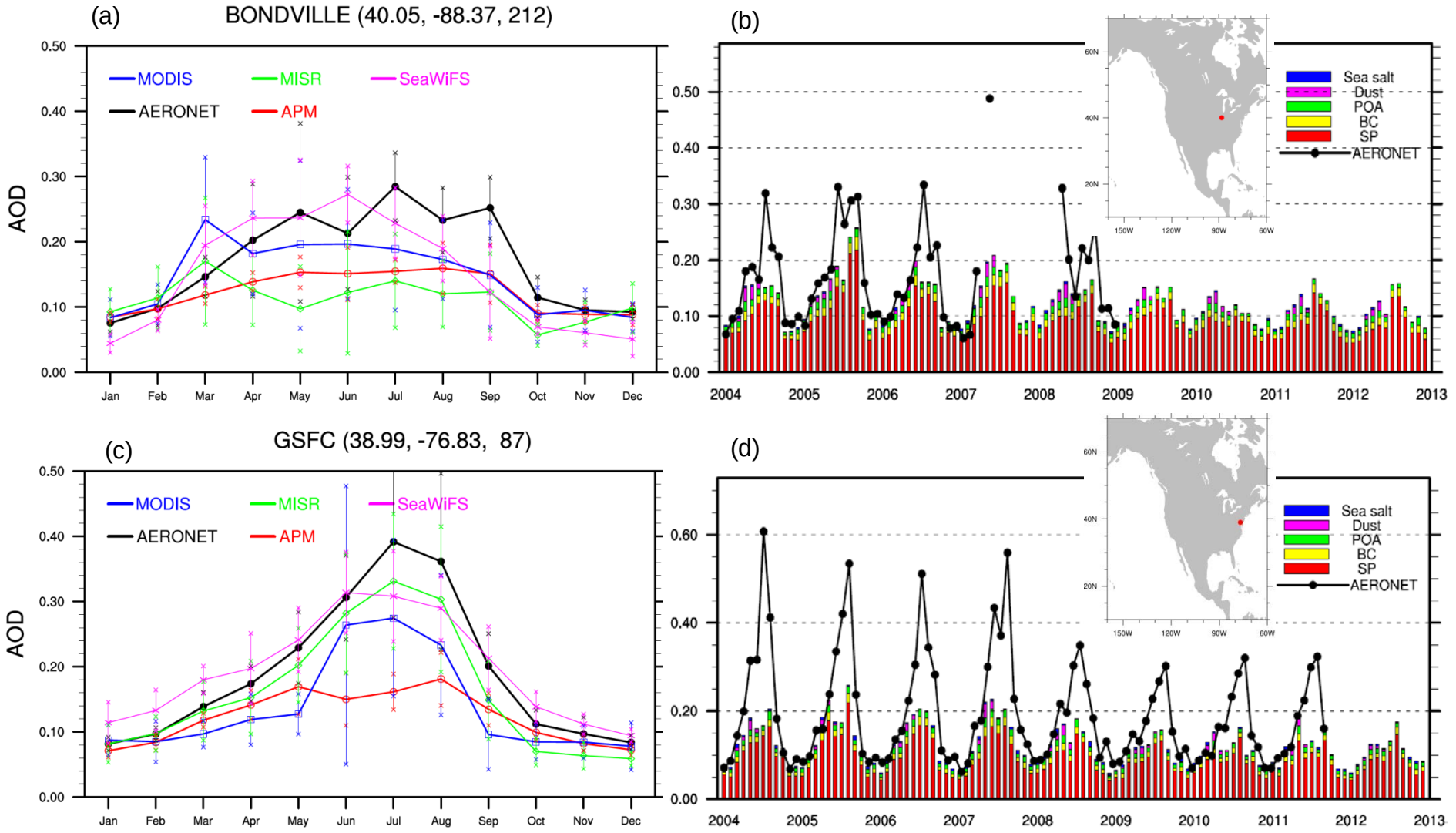
Selection criteria:

- at least 36 months data available
- eliminated the sites with a low spatial domain and with a low data quality according to the site assessment provided by Kinne et al. (2013)

Selected AERONET Sites



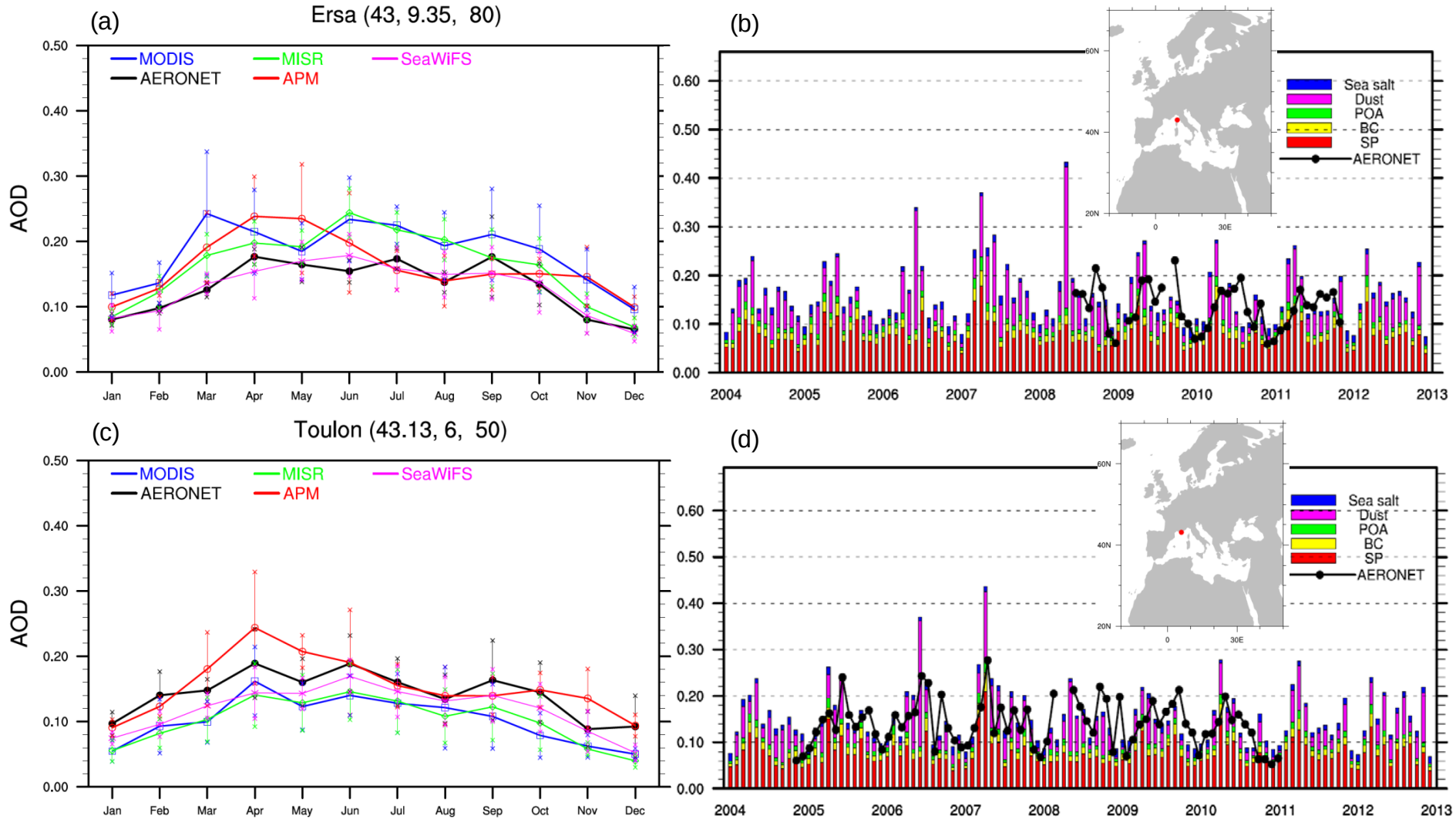
North America



- Secondary Particle (SP: Sulfate, Nitrate, Ammonia, SOA) dominates
- Smaller inter-annual variabity in the model

Ma and Yu (Tellus B, 2015)

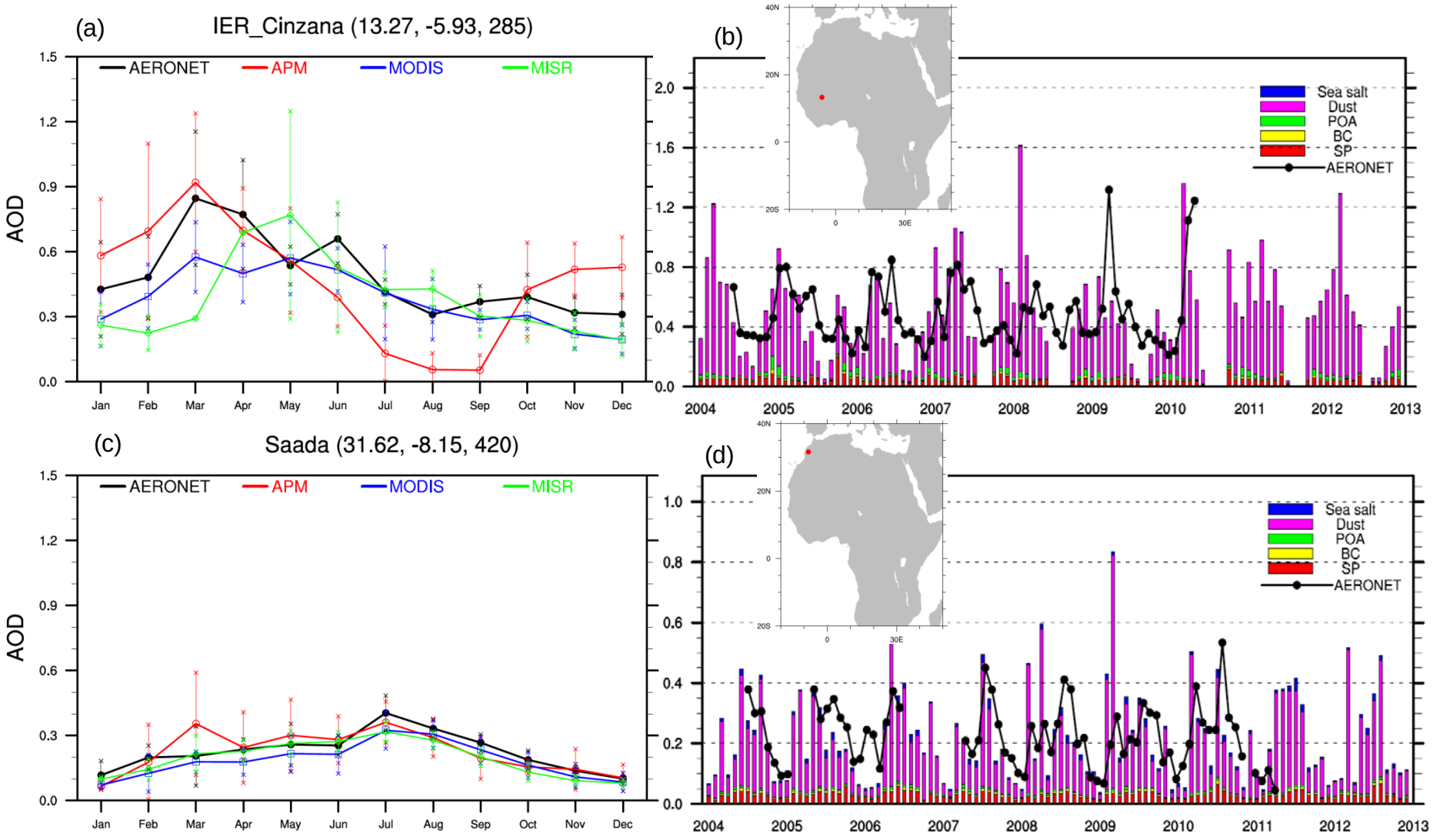
Europe



- Secondary Particle and dust dominate. dust transported from North Africa too high?
- Reasonable inter-annual variation

Ma and Yu (Tellus B, 2015)

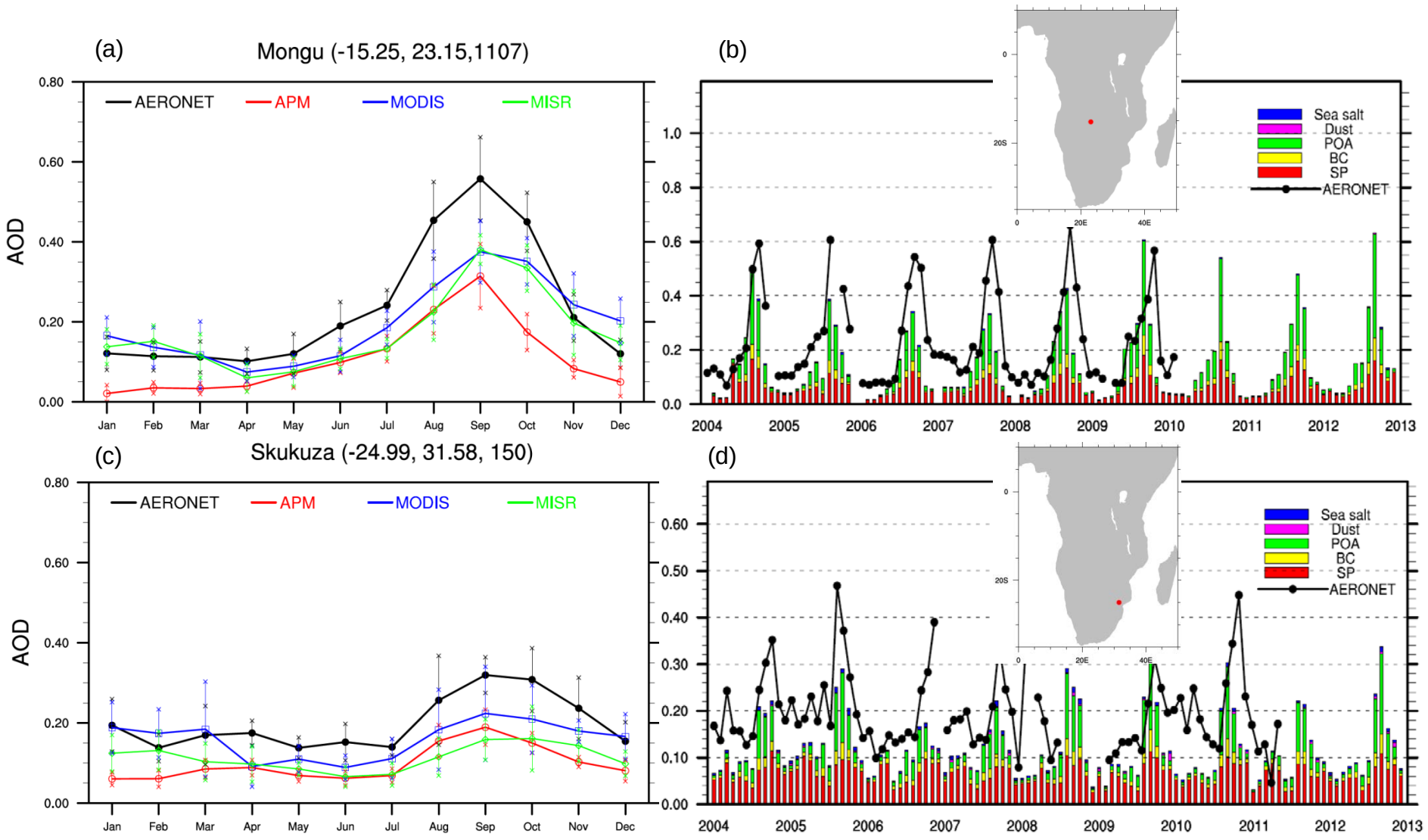
North Africa



- Mineral dust dominate. dust transported from North Africa too high?

Ma and Yu (Tellus B, 2015)

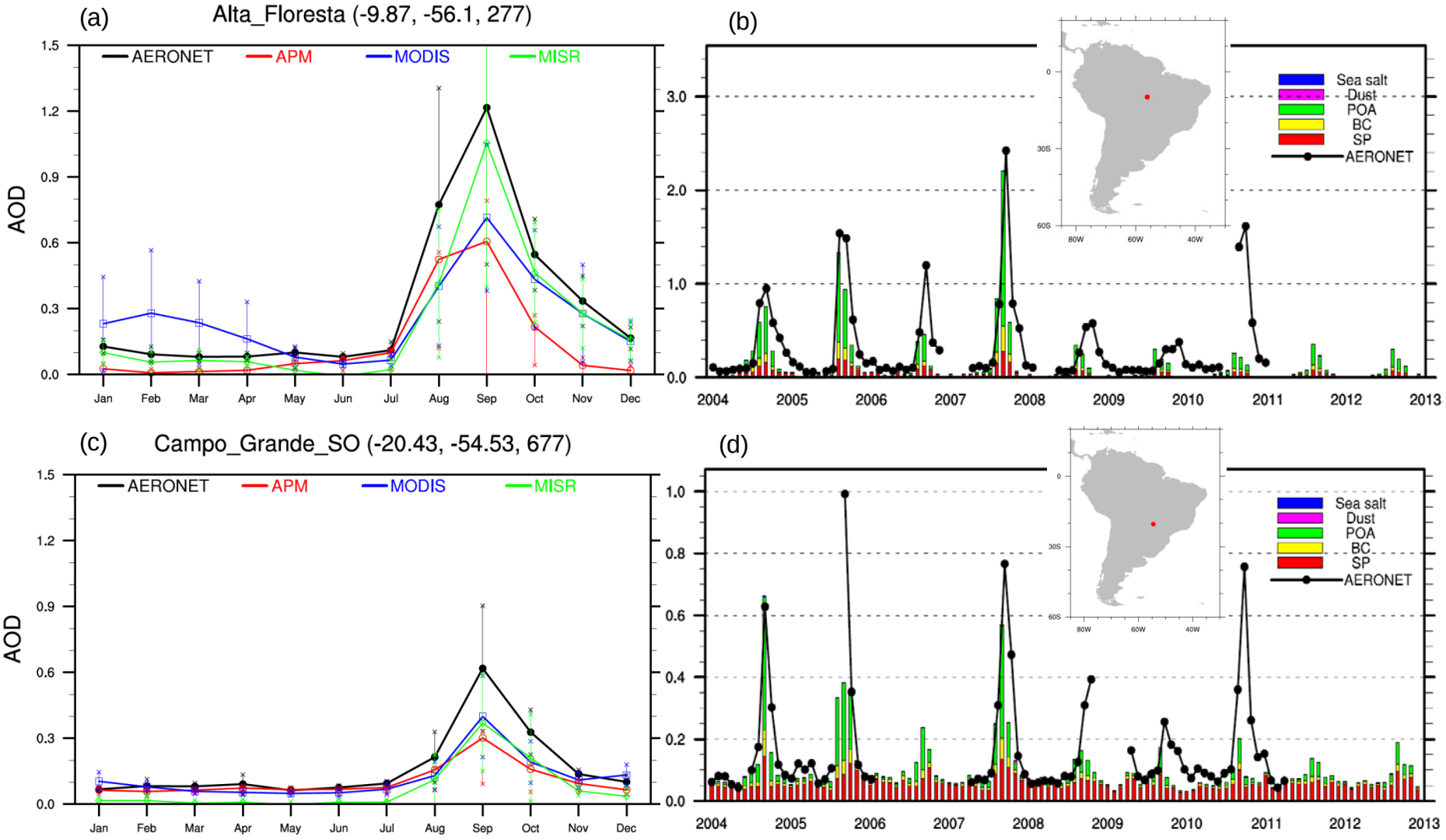
South Africa



- POA dominates, SP contributes secondly high.
- Consistent seasonal variation (highest in Fall due to BB).

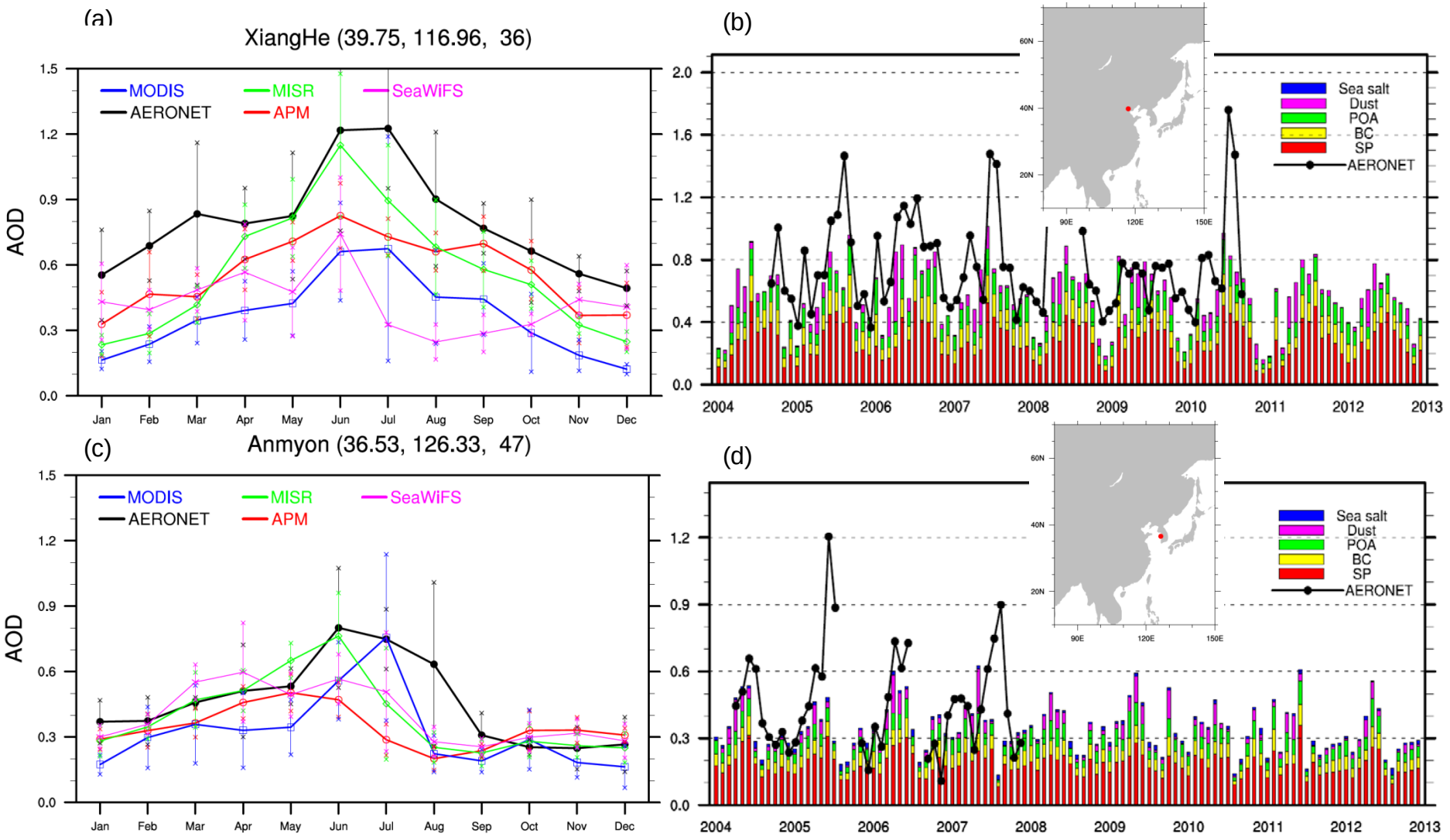
Ma and Yu (Tellus B, 2015)

South America



- POA dominates
- the burning season in South America is shorter compared to South Africa

East Asia

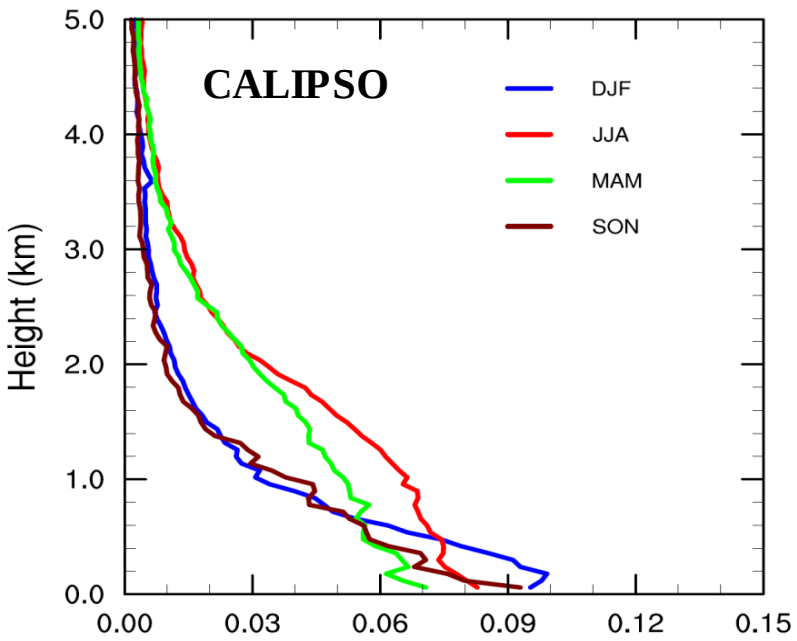


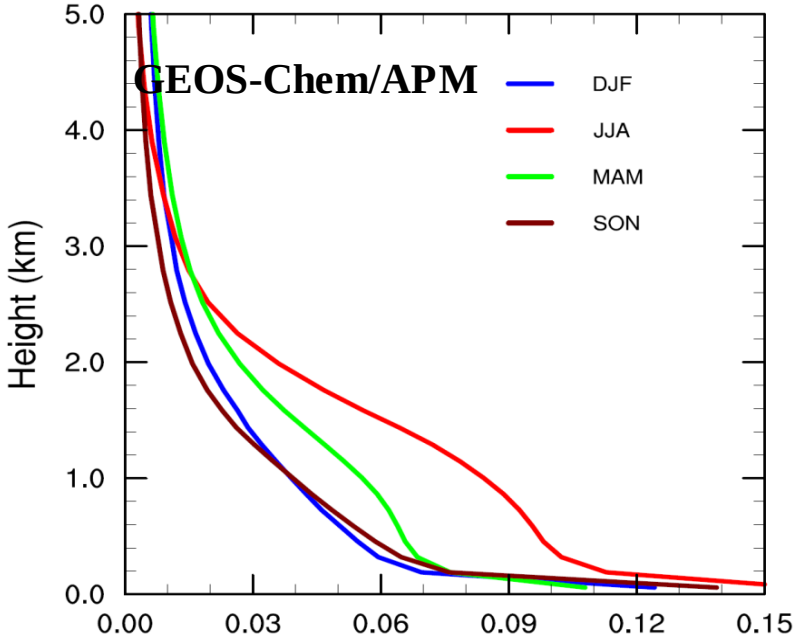
- Secondary Particle (SP: Sulfate, Nitrate, Ammonia, SOA) dominates, POA and BC contribute more than in North America and Europe.

Ma and Yu (Tellus B, 2015)

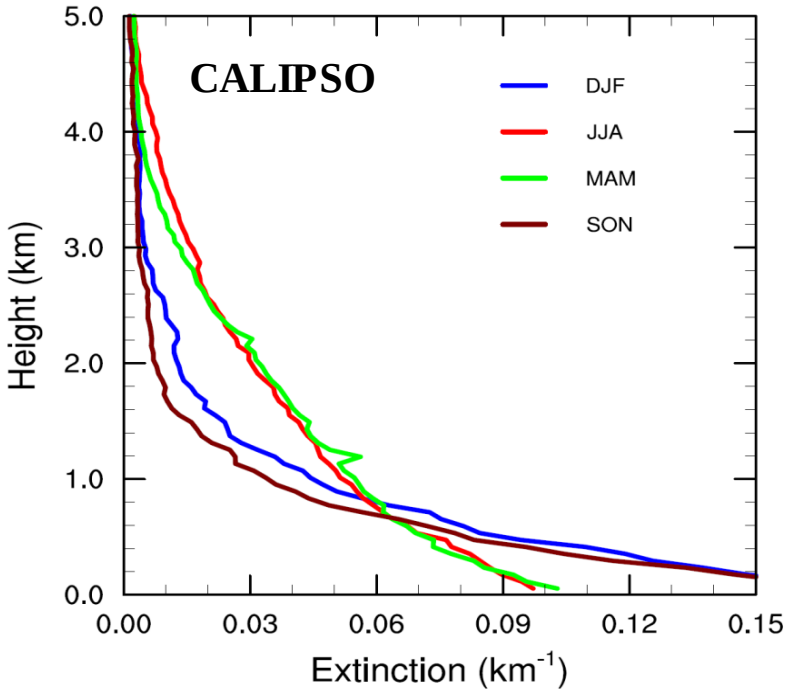
Vertical profile of aerosol extinction

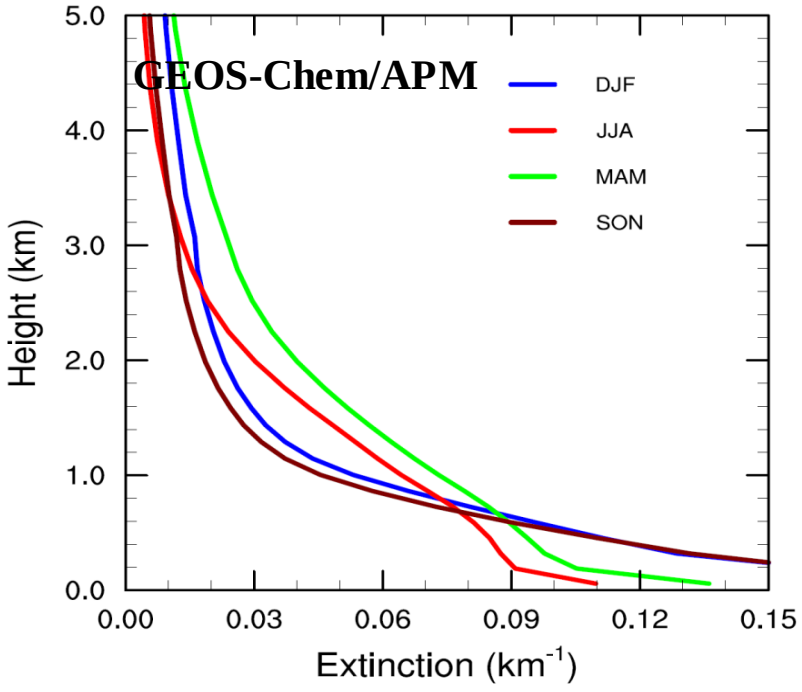
EUS



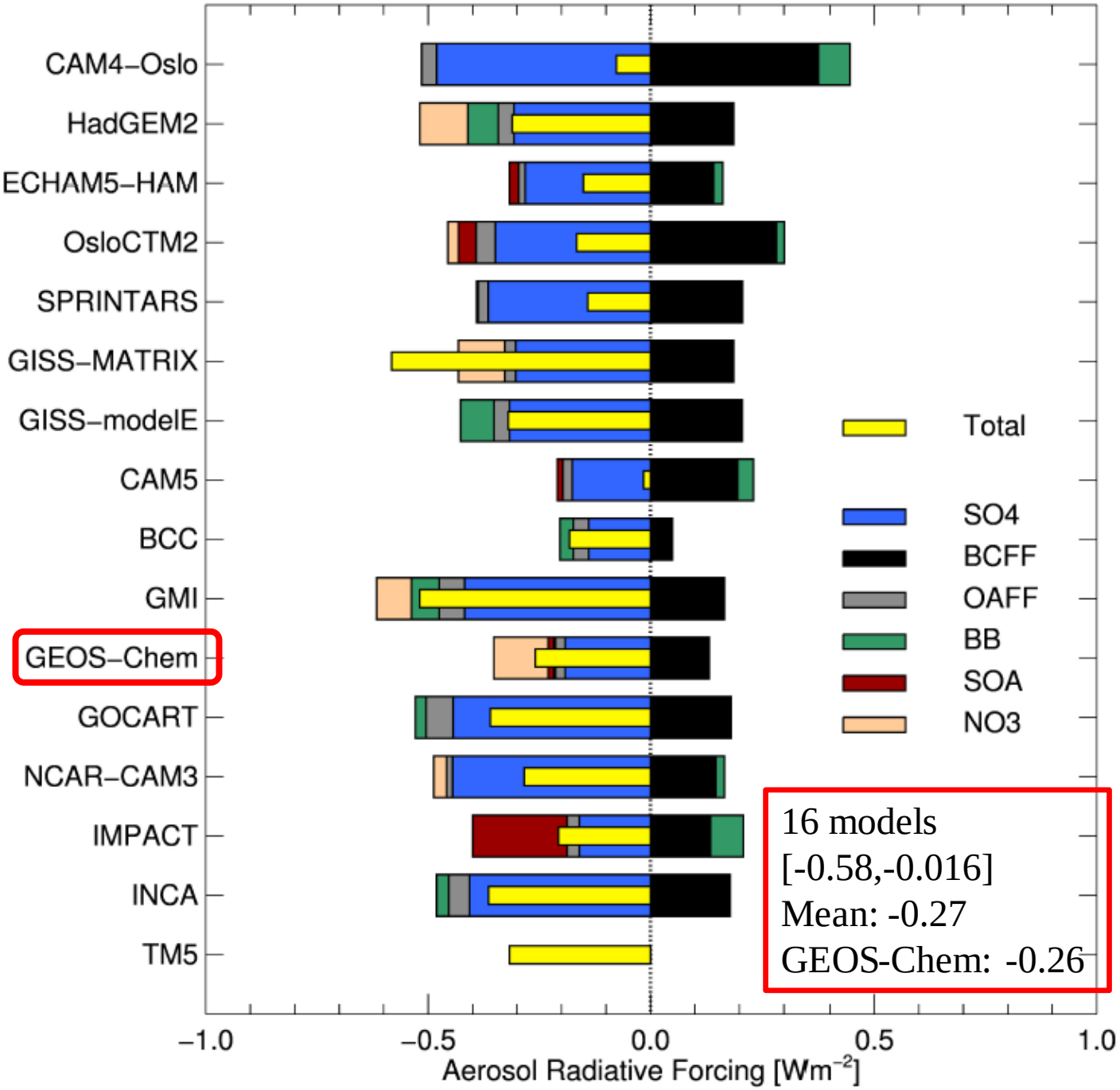


WEU

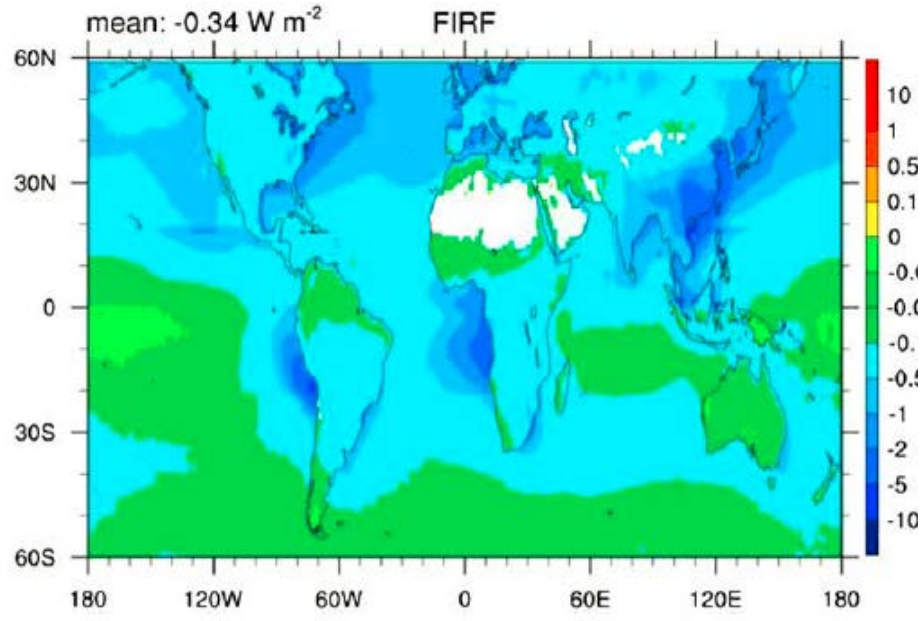


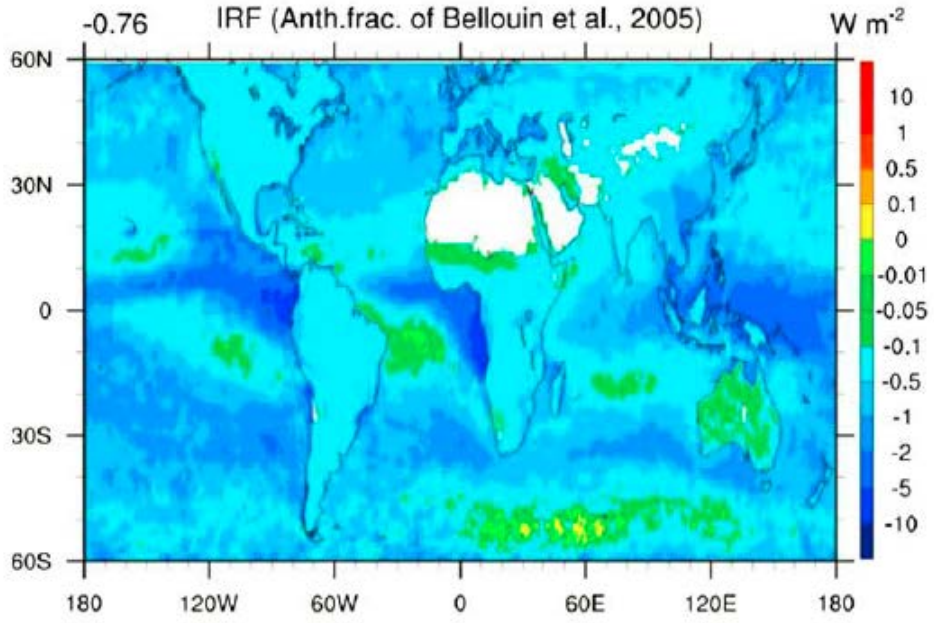


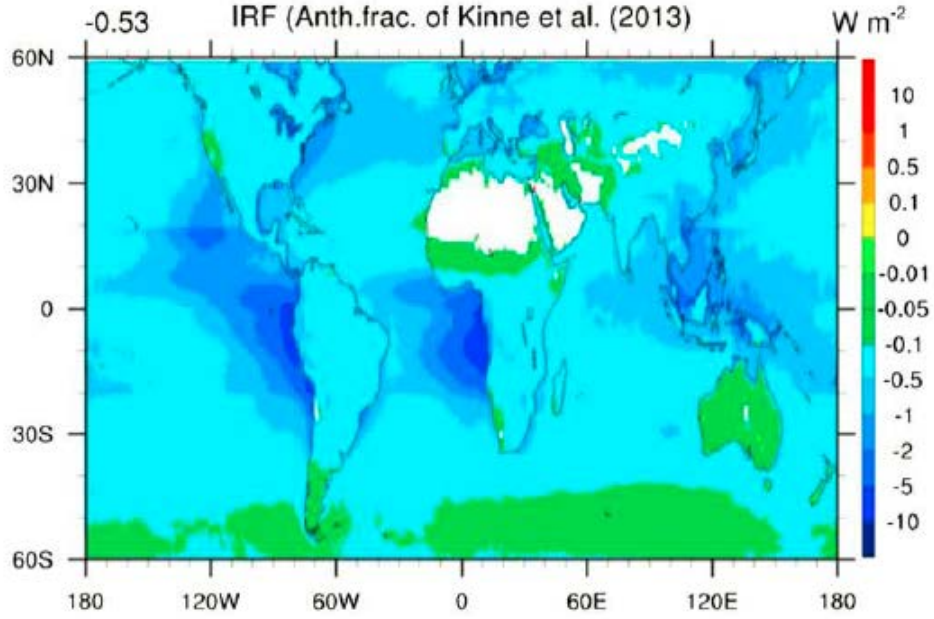
- Dire



Myhre et al. (2013), Ma et al., 2013







Anthropogenic RF is generally stronger over oceans even though anthropogenic aerosol sources are on land.

Because maritime clouds are more susceptible to changes in aerosol concentrations.

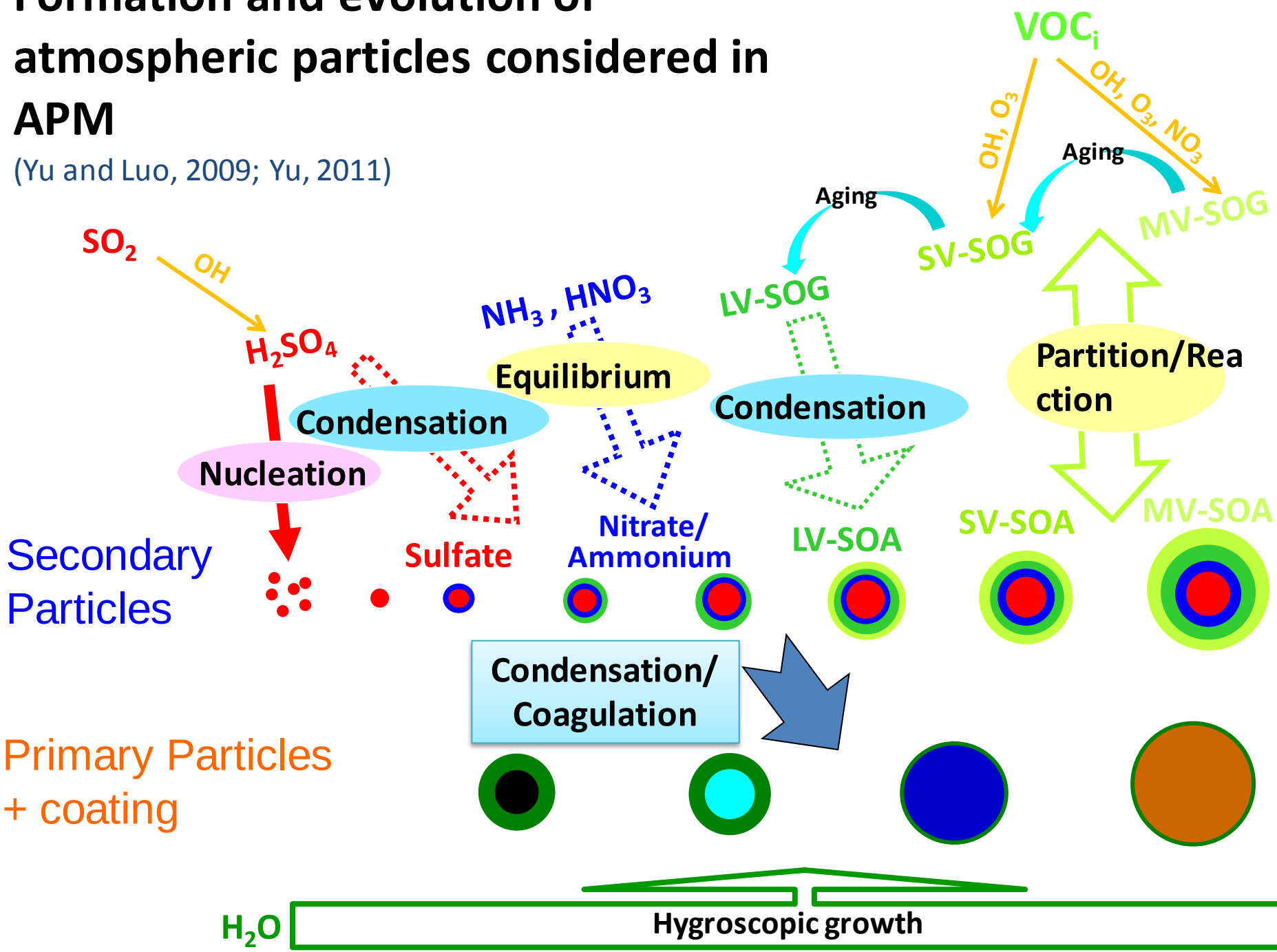
Ma et al. (JGR, 2014)

Summary and conclusions

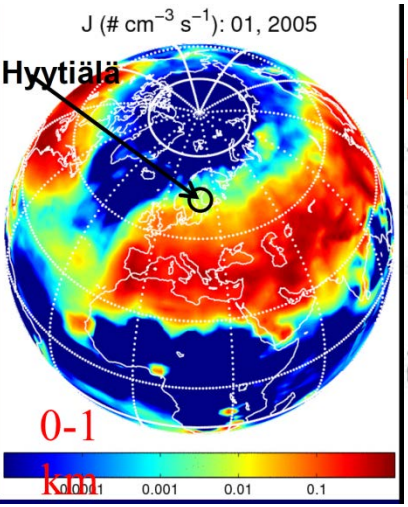
- Predict sulfate mass concentrations much better than BC.
- Capture the observed seasonal of AOD over all representative regions.
- Overall weak inter-annual variability compared to observations.
- Vertical profile of AOD at EUS and WEU agree well with CALIPSO.

Formation and evolution of atmospheric particles considered in APM

(Yu and Luo, 2009; Yu, 2011)



Simulated and observed particle size distribution



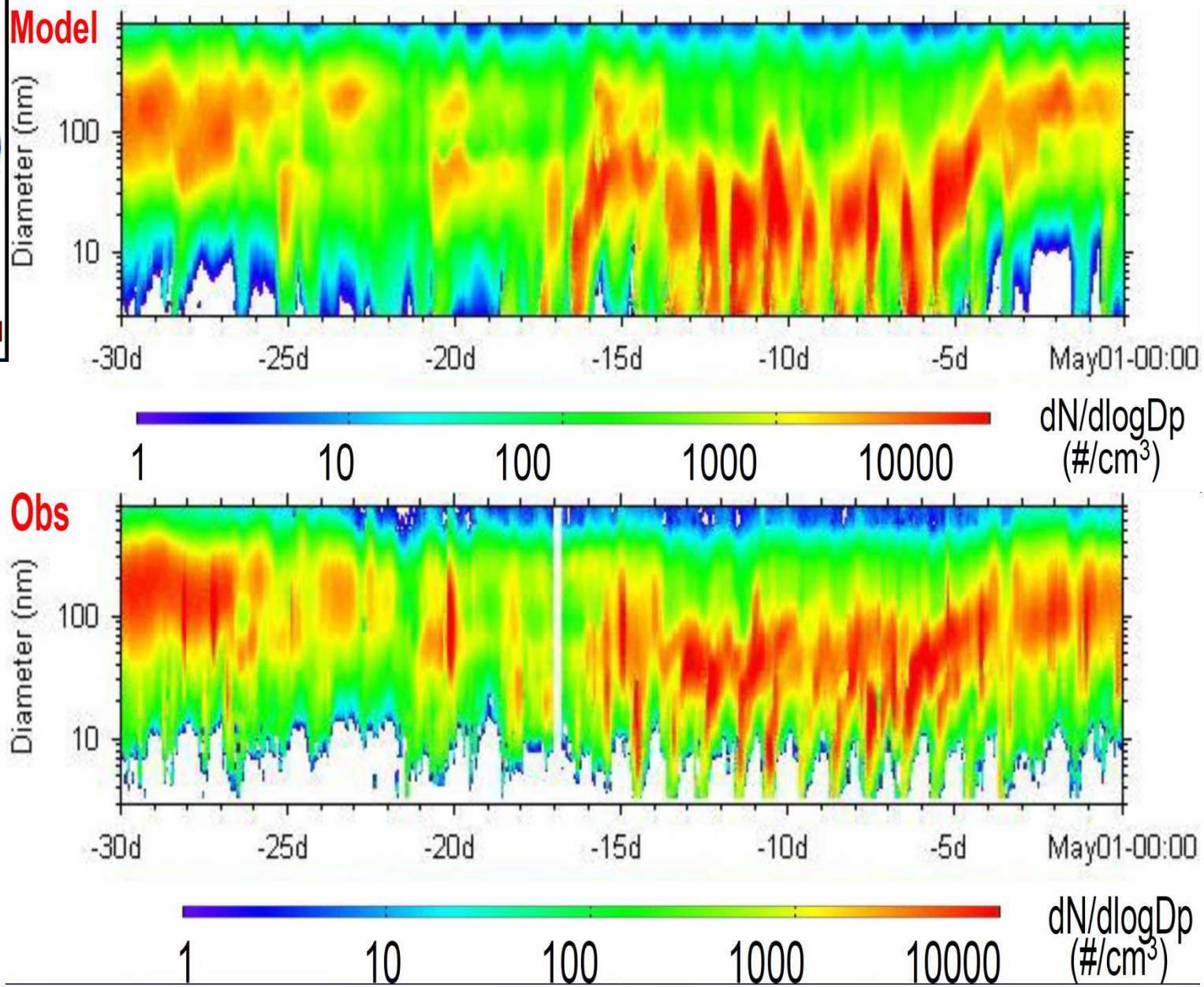


Table 1. Comparisons of AOD in clear sky from the GEOS-Chem-APM with satellite data MODIS, MISR and SeaWiFS, and comparisons in 72 AERONET sites having at least 36 months data available between the model and the observations. The AERONET sites with low quality and low spatial domain are also excluded

	GEOS-Chem-APM	MODIS	MISR	SeaWiFS	AERONET
Global	0.102	0.154	0.168	0.130	
Land	0.135	0.188	0.198	0.188	
Ocean	0.088	0.139	0.157	0.110	
Low AOD (<0.1)	0.055	0.069	0.075	0.066	
Median AOD (0.1,0.3)	0.148	0.156	0.162	0.158	
Large AOD (>0.3)	0.506	0.471	0.460	0.458	
72 AERONET sites	0.168	0.192	0.206	0.193	0.223