AeroCom INSITU Project: Comparing modeled and measured aerosol optical properties

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MOTIVATION

Models are important tools for predicting atmospheric behavior/climate, but they often cannot reproduce climatology, co-variance or temporal variability of aerosol

- Models often have difficult reproducing seasonal cycles observed by surface in-situ aerosol instruments (e.g., Shindell et al., 2008)
- Vertical profiles difficult for models to reproduce (Schwarz et al., 2013; Skeie et al., 2011)
- In-situ surface optical measurements available to evaluate models

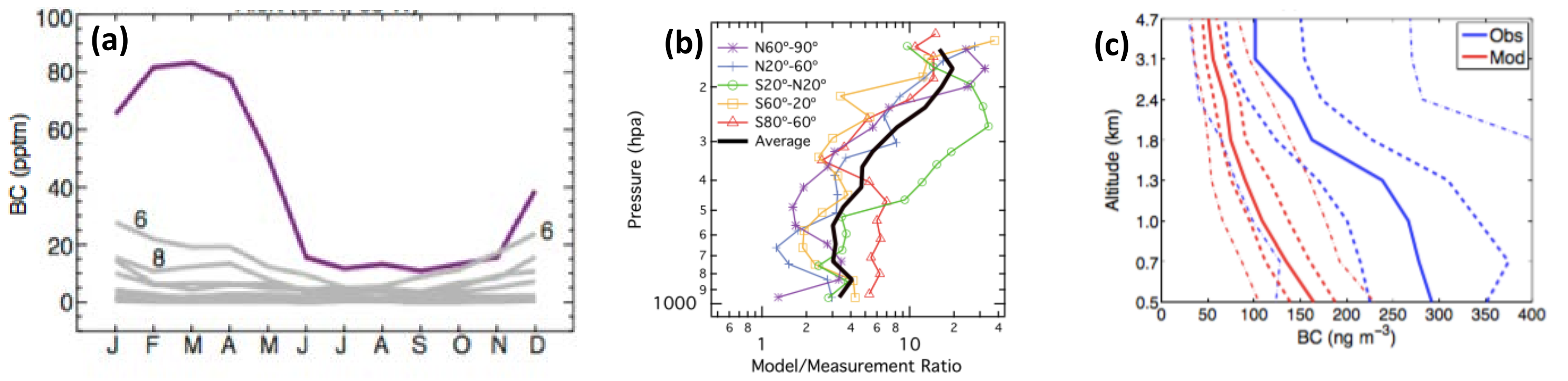

Figure 1. (a) Measured (purple) and modeled (gray) EBC concentrations at Alert, Canada from Shindell et al. (2008); (b) Vertical profiles of EBC concentration model/measurement ratios from the HIPPO campaign from Schwarz et al. (2013); (c) Vertical profiles of measured (blue) and modeled (red) EBC in rural Oklahoma in summer from Skeie et al. (2011)

OBJECTIVES

I. Evaluate AeroCom model simulations of aerosol optical properties using long-term, in-situ surface measurements
II. Improve the predictive capability of global climate models through improvement of aerosol modules

METHODS

AeroCom INSITU project is divided into **three** phases

TIER I
Evaluation of dry, in-situ optical parameters

TIER II
Trend analysis of dry optical properties

TIER III
Evaluation of hygroscopicity of aerosol scattering

→ **Only results from Tier I presented here**

1. Collect data from LONG-TERM in-situ aerosol monitoring sites

- Data ingested from EBAS/WDCA archive (consistent format and treatment (e.g., corrections, averaging))
- Measured spectral aerosol light scattering and back scattering from integrating nephelometers
- Measured spectral aerosol light absorption from filter-based measurements (i.e., PSAP, CLAP, MAAP)
- Visible wavelengths (400-700 nm range depending on instruments)
- Low RH (RH<40%)
- Calculated single scattering albedo (SSA), asymmetry parameter, scattering Ångström exponent, and absorption Ångström exponent

2. Review and develop benchmark data set for in-situ data

3. Collect model output requested from AeroCom participants

- high frequency model output (hourly, daily, monthly)
- wavelengths, RH, parameters consistent with in-situ data
- model output sampled at station locations

4. Compare models and measurements

- annual climatology
- temporal variability
- co-variance (not shown)

AEROSOL OPTICAL PROPERTY DATA

IN-SITU MEASUREMENTS

Why long-term, in-situ surface aerosol optical data?

- Data continuity (i.e., long-term measurements) - allows for evaluation of seasonality and interannual variability
- High temporal resolution – can represent timescale of different processes
- Parameters allow for calculation of radiative forcing efficiency at low RH

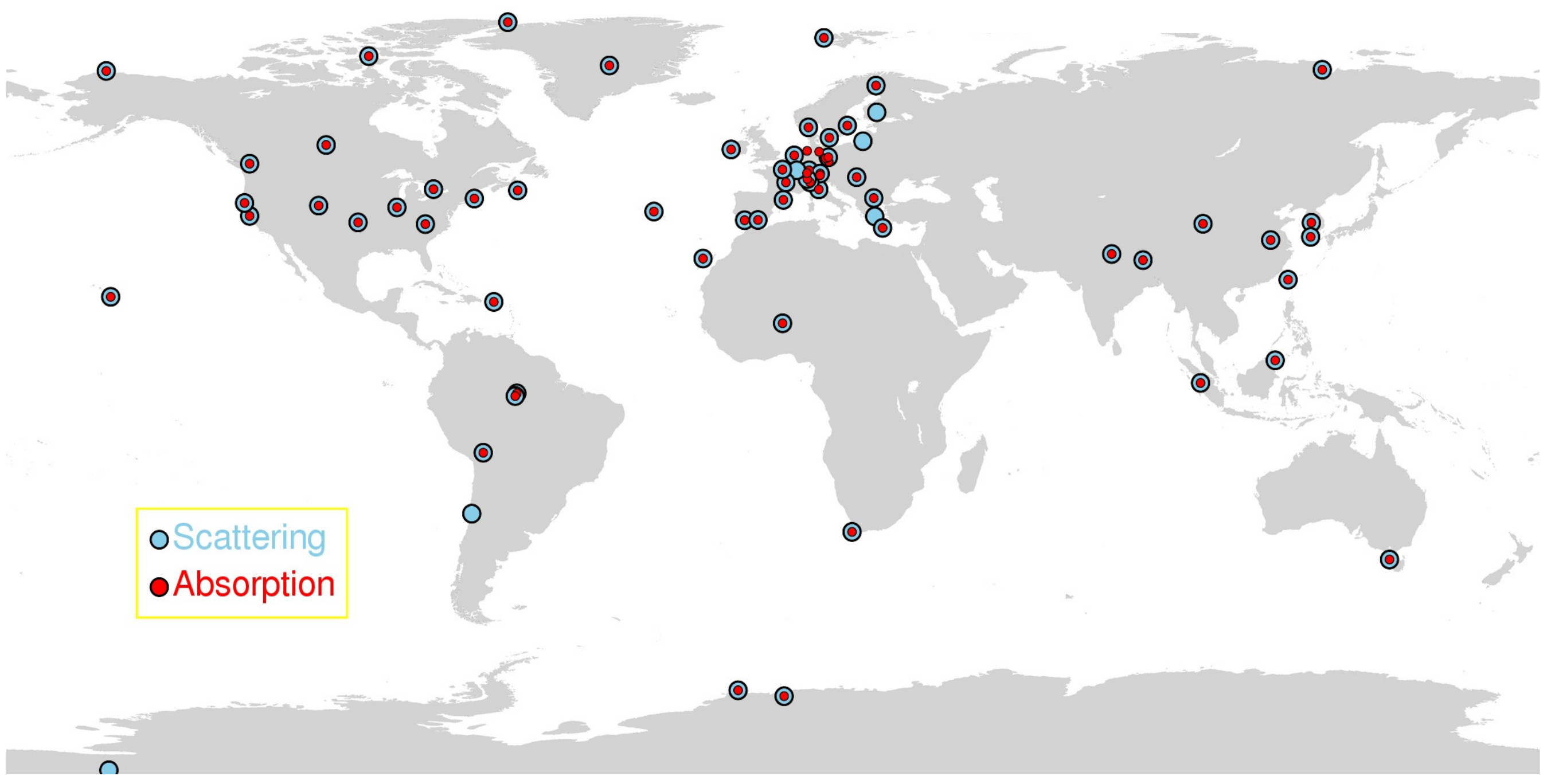

Figure 2. Geographical distribution of over 75 sites contributing in-situ measured aerosol optical properties

MODEL OUTPUT

Tale 1. Models contributing runs to the AeroCom INSITU comparison proejct

Model Name	Research Institution	Gridbox size
CAM5	PNNL	2.4° x 0.9°
ECHAM6-SALSA	FMI	1.8° x 0.9°
MERRAero	NASA GSFC	0.6° x 0.3°
OsloCTM2	MetNo	2.8° x 2.8°
GOCART	NASA GSFC	2.5° x 2.0°
MPIHAM	U. Of Oxford	1.8° x 0.9°
SPRINTARS	Kyushu U.	1.1° x 1.1°
TM5	KNMI	3° x 2°

- Modelers provided model output of the following:
  - Dry (0%RH) absorption and extinction @ 440, 550, 870nm
  - Dry asymmetry parameter
  - T, P, RH
  - AOD @ 550nm
  - Chemical composition as mass mixing ratio profiles

ANNUAL CLIMATOLOGY: ABSORPTION

- General pattern of absorption similar for models and in-situ measurements
- Biggest differences observed for some high altitude and marine sites

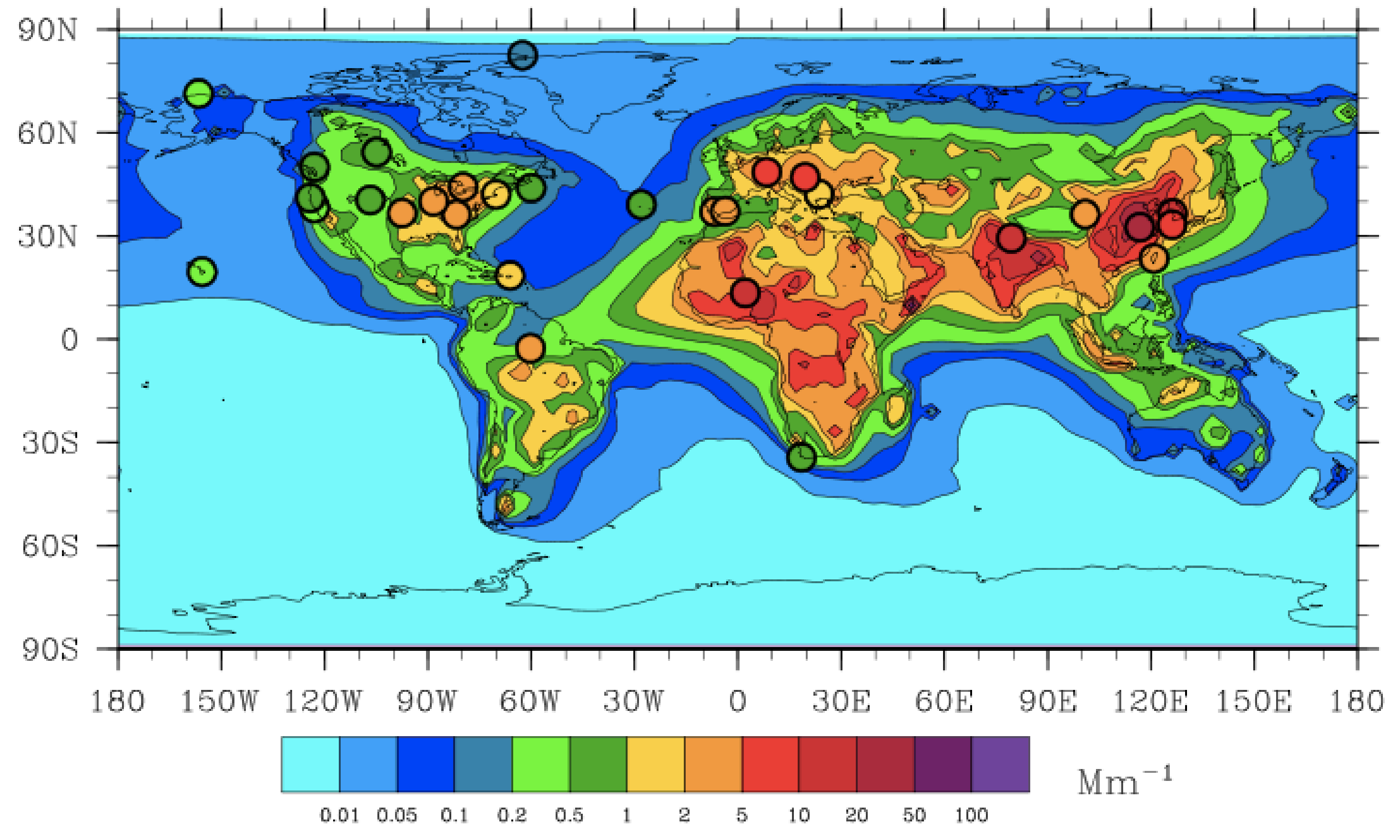

Figure 3. Contour plot of annual mean aerosol absorption from OsloCTM model for year 2008, overlaid by points of in-situ measured annual mean absorption coefficient (not all sites included here)

AEROSOL SEASONALITY: ABSORPTION

- Models do not capture seasonality of aerosol absorption at many sites
- Discrepancies in seasonality may help identify issues with model emissions, transport and/or atmospheric processing

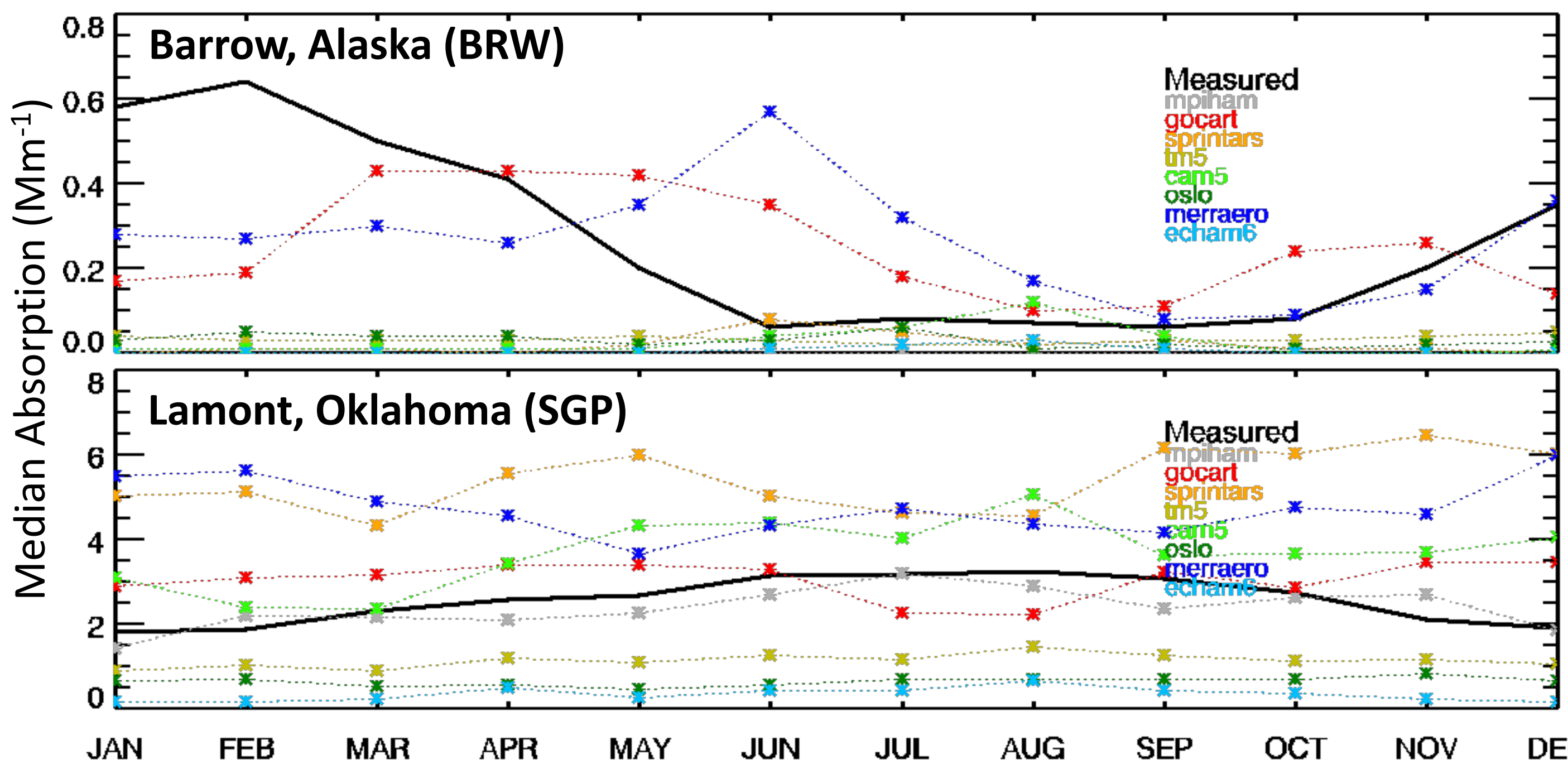

Figure 4. Modeled and measured annual cycles of aerosol absorption at BRW and SGP monitoring stations

ANNUAL CLIMATOLOGY: SSA

- Models tend to predict lower SSA than in-situ observations
- No obvious dependence on model grid size

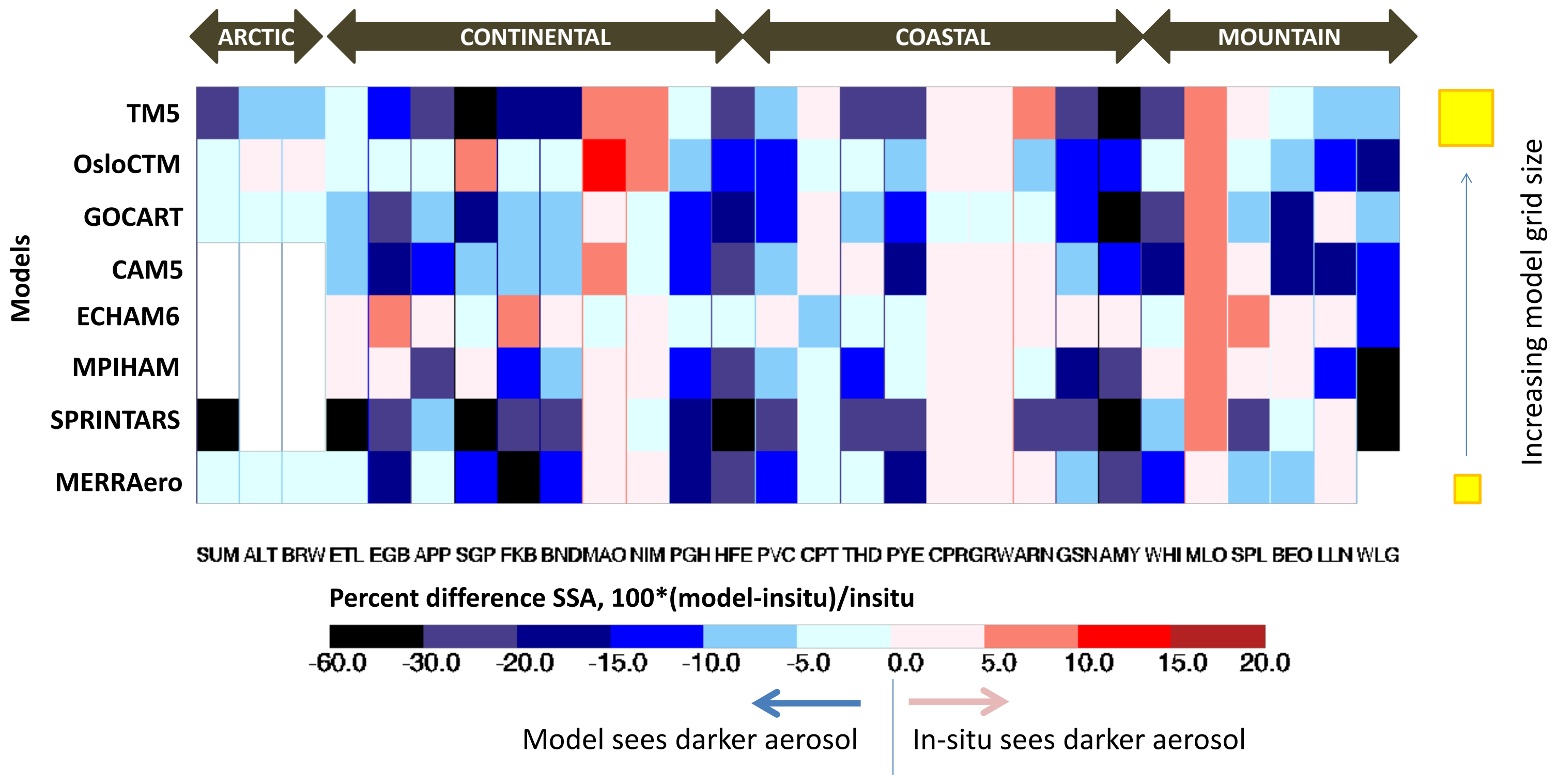

Figure 5. Quilt plot of percentage difference in SSA between modeled and measured optical parameters

WHAT'S NEXT?

- More AeroCom models committed to providing data for analysis
- Benchmark dataset of in-situ measured aerosol optical parameters will be publically available
- Tier II (trend) and Tier III (hygroscopicity) analysis to come
- Results from Tiers I and II will inform perturbation runs for further diagnosis of model biases

References

Schwarz et al., (2013). Global-scale seasonally resolve black carbon vertical profiles over the Pacific. GRL, vol. 40, 5542-5547.

Shindell et al., (2008). A multi-model assessment of pollution transport to the Arctic. Atmos. Chem. Phys., 8, 5353-5372.

Skeie et al., (2011). Black carbon in the atmosphere and snow, from pre-industrial times until present. Atmos Chem. Phys., 11, 6809-6836.

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