Progress report on multi-model results for for HTAP2 assessment

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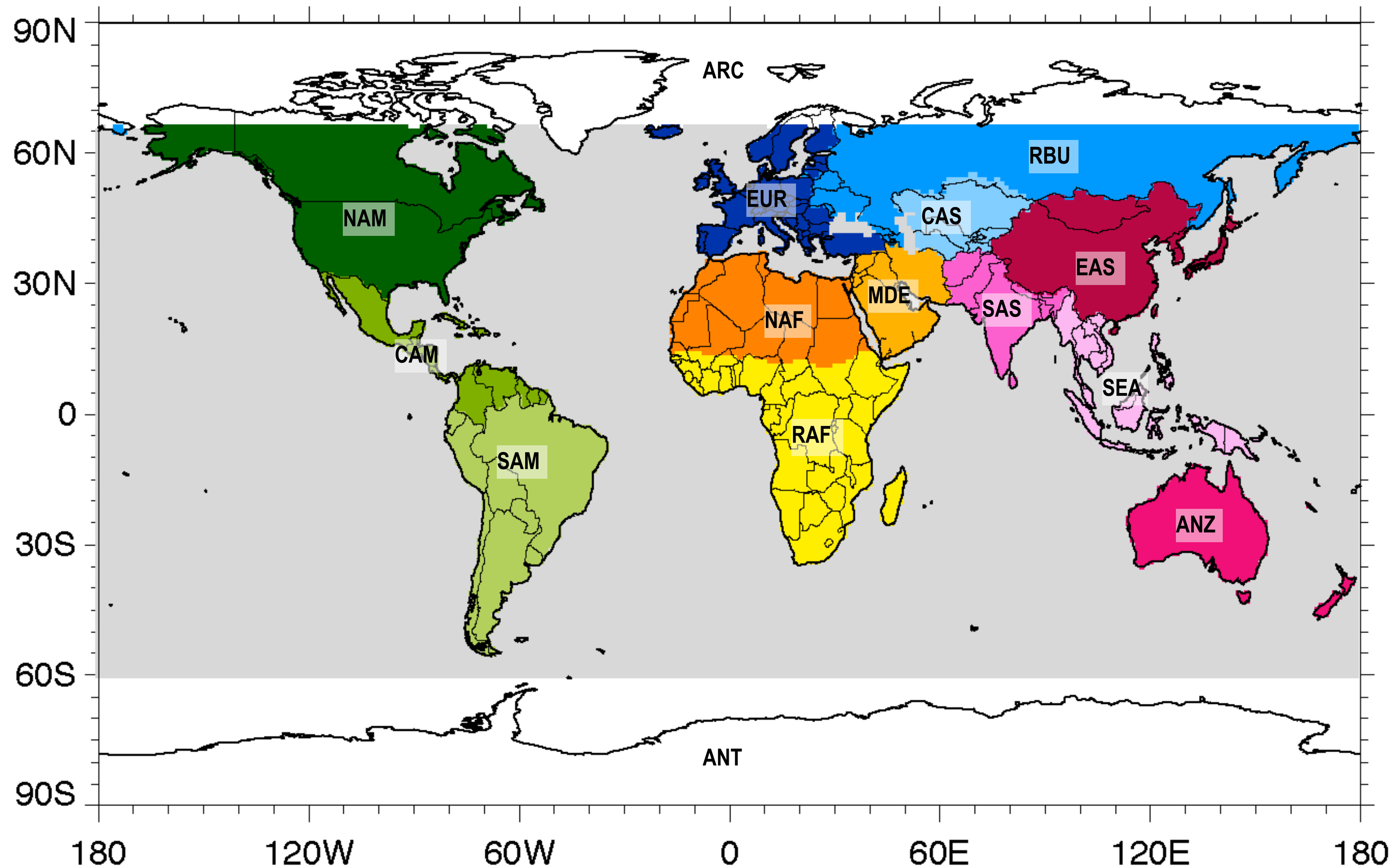
A few words about HTAP2

- Hemispheric transport of air pollution (HTAP) is a UN TF HTAP coordinated international assessment activity
- 2nd phase (HTAP2) Objectives include:
  - Examine the transport of aerosols, including anthropogenic, dust, and biomass burning, from source regions to downwind regions
  - Assess the emission and transport impacts on regional and global air quality, ecosystems, public health, and climate
  - Provide information on potential emission mitigation options
- AeroCom is coordinating the HTAP2 aerosol modeling activity
- Models use the same prescribed HTAP anthropogenic emissions and perform base simulations and perturbed regions/source types simulations

HTAP2 Tier 1 regions of interest



Anthropogenic source regions:
NAM, EUR, EAS, SAS, RBU, MDE

Dust source regions:
NAF, CAS, EAS, MDE

Fire source region:
GLO

Report of multi-model aerosol results on:

1. Evaluate model simulated surface aerosol concentrations over North America, Europe, and Asia with available surface measurements
2. Calculate the source attributions in the NH regions of NAM, EUR, SAS, EAS, and ARC (Arctic)
3. Estimate the "Response to extra-regional emission reduction (RERER)"

This analysis is based on model simulations for 2010

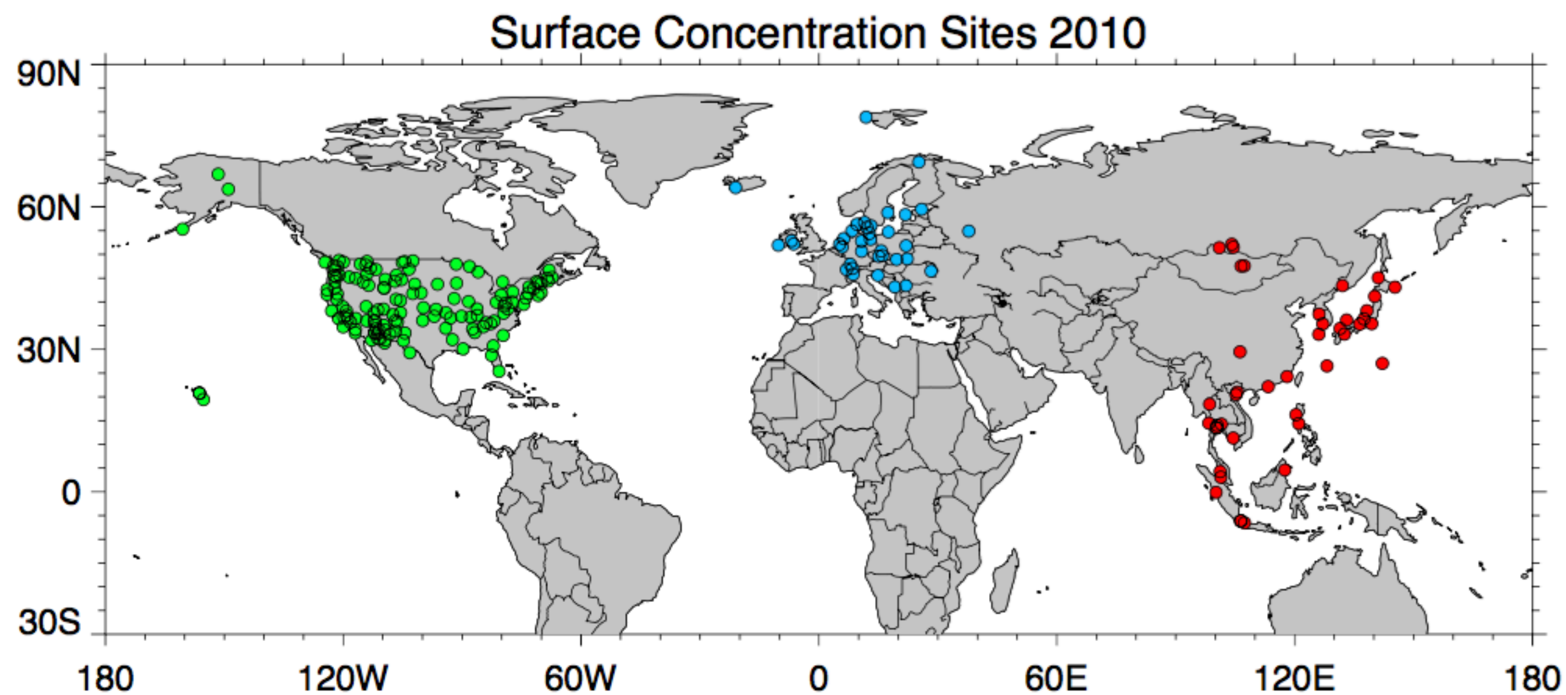
Models with aerosol-relevant results

Models	ID	Institute	Spatial gridcells #lon x #lat x #lev (lon°x lat°)	Simulation period
C-IFS*°	IF	ECMWF, Europe	512 x 256 x 54 (0.7°x0.7°)	2008, 2010
CAMchem°	CA	NCAR, USA	144 x 96 x 56 (2.5°x1.875°)	2008, 2009, 2010
CHASER_re1	C1	Nagoya University, Japan	128 x 64 x 32 (2.8°x2.8°)	2008, 2009, 2010
CHASER_t106	C2	Nagoya University, Japan	320 x 160 x 32 (1.1°x1.1°)	2010
GEOS5	G5	NASA GSFC, USA	288 x 181 x 72 (1.25°x1°)	2008, 2010
GOCARTv5	GO	NASA GSFC, USA	288 x 181 x 72 (1.25°x1°)	2008, 2010
OsloCTM3.v1°	OS	CICERO, Norway	128 x 64 x 60 (2.8°x2.8°)	2010
SPRINTARS	SP	Kyushu University, Japan	320 x 160 x 56 (1.1°x1.1°)	2008, 2009, 2010

*Only used in model evaluation because incomplete information submitted for source attribution and RERER

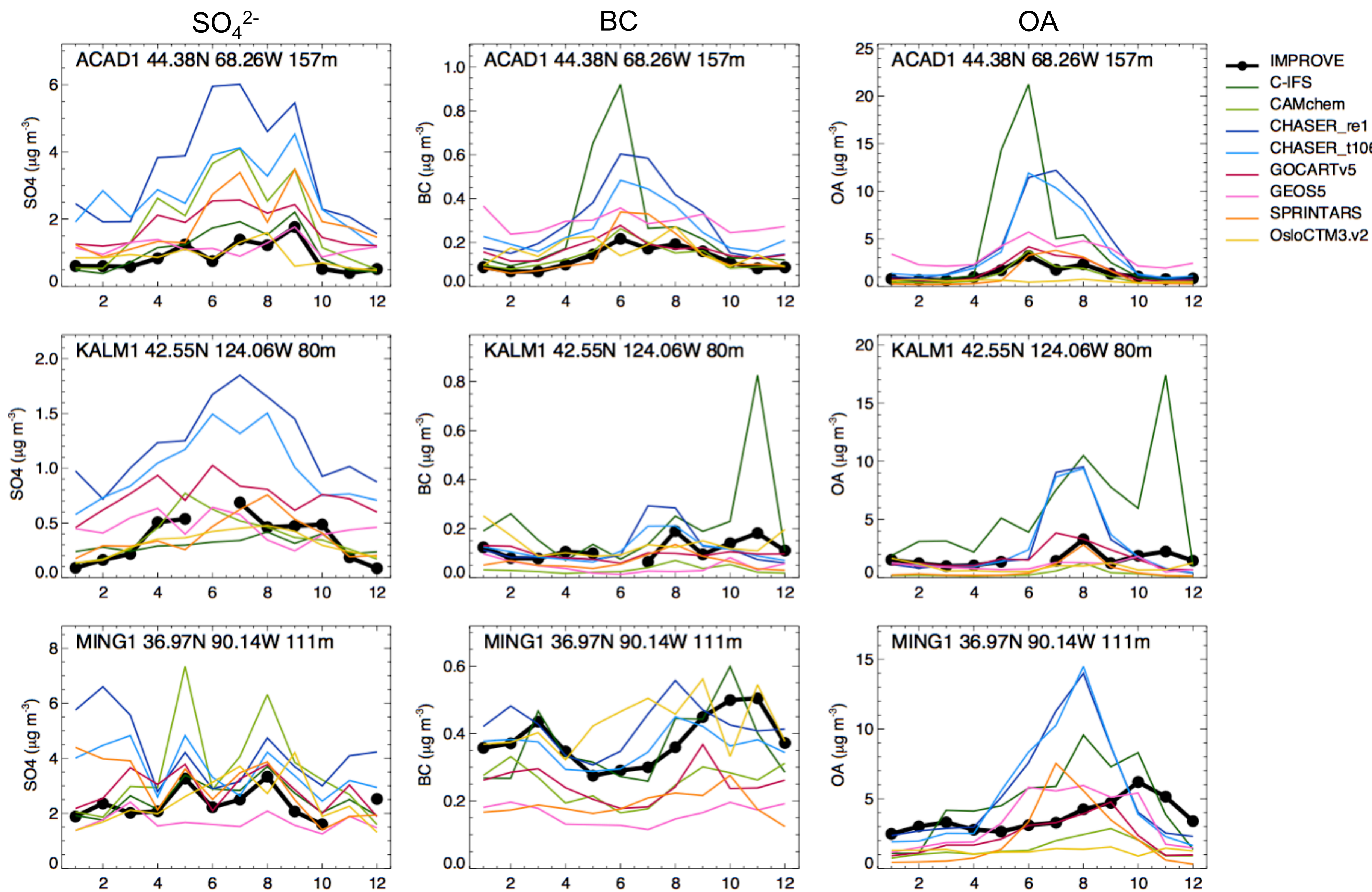
°No od550aer submitted

1a. Comparisons between measured and model simulated surface concentrations in North America, Europe, and Asia

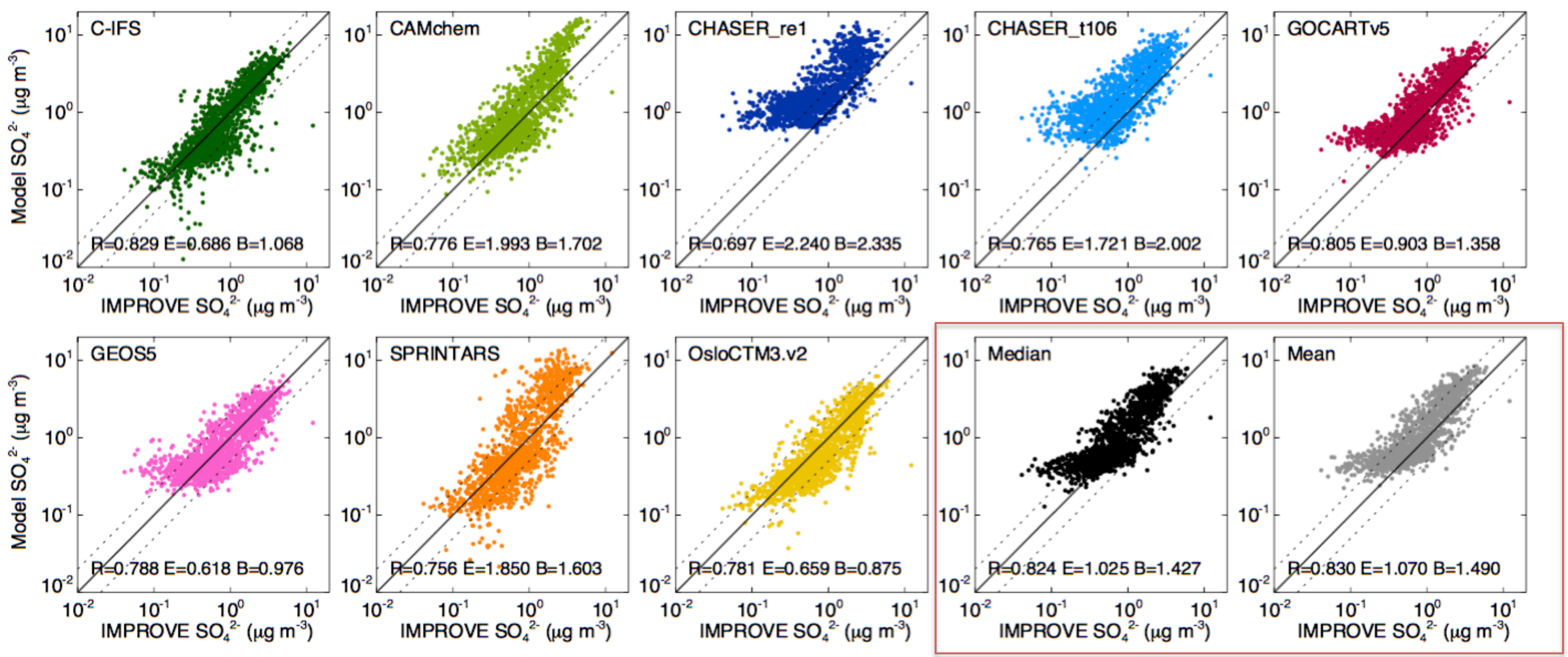


North America: 140 IMPROVE network sites, BC, OM, SO_4^{2-}
Europe: 37 EMEP network sites, SO_2, SO_4^{2-}
Asia: 42 EANET network sites, SO_2, SO_4^{2-}

IMPROVE 2010 monthly mean

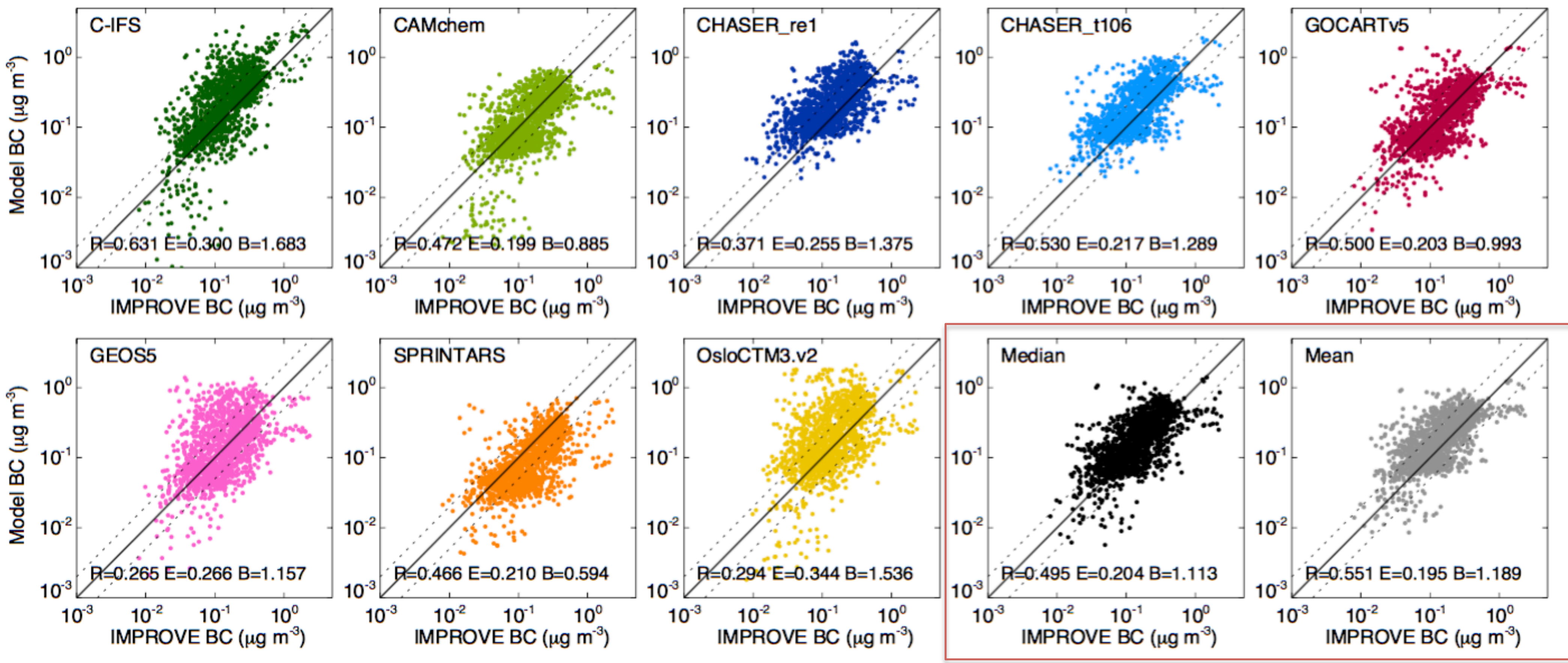


Overall comparisons with IMPROVE SO_4^{2-}



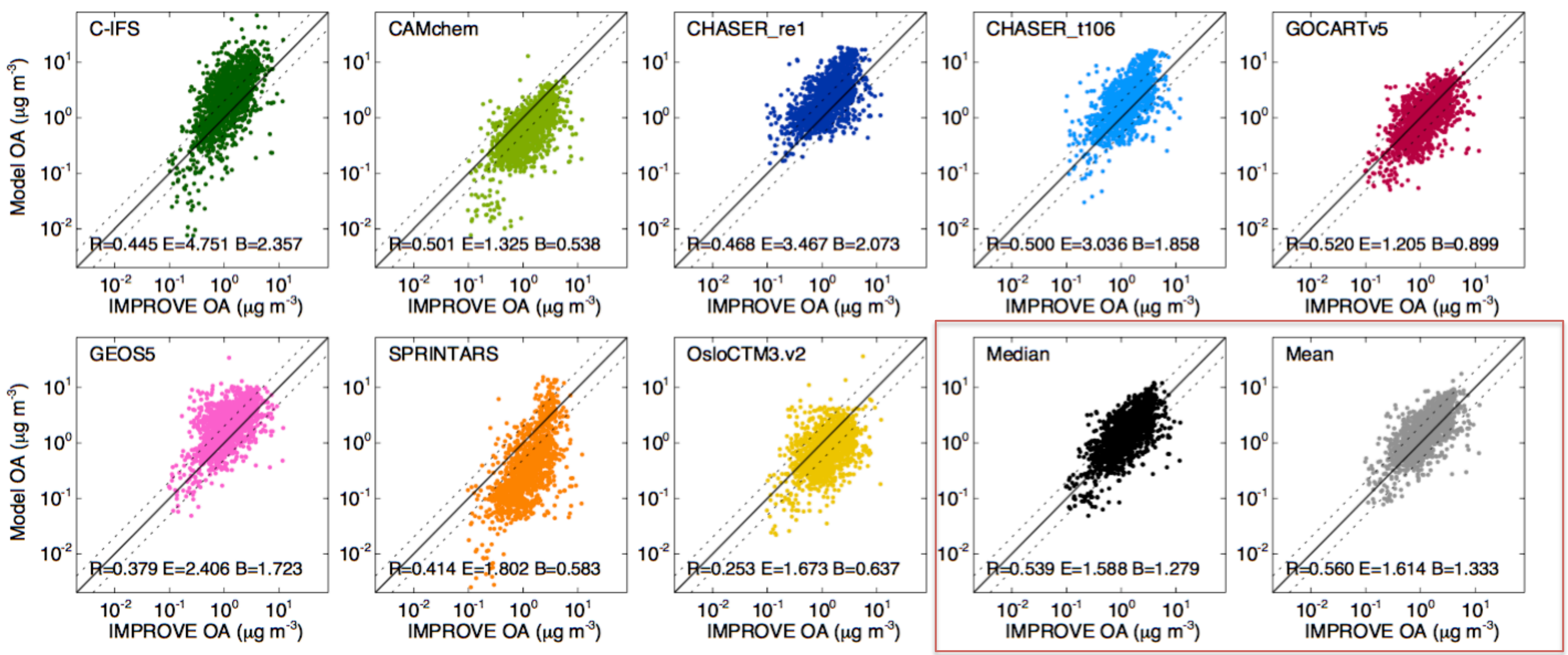
- R=0.7-0.9, B=0.9-2
- Models show similar features (e.g., more overestimate at lower concentrations

Overall comparisons with IMPROVE BC



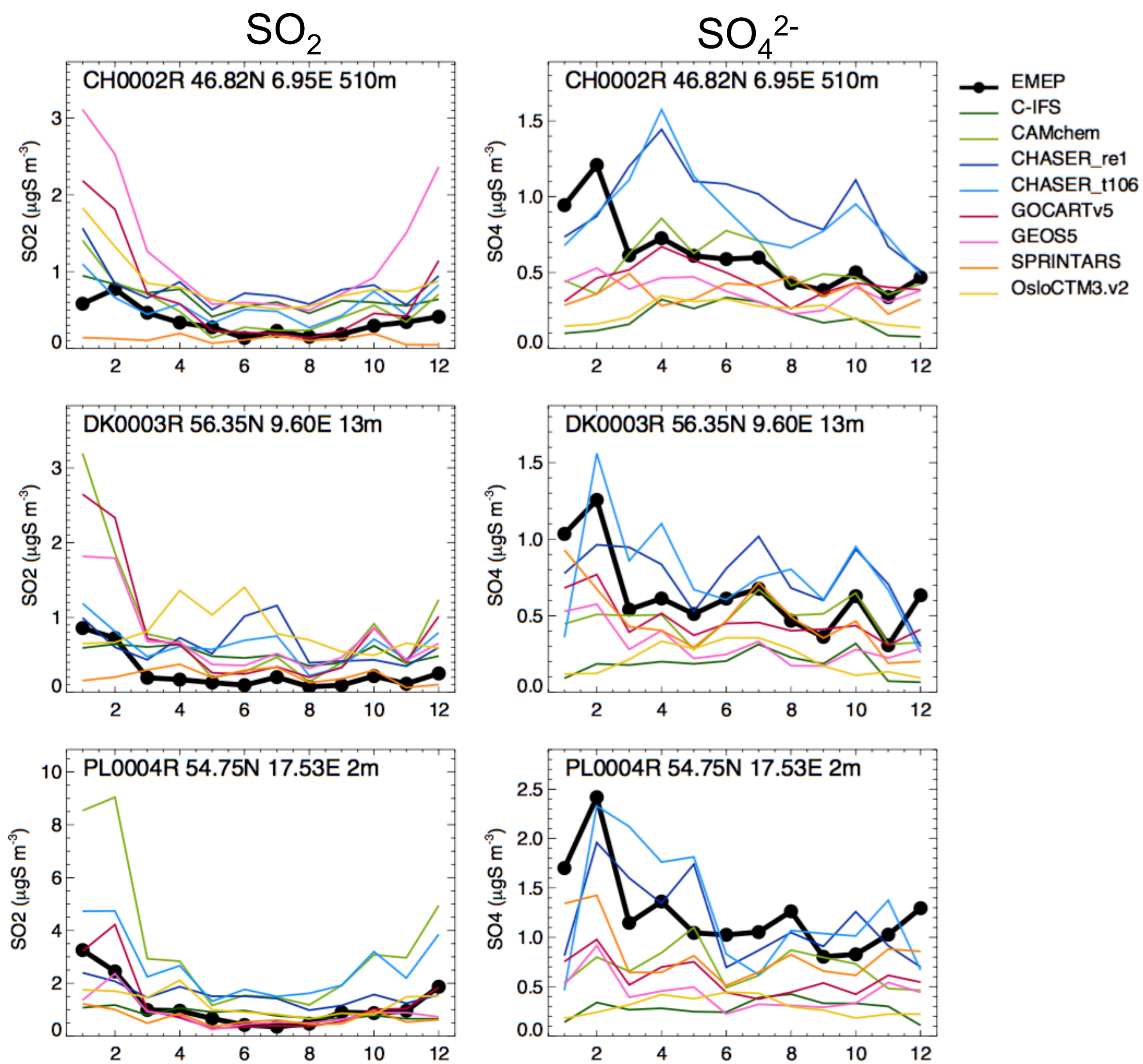
- R=0.3-0.5, B=0.6-1.5
- Models show similar features (e.g., more underestimate at lower concentrations

Overall comparisons with IMPROVE OA

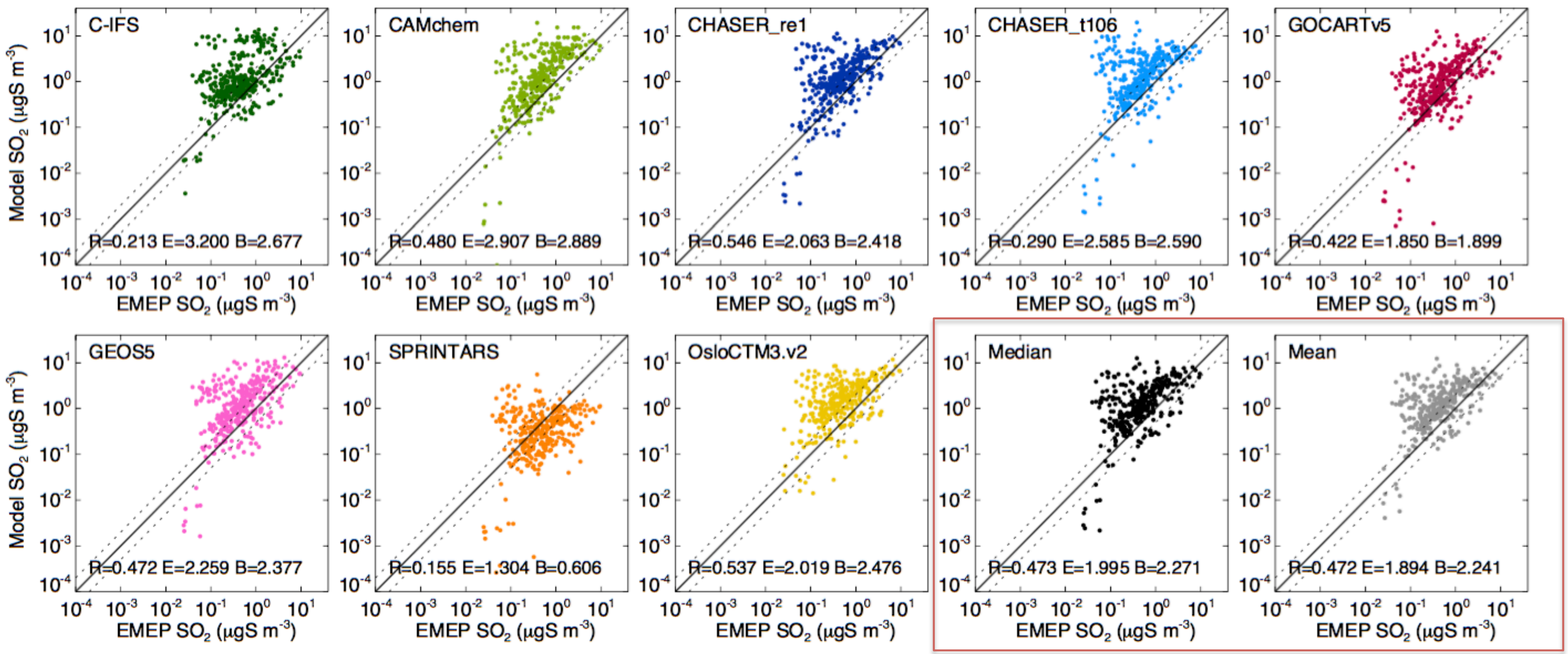


- R=0.3-0.5, B=0.6-2.3
- Models show different behavior of biases

EMEP 2010 monthly mean

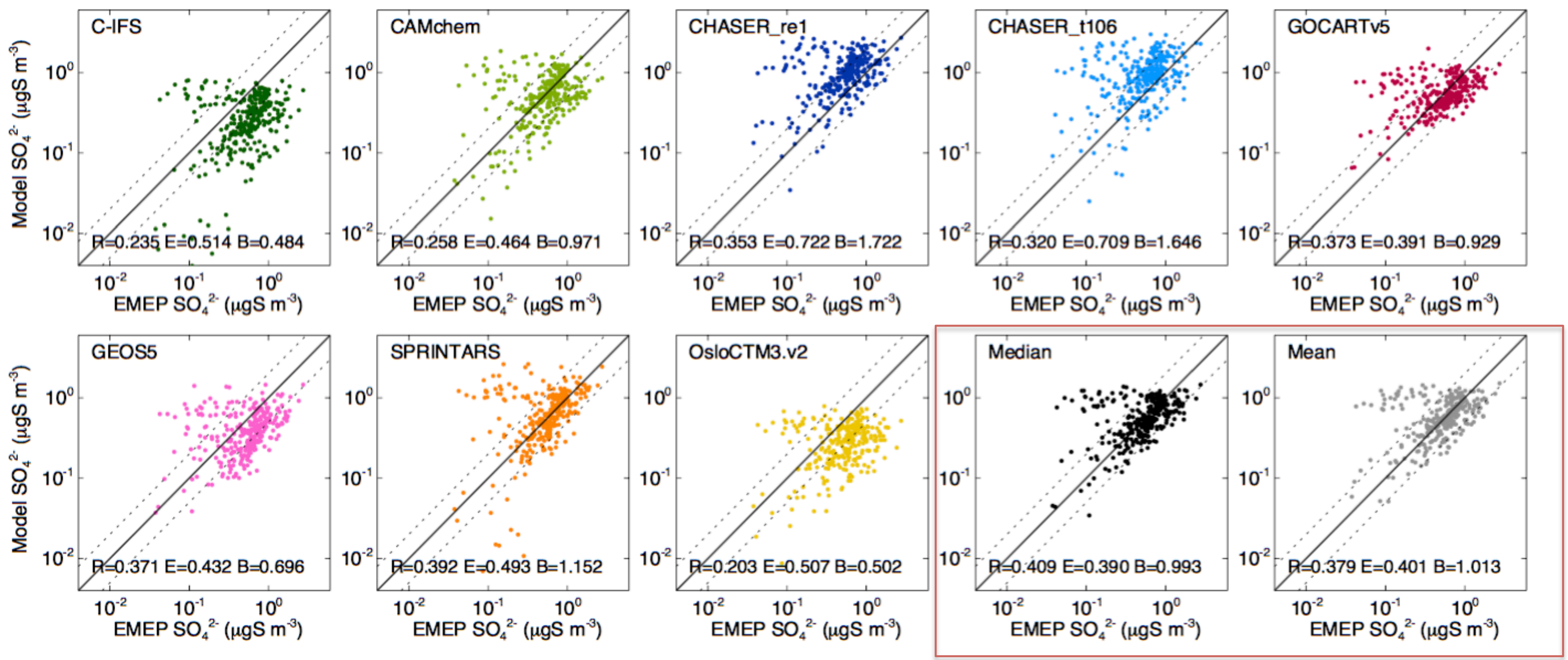


Overall comparisons with EMEP SO_2



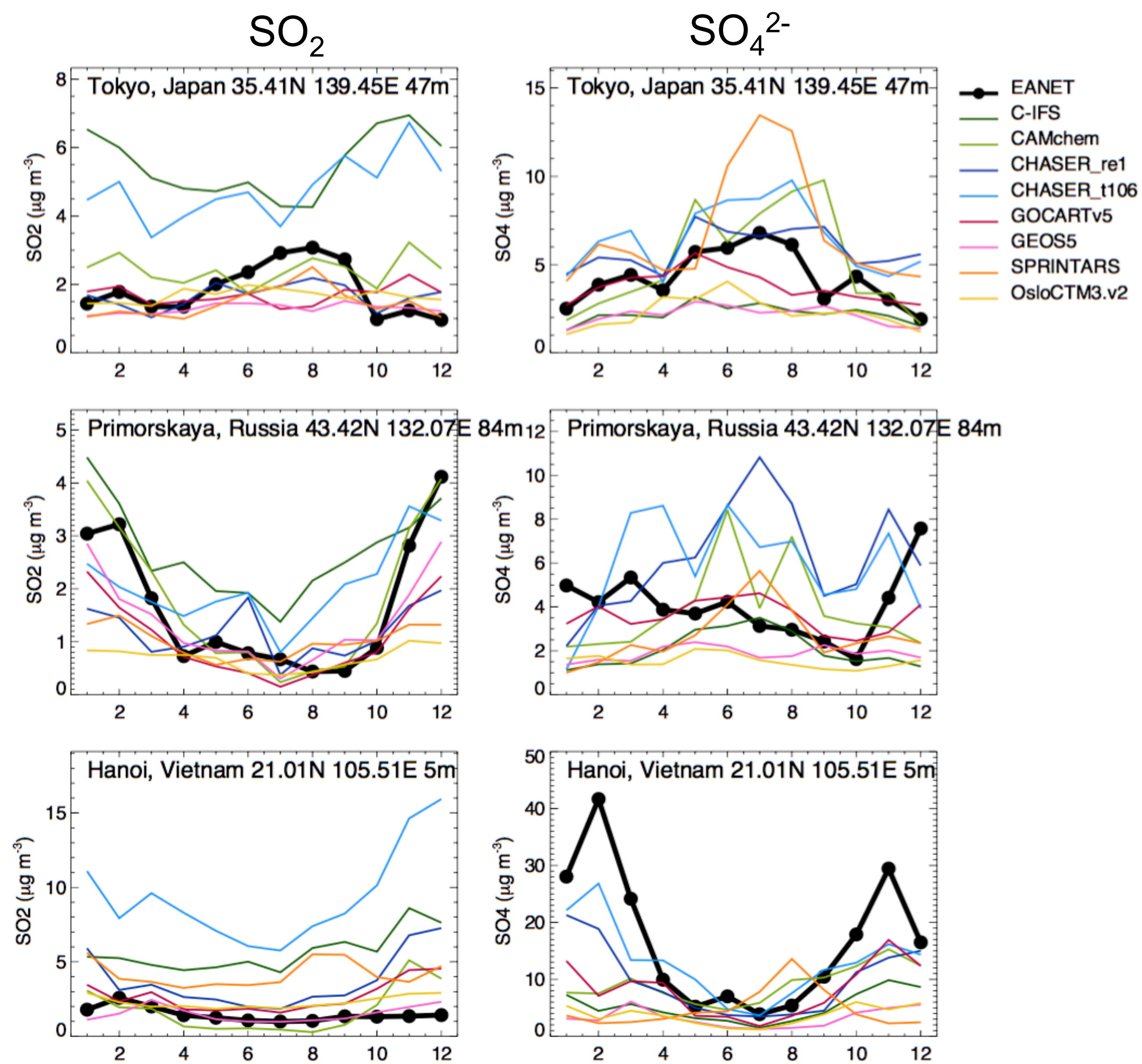
- R=0.2-0.5, B=0.6-2.9
- Models show similar features, e.g, seven models show a factor of 2 overestimation of EMEP SO_2

Overall comparisons with EMEP SO_4^{2-}

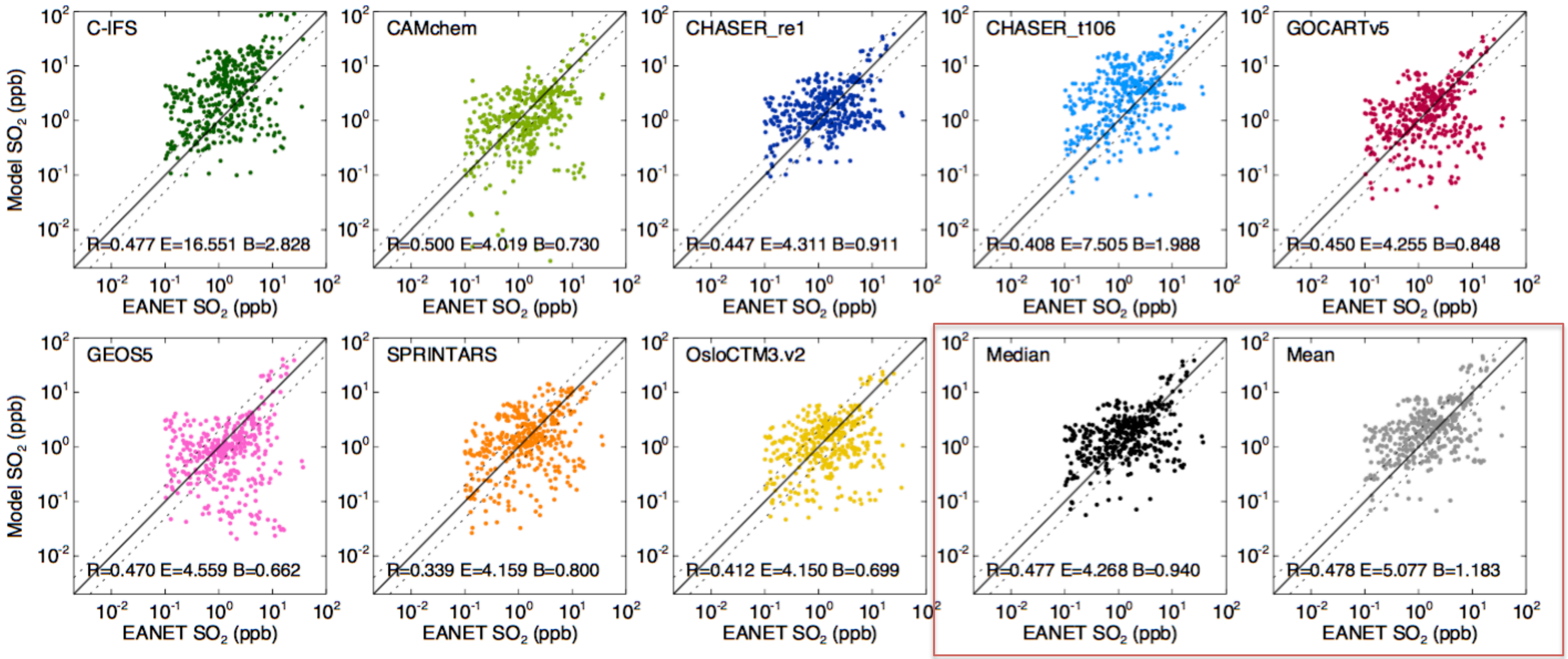


- R=0.3-0.5, B=0.5-1.7
- Models show similar features (e.g. two branches in the scatter plots)

EANET 2010 monthly mean

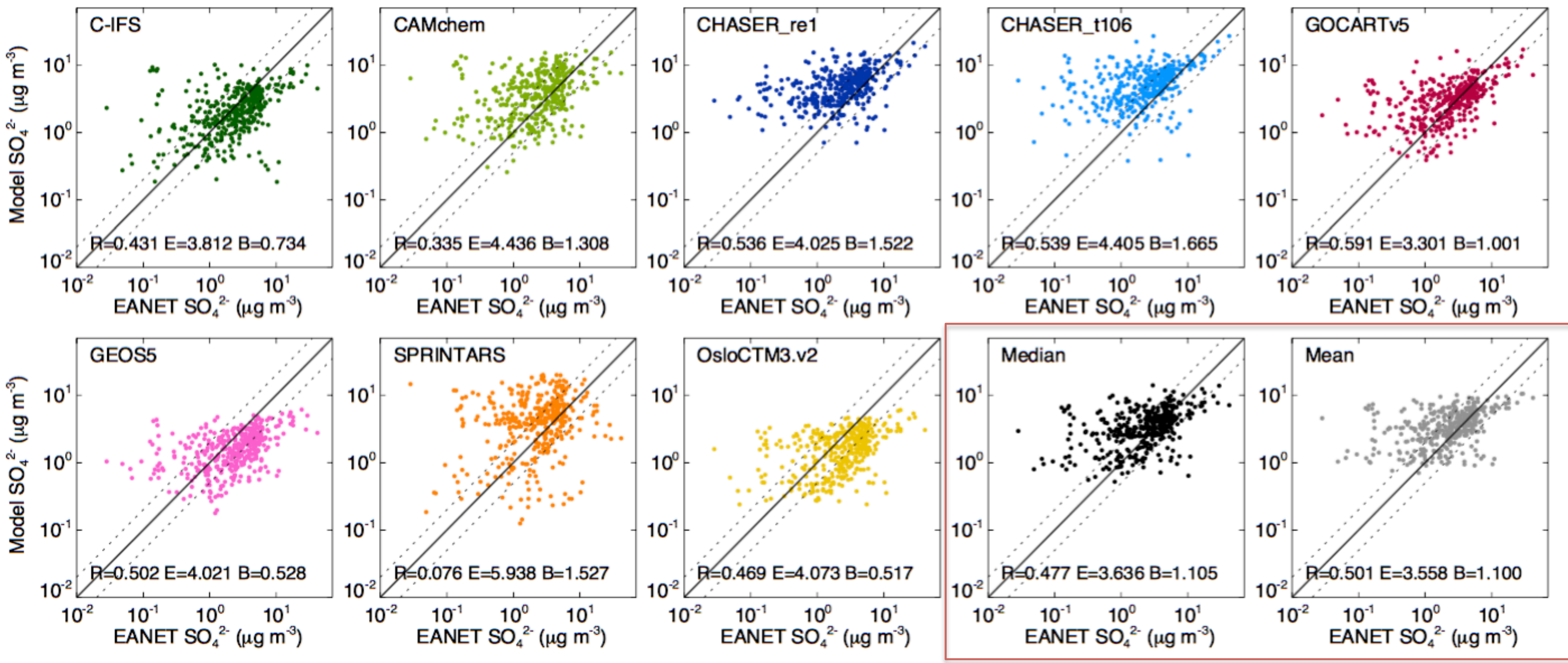


Overall comparisons with EANET SO_2



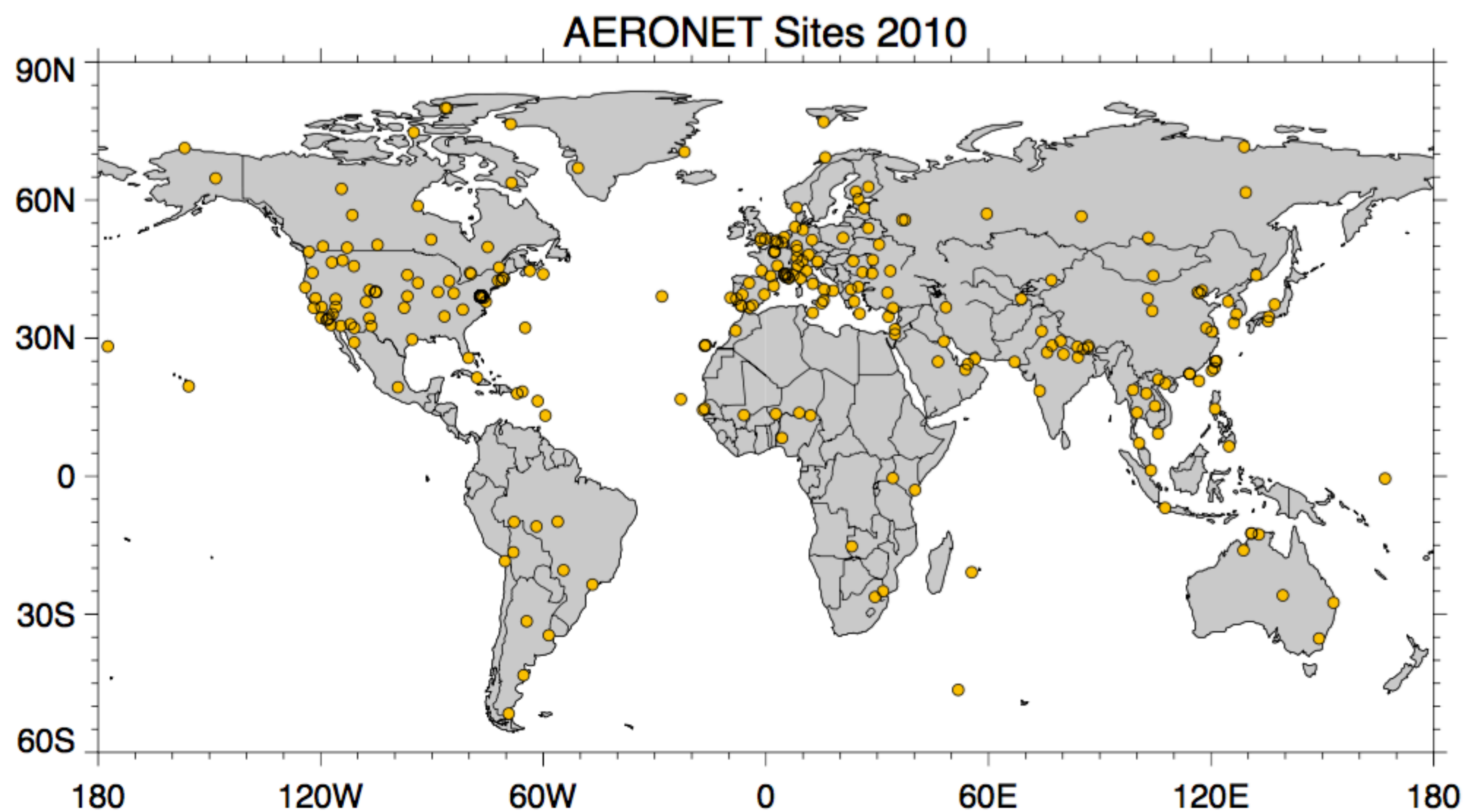
- R=0.3-0.5, B=0.7-3
- Models show similar degree of scatter

Overall comparisons with EANET SO_4^{2-}



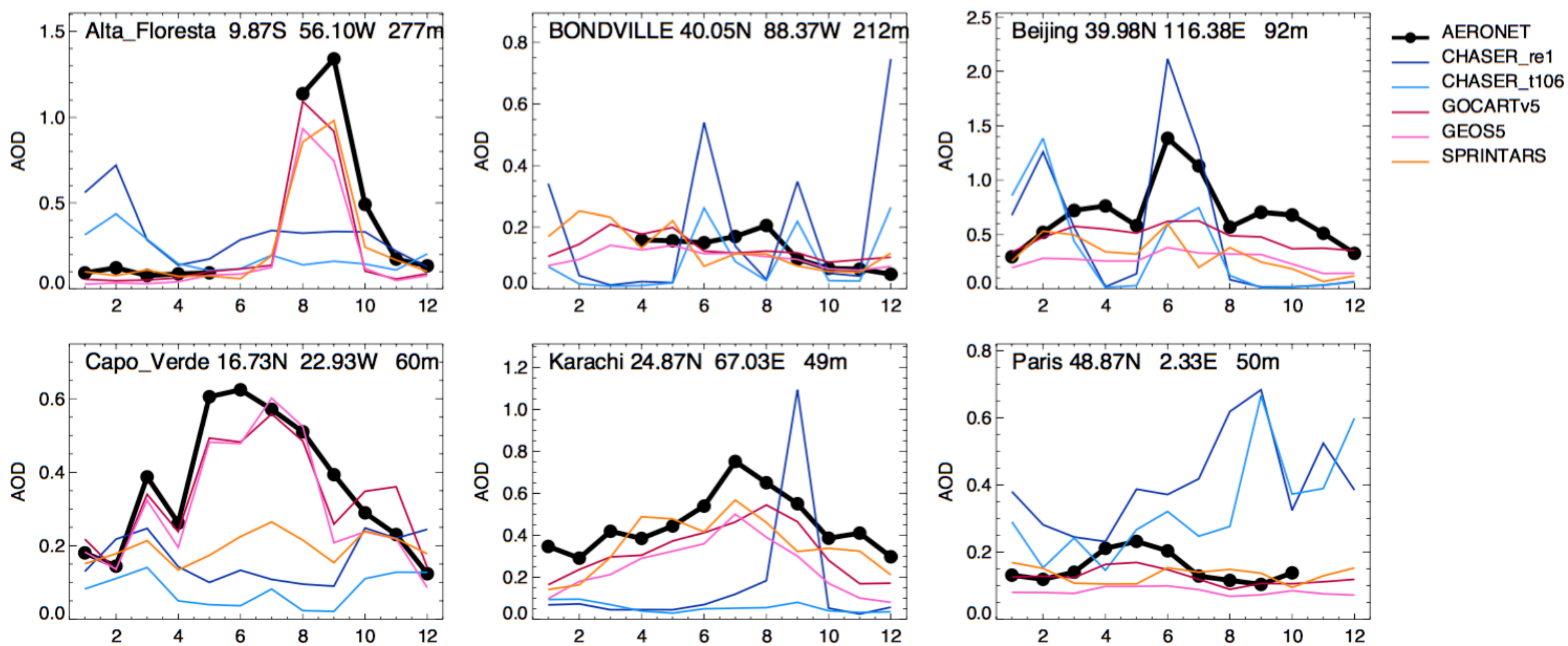
- R=0.3-0.6, B=0.5-1.7
- Most models (except one) show similar scatter and similar feather (high bias at low concentration)

1b. Comparisons between measured and model simulated AOD

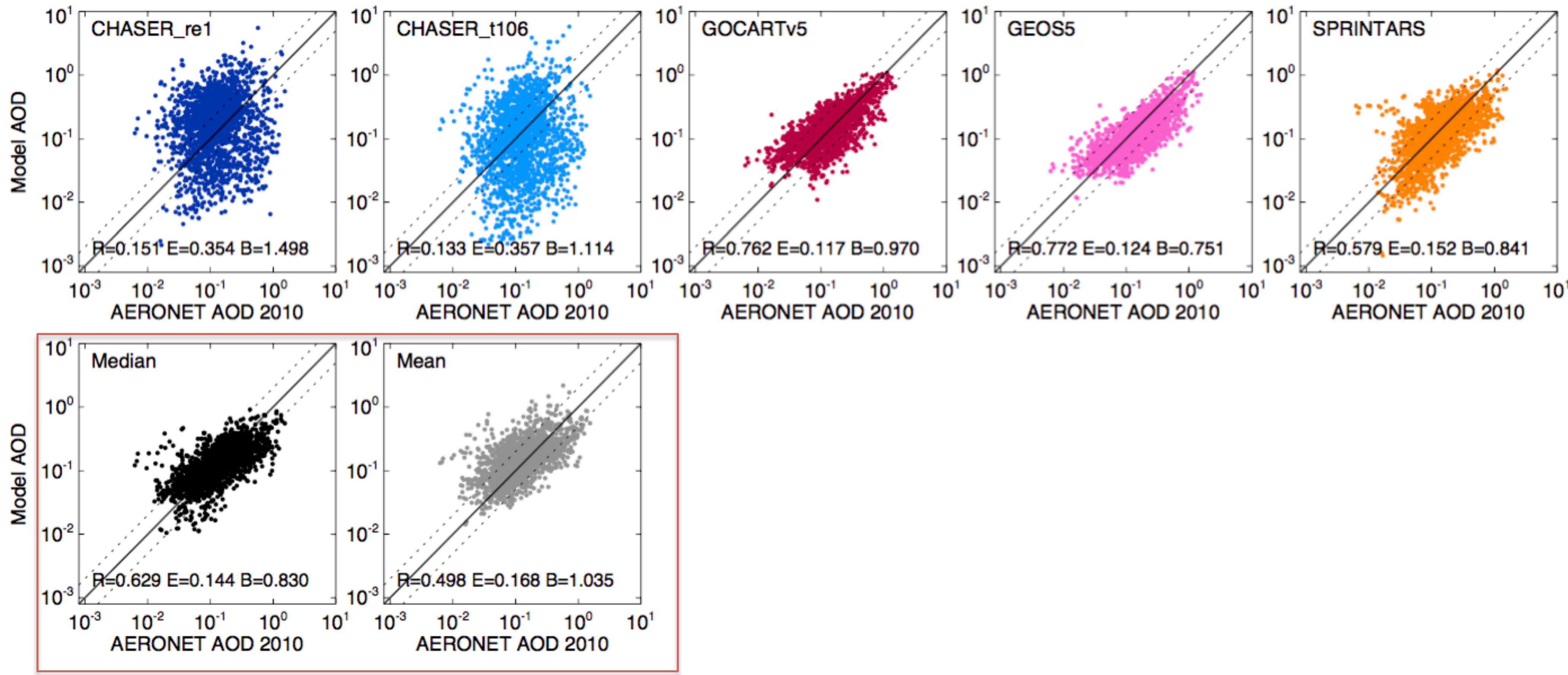


Total 271 sites in 2010 with monthly data

Comparisons of AOD at selected sites

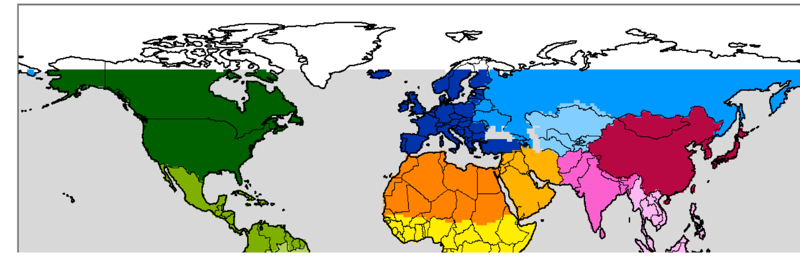


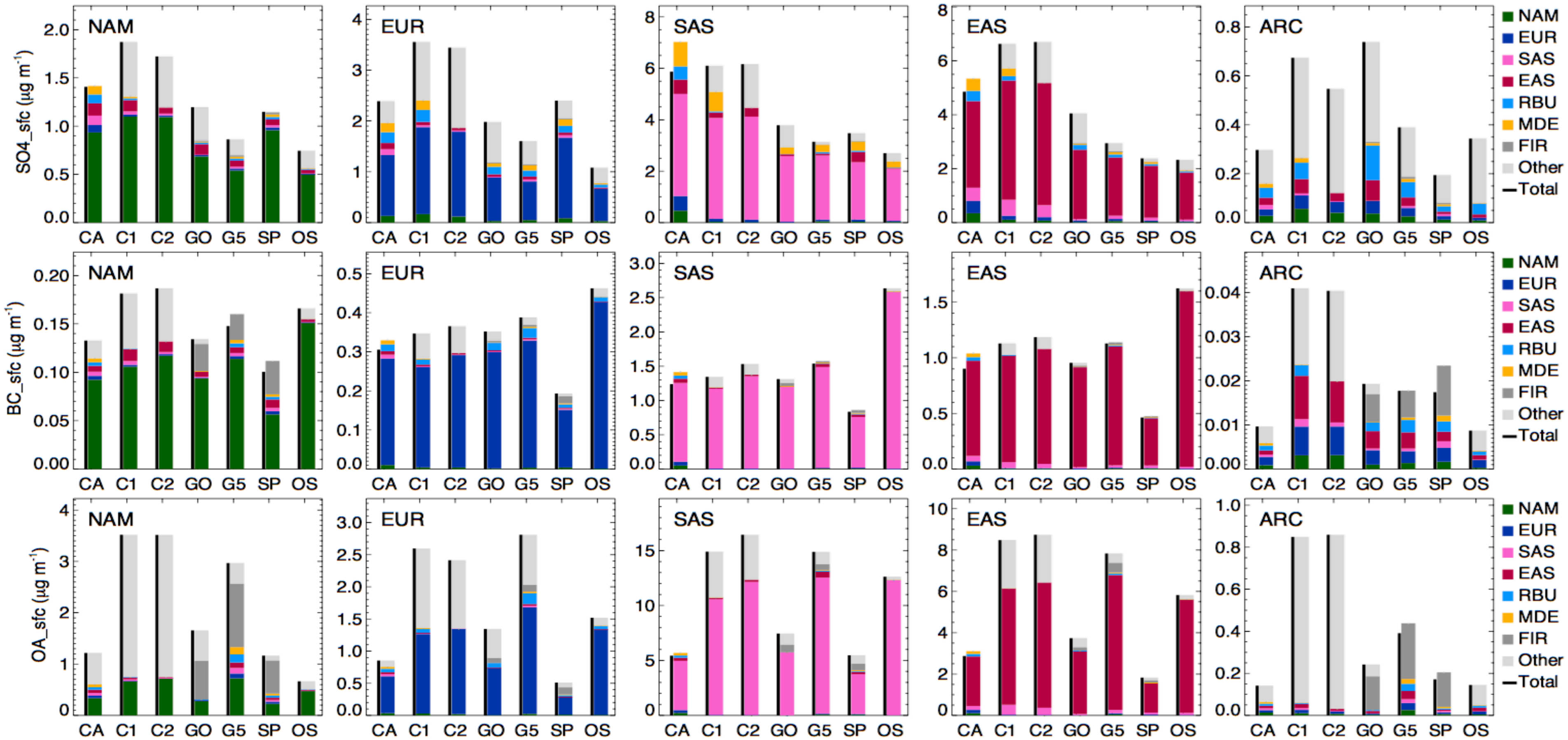
Overall comparisons with AERONET AOD



- 2 CHASER model simulations are significantly different from other 3 models with much more scatter
- R=0.13-0.15 for CHASERS, R=0.6-0.8 for other models, B=0.75-1.5

2. Source Attribution





- Model calculated regional averaged concentrations can differ by a factor of 2 to 5. The model diversity is larger for OA and over the Arctic
- Surface concentrations in the source regions are dominated by regional pollution sources except OA in NAM
- Over the Arctic, NH mid-lat non-BB anthropogenic source contributes to no more than half of the surface aerosol concentrations

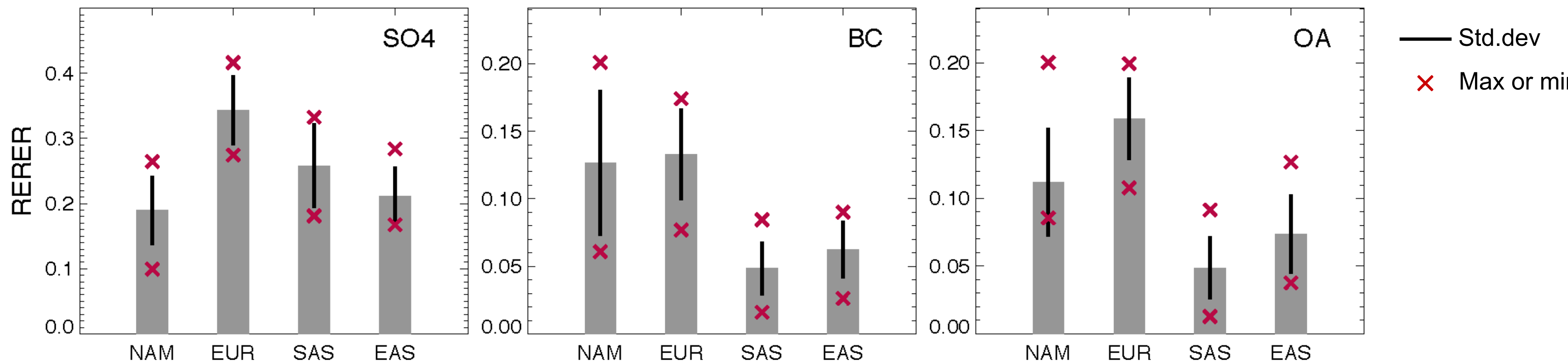
3. Response to extra-regional emission reduction (RERER)

- RERER (or *R*) for each region *i* is the regional concentration change due to the extra-regional emission reduction relative to that due to the global emission reduction (regional + extra regional), which can be written as

$$R_i = \frac{\Delta C_{i,glo} - \Delta C_{i,rgn}}{\Delta C_{i,glo}}$$

- The lower the R_i, the less sensitive the amount within a region to the extra-regional emission reduction (or the more sensitive to the emission reduction within its own region)

Model average RERER for surface concentration



EUR is most sensitive to extra-regional SO_2 emission change

SAS and EAS are least sensitive to extra-regional BC emission change

EUR is most and SAS is least sensitive to extra-regional OA emission change

Summary

- HTAP2 models seem to have considerable improvements over HTAP1 in simulating the surface aerosol concentrations over NH polluted regions
- Although there are still large differences among models in terms of regional averaged sulfate, BC, and OA concentrations, models show a general agreement on source attributions and regional response to extra-regional emission reduction, which is useful for HTAP assessment
- So far only three models have done tagged dust and fire regions – not enough for statistics

Appendix: evaluation statistics at-a-glance

Network data		C-IFS	CAM chem	CHASER_ re1	CHASER_ t106	GOCARTv5	GEOS5	SPRINTARS	OsloCTM3. v2	Median	Mean
CORRELATION COEF. R:											
IMPROVE	BC	0.631	0.472	0.371	0.530	0.500	0.265	0.466	0.294	0.489	0.551
	OA	0.445	0.501	0.468	0.500	0.520	0.379	0.414	0.253	0.539	0.560
	SO_4^{2-}	0.829	0.776	0.697	0.765	0.805	0.788	0.756	0.781	0.824	0.830
EMEP	SO_2	0.213	0.480	0.546	0.290	0.422	0.472	0.155	0.537	0.473	0.472
	SO_4^{2-}	0.235	0.258	0.353	0.320	0.373	0.371	0.392	0.203	0.409	0.379
EANET	SO_2	0.477	0.500	0.447	0.408	0.450	0.470	0.339	0.412	0.477	0.478
	SO_4^{2-}	0.431	0.335	0.536	0.539	0.591	0.502	0.076	0.469	0.477	0.497
AERONET	AOD 550 nm	-999.9	-999.9	0.151	0.133	0.762	0.772	0.579	-999.9	0.629	0.498
RELATIVE BIAS B:											
IMPROVE	BC	1.683	0.885	1.375	1.289	0.993	1.157	0.594	1.536	1.087	1.232
	OA	2.357	0.538	2.073	1.858	0.899	1.723	0.583	0.637	1.277	1.322
	SO_4^{2-}	1.068	1.702	2.335	2.002	1.358	0.976	1.603	0.875	1.427	1.490
EMEP	SO_2	2.677	2.889	2.418	2.590	1.899	2.377	0.606	2.476	2.271	2.241
	SO_4^{2-}	0.484	0.971	1.722	1.646	0.929	0.696	1.152	0.502	0.993	1.013
EANET	SO_2	2.828	0.730	0.911	1.988	0.848	0.662	0.800	0.699	0.940	1.183
	SO_4^{2-}	0.734	1.308	1.522	1.665	1.001	0.528	1.527	0.517	1.103	1.184
AERONET	AOD 550 nm	-999.9	-999.9	1.498	1.114	0.970	0.751	0.841	-999.9	0.830	1.035

- $R \geq 0.7$, $B \leq 20\%$ ($0.833 < B < 1.2$)
- $0.5 \leq R < 0.7$, $20\% \leq B < 50\%$ ($B = 0.677$-0.833, 1.2-1.5)
- $0.3 \leq R < 0.5$, $50\% \leq B < 100\%$ ($B = 0.5$-0.677, 1.5-2)
- $R < 0.3$, $B > 100\%$ ($B < 0.5$ or $B > 2$)