

Assessment of aerosol fields over East Asia modeled by CESM with MOSAIC

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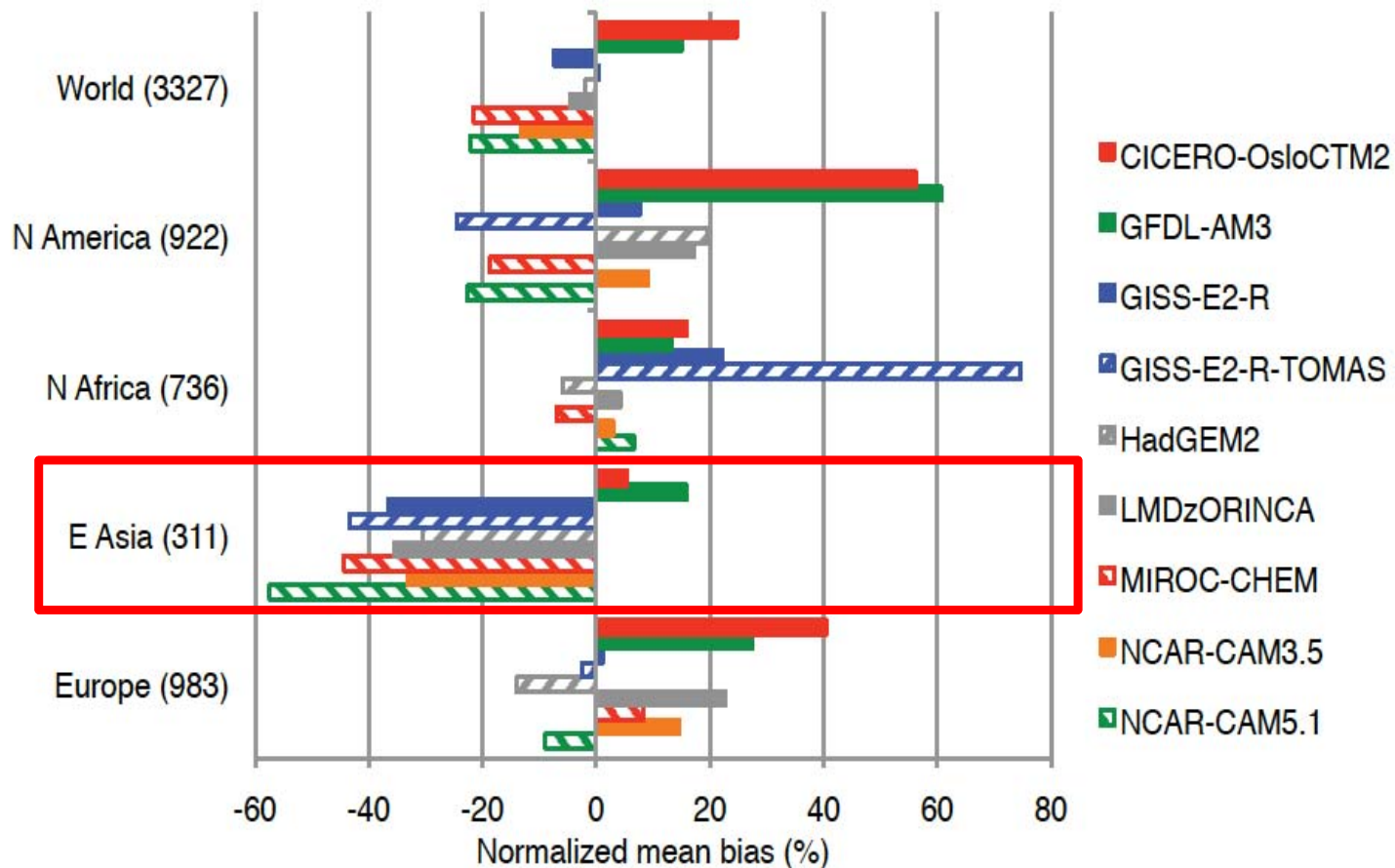
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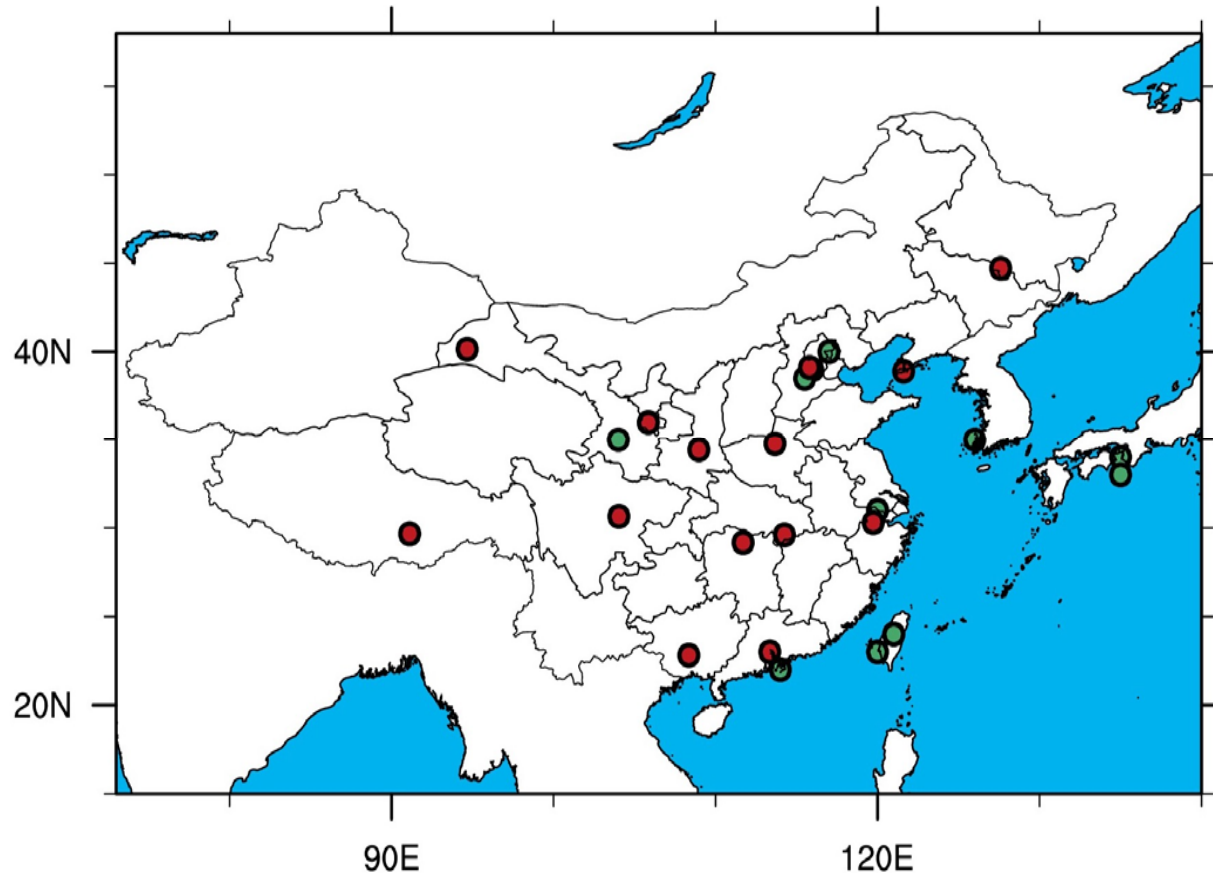
Introduction - Underestimation of AOD in East Asia

Comparison of Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP) models with AERONET AOD



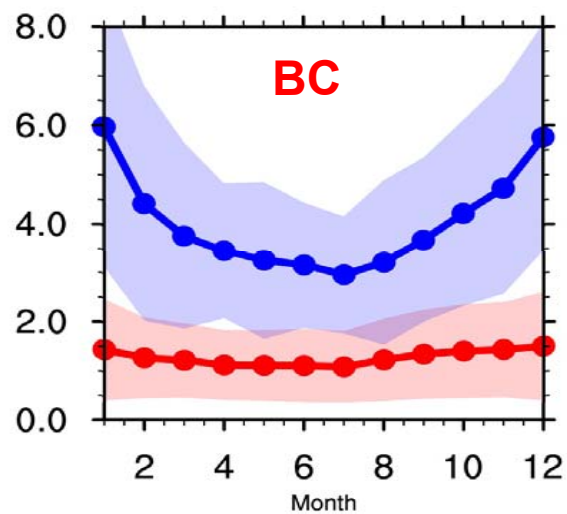
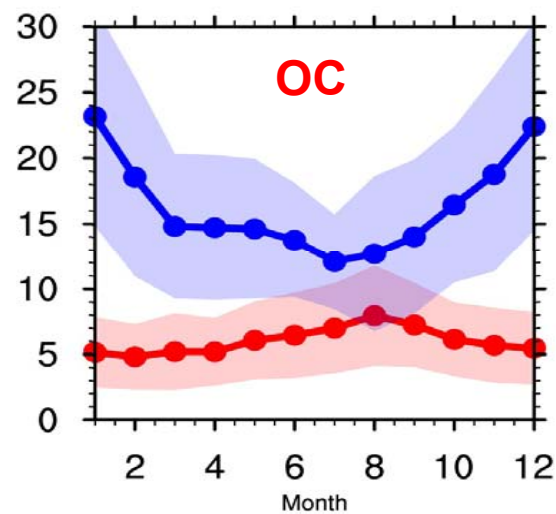
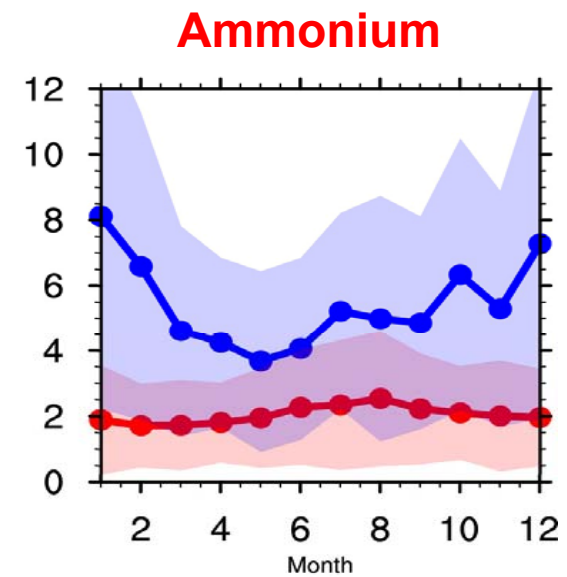
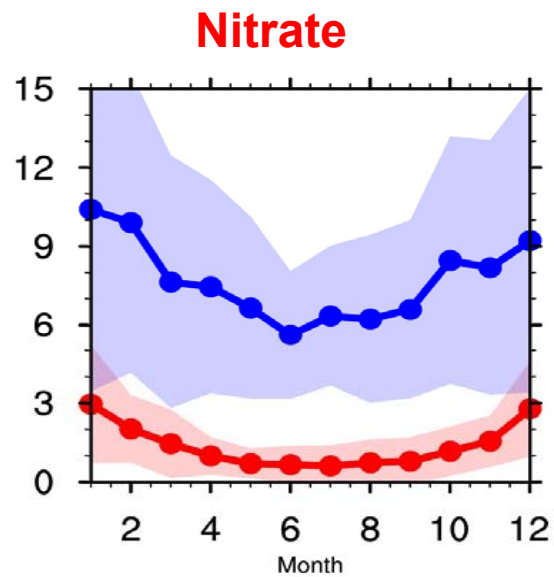
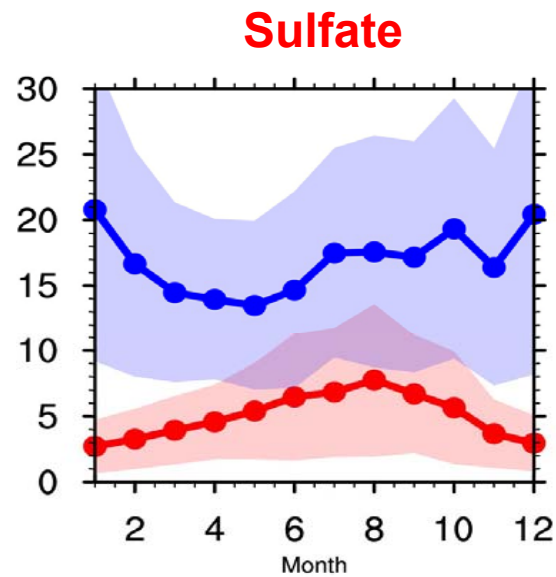
(Shindell et al. 2013)

Introduction – aerosol composition measurements



- **Measured concentrations at surface:** 14 CAWNET sites (**red dots**) of the China Meteorological Administration (CMA) Atmosphere Watch Network (**CAWNET**)
- **AOD measurement:** AERONET (green dots) and satellite observations (MODIS & MISR)

Simulated surface concentrations from ACCMIP models vs. measurements at CAWNET sites



Red: Multi-model mean conc.;

Blue: observed conc.;

Both simulated and measured concentrations are averaged over 14 CAWNET sites

Introduction – possible reasons for underestimation

- Anthropogenic aerosol emissions underestimated?
- Aerosol processes under-represented or missing?
 - Nitrate
 - SOA
 - Dust-sulfate/nitrate chemistry interactions
- GCM model resolution too coarse? Sub-grid variability

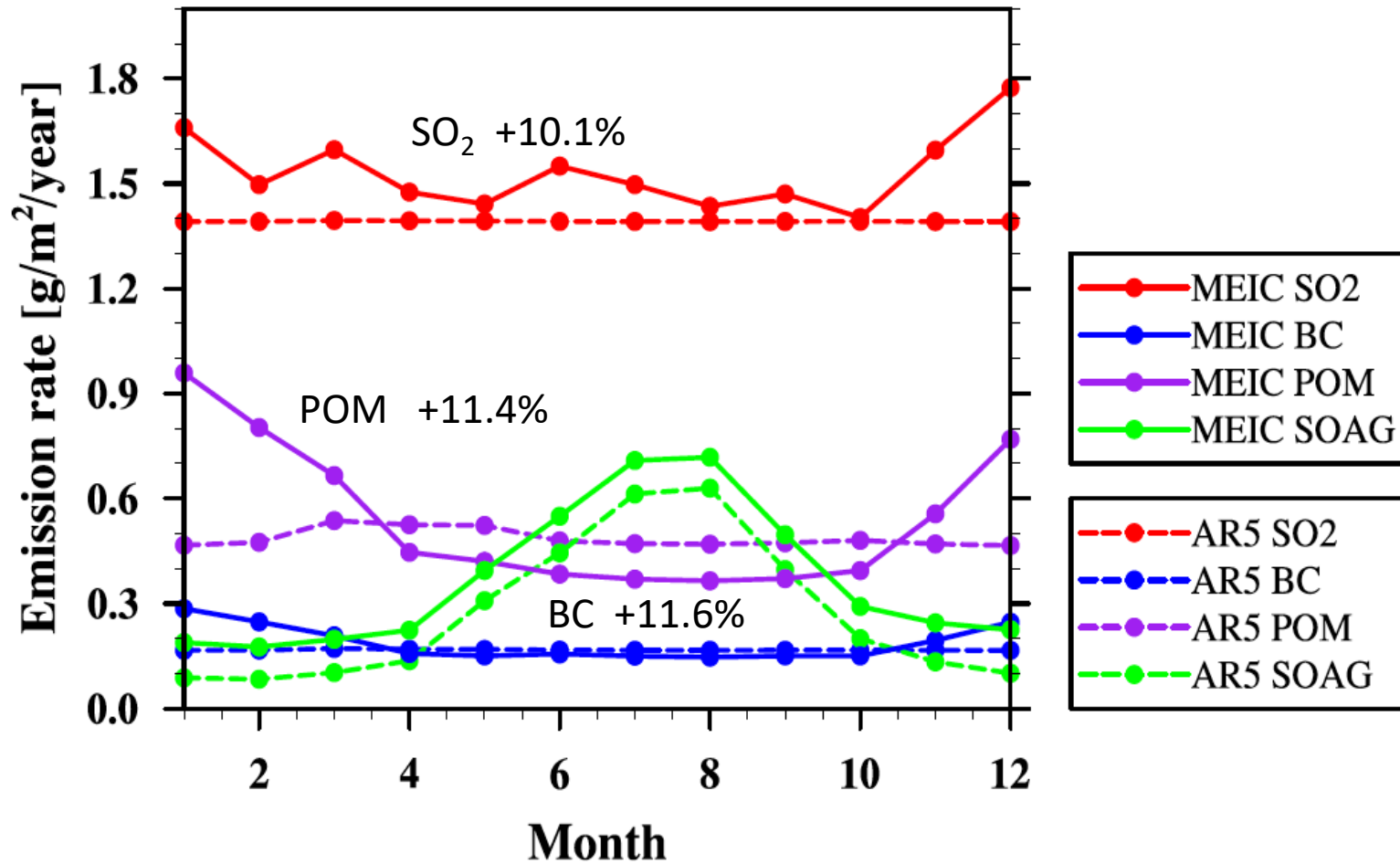
NCAR CAM5.2

- Six-years simulations (2006~2011) nudged by ECMWF re-analysis data
- At $1.9^{\circ} \times 2.5^{\circ}$ resolution

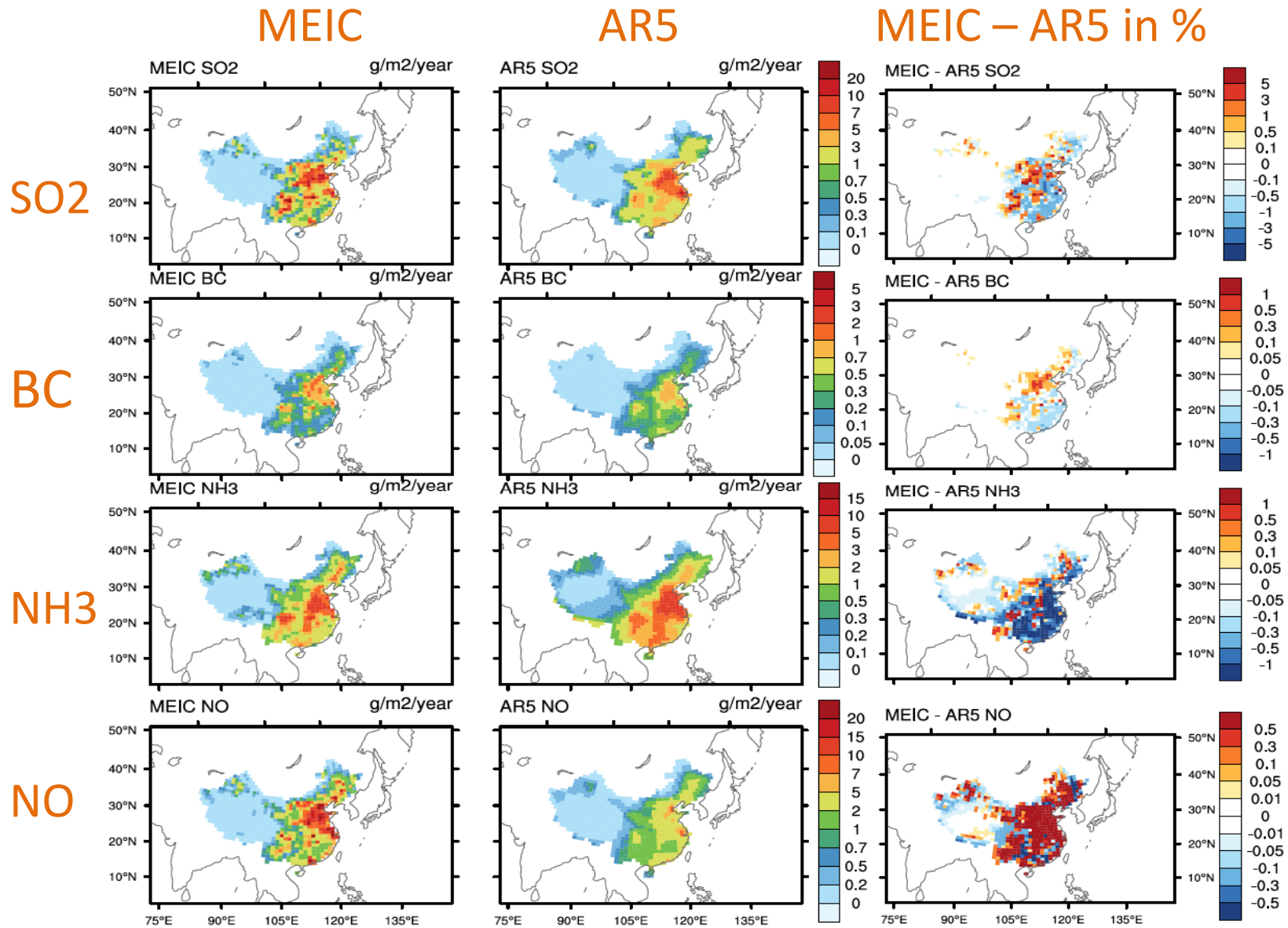
MEIC emissions for China I

- IPCC AR5 emission
 - update every 10 years
 - *no seasonal variation for anthropogenic aerosols*
 - horizontal resolution: $0.5^\circ \times 0.5^\circ$ or model-dependent
 - anthropogenic, biogenic, and biomass burning aerosols
- Multi-scale Emission Inventory for China (MEIC)
 - update every year
 - *seasonal variation*: monthly mean
 - horizontal resolution: $0.25^\circ \times 0.25^\circ$, $0.5^\circ \times 0.5^\circ$, $1^\circ \times 1^\circ$
 - anthropogenic aerosols only

MEIC emissions for China II

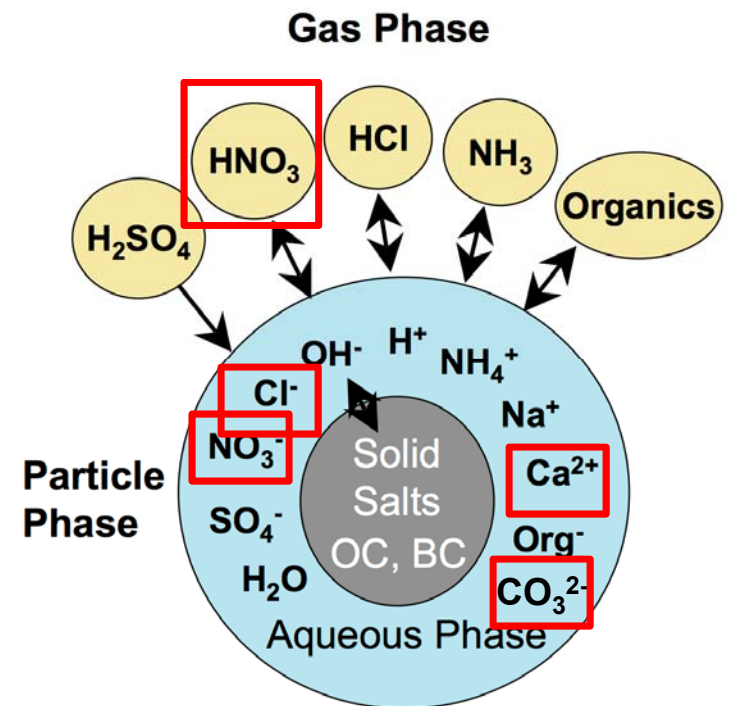


MEIC emissions for China III



Nitrate aerosol in CAM5 I

- In order to treat NO_3 aerosol, [Model for Simulating Aerosol Interactions and Chemistry \(MOSAIC\)](#) module [Zaveri et al., 2008] is coupled with MAM4 and MAM7 (MOSAIC-MAM4/7)
- In the version of MAM coupled with MOSAIC, *gas-aerosol exchange* is treated by MOSAIC. The remaining processes are still treated by MAM



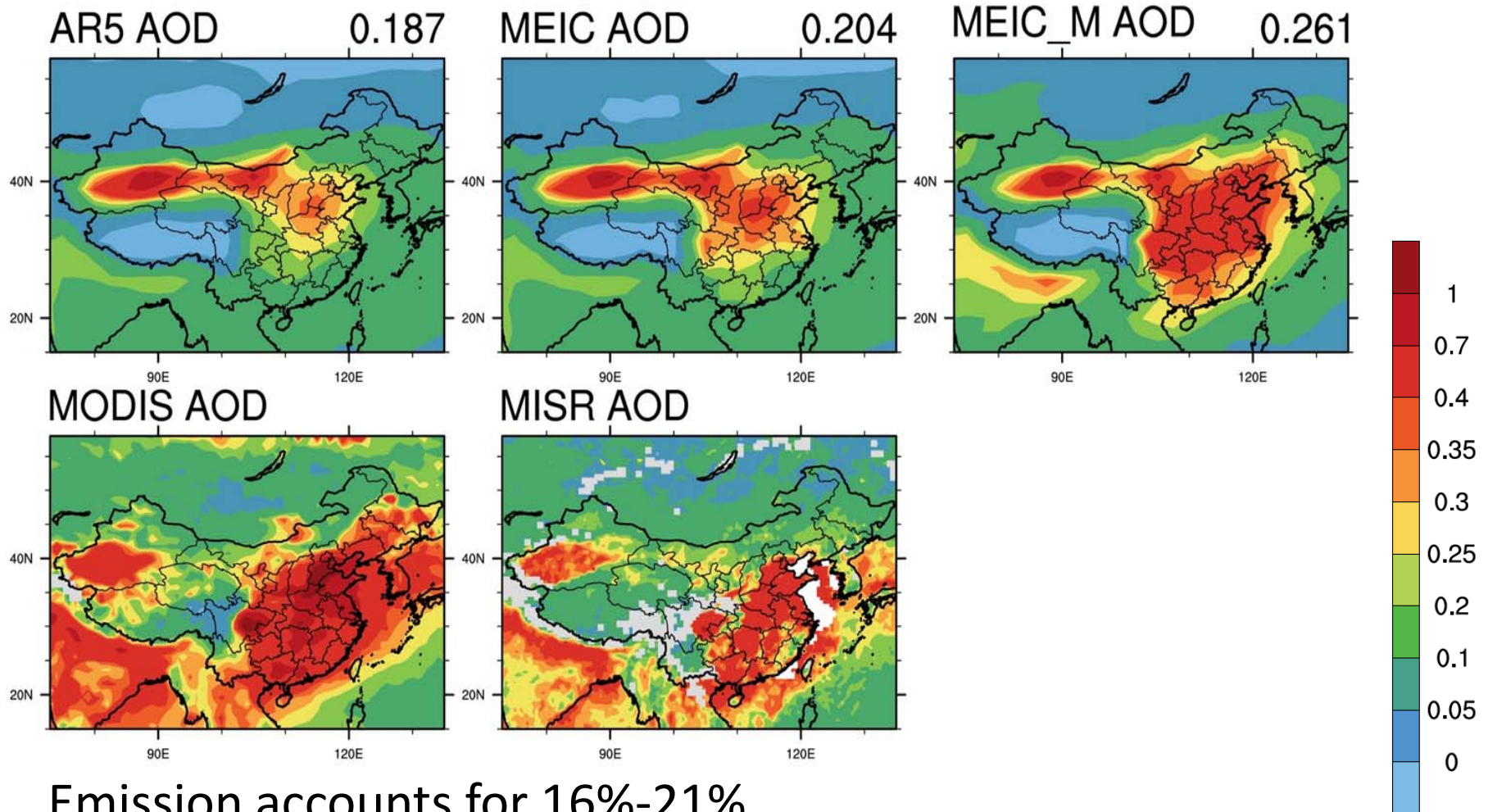
Source: presentation by Zaveri
WRF tutorial, 2008

Nitrate aerosol in CAM5 II

13 new aerosol tracers
25% more computational expense

No.	Species	Accum.	Aitken	coarse	Primary Carbon
1.	BC	X			X
2.	POM	X			X
3.	SOA	X	X		
4.	SO4	X	X	X	
5.	NH4	X	X	X	
6.	NO3	X	X	X	
7.	Cl	X	X	X	
8.	Na	X	X	X	
9.	Dust	X		X	
10.	Ca	X		X	
11.	CO3	X		X	
Total		11	6	8	2

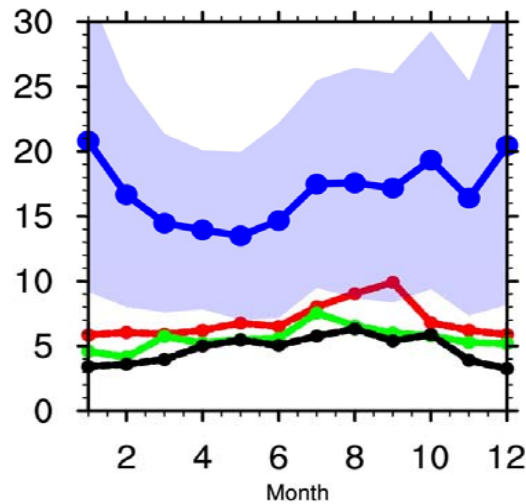
Results – modeled AOD



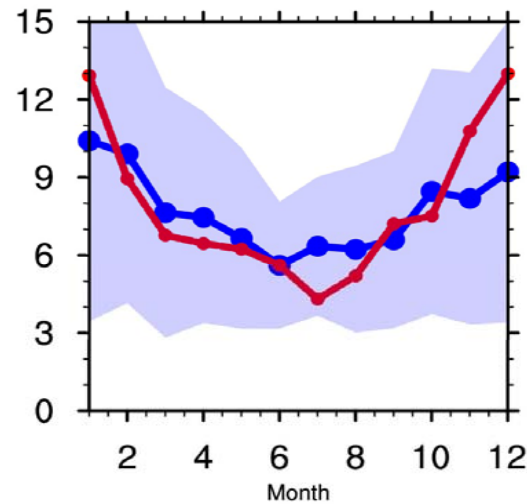
Emission accounts for 16%-21%,
emission & nitrate account for 63%-86% of the modeled AOD low
biases in eastern China

Results – Simulated surface concentrations from CAM5

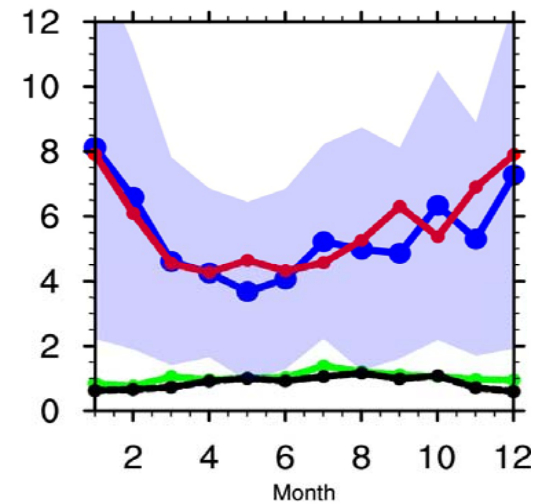
Sulfate



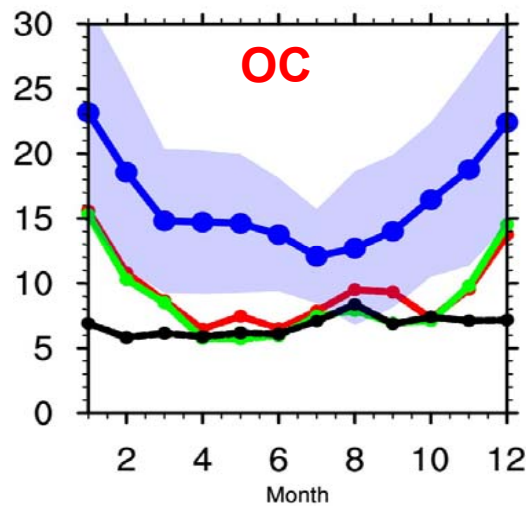
Nitrate



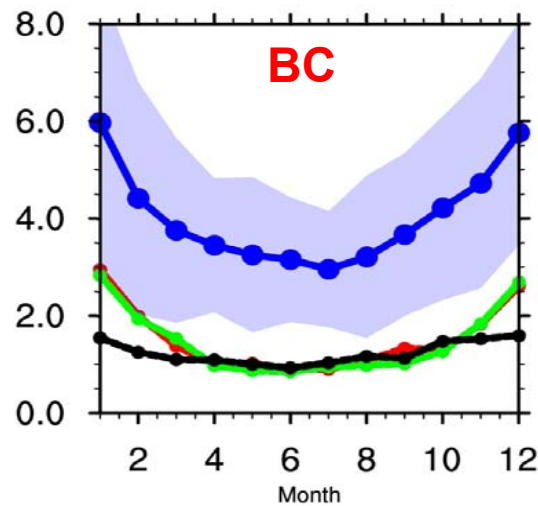
Ammonium



OC



BC

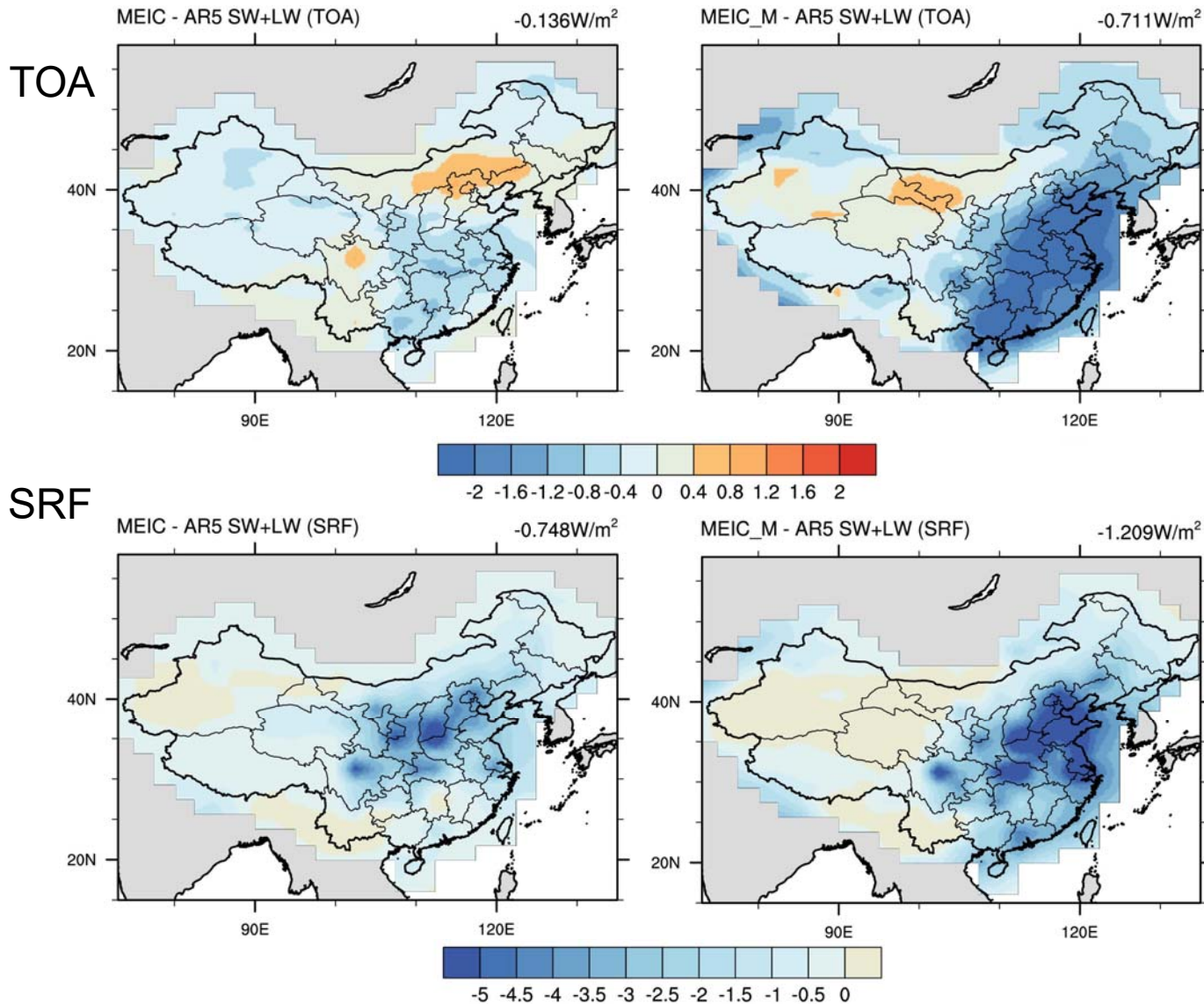


Blue: CAM5 w/ AR5 emission
green: CAM5 w/ MEIC emission
Red: CAM5 w/ MEIC & nitrate
Blue: observed conc.

Results – Aerosol direct radiative effect (ADRE) at TOA & surface

MEIC – AR5

MEIC_M – AR5



MEIC – AR5

- At TOA, cooling over southern China; warming due to more BC in MEIC case
- At Surface, cooling over Northern China Plain

MEIC_M – AR5

- Strong cooling effects over both TOA and Surface
- Small warming over Gobi desert due to stronger wet removal process of dust in MEIC_M case

Conclusions

- Comparing with long-term aerosol composition measurements (CAWNET) in China, we found that CAM5 (and ACCMIP models) significantly underestimate the magnitudes of both primary (e.g., BC) and secondary anthropogenic aerosols (e.g., sulfate) in China, especially in winter, and modeled seasonal variations are not correct.
- Using both MEIC emission dataset as well as treating nitrate aerosol, CAM5 simulated magnitude and seasonality of aerosol composition and AOD over China are significantly improved. However, BC emission in China may be still too low, and model misses sulfate formation mechanisms in models (e.g., Wang et al. 2016, He et al. 2014, Huang et al. 2014)