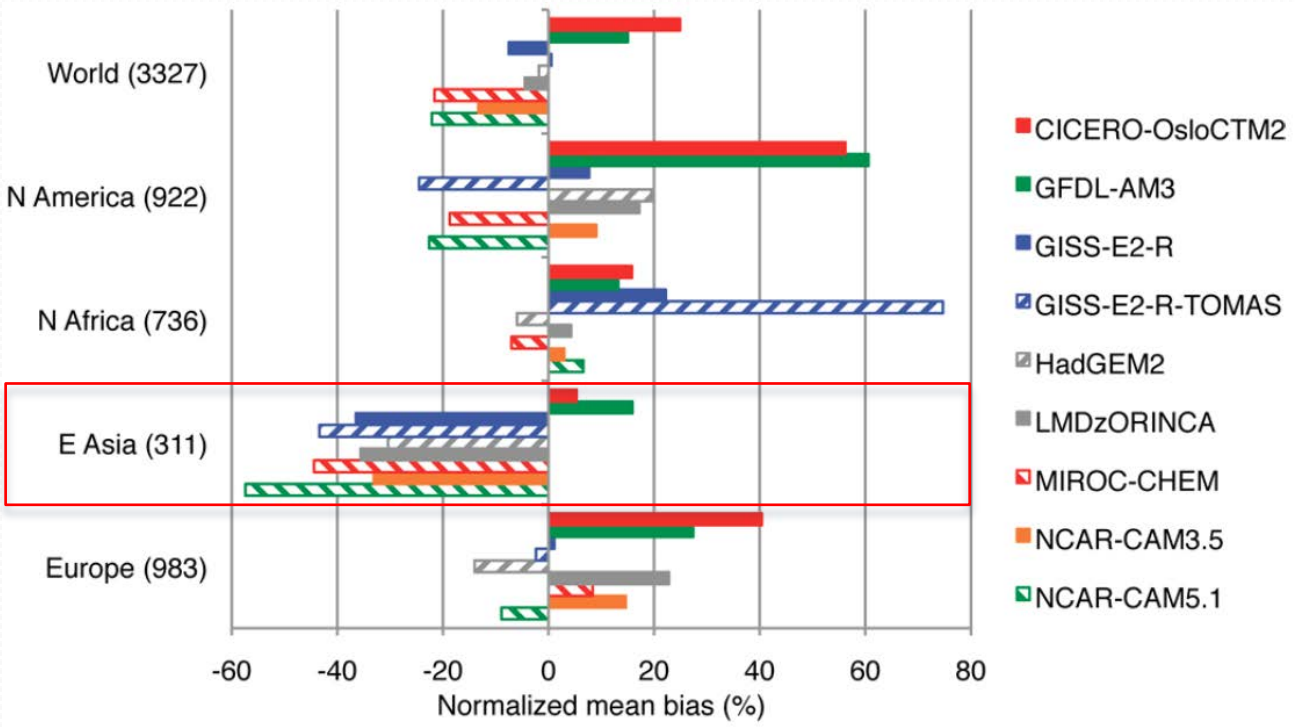
Impact of a new emission inventory on CAM5 simulations of aerosols and aerosol radiative effects in eastern China

Tianyi Fan[1], Xiaohong Liu[1,2], Po-Lun Ma[3], Qiang Zhang[4], Zhanqing Li[1, 5]
Yiquan Jiang[6], Fang Zhang[1], Chuanfeng Zhao[1], Xin Yang[1]

1. College of Global Change and Earth System Science, Beijing Normal University, Beijing, 100875, China
2. Department of Atmospheric Science, University of Wyoming, USA
3. Atmospheric Sciences and Global Change Division, Pacific Northwest National Laboratory, Richland, Washington, USA.
4. Center for Earth System Science, Tsinghua University, Beijing 100084, China
5. Department of Atmospheric and Oceanic Science & ESSIC, University of Maryland, College Park, Maryland 20742, USA
6. Institute for Climate and Global Change Research, School of Atmospheric Sciences, Nanjing University, Nanjing, China

Motivation

Global aerosol-climate models are associated with large biases in East Asia and China. Improving the emission inventory is necessary.



ACCMIP models v.s. AERONET AOD (Shindell et al., 2013)

The emission inventory of aerosol and precursor gases

- Default: IPCC AR5 emission dataset
  - based on 2000 emission, update every 10 years
  - no seasonal variation

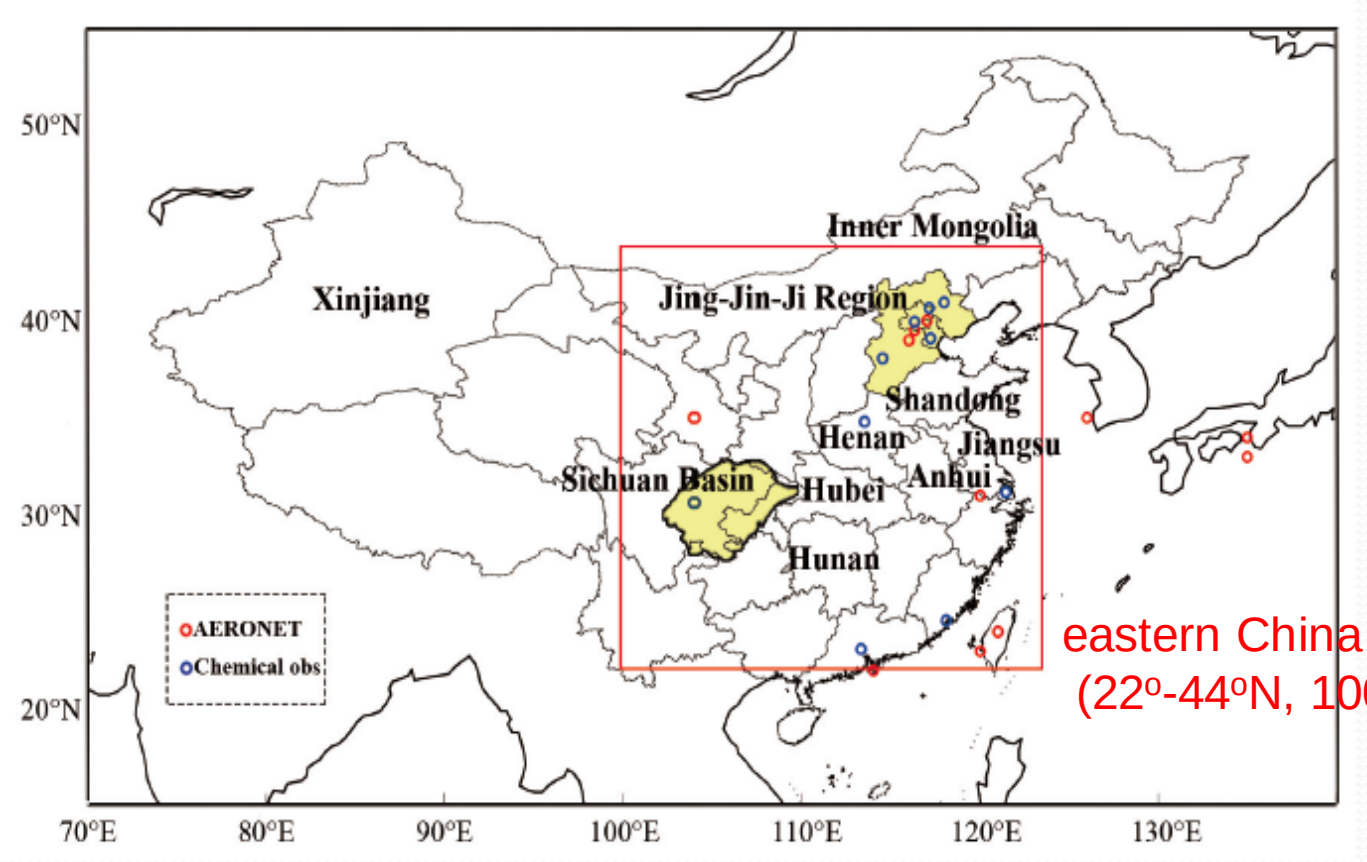
- Replacing with the new emission inventory

  Multi-resolution Emission Inventory for China (MEIC) (www.meicmodel.org) Tshinghua University, China
  - technology-based, rapid techonology renewal, China's statistics
  - gridded data available in 2008, 2010, 2012. National averaged trend in 1990-2012
  - seasonal variation (monthly)

Model configuration

- MEIC emission in China and AR5 emission elsewhere.
- Nudged winds towards ERA-Interim in 2009.
- $0.9^{o} \times 1.25^{o}$ x 30 layers.
- 3-mode Modal aerosol Model (MAM3): Sulfate, black carbon (BC), Primary organics matter (POM), Secondary organic aerosol (SOA).
- Aerosol Direct Radiative Effect (ADRE): all-sky radiative fluxes difference between with and without aerosol scattering and absorption [Ghan, 2013].

Study area and observational sites



eastern China
(22°-44°N, 100°-124°E)

AOD and SSA retrievals: AeroNet, MODIS (Terra collection 6 deep blue), and MISR

Chemical observation of PM2.5 from literatures

Ground-based radiative effect observation: CSHNET and literatures

The MEIC is 12% to 47% higher than the AR5 dataset

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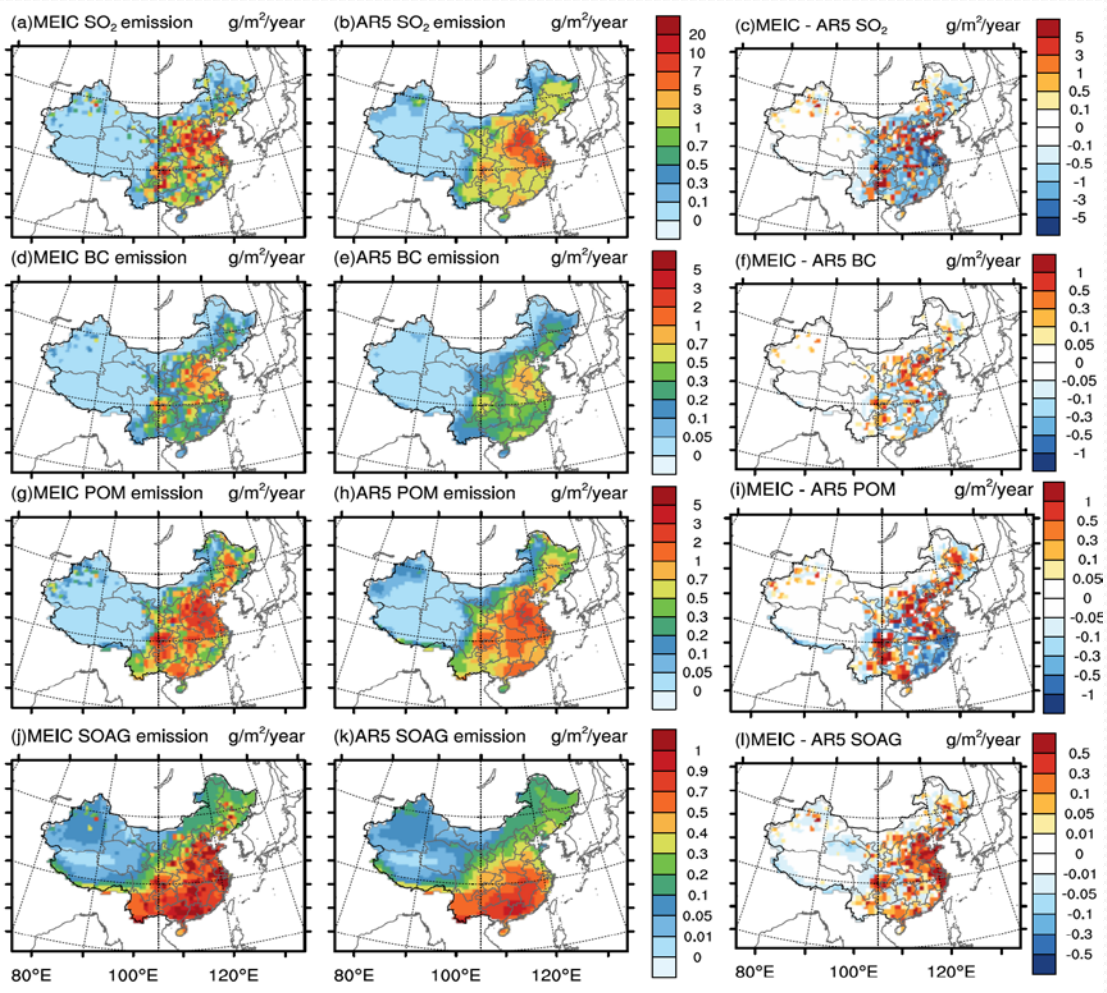
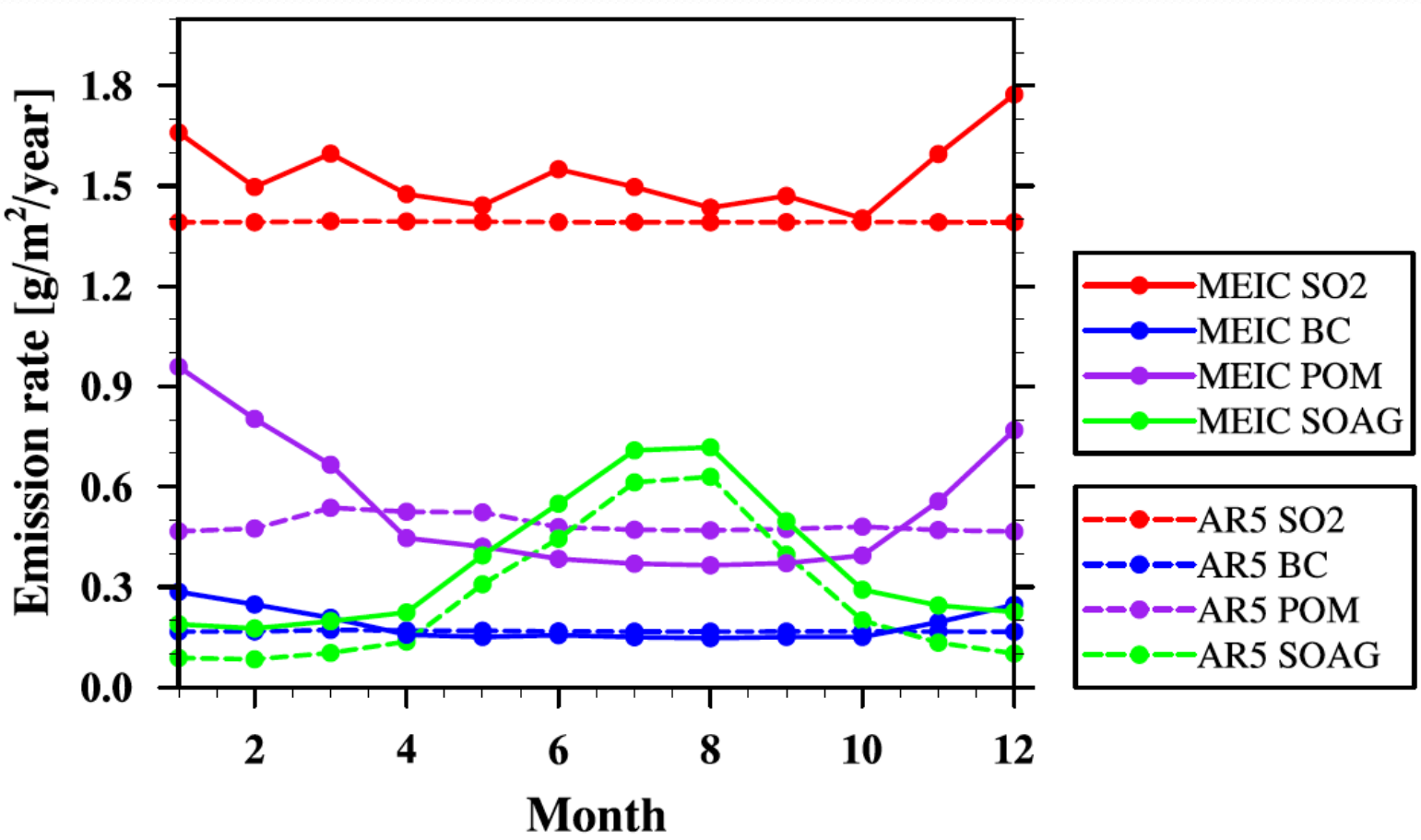
	MEIC	AR5	MEIC - AR5	(MEIC-AR5)/AR5
SO_2				+12.57%
BC				+13.35%
POM				+12.04%
SOAG				+46.88%



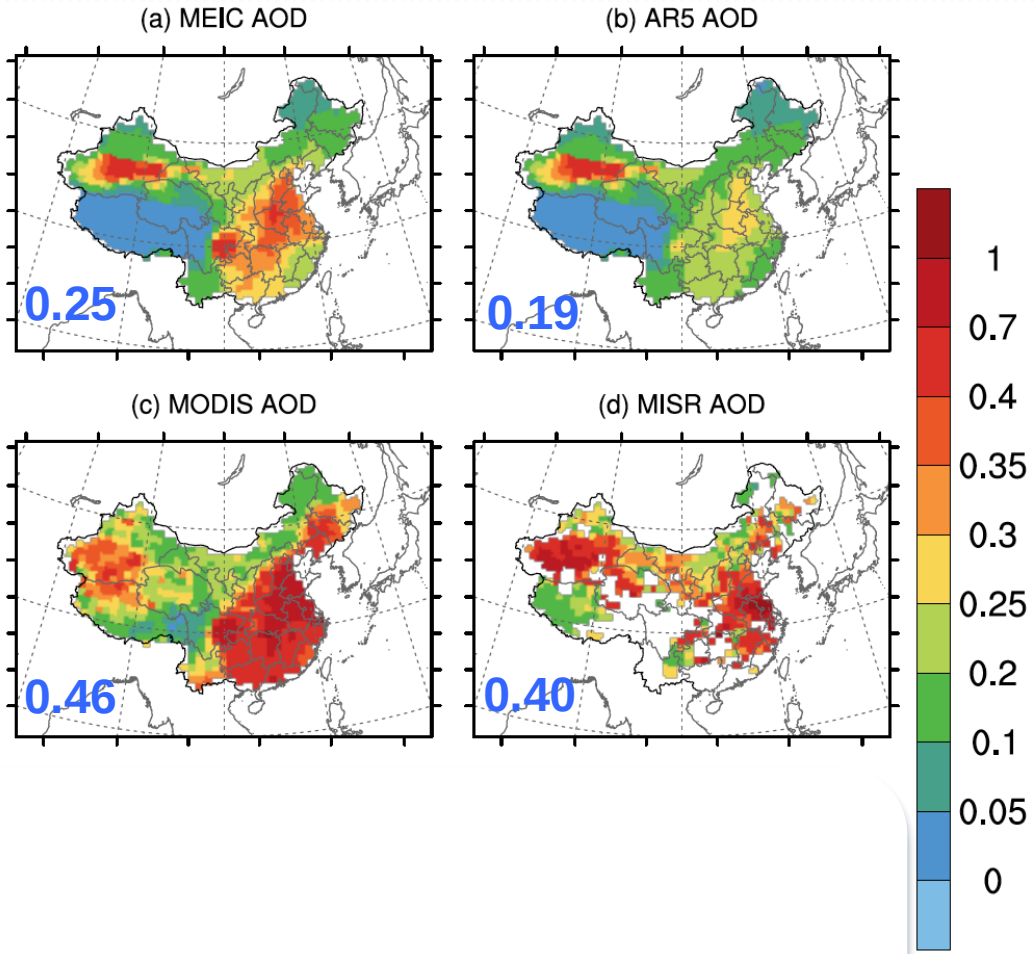
Seasonal variation of the emission inventories



The emission accounts for 22%-28% of the modeled AOD low biases in eastern China

CAM5 AOD

Satellite AOD



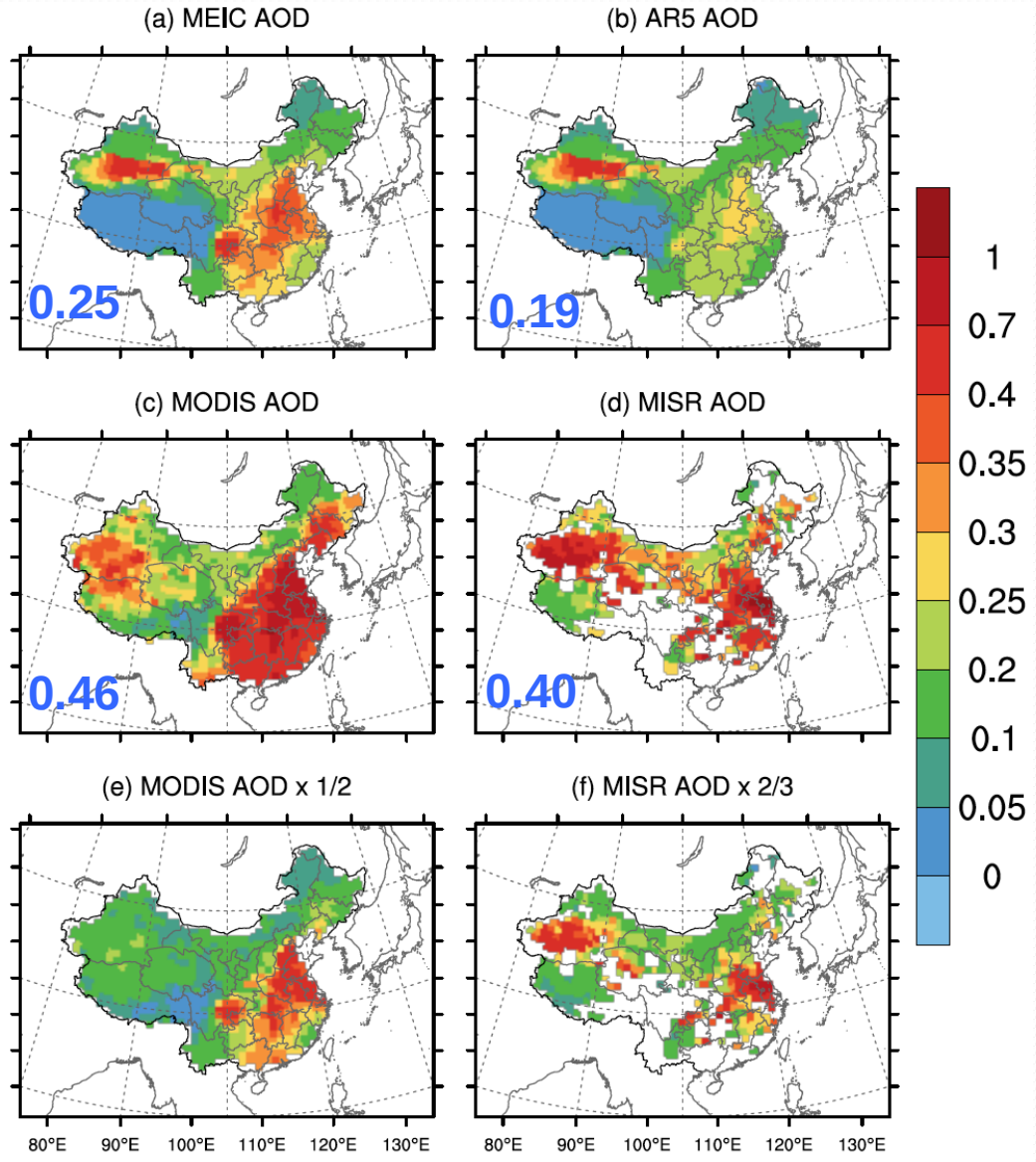
AOD is still underestimated by CAM5 with MEIC.

MEIC reproduces the spatial pattern of AOD

CAM5 AOD

Satellite AOD

MODIS x ½,
MISR x ⅔



Improved seasonal variation of AOD by MEIC

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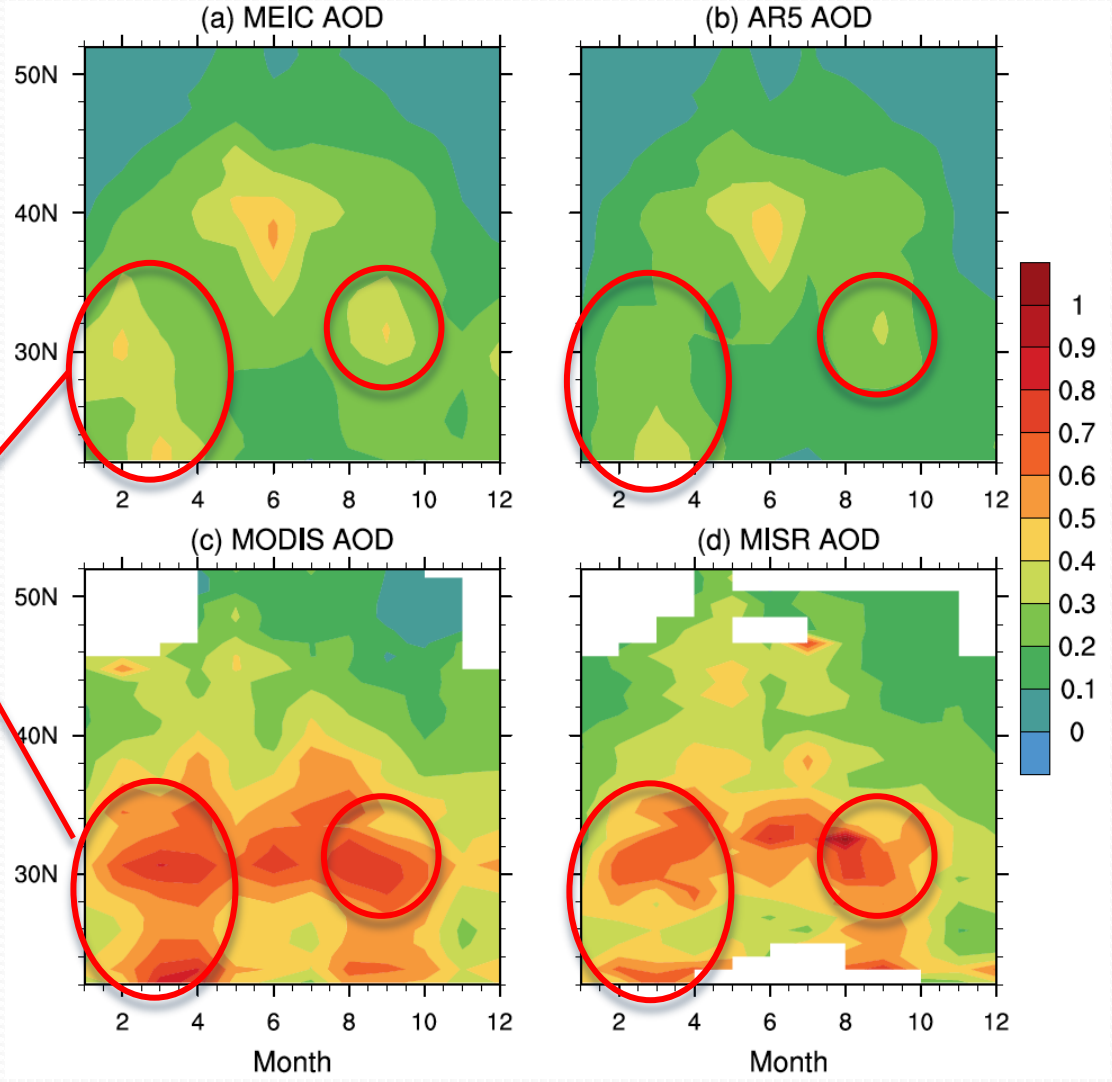
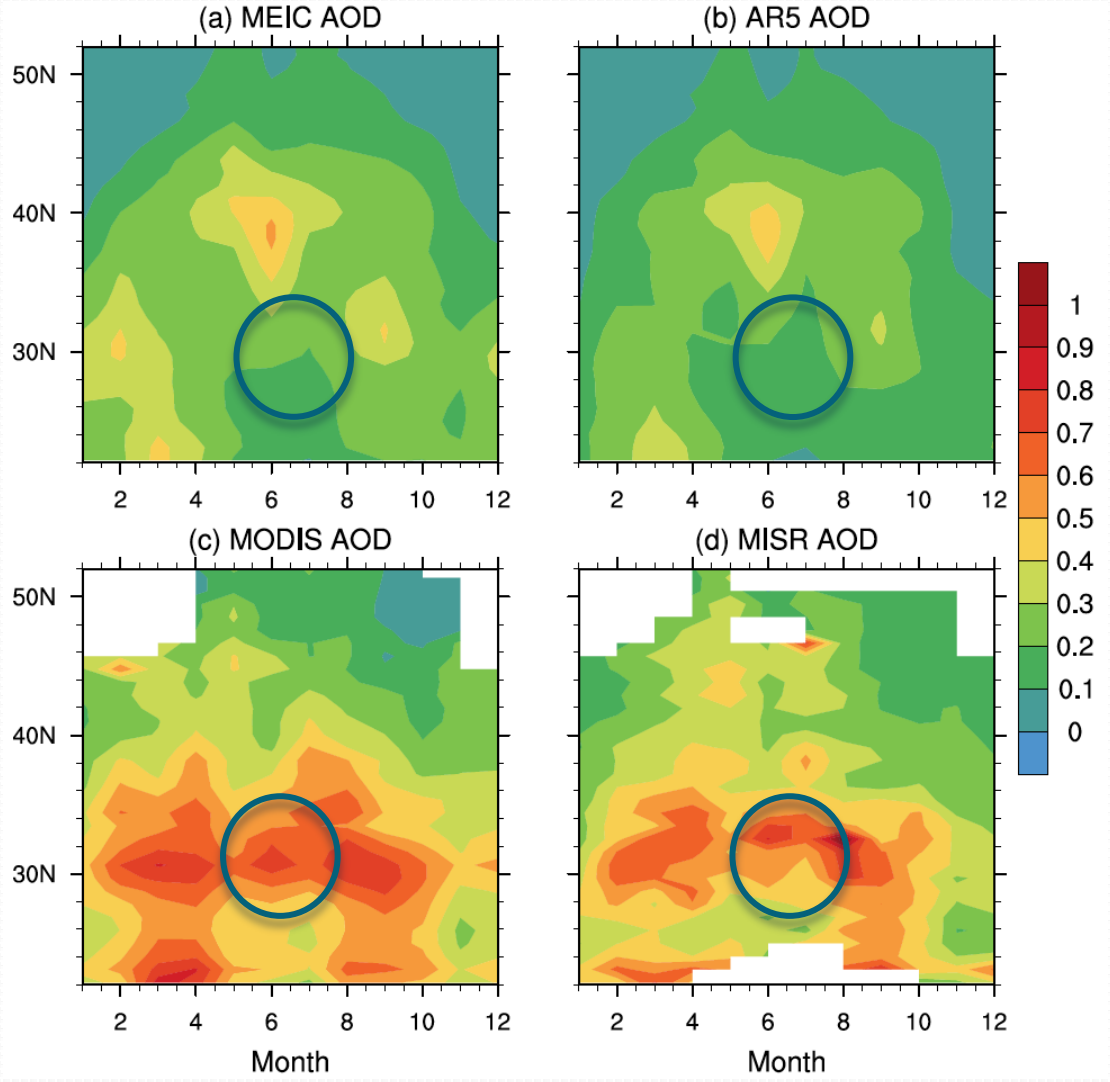
Sulfate aerosol and POM



Missing summer maximum of AOD due to precipitation bias



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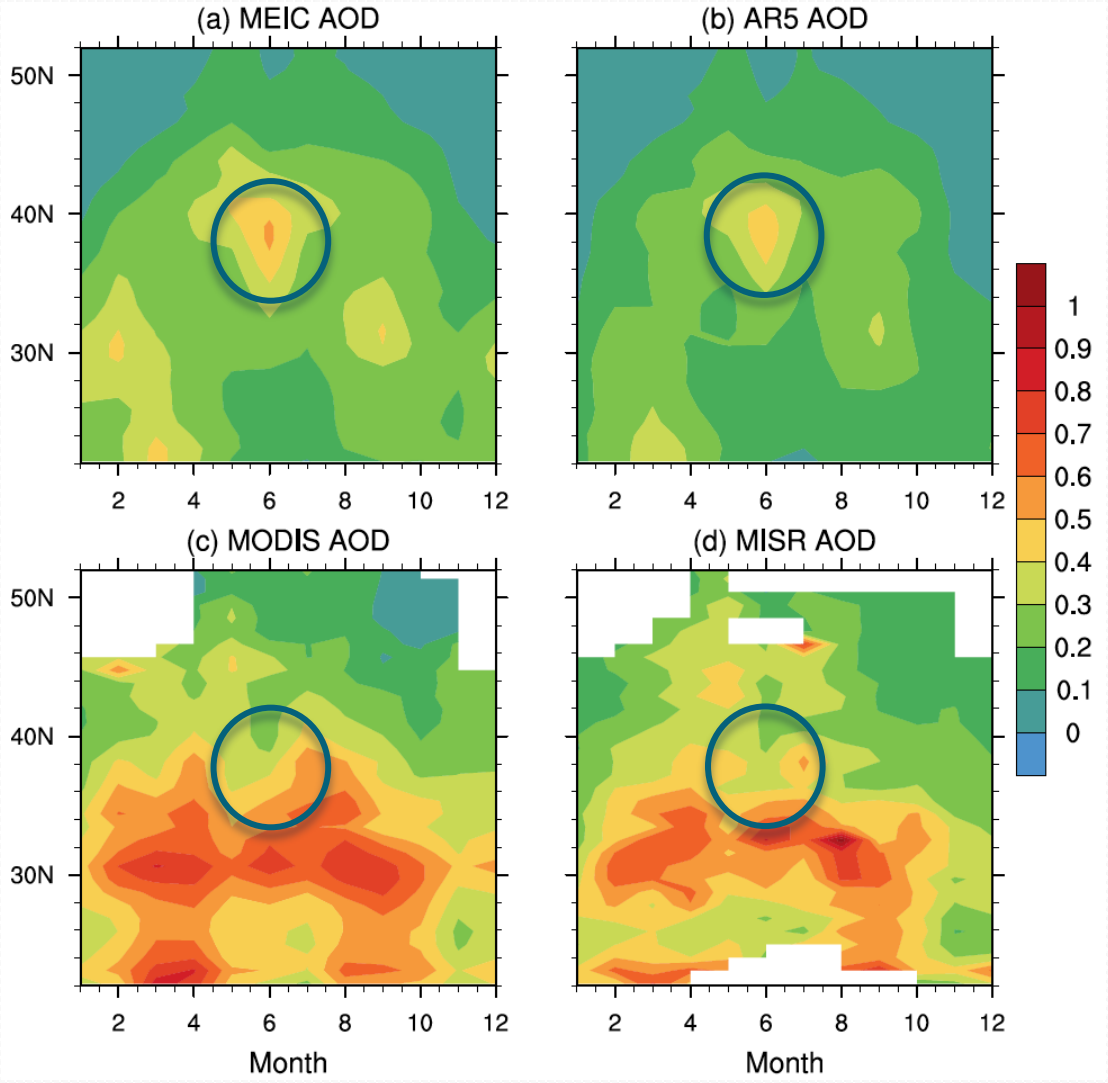
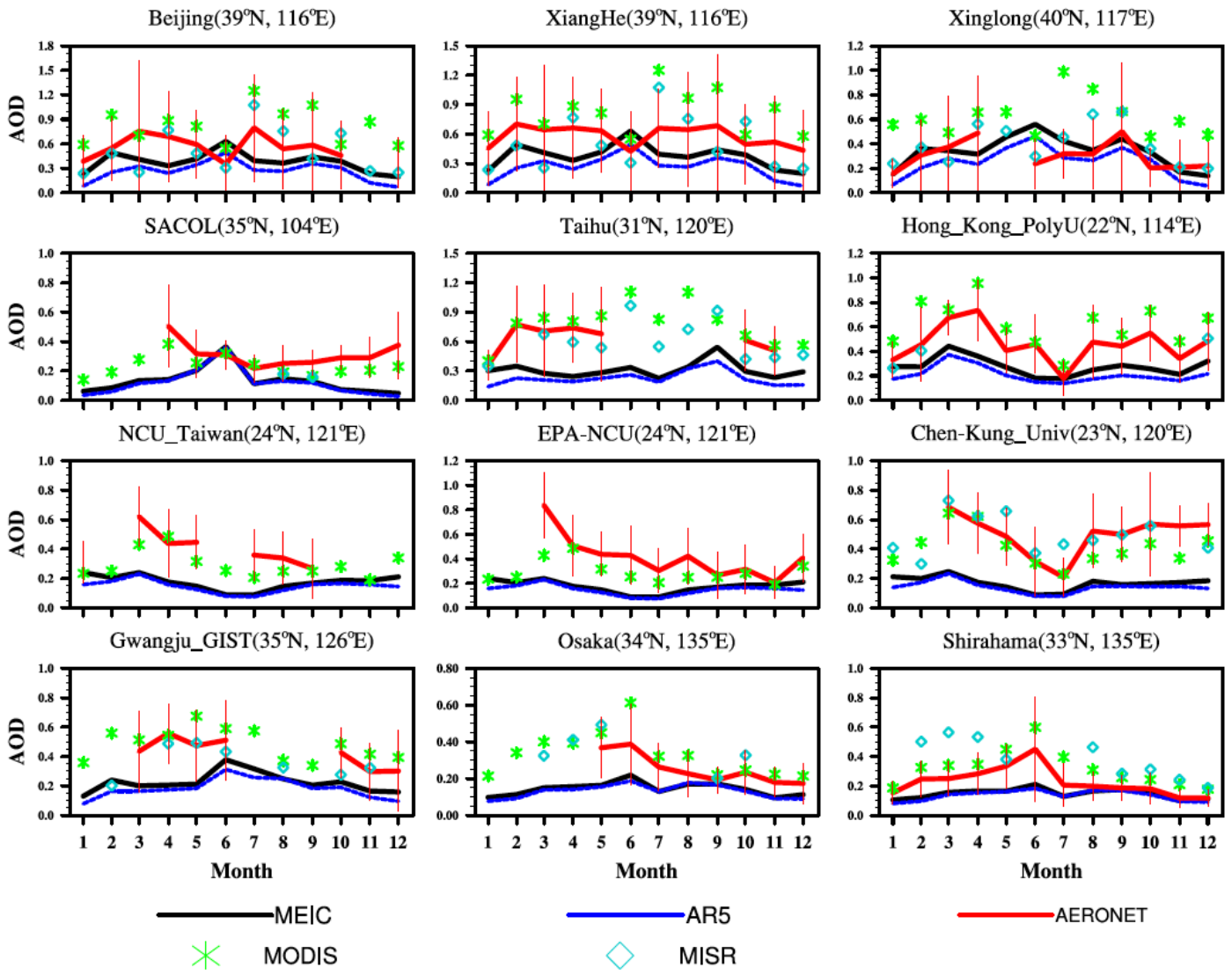
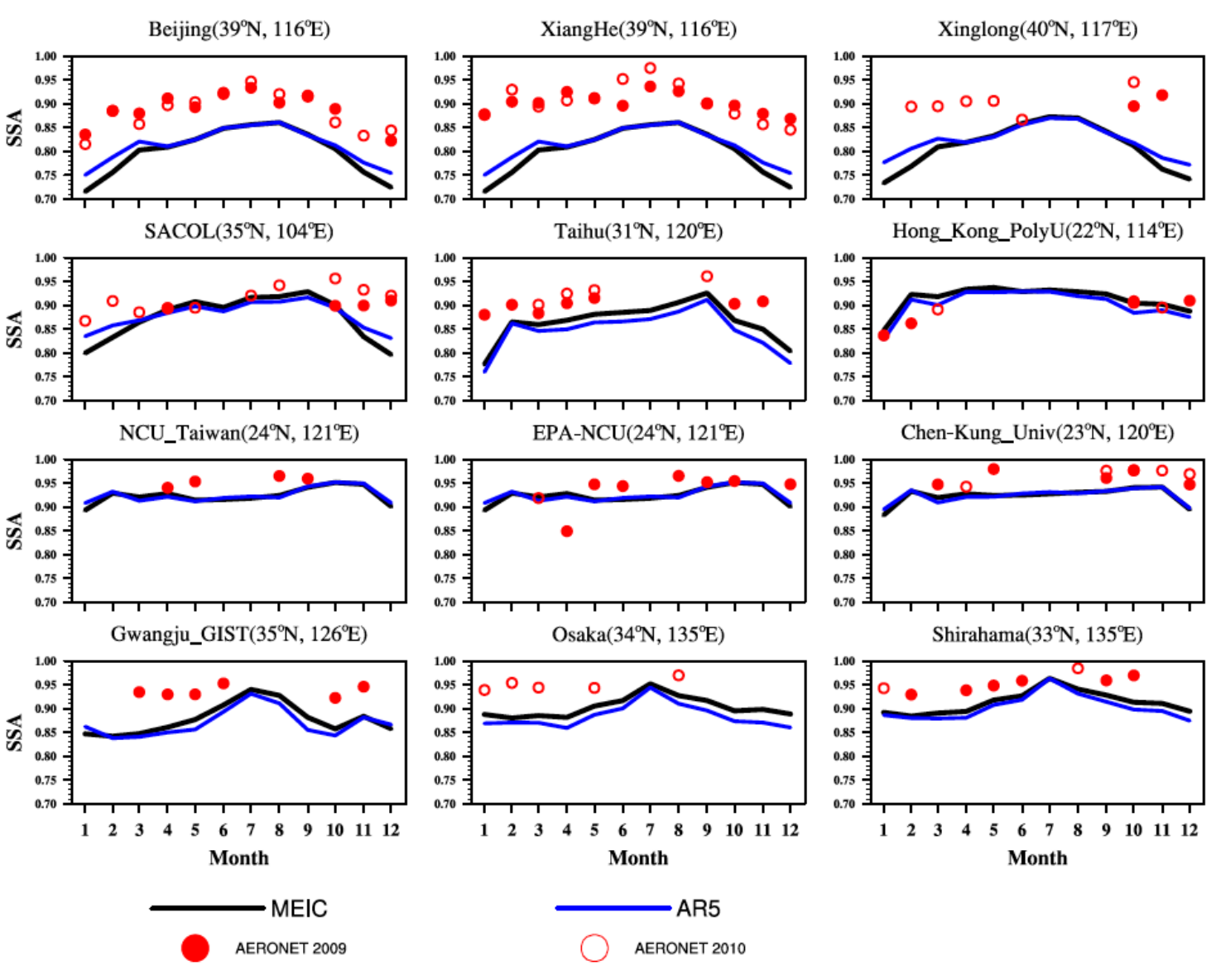
Modeled dust transport that is not observed by satellites



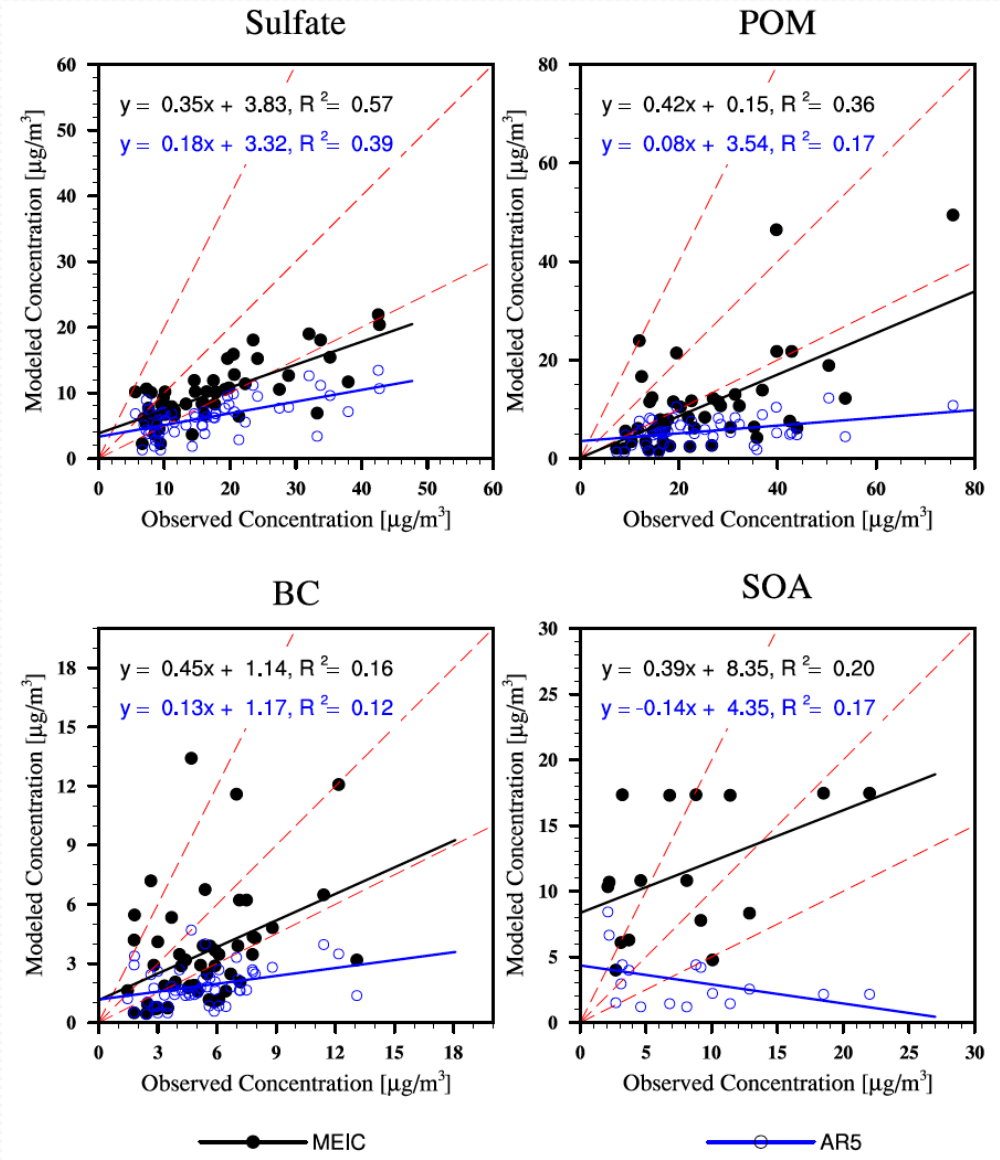
AOD modeled with MEIC agrees better with observations than the AR5 emissions

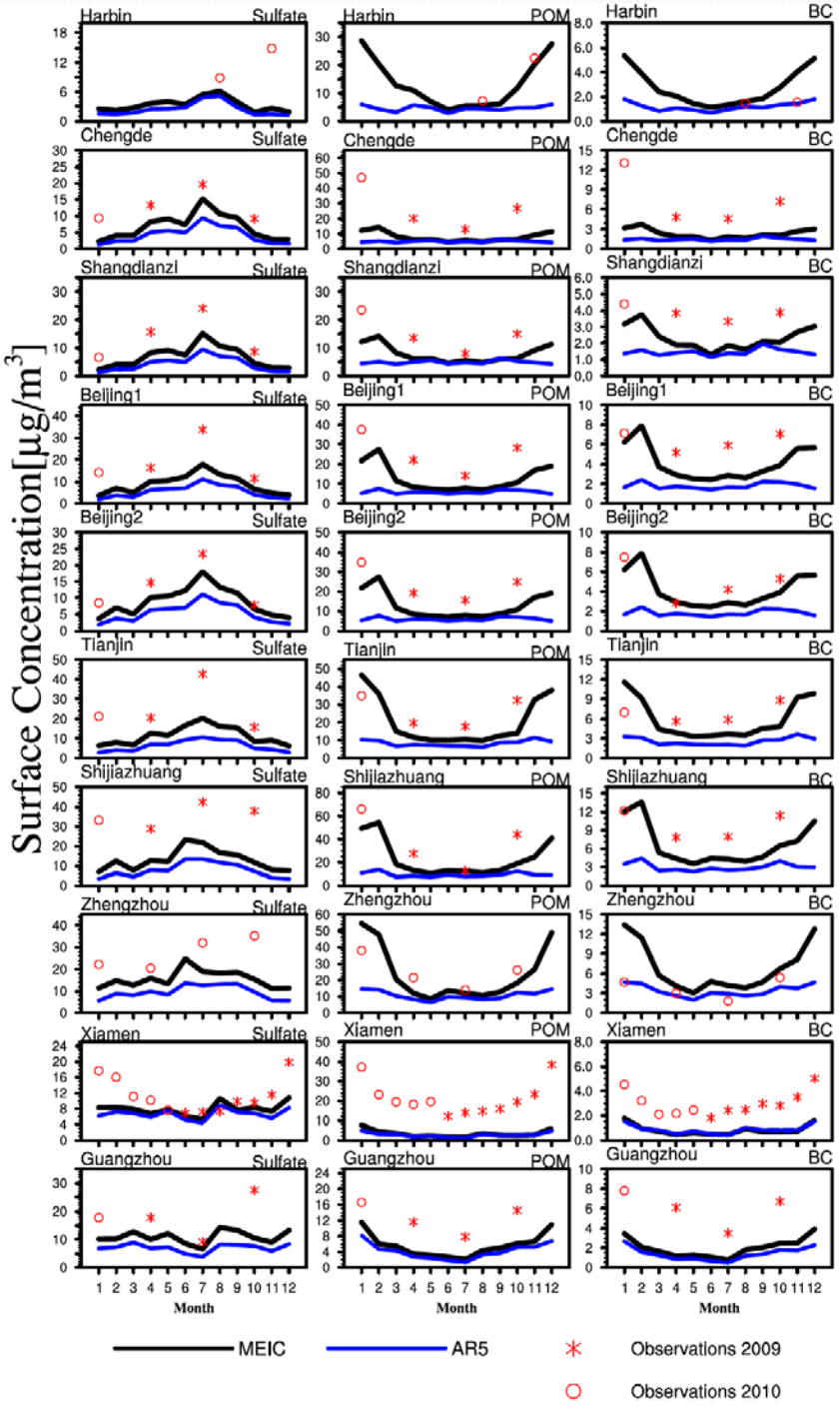


SSA modeled with MEIC and AR5 emissions compared with AERONET



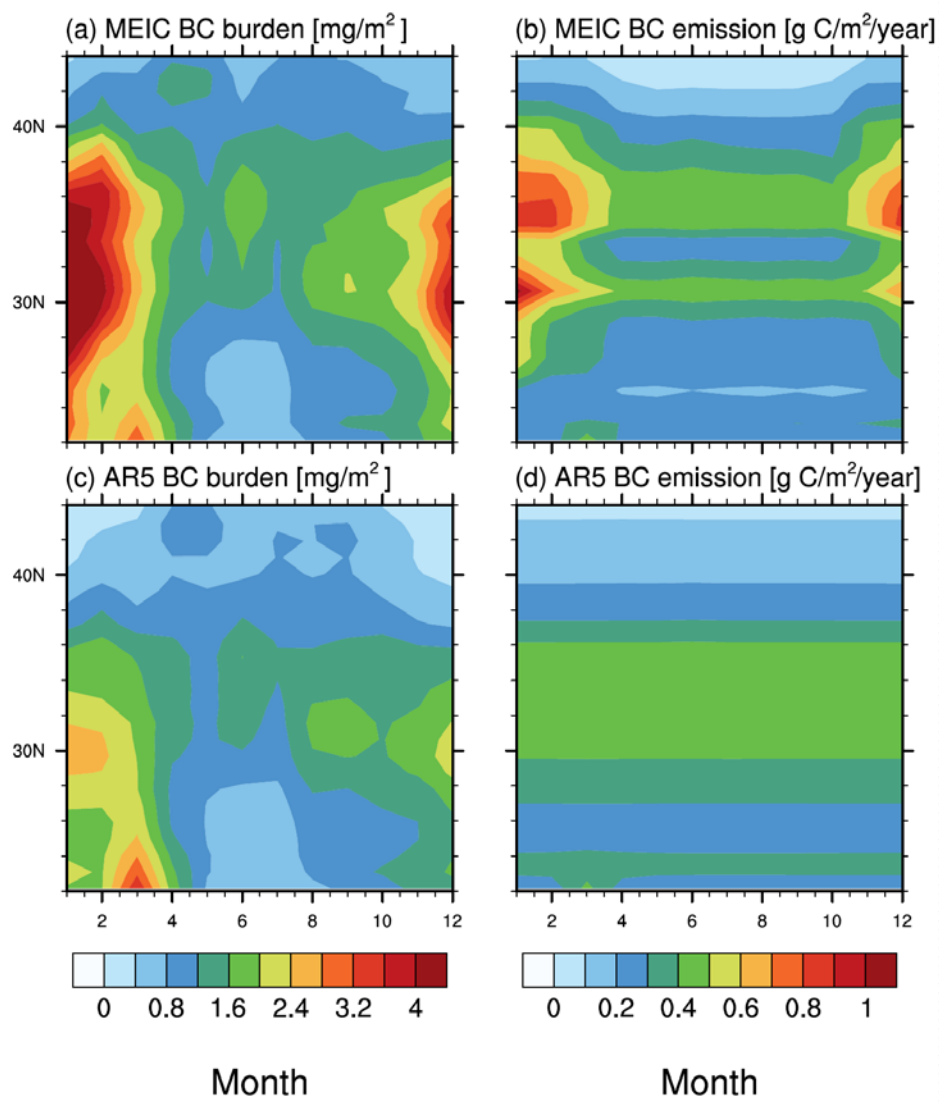
The simulated surface concentrations of all species are improved with MEIC



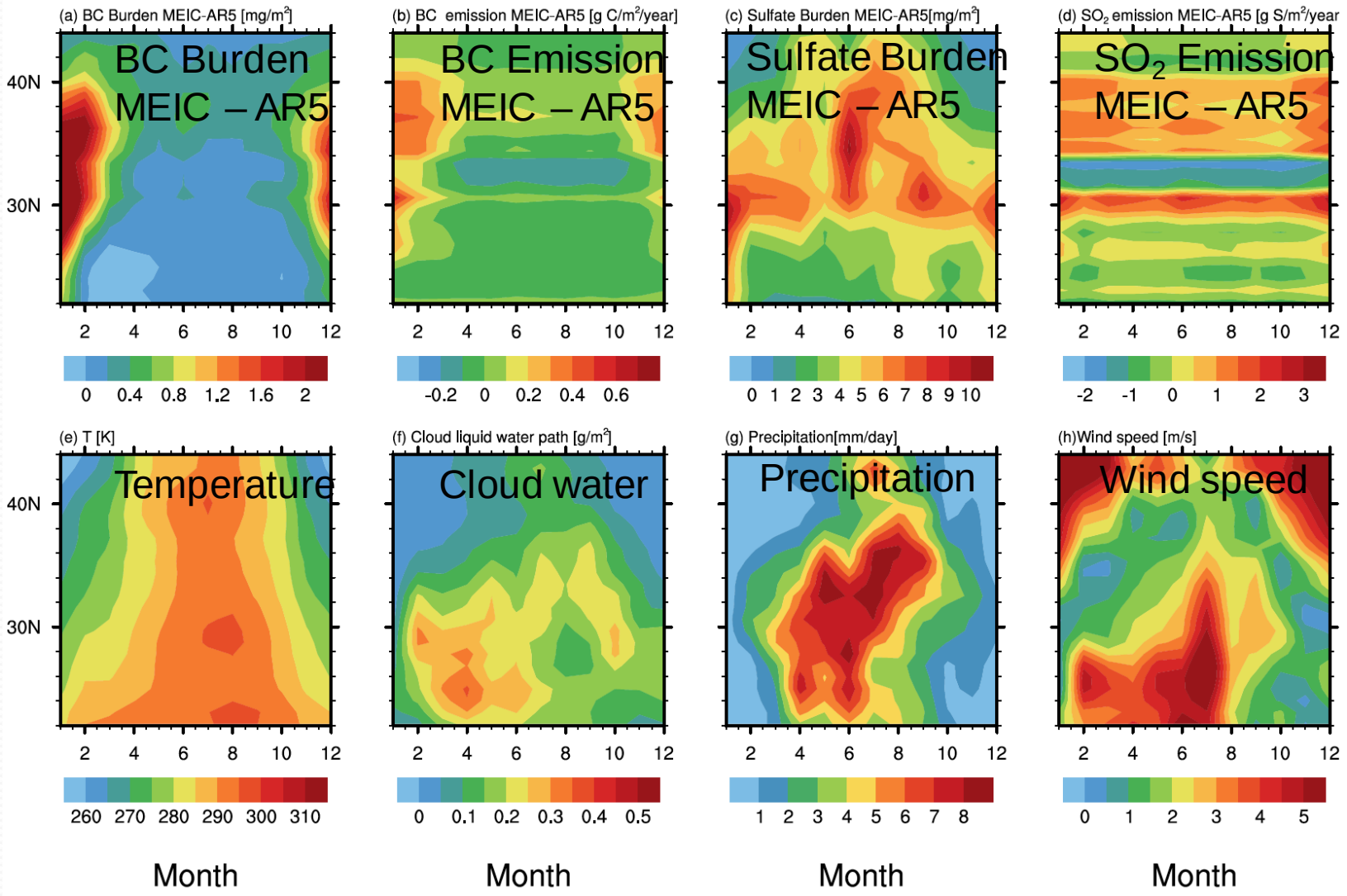


- The impact of emission on seasonal variation of sulfate is not obvious.
- MEIC emission significantly increases and improves the model simulations of BC and POM concentrations.

Seasonal variations of both the emission and meteorology play important roles



The impacts of emission on primary and secondary aerosols are different



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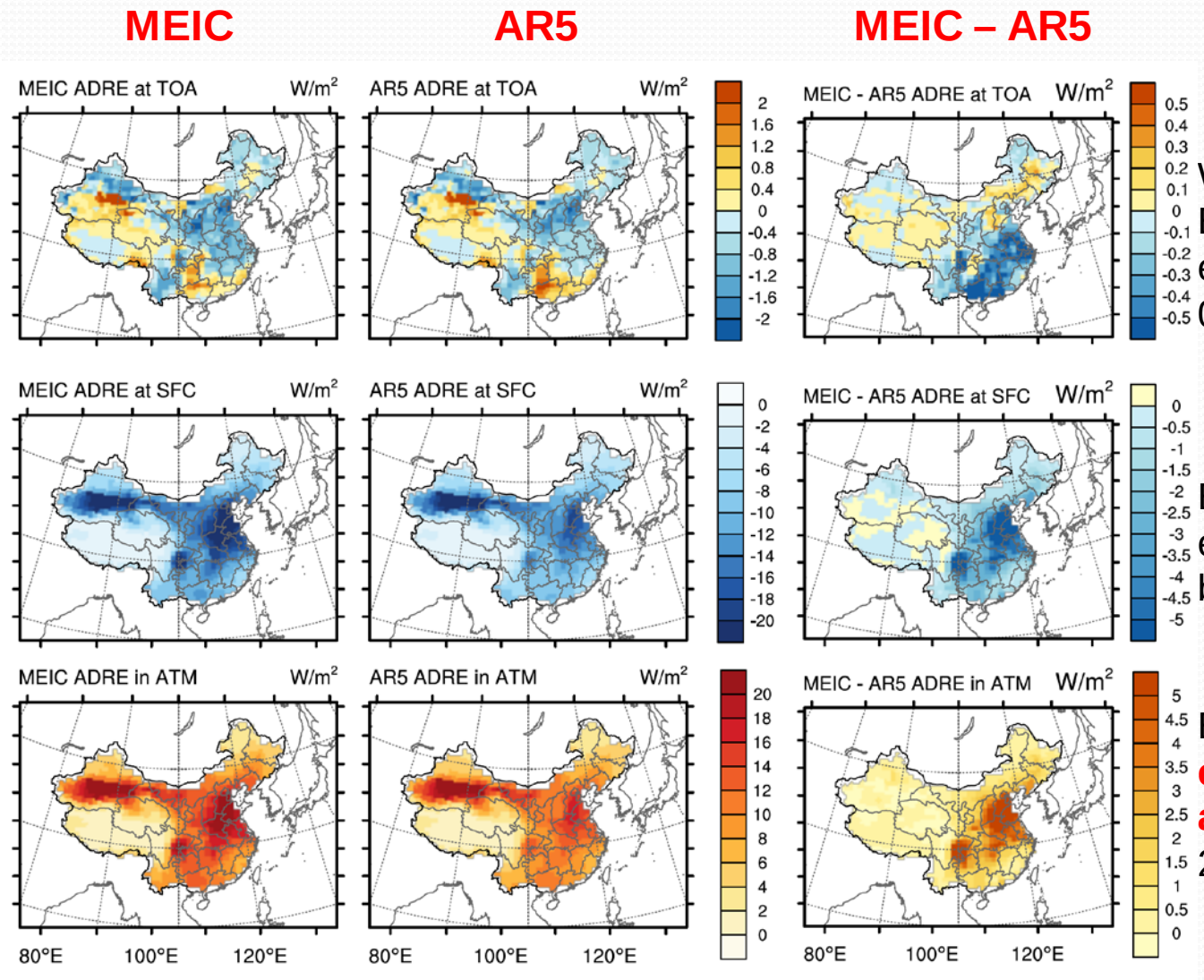
MEIC estimate the averaged aerosol DRF at TOA, surface, and atmosphere to be -0.50, -12.76, 12.26 Wm^{-2} over eastern China



With MEIC:
Enhanced cooling effect **at TOA** by -0.19 Wm^{-2}

Enhanced cooling effect **at surface** by -2.42 Wm^{-2}

Enhanced warming **effect in the atmosphere** by 2.23 Wm^{-2}

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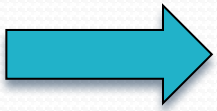
About 12% to 47% difference of the anthropogenic emission rates

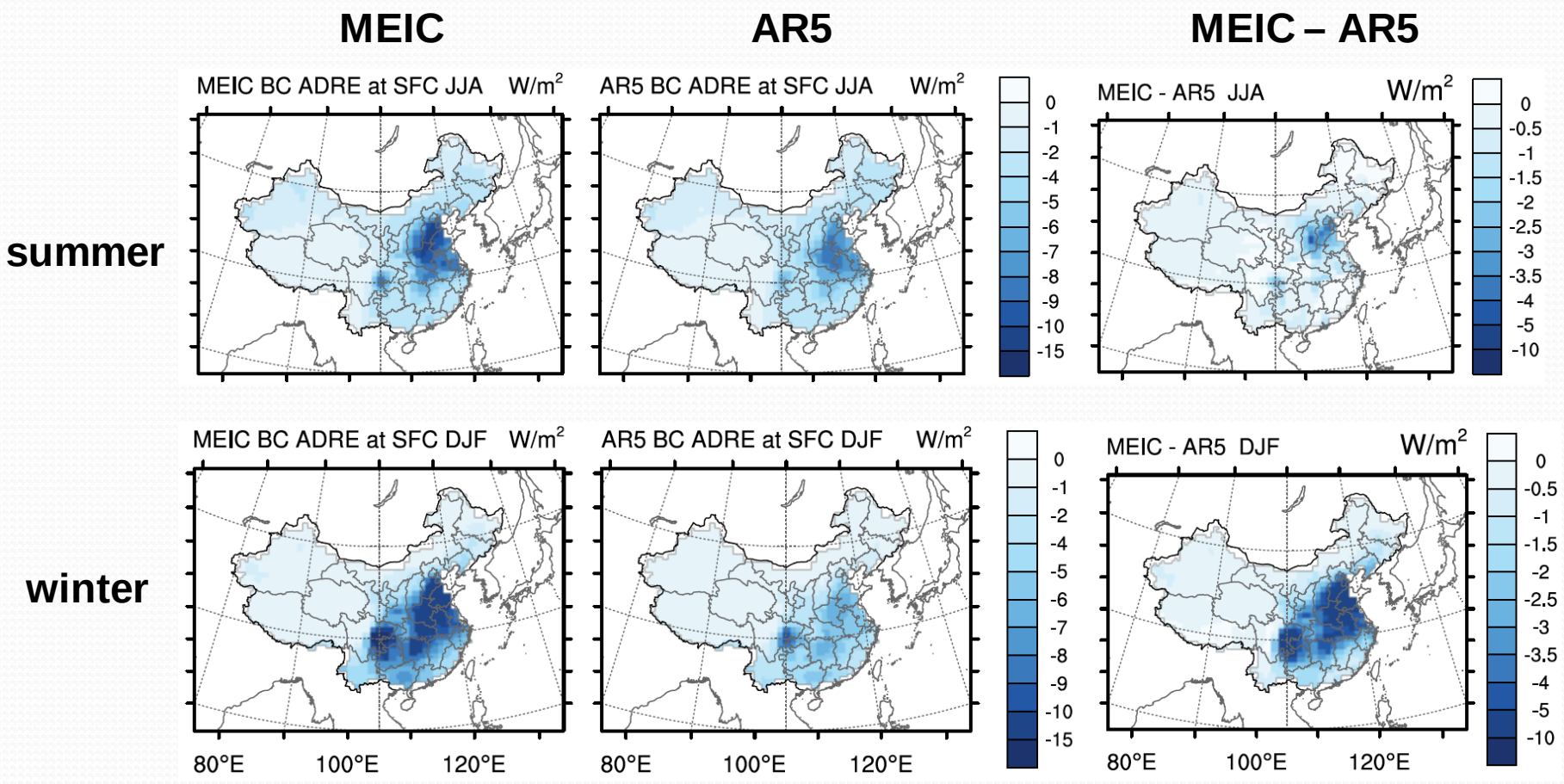


About 30% difference of the total AOD of all species

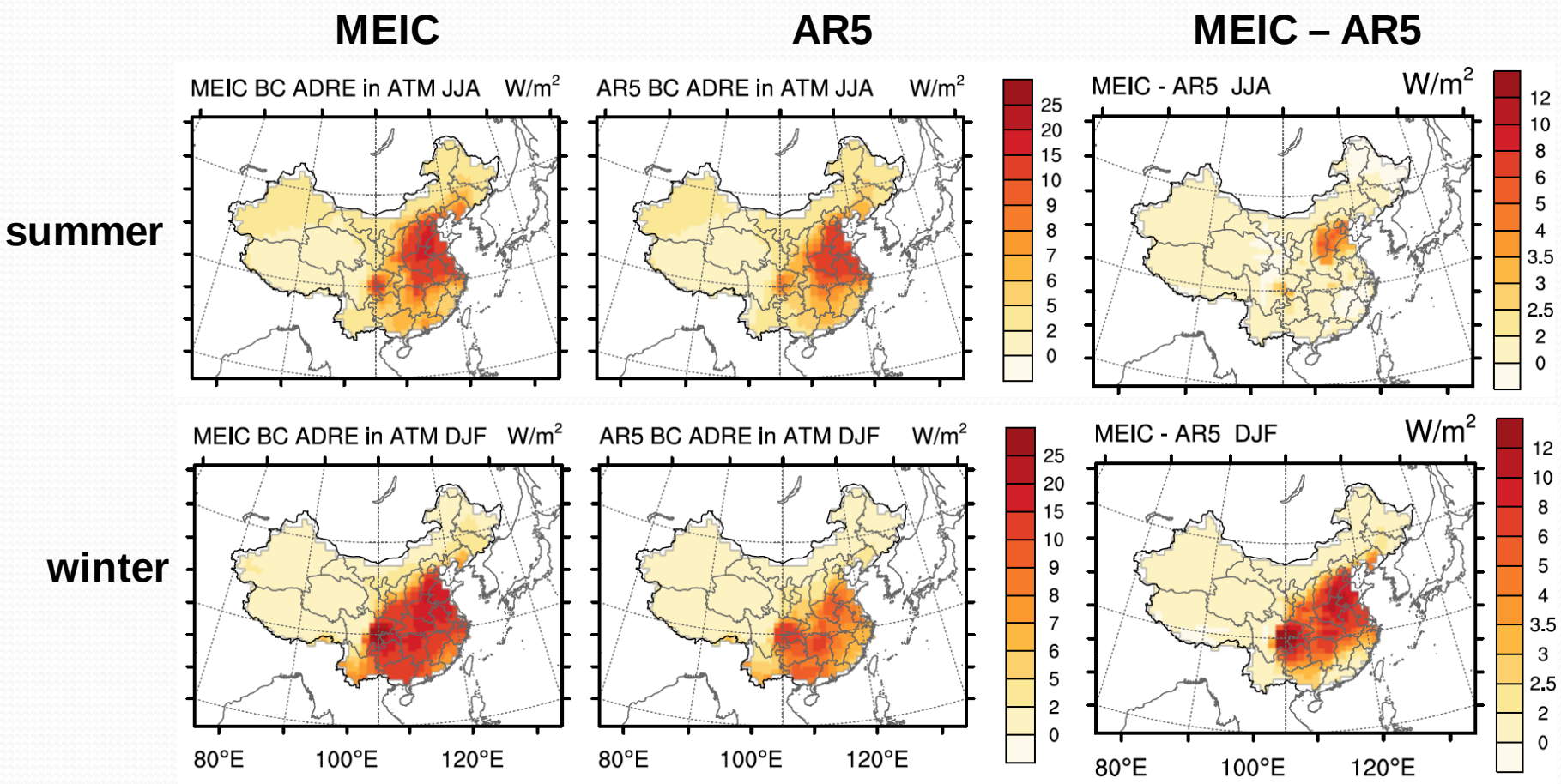
About 22% difference of ADREs at the surface and in the atmosphere
About 63% of the ADRE at TOA

The impacts of the emission on AOD and ADRE are significant.

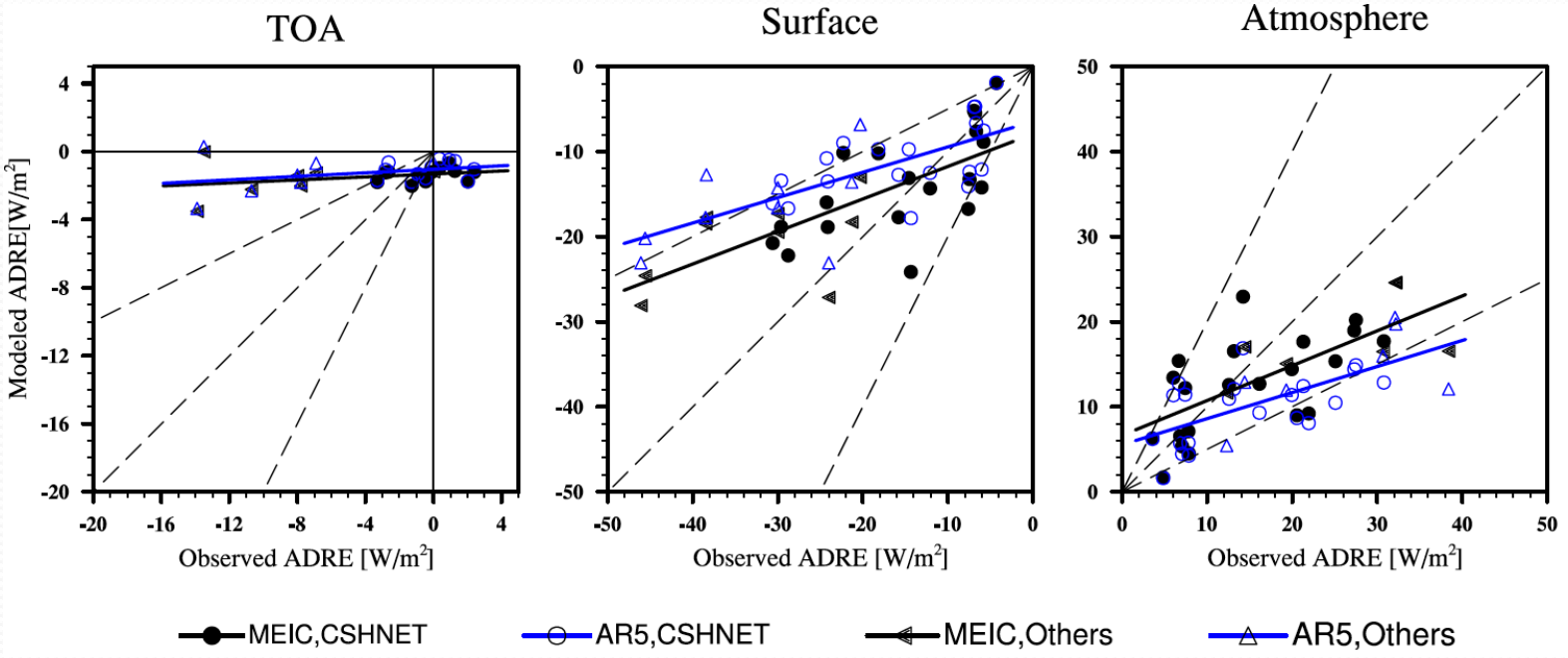
The impact of emission on ADRE of BC is more significant than the meteorological effects



So does atmospheric warming due to BC



Modeled ADREs are improved with MEIC, but still underestimated



Observational data from Chinese Sun Hazemeter Network (CSHNET) (Xin et al., 2007; Li et al., 2010) and other literatures.

Summary

- This research highlights the critical importance of improving aerosol and precursor emissions for the modeling of aerosols and aerosol effects in East Asia.
- The new aerosol and precursor gases emission MEIC explains 22% to 28% of the AOD low-biases in eastern China in a GCM compared to satellite observations.
- The new emission inventory estimates the averaged aerosol direct radiative forcing at TOA, surface, and atmosphere to be -0.50, -12,76, and 12.26 W/m^2 over eastern China, which are enhanced by -0.19, -2.42, and 2.23 W m^{-2} compared with the AR5 emission .
- Seasonal variation of MEIC emission determines the seasonal cycle of the primary aerosols, but not the secondary aerosols.
- In winter AR5 emission results in significantly lower cooling effect at the surface and warming in the atmosphere due to reduced black carbon emission than the MEIC emission.