Using *in situ* data to better understand Chinese air pollution events

- Air pollution in China is a major health issue, resulting in over 1.3 million deaths per year.
- New a emissions inventory and *in situ* datasets allow us to better understand air quality in China.

Pictures taken in Beijing during summer 2016

5/3/17
IGC8

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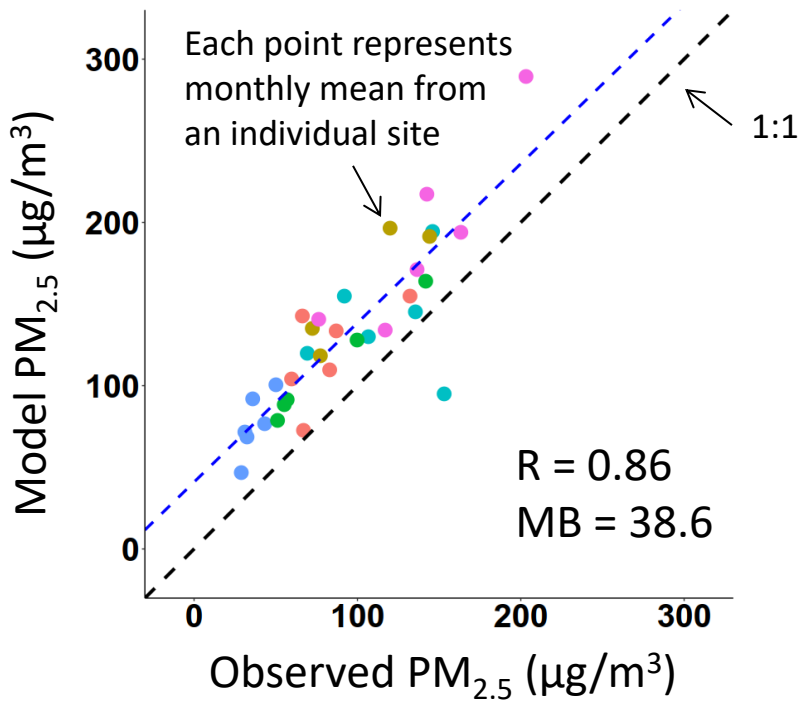
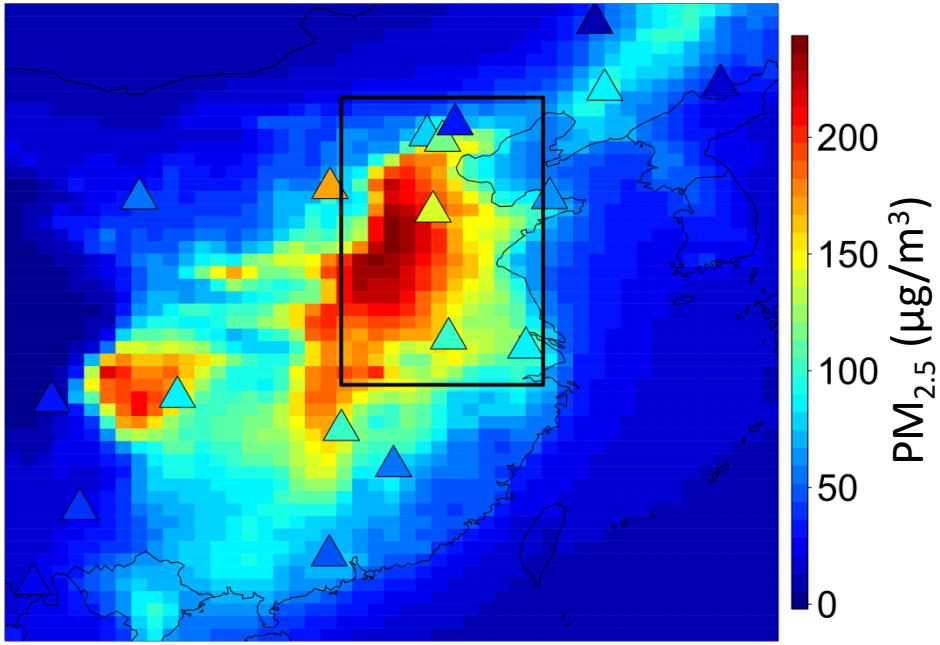
In situ data and GEOS-Chem can help us understand Chinese pollution events

- GEOS-Chem has previously been shown to do a bad job capturing winter $PM_{2.5}$ variability and magnitude over the North China Plain (NCP).
- A new standard simulation with MERRA2 meteorology and updated emissions inventories from Tsinghua University shows a better match with observations but now an overestimate of $PM_{2.5}$.

DJF monthly means $PM_{2.5}$ for 6 sites in North China Plain (2012-2013)



Nested China Simulation using MERRA2 DJF (2012-2013)



For 29 sites across China: R = 0.66; MB = 4.81

Setup of new China simulation

- MERRA2 meteorology
- Nested Asia grid (0.5x0.625°)
- Multi-resolution Emissions Inventory for China (MEIC) for 2012 and 2013
  - China component of default MIX inventory for Asian emissions in GEOS-Chem v11.01
  - Individual power plant database with unit specific parameters
  - County level transportation information and digital road map

- MEIC 2012 emissions relative to 2010 MIX emissions:

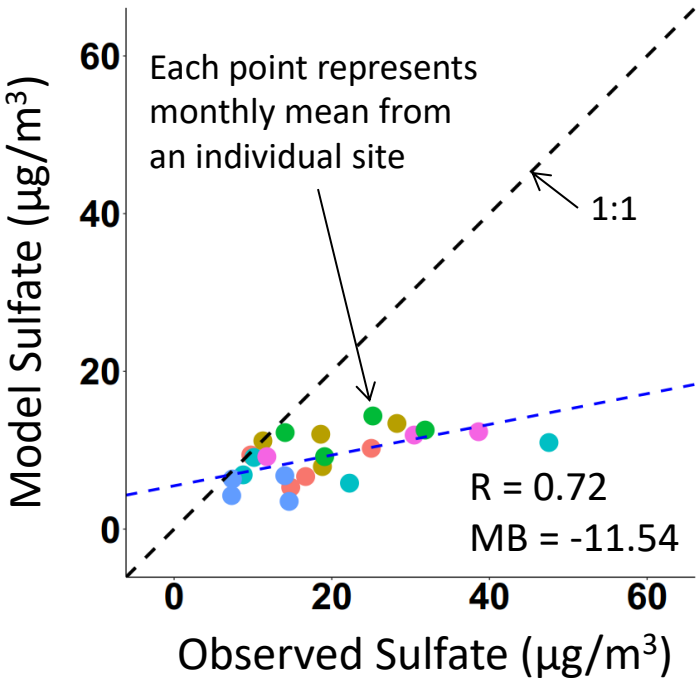
	MEIC	Standard scaling
NO_x	+1%	+5%
SO_2	+3%	-1%
NH_3	+8%	+0%
BC	-1%	+5%
OC	-7%	+4%

Coal-fired power plant in Shanxi, 2015 (Getty Images)

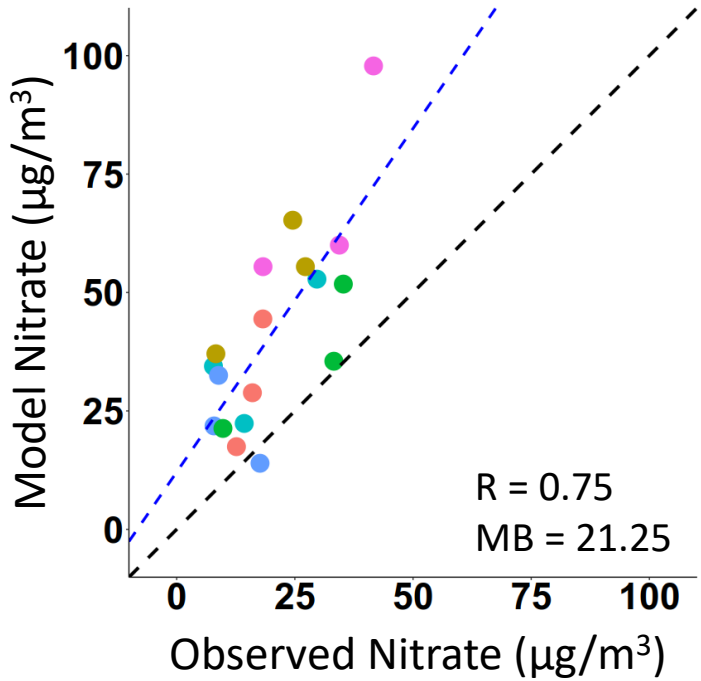
Relatively good $PM_{2.5}$ match hides component issues

DJF monthly mean components for North China Plain

Sulfate 2012-2013



Nitrate 2012

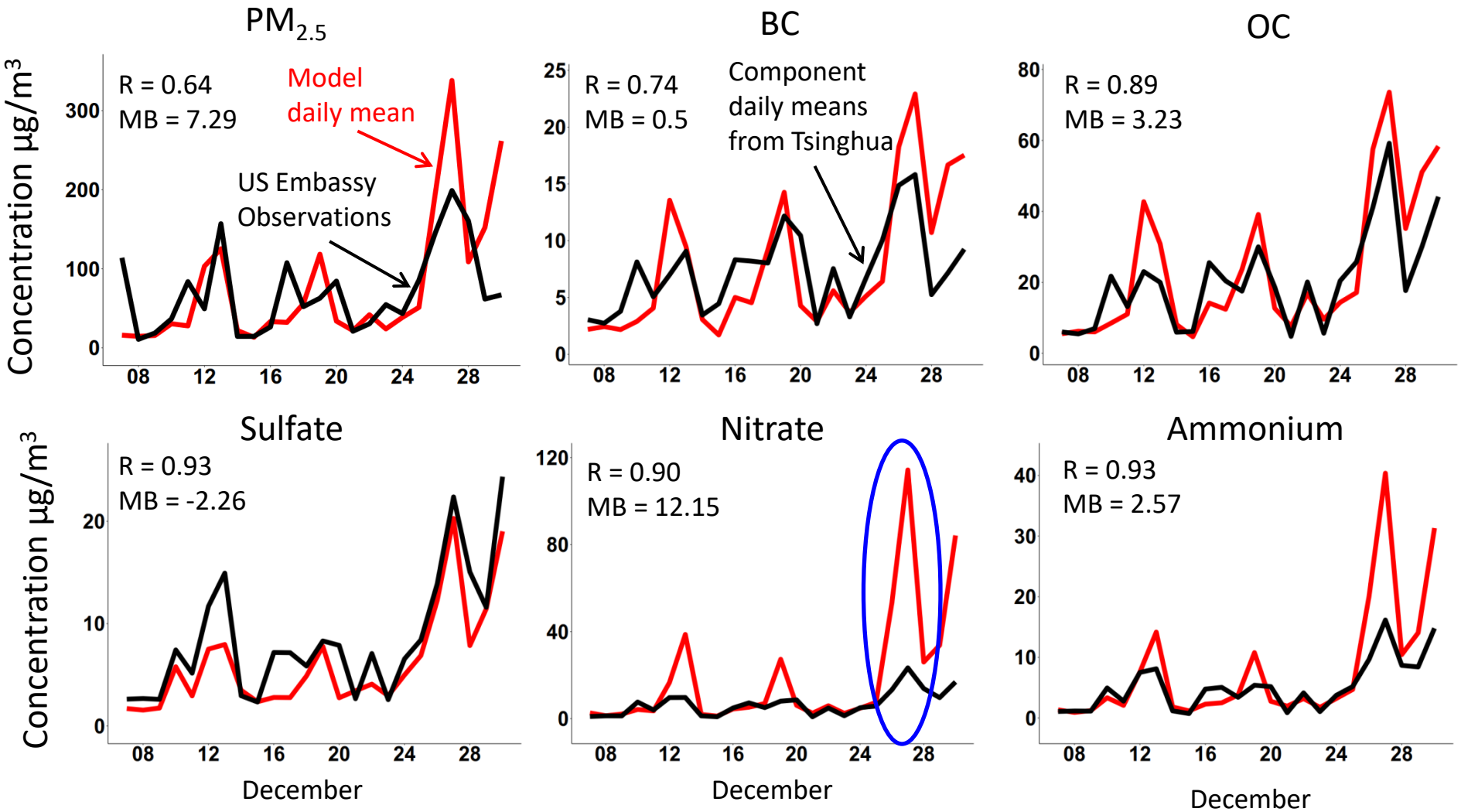


During winter sulfate is underestimated and nitrate is overestimated across the North China Plain.

Hypotheses to be tested:

- Missing sulfate oxidation mechanism is leading to too little sulfate, which allows for excess nitrate in the presence of ammonia.
- Excessively high ammonia emissions allow too much nitrate to enter the aerosol phase.
- There is an issue with NO_x partitioning or missing NO_x sink

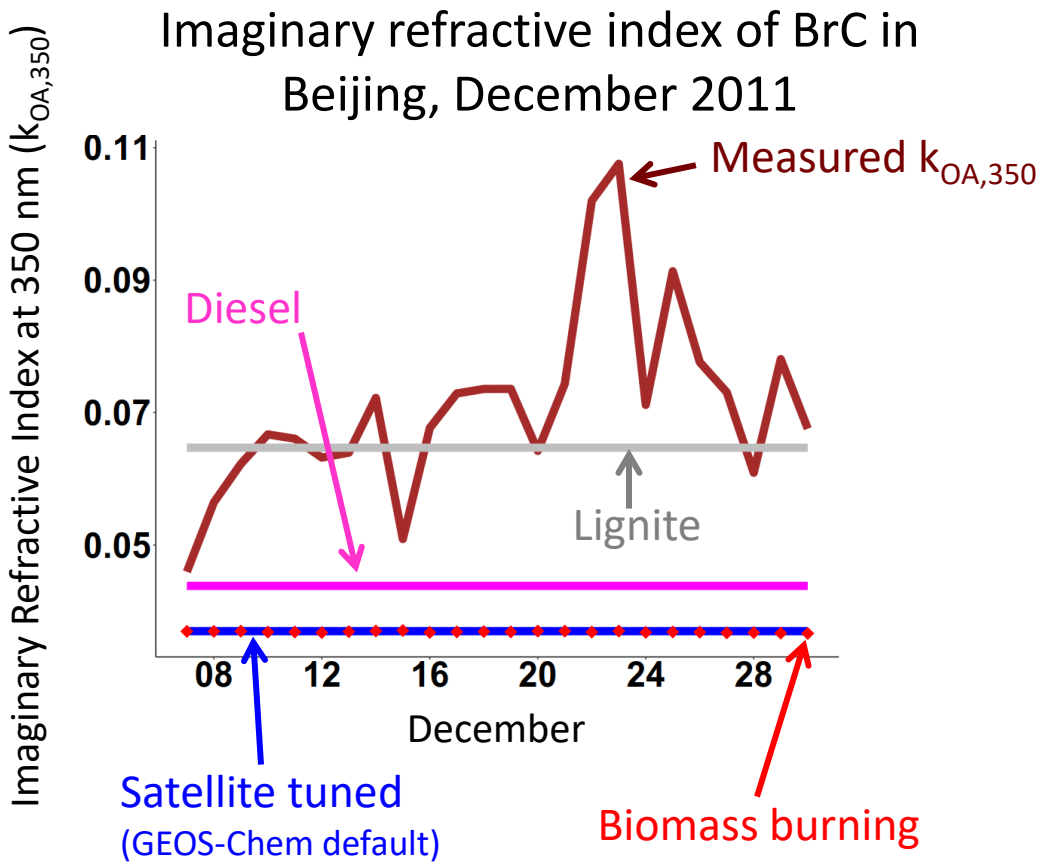
Comparison with Beijing daily data in 2011 shows similar bias



Comparison of GEOS-Chem with daily observations in Beijing 2011 also show an overestimate of $PM_{2.5}$ driven primarily by excess model nitrate during pollution episodes.

Component observations provided by Yuan Cheng

Switching gears to brown carbon: possibly an important absorber in China



- Brown carbon is the light absorbing portion of OC.
- Brown carbon and BC may play an important role in strengthening Chinese pollution episodes by absorbing radiation and stabilizing the planetary boundary layer.
- Surface measurements indicate brown carbon in China may be much more absorbing than current parameters for brown carbon in GEOS-Chem anticipate.

Reasons why $k_{OA,350}$ might be variable:

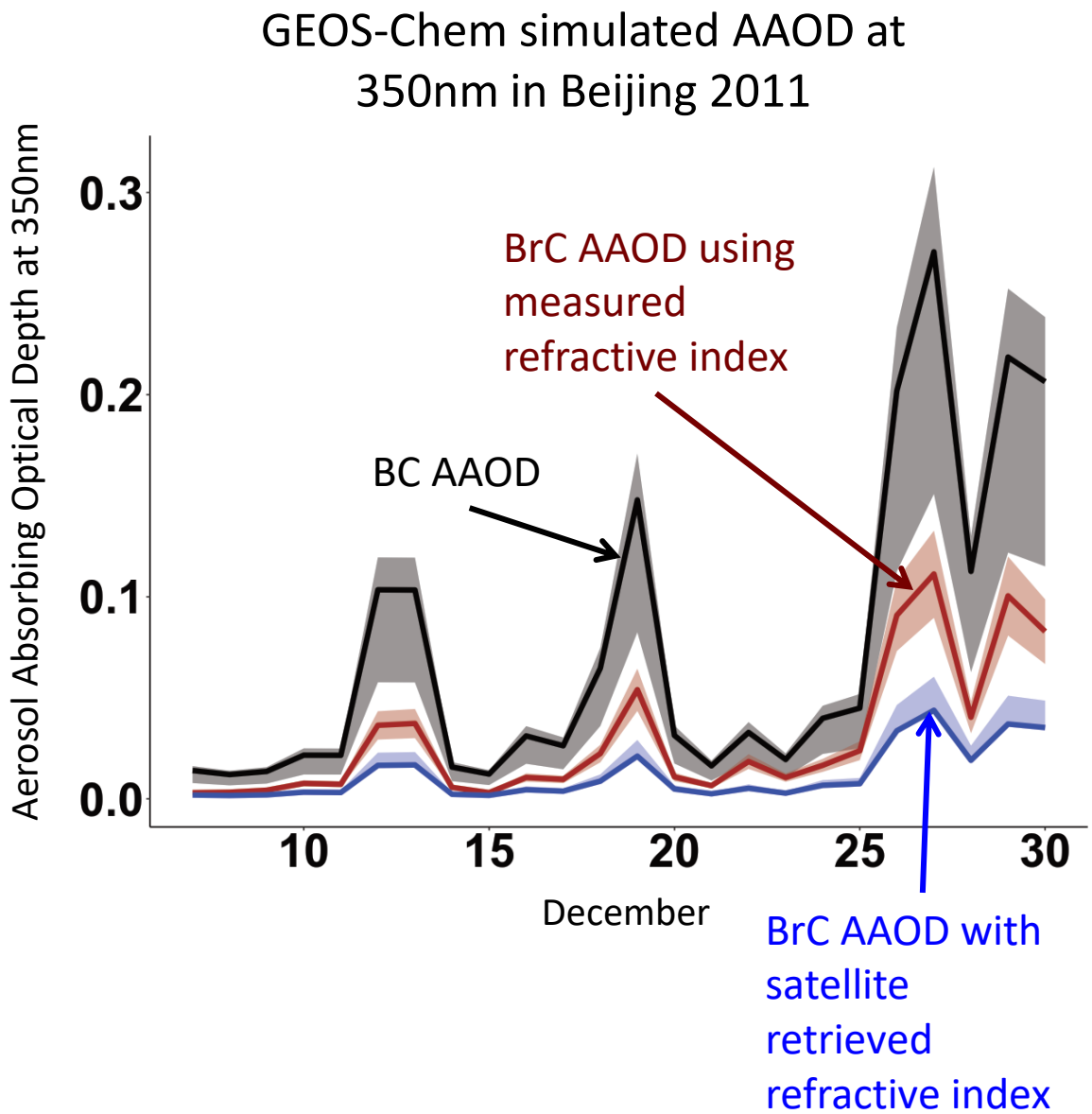
- Changing emissions
- Secondary brown carbon formation
- Photobleaching

Cheng et al., 2016; Hammer et al., 2016; Lu et al., 2015

Brown carbon may be a significant absorber at short wavelengths

Using in situ mass absorption coefficient for BrC leads to BrC making up on average 30% of total simulated AAOD over December versus 16% if using static satellite derived values.

Depending on mixing state assumptions about BC, brown carbon could make up 20-50% of total absorption over Beijing at short wavelengths.



Next steps

- Examine importance of increased nitrate removal for nitrate and ammonium overestimates.
- Examine importance of ammonia emissions for nitrate and total $PM_{2.5}$ overestimates.
- Use measurements of surface BC and BrC and aerosol optical depths to constrain GEOS-Chem simulations of BrC and BC.
- Estimate the effects of BrC and BC on regional climate.

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