Field observations of *aerosols and related species* in East Asia to constrain *model simulations* and *emission inventory*

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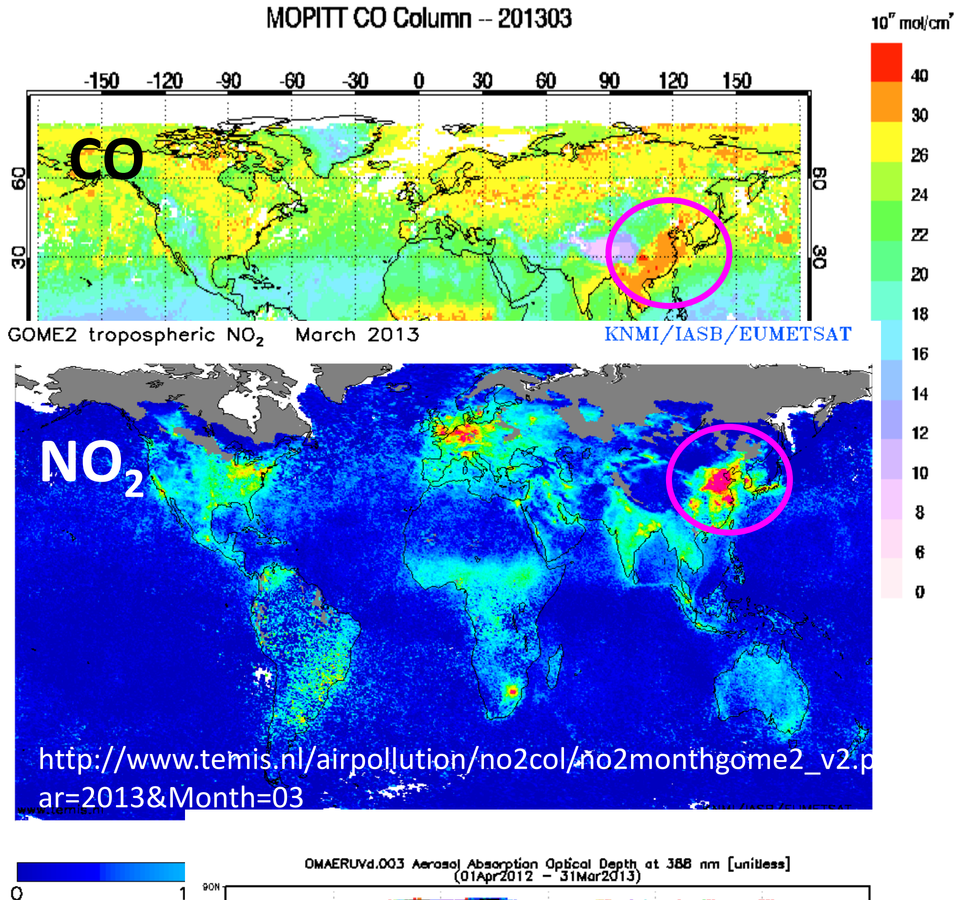
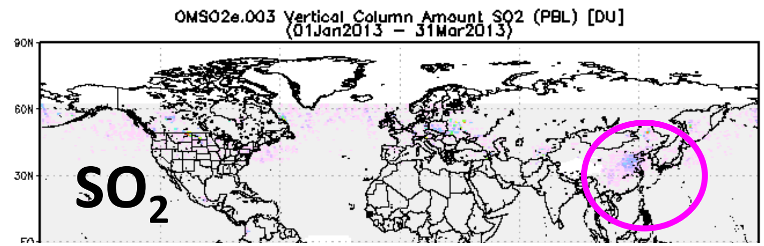
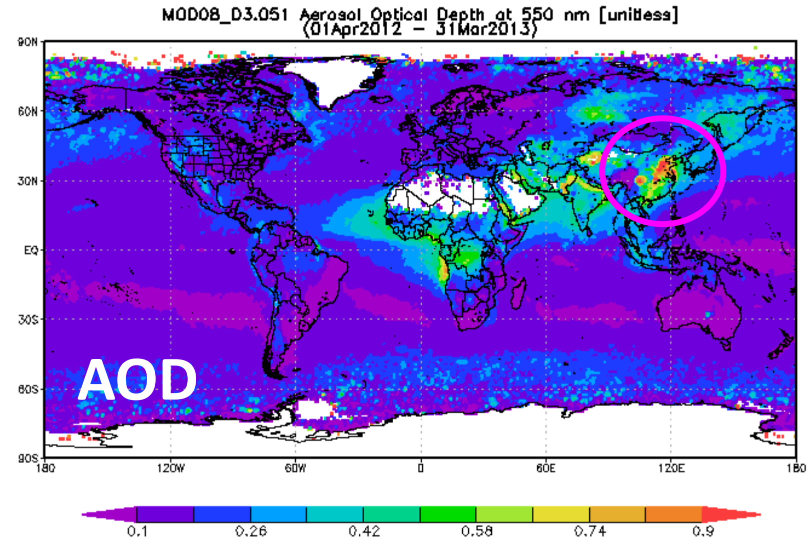
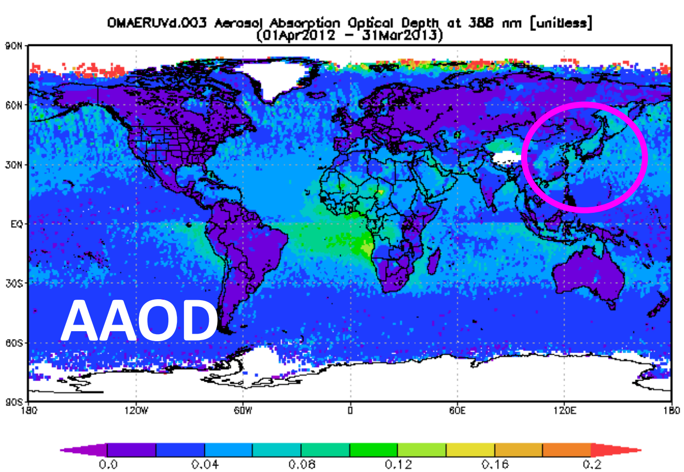
Supported by ERTDF S-7 project

East Asia as hot emission spots



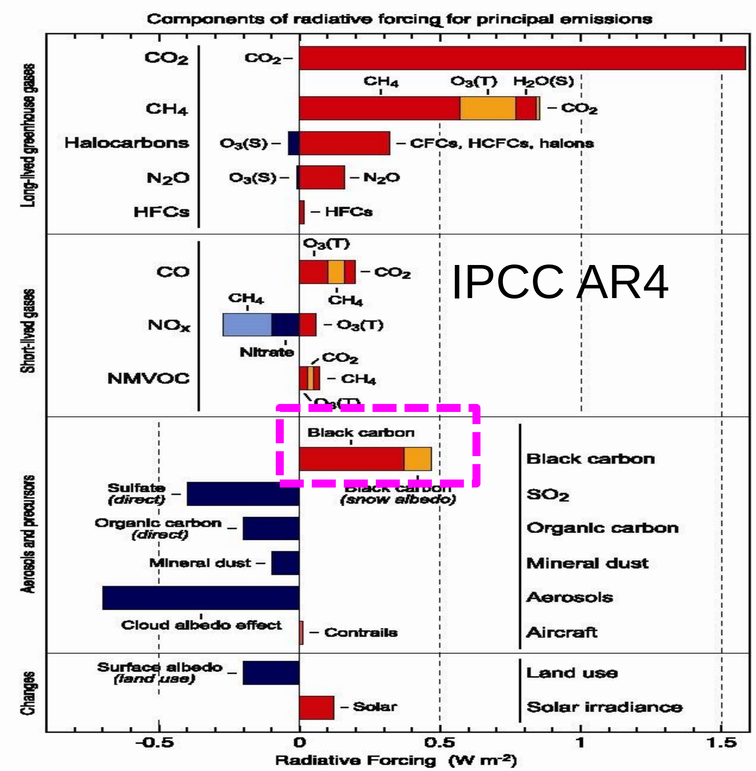




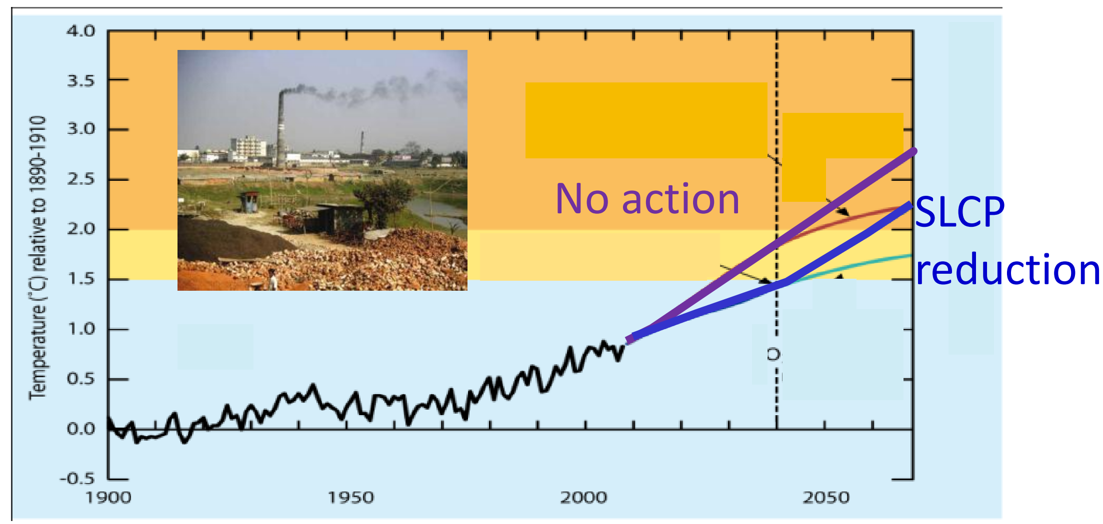


- still difficult to observe BC and OC from satellite
- demand for field observations

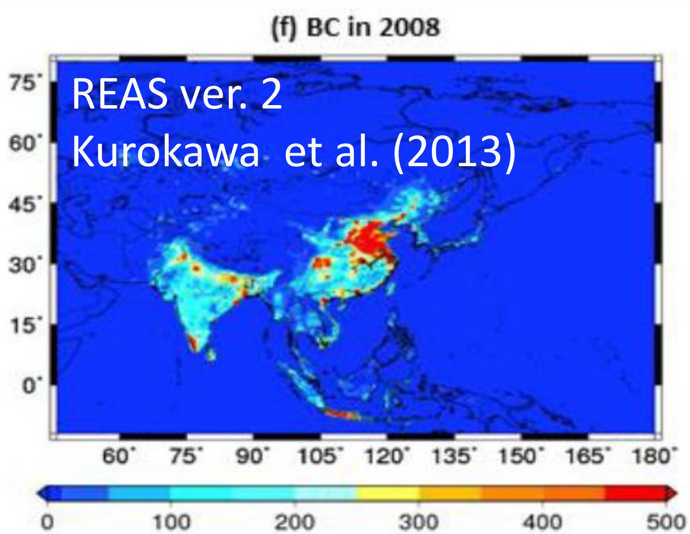
Motivation to study BC + organics in the field



● quantify BC, as SLCP (Short-lived Climate Pollutant) of mitigation target

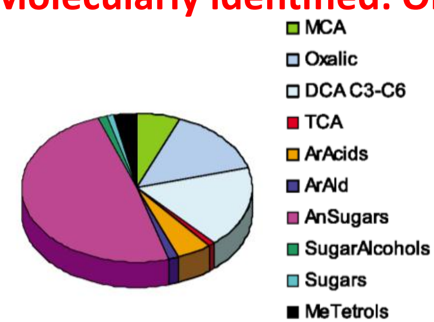


UNEP/WMO



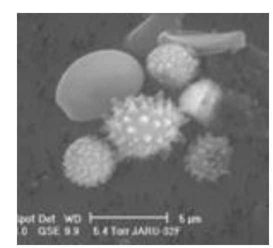
●Major fraction of organics is still unidentified

Molecularly identified: Only 10%

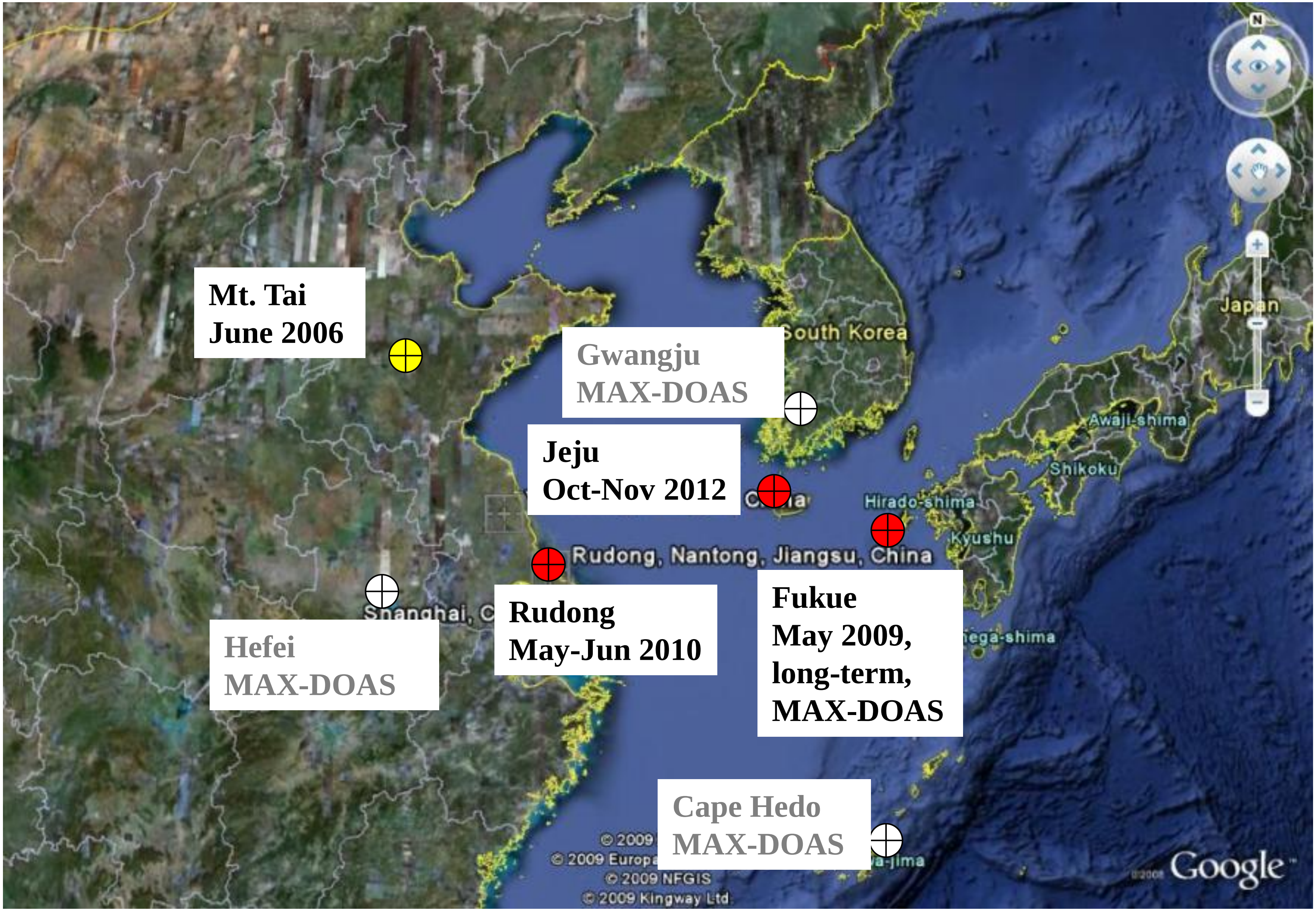


Decesari et al., 2006

90% Unknown:
humic-like substance?
bioaerosols?



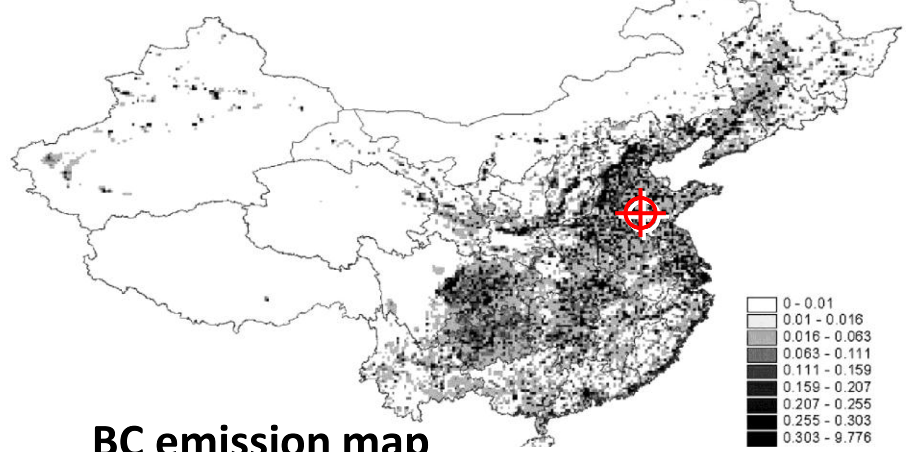
Observational sites



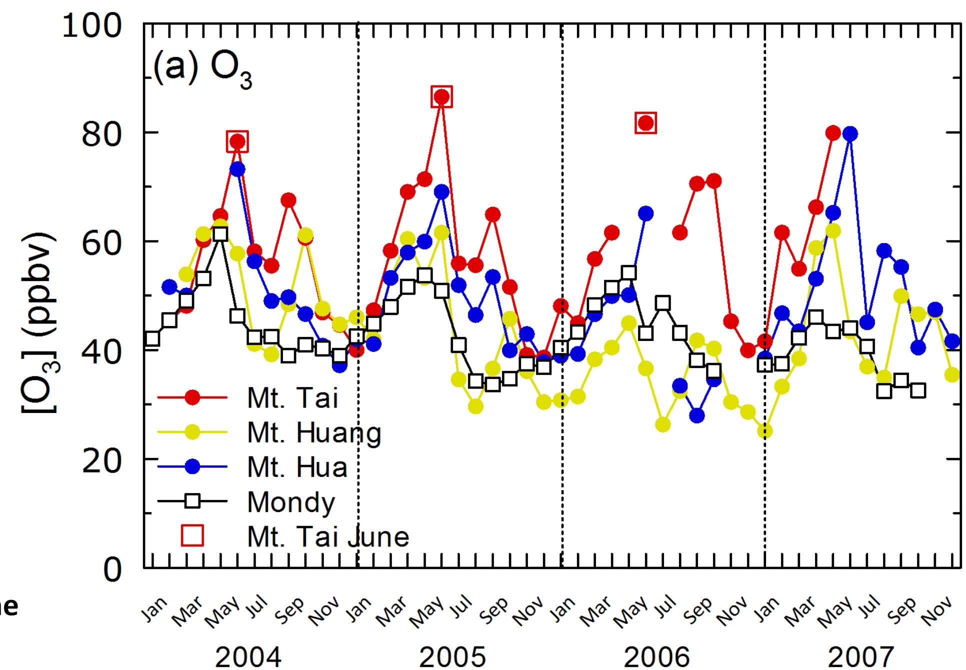
The Mount Tai Experiment 2006

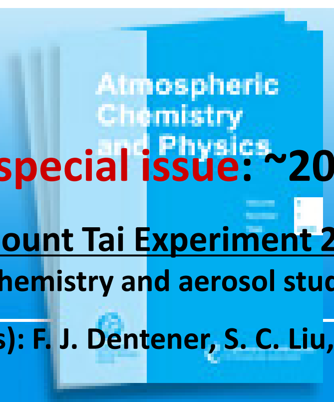
- To measure O_3, O_3 precursors, aerosol chemical species
- At the top of Mt. Tai, located in the middle of Central East China (CEC), regarded as one of the most significant source regions in the world
- In June, when O_3 and other pollutants show maximum concentrations
- to study O_3 and aerosol chemistry and transport that control regional pollution,
- under close collaboration between observations and model simulations

36.26N, 117.11E 1534 m asl.



BC emission map





ACP special issue: ~20 papers!

The Mount Tai Experiment 2006 (MTX2006): regional ozone photochemistry and aerosol studies in Central East China

Editor(s): F. J. Dentener, S. C. Liu, and L. T. Molina

Overview paper: Kanaya et al., ACP, in press, 2013

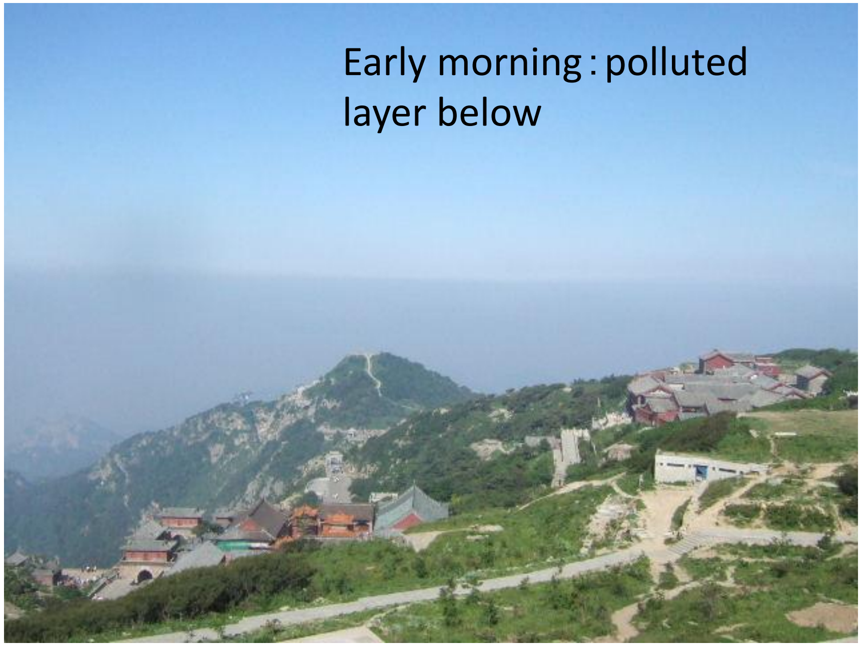
Observed species

Observed species	Method	PI
O_3, CO	UV absorption, NDIR	P. Pochanart, JAMSTEC
O_3	UV absorption	T. Wang, J. Gao, Shandong Univ.
NO/NOx/NOy	LED/Molybdenum converter /Chemiluminescence	H. Tanimoto, NIES
NO/NOx*	Chemiluminescence	T. Wang, J. Gao, Shandong Univ.
NMHCs	Canister/GC-FID/GC-MS	S. Kato, Tokyo Met. Univ.
NMHCs	Canister/GC-MS	Y. Wang, IAP
NMHCs, VOCs	PTR-MS	H. Tanimoto, S. Inomata, NIES
CO_2	NDIR	Y. Komazaki, JAMSTEC
NO_2 VCD & AOD from mountain	MAX-DOAS	H. Irie, Y. Kanaya, JAMSTEC
NO_2 VCD & AOD from foothill	MAX-DOAS	H. Irie, Y. Kanaya, JAMSTEC
Actinic flux & J values	Spectralradiometry	Y. Kanaya, JAMSTEC
T, RH, P, wind	Conventional instruments	Meteorological observatories
Blackcarbon (PM1, PM2.5)	Multi-Angle Absorption Photometry	P. Pochanart, JAMSTEC
EC/OC	Thermal-Optical-Transmittance	Y. Komazaki, JAMSTEC
Aerosol absorption	Particle Soot Absorption Photometry	Y. Komazaki, JAMSTEC
Blackcarbon	Aethalometer	T. Wang, J. Gao, Shandong Univ.
Size segregated aerosol chemicals	Cascade impactor/ post analysis	Y. Wang, IAP
Ion analysis of TSP and PM2.5	Sampling/ post analysis	G. Zhuang, Fudan Univ.
Organic gases/aerosols	High volume air sampler, filterpack collections/ post analysis	K. Kawamura, Hokkaido Univ.
PAHs/size segregated aerosols	Sampling/ post analysis	G.Wang, Nanjing/Hokkaido Univ.

36.26N, 117.11E 1534 m asl.

Clean and hazy cases

Day with Good visibility

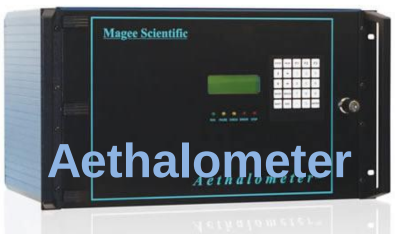


Early morning : polluted layer below

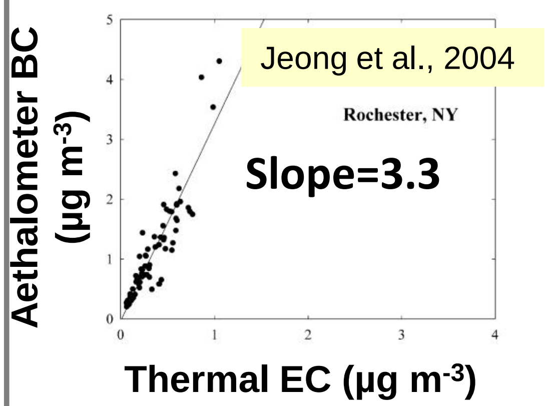
Before noon: polluted layer comes up

Select reliable BC instruments

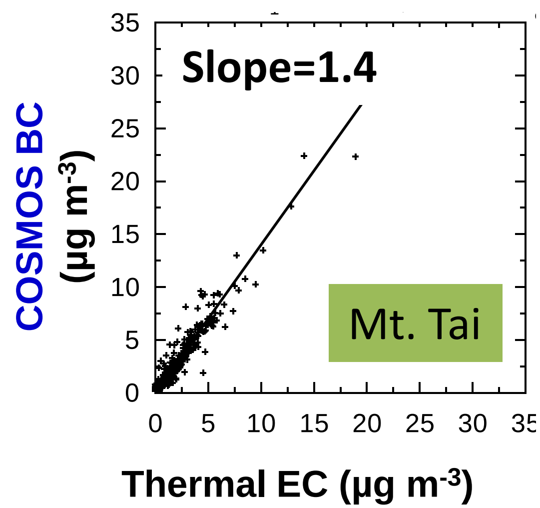
Recommendation: Use COSMOS (heated PSAP) and MAAP, less influenced by scattering particles, and base on ECOC analyzer.



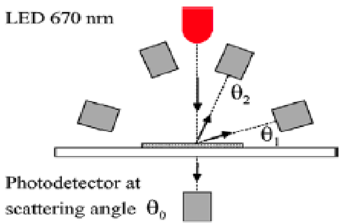
Rochester, NY

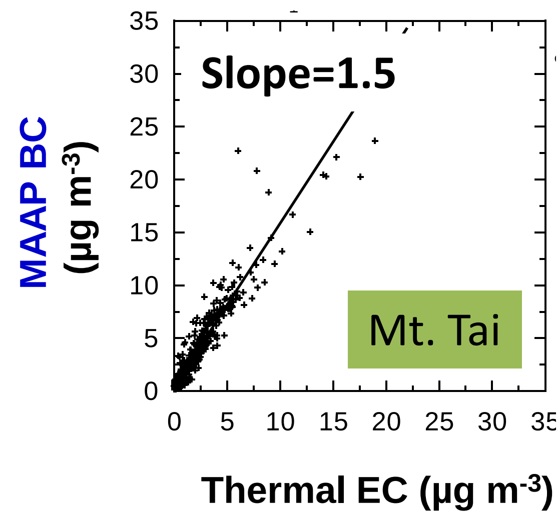


Pre-heat to 400C to remove non-refractive scattering particles



Multi-angle detection to compensate scattering effect

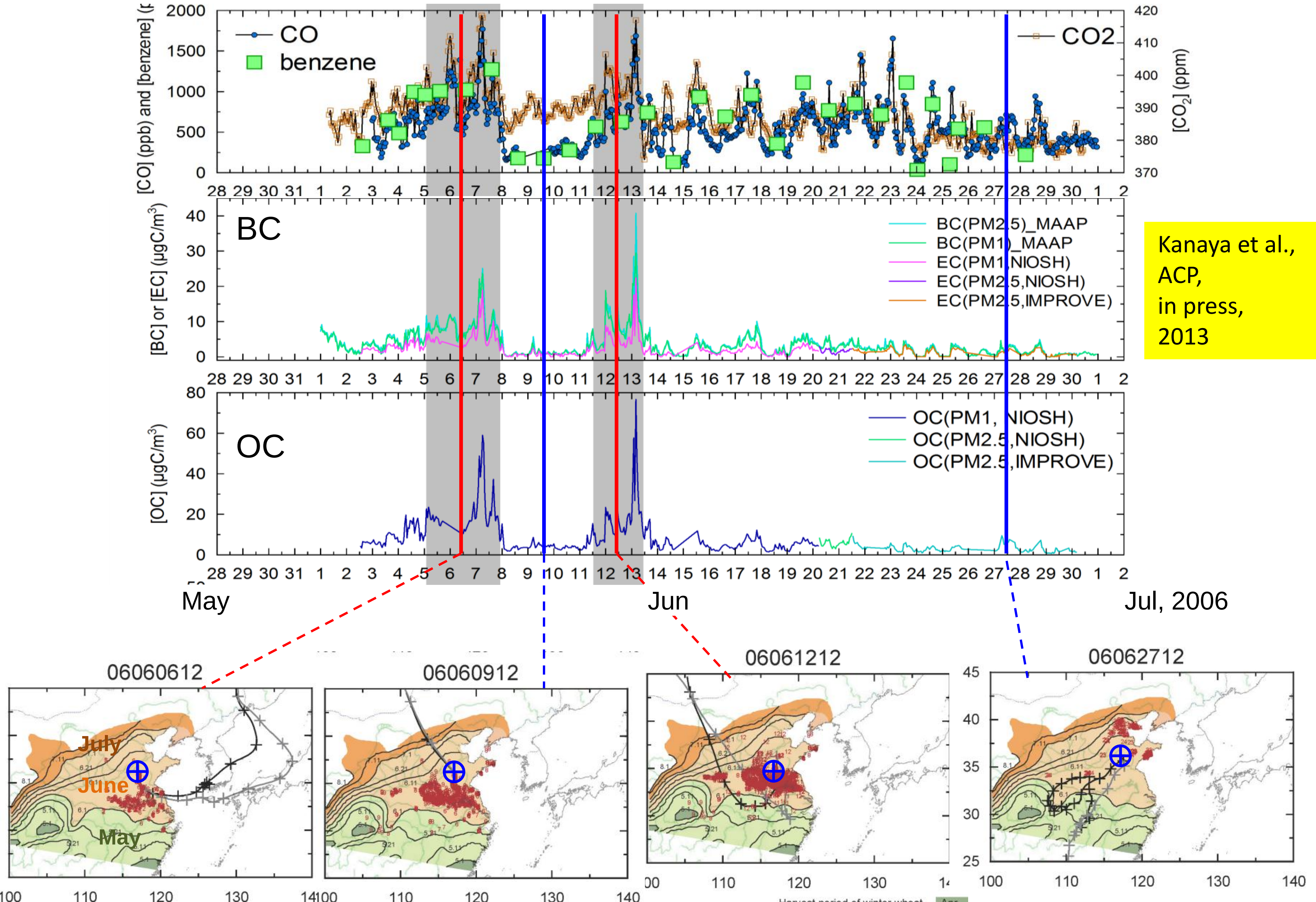




Kanaya et al., ACP, 2008

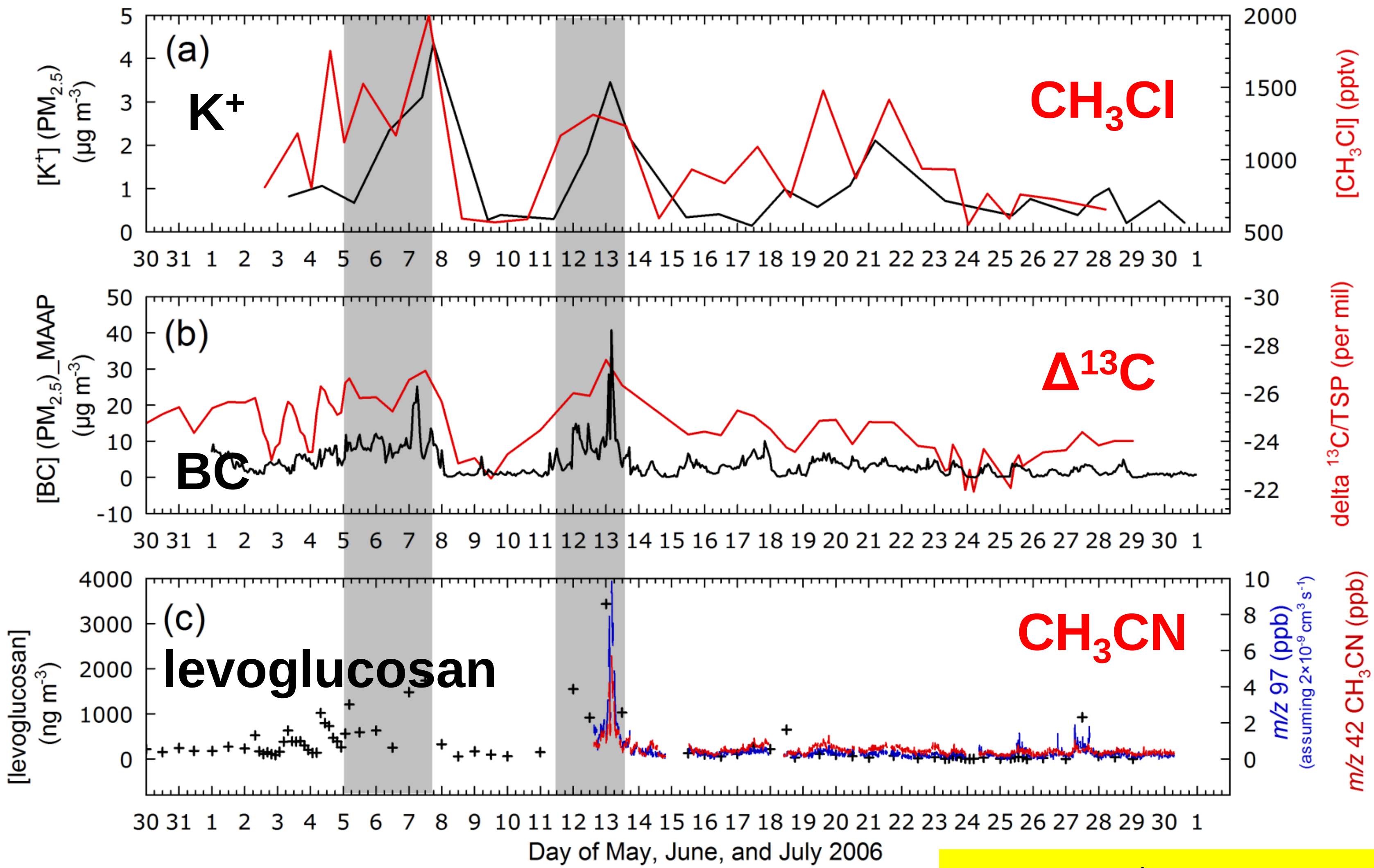
To constrain emission rates better than a factor of 1.5, we need to be able to observe with better accuracy.

CO, BC, OC influenced by open crop residue burning



Kanaya et al., ACP, in press, 2013

Chemical fingerprints of biomass burning



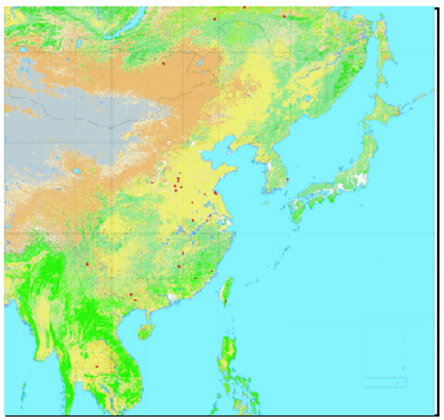
Kanaya et al., in press, ACP 2013

Refinement of OCRB emission using satellite hotspot data

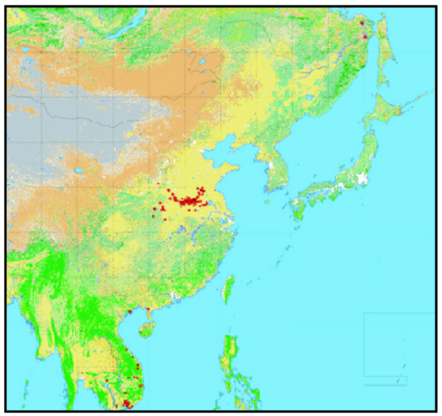
Annual emission: fraction of crop residue burnt in the field [Yan et al. 2006]

Daily and spatial allocation: based on hotspot distribution (Aqua/Terra MODIS)

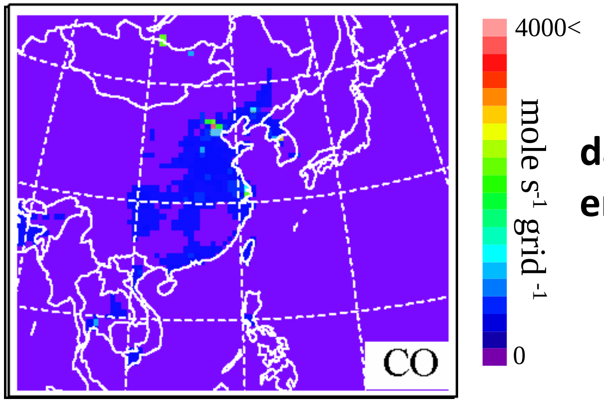
28 June 2006

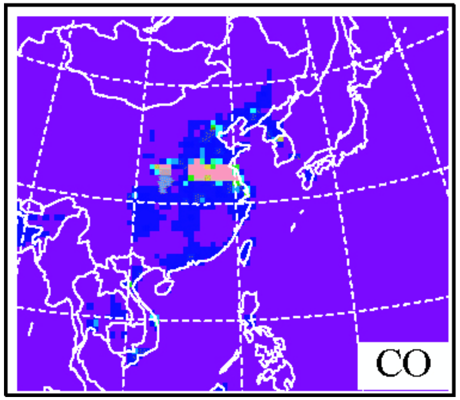


7 June 2006



MODIS hotspot





daily CO emission

Ref: A day with low BB activities

Days with high BB activities

Yamaji et al., ACP, 2010

Modeling O_3/aerosol with revised emission inventory

CMAQ/RAMS regional model

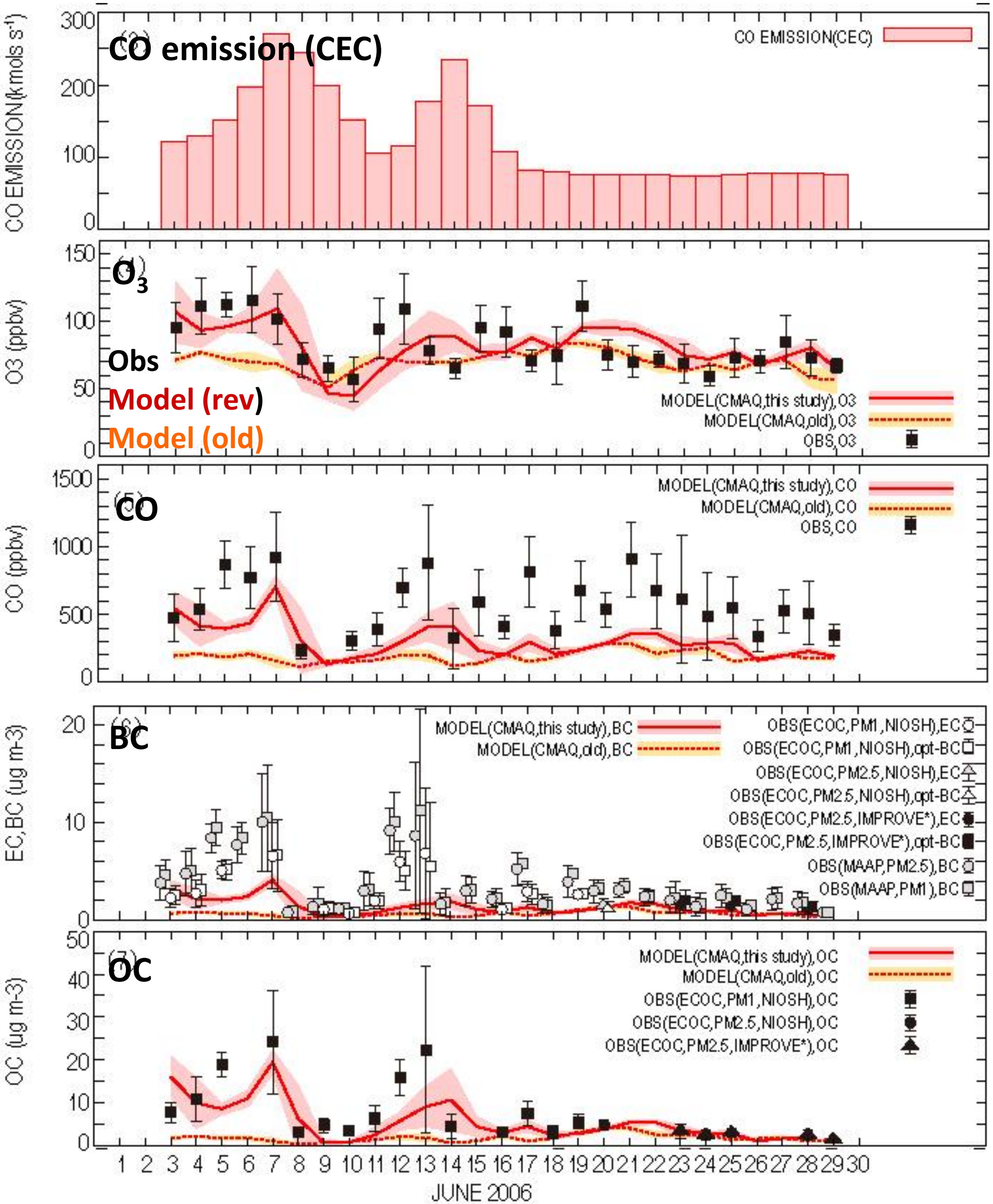
Resolution: 80x80km^2

Boundary: Global CTM (CHASER)

Gas chem: SAPRC99

Aerosol: AERO3 (SORGAM, ISSOROPIA, RPM)

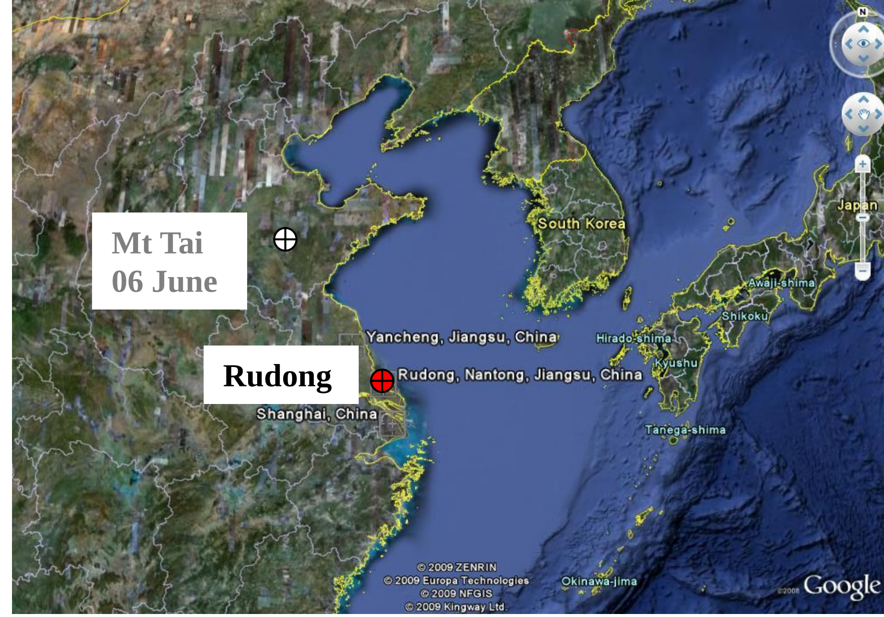
OCRB emissions contributed 6% of O_3, 20% of CO, 43% of BC, and 53% of OC concentrations over CEC for the whole month of June



Yamaji et al., ACP, 2010

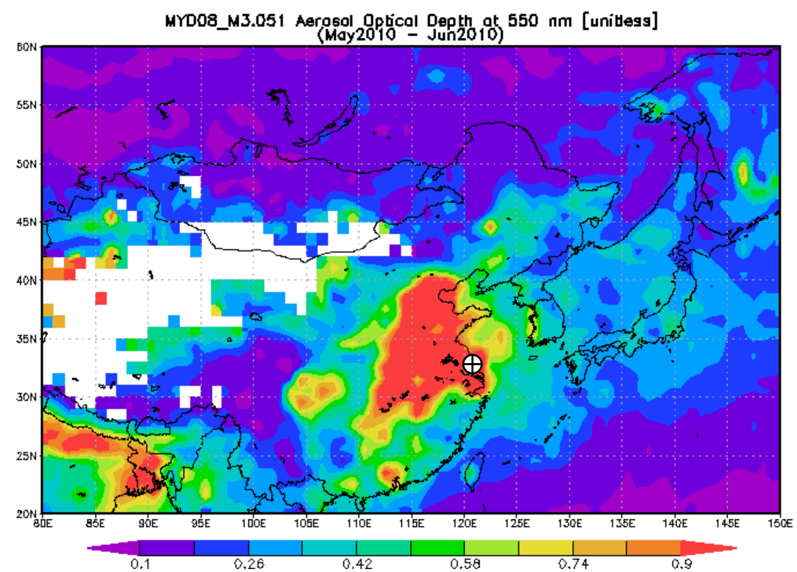
Rudong field campaign 2010

•Observe O_3/aerosols and their precursors
•in May-June 2010, in seasons with high O_3/aerosols,
•to closely observe biomass burning



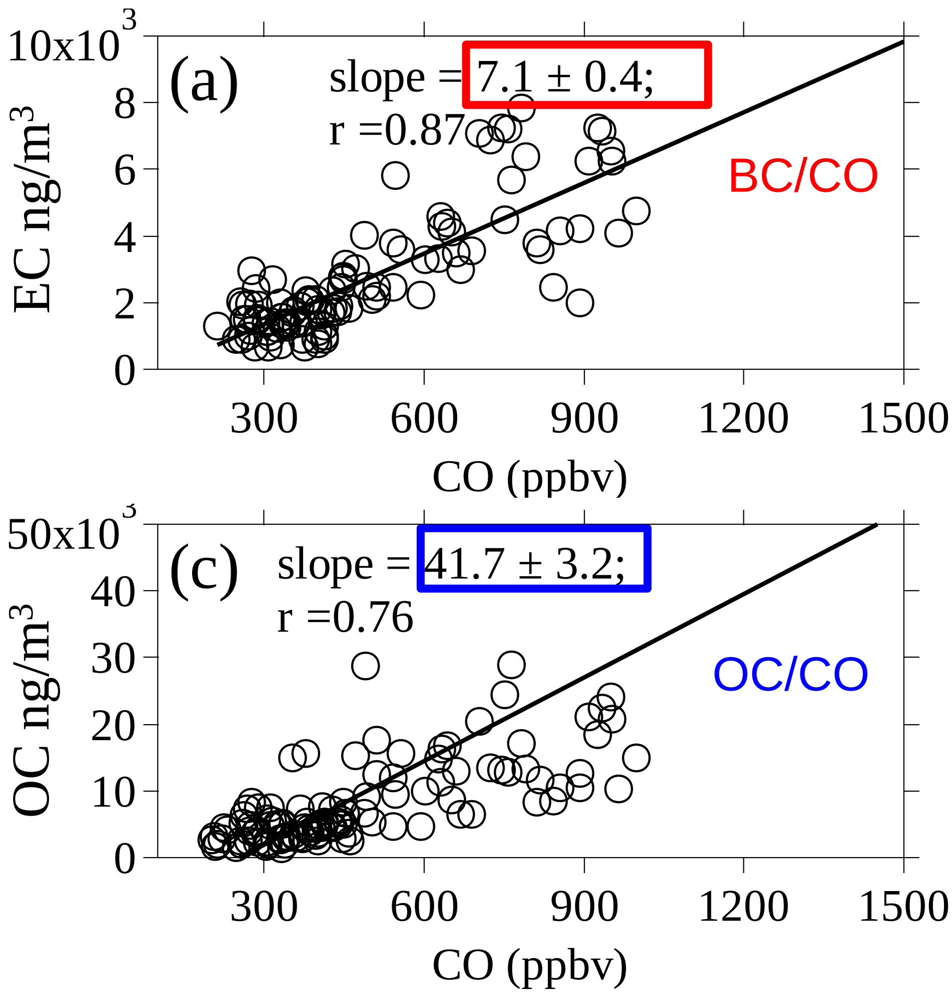
100 km north of Shanghai

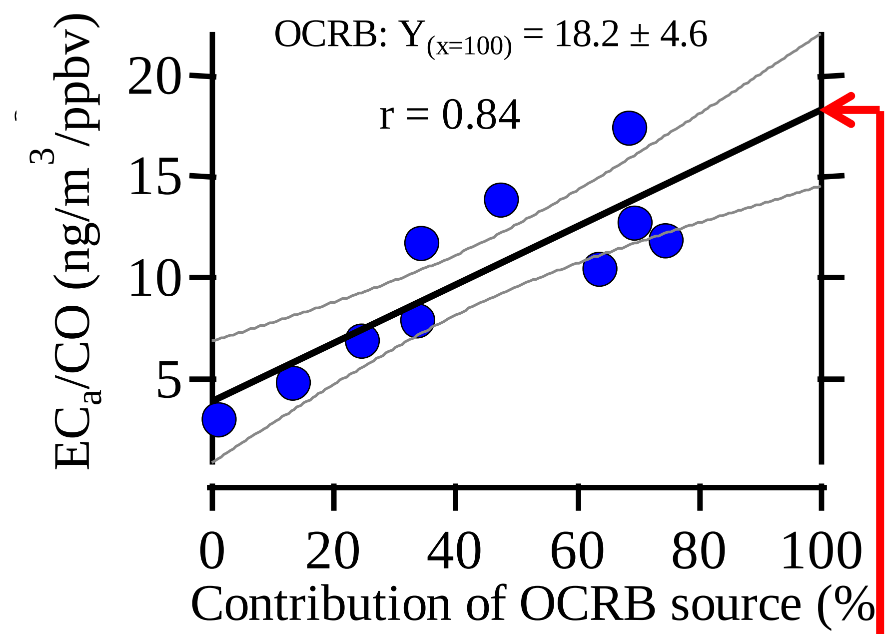
crop residue



BC/CO emission ratio

BC/CO = 7.5 ng/m³/ppbv (Andreae and Merlet, 2001, agricultural waste burning) is often used but the ratio could be larger





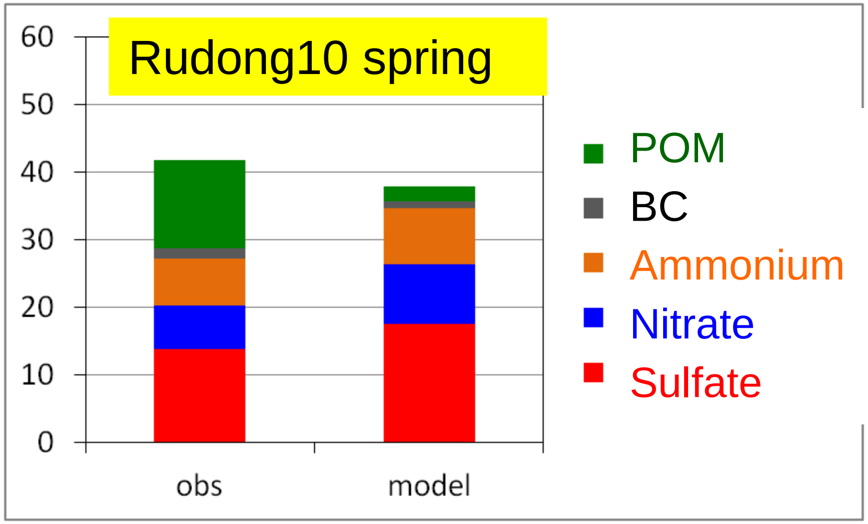
Estimated Emission ratio:

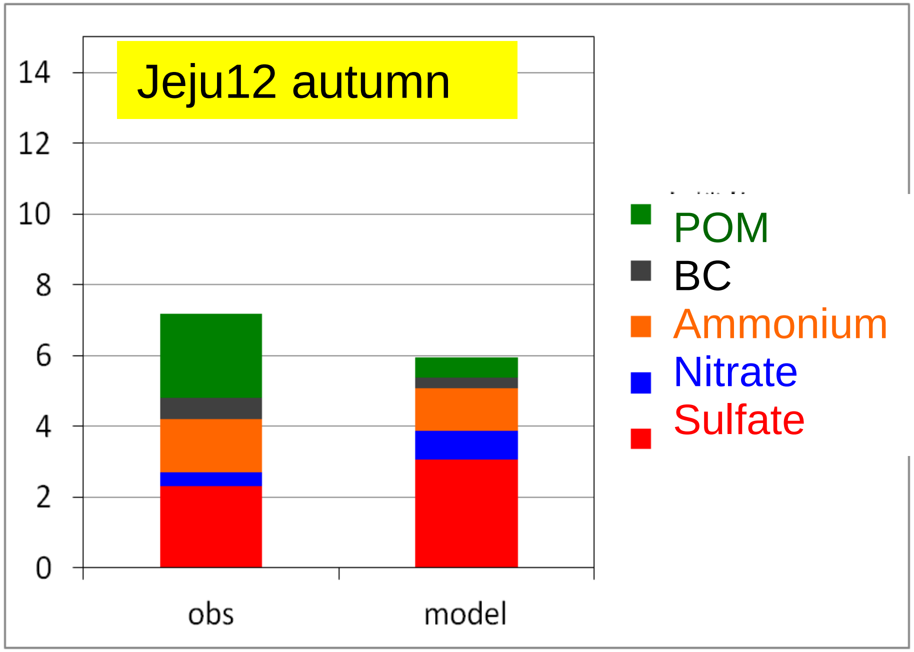
BC/CO = 18.2 ng/m³/ppbv

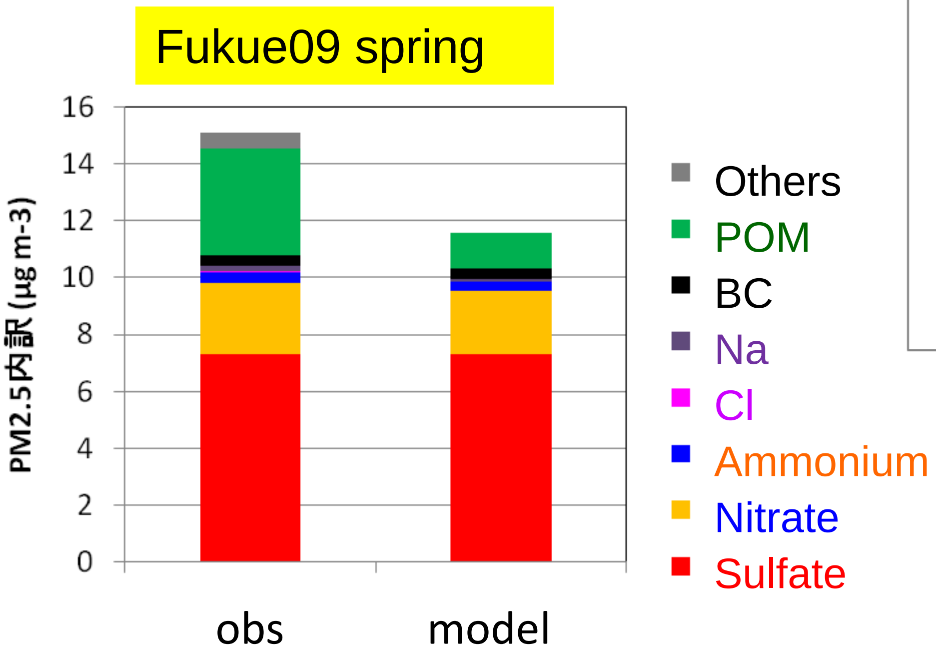
OC/CO = 101 ng/m³/ppbv

Pan et al., JGR 2012

PM$_{2.5}$ composition: obs vs. model (μg m^{-3})



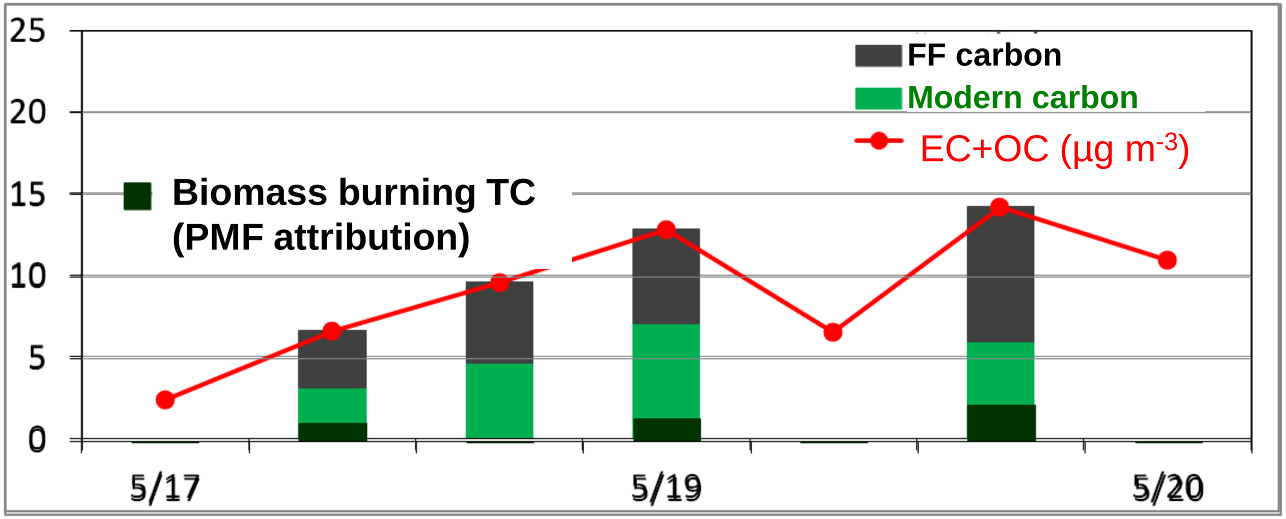




- Common underestimation of POM by factors of 4-6
- SNA relatively well reproduced

Explore origins of missing carbonaceous aerosols using ^{14}C

(Rudong, May-June, 2010)

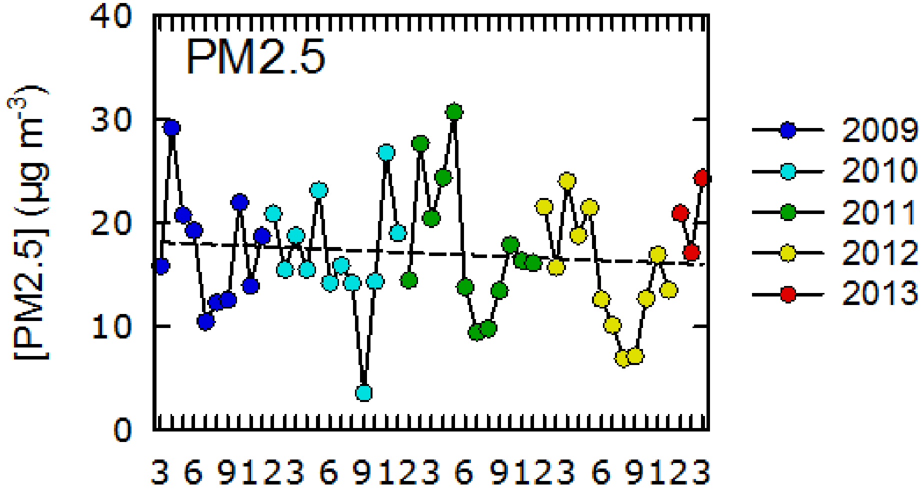


Urban/industrial emission dominant,
But large amount of modern carbon: 3-7µg m^{-3}

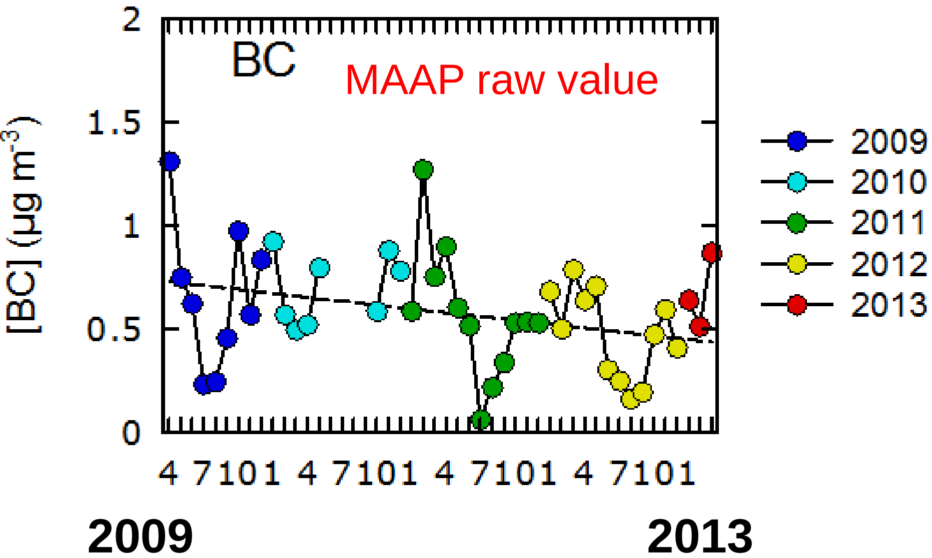
PMF attribution to Biomass burning (TC): only **0-2 µg m^{-3}**

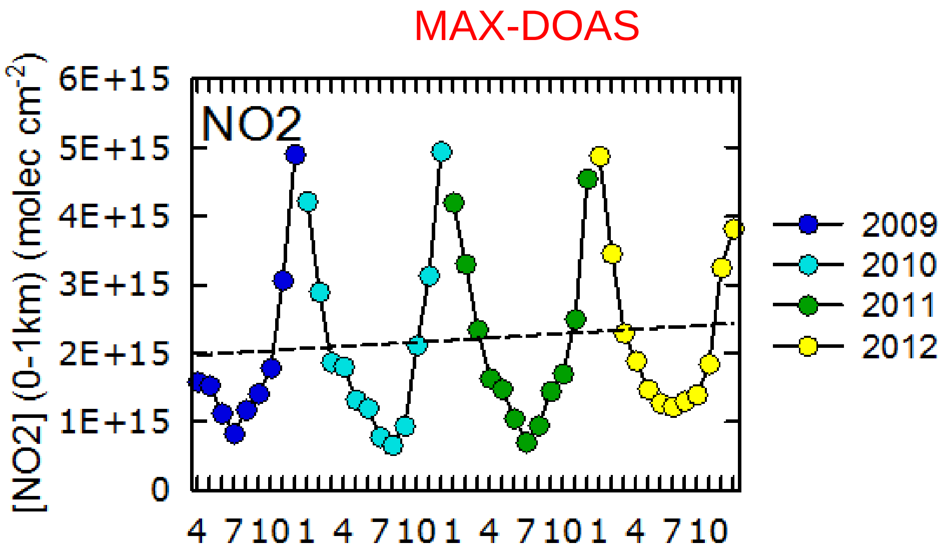
Suggesting more modern carbon from **Prim/Sec biogenic OA**

Decreasing BC trend at Fukue? (preliminary)

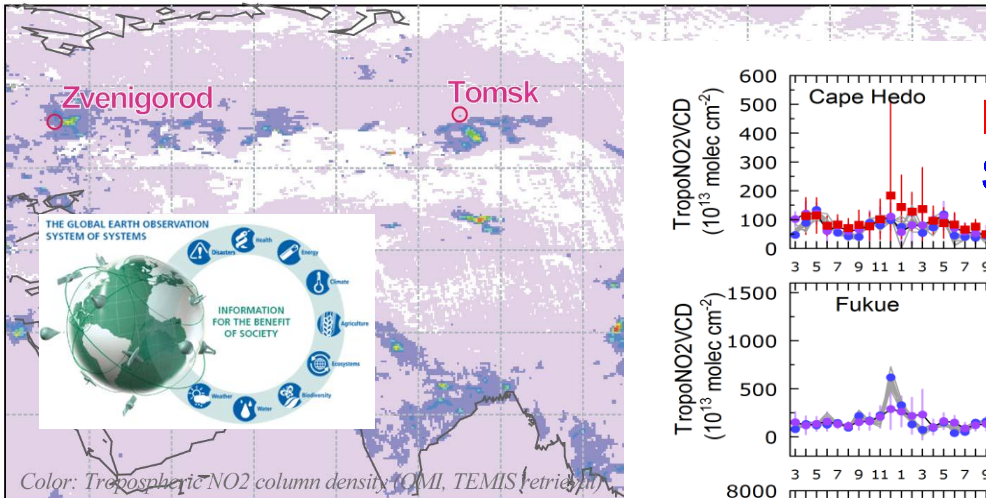


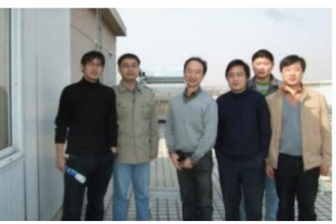
- Downturn of BC emission started?
- Or coupled to meteorology changes?

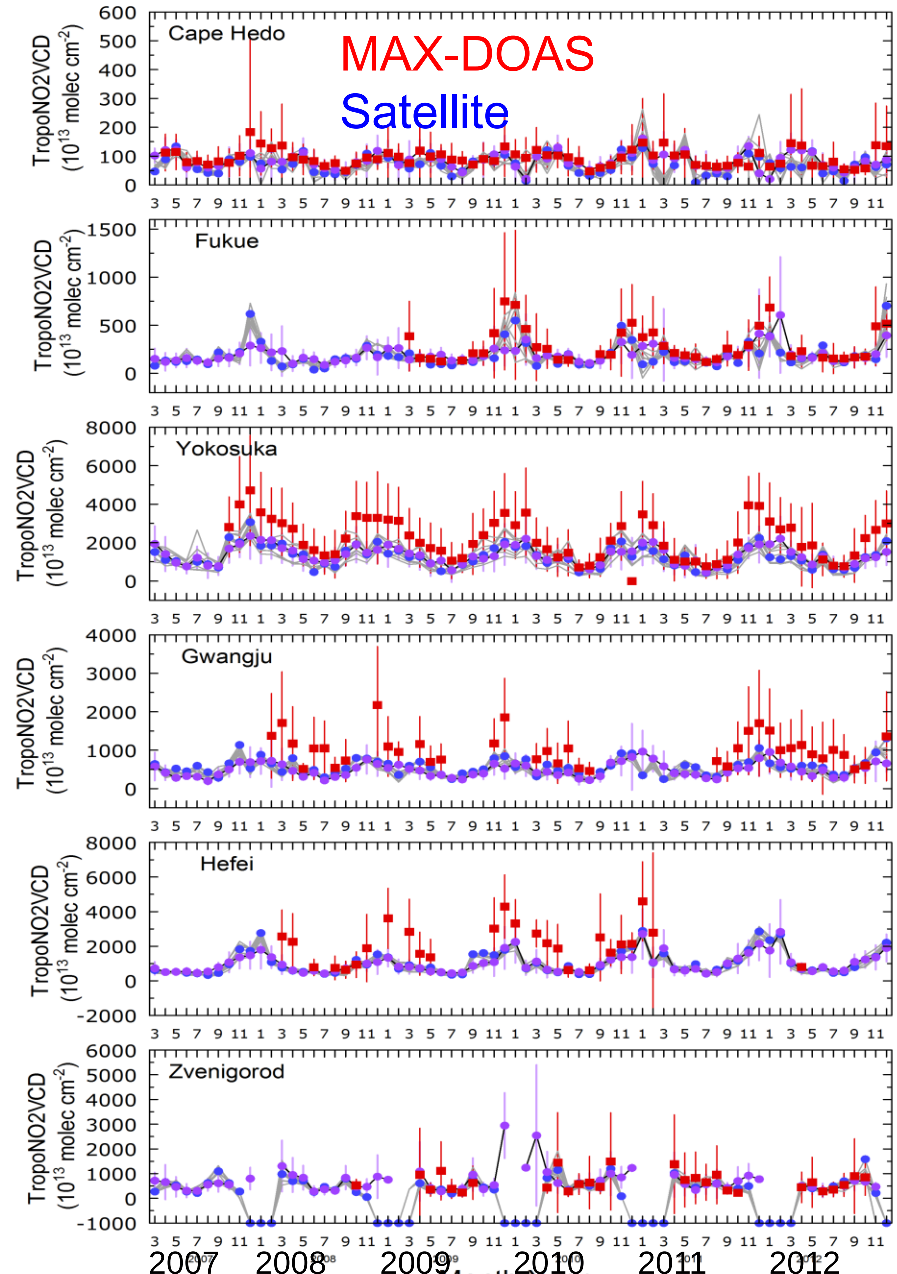




MAX-DOAS network over Asia and Russia



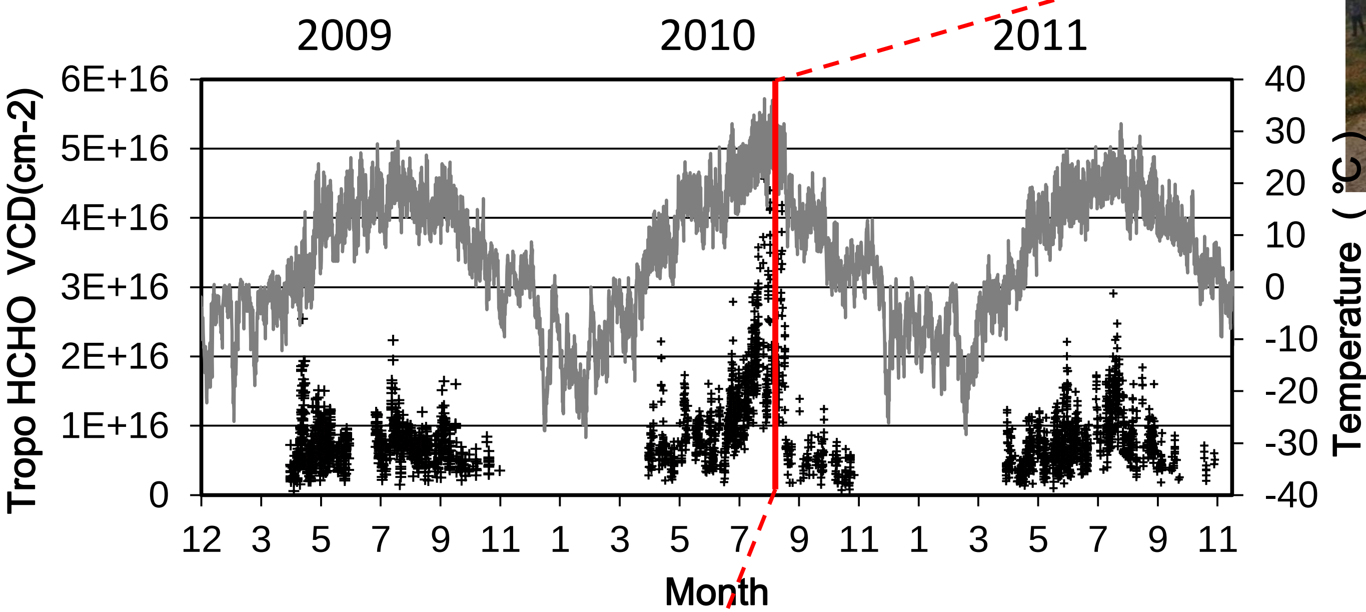


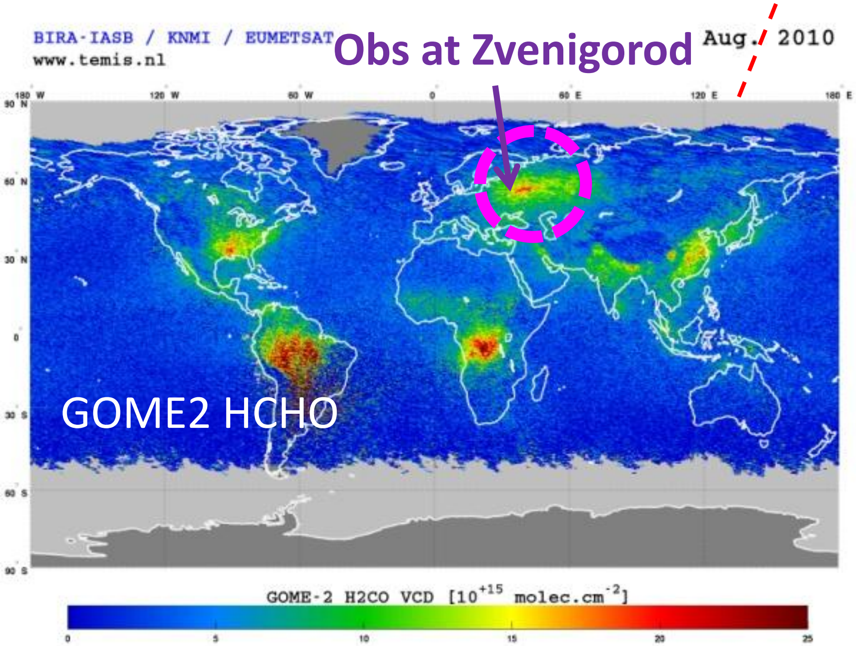


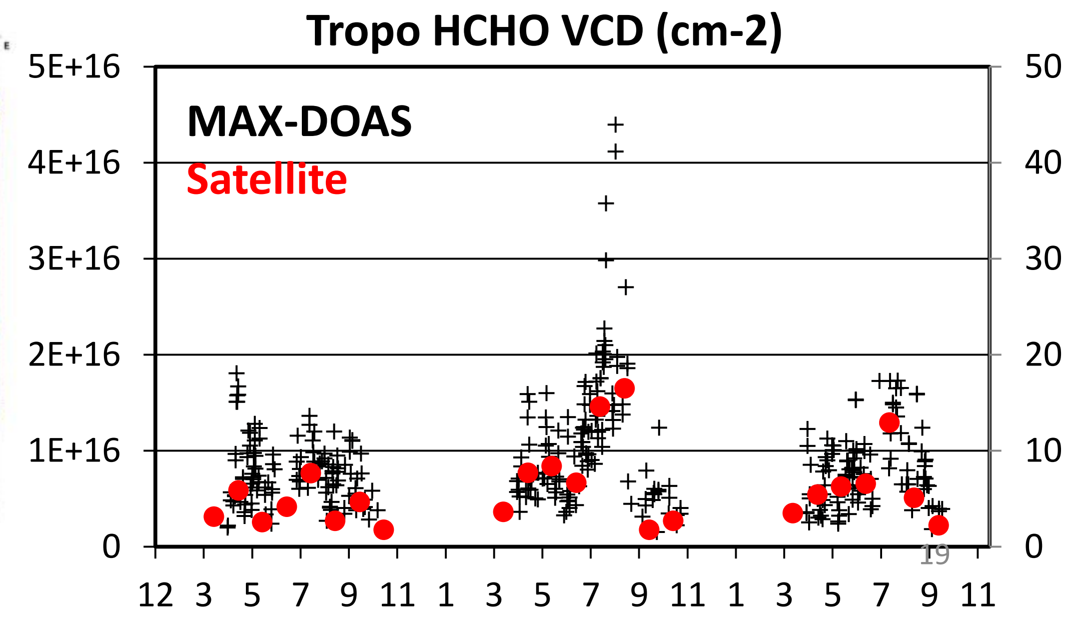
- Wanted: partners for obs in SE/S Asia!
- Climatology of NO2 and aerosols
- Validation of satellite & model

http://ebcrpa.jamstec.go.jp/maxdoashp/

HCHO from Russian Forest Fire 2010







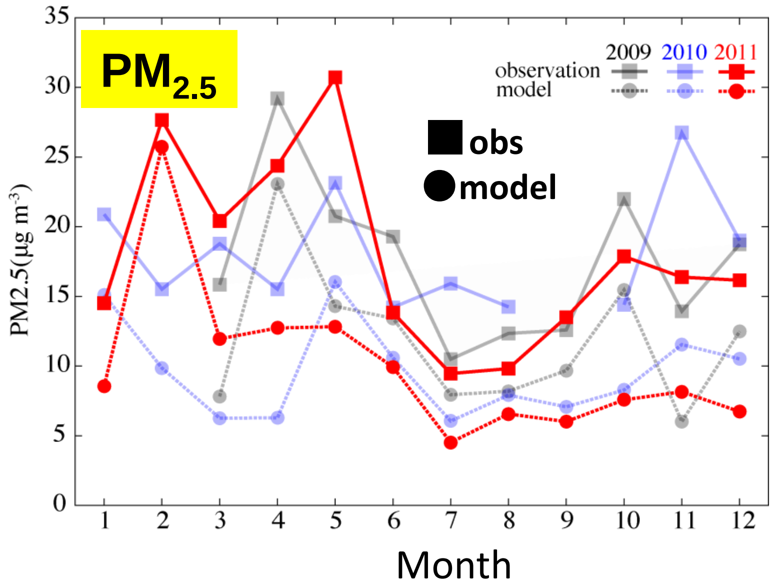
Summary

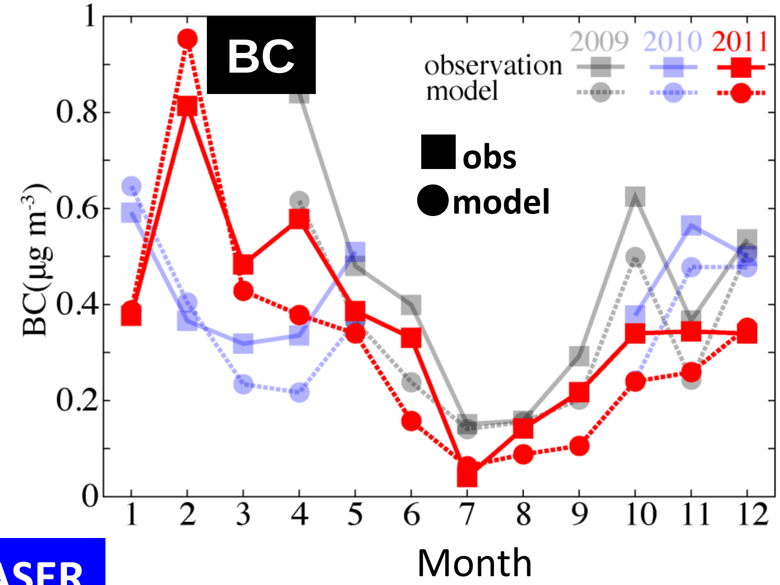
- Regional-scale open crop residue burning (OCRB) in CEC is an importance source of air pollution
- BC emission rates from OCRB could be underestimated by a factor of 2.5
- Organics: underestimated by a factor of 5, at 3 field campaigns;
  More natural source suggested by ^{14}C analysis
- Long-term BC reduction is observed at Fukue, needing confirmation

- MAX-DOAS detected HCHO emission from Russian forest fire in 2010: good agreement with satellite

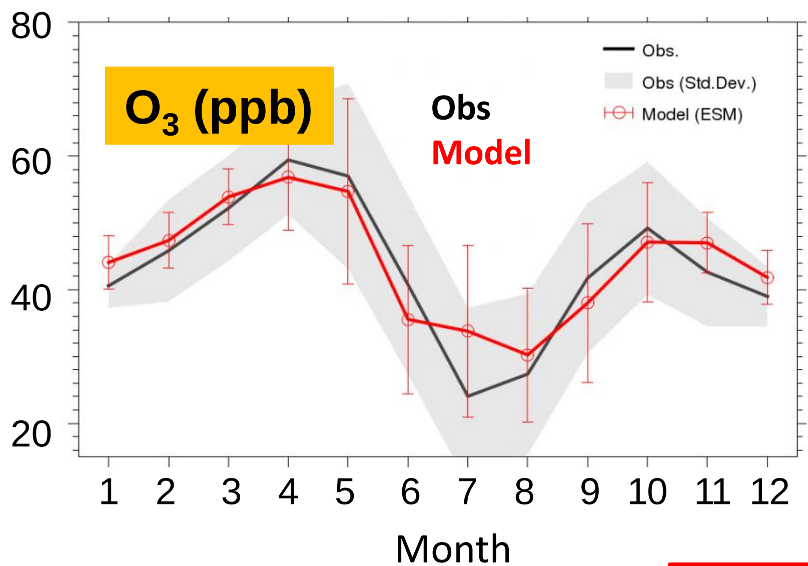
Comparison of seasonality at Fukue

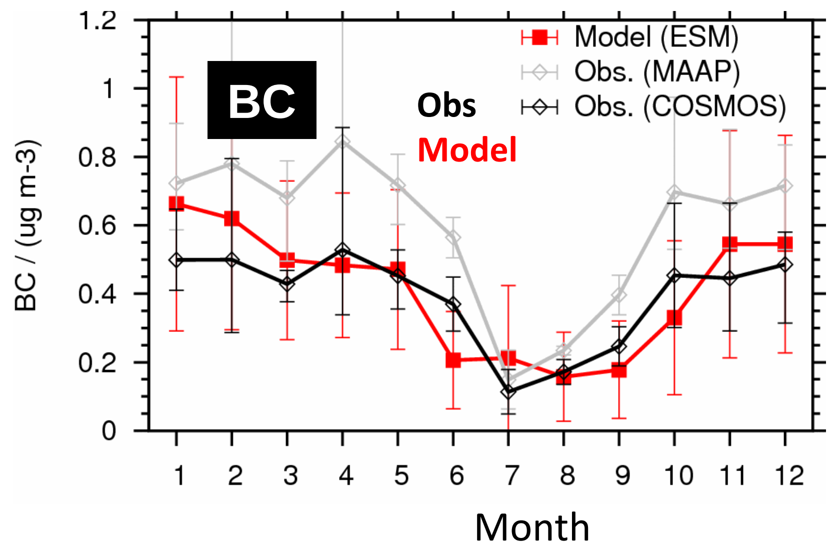
WRF-CMAQ





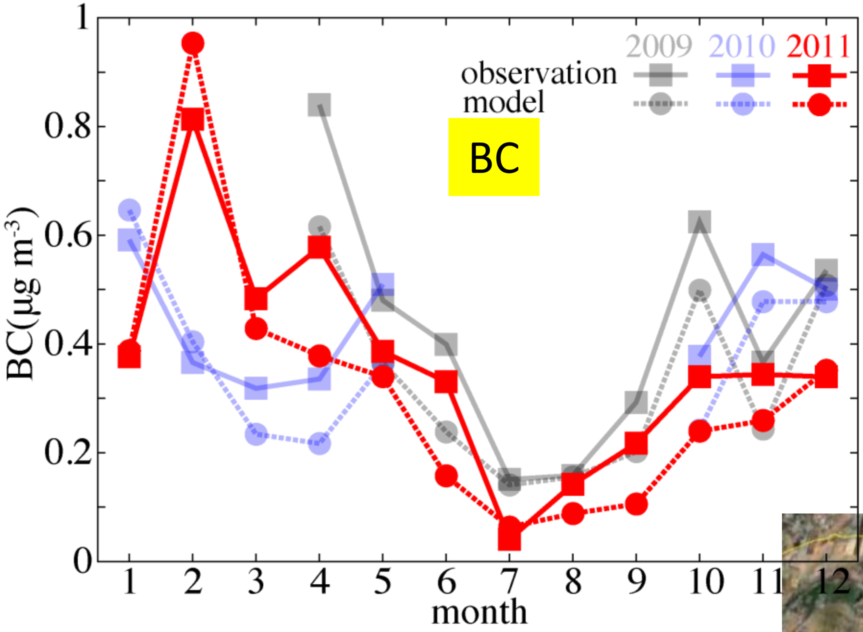
CHASER





Generally good agreement

BC at Fukue, in the downwind, is in agreement with model…



BC emission increase will result in overestimation of BC at Fukue

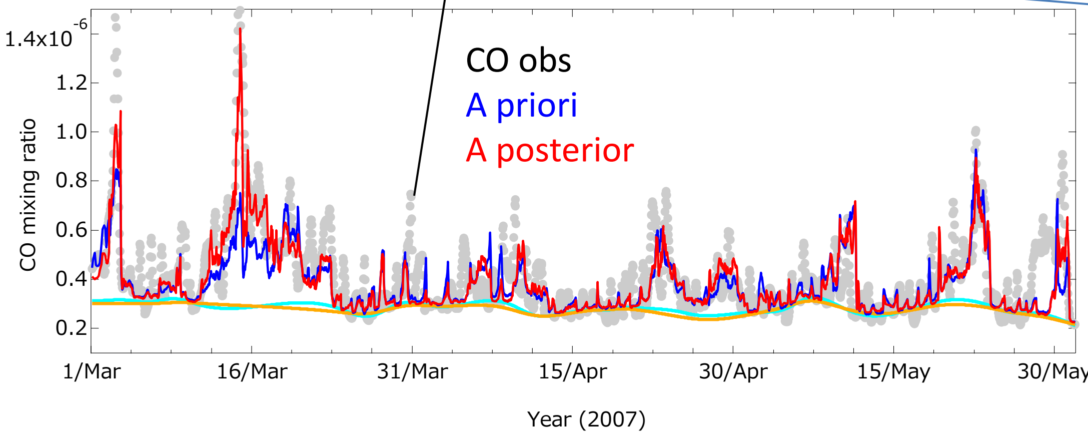
biomass burning is not a major source
Or the loss rate of BC could also be faster

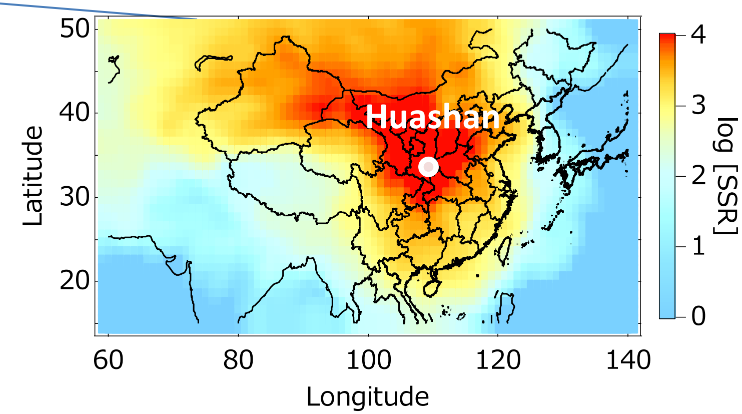
BC in downwind in Japan is well reproduced by the model, suggesting that major BC emission source is different and well constrained, or lifetime of BC is shorter and compensates larger emission rates

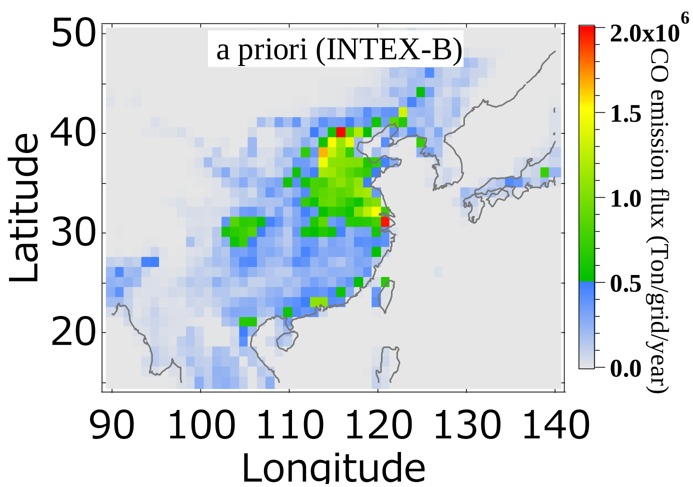
Bayesian inversion & WRF_FLEXPART model to optimize CO emission

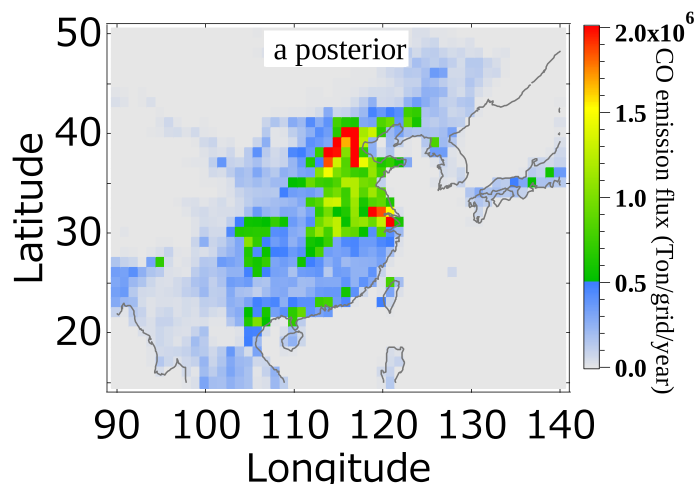
Pan et al., in preparation

Basic equation: $y_m = M_{m\times n} \cdot x_n + \varepsilon$









- Need more emission around Beijing, YZRD regions
- CO emission is likely 30% underestimated
- BC emission rates, based on BC/CO ratio, also need to be increased further by 30%