International Workshop on "Inventory, Modeling and Climate Impacts of Greenhouse Gas emissions (GHG's) and Aerosols in the Asian Region, Jun26-28, 2013 @Tsukuba

Simulation of aerosol spatial distribution over Asia using a global aerosol model

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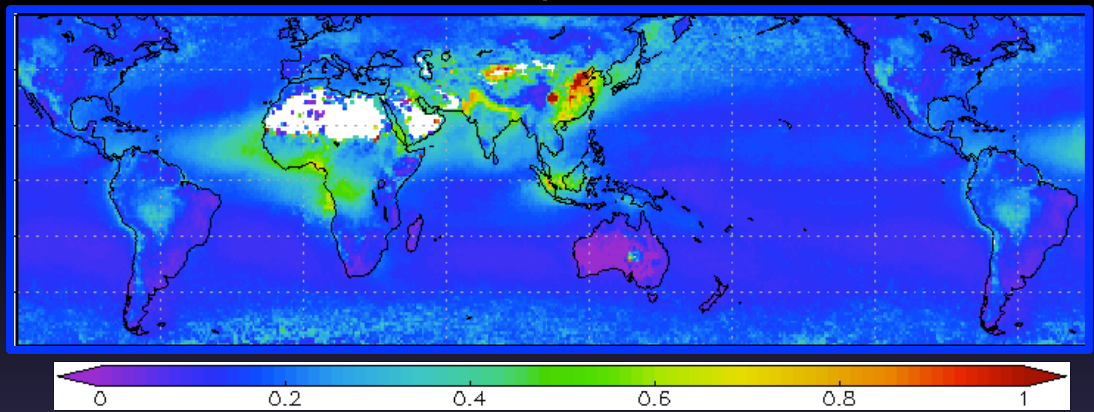
Why do global aerosol models focus on Asia?

Annual mean AOT by MODIS/Terra in 2006

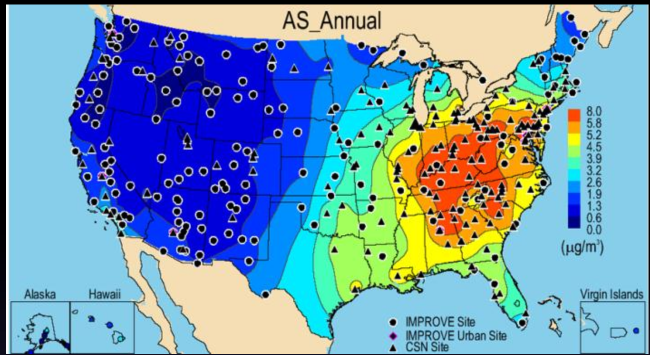


- Asia is very polluted (US and EU are clean).
- Asian aerosols have impacts on global air pollution and climate change.

→ Need to improve the simulation over Asia even in global models

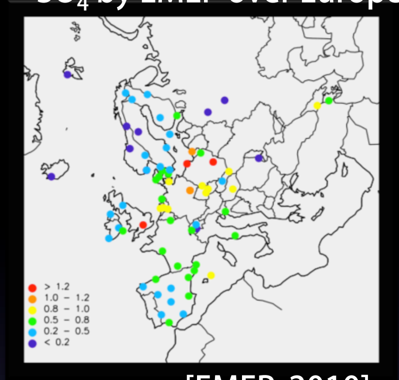
Relatively limited observation in Asia

$(NH4)_2SO_4$ by IMPROVE over US



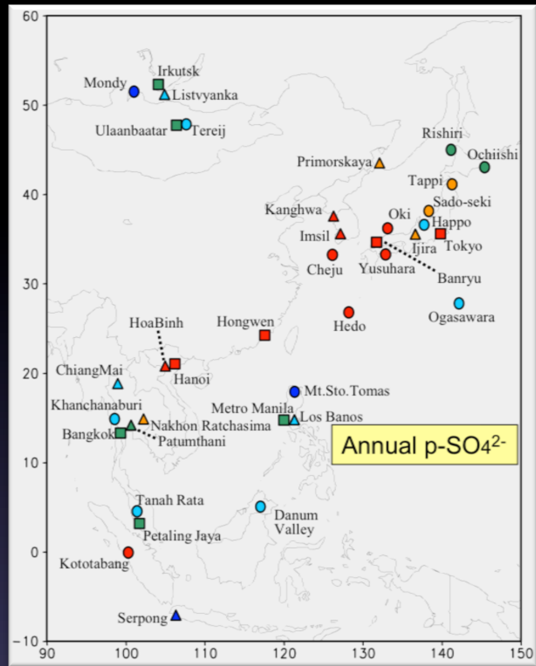
[Hand et al., 2011]

SO_4 by EMEP over Europe



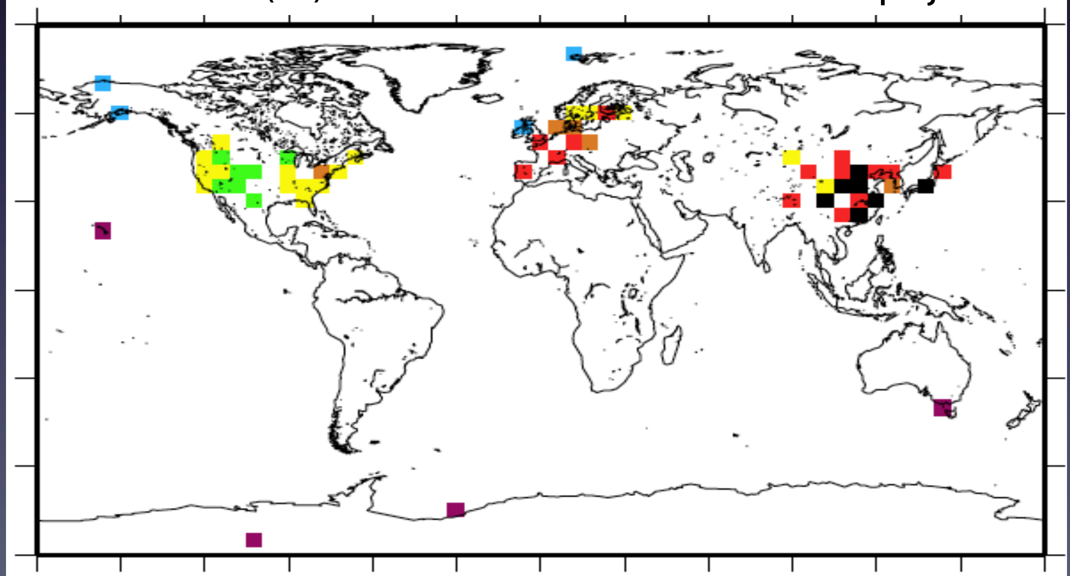
[EMEP, 2010]

SO_4 by EANET (2011) over east Asia



[EANET report, 2011]

Black carbon (BC) mass concentration used in AeroCom project



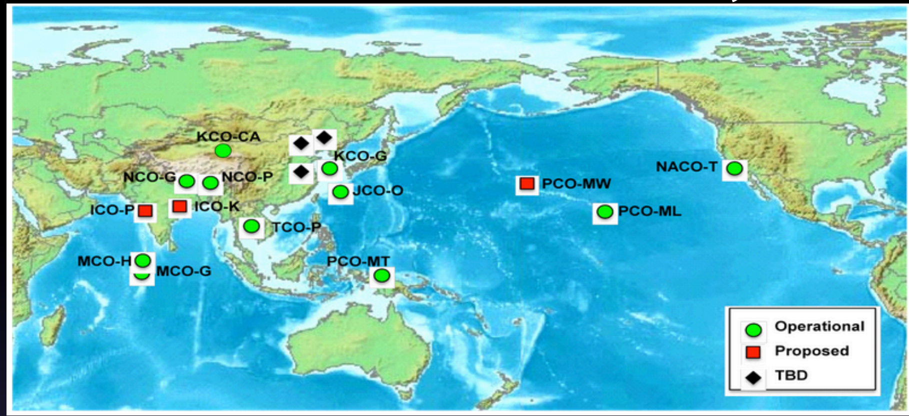
[Koch et al., Atmos. Chem. Phys., 2009]

Lack of measurements in China and India

Motivation in/beyond the present study

- Measurements of aerosol compounds were limited over Asia, therefore validation of models are inadequate.
- To combine traditional network (e.g., IMPROVE, EMEP, EANET), own measurements under specific projects, new network like UNEP/ABC-Asia observatory and column burden of aerosol optical products obtained by AERONET/NASA, SKYNET/Japan, and NIES-Lidar, we start to multi-compare results of the aerosol-transport models and try to understand their performance.

UNEP/ABC-Asia Observatory



AERONET

CIMEL sun photometer in ARM project

SKYNET

PREDE skyradiometer in Tohoku Univ.

ADNET

Lidar at NIES (until 2000yr)

Description: SPRINTARS coupled to GCMs

- MIROC-SPRINTARS (e.g., Takemura et al., 2005)
  - **GCM (CGCM and AGCM)** is made in Japan by Watanabe et al. (2010) including CCSR (Now AORI) of The University of Tokyo, NIES, FRCGC (Now JAMSTEC).
  - Spectral transform method with the hydrostatic approximation for climate model
  - Many contributions to international projects; IPCC-TAR (2001), IPCC-AR4(2007), ACCMIP, AeroCom, …
- NICAM-SPRINTARS (e.g., Suzuki et al., 2008)
  - NICAM is developed by Tomita and Satoh (2004), Satoh et al. (2008), etc.
  - Grid point method with the non-hydrostatic approximation for global cloud-resolving model (GCRM)
  - Produce MJO for the first time with dx=3.5km (Miura et al., science 2007)

~100 Pflops
160nodes, NEC
@JAMSTEC (Yokohama)

>10 Pflops
>80000nodes, Fujitsu
@RIKEN (Kobe)

4 Tflops
16nodes, NEC
@NIES (Tsukuba)

Description: SPRINTARS as a module

- 3-dimensional Aerosol Radiation-Transport Model
  - Transport, deposition, emission, advection, vertical convection, sulfur chemistry
  - w/o aerosol dynamics such as coagulation and condensation
- Tracers:
  - Sulfate, Carbonaceous (Mixed BC+OC, OC, BC), Dust, Seasalt
- Output:
  - Aerosol mass/number concentrations
  - Aerosol optical thickness (AOT), Single scattering albedo (SSA), Radiative forcing by aerosol direct effect (coupling with radiative transfer model, MSTRN-8, by Nakajima et al., 2000)
  - Considering refractive index of each aerosol depending on wavelengths, size distributions, and hygroscopic growth (Mie theory with volume-weighted mixing)
  - Radiative forcing by aerosol indirect effect
- References:
  - Modules:
    - Takemura et al. (JGR2000, JC2002, JGR2005, ACP2009)
    - Goto et al. (JGR2008, ACP2011, ACPD2012)
  - Validation: Goto et al. (AE2011, AG2011, GRL2011, AE2012)

SPRINTARS results under AeroCom project

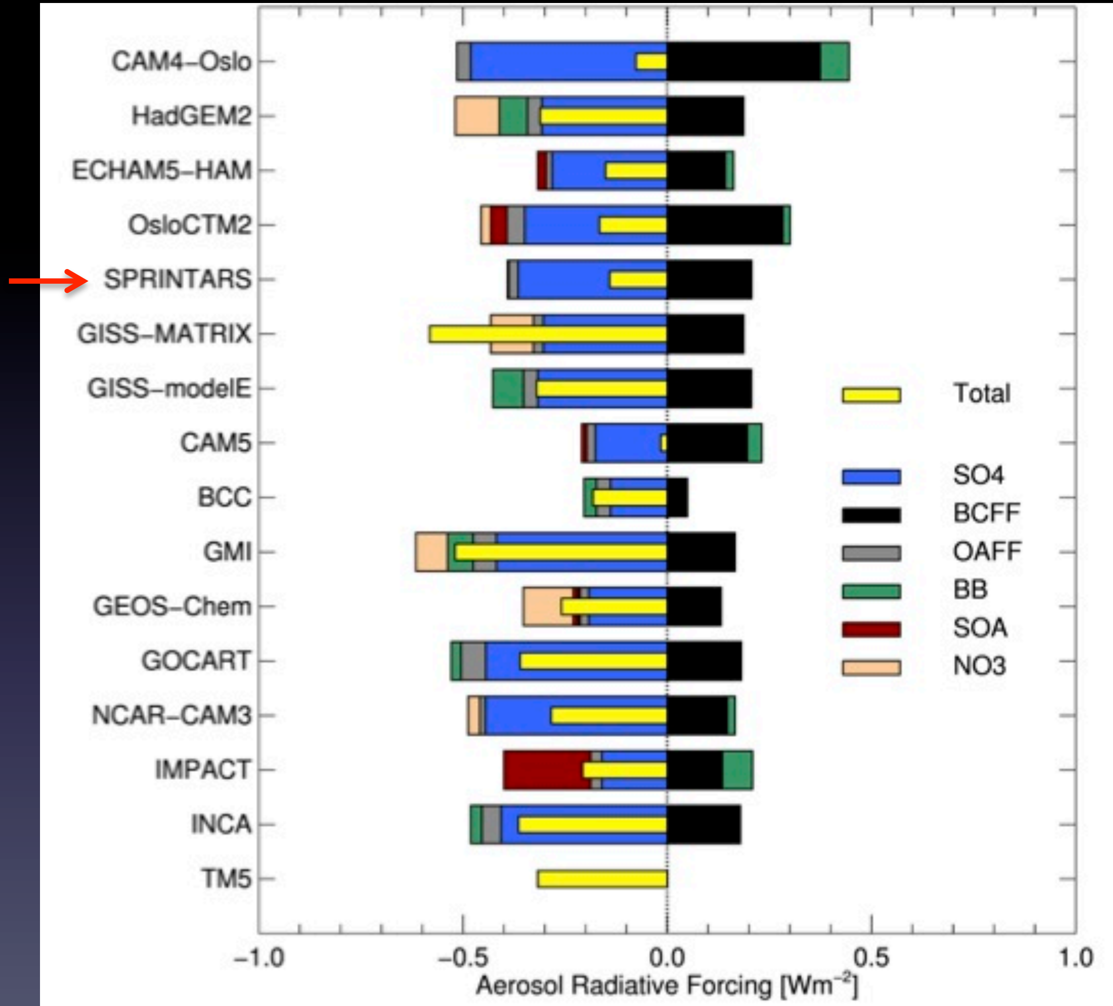
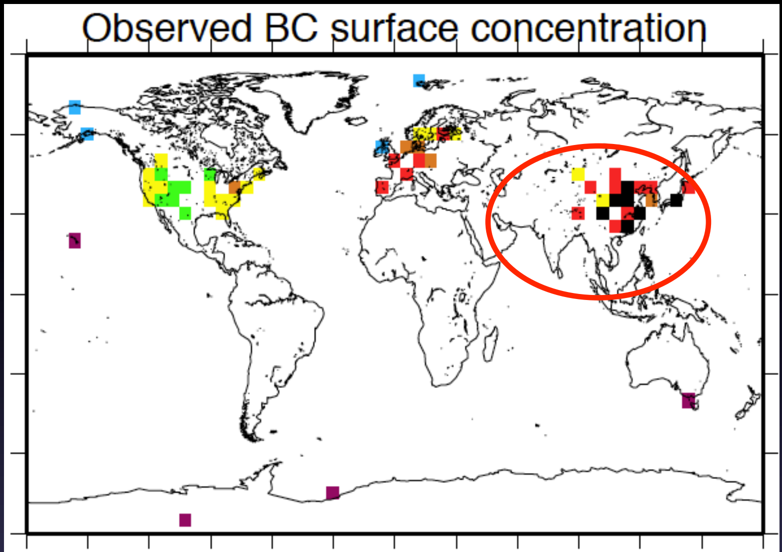


Fig. 4. Radiative forcing from the six components, overlain with the (unmodified) model total forcing (yellow bars).

Myhre et al. (2013)

Start to validation of SPRINTARS especially over Asia

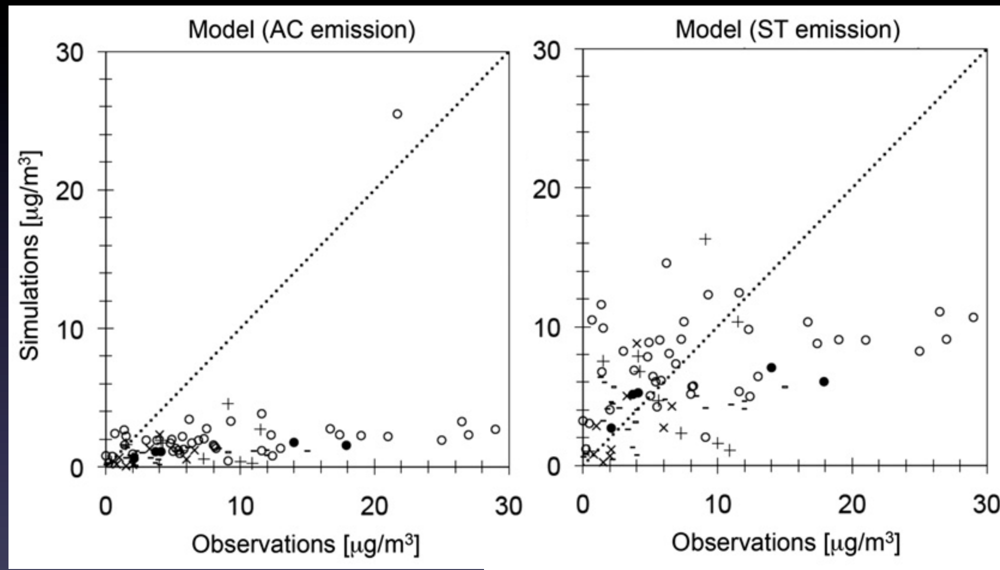
Comparison over India



Koch et al. (2009) under AeroCom study

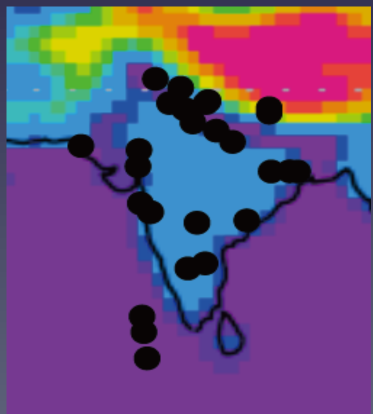
AeroCom Emission

Modified Emission
Based on Streets



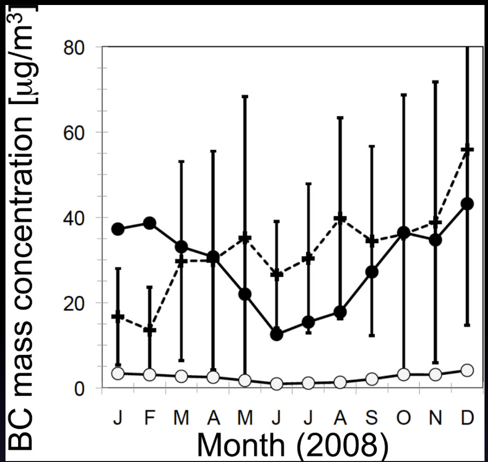
●: annual, O: dry, +:pre-monsoon,
X: monsoon, -:post-monsoon

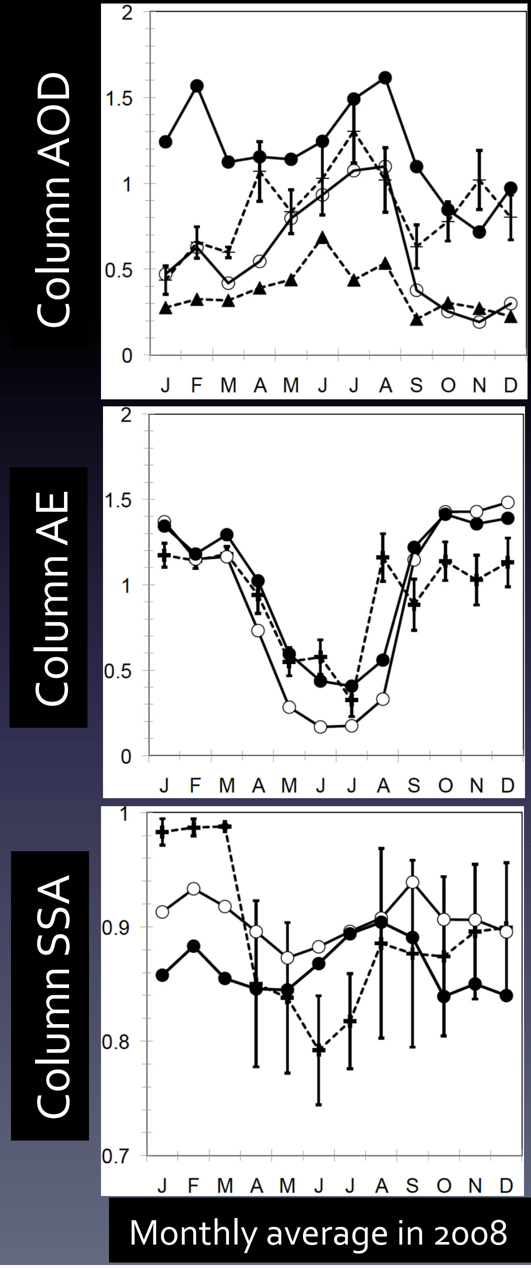
Asian observations for use of GCM validation are very limited.
→ We start to collect the observation results from literature during 2000's



Goto, Takemura, Nakajima, & Badarinath (Atmos. Environ., 2011)

The surface BC and column AOP @Hyderabad/INDIA





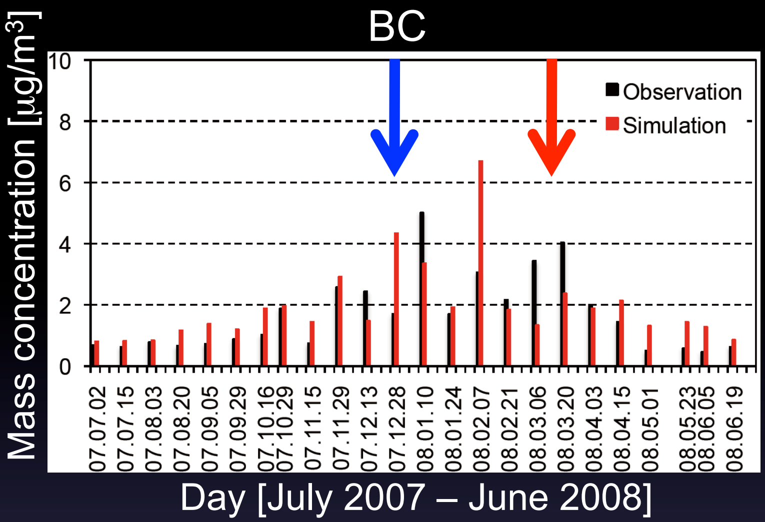
- Surface BC of CTL is quite underestimated, but AOD of CTL during May-August is OK.
- Low SSA (0.8-0.9) seen in observation during June-July could NOT be found at simulation.

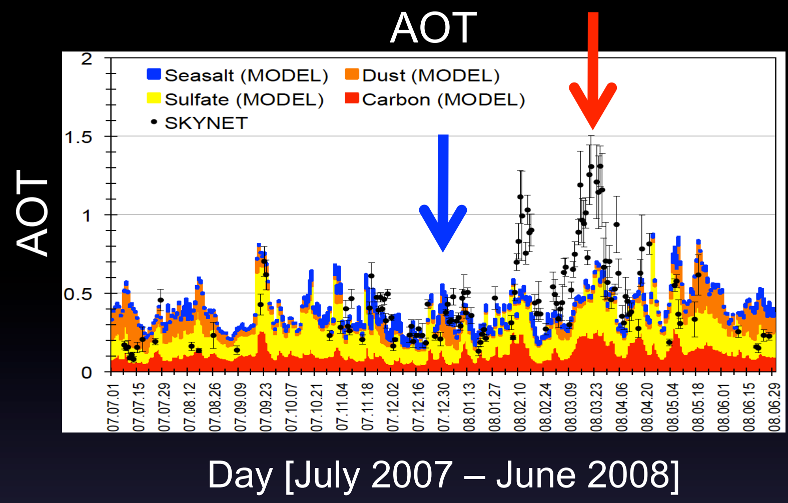
→Vertical distribution of BC and others (firstly use model with small dx)
→Consider BC+Dust internally mixture

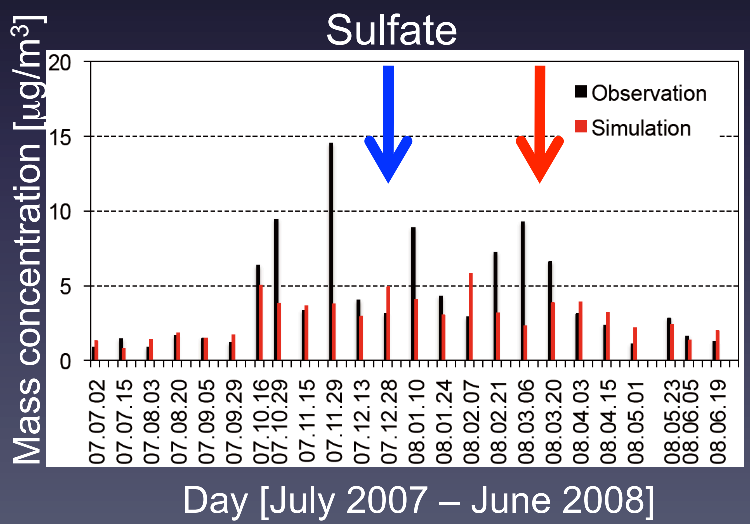
"Multiple comparison is important!"

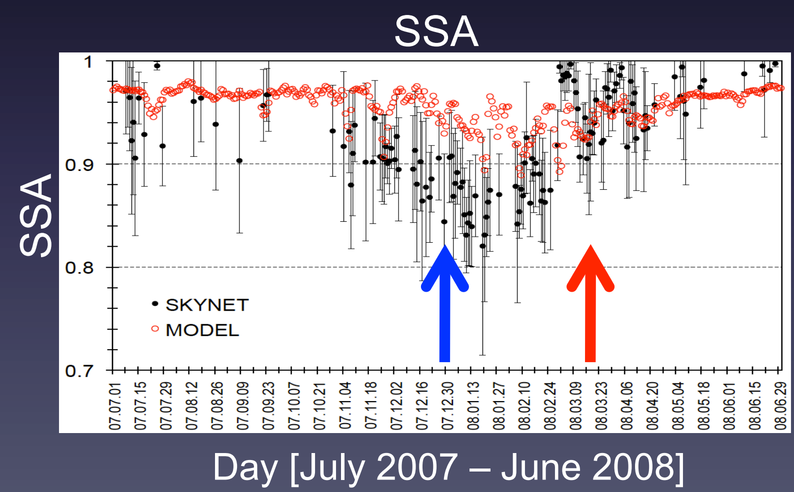
Goto, Badarinath, et al. (ANGEO, 2011)

The surface BC and column AOP @Phimai/Thailand



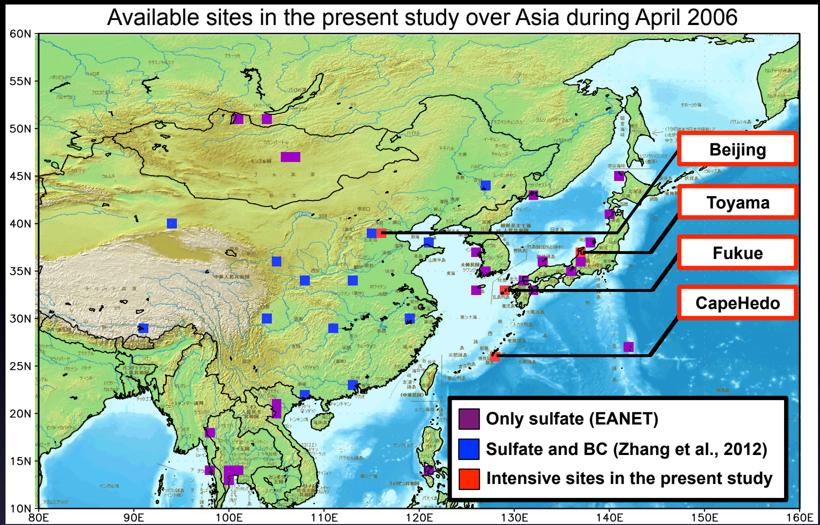




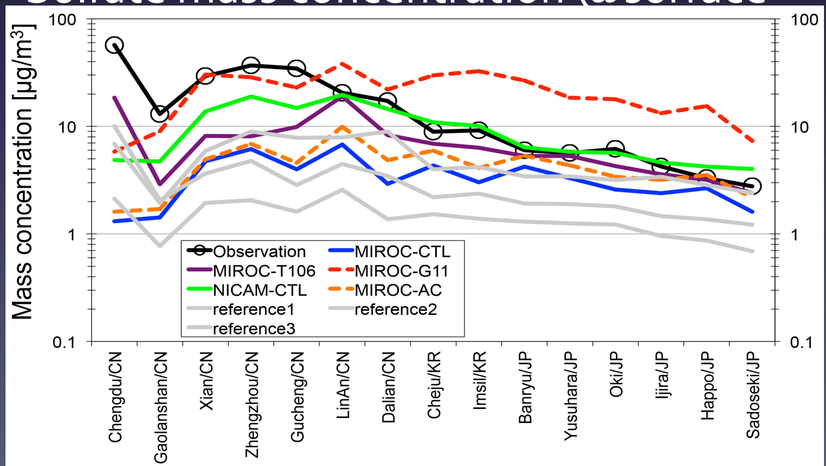


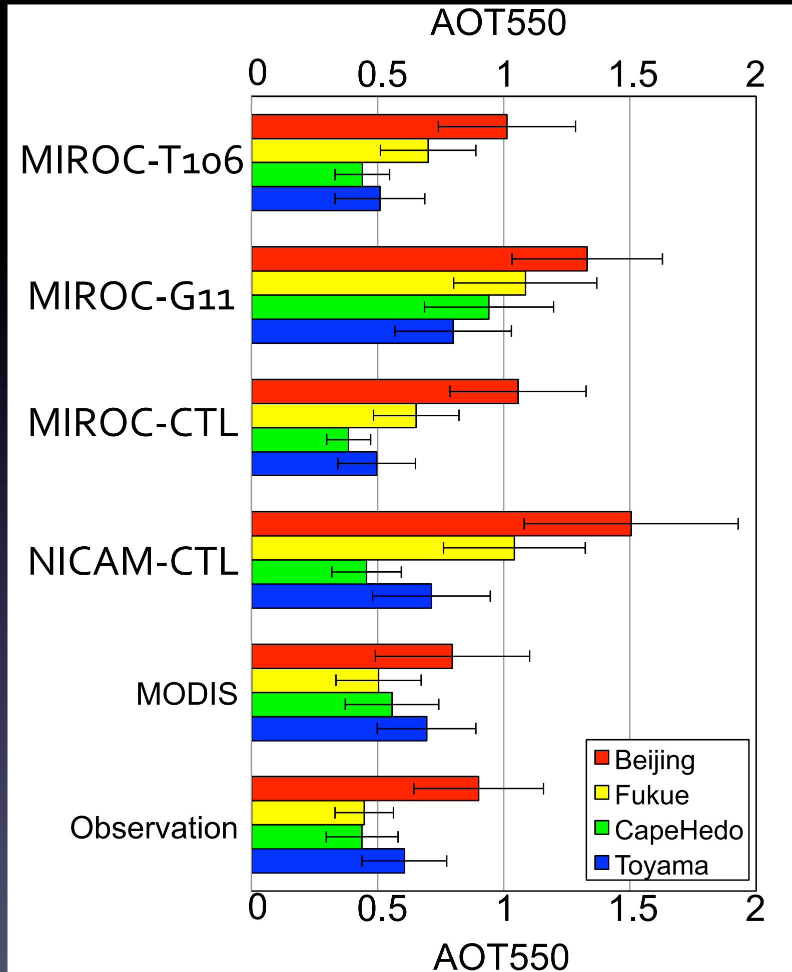
Goto, Tsuruta, et al. (in prep. from 2011?)

Multi-comparison using SPRINTARS modules and measurements during April 2006



Sulfate mass concentration @surface

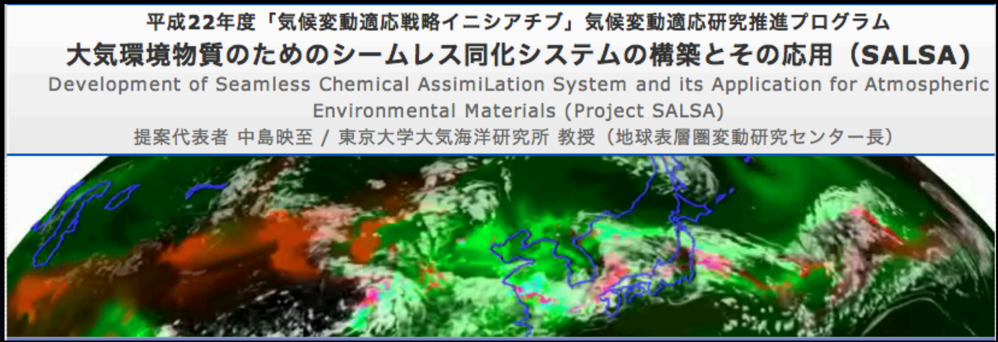




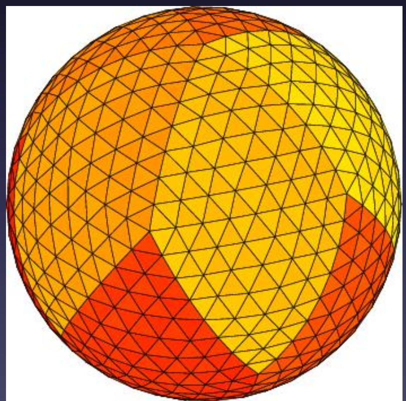
Observation represents AERONET @Beijing and SKYNET @Fukue, Cape Hedo, Toyama by Dr. Aoki

Goto, Dai, et al. (in prep., 2013a) by collaborating with ABC-Asia project

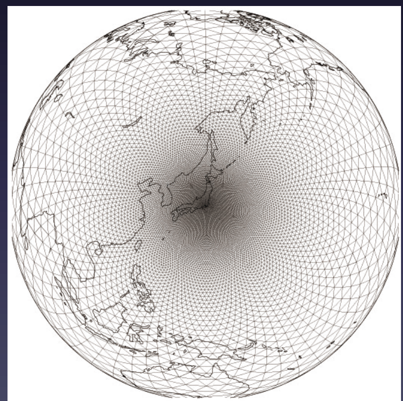
Resolving heterogeneity of aerosol around megacity: SPRINTARS with dx=10km using stretch-NICAM



Global NICAM



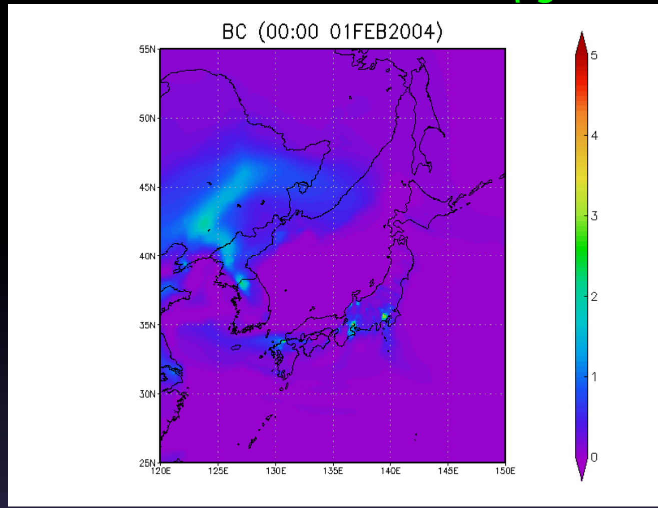
Stretch grid system
(Tomita, 2008a)



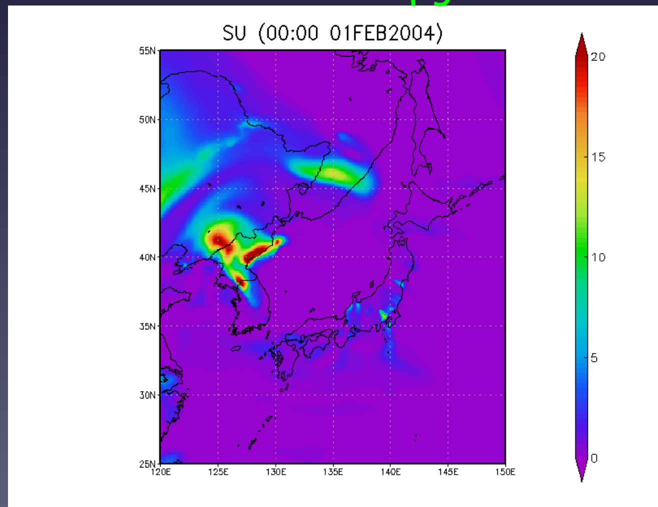
Easily change the center

Low computational cost
Use the common code

Black carbon (BC) in unit of μg/m³



Sulfate in unit of μg/m³



Goto & MEXT/RECCA/SALSA project team (in prep., 2013b)

Summary

- To improve a global aerosol-transport model, SPRINTARS, we start to validate the model performance over Asia where atmospheric aerosols have great impacts on the global scale.
- Precise validation is requited by using multiple products including aerosol composition at the surface and column burden at various sites (NOT one site)
- To further develop the model, we will be comparing the simulation with multi-measurements around emission sources such as megacities.
- Collaboration of global model – regional model – in situ measurement – satellite (multi-comparison) is important more and more to share our understanding from various aspects.

～Thank you so much～