Modeling of black carbon emissions and their transport in China and North-East Asia

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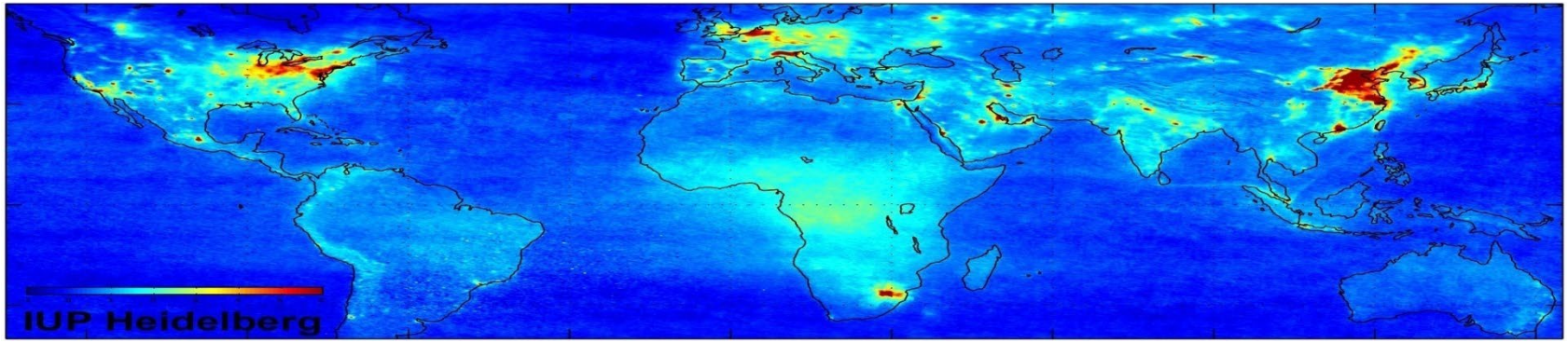
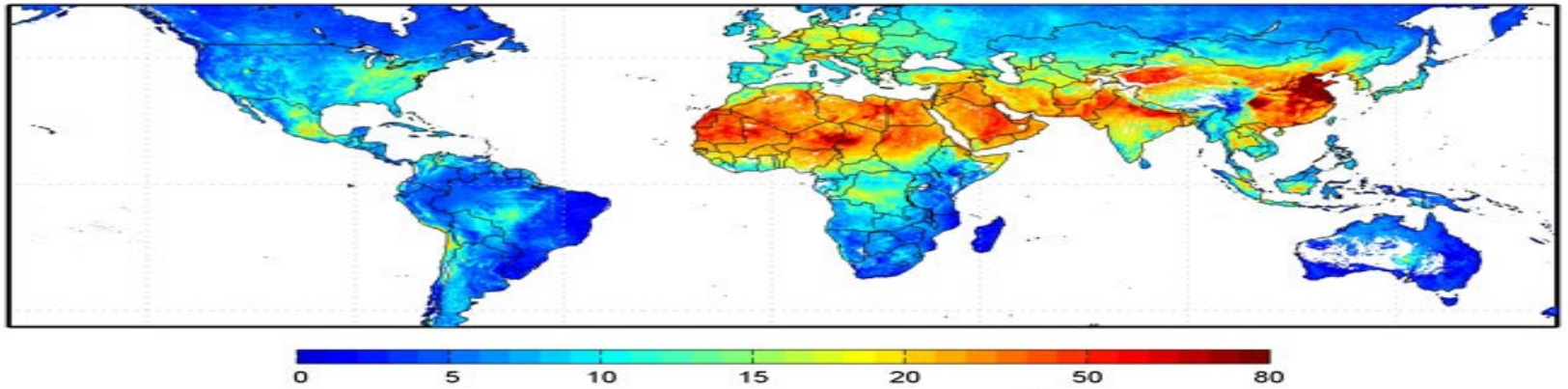
Glaobal and Regional Air Pollution



global mean tropospheric nitrogen dioxide (NO2) vertical column density (VCD) between January 2003 and June 2004, as measured by the SCIAMACHY instrument on ESA's Envisat. The scale is in 1015 molecules/cm-2. Image produced by S. Beirle, U. Platt and T. Wagner of the University of Heidelberg's Institute for Environmental Physics.

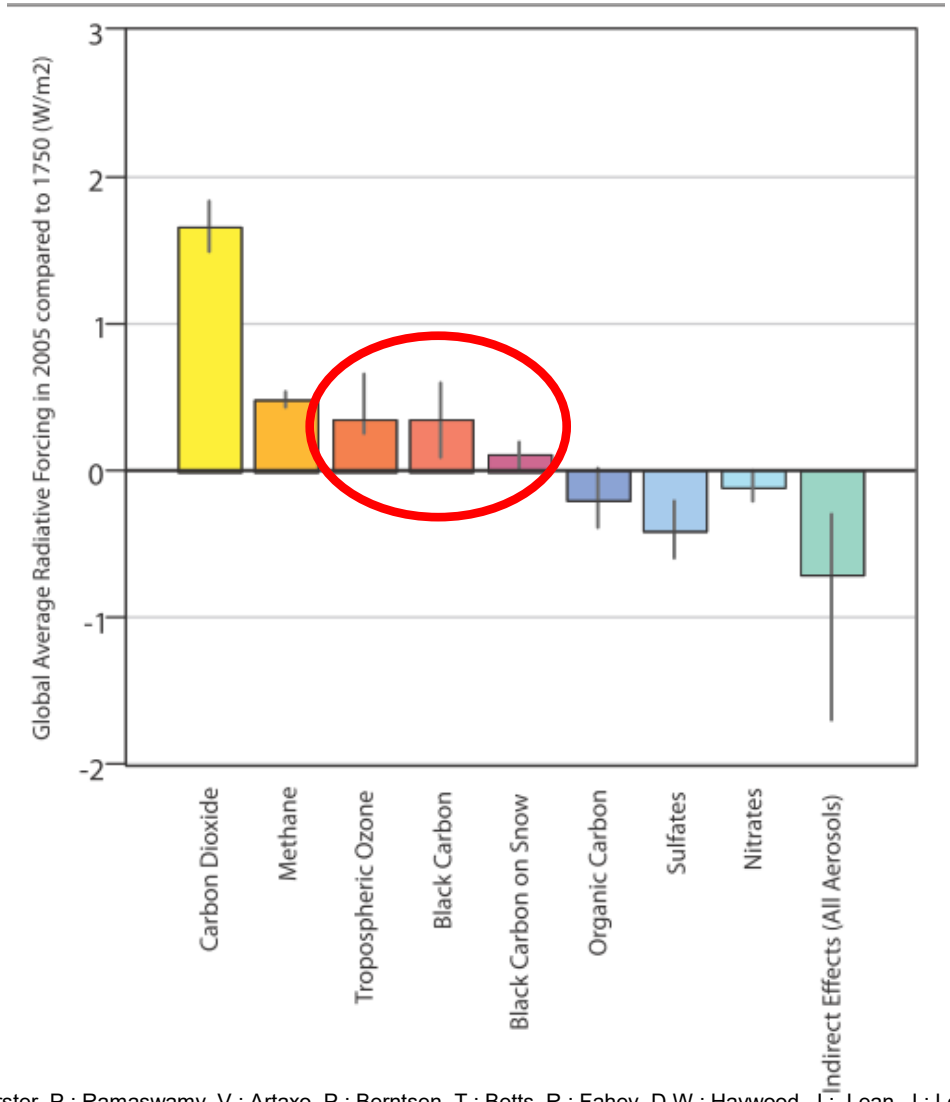


Global satellite-derived map of PM2.5 (ug/m3) averaged over 2001-2006.
Credit: Dalhousie University, Aaron van Donkelaar

Short-Lived Climate Forcer(SLCF)

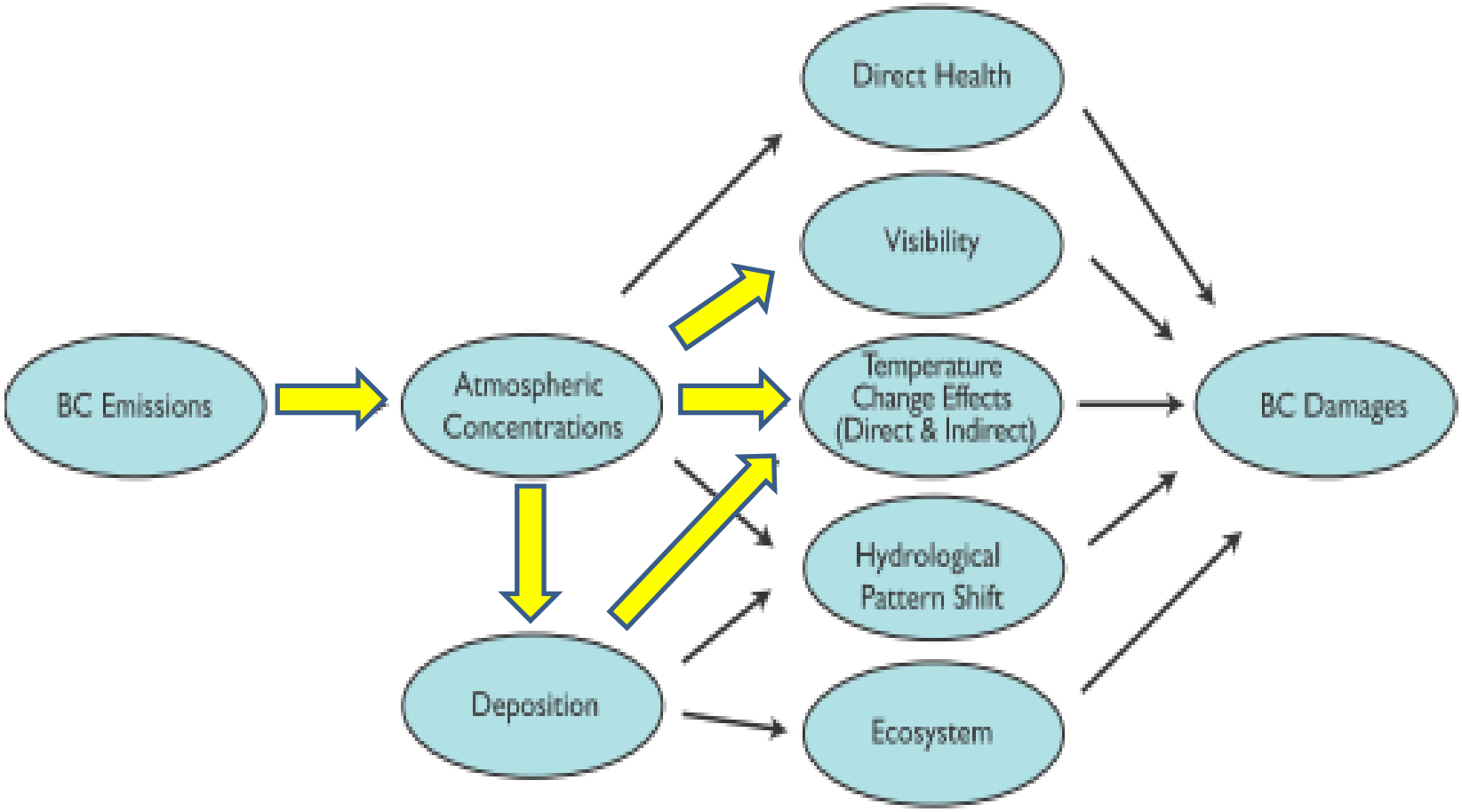
- Relatively short life span: days or weeks(Prather, 2005).
- Black carbon warms primarily by absorbing solar radiation, heating the atmosphere.
- Change of ice or snow albedo due to BC leads to warming of the lower atmosphere and melting of snow and ice(Flanner, 2007) .
- Co-benefit.

Radiation Forcing Componet

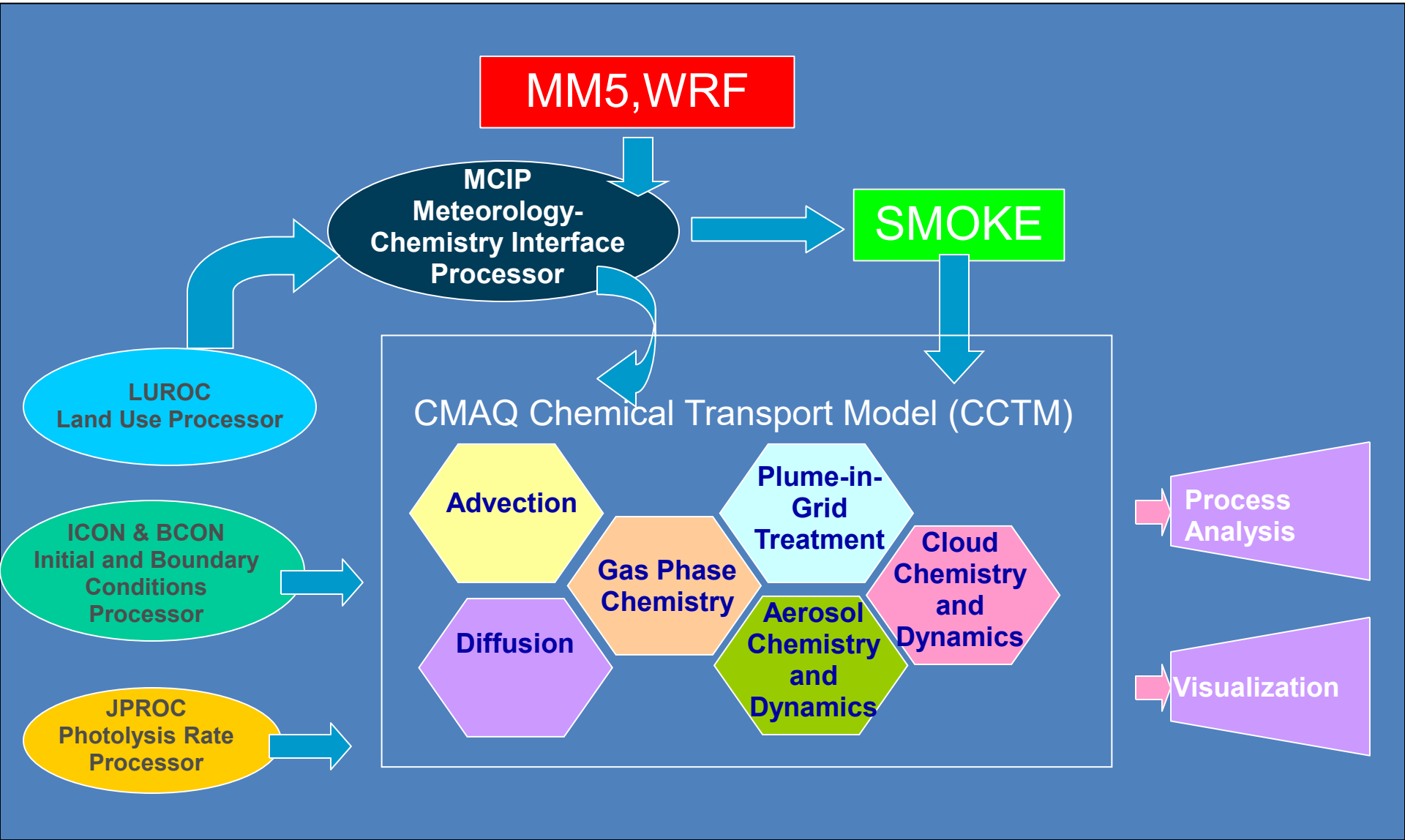


Source: Forster, P.; Ramaswamy, V.; Artaxo, P.; Berntsen, T.; Betts, R.; Fahey, D.W.; Haywood, J.; Lean, J.; Lowe, D.C.; Myhre, G.; Nganga, J.; Prinn, R.; Raga, G.; Schulz, M.; Van Dorland, R. Changes in Atmospheric Constituents and in Radiative Forcing. In Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, Eds.; Cambridge University Press: Cambridge, United Kingdom and New York, NY, USA, 2007.

What can our regional CTMs tell about BC?



CMAQ Modelling System
CMAQ version 4.7



CMAQ气相化学反应机理

Chemistry

- CB4, 36 species, 93 reactions, 11 photolysis , 9 VOC （3 explicit + 5 carbon bond types + NR）
- RADM2： 57 model species， 15 VOC species and 158 reactions, 21 photolytic.
- SAPRC-97 (90,93), semi-explicit, over 100 individual organic compounds.

CMAQ Aerosol Modules

Aerosol:

- ISORROPIA and ISORROPIA II are models that calculates the composition and phase state of an
- ammonia -sulfate -nitrate -chloride -sodium -calcium -potassium -magnesium -water inorganic
- aerosol in thermodynamic equilibrium with gas phase precursors.
- 3 modes=> sectional

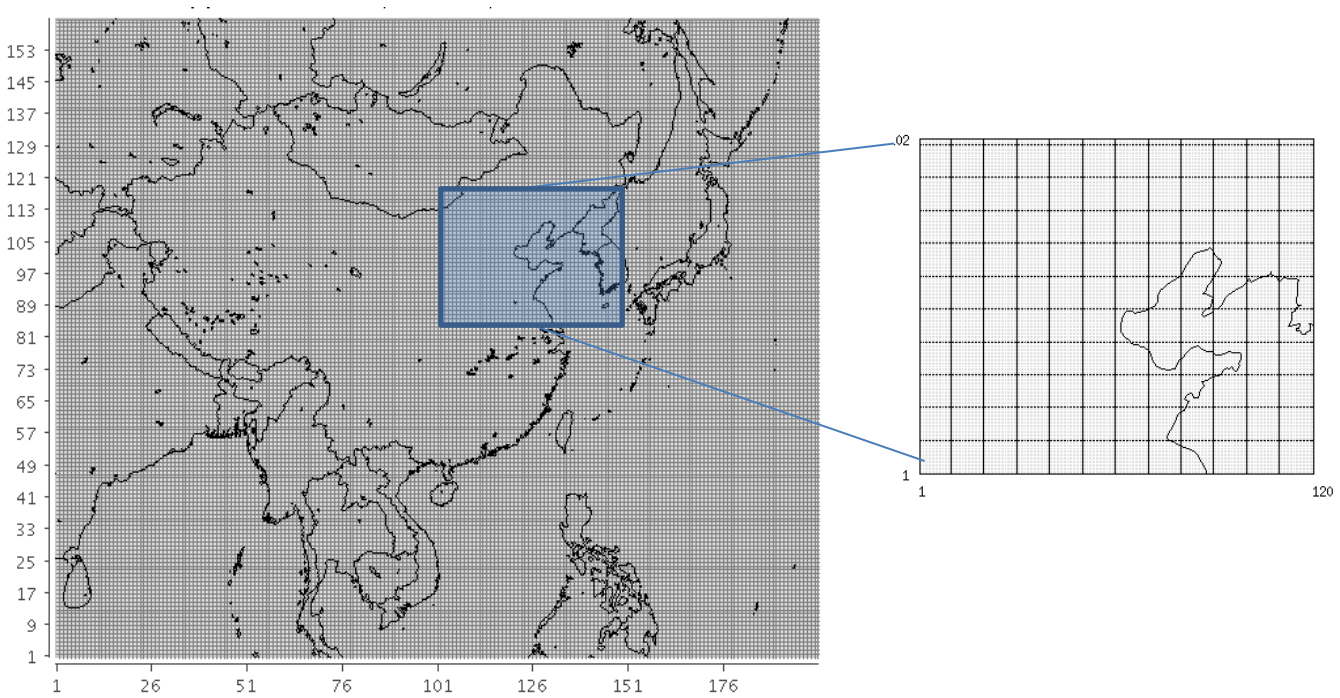
Aerosol Extinction in CMAQ 4.7

1. Integration of the Mie extinction efficiency over a log normal particle size distribution.
2. A module for absorption was added.

References:
Heintzenberg, J. and M. Baker Spherical particle populations: approximate analytic relationship between size distribution parameters and integral optical properties, Applied Optics, Volume 15, Number 5 pp 1178-1181, May 1976.
Penndorf, R. Scattering and Extinction Coefficeints for small spherical particles, J. Atmospheric Sciences, Volume 19, p 193, March 1962.
Willeke, K. and J. E. Brockmann, Extinction coefficients for multmodal atmospheric particle size distributions, Atmospheric Environment, vol. 11, pp 95-999, 1977.

CMAQ Model Configurations

20 Vertical Layers



σ	m
0	15000
0.2	12000
0.32	10200
0.44	8400
0.51	7350
0.58	6300
0.685	4725
0.755	3675
0.82	2700
0.85	2250
0.875	1875
0.9	1500
0.92	1200
0.94	900
0.96	600
0.97	450
0.98	300
0.99	150
0.995	75
0.9975	37.5
1	0

- **Two level nesting, 200x160, 36km and 120x102 12km**
- **Lambert conformal projection，centered at (110E, 35N), standard parallels are 24N and 46N.**
- **SAPRC99 gas phase chemistry ,**
- **AE5 aerosol module which can simulate more detailed SOA and heterogenic reactions .**

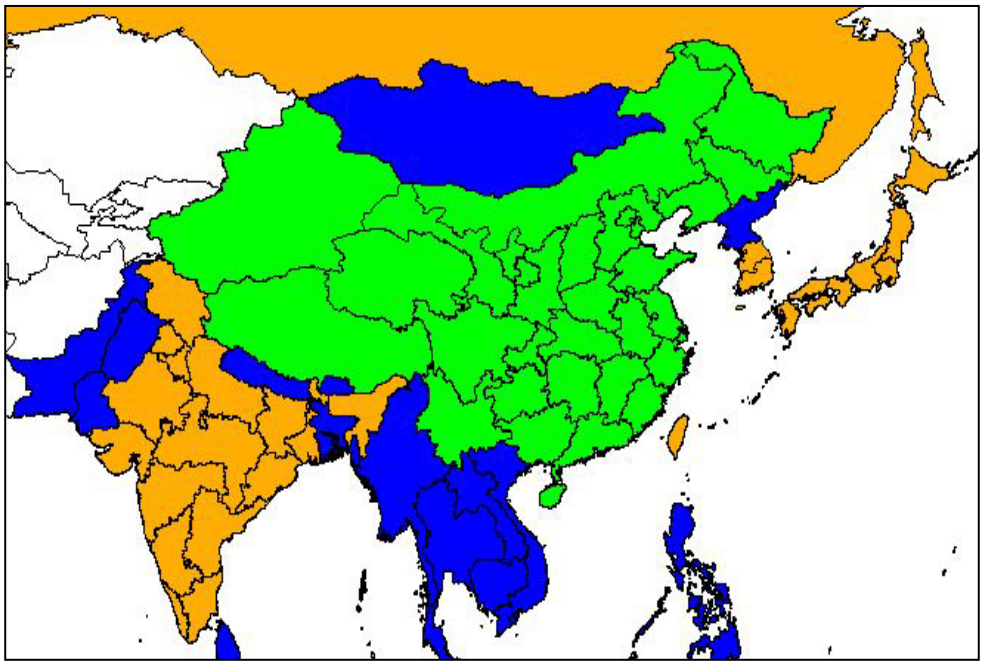
Emission Inventory

Base Year：Updated from 2007

Emission Sources: Stationary and Mobile

Pollutants: SO_2、NO_X、CO、VOCs、NH_3、PM including BC.

BC: On-going projects for on-road mobile source, project for other source categories.

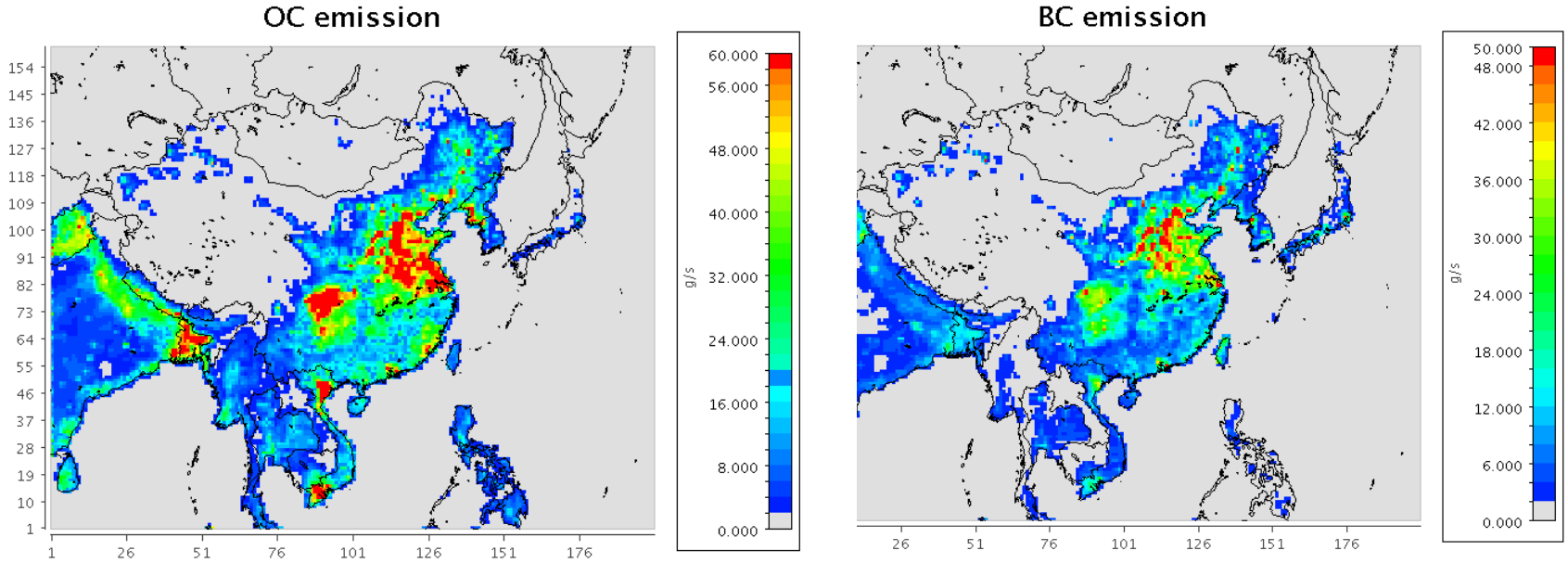


Emission Inventory to be updated in this project

INTEX-B 2006 Emission Inventory

Data from other sources

Gridded Emission of SO2, NOx, CO, NMVOC, OC, BC of INTEX-B 2006 2006 (units: Gg/year).

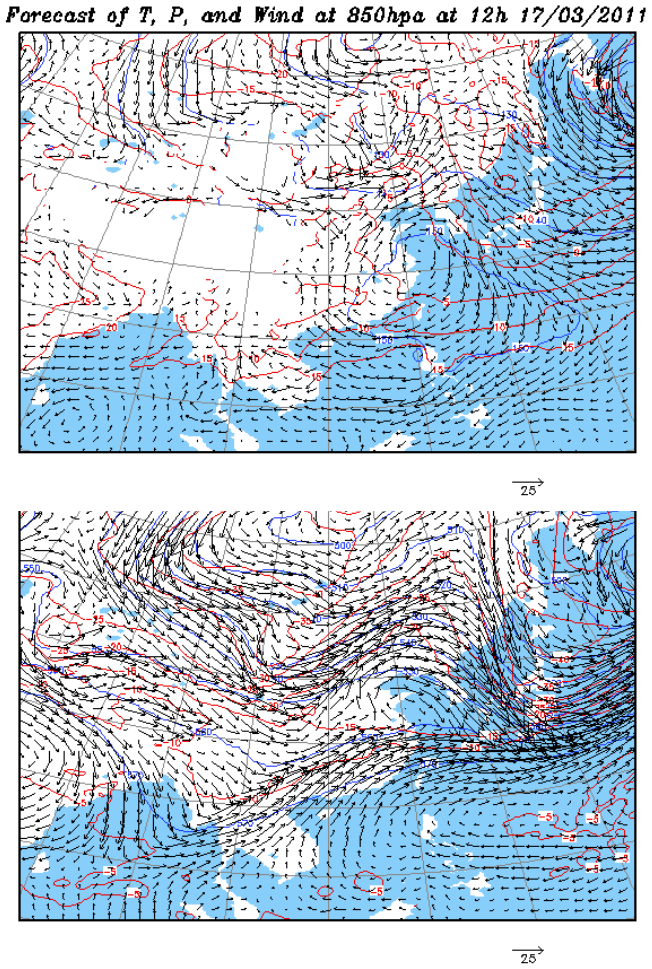


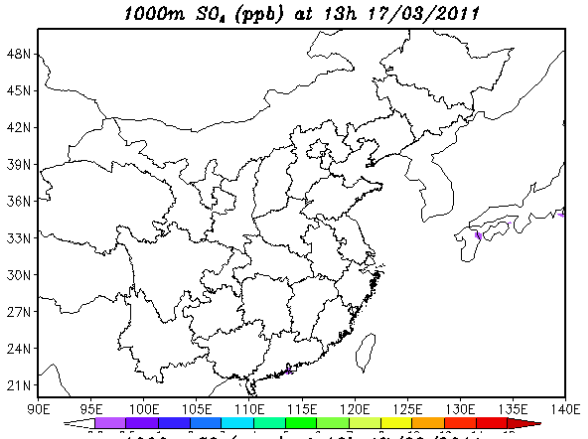
Country	SO2	NOx	CO	NMVOC	PM10	PM2.5	BC	OC
China	31020	20830	166889	23247	18223	13266	1811	3217
India	5596	4861	61106	10767	4002	3111	344	888
Indonesia	1451	1583	17742	6617	1838	1610	170	803
Pakistan	2882	681	7378	1405	873	752	115	349
Other Countries	6184	8726	45059	12516	4261	3432	527	1314
Asia 2006 Total	47133	36681	298174	54552	29197	22171	2967	6571

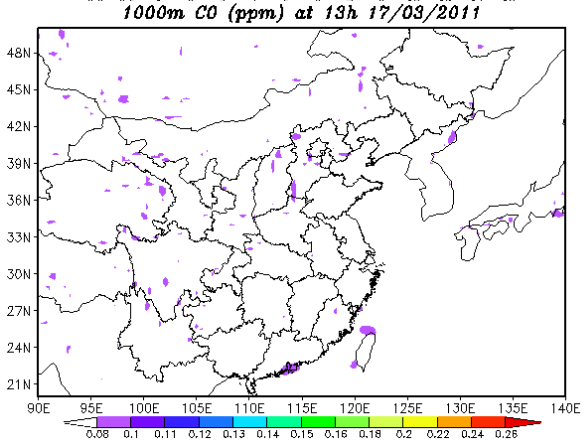
Atmos. Chem. Phys. Discuss., 9, 4081–4139, 2009

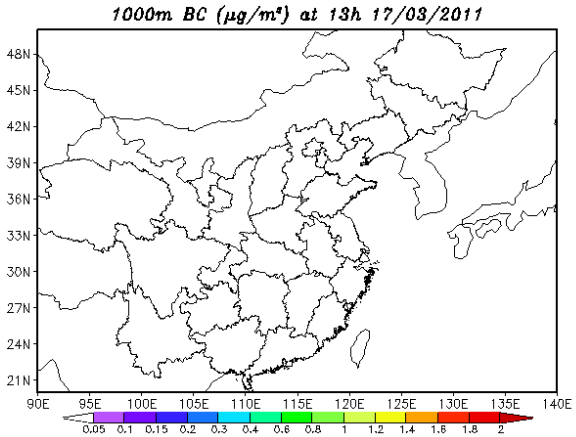
Preliminary Modeling Results

Some Real-time Prediction Results

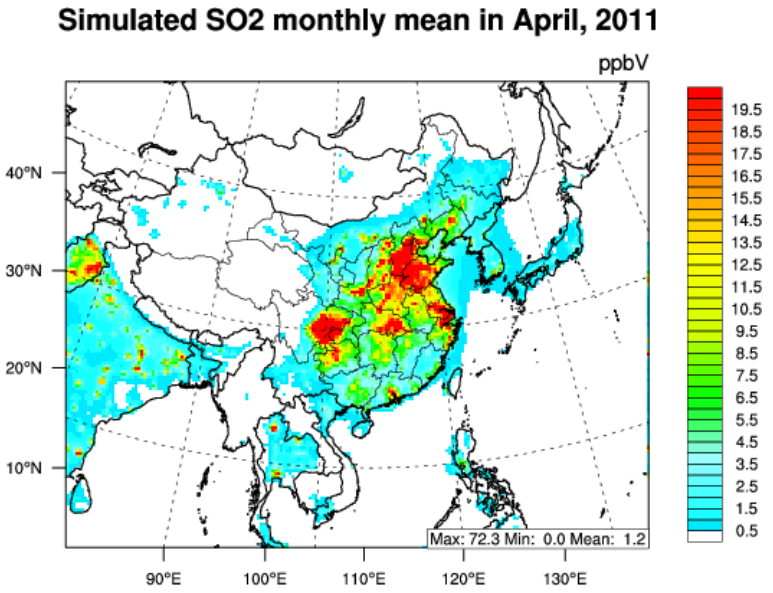


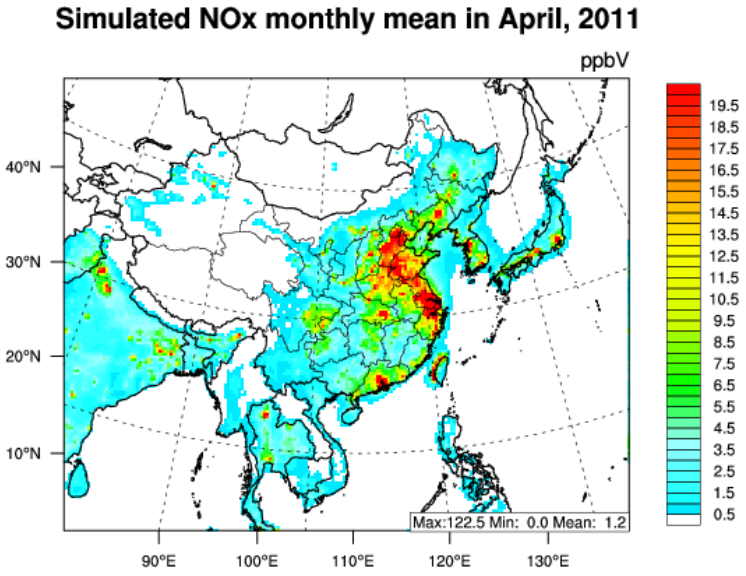


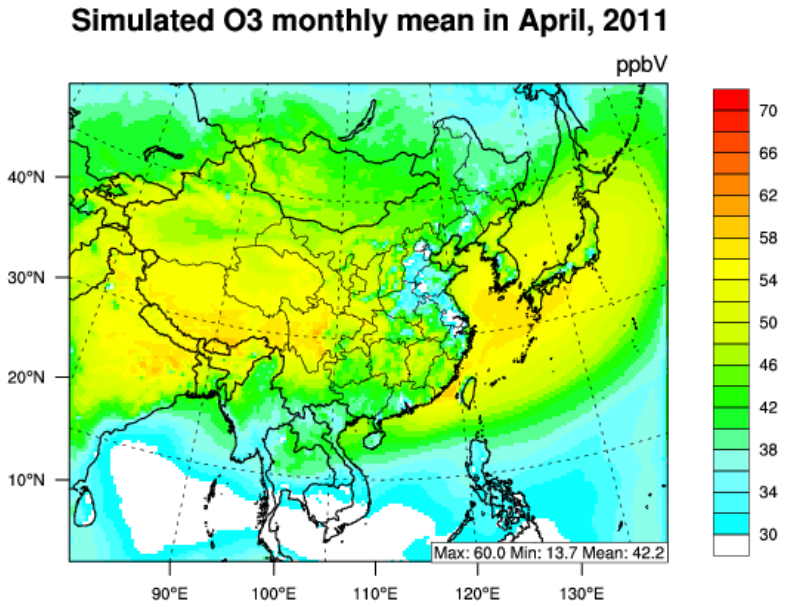




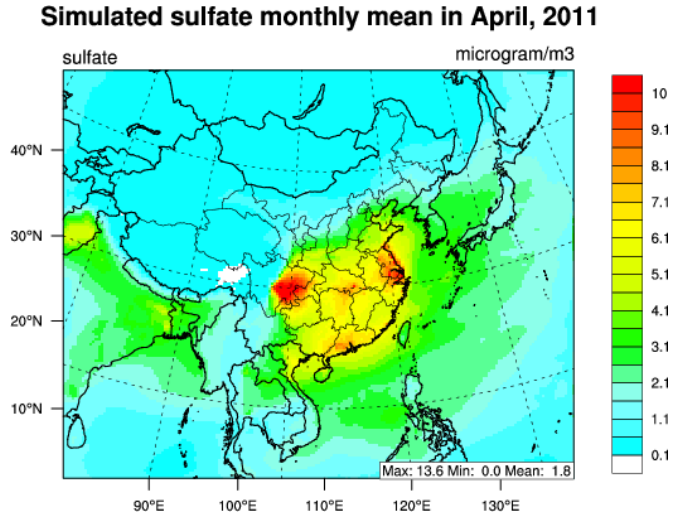
Monthly Averaged Gaseous Concentraion in April, 2011

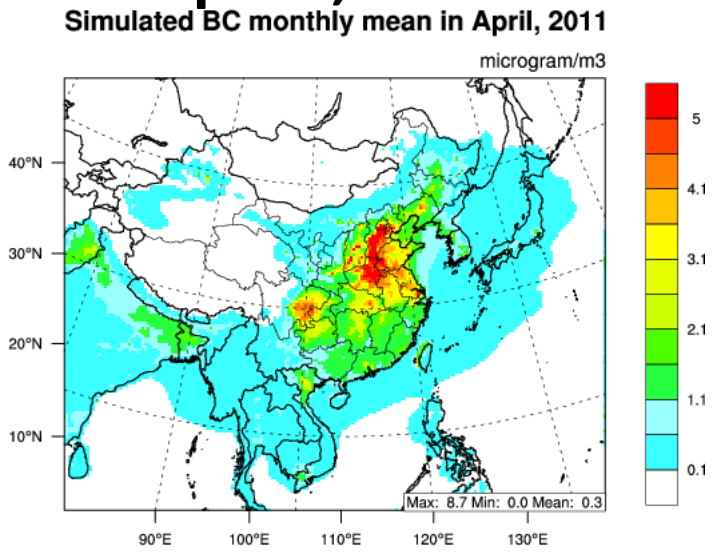


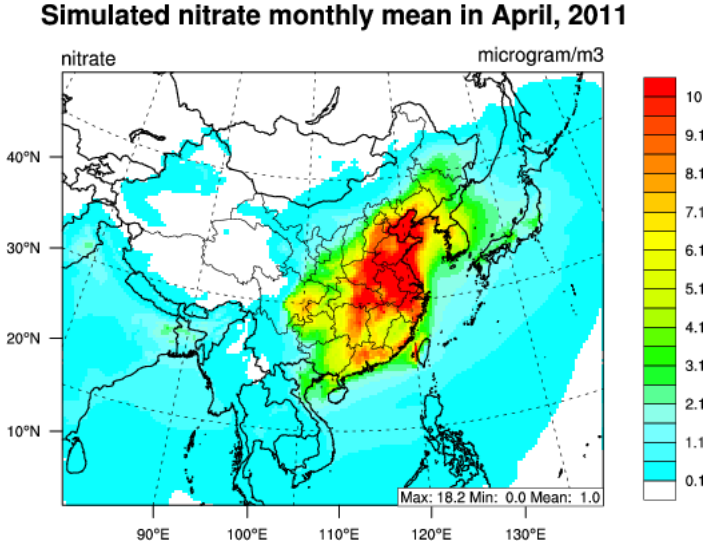


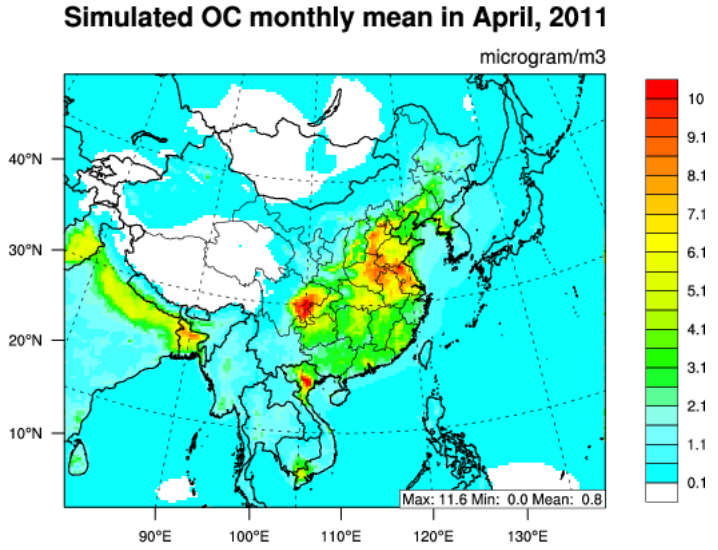


Monthly Averaged Aerosol Concentraion in April, 2011

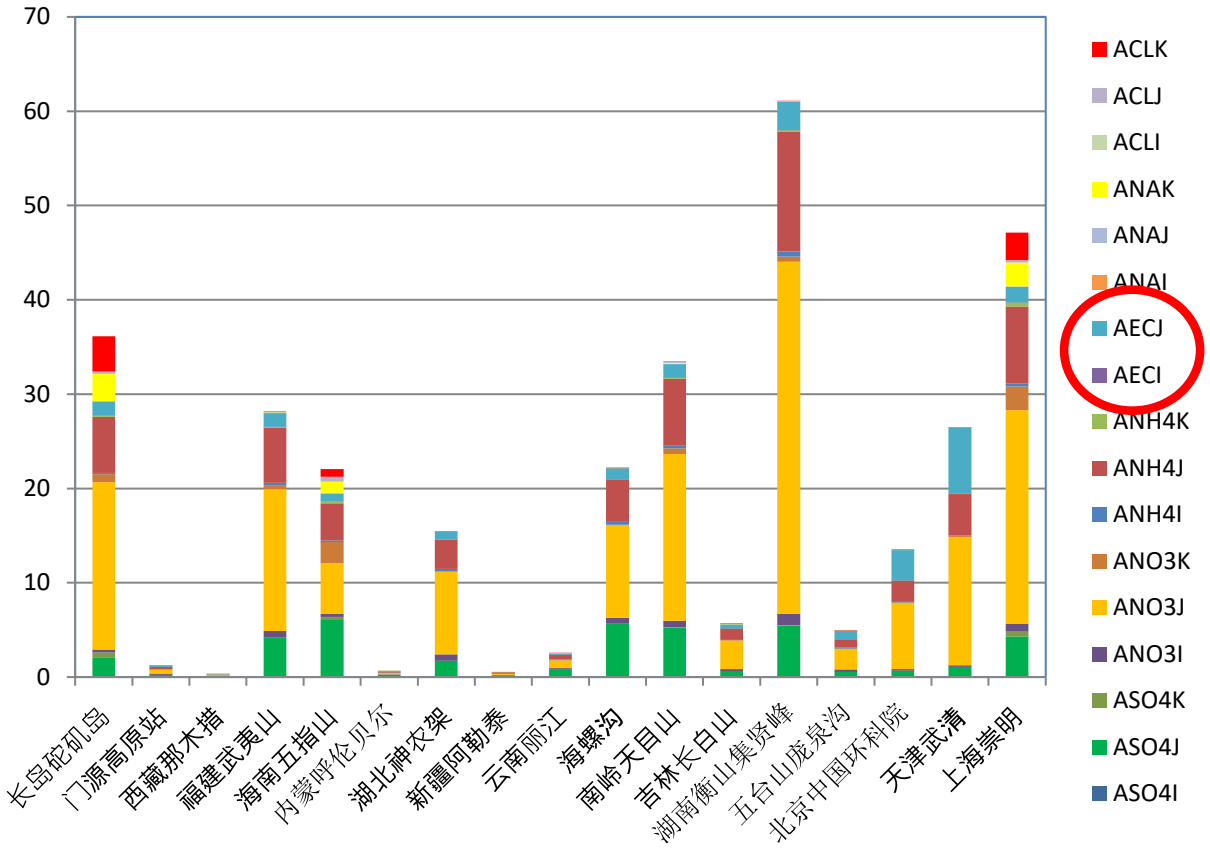


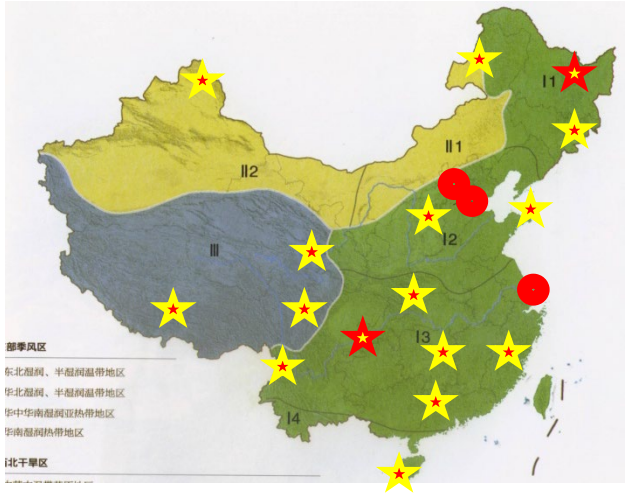




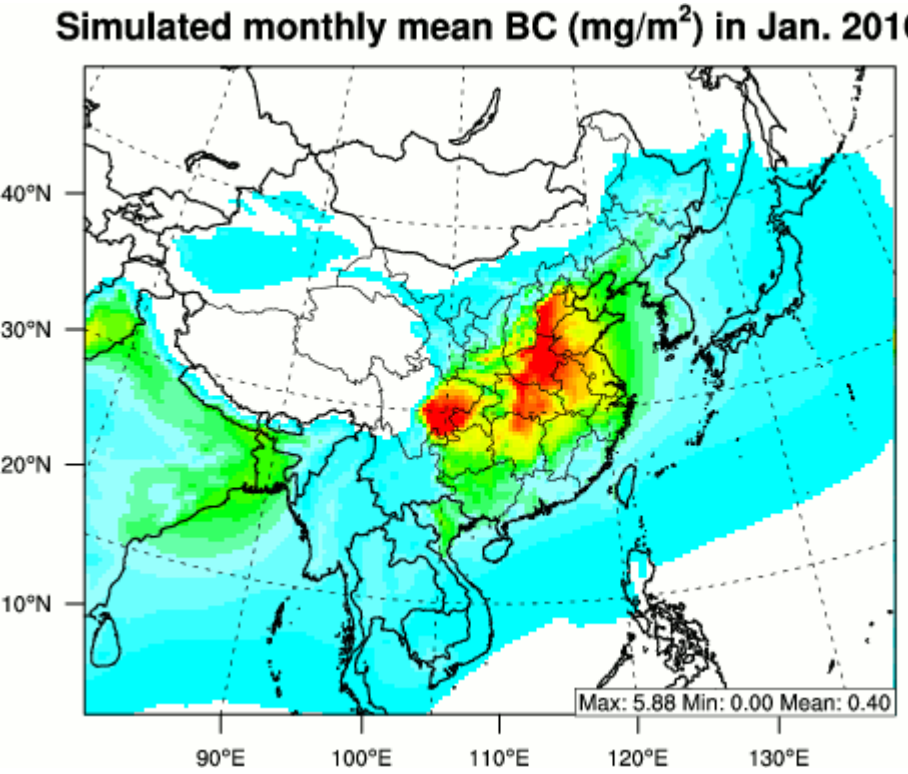


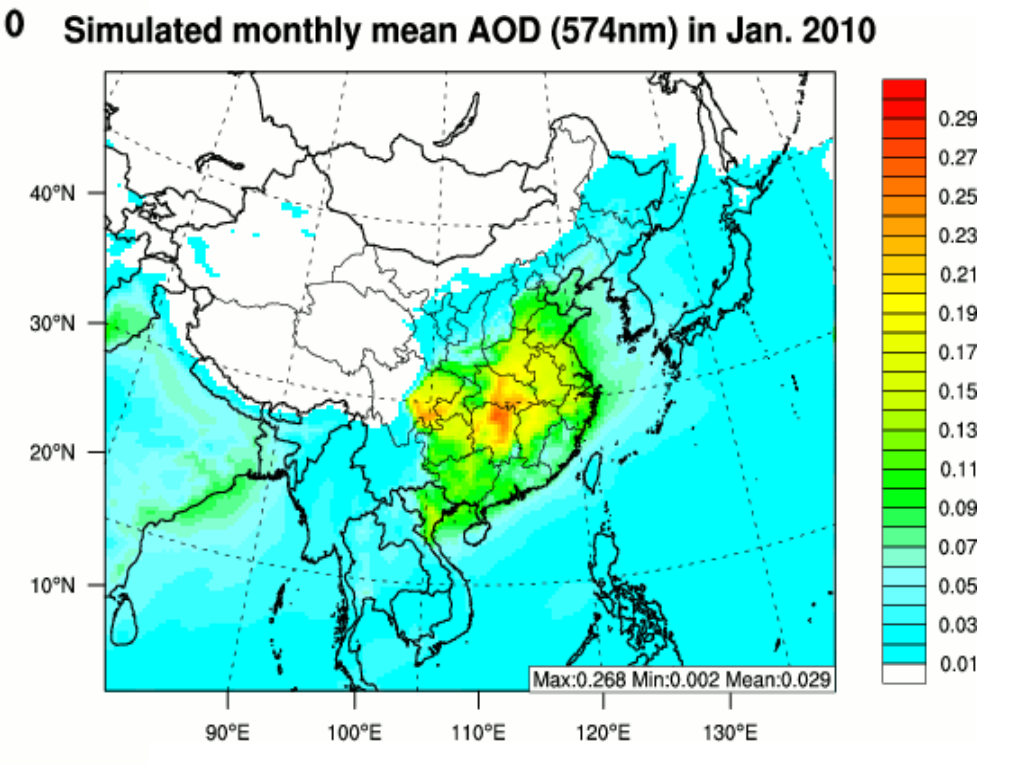
Averaged Composition of Simulated Aerosol (OC not included) for Dec.06-26, 2008

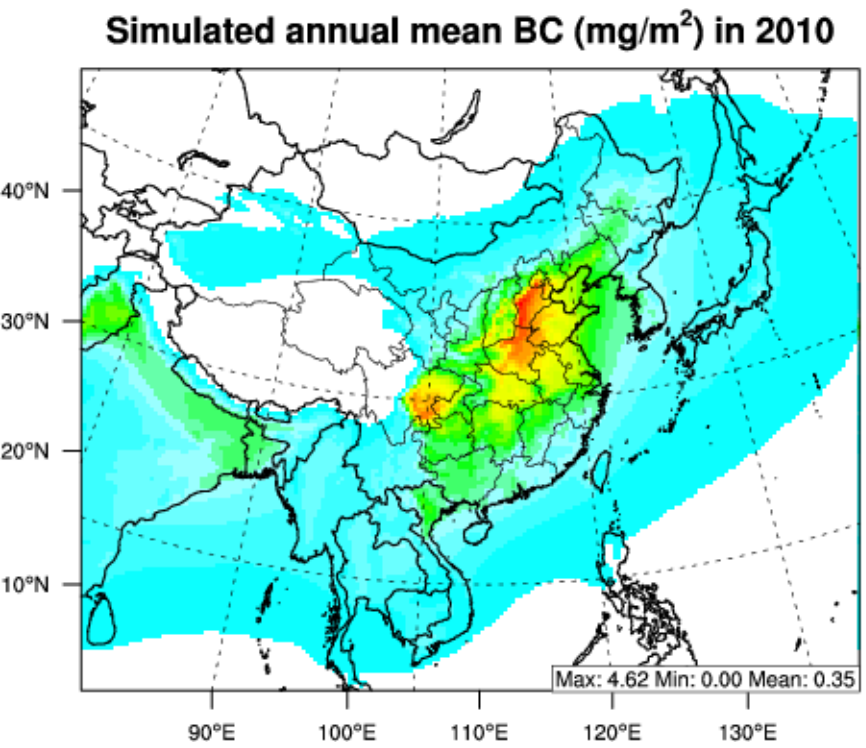


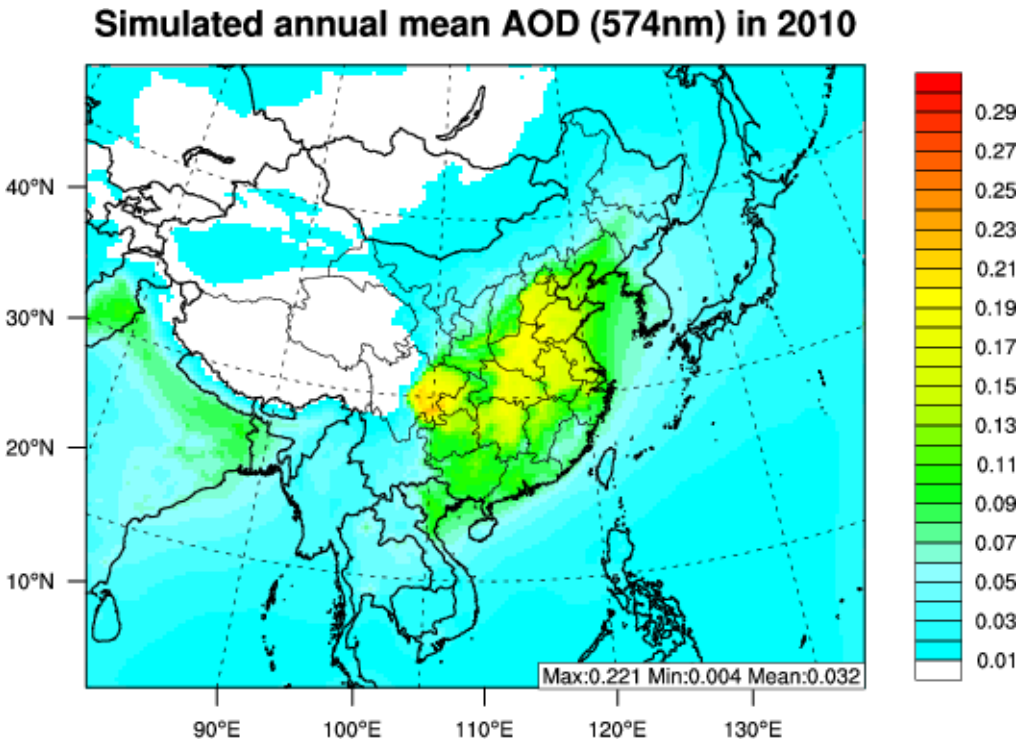


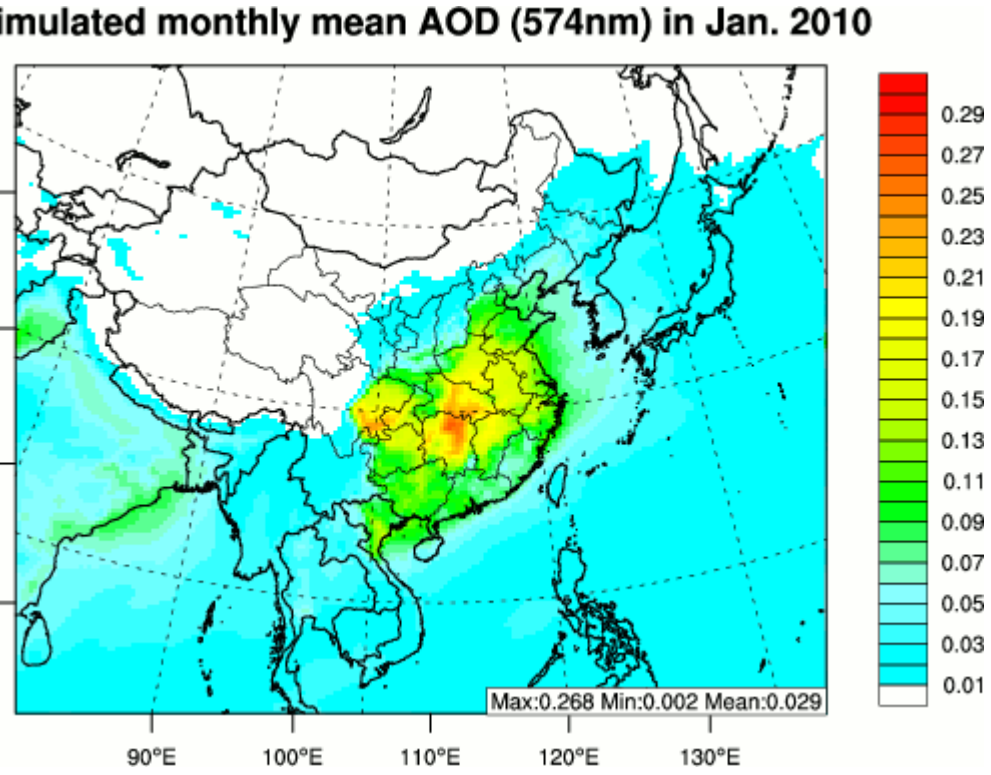
CNEMC Background Sites


Simulated monthly mean BC (mg/m^2) in Jan. 2010
40°N
30°N
20°N
10°N
90°E
100°E
110°E
120°E
130°E
Max: 5.88 Min: 0.00 Mean: 0.40


Simulated monthly mean AOD (574nm) in Jan. 2010
40°N
30°N
20°N
10°N
90°E
100°E
110°E
120°E
130°E
Max:0.268 Min:0.002 Mean:0.029
0.29
0.27
0.25
0.23
0.21
0.19
0.17
0.15
0.13
0.11
0.09
0.07
0.05
0.03
0.01


Simulated annual mean BC (mg/m2) in 2010
40°N
30°N
20°N
10°N
90°E
100°E
110°E
120°E
130°E
Max: 4.62 Min: 0.00 Mean: 0.35


Simulated annual mean AOD (574nm) in 2010
40°N
30°N
20°N
10°N
90°E
100°E
110°E
120°E
130°E
Max:0.221 Min:0.004 Mean:0.032
0.29
0.27
0.25
0.23
0.21
0.19
0.17
0.15
0.13
0.11
0.09
0.07
0.05
0.03
0.01


imulated monthly mean AOD (574nm) in Jan. 2010
0.29
0.27
0.25
0.23
0.21
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0.17
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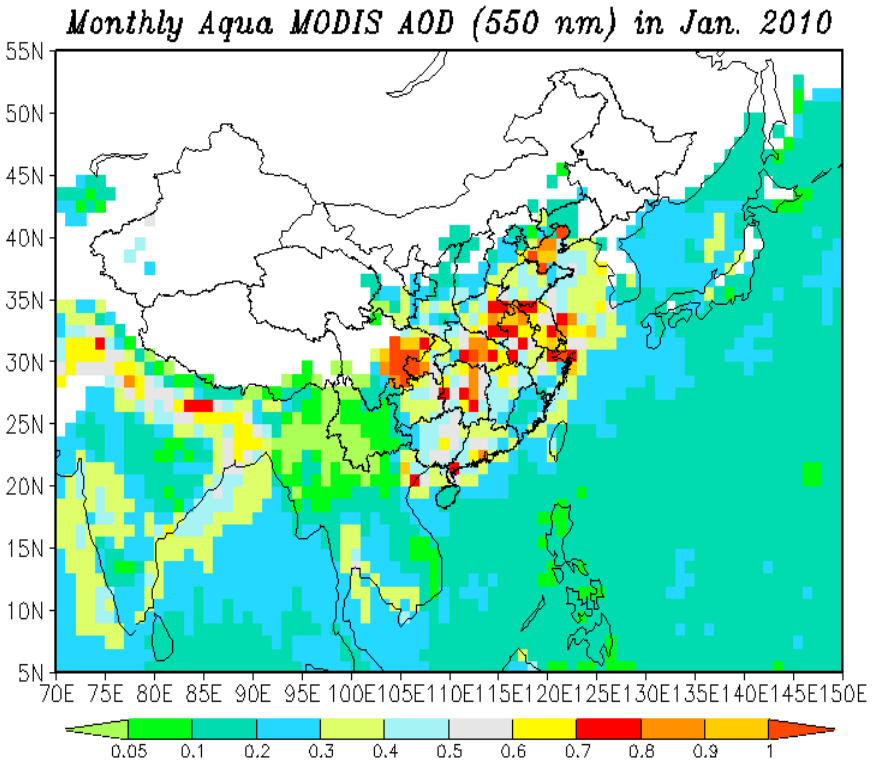
0.13
0.11
0.09
0.07
0.05
0.03
0.01
Max:0.268 Min:0.002 Mean:0.029
90°E
100°E
110°E
120°E
130°E


Monthly Aqua MODIS AOD (550 nm) in Jan. 2010
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
5N
70E 75E 80E 85E 90E 95E 100E105E110E115E120E125E130E135E140E145E150E
0.05 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Summary and Way Ahead

- The regional modeling systems are established already for simulate the trans- boundnary transport, concentration distribution, impact on visibility and atmospheric radiation of BC.
- More comparison with measurements, satellite AOD and column concentration data will be conducted.
- Emission data will be updated, however, still need to be checked to reduce the uncertainties. There are ongoing MEP projects for development of BC emission from mobile sources and other sectors.

Summary and Way Ahead

- Regional distribution of BC can be found from preliminary simulation.
- To improve the understanding of the physical and chemical characteristics of regional BC, to investigate the impact of BC on health and climate to assess the effect of mitigation policy, international cooperation are essential.

Thank You

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