Current Progress in global BC modeling

Black carbon emission inventory (10km×10km)

✓ **Global Combustion Energy Database**

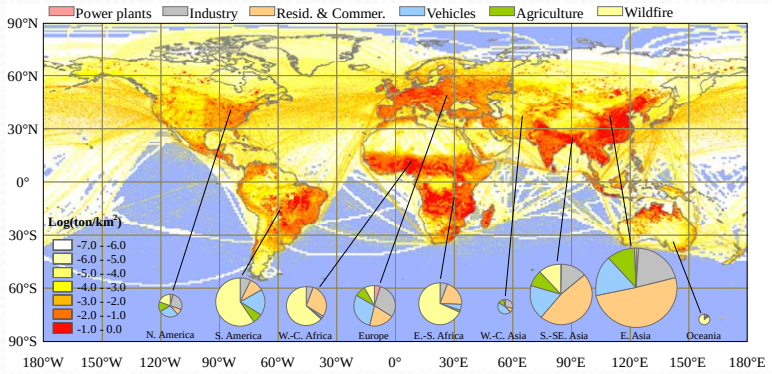
A new global 0.1° ×0.1° (~ 10 km) resolution map of combustion in 2007 for 64 fuel types basing on sub-national information for 45 countries including China and the United States.

✓ **Spatial / temporal resolved Emission factor (EF, mass of BC emitted per fuel consumed) database**

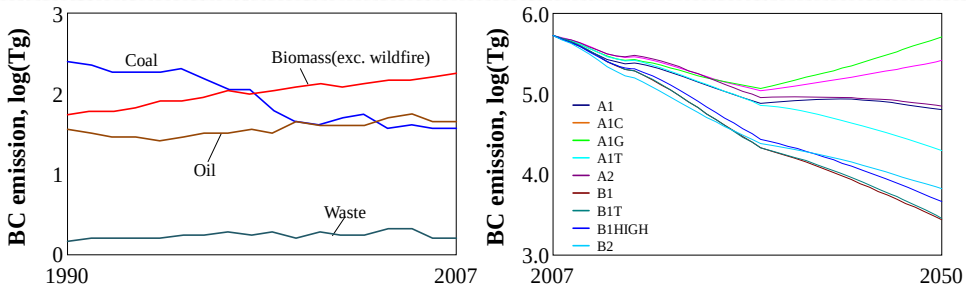
64 sources were categorized into 3 types:

- EF varied in space/time and was modeled in the study (eg., motor vehicles, coke production)
- EF varied in space/time but input as a constant due to the lack of measurement (eg., brick kilns)
- EF was constant for different year and country (eg., residential biofuel)

Global black carbon emission map for 2007



Global black carbon emission from 1990 to 2050



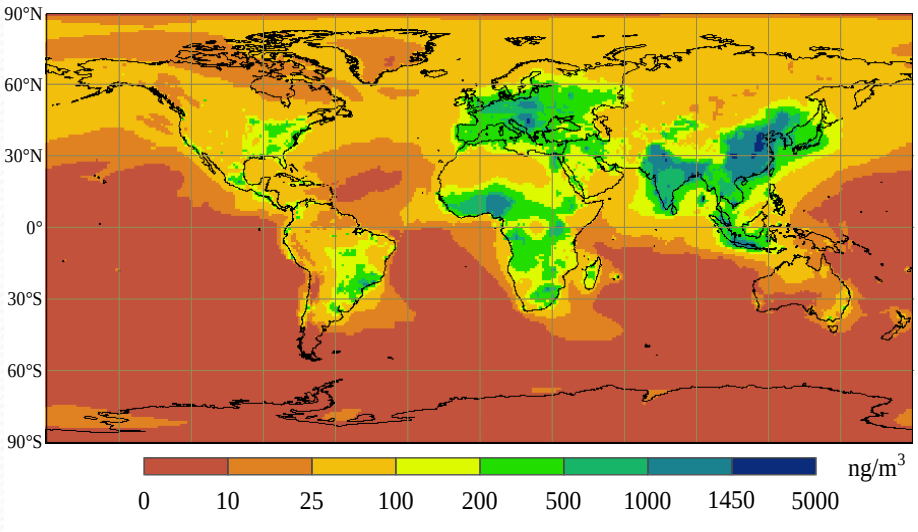
A global transport model of black carbon (BC)

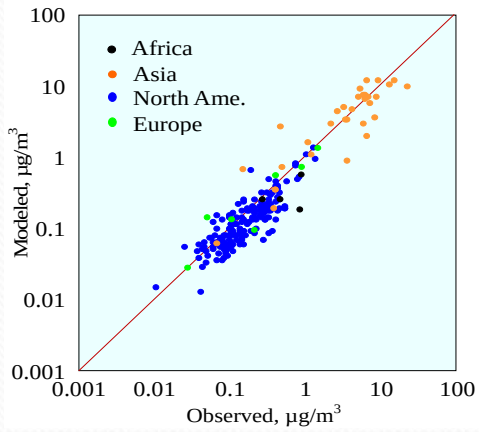
A global atmospheric transport model (ATM) of BC, CanMETOP-BC, was developed by modifying to a regional transport model, CanMETOP (Canadian Model for Environmental Transport of Organochlorine Pesticides) (*Ma,2003*).

Physical/chemical process of BC:

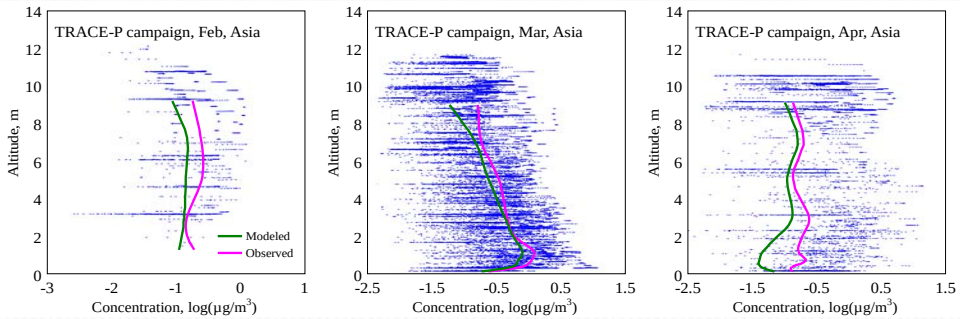
- Aging of BC in the air: correlated with atmospheric OH radical concentrations
- Dry deposition of hydrophilic and hydrophobic BC (depend on land cover)
- Below cloud scavenging of BC: snow / rain
- In-cloud scavenging of BC : convective / stratiform precipitation

Validation 1: surface concentration

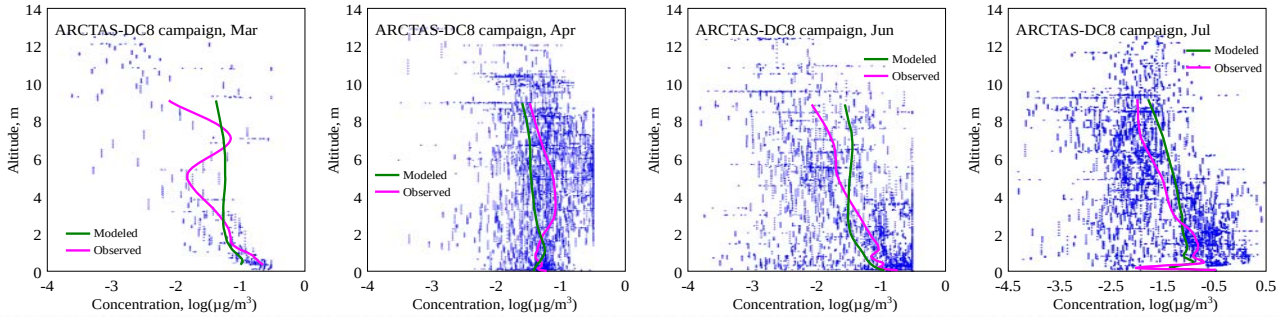


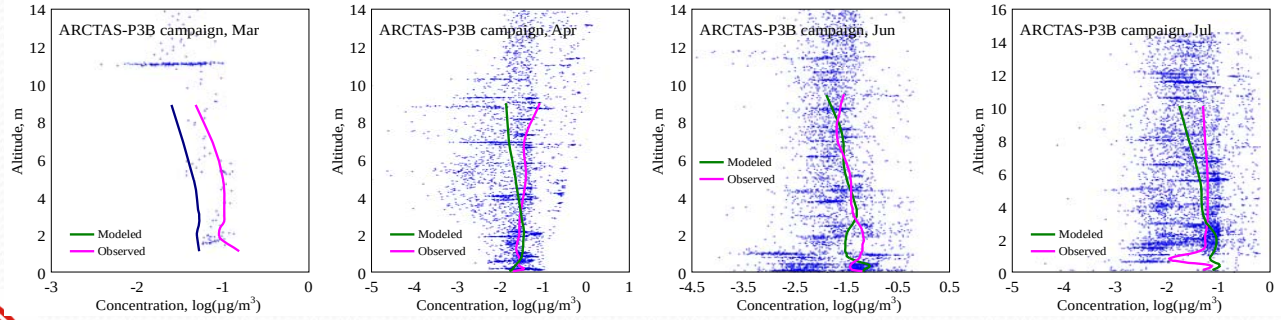


Validation 2: Comparison to aircraft measurements



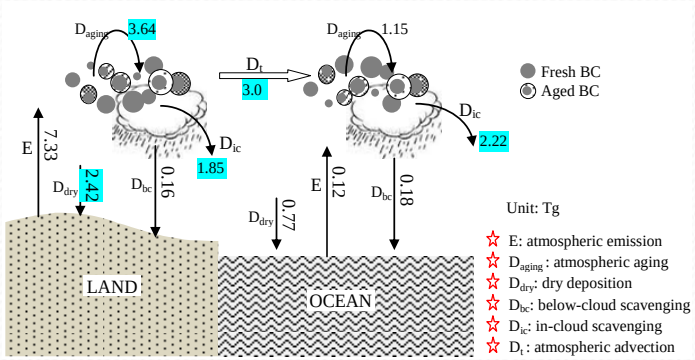
Asia-Pacific





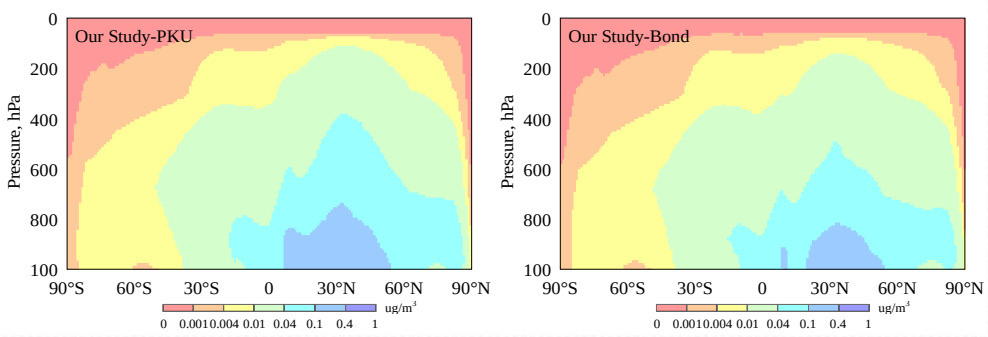
North America-Arctic

Initial results: global BC budget



Model	E,Tg	D_{dry},Tg	D_{wet},Tg	lifetime,d	burden,Tg	Aging
This study	7.5	3.1(45%)	4.4(55%)	8.2	0.17	Depending on OH
AM3	7.7	3.3(43%)	4.4(57%)	9.5	0.20	Depending on OH
GATOR-GCMOM	9.9	0.8(8%)	9.1(92%)	4.7	0.13	Sized-resolved
AGCM	8.0	2.0(25%)	6.0(75%)	4.9	0.11	Depending on TAS
CAM4	10.5	2.5(24%)	8.0(76%)	5.5	0.16	Fixed 1 day
GISS-GCM	10.7	3.2(30%)	7.5(70%)	7.3	0.22	Fixed 1 day
GISS-MATRIX	6.9	1.8(26%)	4.9(71%)	4.1	0.08	Fixed 1 day
GISS-modelE	6.9	1.9(28%)	4.8(70%)	5.6	0.11	Fixed 1 day
HadGEM2	5.2	1.2(23%)	4.0(77%)	17.1	0.24	-
MPIHAM_V2_KZ	8.1	0.6(7%)	7.5(93%)	5.5	0.12	-
SPRINTARS	7.8	1.7(22%)	6.1(78%)	6.8	0.15	-
TM5	8.2	0.2(24%)	7.9(96%)	6.6	0.15	Depending on size

Initial results: zonal distribution



Zonal distribution of BC was calculated using this transport model based on different emission inventories

Initial results: sensitivity test

Sensitivity test	E,Tg (HO+HI)	D_{dry},Tg	D_{wet},Tg	burden,Tg (hydrophobic BC+hydrophilic BC)	Aging lifetime,d	Removal lifetime,d
Standard run	7.5(6+2.5)	3.19	4.41	0.171(0.0247+0.146)	1.88	8.21
Dry deposition ÷2	7.5(6+2.5)	2.25	5.31	0.212(0.0284+0.184)	1.95	10.26
Dry deposition ×2	7.5(6+2.5)	4.14	3.49	0.130(0.0203+0.110)	1.81	6.22
In-cloud scavenging÷2	7.5(6+2.5)	3.44	4.09	0.225(0.0247+0.201)	1.88	10.9
In-cloud scavenging×2	7.5(6+2.5)	3.01	4.63	0.135(0.0247+0.111)	1.88	6.46
Below-cloud scavenging ÷2	7.5(6+2.5)	3.21	4.38	0.175(0.0249+0.150)	1.89	8.41
Below-cloud scavenging ×2	7.5(6+2.5)	3.13	4.47	0.164(0.0244+0.139)	1.87	7.85
Aging rate ÷2	7.5(6+2.5)	3.32	4.26	0.182(0.0441+0.138)	3.66	8.75
Aging rate ×2	7.5(6+2.5)	3.10	4.51	0.166(0.0136+0.152)	0.97	7.96

- Dry deposition and in-cloud scavenging were the two key processes governing the global BC lifetime and atmospheric burden in the troposphere.

- Aging is the factor controlling the fraction of hydrophilic BC, which is the effective form causing radiative forcing.

Problems

Aging of BC

What is the component other than BC in aged aerosol? dust or sulfate

How to consider the change of aerosol size in aging?

How to consider the impact of organic carbon (OC) on aging rate of BC?

- Aging rate of the present model was only dependent on OH radicals.

Uncertainty in removing rate

Example: size distribution of snow particles...
In high-latitude regions, removing rate of BC is very sensitive to the size distribution of snow particles (second-order moment), which is associated with a extremely high uncertainty for different crystal types in snow.

Unknown factors

Future work

Inter-continent transport of BC

Global direct and indirect radiative forcing (RF) of BC

Influence on regional temperature and precipitation