Discussion:

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Anderson et al., Science, 300 (5622): 1103-1104 **Climate Forcing by Aerosols--a Hazy Picture**

- Explain the différences between ''forward calculations'', ''inverse calculations'' and ''applications'' when talking about climate forcing.
- What is meant by ''a Hazy Picture'' in the title of this paper ?
- How will climate forcing evolve in the future (2030, 2050, 2100) ?

Koch et al., Atmos. Chem. Phys., 9, 9001–9026, 2009, **Evaluation of black carbon estimations in global aerosol models**

- How does black carbon differ from the other aerosols such as sulphate, nitrate and sea-salt ?.
- Why is Absorption Optical Depth (AAOD) such an important quantity?
- Where do model differ most,
- Could you think of improvements that can be included in the models to better represent the properties of Black Carbon ?

Inverse Method

Vs

Forward Method

Inverse Method:

Advantages:

lower uncertainty
Directly assess the forcing from temperature change

Disadvantage:

relying on the model for other species & uncertainty
it cannot quantify the basic mechanisms causing the forcing, as well as identifying the effect of various pollutants and different physical processes. Thus, it cannot give enough information to guide the control policies.

I believe forward method is a better choice, which can clarify the mechanisms of forcing and key factors governing the results

An example of forward method: modeling of BC, one of the most important SLCFs (short-lived climate forcers)

Uncertainty for BC modeling:

1. chemical/**physical** processes:

mixing state of BC: influence the solubility of BC, and thus the wet deposition

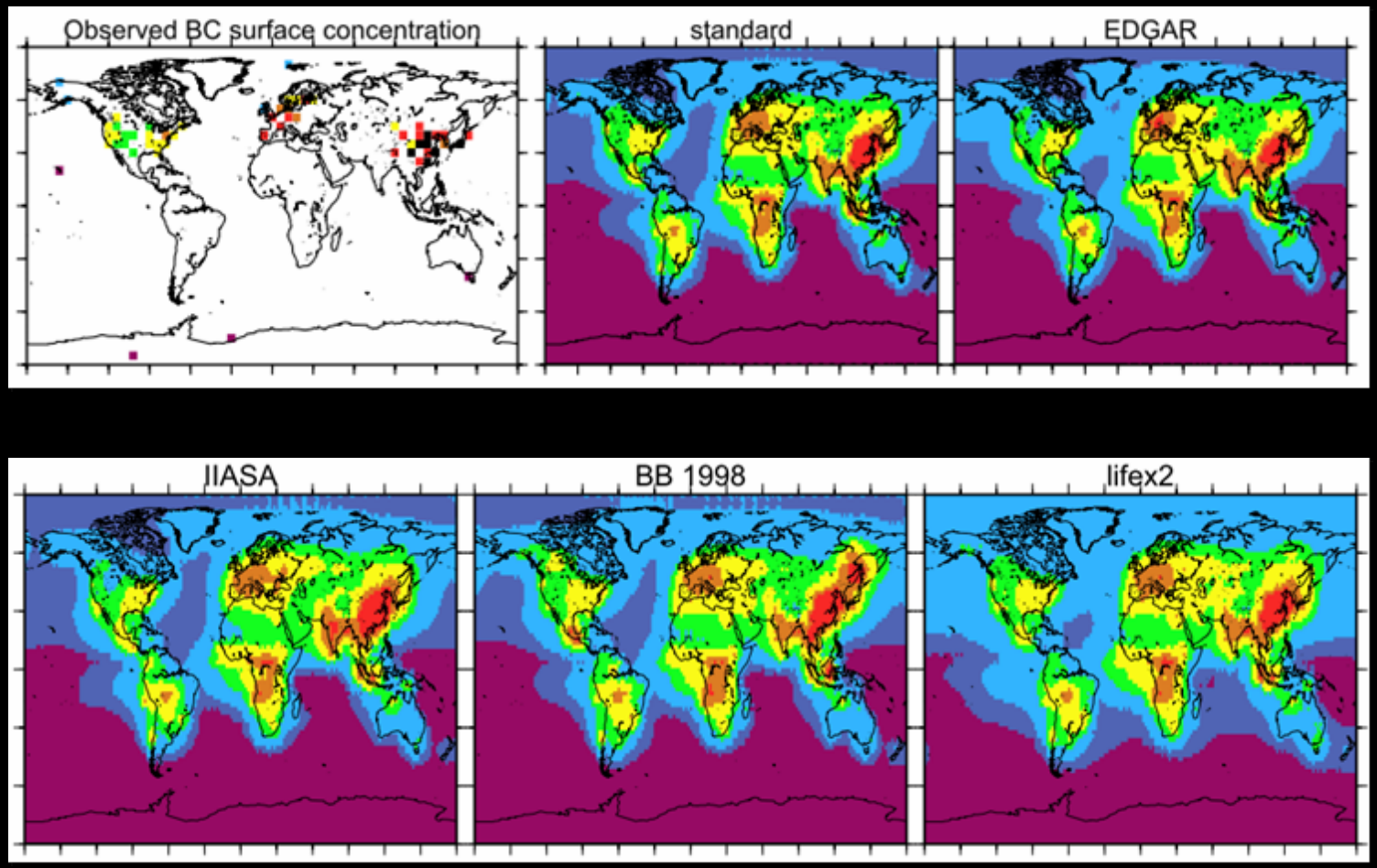
size of BC particles: influence the removing ratio by dry and wet deposition

other factors:

rain/snow: a change of removing ratio by 1-2 magnitudes
convective/stratiform rain: a change of removing ratio by 1-3 factors
snow crystal: different crystal types can result in a removing ratio by 1-2 magnitudes
surface landcover: influence the dry deposition velocity of BC

2. Emission inventories: **my focus**

Sensitivity test by AeroCom models



Koch, 2009

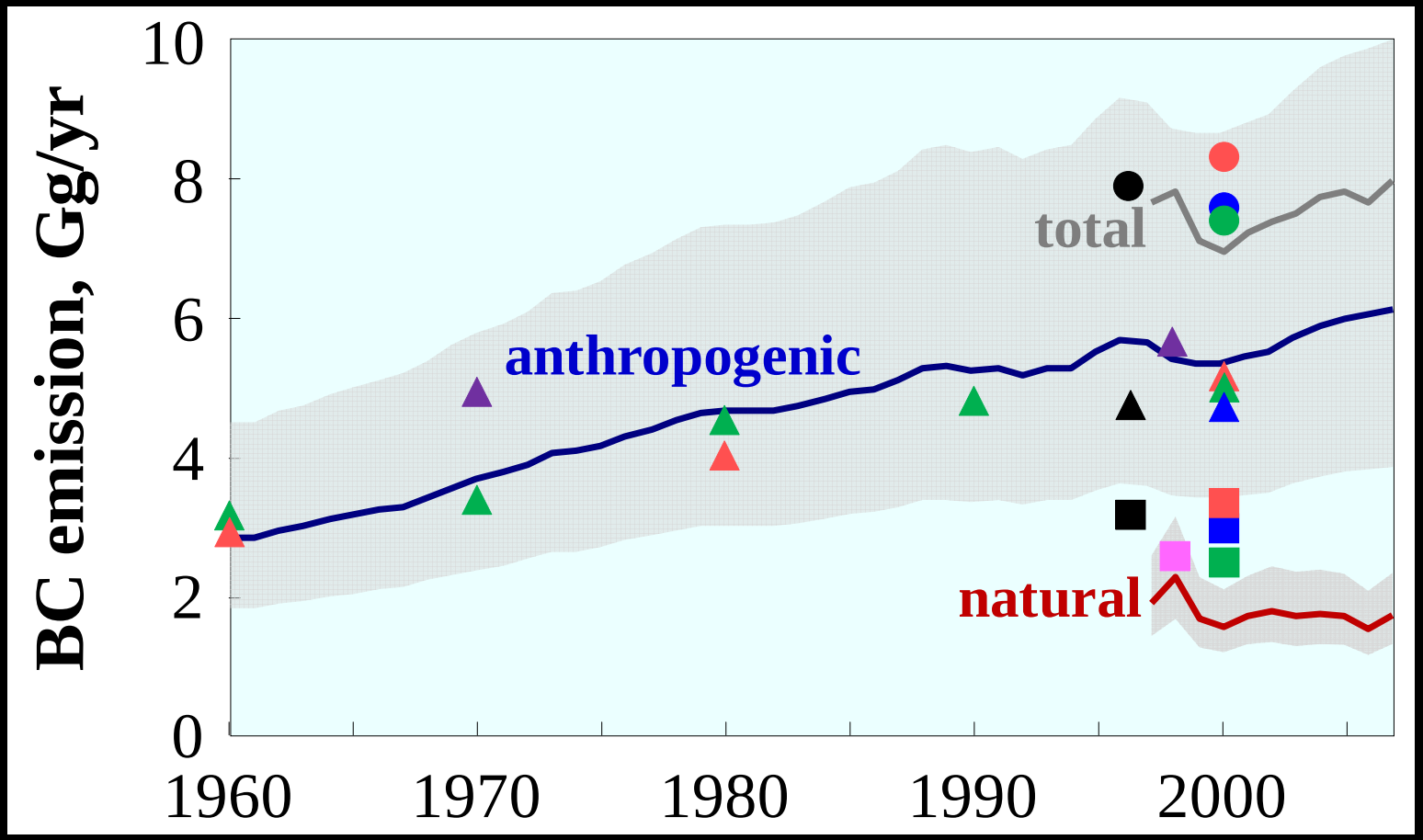
How is the emission calculated

1. Activity data (fuel consumption, product produced, etc.)

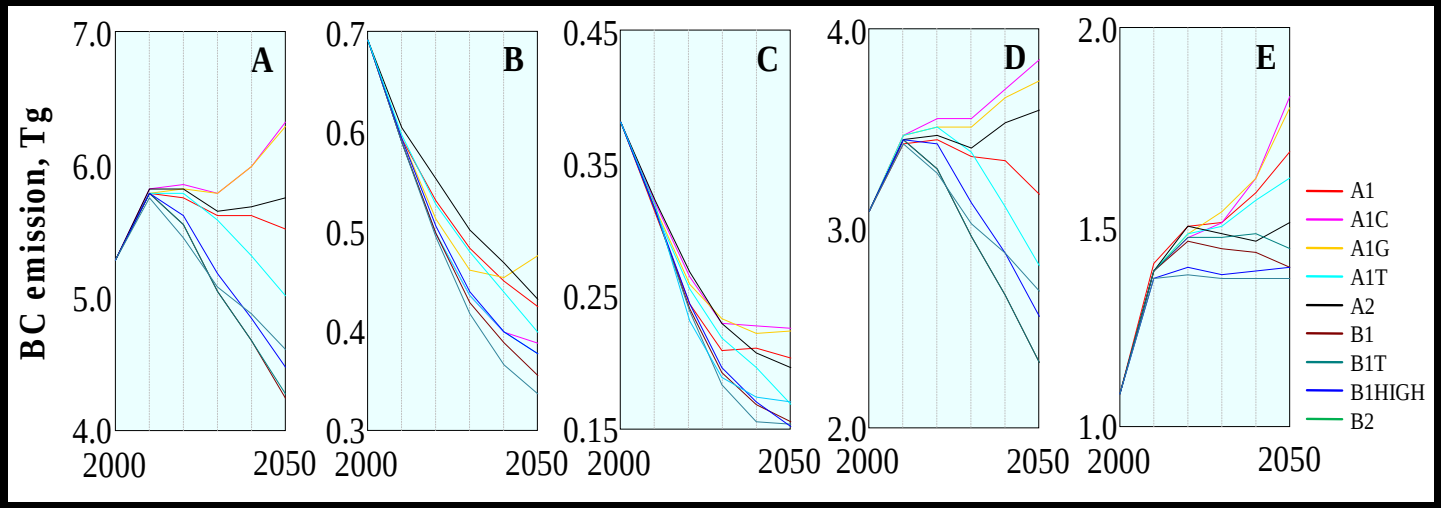
2. Emission factors (mass of pollutants emitted per fuel consumed and product produced)

1. Global/regional total emissions

Global emission history of BC



Prediction of anthropogenic BC emission



Global total (**A**), OECD90 (**B**), REF (**C**), ASIA (**D**) and ALM (**E**)

An example for China

Total BC emission (2007): <u>1941</u> Gg (1227 - 3101Gg as R_{50})

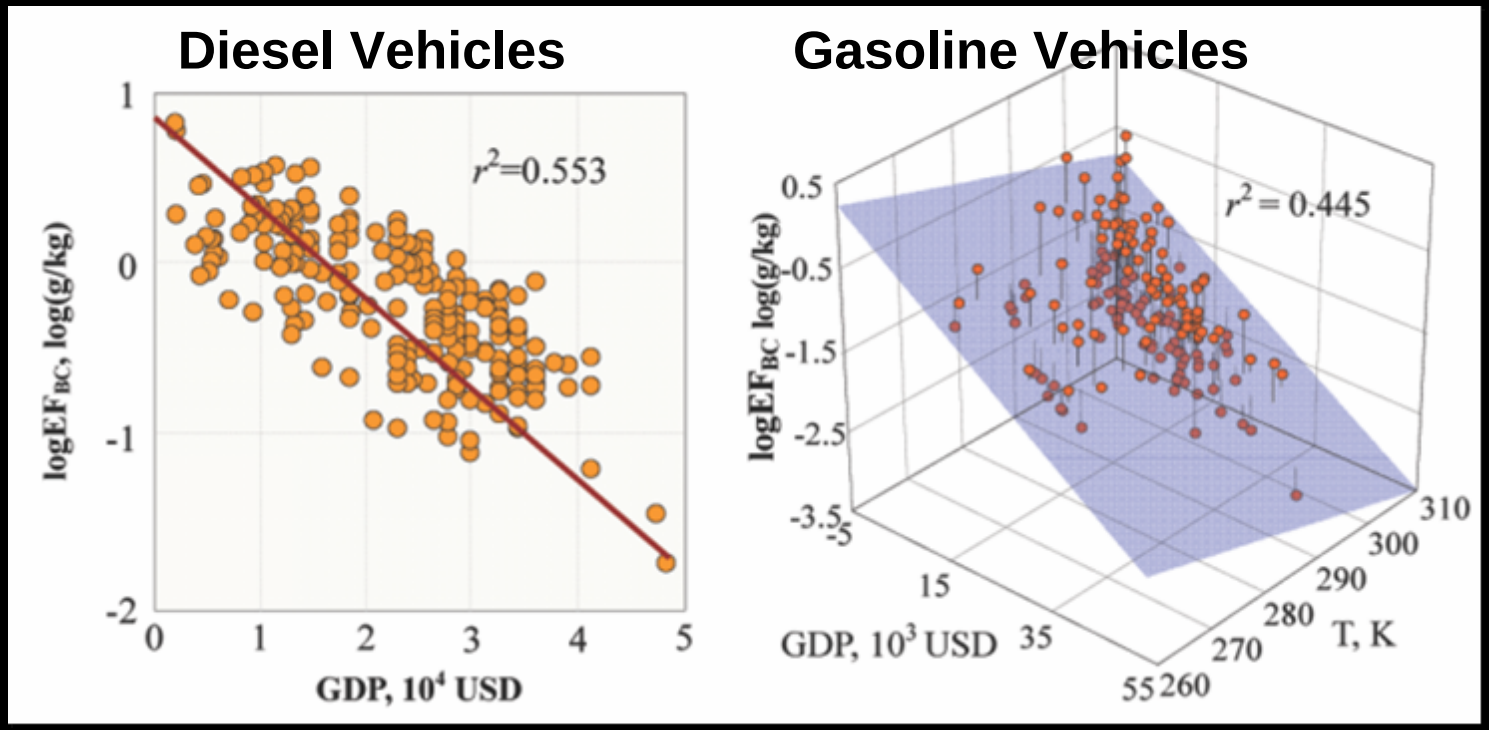
The total emission estimated in this study (2007) was higher than those reported by Bond et al. (1489 Gg for 1996) , Cao et al. (1499 Gg for 2000) , Ohara et al. (1137 Gg for 2003) , and Zhang et al. (1811 Gg for 2006) , largely due to the update of EF_{BC} for **residential fuels and industrial activities and inclusion of a non-compliance rate of control facilities** in the new inventory.

According to our latest real-world measurements, it's found that the emission factors of these traditional residential fuels are underestimated by previous inventories.

For Motor Vehicles:

1. emission factors for motor vehicles will change with time and space, and a good relation with per capital GDP is revealed (Wang, 2012).

2. emission factors for motor vehicles in previous inventories of China were mainly from the studies conducted in developed countries, which might underestimate the vehicles emission in China



Wang, 2012

Emission factors for other sources were not available when these previous inventories were developed. Update of these emission factors will be necessary.

- Firewood and residential crop residues
- Coke production
- Brick production
- Two-stroke gasoline vehicles (motorcycles)
- Brick production

With more emission factors for different technologies, the technology split will become very important.

Two different types of coke productions:

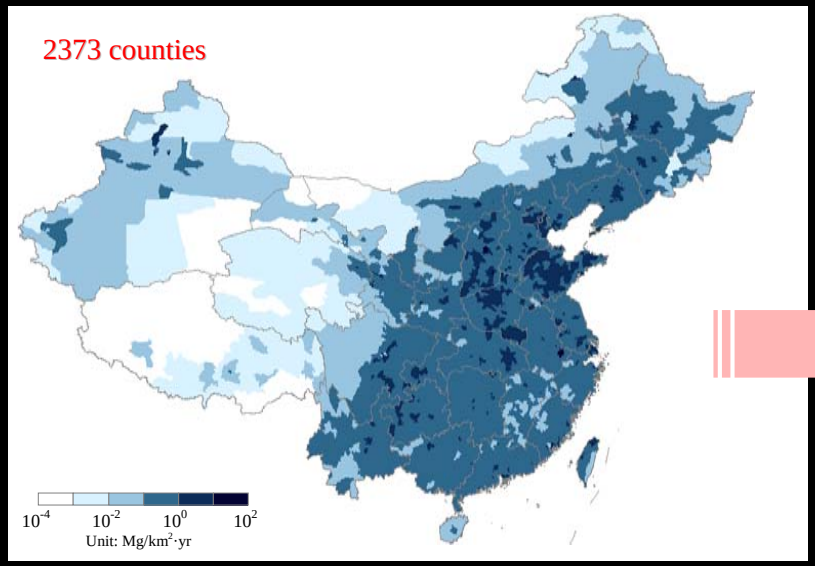
Beehive coking

Recovery battery coking

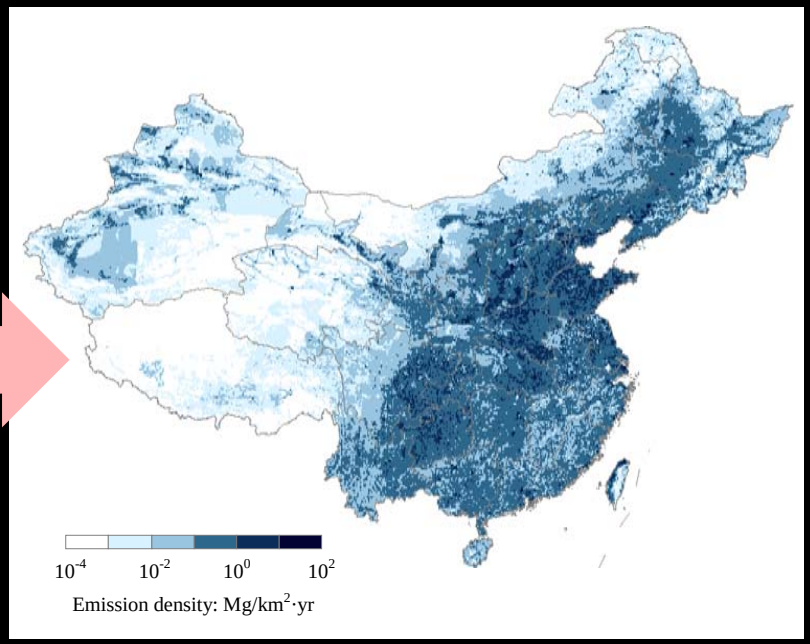
2. Spatial Allocation

Stepwise spatial allocation process: An example in China

county emission map

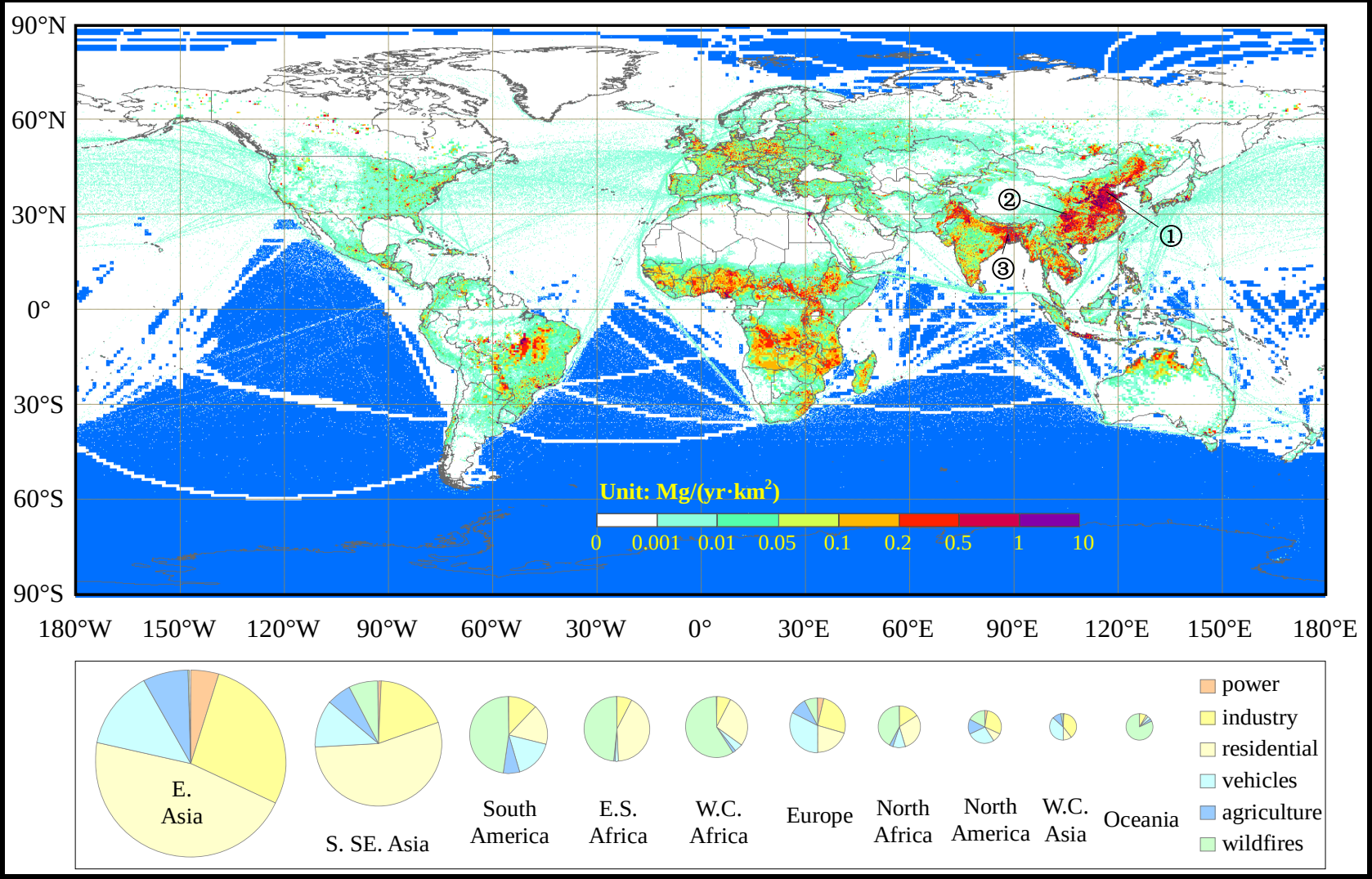


0.1° ×0.1° gridded emission map



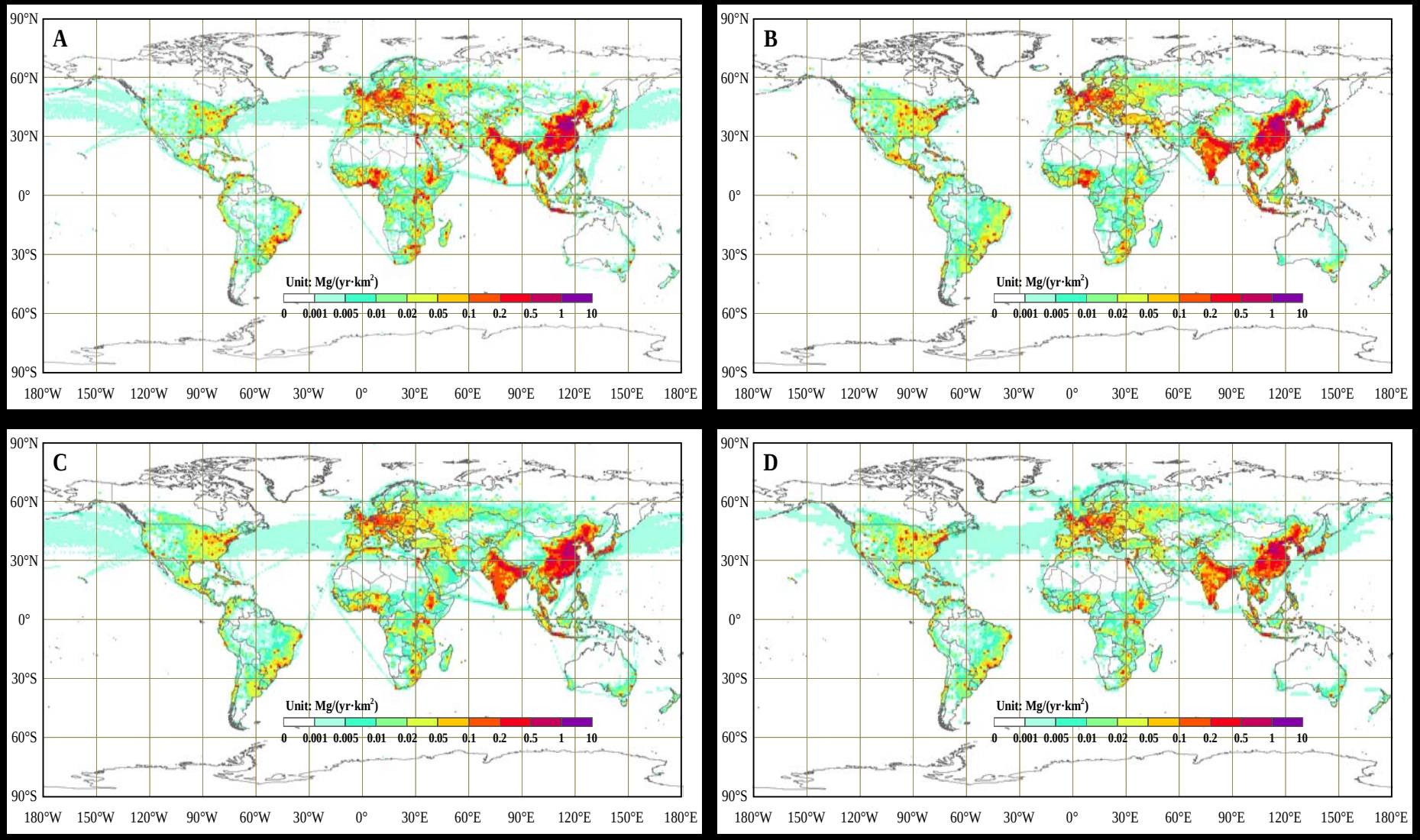
Using population/GDP/rural population/urban population as a proxy within counties

High-resolution emission map for 2007

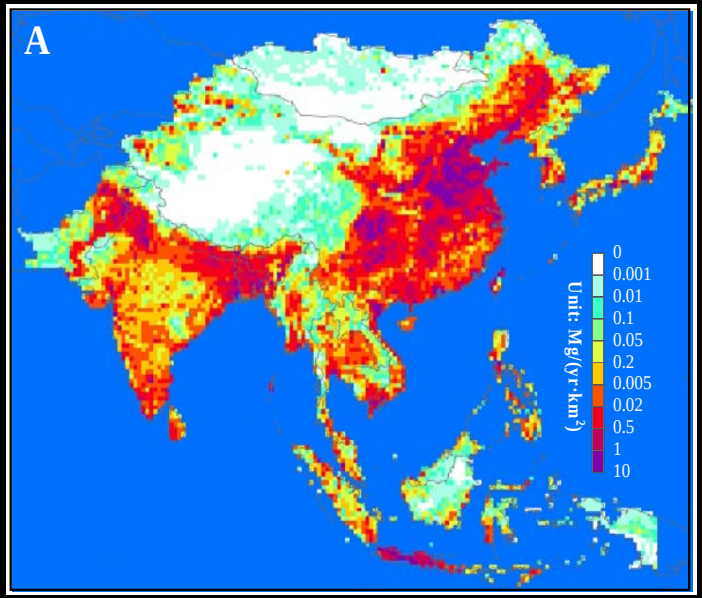


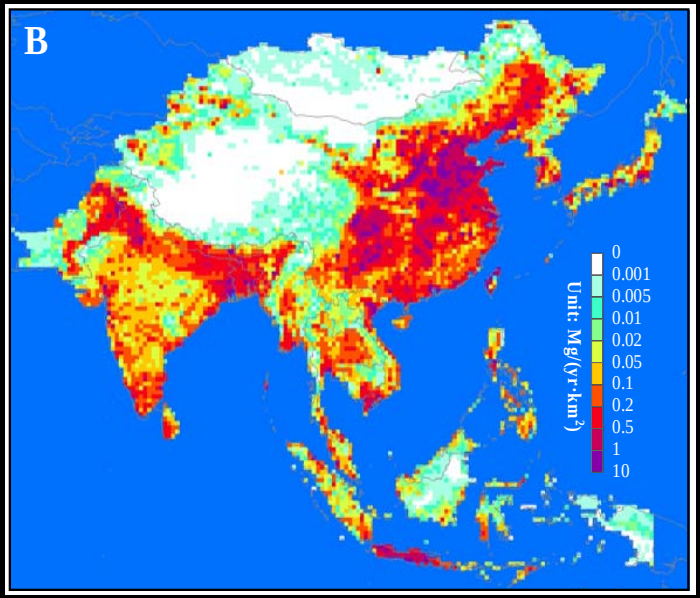
Compare to other inventories

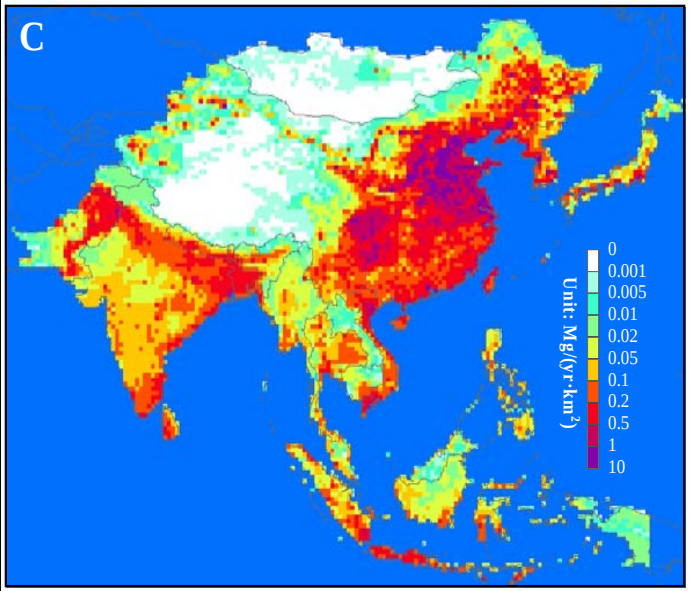
(**A**) Our inventory, (B) AeroCom inventory, (C) IPCC, (D) Bond



(A) our inventory, (B) REAS inventory, (C) INTEX-B inventory





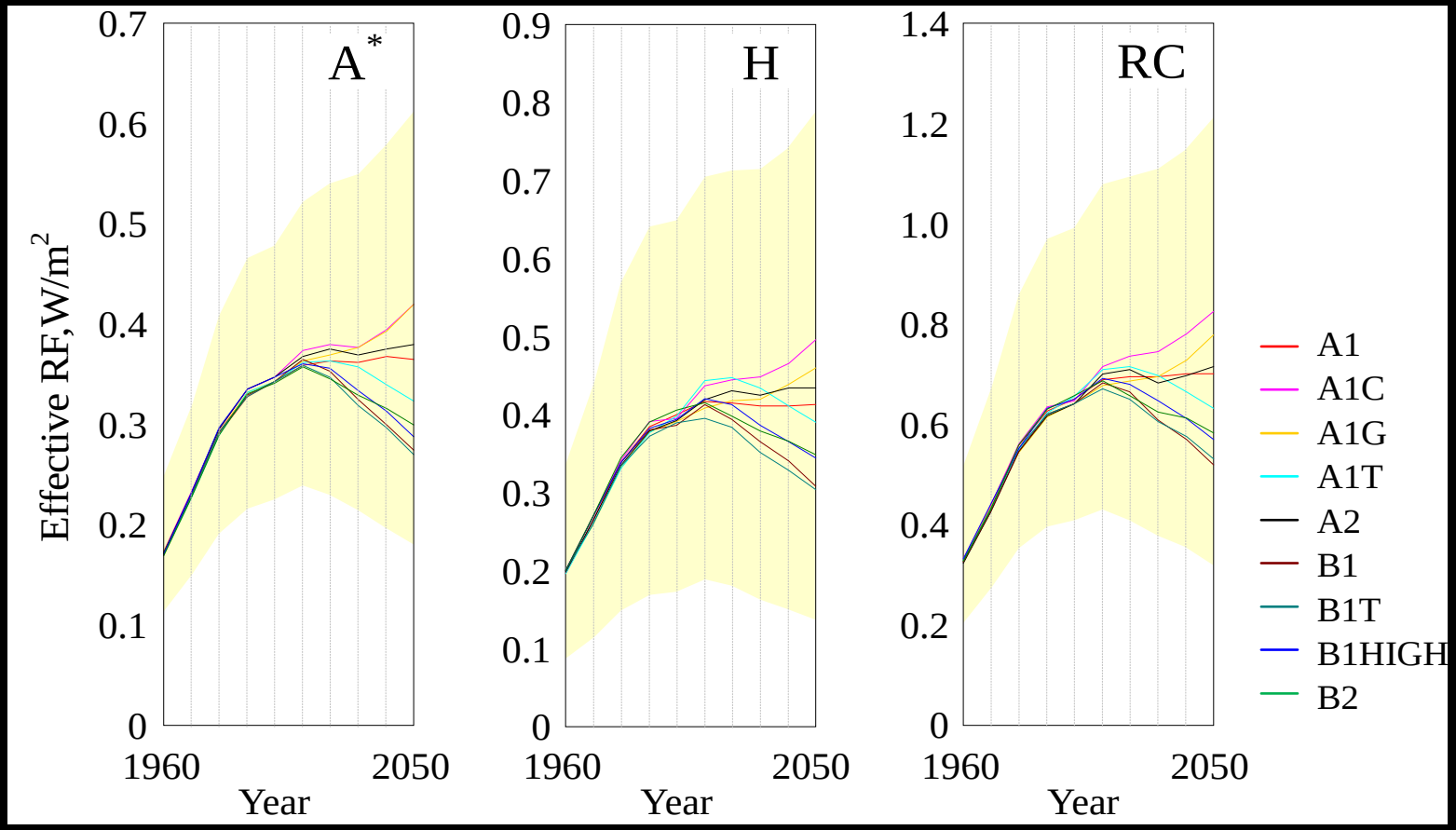


3. Climate forcing

Kopp et al. developed a method to unify effective *RF* (RF_e) of carbonaceous aerosols calculated by different models (A^*, H and RC models) using a standard emission inventory (*Kopp,2010*). Basing on this method, the radiative forcing of BC can be calculated if our inventories are applied.

The uncertainty in BC modeling is large, but significantly lower than that in emission inventories.

Time series of BC's radiative forcing (RF)



Summary

1. Forward method: a sound approach to understand the climate effect of BC. But, how to reduce the uncertainty is very important.

2. Uncertainty of the emissions (global/regional emissions) is large (60 ~ 80%).

3. Uncertainty of the emission maps (gridded emissions) is larger (120 ~ 200%).

4. The uncertainty in BC modeling is large, but significantly lower than that in emission inventories. Thus, getting an accurate emission estimation and a high-resolution emission map is another key in assessing the radiative forcing of BC.