Development of a global black carbon emission inventory (PKU-BC), and the implications for BC modeling

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Abstracts

Black carbon (BC) is recognized as a significant contributor to global climate change and local air pollutant. However, global atmospheric models often underestimate the surface concentrations as well as light absorption (AAOD) of BC. It's argued that the underestimation is due to a low bias in the emissions, suggesting a need to revisit the inventories. We develop a BC emission inventory (PKU-BC) at 10 km resolution based on a recently published global fuel consumption dataset and updated emission factor measurements. As a result, the global total and anthropogenic BC emission in 2007 was 9.1 and 6.7 Tg, and the latter is ~30% higher than in other inventories (average of 4.9±0.4 Tg). Meanwhile, the spatial pattern changes remarkably, because information contained in sub-national dataset (e.g., at county level in China and U.S.A.) has been included. To evaluate the inventory, we employ a high-resolution atmospheric model, and find that using the PKU-BC inventory can result in a better agreement between the modeled surface concentrations and AAOD with observations than that using another BC inventory (MACCity). In addition, the BC emissions are also estimated for the period 1960 to 2007. We propose that a standard method to quantify the uncertainty in emissions should be developed and applied for the inventories of more species.

Methods

Sixty-four combustion-related sources are included in PKU-BC. To develop the inventory, a sub-national method is developed and used to construct a global high-resolution fuel consumption data set. In addition, recently measured EF_{BC}, especially those measured in China and other developing countries, have been used. Uncertainty of the emission is quantified by Monte Carlo simulations. Median and semi-interquartile range are calculated and used to run the atmospheric models. Detailed description of the methods are presented in Ref (1-5).

Results

The spatial distribution of BC emissions in PKU-BC is different with that in MACCity.

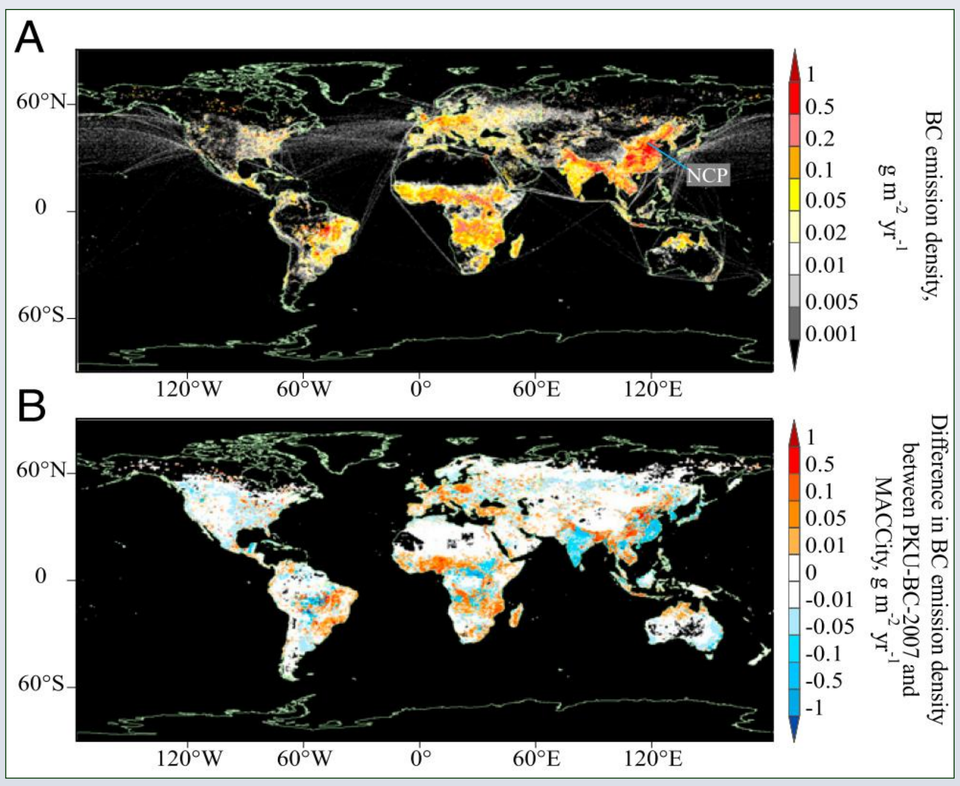

Figure 1. Geographic distribution of BC emissions in PKU-BC in 2007 (A), and the difference with that in MACCity (B).

The PKU-BC and MACCity inventories are both used to run the model, and simulated surface concentrations are evaluated by field measurements collected in Ref (2).

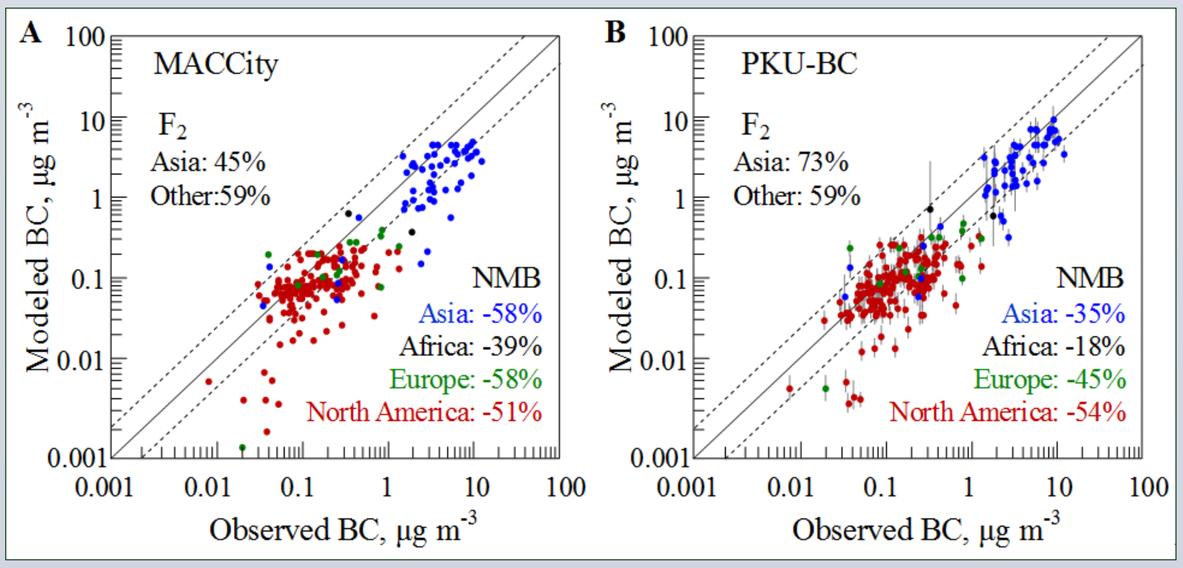

Figure 2. Comparison of modeled and observed BC surface concentrations by using the PKU-BC (A) and MACCity (B) inventories. An Asia-nested LMDZORINCA model is employed to evaluate the effects of using different inventories. NMB: normalized mean bias. F_2: percentages of sites with deviations less than a factor of two. The error bars in (B) is derived from using the first and third quartiles of the emissions.

In addition to the surface concentrations, the modeled BC aerosol absorption optical depth (AAOD) using the PKU-BC inventory also matches well observations from the global ground-based remote sensing Aerosol Robotic Network (AERONET).

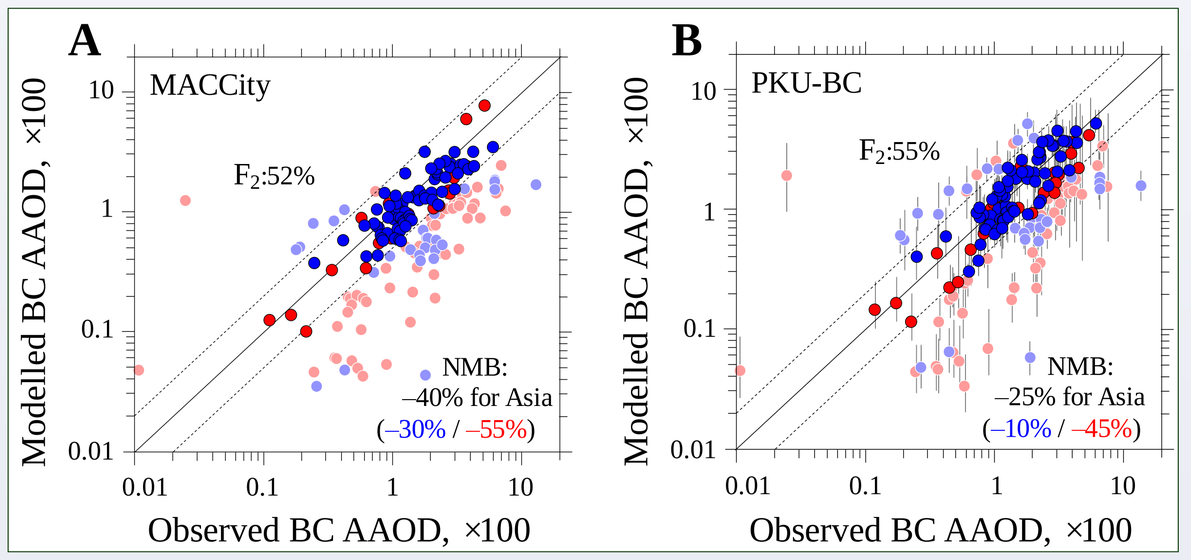

Figure 3. Comparison of modeled and observed BC AAOD at 900 nm in East Asia (blue circles) and South Asia (red circles) by using the MACCity (A) and PKU-BC (B) inventories. NMB: normalized mean bias. F_2: percentages of sites with deviations less than a factor of two. The error bars in (B) is derived from using the first and third quartiles of the emissions.

The historical trend in global anthropogenic BC emissions from PKU-BC is compared with other estimates over the period.

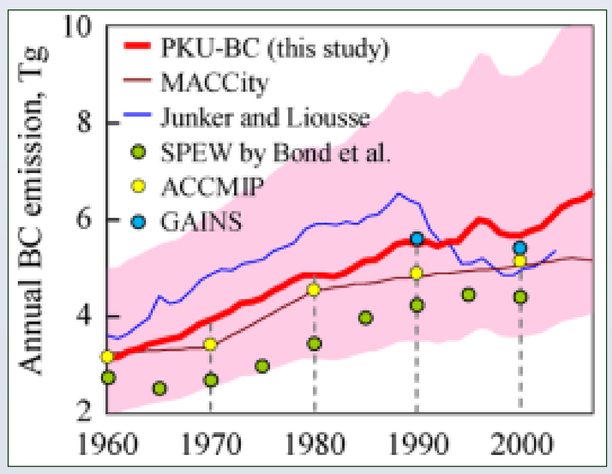

Figure 4. Comparison of annual anthropogenic BC emissions from 1960 to 2007 between PKU-BC and those in other inventories: ACCMIP; MACCity; SPEW by Bond et al.; GAINS; and Junker and Liousse. The annual BC emissions and uncertainties in PKU-BC are shown as median values (red line) and R50 (shaded area) from Monte Carlo simulations.

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