Atmos. Chem. Phys. Discuss.,
doi:10.5194/acp-2016-1032-RC3, 2017

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Source attribution of black carbon and its direct radiative forcing in China" *by* Yang Yang et al.

Anonymous Referee #3

Received and published: 18 January 2017

This study quantified source contributions of black carbon (BC) mass concentrations, trans-Pacific transport of BC, and direct radiative forcing of BC from seven regions in China using the Community Earth System Model with a source-tagging technique. The authors showed that BC concentrations were dominated by local emissions for regions with high emissions (e.g., North China, South China), whereas non-local emissions were important for regions with low emissions (e.g., Northwest China, Tibetan Plateau). They also showed that emissions from China and other regions were equally important for the BC outflow from East Asia and that emissions from China would be important for air quality in western United States. The annual mean direct radiative forcing of BC in China in their simulations was 2.3 W m-2, and the contribution from emissions in China was estimated to be 66%.

The purpose of this study is interesting and the results obtained in this study are impor-

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tant to understand BC behavior in the atmosphere over East Asia. I think the authors should describe several points (shown below) more clearly, but overall the manuscript is written well and is suitable for the publication of this journal.

Major comments:

(1) Importance of BC in air quality problems

The authors sometimes use BC as an indicator of pollution (or air quality) in China (Lines 39-40, Lines 101-102, Lines 429-431, and Lines 571-572). However, I think it is questionable whether the concentrations and/or source contributions of BC can be used to represent those of total aerosols. Inorganic and organic species are dominant in China during polluted days, and spatial/temporal variations and source contributions of these species are largely different from those of BC because spatial distributions of emissions (e.g., BC v.s. SO2) and formation processes (primary v.s. secondary) are considerably different. For example, Matsui et al. (2009) showed that primary aerosols around Beijing were controlled by emissions within 100 km around Beijing within the preceding 24 h, while emissions as far as 500 km and within the preceding 3 days were found to affect secondary aerosols. Therefore, it is not always correct to extend the results of BC (e.g., source contributions) to the discussions on pollution and air quality because inorganic and organic species could have larger contributions from non-local emissions than BC. Please consider this point and describe the limitation of using BC results only in the discussions of air quality problems. In addition, please show the percentage of BC mass to total mass (PM2.5) in China in the manuscript.

(2) Treatment of optical property and CCN activity of BC (Lines 151-169)

I could not find the description on the treatment of optical property (well-mixed, core-shell, or others) and CCN activity (conversion from hydrophobic to hydrophilic BC) of BC in the MAM3 model. I assume that well-mixed optical treatment is used to calculate BC absorption and that all BC particles are treated as hydrophilic BC in MAM3. Please describe the treatment of optical property and CCN activity of BC in the manuscript,

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and add some description on the potential impact (uncertainty) of these treatments on the estimation of BC concentrations, trans-Pacific transport of BC, AAOD, and direct radiative forcing of BC and their source contributions.

Other comments:

(3) Line 70

Please describe the reason of the faster regional removal.

(4) Lines 168-169

Please clarify the definition of the direct radiative forcing of BC. Is this calculated from the difference of two radiative transfer calculations with and without BC for the clear-sky condition?

(5) Lines 182-204

Please show the difference of BC emission fluxes between the emission inventory used in this study and other emission inventories (e.g., INTEX-B, HTAP). The values are shown later (at Lines 534-538), but I think it is better to show them here. In addition, please add some comments on the impact of larger values of BC emissions in this study on the estimation of source contributions of BC. Can you add the values of BC emissions from outside China (e.g., India, Southeast Asia, Japan, Korea) to Figure 1b?

(6) Lines 261-263

You can show the contributions from outside China quantitatively from the tagged simulation results.

(7) Line 281

Please describe the reason of BC underestimation by up to a factor of 20.

(8) Line 343

I cannot find large sources of BC in Northwest China in Figure 1a. Does the description

here mean that there may be large sources of BC which are not considered in the emission inventory? Can you show the contribution of BC and dust to AAOD (in model) over this region? I think dust is dominant over this region.

(9) Lines 667-669

Related to the comment (2), is an internally-mixed treatment used in the calculations of AAOD? If so, AAOD should be lower (underestimated more) when more realistic BC mixing state treatment is used in the optical calculations.

Reference:

Matsui, H., et al. (2009), Spatial and temporal variations of aerosols around Beijing in summer 2006: Model evaluation and source apportionment, J. Geophys. Res., 114, D00G13, doi:10.1029/2008JD010906.

Interactive comment on Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-1032, 2016.

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