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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "The study of emission inventory on anthropogenic air pollutants and VOC species in the Yangtze River Delta region, China" *by* C. Huang et al.

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RC C162: 'Reviewer's comments', Anonymous Referee 1, 11 Feb 2011

1. The title read a bit strange, could be changed to The study on emission inventories of major anthropogenic air pollutants in the Yangtze River Delta region, China ?

Re: According to the comments of RC C1315, we would like to change the title to "Emission Inventory of anthropogenic air pollutants and VOC species in the Yangtze River Delta region, China".

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Interactive Discussion

Discussion Paper

2. The methods for emission inventories, such as mass balance, top-down approach, and bottom-up approach are used in the manuscript. I wonder why? The equation (2) does not look like a reliable mass balance methods (the residue in coal ash were not counted), and secondly, is it possible to have inter-comparison of these approaches?

Re: In this study, only SO2 emission factor was considered to use mass balance method. The emission factors of other pollutants were taken directly from the latest literature. We have mentioned that in section 2.3.1, page 956, line 23. Top-down and bottom-up approaches are common methods to compile emission inventory. In this study, different emission sources use different approaches. For the fuel combustion facilities, like power plants, boilers, and furnaces, we used bottom-up approach based on the environmental census data of the individual facility. For the area sources without detail census data, we calculated the emissions of a total county based on the statistical yearbook data with the average emission factor. We define it as top-down approach. It is obvious that bottom-up approach is more accurate than top-down method, but we think its hard to qualify the difference of these two approaches.

3. The activity data have also two sources: the environmental census and Statistical Yearbook, for the cities that have both sources, is it possible to compare these two datasets? At least give an idea to the readers how different they will be? And also important, the MS stated that the high-resolution of emission inventories is essential, how to get the activity data for the countryside in the YRD region? The author needs to explain this part to convince readers that the activity data of this MS is more complete than previous ones.

Re: The environmental census covers the detail information of the individual industrial source, such as geographical data, fuel type, fuel consumption, sulfur content, ash content, boiler types, capacity, and exhaust control efficiency, etc. These census data can support us to calculate the emission for the individual facility with high resolution. While the Statistical yearbook only gives the total amounts of energy consumption, industrial products, organic solvent or paint use, etc. in one administrative region. We can only calculate a total emission with an average emission factor of the administrative region. To clearly explain the difference between environmental census and Statistical Yearbook, we would like change the section 2.3.1, page 956, lines 4-14 to: "A nationwide campaign of pollution source census was conducted to get the basic data of these facilities one by one in each administrative region for the year of 2007. For the other regions whose census data were not available, the activity data were collected from the national key pollution source lists reported by the government every year. These two datasets covered most of the industrial sources in the YRD region and supplied detailed information for individual emission source calculation, such as geographical data, fuel type, fuel consumption, sulfur content, ash content, boiler types, capacity, and exhaust control efficiency, etc. Since there was no census data available for the emission sources in commercial and civil sector, we collected fuel consumption data for a whole administrative region from its statistical yearbook and calculated the emissions with the average emission factors. Relatively high uncertainty can be expected by use of statistical yearbook compared with the census data." For another question, we think there maybe some misunderstanding for the "city" which we mean in the paper. Commonly, "city" in China means an administrative region equal to the "county-level" of the United States. So both environmental census and Statistical Yearbook include the activity data in the urban and countryside areas. To avoid the confusion in the paper, we think it would be better to make the following changes: (1) section 2.1, page 954, line 12: replace "city scale" to "county scale"; (2) section 2.1, page 954, line 14: replace "city scale" to "county scale"; (3) section 2.1, page 954, line 18: replace "several counties" to "several countrysides"; (4) section 2.3.4, page 958, line 18: replace "the statistical yearbooks of the cities" to "the statistical yearbook of each administrative region"; (5) section 2.3.5, page 958, line 23: replace "the cities' annual statistical data" to "the annual statistical data of each administrative region"; (6) section3.1, page 960, line 12: replace "cities" to "administrative regions"; (7) section3.1, page 960, lines 25-26: replace "in the cities of YRD region" to "in the YRD region"; (8) section3.1, page 961, line 1: replace "city" to "administrative region"; (9) section3.1, page 961, line 9: replace

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“cities” to “countrysides”; (10) section3.5, page 964, line 12: delete “the cities of”.

4. The major obstacle of the MS come from the selection of emission factors. I notice that the authors mainly cited the EFs from literatures, and this is a highly risky way. I believe if the authors compare the EFs for the same source from different researchers, the difference would be very large. I would like the authors put more efforts in this section, and illustrate to the readers the current understanding and progress of the emission factors, why the emission factors were selected for the 2007 YRD inventories.

Re: It is true that the emission factors in this study are mainly cited from relative literatures. We agree with the reviewer that the difference of the EFs from different researches sometimes is larger than expected. Due to the lack of local measurement on emission factor in recent years, we prefer to cite the emission factors from the literatures. The literatures on domestic measurement studies or the summarization of previous studies are prior to be cited to ensure the representatives of the emission factors. European or American studies are referenced when domestic measurement data is not available. To illustrate the current understanding and progress of the emission factors, we would like to make the following changes in the manuscript: (1) Re-write the section 2.3.1, page 956, line 21 to page 957, line 7: “For SO2 emissions, the annual inventory was compiled using the mass balance method by Equation (2). The emission factors of NOx, CO, PM10, PM2.5, and VOCs were taken directly from the latest literature. Domestic measurements or relative studies in recent years are prior to be cited in this study. Foreign studies in line with current technology level in China will be considered when there is no domestic study available. The literature reviews of previous studies obtain a range of 2.38-10.0 kgâĂćt-1 for NOx emission factors (Kato and Akimoto, 1992; Hao et al., 2002; Streets et al., 2003). To better understand the NOx emission level of coal-fired boilers in China, Tian (2003) studied more than 100 power plant boilers and obtained a mix of NOx emission factors of various boiler types with or without LNB. Based on Tian’s study, Zhang et al. (2007) predicted the NOx emission factors of coal-fired boilers for 1995-2004 in China, which we believe are more representative to current NOx emission level of the facilities in the YRD region. Previous studies illustrate the big differences of CO emission factors between different types of combustion facilities. Ge et al. (2001) obtained the average CO emission factor (15 kgâĂćt-1) of automatic stoker furnaces based on the measurements. While the CO emission factor of hand-feed stoker furnaces could be 7 times higher according to USEPA's study (2002). Zhang et al. (2000) tested 19 household stoves and obtained a range of 19-170 kgâĂćt-1 for CO emission factor. Based on these studies, Wang et al. (2005) summarized the CO emission factors of each kind of fuel combustion source in China, so we cited the CO emission factors from the study of Wang et al. (2005). PM emission factors usually depend on ash content in coal, boiler technology, and the efficiency of exhaust control. There is little PM emission measurement study in China. Zhang (2005) summarized the domestic and foreign studies from USEPA (2002), Klimont et al. (2002), and Zhang et al. (2002) and reported a group of PM10 and PM2.5 emission factors which we listed in Table 1 and 2 according to the technology level of the facilities in China. The emission factors of other pollutants were mainly based on the European or American results due to the lack of corresponding measurement data in China. VOCs emission factors came from the study of Bo et al. (2008). NH3 emission factors were negligible in the fuel combustion sources."

Kato, N., and Akimoto, H.: Anthropogenic emissions of SO2 and NOx in Asia: Emission inventories, Atmospheric Environment, 26, 2997-3017, 1992. Klimont, Z., Cofala, J.,Bertok, I., Amann, M., Heyes, C., Gyarfas, F.: Modelling particulate emissions in Europe: A framework to estimate reduction potential and control costs. Interim report, IR-02-076, International Institute for Applied Systems Analysis, Laxenburg, Austria, 2002a.

(2) Re-write the section 2.3.2, page 957, lines 17-18: "USEPA (2002) reports the emission factors of each industrial process source category in AP-42 emission factor compilation. The emission factors of major PM emission sources in this study, such as coke production, iron steel manufacturing, steel foundries, ferroalloy, and aluminum prod-

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ucts, etc., are mainly cited from AP-42 with some adjustments to reflect poorer performance and lower particulate collection efficiencies of the technology level in China. VOCs emission from the industrial process is an important source which contributes about 31.5

Passant, N.R., Vincent, K.: Review of the efficiency and cost of control measures for sulphur dioxide and volatile organic compounds. Draft final report AEAT-3851. AEA Technology, Culham, UK, 1998.

(3) Re-write the section 2.3.4, page 958, lines 13-17: “The fugitive VOCs emission sources considered in this study mainly consist of domestic paint use for building and furniture, domestic solvent use, and oil/gas dissipation. For the architectural and domestic use of paint, this study uses paint consumption as the activity unit for these activities and for vehicle treatment. The emission factors of domestic paint and solvent uses and waste landfills are cited from Klimont et al. (2002). The volatilization and leakage of VOCs emissions from the distribution and storage process of petroleum products mainly involve with the aspects including liquid loading losses, tank breath losses, and vehicle refueling operation losses. Bo et al. (2008) indicates that most gas stations adopted underground tanks and had no control in vehicle refueling operation by 2007. Therefore, we select the emission factors from that study.”

(4) Re-write the section 2.3.5, page 958, lines 21-23: “Anthropogenic ammonia sources include livestock feeding, N-fertilizer application, sewage treatment, waste landfills, and human discharge in this study. The emission rates of major ammonia sources are subject to be influenced by local geography and climate conditions, so the emission factors mainly come from the domestic studies (Dong et al., 2009; Zhang et al., 2010; Yin et al., 2010). Only human discharge emission factor is referenced by European study (EEA, 2006) since there is no local study available. The activity data of these sources are collected from the annual statistical data of each administrative region.”

(5) Re-write the section 2.3.6, page 959, lines 2-5: “Biomass burning emissions in

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this study come from household use and crop residue burning. The burning mass is estimated based on the statistical data of crop production, residue/crop ratio, and the percentage of burning. Most of emission factors in the studies on biomass burning emissions originate from Andreae and Merlet (2001) and Zhang et al. (2000). We use the summarized emission factors reported by Cao et al. (2005) in this study."

5. The uncertainty analysis is weak. For an inventory work, the reviewer believes that the uncertainty analysis is equally important as the emission data. One could not understand the statement for the solid or problematic of the inventories just from the current description. I would like to suggest a quantitative evaluation for typical inventories (e.g. SO2, Nox, and VOCs), and for typical sources (e.g. vehicle, biomass burning).

Re: To enhance the uncertainty analysis part, we supplement a uncertainty analysis table and more descriptions in this section. Please check it in the following modifications: Re-write Section 3.5, page 964, lines 14-20 to: "Table 7 (in the supplement) illustrates a preliminary uncertainty analysis on the 95The overall uncertainties for SO2, NOx, CO, PM10, PM2.5, VOCs, and NH3 in the inventory are respectively $\pm$19.1

6. The English expression in the manuscript needs to be imporved. The introduction section is too generally, I would like to add technical progess here for the emission inventory development, e.g. the EFs, and how to get reliable activity data, how to better allocate the emissions?

Re: We re-write the introduction section (section 1, page 953, lines 22-28) as follows: "Emission factor is an important parameter to compile an emission inventory. Compared with European and American studies (EEA, 2006; USEPA, 2002), the fundamental work of emission factors in China is relatively weak. Former studies were subject to use an average emission factor for one fuel category in a whole sector, such as industry, domestic, and transport (Kato and Akimoto, 1992; Hao et al., 2002; Streets et al., 2003). To refine the emission inventory, Tian (2003), Wang et al. (2005), and

Zhang (2005) improved the emission factors to facility level based on domestic measurement studies. Some recent studies reported more detailed emission inventories which can be refined to technology level for one facility category (Zhang et al., 2007; Lei et al., 2008). Most of the emission inventories in China were mainly established based on top-down approach with low resolution of emission allocation since the detailed activity data is hard to obtain. The previous studies on macro- or meso-scale emission inventories mainly depended on the statistical data of each administrative region. It is hard to allocate the emissions to the specific sources just based on the statistical data. Low-resolution inventories were thought to cause under-estimation of air pollution simulation in recent modeling studies (Liu et al., 2010). In order to support regional air pollution study and management in the city clusters of China, some studies introduced highly resolved regional air pollutant emission inventories by bottom-up approach (Zheng et al., 2009a; Zheng et al., 2009b)."

7. For industrial sources, is the term "exhaust treatment efficiency" or "exhaust control efficiency" correct? Why use two different terms?

Re: We would like to uniform the terms to "exhaust control efficiency".

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/11/C1454/2011/acpd-11-C1454-2011-supplement.pdf

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