Atmos. Chem. Phys. Discuss., 11, C1695–C1702, 2011
www.atmos-chem-phys-discuss.net/11/C1695/2011/

Atmospheric Chemistry and Physics Discussions

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.

C. Huang et al.

huangc@saes.sh.cn

Received and published: 12 April 2011

RC C1315: 'Review MS No.: acp-2010-893', Hugo Denier van der Gon, 29 Mar 2011

1. The authors compare their result to an earlier Pearl River Delta (PRD) inventory. It may be true that this is the most "comparable" regional inventory. However, for the international community this reviewer would request including a comparison to Emission inventories for China as a whole as published by e.g. Lamarque et al (2010 – although base year is 2000), EDGAR v4.1 (base year 2005) or GAINS-Asia (IIASA). In section

2.1 the authors explain that "the GDP (Gross Domestic Product) of the YRD region reached 6.55 trillion yuan, about 20% of total national GDP in 2007 (National Bureau of Statistics of China, 2008b). Correspondingly, the energy consumption in the YRD region reached 440 million tce, about 17% of the national total by the end of 2007." The relative importance and proportion of the YRD to all of China offers the possibility to indicatively compare the final results for certain sectors that are not completely dominated by local conditions (like road transport, industry) to the estimated emissions for all of China by assuming that these should be in the order of 15-25%, maybe 10-30%. If the comparison would reveal that for some sectors this is in fact 5% or 50+%, this could be interpreted as a contradiction between the YRD inventory and national scale inventories that may require further investigation (not necessarily in this paper but in future work). This approach serves 2 goals; 1) there is simply more to compare to than only the PRD inventory and 2) most people are still more acquainted with national total emissions and an indication whether the detailed YRD inventory is in line or contradicts part of the national inventory is valuable.

Re: It is a good suggestion to make inter-comparison between regional inventory and national inventory. We would like supplement some comparisons with national inventories in section 3.2, page 962, line 18 as follows: "To reveal the emission contributions of the YRD region to the whole China, we compare our work to the emission inventories for China as a whole (in Table 7) as published by ACCMIP datasets (Lamarque et al., 2010), EDGAR v4.1 (EC-JRC/PBL, 2011), GAINS-Asia (Amann et al., 2008), and INTEX-B (Zhang et al., 2009). Power generation is an important source of SO2 and NOx emission. The power sector of the YRD generates nearly 20% of the electricity in the whole China and its NOx and PM10 emissions contribute about 11%-40% of the total compared with the studies mentioned above. While the proportion of SO2 emission in the YRD region is only 5%-10% due to the installations of FGD units in some power plants by 2007. The industry sector of the YRD totally consumes 18% of the energy in the industry sector of the whole China and its SO2, NOx, PM10, and PM2.5 emissions contribute about 8%-28% of the total. The proportion of VOCs emission in industry of the YRD is relatively higher, about 23%-120% of the whole industry in China, which is mainly because that some industry sectors with high VOCs emissions, such as oil refinery, petrochemical industry, etc. are largely gathering in the YRD region. The road transport sector in the YRD region contributes 4%-23% of the emissions and 18% of the automobile ownerships correspondingly. In general, the comparisons reveal that the YRD emission inventory in this study is in line with most of the national inventories. However, there are still some contradictions between this inventory and some studies which require further investigations in the future."

{Amann, M., Jiang, K.J., Hao, J.M., Wang, S.X., Zhuang, X., Wei, W., Deng, Y.X., Liu, H., Xing, J., Zhang, C.Y., Bertok, I., Borken. J., Cofala, J., Heyes, C., Höglund, L., Klimont, Z., Purohit, P., Rafaj, P., Schöpp, W., Toth, G., Wagner, F., Winiwarter, W.: Scenarios for cost-effective control of air pollution and greenhouse gases in China. International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, 2008. European Commission: Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL), Emission Database for Global Atmospheric Research (EDGAR), release version 4.1. http://edgar.jrc.ec.europa.eu/index.php (last access: 02 April 2010), 2011. Lamarque, J.F., Bond, T.C., Eyring, V., Granier, C., Heil, A., Klimont, Z., Lee, D., Liousse, C., Mieville, A., Owen, B., Schultz, M.G., Shindell, D., Smith, S.J., Stehfest, E., Van Aardenne, J., Cooper, O.R., Kainuma, M., Mahowald, N., McConnell, J.R., Naik, V., Riahi, K., van Vuuren, D.P.: Historical (1850–2000) gridded anthropogenic and biomass burning emissions of reactive gases and aerosols: methodology and application. Atmospheric Chemistry and Physics, 10, 7017-7039, 2010.}

2. The uncertainty assessment in the paper is too brief. For example section 2.3.6 Biomass burning is usually a highly uncertain source. How (un)reliable are the biomass burning activity data for the YRD region? +/- 10%; 100%; 200%? The key question in the YRD inventory would be – does it matter? The YRD EI seems to be completely dominated by industry and power plants. So, for example if biomass burning activity is

+/-100% uncertain but than still makes a minor contribution to the total YRD emission? – if so, this source is not an important contributor to uncertainty in the annual totals (this leaves unchanged that in episodes such a source can be dominating). Such information is relevant and could be included in section 3.5. In general, based on fig 3. the key sources can be identified and some further quantification of the possible ranges for these key sources should be given. From this may follow recommendation and prioritization of future research.

Re: We agree with the reviewer's recommendation, so we would like to re-write the section 3.5, page 964, lines 14-20 to be the following paragraph and insert a table of uncertainty assessments. "Table 7 illustrates a preliminary uncertainty analysis on the 95% confidence interval for each source category in the emission inventory. The uncertainty assessment indicates that the fuel-related combustion sources such power plants and boilers are more reliable compared with the other source categories because the emissions are calculated based on detailed census data of fuel consumption, technology, and exhaust control efficiency. The industrial processes including iron & steel production, oil refinery, mineral products process, and chemical production, etc. have relatively higher uncertainties mainly due to the lack of local emission factors for each production process and exhaust control technology. Vehicle emissions are expected to have low uncertainties. Vehicle emission factors have been modified by real world measurement data in Shanghai (Chen et al., 2007; Wang et al., 2008) and average mileage data is adjusted by the statistical data of gasoline and diesel consumption in each region. Relatively, road dust emissions have much high uncertainty since the parameters have large differences in different areas. Other emission sources like domestic painting and printing, fertilizer application, and biomass burning all have high uncertainties in the study. More researches is necessary to be conducted both on emission factors and on activity surveys in the future in the YRD region. The overall uncertainties for SO2, NOx, CO, PM10, PM2.5, VOCs, and NH3 in the inventory are respectively $\pm$19.1%, $\pm$27.7%, $\pm$47.1%, $\pm$117.4%,$\pm$167.6%, $\pm$133.4%, $\pm$112.8%. The uncertainties of SO2, NOx, and CO are improved due to the fact that the activity data of major emission sources such as power plants, boilers, and other fuel combustion facilities are refined by bottom-up approach. However, PM10, PM2.5, VOCs, and NH3 still remain high uncertainty since their emission factors are mainly taken from the research findings of the United States and Europe, which result in large differences compared with the real situation in the YRD region."

3. Title: change to: "Emission Inventory of anthropogenic air pollutants and VOC species in the Yangtze River Delta region, China

Re: We will change it in the revised manuscript.

4. p 956, l12. This is referred to as a "top-down" approach. Please reconsider. I would personally prefer "down-scaled". I would qualify Top-down as done with inverse modelling, from ambient measurements or satellite observations. Multiplying energy statistics with emission factors is still a bottom-up approach only the scale is not as detailed as the individual facility level. Also in section 3.5 you simply refer to the whole study as a bottom-up approach.

Re: Maybe there are some divergences for the definitions of top-down and bottom-up approach. In most of the papers we referenced, they are accustomed to use top-down approach to indicate the method of multiplying energy statistics with emission factors and allocating emissions by population distribution data. So we suggest to keep the statements of these approaches in this paper.

5. p957 l 21; How was the annual travelled mileage estimated exactly? Did you use a fixed mileage per litre of fuel?

Re: We assume different fuel economies for different vehicle and fuel type based on experience. To clearly explain how to estimate the annual travelled mileage, we would like to re-write the section 2.3.3, page 957, line 20 to page 958, line 3 as follows: "The IVE model (ISSRC, 2004) is used to calculate vehicle emissions during the phases of driving, cold start and VOCs evaporation. According to the model needs, we classify

the vehicle fleet into light-duty car, light-duty truck, taxi, urban bus, heavy-duty bus, heavy-duty truck, and motorcycle. The study surveys the numbers of each vehicle type from the statistical yearbook of each administrative region. To prepare the fleet files of each city, detailed information about vehicle technology, fuel type, emission standard, and vehicle age is surveyed in the representative cities of Nanjing, Hangzhou, and Shanghai. The average annual travel mileage of each vehicle type is simultaneously obtained based on the relationship between vehicle ages and odometers in these cities (Wang et al., 2008). After that, we assume a fuel economy data (mileage per litre of fuel) for each vehicle and fuel type based on experience and get total gasoline and diesel consumption in each administrative region by multiplying the fuel economies with annual travel mileages. Some adjustments will be made when there are large differences between the predicted data and statistical ones."

6. p 958, l 7-11. This is an important but highly uncertain source. The current description is too brief. How did you get surface silt loading? was it measured? Are there any checks (e.g. from relative importance of crustal components in chemical composition of PM samples) that the estimated emissions for this source make sense?

Re: The estimation of road dust emission in this study is very brief and with high uncertainty. Little local measurement study can be referenced determine the major parameters. We would like to indicate the deficiency of this part and emphasize the importance of conducting local studies in the future. See the revision as follows: Section 2.3.3, page 958, lines 7-11: "Road dust emission is another important source of pollution from the transport sector. The approach to estimate road dust emission is adopted from USEPA (2002), mainly related to such parameters as average weight of the vehicles traveling the road, road surface silt loading, and a particle size multiplier. However, our estimation of this source is very brief and with high uncertainty since there is little local measurement study can be referenced. The parameters of road surface silt loading and particle size multiplier are determined by the studies of sun et al. (2003) and Huang et al. (2006) with some modifications on different road types of different areas in the YRD region."

{ Huang, Y.M., Shu, J., Wei, H.P., Wang, Q.: The estimate and GIS of fugitive dust emission from paved roads in industrial estate. Environmental Science and Management, 31(4), 46-52, 2006 (in Chinese). Sun, J., Shu, J., Lu, X.Q.: Remote sensing interpretation and its management information system of fugitive dust pollution sources in Shanghai. Shanghai Environmental Sciences, 22(5), 295-301, 2003 (in Chinese).}

7. Section 3.2 and fig 3. Please explain what is captured under "process of mineral product" as this is the major PM10 and PM2.5 source. is it realistic? In line with the share compared to the national total for this sector (see above discussion on comparison to other national scale inventories)?

Re: To further explain the PM10 and PM2.5 emission contributions of "process of mineral product" sector to the YRD region, we would like supplement some descriptions in Section 3.2, page 961, line 23: "The process of mineral product contributes 45% and 39% of PM10 and PM2.5 emission, respectively. The mineral production is a major industrial sector which includes the producing of cement, lime, plate glass, and bricks, etc. in the YRD region. Among them, the PM10 and PM2.5 emission from cement production takes up 24% and 16% of the total cement industry according to the study of Lei et al. (2008). Correspondingly, the annual cement products in the YRD region are about 16% compared with the whole China (National Bureau of Statistics of China, 2008a)."

8. p960 l 23 "Another 79 kt SO2 emission could be expected when the rest FGD installation were finished before the end of 2010." change to: "Another 79 kt SO2 emission could be expected before the end of 2010, provided that the remaining planned FGD installation is implemented".

Re: We will change it in the revised manuscript.

9. p963 l3: largest = most important

Re: We will change it in the revised manuscript.

10. p965 top; comparison to INTEX-B: make it a bit more clear in the text which inventory is higher for PM and VOC. Please comment if you think it is due to emission factors or due to different activity data.

Re: We would like to supplement some sentences to better explain the differences between the two studies. See the revision as follows: Section 3.5, page 965, line 8: "The emission intensities of PM10 and VOCs emission in this study are generally higher than INTEX-B. It might be because the activity data collected based on bottom-up approach in this study are usually more detailed and concentrated in some grids compared with the national or continental scale inventory."

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/11/C1695/2011/acpd-11-C1695-2011-supplement.pdf

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 951, 2011.