Atmos. Chem. Phys. Discuss., 8, S4757–S4767, 2008
www.atmos-chem-phys-discuss.net/8/S4757/2008/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Spatial and temporal variation of emission inventories for historical anthropogenic NMVOCs in China" *by* Y. Bo et al.

Y. Bo et al.

Received and published: 14 July 2008

Thank you very much for reviewing our manuscript and providing valuable suggestions, which we believe would help improve the quality of this manuscript. Accordingly, we have revised our manuscript and we would like to demonstrate our responses to your comments as follows:

Comment 1: In general, I believe the authors go too far in trying to promote their own work by casting doubt on previous work. They are by no means the first to tackle the topic of NMVOC emissions in China.

Response: We thank the reviewer for his/her comments. We would like to apologize sincerely to whoever we might have offended for the misunderstanding resulted from our inaccurate language expressions. We have concluded in a more objective and

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

respectful way when we reviewed previous work in the revised manuscript. Some international scientists took the lead in providing China's NMVOCs emission inventories by consulting statistical data in China, and doubtlessly they are pioneers in the study of estimating China's NMVOCs emission inventories. But these inventories are still ameliorable, since there are significant differences between different inventories, which were caused by differences in the selection of emission factors and acquirement of statistical activity data.

Comment 2: In fact, their methodology is very similar to previous work and has few improvements. However, their results are significantly lower than all other estimates, and this paper can only be accepted if they can explain why their results are an improvement over all previous studies. On Page 13, they attempt to do this by saying "Other estimations were all quite larger than ours, which was caused by differences in studied region, source categories and emission factors adopted." This is not an adequate comparison with the work of other researchers.

First, we should observe that the two most recent and reliable studies of NMVOC emissions in China are not even mentioned. These are the TRACE-P inventory (Streets et al., 2003), which has been used widely in air quality modeling both within and outside China, and the REAS inventory (Ohara et al., 2007). Next it should be mentioned that the TRACE-P inventory estimates that NMVOC emissions in China in 2000 were 17.4 Tg; and the REAS inventory estimates that NMVOC emissions in 2000 was 14.7 Tg. These values should be added to Table 11, where the present paper concludes that 2000 emissions were only 11.0 Tg. Thus, the two additional studies also support the view that NMVOC emissions in China are higher than calculated in the present paper.

All of these pieces of evidence make it necessary for the authors to demonstrate exactly why they think emissions are significantly less than the rest of the community thinks. As a general summary, then, the authors claim too much for their paper, and need to do a better job of explaining why it is an improvement over previous work.

ACPD

8, S4757–S4767, 2008

Response: According to the reviewer's comments, we have added the TRACE-P inventory (Streets et al., 2003) and the REAS inventory (Ohara et al., 2007) to our revised manuscript, and have compared the differences between each inventory and analyzed the reasons for those differences.

As shown in Table 11 in our manuscript, Klimont et al. (2002) established China's NMVOCs emission inventories in 1990, 1995, and 2000, and the NMVOCs emission was 15.6 Tg in 2000. Based on the results of Klimont et al. (2002), Streets et al. (2003) added 1.8 Tg NMVOCs emissions from savanna and forest burning to China's emission inventory, and therefore NMVOCs emission in China in 2000 was estimated to be 17.4 Tg. Regarding the REAS inventory established by Ohara et al. (2007), their NMVOCs emissions for 1995 and 2000 were not estimated independently, but instead came from the results of Klimont et al. (2002) and Streets et al. (2003). In addition, their NMVOC emissions for the period 1980-2003 were estimated simply by an extrapolation of the NMVOC emissions for 1995 and 2000, using a proxy indicator per sector. This is why we only compared with the results by Klimont et al. in our original manuscript, since the results in 2000 from Streets et al. (2003) and the results in 1995 and 2000 from Ohara et al. (2007) were both based on the results from Klimont et al. (2002).

To explain why results in our manuscript are significantly less than other estimated NMVOCs emission inventories, we compare the activity data used in Klimont et al. (2002) and in our study, respectively. Activity data for domestic oil production (106 tons), domestic gas production (106 m3), energy consumption (PJ) of coal, oil, gas, hydro, nuclear, other (includes biofuel), vehicle manufacturing (106 vehicles), paint production (103 tons paint), paint use (103 tons paint), and industrial wood (106 m3) are 150, 18, 33532, 8655, 1959, 1742, 147, 8550, 5.5, 2417, 2735, and 101, respectively in Klimont et al. (2002); corresponding activity data in this study are 180a, 40878, 27532, 9333, 2839, 801, 60, 2725, 2.1, 357, 440, and 20, respectively. It is obvious that activity data used in Klimont et al. (2002) are all higher than those adopted in this study, with the exception of those for production and consumption of oil and gas.

ACPD

8, S4757–S4767, 2008

Our data were mainly from China Energy Statistical Yearbook, 2005; China Automotive Industry Yearbook, 2002; China Marketing Yearbook, 2001; and China Forestry Statistical Yearbook, 2006. However, these statistical data of China had not released yet when Klimont et al. (2002) established NMVOCs emission inventory of China in 2000. Their activity data in 2000 were mainly estimated based on China's energy statistical data and related data of energy consumption in U.S. Therefore, our activity data based on China's statistical yearbook differ from those from Klimont et al. calculated for China's each sector. For example, coal consumption was 1.22 times more than ours; biofuel and other energy consumption was 4.19 times more than ours; paint production and use were 6.77 and 6.22 times, respectively, more than ours, and industrial wood production was 5.05 times more than ours. Hence, our estimation of China's NMVOCs emission inventory in 2000 was less than that estimated by Klimont et al. (2002).

Another important factor influencing the result is emission factor. Emission factors adopted in this study are slightly lower than those applied by Klimont et al. (2002). Taking the vehicle source for example, emission in 2000 calculated by Klimont et al. (2002) was 5071 Gg, which was much larger than our estimation of 3081 Gg. This was not only because their activity data were larger than ours as were shown in Table 1, but also because their applied emission factors for vehicle were slightly higher than ours. The emission factors adopted by Klimont et al. (2002) to estimate China's transport source emissions in 2000 were based on the European experience of the mid-1980s. However, emission standards equivalent to Europe I have came into effect in China since 2000. Therefore, it was not quite suitable to calculate China's emission in 2000 by using emission factors based on the European experience of the mid-1980s. Upon consideration on the execution of vehicle emission standards, we calculated China's region-specific and year- specific NMVOCs emission factors for vehicles, using COPERT III model which was widely used in Europe. Comparison of China's vehicle emission factors calculated by MOBILE, COPERT III and platform experiments is shown in Xie et al, (2006). For emission factors of light-duty gasoline vehicle, heavy-duty gasoline vehicle, light-duty diesel vehicle, medium-duty diesel vehicle, heavy-duty diesel

ACPD

8, S4757–S4767, 2008

Interactive Comment

vehicle, and motorcycle, the results calculated by COPERT are 3.35, 6.86, 0.2, 2.81, 2.81, and 6.65; those calculated by MOBILE are 7.96, 10.94, 1.39, 1.51, 4.28, and 5.25; and those from platform experiment are 2.7, 6.4, 0.2, 0.665, 0.971 and no data (unit: g/km/vehicle). It is obvious that China's vehicle emission factors calculated by MOBILE, COPERT III and platform experiments, demonstrates that NMVOCs emission factors calculated by COPERT III are closer to measured values than MOBILE model. Moreover, for some vehicle types, emission factors calculated by MOBILE are higher than those calculated by COPERTIII, and this is why some Chinese vehicle NMVOCs emissions calculated by MOBILE are higher than our results.

As described above, activity data of each source obtained from available and convincible published statistical yearbooks and adopted emission factors were both lower than those compiled by Klimont et al.(2002), Streets et al.(2003), Ohara et al. (2007), Olivier et al. (2001, 2002) and Tonooka et al. (2001).

Comment 3: Finally, we might note that there has been widespread belief that emissions of NMVOC are underestimated in China, evidenced partly by the inability of models such as CMAQ to generate sufficient ozone around Beijing and other regional centers of China to agree with observations.

Response: Thanks to the reviewer for bringing forward this interesting question, and we would like to explain as follows. It is known that NMVOCs emissions come from both biogenic and anthropogenic sources. In this paper, we focus on China's anthropogenic source emissions, and China's biogenic NMVOCs emissions are still temporally deficient. Regarding the raised question that "CMAQ was unable to generate sufficient ozone around Beijing and other regional centers of China to agree with observations", it is presently unclear which of anthropogenic and biogenic NMVOCs emission was indeed underestimated, and further investigation is required to figure out the truth. American studies show that NMVOCs emissions from biogenic sources are higher than those from anthropogenic sources (EPA, 2000), and the contribution of biogenic emissions to ground-level ozone formation is more important than anthropogenic emissions

ACPD

8, S4757–S4767, 2008

(Efthimios et al., 2006). In addition, Chinese scientists indicate that biogenic emissions have remarkable impacts on surface ozone formation in eastern China (Wang et al., 2008). Moreover, reactive components of VOCs are important for ozone formation. Thus, identification of speciated reactive NMVOCs components is needed. Furthermore, mechanism of ozone formation remains a debatable subject nowadays; since some scientists maintain that one important reason for the underestimated ozone concentrations generated by models is that the ozone formation mechanism requires further and complete identification and justification (Li et al., 2008).

Comment 4: One might argue that the authors of the present paper have used better, different, or more local data. Indeed, they claim (Page 3): "these [previous] emission inventories were estimated by limited sources of Chinese data". Yet the reader will find that in fact there is very little difference between the data used in this work and previous work. The reader might hope to find that a lot of new emission factors have been included, based on measurements of Chinese sources, yet a detailed reading of the paper suggests that western sources like AP-42 were used extensively, just like in previous work.

Response: Thanks for the reviewer's pointing out our inaccurate expression of the sentence: "these [previous] emission inventories were estimated by limited sources of Chinese data". We referred to the inadequate research conducted on NMVOCs emission compilation in China, due to the lack of emission factors from various sources and insufficient Chinese statistical data needed, especially obtaining those data before 1990s. Therefore, estimation of China's NMVOCs emission inventories trailed along behind developed countries and seldom had updates. We have corrected our expressions to avoid further misunderstanding.

Regarding the selection of emission factors, we adopted experimental data in China, and we also adopted some data from AP-42 Report. Still, there are great differences in data selection and collection between our study and previous work, as have been demonstrated in our answer to question 2.

ACPD

8, S4757–S4767, 2008

Comment 5: It is wrong also (same sentence on Page 3) to suggest that previous work revealed "little information of spatial variation of NMVOCs emissions." There are detailed, high-resolution NMVOC emissions maps in several of the previous papers.

Response: Spatial variation of NMVOCs emissions at high resolution of 1o*1o was shown by Klimont et al. (2002), based on the population density map. However, emissions of some NMVOCs sources were not significantly related with population density, such as fossil fuel combustion, industrial processes, storage and transport, and biomass burning. Thus, it is inappropriate to distribute NMVOCs emissions simply by population density, which would even result in a misleading spatial distribution of NMVOCs emissions. Considering the relationship of specific NMVOCs sources with dependent factors, we distributed NMVOCs emissions from different sources based on GDP, population, and crops seeded area, as is shown in Table 1. This is why we stated that "little information of spatial variation of NMVOCs emissions" in our original manuscript and we have amended the statement in our revision to avoid any inaccuracy. Thanks for the reviewer's comments.

Comment 6: That includes a number of heroic assumptions about time trends (take a look at Table 2, for example) that weaken the confidence in the year-to-year variation.

Response: China's economic development has been planned by an interval of five years, for example, 1981-1985 was named 6th Five-year plan, and 2006-2010 was named 11th Five-year plan. At the last year of each Five-year plan, such as 1980, 1985 etc., statistical data are relatively complete and reveal a better summarization for the development trend over the past five years. Therefore, selecting the last year of a Five-year Plan as a representative year for the estimation of China's NMVOCs emissions is currently believed representative for a five-year interval. Thus, we focused on NMVOCs emission inventories at an interval of five years. However, we are compiling annual data needed for estimation of other years, in order to demonstrate the year-to-year variation of the emission inventories.

ACPD

8, S4757–S4767, 2008

Specific comments: Comment (1): Lines 35-40 should be omitted. This is not a paper concerned with the health effects of NMVOC and it is not necessary to justify interest in NMVOC on health grounds.

Response: We have deleted Lines 35-40 in our revision according to the reviewer's comment.

Comment (2): Lines 69-77. I do not understand why these three old and largely irrelevant publications are cited (and they are not databases). There are many more up-to-date emission factor databases that could be cited like AP-42, CORINAIR, etc.

Response: China has experienced high-speed development in recent years, some commentary even stated that China has experienced the same degree of industrialization, urbanization and social transformation in two decades as Europe had done in two centuries. However, it cannot be neglected that there is still a big gap in technology level and resource utilization efficiency between China and developed countries. Besides; there is notable diversity between different regions in China. For example, there are remarkable differences in technical renovation and resources utilization efficiency between developed Eastern China and undeveloped Western China and between urban regions and rural areas. Therefore, emission factors for even the same source are quite different in various areas of China. Based on these objective conditions, technology level in China is generally considered to lag about ten years behind that in developed countries. Thus, we applied available measured data in China when we established the emission inventory. Due to the insufficient measured data, we selected emission factors of developed country in the 1990s instead of current emission factors in developed countries.

Besides, it was inappropriate to regard those three references as "database". We have corrected that in our revised manuscript.

Comment (3): Line 390, "estimation" is misspelled. Line 455, "decennary" is not the word to use; "ten-year period" is correct. In several references (Cai, Li, Shao, Song,

ACPD

8, S4757–S4767, 2008

Streets, etc.) China, Beijing, etc. need initial capital letters. In the caption to Table 1, "proxy" is misspelled.

Lines 110 and 114, "capita" is misspelled three times.

In a number of places, "fossil fuel" is misspelled as "fossile fuel".

Response: Thanks for pointing out our mistakes and we have corrected them accordingly.

Comment (4): There is frequent misuse of English words and phrases: Line 42, explain what is meant by "an outstanding contribution", it is not clear. Line 57, do not say "a crushing force", replace with "became serious" or something similar. Line 265, not "tanglesome"; do you mean "congested"? Line 265, not "tanglesome"; do you mean "congested" Line 266, not "blossom" but "boom". Line 329, why is Guizhou called "a granary province"?

Lines 381 and 828 and Table 11 should say "Hong Kong", and North Korea/South Korea or DPR Korea/R of Korea; "Corea" is not an English word. Also, Cambodia is preferred to "Kampuchea" these days.

Response: Thanks for pointing out our misuse of English words and phrases and we have tried to correct them accordingly as follows:

We have replaced "an outstanding contribution" with "a significant contribution", which is what we really mean. We have replaced "a crushing force" with "became serious" and have replaced "tanglesome" with "low-grade road".

Generally, rural road condition is very complex in China, with low technical classes on the whole. Tertiary and quarternary roads are usually constructed. Meanwhile, off-grade road and non-cement or non-asphaltum paved road occupy a large proportion in total. Therefore, the motorcycle is in extensive demand in rural area, due to its low requirement for the road. "tanglesome" used here was not clear, and we have changed "tanglesome road situation" to "low-grade road".

ACPD

8, S4757–S4767, 2008

Interactive Comment

We have changed "a granary province" to "a province dependent on agriculture in the middle of China" to make clear what we intend to mean. This is because Guizhou is a province depending on agriculture, and has a large population of peasants. Crop residues are widely used as household fuels there.

Thanks for pointing out our misuse of English words and phrases and we have corrected them accordingly.

Comment (5): No sources of emission factors are presented in Tables 8 and 9, and the text is not clear on this matter.

Response: Emission factors in Table 8 and 9 rooted in AP-42(1995). In Table 8, emission factors for solvent utilization were selected, and unit conversion was done with consideration of the corresponding activity data available in China. In Table 9, emission factors for industrial processes were collected and modified based on characteristics of Chinese industrial process.

Finally, we sincerely thank the reviewer again for his/her careful work. We also appreciate his/her suggestions and comments, and his/her respectful efforts to point out our misuse of words and phrases in detail, which help greatly improve the quality of our manuscript.

References: Efthimios, T., Liao, K. J., Manomaiphiboon, K., Russell, A. G., Woo, J. H., He, S., Amar, P., and Leung, L. Y.: Climate change impacts on us air quality: examination of ozone and fine particulate matter concentrations and their sensitivity to emission changes, http://www.cmascenter.org/conference/2006/abstracts/tagaris_session8.pdf, last access: 11 July 2008, 2006.

Environmental Protection Agency (EPA): National air pollutant emission trends, 1900-1998, EPA-454/R-00-002, March 2000.

Guenther, A., Geron, C., Pierce, T., Lamb, B., Harley, P., and Fall, R.: Natural emissions of non-methane volatile organic compounds; carbon monoxide, and oxides of nitrogen

ACPD

8, S4757–S4767, 2008

from North America, Atmos. Environ., 34, (12-14), 2205-2230, 2000.

Li, S. P., Matthews, J., and Sinha, A.: Atmospheric hydroxyl radical production from electronically excited NO2 and H2O, Science, 319, 1657-1660, 2008.

Li, W., Fu, L., X., Hao, J. M., Ma, H., Li, S. Q., and Hu, W.: Emission inventory of 10 kinds of air pollutants for road traffic vehicles in China, Urban Environment & Urban Ecology, 16,(2), 36-38, 2003.

Luecken, K. J., and Mebust, M. R.: Technical challenges involved in implementation of VOC reactivity-based control of ozone, Environ. Sci. Technol., 42, 1615-1622, 2008.

Ohara, T., Akimoto, H., Kurokawa, 5 J., Horii, N., Yamaji, K., Yan, X., and Hayasaka, T.: An Asian emission inventory of anthropogenic emission sources for the period 1980-2020, Atmos. Chem. Phys., 7, 4419-4444, 2007.

Streets, D. G., Bond, T. C., Carmichael, G. R., Fernandes, S. D., Fu, Q., He, D., Klimont, Z., Nelson, S. M., Tsai, N. Y., Wang, M. Q., Woo, J.-H., and Yarber, K. F.: An inventory of gaseous and primary aerosol emissions in Asia in the year 2000, J. Geophys. Res., 108, 8809, doi:10.1029/2002JD003093, 2003.

Wang, Q. G., Han, Z. W., Wang, T. J., and Zhang, R. J.: Impacts of biogenic emissions of VOC and Nox on tropospheric ozone during summertime in eastern China, Sci. Total Environ., 395, 41-49, 2008.

Xie, S. D., Song, X. Y., and Shen, X. H.: Calculating vehicular emission factors with COPERT III mode in China, Environmental Science, 27, (3): 415-419, 2006.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 11519, 2008.