Atmos. Chem. Phys. Discuss., 13, C6768–C6775, 2013
www.atmos-chem-phys-discuss.net/13/C6768/2013/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Emissions of air pollutants and greenhouse gases over Asian regions during 2000–2008: Regional Emission inventory in ASia (REAS) version 2" *by* J. Kurokawa et al.

J. Kurokawa et al.

kurokawa@acap.asia

Received and published: 11 September 2013

The authors would like to thank Anonymous Referee #3 for taking his or her time to review our manuscript and for giving very constructive and informative comments. These comments helped us improve the quality and clarity of the manuscript. We revised our manuscript based on them. Below are our detailed responses to the comments.

First, we found there were trivial errors in the calculations of CO2 emissions in China. We corrected the values in Tables 2 and 3, Figs. 6e and 6f, and Tables S2l and S3a

(Tables 2 and 3 are Tables 6 and 7 in the revised manuscript). Several values in the main text (Abstract, Sects. 3.1.1, 3.1.2, 3.1.7, and 4) were also corrected. However, there is no influence on the discussion and conclusions of this paper.

Reply to specific comments:

Comment 1:

The reviewer strongly suggests the authors adding tables summarizing the yearly activity rates and emission factors for the REAS 2.1 inventory (similar to Table 2 and Table 3 in the REAS 1.1 paper, Ohara et al., 2007). This information is essential and important for an inventory, and it could help the other researchers compare with their own works.

Reply:

A table (new Table 2) to present fuel consumption of China, India, and the rest of the Asian countries by sector and fuel type in 2000, 2004, and 2008 was added to the revised manuscript and described in Sect. 2.3. As for the emission factors, in the revised manuscript, three tables (new Tables 3, 4, and 5) were added to provide emission factor values and described in Sect. 2.4. In this study, majority of update was done for emission factors of air pollutants in China. Emission factors for fuel combustion in India were also updated and used for other South Asian countries. In general, for most species, the largest contributing source is fuel combustion. Therefore, new Table 3 gives net emission factors of major air pollutants for stationary combustion in China, South Asia and the rest of Asian countries. New Tables 4 and 5 provide emission factors for road transport and industrial process sources in China, respectively.

Comment 2:

A power plant emission database was developed in the REAS 2.1 inventory for the Asian region based on the CARMA Database and UDI World Electric Power Plants Database. First, the authors used the old version of the CARMA (i.e., 2000, 2007), which, to the reviewer's knowledge, contains incomplete and inaccurate information,

ACPD
13, C6768–C6775, 2013

especially for China. Second, even for the new version of CARMA (i.e., 2004, 2009), the information is not completed. For example, there are more than 2200 Chinese power plants in the CARMA for year 2009; however, more than 500 plants (accounting for 20% of the total electricity generation) do not have location information (latitude/ longitude). The reviewer did not see any discussion in the manuscript about this issue. Distributing the total power sector emissions only to location-known plants will overestimate emissions in these plants (e.g., overestimate by 25%+). The reviewer is wondering why the REAS 2.1 does not incorporate more reliable unit-based inventories developed specifically for China's power plants by Zhao et al. (2008), Zhang et al. (2009), or Wang et al. (2012).

Reply:

First, with respect to data handling of CARMA Database, actually, we did not use all data sets in CARMA. We used the data for power plants which had position information and whose annual CO2 emissions estimated by CARMA were more than 1 Mt. We compared the total energy consumptions of power plants based on CARMA and those in energy statistics of each country and region. Mostly, values from CARMA were less than those from energy statistics although there were some cases when the values of CARMA are larger than national or regional statistics. As for locations, we checked the longitude and latitude of power plants whose CO2 emissions in 2007 were more than 10 Mt and they (about 100 power plants) were corrected if we obtained accurate information. For other power plants, we did not change the position data. It is right that these are causes of uncertainties in emissions from power plants in REAS version 2. In the revised manuscript, above discussion was added to Sect. 2.3. Second, the reason why we decided to use CARMA Database and UDI World Electric Power Plants Database is that they were relatively easy to access when we started to develop REAS version 2. We did not use databases of Zhao et al. (2008), Zhang et al. (2009), and Wang et al. (2012) because unfortunately, they were not opened to public and we didn't have connections with them. However, your suggestion, that their databases based on

ACPD
13, C6768–C6775, 2013

detailed local information are more reliable and will improve the accuracy of emissions from power plants, is right. We would like to propose collaborative researches to them for the next version of REAS.

Comment 3:

To the reviewer's knowledge, there have been several published papers using the REAS 2.1 inventory in model simulations, such as Irie et al. (2013), Itahashi et al. (2013a), Itahashi et al. (2013b), etc. The reviewer suggests the authors adding a section in the manuscript summarizing the current applications of the updated inventory The use of the inventory and the new knowledge gained from the modeling activities will support that the REAS 2.1 is a valuable and reliable product for the Asian modeling community.

Reply:

We appreciate the suggestions to improve our manuscript. However, we would like to focus this manuscript on presenting methodology, results and discussion on bottom-up emission inventory without embarking on the atmospheric concentrations and chemical transport but as a detailed reference paper for the emissions database. We consider the number of research works which used REAS 2.1 still limited and we expect more feedbacks on REAS 2.1 from atmospheric chemical transport modelers using inverse modeling techniques and the online released REAS 2.1. Different studies might give different conclusions about REAS 2.1, which we collect and on which we would like to write another paper summarizing the evaluations and suggestions to improve REAS 2.1 based on them.

Comment 4:

Page 10059, lines 4-16. The authors said that "in REAS 2.1, emissions from agricultural activities during 2001 and 2008 were extrapolated from the gridded emission data of REAS 1.1 for 2000". The resolution of the old REAS 1.1 inventory is 0.5 degree by

ACPD
13, C6768–C6775, 2013

0.5 degree, but the new REAS 2.1 inventory has a resolution of 0.25 degree by 0.25 degree. The reviewer is wondering how the agricultural emissions were distributed to a finer grid. Were any surrogates used? Or the REAS 2.1 just retains the coarse resolution for this sector?

Reply:

For emission data sets of agricultural activities, the resolution of REAS 2.1 retains the coarse resolution of REAS 1.1 (i.e. 0.5 degree by 0.5 degree) because we could not obtain appropriate surrogate data. We added this description to Sect. 2.2.5 in the revised manuscript.

Comment 5:

Page 10066, lines 25-26 and Table 4. The reviewer is wondering why the authors gave an additional separate table for Southeast Asian countries, not other regions. Are there any specific reasons?

Reply:

In the first submitted manuscript, this table is prepared just for readers' convenience. Actually, there is no specific reason for this table and in addition, new tables were added to the revised manuscript. Therefore, this table was deleted.

Comment 6:

Section 3.3. Only monthly emissions for SO2, NOx, and BC are shown and discussed. How about the other 9 species?

Reply:

Monthly variation of CO and primary aerosols (PM10, PM2.5, BC, and OC) is generally controlled by emissions from combustion of fossil and biofuels in the domestic sector. Seasonality of emissions of these species is similar and thus, we plotted only BC emissions in Figs 8, 9, and 10 in order to save space. Seasonal variation of CO2 emissions

ACPD
13, C6768–C6775, 2013

is similar to that of anthropogenic emission of NOx. As for NMVOC, NH3, CH4 and N2O, monthly variation of fossil fuels is similar to NOx and that of biofuel is similar to BC. However, we assumed no seasonal variations in evaporative emissions of NMVOC and in the emissions of NH3, CH4, and N2O from agricultural activities. As a result, monthly variation of total emissions of these species is relatively small. Therefore, we omitted the maps and graphs for these species in the manuscript. However, these descriptions were added to Sect. 3.3 in the revised manuscript.

Comment 7:

Section 3.5. First, only the comparisons of 9 species (i.e., SO2, NOx, CO, NMVOC, BC, OC, NH3, CH4, and N2O) with previous works are presented. How about the other 3 species? Second, from the reviewer's point of view, the authors missed some important previous works, such as GAINS (Klimont et al., 2009) for all species in all countries and regions, IPCC RCP inventories for all species in all countries and regions, Smith et al. (2011) for SO2 in all countries and regions, Zhao et al (2011) for all species in China, etc.

Reply:

In the revised manuscript, comparisons of emissions of PM10, PM2.5, and CO2 in REAS 2.1 with other works were added to the tables (new Tables 9, 10, and 11) and discussed in Sect. 3.5. For additional comparisons, we compared results of REAS 2.1 with those from Klimont et al. (2009), Smith et al. (2011), Zhao et al. (2011), Huang et al. (2012), and Bond et al. (2007). These values were also added to new Tables 9 and 10 and discussed in Sect. 3.5 in the revised manuscript.

Reply to technical corrections:

> Page 10053, line 15. Change "discussions' to "discussion".

Reply:

Indicated point is corrected in the revised manuscript.

ACPD

13, C6768–C6775, 2013

> Page 10079, lines 17-19. “Fig. 1S” should be “Fig. S1”. And these figures should be in the main text instead of in the Supplement.

Reply:

Figures in the supplementary materials were moved to Fig. 7 in the main text.

> Page 10079, line 21. “in January and July”. Figure 8 shows monthly emissions in July and December.

Reply:

“in January and July” is wrong and corrected in the revised manuscript.

> Fig. 12. “NMV” in figures should be “NMVOC”.

Reply:

Indicated point is corrected in the revised manuscript.

Reference

Bond, T. C., Bhardwaj, E., Dong, R., Jogani, R., Jung, S., Roden, C., Streets, D. G., and Trautmann, N. M.: Historical emissions of black and organic carbon aerosol from energy-related combustion, 1850–2000, Global Biogeochem. Cycles, 21, GB2018, doi:10.1029/2006GB002840, 2007.

Huang, X., Song, Y., Li, M., Li, J., Huo, Q., Cai, X., Zhu, T., Hu, M., and Zhang, H.: A high-resolution ammonia emission inventory in China, Global Biogeochem. Cycles, 26, GB1030, doi:10.1029/2011GB004161, 2012.

Klimont, Z., Cofala, J., Xing, J., Wei, W., Zhang, C., Wang, S., Kejun, J., Bhandari, P., Mathur, R., Purohit, P., Rafaj, P., Chambers, A., Amann, M., and Hao, J.: Projections of SO2, NOx, and carbonaceous aerosols emissions in Asia, Tellus, 61B, 602–617, 2009.

Smith, S. J., van Aardenne, J., Klimont, Z., Andres, R. J., Volke, A., and Arias, S. D.: Anthropogenic sulfur dioxide emissions: 1850–2005, Atmos. Chem. Phys., 11,

1101–1116, doi:10.5194/acp-11-1101-2011, 2011.

Wang, S. W., Zhang, Q., Streets, D. G., He, K. B., Martin, R. V., Lamsal, L. N., Chen, D., Lei, Y., and Lu, Z.: Growth in NOx emissions from power plants in China: bottom-up estimates and satellite observations, Atmos. Chem. Phys., 12, 4429–4447, doi:10.5194/acp-12-4429-2012, 2012.

Zhang, Q., Streets, D. G., Carmichael, G. R., He, K. B., Huo, H., Kannari, A., Klimont, Z., Park, I. S., Reddy, S., Fu, J. S., Chen, D., Duan, L., Lei, Y., Wang, L. T., and Yao, Z. L.: Asian emissions in 2006 for the NASA INTEX-B mission, Atmos. Chem. Phys., 9, 5131-5153, doi:10.5194/acp-9-5131-2009, 2009a.

Zhao, Y., Wang, S., Duan, L., Lei, Y., Cao, P., and Hao, J.: Primary air pollutant emissions of coal-fired power plants in China: Current status and future prediction, Atmos. Environ., 42, 8442–8452, 2008.

Zhao, Y., Nielsen, C. P., Lei, Y., McElroy, M. B., and Hao, J.: Quantifying the uncertainties of a bottom-up emission inventory of anthropogenic atmospheric pollutants in China, Atmos. Chem. Phys., 11, 2295-2308, doi:10.5194/acp-11-2295-2011, 2011.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 10049, 2013.