Atmos. Chem. Phys. Discuss., 14, C1251–C1261, 2014
www.atmos-chem-phys-discuss.net/14/C1251/2014/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Vehicular emissions in China in 2006 and 2010" *by* N. Chao et al.

Anonymous Referee #2

Received and published: 9 April 2014

This study estimates China's vehicular emissions of eight air pollutant categories based on census data of vehicle registration, emission factors and VMT values. The authors also allocate the emissions into the road net for each province based on road infrastructure information. Overall, the methodology of this study is not that novel. I also have numerous issues with the data used in this study, such as vehicle emission factors and VMT values. The authors determined the key parameters (e.g., emission factors, VMT) based on very limited and even unsuitable references without any needed critical review. In addition, the authors used national-averaged data for emission factors and VMT and didn't consider the provincial differences of local features (e.g., fuel quality, in-use vehicle control, operating conditions, etc.). The two case years (2006 and 2010) were quite close, which made the possible changes of vehicular emissions even smaller than the uncertainties. Therefore, the relevant conclusions without proper validation might be not solid enough to properly inform policy-makers.

Furthermore, the presentation quality of this manuscript at this stage is rather poor with a lot of errors. For example, the authors are not very familiar with the standards of vehicle emissions and presented them inappropriately. I suggest this manuscript should be substantially improved by a native speaker.

I therefore feel that the paper is far below the standard required for Atmospheric Chemistry and Physics. I would suggest that the authors could take the following concerns for future researches.

Major Concerns: Page 4907, Lines 22-25: The author should precisely clarify whether the standards meant for light-duty vehicles or heavy-duty diesel vehicles. If for light-duty gasoline vehicles, standards should be presented using Arabic numerals instead of Roman numerals, such as "Euro 3" instead of "Euro III". TWC has been a required after-treatment device since the Euro 1 standard, which was adopted in China starting from 2000. For heavy-duty diesel vehicles in China, they in general didn't apply after-treatment devices (e.g., SCR or DPF) to comply with the Euro III standards. The author should refer to some appropriate literatures.

Page 4909 to Page 4910: Please substantially streamline the literature review of the vehicular emission inventories. The author should summary the methodologies, implications and potential limitations from those references, rather than list them one by one in the manuscript.

Page 4910, Line 24: Please rewrite standards throughout the manuscript. For example, Euro 1 to Euro 4 for light-duty and Euro I to Euro IV for heavy-duty diesel vehicles. In some megacities, such as Beijing, Shanghai and Guangzhou, emission standards implemented there were earlier than the rest of China. The authors need to address this point.

Page 4911, Line 9: Why choose two years 2006 and 2010 in this manuscript? I think those two years might be too close. The changes of vehicular emissions would be minor compared to the uncertainties in vehicular emissions. I suggest the authors

should extent the study to a longer and continuous period, e.g., 2000-2010.

Page 4912, Lines 14 to Lines 19: The dentition of vehicle classifications is not consistent with the statistical yearbooks in China. Please provide needed description of each vehicle classification and illustrate how to merge the census data into vehicle population by classification used in this study. It is very fundamental to final results. In addition, does the HDDVs only mean coaches and buses? If so, I suggest the authors should present as heavy-duty diesel buses or heavy-duty diesel passenger vehicles to avoid possible misunderstanding, since the HDDVs usually include buses and trucks. Similar to LDGVs.

Page 4913, Line 23 to 4914, Line 2: Vehicle-use intensity indicated by VMT is fundamental to emission inventory. However, the authors assumed national-averaged VMT by vehicle type only based on one literature (i.e., Liu et al., 2008). The data fundamental is very weak and can bring substantial uncertainties in results. The authors should validate their VMT values and their variances, which are essential to simulate the uncertainties by using the Monte Carlo method. For example, I think the authors overrated the VMT values for light-duty vehicles and motorcycles meanwhile underestimated the VMT values for heavy-duty trucks, especially long-haul freight trucks. As a result, such great uncertainties could result in higher CO and NMHC emissions but lower NOX and PM2.5 emissions. VMT for each vehicle classification can vary by province. For example, Beijing adopted the restrictions on vehicle use for motorcycles, trucks and light-duty passenger vehicles. These restrictive policies can significantly influence the VMT for those vehicle classifications. The authors should consider the provincial differences in this study, considering the spatial resolution of emission inventory is emphasized in this study. In addition, the authors should take the deterioration of VMT with vehicle age into account. Namely the VMT for older vehicles (e.g., Euro 0) should be lower compared to newer vehicles (e.g, Euro 3, Euro 4). Otherwise, the emission contribution of older vehicles will be overly estimated.

I recommend the following paper to the authors for more information and insights. Huo,

H., Zhang, Q., He, K., et al. Vehicle-use intensity in China: current status and future trend. Energy policy, 2012, 43, 6-16.

Page 4914, Section 2.1.3: The authors refer to several studies to determine the distance based emission factors by vehicle classification, fuel type and emission certification level. However, for each vehicle type, the authors relied on just one single study without needed description. Many of the cited references are too old and unsuitable, even much earlier than when the emission standards were implemented in China. That means those estimates cannot be supported or validated by local measurement data, which make the database with substantial uncertainty. I strongly suggest the authors should make a throughout critical review again, particularly to involve recent local measurement results. I wonder whether the emission factors are the same for various provinces. A lot of local features can influence emission factors even vehicles meet a same emission certification level, such as driving cycles, altitude, temperature, inspection and maintenance programs, and fuel quality. The author should clarify the impacts on emission factors of vehicle operating conditions other than emission standards. For example, there were always mismatches between the actual fuel quality and emission standards for many provinces (Zhang et al., 2010). Zhang, K., Hu, J., Gao, S., et al. Sulfur content of gasoline and diesel fuels in northern China. Energy Policy, 2010, 38(6), 2934-2940.

Is evaporative HC emissions included for gasoline powered vehicles? The author should clarify. Since for tropical provinces, the evaporative emissions and cold start emissions are substantially different with those in cold provinces. Please reduce significant digits for BC and OC emission factors for all vehicle types. If you cannot achieve that accuracy, they would be meaningless. Is it appropriate to apply same mass ratios of BC or OC for various emission standards? For LDGVs, why the NOX EF for Euro 4 is higher than that for the Euro 3? Is this reduction statistically significant, since it is not consistent with the findings from most measurement results? The authors should carefully reviewed the reference. Furthermore, I think the PM and OC

emission factors for LDGVs in China should have been reduced in accord with over the past decade, especially when compare Euro 0 and post-Euro 0 LDGVs. Similar concerns on PM emission factors for other gasoline vehicle categories. The following paper might be helpful to the authors. May, A.A., Nguyen, N.T., Presto, A.A., et al. Gas- and particle-phase primary emissions from in-use, on-road gasoline and diesel vehicles. Atmospheric Environment, 2014, 88, 247-260. For LDDVs, the authors referred to a Chinese project report released in 2005. However, considering that the LDDVs are limited in many places of China, I doubt the samples of LDDVs. In addition, the Euro 3 and 4 emission standard was not adopted in 2005. Therefore, I think the authors should consider other studies. Recent studies in Europe indicate that real-world NOX emission factors of diesel passenger cars have not been improved even through the Euro 5, which is one of the most important concerns for urban air quality. Chen, Y., Borken, J. Real-driving emissions from cars and light commercial vehicles–Results from 13 years remote sensing at Zurich/CH. Atmospheric Environment, 2014, 88, 157-164. Weiss, M., Bonnel, P., Hummel, R., et al. On-road emissions of light-duty vehicles in Europe. Environmental Science & Technology, 45, 8575-8581. For HDVs, the drive cycles for urban coaches and long-distance are completely different. Therefore, urban diesel buses have significantly higher emission factors than long-distance buses with higher average speed. The authors should state how to aggregate two categories of heavy-duty diesel coaches in this study. In particular, the Euro IV emission standards have only urban public fleets like transit buses in Beijing, Shanghai and Guangzhou by 2010. Considering the low-speed driving conditions for urban buses, the authors might underestimate the NOX emission factors for those Euro IV urban HDDVs. Besides, there are significantly reductions in VOC and CO emission factors of the Euro IV HDDVs compared to the Euro III. Which factors can result in reductions nearly 80%-90%, the authors provide needed information in the table footnote. Please refer to the following papers: Fu, M., Ge, Y., Wang, X., et al. NOx emissions from Euro IV busses with SCR systems associated with urban, suburban and freeway driving patterns. Science of the Total Environment, 2013, 452-453, 222-226. Wu, Y., Zhang, S.J., Li, M.L., et al.

The challenge to NOx emission control for heavy-duty diesel vehicles in China. Atmospheric Chemistry and Physics, 2012, 12, 9365-9779. For HDT, the trends in NOX in emission factors are awkward. Please explain why NOX emission factor for the Euro I HDT is much lower than those of the Euro II and Euro III. In addition, the Euro IV emission standard has not been adopted in China since 2013. Why the authors estimate the emission factors for the Euro IV HDTs? The following paper might be informative. Huo, H., Yao, Z., Zhang, Y., et al. On-board measurements of emissions from diesel trucks in five cities in China. Atmospheric Environment, 2012, 54, 159-167.

Page 4915, Lines 5 to 11: The descriptive text is too wordy and not clear enough. Some equations are needed to illustrate the method. Why should the productions of secondary and tertiary industries be investigated? Were the value in 2006 and 2010 based on a same pricing level? I suggest the authors rewrite the method of spatial allocation.

Page 4915, Lines 15 to 22: The units for all parameters are missing, which makes the method unclear. For example, is the turnover volume for freight trucks unit in ton*km or veh*km? The authors need to clarify.

Page 4916, Line 6: Please provide more information of the SF, such as the way to determine the SF values. Are SF values same for various classes of roads? If the authors use the same SF value for different classes, the impacts of traffic patterns would be ignored. For example, the urban driving conditions are usually congested compared to inter-city driving conditions, which make the emission factors of major air pollutants higher in urban areas.

Page 4918, Lines 7 to 9: Rewrite this sentence. It is not clear. From my understanding, two study years (i.e., 2006 and 2010) are too close. The authors could hardly conclude any statistically discussion the changes of estimated national vehicular emissions if taking the uncertainty range into account.

Page 4917 Line 24 to Page 4918 Line 20: Uncertainty ranges should follow each emis-

sion and proportion value. I suggest the authors compare the estimated results for the year 2010 with the Vehicle Emission Annual Report released by the Vehicle Emission Control Center of Ministry of Environment Protection in 2011 (VECC-MEP), since the output frameworks are similar.

Page 4919, Line 14: please rewrite the subhead of the section 3.2, which reads very awkward. In addition, all the texts of this section are very wordy without a proper layout. It will hardly impress readers. The authors should carefully readjust this section and think about their own major findings from a plenty of numbers.

Page 4921, Line 13 to 15: Euro 1 and Euro 2 LDGVs also adopted TWC to control gaseous exhaust pollutants as a principle after-treatment device. Is there any observation could support your result that NH3 vehicular emission intensity in Beijing is higher than other provinces? NH3 emissions from on-road vehicles are very lower compared the other sector. I don't think it is an issue of great significance unless urea-SCR systems are largely adopted for HDDVs.

Page 4921, Line 16 to 22: Please remove this text from the result section. Furthermore, without link-based traffic flow or traffic demand data, the spatial allocation is only based on the infrastructure information and makes very limited improvement. Therefore, estimated results are still not the actual emissions.

Page 4921, Line 25 to Page 4922, Line 24: The comparative analysis is crucial for inventory studies. However, the authors just listed the visible discrepancies with previous studies. I suggest the authors should carefully dig into the major factors resulting those differences and then review the key input data.

Page 4925, Section 4.3: During the 11th Five Year Plan Period, anthropogenic NOX emissions from other sectors (e.g., power plants, cement industry, etc.) were also substantially increased due to the absences of the total emission reduction target. Based on the MEP's estimate, estimated NOX emissions from on-road vehicles contributed approximately 26% of China's total anthropogenic NOX emissions, which was less

than those from power plants. Only in the urban areas where power plants and industries are scare (e.g., Beijing) can the vehicular emissions dominate the source of NO2. Therefore, the observed trends in NO2 concentration cannot be just attributed to vehicular emissions.

Page 4925 Line 15 to Page 4926 Line 5: The author should quantitatively assess the benefits from implementation of tightened emission standards. Emission control scenarios could be designed with various implementation date and certification level of emission standards taken into consideration. When it comes to the vehicular emission control in Beijing, control strategies and measures adopted were much more comprehensive than other regions. The author could not count the benefits merely on the role of stricter emission standards. The authors should improve their understanding of the vehicular emission regulations in China (Table 6). They for light-duty vehicles, heavy-duty diesel vehicles, heavy-duty gasoline vehicles and motorcycles, not for gasoline and diesel!

Page 4926 Lines 13 to 23: There was very significant mismatch between the actual sulfur content and claimed fuel quality in China (Zheng et al., 2010). As a result, the authors overrated the benefit of emissions reductions from improved fuel quality. Zhang, K., Hu, J., Gao, S., et al. Sulfur content of gasoline and diesel fuels in northern China. Energy Policy, 2010, 38(6), 2934-2940.

Page 4927, Section 4.5: The uncertainties in vehicular emissions depend on the probability functions of key input data, such as emission factors, vehicle population by type, annual VMT. The authors should clarify the probability functions for those above input data, since the references cited here didn't provide detailed information. Otherwise, the uncertainty analysis becomes a kind of statistical play based on I also think it is strange and possibly misleading that the relative uncertainty range in 2010 is a bit wider than 2006. Usually, the relative uncertainty range would be narrowed with the improvement of vehicle emission control and data collection. I suggest the authors could read the following paper: Kioutsioukis, I., Tarantola, S., Saltelli, A., et al. Uncertainty and global

sensitivity analysis of road transport emissions estimates. Atmospheric Environment, 2004, 38, 6609-6620

Minor Comments: Page 4907, Line 5: The authors should clearly note whether motorcycles and rural vehicles included in the statistical data here.

Page 4907, Lines 6-7: should be “within 12 years”. Please present in an appropriate way throughout the manuscript, such as Page 4908, Line 10.

Page 4907, Line 10: Does the NOX means emissions or ambient concentration? The author should clarify this point. In addition, I strongly suggest that the authors should refer to more recent studies regarding the characteristics of vehicular emissions in China.

Page 4907, Lines 12-15: This sentence reads very awkward. Please rewrite it in a clear way and add some needed concrete data.

Page 4907, Lines 17-27: In general, the carbon monoxide is a relatively stable pollutant category. Its contribution to fine particles and ozone is considered minor compared to nitrogen oxides (NOX) and active species of hydrocarbons (HC). In addition, the emissions of NH3 from vehicles are much lower compared to other process, such as agricultural activities. The authors should improve the understanding of pollutant emissions and major reactions in the atmosphere, and avoid any wordy description.

Page 4907, Lines 25-27: Please clarify the mass contribution of nitrates and sulfates in PM2.5 for China’s megacities? The paper listed as below might be helpful to the authors. Yang, F., Tan, J., Zhao, Q., et al. Characteristics of PM2.5 speciation in representative megacities and across China. Atmos. Chem. Phys., 2011, 11, 5207-5219.

Page 4907 Line 27 to Page 4908 Line 1: Please rewrite this sentence.

Page 4908, Line2: Why estimating vehicular emissions is convenient? Compare to which methods?

Page 4910, Lines 20-21: Please provide some information about the changes in vehicle stock and emission certifications.

Page 4911, Line 1: should be “uncertainties because of the lack”

Page 4913, Line 4: “emission standards” instead of “emissions standards”

Page 4913, Line 7: “complying with” instead of “with”

Page 4913, Line 10: delete “the total population and”

Page 4913, Line 13: please rewrite the second half of that formula, which seems awkward, e.g., when j=Euro 0, meanwhile j=1 to 4.

Page 4913, Line 15: what is the vehicle “type”, defined by vehicle classification or fuel type? Please clarify it.

Page 4913, Lines 18-20: why the calculated population of Euro 0 vehicles can be negative? Some explanations are needed.

Page 4915, Line 21: Please clarify the traffic flow pattern for each road class.

Page 4917, Lines 1 to 16: This is very simple and tradition cell gridding technology. The authors may drop off this part.

Page 4918, Line 5: Please add some references to illustrate how the application of TWC influence the NH3 emissions from vehicles.

Page 4919, Line 3: It is not correct. For example, the Euro 4 emission standard was adopted in Guangzhou just before the Asian Game in 2010 (also in Shanghai). When it comes to the emission standards, the authors should note for which vehicle category, such as light-duty or heavy-duty diesel.

Page 4919, Line 11: “phasing out” instead of “eliminating”; “complying with” instead of “with”

Page 4919, Line 18: “fleet configuration” instead of “vehicle composition”

Page 4920, Line 11: Please define all the geographic terms, such as Sichuan Basin, Urumqi regions?

Page 4924, Lines 1 to 3: Please add some necessary references.

Page 4924, section 4.2: I suggest the authors should clarify the dentition of oil consumption. Gasoline, diesel or even including other petroleum products (e.g., kerosene)? Consumption for transportation sector or total consumption?

Page 4924, Lines 21 to Lines 26: There are many other control measures adopted in Beijing and Shanghai in addition to tightening emission standards, to improve emission factors of air pollutants. Besides, the emissions standards adopted in Jiangsu were consistent with national requirements by 2010.

Page 4925, Lines 7-15: Please remove this paragraph. It just repeats the results presented upfront.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 4905, 2014.