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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The impact of China's vehicle emissions on regional air quality in 2000 and 2020: a scenario analysis" *by* E. Saikawa et al.

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We thank the reviewer #2 for his/her helpful comments on our manuscript. Here, we respond to the comments in the order in which they were made.

Comments:

1. There are a few areas in which results may be presented with a different emphasis or focus to enhance the significance of this work. The main conclusion is, presently, that if vehicle emissions in China were regulated, air quality in China would be improved. This may seem somewhat obvious, particularly after having established that the projected increases in vehicle emissions are occurring at a much more substantial rate than those for the other emissions sectors (i.e., total CO emissions less than double, yet

vehicle CO emissions increase by a factor of 7 for the BAU case). It seems that much of the effort for this work went into constructing the emissions inventories themselves, and thus the latter aspect alone is one of the more fundamental conclusions of the manuscript.

Thank you for pointing out the need for clarification. In fact this analysis compares current vehicle regulations (Euro 3) with what pollution levels might have been without these regulations (BAU). We will change the first paragraph of the conclusion as follows, putting an equal focus on the development of emissions inventory and the impact of those emissions: In this paper, we construct a new emissions inventory for China's road transport sector for 2000. We also develop 2 scenarios for 2020 (Euro 3 which represents implementation of existing regulation and BAU which describes emissions as they would be without regulation), and examine the present and future impacts of China's vehicle emissions on regional air quality.

The air quality metrics used for assessing O3 and PM2:5 (monthly averages) aren't inline with any of the metrics actually used for policy. Recasting the findings in terms of quantities such as exceedances, or the maximum running 8-hour average O3 concentrations, would greatly improve the relevancy of this work and possibly lead to altered conclusions, as small changes to concentrations can lead to large changes in the frequency of exceedances above a threshold. For example, the WHO targets cited on page 13160, line 21-24, could be explicitly evaluated.

Thank you for this suggestion. We now calculate the 8-hour average O3 concentrations in Lin'an, Rishiri and Oki for each scenario, and find that the number of days where the 8-hour O3 and PM2.5 average is above 81ppbv and 35μg m-3, respectively, is as listed in Table S1#2. The important finding from this analysis is that by implementing the Euro 3 emission standards in 2020, Lin'an is able to at least keep, if not lessen the exceedance level of PM2.5 as in 2000. Although O3 mole fractions increase quite rapidly due to the increased emissions in all sectors, we find that implementing the Euro 3 standards leads to a reduction of 7 exceedance days in July in Lin'an. We will

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Interactive Discussion

Discussion Paper

include this analysis in the final revised manuscript in section 5.3.

The discussion/quantification of the impact of the emissions regulations in China on regional air quality could be expanded beyond the one paragraph on page 13161.

Based on the 8-hour average O3 concentrations in Oki and Rishiri, we will include the following discussion before we discuss Fig. 10 after the current paragraph: We find that implementation of the Euro 3 standard in China reduces the number of days that both O3 and PM2.5 exceed ambient standards relative to the BAU scenario (see Table S1#2). However, the reduction is only 1 exceedance day per month or less. Under Euro 3 the maximum 8-hour O3 and PM2.5 average at Oki is also 1-3 ppbv and 3-7 μg m-3 lower, respectively, than under BAU.

From a policy point of view, it seems that one of the most interesting questions is to what extent could vehicle emissions reductions alone achieve air quality standards in China. This is only briefly mentioned in the conclusions. The implications of this work for considering the most effective way to achieve air quality goals could be considered.

We agree that what you raise is a very interesting question. What we show in this paper is the possible effect of all the vehicles in China meeting the Euro 3 emission standards. Even with no regulation in other sectors, our result shows that there are significant benefits to regulating vehicle emissions, especially for keeping the PM2.5 concentrations at 2000 levels, even with a rapid increase in vehicle numbers. Whether this is the most effective way to improve air quality is a separate question that will need to be addressed in the future. For example, we may do a study where we also regulate emissions from domestic and power sectors. However, we do illustrate that regulating vehicle emissions alone does not achieve air quality standards in China, as the exceedance levels for O3 and PM2.5 illustrate in 2020. Further regulations in other sectors are essential to achieve this goal. We will state this in the final revised manuscript in section 5.3 and also in section 6.

2. Does WRF-Chem include feedbacks of aerosol concentrations on the gas-phase

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Discussion Paper

chemistry via heterogeneous chemistry and/or photolysis rates?

We use the RADM2 chemical mechanism in the WRF/Chem model, and it does not include these feedbacks. The next step of our research will be to use different chemical mechanisms such as CBMZ, which does include feedbacks of aerosol concentrations on the gas-phase chemistry via heterogeneous chemistry to analyze the feedback impact, but this is beyond the scope of our paper. We will include the statement that the chemical mechanism we used does not include these feedbacks of aerosol concentrations in the revised manuscript in section 3.1.

3. p13146, 4: It wasn't entirely clear to me which species are regulated, as Table 1 implies it would be NOx, PM, CO and HC, yet here we see distinctions for BC and OC.

Sorry for the confusion. The species regulated are the ones listed in Table 1, so they are CO, HC, NOx and PM. We created emission factors for BC and OC separately, as although both of them are categorized as PM in the regulation, they have different emission factors and sources. We will rewrite p. 13147 as follows: We classify vehicles into six categories (motorcycles, private cars, light-duty vehicles, buses, trucks and rural vehicles) and two fuel types (gasoline and diesel) as listed in Table 2. CO, NOx, HC and PM are regulated by vehicle emission standards, and thus we calculate emissions for the following five chemical species (CO, NOx, NMVOCs, BC and OC).

4. 13162,4: Formation of nitrate aerosol is often limited by availability of excess NH4. Was that constant for these simulations, or was nitrate uptake really enhanced by increased NOx emissions?

Thank you for raising this important issue. We calculate the gas-ratio in order to determine whether the formation of nitrate aerosol was due to the availability of excess NH4 or not, following Ansari and Pandis (1998). Our calculation results indicate that in 2000 BASE January scenario, there was only 1 day in a month where the gas ratio was below one (which indicates ammonia-limitation). In 2020 BAU January, this number increases to 17 but in 2020 Euro 3 January, it again reduces to 3. These values indicate that nitrate increase was enhanced by increased NOx emissions but also by the availability of excess NH4 emissions. We will need to do a further study on what is behind this nitrate increase, but this is beyond the scope of our paper. We will change the sentence p. 13162, l. 13 to “Although the road transport sector is responsible for a small fraction of BC and OC emissions (Fig. 2), with Euro 3 regulations we find significant PM2.5 surface concentration reductions also due to less formation of nitrate aerosols from reduced NOx emissions and due to the reduced availability of excess NH4.”

5. The figures are not always easily legible (specifically, captions and labels on Fig 2, 4, though all are a bit small). Suggest using larger fonts, making better use of white space on plots for placement of labels, legends, within the plot space. Also, visible country borders for the geo-spatial model results would be appreciated.

Thank you for this suggestion. We will make the figure captions and labels bigger.

6. What assumptions are made about the sulfur content of fuel, and this sulfur content being constant or changing in the various scenarios?

Thank you for the clarification. The sulfur content of the Euro 3 scenario matches with the Euro 3 fuel quality standard, which is 15ppm for gasoline and 35ppm for diesel. As for the 2000 and 2020BAU scenarios, we used the sulfur content that is used in the REAS emissions inventory before our modification. The numbers are 1200ppm for gasoline and 1630ppm for diesel (with an exception of the Northeast where the sulfur content is 350ppm). We will include this information after the first sentence on p. 13147, l. 18.

Technical corrections 13151, 14: observed > included 13151, 20: lateral boundary > lateral chemical boundary 13155, 3: relative to what? 13159, 3: in excess > an excess 13162, 4: In summary

Thank you for these corrections. We will incorporate them in our revised manuscript.

Reference:

Ansari, A. S. and Pandis, S. N.: Response of Inorganic PM to Precursor Concentrations, Environ. Sci. Technol., 32 (18), 2706-2714. 1998.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 13141, 2011.

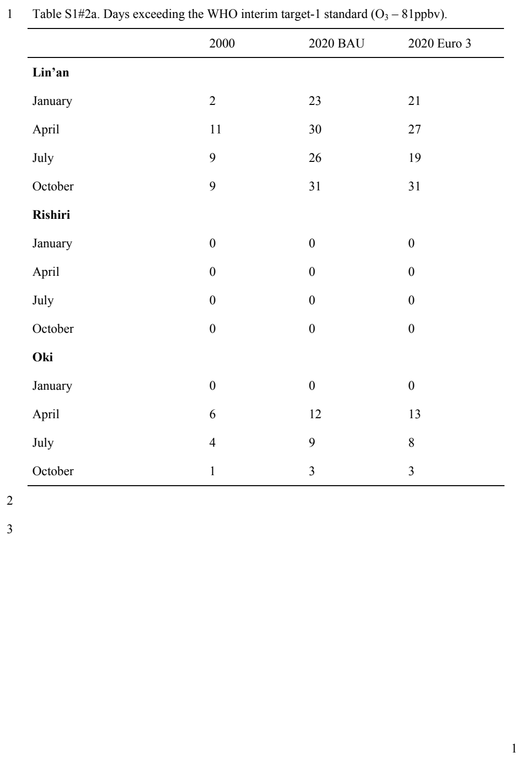

Table S1#2a. Days exceeding the WHO interim target-1 standard (O_3 – 81ppbv).

	2000	2020 BAU	2020 Euro 3
Lin'an			
January	2	23	21
April	11	30	27
July	9	26	19
October	9	31	31
Rishiri			
January	0	0	0
April	0	0	0
July	0	0	0
October	0	0	0
Oki			
January	0	0	0
April	6	12	13
July	4	9	8
October	1	3	3

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Fig. 1. Table S1#2a

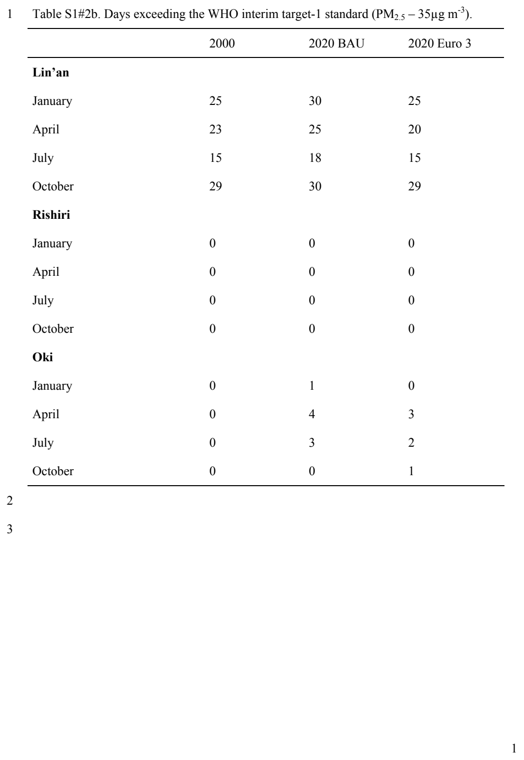

Table S1#2b. Days exceeding the WHO interim target-1 standard (PM$_{2.5}$ – 35µg m^{-3}).

	2000	2020 BAU	2020 Euro 3
Lin'an			
January	25	30	25
April	23	25	20
July	15	18	15
October	29	30	29
Rishiri			
January	0	0	0
April	0	0	0
July	0	0	0
October	0	0	0
Oki			
January	0	1	0
April	0	4	3
July	0	3	2
October	0	0	1

Fig. 2. TableS1#2b

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