Reply to comments on "The Challenge to NO_X Emission Control for Heavy-duty Diesel Vehicles in China" by Y. Wu et al.

Reply to comments from Referee #1:

We appreciate the comments from the respectful referee. Your comments help us improve our manuscript. Our point-to-point responses to your comments are listed as follows.

1. P18573, L6: I think there should be a time (T) also in the denominator. The units now do not seem to be correct. The numerator shows the total emission in grams. The denominator should give the total driving distance, not the speed.

Equation 3 was revised according to the reviewer's comment (see page 8, lines 1-5).

2. P18757, L10: Specify what the uncertainty range given by the emissions represents. Is it the min-max or standard deviation on the total set of data?

In this revised manuscript, all uncertainty ranges represent the 95% confidence interval. We also estimated uncertainties in NO_X emissions for the HDDVs fleets in Beijing at the 95% confidence level, based on the uncertainties in on-road emission factors.

We made the statement clear according to the reviewer's comment (see page 9, line 27; page 12 line 9; page 13 lines 19; page 16 lines 13).

3. P18580, L7: Please explain 'ESC control zone'.

We explained "ESC control zone" in manuscript and added a paper as reference for information (see Page 15, lines 4-6).

- Krahl, J., Knothe, G., Munack, A., Ruschel, Y., Schröder, O., Hallier, E., Westphal, G., Bünger, J.: Comparison of exhaust emissions and their mutagenicity from the combustion of biodiesel, vegetable oil, gas-to-liquid and petrodiesel fuels. Fuel, 88(6), 1064-1069, 2009.

4. P18599, Fig 3: The COPERT model has updated the NOx emission factors for Euro-IV, -V and -VI trucks in 2010 (Gkatzoflias and Ntziachristos, COPERT 4 v8.0, Report No. 10.RE.0037.V1, 2010). Has this been taken into account in the data in Figure 3?

Thanks to the reviewer's comment, we notice that the NO_X emission factors for Euro-IV, -V and –VI HDVs have been updated since the COPERT4 v7.1 model. Therefore, we have accordingly updated the estimated emission factors with the most recent version COPERT4 v9.0 in this manuscript. For example, the updated estimated NO_X emission factor of Euro IV diesel urban buses is 7.2 g km^{-1}, compared to 5.9 g km^{-1} with the COPERT4 v7.1 model. (see Page 9, line 21 and Fig. 3). We also added a new paper (see below) as the reference for the new COPERT4 v9.0 model.

- Gkatzoflias, D., Kouridis, C., Ntziachristos, L.: Description of new elements in COPERT 4 v9.0, 2011. available at http://www.emisia.com/files/COPERT4_v9_0.pdf

Reply to comments from Referee #2:

We appreciate the comments from the respectful referee. Your comments help us improve our manuscript. Our responses to your comments are listed as follows.

1. It would be good to know however, whether NO and NO2 were speciated in the measurements. I think not and only NO was measured? If this is the case then the authors should state so. In heavy duty vehicles typically about 15% of the total NOx is in the form of NO2 (by volume), but the amount will depend on the driving conditions. The SCR system also produces NO2 as part of its operation and vehicles fitted with SCR could emit higher proportions of NO2. Again, if this is the case a measurement of just NO will 'miss' an important contribution of NO2. The authors should therefore clarify exactly what has been measured and add additional discussion about the implications if the NOx measurements are actually NO. Similarly, if NO2 and NO were measured it would be very useful to have the emission factors speciated throughout the paper.

We understood the reviewer's concern and added a paragraph to discuss this issue (see Page 11, lines 10-26).

In this study we applied two PEMS systems. The Horiba OBS-2200 PEMS could only measure total NO_X rates (NO plus NO_2). Therefore, the speciated NO and NO_2 emission factors are not available from the OBS-2200 PEMS. However, the SMETECH-D PEMS could measure NO and NO_2 emission rates separately. We revised our manuscript to make the statement clear (see Page 5, lines 26-30). In this manuscript, we use NO_X to present NO plus NO_2 together.

We collected on-road emission measurement results by using SMETECH-D PEMS of eight Euro III diesel buses without after-treatments and four Euro IV diesel buses with SCR systems. Average fractions of primary NO_2 to total NO_X for those two vehicle groups are $3.2 \pm 1.5\%$ and $1.0 \pm 1.3\%$, respectively. Both results show low fractions of primary NO_2 to total NO_X. The reviewer mentioned higher ratio of ~15% for NO_2. Such high ratio is probably derived from HDDVs equipped with DOC or DPF. We added a paragraph to discuss this issue (see Page 11, lines 10-26).

We added three new papers here as references (see below) since they tie closely to the topic regarding HDDV primary NO_2 emissions.

- Grice, S., Stedman, J., Kent, A., Hobson, M., Norris, J., Abbott, J., Cooke, S.: Recent trends and projections of primary NO_2 emissions in Europe. Atmos. Environ., 43(13), 2154-2167, 2009.
- Hu, J., Wu, Y., Wang, Z., Li, Z., Zhou, Y., Wang, H., Bao, X., Hao, J.: Real-world fuel efficiency and exhaust emissions of light-duty diesel vehicles and their correlation with road conditions. J. Environ. Sci., 24(5), 865-874, 2012.
- Kousoulidou, M., Ntziachristos, L., Mellios, G., Samaras, Z.: Road-transport emission projections to 2020 in European urban environments. Atmos. Environ., 42, 7465-7475, 2008.