Response to reviewers' comments

We thank the Editor and the reviewer for the constructive comments. We have addressed all the comments, and listed our point-by-point reply below. We list the reviewers' comments in black and our replies in blue.

1. The concentration of different air-pollutants was simultaneously measured and evaluated using WRF-Chem in "Nepal Ambient Monitoring and Source Testing Experiment (NAMaSTE): Emissions of particulate matter and sulfur dioxide from vehicles and brick kilns and their impacts on air quality in the Kathmandu Valley, Nepal". Authors have done a non-trivial work by updating an existing emission inventory for Kathmandu Valley. However, there are some issues need to be resolved. 1. The authors have mentioned that "Since we lack survey data for trucks and cars in Kathmandu, we used the data from Pune, India for these two types of vehicles" (Section 2.2.1). Using survey data of a western Indian city could increase the uncertainty related to the emission calculation. Authors, therefore, must include some logical arguments to establish the reasons behind using survey data of Pune in Kathmandu.

We agree with the reviewer that the survey data of Pune from India could introduce additional uncertainty compared to using the local data of Kathmandu. We only did this because the data for Kathmandu was unfortunately not available. Pune was the only representative city within South Asia, where the International Sustainable System Research Center (ISSRC) conducted a detailed study of vehicle activity. We added the following in the manuscript in section 2.2.2 in line 164:
Pune was the only representative city within South Asia, where the International Sustainable System Research Center (ISSRC) conducted a detailed study of vehicle activity.

2. The authors have assumed the emitted PM as $PM_{2.5}$ (section 2.2.1). Gillies et al. (2001) have estimated the emission factor of $PM_{2.5-10}$ from a tunnel experiment in Los Angeles as 26% of total PM. Handler et al. (2008) reported the mass emission of $PM_{2.5-10}$ almost equals to $PM_{2.5}$ during an on-road motor-vehicular study in Vienna. Therefore, the authors need to explain the reason behind their assumptions logically. The IVE model gives an output of PM_{10} (IVE model user manual, V2.0)

The reviewer correctly points out that the PM in the IVE model refers to PM_{10}. The ratio of $PM_{2.5}$ to PM_{10} is 0.92 for diesel vehicles and 0.88 for gasoline vehicles according to EPA's 2014 MOVES model. Since $PM_{2.5}$ is the dominant particulate matter and diesel engines appear to be the biggest source of $PM_{2.5}$ on road, we assumed the emitted PM as $PM_{2.5}$ to simplify our estimation. Both Gillies et al. (2001) and Handler et al. (2008) indicated that emissions of coarse particles were dominated by resuspended dust as well as by brake wear, while fine particles were mainly derived from combustion processes. We added the following in the new section 2.2.2 in l. 174:
All emitted PM was assumed to be $PM_{2.5}$ because the ratio of $PM_{2.5}$ to PM_{10} is 0.92 for diesel vehicles and 0.88 for gasoline vehicles in EPA 2014 MOVES model. Studies such as Gillies et al. (2001) and Handler et a. (2008) have also found that 74% and 67% of PM_{10} is $PM_{2.5}$ in on-road studies. Although we understand that assuming all emitted PM_{10} to be $PM_{2.5}$ is potentially an overestimation, we believe that this is acceptable, given the lack of observational data in Nepal or in South Asia.

3. As this model does not provide direct OC and EC output, therefore, the authors have used factors derived from Kim Onah et al. 2010. I would like to request the authors not to use the reference of Shresta et al.(2013) in this line. They should mention the reference of Kim Onah et al. 2010. The uncertainty related to this conversion factor for PM-to-EC and PM-to-OC is very high as shown by Kim Onah et al. (2010), and also the study has been carried out in a different country with different fuel quality and different meteorology compared to the present study. Therefore, I would like to suggest the authors use some probabilistic methods where the uncertainty related to these conversion factors could be taken care of. Else, the authors could include a separate section describing the uncertainty and if possible quantify it.

We have changed the reference as suggested by the reviewer. In addition, we created a pool of PM-to-EC and PM-to-OC conversion factors from multiple references to describe the potential uncertainties of these conversion factors (new Table S1). We also corrected our description and briefly discussed the uncertainties. The revised sentences read as follows in section 2.2.2, l. 180:

Because the IVE model does not directly estimate emissions of EC or OC, we used conversion factors derived from the study of Kim Oanh et al. (2010) to estimate these emissions. Kim Oanh et al. (2010) specifically focused on the emissions of diesel vehicles in developing countries and had tested a large number of vehicles. For vans, we used EC/PM mass ratio of 0.46 and OC/PM of 0.2, while for trucks and buses, we used EC/PM of 0.48 and OC/PM of 0.13. We collected a group of these conversion factors from different studies in Table S1. Our EC/PM mass ratio is close to median value of all the studies listed below. While we acknowledge that using conversion factors from one study ignores the potential uncertainty due to driving pattern, weather conditions, fuel quality, and vehicle characteristics, we also feel that our estimate provides a good middle ground, given the existing study results.

Table S1: Summary of EC-to-PM and OC-to-PM mass ratios sampled from literature

No.	EC/PM	OC/PM	Sampling method	Vehicle	Location	Component	Reference
1	0.31 ± 0.03	0.2 ± 0.02	Chassie dynamometer	Medium duty diesel truck	California, US	$PM_{2.5}$	Schauer et al., 1999
2	0.34 ± 0.04	0.25 ± 0.12	Chassie dynamometer	Heavy duty diesel vehicle	UK	Total PM	Shi et al., 2000
3	0.61 ± 0.07	0.33 ± 0.15	On-road	Heavy duty diesel truck	California, US	Total PM	Shah et al., 2004
4	0.44 ± 0.09	0.33 ± 0.15	Tunnel	Mixed light & heavy duty vehicles	California, US	$PM_{2.5}$	Gillies et al., 2001
5	0.43	0.16	Tunnel	Light duty composite	Marseille, France	$PM_{2.5}$	Haddad et al., 2009
6	0.45 ± 0.48	0.22 ± 0.23	Tunnel	Mixed light & heavy duty vehicles	Guangzhou, China	$PM_{2.5}$	He et al., 2008
7	0.46 ± 0.23	0.2 ± 0.11	Chassie dynamometer	Light duty composite	Bangkok, Thailand	$PM_{2.5}$	Kim Oanh et al., 2010
8	0.48 ± 0.18	0.13 ± 0.14	Chassie dynamometer	Heavy duty composite	Bangkok, Thailand	$PM_{2.5}$	Kim Oanh et al., 2010
9	0.5 ± 0.57	0.18 ± 0.14	On-road	Light duty diesel cars	Deli, India	$PM_{2.5}$	Jaiprakash, 2015
10	0.48	0.25	Chassie dynamometer	Light duty diesel cars	Taiwan	$PM_{2.5}$	Chiang et al., 2012
11	0.5 ± 0.44	0.26 ± 0.28	Tunnel	Mixed light & heavy duty vehicles	Hong Kong	$PM_{2.5}$	Cheng et al., 2010

4. The authors have nicely explained the reasons behind the underestimation of EC. As per as the underestimation of SO_2 is concerned, the authors have repeatedly discussed the Bode site. There is a distinct discrepancy between measured and observed values of SO_2 in all the sites which indicates the presence of another source of SO_2 that is not being considered. The authors need to rewrite the section (4.4) and try to explain the reasons behind the underestimation.

Based on our analysis, brick kilns are one of the largest sources of SO_2 in Kathmandu Valley, which has not been considered in current global or regional emission inventories. Since we have limited emission factors for SO_2 from brick kilns, we hypothesized that the main reason was due to our underestimation of SO_2 emissions from this sector, although it was our best estimate. We added the following sentence to discuss this issue in section 4.4, l. 449:

This underestimation is probably due to brick kiln SO_2 emissions. We applied an emission factor of 12.7 g/kg of fuel measured from Zigzag kilns (Stockwell et al, 2016) to all types of brick kilns. This was the only available observational data in Nepal at the time of this study. A more recent study by Nepal et al. (2019) reported that the mean value of SO_2 emission factor from Zigzag kilns is 24±22 g/kg fuel, which is almost twice as high as that used in our study. If we doubled our SO_2 emissions for brick kilns, the modeled SO_2 concentrations would be much closer to the observations. Assuming the linear relationship in SO_2, the average difference between the observed and modeled SO_2 concentrations would drop from 4.4 $\mu g\ m^{-3}$ to

2.8 μg m^{-3}. We plan to revisit our brick kiln emissions inventory, as more emission factors become available. Our study highlights the importance of improving emission factor of SO_2 for brick kilns in Nepal."

References

Gillies, J. A., Gertler, A. W., Sagebiel, J. C., & Dippel, N. W. (2001). On-road particulate matter ($PM_{2.5}$ and PM_{10}) emissions in the Sepulveda Tunnel, Los Angeles, California, *Environmental Science & Technology*, **35** (6), 1054-1063.

Handler, M., Puls, C., Zbiral, J., Marr, I., Puxbaum, H., & Limbeck, A. (2008). Size and composition of particulate emissions from motor vehicles in the Kaisermühlen-Tunnel, Vienna, *Atmospheric Environment*, **42** (9), 2173-2186.

Kim Oanh, N. T., Thiansathit, W., Bond, T. C., Subramanian, R., Winijkul, E., & Paw-armart, I. (2010). Compositional characterization of $PM_{2.5}$ emitted from in-use diesel vehicles. *Atmospheric Environment*, **44** (1), 15-22.

Nepal S, Mahapatra PS, Adhikari S, Shrestha S, Sharma P, Shrestha K, Banmali Pradhan, Bidya Praveen, P. S. (2019). A comparative study of stack emissions from straight-line and zigzag brick kilns in Nepal, *Atmosphere*, **10** (3), 107.