Interactive comment on “Simulations of Black Carbon Over Indian Region: Improvements and Implications of Diurnality in Emissions” by Gaurav Govardhan et al.

We appreciate the summary evaluation on the importance of our work and the overall favorable recommendation, along with comments to be considered during revision. We have carefully considered the comments and revised the paper accordingly. Our point-by-point responses to the comments, based on which the revisions are made, are given below:

The comments from referee are written in red colored text, while the author responses are written in black colored text.

Anonymous Referee #1

1) I am not convinced how the scaling factor for diurnal emissions has been arrived at, that too an average factor for the whole country. Is this factor based on real observations? Why the authors did not consider the regional variations to bring better results?

- The characteristic shape of the proposed diurnal variation has been decided keeping in mind the daily hours of the vehicular traffic and domestic cooking activities, typically prevailing in India. The choice of the shape is mainly motivated from the guidelines provided in fig. 2 of Freitas et al. (2011), who have designed a widely used emissions pre-processor, 'prep_chem_sources', for use in the WRF-Chem model. They have suggested a double Gaussian distribution of emissions in the day, with a constraint that, the total emission of the pollutant over a day remains the same with or without the prescription of the diurnal variation.

Our prescribed diurnal variation compares well with the previous studies which have attempted to reveal diurnal variation of traffic using global activity related data (Olivier et al. (2003)), local vehicular traffic data (Pollack et al. (2006)) and concentration inversion techniques (Dutkiewicz et al. (2009)), over different regions of the world. Over the Indian region however, there are very few such studies (eg. Goyal and Krishna, 1998; Sivacoumar et al., 2001); which have attempted to derive diurnal variation of anthropogenic pollutants. Due to lack of observational data on diurnal variation of emissions over the Indian region, we resort to the guidelines outlined in Freitas et al., 2001.

We agree with the reviewer that, specification of a regionally varying diurnal variation would be more appropriate; however this would need extensive characterization of the diurnality of emissions in distinct regions/ seasons. Such studies do not exist over India, and it is hoped that our present work may provide motivation for initiating such studies. Our results in the present paper are limited by this aspect. We indicate this in the revised manuscript.

2) What is the purpose of additionally doing one more simulation by multiplying a factor of 3? It is obvious that such simulations will improve the black carbon concentrations. In the conclusions, those results are not mentioned. It is an academic interest and does not add to any new knowledge. I suggest those results may be excluded from this paper.

- The modifications carried out in the emissions of BC in the model, comprise of prescription of both the 'Diurnality Factor' (DF) and the 'Adjustment Factor' (AF=3). The improved simulations of near-surface BC are achieved only after the prescription of both the factors. The diurnality factor though controls the simulated BC on hourly time-scale, it leaves the simulated daily mean BC largely undisturbed, due to cancellation of positive changes during evening-night times and negative changes during midnight-morning hours. Thus, AF plays a crucial role in bringing the simulated BC closer to the observed BC magnitudes. Hence, we include both DF and AF in our analysis. This adjustment factor is necessitated by the in-accurate emission inventories over south Asian region and also poorer representation of atmospheric boundary layer during night-time and winter conditions when convective mixing is weak (as has been revealed by several earlier studies mentioned in the manuscript). The AF overcomes this to some extent; again with regional

differences. This aspect is mentioned in the manuscript.

3) In Fig 3, the scales (X and Y) are not symmetric. Put the same intervals and range and then plot a 450 line to show that red dots have improved in slope.
- We thankfully accept this suggestion, and the figure has been modified accordingly.

4) The statistical analyses (correlations and differences) always should be tested for statistical significance.
- We agree. The statistical significance of the correlations has been tested using the t-test by computing the p-value (Frenton and Neil, 2012). It is mentioned in the caption to fig. 6. It is also mentioned in the main text, in the revised version of the manuscript.

5) The study clearly brings out that there are large uncertainties in the emission inventories over the Indian region. Therefore, the future efforts should be made to improve the emission inventories of black carbon over the region. This kind of studies only are of academic interest, that too by considering one average diurnal profile of scaling factor for the whole India.
- We agree with the reviewer that prescription of one average profile of diurnality factor to the whole India does not represent the heterogeneity in the emission sources across the country. However, due to lack of data on diurnal variations of emissions locally, we had to resort to this option. We agree with the reviewer that in future a large efforts are needed to improve the emission inventories across India especially on the diurnal time scales. Such efforts are being undertaken very recently, though on highly regional scale and this work would bring the need for such efforts over a wider spatial scale.

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