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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Using satellite measurements and mesoscale modelling to understand the contribution to an extreme air pollution event in India" *by* Ashique Vellalassery et al.

Anonymous Referee #2

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General Description and Comments:

This paper describes the application of combining satellite observation of CO with WRF-Chem modeling to better understand the transport patterns and contribution of various sources to high CO concentration in North India in November 2018. WRF-Chem model outputs are compared against XCO from TROPOMI and surface CO concentration from ground-based stations. CO from biomass burning source, anthropogenic source, and background are tagged separately in the WRF-Chem simulation to assess the contribution of each source to total CO. The authors state that there is

a good consistency between TROPOMI XCO observation and modeled values. Lower agreement was observed between ground stations and model values due to higher sensitivity of surface concentration to meteorology variables such as PBL and wind speed. Authors state that WRF-Chem captured the transport pattern well during this period but fail to provide enough evidence for this. They found minimal role of CO from biomass burning sources to the total column and surface CO enhancements except in regions close to biomass burning sources. Finally, they emphasize the importance of mitigation policies that focus mostly on controlling anthropogenic sources because of the significant impact of these sources on regional air quality.

In my opinion, the paper is well-written and well-organized. However, I did not find enough evidence for the major conclusions in the paper. I would recommend this paper for publication only after major revision and adding more discussion on the transport of plume in the model and the model performance in capturing these patterns. The uncertainties (either in emission or transport) need to be discussed further. Some ideas on how to strengthen your argument:

- Adding backtrajectory analysis can help better understand the transport pattern in the model. - A perturbation run with increased fire emission can help examine your conclusions further and also gives an insight into the transport error of the model. Or using other fire emission inventories - Cross section plots can help with understanding the transport patterns.

General comments: - Add more details of WRF-Chem model configuration. Any nudging or re-initialization of the model? By running the model freely for a month will increase the errors in the model.

- There is no model performance evaluation with respect to meteorology variables. Please consider adding it to the discussion.

- Even after reading P5 L11-19, I still think that this study is very similar to Dekker et.al 2019. Consider adding more analysis to your study.

- Consider adding evaluation of fire emission performance. Perhaps compare the emission with VIIRS active fire points to see how emission inventory underestimated CO emission. What about other fire emission inventories?

- Have you looked at the performance EDGAR inventory in this region in the literature? Can errors in EDGAR partly justify the large errors in surface CO?

- Map of the contribution of emission CO source to total in November 2018 can be helpful.

Specific Comments

P5 L15 – I did not find (2) in the paper. Where did you examine the regional distribution of CO for the entire year? You also did not specify which model configuration you used and why you used these options.

P6 L40 – I recommend using a map marking station locations rather than listing stations in Table 2. Perhaps replacing Table 2 with Figure 8.

P7 L2-9 – Add more details about the WRF-Chem configuration and options.

P7 L34 – consider adding Pan et al 2020 reference.

P7 L37 – So all emissions from fires are released from the surface? How does this limit the model performance?

P8 L1 – Multiple physics and chemistry options and dynamics schemes are not discussed in the paper.

P9 L22-26 – consider referencing Kulkarni et al. 2020 here on fire activities

P10, sec 5.3.1. – It is difficult to see the differences between model and obs in Figure 3. Please add bias map for Nov 6-9 (similar to Fig 4 a). Perhaps you may want to reorganize the panels in fig 3 and 4. Consider using different color bars for bias maps and XCO maps.

P11 L4-7 – You have a relatively large domain and you are focusing in a smaller region in the domain with high biomass burning activities. Averaging the biases over the whole domain cannot really help with your discussion. I suggest providing statistics only for IGP region.

P11 L8 – by “biomass-burning period” do you mean the month of November or just Nov 6-9? Fig 4 only shows November.

Figure 5 – add another column with CO emission from fire similar to Fig 2-b but for each day. Discuss how fire emission varied day by day and if model captured it.

P11 L17 – Looking at Fig 5 it looks like on Nov 6 and 7 model didn’t capture emissions correctly and on Nov 8 model didn’t transport the pollutant correctly. Please discuss the errors further. There are other papers that looked at a similar problem for Nov 2018 such as Kumar et al., 2020 and Roozitalab et al., 2020, please compare your findings with their conclusions.

P11 L 18 – Fig 6 Can you mark these locations on the map on Fig 5? Please use same XCO range for all three sub plots.

P11 L18-34 – Adding backtrajcetory analysis can be beneficial for the argument here. More discussion on model errors in capturing transport pattern is needed. Before doing inverse modeling to constrain emission you need to understand the model errors.

P11- L35 – Are Punjab and Delhi region showed in Fig 6 and 7 the same regions? I suggest marking these regions on the map for both column and surface observations.

P12 L3 – What do you mean by larger variability? To me, it looks like obs CO variability is lower in Punjab compared to Delhi

P12 L28 – From Fig 5 it looks like model did not have any fires near Punjab on Nov 6 and Nov 7. You can add a similar discussion in this section by referring to fig 5. Also adding backtrajectory analysis can help with understanding the transport patterns.

P13 L10 – What do you mean by observed variability? The influence of background is not minimal when looking at column CO.

P13 L20 – Since GFAS underestimates fire emissions do you expect a higher contribution of fire CO to total CO in Punjab in reality?

P13 L32 – Please overlay obs surface CO and model in these plots. Also, use the same range for Y axis for all plots. Comparing with observed meteorology variables can greatly benefit the discussion here and help justify the large biases of surface CO for some days.

P14 L1 – You got to this conclusion based on correlation numbers from Nov 3-20 and I don't think that is enough. How are the correlations during Nov 6-9?

P14 L15 – The level of contribution of meteorology to regional air quality can vary day by day. Have you looked at other studies that looked at Nov 2018 such as Kumar et al., 2020 and Roozitalab et al., 2020?

Reference: Kumar, R., Ghude, S. D., Biswas, M., Jena, C., Alessandrini, S., Debnath, S., Kulkarni, S., Sperati, S., Soni, V. K., and Nanjundiah, R. S.: Enhancing Accuracy of Air Quality and Temperature Forecasts During Paddy Crop Residue Burning Season in Delhi Via 775 Chemical Data Assimilation, Journal of Geophysical Research: Atmospheres, 125, e2020JD033019, 2020.

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T., da Silva, A., and Wang, J.: Six global biomass burning emission datasets: intercomparison and application in one global aerosol model, Atmospheric Chemistry and Physics, 20, 969-994, 2020.

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