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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Attributions of meteorological and emission factors to the 2015 winter severe haze pollution episodes in Northern China" *by* Tingting Liu et al.

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1. The authors conduct numerical experiments to investigate the effectiveness of meteorology versus emission. To ensure convincing results, the well-simulated meteorology and particulate matter is prerequisite. The model skill can be evaluated using multi-site measurements. The simulated meteorological parameters and particulate pollutants should be compared with observing data in temporal contrast, and statistical analysis is helpful for the validation. Besides, the uncertainty quantification of the results needs to be performed.

Response: Six statistical indices, i.e., index of agreement (IOA), correlation coefficient (R), standard deviation (STD), root mean square error (RMSE), mean bias (MB), and

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mean error (ME), were employed to investigate the performance of the modeling system (Table S1 and Table S2). Direct comparison between observed and simulated daily average PM2.5 concentrations is shown in Figure S2. In general, the model can well reproduce the variation characteristics of meteorological parameters and air pollution, and are comparable with previous studies. See the response to Q2 for reviewer 1.

2. A large disparity was found between the mean observed and simulated PM2.5 concentration (in Table 3). How about the time and space variations of the simulated bias? What were the main sources of error?

Response: A new set of numerical simulations were conducted, which was introduced in the revised manuscript. The comparison between simulated and observed PM2.5 concentration (Figure S2), and the statistical analysis reveal that the model can well reproduce the variation characteristics of PM2.5 concentration. The emission inventory used in the mdoel represents the emission in 2013. It is very difficult to acquire the near real time pollutant emission. The error of simulated PM2.5 concentrations is partially caused by the uncertainty of emission inventory. The error of simulated meteorological fields is another important source for the error of simulated PM2.5 concentrations. However, the error is acceptable because it is comparable with previous studies (See the response to Q2 for reviewer 1). The content in Table 3 has been modified according to the new simulation. The bias of PM2.5 concentration from new simulation is significant less than that from old simulation, indicating relative less uncertainty for modeling analysis (section 5).

3. The limitations and uncertainties in the approach of quantifying of meteorological contribution needs to be addressed. For example, one of the underlying assumptions for the approach is that amount and spatiotemporal distribution of the precursor sources emission are accurate; but it is well documented that emission inventory in Asia/China could associated with considerable uncertainty. How about the emission data used in the modelling? The potential impact of the emission uncertainty on the quantification results needs to be discussed.

Response: The model has an independent pollution emission module, which contains natural and anthropogenic emissions including many gas and particle matter emissions (Gong et al., 2009). Anthropogenic emissions of SO2, NOx, CO, VOCs, PM2.5, PM10, BC, OC, etc. used in emission module were developed by China Meteorological Administration based on Multi-resolution Emission Inventory for China (MEIC), INTEX-B inventory, the emissions database for global atmospheric research (EDGAR) and environmental statistics database. Some old data was corrected or updated according to the variation rate of anthropogenic emissions from environmental statistics database. An improved emission with high temporal–spatial resolution vehicle emission over Beijing was used to replace the old vehicle emission (He et al., 2016). The emission inventory in the model simulation represents the emission in 2013. The comparison of the emission inventory (representing the emission in 2013) to other inventories was presented in He et al. (2016). More discussions about the potential impact of the emission uncertainty have been provided in the revised manuscript. On the other hands, even though the spatial distribution of emission intensity may have an impact on the pollution levels in a city, the meteorological contribution for a city with a constant emission obtained from the current approach is reasonable and is best we can do at the moment. Reference: Gong, S. L., Zhang, X. Y., Zhou, C. H., Liu, H. L., An, X. Q., Niu, T., Xue, M., Cao, G. L., and Cheng, Y. L.: Chemical weather forecasting system CUACE and application in China's regional haze forecasting, in: Proceeding of the 26th Annual Meeting of Chinese Meteorological Society, Hangzhou, 2009 . He, J., L. Wu, H. Mao, H. Liu, B. Jing, Y. Yu, P. Ren, C. Feng, and X. Liu (2016), Development of a vehicle emission inventory with high temporal–spatial resolution based on NRT traffic data and its impact on air pollution in Beijing – Part 2: Impact of vehicle emission on urban air quality. Atmos. Chem. Phys., 16, 3171–3184.

4. Please re-evaluate the reliability of quantifying the contribution of emission change since the indirect method may have pronounced uncertainty.

Response: This is a good question. We agree that there exist some uncertainties in

doing such assessment. However, the method proposed in this paper is a step forward to quantify the contribution of emission changes. Further study is needed to improve the methodology.

5. How were the wind speed convergence lines (WSCL) calculated? Could model reproduce the observed WSCL? Please provide the supporting materials for the WSCL analyses.

Response: Wind speed sheer, i.e., abrupt decrease (increase) of wind speed, forms a convergence (divergence) zone. Based on weather analysis method, the WSCL was identified according to wind speed sheer line. The instruction of WSCL has been provided in the revised manuscript.

6. Abstract: The authors are advised to present the method and quantitative results in brief here. Response: It has been modified according to the suggestion.

7. Line 17: “meteorology” âĂŤ> “meteorological” Response: It has been corrected in the revised manuscript.

8. Page 3, Line 6-8: Zhao et al is not found in the reference list. If possible, please add references on the association of haze with ENSO. Response: It has been corrected. A new reference has been added in the revised manuscript.

9. The authors are advised to limit the number of cited non-English references. Response: Thanks for your suggestion. Non-English references have been marked and limited as much as possible in the revised manuscript.

10. P8,Line2: In my opinion, “wind convergence line” is more accurate than “wind speed convergence line” (WSCL).

Response: Wind sheer includes wind speed sheer and wind direction sheer. The convergence in North China is caused by wind speed sheer. So we use “WSCL” in the manuscript.

11. 2nd paragraph: The analyses in this paragraph need sufficient supporting materials, and the conclusions need further discussed. The association of ENSO with East Asian winter monsoon and shifting of the WSCL can not be simply established in the analysis.

Response: The relation between atmospheric circulation in North China and Area averaged SST anomalies (SSTA) over the Nino3 are analyzed in the revised manuscript. It seems that ENSO (SSTA>0) results in weak cold air and northerly wind, while opposite for La Nina (SSTA<0). These relations indicate that the worse air quality in December 2015 over North China maybe relate to significant ENSO.

12. P8, L19: “Research [Si et al., 2016]” -> “Si et al. (2016)” Response: It has been corrected.

13. P9, L2: How to draw the conclusion “the cold front in 2015 could not extend to the degree as in 2014”? It is not completely reasonable. The mesoscale cold fronts are embedded in the extratropical weather systems (i.e. baroclinic waves and the associated extratropical cyclones). Usually, the cold fronts exhibit fast movement and low occurrence frequency (about 5∼10 days per time) in the mid-latitude region. Hence, the cold front locations are not suitable to be monthly averaged for this analysis. As far as one case was concerned, the cold front in 2015 could extend to that degree/location.

Response: We agree that for each individual cold front, the degree or location reached may vary. This paper is to discuss the averaged pollution levels, therefore, we use the averaged cold front location and degree to illustrate its impact on the area and degree of air pollutant levels in these cities between 2014 and 2015.

14. PBL height is an important meteorological parameter for atmospheric transport and dispersion. The meteorological factors will be more comprehensively considered if the analysis of PBL height is added.

Response: The correlation between PM2.5 concentrations and PBL height, and the

comparison of PBL height between December 2014 and December 2015 have been provided in the revised manuscript.

15. P13, L13: Please briefly address the “2010 HTAP emission inventory data” and spatiotemporal variations of “hourly-gridded data”.

Response: To get more accurate air quality simulation, new numerical simulation was conducted in the revised manuscript. Anthropogenic emissions of SO2, NOx, CO, VOCs, PM2.5, PM10, BC, OC, etc. used in emission module were developed by China Meteorological Administration based on Multi-resolution Emission Inventory for China (MEIC), INTEX-B inventory, the emissions database for global atmospheric research (EDGAR) and environmental statistics database. Some old data was corrected or updated according to the variation rate of anthropogenic emissions from environmental statistics database. An improved emission with high temporal–spatial resolution vehicle emission over Beijing was used to replace the old vehicle emission. The model’s parameters and emission inventory are the same as previous study (He et al., 2016).

16. L14-17: Many model’s parameters (e.g., grid number, vertical levels and model initialization) should be clarified. Response: It has been provided in the revised manuscript.

17. References: Check and correct the reference format. Non-English reference should be given clear indication of the language (for example, “in Chinese”). Response: It has been corrected.

18. Some new papers (e.g., Wang et al., 2016; Yang et al., 2016) are closely relevant to this work. The authors are advised to cite or discuss these works. Response: Some views from new papers has been added in the revised manuscript.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/acp-2016-798/acp-2016-798-AC3-supplement.pdf

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