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.

Tingting Liu et al.

sunling@camscma.cn

1. The approach for meteorological factor analysis: It is an interesting approach to examine the linkage between weather pattern and PM2.5 level. It seems that some meteorological parameters are more strongly associated with PM2.5 concentrations than others. The analysis can be enhanced if these associations can be illustrated by comparing the correlations between PM2.5 and each parameter (wind speed, wind direction, temperature, and relative humidity) in the two years.

Response: Thanks for the advice. The correlations between the daily average PM2.5 concentrations and daily average meteorological parameters during 2014-2015 are added in Figure 3 in the revised manuscript. PM2.5 concentrations are positively cor-

related with 2-m temperature and relatively humidity, while negatively correlated with 10-m wind speed and boundary layer height. The correlation coefficients are significant except correlation for 2-m temperature in Shijiazhuang.

2. Considerable uncertainty may be associated with the indirect method utilized to quantify emission contribution to wintertime PM2.5 changes between the two years. The emission contribution is derived from the difference between simulated and observed PM2.5 changes under the meteorological conditions representing 2014 and 2015. The model simulations are subject to uncertainty in predicting both meteorological parameters and PM2.5 concentration (e.g., Table 1). It may be useful to address these uncertainties by first evaluating the model skills to predict key meteorological parameters.

Response: A new set of numerical simulations were conducted with the new results used in the revised manuscript. Six statistical indices, i.e., index of agreement (IOA), correlation coefficient (R), standard deviation (STD), root mean square error (RMSE), mean bias (MB), and mean error (ME), were employed to investigate the performance of modeling system (Table S1 and Table S2). In general, the model can well reproduce the variation characteristics of meteorological parameters and air pollutant levels, which are comparable with previous studies (He et al., 2016; Kioutsioukis et al., 2016). Reference: He J.J., Wu L., Mao H.J., Liu H.L., Jing B.Y., Yu Y., Ren P.P., Feng C., Liu X.H.: Development of a vehicle emission inventory with high temporal-spatial resolution based on NRT traffic data and its impact on air quality in Beijing-Part 2: Impact of vehicle emission on urban air quality. Atmos. Chem. Phys., 16, 3171–3184, doi:10.5194/acp-16-3171-2016, 2016. Kioutsioukis, I., de Meij, A., Jakobs, H., Katragkou, E., Vinuesa, J., and Kazantzidis, A.: High resolution WRF ensemble forecasting for irrigation: Multi-variable evaluation, Atmos. Res., 167, 156-174, doi:10.1016/j.atmosres.2015.07.015, 2016.

3. A more direct method to quantify emission contribution would be to conduct additional simulations by using emission data representing the two winters. A challenge of

such a method is to obtain accurate emission trends for key precursors to PM2.5. It may be possible to derive such trends from the ground or satellite observations near emission sources or during particular time window (e.g., 6-9am local time for mobile sources from near road monitors). Adding these additional analyses will make the emission attribution more convincing.

Response: We agree that this is another way to assess the emission contributions. However, it is almost impossible to get the accurate emissions for different chemical species from ground or satellite data. As a matter of fact, this paper is trying to use the model to get such information.

4. Page 2: L2-3 with an annual mean concentration of fine particulate matter (PM2.5) ranging from . . . Response: It has been modified according to the suggestion.

5. P2L6: change "negative" to "adverse". Response: It has been modified according to the suggestion.

6. P2L12: change drop to dropping Response: It has been modified according to the suggestion.

7. P2L18: change "hardly combined" to "did not consider" Response: It has been modified according to the suggestion.

8. Page 3: L11-12: study of air pollution conditions in the last two months of 2015 Response: It has been modified according to the suggestion.

9. P3L15: give abbreviations for both terms first used here. Response: The abbreviations appear in the revised manuscript has been checked carefully.

10. Page 6: Figure 2. It is difficult to discern the numbers and text in these maps. Please simplify the background and highlight the text/numbers relevant to the main message here. Response: The Figure has been replotted in the revised manuscript.

11. Page 7: Table 1. If we use SO2 as an indicator to coal burning emission sources

and NOx to mobile sources, it seems that either coal burning was significantly lower in 2015, or SO2 to sulfate conversion was more efficient, regardless of increased concentrations in CO and NO2 from 2014 to 2015. How important is sulfate to PM2.5 in these cities? If chemical speciated measurements of PM2.5 are available during this study, it would interesting to analyze the SO2 to sulfate ratio and NO2 to nitrate ratio to see if the gas-to-particle conversion has changed over time. It will be useful to understand the relative contribution from emissions, transport, or gas-to-particle processes.

Response: Thanks for your advice. The chemical species can help us to understand the relative contribution from emissions and atmospheric chemical processes. Unfortunately, there isn't chemical observed data for us in December 2014 and 2015.

12. Page 8: L2. How was WSCL calculated here? Please provide either details of the calculation or a traceable reference.

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.

13. Page 9: L1. Please clarify "temperature anomaly". Is it higher or lower than the average? Response: It has been modified to make the description clearer.

14. P9L4. northward? Response: It has been modified according to the suggestion.

15. P9L14. Remove "were". Response: It has been modified according to the suggestion.

16. Page 10: L9: 2015 Response: Thanks for your reminding. It has been corrected.

17. Page 11: L2: remote "was" L13: more than 27% or doubled? Response: It has been modified according to the suggestion.

18. Page 13: L9: emission modeling system; L14: mode(l) Response: It has been

modified according to the suggestion.

19. P15: L1: define how was the difference percentage calculated. Response: An explanation has been provided in the revised manuscript.

20. P16: L1-3: the 8% seems be reasonable for emission changes from one year to the next, but the number is very small considering the large changes and opposite directionality in PM2.5 precursor concentrations.

Response: Thanks for your advice. The values of PM2.5 concentration variation between December of 2014 and 2015 due to emission control have some uncertainty caused by uncertainty of air quality simulation. Hence these descriptions have been removed in the revised manuscript.

21. Table 3: large discrepancy exists between observed and simulated PM2.5 concentrations. What are the major reasons underlying these biases and how will the biases be propagated into the met/emission attribution?

Response: New numerical simulation was 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 CUACE model can well reproduce the variation characteristics of PM2.5 concentration. Large discrepancy between observed and simulated PM2.5 concentrations was caused mostly by uncertainty of emission inventory. The discussion about the performance of CUACE has been provided 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-AC1-supplement.pdf