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Reply on RC3

Qingyang Xiao et al.

Author comment on "Separating emission and meteorological contributions to long-term $PM_{2.5}$ trends over eastern China during 2000–2018" by Qingyang Xiao et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-28-AC3, 2021

This work used a combination of machine learning model, statistical model and chemical transport model to quantify the contribution to PM2.5 variation from meteorological impacts and emission changes during 2000–2018. It is indicated that although emissions dominated the long-term PM2.5 trends, the meteorology-driven anomalies also played a crucial role in PM2.5 trends. Overall, this manuscript is well structured and well written. I think this work well fits the scope of this journal and it is suggested to be published after addressing the following issues.

Response: We thank the referee for the positive tone and the valuable suggestions to improve our manuscript.

The authors emphasized the contribution of meteorology to interannual and seasonal trends of PM2.5, especially in fall and winter. Though some existing studies have conducted similar analysis, it would be more interesting to discuss the different meteorological factors in detail based on this GAM model, rather than summarizing as meteorological effects. Also, the mechanism of meteorological impact on PM2.5 might be quite different in the cold and warm season. It is also worth being analyzed since that the seasonal variation of PM2.5 is discussed here.

Response: Thank you for these suggestions. We fitted regressions with normalized meteorology parameters and discussed their relative contributions in line 314-319, "Regarding the relative contribution of the different meteorology parameters, we found that over the south coast region, temperature and humidity showed greater effects than did the boundary layer height and precipitation. In winter, humidity, boundary layer height and precipitation were critical for the $PM_{2.5}$ variations in the middle and north of China. In summer and fall, the temperature and humidity were critical for the $PM_{2.5}$ variations across southern China. In spring, the temperature showed notable effects in the south coast region, and the precipitation exhibited large effects in the North China Plain." We summarized seasonal differences in meteorological effects on $PM_{2.5}$ in Figure A4 and in line 302-314, "Consistent with previous studies, we also observed spatially and seasonally varying associations between $PM_{2.5}$ and meteorological parameters that reflect the varying $PM_{2.5}$ responses to meteorological changes (Fig. A4). Temperature was positively associated with $PM_{2.5}$ in spring, summer and fall across East China; however, in winter, the temperature was negatively associated with $PM_{2.5}$ in northern China (He and Wang, 2017;Qiu et al., 2015) due to the low-temperature-related stable

atmosphere and decreased evaporation loss of $PM_{2.5}$. Humidity yielded positive effects in northern China and negative effects in southern China in all seasons, especially in winter (He et al., 2017;Zhai et al., 2019). The spatial difference in the effects of humidity on $PM_{2.5}$ may occur due to a threshold of the humidity altering the direction of the humidity influence, from hygroscopic increase to wet deposition. Zhai et al. (2019) also discussed the north-south contrast in the $PM_{2.5}$-humidity associations and indicated that the positive effects of humidity on $PM_{2.5}$ in the north were partly attributed to the favorable role of aqueous-phase aerosol chemistry in secondary $PM_{2.5}$ formation and the negative $PM_{2.5}$-humidity associations in the south were partly attributed to the precipitation related wet deposition. The boundary height and precipitation were negatively associated with $PM_{2.5}$ across East China in all seasons, and the effect of precipitation was greater in northern China than that in southern China (Wang and Chen, 2016)." We also added discussion on the mechanisms of seasonal variations in meteorological impacts in line 319-321, "The seasonal variations in meteorological impacts could be due to the interactions between meteorological parameters that showed significant seasonal patterns. Further studies are needed to understand the mechanism of seasonal differences in the meteorology-pollution relationships."

Section 2.2 Although similar methods have been applied before, it is suggested to specify and justify the methodology and parameters used in this work. Some explanation is still needed. For example, why the PM2.5 concentration is correlated to wind at 500 hPa but some other work (e.g., Zhai et al., 2019) chose 850hPa.

Response: We selected these meteorology parameters since they are previously reported significantly affect air pollution (Chen et al., 2018;Chen et al., 2020) and they contributed critically in previous $PM_{2.5}$ prediction models (She et al., 2020;Xiao et al., 2018). Specifically, we selected wind at 500 hPa rather than wind at 850 hPa since wind at 500 hPa is used to characterize air stagnation (Feng et al., 2020) and it performed significantly in the GAM model. It is notable that these meteorology parameters are correlated with each other (Cai et al., 2017) and it is hard to analyze the effects of individual meteorological factor with statistical methods. We added the following sentences to clarify the parameter selection in line 150-152, "These meteorological parameters have been reported to be strongly associated with $PM_{2.5}$ concentrations in various regions in China (Chen et al., 2020;Feng et al., 2020) and contributed significantly in previous $PM_{2.5}$ prediction models (She et al., 2020)."

Line 143, missing "V wind at 500 hPa"?

Response: We added these missing words.

Section 3.1 and 3.2 are too short to be an individual section.

Response: Thank you for this suggestion. We combined these two sections as Section 3.1.

Line 165: delete the redundant reference "Maji et al., 2019 "

Response: We deleted the repeated references.

Line 209, change to "interannual variability" or "long-term trends". It needs to be checked and corrected throughout the manuscript.

Response: We changed the section title to "Interannual and seasonal variabilities

of meteorology-associated $PM_{2.5}$". We also reviewed the manuscript and corrected the related error.

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