Authors reply to reviewer's comments:

Dear Anonymous Referees,

Thanks for your careful review of the manuscript. We read the reviewer's comments carefully, and have responded and taken all of reviewer's comments into consideration and revised the manuscript accordingly. My detailed responses, including a point-by-point response to the review and a list of all relevant changes, are as follows:

"Reviewer #2: This paper uses very comprehensive measurements, including PM2.5 mass concentrations, radiosonde observations, etc., to understand the two-way feedback mechanism between unfavorable meteorological conditions and cumulative aerosol pollution in several heavily and less heavily polluted regions in China. Previous studies have been focused on the North China region, while this study can provide a more general picture with extended study regions.

"1) My major concern for the paper is that the presentations of the results are descriptive, and I would suggest the authors provide more in-detailed calculations and present in a more quantitative way."

Response: Two figures (Fig.5 and Fig. 16) and corresponding discussions have been added to further quantitatively estimate the magnitude of the two-way feedback from TSs to CSs in different regions (L242-L260; L514-524). To better show the aerosol-induced temperature reduction, we mainly focused on polluted Beijing, Xi'an, and Shenyang, which have more striking meteorological modification.

"2) Near ground temperature bias are shown at different PM2.5 concentrations, however, it is not clear to what extend is contributed by aerosol effects. It is likely that those temperature structures co-occur with different stagnant conditions and thus are different at different PM2.5 concentrations. It would be better to provide more quantitative results here."

Response: The contributions of aerosol-radiation feedback and decrease in turbulent diffusion to $PM_{2.5}$ growth has been quantified using an online model, GRAPES_CUACE, which also indicates online calculation of the aerosol-radiation feedback is essential for the prediction of $PM_{2.5}$ explosive growth and peaks during HPEs. With the online aerosol feedback, the modeled local inversion was much closer to the sounding observations (Wang et al., 2018). In this manuscript, we wanted use statistical analysis to show the aerosol-induced temperature modification. Although the effect of aerosols on radiative transfer in the atmosphere is modeled based on prescribed climatological aerosol distributions (Dee et al., 2011), it has not considered the two-way feedback mechanism between the cumulated aerosol pollution and the worsened meteorological conditions (Simmons, 2006). Therefore, the magnitude of the feedback mechanism could be statistically reflected by the gaps between the ERA-interim reanalysis and the meteorological radiosonde observations. The disparities have been used to present the observational evidence of aerosol-PBL interactions in Beijing (Ding et al., 2016; Huang et al., 2018).

Previous studies have shown that HPEs generally included the TSs, whose aerosol pollution formation is primarily caused by pollutants transported from polluted regions, and the CSs, in which the $PM_{2.5}$ increase is dominated by stable atmospheric stratification characteristic near-ground anomalous inversion, moisture accumulation and reduced BL height under slight or calm winds. During the CSs, the temperature inversion was found to be caused or reinforced mainly by accumulated aerosols. Other factors, including topography, advection and long-wave radiation are likely conducive to weak/normal inversion, but not dominant with respect to anomalous inversion (Zhong et al., 2018a; Zhong et al., 2018b; Zhong et al., 2017).

> **"3) Line 41-43: It is not surprising that FWRP and YRD regions are largely influenced by inter-regional and trans-regional transport. It would be more valuable to know in these regions, how important are the two-way feedback in cumulative periods, compared to the abrupt injection of transport."**

Response: As suggested, we added figures and discussions about the comparison and magnitude of the two-way feedback mechanism in TSs and CSs (Fig. 5 and Fig.16; L242-L260; L514-524), particularly in the polluted Beijing, Xi'an, and Shenyang with more striking meteorological modifications. Overall, the temperature modification was more striking with increasingly worsened aerosol pollution. For different stages, aerosol-induced near-ground cooling bias in the TSs was 18.6%, 48.7% and, 28.2% of that in Beijing, Xi'an and Shenyang. It is expectable because from the TSs to the CSs aerosol pollution worsened with increasing radiative cooling effects. Moreover, though relatively strong winds in the TSs were conducive to pollution transport, they were unfavorable for the formation and maintenance of stable stratification, in which occurred aerosol self-induced pollution deterioration frequently.

Dee, D.P. *et al.*, The ERA-Interim reanalysis: configuration and performance of the data assimilation system, *Quarterly Journal of the Royal Meteorological Society* **137**(2011), pp. 553-597.

Ding, A.J. *et al.*, Enhanced haze pollution by black carbon in megacities in China, *Geophysical Research Letters* **43**(2016).

Huang, X., Wang, Z., Ding, A., Impact of Aerosol-PBL Interaction on Haze Pollution: Multiyear Observational Evidences in North China, *Geophysical Research Letters* **0**(2018).

Simmons, A., ERA-Interim: New ECMWF reanalysis products from 1989 onwards, *ECMWF newsletter* **110**(2006), pp. 25-36.

Wang, H. *et al.*, Contributions to the explosive growth of PM 2.5 mass due to aerosol–radiation feedback and decrease in turbulent diffusion during a red alert heavy haze in Beijing–Tianjin–Hebei, China, **18**(2018), pp. 17717-17733.

Zhong, J. *et al.*, Feedback effects of boundary-layer meteorological factors on cumulative explosive growth of PM2.5 during winter heavy pollution episodes in Beijing from 2013 to 2016, *Atmos. Chem. Phys.* **18**(2018a), pp. 247-258.

Zhong, J., Zhang, X., Wang, Y., Liu, C., Dong, Y., Heavy aerosol pollution episodes in winter Beijing enhanced by radiative cooling effects of aerosols, *Atmospheric Research* **209**(2018b), pp. 59-64.

Zhong, J. *et al.*, Relative contributions of boundary-layer meteorological factors to the explosive growth of PM 2.5 during the red-alert heavy pollution episodes in Beijing in December 2016, *Journal of Meteorological Research* **31**(2017), pp. 809-819.