Response to Reviewer #1:

Aerosol-planetary boundary layer (PBL) interaction is proposed as an important mechanism to stabilize the atmosphere and exacerbate surface air pollution. Attempts to analyze aerosol-PBL interaction by using observation data are rare and worth encouraging. Thus, I recommend a minor revision before publication. The detail comments or suggestions are shown below:

Response: We appreciate the reviewer's positive and constructive comments on our work. All of the comments and concerns raised by the referee have been carefully considered and incorporated into this revision. Our detailed responses to the reviewer's questions and comments are listed below.

1. *My main concern about this study is how to get cause-effect from correlations. As we know, PBL has a strong impact on surface aerosol concentration and aerosol vertical profile (forward effect). Compared to that, the impact of aerosol on PBL (reverse effect) can be treated as a perturbation. Thus, it is hard to get the contribution of reverse effect only. For example, Line 265 to 272. It is claimed that "In general, there are stronger correlations between PBLH and PM2.5 under inverse aerosols structure. This phenomenon indicates that the absorbing aerosol could play a more important role in the inverse aerosol structure.". Let's imagine that the decreasing and inverse profile are formed by specific PBL structure, we may get a similar relationship between PBL height and PM2.5 in Figure 5. Moreover, it is possible that the correlations are caused by some other factors, simultaneously, like the front process or precipitation.*

Response: Indeed, the PBL and aerosols mutually affect each other. While it is challenging to differentiate their respective impacts on each other, we have used the MPL-derived PBLH and in situ $PM_{2.5}$ data to show their correlation, which can indicate the overall intensity of aerosol-PBL interaction, but cannot represent the feedback intensity. Since we considered only cloud-free cases, rainfall would

not affect the correlations. But many other factors do affect the PBLH- $PM_{2.5}$ correlations, as well as the aerosol-PBL interaction. Therefore, the correlations cannot explain the causality and aerosol feedback loop. The correlations between PBLH and $PM_{2.5}$ provide hints about the differences in aerosol-PBL interactions for different aerosol structures. Using SBDART constrained by ample observations, we investigated the vertical profiles of radiative forcing induced by aerosols and its impacts on atmospheric stability.

A detailed discussion has been incorporated into the revised Section 3.2.

2. *I don't quite understand the role of Figure 6 and the corresponding part of the manuscript. It seems that Figure 6 does not support the topic directly and may be considered to be moved to SI.*

Response: We apologize for not clearly describing and elaborating on the role of Figure 6 in making an important point.

In general, the inverse structure is characterized by higher aerosol loading and a lower PBLH, whereas the decreasing structure is characterized by light pollution and a well-developed PBL. For the inverse structure, the lower PBLH growth rate, along with high aerosol loading, can be explained by the strong aerosol-PBL interaction. The diurnal variations in aerosols and the PBL are controlled by many factors. The strong aerosol-stability interaction generates an unfavorable condition for aerosol vertical dissipation in the vertical, so surface aerosol loading can continuously accumulate due to emissions.

The discussion has been incorporated into the revised Section 3.2.

3. *More quantitative analysis is needed in the Results part. I can barely find the detail of quantitative discussion figures, especially in 3.3. I'm not sure if Figure 7 is a specific case, a statistic scenario or just a diagram? It seems there are too many*

diagrams in the manuscript.

Response: Figure 7 presents statistical results derived from all available measurements (same as Figure 6). We revised the figure description to avoid any misunderstanding. Based on observations, we calculate the aerosol radiative forcing by SBDART for all cases. We can then obtain averaged diurnal cycles of the vertical profile of aerosol radiative forcing for different aerosol structures.

4. *It might be helpful to show some statistical information and meteorological condition information. For example, the occurrence/frequency of each aerosol vertical structure within PBL. Does it occur in specific seasons or weather conditions?*

Response: We added the number of AEC profiles for different aerosol structures during the study period in the revised Section 3.1.

"The number of samples and percentages of decreasing, well-mixed, and increasing aerosol structures are 998 (51%), 611 (32%), and 330 (17%), respectively."

All three types of profiles commonly occur in the real atmosphere. The decreasing structure is more frequent during the afternoon, partly due to the entrainment at the top of a PBL. Through the PBL development, entrainment brings dry and clean air from the free atmosphere into the PBL, diluting the aerosol loading in the upper PBL.

Multiple entangled factors are related to the formation of different aerosol structures within the PBL, including synoptic patterns, new particle formation, vertical turbulence, horizontal transport, entrainment rates, to name a few. The complexity of this issue is an important reason for the poor representation of aerosol vertical distributions in numerical models. We will further investigate this issue, which will be presented in a future paper.