Response to Reviewer #2:

The manuscript addresses a critical and challenging issue in aerosol effects on weather and climate, i.e. the influence of aerosol vertical structure on boundary layer stability and height. The two-year concurrent observations from micropulse lidar, sun-photometer, and radiosonde were employed to provide direct and quantitative evidence on the aerosol radiative effects on the boundary layer development. The contrasting effects of different aerosol vertical structures identified by this study are important to know and call on a better representation of aerosol vertical profile in numerical models for future aerosol effect assessment. The paper is well written overall, and its scientific merit is clear. I recommend its publication with ACP, while I also have comments below for the authors to address.

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. *Figure 2, are the data here from three cases or composites from all available observations? I have the similar question for Figs. 3-7 as well. Please clarify the data source and sampling range in the figure captions.*

Response: We clarify that the results are averaged from all available observations during the study period. We added the number of samples in the panels or in the descriptions of the figures. The latter are carefully checked to assure that the data sources are clearly stated.

2. *Is R* in Figure 3 for linear regression and R* in Figure 5 for the inverse fitting? Better to use different symbols for different types of regression.*

Response: Revised, per your suggestion.

3. *As shown in Figure 5, the weakly absorbing aerosols can also suppress PBLH. I assume it is caused by the reduction in solar radiation reaching the surface and the consequent suppression*

in surface latent/sensible heat fluxes. Since the authors have performed the radiation transfer simulations, I'm wondering if they can illustrate the importance of atmospheric heating and surface cooling for PBL development when absorbing aerosols are present.

Response: Thanks for raising this point. We clarify that both absorbing and weakly absorbing aerosols reduce the radiation reaching the lower atmosphere and the surface, thus suppressing the PBLH. Both decreasing and inverse aerosol structures can cool the surface and suppress sensible heat, thereby stabilizing the PBL. Despite the different aerosol structures, aerosols cause a notable stabilizing effect near the surface.

On the other hand, for the decreasing with height structure, the abundance of aerosols near the surface generates a stronger aerosol heating rate in the lower PBL than in the upper PBL. Such aerosol radiative forcing decreases the potential temperature gradient ($d\theta/dz$) in the middle to upper PBL, further strengthening vertical convection in the middle to upper PBL. The opposite aerosol effects on PBL stability weakens the aerosol-PBL feedback, as is shown in our study. For the inverse aerosol structure, the significant heating effect in the upper PBL facilitates the formation of a temperature inversion and further increases the stability and suppresses the PBLH. The notable increase in stability lead to the strong, positive aerosol feedback, as is demonstrated in Figure R1 (the revised Figure 9).

Turbulent fluxes and eddies in the PBL can spread out and redistribute the radiative effects induced by aerosols. We need to resort to numerical simulations to quantify the aerosol impacts on the PBL. Since the aerosol vertical distribution is still poorly represented in numerical models, improvements in model simulations are warranted to better understand the aerosol-PBL interaction quantitatively. This is an ongoing study by our team that will be presented in a future paper.

A detailed discussion has been incorporated into the revised Section 3.3 and Section 4.

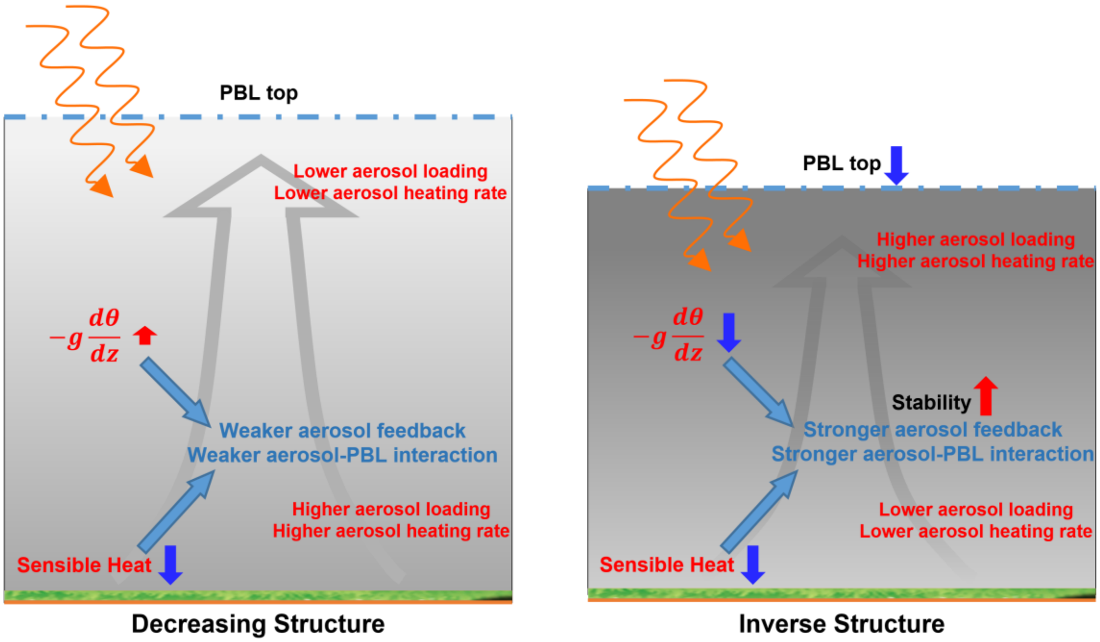

Figure R1. Schematic diagrams describing aerosol-PBL interactions when decreasing and inverse aerosol structures are present. The blue dash-dotted line indicates the top of the PBL. Orange curved arrows indicate solar radiation. The background grey arrow shows the vertical transport of humidity, aerosols, and heat. The background greyscale indicates the pollution level.

4. *L285-286, the sentence is hard to follow. What do you mean by "significant heating in the different parts of PBL"?*

Response: We revised this sentence as follows:

"Figure 7 shows that the vertical distributions of the heating rate differ drastically among the different aerosol structures."

5. *Since the authors possess ample observations data, can you show the occurrence/frequency of each aerosol vertical structure within PBL (decreasing, inverse, and well-mixed)? It is interesting to know the relative importance of those three structures in the real atmosphere. Moreover, can you sort out what factors determine those distributions within PBL?*

Response: Per your guidance, we present the number of samples for each aerosol structure 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."

The decreasing structure is more frequent during the afternoon, partly due to the entrainment process. Through the development of a PBL, entrainment brings dry and clean air from the free atmosphere into the PBL, diluting the aerosol loading in the upper PBL. Note that multiple entangled factors can contribute 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 the aerosol vertical distribution in numerical models.

This discussion has been incorporated into the revised Section 3.2.

6. *L309-315 and Figure 9. What is the physical/chemical mechanism of the negative feedback, i.e. stable PBL leads to less aerosol formation? The color of big red arrow in the upper part of Figure should be changed to blue, as it is about negative feedback.*

Response: A low PBLH and high stability increase the aerosol loading. This mechanism is straightforward and clear. We investigate the opposite effect: how aerosols affect the PBL via their feedbacks. If the aerosol heating effect is much stronger on near surface than upper PBL, aerosol can decrease the stability in PBL, and cause the negative feedback. Negative feedback partly offset the PBL's impact on the aerosol loading. The large variations in the impact of aerosols on stability and PBL development lead to different magnitudes in the aerosol-PBL interaction.

This discussion has been incorporated into the revised Section 3.3. We also use a revised figure (Figure R1) to replace the previous Figure 9 to better demonstrate the interactions.

7. *L334, it should be Wang et al. 2013.*

Response: Revised.

8. *Please remove "conclusive" from the title, as it is a very subjective word.*

Response: Per your comment, we changed it to "significant".