Responses to comments of "Interaction between aerosol and thermodynamic stability within the PBL during the wintertime over the North China Plain: Aircraft observation and WRF-Chem simulation [Preprint acp-2021-769]" to *Atmospheric Chemistry and Physics*.

Hao Luo, Yong Han*, and co-authors

We would like to thank the editor Dr. Li, Z. and the reviewers for giving constructive criticisms and comments, which are very helpful in improving the quality of the manuscript. We have made the point-by-point response to the comments (Report #3) below and revised the manuscript accordingly. We hope that the revised version can meet the favorable approval and journal requirements. The referee's comments are reproduced (*black, italic*) along with our replies (blue) and changes made to the text (red) in the revised manuscript. All the authors have read the revised manuscript and agreed with the submission in its revised form. Please check them.

Responses to Referee

Anonymous Referee #1 (Report #3)

The authors make substantial changes to their manuscript. However, a few problems have been well addressed in the response.

Response:

Dear Reviewer,

We would like to thank you for your time in reviewing this manuscript. The manuscript has been revised according to your substantive comments. Please check the point-by-point response to your remarks below.

Comment NO.1

1. As discussed in Ma et al. (2020), the stove/dome effects are mainly related to the aerosol vertical distributions, which are affected by multiple factors. Horizontal advection may not lead to a certain type of aerosol vertical distribution.

Response: Thank you for your critical comments and insightful suggestions. We agree with your assessment that the horizontal advection may not lead to a certain type of aerosol vertical distribution, as other factors (e.g. topography, surface cover type, mountain breeze, emission source, etc.) may also contribute to the variations in aerosol vertical dispersion (Su et al., 2018, Ma et al., 2020). Su et al. (2018) has found a nonlinearly negative response of surface particulate matter to planetary boundary layer height (PBLH) evolution over the polluted regions in China, especially in the North China Plain (NCP), which supports your opinion. However, in this study, our principal result is that the synoptic forcing (e.g. horizontal advection) may contribute to the PBL

thermal structure and PBLH, and then the PBL influences the vertical dispersion of aerosols. The previous study has also verified the conclusion that wind field and PBLH tend to be correlated, which means meteorologically favorable horizontal and vertical dispersion conditions are likely to occur together (Su et al., 2018). To make the paper clearer, some explanations have been added in the revised version.

Reference

Ma, Y., Ye, J., Xin, J., Zhang, W., Vilà-Guerau de Arellano, J., Wang, S., Zhao, D., Dai, L., Ma, Y., Wu, X., Xia, X., Tang, G., Wang, Y., Shen, P., Lei, Y., and Martin, S. T.: The Stove, Dome, and Umbrella Effects of Atmospheric Aerosol on the Development of the Planetary Boundary Layer in Hazy Regions, Geophysical Research Letters, 47, e2020GL087373, 10.1029/2020GL087373, 2020.

Su, T., Li, Z., and Kahn, R.: Relationships between the planetary boundary layer height and surface pollutants derived from lidar observations over China: regional pattern and influencing factors, Atmos. Chem. Phys., 18, 15921-15935, 10.5194/acp-18-15921-2018, 2018.

Changes in Manuscript:

[Page 21 Lines 394-395 (in the "Track Changes" version)]

"The previous study has also verified the conclusion that wind field and PBLH tend to be correlated, which means meteorologically favorable horizontal and vertical dispersion conditions are likely to occur together (Su et al., 2018)."

Added Reference

Su, T., Li, Z., and Kahn, R.: Relationships between the planetary boundary layer height and surface pollutants derived from lidar observations over China: regional pattern and influencing factors, Atmos. Chem. Phys., 18, 15921-15935, 10.5194/acp-18-15921-2018, 2018.

Comment NO.2

2. Based on the schematic diagram (Figure 16), absorbing aerosols and warm advection will lead to the stove effect, which increases the PBLH. As aerosol will significantly suppress the sensible heat, it may need more elaborations. Lape rate is only one of the impact factors.

Response: Thank you for your constructive criticisms. We agree with you that the stove effect of the near-surface absorbing aerosol traps the solar radiation and leads to a decrease in the surface sensible heat. Ma et al. (2020) has confirmed that the radiative heating of high concentration absorbing aerosols near the surface will offset and exceed the reduction of surface sensible heat flux, resulting in near-surface heating. The low-layer heating, together with the surface buoyancy flux, aids in the growth of PBLH (Ma et al., 2020). We have elaborated on it in the revision.

Reference

Ma, Y., Ye, J., Xin, J., Zhang, W., Vilà-Guerau de Arellano, J., Wang, S., Zhao, D., Dai, L., Ma, Y., Wu, X., Xia, X., Tang, G., Wang, Y., Shen, P., Lei, Y., and Martin, S. T.: The Stove, Dome, and Umbrella Effects of Atmospheric Aerosol on the Development of the Planetary Boundary Layer in Hazy Regions, Geophysical Research Letters, 47, e2020GL087373, 10.1029/2020GL087373, 2020.

Changes in Manuscript:

[Page 19 Lines 356-359 (in the "Track Changes" version)]

"Ma et al. (2020) has confirmed that the radiative heating of high concentration absorbing aerosols near the surface will offset and exceed the reduction of surface sensible heat flux, resulting in near-surface heating (stove effect). The low-layer heating,

together with the surface buoyancy flux, invigorates the turbulent mixing and leads to a higher lapse rate and PBLH (Ma et al., 2020)."

Reference

Ma, Y., Ye, J., Xin, J., Zhang, W., Vilà-Guerau de Arellano, J., Wang, S., Zhao, D., Dai, L., Ma, Y., Wu, X., Xia, X., Tang, G., Wang, Y., Shen, P., Lei, Y., and Martin, S. T.: The Stove, Dome, and Umbrella Effects of Atmospheric Aerosol on the Development of the Planetary Boundary Layer in Hazy Regions, Geophysical Research Letters, 47, e2020GL087373, 10.1029/2020GL087373, 2020.

Comment NO.3

3. The authors may further revise the description in section 3.4. The interannual variabilities are affected by numerous factors. How the correlations conclude that "EAWM and SH with the prevailing south wind stabilize the PBL and constrain the aerosols to the near-surface, while the strong EAWM and SH play the opposite role."

Response: Thank you for your valuable comments. We agree with your suggestions and have added the relevant descriptions in the revised version.

Changes in Manuscript:

[Page 24 Lines 443-444 (in the "Track Changes" version)]

"In fact, the inter-annual variabilities of the PBL are affected by numerous factors, and we only discuss the influence of meridional wind intensity in this study, which is a climatological extension of the case study."

[Pages 24-25 Lines 453-457 (in the "Track Changes" version)]

"Weak EAWM and SH, in conjunction with the prevailing south wind, decrease the lapse rate between 1000 hPa and 850 hPa and stabilize the PBL, while the strong

EAWM and SH play the opposite role. According to the above synoptic analysis, it is concluded that the changes in PBL properties will further affect the surface air quality, aerosol vertical distribution, and ARE. As a result, the EAWM and SH indirectly influence the aerosol vertical distribution by modulating the PBL thermodynamic structure."

Again, we would like to thank you for taking time to review this manuscript and providing insightful comments and advice. we believe that this work has been much improved with your constructive and informative remarks.

Dr. Yong Han

On behalf of all the authors