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Comment on acp-2021-769

Anonymous Referee #3

Referee comment on "Interaction between aerosol and thermodynamic stability within the planetary boundary layer during wintertime over the North China Plain: aircraft observation and WRF-Chem simulation" by Hao Luo et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-769-RC1, 2021

The manuscript presents the interaction of absorbing and scattering aerosol with PBL under different synoptic patterns based on the observation and WRF-Chem model simulations. It's an interesting study that help understand how such aerosol-PBL interactions affect the PBL thermodynamics and air quality (PM2.5). This paper also discussed potential impact of synoptic weather conditions on the PBL thermodynamics. Overall, the paper is written well. But, there are some confusions or missing parts that need be clarified.

Specific comments:

1. The paper was lack of describing how aerosols optical parameters (absorption and scattering coefficient) are obtained and constrained in the WRF-Chem model in order to estimate aerosol-radiative-effect (ARE). For instance, how large are those aerosol absorption coefficients for black carbon(BC) abd single scattering albedo (SSA) used?

2. The paper did not clearly show the PBL-height until they were given in Fig.10 in Page-19. Please describe how the PBL-height is calculated or obtained? Is it based on the Richardson number or potential temperature gradient method, or else? It might be better to display the PBLH in Fig.7 or earlier.

3. The lapse rate is used for many times in the paper. What range of the altitude is it calculated or referred? In Line 376-377, it is referred the range between 1000 mbar and 850-mbar, but in Line 355it is referred below 1.5 km altitude.

4. Fig. 2 (d)-(e), why are there no temperature and wind data below 750-m from the aircraft observation which are critical to assess the PBL height and thermal stability? Fig. 2 (e), why do the observed wind speeds show so large fluctuations and many stratified structures below 3 –km?

5. Fig.4, it might be better to give the horizontal wind speed, wind direction and vertical wind velocity on Jan.3 and 4 as shown for the temperature.

6. Fig.6 (a)-(c), what are those the horizontal dash lines? Fig.6, the observed aerosol number density profiles on Jan.3 and Jan.4 show very similar stratification structures below 1 km altitude except higher concentration on Jan.3. Was the aloft aerosol layer at 1.0-1.7 km altitude on Jan.4 related to the PBL vertical mixing transport?

7. Fig.8, How do the results show strong heating effects from BC and aerosol cooling effects in the night of Jan 3 and early morning of Jan 4 when there were lack of solar radiance?

8. Line 157, Which metric or parameter is used to quantify PBL thermodynamic stability?

9. Line 265-275, authors pointed out that the PBL thermal stability potentially related to the simulated aerosol vertical distribution in Fig.7, but there are no potential temperature and winds displayed. Please give them for better understanding the discussions in Line 265-275 if possible.

10. Fig.13, how to calculate the standardized anomaly of the wintertime boundary layer lapse rate?

11.Line 289, how do you judge "stronger vertical mixing" on Jan.4 than those on Jan.3?

12. Line 351, "….which are sensitive to the PBL thermal structure." The phrase "are sensitive to" might be replaced with "affect".

13. Line 389, please take out the word "systematically". This study only shows the analysis for the two-day data.

14. The paper only considers the PBL thermodynamics and turbulent mixing related to the

lapse rate and temperature variation, but ignores temperature-RH related secondary aerosols formation (SOA) on Jan.3 and 4 such as nitrate and sulfate SOA.