Comments on "Classification of summertime synoptic patterns in Beijing and their association with boundary layer structure affecting aerosol pollution"

General Comments

It is well known that air pollution is directly associated with atmospheric boundary layer height (BLH). The daytime convective boundary layer (CBL) develops in the synoptic background. Thus the synoptic conditions affect the BLH and consequently air pollution. In this paper, the authors divided the summertime synoptic conditions in Beijing area into seven typical patterns and analyzed the BLH and air pollution level in different synoptic patterns. The results suggest that, the positive synoptic conditions promote CBL development, and higher BLH leads to light air pollution, whereas the adverse synoptic conditions suppress CBL development, and lower BLH leads to heavy air pollution. The authors provided some details about how the special synoptic conditions influence the BLH, and proposed a possible mechanism to explain the reason. The results in this paper can help to understand the impact of synoptic conditions on air pollution. However, some statements and discussion are not convincing, and the English writing should be further improved. Therefore, my recommendation is publication in ACP after major revisions.

Specific Comments

1. For Eq. (1), presence of u_* (not bu_*^2) in the right hand side is an error. If the authors used this formula to calculate the BLH, the results are incorrect.

2. This study emphasizes that heavy air pollution is caused by low BLH. But the authors did not provide solid evidences. In Fig. 3b, the results show that the diurnal variation of 1 h-bin averaged PM2.5 concentration is not significant, but the difference in BLH between 14:00 and 08:00 (or 20:00) is very larger. In addition, even for the situation at 14:00, Fig. 4b shows that the correlation coefficient between PM2.5 concentration and BLH is relatively low. Then the problem arises. What is the major reason for the formation of heavy air pollution in Beijing in summertime, reduction of BLH or transportation of pollutant? In my opinion, discussing the impact of BLH on air pollution level is based on the premise that the air pollution is caused by local emissions. The above mentioned results suggest it may be not the case. If the air pollution is caused by transportation of pollutant, the low BLH may be the result rather than the reason of heavy air pollution. Therefore, the authors should be cautious when discussing the relationship between BLH and air pollution level, and state their results more reasonably.

3. For the results in Fig. 8, I do not know how the authors obtained the correlation coefficients. This figure shows that the correlation coefficient between PM2.5

concentration and BLH is -0.97 (the absolute value is very close to 1.0). In page 12 line 7, the authors said ‘the BLH is the most crucial factor related to aerosol pollution level under different synoptic conditions’. But Fig. 4b shows that the correlation coefficient is very low (the absolute value is smaller than 0.4). I cannot understand such a large difference between the two results. The authors should explain why. Secondly, Fig. 8 shows a high positive correlation between PM2.5 concentration and CLD and a high negative correlation between PM2.5 concentration and CLD. These results imply that the lower BLH is highly related to the larger cloud cover. It is know that the daytime CBL is driven by surface heating. The large cloud cover reduces radiation arriving the surface and then the surface sensible heat flux. This may be the reason for the lower BLH in cloudy days. But the authors only emphasize the effect of capping inversion (they propose a mechanism about this as illustrated in Fig. 13). Thirdly, results in this figure suggest that the wind direction plays an important role in the formation of air pollution. High air pollution level is associated with south wind, implying that the pollutants may come from the cities south of Beijing. In this situation the lower BLH may be caused by the enhanced air pollution. However, the authors’ analyses give me a strong feeling that the reduced BLH leads to heavy air pollution. So my question is how to interpret the results in Fig. 8. The authors should provide us a “clear picture”.

4. Page 13, line 1-2 ‘Among the seven identified synoptic patterns, the strongest near-surface could advection is associated with Type 1 (Fig. 11a), leading to the coldest PBL at 1400 BJT (Fig. 9a)’, and line 5-6 ‘Types 2, 4, 5 and 6 also show cold advection toward Beijing but it is less prominent (Figs. 11b and 11d-f)’. I am not sure if the PT anomaly is caused by cold advection. Large cloud cover may also reduce PT in the boundary layer. The PT anomaly in Type 2 is similar to that in Type 1, and the other conditions in the two types are almost the same: the same CLD, no warm advection above CBL top. Why Type 1 has a negative BLH anomaly but Type 2 has a positive BLH anomaly? Moreover, the BLH in Type 1 is slightly lower than the seasonal average while the BLH in Type 2 is slightly higher than the seasonal average (as shown in Fig. 6a), and the BLH difference in the two types is merely about 200 m. Why such a small difference in BLH can introduce large difference in PM2.5 concentration (one is 101 $\mu g\ m^{-3}$, another is 67$\mu g\ m^{-3}$)? I guess, transportation of high concentration pollutants may contribute to heavy air pollution in Type1, because Type 1 has south wind whereas Type 2 has east wind.

5. For Fig. 11, I do not think the PT anomaly and the wind field can match very well. Fig. 11d shows an elevated negative PT-anomaly area, stretching from the right to the left. But the wind direction is form the left to the right together with a downward component. Actually, Fig. 6a shows that the boundary layer wind blows towards northeast (with a relatively small west component). It means that the flow passing Beijing does not come from Bohai or Yellow Sea (the same

evidence can be found in Fig. 10d). Also, Fig. 11e shows an isolated maximum negative PT-anomaly area over Beijing. If this negative PT-anomaly area is caused by cold advection, the magnitude of PT-anomaly in the right area should be larger than, or at least the same as, that in this area. I mean the maximum negative PT-anomaly area should stretch to the right side of picture, as shown in Figs. 11a&b or Fig. 11f. Can the isolated maximum negative PT-anomaly area over land be regarded as the result of cold advection from sea? In my opinion, the isolated maximum negative PT-anomaly area over Beijing implies a local cooling. So, my question is, can the negative PT-anomaly be interpreted as the result of cold advection from sea? I think the authors should discuss this issue cautiously.

6. For Fig. 13, I suggest to remove this schematic map. I think there is no solid evidence to support the so-called "advection mechanism". The authors can add the seasonal mean PT profile in each panel of Fig. 9. By comparing the PT profile in each type with the seasonal mean PT profile, we can know whether the capping inversion is enhanced or weakened in each synoptic pattern. Then the authors can discuss the possible reasons.

7. For the English wording and writing, I suggest that the authors get a fluent writer/speaker of English to look through the paper.