Anonymous Referee #2

The paper deals with the pollution in the Beijing area. The authors suggest a methodbased on objective classification and identify four weather types that can promote intensepollution. The work is interesting, however I have some general concerns. Firstof all, it is well-know that the pollution is strongly influenced by the meteorological conditionsboth at local and large scale. In this sense, the paper does not add any noveltyto the literature. Second, the number of cases considered (32) seems to be not sufficientfor a statistical analysis. Third, the results are not compared with any othermethods in order to assess the feasibility of the proposed procedure.My general impression is that the great effort made by the authors in terms of measurements and data analysis does not yield to robust and founded results.

Response to comments:

Thanks a lot for the reviewer's comments. To clearly reveal the scientific meaningfulness of this study, we have done much improvement in figures, content, and also the presentation, grammar etc. There are two purposes in this manuscript: first is to study the relationship between synoptic scale system and pollution boundary layer on the basis of objective classification of heavy pollution weather, and the second is to reveal how synoptic pattern shapes pollution boundary layer and influence the formation of haze. We clarified the two points in the new version and reorganized the introduction to highlight the key points accordingly.

In this paper and we have already discussed in section 2.2, this research uses the atmospheric pollution cases are 32, every process for at least more than 3 days, atmospheric pollution of persistent air pollution process standard has undergone strict control and 125 days were selected. Then, the 925hPa geopotential heights with 6h resolution (500 samples ：4 times each day in 125 days) were used to determine which mode the pollution events belong to according to the characteristic values of the different pollution events. The data volume is large enough to do objective analysis. Finally, 125 days of air pollution, 3000 hours of observation data, with vertical observation of meteorological data (wind profile data, vertical velocity data, microwave radiometer data) are used for further analysis. According to the atmospheric pollution weather type which these samples belong to, the time and vertical structure of the samples are synthesized..The results of the research carried out under the statistical analysis of large sample data should be stable and reliable. We have provided the relevant information in Section 2.2.

We deleted the content of Section 3.4.2 and rewrote it. Based on an analysis of 125 days (more than 3,000 hours) of data., we chose a five-day continuous pollution process to show more details, and also to illustrate the three-dimensional spatiotemporal variation of haze process. We have compared the four types of this study with the existing similar studies in Beijing or North China in the new version.

Other comments

In the discussion the authors go deep into details but the effect is loss of clarity andsome of the statements appear to be conjecture rather than evidence.

Response to comments:

We deleted the content of Section 3.4.2 and rewrote it. At the same time, the other contents of the discussion section have been modified a lot.

In Figure 1 it is not clear what does represent the last panel (i). I suggest to move it toanother figure.

Response to comments:

Figure 1i represents the topographic height of North China, which is illustrated at the bottom of the figure: Topography height. However, we omit the description in Figure 1, which has caused confusion to reviewer. We are very sorry for that. We have added the instructions.
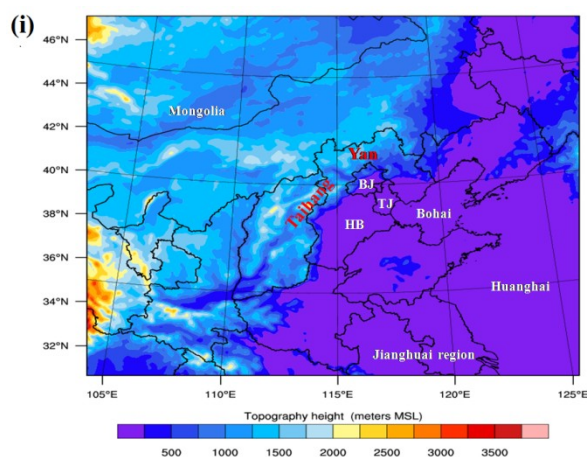

Figure 3: Are the profiles a mean over a period?

Figure 5: Same as for Figure 3

Response to comments:

Sorry for this mistake, we didn't write that we averaged the observed elements in time and space based on classification of weather type. In Section 3.2,related content has been added, as follows:

" Figure 3 to Figure 6 presented the vertical distribution of temperature, wind and RH, respectively. The temperature in Fig. 3 and vertical speed profiles in Fig.5 are averaged for each weather type by using the 6h ERA-Interim reanalysis data, respectively. The mean wind profiles in Fig.4 are observed with a wind profiler radar at the Beijing Observatory, and the mean relative humidity in Fig.6 is measured with a microwave radiometer at the same site. According to the classification of weather type, the spatial-temporal average is carried out."

How long do the events last and how is the duration defined?

Response to comments:

It is explained in Section 3.2 of the original text.

"As this study focuses on episodes of heavy haze pollution, we first defined the criteria. Haze is defined by the relative humidity and visibility. Considering that haze pollution mainly refers to reduced visibility caused by fine particulate matter, as well as taking into account the effects of the pollution levels and duration, the screening criteria for heavy haze pollution were still based on the AQI, PM2.5 concentration, and the duration of low visibility. The specific criteria of a haze pollution event can be defined as follows: the AQI reaches a moderate pollution level (AQI≥150) for more than or equal to 3 days in which at least 1 day reaches the heavy pollution level (AQI>200). The primary pollutant is

PM2.5 in Beijing area. As defined by the AQI, the 24-h average concentration of PM2.5must be above 115 μg m^{-3} for more than three consecutive days and above 150 μg m–3 for at least 1 day. At the same time, the accumulated time of horizontal visibility, that is, less than 5 km, has a duration ofat least 12 h each day at the Beijing Observatory station.

Based on these criteria, 32 events (125 days) were screened for heavy haze pollution in Beijing between2014 and2016. Eight events occurred in spring and summer while 24 events were concentrated in autumn and winter, 32 events accounting for 75% of the events that occurred during the study period (2014–2016). We collected ground-based routine meteorological observation data in North China, L-band radar second-order sounding data (including wind, temperature, and humidity), wind profile data, ceilometer data, and tower data during these events."

How are conceptual models built? Is some method used or are they simply qualitative?

Response to comments:

The establishment of the conceptual model is based on the basic principles of weather dynamics with the comprehensive analysis of the characteristics of weather types and vertical thermal and dynamic structures. Firstly, the daily air pollution weather pattern is objectively classified, and then the vertical structure of horizontal wind, vertical wind, temperature and relative humidity of each weather pattern is calculated by using the spatial-temporal average analysis method. Finally, the characteristics of horizontal and vertical structure of the atmosphere are comprehensively extracted and the conceptual model is established.In Beijing area, 700hPa,850hPa and 925hPaare generally located at a height of about 3000m,1500m and 800m.

Lines 428-429 This sentence is not clear. What is the pollution weather pattern andhow it causes the pollution boundary type.

Response to comments:

This description is not accurate and we have deleted it.

In summary, it is not clear what the applicability of this method is. It is not clear whetherit can be applied to other cases.

Response to comments:

In the discussion, we try to compare the research results with those in Beijing or North China. In addition, the method is the objective in this study, especially based on REOF weather classification, can be used in other cities and regional, the classification results are reliable, from the ground and upper air meteorological elements analysis, and 3-d structure analysis of aerosol can be seen, the research content is self-consistent.

In general it seems to me that the conclusions of thiswork are already well known and this article does not add much more. It is known thatthe height of the boundary layer is related to pollution as well as other weather factorshave a direct influence on the presence of pollutants.

Response to comments:

The innovation of this paper has been explained in the previous section. Our research focuses on the shaping effect of weather patterns on the pollution boundary layer. In addition, the distribution of weather patterns in the process of persistent haze was also studied, which was not carried out by

previous studies. Other cities and regions can also obtain objective pollution boundary layer structure by using the method in this study. Rather than subjective summaries and guesses, to build conceptual models. This greatly saves the manpower cost in the process of air pollution analysis.