We truly grateful for the reviewers’ positive assessments of our manuscript and the helpful suggestions. We have revised the manuscript carefully according to the reviewers’ comments. Point-to-point responses are given below. The original comments are black in color, while our responses are in blue. The revised parts in the manuscript are marked in red. All the page number and line number are referred to the revised manuscript.

**Major comments**

(1) There are many studies on air pollution in Beijing in the past decade, and the authors need to highlight the innovations of this paper to distinguish it from other studies. In other words, this study revealed the vertical distribution characteristics of anthropogenic aerosols and dust mass concentrations, what kind of research can be conducted in the future based on polarization Raman dataset presented in the manuscript. What is the significance or implications of those research results for air pollution in Beijing.

R: We think this comment is meaningful and valuable. We also mentioned in the article that most of the previous studies focused on the surface air pollution in Beijing, and mainly focused on the total aerosol mass concentration. In this study, the vertical distribution characteristics of aerosol types and their optical properties were captured by long–term continuous polarization Raman lidar observation. We focused on the long‒term vertical distributions of dust (coarse) and anthropogenic aerosols (fine) and their relationships with mixing layer height, which have not been revealed in previous studies, and found large amounts of anthropogenic aerosols accumulate at the top of the mixing layer, which is most noticeable in summer. This also provides a new impetus for research on the relationship between vertical distribution of air pollutants and mixing layer height. In addition, the data set presented in the manuscript can also be used for further research, for example:

1. At the end of 2019 and the beginning of 2020, the epidemic control policy led to the reduction of anthropogenic emissions in Beijing. The effect of anthropogenic emission reduction on the vertical structure of fine particulate matter in Beijing can be further discussed.
2. We found a large number of fine particles at the top of the mixed layer in Beijing, while the formation, accumulation and dissipation mechanism of air pollutants at the top of the mixing layer, as well as its impact on the surface radiation feedback, still need to be investigated in detail. Although we speculate that the aerosol hygroscopic growth may be a key process, there is no direct evidence.
3. Our observation results, especially the vertical profile of different aerosol types, can also be integrated into the dust generation and convection and chemical migration models of the North China Plain. Lidar data assimilation has long been recognized for its potential to improve numerical modeling analyses (Zhang et al., 2011). Recent research presents the assimilation of CALIPSO extinction coefficient measurements in the chemistry transport model, they focus on the dessert dust outbreak and found that the assimilation of CALIPSO lidar observations improves the statistics compared to the model free run (Amraoui et al., 2020). In addition, the vertical profile of depolarization ratio and lidar ratio, as well as the aerosol classification results can be used as the assimilation data of the model to optimize the simulation. With integrated information from various sources, i.e. numerical simulation, ground-based and satellite remote sensing, these results can more accurately describe the three-dimensional distribution pattern of aerosols.
4. Our data can also be used to support basic data analysis for spaceborne lidar missions such as CALIPSO (Cloud‒Aerosol Lidar and Infrared Pathfinder Satellite Observations) (Winker et al., 2009), ALADIN (Atmospheric LAser Doppler INstrument) (Witschas et al., 2020), and ATLID (Atmospheric Lidar) (Illingworth et al., 2015), upgrading the accuracy of regional terrestrial and global satellite lidar inversions.

We also include these important perspectives in the manuscript. Please refer to Page 3 Line 28–31 and Page 19 Line 16–26 in the manuscript.

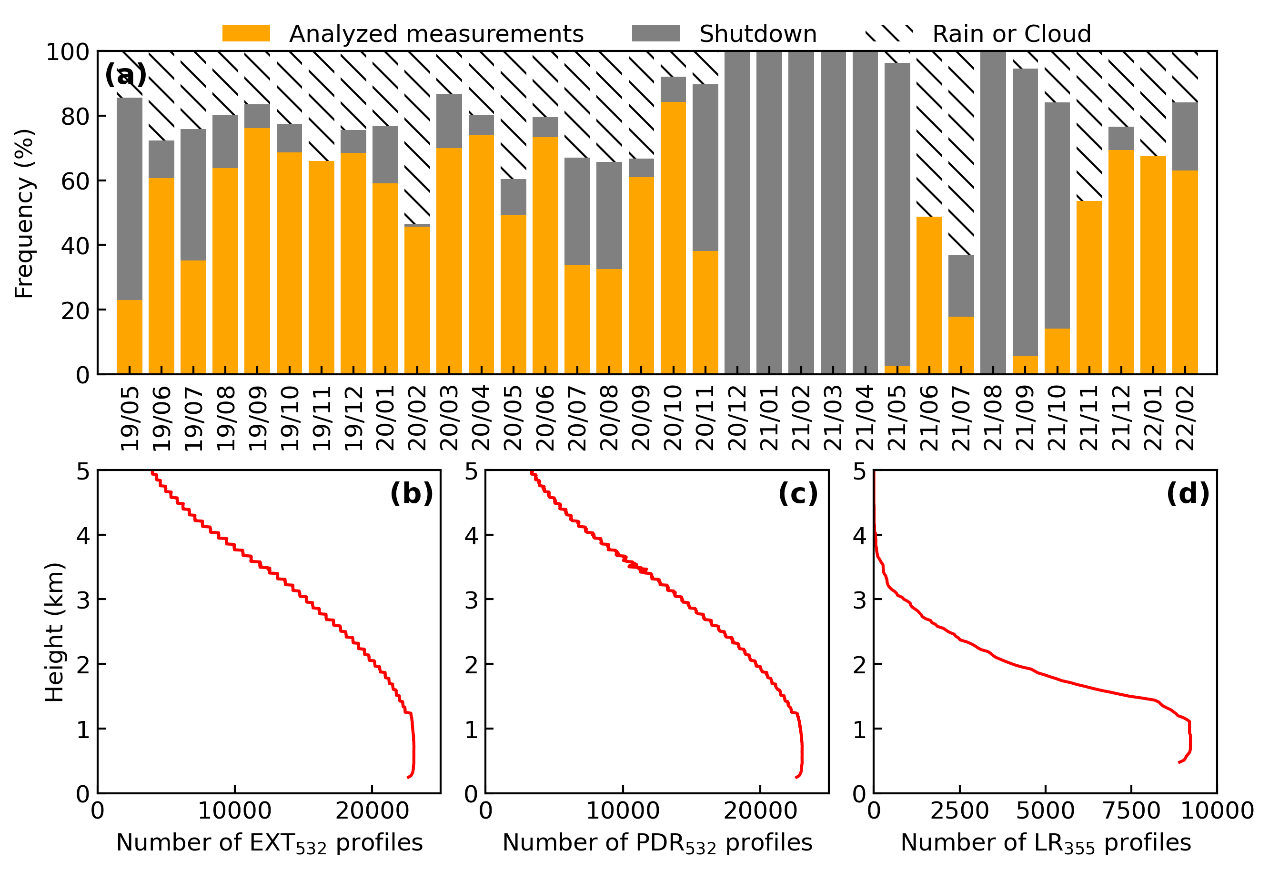
**Other comments**

(1) In section 2.2-2.5, the author uses a variety of data. It is necessary to introduce the main purpose of the data and its role in this article before starting.

R: Thanks for your suggestion, we have added an introduction to the data and methods before section 2.1. “In this section, we specify the instrument, materials and methods employed throughout the study. Section 2.1 introduces the PRL system, Section 2.2-2.5 describes the auxiliary data, and the polarization lidar photometer networking (POLIPHON) method for retrieving dust and anthropogenic aerosols mass concentration is described in Section 2.6. Aerosol Robotic Network (AERONET) aerosol optical parameters were the input parameters of POLIPHON method, surface PM10 and PM2.5 mass concentrations are used for validation of POLIPHON method results, Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model and reanalysis data are used for auxiliary analysis.” Please refer to Page 3 Line 5–10 in the manuscript.

(2) In section 3, the data was from 22 May 2019 to 20 February 2022. But PRL data were missing from 16 November 2020 to 29 May 2021. In the following Fig.3, Fig.5, Fig.7, Fig.9 and Fig.10, the monthly average data was used. It is necessary to clarify which period of time is used for averaging.

R: We discuss the coverage of PRL measurements in detail in Section 2.1 and present the relevant content in the supplemental materials. we excluded signals when the signal to noise ratio was less than 1, as well as data measured under rain, snow and low cloud conditions. Percentage of analyzed PRL measurements from May 2019 to February 2022 are shown in Figure R1, the unanalyzed measurements of “Shutdown” and “Rain or Cloud” are due to the instrument failure or weather conditions.

***Figure R1****. Coverage of Polarized Raman Lidar (PRL) measurements from May 2019 to February 2022. (a) Percentage of analyzed PRL measurements, the unanalyzed measurements of “Shutdown” and “Rain or Cloud” are due to instrument failure or weather conditions. The analyzed number of (b) EXT532, (c) PDR532, and LR355 points at different heights. The PRL detection error increases with the increase of height, and the number of points also decreases with the increase of height.*

(3) Page 9, line 8, “Fig1b shows the PRL-derived AOD in the ML and FT”, Fig1b? It should be Fig. 3b.

R: Thanks for pointing out the unsuitable expression. We have corrected it accordingly. Please refer to Page 9 Line 19 in the manuscript.

(4) Page 11, line 32, “MERRA” is misspelled.

R: Thanks for pointing out the unsuitable expression. We have followed this suggestion and corrected it accordingly. Please refer to Page 12 Line 13 in the manuscript.

(5) Page 14, line 19, “from the surface to more than 5 km”. Data below 0.25 km and above 5 km are not presented in the manuscript.

R: Thank you for your comments. We don't show it in the figure, but the data set we provide shows dust aerosols over 5 km. The surface PM10 mass concentration also captures dust aerosols. Thus, the distribution of Asian dust can extend from the surface up to more than 5 kilometers.

(6) Page 16, line 31, explain “non-dust”, is it anthropogenic aerosols?

R: Here we refer to anthropogenic aerosols, and we have corrected it in the manuscript. Please refer to Page 17 Line 19 in the manuscript.

(7) Page 17, line 2, “dust aerosol (about 50 µg/m3) is mainly above the ML”. Not only above the mixed layer, the dust concentration is also higher below mixing layer.

R: The dust concentration is indeed higher below the mixing layer, but we want to emphasize that the dust is mainly concentrated above the mixed layer. Obviously, the dust mass concentration above the mixed layer is higher than that in the mixed layer.

(8) In section 3.3.2, the concentration of anthropogenic aerosols was low in winter. However, during the observation period, especially at the end of 2019 and the beginning of 2020, epidemic control policy led to the reduction of anthropogenic emissions. Whether these reductions had any effect on the observations of this study? and these effects also remain to be explored.

R: Obviously, reductions in anthropogenic emissions can affect our observations. There have also been many studies analyzing the impact of lockdown during the epidemic on air pollution in Beijing (Hu et al., 2021, Zhao et al., 2020, Zhang et al., 2022). Hu et al. (Hu et al., 2021) found that the epidemic control policy led to the reduction of air pollutants in Beijing during the 2020 Spring Festival by 35.1%-51.8%. However, the meteorological conditions during the Spring Festival in 2020 are not conducive to the diffusion of air pollutants, leading to the occurrence of haze episodes. During 23-28 January and 8-13 February, Beijing experienced two large-scale air pollution events. The first is mainly affected by local emissions, such as building heating, and the second is mainly affected by regional transport over the North China Plain. The observation of PRL also captures the vertical distribution of air pollutants during the COVID-19 period, but this manuscript mainly discusses the long-term evolution of air pollutants and their relationships with mixing layer height, and these effects can be studied in the future.

(9) In discussion section, authors found that there is a significant negative correlation between anthropogenic aerosols and MLH in four seasons. Are there any similar observation results or simulation results with the same conclusions as this paper?

R: There are plenty of theoretical and observational studies on aerosols in Beijing (Zhong et al., 2019; Guo et al., 2016; Miao et al., 2015; Miao et al., 2018), most of them only consider total aerosol mass concentrations and focus on heavy pollution episodes, the long‒term evolution of dust (coarse) and anthropogenic aerosols (fine) and their relationships with mixing layer height have not been revealed, which is also one of the innovations of this paper.

(10) In section 5, the conclusion should point out the shortcomings in this study and future research perspectives.

R: This is a very valuable comment. Although our results elucidate the long‒term vertical distributions of dust (coarse) and anthropogenic aerosols (fine) and their relationships with mixing layer height, our research also has two shortcomings. Firstly, PRL has incomplete overlap region, about 0.25 km, which prevents us from capturing the evolution of air pollutants at the lowest level (0-0.25 km). Due to the incomplete overlap region, our inversion of the MLH also starts from 0.25 km, which may lead to the overestimation of the MLH. Secondly, due to the limitations of the POLIPHON method, we excluded cases with relative humidity greater than 85%, and the accumulation of particles at the top of the ML may undergo a significant hygroscopic growth, so the anthropogenic aerosols mass concentration at the top of the ML may be underestimated. The perspectives of the research are detailed in "Major comments".

We also include these shortcomings and perspectives in the manuscript. Please refer to Page 19 Line 16–26 in the manuscript.

(11) Suggestion: It would be better to combine Figure 11 and Figure 12 into a single figure, and also for Figure 13 and Figure 14.

R: We have followed this suggestion and combine Figure 11 and Figure 12 into a single figure, and also for Figure 13 and Figure 14. Please refer to Fig.12 and Fig.13 in the manuscript.

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