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In this file, **the text in black** shows the comments from reviewers and editor, while **the text in blue** is our replies.

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Editor decision from Dr. Paul Zieger:

SUMMARY:

Thank you for your revised version. The reviewers are generally satisfied with your changes and only one short comment by reviewer #3 concerning the re-analysis data should be considered further before we can finally accept your manuscript.

Dear Editor,

We would like to express our sincere thanks to you and reviewers for the kind evaluation. We accept the comments and revised the manuscript accordingly.

We agree with the reviewer that model grid reanalysis data has a similar vertical resolution with sounding data. The model grid reanalysis data may be a good substitute of sounding data in some circumstances. We also explain the necessity of using sounding data to validate the reliability of reanalysis data in this study.

Thank you again for your consideration.

Sincerely Yours,

Guixing Chen, Ph.D.

On behalf of the authors of ACP-2022-9

September 19, 2022

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Reviewer #3

COMMENTS:

The authors well addressed my previous comments. However, I still have some questions related to the usage of JRA-55 reanalysis data. I would like to recommend this manuscript be considered for publication after these questions have been addressed.

Based on the information provided in the replies, the authors use JRA-55 1.25-degree latitude/longitude grid data (LL125). However, JRA-55 also has 6-hourly reanalysis data on model grid data (TL139, https://jra.kishou.go.jp/JRA-55/document/JRA-55_handbook_TL319_en.pdf). TL139 has 60 vertical levels, which have 11 levels under 850hPa. Model variables include geopotential height, temperature, u/v-component of wind, specific humidity, etc. Although the vertical levels are not in the isobaric surfaces as LL125, the authors can still do the interpolation under the hydrostatic equilibrium assumption. On the other hand, back to my previous comment 1.2, since TL139 has 11 levels under 850hPa, this is similar to the sounding data, which has 8-14 levels below 850hPa.

I also suggest that the authors list the data source for all variables used in this manuscript in a Table. e.g., summarize which variables are from JRA-55 and which variables are from the local station.

Response: Thank you for your advice. We agree that the model grid data of JRA-55 reanalysis (TL319L60) has a similar vertical resolution with sounding data. Our results also suggest the JRA-55 reanalysis data and sounding data have good consistency in describing vertical structure of atmospheric boundary layer. Thus, the model grid reanalysis data is thought to be a good substitute of sounding data in our future work.

Here. we would like to explain why we use sounding data in this study. In section 4.1, the sounding data is employed to verify whether reanalysis data could well capture the structure of atmospheric boundary layer, and whether the depth (DP) of cold airmass could represent the mixing layer height (MLH). Since the calculation of DP is already based on JRA-55 reanalysis data, the MLH used for comparison is better to be calculated by observing data such as sounding data rather than JRA-55 reanalysis data. On the other hand, the sounding data provides a direct detection of atmospheric vertical profiles, which could be used to validate the reliability of model-simulated reanalysis data. Due to above concerns, the analysis of sounding data and its comparison with reanalysis data is remained in this study.

Accordingly, we rephrase the relevant text in section 2.1: "The sounding data obtained from the University of Wyoming provides a direct detection of atmospheric vertical profile, which would help to explain the changes of AQI observation. Four sounding stations were selected in NEC: Beijing (39.8°N, 116.5°E), Zhangqiu (36.7°N, 117.6°E), Nanjing (31.9°N, 118.9°E) and Baoshan (31.4°N, 121.5°E). Observation times were 00 and 12 UTC (08 and 20 LT). The vertical resolution of the sounding data is comparable to that of JRA-55 model grid

reanalysis data. For example, sounding data at Beijing station has 60–70 levels in total and 8–14 levels below 850 hPa during a CAO event of 14–17 Dec 2016."

Following your suggestion, we also add a table (Table R1) showing the data source of variables used in this study in section 2.1. See revised text at Line 98: "The data sources of all variables used in this study are listed in Table 1."

Table R1: Data source of variables used in this study. Here, u: zonal winds, v: meridional winds, T: air temperature, Φ: geopotential height, p_s: surface pressure.

Data source	Variables
JRA-55 reanalysis data (Japan Meteorological Agency)	u, v, T, Φ (1000~100 hPa) and p_s
Air quality monitoring data (Ministry of Ecology and Environment of the People Republic of China)	AQI
Radio sounding data (University of Wyoming)	u, v, T, Φ (surface to 100 hPa)

We acknowledge your great help to improve the manuscript.

Thank you very much.