

Atmos. Chem. Phys. Discuss., referee comment RC1
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Comment on acp-2022-9

Anonymous Referee #2

Referee comment on "Rapid reappearance of air pollution after cold air outbreaks in northern and eastern China" by Qian Liu et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2022-9-RC1>, 2022

Using observation data and reanalysis data, this paper utilizes a quantitative measurement of cold airmass to identify CAO and related dynamic/thermodynamic properties. The authors find the generic existence of air pollution reappearance after CAO, and raise a possible mechanism in the manuscript. This manuscript overall is interesting, but I do have some comments regarding the details of data and methods.

My major and minor concerns are described below.

Major comments:

1. The authors define north China as 30-40 N, 114-122 E. However, this is not a good definition. Furthermore, two sounding stations used in this manuscript, Nanjing and Baoshan (which is in Shanghai), are in East China. The authors can refer to the definition of the North China Plain in Kang et al. 2018

Kang, S., Eltahir, E.A.B. North China Plain threatened by deadly heatwaves due to climate change and irrigation. *Nat Commun* **9**, 2894,2018.
<https://doi.org/10.1038/s41467-018-05252-y>

2. In Section 2.1, more details are needed. For example

(1) What's the spatial distribution of those local AQI stations? Are most of them in the big cities?

(2) What's the vertical and horizontal resolution for the sounding data? And why do authors use sounding station data for the wind and air temperature? The temporal resolution is not good. Why don't you use reanalysis data as well?

(3) I am not sure which JRA-55 products are used in this study. First of all, JRA-55 should have a 3-hourly reanalysis, and usually, the vertical pressure levels are 60 levels.

Minor comments:

1. In the introduction, the recent COVID-19 lockdowns also provide a unique opportunity to study the complex chemical effects of air pollution as well as meteorology. Here are some references.

1) Le T, Wang Y, Liu L, Yang J, Yung YL, Li G, Seinfeld JH. Unexpected air pollution with marked emission reductions during the COVID-19 outbreak in China. *Science*. 2020 Aug 7;369(6504):702-6.

2). Wang Y, Wen Y, Wang Y, Zhang S, Zhang KM, Zheng H, Xing J, Wu Y, Hao J. Four-month changes in air quality during and after the COVID-19 lockdown in six megacities in China. *Environmental Science & Technology Letters*. 2020 Sep 9;7(11):802-8

3). Zhao N, Wang G, Li G, Lang J, Zhang H. Air pollution episodes during the COVID-19 outbreak in the Beijing–Tianjin–Hebei region of China: an insight into the transport pathways and source distribution. *Environmental Pollution*. 2020 Dec 1;267:115617.

2. Section 2.1, "with observations made 24 times per day", is it measured equal frequency (i.e., 1h frequency)?

3. Line 87, 89, vertical integral -> vertical integration.

4. For the definition of mass flux, the common definition is the rate of mass flow (SI unit $\text{kg}/(\text{m}^2 \text{ s})$).

5. Line 95, why do authors use the standard deviation to define the CAO? This only makes sense when the mean value of cold airmass depth is very close to zero. (Think about one example, if the cold airmass depth is 50 hPa, the standard deviation is still 169.7 hPa, then CAO should be defined as a cold airmass depth exceeding $50+169.7 = 219.7$ hPa)

6. In Figure 1, The day0 (March 09) are both in before-CAO and During-CAO periods. But Mar 10 is only in the During-CAO period. So, the definition of the period boundaries is not consistent. This may affect the analysis results (e.g., Figure 4 and so on).

7. Figure 4, better to define the different color lines in the caption.