

Atmos. Chem. Phys. Discuss., referee comment RC2  
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## Comment on acp-2022-9

Anonymous Referee #3

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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.,  
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Reviewer summary:

This work focused on the rapid increasing of air pollution after cold air outbreaks. The changes of AQI after CAO events is divided into two types of events: rapid change and slow change. By comparing and analyzing one example from each of the two types of events, the authors indicated that the depth, duration and coldness of cold air masses, as well as the stability of the vertical structure, modulated the changes in air pollution after the CAO events, and also made a comparative analysis of the role of thermal and dynamic processes. In addition, the two types of events corresponded to different atmospheric circulation systems, which may become previous signals. However, a lot of work mentioned about the drop of air pollution during the CAO and the subsequent rebound. The influence of the depth and duration of the cold air mass on the rebound of air pollution is also a classic conclusion in textbooks. Therefore, I think this research is not innovative enough. In addition, when analyzing the effects of cold air mass, the authors only conducted statistical analysis based on a single case, without the verification of numerical experiments, so its credibility and persuasion are not enough. A mandatory major revision is recommended

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Major comments:

Line 71-72: Air pollution in winter is mainly haze, but the data used in this study is AQI. I hope to know the change of PM<sub>2.5</sub> during and after CAO and whether it is consistent with the conclusion of AQI.

Lines 73-74: The data in this study is only used until 2018/2019. Why aren't the data for the last three years used? Especially in the winter of 2020/2021, many cold air events happened in North China, including record-breaking cold waves. The CAO events in the present study does not cover the recent years, lacking the timeliness of the facts.

Line 142-143: Only more than 50% of CAOs are found to show a worse AQI after reappearance. This ratio indicates that the change of AQI after CAO event is irregular, and the probability of its increase and decrease is basically the same. The phenomenon of air quality rapid rebounding after the CAO needs to be further confirmed.

Lines 146-150: This part of the description is not very clear and hard to understand. The CAOs are divided into two groups: slow reappearance and rapid reappearance. In fact, not all AQI increased after CAO events. However, using "reappearance" to describe the two groups is misleading. In addition, the title of the abscissa in Figure 3c is "Increase of AQI after CAO", but actually there have decrease of AQI after some CAO events, so it is not appropriate to use "increase". In my understanding, the difference between the value of the arrowhead and tail should equal to the value of the abscissa, but obviously there are many points that do not correspond well. Please check the correctness of Figure 3c and add to the explanation in this part.

Lines 189-190: When analyzing the effect of the depth and NFC of cold air mass on the rapid events and slow events, only one case is used for statistical analysis respectively, and the verification of numerical experiments is lacking. I am not sure whether the conclusion drawn through the individual case apply to most of the other rapid and slow events, so I am skeptical about the applicability and credibility of the effect of the depth and NFC of cold air mass. In addition, numerical experiments should be added to confirm the conclusion in Section 4.

Specific comments:

Lines 30-33: The use of tenses is confusing, alternating between the general present tense and the past tense. Suggest to check the whole text and unify tenses.

Lines 28-30: What does the air pollution mainly refer to in the study? Is it haze pollution? Many articles about haze pollution are cited in the formation of air pollution in the following paragraph. Be more specific about the characteristics of air pollution.

Lines 40-41: impacting the variations in air pollution [on the synoptic time-scale].

Line 50: increased as much as 2.8 times than what?

Line 100: defined as the two days before onset day [to] the onset day

Lines 100-101: Does "the three following the period during the CAO" refer to day 1 to 4?  
It does not match the annotation in Figure 1.

Line 142-144: This view should be presented with caution. It is probably because the selection time of the period before CAO avoids the high value AOI, which may have been affected by cold air.

Figures:

Figure 5 and 6: Add the meaning of the black box in the caption.

Figure 10: what does the dots refer to?