Response to Comments of Reviewer 1

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Title: Influence of the previous North Atlantic Oscillation (NAO) on the spring dust aerosols over North China

General comments:

Using the station observations and multi reanalysis data, the authors investigated the possible influences of the previous NAO on the dust aerosols over northern China. Authors concluded that the boreal winter NAO has significant impacts on the following spring dust aerosols, particularly during the negative phase of the NAO. The thermal and dynamical processes relevant to the anomalous NAO on the circulation are analyzed, and it indicated that the impact of transient eddy fluxes transport plays important role in the formation of the dust aerosol events. I agree with the authors that the influence of previous NAO on dust aerosols in China cannot be ignored. And it is an important interdisciplinary issue that needs more attention and deep research. Overall the manuscript is well written and clear, and the figures are also appropriate and clear. However, there are some problems with this manuscript, and it cannot be accepted by ACP as it is now. Some specific comments or suggestions are listed as follows.

Response:

Thanks to the reviewer for the helpful comments and suggestions. We have revised the manuscript seriously and carefully according to the reviewer's comments and suggestions. The point-to-point responses to the comments are listed as follows.

Specific comments are as follows:

1. Introduction: the review of the dust aerosol's climate effect and the NAO's impacts on the regional climate anomalies are a little repetitive and lengthy. Address and summary the major research progress of the present work.

Response:

Thanks for your comment and suggestion.

We have refined the introduction, and deleted some repetitive and lengthy parts in the revised manuscript.

2. NAO index: There are lots of definitions of the NAOI, what is the advantage of the NAOI used, and whether the result is robust if other definitions are used. The authors need to further compare the different NAOI, and clarify whether the result is subject to the NAOI.

Response:

Thanks for your comment and suggestion.

A systematic comparison of NAO indices by Li and Wang (2003), including the NAOI used in the manuscript, shows that the NAOI used provides a much more faithful and optimal representation of the spatiotemporal variability associated with the NAO, suggesting the NAOI as a better choice for describing and monitoring variability of the broad-scale NAO and for diagnosing relationships between the NAO and global climate variations.

We also use the NAOI provided by Climate Prediction Center, which has been used in many studies (Zuo et al., 2015; Li et al., 2021; Yao et al., 2022), for correlation analysis with the NAOI used in this manuscript. A good agreement with a correlation coefficient of 0.83 is shown between these two indices (Figure R1). The robustness of the results will not be affected by the NAOI verified by above process (Lines 595-599 in the revised manuscript).

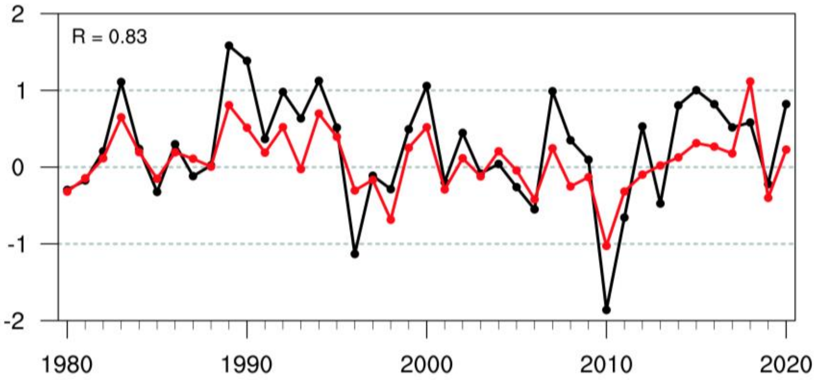

Figure R1. The annual mean NAOI used in the manuscript (black line) and provided by Climate Prediction Center (red line) during 1980-2020.

3. The role of previous winter NAO on the following spring dust aerosols is discussed, however, as reported ENSO shows a significant role in determining the winter and spring climate anomalies over eastern China. it is of interest to further discuss whether the impacts of NAO on the aerosols are independent of ENSO.

Response:

Thanks for your comment and suggestion.

We have adopted the comment of the review by further examining the possible effect of ENSO on the relationship between the NAO and dust aerosols. Through partial correlation (after removing the impact of ENSO), it can be found that there is still a good correlation between the spring dust aerosols in North China and previous winter NAOI during 1980-2020 (Figure R2). Therefore, it is proved that the impact of NAO on the aerosols are independent of that of ENSO.

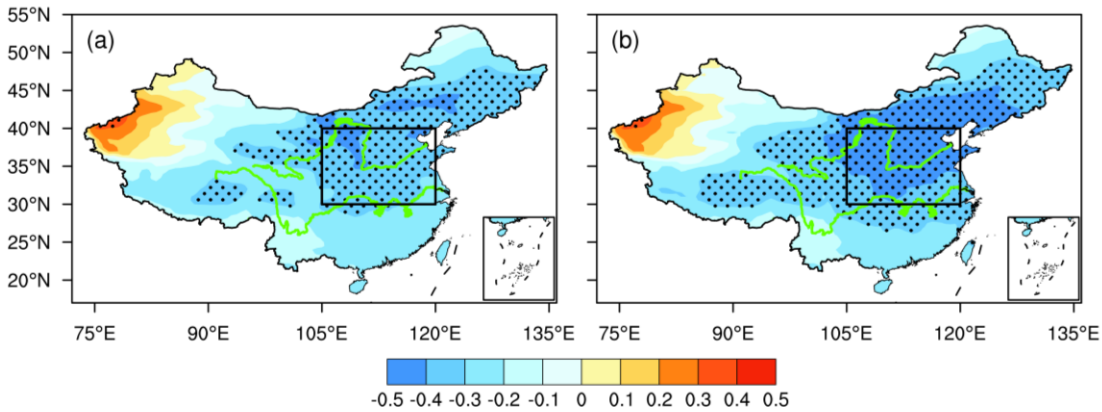

Figure R2. (a) Correlations between the dust aerosols during springtime and NAOI in previous winter during 1980-2020. (b) As in (a), but for the partial correlations after removing the effects of

ENSO. The black box indicates the North China. The black dotted areas are statistically significant at the 95% confidence level.

4. L218: prior to rather than previous to

Response:

Thanks for your suggestion.

We have revised it (Line 192 in the revised manuscript), as well as checked the whole manuscript and revised similar errors.

5. Line 34: The descriptions are confusing.

Response:

Thanks for your comment.

Transient eddy fluctuations contribute to the maintenance of the atmospheric energy balance through energy transport, and the energy transport process causes the divergence and convergence of energy and mass between different regions, thus forming new regions of forcing within the atmosphere (Li et al., 2019). When the transient eddy flux transport characteristics of the upstream regions of North China including the dust aerosol source regions and the Ural Ridge have disturbed, the upper-level wind speed over North China shows a weakened state.

Therefore, it can be considered that the divergence of energy and mass have been changed over North China, which in turn has affected the wind speed over North China. To avoid confusion, we have revised the description, as shown in Lines 32-35 in the revised manuscript.

6. In the upper troposphere, it is emphasized that both the jet stream and downward transmission of high-altitude wind speed momentum contribute to the formation of the dust aerosols, however, without a detailed physical explanation of the combined role the two.

Response:

Thanks for your comment.

Before the outbreak of dust aerosol events, under the impact of the jet stream, there are anomalous positive zonal winds and negative zonal winds controlling the dust source areas of Xinjiang, Mongolia and North China, respectively. Through the effect of vertical circulation, abnormal winds at high altitudes can influence middle and low altitude winds through momentum compensation and downward (Li et al., 2015; Wu et al., 2016).

Therefore, which may lead to the generation of windy weather near the dust source areas and the maintaining the dust aerosol concentration in North China, both of which contribute to the occurrence of dust aerosol events in North China. To illustrate a detailed physical explanation, we have rewritten this section, as shown in Lines 331-337 in the revised manuscript.

7. In the middle troposphere, the evolution of the trough-ridge system along with the occurrence of the dust aerosol events should be further analyzed. The involved physical process, particularly, which variable is more important in the process warranty further illustration.

Response:

Thanks for your comment.

Before the outbreak of dust aerosol events, the trough-ridge situation is characterized by two troughs and Ural Ridge throughout the middle-high latitudes of the Eurasian continent. The troughs are manifested as negative variations, while the Ural Ridge is manifested as gradual enhancement. On account of the strengthening advancement of the trough-ridge situation, the middle-high latitudes are dominated by the strong meridional circulation, the transport of northern cold air increases, and the southward invasion of the cold air enhances the local surface wind speed in the dust aerosol source areas, leading to the uplift of dust aerosols.

We have revised this section to show the evolution of the above circulation trend has promoted the outbreak of dust aerosol events in North China, as well as the important role of both troughs and Ural Ridge in the process (Lines 374-377 in the revised manuscript).

8. There are lots of clerical errors, i.e.,
   L306, should be 0.1 in and 0.2 in
   L351, should be 35 °-50 °N, 70 °-110 °E
   L356-360, lengthy and repetition
   L377, should be prior to
   L404, should be 30 °-60 °N, 105 °-130 °E
   The authors should carefully check the whole manuscript.

Response:

Thanks for your comments and suggestions.

We have checked the whole manuscript and revised all errors.

9. Figures 2, 4, 7, 10, 13, without clarification of the axis, Figure 3, without units.

Response:

Thanks for the comment and suggestion.

We have revised all the legends of these figures.

References:

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