Response to Comments of Editor

Manuscript number: egusphere-2024-955

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Title: Synergistic effects of previous winter NAO and ENSO on the spring dust activities in North China

General comments:

1. Setting the threshold for statistical significance to p=0.10 resulted in a reduction of overall significance of your results. Therefore, 1) the discussion of some figures should be adjusted to the new results; 2) the overall low statistical significance of the results should be highlighted and discussed in the conclusions.

Response:

Thanks for the suggestions.

We have revised the relevant discussions to adjust the new results throughout the manuscript.

We have added the corresponding descriptions, as shown "The present study focuses on the period 1979-2022, due to the longevity of the MERRA-2 dust content dataset. There are only 7 co-occurrence years of negative NAO and ENSO, which take up to 17% of the whole study period. It is noted that the co-occurrence events are not as many as either the negative NAO or ENSO, thus a significance level of 0.1 is displayed. It is worthy to examine their joint impacts by employing longer datasets or models outputs, to further explore their synergistic effects and any possible variations in their modulations" in Lines 537-543.

2. English still needs to be improved, there are still many typos and mistakes, odd expressions and some sentences don't read fluently. I recommend a further deep revision of the language.

Response:

Thanks for the suggestions.

We have done our best to revise the manuscript. Additionally, we have conducted a thorough language check to enhance overall clarity and coherence.

Specific comments to the manuscript:

1. L21: WNP is not used elsewhere in the abstract, please remove it.

Response:

Yes, done.

2. L52: westerly belt, do you mean the mid-latitude westerly regime.

Response:

Thanks for the comments.

We have revised it to "mid-latitude westerly regime" (Line 49).

3. Figure 1: how do you get a spatialised map from station data? Did you apply any spatialisation technique? Please clarify. Also specify the unit for DI.

Thanks for the comments and suggestions.

In order to better compare the DI with the reanalysis, we first interpolate the site data into grid points by Cressman (1959), and then obtain the gridded DI. We have added corresponding descriptions into the revised manuscript (Lines 132-134).

$$\mathrm{DI} = 9 \times \mathrm{DS} + 3 \times \mathrm{BD} + 1 \times \mathrm{FD} \quad (1)$$

It is worth noting that the value of 1 represents the normalized mass weight of dust content for each FD, while 3 and 9 represent the relative mass weight of dust content for BD and DS, respectively (Equation 1) (Wang et al., 2008). Therefore, DI is an index used to indicate the dust content which does not have unit. We have included the corresponding revision in the revised manuscript (Lines 129-132).

4. L137: "overall consistent".

Response:

Yes, done.

5. L149: please clarify in the text whether winter 2022 is defined from December 2021 or December 2022.

Response:

Thanks for the suggestions.

The winter are during 1979-2021, and the spring are during 1980-2022, to highlight the preceding impacts of previous winter NAO and ENSO on the following spring dust activities over North China. The winter 2022 is not considered in the manuscript due to the longevity of the dataset.

We have added corresponding descriptions, as shown "The winter is defined as the average of December-February (December-January-February, DJF), with the winter 1979 (2021) corresponding to the average of December in 1979 (2021), January and February in 1980 (2022). The spring seasonal mean is the average of March, April, and May. Thus, the previous winter is from 1979 to 2021, and the following spring is from 1980 to 2022" in Lines 143-146.

6. L161: NAOI from Hurrell and Jones have been used to validate the NAOI by Li and Wang.

Response:

Yes, done.

7. L166: the justification for focusing on previous winter is given in Sec. 3.1. Here you can just tell how seasonal means are computed.

Response:

Thanks for the suggestions.

We have included the seasonal means in Sec. 2.1. The winter is defined as the average of December-February (December-January-February, DJF), with the winter 1979 (2021) corresponding to the average of December in 1979 (2021), January and February in 1980 (2022). The spring seasonal mean is the average of March, April, and

May. Thus, the previous winter is from 1979 to 2021, and the following spring is from 1980 to 2022.

8. L195: please revise the definitions: p should be pressure and U should be U=(U, V, 0) (you need a 3D vector wind for a 3D formulation). What is the difference between f0 and f? What is N? what is z?

Response:

Thanks for the suggestions and comments.

We have revised the definitions, as shown "In the expression, p, φ, λ, f_0, and a represent the atmospheric pressure, latitude, longitude, Coriolis parameter, and Earth's radius, respectively. $\psi' = \Phi'/f_0$ (where Φ represents the geopotential height) denotes the disturbance of the quasi-geostrophic stream function relative to the climatology. N is buoyancy frequency, $z = -Hln(p)$ with H being a constant scale height (H=8 km). The basic flow field $\boldsymbol{U} = (U, V, Z)$ (where Z represents the selected level) denotes the climatic field, where U and V indicate the zonal and meridional velocities, respectively" in Lines 189-194.

9. L202: NAO std actually peaks in February.

Response:

Thanks for the comments.

We have revised it, as shown "The NAO shows the strongest variability during the winter months, with the maximum standard deviation in February" in Lines 197-198.

10. Figure 2: I'm wondering why, being the NAOI standardised, the std in panel (a) shows such high values. Shouldn't be around 1 on an annual basis? As shown by the ENSO index in panel (b).

Response:

Thanks for the comments.

In Figure 2, it is the raw series instead of the standardized series to calculate the standard deviation of NAOI and ENSO index.

11. L230: are the correlation coefficients significant?

Response:

Thanks for the comments.

We have revised it, as shown "with correlation coefficients of -0.36/-0.35 statistically significant at the 0.1 level" in Lines 217-218.

12. Figure 3: panels (a) and (b) are the same as in Fig. 2, please remove them and modify caption and text accordingly.

Response:

Thanks for the suggestions.

We have revised the figure and caption (Figure 3 in the revised manuscript, also seeing in Figure R1). And we have modified the text accordingly in the revised manuscript.

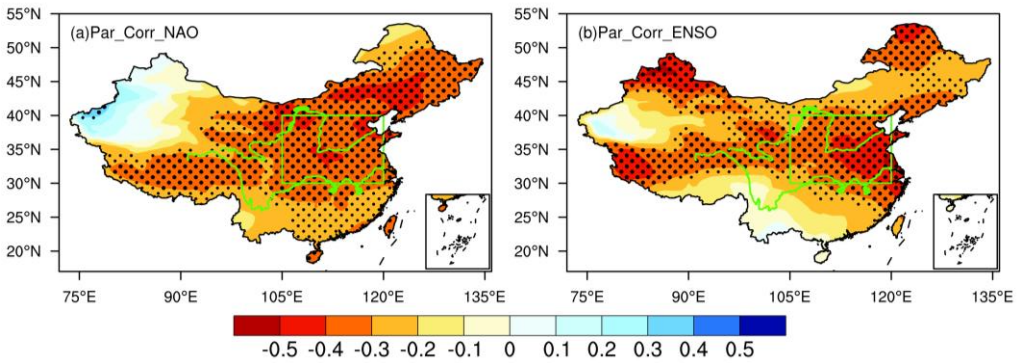

Figure R1. (a) Spatial distribution of partial correlation coefficients between the previous winter NAOI and spring dust content after removing the effect of ENSO. (b) As in (a), but after removing the effect of NAO. The green box represents North China. Thick and fine stippled areas are statistically significant at the 0.05 and 0.1 level, respectively. The green lines represent the Yellow River (northern one) and the Yangtze River (southern one), respectively.

13. L260: please provide information about the significance of correlations.

Response:

Yes, done.

14. L262: what do you mean by correlation distribution? Is it not just correlation?

Response:

Thanks for the comments.

We have revised it to “the correlation coefficients between NAOI and SDI” (Line 244).

15. L263: please provide information about correlation coefficients and significance.

Response:

Yes, done.

16. L264: ENSO in brackets is confusing, please rephase in a more readable way.

Response:

Thanks for the suggestions.

We have revised it, as shown “These results demonstrate that the impacts of the previous winter NAO and ENSO on the SDI exhibit asymmetrical characteristics, with significant effects primarily manifested during their negative phases” in Lines 250-252.

17. Figure 5: thanks for improving the description of the figure, which is now much clearer. I also think that error bars are no longer necessary (I apologise for changing my mind on that, it’s just that I couldn’t understand the plot). I rather suggest that you provide information about the statistical significance of the SDI in the different cases. Specifically: NAO vs NAO-; ENSO vs ENSO-; NAO vs NAO&ENSO; ENSO vs NAO&ENSO.

Response:

Thanks for the suggestions.

The statistical significance of the SDI in different cases is shown in Figure R2. It is noted that the SDI anomalies are statistical insignificant when negative NAO or ENSO occurs alone. This suggests that the overlapped negative NAO and ENSO events show a synergistic effect on dust activities in North China.

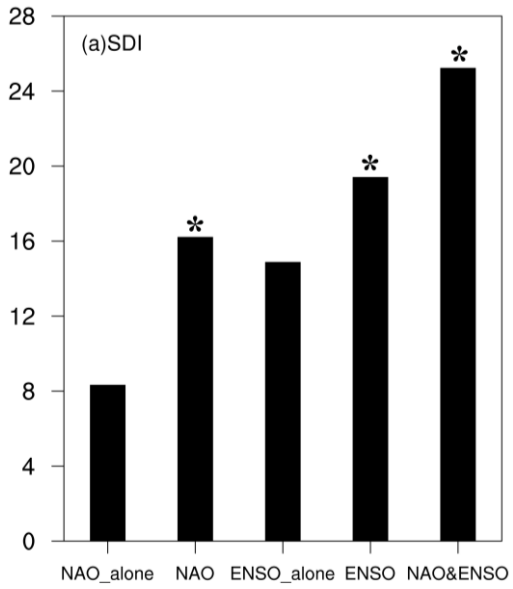

Figure R2. Spring dust content over North China in the different cases. * indicates statistically significant at the 0.1 level.

18. L309: zonal wind is stronger in NAO&ENSO case wrt the NAO- case, but not so clear wrt the ENSO- case. You should provide robust evidence, or mitigate this claim.

Response:

Thanks for the suggestions.

We have made the corresponding revisions in the revised manuscript (Lines 287-298).

19. Figure 7: after the change in the significance level, this figure is now problematic. The NAO- case show no significant anomalies, while ENSO- and NAO&ENSO cases only show significant anomalies north west of North China, and no significant anomalies in North China. You should modify the discussion of this figure in the light of the new results.

Response:

We have modified the discussion of this figure in the light of the new results, as shown “During the negative NAO phase, humidity and precipitation slightly decrease in northern northwest China, impacting dust lifting and transport in the dust source

regions (Figures 7a-b). In the negative ENSO phase, the variations in humidity and precipitation are similar to that as in the negative NAO, but with greater amplitude (Figures 7c-d). When both the NAO and ENSO are in their negative phases, the humidity and precipitation anomalies in the dust source regions are more intense than those caused by the individual factors (Figure 7e-h)" in Lines 353-359.

20. L415: Figures 8bc don't show the SDI-NATI correlation, but the SDI-SST correlation.

Response:

Thanks for the suggestions.

We have revised it, as shown "The correlation analysis between the high and low years of SDI and SST reveals a pronounced difference, indicating an asymmetric correlation (Figures 8b-c)" in Lines 385-387.

21. L416: where do we see the significant relationship between SDI and NATI?

Response:

Thanks for the comments.

We have revised the description, as shown "Specifically, the significant relationship between SDI and NATI only exists in the positive SDI years, with a significant correlation coefficient of -0.47, implying that the occurrence of NATI would associate with more dust activities over North China" in Lines 387-390.

22. L429: please provide significance for the correlations.

Response:

Yes, done.

23. Figure 10g-i: the first impression here is that the correlation pattern is not stronger than in the NAO- and ENSO- cases. You should provide quantitative evidence, or mitigate the claim at L481-485.

Response:

Thanks for the suggestions.

We have made the corresponding revisions in the text to mitigate this claim, as shown “Notably, when both the NAO and ENSO are in their negative phases, the correlation patterns of the teleconnection structure are similar, however the anomalies over North China is enhanced, showing significant anomalies in the vorticity field (Figures 10g-i), confirming their synergistic effects on the circulation processes affecting dust activities in North China” in Lines 446-450.

24. Figures 10, 11 and 12: you should explain (in the caption) why regressions fields are multiplied by -1.

Response:

Thanks for the suggestions.

We have revised the caption in Figure 10, 11 and 12, as shown “Regression fields have multiplied by -1 (to facilitate a direct comparison between the NAO&ENSO associated circulation anomalies and the climatology)”.

25. Figures 10 and 12: please display North China.

Response:

Yes, done

26. Section 4: please discuss in this section the limitations associated with the overall low statistical significance of your results.

Response:

Thanks for the suggestions.

We have added the discussions in Section 4, as shown “The present study focuses on the period 1979-2022, due to the longevity of the MERRA-2 dust content dataset. There are only 7 co-occurrence years of negative NAO and ENSO, which take up to 17% of the whole study period. It is noted that the co-occurrence events are not as many as either the negative NAO or ENSO, thus a significance level of 0.1 is displayed. It is worthy to examine their joint impacts by employing longer datasets or models outputs,

to further explore their synergistic effects and any possible variations in their modulations" in Lines 537-543.

27. L541: please avoid using acronyms that you don't use much in this section, e.g. WNP, SH.

Response:

Yes, done.

28. L573: please clarify how "the availability of dataset" affects the study of the interdecadal variability.

Response:

Thanks for the comments.

The present work mainly focuses the interannual modulation of NAO and ENSO on the dust activities over North China, however, the NAO and ENSO, as well as dust activities over North China, bear strong interdecadal variations, long-term datasets are needed to further explore their impacts on the dust activities (Lines 533-537).

29. L587: this last sentence could be moved to the discussion of the interdecadal variability above.

Response:

Thanks for the suggestions.

We have revised it in the revised manuscript (Lines 546-548).

Reference

Wang, X., Huang, J. P., Ji, M. X., and Higuchi, K.: Variability of East Asia dust events and their long-term trend, Atmos. Environ., 42, https://doi.org/10.1016/j.atmosenv.2007.07.046, 2008.

Cressman, G. P.: An operational objective analysis system, Mon. Weather Rev., 87, 367–374, https://doi.org/10.1175/1520-0493(1959)087<0367:AOOAS>2.0.CO;2, 1959.