Response to Comments of Reviewer 3

Manuscript number: egusphere-2023-52

Author(s): Yan Li, Falei Xu, Juan Feng, Mengying Du, Wenjun Song, Chao Li, and Wenjing Zhao

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

General comments:

This study investigates the impacts of North Atlantic Oscillation (NAO) on spring dust aerosols over North China based on station observation data and multi reanalysis datasets. They found that late spring dust aerosols are negatively correlated with the boreal winter NAO index. They further illustrate that the changes in transient eddy momentum over the dust source region the Ural Mountains could explain the relative high spring dust levels following the negative winter NAO events. The topic is interesting and method is sound. I recommend it can be published after addressing my minor comments below.

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. My main comment is about how is the station observation of dust events and reanalysis data connected. Many results of this study are based on MERRA-2 dust column mass. However, how the MERRA-2 captures the dust events over the 41-years, especially those related to the negative NAO, comparing to the surface observation should be examined. Also, the dust events are separated into dust storm, blowing dust and floating dust. Are they show the same relationship with NAO?

Response:

Thanks for your comment and suggestion.

From the results of previous studies, MERRA-2 reanalysis data has good accuracy and applicability for studying the evolutionary situation of dust events in Asia, as well as its analysis results are more excellent compared with MODIS, OMPS, CALIPSO and Hamawari-8 data (Kang et al., 2016; Wang et al., 2018; Yao et al., 2020; Wang et al., 2021). And the frequency of dusty weather from the station data is calculated and converted into the intensity index (Wang et al., 2008), which can be used to represent the dust aerosol content. It is found that use of the intensity index and the dust column mass density from MERRA-2 reanalysis data to analyze the spatiotemporal distribution characteristics and the changing situation of dust aerosol content in China are basically the same (Figure R1).

The dust storm, blowing dust and floating dust are also closely related to the NAO, similarly to that of the dust events in our study. We select the years which that spring blowing dust and floating dust events (no dust storm events) in North China during the period of 1980-2020 occurred (Table R1).

And it is found that the previous winter sea level pressure of the North Atlantic in the years which different dust events occurred, the dipole structure of "+ -" can be observed in the lower, middle and upper troposphere (Figure R2), which is a significant negative phase characteristic of NAO, indicating that there is a significant negative correlation between the previous NAO and different types of dust events.

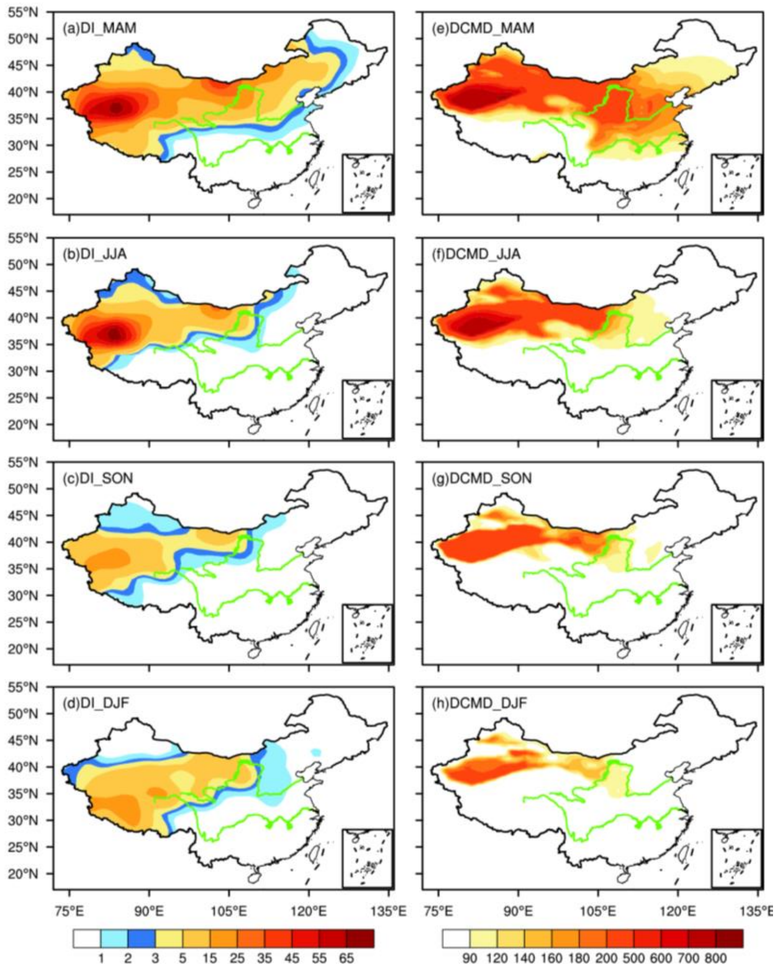

Figure R1. (a-d) Seasonal distribution of DI from station data, (e-h) As in (a-d), but for dust column mass density from MERRA-2 reanalysis data (The unit in (a-d) is $mg\ m^{-2}$).

Table R1. The years in which spring dust storm, blowing dust and floating dust events in North China during 1980-2020 occurred.

Dust storm events	Blowing dust events	Floating dust events
None	1980, 1981, 1982, 1983, 1984, 1988, 1990, 1995, 1998, 2000, 2002, 2010, 2013	1980, 1981, 1982, 1983, 1984, 1985, 1987, 1988, 1990, 1992, 1993, 1995, 1998, 2002, 2010

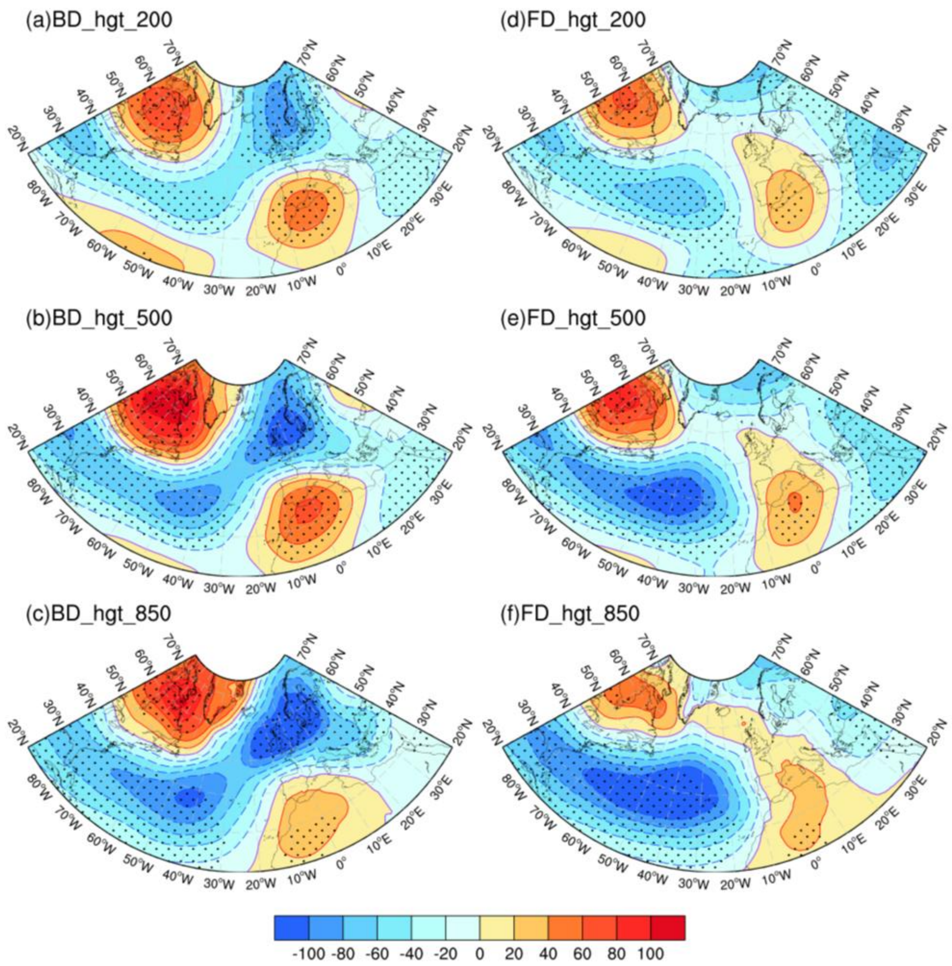

Figure R2. (a-c) Spatial distribution of the 200 hPa, 500 hPa, and 850 hPa geopotential height anomalies in previous winter of the year when the blowing dust occurred, (d-f) As in (a-c), but for the year when the flowing dust occurred.

2. In the abstract, the correlation coefficient between the boreal winter NAO index and the late spring DAs in the North China is -0.39, but I did not find thin value in the main text (probably in line 260).

Response:

Thanks for your comment.

We have revised the description as "Furthermore, significant correlation coefficients can be found between the spring DAs in North China and the NAOI in previous DJF, JFM, and FMA, and the correlation coefficients are -0.39, -0.40, -0.40, -0.28, respectively", as shown in Lines 226-228.

3. Line 54: Studies also reported that the dust can interact with winds in China through its radiative effect, which further weakens winds during weak wind years in winter over North China (e.g., Yang et al., 2017).

Response:

Thanks for your suggestion.

Study of Yang et al. (2017) is truly related to our work. We have quoted the work in the introduction section as "In particular, the radiative forcing of DAs is comparable to that of clouds on a regional-scale and has a key impact on the local weather-climate (Kaufman et al., 2002; Huang et al., 2014a; Yang et al., 2017)", as shown in Lines 40-43.

4. The authors explain the impacts of NAO on dust in North China through changes in energy and large-scale circulation. But they also showed that NAO can cause unusual rainy climate, which can influence the wet removal of dust. How this effect considered in the study.

Response:

Thanks for your comment and suggestion.

Previous researches have indicated that the NAO stimulates the Rossby wave and brings water vapor to the Yangtze River, China, resulting in the excessive precipitation there (Han and Zhang, 2022). In addition, the NAO is significantly correlated with the variations of East China rainfall through the Eurasian teleconnection (Wang et al., 2018). In this work, we demonstrates that during the DEs under the modulation of the NAO negative signal, North China is controlled by an anticyclonic system dominated by sinking airflow. Therefore, poor precipitation conditions lead to the weak wet-deposition of DAs during transport (Kutiel and Furman, 2003).

According to your suggestion, we have added description as shown in in Lines 388-391.

5. The mechanism of the NAO impacts may not be only limited to dust in China, but also dust over the central Asia and North Africa. The authors could add some discussion about it.

Response:

Thanks for your comment and suggestion.

In the revised manuscript, according to your suggestion, we added the description "Furthermore, NAO is closely related to dust activities in many regions, except for China. For example, Moulin et al. (1997) and Ginoux et al. (2004) both indicated a strong correlation between the NAO and dust activity in North Africa, using satellite data and dust transport models, respectively. Banerjee et al. (2021) and Li et al. (2022) emphasized the important role of NAO in the dust activities of South Asia and Central Asia. Hence, future studies are needed to explore the relationship between the dust activities in other regions and NAO" in discussion (Lines 688-693 in the revised manuscript).

References:

Banerjee, P., Satheesh, S. K., and Moorthy, K. K.: Is the Atlantic Ocean driving the recent variability in South Asian dust? Atmospheric Chemistry and Physics, 21, 17665-17685, https://doi.org/10.5194/acp-21-17665-2021, 2021.

Li, Y., Song, Y. G., Kaskaoutis, D. G., Zhang, X. X., Chen, X. L., Shukurov, N., and Orozbaev, R.: Atmospheric dust dynamics over Central Asia: A perspective view from loess deposits, Gondwana Res., 109, 150-165, https://doi.org/10.1016/j.gr.2022.04.019, 2022.

Ginoux, P., Prospero, J. M., Torres, O., and Chin, M.: Long-term simulation of global dust distribution with the GOCART model: correlation with North Atlantic Oscillation, Environ. Modell. Softw., 19, 113-128, https://doi.org/10.1016/s1364-8152(03)00114-2, 2004.

Han, J. P. and Zhang, R. H.: Influence of preceding North Atlantic Oscillation on the spring precipitation in the middle and lower reaches of the Yangtze River valley, Int. J. Climatol., 42, 4728-4739, https://doi.org/10.1002/joc.7500, 2022.

Kang, L. T., Huang, J. P., Chen, S. Y., and Wang, X.: Long-term trends of dust events over Tibetan Plateau during 1961-2010, Atmos. Environ., 125, 188-198, https://doi.org/10.1016/j.atmosenv.2015.10.085, 2016.

Kurosaki, Y. and Mikami, M.: Recent frequent dust events and their relation to surface wind in East Asia, Geophysical Research Letters, 30, 4, https://doi.org/10.1029/2003gl017261, 2003.

Moulin, C., Lambert, C. E., Dulac, F., and Dayan, U.: Control of atmospheric export of dust from North Africa by the North Atlantic oscillation, Nature, 387, 691-694, https://doi.org/10.1038/42679, 1997.

Yao, W. R., Che, H. Z., Gui, K., Wang, Y. Q., and Zhang, X. Y.: Can MERRA-2 Reanalysis Data Reproduce the Three-Dimensional Evolution Characteristics of a Typical Dust Process in East Asia? A Case Study of the Dust Event in May 2017, Remote Sens., 12, 18, https://doi.org/10.3390/rs12060902, 2020.

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, 3156-3165, https://doi.org/10.1016/j.atmosenv.2007.07.046, 2008.

Wang, T. H., Tang, J. Y., Sun, M. X., Liu, X. W., Huang, Y. X., Huang, J. P., Han, Y., Cheng, Y. F., Huang, Z. W., and Li, J. M.: Identifying a transport mechanism of dust aerosols over South Asia to the Tibetan Plateau: A case study, Sci. Total Environ., 758, 11, https://doi.org/10.1016/j.scitotenv.2020.143714, 2021.

Wang, Z. Q., Yang, S., Lau, N. C., and Duan, A. M.: Teleconnection between Summer NAO and East China Rainfall Variations: A Bridge Effect of the Tibetan Plateau, J. Clim., 31, 6433-6444, https://doi.org/10.1175/jcli-d-17-0413.1, 2018.

Wang, Z. Q., Yang, S., Lau, N. C., and Duan, A. M.: Teleconnection between Summer NAO and East China Rainfall Variations: A Bridge Effect of the Tibetan Plateau, J. Clim., 31, 6433-6444, https://doi.org/10.1175/jcli-d-17-0413.1, 2018.