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Responses to Referee #1

This study analyzed the impacts of different types of El Niño on dust activities over China using E3SMv1 model simulation. The authors showed that El Niño causes changes in boreal winter (DJF) dust concentrations over China by modulating wind speed and relative humidity near the dust sources (e.g., Gobi desert). The impacts on boreal spring (MAM) dust concentrations are statistically unclear. The influences of different types of El Niño are discussed. Overall, the paper is well organized, helpful and appropriate for publication in ACP. I may recommend publication of this manuscript after the following comments are addressed.

We thank the reviewer for all the insightful comments. Below, please see our point-by-point response (in blue) to the specific comments and suggestions and the changes that have been made to the manuscript, in an effort to take into account all the comments raised here.

Specific comments:

1. The results might be sensitive to the model selected (i.e., E3SMv1). The authors pointed out that there are model biases in simulating dust emissions (Section 2.3). However, explanation on how these biases may affect the key results (e.g., as shown in Figure 2) is not clearly discussed. The discussion given in Section 4 might be too short. Further, is it possible to suggest that these biases are associated with the model biases in simulating humidity or near surface wind?

Response:

Thanks for the suggestion. Compared to the observations, E3SMv1 overestimates AOD near some desert source regions and the bias is even larger in its predecessor CAM5. The bias is partly related to the dust treatment in the model that dust is emitted into a shallow model bottom layer in E3SMv1 for increased model vertical resolution (Wang et al., 2020). In addition, stronger 10-m wind speed simulated by the model compared to the observation (Fig. S3) also contributes to the higher dust loading. We have now added these explanations in the model evaluation section.

In Section 4, we have also added some discussion related to the bias of dust loading, as "This high bias of dust loading near the dust source regions are related to the dust treatment in the model, dust parameterization and stronger winds in model than observations. The low bias of long-range transport of dust is due to the strong dust deposition considering that dust is emitted in the shallow model bottom layer in the model. Therefore, the estimate of El Niño impact on dust emissions and concentrations are likely to be overestimated near the source regions, but impact from changes in large-scale circulation related to El Niño on dust transport is possibly underestimated."

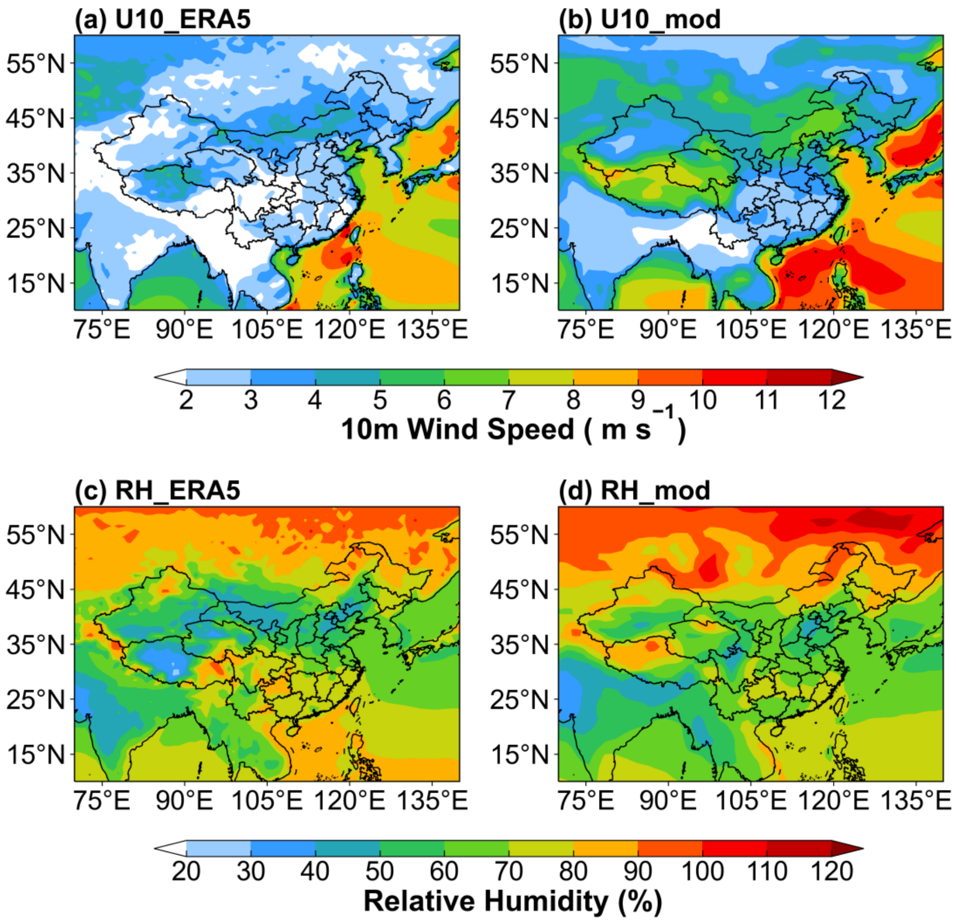

Figure S3. Spatial distributions of DJF mean 10-m wind speed (m s^{-1}) (top panels) and relative humidity (units: %, bottom panels) from ERA5 over 1950–2020 in (a) and (c) and CLIM experiment in (b) and (d), respectively.

2. I am wondering if the current model can provide the output of dust deposition and if the analysis of El Niño impacts on dust deposition is necessary.

Response:

Thanks for your insightful suggestion. The model can provide the output of dust deposition and we have added Fig.S6 and Fig.S11 to show the dust wet deposition during different types El Niño. "Furthermore, a reduced DJF precipitation during both EP and CP El Niño events (Fig. S5) should weaken the wet removal of dust from the atmosphere in northern China. However, only insignificant decreases in wet deposition appear in part of northern China and significant increases in wet deposition are located in central and southern China related to increases in dust loading during EP and CP El Niño events (Fig. S6). It suggests that El Niño impact on dust concentrations is mainly through changing the emission and transport of dust rather than the scavenging in winter." "Along the transport pathway, the weakened precipitation (Fig. S10) partly reduces the dust wet removal (Fig. S11), leading to the strong increase in MAM dust concentration over northern China during the LD El Niño. However, this effect is largely overwhelmed by the increased dust wet removal due to the emission-induced increase in dust concentrations." We have added these descriptions in the revised manuscript.

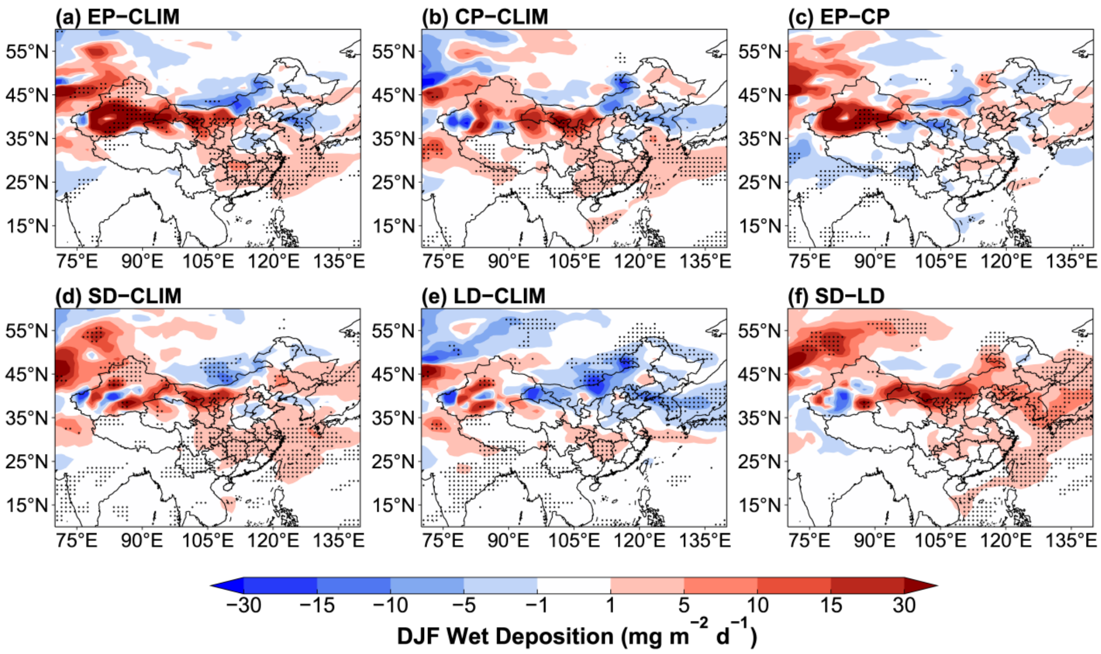

Figure S6. Composite differences in DJF mean dust wet deposition (mg m^{-2} d^{-1}) between EP and CLIM in (a), CP and CLIM in (b), EP and CP in (c), SD and CLIM in (d), LD and CLIM in (e), and SD and LD in (f). The stippled areas indicate statistical significance with 90% confidence from a two-tailed T-test.

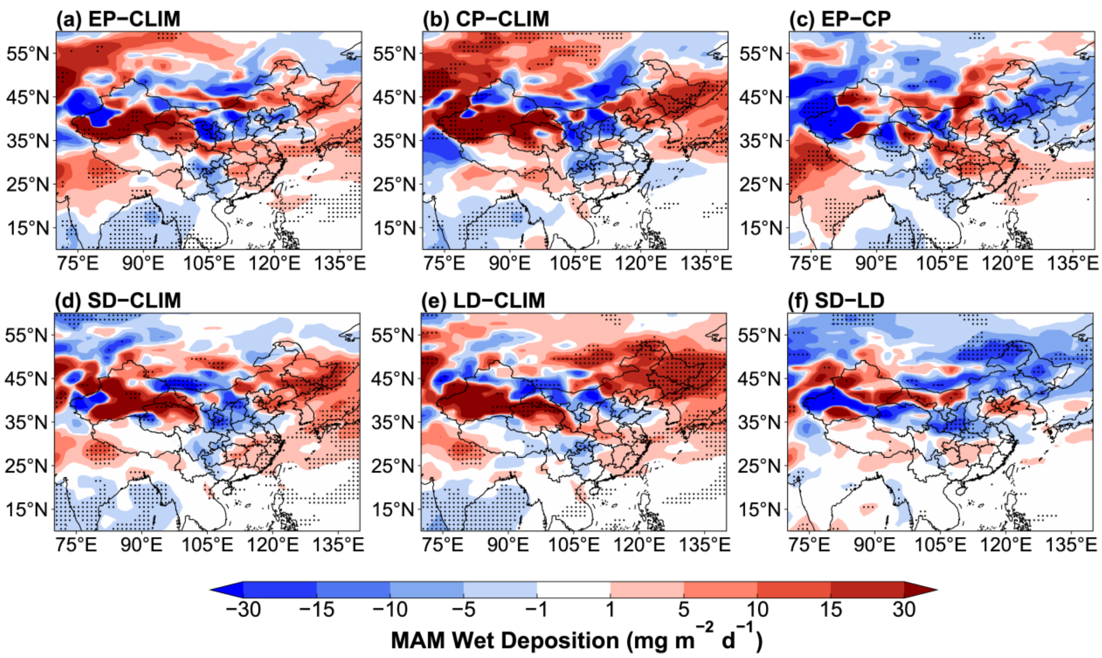

Figure S11. Composite differences in MAM mean dust wet deposition (mg m^{-2} d^{-1}) between EP and CLIM in (a), CP and CLIM in (b), EP and CP in (c), SD and CLIM in (d), LD and CLIM in (e), and SD and LD in (f). The stippled areas indicate statistical significance with 90% confidence from a two-tailed T-test.

3. Line 185: It is unclear about the period of the sensitivity experiments. Why did the authors chose 13 years only? I supposed that the period of the sensitivity experiment for SD El Niño should be longer than LD El Niño, as there are more SD El Niño events (Lines 159-160).

Response:

As we described in Sec.2.3, sensitivity simulations are driven by the monthly SST representing the composite of El Niño events, which is generated through adding the mean monthly SST anomalies from Jul^0 to Jun^1 of the different types of El Niño events to the climatological SST between 60°S and 60°N. The monthly SST anomalies are the averages for all SD/LD/EP/CP El Niño events. Each of these 13 years are driven by the monthly SST anomalies repeating for the same year, which is used to reduce the model internal variability. The first 3 years are the model spin-up and the last 10 years are used for analysis.

Technical corrections:

1. Lines 23-24: This sentence needs to be rephrased.

Response:

We have revised the sentence as follows. “Dust is an important aerosol affecting air quality in China in winter and spring seasons. Dust in China is potentially influenced by the interannual climate variability associated with El Niño.”

2. *Line 26 and others: Do you mean ‘boreal winter’?*

Response:

Added.

3. *Line 26: ‘an’ → ‘a’*

Response:

Revised.

4. *Lines 79-80: This reference (https://doi.org/10.5194/acp-22-5253-2022) might be helpful to reinforce the statement of El Niño impacts on dust activities. For example, the El Niño–Southern Oscillation (ENSO) shows causal impacts on dust emission over the northwestern China and wetdust deposition over the eastern China. In addition, there is ENSO impacts on dust concentrations over the southern and western China.*

Response:

Thanks for providing the latest relevant reference, which are of great help to our statement of El Niño impacts on dust. We have added this reference here (Le and Bae, 2022).

5. *Line 183: If the results are based on the ensemble mean, it should be stated clearly.*

Response:

The results are based on the ensemble mean. We have now added this statement.

6. *Line 592: 98% or 90%? It is more common to use 99% or 95% significance level, instead of 98%.*

Response:

Thanks for the suggestion. We have revised the significance level to 99%.

Reference:

Le, T. and Bae, D.-H.: Causal influences of El Niño–Southern Oscillation on global dust activities, Atmos. Chem. Phys., 22, 5253–5263, https://doi.org/10.5194/acp-22-5253-2022, 2022.