Manuscript # acp-2022-355

Responses to Referee #3

Thanks for the author's effort in revising the manuscript. However, most comments were not well 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. First, the authors said the E3SMv1 can reproduce the atmospheric anomalies related to the two types of El Nino events in the observations. However, I cannot find the evidences. Actually, the authors only show the climatological distributions of DJF mean 10-m wind speed and relative humidity (Figure S3).

The atmospheric anomalies related to the different spatial types of El Nino events in the observations were also given in the manuscript to compare with those from simulations. For example, Fig.6 and Fig. S4 show the anomalies of relative humidity during different types of El Niño events. Figs. 3 and 4 show simulated 10-m wind speed, winds at 850 hPa and sea level pressure, while the same variables in observations are given in Fig. 5 (EP/CP) and our previous work (Zeng et al., 2021 for SD/LD 850 hPa winds, as shown below). These indicate E3SMv1 can roughly capture atmospheric anomalies in the observations over central-eastern in China. We have revised the figure description to emphasize which one is from observations and correct the description that E3SMv1 can "roughly capture" the atmospheric anomalies over central-eastern China rather than "reproduce" the anomalies. We also note that there are notably differences in atmospheric circulation over many regions of East Asia. It can be partly attributed to the model bias in reproducing the atmospheric responses to El Niño. The observations can also be induced by other climate factors besides El Niño, leading to a potential inconsistency in El Niño impact between model and observation.

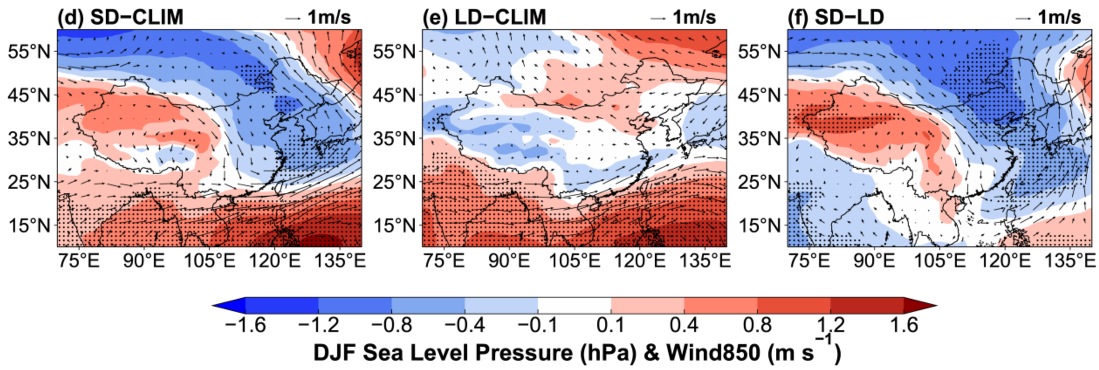

Figure 4. Composite differences in DJF mean sea level pressure (SLP, shaded; units: hPa) and winds at 850 hPa (WIND850, vector; units: m s-1) between SD and CLIM in (d), LD and CLIM in (e), and SD and LD in (f). The stippled areas indicate statistical significance with 90% confidence from a two-tailed T-test.

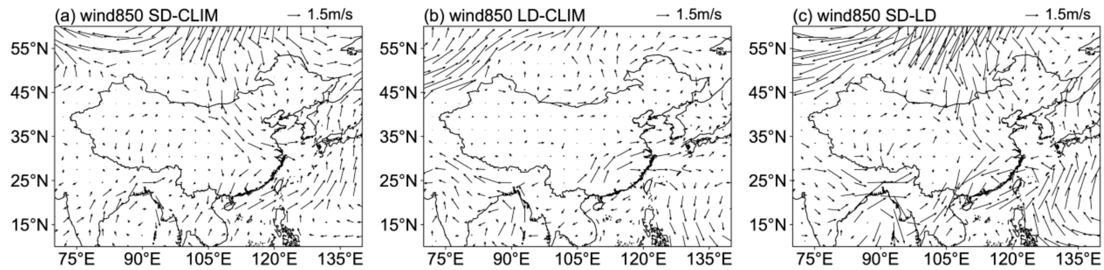

Figure in Zeng et al. (2021). Composite differences in DJF mean winds at 850 hPa (m s^{-1}) between 2015/2016 SD El Niño and climatological mean (1950-2017) (a), 1986/1987 LD El Niño and climatological mean (b), and 2015/2016 SD El Niño and 1986/1987 LD El Niño (c) from the EAR5 reanalysis data. The data were detrended over 1950-2017.

2. Second, as indicated in my previous comment, the results should be sensitive to the selected model. We cannot confirm the robustness of the results. We can obtain different conclusion if using other climate models. Actually, previous studies indicated that El Nino event cannot lead to notable climate and atmospheric anomalies over the regions to the north of China.

We agree with the reviewer that the results are potentially model dependent. But we also notice that some previous studies have shown that changes in tropical sea surface temperature (SST) can lead to notable climate and atmospheric anomalies over northern China. For example, Liu et al. (2022) used the Community Atmosphere Model version 4 (CAM4) to investigate the impact of SST on dust activities in the Gobi Desert and North China and they also noted that tropical Pacific SST variability resulted in the important change in boreal spring dust activity frequency in the Gobi Desert. Moreover, Jung et al. (2022) also pointed out the important modulation of PM_{10} in East Asia by the Madden-Julian Oscillation (MJO), an important meteorological phenomenon in the tropics. Le et al. (2022) and Li et al. (2021) both reported the effect of dust over northwestern China influenced by

ENSO. Due to the limitation of computational resources, we cannot repeat the simulations using different models. Therefore, we added the caveat in the discussion as “results from a single model with relative short simulations may not be representative and may not well remove the internal atmospheric variability (Deser et al., 2014), which can be further investigated by conducting large ensemble and longer simulations using multi-models.”

3. Third, the authors did not explain the mechanisms for the differences of the atmospheric anomalies over North China between different types of El Nino.

The mechanisms for the differences of the atmospheric anomalies between different types of El Nino have been illustrated in many studies. Western North Pacific anomalous anticyclones (WNPAC), which occur during both EP and CP El Niño events, have been proved as a crucial system that links El Niño and East Asian climate (Li et al., 2017). The anomalous southwesterlies at the north of WNPAC transport moisture to southern China, which can block the prevailing northerlies over central-eastern China in winter and weaken the East Asian winter monsoon (Yuan and Yang, 2012). EP El Niño exerts larger meteorological changes over southern China than CP El Niño due to a stronger WNPAC (Jiang and Li, 2022; Kim et al., 2021). Therefore, the anomalous northerlies over the Gobi Desert and central China are hindered and weaker during EP El Niño than CP El Niño (Fig. 4). SD El Niño has a relatively deeper thermocline during its mature phase than LD El Niño and numerous ocean heat can be transported from the eastern Pacific to the South China Sea and the Western Philippine Sea during SD El Niño (Guo and Tan, 2018). The transmitted ocean heat leads to anomalous warming of the North Pacific SST, a smaller-than-normal tilt of the East Asian trough, a weakening of the mid-latitude westerly flow in front of the trough, and anomalous northerly winds along the trough line of the subtropical trough, along with reduced precipitation (Wang et al., 2009). These favor dust emission and transport from north to south during SD El Niño. We have added the detailed description in Sec. 4 of our revised manuscript.

4. Fourth, as indicated in previous comment, in my view, the simulated atmospheric circulation anomalies over East Asia show notably different with those in the observations. I did not think they are similar.

They do show some differences in many regions of East Asia and we did not expect or say they are similar over the whole East Asia. Although the simulated atmospheric circulation anomalies over East Asia show notably different from the observations, the anomalies over northern China, especially in the dust source region, are similar to the observations, which are the key region our manuscript concerns. Therefore, in the last revision, we have added a notice that "It suggests that the atmospheric circulation features over central-eastern China during different types of El Niño are roughly captured by the model. However, we note that there are notably differences in atmospheric circulation over many regions of East Asia. It can be partly attributed to the model bias in reproducing the atmospheric responses to El Niño. The observations can also be induced by other climate factors besides El Niño, leading to a potential inconsistency in El Niño impact between model and observation."

5. Fifth, I do not think 3 ensemble and 10 years mean can well remove the internal atmospheric variability in mid-latitude regions, although the authors suggested that the model response to different types of El Niño events outweighs the effect of the internal variability of the model.
Deser C, Phillips AS, Alexander MA, Smoliak BV (2014) Projecting North American climate over the next 50 years: uncertainty due to internal variability. J Clim 27(6):2271–2296.

We agree with the reviewer that the simulations are relatively short. Due to the limitation of resources and the much more complexity of E3SM than its predecessor CESM1, it is difficult to prolong all simulations for all ensembles. We have tested the SD/LD results by prolonging one ensemble simulations for additional 10 years and the spatial pattern of the dust response does not have a large change over China, except over parts of northeastern China in LD simulation. We also have a caveat that "results from a single model with relative short simulations may not be representative and may not well remove the internal atmospheric variability (Deser et al., 2014), which can be further investigated by conducting large ensemble and longer simulations using multi-models."

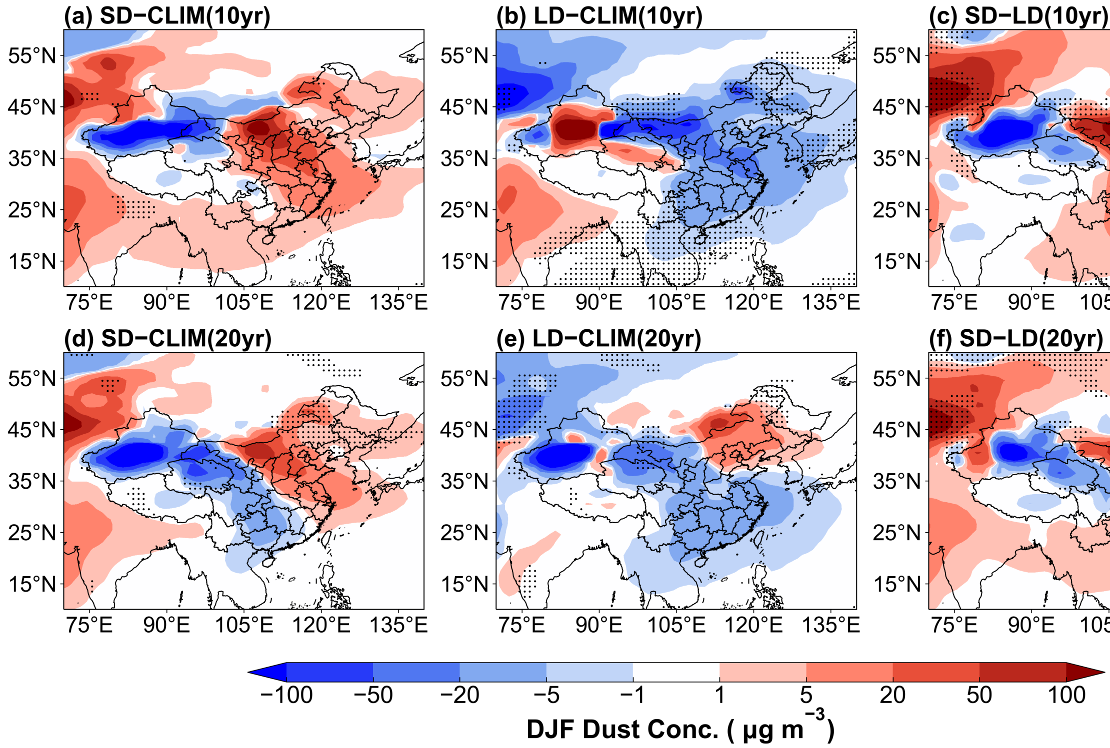

Figure A. Composite differences in DJF mean near-surface dust concentrations (μg m^{-3}) between SD/LD and CLIM for 10-year (top) and 20-year (bottom) simulations with one ensemble. The stippled areas indicate statistical significance with 90% confidence from a two-tailed T-test.

Reference:

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