Manuscript # acp-2022-355

Responses to Referee #2

Comments and suggestions:

This study examines the impacts of different types of El Nino events on dust pollution in China based on an earth system model. According to the model simulation, the authors suggested that dust concentrations during the CP El Nino are much higher in northern China than during the EP El Nino. The short duration (SD) El Nino increases winter dust concentration over northern China, while there is a decrease in dust concentration during the long duration (LD) El Nino. In general, the topic of this study is interesting. However, current version of the manuscript at least needs a major revision. My comments are shown as follows.

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.

1. This study examines the impacts of different types of El Nino events (EP, CP, SD, LD) on the dust concentration over China only based on one model simulation. Can the different impacts of the four types of El Nino event on the dust concentration over China can be obtained in the observations?

Response:

In this study, the anomalies in atmospheric circulation during different types of El Niño events are compared with reanalysis data. It confirms that the model can simulate the anomalies in the atmospheric circulation, which dominates the changes in dust distributions. We have also added Fig. S3 below to compare the modeled climatological wind speed and relative humidity with observations.

The dust concentrations are evaluated by comparing modeled concentrations with spring PM_{10} concentrations over 2015–2021. The dust loading is also evaluated by comparing modeled dust optical depth with that derived from satellite data over 2001–2020. However, the anomalies of dust concentrations were not compared with observations. This is because that dust is jointly influenced by many factors in the observation other than El Niño, such as Mongolian cyclone, sea ice in the Barents Sea, sea surface temperature in Atlantic Ocean, Arctic Oscillation, and human activities (Fan et al 2016, 2018; Mao et al., 2011; Wang et al., 2021; Xiao et al., 2015; Yin et al., 2021), while this study presents the “pure” effects of El Niño on dust using an Earth system model. In addition, PM_{10} is strongly influenced by other anthropogenic aerosols over eastern China, especially in hazy winter. The comprehensive understanding of the impacts from different types of El Niño events on dust in China requires a longer-term observation with sufficient spatial coverage. We have added these discussions in the revised manuscript.

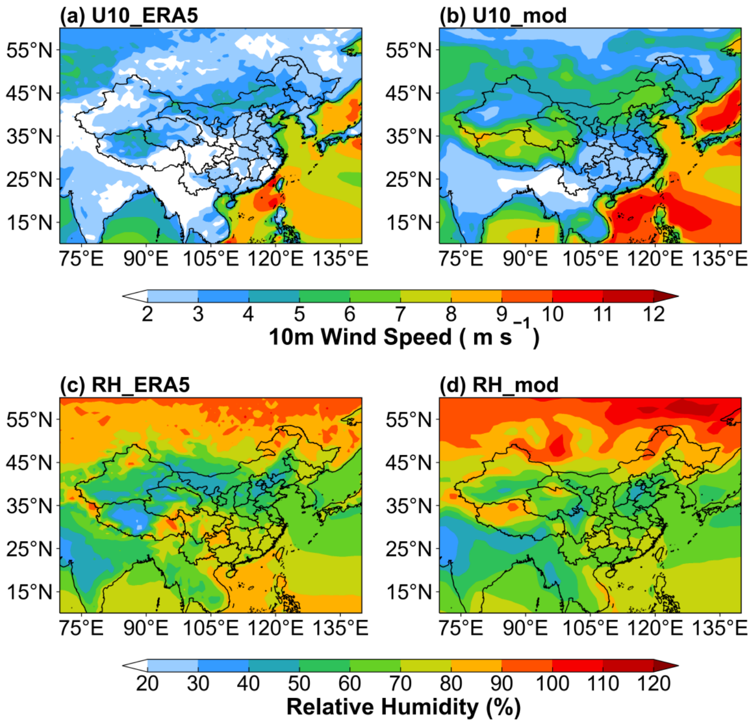

Figure S3. Spatial distributions of DJF mean 10-m wind speed (m s^{-1}) (top panels) and relative humidity (units: %, bottom panels) from ERA5 over 1950–2020 in (a) and (c) and CLIM experiment in (b) and (d), respectively.

2. The obtained results of this study are only based on one model simulation. Many studies have demonstrated that impact of ENSO on extratropical atmospheric circulation and climate variation over East Asia are strongly model-dependent. It cannot confirm the robustness of the results obtained in this study only based on one model simulation.

Response:

The simulated anomalies in atmospheric circulation were compared with reanalysis data and it turns out that E3SMv1 model can simulate the responses in atmospheric circulation to El Niño forcing. We agree with the reviewer that results from one model is not representative. We have added the limitation in the discussion section, as "Also, results from a single model with relative short simulations may not be representative and may not well remove the internal atmospheric variability, which can be further investigated by conducting large ensemble and longer simulations using multi-models."

3. Lines 183-184: 3 ensemble and the last 10 years are used to analysis. It should be mentioned that there exist a large internal variability over extratropics. Thus, 3 ensemble and 10 years mean cannot well remove the internal atmospheric variability.

Response:

The internal variability of the model could affect the results, but most of our results passed a two-tailed t-test at the 90% confidence level, indicating that the model response to different types of El Niño events outweighs the effect of the internal variability of the model. Notwithstanding, we have added the potential limitation in the revised manuscript, as "Also, results from a single model with relative short simulations may not be representative and may not well remove the internal atmospheric variability, which can be further investigated by conducting large ensemble and longer simulations using multi-models."

4. From. Fig. 4, it shows that there exist large differences in the atmospheric anomalies over East Asia related to the four types of El Nino. First, what are the mechanisms for the formations of the atmospheric anomalies induced by the different types of El Nino. Second, what are the factors for the differences of atmospheric anomalies generated by EP and CP El Nino (SD and LD El Nino)?

Response:

Although the mechanisms causing the atmospheric anomalies related to different types of El Niño and their differences are out of the scope of this study, knowing these mechanisms can help to understand the results. The EP El Niño is associated with basin-wide thermocline and surface wind variations and shows a strong teleconnection with the tropical Indian Ocean. In contrast, the CP El Niño appears less related to the thermocline variations and may be influenced more by atmospheric forcing. It has a stronger teleconnection with the southern Indian Ocean (Kao and Yu, 2009). Base on this, many studies have found that EP and CP El Niño cause different atmospheric circulation. Yuan and Yang (2012) pointed that the East Asia winter monsoon is weaker (stronger) during the winter of EP (CP) El Niño. Yu et al. (2020) noted that there are obvious southerly (northerly and northwesterly) wind anomalies at the middle to lower troposphere over eastern China during the winter of EP (CP) El Niño. These are consistent with the results in our study. The thermocline during LD El Niño mature phase is relatively shallower than that of SD El Niño. Moreover, the SST anomalies of SD El Niño are larger than LD El Niño, and the different depths of the thermocline indicates large differences in the recharged energy going into the eastern Pacific, which may lead to different oceanic and atmospheric conditions during their decaying periods (Guo and Tan, 2018). As for EP and CP El Niño, the SST anomaly centers are located in the eastern and central equatorial Pacific, respectively. The different locations of the SSTA generate differences in atmospheric circulation anomalies. As for SD and LD El Niño, the locations of the SST anomalies are similar, but LD El Niño has a longer duration and weaker intensity, thus generating different atmospheric circulations. Due to these mechanisms are complex and out of the scope of our study, we have added these detailed descriptions in the supplementary material (Text S1).

5. Lines 218-222: From Fig. 2c, the difference of dust concentrations over central-eastern China are weak and statistically insignificant. Hence, you cannot conclude that dust concentrations increase more significantly over central-eastern China. In addition, actually, from Fig. 2, differences in the dust concentrations between CP and EP are mostly insignificant in China. The related conclusions you mentioned are incorrect.

Response:

Thanks for the point. We have revised these descriptions as follows. "During CP El Niño relative to the climatological mean, dust concentrations increase more significantly over central-eastern China, with the increases of 20–50 μg m^{-3}, 5–20 μg m^{-3} higher than that during EP El Niño relative to the climatological mean. The large increase during CP El Niño relative to the climatological mean is also more widespread than that during EP El Niño relative to the climatological mean. Compared to CP El Niño, dust concentration over central-eastern China decreased slightly during the EP El Niño, but the changes are mostly insignificant." Other relevant conclusions in the manuscript have been modified accordingly.

6. Lines 276-285: A comparison of Fig. 5 and Fig. 4 indicate that the simulated atmospheric circulation anomalies over East Asia show notably different with those in the observations. How can you say they are similar? In addition, the variables shown in Fig. 5 should be similar to those shown in Fig. 4. For example, SLP anomalies should be shown. In addition, the composites for the SD and LD El Nino events should also be shown in Fig. 5.

Response:

We have now added the sea level pressure anomalies in Fig.5 comparing atmospheric circulation between EP and CP Niño events. As we illustrated in the manuscript, our previous work has confirmed the ability of E3SM in reproducing the atmospheric circulation during SD and LD El Niño events using the same SD and LD simulations (Zeng et al, 2021), so we did not repeat the figure in this study.

From Fig.4 and Fig.5, the simulated atmospheric circulation anomalies over dust source region and central-eastern China are consistent with the reanalysis data (i.e., anomalous southerly winds during EP El Niño and anomalous northwesterly during CP El Niño). These indicate that the model can roughly reproduce the atmospheric circulation features during different types of El Niño over central-eastern China. However, the simulated wind fields and the reanalysis data differ in other regions. This is because the atmospheric circulation is influenced by many factors other than El Niño in the observation, while the simulation only considers the influence of El Niño, so the results from simulation and observation are not fully consistent.

We have revised our descriptions as "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."

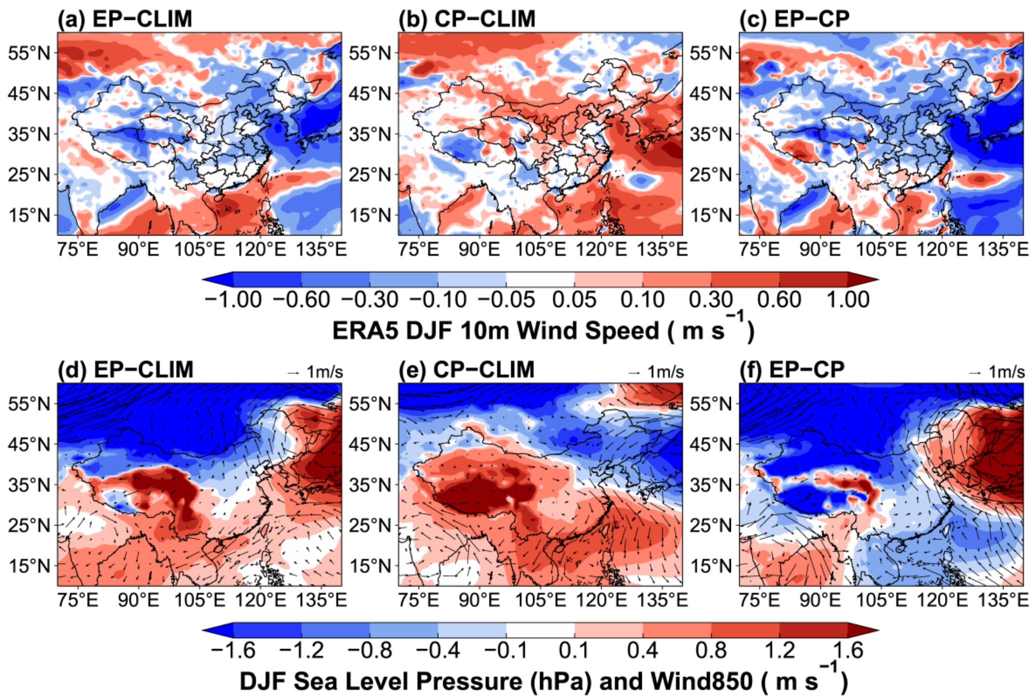

Figure 5. Composite differences in DJF mean 10-m wind speed (m s^{-1}) (top panels) and sea level pressure (SLP, shaded; units: hPa) and wind at 850 hPa (WIND850, vector; units: m s^{-1}) (bottom panels) between 2006/07 EP El Niño and climatological mean (1950–2017) in (a, d), 2014/15 CP El Niño and climatological mean in (b, e), and 2006/07 EP El Niño and 2014/15 CP El Niño in (c, f) from the EAR5 reanalysis data. The data were detrended over 1950–2017.

Minors:

1. *Line 81: the under-->delete the*

Response:

Revised.

2. *Lines 139-140: Nino3.4 SST index is defined as area-mean SST anomalies in the Nino3.4 region.*

Response:

Revised.

3. *Definition of the EP and CP events: You should note that there also exist mixed El Nino event.*

Response:

Added.

4. *The years of CP, EP, SD and LD El Nino events should be shown in a Table.*

Response:

We have added Table S1 to show the years of EP, CP, SD and LD El Niño events.

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