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Responses to Referee #1

This study investigated the different impacts of short duration (SD) and long duration (LD) El Niño on the aerosol pollution in China. The authors found that SD El Niño exerts more significant influences on the $PM_{2.5}$ concentrations in winter, which increase in northeastern and southern China and decrease in central-eastern China. The anomalous atmospheric circulation induced by SD El Niño is the dominant reason for $PM_{2.5}$ concentration changes. These findings are interesting and useful to air quality prediction and improvement. The logic of this article is good. However, there are some major concerns about the physical mechanism that I doubt. The comments below that I expect are helpful for improving the manuscript.

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.

Major comments:

1. The anomalous atmospheric circulation induced by El Niño plays a vital role in changing the $PM_{2.5}$ concentration distribution. The authors should give the observed atmospheric circulation conditions induced by SD and LD El Niño using the reanalysis data. Then, the authors can compare the observed atmospheric circulation with the simulated circulation, and can further evaluate whether the model simulates a reasonable atmospheric circulation. This check is very important, because atmospheric circulation induced by El Niño determines the conclusion of this study.

Thanks for the suggestion. We have added Fig. 7 in order to compare the observed with the simulated atmospheric circulation anomalies during SD and LD El Niño relative to the climatology. "To further verify the model simulations in capturing atmospheric circulation anomalies during SD and LD El Niño events, the wind fields are compared with those from ERA5 reanalysis data. The anomalous atmospheric circulation patterns in the latest SD El Niño event (2015/2016) and LD El Niño event (1986/1987) relative to the climatological mean (1950-2017) from the ERA5 are shown in Fig. 7. Overall, the SD and LD El Niño-induced anomalous atmospheric circulations over China simulated in E3SM are in consistent with the reanalysis data. Both of them show the anomalous northerly winds over central-eastern China at 850 hPa during SD El Niño compare to LD El Niño. In

addition, obvious anomalous cyclone at 500 hPa over most of China can be seen in both E3SM and ERA5." We have added these descriptions in the revised manuscript.

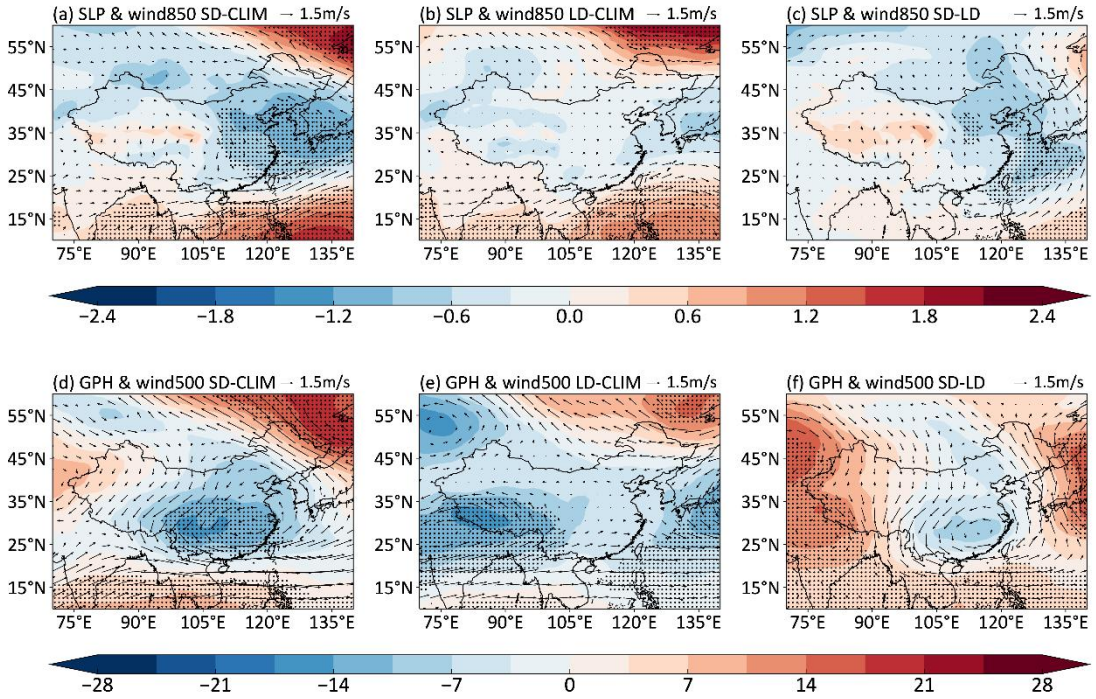

Figure 6. Composite differences in DJF mean sea level pressure (SLP, shaded; units: hPa) and wind at 850 hPa (WIND850, vector; units: m s-1) (top panels) and geopotential height at 500 hPa (GPH500, shaded; units: m) and wind at 500 hPa (WIND500, vector; units: m s-1) (bottom panels) between SD and CLIM (a, d), LD and CLIM (b, e), and SD and LD (c, f). The stippled areas indicate statistical significance with 90% confidence from a two-tailed T-test.

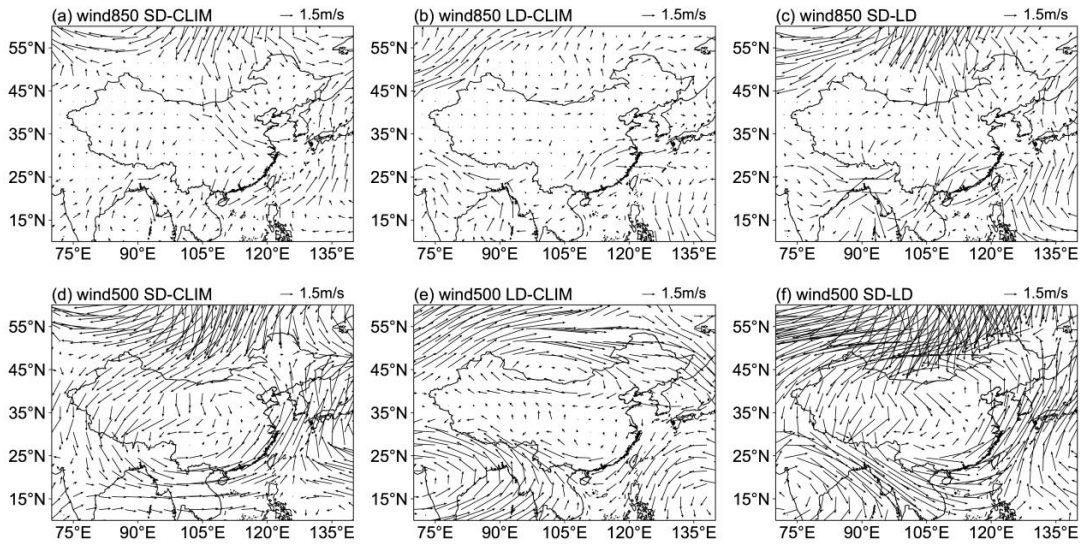

Figure 7. Composite differences in DJF mean winds at 850 hPa (m s^{-1}) (top panels) and 500 hPa (m

s^{-1}) (bottom panels) between 2015/2016 SD El Niño and climatological mean (1950-2017) (a, d), 1986/1987 LD El Niño and climatological mean (b, e), and 2015/2016 SD El Niño and 1986/1987 LD El Niño (c, f) from the EAR5 reanalysis data. The data were detrended over 1950-2017.

2. It is known that the anticyclone over the western North Pacific is the key atmospheric circulation system that El Niño exerts its impact on East Asia. Certainly, the southeasterly winds on the western side of this anticyclone lead to increase of the $PM_{2.5}$ concentration. However, the authors reported that the decrease of the $PM_{2.5}$ concentration in central-eastern China is attributed to the anomalous northerly winds of the cyclone over the East China Sea (Figure 7a). This anomalous cyclone is rarely reported. I doubt whether this anomalous cyclone indeed exists in observation, or it only appears in simulation? So, I suggest the authors should check the observational circulation condition using the reanalysis data to verify the simulated result.

Thanks for your insightful suggestion. As we replied above, we compared the atmospheric circulation anomalies produced by E3SM with ERA5 reanalysis data. Both of them showed anomalous northerly winds of an anomalous cyclone over East China Sea during SD El Niño events relative to the climatology. Chen et al. (2018) also found that an anomalous cyclone appeared over the western North Pacific in late 1986 El Niño. So, the anomalous cyclone does exist in observation. However, we note that atmospheric circulation in the real world is influenced not only by El Niño but also by many other climate phenomenon, such as Arctic Oscillation and Pacific Decadal Oscillation, while the E3SM simulation in this study focuses on the pure effects of El Niño. Since that El Niño is a climate phenomenon in the equatorial Pacific Ocean and has less impact over high latitudes, the circulation anomalies produced by E3SM differ with observations in high latitudes, although it is not the focus area of this study.

Minor comments:

3. Please pay attention to the singular and plural in English grammar, for example:

Line 45, "have" should be changed into "has"

Revised.

Line 77, "have" should be changed into "has"

Revised.

Line 170, "is" should be changed into "are"

Revised.

Line 188, “are” should be changed into “is”

Revised.

4. Line 172-176, please rewrite this sentence

We have revised the sentence as follows: “Niño 3.4 index is detrended SST anomaly over the Niño 3.4 region (170°W-120°W, 5°S-5°N). El Niño event is firstly identified when a 3-month running mean Niño 3.4 index is greater than 0.75°C in any month from Oct^0 to Feb^1 of its developing phase. If the Niño 3.4 index is higher than 0.5°C in any month from Oct^1 to Feb^2 of its decaying phase, the El Niño event is an LD El Niño event; otherwise, it is an SD El Niño event (Wu et al., 2019).”

5. Line 191, plus “anomaly” after “SST”

Revised.

Reference:

Chen, M., and Li, T.: Why 1986 El Niño and 2005 La Niña evolved different from a typical El Niño and La Niña, Clim. Dyn., 51, 4309–4327, https://doi.org/10.1007/s00382-017-3852-1, 2018.