Responses to Anonymous Referee #2

This study investigates the impact of ENSO on the interannual variation of spring aerosols over East Asia. They found that during El Nino year, it is often corresponding the above-normal aerosols and vice versa for the La Nina year. The reason is that during El Nino ensuing spring, the reduced precipitation increases the probability of biomass burning activities in the upstream of East Asia, then the western Pacific anticyclone transports this increased aerosol to the downstream East Asia region. They also compared different types of ENSO and found this effect is mainly from the eastern Pacific ENSO. The result is interesting, and the manuscript is well written. I have some detailed comments and suggestions listed below, but I think minor revision may be enough to address my concerns.

Response: We greatly appreciate these comments and suggestions. The manuscript would be improved in the process of response. Our detail responses are given point by point below in blue. The revised text is highlighted in red.

1. Please add line number in the revision in the whole manuscript. This way, the comments can be easily to track where it comes from.

Response: We are sorry for the inconvenience and have added the line numbers now.

2. Page-2 Line-4: Song et al. (2014) systematically discussed the aerosols effects on the East Asian summer monsoon circulation during the late half of 20th century. Please cite Song et al. (2014) here *Song, F., T. Zhou, and Y. Qian, 2014: Responses of East Asian summer monsoon to natural and anthropogenic forcings in the 17 latest CMIP5 models, Geophysical Research Letters, 41, doi:10.1002/2013GL058705.*

Response: As suggested by the reviewer, we have read the recommended paper carefully and cited this reference in the revised manuscript (Page 2, Line 4).

3. Page-2 Line-5: Dong and Zhou (2014) have quantified the aerosol's effect on the Indian Ocean sea surface temperature trends, belong to the regional climate response you discussed here. Please add this reference here: *Dong, L., and T. Zhou, 2014: The*

Indian Ocean Sea Surface Temperature Warming Simulated by CMIP5 Models during the Twentieth Century: Competing Forcing Roles of GHGs and Anthropogenic Aerosols. J. Climate, 27, 3348–3362.

Response: This reference has now been cited in the revised manuscript (Page 2, Line 5).

4. Page-2 Line-11: external forcing mainly means the forcing outside of climate systems. Here, maybe better just use factors.

Response: We agree that factors such as sea ice, snowpack and sea surface temperature are not external forcings. Therefore, we have changed "external forcing factors" to "other factors" on Page-2 Line-12.

5. Page-2 Line-27: why are the impacts of strong and weak events consistent? Maybe explain it a little bit from the reference you cited.

Response: Yu et al. (2019) suggested that both strong and weak El Niño events can cause similar atmospheric circulation anomalies, that is, significant northwesterly wind anomalies over northern China; and such anomalies act to enhance the seasonal prevailing wind and lead to a decrease in the aerosol concentration over northern China.

We have revised this sentence on Page-2 Line-28 as follows: "Yu et al. (2019) reported that the moderate El Niño events largely increase surface aerosol concentrations over eastern China, which is caused by anomalous southwesterly winds transporting more aerosol particles from South and Southeast Asia; while the strong and weak events obviously decrease the aerosol loading over northern China through the enhanced aerosol diffusions by El Niño-induced northerly wind anomalies."

6. Page-3 Line-14: what do you mean by "from a climatological perspective"? ENSO is an inter-annual variability mode.

Response: Previous studies have examined the impacts of some individual ENSO events on East Asian aerosols during ensuing spring (Feng et al., 2016a, b, 2017; Wang et al., 2019b), which may involve some uncertainty. In contrast, this study composites the effects of several ENSO events based on the long-term data (1980-2019) to reach

out for some statistically significant conclusions. Thus, "from a climatological perspective" aims to emphasise analyses that are climatologically statistically significant, rather than analysing the climate mean state. To avoid confusion, however, we have revised this sentence (Page 3, Line 18) to the following: "Thus, it is necessary to further explore the impacts of ENSO on ensuing spring aerosols over East Asia based on the composite analyses of several ENSO events, which would enlarge the sample size and increase the confidence level."

7. Page-4 Line-17: what CPC means? And how the CPC defines the ENSO? Should be more clearly stated.

Response: (1) We use "CPC" as an acronym for NOAA Climate Prediction Center, as it first appears on Page-4 Line-1 in the manuscript. However, we used "NOAA CPC" instead (Page 4, Line 23) to clarify.

(2) The NOAA CPC defines ENSO as follows: warm (El Niño) and cold (La Niña) periods based on a threshold of +/- 0.5°C for the Oceanic Niño Index (ONI) [3 month running mean of ERSST.v5 SST anomalies in the Niño 3.4 region (120°–170°W, 5°S–5°N)], based on centered 30-year base periods updated every 5 years (https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php).

We have modified the description of the ENSO events definition to clarify this point (Page 4, Line 23-27) as follows: "Events are defined as five consecutive overlapping 3-month periods at or above the +0.5°C SST anomaly in the Niño 3.4 region (120°–170°W, 5°S–5°N) for warm (El Niño) events and at or below the -0.5°C anomaly for cold (La Niña) events, based on centered 30-year base periods updated every 5 years. More details on the definition of ENSO events can be found on the website: https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php."

8. Page-7 Line 20-25: At the same year, Wu et al. (2009) also proposed the similar teleconnection for the connection between preceding ENSO and EASM. Hence, this work should be cited along with Xie et al. (2009). *Wu, B., T. Zhou, and T. Li, 2009:*

Seasonally Evolving Dominant Interannual Variability Modes of East Asian Climate. J. Climate, 22, 2992–3005, https://doi.org/10.1175/2008JCLI2710.1. Five years later, this teleconnection was systematically confirmed in CMIP3 and CMIP5 atmospheric-only and coupled models by Song and Zhou (2014a-b) and found as a key for models to well simulate EASM. Hence, these two references should also be included here to complete the physical picture shown here. *Song, F., and T. Zhou, 2014a: Inter-annual variability of East Asian summer monsoon simulated by CMIP3 and CMIP5 AGCMs: Skill dependence on Indian Ocean-western Pacific anticyclone teleconnection, Journal of Climate, 27, 1679–1697. Song, F., and T. Zhou, 2014b: The climatology and inter-annual variability of East Asian summer monsoon in CMIP5 coupled models: Does air-sea coupling improve the simulations? Journal of Climate, 27, 8761–8777.*

Response: We have cited these references in the revised manuscript (Page 7, Line 26, 29).

9. Page-9 Line-24: missing a CP before "ENSO (Fig. 4)"?

Response: We think it should be “ENSO”, not “CP ENSO”. This is because the AOD anomaly pattern during EP ENSO is similar to that during ENSO, rather than CP ENSO. This implies that the effects of ENSO mainly come from that of the EP ENSO.

Additionally, for a more accurate description, we have added “(Fig. 9a, c, e)” after “EP ENSO” (Page 9, Line 31).

10. Page-9 Line-27: missing a EP before "ENSO"?

Response: Similar to our reply to comment #9, we think it should be only “ENSO” here. Besides, “(Fig. 9e)” at the end of this sentence may be ambiguous and inaccurate, so we move it after “EP ENSO” in this sentence (Page 10, Line 3).

11. Page-10 Line-17: are->is

Response: Revised (Page 10, Line 25).

12. Page-10 Line-31: compared to "activities", I feel the "probability" may be more suitable.

Response: We have now replaced “activities” by “probability” (Page 11, Line 7).

13. Fig. 8: what is the definition of CA mixing ratio?

Response: Carbonaceous aerosols (CA) usually consist of two components, i.e., black carbon (BC) and organic carbon (OC). Here, the CA mixing ratio is the sum of BC and OC mass mixing ratio, which are provided by MERRA2 dataset.

To make this point more precisely and clearly, we have revised the following sentence (Page 9, Line 18) in our revised manuscript: "Thus, the meridional cross-sections of spring CA mass mixing ratio (the sum of BC and OC mass mixing ratio) along 110°–125°E are examined next (Figs. 8a-c)." Besides, we have replaced "CA mixing ratio" with "CA mass mixing ratio" in the caption of Figure 8 (Page 30, Line 2, 4).

14. Fig. 11: it seems that the correlation between Niño 3.4 index and aodi-ia is mainly determined by El Niño event. Do you have any thoughts on this?

Response: As mentioned by the reviewer, the correlation coefficient between AODI-IA and Niño 3.4 index is mainly dominated by El Niño events, since the correlation is 0.63 during El Niño events and only 0.3 during La Niña events. It is known that ENSO has strong asymmetric influences not only on atmospheric circulation and precipitation (Cai and Cowan, 2009; Karori et al., 2013; Ng et al. 2019), but also on East Asian winter aerosols (Sun et al., 2018; Feng et al., 2019). Thus, we think that the domination of El Niño events here may be related to the asymmetric effect of ENSO on East Asian aerosols. As already stated in the manuscript (Page 6, Line 27), we find that the asymmetric influence of the ENSO on East Asian aerosols is also evident during the ensuing spring.

15. Fig. 11 caption: withblack -> with black

Response: Revised.

References:

Cai, W., and Cowan, T.: La Niña Modoki impacts Australia autumn rainfall variability, Geophysical Research Letters, 36, https://doi.org/10.1029/2009GL037885, 2009.

Feng, J., Li, J., Zhu, J., and Liao, H.: Influences of El Niño Modoki event 1994/1995 on aerosol concentrations over southern China, J. Geophys. Res.-Atmos., 121, 1637-1651, 10.1002/2015jd023659, 2016a.

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Ng, C. H. J., Vecchi, G. A., Muñoz, Á. G., and Murakami, H.: An asymmetric rainfall response to ENSO in East Asia, Climate Dynamics, 52, 2303-2318, 10.1007/s00382-018-4253-9, 2019.

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Feng, J., Li, J., Liao, H., and Zhu, J.: Simulated coordinated impacts of the previous autumn North Atlantic Oscillation (NAO) and winter El Niño on winter aerosol concentrations over eastern China, Atmos. Chem. Phys., 19, 10787-10800, 10.5194/acp-19-10787-2019, 2019.