

# Responses to Anonymous Referee #1

## General comments

Given that most of the current studies on the effects of ENSO on aerosols focus on winter and very few on spring, the authors analyzed the effects of ENSO on spring aerosols in East Asia using MERRA2 reanalysis aerosol data from 1980-2019. It is pointed out that during the subsequent spring of El Niño (La Niña) event, dry (wet) air and less (more) precipitation favored an increase (decrease) in biomass burning activity in northern Indochina, resulting in more (less) carbonaceous aerosol emissions. At the same time, the El Niño (La Niña)-related anomalous anticyclone (cyclone) in the western North Pacific enhances (weakens) low-level southwesterly winds from the northern Indochina peninsula to southern Japan, delivering more (less) carbonaceous aerosols downstream. These result in above-normal (below normal) aerosols in the Indochina Peninsula, southern China and the ocean south of Japan. Moreover, the authors note that ENSO's impact on the ensuing spring aerosols is mainly attributed to EP ENSO rather than CP ENSO. The overall structure and layout of the manuscript is clear and the experimental design is reasonable. I will suggest it to be accepted after addressing my comments below.

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

## Specific comments

The authors used AOD to represent aerosols throughout the manuscript. It should be caution that AOD is only the optical property of aerosols, which is not fully representative as aerosol mass or loading. AOD depends on aerosol mass, relative humidity, aerosol size distribution, reflective index, and mixing state...

**Response:** We agree that there are indeed some limitations of using AOD to represent aerosol burden. However, AOD has been widely used to investigate the interactions

between aerosols and climate systems (e.g., Wu et al. 2013; Yang et al., 2016; Lau et al., 2018; Sun et al., 2018; Che et al., 2019). Our study shows that the ENSO-induced East Asian AOD anomalies are mainly attributed to carbonaceous aerosols. This result is also verified by the AOD of carbonaceous aerosol, carbonaceous aerosol flux, carbonaceous aerosol mixing ratio, and the relevant atmospheric circulation fields. Therefore, we believe that our qualitative conclusions are reasonable and acceptable.

Nevertheless, in response to this comment, the following sentence has been added to the conclusions and discussion section (Page 11, Line 20) to further clarify such limitations: “although AOD has been widely used to explore the interactions between aerosols and climate systems in the literature (e.g., Wu et al. 2013; Yang et al., 2016; Lau et al., 2018; Sun et al., 2018; Che et al., 2019), it only represents the optical property of aerosols and could be also affected by other factors such as relative humidity, aerosol size distribution and reflective index (Hänel, 1976; Horvath, 1996).”

Page 3. Besides the impacts of ENSO on aerosols, aerosols can in turn affect ENSO through changing radiative balance and poleward heat transport (e.g., Yang et al., 2016; Lou et al., 2019).

**Response:** As suggested by the reviewer, we have read the relevant papers carefully and learned that aerosols can affect the amplitude of ENSO and the frequency of extreme events. Thus, we have revised the some relevant statements around Lines 3–7, Page 2 in the revised manuscript to the following: “Both effects by aerosols can induce strong large-scale atmospheric circulation change (Allen et al., 2012; Song et al., 2014; Shen and Ming, 2018; Deng et al., 2020), regional climate responses (e.g., Lau et al., 2006; Zhang et al., 2007; Dong and Zhou, 2014; Wang et al., 2019a), and even tropical sea surface temperatures (e.g., Yang et al., 2016; Lou et al., 2019) through changing radiative balance and poleward heat transport.”

Page 7, Line 25. “The differences between these two phases show similar anomalies to the warm phase but with a larger magnitude.” Does the difference between the two phases mean warm phase minus cold phase or the opposite?

**Response:** Yes, the differences between these two phases mean warm phase minus cold

phase.

To make this point more clearly, we have revised the last sentence of the first paragraph in section 4 (Page 8, Line 1) as follows: “The differences between these two phases (El Niño minus La Niña) show similar anomalies to the warm phase but with a larger magnitude (Fig. 5c).”

Page 8, Line 33. Here, ENSO mainly affects the diffusion process of the local aerosols over northern China in winter, which is incoherent with Zhao et al. (2018)’s result that ENSO influenced the wintertime aerosols over southern China more obviously than it did over northern and eastern China. What caused the differences?

**Response:** As shown in Fig. 7c, ENSO induces a significant increase in AOD over northern China during the early winter [November(-1) to December(-1)], and such an increase becomes insignificant or even reverses to a decrease during January(0)-February(0); while ENSO-induced aerosol increase over southern China is significant from January(0) to May(0). Therefore, for the entire winter season [i.e., D(-1)JF(0)], our results are consistent with the findings of Zhao et al. (2018) in that the effect of ENSO is more pronounced over southern China than that over northern China.

In response to this comment, we have revised the following sentence (Page 9, Line 8) in our revised manuscript: “In other words, the ENSO mainly affects the diffusion process of the local aerosols over northern China in **early** winter, while it affects the long-range transport process of aerosols from the Indochina Peninsula to downstream in the ensuing spring.”

Page 9, Line 9. When calculating the zonal average, the longitude range is 110-125E, while the range taken in the legend in Figure 9 is 105-120E.

**Response:** We have double-checked and confirmed that the longitude range is 110°–125°E. This typo in the caption of Figure 8 has been fixed (Page 30, Line 3).

**Typing errors:**

Page 3, Line 31. The aerosol data are “from”

**Response:** Revised (Page 4, Line 5).

Page 7 Line 4. 1. Largesale-> Large-scale

**Response:** Revised (Page 7, Line 10).

Page 26, Line4. “nagetive values” should be replaced by “negative values”.

**Response:** Revised (Page 27, Line 4).

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