To reviewer #1

Dear Professor:

Thank you for your kind comments for our manuscript entitled "**What caused the interdecadal shift of the ENSO impact on dust mass concentration over northwestern South Asia**", submitted to Atmospheric Chemistry and Physics. We appreciate your valuable comments and suggestions to improve it. We are sincerely grateful for giving us the opportunity to improve our work. With regard to your comments and suggestions, we wish to reply as follows:

1. While it's ok to analyze dust-PM2.5, the choice of analyzing dust-PM2.5 (rather than total DUCMASS or DUCMASS10) needs to be justified, since dust is typically regarded as a coarse-mode aerosol and usually have larger impacts on PM10 than PM2.5.

Response: Thank you so much for proposing this. It is true that dust is typically regarded as coarse mode aerosols that are closer to PM10 than PM2.5. Actually, at first, we used the DUCMASS dataset (which is also acquired from MERRA2), and later we compared the time series of DUCMASS and DUCMASS2.5, to find similar variation trend and the association of Niño index with DUCMASS and DUCMASS2.5 showed the same change pattern. Thus, we adopted the DUCMASS2.5 dataset at last, considering that PM2.5 is more widely used. According to your suggestions, we added the corresponding description in the dataset section, i.e., "The time series of DUCMASS25 dataset was compared with that of DUCMASS dataset, to find that the time series of DUCMASS25 and its association with Niño index showed the same change pattern with that of DUCMASS. Only the results acquired by DUCMASS25 were presented in this study". (Page 6 lines 143-146)

2. The caption of Figure 18 needs to be expanded. At least the authors need to point out that this is a Taylor diagram showing correlation and standard deviation of each data set relative to AERONET. The sample size should also be denoted on the corresponding panel of this figure. I would personally not call MERRA2 DUCMASS here as "high precision" given the moderate correlations.

Response: Thank you so much for pointing out this to help us to improve our work. We have changed the caption of Fig. 18 into "Normalized Taylor diagrams showing (a) difference between dust variables acquired from MISR, AERONET, MERRA2 datasets and that acquired from PM2.5 dataset, and (b-d) difference between dust variables from MISR, PM2.5, MERRA2 datasets and that acquired from AERONET dataset. The normalized standard deviation is on the radial axis (black contours); correlation coefficient is on the angular axis (blue contours); and green dashed lines indicate centered RMSE. N indicates the sample size". We also added sample size (n) in each subfigure. (Page 28 lines 541-546)

It is true that using "high precision" here is not appropriate. We changed the original "the DUCMASS used in this study were with high precision" into "the DUCMASS used in this study were relatively reliable for researches about dust". (Page 29 line 559)

3. Please indicate statistical significance in Figures 3 and 5.

Response: Thank you for pointing out this. We are so sorry for this negligence. We added significance test in Figs. 3, 5, and 11.

Thank you again for your careful reading of our manuscript. We hope that the changes having been made to the manuscript meet to your satisfaction.

To reviewer #3

Dear Professor:

Thank you for your kind comments for our manuscript entitled "**What caused the interdecadal shift of the ENSO impact on dust mass concentration over northwestern South Asia**", submitted to Atmospheric Chemistry and Physics. We appreciate your valuable comments and suggestions to improve it. We are sincerely grateful for giving us the opportunity to improve our work. With regard to your comments and suggestions, we wish to reply as follows:

Major concerns:

1. In the Introduction, the authors refer the human health and environmental problems. However, many studies have proved the climatic effects of dusts through different mechanisms (e.g., Miller and Tegen 1998; Mahowald et al., 2014). The authors should add the corresponding descriptions.

Response: Thank you so much for pointing out this to help us to improve our work. We added the corresponding descriptions as "Dust aerosols can also influence the earth's radiation budget balance and climate change through direct and indirect effects (Mahowald et al., 2014; Miller and Tegen, 1998). Dust aerosols can reflect incoming solar radiation and cool the surface, which is known as the direct effects (Mahowald et al., 2006; Tegen et al., 1996); they can also affect the cloud droplet size, cloud albedo and lifespan by forming into cloud condensation nuclei and ice nuclei, which is known as the indirect effects (Hansen et al., 1997)" in lines 35-40 of page 2.

2. As shown in Figs. 6-9, 10-14, and 16, these results are all based on regression of ENSO onto the climatic variables, the results are hard to understand for the readers. I strongly suggest to use the differences in climatic variables between El Niño (EN) and La Niña (LN) yeas to check the large-scale modes of climate variability (e.g., see the ref. Huang et al., 2020). These further results can help us to present the physical mechanisms or process research between ENSO and dust activity interactions.

Response: Thank you so much for pointing out this to help us to perfect the results. We agree with your opinion, in order to present the physical mechanisms of ENSO and dust activity interactions, it is better to use the differences in climatic variables between EN and LN years. However, this study intended to analyze the effect of other large-scale atmospheric factors (e.g., Atlantic and Indian ocean SSTA pattern) on the correlation between ENSO and dust activities in two periods (1982-1996 and 2000-2014). We should calculate the differences in climate variables between EN (ASGI+ and TWITSST+) and LN (ASGI+ and TWITSST-) years during the two periods separately, which make the sample size too small to get the robust results. Besides, we have learnt that regression method is also widely used in the influence mechanism analysis (Du et al., 2009; Han et al., 2016; England et al., 2014; Wu and Kirtman, 2004; Krishnan et al., 2013; Guo et al., 2019; Chattopadhyay et al., 2015), and using regression model can better show the change of the interaction between factors during the two periods, since the different signs of the correlation coefficient indicate the contrary effect. Thus, we kept the results acquired by regression method.

At the same time, considering that your suggestions are helpful for us to clarify the physical mechanisms more clearly, we added the analysis about the differences in climate variables between EN and LN years as well as those between ASGI+/TWITSST+ and ASGI+/TWITSST- during the two periods separately. We got the similar results with the regression model, i.e., the positive regression coefficient appeared when the climatic variables and ENSO (or ASGI/TWITSST) were in phase, while negative regression coefficient appeared when the climatic variables and ENSO (or ASGI/TWITSST) were out of phase. Considering the similarity between the regression and composite difference results, we put the results demonstrated by the composite difference in the supplement file.

Could you please help us to judge whether it is ok to revise the corresponding parts like the abovementioned. Otherwise, we may modify it again according to your suggestions.

The modified parts are shown as follows:

In section 3.2.1 (lines 303-315 of pages 14-15), we added:

In addition, to further elaborate the physical mechanisms of the interaction between ENSO and dust activities, the composite differences of the abovementioned climatic variables between El Nino and La Nina years as well as that between positive ASGI (ASGI+) and negative ASGI (ASGI-) years were presented, as shown in Figs. S1–S2. Figure S1 showed that the SoilM averaged from June to July in El Niño years exhibited positive anomalies, while that in La Niña years exhibited the reversed anomalies. The differences of SoilM between ASGI+ and ASGI- during P1 were negative, which were contrary to that between El Niño and La Niña conditions, while the differences during P2 reversed compared with those in P1. Simultaneously, the differences of VP at 200hPa and 850hPa between ASGI+ and ASGI- also presented contrary change with those between El Niño and La Niña years during P1 and P2, as shown in Fig. S2. The mechanisms illustrated by the composite difference were analogous with the regression between dust activities and the climatic variables, both of which clarified the effect of ASGI on the relationship between ENSO and dust activities over the northwestern South Asian dust source.

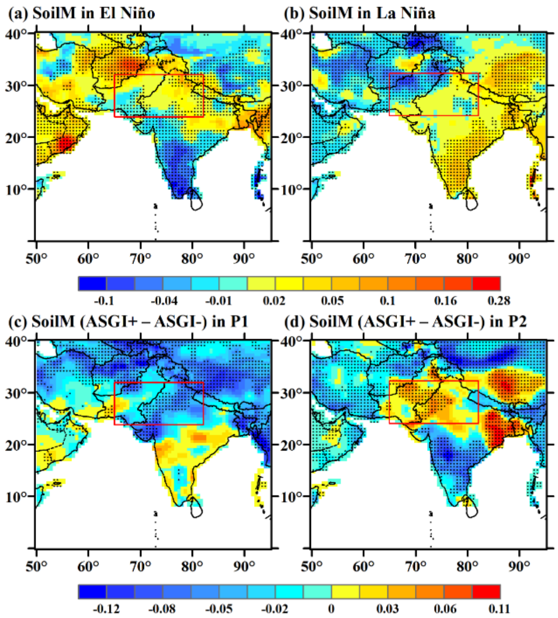

Figure S1: June to July mean soil moisture (SoilM) averaged for the (a) El Niño years, (b) La Niña years, and (c) the difference between positive ASGI years (ASGI+) and negative ASGI (ASGI-) years during P1 (c) and P2 (d). The difference exceeding 90% confidence level was marked by black dots.

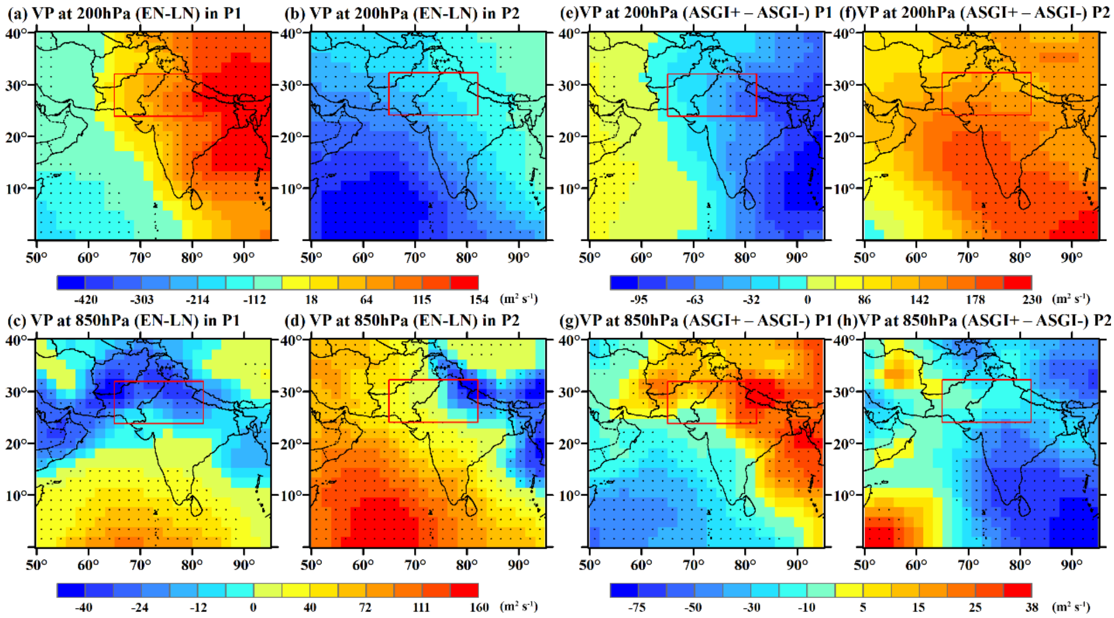

Figure S2: Difference of June to July mean velocity potential (VP) at 200hPa (a-b) and 850hPa (c-d) between El Niño (EN) and La Niña (LN) years during P1 and P2. Difference of June to July mean velocity potential (VP) at 200hPa (e-f) and 850hPa (g-h) between ASGI+ and ASGI- years during P1 and P2. The difference exceeding 90% confidence level was marked by black dots.

In section 3.2.2 (lines 368-381 of pages 17-18), we added:

In addition, to further elaborate the physical mechanisms of the interaction between ENSO and dust activities that was impacted by tropical western Indian ocean, the composite differences of the abovementioned climatic variables between El Nino and La Nina years as well as that between positive TWITSST (TWITSST+) and negative

TWITSST (TWITSST-) years were presented, as shown in Figs. S3-S5. Figures S3-S4 showed that the PPT and SoilM averaged from June to July in El Niño years exhibited positive anomalies, while that in La Niña years exhibited the reversed anomalies. The differences of PPT and SoilM between TWITSST+ and TWITSST- during P1 were negative, which were consistent with that between El Niño and La Niña conditions, while the differences during P2 were contrary to those during P1. Simultaneously, the differences of VP at 200hPa between TWITSST+ and TWITSST- also presented contrary change with those between El Niño and La Niña years during P1 and P2, as shown in Fig. S5. The mechanisms illustrated by the composite difference were analogous with the regression between dust activities and the climatic variables, both of which clarified the effect of TWITSST on the relationship between ENSO and dust activities over the northwestern South Asian dust source.

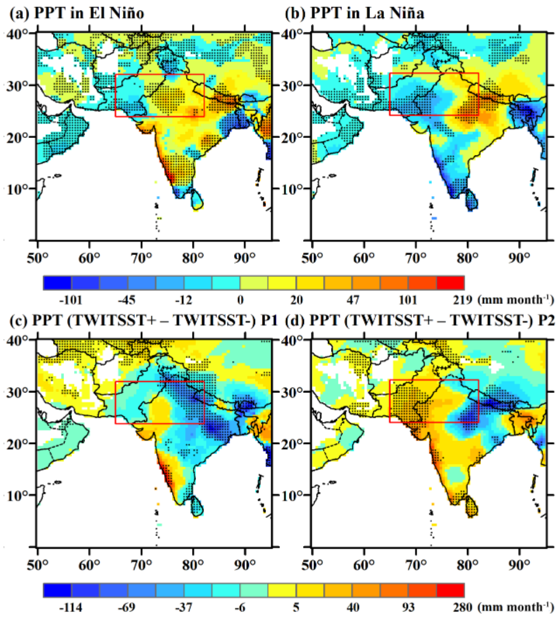

Figure S3: June to July mean precipitation (PPT) averaged for the (a) El Niño years, (b) La Niña years, and (c) the difference between positive TWISST years (TWISST+) and negative TWISST (TWISST-) years during P1 (c) and P2 (d). The difference exceeding 90% confidence level was marked by black dots.

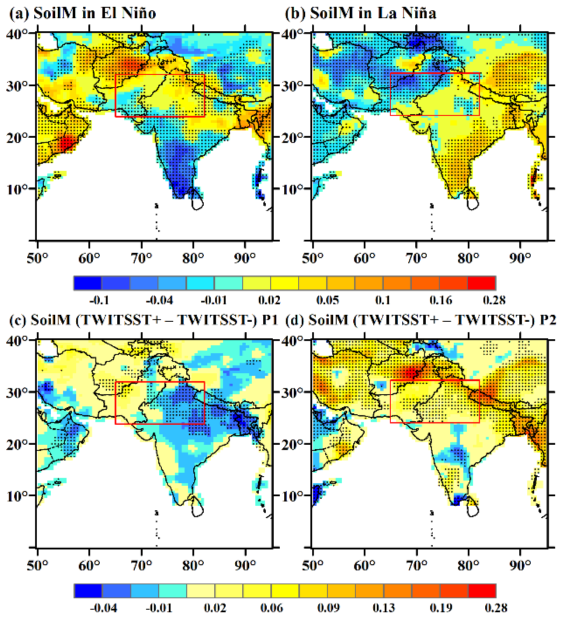

Figure S4: June to July mean SoilM averaged for the (a) El Niño years, (b) La Niña years, and (c) the difference between TWISST+ and TWISST- years during P1 (c) and P2 (d). The difference exceeding 90% confidence level was marked by black dots.

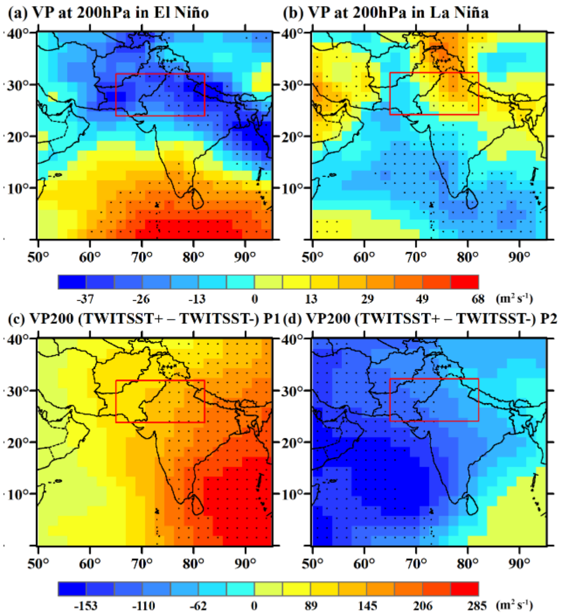

Figure S5: June to July mean VP averaged for the (a) El Niño years, (b) La Niña years, and (c) the difference between TWISST+ and TWISST- years during P1 (c) and P2 (d). The difference exceeding 90% confidence level was marked by black dots.

Specific comments:

1. In line 22 of page 1, what is the "SSTA"? The authors should give the whole name of SSTA in the first time.

Response: Thank you for pointing out this. We are so sorry for making this mistake. We have expanded SSTA into sea surface temperature anomaly (SSTA) (lines 22-23 of page 1).

2. In line 36 of page 2, "Those dust" should be "Those dusts".

Response: Thank you for pointing out this. We are so sorry for making this mistake. We have changed "dust" into "dusts". (line 42 of page 2)

3. In line 38-40 of page2 "Particularly, dust aerosols can change local radiation budget, circulations, and Indian summer monsoon rainfall through absorption and scattering of solar radiation." The authors should add the corresponding references about dust-climate interactions.

Response: We are so sorry for this negligence. We have added reference "(Wu et al., 2018; Jin et al., 2021; Mahowald et al., 2006; Tegen et al., 1996)" at the corresponding location. (line 46 of page 2)

Thank you again for your careful reading of our manuscript. We hope that the changes having been made to the manuscript meet to your satisfaction.

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