

We highly appreciate and would like to thank to reviewer #1 for positive comments and suggestions to improve our manuscript. We have carefully revised the manuscripts as per every comments and suggestions as described below. The editor and reviewers' comments are in black and authors' replies in blue and modified /inserted text in the revised manuscript (red color). For clarity and ease, we have provided the line numbers (from track change mode manuscript) where particular changes have been made in the main manuscript as well as provided the change as a response below the comment. We believe that the revised manuscript has incorporated the concerns and suggestions given by the reviewers.

Reviewer #1 Using observation, satellite and model outputs, the authors investigated the Spatiotemporal aerosol concentration, the influence of meteorological conditions, and underlying aerosol transport mechanisms over the Pan-Third Pole region. They demonstrated the seasonal distribution and spatial variability of aerosol across this wider domain and tried to explore model performance. Even though they have mentioned and highlighted the whole PTP region apart from IGP and China, there is nothing demonstrated in this study over this wide domain. At this level, there isn't enough scientific proof or knowledge enhancement to properly connect the underlying facts as well. With the following factors in mind, I feel the manuscript will be enhanced if the authors make the following changes and, more importantly, if they can eliminate numerous unnecessary discussions.

1) One would expect, from the title of the manuscript, that the authors had conducted research on the Tibetan Plateau and Himalayas region in addition to outer PTP region. However, they have only some information about India and China. So this is an unnecessarily misleading part of the title, abstract and even introduction of this study; this should be avoided.

Response: Thank you for the comments. We agreed and made necessary changes and add more information (1353-368).

2) I'm not sure how authors can make a very crucial assertion like AOD values are maximum across IGP when two models and two observations produce four findings. Despite the fact that WRF-Chem shows that northern China has higher AOD values than IGP, the other three choices

show that the signal endures between seasons. As a result, such a remark in the abstract is not appreciable but also misleads readers.

Response: We agree. Taking this notion in mind that we have modified misleading statement. Instead of just using IGP and East China, we have added other regions where AOD endures throughout the simulation period in (142-43). We also added more information in result section (1363-368).

3) In this study, the authors emphasize aerosol concentration over IGP. If a similar quantity of aerosol concentration is evident above China, however, it is rarely emphasized. This is not a scientifically sound practice.

Response: Thank you for highlighting this issue. We tried our best to avoid such discrepancy. Now we have modified this section (1353-362).

4) A large drop in PM_{2.5} is seen in major Indian cities, according to Sing et al 2021 (10.1016/j.scitotenv.2020.141461). However, the authors make no mention of this in the manuscript. The recent downturn in China, on the other hand, is explicitly acknowledged.

Response: Thank you for the recommending this paper. We have included the finding from this paper in our manuscript (1112-114).

5) I am not sure if there is anything unknown to unravel the effect of meteorological conditions on the spatiotemporal distribution of aerosol over the Himalayas. Many studies have already documented these factors in these regions. Furthermore, they stated in each part that the results are comparable to past studies. So, it's evident that they're simply reinventing something that's been done before. Any such exaggeration should be avoided.

Response: Our study region comprises dynamic geophysical features including arid, semi-arid, mountain to flat land. Previous studies either focuses on Southern flank of Himalayas, Tibetan Plateau, or South East Asia. Thus, we attempt to showcase how different meteorological

parameters play a role in aerosol concentration distribution and transport mechanism in synoptic scale which owns unique geophysical features.

6) Again, I'm not sure why the authors place so much focus on the Third Pole location. Seasonal Spatio-temporal fluctuation of aerosols and total AOD is just discernible over IGP or China in the signals from Figures 4 and 5. As a result, neither the title nor the abstract should be expected to reveal this.

Response: We thanks reviewer for pointing out the inconsistency in result presentation of our manuscript. We sought irregularity in our manuscript and presented more results. We added more findings and discussed more in detail over other than the Third Pole region (l351-357).

7) If the model has a dust aerosol bias, which is indicated as being resolved by masking, how can authors assure that this is not causing problems in surrounding regions through transport?

Response: Thank you for highlighting this issue. In line (l347), our choice of word “mask out” was meant to be that our model did not mimic the general feature of AOD values over arid/semi-arid than reanalysis dataset.

8) Due to the low-quality figure in figure 6, the circulation pattern is difficult to interpret.

Response: Thank you. Now, figure 6 quality is improved.

9) If authors are perfectly aware that the bias comes from the chosen domain, why do they continue to use it? It appears that these are unsubstantiated claims with no scientific basis. The conclusion is littered with ambiguous assertions that should be avoided.

Response: We appreciate the concern raised by reviewer which is valid. Previous study is largely from South Asia and East Asia. Our motivation is to present the synoptic scale picture of aerosol distribution and transport dynamics over geographically complex region. Yes, we are aware that bias is there but we intend to use modeling as tool and showcase the general features of the aerosols

and aid more information over the region. This study underscores the bias correction which was obviously at hand but due to computational cost that could not perform. Further study are needed to improve the model performance especially over complex topography.