

Interactive comment on “Growth in mid-monsoon dry phases over Indian region: Prevailing influence of anthropogenic aerosols” by Rohit Chakraborty et al.

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First of all we wish to thank the reviewer for his comments/suggestions which significantly improved the content of the manuscript. The authors have addressed all the comments raised by the reviewer and incorporated in the revised manuscript.

Major comments - 1. Data - monthly averaged data of CER have several issues as has been studied by several researchers. Reply: We admit that the monthly averaged variation of CER does not provide any statistically significant trends. This may be attributed to certain factors namely: insufficient time frame (<20 years) for studying the long term variation as well as other reliability issues with the data. On the other hand,

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we have shown the evidence of increasing number of dry days even in the presence of increased low cloud cover. Hence this phenomenon indicates the development of second radiative effect of aerosols without the necessity of showing CER trends. However, to improve the contention of this paper, we have removed the CER portion in the manuscript to avoid further ambiguity.

2. MERRA-2 simulations of aerosol properties over India have not been validated, and they have several issues. These simulations cannot be taken to represent the aerosol characteristics, which is a major input on which the paper relies upon. Also, as mentioned above while the current aerosol simulations are not validated, how these simulations can be taken to represent the past and future? Reply: First, we wish to inform that the BC AOT dataset from MERRA 2 is validated against in-situ surface BC concentration measurements over Kolkata, a metropolitan city in Figure S1. Second, there also have been many recent attempts such as Pandey et al. (2017), Randles et al. (2017) and Buchard et al. (2017) which supported the validity of using MERRA datasets for similar climate studies both globally as well as over the Indian region. Finally, we have always used frequency distribution analysis in this paper to show the qualitative relation between aerosols and rainfall. Consequently, we have not focussed on the future trends of aerosols; rather we have exploited their interrelationship with cloud properties to arrive at a possible future trend of rain events.

We have included following references along with discussion in the revised manuscript to support our observations.

Pandey, S.K., Vinoj, V., Landu, K. and Suresh Babu, S., Declining pre-monsoon dust loading over South Asia: Signature of a changing regional climate Scientific Reports, 7: 16062, 2017, DOI:10.1038/s41598-017-16338-w. Randles, C.A., Da Silva, A.M., Buchard, V., Colarco, P.R., Darmenov, A., Govindaraju, R., Smirnov, A., Holben, B., Ferrare, R., Hair, J. and Shinozuka, Y., 2017. The MERRA-2 aerosol reanalysis, 1980 onward. Part I: System description and data assimilation evaluation. Journal of climate, 30(17), 6823-6850, 2017, DOI:10.1175/JCLI-D-16-0609.1 Buchard, V., Randles, C.A.,

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Da Silva, A.M., Darmenov, A., Colarco, P.R., Govindaraju, R., Ferrare, R., Hair, J., Beyersdorf, A.J., Ziemba, L.D. and Yu, H., 2017. The MERRA-2 aerosol reanalysis, 1980 onward. Part II: Evaluation and case studies. *Journal of Climate*, 30(17), 6851-6872, 2017, DOI:10.1175/JCLI-D-16-0613.1

3. Monsoon breaks in Indian monsoon is an important phenomena that contributes to aerosol increase or decrease and contributes to dry days. Reply: Monsoon break phase occurrences may additionally contribute to the increase of dust type aerosols to some extent. However, this investigation is beyond the contention of the present analysis as here we indicate the dominance of anthropogenic aerosols over other natural factors such as ENSO and solar effect in changing the DDF over Indian region.

4. The changes in CER are almost NIL and statistically insignificant, be it in region 3 or region 1. Also, a few changes are quite abrupt. Reply: We have already addressed this issue by keeping away the CER portion in the revised manuscript.

5. Datasets used have different resolution; this is another major issue, because the components exhibit large spatial variations within even 10 km. Reply: It may be noted that we have focussed on three broad study areas each of whom had a minimum aerial coverage of 3x5 Degrees (~300 – 500 Km on both dimensions) as we want to study the redistribution of monsoon rainfall which is not a local phenomenon. Hence to investigate this qualitative relationship we have used several controlling factors from ERA and MERRA with a resolution of 0.5-0.75 degrees (~50-80 km). It may be noted that to understand the variability in this meso to synoptic scale aberration of rainfall diversity, a spatial averaging of various factors are computed. Hence, in no possible case, these relationships will change drastically due to mismatched grid resolutions of by 10-20 km.

6. Figure 4 - the number of dry days do not show any significant difference between the first and last 60 years except for region 1a. Reply: We accept that from Figure 4, the number of dry days does not show any significant difference between the first

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and last 60 years except for region 1a which has led the full focus of the present study to go towards region 1a. Since region 1b also falls in almost the same zone of upper Indo-Gangetic Plane, hence some changes were also expected there; however such variations are not reflected in Fig 4a. But interestingly, further investigations also showed that the 15 day trend values are notably higher in Region 1a compared to 1b. This is again proved, in later sections where it has been indicated that anthropogenic BC has stronger dominance over DDF in region 1a than in overall region 1. Hence, we have to accept the fact that due to combined effect of all natural and anthropogenic factors, the distribution of dry days did not show that much prominent shift in last 60 years over region 1b as it happened over 1a.

We once again thank the reviewer for providing potential suggestions throughout the paper. This review experience was indispensable in pushing us forward to improve our work.

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