

## ***Interactive comment on “Relationship between Asian monsoon strength and transport of surface aerosols to the Asian Tropopause Aerosol Layer (ATAL): Interannual variability and decadal changes” by Cheng Yuan et al.***

**Anonymous Referee #4**

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This study uses the 15-year (2001-2015) NASA MERRA2 reanalysis data to investigate the interannual variability and the decadal trend of CO, carbonaceous aerosol, and dust in the Asian tropopause aerosol layer and their relationship to the Asian summer monsoon strengths during the 15-year time period. While this topic is interesting, I have some major concerns of the methods that lead to the conclusions (see below). I recommend authors reexamine the methods and revise the manuscript accordingly.

1. MERRA2 aerosol of individual species is not “reanalysis data”. For aerosols, only column AOD from MODIS and MISR have been assimilated in MERRA2, so it is ap-

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propriate to call the MERRA2 AOD as a reanalysis product. However, concentrations and AOD from individual aerosol species, such as CA and dust used in this paper, are not a part of reanalysis (more on that in comment #2 below). CO is completely from the model simulation without any assimilation of any observations. This aspect should be clearly stated that the datasets used in this study are not “reanalysis” datasets.

2. MERRA2 aerosol species concentrations are not appropriate for interannual variability and long-term trend analysis. The reason is that the MERRA2 system had to adjust the model simulated total AOD to be close to the satellite observations during assimilation, but there is no speciated aerosol information from satellite data to allow changes of aerosol composition. As a result, all model simulated aerosol species had to be adjusted by the same factor, which can introduce artifacts for increase or decrease of individual aerosol mass or AOD. Such artifacts have been clearly demonstrated in Randles et al., 2017 (Fig. 5 for example). Therefore, the interannual variability or long-term trends of individual aerosol species inferred from MERRA2 might be contaminated by the introduction of the non-physical corrections of individual aerosol species amount to match the total AOD from satellite during the assimilation process. One important practice is to take a look at the so-called “increments” from MERRA2 to see the interannual variability and trends of these increments for individual aerosol species and to assess what impacts the increments might have on the apparent dust and CA interannual variability and long-term trends.

3. Definition of strong and weak monsoon years does not seem to be appropriate. This study uses the total precipitation amount within a selected region as a measure of monsoon strength, which is certainly one of the commonly used methods to define the monsoon strength. What does not seem to be appropriate is that the strength of the ASM is not based on the total precipitation amount but is based on the detrend anomaly of precipitation amount. For example, according to Fig 1c, 2015 is a weak monsoon year with a strength weaker than 2002. However, from Fig.1b, the precipitation in 2015 is 0.5 mm/day above the 2001-2015 average while that in 2002 is about 1.9 mm/day

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below the 15-year average, meaning that the JJA precipitation in 2015 is about 2.4 mm/day more than that in 2002, thus a much stronger monsoon year. If the total precip amount is the criteria for indicating the SM strength, then the determination of strong or weak monsoon years should stick with that definition, not the detrend anomaly.

4. There is a lack of evaluation of the MERRA2 products used in this study to assess the quality of these products. Although observations of dust and CA in the ATAL region is rather limited (there are some aircraft data, though), MLS on Aura satellite has been producing CO in the UTLS since 2004. I wonder if the authors can take a look at the MLS data to see if they are showing similar interannual variability and decadal trend?

Given the above concerns, I think a substantial revision is needed. While MERRA2 is a valuable reanalysis dataset for total AOD, it is not particularly suitable for quantify the interannual variability and trends of individual aerosol species for the reasons I stated above. At least the non-physical aerosol mass change issues associated with AOD assimilation should be addressed/examined since it is particularly relevant to the interannual variability of speciated aerosol concentrations. Meanwhile, the definition of “strong” and “weak” monsoon years should be reconsidered.

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