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comment

Interactive comment on "Global aeolian dust variations and trends: a revisit of dust event and visibility observations from surface weather stations" *by* Xin Xi

Anonymous Referee #3

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The paper is potentially publishable, but their are many issues in both the approach and the presentation that need to be improved before it can be published.

1. The author is not careful about describing the quality of the data analyzed in the paper in the methods section. All 'observational' and model data should include some information about the quality from the literature. A. All of these records are very qualitative, of course. Are there any studies which show that visibility can be used as a proxy? please cite and examine how much you can conclude from qualitative data, or don't use the station data. B. MERRA model output is presented as if it were observations. "CAMS and MERRA2 represent recent advances in developing atmospheric

composition reanalysis using global model systems with capabilities to assimilate satellite observations of atmospheric aerosols and gaseous species (Gelaro et al., 2017; Inness et al., 2019)." The way you describe this, it is as if you think these are assimilations of aerosols, but really very little aerosol data is assimilated and they tend not to do very well against the observations, so please discuss the discrepancies and use these model results NOT as observations but as model results. For example: https://acp.copernicus.org/articles/20/10047/2020/.

2. I also do not think there is value in presenting all the codes in the first few graphs. Do they really have different correlations or trends? If you only showed 2 of these codes, would we learn less? Please think carefully what your take-away messages are and if we would actually learn more if you presented less. 3. Pretty much all the tables and figures have NO description of what is in the table and figures in the figure captions. Please describe what is actually plotted clearly. I probably misunderstood most of the plots and would need to re-review once the plots are explained. 4. The author wants to indicate that drought caused some of the dust, but doesn't show statistical studies of this relationship. Please add in any mechanisms that you want to evaluate and make sure your results are statistically significant.

"Figure 1. Analysis of the continuity of present weather (ww) reports in ISD. (a) Global monthly number of stations (Nstn), number of ww reports (Nww), and number of dust event reports (Ndu). For clarity Ndu is multiplied by 30; (b) Nww from different report types."

"Therefore, the SYNOP data between 1986 and 2019 are most suitable for global-scale dust analysis." I assume this means you will only present the SYNOP data in this paper. This figure can go into the supplement, and say this in the methods instead. But wait, you are using the other times periods, after you say that you shouldn't use them? Seems odd??? Please justify their use, and then discuss how that changes your results whenever you use the data that isn't very consistent.

Table 2 is really unreadable because we can't understand what these codes are. I think in Table 1 you should come up with some short acronym that describes each of these codes, and use it for the rest of the paper, so that we know which code is which and what they mean. Or just exclude this whole section, as not really very important or interesting compared to the others.

"Figure 2. Analysis of the continuity of dust weather code usage. From top to bottom: monthly number of reports of all and individual dust codes in the global SYNOP data. Horizontal lines are all-time averages. Dust weather codes are described in Table 1". This figure caption does not tell us what is plotted. Please describe the variable plotted. Is this the number of observations? Why do you present so many? Are they actually different? The same? If they are the same, then show one. If they are different, tell us how they are different and why.

"Figure 3. Temporal consistency of the harmonic mean visibility associated with dust weather codes. Dash lines are all-time averages. Dust weather codes are described in Table 1." What variable is presented in figure3? It should be described in the figure caption. Is this the number of observations? Or the correlation? Do you really need to present all the variables, or could you just show one and the offset between them?

"Figure 3 shows that while there are significant year-to-year fluctuations in the harmonic mean visibility associated with dust codes, they generally fall into three clusters: ww = 06–09 (3.7 km), ww = 30–32, 98 (1.5 km), and ww = 33–35 (0.7 km)." please tell use why this is important. Does this make sense? Etc. right now there is no context for this statement.

"Figure 4. Decadal mean dust event frequency (FR). Gray dots are stations with FR < 1%." Please indicate in the figure caption exactly which data you use to define this, since there are many ways to do this. Repeat information in the methods to be clear. Your figure captions are so brief as to make reading your paper much more difficult than it needs to be.

"Using Eq. 1, the decadal mean FR 260 is calculated for stations with at least 5 years' data in each decade, as shown in Fig. 4." Please don't write sentences like this that are difficult to understand. Tell us again what equation 1 uses to calculate the frequency of occurrence in English. (for example: Using dust frequency as calcualted from the visibilty data (equation 1), we evaluate the decadal values...)

These two paragraphs are very hand wavey, but on important, and easily plottable points: "The distinctive changes of decadal mean FR can be linked to multidecadal climate variations, especially the occurrence of mega-drought events lasting several years or even decades. Elevated dust activity can be observed in areas affected by persistent drought, where the reduction of soil moisture and vegetation leaves the exposed, dry soil prone to wind erosion. For example, a striking feature in the 1950s is the widespread, frequent dust events in the U.S. Southwest and Midwest, with several stations reporting FR > 20% in the High Plains of Texas and Colorado. The heightened dust activity was fueled by a 11-year-long (1946–1956) drought that afflicted a massive area centered in the Southwest U.S. (Fye et al., 2003). The 1950s drought was characterized by a prolonged lack of precipitation and excessive warm temperatures, which caused crop failure and livestock feed shortage (Goudie and Middleton, 1992). As the drought came to an end in the spring of 1957, FR started to decline and has since remained low in the last 50 years. Similarly, North Africa experienced progressively drier conditions during the 1970–80s in the Sahel, a semiarid dryland belt at the southern border of Sahara Desert (Giannini et al., 2008). The Sahelian drought was triggered by anomalous sea surface temperature (SST) in the tropic Atlantic and Indian Ocean (Dai, 2011). The Sahelian dust frequency during drier-than-normal years, especially in the 1980s when drought was most severe, is significantly higher compared to the pre- or post-drought periods. The drought-induced dust enhancement is also evident from the frequent dust weather observed downstream, including 285 the Caribbean, Gulf of Mexico, and Iberian Peninsula. This is consistent with the long-term in situ dust measurements in Barbados and Miami, Florida, indicating a positive correlation between the Sahel dry anomaly and African dust outflow across the tropical

North Atlantic (Prospero and Lamb, 2003; Zuidema et al., 2019). With the amelioration of Sahelian drought in the 2000s, FR experienced significant decreases at the source and downwind, consistent with ground and satellite observations (Hsu et al., 2012; Li et al., 2014). In the past decade, increased dust activity can be observed in West Africa and the Middle 290 East, which will be discussed later." Please show this is true statistically significantly, in a clear way. perhaps show the 1-sigma and 2-sigma bounds and highlight the time periods above or below, or do a correlatoin.

"if weather stations provide a consistent view of global dust variations, FR and VI are compared with the datasets described in Sect. 2.3." You can compare the dust variations to satellite data and AERONET data and evaluate the dust variables, but please do not pretend that MERRA output is more than model output.

"Figure 6. Global monthly (gray) and annual (black dotted) FR and VI . Horizontal lines are all-time averages." Please describe what you are plotting in complete detail, including repeating which variables are used, etc, so that your figures are self-standing. How are you averaging over the globe when you only have spotty data? Needs to be described in the methods section, and make sure you are doing this in a manner that is consistent with the observations and models you are comparing again (for example, pick each point from the dust station data, and match to the model output at the same grid box, so are weighting similarly).

"Trends are further calculated from the monthly anomalies using the pyMannKendall package developed by Hussain and Mahmud (2019), which consists of multiple Mann-Kendall test options to accommodate the seasonality and serial correlation in the data. The Mann-Kendall test is a non-parametric test of the presence of monotonic trend in the data, and has advantage 330 over parametric methods (e.g., t test) for its insensitivity to outliers, missing values, and the statistical distribution of the data. The Mann-Kendall test is designed for serially independent data and thus can be influenced by the presence of autocorrelation in the data, which either increases the uncertainty of estimated trends or prolongs the length of time period required to detect a given trend

(Weatherhead et al., 1998)." All methods should be in the methods section, or in figure captions, not in the results section.

"The decadal mean FR and VI (Fig. 4 and 5) indicate mega-drought events are associated with extremely active dust periods in the 20th century." To make this statement you need to have compared against precipitation or P-E data and show a statistically significant change/relationship

"Dust variation in North Africa from 1986 to 2019. From top to bottom: monthly Nww and Ndu, and anomalies of FR, VI , MERRA2 DOD, wind speed, soil moisture, and the Jones North Atlantic Oscillation (NAO) index. DOD and soil moisture are averaged over region 10°N–20°N, 20°W–20°E; Dotted curves are annual averages. Dashed lines are Theil-Sen linear regression of FR, VI and DOD, with the annual trends and confidence intervals (CI) shown." What is Nww? Ndu? Should be explained in the figure caption, as well as FR, VI.

"Consistent with previous studies, Fig. 11 shows that African dust was at a historic high during the late 1980s due to abnormally strong winds and low soil moisture, both favorable for dust production (e.g., Prospero and Lamb, 2003; Chiapello et al., 2005; Evan et al., 2016)." Is this statistically significantly true? Please check or put your statistical significance on the plot.

"Indeed, significant correlations are found between NINO 3.4 and scPDSI (r = 0.27, p < 0.001), as well as between PDO and scPDSI (r = 0.53, p < 0.001). PDO also appears to be more correlated (r = −0.36, p < 0.001) with MERRA2 DOD than NINO 3.4 (r = −0.15, p < 0.005). As seen in Fig. 13, PDO has transitioned into positive and weak negative phases since 2015, which has led to the amelioration of drought and consequently, 435 a decrease of dust activity in the Middle East." Is this based on the time series in the plots? Please specify.

"The dust decline was driven by the weakening of surface winds, as shown in Fig. 15 and suggested by past studies, which reported widespread decrease of surface winds

in China during the 1970s– 1990s, with greatest reduction during spring and in the gusty wind segment (Guo et al., 2011; Lin et al., 2013)." Again, do not show your results without showing that they are statistically significant. Please show a correlation coefficient and that it is significant before you make such important, but unclear statements.