Dear Reviewer,

Many thanks for taking the time to provide comments on our manuscript. To each of your comments / queries, we provide responses below using indented bullet points with a bold blue typeface.

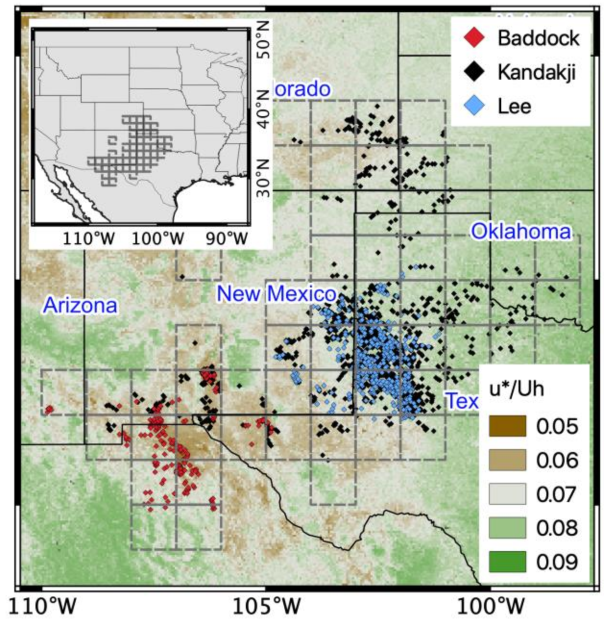
General Comments

This study introduced a novel method based on dynamic land cover change (albedo or earth's shadow) to quantify dust emission with grid precision and thus overcomes the biases from the traditional approach that estimated dust emissions based on constant spatial vegetation distribution from bare soil assumptions. The aim is to investigate point source emission detected by satellites observation varying with time and space. They found that both approaches/models overestimated the occurrence of dusty days, which is mainly from soil wind friction velocity. The more the model overestimates the soil wind friction velocity, the more it entrains high sediment flux once the threshold is exceeded. Therefore, the albedo-based model generates lower emissions than the traditional model due to the new formulation of soil wind friction velocity obtained as function albedo, roughness and horizontal wind velocity. This newly developed albedo-based model suggested to mimic the soil bareness and vegetation cover before and after dust emissions, and the results proved moderately good performance. This study is important and has potential impact for modelling community especially in quantifying effective emission of dust. Some questions for the experiment design and results are need to be addressed prior to the publication.

Specific Comments

1. Dust Point Source locations are only shown on a small-domain map in Figure 1; Later, the authors described the roughness, wind speed, and dust flux in Figure 5 over a larger-domain map, would the authors show the DPS over a larger-domain map, such as the continental US (CONUS)? And, if possible, a map of North America is preferred to display district boundaries, deserts, vegetation and etc.

- **The dust emission point source (DPS) data are from all the existing studies for which data are available. All the DPS data in North America used in this evaluation are shown in Figure 1 of the manuscript. The spatial extent of those DPS data is in, and around, New Mexico. No other DPS data are currently available.**
- **To make the previous point clear, we show these DPS data inset over the larger North American domain (Figure R1). This new figure will be included in the revised manuscript.**



- **Figure R1. Location and publication source (Kandakji et al., 2020; Lee et al., 2012; Baddock et al., 2011) inventory in New Mexico and Texas between 2001-2016 (Kandakji), 2001-2009 (Lee) and in 2001-2009 in the Chihuahuan Desert and New Mexico (Baddock) using satellite observed dust emission point sources (DPS) set against a background of total wind friction velocity (u_*/U_{10}) derived from MODIS albedo (500 m). The inset shows the location of DPS data in North America.**

AOD represents the total aerosol burden in the atmosphere. DOD is meant for detecting dust particles in the atmosphere. In this study, the authors preferred to employ a threshold of 0.2 for DOD (DOD>0.2) as from previous study of Ginoux et al (2012) to separate dust from background over North America during spring season.

- **We followed the methodology using the established criteria and using a threshold of 0.2 for dust optical depth (DOD>0.2; Ginoux et al., 2012) to avoid misrepresenting the DOD.**

However, Ginoux et al (2012) used the threshold DOD>0.25 for most of the regions, and the threshold from this previous study is retrieved from the MODIS-DB L2 product at the 10 km x10 km grid resolution that is much finer than 1 degree resolution used in this study.

- **Ginoux et al. (2012 bottom of page 10) state that in North America, the highest frequency of dust events is found in the southwestern U.S. and northern Mexico. Along the border between the U.S. and northern Mexico, events with DOD>0.2**

appear as frequently as 30% of the time in MAM. This is in agreement with the long-term record of visibility data at El Paso (Texas).

- **Satellite observed dust emission point sources (DPS) have an uncertainty of around +/-2 km (Kandakji et al., 2020) due to the phase difference between timing of dust emission and availability of the imagery. At the point scale, unexplained (nugget) variance between DPS is reduced by aggregating data over time to months, and over space to 1 degree grid boxes. This approach is well-established in geostatistical literature and used across multiple disciplines and tackles the issue of incompatible scales described by Gotway and Young (2002).**
- **We used monthly MODIS Deep Blue Collection 6 data (MOD08 M3 V6.1) to establish DOD across 1-degree grid boxes compatible with the DPS data.**

> Given that the authors in this study overestimated the frequency (Figure 3) even with the lower DOD threshold of 0.2 without quality control, why didn't the authors sample DOD with quality flag at higher resolution and then average over one degree resolution? Otherwise, is 0.2/0.25 reasonable for one-degree resolution? Over such a large grid, smaller value may be preferred? please clarify.

- **Consistent with previous studies using DOD to display spatial variability, we show in Figure 3 of the manuscript, the discrepancy between the spatial variation in dust emission point sources (DPS; Figure 3a) and dust in the atmosphere measured using DOD (Figure 3b).**
- **To investigate the reviewer's question about the sensitivity of the maps to the threshold used, we reproduced Figure 3b in the manuscript with different thresholds: dust optical depth (a) DOD>0, (b) DOD>0.1, (c) DOD>0.2, and (d) DOD>0.25.**
- **These results (Figure R2) show that there is very little difference in P(DOD>threshold) along the USA and Mexico border, and small differences in areas exceeding threshold more frequently at smaller thresholds further north and east.**
- **These new results confirm that the choice of threshold around DOD>(0.2-0.25) makes little difference to our results and interpretations.**
- **Notably, where no threshold is applied (Fig. R2a), dust occurrence increases in the northern areas of the figure. This type of threshold is not applied in the DOD literature because it is vulnerable to erroneous observations due to atmospheric and surface conditions that would otherwise be screened out with the application of a threshold. We will include these findings in the Appendix of the revised manuscript.**

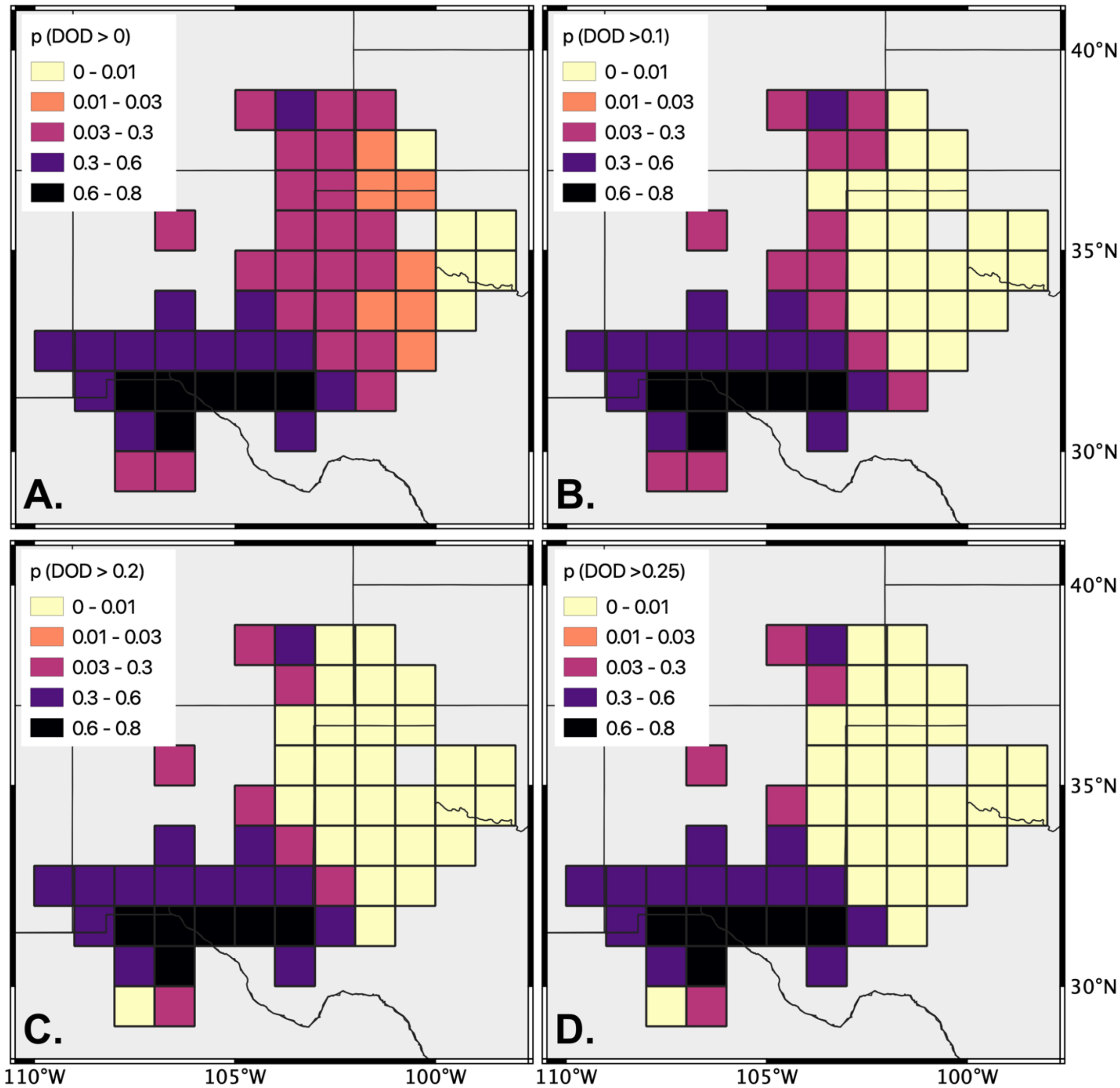


Figure R2. Comparison between the probability of MODIS dust optical depth (DOD>T) where T=0 (a), T=0.1 (b), T=0.2 (c) and T=0.25 (d) during the study period 2001-2016. All available MODIS DOD data were used, quality flags were not used to filter these data. The missing value of the pixel in the south-east of MODIS DOD is evident in the original data and has not been removed during processing.

2. The results showed that high dust emissions were generated mainly from the Great Plains extending from Montana, Wyoming, Dakota, Colorado, New Mexico, and Texas, and slight dust emission were from the semi-arid and arid regions of the western deserts (Sonoran, Chihuahua, Mohave and great basin deserts). Therefore, I

think the authors should also explain why those semi-arid and arid regions did not have any DPS.

- **The reviewer notes that dust emission (evident in Figure 5 of the manuscript) occurs in regions other than those where dust emission point source data (DPS) has previously been measured. The reason we do not show any DPS data for those regions is that we did not use any DPS data in those regions. This is because there are no available DPS data outside of those regions we showed.**
- **The identification of DPS data is a highly time-consuming and labour-intensive activity. Consequently, there are few (published) studies relative to the large number of dust source regions. We will use this last sentence in the revised manuscript to explain the availability of DPS data.**

3. How does the study incorporate the soil texture/ soil type especially particle size threshold for starting the dust saltation? More explanation is preferred.

- **There are several places in the existing manuscript where soil texture is used in the sediment transport *Q* and dust emission *F* modelling. Firstly, equations 1-3 in the Introduction (of the main text) demonstrates *Q*(*d*) where in the entrainment threshold u*ts(d). Secondly, equation 5 in the Introduction demonstrates that dust in the atmosphere is a function of the relative particle size surface area and of the clay content.**
- **The precise description of how soil texture is included in the modelling is provided in the Appendix and includes a description of the entrainment threshold and the soil moisture function, which adjusts u*ts, depending on the clay fraction. In the revised manuscript we will ensure that the Introduction refers more to the Appendix.**

Minor Comments

4. The paragraph from 231-237 describes Figure 2a for the albedo-based model. It seems that the results from the smooth and rough cases overlap. Please clarify if they are identical.

- **In the manuscript, L231-237 describes the model assumptions applicable to a traditional model and the albedo-based model (AEM).**
- **Figure 2a is described from L. 297. The AEM dust emission with a smooth condition (us*/Uh=0.035) represented by a dotted line which extends to the entrainment threshold of us*=0.2. The AEM dust emission under a rough condition (us*/Uh=0.022) is represented by a solid black line. The AEM dust emission response overlaps.**

- **In the revised manuscript we will change the line styles to make the overlap visible.**

5. In Figure 5 and 6, U_h should be replaced by U_{10}. Please also correct others if any.

- **Thanks for identifying those typographic mistakes. In the revised manuscript, we will rectify those errors and any others that we find.**