Reply to Reviewer 1

Interactive comment on "Development of adynamic dust-source map for NMME-DREAM v1.0model based on MODIS NDVI over the ArabianPeninsula" by Stavros Solomos et al.

Parajuli (Referee)
psagar@utexas.edu
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The paper proposes a dynamic dust source map based on NDVI values and use it in adust model. The "dynamics" of dust sources is an important aspect of dust emission,which is currently not represented in many dust models. In this regard, this paper attemptsto address an important concern of the dust modeling community. The paper is written concisely with great focus, which I greatly appreciate. However, some importantrelevant descriptions required are missing in the manuscript. In addition, it is not clearif the results dictate enough to justify the use of dynamic dust source map. My specificcomments are given below.

[REPLY] We thank the reviewer for the constructive comments. The general purpose of our work is to describe the development of this alternative method to our usual static representation of dust sources in DREAM. It is true that this first application is encouraging but cannot justify the replacement of current model configurations over different source regions. More tests for other areas and periods will be required with the new model setup before we conclude to an optimal dust source description which in the end might be a combination of both static and dynamic maps.

Line 52-59. It is mentioned that dust sources are represented by global datasets but it is not described 'how' exactly they are represented. Please describe how it is done, at least in DREAM. Please explain how exactly dust emission is affected when we usethe new dust source map in the DREAM model. Please show and explain the detail of the particular equation that is affected. I believe the main change is the fraction of agrid point covered by desert surface, as in equation 3 of Nicovic et al., (2001).

[REPLY] We have updated the model description section to include more information: "The original classification of dust sources in DREAM is based on Ginoux et al., (2001) that takes into account the preferential sources related to topographic depressions and paleolake sediments. The global mapping of dust sources in Ginoux et al.,(2001) is determined from the comparison between the elevation of surface grid points at 1°×1° resolution with the surrounding hydrological basins and with the 1°×1° AVHRR (Advanced Very High Resolution Radiometer) vegetation map (DeFries and Townshend, 1994)."In the new version the ratio of arid and semi-arid vegetation points to the total vegetation points inside a model grid-box is used to calculate the corresponding dust productivity of each particular cell.

60-73: You describe other works that used dynamic dust source map but it is not clear how your 'proposed' work is similar/different to these previous works. Please make itclearer.

[REPLY]Our work is similar to Kim et al., 2013, Vukovic et al., 2014 and Solomos et al., 2017 in terms of the general objectives and methodology. We have added a revised section: "The main

differences in our approach compared to the previous studies referenced above, is that we use a very high resolution NDVI product (500×500 m) in a regional modeling domain (e.g. Kim et al., 2013 used an 8×8 Km NDVI dataset extrapolated to 1°x1° global modeling domain) and our study is not limited to specific test cases (like for example Vukovic et al., 2014 and Solomos et al., 2017), but covers an extended time period, as presented below."

78-79, in the 1) control run, do you use Ginoux et al. 2001 source map or Olson dataset? Please clarify the link between these two datasets.
[REPLY] Thank you for pointing this out. We use Ginoux et al., 2001. We have revised this sentence as: "Control run, where the dust source definition is based on the Ginoux et al., (2001) dataset"

91-99. this description is not so relevant to this study. It is not necessary to talk about partial differential equations or turbulent parameters here. This study is more about the dust source characterization so there should be more background or descriptionfrom 'dust-source' point of view. A few sentences about the overall model descriptionis sufficient. Rather, a brief description and comparison of different dust emissionmodels currently in use, e.g., GOCART (WRF), DEAD (CESM), MACC etc., would be helpful for the readers. Also the literature on dust source map should be extended to cover the most recent developments in this topic. Some relevant starting referencesare given below:
Parajuli, S. P and C. Zender (2017), Connecting geomorphology to dust emission through high-resolution mapping of global land cover and sediment supply, Aeol. Res., 27, pp. 47-65, doi:10.1016/j.aeolia.2017.06.002.
Ginoux, P., J.M. Prospero, T. E. Gill, N. C. Hsu, and M. Zhao (2012), Global-scale attribution of anthropogenic and natural dust sources and their emission rates based on MODIS deep blue aerosol products, Rev. Geophys., 50(3), doi:10.1029/2012RG000388.
[REPLY] We have increased the information on the surface dust source map considerations. The revised section is now:
"The original classification of dust sources in DREAM is based on Ginoux et al., (2001) that takes into account the preferential sources related to topographic depressions and paleolake sediments. The global mapping of dust sources in Ginoux et al.,(2001) is determined from the comparison between the elevation of surface grid points at 1°×1° resolution with the surrounding hydrological basins and with the 1°×1° AVHRR (Advanced Very High Resolution Radiometer) vegetation map (DeFries and Townshend, 1994). Recent studies indicated the contribution of both natural and anthropogenic dust sources to the overall dust emissions detected in MODIS Deep Blue product (Ginoux et al., 2012) and also the relevance of local geomorphological conditions and sediment supply (Parajuli and Zender, 2017) on the global dust emissions. All these advances in dust emissions are based on static map considerations."

Line 103: Make it clear that August 2016 is test run but simulations are conducted forthe whole year.
[REPLY] This sentence is revised as follows: "August 2016 has been selected as a test period for the model development due to the significant dust activity and variability in wind properties

during this month. One-year runs for the entire 2016 have been conducted to evaluate the performance of the static and dynamic database emission maps".

107-108: is it updated monthly or every 16 days? In many models, it is generally updated monthly. Please clarify. Also please describe the 'numerical procedure' that you mention in more detail explaining how the NDVI data is used to define the dustsources.
[REPLY] Yes we used the 500×500 m 16-day averaged NDVI from MODIS. We assume that regions with NDVI values from 0 to 0.1 correspond to bare soil and therefore can be efficient sources. The NDVI dataset is at finer resolution than the model grid and in order to find the potential for dust production in each model grid box, we calculate the ratio: number_of_dust_points / total points. The scaling of satellite data over model grid points allows the use of the same algorithm for different model configurations.

112/113: Is this ratio a modification from Nicovic et al., 2001, equation 3? Please clarify.
[REPLY] Yes, it is formally of the same kind but the input parameters are different. Instead of desert, semidesert, arid and semiarid vegetation points we use NVDI<0.1 points.

120: how are those mountainous areas removed? Western Saudi region has many dust sources with intermountain deposits; make sure that you do not overlook these sources. See below for those dust sources.
Anisimov et al. (2017), Quantifying local scale dust emission from the Arabian Red Sea coastal plain, Atmospheric Chemistry and Physics, 2017;17(2):993-1015 DOI 10.5194/acp-17-993-2017.
[REPLY] The following paragraph has been added in the revised version: "In order to exclude such unrealistic emissions from non-soil bare areas or snow-covered areas we have applied a limit of zero dust production above 2500 m over the entire domain. This simple approach has been selected in order to keep our straightforward NDVI mapping independent of vegetation and soil information. The threshold value of 2500 m does not suppress the emissions from lowlands and hillsides (e.g. the coastal areas of Hejaz Mountains in Red Sea that have been identified as hot dust spots by Anisimov et al., 2017)."

Line 146: How is effective strength of dust source defined? It is not described clearly.
[REPLY] "The high-resolution mask was used to calculate the percentage of barren land in each 0.1°x0.1° model grid cells and this percentage was used to define A_{grid_box} in Eq.1"

155-165: This paragraph belongs to the 'methods' section, not the results section. Soit should appear early in the manuscript.
[REPLY] Done. We moved this paragraph to Section 1.1 (Model Description).

Line 156/157. Please describe how exactly the static Ginoux et al., 2001 dust sourcemap was used in the model previously? Is the dust emission equation 'tuned' to achieve a target AOD as commonly used in many dust models? The comparison would bebetter if the control and NDVI run both were tuned to achieve some observed AODvalue. Was the model tuned in some way to get a desired AOD?

[REPLY] The control run (CTRL) is our standard configuration and it is tuned to reproduce as much as possible the AOD over both African and Asia sources. The NDVI run is performed with exactly the same configuration other than the definition of dust sources (Eq.1).

Figure 2b. Is this map showing the values from A_gridbox that you defined earlier? Please clarify what exactlyare the plotted values.
[REPLY] Yes. This in now clarified in the caption.

Figure 3 titles: May be DREAM-CTRL and DREAM-NDVI are better titles?
[REPLY] Yes indeed, thank you. We have changed these titles throughout the revised text.

Figure 4. Please describe Figure 4 in the text properly.
[REPLY] In the revised manuscript we have changed lines 199-200 to: "The modeled dust optical depth is compared with the regional AERONET ground-based photometric measurements of AOD (Figure 4)…."

Figure 5. Please describe Figure 5 in the text properly. Is it NDVI_run or NDVI_topo_run in the legend? I think you use topographic source function (Ginoux et al., 2001) in the control run so it is confusing.
[REPLY] In the revised manuscript we use DREAM_CTRL and DREAM_NDVI instead.

You may not need to set the color bar maximum value to 6.4, which is very high. A lower value of 1-2 would be sufficient.
[REPLY] This probably refers to Figure 3. This color bar is now revised in this plot. A maximum value of 3.2 is selected, as this is the maximum value from the simulations output.

About the evaluation metrics used in the paper: This paper is about the benefit of representing 'dynamics' of dust sources. So the time-correlations should increase if the new changes are beneficial. Improvement in bias does not confirm that it is because of the better representation of the 'dynamical' aspect of dust sources. The simulated values of AOD and their range also affect the bias, which are sensitive to the process of model tuning. That is why I mentioned about tuning previously. In addition, the RMSE is reduced only in one case and it is increased in other three cases? What doesthis tell?
[REPLY]An overall tuning factor is often applied homogeneously over modeling domains. This can only result in a linear emission increase which may benefit the model results in one area but deteriorate the statistics in other areas. This is not the case here since the only change in the model (Eq.1) is the replacement of dust sources (Ginoux et al., 2001) with the NDVI dust points. The RMSE is increased for the DREAM_NDVI run due to the increase in maximum modeled AODs. For the severe dust episodes (AOD>1) the RMSE is improved.

We should perhaps think of better control and model experiments so that the comparison of the two is fairer and the difference will show the expected outcome.

[REPLY] In our opinion, the method presented in our work clearly shows the potential of satellite retrievals as an alternative method for the mapping of dust sources. In general, we believe that dust emissions should be described in atmospheric models based only on physical considerations without the need for empirical tuning factors. In this direction a combination of up to date and detailed land cover mapping with synchronous remote sensing information (e.g. NDVI from various sensors) could lead to better results in future work.

Table 1. What are fractional gross errors and mean fractional bias? Why are they relevant here? I think it is not necessary to show these values.
[REPLY] These are common statistical metrics used for example by the WMO SDS-WAS system and are included here for consistency with the operational evaluation of dust models. More description has been added in the revised text.

Some minor typing errors:
Line 6. Normalized difference
Line 9. One year
Line 31.Precipitation process
Line 68. ..be even ..
Line 248/249: rewrite the first sentence, themain purpose

[REPLY] Done, thank you.