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Reply on RC3

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Author comment on "Investigating the impact of Saharan dust aerosols on analyses and forecasts of African easterly waves by constraining aerosol effects in radiance data assimilation" by Dustin Francis Phillip Grogan et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-129-AC3, 2021

Response: We appreciate the reviewer's suggestions for improving the manuscript. Our responses follow.

General Comments: Direct aerosol-affected radiance calculations are not practically adopted in current operational numerical weather prediction (NWP) and data assimilation (DA) systems. This is mainly due to computational cost issues. Also, uncertainties of land surface conditions in radiative transfer models contribute to the limitation. Thus, this paper are appropriate to the NWP development direction and requirement. The topics of the paper addresses the impact of aerosol-aware daiance calculation on the dynamical atmospheric structure on northern Africa. However, general recommendation is a major revision to the paper and additional experiments and evidences to draw a concrete conclusion and discussion. 2017 August time period was used in the experiment to investigate the dust impact on circulation patterns involving two Hurricanes cases, Gert and Harvey. The authors were able to identify that the aerosol-aware run reduces the errors of forecasting the African easterly waves. The improvement is positive especially for Hurricane Harvey case but neutral or no improvement for the Hurricane Gert case. Obviously additional experiment for different time period is needed for robust conclusion. General editorial comments about the current version of the paper: overall writing quality is not clear and additional literature survey is needed. Details are missing in figure and table captions and titles. At this stage, my opinion is to suggest major revisions and additional experiments for the paper. Detail editorial corrections and comments can be provided once a mature version is resubmitted. Nonetheless, a few early remarks and suggestions are given below. **Response:** In the revised manuscript, we have made the following changes to address the reviewer's concerns:

1. Refine the intro by including over 20 additional references, adding more motivation and a clearer hypothesis.
2. Bolster the methodology section by providing more details of the experiments for each step of their workflow (i.e., gdas, obs, ngac, and gfs), assessing the NGAC aerosols, and examining DA statistics for the infrared (IR) brightness temperatures from IASI for each experiment.
3. Combine sections 3 and 4 to streamline results with their explanation and remove unnecessary figures.
4. Expand the conclusions section to remind the reader of the methodology, present what has been learned in the study, and discuss the implications.

In regards to conducting additional experiments, we argue that the two cases, Harvey and Gert, are sufficient for this study. In particular, this study incorporates aerosol

transmittance effects on satellite radiance calculations during data assimilation to (i) investigate their impact on the analysis and forecasts and (ii) explain the differences in the context of physical mechanisms driving dust radiative effects on AEWs. This study recognizes that more than one mechanism involving dust radiative effects is at play for the analysis fields of our two AEW cases, which we suggest is the reason for the improved forecast of Harvey and not Gert. Thus our study exposes the utility of our approach on AEWs interacting with dust. Nonetheless, we agree with the need for additional cases to increase the robustness of our results, which is touched on in the conclusion section of the revised manuscript.

Main Comments:

1. Title slightly misleads discussion points. Is the main point about the effect of Saharan Dust on AEW from AGCM dynamics point of view or impact from DA procedures? Detail dust structures and distributions are not provided in the paper. DA and analysis statistics are not fully provided. **Response:** We have changed the title of the manuscript to: "Investigating the Impact of Saharan Dust Aerosols on Analyses and Forecasts of African Easterly Waves by Constraining Aerosol Effects in Radiance Data Assimilation." The main point is to incorporate aerosol transmittance effects on satellite radiance calculations to determine how, and to what extent, the assimilation captures dust radiative effects that operate on AEWs in the analysis fields, and what impact this has on forecasts for the AEWs downstream.

2. Model experiments: Current operational version of the NCEP GFS system is based on the cubed sphere FV3 dynamical core and version number has already reached around version 16. GFS v14 used in the paper is considerably outdated. Prescribed monthly aerosol climatologies obtained from the OPAC package were applied in the experiments. It is very difficult to make any opinion about how useful the OPAC aerosol data sets are for direct applications in the NWP DA systems. Clearly, a trouble is to understand about the experiment design and approach: monthly climatological aerosol data set for one month NWP forecast and DA experiments. **Response:** The revised manuscript presents the design and approach of our study more clearly and provides an in-depth description of the experiments conducted. Moreover, discussions involving the interplay between OPAC, from the forecast model, and NGAC, from the assimilation system, on the analysis fields are discussed in the context of dust radiative effects on AEWs.

3. Figure 1 shows that NGAC data is used in the GDAS cycles. Again, DA analysis statistics of the aerosol-aware experiments are critically important for discussion. **Response:** In the revised methodology section, we provide statistics for the IR brightness temperatures from IASI for each experiment.

4. In the paper, mean forecast field differences are extensively compared for the experiments with and without aerosol-aware data assimilation. Since the experiments are based on the whole month of August, distinguishing aerosol background structures are key factors and following impact on the brightness temperature calculation should be provided for all assimilated infrared observation data sets. Single IASI scatter plot figure (in figure 9) is not sufficient. **Response:** We now mention in the methodology that IASI, and other thermal IR sensor observations, are ingested in the assimilation system. As mentioned in comment 3 above, statistics are now performed for IASI on a channel in the IR window, which serves as a representative case for other IR channels and thermal IR sensors. In the revised manuscript, the single IR scatter plot now includes an example for Gert, which allows for a clear comparison to explain the impacts on Harvey.

5. Forecast RMSE differences are compared in Table 1 to identify the improvement. Obviously, there is a statistical risk to draw any conclusion with limited forecast samples. **Response:** In the conclusions of the revised manuscript, we identify that additional work is needed to improve the robustness of our results, which includes the investigation of additional cases.