

Atmos. Chem. Phys. Discuss., author comment AC1
<https://doi.org/10.5194/acp-2021-129-AC1>, 2021
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Reply on RC1

Dustin Francis Phillip Grogan et al.

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-AC1>, 2021

Response: We appreciate the Reviewer's careful reading of the manuscript. The Reviewer's suggestions, which we have fully addressed, have resulted in an improved manuscript.

Summary: The assimilation of aerosol information is still not fully realised in most NWP systems and I thus welcome studies that explore potential impacts as this one. Overall I find the experimental design and outcome of this paper interesting and relevant for the readership of ACP, but the presentation of the results is not as clear and convincing as should be. The reference to relevant literature is a little thin, many figures are only superficially described and some important background information is missing. I therefore propose that major revisions are needed before I can recommend this work for final publication in ACP. Details are given below. **Response:** We agree with the reviewer's assessment of the paper and thus have followed their guidance below, which has produced a much-improved manuscript.

Major Comments:

Title: I am not sure that this is an optimal title for this work. The second part read suite complicated and technical and I doubt people will really understand what that means. The first bit is fine but you leave out the aspect of TC genesis. You mention data assimilation but not forecasting. How about the following: Effects of Saharan dust assimilation on the analyses and forecasts of African easterly waves and Atlantic tropical cyclogenesis?

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 revised title takes elements of the suggested title by the reviewer, but excludes dust data assimilation, as this study ingests dust for the sole purpose of incorporating it into radiance calculations.

Abstract: The first paragraph reads well but the second is mostly a repetition of the first and should be omitted. Instead you should much better explain your experimental design (take information from aerosol model NGAC for the assimilation, change of initial condition but not of forecast model, comparison to satellite data). I would also explain that your results are consistent with qualitative arguments of baroclinic and barotropic instability.

Response: As suggested, the revised abstract has been combined into a single paragraph, includes a description of our experimental design, describes the time-averaged and case results, and connects the results to dust radiative effects operating on the background and episodic dust fields.

Literature: Your introduction is relatively thin on references to relevant work. I would ask

you to do a more thorough research and include more references. A few that come to my mind include Benedetti et al. (2018, ACP, overview paper for aerosol prediction), Knippertz and Todd (2010, JGR, dust and AEWs), Jones et al. (2003, JCLI, AEW and dust transport), Karyampudi et al. (1999, BAMS, Saharan air layer), Pope et al. (2016, GRL, dust data assimilation), Schwendike & Jones (2010, QJ, AEW merging and TC cyclogenesis), **Response:** We have included most of the above-mentioned references in the introduction, and several others throughout the manuscript. In total, 30 additional references have been added to the revised manuscript.

Methodology: Your dust information come from NGAC and you only mention this in passing. I see that you are giving references here but this information is so essential for understanding the present paper that you need to give a summary here. How does this model work? What data is assimilated? How good is it? You need to justify your approach much better! In addition the radiative impact will depend a lot on the chosen optical properties. What is used here? How sensitive are the results to this? In the infrared the sensitivities can be quite large, as shown in a recent paper by Claudia di Bagio and co-authors! **Response:** The methodology has been bolstered significantly and addresses these questions. In particular, we now (i) provide more details of the experiments for each step of the workflow (i.e., gdas, obs, ngac and gfs), (ii) assess the NGAC aerosols, and (iii) examine statistics for the observed-forecast infrared brightness temperatures from IASI for each experiment.

Introduction: In addition to more literature, your introduction should elaborate a clear hypothesis to test. There is a lot of literature on the link dust-radiation-temperature wind-AEWs-TCs including mechanisms of barotropic and baroclinic instability. The way the paper is written now, this link comes really late. I would bring this to the very front and cast it as a hypothesis you are testing. This would make the paper much more interesting to read and easier to understand. Doing this, you could even hypothesize that only the forecast of TCs that form from northern vortices will be strongly affected by including dust, as the southern ones are too far away from the plumes. Harvey is a nice example, where the contribution of the northern vortex "wins"! You should stress this aspect more!

Response: We have refined the intro in the revised manuscript. The overlaying flow remains similar, but we have streamlined the front end to get to the motivation quicker. The literature involving dust-radiation-AEWs is retained and is drawn upon more in the paper for interpreting the results, making it more essential. For this study, our focus is to determine if dust radiative effects on AEWs identified in the literature can be captured within our aerosol-aware assimilation. Given that the study focuses on two cases, more cases may be needed to test if TCs that form from northern vortices will always be strongly affected by dust.

Balance between sections 3 and 4: The description of results in section 3 is in places too short and superficial. Some aspects are then picked up again in section 4. I would merge these two for a better storyline. Make sure each panel of each plot is discussed in the paper. If not discussed, it can be omitted. **Response:** In the revised manuscript, we have combined sections 3 and 4, removed unnecessary figures, and discussed all the panels within each figure.

Conclusions: If you follow my advice on formulating a clear hypothesis, you can use the conclusion section to explain to what extent you find that hypothesis confirmed. You should also clearly articulate what we have learned from this study we didn't know before or in other words what is the innovation? Compare your results to those of other studies! Remind the reader of your very special methodology of taking dust from a model to assimilate into another model to change initial conditions to then make forecasts using a dust climatology. This is not straightforward and limits the interpretation of the results. **Response:** The conclusions have been expanded in the revised manuscript. In the new version of the conclusions, we remind the reader of our methodology, present what we've learned in the study, and discuss the implications of the study on forecasting AEWs in NWP.

Minor Comments:

Grammar Comments Response: All minor comments pertaining to grammar have been

fixed in the revision.

General: Your geographical descriptions are often imprecise. What you call North Africa, I would call West Africa in some cases. What you call the southern Sahara, I would call the Sahel etc. Please check throughout and try to be consistent with common terminology.

Response: Fixed.

Abbreviations: Make sure you define all at first use and then use abbreviation only.

Don't define them, if not used again. **Response:** We elect to redefine some acronyms in the methodology so that the section is self-contained.

L200: This is confusing. The monsoon flow is southwesterly. You are showing that the westerly component accelerates but if the southerly decelerated, the total wind would not change. Please be clear or analyse both components. **Response:** We now say on L264-L265, "the aerosols...accelerate... the westerly flow of the WAM..." In the AER run, the southerlies of the WAM were also accelerated, but we exclude this because it has little relevance to AEWs.

L201: Again confusing. I would call a positive change in an easterly flow deceleration not acceleration?!? **Response:** The latitude range was incorrect in the original manuscript. We have removed this sentence in the revised manuscript to improve clarity.

P8: I would explain the temperature first, then wind, as the latter is the consequence of the former. **Response:** Fixed.

L221: why modulus?? **Response:** We have removed the vorticity modulus figure and replaced it with the 2-6 day filtered meridional variances, which is a well-established proxy for AEWs. The results are the same.

P12: The IASI data should be introduced in the method section. What exactly you do with them, is somewhat unclear to me. You need to describe this much better and discuss the results more clearly. Maybe good to show Gert, too, for contrast?! **Response:** IASI is now mentioned in the methodology section. We also present statistics on the IASI infrared observations during assimilation to demonstrate differences among the two experiments in the methodology section. In the results section, Fig. 9 now includes one panel for Gert and one panel for Harvey, as suggested, to ease comparison and thus provide a better explanation for the results from this Figure.

L313: better "the authors" to avoid repetition. **Response:** The sentence referenced has been removed in the revised manuscript. The discussion pertaining to this sentence, which has been moved to section 3.2, is re-written to provide better clarity in explaining the results presented in Fig. 9. (L347-L354).

Caption Fig. 1: Too short, more details here or reference to text. **Response:** The caption refers the reader to the text for more details. Fig. 1 is now referenced throughout the methodology section of the revised manuscript

Figs 2,3,4,5,9 Response: All suggestions have been adopted into the Figures.