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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Models transport Saharan dust too low in the atmosphere compared to observations" *by* Debbie O'Sullivan et al.

Anonymous Referee #1

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The authors present a study with combined modeling, remote sensing and in-situ data and they point out certain deviations between the operational modeling simulations for dust transport and the actual observations. The performance of dust transport models and especially of those with lower resolutions is known to be problematic especially for the long range transport. This work identifies certain modeling elements that may be responsible for these discrepancies including the particle size distribution, optical properties calculations and prediction of wind fields. The study is clearly written and it can be an interesting addition to the relevant literature. I recommend publication with minor revisions. Specific comments are following below:

- Title: "Models transport Saharan dust too low in the atmosphere compared to observations". The title should change to something referring to MetUM and CAMS specif-

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Discussion paper

ically because it is not justified in the paper that all available models at all possible configurations transport the dust too low in the atmosphere.

- This work highlights an important consideration regarding the contribution of the smaller dust particles to the extinction coefficient and how this is used to compensate for the absent of large particles in dust models. The models are fine-tuned to represent the observed optical properties, which is sufficient for further direct effect studies (i.e. radiative transfer). However the indirect processes (e.g. IN/CCN activation) are mostly governed by particle concentration and thus it is not possible to obtain reasonable results for the indirect effect in the aforementioned models. This should be highlighted also in the abstract.

- [Line 25] "An analysis of the processes driving dust uplift in the models suggests that errors in the large scale wind". The large scale wind issue is not adequately supported by the results of this study.

- [Line 40] Please put the references in chronological order

- [Line 107] "....uses the 2-bin dust scheme, with a fine and accumulation mode bin (division 1 or d1, 0.2 - 4.0 μm diameter) and a coarse mode bin: (division 2 or d2, 4.0 - 20 μm diameter)", but in the paper you generally assume <1um as fine and > 1um as coarse. Please clarify how the MetUM bins fit into the general fine-coarse division in your study.

- [Line 225] "..... using the Numerical Atmospheric Modelling Environment (NAME) (Jones et al, 2007) and the Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT)". Please provide information on the meteorological data that you used to drive the Lagrangian simulations. Is it from MetUM and CAMS or from other models?

- [Line 310] "As already highlighted from Fig 2, the MetUM has the dust layer extending right down to the ocean surface. It is moreover dominated by the smaller size bin (d1,

0.2 – 4.0 μm diameter), in particular for the aerosol below 1km primarily. The concentration predicted by CAMS for this case is less than half of that in the MetUM, and however the magnitude of the predicted extinction is similar, although with differences in the dust layering". It would be useful for the reader to elaborate more on these concentration/optical products comparisons and possibly to explain also the methodology that you used to retrieve the extinction efficiencies.

- [Line 350] "The differences between models and observations could possibly be associated to the dust having been uplifted by a strong haboob, for which models may fail to capture the strength of the uplift (Roberts et al., 2018)." You could explain further here the reasons why these models do not capture the convective density currents e.g. due to their coarse resolution.

- [Line 356] "Compared to the very large differences between the measured and modelled dust concentration, the modelled extinction is much closer to the observations." Again this is an interesting highlight of this study and should be emphasized more and included in the abstract.

- [Line 485] "Previous studies which have looked at this issue more comprehensively do however suggest that there is an underprediction of wind fields in the models, which is also linked to coarse resolution modelling (eg. Chouza et al., 2016). Evan et al, (2016) showed that desert dust emission is to first order a function of wind speed, and it is against this quantity that models parametrise the dust source. Therefore, it seems reasonable that improving the wind speed in the models is a key part of getting the amount of dust uplift right." It is already well known that wind plays a key role in dust mobilization and transport. Please elaborate more on these wind considerations if you want to make a specific statement for your study as a simple reference in previous papers might not be adequate in this case.

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