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Comment on acp-2022-655

Anonymous Referee #2

Referee comment on "Comparison of dust optical depth from multi-sensor products and MONARCH (Multiscale Online Non-hydrostatic Atmosphere Chemistry) dust reanalysis over North Africa, the Middle East, and Europe" by Michail Mytilinaios et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2022-655-RC1>, 2022

The paper presents a thorough evaluation of the MONARCH regional dust reanalysis over North Africa, Europe, and Middle East in terms of comparisons to satellite and ground-based dust aerosol optical depth products (DOD). The presentation is well written and the figures—although complex—are relatively easy to read. I have only a few minor clarifications and two major points, though I don't think they require extensive revision.

Line 153 - I am confused by the use of the word "ensemble" here and in the remainder of this paragraph. What ensemble is being referred to? The statistics presented later are data sets versus one another of the reanalysis versus the data sets.

Line 402 - I don't agree "low RMSE" in the region being described. I see high RMSE in bottom left quadrant of, e.g., Figure 2j

Line 406 - I don't understand MISR shows smaller differences against AERONET in the regions indicated. It looks worse than MIDAS in terms of MB on the North African coast (comparing Figure 2g and 2h).

Two major comments:

I question the conclusion stated on line 737. The “gold standard” here is AERONET, and the comparisons in Section 3 make plain that MIDAS and AEROIASI underestimate AERONET AOD over source regions in both total and coarse DOD (MIDAS) and coarse DOD (AEROIASI). MONARCH is high AOD over those regions relative to MIDAS and AEROIASI, but still low compared to AERONET in both total and coarse DOD (Figure S3 and S7). Admittedly you don’t have the regional coverage from AERONET that the satellites provide, but still I think my assessment there is fair. Comparing the numbers in Figure S3 and S7 for North Africa, there is also some insight into the coarse/total DOD partitioning in the model and data, as well as interesting aspects in seasonal variability (MONARCH goes from a ratio of 0.14:0.4 (35%) to 0.22:0.31 (71%) from MAM to JJA; AERONET goes from 0.19:0.48 (40%) to 0.26:0.39 (67%)). That’s pretty good and that seasonal change in the coarse:total DOD ratio seems like something to note. The authors are well aware of the recent body of literature on the “under appreciated” dust coarse mode, and MONARCH seems to be doing something robust there.

On the other hand, the gradient from land to ocean is noted as a discrepancy and there are at least two things there to consider. First, it seems notable that the data assimilation only corrects the model over land using the MODIS Deep Blue products. (An interesting aside: how do the data being assimilated compare to the AERONET data? This seems not to be considered here.) So if the data is correcting forward model biases over land that may be conveyed over ocean. Secondly, to those model biases, that models tend to deplete dust over land range transport too efficiently is I think also well known. Without an evaluation of the dust vertical profile it’s hard to tell what’s going on here. It’s also the case that some models are overly aggressive in loss processes, both dry and wet, and some statement of that to the effect of the budget of MONARCH compared to, say, AEROCOM models would be useful.

So I think the authors should address these two major points in their conclusions at least with a couple of paragraphs that expand on these ideas as the pertain to their study.