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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Particle size traces modern Saharan dust transport and deposition across the equatorial North Atlantic" *by* Michèlle van der Does et al.

Anonymous Referee #1

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Review of Does et al.

There is a lot of potential in this paper, but as written there are some serious issues with relating the data presented here with the conclusions. Even for big picture ideas (size gets smaller as you go across the Atlantic), it's not clear to me how to interpret particles from sediment traps, so I think this needs to be discussed much more explicitly in the paper. The data itself, with the size changes across the ocean, should be publishable, but it's the interpretation that is really an issue in this paper.

The big issue is: what is the aerosol in the trap and how is it related to what comes in at the top? Previous studies have shown that there are at least seasonally modulated relationships between the two (Bory et al., 2002), but here the authors are trying to

interpret these seasonal changes as occurring in the atmosphere, which could be true. But the fact that the aerosol size is systematically different at the deeper cores suggests there is something else going, and the assertion that this must be from changes in the dust sources (agriculture!) is too speculative to be convincing. I am not even sure I believe the sizes they are getting represent aerosols, and definitely the time and space lag issues related to aerosol transport and processing in the oceans is too important, and almost completely neglected here, will heavily modify the signal they are trying to interpret!

1. size: "This resulted in particle-size distributions consisting of 92 logarithmic size classes ranging from 0.375 to 2000 μm. Grain-size statistics were calculated geometrically using the graphical method of Folk and Ward (1957) using GRADISTAT (Blott and Pye, 2001)." It sounds like you are assuming that the size of the particles you are measuring in the sediment trap is the size of the particles in the atmosphere? There is a lot that goes into that kind of set of assumptions, so please spend at least a paragraph in the methods describing why you think this will work, previous papers which showed a relationship (or not) and what kind of assumptions it requires. Wetting an atmospheric aerosol during deposition, could either make particles coagulate or break the bonds of particles. On the other hand, material can coagulate onto the particles in the ocean, and change or process them. Already your evidence that the sizes are different at the trap and deeper down suggests changes in size or processing (or advection: see next point). Please be explicit about the assumptions you are making and justify them here in the results, and then in summary and conclusions discuss the implications of your assumptions for your work. Are these aerodynamic or geometric measurements, as a basis? Size of aerosols is tricky to measure (e.g. Reid et al., 2003) and different measurement methods get quite different results: how do your methods compare? Is there any way you can use previous measurements of size in aerosols (e.g. Reid et al., 2003; Skonieczny et al. (2013)) to help you with this problem? How do you know that these particles are from eolian deposition and not some other process?

2. advection and sedimentation rates: The second issue is the relationship of what enters the top of the ocean and what is deposited in the sediment traps. Previous studies (Bory et al., 2002) have suggested that productivity could modulate the transfer rate between the top of the ocean, and the cores. We know that the dust has to be carried with the current as it floats downward: how far downward? (Han et al., 2008; Siegel and Deuser, 1997) show that it really can be quite far. If it also seasonally being modulated, that would really mess up your signal!

3. deposition rates. What are the deposition rates you are getting? Are they consistent with your assumptions? Are the deposition rates reasonable? Are they the same in the sediment traps as the sediment below? Please describe this a bit more.

More details

"However, grain sizes in the seafloor sediments are substantially finer than found in the sediment-trap samples, and the downwind decrease in grain size is also less steep for the seafloor sediments." What does this mean for interpretation? The more processed the cores, the finer they look? Or that they are being dissolved? Or that they are advected from farther upstream? I find this observation very difficult to understand, and makes me doubt your methodology.

"Since the seafloor sediments represent a longer time average of Saharan dust deposition than the sediment-trap samples, it implies that the downwind fining is a long-lived trend." How long is the time average for the sedments on the seafloor compared to the traps?

"Mahowald et al. (2014) hypothesize that dust in the high atmosphere is finer grained than in the lower atmosphere, which is in turn finer than the deposited dust, due to the preferential settling of coarse particles. However, we observed giant particles ($\geq$100 μm) as far as station M4 (49ËŽ W; approximately 3500 km from African coast) (Fig. 4)." On the surface of it, these two statements have nothing to do with each other, since one is talking about vertical height in the atmosphere and the other is talking

about horizontal distance from Africa. You seem to be implying that they are somehow contradicting each other, but it doesn't seem possible to infer from distance downwind anything about vertical structure tof the atmosphere?.

"The particle-size distribution found in the sediment-trap samples closely resemble Saharan dust sampled directly from the atmosphere, which has modal grain sizes varying between 8 and 42 μm (Stuut et al., 2005)." This is really important, but you don't say where this observation is made? Size is varying along the transect in the atmosphere also. . ... what type of observation is this? What kind of uncertainties are in that method (i.e. look at (Reid et al., 2003))

"By contrast, modal grain sizes in the underlying seafloor sediments range between 4 and 6 μm. Since the seafloor sediments represent a longer time period, this suggests that Saharan dust was significantly finer in the recent past than it is today." And in the conclusions: "Coarser dust found in the sediment traps opposed to the seafloor sediments could result from emission of coarser dust due to the onset of commercial agriculture in the 19th century." This is a huge jump, which seems incredibly unlikely. Most likely there is ocean processing. . ..

"The lower (3500 m) traps show less seasonality and are generally slightly coarser than the upper (1200 m) traps. This may be due to the disaggregation of marine snow, releasing the individual dust particles and thus decreasing their settling velocity. Therefore, it would take longer for particles to reach the lower traps at 3500 m, especially very fine particles, and as a result the particle-size distributions lose their seasonal characteristics. This would also explain why the dust in the lower traps (at M2 and M4) is slightly coarser than their upper counterparts, since these coarse particles settle more quickly, and the very fine particles may not reach the lower traps." This is really important, and should be talked about first: you need to convince us that you can say anything about seasonality in the dust size from sediment trap data, especially with the observed bias between sediment trap and core sizes. So I would start from this and really convince us that any of the signal is actually from the atmosphere first.

“We have shown seasonal and spatial changes in Saharan mineral dust transport and deposition across the Atlantic Ocean by means of sediment-trap sampling between October 2012 and November 2013, and seafloor sediments at the same stations.” So at this point, this statement has not been proven: you have only shown sea floor sediment changes in size. It is interesting that you see these trends, but anything about the atmospheric aerosols is speculation.

Han, Q., Moore, J.K., Zender, C., Measures, C., Hydes, D., 2008. Constraining oceanic dust depostion using surface ocean dissolved Al. Global Biogeochemical Cycles 22, doi:10.1029/2007GB002975. Reid, J.S., Jonson, H., Maring, H., Smirnov, A., Savoie, D., Cliff, S., Reid, E., Livingston, J., Meier, M., Dubovik, O., Tsay, S.-C., 2003. Comparison of size and morphological measurements of dust particles from Africa. Journal of Geophysical Research 108, 8593: doi:1029/2002JD002485. Siegel, D.A., Deuser, W.G., 1997. Trajectories of sinking particles in the Sargasso Sea: modeling of statistical funnels above deep-ocean sediment traps. Deep-Sea Research 44, 1519-1541.

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