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Atmospheric Chemistry and Physics Discussions

# *Interactive comment on* "Observations of Saharan dust microphysical and optical properties from the Eastern Atlantic during NAMMA airborne field campaign" *by* G. Chen et al.

**G. Chen et al.**

gao.chen@nasa.gov

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General comments: My understanding of research is as follows: I have a question which can be solved with scientific means. So I'm looking for instruments or methods and locations to tackle this question. If instruments and/or methods are not available, I'm trying to develop them. If that is too expensive and/or too difficult, the question cannot be tackled this time. It seems to me that the authors follow a quite different approach. They are offered a logistic opportunity (an aircraft and a campaign). They look around in the laboratory; collect a number of instruments and action. The scientific question is raised after the campaign and the suitability of the instruments also is tested



after the campaign (page 13452, line 5).

Sorry, I'm unable to honor such approach.

In addition. The authors have done a great effort to scan the literature. But with one exception (a monograph from 1983) all the reference are mainly from the last decade. There is scientific life before that. Despite such general remarks, a few specific comments are added.

Response: Characterization of the Sahara dust particle properties is a planned activity for NAMMA airborne field campaign. One of the NAMMA scientific questions stated by Zipser et al. (2010) is "What is the characteristic vertical distribution, microphysical and optical properties, and composition of the African dust, and in what specific ways does the dust affect cloud microphysics and cloud dynamics?" This is an important part of NAMMA research to gain an improved understanding of the linkage between AEWs, the SAL, and tropical cyclogenesis. The instrument payload for NAMMA was designed to make state-of-art measurements of the dust particle's optical and microphysical properties as well as compositions, which reflected the NAMMA science needs. Although there are various limitations, the selected instruments have been successfully used in previous airborne field campaigns and tested before and after NAMMA study. This manuscript reports the analysis of the observations we made during NAMMA airborne field campaign. We believe that we have made significant contributions to further our understanding on the Sahara microphysical and optical properties.

We will go through the manuscript to find the appropriate places to insert the earlier references.

Specific comments:

Comment: Page 13448, line 3: This is a very limited view and not very exact. Such numbers are empty, if not specified with an upper size limit for particles enclosed. Also one has to distinguish what has been liberated and what arrives after traversing the

North Atlantic Ocean. Mineral dust (< 20 $\mu$m diameter) is estimated for 2150 Tg/year (IPCC) liberated from the deserts globally. The Saharan desert is about 30% of all deserts. So about 700 Tg/year are leaving the Saharan desert. For a deeper understanding of this subject I recommend "Jaenicke, R. (2007) Is Atmospheric Aerosol and Aerosol? - A Look at Sources and Variability. Faraday Discussions 137,235-243".

Response: We now realize that the sentence referred by the reviewer is less than precise. We did not intend to describe the magnitude of the dust emission but simply state one estimate of the Sahara dust being transported to the North Atlantic region. This estimate is derived from MODIS observations and is most sensitive to mid-visible optically active dust. As the larger dust may not be taken into account, this estimate can be considered as a lower limit. In light of the reviewer's comment, we will modify the text to clarify this point.

Comment: Page 13448, line 7: Fig. 1 could be eliminated. Such Figures have been published much too often.

Response: We respectfully disagree with the reviewer. The Fig 1 shows a large scale picture for the dust outbreak particularly during the NAMMA sampling period. It provides a relevant context for the discussion of dust particle properties.

Comment: Page 13451, line 20: This upper limit is very crucial and makes any conclusion about the Saharan aerosol in general very questionable.

Response: We agree with the reviewer that it is very important to clearly state the upper size cut of the sampling. We will systematically go through the manuscript to make clear that the NAMMA sampling of the Sahara dust is mostly limited to the particles with diameter less than $\sim$4 $\mu$m, which may not be representative of the total dust population.

Comment: Page 13452, line 20: With most of its measuring range above the cut-off of the airplane inlet, the use of such an instrument is questionable.

Response: The use of APS instrument is for sampling of the supermicron particles.



As stated in the manuscript, the supermicron particles have the largest contribution to both particle loading and optical properties (i.e., scattering and absorption).

Comment: Page 13452, line 25: A Figure is needed showing the size range of the used instruments and their collection efficiency together with the efficiency and cut-off sizes of the airplane inlet.

Response: This issue is too complicated to be described by one figure. The detailed discussion is provided by the cited reference, McNaughton et al. (2007), regarding the determination of the size cut.

Comment: Page 13454, line 11: Where in the duct have the particles for electron microscopy been collected? Are particle investigated smaller than 4 $\mu$m only?

Response: Electron microscope samples were collected through a counterflow virtual impactor with the counterflow turned off. This is now added to Table 1. The subisokinetic nature of the CVI means higher collection efficiencies for larger particles, and particles as large as 5.3 microns physical diameter were analyzed (see revised Table 1, which now includes particle size information).However, since only 100 particles were analyzed per sample and the impactor minimum size cut was about 0.1 microns, most of the particles analyzed were much smaller.

Comment: Page 13454, line 14: Table 1 is trivial: Saharan dust particles in the Saharan layer and sea salt particles in the boundary layer!

Response: We respectively disagree with the reviewer. Table 1 shows that both dust particles and sea-salt co-exist in the marine boundary layer. The MBL dust population was shown to be major particle component in the number fraction, i.e. 33% which was just below that for sea-salt at 40%. In addition, there was significant presence of mixed particles, i.e., dust mixed with sulfate, chloride, or salts.

Comment: Page 13455, line 17: These are number concentration densities rather than number concentration, see Fig. 5.

Response: We agree with the reviewer. Correction will be made.

Comment: Page 13455, line 23: Are these dry particles? Number densities are reported to ambient pressure and temperature. Then also ambient humidity is expected. With ambient humidity the density value should be closer to 1 gcm-3.

Response: Yes, the dust particle sampling was mostly under dry ambient conditions as indicated in the Table 2. In addition, the sampled particles are further dried within the inlet at relative humidity less than 40%

Comment: Page 13455, line 26: In view of the many uncertain circumstances, the thoughts about the shape factor are more or less useless. If water is attached to the particles, the shape factor is getting closer to one anyhow. I recommend "Yang, J. et al (1999) The Condensational Growth of Aerosol Particle and Its Effect in Aerosol Measurements. J. Aerosol Sci. 30, S69-S70" for reading.

Response: We do not believe this is the case. Table 2 shows that the SAL is very dry.

Comment: Page 13456, line 16: My remarks for the shape factor also are valid for the index of refraction.

Response: Again, we respectively disagree with reviewer for the same reason stated above; the SAL is very dry.

Comment: Page 13460, line 11: Such critical conclusions are to be praised, but should have influenced the planning of the instrument selection.

Response: We would like to state we consider many factors before the instrument selection. The selection of UHSAS is primarily based on the need of submicron particle size measurement and the instrument performance.

Comment: Page 13462, line 7: The term "NAMMA dust layer" is not very exact. It is not caused by NAMMA hopefully. Why don't you term it "Saharan dust layer"?

Response: We will clarify this text and use the term “NAMMA sampled dust layer”.



Comment: Page 13462, line 9: See my earlier remarks about the influence of the humidity on the measurements of size distributions and the assumptions about the density and refractive index.

Response: As the SAL is very dry, we do not believe humidity had much impact on either size or refractive index.

Comment: Page 13462, line 19: Better term it N .01-4 $\mu$m (indicating the size range).

Response: We agree with the reviewer. Correction will be made.

Comment: Page 13462, line 26: Between 200 and 300 $^{\circ}$C cellulose is burning. Do you assume that cellulose is a volatile compound? See also "Eglinton, T.I. et al (2002): Composition, age, and provenance of organic matter in NW African dust over the Atlantic Ocean. GEOCHEMISTRY GEOPHYSICS GEOSYSTEMS 3, 1050".

Response: The terms of “volatile” and “non-volatile” are functional definitions widely used in the aerosol measurement community to describe the unheated and heated particle concentration measurements, respectively. The non-volatile measurement was to provide a measure of the refractory particles such as soot, dust and sea salt by evaporating the volatile aerosol components (i.e., organics, nitrates, sulfate, etc.) at a given temperature. In the case of NAMMA, this measurement can be used as a crude way to identify dust particles in the free troposphere. This reflects the fact that the observation of the low CO levels suggests minimum soot impact on the non-volatile particle counts.

Comment: Page 13463, line 15: Table 4 reaches from 0.6 to 6 $\mu$m while Fig 5 reaches from 0.06 to 5 (or 4 taking the inlet into account) $\mu$m. Why that?

Response: We thank the reviewer pointed out the inconsistency. Corrections will be made to show the size range between 0.06 to 6 $\mu$m.

Comment: Page 13465, line 21: The size distribution definitely is changing. See "Schütz, L. (1979) Sahara Dust Transport Over the North Atlantic - Model Calculations and Measurements. SCOPE 14: Sahara Dust: Mobilization, Transport, Deposition. 267-277". If you have a different opinion, prove that the Schütz data are wrong.

Response: We believe that there may not be a dramatic conflict between our recent work and that by Schütz L. (1979). We would like to first point out the key difference in the size range of the measurements. Schütz L. (1979) showed ground-based measurement up 100 $\mu$m while the NAMMA inlet limited the sampling up to $\sim$4 $\mu$m. It is quite likely that the size distribution does undergo large changes along the transport process due to the loss of the large particles (especially when comparing measurements directly at the source). The relative constant Reff has been observed from several past airborne campaigns as well as satellite remote sensing measurements. However, we do not believe any of these observations are sensitive to particles larger than 10 $\mu$m. To reflect the reviewer's point, we will modify the text and qualify our conclusion by indicating the range of the size measurement.

Comment: Page 13469, line 25: Make up your mind and present size distributions whether linear or logarithmic on the y-axis.

Response: The scale is chosen to best show the difference between size distributions.

Comment: Page 13472, line 19: If the size distribution remains rather unchanged during transport, then please explain the deep sea sediments across the Atlantic Ocean in this region.

Response: We would like to clarify the notion of the relative constant size distribution: 1) several independent observations have been consistently supporting this; 2) the relative constant size distribution may be biased due to the observable size ranges in the inlet; and 3) even though the size distribution has small changes, the actual dust loading does decrease as being transported eastward. This may suggest that the deposition may not have weaker size dependence for the part of size range observed during NAMMA.

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Interactive comment on Atmos. Chem. Phys. Discuss., 10, 13445, 2010.