Atmos. Chem. Phys. Discuss., 10, C7963–C7970, 2010
www.atmos-chem-phys-discuss.net/10/C7963/2010/

Atmospheric Chemistry and Physics Discussions

ACPD

10, C7963–C7970, 2010

Interactive Comment

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

Received and published: 24 September 2010

Comment: The paper reports on aerosol size distribution, volatility, scattering and absorption measurements on board of an aircraft during the NAMMA campaign in 2006. Additionally, some results of electron microscopy are discussed. New data material is presented. The publication is appropriate in formal terms, and it addresses a relevant subject. Literature is referenced well. However, the described experiment has the same problem as, e. g., the SHADE campaign: the aircraft inlet, which prohibits large particles from being measured, though we know that they are present. While this should surely not hinder publication, they drawbacks should be clearly addressed in

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

this work and they authors should refrain from claiming representativity of the findings for the "complete" Saharan dust.

Response: We agree with the reviewer. All major conclusions will be qualified by indicating the incomplete sampling of the Sahara dust due to lower inlet collection efficiency for particles larger than 5 μm in aerodynamic diameter. The “4 μm” cited in the manuscript was incorrect; it should be 5 μm for the sampling inlet size cut. Reid et al. (2008) indicated that sampling large particles from fast moving airborne platform is inherently difficult. The size cut (i.e., 50% collection efficiency size) for the NAMMA sampling inlet was methodically characterized during a dedicated airborne experiment, DICE (DC-8 Inlet/Instrument Characterization Experiment). Because the difficulties in sampling the larger particles, we will state the estimated SSA value should be treated as an upper limit value. Similarly, the imaginary part of the refractive index is a lower limit estimate. As for the size distribution, it contains majority of particle population in number which is useful for studies of the dust impact on cloud microphysics.

Detailed comments

Comment: page 13451/lines 15-22: Unfortunately it is not mentioned by the authors, which of the inlets (UH, UNH, LaRC) described in the referenced work (McNaughton et al. 2007) was used. Judging from the state 50% transmission diameter of 4 μm, it has to be assumed that they used the UNH inlet. However, they authors do not explain that the given diameter is aerodynamic diameter and translates to about 2.5 μm geometric diameter for mineral dust (according to the referenced McNaughton et al. 2007). The argumentation below regarding the particle size in terms of optical properties should rather be done referencing the approximated geometrical particle size.

Response: The so called “UH” sampling inlet was installed on the NASA DC-8 aircraft platform during NAMMA field campaign. This sampling inlet was designed by the University of Hawaii and manufactured at NASA Langley Research Center. The actual 50 transmission aerodynamic diameter should 5 μm not 4 μm cited in the manuscript. We will correct this mistake. The cited 5 μm aerodynamic size cut is equivalent to ~4 μm for Sahara dust in geometric diameter with assumed density of 2.6 g cm-3 and shape factor of 1.6.

Comment: 13452/5-7: Does this mean the heating tube was unevenly heated? Or what gradient was present in the tube to account for 30 % of thermophoretic losses?

Response: The tube was evenly heated, but there were large temperature gradients on both ends. This is not really a problem on the upstream end as the cold particles tend to be focused along the center of flow as they encounter the hot walls of the heated tube. However, as the now heated particles exit the heated tube and flow through a section of unheated stainless steel tubing, they tend to migrate to the cold walls where many (30%) are lost through the "thermophoretic" deposition process. Several investigators have reduced the thermophoretic loses by gradually cooling the flow as it exits from the heating tube, but since we primarily use the "hot"/"cold" CN ratio as a qualitative indicator of aerosol volatility and given that space and power budgets are limited aboard the aircraft, we have not implemented the more complex sample heating and cooling techniques. We would like to note that the size distribution and optical property measurements were made upstream of the thermal denuder and were not affected by the thermophoretic loss.

Comment: 13452/27: It doesn't make any sense here to speak of 0.7 - 20 μm integrated diameter, if the inlet has a 50% cut-off at 4 μm aerodynamic diameter.

Response: The text will be modified to reflect the reviewer's comments. We believe this change should be made in page 13453 and line 27, instead of 13452/27.

Comment: 13454/11-14: More information on the type of analysis performed (type of electron microscopy, used parameters and substrate, and, especially, the number and size of measured particles) would help the reader to understand a potential significance of the results. Which type of soluble material was found to be mixed with mineral dust (and, with which type of dust? Silicates, carbonates, . . .?)

Response: We agree with the reviewer that more information on the electron microscopy would be useful. In section 2.2, we will add the type of microscopy and analysis (TEM and energy dispersive X-ray spectrometry), as well as typical composition of the dust particles, which were primarily aluminosilicate based sometimes mixed with salts or sulfate. In Table 1, we will add four new columns for the number of particles analyzed per sample, and the median, mean, and range of sizes analyzed. In the footnotes, we will describe the TEM instrument and substrate used.

Comment: 13456/24-25: This is true for most of the mineral dusts. However, iron oxide in mineral dust is not necessary present as pure iron oxide particles, though than can occur. In contrast, it often is incorporated into or on the surface of the said silicates as small grains (Kandler et al., 2009; Lafon et al., 2006; Ro et al., 2005). Thus, from a dominant presence of silicates it is not possible to conclude on the iron oxide content (and the refractive index, subsequently). In addition, the authors state the presence of clays – how were they discriminated from other silicates?

Response: The clays were distinguished by the prevalence of iron, potassium, calcium and magnesium as well as silicon and aluminum. The dust particles were fairly homogeneous in composition, nearly all containing some iron. However, we agree with the reviewer that because our analysis did not discriminate between iron inherent in the dust structure and iron present as grains on the surface, we cannot positively determine effects on the absorption coefficient. Thus, we will remove the offending sentence from this section.

Comment: 13456++: "Closure": A closure is performed, when there several ways of determining a variable with according uncertainties, and if they agree on a chosen level of significance, closure is achieved. While this is the case in principle in this work, though – given the large uncertainties in SCF and refractive index, where the authors have chosen a "most suitable" SCF of 1.27 and n_i of 0.0022 – the representativity of an achieved closure can be doubted.

ACPD
10, C7963–C7970, 2010

Response: We agree with the reviewer that the use of the word “Closure” is somewhat less than accurate, especially in the case of absorption. The reviewer is correct to indicate that ni is derived from the absorption comparison between the direct observation and Mie-Theory calculation. Appropriate changes will be made to the text from page 13455 to 13460.

Comment: 13461/19-25: The authors state that the variability for size distribution and scattering measurements is linked, but that there are systematic differences in the values. Despite that, they conclude that the characterization of the dust properties is accurate. That seems to be illogic.

Response: The paragraph referenced by the reviewer is in context of that the high R2 values are found between the direct observed scattering (absorption) coefficient with that from the Mie-Theory calculation based on the observed dust particle size distribution. This suggests the high level of covariance between the size distribution measurements and the optical property measurements. As the reviewer pointed out, there is a significant systematic difference revealed in the scattering closure test. We believe, however, that this difference is relative small in magnitude, i.e., 25%. Therefore, the text in the manuscript stated “... NAMMA observations can provide a consistent and reasonably accurate characterization of the optical and microphysical properties...” We will have discussion to modify the text in light of this reviewer’s comments.

Comment: 13462/28-29: Concluding from a non-volatile-fraction of 70 % and a "potential" (unknown?) particle loss of 30 % in the heating tube to the presence of well over 90 % non-volatile particles is quite speculative, though the stated value is not unreasonable for mineral dust. However, these values should then be rather addressed as a tendency.

Response: The text was supposed to state that non-volatile-fraction can potentially be much higher than the estimated value of 70%. Like the reviewer suggested here, we intended to address the “well over 90%” as a tendency. We will modify the text to clarify

ACPD

10, C7963–C7970, 2010

this point.

Comment: 13463/2: Is the potential particle loss of 30 % included in the value 45 % $\pm$ 26 %?

Response: No, it is not included.

Comment: 13463/24-26: As we know from other measurements (McConnell et al., 2008; Weinzierl et al., 2009) and many ground-based measurements, there are significant amounts of large particles with d > 5 μm in Saharan dust. Given the lack of large particles in the size distributions shown here and the knowledge about the inlet transmission, it is not justified to claim representativity with respect to Saharan dust for the size distributions shown in this work. Maybe they can be addressed as being representative for PM_2.5.

Response: In the text referenced by the reviewer, an assumption was stated in the manuscript: "provided the impact of the 4 μm sampling inlet size cut is limited". Thus, we believe we are actually in agreement with the reviewer. We (among the co-authors) will explore ways to better qualify the statement.

Comment: 13464/14: There is no evidence given that the submicron particles influencing the size distribution can be addressed as "dust". Given a size range starting at 0.3 μm, there is probably ammonium sulfate present, also anthropogenic material can occur. If there is more information existing (i.e. electron microscopy as mentioned above), it should be presented.

Response: We would like to clarify this issue. In page 13454 line 11 to 13, it is stated that "Electron microscopy of collected particles larger than 0.1 μm showed that the predominant particle types in the SAL were Saharan dust, while in the marine boundary layer, both seasalt and primary dust, as well as dust mixed with soluble material, were present (Table 1)." We will consider restate this finding in page 13464.

Comment: 13464/24-27: With the steep decrease in inlet transmission, of course the

ACPD

10, C7963–C7970, 2010

VMD is limited to smaller values. And so is its representativity for the aerosol outside the aircraft.

Response: We agree with the reviewer. Text will be appropriately adjusted in the description of background particles to reflect the reviewer's comments.

Comment: 13465/8: Given uncertainties of 35% and 25%, values in a broad range can be declared as agreement. The level of confidence for this agreement being representative is low, conclusions based thereon should be avoided. However, the data scatter shown in Fig. 6 seems to exhibit closer connection than the uncertainties may imply.

Response: We respectfully disagree with the reviewer's notion that the relatively large uncertainties would decrease the confidence level for the comparison between NAMMA in-situ and MODIS observations. We do recognize that the large uncertainty (a combination of random and systematic uncertainties) may lead to large scatter, bias, or a combination of both. In this case, as the reviewer noted, Fig 6 shows a tight grouping near the 1:1 line and the scatter of the points is well within the specified uncertainties. The average ratio of 1.15 ± 0.15 quoted in the manuscript represents the central tendency of the comparison, which suggests NAMMA and MODIS Reff observations were generally consistent within 15%. Fig 6 also shows that the range of variation in Reff is limited for both NAMMA and MODIS while the MODIS AOD values has much larger variation. The Reff appears to be insensitive to the value of MODIS AOD, which can be viewed as an indicator of column dust loading. The MODIS Reff is a column average which may involve complicated vertical dust layer structures as showed by NAMMA observations. By contrast, the NAMMA Reff is derived from the observations for one of the dust layers within the column. Therefore, we believe that MODIS and NAMMA in-situ comparison provides another indication of the relative constant Reff value over a wide range of Sahara dust layer in terms of altitude and the loading of the dust layers.

Comment: 13465/18-21: Again, the inlet is limiting the variability of the VMD, and thus, the VMD inside the aircraft is not a good measure the represent and draw conclusions

ACPD

10, C7963–C7970, 2010

Interactive Comment

for the SAL, although the reasons given for a slowly changing size distribution are plausible.

Response: To reflect the reviewer's comments, we will add text to state the VMD invariability is observed for dust particle size smaller than ~4 μm.

Comment: 13470/19-20: Size distribution uniformity in terms of PM_2.5!

Response: We generally agree with reviewer and text will be added to emphasize the size range of the NAMMA observations.

Comment: 13482: The definition "U=eastward/westward wind speed component" is somewhat misleading, positive values (a positive eastward/westward wind) would mean an easterly wind, but it looks like negative values means easterlies – this should be rephrased.

Response: Changes will be made according to the reviewer's suggestion. "U=east/west wind speed component, positive east" and "V=north/south wind speed component, positive North"

Comment: 13489/Fig 5 caption: Please mention the type of particle diameter for this graph in the caption.

Response: Change will be made according to the reviewer's suggestion. The particle size is given in geometric diameter in Fig 5.

Reid, J. S., Reid, E. A., Walker, A., Piketh, S., Cliff, S., Al Mandoos, A., Tsay, S. C., and Eck, T. F.: Dynamics of southwest asian dust particle size characteristics with implications for global dust research, Journal of Geophysical Research-Atmospheres, 113, D14212 10.1029/2007jd009752, 2008.

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