Atmos. Chem. Phys. Discuss., 11, C11674–C11680, 2011
www.atmos-chem-phys-discuss.net/11/C11674/2011/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Complex refractive indices of Saharan dust samples at visible and near UV wavelengths: a laboratory study" *by* R. Wagner et al.

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Received and published: 9 November 2011

We thank Referee #1 for his critical comments to improve the quality of the paper in particular with respect to its structure and way of presentation. Below, we address the individual comments and outline our suggested changes of the manuscript organization.

COMMENT:

1. Introduction: The description of work performed in particular during the SAMUM studies is too detailed and should be shortened significantly. Interested readers may refer to the original papers instead. The entire paragraph from page 21366/line 24 to

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page 21367line 16 should be moved to Section 2 and should be checked for duplication.

ANSWER:

We consider the reference to the SAMUM project as an important part of our introduction because we have partly applied the same techniques (SOAP absorption measurements, electron microscopic single particle analysis, mixing rule approach) in our work and have also employed three soil samples from the SAMUM-1 source region. We will add a statement of this aspect to the introductory section so that the link to SAMUM immediately becomes obvious. Detailed and partly duplicate information, however, will be removed from the manuscript text in the revised version (e.g., two experiments in different regions which is later discussed in Sect. 5.2, too detailed methodical information). As suggested by the referee, the paragraph from page 21366/line 24 to 21367/line 16 will be removed from the introduction and its information will be presented in the re-arranged Sect. 2.

COMMENT:

2. Experimental: The description of aerosol generation and optical methods is too lengthy and requires a clearer presentation. If the authors want to stick to the detailed presentation, part of the material should be moved to an appendix. Otherwise the reader is unable to catch the structure of the conducted experiments.

ANSWER:

We propose the following re-arrangement of Sect. 2 to enhance its readability. We will insert a new sub-section 2.1 entitled “General procedure” which outlines the basic structure of the conducted experiments – partly containing information from the paragraph removed from Sect. 1 – so that the reader immediately becomes familiar with the general set-up. Furthermore, we will split the information from the rather long old Sect. 2.1 into two new sub-sections entitled 2.2 “Aerosol Generation” and 2.3 “Size

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Distribution Measurements". The old Sect. 2.2 will be moved to the new Sect. 2.4 "Optical measurements". The old Sect. 2.3 will be completely removed and its information shifted to the re-arranged Sect. 3 (see below).

In our opinion, it is not possible to significantly shorten the information contained in Sect. 2 (except from a few instrumental details, e.g. LOPES description, page 21371, which indeed could be removed) because we have already frequently referred to former publications in our text (Linke et al., 2006; Schnaiter et al. 2005; Müller et al., 2011; etc). The re-arrangement of the text should help to better catch the presented information. Aspects which are discussed in greater detail in Sect. 2 (impaction stages of the cyclone system and size range of the dust particles, combination of the SMPS and APS measurements and its uncertainty regarding the appropriate choice of the shape factor, uncertainty level of SOAP absorption measurements due to cross-sensitivity to scattering) are essential for the later discussion and should not be transferred to an appendix.

COMMENT:

3. Desert Dust Samples: In this section method description, presentation of results and discussion is mixed. It is highly recommended to divide this section into clearly identifiable subsections on methods, results and discussion.

ANSWER:

Following the referee's suggestion, we will insert a new sub-section 3.2 entitled "Bulk and single particle analysis of chemistry and mineralogy" where the information on the applied techniques are gathered, including the text on page 21374, line 11 – 14; 21375/4 to 21375/22; 21376/11 to 21376/16; and the information from the former subsection 2.3. Duplicates will be removed from the text, e.g. page 21378, line 11. An additional remark will be introduced to clarify the application of the techniques: "XRF and XRD have been applied to the soil samples, electron microscopy was performed on the suspended dust samples." The new Sect. 3.3 will be entitled "Results and

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Discussion" with two sub-chapters 3.3.1 and 3.3.2 which are used to separate bulk and single particle results and their related discussion. Given the huge amount of data to be presented and discussed (including three tables (2-4) and four figures (3-6)), we strongly propose to avoid a further, formal splitting into a "Results" and a "Discussion" chapter because – in our opinion – the reader is better guided through the text when the various results are presented and discussed in a stepwise manner.

COMMENT:

4. Inversion scheme: As in the Experimental Section, details of the applied methods may be shifted to an appendix. This section is by far too long and important information is getting lost. The authors may focus on the important pieces of information they want the reader to catch.

ANSWER:

As suggested by the referee, we will greatly condense the information from Chapter 4 in the revised manuscript text and transfer supplementary material to an appendix. From Sect. 4.1, we will only keep the first paragraph (21379/20 to 21380/10) in the main text. The following computational details will be moved to an appendix. Sect. 4.2 contains necessary information for understanding the shape dependency of the retrieval results outlined in Sect. 4.4. We will, however, also move this section to an appendix and refer to these findings only when they are needed in Sect. 4.4. The major part of our old Sect. 4.3 can be removed for the revised manuscript version because we have only tested but not relied on this approach. We propose to add a short new Sect. 4.2 to our revised text entitled "Retrieval approach: Basic considerations" where we briefly describe the test of our initial approach and that detailed information can be found in ACPD manuscript. This new Sect. 4.2 would then also contain the motivation for our modified retrieval approach (prescribing the value for the real part of the complex refractive index), adopted from 21387/23 to 21388/22 of the ACPD manuscript text. Our new Sect. 4.3 will then contain the outline of our actual retrieval approach and will

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directly start with the description of the retrieval scheme shown in Fig. 10.

COMMENT:

5. Results and Discussion: The authors may think about focusing on discussion only because part of the results is already presented earlier. They should also check for duplication between Section 5 and Section 6.

ANSWER:

Section 5.1 contains for the first time the actual retrieval results for the spectra of the imaginary part of the complex refractive index based on the methodology presented in the new Sect. 4.3. Sect. 4.3 is only a method description including a proof of concept and an estimate of the errors. So, none of the results shown in Sect. 5.1 are given before. We could emphasize this by re-naming Sect. 5 “Retrieval results and discussion”.

Sect. 6 is intended as a summary and, as such, necessarily contains some of the information presented before, not only from Sect. 5 but also key findings from the dust particle characterization (Sect. 3) and the retrieval methodology (Sect. 4). It is a personal aspect whether a Summary section besides the abstract is considered to be necessary. We consider a short summary as appropriate.

COMMENT:

6. Figures: The figure captions of Figs. 7-9 are far too detailed. The authors should shift part of the caption to the text and check for duplication. Figure 9 should be revised because axis labels and data point labels are hardly readable.

ANSWER:

As outlined above, Figs. 7 and 8 will be moved to an appendix and their figure captions will be condensed as suggested by the referee. Fig. 9 will be removed from the final manuscript version.

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COMMENT:

7. In Fig. 14 the authors present an intercomparison between two applied methods for measuring absorption. As is stated correctly, both methods (filter-based Spectral Optical Absorption Spectrometer SOAP and 4-wavelength Photoacoustic Spectrometer) show similar trends in the wavelength dependence of the absorption coefficient. However, the authors do not present a quantitative analysis of the absorption coefficient measurements by both methods. Since the absorption coefficient is the key reference parameter for the applied inversion scheme for the complex refractive index retrieval, at least some kind of quality assurance of the absorption coefficient measurement is highly recommended. One potential way could be a comparison of absorption, scattering and extinction in case an integrating nephelometer was also used in this study. If no integrating nephelometer data is available the authors may repeat at least one retrieval of the complex refractive index also for 4-wavelength photoacoustic data in order to check the uncertainty in the retrieved results caused by uncertainties in the input data on aerosol absorption.

ANSWER:

The error estimate of our retrieved k data sets is indeed a crucial aspect in our work. The large error bars for the SOAP retrievals (Fig. 14) reflect the weakness of any filter-based absorption measurement, namely a residual cross sensitivity to aerosol scattering. Even if this cross-sensitivity is small and a good measurement of the scattering coefficient is available, it cannot be completely corrected because it is an inherent problem of the method. This error is particularly pronounced for aerosols with a single scattering albedo above 0.95, i.e., for the spectral range above 600 nm in the case of mineral dust. The good reproducibility of the SOAP retrievals shown in Fig. 13 therefore reflects the good precision of the instrument but tells nothing about its accuracy. Unfortunately, using closure between scattering and extinction, as suggested by the referee, would also not help because we have a similar inherent problem in this difference method in the case of weakly absorbing aerosols.

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We therefore completely agree to extend the inter-comparison between the SOAP and the photoacoustic data in the revised manuscript text although the novel 4-wavelengths photoacoustic spectrometer has been employed for the first time to measure dust absorption and its estimated uncertainty levels at the different wavelengths (Fig. 14) were derived from former inter-comparison measurements with the difference method for strongly absorbing soot aerosols (Ajtai et al., 2010).

The comparison with the photoacoustic data shown in Fig. 14 already highlights one important finding, namely that the varying background absorption level of the dust probes above 600 nm is indeed a real physical effect because the variation in the absorption coefficients of the two dust probes is much larger than the estimated uncertainty level of the photoacoustic data.

As suggested, we will repeat at least two retrievals of the imaginary complex refractive indices also for the photoacoustic data and will add these data, together with their error estimates, to Figs. 13/15. These data will also corroborate that the variability of the magnitude of the k values for the different dust probes towards UV wavelengths depends on their iron oxide content because it is much larger than the uncertainty level of – in particular – the photoacoustic data, being the second major conclusion from this manuscript. The difference between the SOAP and photoacoustic k retrievals will then also be a more realistic estimate of the uncertainty of the retrieval results than the standard errors currently denoted in Table 5 and shown in Fig. 13 as error bars. This aspect will be discussed and corrected in the revised manuscript text.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 21363, 2011.