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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Variability of the infrared complex refractive index of African mineral dust: experimental estimation and implications for radiative transfer and satellite remote sensing" *by* C. Di Biagio et al.

Anonymous Referee #2

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This paper is describing an experimental method to estimate the dust infrared refractive index from five samples collected during the AMMA campaign at Banizoumbou (Niger) and Tamanrasset (Algeria). Along with transmission measurements, size distribution and complete mineralogical measurements were performed. The results were then compared to previous studies and highlight a relatively good agreement.

The introduction is well written but the following sections need to be restructured. Indeed the manuscript is long and probably too long. As the introduction stated it, you

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should use your collected data to retrieve the refractive indexes (RI) and compare it to the databases to highlight discrepancies. However, the last parts (Implications for satellite remote sensing, Implications for dust radiative forcing) are superficial and do not add anything to the paper. Indeed, this manuscript is long (more than 30 pages) and probably needs to be shortened.

The paper needs major revisions before submission to ACP.

General comments:

First the authors need to proof read the paper. There are several careless mistakes that need to be corrected within the paper as well as some grammatically incorrect sentences. I highlighted some but there are more that I probably missed.

From my knowledge, this technique is used since the 70s. What are the benefits of your technique compare to earlier studies? Please add descriptions of how the earlier studies retrieved the RI, otherwise the readers can't understand (i) The benefits of your study and (ii) where the differences highlighted in figure 7 are coming from. Moreover, what are the main limitations of this technique? To create your pellet you have to modify the dust properties such as the size (random selection of dust from the sample) and probably the chemical composition during the storage in an oven (100°C). How could you be sure that the size distribution within the pellet is the same than the one on the filter and thus the same than measured by the OPC? If there is any difference how would it change your results? Could you do a sensitivity study to estimate the errors? I would like to see a discussion on those issues in the paper.

It has been proven (Schuster et al., 2013 and several others) that the refractive index of dust particle in the visible depends on the mineralogical composition of dust. To calculate dust refractive indexes you are using the same assumption (n=1.53) for each sample on the refractive index of those dusts in the visible (i) to resolve the equation 5 and (ii) to correct the dust size distributions. You need then to explain the impact of this assumption on your results? Is there any modification of the dust RI in the visible

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as a function of the type/mineralogical composition of dust particles?

You state that in average 94 and 98% of the particles in number concentration satisfy the a/lambda < 0.1. Could you estimate the errors due to large particles made on your calculations?

Finally, Dubovik et al. (2006) described a new code for spheroids that would be much more suitable than Mie code to retrieve optical properties for dust. Have you tried it?

Specific comments :

P10598, L18-20 Need to rephrase 'We also found that the real and the imaginary parts of the refractive index from part of literature studies do not verify Kramers–Kronig relations, thus resulting theoretically incorrect.'

P10598, L20-24 : You should split this sentence.

P10600, L 26 : You have to be more specific cause some optical properties may be measured in the IR like the absorption, extinction and scattering coefficients. . .

P10601, L26 : the composition of dust may BE additionally modifIED due to the. . .

P10602, L4-21 : This paragraph is really confusing. First, you describe your set up and your methodology and then you said that methods that have been used are far from perfect. Maybe here you should start with the limitations from previous studies and then highlight the improvements in your method and therefore state that the 'natural variability of the dust infrared refractive index remains not represented'.

P10602, L 22-28 : You need to integrate that paragraph in the previous one.

P10603, L 9-10 : Need to rephrase that sentence : 'of dust at most after 1–2 days of their atmospheric transport.'

P10604, L 1 : Wintertime 'corresponding to the' dry season

P10604, L5-9 : Long sentence. . . You need to rephrase it in order to facilitate the

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reader's understanding. 'The SOP0–47 case sampled during the dry season occurred on February 9th 2006. This event was associated to a medium-range transport event originated from the Central-Western part of Niger, between the Algeria-Niger and the Mali-Niger frontier regions.' Have you looked to the satellite measurements to make sure the desert areas close to the Air massif were included in the source area ?

P10604 : UTC is usually the most common unit for time. You should consider replacing UT by UTC.

P10604, L18-22 : 'SOP1–17 was instead a post-erosion event characterized by the advection of dust which was locally emitted at Banizoumbou _ 3 h before the sampling started.' So it's a local event ? How long the dust erosion event over Banizoumbou last for?

P 10605, L 2-6 : Need to rephrase this sentence.

P 10605, L18-26 : It seems like this very general paragraph has been added after the others and do not belong here. Also part of it has been already said in the introduction. And :'among the largest sources for dust'.

P10606, L3-5 : Which criteria did you use to collect dust ? The total concentration had to be larger than a threshold or the concentration of particles larger than a fixed diameter was larger than another threshold? Could you be more specific?

P 10606, L 15 : the wavelength range 2.5–25 μm (400–4000 cm$-$1). You need to add sigma in the parenthesis.

P1060, L23 : 'a delicate operation' . Yes it is, so could you estimate the errors due to an incomplete transfer rom the filter to the pellet ?

Section 3.1 : You shortly described the pellet technique earlier (P10602) Where it was probably not adapted.

P10607, L3 : Left not leaved.

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P10607, L 17 : 'Passing the samples in the oven does not modify the dust mineralogical composition, as at these temperatures the only effect is water evaporation'. Could it remove the volatile components that may be present on dust's surfaces? Could it rearrange the mineralogical structure of dust ? This is an important hypothesis and I believe that it deserves at least one reference.

P10607, L 22 : Does the 10 tons (AND this is not a pressure ! this is a weight.) change the size, the morphology or the mineralogical structure of the dust particles ? If yes what are the consequences for your study if not this statement deserves also a reference.

P10607 L23-24: Then all the pellets are put in the oven at 100 _C until they are used for transmission spectroscopy measurements. How long could that period last for ? So what are the consequences for dust particles (see comment just above) ?

P10608, L25: You need a reference for the dust density. Is it the same density you used to plot the volume size distributions of dust particles (Fig 1b)? Besides, you used the same density for each type of dust? Could you at least note it within the manuscript, estimates the errors (compare to the dust smallest and largest density ever measured?) and refer to previous studies.

P10609, L 2 : Dust particles are known to be a particle that scattering the solar light more than absorbing in the visible range. So you need to be specified the wavelength range you are talking about.

P10609, L 8 : 'Following Mie Theory for Rayleigh spherical particles'

P10610, L11-13 : This sentence is not clear and I don't have a clue on what you are doing with these iterative non linear fitting.

P10611, L9 : This discussion should occur earlier in the manuscript. What would be the influence of the shape of the aerosol? Could you evaluate the associated errors? The code to take into account the non-sphericity already exists and was developed

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by a French team. Did you ever contact them to run the scheme for you? Another hypothesis is that the real part of the dust refractive index has been set to 1.53. Do you think that this number is valid for all type of dust from all the sources in the world or even in West-Africa?

P10613, L 7: If I understood well you corrected the measured size distributions with a mean refractive index given in the literature to retrieve the refractive index of sampled dust. Could you evaluate the errors that this hypothesis could cause to your retrievals?

P10613, L11-12 : 'Whereas (remove for) Tamanrasset measurements '

P10613, L18 : You are using a 5 mode fit. Is it usual ?

P10613, L20 : You meant that the left side of the tail is not well defined. You should clarify that point.

P10614 L12-13 : Does the clays partitioning differences may change the real part of refractive index ?

P10614, L 21-22 : 'SOP1–8, emitted in correspondence of a strong Sahelian local erosion event' What does that mean ?

P10614, L21-22 : Studies using lidar measurements have shown strong differences in dust optical properties according to dust sources. You also found that the mineralogical composition is changing a lot. Why would you think that the real part of the refractive index would be the same?

P10619, L5: The errors associated with the real part of the refractive index are extremely low compare to the imaginary part. How could those errors be that low knowing the pellet technique limitations?

P106021 : For the comparison of your results with the literature, it would be valuable to add the error bars associated with your results as well as the error bars from previous studies if given.

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P10622, L 27 : They result incorrect ??? As I said earlier the paper need to be proof read to remove all the grammatically incorrect sentence.

P10624, L 11-13 : Why is that surprising? Size does matter for the refractive index calculations. Could you introduce the main goal of this paragraph ?

P10624, L 18 : 'Due to dominant mode of particle at 5um in its size distribution' That is not properly said.... Due to the presence of a particle mode centered on 5um' or something else but you can't leave it like this.

P10624, L 27 : Replace 'in situ' by 'in-situ' and 'particles size distribution' by 'particle size distributions'.

Again I don't think that the next sections should appear in this manuscript. It's really interesting but need more work and deserve a paper by itself.

P10626, L 3-6 : What is your solution on a global scale ?

P10626, L 18-20 'For example, the integrated area of kext over the 11 and 12 μm MODIS bands is 0.089 and 0.087 for OPAC, compared to 0.123 and 0.110 for the estimated maxima values of kext at the bands, and 0.067 and 0.054 for the corresponding kext maxima' I'm not sure what you are talking about? The first numbers are coming from OPAC that is what you said and then where all thoses following numbers are coming from ? Estimated from which calculations ?

Fig. 1 : SOP1-8 shows a mode at $\sim$20um similarly to N92 and N32. Then, it is hard to believe that the size distribution is playing a major role between these samples. These samples may be the worst to work with according to the a/lambda conditions. Could you comment on that ?

Figure 7 : 'The real and the imaginary parts of the Longtin et al. (1988) refractive index are plotted against the right side y-axis for both plots. ' Do you mean that the Longtin RI axis are located on the right side while all the other studies are associated to the left side ? If yes it needs to be rephrased and probably to appear later in the caption. Also

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in the caption you refered to curve 4. What are they ?

Figure 8a : I still don't see the point of that figure. Of course the size distribution is playing a major role in the RI calculations. Using the same aerosol size distribution for all the samples is gonna smooth all your rg, w, kext calculations.

Figure 9. : This figure deserves its own legend. The readers don't have to go to Figure 8 (and not Figure 9 as you wrote in the caption) to know what colors correspond to what sample . . ..

Appendix A : Again, about the AOD/PM relationship, in your case the aerosol mass is a linear function of the AOD due to homogeneous aerosol vertical distribution. Unfortunately, the aerosol hygroscopicity could impact the relation between column integrated measurements and aerosol mass within the BL. Do you have any RH profiles, could you use the RH profiles from CALIPSO ?

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 10597, 2014.