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Interactive comment on "Advanced characterization of aerosol properties from measurements of spectral optical depth using the GRASP algorithm" *by* B. Torres et al.

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Interactive comment on "Advanced characterization of aerosol properties from measurements of spectral optical depth using the GRASP algorithm" by B. Torres et al. Anonymous Referee 1 Received and published: 19 January 2017 The paper deals with the retrieval of aerosol microphysical properties from spectral aerosol optical depth (AOD) using the Generalized Retrieval of Aerosol and Surface Properties (GRASP) algorithm. The main objectives of the paper are well described and discussed. GRASP is becoming a very powerful tool for aerosol characterization from remote sensing measurements and the inclusion of this new capability is of great interest for the scientific

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community. There are very large databases of spectral AODs alone compared with the classical inversion that also requires sky-radiances measurements. The accuracy and errors in the retrievals are well presented, and it is shown how the final products are below 20% uncertainty. The inclusion of AOD measurements at 1640 nm is very interesting and actually allows retrievals of coarse mode with good accuracy. This point should be pointed out more as an improvement to previous developments. The applicability to night-time photometric measurements is great an interestingly presented as such measurements can only provide AODs. Night- time measurements are expecting to increase with the recent developments in moon photometry. Therefore, the research presented in the article is recommended to be published in Atmospheric Measurement Techniques. However, in my opinion, the paper needs improvements before its final publication. Although is generally well structured, the writing can be improved as there are many unnecessary discussion (e.g. in page 7, lines 20-30 about the multi-pixel capabilities of GRASP seem out of context) and repetitions. Also, there are many editing errors and English misspellings.

The editing errors and English misspellings pointed out by the different referees have been corrected. The multi pixel approach is recognised as one of the major advances presented by GRASP code. We consider that the fact that we have not used this capability in this study (not being in the the scope of the work) should be commented. At the same time, we would like to note that checking the possible use in the future could be interesting.

My major scientific concerns are: As commented, the use of 1640 nm provides very good retrievals of coarse mode. However, many AERONET measurements do not include this filter. A discussion (extra analyzed if required) about the use of the classical spectral range of measurements 380-1020 nm need to be included. I also agree with the editor that the analysis should be extended to lower and higher AOD values.

We have added 4 new aerosol cases in the sensitivity analysis: GSFC0 and LANA0 with $\tau(440) = 0.1$ and SOLV4 ZAMB4 with $\tau(440) = 1.5$ (low and large aerosol op-

tical load). We have included a new study for the spectral range of the old polarized photometers from 440 to 1020 nm (new section 3.4.3).

It is not clear to me which approach you eventually use about spherical/non-spherical particles. Is it critical for the retrieval?

We have added that we assume the sphericity parameter in the inversion strategy description. We use a sphericity parameter of 0 (i.e., all particles are non-spherical) for the cases with Ångström exponent smaller than 0.6. We use a linear approximation with respect to the Ångström exponent to select intermediate values of the sphericity parameter for the cases with Ångström exponents between 0.6 and 1.1 (for instance in the sensitivity analysis: SOLV1, BAHR2, and BAHR3). That is, we use sphericity parameters of 0 and 100 for Ångström exponents of 0.6 and 1.1 (respectively), and linearly interpolate the intermediate values. For the cases with Ångström exponents greater than 1.1, we fixed the sphericity parameter at 100 (considering all the particles as spheres). At the same time we have included the subsection "3.6 Variations on the sphericity parameter", where the effects of this assumption are described.

I also have minor concerns that could be useful to improve the manuscript. The final products of the approach presented are the parameters of a log-normal bi-modal size distribution. If I am right, you need to retrieve first the size distribution. So I do not understand well what the improvement instead of using 22 bins is. Please clarify.

We have assumed simplified bimodal lognormal functions to directly retrieve size distributions, and we do not pass from 22bins functions. We have specific Kernels to make this possible.

The authors show the dependence of size distribution with refractive index, but such dependences are within the error claimed. However, it is not clear to me how they select the input refractive index for experimental measurements.

To run the GRASP-AOD inversions, we have assumed climatological values of the

refractive index for the different sites in Table 13. This is now clearly stated in the text. In any case, in real applications of the code, we would suggest exploring other alternatives (to use the data from the closest AERONET standard inversion (if there are in the same day), monthly climatologies, etc.)

It is not clear to me how you obtained refractive indexes of Table 1. If you used AERONET sky-radiance inversion, how did you obtain values in 340 and 380 nm.

We did it by extrapolating the values in those cases where they are not constant.

Figure 2 does not show something new and could be removed. Also, section 3.5.1. 'Pre-analysis with the forward code' can be shortened as it is well known by the scientific community. In my opinion, Appendixes can be skipped and references are enough.

Figure 2, section 3.5.1 and the Appendix were commented and corrected by other referees. We would like to keep them in their current form if the editor agrees.

The authors reference many times the results of Dubovik et al., (2002). Why not including a table that summarizes the main results used in the current manuscript?

Please note that Table 1 and Table 2 already summarize the main result that we use in the manuscript.

Page 16 lines 14-15. Please add a reference.

We have tried to retrieve the refractive index in preliminary tests but we quickly realized that the solutions were not stable. Note the difficulty in retrieving 22 parameters (16 refractive index+ 6 parameters describing the size distribution) from only 8 measurements. Moreover, the section 3.5.1 itself shows the low sensibility of aerosol optical depth to refractive index compared to parameters that describe the size distribution.

Section 3.4 Simulation of aerosol optical depth errors. For wavelengths below 400 nm AERONET instruments have errors of 0.02. Also, moon photometers might have errors of 0.02 or even higher. I suggest adding a brief discussion about the effects of these

larger errors.

We have repeated the tests in section 3.4 (Simulation of aerosol optical depth errors) assuming double uncertainty for the wavelengths 340, 380 and 1020 nm. The latter was included due to its dependency on the temperature.

Section 3.5.2. I miss a general conclusion or a table that summarizes the conclusions. What are the final results adding all the errors you computed?

We think that we would not get a realistic uncertainty if we directly added all the errors/differences computed from the sensitivity tests, since they have rather different nature: in some cases we treat assumptions, in others errors in the measurements, etc. Moreover, note that in some cases we have exaggerated the uncertainties in the assumption, given that our main interest was to better understand their effects.

The variables in Table 3 are confusing. Please choose another way to remark that are differences between model and retrieved parameters.

We have added the symbol Δ to indicate that we talk about differences.

Figure 10: Please make the points corresponding to experimental measurements bigger. In their current shape they are difficult to see. The same happens in Figure 11.

We have modified the figures. Thank you.

Why not showing temporal evolution of radius and volume concentrations retrieved in Figures 10 and 11?

We have stated in the text that in both cases they do not vary considerably. We think that the manuscript is already overloaded and showing a table with such little variations would be unnecessary.

Why did you not say anything about your applications to experimental measurements in the conclusions section?

We have added the following sentence in the conclusions: “Finally, we have presented two practical applications of the GRASP-AOD code: some retrievals during night from moon photometer data and retrievals from data obtained at different heights with the airborne sun-tracking photometer PLASMA.”

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