Ground-based MFRSR UV-Vis spectral retrievals of Saharan dust absorption at Izaña Observatory

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Response to Referee # 2

Reviewer's comments: In blue-italic fonts

***Authors' comments: In black-regular fonts**

For the (non) sphericity part, the 1st reviewer has been asking a number of questions so I will not repeat some of them here.

We encourage the referee to refer to our response to the comments related to the non-sphericity of dust aerosols offered by Referee # 1.

Probably minor: Radiatively equivalent wavelength: Should this be different for Rayleigh, aerosol and gases since this is actually a multiplication of the filter function and the spectral function of each one of them, in the end integrated?

Radiatively equivalent wavelengths are determined based on the spectral response function of each MFRSR filter, as shown in Figure 2 of the paper. All radiative transfer calculations for the Rayleigh, aerosols, and trace gases are carried out at the respective radiatively equivalent wavelengths for each filter.

Methodology for UV retrievals. I think that the comparison of retrieved SSAs for 440nm from MFRSR and CIMEL is quite good and helps understanding that the method works as this "direct to global inversion"-based method agrees with a radiance based one. However, for the UV there are some additional aspects, that also in some extend are interconnected:

a. The CIMEL AOD@UV uncertainty is higher compared with the one at 440nm

b. The forward scattering effect on the field of view is also higher

c. There is an Angstrom based interpolation/extrapolation in order to retrieve the AOD at UV.

The extrapolation of AERONET AOD to the shorter UV wavelengths of 325 nm and 332 nm is carried out following a quadratic relationship between AOD and wavelengths in log-log space using the 340-500 nm spectral AOD. Refer to section 3.1.

d. There is a correction, based on a calibration constant derived on a different day

The calibration constant (*lnV0*) of MFRSR is calculated on cleaner days with AOD440<0.1 and applied to the dusty days (AOD440>0.2) within the same month. In other words, the calibration constant correction is applied on monthly basis.

Concerning a and c. It would be interesting to calculate the effect of CIMEL AOD UV uncertainty to the overall uncertainty of the final SSA calculations.

The response to this comment is provided below.

Combined a) with c): This uncertainty can impact a lot the calculated Angstrom exponents especially in dust related cases. For example: the paper example on figure 8 shows negative Angstrom (panel a) and almost zero Angstrom for b and c. How uncertain this could be? and what would be the effect on SSA retrieval?

The spectral AOD values reported in Figure 8 (a, b, c) are <daily averaged> values. The Ångström Exponent calculated from the 440-870 nm wavelength pair of AERONET for individual measurements might be different, i.e., positive or negative. While the Ångström Exponent is used to separate dust cases (AE<0.6), it is not used in the inversion procedure. The uncertainties in the retrieved SSA and imaginary part of the refractive index caused by error in the AOD measurements are added to the revision. Please refer to one of the following responses.

Concerning the forward scattering effect: CIMEL is slightly affected but spectrally going down to 325nm (extrapolation) this could play a role.

The 340 nm and 380 nm AOD uncertainty of ±0.02 in AERONET is dominated by calibration uncertainty and also interference filter degradation in time which impacts the calibration of field instruments. The effect of forward scattering in the CIMEL instrument FOV is not accounted for in this estimate. However, this effect is very small for low AOD days considered for deriving calibration constant for MFRSR. Uncertainties in retrieved *k* and SSA for higher AOD days (AOD440>0.4) are quantified accounting for AERONET AOD uncertainty of ±0.02 at the UV wavelengths. Any further errors in the AERONET AOD arising from forward scattering would produce larger errors in the aerosol absorption retrieval than that estimated and described in Section 4: Uncertainty Characterization.

In general looking for systematic effects e.g. an underestimation of the AOD (extrapolation, field of view forw. Scattering effect, etc) at equation 2 and through step2 (2.2.2) and 3 (2.2.3) will lead to a higher diffuse vs direct ratio (e.g. direct overestimation will lead also to diffuse underestimation and this will have an impact on the ratio). This can have a systematic effect for the Inversion part. Maybe will be interesting to do a sensitivity analysis on such effect and the final outcome towards calculating SSA.

Thank you for this important suggestion. We have reprocessed the entire Izaña MFRSR observational record added an estimate of the uncertainties in the retrieved imaginary part of the refractive index (*k*) and the single-scattering albedo (SSA) for each 1-minute measurement. The analysis explicitly accounts for the systematic uncertainties in the AERONET AOD (±0.01 at 440 nm and ±0.02 at UV wavelengths), as well as random uncertainties caused by 1% error in the MFRSR diffuse-to-direct irradiance measurements.

To address these points, we have added a new Section 4: Uncertainty Characterization, describing the methodology and resulting uncertainty estimates in detail. In addition, two new figures (Figures 7 and 8) have been included, illustrating the dependence of the estimated uncertainties in *k* and SSA on AOD, respectively.

Minor comment: I think parts of lines 114-120 and 145-154 are similar so something can be erased or summarized.

The content presented in section 2.1 is now transferred to the Introduction section, as it made more sense to discuss about the instrument and its deployment in the Introduction and prior to discussing the calibration procedure. Header structure and numbers for Section 2 are changed accordingly.