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Interactive comment on "Characterization of an EKO MS-711 spectroradiometer: aerosol retrieval from spectral direct irradiance measurements and corrections of the circumsolar radiation" by Rosa Delia García-Cabrera et al.

Referee #3

The paper presents results of direct sun measurements and aerosol optical depth (AOD) retrieval for an EKO MS-711 spectroradiometer. An extended investigation is presented for the circumsolar radiation correction.

In my opinion the paper is very well written and is well within the scope of AMT. Spectroradiometers have been used less nowadays for atmospheric monitoring due to reasons that the authors quote in their manuscript and I personally agree. However, they are very important instrumentation as the spectral characteristics of the solar irradiance is the desired one in order to be used for a number of atmospheric-radiation related issues.

I only have some minor comments on the manuscript.

Authors: We appreciate the positive and constructive comments of the Referee. Below we respond to his/her general comments.

Instrument characterization and performance.

The authors use the term instrument characterization in the title so I would expect some results on other aspects such as linearity, stray light etc.

Authors: We fully agree. We have modified the title of the manuscript as follows:

> ***Title: "Aerosol retrievals from the EKO MS-711 spectral direct irradiance measurements and corrections of the circumsolar radiation"***

In their instruments characteristics table they quote that the instrument step is way less (≈20 times) that the optical resolution. Can you provide some more information on how each measurement is performed? is it some kind of averaging? or just a very wide entrance slit?

Authors: The EKO MS-711 spectroradiometer measures one spectrum per minute. The exposure time is not constant, but the setting changes automatically the exposure time between 10 ms to 5 s, according to the intensity of the irradiance.

So, we have added this information as follows:

Section 2.2

> *"…This spectroradiometer has been mounted on an EKO sun-tracker STR-21G-S2 (accuracy of <0.01°).* ***This setup performs one spectrum per minute, with an exposure time that changes automatically according to the intensity of the irradiance that varies***

from 10 ms to 5 s. *The main specifications of the EKO MS-711 spectroradiometer are shown in Table 1…"*

The fact that the optical resolution is ≈7nm compared with 2nm and 4nm for CIMEL UV bands (I had the impression that CIMEL 380nm filters are also 2 nm wide), could be a source of uncertainties in the Rayleigh or Langley constants parameters of the EKO compared with the CIMEL? Meaning that the spectrum relative changes for different solar angles and atmospheric conditions can be different for irradiances at 340nm ±7nm and 340nm ±2nm.

Authors: For determining the AOD with the EKO MS-711 spectroradiometer, we have considered the same nominal wavelengths and bandwidths (Filter Bandpass) as those of the Cimel (340: 2 nm, 380: 4 nm, 440: 5 nm, 500: 5 nm, 675: 5 nm and 870: 5 nm) as indicated on Table 2 of the manuscript. Centred on each wavelength and with its corresponding bandwidth, we have performed the integration of the irradiance on the considered spectral range. For example, in the AOD retrieval at 500 nm, the range 495-505 nm is used to perform the integration:

$$DNI(\lambda) = \int_{495\ nm}^{505\ nm} DNI(\lambda)_{EKO-MS711} d\lambda$$

This integrated value is the one used in equations of paragraph 3.2.

We have modified this paragraph as follows:

"…In this work, we have calculated the EKO AOD at the same nominal wavelengths as those of the Cimel (340, 380, 440, 500, 675 and 870 nm), ***by integrating the measured irradiance on the considered bandpass (see Table 2),*** *following the methodology used by AERONET (Holben et al. (2001); Giles et al. (2019), and references herein).* ***For each wavelength****, we have taken into account the spectral corrections shown in Table 2.* ***All wavelengths have been corrected by the Rayleigh scattering (see Sect. 3.1). Furthermore*** *the 340, 380, 440 and 500 nm channels have been corrected from nitrogen dioxide (NO_2) absorption, being its optical depth calculated using the OMI total column NO_2 climatological monthly averages, and the NO_2 absorption coefficient from Burrows et al. (1999).* ***The 340, 500 and 675 nm channels have been corrected of ozone, using the ozone values from a GAW reference Brewer spectroradiometer sited at Izaña Observatory..."***

The calibration constants and difference with the manufacturer ones seems noisy in the UV range, authors claim that "differences are attributed to the low halogen lamp signal in this region experienced during the factory calibration, and low instrument sensitivity in this region" could this affect AOD at UV results?

Authors: Yes, it affects to AOD uncertainty in the UV range. We have clarified this issue as follows:

"… The scatter also is significantly reduced for all wavelengths and aerosol loads, except in the 340 nm UV channel. This is ***mainly*** *attributed to* ***the instrumental error in the spectral range between 300 and 350 nm (17.2%), of which 6% corresponds to stray-light and 6% corresponds to measurement repeatability (Zong et al., 2006), to the different FWHM between EKO (7 nm) and CIMEL (2 nm) at 340 nm, and to the fact that Rayleigh and aerosol scattering are higher in the UV range (Cuevas et al., 2019)…"***

However, the stability of the instrument in the visible+ range for the 3 years period between the manufacturer and the Langley calibrations are impressive. Maybe this also has to be pointed out in the text.

Authors: We have added this information in the final manuscript as follows:

> ***"…**The comparison between the factory calibration performed by EKO Instruments in 2016 and the IZO Langley-Plot calibration (2019) is shown in Figure 7. **These results indicate that the stability of the EKO MS-711 in the range 300-1100 nm during a 3 years period, between the manufacturer lamp calibration and the Langley calibrations at IZO, is remarkable..."***

Circumsolar radiation

Circumsolar radiation contribution to the "true" measured direct irradiance is linked with AOD and also with aerosol types (phase functions). Higher AODs and forward scattering aerosols would introduce higher circumsolar correction factors. As in this work it is mentioned that a mixed (OPAC) based aerosol type is used, have you tested the actual correction and the effect on the AOD retrievals on a day with very high AOD and forward scattered aerosol type (e.g. dust aerosols) ?

Authors: Yes. We have tested/validated the circumsolar radiation correction for dust and for different AOD intervals in the AOD range that we have been able to measure at IZO (up to 0.2). The results are shown in Figures 9 and 10 of the manuscript. Validations for data corrected by CSR are shown in blue

Line 41 GAW-PFR showing lower values

Authors: Done

Table 1 : cosine response : is that applicable to the DNI spectral measurements ?

Authors: No. It is not applicable to DNI measurements. The specifications given in Table 1 correspond to EKO MS-711 spectroradiometer measuring the global solar spectral radiation.

Lines 108-110: is this for direct or global irradiance?

Authors: It is for global irradiance

Lines 212: 0.09"

Authors: Done

Congratulations for a very interesting work.

Authors: Thank you very much for your comment.