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Atmospheric Measurement Techniques Discussions

Interactive comment on "The polarized sun and sky radiometer SSARA: design, calibration, and application for ground based aerosol remote sensing" *by* Hans Grob et al.

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RECOMMENDATION:

Minor revisions

GENERAL COMMENTS:

The authors present the design, calibration, and application of the polarized sun and sky radiometer SSARA for ground based aerosol remote sensing. SSARA contains 12 radiometric channels within 340-1640 nm, similar to AERONET's CIMEL. Polarimetric capability was recently added to the ∼500 nm band. Four of the spectral bands, in-

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cluding the polarimetric band, are capable of performing diffuse sky measurements in addition to direct sun measurements, which are available for all bands. The magnitude and orientation of the diattenuation for the 3 polarimetric channels (0, -45, 90 degree analyzer orientations) are determined in the polarimetric calibration using the partially polarized POLBOX source. Radiative transfer simulations using MYSTIC show that the polarimetric calibration improves the radiometry by ∼1% and the degree of linear polarization by ∼2% (relative). Absolute radiometric calibration is performed in the lab using LOA's radiometrically calibrated SphereX, and on a mountain top using a Langley calibration. An advanced quaternion-based geometric calibration model was developed to derive the instrument pointing from direct sun views throughout the day. Recent modifications to the aerosol retrieval algorithm are described, followed by measurements and retrievals on a clear and a cloudy day during the A-LIFE campaign. On both days, the direct sun AOD matches the AERONET direct sun AOD closely, whereas the almucantar and principal plane retrievals typically overestimate the total AOD by ∼0.1. Separate AOD retrievals for fine and coarse mode show an increase in coarse mode which is linked to lidar measurements of incoming Sahara dust. In addition to AOD, the microphysical parameters of effective radius and real refractive index are retrieved for both size modes and compared to AERONET. The paper is very well written.

SPECIFIC COMMENTS:

1a. Section 4: "We introduced a new method for polarimetric calibration of polarized sun and sky radiometers. In contrast to pevious calibration methods, it can simultaneously determine orientation and diattenuation of a polarized channel. This reduces the experimental effort, as only measurements at a single degree of polarization are necessary." There are other mentions of the novelty of the polarimetric calibration as presented in the paper. However, polarimetric calibration using a single degree of polarization to simultaneously determine orientation and diattenuation of a polarized channel is common practice, typically using a rotating high-extinction polarizer.

1b. P5-14: "Since the angle of the plate can be determined with high accuracy, also the

DoLP is known to a high precision." Is the word "precision" used instead of "accuracy", because there is uncertainty in the refractive index of the glass plates? What is the total uncertainty in the POLBOX output DoLP?

1c. The POLBOX can generate DoLP between 0 and ∼58%. It seems like the polarimetric calibration only uses a single DoLP, i.e. the maximum DoLP. What is the advantage of using the POLBOX at a single DoLP of 58% vs a high-extinction polarizer which would provide the maximum possible calibration signal?

2a. The validation and interpretation of the aerosol retrieval results using the AERONET comparisons would probably benefit from having error bars on both the SSARA and AERONET retrievals. For example, the effective radii are somewhat different, but it is unclear how significant the differences are, and the refractive index seems to lack sensitivity as pointed out by the authors, but it does vary on the ± 0.1 level. Another example is the coarse mode AOD during the Sahara dust event which matches the AERONET retrievals very closely, but the fine mode AOD is off in a seemingly systematic way.

2b. It is pointed out that the direct sun total AOD is never used as a constraint in the aerosol retrievals, in contrast to AERONET, because direct sun measurements might not be available in cloudy situations. To better understand the discrepancies in the retrieval results, it may be instructive to analyze the effect of using direct sun constraints whenever available.

DETAILED COMMENTS:

P2_2: "not good enough to properly resolve": What would be the required resolution?

P2_13-17: Since the paper is about a groundbased instrument, consider using the following references for GroundSPEX and GroundMSPI:

- Van Harten et al., AMT 7:4341-4351, 2014

- Di Noia et al., AMT 8:281-299, 2015

- Diner et al., Atmosphere 3:591-619, 2012

P3_4: “SSARA is . . . Munich”: Provide reference, or is this it?

P3_13: “channels 13-15 are equipped with linear polarizers”: Has this been published before, or is this a recent addition?

P3_14: “linear polarizers”: What kind of polarizers?

P4_Table-1: Consider adding column “direct sun / diffuse sky”

P4_Table-1: Channels 4 and 13-15 are very similar. Have their radiances been compared?

P4_10: “simultaneously, because it does not use a filter wheel”: How long does the AERONET filter wheel sequence take?

P5_6: Add “Li et al., 2018”

P5_22: “exiting light” -> “refracted light inside the glass”

P6_Figure-2: Consider adding dimensions and angle theta.

P7_8: “transmission values”: amplitude or intensity transmission?

P7_26: “It is independent of the intensity of the incoming radiation I0”. But it is retrieved from sequential measurements at different POLBOX angles, so light source stability is not unimportant.

P8_Table-2_caption: “unpolarized, so . . . D=0”: It is not uncommon for non-polarimetric channels to exhibit diattenuation. The POLBOX experiment could be used to quantify and potentially correct polarization sensitivity in the non-polarimetric channels.

P14_9-13: Was the radiometric calibration on Mount Zugspitze compared to the radiometric calibration in the LOA lab using SphereX?

P15_8: “A ground albedo of 0.15 . . . is used for all wavelengths”: Is that a good as-

sumption? What kind of surface was assumed?

P16_25: “AOD data” -> “AOD data in Fig. 9”

P16_29: “as shown in sensitivity studies”: Reference?

P17_5: “in space”: How realistic is this explanation at the deployment location?

P17_6: “in time . . . 15 min”: Figure 9 shows very stable direct sun AOD for hours.

P18_Figure-9: Don’t forget to point out that the direct sun results match AERONET very well.

P20_bottom: “single degree of polarization”: Was the POLBOX used at different DoLP settings, for example to validate the accuracy of the polarimetric calibration?

P21_10: “error of up to 1.9% in total radiance and 3.9% in DoLP” -> “error of up to $\pm$1% in total radiance and $\pm$2% in DoLP”

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