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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.

Anonymous Referee #2

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GENERAL COMMENTS:

In this submission, the authors present the design, calibration and application of a polarisation sensitive radiometer (SSARA) for direct sun and skylight observations. The SSARA features 15 channels sensitive to different wavelength bands between 340 to 1650 nm. At 500 nm there are three channels additionally equipped with polarizing filters at different orientation. Measurement principle and design are very similar to other radiometers, e.g. the Cimel sun photometer used within the Aerosol Robotic Network (AERONET). The calibration procedures described involve polarimetric, radiometric and pointing calibration. The instrument's applicability in the field is demonstrated for

different conditions on data from two days of a measurement campaign conducted in 2017. In this context, the authors also apply a recently developed aerosol property retrieval algorithm. The obtained results are compared to data from a nearby located AERONET station.

I hold this publication to be of value for the scientific community, predominantly because it provides a well written and structured overview on the challenges and possible solutions encountered during the development of state of the art polarized radiometers. Further, it constitutes an important reference to cite in future project and/or instrument related publications. I recommend publication after the comments below have been adressed.

SPECIFIC COMMENTS:

I do not fully agree with the statement, that the presented approaches for the polarimetric and mount calibrations are "novel" or "new", since they mostly follow the procedures described in previous publications that the paper even refers to (Balois 1998 and Riesing 2018, respectively). In the case of the mount calibration I suggest to use "recently developed" instead. Regarding the polarimetric calibration: The approach is valid but I do not see the new/advantageous aspect here because: 1.) I expect that using a single DoLP makes the calibration less reliable, however for some applications this might be outweighed by the reduced effort. 2.) in my eyes using a single DoLP makes the POLBOX (with the main advantage to produce variable DoLPs) obsolete. Wouldn't it be much easier and probably even more accurate to replace the POLBOX by a polarizer with high extinction ratio (e.g. Glan-type polarizer: 10^5) as it is often done?

The approach to use separate telescopes for each channel allows for simultaneous measurements of different wavelengths and polarisations. I would consider this as an advantage over filter wheel instruments in particular when it comes to aerosol observations during cloudy conditions with high temporal variability in intensity. This aspect

might be pointed out more clearly.

P9: Simulation of uncertainties with MYSTIC: Shown are the uncertainties for an uncalibrated instrument. It might be interesting to do the same simulation for the calibrated instrument (inserting the remaining uncertainties from table 2 into the RTM) to demonstrate the improvement and to see how accurate one can get applying the described calibration method.

Section 3: I think for a meaningful comparison it is important to add errorbars here for the AERONET and the SSARA direct sun observations. For the SSARA skylight measurements showing the retrieval residual is sufficient. However, also here an additional sentence in how far the residual reflects the real uncertainty of the respective values might be useful.

P2, Figure 1: It might be interesting to add one or two subfigures here from another perspective (e.g. showing the sensor head on the mount and the controller box respectively), giving the reader a better impression on the size and appearance of the total instrument setup. If this cannot be done I would suggest to at least add an approximate size indicator in the present figure.

P3, L8: Why was FOV=1.2° chosen? Sun disk + sun tracker inaccuracy?

P3, L14: What type of polarizers are used in the instrument? Wire-grid? Glan-Type?

P4, L6-8: I do not understand the details here. How/where is this baffle mounted? Onto the telescope shown in Image 1? Where do the 3.5° come from? And in general: which elements limit/define the FOV? Might be an option to add a sketch of one channel with the important optical elements and light path geometries.

P5, L14: “Known to a high precision”. Don’t you need the accuracy for the calibration? According to my experience measuring absolute angles accurately is not trivial. How well does that work?

P8, Table 2: Clearly for the unpolarised channels the diattenuation “D” should be zero

by theory. But has this been measured? If yes, I would suggest to insert and discuss the obtained values, as they may provide valuable information on the reliability of the instrument and/or the calibration method. Regarding the diattenuation of the polarized channels: I do not know what kind of polarisers are applied in the SSARA, but the values seem rather small. The same holds for the uncertainties. Considering that moving parts are used during the calibration procedure, are the uncertainties realistic? This is one of the reasons why the diattenuation values for the unpolarised channels mentioned above would be of interest. Finally, there are no uncertainties for a’ given. They should be added if available.

TECHNICAL CORRECTIONS:

P5, L2: Typo: “Polarimetric calibration”

P5, L10: when introducing the DoLP here already, maybe add a reference to equation 10 on the next page.

P6, L14: “orders of magnitude smaller”. How many? Just an approximate number would be nice.

P7, L21+22: remove “since” or “so” from the sentence.

P9, Figure 2 and P10, Figure 5: I suggest to indicate the sun’s position by inserting a dot or sun symbol at the respective position in the polar plot.

P9, L13: Remove “by” from “varies by between” (?)

P12, L5: Should be “r_s” instead of “r_v” at end of line (?)

P12, L35: “using” instead of “used”

P13, L15: typo: “irrandiance”

P14, L23: Please reference Grob 2019 once more here. Otherwise it is not clear that the mentioned validation is published there.

P15 L10: “has been be revised”: remove “be”

P16, L5: “To evaluate of the retrieval”: remove “of”

P16, L33: Meaning of the black tickmarks might be moved to section before where the other general remarks on the plots are given.

P17, L15: At end of line: reference Grob 2019 again here.

P17, L18: “The same is true for the coarse mode . . .” is misleading, since it is not clear to which statement in the sentence before “same” refers to: To “effective radii are somewhat smaller” (which is true) or to “within the 0.1 μ limit” (which is definitely not the case). Suggestion: “An underestimation is also observed for the coarse mode . . .”

Figure 10 + 13: What is the “hybrid” AERONET inversion? Is it described somewhere?

P20, end of Section 3: “lacking sensitivity”: Why would you expect that? From investigations in Grob 2019 or Xu 2015 maybe? If so, please add the corresponding reference.

P20, Section 4, L3: Remove “To use this,”

P21, L19: “retrieval’s”

P23, L1: “this an unlikely error”: add “is” here

P24, L17: “. . . a quaternion with a real part of 0”: Changing this to “a quaternion with q_0 = 0 and q_1, q_2 and q_3 being the Eucledian vector components in x, y and z direction” might improve clarity here.

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