Dear Referee,

thank you for your detailed review and valuable comments. We have addressed all the points you mentioned.

Sincerely,
Hans Grob

Referee's 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.

As this point was also raised by reviewer #1 the same answer is provided:
We agree that the calibration methods themselves are not novel. However, all literature currently being cited on the calibration of sun photometers (esp. AERONET) lack a rigorous mathematical derivation of the formalism and a description of the corresponding calibration process. This and the fact that diattenuation and polarizer angles can be determined in a single step are – in our opinion – actual improvements over the existing methods. Especially as this allows for the use of a less sophisticated polarized light source (see later).
However, "novel" is not the correct expression in this case, so the wording has been changed as suggested.

> 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: 105) as it is often done?

POLBOX was used for SSARA calibration, because LOA (Lille) kindly granted us access to it. The possibility of setting and arbitrary DoLP is indeed not needed in our method.
Also, as now mentioned in the text, the uncertainty of D is limited by the uncertainty of the DoLP produced by the POLBOX. A polarizer with a higher

precision would likely improve the calibration of D, but we did not have this available.

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.

Thank you for this comment. We included the following sentence: "All channels are installed parallel to each other, allowing for simultaneous measurements at different wavelengths and polarizations. This is a big advantage in particular for aerosol observations during cloudy conditions with high temporal variability."

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.

Thank you for this suggestion. We did the uncertainty simulations for the calibrated instrument and included the results in the manuscript.

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.

The error of the retrieval of AOD from direct sun observations is very small, errorbars would not be visible on the scale of the figures. Therefore we take those values as the "reference" in clear sky conditions.
To clarify that the residual does not reflect the real uncertainties we included: "Since the total error of the retrieved values cannot easily be estimated, we show the residual of the minimization as an indicator of the performance of the retrieval for a given measurement."

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.

We have included another photograph showing the SSARA instrument on the alt-azimuthal mount with straylight baffle.

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

A FOV of 1.2° was chosen for consistency with CIMEL sun-photometers. This information has been added to the text.

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

The instrument includes linear film polarizer sheets. This information has been added to the text.

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.

We have included an additional figure showing how the straylight baffle is mounted on the telescope. Moreover, we have tried to clarify the description of the straylight baffle in the text.

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?

We refer to Li et al (2010 and 2018) who have determined the accuracy of the DoLP of the POLBOX.

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.

For the unpolarised channels the diattenuation has not been measured. We obtained the small values of D from the Levenberg Marquardt fit using Eq. 17 as model and we do not find any mistake here. The error of a' cannot be determined as long as the error of the intensity emitted by the SphereX is unknown.

Referee's Technical Corrections

P5, L2: Typo: "Polarimetric calibration"

Done.

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

Moved definition of Stokes vector and degree of polarization to beginning of Section.

P6, L14: "orders of magnitude smaller". How many? Just an approximate numberwould be nice.

It is about three orders of magnitude smaller. This has been added to the text and further references with benchmark results including circular polarizations have been added.

P7, L21+22: remove "since" or "so" from the sentence

Removed "so".

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

We included the sun position as red marker in the figures.

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

Done.

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

Corrected.

P12, L35: "using" instead of "used"

Corrected.

P13, L15: typo: "irrandiance"

Corrected.

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

Included.

P15 L10: "has been be revised": remove "be"

Corrected.

P16, L5: "To evaluate of the retrieval": remove "of"

Corrected.

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

Included explanation of black tickmarks where general remarks on plots are given.

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

Included reference.

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 0.1μ limit" (which is definitely not the case). Suggestion: "An underestimation is also observed for the coarse mode..."

Thank you for the suggestion, included.

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

Added reference Giles 2019 for the description of the "hybrid" inversion.

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

We included the reference Grob 2019 here, were the same was observed.

P20, Section 4, L3: Remove "To use this,"

Done.

P21, L19: "retrieval's"

Corrected.

P23, L1: "this an unlikely error": add "is" here

Included.

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.

Changed as suggested.