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Interactive comment on "Autonomous marine hyperspectral radiometers for determining solar irradiances and aerosol optical properties" *by* John Wood et al.

Anonymous Referee #3

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The paper describes an interesting and useful development of a commercial instrument for simultaneous monitoring of global and diffuse spectral irradiances, allowing for the determination of the aerosol optical depth. The paper provides a description of the device, with two different setups, and a first evaluation of the collected data in an oceanic cruise and during groud-based measurements.

The instruments appear to perform well under different conditions, and the proposed solution is particulary useful since it permits the automated acquisition of spectral global and diffuse irradiances, and to retrieve spectral aerosol optical depths. The same device, in correspondance with absorption bands of atmospheric gases, might also be used to determine column amounts of different atmospheric species.

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Discussion paper

The paper deserves publication; however, the following aspects should be improved:

1. the overall organization of the paper, which seems to somewhat mix up different things

2. the description and treatment of the measurement uncertainties.

3. the description of the instrumental characteristics and calibration procedures.

Regarding the first point, I would suggest discussing in separate chapters: i. the technological implementation (sections 2.2.1-2.2.5, 2.2.7-2.2.8); ii. the description of the measurement sites and setup; iii. corrections for ship motion and FOV to AOD measurements; iv. intercomparison of corrected AODs and irradiances.

Secondly, the discussion of the uncertainties may be improved (see, e.g., Miller et al., 2004); for instance, a discussion of the role of the instrument temperature dependence, cosine response, response time, as well as the effect of uncertainties on the instrument attitude (influence of angle uncertainty on the tilt angle correction) should be added. In the same context, the authors are using calibrations, or measurements with different instruments referring to calibrations, performed over a wide temporal interval (2011-2016). Possible effects due to instrumental long-term drifts should be discussed.

As a third point, the authors should provide additional information on the spectral resolution, in addition to the pixel resolution, spectral stability, and temperature dependence of the two spectrometers. Similarly, the main characteristics of the HyperSAS instrument should be included. Measurements uncertainties on PAR and global shortwave irradiances should also be reported.

Minor comments follow.

page 4, line 9: to my knowledge, the first application of the rotating shadowband technique to AOD measurements on ships is by Guzzi et al. (1985).

p.4, l. 10: the discussion is valid only for instruments with an ideal cosine responsivity

of the input optics

p.5, l. 16: this is one of different possible relationships for the airmass

p.7, l. 18: what is the spectral resolution of the spectrometer? Is there any information on long-term stability, temperature dependence, and stray light?

p.8, l. 3: same as above, for the Zeiss spectrometer.

p.11, l. 5-6: how is the lamp calibration with the integrating sphere made? What is intended for "approximately correct overall calibration"? Which lamp types are used? Please, add details.

p. 11, l. 9-11: figure 4 shows extraterrestrial irradiances derived with the Langley plot method throughout the spectrum; the method is not directly applicable in correspondence with absorption lines/bands. For instance, the value retrieved from the Langley plot method is not expected to correspond with the extraterrestrial irradiance in particular in the 940 nm water vapour band.

p. 11, l. 11-12: differences in figure 4 appear to be between few and about 20%, with large differences mainly at 1020 nm. What is the estimated uncertainty on the different determinations? May those be added to the graph? May the time different between calibrations have a role? These differences in the extraterrestrial values are expected to produce a significant impact on the retrieved AOD values. Which extraterrestrial values have been used in the analysis?

p.12, l. 5: "Both spectrometer systems...": please, start a new paragraph

p. 13, l. 4: please, specify where these data have been acquired.

p.13, l. 18-22: please, provide information on the HyperSAS spectral resolution. What are the estimated uncertainties on the measured irradiances? Please, note that largest diferences occur within absorption bands; different spectral resolutions may play a role here.

p.14, l. 2-4, and figure 10: the linear regression seems to be strongly influenced by few data points with large POM AOD and small Spectrometer AOD, especially at 675 and 870 nm; did the authors try to identify and understand why there are large differences between POM and the spectrometer for these points? Is there a reason for the exclusion of data at 1020 nm?

p.14, l. 11-14: the relationship seems to be non-linear (figure 11).

p.15, l. 4-6: "... introducing calibration errors to the notional 7.5° detector measurement...": the sentence is not clear. What is author's best estimate of the dependency on solar zenith angle? Is it negligible? If it is not, the correction scheme should take into account the solar zenith angle. Maybe I miss something, but it is not clear to me why the simulations produce a positive Y-axis intercept, since a larger FOV always implies an overestimate of the direct component. Do the authors have an explanation for this?

p.15, l. 24, and figure 14: it may be helpful to add the corresponding longitude on the upper X axis, or a map of the ship track. Which is the frequency of Microtops measurements? Are the data single measurements, daily/latitude averages? Please, specify.

p.16, l. 4-6: is not this difference in the RMSE expected? Data in figure 11 are on the ground, and no uncertainties due to the platform motion are present. Moreover, the Microtops AOD has a somewhat larger uncertainty than Cimel.

p.16, l. 13: shading, cleaning, and soiling effects were not discussed previously in the text; how and how many many data have been discarded? Can some of the data affected by these effects be identified in the scatterplots?

References

Guzzi, R., G.C. Maracci, R. Rizzi, and A. Siccardi, Spectroradiometer for ground-based atmospheric measurements related to remote sensing in the visible from a satellite,

Appl. Opt., 24, 2859-2864, 1985.

Miller, M.A., M. J. Bartholomew, and R. M. Reynolds, The accuracy of marine shadowband Sun photometer measurements of aerosol optical thickness and Angstrom exponent, J. Atmos. Oceanic Tech., 21, 397-410, 2004.

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