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Atmospheric Measurement Techniques Discussions

Interactive comment on "Ship borne rotating shadow band radiometer observations for the determination of multi spectral irradiance components and direct sun products for aerosol" *by* Jonas Witthuhn et al.

Anonymous Referee #3

Received and published: 9 November 2016

General comments

The paper describes a shadowband radiometer, which has been developed to measure AOD and global, direct and diffuse irradiances at 19 wavelengths in the UV, visible and shortwave IR. The advantage of this instrument is that it can be used for automated measurements on a ship. In principle, this is an important extension of the current measurement capability for atmospheric radiation and aerosol measurements during ship cruises.

The paper describes the instrument, its calibration, the AOD retrieval algorithm, and an

error analysis of the irradiance and AOD measurements.

a. In general, the paper is (in parts) well readable, and the algorithm steps and errors are described in detail. However, the structure is often confusing and not logical. Different topics are mixed in one section. Reordering of sections and figures is needed. The overall presentation should be clearly improved. See specific comments below.

b. The theoretical AOD error estimate of Sect. 3 should be confronted with the real AOD errors of Sect. 4, preferably in a separate discussion section for land and ocean. Now the Melpitz field campaign over land gets much more attention than the Polarstern field experiment, whereas the latter is the real innovative application.

c. The paper is missing a description of the advantage/purpose of measuring at 19 wavelengths. Only results for a few wavelengths are shown. Please add more spectral results to show the capability of the instrument for future applications.

The paper could be published when the comments are taken into account, especially a better structuring of the paper.

Specific comments

1. The title should include the terms "algorithm" and "error analysis". Please replace the vague term "direct sun products" by AOD.

2. Abstract: define CI. This acronym is used throughout the paper without any explanation. Please replace where possible by a clear term.

3. Throughout the paper errors are given as percentages with 2 decimals. This suggests an accuracy that is not attainable, as is shown by the results. For example, the abstract mentions 4.24 % total uncertainty. See also Table 1. Please reduce the number of decimals to 1 or 0.

4. How to calibrate in the field the fast degrading 750 nm and 1550 nm channels? Could you use a fixed relation between stable and unstable channels for specific

scenes ?

5. Sect. 3 contains three topics: the correction steps, the AOD retrieval algorithm, and the error analysis. Please separate these three topics in in three sections.

6. Equation 1: define \tau. In general: define all symbols directly when they are used.

7. Equation 1: it is strange that you define R_E as a ratio of distances and not as a distance. Please use a more appropriate symbol.

8. Add directly below Equation 1 in an equation that you assume m = 1/mu0.

9. P. 5, l. 21: “sun below a zenith angle of 70 deg” : this is unclear, please rephrase (occurs more often)

10. P. 5, l. 28: first step: how are the steps numbered?

11. Equations 3-5: How are these factors C1, C2, C3 used in your algorithm? What is the correction formula?

12. P. 6, l. 18, l. 24: The deviation of what from what?

13. P. 6, l. 18: lower wavelengths > smaller wavelengths

14. P. 7, l. 12-13: repetition of text. Refer to the above subsection.

15. P. 7, l. 21: Please give the resulting error that follows from Fig. 4.

16. P. 8, l. 28: . . . is calculated as the difference between the global and the direct irradiance.

17. P. 9, l. 20: please start a new subsection here on H2O channel calibration.

18. Equation 10: please remove the superfluent term X

19. P. 9, l. 27: transmittance from Rayleigh ... > extinction by Rayleigh . . .

20. P. 10, l. 1-14: this part is very unclear. Please remove if possible, since the use of

this channel is so debatable. Basically: what is the use of the GUVIs 940 nm channel which drifting so much that you need an alongside Aeronet measurement?

21. P. 10, l. 15 – l. 27: please move this part up, above the H2O discussion, since Rayleigh and ozone-NO2 correction is much more important than H2O correction.

22. P. 10. L. 16: uncertainty > absolute uncertainty \Delta

23. P. 10., l. 20: variate > varying

24. P. 10, l. 25: please give recent references on the accuracy of the current OMI product versions.

25. P. 11, l. 4: \tau_w > \Delta \tau_w

26. P. 10: Please summarize all OD errors from Sect. 3 in a Table.

27. Sect. 4 contains four different topics in one section: a theoretical uncertainty estimate in Sect. 4.1, two field experiments - one on land and one on ocean - and a discussion. Please detach these parts. Sect. 4.1 clearly belongs to the last part of Sec. 3, the theoretical error estimate. The two fields experiments, showing the real errors, are different in content, plots etc., and could be separated. The ship based measurements show the realistic capability of the instrument. The discussion in Sect. 4.4 deserves a separate discussion section in which the theoretical errors should be confronted with the real errors.

28. Please show also the differences in AOD between GUVis and Microtops in Fig. 11.

29. P. 12, sect. 4.1: Number the equations on l. 6 and l. 19.

30. P. 12, l. 6: What is DNI_noi ? Same as DNI_hf?

31. P. 12, sect. 4.1: Please do not use acronyms in equations but symbols. So please use I instead of DNI in the equation on l. 6 and eq. (15). Please use \tau instead of AOD and OD in Eq. on l. 19.

32. P. 13, l. 4: What are T_G and T_C?

33. P.13, l. 4-9: this paragraph is unclear, please rephrase.

34. P. 13, l. 33: only small. . .: the difference for ozone is very large.

35. P. 14, l. 4: what is E_T? it is not used in any equation.

36. P. 14, Eqs. 17 and 18: please give these equations earlier, in sect. 4.1, as part of (new) sect. 3 error analysis.

37. P. 15, l. 17-21: please give a quantitative result of the real GUVis AOD error on the ship, from comparison with the Microtops.

38. P. 17, l. 11 ff: Does the percentage error mentioned here relate to AOD? Percentage errors are not very useful for AOD, since the AOD is very variable. Only absolute errors are useful, which can also be seen from Eq. 1, which is the relationship between AOD and transmittance. This point holds for the entire AOD error discussion.

39. P. 18, l. 4: remove: and radiative effects (since this is not shown).

40. P. 18, l. 13: if only > but only

41. P. 18, l. 21-25: For these applications of this instrument, it should be demonstrated that the other wavelengths of the GUVis, for which no results were shown in this paper, are indeed functioning as required.

42. Table 1: Please clarify caption and header. Caption: please always indicate the number of the column. Header: Deviation of what? Uncertainty in what? What do slope, \sigma and R mean? Comparison to Cimel = Land? Comparison to Microtops = Ocean? Aerosol > AOD ?

43. Please add a table (or a column in Table 1) with the spectral bandwidth and central wavelength of each channel. For which wavelength was the OD calculated?

44. What is the shape of the spectral response functions of the 19 channels?

45. Figure 1: please explain what is what, e.g. with arrows. It would be helpful to have sketch of the GUVis, or a top view.

46. Figure 2: Please number the steps of the data processing algorithm. Calibration: radiometric or spectral? Surrounding pressure> surface pressure. Concentration > column density.

47. Figure 3: explain the two y-axes. The last lines of the caption are a repetition from the main text. Explain in the main text how C_i are used.

48. Figure 4: Caption: Error due to aerosols . . ..

49. Figure 5: This figure should be shown earlier, because it nicely shows the principle of the shadowband measurement.

50. Figure 6: this figure can be removed, since its content can be well described in a few words in the main text.

51. Figure 7: please explain the symbols of the legend in the caption and identify the two equations.

52. Figure 8: Caption: Deviation > Difference . . . Mention the Melpitz campaign and the time period.

53. Figure 9: Explain y axis: Difference in OD . . . Please zoom-in by removing the single outlier (mention specifically) and rescaling the y-axis.

54. Fig. 11: Label the GUVis and Microtops points. Add error bars. Show also the AOD differences GUVis – Microtops.

55. Figure 12: This is a very difficult and confusing plot. There is too much information. Land and ocean data are mixed? Are there also two color codings mixed? Please make separate figures. It anyway requires more explanation in the caption. Give also the year.

56. Fig. 13: This figure should be should before Figure 11, of course. Please give the dates and location in the caption.

57. Why is the slope of the transmittances in Fig. 13 closer to 1 than the AOD? OD correction differences?

Technical corrections

- Explain all acronyms the first time they appear: TROPOS, OCEANET, BSI, OD, . . .

- Explain all symbols the first time they appear. E.g. T_G, T_C, E_T, ... are not explained.

- Write much used scientific and technical terms not as separate words, but as connected words: shipborne, shadowband, multispectral, subproject, airplane, etc.

- All symbols, either in text or in equations, should be in italics. For example, T and w in equation 9.

- All Acronyms should be in upright font. All units and molecular formulae should be in upright font. For example, CO2 and CH4 on p. 11, l. 8-9.

- Please number all subsections (with a boldface title). Now it is confusing that some are numbered and others are not.

- Please remove the historical references to Beer on the extinction law and to Junge on the power law size distribution. This is now all standard textbook material.

- Eq. 7 - 8: remove the unnecessary brackets around the gases in the subscripts, and remove the A, since A stands for aerosol.

- Please check the plurals: This values, etc.

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