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Atmospheric Measurement Techniques Discussions

Interactive comment on "Aerosol optical depth determination in the UV using a four-channel precision filter radiometer" *by* Thomas Carlund et al.

Anonymous Referee #3

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The paper by Carlund et al. presents the UVPFR instrument and how it is able to measure Aerosol Optical Depth at wavelengths in the UVB. The authors describe the instrument in detail before explaining the calibration method and the need to correct for finite FWHM. It is shown how the AOD is calculated and a very comprehensive overview and quantification of the possible sources of uncertainty is given. First results are shown and are compared to co-located Brewer AOD values. The paper highlights the potential of the instrument for accurate AOD retrieval in the UVB and is of great importance for the AOD community. In my opinion, the paper fits well within the scope of AMT and I recommend publication after minor revision.

General comments:

1. Please make sure that you explain all the acronyms/abbreviations the first time they are used in the text

2. some of the equations could do with a bit more explanation on the used terms

Scientific comments

Page 1-2, Introduction: The terms UV and UVB are not always used consistently in the introduction. I would also specify the wavelength range of UVA and UVB somewhere in the text.

Page 1: you write in line 28 that the 'absorption' of surface UV by aerosols has become of major interest because of the harmful effects on UV on humans and the biosphere. I would suggest to write 'extinction' as aerosols can also scatter UV radiation hence increasing UV levels which also has implications for human health

Page 5, equations 2 and 3: please specify the meaning of the different terms in these equations. Also, R is said to be the actual Sun-Earth distance, but R is also used as a subscript referring to Rayleigh airmass and optical depth. Maybe you could use 'r' for Rayleigh instead of 'R'?

Page 6, line 28: where do the values for the Angstrom parameters come from?

Page 8, equation 5: should it not be $\ln(V(\lambda)R^2)$ instead of $\ln(V(\lambda))$ and $\ln(V(0,\lambda))$ instead of $\ln(R^2V(0,\lambda))$?

Page 8, equation 6: p/p0 enters the Rayleigh scattering part. But then $\delta(R,\lambda)$ represents the Rayleigh scattering coefficient and not the Rayleigh optical depth

Page 9, line 7: Should this not be equation 6 instead of 5?

Page 9, equation 8: why is there no term for the NO2 and SO2 airmasses mN and mS? (for ozone, Rayleigh and aerosol, you specify an uncertainty for both the optical depth and the airmasses separately.) Is it because they are assumed to be very small in comparison to the other terms?

Page 10-11 (section 4.2): For me it is not always clear how you obtain the actual values of the uncertainties of the contributing factors. For instance, for the first factor (the spread in the Langley Plots), you explain that you assume a triangular distribution for the V0s and take values close to the max and min of the individual V0s as limits and then determine the uncertainty which is [2.2 1.3 1.7 1.1]/$\sqrt{6}$ %. How do you determine/chose the values used as 'close to the max and min'? Also, if possible, it would be nice if you could clarify this with a figure. Could you maybe clarify the entire paragraph a bit more to make it more understandable for readers who are not so familiar with uncertainty analysis calculations and the statistics behind it?

Page 11, section 4.3; Why did you not include some formula here (e.g. in the form of u(δ(R,λ))= [u(δ(R,λ,p))^2+u(. . .)^2]ˆ1/2 ?

Page 13: for ozone airmass, you take into account the contribution of assuming an incorrect effective ozone altitude. If I understand correctly, you did not take this (an incorrect altitude for Rayleigh) into account for the uncertainty calculation of Rayleigh airmass. Why not? Is it included in the uncertainty due to algorithm uncertainty?

Page 14, line 24: where do the alpha and beta values come from? Why do you use these values? (same question as for page 6, line 28; but different beta value)

Table 2: are the values between brackets not the standard error of the mean V0 (instead of the standard deviation)?

Technical corrections:

Page 1, line 11: please specify the abbreviation 'UVPFR'

Page 1, line 14: instrument => instrument's

Page 1, line 22: 'the total uncertainty of AOD in the UVB ('are' =>) 'is' higher than the ('one' =>) 'ones' reported from . . .'

Page 1, line 28: the term UV is already used in the abstract, I would move the expla-

nation 'ultraviolet (UV)' to the abstract

Page 2, line 6: please add a comma between 'cancer' and 'cataract'

Page 2, line 8-10: I would rephrase this a little bit, e.g.: However, even though the aerosol attenuation of solar radiation in the UVB wavelength range is higher than the one at longer wavelengths, most of the available surface based and satellite AOD measurements are related to the UVA and visible range.

Page 2, line 11: To improve readability, please end the sentence after '380nm' and start a new sentence with 'In addition'.

Page 2, line 14: 'related with' => 'related to'

Page 2, line 17: 'limited' => 'a few'

Page 2, line 17: 'could' => 'can'

Page 2, line 19: replace 'measured irradiance' with 'irradiance measured'

Page 2, line 24: remove 'based on Brewer AOD retrievals' to avoid repeating yourself later in the sentence

Page 2, line 26: 'Lately' => 'recently'

Page 2, line 26: add reference to COST project (eg website)

Page 2, line 27: 'aim' => 'aims'

Page 2, line 27: 'In the course' => 'Over the course'

Page 3, line 4: move the explanation of the abbreviation of PMOD/WRC to where the term was first used (page 2, line 28)

Page 3, line 12-13: 'out of band leakage' => 'out-of-band leakage'

Page 3, line 17: 'these latter' => 'the latter'

Page 4, line 2-5: ‘Calibration of reference sunphotometers with the Langley technique (‘are’ =>) ‘is’ preferably performed at high altitude stations since (‘they’ =>) ‘it’ (‘require’ =>) ‘requires’ low and stable aerosol load (e.g. Shaw 1983). Difficulties with Langley calibrations at a low altitude and urban site, when calibration at a high altitude is not possible, (‘has’ =>) ‘have’ been discussed by Arola and Koskela (2004) and (‘was’ =>) ‘were’ recently demonstrated by (‘Diemoz’ =>) Diémoz et al. (2016).’

Page 4, line 11: please specify the meaning of WMO-CIMO

Page 4, line 15: ‘co-location of’ => ‘co-location with’

Page 4, line 20: I recommend to put part of the sentence between parenthesis: ‘. . . the calibration constant V0 of each wavelength channel, (i.e. the signal that would have been measured at the top of the atmosphere at mean Sun-Earth distance) has been described. . .’

Page 5, line 1: ‘replaces’ => ‘replace’

Page 5, line 1: ‘..the sum of components optical depth δRmR+ δomo+ δama and . . .’ => ‘. . .the sum of the components δRmR+ δomo+ δama and . . .’

Page 5, line 2: ‘solves’ => ‘solve’

Page 5, line 10: ‘The values on’ => ‘The values of’

Page 5, line 16: ‘measurements on’ => ‘measurements of’

Page 6, line 5: the percentage for the longest wavelength (0.44%) is not in agreement with the value in table 2 (0.42%)

Page 6, line 10: ‘. . . than a 1 year. . .’ => ‘. . . than 1 year . . .’

Page 6, line 17: it’s the first time that the acronyms VIS and NIR are used in the text. I suggest specifying their meaning on page 2 line 16 (‘in the visible (VIS) to near infrared (NIR) range of the spectrum’)

Page 6, line 17: ‘are’ => ‘is’

Page 7, line 3: ‘are’ => ‘is’

Page 7, line 4: ‘have been’ => ‘has been’

Page 8, line 4-6: I suggest to rephrase as follows: ‘This showed that the FWHM effects accounted for above are practically entirely caused by the rapidly increasing ozone absorption with decreasing wavelength.’

Page 8, line 28: ‘Values on’ => ‘Values of’

Page 9, line 6: ‘absorption in’ => ‘absorption by’

Page 10, line 27: I suggest to remove the word ‘many’ from the sentence

Page 10, line 28-30: I would rephrase the sentence a little bit: ‘It is not even possible with the additional 12 cases from 2016, to determine the actual distribution of Vo for the two wavelengths with nearly no change in sensitivity over more than a year.’

Page 11, line 11: Should there be ‘%’ after the values?

Page 12, line 7: ‘and it’ => ‘which’

Page 13, line 4: Reference Zerefos et al. 2016 is not yet in your list of references. And I guess you referred to the discussion paper? You can change this to Zerefos et al. 2017 as the paper is now officially published in ACP.

Page 13, line 10-11: you could omit the part ‘at the nominal UVPFR wavelengths [305 311 317 332] nm.’ as it is a repetition of what is stated on page 11, line 3-4

Page 15, line 5: ‘uncertainties’ => ‘uncertainty’

Page 15, line 26-27: I would rephrase this a little bit: ‘For the whole day, AOD at 305 nm would have been lower than at 332 nm and often even lower than at 368 nm.’

Page 16, line 4: ‘specific’ => ‘specifically’

Page 16, line 13-15: I would rephrase this: ‘In addition to the regular calibration of the ozone measurements, Brewer #163 was also absolutely calibrated for AOD determinations versus the UVPFR #1001 during this RBCC-E campaign.’

Page 17, line 2: ‘appear’ => ‘appears’

Page 17, line 3: ‘’determinations’ => ‘determination’

Page 17, line 12-14: I would rephrase a little: ‘The major source of uncertainty is the ozone optical depth uncertainty, resulting from uncertainties in ozone cross section, ozone temperature and total column amount.’

Page 17, line 14: ‘The next’ => ‘The second’

Page 17, line 24: remove ‘and ‘ from the sentence

page 18, line 3: ‘difference’ => ‘differences’

Table 1 – Caption: ‘show’ => ‘shows’

Figure 1 – Caption: ‘calculated from linear fit’ => ‘calculated from a linear fit’

Figure 3 – Caption: ‘uncertainties’ => ‘uncertainty’

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