

Manuscript for AMT:

Aerosol optical depth determination in the UV using a four-channel precision filter radiometer

by T. Carlund, N. Kouremeti, S. Kazadzis, and J. Gröbner

Responses to Anonymous Referee #2

(Reviewer comments in *italic*.)

General comments

1. *Structure of the paper. A more conventional naming of the sections (e.g. “2. Instruments and measuring sites”, “3. Methods”, etc.) would improve the readability. The description of the Izaña observatory (page 4, lines 6-19) could be moved in a dedicated paragraph. Also, the Davos site should be briefly described. Furthermore, the Brewer spectrophotometer should be shortly illustrated for unexperienced readers in the “Instruments” section. An additional section should also be reserved for the assessment of the stability using the Brewer spectrophotometer.*

The sections in the manuscript have been rearranged and, in some cases, renamed according to the recommendations. Descriptions of the sites have been added, as well as a short description of the Brewer. Since the Brewer spectrophotometer is not in the main focus of the paper, an extensive review on Brewer stability has not been given. But the results of operational stability monitoring of the used Brewer #163 during the period analysed are given.

2. *The formulae are not entirely commented and further explanation of the terms should be added.*

Explanations of terms in formulas have been improved.

Specific comments

Page 5, line 16: “errors in d_0 ”. Isn’t (d_0+da) retrieved from the fit in Eq. 3? What kind of error are you referring to?

Attempt has been made to clarify the text.

Page 6, line 15: “due to variation with wavelength in extra-terrestrial solar irradiance and ozone...” clashes with “the FWHM effects ... are entirely caused by the rapidly increasing ozone absorption with decreasing wavelength” (page 8 line 5). Please, explain if the first sentence may refer to larger FWHMs or if the spectral variation of the extra-terrestrial solar irradiance was only a potential, but not real, issue.

The first sentence has been corrected.

Page 6, line 28: Explain the choice of Ångström parameters.

Explanation for the choice of Ångström parameters added.

Page 7, line 24: write formula for ozone optical depth correction. Anyway, wouldn’t it be more physical to consider the slant column density (SCD) of ozone instead of ozone vertical column (VCD) and airmass separately?

Formula for ozone optical depth correction is added a bit later in the text (new Eq. 6). It is a good point that slant column ozone density ($SCD = m_o \cdot TCO$) could be used for the ozone optical depth correction, instead of treating m_o and TCO separately. However, maybe in contrast with intuition, it turned out that even a correction based on SCD would have different sensitivity for different ozone amounts, even though the difference is not as large as for the current case, shown in Fig. 2. Anyway, a similar expression, i.e. $\Delta\delta_{o,\lambda} = f'_{o,DU} \cdot c'_{o,\lambda,350DU} \cdot SCD$, would have been needed also in this case to get an accurate correction. Therefore, the current formulation has been kept.

Page 8, line 25: Explain why two different sets of ozone cross sections and effective ozone temperatures are used throughout the paper (Bass&Paur in Sect. 3 and IUP in Sect. 2.3).

IUP ozone cross sections were used in the modelling of the FWHM effects due to the fact that they were available at the same resolution as the used extra-terrestrial solar spectrum. This has been clarified in the text. Bass & Paur (1985) cross sections are used in the operational TCO determinations and therefore they were also used for AOD determinations with Brewers, as well as for the UVPFR. This has also been clarified in the text.

Page 10, line 14: Explain why 1% was chosen for the ozone amount uncertainty. References?

Explanation for the choice of 1 % TCO uncertainty, including some references, has been added.

Page 10, Sect. 4.2: Are uncertainties from the Rayleigh optical depth (Sect. 4.3), circumsolar radiation (Sect. 4.3), neglected aerosol absorption (Sect. 4.5) and solar position (Sect. 4.6) expected to impact on V_0 ? In that case, include them in the discussion.

This section has largely been rewritten and more potential V_0 uncertainty sources are discussed. Neglected aerosol absorption, as suggested in the review comments, should not have any influence on Langley V_0 s and is therefore not mentioned.

Page 10, line 30: a figure of the V_0 distribution could be interesting for the reader, even though it is not fitted well by any known statistical function.

A figure of V_0 distribution at one of the two wavelengths with small sensitivity change from 2015 to 2016 has been added.

Page 12, line 20: "The amount of NO₂ in the atmosphere over the measuring site is unknown". Is it true for the calibration site as well? Are there no NO₂ measurements at IZO?

Good point. NO₂ measurements are indeed performed at IZO. The text in Sect 4.5 has been changed.

Page 15, line 31: notice that the Angstrom relation is not linear, therefore averages should be in principle calculated on log(AOD) instead of AOD to obtain a straight line from log(AOD) vs log(lambda) as in Fig. 5b.

Good point. Change to average of log(AOD) has been made in text and Fig. 5, right panel. Implications of the change are commented.

Page 16, line 27: "with 85.6% of the differences within the limits: : : this indicates a small change". Could you write what percentage was reached at El Arenosillo at this wavelength during calibration transfer?

Percentage of AOD differences/residuals at El Arenosillo calibration added.

Technical corrections

Page 1, lines 28-30: The first paragraphs of the Introduction have been rewritten.

Page 2, line 1: Suggested clarification adopted.

Page 2, line 11: Suggested correction applied.

Page 1, lines 24-25: It is assumed that this comment is for page 2, lines 24-25. Sentence corrected.

Page1, line 28: It is assumed that this comment is for page 2, line 28. Acronym defined here.

Page 3, lines 17-19: It is assumed that this comment is for lines 22-24. Text has been rewritten.

Page 4, line 20: Suggested correction applied.

Page 5, line 1: Suggested correction applied.

Page 5, Eq. 2: R^2 inserted in also Eq. 1, and explanation given after Eq. 1.

Page 5, line 10: Suggested correction applied.

Page 5, line 11: Sentence has been rewritten.

Page 6, line 19: Suggested correction applied.

Page 6, line 20: The somewhat careless use of “exponential” has been removed.

Page 7, line 10: Write the formula for correction factors.

It is not exactly understood what formula is requested but the following formulation has been added:

“... the V_0 correction factors $c_{FWHM} = V_{0,\lambda,true}/V_{0,\lambda}(\text{Langley})$ were estimated to $c_{FWHM}=[1.012 \ 1.003 \ 1.001 \ 1.000]$ for the UVPFR channels...”

Page 7, line 16: Suggested correction applied.

Page 8, Eq. 5: “ R^2 ” should be on the left-hand side.

Suggested correction applied. (Thanks!)

Page 9, line 1: The used Rayleigh scattering coefficients have been specified.

Page 9, Eq. 7: Define what f is in the equation.

“ f ” has been defined.

Page 9, Eq. 8: Suggested correction applied.