

## ***Interactive comment on “The World aerosol Optical depth Research and Calibration Center (WORCC), Quality assurance and quality control of GAW-PFR AOD measurements” by Stelios Kazadzis et al.***

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### 1-GENERAL COMMENTS

This paper presents an institution and its services (the WORCC) contributing to the gain of quality dataset in geoscience/atmosphere composition (aerosol optical depth: AOD). The paper presents also the methods used at WORCC to improve the quality of the measurements (QA/QC about the collected data, calibration of the instruments) thus this paper addresses totally relevant scientific questions within the scope of GI.

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The innovative part of the paper is that it is the first paper presenting in detail the activity and methods of this key institution (WORCC) doing a key activity for the QM of GAW-PFR network dataset. Until now, there were only some fractions of descriptions widespread in many chapters of many WMO reports, moreover in a too old literature that could not synthesize the many years of dataset of GAW-PFR and all the lessons of its long experience. This synthesis of experience is well presented in this paper.

Substantial conclusions are reached: the paper summarizes in a very clear way the methods to apply (and already applied in the institution of reference that is presented: the WORCC) in order to have a well quality of management of a worldwide network of AOD measurements using sun photometry.

The scientific methods used are well described their validity are discussed, a good balanced use of figures and mathematic equations contributes to a clear outline of them. The long dataset and experience of calibration and data flagging presented in this paper contain enough results to develop pertinent interpretations and conclusions.

One aim of the paper is clearly to describe precisely a QM protocol that is destined to be reproduced in other stations or other networks of sun photometry of AOD. The procedures are well described and this aim is in my opinion perfectly reached.

The references list is completed enough giving proper credit to current and past work related to this topic, even if some technical improvements in the way to cite the literature references would be welcome (see below). The number of references is good balanced and the references are of excellent quality. Thanks to this literature work, the authors could clearly put forward their own contribution to the topics approached in this paper (sun photometry, quality management of AOD dataset and worldwide networks, calibration of the instruments of an AOD network).

The title of the paper reflects the content of the paper in a good way; the abstract is a good complement of the title and a concise and truth summary of the paper.

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The overall presentation is well structured, and despite some minor details (to which I suggested improvements in the part below named “technical comments”) clear expressed.

The language is fluent and precise and it is an obstacle neither to get rapidly a good comprehensive view of this work nor to understand the technical and mathematical details

The mathematical formulae are fairly shown, some improvements would be welcome as I suggest it in “technical comments”, especially for some equations a lack of definition of all parameters used in the equations. Nevertheless, all equations are right, without mistake and globally well understandable.

I would suggest some minor improvements to be done: More information should be given in the introduction about the history of sun photometry; the way to cite the references should be more rigorous; and some equations should be better explained (more details, definition of the parameters). These are minor corrections to be done and I tried to help the authors by making concrete suggestions in the parts below “specific comments” and “technical comments”.

Despite these minor corrections that I suggest, the article is of very good scientific quality of excellent significance and globally of good presentation. This justifies my evaluation here above and the fact that I suggest the editor to accept the manuscript and to ask for minor corrections.

## 2 SPECIFIC COMMENTS

Note: X.Y means Page.Line, ex 5.17 is page 5, line 17

### 2.1 Principal specific comments

- Figure 3: Comparing the uncertainty bars and the slopes, this figure does not show an improvement of the quality of the calibration, when WORCC moved the calibration site from Davos to Izaña. To which is IZO a site of better quality for Langley calibration

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than PMOD-WRC?

- Chapter 3.1. – Instrument calibration: In the case of a calibration against the triad. What is the strategy? Do you try to have a representative panel of airmass and AOD or do you prefer to focus on low AOD in order to test the sensitivity for low values (avoid negative values, improve detection of AOD for low aerosol masses)

- About criteria for the statistics:

o For monthly statistics: “A minimum of 30 hourly values is required” -> implies 2 days of measurements are enough if they are full and in summer. Is it reasonable? Don't you want to introduce a criterion of amount of days per month?

o No criterion of repartition of the minutes during the day. My question about the daily mean: Maybe for one site we have, because of the clouds or the availability of the horizon (mountains), a morning average and in other places an afternoon average -> Would the comparison of the daily AOD at these 2 sites be still pertinent?

### 2.2 Other Specific comments

- In the introduction (1.21), you cite “AOD has been measured with the use of sun-photometers for more than 50 year (Holben et. al., 1998)”. I have two comments to this:

o Holben et al. 2001 (also in references' list) describe better and longer the 50 years long history of AOD measurements with sunphotometers than Holben et al. 1998

o I really suggest you to briefly describe this 50 years story of sunphotometers, and more expansively than Holben et al. did. All the authors of this manuscript are staff members of PMOD-WRC, a very historical institution, this is why, the reader expects from you that you have the ambition and motivation to make this historical description by your own. You can cite Volz (1959, 1969), Flowers, Shaw (1976, 1982), Leiterer and Schulz (wmotd 222, 1988)... And maybe more recent articles describing long time series at specific sites (Weller and Gericke [Met. Zeit. 2005] for MOL-RAO Lindenberg,

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Barreto et. al [AMT 2014] for Izana, something about PMOD-WRC, ...).

- In the introduction (2.17), you mention that "GAW-PFR aims to provide inter-comparison information between networks by overlapping sites". -> Is it only an objective (aim) or are there already studies that make inter-comparison of networks? If there are some studies, please mention them and cite the corresponding publications.

- Chapter 3.2. – Other issues (13.13-21): The QM parameter tested is well described. Could you inform about the threshold of spectral shift that your QC politic allows for the spectral shift of the spectral channel?

- Figure 10, Page 14: It is well shown how each method detects or not some type of clouds. Could you explain what are your own QC using all these different methods? Which data you keep in the Level 2 or Level 3 of GAW-PFR database and which you flag out because you consider them as cloud observations.

### 3 TECHNICAL COMMENTS

Note: X.Y means Page.Line, ex 5.17 is page 5, line 17

#### 3.1. Citations / references

An effort has to be done concerning the reference citations:

A main comment concerning the citations: When a WMO report is cited, since some reports are very long, please in this case, inform the reader about the chapter(s) where the information can be found. Inform the chapter directly in the reference list (see my suggestions below).

Moreover, you have in your references list, 2 WMO/GAW reports of the year 2016, that you both cite with "WMO, 2016":

- WMO/GAW Report n°227 (Guidelines and recommendations)
- WMO/GAW Report n°231 (FRC-IV)

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⇒ I suggest to put in brackets in the references list "WMO, 2016-227" and "WMO, 2016-231", and to cite with "WMO, 2016-227" or "WMO, 2016-227" in the text (see my suggestions below).

For your help, these are all WMO reports citations in the text and after it in my suggestions how you could cite properly:

- 1.19. "WMO, 2016" -> "WMO, 2016-227"
- 1.25. "WMO, 1993" -> keep unchanged, even if I doubt that you do want to cite "WMO, 1995", if not, reference GAW/WMO, report No. 104 (March 1995) can be erased because it would never been cited.
- 2.13. "Wehrli in WMO 2005" -> keep unchanged
- 2.24. "WMO, 2016" -> "WMO, 2016-231"
- 6.22. "WMO, 2001" -> keep unchanged
- 16.12. "WMO, 2016" -> "WMO, 2016-227"
- 16.25. "WMO, 1994" -> It is "WMO, 1993"
- 17.13. "WMO, 2016" -> "WMO, 2016-231"

In the references list, I suggest following changes:

- "GAW Report No. 227, WMO/GAW Aerosol Measurement Procedures, Guidelines and Recommendations, 2nd Edition, WMO- No. 1177, ISBN 978-92-63-11177-7, 2016." -> please list this WMO/GAW report with the same way as the other GAW-WMO reports are cited and specify the chapter of the AOD, and specify that it is named "WMO, 2016-227" in text: "WMO/GAW report No. 227, WMO/GAW Aerosol Measurement Procedures, Guidelines and Recommendations, 2nd Edition, WMO- No. 1177, ISBN 978-92-63-11177-7, (WMO/TD- No. 1177), ISBN 978-92-63-11177-7, August 2016.; Chapter 7. Aerosol Optical Depth (pp. 60 - 67) (in text: WMO, 2016-227)"

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- "WMO/GAW The Fourth WMO Filter Radiometer Comparison (FRC-IV), GAW Report No. 231, 2016" -> Please try to use one unique citation style for WMO/GAW reports and specify that it is named "WMO, 2016-231" in text: "WMO/GAW Report No. 231, The Fourth WMO Filter Radiometer Comparison (FRC-IV), November 2016 (in text: WMO. 2016-231)"

- "WMO/GAW report No. 162, Experts Workshop on a Global Surface-based Network for Long Term Observations of Column Aerosol Optical Properties (WMO TD No. 1287), 153 pp, November 2005" -> Specify the chapter: "WMO/GAW report No. 162, Experts Workshop on a Global Surface-based Network for Long Term Observations of Column Aerosol Optical Properties (WMO TD No. 1287), 153 pp, November 2005; Chapter: 'GAWPFR: A Network of Aerosol Optical Depth Observations with Precision Filter Radiometers' (from Christoph Wehrl, pp. 36-39)"

- "WMO/GAW report No. 101, Report of the WMO workshop on the measurement of atmospheric optical depth and turbidity, (WMO TD No. 659), December 1993." -> Specify the chapter: "WMO/GAW report No. 101, Report of the WMO workshop on the measurement of atmospheric optical depth and turbidity, (WMO TD No. 659), December 1993; Chapter 4: Working Group Discussions – Sunphotometry (pp. 4-5)"

- "WMO/GAW report, Global Atmosphere Watch measurements guide, WMO/TD- No. 1073; GAW Report- No. 143, 2001" -> Specify chapter and use the unique WMO/GAW citation style: "WMO/GAW report No.143, Global Atmosphere Watch measurements guide, WMO/TD- No. 1073; 2001; Chapter 3: Aerosol and Optical Depth (pp. 33-49)"

⇒ Please Sort the WMO/GAW reports by GAW report number in the references list.

- (4.3) Put in the reference list the citation of Michalsky et al. 2001 -> I guess: "Michalsky JJ, Schlemmer JA, Berkheiser WE, Berndt JL, Harrison LC, Laulainen NS, Larson NR, Barnard JC. Multiyear measurements of aerosol optical depth in the Atmospheric Radiation Measurement and Quantitative Links programs. Journal of Geophysical Research: Atmospheres. 2001 Jun 16;106(D11):12099-107."

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- (13.27) Harrison and Michalsky (1994) -> This citation is not the correct one and is not in the references list. I guess you want to cite [Harrison et al. ,1994] (Harrison, Michalsky and Berndt, Appl. Opt. 1994)

- (14.4) Please put in the references list the reference of "Smirnov et al. 2000" -> I guess: "Smirnov A, Holben BN, Eck TF, Dubovik O, Slutsker I. Cloud-screening and quality control algorithms for the AERONET database. Remote Sensing of Environment. 2000 Sep 30;73(3):337-49."

### 3.2. Mathematical formulae (equations):

The quality of the formulae has to be improved. If you use a parameter terminology in a formula it has to be defined in the formula block or in the text above or below. Do not hesitate to write more formulae in order to help the reader to follow the mathematical reasoning.

- Equation 1: In the current version of the manuscript, the paragraph introducing equation 1 (2.32 – 2.37) is unclear. I suggest you to cite before Beer Lambert in the atmosphere (transmission =  $\exp(-(\tau_{aer} + \tau_{rt}))$ ) and to write the equation  $T = I/I_0$ , then only write the equation (1) as a consequence of the 2 others.

- Equation 3: please explain each term used in the equation. Is  $N_{ref}$  the number of referent instruments (in this case of a triad  $N_{ref} = 3$ )? What is the origin of the factor 1.96?

- In the text (9.32) You mention the average values  $\langle V_{0xR} \rangle$  (in the text with a bar for average). Is it an average over the days? Over the number of measurements?

### 3.3. Other technical comments

- (3.4) The origin and computing of U95 is unclear. Can you repeat the GAW/WMO rules in the text and give a citation from a publication or a GAW report explaining U95 in detail?

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- Figure 1: The legend of the left picture is not readable (the points that specify the colors of the wavelengths are too small)
- (5.14). When you talk about uncertainties, please precise if you are discussing an absolute or a relative uncertainty. This would help a lot the reader who tries to follow the reasoning
- (6.1-3). It is hard to understand the relation between  $\Delta_{AOD_{V0}}$  and  $\Delta_{ln(V0)}$ , maybe one equation more would help
- (9.15.) Please cite the WMO report and chapter of the “WMO criteria for AOD inter-comparison”
- (10.10) “in addition we have calculated the  $V0_{U95}$ ...”. But what is shown on the Figure 6 under the denomination “U95(%)”? Is it  $V0_{U95}$ ? Is it CV? Is it something else?
- (14.3) “AOD > 2” -> I guess it is AOD[500 nm]?
- (15.4) “AOD( $\lambda_1$ ) > AOD( $\lambda_2$ )” -> “AOD( $\lambda_1$ ) > AOD( $\lambda_2$ )”

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Interactive comment on Geosci. Instrum. Method. Data Syst. Discuss.,  
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