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Geoscientific Instrumentation Methods and Data Systems Discussions

Interactive comment on "Data flow of spectral UV measurements at Sodankylä and Jokioinen" *by* J. S. Mäkelä et al.

J. S. Mäkelä et al.

kaisa.lakkala@fmi.fi

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Authors' response to the review of the manuscript "Data flow of spectral UV measurements at Sodankylä and Jokioinen" by Mäkelä et al.

The Authors appreciate the constructive comments of the Referee #1 and respond here below to each remark. The comments/questions presented by the referee are indicated as C. The answers are indicated as A. The manuscript has been upgraded following the referee's comments. The corresponding changes in the manuscript are indicated as U.

The revised manuscript has been uploaded as supplement.

Major comments

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C: The English language used throughout the paper needs major improvements. There are various cases that words are missing or sentences are difficult to understand.

A: The authors agree with the referee on this point.

U: The language has been improved and corrected to fulfill the requirements of a scientific publication.

C: Introduction, Paragraph 1 “The Brewer was designed to measure ozone but then UV and now SO2 is measured”. The correct way to write that, is that the instrument was initially designed to measured total column ozone with the differential absorption method (reference) using the direct sun port. In addition, the global (diffuser) port was introduced for measurements of spectral UV. Then the use of the direct sun data have used in order to calculate SO2 (reference), Aerosol Optical depth (e.g. Groebner, Kazadzis, Marenco ..), NO2 (e.g. Cede, Diemoz,..)

A: We fully agree. The sentences have been modified as suggested.

U: The text now reads: The Brewer spectrophotometer (Brewer) was initially designed to measure total column ozone with the differential absorption method (Bais et al. 1996; Brewer, 1973) using the direct sun port. In addition, a global (diffuser) port was introduced for measurements of spectral UV. The direct sun data have also been used to calculate SO2 (Cappellani and Bielli, 1995), aerosol optical depth (Gröbner et al. 2001; Kazadzis et al. 2005; Marenco et al. 2002) and NO2 (e.g. Cede et al. 2006; Diémoz et al. 2014).

C: Paragraph 2 It is interesting to describe this dynamic range and in addition some details about the difficulty for such measurements for places like e.g. Sodankyla where low solar eleva- tions is challenging for UV measurements.

A: In deed, this is an interesting issue. Discussion on the magnitude of the dynamical range and the effect of high SZA is now included.

U: The following text has been added: “The high dynamical range of five to six orders of

magnitude of UV irradiance reaching the surface of the Earth puts great demands to the instruments designed to monitor both the short UV-B wavelengths (290-315 nm) and the longer UV-A wavelengths (315-400 nm). The challenge is to maintain the sensitivity of the instrument at all wavelengths. And: "The location of Finland at high latitude, where high solar zenith angles (SZA) are frequent, brings additional challenges, as the weak signal at UV-B wavelengths is near the noise level of the instrument."

C: Paragraph 3 -It is interesting to mention a recent intercomparison campaign. But these results are not yet published. So in addition to this you could add results of a large number of pre- vious publications that report such differences. (for example the SUSPEN paper by A. Bais and various others also in form of EU publications related with the QASUME trav- elling standard). In addition, describing this recent campaign someone has to clarify if this 20% down to 6% calibration differences are due to: primary calibration sources dif- ferences and processing differences or (/and) changes in the instruments due to their travel to the campaign site.

A: The text has been modified according to the suggestion from the referee. The text regarding the use of a common lamp as calibration source has been excluded, as recent findings have given reasons to be careful in making conclusions based on the measurements done with the common lamp.

U: The following text has been added: "The difficulty of the absolute calibration was already seen in the intercomparison campaigns of the 1990's (Josefsson et al. 1994, Koskela et al. 1997) and in the twenty-first century (e.g., Bais et al. 2001), in which the range of the deviations from the reference for UV spectra was up to $\pm$20%. Despite the efforts to homogenize the measurements, in the last European Brewer comparison organized by the COST 1207 project in El Arenosillo, Spain, six Brewers out of 18 differed by more than 10% from the reference, when using the calibration provided by the operator (http://www.pmodwrc.ch/wcc_uv/wcc_uv.php?topic=qasume_audit). The differences are most likely due to slightly different corrections (for, e.g, temperature dependence and angular response) and processing procedures. Small variations in a

number of corrections and procedures may result in large differences in the outcome."

C: Last paragraph of the introduction -You are mentioning steps like: acquisition, processing, storage, and dissemination. I think that a proper way to describe all these steps is to start from : a. Acquisition and Quality control of raw or e.g. level 0 data. b. Calibration of the measured data c. Quality control and corrections (spikes, straylight, dead time, etc) towards e.g. level 1 data. d. Online real time checks e. Post processing of spectral data and creation of e.g. level 2 or metadata

A: The structure of the paper has been changed following the suggestion to clearly show different levels of data.

U: The structure is now: 3 Data flow 3.1 UV data acquisition 3.2 IDEAS - A quality control tool 3.3 UV data processing 3.3.1 Calibration with Level 1 and Level 2 responsivities 3.3.2 Processing algorithms 3.3.3 Online processing - Level 1 data 3.3.4 Offline processing - Level 2 data 3.3.5 Products

And the following explanatory paragraph has been added: "This study examines and demonstrates the steps that are involved in processing different levels of solar spectral UV irradiance data produced by the Brewer spectrophotometers in possession of the Finnish Meteorological Institute. Due to economical reasons, the Brewer measurements at Jokioinen were terminated in November 2015. Since then, the Brewer #107 has been relocated and operated in Helsinki. Thus, this study also serves as a historical description of the Jokioinen measurements, and as a platform for the development of the procedures to be followed in Helsinki and Sodankylä in the future. A detailed description is given on the process flow from the Level 0 data (raw counts) to the Level 2 data (quality assured spectral UV irradiances and UV products). In a companion paper (Mäkelä et al. 2016) we describe in detail how the final time series of the responsivity of a Brewer spectrophotometer is derived. In another companion paper (Heikkilä et al. 2016) we describe how the quality indicators provided by the European UV database (EUVDB) may be used for quality assurance of Level 2 data."

C: Section 2 It would be useful to provide some graphical example of the data availability from the beginning of the measurements till today. Also a simple graph showing the calibration record (e.g. instrument responses) for all the period, accompanied with the calibration uncertainties that can be probably differ from the early 90s till today.

A: Histograms on the monthly amounts of Level 2 data submitted to the EUVDB has been added in Section 3.3.4.

U: A graph showing the time series of the responsivities of Brewer #037 and #107 has been added to Section 3.3.4 Information on the calibration uncertainty has been added to the text of section 3.3.1 as follows: “Bais et al. 2006 have calculated that the uncertainty of the UV irradiances due to the calibration uncertainty is 1.4%.”

C: Section 3 In order to make all the individual steps clear, I would stick to a format similar than the one described in the end of my comments for paragraph 1. It is important to make the individual steps very clear as this is all that the paper is about.

A: The manuscript has been restructured to make the steps clear. In addition, the figures with the schematic presentations on the data flow have been restructured.

C: A table with the initial steps is essential. But more essential is to accompany this table with the references describe each of the steps. (e.g. figure 6 could be modified towards this goal)

A: Figure 6 has been modified towards to goal suggested by the referee. Figure 4 and Figure 6 have been both restructured.

U: The manuscript now includes a chart giving an overall view on the whole data flow and the steps required to produce the different levels of data, and another chart on the online (NRT) processing scheme.

C: Figure 5 . Instead of providing a print screen image here. You can show internal lamp time series and examples of good and bad measurements and Corrections.

A: As this manuscript includes only UV data flow, and not the ozone data flow, the Figure has been removed as suggested by the Referee #2. The internal lamp results are not directly used for the quality control of UV measurements. Of course if some dramatic change is seen in the internal lamp time series, there is a doubt that something has happened to the instrument, which also affect the UV measurements, and the instrument need to be recalibrated.

C: It is not clear if the IDEAS software is applied in the raw data or in the calibrate & corrected ones. I think you have to report that the software assures of specific "bad data" or instrument failures and not an evaluation of the post correction or calibration methods that are applied.

A: As the manuscript is restructured, the section discussing IDEAS is now placed between sections dealing with "UV data acquisition" and "UV data processing", to clearly indicate the purpose of IDEAS to act as a QC tool for the Level 0 data.

C: Instead of screenshots of "possible warnings" for describing the QA/QC you have to report on all warnings that are included in the process.

A: The description of IDEAS was indeed not as clear as it could be. Among other processes the system identifies the internal test failures that potentially lead to poor data quality, which is now clearly stated in the text. Examples of critical tests are now provided. Well over a hundred of warning types are included in the process and the list is growing as IDEAS is actively being developed. While it would be interesting to include all warning types that are provided by the system, we believe that the list is too long to be part of this paper.

C: I do not understand why "if necessary a wavelength correction is made." How do you know that is necessary or not if you do not already have a report on possible wavelength shifts ?

A: The wavelength correction is done to all spectra. It is based on the shape of the

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extraterrestrial spectrum.

U: The text has been changed to: “The SHICRIVM algorithm (Slaper et al 1995) is used to correct for wavelength shifts.”

C: Personal remark Copying from the manuscript: “These instruments form an important network for monitoring changes in the total ozone column. Nowadays, these spectral UV time series of over twenty years are unique and among the longest measured in the Arctic. “ and “The observatory at Jokioinen is in the process of being shut down, and the spectral UV measurements have been moved to Helsinki. Thus, this paper also serves as a historical description of the Jokioinen measurements.”

So Jokioinen is a “unique” and for sure among the longest not only in the arctic but worldwide, station for ozone and UV measurements but it is in the process of being shut down. Since this paper is co-authored and co-signed from 12 FMI scientists, I want to pose the question: how it is possible to refer it here as a unique and historical station and at the same time to shut it down? And of course moving the instruments somewhere else is not an ideal way of a continuation of this 20 year series.

So for me it seems at least ironic to say that this paper is important (also) because Jokioinen is a unique station in terms of time series. Now, a paper that would show a full 20 year time series of Jokioinen Brewer measurements, calibration efforts, e.t.c. sure would serve as a historical description. On the other hand describing procedures for online quality control (only recently added) for a station that closes down are not useful for a future user of the data, as much as a report/publication on the actual calibrations, correction procedure, uncertainty analysis and measurement trend analysis for the particular station.

A: We agree with the referee.

U: The text has been rephrased to read as follows: “Due to economical reasons, solar spectral UV measurements at the Jokioinen observatory were terminated in

November 2015, and the Brewer #107 was transferred to and set up for measurements in Helsinki, the capital city of Finland. The twenty-year time series of solar spectral UV irradiance obtained in Jokioinen is in the process of being analysed. The methods and procedures reported in this study are still in continuous use in Helsinki and Sodankylä. Brewer #037 is still operated in Sodankylä and continues to collect its over 25-year record of solar spectral UV measurements. In Helsinki, a new time series has been initiated with Brewer #107. Thorough understanding on the different phases in the data flow and further development of the methods is a pre-requisite for the vitality of the monitoring programs also in the future."

Please also note the supplement to this comment:
http://www.geosci-instrum-method-data-syst-discuss.net/gi-2015-42/gi-2015-42-AC1-supplement.pdf

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