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Atmospheric Measurement Techniques Discussions

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Interactive comment

Interactive comment on "Adaption of an array spectroradiometer for total ozone column retrieval using direct solar irradiance measurements in the UV spectral range" *by* Ralf Zuber et al.

Anonymous Referee #2

Received and published: 16 December 2017

Zuber et al., 2017 describe a new spectroradiometer instrument (BTS) for UV measurements between 200 and 430 nm and its application to ozone total column observations. The authors present direct solar irradiance spectral measurements during one day (20 September 2016) at the Izaña Atmospheric Observatory (IZO) and compare them to the QASUMI instrument spectra. The paper also describes total ozone columns (TOC) derived from BTS during the selected day and compares them to TOC from QASUMI, Brewer, Dobson and OMI instruments. The BTS instrument is distinct due to application of different long and short pass filters that are designed to eliminate effects of internal stray light on the accuracy of UV measurements. The topic of the paper is appropriate for publication in ATM. I recommend publishing the paper after appropriate

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Discussion paper

modifications are made.

Main comments:

1. The authors do not provide enough information in the paper to (1) assess the effectiveness of the filter-based method to eliminate stray light and (2) evaluate signal to noise ratio especially as applied to the direct sun irradiance measurements at different solar zenith angles.

2. The authors compare direct solar irradiance spectra measured by their new BTS instrument and QASUMI. Further they compare TOC derived from BTS and QASUMI. However, the differences in derived TOC cannot be directly related to the differences in the spectral measurements since different TOC retrieval schemes were used. I would strongly recommend applying the same retrieval analysis to both QASUMI and BTS datasets for consistency.

Minor comments:

1. p2. Please describe the spectrometer used in BTS2048-UV-S: focal length, f/#, grating, manufacturer, etc.

2. p2. Please provide more information about the detector (e.g. CCD manufacturer, pixel size, well depth, dark current and typical operational temperature)

3. p2. Please explain how SiC photodiode enables fast time resolved radiometric measurements.

4. p2. Please provide a figure showing long-pass filter and four interference filters transmission curves.

5. p3, What is the practical application of the long-pass OoR correction in the system that has multiple band-pass filters? OoR with a long-pass filter is not very accurate due to non-zero transmission in the wavelength of interest.

6. p3, L. 22-23. Please describe "tunable laser systems" used for dispersion charac-

terization. How many wavelengths were measured, what is the wavelength accuracy of the laser line centers.

7. p3, L26. How was the SLF as a function of wavelength described for convolution with high-resolution absorption cross sections? How stable is SLF as a function of temperature and instrument “motion”.

8. p4, L3. Reference for linearity characterization methods is missing.

9. p4, L9. What was non-linearity before the correction was applied?

10. p4, L17. How was absolute radiometric calibration performed in the field?

11. p4, L18. Is 1% stability applicable to all wavelengths?

12. p5 L8. The Izaña Atmospheric Observatory (IZO) altitude is 2373 m a.s.l.

13. p5, L9. Less then 0.1°C is extremely good temperature stability for an outdoor system. Where was temperature sensor located relative to the electronics and spectrometer? What was the set temperature inside the enclosure, what was the outside temperature? What is the temperature controller used? What is the enclosure material?

14. p5, L11. Please show a figure with the instrument field of view measurements (in X and Y direction).

15. p5, L12. Please describe how solar tracking accuracy was measured? Tracking accuracy of better than 0.01° is extremely good. How was the tracking actually done to ensure such accuracy?

16. p5 L15. Did the integration time change as a function of solar zenith angle or was it constant at 8 seconds per full spectrum independent of SZA? Figure 8 caption suggests a constant integration time.

17. p6, L5. The reported 1.025 ratio of BTS to QASUMI spectra is mainly applicable to

the 305 -350 nm wavelength range. What causes such large residuals at wavelength larger than 350 nm? Were the spectra aligned relative to each other to correct for potential wavelength changes during the measurements? What was the stability of wavelength scale during the field measurements?

18. p6. Figure 4 shows comparison of QASUMI and BTS spectra for a small AMF. It will be very informative to show similar plots for measurements at SZA 80° and 85°. Please describe sources of noise at high SZA in this part of the paper. Provide full wavelength range: 280 – 430 nm. Evaluating signal below atmospheric cutoff will give a better idea about instrument internal stray light correction.

19. p7, L5. Information content of figure 5 can be significantly improved for the purposes of this paper by using more appropriate for O3 measurements wavelength ranges (A: integrated between 305 and 310, B: integrated between 340-350 nm, C: 330±1 nm and D: 355±1 nm). Please specify what AMF is plotted in Fig.5. Is it direct + scattered AMF? If yes, can you please show in addition direct sun AMF. Figure 5 shows different pattern in the morning and afternoon for UV-A irradiance ratios. Is it possible that solar tracking accuracy was azimuth angle dependent on that day? Is this behavior present during measurements on other clear sky days?

20. P8, L6. Application of the pre-set aerosol properties in forward radiative transfer calculations does not provide any evidence of "robustness of the applied algorithm". Please rephrase.

21. P9, L11. In the introduction a statement was made that varying integration times and filters can optimize BTS measurements for different purposes. Taking full spectrum from 200 to 430 nm when only 305-310 and 330-360 nm windows are used and fixing the integration time at 8 sec at all solar zenith angles, does not seem to provide an optimal SNR for direct solar irradiance measurements. Please explain why limitations were put in place not to realize full BTS capabilities, as stated in the introduction, for TOC measurements? Figure 8 also shows that the TOC measurements start degrading

at SZA around 71-74° which potentially suggests that dynamic range of the system is smaller than stated earlier.

Table 1: Please add TOC standard deviation for each measurement averaging period

Comments to figures: Please use brackets to distinguish units from fraction symbol in all figures and table

Figure 1: Please expand the information provided, especially in the sensor system part. Provide instrument dimensions.

Figure 4: Please correct the units on the left axis: Solar direct irradiance [W/m2/nm]. Right axis: irradiance ratio (BTS/QASUME). Legend: capitalize QASUME. Please add: averaged BTS/QASUME.

Figure 5: Left axis: Irradiance ratio (BTS/QASUMI)

Figure 6: Please provide left axis scale for the insert graph. Dobson Unit is not a SI unit, please define DU = 2.69E16 molecules/cm2

Figure 7: Left axis: Irradiance ratio (BTS/LibRadtran) Specify date/time of the measurement

Figure 8: OMI TOC is hard to see. Digitization of the BTS TOC is not entirely clear. Please explain in the text.

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