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Atmospheric Chemistry and Physics Discussions

Interactive comment on "High levels of ultraviolet radiation observed by ground-based instruments below the 2011 Arctic ozone hole" *by* G. Bernhard et al.

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We thank the reviewer for his or her comments, which are repeated below, followed by our response.

Comment 1

The authors quote a random 2 sigma uncertainty of the single monochromator Brewers used at the Canadian and Finnish site as ± 6% (from Fioletov et al., 2004). But, in this application, where UVI values at the time of interest are very small, the most important

error budget term is probably the systematic error from stray light. Errors in its determination may dominate the overall uncertainty, and should perhaps be discussed further. However, since the authors are focusing on differences in 2011 compared with other years for similar observing conditions, this is perhaps less important.

Response

Stray light is not a significant contributor to the overall uncertainty, even at the small solar elevations prevailing during the "low-ozone" period. As a test, Eureka data from 1 March 2011 were processed with different stray light corrections. The difference in UV index between non-correction data and data processed with the most sophisticated correction is less than 1%. In that analyzed case, most of erythemal UV is coming from the wavelength near 315 nm and there is practically no radiation from wavelengths below 300 nm even without any stray light correction. The Brewer's single monochromator reduces stray light by 3-4 orders of magnitude. In contrast, the difference in erythemal weighting coefficients between 315 nm and 300-305 nm is less than 2 orders of magnitude. Thus, stray light (even enhanced by the erythemal weighting coefficients) is relatively small.

The following sentence will be added to the manuscript: "The effect of uncertainties in the stray light correction on the accuracy of the measurements was analyzed and the associated uncertainty in UVI data was found to be smaller than 1%."

Comment 2

Fig 2. The blue points in the left panel of Fig 2 are not visible, probably because they are obscured by the other points. This should perhaps be explained, or the symbol sizes varied so they are not fully obscured.

Response

We confirm that the blue points in the left panel of Fig 2 are hardly visible because

they are obscured by the other points. We will reverse the sequence in which the three datasets are drawn such that the "15 minute" dataset is in the front and the "60 minute" dataset is in the back. With this modification, all datasets are visible in all panels.

Comment 3

Fig 2 and in associated text. I would suggest expressing the erythemal dose in SED (where 1 SED = 100 Jm-2 of erythemally weighted UV) rather than the non-standard "CED" that has been introduced.

Response

We believe that the reviewer meant that CED should be changed to SED in Figure 5, not Figure 2 (Figure 2 shows the bias in subsampled data). We note that CED stands for "Cumulative Erythemal Dose" and is therefore a physical quantity, not a unit. SED on the other hand is a unit. We currently express CED in units of kJ/m2. While CED could also be expressed in units of SED, we prefer the more physical unit, but will mention SED in the caption of Figure 5.

The following sentence will be added to the caption of Figure 5: "A CED of 10 kJ/m2 is equivalent to 100 "standard erythemal doses" (SED) [Diffey et al., 1997]"

The following will be added to the list of references: Diffey, B. L., Jansén C. T., Urbach F., and Wulf H. C.: Standard erythema dose - a review, Commission Internationale de l'Eclairage (CIE), Technical Report Nr. 125, 5 pp., CIE Central Bureau, Vienna, Austria, ISBN 978 3 900734 81 7, 1997.

Comment 4

Fig 3. I suggest changing the y-axis scale of the lowest panel from 150% to 50% (or as small as possible)

Response

The scale of the lowest panel (O3 anomaly) goes from -130% max 180% like the scale of the second-to-lowest panel (UVI anomaly). We chose the same scales for the two panels such that the magnitudes of changes in UVI in response to changes in ozone become visually comparable. We recognize that there is now a lot of "white space" in the last panel, which could be reduced by changing the scale as the reviewer suggests. By doing so, the relationship between ozone and UVI would become visually less accessible. For this reason, we would prefer to keep the layout of the figure. However, if the second reviewer also suggests that the figure should be changed, we will change the scale accordingly.

Comment 5

Intro, line 25. "Minimum total ozone". I think the word "minimum" should be omitted, or a verb like "occurred" should be added later in the sentence.

Response

The offending sentence is based on the publication by Bernhard et al. (2012), which discusses the "area-averaged minimum total ozone for March in the Arctic, calculated as the minimum of daily average column ozone poleward of 63° equivalent latitude." In other words, for each day of March, the average ozone column poleward of 63° equivalent latitude was calculated and the value discussed in the paper is the minimum of the 31 daily values. The procedure is repeated on an annual basis, resulting in a multi-year time-series of "minimum total ozone". The metric has been established by [Müller, R., J.-U. Grooß, C. Lemmen, D. Heinze, M. Dameris and G. Bodeker, 2008: Simple measures of ozone depletion in the polar stratosphere. Atmos. Chem. Phys., 8, 251-264] and is widely used.

We recognize that the sentence is difficult to understand and will change it to the fol-

lowing:

"The minimum of the daily average column ozone poleward of 63° equivalent latitude was 297 Dobson Units (DU) in March 2011 (Bernhard et al., 2012). This value is 18 DU below the previous record-low observed in March 2000, and 100 DU (25 %) below the average for 1979-1988."

Comment 6

Intro, top of P5. I suggest re-ordering the sentence to focus on the ground-based measurements as the subject, and then explain why they are better in this case that satellite-derived values.

Response

The sentence will be re-ordered as suggested.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 17253, 2013.