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Interactive comment on "Optimizing UV index determination from broadband irradiances" *by* Keith A. Tereszchuk et al.

Keith A. Tereszchuk et al.

keith.tereszchuk@canada.ca

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Responses to Anonymous Referee #2

Interactive comments on:

Optimizing UV index determination from broadband irradiances
by
Keith A. Tereszchuk et al.

Provided by: Anonymous Referee #2
Received and published: 27 January 2018

Preamble: In addition to the changes made to the manuscript following the suggestions of the two reviewers, we also identified three minor issues that required performing a re-analysis of the data and also modifying comments regarding the comparison to Brewer measurements of Section 2.2. These changes did result in a small correction in the scaling and fit factors, but results remain essentially the same (other than improving the agreement with Brewer UV irradiances). These points are as follows:

1. An adjustment of the broadband wavelength boundaries from 280, 294, 310, and 400 nm to 280.11, 294.12, 310.70, and 400.00 nm (this was an error)
2. A correction in applying a moving boxcar averaging window covering ±0.25 nm about sampling points at intervals of 0.5 nm
3. A correction in the calculation of differences with the Brewer UV spectra in Section 2.2, resulting, most significantly, in a reduction of the mean percent differences for the 311-330 nm band from 7.5% to 2.9% (and implying related text changes).

The correction of few other typographical errors were also made.

GMDD

Interactive comment

Page 1 Row 1: In its current form, the abstract is quite long. The reader would appreciate a more concise abstract where the main objectives and major findings are summarized.

The abstract has been made more succinct.

Page 3 Row 3: As regards the action spectrum for erythema, which is the basis for the UV Index, you refer to McKinlay&Diffey (1987) and CIE Technical Report (2014). However, Eq. (1) does not exactly comply with either of these. In the formulation given by McKinlay&Diffey (1987), there are no "smaller than" ("$<$") signs, only "smaller than or equal" ("$\leq$") signs. This would cause a small jump at 328 nm - which you do not have in your curve in Fig. 1, so probably you are not using the action spectrum of McKinlay&Diffey (1987). CIE Technical Report (2014) refers to ISO/CIE1999 and gives a piecewise function where the signs are like in your Eq. (1). However, the equation for the range 328 $<$ lambda $<$ 400 includes a term (140 – lambda), not (139 – lambda) in the exponent, as does your Eq. (1). Please check which erythemally weighted action spectrum you are using and give a reference for that. An excellent description on the differences between the different erythemally weighted action spectra may be found, for instance, in Webb et al. (2011).

Reference: Webb, A.R., Slaper, H., Koepke, P. & Schmalwieser, A.W. 2011. Know your standard: clarifying the CIE erythema action spectrum. Photochemistry and Photobiology 87: 483-486.

The erythmal action spectrum that was originally intended to be used was the McKinlay&Diffey (1987) reference spectrum. This spectrum had been reported in a number of publications in the literature search of the UV Index as the benchmark erythemal spectrum to be used in the calcualtion of the UV Index. Ultimately, the piece-wise function that was actually used was the one detailed in a NOAA reference article found here:

http://www.esrl.noaa.gov/gmd/grad/neubrew/docs/UVindex.pdf

The article cites their representation of the erythmal action function as being the one published by McKinlay&Diffey (1987). It appears that the NOAA article contains a typo in the wavelength limits that had not been noticed.

The UV calculations in this work and associated figures for the manuscript have been redone using the action spectrum detailled in the CIE Technical Report (2014). The jump referred to at 328 nm is present in the original Fig. 1 plot, but is not large enough to be discernible. The manuscript has been edited to explain the change in the function and reference has been made to the Webb et al. (2011) publication.

Page 4 Line 1: You refer to Long (2003) in the context of UV Index forecasting practices worldwide. More recently, Schmalwieser et al. (2017) has also reported on UV Index monitoring practices in Europe. That work could be also worth referring to.

Reference: Schmalwieser, A.W., Grobner, J., Blumthaler, M., Klotz, B., De Backer, H., Bolsee, D., Werner, R., Tomsic, D., Metelka, L., Eriksen, P., Jepsen, N., Aun, M., Heikkila, A., Duprat, T., Sandmann, H., Weiss, T., Bais, A., Toth, Z., Siani, A., Vaccaro, L., Diemoz, H., Grifoni, D., Zipoli, G., Lorenzetto, G., Petkov, B.H., di Sarra, A.G., Massen, F., Yousif, C., Aculinin, A.A., den Outer, P., Svendby, T., Dahlback, A., Johnsen, B., Biszczuk-Jakubowska, J., Krzyscin, J., Henriques, D., Chubarova, N., Kolarz, P., Mijatovic, Z., Groselj, D., Pribullova, A., Gonzales, J.R.M., Bilbao, J., Guerrero, J.M.V., Serrano, A., Andersson, S., Vuilleumier, L., Webb, A. & O'Hagan, J.

2017. UV Index monitoring in Europe. Photochemical & Photobiological Sciences 16: 1349-1370.

Citation added.

Page 4 Line 26: “the total (clear+cloudy) sky analog”. It is not very clear to this reader what this means. Could you please rephrase?

Clarification made to manuscript.

Page 9 Line 6: You have chosen to use weekly (7-day) averages. Could you please explain to the reader why you have chosen averages calculated for a period of 7 days? Why not 5 days – or 10 days?

While the choice of seven days was arbitrary as fewer or more days could also have been selected, the averaging was done for computational efficiency in the minimization. This text has been added to the manuscript.

Page 9 Line 24: You examine 5-day averages of Brewer measurements. Could you please justify the use of 5-day averages? Why not 7-day averages here?

Again arbitary. It was also partially limited by the number of coincident Brewer measurements, made under clear sky conditions, which were recorded within ∼2 minutes local time of the analogous model data produced for the July-August 2015 period. This has been added in the manuscript.

Page 9 Line 23. You remind the reader that a boxcar averaging window was used for the OMI composite TOA spectrum and point out that the slit function of a Brewer spectrophotometer is trapezoid-shaped. The Brewer spectra can be purged from the effects of the slit function by performing a deconvolution. Could you please briefly discuss on how much the different schemes, averaging with a boxcar window vs. convolution with a triangular slit function, may be estimated to affect to the spectra.

Before proceeding, it is necessary to point out that the text should have referred to an approximately triangular-shaped slit function (not trapezoid-shaped). The text has been corrected. Deconvolving the Brewer spectra could have been performed for the model v. instrument comparison, but would have been an involved process. This not only in considering the Brewer slit function, but also in accounting for the spectral variability present in the TOA solar spectrum in the process. An alternative would have been to apply a triangle-shape averaging function to the TOA spectrum for the simulations instead of the boxcar approach. This would have shown the difference in implications of the two averaging approaches. Notable disparities are visually observed at relative extrema points in some of the plots seen in Fig. 4, suggesting that the differences of averaging functions may play a notable role in these disparities. We preferred not doing this as the overall consistency in spectral shape between the simulated and measured data is sufficient for this work. Note that the text of that section has also been revised due to improvements/corrections in the calculations as pointed out at the beginning of this document.

In addition, it was desired to focus on the re-processing and regenerating the figures and updating the text following the corrections identified above in the preamble (and the adjustment of the applied erythemal action spectrum indicated above).

Page 16 Line 2: “The simulated broadbands”. I think it should be “The simulated broadband irradiances”. There are some other instances in the body text with the same kind of formulation where the actual physical quantity is missing, like on Page 16 Line 28: “all sky broadbands” or Page 14 Line 8: “GEM broadbands”. Please add the name of the physical quantity wherever it is currently missing.

Corrections made. ‘All sky’ has also been changed to ‘all-sky’ for consistency with use of ‘clear-sky’.

Page 17 Line 33: What is a “spectral broadband”? Please explain the term.

The coarse spectral resolution GEM irradiance broadbands. The explanation has been added to the manuscript.

Page 18 (Conclusions). The reader would be extremely interested in any estimate on how much your approach would save computer time as compared to the current operational UV index forecasting. Would you please be able to give an estimate on that?

Neglecting the limitation of the current operational UV index forecasting in providing good UV Index values essentially only over parts of Canada and the northern U.S. (the new setup allows for global coverage at whatever model resolution is available), there are two phases to consider. One is providing the ozone field and or the GEM weather variable or irradiance fields. The second is the calculation of the UV Index itself from the ozone and GEM model output.

The first phase of the two methods are quite different. The operational approach first requires the calculation of total column ozone from weather fields over a predetermined northern hemisphere grid. On the other hand the setup in this paper requires that ozone field assimilation and forecasting be performed first. This by itself would be much more computationally expensive. On the other hand, the ozone assimilation and forecasting process is also intended to benefit other applications. The ozone field forecast is then provided, instead of an ozone climatology, to the model radiation code applied for weather forecasting and so does not add any cost.

For this second phase, it is not believed there would be much or any computational advantage. The calculation for this new setup requires the scaling of the GEM UV surface broadband total irradiances and their application in the integration or linear interpolation approaches. Considering the equations involved, the linear interpolation approach might be a faster and the integration approach could be similar if not a bit slower. The integration was still made to be computationally quite efficient. A few repeat UV Index calculation runs of ∼11500 points for each case required, on average, ∼0.08 seconds for the operational case and the integration approach and about ∼0.07 seconds for the linear interpolation (assuming the units are correct for the conversion of processor clock counts to seconds), with some calculations performed being common to all three cases. This phase of the calculations does not imply any significant time as compared to model forecasting (and estimating the total column ozone for the operational case.

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