Response to the Reviewer 1 comments and suggestions

The following statement (here in italics) summarises the opinion of reviewer 1 in the 'General comments' section of his review of the manuscript:
"*In general, the presentation of the manuscript is clear and logical. Overall, the manuscript is well written and informative, deserving for publication*."
Thus, the authors' response to reviewer 1's opinion includes responses to specific/technical comments, which in his words are ""*Specific and minor comments on formal aspects, mainly asking for explanations and for improving readability*". These are as follow

1. *Consider including, in the introduction, and if possible, a short revision for long available series of UV and erythemal data. The reference to Chubarova et al. (2000), which appears in Section 4, can be included there*.

Responding to this comment we add following text to the introduction

"Long-term series of surface UV radiation from ground-based observations with a length of at least a few decades are rare. To the authors' knowledge, the longest UV monitoring series began in Moscow in 1968 with a broadband (300−380 nm) instrument developed at the Moscow State University Meteorological Observatory (Chubarova et al., 2000). One of the world's longest measurements of solar UV radiation at the Earth's surface (and probably the longest taken by erythemal broadband instruments) comes from Belsk. Measurements began in 1975 and continuous monitoring started on 1 January 1976. From a global perspective, the first UV monitoring results appeared at the World Ozone and Radiation Data Centre (WOUDC) in 1989, but continuous time series over three decades are only available for a limited number of stations including: Uccle (Belgium), Edmonton, Resolute, Toronto, Churchill, Saturna Island (Canada), Tateno (Japan) and Syowa (Antarctica) (WOUDC 2025). Database Network for the Detection of Atmospheric Composition Change (NDACC) include also stations with at least of three decades of measurements such as Lauder (New Zealand), Mauna Loa (USA) and three Antarctica stations – Arrival Heights, Palmer Station and South-Pole (NDACC 2025)." L. 86-97

2. *The different periods and instruments operating along time are repeated several times along the text. Would it be possible to present a table schematising the time periods, instruments, references, the ancillary information used, and methods/models applied*?

A new Table 1 has been added to the text explaining the instruments and data used in the manuscript. L.172

Table 1. The Belsk's instruments and their working periods.

Data	Instrument/data	Operation period	Reference
Daily ERE and UV Index	Robertson Berger Meter	1976−1994	Krzyścin et al. (2024)
	SL Biometer 501 A # 927	1992−1994	
	SL Biometer 501 A # 2011	1995−2013	Krzyścin (2024)
	Kipp-Zonen UV-AE-T # 30616	2013−present	
TCO_3	Dobson Spectrophotometer # 84	1963−present	Krzyścin (2024)
SunDur	Campbell–Stokes sunshine recorder	1966−1968, 1970−1973, 1975−present	Krzyścin (2024)
G	Kipp CM 6	1965−1980	Krzyścin (2024)
	Sonntag PRM-2	1981−1987	
	Kipp&Zonen CM 5	1988−1991	
	Kipp&Zonen CM 11	1992−2010	
	Kipp&Zonen CM 21	2010−present	
AOD_{340nm}	Sonntag pyrheliometers	1976−2013	Krzyścin (2024)
	CIMEL CE 318-T	2004−present	
G and G_0	ERA5 reanalysis	1940−present	ERA5 (2025)
G_0	MERRA-2 reanalysis	1980−present	GMAO (2025)

3. *Lines 11-12. I suggest moving the parentheses "(i.e. energy weighted…)" before "reaching the Earth's surface…"*

In the revised manuscript, these lines have been changed to:

"However, homogenisation of the amount of biologically effective solar energy (i.e. energy weighted according to the sensitivity of the selected biological process to solar radiation) reaching the Earth's surface over long periods is challenging due to changes in measurement methods and instruments." L.10-13.

4. *Lines 28 and 54-56. Clearness index is usually defined (e.g. Liu and Jordan, 1960) as the ratio between horizontal global irradiance and the extraterrestrial (top of the atmosphere) irradiance. Instead, the authors use the clear sky index: i.e. the ratio between actual horizontal global irradiance and that corresponding to clear sky conditions (which can be simulated). I suggest using the denomination 'clear sky index', instead of 'clearness index'.*

Clear-sky index has been used in the revised manuscript instead of "clearness index" :

"….the clear sky index (CI) (i.e. a quotient of the all-sky global solar irradiance (G) at the surface and the corresponding synthetic clear-sky value (G_0) to account for combined cloud/aerosol scattering effects on UVR)". L. 56-58

5. *Line 91. "well-maintained Brewer". I suggest saying something about the Brewer maintenance and stability.*

A reference to our previous paper of the Belsk's Brewer instrument explaining its maintenance and stability has been added.

"The details of the Brewer maintenance can be found in Czerwińska and Krzyścin (2024a)". L105-106.

6. *Line 120. What's the meaning of 'pre-calibrated'?*

The word "pre-calibrated" has been replaced by "roughly" (see l. 154) to better reflect the status of constants for instruments supplied by the biometers manufacturers. It is clear from our long experience with many instruments that such producer constants required considerable re-evaluation.

"Subsequent UVR measurements included SL501 A # 927 (1993−1994) and #2011 (1995−2013), which were only roughly calibrated by the instrument manufacturer prior to shipment" L.135-136

7. *Line 147. 'radiance' Do the authors mean 'radiation'?*

Yes. It should be "radiation".

"To validate the corrected UV observations at Belsk, the long-term variability of BE radiation was also obtained from the UVR reconstruction models (Section 2.3) using proxies (TCO_3 and DCI) from the ground-based observations and reanalysis datasets". L.164-165

8. *Lines 177-178. Add (eryt), (vitD3), (psor) in the Figure caption, as appears in the plot legend.*

"eryt", "vitD3", and "psor" have been added to Fig.1 caption.

"Figure 1. Normalised action spectra for the specific biological effects: erythema appearance (eryt), photosynthesis of previtamin D_3 in human skin (vitD3), psoriasis clearing (psor). " L. 197-198.

9. *Line 199. Why the authors want to "allow for greater variability in the CC values"? I think the sentences in lines 514-519 do contribute to clarify this question. Thus, I suggest to move that explanation to Section 2.3.2.*

In the submitted manuscript we had "…In order to allow for greater variability in the CC values, different criteria for clear sky conditions were applied, and the smoothing procedure was applied to the long (1976−2013) and short (1993−2013) UV time series for the CC1 and CC2 versions, respectively. " This statement has been rewritten following the reviewer's suggestion:

"Different criteria for the selection of cloudless days would result in even greater differences between the two CC versions. In addition, the smoothing procedure was applied to the long (1976-2013) and short (1993-2013) UVR time series for the CC1 and CC2 versions, respectively. We would like to have two different sets of correction coefficients to find out how the long-term pattern of biologically effective radiation is sensitive to the corrections." L. 234-237.

The sentence (l. 515-519 in previous manuscript) has been moved to Sect. 2.3.3.

"Model simulations of erythemal DRE and noon UVI under cloudless sky provide a basis for the correction procedure of the past UVR data. A selection of clear-sky conditions throughout the entire day from the daily proxy values (relative sunshine duration and DCI), which were available for Belsk, is not straightforward as only the examination of the daily course of these measurements would allow to capture cloudless moments within the day. Thus, two different sets of correction coefficients are proposed, called CC1 and CC2.". L.203-207

10. *Line 231. Reference to Outer (2010) appears as 'den Outer' in the references list (and in line 58).*

"Outer" in line 58 has been replaced by "den Outer" in the revised manuscript (L.60).

11. *Lines 247-248. Include in the heading of Table 1 some reference to the Mod1 empirical model.*

The heading of Table 2 (Table 1 has been added) has been changed to:

"Table 2. Estimates of the regression coefficients, α and β, describing the attenuation of erythemal DRE by the empirical model, Mod 1, defined by Eqs. (5−6), for the three SZA ranges at noon (SZAn). L. 285-286

12. *Section 2.4. Why the authors use statistics over relative values (z_i) and not directly over the values? Could this be biasing the results by giving excessive weight to low values?*

The relative values (in percent of the reference annual level from the observed data) are used after summing all the daily (Mod1) and monthly (Mod2 and Mod3) erythemal radiant exposures (in J/m2) over the whole year and summer for each year between 1976 and 2023. Therefore, the bias mentioned above is not present in this case.

13. *I suggest, when assessing agreement between two series or sets of data, defininig the relative difference by subtracting the reference values in the numerator: this would change the sign of the differences, giving positive values when the tested value overestimates with respect the reference value.*

Eq.(9) has been modified as suggested by the reviewer and the results in the following Tables 4-5 and A1 have different signs for the mean relative deviation.

14. *Also, I suggest using the term 'deviation' instead of 'error'; this would lead to use MRD, MAD, SD and RMSD instead of MRE, MAE, SE and RMSE.*

We agree and the reviewer suggestions has been applied (note new definitions by Eqs. (10−13 and MRD, MAD, SD, and RMSD in Tables)

15. *Line 339. The reference to LOWESS has been already given in line 195.*

This has been corrected and LOWESS definition is in line 219.

16. *Line 609. Reference to Blumthaler et al. (1989) should be before those to Borkowski.*

In the revised manuscript, Blumthaler et al. (1989) appears before Borkowski (1998).