Response to the Reviewer 1
(*reviewer text is in italic*)

General comments

The authors analyze a very long (the world's longest as they claim) homogenized series of measured erythemal solar irradiance. Then, for the same period (1976 - 2023) they reconstruct the series using different proxies to determine the contribution of different factors to the observed trends. Although the manuscript is well structured and well written, there are some major issues that must be considered by the authors prior to the submission of a revised version of the paper.

To homogenize the series the authors have scaled the measurements using the reconstructed series of the noon erythemal doses. In my opinion, the scaling should be performed using low-turbidity days to avoid biases due to the impact of changes in the prevailing aerosol species. Gradual changes in aerosol composition would affect optical properties such as the single scattering albedo (SSA) and the Angstrom Exponent (AE), that can affect UV doses and their changes have not been taken into account. Furthermore, the characteristics of different sensors possibly affect the results, even after the scaling to the modelled doses. For example, imperfect angular response, or temperature dependence are possible different for different sensors. If such effects have not been considered they increase the uncertainty in the homogenized series. There should be at least some discussion regarding the remaining uncertainties after the homogenization.

The discussion has been added and in the revised manuscript we have:

"The uncertainty of the homogenisation procedure can be assessed by comparing the descriptive statistics of the differences between the regression model and the observed daily EREs from the KZ meter (operated at Belsk from 2014 to the present day with no required adjustments, as evidenced by the excellent agreement with co-located Brewer spectrophotometer observations; Krzyścin et al., 2025) with the corresponding statistics of the model-observation differences using the homogenised RB and SL501A measurements (1976–1992 and 1993–2013, respectively). The model was trained using data from 2014 to 2023 and applied to pre-2014 periods. For full-year data, the mean relative difference between the model and the KZ observations is 1.4%, whereas it is between −2.7% and 1.6% for the RB and SL501A meters, respectively. The respective standard deviations were found to be 10.4%, 13%, and 14.6% (see Table 4 in Krzyścin et al., 2025). These descriptive statistics are only a few percentage points higher than those obtained for the KZ measurements. Thus, the homogenisation procedure for the period 1976–2013 resulted in a slight increase in uncertainty due to differences in the individual instrumental characteristics of the RB and SL501A meters, as well as the limited aerosol input data (annual mean AOD) used in the regression model, which was derived from sparse Sonntag pyrheliometer measurements in that period." (L. 436-447).

Given the above, considering the specific characteristics of aerosols will not change the accuracy, which is already within the range of measurement error.

The proxies that have been used for the series reconstruction do not always correspond to UV-B (i.e., the part of the solar spectrum that mostly contributes to the erythemal doses). For example, the relationship between the AOD at 340 nm and the AOD below 315 nm depends on the AE (practically from the aerosol species) which has been assumed to be equal to 0. The SSA has not been considered and can also have significant impact on the UV trends. The effects of clouds depend on their type and properties. There should be at least some discussion on the uncertainties related to these factors.

The text has been added to the revised manuscript to explain this problem:

"At first glance, the proposed indices to explain changes in annual and seasonal (summer) erythema exposure appear to be only loosely related to the UV radiation attenuation in the atmosphere. To account for the effect of aerosols, the daily averaged $AOD_{340\ nm}$ was used with an Ångström exponent of 0 across the UV range, while other features were held constant. SunDur, G and CI (i.e. parameters related to global solar radiation rather than UV radiation) were chosen to account for the influence of clouds. In addition, a constant surface albedo of 0.03 was used throughout the year. However, this choice of UV indices ensured excellent agreement between modelled and observed annual ERE, as shown in Fig.6 where the smoothed modelled (GPR_{all}, blue solid curve) and observed (black solid curve) curves were almost superimposed on each other. The descriptive statistics of the relative differences between the model and observations are −0.04%, 0.89%, 0.98 and 1.25% for mean, mean absolute value, correlation coefficient and standard deviation, respectively. These values also confirm the effectiveness of using a limited number of proxies in analyses of long-term variability in surface UV radiation."(L. 465-474).

Specific comments are provided below.

Specific comments

L8: "measured erythemal " instead of "erythemal". There are reconstructed series that are longer.

L10: "observations period" instead of "observations"

The proposed changes were included in the revised manuscript.

Introduction: In additions to being the main source of vitamin D, exposure to UVR has other positive effects. E.g.,:

https://www.tandfonline.com/doi/full/10.4161/derm.20013

https://www.mdpi.com/1660-4601/13/10/1028

The following sentence was added to the introduction (L. 34-36): "In additions to being the main source of vitamin D, exposure to UVR has other positive effects. E.g.,: lowering the blood pressure, psoriasis clearing, improving mood by endorphin release, and increases the melanin production in skin (Juzeniene and Moan, 2012; Trummer et al., 2016)."

Section 2.2: How was the clearness index "translated" to clearness index for ERE? Please provide more details. Furthermore, what about other aerosol properties (e.g., SSA, AE) that affect ERE? Furthermore, please provide a reference for the erythema actions spectrum that has been used to calculate ERE.

The following details have been provided in the revised manuscript:

"The CI value, which is calculated on the basis of daily ERE, CI_{ERE}, is proportional to the CI value from global solar radiation. The conversion formula is often in the form: $CI_{ERE} = \alpha CI^{\beta}$, where the coefficients are derived empirically and may depend on solar zenith angle, resulting in a smaller CI_{ERE}/CI ratio at lower solar elevation (e.g. Krzyścin et al. 2025). " (L. 113-115)

It seems that SSA and AE affect only slightly the CI_{ERE}, as it is calculated as the ratio of the all-sky to clear sky ERE. This means that, in cases where variations in SSA and AE are a concern (i.e. for clear or almost clear conditions), CI_{ERE} is, by definition, close to 1.

ERE was measured by the broadband meters, and instrumental action spectra were close to the actual (at that time) erythemal action spectrum provided by CIE (Commission Internationale de l'Eclairage). All of the differences between spectra were taken into consideration in the homogenisation procedure. The action spectrum for erythemal weighting for the Brewer spectral measurements was CIE 2019 (which is the same as CIE 1998). The reference to action spectrum has been given in line 57.

L184-186: Given that the AE can practically range from ~ 0 (e.g., for dust) to ~2 (e.g., for biomass burning aerosols), and that the greatest contribution to ERE comes from wavelengths at 306 – 308 nm, there can be a difference of up to ~20% between AOD at 340 nm and the AOD at wavelengths that contribute more significantly to ERE. There should be at least some discussion about that. Furthermore, during the cold period, can changes in surface albedo have played a role? Does the assumption of a default surface albedo introduce any uncertainty?

We agree that the characteristics of aerosols in the UV-B range are important for analysing surface erythemal irradiance. However, as discussed in the authors' response to the second General Comment, knowing the detailed characteristics of the aerosols for the study of long-term variability in annual and summer erythemal ERE is much less important.

The effects of albedo can be inferred from the selected proxies using a machine learning approach when a much higher G value is met under cloudless conditions in the cold period.

L233: "monitored" instead of "monitoring"

It was changed in the manuscript.

L277-278: What does 3%p means?

per cent point (%p) is defined in line 298.

L387: Delete "much"

It was changed in the manuscript.