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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Proposal of a new erythemal UV radiation amplification factor" *by* A. Serrano et al.

A. Serrano et al.

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"Proposal of a new erythemal UV radiation amplification factor" by A. Serrano, M. Antón, M.L. Cancillo, and J.A. García

Item-by-item response to referee #1 (L. Alados-Arboledas) Referee's comments: -) Responses: *) (NOTE: The numbers of page and lines referred in this response correspond to the former version prior to the revision.) (NOTE: Figures 3 and 6 have been improved.)

-) Particular comments: The use of the term radiation through the test is far from appropriate in some cases. The authors must use irradiance to describe the measurements performed with their radiometers and the variables used in the equations.

*) According to the referee's comment the term radiation has been properly replaced

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by irradiance where needed (when refering to the specific measurements performed and to the variables in the equations).

-) Stratospheric and tropospheric ozone, that is the total ozone contained in the atmospheric column, is responsible of the attenuation in UVB irradiance (1091-14).

*) Following the referee's comment, "stratospheric ozone" has been replaced by "total ozone" along the text where it was more suitable (page 1091, line 14 and many others).

-) Section "Data" requires additional information on the experimental uncertainty in the UVER and total horizontal irradiance measurements.

*) In order to give information on the experimental uncertainly in the measurements, the following text has been added to Section "2 Data".

Regarding the UVER measurements: "Taking into account the technical specifications for the Kipp&Zonen U-V-S-E-T and for the CR10X data-logger, and the errors in the calibration factors (Cancillo et al., 2005), a final relative uncertainty lower than 3% is obtained for the UVER measurements used in this study. It must be noted that the relative uncertainty is lower for low zenith angles as the ones used in this study."

Regarding the total horizontal irradiance measurements: "The CM6B pyranometer complies with the specifications for first-class instrument in the classification of the World Meteorological Organization (WMO, 1983), being its resolution better than ś5 W/m2. Its relative uncertainty in lower than 0.5% according to the information provided by the manufacturers in the calibration certificate and the technical specifications for the pyranometer CM6B and for the CR10X data-logger."

Also, the corresponding following reference has been added to the bibliography:

World Meteorological Organization: Guide to meteorological instruments and methods of observation. WMO-No. 8, Geneva, 1983.

-) The authors define the term clearness index and indicate that this index could be

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used to characterize cloudy conditions (1093-23:28), nevertheless in the remaining of the text they use the term cloudiness index, a term that has not been defined.

*) According to the referee's comment, the term "cloudiness index" has been replaced by the already defined term "clearness index" all throughout the text.

-) Equation 1 presents some dimensional problems unless the quantity [O3] be normalizad in order to be a dimensionless quantity.

*) The Equation 1 was literally written as it appears in the mentioned article by Madronich et al (1998). However we agree with the referee that it has dimensional problems. In order to solve these problems it is now written as follows:

UVER = C (O3/(1 DU))ˆ(-RAF)

-) It is not easy to follow the link among the different equations in section 3.1. In fact my concern is with equation 2, because equation 4 and previously equation 3 can be easily derived from equation 1: by applying logarithm to eq 1, and assuming the constancy of C a simple differentiation leads to 3, while the consideration of finite differences leads to 4. Nevertheless, if as the author indicated (1095-10) UVER/UVER* is the relative increase in UVER and [O3]/[O3]* is the relative change in the ozone column, equation 2 is not coherent with equation 4 that involves also relative variations of both quantities. The constancy of C in equation 1 is contradicted by the initial statement in section 3.2, unless the influencing factors enumerated in this statement were more or less constant or present a reduced variability.

*) We agree that it was not very easy to follow the link among equations. However, from our point of view, equation 2 and 4 were coherent since the former refered to ratios and the latter to relative differences. Finally, following the referee's comment and for the sake of clarity the Equation (2) and the comment about the constancy of the parameter C have been deleted. Now the link among the different equations can be more easily followed.

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Since the equation (3) has been deleted, all the equations have been re-numbered accordingly.

-) The criterion proposed to select cloudless conditions based on a fixed threshold of the clearness index (the authors used the term "cloudiness index"; that has not been defined (see above)). Previous studies (Alados-Arboledas et al., 2000) have shown that this threshold depends on solar zenith angle and that the proponed threshold could bias the "cloudless skies" conditions to situations with rather low aerosol load.

*) The cloud-free conditions are now based on a threshold applied to the clearness index, and mentions to the cloudiness index have been deleted from the article. It is true that the threshold for selecting cloud-free cases depends on the solar zenith angle. However, since the clear sky conditions were identified in order to evaluate the dependence only with ozone, the more restrictive fixed threshold of 0.75 highly guarantees the clear condition of the selected cases, even there are other clear cases which this threshold doesn't retain. Therefore, while keeping the more suitable fixed threshold of 0.75 for the study, the reference to Alados-Arboledas has been added and this topic has been discussed in the following way:

"Several authors have used 0.65 as a fixed threshold (Kudish et al., 1993; Udo, 2000), and others have shown that this threshold depends on solar zenith angle (Alados-Arboledas et al., 2000). Since the aim is to evaluate the dependence only with ozone, in this study the more restrictive threshold of 0.75 guarantees the clear condition of the 489 cases selected (31% of the total)."

Alados-Arboledas, L., Olmo, F. J., Alados, I. and Perez, M.: Parametric modelling of photosynthetically active radiation in Spain, Agr. Forest Meteorol. 101, 187-201, 2000.

-) Clear and cloudless conditions must not be considered equivalents. (1096-14)

*) We agree that clear and cloudless conditions are not equivalents. However, the large variations in the total solar radiation transmissivity are mainly due to clouds as a

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primary factor of attenuation and to aerosols as secondary factor. From this fact, it is evident the high relation between the clearness index value and cloudiness condition and, therefore, it can be understood certain rough identification between clearness index and cloudiness.

Finally, according to the referee's comment, the text has been changed to replace the "cloud-free" conditions to "clear sky" conditions, which are the real conditions selected by the threshold applied to total solar radiation transmissivity. Also, where needed, the references to "cloud-free conditions" have been rewritten, and the following sentence has been added to the article (page 1093, line 26):

"The decrease in clearness is mainly related to the presence of clouds as a primary factor of attenuation and to aerosols as secondary factor."

-) The authors must explain why the use a different approach for the formulation of their new RAF. In fact Eq 5 formulates a relationship between flux transmissivity and slant ozone column while Eq 1 formulates a relationship between UVER irradiance and total ozone amount. Concerning this equation it is advisable to use a different symbol for the constant C (C in equation 1 is not the same as C in equation 5).

*) Section 1 "Introduction", page 1092, lines 2-15 describe the limitations of the former RAF parameter and the convinience to propose a new approach which overcomes the mentioned limitations. This is, therefore, the aim of this article. It is indeed the new formulation for the flux transmisivity as a function of the slant ozone column, which allows to calculate the RAF involving measurements performed at different solar zenith angle and, therefore, overcaming the limitations and non-comparability of former RAF derived from its need to be calculated for a fixed solar zenith angle.

Following the referees's advise, the constant of Eq. (5) is named C* in order to differ it from the constant C of Eq. (1).

-) Page 1098. The term "Maximum and minimum UVER values" in line11 is not appro-

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priate, because this statement refers to figure 2 is more appropriate to write: "Maximun and minimum UVER irradiances averaged between 10:30 and 11:30 UTC hours". In this sense, in the figure caption of Figure 2 the term "values" must be substituted by "irradiance".

*) Both substitutions suggested by the referee have been performed.

-) Concerning the statement on Figure 3 (1098-18:19): "The inverse correlation between these two variables (monthly average of slant ozone column and UVER transmissivity) is quite striking", it is worthy to note that this is clearly a result of the seasonal behaviour of the cosine of the sun zenith angle that has been used to define the slant ozone column. In fact this variable, slant ozone column, is mainly controlled by the inverse of the sun zenith angle, that can be considered equivalent to a simple estimation of the optical air mass.

*) Indeed it is a result of the seasonal behaviour of the cosine of the sun zenith angle as referee says, but also of the seasonal behaviour of the ozone amount. The text has been rewritten as follows:

"The inverse correlation between these two variables is remarkable. These behaviour results from the combined seasonal variation in solar zenith angle and ozone amount. Thus, UVER transmissivity is lower in winter months than in summer months mainly due to the fact that the slant ozone column crossed by UV erythemal radiation is higher in winter than in summer."

-) Concerning Figure 4 the authors must be aware that the dependence shown is a result of the definition of slant ozone column and the strong dependence of this variable on the inverse of the cosine of the solar zenith angle, i.e the optical air mass. Previous studies (Alados-Arboledas et al., 2003) have shown that the UVER flux transmissivity that they defined presents a clear dependence with the optical air mass (see Figure 2 in Alados et al., 2003) where ktuver has the same meaning as T).

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*) It is true that the behaviour shown by Figure 4 is a result of the dependence of the UVER flux transmissivity on the air optical mass, but also on the ozone column amount. In order to be aware of the dependence suggested by the referee, the following text and reference has been added to the article (page 1098, line 25):

"The behaviour shown by Fig. (4) is the result of a combined effect of the optical air mass and the ozone amount. The dependence with the optical air mass has been previously reported (Alados-Arboledas et al. 2003)."

Alados-Arboledas, L., Alados, I., Foyo-Moreno, I., Olmo, F. J., Alcántara, A.: The Influence of clouds on surface UV erythemal irradiance, Atmos. Res. 66, 273-290, 2003.

-) The statement: ".., there is an important increase of RAF parameter when high total ozone values are considered" (1101-13:14) is not coherent with results shown in Figure 5.

*) It was a typographic mistake. The sentence should say "decrease" instead of "increase". It has been changed to: "Thus, there is an important decrease in the RAF when high values of total ozone are considered."

-) Can be related the increase in RAF with cloudiness with cloud enhancement of UVER due to scattered clouds?.

*) It is difficult to really understand the reasons for the increase of RAF with cloudiness. As suggested by the referee the effect of scattered clouds could contribute to this behaviour. Den Outer (2005) reported this fact. Therefore, this idea is suggested in the text as follows (page 1100, line 18):

"This increase of RAF for decreasing clearness agrees with the results reported by Den Outer (2005). This fact could be attributed to the multireflection effect through Rayleigh scattering and cloud reflection, enhancing the effect of any variation in ozone (Den Outer, 2005). This enhancement could be probably more intense when scattered clouds are present."

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