Response to Referee #2

We thank the referee for all the valuable comments that have improved this manuscript. As a result, more information and analyses have been included. Additionally, following the referee's suggestion, the writing has been improved and the grammar mistakes have been corrected. Please see below our point-by-point replies to the specific comments, with the referee's comments in black colour and our corresponding replies colored in blue.

Comment 1 (p. 1, line 5): The authors say "Although being extremely interesting. . .", they must explain why the diffuse component of UVER is so interesting.

Response 1: This sentence has been replaced by (line 6):
"Despite its important role on the human health and numerous biological processes, the diffuse component ..."

C2 (p. 1, lines 19-28): The sentence in lines 25-26 concerns beneficial effect of UV, it is written between negative effects in lines 20-23 and 26-29. I suggest all beneficial effects be gathered, the same for adverse effects.

R2: Following the referee's comment, the text has been re-ordered as follows (lines 20-28):

"Low doses of ultraviolet radiation are beneficial for human health, particularly for the synthesis of vitamin D3, critical in maintaining blood calcium levels [Webb et al., 1988; Glerup et al., 2000; Holick, 2004]. However, an excessive exposure has adverse consequences such as favoring skin cancer, immune suppression and eye disorders [Diffey, 2004; Heisler, 2010]. The effectiveness of ultraviolet radiation in producing erythema on human skin is usually quantified by the erythemal action spectrum [McKinlay and Diffey, 1987]. The ultraviolet radiation weighted by this action spectrum is named erythemal ultraviolet radiation (UVER). Additionally, ultraviolet radiation may have a negative impact on ecosystems such as corals and phytoplankton communities and affect plant growth [Lesser and Farrell, 2004; Zepp et al. 2008; Häder et al., 2011, 2015]. It is also the main factor for degradation of paints and plastics exposed to outdoor conditions [Johnson and McIntyre, 1996; Verbeek et al., 2011]."

C3 (p. 4, line 112): The authors don't give any detail about the processing of Kipp & Zonen measurements. For ex. which TOC is used ? Is it the same as that included in the models which comes from OMI?

R3: Additional information about the calibration process of the UVER radiometers has been included as follows (lines 101-111):

"*To ensure the reliability of the measurements, the pyranometers of our network are calibrated every two years at "El Arenosillo" Atmospheric Sounding Station of the National Institute for Aerospace Techniques (ESAt/ INTA) in Huelva, Spain (37.10º N, 7.06º W), according to the standard procedure recommended by the Working Group 4 of the COST Action 726 [Webb et al., 2006; Gröbner et al. 2007; Vilaplana et al., 2007]. This calibration procedure involves both laboratory characterization and outdoors intercomparison against a reference instrument, in our case, the QASUME unit belonging to the PMOD/WRC. The relative angular and spectral response functions are measured in the laboratory and integrated in a calibration matrix which depends on the solar zenith angle and the total ozone column (TOC). The uncertainty of UVER radiometers associated to this calibration procedure is about 5 - 7% [Hülsen and Gröbner, 2007, Vilaplana et al., 2007]. In this study the calibration obtained during the intercomparison campaign held in July 2011 was applied to the period of study (2011-2012). The calibration matrix has been applied using the TOC values provided by the NASA Ozone Monitoring Instrument (OMI) for our location."*

C4 (p. 4, line 139): Give the definition of the total transmissivity, kt. Currently, the definition can only be guessed after reading the UVER transmissivity definition in lines 140-141.

R4: Following the referee's comments, the text has been rewritten as follows (lines 156-160):

"Regarding the independent variables to use, it must be noted that most empirical models for total diffuse fraction are primarily based on the total transmissivity (k_t), also named clearness index, as the main factor [Liu and Jordan, 1960; Iqbal,1980]. This quantity is defined as the ratio between the total irradiance at the Earth's surface (G (0)) and the total irradiance at the top of the atmosphere (G(TOA)). In this study, our proposed models will rely on the UVER transmissivity (k_{UVER}), defined analogously to the total transmissivity but applied to the UVER irradiance as follows:"

C5 (p. 4, line 141): I believe that GUVER(0) is the same as GUVER in Equation (1) and line 126. Please, use the same writing.

R5: As the referee pointed out, both terms, GUVER(0) and GUVER, have been used for the UVER global irradiance at the Earth's surface. In order to homogenize the manuscript, only the term $G_{UVER,0}$ will be employed. Consequently, the Equation (1) has been rewritten. Additionally, the same criterion has been apply to the nomenclature of the total diffuse, total global and UVER diffuse irradiance.

C6 (p. 5, Equation (3)): r0 and r should be defined separately, not only via their ratio in line 148.

R6: These two magnitudes have been defined as follows (166-167):

"where θ is the solar zenith angle, r_0 is the mean sun-earth distance, and r is the actual sun-earth distance for each date. The eccentricity correction-factor of the Earth's orbit, $(r_0/r)^2$, was calculated using the Spencer's formula [Spencer, 1971]."

C7 (p. 5, lines 152-155): Figure 1 shows the relationship between UVER diffuse fraction (fUVER) and UVER transmissivity (kUVER). If I understand correctly the first one is derived from measurements of the K&Z radiometers (GUVER(0) and DUVER(0)) and the second one is derived from measurements of GUVER(0) and from a computation (Eq. 3). If it is true, the authors should mention all that (see also another comment below).

R7: Following the referee's comment, the text has been rewritten as follows (lines 174-180):

"Figure 1 shows the relationship between UVER diffuse fraction (f_{UVER}) and UVER transmissivity (k_{UVER}), as derived from Equations (1) and (2), respectively. The former is derived from measurements of the K&Z radiometers ($G_{UVER,0}$ and $D_{UVER,0}$) and the latter is derived from measurements of $G_{UVER,0}$ and from a computation (Eq. 3). A general dependence can be clearly seen though the large scatter suggests the influence of other factors as well. In order to account for this variability, additional magnitudes directly related to the absorption and scattering of radiation in the atmosphere must be considered. This study focused on models relying on variables commonly available at standard radiometric stations, such as radiometric quantities and sun-geometry parameters directly related to the absorption and scattering of radiation in the atmosphere."

C8 (p. 5, line 156): What does "meteorological magnitudes" mean ? Is it not rather "meteorological quantities" or "meteorological parameters" ?

R8: "Meteorological magnitudes" has been replaced by "meteorological quantities".

C9 (p. 5, line 156-157): I don't understand why the authors state that other parameters "could have been included in the models for estimating UVER diffuse fraction". As I told just above concerning Fig. 1, it sounds to me that f_{UVER} was derived from measurements, not from modeling. I am rather confused, so the authors should clarify all that.

R9: Aimed to a clearer text, these lines have been deleted.

C10 (p. 5, line 160): Replace "radiometric magnitudes" with "radiometric quantities" or "radiometric parameters".

R10: "Radiometric magnitudes" has been replaced by "radiometric quantities".

C11 (p. 7, Eq. (6) and (7)): Define N.

R11: N is the number of cases within each hour. This informations has been added in line 243.

C12 (p. 7, line 224): The authors say "where sigma is the standard deviation", they should precise of what it is the standard deviation (of k_{UVER}).

R12: This points has been clarified.

C13 (p. 10, Eq. (19) and (20)): xi and xi* must be defined just after the equations, not much later in lines 325-326.

R13: The definition of xi* and xi has been written now just after Eqs. (19) and (20)

C14 (p. 11, line 334): Explain what "ordinary" means.

R14: Ordinary Least Squares (OLS) is another name for linear least squares. It has been clarified in the text as follows (line 359):

"Ordinary least squares (also known as linear least squares) fitting for models..."

C15 (p. 11, lines 334-336): The authors must explain why they have chosen different fittings (ordinary least squares and non-linear) for two groups of models.

R15: The use of the different fittings has been explained in the text as follows (330-334):

"In principle, linear fitting is preferred since it requires no starting values of the fitting coefficients. Therefore, linear least squares fitting was applied whenever possible, that is, to models which are linear (REU, CGU1, CGU2, CGU3 and KUU) or linearizable, i.e. that can be reduced to a linear form with a change of variables (BOU and RIU). For the remaining cases (RAU1, RAU2 and RAU3) it was necessary to apply non linear fittings."

C16 (p. 12, lines 367-368 and Fig.3): The relative residuals are averaged by intervals of each variable, these intervals should be specified. In Fig. 3 the caption should mention "Mean relative residuals of each UVER diffuse fraction. . .". Moreover dispersion bars around each mean are needed.

R16: Error bars showing the standard deviation of the mean have been added to Figure 3 and the caption of Figure 3 has been rewritten as the referee suggested to arrive at:

"Figure 3. Mean relative residuals of each UVER diffuse fraction model versus a) solar zenith angle, b) UVER transmissivity, and c) predicted UVER diffuse fraction values. The range of the solar zenith angle (10º- 70º) has been divided into six equal bins while the ranges of the k_{UVER} (0, 0.025) and f_{UVER} (0,1) have been split into ten bins. The mean value for each bin (central point) and the standard deviation of the mean are shown (error bars)"

C17 (p. 12, line 381-382): The authors state ". . . although the functional form can be generally suitable for other locations. . .", did they check that ? If yes they must give examples, if not they must reconsider their statement.

R17: Following the referee's comment this part of the sentence has been removed.

C18 (p. 4, line 110): Replace "without been affected" with "without being affected".

R18: This part of the text has been modified

C19 (p. 6, line 184-185): Replace "This new variable has been included by adding the a term. . ." with "This new variable has been included by adding a term" ("the" has been removed).

R19: The text has been corrected according to the suggestion given by the referee.

C20 (p. 7, Eq. (8)): In the left hand side term replace the superscript GC1 with GCU1.

C21 (p. 7, Eq. (9)): In the left hand side term replace the superscript GC2 with GCU2.

C22 (p. 8, Eq. (10)): In the left hand side term replace the superscript GC3 with GCU3.

R20, R21 and R22: These equations have been corrected

C23 (p. 9, line 291): "Ridley et al. [2008]" → "Ridley et al. [2010]".

R23: The reference has been corrected.

C24 (p. 13, 422): "models" → "model".

R24: The text has been corrected.

C25: The reference “Arola et al., 2003” cited p. 1, line 33 is missing.

R25: The corresponding reference has been included in the reference list as follows:

Arola A., K. Lakkala, A. Bais, J. Kaurola, C. Meleti, P. Taalas,. Factors affecting short- and long-term changes of spectral UV irradiance at two European stations, J. Geophys. Res., 108, 4549, 2003. doi:10.1029/ 2003JD003447

C26: The reference “Craig et al., 2014” cited p. 2, line 40 is missing.

R26: The correct reference is: Williamson et al. [2014]. This mistake has been corrected.

This reference is included in the reference list as:

Williamson, C., R. Zepp, R. Lucas, S. Madronich, A. Austin, C. Ballare, M. Norval, B. Sulzberger, A. Bais, R. McKenzie, S. Robinson, D. Häder, N. Paul, and J. Bornman. Solar ultraviolet radiation in a changing climate, *Nature Climate Change*, 4, 434-441, 2014.

C28 (Fig. 2): It is difficult to distinguish the various colors red, magenta and brown. Moreover I cannot see the yellow dot. I suggest making different symbols of various colors.

R28: Colors and symbols size have been change in order to improve the quality of this Figure. The referee should be take into account that models REU (now grey color) and model KUU (now yellow color) present nearly the same behaviour and they overlap as in mentioned in line 391.

C29 (Fig 3): Replace the x-axis caption of the right plot “Fraciton” with “Fraction”. Replace also “Relative residuals” with “Mean Relative residuals” on the y-axes.

R29: The text in Figure 3 has been corrected.

C30 (Table 1): The authors should add the number of cases for fitting and validation for each model.

R30: The number of cases for fitting (3979) and validation (1262) has been included in Table 1. This information has also included in Section 3.2.