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DETERMINATION OF THE UV-INDEX USING MEASUREMENTS PERFORMED BY THE GUV 2511 INSTRUMENT AT STARA ZAGORA

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Abstract: *The UV-index (UVI) is a measure of the power of the UV irradiances at an Earth surface location weighted by the erythema action spectrum. The UVI is influenced mainly by the cloudiness and by the stratospheric ozone content. For public forecasts of the UVI, the maximum daily values UVI are given for clear-sky (cloudless) conditions taking into account only the variations produced by the ozone UV absorption.*

Based on the Tropospheric Ultraviolet and Visible (TUV) Radiation Transfer Model, look up tables were calculated. The tables describe the dependences of the UVI from the zenith angle, the total ozone content and the optical depth of the atmosphere, where the physical parameters were calculated using GUV 2511 measurements. The erythema UVI shows a typical for 40° N maximum between 8.5 and 10 during the summer months. During the same time interval at some days UVI between 3 and 6 are observed due to strong clouds. It was found out that the determined clear-sky erythema UVI for Stara Zagora is in good agreement with the satellite based overpass UVI for Sofia published at the Temis web site (http://www.temis.nl/uvradiation/UVindex.html).

ОПРЕДЕЛЯНЕ НА УВ-ИНДЕКСА ИЗПОЛЗВАЙКИ ИЗМЕРВАНИЯ, ПРОВЕДЕНИ С УРЕДА GUV 2511 В СТАРА ЗАГОРА

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Резюме: *УВ-индексът (UVI) или индексът на биологически активната УВ радиация е мярка за интензивността на ултравиолетовата радиация на дадено място от земната повърхност, свързана с ефектите върху човешката кожа. UVI зависи главно от облачността и съдържанието на озон в стратосферата. За обществени прогнози на UVI се дават максималните дневни стойности на UVI за чисто (безоблачно) небе, като се вземат предвид само измененията, породени от абсорбцията на ултравиолета от озона.*

С помощта на Модела за пренос на ултравиолетовата и видима радиация през тропосферата (TUV) бяха пресметнати look up таблици. Тези таблици описват зависимостта на UVI от зенитния ъгъл, пълното съдържание на озон и оптичната дебелина на атмосферата, като физическите параметри бяха определени от измерванията на уреда GUV 2511. Биологически активният UV индекс при 40° N има типичен максимум между 8.5 и 10 през летните месеци. Същевременно при силна облачност през някои дни през същия период са наблюдавани стойности на UVI между 3 и 6. Беше установено, че определените стойности на биологически активният УВ индекс за Стара Загора за безоблачни условия са в добро съгласие с получените за София по измервания при спътникови преминавания, публикувани на уеб сайта на Темис (http://www.temis.nl/uvradiation/UVindex.html).

Introduction

As it is well known, the ultraviolet (UV) irradiance reaching the Earth surface has an impact on the human's health. The UV-B irradiance stimulates the production of vitamin D. However the strong UV irradiance can damage the skin and it is associated with cataracts and skin cancers. The UVI is a measure of the sunburn producing ultraviolet radiation. The concept of the UVI and methods of the UVI prediction were developed to help peoples to protect themselves from the harmful UV. UVI are given at some locations and/or as maps in many weather reports.

The main goal of the study is the presentation of the developed method of the UVI determination and the results for Stara Zagora location.

UV-index definition

The erythemal Dose rate at a given moment *t* is presented as an integral of the solar irradiance at the Earth surface $F_t(\lambda)$ at the moment *t* measured in mW/(m^{2}nm) weighted by the erythema action spectrum $A_e(\lambda)$ over the wavelength given in nm and vary over the day mainly due to the changes of the zenith angle, the weather conditions and the absorption of ozone [1].

$$D_t = \int_0^\infty A_e(\lambda) F_t(\lambda) d\lambda \quad (1)$$

For the public the UVI forcast is given as its maximum over the day (at solar noon) for cloudless weather conditions taking into account only the UV irradiance absorption by ozone. The erythemal UVI at solar noon is obtained by multiplication of D_{noon} with a scale factor of 1/25 mW/m^2. The clear-sky UVI was developed from Canadian scientists in 1992 as a simple measure of risk from unprotected sun exposure. Since introduction of the UVI many countries have adopted and the World Health Organisation (WHO) has harmonized the UVI and promotes sun protection messages (see http://www.who.int/uv/intersunprogramme/activities/uv_index/en/ and [2]).

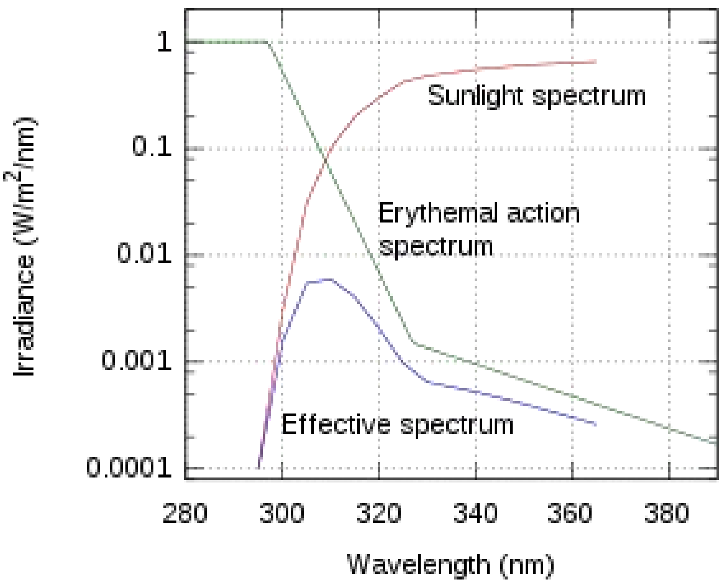

Fig. 1. The effective spectrum obtained by weighting a sun spectrum by the erythemal action spectrum (Source: https://www.revolv/page/Ultraviolet-index)

The erythemal action spectrum together with the sunlight spectrum and the resulting effective spectrum $A_e(\lambda)F_t(\lambda)$ is shown in Fig.1.

Prognosis values of the clear sky UVI are given at many websites (e.g. wetteronline.de/UV, sunburnmap.com) for different locations.

UV-index determination

The basis of the determination of the UVI represents equation (1). Well calibrate spectrometers as SUV 1000 (or monochromators as e.g. Bentham coupled with suitable sensors and detectors) allow to observe global (direct and diffuse) sun irradiance. Such type of instruments are very expensive but highly precise and therefore they are used as standards in intercalibration procedures of different instruments [2, 3]. Another possibility to obtain $F_t(\lambda)$ consists in the spectrum reconstruction from some simultaneous global irradiance filter measurements at only some wavelengths by means of radiation transfer models. Using the Tropospheric Ultraviolet and Visible (TUV) Radiation Transfer Model developed by Madronich [4] look up tables were calculated (see Fig. 2) [5]. They describe the dependences of the UVI from the cloud optical depth (COD) and from the zenith angle (ZA) for different total ozone columns (TOC). The UVI was determined for an annual mean surface albedo of 0.03. Greater deviations from this value are to be expected only for winter conditions if the earth surface is covered by snow. Close snow cover at Stara Zagora appears only during a few days of the year.

The influence of aerosol loading is included in the COD, which has the character of an effective value. Strong aerosol events e.g. evoked by Sahara dust are very rare over Stara Zagora.

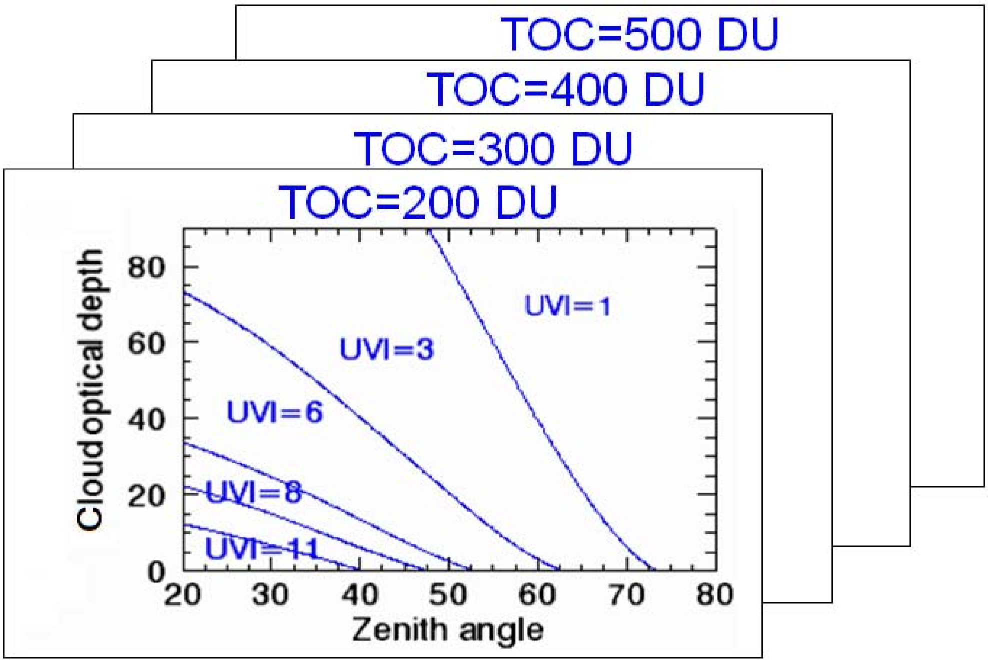

Fig. 2. 3-dimensional look up tables allow the determination of the UVI by interpolation for known ZA, COD and TOC for the moments close to solar noon

Results

The COD's and TOC's were previously determined using GUV 2511 measurements [6,7]. The ZA's were calculated by help of an astronomical algorithm for the measurement moments and then the UVI's for all weather conditions were determined by interpolation of the corresponding Look up table (see Fig. 2). The results are shown in Fig. 3 by blue crosses connected by blue line. The clear-sky UVI's calculated for COD=0 are drawn in Fig. 3 by red open circles and line. The resulting UVI's for clear-sky conditions envelope the UVI for cloudy weather conditions and represent the upper limit. The variability of the clear-sky UVI is caused by changes of the TOC. The UVI shows a typical maximum for latitudes of about 40ºN between 8.5 and 10 during the summer months. For comparison, the clear-sky UVI for the Sofia location obtained from observations by the OMI satellite is considered. As it can be seen from Fig. 4 the agreement is very good characterized by a mean standard deviation of about 0.3**.**

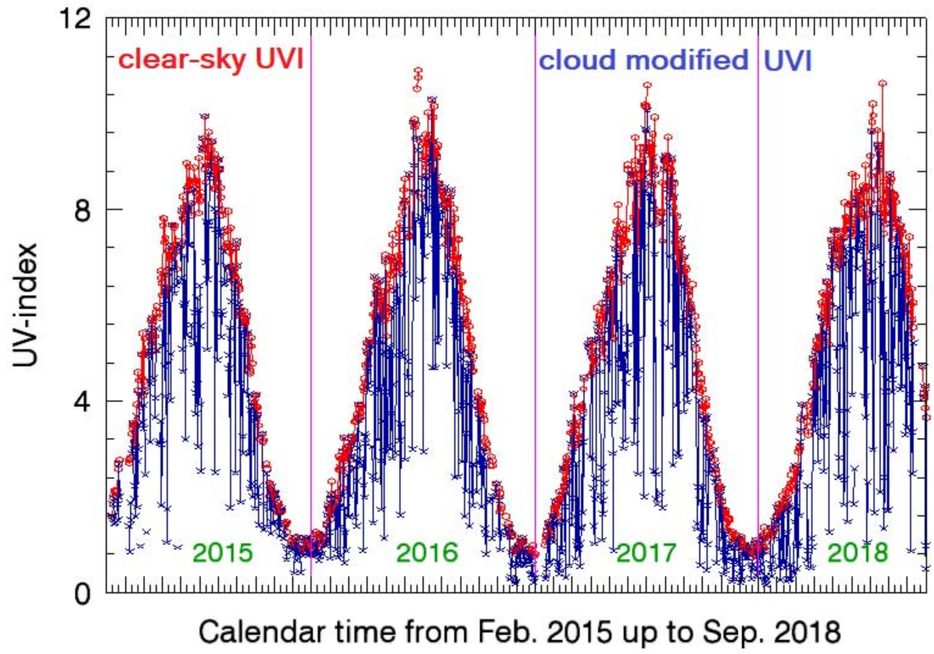

Fig. 3. Cloud modified UVI at Stara Zagora for all weather conditions (blue crosses) and clear-sky conditions (open red circles)

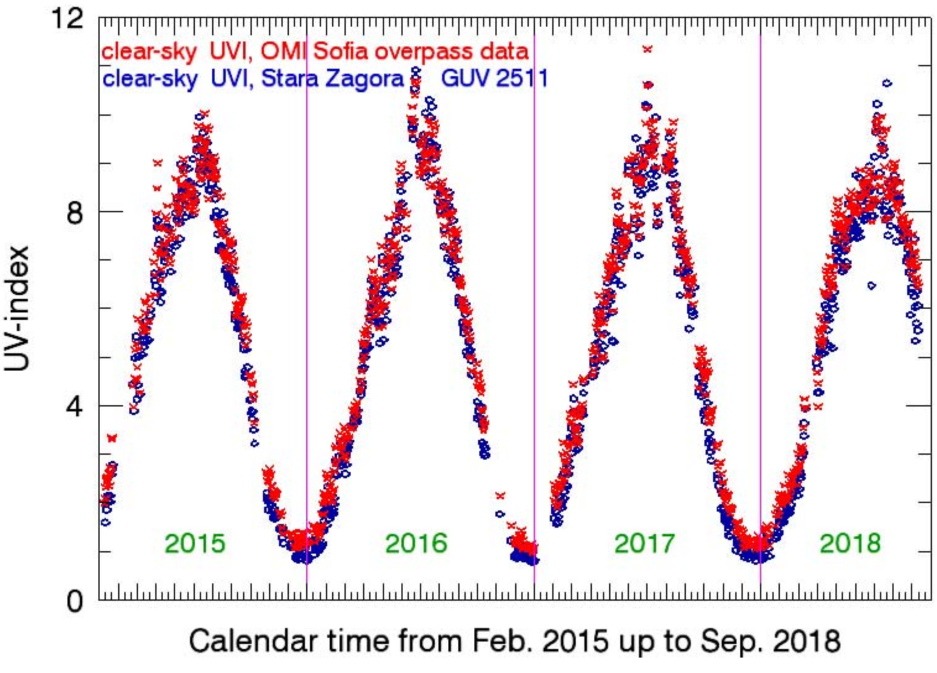

Fig. 4. Clear-sky UVI for Sofia (red crosses) overlaid on the clear-sky UVI for the Stara Zagora location (blue circles)

Conclusions

The results related to the UVI for different weather conditions (clear-sky and cloudiness) based on the retrieval of TOC, COD from the UV irradiance measurements by the algorithms presented here and by the algorithm described in a previous work [5, 6] are typical for 40º N. For the clear-sky UVI a good agreement with UVI based on satellite OMI data was obtained.

Acknowledgments

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