UV Index estimation from global radiation and total ozone observations in Azores.

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Introduction

The UV Index (UVI) is a public-oriented meteorological kind of information about the damaging ultraviolet radiation at the ground (Vaniceck *et al.*, 1999). Its use begins to be so popular as temperatures highs, wind chill, fire risk index, air quality index and other meteorological indexes and parameters.

A UVI scale was already defined by WHO (WHO, 2002) in order to provide a correspondence between UVI levels and protective measures to avoid damaging effects on humans. However, UVI is usually given in integer units, so the required precision for the public must be less or equal than 0.5 UVI units.

While UV dependence on ozone is well understood and easily to model, clouds dependence is more difficult do model and its effect on daily variability is also important. In addition, atmospheric UV measurements are more expensive than global radiation measurements and therefore fewer. However, global radiation is much less dependent on ozone and its variability depends basically on clouds. Therefore, global radiation measurements can be used to correct a simple radiative transfer model for clear sky conditions with respect to the actual cloudiness. The scope of this work is to find an approach to derive UVI from actual global radiation and ozone measurements with acceptable error for public awareness.

Instruments

Global radiation records in Azores started in the 1940's at the Observatory José Agostinho (38º39'32" N, 27º13'23" W, 85 m), located in Angra do Heroísmo city at Terceira Island. In the scope of the research project CLIMAAT (Interreg IIIb), a complete radiation monitoring system was acquired and installed in this site. This system has one automatic sun tracker equipped with one pyranometer for global radiation and two shadow balls for a second pyranometer (diffuse) and for a pyrgeometer (longwave). It has also one NIP pyreliometer and a four-wavelength photometer for aerosol optical depth measurements. An automatic Brewer MKII spectrophotometer is installed at the same place and performing spectral global UV irradiance (290-325 nm) and total ozone measurements several times a day.

Methods

In order to derive UVI from global radiation G, it is assumed that the effect of UVI due to clouds is proportional to the effect on global radiation:

$$\frac{UVI}{UVI_0} \propto \frac{G}{G_0}$$

Where, UVI_0 and G_0 correspond to the same quantities in the absence of clouds. While UV radiation is only reflected by clouds, global radiation is reflected and absorbed, so the attenuation for global radiation should be greater than for UV and more depending on the solar zenith angle and cloud thickness. These effects are difficult to model and require a very complete knowledge of the clouds that is not available. However, the attenuation mechanisms in both cases are directly proportional at first order, so the uncertainty of this approach remains at second order.

In this paper, UVI_0 and G_0 are computed by a simple radiative transfer model for clear sky conditions (Carvalho, 2000) where observed total ozone content and constant conditions for the other attenuation variables are used.

Data collected for this study ranges from August 2004 to August 2006 with some short periods of missing data due to failure problems. Because each UV measurement done by Brewer takes about 3 minutes but global radiation is recorded every 5 seconds, global radiation was integrated over each UV scan period. Daily averages of observed total ozone were used instead of individual observation in order to filter air mass instrumental dependence on the analysis. The spectral integration for the UVI computation was corrected for the 325-400 nm range not measured by Brewer.

Observed diffuse radiation values were also integrated in order to identify periods of radiation intercepted by clouds.

Results

In this analysis was considered three cases: direct sun, cloudy and all conditions. Data were ratio Global/Diffuse greater or equal than 5 were considered as clearly direct sun conditions while data were this ratio was less or equal than 1.1 were considered as clearly cloudy conditions. Linear regression analyses were done in the three cases according the following model:

$$UVI = a\left(\frac{G}{G_0}UVI_0\right) + b$$

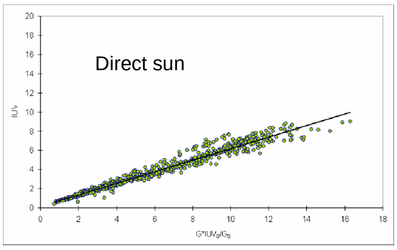


Figure 1 shows the results for the **direct sun** case. A total of 728 pairs of measurements were used. It can be clearly seen that the linear adjust is satisfactory and that data points are well distributed over all the range. However, modeled values are underestimated by the observations due to the super estimation of the UVI0 model or to a different calibration scale of the instrument. For the greater values, data points deviates slightly from the linearity.

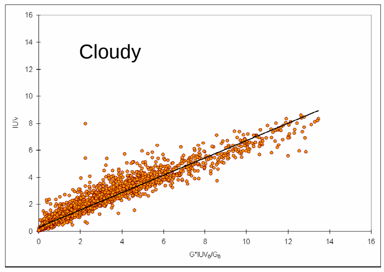
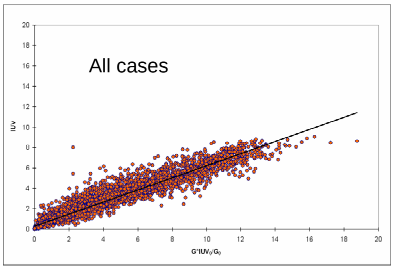


Figure 2 shows the results for **cloudy** conditions case. In this case a total of 3793 pairs of measurements were used. It can be see that it also that linear model is well adjusted and most of data is less than 5-6 UVI units, but obviously with more dispersion. Also in this case, data points deviates slightly from the linearity for the high values.



Finally, in the all the cases,a total of 7151 pairs of observations were used. In these conditions, data points are well distributed over the range but also with a good linear adjustment. Large values below the regression line correspond to the direct sun high values.

Table 1 summarizes the results for the above cases. Excellent correlation coefficients were obtained and therefore linear model is satisfactory and slightly better for direct sun conditions. Standard error ranges from 0.4 UVI units for direct sun conditions to 0.5 units for all and this means that this method can be used for public information purposes.

	R	STD error	a	b
Direct sun	0.97	0.399	0.607 ± 0.004	0.11 ± 0.03
Cloudy	0.93	0.418	0.643 ± 0.003	0.307 ± 0.009
All	0.93	0.498	0.593 ± 0.002	0.303 ± 0.008

The slope "a" is consistent in the three cases and equals to 0.6. Offset "b" is always positive and ranges from 0.1 and 0.3. A positive offset suggests a super estimation of UVI for low values or high zenith angles. Anyway, offsets are inside the standard error and therefore virtually zero.

Conclusions

•A setup for radiation monitoring was installed in the Azores allowing simultaneously measurements of global and diffuse radiation as well as UV spectral irradiances.

•Data collected during two years were used to analyze the relationships between UVI and global radiation during direct sun, cloudy and all conditions.

•A linear model was used to derive UVI from global radiation data and radiative transfer models using observed total ozone data.

•Results show that linear model agrees with correlations greater than 0.97 and standard error less than 0.5 UVI units. These results suggest that this model can be used for public information purposes.

•Linear model parameters suggest that Brewer spectrophotometer calibration scale must be different.

References

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