Solar ultraviolet radiation measurements at South African and Reunion Island Coastal Sites: An indicator of public sun protection

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Solar ultraviolet radiation (UVR) has the potential to cause biological harm to humans. Intensity of solar UVR at the Earth's surface depends on several factors, such as total column ozone and cloud cover, and temporal trends are usually dependent on season and time of day. Understanding such patterns helps inform the development of sun protection awareness information for the public. Here, solar erythemal (sunburning) UVR levels were analysed for three populated coastal sites in South Africa and Reunion Island to determine seasonal and diurnal trends. These trends were then discussed in light of tailoring appropriate public health messages.

Keywords: Erythemal ultraviolet radiation, Sunburn, Durban, Cape Point, Saint Denis, annual variability.

Introduction

Solar radiation covers a broad wavelength range: shorter the wavelength, greater the radiation energy and the greater its capability to produce chemical and biological reactions. Solar ultraviolet radiation (UVR) may be divided into three bands: UV-C, UV-B and UV-A. Most UV-C is absorbed by dioxygen and by stratospheric ozone in the atmosphere and very little reaches the surface of the Earth. UV-B and UV-A are more likely to reach the Earth's surface and impact upon human health. Erythemal UVR is defined as UV spectral irradiance weighted by the action spectrum for sunburn (CIE, 1987) and is a measure of the potential for biological damage due to solar UVR. In this paper, the potential for biological damage was considered for two South African and one Reunion Island coastal sites where the risk of excess sun exposure is relatively high given both populations' outdoor lifestyles and mild climates. Hence, ambient solar erythemal UVR data were analysed to detect seasonal and diurnal trends with the aim of providing information for the development of sun protection awareness campaign information.

Data and Methods

Data collected by South African Weather Service (SAWS) at Cape Point (34.35° S, 18.48° E, 230 metres above sea level (masl)) and Durban (30.0°S, 31.0° E, 8 masl) stations were used (Fig.1). Both are coastal sites. Data from the 2009 year were applied.

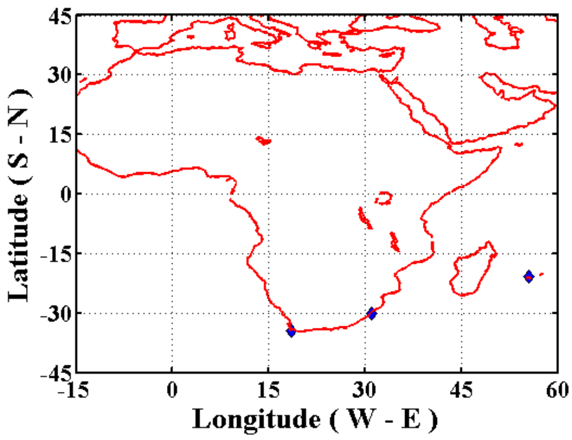

Figure 1.Location of the three solar UVR stations (indicated as ◆ mark) used in this study.

A UV Biometer (model 501) comprising a Robertson-Berger pattern UV radiation detector, digital recorder and control unit is used to measure ambient solar UVR levels at the Cape Point Global Atmosphere Watch station and the Durban weather office. The UV Biometer spectral response closely mimics the McKinley/Diffey Erythemal Action Spectrum (CIE, 1987). Calibration of the UV Biometer enables the logged values to be converted into Ultraviolet Index (UVI) units, an international unit for expressing solar UVR exposure and also to be converted into MED (Minimal Erythemal Dose, 1 MED = 210 Jm^{-2} for skin phototype I) per hour. Recently, the Durban and Cape Point UV Biometers were inter-compared with a travelling standard instrument calibrated against the fast scanning spectro-radiometer SPECTRO 320D NO 15 that has traceability to the International Bureau of Weights and Measures. Analysis found the difference in the instrument pre- and post-calibration was less than 4%.

At Saint Denis, Reunion Island, (20.9° S, 55.5° E, 85 masl), a UV spectro-radiometer is used to measure solar UVR levels. The instrument is a double monochromator Bentham DTMc-300F located at St Denis (20.9° S, 55.5° E, 85 masl). Spectral measurements are performed every 15 min in the 280-400 nm wavelength range, with a 0.5 nm step. Calibration was made against a Bentham CL6-150 W traceable to the National Institute of Standards and Technology. In the UVB range the irradiance expanded uncertainty (coverage factor k = 2) is about 8%. Irradiance measurements were converted to UVI values, thus 8% uncertainty is expected on UVI.

Data were analysed by calculating total daily ambient MED values and comparing by season and time of day by station. For diurnal patterns, the day of the year with the maximum midday UVI value was presented as an illustration of the worst case scenario.

Results and Discussion

The total daily ambient solar UVR levels for the three sites are shown in Figure 2. A typical envelope pattern for Southern Hemisphere annual distribution is evident with highest levels during summer at the beginning (January) and end of the year

(December), and lowest levels during winter in the middle of the year (July). This is indicative of seasonal differences where solar UVR levels decrease from summer to autumn and increase from spring to summer. Public health messages for sun protection are usually provided during summer months, however, such messages should also be conveyed during early autumn and late spring to ensure adequate personal protection is applied by individuals during these potentially at risk periods.

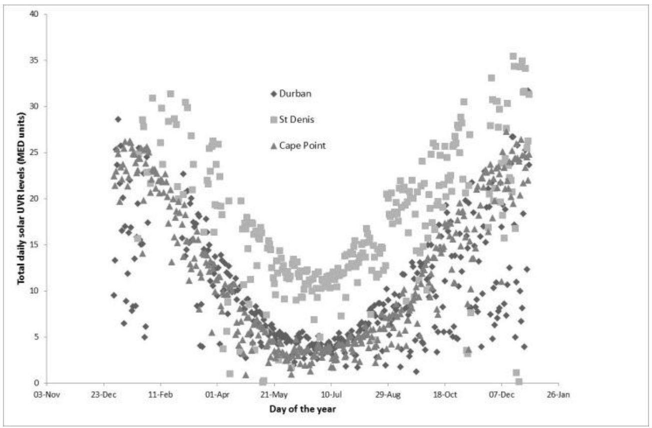

Figure 2. Total daily ambient solar UVR levels (MED units, 12 MED = 210 Jm^{-2}) for Cape Point, Durban and Saint Denis.

Considering the diurnal pattern in ambient solar UVR, Figures 3, 4 and 5 show these for each station for the day on which each station recorded its maximum solar UVR reading for the entire 2009 year. For Cape Point UVR maximum case (Fig. 3) and Durban UVR maximum case (Fig. 4), a reasonably smooth bell-shape with peaks around midday (local solar time) for all three stations is evident, with some deviation likely due to the effects of temporal and spatial short-term changes in cloud cover at all three sites. The diurnal pattern in ambient solar UVR levels for Saint Denis UVR maximum case (Fig. 5) is different from the previous two figures. While the bell-shaped pattern persists, the solar UVR levels for Durban are weak. Cape Point likely experienced a clear-sky day since its UVR levels follow a pronounced bell shape and readings for Saint Denis exhibit some cloud effects, evident from the scatter below the envelope. Partially cloudy skies may enhance solar UVR levels (Pfister et al., 2003) and this may explain the highest reading of the year at St Denis on this day, however other factors may also play a part. Total column ozone also influences surface solar UVR, however, it varies at a far coarser temporal resolution compared to cloud cover on a diurnal time scale.

These diurnal patterns in solar UVR confirm the public health message usually given to the public, i.e. to avoid spending excess time outdoors between 10h00 and 15h00 when the sun is most intense. However, these findings also suggest that the public needs to be made aware that cloud cover plays an important role in diminishing or enhancing surface solar UVR levels.

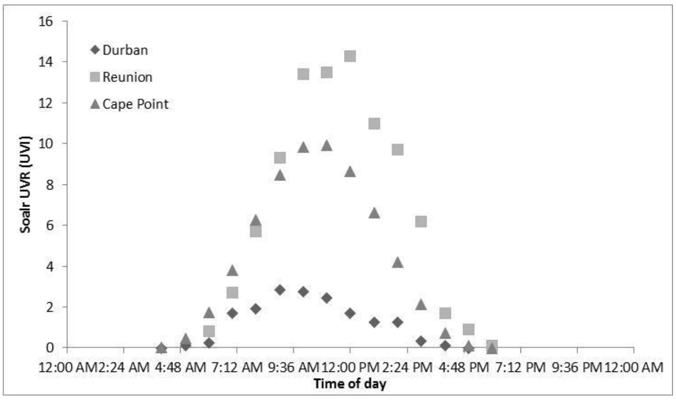

Figure 3. Diurnal pattern in ambient solar UVR levels (UVI) for 11 December 2009 when Cape Point had its highest UVR reading (9.9 UVI).

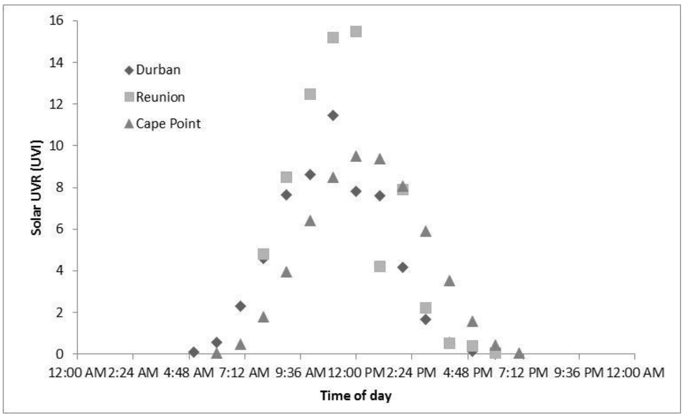

Figure 4. Diurnal pattern in ambient solar UVR levels (UVI) for 30 January 2009 when Durban had its highest UVR reading (11.4 UVI).

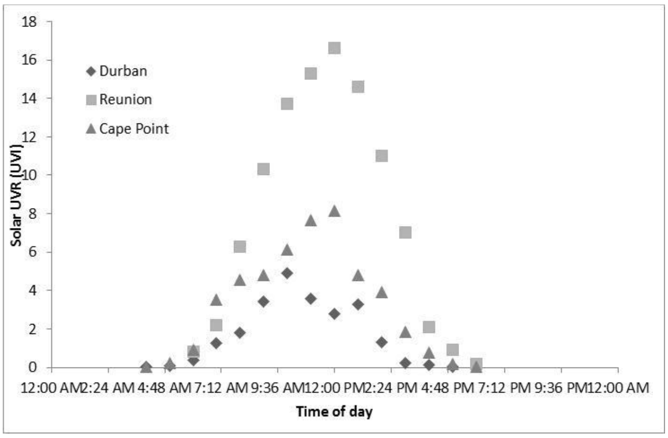

Figure 5. Diurnal pattern in ambient solar UVR levels (UVI) for 23 December 2009 when Saint Denis had its highest UVR reading (16.6 UVI).

A simple message that when the solar disk is completely obscured by dense cloud, sun protection is less necessary (although still preferred since cloud cover may change rapidly) compared to when the solar disk is visible between scattered clouds then additional sun protection is required.

Conclusion

Analysing physical measurements of ambient solar UVR levels is useful for determining seasonal and diurnal patterns in solar UVR which are important for preparing health messages pertaining to sun protection for the general public.

At the three Southern Hemisphere sites analysed here, it was apparent that sun protection messages would be required not only during summer but also during early autumn when ambient solar UVR levels may be high. The data also confirmed the well-known public health message to avoid excess sun exposure between 10h00 and 15h00, but also suggested that cloud cover may weaken or enhance solar UVR levels. A public health message describing an appropriate behavioural response in relation to different cloud cover scenarios may need to be developed for sunny sites such as in South Africa and Reunion Island.

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