Solar Erythemal UV Radiation at New Zealand Centres of Population

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Abstract. Solar erythemal UV radiation has been recorded continuously in central Auckland, Wellington, and Christchurch since 1989. Data were presented at a solar zenith angle of 30^{o} to allow comparisons of UV insolations at different regions and times of the year.

Introduction

Using rugged filter-based UV radiometers, continuous solar erythemal UV radiation measurements has been recorded at centres of population in New Zealand since 1989. These measurements enable temporal and geographical trends in erythemal / carcinogenic solar UV radiation to be established. Knowledge of these trends is of importance in investigating the damaging effects exposure to solar UVB radiation can have on human health, (eg sunburn, and non-melanoma skin cancer) as well as on plants and materials. In addition, trend analysis will aid the understanding the atmospheric factors affecting UV insolation

The end users of this information are atmospheric scientists, materials manufacturers, the agriculture industry and health professionals, such as epidemiologists and government policy makers.

Analysing the Data

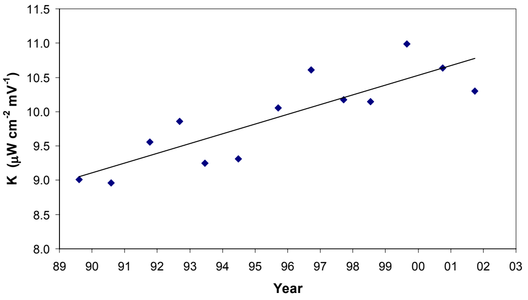
Measured solar UV irradiances were converted to erythemally effective UV irradiances, I, using $I_{\text{erythemal}} = K(\theta)\ I_{\text{measured}}$, where $K(\theta)$ is a proportionality constant;

$$K(\theta) = \frac{\int_{290}^{350} S(\lambda,\theta)\ CIE(\lambda)\ d\lambda}{\int_{290}^{350} S(\lambda,\theta)\ r(\lambda)\ d\lambda}$$

λ = wavelength and θ = solar zenith angle (SZA). The solar spectra, $S(\lambda,\theta)$, used were measured in clear-sky conditions at Lauder in 1996 at SZAs of 22.4° – 60°. $CIE(\lambda)$ is the CIE standard erythemal action spectrum (McKinlay and Diffey, CIE J., 6, 17, 1987).

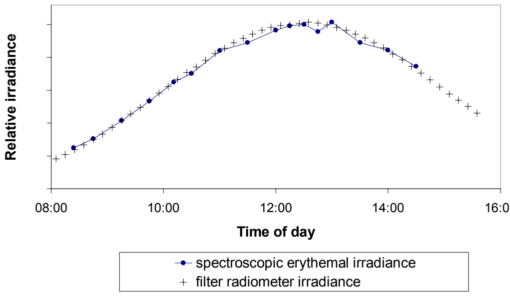
Radiometer absolute spectral responsivities, $r(\lambda)$, were determined by annual calibrations of the instruments, carried out by the New Zealand Measurement Standards Laboratory, Industrial Research Ltd. The calibration factor applied to the data at each site was derived from a linear regression of the calibrations (over 12 years) of each radiometer, as shown in Figure 1.

Fig 1. Calibration of Auckland Radiometer



Data from the filter radiometers were regularly compared with the solar spectra from a spectroradiometer (290 – 350 nm), weighted by the CIE erythemal action spectrum. Comparisons have been made in Wellington on three clear-sky days each year (autumn, summer and spring) since 1998. Excellent correlations between the measured intensities have been found for all intercomparisons, over a wide range of SZAs (corresponding to different times of day and year). A recent example is given in Figure 2.

Fig 2. Comparison of Irradiances, 23 Jan 2002



Results and Discussion

A major determinant in the intensity of solar erythemal UV radiation reaching the earth's surface is the thickness of the atmosphere (and ozone) it has passed through. Thus, in order to draw meaningful conclusions about UV insolations at different geographical locations and times of the year, it is necessary to make comparisons at the same solar zenith angles. Erythemal UV irradiances at a solar zenith angle of 30° in Auckland, Wellington and Christchurch are shown in Figures 3, 4 and 5. The upper envelopes of the graphed data correspond to cloudless (or near cloudless) skies. Higher than cloudless-sky intensities may be due to clouds that are sufficiently close to the sun to act as secondary UV scatterers.

Fig 3. Auckland Erythemal UV, SZA = 30°

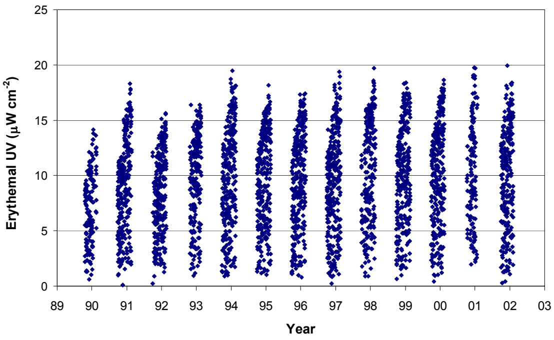


Fig 4. Wellington Erythemal UV, SZA = 30°

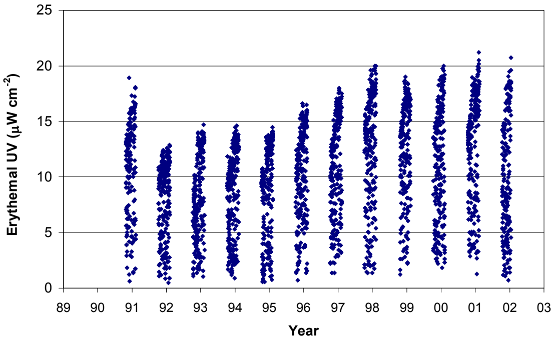
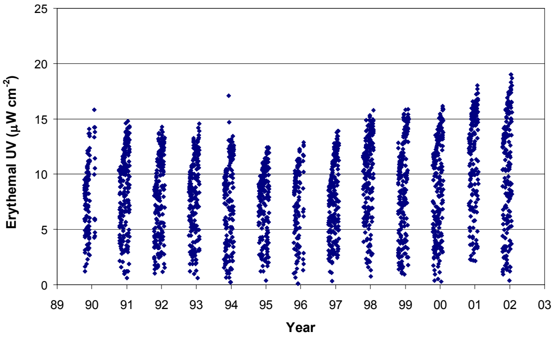
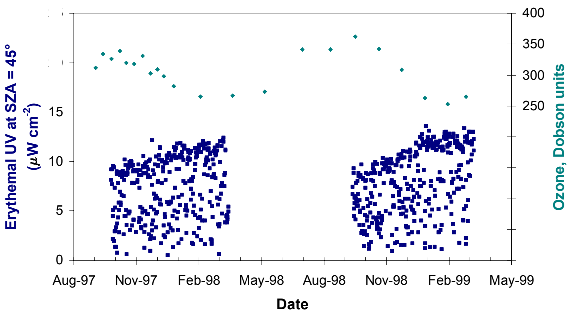


Fig 5. Christchurch Erythemal UV, SZA = 30°



A steady increase from spring to autumn is apparent in all the graphs. This is the result of the naturally occurring annual cycle in stratospheric ozone levels at mid-latitudes where ozone is at a maximum in spring and a minimum in autumn. The correlation between ozone levels (data supplied by R. McKenzie, NIWA) and erythemal UV are shown in Figure 6.

Fig 6. Comparison of Erythemal UV and Atmospheric Ozone



Acknowledgements

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