A UV Atlas for New Zealand

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Abstract. The purpose of the NIWA UV Atlas project is to produce maps and time series of parameters describing the UV radiation environment over New Zealand since 1960. Maps are produced for the area around New Zealand (34°S to 48°S, 166°E to 180°E) while time series are produced at sites where broadband radiation measurements are available (referred to as the UV Atlas sites). The measured broadband radiation measurements are used to infer the effects of cloud cover based on comparisons with modelled clear-sky irradiances [*Bodeker and McKenzie,* 1996; hereafter referred to as BM96]. The first version of a CD containing most of the UV Atlas project outputs for the period 1979 to 2001, as well as data viewing software, has been created. Details on CD availability are available on:

http://www.niwa.co.nz/services/uvozone/atlas

The purpose of this paper is to describe in more detail the contents of the CD and the origin of the data sets provided. The data provided on the CD have a range of applications including long-term trend studies which include the effects of long-term changes in cloud cover, epidemiological studies, analyses of the sources of long-term trends in UV over New Zealand etc.

Method

The primary output from the UV Atlas project is estimated true erythemal UV in the presence of clouds, calculated as follows:

$$E_{true} = E_{model} \times A_{sza} \times (I_{meas}/I_{model})^{Psza} \quad (1)$$

where E_{model} is the modelled clear-sky erythemal UV (see below), I_{meas} is the measured broadband radiation, I_{model} is the modelled clear-sky broadband radiation and A_{sza} and P_{sza} are solar zenith angle dependent coefficients derived from plots of E_R ($=E_{meas}/E_{model}$) against I_R ($=I_{meas}/I_{model}$) at Lauder, where E_{meas} is the measured erythemal UV [BM96]. E_{model} is calculated using the TUV radiative transfer model [*Madronich,* 1993], with ozone and surface pressure as inputs. I_{model} is calculated using a simple one layer radiative transfer model, with surface pressure, temperature and humidity as inputs. The aerosol loading for both models was specified as:

$$\beta = 0.03\times(\cos(2\pi*\text{Day}/365))+0.08 \quad (2)$$

where Day is the day of the year. The value modifying E_{model} to produce E_{true} is called the cloud cover modification factor (CCMF):

$$CCMF = A_{sza} \times (I_{meas}/I_{model})^{Psza} \quad (3)$$

The inputs to the model calculations are also provided on the CD, as described below.

Data on the CD

The data provided in the CD include time series, at a number of locations, of clear-sky erythemal UV, estimated true erythemal UV, CCMFs, modelled broadband radiation, measured broadband radiation, temperature, surface pressure, sea level pressure, humidity, and total column ozone. These are provided at hourly, daily, monthly and annual resolution, except for ozone which does not have data at hourly resolution. The CD also includes maps of clear-sky erythemal UV, estimated true erythemal UV, sea-level pressure, surface pressure, and total column ozone. These are provided at hourly, daily, monthly and annual resolution except for maps of estimated true erythemal UV which are provided only at hourly resolution and ozone maps which are provided only at daily, monthly and annual resolution.

Clear-sky erythemal UV maps

These maps are calculated in real-time using a 4 dimensional look-up table. An example of a clear-sky erythemal UV map, produced by the data viewing software provided on the CD, is shown in Figure 1.

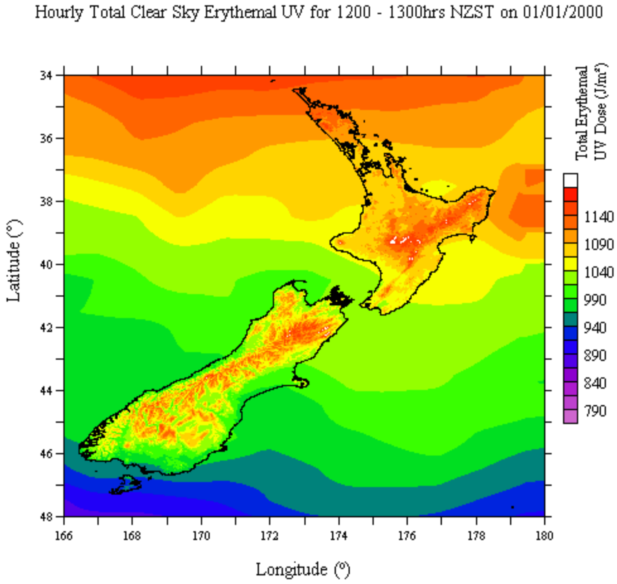

Figure 1: An example hourly total clear sky erythemal UV map.

Estimated true erythemal UV maps

Maps of estimated true erythemal UV irradiance are generated by calculating CCMFs at all available sites, and spatially interpolating these factors for the whole of the country. The applicability of this spatial interpolation is uncertain and care must be taken when interpreting these maps. This is particularly so in the presence of changing topography which can cause strong spatial inhomogeniety in cloud cover. Future research will investigate more appropriate interpolation methods and application of measured or assimilated clouds fields.

Sea level pressure and surface pressure maps

Hourly sea level pressure maps are calculated by interpolating between 12 hourly NCEP/NCAR sea level pres-

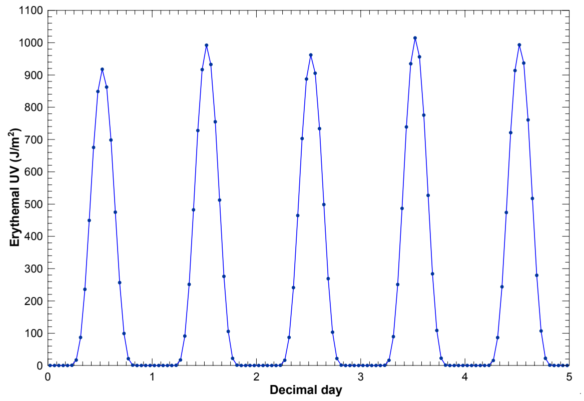

Figure 2: An example hourly clear sky erythemal UV time seri-esfor Christchurch: 1 January to 5 January 2001

sure fields which cover the entire domain, and combining these with the hourly pressure data extracted from the NIWA climate data base (CLIDB) which have the advantage of high spatial and temporal resolution. Surface pressure maps are calculated from sea level pressure maps assuming hydrostatic balance and a layer mean temperature of 283K.

Total column ozone maps

Daily total column ozone fields for the New Zealand domain are extracted from an assimilation of 5 different satellite-based global data sets [*Bodeker et al.,* 2001]. The coverage of these data is incomplete and a least squares regression model which accounts for much of the variability (e.g. annual cycle, trend, QBO, solar cycle, ENSO, volcanoes) is used to estimate the ozone field when no measurements are available.

Clear sky erythemal UV time series

For each of the UV Atlas sites, time series of hourly clear sky erythemal UV have been calculated using the TUV radiative transfer model [*Madronich,* 1993] and are stored on the CD. In addition to the hourly data, daily, monthly or annual mean dose, total dose, maximum irradiance or maximum hourly dose can be displayed. An example of an hourly resolution clear sky erythemal UV time series is shown in Figure 2.

Estimated true erythemal UV time series

As described above, the estimated true erythemal UV is

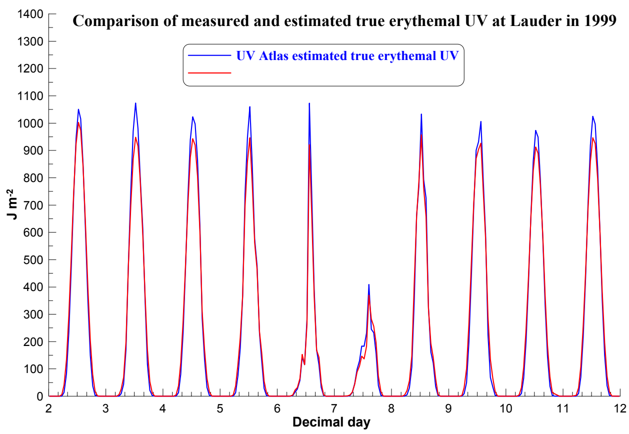

Figure 3: Comparison of measured and estimated true erythemal UV at Lauder in 1999.

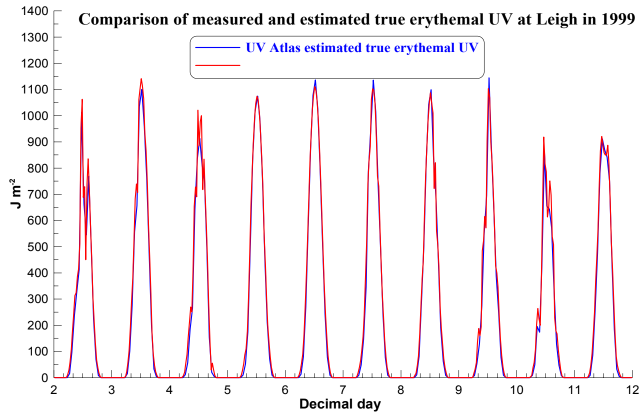

Figure 4: Comparison of measured and estimated true erythemal UV at Leigh in 1999.

derived by multiplying the clear sky erythemal UV with the CCMF. An example of hourly estimated true erythemal UV, together with measurements of the actual UV, at Lauder, is shown in Figure 3. Because the A_{sza} and P_{sza} coefficients used to derive the CCMFs were calculated at Lauder, this comparison may be circular to some extent. To investigate the applicability of the A and P coefficients to other locations, a comparison of measured and estimated true erythemal UV for Leigh is presented in Figure 4.

Auxiliary time series

As part of the data quality control procedures for the surface temperature, pressure and humidity from CLIDB, estimates of these parameters are made from measurements at surrounding locations. These auxiliary data files are also provided on the CD. When surface temperature, pressure, or humidity measurements are unavailable, or are erroneous, the auxiliary time series are used. An example of measured and auxiliary surface pressure time series for

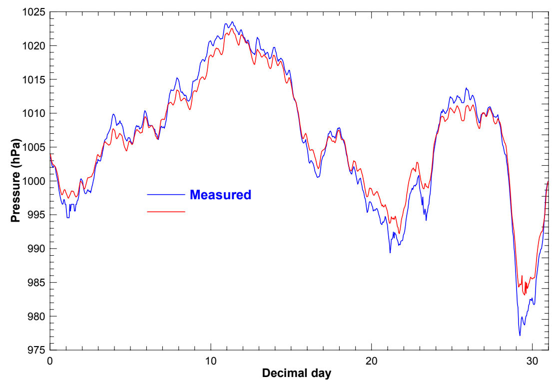

Figure5: An example of an auxiliary surface pressure time series.

Christchurch is shown in Figure 5.

References

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Madronich, S., 1993: UV radiation in the natural and perturbed atmosphere. *Environmental Effects of UV (Ultraviolet) Radiation*, M. Tevini, Ed., Lewis Publisher, Boca Raton, 17-69.