UV Index to the Public

R.L. McKenzie

National Institute of Water and Atmospheric Research, NIWA, Lauder, New Zealand

J.A. Renwick

National Institute of Water and Atmospheric Research, NIWA, Greta Point, New Zealand

Abstract. The UV Index is introduced. Its implementation in New Zealand is described and the results of its skill tests by comparison with Lauder data are presented.

UV Index Forecasting

NIWA provides UV information to the public through the internet (www.niwa.co.nz), and by distribution to the media via the New Zealand Meteorological Service. This information is provided in terms of the UV Index scale (see box), which has been adopted Internationally since 1994 [*WMO*, 1994].

The UV index is a standard measurement of erythemally-weighted [*McKinlay and Diffey*, 1987], or "sun-burning" UV intensity that gives a more objective measure than the old "time to burn" (which is less accurate and cannot account for skin tone). The scale is open-ended, but a UV index of greater than 10 is extreme and a UV index of less than 1 is low. At high altitudes in the tropics the UV Index can exceed 20, and it would reach a value of about 300 outside the Earth's protective atmosphere.

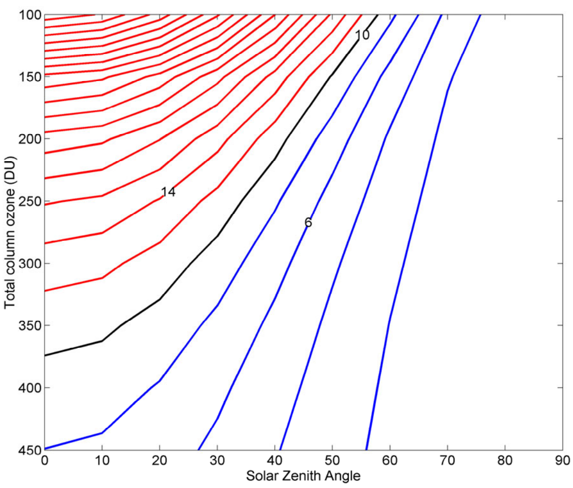
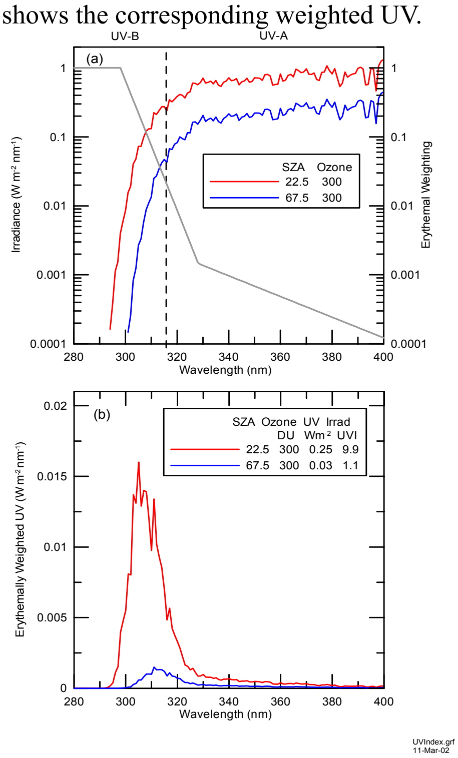


Figure 1. UV Index as a function of ozone and solar zenith angle. In New Zealand, ozone ranges from approximately 250 to 450 Dobson Units (DU). The minimum solar zenith angle in New Zealand is about 15º.

The UV index provided by NIWA is calculated for clear sky conditions, using the solar zenith angle (i.e., the complement of solar elevation) and ozone as inputs, as shown in Figure 1. Allowances are also made for variations in aerosol optical depth at some city sites, and

Definition of the "UV Index" (UVI)

The Internationally-agreed UV Index scale is defined in terms of the erythemally weighted UV (i.e., "skin-reddening", or "sunburning") irradiance. The erythemal weighting function, which is applied to the spectrum, involves an arbitrary normalization to unity at wavelengths shorter than 298 nm, so erythemally weighted UV is not strictly an SI unit. Furthermore, another normalization is applied to provide the UV Index (see equation below). With this normalization, the maximum UV Index in Canada (where the unit was first used) is about 10 for normal ozone conditions. The top panel of the figure below shows sample spectra and the weighting function. The lower panel shows the corresponding weighted UV.



UV Index $= 40 \int I(\lambda)\, w(\lambda)\, d\lambda$, where

λ is the wavelength in nm

$I(\lambda)$ is the irradiance in W m^{-2},

$w(\lambda)$ is the erythemal weighting function, which is defined as:

$w(\lambda) = 1.0$	for $250 < \lambda \leq 298$ nm
$w(\lambda) = 10^{0.094(298-\lambda)}$	for $298 < \lambda \leq 328$ nm
$w(\lambda) = 10^{0.015(139-\lambda)}$	for $328 > \lambda \leq 400$ nm
$w(\lambda) = 0.0$	for $\lambda > 400$ nm

for variations in topography. In clean air conditions, sun-burning UV increases by approximately 5% per km increase in altitude.

Our initial forecasts, in 1994, simply assumed a constant monthly climatology of ozone. The next development stage, in 1997, was to use ozone from TOVS satellite measurements on the previous day and to assume that changes in ozone over the forecast period were small [*Marks and McKenzie*, 1997]. In the summer 2000-2001 we adopted a simple ozone advection scheme based on winds at 100 hPa (about 16 km altitude) predicted by the NCEP global weather forecast model. An immediate success was the prediction of a very low ozone event over southern tip of South America following the breakup of the Antarctic Ozone Hole in October 2000. However, in the long term we found the simple advection scheme induced larger variabilities in forecast ozone than occurred in reality. In October 2001 we implemented the current scheme, which uses forecast ozone fields that are based on measurements from the SBUV instrument, with ozone fields assimilated into the NCEP global analysis at NOAANOAA and predicted as part of the NCEP global forecast. The ozone measurements from satellite are cross-calibrated against ozone measurements from the Dobson spectrometer at Lauder. Typically the satellite ozone retrievals during summer are reduced by 10-15 DU.

Validation of Forecasts

The performance of the ozone and UV forecasts was tested against measurements of ozone and UV at Lauder, and the most recent method was found to be the best (see Table 1). The results for 0 and 48 hour forecasts of ozone over the summer period are summarized in Figure 2.

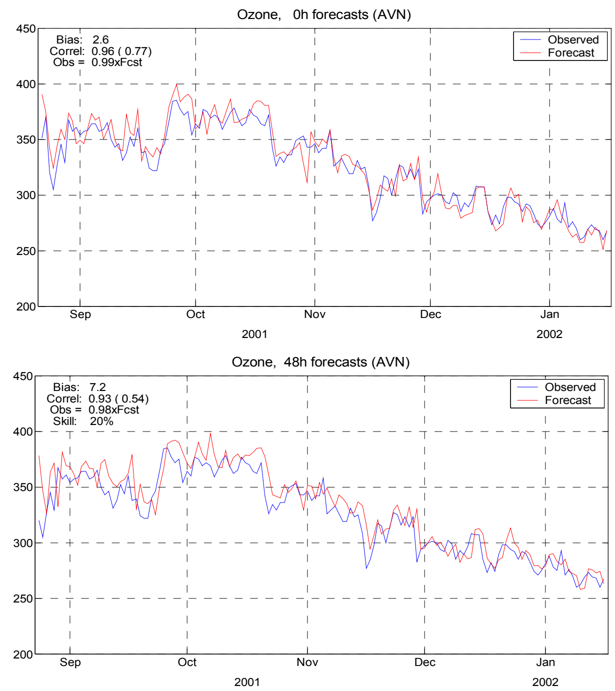


Figure 2. Skill of ozone 0Hr and 48hr forecast for Lauder.

Corresponding results for the UV Index are shown in Figure 3. Note that during the period tested over the "summer" of 2001-2002, there were very few clear days. Consequently, the measured UVI was generally less than the clear-sky UVI predicted.The inclusion of cloud effects of clouds in the forecasts of UV is a possible future improvement. This could be achieved by using a mesoscale model of cloud forecasts. However, this approach is subject to large uncertainties. Even with accurate cloud forecasts, the effects on UV are not easy to predict. Even for rather large fractional cloud cover, UV intensities can be similar to clear sky cases, and can even exceed the clear sky values.

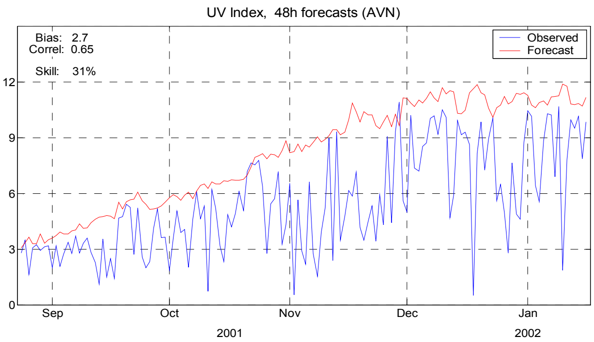


Figure 3. Skill of UVI 48 hr forecast for Lauder.

Table 1. Short term correlation between forecast ozone and measured ozone at Lauder after removing seasonal cycles (note periods analysed are not all the same). The last column shows the skill over persistence for the 48 hr forecast.

Forecast Method	Correlation / Skill		
	0 hr	48 hr	Skill
TOVS + persistence	0.33	0.39	-59%
TOVS + simple advection	0.34	0.33	-66%
SBUV + NCEP advection	0.77	0.54	+20%

References

Marks, C., and R.L. McKenzie, UV Index forecasts and data for New Zealand on the Internet, *Water and Atmosphere*, *5* (4), 13-14, 1997.

McKinlay, A.F., and B.L. Diffey, A Reference Action Spectrum for Ultra-violet Induced Erythema in Human Skin, in *Human Exposure to Ultraviolet Radiation: Risks and Regulations*, edited by W.F. Passchier, and B.F.M. Bosnajakovic, pp. 83-87, Elsevier, Amsterdam, 1987.

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