UV in the Melanoma Capital of the World Compared with Other Locations

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Abstract. UV radiation in New Zealand (NZ) is compared with other locations, and it is shown that while it is high compared with the UK, it is not particularly high in a global sense. Our high skin cancer rates are not due to increased UV from ozone depletion, but mainly to other factors. Further, it is shown that the advice that "no protection is required for UVI less than 3" is flawed for New Zealand conditions, where sunburning doses can occur on winter days when the UVI remain less than that threshold.

Introduction

Previously, it was shown, using satellite data, that the peak UVI in NZ is approximately double that in the UK, but approximately half that in the tropical Andes, where record high values occur (Liley & McKenzie 2006). However, satellite instruments do not take full account of the effects of aerosols in the lower atmosphere. Here we use measurements from a small number of sites, in conjunction with model calculations from a much larger number of sites, to investigate these differences more closely (Table 1).

Table 1. Mean measured UVI at noon for summer and winter for sites in NZ, compared with Australia, and the UK. Sites are listed in increasing distance from the equator, with New Zealand sites in bold. Colour coding is as specified by WHO/WMO

City	Country	Latitude	Summer UVI	Winter UVI
Darwin	AUS	12°S	13	8
Brisbane	AUS	27°S	12	4
Perth	AUS	31°S	12	3
Sydney	AUS	33°S	11	2
Adelaide	AUS	35°S	11	2
Canberra	AUS	35°S	11	2
Auckland	**NZ**	**37°S**	**10**	**1**
Melbourne	AUS	38°S	10	2
Wellington	**NZ**	**41°S**	**9**	**1**
Hobart	AUS	43°S	8	1
Christchurch	**NZ**	**44°S**	**8**	**1**
Lauder	**NZ**	**45°S**	**8**	**1**
Invercargill	**NZ**	**46°S**	**7**	**0**
London (Chilton)	UK	52°N	5	0
Leeds	UK	54°N	5	0
Glasgow	UK	56°N	4	0

The table shows that summer noon UVI values in NZ are twice those in the UK, but they are lower than most Australian cities. For all New Zealand sites, in winter at noon, the mean UVI is 1 or less. Clear-sky values are typically larger by 20 to 30%. Cloud enhancement can also lead to further short-term enhancements of 20 to 30%, so peak values are typically 50% greater than shown in the table.

Calculations with the "TUV" model, as implemented in the GlobalUV app, (McKenzie 2016) were used to extend the coverage to over 400 sites worldwide. Results are shown in Fig. 1.

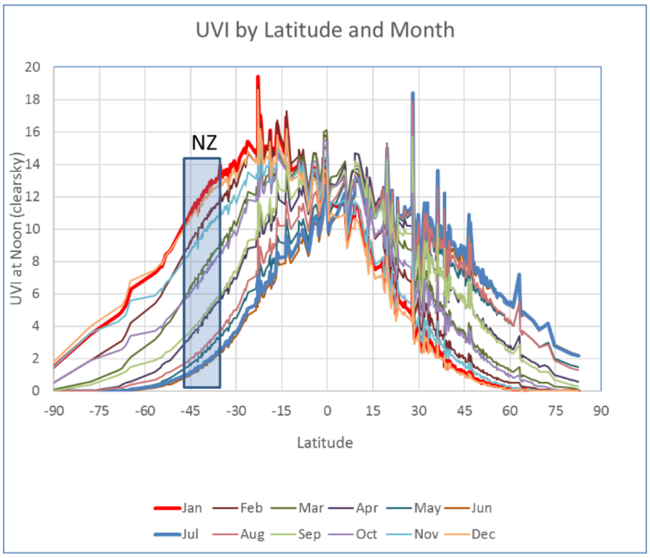

Figure 1. Latitudinal variation of peak UVI, derived from the GlobalUV app for clear sky conditions. All NZ sites are within the shaded area (negative for southern latitudes.

Steep latitudinal gradients associated with changing solar zenith angles are clear, but there is also a distinct interhemispheric asymmetry, with larger UVI values in the southern hemisphere (SH), due to the combined effects of lower ozone, cleaner air, and closer Earth-Sun separation in the SH summer. Consequently, the peak UVI is higher at all SH sites north of NZ, as well as most tropical sites. These clear-sky UVI values are 20 to 30% greater than the mean values including clouds shown in Table 1, and for these conditions, the peak UVI in NZ is again approximately twice that in the UK. The outlier peaks in Fig. 1 are from high altitude sites, notably Mt Licancabur (23°S, alt: 6 km) in the Bolivian Andes, and Mt Everest (28°N, alt: 8.8 km). For these calculations, the peak UVI is again the tropical Andes, but it is less than twice that in NZ. During the winter months of June and July, the clear-sky UVI remains less than 3 throughout NZ. For such low UVI values the recommendation is that "no protection is required". But is that good advice?

In Fig. 2 we show the daily doses of sunburning UV, measured in terms of the "Standard Erythemal Dose" (SED), where 1 SED=100 Jm^{-2} of erythemally weighted UV irradiance, and for which 1 "Minimum Erythemal Dose" (MED) is approximately 2 to 2.5 SED for fair skin (McKinlay & Diffey 1987). The pattern is like that of Fig.

1, with daily doses for summer months exceeding 70 SED over a wide range of southern latitudes. The figure also illustrates that for any month of the year, the daily dose exceeds 3 SED throughout NZ. Since most of the UV arrives within 3 hours of solar noon, this implies that extended activities, such as playing golf over the midday period, can lead to sunburn even in the depths of winter in the southernmost city. This is inconsistent with the advice currently given that "no protection is required for UVI values less than 3". That UV Alert threshold arbitrarily corresponds to the minimum UVI for which fair skinned people will receive perceptible skin damage in less than about 1 hour. It does not apply for longer exposure periods.

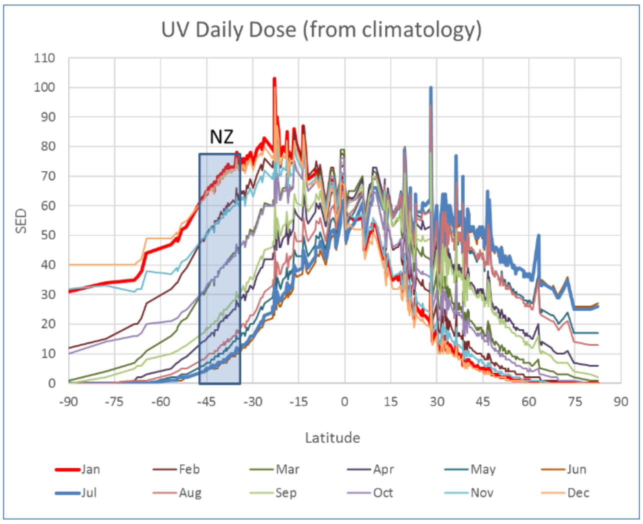

Figure 2. As for Fig. 1, but for daily dose in SEDs, derived from the GlobalUV app for clear sky conditions.

The latitudinal dependence of annual doses at a selection of sites where NDACC-quality measurements are available, is shown in Fig. 3. The calculated values are again higher than measured, except at the highest latitudes, where the UVI changes rapidly during the month, so the assumption that the month value is well represented by that for the mid-month is flawed.

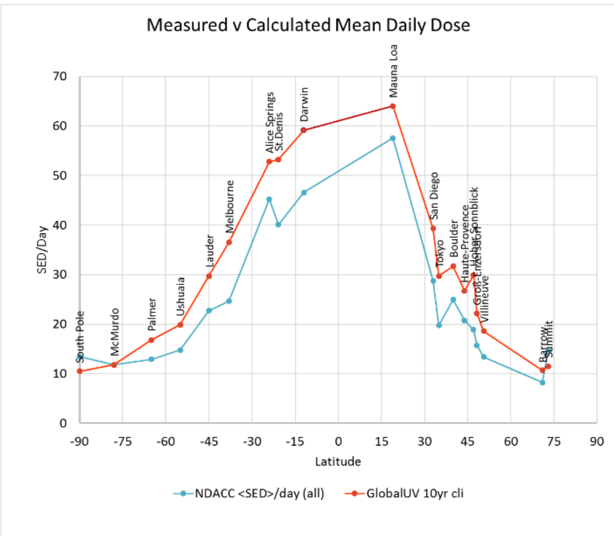

Figure 3. Comparing annual mean daily doses with values calculated for clear skies from the GlobalUV app.

Discussion

Had it not been for the Montreal Protocol, UVI values in NZ would by now be ~20% greater than in 1990 when measurements began. However, because of the success of the Montreal Protocol, UVI values have not changed significantly in NZ since the early 1990s (McKenzie et al. 2018), as shown in Fig. 4.

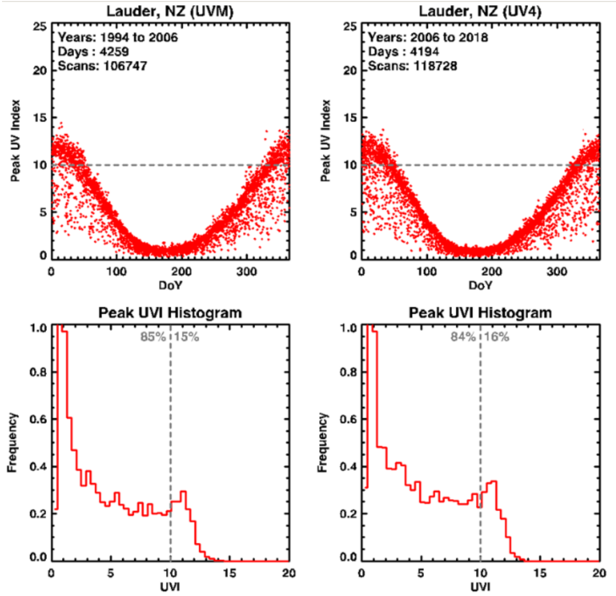

Figure 4. Comparison between annual variation (upper panels) and the frequency distributions (lower panels) of UVI for the past two 12-year periods, based on measurements at Lauder employing the same data sampling protocols.

NZ's high rates of melanoma are not due to changes in ozone. Rather they are likely due to genetic factors associated with inappropriate Anglo-Saxon or Celtic skin types being exposed to much higher levels of UV than those in the British Isles to which they had been adapted. Despite the much higher UVI levels in Australia compared with New Zealand, skin cancer rates are quite similar. We speculate that this may be attributable to different ethnic mixes between the two countries, if a greater proportion of Australia's immigrant population is from southern European countries (e.g., Greece, Spain), for which skin type are typically larger, rather than the British Isles. Another factor, that may be important, is the warmer temperatures in Australia which encourage shade-seeking behaviour, compared with the cooler temperatures in NZ, which encourages sun-seeking behaviour. It is also possible that other factors, such as lower vitamin D status, and smaller per capita investment in public education and health may contribute to NZ's poorer statistics. For whatever reason, mortality rates for all forms of cancer are greater in New Zealand than Australia.

Conclusions

UV radiation levels in NZ are high compared with the UK and corresponding NH latitudes, but they are not particularly high in a global sense. Nor have they changed appreciably in the last 3 decades. Our high skin cancer rates are likely due to our relatively high ambient UV radiation for the skin types of the population, and behavioural factors, rather than ozone depletion. We also show that the advice that "no protection is required" for UVI less than 3 is flawed for New Zealand conditions, where sunburning doses can occur on winter days when the UVI remains less than that threshold.

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