Seasonal and Geographic Variation of Vitamin D Producing Radiation in New Zealand

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Abstract. The role of vitamin-D in maximising health and reducing the risk of disease, which has been discussed extensively in the literature in recent years (e.g., Holick, Zitterman, Lucas and Ponsonby), raises the question of the balance of this beneficial role of ultraviolet (UV) radiation with the well established risks of over exposure in the New Zealand summer. A recent study by Green et. al., at Otago University shows that many New Zealanders have sub-optimal levels of vitamin-D, posing the question of how to balance the benefits of UV exposure against the hazards. The key lies in understanding the wide range in UV intensity with time of day, season and latitude. We also suggest the concept of a "safe zone" between excess and insufficiency.

Table 1. shows the calculated scale of variation, relative to Auckland in summer, in the daily dose of clear sky UV available for vitamin-D production (UVvitD) for selected season and latitude. The action spectrum used was from MacLaughlin, et.al. 1982, and the calculations are for a horizontal surface.

City	Latitude (ºS)	Summer	Winter
Brisbane	27.0	1.1 ± 0.1	0.25 ± 0.05
Auckland	37.0	1.0	0.08 ± 0.02
Invercargill	46.5	0.8 ± 0.1	0.02 ± 0.01

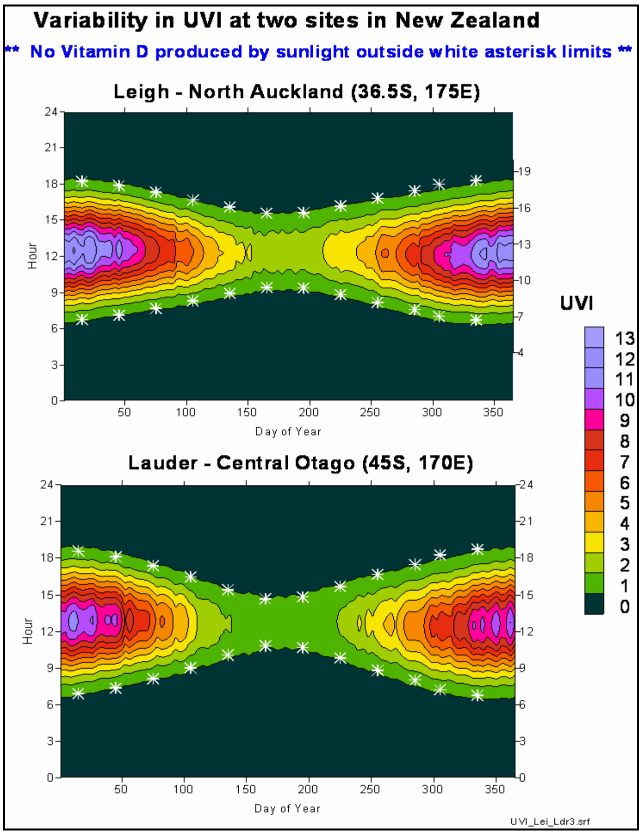
The factor of about 50 (note the large fractional uncertainty in the winter values) difference between summer UVvitD in Auckland and winter UVvitD in Invercargill may surprise. Strong atmospheric absorption by ozone and scattering of UV in the atmosphere for low sun, results in an intensity that is strongly attenuated in winter at higher latitudes. Note the much smaller seasonal extremes in low-latitude Brisbane (1.1 to 0.25) compared to high-latitude Invercargill (0.8 to 0.02). By contrast, visible light under clear skies shows a much smaller variation between seasons and latitudes.

Table 2. shows the calculated variation, relative to Auckland in summer, in the peak daily intensity of clear sky UV available for vitamin-D production at midday.

City	Latitude (ºS)	Summer	Winter
Auckland	37.0	1.0	0.12 ± 0.02
Invercargill	46.5	0.8 ± 0.1	0.03 ± 0.01

Comparison with the daily dose variations in Table 1. shows that in Invercargill, the effective period near midday is shorter. The seasonal variation in dose is larger than the seasonal variation in peak value because of the changes in length of day with season.

An early study on this topic (Webb et al., 1988) showed that in Boston (42°N), at similar northern latitude to the mean southern latitude of New Zealand, vitamin D production from sunlight remained zero for several months over the winter. This is important because the biological half-life of Vitamin D is at most a few weeks (Zitterman, 2003). Engelson, et.al. (2005) used this result to calculate the duration of zero vitamin-D production, and provided a web-based tool for global calculations that is used here to calculate the limits of the day for vitamin-D production near the north and south of New Zealand. Advice to the public on UV intensity uses the internationally accepted UV Index (UVI). In New Zealand the peak UVI in summer can exceed 12, but peak values in winter are less than two. The figure shows that there is a strong latitudinal and seasonal dependence in the periods when UV damage can occur (UVI > 3) and when vitamin-D can be produced (between the asterisks).



To help health advisers reconcile the important need to warn against the risk of excessive UV exposure while maintaining adequate vitamin-D levels in a population with a UV climate that varies widely with time-of-day, season and latitude, we suggest the concept of a 'safe zone', which will ensure the benefit of naturally made vitamin D without high risk of skin damage and cancers. Throughout the country, exposure to the midday sun should be avoided over the summer, especially for the 5-hour period centred on solar noon (e.g., from 11 am to 4 pm). However, if the same advice is heeded in the winter, then no vitamin D will be produced. In the south of the country in the middle of winter, vitamin D production is limited to three hours around solar noon. To produce enough vitamin D, most people should expose skin to the sun around midday in winter, but only in the morning or late afternoon in summer. The optimum exposure periods satisfying both requirements are in the green regions of the plot, where $1 \leq UVI \leq 3$.

For health advisors the strong contrasts in UV intensity are an important consideration. During winter, especially in the south, some UV exposure should be recommended for natural production of vitamin D. It will need to include the midday period; the same time that exposure to the sun should be avoided in summer. Clearly, the effectiveness of following such advice will depend on several factors, not least cloud cover and the need to dress to keep warm in the New Zealand winter. Further work is needed to verify the action spectrum for vitamin D production because of it's importance in calculating UVvitD doses.

NIWA's UV measurements data bases, UV Atlas and scientific skills are available for further research on the vitamin-D question in cooperation with the medical research community.

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