

The Solar UVR Exposure Research Environment in South Africa: Past, Present and Future

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INTRODUCTION

On average, places in South Africa experience between 6 and 12 hours of sunshine per day. Of course, on heavily cloudy and rainy days, less sunshine reaches us, but generally we enjoy a frequent supply of blue skies and bright sun. So, what does this mean in terms of our potential exposure to solar ultraviolet radiation (UVR)?

WHAT IS SOLAR UVR?

Solar radiation may be defined as the solar electromagnetic spectrum which covers a broad wavelength range (Figure 1); the shorter the wavelength, the greater the radiation energy and its capability to produce chemical and biological reactions. Solar UVR is a relatively small part of the spectrum and may be further divided into three bands: UV-C, UV-B and UV-A. Most UV-C is absorbed by ozone in the atmosphere and very little reaches the Earth's surface. UV-B and UV-A are more likely to reach the Earth's surface and pose human health risks.

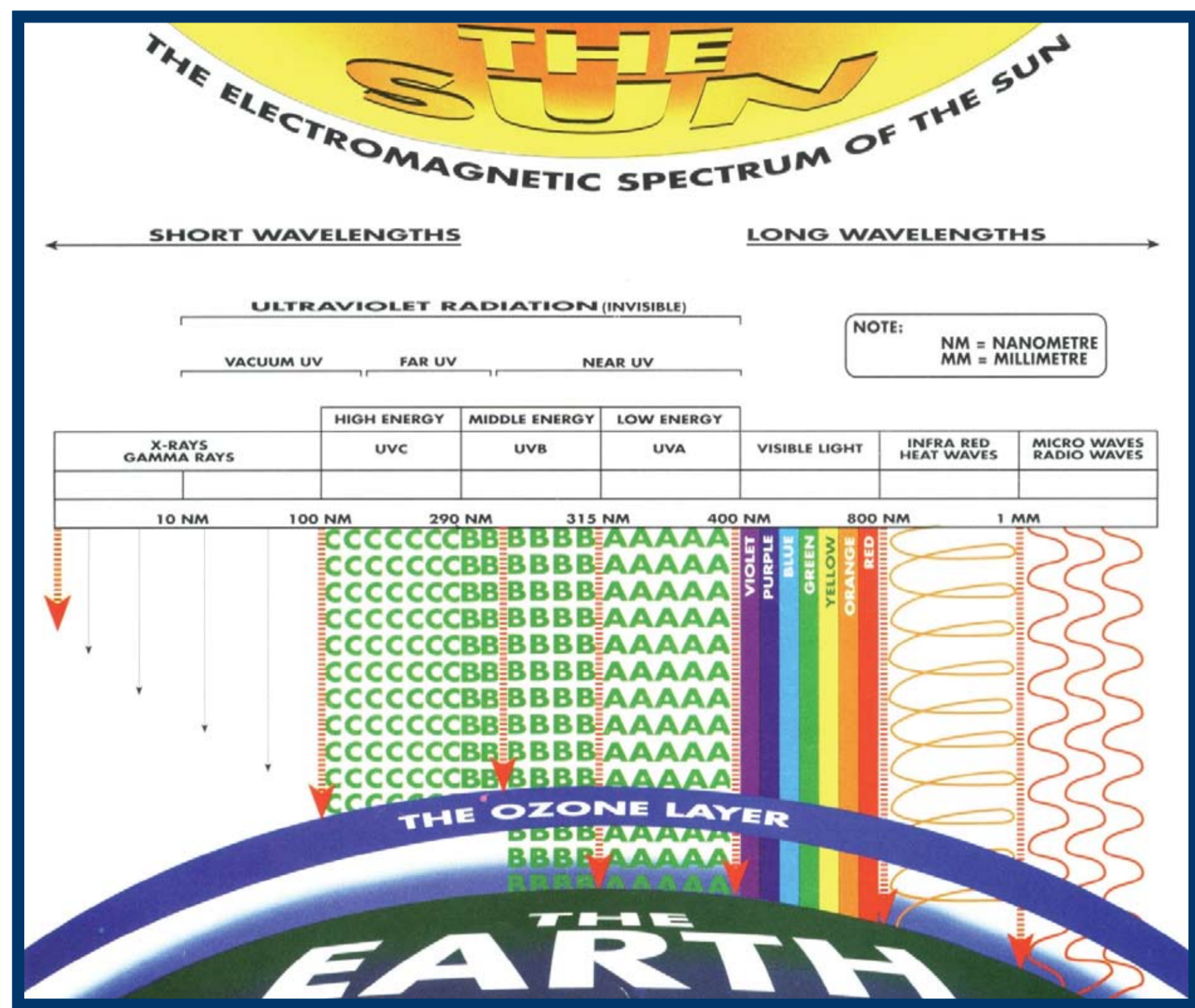


Figure 1: The solar electromagnetic spectrum

HUMAN HEALTH EFFECTS FROM SOLAR UVR EXPOSURE

For humans, solar UVR exposure has both positive and negative effects, as indicated in Table 1. Sunburn and skin cancer (non-melanoma and melanoma skin cancers) are the two most commonly-experienced adverse health effects. The relationship between sun exposure, sunburn and skin cancer is complex. Non-melanoma skin cancers are seldom fatal; however they may be disfiguring and painful. Melanoma is fatal if undetected sufficiently early enough for treatment. Melanin in human skin affords some natural protection against the harmful effects of solar UVR; however, ocular exposure is also a concern in South Africa where the sun shines approximately 3 500 hours every year.

Table 1: The influence of solar UVR exposure on human health

Beneficial effects	Detrimental effects	
	Sufficient exposure	Excess exposure
Adequate vitamin D production Maintenance of bone health	Inadequate vitamin D production Osteomalacia* osteoporosis* rickets*	Immune system activating latent virus infections - herpes labialis* Eyes cataract* snow blindness* pterygium* SCC of the cornea* SCC of the conjunctiva* solar keratoses
Resistance to some diseases Non-Hodgkins Lymphoma	Psychiatric disorders SAD* Schizophrenia	Skin Sunburn* Photodermatoses* BCC of the skin* SCC of the skin* Cutaneous malignant melanoma*
Prostate cancer* Breast cancer* Colon cancer*		
Psychological and general well-being		

Note. * Possible beneficial effects of adequate UVR exposure. # Strong evidence of causality. SAD, Seasonal Affective Disorder; SCC, Squamous Cell Carcinoma; BCC, Basal Cell Carcinoma.

SOLAR UVR EXPOSURE-RELATED HEALTH EFFECTS IN SOUTH AFRICA

According to 1998/9 Cancer Registry records, melanoma and non-melanoma skin cancers account for approximately 30% of all histologically-diagnosed cancers. About 850 South Africans die each year from melanoma. Ocular cataracts are considered responsible for 60% of blindness among South Africans. Individuals with minimum natural protection, including fair skinned individuals, albinos (~25 per 100 000) and people spending extended periods outdoors and unprotected are at risk.

PREVIOUS RESEARCH

In South Africa, limited personal sun exposure research has been carried out (Table 2). This research has focussed on measuring, modelling and analysing the ambient solar UVR and ozone environment; personal solar UVR dosimetry (in other words, measuring real people's sun exposure); the epidemiology of skin cancer; and people's sun behaviour and sun protection. Related work has been on sunscreen chemistry, plant solar UVR exposure and personal use of photochromic eyeglass lenses. Previous research suggested a general increase in ambient UVR between 1979 and 2001. Ambient UVR levels were greatest during summer and in the country's interior. One study investigated sunscreen use among Capetonians in 1991/2 and less than half of those interviewed reportedly applied sunscreen.

Table 2: Main author and date of previously published research relating to personal solar UVR exposure and human health effects

	Main Author, Date	Research focus
UVR and ozone monitoring (12 papers)	Cunningham, 2000	UVB measurements
	Musil, 2003	UVB flux
	Musil, 2002	Instrument calibrations
	Schmalwieser, 2007	Erythral UVR and ozone
	Human, 2002	Model UV Index
	Duigan, 1995	UVB Durban
	Archer, 1995	Erythral UVR Pretoria
	Diab, 1992	Ozone satellite observations
	Karicharran, 1993	Trends in total ozone over South Africa
	Scourfield, 1990	Ozone measurements
Personal UVR dosimetry (3 papers)	Harman, 1996	UVB increases 1979-1992
	Prause, 2000	UVR and ozone Durban
	Guy, 2002	HRA in Durban
Epidemiology of skin cancer	Guy, 2003	Durban children exposure
	Wright, 2004	Anatomical distribution
	Swan, 2003	Melanoma mixed ancestry
	Saxe, 1998	Melanoma Cape Town
	Rippey, 1984	Epidemiology of melanoma in South Africa
	Hudson, 1995	Melanoma in Black South Africans
	Sitas, 1988	Histologically diagnosed melanoma
	Shapiro, 1953	Skin cancer Bantu
	Oettle, 1964	Cancer in South Africa
	Sun behaviour/ protection (4 papers)	Schultz, 1998
Lund, 2008		Lock sun protection albinos
Von Schimming, 1991		Sunscreen use Cape Town
Lund, 2002		Interventions albinos South Africa

Note. For full reference of each paper, please contact cwright@csir.co.za

In 2001, personal sun behaviour and UVR exposure patterns were analysed among a sample of Durban schoolchildren. Children received about 5% of the total daily ambient UVR, a finding consistent with similar studies among children in New Zealand, Australia and the United Kingdom, and activity was the most important influencing factor. However, no published personal solar UVR exposure and sun behaviour research has been carried out in recent years.

RECENT ANALYSES TO CONSIDER PERSONAL SOLAR UVR EXPOSURE AND SUNBURN RISK

The South African Weather Service has been monitoring ambient solar UVR levels for several years at six permanent stations in South Africa: Durban, Pretoria, Cape Point, Cape Town, Port Elizabeth and De Aar. In a rudimentary exercise, monitored ambient solar UVR levels were converted into possible child and outdoor worker exposures using the reported 5%¹ and 20%² of the total daily ambient solar UVR, respectively (Figures 2 and 3). The risk of sunburn, an indication of sun exposure, is provided by skin type in Table 3 and overlaid onto the child and outdoor worker exposure graphs.

Table 3: The Fitzpatrick skin phototype classification with UVR exposure estimates likely to cause sunburn on un-tanned skin

Skin type	Unexposed skin colour	Constitutive characteristics	UVR sensitivity	History of sunburn	History of tanning ability	Continuous UVR exposure estimated to elicit sunburn on un-tanned skin (SED)
I	White	Fair skin, blue or light eyes and freckles	Extremely sensitive	Always burns on minimal sun exposure	Never tans	2 - 3
II	White	Red or blonde hair, blue, hazel or brown eyes and freckles	Very sensitive	Burns very readily	Tans slowly and with difficulty, freckles common	2.5 - 3
III	White or light brown	Brown hair and blue, hazel or brown eyes	Moderately sensitive	May burn on regular sun exposure with no protection	Tans relatively slowly	3 - 5
IV	Light brown	Brown hair and dark eyes	Relatively tolerant to UVR	Burns rarely	Tans rapidly on exposure to minimal UVR	4.5 - 6
V	Brown	Brown eyes and dark brown or black hair	Very variable	Despite pigmentation, may burn surprisingly easily on sun exposure	Difficult to assess because of genetically-determined pigmentation	6 - 20
VI	Black	Brown eyes and dark brown or black hair	Relatively insensitive	Rarely burns, though sunburn is difficult to detect on heavily pigmented skin	Again difficult to assess on heavily pigmented skin	6 - 20

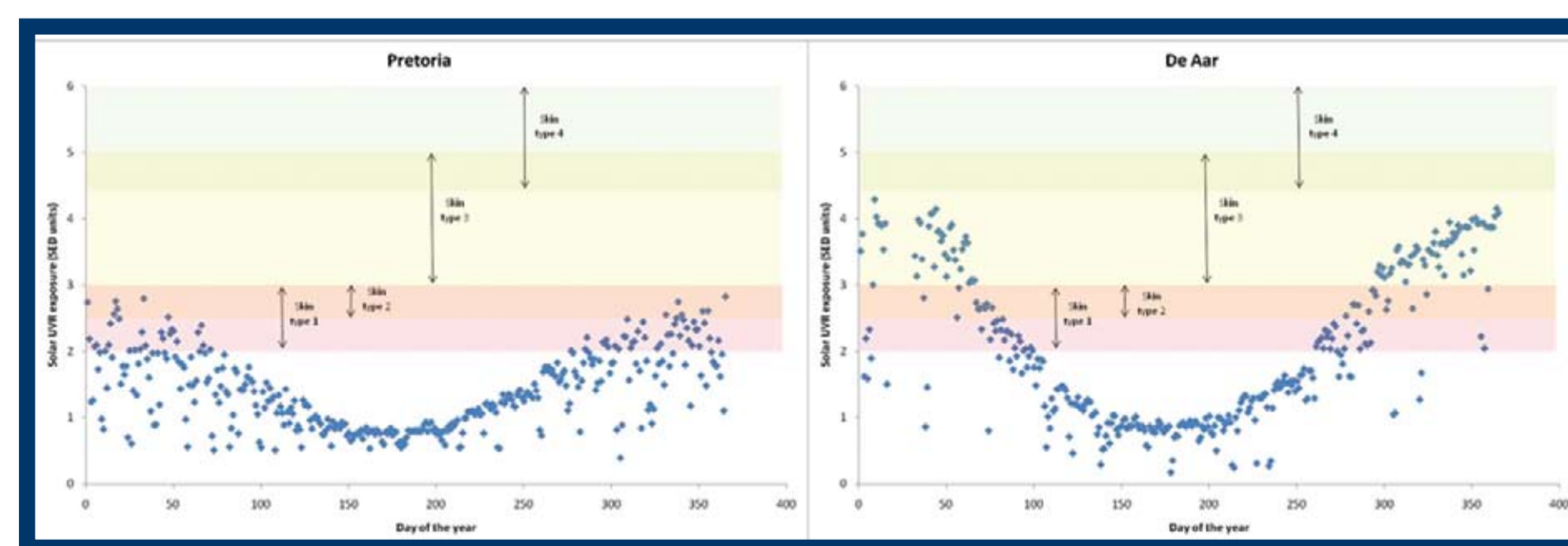


Figure 2: Potential child total daily solar UVR exposure for 2006 at Pretoria and De Aar. Continuous UVR exposure estimates likely to elicit sunburn on un-tanned skin are overlaid – refer to Table 3 for details on each skin type. (SED, Standard Erythral Dose; 1 SED = 100 Jm⁻²)

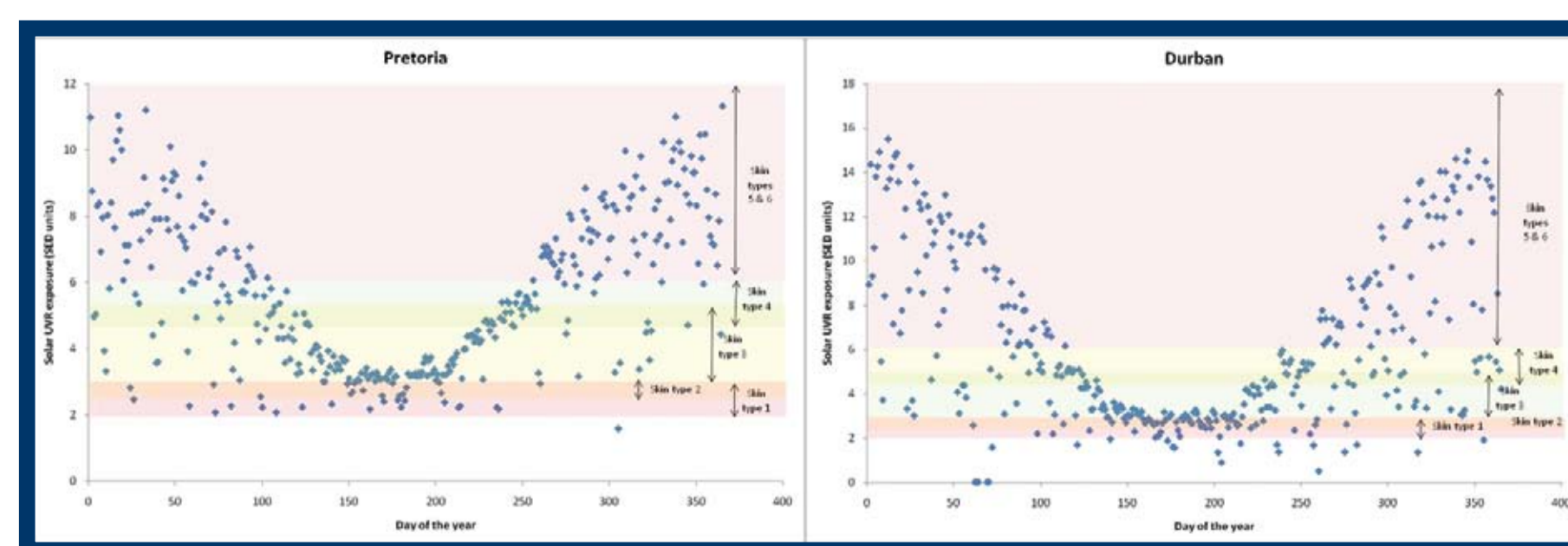


Figure 3: Potential outdoor worker total daily solar UVR exposure for 2006 at Pretoria and Durban. Continuous UVR exposure estimates likely to elicit sunburn on un-tanned skin are overlaid – refer to Table 3 for details on each skin type. (SED, Standard Erythral Dose; 1 SED = 100 Jm⁻²)

Currently there exists no up-to-date information for the design of effective skin cancer prevention and sun protection awareness campaigns and interventions in South Africa. The National Cancer Registry is not operational at present, while limited personal sun exposure research has been carried out in South Africa over the past few years



Results suggest that children and outdoor workers continue to be at risk of sunburn, depending on skin type, sun protection, timing and duration of exposure, and activity. The riskiest hour is from 12:00 to 13:00 when the sun is directly overhead, as shown in Figure 4 which indicates the total ambient solar UVR for this hour. It is common that school lunch break and play time fall within this hour. Outdoor workers (such as road and construction workers, horticulturalists, etc.) may seek shade for a lunchtime break at this time; however, their total exposure remains high due to lengthy time periods outdoors either side of midday.

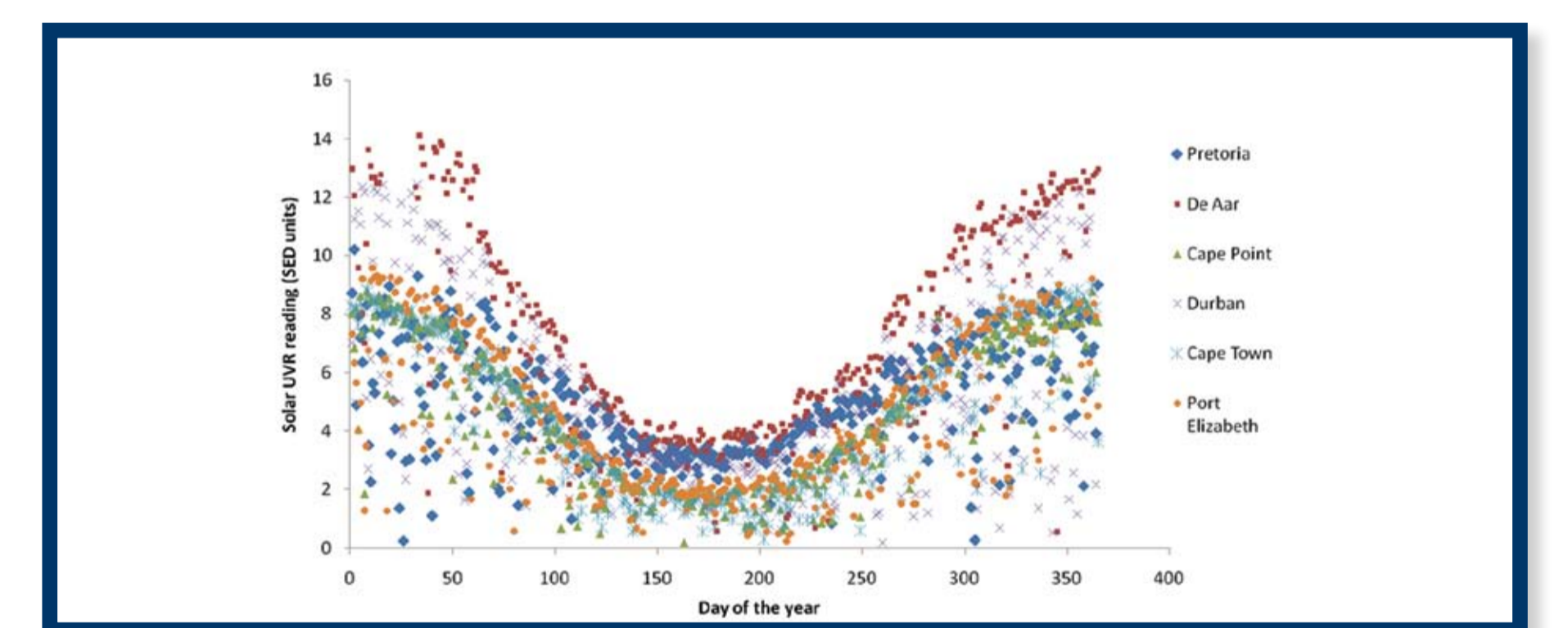


Figure 4: Ambient one-hour solar UVR exposure for midday maximum between 12:00 and 13h00 at 6 stations across South Africa in 2006. (SED, Standard Erythral Dose; 1 SED = 100 Jm⁻²)

FUTURE RESEARCH: ACTION NEEDED

To have up-to-date information for the design of effective skin cancer prevention and sun protection awareness campaigns and interventions, the National Cancer Registry (currently non-existent) needs to be reinstated. Furthermore, calibration, coverage and increased capacity for data management remain issues of concern for the existing solar UVR monitoring network. Future accurate, reliable research will only be achieved when such issues are resolved and a holistic research approach may then be applied.

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REFERENCES

- Guy, C., Diab, R. and Martingh, B.S. 2003. Ultraviolet Radiation Exposure of Children and Adolescents in Durban, South Africa, Photochemistry and Photobiology, 77(3):265-270.
- Hammond, V., Reeder, A.I. and Gray, A. 2009. Patterns of real-time occupational ultraviolet radiation exposure among a sample of outdoor workers in New Zealand. Public Health, 123:182-187.
- Cancer Society of New Zealand. 2005. Position Statement: Vitamin D. Wellington: Cancer Society of Zealand.