Measurements of Solar UVR at Australian Antarctic Stations

Stuart Henderson, Peter Gies, John Javorniczky and Colin Roy

Australian Radiation Protection and Nuclear Safety Agency, Yallambie, Victoria, Australia

Jeff Ayton, Roland Watzl and Des Lugg

Australian Antarctic Division, Kingston, Tasmania, Australia

Abstract. Changes in stratospheric ozone have a direct impact on the solar ultraviolet radiation (UVR) levels reaching the earth's surface. A decrease in ozone leads to an increase in the biologically effective UVB radiation (280-315 nm) with potentially serious consequences for humans [*Diffey*, 2004] and other organisms [*Lubin et al.*, 2004; *Helbling et al.*, 2005]. Measurements of solar UVR in Antarctica provide an indicator of how great an effect the depletion of ozone has at the surface in a region known to have large variations in ozone. ARPANSA has been monitoring solar UVR at the edge of the Antarctic continent and on sub-Antarctic Macquarie Island over many years to track these variations with time.

Introduction

At the request of the Australian Antarctic Division medical personnel, ARPANSA placed UV detectors at all the permanently staffed Australian Antarctic stations in 1989 in order to monitor the UVR environment and assist in determining the exposure of expeditioners. Measurements of solar ultraviolet radiation at Casey (66.3°S), Davis (68.6°S) and Mawson (67.6°S) stations on the Antarctic continent, as well as Macquarie Island (54.6°S) have been collected since that time.

The current generation of detectors, Solar Light UVBiometers Model 501, were installed at Casey and Davis in 1996, Mawson in 2002 and Macquarie Island in 2001. These instruments measure biologically effective solar UVR, often referred to as UVR_{eff} and the results are reported in units of standard erythemal dose (SED)[†] and UV Index[‡]. Casey and Davis stations presently have the longest available data records. Previous years' data, stretching back to 1989, was captured using a different detector system and that data is currently being reconciled with the current data set.

Results and Discussion

The measured annual total UVR_{eff} at each of the Australian Antarctic stations and Macquarie Island for the summer-centred years 1996/97 to 2004/05 are shown in Table 1.

Table 1: The measured annual UVR_{eff} in SED.

	Annual UVR_{eff} [SED]			
Year	**Casey**	**Davis**	**Mawson**	**Mac Is**
1996/97	5084	5460	-	-
1997/98	5559	5164	-	-
1998/99	5785	5993	-	-
1999/00	5672	6071	-	-
2000/01	5337	4859	-	-
2001/02	6049	5884	-	3932
2002/03	4781	4441	4781	3762
2003/04	5088	5381	5079	3855
2004/05	5446	-	4821	3844
Mean	5407	5355	4907	3898
Std dev	395	537	132	64

The Australian Antarctic stations have annual totals significantly higher than would be expected on the basis of their latitudes [*Godar*, 2005]. The annual total UVR_{eff} is substantially higher than those recorded at Macquarie Island. This is due to the presence of ozone depleted air and the ozone hole[§] passing over these Antarctic stations in spring and thereby allowing enhanced transmission of UVB wavelengths to the earth's surface during that time. Maximum daily UV Index values for the Australian Antarctic stations in spring are also significantly higher than at Macquarie Island and are comparable to those measured in the southern capital cities of Australia [*Gies et al.*, 2004].

The differences in annual totals at each site are due to variations from year to year in the cloud cover and ozone. For Casey and Davis, which have the longest data records, this variability is approximately 7 and 9 % respectively, compared to 2 to 4 % for Australian mainland sites.

Presented in Figure 1 is the daily maximum UV Index measured at Davis station. In this representation both the seasonal and inter-annual variation is clearly evident. The most dramatic change between years occurred for the summers of 2001/02 and 2002/03.

The spring of 2002 was unusual amongst the years of our data record in that the influence of the ozone hole was minimal. The mean springtime (September to November) ozone at Casey and Davis was 380 and 340 DU in 2002,

[†] 1 SED is 100 $J.m^{-2}$ when weighted with the CIE 1987 erythemal response. Generally 2 SED will produce erythema (sunburn) in people with fair skin.

[‡] 1 UV Index unit is defined as 25 $mW.m^{-2}$ or equivalently 0.9 SED per hour [WHO 2002].

[§] The ozone hole is defined as the region with ozone levels below 220 Dobson units (DU). 100 DU is equivalent to 1 mm of stratospheric ozone at STP.

while in 2001 it was 250 and 180 DU respectively (the long-term average values are 330 and 270 DU). Casey had only one day and Davis four where the ozone level was below 220 DU in the spring of 2002. This compares to 37 and 94 days, respectively, the previous year. Consequently, at both Casey and Davis, the daily totals (Table 1) and maximum UV Index levels (Figure 1) were high for the summer of 2001/02 and low for the following summer of 2002/03.

Unlike mid-latitude sites, where the yearly UV Index maxima are usually in January, the Antarctic sites generally have their UV Index maxima in late November to early December.

Figures 2 and 3 show the maximum UV Index values recorded at Casey and Macquarie Island every ten minutes for each date of any year over the entire measurement period. These UV "footprints" are determined by the interplay between site latitude, weather conditions, ozone levels and surface albedo characteristic of each site. As

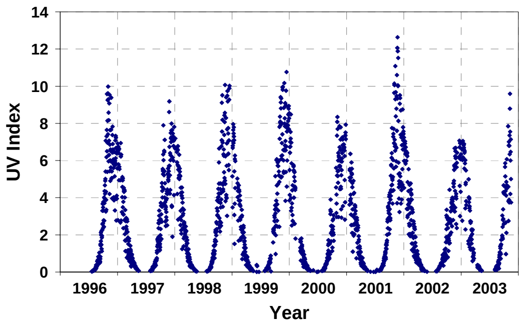

Figure 1: The measured maximum UV Index at Davis (68.6°S) over the period 1996-2003.

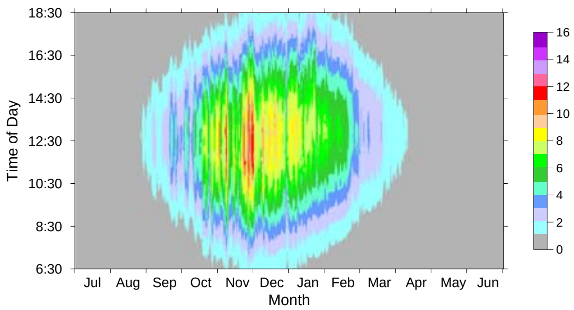

Figure 2: The maximum measured UV Index at Casey (66.3°S) over the period 1997-2004.

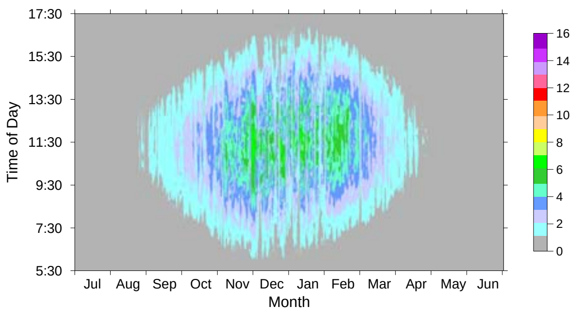

Figure 3: The maximum measured UV Index at Macquarie Is (54.6°S) over the period 2001-2004.

the maximum UV Index value for each time point is shown, clear-sky conditions and minimum ozone values will dominate and the resulting footprints represent the worst-case situation for UV exposure. The footprints for the other Antarctic sites are similar to Casey's, they show that the UV Index reaches extreme levels (>10) in spring.

Casey generally has slightly higher UV Indices than Davis. This may perhaps have to do with the locations themselves (location, local geography and topology). Peak UV Index values at Macquarie Island are rarely greater than 8 compared to 10 and occasionally 12 for Casey, Davis and Mawson.

Conclusion

The Australian Antarctic stations have annual solar UVR totals significantly higher than expected for their latitude and higher than those recorded at Macquarie Island. This is due to the presence of ozone depleted air and transit of the ozone hole over the stations facilitating enhanced transmission of UVB wavelengths through the atmosphere in spring.

Maximum daily UV Index values for the Australian Antarctic stations in spring are also significantly higher than at Macquarie Island and are comparable to those measured in the southern capital cities of Australia.

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