Measurement of the UVR Exposures of Expeditioners on Antarctic Resupply Voyages.

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Abstract. A pilot study assessment of the potential exposure to solar ultraviolet radiation (UVR) of expeditioners on the Australian Antarctic resupply voyages was carried out over the summer of 2004/05 using UVR sensitive polysulphone (PS) badges. Subjects wore their PS badges on the chest for the duration of their working day, which ranged from 9 to 14 hours. Ambient solar UVR was also measured using PS badges located in an unshaded area in the vicinity of the workers. The subjects wore standard Australian Antarctic clothing, although the face and in some cases the hands were uncovered and subject to exposure to UVR. Measurements were carried out during unloading of two resupply vessels while they were at the three Antarctic stations of Casey, Davis and Mawson. The ozone levels above the stations were approximately 277 ± 15 dobson units (DU) for the days when measurements were taken. Ambient solar UVR ranged from 7 Standard Erythemal Doses (SEDs) to 23 SEDs per day and the subject badges received exposures ranging from 0.2 to 10 SEDs.

Introduction

The persisting ozone hole over Antarctica during spring and early summer has increased awareness over the possible adverse human health effects due to increased levels of solar ultraviolet radiation (UVR). The amount of UVR that reaches the surface can be highly variable, UVR levels can be calculated for varying solar elevation and time of day, however, other factors such as atmospheric ozone and cloud cover are less predictable. It is important to quantify the UVR exposure levels of expeditioners in Antarctica and personal dosimeters provide a simple method of evaluating the UVR exposures. This pilot study assessed the potential exposure of 6 to 14 workers in the Antarctic at Casey, Davis and Mawson during January and March 2005 using UVR sensitive PS badges. Subjects included a diverse group of workers from machinery operators to barge unloaders. The PS badges were placed on the chest of the workers as shown in Figure 1. Badges were also placed onto a horizontal unshaded surface to measure the ambient solar UVR during a typical 9 to 14 hour working day. Workers wore clothing provided by the Australian Antarctic Division (AAD), but in some cases the face and hands were uncovered. The workers were also provided sunglasses for protection of the eyes and sunscreen for areas of skin not covered by clothing.

Previous studies of outdoor workers such as [*Gies and Wright,* 2003] in Queensland showed that the UVR doses received by a worker were significant and often well in excess of the recommended exposure limits. *Herlihy et al,* 1994 measured the personal UVR exposures for people engaged in outdoor activities and concluded that the subjects received a significant proportion of ambient radiation. [*Cockell et al,* 2001] measured the exposure of Artic field scientists to UVR using personal dosimeters. For a typical day of activities under clear sky conditions the dose was near 5.8 SEDs.

Figure 1. A worker with a PS Badge attached to his chest.

Results and Discussion

The results of the personal UVR exposures received by the workers in Antarctica are shown in Table 1. Outdoor workers are a group that can receive frequent and significant solar UVR exposures. There is significant variation between the workers due to the type of work they were doing and the orientation of the badge relative to the suns position. The Antarctic stations are all situated near the coast so the workers on barges can be receiving UVR directly from the sun and also reflected from the water.

For January both Casey and Davis had relatively clear sky days whilst Mawson was generally overcast. The ambient solar UVR ranged from 12.5 to 23.3 SEDs for the clear days and 3.9 to 7.0 SEDs for overcast days. This was also evident in the exposure of the workers badges which ranged from 0.3 to 9.8 SEDs in clear sky conditions and 0.2 to 4.1 SEDs during overcast days. The results show that the Antarctic workers received 2 to 74% of ambient UVR. The occupation of the workers

varied from crane operators to riggers and the exposure dose varied depending on the nature of the work. The occupations with the highest UVR exposures were the ones where the workers spent most of the time out in the open such as the barge unloaders and riggers whilst crane drivers were protected by a canopy which limited there UVR exposure.

In Figure 2 the ozone levels were above the 220 DU threshold for the ozone hole except in March where the ozone dipped below 220 DU. The results show that it is not just during spring time and early summer that lower ozone can affect UVR exposure. Unlike the mid latitude sites where the UV maximum are usually in January in the Antarctic the UV maximum is in late November to early December.

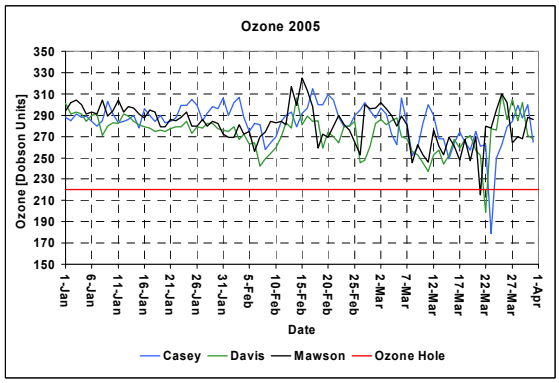

Figure 2. Ozone levels over the Antarctic sites for the months of January to April 2005.

A number of the workers who participated in the study had exposures that exceeded 2 SEDs which is the dose required to achieve erythema (sunburn) for people with sensitive skin. Some of the workers reported mild cases of sunburn to the face. All workers were provided sunscreen but either did not apply any or applied it insufficiently to provide adequate protection.

The results of the pilot study have shown that exposure of the expeditioners to UVR requires a more detailed field study to measure the anatomical distribution of solar UVR and how it varies with the type of activity.

The Antarctic resupply voyages are generally between January and March, which allow for measurements during the Antarctic summer but not during spring when ozone concentrations can drop below 220 DU.

Conclusions

Personal UVR exposures as a result of working outdoors can be a significant proportion of the available ambient radiation. With the ozone hole over the Antarctic stations during spring and early summer appropriate personal protection must be taken to reduce any risk to the health of expeditioners in Antarctica from occupational UVR exposure. The pilot study has shown that there is the potential for workers in Antarctica to be exposed to high solar UVR so appropriate personal protection is needed to reduce the exposure. These results suggest that as in other studies [*Gies et al,* 2003] solar UVR exposure is not being taken seriously as a hazard by outdoor workers.

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Table 1. The measured erythemal weighted doses (SED) for the Antarctic workers and ambient badges. The corresponding number of workers that exceeded 2 SEDs and the reported erythema (sunburn) to the face.

Station	Date	PS Badge	Ambient	% Ambient	< 2 SEDs	>2 SEDs	Sunburn
Casey	11 Jan	0.3 – 8.8	19.1	1.8 – 46.0	2	4	2
Casey	12 Jan	2.5 – 9.8	23.3	10.5 – 42.2	0	6	3
Davis	20 Jan	0.7 – 8.8	12.5	5.7 – 70.2	1	5	2
Davis	21 Jan	1.2 – 4.1	7.0	16.4 – 58.5	5	1	4
Mawson	7 Mar	0.2 – 2.9	3.9	7.7 – 73.8	9	2	-
Mawson	9 Mar	0.6 – 3.2	5.2	11.7 – 60.7	5	5	-

* One Standard Erythema Dose (SED) is equivalent to an erythemal effective radiant exposure of 100 Jm^{-2}.