Understanding UV reflection in the urban environment.

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Abstract. Outdoor workers in Australia are exposed to very high ambient levels of ultraviolet (UV) radiation. Studies have shown that up to 90% of outdoor workers experienced UV exposures in excess of the occupational UVR exposure standard [1]. Surfaces that reflect UV have been shown to significantly affect UV exposures and vary with solar zenith angles (SZA) and orientation of the surface [2] and surface type [3].

This investigation shows that seasonal variation is just as important to UV exposures affected by reflected UV radiation. In fact, UV exposures received in cooler seasons appear to be impacted more by reflected UV than warmer seasons, despite higher levels of global UV. The presence of such high ambient UV levels is proposed to be the reason for the disparity between UV exposures measured in spring and autumn, due to proportions of direct and diffuse UV radiation, despite the use of a UV reflector that has a high UV reflectivity in comparison to natural surfaces (at least 20% in the UVB waveband).

Calculating reflective capacities

This study was carried out using polysulphone dosimeters (to approximate UV exposure) attached to manikins placed in a variety of situations. A manikin was placed near a UV reflective wall, a second manikin was placed near a non-reflective wall and a third manikin placed in the open. Dosimeters were positioned at the same place on each head. The manikins were placed at 0.5 m distance from the wall, at the point of the shoulder, approximating arm length. The dosimeters were replaced after each hour of exposure to determine the hourly exposures over an entire day. The dosimeters were calibrated to a spectroradiometer (model DTM 300, Bentham Instruments, Reading, UK) and weighted against the erythemal action spectrum. The final results in this study concentrate only on the dosimeters located on the face. The spectral analysis was carried out with a USB 4000 Plug-and-Play spectrometer (Ocean Optics, Inc., USA). This was also calibrated against the Bentham spectroradiometer. The walls used in the dosimeter study included zinc aluminium coated steel in trapezoidal shape (reflective surface) and black felt covered steel in trapezoidal shape (non-reflective surface). The experiments were carried out at the University of Southern Queensland, Toowoomba, in Queensland, Australia.

Observations

The data collected shows that during late autumn the presence of a nearby reflective wall can increase personal UV exposures to the face by nearly a third (Figure 1a). However, when the same experiment is carried out during late spring of the same year, the effect of the reflective wall on personal UV exposure appears to cause only slightly higher UV exposures with the exception of 10am to 11am (Figure 1b) compared to measurements obtained with no wall nearby in the mornings. Afternoons show low to no increase for UV exposures in spring.

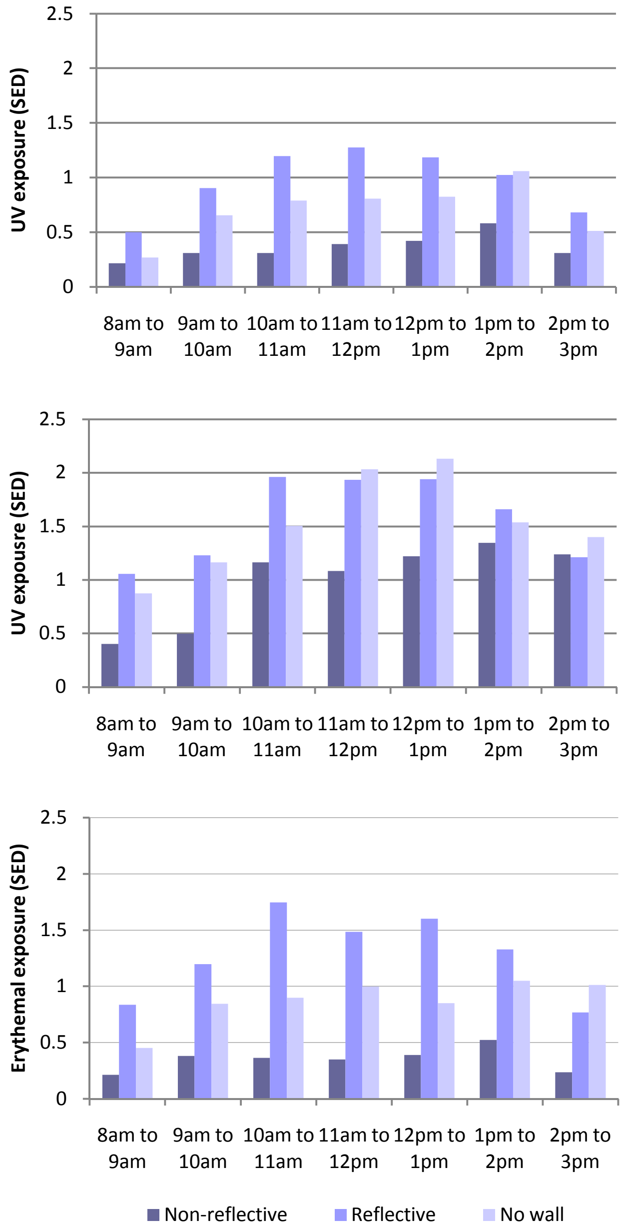

Figure 1. From top: average facial erythemal exposure (SED) for three exposure types (a) comparing walls in Autumn 2008 (b) comparing walls in Spring 2008 (c) comparing corners in Autumn 2009.

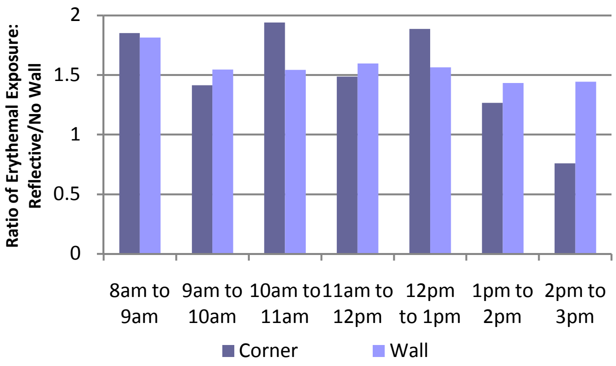

Figure 2. Comparison of relative effectiveness of increasing erythemal exposure due to a wall or corner.

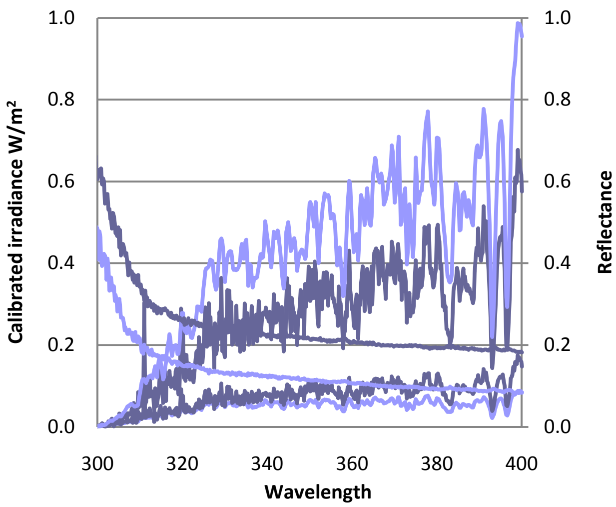

Figure 3. Comparison between spring and autumn data for 2008. Light shade: Spring 2008; dark shade: Autumn 2008. From top the paired lines are: global spectral UV irradiance, reflectance ratio and spectral reflected UV irradiance.

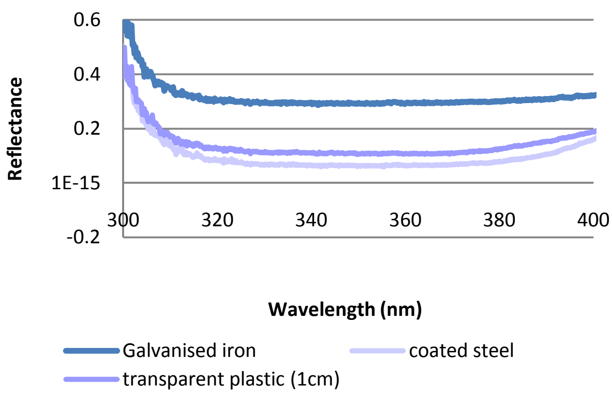

Figure 4. Other UV reflective surfaces that may increase UV exposure.

An investigation into the effect of two walls (positioned in a corner situation) shows that autumn measurements in 2009 also increase overall UV exposure (Figure 1c). The relative value of UV exposure due to a reflective wall nearby is still approximately a third higher than when no wall is nearby. Figure 2 confirms this, showing little relative variation between wall or corner influence to UV exposures compared to no wall present nearby. Despite higher ambient UV in spring, UV exposures (averaged over the day) incurred do not appear to have significantly increased due to the presence of a reflective wall, unlike the overall UV exposure incurred during autumn.

Figure 3 shows a sample of spectral UV irradiance data measured at noon, with higher global UV measured in spring compared to autumn and the reflected UV from the wall remaining approximately the same for both seasons. The higher global spectral UV is due to smaller SZA present in spring. It appears that while higher spectral UV irradiance is present, the reflectance capacity of the UV reflective surface remains relatively constant from season to season. The most logical explanation for this behaviour is that UV reflective surfaces must reflect mostly direct UV radiation, with little to no impact on diffuse UV radiation. The proportion of direct to diffuse UV radiation changes from season to season, with direct UV radiation levels changing less significantly than diffuse UV radiation. Figure 4 shows other examples of UV reflective surfaces, indicating that other higher reflecting UV surfaces may also display this behaviour.

Conclusion

Outdoor workers should be advised to take the same safety precautions working near UV reflective materials in cooler seasons as they would working outdoors in warmer seasons, particularly when thermal considerations may encourage them to remain in sunny areas. Workers should also be advised that working near UV reflective walls have the same effect as working near UV reflective corners and should again take appropriate precautions against excessive UV exposure when working in these conditions.

References

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