Experimental Evaluation of Detection of 340 nm Direct Solar UVA Irradiances Using a Smartphone.

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Introduction

The division of the UVA waveband at 340 nm into UVA I and UVA II represents an important photobiological boundary for DNA damage from exposure to the sun (Diffey, 2002). This wavelength is highly scattered in the Earth's atmosphere, particularly, at high solar zenith angles. However, at low zenith angles, particularly at solar noon during summer in places such as Australia when insolation is at its peak, this wavelength is less scattered and is a major skin cancer concern for those pursuing outdoor activities (Anton et al. 2009).
Traditional methods of observing and measuring direct sun UVA at wavelengths of 340 nm include the Solar Light Microtops II sunphotometer (Igoe et al. 2013a; Morys et al. 2001). However, all equipment that are used by research bodies are largely inaccessible to the people most likely to be directly affected by solar radiation. Smartphones are technology that are not only ubiquitous, but have considerable processing power and possess a complementary metal oxide semiconductor (CMOS) image sensor that has an inherent sensitivity to UV radiation (Igoe et al. 2013b).

Methods

As part of a greater project (Igoe et al. 2013a; Igoe et al. 2013b), the detection and measurement of direct solar UVA at 340 nm was performed using a smartphone image sensor and Android programming and not using external sensors. The observations were performed in various locations in rural Queensland, Australia across all seasons and at sun zenith angles ranging between 70° and 2°. The use of a smartphone with 340 nm narrow passband and neutral density filters provided a quantifiable signal in the CMOS image sensor that was quantified and analysed with a specifically written Android app (Igoe et al. 2013a).

Results

Despite the UV attenuation from the outer lens of the smartphone camera, images of the sun at 340 nm are clearly visible as a deep red disk and are well defined in the grayscale (intensity) profile response from the negligible background noise levels, with a well-defined outline (Figure 1). Using the neutral density filters had the additional advantage of removing diffuse noise.
Field tests measuring direct solar irradiances at 340 nm in comparison to observations recorded from the Microtops yielded a correlation of determination in excess of 0.97, demonstrating that the smartphone is a viable and accessible tool to be used to complement traditional observation technologies (Igoe and Parisi, 2015; Igoe et al. 2013a). A comparison between corresponding irradiance observations of the Microtops and smartphone are provided in Figure 2, with a 1-to-1 line included.

Conclusion

The smartphone camera has been proven to be an effective and cost-effective method of evaluating 340 nm direct solar irradiances.

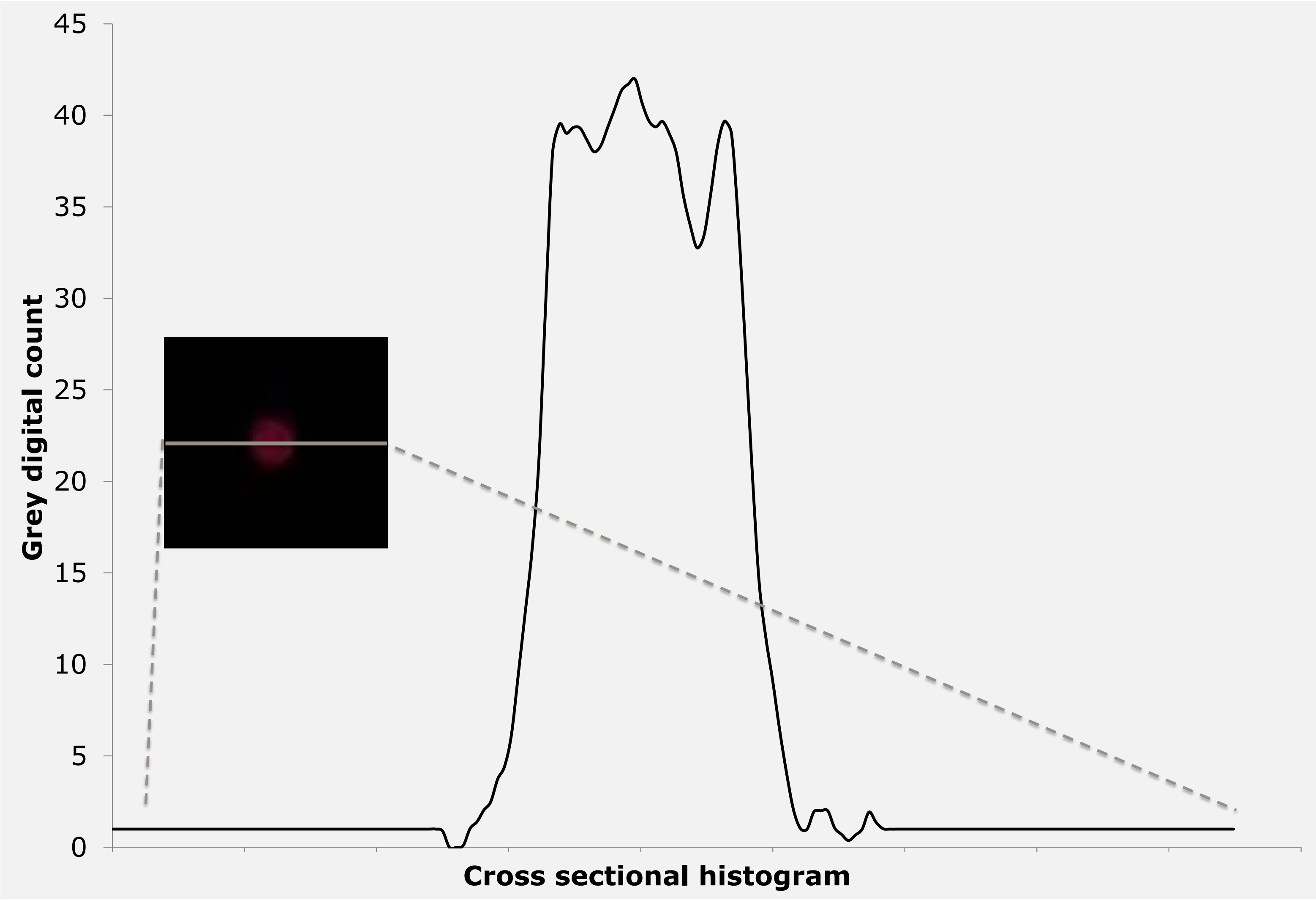

Figure 1 - Luminance (grayscale) cross section profile through an image of the sun taken at local solar maximum at 340 nm, using a smartphone camera. The image is distinct from the minimal background noise present on the image sensor.

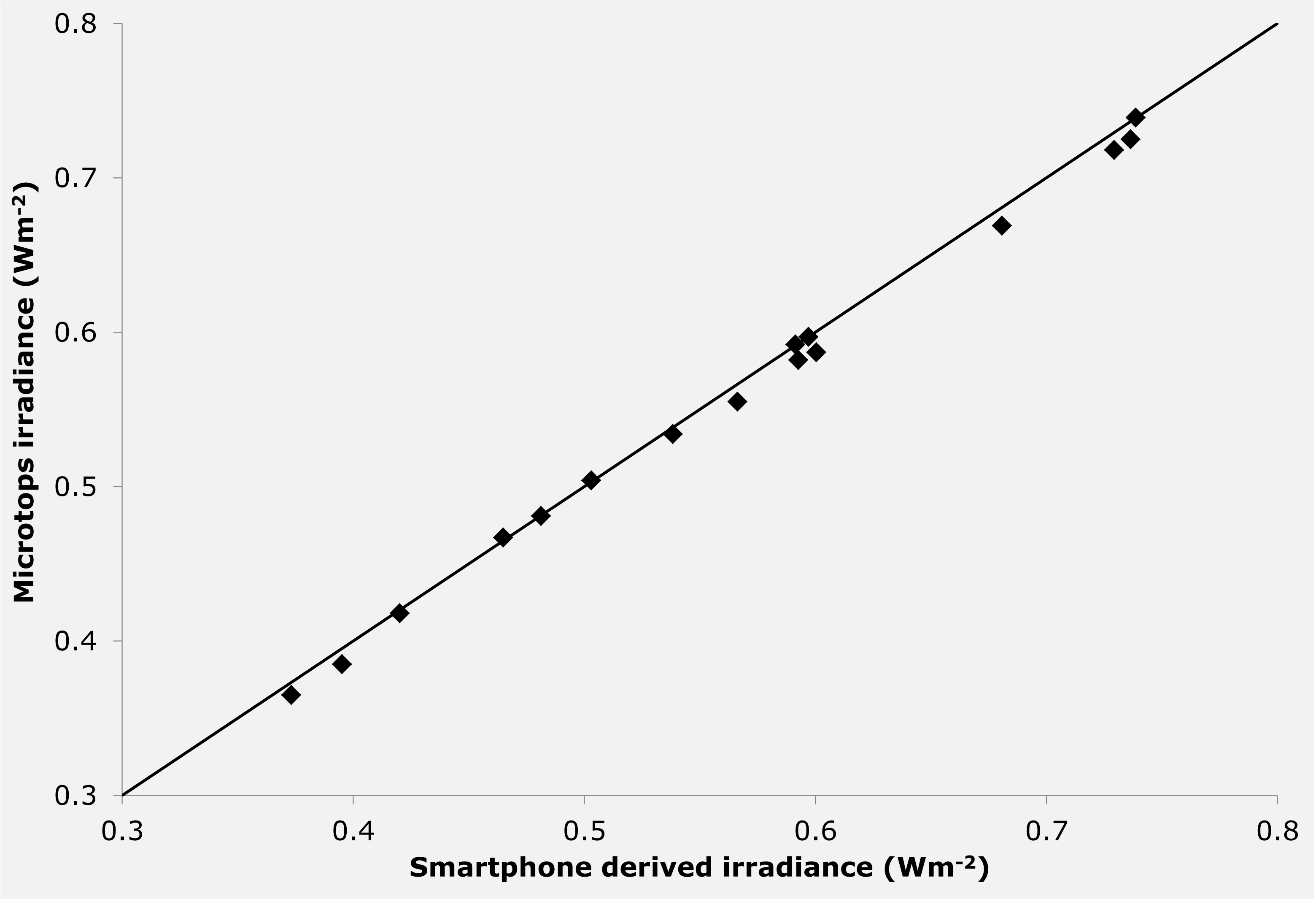

Figure 2 - Comparison between 340 nm direct solar irradiances measured using a Solar Light Microtops II Ozonometer and those derived from the smartphone image sensor luminance (grayscale) response. The line represents an exact match between the two measurement tools.

References

- Igoe, D. and Parisi, A.V. 2015, 'Evaluation of a Smartphone Sensor to Broadband and Narrowband Ultraviolet A Radiation', Instrumentation Science and Technology, vol. 43, pp. 283-289
- Igoe, D., Parisi, A.V. and Carter, B. 2013a, 'Smartphone-Based Android app for Determining UVA Aerosol Optical Depth and Direct Solar Irradiances', Photochemistry and Photobiology, vol. 90, pp. 233-237
- Igoe, D., Parisi, A.V. and Carter, B. 2013b, 'Evaluating UVA Aerosol Optical Depth using a Smartphone Camera', Photochemistry and Photobiology, vol. 89, pp. 1244-1248
- Anton, M., Serrano, A., Cancillo, M. and Garcia, J. 2009,' Influence of the relative optical air mass on ultraviolet erythemal irradiance', .Journal of Atmospheric Solar and Terrestrial Physics, vol. 71, pp. 2027–2031.
- Diffey, B. 2002, 'What is Light?', Photodermatology, Photoimmunulogy and Photomedicine, vol. 18, pp. 68-74
- Morys, M., Mims III, F. Hagreup, S. Anderson, S., Baker, A., Kia, J. and Walkup, T., 2001, 'Design, calibration, and performance of MICROTOPS II handheld ozone monitor and sun photometer', Journal of Geophysical Research, vol. 106, pp. 14573–14582

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