Inter-comparison of Solar Spectral Irradiance Measurements in Melbourne

Peter Gies[1], Stuart Henderson[1], John Javorniczky[1], Colin Roy[1] and Don Anderson[2]

1 Australian Radiation Protection and Nuclear Safety Agency, Lower Plenty Rd Yallambie VIC 3085
2 Bureau of Meteorology, Collins St Docklands, Melbourne, VIC 3008

Abstract: During much of 2001 and 2002, spectral irradiance measurements of solar ultraviolet radiation (UVR) were made in Melbourne by both the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and the Bureau of Meteorology (BOM). The two measurement sites are separated by 12km. Both instruments made measurements on selected days, generally as clear and cloud free as possible. Examination of the two data sets gave 15 days when both instruments collected sufficient data to allow comparison. The spectral measurements made by ARPANSA provide calibrations for the network of radiometric detectors based in the Australian Capital cities. Comparison with the BOM data gives independent traceability to the measurements of spectral irradiance through two separate spectral irradiance standards (Australia and New Zealand). UV Index results from the two spectral measurement sets differ by 5.8 % on average.

Introduction:

The Global Solar UV Index (WHO 2002) was designed as a simple way to inform the public of the levels of solar ultraviolet radiation. The Australian Bureau of Meteorology (BOM) have presented computer generated forecasts of the next day's UVI since 1996. An ongoing cooperative programme to validate the BOM forecast results against ARPANSA's ground based measurements has been underway since then (Lemus-Deschamps et al 1999, Gies et al 2004, Lemus-Deschamps et al 2004). There is also continuing cooperation with the Australian Cancer Society to promote the media use of the UVI, to ensure uniformity of reporting and to maximise the impact on the public.

ARPANSA has a network of radiometric UV detectors located at most of the capital cities in Australia. Underpinning the calibration of this network is a spectroradiometer (SRM) measurement system and 1000W standard lamps traceable to the National Measurement Institute. Simultaneous measurements of solar UVR by the radiometric detectors and the SRM allows the transfer of the calibration to the detectors (Roy et al 1995). Part of the World Meteorological Office's aims to stanadardise UVR measurements worldwide is to intercompare measurements and calibrations between different organizations and countries (WMO 2003). During 2001/02, the BOM had spectral instruments located in Melbourne, which provided the opportunity to compare spectral UVR measurements. This paper briefly looks at some of the results from that comparison of data. Clear days or times when the days were clear were chosen from the data points.

Materials and Methods

Description of the BOM Measurement System

The UV spectroradiometer used by BOM was developed by the National Institute of Water and Atmosphere (NIWA) and is based on a Bentham DTM 300 double monochromator (Mckenzie et al 1993). The nominal resolution of the instrument is 0.6 nm. The entrance optics consist of a shaped PTFE diffuser that is coupled to the entrance slit of the monochromator with a custom made fibre optic bundle. The system is housed in a weatherproof temperature controlled enclosure that maintains the instrument temperature to within ± 1 degree Celsius. The instrument has an internal laptop computer that controls data logging and communications. An internal GPS system is used to ensure that the logging times are kept accurate to with 3 seconds. The instrument scans from 450 to 285 nm and then back to 450 nm. The wavelength step size is 0.2 nm and the duration of the scan is 272 seconds. The instrument is configured to take scans at 5-degree steps of solar zenith angle (SZA) from 95 degrees except during a 2.5 hour period about local noon where scans are taken every 15 minutes.

The calibration of the instrument is maintained by 45 W transfer standards. Duration of scans is 7 to 10 mins, with scans done from 400 to 280 nm and then back to 400 nm. The transfer standards are calibrated by NIWA using 1000 W FEL lamps traceable to NIST. Processed data are cosine corrected and wavelength corrected using correlation with the Fraunhofer structure in the solar spectrum.

Description of the ARPANSA Measurement System

Spectral measurements of solar UVR are made on clear days using a Spex 1680B double mono-chromator spectroradiometer (SRM) based at the ARPANSA Melbourne site. Calibration of the SRM is provided by 1000 W tungsten halogen calibration lamps traceable to the National Measurement Institute at Lindfield, Australia. Although calibrations for the various Solar Light UV Biometers 501 are supplied by the manufacturer, these are checked against simultaneous measurements of solar UVR made by the SRM in Melbourne, which allows transfer of a traceable calibration to the detectors used in the ARPANSA network before installation at their remote measurement location. The portable Spex 1680B SRM has participated in international inter-comparisons of spectral measurement equipment (McKenzie et al 1993, Seckmeyer et al 1995) to provide confirmation of the system performance and allow comparison against other international calibration standards.

Spectral scans are usually of 10 mins duration and cover the wavelength range from 280 to 400 nm in 1 nm steps with a wavelength accuracy of 0.1 nm.

Results and Discussion

Integrated spectral scans in terms of UV index for both the BOM and ARPANSA systems are shown in Figure 1 for a typical day along with the ratio of the two, which for this day had a mean of 1.063. Also shown are the Solar Light 501 biometer measurements.

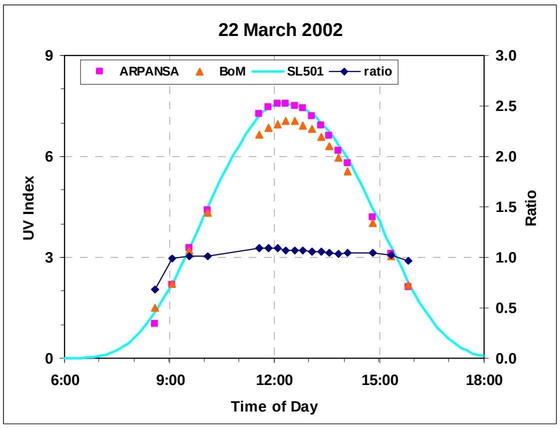

Figure 1. Comparison of spectral UV Index measurements between ARPANSA and BOM for a typical day.

The results for the spectral measurements for the clear sky days when both systems recorded data are shown in Figure 2. The mean ratio for all measurements was 1.058 ± 0.88, with the ARPANSA instrument measuring 5.8 % higher than the BOM instrument. This is consistent with two previous intercomparisons, where the ARPANSA SRM was generally slightly above the mean of all the instruments that participated in the intercomparisons, reading 7.0% above the mean in the 1993 New Zealand intercomparison (McKenzie et al 1993) and 6% above the mean in the 1994 German intercomparison (Seckmeyer et al 1995). Further intercomparisons between the BOM and ARPANSA are planned in 2006/07 in Alice Springs.

Conclusions

Intercomparison of spectral measurements of UV Index for 15 days in 2001/02 between the BOM and ARPANSA indicated that the differences were 5.8%. This is consistent with previous results.

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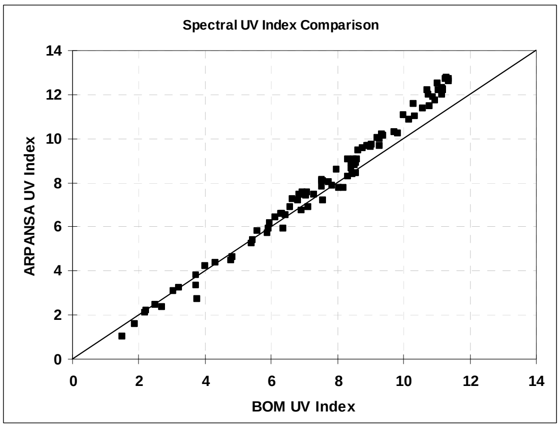

Figure 2. Comparison of all spectral data for the clear sky days when both systems recorded data.

References

Gies, P., C. Roy, J. Javorniczky, S. Henderson, L. Lemus-Deschamps and C. Driscoll (2004) Global Solar UV Index: Australian Measurements, Forecasts and Comparison with the UK. *Photochem Photobiol*, 79: 32-39.

Lemus-Deschamps, L., L. Rikus and P. Gies. (1999) The operational Australian ultraviolet index forecast 1997. *Meteorol. Appl.* 6, 241-251.

Lemus-Deschamps, L., L. Rikus, S. Grainger, P. Gies, J. Sisson and Z. Li. UV Index and UV dose distributions for Australia (1997-2001). *Aust. Met. Mag.* 53: 239-250, 2004.

McKenzie, R.L., M. Kotkamp, G. Seckmeyer, R. Erb, C.R. Roy, H.P. Gies and S.J. Toomey (1993) First Southern Hemisphere Intercomparison of Measured Solar UV Spectra. *Geophys. Res. Let.* **20**, 2223-2226.

Roy, C.R., H.P. Gies, and S. Toomey (1995) Solar UV radiation environment: measurement techniques and results. *J. Photochem. Photobiol. B: Biology* **99**, 21-27.

Seckmeyer, G., B. Mayer, G. Bernhard, R.L. McKenzie, P.V. Johnston, M. Kotkamp, C.R. Booth, T. Lucas, T. Mestechkina, C.R. Roy, H.P. Gies and D. Tomlinson (1995) Geographical differences in the UV measured by intercompared spectroradiometers. *Geophys. Res. Let.* **22**, 1889-1892.

World Health Organization (2002) *Global Solar UV Index: A Practical Guide.* WHO, Geneva, Switzerland.

World Meteorological Organization, Global Atmosphere Watch (2003) Quality Assurance in Monitoring Solar Ultraviolet Radiation: The State of the Art. *WMO GAW* No.146.