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The University of Manchester

Initial laboratory instrument characterisation and solar simulator measurements of Manchester spectrometers involved in the EMRP project.

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Introduction

For the EMRP project two array spectrometers (A Metcon and Ocean Optics) both with two channels will be used for varying periods during 2013-2014 to monitor the global and direct irradiance at a site in Manchester UK. Before deployment the instruments were upgraded by placing in temperature controlled boxes and having the direct optics weather proofed. The Ocean Optics was also later fitted with a new global head to improve the cosine response and new software was written for both instruments. They were then characterised and calibration data determined in the Laboratory. Some results from the these measurements are presented here.

Source	DASR (GBA)	Ocean Optics (GBO)
1KW NIST Calibration standard	< 5%	< 5%
Non-linearity	<2%*	<2%*
Dark signal	< 2 % **	< 1% **
Stray light	< 2%	< 2%
Wavelength errors	< 1%	< 1%
Error added in quadrature	6.1	5.9

Table 1 List of sources of error

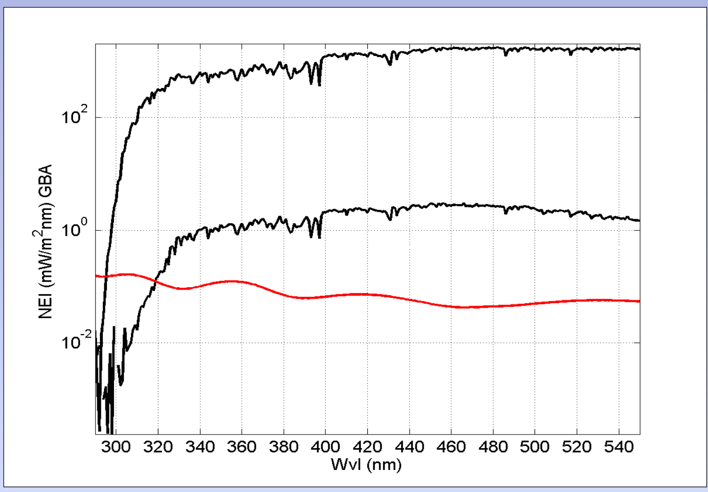
* for counts < 90% of maximum ** When instrument temperature stabilised and properly equilibrated.

Sources of error

Table 1 lists the main sources of error in the calibration and operation of the array spectrometers.

SMA fibre connection

One other possible source of change in the system is due to change in throughput of up to 6% due to removal and reconnection of the SMA fibre connection. So wherever possible fibre are left in place after calibration.



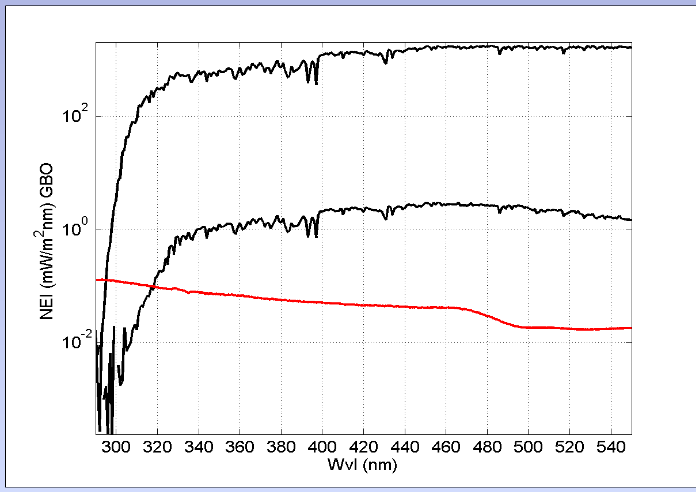


Fig 1. Noise equivalent irradiance (GBA) 25 ms

Fig 2. Noise equivalent irradiance (GBO) 10ms

NEI plots for global heads of two array spectrometers used for monitoring. The spectra for midday and sunset in June (SZA = 33 and 88 deg) were taken with a Bentham DTM300

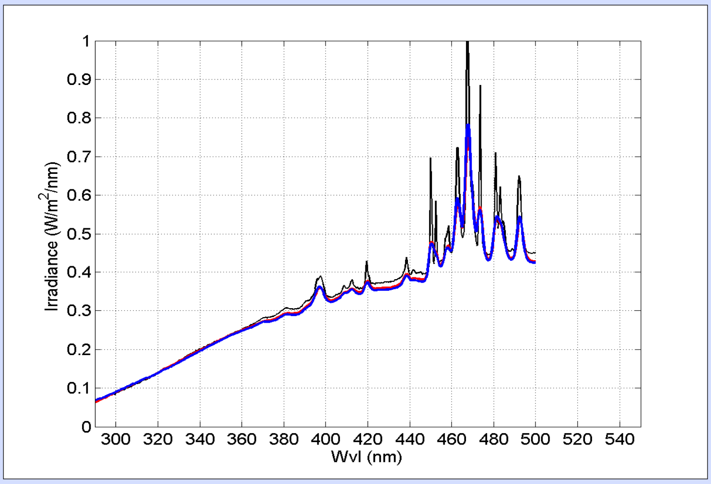


Fig 3. Plot of spectra of solar simulator

Spectra taken with Bentham DTM300, Metcon and Ocean optics.

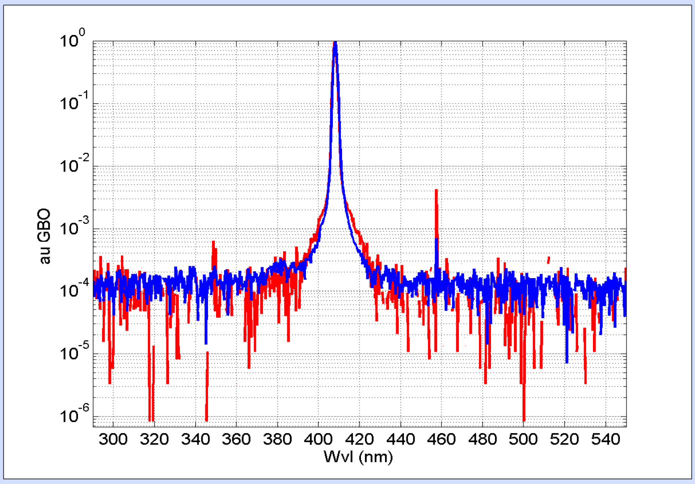


Fig 4 GBO Measurements of 408 nm laser 1 year apart.

Solar Simulator tests of stray light correction.

To test stray light correction measurements of a solar simulator were made with the two array spectrometers and the Bentham DTM300. Unlike the sun the UVB doesn't drop to zero at ~290 nm. So this allowed testing of the stray light correction (Kreuter et al 2009) down to shorter wavelengths. The ratio of array to scanning spectrometer gave a difference of less than 2% over the whole wavelength range.

Conclusions

Results suggest the array spectrometers are stable enough to use for longer monitoring periods as long as the correct procedures for calibration, stray light correction, setup and operation are used. The use of stray light correction enables the instruments to reach their detection limits which are determined by the quantum efficiency of the detectors and the solar UVB cut off.

Long term Stability

Any instrument used for long term monitoring needs to be stable for periods of at least a year. Wavelength calibration has been found to be stable and changed by less than 0.02 nm with no systematic drift during the previous 6 years.

Because the METCON and Ocean Optics have been used with many different setups and a range of input optics the stability of the absolute calibration is hard to determine but the Ocean optics has been setup with the same global head on several occasions over the previous 6 years. The change in absolute calibration is less than 4% which is smaller than possible errors due to removal and reconnection of the fibres.

Laser line measurements (GBO shown above) of the 4 channels show that over a year, the internal light scattering and stray light did not vary by a significant amount.

References

Kreuter A, Blumthaler M. (2009). *Stray light correction for solar measurements using array spectrometers. Review of Scientific Instruments* ***80,*** *096108*

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