National Renewable Energy Laboratory

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Memo

Subject: Calibration of SRRL Baseline Measurement System (BMS) Global UVB Radiometers
Instruments: Kipp & Zonen UV-S-B-T s/n 010538 and CUVB1 s/n 952010, EKO MS-210W s/n S92096.04, Yankee UVB-1 s/n 930401 and s/n 921106, and Solar Light 501A s/n 1898

NREL PV Radiometric Measurements Task monitored the millivolt output of six (6) BMS Global UVB Radiometers while measuring the spectral distribution of natural sunlight in global horizontal incidence mode on 12 September 2006 from 280 nm and 400 nm at 2nm steps using an Optronic Laboratories OL-756 (double monochromator UV spectroradiometer). The millivolt output from the BMS Radiometers were recorded by the BMS CR23X datalogger.

The OL-756 spectrometer calibrated against NREL's National Institute of Standards and Technology (NIST) Standard of spectral irradiance F407 on 12 April 2006. Spectral data was corrected based on measurements of the EKO portable light source made on April 12 and September 12, 2006, which was on average of about 5% increase across all wavelengths.

The spectra were integrated between 280 nm and 315 nm to produce the total power under each spectral distribution. All data were used to compute the calibration factors shown in Table 1.

Table 1. September 12, 2006 NREL Global UVB Calibration Summary

Time (MST)	**Spectrum W/m^2**	**UV-S-B-T V (avg.)**	**$W/m^2/V$**	**CUVB1 V (avg.)**	**$W/m^2/V$**	**MS-210W mV (avg.)**	**$W/m^2/mV$**
11:53	1.314048	1.9427	0.6764	-0.3494	-3.7610	1.2108	1.0853
11:55	1.309095	1.9381	0.6755	-0.3486	-3.7558	1.2086	1.0831
11:57	1.305863	1.9353	0.6748	-0.3481	-3.7514	1.2073	1.0817
11:59	1.302659	1.9353	0.6731	-0.3479	-3.7447	1.2062	1.0799
12:01	1.298615	1.9339	0.6715	-0.3476	-3.7364	1.2043	1.0783
12:03	1.297110	1.9361	0.6700	-0.3480	-3.7278	1.2050	1.0765
12:05	1.286648	1.9274	0.6675	-0.3461	-3.7173	1.1995	1.0727
12:07	1.283963	1.9254	0.6668	-0.3458	-3.7135	1.1996	1.0703
		Avg.	**0.672**		**-3.738**		**1.0785**
		Sigma	**0.0036**		**0.0177**		**0.0051**

Time (MST)	**Spectrum W/m^2**	**UVB-1 V (avg.)**	**$W/m^2/V$** s/n 930401	**501A V (avg.)**	**$W/m^2/V$**	**UVB-1 V (avg.)**	**$W/m^2/V$** s/n 921106
11:53	1.314048	1.3535	0.9709	0.7718	1.7026	1.3607	0.9657
11:55	1.309095	1.3499	0.9697	0.7697	1.7007	1.3682	0.9568
11:57	1.305863	1.3479	0.9688	0.7685	1.6992	1.3689	0.9540
11:59	1.302659	1.3471	0.9670	0.7680	1.6961	1.3689	0.9516
12:01	1.298615	1.3458	0.9650	0.7674	1.6923	1.3669	0.9501
12:03	1.297110	1.3471	0.9629	0.7682	1.6886	1.3682	0.9480
12:05	1.286648	1.3408	0.9596	0.7643	1.6835	1.3626	0.9443
12:07	1.283963	1.3399	0.9582	0.7636	1.6815	1.3614	0.9431
		Avg.	**0.965**		**1.693**		**0.952**
		Sigma	**0.0047**		**0.0080**		**0.0073**

The erythema response for the 501A was determined by multiplying the spectra from 280-400nm by the CIE 1987 Erythema Action Spectrum (shown in Figure 2) and then integrating under the entire curve to produce the total power under each spectral distribution. All data were used to compute the erythema calibration factors shown in Table 2.

Table 2. September 12, 2006 NREL Global Erythema Calibration Summary

Time (MST)	Erythema Spectrum W/m^2	Erythema Spectrum MED/Hr	Erythema Spectrum Index	501A V (avg.)	Erythema MED/Hr/V	Erythema Index/V
11:53	0.17520	3.00518	7.00808	0.77177	3.8939	9.0805
11:55	0.17453	2.99360	6.98107	0.76973	3.8892	9.0695
11:57	0.17422	2.98826	6.96863	0.76853	3.8883	9.0675
11:59	0.17386	2.98220	6.95450	0.76805	3.8828	9.0548
12:01	0.17332	2.97287	6.93274	0.76739	3.8740	9.0342
12:03	0.17311	2.96925	6.92430	0.76817	3.8654	9.0140
12:05	0.17177	2.94635	6.87088	0.76426	3.8551	8.9902
12:07	0.17133	2.93881	6.85331	0.76360	3.8486	8.9750
				Avg.	**3.875**	**9.036**
				Sigma	**0.0168**	**0.0392**

Note: 1 MED/Hr = 0.0583 Erythema-W/m^2 and 1 Index = 0.025 Erythema-W/m^2

UNCERTAINTY

The estimated uncertainty in the OL-756 spectral irradiance calibration is ±4.0% from 300 nm to 400nm. The accuracy of the CR23X data logger was about 0.8%. Estimated uncertainty in the derived calibration factor is ±4.8% (limit of error). Spectral data is provided below.

Figure 1. Measured Spectral Distributions indicated by OL-756 UV Spectroradiometer 12 Sept 2006

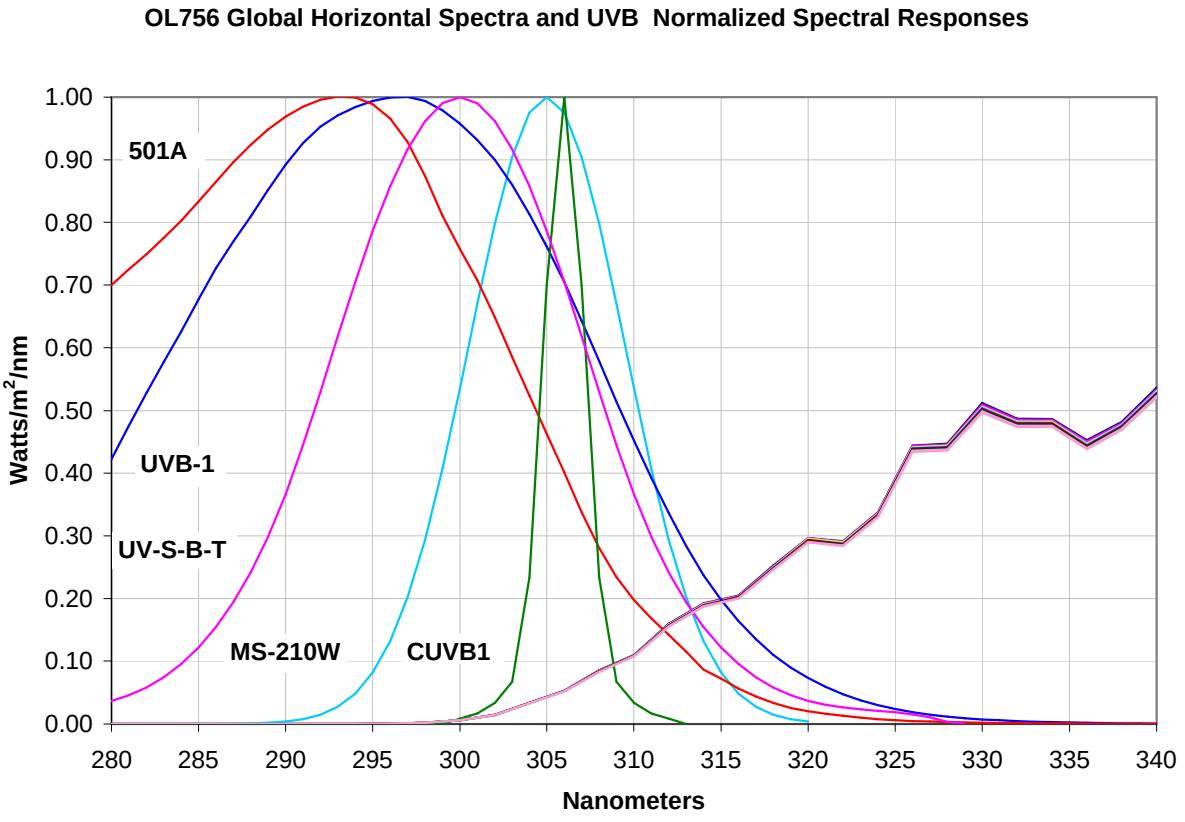
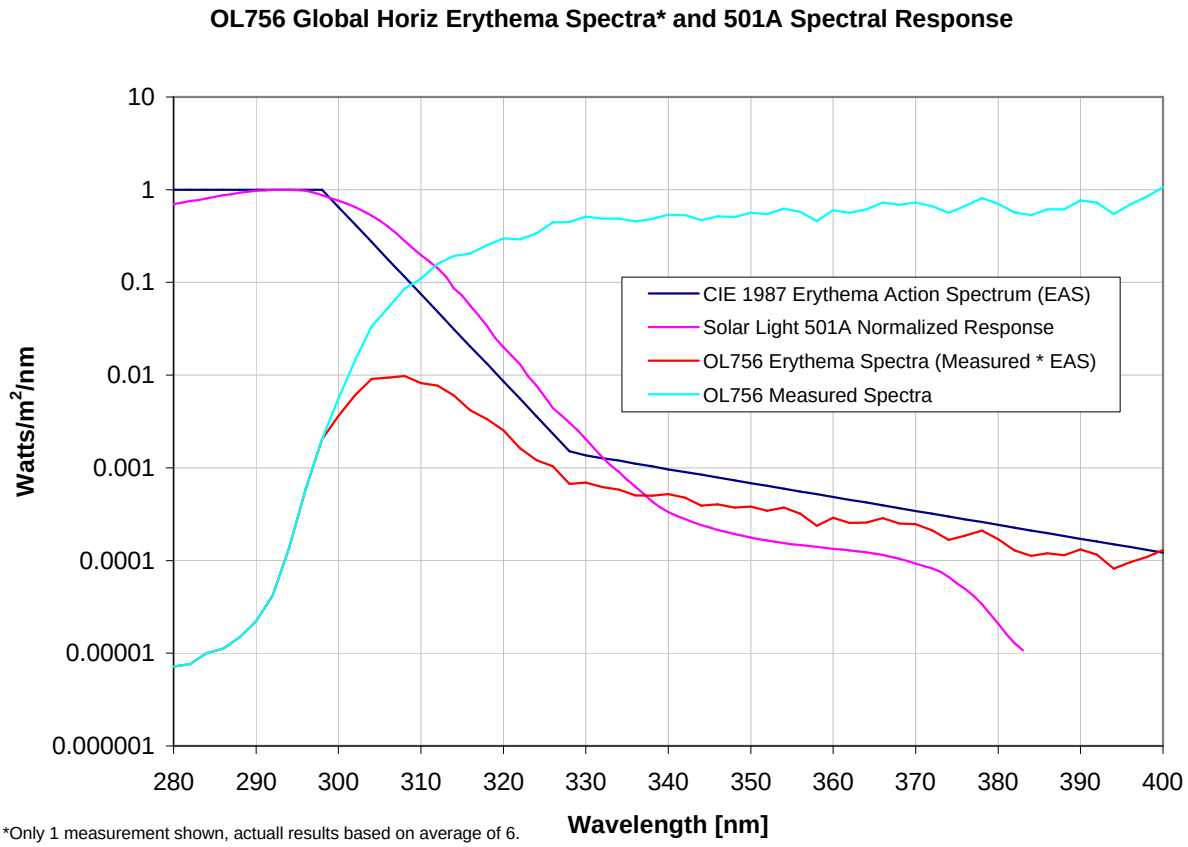


Figure 2. Derived Erythema Spectral Distributions indicated by OL-756 on 12 Sept 2006



*Only 1 measurement shown, actuall results based on average of 6.