

Calibration Certificate

No. 2008-81-1

Calibration Item

Brewer spectrophotometer

Manufacturer	Kipp&Zonen
Type	MKIII
Serial number	163

Customer

PMOD/WRC
Dorfstrasse 33
7260 Davos Dorf
Switzerland

Calibration Mark

2008-81-1

Date of calibration

09 June - 12 June, 2008

Davos Dorf, 26 September, 2008

Dr. Gregor Hülsen
In charge of calibration

Dr. Julian Gröbner
Head UV Center

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Calibration procedure

Measurements of the spectral solar irradiance were performed regularly from the morning to the evening at Davos (lat: 46.817 N; long: 9.845 E; altitude: 1610 m a.s.l.). Synchronised solar spectra were obtained in the range of 290 to 363 nm, every 0.5 nm, with a wavelength increment every 3.0 seconds. The solar spectra were converted to a common wavelength scale and to a nominal resolution of 1 nm using the SHI-CRivm software package, version 3.075. A detailed description of the measurement procedure is published in Gröbner et al. (2005).

The QASUME calibration factors $C(\lambda)$ and $C50(\lambda)$ are obtained from the average spectral ratio of all synchronised measurements relative to the European transportable reference spectroradiometer QASUME¹ for the SZA range 24° to 75° and 24° to 50° respectively. A calibrated solar spectrum is obtained by dividing the measured solar spectrum Secondary calibration standards T61251, T68522 and T68523 have been used during the calibration.

QASUME calibration factors $C(\lambda)$:

λ [nm]	$C(\lambda)$	$C50(\lambda)$	λ [nm]	$C(\lambda)$	$C50(\lambda)$	λ [nm]	$C(\lambda)$	$C50(\lambda)$
300	0.987	1.005	322	1.008	1.006	344	0.991	0.991
301	1.017	1.012	323	0.995	0.994	345	1.012	1.011
302	0.982	0.988	324	1.012	1.009	346	0.990	0.990
303	1.019	1.026	325	0.985	0.984	347	1.007	1.007
304	0.993	0.994	326	1.001	0.999	348	1.003	1.002
305	1.020	1.016	327	1.007	1.005	349	0.993	0.992
306	1.001	1.001	328	0.998	0.998	350	1.005	1.005
307	1.011	1.009	329	0.997	0.995	351	1.004	1.003
308	1.006	1.004	330	1.023	1.020	352	1.008	1.008
309	0.996	0.997	331	1.003	1.004	353	0.996	0.996
310	0.986	0.984	332	1.008	1.007	354	1.006	1.005
311	1.010	1.008	333	1.008	1.006	355	1.015	1.015
312	0.995	0.993	334	1.000	0.999	356	1.007	1.007
313	0.996	0.993	335	1.011	1.010	357	0.991	0.991
314	0.995	0.994	336	1.010	1.010	358	0.991	0.992
315	1.009	1.007	337	0.998	0.997	359	0.999	0.998
316	0.979	0.977	338	0.995	0.995	360	1.021	1.020
317	1.000	0.999	339	1.001	1.000	361	0.998	0.998
318	0.982	0.982	340	1.011	1.010	362	0.989	0.988
319	1.005	1.003	341	0.998	0.998	363	1.009	1.009
320	1.003	1.003	342	1.004	1.004			
321	1.000	0.998	343	1.017	1.016			

Expanded uncertainty of measurement u :

u	SZA < 75°	SZA < 50°
300 < λ < 310 [nm]	0.246	0.085
$\lambda \geq 310$ [nm]	0.060	0.053

The reported expanded uncertainty of measurement u is stated as the standard uncertainty of measurement multiplied by the coverage factor $k = 2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.

¹The QASUME spectroradiometer B5503 is made available by the Institute of Health and Consumer Protection of the Joint Research Centre of the European Commission, Ispra, Italy through a collaboration agreement with PMOD/WRC.

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Measurement conditions:

Number of measured solar spectra	67
Minimum SZA	24°
Maximum SZA	75°
Minimum UV Index	0.0
Maximum UV Index	8.9

Atmospheric conditions:

09 June, 2008	Mix of sun and clouds; few drops in the afternoon
10 June, 2008	Clear sky with few cirrus clouds in the morning; mix of sun and clouds during the day
11 June, 2008	Overcast sky with stratus cumulus clouds.
12 June, 2008	Mix of sun and clouds.

Comments:

The absolute spectral irradiance is traceable to the primary irradiance standard of the Physikalisch-Technische Bundesanstalt (PTB), Germany, through the transfer standards F300, F304, F324, F330, F376 (Gröbner and Sperfeld, 2005).

References

- J. Gröbner and P. Sperfeld. Direct traceability of the portable QASUME irradiance scale to the primary irradiance standard of the PTB. *Metrologia*, 42:134–139, 2005.
- J. Gröbner, J. Schreder, S. Kazadzis, A. F. Bais, M. Blumthaler, P. Görts, R. Tax, T. Koskela, G. Seckmeyer, A. R. Webb, and D. Rembges. Traveling reference spectroradiometer for routine quality assurance of spectral solar ultraviolet irradiance measurements. *Appl. Optics*, 44:5321–5331, 2005.

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Measurement summary:

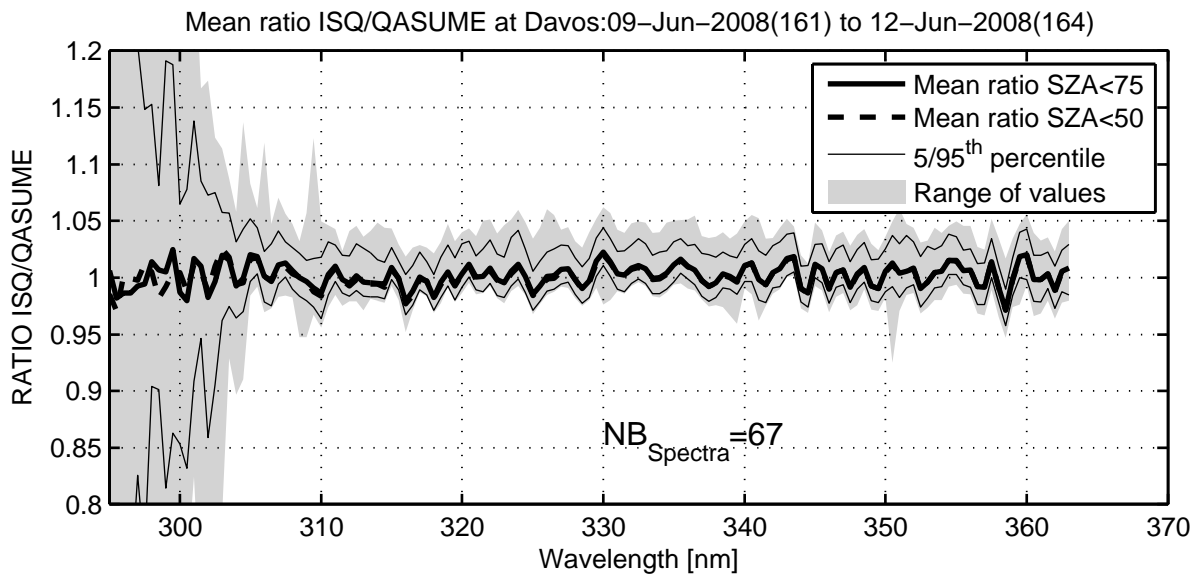


Figure 1: Average ratio spectrum Br #163 to QASUME.

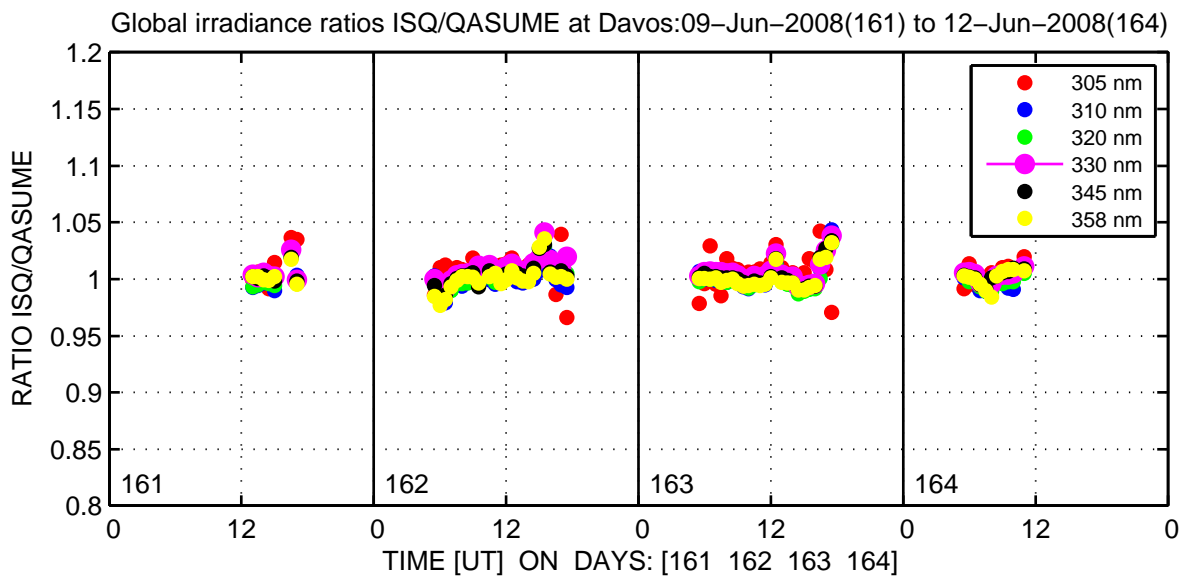


Figure 2: Temporal evolution of the ratio Br #163 to QASUME. Each point in the graph represents a measurement averaged over a wavelength interval of 5 nm centred on the respective wavelength.