

Protocol of the intercomparison at FMI, Helsinki, Finland on June 6 to 11, 2026 with the travelling reference spectroradiometer QASUME from PMOD/WRC

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The purpose of the visit was the comparison of global solar irradiance measurements between the Brewer spectrophotometer operated by the Finnish Meteorological Institute (FMI) and the travel reference spectroradiometer QASUME. The measurement site is located at Helsinki: Latitude 60.204 N, Longitude 24.961 E and altitude 50 m.a.s.l.

The horizon of the measurement site is free down to at least 85° solar zenith angle (SZA). Measurements between 2:30 UT and 20:00 UT have been analysed.

QASUME was installed on the measurement platform of FMI-Helsinki in the morning of June 6, 2026. The spectroradiometer was installed next between the Brewer spectrophotometer “FIJ” with the entrance optic of QASUME within 2 m to the other instruments. The Brewer Spectrophotometer FIJ is a double monochromator (Brewer MkIII #107).

The intercomparison between QASUME and the Brewer Spectrophotometers lasted 6 days, from the noon of June 6 to the morning of June 11.

QASUME was calibrated several times during the intercomparison period using a portable calibration system. Three lamps (T157824, T157825 and T68523) were used to obtain an absolute spectral irradiance calibration traceable to the primary reference held at PMOD/WRC, which is traceable to PTB. The daily mean responsivity of the instrument based on these calibrations varied by less than $\pm 0.5\%$ during the intercomparison period. The internal temperature of QASUME was $27.17 \pm 0.07^\circ\text{C}$ and the diffuser head was heated to a temperature of $29.00 \pm 0.43^\circ\text{C}$.

The wavelength shifts relative to the QASUMEFTS (Gröbner et al., 2017) spectrum as retrieved from the matSHIC analysis were between ± 50 nm in the spectral range 290 to 400 nm.

Protocol:

The measurement protocol was to measure one solar irradiance spectrum every 30 minutes from 290 nm to 400 nm, every 0.5 nm, and 3.0 seconds between each wavelength increment. QASUME recorded the spectra with 0.25 nm increments and the Brewers with 0.5 nm increment. The max. wavelength of Brewer 107 is 365 nm.

Because of time delays of Brewer 107 the increment time was increased to 3.4 to 3.6 seconds.

DOY	Date	DAY	Weather	Comment (times are in UT)
157	06.Jun	Saturday	Mostly raining	Installed at 8:00 UT 08:30 start UV measurements
158	07.Jun	Sunday	Diffuse sky in the morning Clear sky after 8:30 UT	09:42 Calibration T157824
159	08.Jun	Monday	Mix of sun and clouds Clear sky in the early morning	10:45 Calibration T157824 11:01 Calibration T157825 11:18 Calibration T68523
160	09.Jun	Tuesday	Diffuse sky Rain starting 7:00 UT	
161	10.Jun	Wednesday	Mix of sun and clouds Clear sky after 13:00 UT	06:14 Calibration T157825
162	11.Jun	Thursday	Mix of sun and clouds	05:45 Calibration T157825 05:55 End of Campaign

Results:

In total 108 synchronised simultaneous spectra from QASUME and Brewer 107 are available from the measurement period. Measurements between 2:30 and 20:00 UT have been analysed (SZA smaller than 90°).

Conclusions:

1. The average spectral ratio between FIJ and QASUME has a slight spectral trend, from 1.01 at 305 nm decreasing to 0.98 at 365 nm.
2. The temporal variation of the spectra between FIJ and QASUME was very stable, with variations less than 2% during the whole campaign.
3. The wavelength shifts of FIJ relative to the high spectral resolution solar spectrum are between ± 20 pm in the spectral range 290 nm to 365 nm.

Comparison to previous QASUME site visits

The long-term stability of FIJ was assessed by comparing QASUME site visits performed since 2002. The measurements before 2014 were performed at Jokioinen.

As seen in figure 1, the campaign average ratio to QASUME has been stable to within 2% since 2014. Measurements before 2014 were slightly higher than QASUME by between 3% (2002 and 2003) to 6% (2007, 2010).

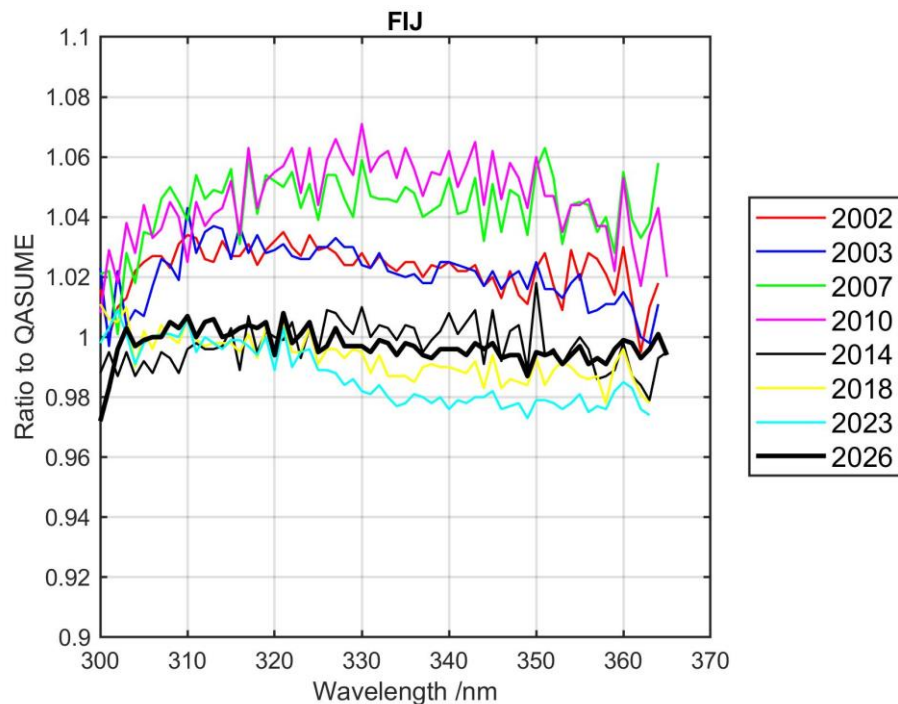


Figure 1 solar spectral ratios of FIJ to QASUME averaged over each QASUME site visit.

Summary:

The audit showed that the UV measurements performed at FMI with the Brewer 107 spectroradiometer are within the expected combined measurement uncertainty:

$$U_{\text{comp}} = \sqrt{U_{\text{qas}}^2 + U_{\text{FMI}}^2}$$

With $U_{\text{qas}} = 1.74\%$, $U_{\text{qas}} = 7.34\%$ ($\lambda < 300 \text{ nm}$) (Hülsen et al., 2016). U_{FMI} was estimated to be 4%.

The following point should be investigated in more detail:

- 1.) The combined expanded uncertainty of the comparison is shown in the Figures (see Appendix) as grey area (dotted lines show the uncertainty of Qasume). As the actual uncertainty budget of the test spectroradiometers are unknown a relative standard uncertainty of 2% (confidence level of 66%) was chosen. We strongly recommend deriving an uncertainty budget for the UV measurements at FMI.

References:

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Appendix

Detailed results for all Brewer spectrophotometers with respect to the reference spectroradiometer QASUME

