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Traceability of Solar UV Filter Radiometers

Introduction

Today the factory setting of UV broadband radiometers are not suitable to achieve measurements of solar UV irradiance with an uncertainty smaller than 5% and neither NMIs nor instrument manufacturers currently offer SI-traceable calibrations of solar UV broadband filter radiometers. The current accepted calibration methodology is to use a mixture of laboratory-based instrument characterizations, combined with an outdoor calibration using the sun as source.

In view of improving the status of the solar UV measurements within the UV monitoring community, the World Calibration Center for UV (WCCUV) organizes the UVC-III. This is the 3rd solar ultraviolet broadband radiometer campaign after the campaigns in 2006 and 2017 [1][2]. Over 70 instruments will be characterized in the laboratory of the WCCUV and calibrated outdoors relative to the QASUME reference spectroradiometer. After the calibration period all devices will be returned to their owners including a certificate demonstrating traceability to the international system of units (SI).

Challanges

The spectral responsivity of UV radiometers (SRF) changes with a steep flank over 4 decades between the UVB to the UVA wavelength range. The solar spectra increase over several decades from UVB to UVA – opposite to the spectral responsivity of the detector.

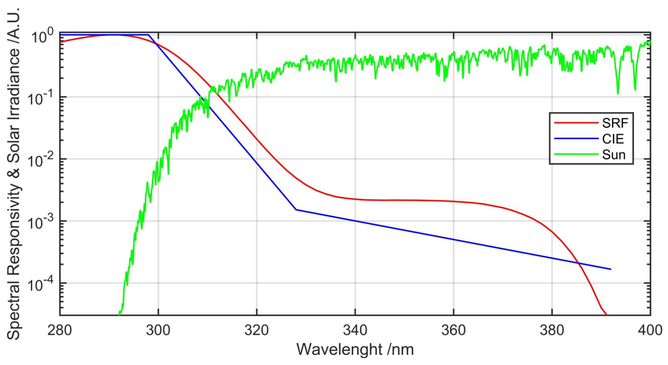

Figure 1. SRF vs. Solar irradiance spectrum.

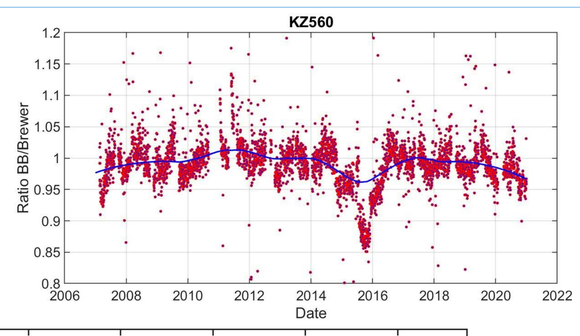

Figure 2. Long term stability of UV Radiometers

The sensitivity of the radiometer changes over the decades of operation, requiring a regular recalibration.

Radiometer signal offsets larger than 10% caused by bad factory settings.

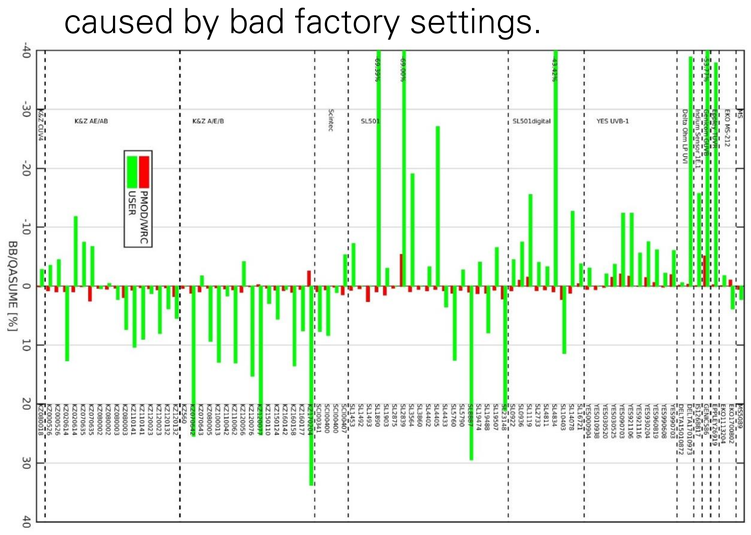

Figure 3. Summary of the UVC-II, 2017

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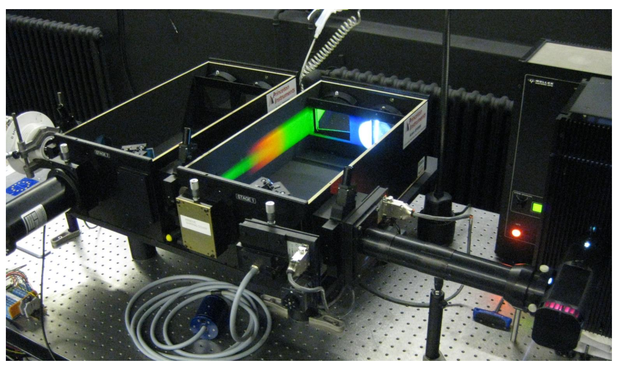
Instrumentation at PMOD/WRC



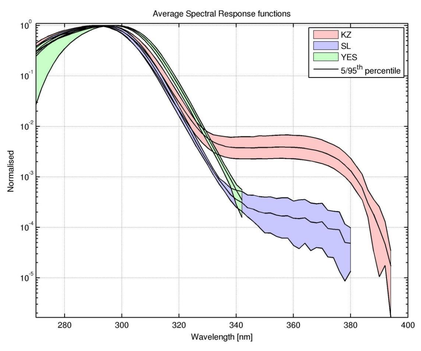
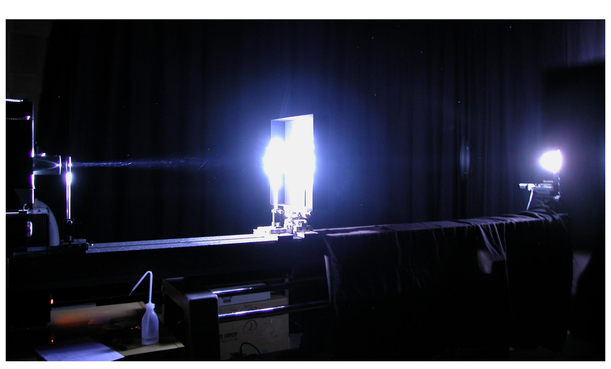


Figure 4. Left: Spectral Response Facility with an Acton SP2500 monochromator and a 500 W Xenon Source. Right: Typical SRF of UV radiometers



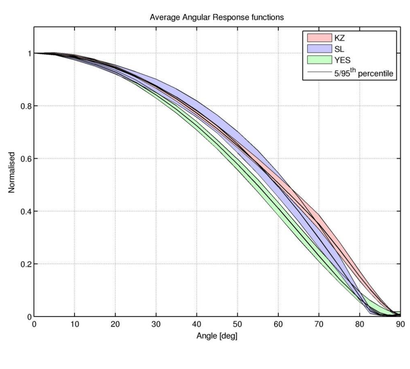
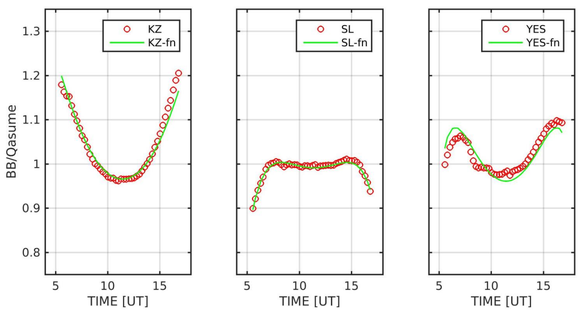
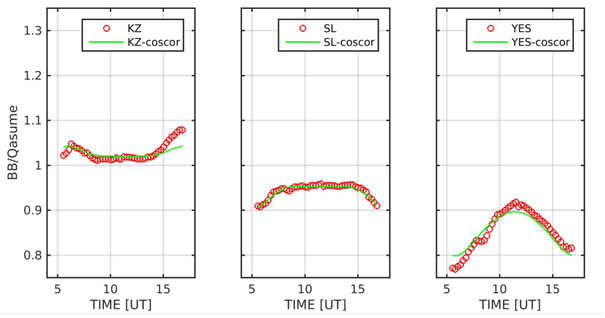


Figure 5. Left: Angular Response Facility with a 1 kW Xenon Source. The test instruments is mounted on a goniometer. Right: Typical ARF of UV radiometers.



From the data a transfer from the detector specific filter function to a normalized UV weighting function, f_n, (e.g. CIE erythema) can be calculated.



The 2nd laboratory characterisation is the angular responsivity measurement to find a suitable correction function, *Coscor*, for solar UV measurements.

Figure 6. PMOD/WRC Roof Platform for the absolute calibration relative to the Qasume reference spectroradiometer [3].

High quality solar UV weighted irradiance derived from filter radiometers require all three calibration factors.

$$E_{CIE} = (U - U_{offset}) \cdot C \cdot f_n(SZA, TO_3) \cdot Coscor$$

Conclusions

- Calibration factors and measurement equations used by the participating institutes not always follow the recommendations of the WMO [4].
- We see a sometimes scarce to non-existent recalibration frequency of the solar UV radiometers.
- The control of the humidity inside the device is crucial for most UV radiometer types [5].
- The original factory settings of the radiometers show calibration error over 10%.

References

[1] Hülsen G., and Gröbner J. (2018), Report of the Second International UV Filter Radiometer Calibration Campaign UVC-II, GAW Report- No. 240, WMO.

[2] Hülsen G., Gröbner J., Bais A., Blumthaler M., Diemoz H., Bolsee D., Diaz A., Fountoulakis I., Naranen E., Schreder J., Stefania F., and Vilaplana Guerrero J. M. (2020), Second solar ultraviolet radiometer comparison campaign UVC-II, Metrologia 57

[3] Hülsen, G., et al. (2016), Traceability of solar UV measurements using the QASUME reference spectroradiometer, Applied Optics, 55, 26, 7265-7275.

[4] Webb A., Gröbner J., and Blumthaler M. (2007), A Practical Guide to Operating Broadband Instruments Measuring Erythemally Weighted Irradiance, EUR 22595, ISBN 92-898-0032-1.

[5] Huber M., Mario Blumthaler M. and Schreder J. (2002), Effect of ambient temperature and internal relative humidity on spectral sensitivity of broadband UV detectors, Proc.SPIE 4482

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