Characterization of broadband UV radiometers in the Arpa Piedmont Optical Laboratory and intercomparison with the World Calibration Center for UV (WCC-UV).

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Abstract

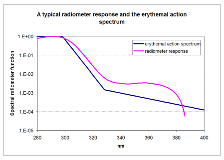
UV monitoring networks for UV index measurements have been developed during the last years in Italy. These monitoring networks are based on stations allowing continuous measurements through the use of broadband radiometers with spectral response matching the erythemal action spectrum.

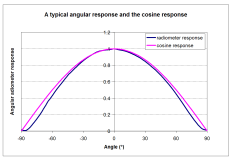
Since the radiometer spectral response differs from the erythemal action spectrum, it was necessary to set a specific calibration procedure for solar radiometers, in order to obtain accurate and reproducible UV index data. This procedure consists of two steps. First, the radiometers are characterized in laboratory, measuring their spectral and angular responses. Second, the radiometers are exposed to solar radiation and the absolute calibration factor is calculated by the comparison to a reference spectroradiometer. The aim of this work is to show the results obtained by the Arpa Piedmont Laboratory from the characterization of two of the mainly used radiometer types. Moreover the comparison of these results with those obtained by the World Calibration Center for UV is shown.

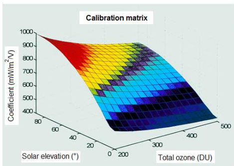
The results point out the operative difficulties associated to the laboratory characterization, with particular reference to the spectral response in the region where the radiometers are less sensitive. Due to these difficulties, it is essential a fine tuning of the instrumental chain, in order to obtain a good radiometer characterization and consequently, accurate and reproducible measurements of UV index.

Calibration matrix of erythemal radiometers

The matching between the radiometer and ideal responses (angular and spectral) is often not good, thus requiring a specific setting to the calibration procedure for solar radiometers. This procedure needs the knowledge of the radiometer spectral and angular responses and allows to define a calibration matrix, in order to convert the radiometer voltage to erythemal irradiance. The radiometer responses have to be measured in laboratory.



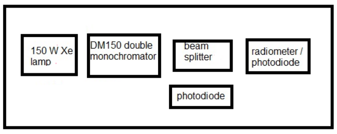




Measurements of radiometer responses in laboratory

The spectral response facility

The spectral response facility consists of a Bentham DM 150 double monochromator coupled to a 150 W Xenon lamp in order to maximize the monochromator throughput.

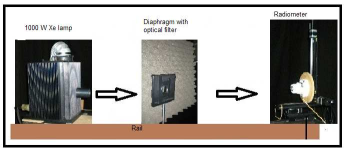


Behind the exit slit of the monochromator is placed a beam splitter. It allows to check the stability of the system during the spectral response measurement, through a photodiode placed at the exit of the beam splitter with lower intensity.

The throughput of the facility is characterized by means of a power calibrated photodiode over the 280-400 nm spectral range. At each wavelength the spectral response is calculated as the ratio between the radiometer voltage and the power measured by the photodiode

The angular response facility

The source used to measure the angular response is a 1000 W Xe lamp, placed three meters away from the radiometer, which is irradiated with a uniform field. It is rotated to obtain measurements for different incidence angles. The rotation axis passes through the radiometer's reception plane.



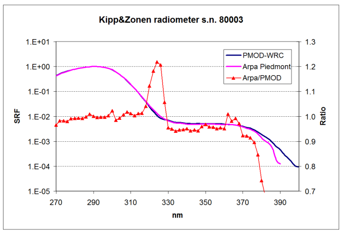
Radiometer characterization in the Arpa Piedmont Laboratory and comparison with the World Calibration Center for UV in Davos

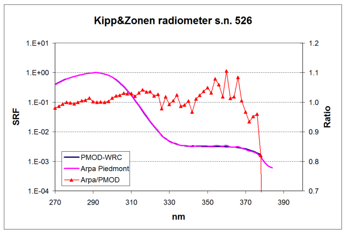
The spectral and angular responses of three radiometers were measured in the Arpa Piedmont Optical Laboratory and the measurement results were compared with those obtained by the World Calibration Center for UV (PMOD-WRC).

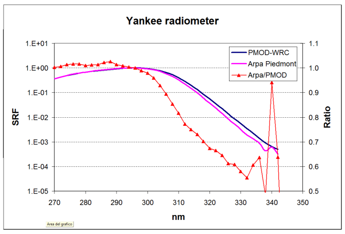
In particular the radiometers measured are two of the mainly used radiometers and are reported in the following table:

Radiometer	Holder
Kipp&Zonen UV-S-AE-T s.n. 526	Arpa Vda
Kipp&Zonen UV-S-AE-T s.n. 80003	Arpa Piedmont
Yankee Env. Syst UVB-1	Arpa Vda

Spectral responses



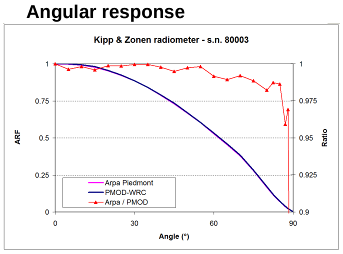


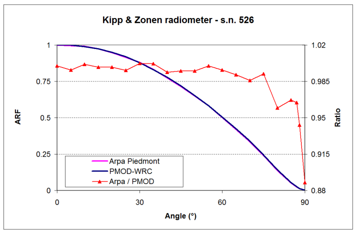


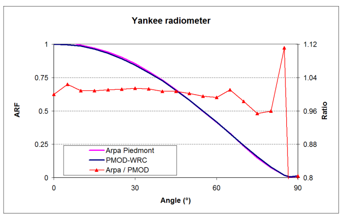
For Kipp&Zonen radiometers the differences between the two SRFs are less than 10 % in the 270-380 nm spectral range, except for the first radiometer at some wavelengths around 325 nm, where differences are higher than 20%. Likely these higher differences are due to an error in the measurement of the transmission function of the spectral response facility. In fact before measuring the SRF of the other Kipp&Zonen radiometer, the transmission function was measured again, and, in this case, the SRFs obtained by both two laboratories are in accordance around that wavelength. The different spectral range characterized for the two radiometers is due to their different sensitivity.

Regarding the Yankee radiometer, the differences between two measurements are already significant at wavelength higher than 300nm. These differences might be due to a different characterization of the dark signal and to the radiometer instability.

Angular response



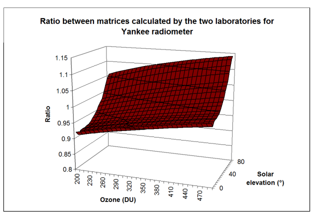


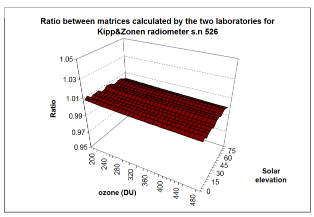


For all radiometers, the differences between the ARFs calculated by the two laboratories is equal to a few percentage points for angles less than 80 degrees. For higher angles the differences increase slightly, remaining below 20%. The accordance between results, on the whole, can be considered good.

Calibration matrices

Since the response functions must be measured in order to calculate the radiometer calibration matrix, these matrices have been calculated using the functions measured by the two laboratories and the solar measurements carried out by Arpa Valle d'Aosta during the calibration of its radiometers. In the figures shown below, the ratio between the matrices calculated using the functions measured by the two laboratories are reported.





Conclusions

For Kipp&Zonen radiometers, the comparison results are really good and the calibration matrix coefficients differ not more than 1%. Whereas for Yankee radiometer, the accordance is worse but, concerning the matrices, within 12%, although the differences between the SRFs are much higher (up to 35%).