

Standard calibration method

Calibration principle:

The fundamental problem on the calibration of the biometers is that their spectral sensitivity (response) deviates from the CIE action spectrum. The Erythral irradiance I_E is defined as

$$(1) I_E = \int_{\varphi} \int_{\theta} \int_{\lambda} R(\lambda, \theta, \varphi, O_3) \cdot CIE(\lambda) \cdot \cos(\theta) \cdot \sin(\theta) \cdot d\lambda \cdot d\theta \cdot d\varphi = \int_{\lambda} I(\lambda, O_3) \cdot CIE(\lambda) \cdot d\lambda$$

where $R(\lambda, \theta, \varphi, O_3)$ is the spectral radiance, depending on the wavelength λ , the incidence zenith angle θ , the azimuth angle φ and the total ozone amount O_3 . $I(\lambda, O_3)$ is the global spectral irradiance and $CIE(\lambda)$ is the CIE action spectrum.

The biometer signal S_B however results

$$(2) S_B = \frac{1}{C_B} \cdot \int_{\varphi} \int_{\theta} \int_{\lambda} R(\lambda, \theta, \varphi, O_3) \cdot RSE_B(\lambda) \cdot CF_B(\theta) \cdot \cos(\theta) \cdot \sin(\theta) \cdot d\lambda \cdot d\theta \cdot d\varphi$$

with the relative spectral response $RSE_B(\lambda)$, the cosine error $CF_B(\theta)$ and the calibration factor C_B . Equation 2 assumes that the instruments angular responses does not depend on wavelength and azimuth. The spectral and angular responses of the biometers also vary with other parameters, like e.g. the internal humidity or temperature of the detectors or simply their age. So the calibration factor C_B and $RSE_B(\lambda)$ are valid only if the instrument's state remains constant.

C_B is determined by a field intercomparison of the biometer against a spectroradiometer measuring the global spectral irradiance I . C_B may be approximated using (2) with

$$(3) C_B \approx \frac{1}{S_B} \cdot \int_{\lambda} I \cdot RSE_B \cdot d\lambda$$

The cosine error of the biometer (and also of the spectrometer) cause a dependency of C_B on solar elevation and cloudiness. However, under similar directional sky radiance distributions C_B mainly depends on the solar zenith angle θ_{SUN} . Therefore C_B is usually expressed as a function of θ_{SUN} , thus also including the instruments cosine error.

Combining (1) and (2) we get

$$(4) \quad I_E = S_B \cdot C_B \cdot \frac{\int_{\lambda} I \cdot CIE \cdot d\lambda}{\int_{\varphi} \int_{\theta} \int_{\lambda} R \cdot RSE_B \cdot CF_B \cdot \cos(\theta) \cdot \sin(\theta) \cdot d\lambda \cdot d\theta \cdot d\varphi}$$

To obtain the Erythemal irradiance the biometer signal S_B has to be multiplied with the calibration factor C_B and the ratio in (4).

Inserting (3) in equation 4 gives

$$(5) \quad I_E \approx S_B \cdot C_B \cdot \frac{\int_{\lambda} I \cdot CIE \cdot d\lambda}{\int_{\lambda} I \cdot RSE_B \cdot d\lambda} \approx S_B \cdot C_B \cdot ADA(\theta_{SUN}, O_3)$$

The ratio in (5) will be called ADA and depends on the biometer's spectral response and especially on the global spectral irradiance. Changes in global spectral irradiances by a constant factor in the irradiance cancel out in ADA. Therefore ADA is calculated with a radiative transfer model for a set of possible solar zenith angles and total ozone amounts O_3 for each measurement site with its individual characteristics. ADA is influenced only very little by clouds and changing aerosol amounts.

The best estimation for the 'true' Erythemal irradiance I_E finally is calculated by multiplication of S_B with C_B and ADA. To simplify the application the calibration matrix $ADACAL(\theta_{SUN}, O_3)$ is generated by multiplying C_B and ADA

$$(6) \quad \boxed{I_E \approx S_B \cdot ADACAL(\theta_{SUN}, O_3)}$$

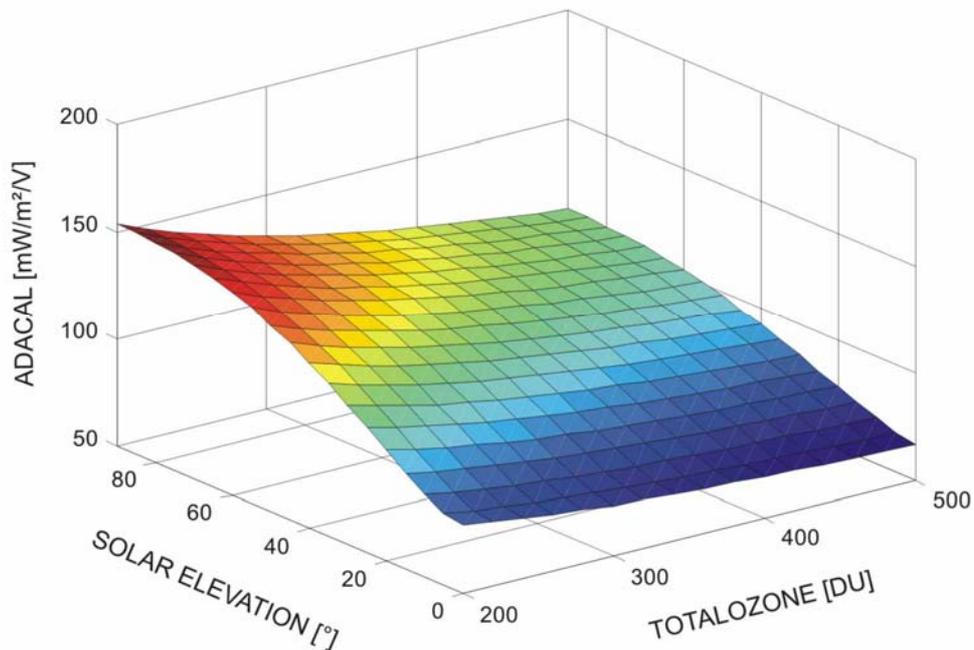


Fig. 1: Calibration matrix of a biometer. In order to convert the instruments output signal to the CIE-defined erythemal irradiance multiply the detector signal by ADACAL