

Calibration Certificate

No. 2023-2853-03

Calibration Item

Pyrgeometer

Manufacturer	Kipp & Zonen
Type	CGR4 with PT100 body thermistor
Serial number	160176

Customer

Alfred Wegener Institut
Helmholtz-Zentrum für Polar und Meeresforschung
Am Handelshafen 12
27570 Bremerhaven
Germany

Calibration Mark

2023-2853-03

Period of Calibration

02-Jul-2023 to 16-Jul-2023

Davos Dorf, 17 July, 2023



C. Thomann
In charge of calibration



Dr. Julian Gröbner
Head IR Radiometry Section

PMOD/WRC follows the requirements for the competence of testing and calibration laboratories according to ISO/IEC 17025:2017. Calibration certificates without signature are not valid. This calibration certificate shall not be reproduced except in full without the written approval of the Physikalisch-Meteorologisches Observatorium Davos and World Radiation Center.

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Calibration procedure

This instrument was calibrated by an outdoor comparison to the pyrometer reference group (PIR 31463F3, PIR 31464F3, CG4 FT004, and CG4 010535) of the infrared radiometry section of the World radiation Center (WRC-IRS) at PMOD/WRC according to the document "QM-SOP-IRS-0019". The comparison is made during nighttime with cloudy and cloud-free situations. The pyrometer was installed in a PMOD-VHS ventilation unit with a heated air flow around the dome.

From the measurements the responsivity C is determined by using the standard relation (see Eq. 1 below), which involves the pyrometer signal U_{emf} and the body temperature T_{B} of the pyrometer. Body temperature is determined using equation (2) below. The longwave downward irradiance E is calculated using the following equation:

$$E = \frac{U_{\text{emf}}}{C} (1 + k_1 \sigma T_{\text{B}}^3) + k_2 \sigma T_{\text{B}}^4 \quad (1)$$

The Stefan-Boltzmann constant σ was set to the 2018 recommended CODATA value,

$$\sigma = \frac{\pi^2 k^4}{60 \hbar^3 c^2} = 5.670374 \dots \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$$

The conversion of the resistance to temperature used the equation shown below:

$$T = \frac{-a + \sqrt{a^2 - 4b \left(1 - \frac{R}{100}\right)}}{2b} + 273.15 \quad (2)$$

where the temperature T is given in Kelvin and the thermistor resistance R is given in Ohm. The constants a and b are listed below:

$$a = 3.90802 \times 10^{-3} \quad b = -5.80195 \times 10^{-7}$$

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Calibration results

Responsivity: $C = 9.45 \mu\text{VW}^{-1}\text{m}^2$

$U = 0.31 \mu\text{VW}^{-1}\text{m}^2$

The responsivity C was derived using the following pyrogeometer coefficients k_1 and k_2 :

$$k_1 = -0.03 \quad k_2 = 0.9972$$

The reported relative 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%.

Calibration remarks

Logger used for WISG reference : CR23X1-1028 (2023)

Logger used for DUT : CR23X3-1031 (2023)

Radiation and temperature conditions during the calibration:

Longwave downward radiation (LDR)	265 W/m ²	to	333 W/m ²
Net radiation	-93 W/m ²	to	-72 W/m ²
Pyrogeometer body temperature	6.4 °C	to	19.8 °C
Integrated water vapour (IWV)	14.5 mm	to	25.9 mm
Residuals (2.5% to 97.5% percentile)	0.6 W/m ²		

Measurement period 02-Jul-2023 to 16-Jul-2023

Measurement days 9

Comments

The coefficients k_1 and k_2 were determined in the reference blackbody source of PMOD/WRC on 28 June 2023 using blackbody temperatures between -19 °C and +15 °C and pyrogeometer body temperatures between -10 °C and +20 °C.

The dome of the instrument was cleaned regularly and the sillicagel was changed on arrival.