Physikalisch-Meteorologisches Observatorium Davos
World Radiation Center

pmod wrc

Calibration Certificate

No. 2022-2669-05

Calibration Item

Pyrgeometer

Manufacturer	Kipp & Zonen
Type	CGR4 with PT-100 body thermistor
Serial number	110400

Customer

Alfred Wegener Institut
Helmholtz-Zentrum für Polar und Meeresforschung
Am Handelshafen 12
27572 Bremerhaven
Germany

Calibration Mark

2022-2669-05

Period of Calibration

22-Aug-2022 to 22-Sep-2022

Davos Dorf, 28 September, 2022

C. Thomann
In charge of calibration

Dr. Julian Gröbner
Head IR Radiometry Section

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Calibration procedure

This instrument was calibrated by an outdoor comparison to the pyrgeometer 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 pyrgeometer 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 pyrgeometer signal U_{emf} and the body temperature T_{B} of the pyrgeometer. Body temperature is determined using equation (2) below. The longwave downward irradiance E is calculated using the following equation:

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

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

$$\sigma = \frac{\pi^2 \mathrm{k}^4}{60\hbar^3 \mathrm{c}^2} = 5.670374\cdots \times 10^{-8}\ \mathrm{Wm}^{-2}\mathrm{K}^{-4}$$

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

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

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: $C = 8.49\ \mu\mathrm{VW}^{-1}\mathrm{m}^2$

$\mathrm{U} = 0.27\ \mu\mathrm{VW}^{-1}\mathrm{m}^2$

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

$k_1 = 0.04$ $\quad$ $k_2 = 0.9983$

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 (2022)
Logger used for DUT : CR7X2-001 (2022)

Radiation and temperature conditions during the calibration:

Longwave downward radiation (LDR)	241	W/m^2	to	308	W/m^2
Net radiation	-99	W/m^2	to	-73	W/m^2
Pyrgeometer body temperature	3.9	°C	to	15.9	°C
Integrated water vapour (IWV)	10.4	mm	to	19.6	mm
Residuals (2.5% to 97.5% percentile)	0.7	W/m^2			

Measurement period	22-Aug-2022 to 22-Sep-2022
Measurement days	16

Comments

The coefficients k_1 and k_2 were determined in the reference blackbody source of PMOD/WRC on 27 September 2022 using blackbody temperatures between -19 °C and +15 °C and pyrgeometer body temperatures between -10 °C and +20 °C.

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

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