

## Calibration Certificate

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No. 2021-2333-01

### Calibration Item

#### Pyrgeometer

Manufacturer	Kipp & Zonen
Type	CGR4 with PT-100 body thermistor
Serial number	110386

### Customer

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

### Calibration Mark

2021-2333-01

### Period of Calibration

06-Aug-2021 to 15-Aug-2021

Davos Dorf, 17 August, 2021



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 pyrgometer 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 V2.2". The comparison is made during nighttime with cloudy and cloud-free situations. The pyrgometer 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 pyrgometer signal  $U_{emf}$  and the body temperature  $T_B$  of the pyrgometer. Body temperature is determined using equation (2) below. The longwave downward irradiance  $E$  is calculated using the following equation:

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

The Stefan-Boltzmann constant  $\sigma$  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:  $C = 12.56 \mu\text{VW}^{-1}\text{m}^2$

$U = 0.42 \mu\text{VW}^{-1}\text{m}^2$

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

$$k_1 = 0.04 \quad k_2 = 1.0009$$

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 (2021)

Logger used for DUT : CR23X-2049 (2021)

Radiation and temperature conditions during the calibration:

Longwave downward radiation (LDR)	275 W/m <sup>2</sup>	to	327 W/m <sup>2</sup>
Net radiation	-92 W/m <sup>2</sup>	to	-76 W/m <sup>2</sup>
Pyrgeometer body temperature	8.3 °C	to	18.9 °C
Integrated water vapour (IWV)	17.2 mm	to	23.9 mm
Residuals (2.5% to 97.5% percentile)	0.3 W/m <sup>2</sup>		

Measurement period 06-Aug-2021 to 15-Aug-2021

Measurement days 5

### Comments

The coefficients  $k_1$  and  $k_2$  were determined in the reference blackbody source of PMOD/WRC on 2 August 2021 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.