

## Calibration Certificate

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No. 2015-1060-03

### Calibration Item

#### Pyrgeometer

Manufacturer      Kipp & Zonen  
Type                CGR4 with PT-100 body thermistor  
  
Serial number      110399

### Customer

Alfred-Wegener-Institut für Polar- u. Meeresforschung  
Geschäftszimmer/Gebäude E  
Am Handelshafen 12  
27570 Bremerhaven  
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### Calibration Mark

2015-1060-03

### Period of Calibration

27-Jul-2015 to 20-Aug-2015

Davos Dorf, 21 August, 2015



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 SOP "IRS\_Pyrgeometer\_calibration". 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 sensitivity factor  $C$  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:

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

The Stefan-Boltzmann constant  $\sigma$  was set to the 2006 recommended CODATA value.

$$\sigma = 5.6704 \cdot 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$$

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:

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

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### Calibration results

**Sensitivity:**  $C = 10.59 \mu\text{V W}^{-1} \text{ m}^2$

$u = 0.39 \mu\text{V W}^{-1} \text{ m}^2$

The sensitivity C was derived using the following pyrheliometer coefficients  $k_1$  and  $k_2$ :

$$k_1 = 0.00 \quad k_2 = 0.9981$$

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

Radiation and temperature conditions during the calibration:

Longwave downward radiation (LDR)	278 W/m <sup>2</sup>	to	349 W/m <sup>2</sup>
Net radiation	-98 W/m <sup>2</sup>	to	-72 W/m <sup>2</sup>
Pyrheliometer body temperature	8.6 °C	to	21.6 °C
Integrated water vapour (IWV)	13.6 mm	to	24.6 mm
Residuals (2.5% to 97.5% percentile)	0.9 W/m <sup>2</sup>		

Measurement period 27-Jul-2015 to 20-Aug-2015  
Measurement days 13

### Comments

The coefficients  $k_1$  and  $k_2$  were determined in the reference blackbody source of PMOD/WRC on 23 July 2015 using blackbody temperatures between -19 °C and +15 °C and pyrheliometer body temperatures between -10 °C and +20 °C.