

## Calibration Certificate

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No. 2013-113-02

### Calibration Item

### Pyrgeometer

Manufacturer	Kipp & Zonen
Type	CGR4 with PT100 body thermistor
Serial number	110385

### Customer

Alfred Wegener Institut  
Helmholtz-Zentrum für Polar und Meeresforschung  
Am Luneort 15  
27572 Bremerhaven  
Germany

### Calibration Mark

2013-113-02

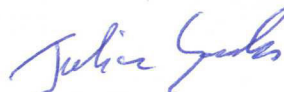
### Period of Calibration

02-Sep-2013 to 14-Sep-2013

Davos Dorf, 16 September, 2013



Dr. S. Nyeki  
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 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 SOP "IRS\_Pyrgometer\_calibration". 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 sensitivity factor  $C$  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 2006 recommended CODATA value.

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

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:**  $C = 8.55 \mu\text{V W}^{-1} \text{m}^2$   
 $u = 0.28 \mu\text{V W}^{-1} \text{m}^2$

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

$$k_1 = 0.03 \quad k_2 = 0.9997$$

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)	245 W/m <sup>2</sup>	to	313 W/m <sup>2</sup>
Net radiation	-99 W/m <sup>2</sup>	to	-74 W/m <sup>2</sup>
Pyrgometer body temperature	2.4 °C	to	16.1 °C
Integrated water vapour (IWV)	10.7 mm	to	22.0 mm
Residuals (2.5% to 97.5% percentile)	0.7 W/m <sup>2</sup>		

Measurement period 02-Sep-2013 to 14-Sep-2013  
Measurement days 8

## Comments

The coefficients  $k_1$  and  $k_2$  were determined in the reference blackbody source of PMOD/WRC on 30 August 2013 using blackbody temperatures between -19 °C and +15 °C and pyrgometer body temperatures between -10 °C and +20 °C.