

Calibration Certificate

No. 2009_073_06

Calibration Item

Pyrgeometer

Manufacturer	The Eppley Laboratory, Inc.
Type	Precision Infrared Radiometer, modified with three dome thermistors
Serial Number	26956F3

Customer

Alfred-Wegener-Institut für Polar- und Meeresforschung
Geschäftszimmer/Gebäude E
Am Handelshafen 12
27570 Bremerhaven
Germany

Calibration Mark

Label 2009_073_06

Period of Calibration

1 to 19 July 2009

Davos Dorf, 14 August 2009



D. Bühlmann
In charge of calibration



Dr. J. 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. 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), which involves the pyrgeometer signal U_{emf} , the body temperature T_B and the Dome temperature T_D of the pyrgeometer. Body and Dome temperatures are determined using the Steinhart and Hart equation and the YSI coefficients of the YSI 44031 thermistor (see Eq. 2). The dome temperature T_D is calculated from the average of the three dome temperature measurements. The longwave downward irradiance E is calculated using the following equation:

$$E = \frac{U_{emf}}{C} (1 + k_1 \cdot \sigma T_B^3) + k_2 \cdot \sigma T_B^4 - k_3 \cdot \sigma (T_D^4 - T_B^4) \quad (1)$$

The Stefan-Boltzmann constant σ was set to the 2006 recommended CODATA value

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

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

$$\frac{1}{T} = a + b \cdot \log(R) + c \cdot \log(R)^3 \quad (2)$$

where the temperature T is given in Kelvin and the thermistor resistance R is given in Ohm. The constants a , b , and c , were determined for the temperature range -30°C to $+40^\circ\text{C}$ using the nominal resistance to temperature values provided by the manufacturer. These coefficients are listed below:

$$a = 10297.2 \cdot 10^{-7} \quad b = 2390.6 \cdot 10^{-7} \quad c = 1.5677 \cdot 10^{-7}$$

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Calibration results

Sensitivity: $C = 4.26 \mu\text{V W}^{-1} \text{ m}^2$

$u = 0.11 \mu\text{V W}^{-1} \text{ m}^2$

The sensitivity C was derived using the following pyrgeometer coefficients k_1 , k_2 and k_3 :

$k_1 = 0.13$

$k_2 = 0.9988$

$k_3 = 3.5$

The reported 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%.

Calibrations Remarks

Radiation and temperature conditions during the calibration:

Longwave downward radiation (LDR)	259 W/m ²	to	353 W/m ²
Net radiation	-77 W/m ²	to	-15 W/m ²
Pyrgeometer body temperature	3.0 °C	to	17.8 °C
Residuals (2.5% to 97.5% percentile)	1.3 W/m ²		

Measurement period 1 to 19 July 2009

Measurement days 13

Comments

The coefficients k_1 , k_2 and k_3 were determined in the reference blackbody source of PMOD/WRC using blackbody temperatures between -30 °C and +15 °C and pyrgeometer body temperatures between -15 °C and +20 °C.