Physikalisch-Meteorologisches Observatorium Davos
World Radiation Center

pmod wrc

Calibration Certificate

No. 2009_073_05

Calibration Item	Pyrgeometer	
	Manufacturer	The Eppley Laboratory, Inc.
	Type	Precision Infrared Radiometer, modified with three dome thermistors
	Serial Number	26955F3
Customer	Alfred-Wegener-Institut für Polar- und Meeresforschung Geschäftszimmer/Gebäude E Am Handelshafen 12 27570 Bremerhaven Germany	
Calibration Mark	Label 2009_073_05	
Period of Calibration	1 to 19 July 2009	

Davos Dorf, 14 August 2009

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In charge of calibration

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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:

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

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

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

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

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

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 °C using the nominal resistance to temperature values provided by the manufacturer. These coefficients are listed below:

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

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Calibration results

Sensitivity: $C = 4.63\ \mu V\ W^{-1}\ m^2$

$u = 0.10\ \mu V\ W^{-1}\ m^2$

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

$k_1 = 0.11$ $k_2 = 0.9989$ $k_3 = 2.9$

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/m²	to	353	W/m²
Net radiation	-80 W/m²	to	-17	W/m²
Pyrgeometer body temperature	3.4 °C	to	18.2	°C
Residuals (2.5% to 97.5% percentile)	0.9 W/m²			

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.

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