Calibration Report: Eppley PIR Pyrgeometer

Summary

Calibration Date: January 2002 Calibration Due Date: January 2004

Serial No.	C $\mu V/W/m^2$	k1	k2	k3	Cs $\mu V/W/m^2$	K'
24323F3	4.28	0.1084	1.0027	3.533	3.87	3.50
26036F3	4.30	0.1105	1.0016	3.550	3.86	3.49
26168F3	4.38	0.0641	1.0870	3.420	4.18	3.16
26181F3	3.53	0.0051	0.9976	2.972	3.48	3.05

$$E = \frac{U_{emf}}{C}(1 + k_1\sigma T^3_B) + k_2\sigma T^4_B - k_3\sigma (T^4_D - T^4_B) - f\Delta T_{S-N} \qquad EQN\ 1$$

Where:

E = Irradiance, W/m^2

U_{emf} = Thermopile output voltage, μV

C = Sensitivity Coefficient, $\mu V/W/m^2$

$k1,k2,k3$ = Correction factors

σ = Stephan-Boltzmann Constant, 5.67 x 10^{-8} $W/m^2\ K^4$

T_B = Output of body thermistor YSI 44031 , K

T_D = Output of dome thermistor YSI 44031, K

f = Correction factor for long wave component of direct sun if the instrument is used without a shading disk.

$\Delta T_{S-N} = (T_{SE} - T_N) + (T_{SW} - T_N)$

T_{SE}, T_N, T_{SW} = Output of dome thermisters, southeast, north and southwest respectively, K

$$E = \frac{U_{emf}}{Cs} + \sigma T^4_B - K'\sigma (T^4_D - T^4_B) \qquad EQN\ 2$$

Where:

E = Irradiance, W/m^2

Cs = Sensitivity Coefficient, $\mu V/W/m^2$

U_{emf} = Thermopile output voltage μV

σ = Stephan-Boltzmann Constant, 5.67 x 10^{-8} $W/m^2\ K^4$

T_B = Output of body thermister YSI 44031, K

K' = Dome heating constant

T_D = Output of dome thermister YSI 44031, K

Calibration Report: Eppley PIR Pyrgeometer

Abstract

Four Eppley Laboratory, Inc. Precision Infrared Pyrgeometers (PIR) instruments were calibrated. This calibration was performed in order that the instruments comply with specifications set in the Baseline Surface Radiation Network (BSRN) Operator's Manual, V 1.0, 1997. Physikalisch-Meteorolisches Observatorium Davos (PMOD) in Davos-Dorf, Switzerland performed the calibration. The calibration date is 31 January 2002. The serial numbers of the units modified and calibrated were 24323F3, 26036F3, 26168F3, and 26181F3.

1. Introduction

Four Eppley Laboratory, Inc. Precision Infrared Radiometers (PIR) Pyrgeometer instruments were calibrated to meet the 1997 Baseline Surface Radiation Network (BSRN) specifications. The Physikalisch-Meteorolisches Observatorium Davos (PMOD) in Davos-Dorf, Switzerland completed these calibration tasks.

2. Results

Calibration results for each instrument are shown in the above summary page along with the governing equations. The use of EQN. 1 with the above tabular values is described in each of the Calibration Certificates provided by PMOD. EQN. 2 and the associated tabular values are provided as a historical connection to the Albrecht et al. single sensitivity factor method.

3. Discussion

These sensors have been modified and calibrated to permit the measurement of diffuse radiation. Global measurements involve determination of the factor *f*. The manufacturer, Eppley Laboratories, Inc., defines an uncertainty of 5%. Field data need to be examined in order to assess the standard uncertainty made by the modified instruments.

The single sensitivity factor calibration histories of the four sensors are as follows:

24323F3

Jan. 2002	PMOD	3.87 $\mu V/W/m^2$
Apr. 1998	PMOD	3.79 $\mu V/W/m^2$
July 1992	CMDL	4.022 $\mu V/W/m^2$
Oct. 1987	NARCK	4.19 $\mu V/W/m^2$
Sept. 1987	Eppley	4.01 $\mu V/W/m^2$
Apr. 1986	Eppley	4.06 $\mu V/W/m^2$
Aug. 1984	Eppley	4.01 $\mu V/W/m^2$

26036F3

Jan. 2002	PMOD	3.86 $\mu V/W/m^2$
Apr. 1998	PMOD	3.84 $\mu V/W/m^2$
July 1992	CMDL	4.055 $\mu V/W/m^2$
Oct. 1987	NARCK	4.28 $\mu V/W/m^2$
Sept. 1987	Eppley	4.14 $\mu V/W/m^2$
Apr. 1986	Eppley	4.26 $\mu V/W/m^2$
Nov. 1985	Eppley	4.14 $\mu V/W/m^2$

26168F3

Jan. 2002	PMOD	4.18 $\mu V/W/m^2$
Apr. 1998	PMOD	4.22 $\mu V/W/m^2$
July 1992	CMDL	4.366 $\mu V/W/m^2$
Oct. 1987	NARCK	4.43 $\mu V/W/m^2$
Sept. 1987	Eppley	4.38 $\mu V/W/m^2$
Apr. 1986	Eppley	4.52 $\mu V/W/m^2$
Apr. 1984?	Eppley	4.38 $\mu V/W/m^2$

26181F3

Jan. 2002	PMOD	3.48 $\mu V/W/m^2$
Dec. 1999	PMOD	3.47 $\mu V/W/m^2$
Oct. 1997	NREL	3.58 $\mu V/W/m^2$
July 1992	CMDL	3.763 $\mu V/W/m^2$
Oct. 1987	NARCK	3.93 $\mu V/W/m^2$
Sept. 1987	Eppley	3.90 $\mu V/W/m^2$
Apr. 1986	Eppley	3.77 $\mu V/W/m^2$

Each instruments single sensitivity factor, *Cs*, has remained within variability of 5% or less through each of the calibrations, which did not involve physical changes to the instrument. This variability is within manufacturer stated design specifications.

4. Summary

A calibration of four Eppley Laboratory Inc. Precision Infrared Radiometer, (PIR) instruments has been completed. Data analyses have been performed. The calibration factors are presented in the summary table above and in the Calibration Certificates.

No apparent performance anomalies are indicated from the single sensitivity factor calibration history of the sensors.

These calibration factors can be used with these four instruments from 31 January 2002.

REFERENCES

Albrecht, B., and S.K. Cox, Procedures for Improving Pyrgeometer Performance, Journal of Applied Meteorology, 16, 179-188, 1977.

Frohlich, C., and R. Philipona, Characterization of pyrgeometers and the accuracy of atmospheric longwave measurements, Ch., Betz, Applied Optics, 34(9), 1598-1605, 1995.

McArthur, J.B., World Climate Research Program, Baseline Surface Radiation Network Operations Manual, Version 1.0. June 1997.

wrc pmod
Weltstrahlungszentrum Centre Mondial de Rayonnement World Radiation Center
Physikalisch-Meteorologisches Observatorium Davos

Calibration Certificate for Pyrgeometer

Model : Eppley PIR Pyrgeometer
Serial No. : 24323F3 (with 3 dome thermistors)
Owner: SAIC

Calibration measurements were performed in the black body radiation source of PMOD/WRC at Davos. Measurements are made at three body temperatures of t_B = 25° C, 10° C and -5° C and the black body temperature was set at about 10° C and 25° C below the body temperature of the instrument. Four different dome temperatures are chosen for the measurements with t_B = 10°C. Body and dome temperatures are determined using the Steinhart and Hart equation and the YSI coefficients of the YSI 44031 thermistors.

From these measurements the sensitivity factor C and three correction factors k_1, k_2 and k_3 are determined.

C = 4.28 μV/Wm^{-2}
k_1 = 0.1084
k_2 = 1.0027
k_3 = 3.533

If the pyrgeometer is used without a shading disk the long-wave part of the direct sun has to be subtracted. For this a correction factor f has to be determined during clear days and this factor should be checked monthly.

The dome temperature is calculated as a mean value of the three dome temperature measurements. The instrument has to be positioned such that the cable points to the North. The South-North temperature difference of the dome is calculated using the following formula $\Delta T_{S\text{-}N} = (T_{SE} - T_N) + (T_{SW} - T_N)$. If necessary a constant value has to be added or subtracted in order to get $\Delta T_{S\text{-}N}$ equal to zero over night.

The long-wave downward irradiance E is calculated using the following equation.

$$E = \frac{U_{emf}}{C}\left(1 + k_1 \sigma T_B^3\right) + k_2 \sigma T_B^4 - k_3 \sigma \left(T_D^4 - T_B^4\right) - f\,\Delta T_{S-N}$$

For calculations with the old pyrgeometer formula after Albrecht et al. the sensitivity factor C and the correction factor K are also calculated from the same calibration measurements.

C = 3.87 μV/Wm^{-2} K = 3.5

Davos Dorf, 31. Januar 2002

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