Calibration Report: Eppley PIR Pyrgeometer

Summary

Calibration Date: May 2014 Calibration Due Date: May 2016

NREL/SRRL Equation and Coefficients:

Serial No.	*k0*	*k1*	*k2*	*k3*	*Sigma*	±*U95* (W/m^2)
26181F3	0.00	0.2670	1.0010	-3.7	$5.6704 * 10^{-8}$	2.7
33974F3	0.00	0.2760	1.0060	-3.5	$5.6704 * 10^{-8}$	2.9

NREL/SRRL Equation:

$$W_{in} = K_0 + K_1 * V_{TP} + K_2 * W_r + K_3 * (W_d - W_r)$$

Where:

- K_0, K_1, K_2 and K_3 = calibration coefficients.
- V_{TP} = thermopile output voltage, in micro-Volt.
- $W_r = \sigma * T_r^4$ = receiver irradiance, in W/m^2,

  Where:

  - $\sigma = 5.6704 * 10^{-8}$, in W . m^{-2} . K^{-4}
  - $T_r = T_c + 0.0007044 * V_{TP}$ = Receiver temperature, in Kelvin.
  - T_c = Case temperature, in Kelvin
- $W_d = \sigma * T_d^4$, in W/m^2, where T_d = Dome temperature, in Kelvin.

UUT Calibration Coefficients:

26181F3: K_0 = 0.00; K_1 = 0.2670; K_2 = 1.0010; K_3 = -3.7
33974F3: K_0 = 0.00; K_1 = 0.2760; K_2 = 1.0060; K_3 = -3.5

Expanded Uncertainty: (see attached figure for calibration data)

26168F3: U_{95} = ± 2.7 W/m^2 (w.r.t. WISG*) with Coverage Factor = 2.0
33974F3: U_{95} = ± 2.9 W/m^2 (w.r.t. WISG*) with Coverage Factor = 2.0

**World Infrared Standard Group*

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Abstract

Two Eppley Laboratory, Inc. Precision Infrared Pyrgeometer (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 2.1, 2005. The National Renewable Energy Laboratory's (NREL) Solar Radiation Research Laboratory (SRRL) Metrology Laboratory in Golden, Colorado performed the calibration. The calibration period was 1 May – 19 May 2014. The serial numbers of the units calibrated were 26181F3 and 33974F3.

1. Introduction

Two Eppley Laboratory, Inc. PIR's were calibrated to meet the 2005 Baseline Surface Radiation Network (BSRN) specifications. NREL's SRRL's Metrology Laboratory in Golden, Colorado completed these calibration tasks.

2. Results

Calibration results for each instrument are shown in the above summary page along with the governing equation. The use of the NREL/SRRL equation with the above tabular values is described above. The PIR instruments at COVE have been using the NREL/SRRL equation since June 2012. The NREL/SRRL equation replaced the PMOD equation that was used in previous years. The reason for the change is the NREL/SRRL equation results in better precision (i.e. smaller standard deviation).

The Calibration Certificates provided by NREL/SRRL describe their method of calibration.

3. Discussion

These sensors have been 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 calibrated instruments.

Since we have used a different equation since June 2012 to determine the new calibration coefficients, the single sensitivity factor calibration histories will be replaced with the four calibration coefficients shown on the first page. Note: No previous calibration found for 33974F3.

26181F3

May 2014	NREL	K_0= 0.00, K_1= 0.2670, K_2= 1.0010, K_3= -3.7
Jul. 2009	PMOD	3.86 $\mu V/W/m^2$
Jan. 2002	PMOD	3.53 $\mu V/W/m^2$

Dec. 1999 PMOD 3.57 $\mu V/W/m^2$

33974F3

May 2014 NREL K_0= 0.0, K_1= 0.2760, K_2= 1.0060, K_3= -3.5

The variability between calibrations cannot be compared at this time since we are switching to a new equation. 5% or less variability through each of the calibrations is the manufactured stated design specification.

4. Summary

A calibration of two Eppley Laboratory Inc. PIR instruments has been completed using the new NREL/SRRL equation. This equation has replaced the PMOD equation since June 2012, due to the NREL/SRRL equation providing better precision. Data analyses have been performed. The calibration factors are presented in the summary table above and in the Calibration Certificates.

Please see the archived calibration write-ups on the PIR's if you want to see the old PMOD equation used before switching to the new NREL/SRRL equation. It is located under Pyrgeometer at http://cove.larc.nasa.gov/calibration.html.

These calibration factors can be used with these two instruments after 19 May 2014.

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 2.1., 2005.

National Renewable Energy Laboratory

Solar Radiation Research Laboratory

Metrology Laboratory

Calibration Certificate

UUT Model: PIR
UUT Serial Number: 26181F3
Owner: SSAI-NASA
Traceability: World Infrared Standard Group (WISG), using PIR-31197F3
Outdoor Calibration Period: May 1 to 19, 2014
Environmental Conditions: Outdoors, variable sky conditions

Measurement Equation:

$W_{in} = K_0 + K_1 * V_{TP} + K_2 * W_r + K_3 * (W_d - W_r)$

Where:

- K_0 , K_1 , K_2 and K_3 = calibration coefficients.
- V_{TP} = thermopile output voltage, in micro-Volt.
- $W_r = \sigma * T_r^4$ = receiver irradiance, in W/m^2,

  where:
  - $\sigma = 5.6704 * 10\text{-}8$, in W . m-2. K-4 .
  - $T_r = T_c + 0.0007044 * V_{TP}$ = Receiver temperature, in Kelvin.
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UUT Calibration Coefficients:

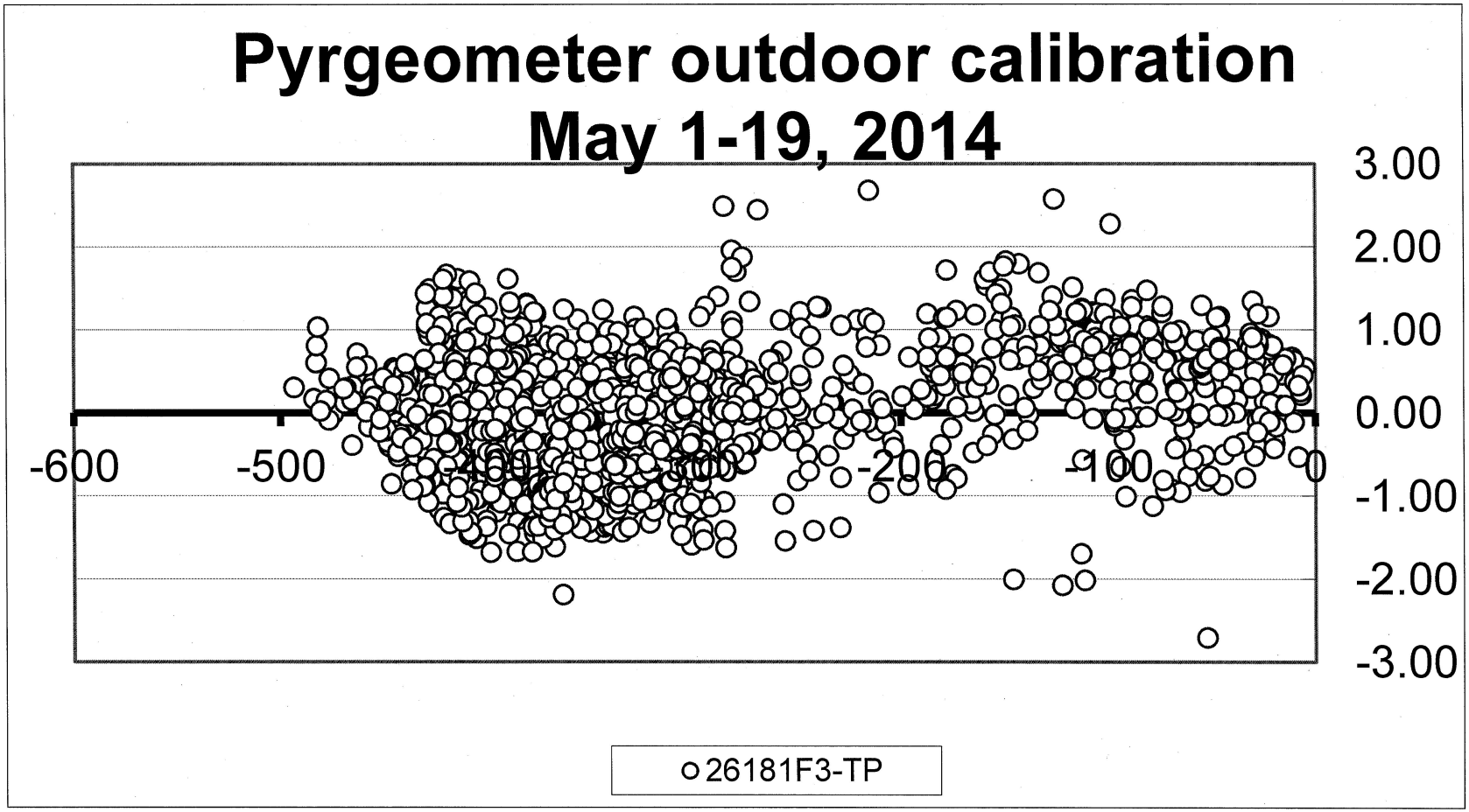
K0 = 0.00 ; K1 = 0.2670 ; K2 = 1.0010 ; K3 = -3.7

Expanded Uncertainty: (see attached figure for calibration data)

$U_{95} = \pm$ 2.7 W/m^2 (w.r.t. WISG), with Coverage Factor = 2.

Calibrated by : Ibrahim Reda
Title: Principle Scientist-VI
Signed:
Date: May 23, 2014

QA by: Afshin Andreas
Title: Senior Scientist-IV
Signed:
Date: May 23, 2014


Pyrgeometer outdoor calibration
May 1-19, 2014
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-600
-500
-200
-100
0
26181F3-TP

National Renewable Energy Laboratory

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Calibrated by : Ibrahim Reda
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Date: May 23, 2014

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Title: Senior Scientist-IV
Signed:
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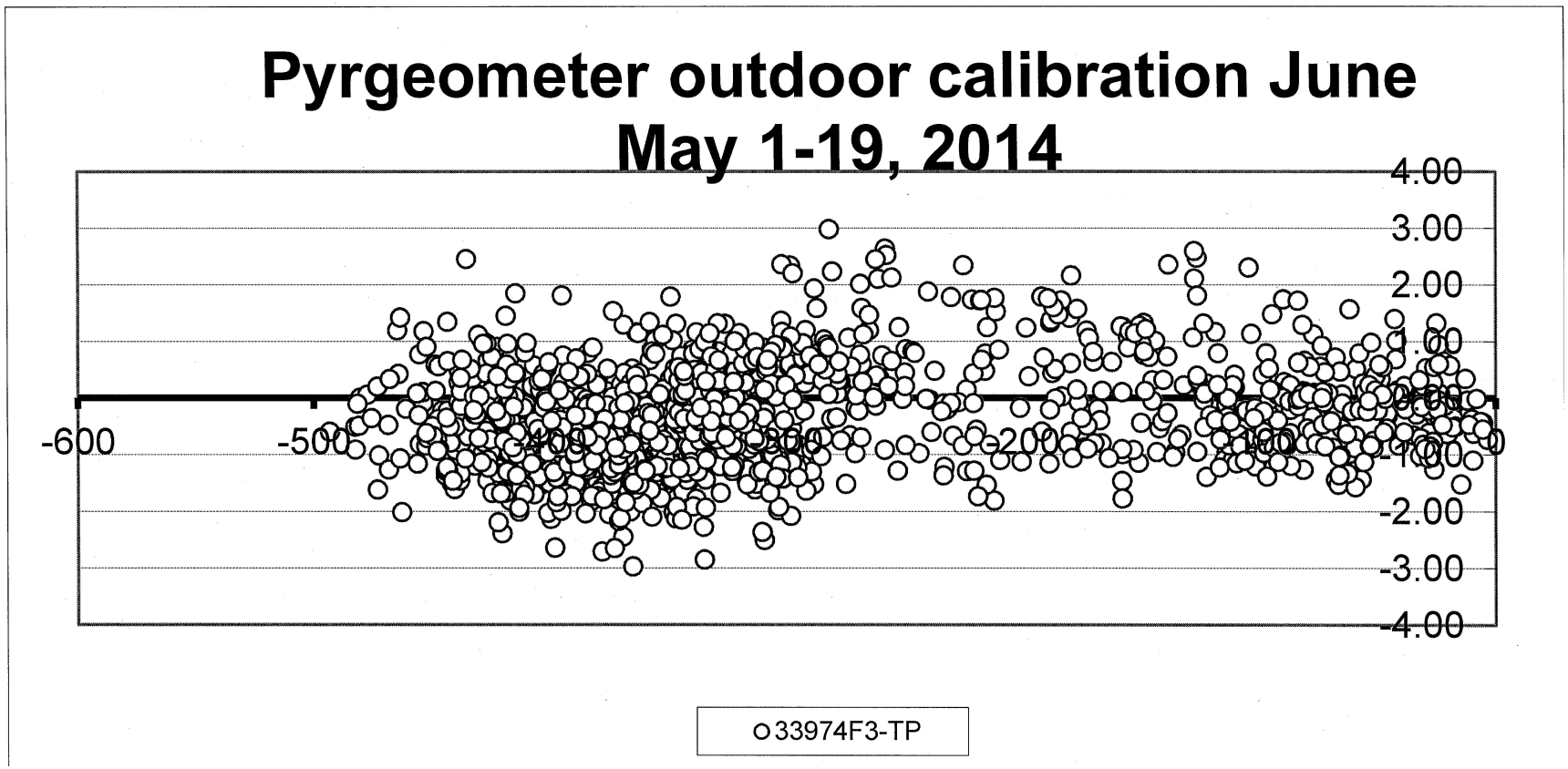
Pyrgeometer outdoor calibration June
May 1-19, 2014
4.00
3.00
2.00
1.00
-2.00
-3.00
-4.00
-600
-500
-200
33974F3-TP