Calibration Report: Pyranometer CM22-000025
World Meteorological Organization number 39035
(For the Baseline Radiation Network)

Fred M. Denn and Bryan E. Fabbri.
Science Systems & Applications, Inc., Hampton, Virginia.
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Calibration date: 2025-04-30.
Next calibration: 2027-04-30.
Reference standard: AHF-31041, minimum irradiance 700W/m**2
The method here is described in "ISO 9846 Solar energy – Calibration of a pyranometer using a pyrheliometer, First edition 1993-12-01". The shade and unshade intervals have been extended to get several measurements on each cycle.

The calibration coefficients and their associated uncertainties (U95%) have been determined for a pyranometer. The pyranometer was mounted with the connector at an azimuth of approximately 195º with respect to the tracker, sun direction being azimuth = 0.0º. Data were collected during March of 2023, details are below. Only data between solar zenith angles of 40º and 50º were used. The calibration is traceable Through the Golden Colorado National Renewable Energy Laboratory's (NREL) September 2022 National Pyrheliometer Comparison (NPC) to the World Radiation Reference Maintained at the Physikalisch-Meteorologisches Observatorium Davos / World Radiation Center. The NREL cavity reference group attended the International Pyrheliometer Comparison held in Davos during September and October of 2021.

The sensitivity factors and their associated uncertainties (95%) are as follows:

Sensor	S (μV/(W/m^2)) $\pm$ U95%	Method
CM22-000025	9.295 $\pm$ 1.275%	shade/unshade
WMO number 39035		

Application

$$I = (\mu V \text{ output})/S \pm \text{sqrt}(2)*U95\%$$

Where: I = the irradiance measured by the pyranometer
(μV output) = microvolt output of the pyranometer
S = calibration coefficient of the pyranometer
U95% = the 95 % confidence level

Some supporting plots, a list of past calibration values, and a brief description of the calibration process is presented below.

CALIBRATION LOCATION
NASA Langley Hampton VA.
Latitude = 37.1038 deg., Longitude = -76.3872 deg., Elevation = 6 meters.

CALIBRATING PERSON(S)
Fred Denn, Bryan Fabbri

TRACEABILITY
The reference standard was Eppley Laboratories Inc., absolute cavity radiometer AHF31041, with its associated data acquisition system. Cavity AHF31041 participated in the 2000, 2005, 2010, and 2015 International Pyrheliometer Comparisons (IPC) at the Physikalisch-Meteorologisches Observatorium, in Davos Switzerland, where the World Radiation Reference (WRR) is kept. Cavity AHF31041's calibration is verified annually at the National Pyrheliometer Comparison (NPC) held at the National Renewable Energy Laboratory (NREL) in Golden Colorado. In 2021 a new Campbell CR1000x data acquisition system was developed by a member of our group (Fred Denn) at NASA Langley. Traceability of the new data acquisition system to the WRR was established at the September/October 2022 and 2023 NPCs.

HARDWARE CONFIGURATION
The pyranometer was mounted on a Kipp Zonen tracker with the standard shading mechanism. The nut on the little bolt near the base of the tracker that holds the flat rod that that holds the shading mechanism is removed. The flat bar is removed from the bolt and the shading ball mechanism is allowed to descend until it rests on the arm assemble to place the pyranometers in the unshaded (global) position. The flat bar is placed on the bolt to place the pyranometers in the shaded configuration. Pyranometers are placed in the global position for approximately five minutes, and it the shaded position for about five minutes.

DATA DAYS
Data for this calibration event were collected during in year 2025, on the following days March 12, 21, and April 09, 16, 17. Only the mean of measurements between solar zenith angles of 40º and 50º were used for the final value. Data outside that range illustrate the solar zenith angle response of the pyranometer.

Pyranometer Calibration Plot

○ /Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr/groups_2025-03-12_cm22-000025.lrc.dat
□ /Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr/groups_2025-03-21_cm22-000025.lrc.dat
◇ /Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr/groups_2025-04-09_cm22-000025.lrc.dat
△ /Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr/groups_2025-04-16_cm22-000025.lrc.dat
◁ /Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr/groups_2025-04-17_cm22-000025.lrc.dat

slope= 0.004666

Zen_all_pnts_case_cm22-000025_2025.eps
Apr 22 12.15.43 2025
/Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr_groups
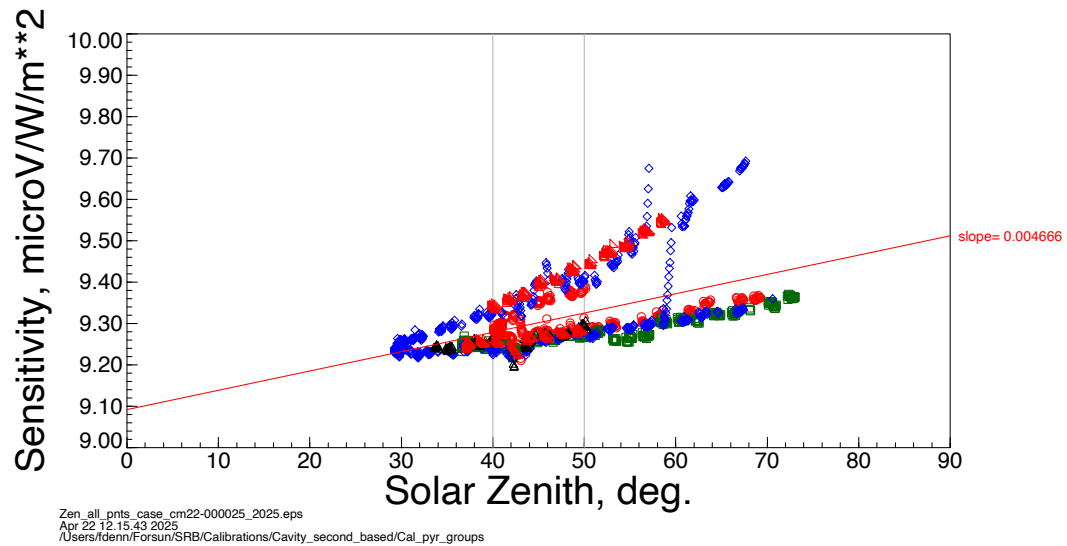
Calibration coefficients for, all zenith angles, several days. This displays the solar zenith angle dependance of the calibration values.

Pyranometer Calibration Plot

○ /Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr/groups_2025-03-12_cm22-000025.lrc.dat
□ /Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr/groups_2025-03-21_cm22-000025.lrc.dat
◇ /Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr/groups_2025-04-09_cm22-000025.lrc.dat
△ /Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr/groups_2025-04-16_cm22-000025.lrc.dat
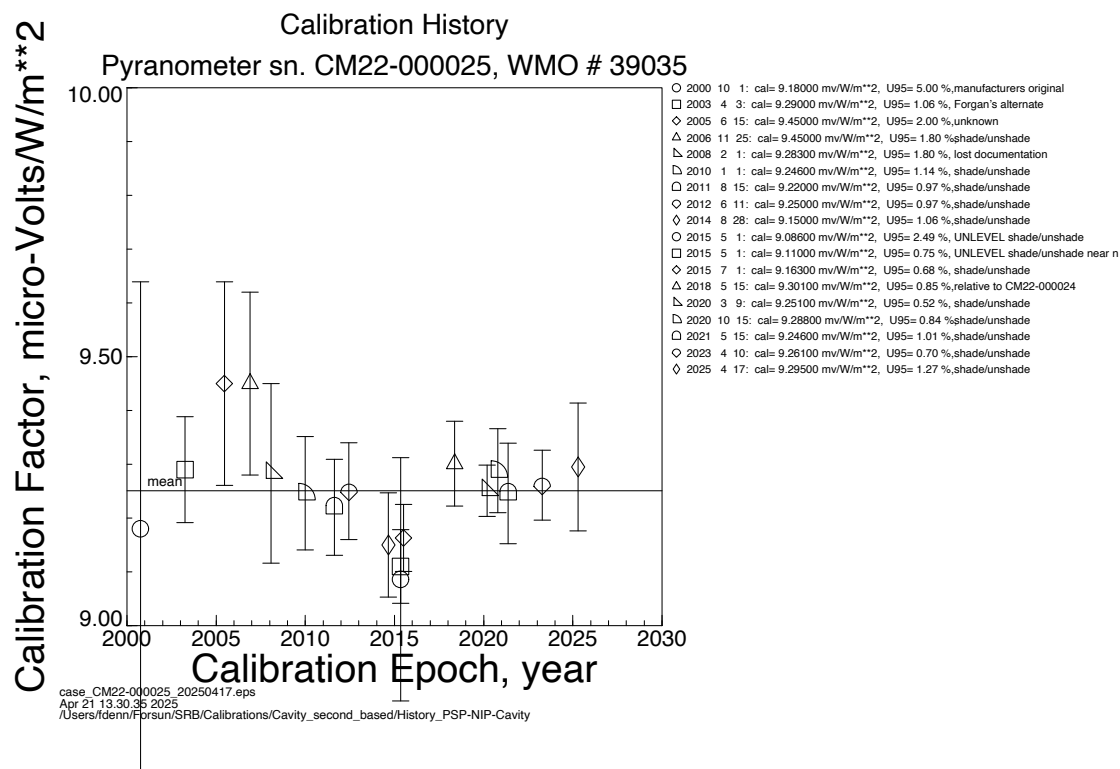◁ /Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr/groups_2025-04-17_cm22-000025.lrc.dat

Zen_Range_case_cm22-000025_2025.eps
Apr 22 12.15.43 2025
/Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/Cal_pyr_groups
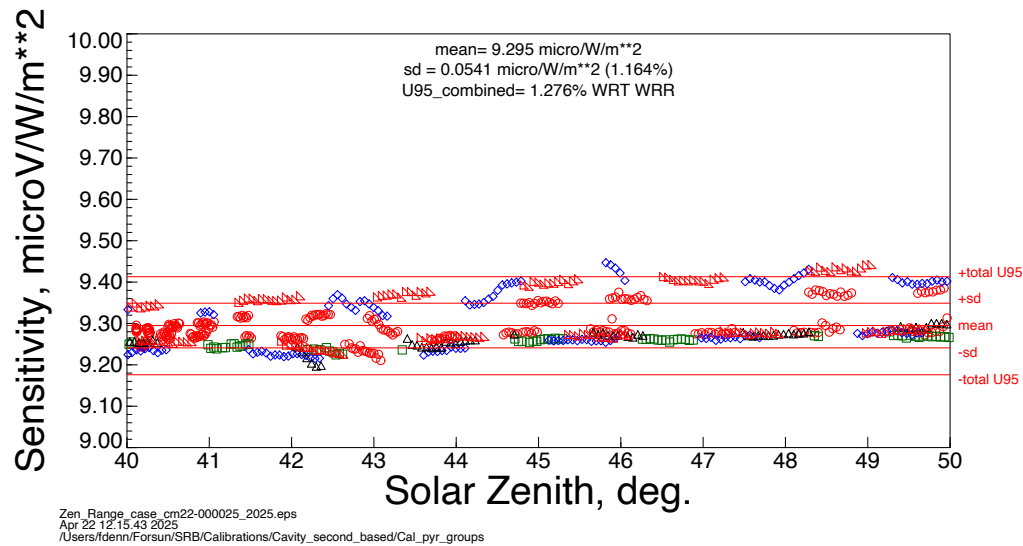
Calibration coefficients for several days. Each symbol represents an individual calibration value. The mean of these values will be taken to be the final calibration value. The overall U95 uncertainty is also displayed here. Data is limited to solar zenith angles 40º through 50º.

Calibration History
Pyranometer sn. CM22-000025, WMO # 39035

Calibration Factor, micro-Volts/W/m**2
Calibration Epoch, year

○	2000 10 1:	cal= 9.18000 mv/W/m**2, U95= 5.00 %,manufacturers original
□	2003 4 3:	cal= 9.29000 mv/W/m**2, U95= 1.06 %, Forgan's alternate
◇	2005 6 15:	cal= 9.45000 mv/W/m**2, U95= 2.00 %,unknown
△	2006 11 25:	cal= 9.45000 mv/W/m**2, U95= 1.80 %shade/unshade
◁	2008 2 1:	cal= 9.28300 mv/W/m**2, U95= 1.80 %, lost documentation
◿	2010 1 1:	cal= 9.24600 mv/W/m**2, U95= 1.14 %, shade/unshade
◖	2011 8 15:	cal= 9.22000 mv/W/m**2, U95= 0.97 %,shade/unshade
○	2012 6 11:	cal= 9.25000 mv/W/m**2, U95= 0.97 %,shade/unshade
◇	2014 8 28:	cal= 9.15000 mv/W/m**2, U95= 1.06 %,shade/unshade
○	2015 5 1:	cal= 9.08600 mv/W/m**2, U95= 2.49 %, UNLEVEL shade/unshade
□	2015 5 1:	cal= 9.11000 mv/W/m**2, U95= 0.75 %, UNLEVEL shade/unshade near n
◇	2015 7 1:	cal= 9.16300 mv/W/m**2, U95= 0.68 %, shade/unshade
△	2018 5 15:	cal= 9.30100 mv/W/m**2, U95= 0.85 %,relative to CM22-000024
◁	2020 3 9:	cal= 9.25100 mv/W/m**2, U95= 0.52 %, shade/unshade
◿	2020 10 15:	cal= 9.28800 mv/W/m**2, U95= 0.84 %shade/unshade
◖	2021 5 15:	cal= 9.24600 mv/W/m**2, U95= 1.01 %,shade/unshade
○	2023 4 10:	cal= 9.26100 mv/W/m**2, U95= 0.70 %,shade/unshade
◇	2025 4 17:	cal= 9.29500 mv/W/m**2, U95= 1.27 %,shade/unshade

case_CM22-000025_20250417.eps
Apr 21 13.30.35 2025
/Users/fdenn/Forsun/SRB/Calibrations/Cavity_second_based/History_PSP-NIP-Cavity

Calibration history for pyranometer CM22-000025. The solid horizontal line represents the mean value. The symbols and their error bars represent the mean and U95 of each calibration event. The column on the right presents numerical values for each calibration event and a brief description of the calibration method used.

CALIBRATION HISTORY
(doy = day of year)

Pyranometer: Kipp and Zonen CM22-000025

date	S (μV/W/m^2)	U95 (%)	calibration type
2025 April 17	9.295	1.276	shade/unshade
2023 April 10	9.261	0.702	shade/unshade
2021 May 15	9.246	1.01	shade/unshade
2020 Oct 15	9.288	0.84	shade/unshade
2020 Mar 09	9.251	0.52	shade/unshade
2018 May 15	9.301	0.85	relative to CM22-000024
2015 July 01	9.163	0.68	shade/unshade
2015 May 01	9.110	0.75	UNLEVEL shade/unshade
2014 Aug 28	9.15	1.06	shade/unshade
2012 Jun 11	9.25	0.97	shade/unshade
2011 Aug 15	9.22	0.97	shade/unshade
2010 Jan 01	9.25	1.14	shade/unshade
2008 Feb 02	9.28	1.8	lost document, shade/unshade
2006 Nov 25	9.45	1.88	shade/unshade
2006 May 17	-----	-----	bad cavity data, removed
2003 Apr 03	9.29	1.06	Forgan's alternate
2000 Oct 01	9.18	5.00	manufacturers original

Photo of a pyranometer mounted on a sun tracker. Note connector position.

A Very Brief Description of the Calibration Process.

1) Pyranometers are to be mounted horizontally, while pyrheliometers are to be mounted on the tracker pointing at the sun.
2) Deploy the Cavity Radiometer, select the 4 second data collection parameter file. Start the cavity calibration process.
3) Modify the field radiometer program, so that a file of second data is produced in addition to the minute resolution data file.
4) Prepare the tracker hardware to operate in manual shade/unshade mode. Either in manual mode or with the automatic pneumatic cylinder.
5) Start the cavity system, first calibrating the cavity, then collecting data for about 20 minutes before doing a recalibration. Repeat the calibration/measure process for the entire calibration period.
6) Collect pyranometer data in the unshaded configuration for about 5.0 minutes, and in the shaded configuration for about 5.0 minutes.
7) Continue this process while sky conditions permit while cavity irradiance is greater than 700 Watts/meter**2.
8) Transfer the cavity and pyranometer data to the data processing computer.
9) Remove unstable (greater than 1 w/m**2 variation over 3 seconds) in the cavity data file. This depends on which cavity control system is used.
10) Run a splitter program on the field radiometer file to generate a separate file for the shaded and unshaded periods for each instrument.
11) Run a plotting program on each data file so the data can be reviewed for: cloud events; bad shading; errors in the splitting routine; etc. Remove bad data records.
12) Run calibration programs to determine the calibration coefficient for each instrument.
13) Combine several days of calibration data to get a final calibration coefficient.
14) Produce a calibration document, such as this one, for each instrument. To be considered valid, a calibration must be documented and traceable to recognized standards, in this case the World Radiation Reference (WRR) in Davos Switzerland.