Calibration Report: Pyranometer CM22-000024

Fred M. Denn and Bryan E. Fabbri.
Science Systems & Applications, Inc., Hampton, Virginia.
Document date 2020 May 23.

<table>
<tr>
<td>
Calibration date: 2020-03-09. Calibration data limited to one day due to the COVID-19 pandemic.
Next calibration: 2022-07-01.
Reference standard: AHF-31041

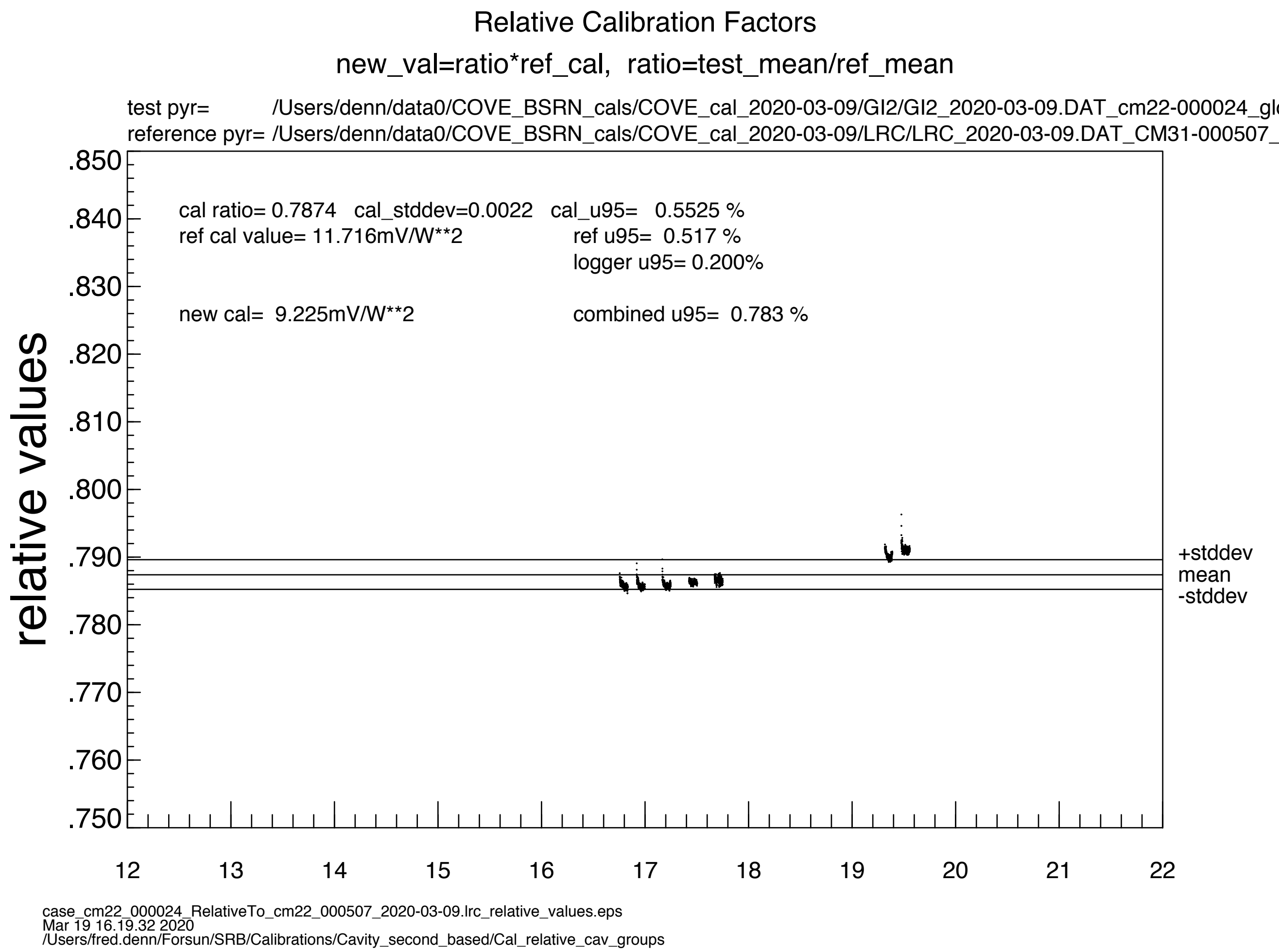
The calibration coefficients and their associated uncertainties (U95%) have been determined for one pyrheliometer. The unit of the calibration coefficient (S) is $\mu V/(W/m^2)$. The reference standard was Eppley Laboratories Inc., absolute cavity radiometer AHF31041, with its associated data acquisition system. Cavity AHF31041 participated in the 2015 International Pyrheliometer Comparison (IPC XII) at the Physikalisch-Meteorologisches Observatorium, in Davos Switzerland. It is therefore traceable to the World Radiation Reference. Cavity AHF31041's calibration is verified annually at the National Pyrheliometer Comparison held at the National Renewable Energy Laboratory in Golden Colorado, most recently in September of 2019.

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

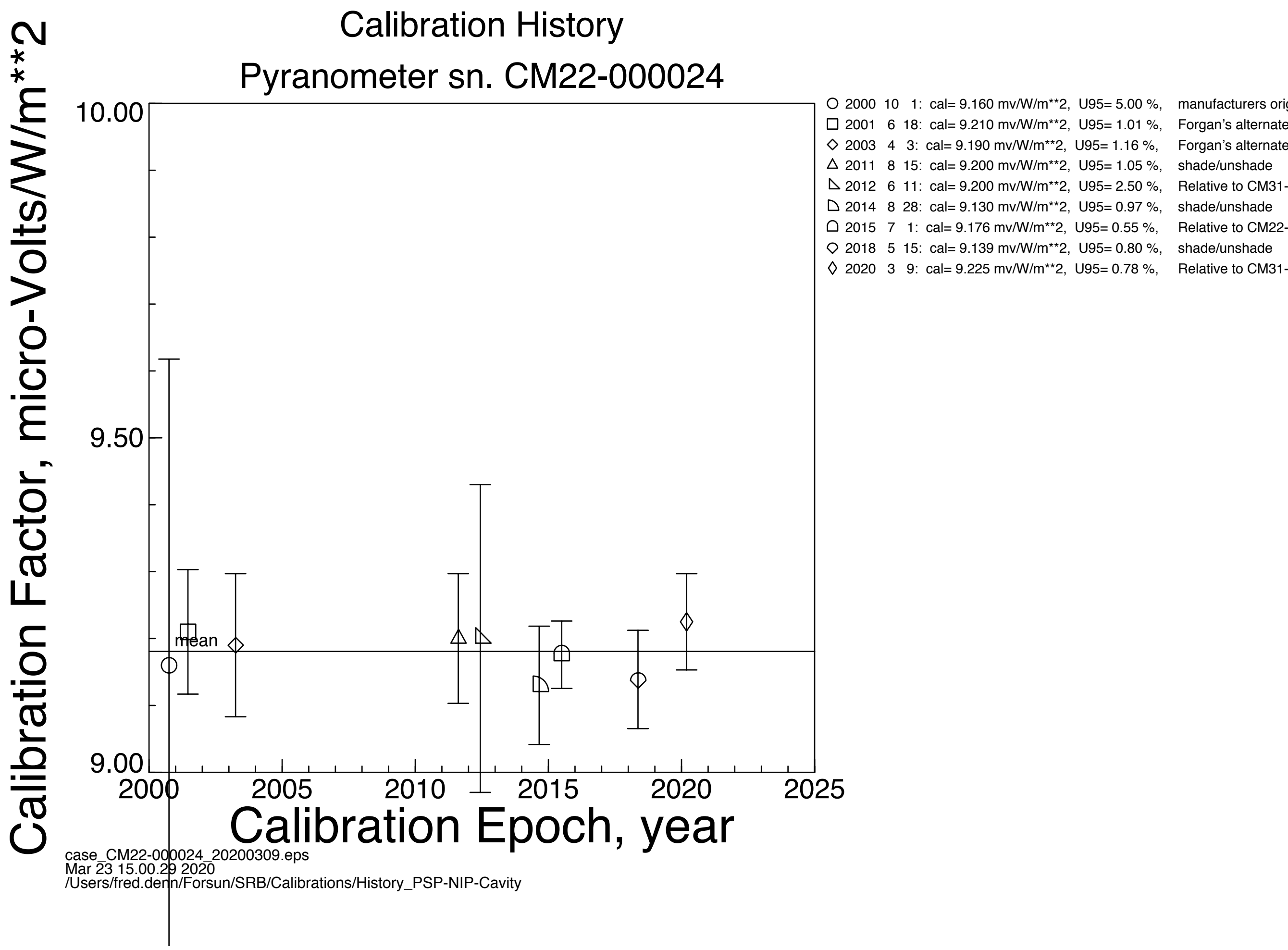
Sensor | S ($\mu V/(W/m^2)$) ± U95% | Method
CM22-000024 | 9.225 ± 0.78% | relative to CM31-000507

Application
$$I = (\mu V\ output)/S \pm sqrt(2)*U95\%$$
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
</td>
<td>25</td>
</tr>
</table>

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



Calibration coefficients for several days. Each symbol represents a cavity run which is approximately 25 minutes. These data are combined to get a final calibration coefficient for the entire, multi-day, calibration session.



Calibration history for pyranometer CM31-000507. 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

Pyranometer: Kipp and Zonen CM22-000024

date	S (μV/W/m^2)	U95 (%)	calibration type
2020-03-09	9.22	0.78	relative to CM31-000507
2018-05-15	9.14	0.84	shade/unshade
2015-07-01	9.18	0.55	relative to CM22-000025
2014-08-28	9.13	0.97	shade/unshade
2012-06-11	9.20	2.50	relative to CM31-000507
2011-08-15	9.20	1.05	shade/unshade
2003-04-03	9.19	1.16	Forgan's alternate
2001-06-18	9.214	1.013	Forgan's alternate
2000-10-01	9.16	5.00	manufacturers original

A Very Brief Description of the Calibration Process.

1) Deploy the Cavity Radiometer, select the 4 second data collection parameter file. Start the cavity calibration process.
2) Modify the field radiometer program, set the parameter that causes one second data collection.
3) Prepare the tracker hardware to operate in manual shade/unshade mode. Either in manual mode or with the automatic pneumatic cylinder.
4) Start the cavity in sun-run mode, do this on a minute that is a multiple of 5 into the hour. Note a cavity calibration and sun-run takes almost 30 minutes.
5) Raise or lower the tracker shading balls every 5 minutes, on multiples of 5 minutes into the hour.
6) Continue this process as long as sky conditions permit while cavity irradiance is greater than 700 Watts/meter**2.
7) On both the cavity computer and the field radiometer computer, open a web browser and email the data files to the data processing computer, Files could also be copied to an external memory stick.
8) Remove data that is flagged as "unstable" in the cavity data file.
9) Run a splitter program on the field radiometer file to generate a separate file for the shaded and unshaded periods for each instrument.
10) Run a plotting program on each data file so the data can be reviewed for: cloud events; bad shading; errors in the splitting routine; ect. Remove bad data.
11) Run a calibration program to determine the calibration coifficient for each instrument.
12) Combine several days of calibration data to get a final calibration coefficient.
13) Produce a calibration document, such as this one, for each instrument. To be considered valid a calibration must be both traceable to recognized standards, in this case the World Radiation Reference (WRR) in Davos Switzerland, and documented.