Calibration Report: Pyrheliometer
Kipp and Zonen CH1-960133

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Calibration date: 2022 March 01.
Next calibration due: 2024-March-01.
Reference standard: AHF-31041, minimum irradiance 700 W/m**2.

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 sensitivity factor and its associated uncertainty (95%) are as follows:

Manufacturer	Serial Number	$\mu V/(W/m^2)$	U95
Kipp and Zonen	CH1-960133	10.679	± 0.52%

Application

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

Where: I = the irradiance measured by the pyrheliometer
(mV output) = microvolt output of the pyrheliometer
S = calibration coefficient of the pyrheliometer
U95% = the 95 % confidence level of a field measurement.

Supporting information, 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 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.

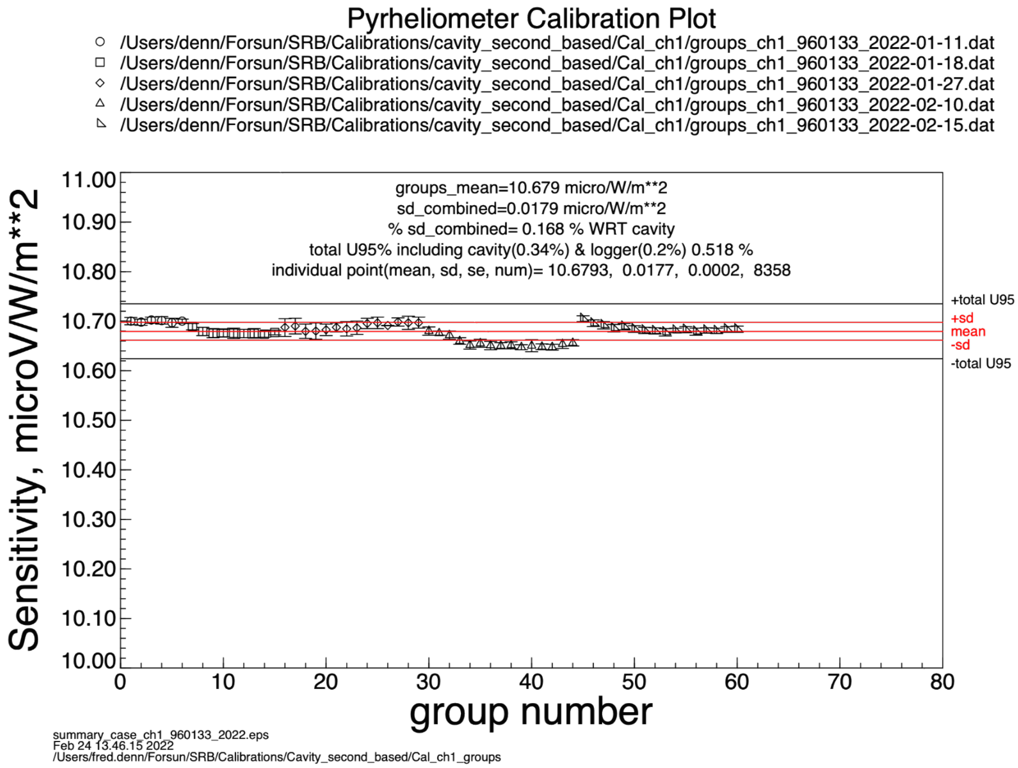
HARDWARE CONFIGURATION

The pyrheliometer was mounted on a Kipp Zonen 2AP tracker and aligned with the sun.

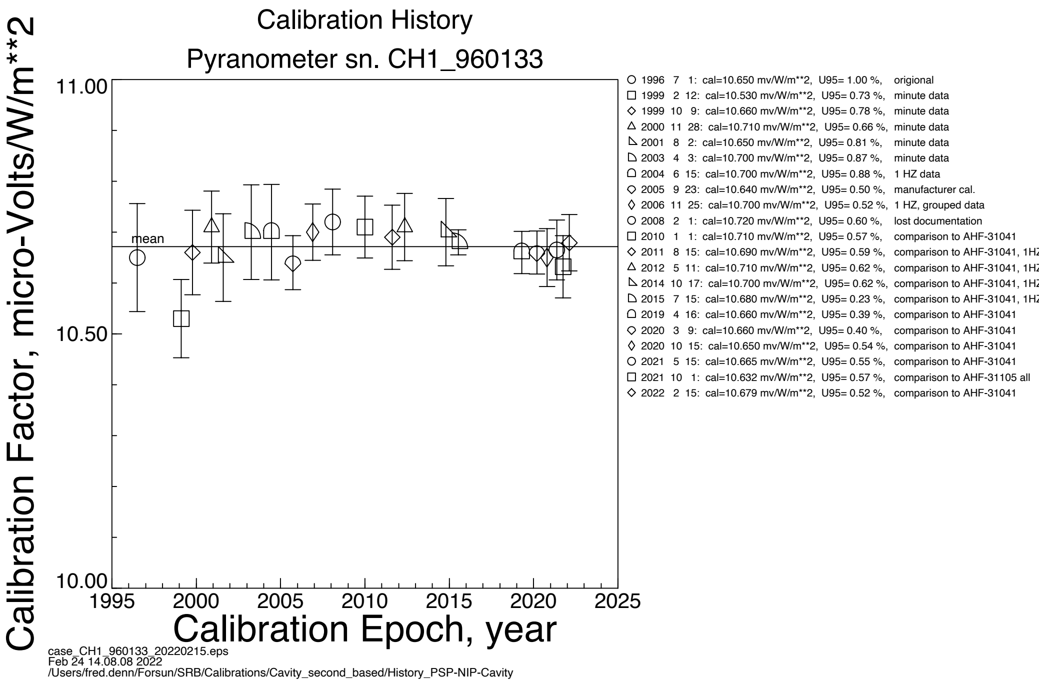
DATA COLLECTION

Data were collected on four days in January and February of 2022 data collection periods are presented below. Test pyrheliometer data are calibrated against cavity pyrheliometer data taken at four second intervals during runs of approximately twenty minutes generally starting on the hour and half hour.

Date	hour range, UCT
2022-01-11	10.4 – 20.4
2022-01-18	16.3 – 21.0
2022-01-27	13.5 – 21.0
2022-02-10	14.5 – 21.3
2022-02-15	13.2 – 21.3



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 pyrheliometer CH1-960133. 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 HISTORIES

Pyrheliometer: Kipp and Zonen CH1-960133.

date	S (μV/(W/m^2))	U95 (%)	Note
2022 Mar 01	10.679	0.52	1HZ, ref. AHF-31041
2020 Oct 15	10.65	0.54	1HZ, ref. AHF-31041
2020 Mar 09	10.658	0.50	1HZ, ref. AHF-31041
2019 Apr 16	10.66	0.50	1HZ, ref. AHF-31041
2015 Jul 15	10.68	0.23	1HZ, ref. AHF-31041
2014 Nov 17	10.70	0.62	1HZ, ref. AHF-31041
2012 May 11	10.71	0.62	1HZ, ref. AHF-31041
2011 Sep 01	10.69	0.59	1HZ, ref. AHF-31041
2010 Jan 01	10.71	0.57	comparison to AHF-31041
2008 Feb 01	10.72	0.60	lost document
2006 Nov 25	10.70	0.58	(1 HZ grouped data)
2006 May 10			Setup error, no useable data.
2005 Sep 23	10.64	0.50	(manufacturer calibration)
2005 Jun 15			Failed, sent in for repairs.
2004 Jul 15	10.70	0.88	(1 HZ data)
2003 Apr 02	10.70	0.87	(minute data)
2001 Aug 02	10.65	0.81	(minute data)
2000 Nov 28	10.71	0.66	(minute data)
1999 Oct 09	10.66	0.78	(minute data)
1999 Feb 12	10.53	0.73	(minute data)
1996 Jun 30	10.65	0.50	(manufacturer calibration)

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 test pyrheliometer data, while cavity irradiance is greater than 700W/m**2.
7) Continue this process as long as 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 cavity data that is flagged as "unstable" in the cavity data file.
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 both traceable to recognized standards, in this case the World Radiation Reference (WRR) in Davos Switzerland, and documented.