Pyranometer Calibration Round Robin: Evaluation of Calibration Practices of Three Research Laboratories

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Abstract — Accurate measurements of solar irradiance are not only essential in assessing of the performance of solar energy collectors, but also critical to solar resource research activities. The reliable transfer of calibration values from primary reference instruments, such as pyrheliometers, to field-deployed devices, such as pyranometers, is essential to defining measurement accuracy and uncertainty through traceability to the world standard. The focus of this study was to quantify the pyranometer calibration results from three research labs. The calibration methods and results of the three labs are investigated through a calibration round robin where the responsivity of three instruments was measured by the three research groups.

***Index Terms* — solar irradiance, pyranometer, pyrheliometer, absolute cavity radiometer (ACR), responsivity, calibration, shade/unshade**

I. INTRODUCTION

In 2023 a comparison of pyranometer calibration methods was conducted with three participating institutions: The University of Oregon's Solar Radiation Monitoring Laboratory (SRML), Sandia National Laboratories' Photovoltaic Systems Evaluation Laboratory (PSEL), and Analytical Mechanics Associates (contracted to NASA's Langley Research Center's Research Science and Engineering Services). Each laboratory contributed a single broadband global pyranometer to the study and each laboratory calibrated the three instruments using their standard methods and practices.

The motivation of this project originated from the fact that some solar resource laboratories have calibration practices that date back several decades. Although in general these legacy practices align with internationally recognized industry standards [1, 2, 3, 4, 5] they don't necessarily harmonize in every aspect, and therefore differences in opinions based on decades of practical experience exist. These discrepancies stem from the fact that the standards leave some room for interpretation in various aspects of their implementation. The intent of this study was to investigate if and how these differences in approaches affect the calibration results.

The focus of this study had three goals: 1.) to define bounds of reasonable agreement between the calibration results of the three participants; 2.) to evaluate how variations in the data collection methods impact the calibration results; 3.) to evaluate how variations in the data analysis methods impact calibration results. With these goals in mind, the results from this analysis were used to inform refinements in each lab's ever-evolving practices to improve its measurement processes.

This document is organized as follows: First an overview of the basic calibration procedure is outlined, then the experimental setup of each lab is described along with a description of the data processing protocols of each lab. To illustrate how the data progresses though the data processing steps, various steps along the process are highlighted in Section 5. The results of the various studies are given in section 6 followed by conclusions.

II. CALIBRATION BASICS

The goal of a calibration is to obtain a responsivity value (R) for the Device Under Test (DUT). For this comparison, the calibration was transferred from pyrheliometers to pyranometers. In the case of pyranometers with thermopile detectors, the units of responsivity are expressed in $\mu V/W/m^2$. The responsivity is obtained by measuring the voltage of the DUT and the irradiance of co-located reference instruments simultaneously. The reference instruments used in this study were a type of pyrheliometer called an Absolute Cavity Radiometer (ACR), and are traceable to the World Radiometric Reference (WRR) standard [6, 7]. These instruments are considered the "Truth" during the calibration.

In general, the outdoor calibration values of a pyranometer can be computed one of three ways: 1) by using another previously-calibrated pyranometer as a reference, 2) by using a combination of a reference pyrheliometer as a direct normal irradiance (DNI) reference, and a pyranometer with a shadeball or disc as a DHI reference which results in a calculated GHI reference, and finally 3) by using a pyrheliometer as a reference and applying the shade/unshade calibration method. In this report, method 3 will be discussed. Pyranometers are also calibrated indoors using solar simulators with Xe or LED lamps that emit light levels that are comparable to that of the sun and are spectrally matched. The details of indoor calibrations are beyond the scope of this document.

It should be mentioned that for all methods the basic principle is the same, the irradiance value of a trusted source is compared to the voltage of the DUT. In method 1, the trusted source is the other pyranometer. In method 2 the trusted source is the component sum irradiance of the two reference instruments. In method 3 the trusted source is the pyrheliometer.

In all three methods the reference and DUT instruments must be collocated. Both sensors must be clean and aligned properly. It is critical that the horizontal sensors be as level as possible for reliable results. In addition, the reference instrument must have direct traceability to the world standard. For all three methods, measurements are taken throughout the day at frequencies of one minute or less. Making measurements in the summer allows for a greater range of solar zenith angles to be observed. Timestamps of both the reference irradiance and DUT data acquisition systems must be synchronized to one second or less. Also, it is best to do calibrations under clear sky conditions. A mechanism to filter out outlying data points must be incorporated in all three methods.

Method 3 is the only feasible means to transfer the calibration of the world standard (a pyrheliometer) to that of a pyranometer. Methods 2 and 3 result in lower uncertainty values than that of method 1. Methods 1 and 2 are employed by many research labs to calibrate the bulk of their sensors. In method 2 the reference diffuse instrument is a pyranometer that has been previously calibrated using method 3.

For this study, method 3 was used to calibrate the sensors. The shade/unshade method compares DUT voltage values when the sensor is in full sun (unshaded, global measurement) and DUT voltage values when the sensors are occluded by a shade disc or ball (shaded, diffuse measurement). The DUT is repeatedly shaded then unshaded. The shade/unshade cycles repeat throughout the day. In the shade/unshade method it is assumed that the shaded measurements do not vary drastically in time. With this assumption, the diffuse measurements that occur before and after the unshaded (global) periods can be interpolated during the unshaded period. In doing this, virtually simultaneous global and diffuse values are both known, and a direct component can be computed. Minor variations between the three laboratories exist between how the DHI interpolation and DNI calculation are performed. For instance, Lab 3 generates Global Normal Irradiance (GNI) and Diffuse Normal Irradiance (DfNI). Meanwhile, GHI and DHI were measured by Labs 1 and 2. This is one of the areas where the standards allow for some flexibility. Table 1 highlights some of the differences in measurement techniques between the three labs.

In method 3 the DNI signal is obtained from the global and diffuse measurements using Equation 1.

$$DUT_{DNI(\mu V)} = \frac{G - Df}{Cos(AOI)} \qquad (1)$$

In Equation 1, $DUT_{DNI(\mu V)}$ is the DUT DNI microvolt computed value. G is the DUT global (unshaded) microvolt measurement. Df is the DUT diffuse (shaded) microvolt measurement. The cosine of the angle of incidence (*AOI*) is needed to transform the orientation of the DUT measurements to normal irradiance measurements. For horizontally mounted sensors, the AOI is equivalent to the solar zenith angle. For sensors mounted normal to the sun, the AOI is zero and the bottom of Equation 1 is unity.

To generate responsivity values from shade/unshade tests Equation 2 is used.

$$R = \frac{DUT_{DNI(\mu V)}}{DNI} \qquad (2)$$

Where R is the responsivity of the DUT, and DNI is the Direct Normal Irradiance measured with an ACR.

The nature of the shade/unshade experimental configuration allows for both horizontal and normal configurations to be valid. The field of view of the two configurations is different, with the horizontal *seeing* the entire sky dome and none of the ground, while the normal configuration only *sees* a portion of the sky dome and does allow the pyranometer to *see* ground. However, in both configurations since the diffuse measurement is subtracted from the global measurement, the sky (and ground) cancel each other, resulting in just the direct component remaining.

III. Experimental Setup

Each lab contributed a Class-A secondary standard pyranometer to the study. Lab 1 and 3 each provided a *Kipp and Zonen* CMP11. Lab 2 provided a *Kipp and Zonen* CM21. The CMP21 and CMP11 have similar physical characteristics. These global radiometers measure global and diffuse solar flux on incident surfaces expressed in W/m^2. They have thermopile detectors protected by two glass domes, are considered spectrally flat, and have minimal directional response dependency.

All three labs performed a shade/unshade calibration using their respective ACRs as reference DNI devices. Lab 1 and 2 used *Eppley Laboratories* Automatic Hickey-Frieden (AHF). Lab 3 averaged the outputs of three ACRs (*Technical Measurement Inc.* (TMI) Mark VI, *Eppley Laboratories* AHF, and *Davos Instruments* PMO8). The ACRs of all three labs are calibrated yearly [6, 7].

Subtle variations in the data collection process are present between all three groups. These minor variations are a point of interest in this study. Questions to be answered are: 1) How did the different experimental configurations influence the results of the calibration? And 2) What techniques (if any) generated significant differences in the results? A summary of the various experiment configurations are given in Table 1.

Notable differences between the three laboratories include the number of data points collected by each group. With Lab 2 and 3 collecting more days of data than Lab 1. Also, Lab 3 recorded normal incident data for the DUTs, whereas Lab 1 and 2 recorded horizontal DUT data. Lab 2 ventilated the DUTs which aids in a more uniform thermal response and lastly the shade/unshade cycle duration of the three groups varied by between 10 and 30 seconds.

It should be noted that Lab's 1 and 3 also performed a component sum calibration for the sensors as well. The details of this calibration are beyond the scope of this document. The results from this secondary study were very similar to the results from the shade / unshade study and are presented in the conclusions.

Table 1. Shade/unshade experimental parameters associated with each lab.

Parameter	Lab 1	Lab 2	Lab 3
Number of ACRs	1	2	3
Shade/unshade interval	2 / 2 minutes	4 / 4 minutes	5 / 5 minutes
Data frequency	10 seconds	20 - 30 seconds	30 seconds
Sensor orientation	Horizontal	Horizontal	Normal
Shade mechanism	Manual	Automated	Automated
Number of days	1-2	6	3
Dates (Year-Month)	2023-07	2023-03	2023-06
Pyranometer ventilation	Not ventilated	Ventilated	Not ventilated

IV. DATA FILTERING AND PROCESSING

In addition to variations in the data collection methods, there were variations in how the data was processed. The variations from this procedure are highlighted in Table 2.

For a shade/unshade calibration, the drastic change in irradiance incident on the sensor from shaded to unshaded (or vice versa) results in the sensor not being in thermal equilibrium. For this reason, a portion of the data immediately after the change is omitted from the data set. In Table 2, the row "Seconds omitted after shade/unshade" defines the amount of time each lab omitted.

The row titled "Seconds included in DHI running average", is a measure of how many seconds on either side of the point in question are used to generate a DHI running average. For example, for lab 1, data points 120 seconds before and 120 seconds after the point in question are included in the running average. These diffuse data points have the transient measurements removed, such that only "good" diffuse measurements are included in the running average.

All three laboratories performed a manual inspection of the data. Outlying data points due to unstable data sky conditions or anomalous signals were manually eliminated. For each lab this manual inspection process was the primary quality control mechanism of the data.

Table 2. Processing parameters associated with each lab.

Parameter	Lab 1	Lab 2	Lab 3
R computed SZA/Solar Time	40 -50° (SZA)	40-50° (SZA)	10:00-14:00 (Solar time)
Seconds omitted after shade / unshade	40	180	210
Outlier detection method	Manual	Manual	Manual
Seconds included in DHI running average	120	240	90 (before point in question)

In addition, for Lab 3 all data used for analysis must pass each of the following automated tests.

- Minimum of 3 days
- Clearness index test: (DNI/GNI > 0.85)
- Wind speed test: WS <10 m/s
- ACR variation test: ACR differences < .5 % (averaged .02% for this comparison)
- Shade/unshade errors

For labs 1 and 2, after the data was filtered, the responsivities of the instruments were computed as a function of Solar Zenith Angle (SZA). For lab 3 the responsivities equated to the mean of the differences of device responses between sun and shade cycles and the resulting values were applied to the raw data and errors were evaluated.

Labs 1 and 2 generate a running average of the DHI data set. Lab 3 averages the last 3 data points of each sun-shade cycle. This average value is applied forward to the next unshaded measurements.

After the data was filtered, the responsivity of the remaining data were computed using Equation 2. The results in section 6 highlight the responsivity as a function of solar zenith angle. This common metric allows the analyst to evaluate the stability of devices.

V. DATA PROCESSING STEPS

This section is intended to give the reader an understanding of the post processing steps involved in performing a calibration.

Figure 1 gives a sample of the DUT mV data as well as the corresponding ACR data plotted vs the solar azimuthal angle (AZM). The ACR data is plotted on the right axis. The DUT data has been separated into unshaded (GHI) and shaded (DHI) data sets as sensors cannot be simultaneously shaded and unshaded. As such, in Figure 1, the global (green) and diffuse (blue) measurements alternate. The running average DHI data is shown by the DHI average line running through the DHI data set. The DUT DNI data is computed at the minutes of the GHI measurements using the DHI average as the diffuse measurement in Equation 1. In Figure 1, outlying and transient data points have been omitted. Or in other words, data that was captured when sky conditions were unstable, and/or data captured during periods right after the shadeball or disc articulated have been removed. The ACR instrument requires periodic calibration while it is running (typically twice per hour). This is the reason for the breaks in the ACR data set.

In Figure 2, the DNI data of both the DUT and the ACR are plotted vs AZM. The data shown in Figure 2 is from a complete day of data collection. The vertical scale highlights the device output over the full range of irradiance. The DUT and the ACR agree quite well, underscoring the validity of the data.

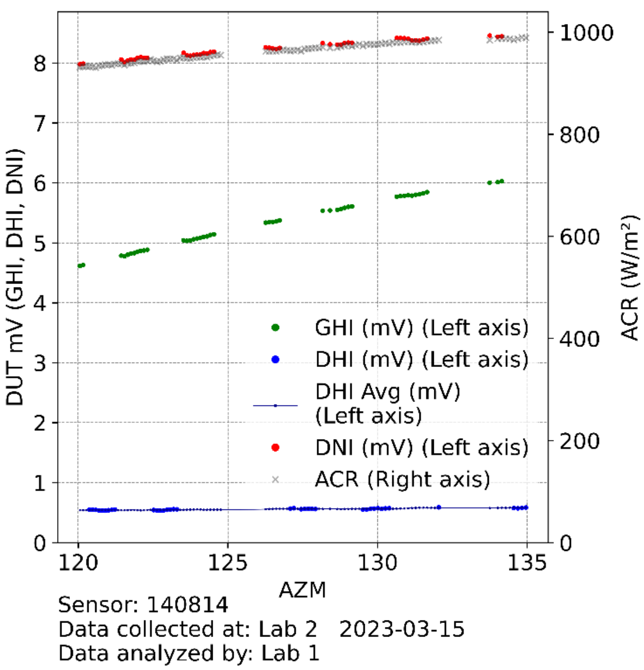

Figure 1. DUT millivolt and reference irradiance data vs solar azimuthal angle. The data shown here is from 09:00 to 10:00. (DUT mV primary axis, ACR W/m^2 on secondary axis)

The responsivity of the DUT was computed using Equation 2. and is plotted in Figure 3. The responsivity was consistent over the full range of SZA with a variation in R of 8.45 to 8.6 μV / (W/m^2), corresponding to a 1.76 % variation throughout the entire day.

Although, the responsivity was stable, in general it decreases throughout the day. This is likely caused by either the directional response of the sensor or a non-level sensor. It should be reemphasized that when mounting global radiometers, the instruments must be properly leveled to ensure accurate results.

Results similar to those shown in Figure 3 were generated by each lab for each instrument for each of the days in the study. Each lab then aggregated the results for each instrument across days, and a final responsivity value was computed. For labs 1 and 2 the responsivity was computed in the 40 < SZA < 50 range. For Lab 3 the responsivity was computed from data collected during a ±2 hour solar noon window. Under normal circumstances, this would then be the reported responsivity value that would be used for this instrument when it is deployed in the field.

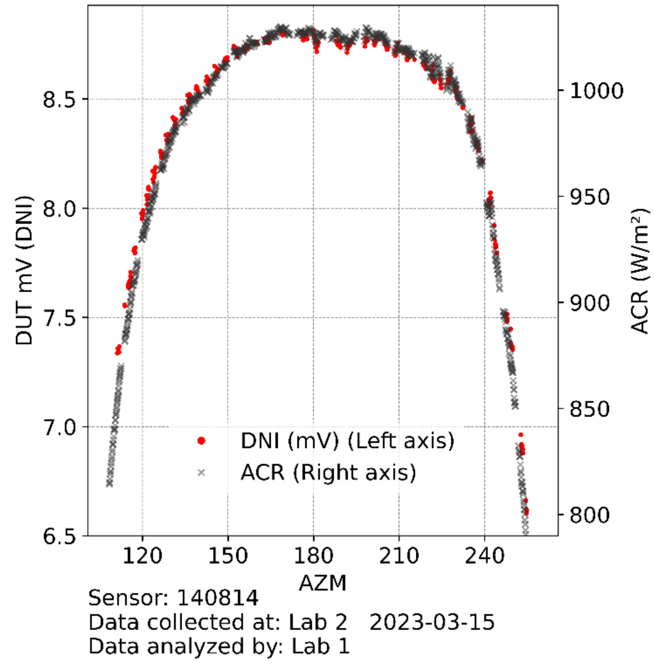

Figure 2. DUT millivolt and reference irradiance data vs solar azimuthal angle. The data shown here is for the entire day. (DUT mV primary axis, ACR W/m^2 on secondary axis)

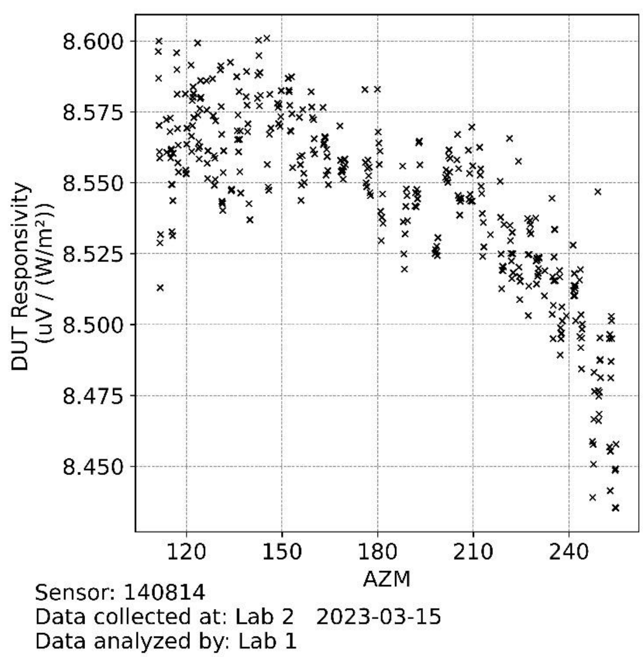

Figure 3. Responsivity vs solar azimuthal angle

VI. RESULTS: CALIBRATION FACTORS

With three data collection methods and three processing procedures, interpolating the results is challenging. To further investigate any of these features, it was decided that each laboratory would perform their post processing steps on the other participants' data. In this way, differences in experimental methods vs differences in post processing can be identified. Or in other words, the begged question is "*Are differences in results caused by data collection techniques or data processing techniques, or both?*" In this section this question will be answered through a series of three tests.

Test1:

Lab 1 analyzed the results from all three research groups. In doing this, the data analysis protocols were kept constant and the data collection techniques could be analyzed in detail. Given differing acquisition intervals and formats between the labs, minor modifications to Lab 1's techniques were required to accommodate the different data structures.

Figure 4 shows the results of this analysis. The average responsivity over a range of SZA values is given. From Figure 4, there is good agreement with the responsivity generated from the three data collection methods. However, it is clear that there are some differences in experimental data collection techniques between the three groups. Lab 3 collects significantly more data but only over a limited SZA range. Labs 2 and 3 collect data over multiple days. Lab 1 collects less data but over a wider range of SZA values. Lab 2 ventilates all of the test devices but Labs 1 and 3 do not. The results from Lab 1 appear to be higher than the results from Lab 2. It should be noted that the results from Figure 3 are a subset of the results in Figure 4 (blue points).

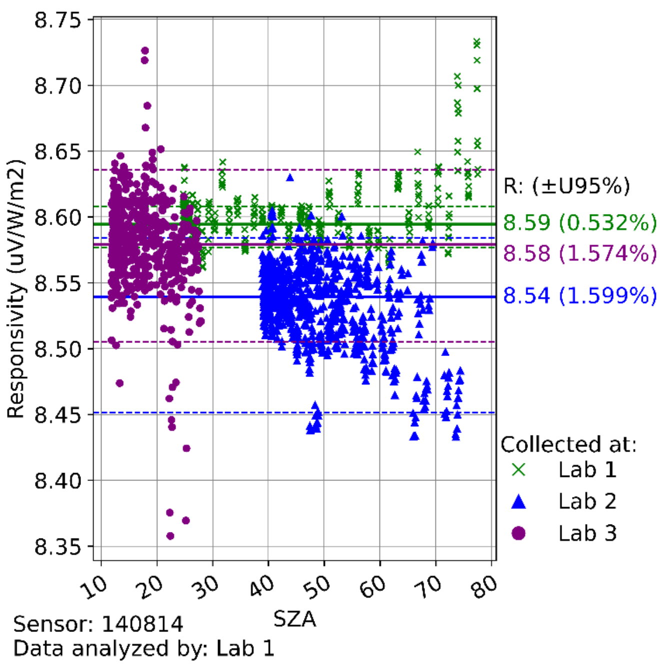

Figure 4. Comparing data collection techniques. The data from all three labs was analyzed by Lab 1.

In Figure 4 the responsivity of each data set was computed. The spread in the data set was combined with the uncertainty associated with the ACR measurements (0.39%) using the sum of the squares method, resulting in an overall percent uncertainty at the 95th level of confidence. Because Lab 3 only collected data at small zenith angles, the responsivity of Lab 3 was computed using all the data.

Given these multiple variations in experimental techniques and conditions, the calibration results of the three labs are quite robust. The overall spread in the R across all groups is 2.2%, with ranges from 8.45 to 8.64 μV / (W/m^2).

Explicitly the variations in the techniques include the following,

- Different reference instruments
- Different data collection hardware and software
- Horizontal mounting vs normal mounting
- Ventilated or unventilated sensors
- The number of data points taken
- Manual shading vs automatic shading
- Data frequency (scan rate)
- Shade/unshade frequency
- Weather conditions, turbidity, elevation etc.

Test 2:

Next the data processing techniques were investigated. The data from Lab 2 was analyzed by all three labs. Or in other words, the same data set was given to all three groups and each lab used its own data processing techniques to filter and analyze the data. Labs 1 and 3 made minor modifications to their analysis techniques to accommodate the unique timing and data structure of the data acquired by lab 2.

Figure 5 shows the results of this study. Both Lab 1 and 2 showed very similar results. Lab 3 shows some differences in their analysis technique.

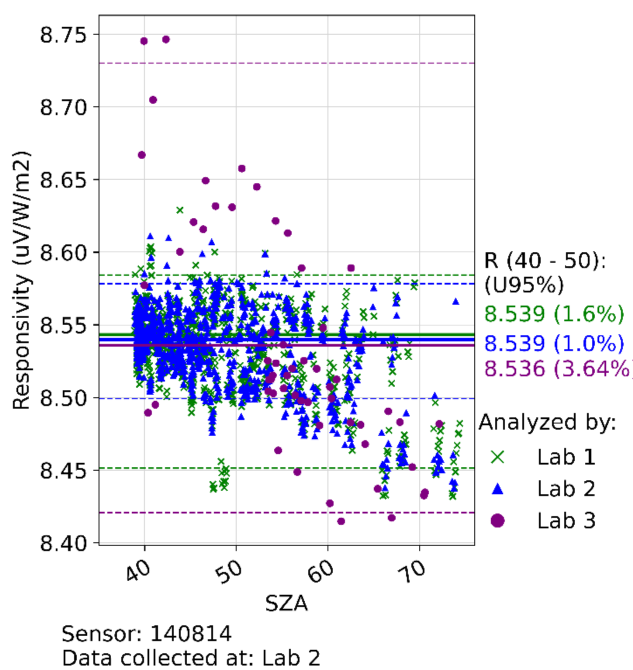

Figure 5. Comparing data processing techniques. The data from a Lab 2 was analyzed by all three labs.

For Labs 1 and 2, structures within the data are visible in both data sets, which implies the similar filtering techniques were used by both groups. The differences between the two groups originate in details related to how some individual data points were handled. It is expected that the leading contributors to the differences are how the running DHI is computed as well as how the undesirable data points are eliminated. Overall, the responsivity of both techniques results in very similar results.

It is evident that Lab 3's data processing method, which although adequate for its own measurement methods, when applied to Lab 2's data resulted in significantly fewer data points that than Labs 1 and 2 and an overall greater spread in the data. This is likely due to filtering that is optimized for instruments mounted normal to the sun, for which uncertainty associated with cosine corrections is non-existent. Conversely when said filtering yields limited data in the 40 < SZA < 50 range, the uncertainty in the measurement is quite high. Lab 3 is investigating incorporation of analysis methods similar to those of Labs 1 and 2 for future studies of horizontal vs normal calibration methods.

The overall uncertainty at the 95th level of confidence is reported to the right of the reported uncertainty. Between Labs 1 and 2 there is no statistically significant difference between the data processing techniques.

Test 3:

The final analysis was the investigation where the data gathered by each lab was processed using that labs data processing techniques. Or in other words, Lab 1 analyzed Lab 1's data, Lab 2 analyzed Lab 2's data, and Lab 3 analyzed Lab 3's data. This study is the main emphasis of this process, in that it informs how well each lab is doing relative to their peers.

The results of this analysis are shown in Figure 6. These results are consistent with previous results. The goal of this study was to investigate the standard calibration techniques of transferring calibration from a pyrheliometer to a pyranometer of each lab. Figure 6 quantifies the level to which this true.

Lab 1 had a tight spread in the data during the 40 < SZA < 50 zenith angle range. This resulted in an overall uncertainty in the measurement of an impressive 0.53%. However, the limited amount of data coupled with the rise in the responsivity at high zenith angles makes the results slightly questionable.

Lab 2's results are consistent with those seen in Figure 5. The large spread in responsivity is indicative of a sensor leveling issue. To diagnose this problem further, plotting the data vs AZM (instead of SZA) would highlight time of day discrepancies. This is what was shown in Figure 3.

The Lab 3 data has many of the same features seen in the other two data sets. The DUTs and the reference ACRs are normal to the sun and irradiance were stable across solar noon over 3 consecutive days with only very clear sky data being used, so in general the measurements are quite repeatable. Because Lab 3 uses the last few points of each shade cycle for analysis, only manual elimination of gross outlier data points is performed. However, it is evident that additional filtering of outlier data points would improve uncertainty.

In Figure 6. the inherent noise visible in the responsivity is largely unavoidable. This noise is likely caused by variations in the weather during the measurement. Many factors can contribute to the noise experienced by sensors. This noise is accounted for in the uncertainty in the measurement using the sum of squares method, where the P95 spread in data is combined with the other sources of uncertainty associated with the measurement. For this study only the uncertainty of the ACRs was considered (0.39%). Other sources typically are much less than this and do not significantly contribute to the sum of the squares calculation.

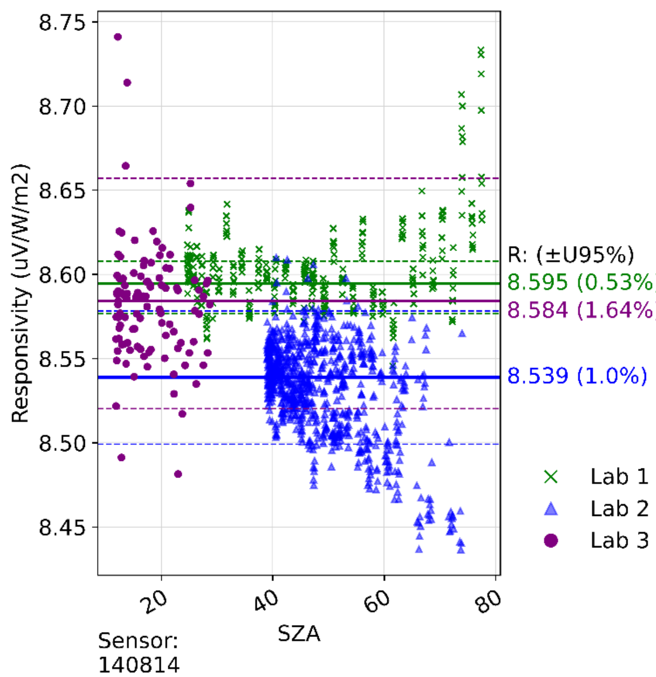

Figure 6. Responsivity vs SZA for each lab.

Results similar to that shown in Figure 6 were generated for each of the three sensors used in the study. The results of the study determined that the responsivity values of the three labs for all three sensors agreed very well. A summary of the findings is given in Table 3. Note the right three columns in Table 3 correspond to the three pyranometer serial numbers used.

In Table 3, to distinguish the cross-examination results, the data set used in the analysis is explicitly listed along with the calibration method and orientation. The lab that performed the analysis is also listed in a separate column. The notation "S-unS" denotes a shade/unshade calibration. Both Lab 1 and Lab 3 also generated a component sum calibration at SZA = 45°, denoted as "CS".

The mean responsivity of each instrument is computed along with the percent difference of the multiple calibrations compared to the average for each instrument. The largest percent difference is reported in the last row.

Data set	Analysis method	CMP21_041281 R (U95%)	CMP11_140814 R (U95%)	CMP11_174016 R (U95%)
Lab 1 (S-unS, Horizontal)	Lab 1	10.748 (1.3%)	8.595 (0.53%)	8.861 (0.49%)
Lab 1 (S-unS, Horizontal)	Lab 3	10.722 (NA%)	8.58 (NA%)	8.841 (NA%)
Lab 2 (S-unS, Horizontal)	Lab1	10.584 (1.34%)	8.539 (1.6%)	8.847 (1.49%)
Lab 2 (S-unS, Horizontal)	Lab2	10.584 (0.87%)	8.539 (1.0%)	8.847 (0.9%)
Lab 2 (S-unS, Horizontal)	Lab3	10.66 (0.83%)	8.556 (2.88%)	8.838 (0.83%)
Lab 3 (S-unS, Normal)	Lab 1	10.697 (0.93%)	8.579 (1.57%)	8.787 (1.18%)
Lab 3 (S-unS, Normal)	Lab3	10.704 (1.1%)-	8.579 (1.64%)	8.787 (1.18%)
Lab 1 (CS, Horizontal))	Lab 1	10.765 (1.8%)	8.494 (0.98%)	8.778 (1.25%)
Lab 3 (CS, Horizontal)	Lab 1	10.588 (1.47%)	8.456 (1.02%)	8.717 (0.88%)
Lab 3 (CS, Horizontal)	Lab 3	10.64 (1.63%)	8.45 (1.15%)	8.73 (1.4%)
Mean		10.68	8.548	8.813
Max Percent difference (%)		0.94%	1.00%	1.48%

Table 3. Results of study. The responsivity of each instrument is given in μV/W/m². S-unS corresponds to shade/unshade measurements. CS corresponds to component sum measurements. The max percent difference is a measure of how much the individual responsivity values compare to the mean for each sensor.

The results show that all three labs are in excellent agreement. This is remarkable given the variety of conditions, locations, experimental setups, and data acquisition, filtering, and analysis techniques. The largest percent difference between the mean and an individual calibration is 1.48%. In addition, the uncertainty in the individual calibration results (the terms in parentheses for each calibration), are also impressive, typically less than 2%.

In Figure 7. the results shown in Table 3 are shown. To accommodate the different responsivity values of the three sensors, the responsivity of each trial was normalized to one by dividing by the average R for each sensor. Note that the horizontal scale in Figure 7 represents ±2% variation in the R. The error bars in Figure 7, represent the u95% uncertainty reported in Table 3.

In Figure 7, there is not a statistically significant difference between any of the lab's processes. Or in other words, none of the trials is significantly different from the others. Specifically, none of the various parameters listed in Table 1 or 2 seem to significantly influence the result. This includes both direct normal and horizontal calibrations orientations. That being said, it is critical that the sensors be mounted and operated properly during the calibration. It is suspected that outlier in sensor 041281 corresponds to a human error mounting error in the data collection process.

An interesting feature appearing in Figure 8 is the shape of the sensors relative to each other for each data collection lab. Notice that for Lab 2's data collection, the responsivity of sensor 041281 is less than 174016 for all three data analysis techniques. Different shapes are present for Lab 1 and Lab 3's results. This further indicates how the experimental setup of the sensors influences the results.

Both Lab 1 and Lab 3 did a component sum calibration as well. From Figure 7 it appears that this calibration method results in smaller responsivity values than the shade/unshade methods. Further tests are needed to confirm the validity of this result.

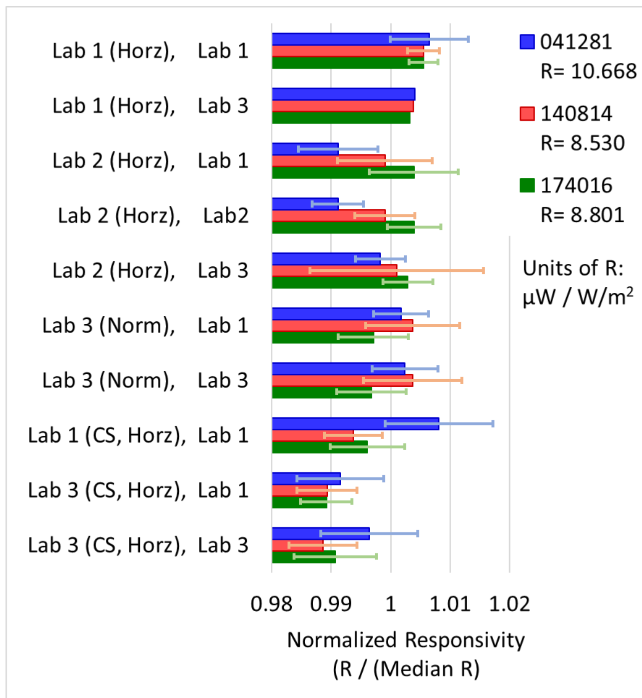

Figure 7. Normalized responsivity values of each trial given in Table 3.

VIII. CONCLUSION

In conclusion, this calibration round robin resulted in valuable learning experiences for the three labs involved. By comparing and contrasting the different methods, similarities and differences between the groups were exposed.

The results from the study showed that responsivity values between the three groups varied by less than 1.5%. When considering the various data acquisition methods and post processing methods involved this is quite impressive.

Additionally, modifications to the methods and practices of all three groups have been incorporated into their calibration routines. For example, Lab 1 has modified its experimental protocol to make measurements for three or more good days. Lab 3 found it instructive to understand how the data processing of the other labs is performed. It is expected that modifications to the Lab 3 data processing will be incorporated in the upcoming calibration season. The participants encourage other groups to participate in a similar round robin process, specifically those having a unique local data acquisition and analysis practices.

ACKNOWLEDGEMENTS

The University of Oregon, SRML is a regional solar radiation monitoring lab. The SRML is sponsored by the National Renewable Energy Laboratory, Bonneville Power Administration, the Energy Trust of Oregon, and Sandia National Lab.

Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Analytical Mechanics Associates works under NASA Langley Research Center's Research, Science and Engineering Services contract and this work is funded by NASA's Clouds and the Earth's Radiant Energy System project.

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