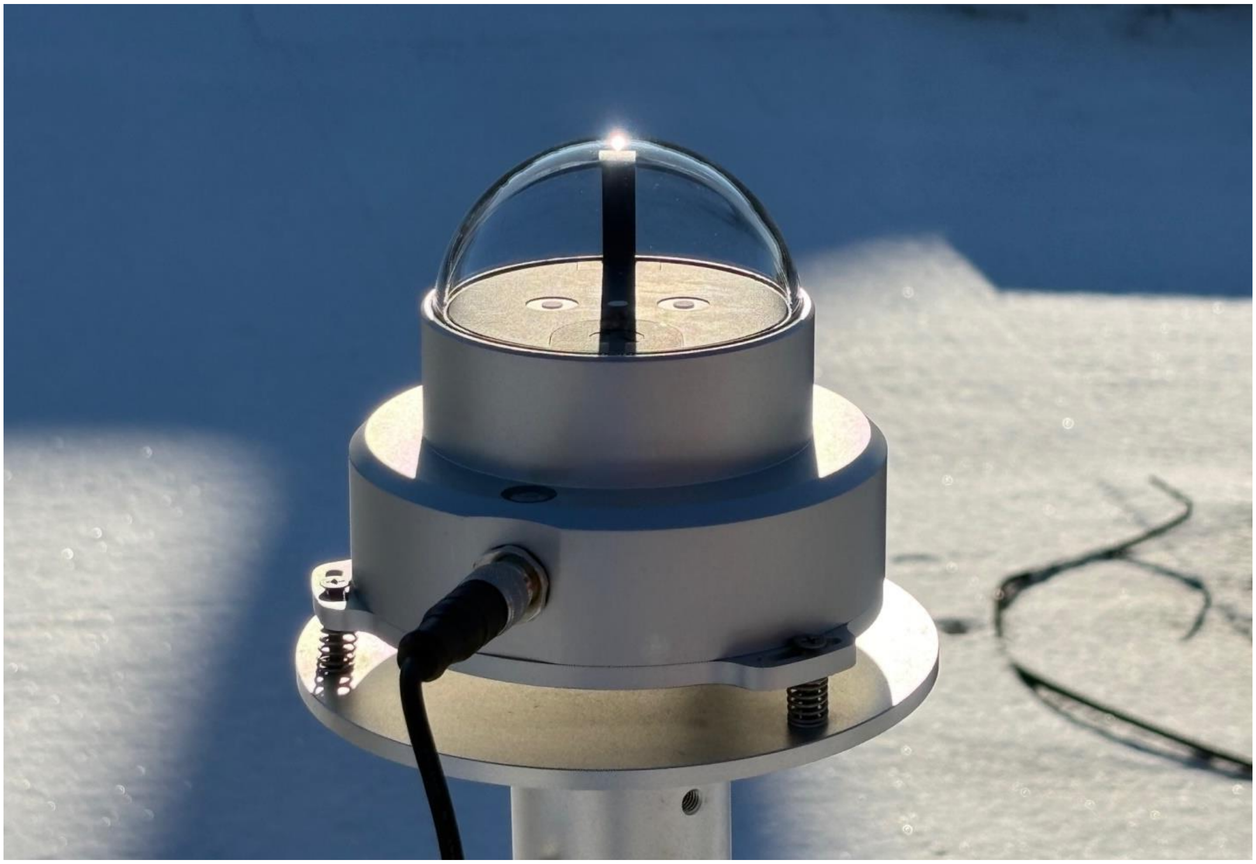
Comparative Performance Testing of the SolarBand-C3



October 6th – November 11th, 2024
Ottawa, Canada

1. Executive Summary

In October-November 2024, Spectrafy conducted comparative performance testing of a SolarBand-C3 prototype at our on-sun test site in Ottawa, Canada.

Diffuse Horizontal Irradiance (DHI) and global horizontal irradiance (GHI) measurement accuracy was analysed over 37 days versus reference pyranometers.

The SolarBand-C3's DHI measurements exhibited a mean bias of -0.36 W/m^2 and RMSE of 6.77 W/m^2 for 17,000 data points analyzed, versus the SR20 pyranometer reference.

The SolarBand-C3's GHI measurements exhibited a mean bias of 0.22 W/m^2 and RMSE of 6.56 W/m^2 for 17,000 data points analyzed, versus the SolarSIM-G reference.

Overall, the test results serve as an important validation of the SolarBand-C3 as an accurate and reliable sensor for measuring global and diffuse broadband irradiance.

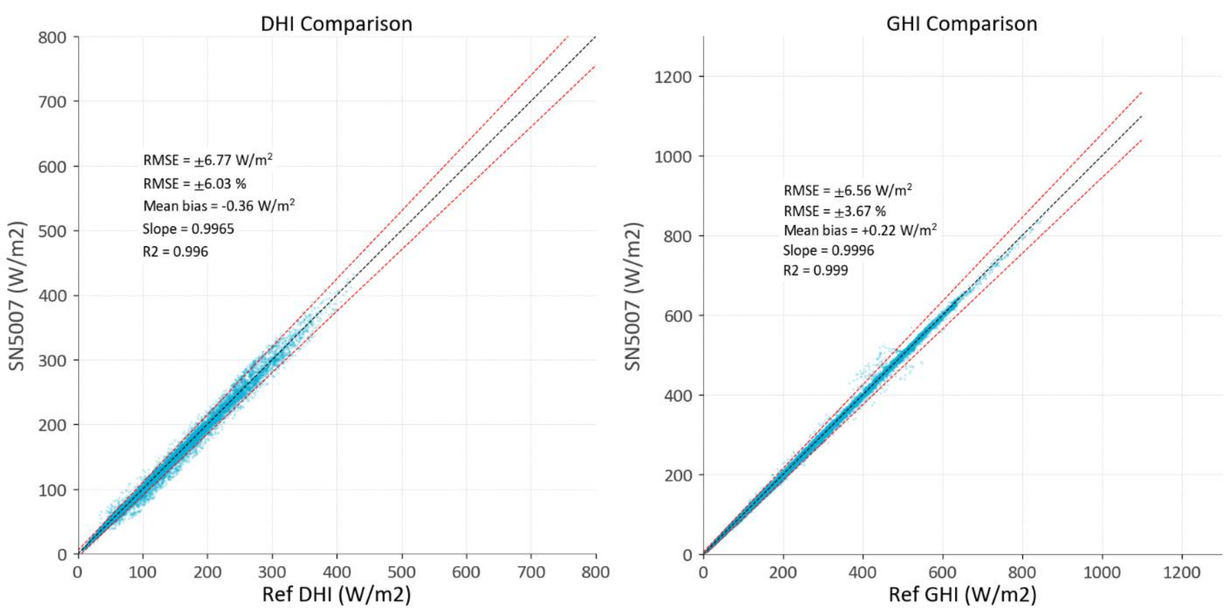


Figure 1. Scatter plots of SolarBand-C3 DHI vs. reference DHI (LHS) and SolarBand-C3 GHI vs. reference GHI (RHS).

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2. Introduction

In October 2024, Spectrafy deployed a SolarBand-C3 prototype at our rooftop test site in Ottawa, Canada, as shown in Figure 2. The evaluation period covered October 3rd – November 11th, 2024. The purpose of the test was to evaluate the SolarBand-C3's DHI and GHI measurement accuracy against reference pyranometers.

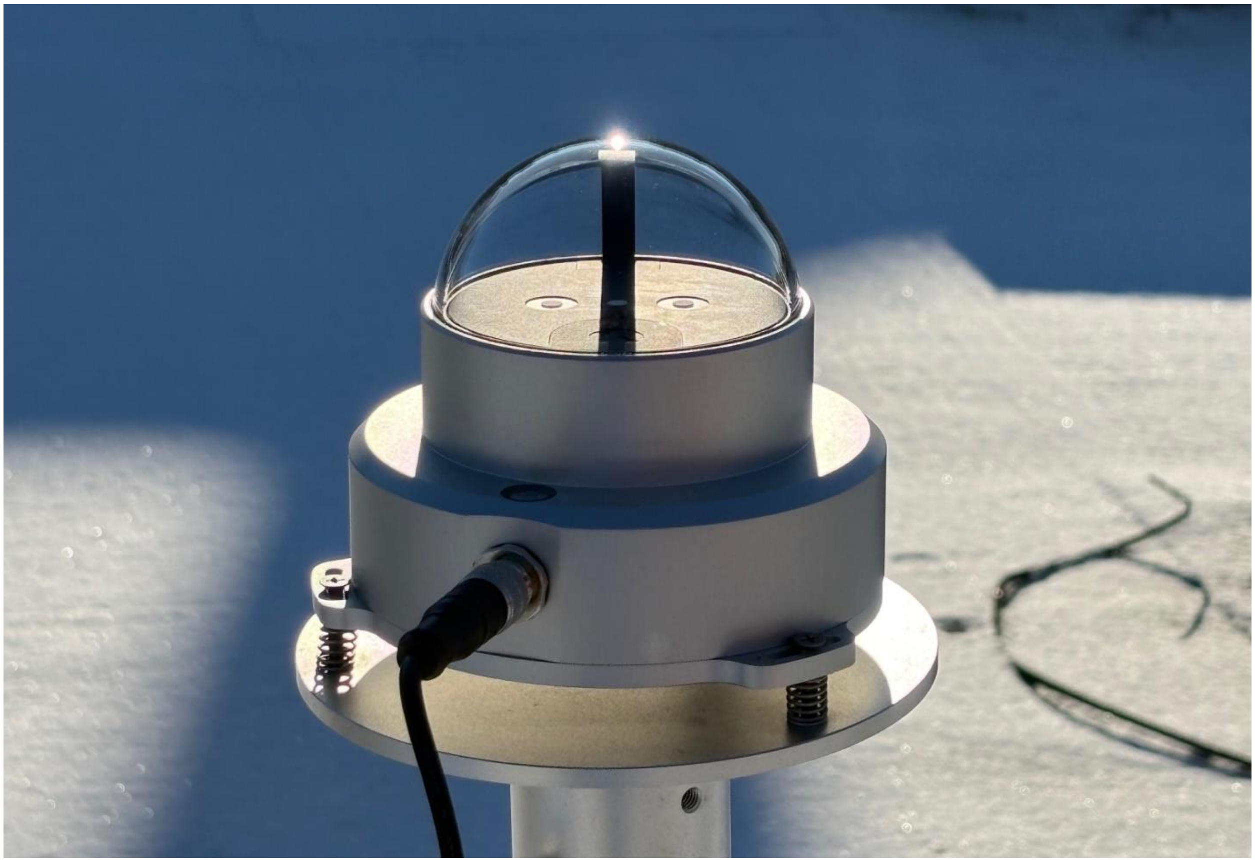

Figure 2. The SolarBand-C3 prototype in operation at Spectrafy's on-sun test site.

3. SolarBand-C3 Overview

The SolarBand-C3 represents an exciting step forward in the measurement of diffuse solar irradiance. The SolarBand-C3 combines the accuracy of an automated shadow band with the reliability of a fully enclosed system to provide accurate, affordable measurements of diffuse, global and direct irradiance, from a single, digital sensor with no external moving parts.

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The SolarBand-C3 employs three photodiodes (two global, one diffuse) and an automated, internal shadow band to measure global and diffuse irradiances simultaneously. The shadow band is mounted to an internal motor that slowly rotates over the course of each day, ensuring that the diffuse sensor remains continuously shaded.

4. SolarBand-C3 Specifications

Diffuse Horizontal Irradiance

Accuracy (k=2)	± 4% Daily integral ± 4% ± 5 W/m^2 hourly average ± 5% ± 5 W/m^2 individual readings
Measurement range	0 - 2000 W/m^2
Response time (95%)	< 0.1s
Non-stability (change per year)	< 0.2%
Non-linearity	< 0.5%
Zero offset A	n/a
Zero offset B	n/a
Spectral range	300-1130 nm
Temperature response (-10 °C - +40 °C)	< 0.5% (on-board temp. correction)
Latitude capability	-90º to +90º

Global Horizontal Irradiance

ISO 9060:2018 classification (excl. spectral error)	Class B, Fast response
Max. spectral error (per ISO9060:2018)	± 2.1% (± 8.8 W/m^2)
Accuracy (k=2)	± 3% ± 5 W/m^2 individual readings
Measurement range	0 - 2000 W/m^2
Non-stability (change per year)	< 0.2%
Non-linearity	< 0.5%
Cosine error	< 10 W/m^2
Zero offset A	n/a
Zero offset B	n/a
Spectral range	300-1130 nm
Temperature response (-10 °C - +40 °C)	< 1.0% (on-board temp. correction)
Tilt response	negligible

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Measurands

Global horizontal irradiance	W/m^2
Diffuse horizontal irradiance	W/m^2
Direct normal irradiance (calculated)	W/m^2
Sunshine duration	Hrs

General

Weight	1.2 kg
Dimensions	132 x 132 x 110 mm
Power supply and use	12 VDC, <3W
Communication	RS-485 Modbus RTU, Direct to PC, serial over ethernet
Operating temperature range	-30 to 65 °C
Humidity range	0 to 100% RH
Max measurement frequency	1s
Ingress protection rating	IP67
Mounting	Three M4 thru-holes, equally spaced on 130mm circle

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5. Calibration

The SolarBand-C3 prototype (SN5007) underwent two optical calibrations. The central, shaded sensor was calibrated while in horizontal orientation against a collocated SR20 thermopile pyranometer mounted on a dual-axis sun tracker (Spectrafy ST-5) and shaded by a shading disk. The two global irradiance sensors were calibrated in global normal orientation against one of our SolarSIM-G reference units.

The calibrations took place in early October, under clear-sky conditions.

Figure 3. Spectrafy roof-top test site showing SolarBand-C3 prototypes, alongside broadband and spectral reference sensors.

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6. Diffuse Horizontal Irradiance measurement performance

DHI measurement performance of the SolarBand-C3 prototype was compared against DHI measured by a SR20 pyranometer production unit mounted on a Spectrafy ST-5 Sun Tracker and shaded by a shadow disk. Data was sampled every second and was reported as one minute averages.

Figures 4 and 5 present daily DHI profiles as measured by the SolarBand-C3 prototype, for the 6th and 12th of October. The SR20 DHI is also plotted for comparison. The 6th of October presented a range of atmospheric conditions, varying from relatively clear-sky in the morning to a mix of intermittent cloud and overcast conditions in the afternoon. October 12th was a sunny day with some very low, clear-sky DHI values. In both cases, the SolarBand-C3 provides accurate measurements of DHI, as compared to the SR20.

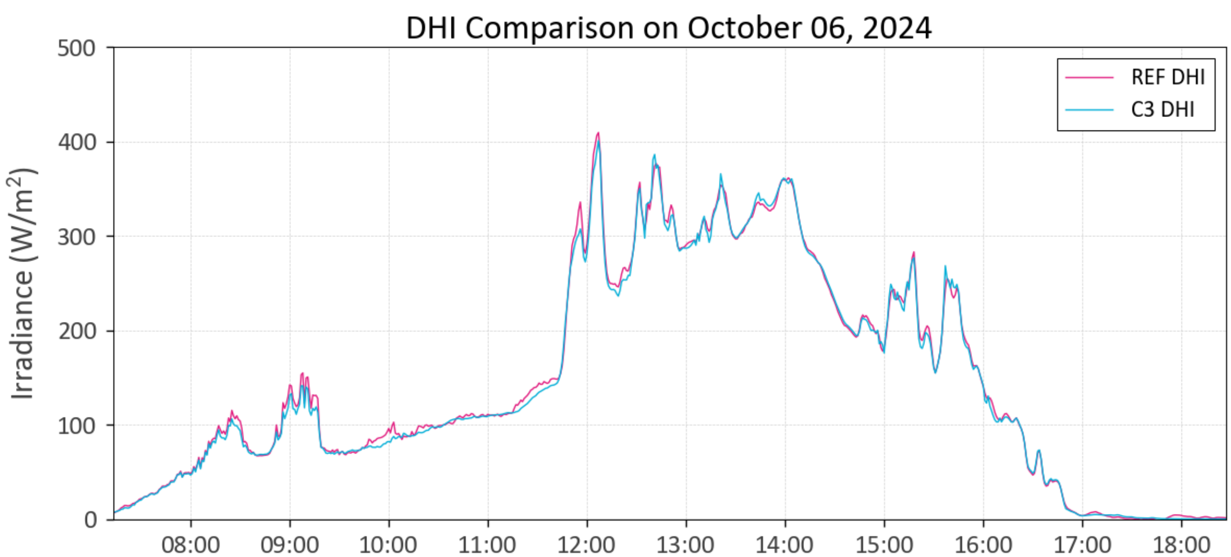

Figure 4. A daily plot of DHI data obtained from the SolarBand-C3 prototype (blue), compared to SR20 DHI data (pink) for October 6th, 2024.

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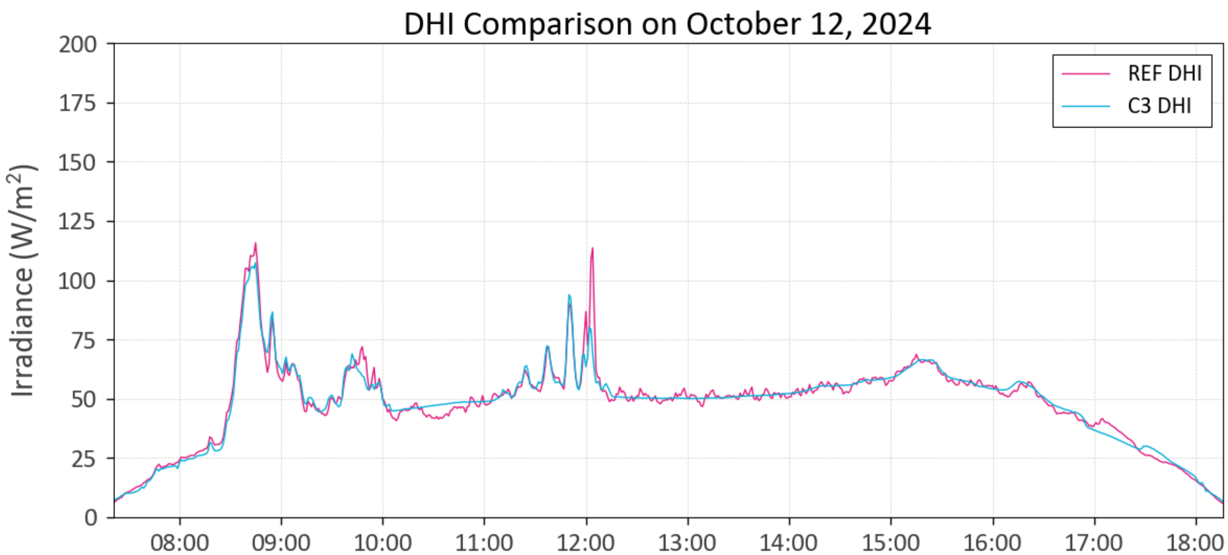

Figure 5. A daily plot of DHI data obtained from the SolarBand-C3 prototype (blue), compared to SR20 DHI data (pink) for the October 12th, 2024. Note, the 'noise' observed in the SR20 DHI data under clear-sky conditions is an artifact of the SR20 thermopile sensor.

A more holistic analysis of the SolarBand-C3's DHI performance is presented in Figure 6 via a scatter plot of the SolarBand-C3 DHI data versus the SR20 DHI data. As shown, the root mean square error (RMSE) is well below 10 W/m^2, with over 17,000 data points analyzed. A slope value of 0.9965 was observed.

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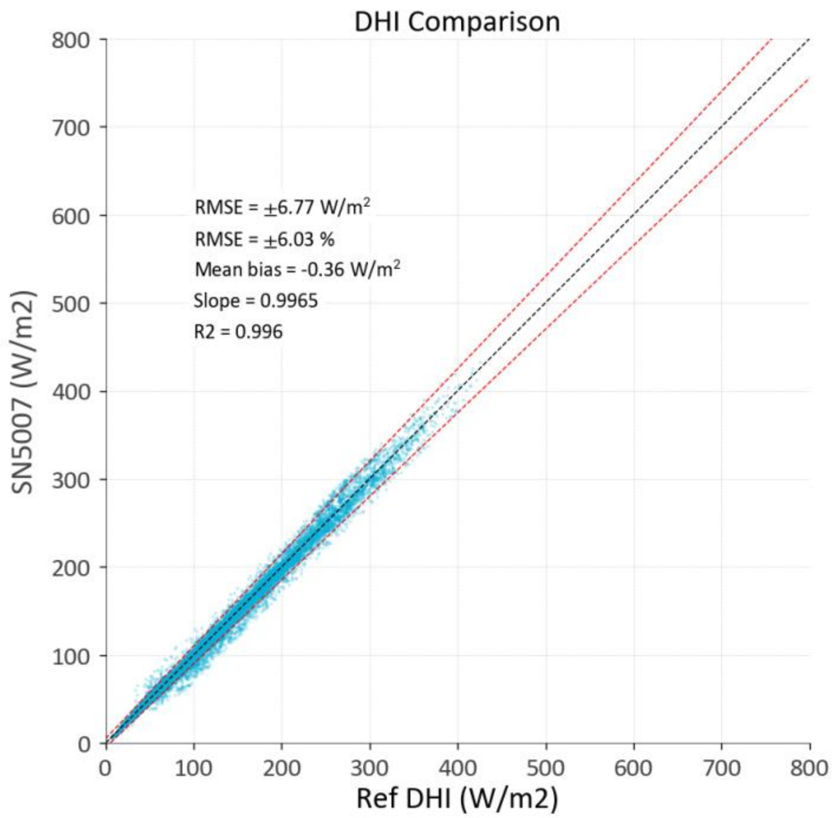

Figure 6. Scatter plot of the DHI data obtained from the SolarBand-C3 (SN5007) plotted against the SR20 DHI data for the period October 6th to November 11th, 2024. The RMSE is well within ± 10 W/m^2 with over 17,000 data points analyzed. The red dotted lines represent ±5% ±5 W/m^2.

7. Global broadband measurement performance

GHI measurement performance of the SolarBand-C3 prototype was compared against GHI measured by a SolarSIM-G production unit (SN1062). For the SolarSIM-G, data was sampled every one second. For the SolarBand-C3, data was sampled every two seconds. For both instruments, data was reported as 1 minute averages.

Figures 7 and 8 present daily GHI profiles as measured by the SolarBand-C3 prototype, for the 15th and 18th of October. The SolarSIM-G GHI is also plotted for comparison. The 15th of October was largely overcast with some sun in the morning. The 18th of October was a clear-sky day. In both cases, the SolarBand-C3 prototype provides highly accurate measurements of GHI as compared to the SolarSIM-G reference.

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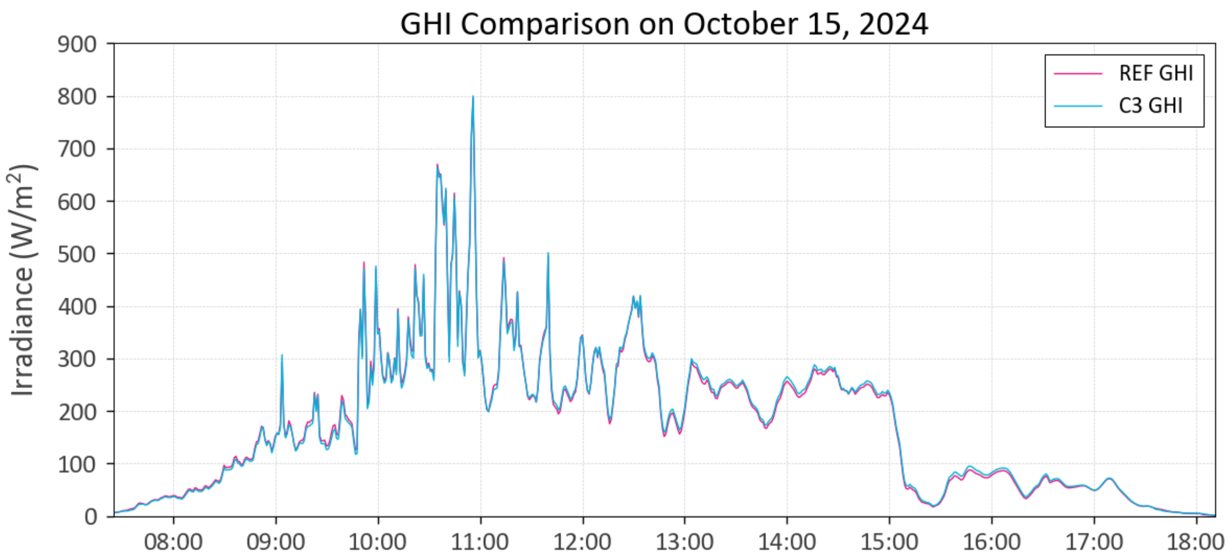

Figure 7. A daily plot of GHI data obtained from the SolarBand-C3 prototype (blue), compared to the SolarSIM-G reference GHI data (pink) for October 15th 2024. This day was largely overcast with some sun mid-morning.

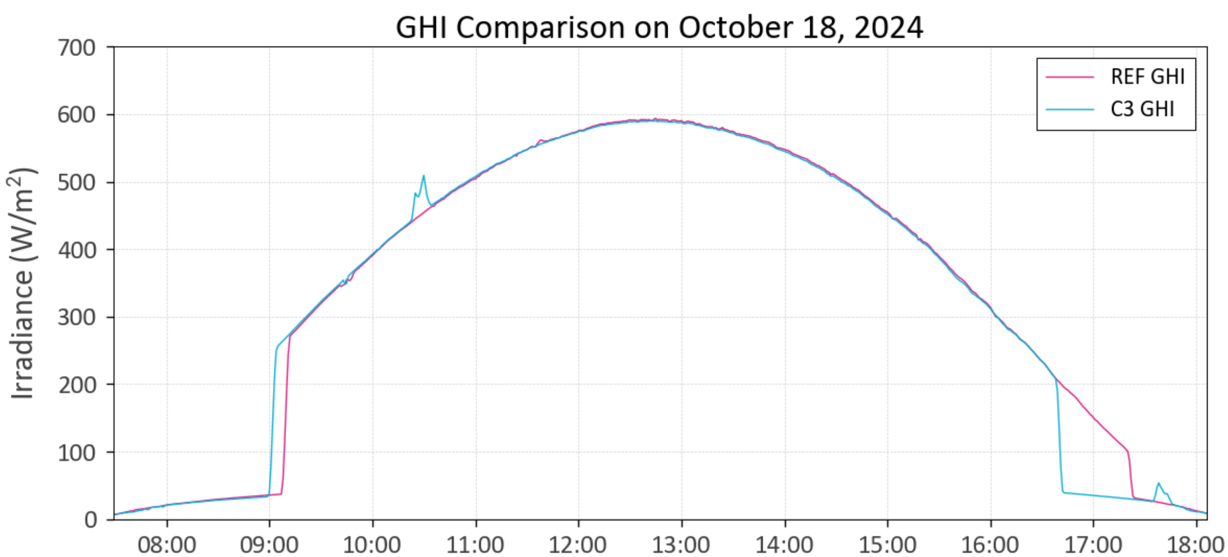

Figure 8. A daily plot of GHI data obtained from the SolarBand-C3 prototype (blue), compared to the SolarSIM-G reference GHI data (pink) for October 18th 2024. Note the divergences observed at the start and end of the day, and at ~10:30am are caused by differences in horizon shading and reflection. On this day, solar elevation reached a maximum of ~35°.

A more holistic analysis of the SolarBand-C3's GHI performance is presented in Figure 9 via scatter plots of the SolarBand-C3 GHI data versus the SolarSIM-G reference GHI data. As shown, the root mean square error (RMSE) is well below 10 W/m^2, with over 17,000 data points analyzed. A slope value of 0.9996 was obtained.

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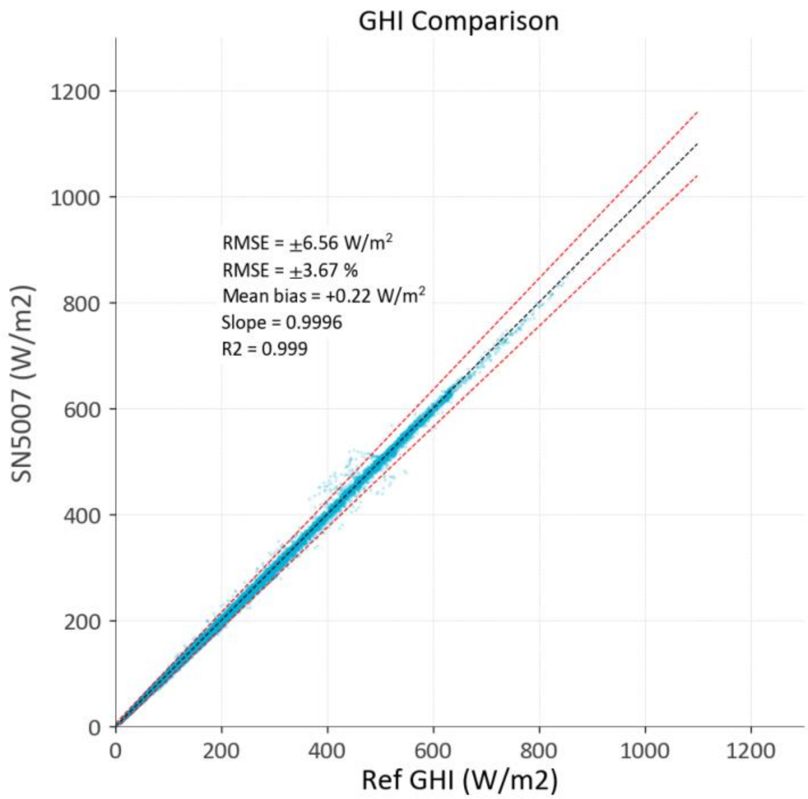

Figure 4. Scatter plots of the GHI data obtained from the SolarBand-C3 (SN5007) plotted against the SolarSIM-G GHI data for the period October 6th to November 11th, 2024. The RMSE is well within ±10 W/m² with over 17,000 data points analyzed. The dotted red lines represent ±5% ±5 W/m².

8. Conclusions

A SolarBand-C3 prototype's (SN5007) DHI and GHI measurement performance has been tested on-sun at Spectrafy's Ottawa test site. From October 6th to November 11th, 2024, over 17,000 measurements of DHI and GHI have been compared against reference pyranometers. For DHI measurements a mean bias and RMSE of -0.36 W/m² and 6.77W/m² were observed. For GHI measurements a mean bias and RMSE of 0.22 W/m² and 6.56W/m² were observed.

These results serve as an important validation of the SolarBand-C3 as an accurate sensor for measuring both global and diffuse broadband irradiance, under all sky conditions.

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