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Heated Pyrheliometer Field Campaign Report

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ARM

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Acronyms and Abbreviations

ARM	Atmospheric Radiation Measurement
DNI	direct normal irradiance
NPC	NREL Pyrheliometer Comparison
NREL	National Renewable Energy Laboratory
NSA	North Slope of Alaska

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1.0 Summary

The purpose of the campaign was to test the performance of two Kipp & Zonen pyrheliometers of identical main design but with slight modifications in an arctic setting. The Kipp & Zonen CHP1 pyrheliometer measures the direct normal irradiance (DNI) with high accuracy (https://www.kippzonen.com/Product/18/CHP1-Pyrheliometer#.Xcx5Mr-Uv2I). The main IOP goals were:

1. Check data availability increases when using a heated pyrheliometer
2. Evaluate the effect of heating a pyrheliometer on its readings compared to those of an unheated one.

Two Kipp & Zonen CHP1 pyrheliometers have been installed on either side of the sky radiometer (SKYRAD) Solar Tracker on top of the U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) North Slope of Alaska (NSA) Barrow observatory C-1 Great White shelter (Figure 1). While the two CHP1 pyrheliometers collected data between 03/14/2018 and 7/30/2018, a Campbell Scientific CR6 data logger recorded direct beam solar irradiance (w/m^2) every 30 seconds from both the heated and unheated pyrheliometer. One CHP1 had an internal heater connected, and one did not. The windows of these instruments were not cleaned of ice and snow as they normally are because the goal was to evaluate and distinguish the performance of the heated pyrheliometer against an unheated instrument in terms of data availability and quality. The data availability and irradiance values from the unheated and heated pyrheliometer were compared.

Figure 1. Two Kipp & Zonen CHP1 pyrheliometers installed at either side of the NSA C1 SKYRAD Solar Tracker.

The effects of the pyrheliometer window heating could be evaluated during significant weather events in spring 2018. Instrument icing occurred on several occasions. One example from April 14, 2018 is shown in Figure 2.

Figure 2. Icing event on April 14, 2018.

2.0 Results

On certain days it was clearly visible that the DNI increased when using the heated pyrheliometer. (See image below). Differences peaking up to about 200 W/m^2 were observed during a short period (Figure 3). Predominantly, the DNI measurements agreed very well between the two instruments.

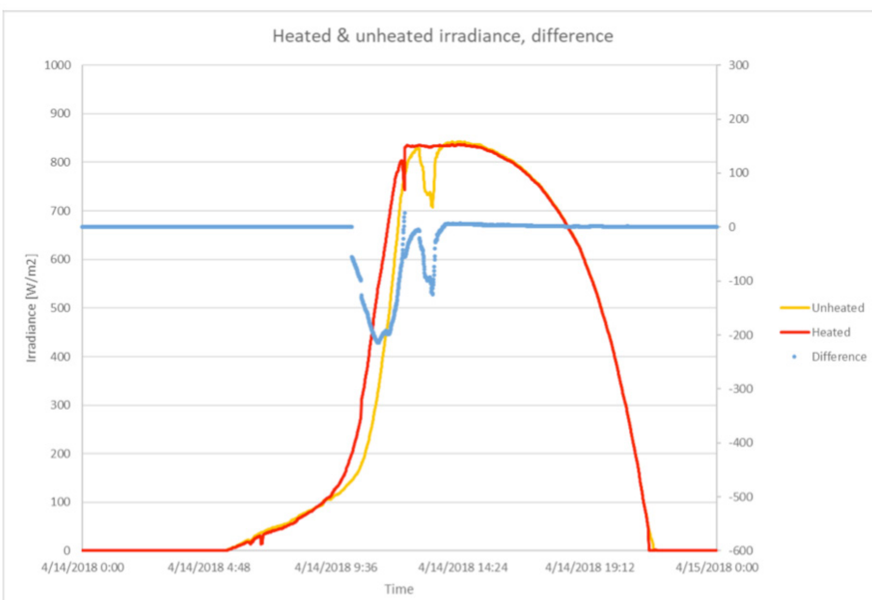

Figure 3. Heated versus unheated pyrheliometer measurements during days with icing (April 14-15, 2018).

The irradiance data and evaluation of images taken of the radiometers every 10 minutes from a nearby camera revealed that the heated pyrheliometer was ice/dew free all of the time. This is especially visible in the case of March 24 2018 (Figure 4). However, there was one case with significant differences in the DNI measurements. Quickly changing irradiances during May 31, 2018 revealed a short period of significant instrument discrepancy (Figure 5). It seems there was a delay of the irradiance to defrost the unheated pyrheliometer during the morning hours of May 31, and it took about 1 hour until the instruments agreed again.

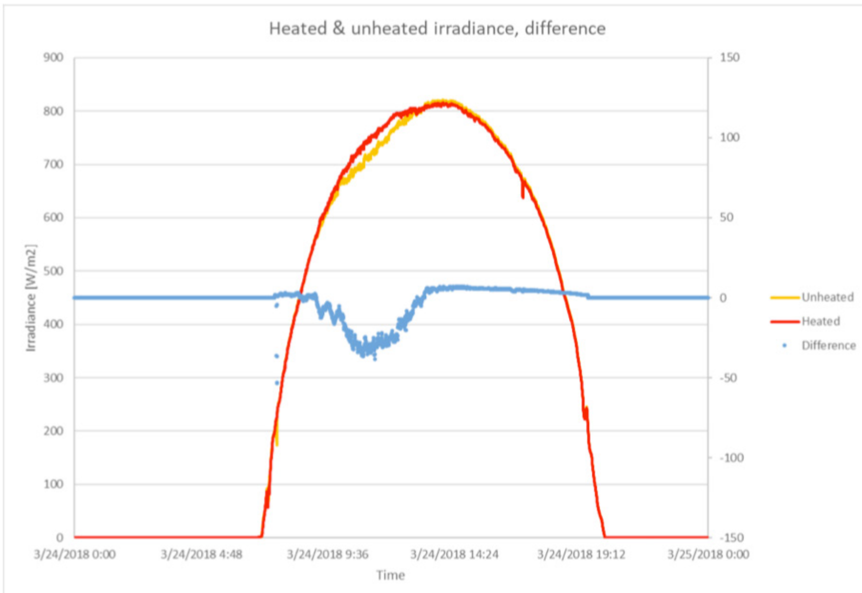

Figure 4. Heated versus unheated pyrheliometer measurements during days with icing (March 24-25, 2018).

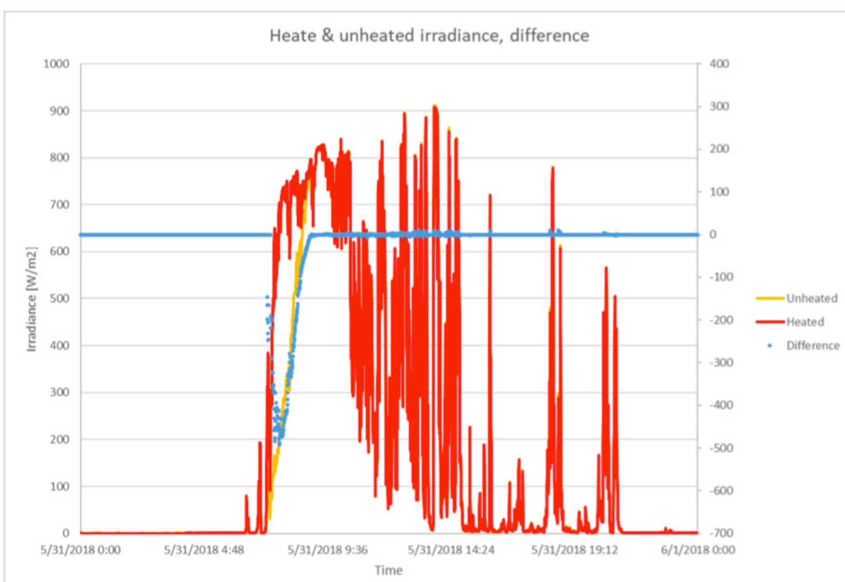

Figure 5. Heated versus unheated pyrheliometer measurements during days with icing (March 31-June 1, 2018).

Comparison with local (cleaned) pyrheliometer data will give more insight. The same pyrheliometers that were tested at Barrow were also tested at the National Renewable Energy Laboratory (NREL) Pyrheliometer Comparison (NPC) testing (see Figure 6). The NPC results showed that there is a minimal effect of heating the front window of the pyrheliometer on the calibration constant. The effect of heating on the measurement proved to be minimal, which was good news.

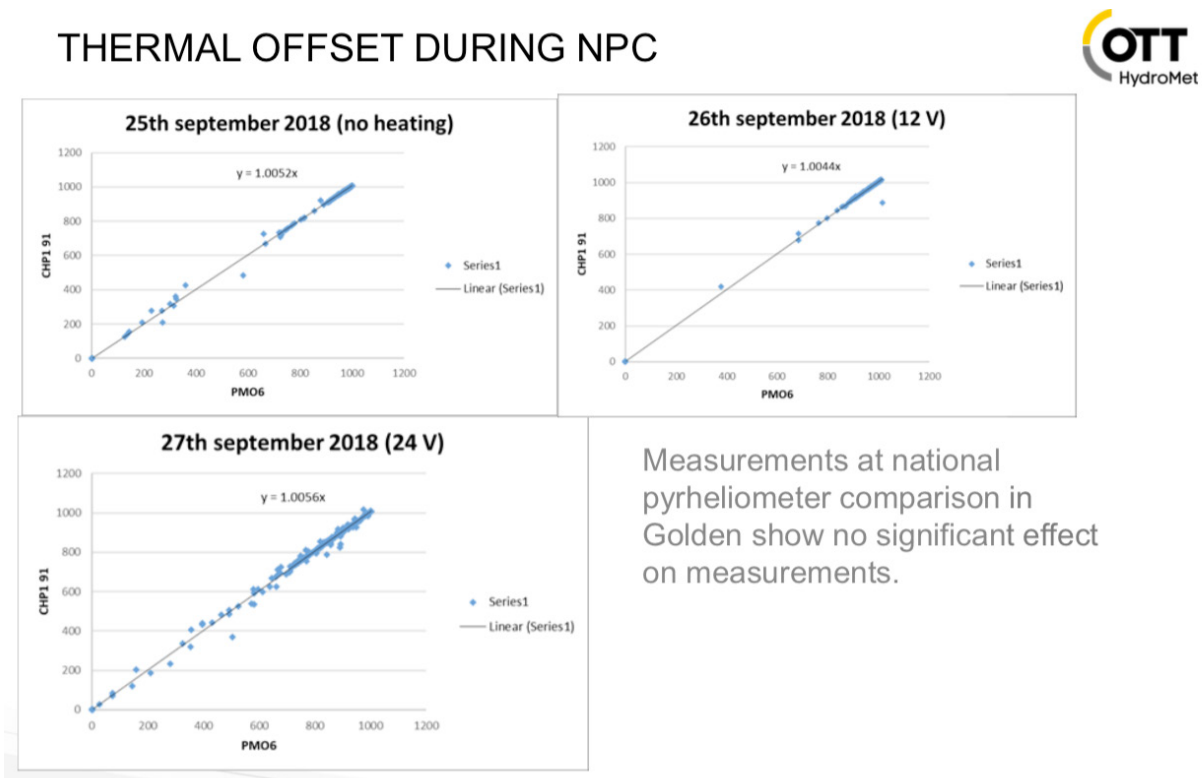

Figure 6. NREL NPC heated and unheated CHP1 calibration testing.

In conclusion, the test of the heated versus the unheated CHP1 instruments showed that the front window temperature of the heated CHP1 shows increased heating up to 17ºC (result from laboratory). The thermal offset was less than 2.5 W/m^2. The NPC data revealed that the calibration did not change for the pyrheliometer with the heating element modification. The ARM pyrheliometer was a great success due to the numerous icing events accounting for perfect test conditions. The heated pyrheliometer has provided more accurate DNI data during periods of icing conditions. It was predominantly ice free and more image analysis is needed to evaluate if any ice contamination occurred at all on the heated pyrheliometer window.

3.0 Publications and References

As yet there have been no publications of the findings.

4.0 Lessons Learned

For certain circumstances a very high heating power is preferable for arctic locations such as the ARM NSA site. That could involve modifying the internal resistance of the instruments for these extreme locations as well as using 24V power supply instead of a 12V supply.

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