SR30: Solar measurement in cold climates

An excellent alternative to externally ventilated pyranometers in cold climates.

The U.S. National Oceanic and Atmospheric Administration (NOAA) is currently conducting the De-Icing Comparison Experiment (D-ICE) for radiometers at their Barrow, Alaska Observatory. Hukseflux has supplied several instruments for this experiment, including an SR30. A preliminary analysis by Hukseflux of the publicly available data confirms that SR30 is an excellent alternative to traditional, externally ventilated pyranometers, even in the extremely frosty Alaskan winter! SR30 provides similar performance at a lower cost, lower power consumption and lower maintenance requirements.*

Introduction

Accurate measurement of solar irradiance with a pyranometer in cold climates is challenging. Figure 2 shows a typical problem in freezing conditions: ice accumulation on the dome surface perturbs the incoming sunlight and renders the measured data unreliable. We call this a reduction in "data availability". Dew, frost, rime and snow all have an adverse effect on data availability. Moreover, the extent of these effects can not always be estimated reliably from the data, possibly contaminating the data without you even knowing (shown in Figure 1). It is therefore important to use the right instrument in such harsh conditions.

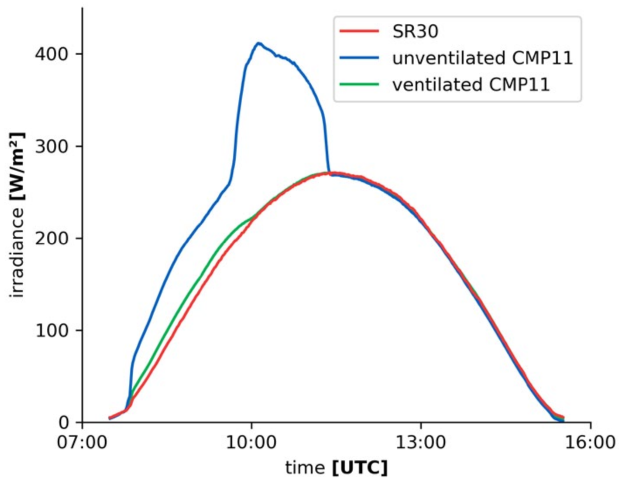

Figure 1 *Data availability in cold climates is negatively impacted by various factors. In this example, we examine a single rime event on a clear sky day in the Netherlands. SR30 is compared to two traditional Kipp & Zonen CMP11 pyranometers: one is unventilated and unheated while the other is externally ventilated and heated. On such a clear sky day, one expects a cosine-like curve such as the SR30 shows. Although the deviation of the unventilated pyranometer curve might be filtered out by data quality control, the deviation of the ventilated pyranometer curve can not be filtered out reliably, contaminating the data without you even knowing. Data taken on 4 DEC 2016, courtesy of KNMI.*

Figure 2 *A typical problem in freezing conditions: ice accumulation on the pyranometer dome surface reduces data availability.*

The SR30 is Hukseflux' response to these issues. In this white paper, we will use data provided by an independent cold climate test to confirm that the SR30 is an excellent alternative to the traditional solution: externally ventilated pyranometers. In addition, we will highlight several of SR30's distinct advantages.

** The use of an instrument by NOAA in the D-ICE experiment does not constitute an approval or endorsement. Data used by Hukseflux are taken from NOAA as published on the NOAA website, which is part of the public domain. Conclusions in this report represent the opinion of Hukseflux only.*

Find out more about D-ICE on the NOAA website:
https://www.esrl.noaa.gov/psd/arctic/d-ice/

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The problems with external ventilation

External heating and ventilation, the traditional solution to operating a pyranometer in cold climates, has several drawbacks. First off, purchase of an external ventilation unit and the accompanying extra maintenance introduce additional costs. Secondly, power consumption is higher and the fan may freeze or get stuck. Finally, application of external heating can lead to offsets for thermal sensors like pyranometers.

A next level solution

Hukseflux SR30 provides a next level solution to pyranometer operation in cold climates. Internal Recirculating Ventilation and Heating (RVH™) technology (Figure 3) provides the advantages of external heating without the drawbacks.
Heated air is ventilated throughout the sensor, raising the sensor temperature evenly. This prevents ice accumulation while reducing thermal offsets caused by a dome-sensor temperature difference. Also, because the heated air is recirculated, the required heating power is much lower: 2 W versus a typical 10 W for external ventilation. This combination makes SR30 a very attractive and versatile sensor for operation in cold environments.

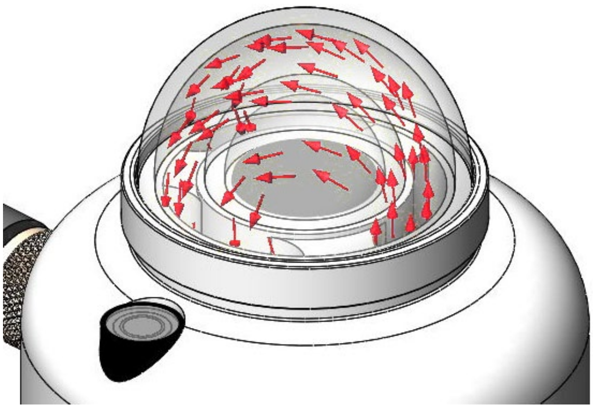

Figure 3 *SR30 is equipped with Recirculating Ventilation and Heating (RVH™) technology. It enables uniform heating of the sensor while reducing thermal offsets.*

Case in point: D-ICE

To compare the performance of pyranometers in cold climates, the U.S. National Oceanic and Atmospheric Administration (NOAA) is conducting the De-Icing Comparison Experiment (D-ICE) at their Barrow, Alaska Observatory. Located more than 500 km north of the polar circle, this is the ideal testing ground for equipment in harsh, arctic conditions (see Table 1 for climate data). Hukseflux has supplied an SR30 for this experiment, to be tested alongside several traditional, externally ventilated pyranometers. SR30's performance so far has, in our opinion, been remarkable, as the following data will show.

Table 1 *Climate data for Barrow, Alaska*

polar night	18 NOV – 23 JAN	
polar day	11 MAY – 1 AUG	
yearly rainfall equivalent	115 mm (desert)	
yearly snowfall	960 mm	
coldest month	February avg. low -29.1 °C	
warmest month	July avg. high 8.3 °C	
temperature extremes during D-ICE (SEP 2017 – APR 2018)	9.5 °C -38.4 °C	3 SEP 2017 28 FEB 2018

Figure 4 *SR30 is battling the elements in Barrow, Alaska: the dome remains ice-free. Note that the neighbouring, completely ice-free sensors are heated with ten times more heating power. Picture taken on 27 JAN 2018 (temperature -30 °C), courtesy of NOAA.*

Data availability

With sub-freezing daily highs on roughly two-thirds of the days per year, ice accumulation is a real problem in Barrow, Alaska. Regularly taken camera images, such as Figure 4, show that SR30 is holding its own in this environment: ice and snow accumulation only happen on the harshest of days, when the externally ventilated sensors also can not cope. Figure 5 illustrates irradiance totals as measured by SR30 and four traditional, secondary standard, externally ventilated pyranometers. Here, we see that SR30 is on par with competitor models in terms of measurement performance as well.

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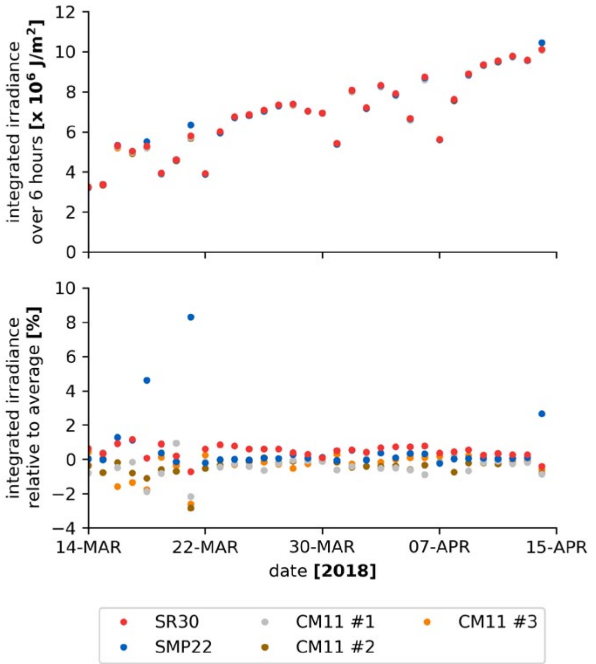
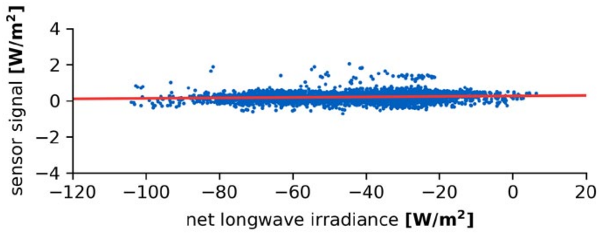


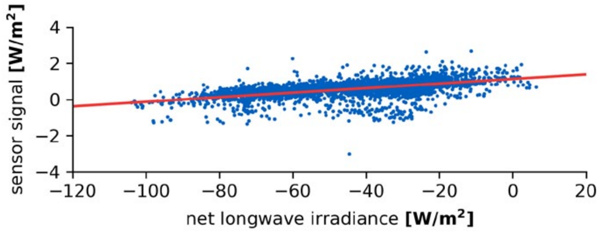
Figure 5 *Irradiance totals for a representative month in Spring 2018 in Barrow, Alaska. The measured totals of SR30 are compared to four traditional Kipp & Zonen externally ventilated pyranometers: one digital SMP22 and three analogue CM11's. Due to the sensor positioning, various shadows from surrounding structures are cast on the sensors in the early mornings and late evenings. Therefore, for a fair comparison, we have opted to calculate totals only during a six-hour window around solar noon.*
Hukseflux' SR30's performance is comparable to the four externally ventilated pyranometers. On a few days, SR30 performs even better than the digital Kipp & Zonen pyranometer, which suffers from lensing due to ice accumulation on the dome (as verified using camera images). Data courtesy of NOAA.

Thermal offsets

SR30's careful design focuses on a uniform sensor temperature and low thermal offsets. This is also reflected in the D-ICE data. We have compared nighttime offsets of SR30, referenced to net longwave radiation as measured by a pyrgeometer, to the offsets of a secondary standard, externally ventilated Kipp & Zonen CMP22.
The results, illustrated in Figure 6, show a very low "zero-offset a" (offset at -200 W/m^2 of longwave thermal exchange), longwave sensitivity and static offset (at 0 W/m^2 of longwave radiation). This makes SR30 a very accurate measurement instrument, even in extreme conditions.



a) *SR30 nighttime offsets*



b) *Nighttime offsets for an analogue Kipp & Zonen CMP22 pyranometer, externally ventilated and heated*

c) *Fitted thermal offset parameters*

	SR30	**CMP22**
longwave sensitivity **[x 10^{-3} (W/m^2) / (W/m^2)]**	1.3	12.5
static offset **[W/m^2]**	0.3	1.1
zero-offset a **[W/m^2]**	0.3	2.5

Figure 6 *Comparison of nighttime thermal offsets of SR30* ***(a)*** *and an analogue, externally ventilated and heated Kipp & Zonen CMP22* ***(b)****, referenced to net longwave irradiance as measured by a pyrgeometer. Data was collected during the D-ICE campaign in Barrow, Alaska over approximately 8 months (SEP 2017 – APR 2018). Longwave sensitivity, static offset and "zero-offset a" are calculated from a linear fit on the data* ***(c)****. SR30's design with focus on low thermal offset is paying off: SR30´s offsets are lower than the externally ventilated CMP22. Data courtesy of NOAA.*

Conclusion: an excellent alternative

First results from the De-Icing Comparison Experiment show that:

- SR30's icing and measurement performance is comparable to externally ventilated pyranometers; and
- SR30 has low thermal offsets

In addition, power consumption, maintenance needs and costs are reduced. This combination makes SR30 an excellent alternative to traditional, externally ventilated pyranometers!

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See also

- SR30 brochure
- view our complete product range of solar sensors

Worldwide support

Hukseflux has support available around the globe, with local representatives in:

- EU (Amsterdam region)
- USA (New York region)
- India (New Delhi region)
- China (Shanghai region)
- Japan (Tokyo region)

About Hukseflux

Hukseflux Thermal Sensors offers measurement solutions for the most challenging applications. We design and supply sensors as well as test & measuring systems, and offer related services such as engineering and consultancy. Our main area of expertise is measurement of heat transfer and thermal quantities such as solar radiation, heat flux and thermal conductivity. Hukseflux is ISO 9001 certified. Hukseflux sensors, systems and services are offered worldwide via our office in Delft, the Netherlands and local distributors.

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