Solar measurement in cold climates

Heated SR30(0) matches performace of externally ventilated pyranometers

The U.S. National Oceanic and Atmospheric Administration (NOAA) has conducted the De-Icing Comparison Experiment (D-ICE) for radiometers at their Barrow, Alaska Observatory. Hukx has supplied several instruments for this experiment, including an SR30*. A preliminary analysis by Hukx 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 (or the latest model SR300) performs as well at a lower cost, with less power consumption and at a much lower maintenance level.

Introduction

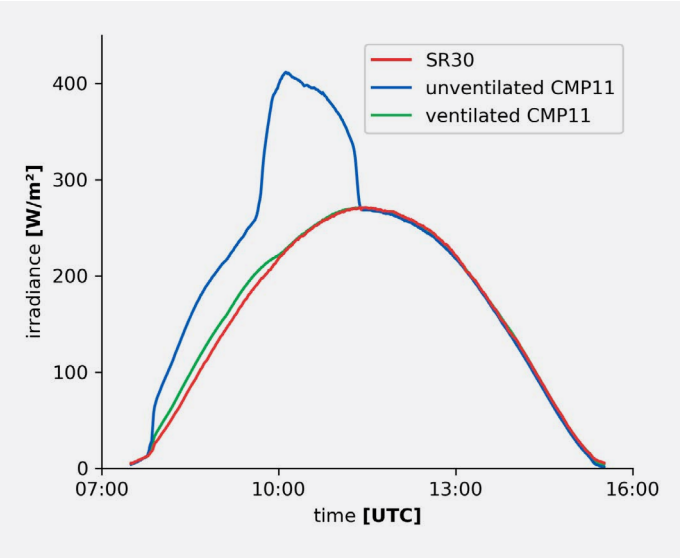
Accurately measuring solar irradiance with a pyranometer in cold climates is challenging. Figure 2 shows a typical problem in freezing conditions: ice accumulated on the dome surface scatters the incoming sunlight and renders the measured data unreliable. We call this a reduction in "data availability." 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 the user's knowledge (shown in Figure 1). It is therefore important to use the right instrument in such harsh conditions.

The SR30 is Hukx's response to address these issues in cold climates. 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 of externally ventilated pyranometers. In addition, we will highlight several of SR30's distinct advantages. In 2025 SR30 has been replaced by SR300, which has similar performance when it comes to dew and frost mitigation.

* The use of an instrument by NOAA in the D-ICE experiment does not constitute an approval or endorsement. Data used by Hukx 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 Hukx only.

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

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 unventilated and unheated, and the other externally ventilated and heated. On a clear sky day, a cosine-like curve is expected, as seen with the SR30. Although the deviation of the unventilated pyranometer curve might be filtered out by data quality control, the deviation of the ventilated pyranometer curve cannot be filtered out reliably, while the user is unaware that frost is contaminating the data. Data taken on 4 DEC 2016, courtesy of KNMI.



The problems with external ventilation

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

SR30, the first heated pyranometer

Hukx SR30 provides a next-level solution to pyranometer operation in cold climates. Internal Recirculating Ventilation and Heating (RVHTM) technology (Figure 3) has all the benefits of external heating without the disadvantages.

Heated air is ventilated between the inner and outer dome of the sensor, raising the sensor temperature evenly. This prevents ice accumulation, while reducing thermal offsets caused by a dome-sensor temperature difference. Also, since the heated air is recirculated, the SR30 requires much less heating power: 2 W versus a typical 10 W for external ventilation. This combination makes SR30 a very attractive and versatile sensor for reliable operation in cold environments.

Figure 2 A common issue in freezing conditions: ice accumulation on the dome of a traditional pyranometer (left) reduces data availability. The heated SR30 (right) mitigates this problem.

D-ICE experiment

To evaluate the performance of pyranometers in cold climates, the U.S. National Oceanic and Atmospheric Administration (NOAA) conducted the De-Icing Comparison Experiment (D-ICE) at their Barrow, Alaska Observatory. Located more than 500 km north of the polar circle, this is an ideal testing ground for equipment in harsh, arctic conditions (see Table 1 for climate data).

Hukx supplied a heated SR30 for this experiment, which was tested alongside several traditional, externally ventilated pyranometers. SR30's performance has, in our opinion, been remarkable, as the following data will show.

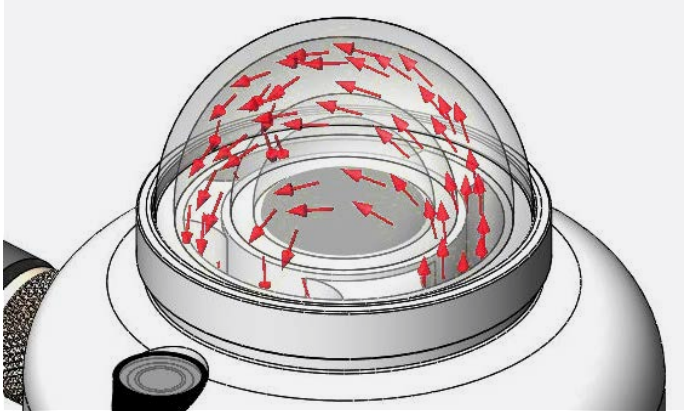


Figure 3 SR30 features Recirculating Ventilation and Heating (RVHTM) technology that enables uniform heating of the sensor while minimizing thermal offsets.

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	Feb avg. low -29.1 °C
warmest month	Jul avg. high 8.3 °C
temperature extremes during D-ICE (Sep 2017 – Apr 2018)	9.5 °C 3 Sep 2017 -38.4 °C 28 Feb 2018

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 5, 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 suffer from the same conditions. Figure 4 illustrates irradiance totals as measured by SR30 and four traditional, Class A (secondary standard), externally ventilated pyranometers. Here, we see that SR30 is on par with competitor models in terms of measurement performance.

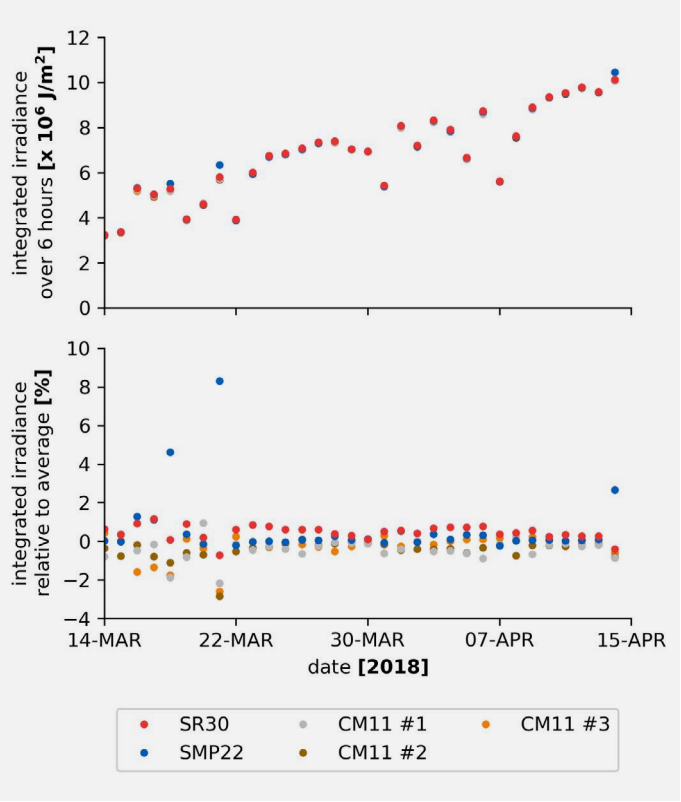


Figure 4 Irradiance totals for a representative month in Spring 2018 in Barrow, Alaska. The measured totals of SR30 are compared to four traditional Kipp & Zonen externally ventilated pyranometers: one digital SMP22 and three analog CM11's. Due to the sensor positioning, various shadows from surrounding 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.

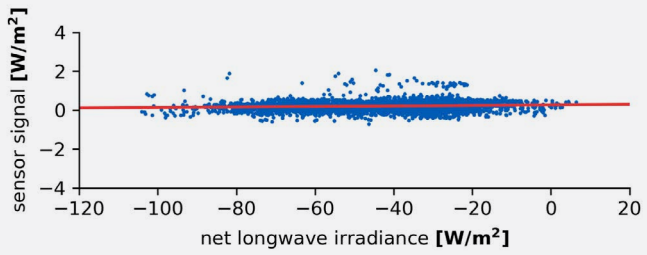
Hukx's SR30 performance is comparable to the four externally ventilated pyranometers. On a few days, SR30 performs even better than the digital Kipp & Zonen pyranometer, which suffers from lensing due to ice accumulation on the dome (as verified by camera images). Data courtesy of NOAA.

Figure 5 SR30 is battling the elements in Barrow, Alaska, yet the dome remains ice-free. Note that the neighboring, completely ice-free sensors are heated with five times more heating power. Picture taken on 27 JAN 2018 (temperature -30 °C), courtesy of NOAA.

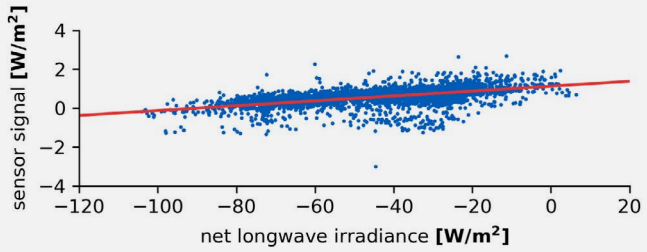
Thermal offsets

SR30's careful design focuses on a uniform sensor temperature and low thermal offsets. This performance is also confirmed in the D-ICE data. We have compared nighttime offsets of SR30, referenced to net longwave radiation measured by a pyrgeometer, to the offsets of a Class A, externally ventilated Kipp & Zonen CMP22.

As shown in Figure 6, the SR30 exhibits a very low "zero-offset A" (offset at -200 W/m² of longwave thermal exchange), longwave sensitivity, and static offset (at 0 W/m² of longwave radiation). These characteristics makes SR30 a very accurate measurement instrument, even under extreme arctic conditions.



a) SR30 nighttime offsets



b) nighttime offsets for an analog Kipp & Zonen CMP22 pyranometer, externally ventilated and heated

	SR30	CMP22
longwave sensitivity [x 10^{-3} (W/m²) / (W/m²)]	1.3	12.5
static offset [W/m²]	0.3	1.1
zero-offset a [W/m²]	0.3	2.5

c) fitted thermal offset parameters

Conclusion: an excellent alternative

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!

Final D-ICE Report

Cox, C., Morris, S. M., et al The De-Icing Comparison Experiment (D-ICE): a study of broadband radiometric measurements under icing conditions in the Arctic European Geosciences Union, 2021

See also

– SR300 brochure
– view our complete product range of solar radiation sensors

Worldwide support

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

– EU
– USA
– India
– Brazil
– China
– Japan
– SEA (Singapore and Australia)

Figure 6 Comparison of nighttime thermal offsets of SR30 (a) and an analog, 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 a focus on low thermal offset, is paying off: SR30´s offsets are lower than that of the externally ventilated CMP22. Data courtesy of NOAA.

About Hukx

Hukx is the leading innovator in solar radiation and heat flux sensor technology. We are proud to set the standard in high-accuracy measurement, and to be working at the heart of the energy transition.

Customers worldwide rely on our bestselling pyranometers and heat flux sensors. From sensor design and selection to supply and recalibration, we support you across the entire lifecycle.

Hukx is headquartered in the Netherlands, with locally owned representative sales offices in the USA, Brazil, India, China, Southeast Asia, and Japan.

Let us help you select the best sensor for your application.
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