Quick Read Whitepaper

Precision Sunshine Duration Monitoring

With the **MS-95S Sunshine Duration Sensor**

QRW_PSDM 04-2023

Executive Summary

In climate research, meteorology and reporting, **sunshine duration** quantities are valuable to monitor seasonal variations between different locations, and are a useful indicator for a variety of applications, such as calculating solar energy potential, assessing crop growth conditions, or predicting weather patterns. Many solutions exist to measure **sunshine duration**, but until now, have all come with their own set of challenges or drawbacks. This is why EKO Instruments developed the **MS-95S**.

This Quick-Read Whitepaper will give you an overview of this new-concept **sunshine duration sensor**, break down its unique measurement principle, and outline how the **MS-95S** is revolutionizing **sunshine duration monitoring** for researchers, academics, and industry professionals around the world.

Patent pending

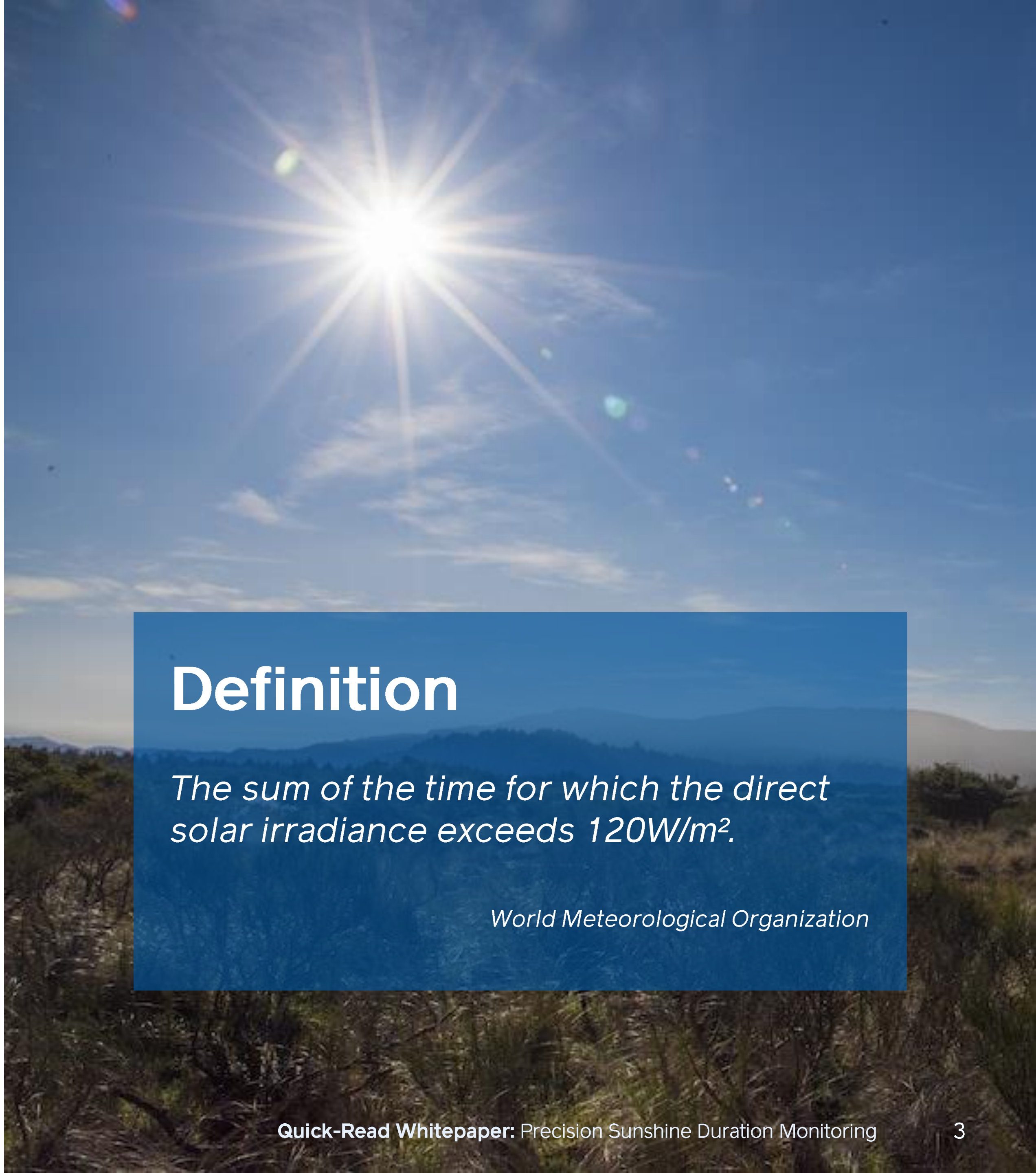
What is **Sunshine Duration?**

Sunshine duration is the period of sunshine in a day, defined by the World Meteorological Organization as the sum of time in which direct solar irradiance exceeds 120 watts per square meter (W/m²).

As opposed to solar irradiance measurements, which indicate the radiative energy received from the sun, **sunshine duration** is simply the time for which the irradiance (received energy from the sun) accumulated over a day or a month-long period exceeds the 120W/m² threshold.

It has long been measured and used not merely for weather maps and forecasts but as a climatologic indicator of weather trends across different regions and periods of time. For example, sunshine duration hours can be used to compare climatological normal sunshine against years of drought. Its measurement requires a certain degree of accuracy and is a crucial parameter in tracking and analyzing climate change.

So, sunshine duration is important, sure, but how do we go about measuring it and what are the best tools and methods to do so? Enter the **Sunshine Duration Meter**.



Definition

The sum of the time for which the direct solar irradiance exceeds 120W/m².

World Meteorological Organization

History of Development

Previous sunshine duration solutions developed by EKO like the MS-093 utilized a rotating-mirror sunshine duration meter concept.

Campbell–Stokes Sunshine Recorder

Jordan Pattern Sunshine Recorder

Solar Cell SD Sensor

EKO MS-093 SD Sensor (Rotating Mirror)

For years, this product was proven to have high accuracy and has been adopted by prominent global research institutes such as the National Oceanic and Atmospheric Administration (NOAA) and Japan Meteorological Administration for its Automated Meteorological Data Acquisition System (AMeDAS).

While it remains a viable, highly-accurate solution, rotating-mirror concepts like this require specific orientation of azimuth and latitude, and need periodical maintenance and recalibration. In addition, they can be costly and time consuming to produce due to the special structure and complex shape of the mirror.

A Look Back

Throughout history, several types of sunshine recording devices have been developed and used, from photoelectric sunshine recorders, reference pyrheliometers, to rotating mirror recorders, etc.

Each has had its own critical limitations such as cost, maintenance requirements, or accuracy during days with sporadic cloud coverage, which prevent it from being an indisputable all-encompassing solution.

A New-Concept Sunshine Duration Sensor

To combat these limitations, EKO has developed the **MS-95S Sunshine Duration Sensor** with a revolutionary new design and measurement principle.

By combining an ultra-wide-angle lens and a quadrant silicon photodiode array sensor, the **MS-95S** is able to achieve unprecedented accuracy while maintaining a compact, low-cost and easy-to-install form factor with no moving parts or complex on-site adjustment required.

MS-95S Features

Fig. 1 MS-95S Top view

Full Hemisphere Ultra-Wide Angle Lens Design for All-Sky Observation

Unmatched Stability, No Recalibration Required

Smart 4-Channel Analog & Digital Interface

Internal Diagnostics for Temperature, Tilt & Roll

MS-95S Specifications

Measurement Accuracy	< ±15 % (for 120W/m² threshold) (1) > 90 % (monthly sunshine hours)
Signal Output (2)	Digital (Modbus RTU / SDI-12) Analog (4-20mA / 0-1V with 100Ω shunt resistor)
Wavelength Range	400 to 1100nm
Operating Temperature	-40 to +80°C
Environmental Protection	IP67
Response Time	200ms
Weight	0.4kg
Power Supply	Modbus : DC5V or DC8V―DC30V 0-1V/4-20mA : DC8V―DC30V SDI-12 : DC9.6V―DC16V
Power Consumption	Digital : <0.2W Analog : <0.7W
Diagnostic Function	Temperature / Humidity alert / Tilt & Roll angle

(1) WMO Compliant
(2) Sensor settings can be adjusted using our free configuration software, 'Hibi'.
Please see the 'Hibi' section of this whitepaper for more details.

MS-95S Overview

The MS-95S reinvents sunshine duration sensors, setting new standards for accuracy and stability. Low-cost, compact, light, and robust, the MS-95S does not require calibration and, paired with the MV-01 Ventilator & Heater, performs consistently in all weather conditions.

Static and easy to install, with no special mount, moving parts, or complex on-site adjustment required, the MS-95S, part of EKO's elite S-Series range of solar monitoring solutions, includes a unique 4-channel smart interface compatible with most data loggers, DAQ, and SCADA systems, plus internal diagnostic sensors for remote visibility over internal temperature, tilt and roll angle.

With an optical sensor design built around a new ultra-wide-angle lens that observes the sky in 180°, the MS-95S employs a unique method to distinguish and record direct beam radiation from total sky radiation. Unaffected by detector temperature effects, irradiance conditions, solar elevation angle or detector non-linearity, the MS-95S is the ultimate choice for maintenance-free, long-term operation.

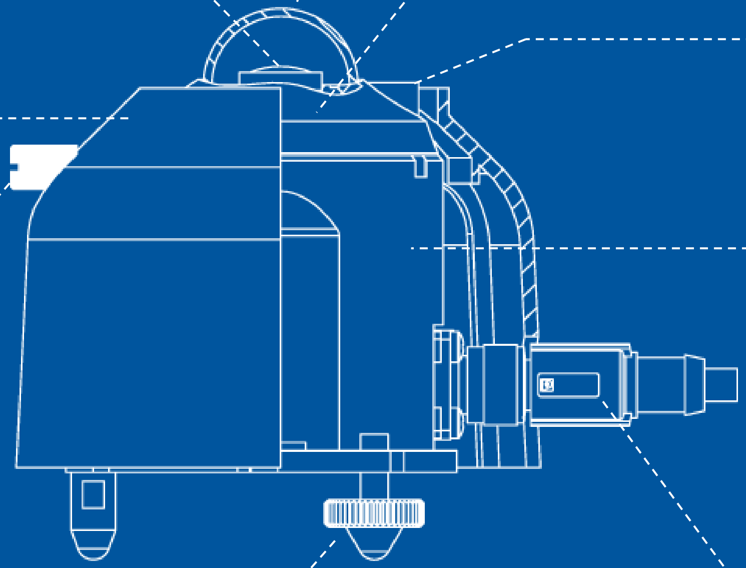
Feature Diagram

Full-hemispherical Lens:
Projects global horizontal irradiance to the array sensor.

Sun Shield:
Prevents body temperature increase from solar irradiance

Knurling Screw:
Fixes the sun shield to the body

Leveling Screw:
Levels the sensor



Glass Dome:
Protects the sensor from dirt & rain

Silicon Photodiode Array Sensor:
Generates current when detecting light

Bubble Level:
Helps set up and maintain the sensor in a horizontally leveled position

Smart Electronics:
All-in-one smart signal transducer with 4 different outputs

Cable/Connector:
Connects the MS-95S to a PC or data logger and outputs signal and data communication

Fig. 2 Part Names & Descriptions

Measurement Principle

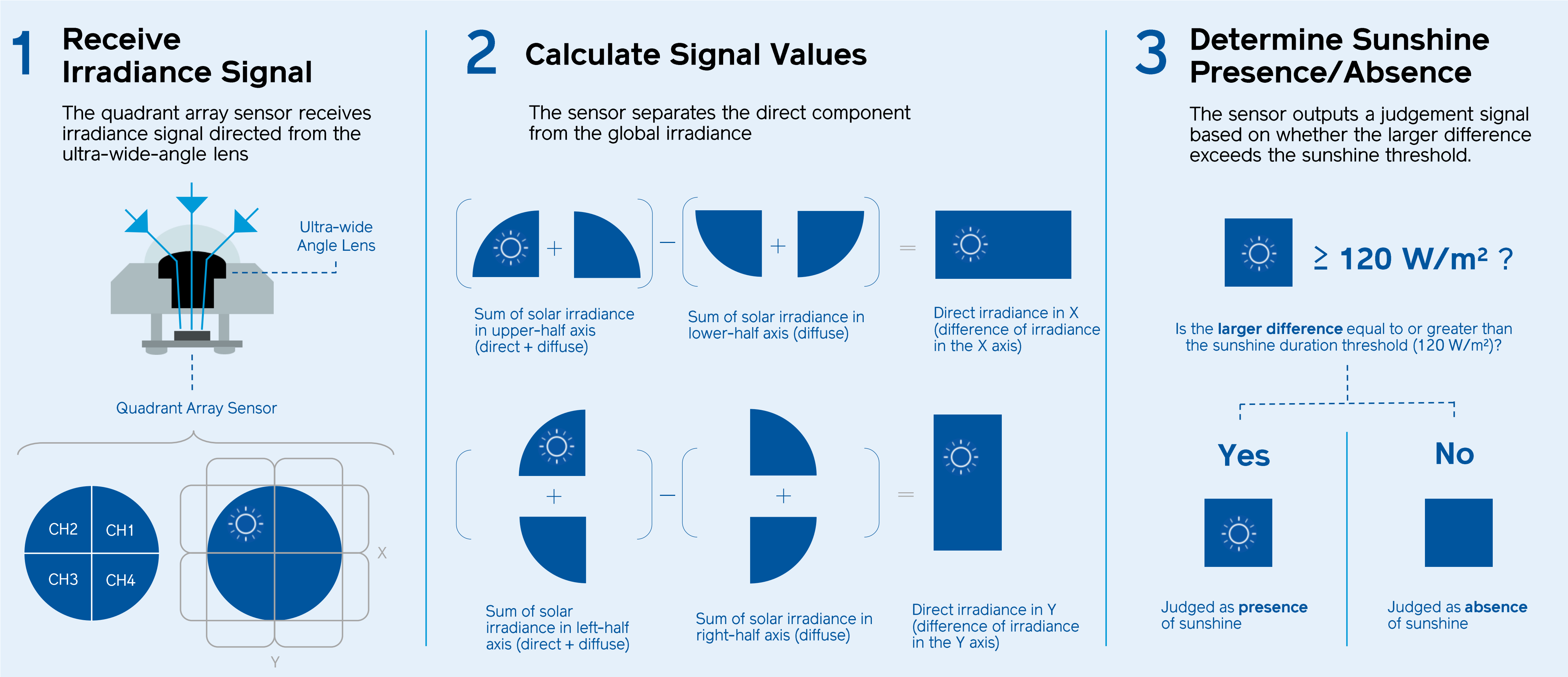


Fig. 3 Measurement Principle Illustration

EKO

No. Calibration. Required.

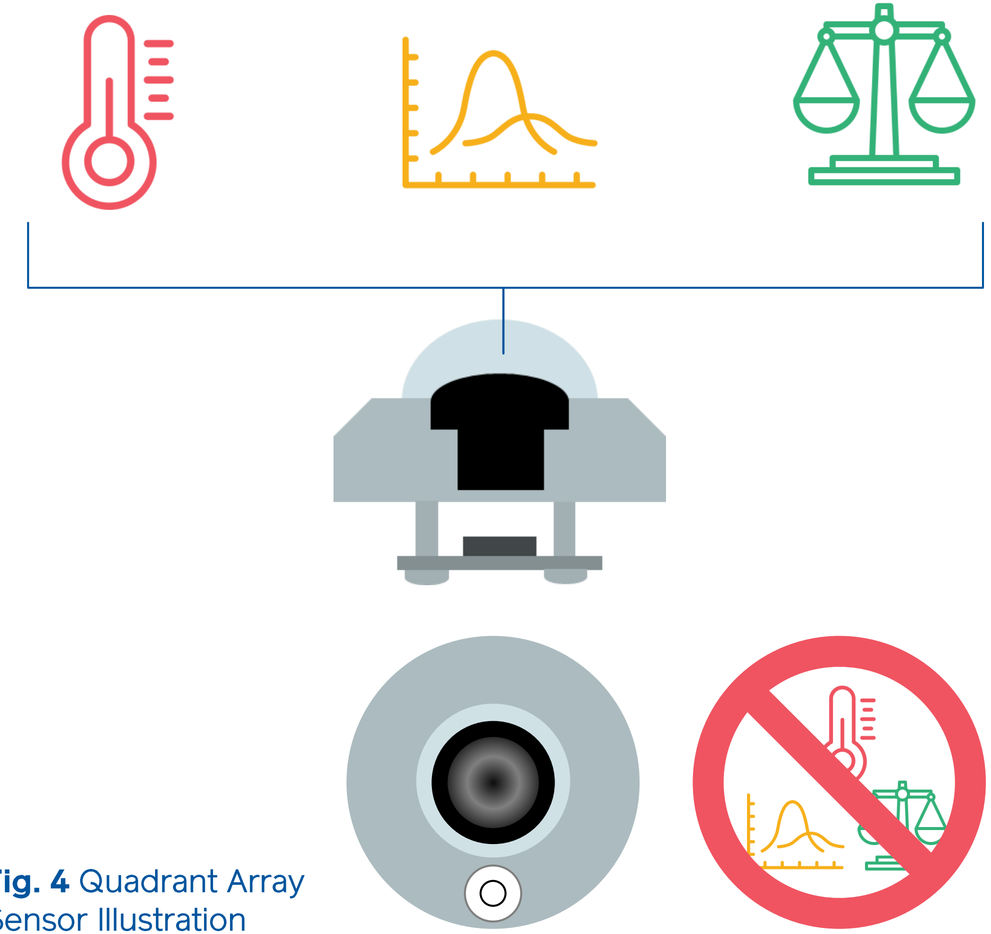


Fig. 4 Quadrant Array Sensor Illustration

The **MS-95S** is designed for minimal maintenance and is ideal to be deployed in remote meterological networks.

Its unique quadrant array sensor cancels out any **temperature effects**, **nonlinearity** and long-term **stability** changes over time. No other sensor currently available exists with such performance characteristics and without the need to be recalibrated at regular intervals.

Utilizing the EKO Universal Sensor Design, the **MS-95S** is also compatible with a range of accessories like the MV-01 Heater & Ventilator unit, further expanding the possibilities of where it can be installed. And, being an S-Series Sensor, it can also take advantage of our proprietary software, 'Hibi'.

With 'Hibi', a custom, free-to-download, programme developed by EKO, users can connect their S-Series Sensors with a standard laptop for real-time access to the internal diagnostics, custom settings, and measurement data.

Hibi helps to make the MS-95S the most accessible sunshine duration sensor available. Easy to use, deploy, and maintain.

S-Series Control

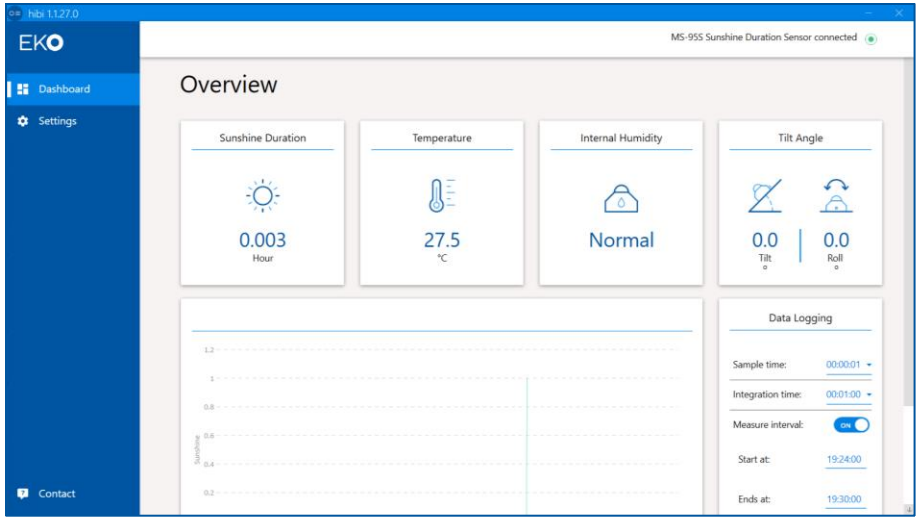


Fig. 5 Hibi Dashboard

The dashboard shows live diagnostic information at a glance, giving users unprecedented visibility and control over their sunshine duration monitoring.

Outputs can also be toggled between digital and analogue, and data logging options can also be changed in the settings.

These S-Series features bring the **MS-95S** to a new level and represent a breakthrough for Sunshine Duration Sensors.

Validating Measurement Results

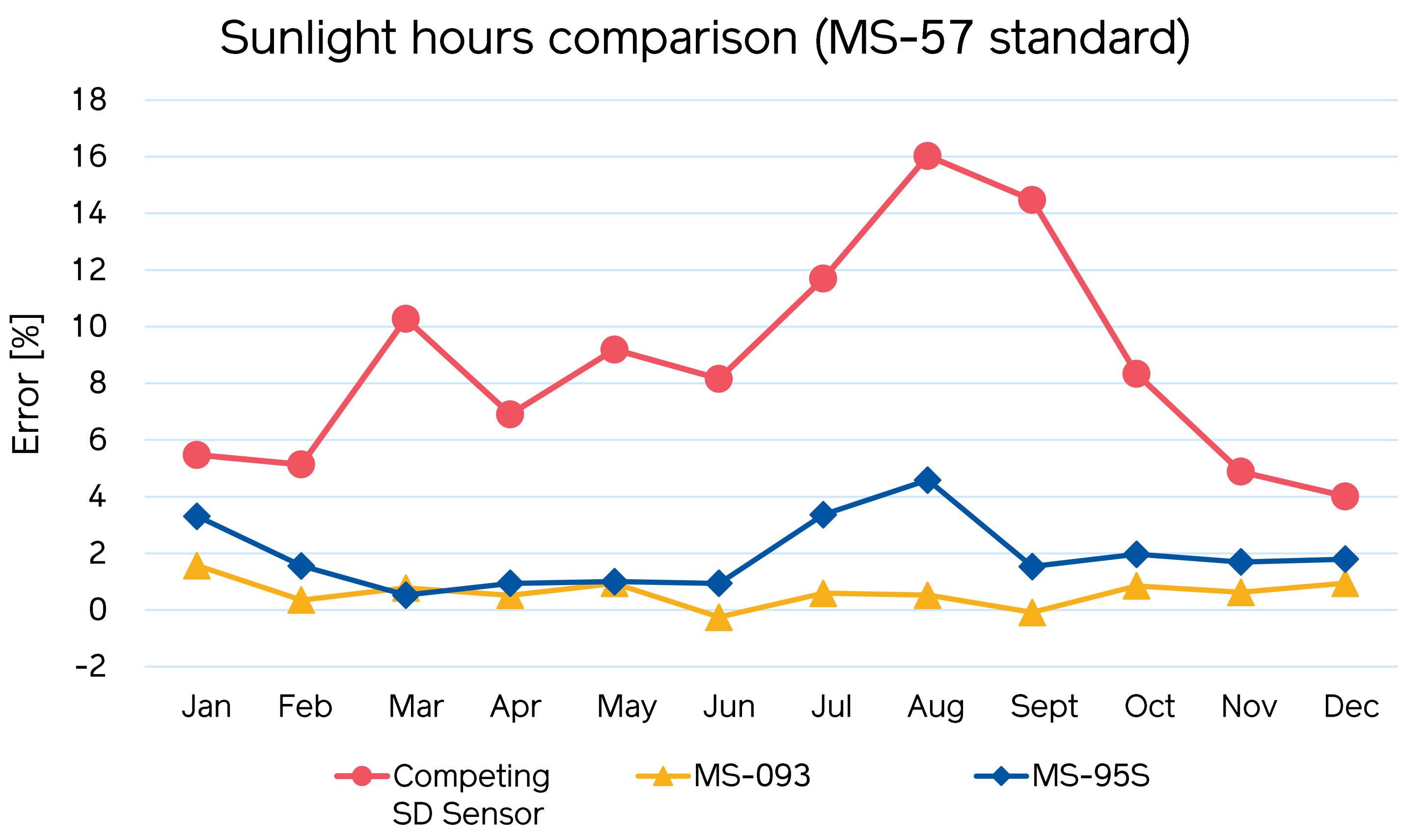


Fig. 6
Comparison of monthly sunshine hours from a test conducted from January to December 2022

The test results show sunshine duration measurement between x3 sensors, the MS-95S, the MS-093, and the top competing SD sensor.

Against the MS-57 (reference pyrheliometer), seasonal variations of each sunshine duration sensor model are shown. The seasonal variations of EKO's MS-093 and MS-95S were **5% or less**.

However, the top competing sunshine duration sensor has large errors in monthly sunshine duration measurement data and large seasonal variation.

Sensor Comparison

Sunshine duration sensors are put to the test when the sky fluctuates between sunny and cloudy conditions, since the received direct normal irradiance teeters close to the 120W/m² threshold. To illustrate, Fig. 7a & 7b on the right show DNI data for days with clear or variable conditions.

Figures 8a to 8d on the following page show graphs that select one day from every season from a sunny and cloudy day and plot the sunshine duration difference by time. Again, we can see the top competing sunshine duration sensor has a larger sunshine duration difference against a pyrheliometer's sunshine duration on a day with a large number of direct irradiance near the threshold, whereas the MS-093 and MS-95S have a small sunshine difference even in such conditions.

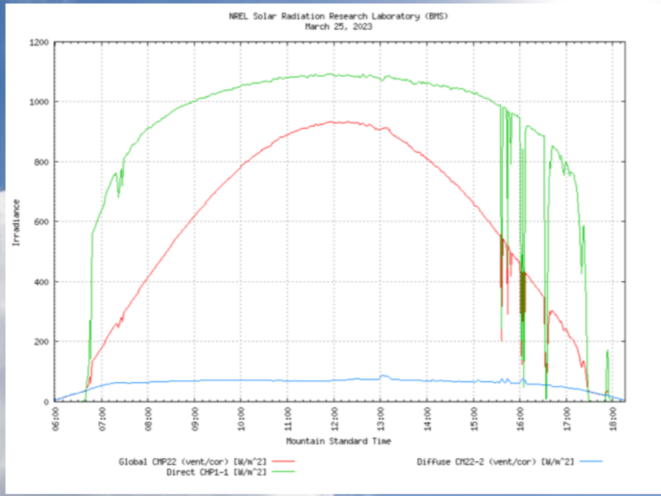


Fig. 7a
Irradiance Data for a day with sunny, clear conditions

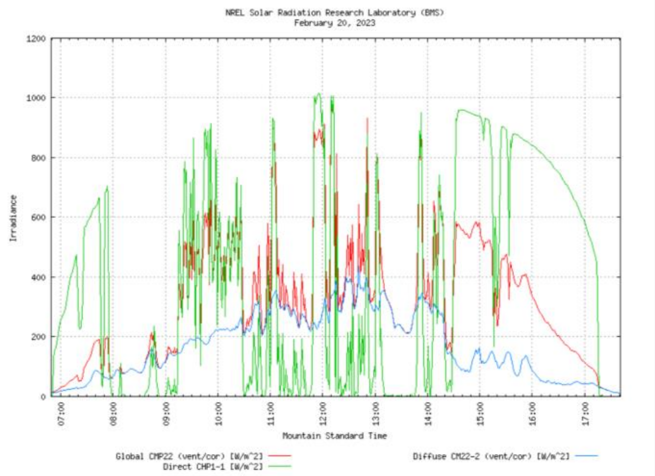


Fig. 7b
Irradiance Data for a day with varying conditions

EKO

Data Snapshots

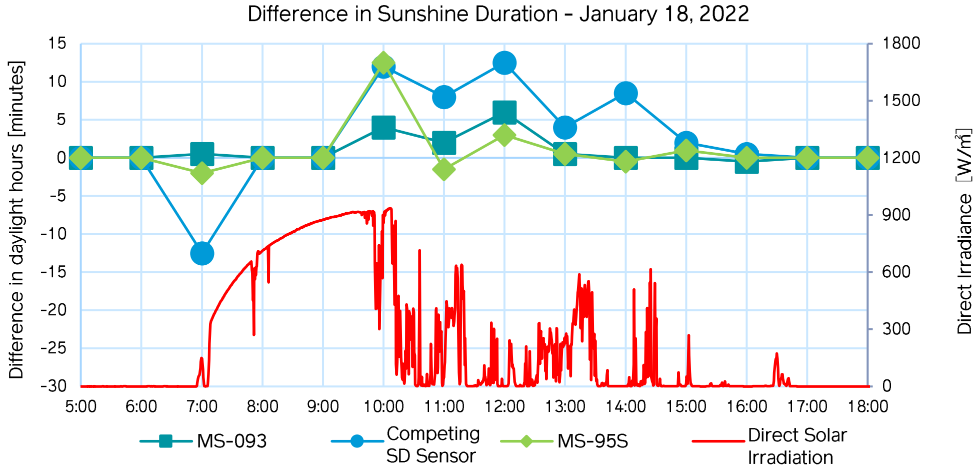


Fig. 8a Difference in daylight hours by time of day for each instrument (January)

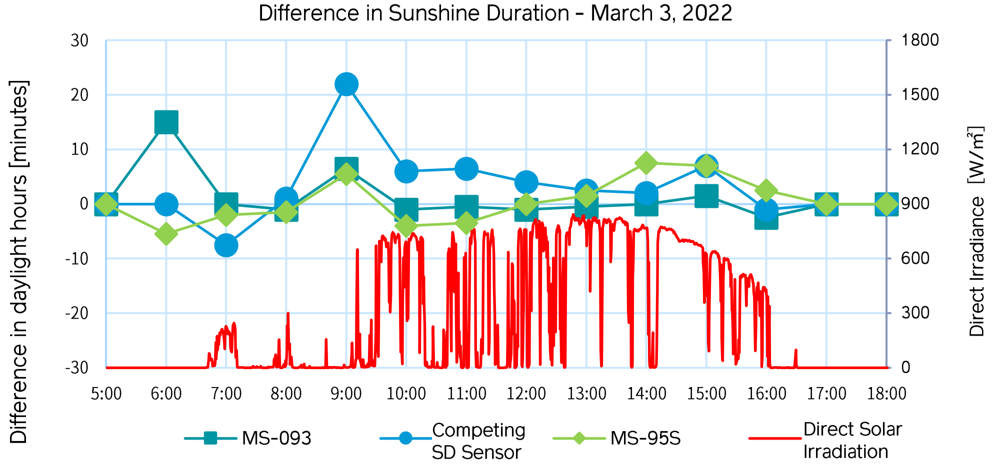


Fig. 8b Difference in daylight hours by time of day for each instrument (March)

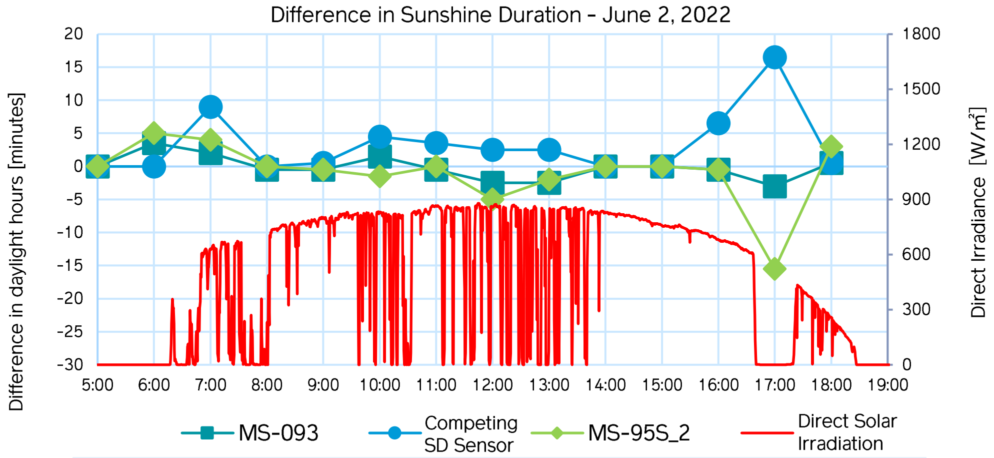


Fig. 8c Difference in daylight hours by time of day for each instrument (June)

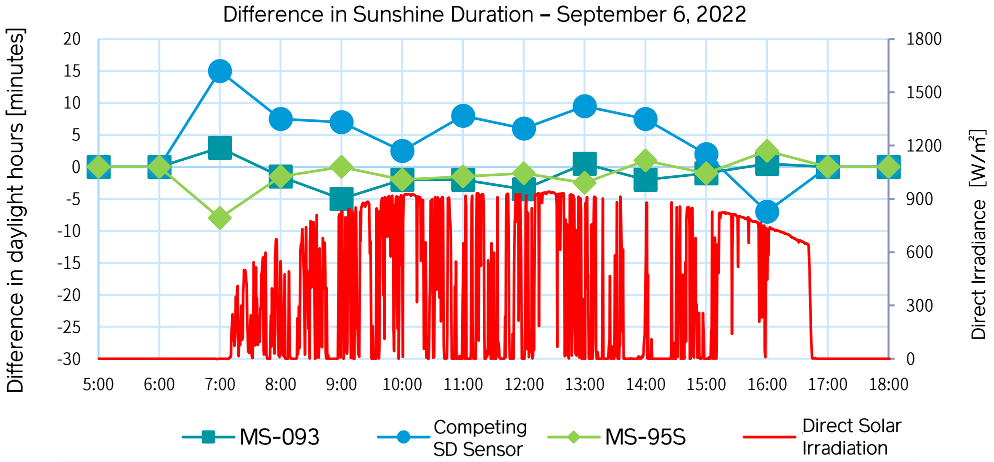


Fig. 8d Difference in daylight hours by time of day for each instrument (Sept)

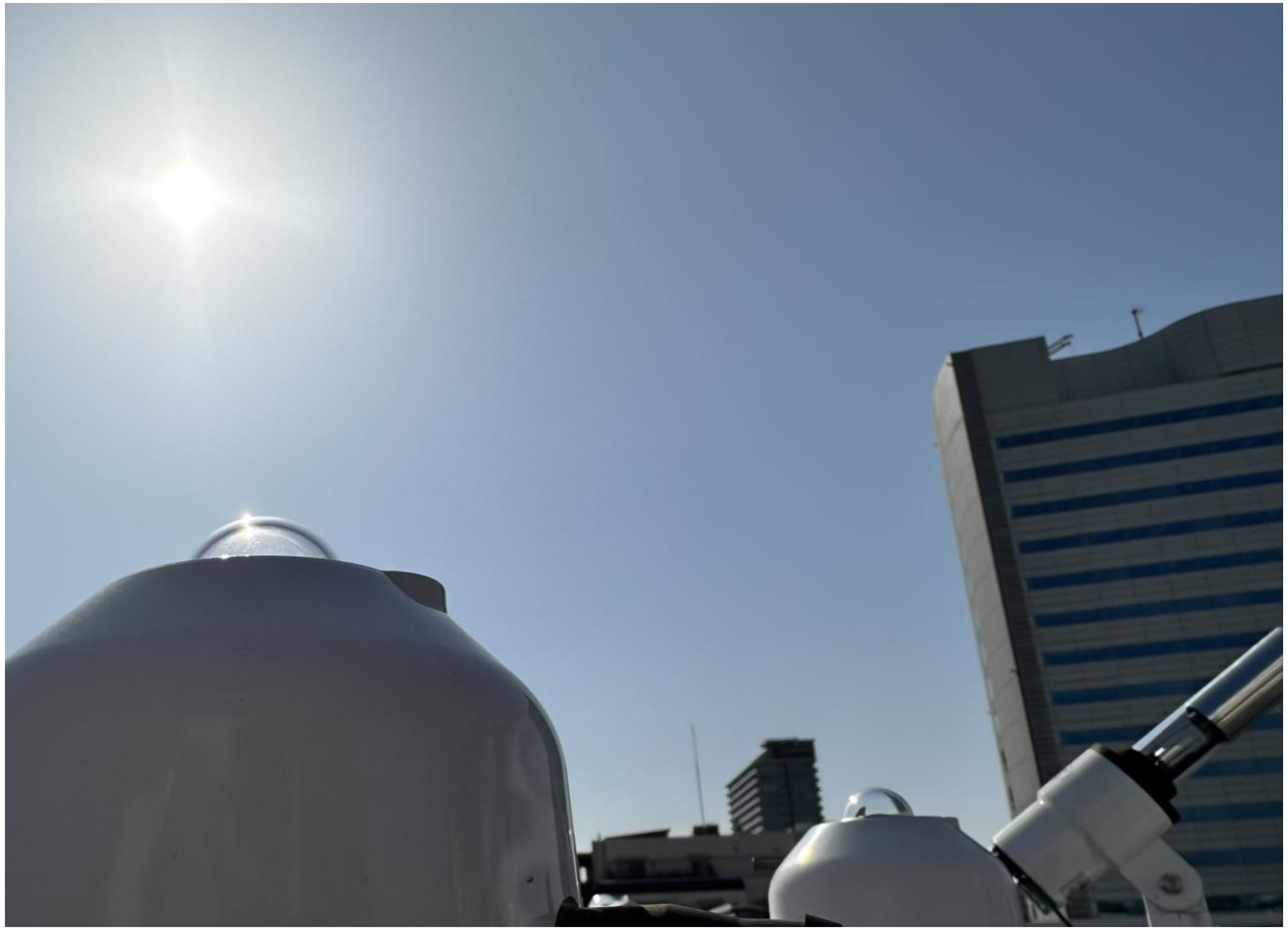
Low Power, High Performance

Precision Sunshine Duration Monitoring

The first of its kind, the **MS-95S** makes sunshine duration monitoring easier, faster, and more accurate than its predecessors.

Tested and validated against conventional sunshine duration measurement principles, the **MS-95S** comes out on top, far and away from even the top competing SD sensors.

Together with its S-Series features and all-weather capability with the MV-01, it is the ideal choice for all situations that require **precision sunshine duration monitoring**.



Find out more

Visit eko-instruments.com to find your nearest EKO office and supplier.

EKO Instruments Co., Ltd.
1-21-8 Hatagaya, Shibuya-ku
151-0072
Tokyo, Japan
P: +81-3-3469-6713
https://eko.co.jp

EKO Instruments USA Inc.
111 North Market Str. Suite 300
CA 95113
San José, United States
P: +1 408 977 7751

EKO Instruments Europe B.V.
Lulofsstraat 55, Unit 28
2521 AL
Den Haag, Netherlands
P: +31 (0)703050117

EKO Instruments Sales China
Hong Kong

EKO Instruments Sales India
Mumbai

EKO

Over 90 years of Japanese design, reliability & precision in solar energy sensors, environmental science, and material analysis. EKO Instruments are today deployed around the world, supporting environmental research and renewable energy projects through continuous innovation, industry leading turn-key solutions, and an uncompromising commitment to quality.

Find out more at **eko-instruments.com**