

Recent Update of International Standards on Radiometry

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Abstract

- ❖ International radiometric standards serve as the foundation for accuracy and uniformity in solar irradiance measurement.
- ❖ These standards lay out universally accepted protocols for the calibration, classification, and usage of radiometric instruments, such as pyranometers and pyrhemimeters, which quantify various aspects of solar radiation, including global horizontal irradiance (GHI), direct normal irradiance (DNI), and diffuse horizontal irradiance (DHI).
- ❖ By adhering to these standards, solar resource measurements become traceable, dependable, and comparable on a global scale.
- ❖ These standards are developed by organizations like the World Meteorological Organization (WMO), the International Organization for Standardization (ISO), and the American Society for Testing and Materials (ASTM).
- ❖ The implementation of radiometric standards is essential for obtaining high-quality data, which are vital for precise solar resource assessments, photovoltaic design, durability studies, and energy yield predictions.
- ❖ The National Renewable Energy Laboratory (NREL) has taken a leading role in various international subcommittees, including the ISO/TC180 SC1 Climate – Measurement and Data and the ASTM G03.09 Radiometry subcommittee.
- ❖ Recently, NREL and its partners have been actively involved in updating and developing multiple standards to incorporate the latest advancements in knowledge, science, and technology.

Standards With Major Updates and Standards Under Development

a. ISO 9846: Solar energy — Calibration of a pyranometer using a pyrhemimeter

- ❖ The second edition of this standard replaces the first edition, which was released in the early 1990s.
- ❖ The revisions include substantial technical updates, such as enhanced guidelines for uncertainty evaluation, offering users specific references to standards such as ASTM G213 for assessing uncertainties in the calibration process.
- ❖ Terminology has been significantly revised to align with recently published standards, including ISO 9488, ISO 9847, and ISO 9060.
- ❖ A major addition is the introduction of the collimation tube calibration method for calibrating pyranometers (Figure 1).
- ❖ There are two options in the collimation method of the standard for determining the diameter dome size and detector size of the pyranometer (Figure 1):
 - The dome size refers to the hemispherical transparent glass that covers the detector and allows specific wavelengths of incoming solar radiation to pass.
 - The detector size refers to the area of the thermopile sensor that converts solar radiation into an electrical signal.

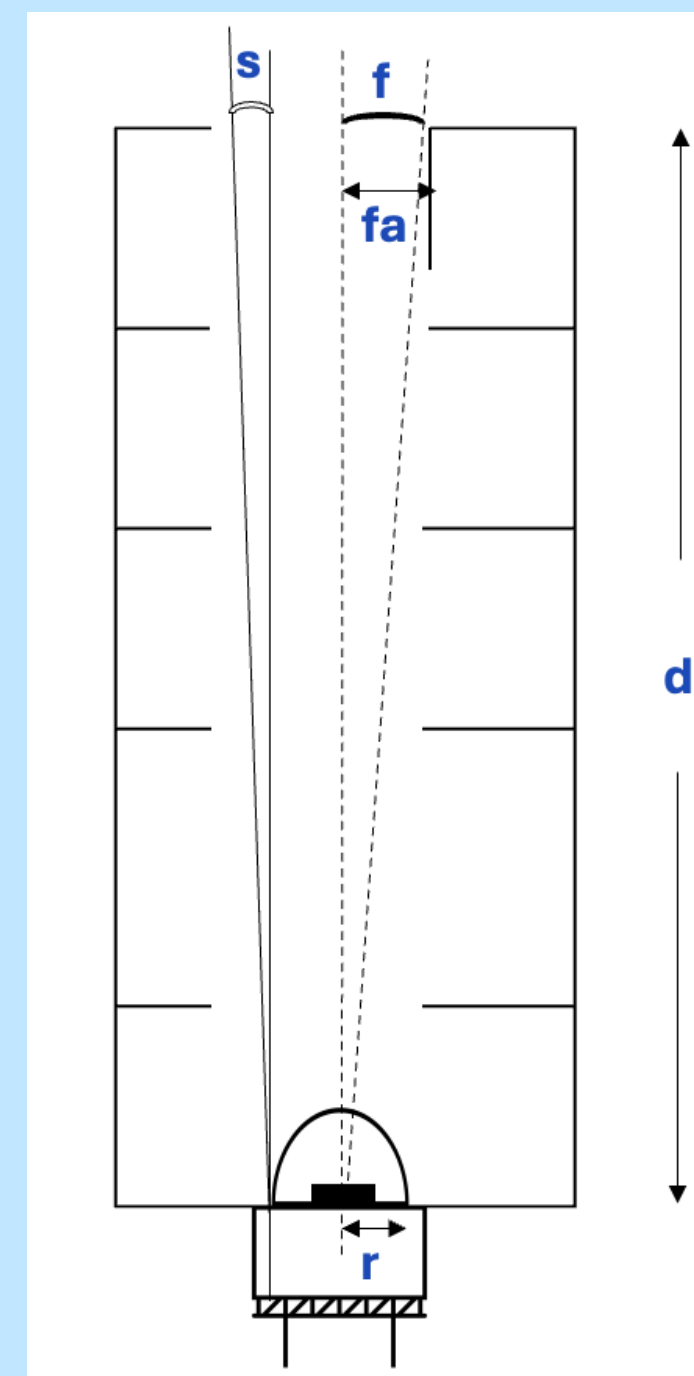


Fig. 1. Schematic illustration of a collimation tube calibration method

where
s = slope angle
radius
f = FOV radius
fa = aperture radius
d = tube length
r = pyranometer dome radius

c. ASTM E824 Standard Test Method for Transfer of Calibration From Reference to Field Radiometers

- ❖ This standard specifies the procedures for transferring the calibration from reference radiometers to field radiometers, applicable to both pyranometers and filtered radiometers.
- ❖ The standard includes several updates, such as the clarification of calibration methods and traceability chains for both types of radiometers. Pyranometers are referenced to the World Radiometric Reference (WRR), whereas filtered radiometers connect to the National Metrology Institute (NMI).
- ❖ A significant enhancement in this revised standard is the introduction of a spectral mismatch correction for filtered radiometers, particularly for UV-A and UV-B radiometers.
 - This correction applies under two conditions:
 - When there's a difference between the spectral sensitivity of the UV radiometer and the spectral distribution of the radiation source used during calibration, such as solar radiation or an artificial light source.
 - A spectral mismatch arises when the test and reference UV radiometers are different models and types, leading to variations in their spectral responses that require correction.

$$\Phi_{UVB} = \left[\frac{\int_{280}^{320} S^{UVB}(\lambda) \cdot E^{SUN}(\lambda) d\lambda}{\int_{280}^{320} E^{SUN}(\lambda) d\lambda} \cdot \frac{\int_{280}^{320} E^{LAMP}(\lambda) d\lambda}{\int_{280}^{320} S^{UVB}(\lambda) \cdot E^{LAMP}(\lambda) d\lambda} \right]$$

where $S^{UVB}(\lambda)$ is the normalized spectral response function for the UV-B (or UV-A) radiometers; $E^{sun}(\lambda)$ is the spectral irradiance for the sun (or, if not the sun, the source under which the radiometers were originally calibrated); and $E^{lamp}(\lambda)$ is for the lamp, or the source of ultraviolet radiation, for which the UV-A and UV-B radiometers are being corrected to measure its irradiance.

b. ISO 9059: Solar energy — Calibration of pyrhemimeters by comparison to a reference pyrhemimeter

- ❖ The standard has been updated to reflect the latest advancements in knowledge and technology. In line with the changes made to ISO 9846, the terminology and methods for quantifying uncertainty have been aligned with new standards in the field of radiometry, such as ISO 9060, ISO 9847, and ISO 9488.
- ❖ Additionally, the standard features enhanced mathematical treatments for both indoor and outdoor calibration techniques.
- ❖ Indoor calibration, a new feature compared to the previous edition, involves a controlled environment using an artificial light source, while outdoor calibration depends on natural sunlight.
- ❖ Outdoor calibration is generally preferred due to the specific application of pyrhemimeters, Indoor calibration offers practical benefits, including controlled conditions, repeatable results, and year-round availability.
- ❖ The standard recommends to complete the calibration over two or more days to obtain enough samples and to cover a greater range of environmental and atmospheric conditions. If the data are taken over less than two days, justification is needed. Figure 2 shows example checks that can be done by looking at multiple calibration events.

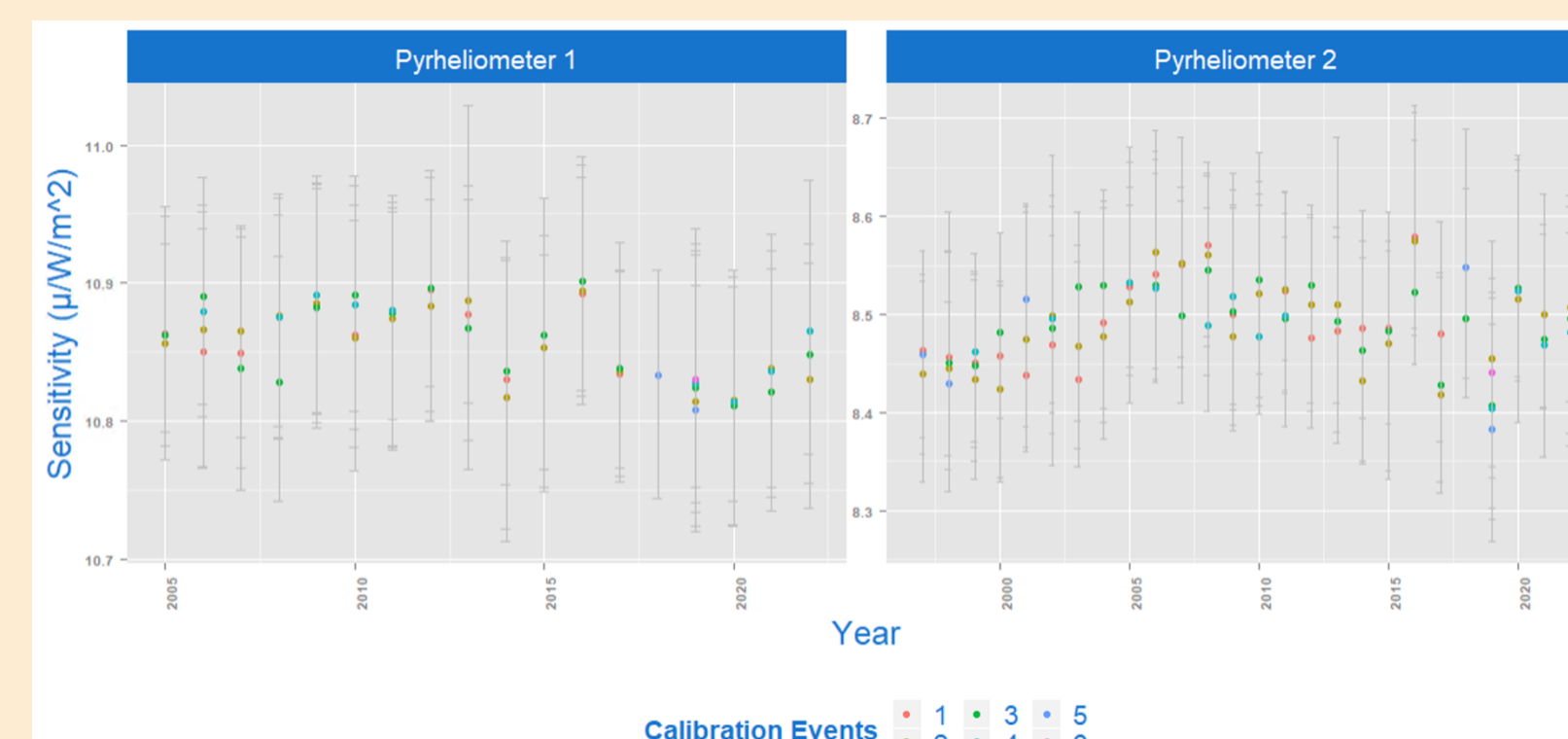


Fig. 2. Example of sensitivity and associated uncertainty values depicted by uncertainty error bars for two pyrhemimeters for multiple calibration events in a single calendar year over many years

Summary

- ❖ These standards are some of the many standards that assist in ensuring uniformity of radiometric data across regions and institutions.
- ❖ They provide reliability, which guarantees accurate calibrations and measurements for research and applications such as solar energy systems, forecasting, climate research, and weathering and durability.
- ❖ By defining procedures for radiometer calibration, uncertainty evaluation, and data quality control, these international standards play a pivotal role in advancing these technologies and assist in moving toward a sustainable future.