OWNER'S MANUAL

PYRANOMETER

Model JSP-110 and JSP-230

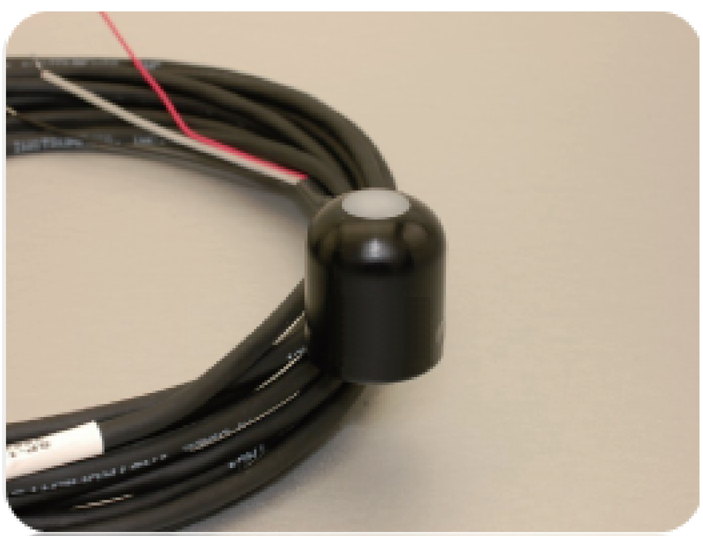


TABLE OF CONTENTS

DECLARATION OF CONFORMITY

CE and ROHS Certificate of Compliance

Declare under our sole responsibility that the products:

Models:JSP-110, JSP-230
Type: Pyranometer

are in conformity with the following standards and relevant EC directives:

Emissions: EN 61326-1:2013
Immunity: EN 61326-1:2013
Safety: EN 61010-1:2010

EU directive 2004/108/EC, EMC
EU directive 2002/95/EC, RoHS (Restriction of Hazardous Substances)
EU directive 2011/65/EU, RoHS2

Please be advised that based on the information available to us from our raw material suppliers, the products manufactured by us do not contain, as intentional additives, any of the restricted materials including cadmium, hexavalent chromium, lead, mercury, polybrominated biphenyls (PBB), polybrominated diphenyls (PBDE).

Further note that does not specifically run any analysis on our raw materials or end products for the presence of these substances, but rely on the information provided to us by our material suppliers.

INTRODUCTION

Solar radiation at Earth's surface is typically defined as total radiation across a wavelength range of 280 to 4000 nm (shortwave radiation). Total solar radiation, direct beam and diffuse, incident on a horizontal surface is defined as global shortwave radiation, or shortwave irradiance (incident radiant flux), and is expressed in Watts per square meter (W m^{-2}, equal to Joules per second per square meter).

Pyranometers are sensors that measure global shortwave radiation. JSP series pyranometers are silicon-cell pyranometers, and are only sensitive to a portion of the solar spectrum, approximately 350-1100 nm (approximately 80 % of total shortwave radiation is within this range). However, silicon-cell pyranometers are calibrated to estimate total shortwave radiation across the entire solar spectrum. Silicon-cell pyranometer specifications compare favorably to specifications for World Meteorological Organization (WMO) moderate and good quality classifications and specifications for International Organization of Standardization(ISO)second class and first class classifications, but because of limited spectral sensitivity, they do not meet the spectral specification necessary for WMO or ISO certification.

Typical applications of silicon-cell pyranometers include incoming shortwave radiation measurement in agricultural, ecological, and hydrological weather networks, and solar panel arrays.

JSP series pyranometers consist of a cast acrylic diffuser (filter), photodiode, and signal processing circuitry mounted in an anodized aluminum housing, and a cable to connect the sensor to a measurement device. Sensors are potted solid with no internal air space and are designed for continuous total shortwave radiation measurement on a planar surface in outdoor environments. JSP series sensors output an analog voltage that is directly proportional to total shortwave radiation from the sun. The voltage signal from the sensor is directly proportional to radiation incident on a planar surface (does not have to be horizontal), where the radiation emanates from all angles of a hemisphere.

SENSOR MODELS

JSP series pyranometer models covered in this manual are un-amplified versions that provide a voltage output; models JSP-110 and JSP-230. Amplified models, which provide larger voltage signals, and models that provide a current output, 4-20 milliamps, are also available; see manuals for JSP-212 and JSP-215 pyranometers or JSP-214 pyranometers.

Sensor model number, serial number, production date, and calibration factor are located near the pigtail leads on the sensor cable.

SPECIFICATIONS

Power Supply: JSP-230 integrated heaters: 12 VDC with a nominal current draw of 15 mA

Sensitivity: 0.20 mV per W m^{-2}

Calibration Factor: 5.0 W m^{-2} per mV (reciprocal of sensitivity)

Calibration Uncertainty: ± 5 % (see Calibration Traceability below)

Measurement Repeatability: < 1 %

Non-stability (Long-term Drift): < 2 % per year

Non-linearity: < 1 % (up to 1750 W m^{-2})

Response Time: < 1 ms

Field of View: 180°

Spectral Range: 360 nm to 1120 nm (wavelengths where response is 10 % of maximum; see Spectral Response below)

Directional (Cosine) Response: ± 5 % at 75° zenith angle (see Cosine Response below)

Temperature Response: -0.04 ± 0.04 % per C (see Temperature Response below)

Operating Environment: -40 to 70 C
0 to 100 % relative humidity
Can be submerged in water up to depths of 30 m

Dimensions: 2.40 cm diameter and 2.75 cm height

Mass: 90 g (with 5 m of lead wire)

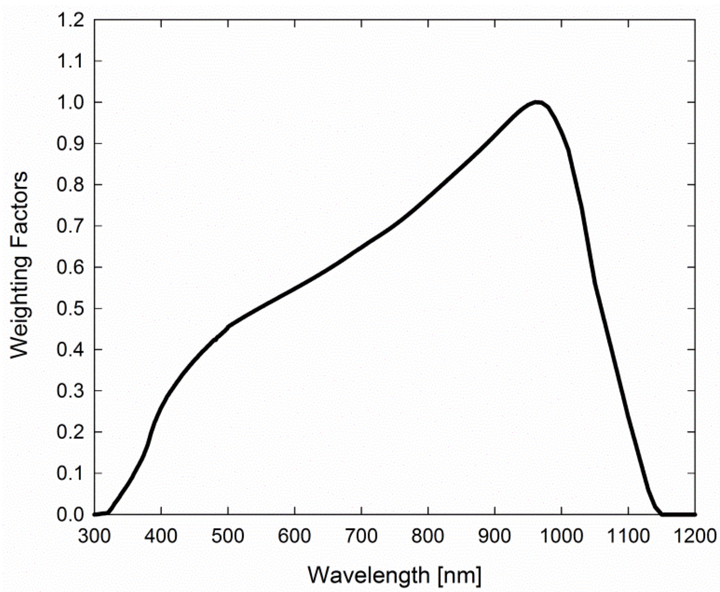
Cable: 5 m of shielded, twisted-pair wire.
Additional cable available in multiples of 5 m
Santoprene rubber jacket (high water resistance, high UV stability, flexibility in cold conditions)
Pigtail lead wires

Calibration Traceability:

JSP series pyranometers are calibrated through side-by-side comparison to the mean of four model JSP-110 transfer standard pyranometers (shortwave radiation reference) under high intensity discharge metal halide lamps. The transfer standard pyranometers are calibrated through side-by-side comparison to the mean of at least two ISO-classified reference pyranometers under sunlight (clear sky conditions) in Logan, Utah.Each of four ISO-classified reference pyranometers are recalibrated on an alternating year schedule (two instruments each year) at the National Rene wable Energy Laboratory

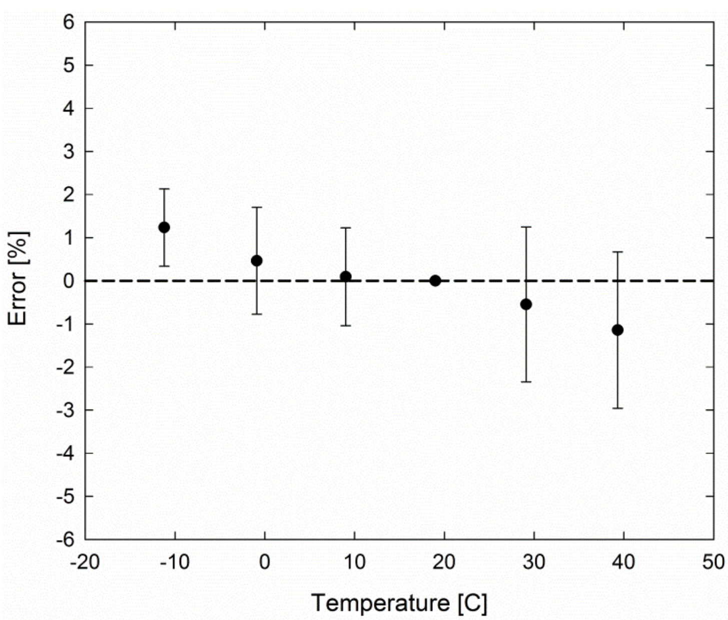
(NREL) in Golden, Colorado. NREL reference standards are calibrated to the World Radiometric Reference (WRR) in Davos, Switzerland.

Spectral Response:



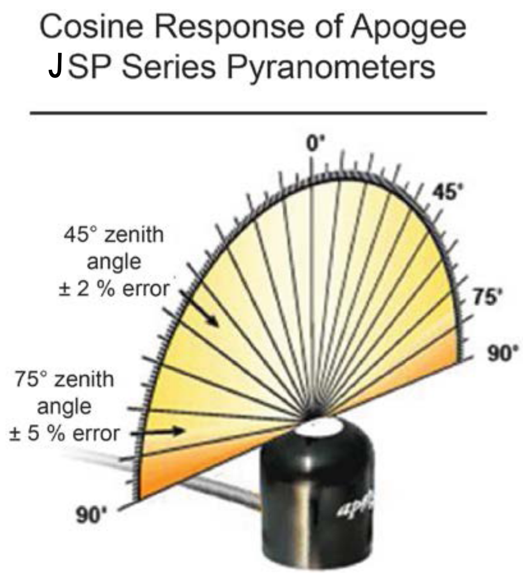
Spectral response estimate of silicon-cell pyranometers. Spectral response was estimated by multiplying the spectral response of the photodiode, diffuser, and adhesive. Spectral response measurements of diffuser and adhesive were made with a spectrometer, and spectral response data for the photodiode were obtained from the manufacturer.

Temperature response:

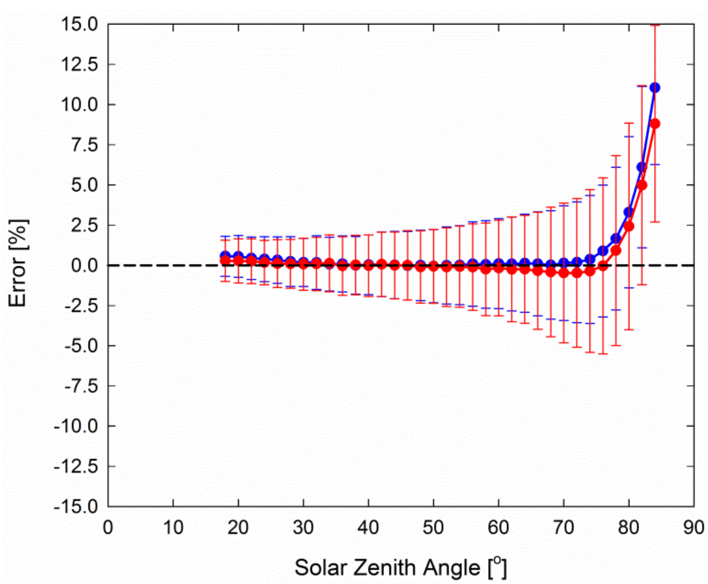


Mean temperature response of ten silicon-cell pyranometers (*errors bars represent two standard deviations above and below mean*). Temperature response measurements were made at 10 C intervals across a temperature range of approximately -10 to 40 C in a temperature controlled chamber under a fixed, broad spectrum, electric lamp. At each temperature set point, a spectroradiometer was used to measure light intensity from the lamp and all pyranometers were compared to the spectroradiometer. The spectroradiometer was mounted external to the temperature control chamber and remained at room temperature during the experiment.

Cosine Response:



Directional, or cosine, response is defined as the measurement error at a specific angle of radiation incidence. Error for silicon-cell pyranometers is approximately ± 2 % and ± 5 % at solar zenith angles of 45° and 75°, respectively.



Mean cosine response of eleven silicon-cell pyranometers (*error bars represent two standard deviations above and below mean*). Cosine response measurements were made during broadband outdoor radiometer calibrations (BORCAL) performed during two different years at the National Renewable Energy Laboratory (NREL) in Golden, Colorado. Cosine response was calculated as the relative difference of pyranometer sensitivity at each solar zenith angle to sensitivity at 45° solar zenith angle. The blue symbols are AM measurements, the red symbols are PM measurements.

DEPLOYMENT AND INSTALLATION

Mount the sensor to a solid surface with the nylon mounting screw provided. To accurately measure total shortwave radiation incident on a horizontal surface, the sensor must be level. An model AL-100 leveling plate is recommended for this purpose. To facilitate mounting on a cross arm, model AM-110 mounting bracket is recommended.

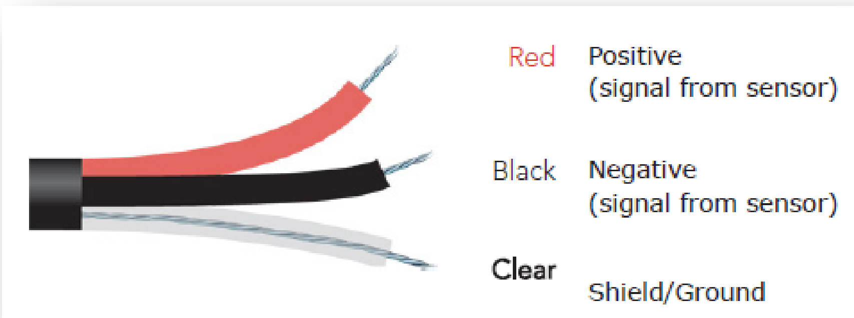
To minimize azimuth error, the sensor should be mounted with the cable pointing toward true north in the northern hemisphere or true south in the southern hemisphere. Azimuth error is typically less than 1 %, but it is easy to minimize by proper cable orientation.

In addition to orienting the cable to point toward the nearest pole, the sensor should also be mounted such that obstructions (e.g., weather station tripod/tower or other instrumentation) do not shade the sensor. **Once mounted, the green cap should be removed from the sensor.** The green cap can be used as a protective covering for the sensor when it is not in use.

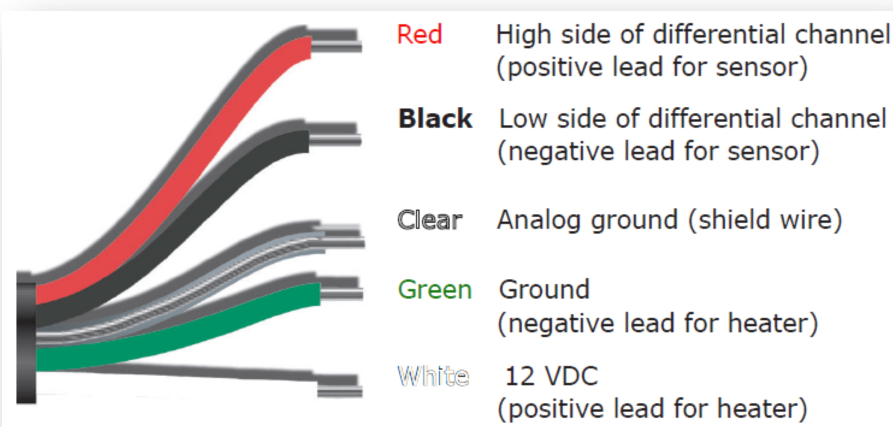
OPERATION AND MEASUREMENT

Connect the sensor to a measurement device (meter, datalogger, controller) capable of measuring and displaying or recording a millivolt (mV) signal (an input measurement range of approximately 0-250 mV is required to cover the entire range of total shortwave radiation from the sun). In order to maximize measurement resolution and signal-to-noise ratio, the input range of the measurement device should closely match the output range of the pyranometer.

JSP-110: The sensor is self-powered and applying voltage will damage the sensor.



JSP-230: Only apply voltage to the integrated heaters. The sensor is self-powered and applying voltage will damage the sensor.



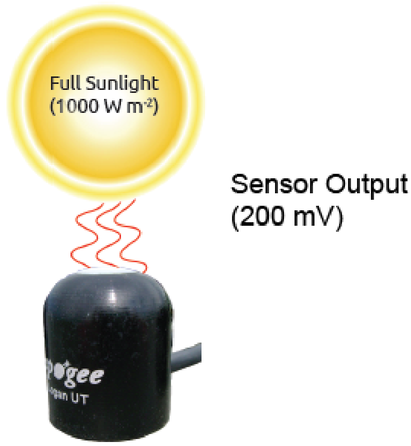
All un-amplified pyranometer models have a standard calibration factor of exactly:

5.0 W m^{-2} per mV

Multiply this calibration factor by the measured mV signal to convert sensor output to shortwave radiation in units of W m^{-2}:

Calibration Factor (5.0 W m^{-2} per mV) * Sensor Output Signal (mV) = Total Shortwave Radiation (W m^{-2})

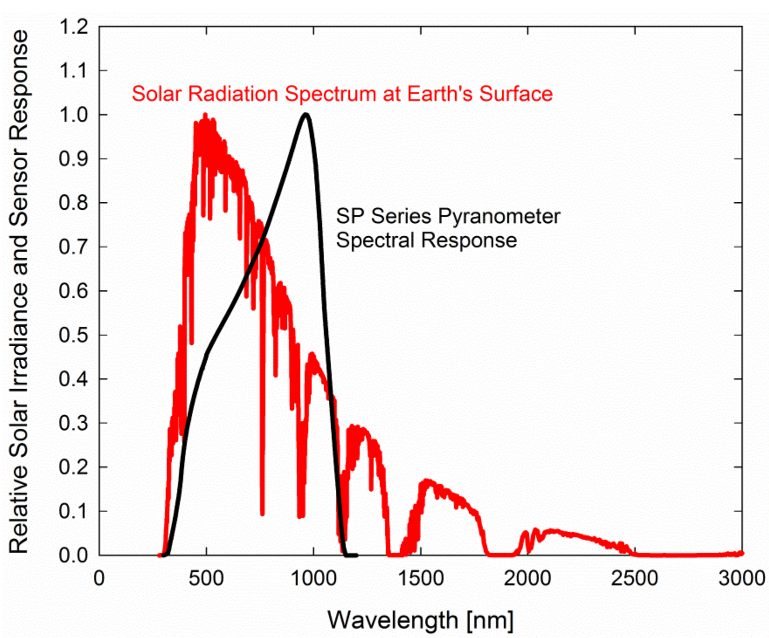
5.0 * 200 = 1000



Example of total shortwave radiation measurement with an JSP-110 pyranometer. Full sunlight yields total shortwave radiation on a horizontal plane at the Earth's surface of approximately 1000 W m^{-2}. This yields an output signal of 200 mV. The signal is converted to shortwave radiation by multiplying by the calibration factor of 5.0 W m^{-2} per mV.

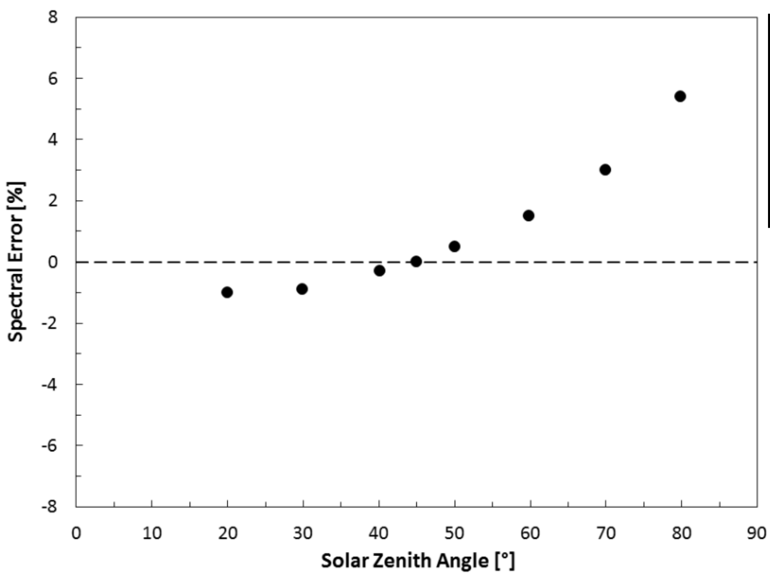
Spectral Errors for Measurements with Silicon-cell Pyranometers:

JSP series pyranometers are calibrated under electric lamps in a calibration laboratory. The calibration procedure simulates calibration under clear sky conditions at a solar zenith angle of approximately 45°. However, due to the limited spectral sensitivity of silicon-cell pyranometers compared to the solar radiation spectrum (see graph below), spectral errors occur when measurements are made in conditions that differ from conditions the sensor was calibrated under (e.g., the solar spectrum differs in clear sky and cloudy conditions, thus measurements in cloudy conditions result in spectral error because sensors are calibrated in clear sky conditions).

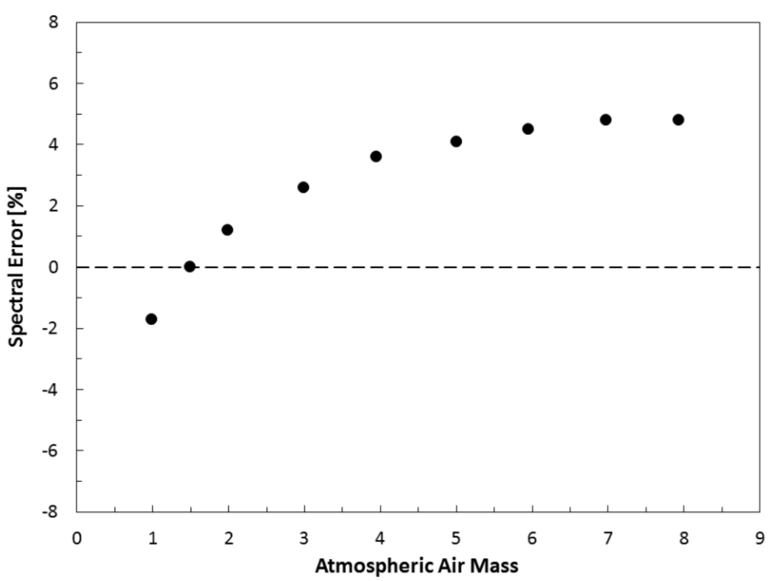


Spectral response of JSP series pyranometers compared to solar radiation spectrum at Earth's surface. Silicon cell pyranometers, such as JSP series, are only sensitive to the wavelength range of approximately 350-1100 nm, and are not equally sensitive to all wavelengths within this range. As a result, when the spectral content of solar radiation is significantly different than the spectrum that silicon-cell pyranometers were calibrated to, spectral errors result.

Silicon-cell pyranometers can still be used to measure shortwave radiation in conditions other than clear sky or from radiation sources other than incoming sunlight, but spectral errors occur when measuring radiation with silicon-cell pyranometers in these conditions. The graphs below show spectral error estimates for silicon-cell pyranometers at varying solar zenith angles and varying atmospheric air mass. The diffuser is optimized to minimize directional errors, thus the cosine response graph in the Specifications section shows the actual directional errors in practice (which includes contributions from the spectral shift that occurs as solar zenith angle and atmospheric air mass change with time of day and time of year)heT table below provides spectral error estimates for shortwave radiation measurements from shortwave radiation sources other than clear sky solar radiation.



Spectral error for JSP series pyranometers as a function of solar zenith angle, assuming calibration at a zenith angle of 45°.



Spectral error for JSP series pyranometers as a function of atmospheric air mass, assuming calibration at an air mass of 1.5.

Spectral Errors for Shortwave Radiation Measurements with JSP Series Pyranometers

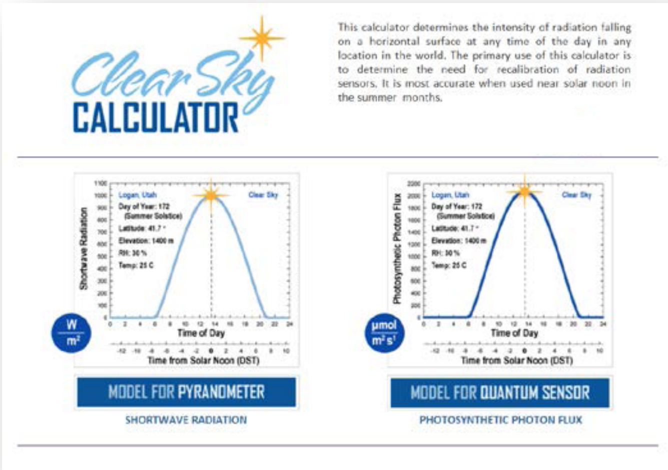
Radiation Source (Error Calculated Relative to Sun, Clear Sky)	Error [%]
Sun (Clear Sky)	0.0
Sun (Cloudy Sky)	9.6
Reflected from Grass Canopy	14.6
Reflected from Deciduous Canopy	16.0
Reflected from Conifer Canopy	19.2
Reflected from Agricultural Soil	-12.1
Reflected from Forest Soil	-4.1
Reflected from Desert Soil	3.0
Reflected from Water	6.6
Reflected from Ice	0.3
Reflected from Snow	13.7

MAINTENANCE AND RECALIBRATION

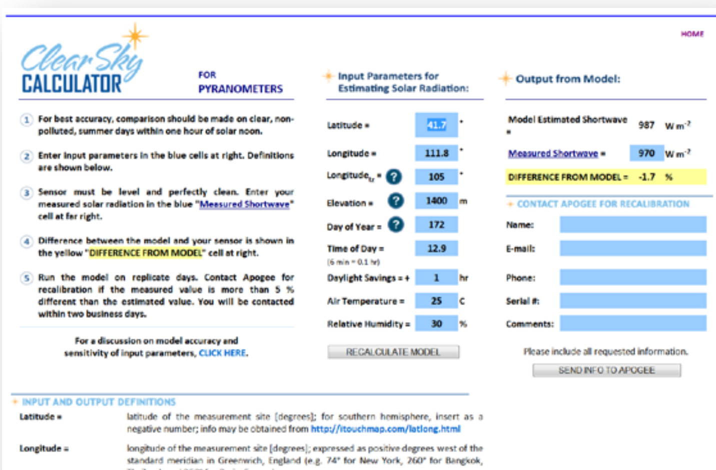
Moisture or debris on the diffuser is a common cause of low readings. The sensor has a domed diffuser and housing for improved self-cleaning from rainfall, but materials can accumulate on the diffuser (e.g., dust during periods of low rainfall, salt deposits from evaporation of sea spray or sprinkler irrigation water) and partially block the optical path. Dust or organic deposits are best removed using water or window cleaner and a soft cloth or cotton swab. Salt deposits should be dissolved with vinegar and removed with a soft cloth or cotton swab. **Never use an abrasive material or cleaner on the diffuser.**

The Clear Sky Calculator (www.clearskycalculator.com) can be used to determine the need for pyranometer recalibration. It determines total shortwave radiation incident on a horizontal surface at any time of day at any location in the world. It is most accurate when used near solar noon in spring and summer months, where accuracy over multiple clear and unpolluted days is estimated to be ± 4 % in all climates and locations around the world. For best accuracy, the sky must be completely clear, as reflected radiation from clouds causes incoming radiation to increase above the value predicted by the clear sky calculator. Measured values of total shortwave radiation can exceed values predicted by the Clear Sky Calculator due to reflection from thin, high clouds and edges of clouds, which enhances incoming shortwave radiation. The influence of high clouds typically shows up as spikes above clear sky values, not a constant offset greater than clear sky values.

To determine recalibration need, input site conditions into the calculator and compare total shortwave radiation measurements to calculated values for a clear sky. If sensor shortwave radiation measurements over multiple days near solar noon are consistently different than calculated values (by more than 6 %), the sensor should be cleaned and re-leveled.



Homepage of the Clear Sky Calculator. Two calculators are available: One for pyranometers (total shortwave radiation) and one for quantum sensors (photosynthetic photon flux).



Clear Sky Calculator for pyranometers. Site data are input in blue cells in middle of page and an estimate of total shortwave radiation is returned on right-hand side of page.

TROUBLESHOOTING AND CUSTOMER SUPPORT

Independent Verification of Functionality:

Models JSP-110 and JSP-230 pyranometers are self-powered devices and output a voltage signal proportional to incident shortwave radiation. A quick and easy check of sensor functionality can be determined using a voltmeter with millivolt (mV) resolution. Connect the positive lead the wire from voltmeter to the red wire from the sensor and the negative (or common) lead wire from the voltmeter to the black wire from the sensor. Direct the sensor diffuser toward a light source and verify the sensor provides a signal. Increase and decrease the distance from the sensor head to the light source to verify that the signal changes proportionally (decreasing signal with increasing distance and increasing signal with decreasing distance). Blocking all radiation from the sensor should force the sensor signal to zero.

The heaters inside model JSP-230 are designed to mitigate effects from snow, frost, and dew by warming the sensor body temperature approximately 3 C above ambient air temperature, while under conditions of no solar loading or radiant heating. A quick and easy check of heater functionality can be accomplished with an ohmmeter. Connect the lead wires of the ohmmeter to the white and green wires from the sensor. The resistance should read approximately 780 Ω ± 1%.

Compatible Measurement Devices (Dataloggers/Controllers/Meters):

Models JSP-110 and JSP-230 pyranometers are calibrated with a standard calibration factor of 5.0 $W\ m^{-2}$ per mV, yielding a sensitivity of 0.2 mV per $W\ m^{-2}$. Thus, a compatible measurement device (e.g., datalogger or controller) should have resolution of at least 0.2 mV, in order to provide shortwave radiation resolution of 1 $W\ m^{-2}$.

Effect of Cable Length:

When the sensor is connected to a measurement device with high input impedance, sensor output signals are not changed by shortening the cable or splicing on additional cable in the field. Tests have shown that if the input impedance of the measurements device is 1-megaohm or higher then there is negligible effect on the pyranometer calibration, even after adding up to 100 m of cable. Model JSP series pyranometers use shielded, twisted pair cable, which minimizes electromagnetic interference. This is particularly important for long lead lengths in electromagnetically noisy environments.

WARRANTY POLICY

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What is Covered

All products manufactured are warranted to be free from defects in materials and craftsmanship for a period of four (4) years from the date of shipment from our factory. To be considered for warranty coverage an item must be evaluated either at our factory or by an authorized distributor.

What is Not Covered

The customer is responsible for all costs associated with the removal, reinstallation and shipping of suspected warranty items to our factory.

The warranty does not cover equipment that has been damaged due to the following conditions:

1. Improper installation or abuse

2. Operation of the instrument outside of its specified operating range

3. Natural occurrences such as lightning, fire, etc.

4. Unauthorized modification

5. Improper or unauthorized repair

Please note that nominal accuracy drift is normal over time. Routine recalibration of your sensor/meter is considered part of proper maintenance and is not covered under warranty.

Who is Covered

This warranty covers the original purchaser of the product or other party who may own it during the warranty period.

What We Will Do

At no charge we will:

1. Either repair or replace (at our discretion) the item under warranty.

2. Ship the item back to the customer by the carrier of our choice.

Different or expedited shipping methods will be at the customer’s expense.