OWNER'S MANUAL

PYRANOMETER

Models JSP-212 and JSP-215

(including SS models)

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CERTIFICATE OF COMPLIANCE

EU Declaration of Conformity

for the following product(s):

Models: JSP-212, JSP-215
Type: Pyranometer

The object of the declaration described above is in conformity with the relevant Union harmonization legislation:

2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Hazardous Substances (RoHS 2) Directive

Standards referenced during compliance assessment:

EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use – EMC requirements
EN 50581:2012	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

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 Apogee Instruments 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. Apogee 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.

Apogee Instruments 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

This manual covers model JSP-212 and JSP-215 pyranometer sensors that provide a voltage output. Additional models are covered in their respective manuals.

Model	Signal
JSP-212	**0-2.5 V**
JSP-215	**0-5 V**
JSP-110	Self-powered
JSP-214	4-20 mA
JSP-230	Self-powered
JSP-420	USB
JSP-421	SDI-12
JSP-422	Modbus

Sensor model number and serial number are located near the pigtail leads on the sensor cable. If you need the manufacturing date of your sensor, please contact Apogee Instruments with the serial number of your sensor.

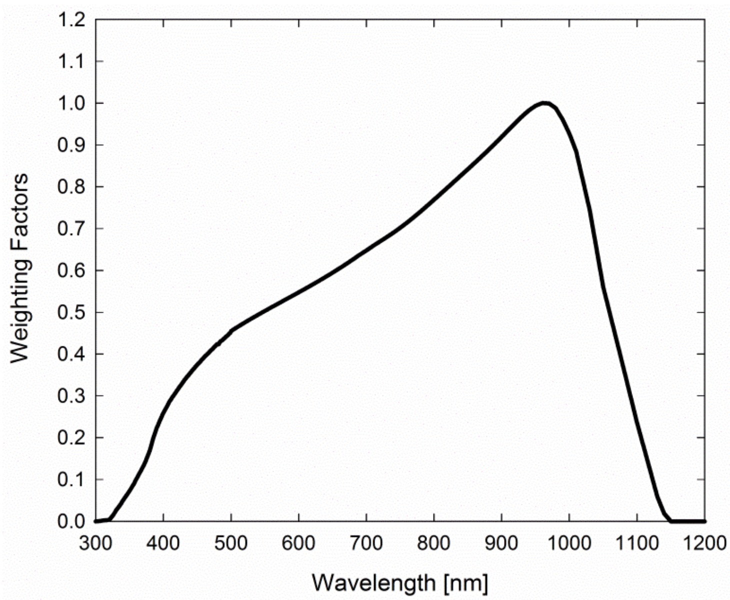
SPECIFICATIONS

	JSP-212	JSP-215
Power Supply	3.3-24 V DC with a nominal current draw of 300 µA	5.5-24 V DC** with a nominal current draw of 300 µA **Sensors with a serial number smaller than 4502 should not be powered with more than 5 V DC
Sensitivity	2.0 mV per W m^{-2}	4.0 mV per W m^{-2}
Calibration Factor (Reciprocal of Sensitivity)	0.5 W m^{-2} per mV	0.25 W m^{-2} per mV
Calibration Uncertainty	± 5 % (see Calibration Traceability below)	
Calibrated Output Range	0 to 2.5 V	0 to 5.0 V
Measurement Repeatability	Less than 1 %	
Long-term Drift (Non-stability)	Less than 2 % per year	
Non-linearity	Less than 1 % (up to 1250 W m^{-2}; maximum radiation measurement is 1250 W m^{-2})	
Response Time	Less than 1 ms	
Field of View	180°	
Spectral Range	360 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	24 mm diameter; 28 mm height	
Mass	90 g (with 5m of lead wire)	
Cable	5 m of two conductor, 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

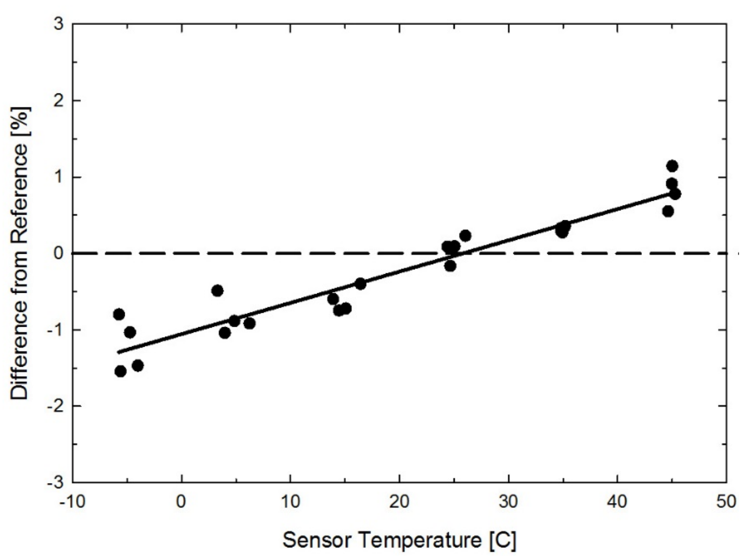
Apogee Instruments JSP series pyranometers are calibrated through side-by-side comparison to the mean of four Apogee model JSP-110 transfer standard pyranometers (shortwave radiation reference) under high intensity discharge metal halide lamps. The transfer standard pyranometers are calibrated through 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 Renewable Energy Laboratory (NREL) in Golden, Colorado. NREL reference standards are calibrated to the World Radiometric Reference (WRR) in Davos, Switzerland.

Spectral Response



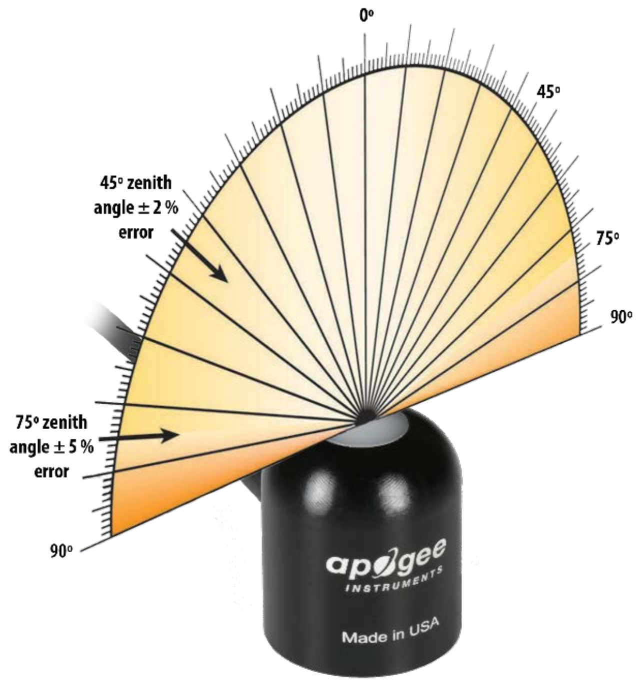
Spectral response estimate of Apogee silicon-cell pyranometers. Spectral response was estimated by multiplying the spectral response of the photodiode, diffuser, and adhesive. Spectral response measurements of diffuser and adhesive were made with a spectrometer, and spectral response data for the photodiode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

Temperature Response

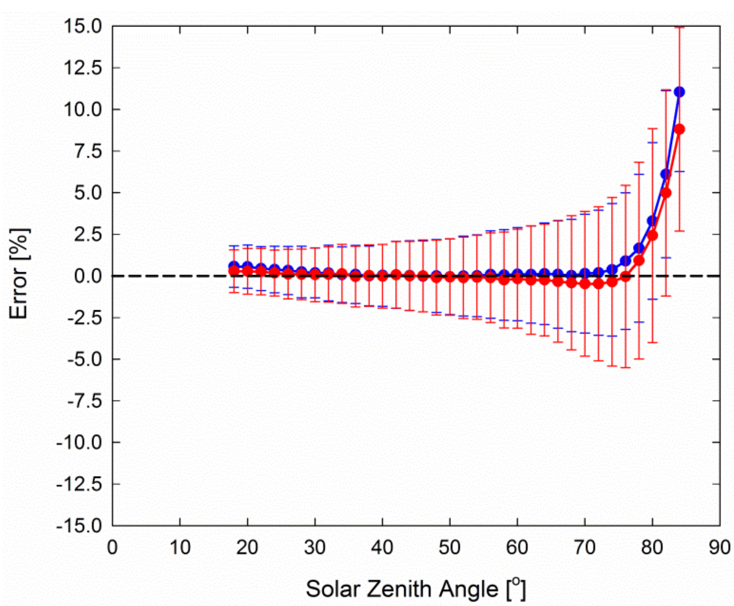


Mean temperature response of four Apogee silicon-cell pyranometers. Temperature response measurements were made at approximately 10 C intervals across a temperature range of approximately -10 to 50 C under sunlight. Each pyranometer had an internal thermistor to measure temperature. At each temperature set point, a reference blackbody pyranometer was used to measure solar intensity.

Cosine Response



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

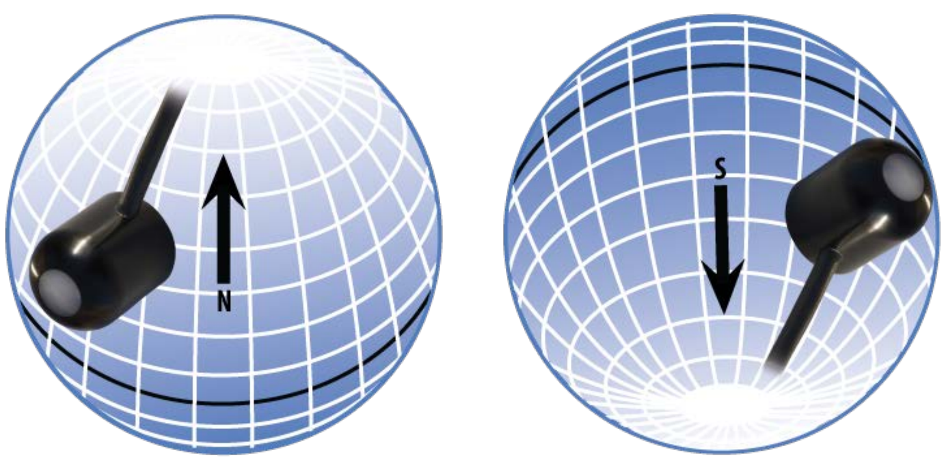


Mean cosine response of eleven Apogee silicon-cell pyranometers (***error bars represent two standard deviations above and below mean***). Cosine response measurements were made during broadband outdoor radiometer calibrations (BORCAL) performed during two different years at the National Renewable Energy 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. The error bars represent two standard deviations from the mean.

DEPLOYMENT AND INSTALLATION

Mount the sensor to a solid surface with the nylon mounting screw provided. To accurately measure PPFD incident on a horizontal surface, the sensor must be level. An Apogee Instruments model AL-100 Leveling Plate is recommended to level the sensor when used on a flat surface or being mounted to surfaces such as wood. To facilitate mounting on a mast or pipe, the Apogee Instruments model AL-120 Solar Mounting Bracket with Leveling Plate 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.

Cable Connectors

Apogee started offering in-line cable connectors on some bare-lead sensors in March 2018 to simplify the process of removing sensors from weather stations for calibration by not requiring the full cable to be uninstalled back to the data logger.

The ruggedized M8 connectors are rated IP67, made of corrosion-resistant marine-grade stainless-steel, and designed for extended use in harsh environmental conditions.

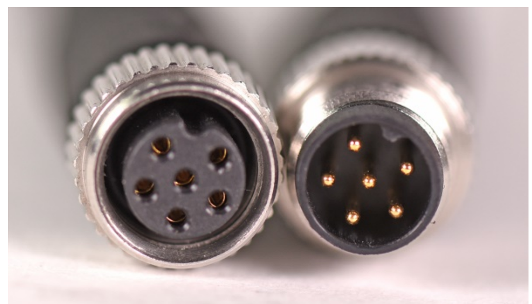
Inline cable connectors are installed 30 cm from the head (pyranometer pictured)

Instructions

Pins and Wiring Colors: All Apogee connectors have six pins, but not all pins are used for every sensor. There may also be unused wire colors inside the cable. To simplify data logger connection, we remove the unused pigtail lead colors at the data logger end of the cable.

If you ever need a replacement cable, please contact us directly to ensure ordering the proper pigtail configuration.

Alignment: When reconnecting your sensor, arrows on the connector jacket and an aligning notch ensure proper orientation.



A reference notch inside the connector ensures proper alignment before tightening.

Disconnection for extended periods: When disconnecting the sensor for an extended period of time from a station, protect the remaining half of the connector still on the station from water and dirt with electrical tape or other method.

When sending sensors in for calibration, only send the short end of the cable and half the connector.

Tightening: Connectors are designed to be firmly finger-tightened only. There is an o-ring inside the connector that can be overly compressed if a wrench is used. Pay attention to thread alignment to avoid cross-threading. When fully tightened, 1-2 threads may still be visible.

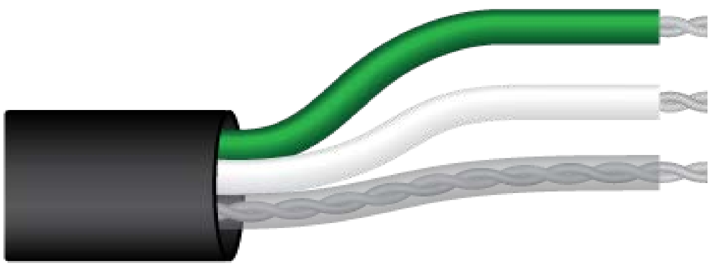
Finger-tighten firmly

OPERATION AND MEASUREMENT

Connect the sensor to a measurement device (meter, datalogger, controller) capable of measuring and displaying or recording a voltage signal (an input measurement range of 0-2.5 V or 0-5 V 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. **DO NOT connect the sensor to a power source greater than 24 VDC.**

VERY IMPORTANT: Apogee changed all wiring colors of our bare-lead sensors in March 2018 in conjunction with the release of inline cable connectors on some sensors. To ensure proper connection to your data device, please note your serial number or if your sensor has a stainless-steel connector 30 cm from the sensor head then use the appropriate wiring configuration below.

Wiring for JSP-212 and JSP-215 with Serial Numbers range 0-9897

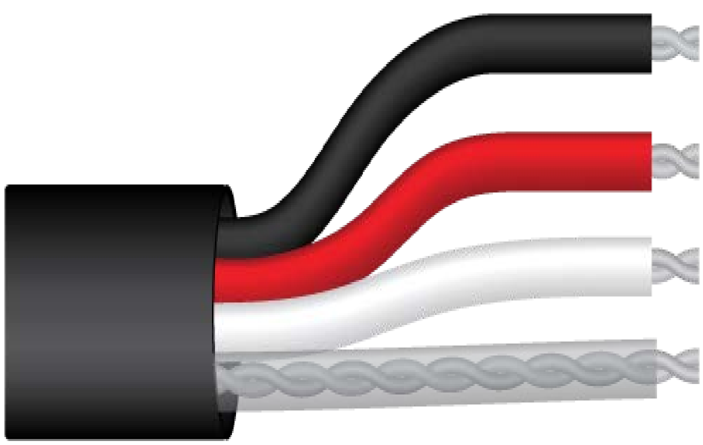


Green: Positive (signal from sensor)

White: Input power

Clear: Ground (from sensor signal and input power)

Wiring for JSP-212 and JSP-215 with Serial Numbers 9898 and above or with a cable connector



Black: Ground (from sensor signal and output power)

Red: Input Power JSP-212 3.3-24 V DC, JSP-215 5.5-24 V DC

White: Positive (signal from sensor)

Clear: Shield/Ground

Sensor Calibration

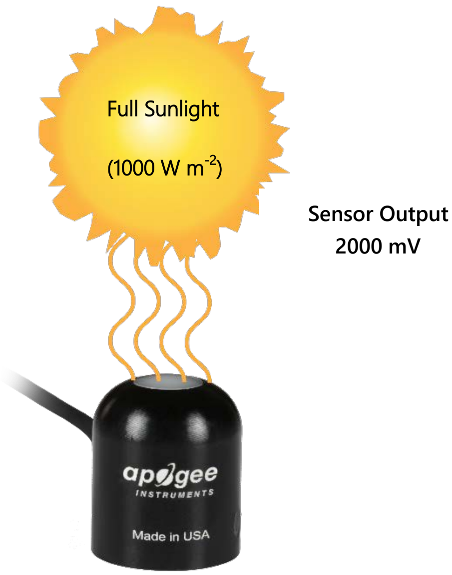
Apogee amplified pyranometer models have a standard calibration factor of exactly:

JSP-212: 0.5 W m^{-2} per mV
JSP-215: 0.25 W m^{-2} per mV

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

Calibration Factor (0.5 W m^{-2} per mV) * Sensor Output Signal (mV) = Shortwave Radiation (W m^{-2})

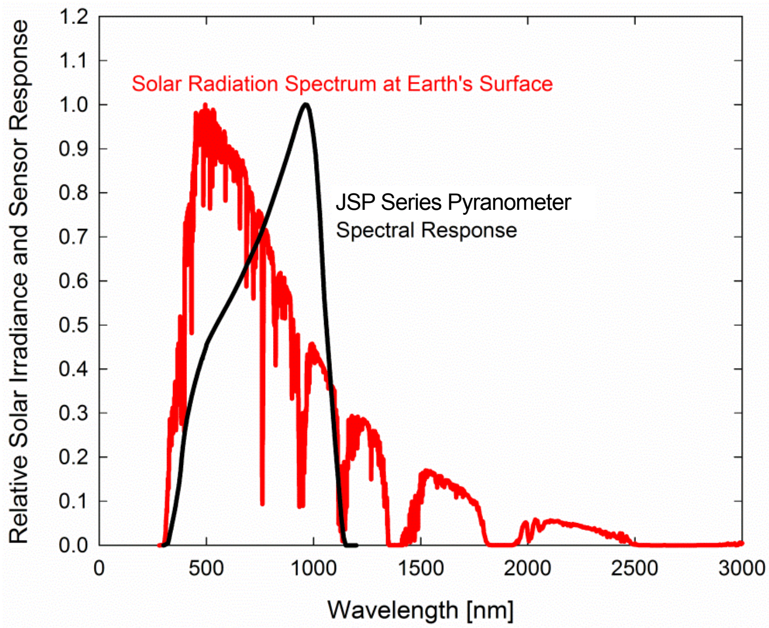
0.5 * 2000 = 1000



Example of total shortwave radiation measurement with an Apogee SP-212 pyranometer. Full sunlight yields total shortwave radiation on a horizontal plane at the Earth's surface of approximately 1000 W m^{-2} s^{-1}. This yields an output signal of 2000 mV. The signal is converted to shortwave radiation by multiplying by the calibration factor of 0.5 W m^{-2} per mV.

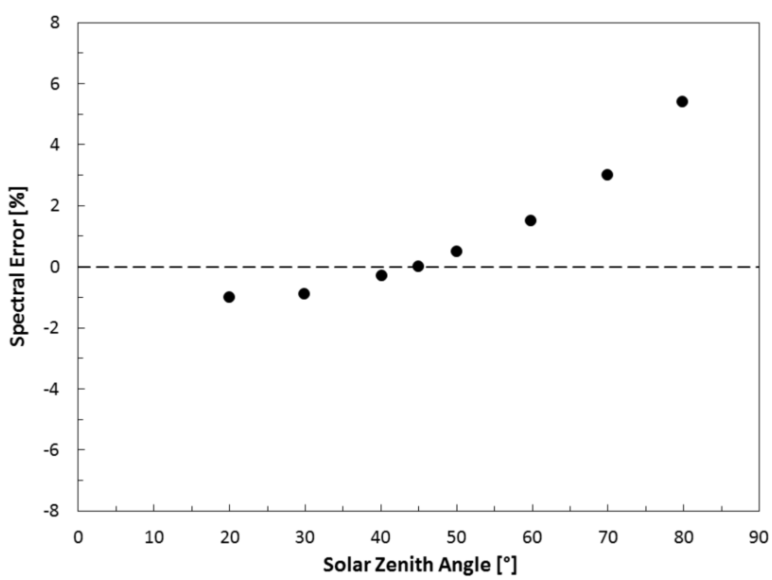
Spectral Errors for Measurements with Silicon-cell Pyranometers

Apogee 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).

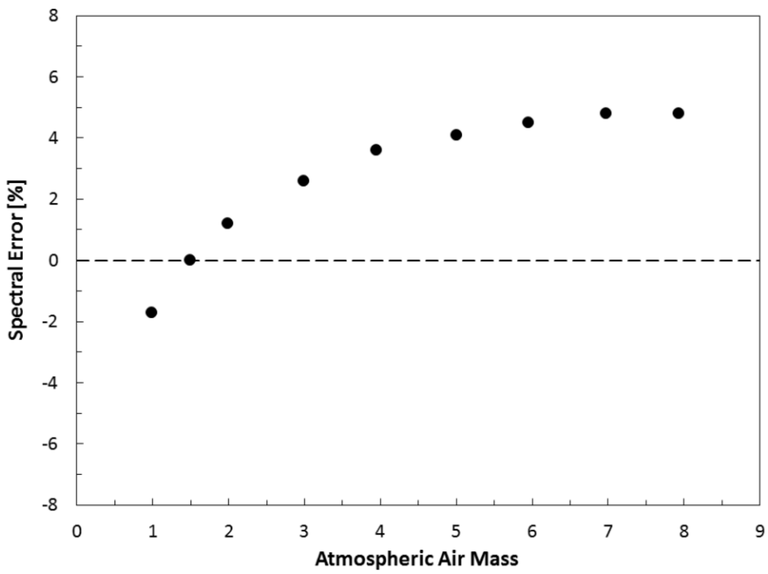


Spectral response of Apogee JSP series pyranometers compared to solar radiation spectrum at Earth's surface. Silicon-cell pyranometers, such as Apogee JSP series, are only sensitive to the wavelength range of approximately 350-1100 nm, and are not equally sensitive to all wavelengths within this range. 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 Apogee 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). The table below provides spectral error estimates for shortwave radiation measurements from shortwave radiation sources other than clear sky solar radiation.



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



Spectral error for Apogee 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 Apogee 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