

APOGEE PYRANOMETERS | Silicon-cell & Thermopile Series

Features

Apogee offers two types of pyranometers; our original silicon-cell models and our new line of thermopile pyranometers, both of which are now **ISO 9060:2018 Class C** rated. **Silicon-cell** solar radiation sensor models are excellent for applications that do not require the higher accuracy and cost of a thermopile pyranometer. They are less expensive and have a faster response time, but have higher errors under cloudy conditions. Our new cost-effective **thermopile pyranometers** features a blackbody thermopile detector that provides a much broader and more uniform spectral response for better performance in all atmospheric conditions that compares favorably to other thermopile pyranometers at a fraction of the cost.

Stable Measurements

Long-term non-stability determined from multiple replicate pyranometers in accelerated aging tests and field conditions is less than 2 % per year.

Unique Design

An accurate, cosine-corrected patented design sheds water and dirt for a self-cleaning performance. A heated option is available with a 0.2 W heater to minimize errors caused by dew, frost, or snow.

Typical Measurement Applications

- Solar panel arrays
- Agricultural, ecological, and hydrological weather networks

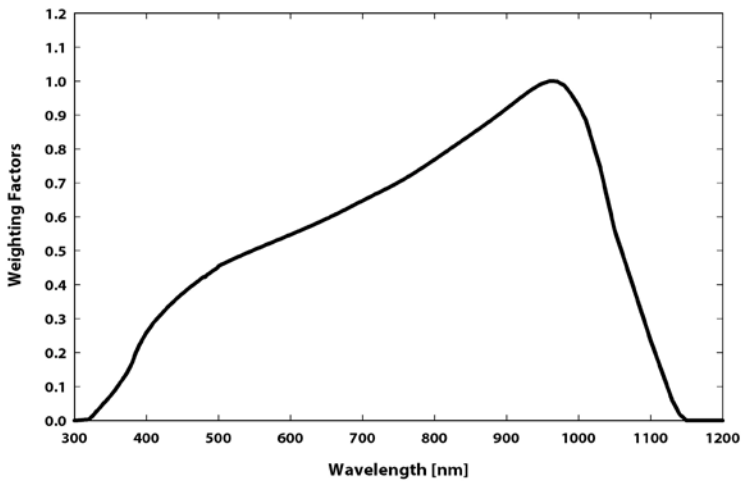
Calibration Traceability

Apogee SP series pyranometers are calibrated through side-by-side comparison to the mean of four transfer standard sensors under a reference lamp. The reference sensors are recalibrated under sunlight in Logan, UT traceable to the National Institute of Standards and Technology (NIST).



SP-230 Heated Silicon-cell Pyranometers

Spectral Response of Silicon-cell Pyranometers



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.



THERMOPILE PYRANOMETERS | SP-510 & SP-610

Output Options

- 0 to 114 mV
- Downward sensor available for measuring shortwave reflectance, or combine with an upward head to measure albedo

Specifications

	SP-510-SS	SP-610-SS
ISO 9060:2018	Class C	N/A
Sensitivity (variable from sensor to sensor, typical values listed)	0.057 mV per W m^{-2}	0.15 mV per W m^{-2}
Calibration Factor (reciprocal of sensitivity) (variable from sensor to sensor, typical values listed)	20 W m^{-2} per mV	6.7 W m^{-2} per mV
Calibration Uncertainty	± 5 %	
Output Range	0 to 114 mV	0 to 300 mV
Measurement Range	0 to 2000 W m^{-2} (net shortwave radiation)	
Measurement Repeatability	Less than 1 %	
Long-term Drift	Less than 2 % per year	
Non-linearity	Less than 1 %	
Detector Response Time	0.5 s	
Field of View	180°	150°
Spectral Range (50 % points)	385 nm to 2105 nm	295 nm to 2685 nm
Directional (Cosine) Response	Less than 30 W m^{-2} at 80° solar zenith	Less than 20 % for angles between 0 and 60°
Temperature Response	Less than 5 % from -15 to 45 C	
Zero Offset A	Less than 5 W m^{-2}; Less than 10 W m^{-2} (heated)	
Zero Offset B	Less than 5 W m^{-2}	
Uncertainty with Daily Total	Less than 5 %	
Operating Environment	-50 to 80 C; 0 to 100% relative humidity	
Heater	780 Ω, 15.4 mA current draw and 185 mW power requirement at 12 V DC	
Dimensions	28.7 mm height, 23.5 mm diameter	
Mass	90 g	100 g
Cable	5 m of four conductor, shielded, twisted-pair wire; additional cable available in multiples of 5 m; TPR jacket (high water resistance, high UV stability, flexibility in cold conditions); pigtail lead wires	
Warranty	4 years against defects in materials and workmanship	



Accurate and stable global shortwave (solar) radiation measurement

SILICON-CELL PYRANOMETERS | SP-100 & SP-200 Series

Output Options

- 0 to 350 mV
- 0 to 5 V
- USB
- Modbus
- 0 to 2.5 V
- 4 to 20 mA
- SDI-12
- or hand-held meter



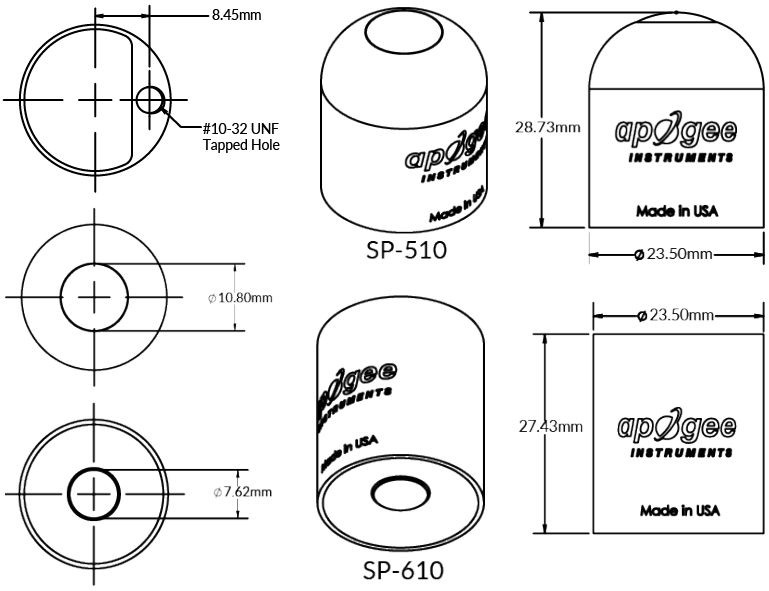
MP-200

Specifications

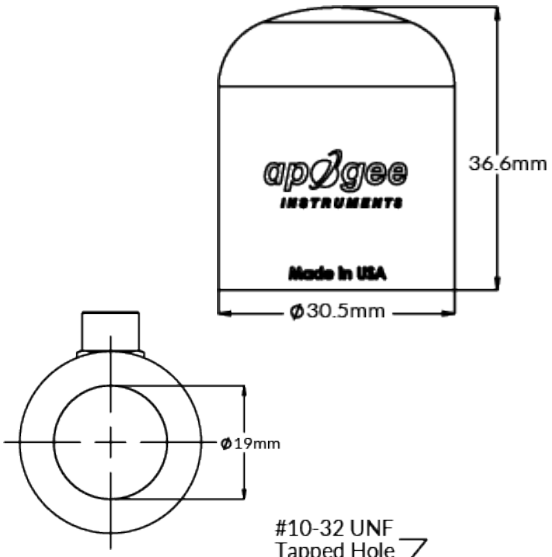
	SP-110-SS	SP-212-SS	SP-214-SS	SP-215-SS	SP-230-SS	SP-420	SP-421-SS	SP-422-SS
ISO 9060:2018	Class C							
Power Supply	Self-powered	3.3 to 24 V DC	7 to 24 V DC	5.5 to 24 V DC	12 V DC for heater	5 V	5.5 T0 24 V DC	
Current Draw	–	10 µA	22 mA maximum, 2 mA quiescent	10 µA	15.4 mA	61 mA when log-ging	0.6 mA (quiescent); 1.3 mA (active)	20 mA maximum
Output (sensitivity)	0.2 mV per W m^{-2}	1.25 mV per W m^{-2}	0.008 mA per W m^{-2}	2.5 mV per W m^{-2}	0.2 mV per W m^{-2}	USB	SDI-12	Modbus
Calibration Factor (recipro-cal of output)	5 W m^{-2} per mV	0.8 W m^{-2} per mV	125 W m^{-2} per mA, 4 mA offset	2.5 W m^{-2} per mV	5 W m^{-2} per mV	Custom for each sensor and stored in firmware		
Calibration Uncertainty	± 5 %							
Measurement Repeatability	Less than 1 %							
Long-term Drift	Less than 2 % per year							
Non-linearity	Less than 1 % up to 2000 W m^{-2}							
Response Time	Less than 1 ms					Software updates every second	Less than 0.6 s	320 ms
Field of View	180°							
Spectral Range	360 to 1120 nm							
Directional (Cosine) Re-sponse	± 5 % at 75° zenith angle							
Temperature Response	0.04 ± 0.04 % per C							
Operating Environment	-40 to 70 C; 0 to 100 % relative humidity; can be submerged in water up to 30 m							
Dimensions	24 mm diameter, 33 mm height	30.5 mm diameter, 37 mm height				24 mm diameter, 33 mm height	30.5 mm diameter, 37 mm height	
Mass (with 5 m of cable)	90 g	140 g				90 g	140 g	
Cable	5 m of shielded, twisted-pair wire; TPR jacket (high water resistance, high UV stability, flexibility in cold conditions); pigtail lead wires							
Warranty	4 years against defects in materials and workmanship							

Dimensions

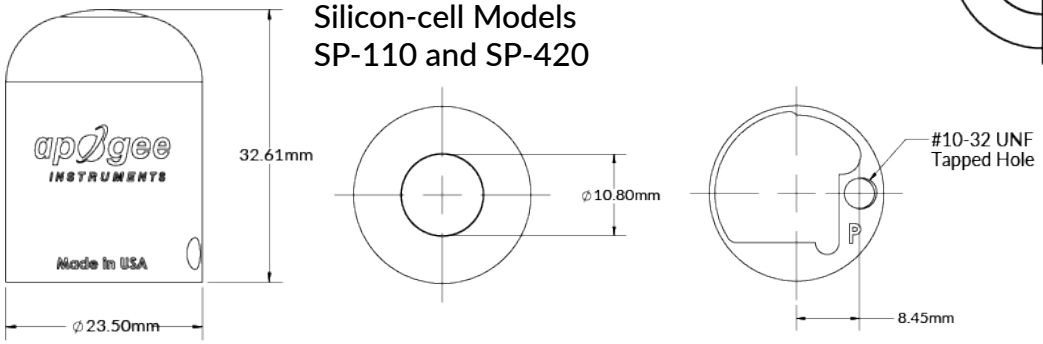
Thermopile Models



All other silicon-cell pyranometer models



Silicon-cell Models SP-110 and SP-420



Digital Models

SP-420 USB

Sensor connects to computers and tablets via USB using ApogeeConnect software for Widows and Mac for data logging, graphs, calibration, real-time PPFD readings, and storing downloadable CSV files for further analysis. Sensor can also store 10,000 measurements internally while connected to a stand-alone 5 V DC USB “always-on” power source.

SP-421 SDI-12

Uses the SDI-12 communication protocol, which is low-power and has the ability to connect multiple sensors to one long bus cable making them ideal for remote locations. Cables only have 3 conductors including a serial data line, a ground, and a 12-volt line. Complex self-calibration algorithms are done in an internal microprocessor making the sensors compatible with a wide variety of data recorders.

SP-422 Modbus

The SP-422 outputs a digital signal using Modbus RTU digital signal over RS-232 or RS-485, based on wiring configuration. Modbus is open protocol and used by many manufacturers in many industries.

Apogee Modbus Sensor Communication
Defaults: Modbus RTU
Slave address: 0x1
Baudrate: 115200
Data bits: 8
Stop bits: 1
Parity: None
Byte order: Big Endian (most significant Byte sent first)
*User configurable values include the baudrate and slave address.