



## Features

Apogee offers **silicon-cell** and **thermopile** pyranometers that are both rated ISO 9060:2018 Class C (fast response). Our popular silicon-cell models are less expensive and have a faster response time, but can have errors under cloudy conditions. Our thermopile pyranometers feature a unique, cost-effective design with an inexpensive diffuser and blackbody thermopile detector that provides a broader and more uniform spectral response for better performance in all atmospheric conditions.

### 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 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 World Radiometric Reference (WRR) in Davos, Switzerland.



SP-522



SP-110

Blackbody accuracy with a cost-effective design

### Output Options

- 0 to 114 mV
- Modbus
- Downward sensor available for measuring shortwave reflectance, or combine with an upward head to measure albedo (see SP-710-SS albedometer package)

SP-522



SP-510



SP-610

### Product Specifications

	SP-510-SS	SP-610-SS	SP-522-SS
ISO 9060:2018	Class C (fast response)	N/A	Class C (fast response)
Sensitivity (variable from sensor to sensor, typical values listed)	0.045 mV per $W\ m^{-2}$	0.035 mV per $W\ m^{-2}$	—
Calibration Factor (reciprocal of sensitivity) (variable from sensor to sensor, typical values listed)	22 $W\ m^{-2}$ per mV	28.5 $W\ m^{-2}$ per mV	—
Input Voltage Requirement	—		5.5 to 24 V
Calibration Uncertainty at 1000 $W\ m^{-2}$	Less than 3 %		
Output Range	0 to 90 mV	0 to 70 mV	Modbus
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		0.5 s (baudrate dependent)
Field of View	180°	150°	180°
Spectral Range (50 % points)	385 nm to 2105 nm	370 nm to 2240 nm	385 nm to 2105 nm
Directional (Cosine) Response	Less than 30 $W\ m^{-2}$ at 80° solar zenith	Less than 20 $W\ m^{-2}$ for angles between 0 and 60°	Less than 30 $W\ m^{-2}$ at 80° solar zenith
Temperature Response	Less than 5 % from -15 to 45 C		
Zero Offset A	Less than 2 $W\ m^{-2}$ ; Less than 10 $W\ m^{-2}$ (heated)	Less than 2 $W\ m^{-2}$ ; Less than 10 $W\ m^{-2}$ (heated)	Less than 2 $W\ m^{-2}$ ; 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 $\Omega$ , 15.4 mA current draw and 185 mW power requirement at 12 V DC		4 mA (heater off); 30 mA (heater on)
Dimensions	23.5 mm diameter, 28.7 mm height	23.5 mm diameter, 27.5 mm height	30.5 mm diameter, 37 mm height
Mass	90 g	100 g	140 g
Cable	5 m of four conductor, 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		

## Accurate and stable global shortwave (solar) radiation measurement

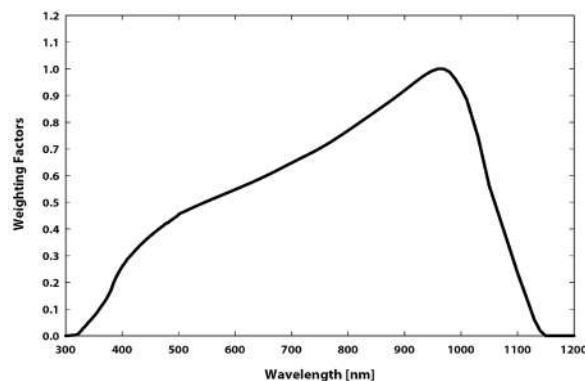
## Output Options

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



MP-200

## Spectral Response

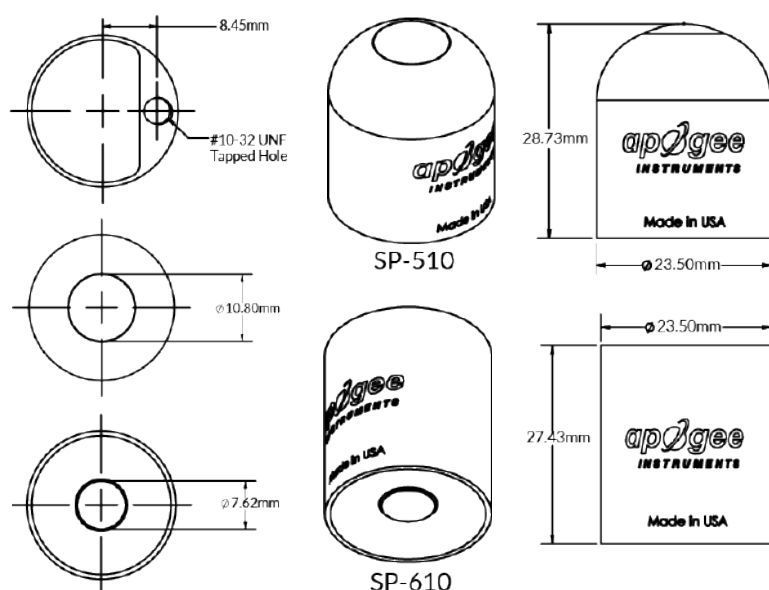


**Spectral response estimate of Apogee silicon-cell pyranometers.**

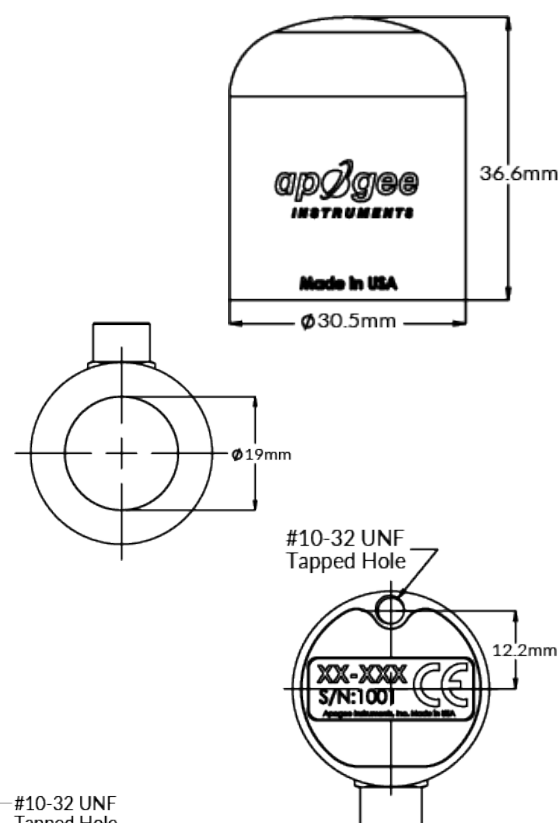
## Product Specifications

	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 (fast response)							
Power Supply	Self-powered	5 to 24 V DC	7 to 24 V DC	5.5 to 24 V DC	12 V DC for heater	5 V USB	5.5 TO 24 V DC	
Current Draw	—	300 µA	22 mA maximum, 2 mA quiescent	300 µA	15.4 mA	61 mA when logging	1.5 mA (quiescent); 1.9 mA (active)	RS-232 37 mA; RS-485 quiescent 37 mA, active 42 mA
Output (sensitivity)	0.2 mV per W m <sup>-2</sup>	1.25 mV per W m <sup>-2</sup>	0.008 mA per W m <sup>-2</sup>	2.5 mV per W m <sup>-2</sup>	0.2 mV per W m <sup>-2</sup>	USB	SDI-12	Modbus
Calibration Factor (reciprocal of output)	5 W m <sup>-2</sup> per mV	0.8 W m <sup>-2</sup> per mV	125 W m <sup>-2</sup> per mA, 4 mA offset	0.4 W m <sup>-2</sup> per mV	5 W m <sup>-2</sup> per mV	Custom for each sensor and stored in firmware		
Calibration Uncertainty at 1000 W m <sup>-2</sup>	Less than 3 %							
Measurement Repeatability	Less than 1 %							
Long-term Drift	Less than 2 % per year							
Non-linearity	Less than 1 % up to 2000 W m <sup>-2</sup>							
Response Time	Less than 1 ms					Updates every second	Less than 0.6 s	Less than 200 ms
Field of View	180°							
Spectral Range	360 to 1120 nm							
Directional (Cosine) Response	± 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 d; 33 mm h	30.5 mm diameter, 37 mm height				24 mm d; 33 mm h	30.5 mm diameter, 37 mm height	
Mass (with 5 m of cable)	90 g	140 g			90 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							

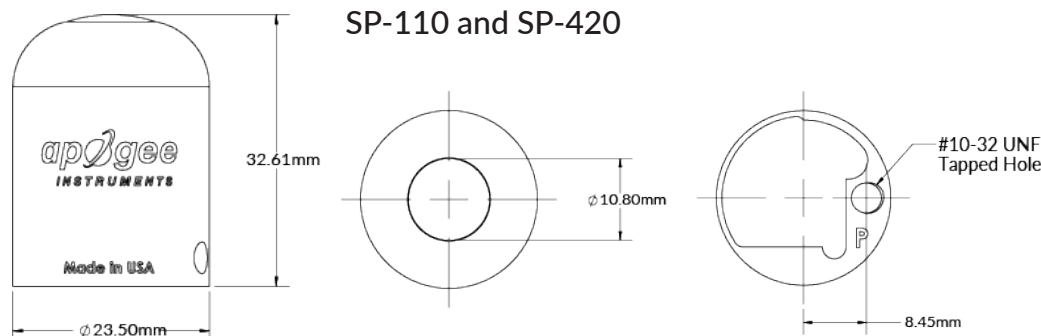
## Thermopile Models



All other silicon-cell pyranometer models and SP-522-SS



## 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 Windows 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 & SP-522 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 numerous industries.

Apogee Modbus Sensor Communication

Defaults: Modbus RTU

Slave address: 0x1

Baudrate: 19200

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.