



# 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

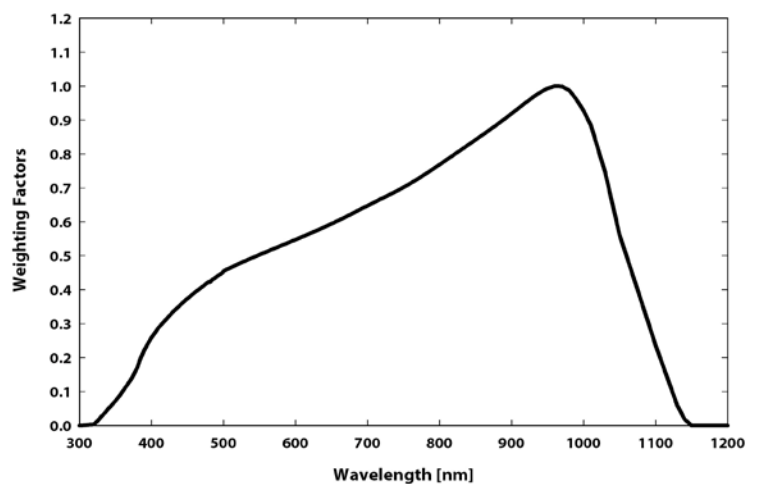
### Calibration Traceability

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.

Blackbody accuracy with a cost-effective design



## 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	$\pm 5 \%$	
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 $\Omega$ , 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	

# 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

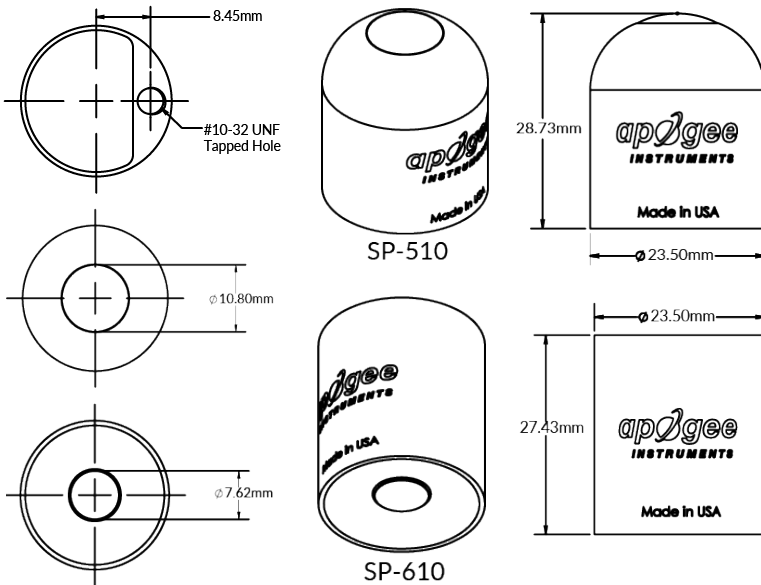


MP-200

### Specifications

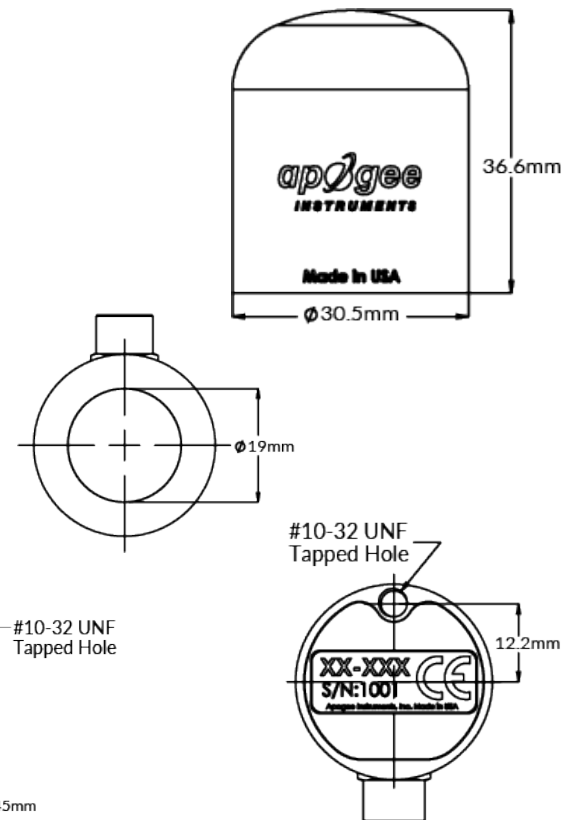
	SP-110-SS	SP-212-SS	SP-214-SS	SP-215-SS	SP-230-SS	SP-420	SP-421-SS	SP-422-SS
ISO 9060:2018	Class C							
Power Supply	Self-powered	3.3 to 24 V DC	7 to 24 V DC	5.5 to 24 V DC	12 V DC for heater	5 V	5.5 TO 24 V DC	
Current Draw	—	10 $\mu$ A	22 mA maximum, 2 mA quiescent	10 $\mu$ A	15.4 mA	61 mA when logging	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 (reciprocal 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	$\pm 5\%$							
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) Response	$\pm 5\%$ at 75° zenith angle							
Temperature Response	0.04 $\pm$ 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							

## Thermopile Models

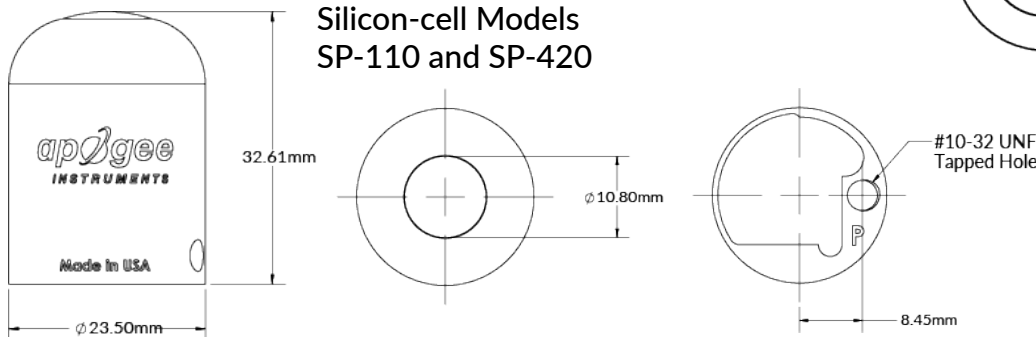


## Dimensions

All other silicon-cell pyranometer models



## Silicon-cell Models SP-110 and SP-420



## 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 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.

## Digital Models