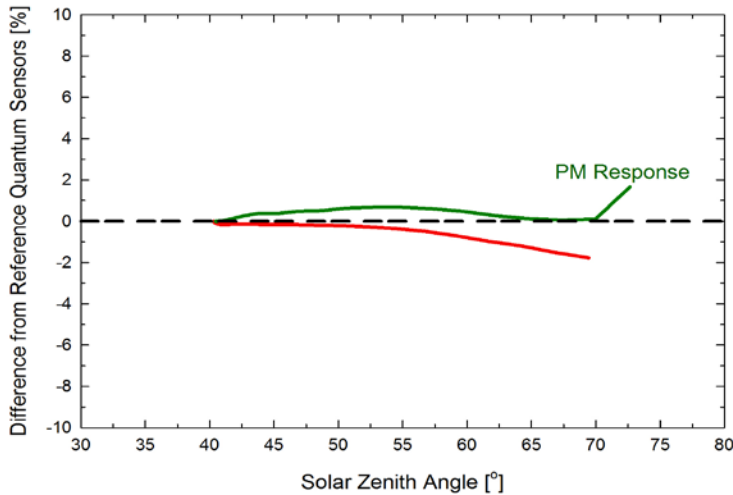
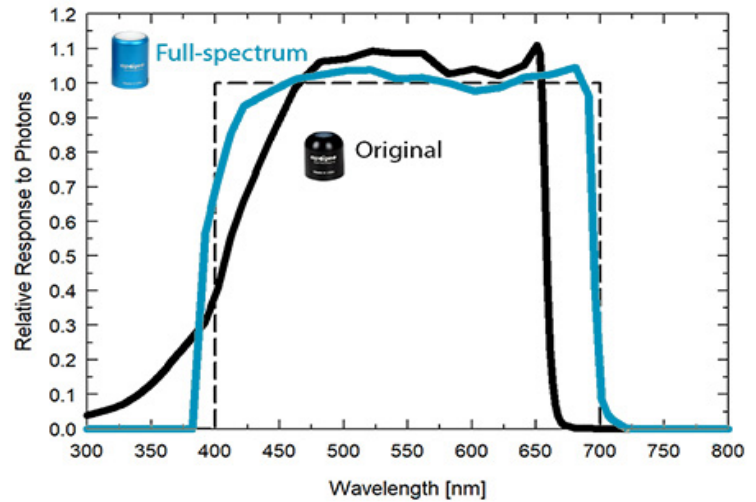




Response Graphs



Mean **cosine response** of seven Apogee SQ-500 quantum sensors. The red data are AM measurements; the green data are PM measurements.

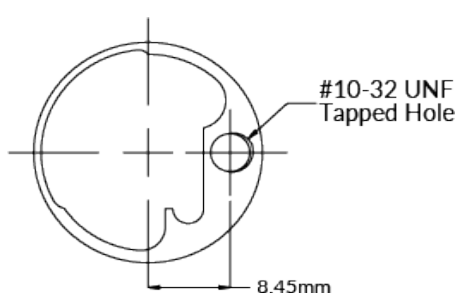
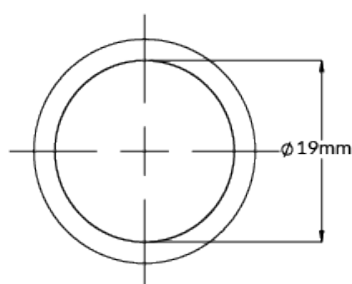


Mean **spectral response** measurements of six replicate Apogee SQ-100 and SQ-500 series quantum sensors.

Product Specifications

USB quantum sensor with an improved spectral response providing research grade measurements under all light sources, including LEDs

SQ-520	
Power Supply	Uses a 5 V USB power source; 2.1 mA current draw when logging
Resolution	0.1 $\mu\text{mol m}^{-2} \text{s}^{-1}$
Calibration Factor	Custom for each sensor and stored in the firmware
Calibration Uncertainty	$\pm 5 \%$
Measurement Repeatability	Less than 0.5 %
Long-term Drift (non-stability)	Less than 2 % per year
Non-linearity	Less than 1 % (up to 4000 $\mu\text{mol m}^{-2} \text{s}^{-1}$)
Response Time	Software updates every second
Field of View	180°
Spectral Range	689 to 692 nm ± 5 nm (wavelengths where response is greater than 50 % of maximum)
Spectral Selectivity	Less than 10 % from 412 to 682 nm ± 5 nm
Directional (Cosine) Response	$\pm 5 \%$ at 75° zenith angle
Temperature Response	-0.11 $\pm 0.03 \%$ per C
Uncertainty in Daily Total	Less than 5 %
IP Rating	IP68
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, 37 mm height
Mass	100 g (with 5 m of lead wire)
USB Cable	4.6 m (15 ft)
Warranty	4 years against defects in materials and workmanship



Features

ACCURATE, STABLE MEASUREMENTS

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

UNIQUE DESIGN

Measure photosynthetically active radiation with a research grade, full-spectral response sensor. Offers a self-cleaning, cosine-corrected head to minimize errors and is fully-potted for a waterproof design.

NO DATALOGGER REQUIRED

Sensor can be connected to a desktop, laptop, or tablet computer via a USB 2.0 type A plug. The ApogeeConnect software gives the user control of data logging and calibration settings, provides real-time output display and graph of PPFd measurements, and allows the data set to be saved as a csv file for analysis. Sensor has internal data storage ability to hold up to 10,000 measurements.

CALIBRATION TRACEABILITY

Apogee SQ-500 sensors are calibrated through side-by-side comparison to the mean of four transfer standard sensors under a reference lamp. The reference sensors are recalibrated with a quartz halogen lamp traceable to the National Institute of Standards and Technology (NIST).

Spectral Errors

	Apogee SQ-500	Apogee SQ-110 SQ-120	LI-COR LI-190	Kipp & Zonen PQS 1
Sun (Clear Sky)	0.0	0.0	-0.4	-1.0
Sun (Cloudy Sky)	0.1	0.2	-0.2	-1.3
Sun (Reflected from Grass Canopy)	-0.3	3.8	-0.8	1.1
Sun (Transmitted below Wheat Canopy)	0.1	4.5	-0.1	-0.3
Cool White Fluorescent (T5)	0.0	0.0	0.0	0.0
Metal Halide	0.9	-2.8	0.2	-1.7
Ceramic Metal Halide	0.3	-16.1	0.4	-0.7
High Pressure Sodium	0.1	0.2	1.3	1.4
Red LED (667 nm peak, 20 nm full-width half-maximum)	2.8	-62.1	3.5	-1.8
Red, Blue, White LED Mixture (60 % Red, 25 % White, 15 % Blue)	-2.0	-35.5	2.6	-1.7

SPECTRAL ERRORS OF COMMERCIAL QUANTUM SENSORS

Spectral errors are theoretical errors calculated from sensor spectral responses and spectral output of radiation sources. Only spectral errors are listed in the table. Calibration, cosine, and temperature error can also contribute to measurement error.