

Comparison of Apogee SQ-500 and LI-COR LI-190R Quantum Sensors

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Introduction

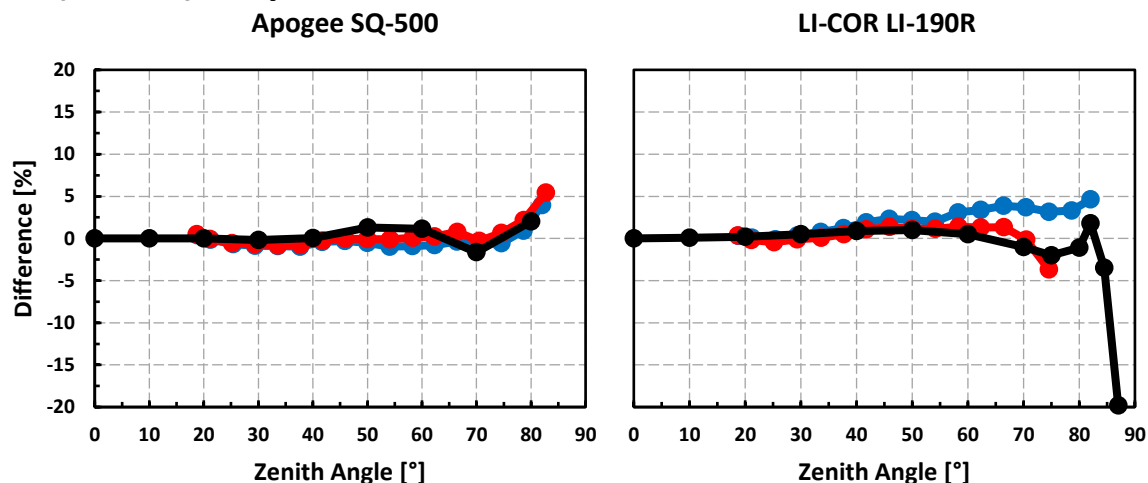
Photosynthetically active radiation (PAR) is defined and quantified as photosynthetic photon flux density (PPFD), the sum of photons between 400 and 700 nm in units of $\mu\text{mol m}^{-2} \text{s}^{-1}$. Quantum sensors, sometimes called PAR sensors, are used to measure PPFD. Multiple models are available. This technical note compares the two most widely used research-grade quantum sensors in the United States. These data are summarized from a comprehensive study that compared eight quantum sensors (Blonquist and Johns, 2018).

Specifications

Specifications below are from the product manuals. List prices for the United States are from the company websites.

Specification	Apogee SQ-500	LI-COR LI-190R
Sensitivity (mV per $\mu\text{mol m}^{-2} \text{s}^{-1}$)	0.01	0.003-0.006 (with 604 Ω resistor)
Calibration Factor ($\mu\text{mol m}^{-2} \text{s}^{-1}$ per mV)	100	165-330 (with 604 Ω resistor)
Calibration Uncertainty	5 %	5 %
Non-linearity	1 % up to 4000 $\mu\text{mol m}^{-2} \text{s}^{-1}$	1 % up to 10000 $\mu\text{mol m}^{-2} \text{s}^{-1}$
Directional (Cosine) Response		See graphs below
Spectral Response		See graphs below
Temperature Response	-0.11 \pm 0.04 % per C	\pm 0.15 % per C
Manufacturer List Price (U. S. Price)	The LI-COR LI-190R is \approx 25 % more than the Apogee SQ-500	

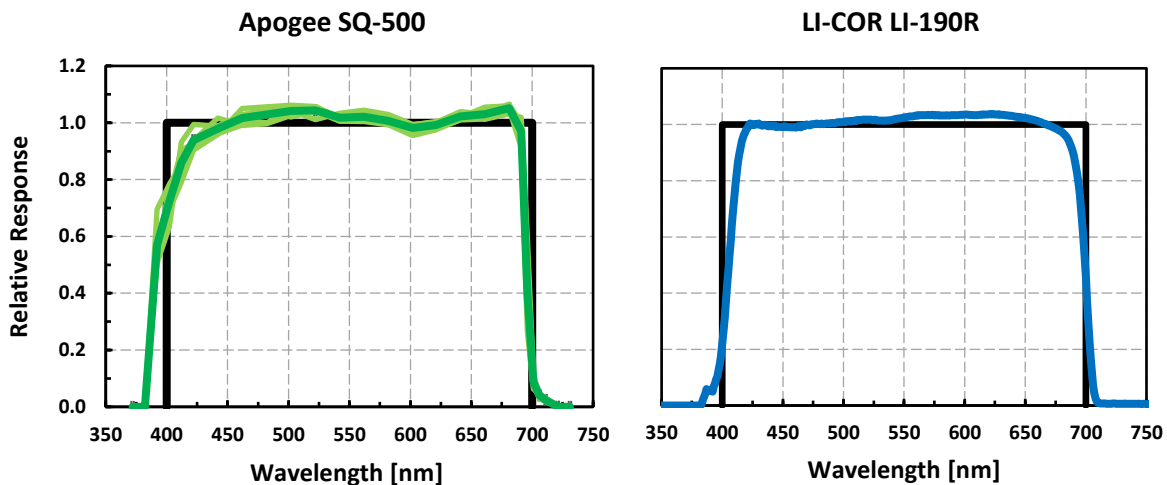
Directional (Cosine) Response



Directional responses of the quantum sensors. The response of six replicate SQ-500 and three replicate LI-190R quantum sensors (see photo below) were determined under sunlight (dawn to dusk) by comparison to PPFD calculated from shortwave irradiance measurements (blue lines are mean AM responses and red lines are mean PM responses). These data closely matched the directional response measured in the laboratory for the SQ-500 (black line) and the directional response from the product manual for the LI-190R (black line). Directional errors were less than 2 % up to zenith angles of about 60° and less than 5 % up to zenith angles of about 75°. Quantum sensors from some other manufacturers had larger directional errors (Blonquist and Johns, 2018).



Spectral Response



Spectral responses compared to defined PAR (black line). The response of the Apogee SQ-500 was measured in a monochromator (dark green line is the mean of six replicates, light green lines are data for each replicate). The response of the LI-190R is from the product manual. Spectral responses of quantum sensors from some other manufacturers did not match defined PAR as well as these two sensors (Blonquist and Johns, 2018).

Spectral Error

Spectral errors for sunlight and common electric lights were calculated from the spectral responses. Spectral errors for both sensors were less than 4 % for all lights tested. Quantum sensors from some other manufacturers did not achieve these small spectral errors (Blonquist and Johns, 2018).

Radiation Source	Apogee SQ-500	LI-COR LI-190R
Clear Sky	0.0 (0.0)	0.0 (0.0)
Overcast Sky	0.1	0.1
Reflected from Plant Canopy	-0.3	1.1
Transmitted below Plant Canopy	0.1 (4.9)	0.7 (1.1)
Cool White Fluorescent T5	0.1	1.8
Metal Halide	0.9 (-0.4)	0.4 (0.8)
Ceramic Metal Halide	0.3	1.3
Mogul Base High Pressure Sodium	0.1 (2.2)	3.2 (3.3)
Dual-ended High Pressure Sodium	-0.1	2.8
Blue LED 448 nm Peak	-0.7	-0.2
Green LED 524 nm Peak	3.2	2.2
Red LED 635 nm Peak	0.8	3.6
Red LED 667 nm Peak	2.8 (5.2)	0.9 (2.4)
Cool White LED	0.5	2.0
Neutral White LED	0.5	2.0
Warm White LED	0.2	2.1

Numbers in parentheses refer to spectral errors published in a technical note (LI-COR Biosciences, 2018). To allow relative comparison, the numbers from the LI-COR technical note were scaled so errors were zero under sunlight. The LI-COR data for the SQ-500 are from an earlier version of the SQ-500. The Apogee data for the SQ-500 were from the latest version, which was released in October 2017. The latest version includes a more exact 700 nm cutoff.

Blonquist Jr., J.M., and J.A. Johns, 2018. Accurate PAR measurement: Comparison of eight quantum sensor models. Apogee Instruments Research Report, published online May 2018 (<https://www.apogeeinstruments.com/content/Comparison-of-Eight-Quantum-Sensor-Models.pdf>).

LI-COR Biosciences, 2018. Comparison of quantum sensors with different spectral sensitivities. LI-COR Biosciences Technical Note, published online February 2018 (<https://www.licor.com/documents/oi26ib7eb6wm5y5u9ebv4b3jodm09tf9>).