CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

Comparison of the CS310 and LI190R Quantum Sensors

Introduction

Photosynthetically active radiation (PAR) is defined as the photosynthetic photon flux density (PPFD), the sum of photons between 400 and 700 nm, with units of µmol/m²/s (micromoles of photons per meter squared per second). Quantum sensors, also known as PAR sensors, measure the PPFD. This document compares the two research grade quantum sensors offered by Campbell Scientific—the CS310 and the LI190R (Figure 1). It uses data from a comprehensive study that compared eight different types of quantum sensors (Blonquist and Johns. May, 2018[a]).

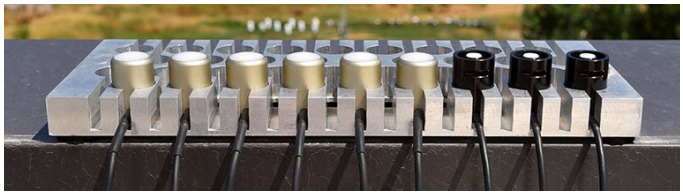

Figure 1. Six CS310 quantum sensors (manufactured by Apogee) and three LI190R quantum sensors (manufactured by LI-COR) monitor sunlight for the comprehensive research study.

Specifications

Specification	CS310	LI190R
Sensitivity	0.01 mV per µmol/m²/s (constant)	0.003 to 0.006 mV per µmol/m²/s with 604 Ω resistor (varies for each sensor)
Calibration Factor	100 µmol/m²/s per mV	16 to 330 µmol/m²/s per mV with 604 Ω resistor (varies for each sensor)
Calibration Uncertainty	±5%	±5 %
Non-linearity	< 1% (up to 4000 µmol/m²/s) (2 times full sunlight)	1 % up to 10,000 µmol/m2/s (5 times full sunlight)
Directional (Cosine) Response	Figure 2	Figure 2
Spectral Response	Figure 3	Figure 3
Temperature Response	–0.11 ±0.04% per °C	± 0.15 % per C

Directional (Cosine) Response

The cosine response of six replicate CS310 and three replicate LI190R quantum sensors were determined under sunlight (dawn to dusk) by comparison to the PPFD calculated from shortwave irradiance measurements (Figure 1). In Figure 2, the blue lines are mean a.m. responses and red lines are mean p.m. responses. These measurements closely matched the directional response measured in the laboratory for the CS310 (black line) and the directional response from the product manual for the LI190R (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 other manufacturers had larger directional errors (Blonquist and Johns. May, 2018[a]).

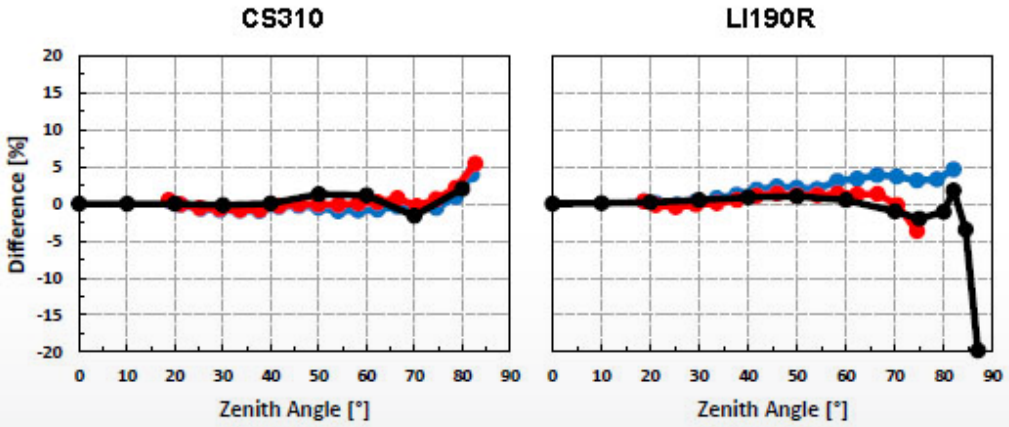

Figure 2. Directional response graphs show both sensors have less than 2 % error up to zenith angles of 60°.

Spectral Response

Spectral responses compared to defined PAR (black line). The response of the CS310 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 LI190R 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[a]).

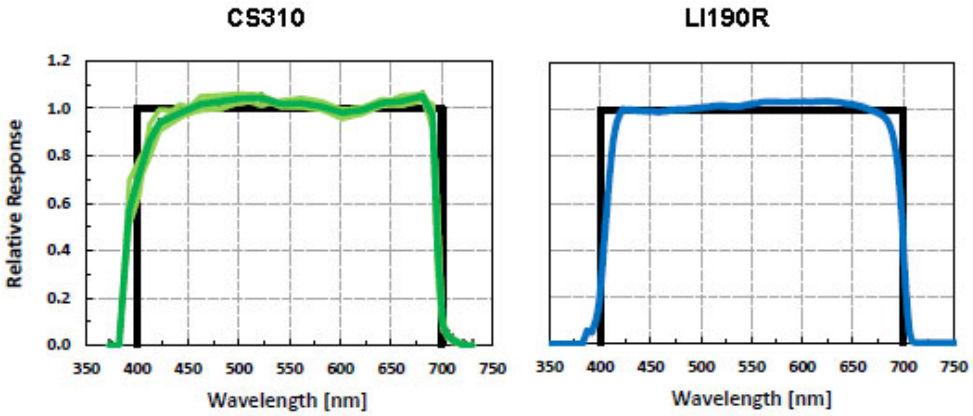

Figure 3. Spectral response graphs show the spectral errors for both sensors were less than 4 % for all lights tested.

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[a]).

Radiation Source	CS310	LI190R
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[b]). The LI-COR data for the CS310 are from an earlier version of the sensor. The Apogee data for the CS310 were from the latest version, which was released in October 2017. The latest version includes a more exact 700 nm cutoff. To allow relative comparison, the numbers from the LI-COR technical note were scaled so errors were zero under sunlight.*

[a]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 (www.apogeeinstruments.com/content/Comparison-of-Eight-Quantum-Sensor-Models.pdf)

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

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