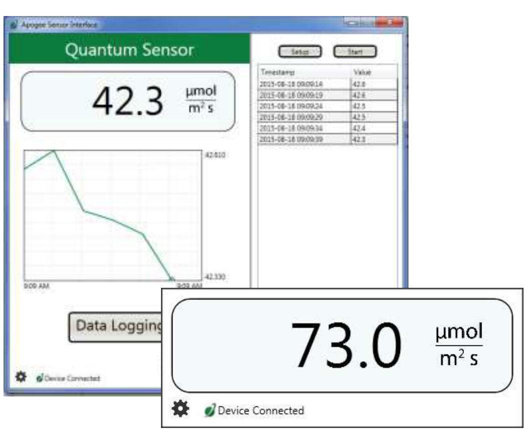
USB QUANTUM SENSOR

Model JSQ-420

Application

The JSQ-420 is used to measure incoming and reflected PPFD around plants and other organisms in outdoor environments, greenhouses, growth chambers, and underwater.



Internal Data Storage

The sensor has internal data storage capability with the ability to hold up to 10,000 measurements. This allows the sensor to collect data while connected to a stand-alone 5 V DC power supply such as an independent battery pack or USB wall adapter.

No Datalogger Required

The sensor can be connected to a desktop, laptop, or tablet computer via USB 2.0 type A plug to be used with the software. The included Apogee software gives the user control of data logging and calibration settings, provides a real time output display and graph of PPFD measurements and allows the data set to be saved as a csv file.

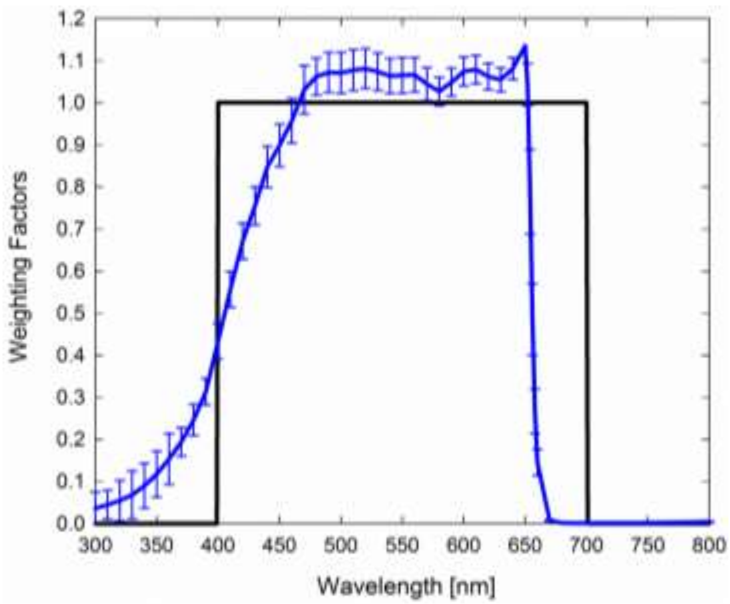
Independent Calibration

The JSQ-420 is calibrated independently for sunlight and electric light to improve measurement accuracy. The light source calibration can be selected in the settings menu of the Apogee software.

SPECIFICATIONS

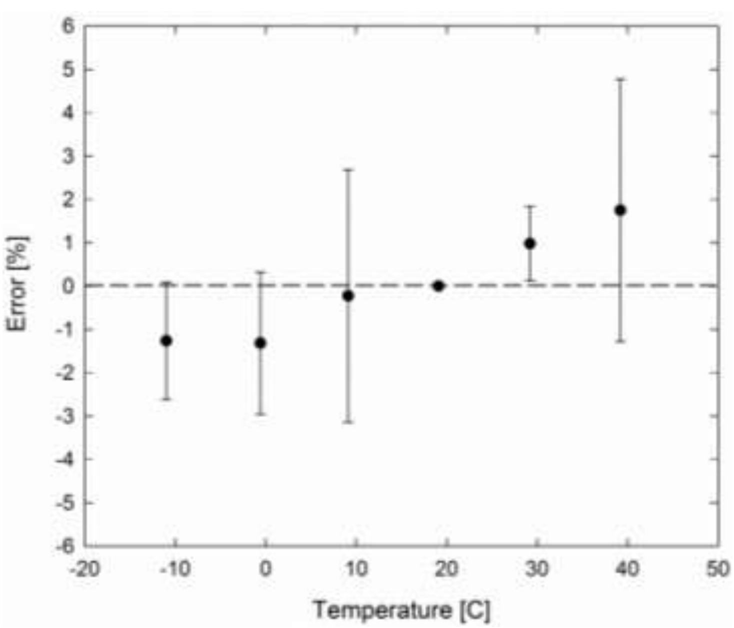
- Resolution: 0.1 µmol m-2 s-1
- Calibration Factor: custom for each sensor and stored in the firmware
- Calibration Uncertainty: ± 5 % (see Calibration Traceability below)
- Measurement Repeatability: less than 1 %
- Non-stability (Long-term Drift): less than 2 % per year
- Non-linearity: less than 1 % (up to 3000 µmol m-2 s-1)
- Response Time: software updates every second
- Field of View: 180o
- Spectral Range: 410 nm to 655 nm
  (wavelengths where response is greater than 50 % of maximum; see Spectral Response below)
- Directional (Cosine) Response: ± 5 % at 75o zenith angle
  (see Cosine Response below)
- Temperature Response: 0.06 ± 0.06 % per °C
  (see Temperature Response below)
- Operating Environment: -40~70°C, 0~100%RH
  (Can be submerged in water up to depths of 30 m)
- Dimensions: 2.4 cm diameter and 2.8 cm height
- Mass: Sensor head weighs 90 g
- USB Cable: 4.6 m (15 ft)
- Current Draw (when Logging): 0.35 mA

Spectral Response:



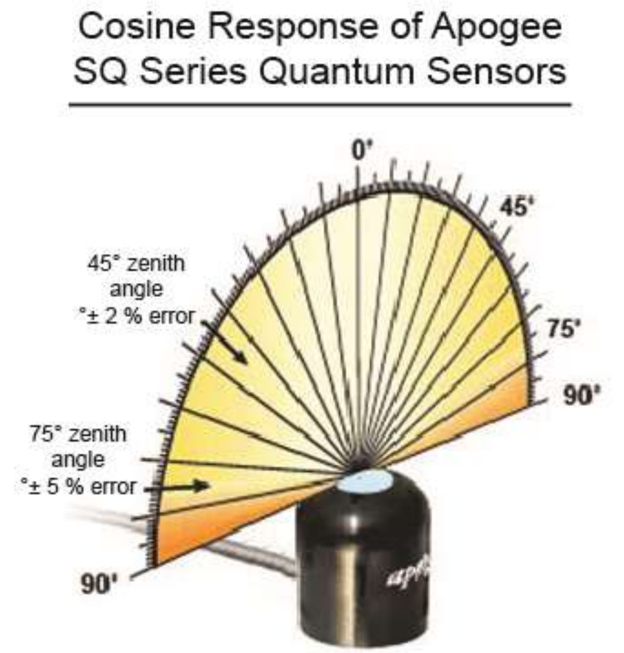
Mean spectral response of six sensors (***error bars represent two standard deviations above and below mean***) compared to PAR (PPFD) weighting function. Spectral response measurements were made at 10 nm increments across a wavelength range of 300 to 800 nm in a monochromator with an attached electric light source. Measured spectral data from each quantum sensor were normalized by the measured spectral response of the monochromator/electric light combination, which was measured with a spectroradiometer.

Temperature response:

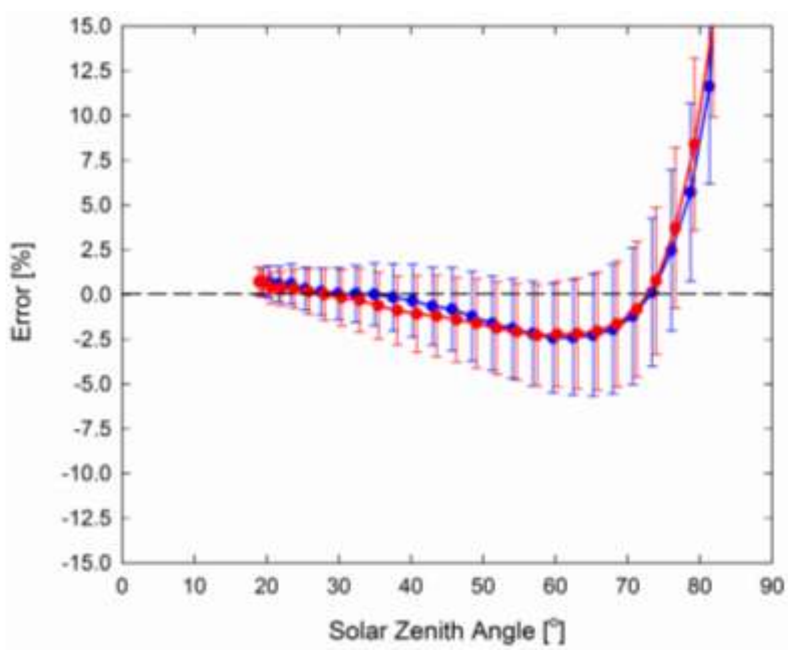


Mean temperature response of eight replicate sensors (***errors bars represent two standard deviations above and below mean***). Temperature response measurements were made at 10 C intervals across a temperature range of -10 to 40 C in a temperature controlled chamber under a fixed, broad spectrum, electric lamp. At each temperature set point, a spectroradiometer was used to measure light intensity from the lamp and all quantum sensors were compared to the spectroradiometer. The spectroradiometer was mounted external to the temperature control chamber and remained at room temperature during the measurements.

Cosine Response:



Directional, or cosine, response is defined as the measurement error at a specific angle of radiation incidence. Error for Apogee SQ series quantum sensors is approximately ± 2 % and ± 5 % at solar zenith angles of 45° and 75°, respectively.

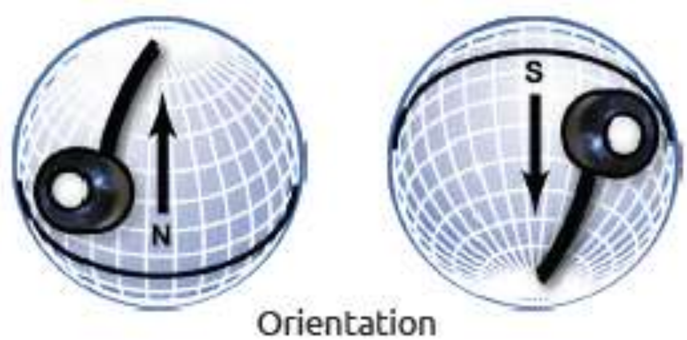


Mean cosine response of twenty-three replicate sensors (***error bars represent two standard deviations above and below mean***). Cosine response measurements were made by direct side-by-side comparison to the mean of four reference thermopile pyranometers, with solar zenith angle-dependent factors applied to convert total shortwave radiation to PPFD. Blue points represent the AM response and red points represent the PM response.

DEPLOYMENT AND INSTALLATION

Mount the sensor to a solid surface with the nylon mounting screw provided. To accurately measure PPFD incident on a horizontal surface, the sensor must be level. An Apogee Instruments model AL-100 leveling plate is recommended for this purpose. To facilitate mounting on a cross arm, an Apogee Instruments model AM-110 mounting bracket is recommended.

To minimize azimuth error, the sensor should be mounted with the cable pointing toward true north in the northern hemisphere or true south in the southern hemisphere. Azimuth error is typically less than 1 %, but it is easy to minimize by proper cable orientation.



In addition to orienting the cable to point toward the nearest pole, the sensor should also be mounted such that obstructions (e.g., weather station tripod/tower or other instrumentation) do not shade the sensor. **Once mounted, the green cap should be removed from the sensor.** The green cap can be used as a protective covering for the sensor when it is not in use.

OPERATION AND MEASUREMENT

Spectral Errors and Yield Photon Flux Measurements:

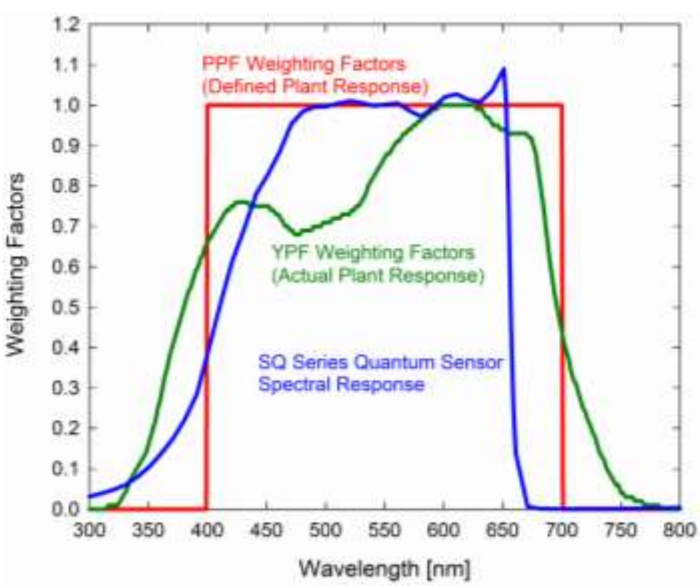
Apogee quantum sensors are calibrated to measure PPFD for either sunlight or electric light. The difference between the calibrations is 14 %. A sensor calibrated for electric lights (calibration source is T5 cool white fluorescent lamps) will read approximately 14 % low in sunlight.

In addition to PPFD measurements, Apogee SQ series quantum sensors can also be used to measure yield photon flux density (YPFD): photon flux weighted according to the plant photosynthetic action spectrum (McCree, 1972) and summed. YPFD is also expressed in units of µmol m^{-2} s^{-1}, and is similar to PPFD, but is typically more closely correlated to photosynthesis than PPFD. PPFD is usually measured and reported because the PPFD spectral weighting function (equal weight given to all photons between 400 and 700 nm; no weight given to photons outside this range) is easier to define and measure, and as a result, PPFD is widely accepted. The calibration factor for YPFD is 10 % lower than the calibration factor for PPFD.

The weighting functions for PPFD and YPFD are shown in the graph below, along with the spectral response of Apogee SQ series quantum sensors. The closer the spectral response matches the defined PPFD or YPFD spectral weighting functions, the smaller spectral errors will be. The table below provides spectral error estimates for PPFD and YPFD measurements from light sources different than the calibration source. The method of Federer and Tanner (1966) was used to determine spectral errors based on the PPFD and YPFD spectral weighting functions, measured sensor spectral response, and radiation source spectral outputs (measured with a spectroradiometer). This method calculates spectral error and does not consider calibration, cosine, and temperature errors.

Federer, C. A., and C. B. Tanner, 1966. Sensors for measuring light available for photosynthesis. Ecology 47:654-657.

McCree, K. J., 1972. The action spectrum, absorptance and quantum yield of photosynthesis in crop plants. Agricultural Meteorology 9:191-216.



Radiation weighting factors for PPFD (defined plant response to radiation), YPFD (measured plant response to radiation), and Apogee SQ Series quantum sensors (sensor sensitivity to different wavelengths of radiation).