## OWNER'S MANUAL

# USB PYRANOMETER

Models JSP-420


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# CERTIFICATE OF COMPLIANCE

## EU Declaration of Conformity

Models: JSP-420
Type: Pyranometer

The object of the declaration described above is in conformity with the relevant Union harmonization legislation:

| | |
|---|---|
| 2014/30/EU | Electromagnetic Compatibility (EMC) Directive |
| 2011/65/EU | Restriction of Hazardous Substances (RoHS 2) Directive |

Standards referenced during compliance assessment:

| | |
|---|---|
| EN 61326-1:2013 | Electrical equipment for measurement, control and laboratory use – EMC requirements |
| EN 50581:2012 | Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances |

Please be advised that based on the information available to us from our raw material suppliers, the products manufactured by us do not contain, as intentional additives, any of the restricted materials including cadmium, hexavalent chromium, lead, mercury, polybrominated biphenyls (PBB), polybrominated diphenyls (PBDE).

# INTRODUCTION

Solar radiation at Earth's surface is typically defined as total radiation across a wavelength range of 280 to 4000 nm (shortwave radiation). Total solar radiation, direct beam and diffuse, incident on a horizontal surface is defined as global shortwave radiation, or shortwave irradiance (incident radiant flux), and is expressed in Watts per square meter (W $m^{-2}$, equal to Joules per second per square meter).

Pyranometers are sensors that measure global shortwave radiation. JSP series pyranometers are silicon-cell pyranometers, and are only sensitive to a portion of the solar spectrum, approximately 350-1100 nm (approximately 80 % of total shortwave radiation is within this range). However, silicon-cell pyranometers are calibrated to estimate total shortwave radiation across the entire solar spectrum. Silicon-cell pyranometer specifications compare favorably to specifications for World Meteorological Organization (WMO) moderate and good quality classifications and specifications for International Organization of Standardization (ISO) second class and first class classifications, but because of limited spectral sensitivity, they do not meet the spectral specification necessary for WMO or ISO certification.

Typical applications of silicon-cell pyranometers include incoming shortwave radiation measurement in agricultural, ecological, and hydrological weather networks, and solar panel arrays.

JSP series pyranometers consist of a cast acrylic diffuser (filter), photodiode, and signal processing circuitry mounted in an anodized aluminum housing, and a cable to connect the sensor to a measurement device. Sensors are potted solid with no internal air space and are designed for continuous total shortwave radiation measurement on a planar surface in outdoor environments. SP series sensors output an analog voltage that is directly proportional to total shortwave radiation from the sun. The voltage signal from the sensor is directly proportional to radiation incident on a planar surface (does not have to be horizontal), where the radiation emanates from all angles of a hemisphere.

# SENSOR MODELS

This manual covers the USB smart sensor model JSP-420. For additional models see manuals JSP-110/JSP-230, JSP-212/JSP-215, and JSP-214.

| Model | Signal |
|---|---|
| **HSP-420** | **USB** |
| JSP-110 | Self-powered |
| JSP-230* | Self-powered |
| JSP-212 | 0-2.5 V |
| JSP-214 | 4-20 mA |
| JSP-215 | 0-5 V |

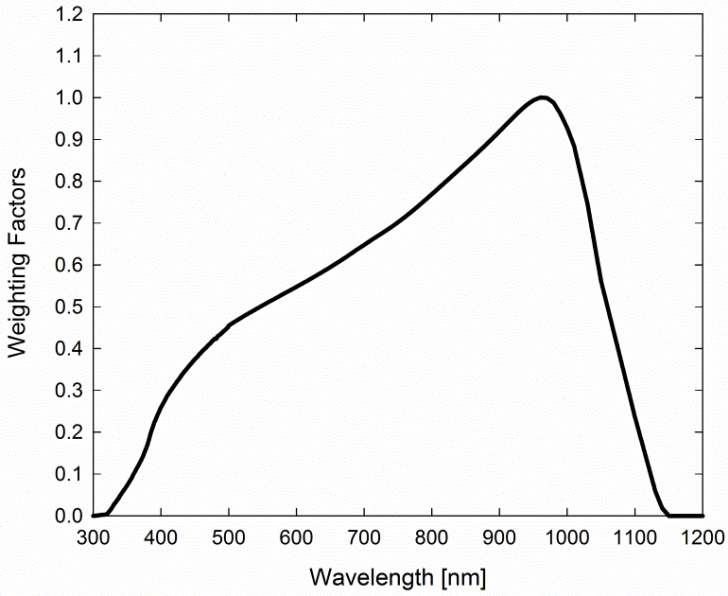
# SPECIFICATIONS

| | JSP-420 |
|---|---|
| Resolution | 0.1 W $m^{-2}$ |
| Calibration Factor | Custom for each sensor and stored in firmware |
| Calibration Uncertainty | ± 5 % (see Calibration Traceability below) |
| Measurement Repeatability | Less than 1 % |
| Long-term Drift (Non-stability) | Less than 2 % per year |
| Non-linearity | Less than 1 % (up to 1750 W $m^{-2}$) |
| Response Time | Software updates every second |
| Field of View | 180° |
| Spectral Range | 360 to 1120 nm (wavelengths where response is 10 % of maximum; see Spectral Response below) |
| Directional (Cosine) Response | ± 5 % at 75° zenith angle (see Cosine Response below) |
| Temperature Response | 0.04 ± 0.04 % per C (see Temperature Response below) |
| 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, 28 mm height |
| Mass | Sensor head weighs 90 g |
| USB Cable | 4.6 m (15 ft) |
| Current Draw (when Logging) | 2.1 mA |

**Calibration Traceability**

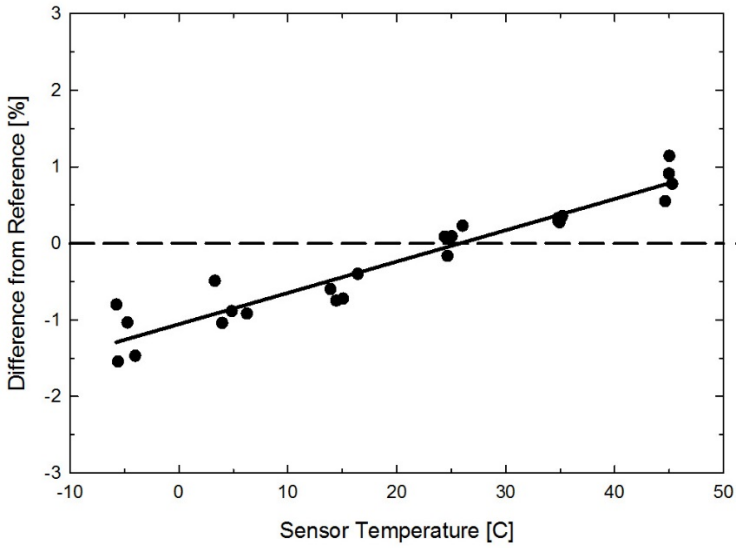
JSP series pyranometers are calibrated through side-by-side comparison to the mean of four model JSP-110 transfer standard pyranometers (shortwave radiation reference) under high intensity discharge metal halide lamps. The transfer standard pyranometers are calibrated through side-by-side comparison to the mean of at least two ISO-classified reference pyranometers under sunlight (clear sky conditions) in Logan, Utah. Each of four ISO-classified reference pyranometers are recalibrated on an alternating year schedule (two instruments each year) at the National Renewable Energy Laboratory (NREL) in Golden, Colorado. NREL reference standards are calibrated to the World Radiometric Reference (WRR) in Davos, Switzerland.

**Spectral Response**



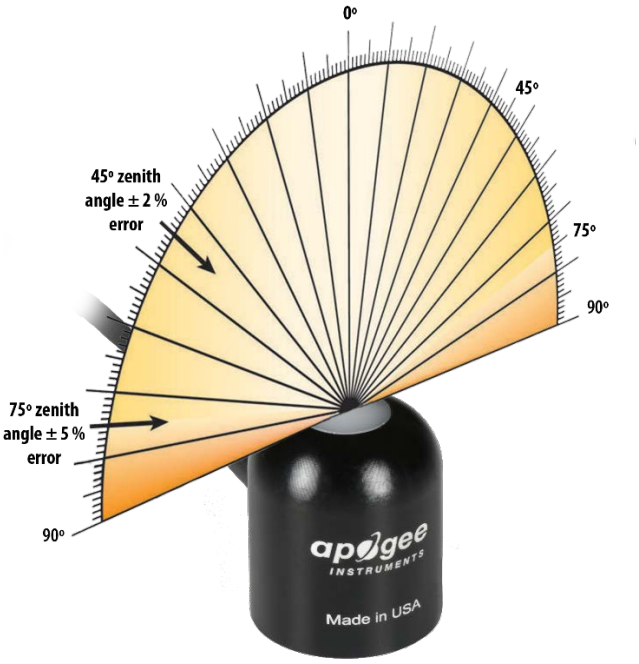

Spectral response estimate of the silicon-cell pyranometers. Spectral response was estimated by multiplying the spectral response of the photodiode, diffuser, and adhesive. Spectral response measurements of diffuser and adhesive were made with a spectrometer, and spectral response data for the photodiode were obtained from the manufacturer.

**Temperature Response**

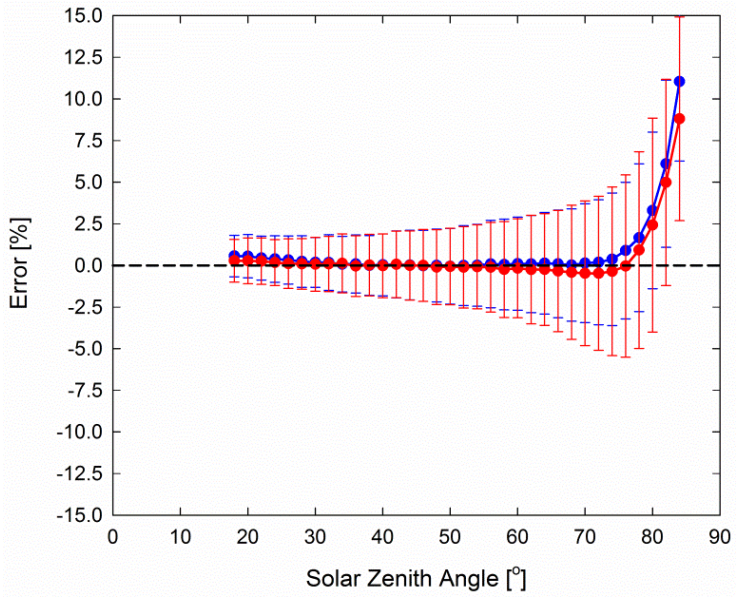



Mean temperature response of four the silicon-cell pyranometers. Temperature response measurements were made at approximately 10 C intervals across a temperature range of approximately -10 to 50 C under sunlight. Each pyranometer had an internal thermistor to measure temperature. At each temperature set point, a reference blackbody pyranometer was used to measure solar intensity.

**Cosine Response**




Directional, or cosine, response is defined as the measurement error at a specific angle of radiation incidence. Error for the silicon-cell pyranometers is approximately ± 2 % and ± 5 % at solar zenith angles of 45° and 75°, respectively.




Mean cosine response of eleven the silicon-cell pyranometers (***error bars represent two standard deviations above and below mean***). Cosine response measurements were made during broadband outdoor radiometer calibrations (BORCAL) performed during two different years at the National Renewable Energy Laboratory (NREL) in Golden, Colorado. Cosine response was calculated as the relative difference of pyranometer sensitivity at each solar zenith angle to sensitivity at 45° solar zenith angle. The blue symbols are AM measurements, the red symbols are PM measurements.

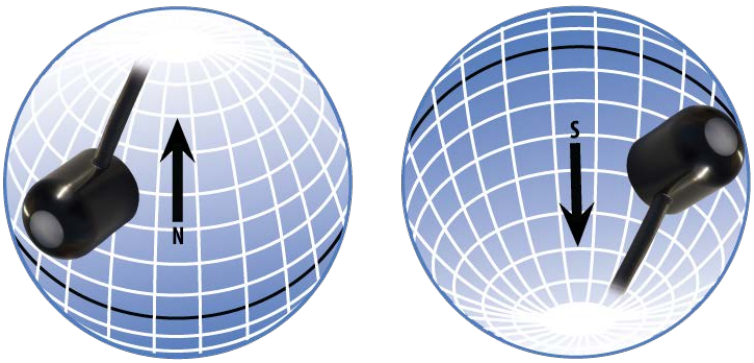
# DEPLOYMENT AND INSTALLATION

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

Nylon Screw: 10-32x3/8

Model AL-100

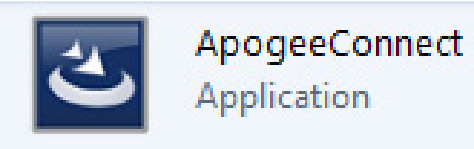
To minimize azimuth error, the sensor should be mounted with the cable pointing toward true north in the northern hemisphere or true south in the southern hemisphere. Azimuth error is typically less than 1 %, but it is easy to minimize by proper cable orientation.




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.

# SOFTWARE INSTALLATION

**Installing the software on a PC**




1. Double click on the installer package:
2. On the 'Welcome' screen, please click 'Next' to continue.
3. Select the radio button next to "I Agree" to the UELA… and click 'Next' to continue.
4. On the 'Ready to Install the Program' screen, click 'Install' to continue.
5. Click 'Finish' to complete the installation. There are shortcuts on your desktop and in your start bar.

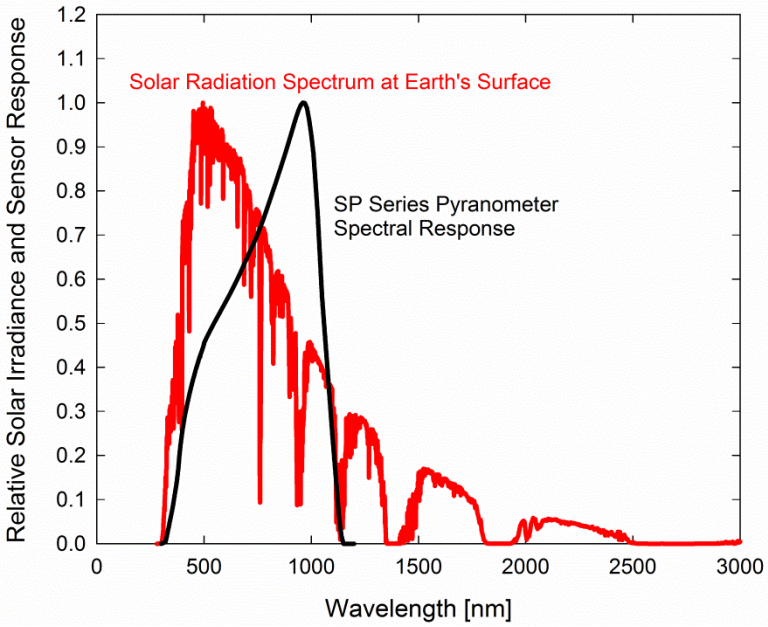
**Installing the software on a Mac**

The software will automatically download.

# OPERATION AND MEASUREMENT

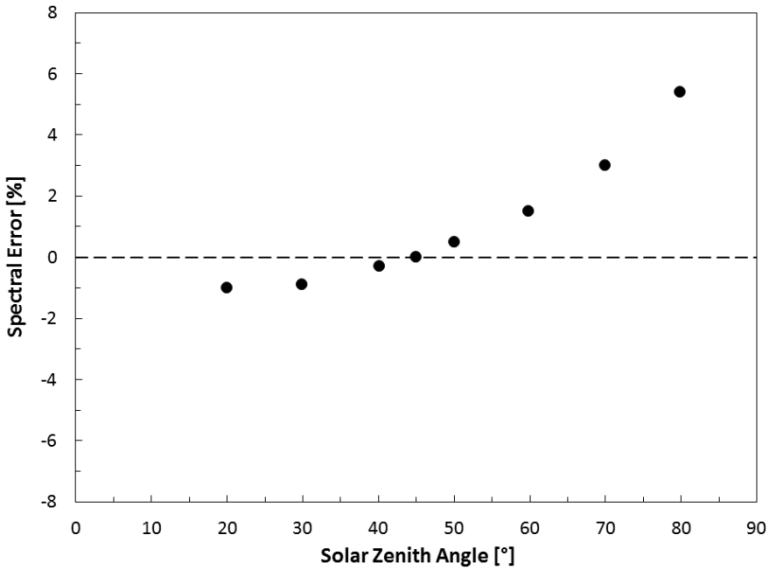
**Spectral Errors for Measurements with Silicon-cell Pyranometers**

JSP series pyranometers are calibrated under electric lamps in a calibration laboratory. The calibration procedure simulates calibration under clear sky conditions at a solar zenith angle of approximately 45°. However, due to the limited spectral sensitivity of silicon-cell pyranometers compared to the solar radiation spectrum (see graph below), spectral errors occur when measurements are made in conditions that differ from conditions the sensor was calibrated under (e.g., the solar spectrum differs in clear sky and cloudy conditions, thus measurements in cloudy conditions result in spectral error because sensors are calibrated in clear sky conditions).

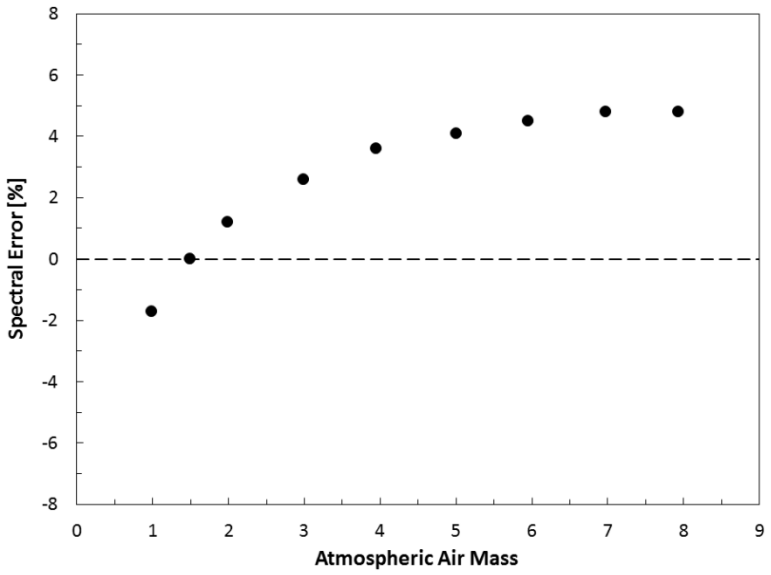



Spectral response of JSP series pyranometers compared to solar radiation spectrum at Earth's surface. Silicon-cell pyranometers, such as JSP series, are only sensitive to the wavelength range of approximately 350-1100 nm, and are not equally sensitive to all wavelengths within this range. As a result, when the spectral content of solar radiation is significantly different than the spectrum that silicon-cell pyranometers were calibrated to, spectral errors result.

Silicon-cell pyranometers can still be used to measure shortwave radiation in conditions other than clear sky or from radiation sources other than incoming sunlight, but spectral errors occur when measuring radiation with silicon-cell pyranometers in these conditions. The graphs below show spectral error estimates for the silicon-cell pyranometers at varying solar zenith angles and varying atmospheric air mass. The diffuser is optimized to minimize directional errors, thus the cosine response graph in the Specifications section shows the actual directional errors in practice (which includes contributions from the spectral shift that occurs as solar zenith angle and atmospheric air mass change with time of day and time of year). The table below provides spectral error estimates for shortwave radiation measurements from shortwave radiation sources other than clear sky solar radiation.



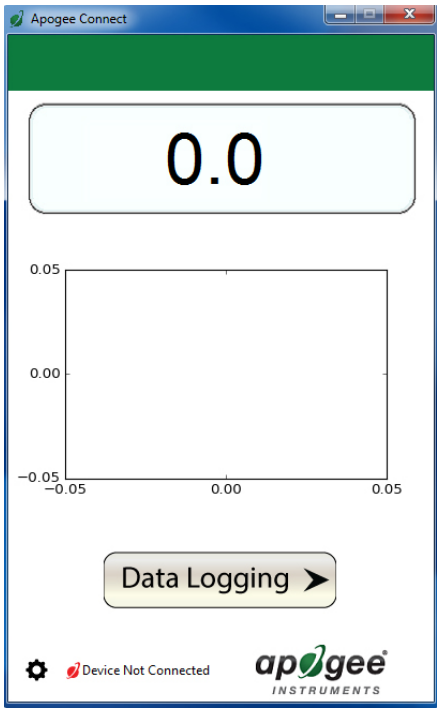

Spectral error for JSP series pyranometers as a function of solar zenith angle, assuming calibration at a zenith angle of 45°.



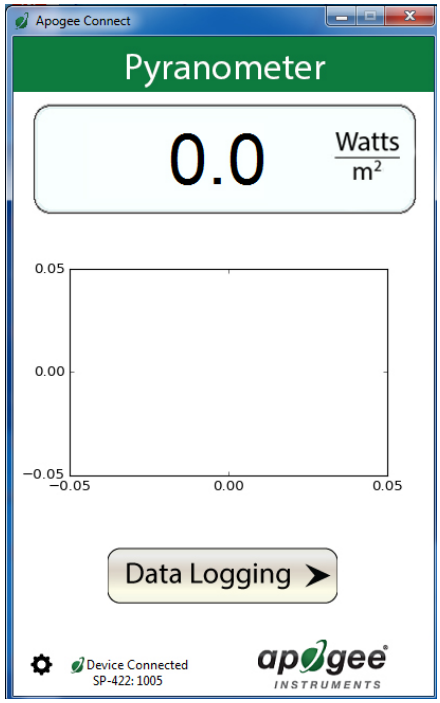

Spectral error for JSP series pyranometers as a function of atmospheric air mass, assuming calibration at an air mass of 1.5.

# WINDOWS SOFTWARE

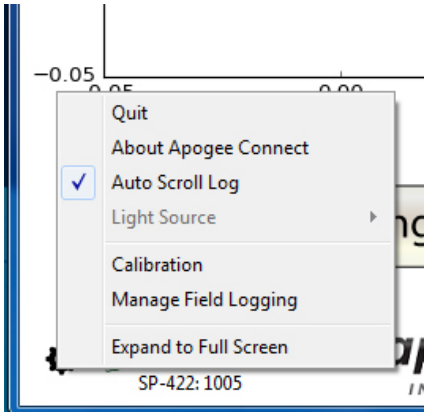
When the JSP-420 sensor is not plugged into the USB port, the software will display a message in the lower left corner, "Device Not Connected," indicating it cannot establish communication with the sensor.



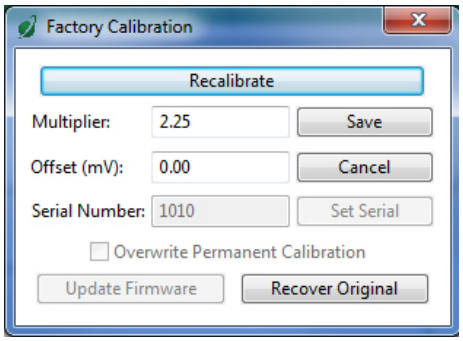

Plug the sensor into a USB port and allow some time for the sensor to automatically establish communication with the software. Once established, the message in the lower left corner will display "Device Connected SN: ####" and real-time shortwave radiation readings will update on the screen. Moving the sensor closer to a light source should increase the readings, while blocking all light from the sensor should drop the reading to zero.



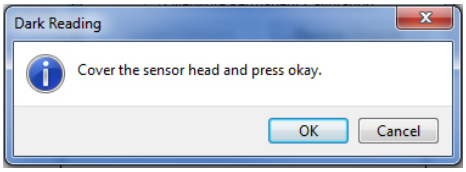
Click the '**Settings**' icon to display the software options. Note **'Light Source'** is not a setting for the JSP-420.



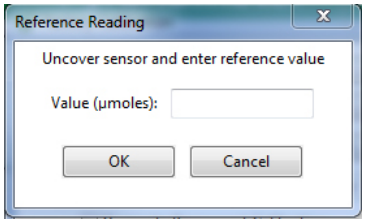

Clicking **'Calibration'** will display the factory calibrated multiplier and offset values. These values are saved in firmware and can be recovered by clicking the 'Recover Original' button. Deriving a new calibration multiplier and offset is accomplished by clicking the 'Recalibrate' button. This is applicable if users want to calibrate the sensor to their own specific light source. Note that a reference value of the light source is required to complete a recalibration.



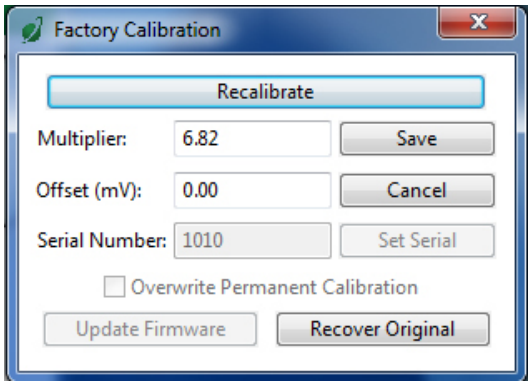

After clicking the 'Recalibate' button the user will be prompted to cover the sensor. Place a dark cap over the sensor and wait for the real-time shortwave readiation reading to settle at zero. Click OK.



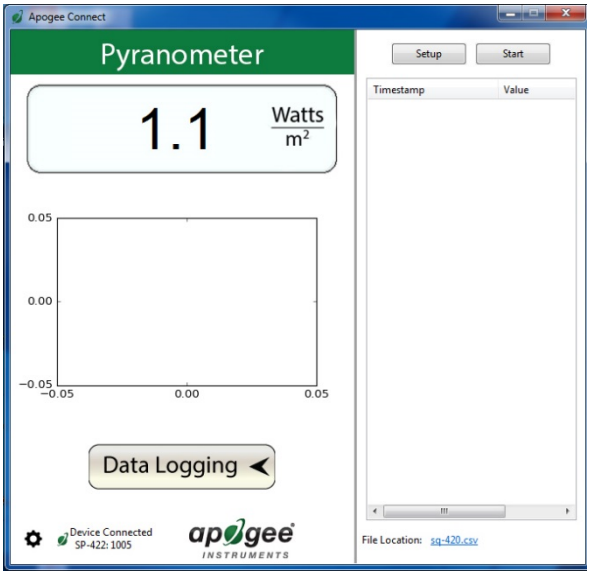
Uncover the sensor and wait for the shortwave radiation reading to settle ***before*** entering the reference value. Click OK.




The multiplier and offset values will automatically calculate and update in the appropriate field. Be sure to click 'Save' to retain the new multiplier and offset.

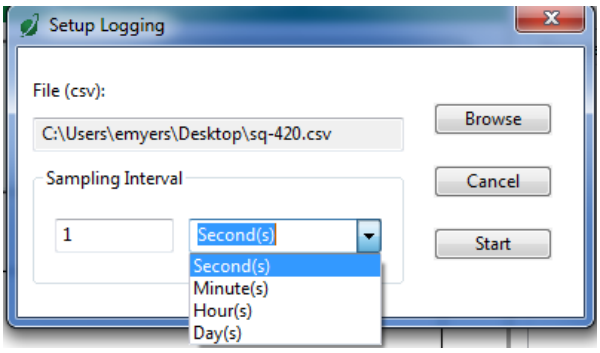



Clicking **'Data Logging'** will allow the user to log interval measurements in a csv file while the software is open and communicating with the sensor.



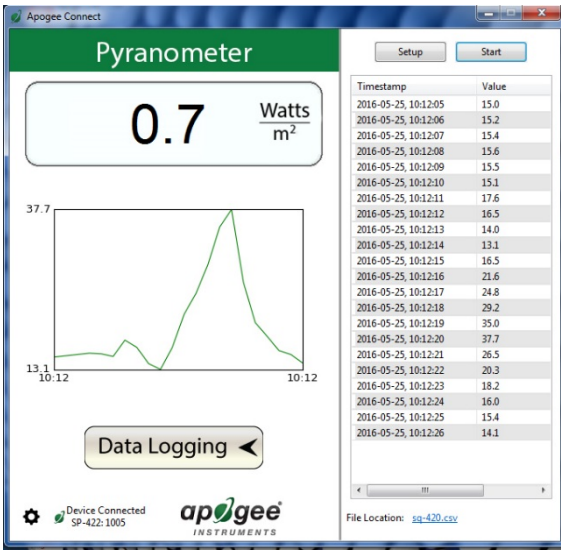

Click 'Setup' and the Setup Logging window appears. Click the 'Browse' button to create or select a csv file.

Select the desired sampling interval. Note that 1 second is the minimum interval allowed. Click 'Start'.

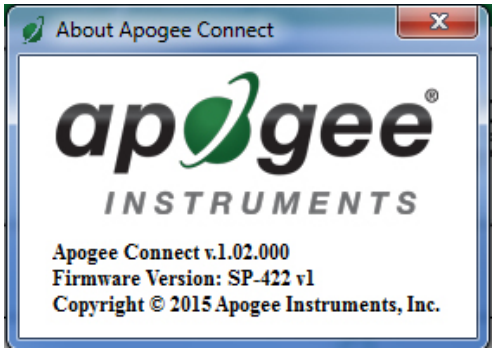


The data logging window will start to update at the specified sampling interval and display the Timestamp and Data Value. At the same time, data will be written to the csv file. Note that if the csv file is open in another program new data will not be saved to it.

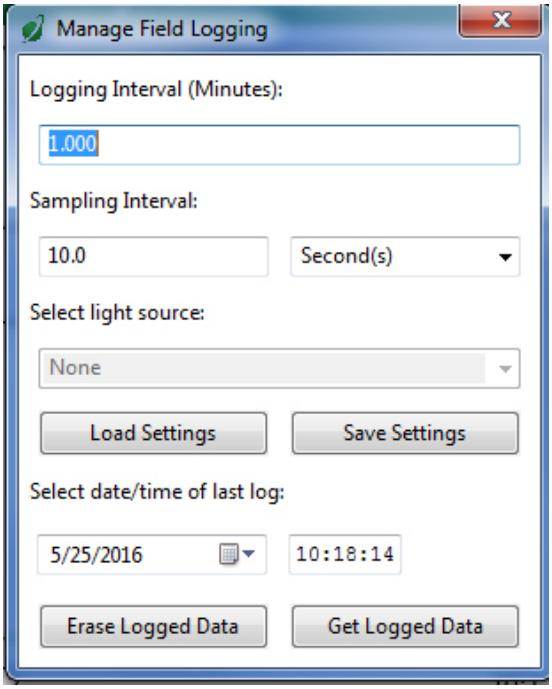
The data logging window can be closed without affecting logged data by clicking the 'Exit' button. The 'Stop' button must be clicked to end data logging.



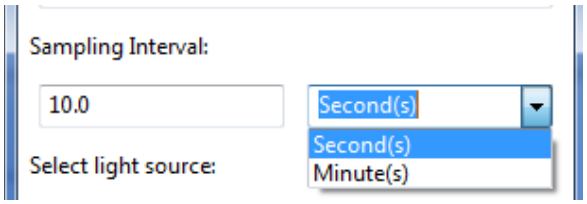

The about screen tells you the software and firmware versions. These can be used to help troubleshoot if problems arise.



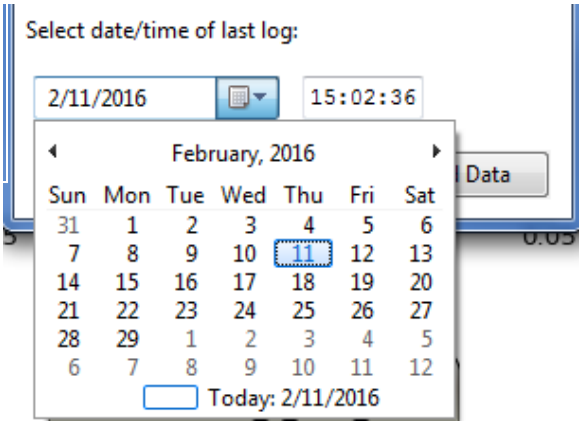

**'Manage Field Logging'** is used to setup the JSP-420 for use in the field. When the JSP-420 is supplied power from a USB power source it will log data which you can retrieve. Choose the interval that data is saved as well as the interval that data is sampled and the light source used. The shortest sampling interval is 1 second. The longest sampling or logging interval is 1440 minutes (1 day). Click 'Load Settings' to see current settings and 'Save Settings' to save the settings you want to the sensor. Note: If you don't click save the sensor won't change the settings.



Set the sampling interval in minutes or seconds. The sampling interval is how often a measurement is taken and logging interval is how often the data is saved. The logged data is the average of the samples. The logging interval must be evenly divided by the sampling interval. For example if the logging interval is 5 minutes and the sampling interval is 2 minutes it causes an error. But a sampling interval of 1 minute is acceptable.

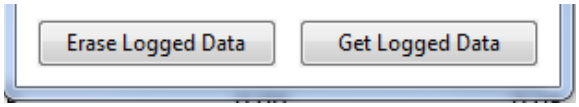



Before clicking 'Get Logged Data' it is important to set the time of the last logged data point. This is used to back calculate the timestamps for the remaining data points. If you just unplugged the sensor and plugged it into the computer the preloaded day and time should be sufficient.




Click **'Get Logged Data'** to save the data to your computer. You will be asked where you want to save the data.

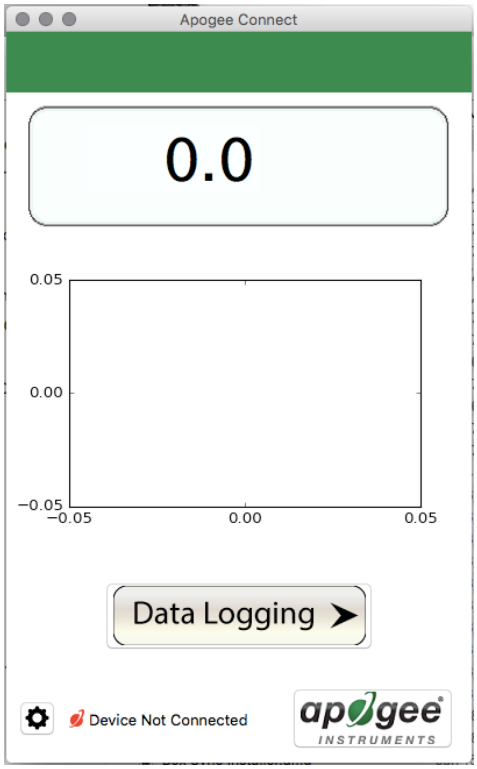
Click **'Erase Data'** to erase all the saved data. This can't be undone.



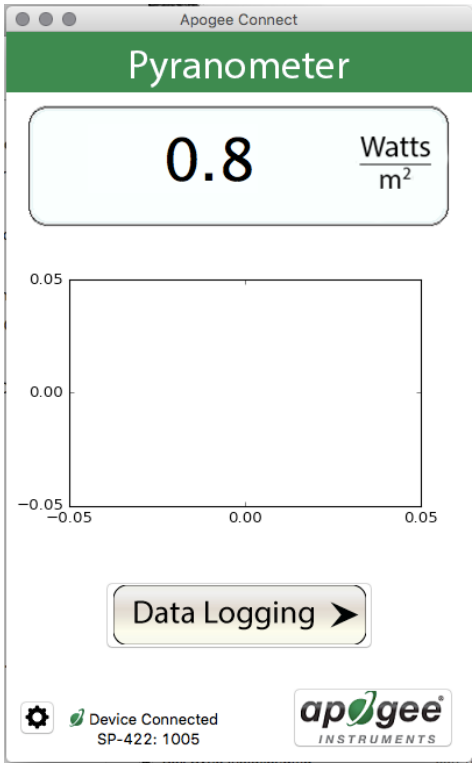

To use additional JSP-420 devices, open additional ApogeeConnect software windows. The device serial number will display in the lower left hand corner of the corresponding software window. Devices may be selected by serial number in the tool bar.

# MAC SOFTWARE

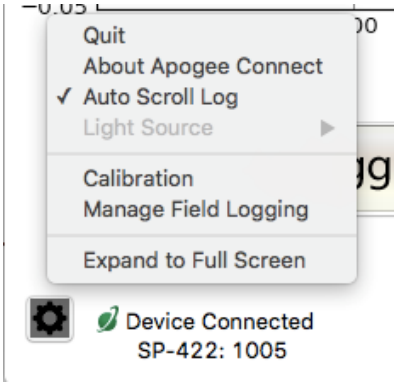
When the JSP-420 sensor is not plugged into the USB port, the software will display a message in the lower left corner, "Device Not Connected," indicating it cannot establish communication with the sensor.




Plug the sensor into a USB port and allow some time for the sensor to automatically establish communication with the software. Once established, the message in the lower left corner will display "Device Connected Model: SN ####" and real-time shortwave radiation readings will update on the screen. Moving the sensor closer to a light source should increase the readings, while blocking all light from the sensor should drop the reading to zero.



Click the **'Settings'** icon to display the software options. Note **'Light Source'** is not a setting option for the JSP-420.

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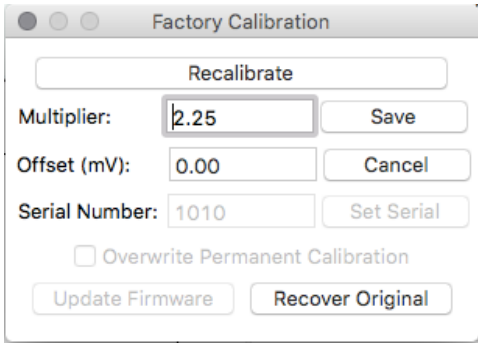
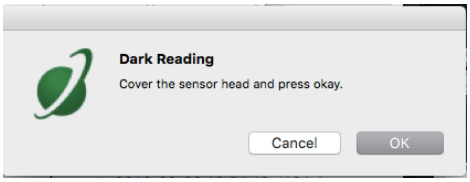
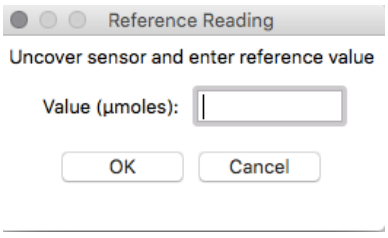


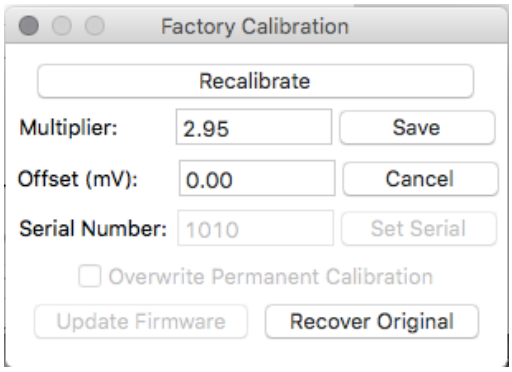

After clicking the 'Recalibrate' button the user will be prompted to cover the sensor. Place a dark cap over the sensor and wait for the real-time shortwave radiation reading to settle at zero. Click OK.




Uncover the sensor and wait for the shortwave radiation reading to settle ***before*** entering the reference value. Click OK.



The multiplier and offset values will automatically calculate and update in the appropriate field. Be sure to click 'Save' to retain the new multiplier and offset.

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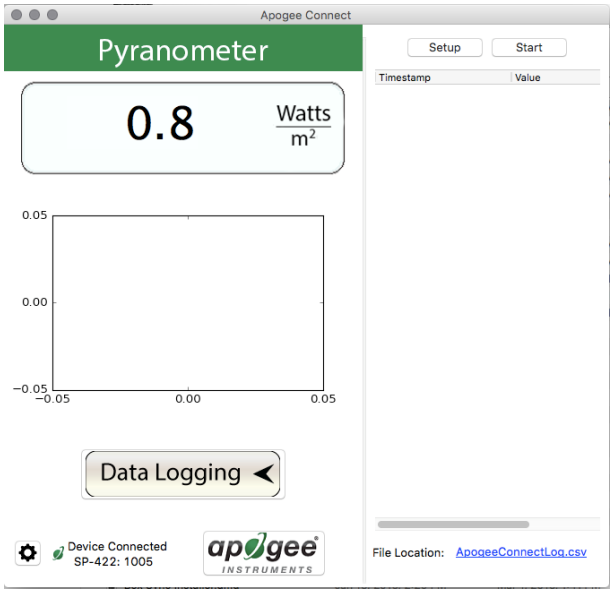
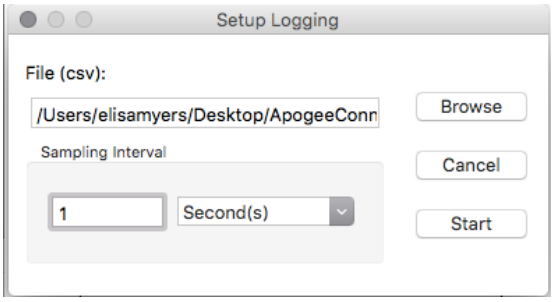


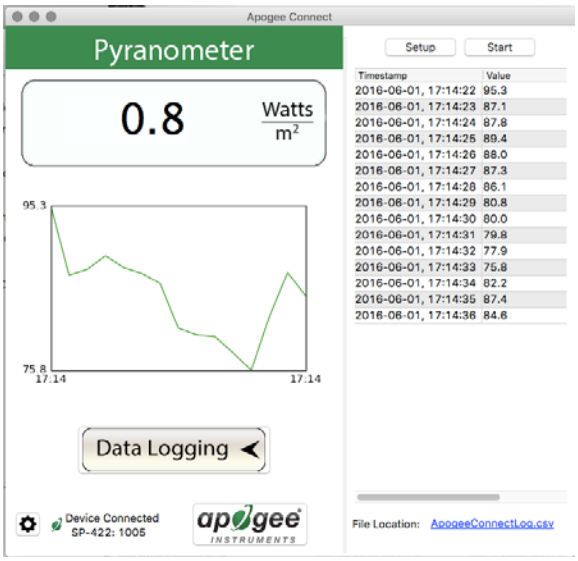

Click 'Setup' and the Setup Logging window appears. Click the 'Browse button to create or select a csv file.

Select the desired sampling interval. Note that 1 second is the minimum interval allowed. Click 'Start'.



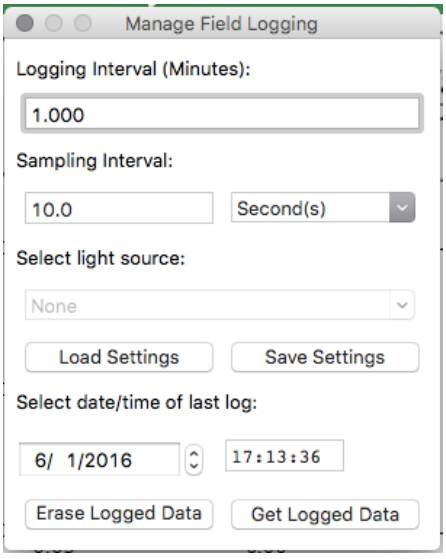
The data logging window will start to update at the specified sampling interval and display the Timestamp and Data Value. At the same time, data will be written to the csv file. Note that if the csv file is open in another program new data will not be saved to it.

The data logging window can be closed without affecting logged data by clicking the 'Exit' button. The 'Stop' button must be clicked to end data logging.

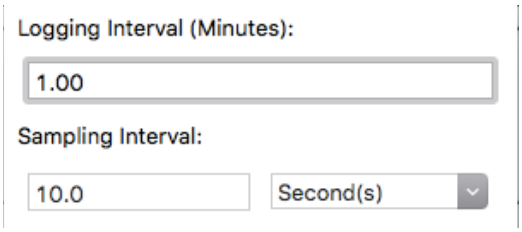



The about screen tells you the software and firmware versions. These can be used to help troubleshoot if problems arise.


'**Manage Field Logging**' is used to setup the JSP-420 for the use in the field. When the JSP-420 is supplied power from a USB power source it will log data which you can retrieve. Choose the interval the data is saved as well as the interval that data is sampled and the light source used. The shortest sampling interval is 1 second. The longest sampling or logging interval is 1440 minutes (1 day). Click 'Load Settings' to see current settings and 'Save Setting' to save the settings you want to the sensor. Note: If you don't click save the sensor won't change the settings.



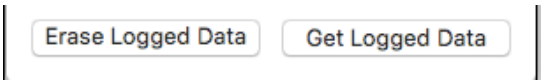
Set the sampling interval in minutes or seconds. The sampling interval is how often a measurement is taken and logging interval is how often the data is saved. The logged data is the average of the samples. The logging interval must be evenly divided by the sampling interval. For example if the logging interval is 5 minutes and the sampling interval is 2 minutes it causes an error. But a sampling interval of 1 minute is acceptable.




Before clicking 'Get Logged Data' it is important to set the time of the last logged data point. This is used to back calculate the timestamps for the remaining data points. If you just unplugged the sensor and plugged it into the computer the preloaded day and time should be sufficient.


Click '**Get Logged Data**' to save the data to your computer. You will be asked where you want to save the data.

Click '**Erase Data**' to erase all the save data. This can't be undone.




To use additional JSP-422 devices, open additional ApogeeConnect software windows. The device serial number will display in the lower left hand corner of the corresponding software window. Devices may be selected by serial number in the tool bar.

**Spectral Errors for Shortwave Radiation Measurements with JSP Series Pyranometers**

| Radiation Source (Error Calculated Relative to Sun, Clear Sky) | Error [%] |
|---|---|
| Sun (Clear Sky) | 0.0 |
| Sun (Cloudy Sky) | 9.6 |
| Reflected from Grass Canopy | 14.6 |
| Reflected from Deciduous Canopy | 16.0 |
| Reflected from Conifer Canopy | 19.2 |
| Reflected from Agricultural Soil | -12.1 |
| Reflected from Forest Soil | -4.1 |
| Reflected from Desert Soil | 3.0 |
| Reflected from Water | 6.6 |
| Reflected from Ice | 0.3 |
| Reflected from Snow | 13.7 |