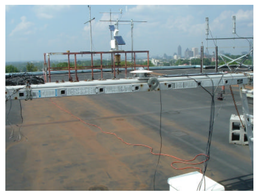
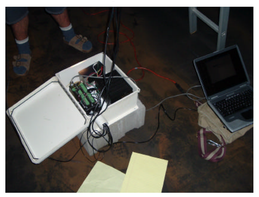
Suitability of the BP MSX 01 Photovoltaic Module for Use as a Pyranometer

Bryan Woods, UMass Lowell

Observations were taken at a rooftop meteorological station at Clark Atlanta University. Samples were taken every second and averaged for 10 seconds. Data was stored in a Campbell Scientific CR10X Data Logger. Measurements were taken from 3 BP MSX 01 Photovoltaic Modules, an Eppley Precision Spectral Pyranometer, and a Li-cor LI-200SZ Pyranometer.



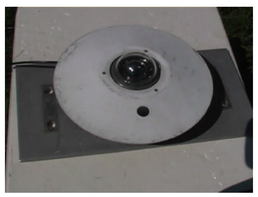
Rooftop Station



CR10X Data Logger

Eppley Precision Spectral Pyranometer

- Designed for the measurement of sun and sky radiation,
- Comprises a circular multi-junction wire-wound Eppley thermopile which has the ability to withstand severe mechanical vibration and shock.
- Receiver is coated with Parson's black lacquer (non-wavelength selective absorption).
- Supplied with a pair of removable precision ground and polished hemispheres of Schott optical glass.
- Hemispheres are made of clear WG295 glass which is uniformly transparent to energy between 0.285 to 2.8µm.
- Has a cast bronze body with a white enameled guard disk (shield)
- Specifications
  - Spectral Range: 295-2800 nm
  - Sensitivity: ~9 µV/Wm^{-2}
  - Typical Output: 0-10 mV analog signal
  - Impedance: ~650O
  - Physical Characteristics: 7.5” diameter, 3.5” high, 7 pounds
  - Mounting: 3 holes on 4.75” diameter bolt circle
  - Calibration: traceable to the World Radiation Reference
  - Classification: ISO 9060 Secondary Standard Pyranometer
  - Response time: 1 second
  - Linearity: ±0.5% from 0 to 2800
  - Cosine: ±1% from normalization 0-70° zenith angle; ±3% 70-80° zenith angle
  - Temperature Response: ±1% from -20 to +40°C
  - Tilt Error: none
  - (Eppley Lab)

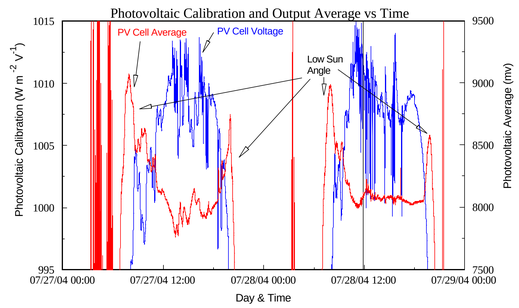


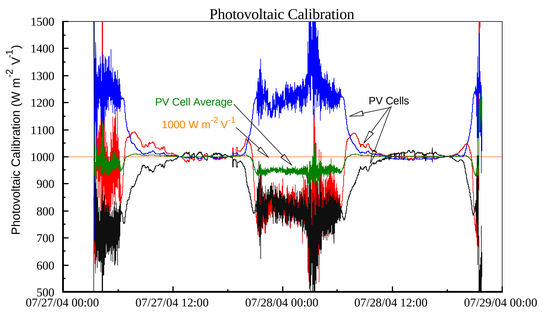
Eppley Precision Spectral Pyranomter

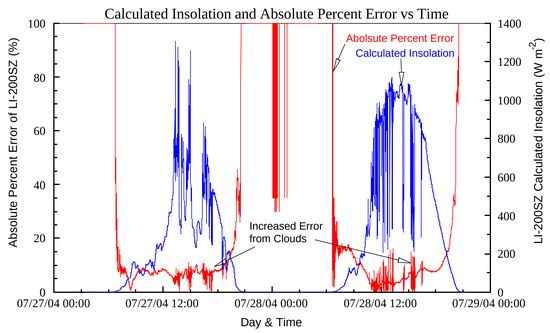
Li-cor LI-200SZ Pyranometer

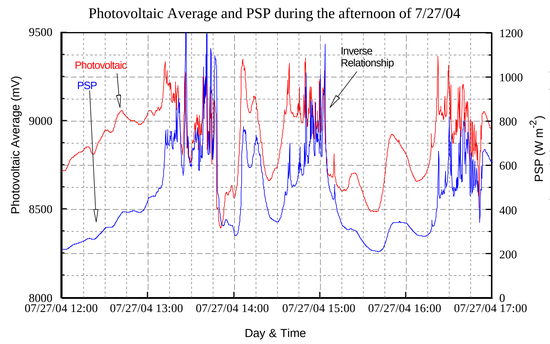
Li-cor LI-200SZ Pyranometer

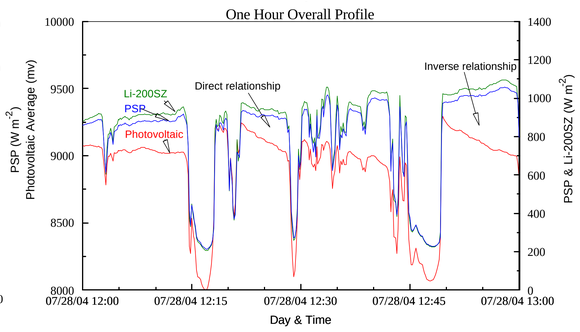
- Silicon Photodiode Sensor with equal spectral response from 280-2800 nm
- Mounted on Li-cor 2003S Mounting and Leveling Fixture
- Response Time: 10 µs
- Temp. Dependence: ± 0.15% per ° C maximum
- Cosine Correction: Cosine corrected up to 80 ° angle of incidence.
- Azimuth: < ± 1% error 360° at 45 ° elevation.
- Tilt: No error induced from orientation.
- Detector: High stability silicon photovoltaic detector (blue enhanced)
- Sensor Housing: Weatherproof anodized aluminum case with acrylic diffuser and stainless steel hardware.
- Size: 2.38 cm Diameter X 2.54 cm Height (0.94” x 1.0”)
- Calibration: Calibrated against Eppley Precision Spectral Pyranometer (PSP) under natural daylight conditions. Absolute error under these conditions is ± 5% maximum, typically ± 3%.
- Sensitivity: Typically 80 µA per kW m^{-2}
- Stability <± 2% change over a one year period.











Conclusions

- LI-200SZ error analysis well within bounds provided for Li-cor calibration and specifications
- Photovoltaic calibration requires significant amounts of additional data, both clear and cloudy conditions
- LI-200SZ correlates (.9992) much better than photovoltaic cells (.6856) in comparison to PSP at first glance
- Still unexplained behavior involving solar module voltage spikes and following decay curves.
- Each photovoltaic cell has a unique calibration equation. (Possibly related to slight angle of mount?)
- Photovoltaic cells show larger errors during periods of low sun angle making them less suitable for northern, winter, and twilight applications.
- Photovoltaic cells show overall minor calibration constant fluctuations .
- On the seconds and hour scales, photovoltaic cell correlate well.
- Errors emerge on photovoltaic calibrations on the minute scale.

Future Research

- Explain solar module decay curve relationships
- Determine polynomial calibration equation for each cell. Be sure to include vertical translation of each curve.
- Examine cell reactions to smog, ice/snow/rain, thick stratus cloud cover, and spotty convective cloud cover.
- Determine cell response time and sensitivity.

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