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Informal Report

# *METEOROLOGICAL SERVICES*

# *ANNUAL DATA REPORT FOR 2012*

John Heiser & Scott Smith
Meteorological Services
Environmental Research & Technology Division
Environmental Sciences Department
Brookhaven National Laboratory

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**Environmental Sciences Department/Energy Research and Technology Division**

**Brookhaven National Laboratory**
P.O. Box 5000
Upton, NY 11973-5000
www.bnl.gov

## DISCLAIMER

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## Purpose

This document presents the meteorological data collected at Brookhaven National Laboratory (BNL) by Meteorological Services (Met Services) for the calendar year 2012. The purpose is to publicize the data sets available to emergency personnel, researchers and facility operations. Met services has been collecting data at BNL since 1949. Data from 1994 to the present is available in digital format. Data is presented in monthly plots of one-minute data. This allows the reader the ability to peruse the data for trends or anomalies that may be of interest to them. Full data sets are available to BNL personnel and to a limited degree outside researchers. The full data sets allow plotting the data on expanded time scales to obtain greater details (e.g., daily solar variability, inversions, etc.).

## Background

Meteorological Services (Met Services) is responsible for the maintenance, calibration, data collection and data archiving for the weather instrumentation network at Brookhaven National Laboratory. Measurements include wind speed, wind direction, temperature, rainfall, barometric pressure and relative humidity. Wind speed, wind direction and temperature are measured at 85 meters, 50 meters and at 10 meters. Rainfall, relative humidity, temperature and barometric pressure are taken at the 2 meter height. This critical data set is used for NEPA calculations, for emergency planning and operations (i.e., chemical spill or accidental release) and general research. In addition to the weather sensors, Met Services maintains a solar resource base station which measures solar radiation at BNL. Instruments include Solys-2, sun tracker equipped with a pyrheliometer (direct normal incidence radiation), a ventilated, shaded pyrgeometer (downwards long-wave, infrared radiation), a ventilated, shaded, research grade pyranometer (diffuse solar radiation) and a ventilated, unshaded, research grade pyranometer (global solar radiation). The base station also has a Total Sky Imager for cloud imaging and two SP-Lite2 pyranometers that replicate the research array sensors at the Long Island Solar Farm (LISF).

Meteorological data is also presented in real time via a webserver at http://wx1.bnl.gov. Current weather parameters are posted here. Using buttons and pull-down menus the user has a method to graph the data from several hours to several days for the past 12 months ( http://wx1.bnl.gov/graph.html ) and stability class (http://wx1.bnl.gov/stability.php ). Graphing includes barometric pressure, temperature (@ all locations), wind speed, wind direction, wind gust, humidity, precipitation and solar radiation.

## Site

Weather conditions at the BNL site have been recorded since August 1948. BNL is broadly influenced by continental and maritime weather systems. Locally, the major weather systems are modified by the Long Island Sound, the Atlantic Ocean and associated bays, which influence wind directions and humidity, and provide a moderating influence on extreme summer and winter temperatures.

BNL is a well-ventilated site, with an annual distribution of wind direction reflecting a predominance of westerly components. Prevailing winds are from the southwest during the summer, from the northwest during the winter, and about equally from these two directions during the spring and fall.

**Instrument Towers**

**85-meter Tower**

The 85-meter (280-ft.) meteorological tower was placed in operation in May 1981 to replace the former and original "Ace Tower" used in the first 30 operational years at BNL. The tower (Fig. 1) is located in an open field west of the majority of the Brookhaven building complex at latitude 40°52'14.84"N and longitude 72°53'20.05"W and its base is 24 m (80 ft.) above sea level and is referred to as "Tower Ten". In this document, the primary, tall tower will be called, the main or 85-meter tower to avoid confusion with the smaller, secondary 10-meter tower also in operation at the Met field.

The main tower is made of galvanized steel, is triangular in shape with 3 ft. sides and has 3 sets of 8 guy wires to keep it upright. It has an inside ladder for climbing, and two working levels with small platforms. It is difficult to mount booms and equipment or to work on this tower. Special safety belts and harnesses are required when climbing, maintaining or calibrating equipment on this tower. Sensor location names designate the approximate height of the sensors above the ground. At each location there are fully redundant sensor sets. Each set is independent of the other with unique data loggers and sensors. At locations M85 and M50 instrumentation includes; R.M. Young model 5106 Marine grade wind monitors for wind speed and direction and R.M. Young model 41342VC temperature probes. The temperature probes are protected by naturally aspirated radiation shields. Data collection is via Campbell CR1000 data loggers and transmitted to the main data computer via Campbell model RF401, 900-MHz Spread-Spectrum Radio modems.

**10-meter Tower**

A foldable-mast, ten-meter tower is located approximately at the center of the Meteorological field. Again, fully redundant sensor sets are present. Instrumentation includes R.M. Young model 5106 Marine grade wind monitors for wind speed and direction and R.M. Young model 41342VC temperature probes. The temperature probes are protected by naturally aspirated radiation shields. Data collection is via Campbell CR1000 data loggers and transmitted to the main data computer via Campbell model RF401, 900-MHz Spread-Spectrum Radio modems.

**2-meter pole**

At two meters (located near the 10-meter tower) sensors include; R.M. Young model 41372VC temperature and relative humidity probes and R.M. Young model 61302V barometric pressure sensors. The T/RH probes have actively aspirated (powered fan) shields. Data collection is via Campbell CR1000 data loggers and transmitted to the main data computer via Campbell model RF401, 900-MHz Spread-Spectrum Radio modems.

Two tipping-bucket rain gauges (Novalynx model 260-2501) are maintained on the roof of building 490D. This location was chosen for available 115VAC for the heaters in the gauges required for winter use. Data collection is via Campbell CR1000 data loggers with direct network connections.

**Solar Base Station**

Met Services maintains a platform on the roof of building 490D. This platform is used for testing of sensors and also houses the LISF research projects base station for solar irradiance measurements. Instrumentation at this location includes; a Kipp and Zonen model Solys-2 suntracker equipped with a shaded Kipp and Zonen model CGR-4 pyrgeometer for long-wave, far infrared radiation, a Kipp and Zonen model CHP-1 pyrheliometer to measure direct normal indicent radiation and two Kipp and Zonen CMP-22 research grade pyranometers, one shaded and one unshaded, to record diffuse and global radiation. BNL is also home to the Long Island Solar Farm (LISF) where we maintain a research array of sensors including pyranometers. As a reference for the LISF sensor array, two Kipp and Zonen model SP-lite2 pyranometers are maintained, one in-plane (aka tilted global radiation) at the 27° angle of inclination for the panels at the LISF and one horizontal (global radiation). Data collection is via a Campbell CR3000 data loggers directly connected to the network. Additionally a Total Sky Imager (TSI) is mounted on the platform and is directly connected to the network. Images from the TSI are available to BNL users.

**Calibrations**

All sensors are calibrated annually in accordance to the BNL Meteorological Instrument Network Calibration Plan (Heiser 2012). Where an instrument is sent off site for calibration a duplicate calibrated unit is available for replacement.

The calibration and maintenance frequency is based on the following hierarchy:

1. Manufacturers recommendation as stated in the instruments Operation Manual or Owner's Instruction Manual.

2. Manufacturers recommendation as stated in other communications such as a memorandum, email, or documented phone conversation.

3. Other engineering or scientific standards specifically referring to a particular type of instrument (e.g., American Nuclear Society, American National Standards Institute).

4. Met Services determination of calibration needs based on experience with the equipment or recommendations from other sources.

Calibration certificates are required from the companies performing calibrations and these certificates are compiled in the Instrument Calibration Notebook. For sensors that are calibrated on site or in-situ by BNL personnel, the data taken is recorded on instrument specific data sheets and the sheets are compiled into the Instrument Calibration Notebook. The original notebook is

maintained by the head of Met Services. Additionally, an electronic master list of equipment and the current status of each instruments calibration along with calibration coefficients is maintained on the Met Services master computer with copies available from the Head of Met Services and the Operations Officer.

**Data Sets and Data Availability**

Meteorological sensors are checked daily and duplicate sensors intercompared. On a monthly basis the data goes through a QA/QC process to help eliminate bad records and correct or remove any erroneous values. The post processing of the data involves visually analyzing the data in eight day increments looking for bad data points. MatLab, data analysis software, is used for this purpose. Using a series of scripts it is relatively easy to remove single or multiple data points. Once the bad data is removed the operator can chose to fill in the missing points by interpolation or leave the data as "missing". The data is then saved to a file. This data is then backed up along with the raw unedited data. In addition to this we also do a comparative analysis on the "A" and "B" datasets to insure precision between the two independent systems. Data reported is generally taken from the "A" side sensors with "B" side sensors serving as backups. If data checks show the A sensors to be out of service, out of spec or questionable the data is replaced by B sensor data until the A sensor is replaced/repaired.

After the editing is complete, daily and hourly averages and sums are calculated and saved to files to be disseminated upon request. The averages are then added to a spreadsheet that includes all the past data collected here at BNL, going back as far as 1949. See; http://www.bnl.gov/weather/MonthlyClimatology.asp

Currently data is available as monthly, daily, hourly and one minute averages. Subsets of the main data set are also available. Most requests are for a small, specific time frame, which can usually be produced in one to two days.

**Meteorological Data Recovery for 2012**

In 2012 the transition from the old, rundown equipment, to the new instrumentation and data collection equipment was completed. On June 1st at approximately 1335 hours the next generation of meteorological equipment on the main tower went into service. This has dramatically increased the reliability of the system overall.

For the year, because of the new hardware and data collection method, Met Services had a 100 percent record retrieval rate. Collecting all of the 527,040 records for the year is the first step in achieving a better than 99 percent data recovery rate. During the course of the year there were a number of instrument failures that resulted in a loss of data. The large majority of these occurred prior to the completion of the instrument upgrade. In January the solar irradiance sensor stopped reporting for 3 days and this amounted to approximately 4300 lost data points. This combined with other sporadic loses totaled 4784 data points lost for the month. In March the 85 meter level was transmitting sporadically in addition to losing 1354 consecutive measurements from this

level. There was a total loss of 7018 data points during the month of March. All of the other months had less than 1000 datapoints lost with 4 months reporting no loss of data.

Of the 9,227,520 data points available for collection the system failed to record 13,006 points. This equates to a loss of just 0.141% of the total amount of data available for recording or 99.86% data recovery for the year.

2012 was the first full year that the Solar Base Station (SBS), that supports the LISF, was in operation. There was one major failure to the tracker that required that it be returned to the factory for repair. This repair took the better part of six weeks to complete. Therefore, the CHP and the diffused measurements were not taken. There also was a weekend power outage in the building that houses the equipment in addition to a few minor stoppages of data.

For the first year of operation we collected 517476 of a possible 527040 records for the year. That is 98.19% of all possible records were recorded. Of the collected data we expected to see 3,622,332 fields of good data. We had 169,593 fields with bad data. That is 4.68% of the fields contained bad data. So of the 98.19% data we recovered 95.32% was considered good data.

**2012 Meteorological Data**

**Table 1. 2012 Extremes and Totals[a]**

| | |
|---|---|
| Highest Temperature | 34.8 C° July 18th |
| Lowest Temperature | -14.2 C° January 16th |
| Average Yearly Temperature | 12.4 C° |
| Annual Precipitation | 48.93" |
| Maximum Monthly Precipitation | 8.26" in July |
| Minimum Monthly Precipitation | 1.11" in March |
| Maximum Daily Precipitation | 5.56" on July 28th |
| Maximum Hourly Rainfall | 1.78" on July 28th from 0800hrs to 0900hrs |
| Maximum Wind Speed (85 meters) | 28.4 m/s (63.5 mph)<br>October 29th Tropical Storm Sandy |
| Maximum Wind Gust (85 meters) | 40.1 m/s (89.7 mph)<br>October 29th Tropical Storm Sandy |
| Maximum Wind Speed (10 meters) | 16.2 m/s (36.2 mph)<br>October 29th Tropical Storm Sandy |
| Maximum Wind Gust (10 meters) | 26.8 m/s (60.0 mph)<br>October 29th Tropical Storm Sandy |
| Maximum Barometric Pressure | 1036.1 November 18th |
| Lowest Barometric Pressure | 965.8 mbar<br>October 29th Tropical Storm Sandy |
| Lowest Relative Humidity | 13% April 3rd |
| Heating Degree Days | 4784.0 |
| Cooling Degree Days | 786.3 |
| Average Daily Irradiance | 168.9 W/m$^2$ |

a = Measurements taken at the 2 meter height unless otherwise noted.

**Air Temperature**

Temperature is measured at 2-meters, 10-meters, 50-meters and 85-meters at the locations described above. The probes are calibrated internally by BNL staff. A high quality constant temperature bath along with a reference platinum resistance thermometer (PRT) are used to perform a comparison calibration curve. The PRT is calibrated off-site to NIST standards. Air temperature sensors are maintained to ±0.1°C, which is the requirement for determining stability class by temperature differential.

Met Services uses a characterization calibration using four points (temperatures T=-10°C, 5°C, 20°C and 35°C). For platinum resistance probes and modest accuracy applications the resistance-temperature relationship can be approximated by the Callendar-Van Dusen equation as:

$R(t) = R(0)[1 + At + Bt2 + C(t-100)t3]$

Where:
t = temperature (°C),
R(t) = resistance at temperature t,
R(0) = resistance at 0°C,
and using ASTM 1137 and IEC 60751 coefficient values for a standard 100 ohm sensor having an alpha value of 0.00385;
A = 3.9083 x 10-3 (°C-1),
B = -5.775 x 10-7(°C-2) and
C = -4.183 x 10-12 (°C-4) [for temperatures above 0°C, C = 0]

Within the temperature range of BNLs minimum observed temperature (-31°C) and maximum observed temperature (38°C), the B and C coefficients can be ignored and approximated as zero and;

$R(t) = R(0) + R(0) \bullet At$

Met Services uses the comparison method of calibrating temperature sensors. The thermometer is calibrated by comparison with a reference or standard thermometer in a thermally stabilized bath. The procedure uses a four point calibration consisting of -10°C, 5°C, 20°C and 35°C. ANSI/ANS-3.11-2005 lists the air temperature minimum accuracy of 0.5°C and a minimum resolution of 0.1°C (see Appendix H). For stability class determinations using vertical temperature differences the requirements are; a minimum accuracy of 0.1°C and a minimum resolution of 0.01°C. Meteorological data (data from the met field towers) is held to the later (LISF data to the former).

Daily average temperature for the year is presented in Figure 1. Daily minimums and maximums for the year are shown in Figure 2. Table 2 summarizes the 2 meter monthly average daily temperatures, average daily minimum and maximum temperatures and monthly extreme high and lows. Figure 3 depicts the 2012 monthly temperature means and compares them to historic means. Table 3, 4 and 5 lists the historic monthly average, average monthly maximum and average monthly minimum temperatures from 1949 to 2012. Monthly data plots of 1-minute data at the four met field measurement locations are presented in Figures 4 through 15.

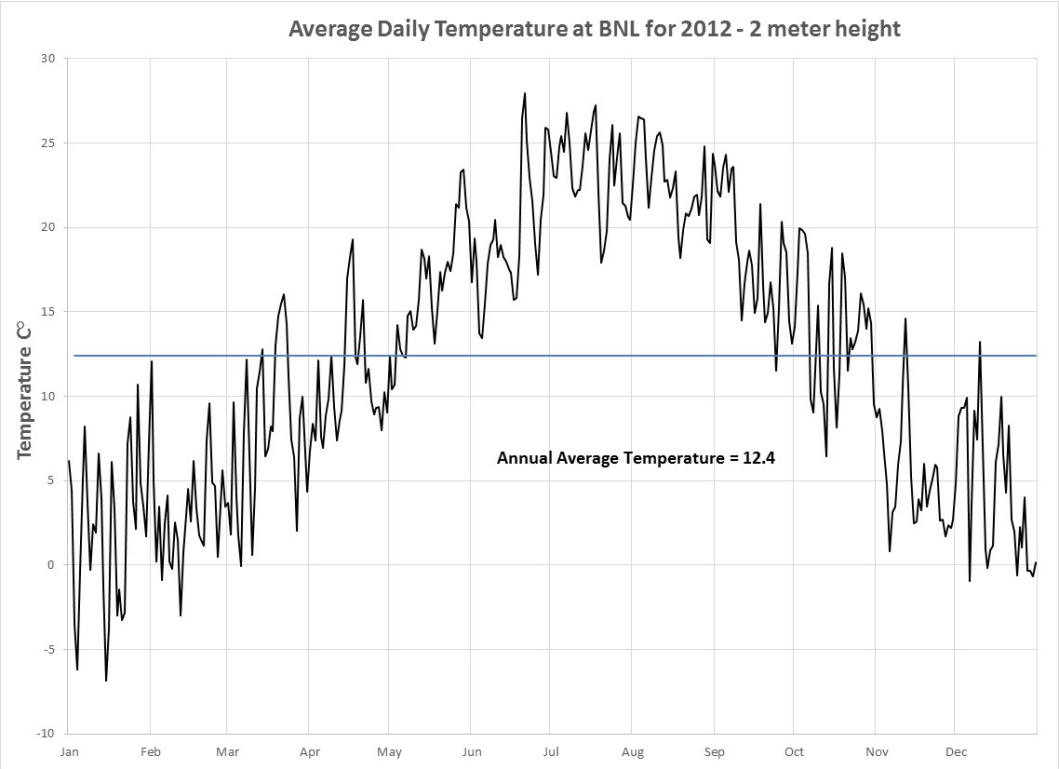


Figure 1 Average Daily Temperature taken at the 2 meter height at BNL for 2012

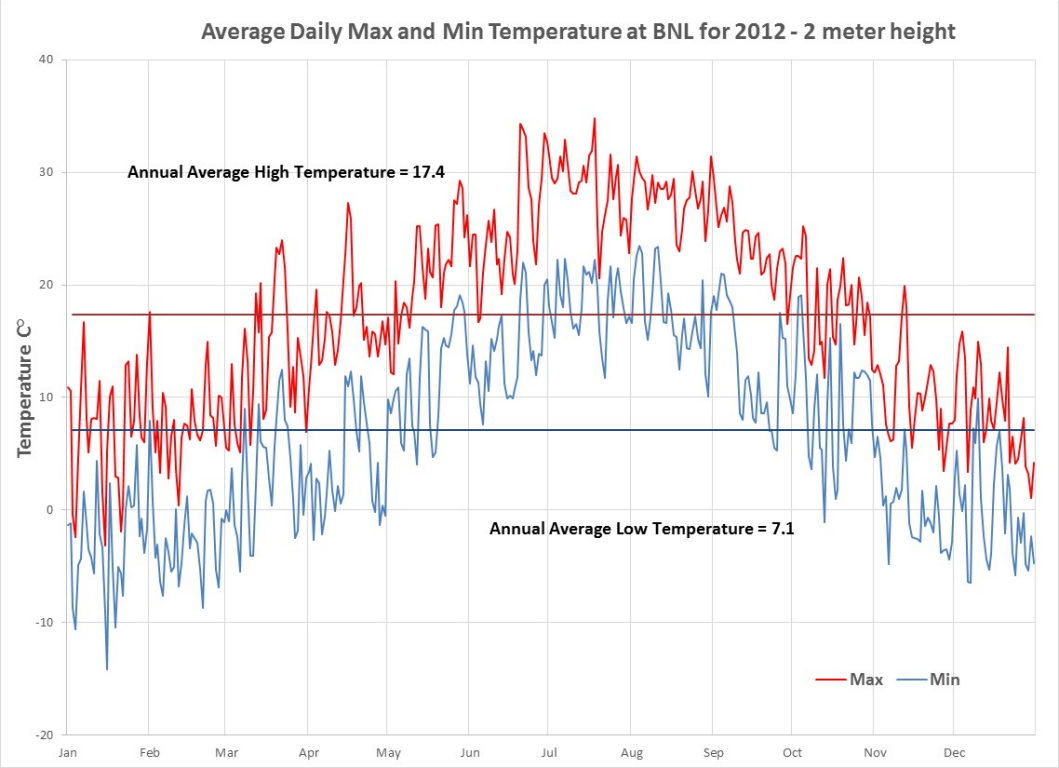


Figure 2 Daily Minimums and Maximums in Temperature taken at the 2 meter height at BNL for 2012

**Table 2. Monthly Temperature Summary**

| Month | 2012 Temperatures (2 meters) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Average | | | Extremes | | | |
| | Daily Mean | Daily High | Daily Low | High | date | Low | date |
| Jan | 2.2 | 7.0 | -3.2 | 16.7 | Jan 7 | -14.2 | Jan 16 |
| Feb | 3.2 | 7.9 | -2.6 | 17.6 | Feb 1 | -8.7 | Feb 21 |
| Mar | 8.0 | 13.2 | 3.0 | 24.0 | Mar 22 | -5.5 | Mar 6 |
| Apr | 10.7 | 16.8 | 3.8 | 27.3 | Apr 16 | -2.7 | Apr 3 |
| May | 16.5 | 21.3 | 11.9 | 29.3 | May 28 | 4.0 | May 12 |
| Jun | 19.5 | 25.0 | 13.9 | 34.3 | Jun 29 | 7.6 | Jun 6 |
| Jul | 23.4 | 28.7 | 18.5 | 34.8 | Jul 18 | 11.7 | Jul 22 |
| Aug | 22.7 | 28.0 | 17.4 | 31.4 | Aug 3 | 10.1 | Aug 30 |
| Sep | 18.3 | 23.4 | 12.7 | 29.4 | Sep 1 | 5.3 | Sep 25 |
| Oct | 14.0 | 18.2 | 9.4 | 25.2 | Oct 5 | -1.1 | Oct 13 |
| Nov | 5.2 | 10.1 | 0.0 | 19.9 | Nov 12 | -4.8 | Nov 6 |
| Dec | 4.4 | 8.5 | -0.1 | 15.9 | Dec 4 | -6.5 | Dec 7 |

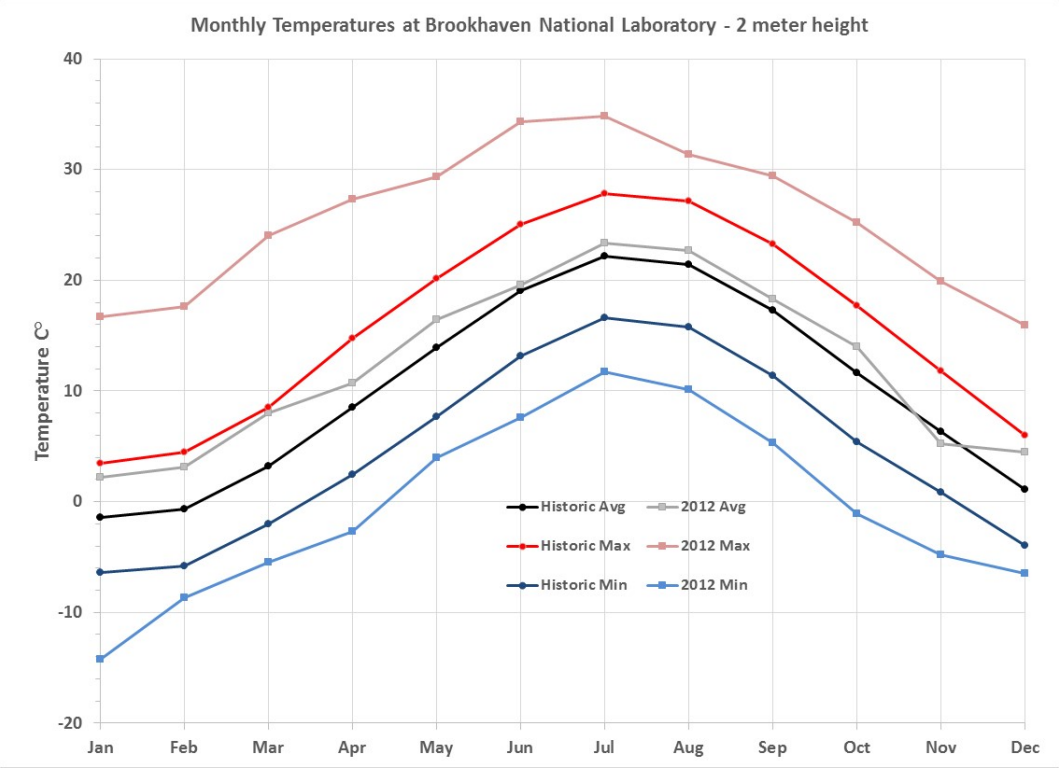


Figure 3 Monthly Mean Temperatures at Brookhaven National Laboratory

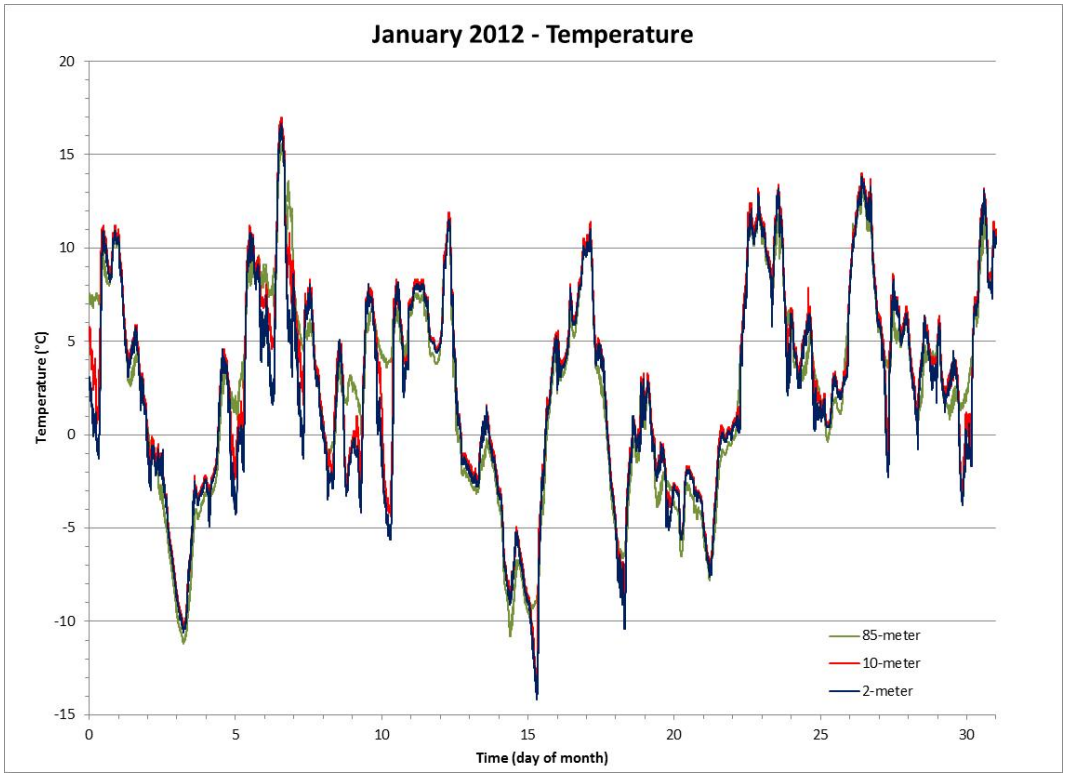


Figure 4 Air Temperature for the Month of January 2012

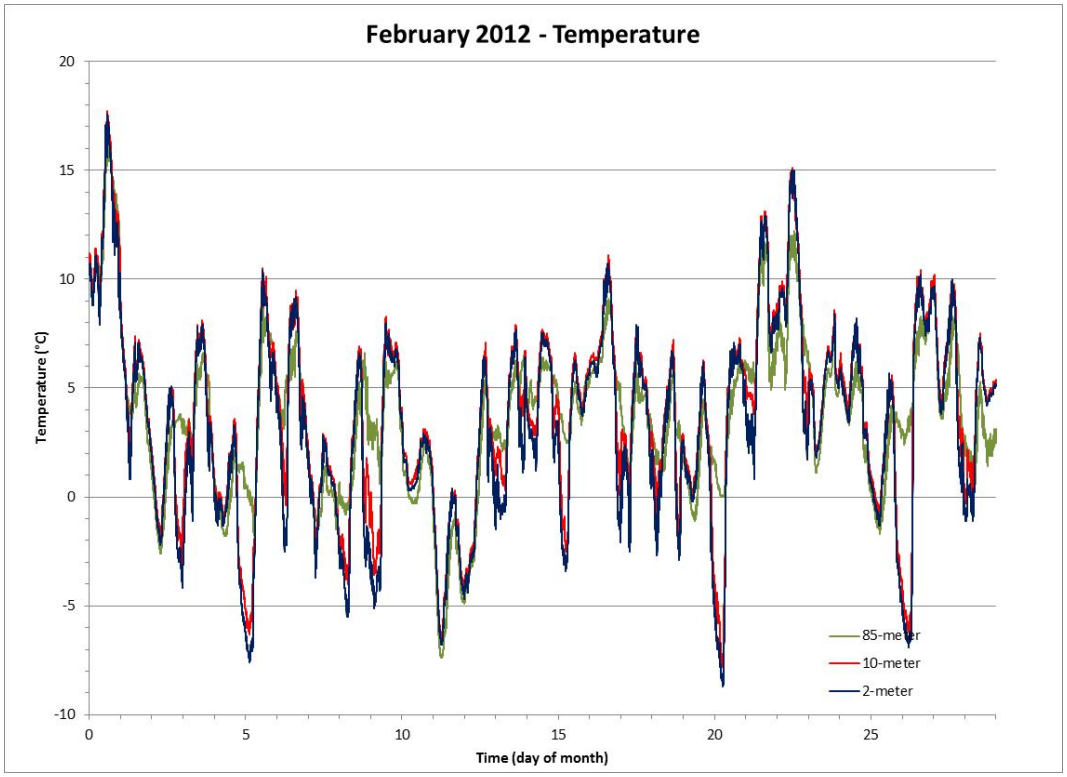


Figure 5 Air Temperature for the Month of February 2012

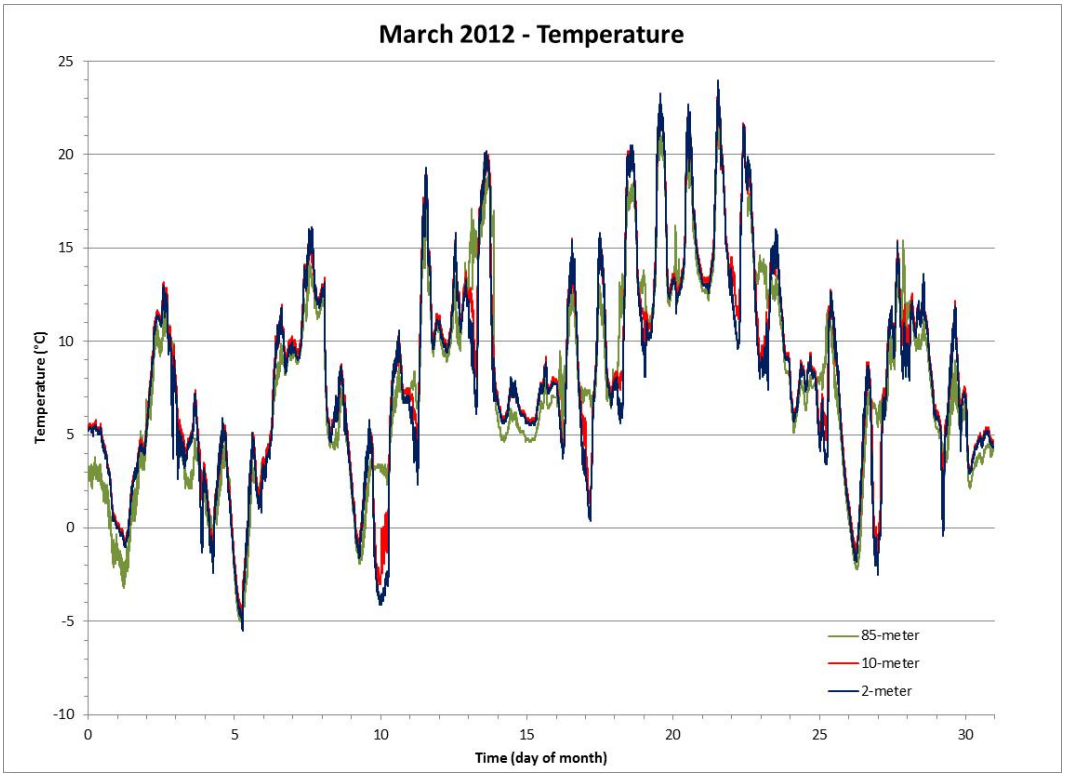

Figure 6 Air Temperature for the Month of March 2012

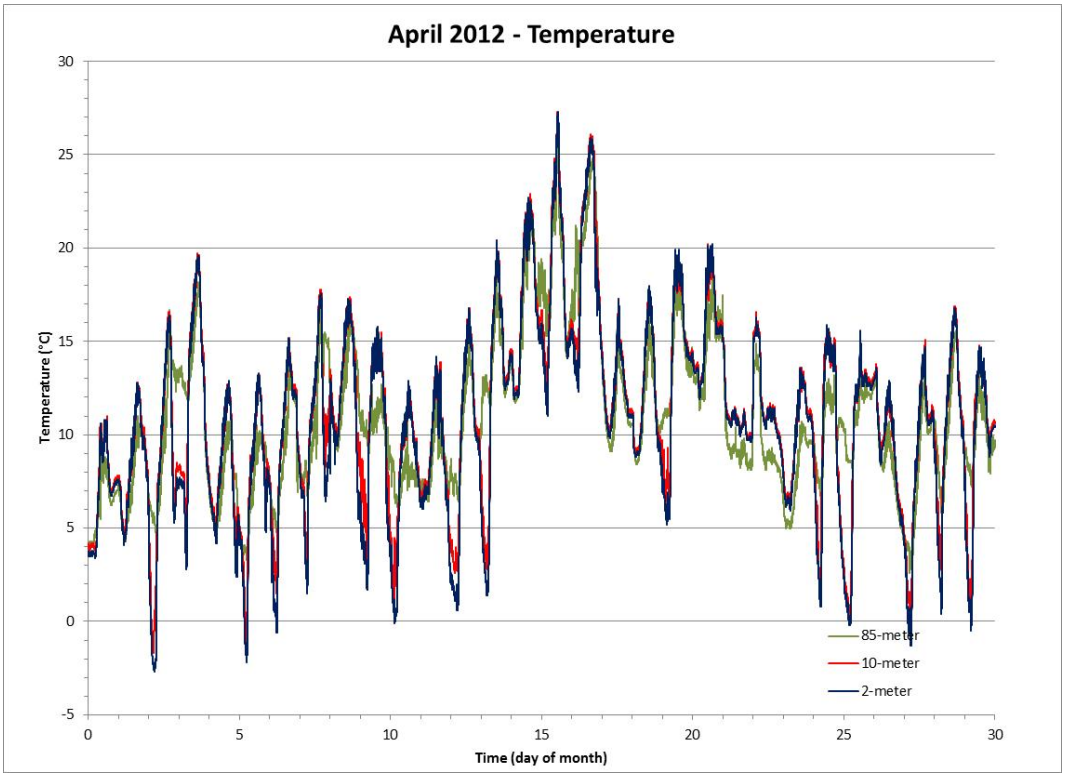

Figure 7 Air Temperature for the Month of April 2012

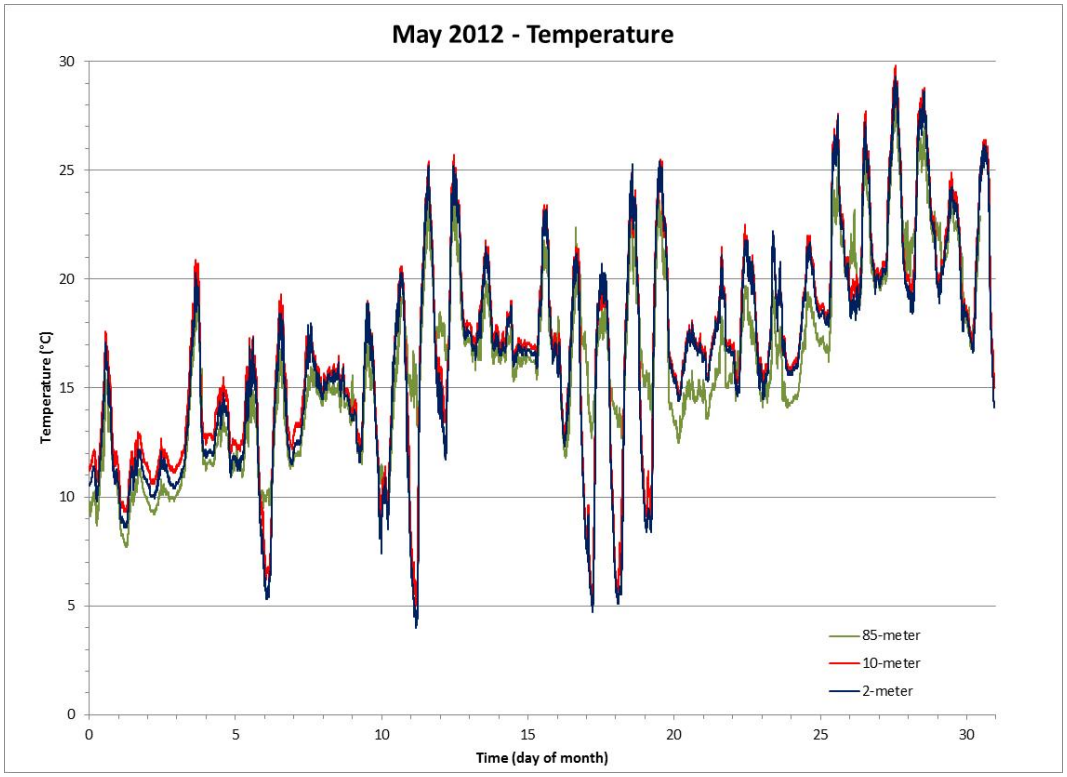

Figure 8 Air Temperature for the Month of May 2012

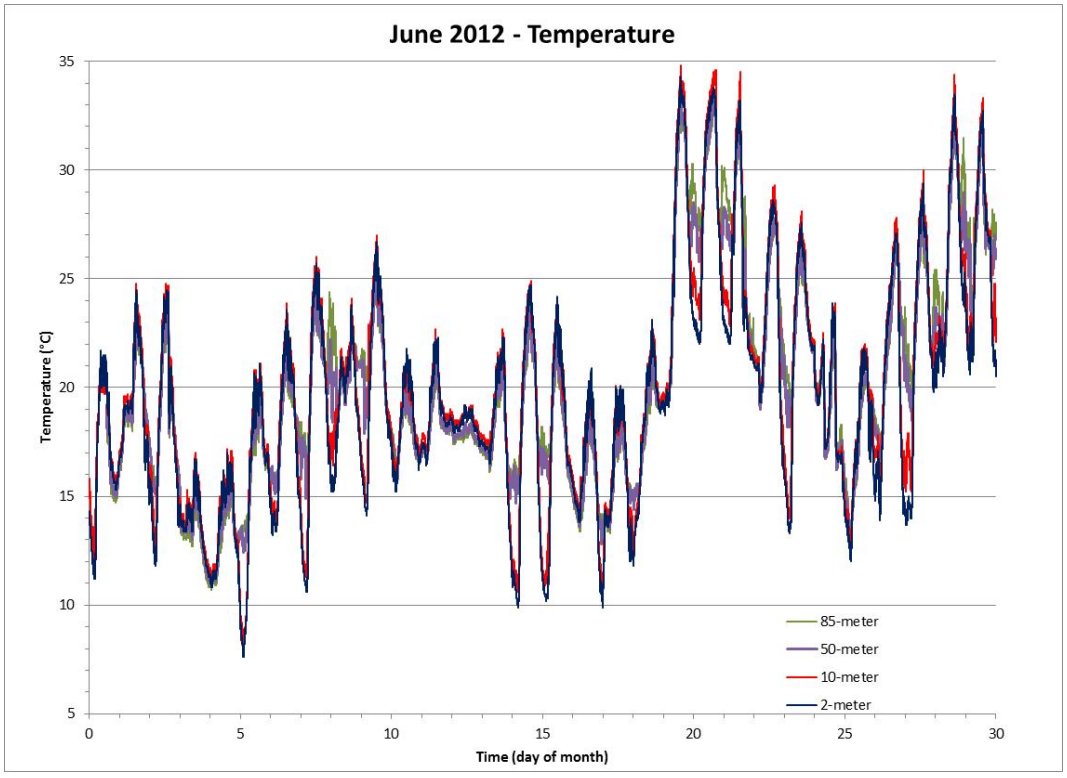

Figure 9 Air Temperature for the Month of June 2012

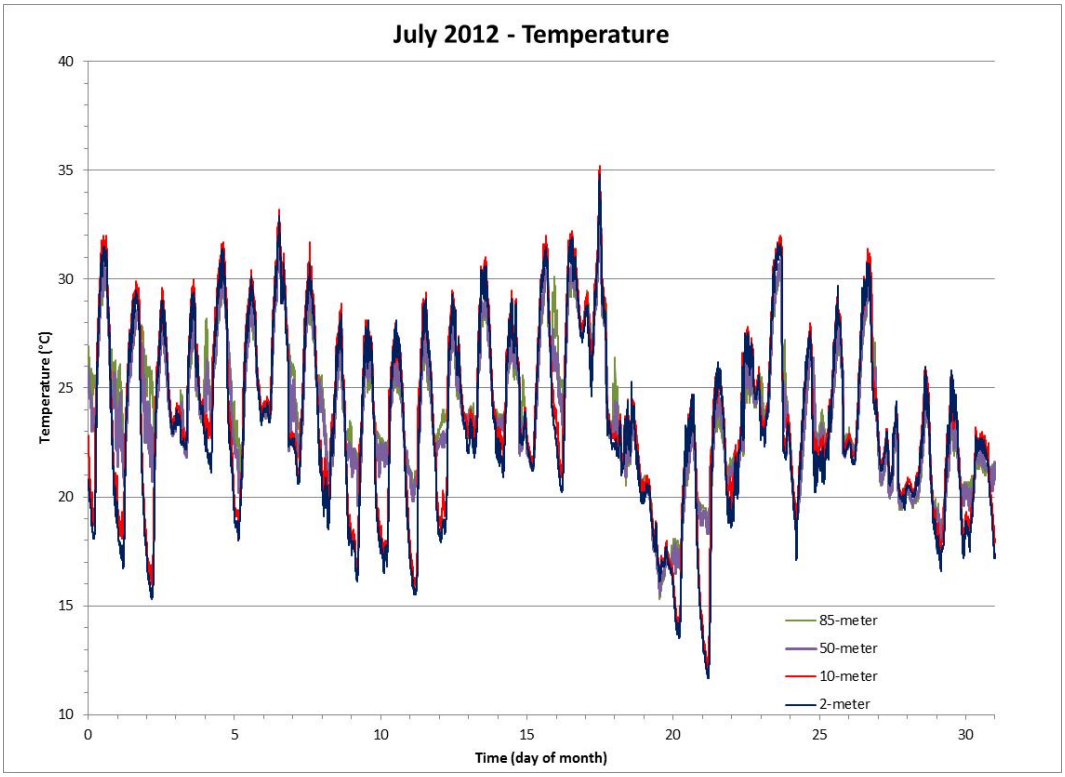

Figure 10 Air Temperature for the Month of July 2012

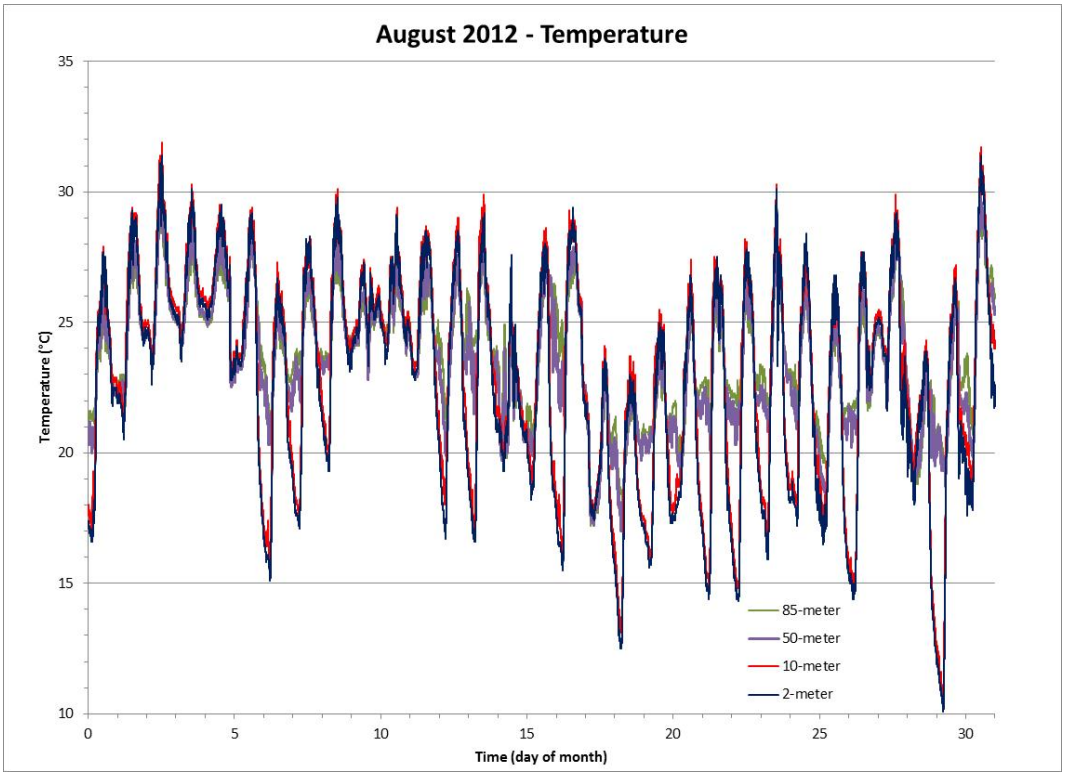

Figure 11 Air Temperature for the Month of August 2012

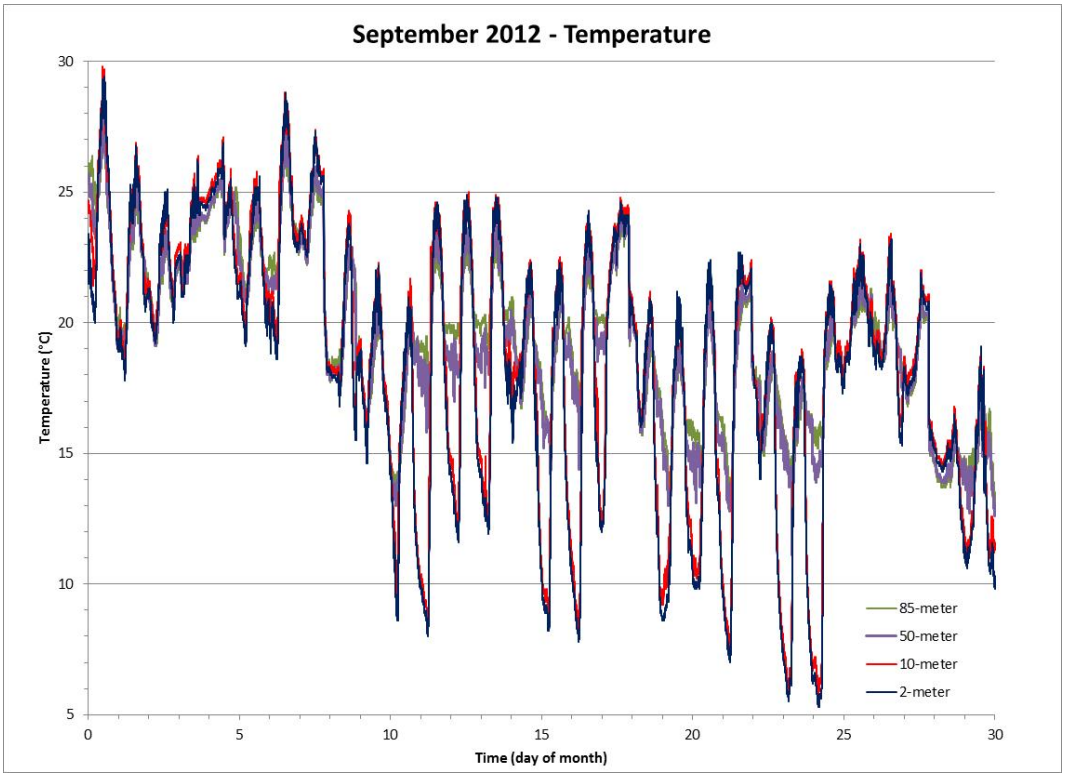

Figure 12 Air Temperature for the Month of September 2012

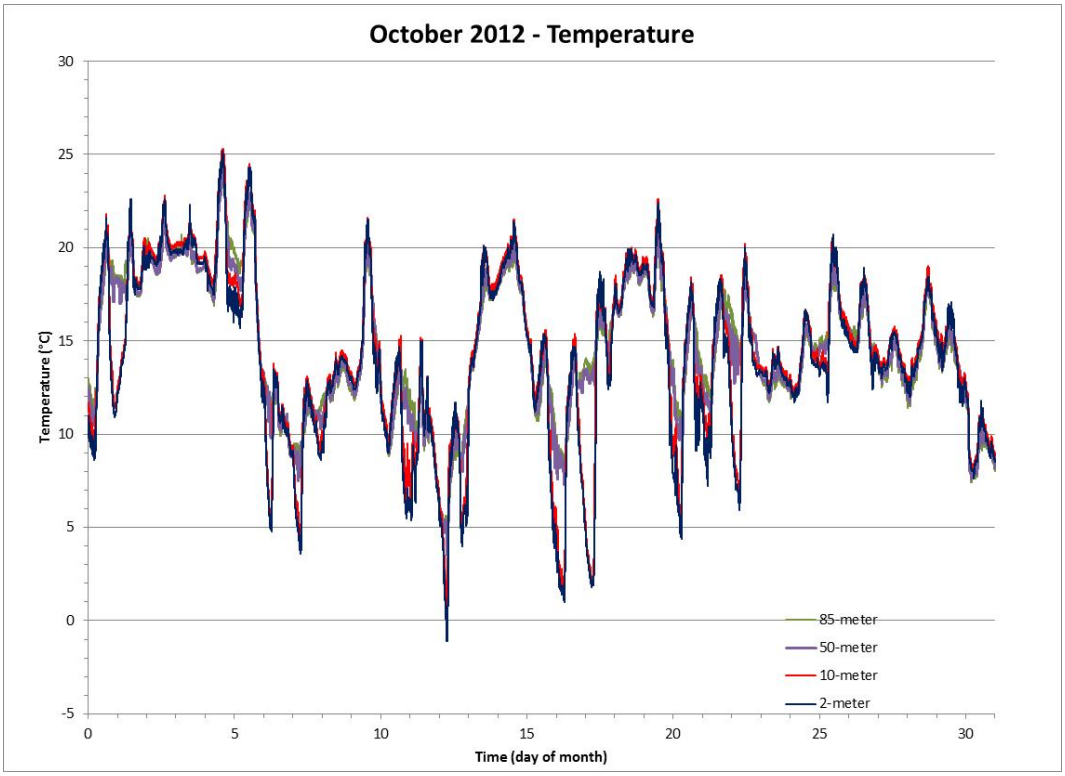

Figure 13 Air Temperature for the Month of October 2012

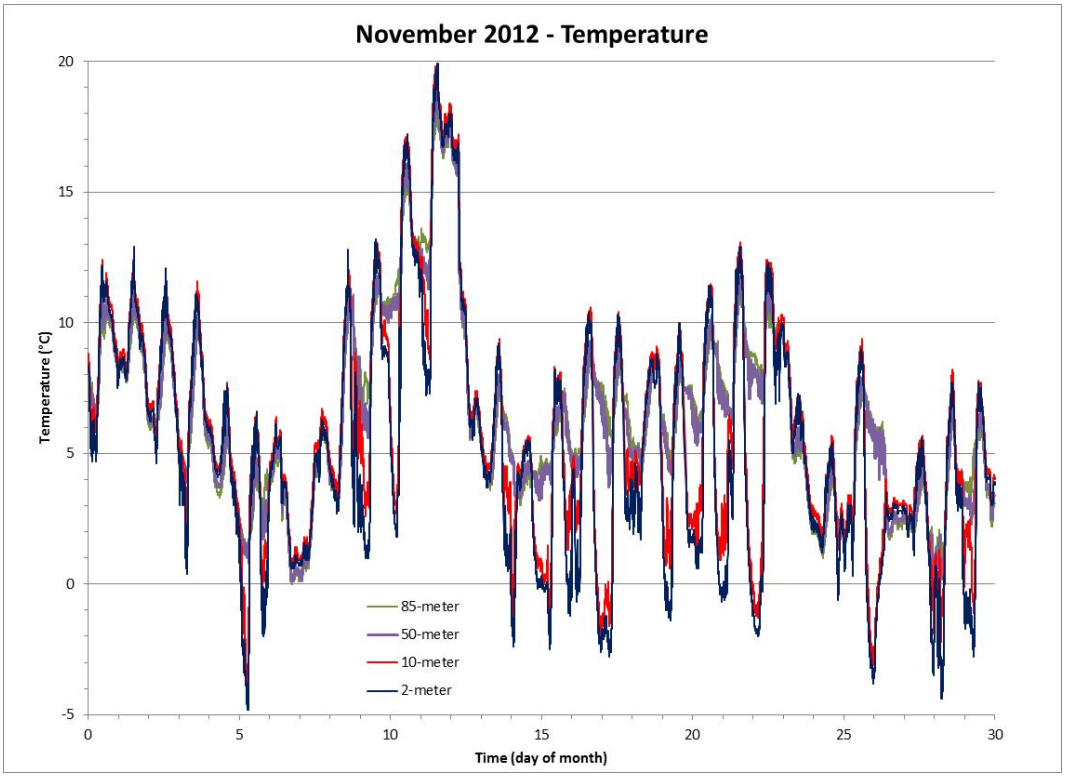

Figure 14 Air Temperature for the Month of November 2012

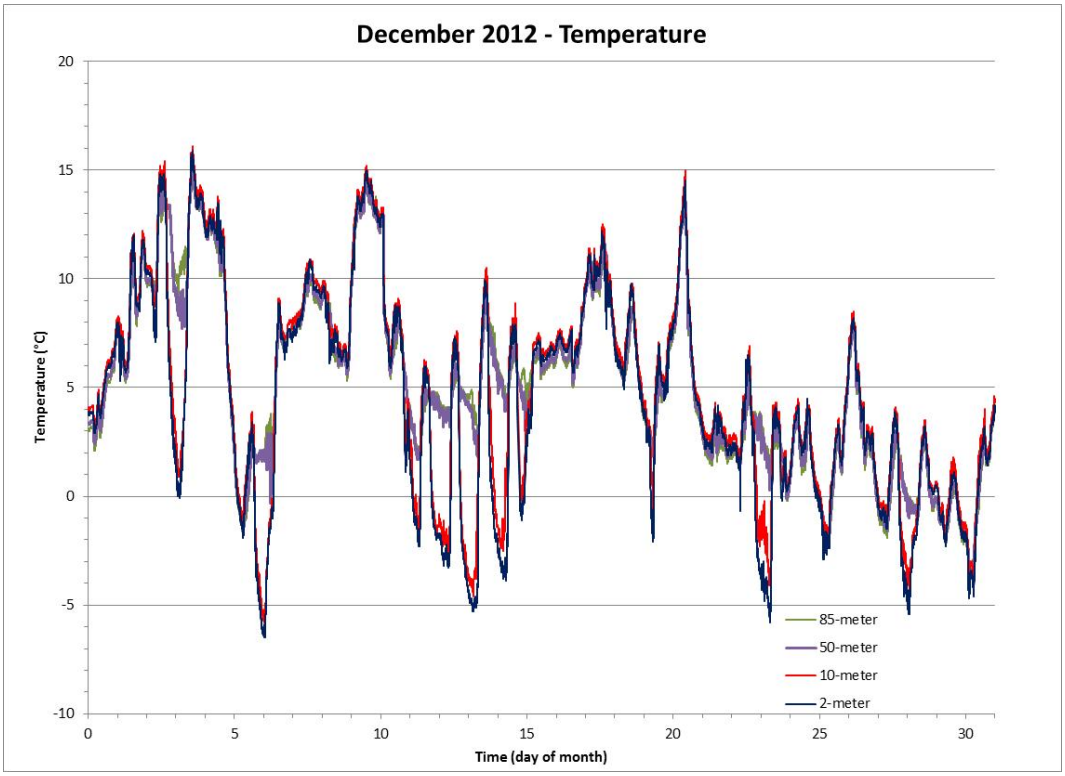

Figure 15 Air Temperature for the Month of December 2012

**Table 3. Historic Monthly Mean Temperatures for Brookhaven National Laboratory from 1949 to 2012 (@ 2 meters)**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1949 | 36.1 | 35.6 | 38.4 | 49.1 | 57.8 | 68.1 | 73.9 | 71.4 | 61.2 | 57.4 | 42.0 | 34.2 | 52.1 |
| 1950 | **38.0** | 28.9 | 33.1 | 43.3 | 53.4 | 64.2 | 70.0 | 67.4 | 59.8 | 53.8 | 43.4 | 32.0 | 48.9 |
| 1951 | 32.2 | 31.8 | 37.7 | 47.4 | 57.0 | 63.7 | 70.7 | 68.6 | 62.4 | 53.4 | 40.0 | **45.0** | 50.8 |
| 1952 | 32.4 | 31.9 | 36.8 | 48.6 | 55.1 | 67.7 | 74.3 | 70.1 | 62.0 | 49.6 | 42.6 | 34.9 | 50.5 |
| 1953 | 34.1 | 34.8 | 38.9 | 47.1 | 58.3 | 65.0 | 70.7 | 68.3 | 63.3 | **65.0** | 43.2 | 37.5 | 52.2 |
| 1954 | 26.5 | 34.6 | 37.0 | 47.5 | 53.5 | 66.0 | 69.5 | 67.0 | 61.0 | 55.5 | 40.5 | 32.0 | 49.2 |
| 1955 | 27.6 | 30.0 | 37.5 | 48.6 | 58.5 | 63.2 | 74.9 | 71.8 | 60.5 | 54.4 | 40.1 | 24.7 | 49.3 |
| 1956 | 28.0 | 32.6 | 33.2 | **42.1** | 52.6 | 65.1 | 68.5 | 68.7 | 59.3 | 59.0 | 41.8 | 36.1 | 48.9 |
| 1957 | 23.7 | 32.9 | 38.2 | 48.2 | 56.6 | 69.3 | 71.5 | 66.6 | 63.4 | 51.6 | 45.3 | 36.8 | 50.3 |
| 1958 | 29.8 | 25.5 | 37.0 | 47.0 | 53.0 | **61.3** | 72.1 | 68.7 | 61.2 | 50.2 | 42.4 | 24.3 | 47.7 |
| 1959 | 27.7 | 27.6 | 35.7 | 47.2 | 58.2 | 64.0 | 70.4 | 71.8 | 65.0 | 54.0 | 42.7 | 34.8 | 49.9 |
| 1960 | 30.5 | 34.2 | **31.0** | 47.5 | 57.6 | 66.1 | 68.7 | 68.9 | 60.1 | 50.1 | 44.3 | 27.3 | 48.9 |
| 1961 | 23.3 | 29.5 | 36.5 | 44.7 | 54.2 | 66.0 | 70.9 | 70.3 | **69.0** | 54.5 | 42.9 | 32.5 | 49.5 |
| 1962 | 29.9 | 29.9 | 37.2 | 45.7 | 56.0 | 65.4 | **66.8** | 67.0 | 58.6 | 50.6 | 39.2 | 28.1 | 47.9 |
| 1963 | 28.0 | 25.9 | 39.3 | 47.1 | 55.2 | 66.4 | 69.9 | 67.3 | 59.3 | 55.8 | 46.4 | 26.7 | 48.9 |
| 1964 | 30.2 | 27.4 | 37.4 | 43.8 | 59.2 | 64.5 | 71.3 | **65.9** | 61.6 | 50.7 | 42.8 | 35.0 | 49.2 |
| 1965 | 25.5 | 29.1 | 35.7 | 43.8 | 59.5 | 64.8 | 68.5 | 68.5 | 62.8 | 50.9 | 40.7 | 34.2 | 48.7 |
| 1966 | 27.8 | 30.1 | 37.7 | 42.5 | 52.8 | 66.0 | 72.4 | 70.0 | 60.8 | 48.6 | 43.4 | 31.2 | 48.6 |
| 1967 | 32.9 | 24.7 | 32.1 | 44.2 | **50.2** | 65.3 | 70.8 | 69.1 | 59.8 | 49.9 | 38.3 | 32.8 | **47.5** |
| 1968 | 24.3 | 24.8 | 37.6 | 46.7 | 53.3 | 64.0 | 71.4 | 69.0 | 64.1 | 50.2 | 42.4 | 29.8 | 48.1 |
| 1969 | 27.9 | 29.6 | 34.0 | 47.1 | 55.5 | 63.7 | 68.4 | 71.6 | 62.2 | 51.2 | 40.9 | 30.8 | 48.6 |
| 1970 | 21.7 | 28.4 | 34.5 | 46.3 | 57.5 | 66.3 | 72.3 | 71.4 | 64.6 | 52.8 | 44.2 | 32.3 | 49.4 |
| 1971 | 24.0 | 30.8 | 37.0 | 42.7 | 54.0 | 65.5 | 69.2 | 68.5 | 66.1 | 58.0 | 41.0 | 37.1 | 49.5 |
| 1972 | 31.2 | 28.5 | 36.0 | 43.0 | 56.8 | 64.5 | 72.9 | 69.0 | 64.7 | **47.3** | 39.2 | 35.5 | 49.1 |
| 1973 | 31.4 | 30.5 | 42.9 | 49.2 | 55.4 | 69.5 | 72.4 | 71.9 | 62.1 | 52.3 | 43.9 | 36.0 | 51.5 |
| 1974 | 32.0 | 27.5 | 39.3 | 49.5 | 55.2 | 65.2 | 71.9 | 71.7 | 62.8 | 47.8 | 43.4 | 34.9 | 50.1 |
| 1975 | 34.1 | 30.5 | 35.0 | 43.8 | 59.7 | 66.5 | 73.3 | 66.4 | 61.0 | 54.2 | 47.3 | 33.5 | 50.4 |
| 1976 | 23.7 | 34.9 | 38.5 | 49.7 | 55.5 | 68.1 | 69.9 | 70.1 | 61.5 | 49.4 | **37.7** | 26.5 | 48.8 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | **19.5** | 29.4 | 42.0 | 46.9 | 58.8 | 64.5 | 72.2 | 71.6 | 65.1 | 50.6 | 43.8 | 32.0 | 49.7 |
| 1978 | 26.1 | 22.2 | 34.6 | 46.0 | 57.3 | 63.9 | 68.0 | 71.2 | **58.1** | 49.1 | 42.6 | 34.5 | 47.8 |
| 1979 | 29.3 | **20.3** | 41.8 | 45.3 | 59.3 | 62.8 | 72.6 | 71.4 | 62.2 | 52.7 | 47.1 | 37.9 | 50.2 |
| 1980 | 29.9 | 26.5 | 35.1 | 47.3 | 59.2 | 64.1 | 73.1 | 70.8 | 65.6 | 52.7 | 40.4 | 29.0 | 49.5 |
| 1981 | 19.6 | 32.6 | 36.6 | 48.8 | 58.3 | 68.4 | 74.5 | 70.8 | 62.8 | 49.4 | 43.7 | 32.9 | 49.9 |
| 1982 | 22.6 | 31.1 | 35.9 | 45.0 | 58.6 | 62.9 | 72.0 | 68.2 | 61.7 | 52.0 | 45.6 | 39.2 | 49.6 |
| 1983 | 32.0 | 30.3 | 41.0 | 47.7 | 54.4 | 66.8 | 73.4 | 71.5 | 65.5 | 53.2 | 44.9 | 31.5 | 51.0 |
| 1984 | 24.8 | 37.1 | 33.3 | 47.1 | 55.1 | 68.1 | 70.5 | 71.8 | 60.1 | 55.4 | 42.9 | 39.1 | 50.4 |
| 1985 | 24.4 | 31.3 | 40.5 | 50.0 | 58.7 | 63.1 | 71.4 | 69.3 | 64.2 | 53.0 | 46.7 | 30.4 | 50.3 |
| 1986 | 30.0 | 28.2 | 38.9 | 47.4 | 59.2 | 65.1 | 71.3 | 67.9 | 61.2 | 52.8 | 41.4 | 35.4 | 49.9 |
| 1987 | 29.3 | 29.3 | 39.9 | 49.4 | 57.9 | 68.4 | 73.2 | 68.3 | 62.9 | 49.3 | 44.1 | 34.7 | 50.6 |
| 1988 | 24.5 | 30.7 | 37.7 | 46.0 | 57.7 | 65.9 | 73.9 | 73.4 | 61.0 | 48.1 | 43.7 | 31.6 | 49.5 |
| 1989 | 32.7 | 30.0 | 37.7 | 45.8 | 57.8 | 68.6 | 71.4 | 71.3 | 63.8 | 53.5 | 42.1 | **23.9** | 49.9 |
| 1990 | 37.3 | 35.2 | 39.9 | 47.7 | 55.7 | 66.8 | 72.5 | 72.1 | 62.6 | 57.5 | 45.7 | 39.4 | 52.7 |
| 1991 | 31.0 | 35.5 | 41.8 | 51.0 | **62.4** | 68.6 | 72.9 | 72.9 | 62.2 | 54.7 | 44.7 | 36.7 | 52.9 |
| 1992 | 31.1 | 32.8 | 36.1 | 45.0 | 55.7 | 64.8 | 69.1 | 68.2 | 63.2 | 50.3 | 42.6 | 34.8 | 49.5 |
| 1993 | 33.2 | 26.7 | 35.5 | 48.3 | 59.6 | 67.6 | 73.9 | 71.7 | 63.9 | 50.8 | 42.4 | 34.1 | 50.6 |
| 1994 | 24.7 | 27.5 | 37.5 | 49.9 | 56.3 | 69.9 | **76.9** | 69.0 | 63.0 | 52.5 | 48.3 | 38.7 | 51.2 |
| 1995 | 36.6 | 29.7 | 40.9 | 46.5 | 56.1 | 67.0 | 74.4 | 72.0 | 62.6 | 56.4 | 41.2 | 30.0 | 51.1 |
| 1996 | 29.1 | 31.2 | 34.5 | 47.5 | 56.7 | 67.3 | 69.9 | 70.5 | 64.4 | 52.1 | 39.7 | 38.4 | 50.1 |
| 1997 | 30.1 | 36.5 | 37.7 | 46.9 | 54.7 | 65.5 | 72.1 | 70.2 | 62.8 | 52.0 | 41.3 | 35.4 | 50.4 |
| 1998 | 37.9 | 37.3 | 40.6 | 48.5 | 60.1 | 65.7 | 72.3 | 72.3 | 65.7 | 53.9 | 44.1 | 38.2 | 53.1 |
| 1999 | 32.2 | 34.3 | 39.3 | 48.4 | 58.7 | 69.2 | 76.3 | 71.7 | 65.7 | 51.9 | 47.4 | 37.5 | 52.7 |
| 2000 | 28.7 | 33.9 | 42.9 | 46.8 | 59.1 | 67.3 | 69.1 | 70.5 | 63.1 | 53.3 | 42.8 | 29.2 | 50.6 |
| 2001 | 29.4 | 32.4 | 36.6 | 49.3 | 59.4 | 70.0 | 69.2 | 74.3 | 63.7 | 54.2 | 48.2 | 40.5 | 52.3 |
| 2002 | 37.4 | 36.1 | 41.7 | **51.4** | 56.9 | 66.7 | 74.2 | 73.9 | 65.6 | 52.7 | 43.1 | 33.0 | 52.7 |
| 2003 | 26.2 | 28.0 | 38.5 | 46.4 | 55.2 | 65.9 | 72.9 | 74.6 | 65.8 | 52.1 | 47.3 | 36.2 | 50.8 |
| 2004 | 23.6 | 32.5 | 40.0 | 49.5 | 61.1 | 66.9 | 71.8 | 70.8 | 66.2 | 53.4 | 44.7 | 34.9 | 51.3 |
| 2005 | 28.7 | 32.1 | 35.0 | 49.1 | 54.1 | 69.4 | 74.1 | **76.2** | 68.4 | 55.8 | 47.0 | 33.2 | 51.9 |
| 2006 | 37.4 | 32.4 | 38.9 | 49.9 | 58.9 | 68.3 | 74.9 | 72.3 | 62.8 | 53.1 | 48.6 | 40.9 | 53.2 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | 35.8 | 28.1 | 38.1 | 46.2 | 59.6 | 67.3 | 72.4 | 71.9 | 65.7 | 61.0 | 42.4 | 34.4 | 51.9 |
| 2008 | 33.8 | 34.4 | 36.9 | 50.2 | 55.9 | 70.3 | 74.4 | 70.9 | 63.8 | 51.9 | 42.5 | 38.6 | 52.0 |
| 2009 | 26.1 | 34.0 | 38.1 | 50.1 | 58.2 | 64.1 | 70.0 | 73.1 | 62.5 | 52.6 | 48.8 | 34.4 | 51.0 |
| 2010 | 29.7 | 31.4 | 44.2 | 51.3 | 61.1 | **70.4** | 76.3 | 72.8 | 67.5 | 55.1 | 44.7 | 31.3 | 53.0 |
| 2011 | 27.1 | 32.5 | 39.2 | 49.9 | 60.4 | 68.3 | 75.4 | 72.1 | 67.3 | 54.9 | **48.9** | 40.4 | 53.0 |
| 2012 | 36.0 | **37.7** | **46.4** | 51.3 | 61.6 | 67.2 | 74.0 | 72.8 | 65.0 | 57.2 | 41.3 | 40.0 | 54.2 |
| | | | | | | | | | | | | | |
| **Average** | **29.5** | 30.8 | 37.8 | 47.3 | 57.1 | 66.3 | **71.9** | 70.5 | 63.1 | 53.0 | 43.4 | 34.0 | 50.4 |
| **Max** | 38.0 | 37.7 | 46.4 | 51.4 | 62.4 | 70.4 | **76.9** | 76.2 | 69.0 | 65.0 | 48.9 | 45.0 | 54.2 |
| **Min** | **19.5** | 20.3 | 31.0 | 42.1 | 50.2 | 61.3 | 66.8 | 65.9 | 58.1 | 47.3 | 37.7 | 23.9 | 47.5 |

**Min** **Max**

**Table 4. Historic Monthly Mean Maximum Temperatures for Brookhaven National Laboratory from 1949 to 2012 (@ 2 meters)**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1949 | 43.8 | 44.8 | 47.2 | 59.0 | 68.8 | 78.8 | 83.7 | 82.3 | 71.1 | 67.9 | 52.7 | 44.4 | 62.0 |
| 1950 | **47.0** | 37.6 | 43.4 | 53.6 | 64.2 | 75.9 | 80.8 | 77.5 | 70.0 | 66.0 | 55.0 | 41.5 | 59.4 |
| 1951 | 42.5 | 43.0 | 47.0 | 60.5 | 70.5 | 74.5 | 81.5 | 79.2 | 74.9 | 63.9 | 50.8 | 45.2 | 61.1 |
| 1952 | 41.7 | 40.8 | 44.7 | 59.8 | 67.1 | 79.3 | 86.9 | 80.9 | **84.3** | 62.2 | 53.6 | 43.3 | 62.1 |
| 1953 | 43.1 | 44.6 | 47.7 | **75.3** | 68.3 | 78.9 | 83.4 | 80.6 | 76.4 | 65.8 | 56.1 | 47.5 | **64.0** |
| 1954 | 36.6 | 45.8 | 48.1 | 59.4 | 65.2 | 77.4 | 82.0 | 78.5 | 71.8 | 67.1 | 50.9 | 40.1 | 60.2 |
| 1955 | 35.1 | 39.5 | 46.8 | 58.9 | 72.4 | 75.1 | 85.2 | 82.2 | 71.7 | 65.2 | 49.6 | 33.8 | 59.6 |
| 1956 | 35.5 | 40.9 | 42.5 | 54.0 | 64.6 | 78.2 | 77.8 | 79.7 | 70.0 | 63.9 | 52.3 | 45.7 | 58.8 |
| 1957 | 32.7 | 42.0 | 48.5 | 59.9 | 69.0 | **80.9** | 83.5 | 78.5 | 74.2 | 62.5 | 55.4 | 46.3 | 61.1 |
| 1958 | 37.5 | 33.2 | 44.8 | 58.1 | 63.2 | 72.2 | 81.2 | 78.7 | 71.7 | 60.5 | 52.8 | 34.4 | **57.4** |
| 1959 | 37.0 | 37.5 | 44.8 | 58.1 | 70.3 | 74.3 | 79.1 | 81.3 | 76.3 | 63.9 | 52.2 | 43.9 | 59.9 |
| 1960 | 38.2 | 42.9 | **39.3** | 59.3 | 69.3 | 77.4 | 79.9 | 78.9 | 70.4 | 63.3 | 55.8 | 38.7 | 59.5 |
| 1961 | 33.9 | 40.4 | 45.8 | 54.3 | 64.9 | 77.2 | 80.8 | 80.1 | 78.7 | 65.6 | 52.3 | 40.5 | 59.5 |
| 1962 | 38.8 | 37.0 | 47.8 | 57.3 | 69.1 | 76.4 | 78.7 | 77.6 | 70.0 | 62.4 | 49.3 | 38.0 | 58.5 |
| 1963 | 37.7 | 35.9 | 48.2 | 59.9 | 68.1 | 78.4 | 81.3 | 78.0 | **69.1** | 69.0 | 55.2 | 34.9 | 59.6 |
| 1964 | 39.9 | 36.7 | 46.7 | 53.9 | 72.8 | 75.8 | 79.1 | 77.9 | 73.0 | 63.1 | 55.8 | 42.8 | 59.8 |
| 1965 | 34.7 | 37.8 | 44.5 | 55.1 | 72.6 | 76.7 | 79.8 | 78.8 | 72.3 | 61.4 | 51.1 | 43.7 | 59.0 |
| 1966 | 36.0 | 39.4 | 47.5 | 53.7 | 63.9 | 77.6 | 84.8 | 81.7 | 71.4 | 62.7 | 54.6 | 40.9 | 59.5 |
| 1967 | 42.2 | 35.7 | 42.3 | 55.1 | **61.4** | 76.6 | 79.8 | **77.4** | 72.0 | 62.6 | 48.1 | 43.1 | 58.0 |
| 1968 | 33.2 | 35.4 | 48.6 | 61.8 | 65.8 | 73.8 | 82.4 | 80.3 | 77.0 | 65.5 | 50.8 | 38.5 | 59.4 |
| 1969 | 35.8 | 35.9 | 43.4 | 58.3 | 67.8 | 74.9 | **76.8** | 81.7 | 73.2 | 63.5 | 50.6 | 38.5 | 58.4 |
| 1970 | 30.7 | 39.0 | 43.3 | 57.4 | 67.9 | 75.9 | 81.3 | 82.6 | 75.4 | 64.5 | 53.4 | 40.1 | 59.3 |
| 1971 | 32.8 | 39.4 | 45.4 | 54.7 | 65.0 | 77.7 | 80.0 | 80.4 | 74.8 | 69.0 | 50.0 | 46.0 | 59.6 |
| 1972 | 41.5 | 38.4 | 44.9 | 54.4 | 68.8 | 73.2 | 82.0 | 80.4 | 75.8 | 59.3 | **46.8** | 41.8 | 58.9 |
| 1973 | 41.0 | 38.4 | 52.0 | 59.1 | 64.6 | 78.6 | 82.6 | 84.0 | 74.4 | 65.5 | 52.8 | 45.8 | 61.6 |
| 1974 | 41.0 | 37.1 | 49.0 | 60.3 | 66.0 | 75.0 | 83.1 | 83.3 | 72.3 | 60.3 | 54.1 | 44.0 | 60.5 |
| 1975 | 42.6 | 39.6 | 45.4 | 54.8 | 71.4 | 76.0 | 82.6 | 81.2 | 70.9 | 65.2 | 57.8 | 42.5 | 60.8 |
| 1976 | 34.0 | 46.8 | 48.4 | 62.8 | 66.6 | 78.7 | 80.1 | 80.4 | 73.3 | **58.4** | 47.5 | 36.5 | 59.5 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | **28.5** | 38.3 | 52.0 | 58.7 | 72.1 | 74.9 | 83.5 | 81.6 | 73.7 | 60.7 | 52.1 | 40.1 | 59.7 |
| 1978 | 34.7 | 32.4 | 44.4 | 56.5 | 66.3 | 76.0 | 78.0 | 79.9 | 70.2 | 61.0 | 52.1 | 43.8 | 57.9 |
| 1979 | 37.1 | **27.4** | 51.1 | 55.7 | 68.4 | 73.1 | 82.7 | 79.5 | 73.0 | 61.7 | 56.1 | 45.4 | 59.3 |
| 1980 | 38.3 | 34.9 | 43.4 | 57.2 | 71.0 | 75.3 | 81.7 | 83.5 | 76.9 | 62.0 | 49.3 | 38.6 | 59.3 |
| 1981 | 29.3 | 42.1 | 46.5 | 58.4 | 69.5 | 78.3 | 84.5 | 80.5 | 71.6 | 59.2 | 51.9 | 40.3 | 59.3 |
| 1982 | 31.9 | 38.5 | 45.9 | 56.8 | 69.4 | **71.6** | 82.7 | 78.4 | 72.8 | 64.8 | 55.5 | 48.2 | 59.7 |
| 1983 | 40.6 | 42.2 | 49.5 | 57.8 | 64.4 | 80.1 | 85.2 | 82.1 | 78.1 | 63.4 | 54.9 | 40.6 | 61.6 |
| 1984 | 34.2 | 45.5 | 42.2 | 57.1 | 65.8 | 79.2 | 79.5 | 82.0 | 72.4 | 65.6 | 53.3 | 49.6 | 60.5 |
| 1985 | 33.6 | 40.3 | 51.6 | 61.2 | 70.5 | 74.3 | 82.4 | 79.9 | 76.3 | 65.4 | 55.0 | 39.2 | 60.8 |
| 1986 | 40.2 | 36.2 | 50.6 | 59.0 | 72.2 | 76.2 | 81.0 | 77.7 | 71.1 | 63.8 | 51.5 | 43.3 | 60.2 |
| 1987 | 37.9 | 38.5 | 51.2 | 59.7 | 69.8 | 78.9 | 83.4 | 79.2 | 73.0 | 62.7 | 54.8 | 43.7 | 61.1 |
| 1988 | 34.9 | 40.1 | 48.8 | 55.6 | 68.4 | 78.2 | 83.5 | 83.5 | 73.1 | 59.0 | 55.3 | 41.8 | 60.2 |
| 1989 | 42.8 | 38.7 | 46.7 | 57.3 | 68.2 | 78.3 | 81.0 | 80.7 | 74.8 | 65.4 | 51.5 | **32.8** | 59.9 |
| 1990 | 45.2 | 45.3 | 50.8 | 57.1 | 66.0 | 77.2 | 80.9 | 80.8 | 73.5 | 67.9 | 56.8 | 48.4 | 62.5 |
| 1991 | 40.8 | 45.5 | 50.5 | 61.5 | **74.7** | 80.1 | 83.8 | 82.7 | 72.9 | 65.1 | 53.4 | 46.2 | 63.1 |
| 1992 | 41.0 | 42.3 | 45.8 | 55.2 | 68.2 | 75.1 | 79.1 | 77.9 | 72.1 | 61.6 | 51.4 | 43.6 | 59.4 |
| 1993 | 41.3 | 37.5 | 44.2 | 58.0 | 71.9 | 78.2 | 85.3 | 82.2 | 72.7 | 61.2 | 54.5 | 42.9 | 60.8 |
| 1994 | 33.9 | 36.7 | 47.0 | 61.7 | 68.2 | 80.1 | 85.8 | 79.2 | 73.4 | 64.6 | 58.0 | 48.3 | 61.4 |
| 1995 | 43.9 | 39.6 | 50.8 | 57.7 | 66.8 | 77.2 | 83.3 | 84.4 | 74.1 | 68.3 | 50.1 | 39.6 | 61.3 |
| 1996 | 37.5 | 40.0 | 45.2 | 57.4 | 67.7 | 76.3 | 77.6 | 79.3 | 73.1 | 63.3 | 49.1 | 46.1 | 59.4 |
| 1997 | 38.8 | 45.4 | 47.6 | 57.9 | 65.6 | 77.6 | 83.2 | 80.4 | 73.7 | 64.0 | 50.0 | 44.4 | 60.7 |
| 1998 | 45.9 | 46.0 | 49.5 | 59.4 | 71.0 | 74.6 | 82.6 | 83.0 | 76.5 | 64.0 | 54.1 | 48.6 | 62.9 |
| 1999 | 42.0 | 43.8 | 49.5 | 60.7 | 71.0 | 80.2 | **87.3** | 80.8 | 75.0 | 63.8 | 57.3 | 46.5 | 63.2 |
| 2000 | 37.8 | 43.1 | 53.9 | **56.3** | 69.9 | 77.0 | 78.5 | 79.3 | 73.5 | 64.4 | 52.0 | 37.7 | 60.3 |
| 2001 | 39.1 | 42.0 | 44.9 | 60.5 | 70.3 | 80.3 | 79.9 | 81.5 | 75.0 | 66.0 | **59.3** | 50.0 | 62.4 |
| 2002 | 45.8 | **47.7** | 51.5 | 62.4 | 67.8 | 77.5 | 84.9 | 84.1 | 76.0 | 61.9 | 51.6 | 42.0 | 62.8 |
| 2003 | 33.4 | 36.1 | 50.3 | 55.9 | 65.1 | 74.9 | 81.9 | 82.5 | 74.6 | 62.2 | 56.7 | 44.9 | 59.9 |
| 2004 | 30.8 | 42.0 | 47.8 | 58.9 | 71.2 | 77.1 | 80.6 | 79.5 | 76.5 | 62.5 | 54.6 | 44.6 | 60.5 |
| 2005 | 36.8 | 42.1 | 45.1 | 61.7 | 64.4 | 78.7 | 83.3 | **86.0** | 81.1 | 63.7 | 56.7 | 41.7 | 61.8 |
| 2006 | 46.1 | 42.2 | 48.8 | 62.3 | 68.6 | 76.5 | 83.7 | 81.9 | 72.5 | 63.4 | 57.3 | **50.1** | 62.8 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | 43.0 | 35.6 | 48.5 | 56.6 | 72.2 | 77.6 | 81.7 | 81.3 | 76.8 | **70.0** | 51.9 | 42.3 | 61.5 |
| 2008 | 41.8 | 43.3 | 47.1 | 61.5 | 67.0 | 80.6 | 84.0 | 81.7 | 72.8 | 62.6 | 50.8 | 46.9 | 61.7 |
| 2009 | 33.8 | 43.0 | 48.0 | 60.4 | 67.7 | 73.2 | 79.3 | 82.5 | 72.4 | 61.9 | 55.8 | 41.5 | 60.0 |
| 2010 | 36.7 | 37.7 | 53.8 | 65.0 | 72.4 | 80.1 | 86.8 | 82.0 | 76.2 | 64.0 | 53.1 | 37.2 | 62.1 |
| 2011 | 33.7 | 41.8 | 48.0 | 58.9 | 70.4 | 78.2 | 85.3 | 81.1 | 75.8 | 64.1 | 58.6 | 49.5 | 62.1 |
| 2012 | 44.6 | 46.2 | **55.8** | 62.2 | 70.3 | 77.0 | 83.6 | 82.4 | 74.1 | 64.8 | 50.2 | 47.3 | 63.2 |
| | | | | | | | | | | | | | |
| **Average** | **38.2** | 40.1 | 47.4 | 58.6 | 68.3 | 77.0 | **82.1** | 80.8 | 73.9 | 63.8 | 53.2 | 42.8 | 60.5 |
| **Max** | 47.0 | 47.7 | 55.8 | 75.3 | 74.7 | 80.9 | **87.3** | 86.0 | 84.3 | 70.0 | 59.3 | 50.1 | 64.0 |
| **Min** | 28.5 | **27.4** | 39.3 | 53.6 | 61.4 | 71.6 | 76.8 | 77.4 | 69.1 | 58.4 | 46.8 | 32.8 | 57.4 |

**Min** **Max**

**Table 5. Historic Monthly Mean Minimum Temperatures for Brookhaven National Laboratory from 1949 to 201 (@2 meters)**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1949 | 28.9 | 26.4 | 30.5 | 39.8 | 46.2 | 57.3 | 64.2 | 60.4 | 51.2 | 47.0 | 31.3 | 24.1 | 42.3 |
| 1950 | 29.0 | 20.1 | 22.9 | 33.3 | 42.6 | 52.6 | 59.3 | 57.0 | 50.0 | 41.0 | 32.0 | 24.5 | 38.7 |
| 1951 | 22.0 | 23.0 | 27.5 | 34.5 | 44.0 | 54.0 | 60.5 | 58.0 | 49.8 | 42.7 | 29.7 | 24.5 | 39.2 |
| 1952 | 23.0 | 22.8 | 28.2 | 38.1 | 44.2 | 55.7 | 61.6 | 59.7 | 48.6 | 36.9 | 32.2 | 26.3 | 39.8 |
| 1953 | 26.1 | 25.1 | 30.1 | 37.2 | 48.3 | 52.9 | 57.8 | 55.4 | 50.2 | 39.3 | 29.9 | 27.4 | 40.0 |
| 1954 | 17.5 | 24.7 | 26.4 | 35.5 | 41.0 | 54.6 | 57.1 | 55.7 | 50.8 | 43.3 | 29.5 | 23.7 | 38.3 |
| 1955 | 20.0 | 20.5 | 27.5 | 38.3 | 44.6 | 51.3 | 64.6 | 61.2 | 49.7 | 43.6 | 30.9 | 15.4 | 39.0 |
| 1956 | 20.6 | 24.4 | 23.7 | **30.1** | 40.6 | 51.6 | 59.1 | 57.8 | 48.5 | 37.5 | 31.4 | 26.7 | 37.7 |
| 1957 | 14.6 | 23.6 | 28.0 | 36.6 | 44.2 | 57.8 | 59.5 | 54.7 | 52.6 | 40.7 | 35.2 | 27.8 | 39.6 |
| 1958 | 22.1 | 18.0 | 29.9 | 35.8 | 43.0 | **50.5** | 63.1 | 58.4 | 50.8 | 39.8 | 32.2 | **14.1** | 38.1 |
| 1959 | 18.4 | 18.2 | 26.7 | 36.1 | 46.1 | 54.0 | 61.7 | 62.3 | 53.7 | 44.1 | 33.1 | 25.6 | 40.0 |
| 1960 | 22.8 | 26.5 | 22.8 | 35.6 | 45.5 | 54.7 | 57.9 | 59.0 | 49.8 | 37.1 | 32.8 | 16.3 | 38.4 |
| 1961 | 12.8 | 19.4 | 27.2 | 35.2 | 44.1 | 54.3 | 60.9 | 60.5 | 59.3 | 43.5 | 33.5 | 23.5 | 39.5 |
| 1962 | 18.5 | 19.9 | 27.3 | 34.1 | 42.9 | 54.2 | **54.1** | 56.2 | 47.5 | 39.1 | 29.3 | 18.3 | **36.8** |
| 1963 | 18.1 | 15.8 | 30.0 | 34.6 | 42.7 | 54.4 | 59.4 | 56.4 | 49.8 | 42.7 | 37.7 | 19.7 | 38.4 |
| 1964 | 20.5 | 17.7 | 28.1 | 33.7 | 45.6 | 53.7 | 63.4 | **53.9** | 50.2 | 38.5 | 30.1 | 27.3 | 38.6 |
| 1965 | 15.9 | 21.0 | 27.0 | 32.6 | 46.5 | 52.9 | 57.1 | 58.1 | 53.3 | 40.0 | 30.4 | 24.8 | 38.3 |
| 1966 | 19.8 | 20.4 | 27.6 | 31.2 | 41.9 | 54.6 | 60.0 | 58.2 | 50.4 | **34.5** | 32.8 | 21.7 | 37.8 |
| 1967 | 23.9 | 14.0 | **22.1** | 33.4 | 39.3 | 54.1 | 63.3 | 61.1 | 48.0 | 37.6 | 28.8 | 22.3 | 37.3 |
| 1968 | 15.7 | 14.4 | 27.0 | 31.8 | 41.5 | 54.7 | 60.5 | 58.0 | 51.1 | 44.5 | 33.9 | 21.1 | 37.9 |
| 1969 | 19.9 | 23.2 | 24.6 | 36.0 | 43.1 | 52.5 | 60.1 | 60.9 | 51.2 | 40.1 | 31.2 | 23.2 | 38.8 |
| 1970 | 12.7 | 17.7 | 25.6 | 35.5 | 47.1 | 56.4 | 63.1 | 60.0 | 53.8 | 41.7 | 35.0 | 24.6 | 39.4 |
| 1971 | 14.9 | 22.2 | 28.6 | 30.7 | 42.9 | 54.0 | 58.7 | 56.4 | 57.5 | 47.5 | 32.0 | 28.3 | 39.5 |
| 1972 | 20.8 | 18.5 | 27.4 | 31.5 | 44.5 | 55.8 | 63.8 | 57.0 | 53.6 | 35.3 | 31.6 | 29.1 | 39.1 |
| 1973 | 21.2 | 22.6 | 33.7 | 39.4 | 46.2 | 60.5 | 62.1 | 63.5 | 50.0 | 39.1 | 34.9 | 28.0 | 41.8 |
| 1974 | 23.0 | 17.8 | 29.7 | 38.7 | 44.4 | 55.7 | 60.8 | 59.8 | 53.4 | 35.8 | 32.4 | 25.7 | 39.8 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 25.8 | 21.4 | 24.8 | 32.9 | 48.3 | 57.0 | 64.0 | 60.9 | 50.9 | 43.4 | 37.7 | 23.4 | 40.9 |
| 1976 | 13.2 | 22.5 | 28.7 | 36.6 | 44.4 | 57.5 | 59.7 | 59.7 | 49.7 | 40.4 | **27.8** | 16.5 | 38.1 |
| 1977 | 10.0 | 20.3 | 32.0 | 33.6 | 45.4 | 54.1 | 61.0 | 61.7 | 56.4 | 40.4 | 35.4 | 23.9 | 39.5 |
| 1978 | 17.5 | **11.3** | 25.0 | 35.5 | 48.0 | 51.8 | 58.0 | 62.6 | **45.9** | 37.2 | 32.9 | 25.0 | 37.6 |
| 1979 | 21.5 | 13.1 | 31.5 | 34.9 | 50.3 | 52.5 | 62.4 | 63.3 | 51.4 | 43.6 | 38.0 | 30.2 | 41.1 |
| 1980 | 21.5 | 18.1 | 26.8 | 37.3 | 47.4 | 52.9 | 64.4 | 64.3 | 54.2 | 43.4 | 31.5 | 19.5 | 40.1 |
| 1981 | **9.9** | 23.1 | 25.9 | 39.2 | 47.0 | 58.5 | 64.4 | 60.7 | 54.0 | 39.7 | 35.6 | 25.6 | 40.3 |
| 1982 | 13.3 | 23.7 | 25.9 | 33.2 | 47.7 | 54.2 | 61.4 | 58.0 | 50.6 | 39.3 | 35.7 | 30.2 | 39.4 |
| 1983 | 23.4 | 22.1 | 32.5 | 37.6 | 44.3 | 53.5 | 61.5 | 60.9 | 53.0 | 43.0 | 35.0 | 22.5 | 40.8 |
| 1984 | 15.3 | **28.7** | 24.4 | 37.2 | 44.4 | 57.0 | 61.4 | 61.6 | 47.9 | 45.2 | 32.4 | 28.5 | 40.3 |
| 1985 | 15.2 | 22.2 | 29.4 | 38.8 | 46.8 | 51.9 | 60.4 | 58.6 | 52.1 | 40.6 | 38.4 | 21.5 | 39.7 |
| 1986 | 19.9 | 20.2 | 27.2 | 35.8 | 46.1 | 53.9 | 61.6 | 58.1 | 51.4 | 41.8 | 31.0 | 27.5 | 39.5 |
| 1987 | 20.7 | 20.1 | 28.5 | 39.1 | 46.0 | 57.9 | 63.0 | 57.4 | 52.7 | 35.9 | 33.3 | 25.6 | 40.0 |
| 1988 | 14.0 | 21.3 | 26.5 | 36.5 | 47.0 | 53.6 | 64.2 | 63.4 | 48.9 | 37.1 | 32.1 | 21.5 | 38.8 |
| 1989 | 22.7 | 21.3 | 27.6 | 34.3 | 47.4 | 58.9 | 61.9 | 62.0 | 52.8 | 41.5 | 32.6 | 15.1 | 39.8 |
| 1990 | 29.4 | 25.1 | 29.1 | 38.3 | 45.4 | 56.5 | 64.0 | 63.4 | 51.7 | 47.0 | 34.5 | 30.4 | 42.9 |
| 1991 | 21.2 | 25.5 | 33.0 | 40.5 | 50.1 | 57.1 | 62.1 | 63.0 | 51.4 | 44.3 | 36.0 | 27.3 | 42.6 |
| 1992 | 21.3 | 23.5 | 26.4 | 35.0 | 43.2 | 54.5 | 59.1 | 58.5 | 54.3 | 39.0 | 33.9 | 26.1 | 39.6 |
| 1993 | 25.1 | 15.9 | 26.7 | 38.5 | 47.3 | 56.9 | 62.5 | 61.2 | 55.0 | 40.4 | 30.1 | 25.3 | 40.4 |
| 1994 | 15.6 | 18.2 | 28.0 | 38.1 | 44.4 | 59.7 | **68.0** | 58.9 | 52.6 | 40.5 | 38.6 | 29.0 | 41.0 |
| 1995 | 29.2 | 19.6 | 30.9 | 35.2 | 45.5 | 56.8 | 65.6 | 59.6 | 51.2 | 44.5 | 32.3 | 21.4 | 41.0 |
| 1996 | 20.8 | 22.4 | 23.7 | 37.7 | 45.7 | 58.4 | 62.2 | 61.8 | 55.7 | 40.9 | 30.4 | 30.7 | 40.9 |
| 1997 | 21.5 | 27.6 | 27.8 | 36.0 | 43.8 | 53.5 | 60.9 | 60.0 | 52.0 | 40.0 | 32.6 | 26.4 | 40.2 |
| 1998 | **29.8** | 28.6 | 31.8 | 37.6 | 49.2 | 56.9 | 62.0 | 61.6 | 54.9 | 43.9 | 34.1 | 27.8 | 43.2 |
| 1999 | 22.4 | 24.8 | 29.1 | 36.2 | 46.4 | 58.2 | 65.2 | 62.5 | 56.3 | 40.0 | 37.5 | 28.5 | 42.3 |
| 2000 | 19.5 | 24.7 | 31.8 | 37.3 | 48.3 | 57.5 | 59.6 | 61.6 | 52.7 | 42.3 | 33.7 | 20.8 | 40.8 |
| 2001 | 19.7 | 22.8 | 28.3 | 38.0 | 48.5 | 59.8 | 58.5 | 64.6 | 52.4 | 42.4 | 37.2 | 31.0 | 41.9 |
| 2002 | 29.0 | 24.6 | 32.0 | 40.4 | 46.1 | 56.0 | 63.5 | 63.6 | 55.2 | 43.4 | 34.7 | 24.1 | 42.7 |
| 2003 | 19.0 | 19.9 | 26.7 | 36.9 | 44.2 | 56.9 | 63.9 | **66.6** | 57.1 | 42.0 | 38.0 | 27.6 | 41.6 |
| 2004 | 16.3 | 23.0 | 32.3 | 40.2 | 51.0 | 56.8 | 63.0 | 62.2 | 55.9 | 44.2 | 34.9 | 25.2 | 42.1 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | 20.7 | 22.0 | 35.0 | 36.5 | 43.9 | 60.1 | 64.8 | 66.4 | 55.6 | 47.9 | 37.3 | 24.7 | 42.9 |
| 2006 | 28.8 | 22.5 | 29.0 | 37.5 | 49.3 | 60.1 | 66.1 | 62.6 | 53.1 | 42.7 | 40.0 | 31.8 | 43.6 |
| 2007 | 27.2 | 19.2 | 27.3 | 36.0 | 47.1 | 57.0 | 63.2 | 62.4 | 54.6 | **52.1** | 32.9 | 26.6 | 42.1 |
| 2008 | 24.8 | 24.6 | 26.5 | 39.3 | 45.3 | 60.4 | 65.3 | 60.8 | 54.8 | 41.1 | 33.5 | 29.0 | 42.1 |
| 2009 | 17.7 | 25.0 | 28.6 | 39.5 | 49.3 | 56.9 | 60.4 | 64.5 | 52.1 | 42.8 | **40.7** | 26.5 | 42.0 |
| 2010 | 21.5 | 24.5 | 34.7 | **41.9** | 50.0 | **60.6** | 66.4 | 63.2 | 58.3 | 45.2 | 35.4 | 24.5 | 43.9 |
| 2011 | 18.8 | 22.3 | 30.5 | 41.4 | 51.6 | 58.9 | 65.5 | 63.4 | **60.5** | 46.1 | 39.2 | 29.3 | 44.0 |
| 2012 | 26.2 | 27.3 | **37.4** | 38.9 | **53.5** | 57.0 | 65.3 | 63.3 | 54.9 | 48.9 | 32.0 | **31.9** | **44.7** |
| | | | | | | | | | | | | | |
| **Average** | 20.5 | 21.6 | 28.3 | 36.4 | 45.8 | 55.7 | 61.9 | 60.4 | 52.5 | 41.7 | 33.6 | 24.9 | 40.3 |
| **Max** | 29.8 | 28.7 | 37.4 | 41.9 | 53.5 | 60.6 | **68.0** | 66.6 | 60.5 | 52.1 | 40.7 | 31.9 | 44.7 |
| **Min** | **9.9** | 11.3 | 22.1 | 30.1 | 39.3 | 50.5 | 54.1 | 53.9 | 45.9 | 34.5 | 27.8 | 14.1 | 36.8 |

**Min** **Max**

## Barometric Pressure

Barometric pressure is measured at the 2-meter level. The pressure sensors are connected to R.M. Young model 61002 pressure ports to reduce errors due to blowing winds. The sensors are sent off-site for calibration. Average daily pressure for 2012 is plotted in Figure 16. The lowest pressure, 965.8 mbar, occurred on October 29th during tropical storm Sandy. Monthly data plots of the 1-minute data for pressure are presented in Figures 17 through 28.

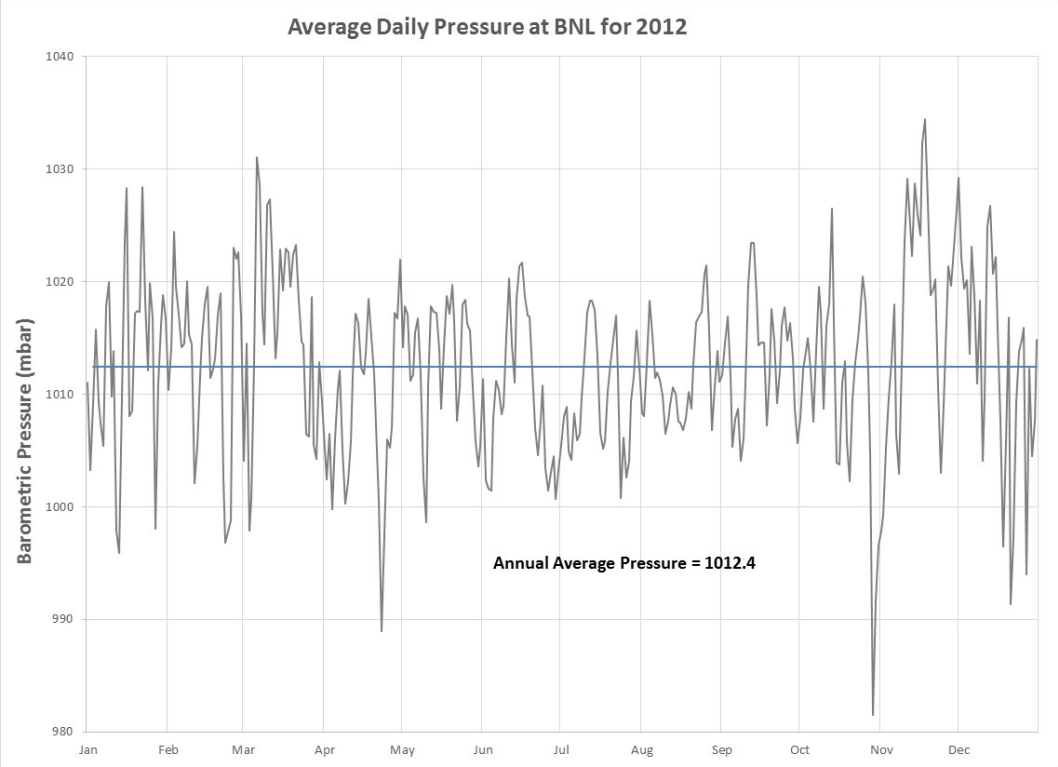


Figure 16 Average Daily Barometric Pressure at Brookhaven National Laboratory for 2012

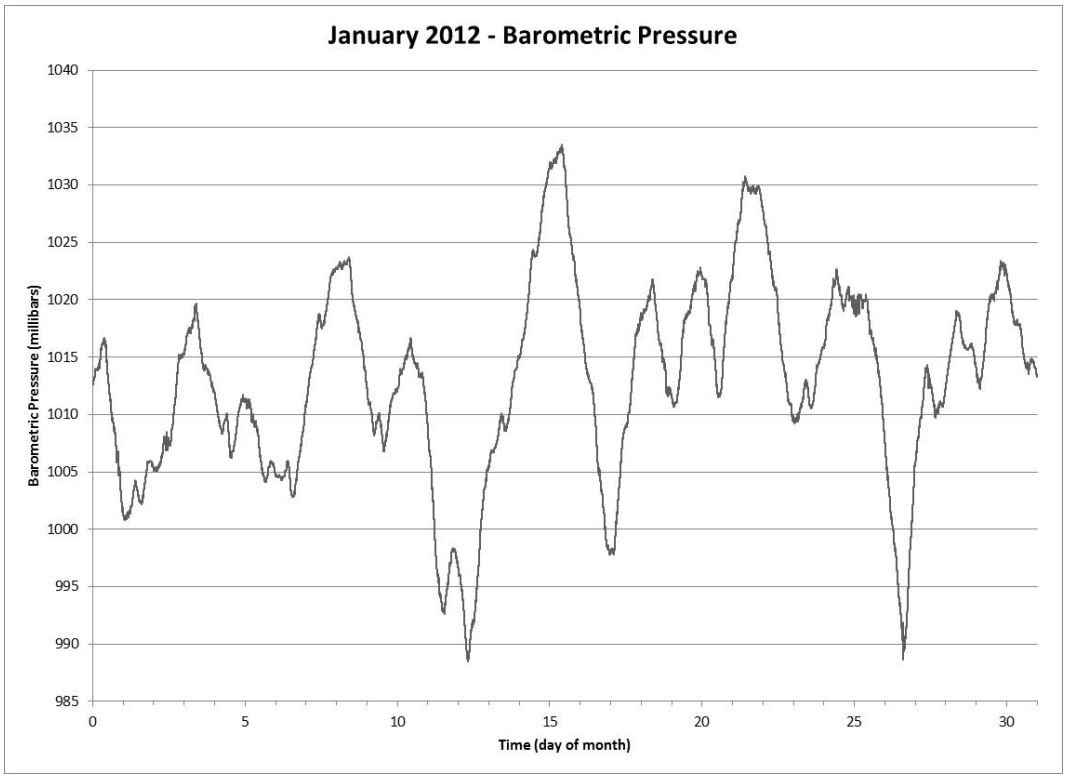


Figure 17 Barometric Pressure for the Month of January 2012

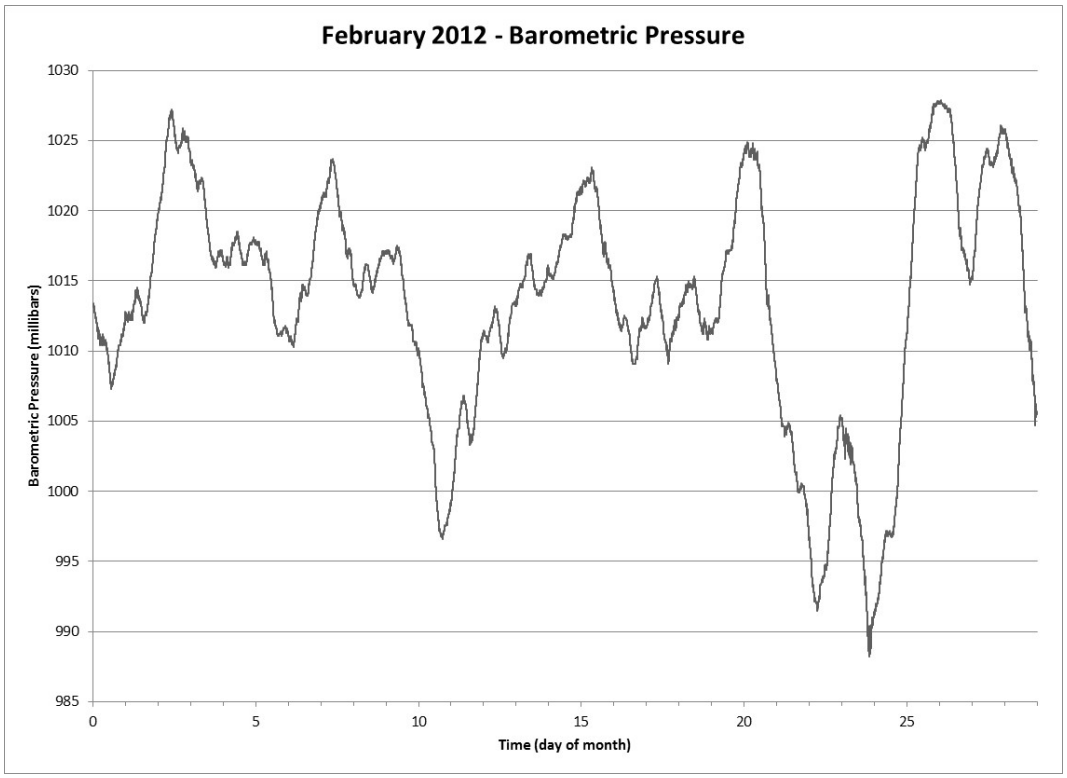


Figure 18 Barometric Pressure for the Month of February 2012

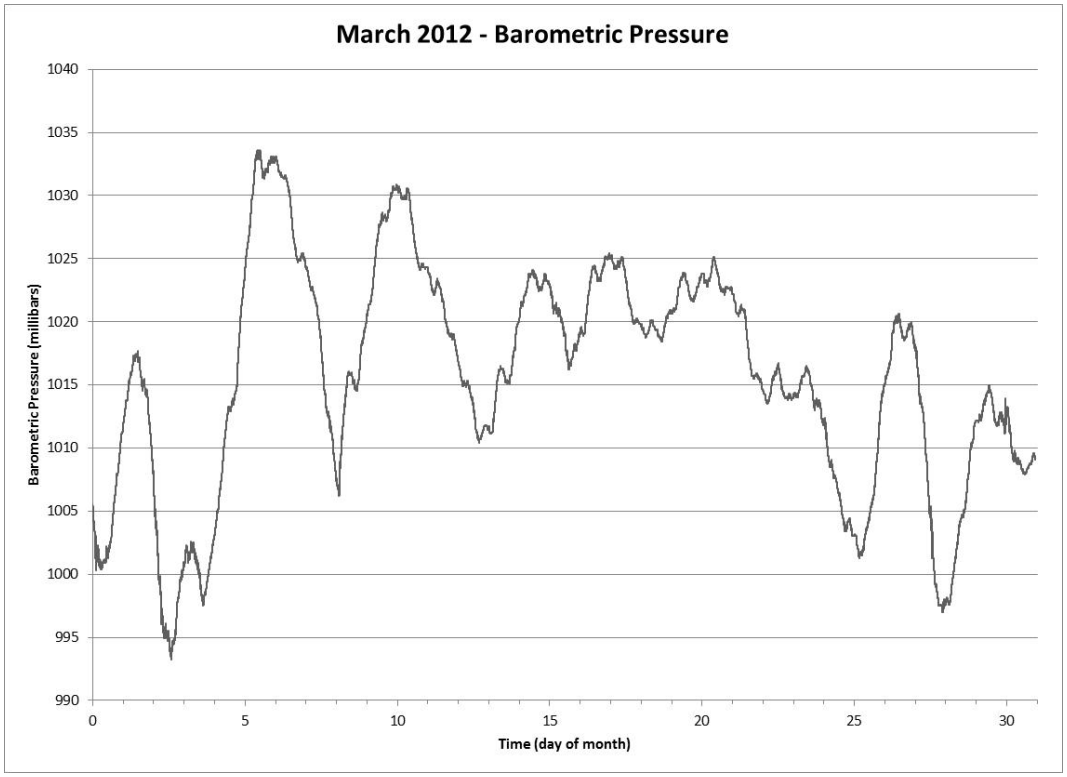

Figure 19 Barometric Pressure for the Month of March 2012

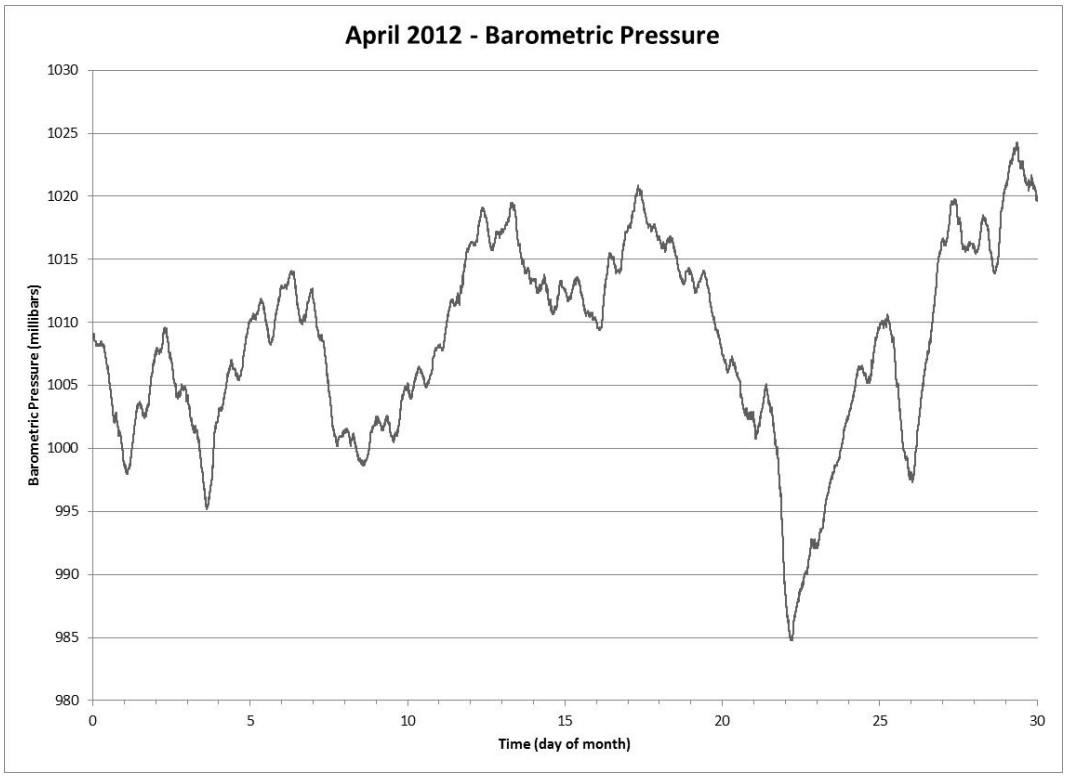

Figure 20 Barometric Pressure for the Month of April 2012

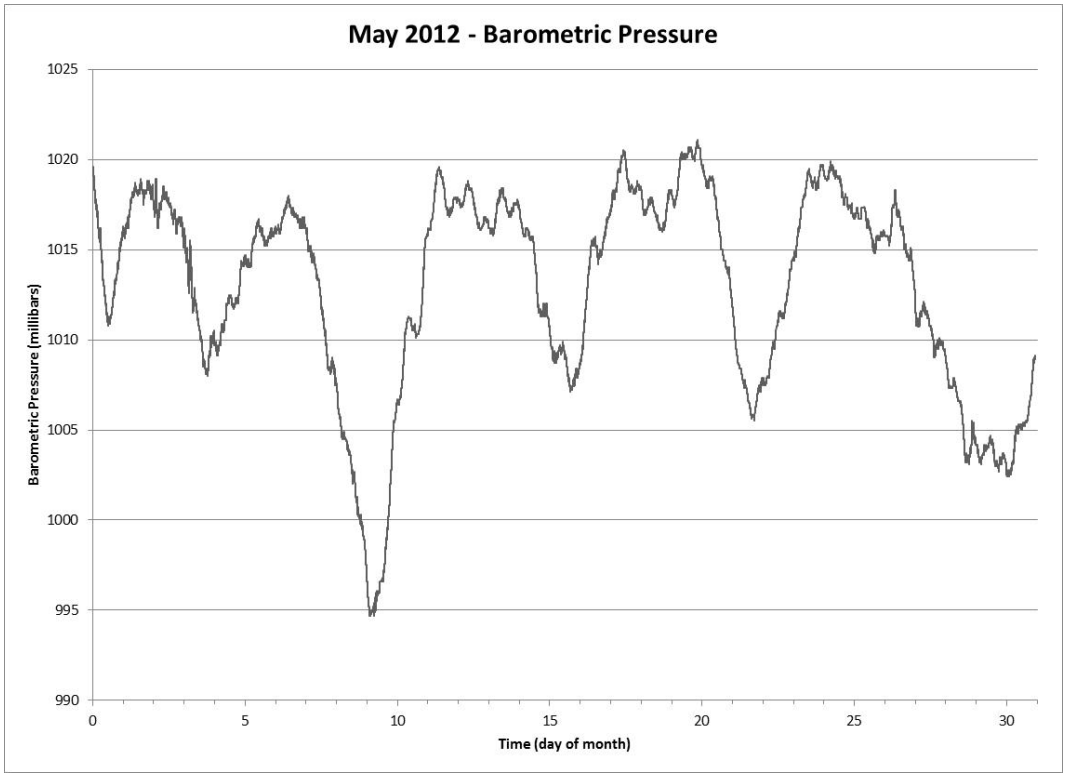


Figure 21 Barometric Pressure for the Month of May 2012

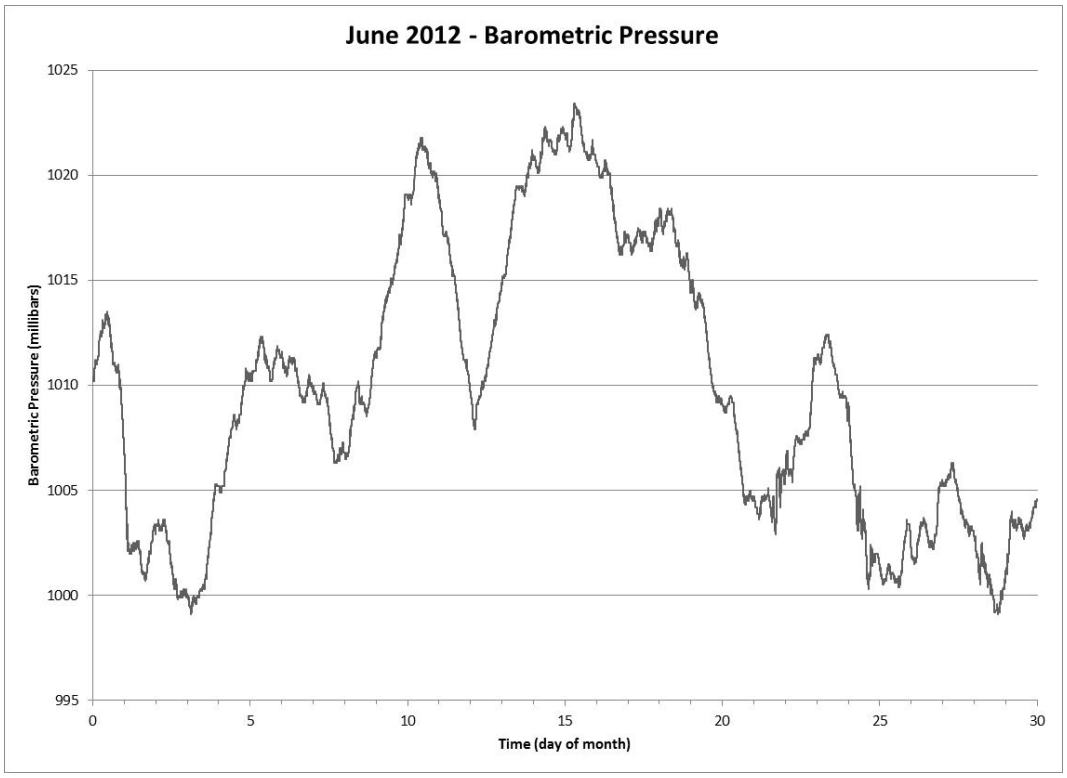


Figure 22 Barometric Pressure for the Month of June 2012

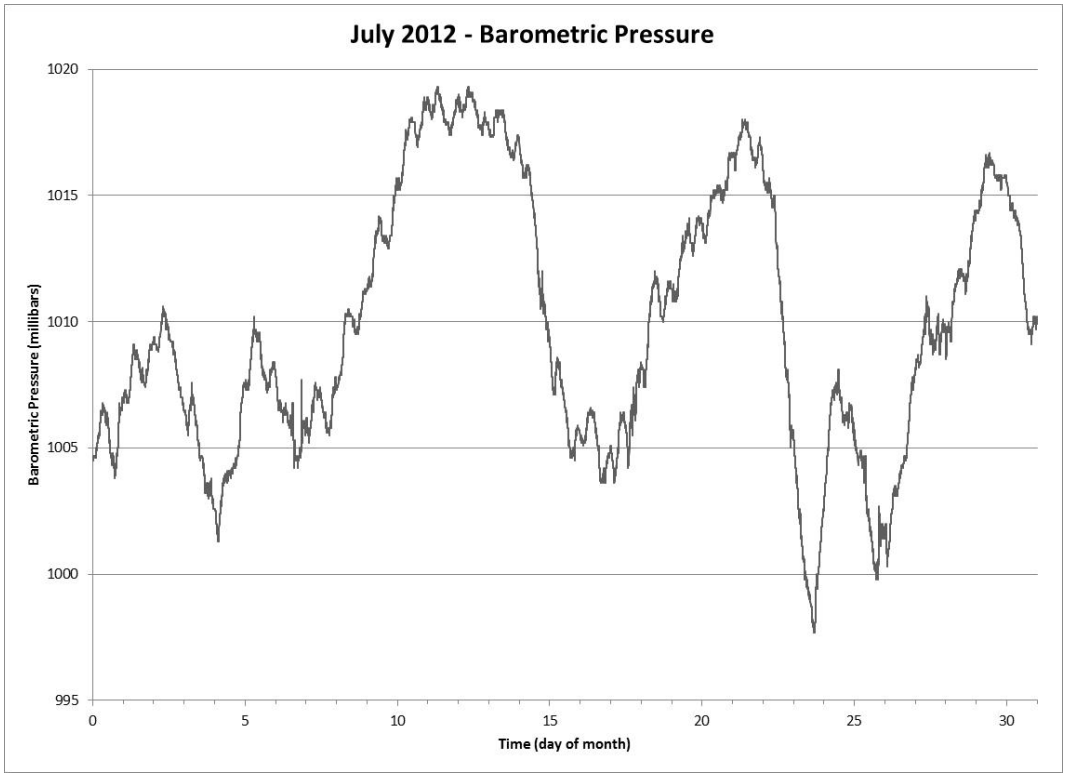

Figure 23 Barometric Pressure for the Month of July 2012

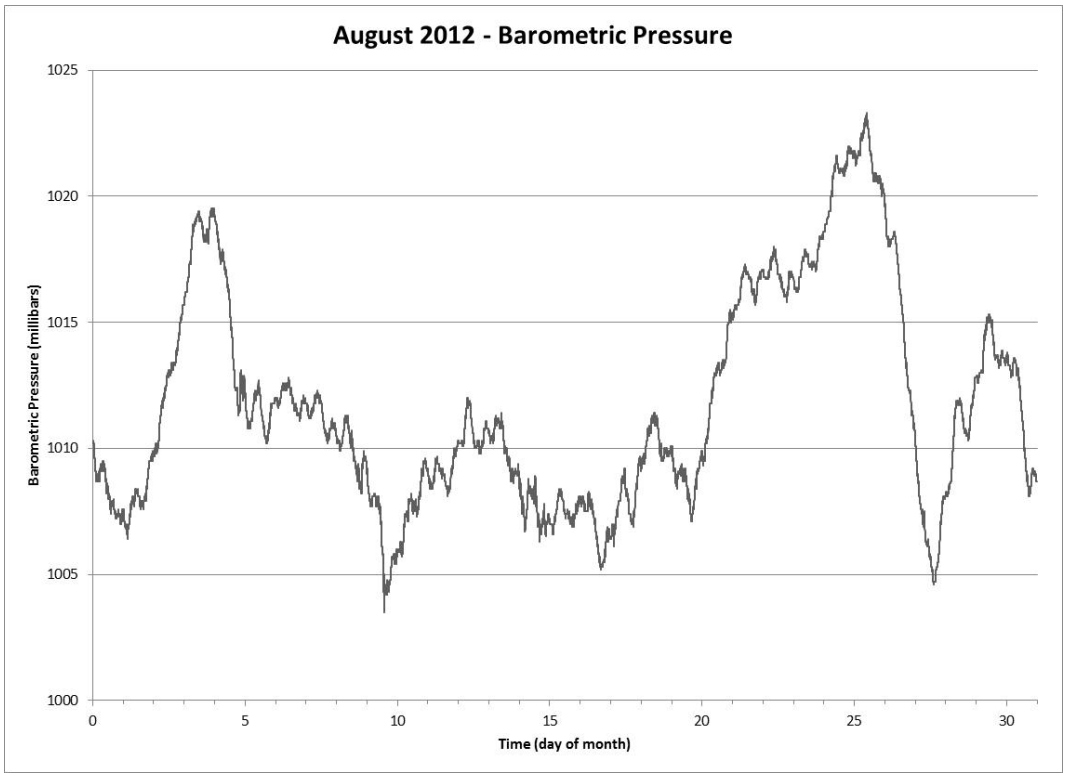

Figure 24 Barometric Pressure for the Month of August 2012

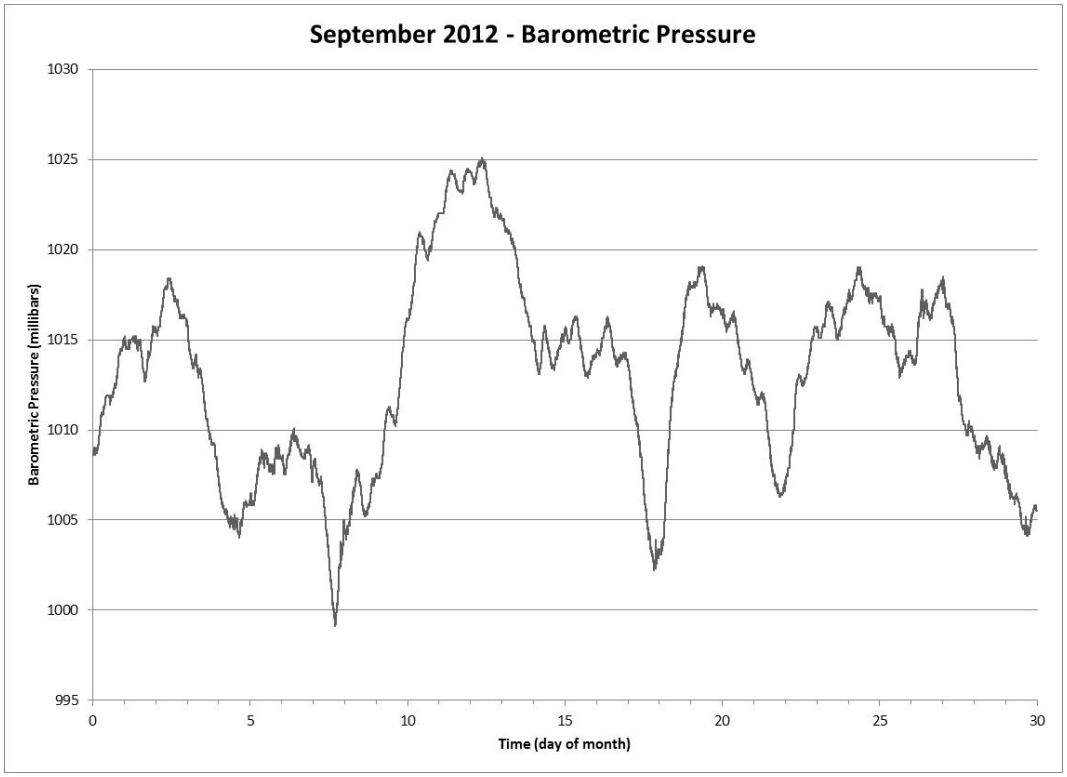

Figure 25 Barometric Pressure for the Month of September 2012

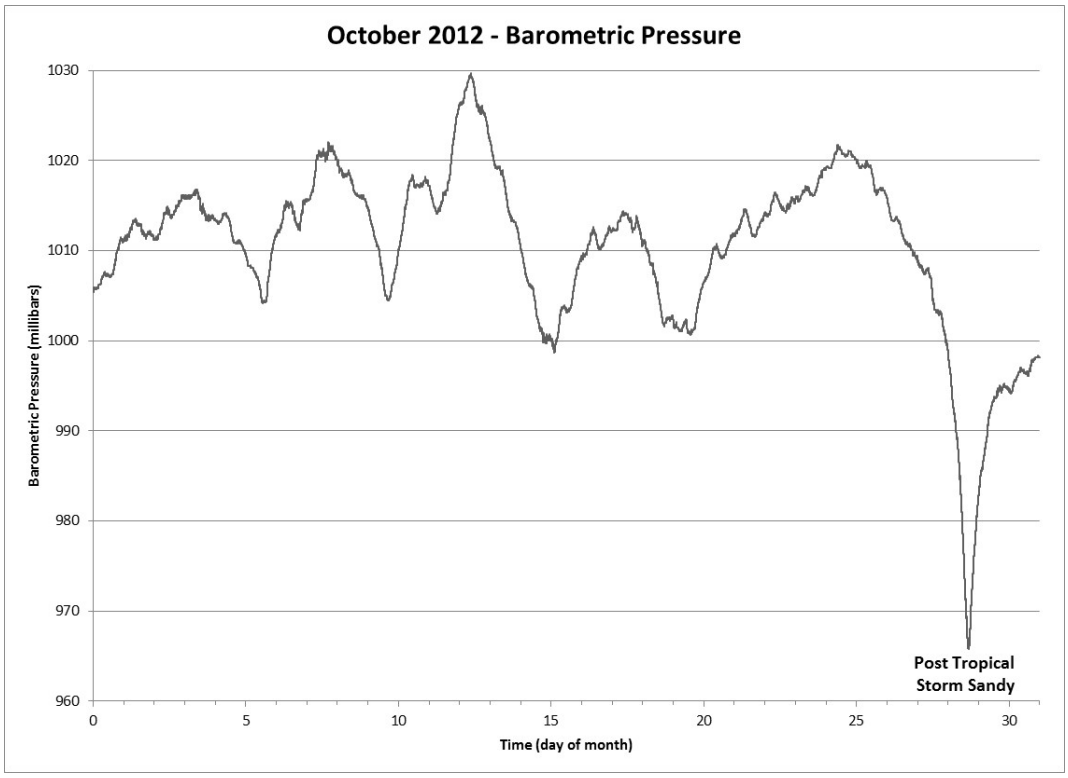

Figure 26 Barometric Pressure for the Month of October 2012

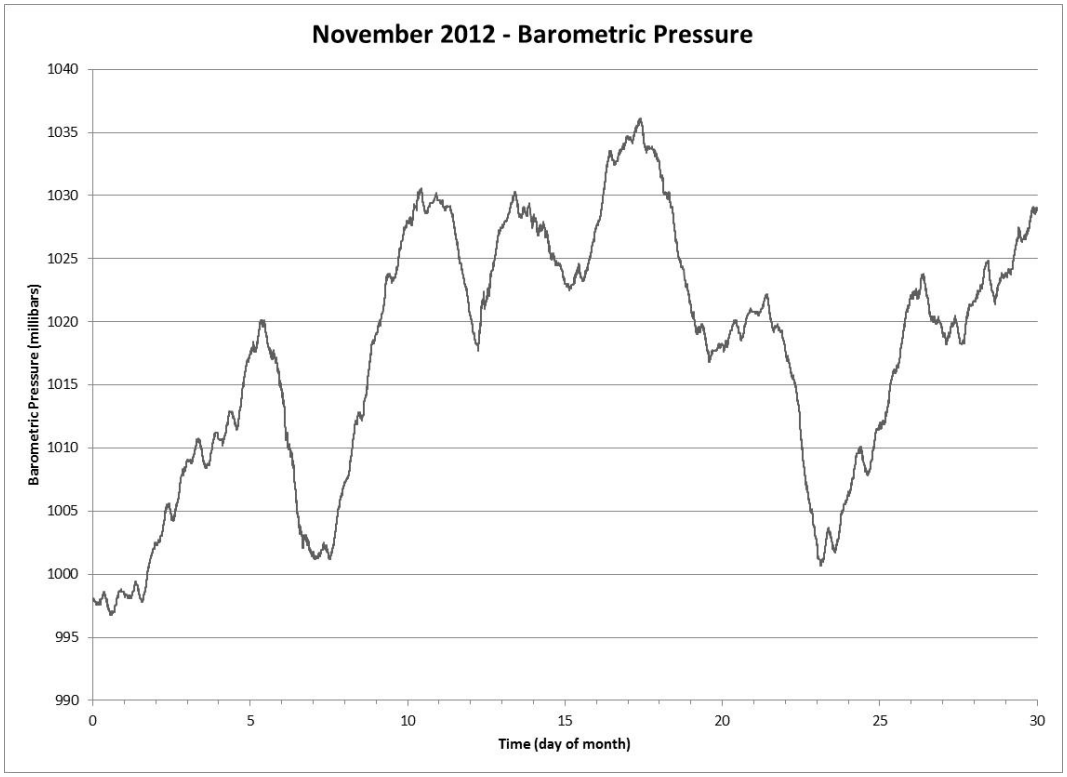

Figure 27 Barometric Pressure for the Month of November 2012

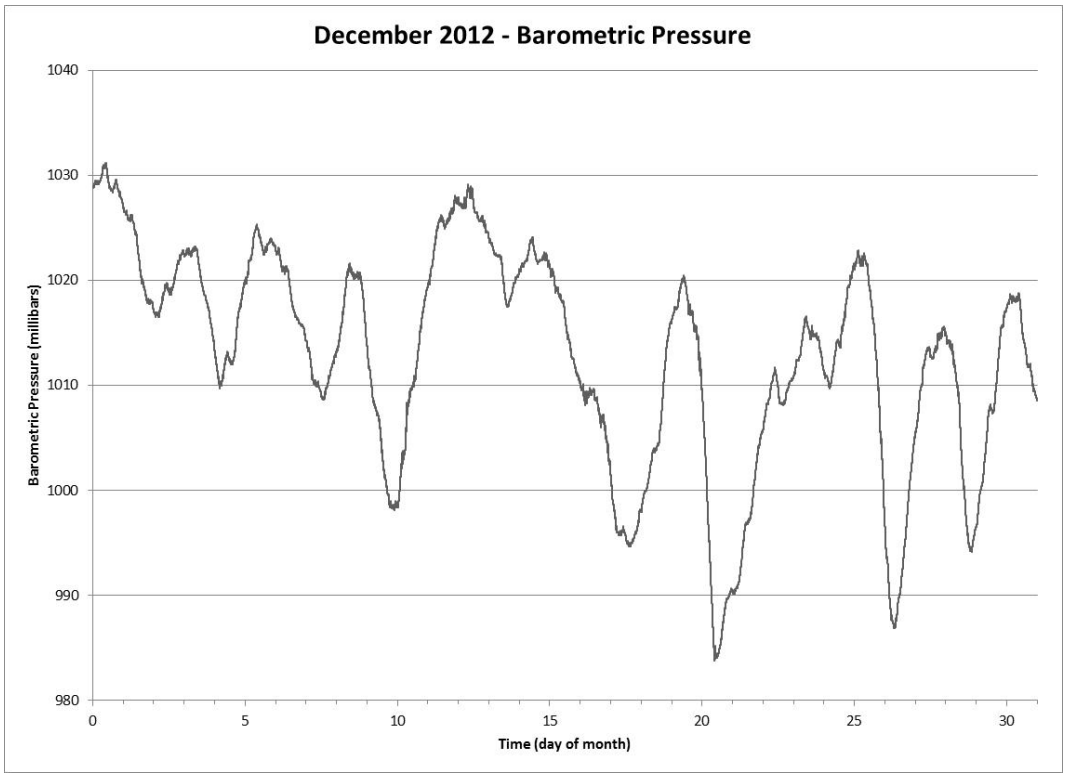

Figure 28 Barometric Pressure for the Month of December 2012

## Relative Humidity

Relative Humidity is measured at the 2-meter level. The sensors are calibrated on site and maintained to ±4%. The relative humidity sensor is calibrated, in the laboratory, using saturated salt baths. The use of saturated salt baths is one of the oldest methods for generating humidity at different levels. The RH value is a function of the chemical properties of the salt when mixed with water, with different saturated salt solutions yielding different RH values. Although cumbersome, saturated salt solutions are very reliable. The saturated salt solutions are easy to make and result in a fairly constant humidity over a reasonable temperature range. BNL Met Services uses saturated aqueous salt solutions as described in ASTM E104-02 to obtain a three point calibration of the RH probes. Specific humidity calibration chamber covers that fit each probe type are used and separate chambers for each salt solution. The reference solutions are stored in sealed chambers. The specific solutions include; Sodium Chloride (NaCl) for 75.5 ±0.2 % RH @ 20°C, Sodium Bromide (NaBr) for 59.1 ± 0.5 % RH @ 20° and Magnesium Chloride (MgCl) for 33.1 ±0.2 % RH @ 20°C. In contrast, the Campbell HMP45C has an accuracy of ±2% RH (0 to 90% RH) ±3% RH (90% to 100% RH) and the R.M. Young 41372VC has a stated accuracy of ±1% @ 20-25°C. The ANS requirement is ±4%. If the probe fails to meet the ±4% it must be replaced.

The average daily humidity at BNL for 2012 was 75.8 %. The average daily low humidity was 51.7 %. The average daily high humidity was 95.2 %. Daily average humidity is plotted in Figure 29, daily minimum in Figure 30 and daily maximum humidity in Figure 31. Monthly data plots of the 1-minute data for relative humidity are presented in Figures 32 through 43.

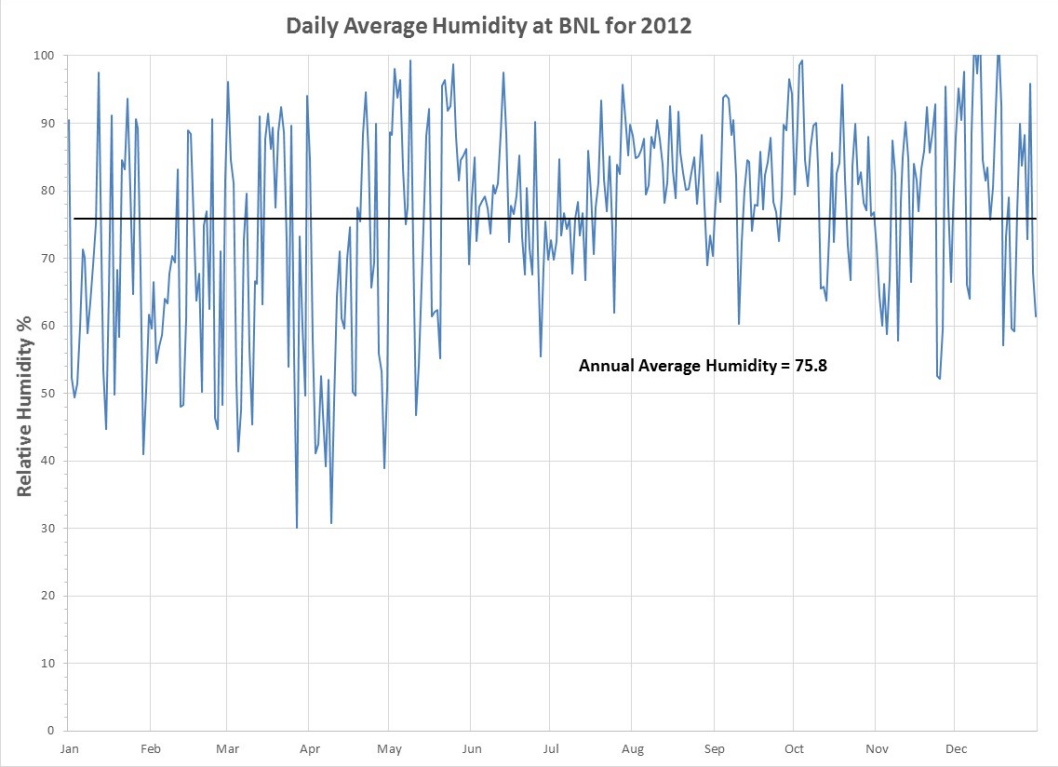

Figure 29 Daily Mean Relative Humidity at Brookhaven National Laboratory for 2012

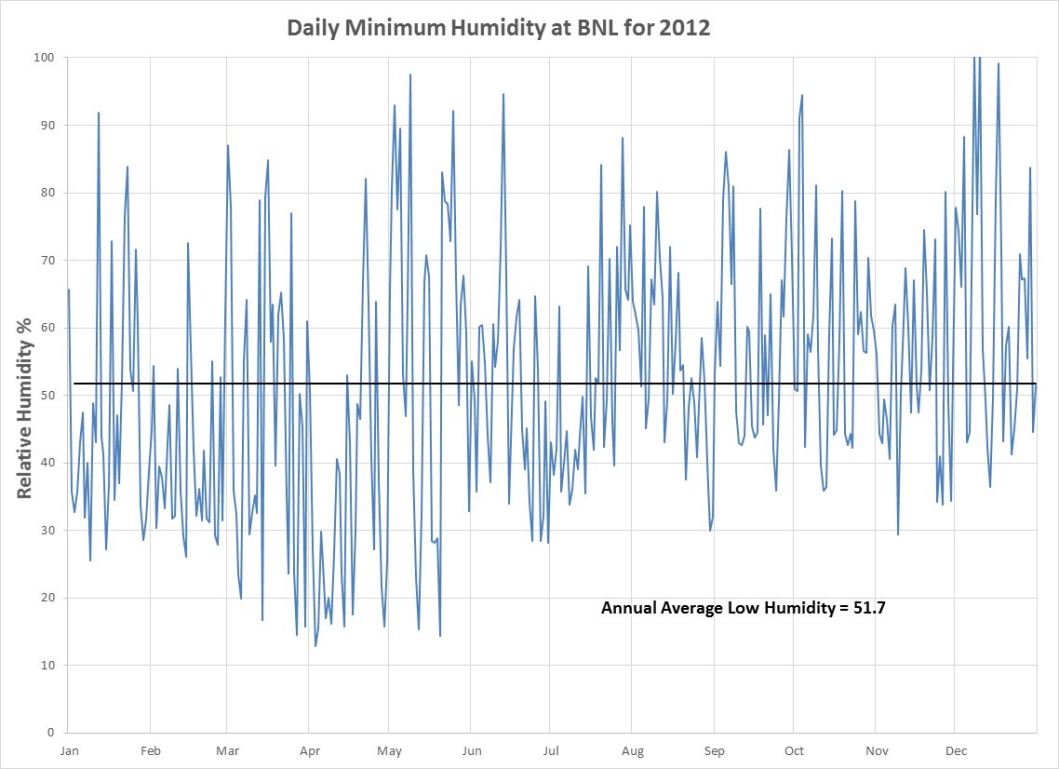


Figure 30 Minimum Daily Humidity at Brookhaven National Laboratory for 2012

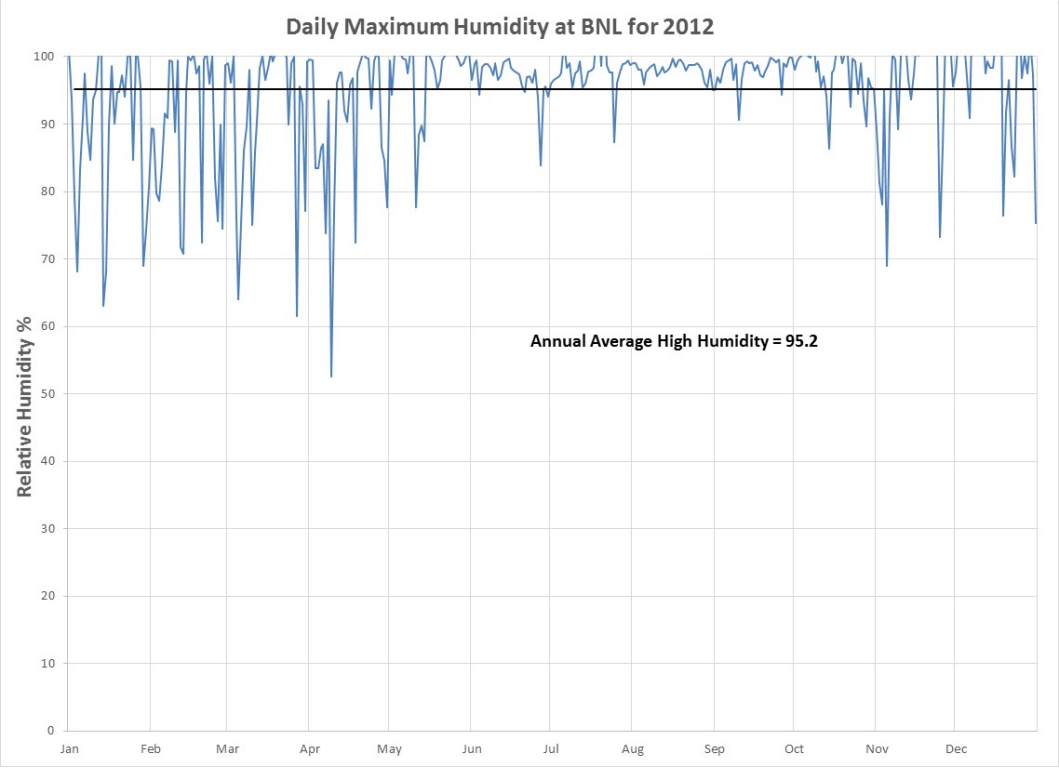


Figure 31 Maximum Daily Humidity at Brookhaven National Laboratory for 2012

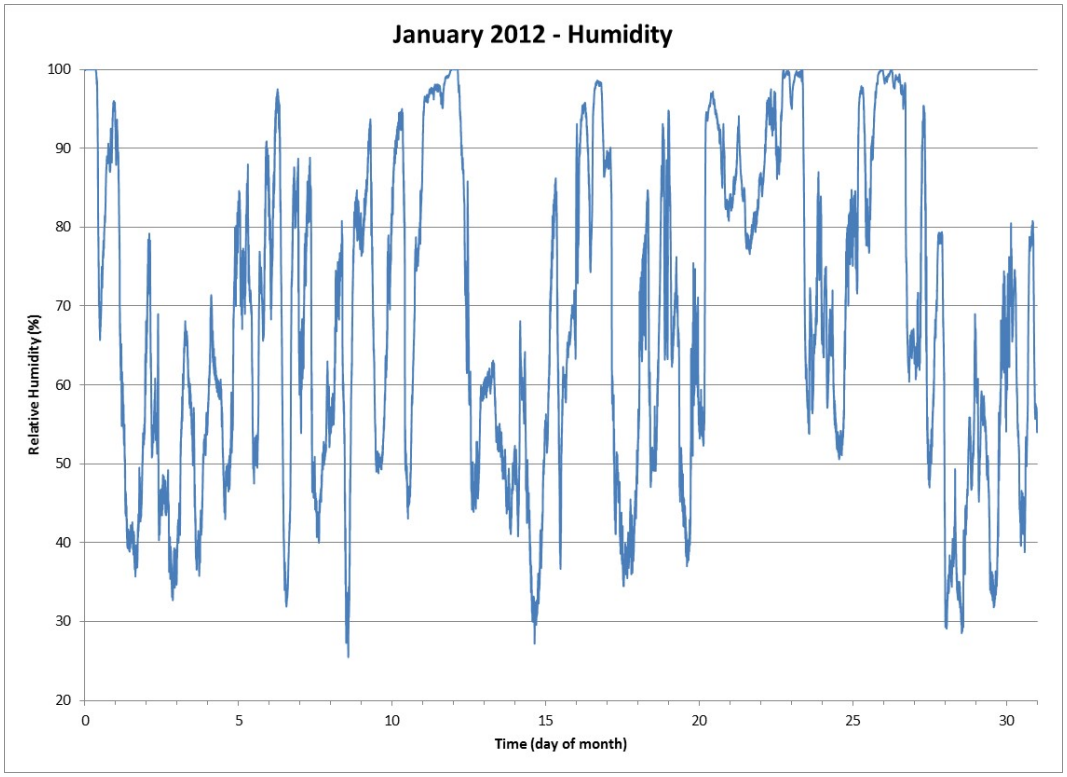


Figure 32 Relative Humidity for the Month of January 2012

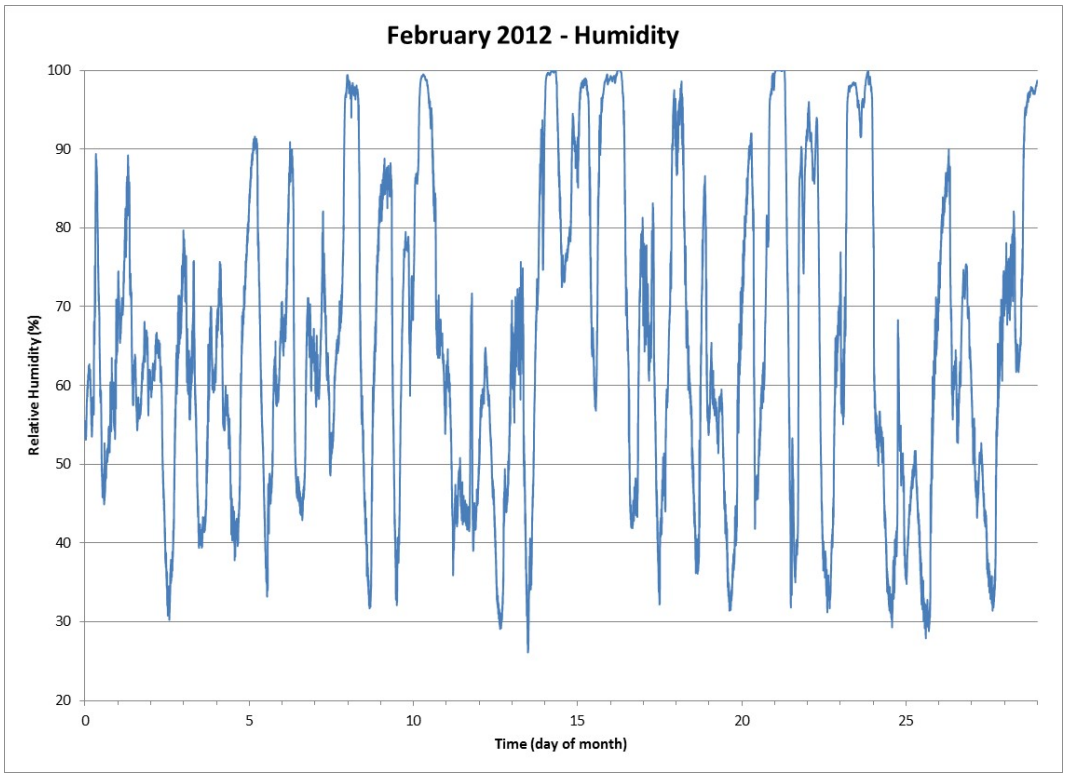


Figure 33 Relative Humidity for the Month of February 2012

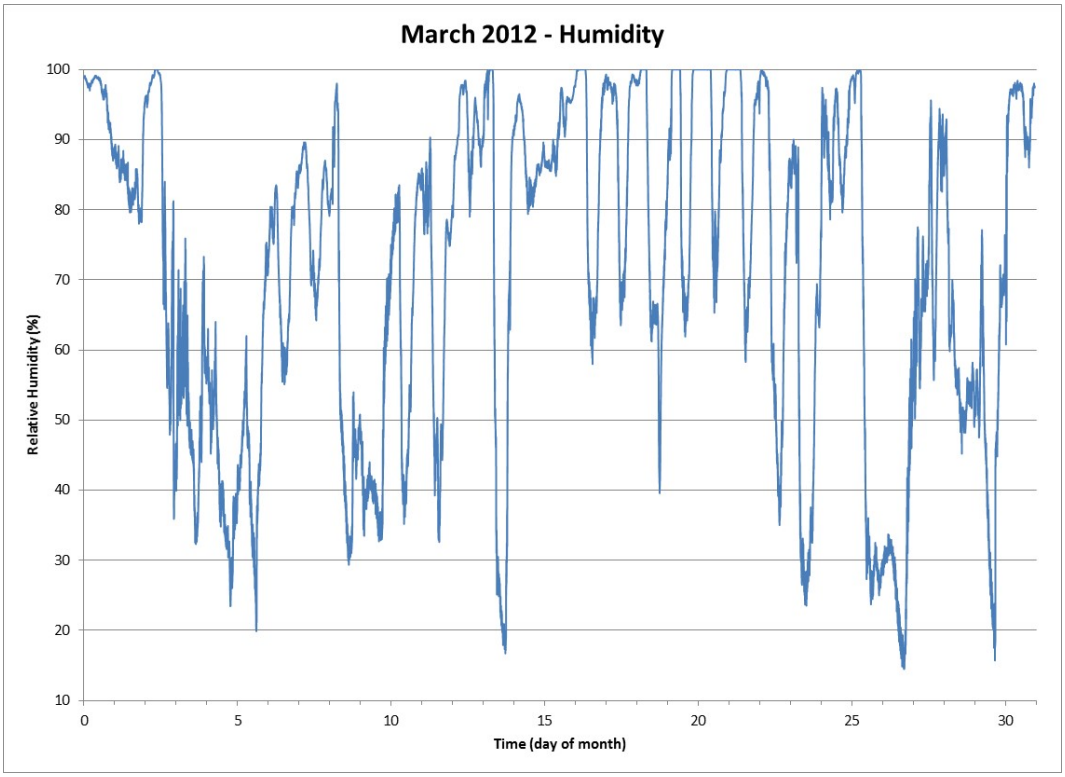

Figure 34 Relative Humidity for the Month of March 2012

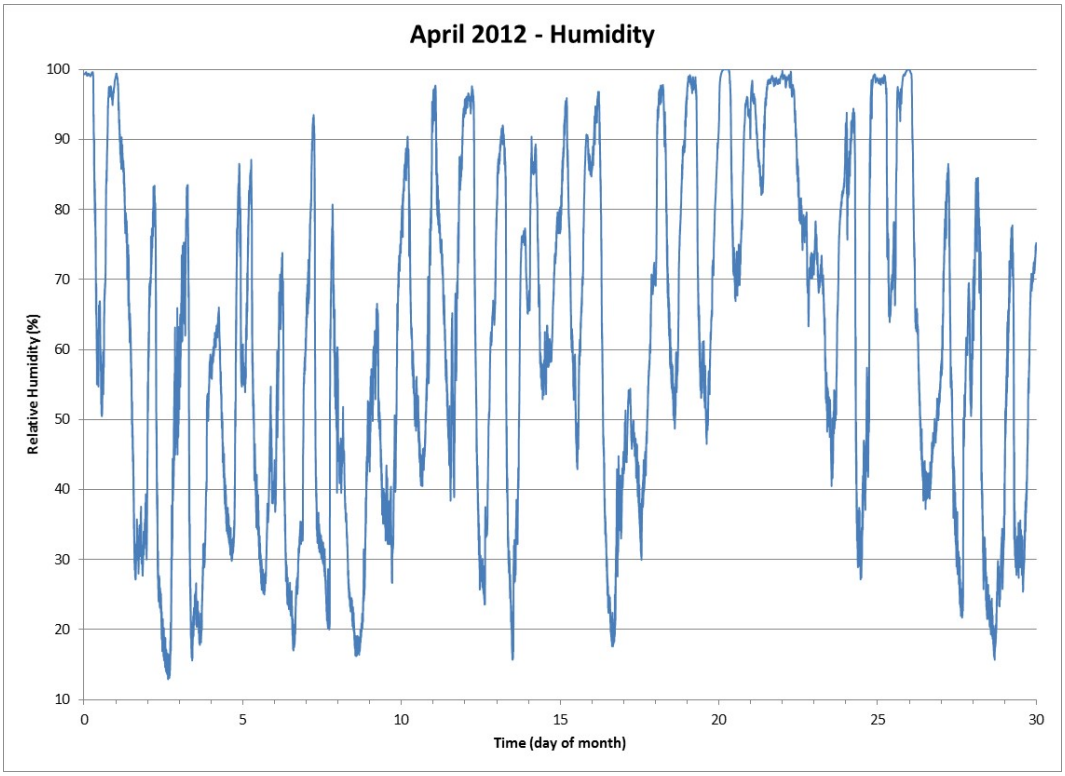

Figure 35 Relative Humidity for the Month of April 2012

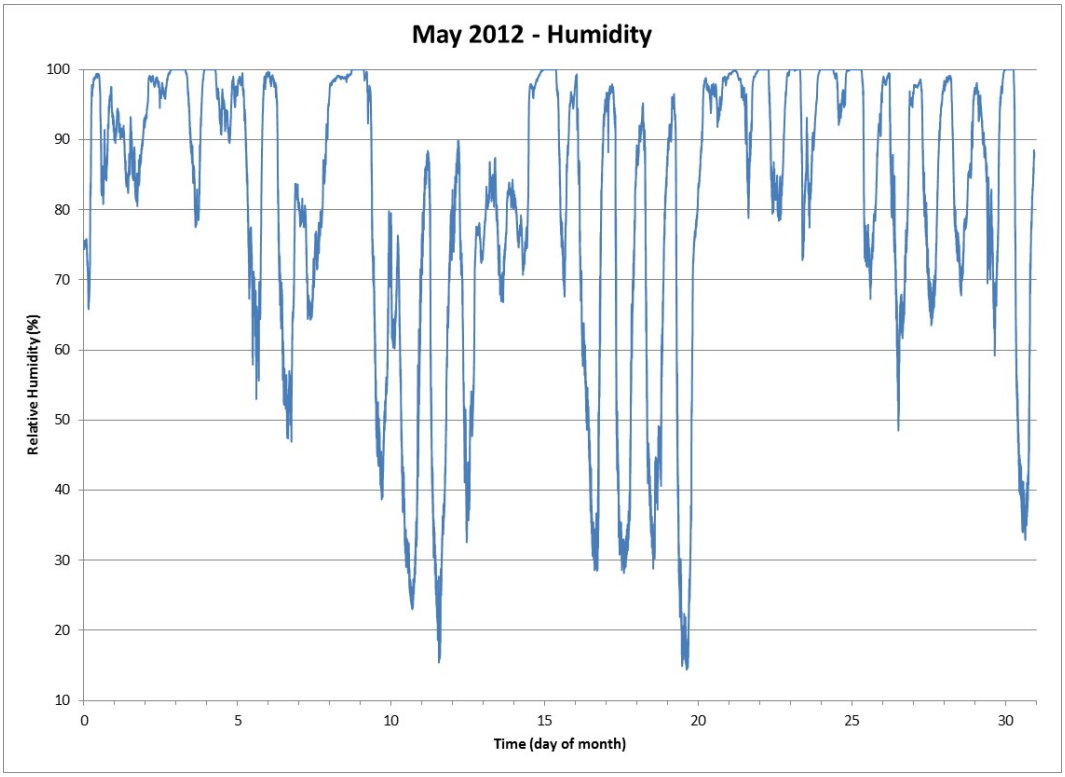


Figure 36 Relative Humidity for the Month of May 2012

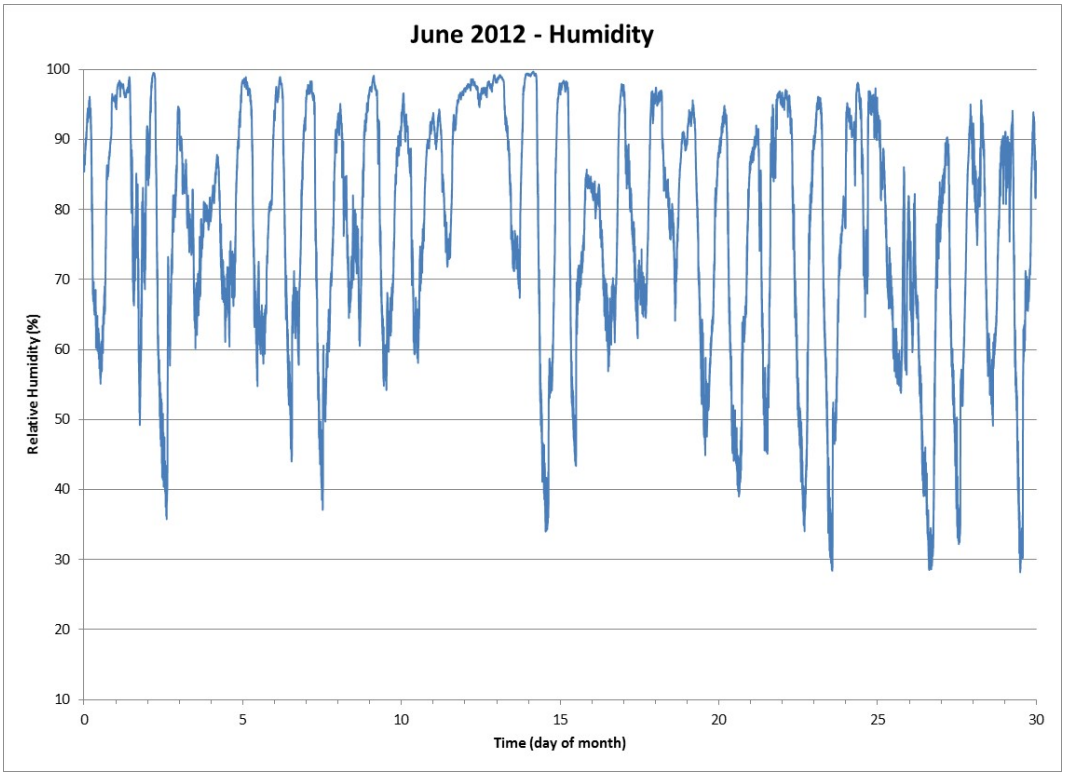


Figure 37 Relative Humidity for the Month of June 2012

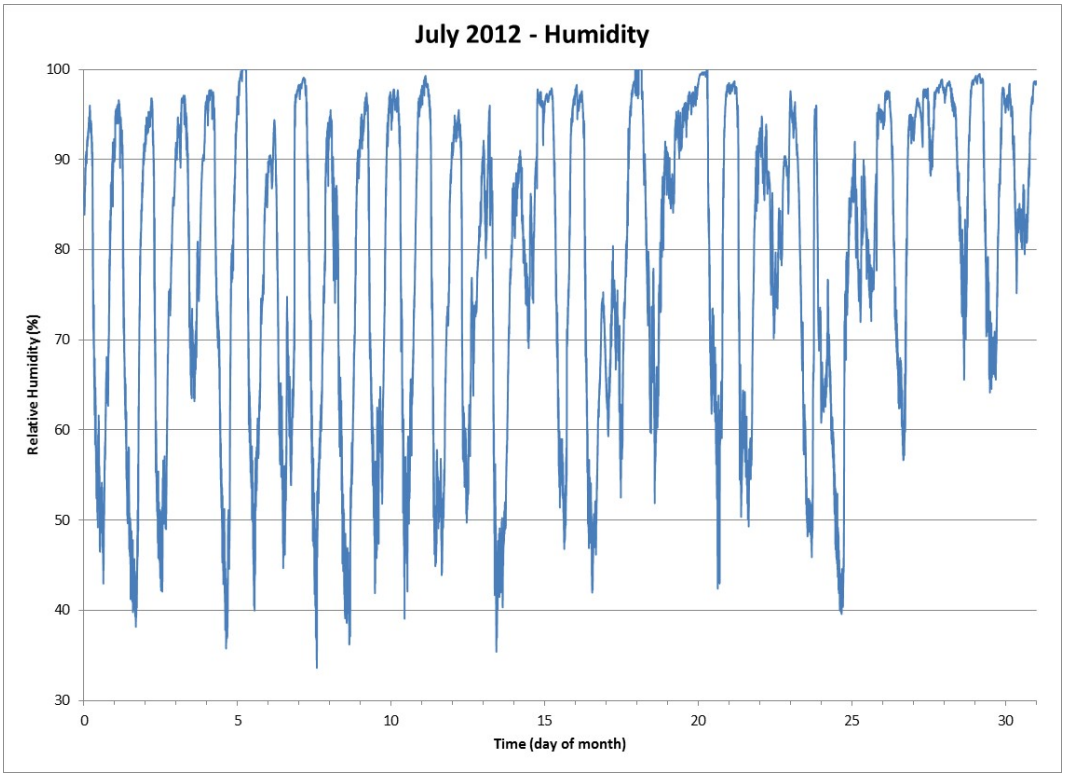


Figure 38 Relative Humidity for the Month of July 2012

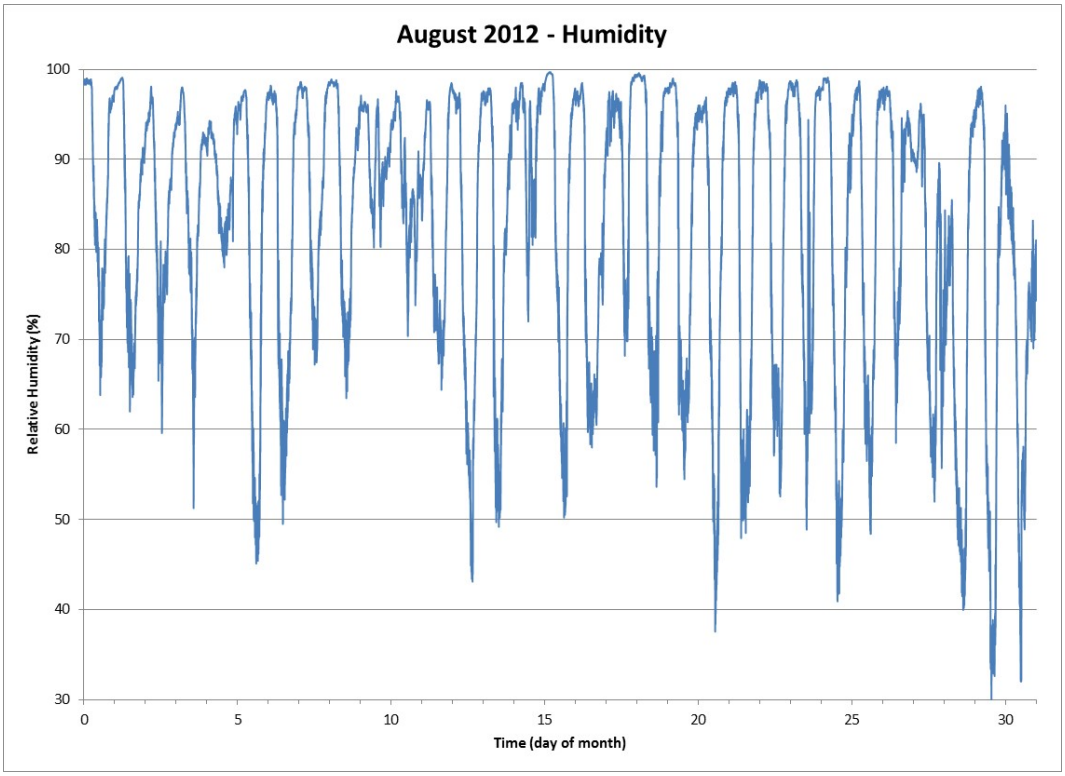


Figure 39 Relative Humidity for the Month of August 2012

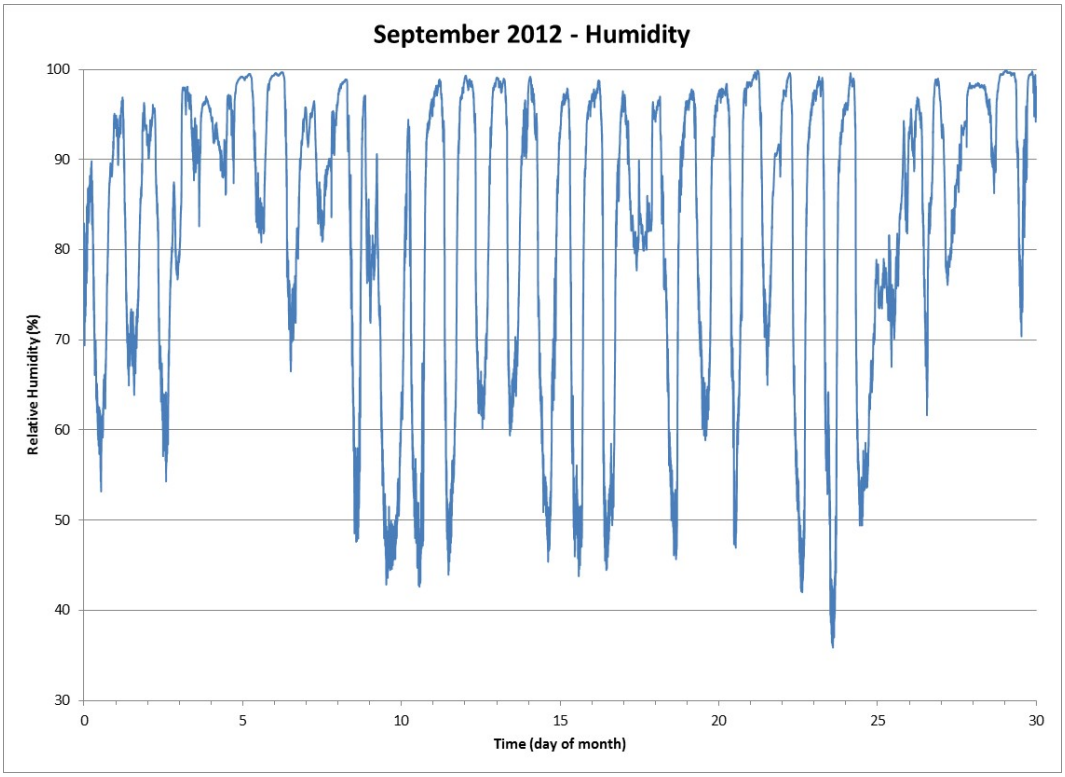


Figure 40 Relative Humidity for the Month of September 2012

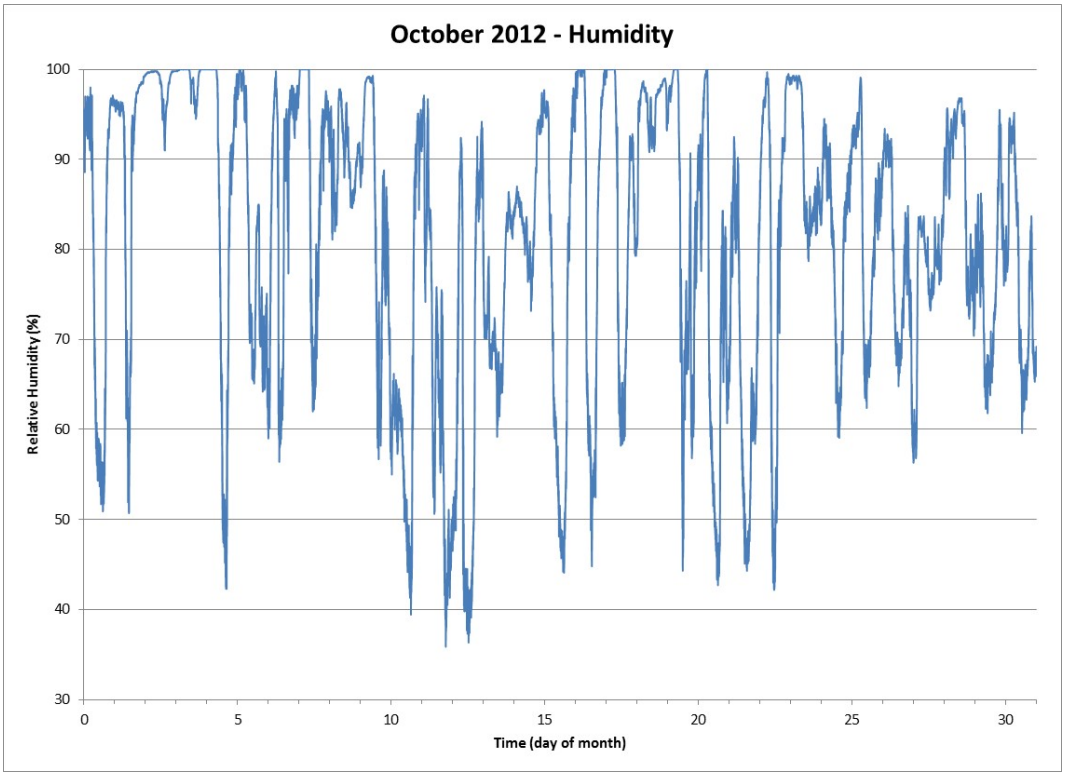


Figure 41 Relative Humidity for the Month of October 2012

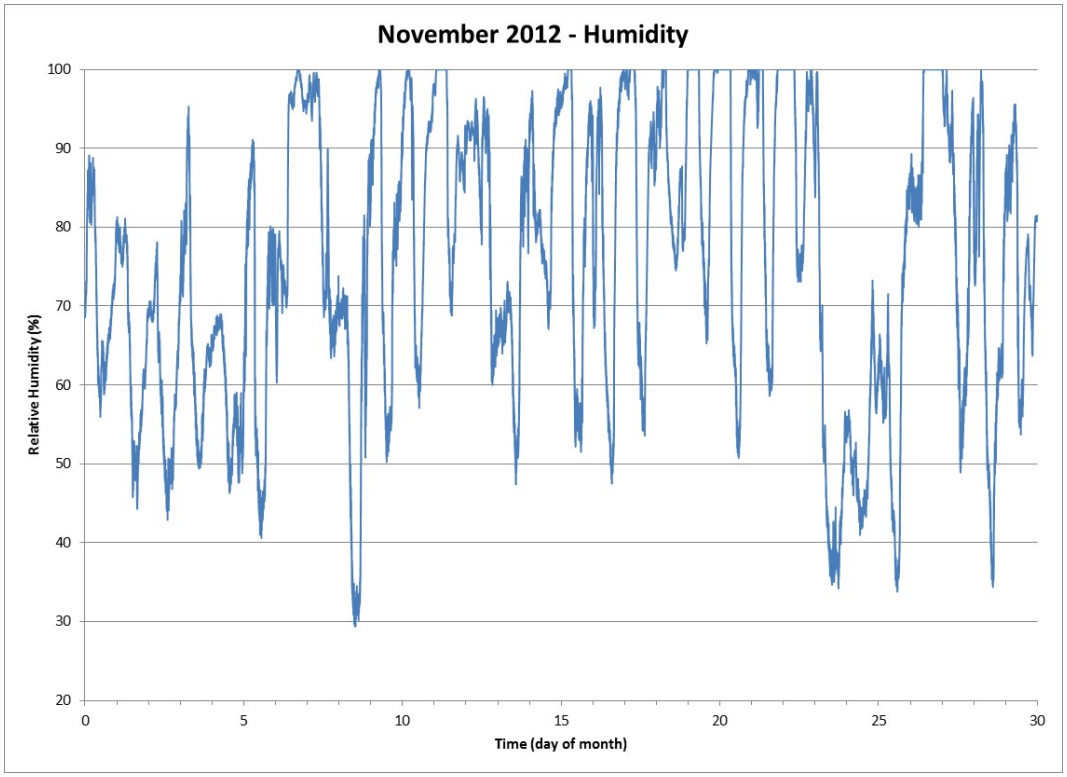


Figure 42 Relative Humidity for the Month of November 2012

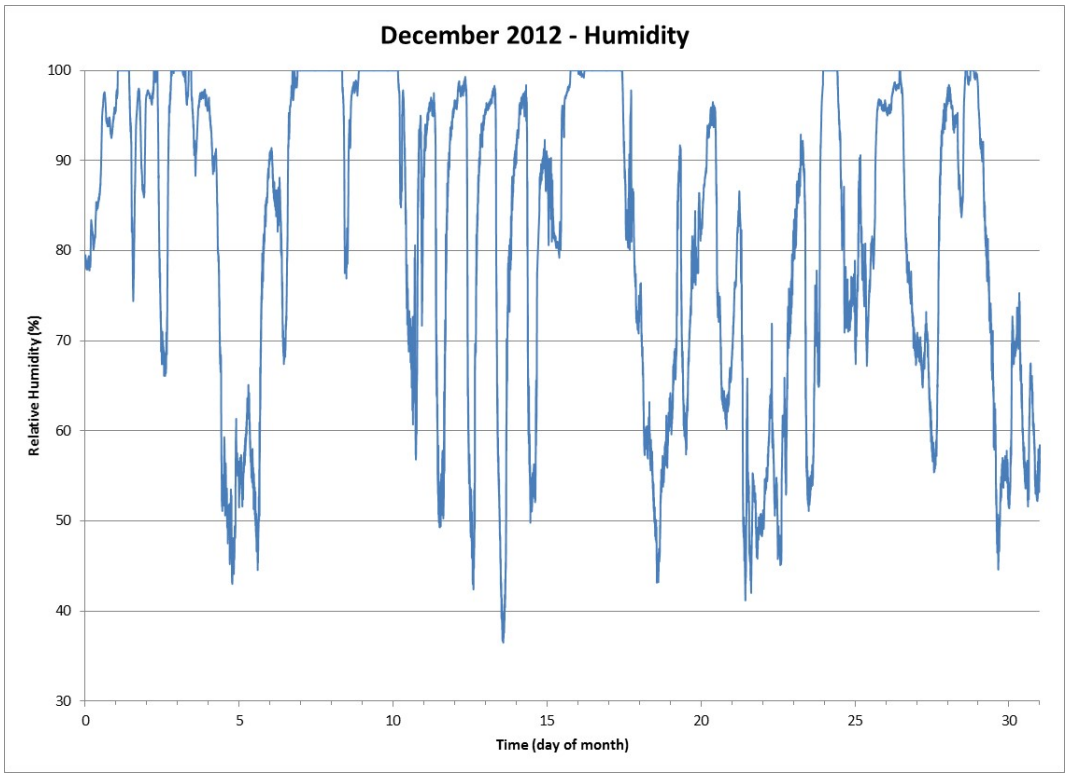


Figure 43 Relative Humidity for the Month of December 2012

## Rainfall

Rainfall is measured using a 12" NovaLynx 2500 electrically heated (for snowfall events), tipping bucket rain gauges which are calibrated annually. The gauges measure tips for each 0.01" of rain. Calibration is accomplished by BNL personnel using the NovaLynx Calibration Assembly (model 260-2595) and is completed in-situ. Accuracy is ±1% for 1 to 3 inches per hour rainfall and ±3% for 0 to 6 inches per hour. If the test results are outside this accuracy requirement the tipping bucket is adjusted to bring it within specs. Daily rainfall totals for 2012 are depicted in Figure 44. Monthly data charts of daily rainfall totals are presented in Figures 45 through 56. Table 6 lists the historic monthly rainfall totals along with monthly averages, maximums and minimums from 1949 to 2012.

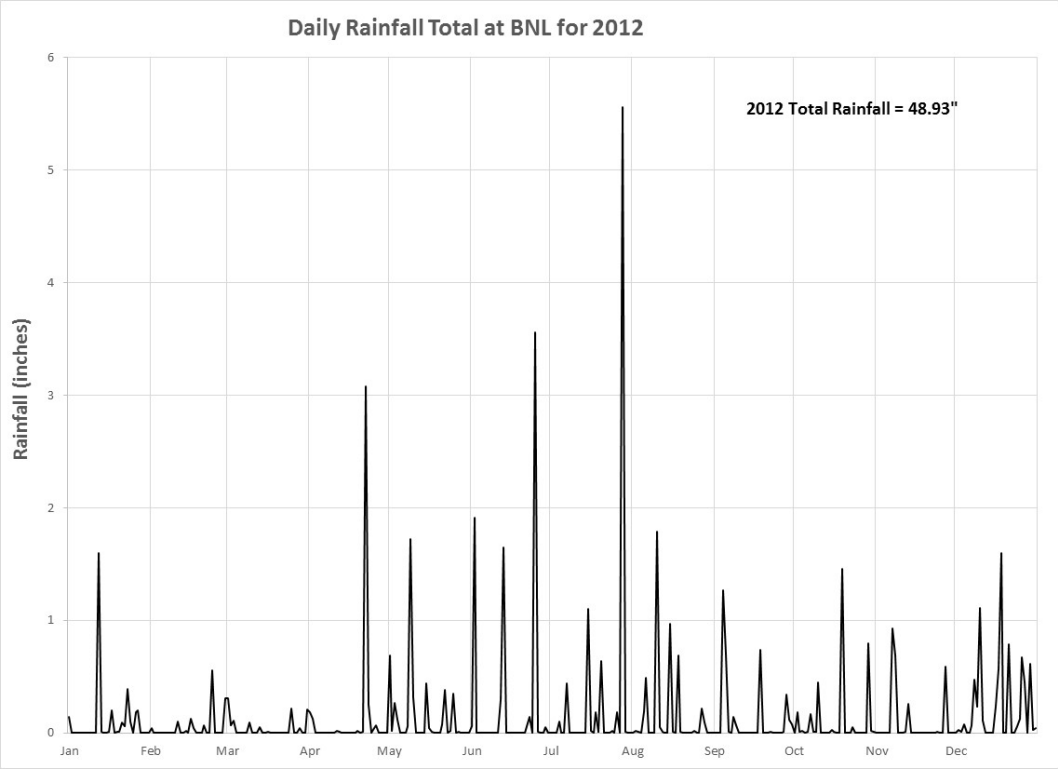


Figure 44 Daily Rainfall Totals at Brookhaven national Laboratory for 2012

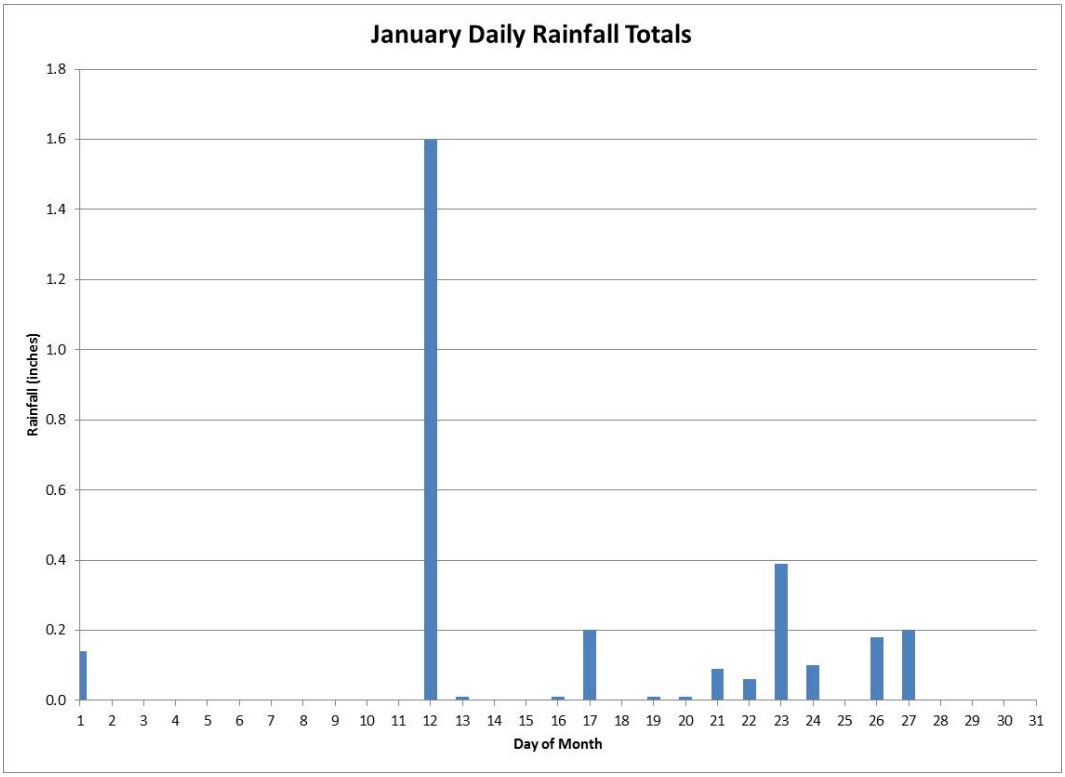


Figure 45 Daily Rainfall for the Month of January 2012

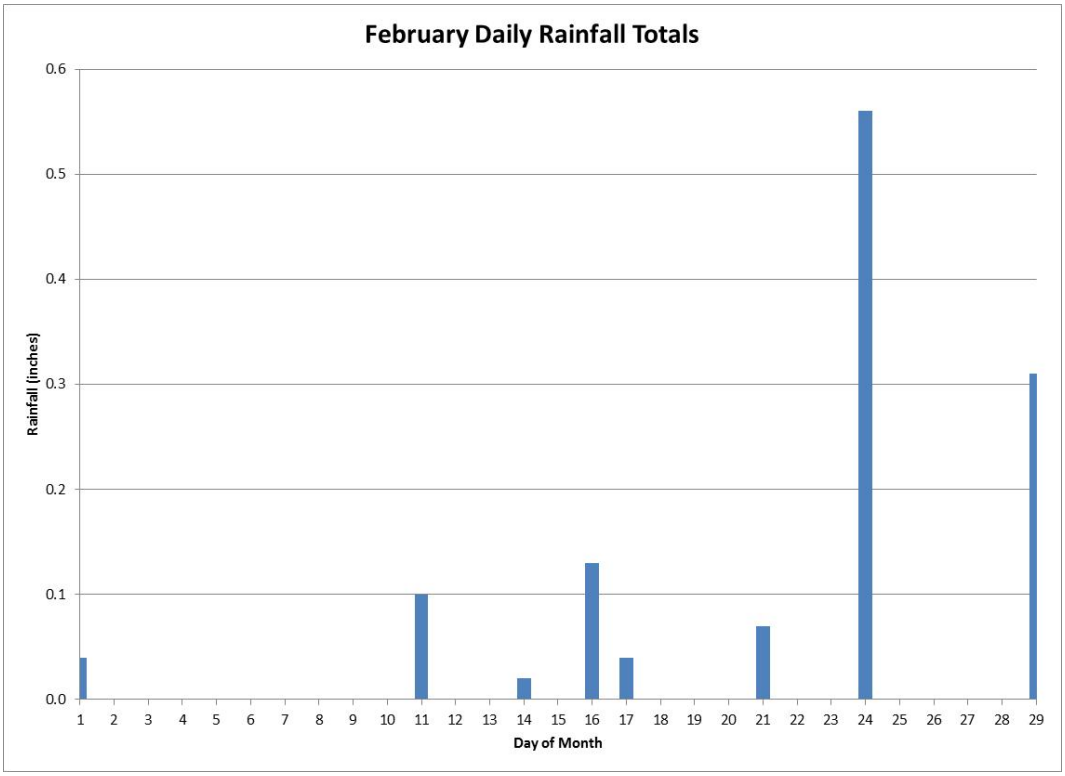


Figure 46 Daily Rainfall for the Month of February 2012

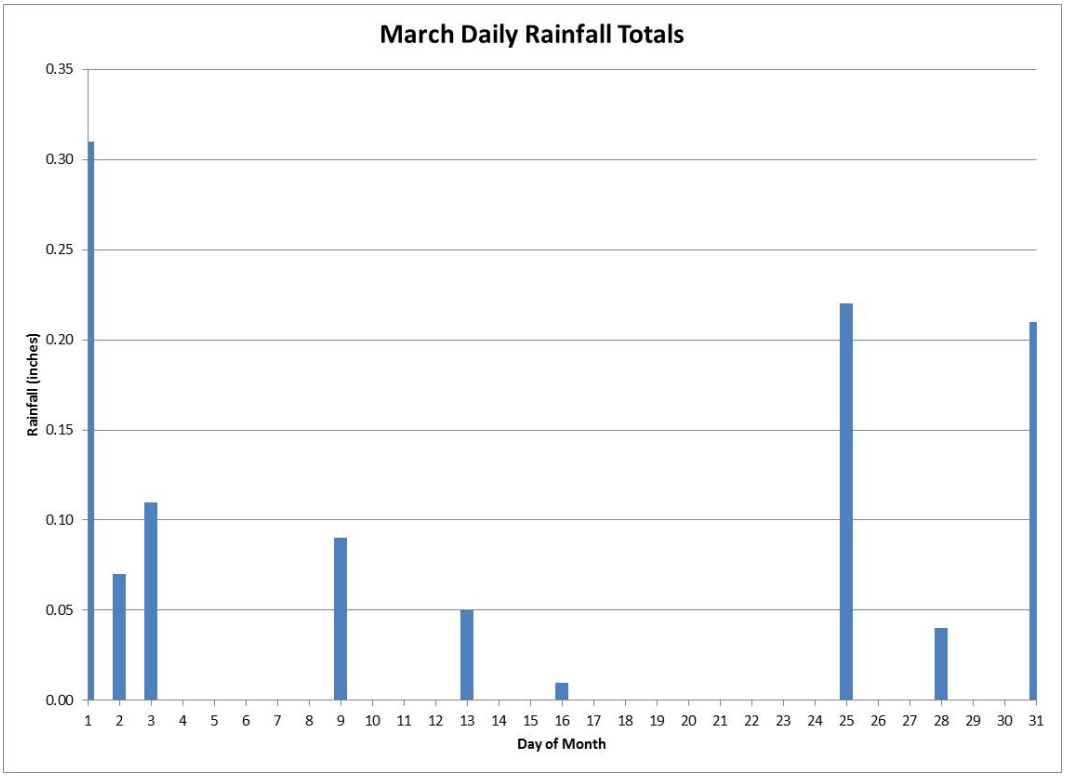


Figure 47 Daily Rainfall for the Month of March 2012

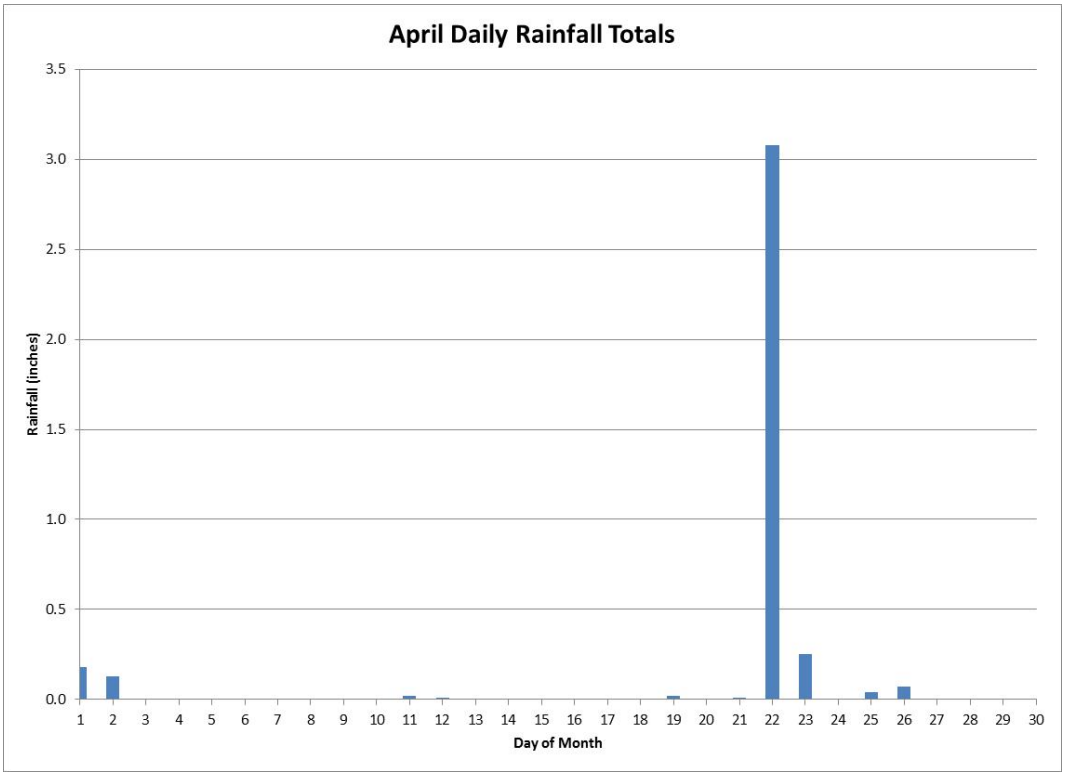


Figure 48 Daily Rainfall for the Month of April 2012

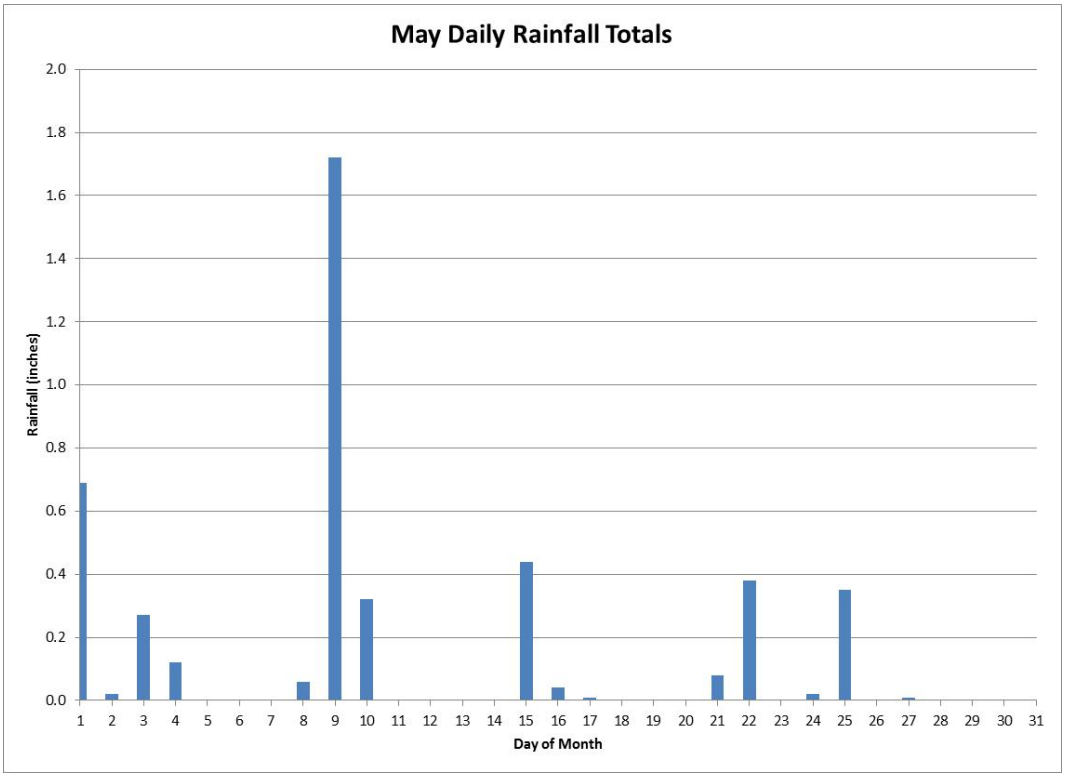


Figure 49 Daily Rainfall for the Month of May 2012

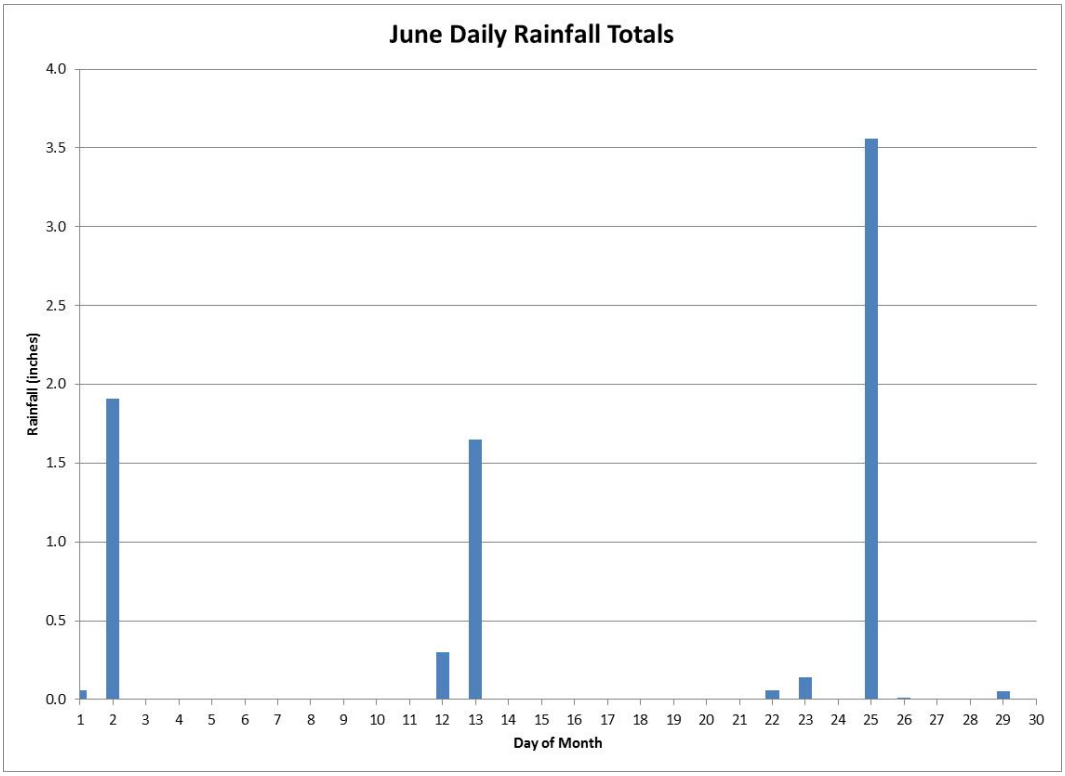


Figure 50 Daily Rainfall for the Month of June 2012

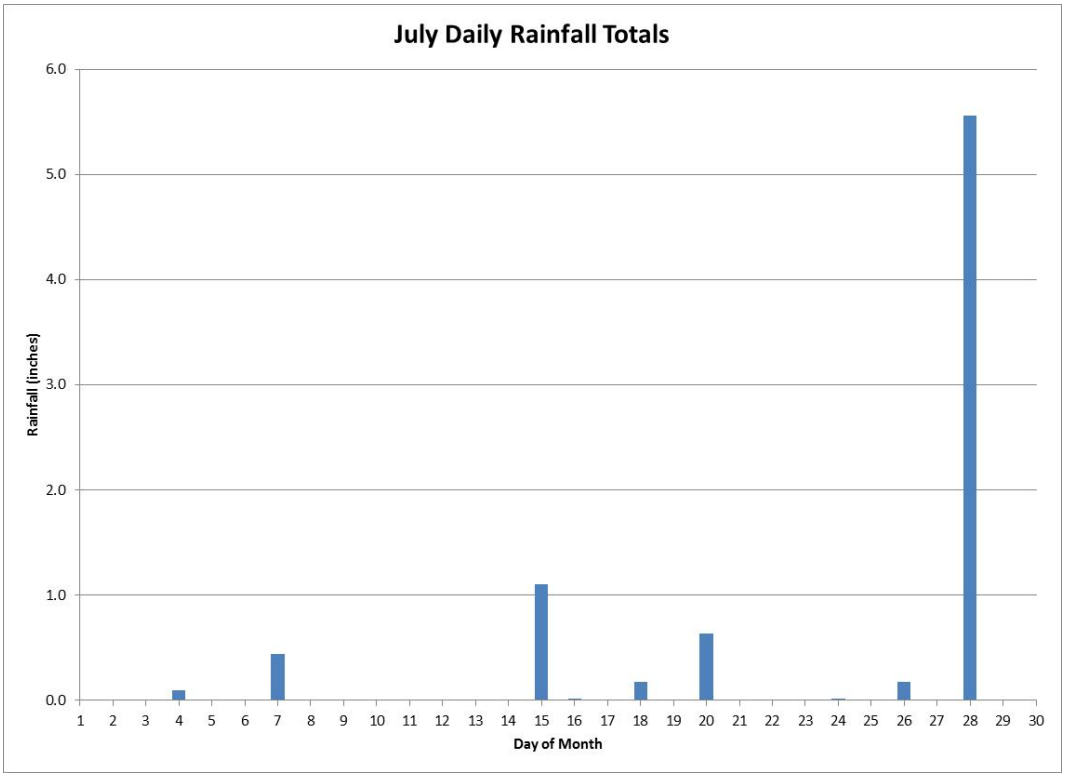


Figure 51 Daily Rainfall for the Month of July 2012

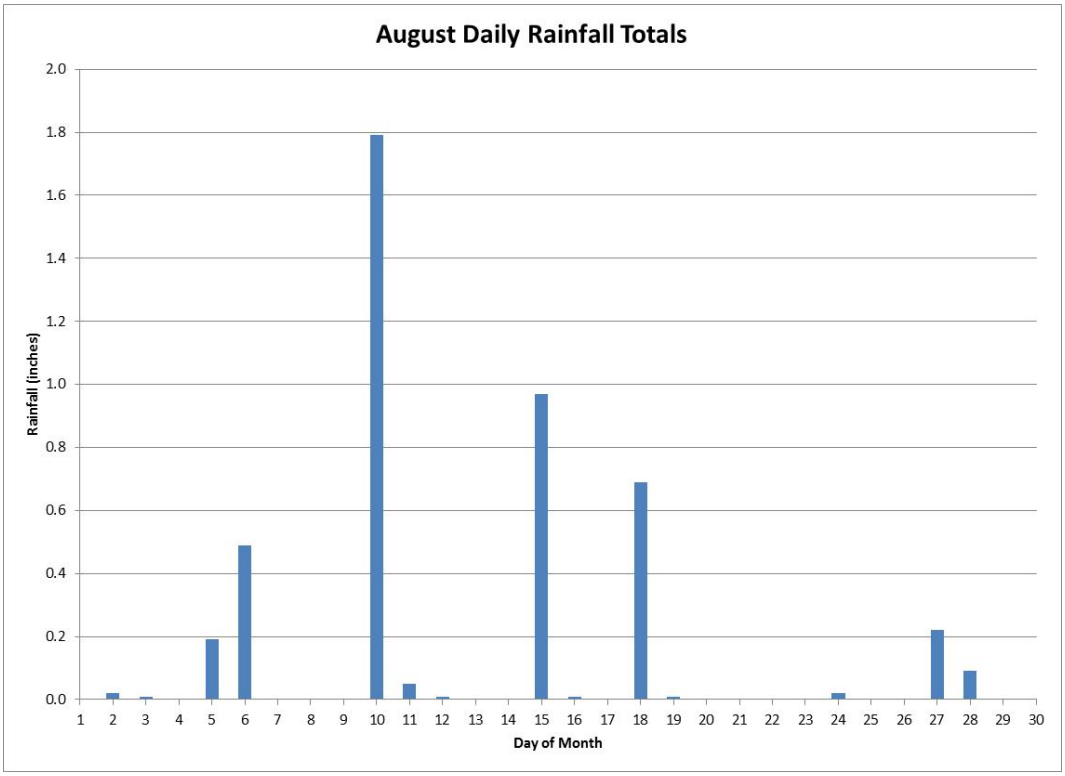


Figure 52 Daily Rainfall for the Month of August 2012

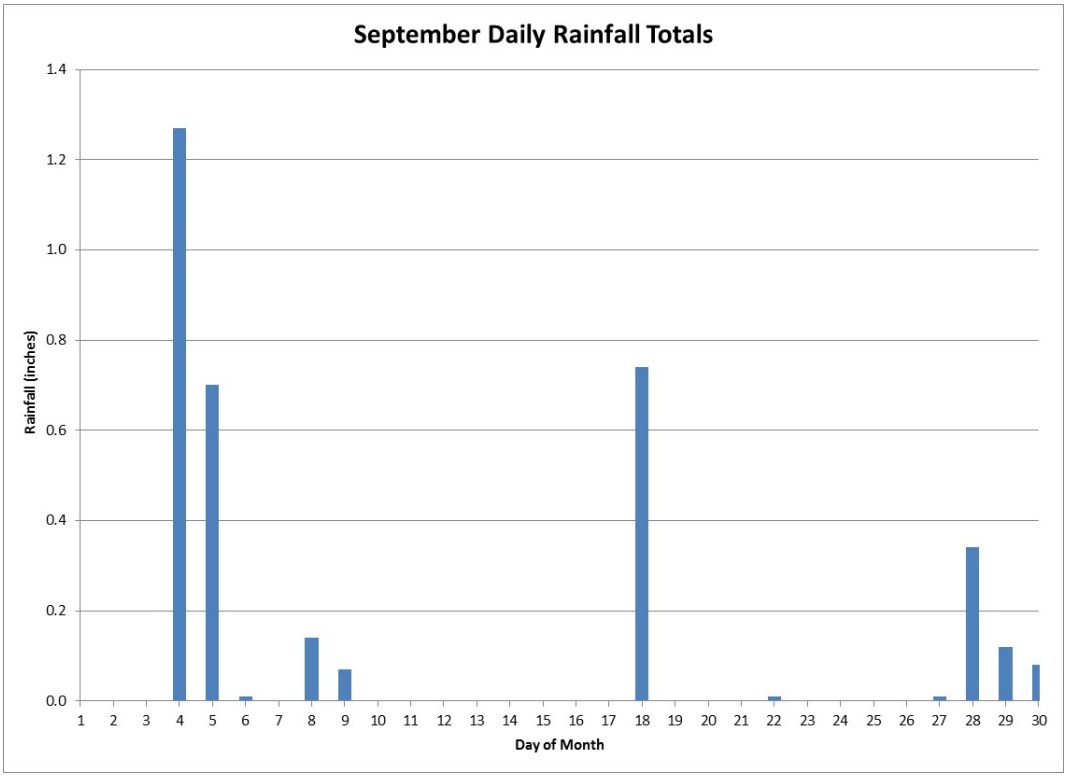


Figure 53 Daily Rainfall for the Month of September 2012

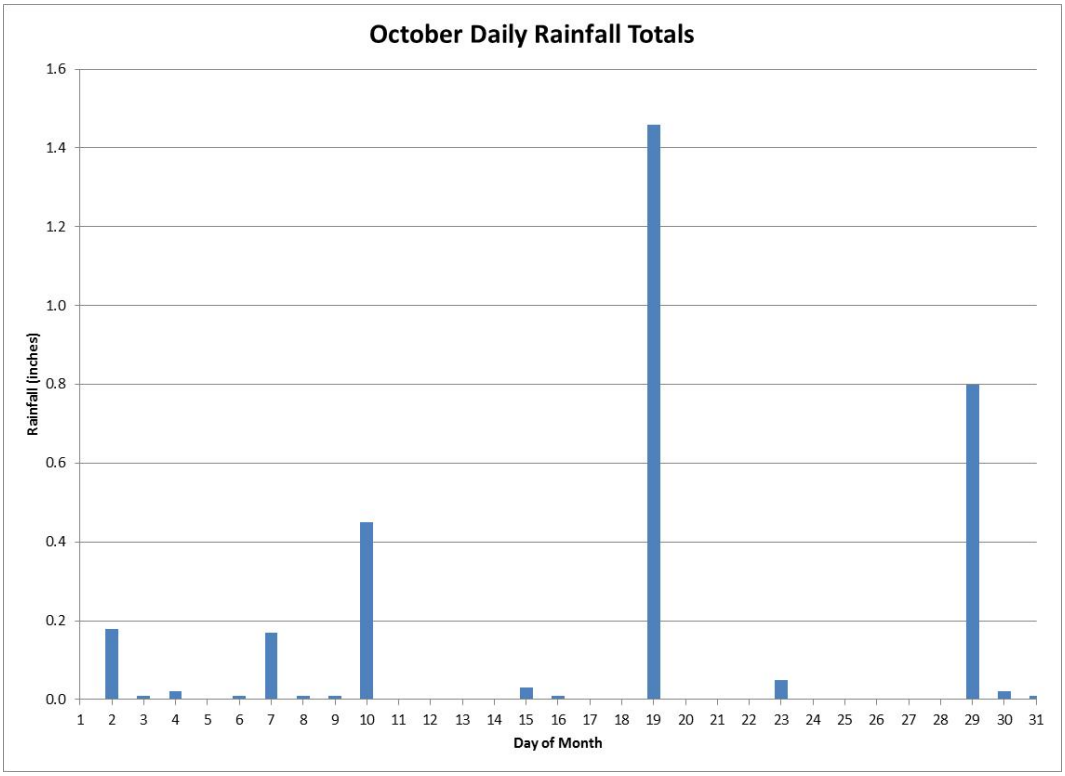


Figure 54 Daily Rainfall for the Month of October 2012

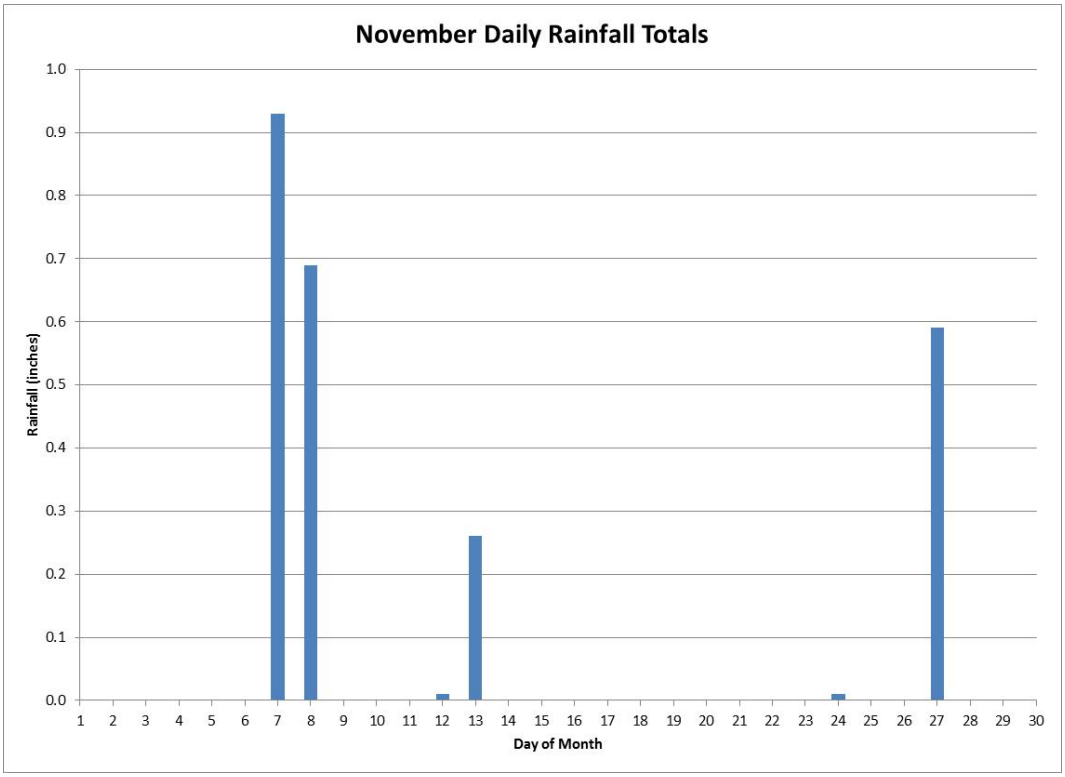


Figure 55 Daily Rainfall for the Month of November 2012

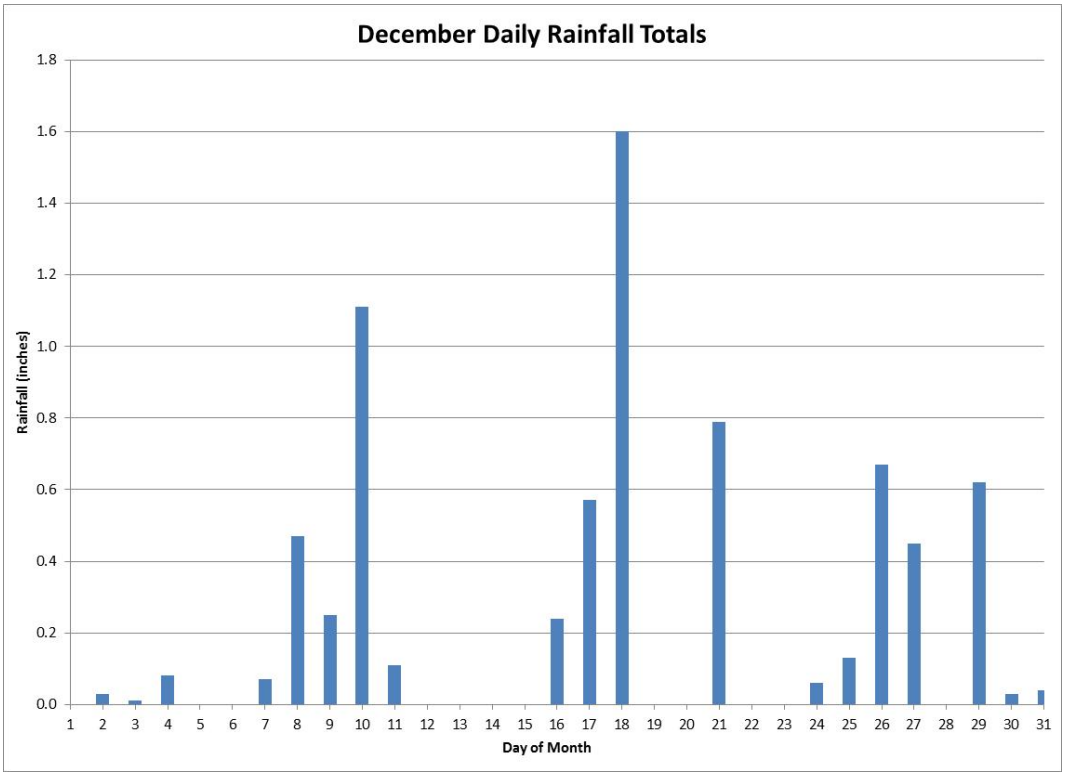


Figure 56 Daily Rainfall for the Month of December 2012

**Table 6. Historic Monthly Precipitation for Brookhaven National Laboratory from 1949 to 2012 (@ 2 meters)**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1949 | 5.55 | 4.71 | 2.88 | 3.63 | 3.32 | Trace | 3.07 | 5.21 | 3.49 | 1.74 | 2.96 | 3.36 | 39.92 |
| 1950 | 2.80 | 4.28 | 3.98 | 2.41 | 5.23 | 2.72 | 3.22 | 4.26 | 1.38 | 1.69 | 4.34 | 4.36 | 40.67 |
| 1951 | 3.75 | 4.99 | 5.02 | 3.42 | 3.68 | 2.64 | 2.08 | 4.50 | 1.06 | 5.48 | 6.01 | 6.17 | 48.80 |
| 1952 | 7.10 | 3.54 | 5.44 | 3.61 | 7.64 | 2.78 | 1.00 | 7.61 | 1.35 | 0.31 | 3.56 | 4.45 | 48.39 |
| 1953 | 6.73 | 4.16 | 10.36 | 5.59 | 3.34 | 1.66 | 2.76 | 2.40 | 0.90 | 3.17 | 5.03 | 6.43 | 52.53 |
| 1954 | 2.74 | 2.18 | 4.21 | 5.36 | 4.08 | 1.69 | 0.94 | **11.98** | **10.47** | 2.44 | 5.42 | 6.39 | 57.90 |
| 1955 | **0.62** | 3.26 | 4.79 | 4.28 | 0.95 | 2.53 | 1.65 | 9.04 | 3.96 | 11.43 | 7.19 | **0.82** | 50.52 |
| 1956 | 3.52 | 6.32 | 5.47 | 2.97 | 2.63 | 3.00 | 5.79 | 1.50 | 3.64 | 2.95 | 4.63 | 6.03 | 48.45 |
| 1957 | 2.36 | 2.53 | 3.20 | 4.44 | 1.46 | **0.42** | 2.84 | 4.25 | 3.57 | 3.86 | 4.41 | 8.45 | 41.79 |
| 1958 | 7.96 | 4.58 | 6.65 | 6.34 | 5.81 | 2.28 | 3.42 | 5.37 | 4.24 | 7.39 | 2.88 | 2.68 | 59.60 |
| 1959 | 2.60 | 2.06 | 6.71 | 3.93 | 1.75 | 5.35 | 6.85 | 3.72 | 1.36 | 3.13 | 4.46 | 5.12 | 47.04 |
| 1960 | 3.59 | 5.48 | 3.38 | 3.27 | 2.54 | 2.13 | 6.03 | 1.79 | 7.49 | 3.94 | 2.62 | 4.31 | 46.57 |
| 1961 | 3.56 | 4.10 | 4.60 | 5.70 | 6.17 | 2.30 | 5.61 | 4.23 | 6.23 | 3.06 | 2.89 | 3.70 | 52.15 |
| 1962 | 4.38 | 5.77 | 3.63 | 3.31 | 1.12 | 3.55 | 1.64 | 7.64 | 4.07 | 4.62 | 5.04 | 2.83 | 47.60 |
| 1963 | 3.27 | 3.88 | 4.27 | 2.56 | 3.08 | 5.51 | 2.65 | 2.10 | 3.66 | **0.18** | 6.89 | 2.78 | 40.83 |
| 1964 | 5.89 | 4.76 | 3.56 | 8.37 | **0.63** | 1.41 | 4.40 | 1.16 | 3.02 | 4.29 | 3.07 | 6.63 | 47.19 |
| 1965 | 4.88 | 3.03 | 2.74 | 4.20 | 1.63 | 1.69 | 3.43 | 5.15 | 1.51 | 2.15 | 1.83 | 2.11 | **34.35** |
| 1966 | 4.57 | 5.18 | 1.73 | 2.13 | 6.55 | 1.40 | 1.12 | 3.23 | 6.53 | 4.45 | 2.89 | 4.15 | 43.93 |
| 1967 | 1.65 | 3.98 | 8.18 | 4.14 | 7.98 | 5.30 | 6.01 | 5.43 | 2.24 | 2.11 | 4.00 | 7.60 | 58.62 |
| 1968 | 3.00 | 2.21 | 7.54 | 2.00 | 4.95 | 4.24 | **0.50** | 3.10 | 2.08 | 3.01 | 8.09 | 8.22 | 48.94 |
| 1969 | 1.04 | 4.03 | 3.62 | 5.15 | 2.44 | 2.06 | **8.62** | 5.51 | 3.60 | 3.69 | 4.48 | 7.83 | 52.07 |
| 1970 | 0.81 | 4.37 | 5.44 | 4.57 | 3.44 | 1.77 | 3.10 | 6.08 | 2.42 | 1.41 | 6.52 | 3.73 | 43.66 |
| 1971 | 2.95 | **6.45** | 3.55 | 3.30 | 3.80 | 0.92 | 5.03 | 3.86 | 2.12 | 3.41 | 6.86 | 2.57 | 44.82 |
| 1972 | 2.41 | 6.12 | 5.40 | 4.53 | 6.10 | 7.30 | 1.03 | 1.29 | 3.08 | 7.64 | 7.51 | 6.22 | 58.63 |
| 1973 | 4.44 | 4.36 | 4.38 | 7.77 | 5.46 | 3.25 | 4.45 | 3.11 | 2.51 | 2.79 | 2.22 | 8.00 | 52.74 |
| 1974 | 4.96 | 2.82 | 5.06 | 3.49 | 3.13 | 2.50 | 0.81 | 2.55 | 5.10 | 2.66 | 1.94 | 6.78 | 41.80 |
| 1975 | 6.50 | 4.06 | 4.27 | 3.89 | 3.45 | 5.37 | 3.33 | 2.01 | 5.58 | 3.61 | 5.89 | 4.92 | 52.88 |
| 1976 | 5.98 | 3.57 | 3.30 | 2.27 | 3.89 | 3.27 | 4.32 | 7.57 | 2.07 | 5.42 | **0.54** | 2.96 | 45.16 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | 3.09 | 2.46 | 5.47 | 4.28 | 2.04 | 4.31 | 1.51 | 5.49 | 5.73 | 6.12 | 6.39 | 6.93 | 53.82 |
| 1978 | 10.72 | 2.60 | 3.33 | 2.39 | 6.47 | 0.81 | 4.63 | 5.22 | 4.26 | 4.11 | 2.79 | 6.12 | 53.45 |
| 1979 | **13.01** | 5.27 | 3.53 | 4.96 | 4.09 | 2.15 | 0.61 | 7.76 | 3.20 | 4.57 | 3.95 | 3.02 | 56.12 |
| 1980 | 2.02 | 1.18 | 7.20 | 6.16 | 1.52 | 3.60 | 1.92 | 1.56 | 0.98 | 3.59 | 4.20 | 1.06 | 34.99 |
| 1981 | 1.15 | 5.16 | 1.80 | 4.59 | 2.17 | 3.14 | 2.69 | 0.96 | 5.17 | 4.49 | 3.16 | 5.55 | 40.03 |
| 1982 | 7.20 | 2.90 | 3.38 | 5.44 | 1.71 | **12.85** | 1.77 | 3.45 | 1.40 | 2.07 | 3.87 | 2.38 | 48.42 |
| 1983 | 4.07 | 4.36 | 8.68 | **11.09** | 4.22 | 2.63 | 4.20 | 4.48 | 2.09 | 3.67 | 8.68 | 5.67 | 63.84 |
| 1984 | 2.87 | 6.38 | 6.92 | 5.41 | 8.08 | 6.68 | 7.06 | 1.02 | 4.16 | 3.20 | 2.40 | 2.98 | 57.16 |
| 1985 | 1.07 | 1.82 | 2.62 | 1.56 | 4.87 | 6.38 | 2.30 | 4.89 | 1.54 | 1.53 | 6.85 | 1.10 | 36.53 |
| 1986 | 3.96 | 3.46 | 3.17 | 2.35 | 1.09 | 1.66 | 5.02 | 5.69 | **0.86** | 2.25 | 6.72 | 7.50 | 43.73 |
| 1987 | 6.74 | 1.21 | 5.95 | 4.32 | 1.83 | 1.86 | 1.48 | 4.38 | 4.05 | 2.22 | 3.55 | 3.20 | 40.79 |
| 1988 | 3.59 | 4.81 | 4.22 | 2.17 | 2.58 | 1.43 | 3.93 | 1.36 | 3.52 | 3.87 | **9.05** | 2.52 | 43.05 |
| 1989 | 2.23 | 4.09 | 5.20 | 4.66 | **10.47** | 7.24 | 5.84 | 9.17 | 4.45 | 8.90 | 5.16 | 1.25 | **68.66** |
| 1990 | 5.24 | 2.92 | 2.14 | 4.96 | 6.52 | 3.95 | 2.64 | 6.75 | 3.04 | 7.17 | 1.78 | 5.90 | 53.01 |
| 1991 | 4.41 | 1.86 | 5.45 | 4.30 | 2.78 | 1.87 | 2.11 | 9.19 | 4.45 | 2.61 | 1.80 | 4.30 | 45.13 |
| 1992 | 2.40 | 2.18 | 3.34 | 1.78 | 3.05 | 4.90 | 4.76 | 5.61 | 3.51 | 1.07 | 5.96 | 6.60 | 45.16 |
| 1993 | 2.47 | 4.10 | 7.11 | 3.81 | 1.71 | 1.37 | 1.84 | 1.61 | 4.36 | 4.69 | 3.72 | 6.11 | 42.90 |
| 1994 | 5.78 | 4.04 | 6.55 | 2.26 | 2.93 | 0.51 | 0.91 | 5.04 | 4.41 | 1.09 | 6.34 | 4.30 | 44.16 |
| 1995 | 2.93 | 3.74 | 1.53 | 2.52 | 2.79 | 3.12 | 1.78 | **0.54** | 4.91 | 5.97 | 5.83 | 3.74 | 39.40 |
| 1996 | 5.22 | 3.51 | 3.58 | 6.40 | 3.39 | 4.41 | 4.94 | 2.68 | 6.08 | 8.24 | 3.11 | **8.66** | 60.22 |
| 1997 | 3.82 | 2.64 | 5.10 | 4.21 | 2.67 | 2.16 | 2.21 | 3.33 | 1.27 | 2.55 | 5.42 | 4.66 | 40.04 |
| 1998 | 7.01 | 5.66 | 8.08 | 6.55 | 8.58 | 8.43 | 0.94 | 3.68 | 2.50 | 1.91 | 2.05 | 1.22 | 56.61 |
| 1999 | 8.85 | 4.81 | 5.32 | 2.35 | 2.41 | 1.04 | 2.12 | 8.71 | 5.90 | 4.78 | 2.58 | 2.85 | 51.72 |
| 2000 | 3.75 | 2.58 | 5.49 | 6.29 | 4.28 | 5.18 | 8.37 | 3.38 | 6.86 | 0.31 | 3.79 | 4.09 | 54.37 |
| 2001 | 3.28 | 2.63 | 10.37 | 2.03 | 4.22 | 6.46 | 3.47 | 4.68 | 4.04 | 1.04 | 0.74 | 2.59 | 45.55 |
| 2002 | 3.07 | **1.16** | 5.05 | 4.58 | 4.48 | 4.37 | 1.37 | 3.94 | 5.84 | 6.40 | 6.18 | 5.63 | 52.07 |
| 2003 | 2.48 | 5.74 | 5.99 | 5.11 | 6.07 | 12.28 | 2.38 | 5.19 | 5.22 | 4.80 | 3.63 | 4.22 | 63.11 |
| 2004 | 2.15 | 3.14 | 3.47 | 4.94 | 2.59 | 1.34 | 3.05 | 4.30 | 5.14 | 1.62 | 2.16 | 1.96 | 35.86 |
| 2005 | 3.32 | 2.10 | 2.47 | 2.53 | 2.36 | 1.48 | 2.16 | 0.87 | 1.09 | **22.14** | 5.00 | 4.60 | 50.12 |
| 2006 | 5.52 | 2.87 | **0.89** | 7.17 | 6.73 | 6.73 | 5.73 | 6.44 | 3.21 | 7.22 | 6.61 | 2.47 | 61.59 |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | 4.32 | 2.00 | 5.58 | 6.87 | 2.06 | 3.18 | 7.58 | 2.78 | 1.69 | 1.71 | 3.31 | 4.25 | 45.33 |
| 2008 | 2.36 | 5.84 | 5.90 | 4.04 | 3.66 | 2.28 | 1.97 | 3.07 | 9.31 | 4.02 | 3.82 | 4.37 | 50.64 |
| 2009 | 1.27 | 1.74 | 1.79 | 5.39 | 6.05 | 7.99 | 7.19 | 1.15 | 3.18 | 6.13 | 4.65 | 7.64 | 54.17 |
| 2010 | 2.15 | 6.01 | **11.98** | **0.74** | 3.88 | 1.64 | 6.70 | 2.21 | 4.56 | 3.08 | 2.91 | 4.08 | 49.94 |
| 2011 | 3.23 | 3.61 | 3.00 | 4.34 | 3.37 | 4.33 | 2.34 | 9.81 | 4.74 | 5.75 | 3.52 | 3.16 | 51.20 |
| 2012 | 3.01 | 1.27 | 1.11 | 3.81 | 4.53 | 7.74 | 8.26 | 4.57 | 3.49 | 3.24 | 2.49 | 7.30 | 50.82 |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
| **Average** | 4.05 | 3.73 | **4.78** | 4.27 | 3.88 | 3.66 | 3.49 | 4.38 | **3.73** | 4.07 | 4.35 | 4.59 | 48.93 |
| **Max** | 13.01 | 6.45 | 11.98 | 11.09 | 10.47 | 12.85 | 8.62 | 11.98 | 10.47 | **22.14** | 9.05 | 8.66 | 68.66 |
| **Min** | 0.62 | 1.16 | 0.89 | 0.74 | 0.63 | **0.42** | 0.50 | 0.54 | 0.86 | 0.18 | 0.54 | 0.82 | 34.35 |

**Min** **Max**

**Wind Direction and Wind Speed**

Wind speed and direction are recorded via R.M. Young 5106 marine grade mechanical wind sensor. This unit has a 0 to 100 m/s wind speed range and has been modified to have a 0.5 m/s wind speed threshold sensitivity. Accuracy is ±0.3 m/s. The direction sensor has a 355° electrical range and 360° mechanical. Direction accuracy is ±3° and sensitivity is 1.1 m/s (wind speed needed for accurate measurement). These units require a wind tunnel calibration and are sent out for calibration on an annual basis. Enough spare units are stocked to allow change out without data loss.

Average daily wind speed recorded at the 85 meter location is given in Figure 57. Monthly wind roses are presented in Figures 58 through 69. A wind rose is a graphic tool used by meteorologists to give a succinct view of how wind speed and direction are typically distributed at a particular location. The wind rose data used in the plots are daily averages generated from one minute data. Each figure has two roses presented for the 10- and 85-meter locations. Speed bins are 0-5 m/s, 5 to 10 m/s and >10 m/s. Percent calm data and percent bad data are also listed. Prevailing winds at BNL are from the west southwest with a secondary south-southwest component at both the 85 meter level and the 10 meter level.

Figures 70 through 93 present the 1-minute data for wind speed and wind gust. Plots for January to June have 10-meter and 85-meter data. July and later plots also contain data from 50-meters, which represents a new sensor location installed in June of 2012 following earlier recommendations from the DOE Meteorological Coordinating Council.

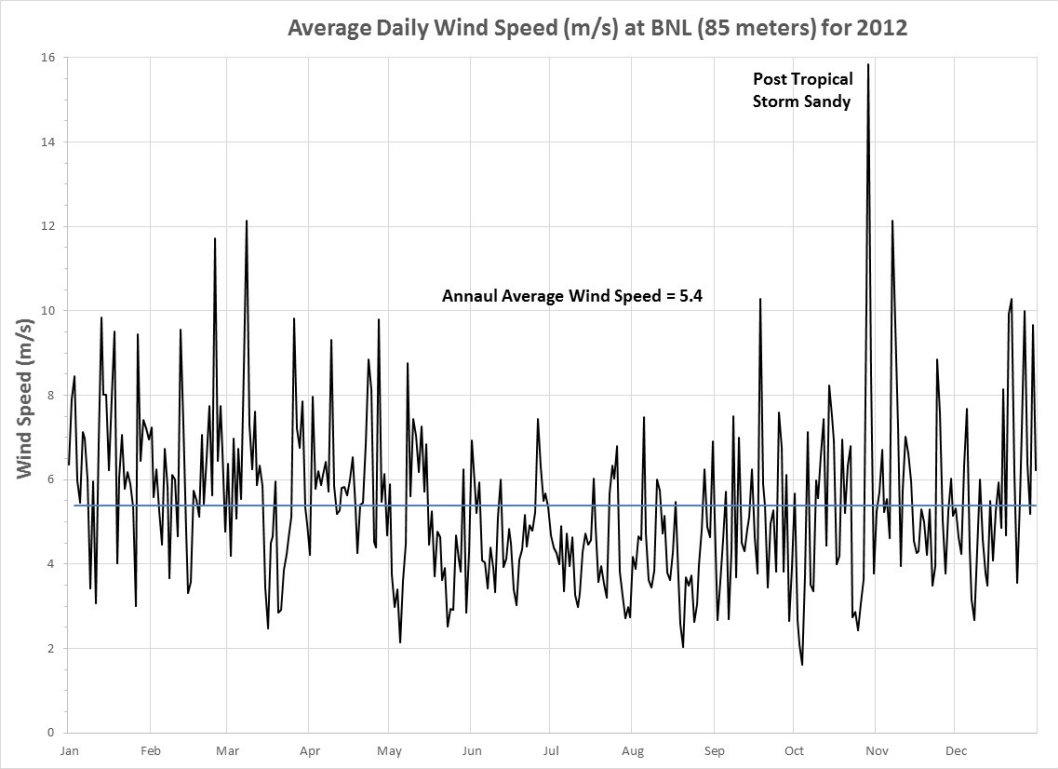


Figure 57 Average Daily Wind Speed (M/s) at the 85-meter height at Brookhaven National Laboratory for 2012

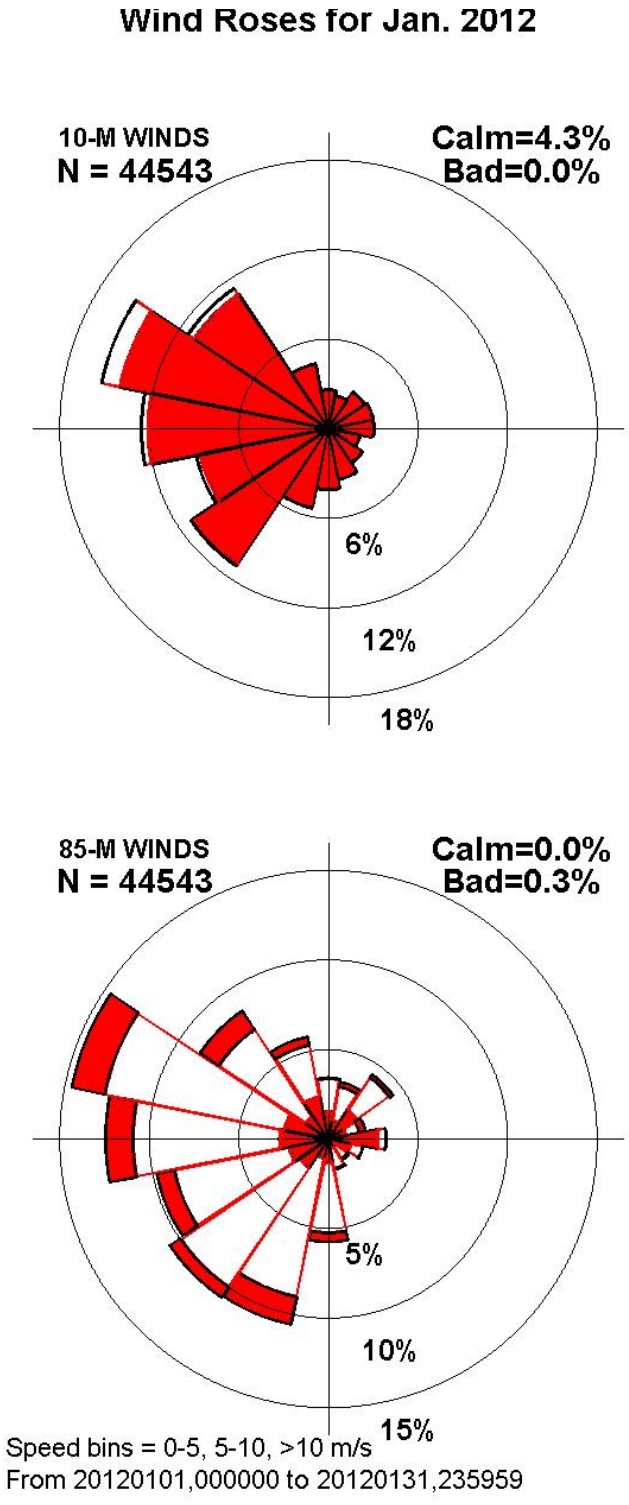


Figure 58 Wind Roses for the Month of January 2012

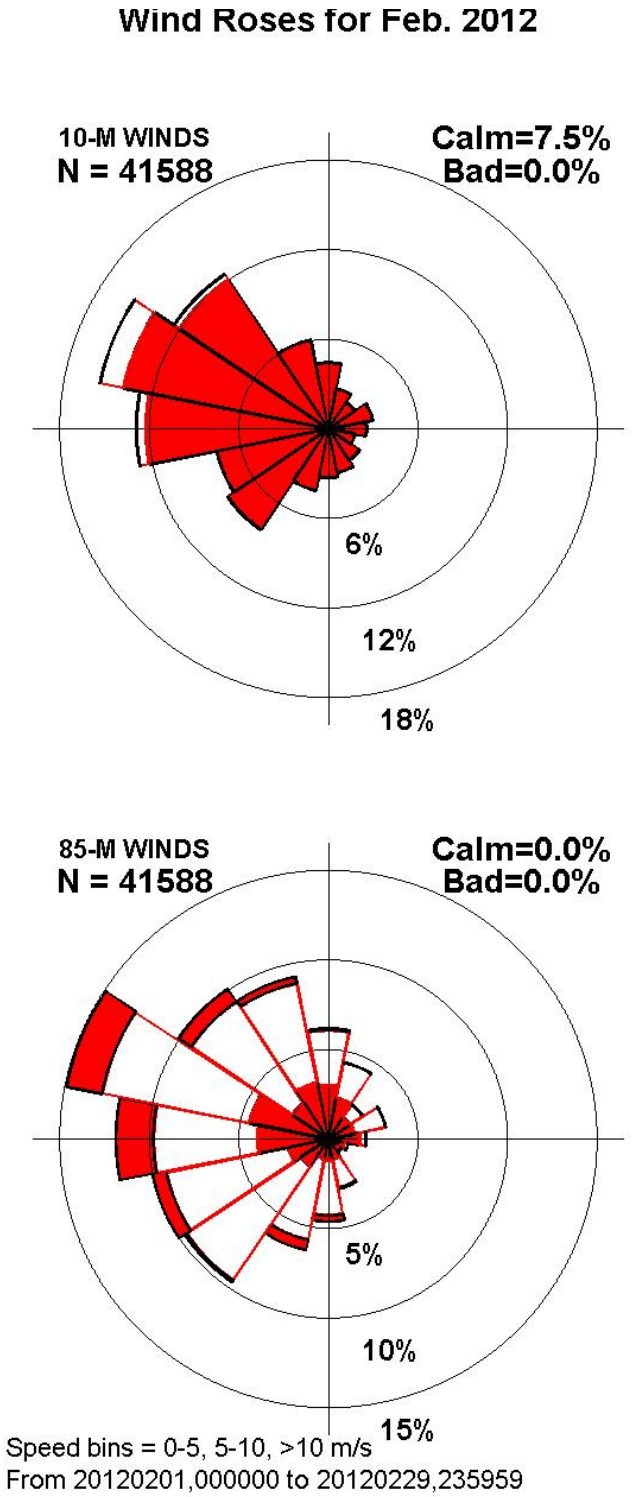


Figure 59 Wind Roses for the Month of February 2012

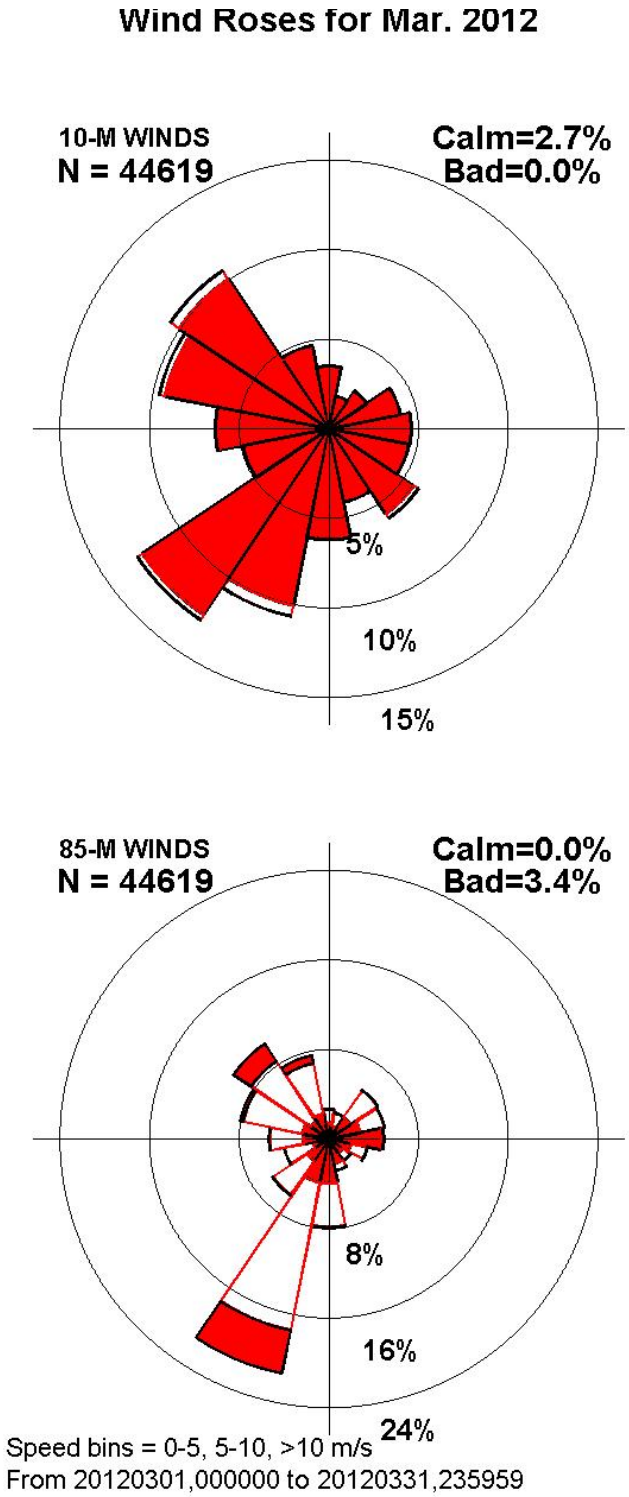


Figure 60 Wind Roses for the Month of March 2012

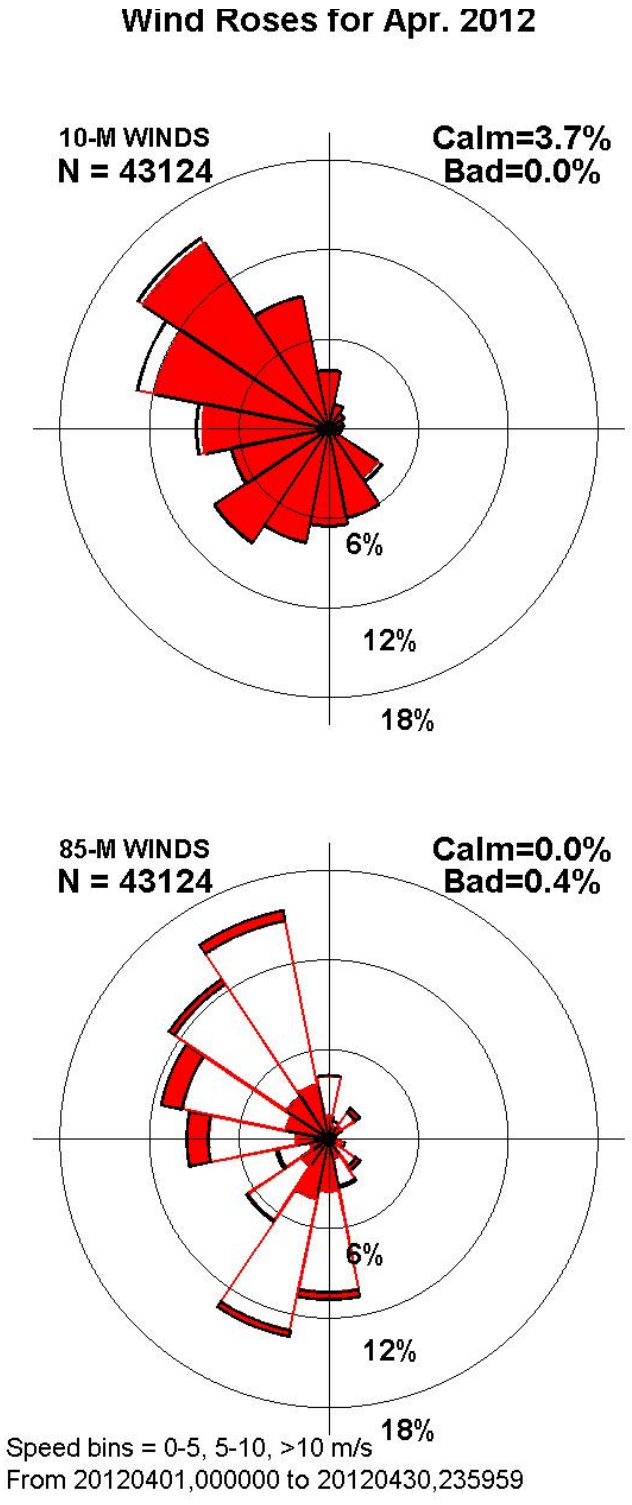


Figure 61 Wind Roses for the Month of April 2012

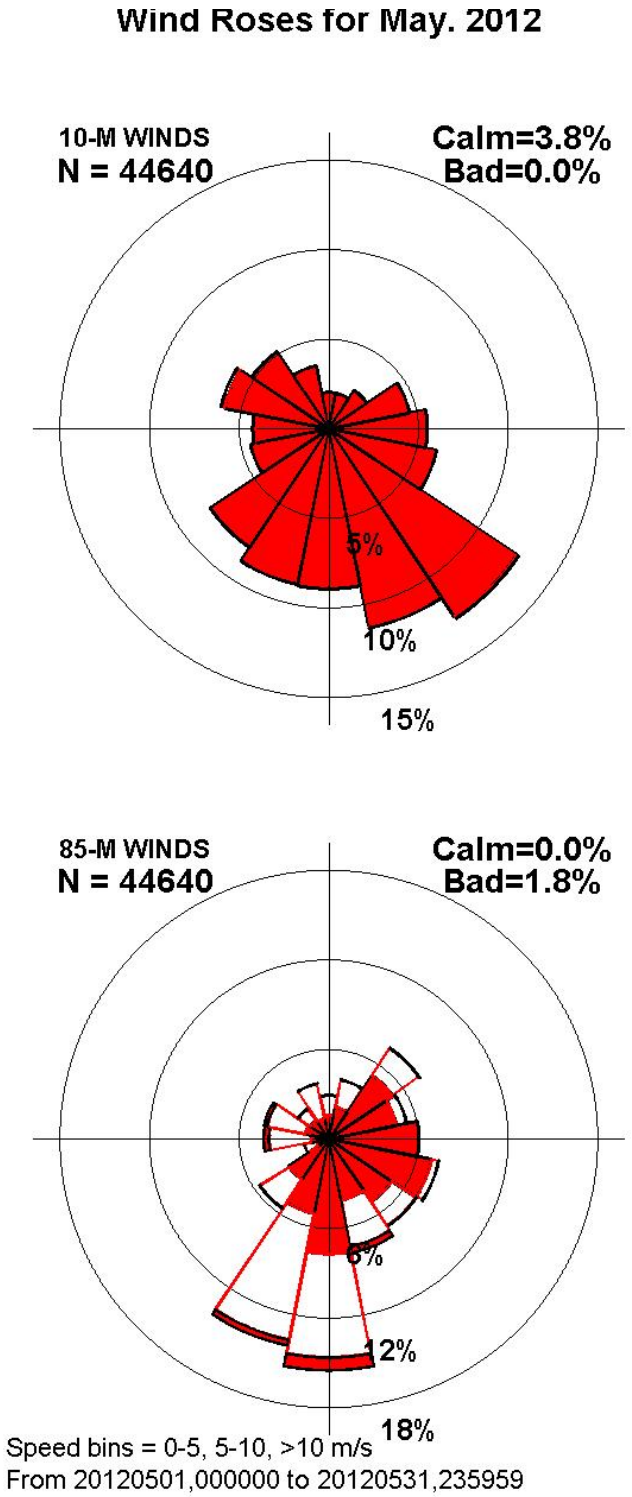


Figure 62 Wind Roses for the Month of May 2012

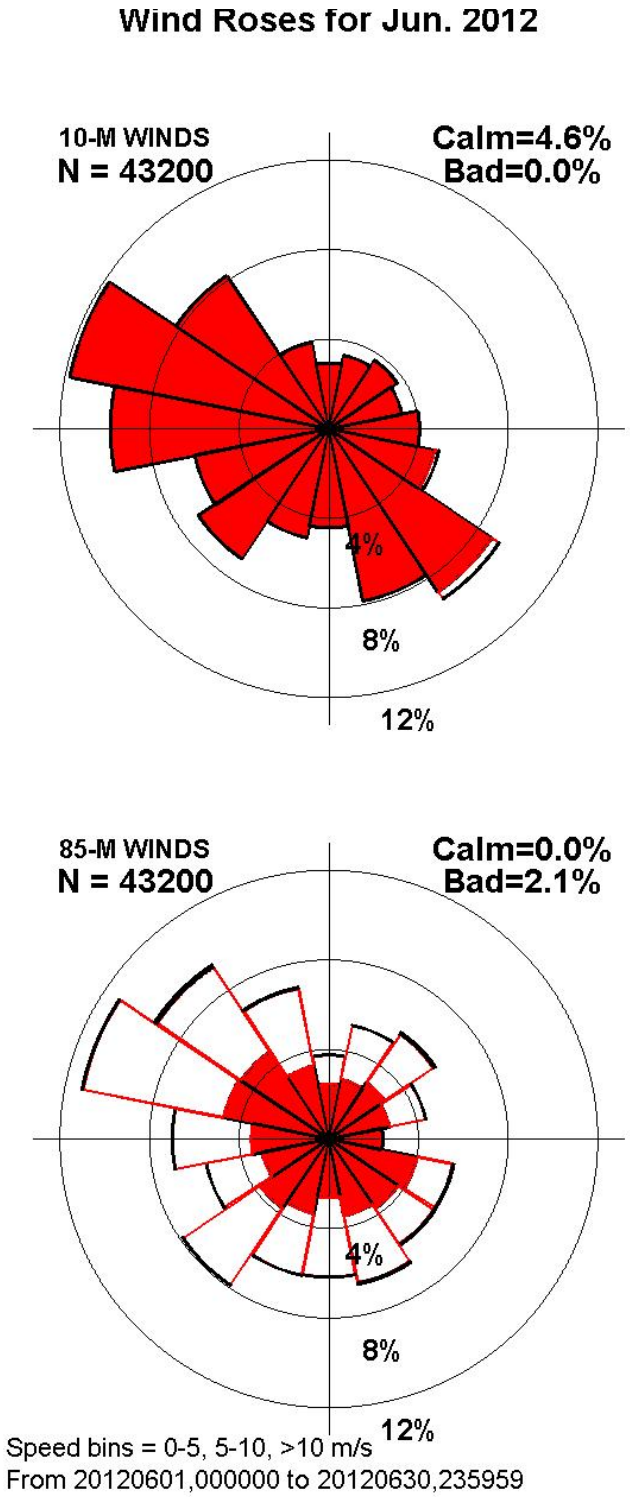


Figure 63 Wind Roses for the Month of June 2012

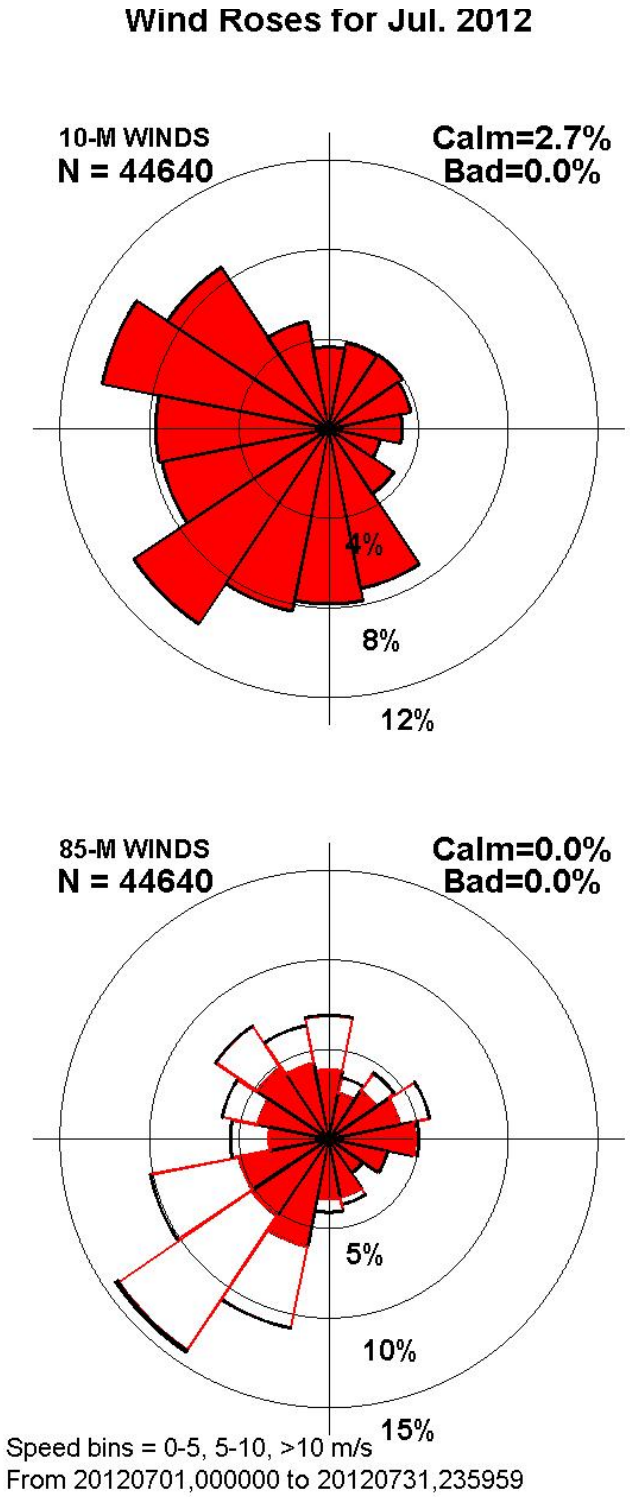


Figure 64 Wind Roses for the Month of July 2012

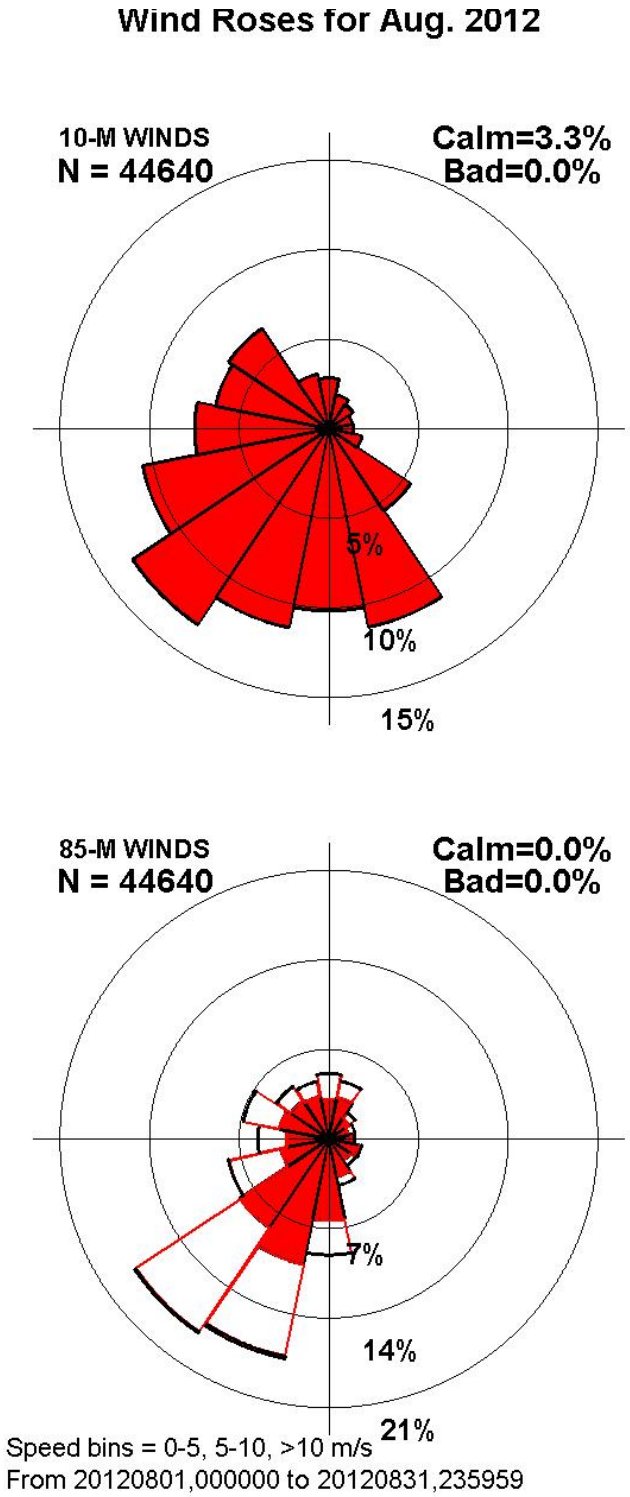


Figure 65 Wind Roses for the Month of August 2012

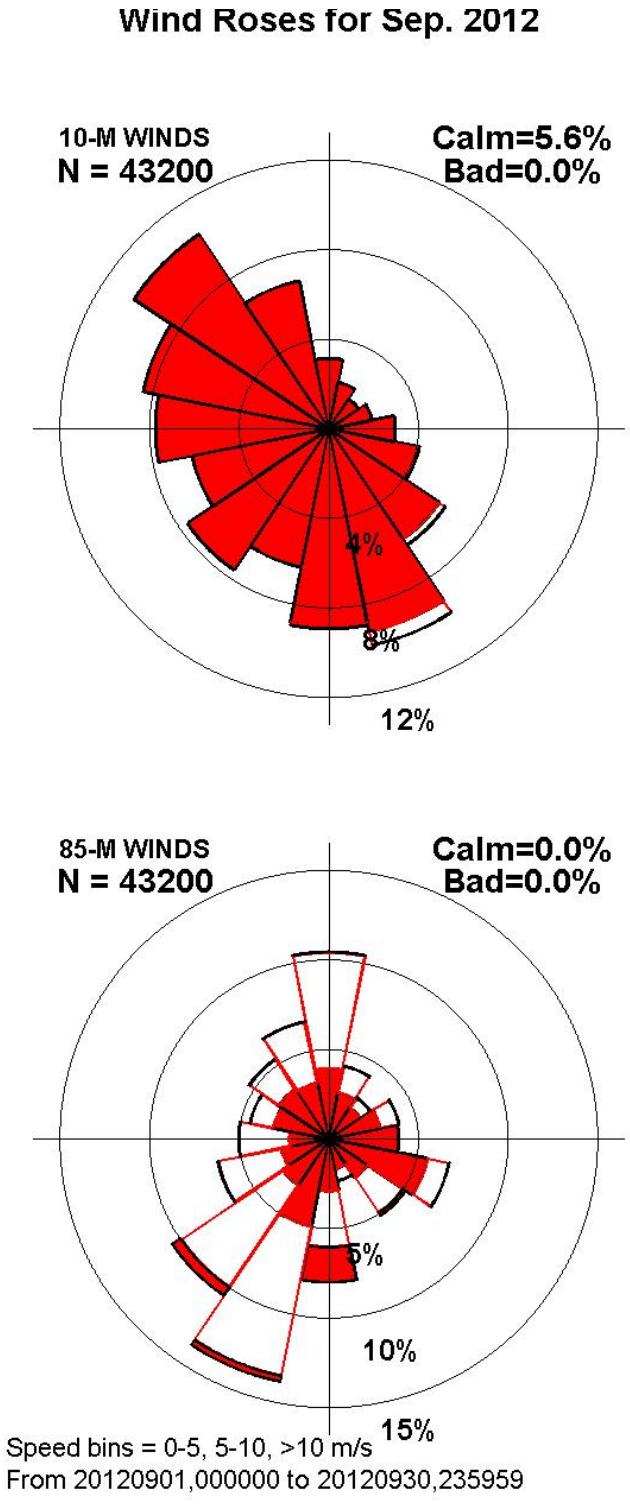


Figure 66 Wind Roses for the Month of September 2012

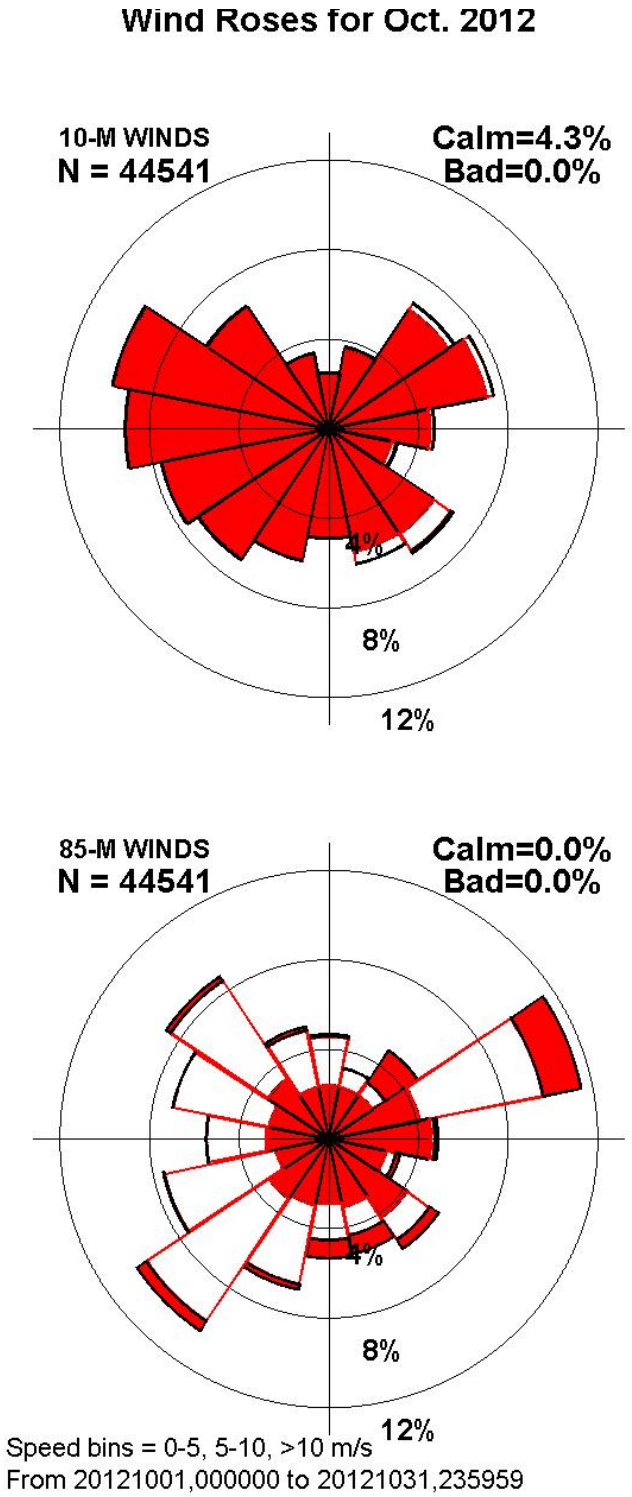


Figure 67 Wind Roses for the Month of October 2012

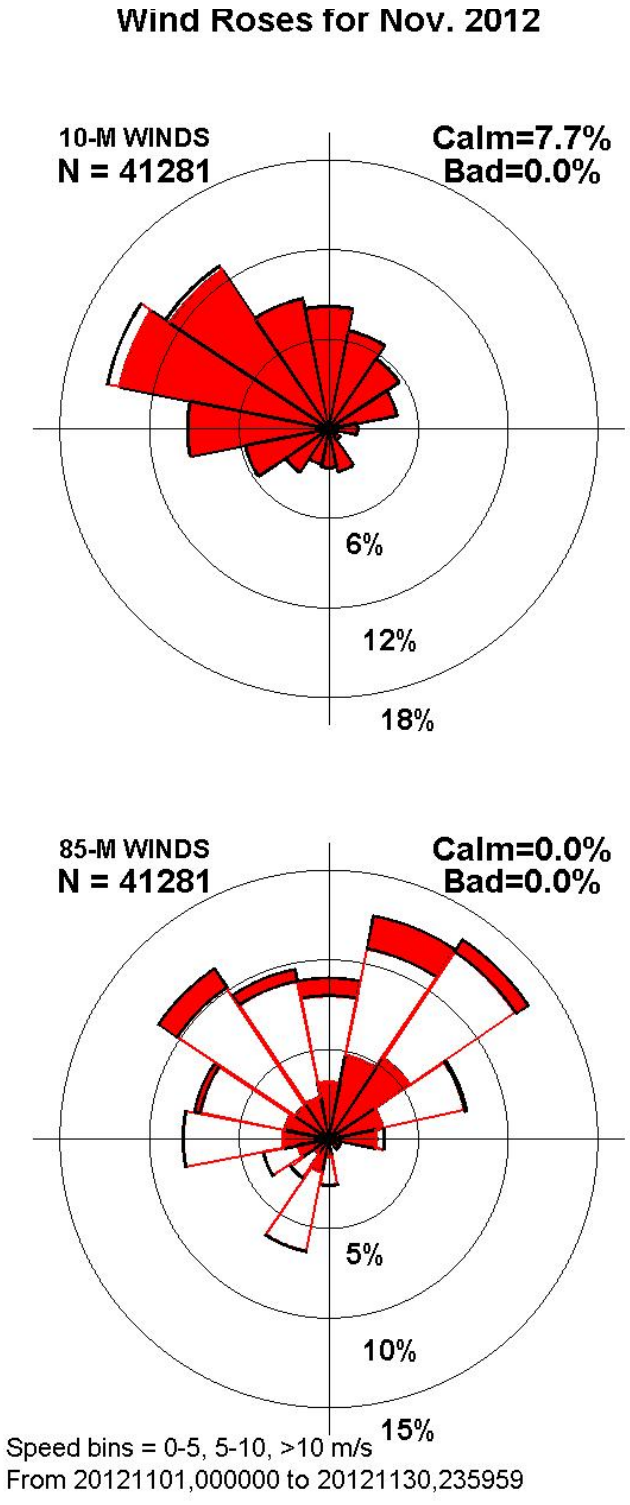


Figure 68 Wind Roses for the Month of November 2012

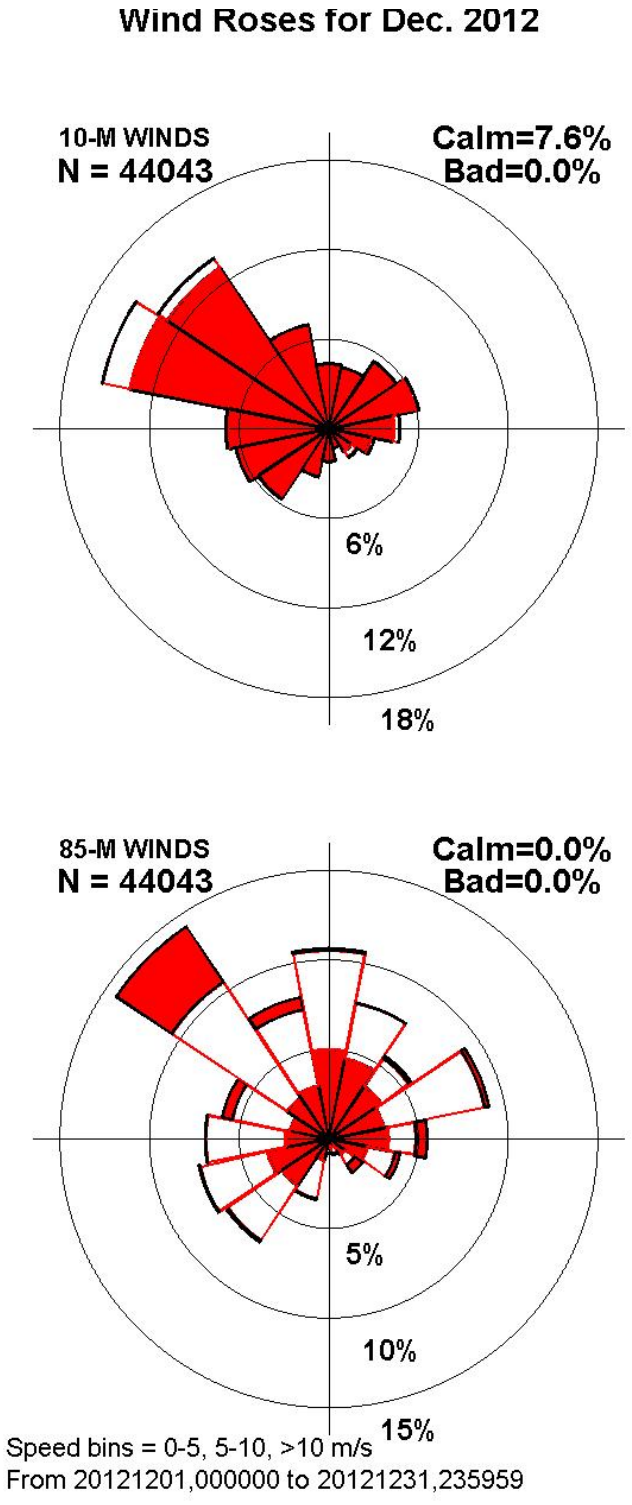


Figure 69 Wind Roses for the Month of December 2012

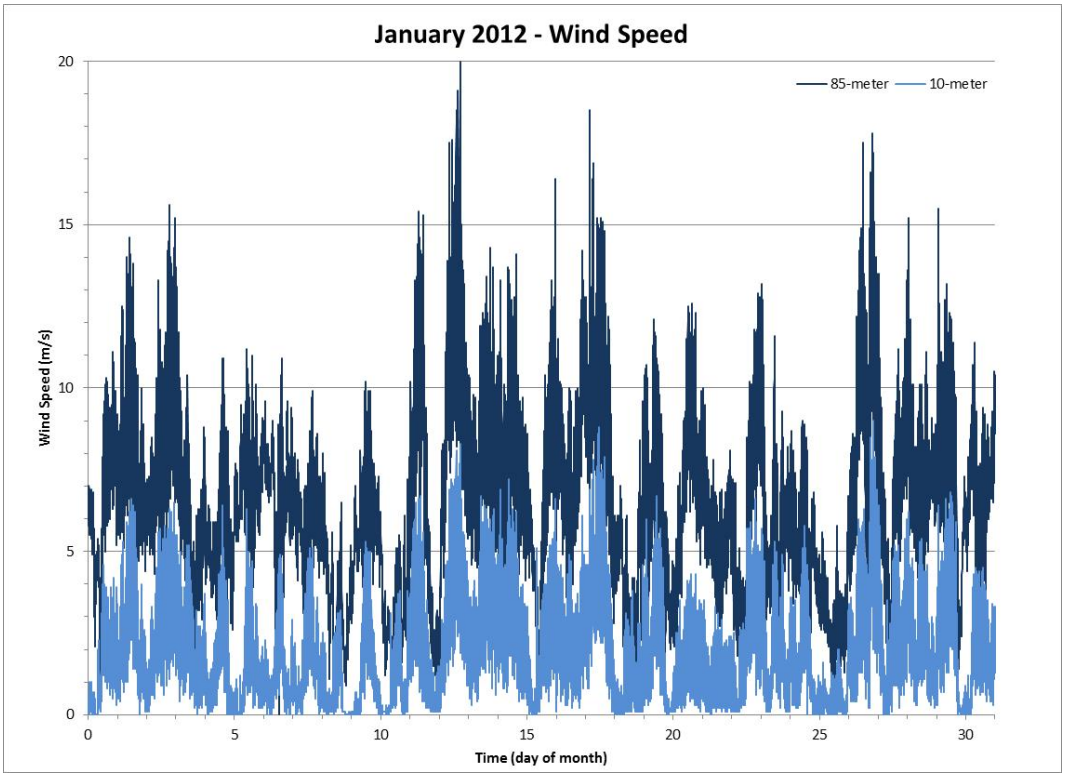

Figure 70 Wind Speed for the Month of January 2012

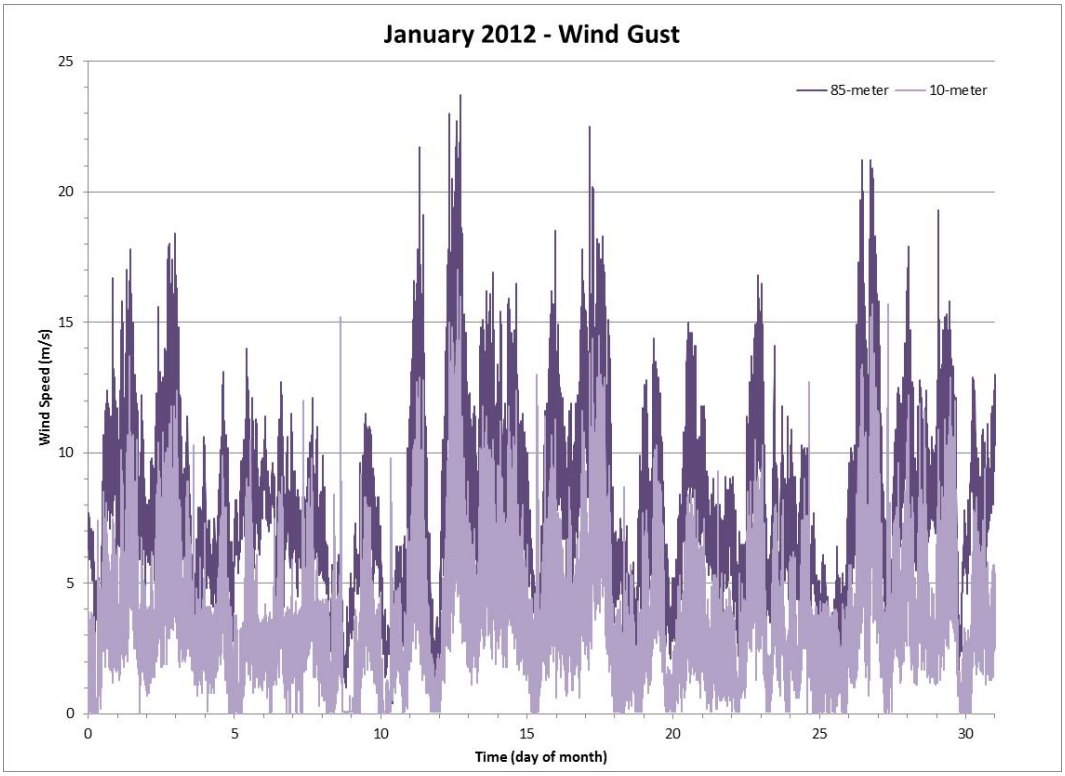

Figure 71 Wind Gust data for the Month of January 2012

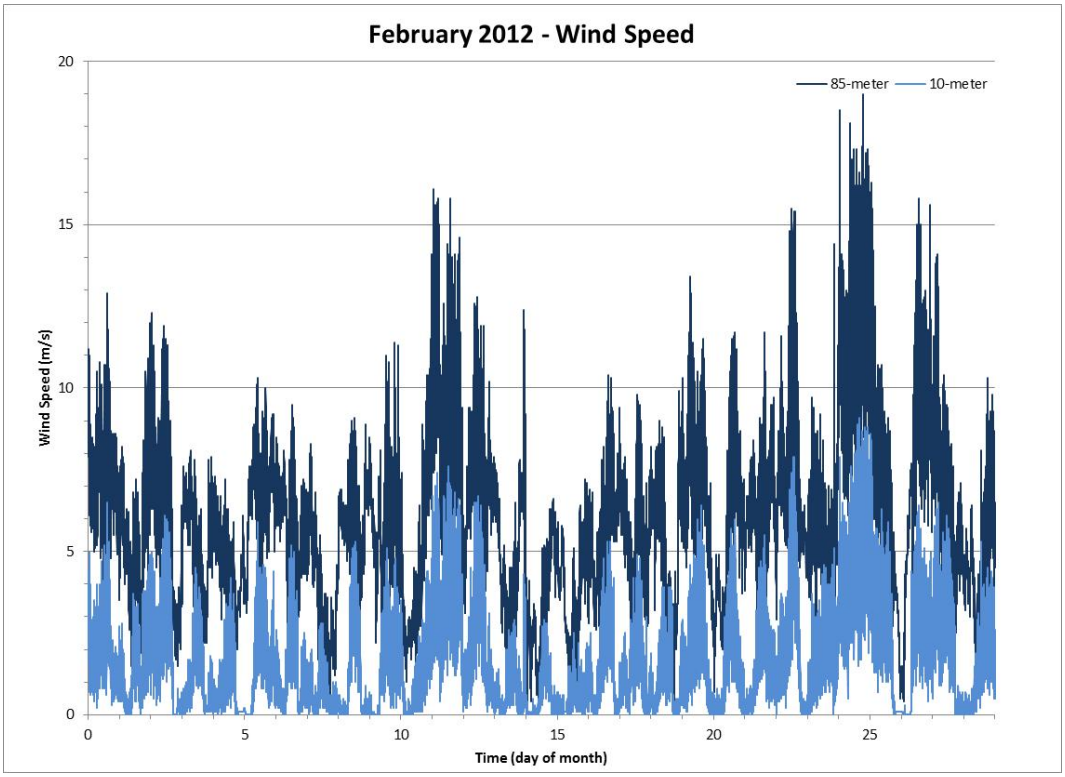

Figure 72 Wind Speed for the Month of February

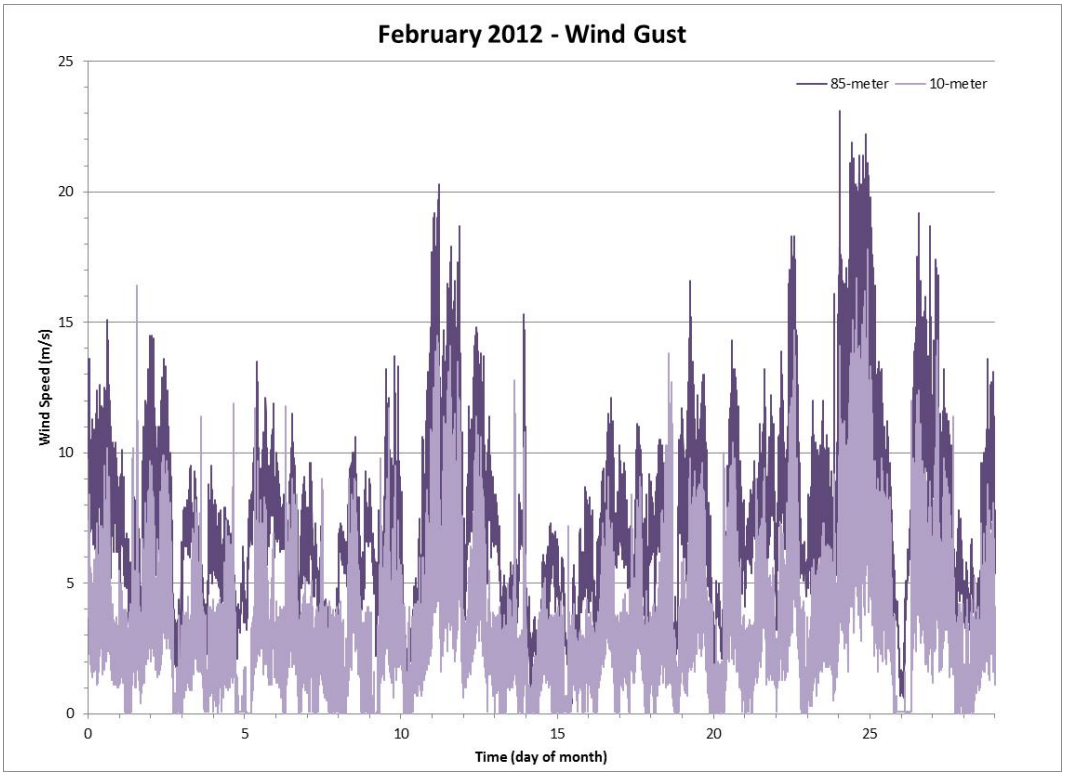

Figure 73 Wind Gust data for the Month of February 2012

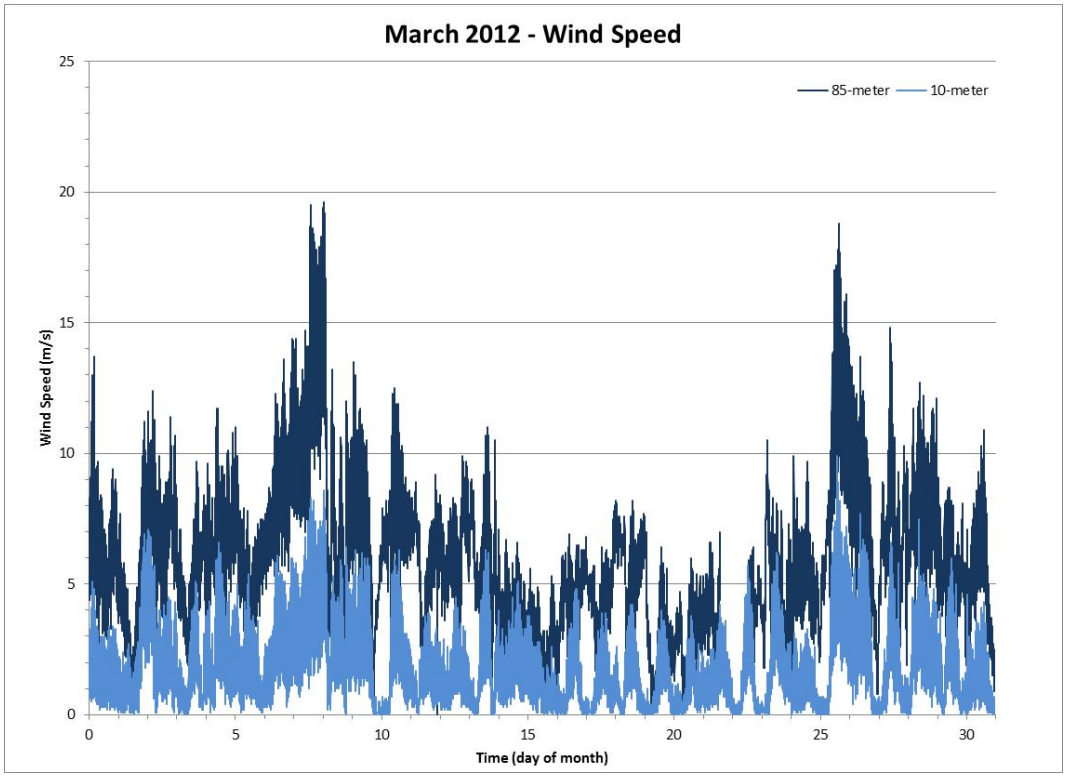

Figure 74 Wind Speed for the Month of March 2012

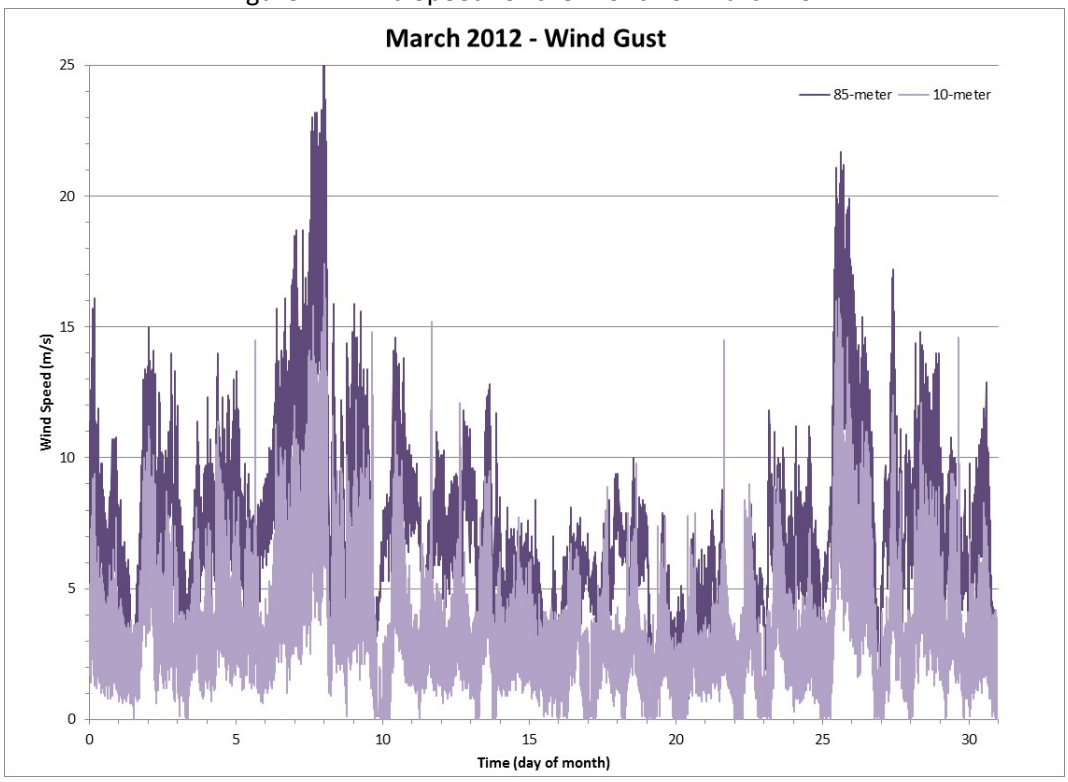

Figure 75 Wind Gust data for the Month of March 2012

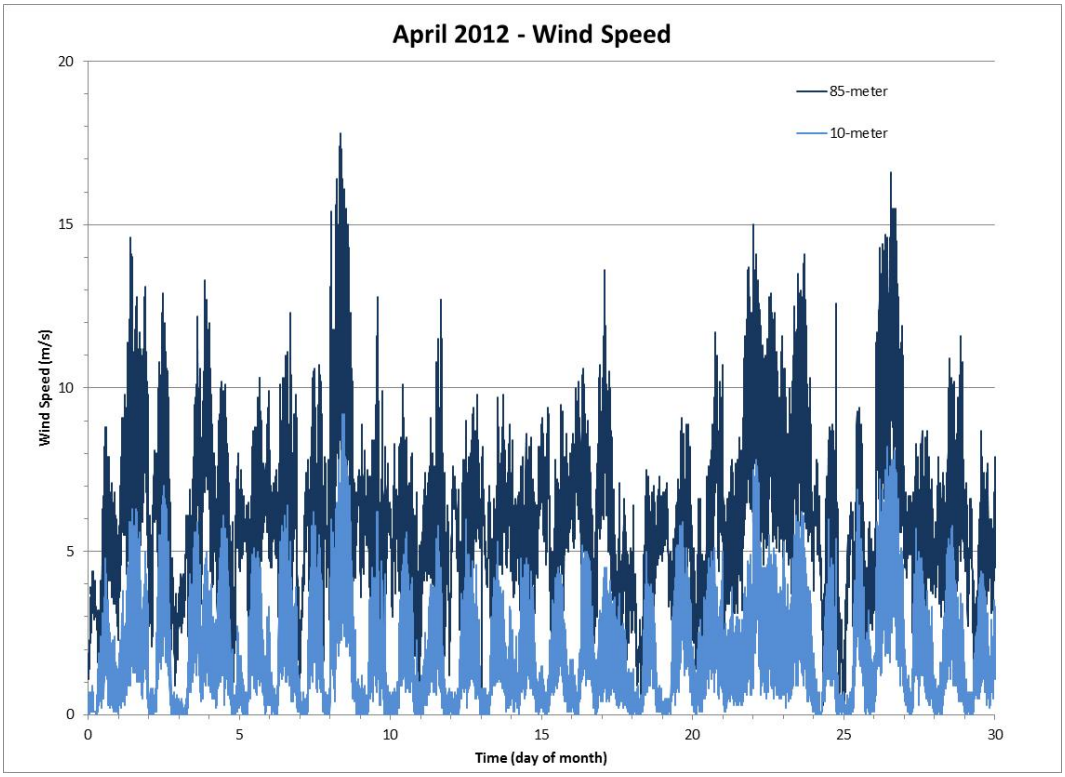

Figure 76 Wind Speed for the Month of April 2012

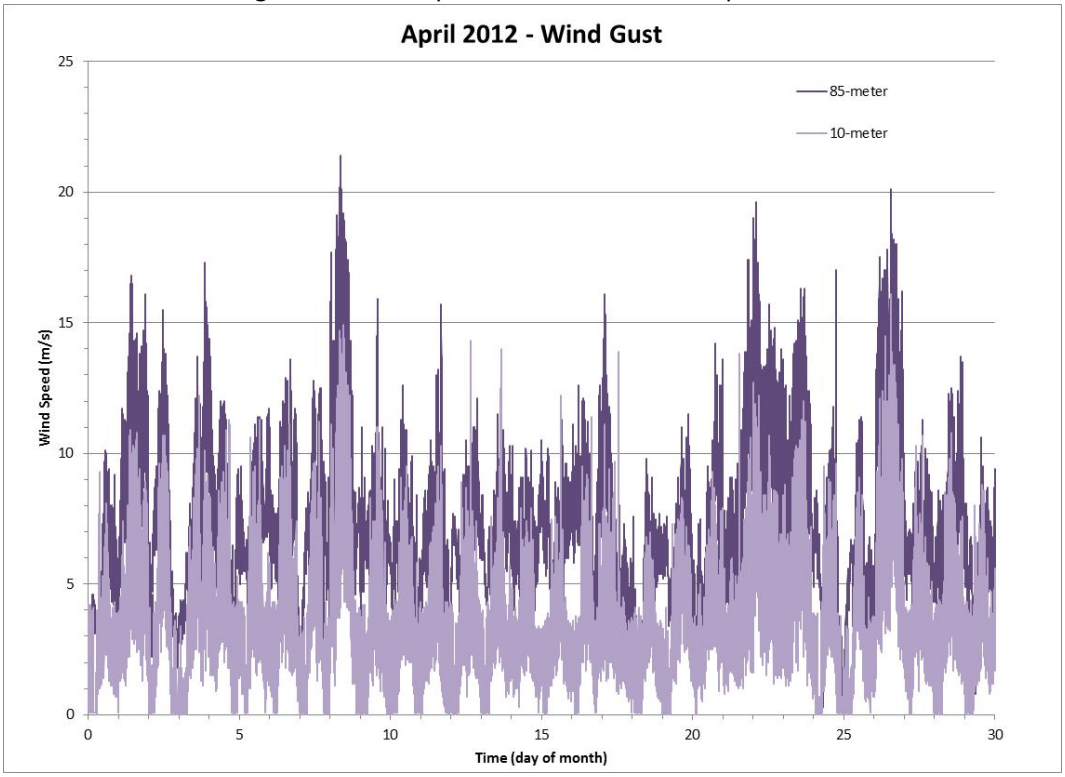

Figure 77 Wind Gust data for the Month of April 2012

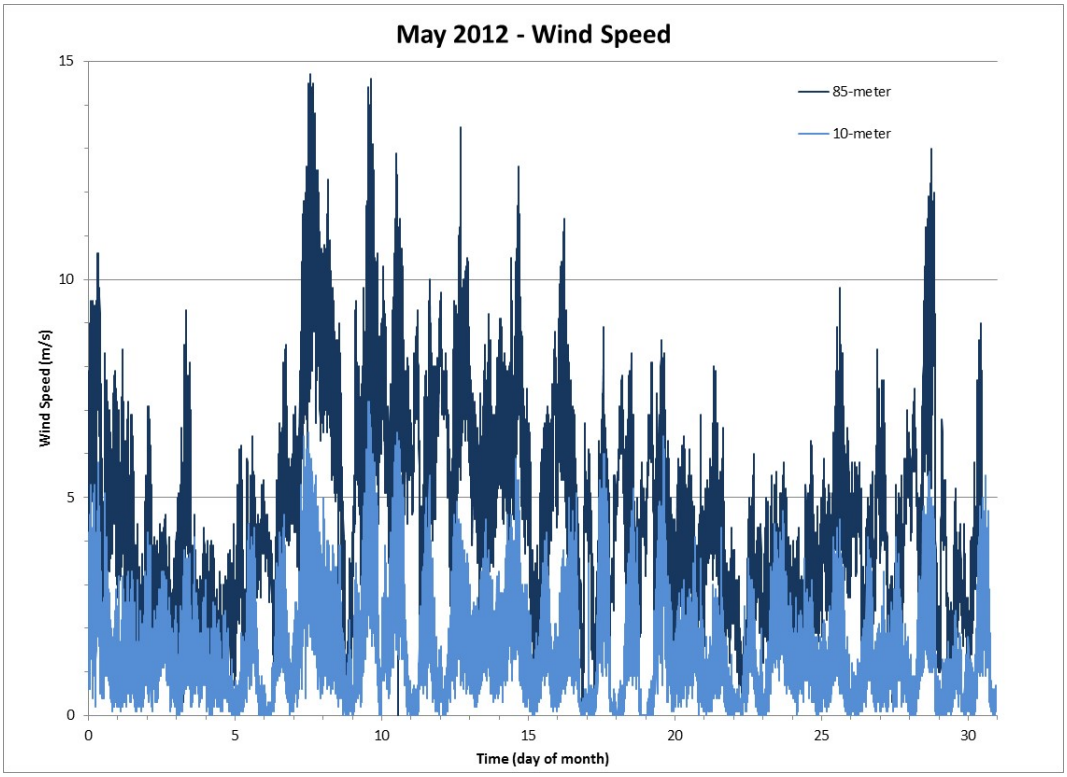

Figure 78 Wind Speed for the Month of May 2012

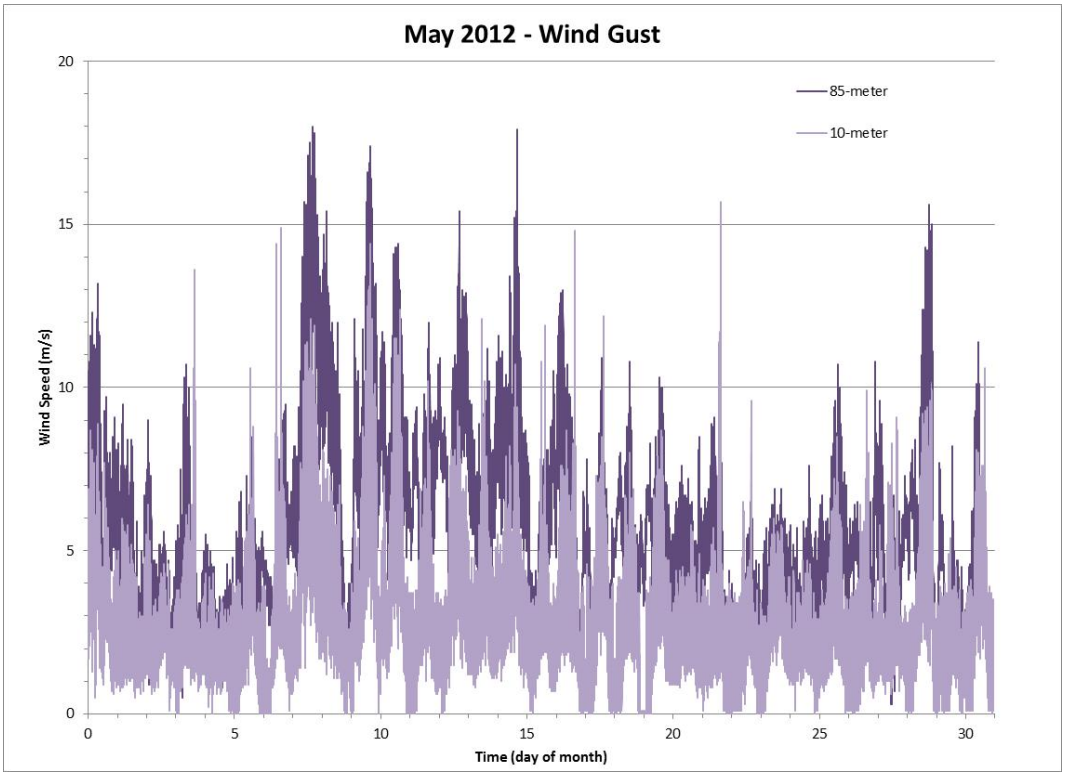

Figure 79 Wind Gust data for the Month of May 2012

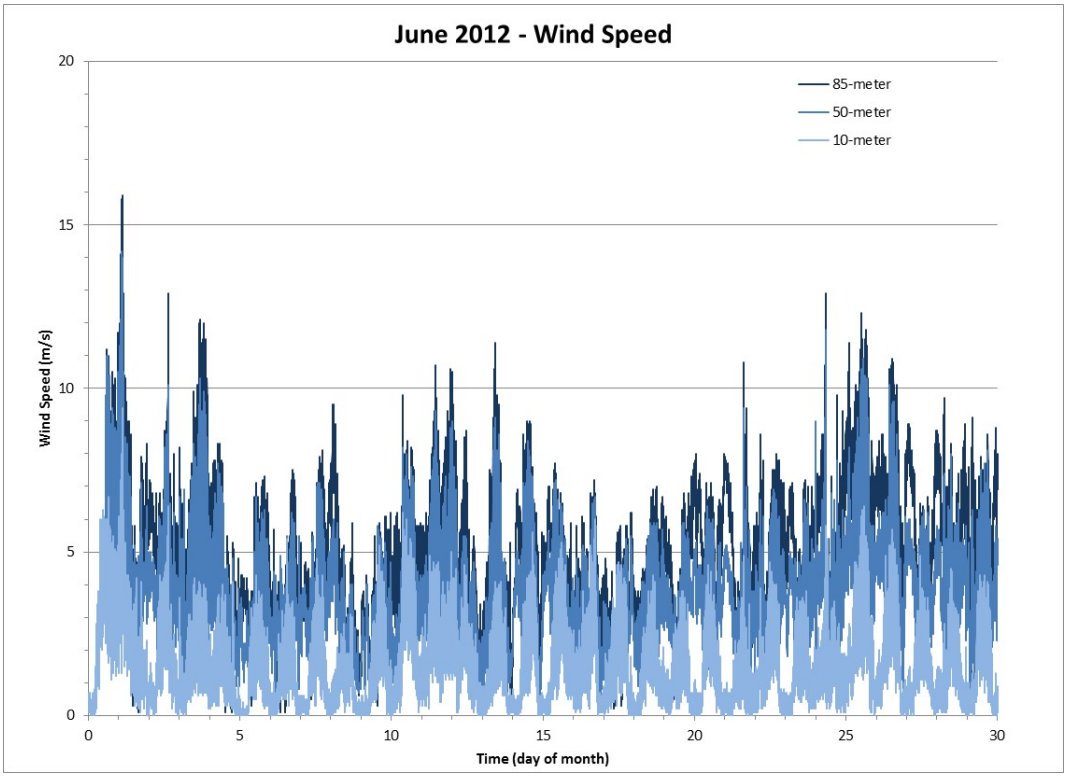

Figure 80 Wind Speed for the Month of June 2012

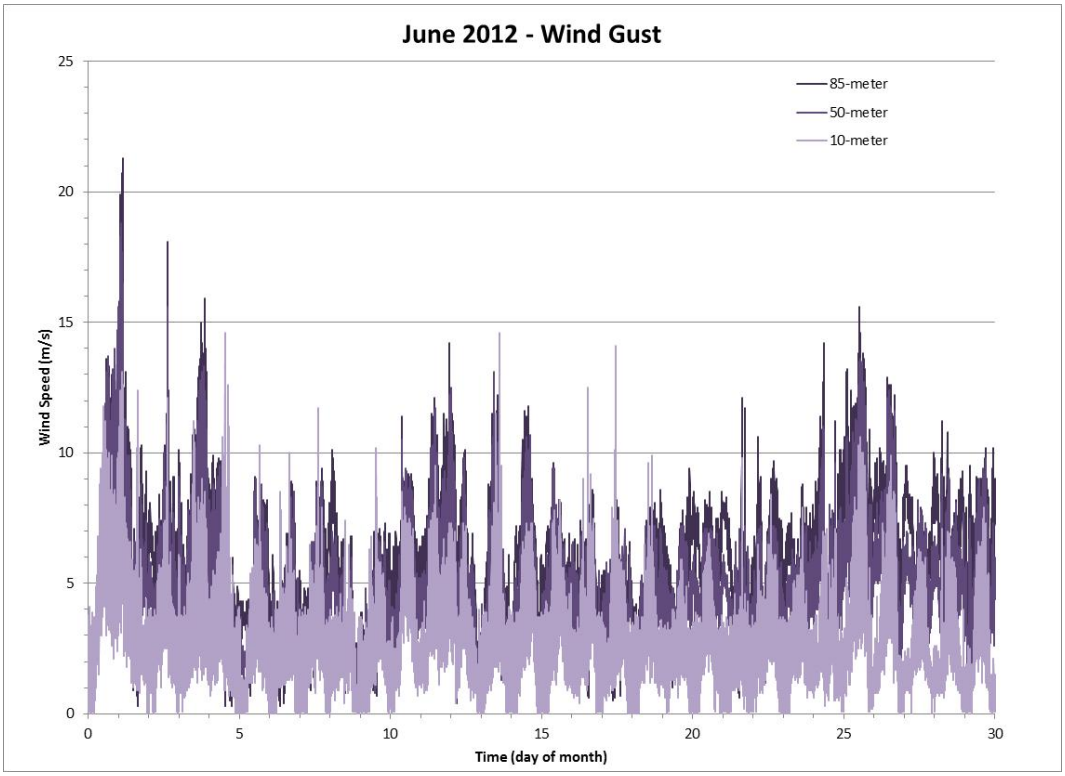

Figure 81 Wind Gust data for the Month of June 2012

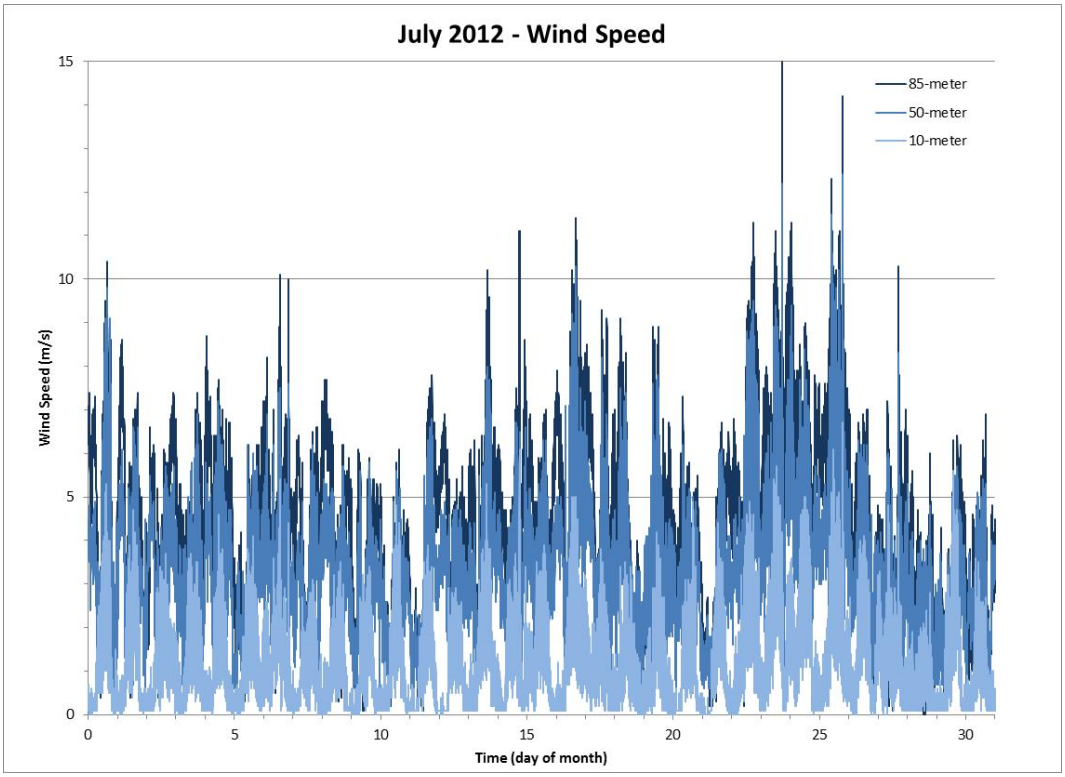

Figure 82 Wind Speed for the Month of July 2012

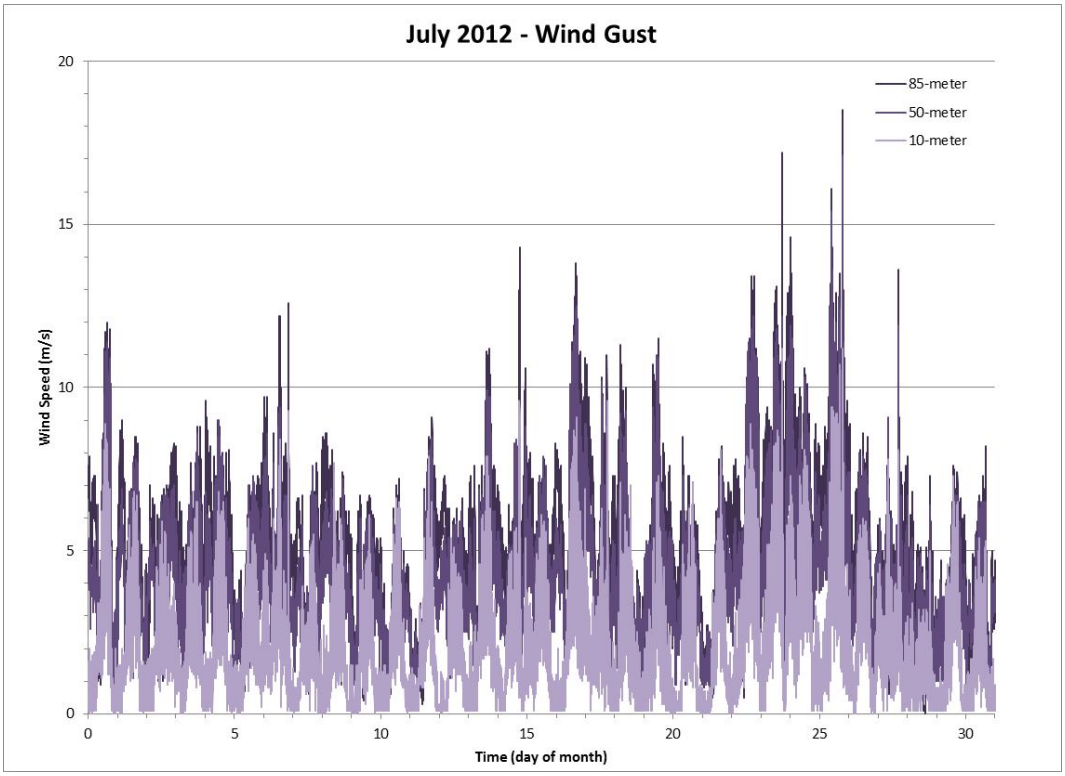

Figure 83 Wind Gust data for the Month of July 2012

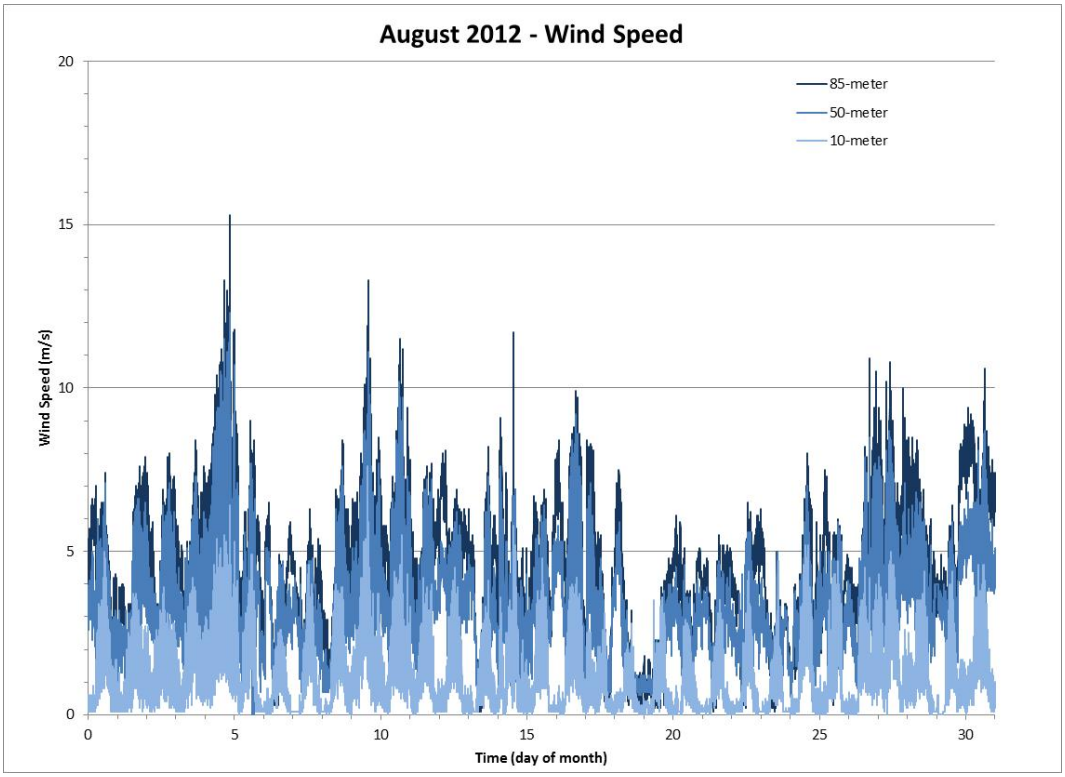

Figure 84 Wind Speed for the Month of August 2012

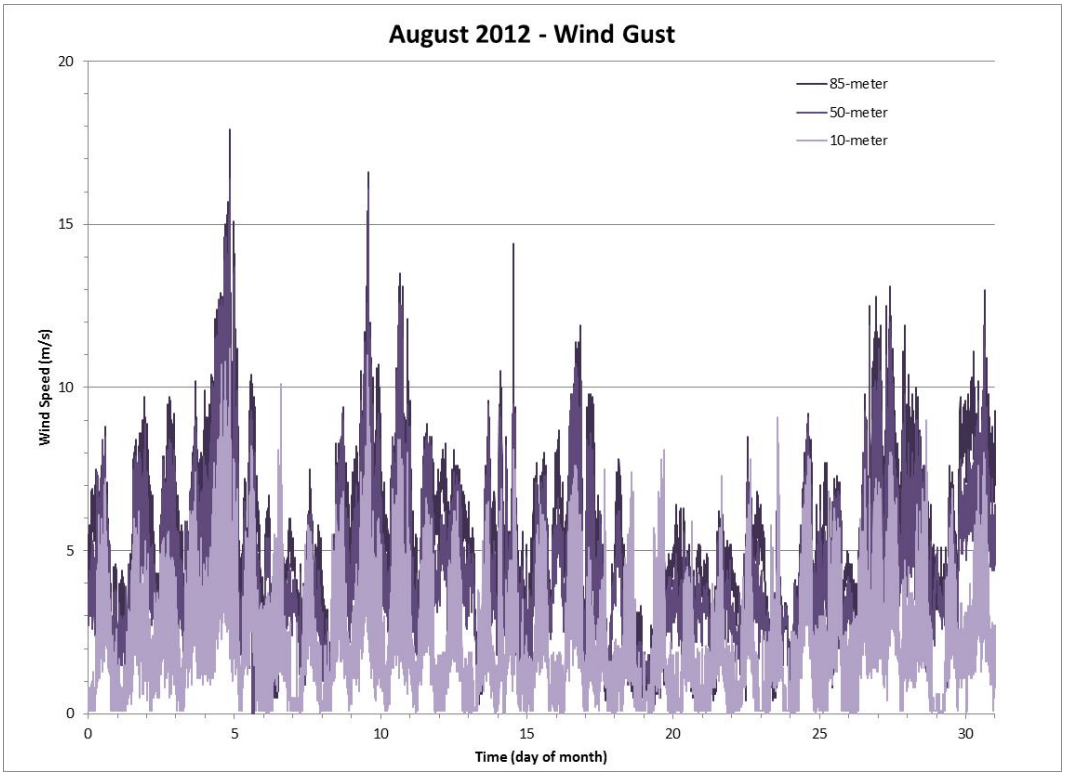

Figure 85 Wind Gust data for the Month of August 2012

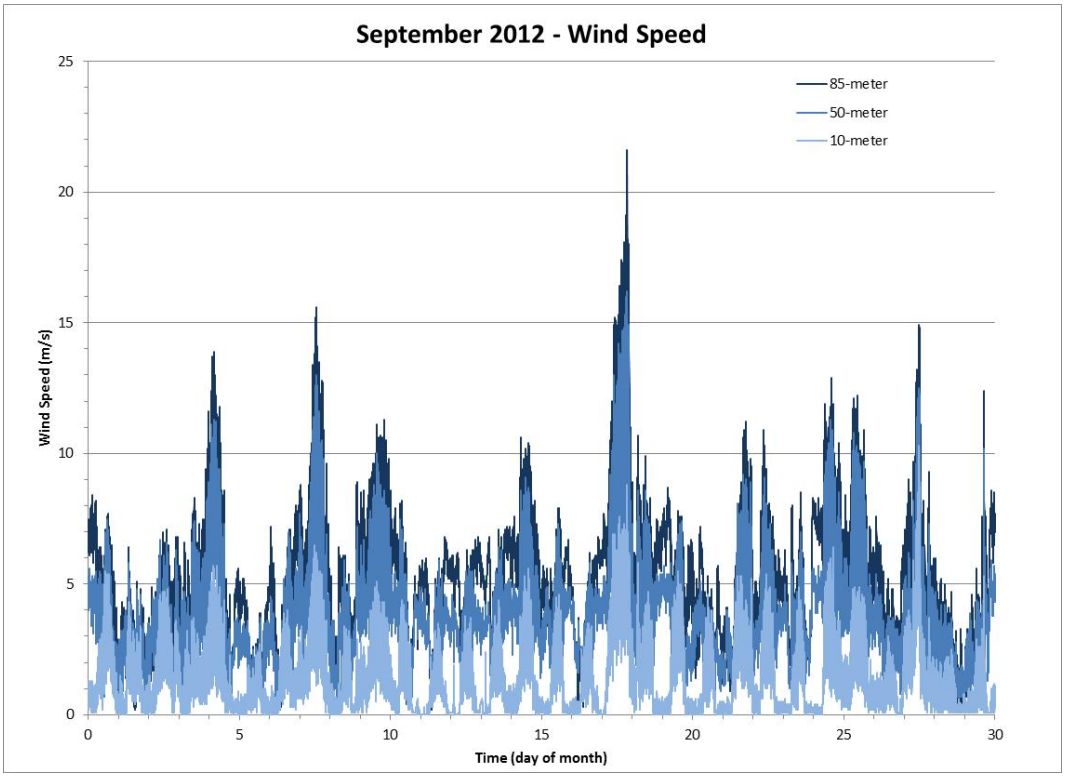

Figure 86 Wind Speed for the Month of September 2012

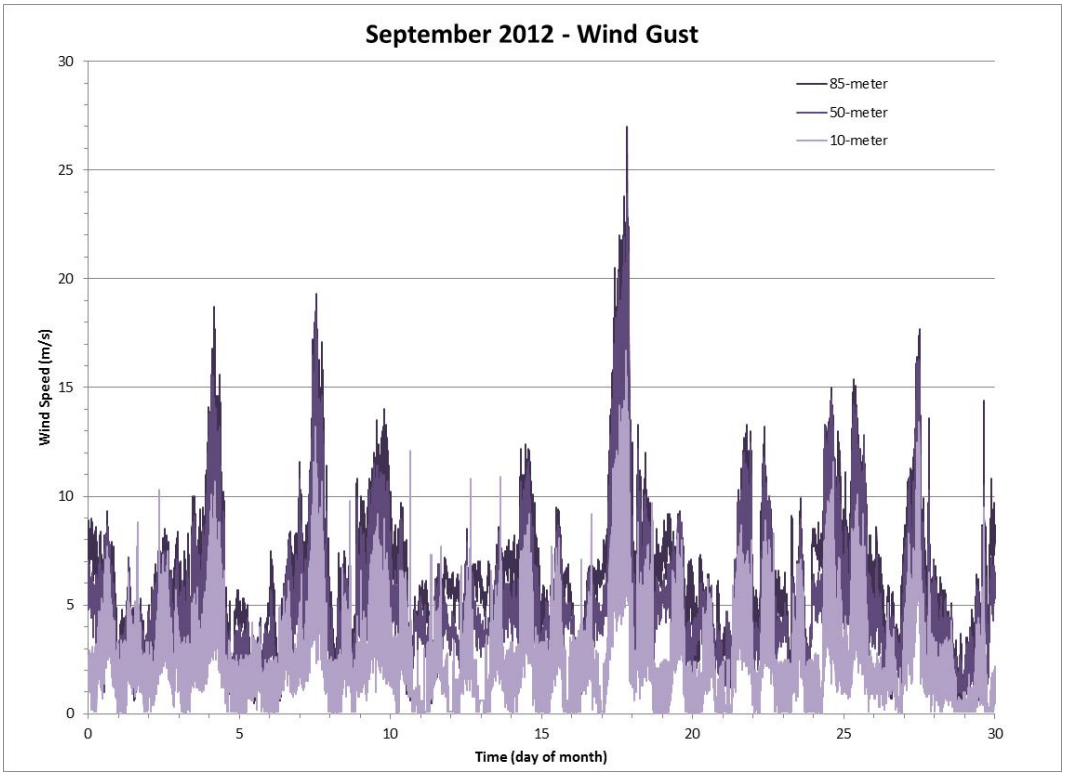

Figure 87 Wind Gust data for the Month of September 2012

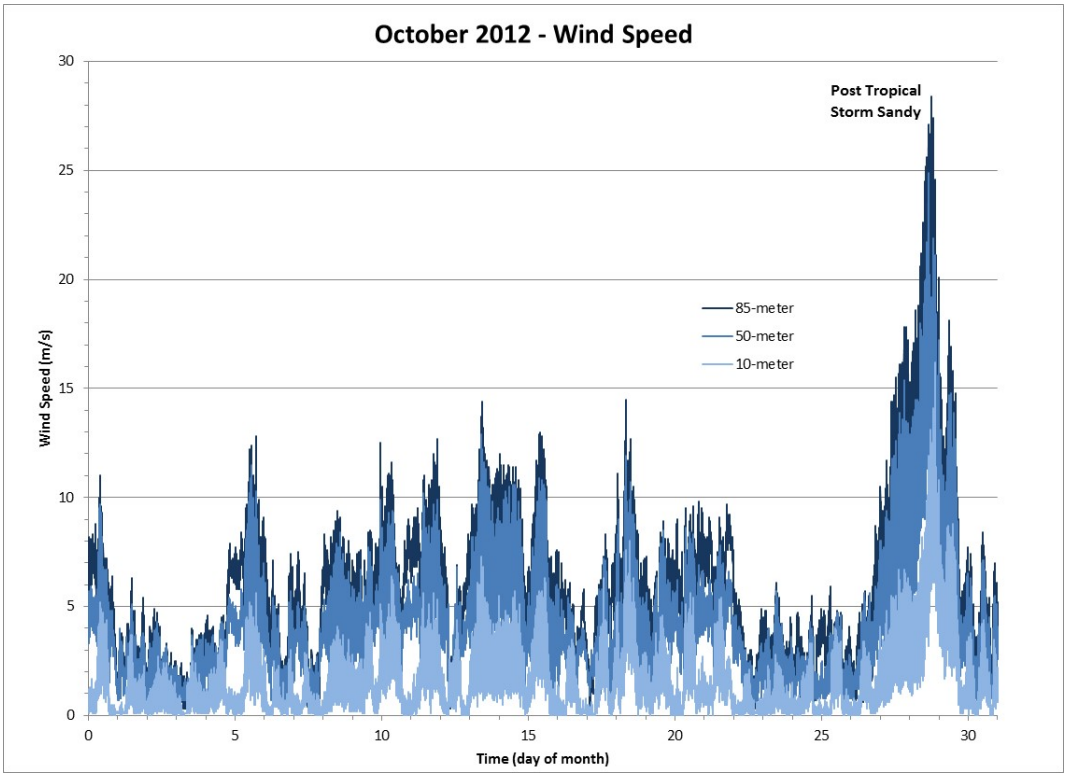

Figure 88 Wind Speed for the Month of October 2012

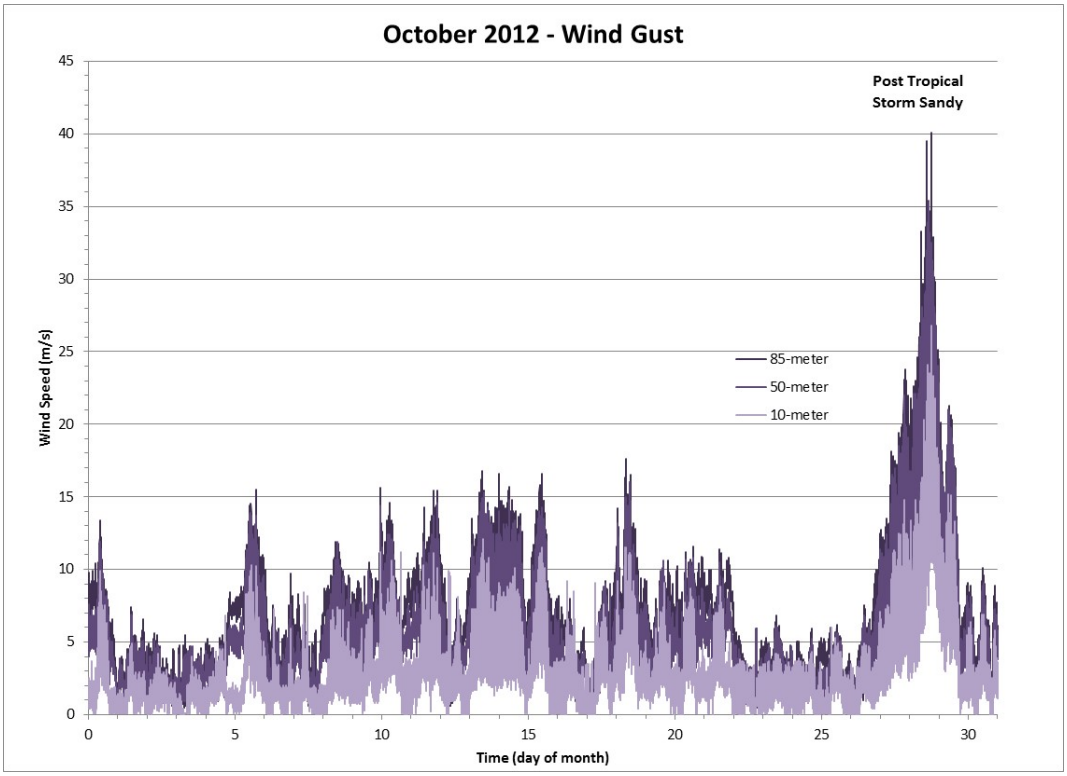

Figure 89 Wind Gust data for the Month of October 2012

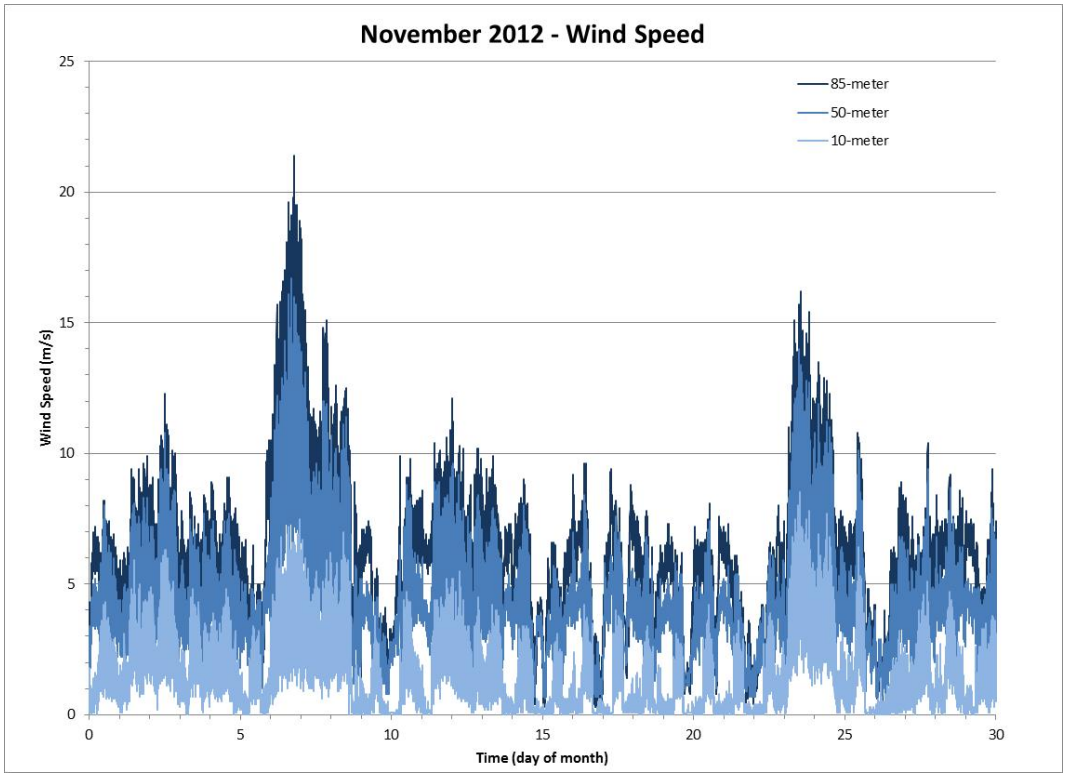

Figure 90 Wind Speed for the Month of November 2012

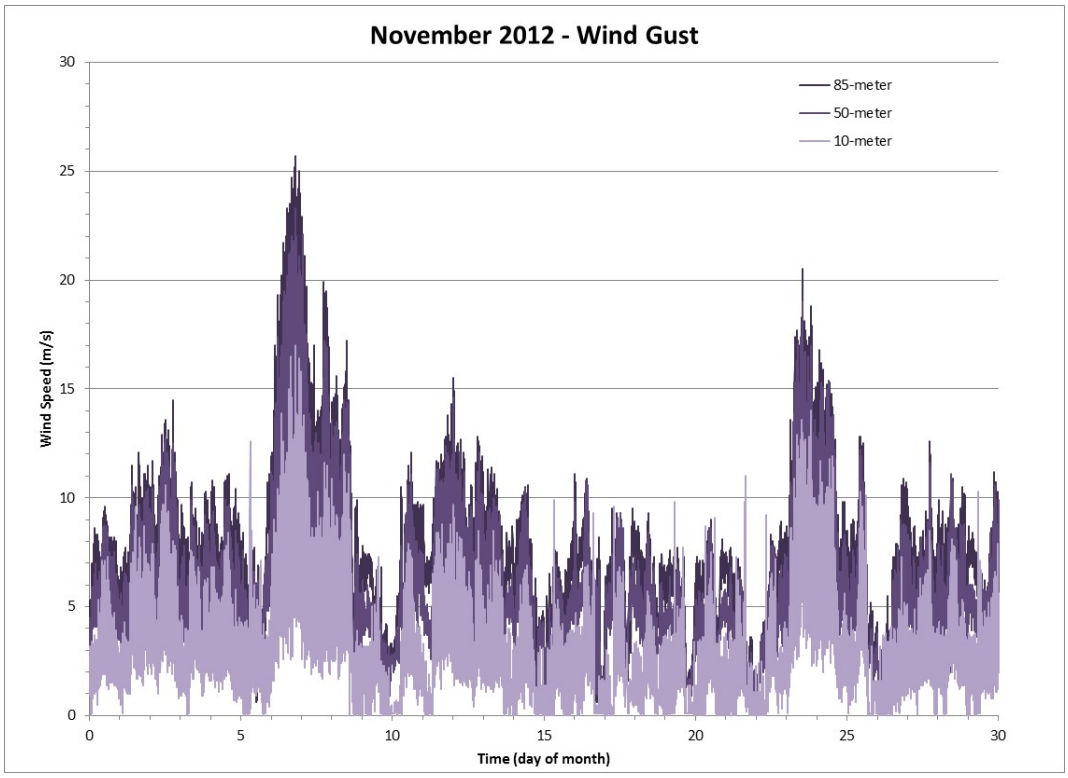

Figure 91 Wind Gust data for the Month of November 2012

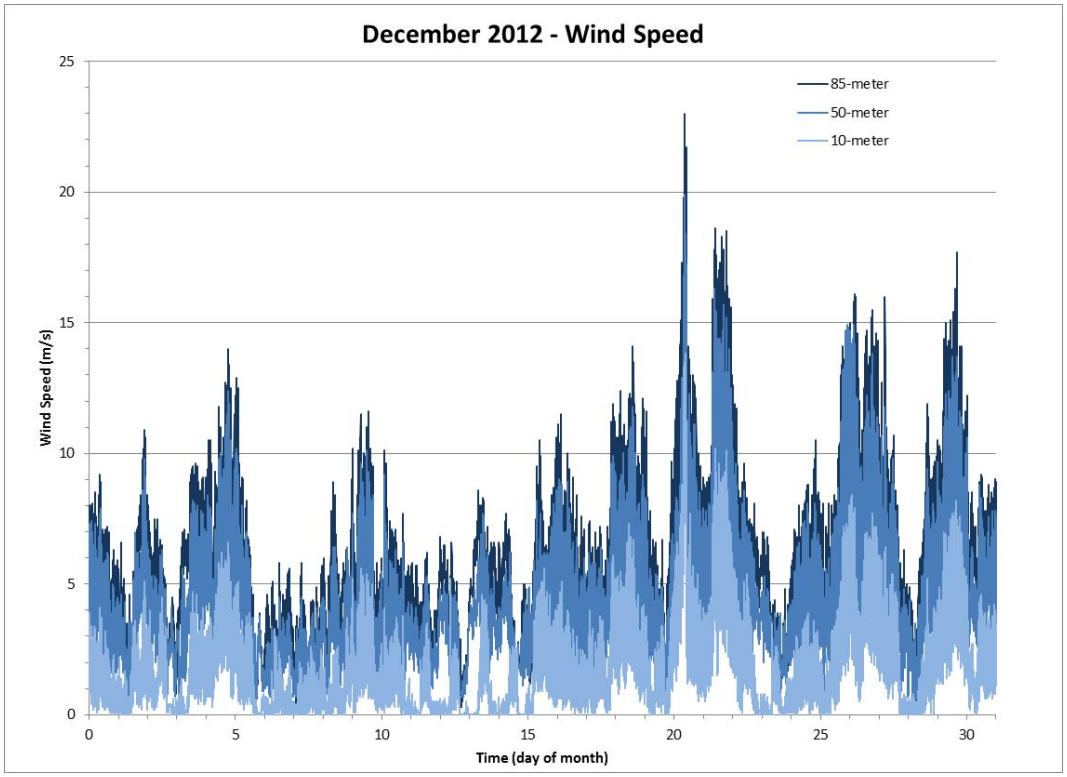

Figure 92 Wind Speed for the Month of December 2012

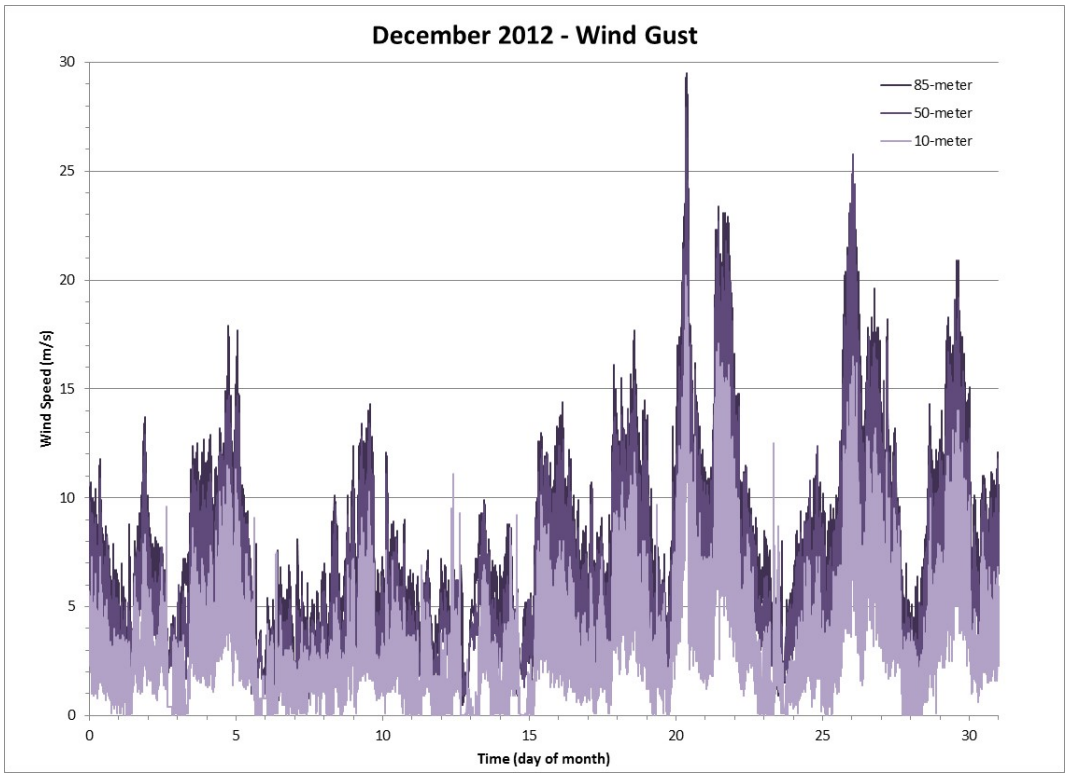

Figure 93 Wind Gust data for the Month of December 2012

## 2012 Solar Resource Data

High quality solar resource data is important to research in the field of renewable energy. With BNL being home to the Long Island Solar Farm (LISF) and future site of the Northeast Solar Energy Research Center (NSERC), it is important that BNL have a local source of dependable, quality assured data on solar radiation. As such BNL maintains a solar base station that records research grade one-minute data. This section reports solar incidence data including monthly data plots of the one-minute data. The SOLYS-2 tracker was out of service from May 9 to July 11, 2011, so data plots for May and July for diffuse, direct and long-wave far infrared radiation are incomplete and June is missing.

## Global Solar Radiation

Global solar irradiance is the total irradiance falling on a horizontal surface. It is the total of diffuse radiation plus the direct normal radiation multiplied by the cosine of the solar zenith angle. Global short-wave radiation (near ultraviolet, visible & near-infrared) is measured using a Kipp & Zonen CMP-22 pyranometer attached to a powered ventilator and mounted on a SOLYS-2 sun tracker. This unit is sent off-site for calibration in the NREL BORCAL program. Currently, when the unit is out for calibration it is replaced with a calibrated CMP-21 pyranometer. The CMP-21 is a high precision research grade pyranometer that includes an integrated housing temperature sensor. The CMP-22 is also a high precision research grade pyranometer with a higher optical quality and higher refractive index quartz dome housing the sensor. Figures 96 through 107 present the monthly plots of global solar radiation.

Figure 94 presents the peak global solar irradiance at BNL for 2012. Table 7 gives the 2012 and historical monthly daily averages for global solar irradiance.

**Table 7. Average Daily Solar Irradiance (Global) at BNL by Month ($W/m^2$)**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1994 | 72.2 | 116.7 | 147.7 | 207.9 | 246.9 | 265.2 | 259.8 | 193.4 | 187.5 | 152.3 | 92.6 | 72.5 | 167.9 |
| 1995 | 74.9 | 108.1 | 182.7 | 231.9 | 281.6 | 168.3 | 97.4 | *301.1* | 290.0 | 151.1 | 85.5 | 77.4 | 170.8 |
| 1996 | 63.2 | 113.9 | 171.6 | 193.7 | 242.0 | 239.0 | 222.8 | 227.1 | 158.6 | 145.2 | 92.9 | *52.5* | 160.2 |
| 1997 | 80.1 | 119.4 | 152.4 | 226.6 | 261.3 | 283.7 | 288.6 | 225.2 | 180.4 | 145.4 | 78.4 | 70.8 | 176.0 |
| 1998 | 72.4 | 113.4 | 146.5 | 215.0 | 243.3 | 283.5 | 268.4 | 255.5 | 204.3 | 139.5 | 98.3 | 64.7 | 175.4 |
| 1999 | 73.5 | 114.4 | 195.3 | 223.2 | 249.6 | 285.3 | 270.1 | 223.9 | 219.4 | 156.0 | 97.1 | 77.6 | 182.1 |
| 2000 | 82.7 | 122.4 | 182.8 | 171.7 | 278.3 | 267.5 | 265.5 | 212.8 | 208.4 | 194.6 | 120.7 | 81.9 | 182.4 |
| 2001 | 81.7 | 125.1 | 148.3 | 220.6 | 289.4 | 281.5 | 284.2 | 227.5 | 202.6 | 159.3 | 105.9 | 74.7 | 183.4 |
| 2002 | 78.0 | 162.4 | 161.2 | 230.5 | 264.4 | 289.4 | 291.7 | 271.6 | 191.7 | 122.8 | 78.8 | 70.3 | 184.4 |
| 2003 | 83.9 | 74.3 | 174.1 | 191.8 | 190.4 | 262.6 | 249.8 | 294.6 | 175.3 | 118.8 | 80.4 | 58.8 | 162.9 |
| 2004 | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan |
| 2005 | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2006 | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan |
| 2007 | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan |
| 2008 | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan |
| 2009 | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan |
| 2010 | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan | nan |
| 2011 | 86.2 | 121.1 | 177.5 | 172.6 | 223.6 | 254.2 | 276.7 | 223.7 | 130.0 | 130.3 | 97.5 | 75.2 | 164.1 |
| 2012 | 91.5 | 126.5 | 163.7 | 254.3 | 199.2 | 268.3 | 249.0 | 231.8 | 179.6 | 110.0 | 92.8 | 59.8 | 168.9 |
| | | | | | | | | | | | | | |
| **Average** | **78.7** | **117.5** | **167.0** | **211.7** | **247.5** | **262.4** | **252.0** | **240.7** | **194.0** | **143.8** | **93.4** | **69.7** | **173.2** |
| | | | | | | | | | | | | | |
| Max | 91.5 | 162.4 | 195.3 | 254.3 | 289.4 | 289.4 | 291.7 | *301.1* | 290.0 | 194.6 | 120.7 | 81.9 | 184.4 |
| Min | 63.2 | 74.3 | 146.5 | 171.7 | 190.4 | 168.3 | 97.4 | 193.4 | 130.0 | 110.0 | 78.4 | *52.5* | 160.2 |

nan indicates missing data, Values in fields filled in yellow are the monthly averages inserted because of partially missing data, the average then changes with addition of this value.

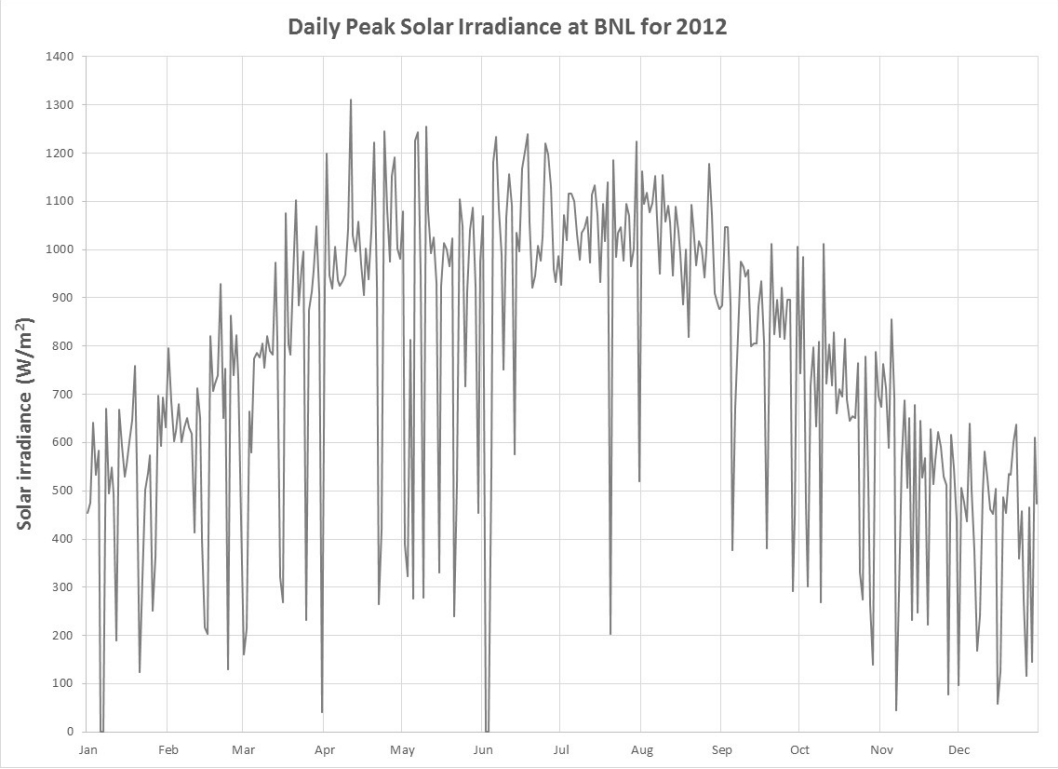


Figure 94 Daily Peak Solar Irradiance at Brookhaven National Laboratory for 2012

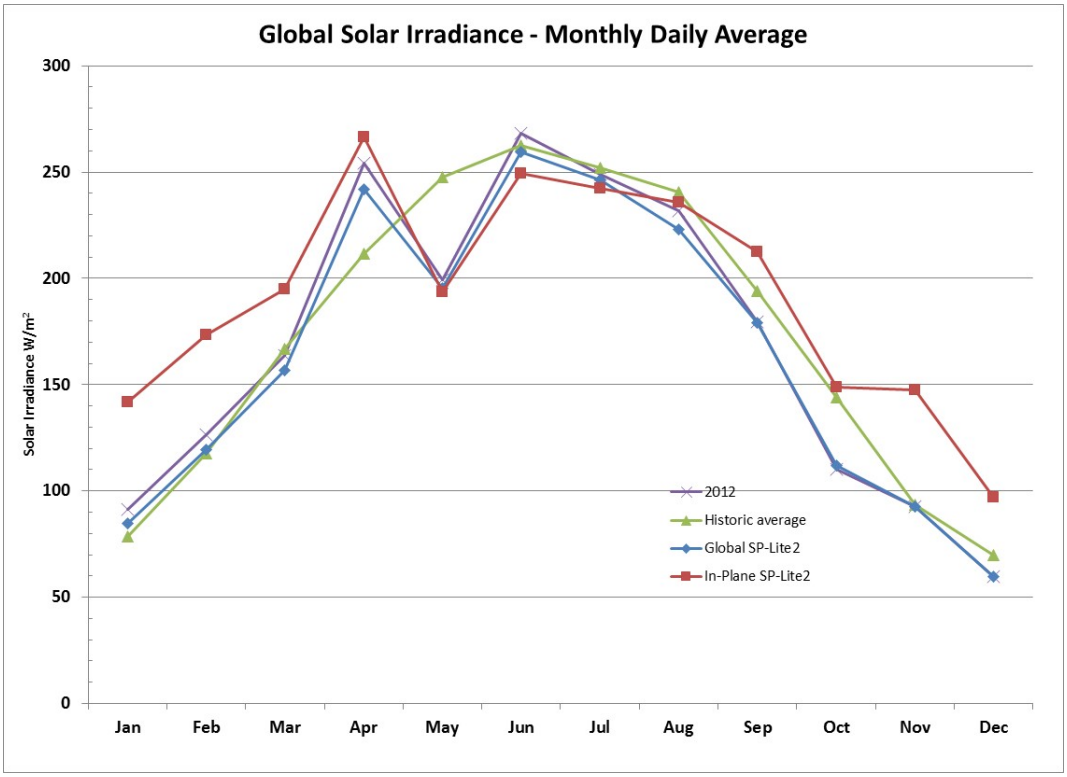


Figure 95 Global Solar Irradiance - Monthly Daily Average

## Diffuse Solar Radiation

Diffuse solar irradiance is the radiation that is scattered (i.e., by clouds and dust particles) as it passes through the atmosphere. Diffuse short-wave radiation (ultraviolet, visible & near-infrared) is measured using a shaded Kipp & Zonen CMP-22 pyranometer with a powered ventilator mounted on a SOLYS-2 sun tracker. This unit is sent off-site for calibration in the NREL BORCAL program. Currently, when the unit is out for calibration it is replaced with a calibrated CMP-21 pyranometer. Figures 108 through 118 present the monthly plots of diffuse solar radiation.

## Direct Solar Radiation

Direct solar irradiance is the solar radiation that travels in a straight path to a detector that is perpendicular to the light path. The direct short-wave radiation is measured with a Kipp & Zonen CHP-1 pyrheliometer attached to a SOLYS-2 sun tracker. The CHP-1 is a thermopile that absorbs 97-98% of the total incident radiation. The reported maximum uncertainty is 2% for hourly measurements and 1% for daily totals. BNL has only one pyrheliometer and direct normal radiation is not directly measured during the time the sensor is out for calibration. [During the calibration interval, direct solar radiation can be calculated from the global and diffuse measurements.] Figures 119 through 129 present the monthly plots of direct solar radiation.

## Long-wave Far Infrared Radiation

Downward long-wave far infrared radiation is measured using a shaded Kipp & Zonen CGR-4 pyrgeometer with a powered ventilator mounted on the SOLYS-2 sun tracker. The CGR-4 is a research grade thermopile. This unit is sent off-site for calibration in the NREL BORCAL program. A duplicate unit is stocked which is sent to NREL for calibration and replaces the in service unit when returned. The CGR-4 has a built in temperature sensor and temperature correction is applied. The reported maximum daily uncertainty is 3%. Figures 130 through 140 present the monthly plots of direct solar radiation.

## LISF Reference Pyranometers

The LISF has a network of pyranometers and meteorological sensors to provide data for solar research. Each of the 25 powerblocks has a pair of Kipp & Zonen pyranometers that measure global and tilted global solar radiation. As a reference for the LISF sensor array, two Kipp and Zonen model SP-lite2 pyranometers are maintained at the base station on building 490D, one in-plane (tilted global radiation) at the 27° angle of inclination used for the panels at the LISF and one horizontal (global radiation). The horizontal (global) solar radiation plots are presented in Figures 141 through 152. The in-plane or tilted global radiation is presented in Figures 153 through 164.

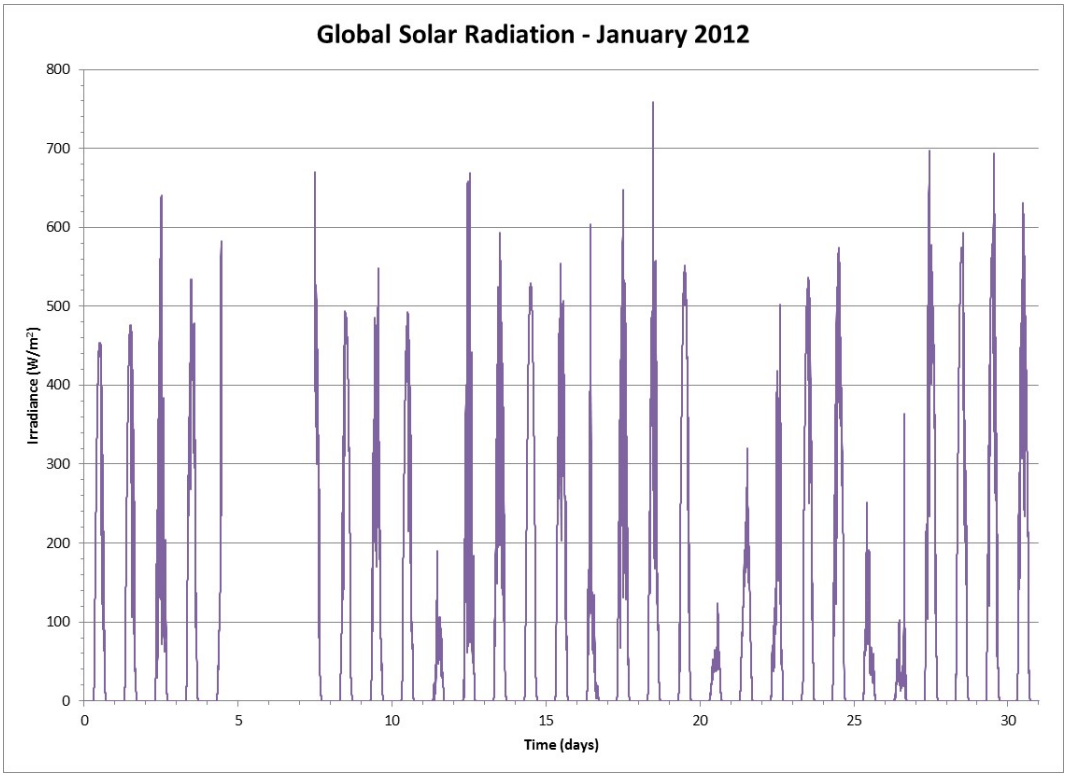


Figure 96 Global Solar Radiation for the Month of January 2012

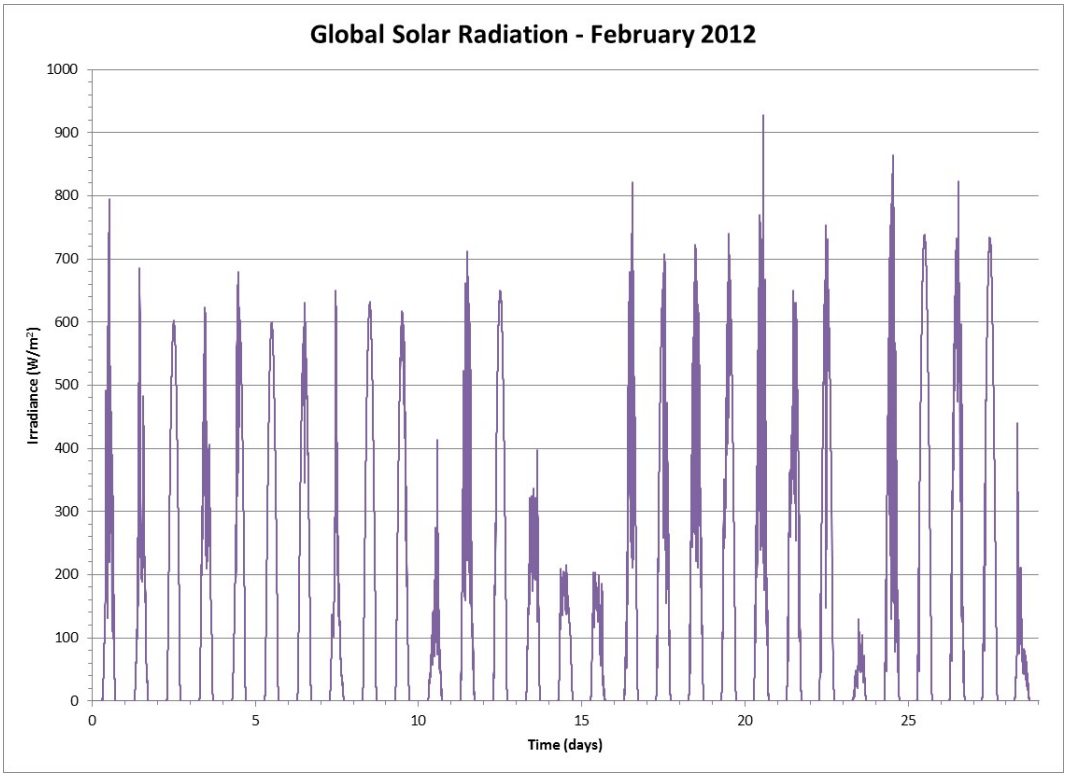

Figure 97 Global Solar Radiation for the Month of February 2012

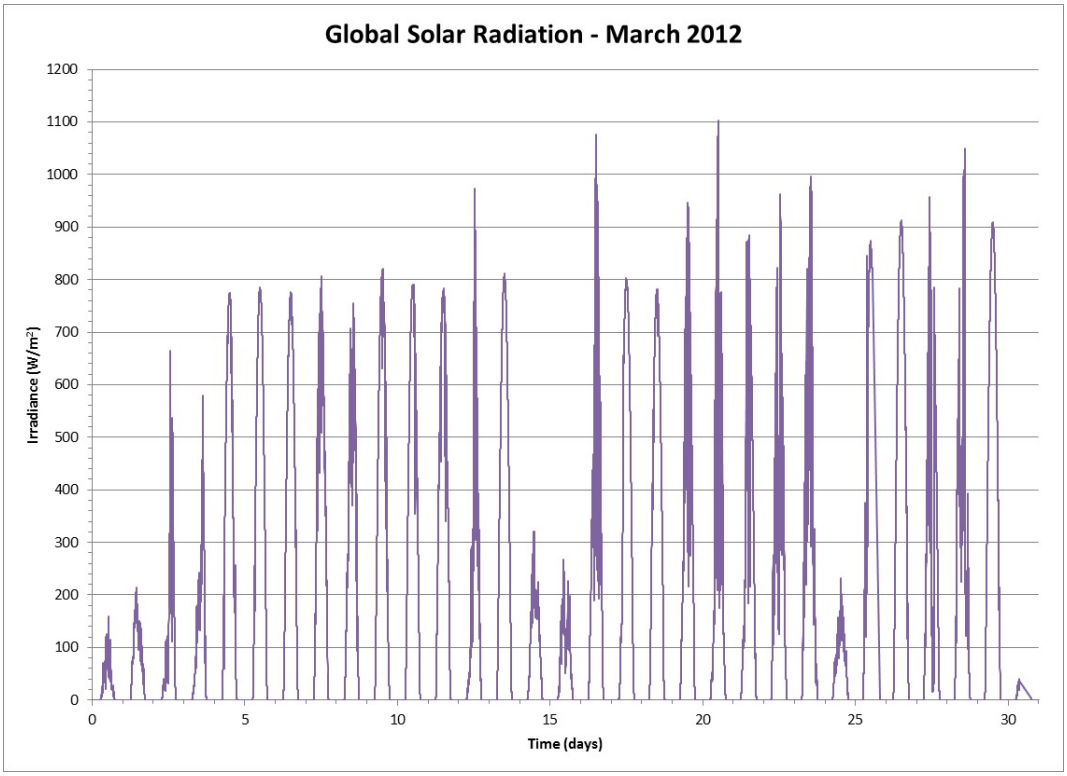

Figure 98 Global Solar Radiation for the Month of March 2012

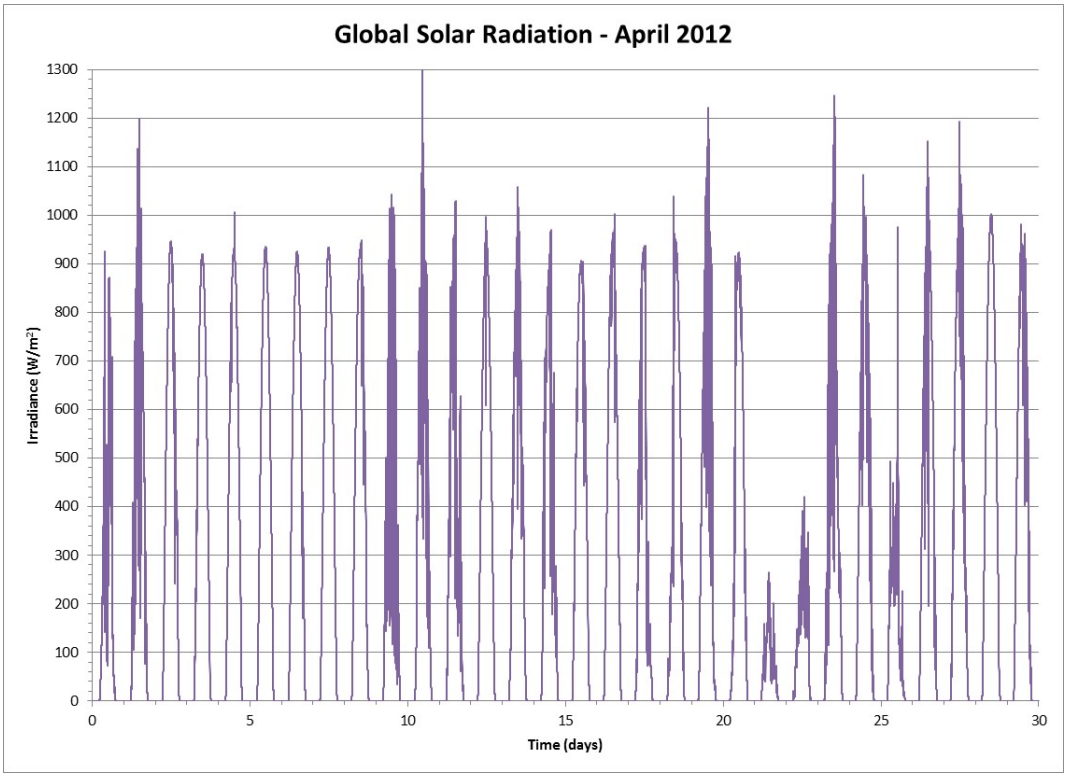

Figure 99 Global Solar Radiation for the Month of April 2012

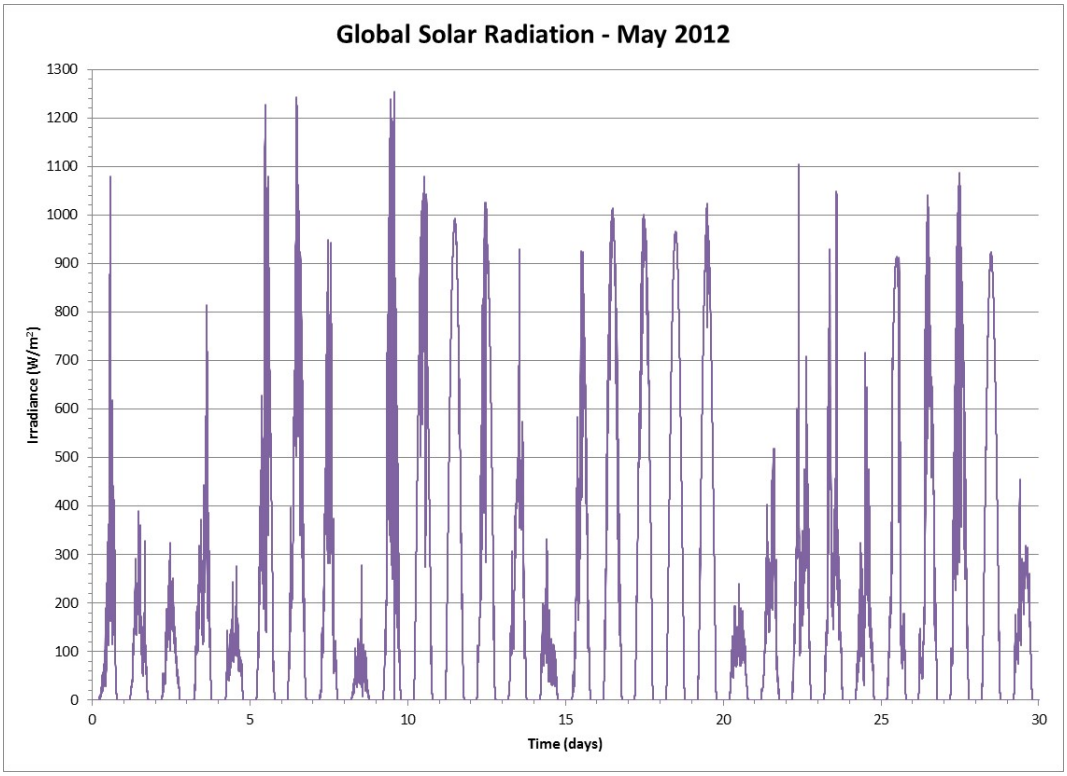

Figure 100 Global Solar Radiation for the Month of May 2012

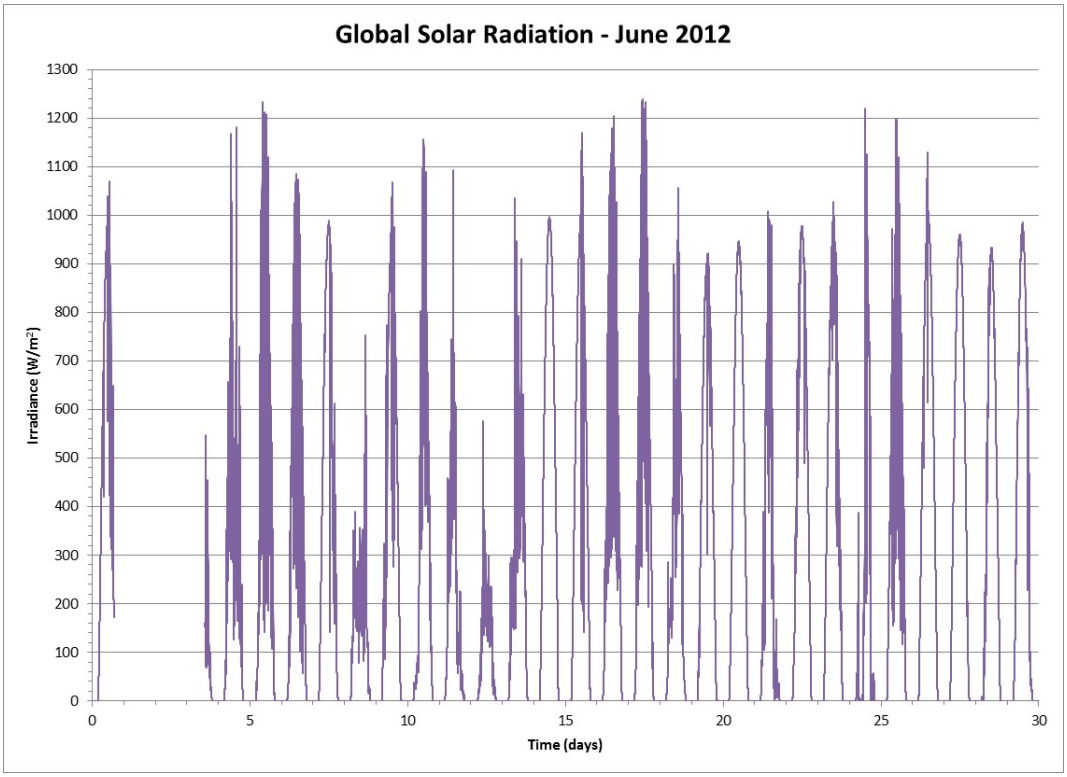

Figure 101 Global Solar Radiation for the Month of May 2012

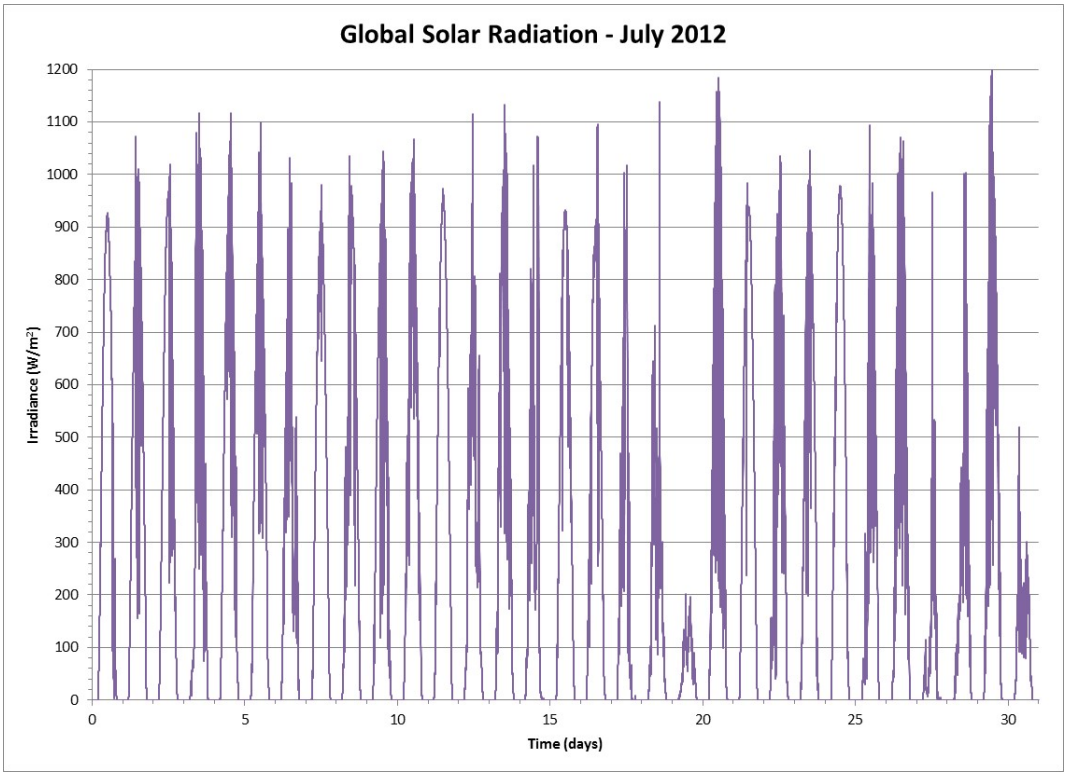

Figure 102 Global Solar Radiation for the Month of July 2012

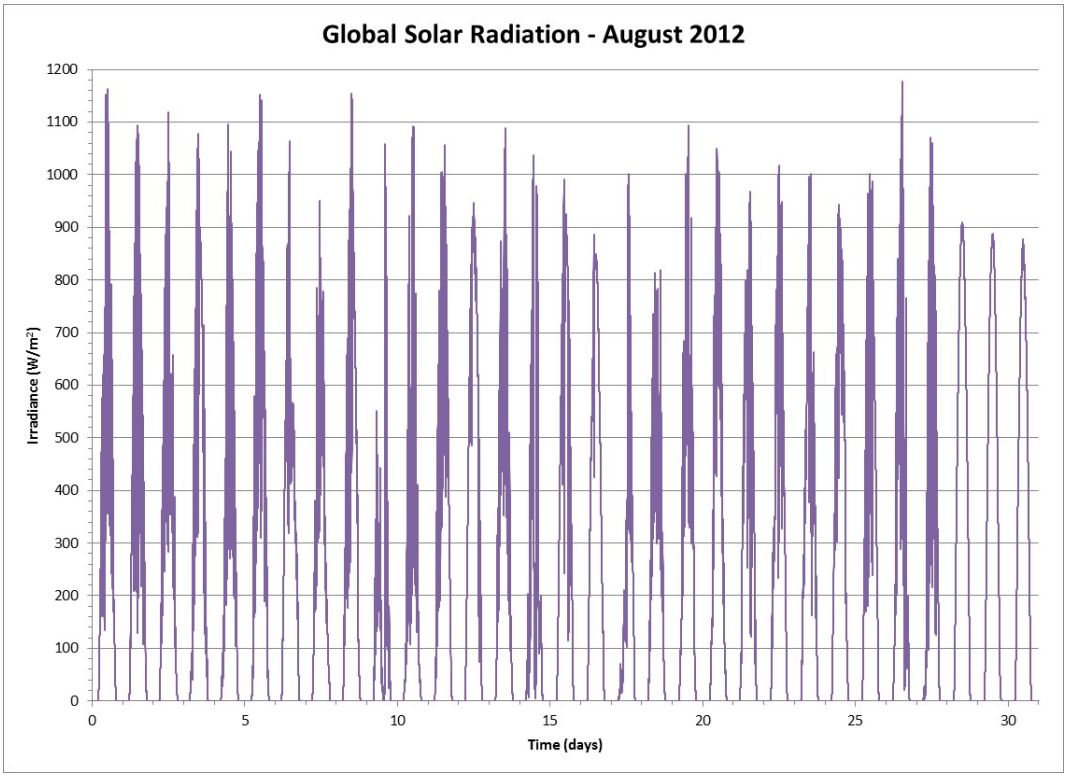

Figure 103 Global Solar Radiation for the Month of August 2012

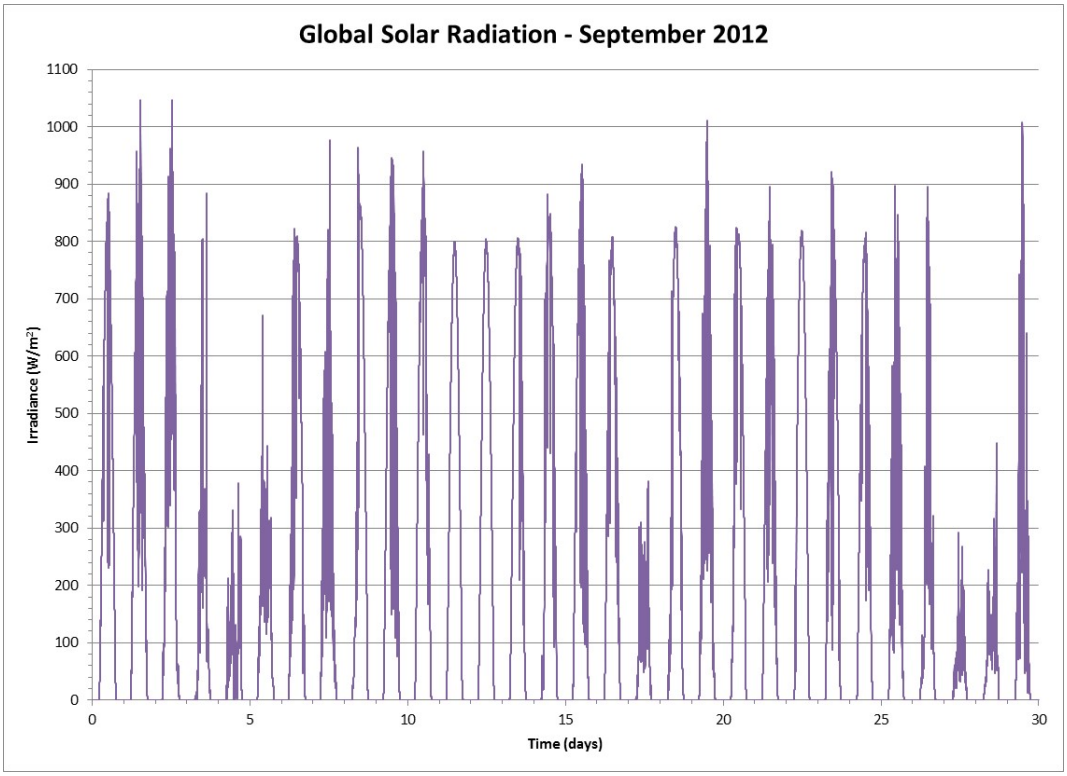

Figure 104 Global Solar Radiation for the Month of September 2012

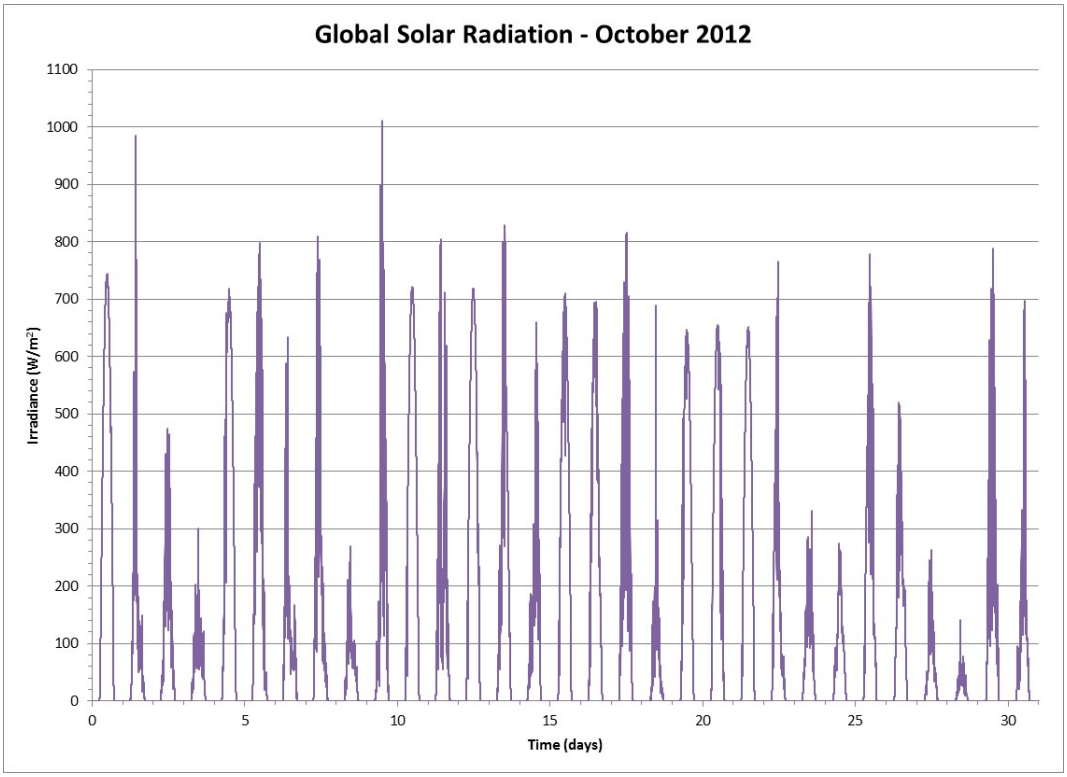

Figure 105 Global Solar Radiation for the Month of October 2012

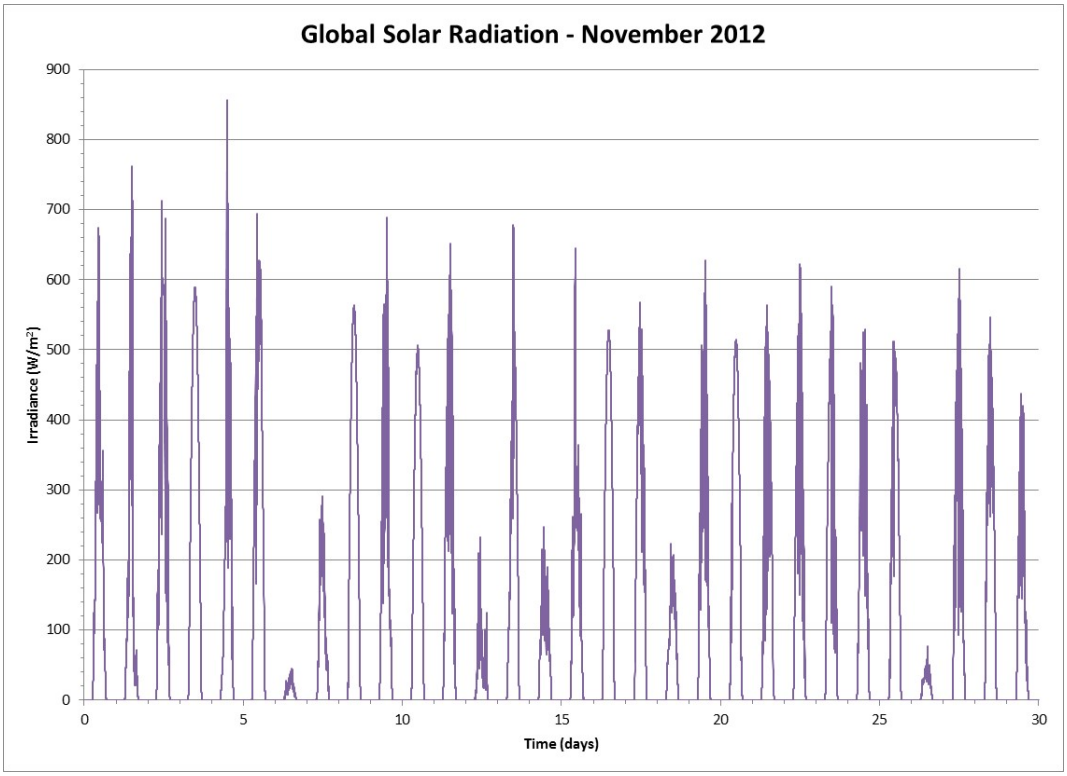

Figure 106 Global Solar Radiation for the Month of November 2012

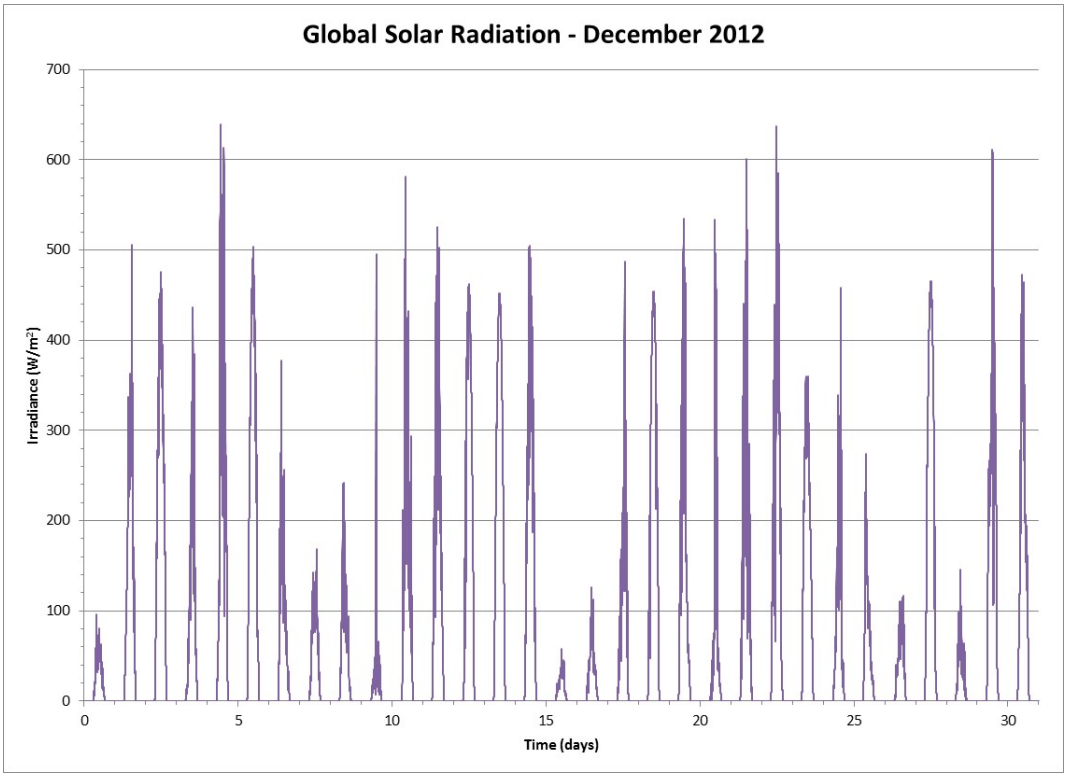

Figure 107 Global Solar Radiation for the Month of December 2012

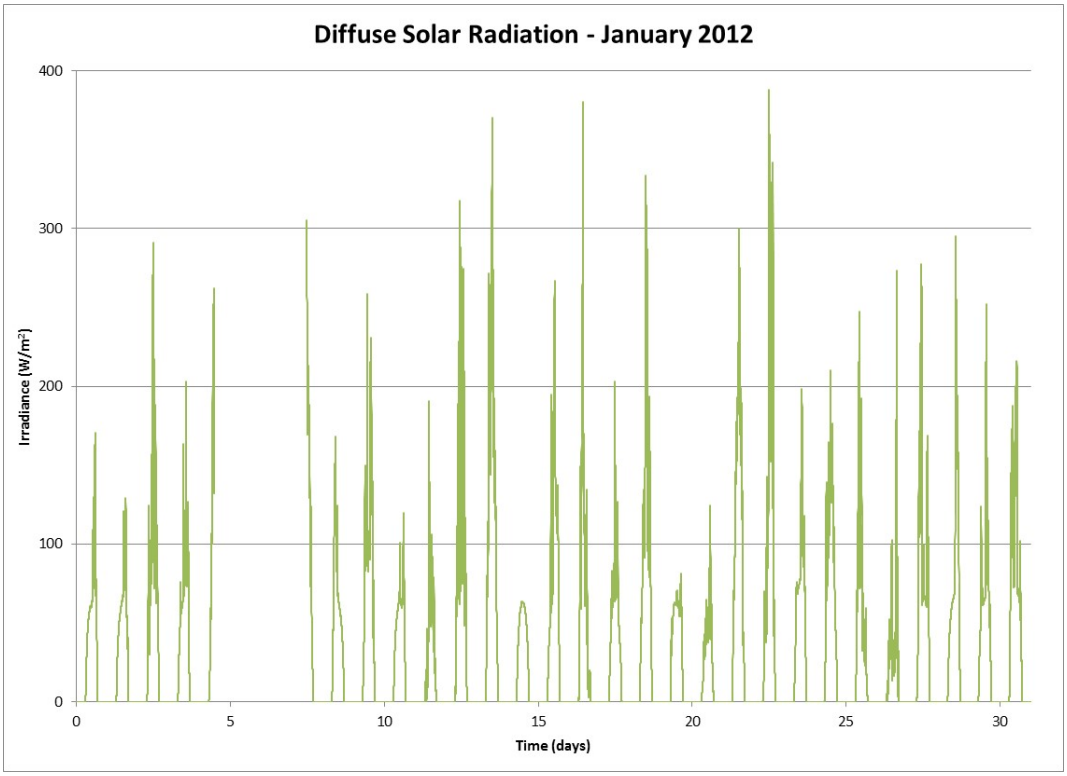

Figure 108 Diffuse Solar Radiation for the Month of January 2012

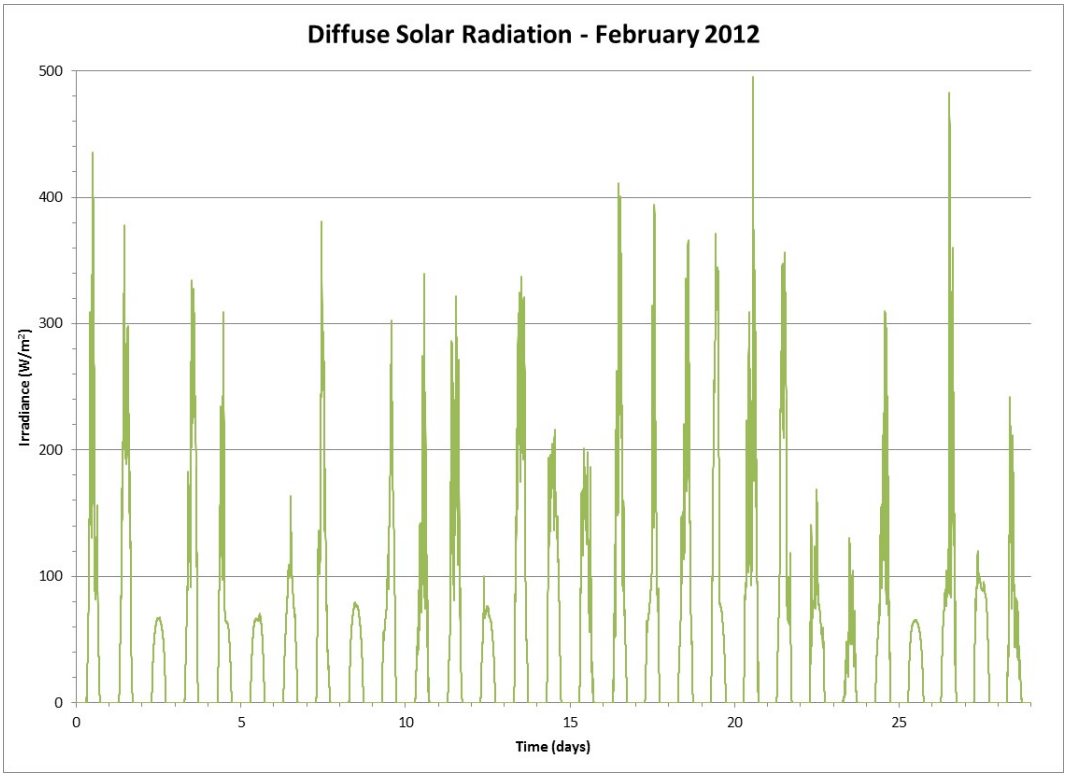

Figure 109 Diffuse Solar Radiation for the Month of February 2012

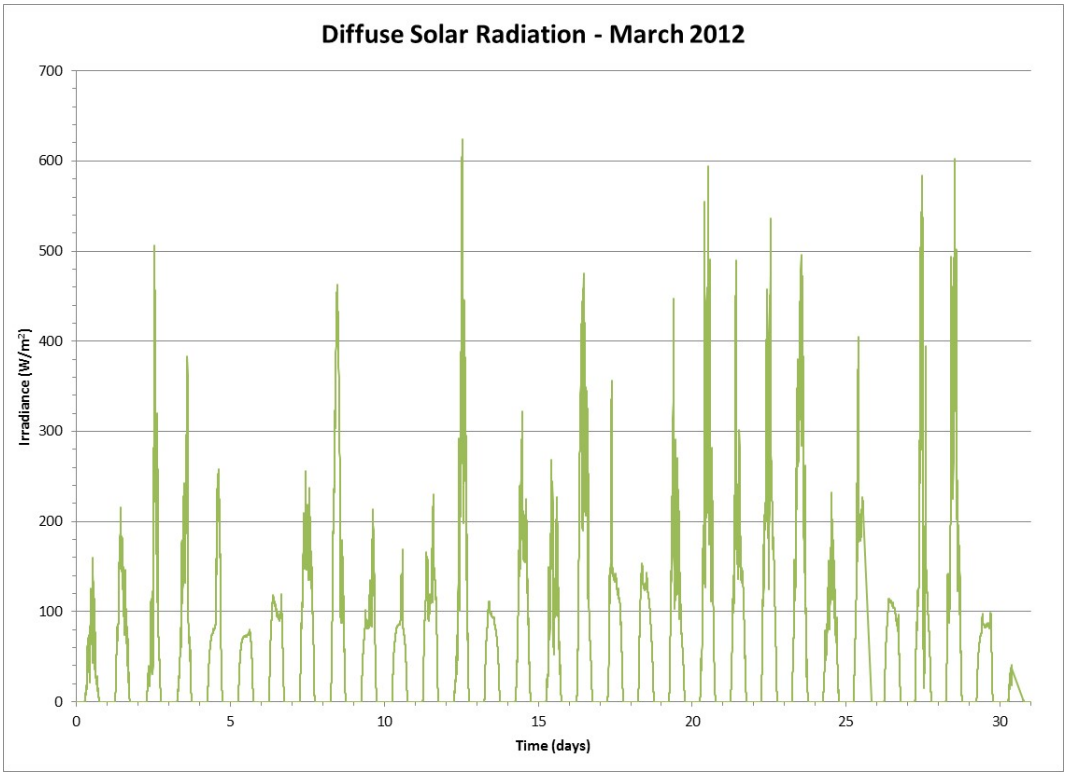

Figure 110 Diffuse Solar Radiation for the Month of March 2012

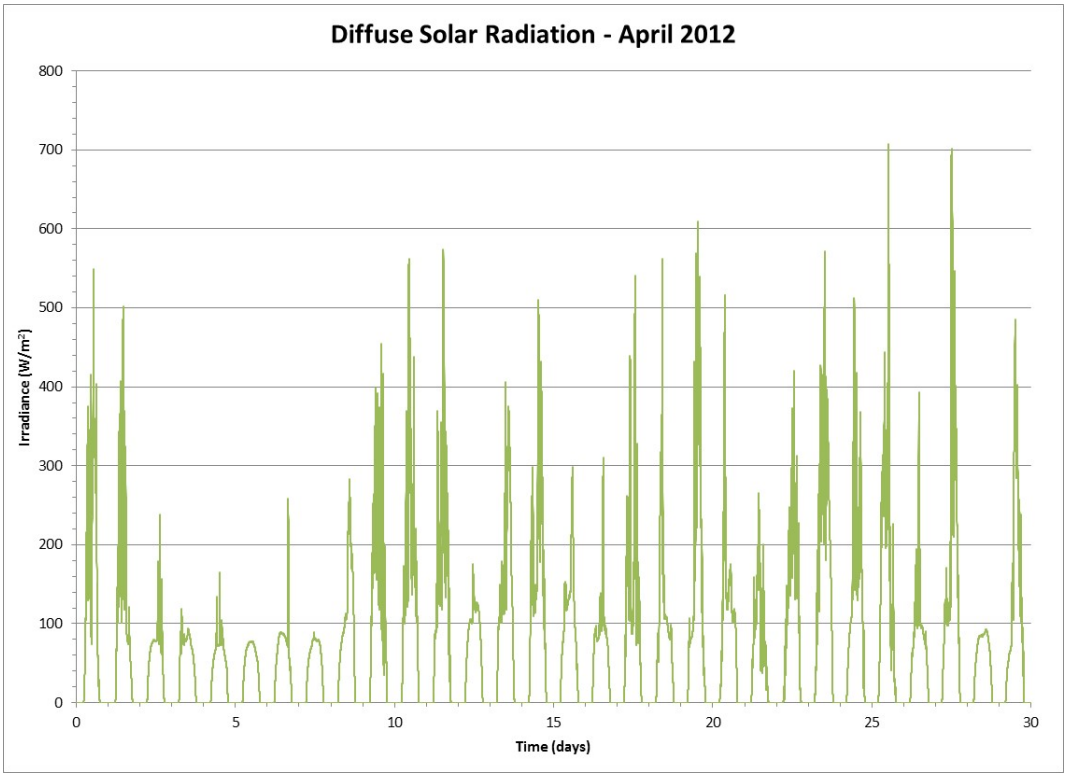

Figure 111 Diffuse Solar Radiation for the Month of April 2012

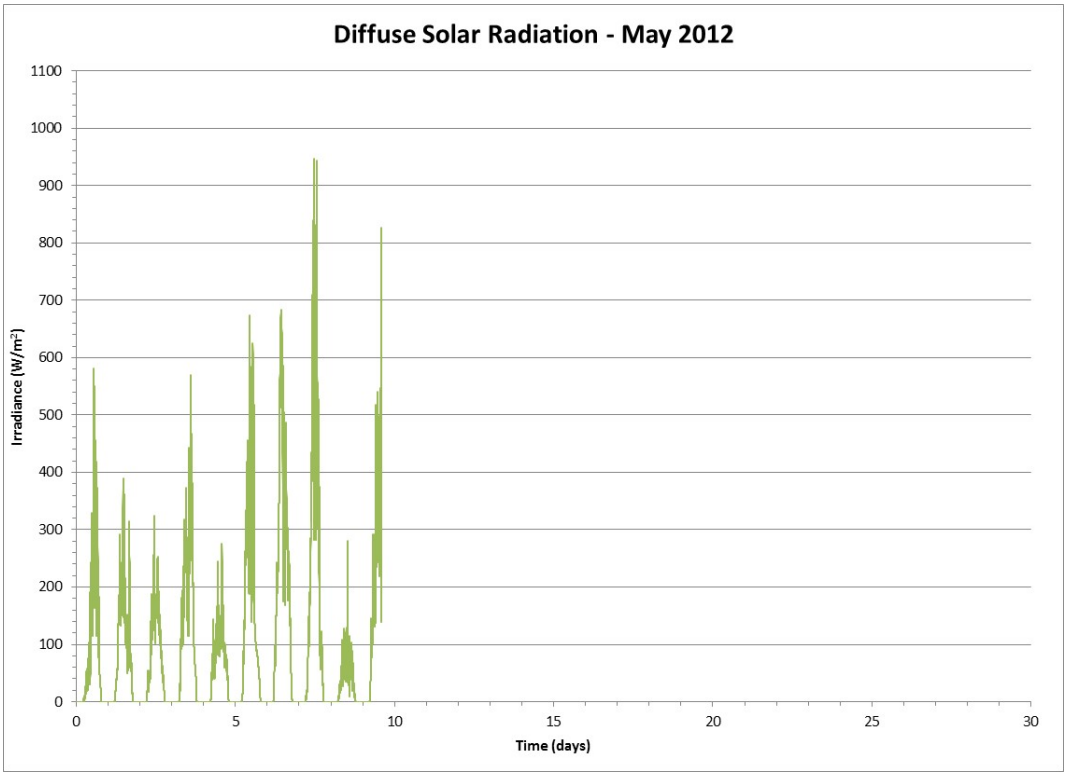

Figure 112 Diffuse Solar Radiation for the Month of May 2012

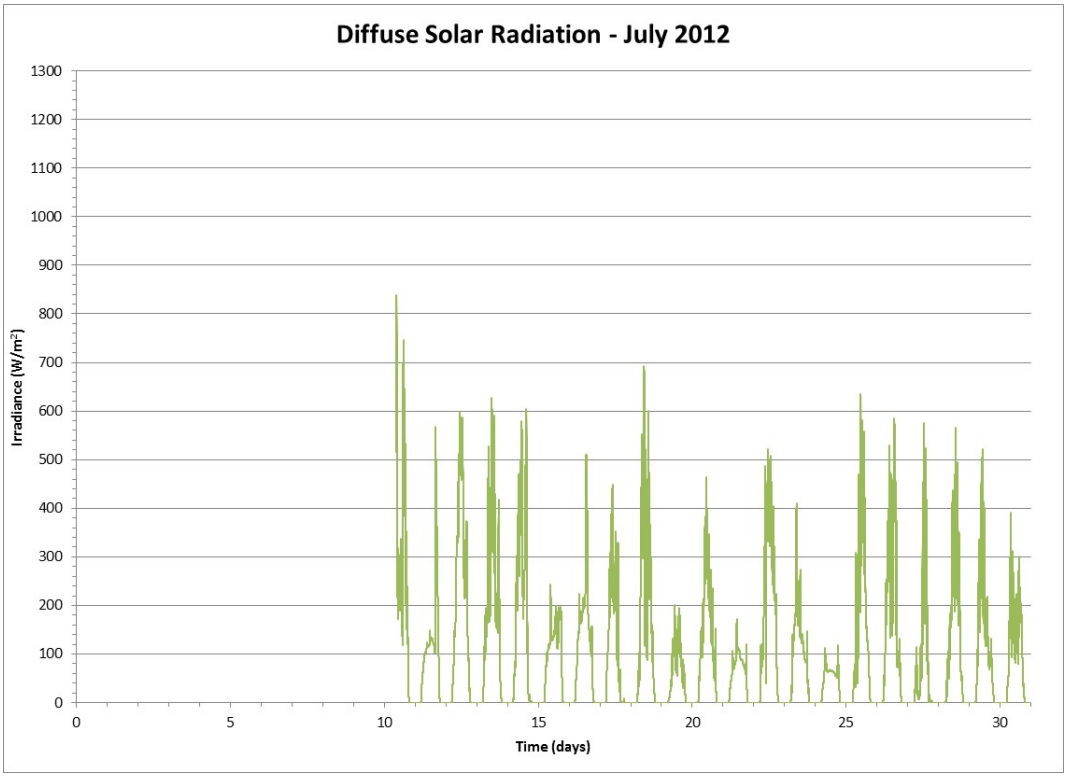


Figure 113 Diffuse Solar Radiation for the Month of July 2012

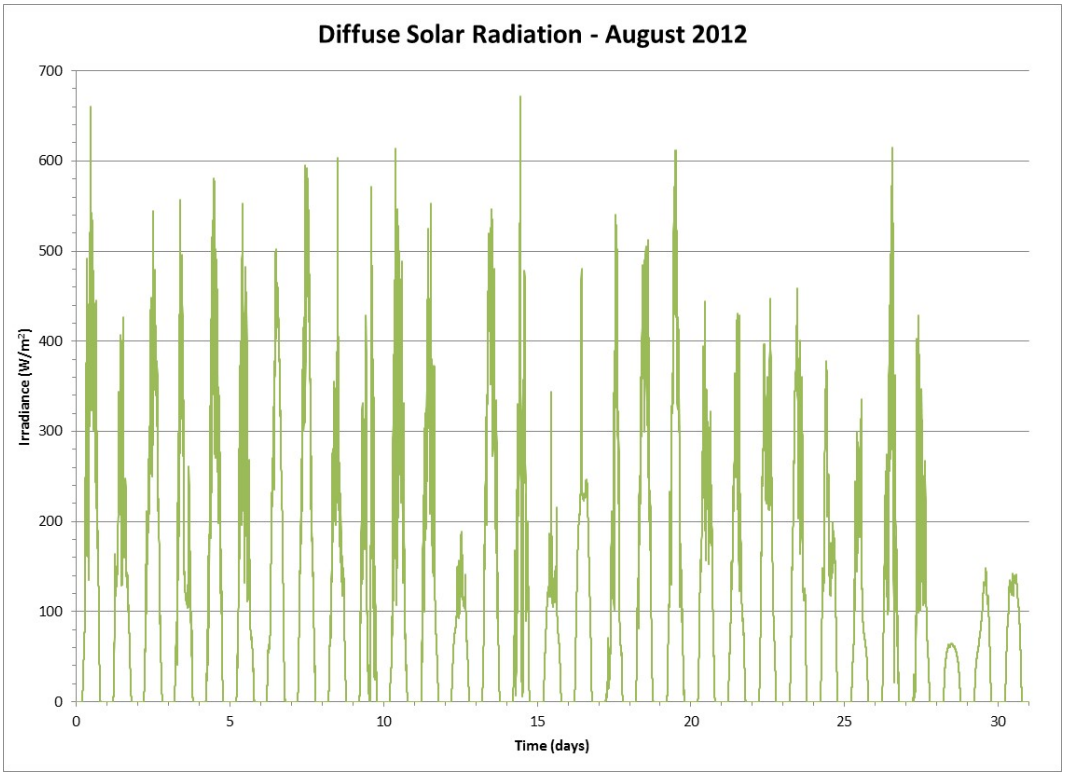


Figure 114 Diffuse Solar Radiation for the Month of August 2012

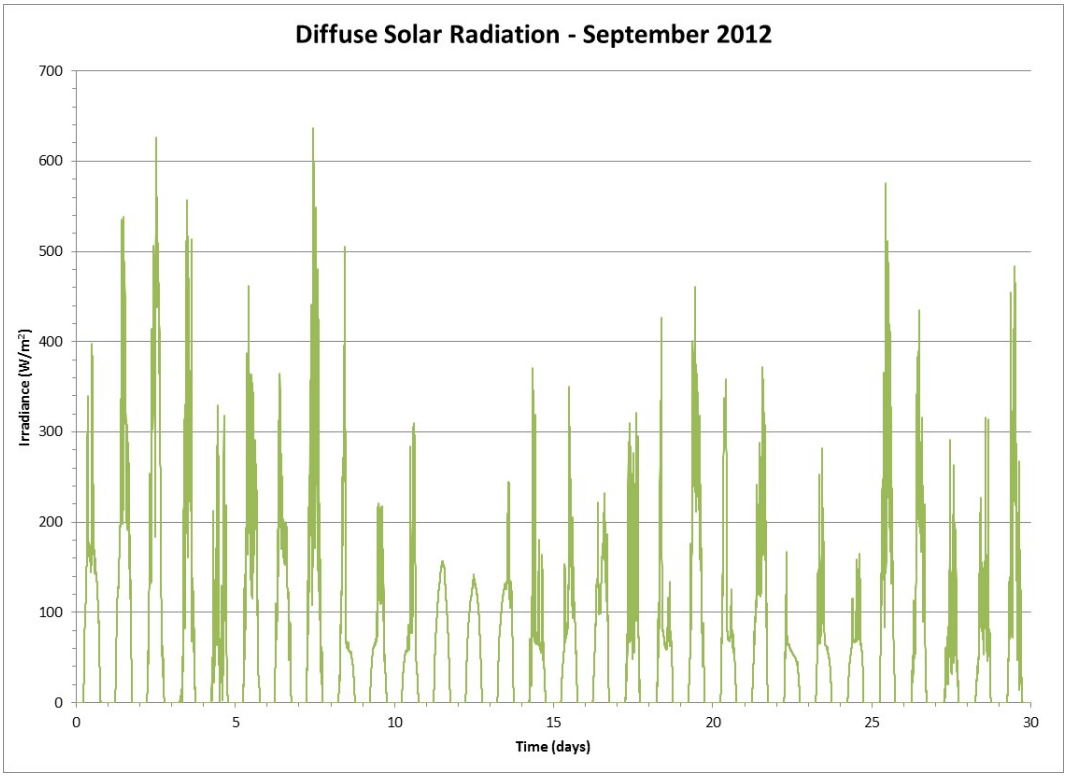

Figure 115 Diffuse Solar Radiation for the Month of September 2012

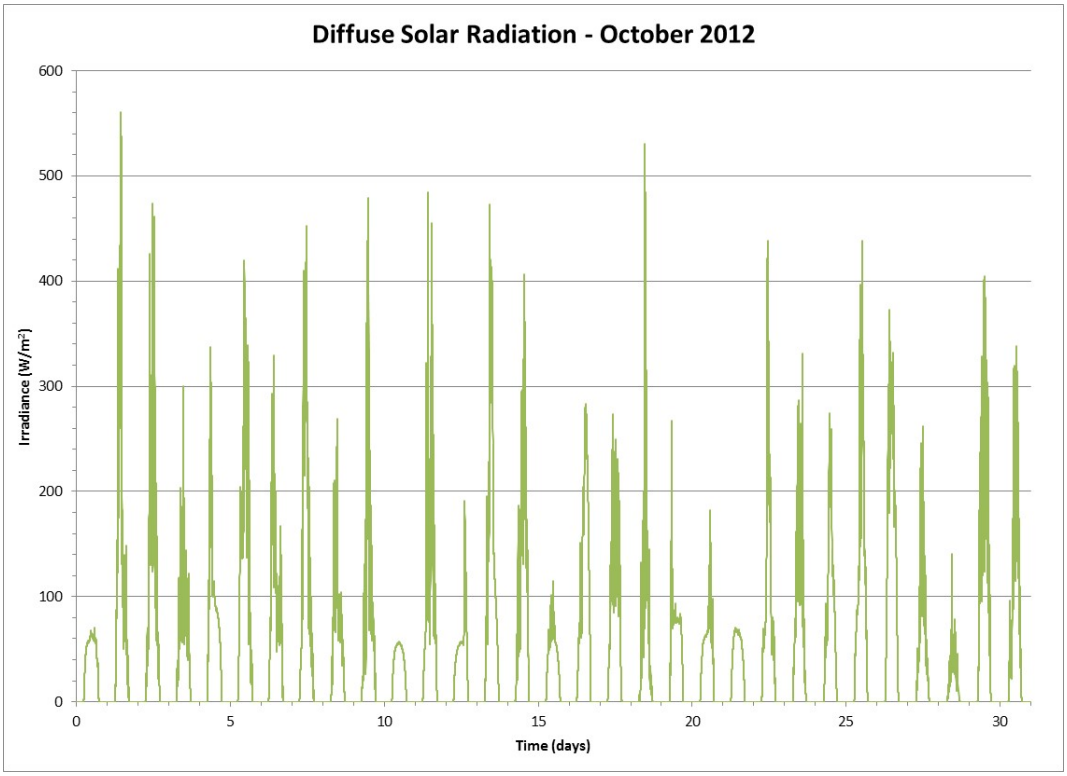

Figure 116 Diffuse Solar Radiation for the Month of October 2012

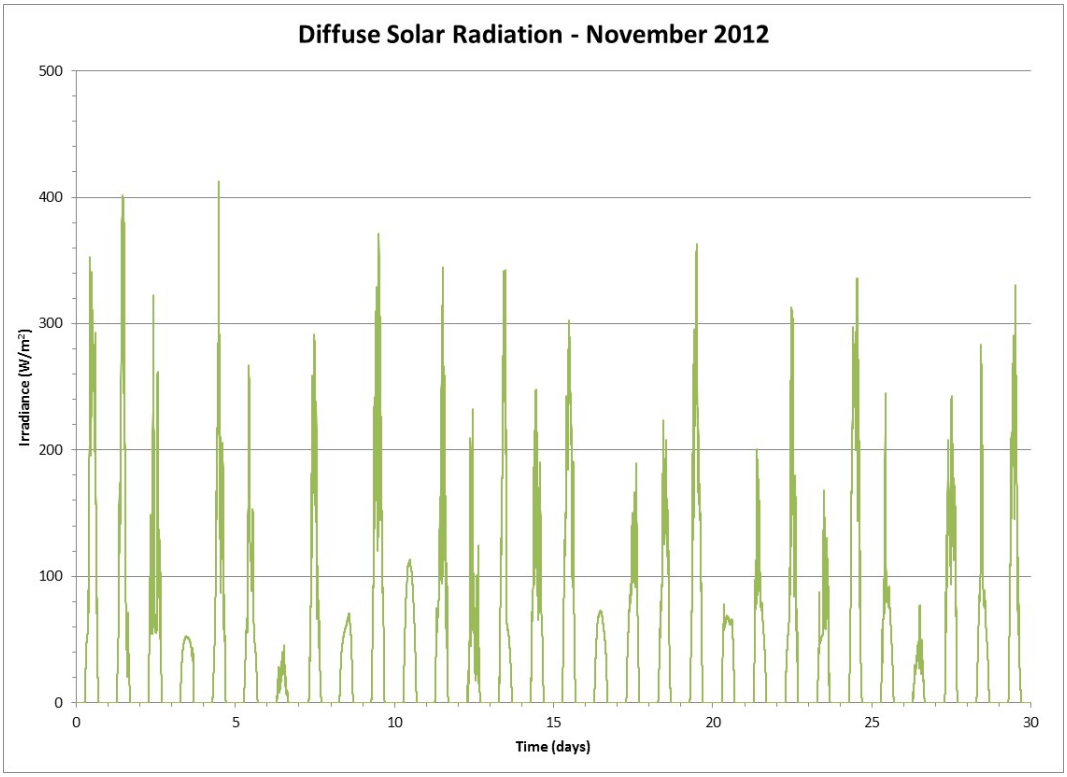

Figure 117 Diffuse Solar Radiation for the Month of November 2012

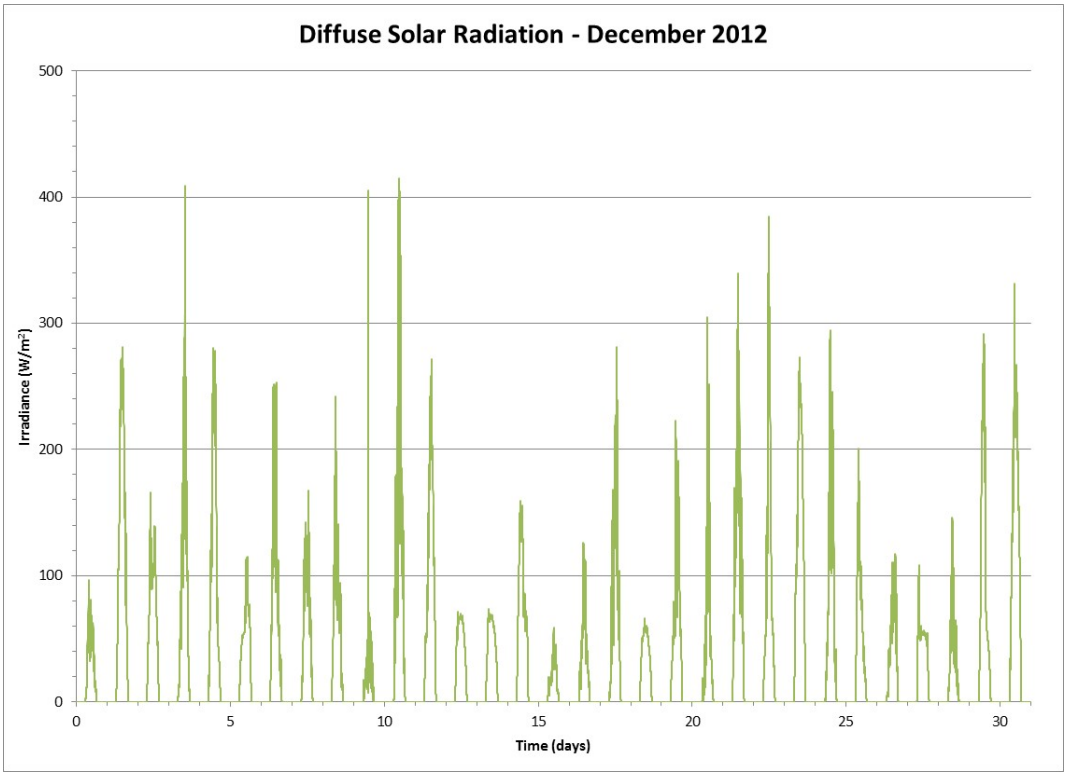

Figure 118 Diffuse Solar Radiation for the Month of December 2012

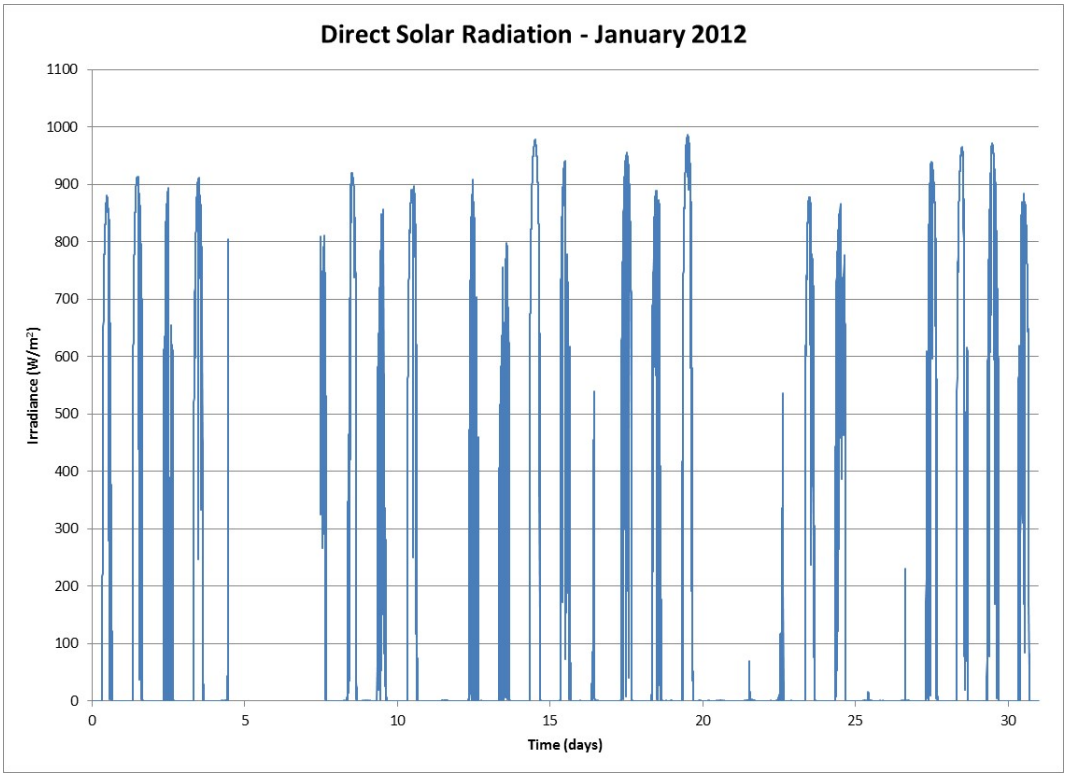

Figure 119 Direct Solar Radiation for the Month of January 2012

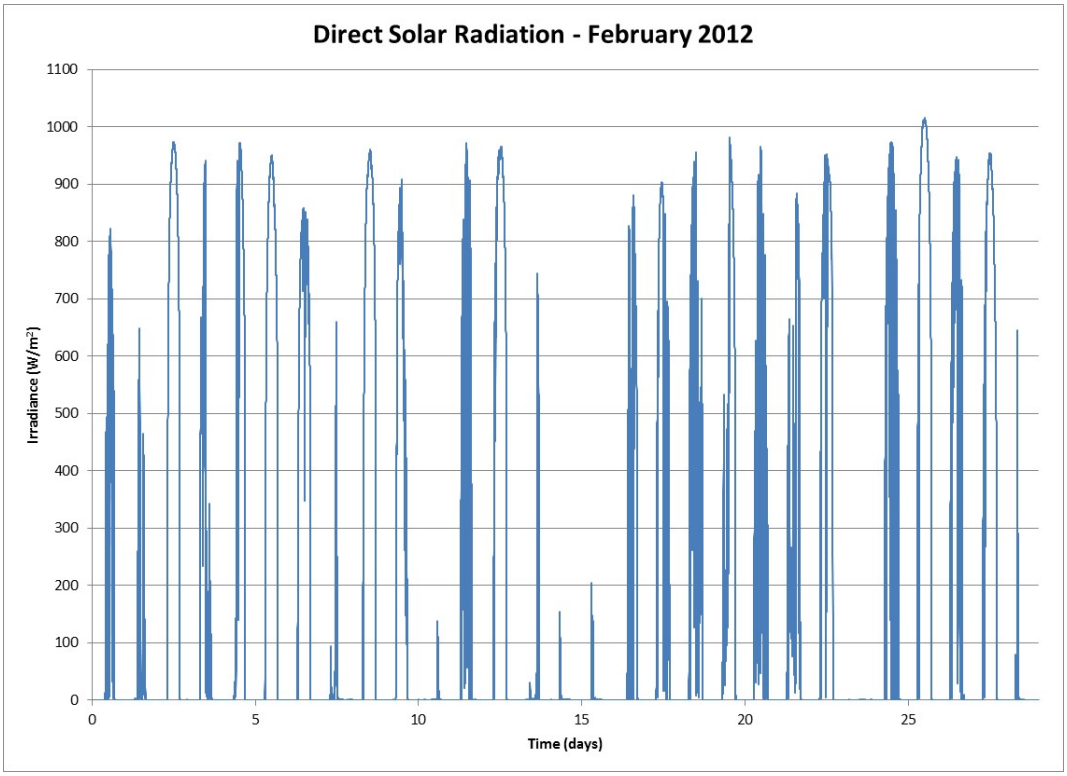

Figure 120 Direct Solar Radiation for the Month of February 2012

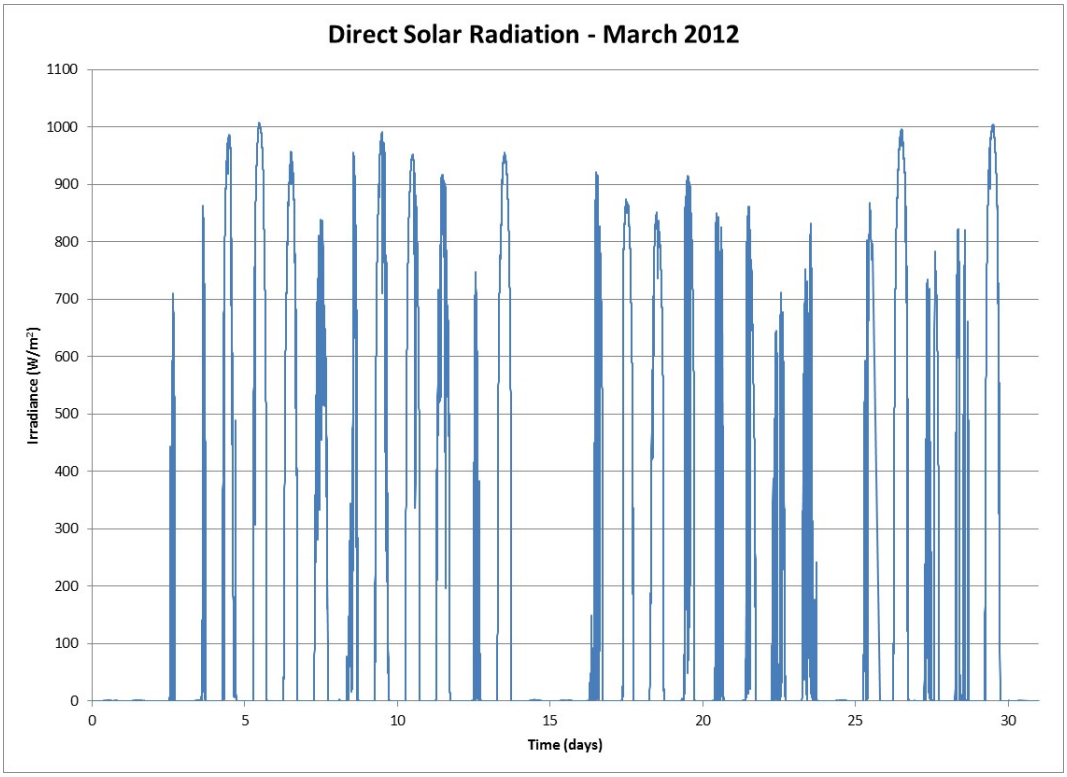

Figure 121 Direct Solar Radiation for the Month of March 2012

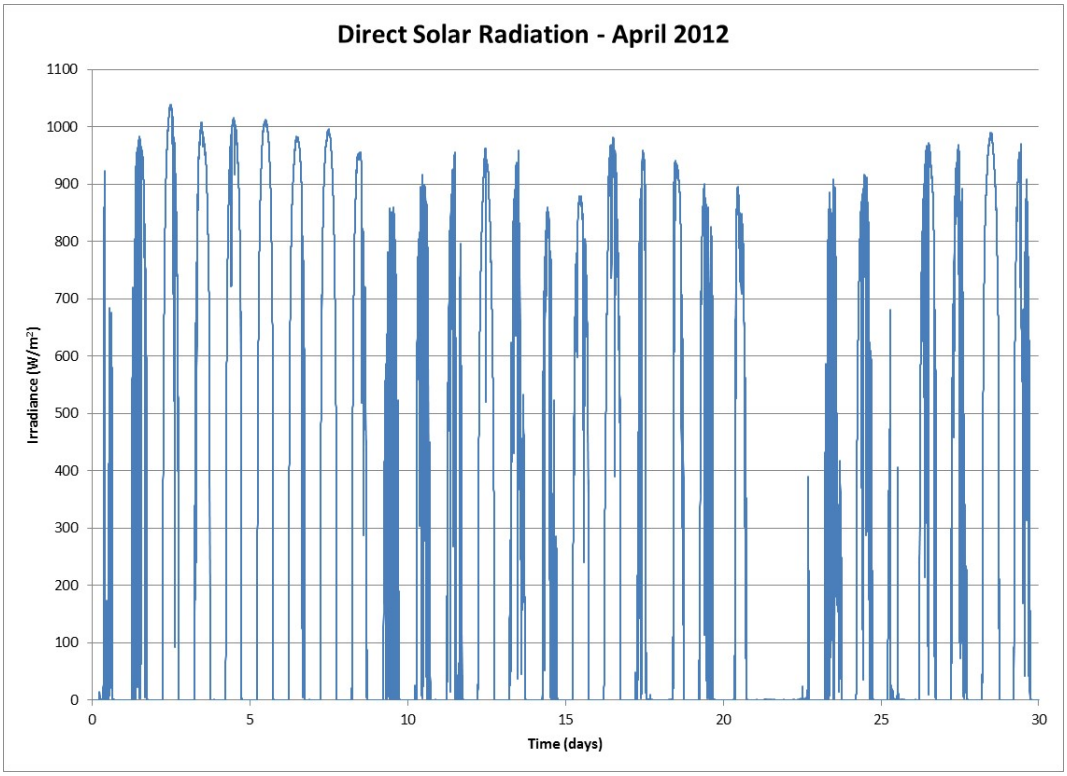

Figure 122  Direct Solar Radiation for the Month April 2012

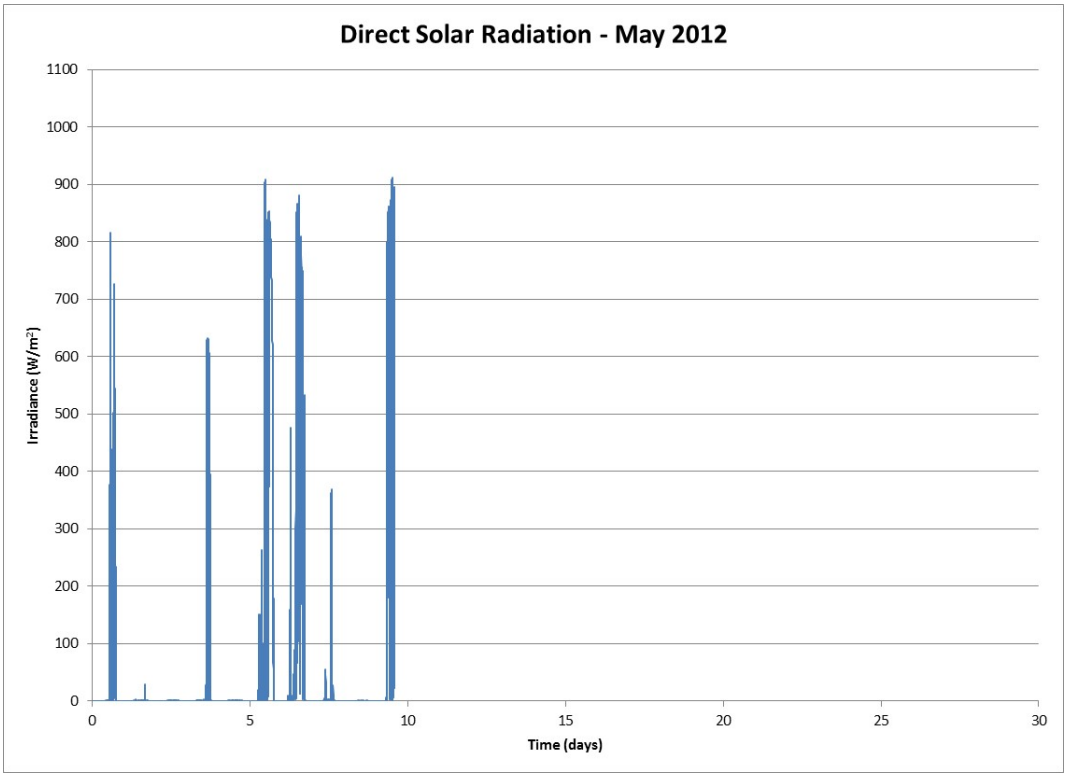


Figure 123 Direct Solar Radiation for the Month May 2012

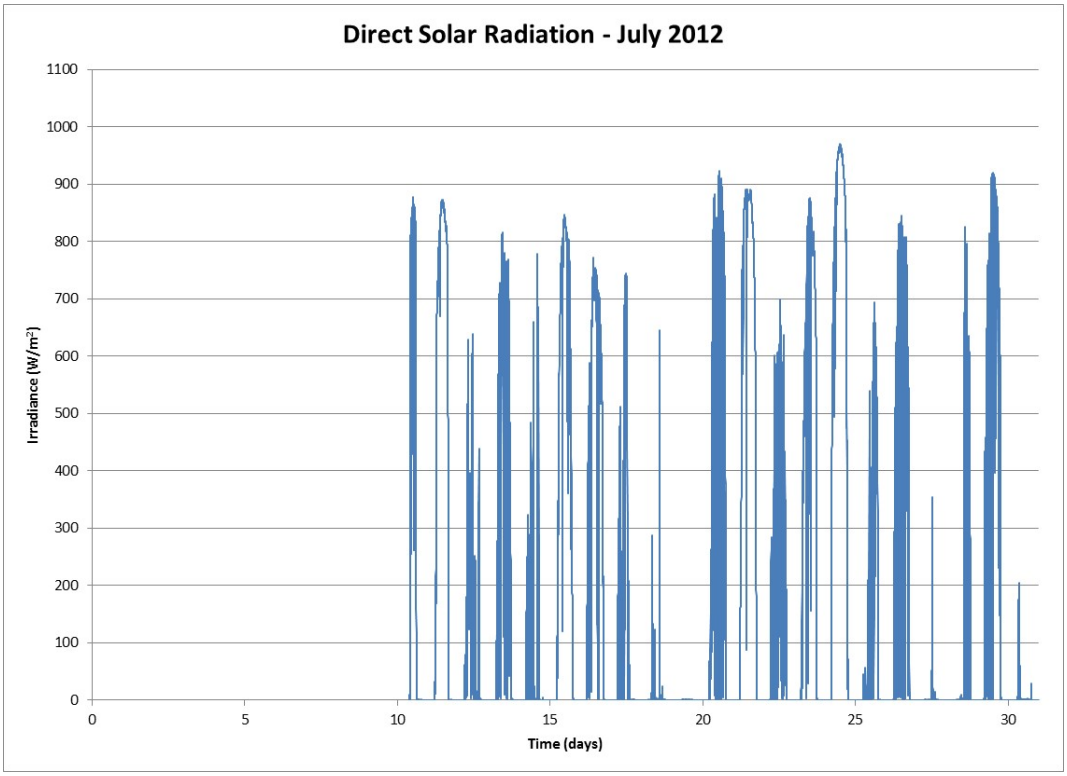


Figure 124 Direct Solar Radiation for the Month July 2012

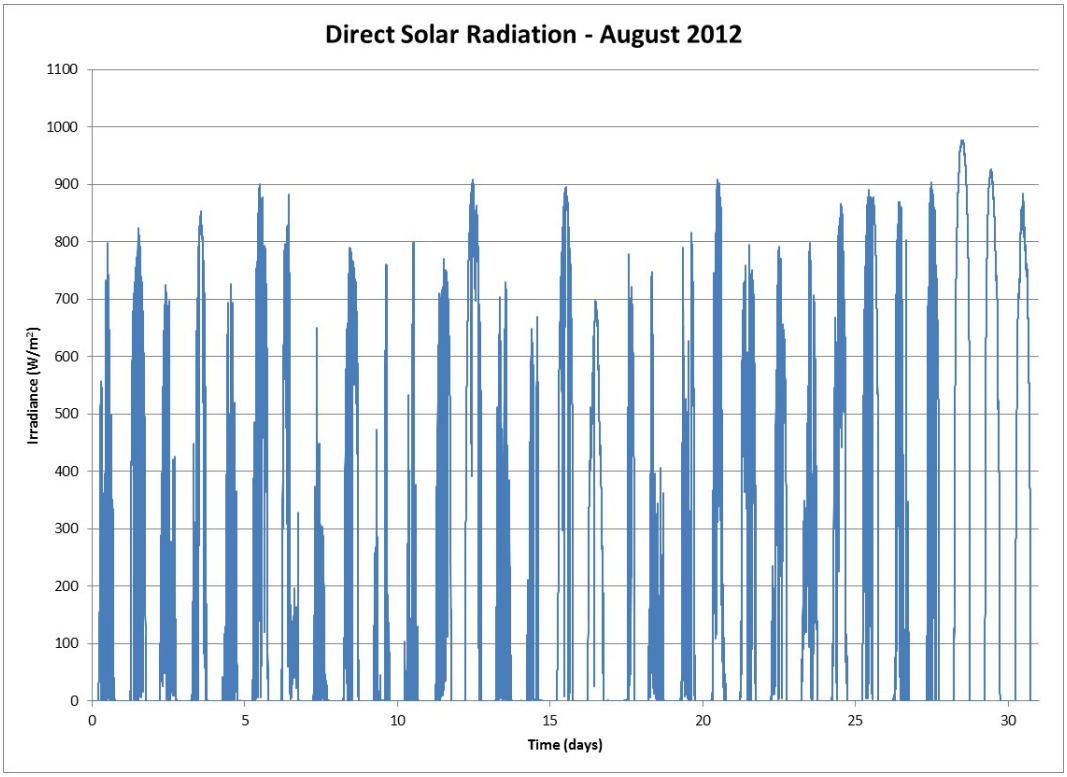


Figure 125 Direct Solar Radiation for the Month August 2012

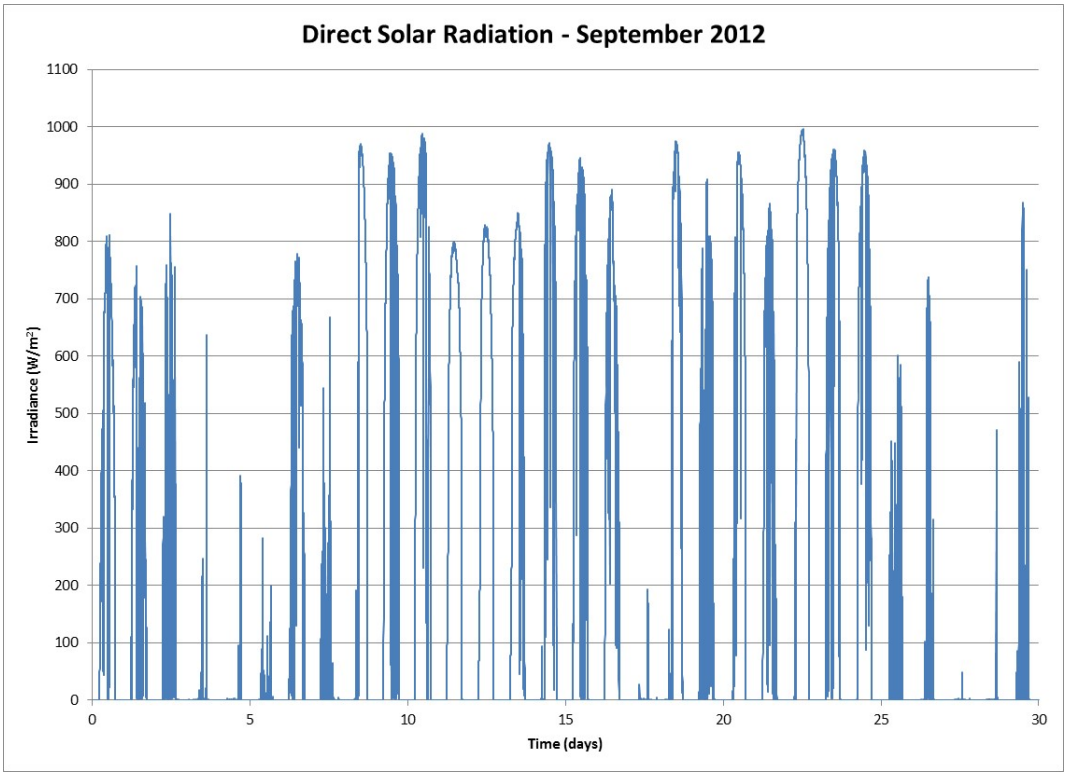


Figure 126 Direct Solar Radiation for the Month September 2012

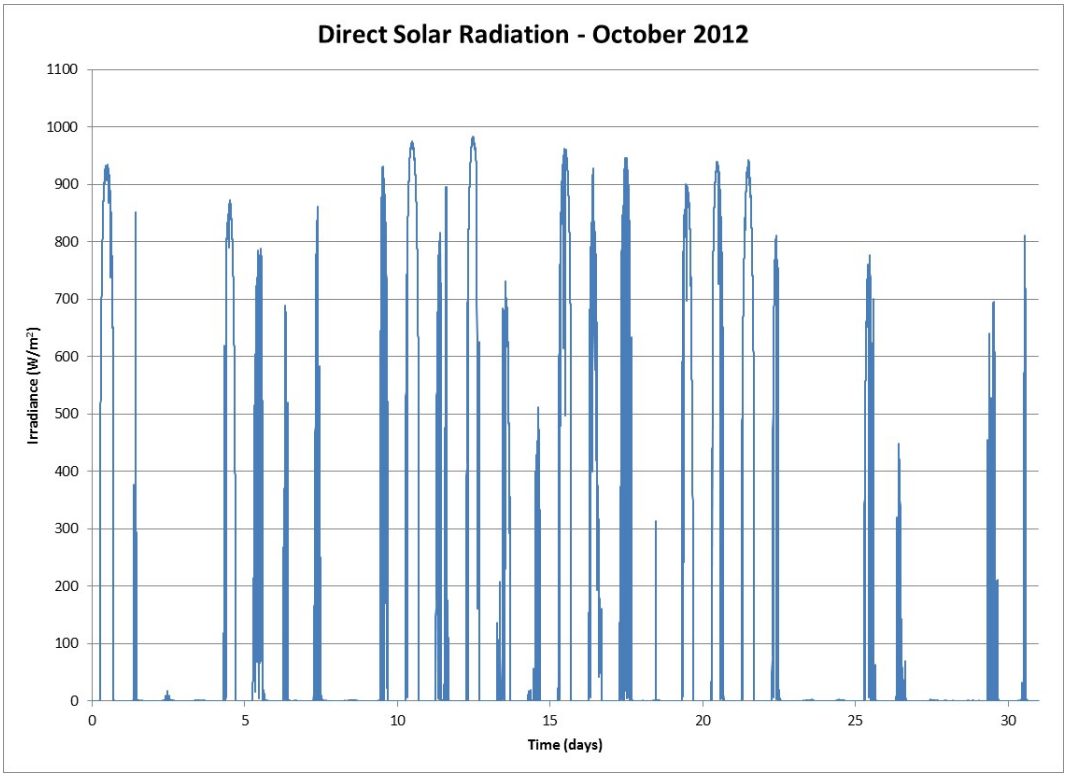

Figure 127 Direct Solar Radiation for the Month October 2012

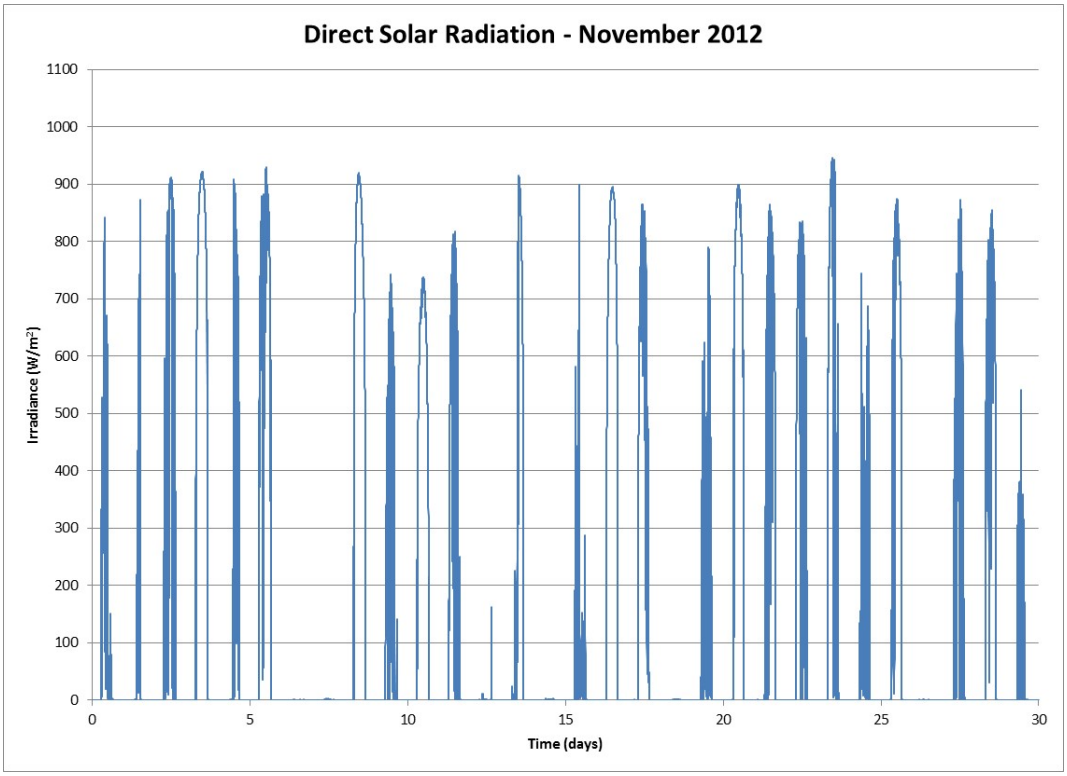

Figure 128 Direct Solar Radiation for the Month November 2012

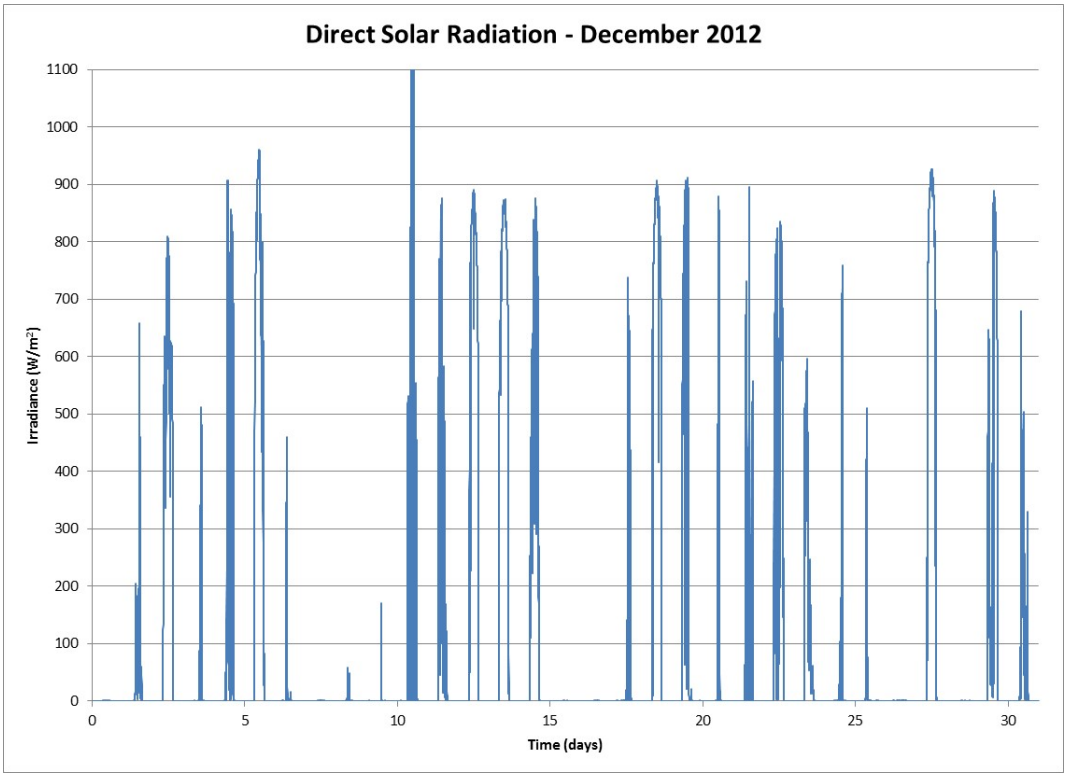

Figure 129 Direct Solar Radiation for the Month December 2012

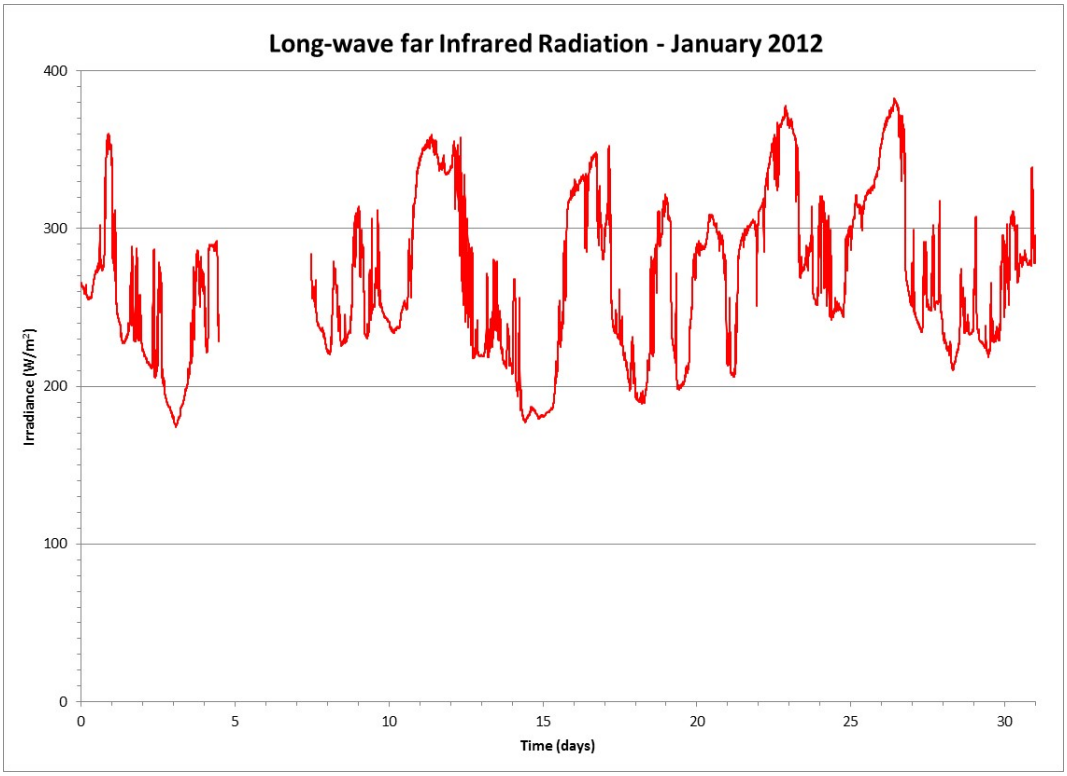

Figure 130 Long-wave Far Infrared Radiation for the Month of January 2012

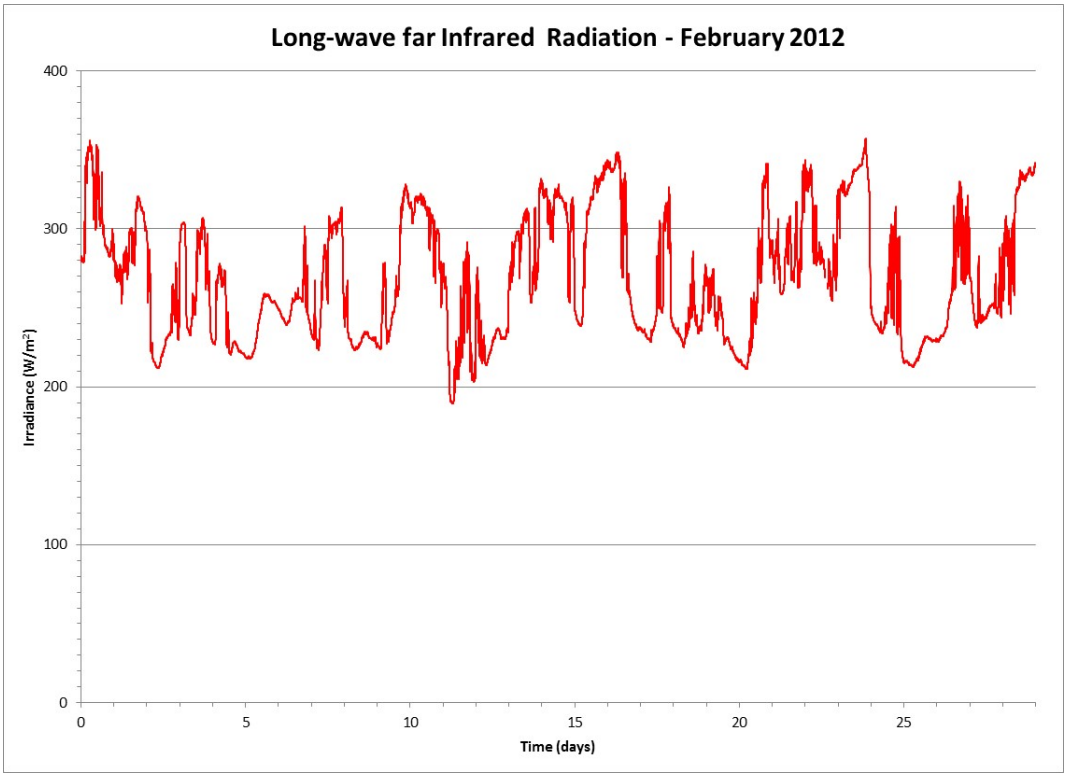

Figure 131 Long-wave Far Infrared Radiation for the Month of February 2012

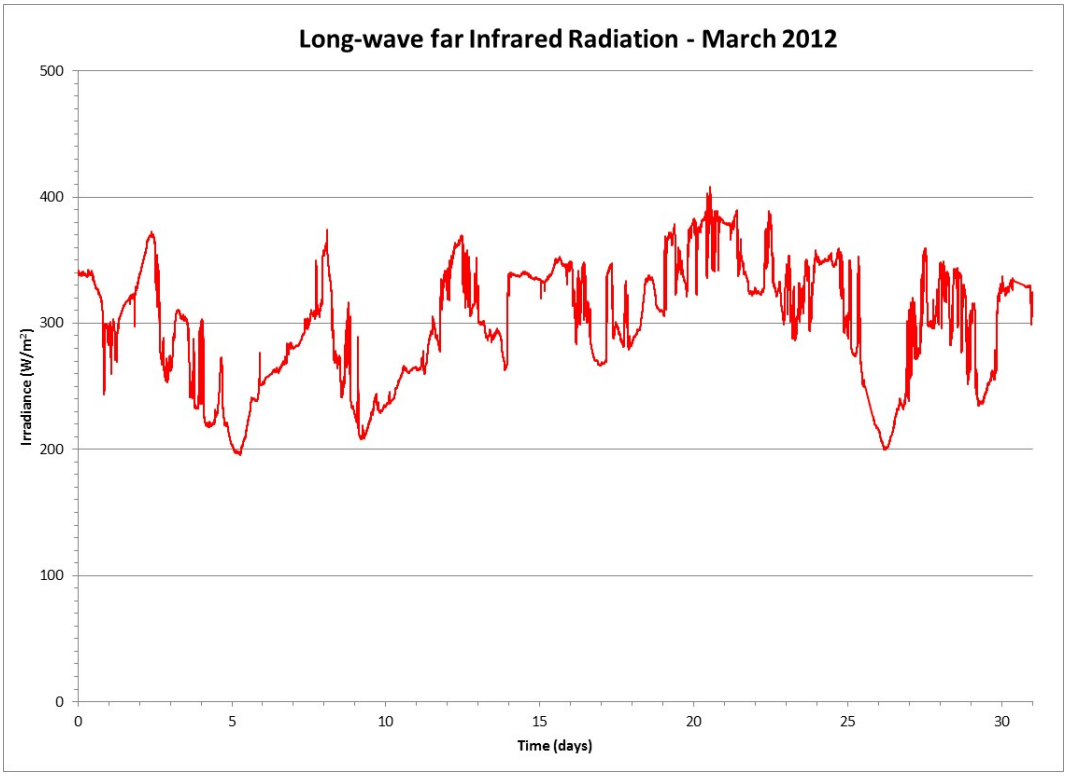

Figure 132 Long-wave Far Infrared Radiation for the Month of March 2012

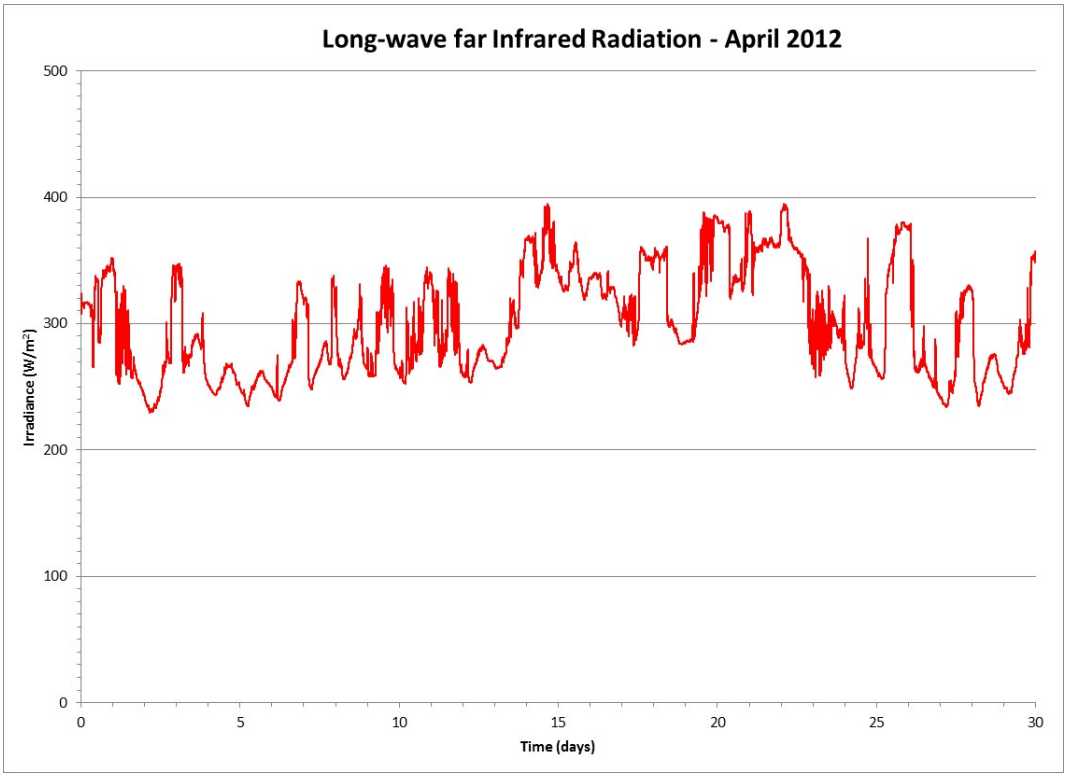

Figure 133 Long-wave Far Infrared Radiation for the Month of April 2012

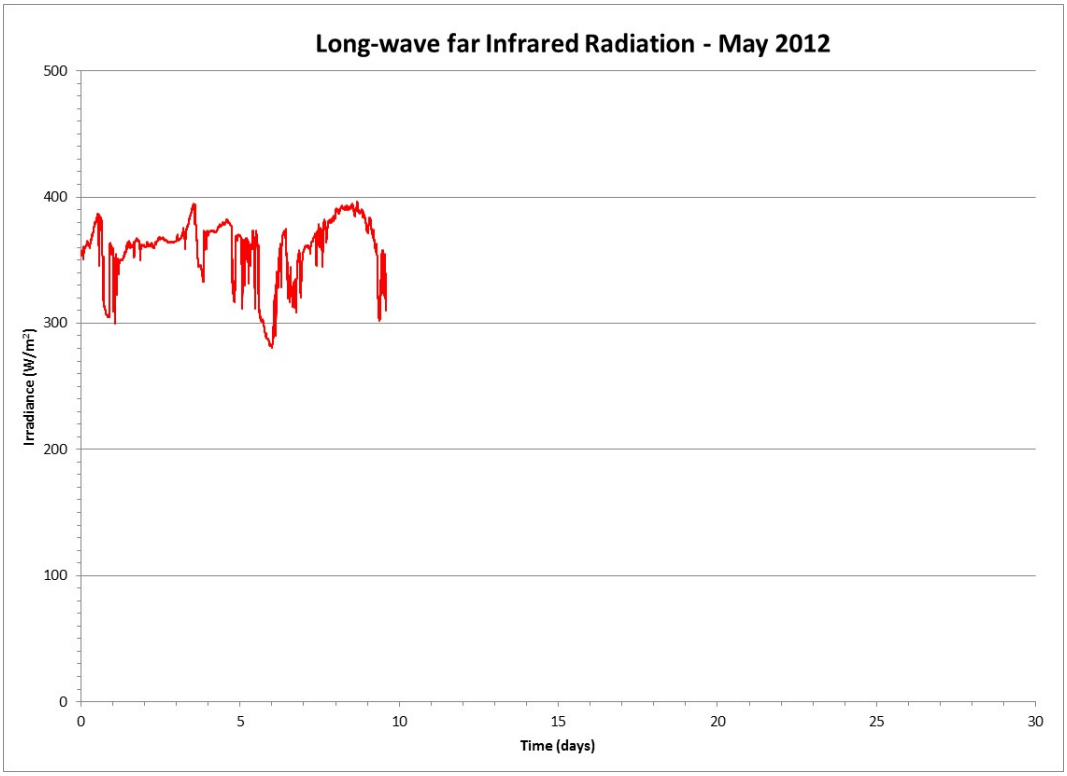

Figure 134 Long-wave Far Infrared Radiation for the Month of May 2012

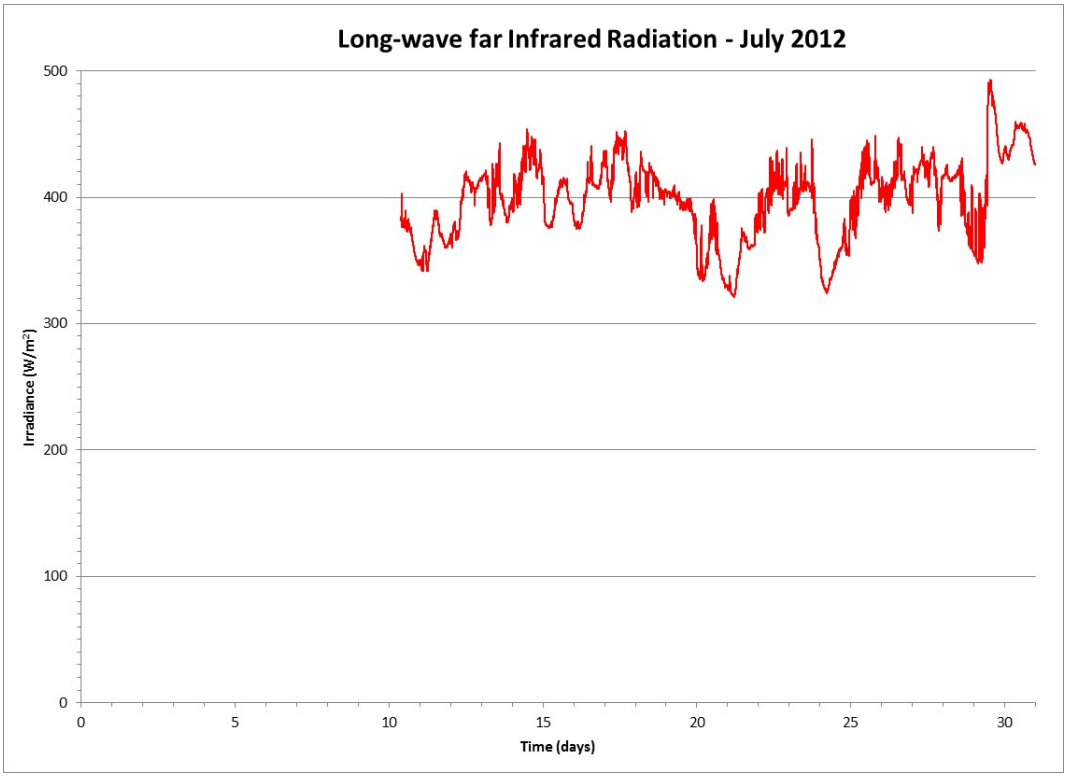

Figure 135 Long-wave Far Infrared Radiation for the Month of July 2012

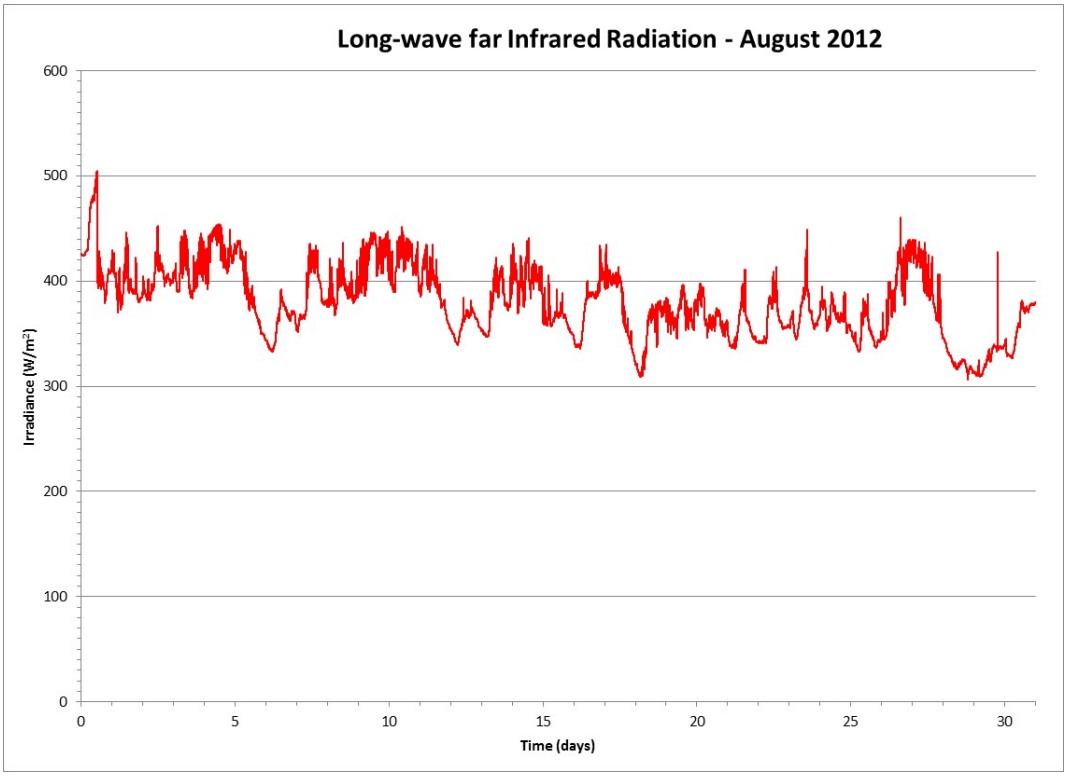

Figure 136 Long-wave Far Infrared Radiation for the Month of August 2012

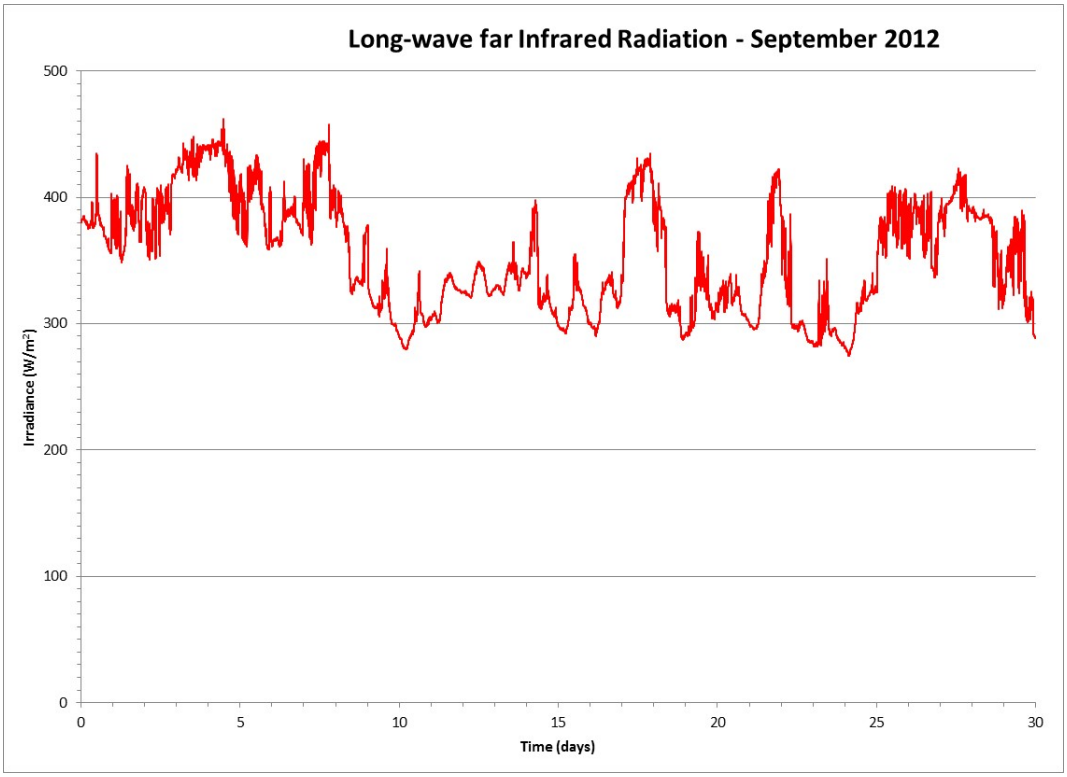

Figure 137 Long-wave Far Infrared Radiation for the Month of September 2012

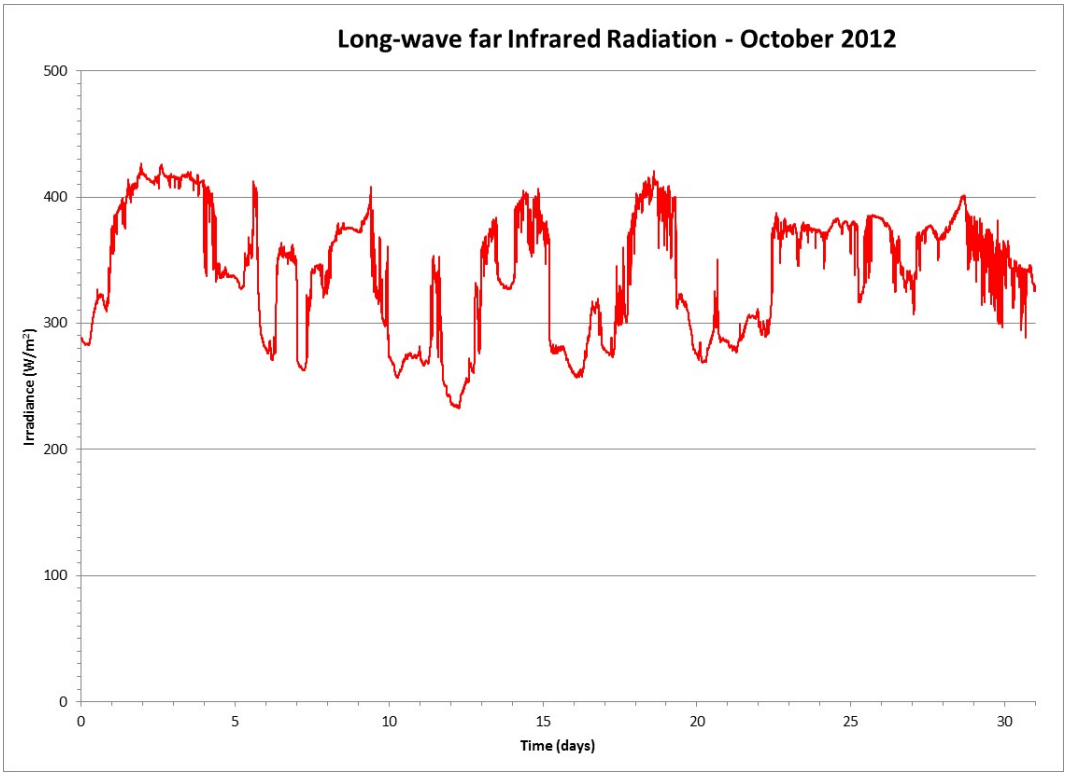

Figure 138 Long-wave Far Infrared Radiation for the Month of October 2012

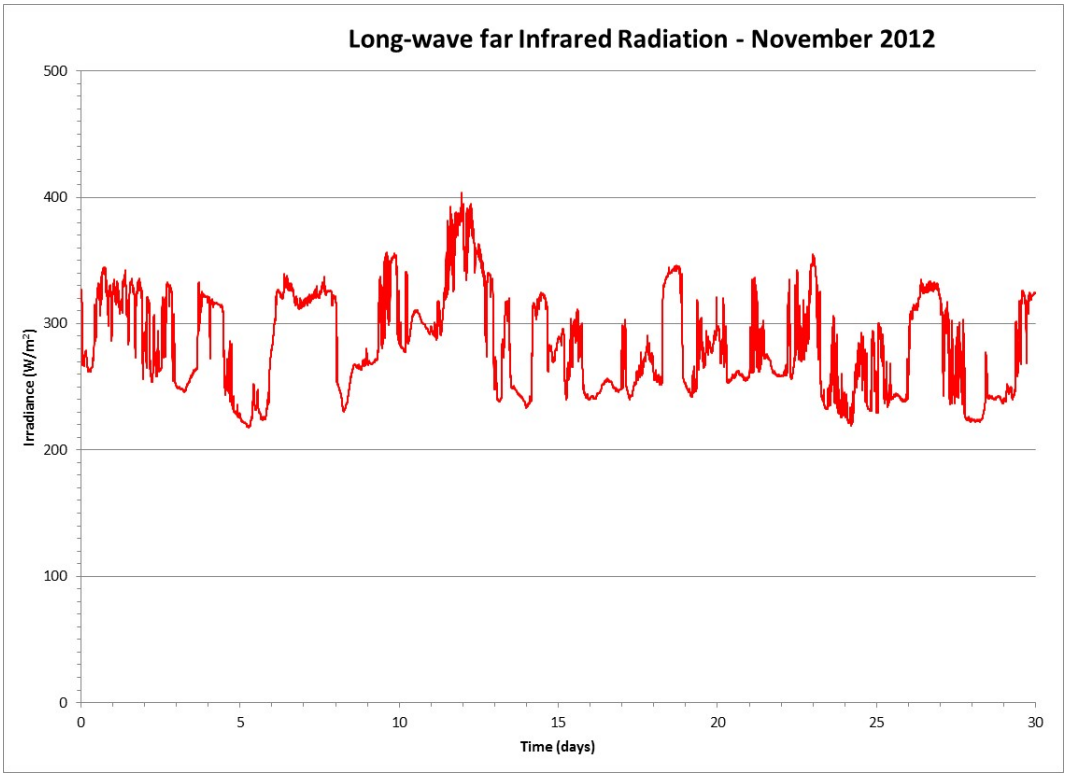

Figure 139 Long-wave Far Infrared Radiation for the Month of November 2012

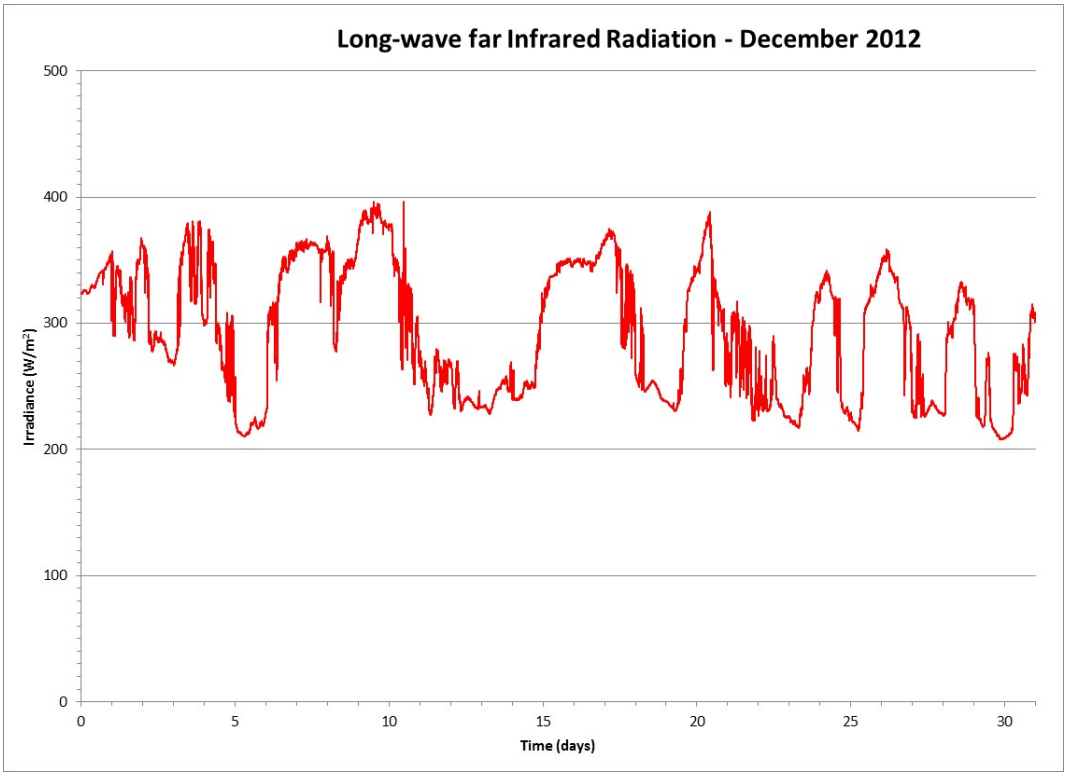

Figure 140 Long-wave Far Infrared Radiation for the Month of December 2012

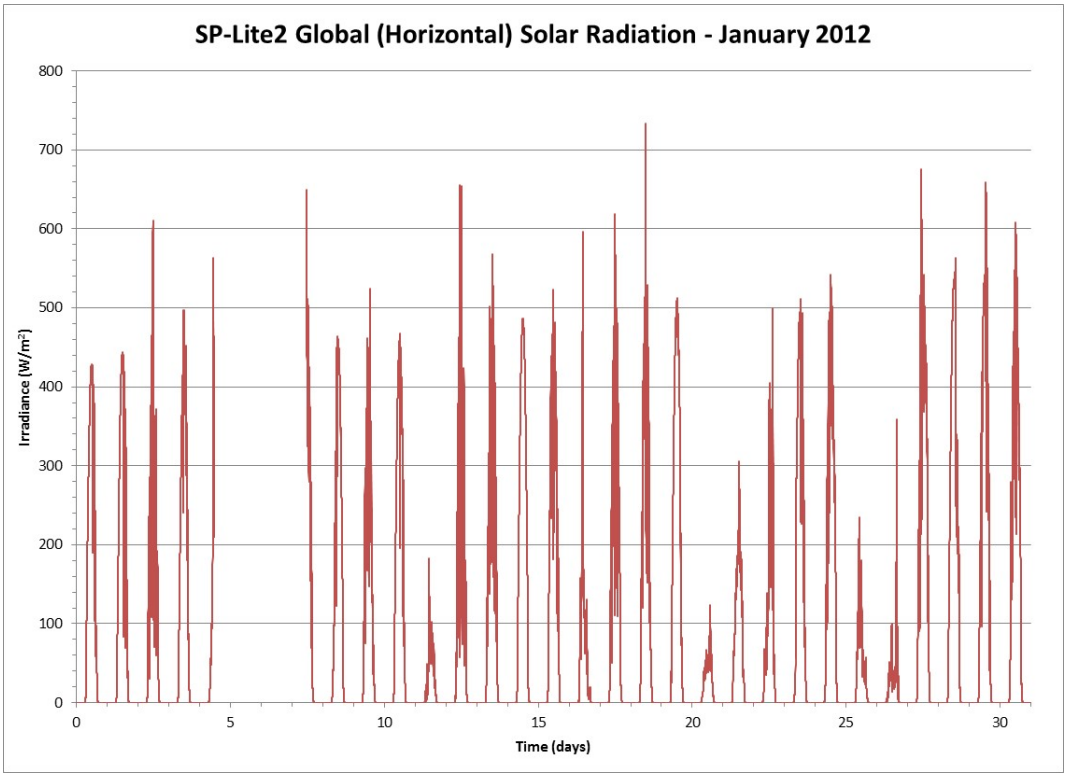

Figure 141 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of January 2012

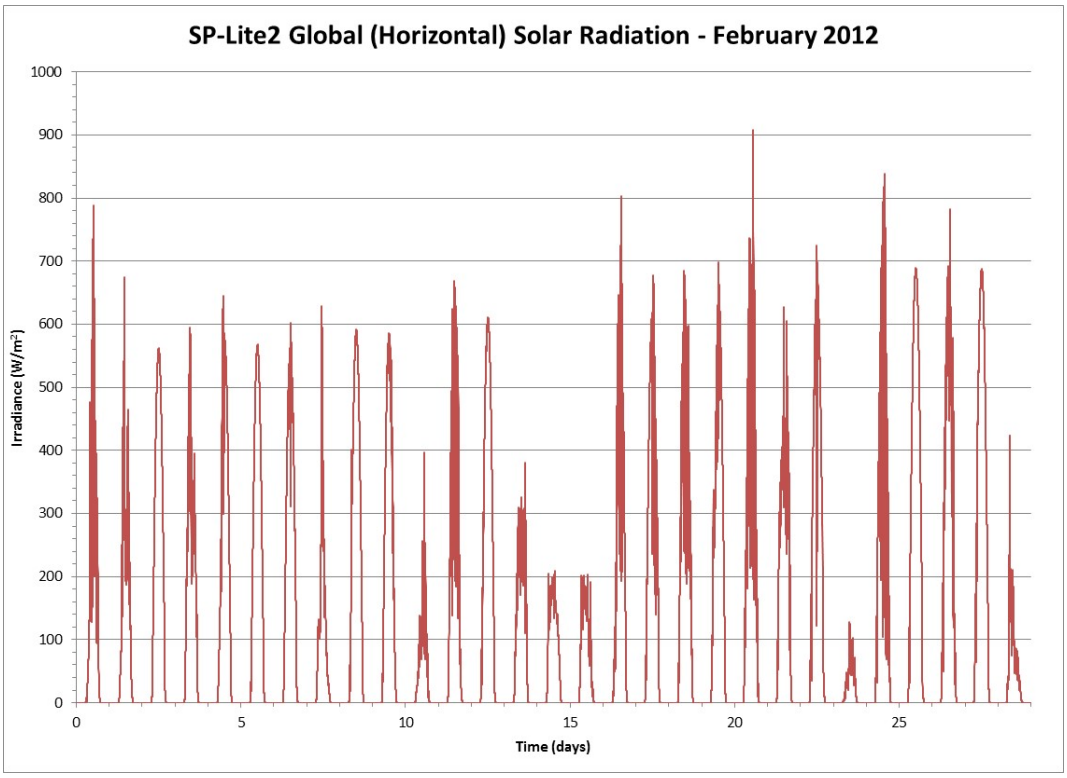

Figure 142 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of February 2012

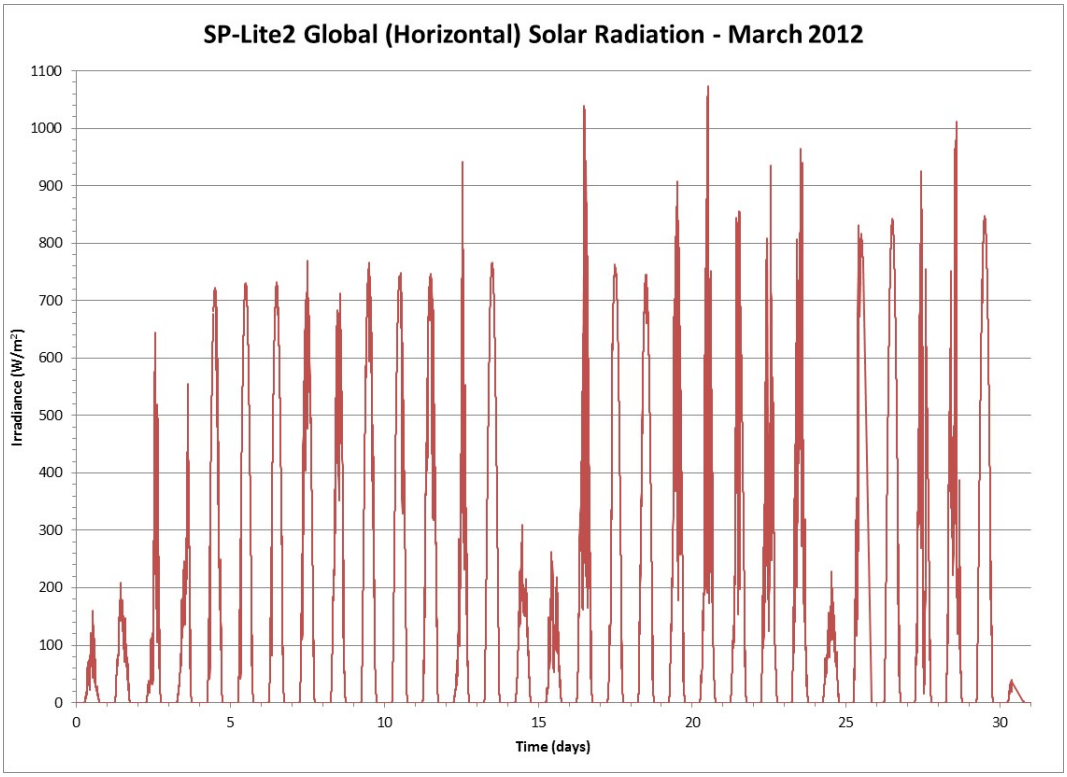

Figure 143 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of March 2012

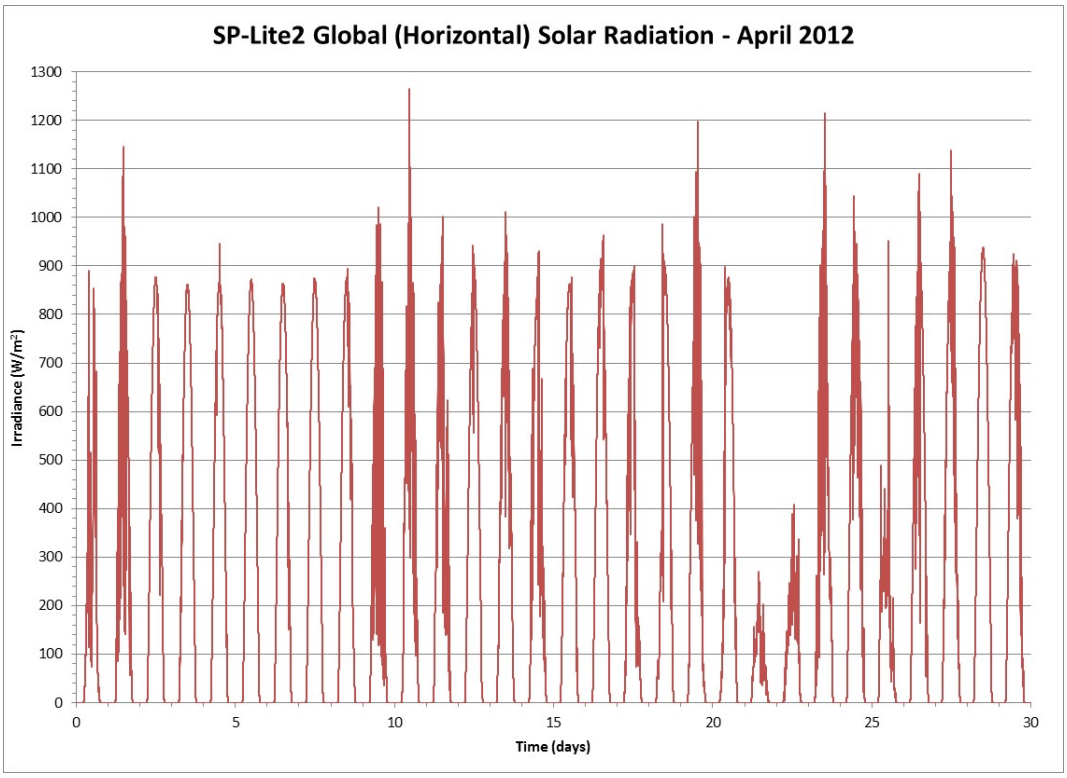

Figure 144 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of April 2012

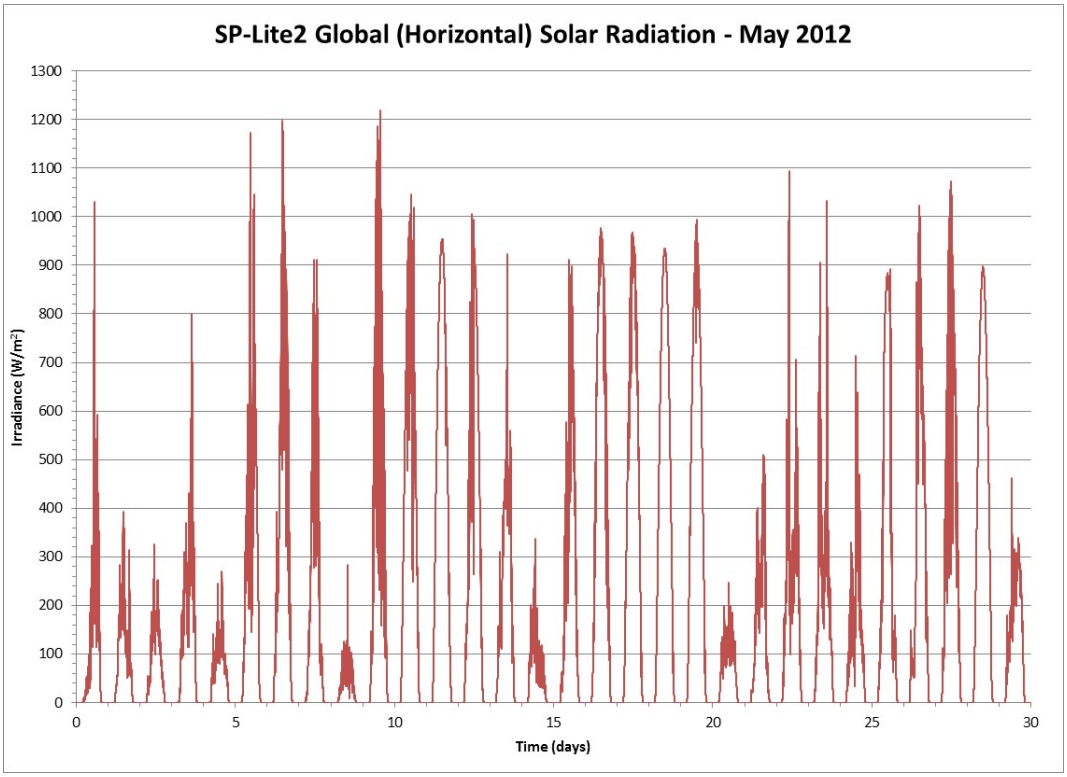

Figure 145 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of May 2012

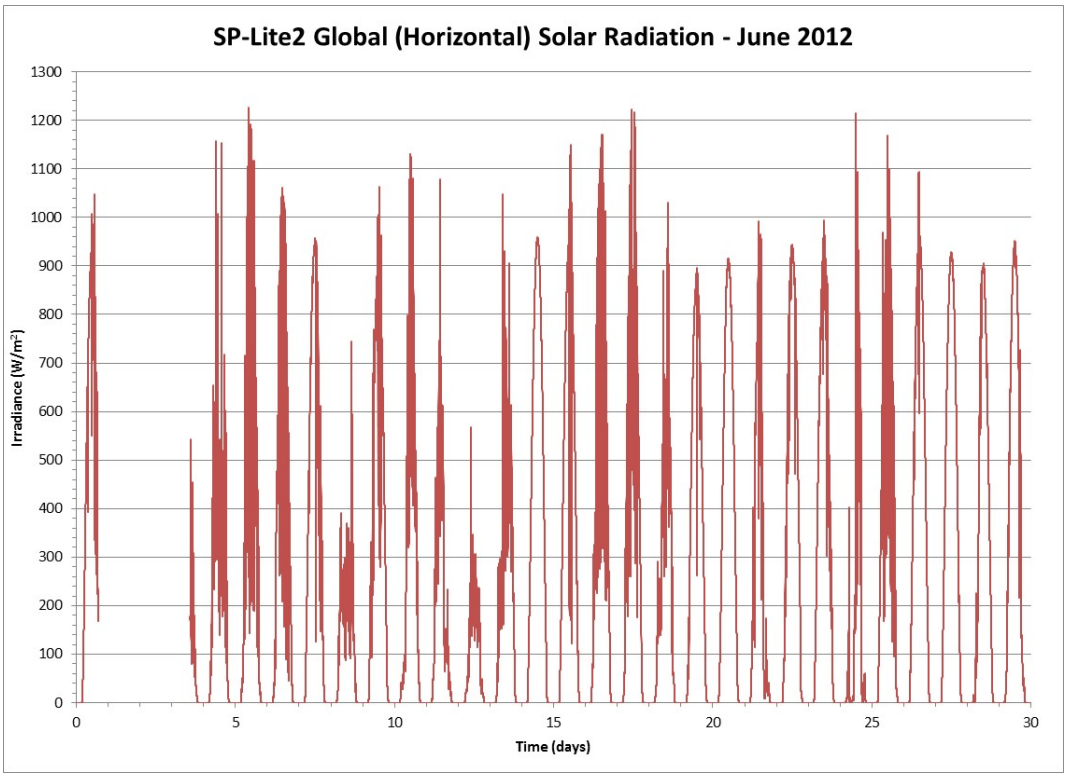

Figure 146 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of June 2012

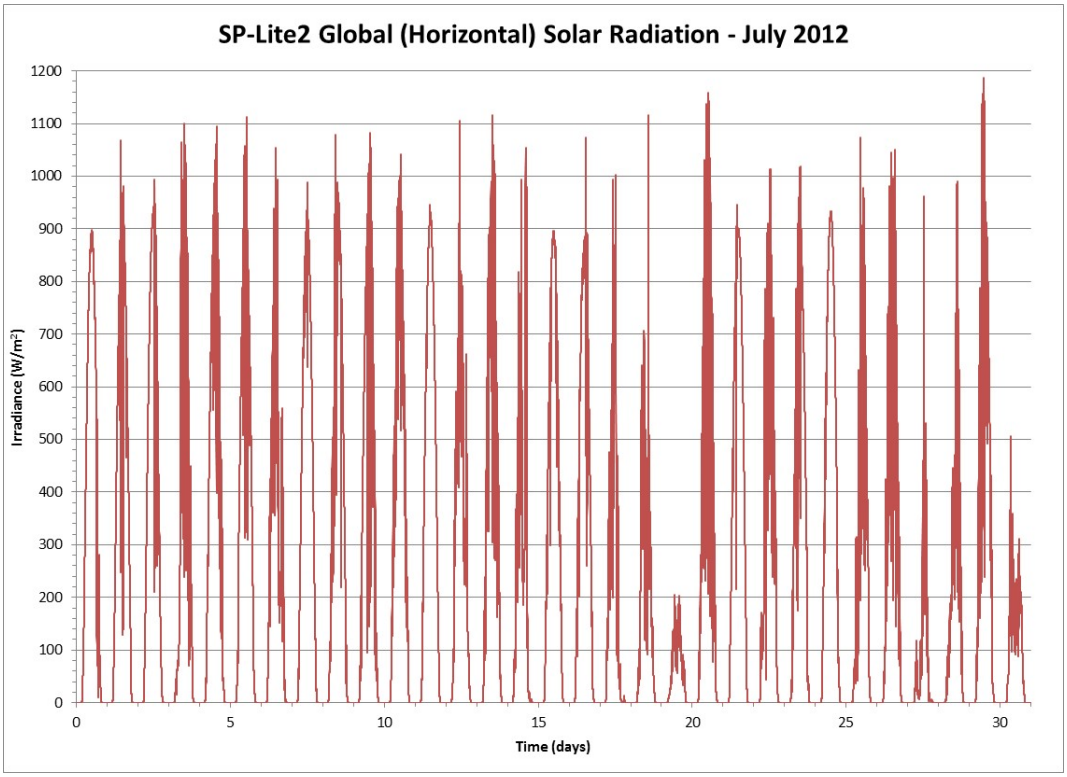

Figure 147 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of July 2012

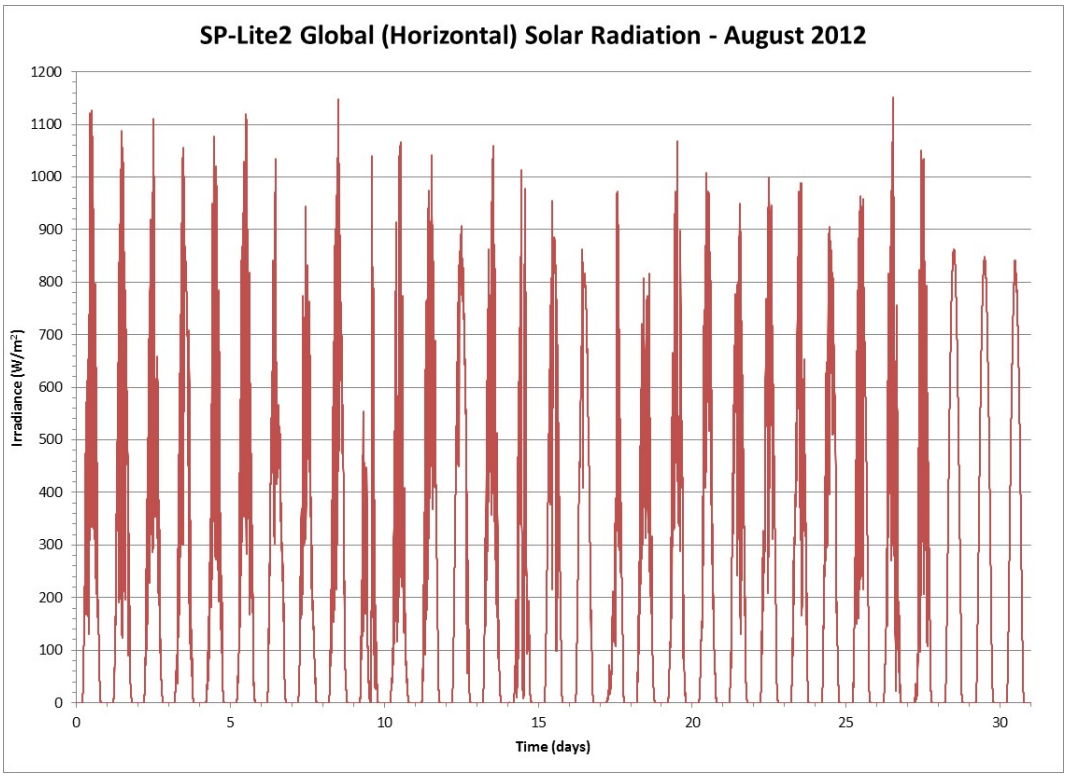

Figure 148 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of August 2012

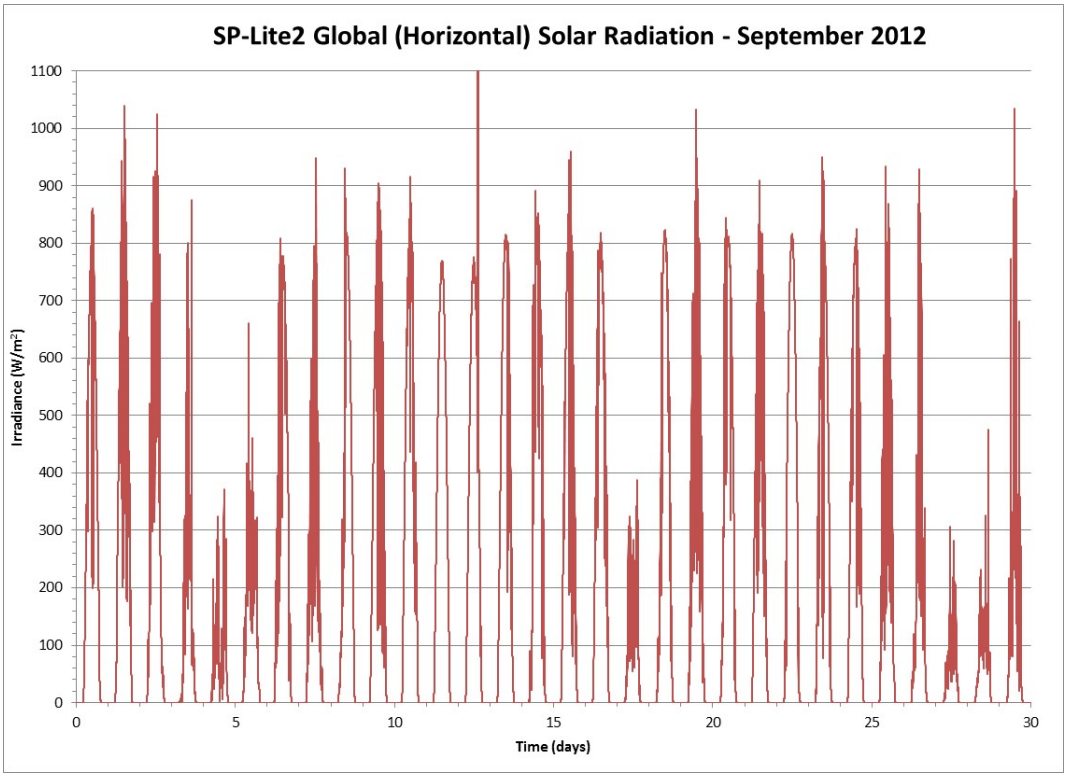

Figure 149 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of September 2012

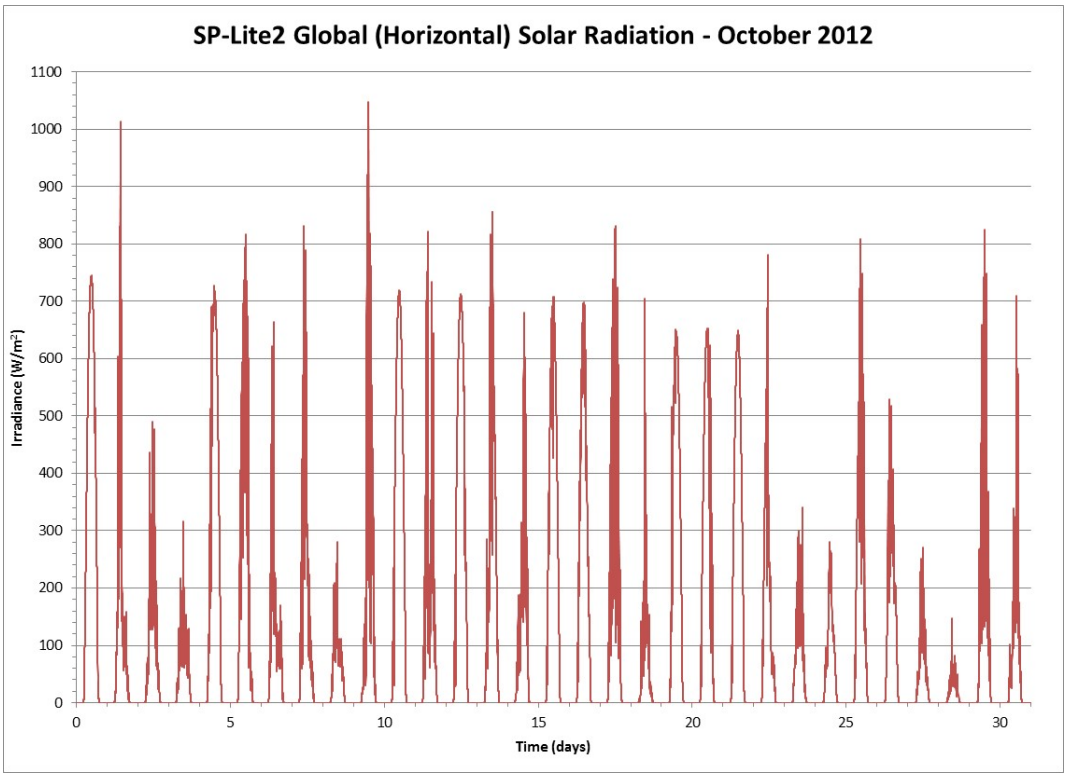

Figure 150 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of October 2012

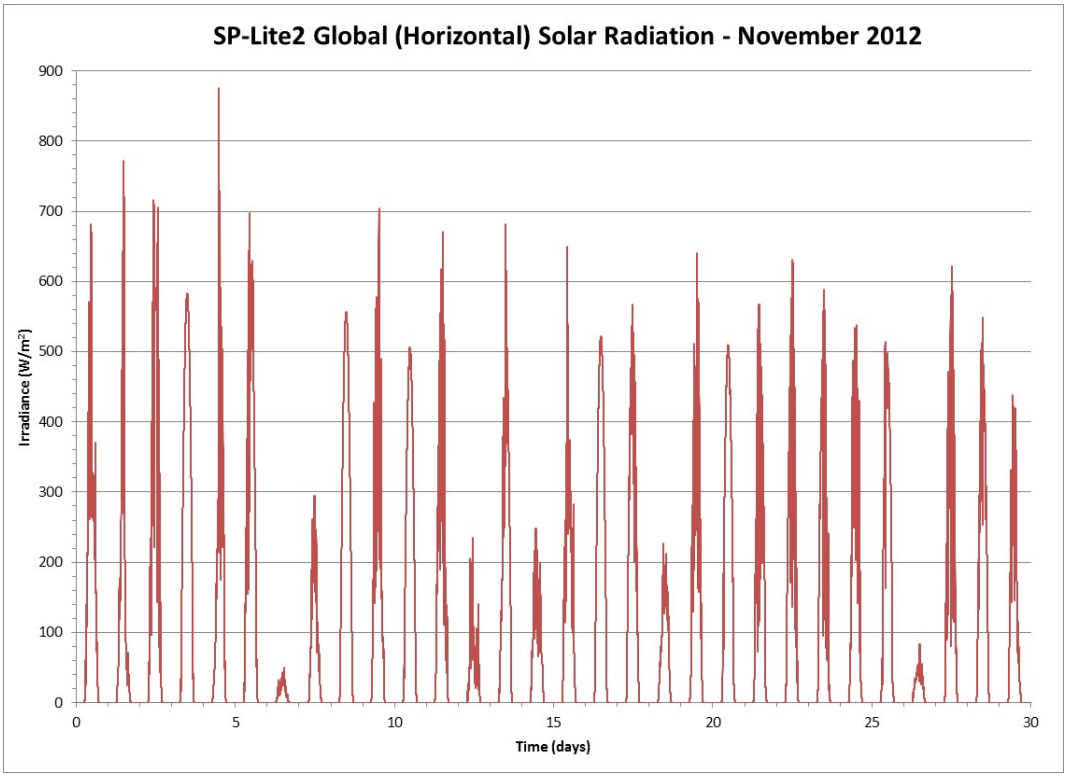

Figure 151 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of November 2012

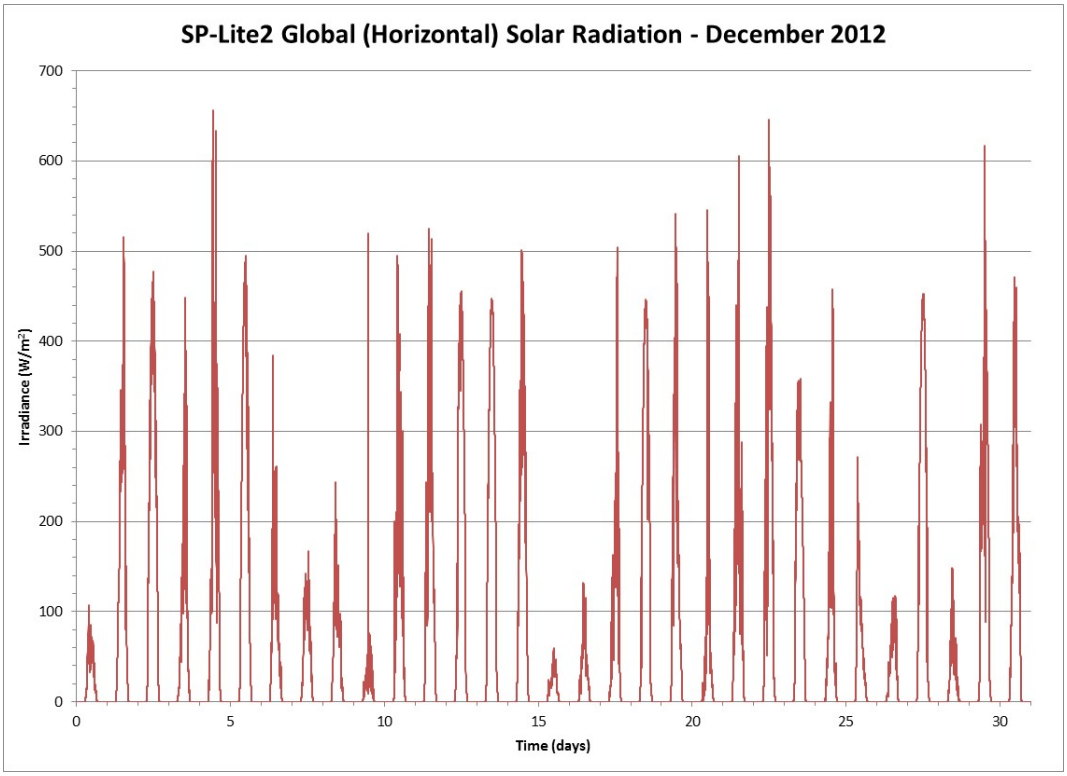

Figure 152 Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of December 2012

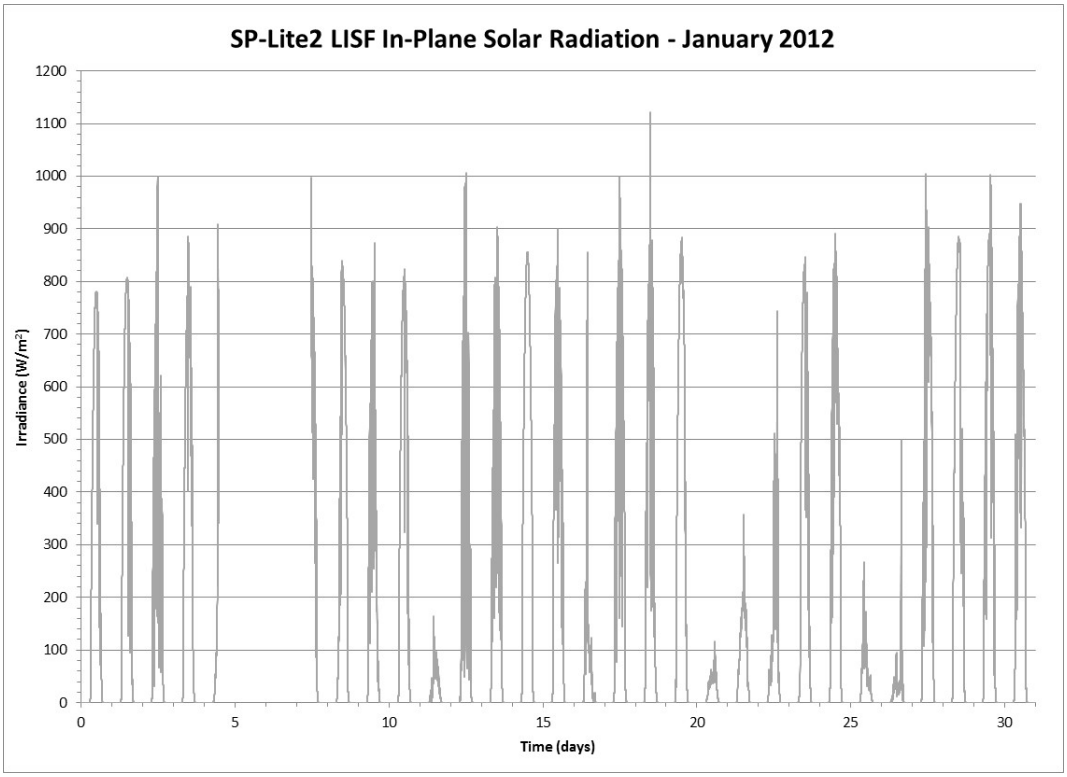

Figure 153 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of January 2012

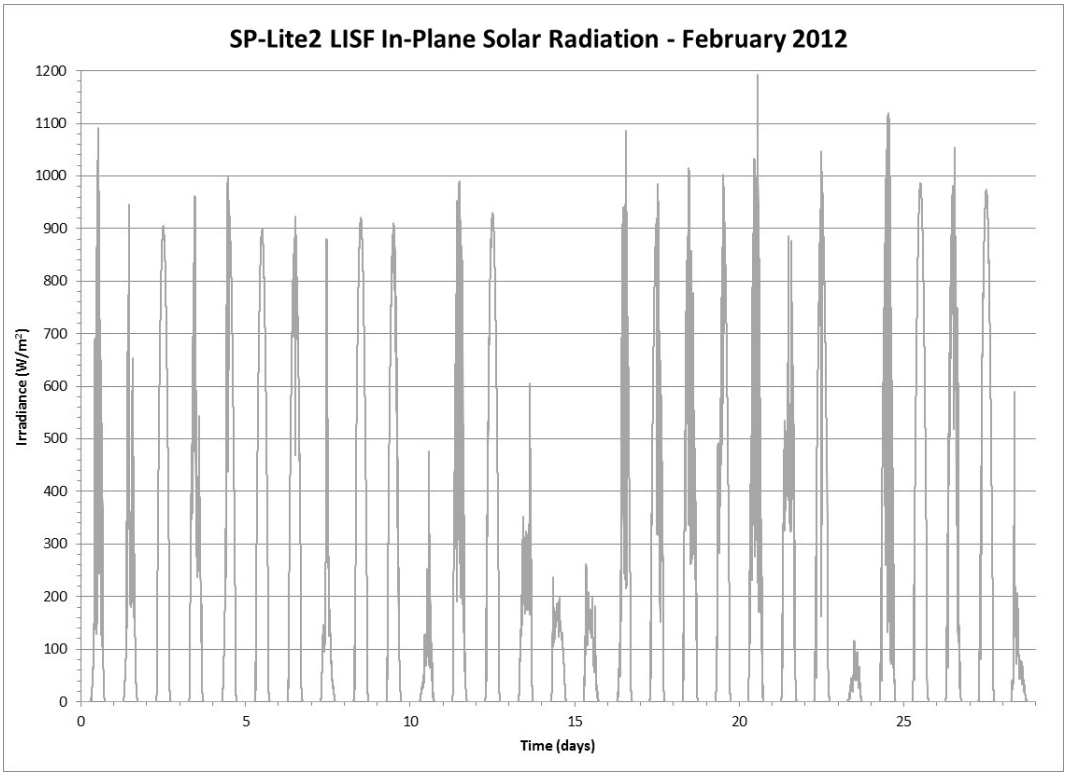

Figure 154 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of February 2012

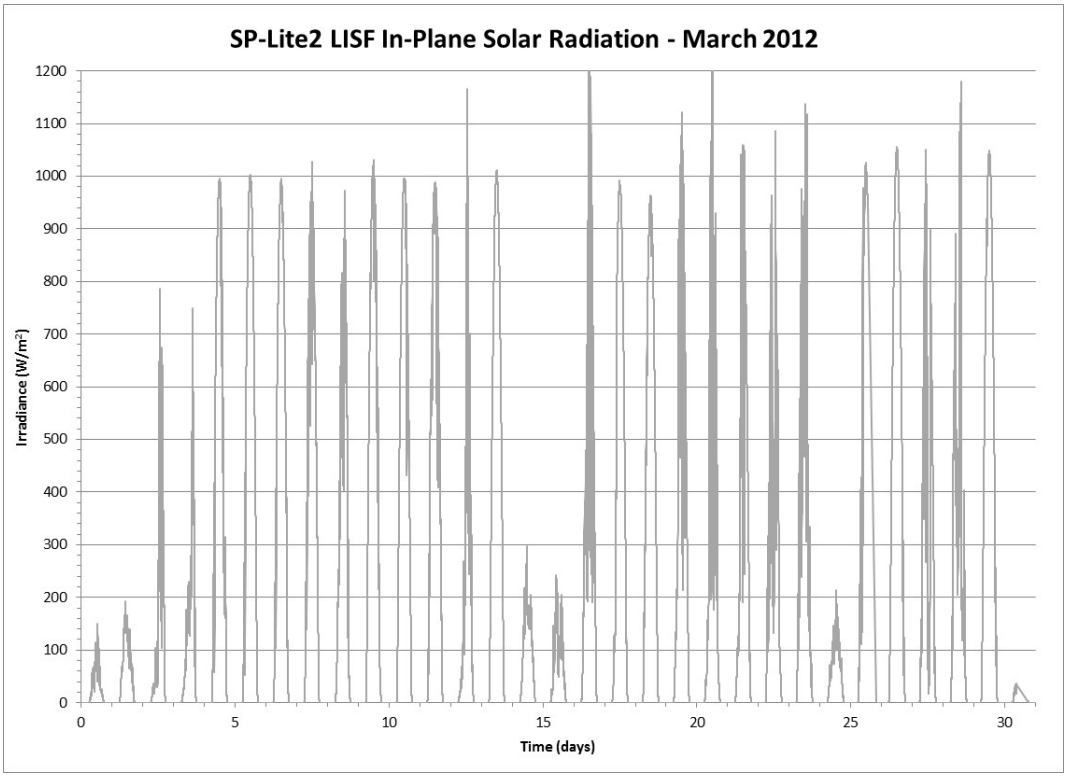

Figure 155 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of March 2012

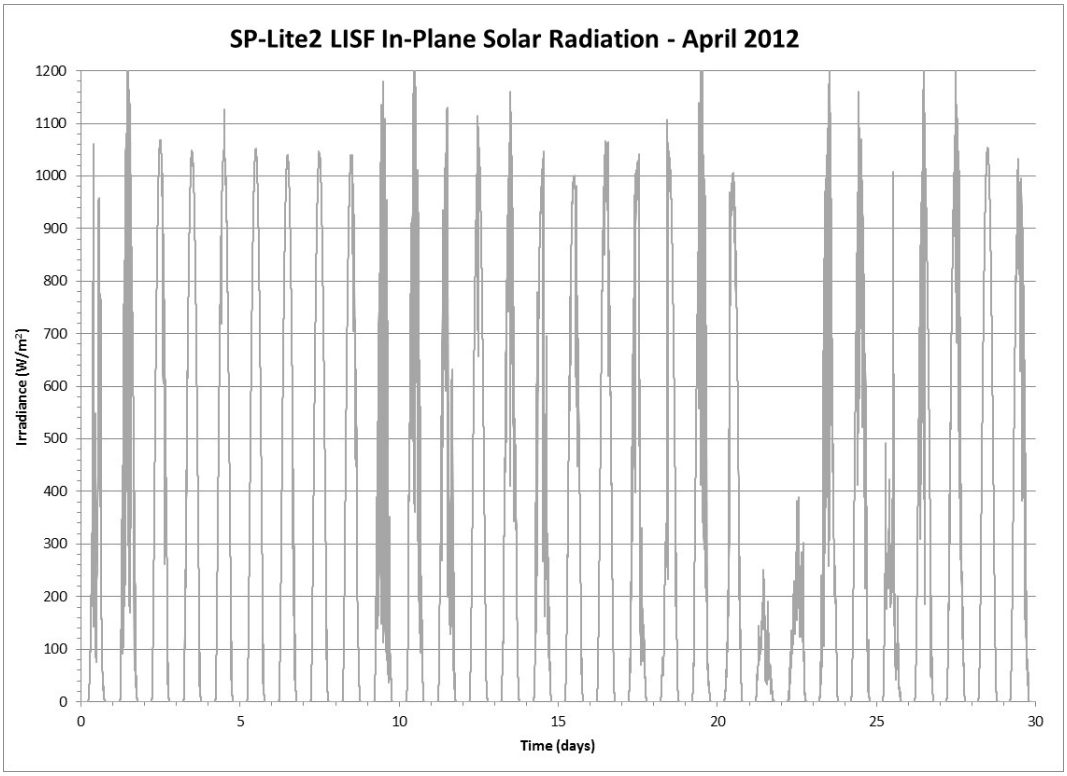

Figure 156 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of April

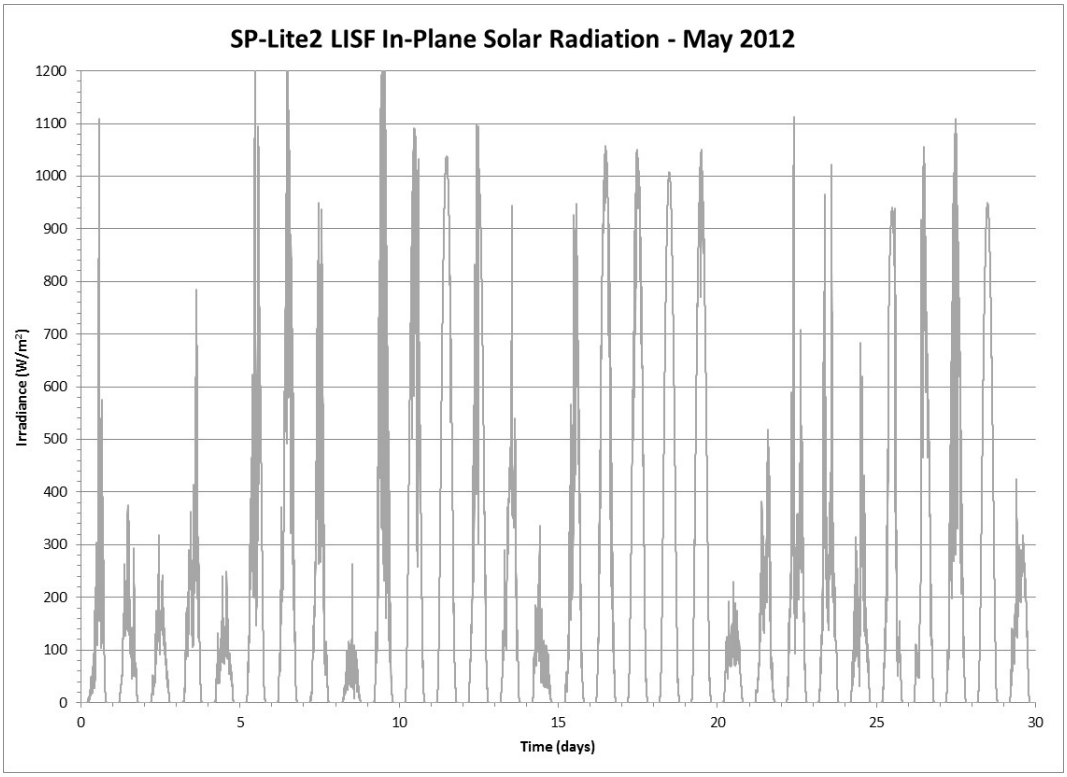

Figure 157 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of May 2012

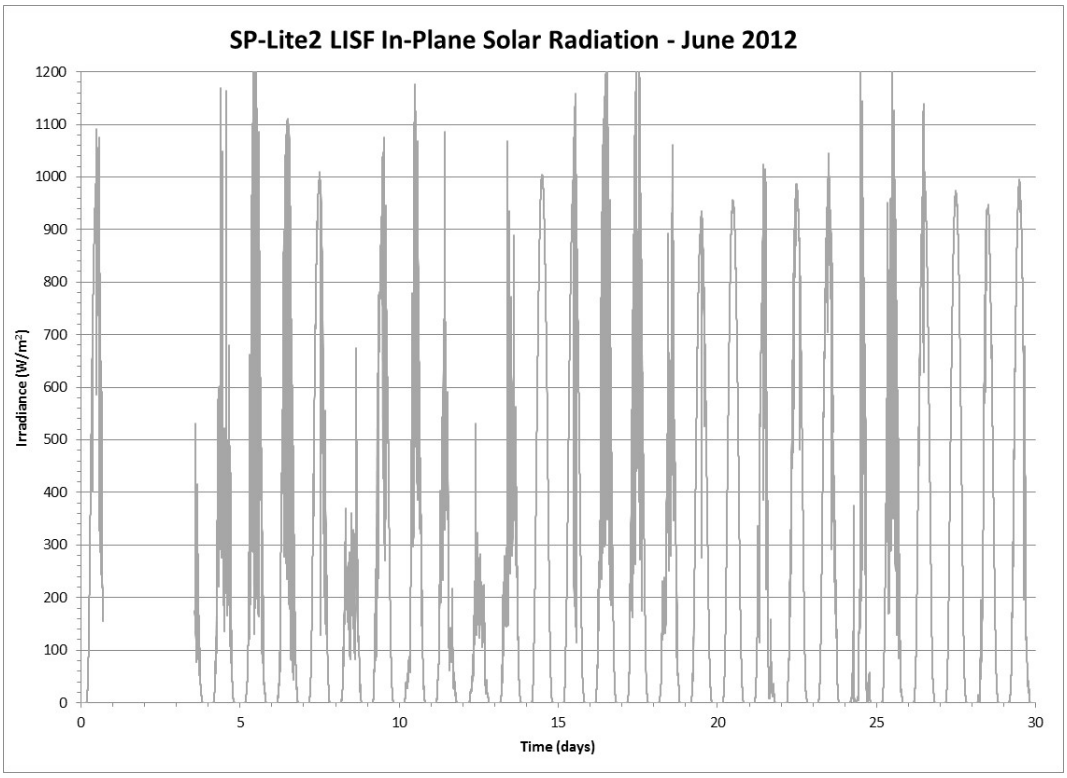

Figure 158 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of June 2012

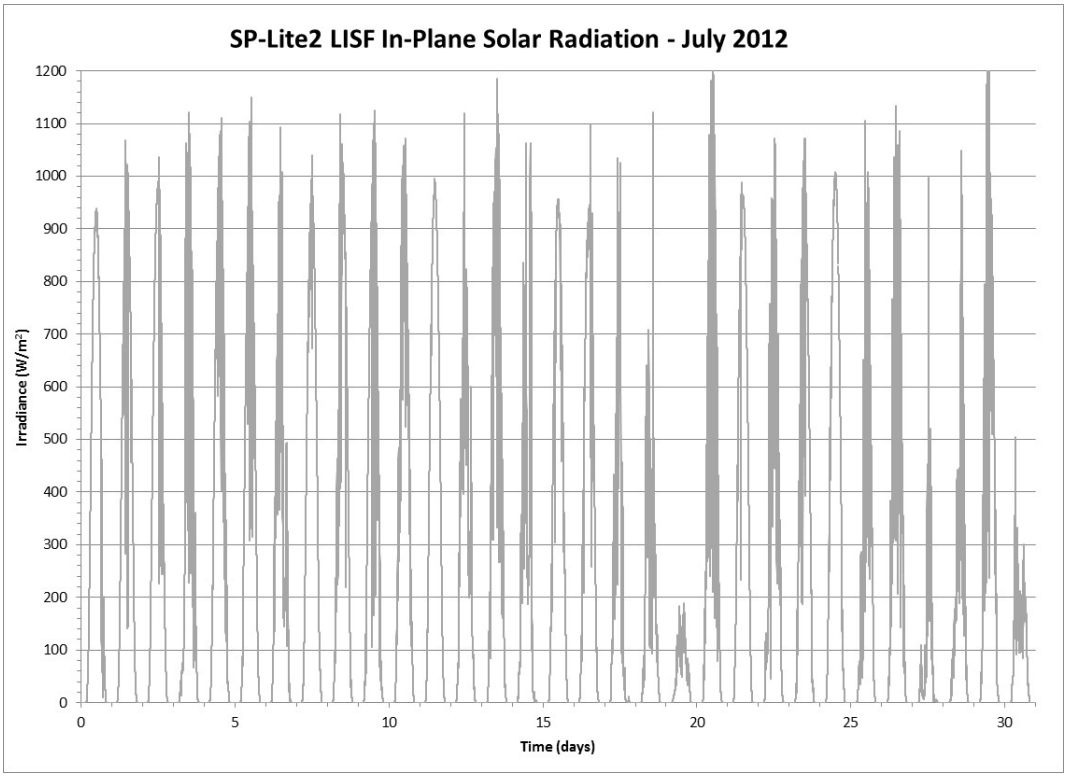

Figure 159 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of July 2012

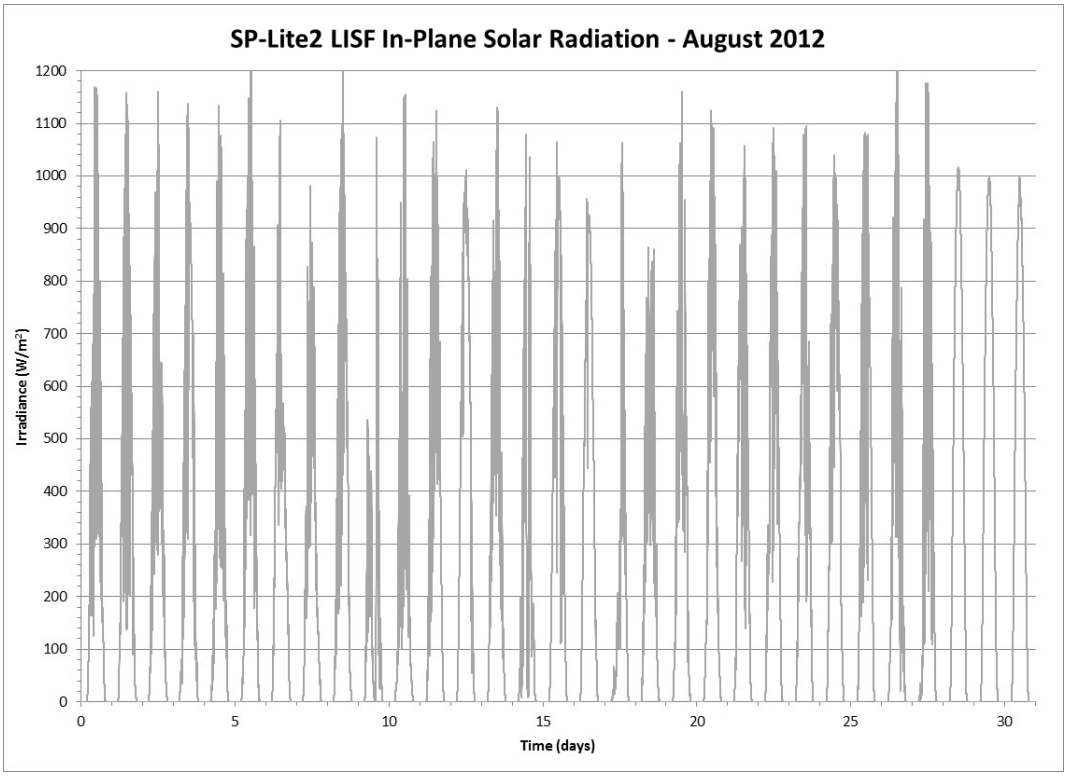

Figure 160 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of August 2012

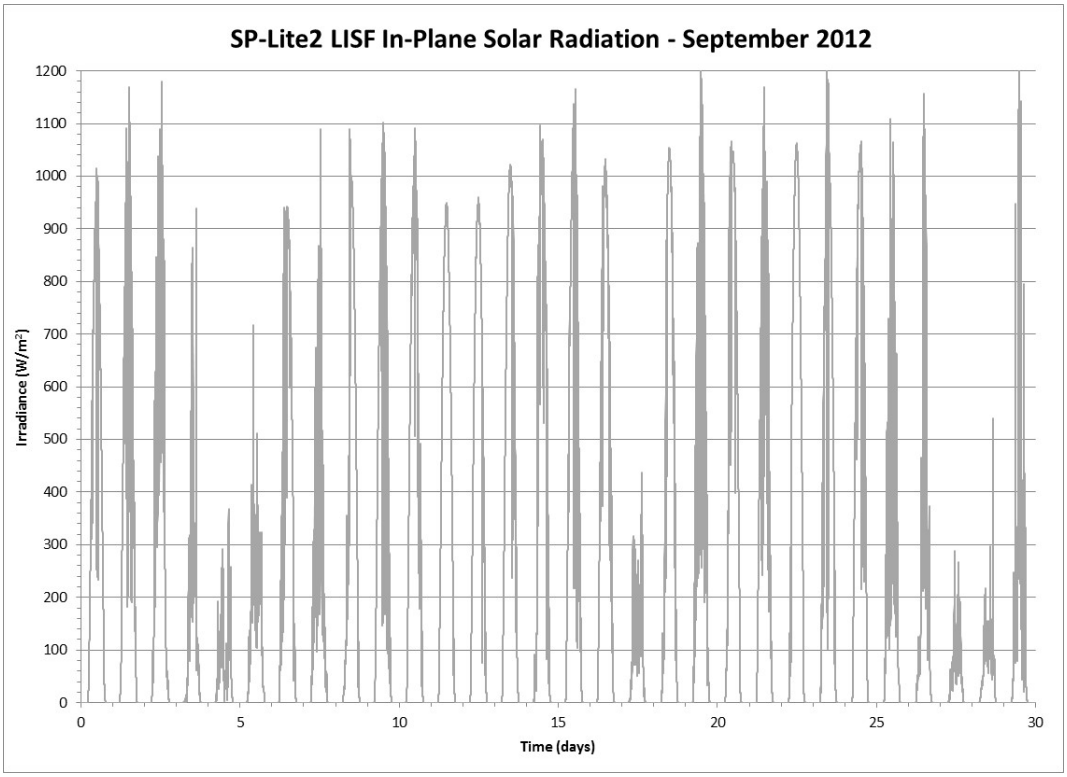

Figure 161 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of September 2012

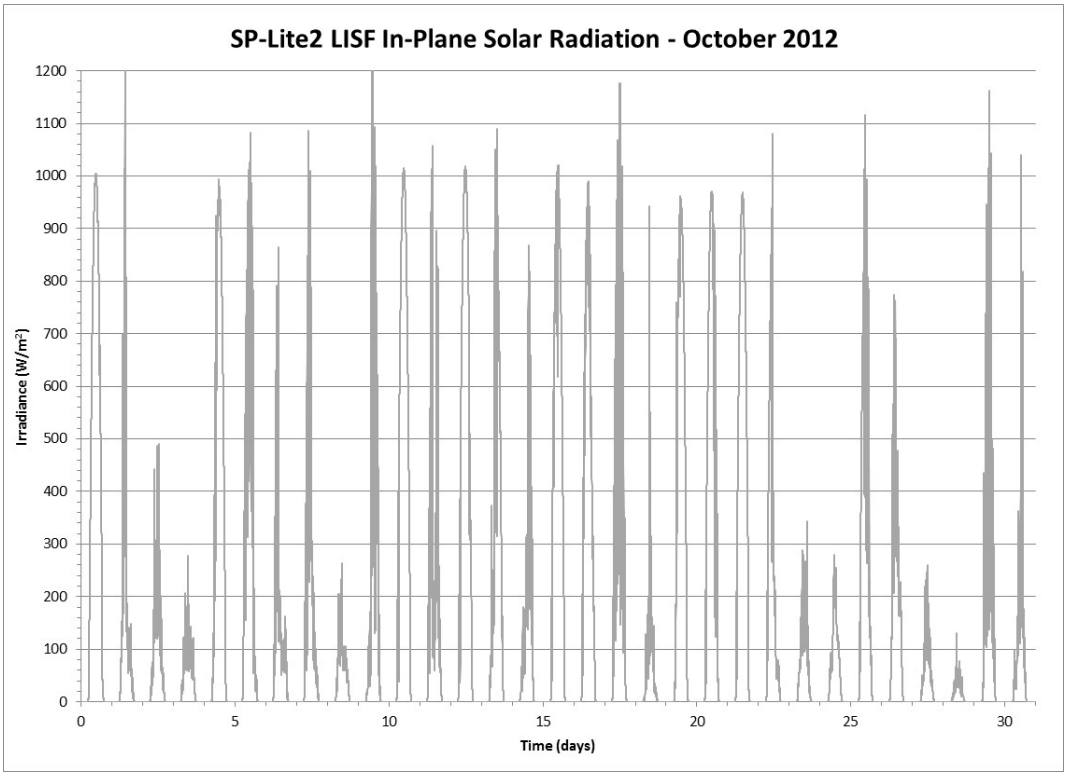

Figure 162 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of October 2012

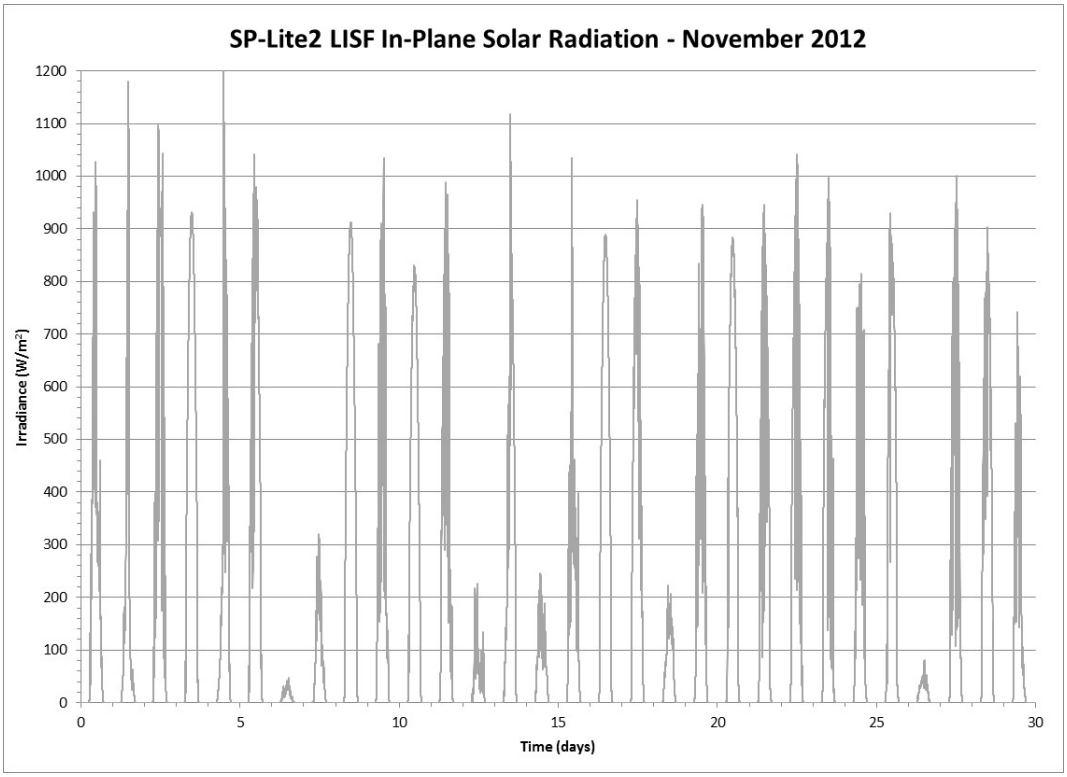

Figure 163 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of November 2012

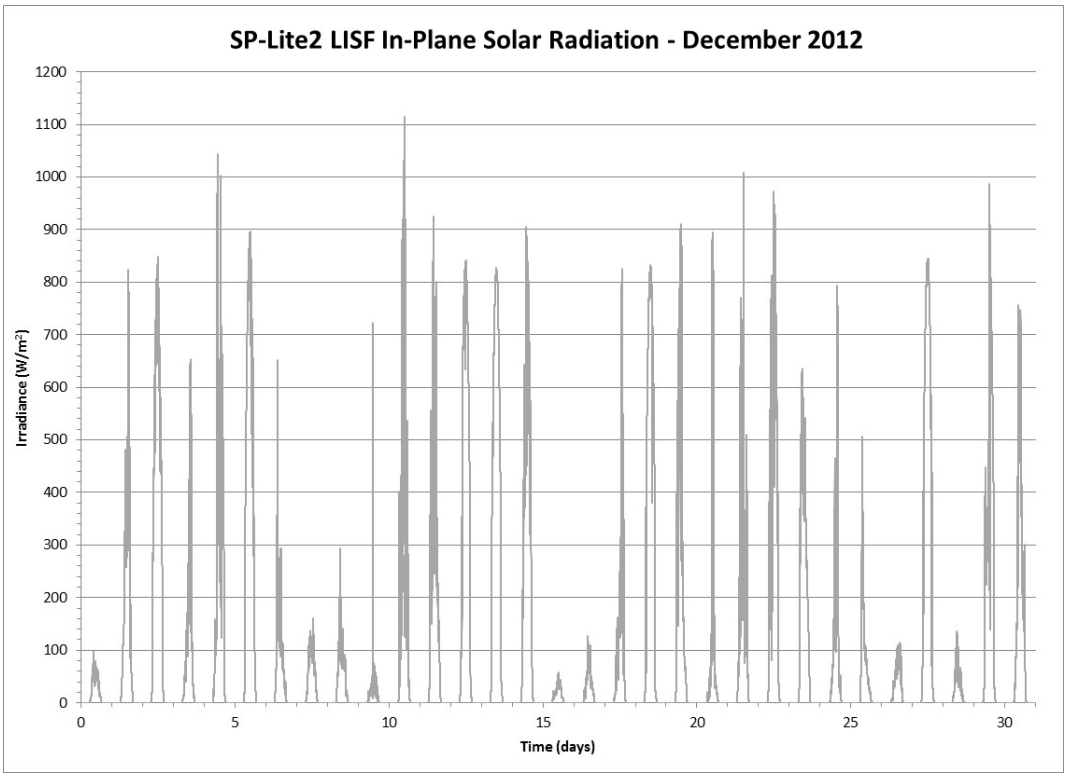

Figure 164 Tilted Global Solar Radiation from an SP-Lite2 Pyranometer for the Month of December 2012

**References**

ASTM D6176-97 (reapproved 2008), Standard Practice for Measuring Surface Atmospheric Temperature with Electrical Resistance Temperature Sensors.

ASTM G183-05, Standard Practice for Field Use of Pyranometers, Pyrheliometers and UV Radiometers.

ASTM D3631-99 (reapproved 2007), Standard Test Methods for Measuring Surface Atmospheric Pressure.

American National Standard ANSI0ANS-3.11-2005, “Determining Meteorological Information at Nuclear Facilities”, American Nuclear Society, 2005.

Heiser, J., Instrument Calibration Plan and Procedures, Brookhaven National Laboratory Informal Report, BNL-99891-2013-IR, February 16, 2013.