

Meteorological Summary for El Verde Field Station: 1975 – 2003

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Introduction

Meteorological data have been collected at El Verde Field Station since 1975. In 1988, McDowell and Estrada summarized available data in an internal CEER report. This summary updates the information provided by McDowell and Estrada Pinto (1988) and provides information on meteorological factors that were recently added to our monitoring station. The objective of this report is to summarize meteorological information and make it more accessible to researchers and students interested in the rainforest of El Verde Research Area.

El Verde Field Station

El Verde Field Station is located at 350 m of elevation within the Luquillo Experimental Forest (congruent with the Caribbean National Forest), Puerto Rico (latitude 18°19' N, longitude 65°45' W). The Institute for Tropical Ecosystem Studies, University of Puerto Rico, administrates El Verde under a special use agreement with the USDA Forest Service. El Verde is also one of the main research stations in the Luquillo Long-Term Ecological Research (LUQ-LTER) program.

El Verde receives an average of 3460 mm evenly distributed over the year, with a drier period from January to April (McDowell and Estrada Pinto 1988). Seasonal patterns in rainfall are difficult to define for El Verde because of the numerous weather systems that pass over the island at any time during the year. Relative humidity is always high, ranging from 60 to 100% (Reagan and Waide 1996).

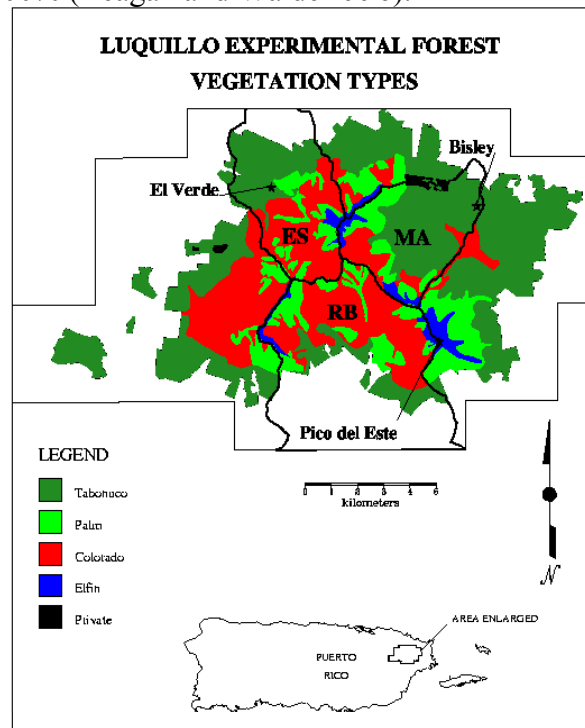


Fig. 1. Location of El Verde Field Station in Puerto Rico and in relation to vegetation zones in the LEF.

Methods

Meteorological data at El Verde Field Station is collected in several locations around the main buildings. A manual rain gage is located on the roof of the main building, a min-max thermometer is located in a box in the shade near the kitchen and the main meteorological station is located at the top of a 20 m tower, the NADP tower, some 50 m behind the laboratory building. All instruments in the tower are located above the forest canopy. An additional meteorological station was installed on the roof for some time, but data from that station was not included in this summary.

Rainfall was collected with a manual gauge located on the roof of the main building at the station. The rain gauge was read at approximately 3:00 pm every day except weekends and holidays. Although we are not presenting daily data here, the amount of rainfall measured the day after days of not recording is distributed equally among days. The entire data set is available on the LUQ-LTER site, database 14 (<http://luq.lternet.edu/data/lterdb14/metadata/lterdb14.htm>).

Additional rain collectors:

- Tipping bucket: Rainfall is also measured with a tipping bucket, which is part of the meteorological station in the NADP tower. Tipping buckets are known to underestimate rainfall due to the instrument's inability to properly record periods of intense rainfall.

The data set is available in the LUQ-LTER site, database 127 (<http://luq.lternet.edu/data/lterdb14/metadata/lterdb127.htm>).

- Belford collector: As part of the National Atmospheric Deposition Program (NADP), rainfall is measured with a Belford rain gauge. The gauge records with ink the amount of rainfall as weight. The data set is available in the LUQ-LTER site, database 77 (<http://luq.lternet.edu/data/lterdb14/metadata/lterdb77.htm>).

- Wet-Dry collector: Also as part of the NADP program, rainfall is measured weekly with a wet-dry collector. Rainfall is determined by manually weighting the wet bucket and applying appropriated transformations. The data set is available in the LUQ-LTER site, database 77 (<http://luq.lternet.edu/data/lterdb14/metadata/lterdb77.htm>).

Relative humidity is measured with in the meteorological station at the NADP tower using a Campbell Scientific Inc. sensor with a radiation shield. Readings are stored hourly in a data logger along with the daily maximum and minimum values. The data set is available in the LUQ-LTER site, database 127 (<http://luq.lternet.edu/data/lterdb14/metadata/lterdb127.htm>).

Temperature is measured in two locations.

- One sensor is in the meteorological station at the NADP tower using a Campbell Scientific Inc. sensor with a radiation shield. Average readings are stored hourly in a data logger along with the daily maximum and minimum values. The data set is available in the LUQ-LTER site, database 127 (<http://luq.lternet.edu/data/lterdb14/metadata/lterdb127.htm>).

- The other monitoring point is in the understory of some large trees near the station's kitchen. A min-max thermometer is located inside a wooden box and a reading is taken daily on weekdays at 3 pm. The data set is available in the LUQ-LTER site, databases 16 and 17 (<http://luq.lternet.edu/data/lterdb14/metadata/lterdb16.htm>) (<http://luq.lternet.edu/data/lterdb14/metadata/lterdb17.htm>).

Solar Radiation or global solar radiation is measured in the meteorological station at the NADP tower using a Licor pyranometer. The amount of radiation hitting the sensor at the hour and the total for the day are stored in a data logger. The data set is available in the LUQ-LTER site, database 127 (<http://luq.lternet.edu/data/lterdb14/metadata/lterdb127.htm>).

Photosynthetic photon density flux (PPDF) or PAR radiation is measured in the meteorological station at the NADP tower using a Licor quantum sensor. The amount of radiation hitting the sensor at the hour and the total for the day are stored in a data logger. The data set is available in the LUQ-LTER site, database 127 (<http://luq.lternet.edu/data/lterdb14/metadata/lterdb127.htm>).

Wind speed and direction are measured in the meteorological station at the NADP tower using a Met One wind sensor. Maximum wind speed, average wind speed, direction and the standard deviation of the direction are recorded hourly and daily in a data logger. The data set is available in the LUQ-LTER site, database 127 (<http://luq.lternet.edu/data/lterdb14/metadata/lterdb127.htm>).

Rainfall

The distribution of rainfall during the year at El Verde Field Station does not show any clear seasonal pattern. Although rainfall is always more abundant during the second part of the year, inter annual variability is large.

| | Average | Max | Min | S.D. |
|------------------|----------------|-------------|------------|-------------|
| January | 233 | 485 | 88 | 97 |
| February | 223 | 520 | 35 | 123 |
| March | 194 | 626 | 50 | 131 |
| April | 241 | 520 | 30 | 129 |
| May | 347 | 632 | 109 | 130 |
| June | 235 | 481 | 12 | 105 |
| July | 309 | 515 | 73 | 107 |
| August | 365 | 682 | 20 | 150 |
| September | 341 | 770 | 151 | 171 |
| October | 284 | 715 | 54 | 149 |
| November | 391 | 802 | 130 | 196 |
| December | 352 | 883 | 71 | 230 |
| Total | 3515 | 7631 | 822 | |

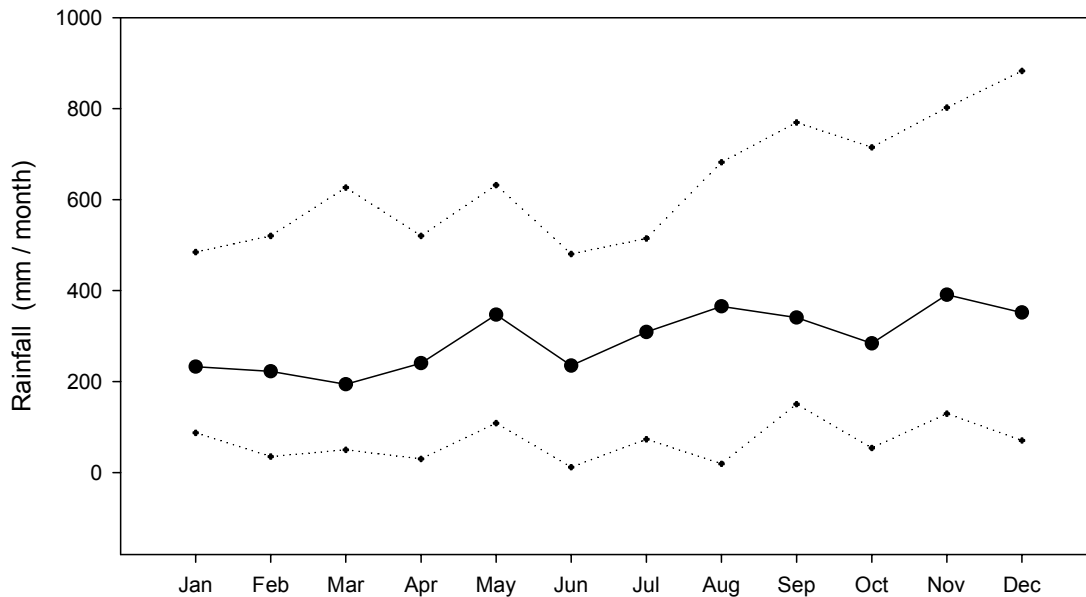


Fig.2. Average, minimum and maximum monthly rainfall for the 1975-2002 period.

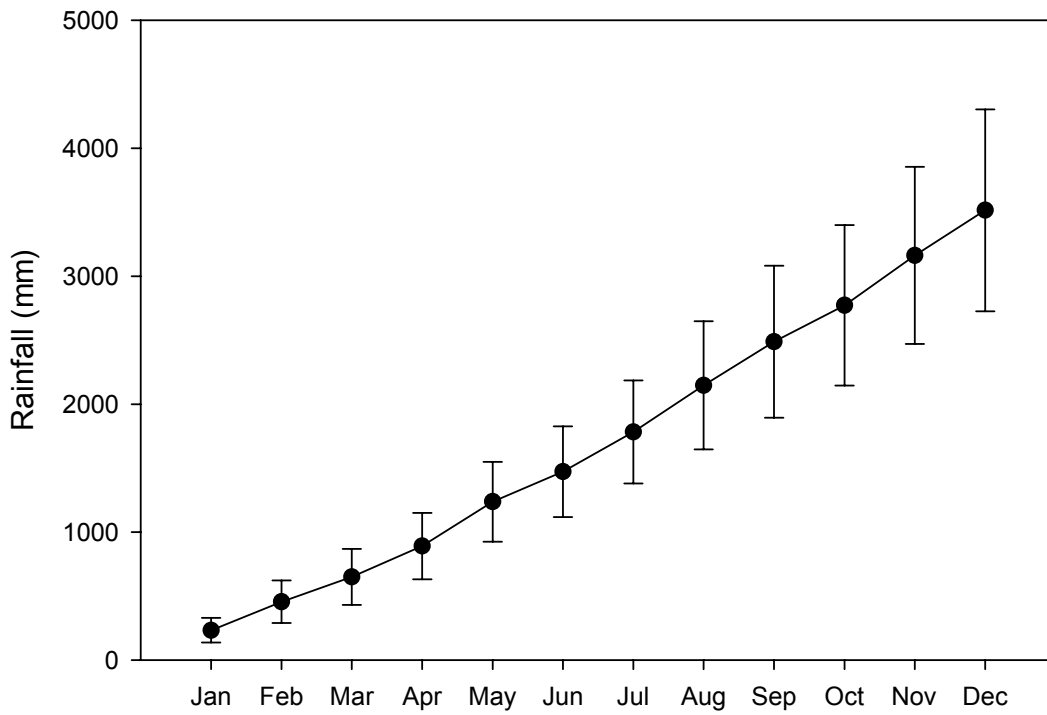


Fig. 3. Accumulative rainfall shows a steadily increase over the year, showing a lack of strong seasonality.

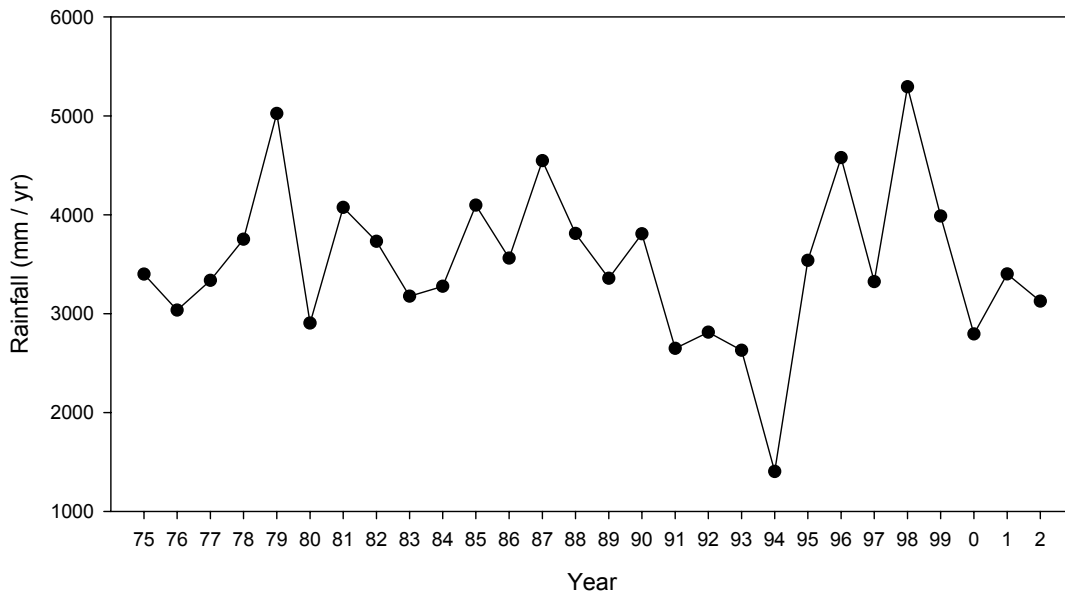


Fig. 4. Total annual precipitation (mm/yr) from 1975 to 2002.

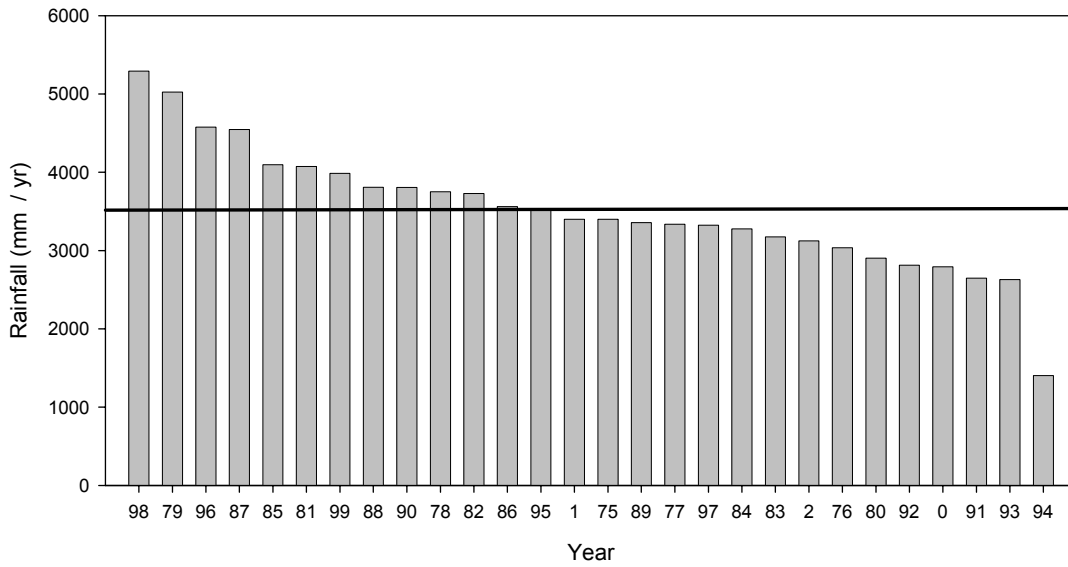


Fig. 5. Annual precipitation ordered from the rainiest to the driest years. The line represents the overall mean.

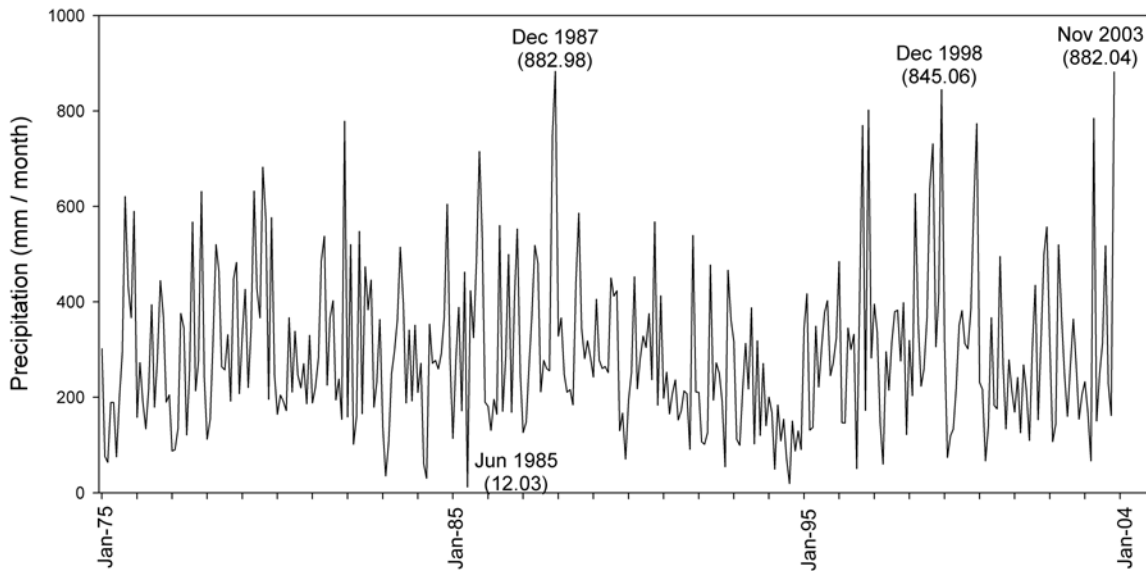


Fig. 6. Monthly precipitation from 1975 to 2003, showing the three rainiest months in record and the driest.

Relative Humidity

Relative humidity changes little over the year at El Verde Field Station. This summary is only for the years 2001 to 2003.

| | Maximum | SD | Minimum | SD |
|-----------|---------|----|---------|----|
| January | 99 | 1 | 83 | 5 |
| February | 100 | 0 | 84 | 5 |
| March | 99 | 2 | 76 | 5 |
| April | 99 | 1 | 85 | 6 |
| May | 100 | 1 | 78 | 2 |
| June | 98 | 1 | 80 | 5 |
| July | 98 | 2 | 78 | 7 |
| August | 100 | 0 | 84 | 3 |
| September | 99 | 2 | 79 | 6 |
| October | 100 | 1 | 80 | 7 |
| November | 99 | 1 | 82 | 3 |
| December | 100 | 1 | 84 | 11 |

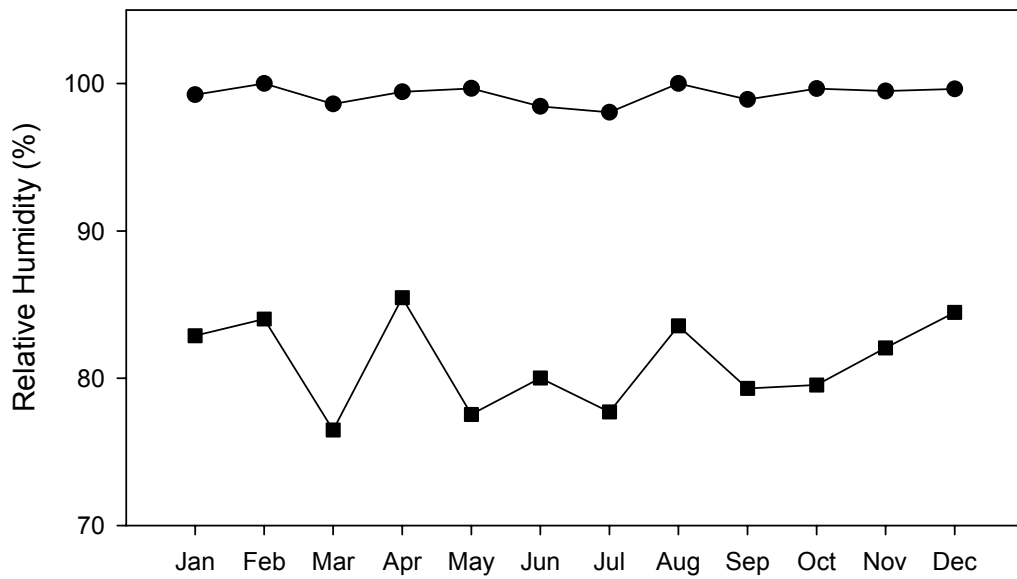


Fig. 7. Monthly minimum and maximum relative humidity for the period 2001 to 2003.

Temperature

Changes in temperature over the year at El Verde Field Station are small, lowest temperatures occur during the end and beginning of the year and are highest during the middle months. The seasonal pattern reflects the 18 °N location of Puerto Rico, lowest in winter and highest in summer.

| | MAX | MIN | S.D |
|------------------|-----|-----|-----|
| January | 27 | 22 | 1.2 |
| February | 27 | 22 | 1.1 |
| March | 28 | 23 | 1.2 |
| April | 28 | 24 | 1.0 |
| May | 29 | 25 | 1.1 |
| June | 29 | 26 | 0.7 |
| July | 29 | 26 | 0.8 |
| August | 29 | 26 | 0.9 |
| September | 30 | 26 | 1.0 |
| October | 30 | 25 | 1.1 |
| November | 28 | 24 | 1.1 |
| December | 28 | 22 | 1.2 |
| Average | 29 | 24 | |

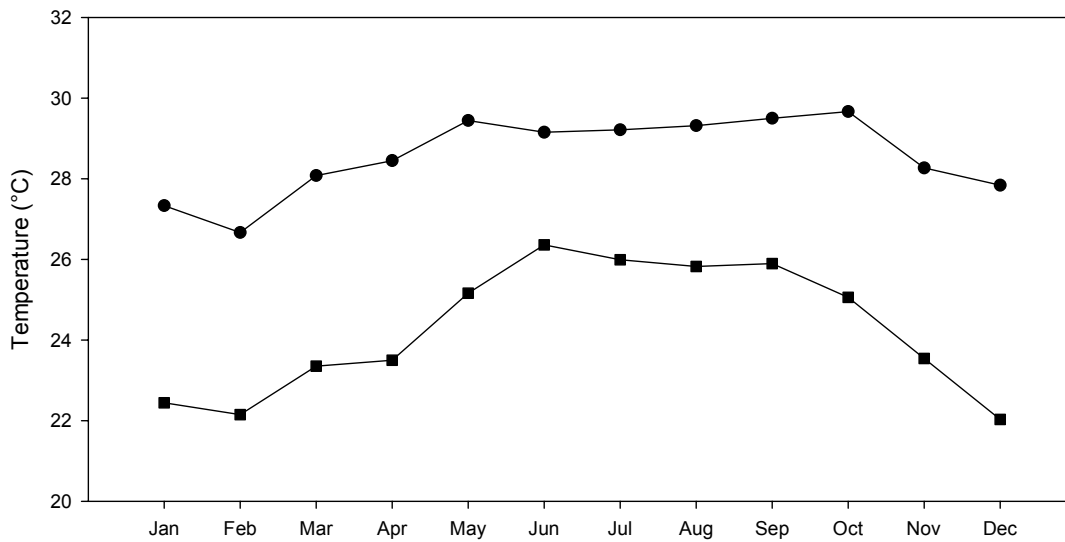


Fig. 8. Monthly average minimum and maximum temperature for the 1975 – 2002 period.

Solar Radiation

Global solar radiation data are available only for 2003. While there is high variation, the pattern is similar to that of temperatures, showing highest levels during the middle of the year.

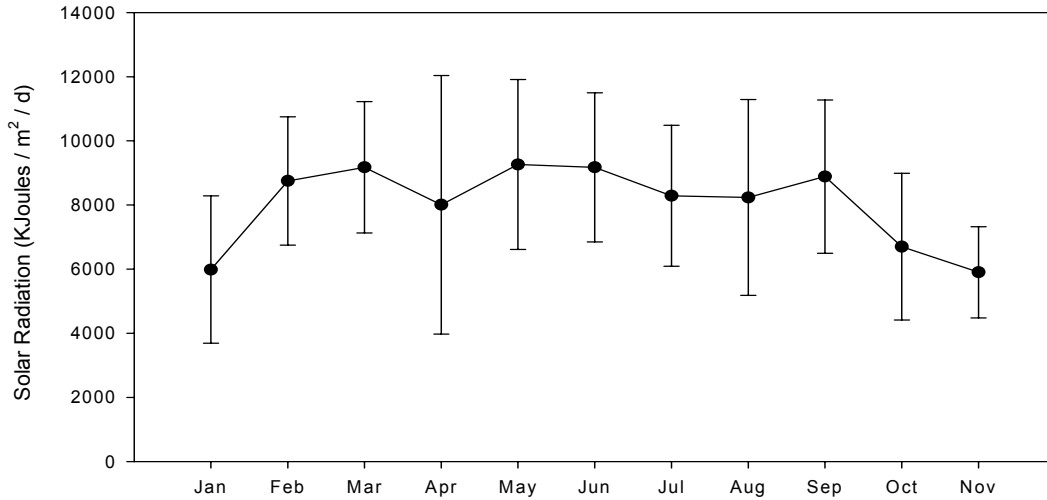


Fig. 9. Mean monthly solar radiation for 2003. The error bars are one standard deviation.

Photosynthetic radiation

Photosynthetic photon density flux (PPDF) is summarized for the period of 2001-2003 only and shows a clear increase during the middle of the year.

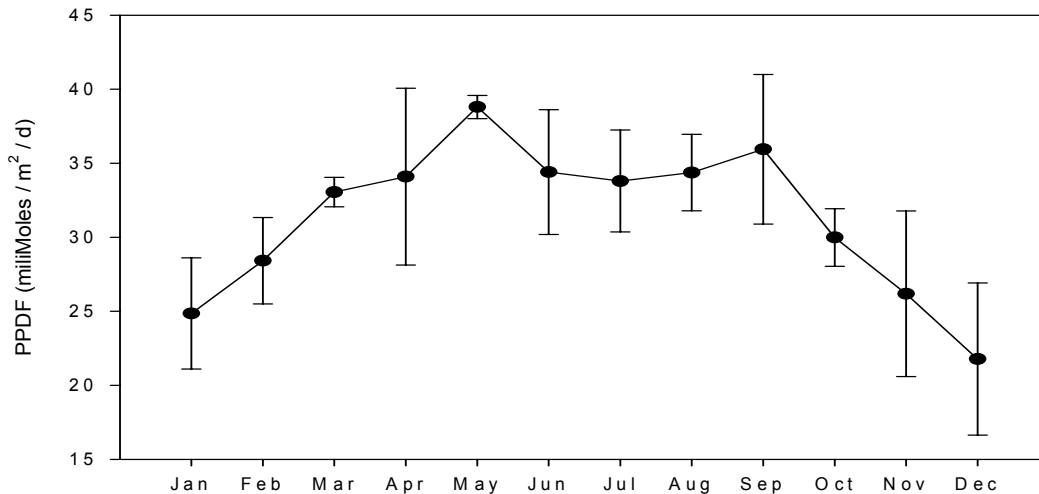


Fig. 10. Mean monthly PPDF. The error bars are one standard deviation.

Wind speed and velocity

Average wind speed is fairly constant, ranging from 1.2 to 1.5 m/sec showing peaks in February and July and winds blow mainly from the southeast. Maximum wind speeds are more variable, but similarly high throughout the year. Wind direction shows a consistent southeast origin. Data are summarized only for 2003.

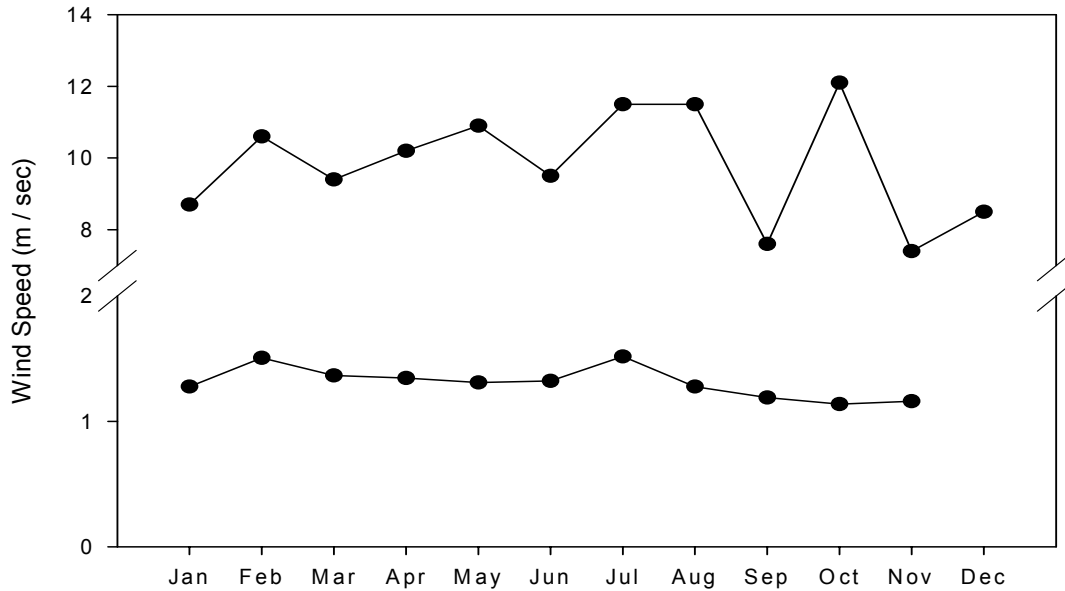


Fig. 11. Maximum and average wind speed (m/s). Each point is the monthly mean.

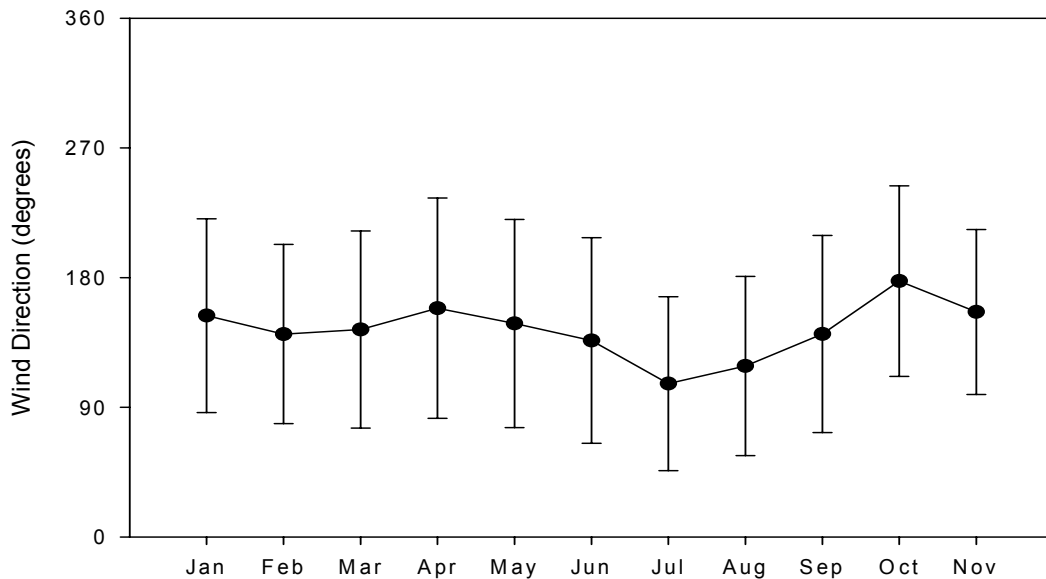


Fig. 12. Monthly wind direction (degrees). The error bars are one standard deviation.

Other variables

Many other variables are collected on a regular basis at El Verde Research Area as part of the LUQ-LTER. Some of them are:

- Soil moisture, mainly measured in the Canopy Trimming Experiment.
- Soil temperature at 5-10 cm depth, measured in the Canopy Trimming Experiment.
- Light levels under the forest canopy, measured in the Canopy Trimming Experiment
- Rainfall reaching the ground under the canopy, or through fall, measured in the Canopy Trimming Experiment
- Stream discharge, measured by the USGS in Quebrada Sonadora and by the LTER in Quebrada Prieta.
- Stream water chemistry, temperature and pH, measured weekly in Quebrada Sonadora, Prieta and Toronja.

See the LUQ-LTER web site to obtain more information about variables measured at El Verde Field Station and Research Area (<http://luq.lternet.edu/data/>).

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