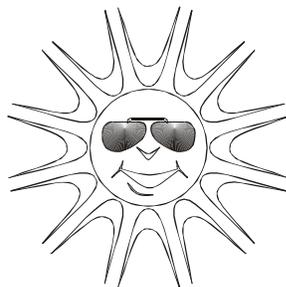


Smithsonian Tropical Research Institute

**1993 Meteorological and Hydrological
Summary for
Barro Colorado Island**

Prepared by: Steven Paton



Introduction

This is the first of a new series of yearly reports summarising each past year's meteorological and hydrological monitoring program on Barro Colorado Island (BCI) that the Smithsonian Tropical Research Institute maintains as part of its Terrestrial-Environmental Sciences Program (T-ESP). This report is not meant to be exhaustive in its coverage in that it summaries only some of the most 'important' or interesting parameters available. Any comments on how future yearly summaries could be improved would be appreciated.

Setting

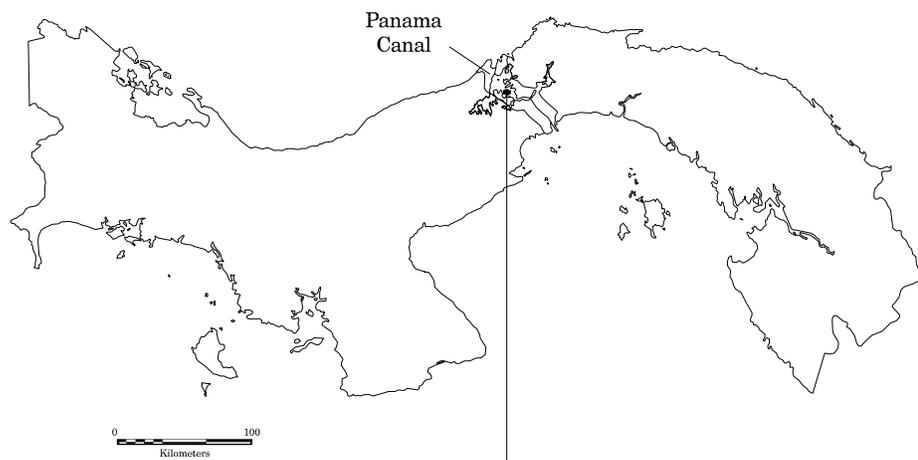
The meteorology and hydrology monitoring programs on BCI are described in detail in Climatic and Moisture Variability in a Tropical Forest: Long-term Records from Barro Colorado Island, Panamá. Windsor (1990). Much of the information on the next five pages has been extracted from this source.

BCI (lat. 9°10'N lon. 79°51'W) is a completely forested, 1500 ha island, rising 137 m above Lake Gatun. The island receives an average of over 2600 mm of rain per year. The year is divided up into a pronounced dry season running from approximately the middle of December until the end of April. On average, only 230 mm of rain falls during this period. Relative humidity, soil moisture, air pressure, solar radiation, wind speed and direction all show marked wet/dry season differences. On the other hand, temperature varies relatively little throughout year.

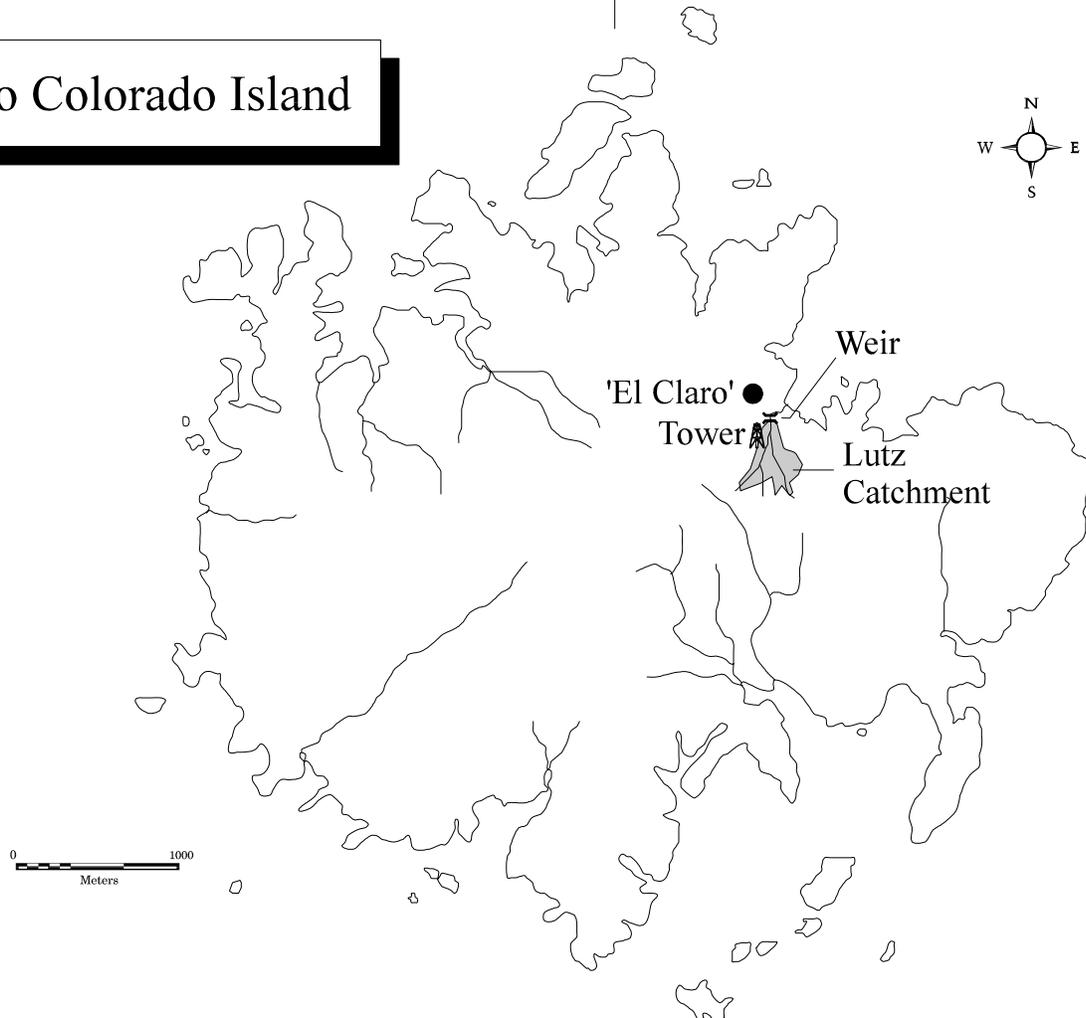
This report summarises data taken from two locations: a 42 m walk-up tower located within of the Lutz catchment, and a small clearing ('El Claro') located among several laboratory buildings (see map on the following page). The tower, with sensors at 10 m intervals, provides a vertical meteorological transect through the forest canopy. The Lutz 10.1 ha catchment on the Northwest slope of BCI and is probably typical of many small catchment areas draining away from the island. The Lutz catchment is located immediately east of the laboratory clearing and dormitory area. The Clearing is a grass-covered area located near several laboratory buildings. The physical aspects of the Clearing have changed little over time, however, the proximity of nearby buildings is less than ideal for long-term meteorological measurements. Furthermore, the recent removal of a nearby building (and possibly others in the near future) may have had effects on the local climate around the Clearing.

Data were collected through two different methods: electro-mechanical (electronic sensors, data loggers, chart recorders, etc.), and manually by a technician - Mr. Raúl Rios. In general, manual readings tend to provide the most accurate measurements over the long-term and as a result, when both types of data are available, the manual readings are used. The disadvantage of these measurements is that they are not available for each day. When both types of data are available, I have used manually collected data for monthly summaries (e.g.

temperature, relative humidity). Daily summaries are based on either a combination of the two types of data (e.g. rainfall) or only on electro-mechanically collected data (e.g. wind, solar radiation)



Barro Colorado Island



The Data

This report summarises the following data:

Lutz Tower	1m	temperature relative humidity
	40m	temperature relative humidity wind speed and direction solar radiation
Lutz catchment		run-off soil moisture
'El Claro'		temperature relative humidity rainfall air pressure

Rainfall

Rainfall was collected by rain gauges in the Clearing, and by tipping buckets in both the Clearing and near the Lutz weir. The rain gauges were read at approximately 9:00 am. Daily readings were not made on weekends or holidays. Tipping buckets provide continuous rainfall information, but tend to underestimate total rainfall by between 2% and 12% and for that reason are not used to provide data on absolute rainfall totals. Tipping buckets generate 'events' for every 0.254 mm of rainfall recorded. The underestimation seems to be due to the instruments' inability to properly record intense periods of rainfall. In order to 'fill in' the missing rain gauge data, a computer program was written by the author that uses tipping bucket rainfall data to distribute the rain gauge data for those days when readings were not made. The program takes the total rainfall collected in the rain gauge and divides it up proportionally according to the rainfall patterns detected by the tipping buckets. The estimated rainfall for the missing days is exactly equal to the rainfall collected by the rain gauge. The daily rainfall for the Clearing is shown on page 7.

Page 8 shows the monthly totals for this year. The graph on the same page compares this year's monthly totals with the average monthly totals (\pm SE) for the period 1929 to 1992.

Page 10 breaks rainfall into approximately wet and dry seasons. The seasons were defined, somewhat arbitrarily, as: Dry Season (Jan. 1 to April 30) and Wet Season (May 1 to Dec. 31). The three graphs on this page are frequency histograms showing the distribution of rainfalls (1929 to 1992) for the Dry and Wet Seasons as well as the yearly totals. The arrow in each graph shows the rainfall for 1993 in relation to previous years. The small cross bar

above each graph represents the mean (vertical bar) and the standard deviation (horizontal bar) for the period 1929 - 1992.

Page 9 shows an analysis of rainfall 'events' (*storms*). For convenience, and again somewhat arbitrarily, I have defined a storm as any continuous period of rain separated by at least an hour from any other rainfall. Since this analysis required the timing of rainfall events, tipping bucket data were used. As a result, the absolute size of rainfall events should be considered as only a rough comparison since they will tend to disproportionately underestimate the size of storms - larger storms will be more underestimated than smaller ones. Keeping this in mind, the tables and graphs on this page compare the maximum storm size and the average storm size and duration per month for the period 1972 to 1992 and for the year 1993.

Run-off

Run-off at the Lutz catchment area was determined from the water level in a 120° V-notch weir. The height of the water was recorded by three separate instruments: continuously by a Stevens A-71 strip-chart, water level recorder, at five-minute intervals with a datalogger, and at five-minute intervals with an ISCO Bubble Flow Meter. Data from each of these devices are converted (either directly or through a digitizing process) into run-off (m³) and then into rainfall equivalents.

Daily Lutz creek weir run-off totals are shown on page 11. These data are shown in terms of the equivalents of precipitation in mm. These values are calculated by taking the run-off and dividing by the total surface area of the catchment area (10.1 ha). In this way, the run-off can be more conveniently compared to the amount of rainfall.

Page 12 shows the total monthly run-off. The graph on the same page compares average monthly run-off for the period 1973 to 1992 with 1993.

Soil Moisture

Soil moisture was determined gravimetrically based on samples collected every two weeks. Samples are taken at two depths (0-10cm and 30-40cm) from ten sites in the Lutz catchment area. Samples of approximately 2.5 cm soil cores are made with an 'Oakfield punch'. Page 13 shows the average soil moistures (% water by wet weight of soil) per month at each sample depth. The graph on the same page compares monthly averages for the period 1986 to 1992 with those for 1993.

Relative Humidity

Relative humidity was measured using the traditional method of wet and dry-bulb psychrometry. Measurements in the Clearing, at the base and top of the Lutz tower (1m and 40m, respectively) were made at approximately 12:30 p.m. using a Taylor Sling Psychrometer. Data were also collected on an hourly basis by dataloggers attached to electronic sensors. These data are not reported in this yearly summary.

The average monthly relative humidities are shown in tabular and graphical form on page 14.

Air Pressure

Air pressure was determined by reading a full-range mercurial barometer at approximately 12:30 P.M.. The average monthly air pressures are shown in tabular and graphical form on page 15.

Temperature

Shaded air temperature was measured in the Clearing, at the base and the top of the Lutz tower by Taylor max-min thermometers. Measurements were made by hand at approximately 8:15 am. Data were also collected on an hourly basis by dataloggers attached to electronic sensors. These data are not reported in this yearly summary. The average monthly maximum and minimum temperatures for these three locations are shown in tabular and graphical form on page 16.

Solar Radiation

Global solar radiation was measured at the top of the Lutz tower using a Li-Cor LI200SB pyrranometer attached to a datalogger. Hourly average ($\text{wh/m}^2/\text{h}$), maximum and minimum ($\mu\text{Wh/m}^2/\text{min}$) was recorded. A Li-Cor 190SB sensor recorded Photosynthetically Active Radiation (PAR) similarly. A failure of the datalogger during the month of November resulted in the loss of two weeks of data.

Page 17 shows the Daily PAR values. The following page shows total monthly global radiation and PAR.

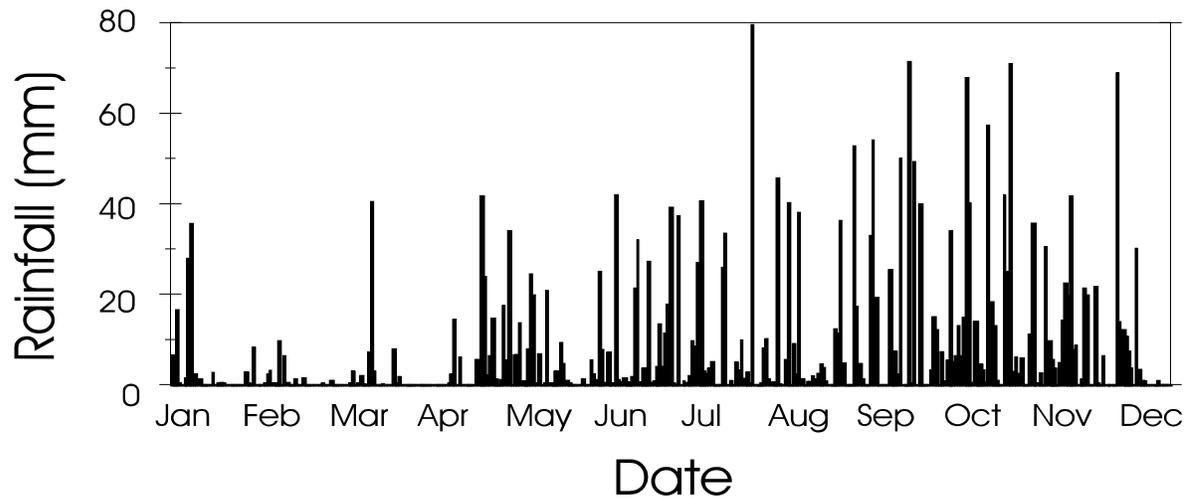
Wind Speed and Direction

Hourly average, maximum and minimum wind speed plus average wind direction was recorded at the top of the Lutz tower using a Model 05035 Young Anemometer connected to a data logger. Failures of this equipment resulted in the loss of data in January and again in October - December.

Page 21 shows the average and maximum daily wind speeds. The next page shows average wind direction. The angles indicated in the table and graph on this page represent the direction from which the wind was predominately blowing on a given day. Pages 19 and 20 show the monthly average wind speeds and directions for the year.

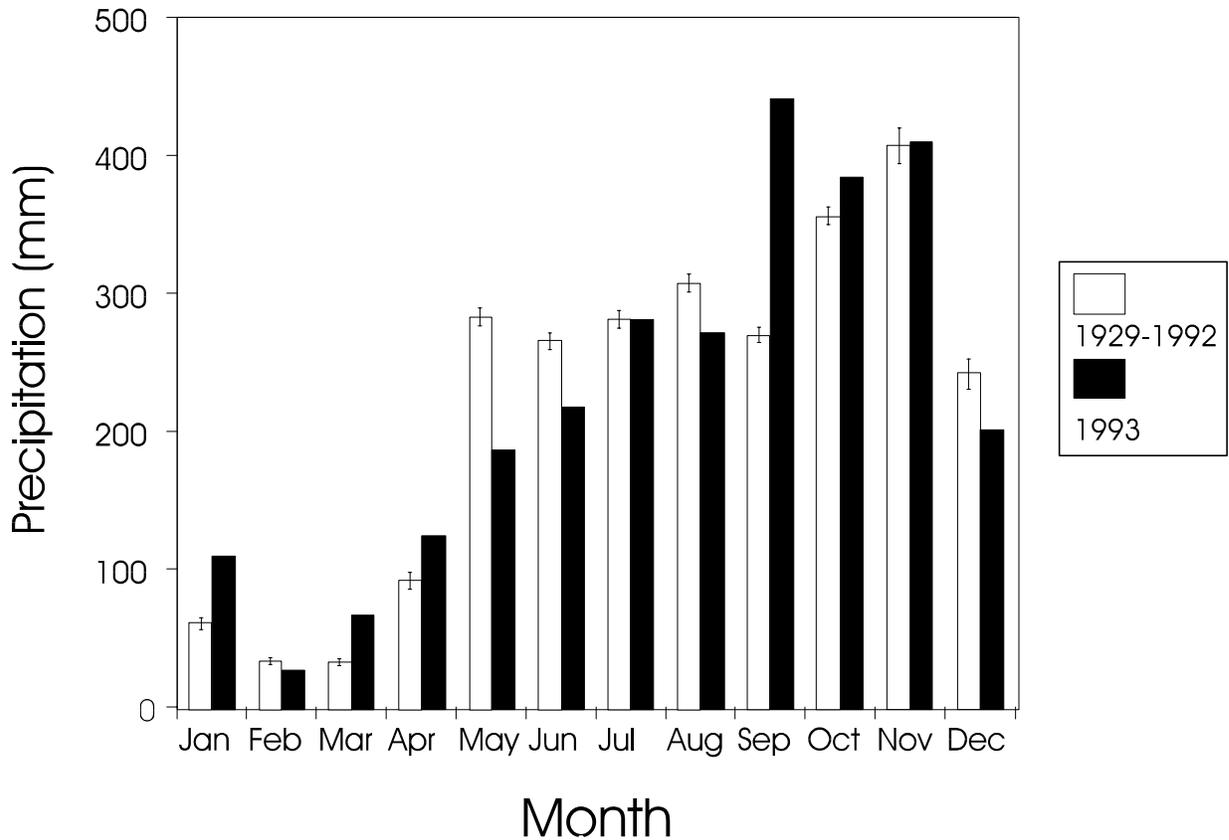
Daily Rainfall (mm) on BCI recorded at 900 hrs

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	6.5	0.0	0.0	0.0	1.1	0.0	17.8	79.6	11.4	39.9	41.9	19.8
2	0.3	0.0	0.0	0.0	17.5	0.0	39.2	0.0	36.3	0.0	25.1	0.0
3	16.6	0.0	0.0	0.0	5.4	5.5	0.3	0.0	4.8	0.0	71.0	0.0
4	0.3	0.4	0.0	0.0	34.0	2.3	0.0	0.4	0.0	0.0	2.9	21.7
5	0.0	2.3	0.0	0.0	0.0	1.1	37.3	8.1	0.0	3.3	6.1	0.3
6	1.5	3.2	0.0	0.0	6.6	25.1	0.0	10.2	0.0	15.0	2.5	0.0
7	27.9	0.3	0.3	0.0	6.7	7.8	0.8	1.2	52.8	12.2	5.9	6.4
8	35.6	0.0	3.0	0.0	13.7	0.5	0.5	0.6	17.3	0.0	0.0	0.0
9	2.3	9.7	0.0	0.0	0.8	7.1	2.0	0.3	4.7	7.3	0.0	0.0
10	2.3	0.0	0.3	0.0	0.0	0.3	9.7	45.7	1.3	0.8	11.2	0.0
11	1.2	6.4	2.0	0.0	7.9	0.3	8.5	0.2	0.0	5.4	35.7	0.0
12	0.0	0.5	0.1	0.3	24.5	42.0	27.0	0.0	0.0	34.0	13.1	68.9
13	0.0	0.0	0.0	2.3	19.8	1.1	40.6	5.6	33.0	5.1	0.3	13.9
14	0.0	0.0	7.2	14.4	0.3	0.6	3.0	40.2	54.1	6.4	2.6	12.2
15	0.0	1.3	40.5	0.0	6.8	1.5	2.5	0.0	19.3	13.0	0.0	10.7
16	2.7	0.0	3.0	6.1	0.0	0.6	3.6	9.1	0.0	6.4	30.5	7.4
17	0.0	0.0	0.0	0.0	0.3	0.5	5.1	2.3	0.0	14.9	9.7	3.6
18	0.3	1.5	0.0	0.0	20.8	1.8	0.0	38.1	0.0	67.9	5.6	0.0
19	0.5	0.0	0.1	0.0	0.3	21.3	0.0	1.3	0.0	40.1	3.6	30.1
20	0.3	0.0	0.0	0.0	0.0	32.0	0.0	0.0	25.4	0.5	0.0	3.4
21	0.0	0.0	0.0	0.0	3.0	0.6	25.9	0.7	0.0	14.0	4.9	1.0
22	0.0	0.0	0.0	5.6	0.3	3.6	33.5	0.7	7.4	0.0	14.2	0.8
23	0.0	0.0	7.9	5.6	9.3	0.5	0.0	1.9	2.3	4.5	22.5	0.0
24	0.0	0.0	0.3	41.7	4.7	27.2	0.9	1.3	50.0	3.3	19.8	0.0
25	0.0	0.3	1.8	23.9	1.0	0.5	0.0	2.5	0.0	0.6	41.7	0.0
26	0.0	0.0	0.0	2.2	0.3	0.8	5.0	4.6	0.0	57.4	7.8	0.0
27	0.0	0.0	0.0	6.4	0.0	4.0	3.3	3.8	71.4	18.3	8.7	0.9
28	2.8	1.0	0.0	14.7	0.0	13.5	9.9	0.8	0.3	13.0	0.0	0.0
29	0.3		0.0	1.3	0.0	4.1	1.4	0.0	49.3	1.0	1.2	0.0
30	0.0		0.0	0.0	0.0	11.4	2.8	0.0	0.0	0.0	21.3	0.0
31	8.3		0.0		1.3		0.4	12.4		0.0		0.0



Monthly Rainfall at 'El Claro' - Rain Guage

	<u>Rainfall (mm)</u>
January	109.6
February	26.8
March	66.5
April	124.3
May	186.3
June	217.4
July	280.9
August	271.4
September	441.1
October	384.0
November	409.8
December	200.9
Total	2719



Storm Analysis

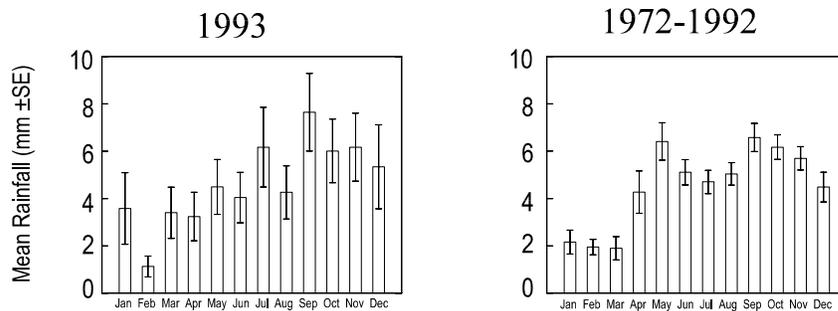
Maximum Rainfall (mm)

Av. Storm Duration (min.)

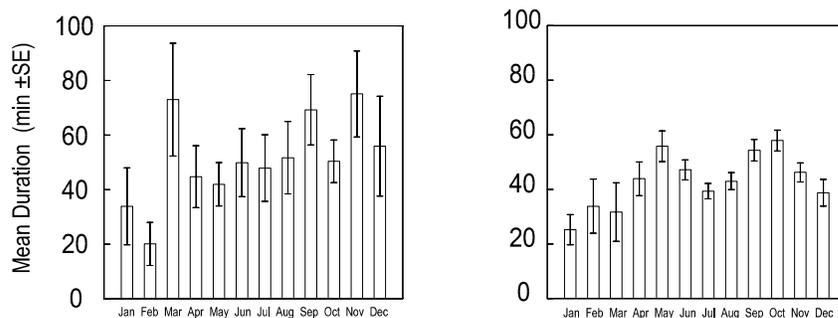
Av. Rainfall (mm)

<u>1972-92</u>		<u>1993</u>	<u>1972-92</u>		<u>1993</u>	<u>1972-92</u>		<u>1993</u>
31.8	31.5		25.2	33.9		2.2	3.6	
18.3	8.4		33.8	20.1		2.0	1.1	
37.1	17.8		31.7	73.0		1.9	3.4	
123.4	29.0		43.8	44.7		4.3	3.2	
106.9	30.2		55.7	42.0		6.4	4.5	
78.5	38.1		47.1	49.9		5.1	4.0	
116.3	51.1		39.3	47.9		4.7	6.2	
72.6	34.8		42.9	51.7		5.0	4.3	
103.4	53.8		54.3	69.2		6.6	7.7	
122.4	50.3		57.8	50.4		6.2	6.0	
65.0	58.4		46.2	75.1		5.7	6.2	
94.2	50.0		38.7	55.9		4.5	5.3	

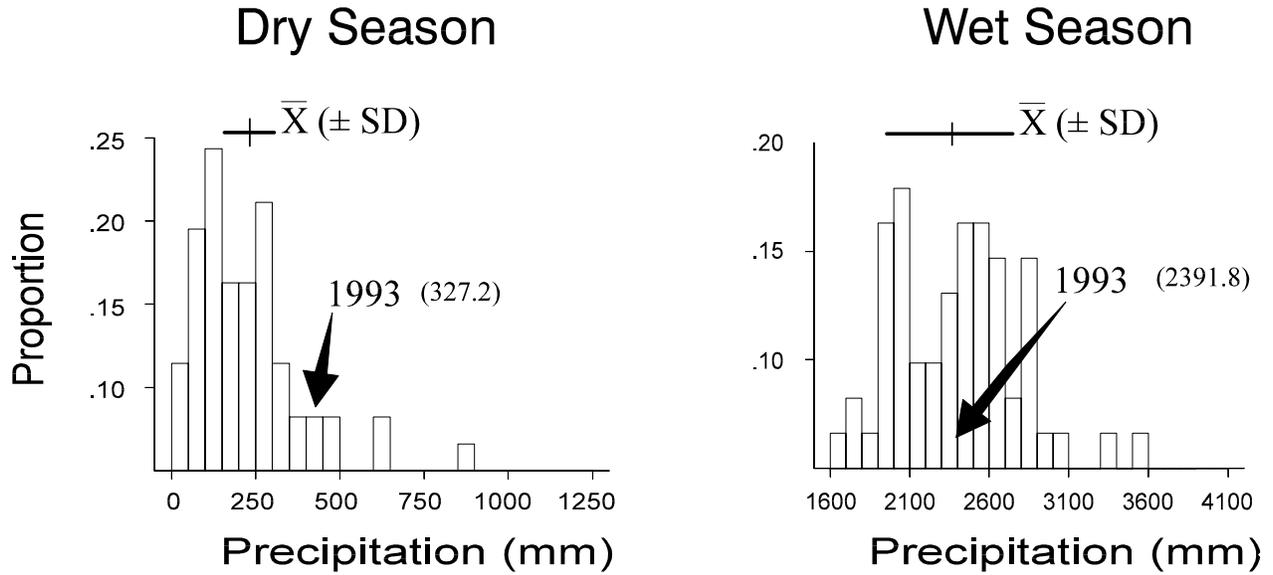
Average Monthly Storm Size



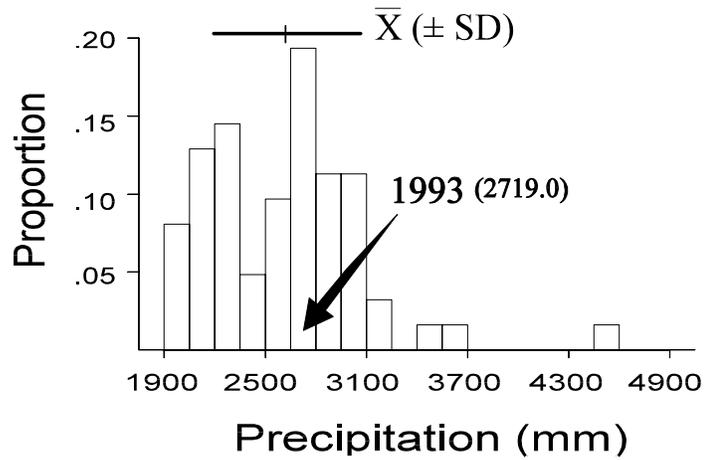
Average Monthly Storm Duration



Seasonal Distribution of Rain

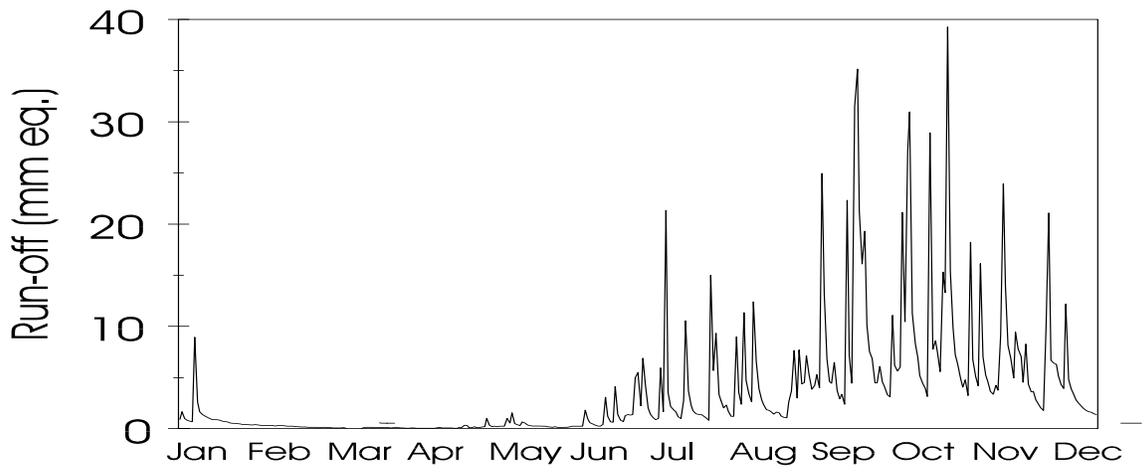


Yearly Total



Daily Lutz Weir Run-off (mm .eq.)

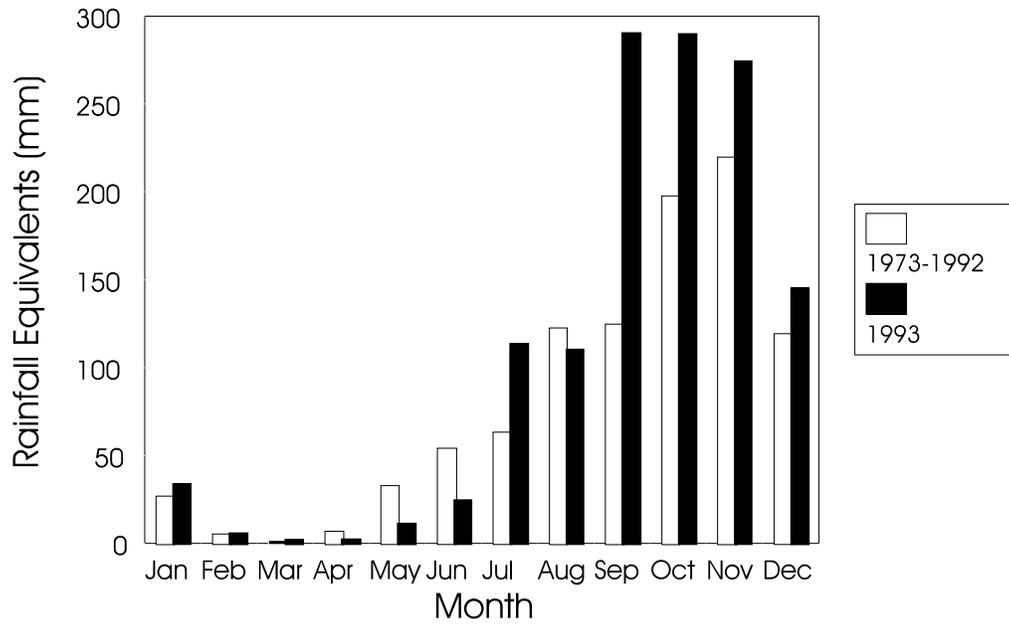
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.92	0.35	0.09	0.05	0.17	0.11	4.99	5.66	3.68	10.14	13.29	7.02
2	1.66	0.32	0.09	0.04	0.19	0.13	5.47	9.33	7.66	7.53	39.25	4.54
3	0.96	0.30	0.08	0.05	1.00	0.12	2.24	3.34	2.99	6.83	15.40	8.25
4	0.80	0.28	0.08	0.06	0.33	0.13	6.86	2.72	7.68	4.47	9.84	4.33
5	0.71	0.29	0.06	0.03	0.20	0.21	4.11	2.03	4.36	4.46	7.22	3.61
6	0.68	0.29	0.07	0.04	0.22	0.24	1.99	2.30	4.50	6.10	6.31	3.67
7	8.95	0.28	0.09	0.03	0.19	0.24	1.43	1.70	7.12	4.56	4.94	2.83
8	2.58	0.25	0.04	0.03	0.23	0.24	1.09	1.19	5.21	4.08	4.05	2.37
9	1.66	0.28	0.00	0.03	0.24	0.23	0.89	1.20	3.85	3.35	4.76	2.03
10	1.41	0.28	0.00	0.04	0.22	0.22	1.00	8.96	4.20	3.11	3.24	1.79
11	1.22	0.29	0.00	0.03	1.00	1.82	5.91	3.56	5.27	11.07	18.20	9.83
12	1.09	0.26	0.00	0.03	0.55	0.95	1.64	2.40	3.99	6.19	6.75	21.08
13	0.97	0.23	0.00	0.05	1.57	0.59	21.35	11.35	24.94	5.64	5.07	6.68
14	0.88	0.24	0.00	0.12	0.49	0.45	3.52	4.73	13.17	6.01	4.17	6.41
15	0.89	0.22	0.08	0.06	0.40	0.33	2.17	3.44	6.79	21.15	16.14	6.28
16	0.87	0.19	0.14	0.06	0.31	0.27	1.85	2.63	4.58	10.45	7.02	5.16
17	0.81	0.18	0.13	0.06	0.65	0.23	1.63	12.40	4.43	27.04	5.22	4.32
18	0.73	0.17	0.12	0.08	0.54	0.41	1.17	6.57	6.49	30.98	4.68	3.90
19	0.70	0.17	0.11	0.06	0.36	3.07	0.97	3.89	3.73	11.26	3.64	12.19
20	0.64	0.16	0.11	0.03	0.31	1.20	2.79	2.82	2.91	8.32	3.36	4.79
21	0.56	0.14	0.09	0.03	0.26	0.66	10.56	2.35	3.37	6.93	4.23	3.88
22	0.52	0.12	0.13	0.08	0.25	0.62	3.68	1.86	2.39	5.20	3.77	3.26
23	0.51	0.13	0.11	0.10	0.26	4.10	2.26	1.79	22.33	4.45	9.13	2.80
24	0.48	0.12	0.09	0.33	0.27	1.40	1.76	1.67	7.16	3.92	23.94	2.47
25	0.44	0.11	0.10	0.29	0.24	0.81	1.47	1.44	4.44	3.13	13.93	2.20
26	0.42	0.11	0.08	0.11	0.21	0.67	1.38	1.63	31.49	28.93	8.13	1.97
27	0.40	0.12	0.09	0.09	0.18	1.25	1.35	1.52	35.13	7.73	6.82	1.79
28	0.40	0.12	0.09	0.21	0.16	1.37	1.25	1.23	21.33	8.59	4.96	1.66
29	0.37		0.09	0.11	0.14	1.33	1.06	1.09	16.09	7.46	9.44	1.58
30	0.36		0.06	0.09	0.18	1.37	0.80	1.08	19.32	5.57	7.77	1.45
31	0.38		0.06		0.14		15.01	2.59		15.30		1.36



Date
Monthly Run-off at Lutz Weir

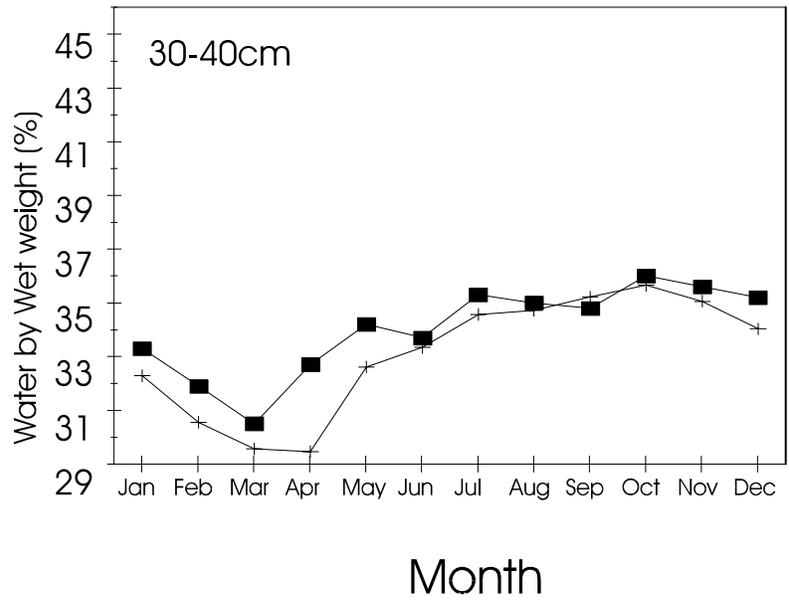
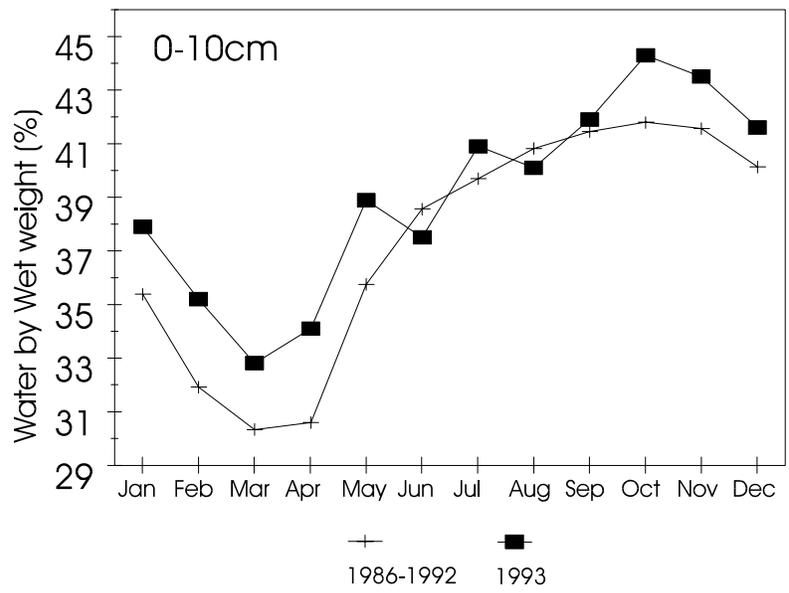
Run-off (mm eq.)

January	34.0
February	6.0
March	2.2
April	2.4
May	11.5
June	24.8
July	113.6
August	110.5
September	290.6
October	289.9
November	274.6
December	145.5
Total	1305.6



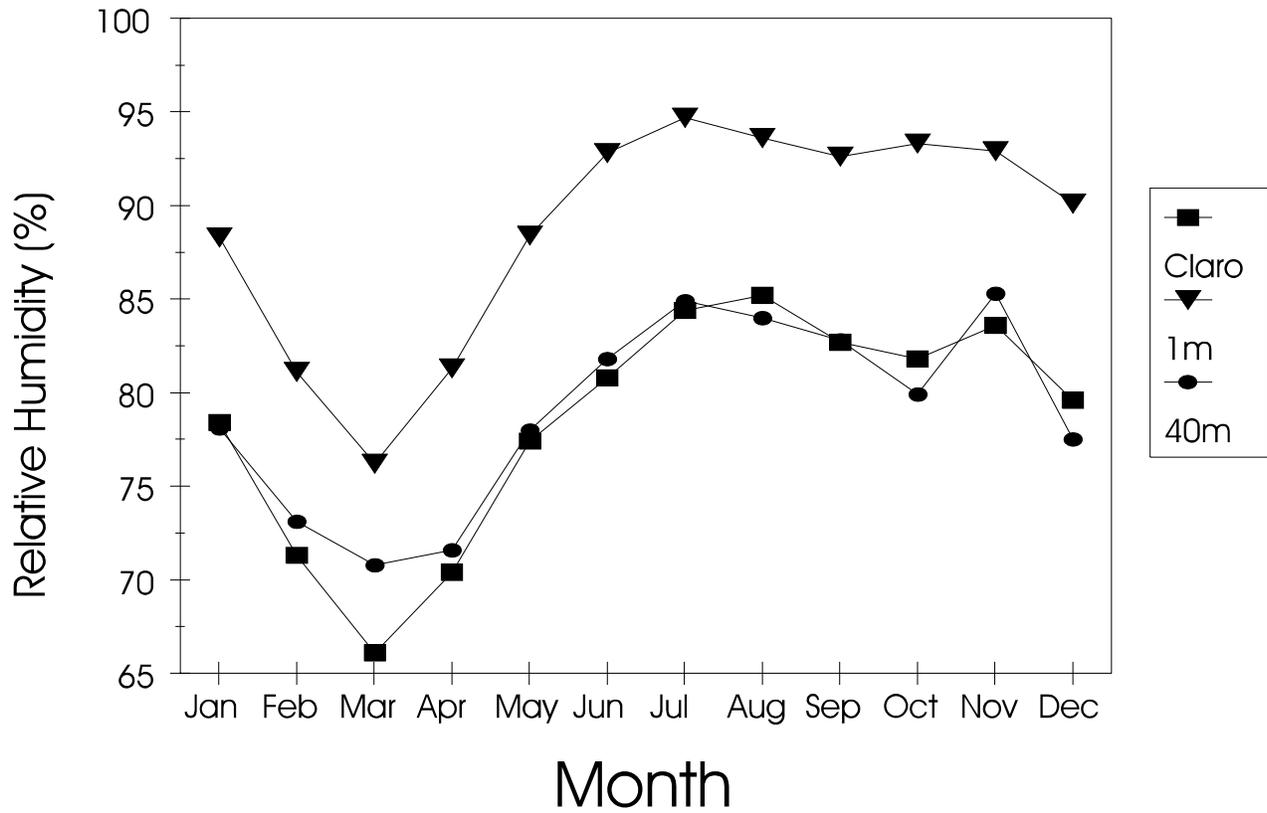
Lutz Catchment Soil Moisture

	<u>0-10 cm</u>	<u>30-40 cm</u>
January	37.9	33.3
February	35.2	31.9
March	32.8	30.5
April	34.1	32.7
May	38.9	34.3
June	37.5	33.7
July	40.9	35.3
August	40.1	35.0
September	41.9	34.8
October	44.3	36.0
November	43.5	35.6
December	41.6	35.2



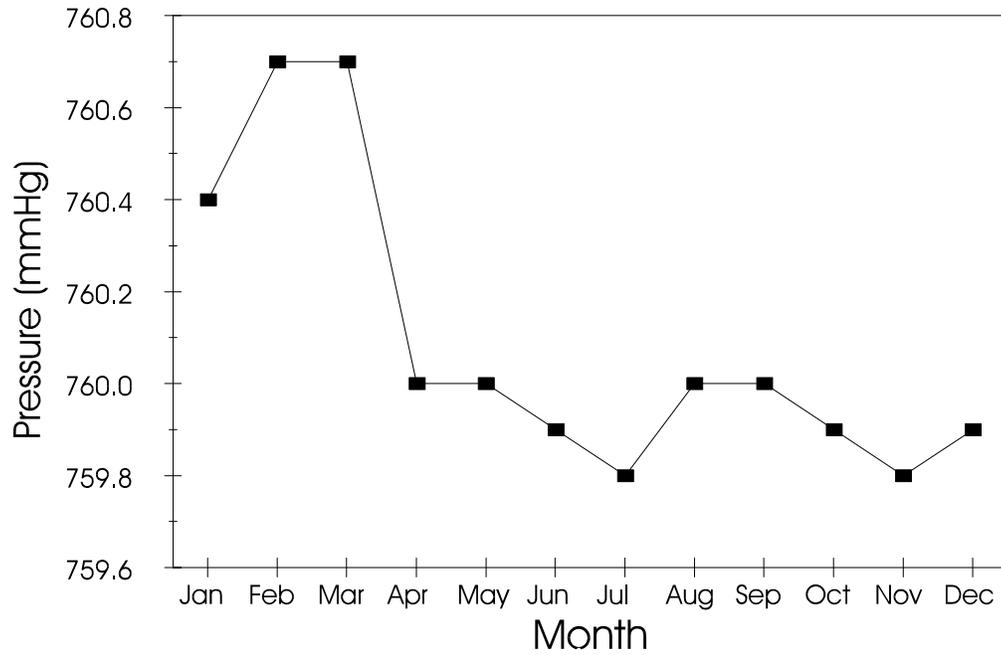
Relative Humidity (%)

	<u>Claro</u>	<u>1m</u>	<u>40m</u>
January	78.4	88.3	78.1
February	71.3	81.1	73.1
March	66.1	76.5	70.8
April	70.4	81.3	71.6
May	77.4	88.4	78.0
June	80.8	92.8	81.8
July	84.4	94.7	84.9
August	85.2	93.6	84.0
September	82.7	92.6	82.8
October	81.8	93.3	79.9
November	83.6	92.9	85.3
December	79.6	90.1	77.5



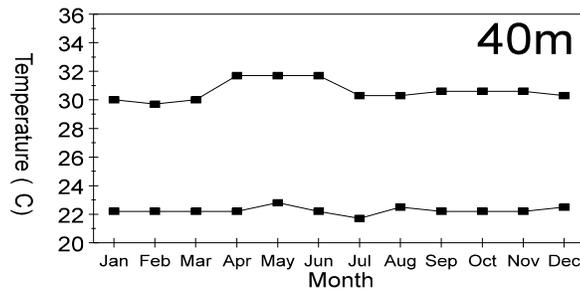
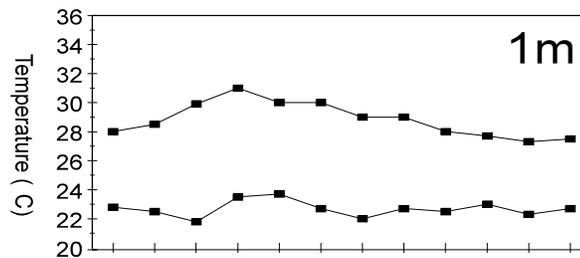
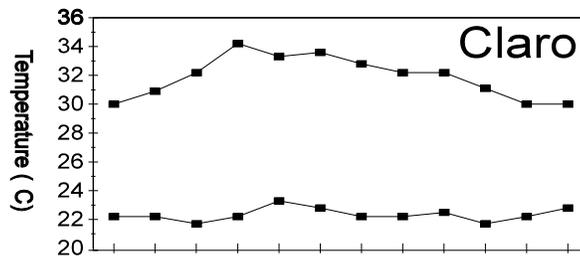
Average Monthly Air Pressure (mm Hg)

January	760.4
February	760.7
March	760.7
April	760.0
May	760.0
June	759.9
July	759.8
August	760.0
September	760.0
October	759.9
November	759.8
December	759.9



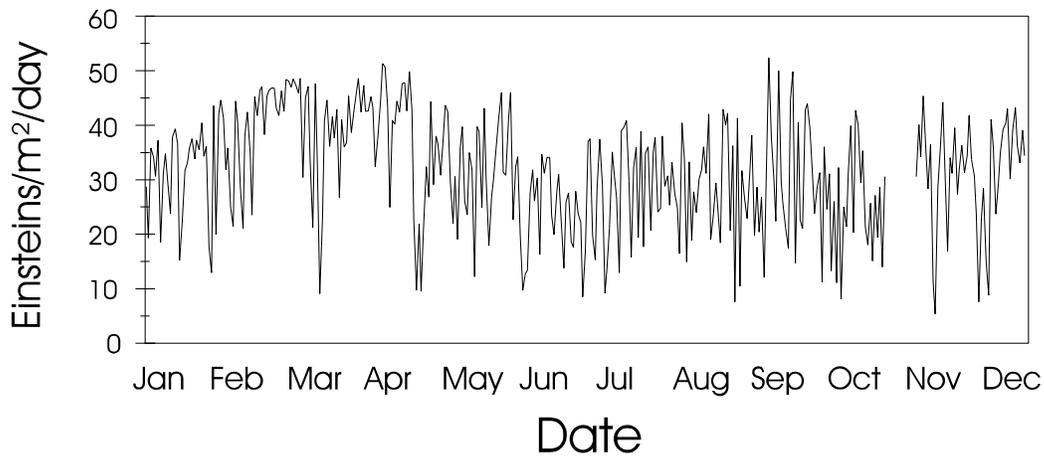
Temperature Maximum & Minimum (°C)

	Claro		1m		40m	
	<u>Max</u>	<u>Min</u>	<u>Max</u>	<u>Min</u>	<u>Max</u>	<u>Min</u>
January	30.0	22.2	28.0	22.8	30.0	22.2
February	30.9	22.2	28.5	22.5	29.7	22.2
March	32.2	21.7	29.9	21.8	30.0	22.2
April	34.2	32.2	31.0	23.5	31.7	22.2
May	33.3	33.3	30.0	23.7	31.7	22.8
June	33.6	32.8	30.0	22.7	31.7	22.2
July	32.8	22.2	29.0	22.0	30.3	21.7
August	32.2	22.2	29.0	22.7	30.3	22.5
September	32.2	22.5	28.0	22.5	30.6	22.2
October	31.1	21.7	27.7	23.0	30.6	22.2
November	30.0	22.2	27.3	22.3	30.6	22.2
December	30.0	22.8	27.5	22.7	30.3	22.5



Daily Total PAR

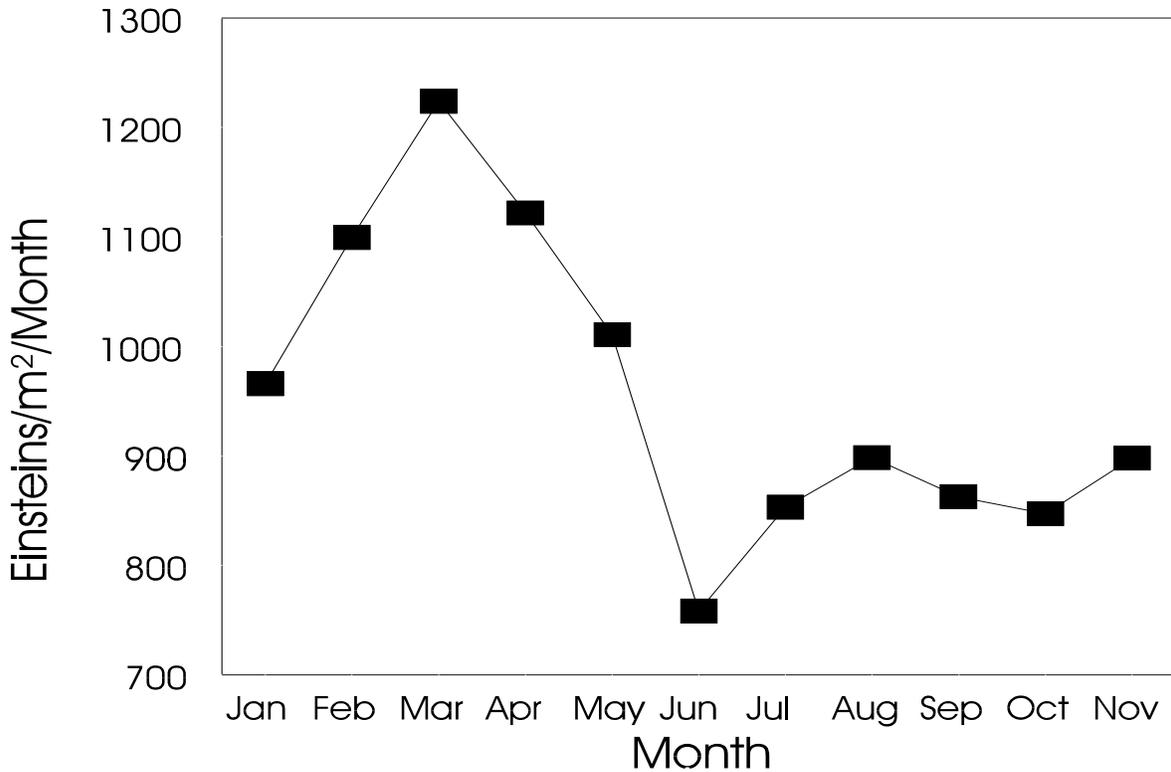
	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>
1	28.7	44.6	48.1	47.3	38.0	46.0	8.5	24.1	36.2	42.8	28.6	31.2
2	19.3	41.3	47.0	42.5	36.6	22.7	17.0	24.8	7.6	43.9	14.0	39.5
3	35.8	31.8	48.5	42.6	30.8	32.3	37.0	38.0	41.3	39.5		27.3
4	34.1	35.8	47.4	45.2	37.5	34.2	37.5	28.8	10.5	31.7		31.8
5	30.6	24.9	45.9	43.3	43.7	19.7	19.9	30.7	31.7	23.8		36.3
6	37.2	21.4	48.6	32.4	42.4	9.7	15.3	25.3	26.5	28.4		31.3
7	18.5	44.4	30.4	37.9	29.6	12.8	28.2	33.2	22.9	31.3		34.4
8	31.1	40.5	45.1	44.7	21.9	13.4	37.4	27.6	31.5	11.2		41.8
9	34.8	28.6	47.1	51.3	30.6	27.6	29.0	24.8	38.2	36.0		33.7
10	29.2	21.1	33.6	50.6	19.1	31.8	9.2	16.4	19.8	24.6		30.7
11	23.8	38.0	21.2	43.4	35.8	26.1	13.5	40.4	28.6	31.1		23.8
12	37.8	42.4	47.6	24.9	39.7	30.3	21.1	33.6	20.4	13.3		7.6
13	39.3	34.8	33.5	40.8	26.1	16.3	35.1	14.9	26.8	26.0		22.8
14	36.6	23.5	9.1	40.2	23.6	34.7	31.4	33.3	12.1	11.1		28.4
15	15.2	45.2	23.0	44.4	35.0	31.2	26.6	18.9	29.3	32.2		15.0
16	22.3	41.8	40.8	42.4	31.8	34.1	12.9	27.8	52.3	8.1		8.8
17	31.7	46.4	44.6	47.6	12.2	34.0	39.0	24.0	37.7	25.0	40.1	41.1
18	33.2	47.1	36.1	47.8	39.7	23.4	39.6	30.1	30.1	21.4	34.2	36.0
19	35.8	38.3	41.6	42.6	38.8	19.9	40.8	31.8	22.4	31.2	45.4	23.7
20	37.5	45.3	37.6	49.8	24.9	28.0	29.7	36.0	50.0	39.9	35.1	29.3
21	33.8	46.4	42.9	42.6	43.1	31.0	15.8	31.2	29.5	20.3	28.3	34.9
22	37.2	46.8	26.7	22.9	29.9	21.9	32.2	42.0	25.5	42.7	36.5	39.2
23	35.5	46.8	41.0	9.7	17.9	13.8	35.9	19.0	21.1	40.1	11.3	40.3
24	40.4	43.2	36.0	21.9	26.9	25.9	19.4	23.3	17.4	29.4	5.4	43.0
25	34.3	41.8	36.8	9.6	29.8	27.6	38.9	29.4	44.7	35.3	28.6	30.1
26	36.1	46.3	45.4	21.5	35.7	18.6	17.7	24.7	49.8	21.4	35.5	39.1
27	17.7	42.5	38.6	32.4	41.1	17.6	34.9	18.4	14.7	18.0	44.2	43.2
28	12.9	48.4	42.8	26.8	46.0	27.9	36.0	42.9	40.5	25.7	32.1	36.2
29	43.6		46.0	44.3	31.4	23.7	20.7	40.1	22.6	15.1	16.9	33.1
30	19.9		48.6	29.1	30.8	22.2	35.0	42.2	21.1	27.1	34.0	39.0
31	42.0		42.4		40.8	37.8	20.7		19.4		34.4	



Total Monthly Solar Radiation

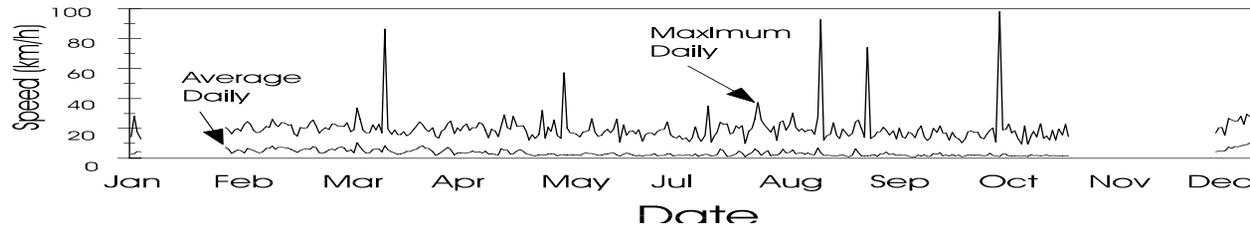
	Pyranometer	Photosynthetically Active Radiation
	(Wh/m²)	(Einsteins/m²)
January	125659.5	965.92
February	154834.5	1099.47
March	171971.1	1223.68
April	157487.9	1122.19
May	143201.3	1011.02
June	108252.5	758.20
July	124150.7	853.16
August	125002.0	898.68
September	106910.0	862.82
October	116984.5	847.28
November	109751.0*	897.80*
December	124499.4	986.90

* Estimates



Daily Average and Maximum Wind Speed

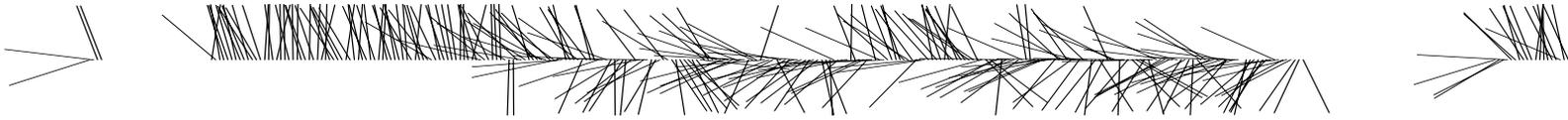
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec									
1	2.8	14.2	7.3	20.6	7.1	21.7	5.6	19.4	5.5	20.6	2.7	18.0	1.3	14.2	3.0	20.8	2.9	18.2	2.0	16.3	
2	3.1	28.3	6.0	19.0	3.6	16.8	6.0	21.8	2.8	19.4	3.0	19.3	2.0	11.4	3.4	18.3	1.9	12.9	3.5	18.8	
3	4.6	17.7	3.3	16.2	3.5	19.0	7.7	24.3	2.9	28.2	3.4	17.0	2.7	15.3	3.7	19.8	2.3	20.2	2.0	20.3	
4	4.4	13.0	4.5	19.0	4.0	20.5	8.2	22.5	5.0	21.4	3.6	19.5	2.6	35.0	2.7	17.8	1.9	14.4	1.5	10.8	
5			5.4	19.8	5.7	19.3	6.6	19.4	5.9	21.4	2.2	26.1	1.4	10.6	3.5	18.7	2.2	13.4	1.2	97.9	
6			5.2	18.2	6.3	23.0	6.6	17.8	4.7	21.9	1.5	10.8	1.8	14.7	2.5	19.1	1.4	17.3	2.9	18.9	
7			3.5	22.6	5.5	22.8	4.5	20.5	2.9	17.9	2.8	22.5	2.4	17.5	2.4	16.0	1.1	16.7	2.6	19.3	
8			6.7	24.7	7.2	21.4	1.9	14.7	2.5	12.3	3.6	15.4	6.3	24.0	6.8	27.5	1.0	13.7	1.7	23.0	
9			6.0	22.8	7.4	21.3	2.8	13.5	2.1	15.9	3.0	18.0	5.3	22.8	3.7	92.7	2.1	19.0	1.4	17.1	
10			5.4	18.8	6.9	21.3	4.3	18.1	1.4	13.3	2.3	18.4	1.3	23.1	1.9	12.2	1.4	21.8	1.4	18.4	
11			4.3	17.1	4.4	23.8	5.6	19.3	2.5	15.9	1.5	16.3	1.3	16.2	1.9	15.1	2.4	14.5	1.5	13.2	
12			3.6	17.3	5.7	17.8	7.3	23.1	2.2	32.0	2.0	19.1	2.1	16.9	2.0	16.1	1.3	11.8	1.2	9.6	
13			4.2	18.7	3.6	19.1	5.8	24.9	2.2	13.4	1.3	11.3	2.9	21.8	1.4	23.8	1.3	13.7	1.6	21.8	
14			6.7	21.3	10.0	33.7	2.4	16.5	2.8	20.7	2.1	15.8	4.9	20.0	1.6	15.4	3.3	20.0	1.2	9.4	
15			6.7	20.5	7.7	26.3	3.3	20.5	2.8	17.9	1.9	16.9	3.6	21.8	2.0	13.2	2.7	17.3	2.4	14.5	
16			8.2	26.0	5.3	18.7	3.6	18.4	3.0	25.6	2.1	16.9	0.9	9.8	2.2	19.7	3.8	21.8	1.9	17.9	
17			6.0	22.8	3.5	17.1	3.7	21.5	1.7	15.3	3.2	15.6	2.8	18.1	1.51	17.2	1.7	16.9	2.0	14.3	
18			7.3	21.0	3.6	17.0	3.6	23.0	2.5	13.3	1.5	18.0	3.8	20.1	1.0	14.7	2.3	17.0	1.7	23.1	
19			7.3	23.9	5.9	22.4	4.0	18.5	2.5	57.1	1.9	19.1	6.3	26.5	2.1	16.8	1.5	12.2	1.9	13.2	
20			7.1	23.6	6.2	19.0	4.8	20.5	2.0	20.4	2.0	19.2	4.8	37.2	6.6	24.4	2.6	17.3	2.3	14.9	
21			6.7	22.1	6.3	22.8	3.9	20.3	2.4	17.1	2.9	24.3	1.9	25.5	3.7	25.5	1.7	14.4	1.5	12.1	
22			5.8	22.5	4.2	17.1	4.4	23.9	2.1	16.8	3.0	15.9	3.6	22.5	1.8	19.7	2.1	13.0	1.9	18.7	
23			5.0	16.4	8.4	86.4	3.6	23.0	2.4	16.1	1.5	14.3	5.1	19.6	1.7	14.0	1.1	10.4	1.6	12.1	
24			3.8	14.9	5.7	19.7	4.8	18.6	1.8	14.2	1.8	13.6	1.7	17.4	1.7	74.0	1.4	13.0	1.6	19.7	
25			5.4	20.6	4.3	16.0	3.0	13.7	3.0	17.4	2.1	15.1	2.5	21.5	1.8	13.2	2.4	17.8	1.6	15.6	
26			5.9	20.2	3.6	19.0	3.0	19.4	3.6	18.0	1.8	12.8	1.9	11.8	2.5	14.6	2.1	18.1	1.8	22.8	
27			6.5	20.3	2.6	15.8	2.5	18.1	3.3	18.6	2.2	13.6	3.3	24.1	1.2	17.5	2.0	17.3	1.6	14.5	
28			5.8	23.7	3.1	16.0	2.2	14.5	3.3	26.4	2.3	11.1	6.0	24.8	3.1	17.8	2.3	17.3		8.7	31.5
29			7.9	25.7	3.5	17.8	6.5	21.7	2.7	17.5	1.7	13.6	3.5	18.8	3.0	20.8	1.9	13.8		5.9	25.2
30					4.6	15.1	5.4	29.0	2.0	14.8	2.9	21.0	3.9	22.8	4.2	18.8	1.6	13.0		5.9	25.2
31	7.3	20.7			4.6	16.3			2.1	15.4			5.6	30.3	2.5	15.5				8.1	24.8



Average Daily
Wind Direction

Average Daily

	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>
1	242.5	5.7	0.6	353.4	343.4	99.9	172.4	345.7	292.5	151.2		
2	280.8	323.8	347.5	354.7	318.7	322.9	166.6	326.1	204.3	313.3		
3	346.7	354.1	338.2	0.3	195.3	339.8	178.4	345.8	327.0	317.4		
4	346.6	349.6	342.4	359.5	334.9	326.4	306.2	337.2	270.9	233.2		
5		347.9	341.2	353.7	350.8	298.7	216.3	334.1	184.5	245.4		
6		349.7	5.2	8.7	347.4	233.4	251.3	318.2	206.3	298.0		
7		351.9	339.8	349.3	241.5	247.7	259.2	317.2	158.3	244.0		
8		345.7	356.1	291.4	273.9	281.9	0.6	343.3	198.4	220.3		
9		345.9	2.5	322.3	299.2	232.6	346.4	245.9	344.6	281.1		
10		349.8	351.7	343.0	198.1	301.7	233.7	148.5	310.0	242.5		
11		338.3	344.7	359.1	179.7	242.1	232.8	140.4	302.5	272.6		
12		340.2	355.9	358.2	225.0	274.7	209.9	227.8	181.2	207.4		
13		348.5	348.6	358.7	202.1	195.3	266.6	238.1	271.5	187.5		243.5
14		2.3	3.0	311.0	183.2	306.7	351.2	184.0	208.1	197.1		225.9
15		0.5	2.0	181.0	218.1	310.9	305.0	226.9	148.2	216.2		230.5
16		355.0	351.9	179.7	335.1	11.2	265.8	271.2	133.1	197.8		275.1
17		8.4	348.2	327.1	252.6	262.6	326.1	240.1	131.8	201.7		328.2
18		359.4	353.6	285.1	221.0	238.9	346.9	219.4	200.8	211.9		325.4
19		359.2	350.8	316.9	271.1	230.3	351.5	304.9	170.3	254.3		350.1
20		351.4	355.6	349.0	188.4	162.2	347.8	354.0	268.3	306.0		338.0
21		359.4	357.2	335.3	200.4	286.7	324.0	356.8	306.5	261.6		344.3
22		0.4	339.9	328.5	233.5	222.3	314.2	251.0	227.0	228.6		346.2
23		349.7	3.6	311.1	334.1	209.3	336.1	235.4	230.8	247.9		4.9
24		347.4	350.3	294.5	314.0	249.0	211.3	234.8	231.3	229.9		2.0
25		0.6	349.5	327.6	157.3	277.7	261.6	251.9	280.6	203.1		359.4
26		348.3	334.3	319.3	174.5	240.1	256.6	262.4	291.5	196.0		353.4
27		1.6	312.9	251.4	159.4	221.0	330.8	207.5	202.3	163.1		342.5
28		8.4	344.0	262.7	151.7	202.8	353.4	326.7	231.2			345.3
29			352.5	351.8	145.7	249.8	332.3	311.0	196.8			304.2
30			348.4	340.5	163.3	219.0	348.0	336.8	181.8			352.4
31	345.7		352.1		153.3		3.3	220.0				344.3



Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec



Average Monthly Wind Speed and Direction

	<u>Speed (km/h)</u>	<u>Direction (°)</u>
January	4.48	325.1
February	5.76	353.3
March	5.35	350.4
April	4.64	340.4
May	2.91	212.8
June	2.38	258.3
July	3.26	315.7
August	2.73	291.9
September	2.03	210.8
October	2.77	221.4
November*		
December	5.05	356.3

* Anemometer failure - no data available

