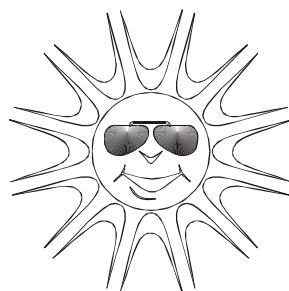


Smithsonian Tropical Research Institute

2003 Meteorological and Hydrological  
Summary for  
Barro Colorado Island

Prepared by: Steven Paton



## Introduction

This is the tenth of a series of yearly reports summarising the past year's Smithsonian Tropical Research Institute's Terrestrial-Environmental Sciences Program (T-ESP) Meteorological and Hydrological Monitoring Program on BCI. 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 Climate 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 ( $9^{\circ}10'N$ ,  $79^{\circ}51'W$ ) is a completely forested, 1567 ha island with a 53.9 km perimeter, rising 137m above Lake Gatun. The island receives an average of 2632 mm of rain per year. The meteorological year is divided into two parts: a pronounced dry season (approximately from mid-December to the end of April), and a wet season (May to mid-December). On average, only 293 mm of rain falls during the dry season. Relative humidity, soil moisture, air pressure, solar radiation, evapotranspiration, wind speed and direction all show marked wet/dry season differences. On the other hand, temperature varies relatively little throughout the year.

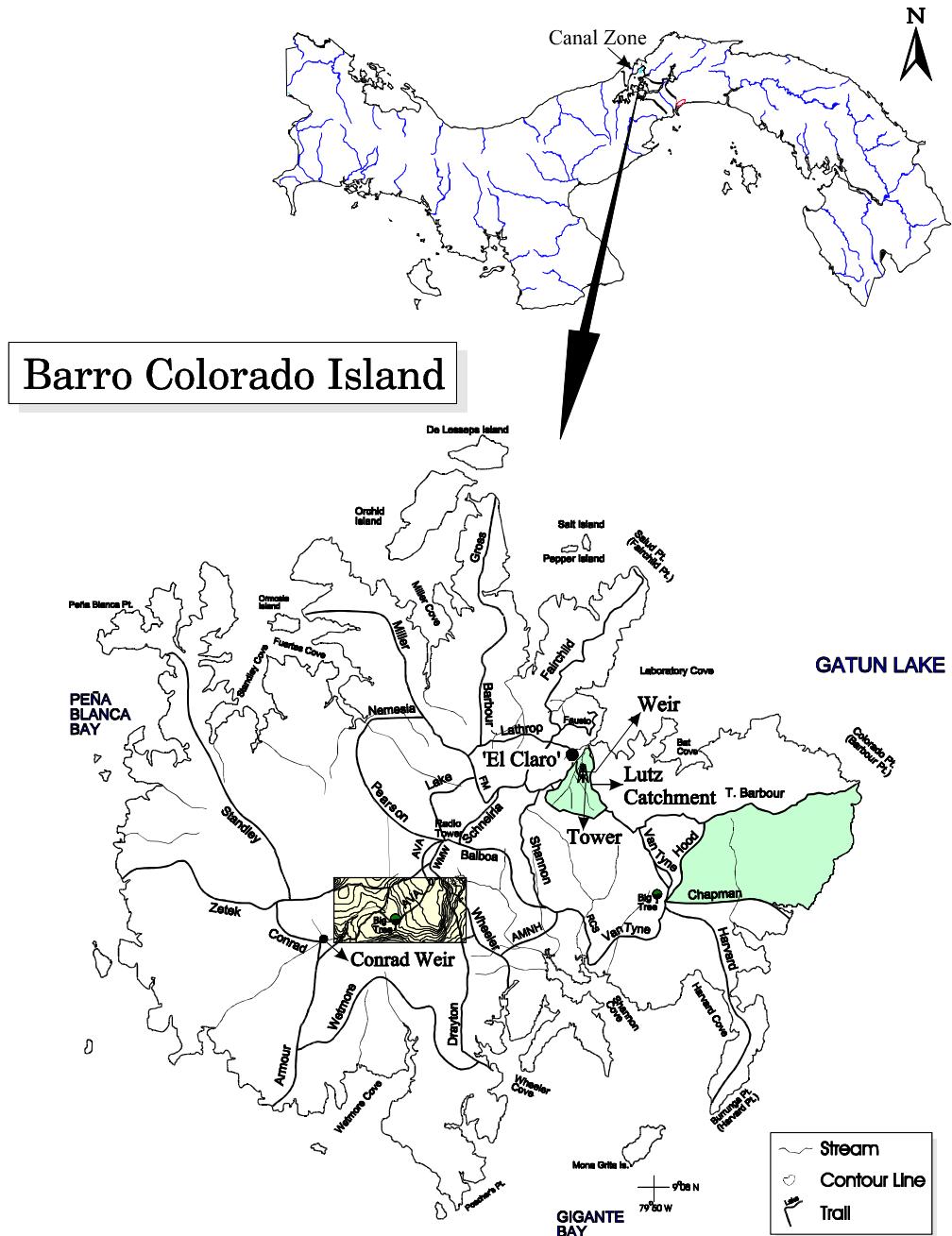
This report summarises data taken from two locations: a 48 m walk-up tower located within the Lutz catchment, and a small clearing ('El Claro') located among several laboratory buildings (see map on the following page). The tower, with sensors at 10 m intervals, provides a vertical meteorological transect through the forest canopy. The Lutz catchment, located on the Northeast slope of BCI, and is probably typical of many small catchment areas on the island. The catchment encompasses 9.73 ha. The Lutz catchment is located immediately southwest of the laboratory clearing and dormitory area. The Clearing is a grass-covered area located near several laboratory buildings.

The physical aspects of both the Clearing and the Tower have changed relatively little over time. However, cycles of vegetation removal and re-growth may have had subtle effects at both locations. The recent removal and construction of buildings near to the Clearing may also have affected the local climate. Furthermore, it is evident that the canopy surrounding the Tower has risen, perhaps by as much as 5m, since the Tower was erected – with possible measurement implications, especially at the highest levels.

In October of 2002, three new, 6-foot sections were added to the top of the tower. It was necessary to remove many banches from trees next to the tower during this operation. The new maximum height of the tower is now approximately 48m. A parallel series of meterological measurements are now being made a both the old maximum height and the

new. The exceptions to this will be: wind direction (it's now not possible to measure at the old height), and solar radiation (assumed to be unaffected by the change in height).

Data were collected using two different methods: electro-mechanically (electronic sensors, data loggers, chart recorders, etc.), and manually (rain gauges, max-min thermometers, sling psychrometers, soil samples, ETGages) by a technician - Mr. Raúl Ríos. 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 in this report. Some of the disadvantages of these measurements are that they are not available for every day, and they are usually taken only once a day (once a week for soil samples).



Some summaries (temperature, relative humidity, and soil humidity) are based entirely on manual measurements. Other summaries (solar radiation, wind direction) are based entirely on electro-mechanical measurements. Finally, some summaries (rainfall and wind speed) are based on combinations of manual and electro-mechanical measurements.

## The Data

This report summarises the following data:

<b>Lutz Tower</b>	1m	relative humidity temperature
	40m	evapotranspiration relative humidity temperature wind speed and direction
	48m	evapotranspiration solar radiation relative humidity temperature wind speed and direction
<b>Lutz catchment</b>		run-off soil moisture
<b>'El Claro'</b>		evapotranspiration rainfall relative humidity temperature

### 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 every day except weekends and 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 recorded by the tipping bucket. 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 8.

Page 9 shows the monthly totals for this year. The graph on the same page compares this year's monthly totals with the average monthly totals ( $\pm SD$ ) for the period 1929 to 2002.

Page 10 shows yearly rainfall totals for all year since 1925. Time series graph and frequency histograms are presented for these data.

Page 11 breaks yearly rainfall approximately into wet and dry seasons. The average beginning and end dates for the seasons as defined by the PCC (Dec. 20 and May 2) were used. The two graphs on this page are frequency histograms showing the distribution of rainfalls (1929 to 2002) for the Dry and Wet Seasons. The arrow → in each graph shows the rainfall for 2003 in relation to previous years. The small crossbar —+— above each graph represents the mean (vertical bar) and the standard deviation (horizontal bar) for the period 1929 - 2002.

Page 12 shows the beginning and end dates of the Panama Canal watershed dry season as defined by the Meteorological and Hydrological Branch of the Panama Canal Authority (PCA). The PCA defines the existence of dry season by tracking 11 variables (see list below). There are no publications justifying the use of this system and any questions should be directed to Mike Hart of the Met. & Hyd. Branch of the Panama Canal Authority. The data from Page 11 are shown graphically on Page 13.

- Westerly Component of 300 HPA Wind
- Gatun Lake Basin evaporation  $> 0.13" \text{ day}^{-1}$
- Sea temperature at Amador  $< 80^{\circ}\text{F}$
- $< 5 \text{ grams of water vapor kg}^{-1}$  below 12.0 ft
- Temp-Dew point difference SFC-400 HPA.,  $> 10^{\circ}\text{C}$
- Howard Airforce Base wind speed SFC-4000 ft.,  $> 15 \text{ knots}$
- Inter-Tropical Convergence Zone  $> 2 \text{ deg. Lat. south of Panama}$
- Pacific Coast sea breeze  $< 2 \text{ hours day}^{-1}$
- Atlantic Coast surface wind average  $> 6.0 \text{ M.P.H.}$
- Gatun Lake level (corrected for water usage) falling
- Gatun Watershed daily rainfall average (of 26 stations)  $< .25"$

Pages 14 and 15 show 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 an estimate 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 2002 and for the year 2003.

## **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 two separate instruments: continuously by a Stevens A-71 strip-chart, water level recorder and at five-minute intervals with an ISCO Bubble Flow Meter. Data from these devices are converted (either directly or through a digitizing process) into run-off ( $\text{m}^3$ ) and then into rainfall equivalents.

Daily Lutz creek weir run-off totals are shown on page 16. 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 (9.73 ha). In this way, the run-off can be more conveniently compared to the amount of rainfall.

Pages 17 show the total monthly run-off. The graph on the bottom of page 18 compares average monthly run-off for the period 1973 to 2002 with 2003. The graph on the top of page 18 compares monthly accumulated precipitation with 2003 and long-term monthly accumulated run-off (in rainfall equivalents).

## **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 19 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 2002 with those for 2003.

## **Relative Humidity**

Relative humidity was measured using the traditional method of wet and dry-bulb psychrometry. Measurements in the Clearing, at the base, middle and top of the Lutz tower (1m, 20m 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 newly installed Vaisala electronic temperature/humidity sensors. These data are not reported in this yearly summary.

The average monthly relative humidities are shown in tabular and graphical form on pages 20 and 21, respectively.

## **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 830 am. Data were also collected on an hourly basis by dataloggers attached

to Vaisala electronic temperature/humidity 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 22 and 23, respectively.

## Solar Radiation

Global solar radiation was measured at the top of the Lutz tower using a Li-Cor LI200SB pyranometer attached to a datalogger. Hourly total ( $\text{KJ m}^{-2}$ ), maximum and minimum ( $\text{J m}^{-2} \text{ s}^{-1}$ ) were recorded. A Li-Cor 190SB sensor recorded Photosynthetically Active Radiation (PAR) similarly.

Page 24 shows the Daily Global Radiation values and Page 25 shows the Daily PAR values for 2003. Page 26 shows total monthly Global Radiation and PAR.

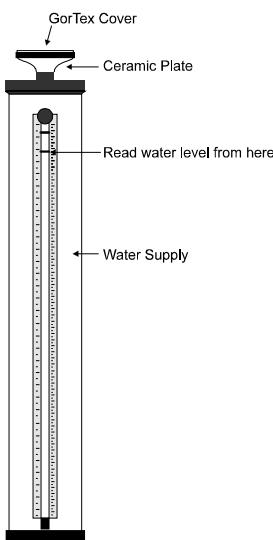
## Wind Speed and Direction

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. Total wind passage was recorded on working days at approximately 9:30 am using an analogue totalizing anemometer. This device is believed to be more accurate than the Young Anemometer, especially during periods of low wind speeds due to totalizing anemometer's lower wind-speed threshold.

Page 27 shows the total daily wind passage from 40m and 48m. Page 28 shows average and maximum daily wind speeds from the Young Anemometer located at 48m. The page 29 shows daily 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. Page 30 shows the monthly average wind speed (based on the totalizing anemometer) from 40m and 48m, and monthly average directions (Young Anemometer) for the year.

## Estimated Evapotranspiration and Water Balance

**ETguage**



Evapotranspiration was added to the meteorological program on BCI beginning on December of 1992 and is estimated using ceramic plate atmometers known as ETgages. ETgages estimate evapotranspiration by allowing water to be drawn up through a ceramic disk and out through a GorTex cover. A recent study by Fontain and Todd (Measuring Evaporation with Ceramic Bellani Plate Atmometers, 1993, Water Resources Bulletin, Vol. 29, No. 5, p. 785-795) found that such devices perform very well compared with more traditional methods of measuring evaporation.

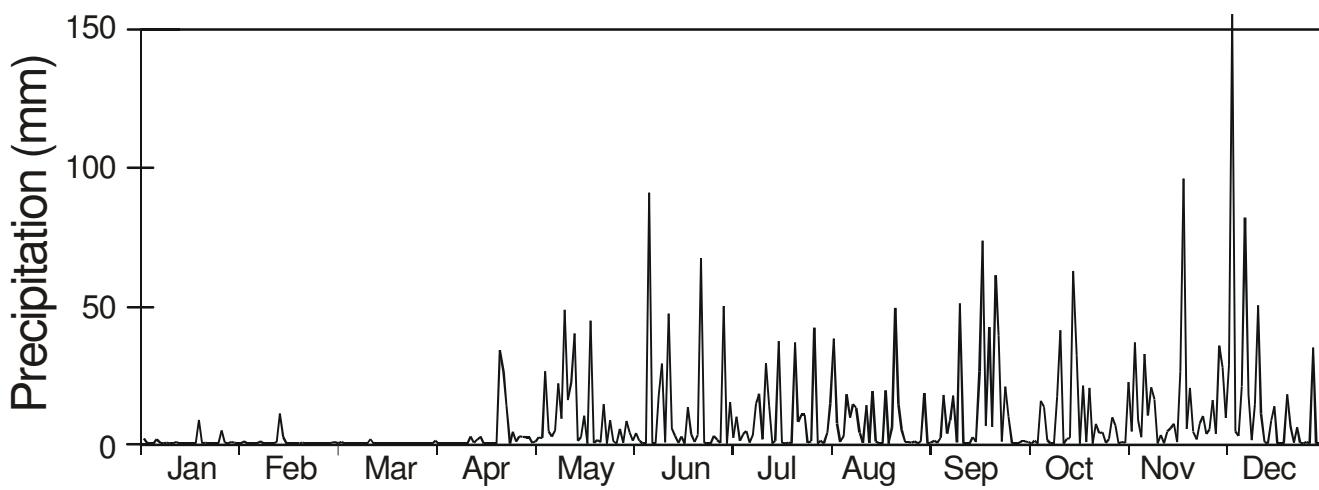
There are two ETgages currently being used on BCI: one in the Clearing located at a height of 1.5m and a second on the top of the 40m tower near the Lutz weir. ETgages are read at approximately the same time of day and with the same frequency and the rain gauges on BCI.

The data from the ETgages are used to estimate the total water balance for the Lutz catchment. Water balance is calculated as: Rainfall - Weir run-off - Evapotranspiration.

The results from the ETgages and the estimated water balance (Precipitation - (Run Off + Evapotranspiration)) for the Lutz Tower for from Nov. 1993 to the end of 2003 are given on pages 31 and 32.

## Daily Rainfall (mm) on BCI recorded at ~930 hrs

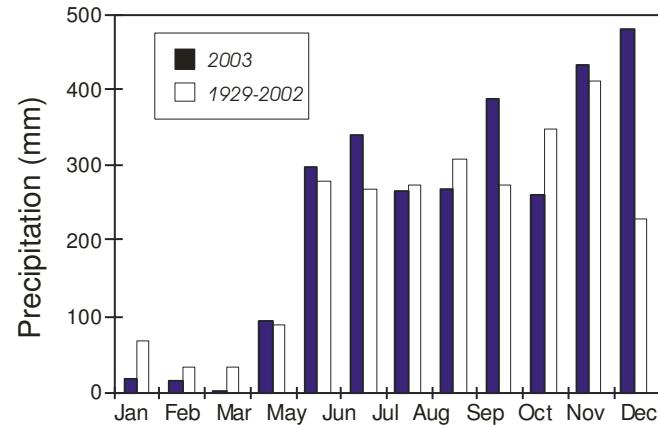
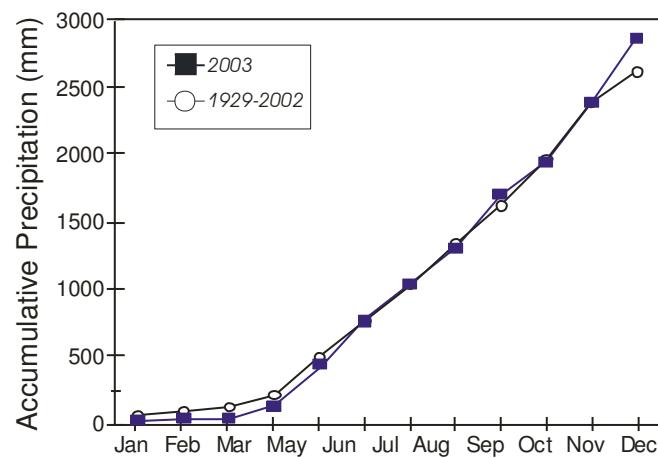
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	1.8	0.8	0.6	1.0	0.3	1.1	15.0	14.5	0.3	0.5	22.2	9.3
2	0.3	0.0	0.0	0.0	0.8	3.8	2.0	38.1	1.0	0.0	4.3	28.5
3	0.0	0.0	0.6	0.0	2.3	1.0	9.7	7.3	0.3	1.0	36.6	155.7
4	0.0	0.0	0.0	0.0	2.0	0.0	1.0	0.6	2.0	0.0	8.4	4.3
5	1.5	0.0	0.0	0.0	26.2	0.0	3.4	2.8	17.6	15.4	2.3	2.8
6	0.3	0.8	0.0	0.0	4.3	90.9	4.5	17.8	3.6	13.3	32.5	20.8
7	0.0	0.0	0.0	0.0	2.5	0.0	0.3	9.4	8.4	1.3	10.2	81.8
8	0.3	0.0	0.0	0.0	4.7	0.0	3.0	14.2	17.3	0.0	20.4	17.7
9	0.0	0.0	0.0	0.0	21.7	17.5	14.5	12.9	0.5	0.0	16.0	1.2
10	0.0	0.0	0.0	0.0	9.0	29.0	18.0	3.8	50.8	17.0	0.0	14.2
11	0.5	0.5	0.0	0.0	48.4	0.5	1.5	0.3	0.0	41.0	3.2	50.0
12	0.0	10.9	1.5	2.5	15.7	47.0	29.1	14.0	0.0	0.0	0.0	10.9
13	0.0	2.3	0.0	0.3	22.1	5.4	13.6	0.3	0.0	1.7	4.3	0.5
14	0.0	0.0	0.0	1.5	39.9	2.8	0.0	19.1	2.2	2.0	5.6	0.0
15	0.0	0.0	0.0	2.5	1.0	0.3	1.0	0.8	0.6	62.5	7.1	8.4
16	0.0	0.0	0.0	0.0	2.3	2.5	37.1	0.0	26.2	32.0	0.5	13.5
17	0.0	0.0	0.0	0.0	10.0	0.0	0.3	0.0	73.4	0.0	26.1	0.0
18	8.6	0.0	0.0	0.0	0.0	13.2	0.0	19.3	6.4	21.0	96.0	0.0
19	0.0	0.3	0.0	0.0	44.6	3.3	0.3	0.0	42.2	0.6	5.3	0.0
20	0.3	0.0	0.0	0.0	0.3	0.5	0.0	5.8	6.0	20.1	20.1	17.8
21	0.0	0.0	0.0	33.8	1.3	3.1	36.6	49.0	61.0	0.0	4.3	6.0
22	0.0	0.0	0.0	25.9	0.5	67.2	7.9	14.2	39.2	7.1	1.4	0.3
23	0.0	0.0	0.0	14.0	14.2	0.3	10.4	4.9	0.8	3.8	7.4	5.8
24	0.0	0.0	0.0	0.0	0.0	0.0	10.4	0.6	20.6	4.1	10.0	0.3
25	4.8	0.0	0.0	4.3	8.5	0.0	0.3	0.6	9.7	0.3	3.6	0.0
26	0.3	0.0	0.0	0.7	0.9	2.8	0.8	0.3	0.0	1.7	5.1	0.6
27	0.0	0.0	0.0	2.6	0.0	1.3	41.9	0.8	0.0	9.5	15.7	0.0
28	0.5	0.3	0.0	2.3	5.3	0.3	0.0	0.0	0.0	6.6	3.6	34.7
29	0.3	0.0	2.3	0.3	49.8	1.0	1.0	0.8	0.0	0.0	35.5	0.0
30	0.0	0.0	2.3	8.1	0.0	0.0	18.3	0.8	0.5	27.6	0.0	
31	0.0	0.0			4.0		4.1	0.0		0.3		0.3
	<b>19.3</b>	<b>15.7</b>	<b>2.8</b>	<b>96.0</b>	<b>301.2</b>	<b>343.4</b>	<b>267.5</b>	<b>270.5</b>	<b>391.4</b>	<b>263.1</b>	<b>435.4</b>	<b>485.3</b>



## Monthly Rainfall at 'El Claro' - Rain Guage

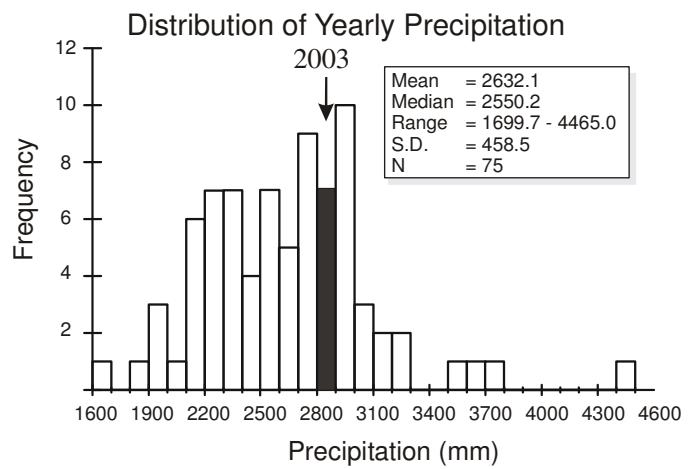
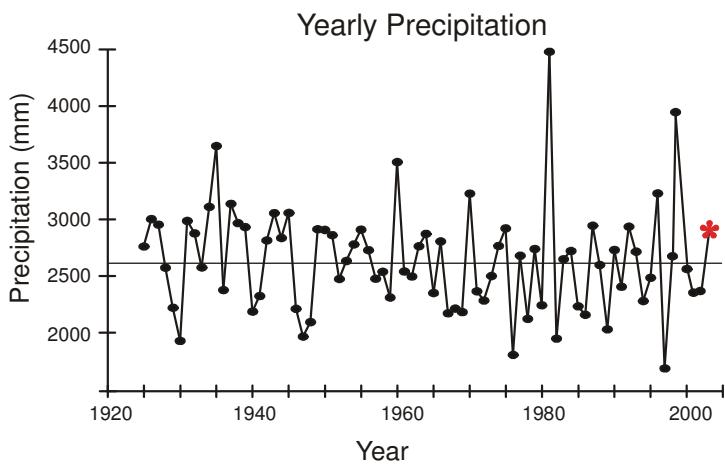
Rainfall (mm)

	Average	Min	Max	S.D.	2003	Rank (n=75)
<b>January</b>	70.8	0.0	374.0	76.3	19.3	<b>53</b>
<b>February</b>	31.7	0.5	186.4	34.1	15.7	<b>45</b>
<b>March</b>	33.3	0.0	173.7	36.4	2.8	<b>70</b>
<b>April</b>	93.6	0.0	463.8	87.0	96.0	<b>31</b>
<b>May</b>	276.6	78.5	622.0	100.3	301.2	<b>28</b>
<b>June</b>	271.2	66.8	541.0	87.8	343.4	<b>16</b>
<b>July</b>	274.7	92.0	725.9	96.5	267.5	<b>42</b>
<b>August</b>	309.5	149.6	586.0	91.8	270.5	<b>48</b>
<b>September</b>	273.3	130.8	507.0	86.1	391.4	<b>7</b>
<b>October</b>	344.9	153.9	544.0	94.8	263.1	<b>57</b>
<b>November</b>	408.6	110.0	1056.1	189.3	435.4	<b>27</b>
<b>December</b>	243.8	15.9	712.7	176.3	485.3	<b>9</b>
<b>Total</b>	<b>2632.1</b>	<b>1699.7</b>	<b>4465.0</b>	<b>458.5</b>	<b>2891.8</b>	<b>20</b>



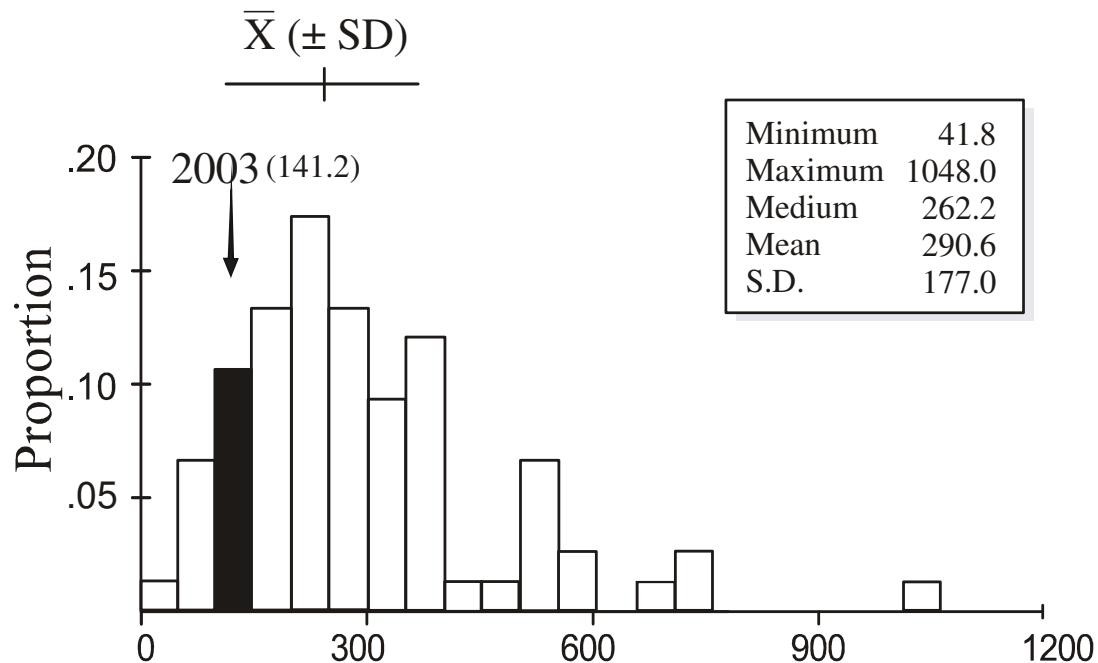
## Yearly Rainfall (mm) at 'El Claro' - Rain Gauge

Year	Rain	Year	Rain	Year	Rain
1925	2764.0	1952	2481.6	1979	2742.0
1926	3003.0	1953	2637.5	1980	2252.0
1927	2956.1	1954	2684.3	1981	4465.0
1928	2579.1	1955	2910.3	1982	1960.0
1929	2228.3	1956	2729.7	1983	2654.0
1930	1940.6	1957	2482.1	1984	2726.0
1931	2981.5	1958	2545.1	1985	2242.0
1932	2878.6	1959	2317.0	1986	2167.6
1933	2581.9	1960	3500.4	1987	2955.2
1934	3109.5	1961	2545.6	1988	2602.9
1935	3642.6	1962	2373.4	1989	2176.2
1936	2384.3	1963	2767.1	1990	2767.5
1937	3117.6	1964	2875.3	1991	2642.4
1938	2969.0	1965	2357.1	1992	3047.5
1939	2932.9	1966	2807.7	1993	2729.2
1940	2195.8	1967	2181.4	1994	2285.2
1941	2332.2	1968	2223.5	1995	2531.1
1942	2816.9	1969	2192.5	1996	3227.8
1943	3055.4	1970	3141.2	1997	1699.7
1944	2838.7	1971	2373.6	1998	2683.8
1945	3058.9	1972	2292.0	1999	3726.1
1946	2221.0	1973	2506.0	2000	2550.2
1947	1978.2	1974	2770.0	2001	2331.2
1948	2105.7	1975	2923.0	2002	2300.6
1949	2916.2	1976	1818.0	<b>2003</b>	<b>2891.8</b>
1950	2908.3	1977	2685.0		
1951	2863.8	1978	2132.0		

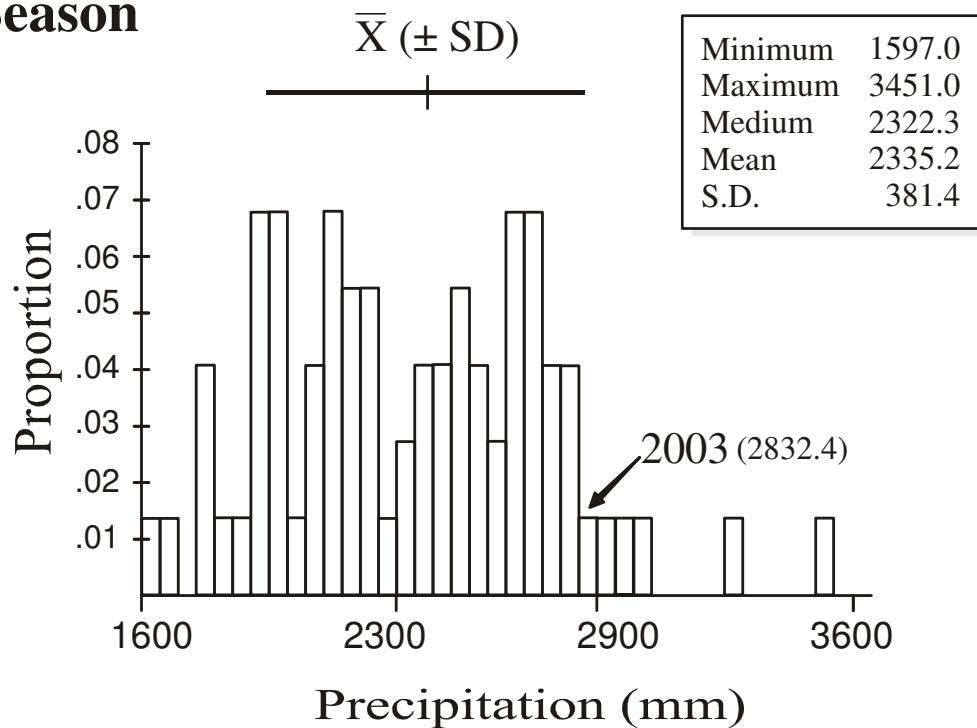


## Seasonal Distribution of Precipitation

### Dry Season



### Wet Season



## PCC Dry Season Beginning and End Dates

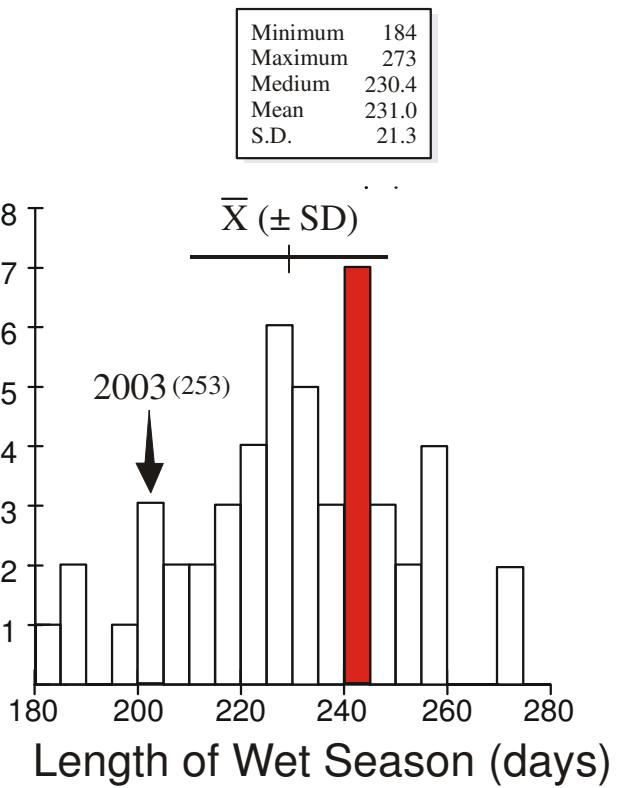
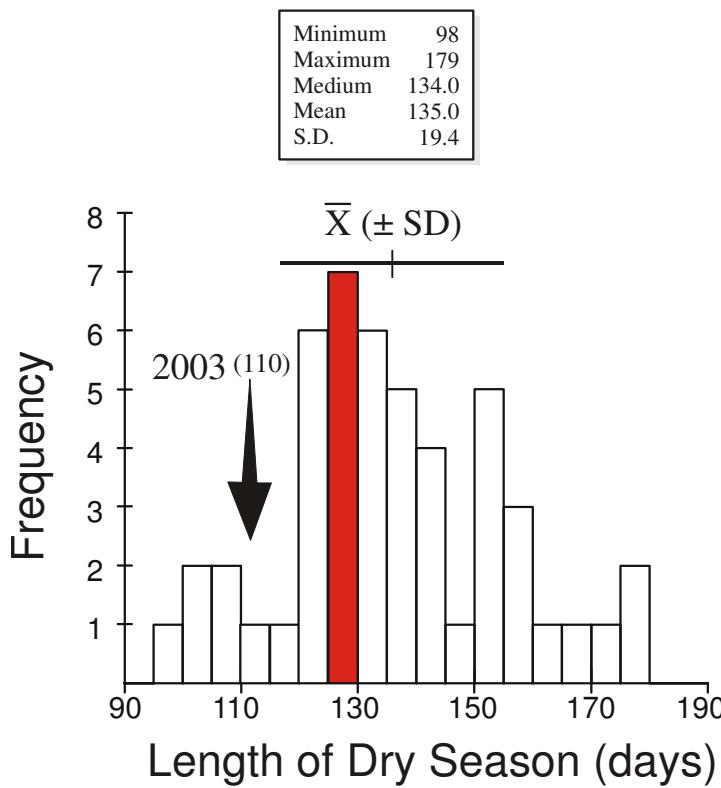
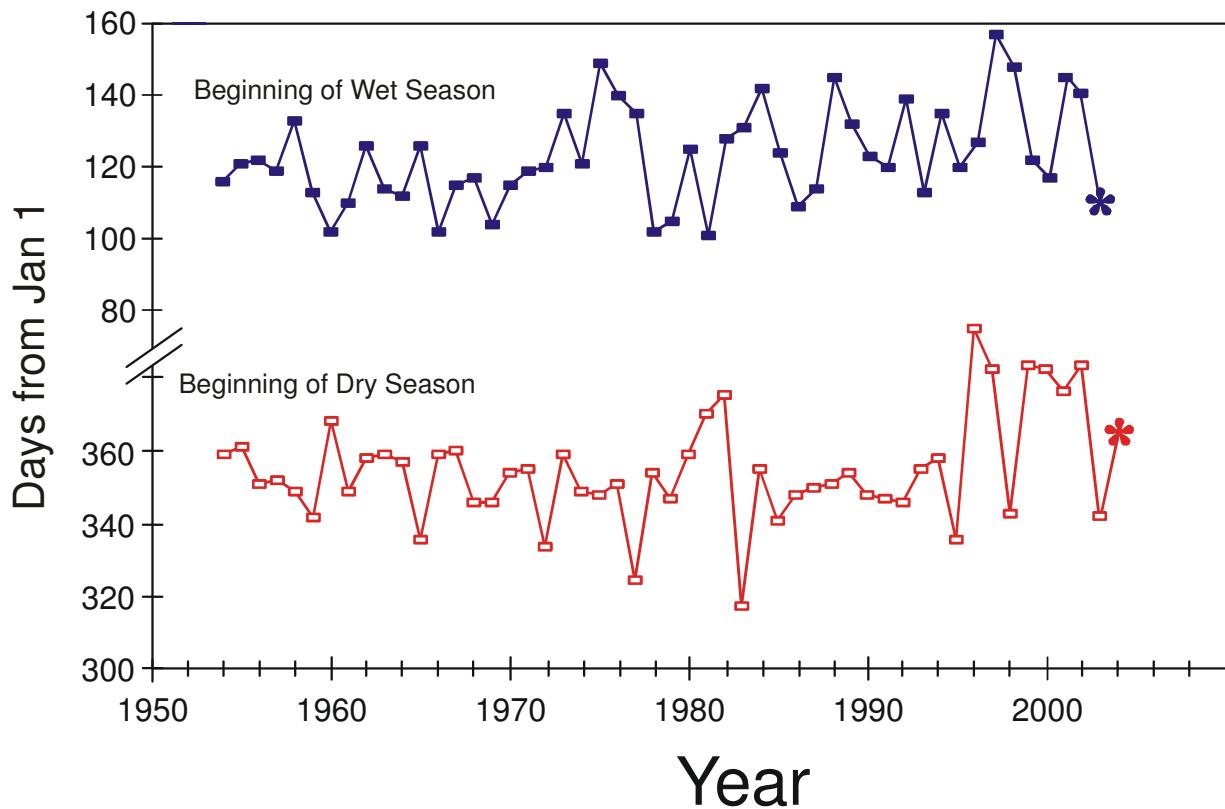
Year	Begin	End	Length		Year	Begin	End	Length		
			Dry Season	Wet Season				Dry Season	Wet Season	
1954	25-Dec-1953	27-Apr-1954	123	244		1998	09-Dec-1997	29-May-1998	171	234
1955	27-Dec-1954	02-May-1955	126	229		1999	18-Jan-1999	3-May-1999	105	259
1956	17-Dec-1955	02-May-1956	137	229		2000	17-Jan-2000	27-Apr-2000	101	258
1957	17-Dec-1956	30-Apr-1957	134	229		2001	10-Jan-2001	26-May-2001	136	237
1958	15-Dec-1957	14-May-1958	150	208		2002	18-Jan-2002	21-May-2002	123	201
1959	08-Dec-1958	24-Apr-1959	137	254		2003	08-Dec-2002	21-Apr-2003	134	253
1960	03-Jan-1960	12-Apr-1960	100	246		2004	30-dec-2003			
1961	14-Dec-1960	21-Apr-1961	128	247						
1962	24-Dec-1961	07-May-1962	134	232						
1963	25-Dec-1962	25-Apr-1963	121	243						
1964	24-Dec-1963	22-Apr-1964	120	223						
1965	01-Dec-1964	07-May-1965	157	232						
1966	25-Dec-1965	13-Apr-1966	109	257						
1967	26-Dec-1966	26-Apr-1967	121	230						
1968	12-Dec-1967	27-Apr-1968	137	228						
1969	11-Dec-1968	15-Apr-1969	125	249						
1970	20-Dec-1969	26-Apr-1970	127	239						
1971	21-Dec-1970	30-Apr-1972	130	214						
1972	30-Nov-1972	30-Apr-1972	152	238						
1973	24-Dec-1972	16-May-1973	143	213						
1974	15-Dec-1973	02-May-1974	138	226						
1975	14-Dec-1974	30-May-1975	167	201						
1976	17-Dec-1975	20-May-1976	155	184						
1977	20-Nov-1976	16-May-1977	177	218						
1978	20-Dec-1977	13-Apr-1978	114	244						
1979	13-Dec-1978	16-Apr-1979	124	253						
1980	25-Dec-1979	05-May-1980	132	244						
1981	04-Jan-1981	12-Apr-1981	98	273						
1982	10-Jan-1982	09-May-1982	119	189						
1983	14-Nov-1982	12-May-1983	179	223						
1984	21-Dec-1983	22-May-1984	153	198						
1985	06-Dec-1984	05-May-1985	150	223						
1986	14-Dec-1985	20-Apr-1986	127	240						
1987	16-Dec-1986	25-Apr-1987	130	236						
1988	17-Dec-1987	25-May-1988	160	208						
1989	19-Dec-1988	13-May-1989	145	215						
1990	14-Dec-1989	04-May-1990	141	223						
1991	13-Dec-1990	01-May-1991	139	225						
1992	12-Dec-1991	19-May-1992	159	215						
1993	20-Dec-1992	24-Apr-1993	125	244						
1994	24-Dec-1993	16-May-1994	143	200						
1995	02-Dec-1994	01-May-1995	150	272						
1996	27-Jan-1996	07-May-1996	101	255						
1997	17-Jan-1997	07-Jun-1997	141	185						

Avg      20-Dec  
 SD      ±15 days

03-May  
 135.2    19.4

230.4    21.3

## Seasonality Distribution



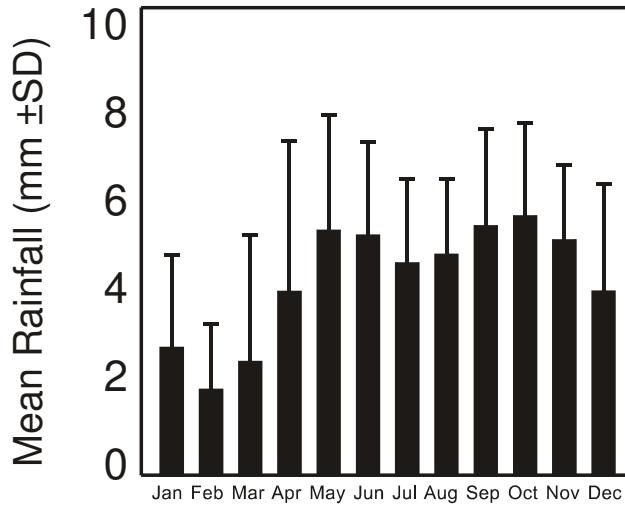
## Storm Analysis

	Max. Rainfall per Storm (mm)			Storm Duration (min.)		
	1984-2002		2003	1984-2002		2003
	Mean	S.D.		Mean	S.D.	
<b>January</b>	23.8	26.1	7.1	31.2	17.6	35.9
<b>February</b>	11.4	12.1	9.9	27.1	25.2	39.2
<b>March</b>	13.6	15.0	1.3	38.4	41.1	16.7
<b>April</b>	31.8	33.2	17.5	44.0	37.5	33.6
<b>May</b>	51.8	30.0	41.9	52.8	19.1	49.5
<b>June</b>	49.4	24.4	82.8	51.9	15.7	63.0
<b>July</b>	45.7	21.6	39.1	44.9	14.2	44.5
<b>August</b>	45.7	19.7	42.2	45.0	14.8	46.5
<b>September</b>	48.0	22.9	58.9	53.0	17.0	49.1
<b>October</b>	47.4	24.0	55.6	53.2	17.8	47.9
<b>November</b>	43.7	17.1	78.2	51.3	19.4	54.7
<b>December</b>	39.1	25.3	69.6	40.0	20.7	63.4

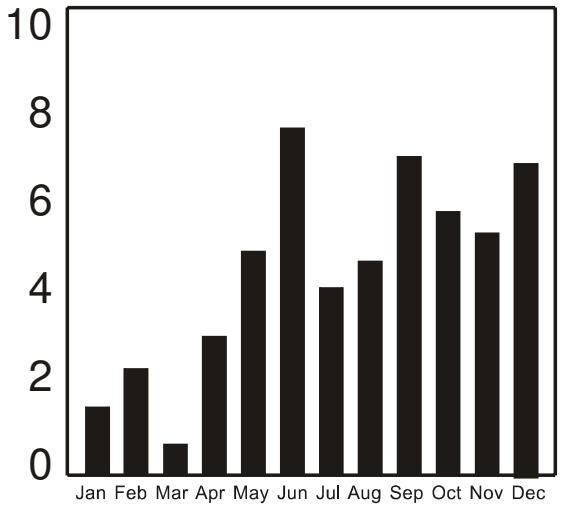
	Av. Rainfall per Storm (mm)		
	1984-2002		2003
	Mean	S.D.	
<b>January</b>	2.7	2.0	1.5
<b>February</b>	1.8	1.4	2.3
<b>March</b>	2.4	2.7	0.7
<b>April</b>	3.9	3.2	3.0
<b>May</b>	5.2	2.5	4.8
<b>June</b>	5.1	2.0	7.4
<b>July</b>	4.5	1.8	4.0
<b>August</b>	4.7	1.6	4.6
<b>September</b>	5.3	2.1	6.8
<b>October</b>	5.5	2.0	5.6
<b>November</b>	5.0	1.6	5.2
<b>December</b>	3.9	2.3	6.6

## Average Monthly Storm Size

1984-2002

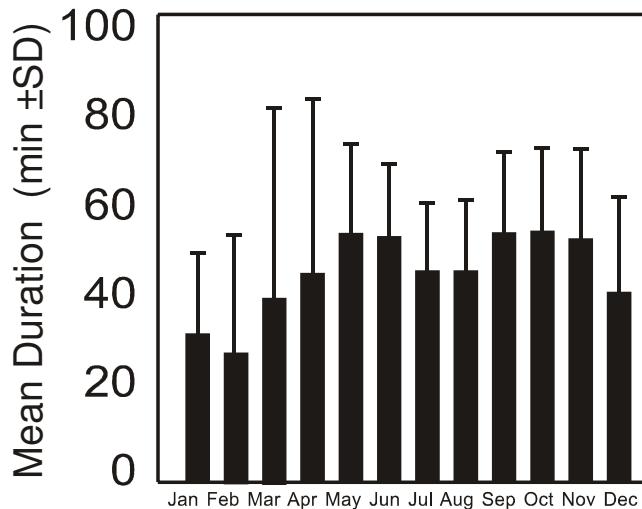


2003

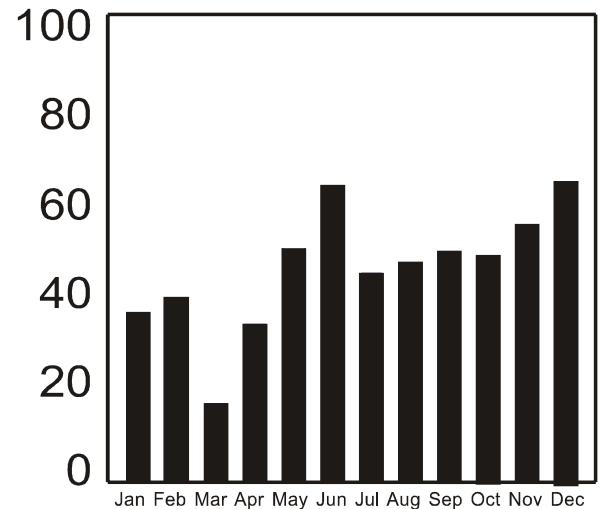


## Average Monthly Storm Duration

1984-2002

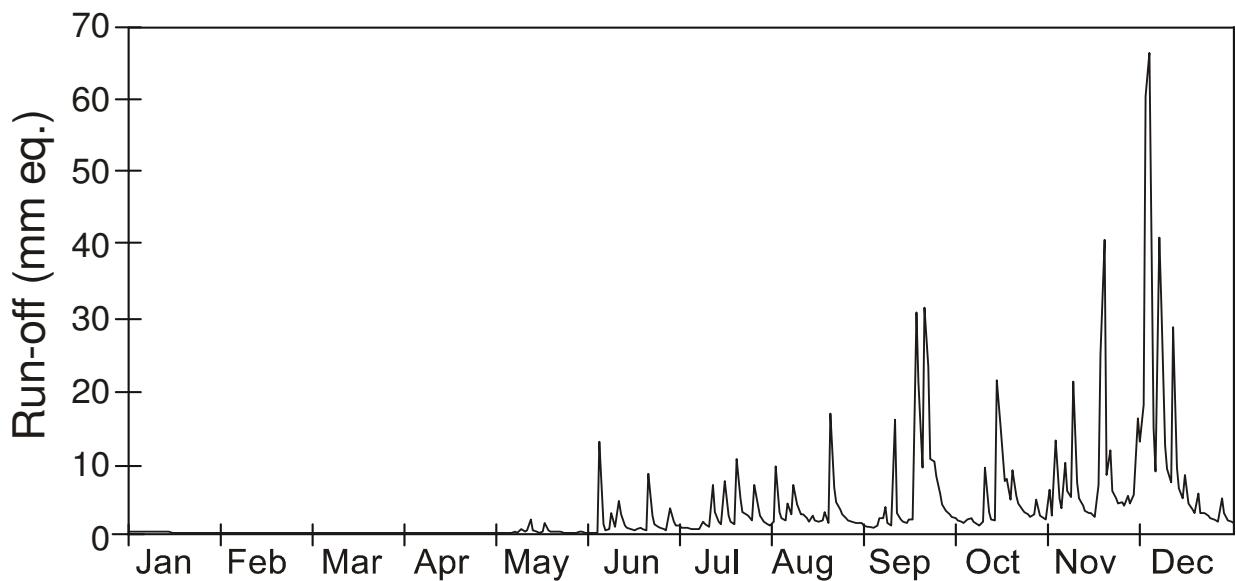


2003



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

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.2	0.1	0.0	0.0	0.0	0.1	1.1	1.6	0.9	1.7	2.3	17.8
2	0.2	0.1	0.0	0.0	0.0	0.1	0.8	9.1	0.8	1.5	12.8	60.6
3	0.2	0.0	0.0	0.0	0.0	0.1	0.7	3.0	0.8	1.3	4.9	66.5
4	0.3	0.0	0.0	0.0	0.1	0.1	0.6	2.1	1.0	1.8	3.5	14.5
5	0.2	0.0	0.0	0.0	0.0	12.7	0.6	1.7	2.1	2.1	9.7	8.5
6	0.2	0.0	0.0	0.0	0.0	1.3	0.5	4.1	2.0	1.5	5.9	41.0
7	0.2	0.0	0.0	0.0	0.0	0.4	0.5	2.6	3.7	1.2	4.9	32.2
8	0.2	0.0	0.0	0.0	0.1	0.5	0.5	6.7	1.4	1.1	21.0	12.2
9	0.2	0.0	0.0	0.0	0.0	2.7	1.5	4.0	1.1	1.5	7.0	8.9
10	0.2	0.0	0.0	0.0	0.4	0.9	1.2	2.6	15.8	9.1	4.9	7.1
11	0.2	0.1	0.0	0.0	0.2	4.5	0.8	2.6	2.8	2.9	3.7	28.5
12	0.2	0.0	0.0	0.0	0.3	2.5	6.6	2.0	1.9	2.0	3.2	9.0
13	0.2	0.0	0.0	0.0	1.8	1.1	3.0	1.6	1.5	1.7	2.7	6.2
14	0.1	0.0	0.0	0.0	0.3	0.7	1.6	2.4	1.4	21.1	2.7	4.8
15	0.1	0.0	0.0	0.0	0.2	0.5	1.2	1.7	2.0	14.7	2.2	8.0
16	0.1	0.0	0.0	0.0	0.1	0.4	7.2	1.6	1.9	7.2	6.8	4.1
17	0.1	0.0	0.0	0.0	0.2	0.5	2.3	1.7	30.6	7.5	24.7	3.3
18	0.1	0.0	0.0	0.0	1.5	0.7	1.5	3.0	21.1	4.6	40.7	2.8
19	0.1	0.0	0.0	0.0	0.4	0.5	1.1	1.4	9.1	8.7	8.0	5.4
20	0.1	0.0	0.0	0.0	0.2	0.4	10.2	16.6	31.3	5.1	11.4	2.7
21	0.1	0.0	0.0	0.0	0.1	8.2	4.7	6.4	23.1	4.1	5.9	2.7
22	0.1	0.0	0.0	0.0	0.2	2.4	3.0	4.2	10.2	3.3	4.8	2.4
23	0.1	0.0	0.0	0.0	0.2	1.3	2.7	3.3	9.9	2.9	4.1	2.1
24	0.1	0.0	0.0	0.0	0.1	0.8	2.3	2.5	7.8	2.5	4.3	1.9
25	0.1	0.0	0.0	0.0	0.1	0.7	1.7	2.0	5.6	2.2	3.7	1.7
26	0.1	0.0	0.0	0.0	0.1	0.6	6.6	1.7	4.0	2.5	5.1	1.6
27	0.1	0.0	0.0	0.0	0.1	0.4	3.8	1.5	3.1	4.7	4.1	4.8
28	0.1	0.0	0.0	0.0	0.1	3.4	2.3	1.3	2.6	2.5	5.3	2.7
29	0.1	0.0	0.0	0.2	1.6	1.6	1.3	1.3	2.3	2.0	15.9	1.7
30	0.1	0.0	0.0	0.2	1.0	1.3	1.3	1.3	2.0	1.8	12.7	1.5
31	0.1	0.0	0.1			1.1	1.0			6.0		1.3



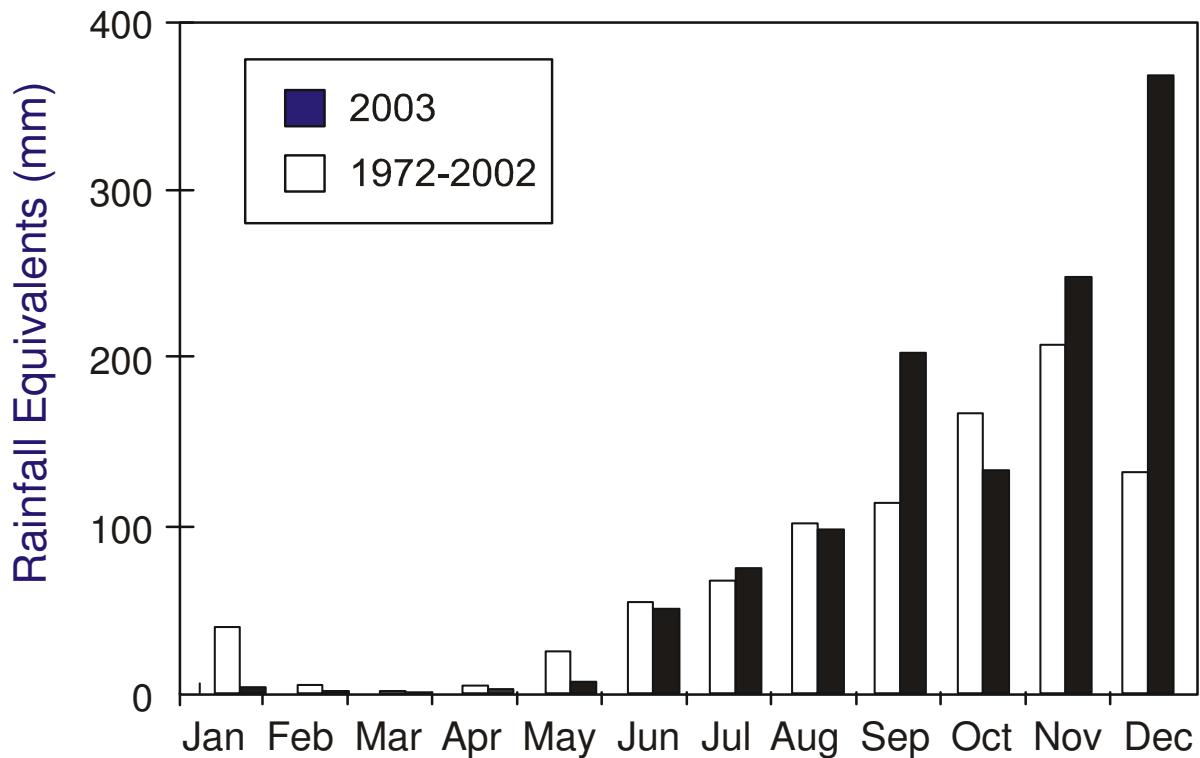
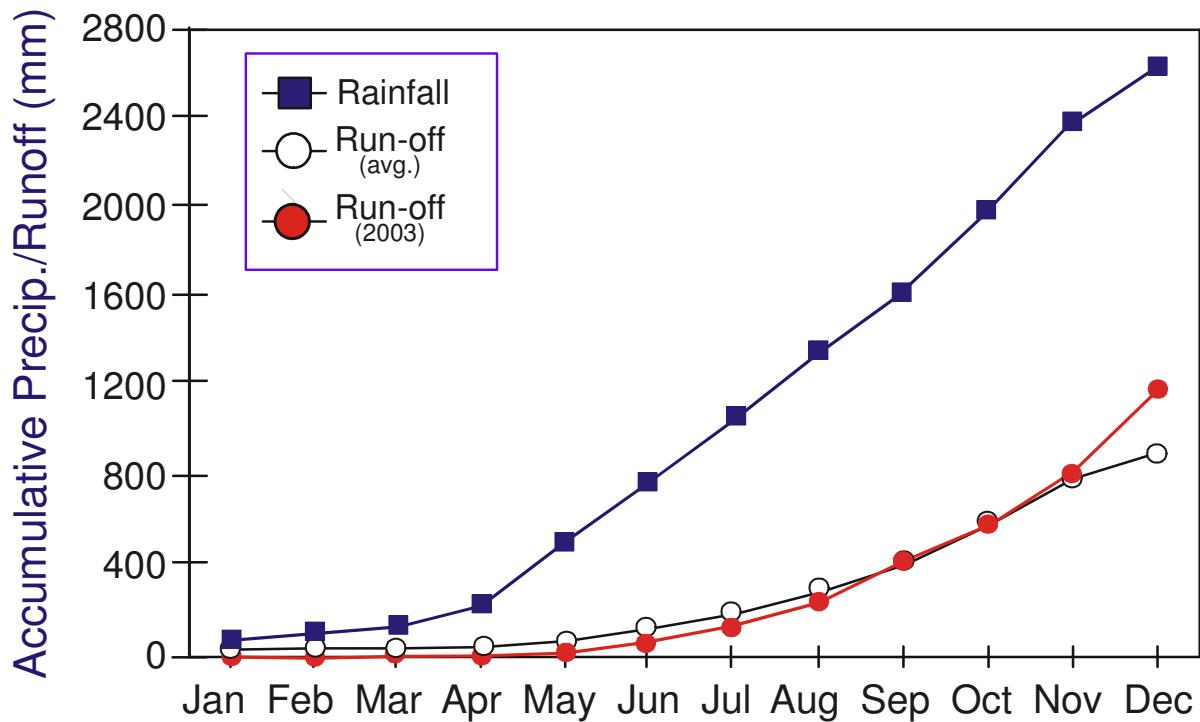
## Monthly Run-off at Lutz Weir

### Run-off (mm eq.)

	Long-term Averages (1972 - 2002)				
	Peak	Delayed	Base	Total	S.D.
<b>January</b>	13.2	2.1	24.0	39.4	62.8
<b>February</b>	0.2	0.2	5.1	5.5	10.2
<b>March</b>	0.1	0.2	1.5	1.8	2.5
<b>April</b>	3.2	0.6	1.8	5.6	19.9
<b>May</b>	12.0	3.6	9.9	25.4	42.9
<b>June</b>	25.5	5.6	24.1	55.2	72.0
<b>July</b>	23.3	6.7	37.6	67.6	51.7
<b>August</b>	40.7	8.1	53.6	102.4	75.2
<b>September</b>	45.5	9.0	62.4	115.9	69.1
<b>October</b>	66.6	10.2	89.2	165.9	85.8
<b>November</b>	81.9	11.7	115.9	209.4	105.9
<b>December</b>	51.0	6.9	82.4	140.3	123.9
<b>Total</b>	364.1	63.4	511.5	940.0	434.9

	2003			
	Peak	Delayed	Base	Total
<b>January</b>	0.0	0.0	4.3	4.3
<b>February</b>	0.0	0.0	0.9	0.9
<b>March</b>	0.0	0.0	0.1	0.1
<b>April</b>	0.0	0.1	0.0	0.1
<b>May</b>	2.0	2.3	3.0	7.3
<b>June</b>	16.9	7.9	26.0	50.8
<b>July</b>	21.7	9.3	44.0	74.9
<b>August</b>	26.7	7.8	64.1	98.6
<b>September</b>	96.2	12.8	94.5	173.2
<b>October</b>	48.8	9.4	74.6	132.9
<b>November</b>	104.7	16.6	127.4	248.7
<b>December</b>	172.8	19.1	176.4	368.4
<b>Total</b>	<b>489.7</b>	<b>85.3</b>	<b>615.3</b>	<b>1160.0</b>

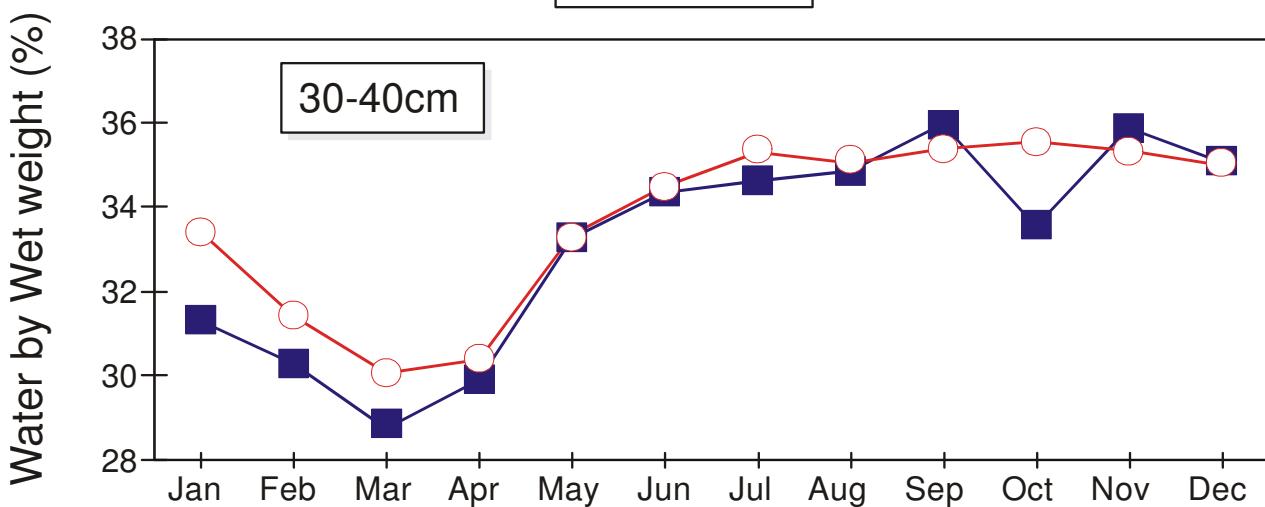
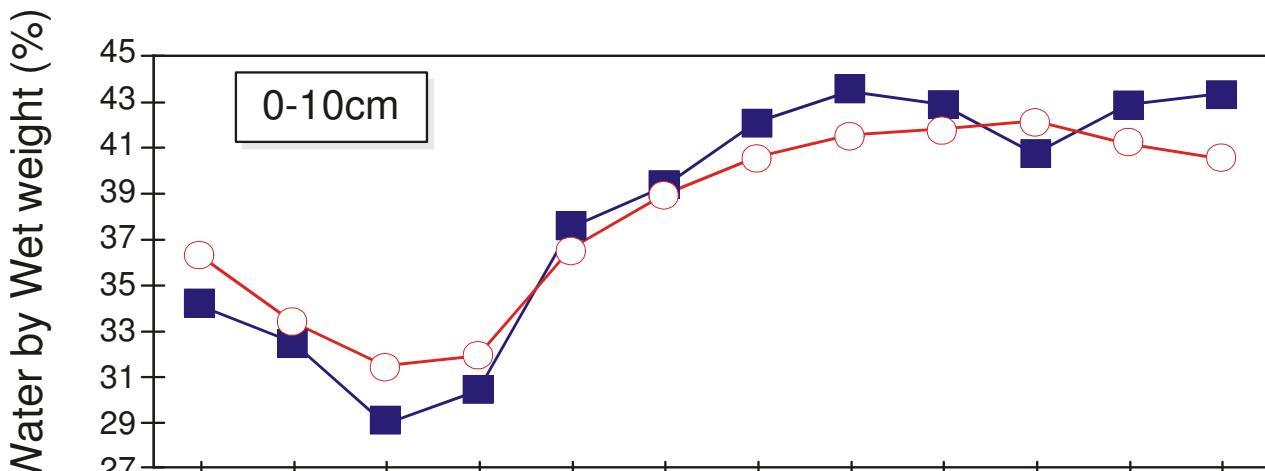
## Monthly run-off at Lutz Weir



## Lutz Catchment Soil Moisture

(H<sub>2</sub>O/wet wt of soil)

	Long-term Averages (1972-2002)				2003	
	0-10 cm		30-40 cm		0-10 cm	30-40 cm
	Mean	S.D.	Mean	S.D.		
January	36.2	3.2	33.3	2.6	34.2	31.3
February	33.4	2.4	31.3	1.4	32.6	30.3
March	31.4	2.2	30.0	1.3	29.2	28.8
April	31.9	2.4	30.3	1.6	30.4	29.9
May	36.7	2.3	33.3	1.4	37.6	33.2
June	39.3	1.6	34.4	1.0	39.4	34.3
July	40.6	1.4	35.3	1.3	42.1	34.6
August	41.6	1.8	35.0	0.7	43.5	34.8
September	41.9	1.5	35.3	1.0	42.8	35.9
October	42.2	1.7	35.4	0.9	40.8	33.5
November	42.6	1.6	35.3	1.1	42.9	35.8
December	40.5	2.9	34.9	1.8	43.4	35.1



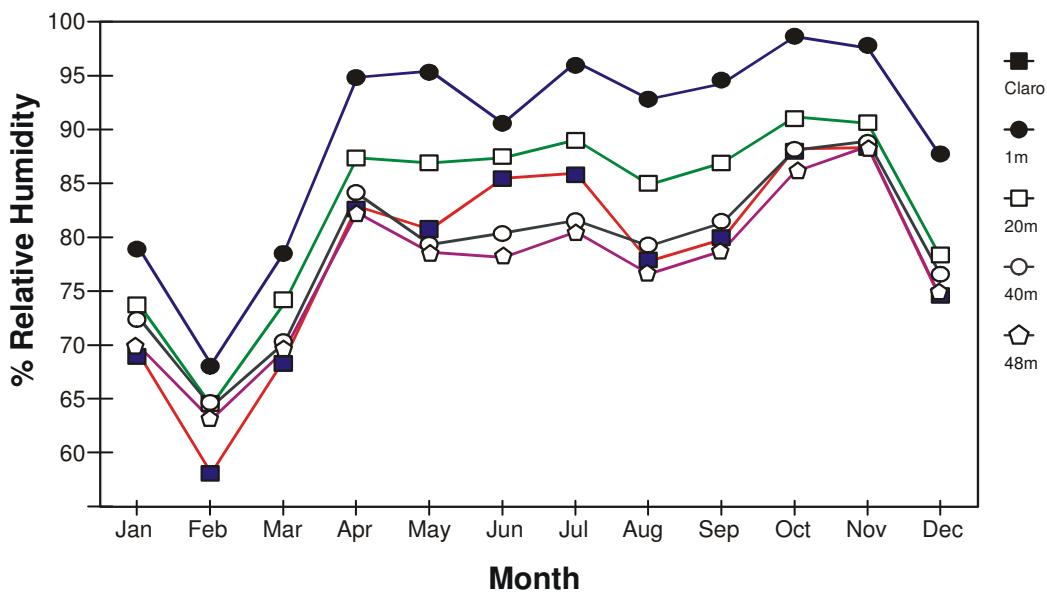
## Relative Humidity (%)

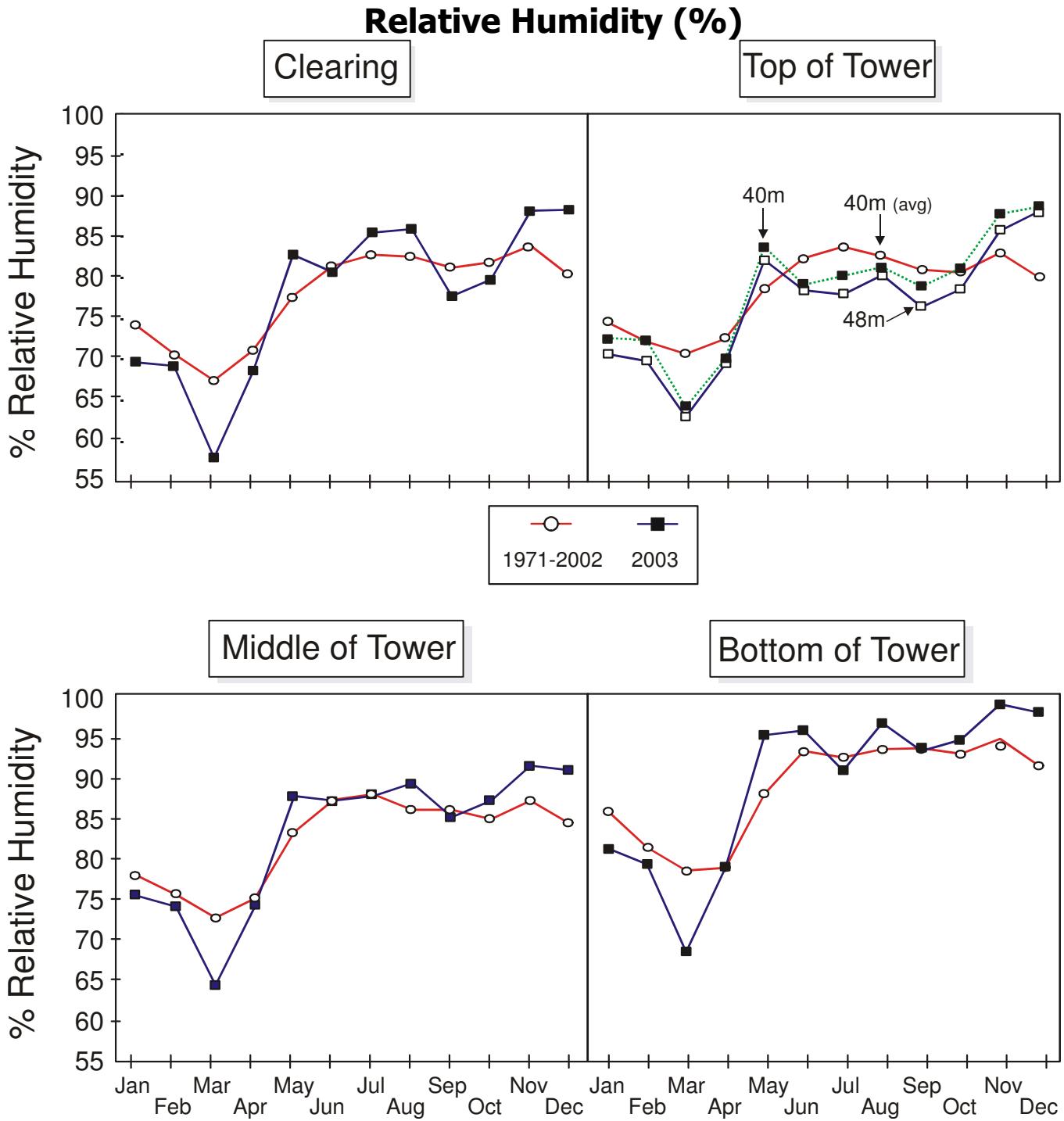
**Long-term Averages (1972-2002)**

	'El Claro'		1m		20m		40m		48m	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
<b>January</b>	74.1	4.4	85.3	3.6	77.6	3.9	74.6	3.4	72.9	2.9
<b>February</b>	70.7	3.9	80.9	3.8	75.3	3.7	72.3	3.9	69.7	0.3
<b>March</b>	67.1	4.1	77.8	4.3	72.0	3.7	70.4	3.1	67.4	6.2
<b>April</b>	71.1	4.8	78.6	4.9	74.8	3.2	72.5	2.7	71.2	2.5
<b>May</b>	77.9	4.8	87.9	4.1	83.3	3.3	79.0	3.8	78.0	6.1
<b>June</b>	81.4	4.1	93.0	2.6	86.9	3.2	82.3	3.3	76.4	3.1
<b>July</b>	82.9	4.3	92.0	6.2	87.6	2.9	83.8	3.2	81.1	4.2
<b>August</b>	82.7	4.4	93.2	2.7	86.0	2.6	82.7	2.4	80.9	0.5
<b>September</b>	81.1	4.6	93.2	1.7	85.6	2.1	81.1	3.1	76.7	0.1
<b>October</b>	81.8	3.9	92.6	5.2	84.8	3.2	80.8	3.2	79.5	1.1
<b>November</b>	84.1	3.9	94.6	2.6	87.1	3.7	83.4	4.0	84.6	1.2
<b>December</b>	80.5	5.2	91.3	3.7	84.4	7.1	80.6	5.0	81.9	6.4

**2003**

	'El Claro'	1m	20m	40m	48m
<b>January</b>	69.7	80.9	75.3	72.7	70.8
<b>February</b>	69.2	79.0	73.9	72.5	69.9
<b>March</b>	58.1	68.2	64.4	64.2	63.0
<b>April</b>	68.6	78.6	73.9	70.1	69.4
<b>May</b>	82.8	94.8	87.4	84.0	82.3
<b>June</b>	80.7	95.4	86.9	79.3	78.6
<b>July</b>	85.5	90.5	87.4	80.4	78.1
<b>August</b>	85.9	96.3	89.0	81.5	80.5
<b>September</b>	77.7	92.8	84.8	79.1	76.6
<b>October</b>	79.8	94.2	86.9	81.3	78.7
<b>November</b>	88.2	98.6	91.1	88.0	86.0
<b>December</b>	88.3	97.5	90.6	88.9	88.4



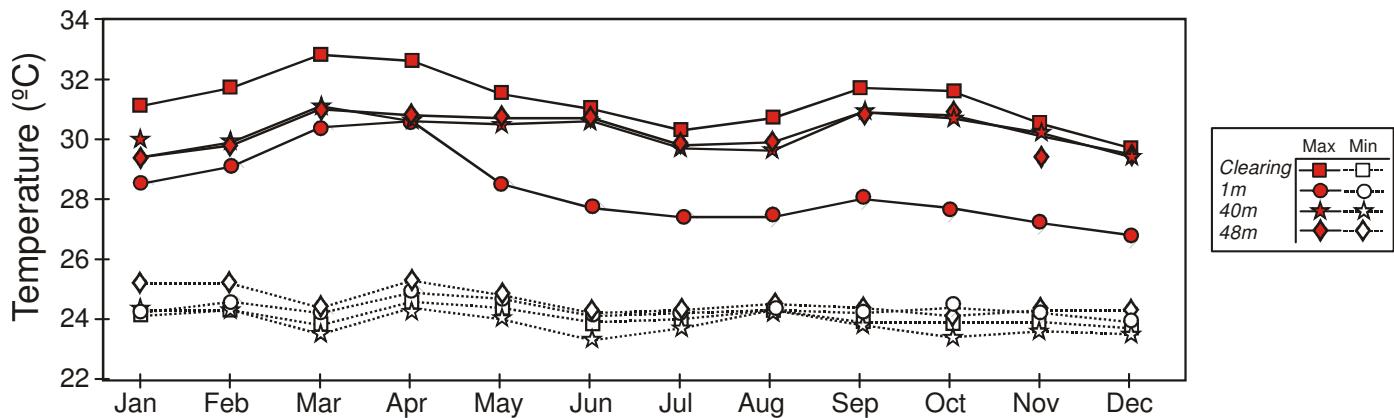


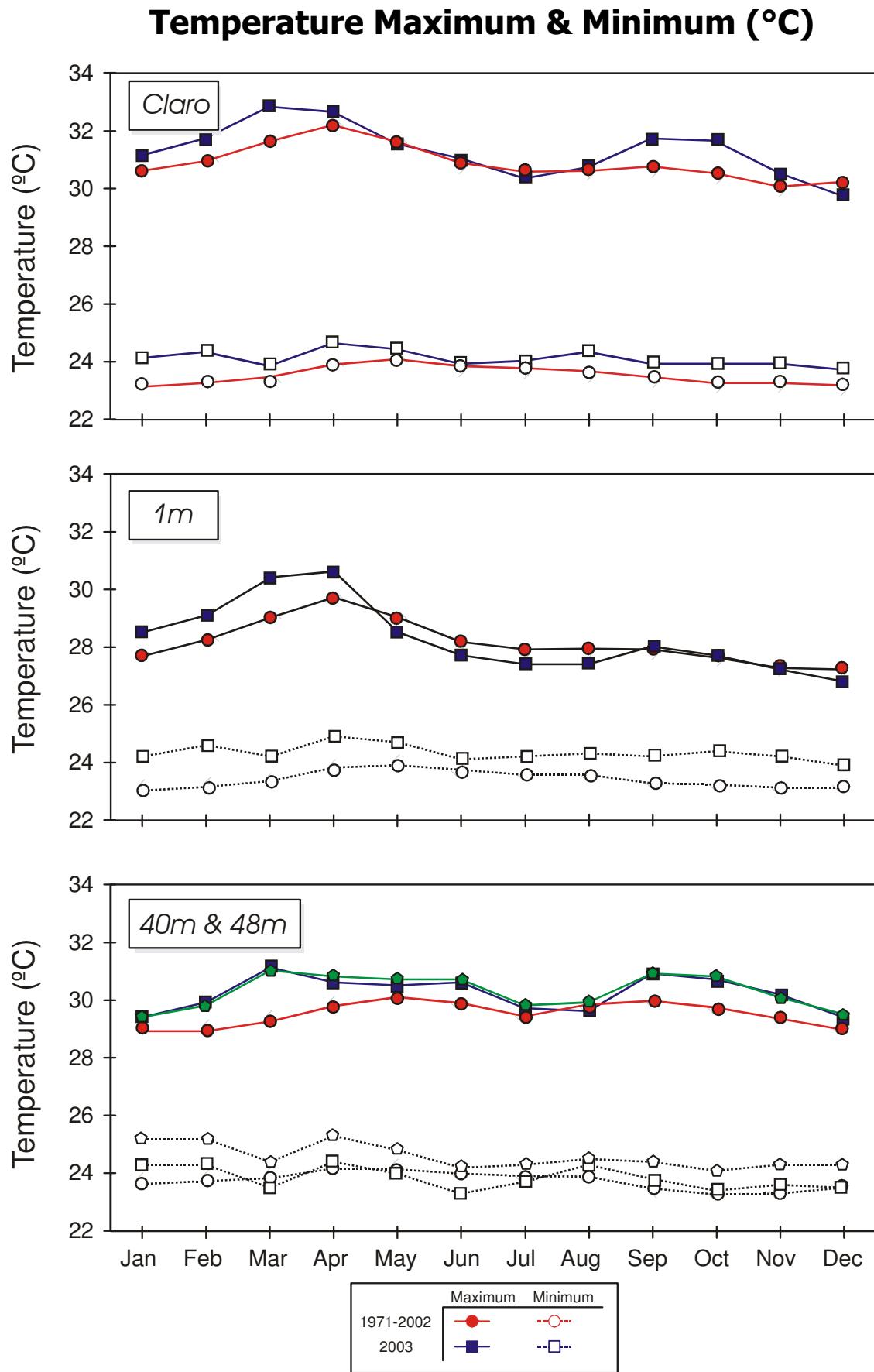
## Avg. Monthly Maximum & Minimum (°C) Temperatures

Long-term Averages (1972-2002)

'El Claro'			1m		40m		48m	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
<b>January</b>	30.6	23.1	27.7	23.0	28.9	23.6	-	-
<b>February</b>	30.9	23.2	28.3	23.2	29.0	23.8	-	-
<b>March</b>	31.6	23.4	29.1	23.4	29.3	23.8	-	-
<b>April</b>	32.2	23.9	29.7	23.8	29.8	24.2	-	-
<b>May</b>	31.6	24.0	29.0	23.9	30.1	24.1	-	-
<b>June</b>	30.8	23.8	28.1	23.7	29.9	24.0	-	-
<b>July</b>	30.5	23.7	27.9	23.6	29.4	23.9	-	-
<b>August</b>	30.6	23.6	27.9	23.6	29.8	23.9	-	-
<b>September</b>	30.7	23.4	27.9	23.3	30.0	23.5	-	-
<b>October</b>	30.5	23.2	27.6	23.2	29.8	23.3	-	-
<b>November</b>	30.0	23.2	27.3	23.1	29.4	23.3	-	-
<b>December</b>	30.2	23.2	27.2	23.1	29.0	23.5	-	-

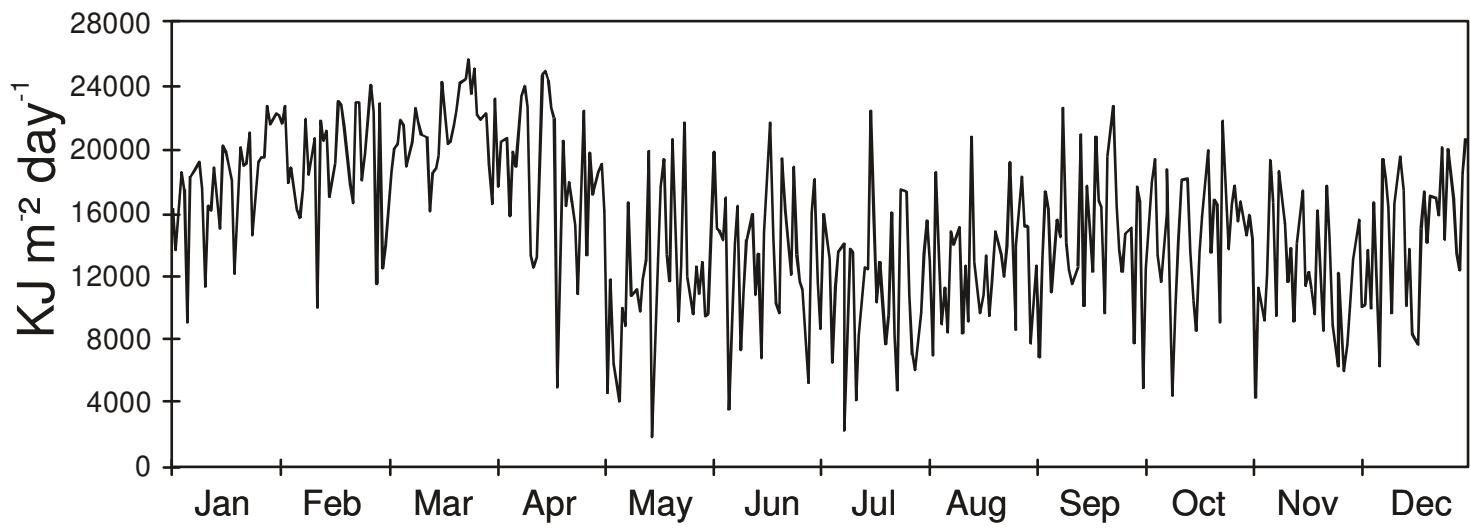
<b>2003</b>	'El Claro'		1m		40m		48m	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
<b>January</b>	31.7	22.8	29.3	23.0	30.3	23.1	30.3	23.9
<b>February</b>	33.3	22.8	30.0	23.3	31.7	22.5	31.7	23.6
<b>March</b>	34.7	21.7	31.5	22.3	33.6	31.1	33.6	22.5
<b>April</b>	34.7	22.8	32.5	23.5	33.3	22.8	33.3	23.3
<b>May</b>	33.3	23.0	31.0	21.9	32.2	22.8	32.5	22.2
<b>June</b>	33.3	22.5	29.0	22.7	32.5	21.9	32.5	22.8
<b>July</b>	32.5	22.8	29.5	23.0	31.1	22.2	31.4	22.8
<b>August</b>	33.3	22.5	28.5	22.5	31.4	22.2	31.7	22.2
<b>September</b>	33.6	22.7	29.5	23.0	32.8	22.2	32.8	22.8
<b>October</b>	35.0	22.8	29.0	23.3	32.2	22.8	33.3	22.8
<b>November</b>	31.4	22.8	27.2	23.0	30.2	22.2	30.1	22.8
<b>December</b>	31.9	21.9	28.0	22.0	31.1	21.9	31.1	23.1





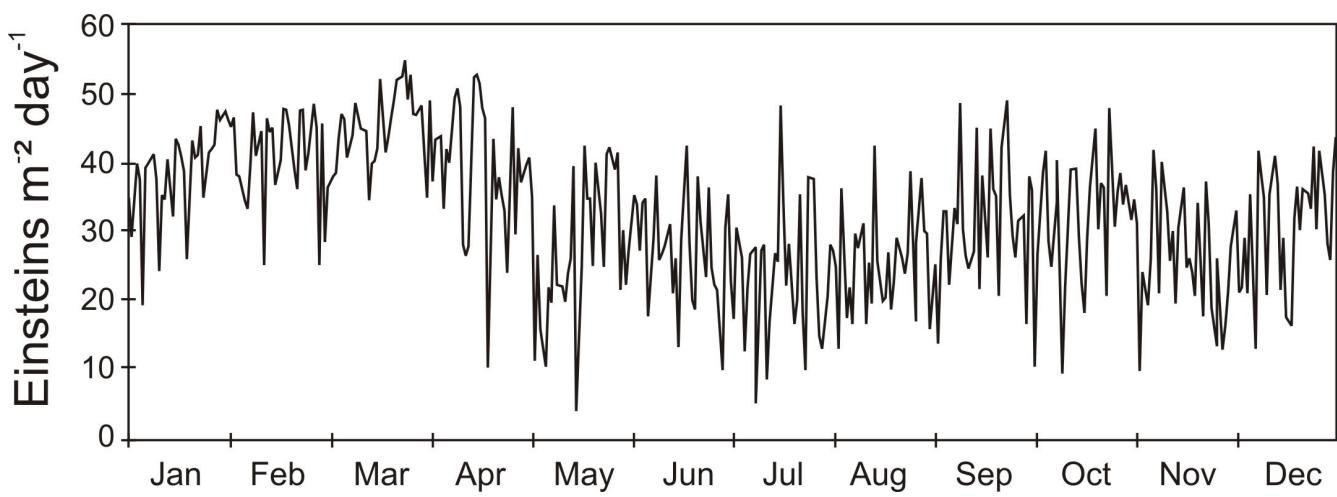
## Daily Total Radiation ( $\text{KJ m}^{-2} \text{day}^{-1}$ )

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	16235	21521	22780	18980	17030	12870	5326	6165	15124	14981	15396	6108
2	13610	22586	12499	16497	18520	9497	15956	9700	15100	7824	16641	7746
3	18518	17833	13917	23036	19028	9648	18036	13402	7823	17586	14571	10097
4	17397	18753	18528	17542	16032	19757	11651	15440	12683	16650	15836	13038
5	9107	16138	19988	20378	4682	14927	8688	12962	6940	5009	14310	15530
6	18184	15651	20203	20593	11787	14786	15883	7032	13093	12450	4419	10074
7	18473	17416	21753	15743	6553	14284	13120	18503	17320	17843	11269	10218
8	19087	21806	21434	19752	4216	16852	6608	8981	16216	19315	9238	13618
9	17454	18302	18860	18834	10000	3690	11302	11303	11027	13277	12063	9960
10	11365	20622	20347	23213	8887	14031	13510	8459	15508	11590	19249	16619
11	16381	9998	22478	23858	16602	16353	14042	14749	14443	15907	16618	6380
12	16081	21709	21659	22562	10789	7414	2382	13973	22466	18680	9508	19286
13	18758	20442	20809	13285	11146	10980	13664	15038	14101	4520	18550	18069
14	14952	21073	20631	12567	9790	14242	13434	8436	12339	10260	15296	16341
15	20120	16965	16036	13191	11793	15875	4227	12669	11506	14104	11631	9663
16	19753	19062	18487	24562	13012	10821	8287	9196	12613	18007	13733	16540
17	18929	22905	18637	24787	19806	13397	12561	20699	20822	18115	9145	19462
18	17957	22667	19503	24184	1974	6876	12412	12858	10133	13586	14035	17356
19	12152	21271	24091	22485	13131	14747	22343	9653	17655	10465	17327	10132
20	20044	17772	20242	21854	17558	21570	15854	10824	12250	8579	11402	13694
21	18886	16526	20429	5024	19268	14476	10365	13290	20755	13495	12264	8345
22	19068	22841	21413	20442	13330	10311	12872	9498	16710	15773	11140	7758
23	20954	22862	22407	16386	11678	9663	7744	11709	16316	19842	9619	14956
24	14555	17952	24012	17851	20522	19375	9585	14755	9671	13470	16080	17319
25	19110	19646	24260	16662	9198	16064	15973	13331	19487	16760	8572	14077
26	19425	23909	25507	15165	12615	12066	8250	11976	22604	16480	17642	16991
27	19409	22240	23337	10896	21598	18859	4847	13847	16367	9111	14508	16881
28	22599	11527	24933	22319	11939	13320	17378	19103	13643	21675	8949	15827
29	21444	22055	13289	9606	11632	17267	8662	12233	13681	6369	20007	
30	22139	21724	19679	12615	11167	10839	13913	14642	16479	12228	14284	
31	22035	22156		10884			7135	18209		17643		19929



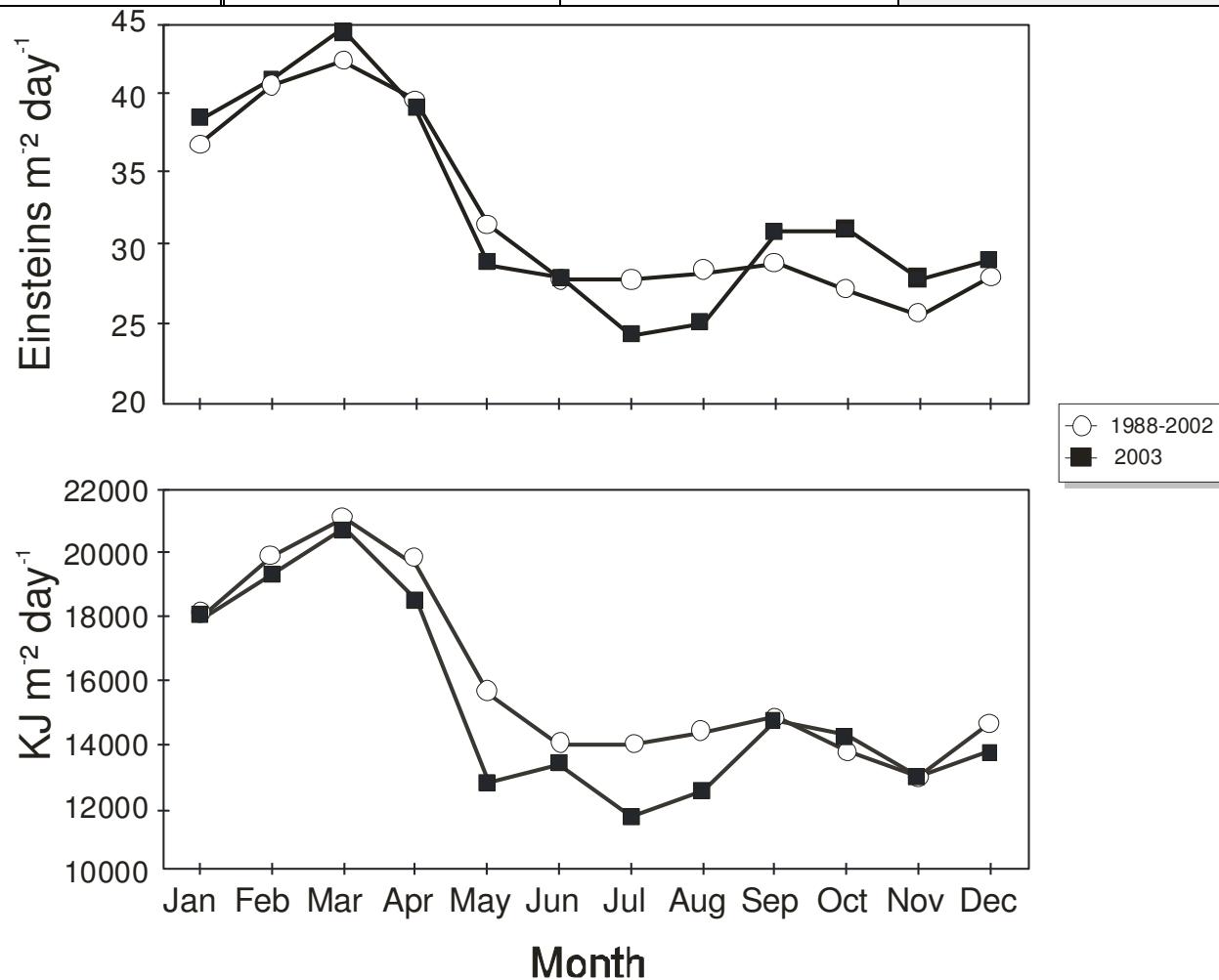
## Daily Total PAR (Einstiens m<sup>-2</sup> day<sup>-1</sup>)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	35.1	45.3	45.8	41.5	37.3	30.4	10.3	13.3	30.3	32.5	34.1	13.3
2	29.4	46.6	28.8	35.1	39.9	22.5	30.7	20.9	30.0	17.0	36.9	16.7
3	40.1	38.4	36.6	49.1	40.8	27.6	35.6	28.3	16.2	38.1	31.9	21.5
4	37.6	38.1	38.2	37.4	35.2	35.4	23.1	27.4	25.5	36.1	34.9	28.1
5	19.7	34.7	38.6	43.4	11.7	34.1	17.7	25.1	14.2	10.9	31.5	33.2
6	39.3	33.5	43.7	43.9	26.8	27.5	30.8	13.3	26.3	27.0	10.2	21.5
7	40.0	39.6	47.1	33.5	16.2	34.4	26.6	36.4	33.1	38.7	24.4	22.3
8	41.3	47.4	46.4	42.1	10.8	35.0	13.0	17.8	33.1	41.9	19.7	29.3
9	37.8	41.1	40.8	40.1	22.3	18.1	22.1	22.3	22.6	28.8	26.3	21.4
10	24.6	44.7	44.0	49.4	20.0	29.3	27.0	17.0	33.6	25.1	41.9	35.5
11	35.4	25.4	48.6	50.8	33.9	38.3	28.0	30.0	31.3	34.5	36.4	13.4
12	34.8	46.5	46.9	48.1	22.6	26.1	5.6	27.8	48.7	40.5	21.4	41.9
13	40.6	44.5	45.0	28.3	22.3	26.9	27.5	31.4	30.6	9.8	40.2	38.3
14	32.3	45.2	44.6	26.8	20.2	28.1	28.3	16.9	26.8	22.3	33.0	35.1
15	43.5	37.0	34.7	28.1	24.1	31.3	8.9	25.8	25.0	30.6	26.0	21.1
16	42.7	40.5	40.0	52.3	26.3	21.3	17.4	19.9	27.4	39.1	30.3	35.5
17	40.9	47.8	40.3	52.8	39.6	26.4	27.1	42.6	45.2	39.3	19.8	41.1
18	38.8	47.7	42.2	51.5	4.5	13.6	25.9	26.0	22.0	29.5	30.8	37.1
19	26.3	45.5	52.1	47.9	25.2	29.1	48.3	20.3	38.3	22.7	36.6	21.8
20	43.4	39.0	41.6	46.5	42.5	42.5	34.3	20.8	26.6	18.6	25.1	29.4
21	40.9	36.3	43.9	10.7	35.0	28.5	22.4	27.3	45.0	29.3	26.4	17.9
22	41.2	47.5	46.6	43.5	35.0	20.3	28.5	19.1	36.2	36.6	24.4	16.7
23	45.3	47.7	49.0	34.9	25.3	19.1	16.9	22.9	35.4	45.1	21.0	32.2
24	35.1	39.0	52.0	38.0	40.1	38.2	20.4	29.4	21.0	30.5	34.4	36.7
25	41.6	41.5	52.5	35.5	32.7	31.7	35.6	26.4	42.3	37.2	18.1	30.4
26	42.0	48.6	54.8	33.3	25.1	23.7	18.4	24.2	49.0	36.5	37.4	36.3
27	42.6	45.2	49.2	24.3	41.3	36.5	10.3	27.1	35.5	20.9	31.2	35.7
28	47.7	25.4	52.8	48.1	42.3	25.1	38.0	38.9	29.6	47.9	19.2	33.5
29	46.2		47.0	29.8	39.1	22.5	37.8	17.3	26.5	30.9	13.7	42.5
30	47.5		47.0	42.3	41.6	21.8	23.7	28.6	31.8	36.0	26.3	30.6
31	46.3		48.3		21.8		15.2	37.9		38.7		41.8



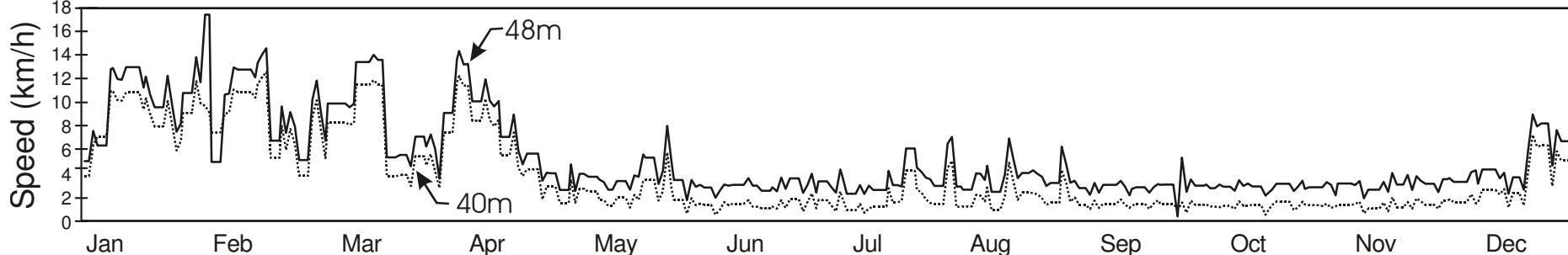
## Total Monthly Solar Radiation

	Long-term Average (1988-2002)				2003	
	PAR (Einstiens $m^{-2}$ day $^{-1}$ )		Pyranometer (KJ $m^{-2}$ day $^{-1}$ )		PAR	Pyran.
	Mean	S.D.	Mean	S.D.		
January	41.0	4.6	17975	1421	38.7	16097
February	42.7	3.3	19938	1021	41.4	18956
March	40.1	3.2	21128	1272	44.8	19167
April	31.7	3.6	19628	1151	39.6	16612
May	28.1	3.4	15528	1570	29.1	16067
June	28.1	3.3	13997	1036	28.2	13291
July	28.6	3.6	14005	1304	24.4	13768
August	29.2	3.1	14383	1400	25.2	13677
September	27.3	4.5	14837	1069	31.3	14670
October	25.7	4.1	13770	1489	31.4	13042
November	28.5	5.8	12965	1062	28.1	11197
December	41.0	4.6	14640	2320	29.4	16985



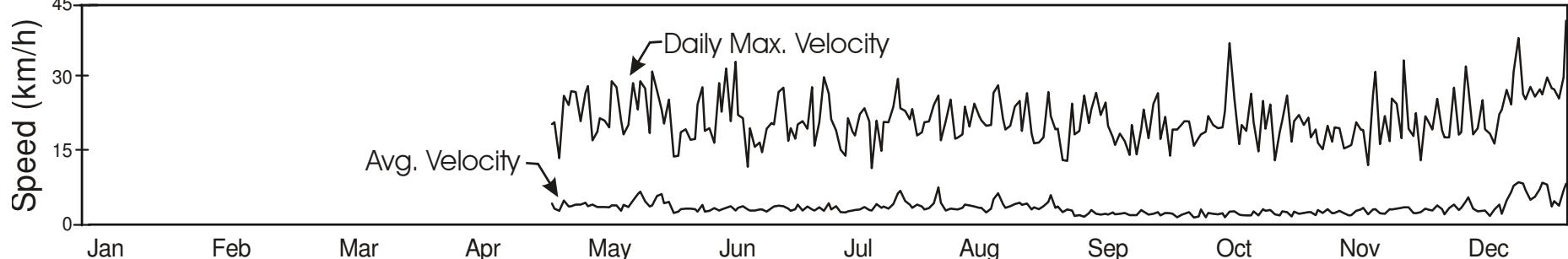
## Daily Average Wind Speed – Totalizing Anemometer (km/h)

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sep.		Oct.		Nov.		Dec.	
	40m	48m	40m	48m	40m	48m	40m	48m	40m	48m	40m	48m	40m	48m	40m	48m	40m	48m	40m	48m	40m	48m	40m	48m
1	3.9	5.2	7.6	5.1	8.4	10.0	11.8	13.7	2.9	4.1	1.5	3.0	1.5	3.0	1.4	3.1	1.5	2.9	1.4	2.9	1.5	3.3	1.7	3.5
2	3.9	5.2	7.6	5.1	8.4	10.0	12.3	14.4	2.9	4.1	1.5	3.0	1.0	2.5	1.4	2.8	1.2	2.4	1.3	2.9	1.5	3.3	1.7	3.5
3	6.5	7.7	7.6	5.1	8.4	10.0	11.5	13.3	2.6	3.9	0.7	2.1	2.6	4.5	1.4	2.8	1.9	3.4	1.3	3.2	1.5	3.3	2.4	4.3
4	7.3	6.5	9.2	10.8	8.4	10.0	11.6	13.4	2.6	3.9	1.1	2.7	2.0	3.9	1.4	2.8	1.3	2.6	1.4	3.0	1.5	3.3	1.7	4.4
5	7.3	6.5	9.3	10.9	8.4	10.0	8.6	10.2	2.6	3.9	1.7	3.2	1.1	2.4	2.4	4.2	1.6	3.2	1.4	3.0	1.6	3.2	1.7	3.3
6	7.3	6.5	11.2	13.1	8.2	9.7	8.6	10.2	2.0	3.7	1.5	3.1	1.1	2.4	2.3	4.1	1.6	3.2	1.4	3.0	1.8	3.5	2.8	4.5
7	11.1	12.9	11.0	12.9	8.4	10.0	8.6	10.2	1.9	3.4	1.6	3.2	1.1	2.4	1.8	3.6	1.6	3.2	1.2	2.7	0.8	2.1	2.8	4.5
8	11.0	13.0	11.0	12.9	11.6	13.5	10.4	12.1	1.4	2.8	1.6	3.2	1.6	3.2	3.0	4.8	1.6	3.2	1.8	3.6	1.2	2.8	2.8	4.5
9	10.3	12.1	11.0	12.9	11.6	13.5	8.6	10.3	1.4	2.8	1.6	3.2	0.9	2.4	1.1	2.6	2.0	3.5	1.5	3.1	1.2	2.8	2.8	4.5
10	10.3	12.0	11.0	12.9	11.6	13.5	8.1	9.8	2.1	3.5	1.6	3.2	1.2	3.1	1.1	2.6	1.5	3.0	1.5	3.3	1.2	2.8	2.4	3.7
11	11.0	13.1	10.5	12.2	11.6	13.5	8.6	10.2	2.1	3.5	1.9	3.8	1.4	2.8	1.1	2.6	1.3	2.3	1.5	3.1	1.2	2.8	2.8	4.2
12	11.0	13.1	11.6	13.4	12.0	14.1	5.7	7.2	2.1	3.5	1.4	3.1	1.4	2.8	2.2	4.0	1.4	2.9	1.5	3.1	1.7	3.5	1.3	2.4
13	11.0	13.1	12.2	14.1	11.6	13.7	5.7	7.2	1.3	2.8	1.4	3.1	1.4	2.8	5.0	7.1	1.6	3.0	1.5	3.1	1.0	2.6	2.5	3.8
14	11.0	13.1	12.7	14.7	11.6	13.7	5.7	7.2	2.4	4.0	1.2	2.7	1.4	2.8	3.5	5.3	1.6	3.0	0.7	2.3	2.2	4.2	2.5	3.8
15	9.5	11.4	5.5	6.9	3.9	5.5	7.6	9.1	1.9	3.9	1.2	2.7	2.9	4.4	1.9	3.8	1.6	3.0	1.2	2.6	1.3	3.2	2.5	3.8
16	10.4	12.3	5.5	6.9	3.9	5.5	4.7	6.1	3.6	5.7	1.2	2.7	1.7	3.2	2.5	4.2	1.2	2.6	1.5	2.8	1.3	3.2	1.5	2.8
17	9.1	10.8	5.5	6.9	3.9	5.5	3.9	4.9	3.6	5.5	1.4	3.0	1.7	3.2	2.5	4.2	1.6	3.0	1.8	3.3	1.3	3.2	4.4	6.1
18	8.1	9.7	8.2	9.8	4.0	5.7	4.5	5.8	3.6	5.5	1.2	2.7	1.9	3.1	2.5	4.2	1.9	3.2	1.8	3.3	1.7	4.0	7.4	9.1
19	8.1	9.7	6.1	7.6	4.0	5.7	4.5	5.8	3.6	5.5	1.9	3.8	4.4	6.2	2.5	4.4	1.6	3.2	1.8	3.3	1.2	2.8	6.4	8.1
20	8.1	9.7	7.9	9.3	4.0	5.7	4.5	5.8	1.9	3.3	1.3	2.9	4.4	6.2	2.4	4.1	1.6	3.2	1.8	3.3	2.1	3.9	6.5	8.4
21	10.2	12.4	6.6	8.1	3.1	4.8	4.5	5.8	2.6	4.4	2.0	3.7	4.4	6.2	2.1	3.9	1.6	3.2	1.1	2.7	1.8	3.6	6.5	8.4
22	8.2	9.8	4.0	5.3	5.6	7.2	2.0	3.5	5.9	8.2	2.0	3.7	2.8	4.6	1.5	3.1	1.6	3.2	1.3	3.1	1.5	3.3	6.5	8.4
23	6.1	7.7	4.0	5.3	5.6	7.2	3.1	4.2	2.8	4.9	2.0	3.7	2.6	4.3	1.7	3.4	1.1	0.5	1.8	3.5	1.5	3.3	3.1	4.8
24	6.9	8.3	4.0	5.3	5.6	7.2	3.1	4.2	1.9	3.6	1.0	2.5	2.0	3.8	1.7	3.4	1.7	5.5	1.5	2.9	1.5	3.3	6.0	7.8
25	9.2	10.9	8.9	10.4	4.8	6.4	3.1	4.2	1.9	3.6	1.7	3.1	1.7	3.7	1.7	3.4	0.8	2.6	1.5	3.0	1.2	2.6	5.2	6.9
26	9.2	10.9	10.3	12.0	5.8	7.4	1.7	2.8	1.9	3.6	2.5	4.1	1.6	3.1	4.5	6.4	1.9	3.6	1.5	3.0	1.9	3.7	5.2	6.9
27	9.2	10.9	7.7	9.2	4.3	6.2	1.7	2.8	0.8	1.9	1.2	2.5	1.6	3.1	3.4	5.0	1.5	3.1	1.5	3.0	1.9	3.7	5.2	6.9
28	11.9	13.9	5.4	6.9	2.9	3.7	1.7	2.8	2.1	3.6	1.9	3.5	1.6	3.1	1.8	3.4	1.5	3.1	1.4	3.0	2.0	3.8	5.2	6.9
29	10.0	11.8			7.6	9.2	3.7	4.9	1.5	3.0	1.9	3.5	4.6	6.7	2.1	3.5	1.5	3.1	1.6	3.4	1.7	3.5	5.2	6.9
30	9.8	17.5			7.6	9.2	1.7	2.7	1.6	3.2	1.9	3.5	5.2	7.2	1.5	2.9	1.5	3.2	1.3	3.2	1.7	3.5	5.1	7.2
31	9.2	17.5			7.6	9.2			1.5	3.0			1.3	3.0	1.5	2.9			1.4	2.3			4.5	6.3



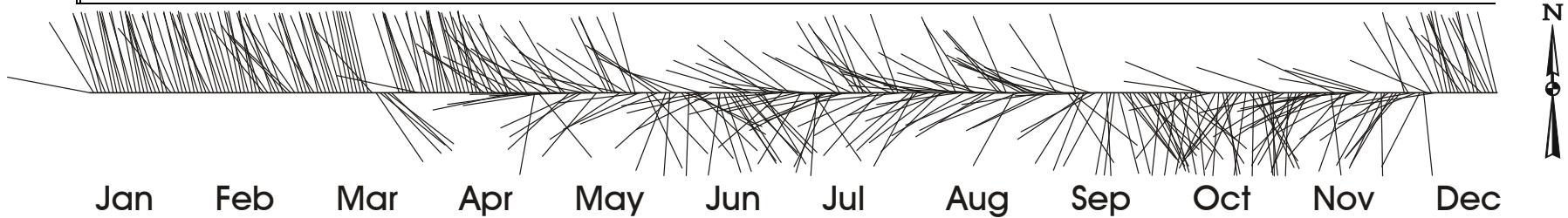
## Daily Average Wind Speed (km/h)

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sep.		Oct.		Nov.		Dec.			
	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max		
1							4.3	27.1	4.2	28.2	2.9	30.2	3.4	25.6	1.9	18.6	1.8	17.9	2.6	15.5	2.2	18.0				
2							4.2	21.3	2.8	19.2	4.6	26.8	3.3	17.7	2.1	19.2	3.2	18.6	3.3	20.3	3.5	18.0				
3							4.6	27.0	2.9	19.8	3.2	21.6	3.2	17.9	1.7	26.5	1.7	19.1	2.4	17.1	4.2	28.1				
4							3.9	28.4	3.5	16.9	4.0	19.3	3.6	18.6	2.4	20.9	2.5	22.3	2.6	19.9	3.1	18.5				
5							4.3	17.4	3.0	29.0	2.7	15.4	4.3	24.3	3.1	23.6	2.4	20.4	3.0	19.8	3.5	19.0				
6							3.7	19.1	3.3	23.2	2.6	14.2	4.1	20.1	2.3	27.0	2.2	19.8	2.4	15.7	4.9	32.4				
7							3.8	21.9	3.6	32.0	2.9	21.9	3.9	24.9	2.2	22.5	2.4	19.9	2.0	16.1	5.7	28.2				
8							3.7	21.4	3.9	21.3	3.1	19.1	3.5	22.3	2.4	25.0	1.7	23.3	2.1	16.3	3.4	18.6				
9							3.7	19.9	3.0	33.4	3.1	18.3	3.6	21.5	2.2	20.4	2.8	37.1	2.9	21.0	2.9	19.8				
10							4.1	29.4	3.6	22.5	3.2	22.6	2.6	20.3	2.6	18.0	2.9	25.8	3.2	19.5	2.9	25.5				
11							4.1	28.2	3.9	21.9	3.7	23.8	3.4	20.5	2.2	16.3	2.1	16.5	3.6	19.4	3.1	19.6				
12							3.0	21.4	3.2	11.9	3.1	21.2	5.3	27.0	2.4	18.7	2.0	20.5	2.2	12.3	1.9	18.7				
13							4.2	18.6	3.0	19.8	3.1	11.7	6.5	28.6	2.6	17.2	2.0	19.2	3.2	26.4	3.2	16.6				
14							3.7	20.5	3.1	16.0	4.4	21.4	4.3	21.8	2.1	14.4	2.0	26.8	3.3	31.3	4.3	22.6				
15							5.0	29.0	3.2	17.0	3.6	15.2	3.6	19.5	2.1	20.5	2.9	21.1	2.4	16.5	2.3	23.5				
16							6.4	23.6	3.3	14.9	3.8	21.1	3.9	20.4	2.1	14.5	2.0	15.1	2.4	22.3	5.0	27.7				
17							6.9	29.4	2.7	19.7	3.4	21.0	4.4	24.3	3.1	19.7	3.3	25.4	3.3	17.2	6.8	24.7				
18							4.9	27.9	3.5	20.9	4.4	24.2	4.6	25.4	2.8	23.6	3.0	19.7	3.3	25.9	8.1	31.4				
19							3.9	18.8	3.8	20.6	6.5	29.9	4.2	19.2	2.2	17.8	3.2	24.7	3.4	24.8	8.8	38.2				
20							4.1	31.4	4.0	27.1	7.1	23.8	4.4	26.9	2.4	24.8	2.2	13.2	3.6	17.8	8.5	26.7				
21							6.0	27.5	3.9	28.1	5.0	23.3	3.3	18.7	2.6	26.9	2.0	19.1	3.7	33.6	7.2	25.7				
22							6.3	23.6	3.4	17.3	4.3	21.6	3.6	16.7	2.0	17.6	2.9	21.4	3.7	19.7	5.3	28.3				
23							4.5	20.8	3.0	19.8	3.6	23.8	3.3	17.0	2.6	22.1	2.6	26.5	2.5	18.2	5.9	26.2				
24							4.7	25.6	3.3	17.7	4.3	18.3	3.9	18.0	2.4	14.2	1.8	17.1	2.4	22.9	7.4	27.8				
25							4.4	20.7	2.5	14.1	4.2	20.6	3.8	19.0	4.8	27.1	2.3	19.5	2.8	21.3	2.7	13.2	8.7	26.6		
26							3.4	21.0	2.8	14.2	3.0	21.3	3.2	21.0	6.2	22.3	1.6	19.5	2.3	22.5	3.4	22.2	8.3	30.1		
27							2.9	13.7	3.3	19.0	3.8	19.7	3.5	21.2	3.5	19.6	2.1	20.7	2.5	20.5	3.2	21.5	3.8	28.0		
28							5.0	26.4	3.3	19.6	3.3	28.2	4.6	24.6	3.8	19.7	2.3	21.3	2.7	22.0	3.0	19.5	5.0	27.8		
29							3.8	24.6	3.4	17.5	3.0	16.2	7.7	26.5	2.7	13.4	2.7	21.2	2.7	18.0	4.1	25.8	4.0	25.9		
30							3.9	27.4	3.3	17.6	3.7	21.1	4.6	17.4	3.2	13.1	1.6	16.2	2.1	19.5	3.3	19.3	7.1	30.2		
31							2.7	24.7			3.0	21.3	3.0	24.9			3.2	16.9			8.5	41.8				



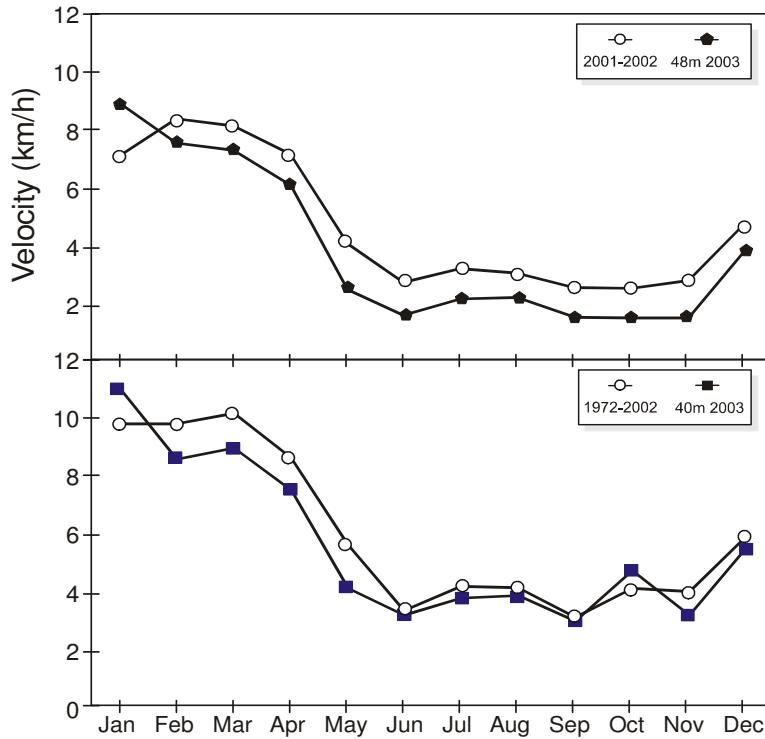
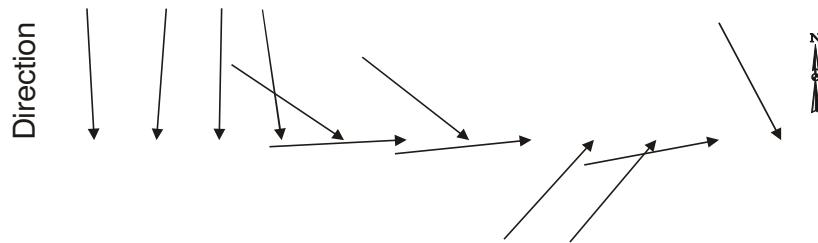
## Average Daily Wind Direction

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	286	338	352	357	274	300	314	234	298	157	161	184
2	333	347	343	356	300	233	279	213	300	157	179	210
3	348	351	347	352	335	147	262	231	295	140	184	240
4	351	347	349	350	318	119	216	290	248	165	293	215
5	343	348	348	342	232	187	282	288	267	191	261	223
6	348	348	346	352	273	125	262	259	250	168	243	225
7	354	349	350	350	250	139	150	280	275	130	187	350
8	353	352	352	349	243	291	189	238	331	148	214	333
9	352	354	354	352	286	266	202	230	286	193	202	265
10	348	354	354	355	298	261	248	255	293	174	215	253
11	353	350	353	352	304	249	252	288	152	137	242	212
12	349	356	352	340	225	168	212	304	134	223	210	179
13	354	353	352	311	275	193	304	341	347	196	230	298
14	355	349	352	340	312	166	334	267	217	179	249	333
15	352	326	323	345	339	150	255	244	206	153	262	266
16	352	331	151	305	342	153	265	280	241	297	264	342
17	347	347	134	324	339	152	300	331	293	283	250	350
18	345	339	142	334	241	141	331	303	247	263	178	354
19	346	340	133	345	286	144	341	289	273	210	299	354
20	354	345	139	334	307	291	344	252	213	189	266	347
21	348	320	95	263	341	298	310	243	182	173	225	343
22	326	319	347	301	350	142	322	277	195	178	204	326
23	342	330	351	314	249	141	251	248	192	219	246	338
24	348	348	349	331	268	154	226	324	171	223	257	345
25	352	349	347	267	160	310	274	323	146	208	271	354
26	349	348	343	195	142	260	244	342	148	225	285	350
27	351	343	287	146	310	296	301	284	171	193	291	319
28	354	332	354	307	253	270	329	214	152	150	241	339
29	347		343	266	308	234	346	254	138	186	292	339
30	350		348	329	206	299	269	302	144	159	214	347
31	345		352	189		297	308			177		352



## Average Monthly Wind Speed and Direction

	Long-term Av.			2003		
	Avg. Speed		Direction	Speed		Direction
	40m	48m		40m	48m	
<b>January</b>	7.1	9.8	356.6	8.9	11.0	347.5
<b>February</b>	8.4	9.8	4.0	7.5	8.6	344.2
<b>March</b>	8.1	10.2	1.3	7.3	8.9	356.7
<b>April</b>	7.1	8.6	352.5	6.1	7.5	335.8
<b>May</b>	4.0	5.6	305.1	2.4	4.1	293.7
<b>June</b>	2.7	3.3	267.0	1.6	3.1	186.3
<b>July</b>	3.2	4.2	308.8	2.1	3.7	286.4
<b>August</b>	3.0	4.1	263.8	2.2	3.8	280.2
<b>September</b>	2.5	3.1	221.4	1.5	2.9	197.5
<b>October</b>	2.5	4.1	218.8	1.5	4.7	175.5
<b>November</b>	2.8	4.0	259.3	1.5	3.2	234.1
<b>December</b>	4.8	5.9	332.9	3.8	5.5	318.4



## Estimated Evapotranspiration and Water Balance

Average (1993-2002)	'El Claro'			'40m'			'48m'		
	Month <sup>-1</sup>	Day <sup>-1</sup>	S.D.	Month <sup>-1</sup>	Day <sup>-1</sup>	S.D.	Month <sup>-1</sup>	S.D.	Day <sup>-1</sup>
January	94.9	3.1	0.8	146.8	4.7	0.7	185.0	6.0	0.1
February	114.1	4.1	0.7	156.6	5.6	0.5	180.3	6.4	0.3
March	135.2	4.4	0.6	178.4	5.8	0.7	181.3	5.8	0.1
April	117.7	3.9	0.5	159.7	5.3	0.4	163.3	5.4	0.4
May	81.5	2.6	0.8	107.1	3.5	0.7	112.3	3.7	1.2
June	56.1	1.9	0.5	80.4	2.7	0.6	83.8	2.8	0.4
July	61.2	2.0	0.3	82.8	2.7	0.6	89.3	3.0	0.5
August	60.8	2.0	0.3	86.2	2.8	0.5	83.0	2.7	0.2
September	65.8	2.2	0.4	87.3	2.9	0.3	102.0	3.4	0.1
October	64.3	2.1	0.3	87.3	2.8	0.3	87.3	2.8	0.2
November	47.0	1.6	0.4	70.8	2.4	0.7	70.3	2.3	0.2
December	60.6	2.0	0.8	96.4	3.1	1.1	111.3	3.6	1.4

2003	Evapotranspiration (mm eq. day <sup>-1</sup> )			Net Water Balance (mm eq. day <sup>-1</sup> )		
	'El Claro'	40 m	48 m	'El Claro'	40 m	48 m
January	4.5	5.9	6.0	-4.0	-5.9	-5.9
February	4.8	5.8	6.2	-4.3	-5.4	-5.8
March	4.9	5.2	5.8	-4.8	-5.2	-5.7
April	4.7	5.1	5.2	-1.5	-1.9	-2.0
May	2.4	2.5	2.9	7.1	7.2	6.9
June	2.4	2.5	3.1	7.3	8.7	8.1
July	2.0	2.1	2.6	4.2	4.9	4.4
August	1.9	2.1	2.6	3.6	4.2	3.7
September	2.7	3.1	3.5	3.5	6.7	6.3
October	2.5	2.6	3.0	1.7	-0.7	-1.1
November	1.8	2.1	2.2	4.5	8.0	7.9
December	2.2	2.7	3.2	13.9	5.1	4.5

