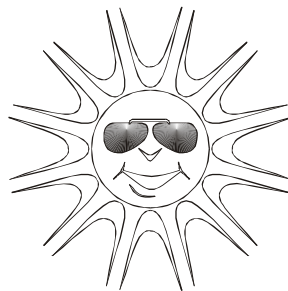




Smithsonian Tropical Research Institute

2023 Meteorological and Hydrological Summary for Barro Colorado Island

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Introduction

This is the 24th of a series of yearly reports summarising the past year's Smithsonian Tropical Research Institute's Physical Monitoring Program on BCI. This report is not meant to be exhaustive in its coverage in that it summarizes only some of the most 'important' or interesting parameters available. Any comments on how future yearly summaries could be improved would be appreciated. Additional copies of this report, reports from previous years, and downloadable data from BCI and other research locations, can be obtained from: http://biogeodb.stri.si.edu/physical_monitoring/research/barrocolorado

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°10'N, 79°51'W) is a completely forested, 1567ha island with a 53.9km perimeter, rising 137m above Lake Gatun. The island receives an average of 2660.7mm of rain per year. The meteorological year is divided into two parts: a pronounced dry season (on average from December 19 to May 2), and a wet season (May to mid-December) – as measured by the manual rain gauge in the Clearing station between 2025 and 2023. On average, 300.3 and 2265.3mm of rain falls during the dry and wet seasons respectively (based on 1972-2023 precipitation). 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 three locations: a 48 m walk-up tower located within the Lutz catchment, a small clearing ('El Claro') located among several laboratory buildings, and the Conrad trail weir (see map on the following page).

The Lutz catchment is located on the Northeast slope of BCI immediately southwest of the laboratory clearing and dormitory area. is probably typical of many small catchment areas on the island. The catchment encompasses 9.69ha. of secondary forest that was cut during the Canal construction sometime between 1880 and 1915. The catchment has a steep grade that drains rapidly into the stream. The Lutz tower, with sensors at 10m intervals, provides a vertical meteorological transect through the forest canopy. Both the tower and the weir were constructed in 1972.

Sometime between April 27 and the 30th, 2018, a tree located approximately 40-50m SW of the tower, fell on the tension cables of the tower. The event left the tower unsafe for taking daily manual measurements. Most critically, this resulted in the suspension of the daily Evapotranspiration measurements which means that we are no longer able to estimate the hydrological balance for the catchment. This event created the largest gap ever observed in the area of the Lutz tower. Damaged to cables left the tower unsafe and, as a result, manual data on the data were not collected beginning on May 1. There is a high probability that the

new gap will have affected temperature & humidity readings for all sensors from 1m to 42m. The tower was still not repaired at the writing of this report.

The Clearing station is in the northwest corner of a large clearing area with a combination of forest and open structures (tower and cages) around the perimeter. The station is located in a fenced in area measuring approximately 5 x 5m. The Clearing is a grass-covered area and is intended to mimic a forest clearing.

The Conrad weir is located on the western side of the island and drains a 42.5ha catchment in the center of the island – including most of the 50ha plot. The catchment is divided into a small, gently sloped area near to the weir, and a much larger, nearly flat area in the center of the island.

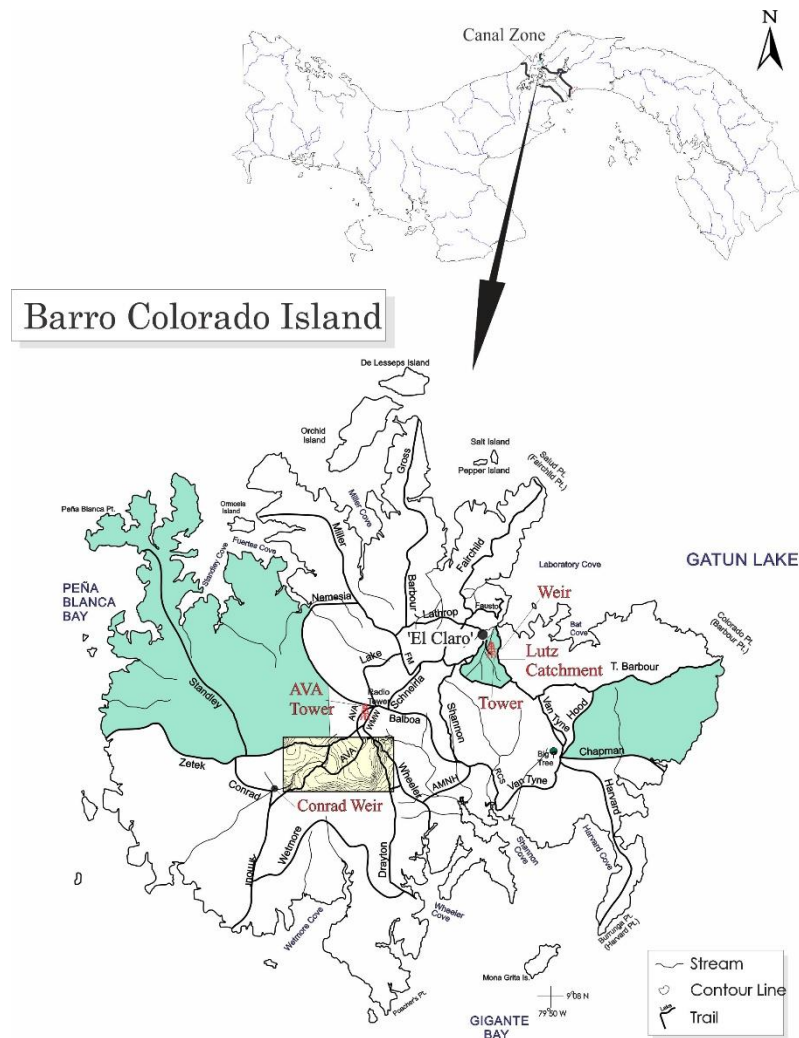
The physical aspects of both the Clearing and the Tower have changed relatively little over time. However, cycles of vegetation removal and re-growth may have had subtle effects at both locations. The recent removal and construction of buildings near to the Clearing may also have affected the local climate. 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 May of 2002, three new, 6-foot sections were added to the top of the tower. It was necessary to remove many branches from trees next to the tower during this operation. The new maximum height of the tower is now approximately 48m. A parallel series of meteorological wind speed measurements were made at both the old maximum height and the new for several years. Temperature and humidity are collected at both heights. Wind direction (it was not possible to measure at the old height) and solar radiation (assumed to be unaffected by the change in height) were moved to the 48m level and never measured in parallel.

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 field technician - Mr. Brian Harvey. Since the Lutz tower tree strike, many of the manual measurements have been suspended. Manual relative humidity, rainfall and evapotranspiration measurements are still being made in the clearing. Soil moisture measurements continue to be made as usual.

Ava versus Lutz towers. With almost three complete years of data at the Ava tower it is now possible meaningfully compare the conditions at the two locations. For the years 2021 & 2023:

- Temperatures at the top of the Ava tower are, on average, 0.7C lower than the top of the Lutz tower (25.2C versus 25.7C).
- Average wind at the top of Ava towers is significantly greater than at the top of the Lutz tower: 8.5 km/h versus 4.7 km/h
- Rainfall at the Ava tower is approximately 11% less than at Lutz: 216mm/month versus 240mm/month
- Solar radiation, temperature and relative humidity at the bottom, relative humidity at the top, and wind direction are not significantly different.



Some summaries (evapotranspiration 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 relative humidity) are based on combinations of manual and electro-mechanical measurements.

The 2020-1 Pandemic

Beginning on March 20, 2020, STRI was forced to shut down almost all field operations. This resulted in the Physical Monitoring Program suspending of all manual measurements on BCI, as well as sensor replacements and calibrations (the latter two were reestablished in Sept.). Most important of these were the evapotranspiration and soil moisture data, for which there are no electronic equivalents. There are also no temperature/humidity data for the 42m Lutz tower sensor between April 14 and Sept. 15. On Feb 1 of 2021, most monitoring activities returned to normal.

The Data

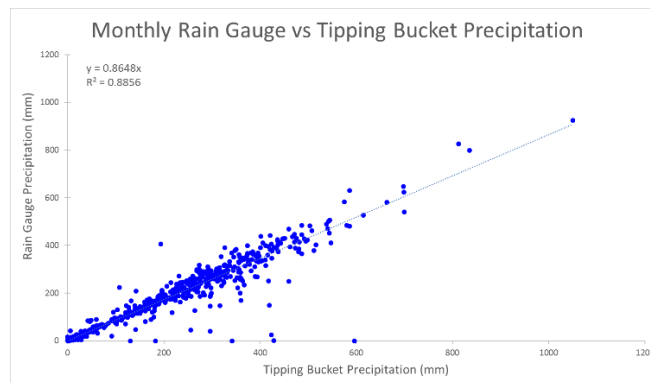
This report summarises the following data:

Lutz Tower	1m	relative humidity temperature
	20m	relative humidity temperature
	42m	relative humidity temperature
	48m	solar radiation (pyranometer) relative humidity temperature wind speed and direction
Lutz catchment		run-off soil moisture (manual and electronic)
Conrad catchment 'El Claro'		run-off air pressure rainfall relative humidity temperature

Rainfall

Rainfall was collected by rain gauges in the Clearing, and by a tipping bucket in the Clearing. 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. 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 10.

During prolonged periods (>7 days) when rain gauge measurements are suspended, tipping bucket data are used to estimate the manual rainfall. A simple correlation analysis between monthly Tipping Bucket and Rain Gauge data shows that on average, the Tipping Bucket underestimates the manual gauge rainfall by 15.63%.

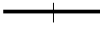


Rainfall Data prior to 1972 are provided by the Panama Canal Authority (ACP) station located approximately 360m to the NNW of the Clearing station.

Page 11 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 2023.

Page 12 shows yearly rainfall totals for all year since 1925. Time series graph and frequency histograms are presented for these data.

Page 13 breaks yearly rainfall approximately into wet and dry seasons. The average beginning and end dates for the seasons as defined by the Autoridad de Canal de Panamá (ACP) (Dec. 19 and May 2) are used. The two graphs on this page are frequency histograms showing the distribution of rainfalls (1929 to 2023) for the Dry and Wet Seasons. The arrow \longrightarrow in each graph shows the rainfall for 2023 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 - 2023.

Page 14 shows the beginning and end dates of the Panama Canal watershed dry season as defined by the Meteorological and Hydrological Branch of the ACP. The ACP defines the existence of dry season by tracking 11 variables (see list below) and then making a subjective decision based on the performance of these variables, and their prior experience with weather patterns in the Panama Canal area. There are no publications justifying the use of this system and any questions should be directed to Johnny Cuevas of the Met. & Hyd. Branch of the ACP (jcuevas@pancanal.com). The data from Page 14 are shown graphically on Page 15. At the time of printing of this report, the 2023 wet season end date had not yet been published by the ACP.

Westerly Component of 300 HPA Wind
 Gatun Lake Basin evaporation $> 0.13 \text{ " day}^{-1}$
 Sea temperature at Amador $< 80 \text{ }^{\circ}\text{F}$
 < 5 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 knots
 Intertropical Convergence Zone > 2 deg. Lat. south of Panama
 Pacific coast sea breeze < 2 hours/day
 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) $< .25 \text{ "}$

Pages 16 and 17 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 2022 and for the year 2023.

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 a Sutton Radar level Recorder (replacing the ISCO Bubble Flow Meter in 2014). Data from these devices are converted (either directly or through a digitizing process) into run-off (m^3) and then into rainfall equivalents.

Daily Lutz creek weir run-off totals are shown on page 18. 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 19 shows the total monthly run-off. The first graph on page 19 compares average monthly run-off for the period 1973 to 2021 with 2023. The second graph compares monthly accumulated precipitation with 2023 and long-term monthly-accumulated run-off (in rainfall equivalents).

Run-off at the Catchment catchment area was determined from the water level in a two-stage, rectangular weir. Water level was originally measured using an ISCO Bubble Flow Meter, but recently has been measure with a pressure gauge. Pages 20 shows the total monthly run-off data for the Conrad Catchment as well as a comparison between the Lutz and Conrad weir run-off.

Soil Moisture

Soil moisture was determined gravimetrically based on samples collected weekly from Dec. and May, and bi-weekly from June to Nov. 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 21 shows the average soil moistures (% water by wet weight of soil) per month at each sample depth. The graph on page 22 compares monthly averages for the period 1986 to 2022 with those for 2023. The sampling locations were changed at the end of 2016 to near-by sites. This is done approximately every 4-5 years due to perturbations to the soil caused by the coring and trampling by the technician.

Electronic sensors were installed on Feb. 15. TEROS 10 sensors (www.metergroup.com/en/meter-environment/products/teros-10-soil-moisture-sensor) were installed at Sites 3 and 10 at 10 and 40cm depths to measure soil water content. A TEROS 21 sensor (www.metergroup.com/en/meter-environment/products/teros-21-soil-water-potential-sensor) was installed at Site 3 at 20cm to measure soil water potential and temperature. Monthly average values are shown on Page 23, Daily average values are shown on Page 24. Monthly and daily graphs are one Page 25

Relative Humidity

Relative humidity data were collected at 15-minute intervals by dataloggers attached to Campbell Sci. CS215 temperature/humidity sensors (Viasala HMP 35/45 sensors prior to 2010) at the same locations. The average monthly relative humidities are shown in tabular and graphical form on pages 26.

Temperature

Shaded air temperature data were collected at 15-minute intervals by dataloggers attached to Campbell Sci. CS215 electronic temperature/humidity sensors (Viasala HMP 35/45 sensors prior to 2010) in the Clearing and at the 1m, 20m, 42m and 48m levels of the Lutz tower. The average monthly daily maximum and minimum temperatures are shown on pages 27 to 28.

Solar Radiation

Global solar radiation was measured at the top of the Lutz tower using one Kipp&Zonen SPLite2 and one LiCor LI200 pyranometer attached to a datalogger. 15-minute interval total (MJ m^{-2}), maximum and minimum ($\text{J m}^{-2} \text{ s}^{-1}$) were recorded. Page 29 shows the

Daily Global Radiation values. Page 30 shows total monthly Global Radiation. For Photosynthetically Active Radiation (PAR) for BCI, please consult the report for the AVA tower.

Wind Speed and Direction

15-minute interval average, maximum and minimum wind speed plus average wind direction was recorded at the top of the Lutz tower using a Model 05103 Young Anemometer connected to a data logger.

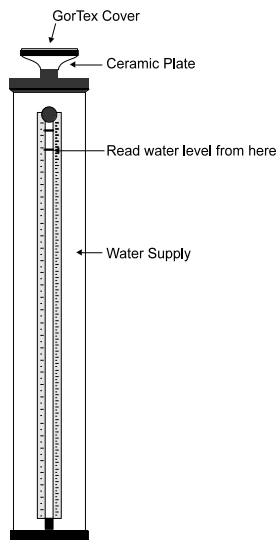
Page 31 shows daily average and maximum wind speeds from the Young Anemometer located at 48m. The page 32 shows daily average wind direction. The angles indicated in the table and graph on this page represent the direction into which the wind was predominately blowing on a given day. Page 33 shows the monthly average and average daily-maximum wind speeds from 48m, and monthly average directions (Young Anemometer) for the year, as well as seasonal windrose figures based on 15-min interval values.

In addition to the electronic anemometers, manually read, totalizing anemometers were in use to measure wind passage between 1998 and 2007. This includes the period 2001-7 when totalizing anemometers were in operation at both 42m and 48m. An analysis of these data is shown on Page 34.

Long-term monthly averages are shown on Pages 35-8. Daily average values for 2023 are shown on Pages 39-40. Average 15-min interval 24-hour average patterns are shown on pages 41-2

Estimated Evapotranspiration and Water Balance

ETguage



Evapotranspiration was added to the meteorological program on BCI beginning in December of 1992 and is estimated using ceramic plate atmometers known as ETgauges. ETgauges 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.

ETgauges provide data that are very comparable with Class-A open evaporation pans. A 4-year study on BCI showed that yearly totals of the two systems vary by approximately 2%. ETgauges slightly overestimate ET during the dry season and underestimate during the rainy season – compared to the pans.

There are two ETgauges located at a height of 1.5m in the Clearing (the Lutz tower ETgauges have not been used since Apr. 2018 due to damage to the tower). The ETgauges are read at approximately the same time of day and with the same frequency as the rain gauges.

Long-term Monthly Averages/Totals

Pages 32 - 35 show the long-term, monthly Averages/Totals for rainfall, runoff, relative humidity, air temperature, evapotranspiration, solar radiation, and wind speed.

Daily Averages/Totals for 2023

Pages 36 and 37 show the daily Averages/Totals for rainfall, runoff, relative humidity, air temperature, evapotranspiration, solar radiation, and wind speed and direction.

Daily Patterns

Pages 38 and 39 show the daily patterns for air temperature, relative humidity, solar radiation, rainfall and wind speed. These figures use electronic sensor data.

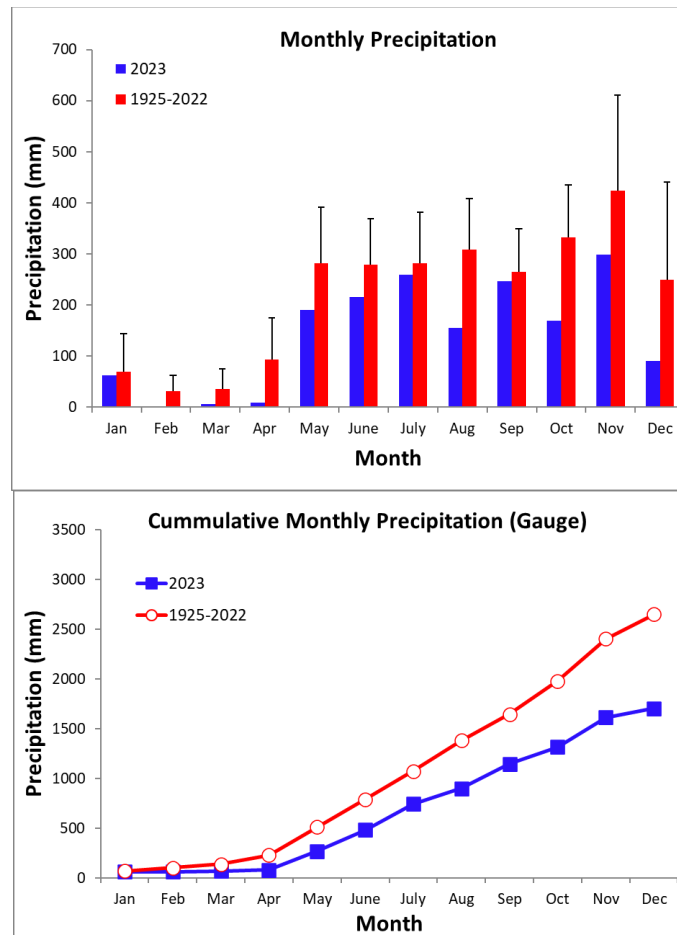
2023 Daily Rainfall (mm) on BCI recorded at ~930 hrs

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.5	0.0	0.0	0.0	6.6	1.0	11.6	26.1	3.7	15.2	13.5	
2	14.2	0.3	0.0	0.0	1.3	0.2	9.4	0.0	49.0	0.3	6.9	
3	0.3	0.0	0.0	0.0	0.0	0.0	19.7	0.3	15.6	0.0	63.1	
4	0.0	0.0	0.0	0.0	0.0	0.0	1.2	4.8	0.3	0.0	11.3	
5	3.6	0.0	0.0	0.0	0.0	0.5	1.7	0.0	0.0	54.0	0.3	
6	0.3	0.0	0.0	1.9	0.0	7.9	0.0	0.0	0.0	0.8	0.0	
7	0.0	0.0	0.0	4.6	0.0	0.0	4.2	11.8	4.3	0.0	0.0	
8	0.0	0.0	1.0	0.0	0.0	8.1	0.5	5.1	0.3	0.0	0.3	
9	0.0	0.0	0.0	0.0	0.6	4.2	0.0	0.7	2.3	0.0	10.3	
10	9.7	0.0	0.0	0.0	0.0	0.3	0.0	9.8	33.8	26.0	5.3	
11	0.0	0.0	0.0	1.5	1.3	0.0	20.5	0.0	0.0	0.0	1.5	
12	12.4	0.0	0.0	0.0	0.0	0.0	0.0	13.9	0.3	0.1	67.9	
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	37.6	10.4	
14	0.0	0.0	0.0	0.5	0.3	0.0	0.4	19.9	1.3	0.0	0.3	
15	0.0	0.0	3.3	0.0	0.3	34.7	0.6	7.4	21.3	0.0	0.0	
16	0.0	0.0	0.0	0.0	103.8	0.3	2.5	5.6	1.9	10.0	1.0	
17	21.5	0.0	0.0	0.0	0.4	35.7	1.3	11.2	37.8	0.0	15.1	
18	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	15.9	1.5	16.3	
19	0.0	0.0	0.0	0.0	0.0	0.3	0.0	1.5	15.9	0.0	5.0	
20	0.0	0.0	0.0	0.0	18.6	1.8	0.0	28.6	7.3	0.5	18.1	
21	0.0	0.0	0.0	0.0	6.8	1.5	0.0	0.8	6.5	0.0	0.0	
22	0.0	0.0	0.0	0.0	29.2	0.0	8.2	1.0	9.1	0.0	10.7	
23	0.0	0.0	0.0	0.0	0.8	70.0	4.5	2.7	0.0	0.0	2.7	
24	0.3	0.0	0.3	0.0	3.6	25.8	6.0	0.2	1.8	11.4	0.3	
25	0.0	0.0	0.0	0.0	0.0	18.7	0.0	0.0	5.2	0.8	29.1	
26	0.0	0.0	0.0	0.0	0.3	0.4	0.8	0.0	13.0	0.0	7.8	
27	0.0	0.0	0.0	0.0	12.5	0.0	19.7	0.0	0.0	0.0	0.0	
28	0.0	0.0	0.0	0.0	1.8	4.3	6.5	0.0	0.5	0.0	0.5	
29	0.0		0.0	0.0	1.5	0.0	0.3	0.0	0.0	0.0	0.3	
30	0.0		0.9	0.0	1.0	0.0	120.6	0.0	2.3	0.0	1.0	
31	0.0		1.3		0.3		18.6	3.0		8.6		
	62.6	0.3	6.7	8.5	190.6	215.5	259.4	155.3	249.5	166.8	298.8	0.0

Monthly Rainfall at 'El Claro' - Rain Guage

	<u>Rainfall (mm)</u>				2023	Rank* (n=98)
	Average	Min	Max	S.D.		
January	69.0	0.5	376.4	109.4	62.6	35
February	31.2	0.3	186.4	101.3	0.3	98
March	36.4	0.0	174.0	106.0	6.7	78
April	93.3	0.0	463.8	87.6	8.5	91
May	281.6	78.5	699.8	38.9	190.0	78
June	278.8	66.8	556.8	32.3	215.5	76
July	282.4	90.6	725.9	35.0	259.4	61
August	309.0	142.7	677.2	32.1	155.3	94
September	264.6	107.6	507.0	32.0	247.1	57
October	332.6	115.3	588.7	30.8	169.2	90
November	423.3	117.1	1056.1	44.3	298.8	73
December	248.9	16.4	1182.9	77.0	90.3	78
Total	2659.6	1698.9	4486.5	477.7	1703.7	97

* Rank: 1 = wettest year.

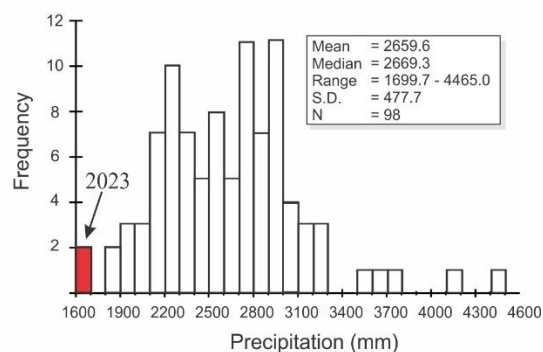
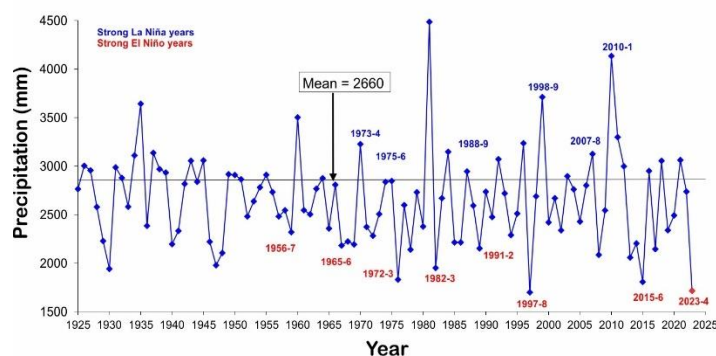


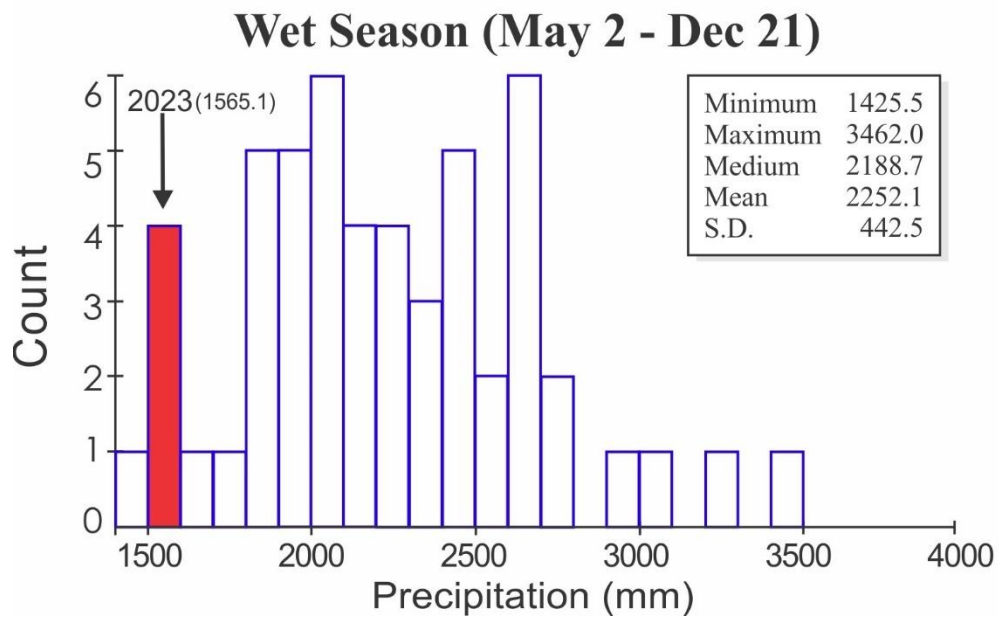
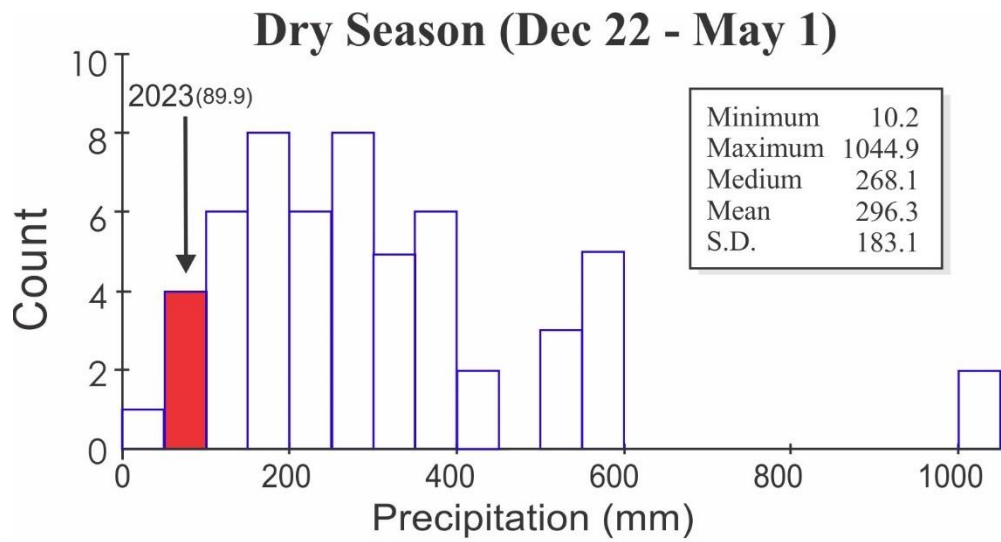
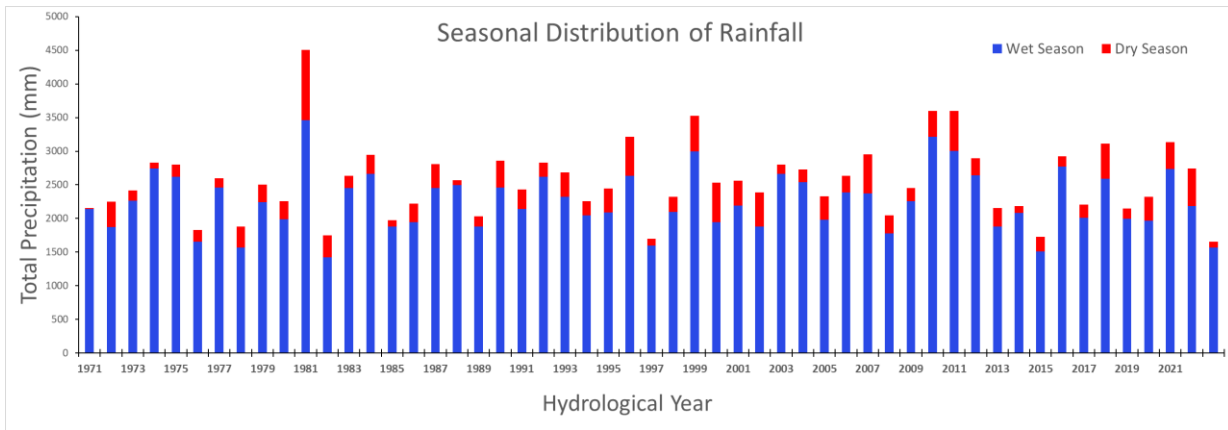
Yearly Rainfall (mm) at 'El Claro' - Rain Gauge

Year	Rain	Year	Rain	Year	Rain
1925	2228.5	1958	2545.1	1991	2475.2
1926	1940.6	1959	2319.5	1992	3071.3
1927	2987.4	1960	3502.3	1993	2718.9
1928	2878.5	1961	2545.4	1994	2289.0
1929	2581.8	1962	2502.8	1995	2511.2
1930	3109.6	1963	2767.1	1996	3236.3
1931	3642.7	1964	2875.2	1997	1698.9
1932	2384.4	1965	2357.2	1998	2688.8
1933	3136.8	1966	2807.7	1999	3712.1
1934	2969.0	1967	2181.4	2000	2420.4
1935	2933.0	1968	2223.4	2001	2669.3
1936	2195.9	1969	2192.5	2002	2338.7
1937	2332.2	1970	3226.7	2003	2896.7
1938	2816.8	1971	2373.6	2004	2760.9
1939	3055.4	1972	2282.4	2005	2428.0
1940	2838.8	1973	2506.0	2006	2800.9
1941	3058.9	1974	2837.3	2007	3125.3
1942	2221.0	1975	2847.0	2008	2085.5
1943	1978.2	1976	1830.5	2009	2544.1
1944	2105.6	1977	2599.1	2010	4135.2
1945	2916.3	1978	2139.7	2011	3298.4
1946	2908.3	1979	2730.9	2012	2998.0
1947	2863.8	1980	2377.5	2013	2058.4
1948	2228.5	1981	4486.5	2014	2203.2
1949	1940.6	1982	1950.7	2015	1810.1
1950	2987.4	1983	2669.5	2016	2950.4
1951	2878.5	1984	3147.7	2017	2188.1
1952	2481.7	1985	2213.3	2018	3054.9
1953	2637.5	1986	2213.4	2019	2338.8
1954	2781.7	1987	2945.2	2020	2599.4
1955	2910.4	1988	2592.6	2021	3062.1
1956	2732.8	1989	2152.7	2022	2701.7
1957	2482.1	1990	2736.2	2023	1703.7

Yearly Precipitation

Distribution of Yearly Precipitation

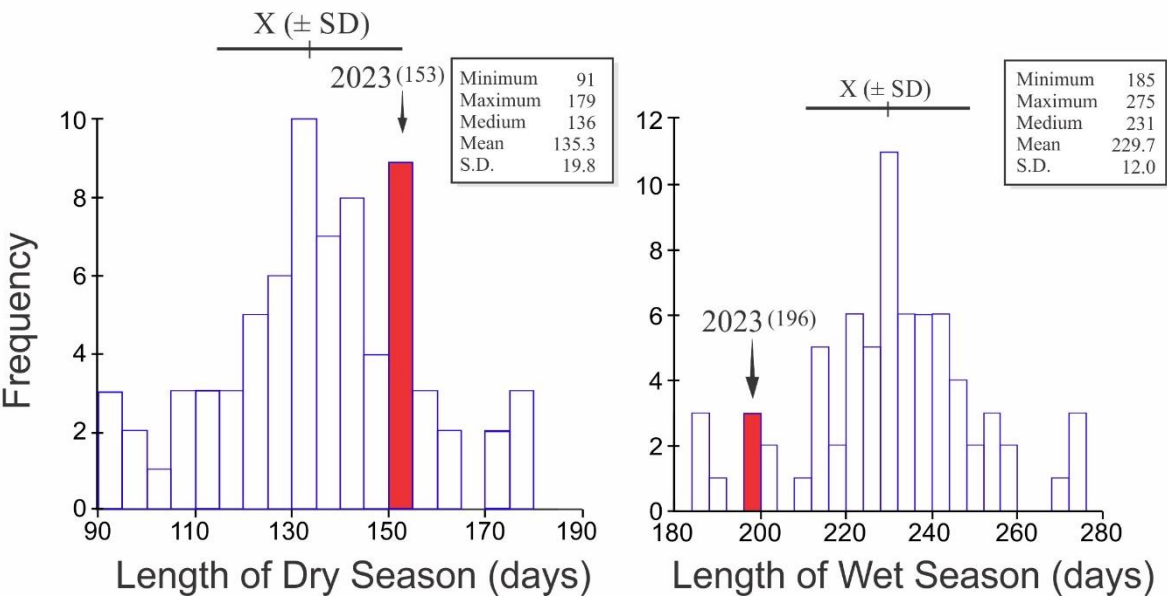
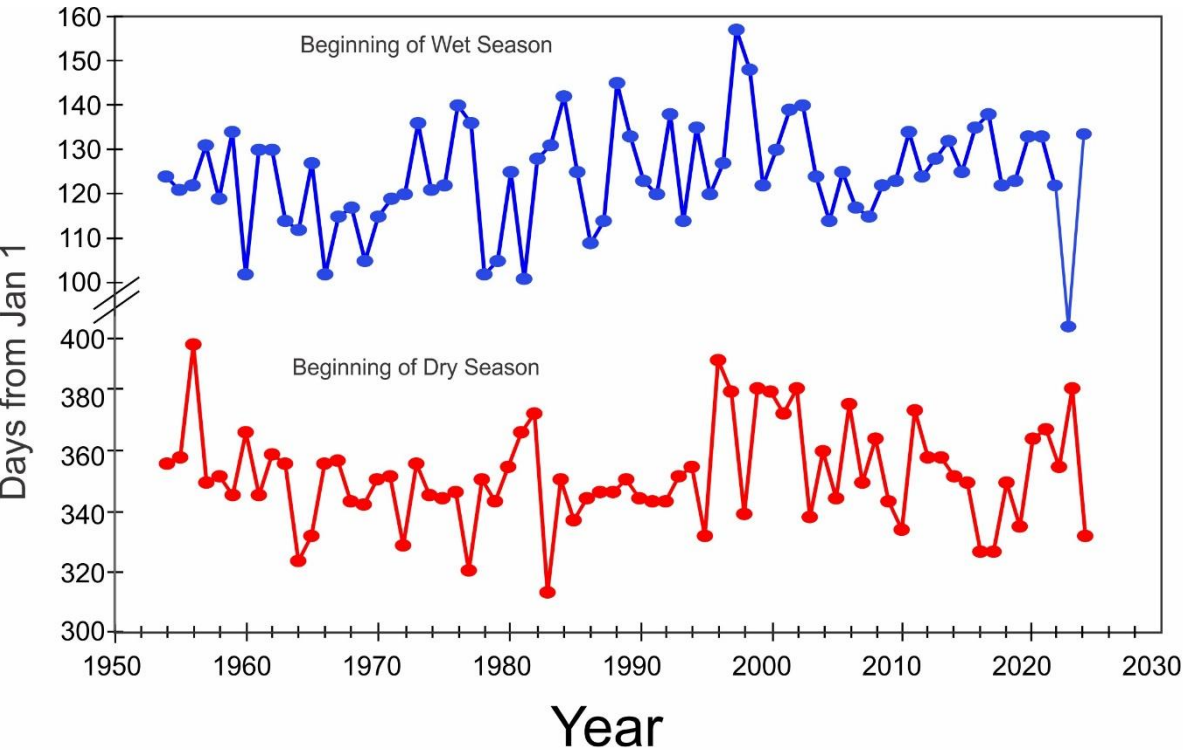




ACP Dry Season Beginning and End Dates

Year	Begin	End	Length		Year	Begin	End	Length	
			Dry Season	Wet Season				Dry Season	Wet Season
1954	25-Dec-53	05-May-54	131	236	1998	09-Dec-97	29-May-98	171	234
1955	27-Dec-54	02-May-55	126	275	1999	18-Jan-99	03-May-99	105	259
1956	01-Feb-56	02-May-56	91	231	2000	17-Jan-00	10-May-00	114	245
1957	19-Dec-56	12-May-57	144	223	2001	10-Jan-01	26-May-01	136	237
1958	21-Dec-57	30-Apr-58	130	229	2002	18-Jan-02	21-May-02	123	201
1959	15-Dec-58	15-May-59	151	234	2003	08-Dec-02	05-May-03	148	238
1960	04-Jan-60	12-Apr-60	99	247	2004	29-Dec-03	24-Apr-04	117	234
1961	15-Dec-60	11-May-61	147	231	2005	14-Dec-04	6-May-05	143	234
1962	28-Dec-61	11-May-62	134	228	2006	13-Jan-06	28-Apr-06	105	252
1963	25-Dec-62	25-Apr-63	121	213	2007	19-Dec-06	26-Apr-07	128	235
1964	24-Nov-63	22-Apr-64	150	224	2008	2-Jan-08	2-May-08	121	251
1965	02-Dec-64	08-May-65	157	231	2009	13-Dec-08	4-May-09	142	225
1966	25-Dec-65	13-Apr-66	109	257	2010	4-Dec-09	15-May-10	162	214
1967	26-Dec-66	26-Apr-67	121	231	2011	11-Jan-11	5-May-11	114	241
1968	13-Dec-67	27-Apr-68	136	229	2012	27-Dec-11	8-May-12	133	236
1969	12-Dec-68	16-Apr-69	125	248	2013	27-Dec-12	13-May-13	137	233
1970	20-Dec-69	26-Apr-70	127	239	2014	21-Dec-13	06-May-14	136	222
1971	21-Dec-70	30-Apr-71	130	213	2015	19-Dec-14	16-May-15	148	195
1972	29-Nov-71	30-Apr-72	153	239	2016	27-Nov-15	18-May-16	173	193
1973	25-Dec-72	17-May-73	143	212	2017	27-Nov-16	3-May-17	157	230
1974	15-Dec-73	02-May-74	138	226	2018	19-Dec-17	4-May-18	136	215
1975	14-Dec-74	03-May-75	140	227	2019	5-Dec-18	14-May-19	160	233
1976	16-Dec-75	20-May-76	156	185	2020	2-Jan-20	13-May-20	132	237
1977	21-Nov-76	17-May-77	177	217	2021	5-Jan-21	3-May-21	118	235
1978	20-Dec-77	13-Apr-78	114	244	2022	24-Dec-21	26-Apr-22	123	267
1979	13-Dec-78	16-Apr-79	124	252	2023	18-Jan-23	20-May-23	122	196
1980	24-Dec-79	05-May-80	133	244	2024	2-Dec-24			
1981	04-Jan-81	12-Apr-81	98	273					
1982	10-Jan-82	09-May-82	119	189					
1983	14-Nov-82	12-May-83	179	222					
1984	20-Dec-83	22-May-84	154	199					
1985	07-Dec-84	06-May-85	150	222					
1986	14-Dec-85	20-Apr-86	127	240					
1987	16-Dec-86	25-Apr-87	130	235					
1988	16-Dec-87	25-May-88	161	209					
1989	20-Dec-88	14-May-89	145	214					
1990	14-Dec-89	04-May-90	141	223					
1991	13-Dec-90	01-May-91	139	226					
1992	13-Dec-91	18-May-92	157	217					
1993	21-Dec-92	25-Apr-93	125	243					
1994	24-Dec-93	16-May-94	143	200					
1995	02-Dec-94	01-May-95	150	271					
1996	27-Jan-96	07-May-96	101	255					
1997	17-Jan-97	07-Jun-97	141	185					
					Avg SD	19-Dec ±16 days	02-May ±12 days	124 11.6	229.4 19.8

Seasonality Distribution

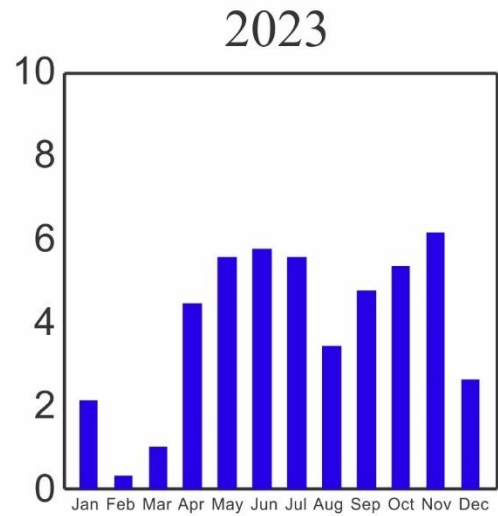
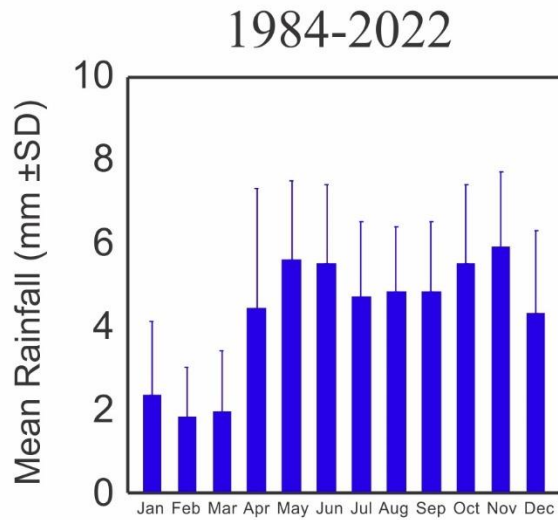


Storm Analysis

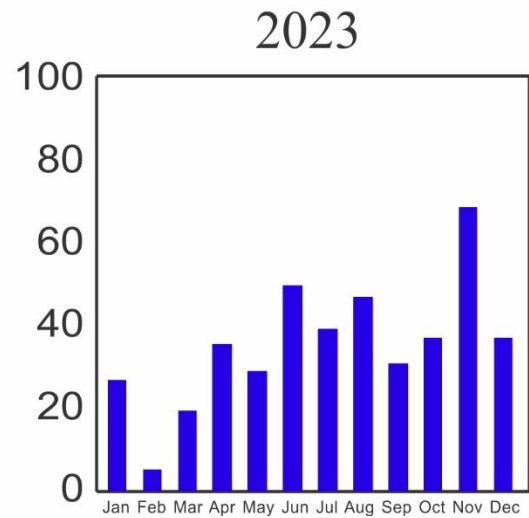
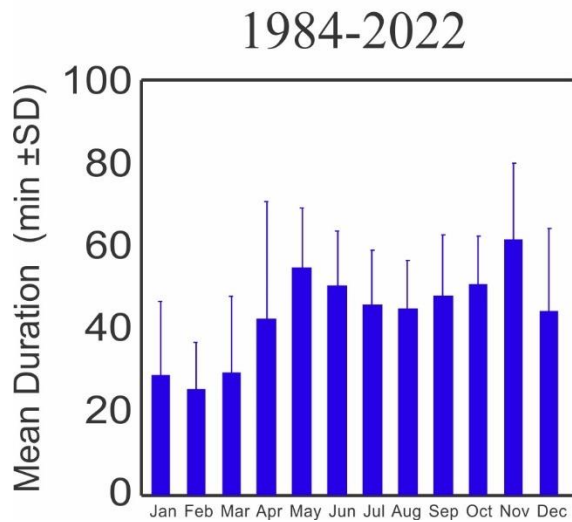
	Max. Rainfall per Storm (mm)			Storm Duration (min.)		
	1994-2022		2023	1994-2022		2023
	Mean	S.D.		Mean	S.D.	
January	19.1	21.7	8.6	25.3	15.8	26.5
February	10.9	11.0	0.3	21.8	13.1	5.0
March	13.0	15.9	3.3	28.8	28.7	19.0
April	34.8	29.5	13.2	39.0	25.6	35.3
May	51.4	21.0	37.8	48.2	17.6	28.6
June	54.7	23.9	53.1	46.6	14.7	49.3
July	48.8	22.9	74.9	41.3	14.2	38.8
August	49.5	18.6	27.2	42.8	13.3	46.6
September	45.6	18.5	49.5	45.9	16.8	30.5
October	50.0	23.5	47.8	48.0	14.4	36.7
November	58.3	38.8	65.5	51.7	21.8	68.1
December	46.0	40.4	17.5	38.4	19.2	36.7

	Av. Rainfall per Storm (mm)		
	1994-2022	2023	
	Mean	S.D.	
January	2.9	2.1	2.1
February	2.3	2.0	0.3
March	2.7	2.5	1.0
April	5.0	3.4	4.4
May	6.4	2.4	5.5
June	6.5	2.5	5.7
July	5.5	1.9	5.5
August	6.2	2.8	3.4
September	6.0	2.2	4.7
October	6.6	2.5	5.3
November	6.6	2.6	6.1
December	5.0	2.8	2.6

Average Monthly Storm Size

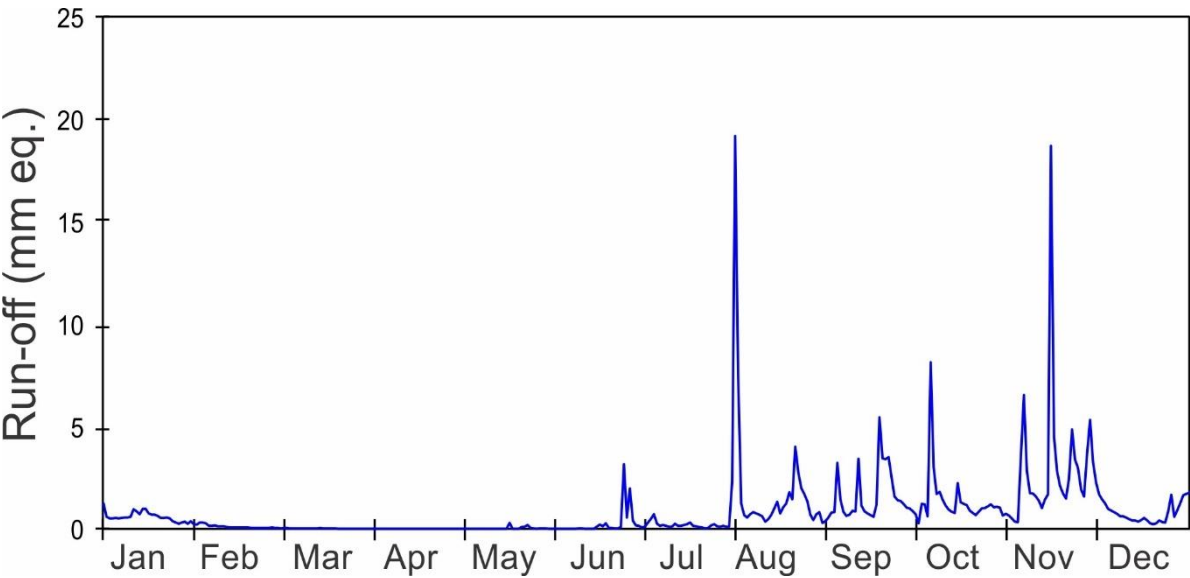


Average Monthly Storm Duration



2023 Daily Lutz Weir Run-off (mm. eq.)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	1.22	0.20	0.03	0.00	0.00	0.00	0.30	1.23	0.82	1.20	0.33	0.97
2	0.60	0.30	0.04	0.00	0.00	0.00	0.49	0.68	3.21	0.62	3.59	0.89
3	0.51	0.31	0.04	0.00	0.00	0.00	0.70	0.56	1.43	8.12	6.52	0.82
4	0.51	0.26	0.03	0.00	0.00	0.00	0.26	0.71	0.83	2.99	2.82	0.73
5	0.53	0.15	0.02	0.00	0.00	0.00	0.15	0.82	0.64	1.70	1.74	0.61
6	0.52	0.15	0.02	0.00	0.00	0.00	0.19	0.75	0.69	1.80	1.72	0.61
7	0.53	0.17	0.03	0.00	0.00	0.01	0.14	0.68	0.88	1.42	1.57	0.55
8	0.54	0.13	0.03	0.00	0.00	0.02	0.11	0.62	0.86	1.14	1.35	0.46
9	0.55	0.13	0.03	0.00	0.00	0.03	0.11	0.35	3.42	0.93	1.01	0.42
10	0.60	0.12	0.03	0.00	0.00	0.00	0.24	0.47	1.13	0.84	1.42	0.40
11	0.95	0.08	0.03	0.00	0.00	0.00	0.15	0.67	0.85	0.78	1.67	0.34
12	0.85	0.06	0.03	0.00	0.00	0.00	0.14	0.99	0.76	2.22	18.69	0.42
13	0.71	0.07	0.02	0.00	0.00	0.00	0.18	1.32	0.67	1.30	4.49	0.53
14	0.97	0.07	0.04	0.00	0.00	0.11	0.22	0.76	0.59	1.21	2.83	0.40
15	0.97	0.06	0.03	0.00	0.00	0.20	0.30	1.05	1.17	1.16	2.10	0.26
16	0.75	0.07	0.02	0.00	0.29	0.12	0.15	1.24	5.44	0.90	1.72	0.24
17	0.70	0.06	0.02	0.00	0.01	0.26	0.12	1.78	3.43	0.78	1.49	0.26
18	0.69	0.06	0.02	0.00	0.00	0.05	0.09	1.44	3.40	0.67	2.42	0.40
19	0.64	0.05	0.02	0.00	0.00	0.04	0.06	4.00	3.49	0.83	4.85	0.32
20	0.54	0.04	0.01	0.00	0.09	0.03	0.03	2.73	2.51	1.00	3.38	0.31
21	0.52	0.04	0.01	0.00	0.10	0.02	0.04	1.99	1.58	1.02	2.97	0.85
22	0.54	0.04	0.00	0.00	0.18	0.08	0.17	1.70	1.39	1.09	1.92	1.66
23	0.51	0.04	0.00	0.00	0.04	3.16	0.22	1.34	1.36	1.20	1.58	0.60
24	0.37	0.04	0.00	0.00	0.02	0.55	0.13	0.70	1.22	1.05	3.68	0.90
25	0.31	0.04	0.00	0.00	0.01	1.97	0.10	0.42	1.03	1.08	5.31	1.26
26	0.24	0.06	0.00	0.00	0.03	0.39	0.15	0.71	0.99	1.04	3.26	1.63
27	0.30	0.05	0.00	0.00	0.03	0.17	0.10	0.82	0.88	0.64	2.25	1.70
28	0.35	0.05	0.00	0.00	0.02	0.15	0.10	0.28	0.72	0.73	1.69	1.75
29	0.25		0.00	0.00	0.01	0.07	2.33	0.36	0.27	0.65	1.44	
30	0.36		0.00	0.00	0.01	0.10	19.17	0.56	1.22	0.51	1.24	
31	0.23		0.00		0.00		7.53	0.80		0.35		

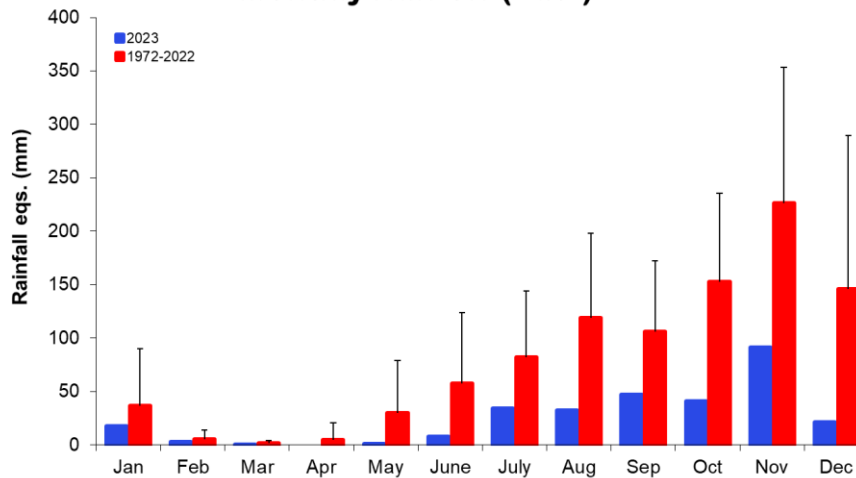


Monthly Run-off

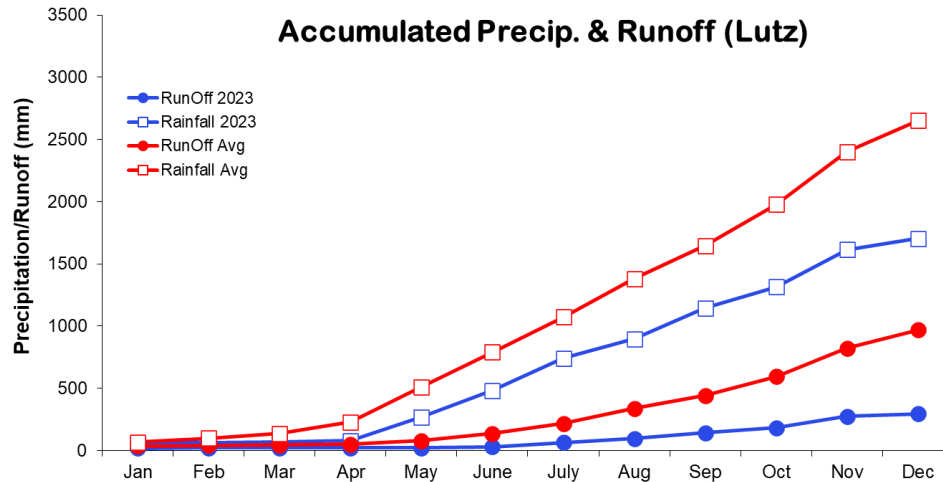
Run-off, Lutz Weir (mm eq.)

	Long-term Averages (1972 - 2022)		2023
	Total	S.D.	Total
January	36.9	53.1	17.8
February	5.6	8.4	2.9
March	1.8	2.3	0.6
April	4.7	16.3	0.0
May	30.1	49.1	0.8
June	57.5	66.5	7.5
July	82.0	62.1	34.2
August	119.0	79.3	32.5
September	106.0	66.1	46.9
October	152.6	82.8	41.0
November	226.4	127.0	91.1
December	146.2	143.6	21.2
Total	964.0	446.8	295.3

Monthly Run-off (Lutz)



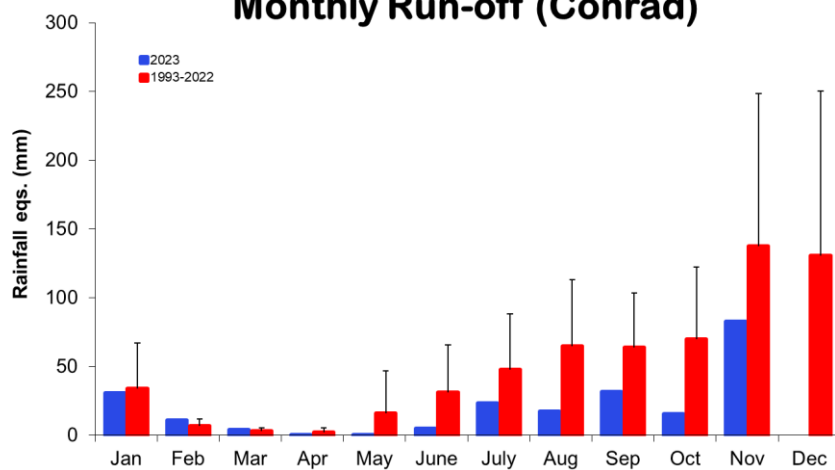
Accumulated Precip. & Runoff (Lutz)



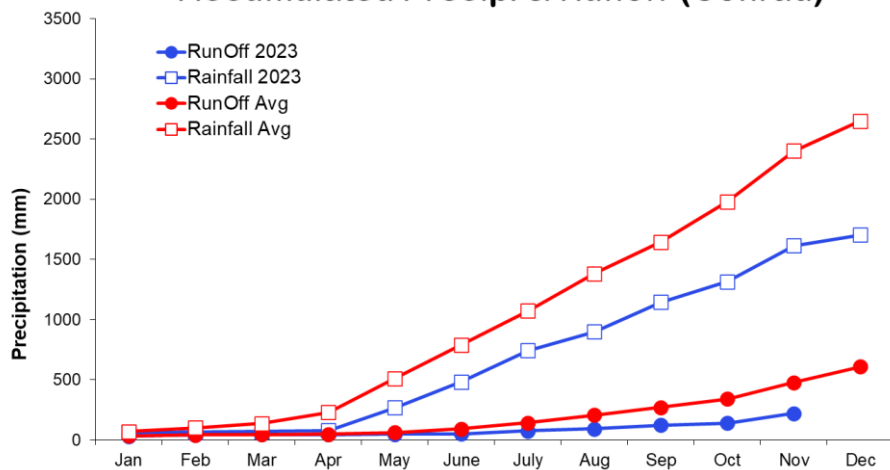
Run-off, Conrad Weir (mm eq.)

	Long-term Averages (1972 - 2022)		2023
	Total	S.D.	Total
January	34.0	33.1	30.7
February	7.0	5.0	10.9
March	3.1	2.5	3.9
April	2.2	3.0	0.0
May	15.9	31.0	0.4
June	31.0	34.9	5.1
July	47.9	40.3	23.2
August	64.8	48.5	17.5
September	63.7	39.9	32.0
October	69.8	52.5	15.4
November	137.4	110.9	82.6
December	130.6	119.6	
Total	646.3	310.1	

Monthly Run-off (Conrad)



Accumulated Precip. & Runoff (Conrad)

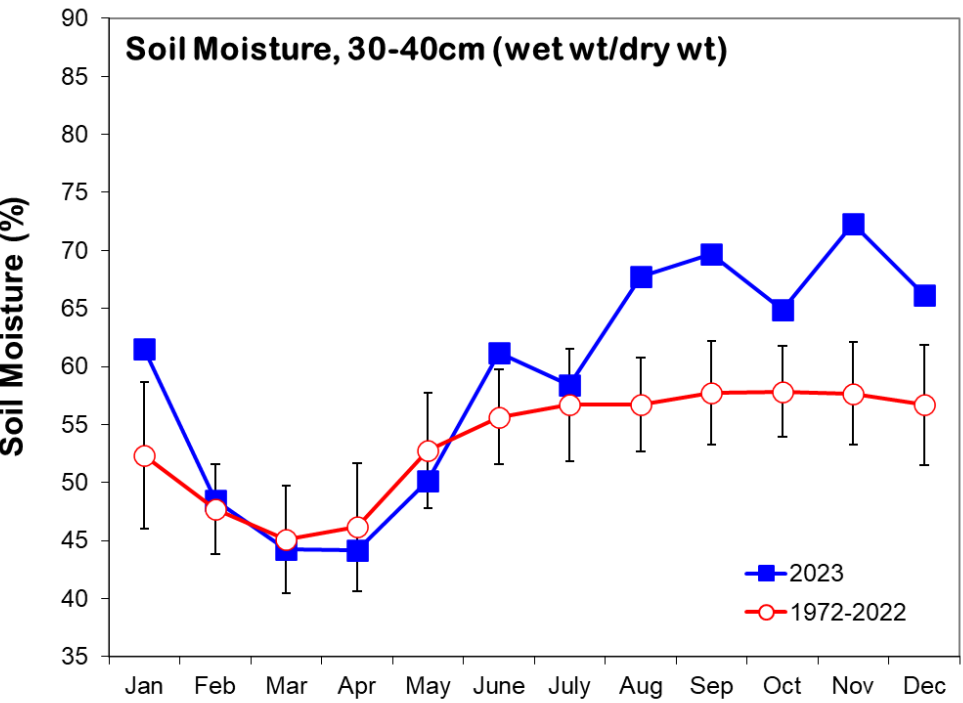
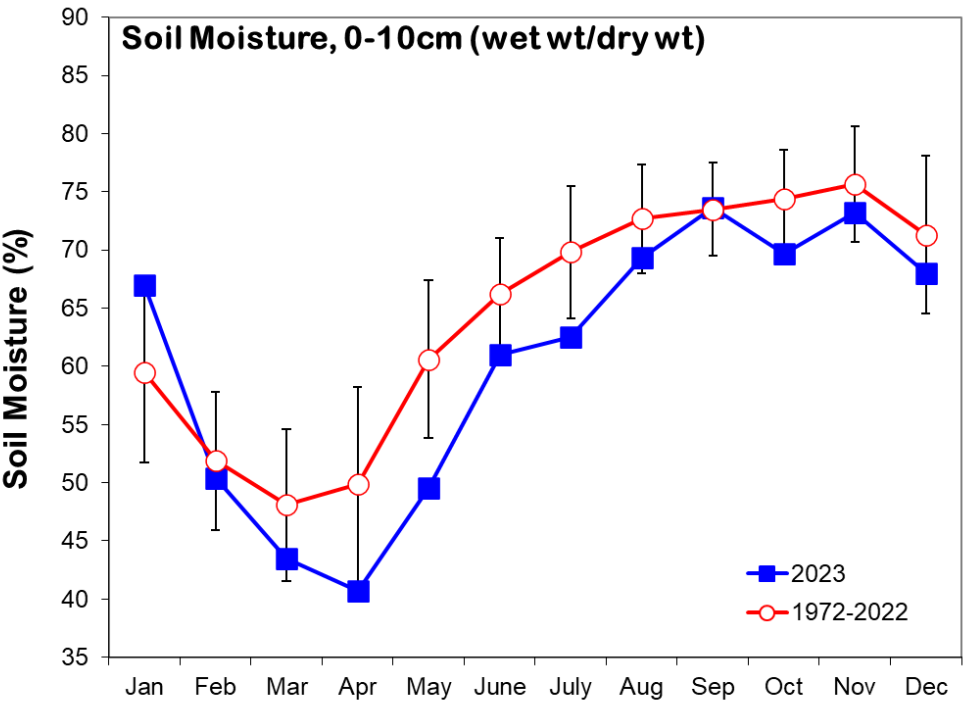


Lutz Catchment Soil Moisture (Manual)

(H ₂ O/wet wt of soil)					
Long-term Averages (1972-2022)					2023
	0-10 cm		30-40 cm		0-10 cm 30-40 cm
	Mean	S.D.	Mean	S.D.	
January	36.8	3.2	33.9	2.5	39.8 37.8
February	33.9	2.5	32.0	1.7	33.2 32.2
March	32.1	2.7	30.7	2.1	30.1 30.5
April	33.0	3.2	31.2	2.4	28.8 30.4
May	37.4	2.5	34.3	2.0	32.9 33.2
June	39.6	1.7	35.3	1.6	37.6 37.5
July	40.8	1.8	35.8	1.9	38.1 36.6
August	41.8	1.7	35.8	1.4	40.5 40.0
September	42.0	1.4	36.2	1.6	41.9 40.6
October	42.3	1.6	36.3	1.5	40.7 39.1
November	42.8	1.7	36.1	1.5	41.7 41.6
December	41.2	2.6	35.7	2.0	40.1 39.6

(H ₂ O/dry wt of soil)					
Long-term Averages (1972-2022)					2023
	0-10 cm		30-40 cm		0-10 cm 30-40 cm
	Mean	S.D.	Mean	S.D.	
January	59.3	7.8	52.1	6.2	67.0 61.6
February	51.9	6.0	47.7	3.9	50.4 48.4
March	48.2	6.5	45.1	4.7	43.5 44.2
April	50.1	8.3	46.2	5.6	40.7 44.2
May	60.8	6.5	52.9	5.0	49.5 50.1
June	66.3	4.8	55.5	4.0	61.0 61.2
July	70.0	5.6	56.7	4.9	62.5 58.4
August	72.8	4.7	56.5	3.7	69.4 67.8
September	73.5	4.0	57.4	4.1	73.6 69.7
October	74.5	4.2	57.7	3.8	69.7 64.9
November	75.7	5.0	57.3	3.8	73.2 72.3
December	71.4	6.9	56.5	5.0	68.0 66.2

Lutz Catchment Soil Moisture (Manual)



Lutz Catchment Soil Moisture (Electronic)

(Soil Moisture Vol. Water Content (m³/m³))

Site 3

	Long-term Averages ()				2023	
	0-10 cm		30-40 cm		0-10 cm	30-40 cm
	Mean	S.D.	Mean	S.D.		
January						
February						
March					0.30	0.37
April					0.28	0.35
May					0.33	0.40
June					0.38	0.44
July					0.40	0.45
August					0.42	0.46
September					0.45	0.46
October					0.46	0.46
November					0.47	0.47
December					0.42	0.44

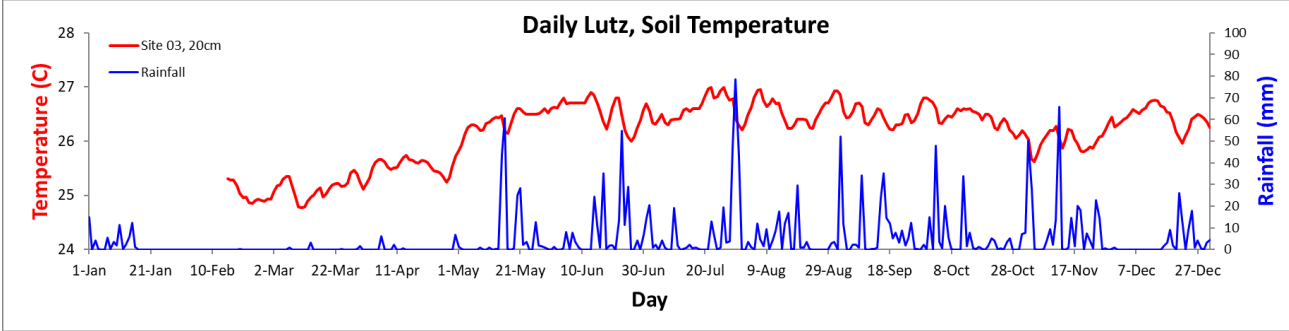
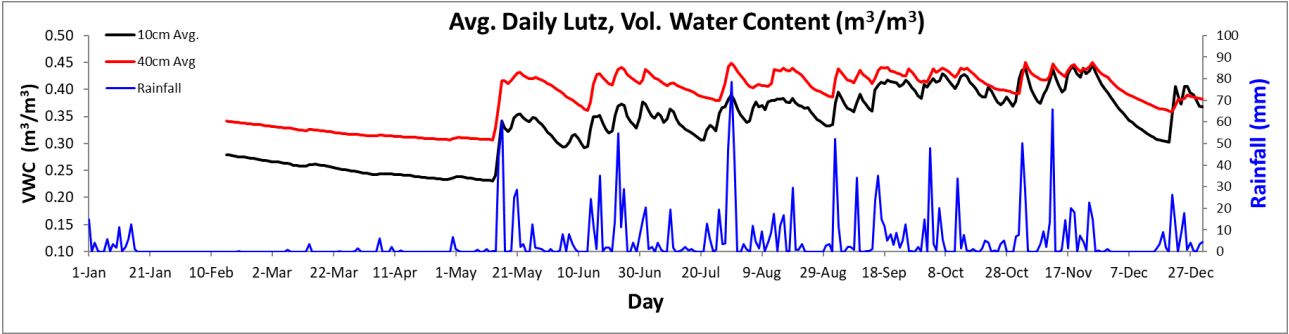
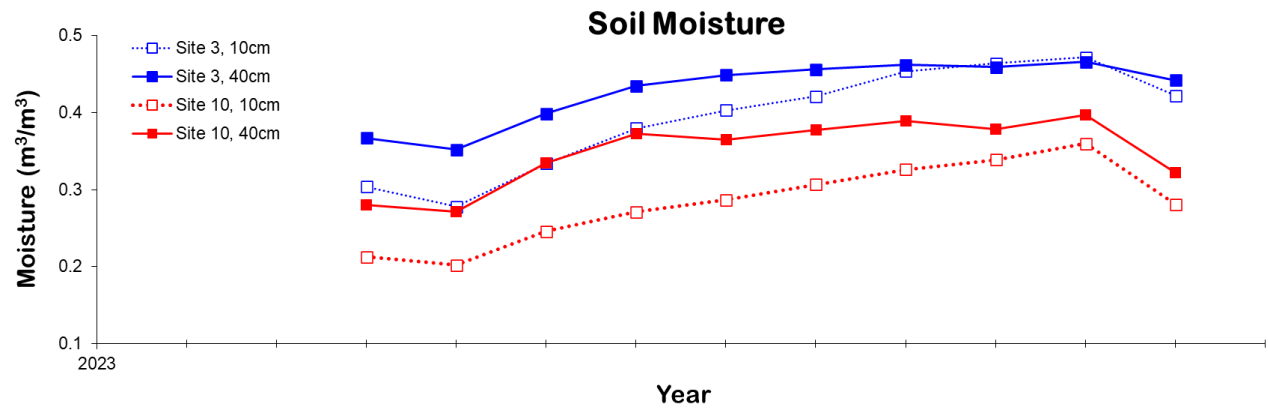
Site 10

	Long-term Averages ()				2023	
	0-10 cm		30-40 cm		0-10 cm	30-40 cm
	Mean	S.D.	Mean	S.D.		
January						
February						
March					0.21	0.28
April					0.20	0.27
May					0.25	0.34
June					0.27	0.37
July					0.29	0.37
August					0.31	0.38
September					0.33	0.39
October					0.34	0.38
November					0.36	0.40
December					0.28	0.32

Lutz Catchment Soil Moisture (Electronic)

(Soil Moisture Vol. Water Content (m^3/m^3))

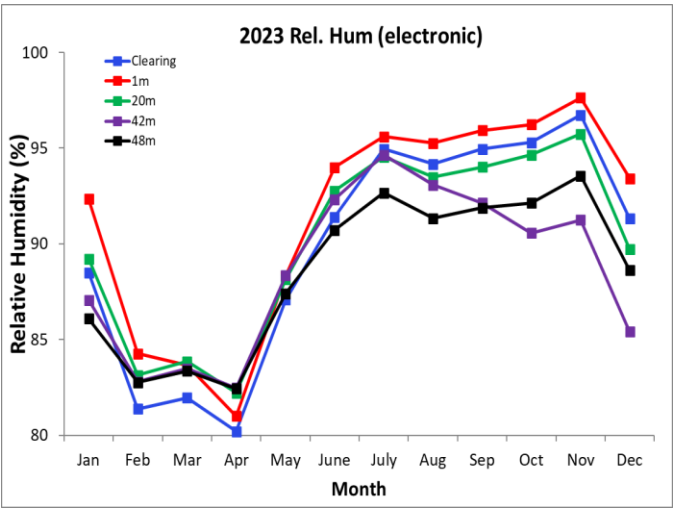
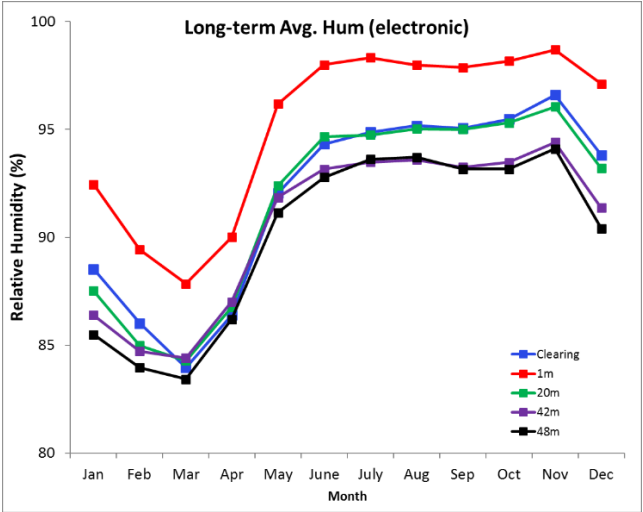
	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sep.		Oct.		Nov.		Dec.	
	10cm	40cm	10cm	40cm	10cm	40cm	10cm	40cm	10cm	40cm	10cm	40cm	10cm	40cm	10cm	40cm	10cm	40cm	10cm	40cm	10cm	40cm	10cm	40cm
1					0.27	0.33	0.25	0.32	0.24	0.31	0.32	0.41	0.38	0.42	0.36	0.43	0.33	0.39	0.41	0.42	0.42	0.39	0.39	0.42
2					0.27	0.33	0.25	0.31	0.24	0.31	0.31	0.40	0.37	0.44	0.35	0.43	0.38	0.42	0.40	0.41	0.44	0.42	0.38	0.41
3					0.27	0.33	0.24	0.31	0.24	0.31	0.30	0.40	0.36	0.43	0.35	0.42	0.40	0.44	0.41	0.43	0.44	0.45	0.37	0.40
4					0.27	0.33	0.24	0.31	0.24	0.31	0.30	0.40	0.35	0.43	0.34	0.41	0.38	0.43	0.42	0.44	0.42	0.44	0.36	0.40
5					0.26	0.33	0.24	0.31	0.24	0.31	0.29	0.39	0.35	0.42	0.34	0.41	0.37	0.42	0.41	0.43	0.40	0.43	0.36	0.40
6					0.26	0.33	0.24	0.32	0.24	0.31	0.29	0.39	0.36	0.42	0.37	0.40	0.37	0.42	0.42	0.44	0.39	0.43	0.35	0.39
7					0.26	0.33	0.24	0.32	0.23	0.31	0.30	0.38	0.35	0.41	0.38	0.41	0.36	0.42	0.43	0.44	0.38	0.42	0.34	0.39
8					0.26	0.33	0.24	0.31	0.23	0.31	0.31	0.38	0.34	0.41	0.37	0.41	0.36	0.41	0.43	0.44	0.37	0.42	0.34	0.39
9					0.26	0.33	0.24	0.31	0.23	0.31	0.32	0.38	0.35	0.41	0.37	0.41	0.37	0.42	0.42	0.43	0.39	0.42	0.33	0.39
10					0.26	0.33	0.24	0.31	0.23	0.31	0.31	0.37	0.36	0.41	0.36	0.41	0.39	0.44	0.41	0.43	0.40	0.42	0.33	0.38
11					0.26	0.33	0.24	0.31	0.23	0.31	0.30	0.37	0.36	0.41	0.38	0.41	0.38	0.43	0.40	0.42	0.41	0.42	0.33	0.38
12					0.26	0.32	0.24	0.31	0.23	0.31	0.29	0.36	0.35	0.41	0.38	0.41	0.37	0.42	0.41	0.43	0.44	0.45	0.32	0.38
13					0.26	0.32	0.24	0.31	0.23	0.31	0.29	0.36	0.34	0.41	0.38	0.44	0.36	0.42	0.42	0.44	0.42	0.44	0.32	0.37
14					0.26	0.33	0.24	0.31	0.24	0.33	0.33	0.38	0.33	0.40	0.38	0.44	0.36	0.41	0.43	0.44	0.41	0.43	0.31	0.37
15		0.28	0.34		0.26	0.33	0.24	0.31	0.30	0.37	0.35	0.41	0.33	0.40	0.38	0.44	0.40	0.42	0.42	0.44	0.40	0.43	0.31	0.37
16		0.28	0.34		0.26	0.33	0.24	0.31	0.34	0.42	0.35	0.43	0.32	0.40	0.38	0.44	0.41	0.44	0.41	0.43	0.40	0.42	0.31	0.37
17		0.28	0.34		0.26	0.33	0.24	0.31	0.33	0.42	0.35	0.43	0.32	0.40	0.38	0.44	0.41	0.44	0.41	0.43	0.43	0.43	0.31	0.36
18		0.28	0.34		0.26	0.32	0.24	0.31	0.32	0.41	0.34	0.42	0.32	0.39	0.38	0.44	0.41	0.44	0.40	0.42	0.44	0.44	0.31	0.36
19		0.28	0.34		0.26	0.32	0.24	0.31	0.33	0.42	0.33	0.42	0.31	0.39	0.38	0.44	0.42	0.44	0.39	0.42	0.44	0.45	0.30	0.36
20		0.28	0.34		0.26	0.32	0.24	0.31	0.35	0.42	0.32	0.41	0.31	0.39	0.38	0.43	0.42	0.43	0.39	0.42	0.43	0.44	0.30	0.36
21		0.27	0.34		0.26	0.32	0.24	0.31	0.35	0.43	0.32	0.41	0.31	0.39	0.37	0.43	0.41	0.43	0.39	0.41	0.42	0.43	0.35	0.36
22		0.27	0.34		0.26	0.32	0.24	0.31	0.35	0.43	0.35	0.43	0.33	0.38	0.37	0.43	0.41	0.43	0.40	0.41	0.44	0.44	0.41	0.37
23		0.27	0.34		0.25	0.32	0.24	0.31	0.35	0.43	0.37	0.44	0.33	0.38	0.37	0.42	0.41	0.43	0.40	0.41	0.43	0.44	0.39	0.38
24		0.27	0.34		0.25	0.32	0.24	0.31	0.34	0.42	0.37	0.44	0.33	0.38	0.37	0.41	0.41	0.43	0.39	0.40	0.43	0.44	0.37	0.38
25		0.27	0.33		0.25	0.32	0.23	0.31	0.34	0.42	0.37	0.44	0.32	0.38	0.36	0.41	0.42	0.43	0.38	0.40	0.45	0.45	0.41	0.38
26		0.27	0.33		0.25	0.32	0.23	0.31	0.35	0.42	0.35	0.43	0.36	0.38	0.35	0.40	0.41	0.44	0.37	0.40	0.43	0.44	0.41	0.39
27		0.27	0.33		0.25	0.32	0.23	0.31	0.35	0.42	0.34	0.42	0.37	0.39	0.34	0.40	0.40	0.43	0.38	0.40	0.42	0.43	0.39	0.39
28		0.27	0.33		0.25	0.32	0.23	0.31	0.34	0.42	0.34	0.42	0.37	0.41	0.34	0.40	0.40	0.43	0.39	0.40	0.41	0.43	0.39	0.39
29					0.25	0.32	0.23	0.31	0.33	0.42	0.33	0.41	0.38	0.44	0.34	0.39	0.39	0.42	0.38	0.40	0.40	0.43	0.38	0.39
30					0.25	0.32	0.24	0.31	0.33	0.41	0.35	0.41	0.39	0.45	0.33	0.39	0.38	0.41	0.37	0.39	0.39	0.42	0.37	0.38
31					0.25	0.32			0.32	0.41			0.38	0.44	0.33	0.39			0.38	0.39			0.37	0.38



(Temperature data not shown)

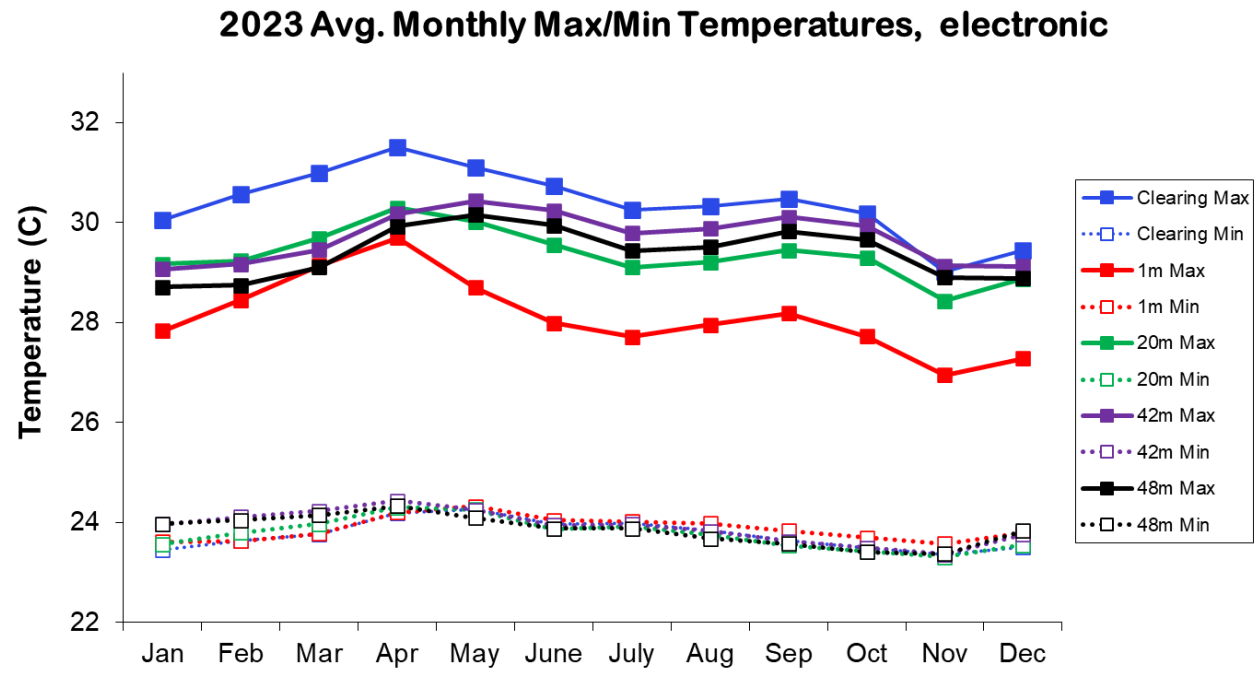
Relative Humidity (%) - Electronic Sensor

	'El Claro'		1m		20m		42m		48m	
	Avg.	2023	Avg.	2023	Avg.	2023	Avg.	2023	Avg.	2023
January	88.4	88.5	92.4	92.3	87.5	89.2	86.4	87.1	85.4	86.1
February	85.9	81.4	89.3	84.3	85.0	83.1	84.7	82.8	83.9	82.8
March	84.2	82.0	88.0	83.7	84.5	83.8	84.6	83.5	83.5	83.4
April	86.7	80.2	90.1	81.0	87.0	82.2	87.2	82.5	86.3	82.4
May	92.2	87.1	96.2	88.3	92.5	88.1	91.9	88.3	91.2	87.4
June	94.3	91.4	97.9	94.0	94.7	92.8	93.2	92.3	92.7	90.7
July	95.0	94.9	98.3	95.6	94.9	94.6	93.6	94.7	93.6	92.7
August	95.2	94.2	97.9	95.3	95.1	93.5	93.6	93.1	93.6	91.3
September	95.0	94.9	97.8	95.9	95.0	94.0	93.3	92.1	93.1	91.9
October	95.4	95.3	98.1	96.2	95.3	94.6	93.4	90.6	93.1	92.1
November	96.6	96.7	98.6	97.6	96.1	95.7	94.4	91.2	94.1	93.5
December	93.6	91.3	97.0	93.4	93.1	89.7	91.2	85.4	90.2	88.6



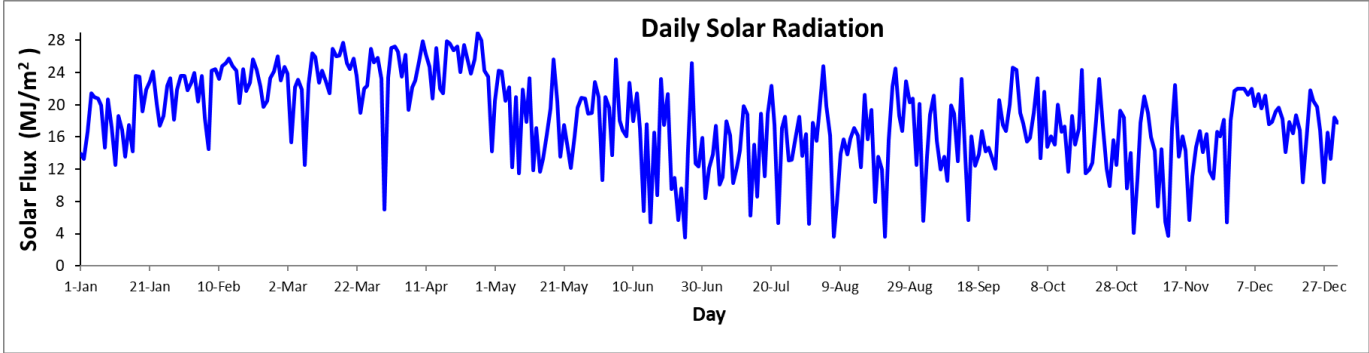
Max/Min/Avg Temperatures (°C) - Electronic

Average	‘El Claro’			1m			20m			42m			48m		
	Max.	Min.	Avg	Max.	Min.	Avg	Max.	Min.	Avg	Max.	Min.	Avg	Max.	Min.	Avg
January	30.1	23.5	25.7	27.8	23.6	25.1	29.2	23.6	25.6	29.1	24.0	25.9	28.7	24.0	25.9
February	30.6	23.6	26.0	28.4	23.6	25.3	29.2	23.8	25.8	29.2	24.1	25.9	28.8	24.0	26.0
March	31.0	23.8	26.3	29.1	23.8	25.6	29.7	24.0	26.1	29.4	24.2	26.2	29.1	24.2	26.2
April	31.5	24.2	26.8	29.6	24.2	26.1	30.3	24.3	26.5	30.2	24.4	26.5	29.9	24.3	26.5
May	31.1	24.2	26.4	28.6	24.3	25.7	30.0	24.2	26.0	30.4	24.2	26.2	30.1	24.0	26.3
June	30.7	23.9	26.1	28.0	24.0	25.4	29.5	23.9	25.6	30.2	23.9	26.0	29.9	23.8	26.1
July	30.3	24.0	25.9	27.7	24.0	25.2	29.1	23.9	25.6	29.8	23.9	25.9	29.4	23.8	25.9
August	30.3	23.8	25.8	27.9	24.0	25.2	29.2	23.7	25.5	29.9	23.8	25.9	29.5	23.6	25.8
September	30.5	23.6	25.7	28.2	23.8	25.1	29.4	23.5	25.4	30.1	23.6	25.7	29.8	23.5	25.7
October	30.2	23.5	25.4	27.7	23.7	24.8	29.3	23.4	25.2	29.9	23.5	25.4	29.6	23.4	25.5
November	29.0	23.3	25.1	26.9	23.5	24.6	28.4	23.3	25.0	29.1	23.3	25.3	28.9	23.3	25.2
December	29.4	23.5	25.4	27.2	23.8	24.9	28.8	23.5	25.4	29.1	23.7	25.6	28.8	23.8	25.8
2023	‘El Claro’			1m			20m			42m			48m		
	Max.	Min.	Avg	Max.	Min.	Avg	Max.	Min.	Avg	Max.	Min.	Avg	Max.	Min.	Avg
January	29.6	23.1	25.5	27.5	23.0	24.8	29.0	23.1	25.5	29.2	23.5	25.9	28.7	23.6	25.8
February	30.2	23.9	26.3	28.8	23.8	25.7	29.2	24.1	26.1	29.1	24.3	26.1	28.6	24.3	26.0
March	30.8	23.5	26.4	30.0	23.4	25.9	29.8	23.6	26.2	29.7	23.8	26.2	29.3	23.9	26.1
April	31.8	24.0	27.1	31.1	23.9	26.6	30.7	24.0	26.8	30.4	24.2	26.8	30.1	24.3	26.7
May	32.0	25.3	27.6	30.4	25.2	27.0	31.1	25.3	27.4	31.2	25.4	27.4	30.8	25.4	27.3
June	31.3	24.6	27.2	28.8	24.5	26.1	30.0	24.5	26.6	30.4	24.6	26.8	30.0	24.7	26.8
July	29.9	24.6	26.6	28.3	24.5	26.1	29.3	24.5	26.5	29.9	24.6	26.7	29.6	24.6	26.6
August	30.4	24.6	26.8	28.6	24.5	26.2	29.7	24.5	26.6	30.1	24.6	26.9	29.4	24.5	26.6
September	30.4	24.5	26.6	28.9	24.5	26.1	30.1	24.4	26.5	30.4	24.5	26.8	30.1	24.6	26.7
October	30.5	24.4	26.3	28.4	24.3	25.7	30.4	24.3	26.2	30.9	24.4	26.5	30.4	24.4	26.4
November	29.2	24.4	26.0	27.4	24.3	25.5	29.1	24.3	25.9	29.6	24.4	26.2	29.3	24.4	26.2
December	30.4	24.9	27.0	28.6	24.7	26.2	30.0	24.9	27.0	30.3	25.1	27.2	29.9	25.2	27.1



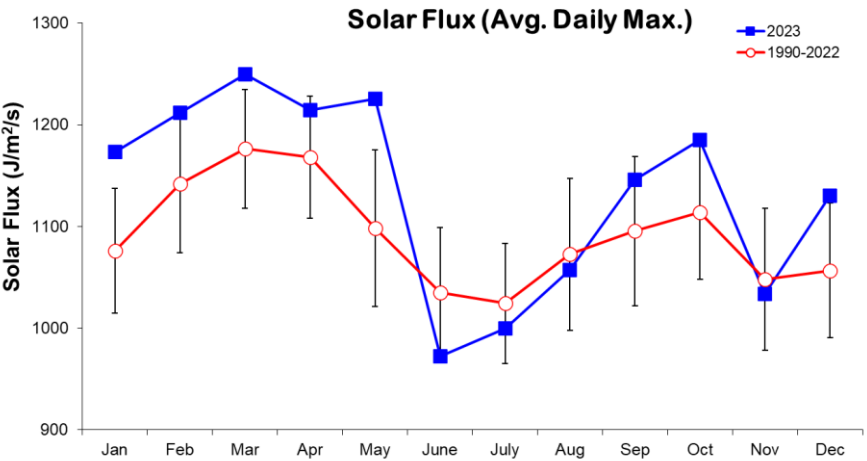
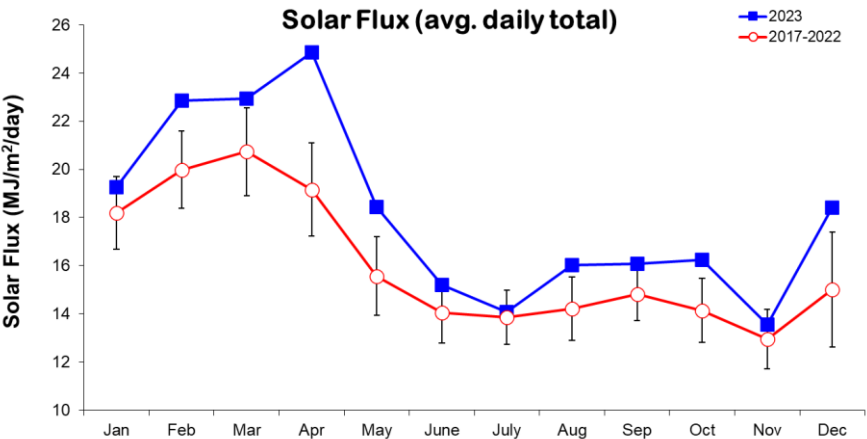
2023 Daily Total Radiation (MJ m⁻² day⁻¹)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	14.0	21.8	24.7	27.1	20.5	10.7	8.4	17.8	20.2	17.7	14.0	21.8
2	13.3	22.7	23.8	27.3	24.3	21.0	12.1	15.5	5.6	15.4	4.1	22.0
3	16.7	24.0	15.3	26.6	24.1	19.7	13.9	19.5	13.6	15.9	10.9	22.0
4	21.5	20.4	22.2	23.5	20.5	13.7	17.4	24.8	18.8	19.0	17.8	22.0
5	21.0	23.6	23.1	26.3	22.2	25.6	10.1	19.8	21.2	23.3	21.0	21.2
6	20.7	18.3	21.9	19.4	12.2	18.0	11.0	16.2	15.5	13.4	19.0	22.0
7	19.9	14.5	12.5	22.2	21.0	16.9	17.9	3.7	12.0	21.6	16.0	19.9
8	14.6	24.3	22.5	23.0	11.5	16.1	16.1	7.7	13.6	14.8	14.3	21.3
9	20.7	24.5	26.4	25.4	21.9	22.8	10.3	13.9	10.6	16.1	7.4	19.5
10	17.3	23.2	25.9	27.9	17.8	18.0	12.2	15.8	19.9	15.1	14.5	21.1
11	12.5	24.8	22.7	26.3	23.3	21.4	14.3	13.9	18.9	20.0	5.5	17.6
12	18.6	25.2	24.3	24.7	11.9	17.0	19.9	15.8	13.0	16.7	3.7	17.9
13	16.8	25.7	23.0	20.8	17.2	6.8	18.8	17.1	23.2	17.3	17.2	19.2
14	13.6	24.8	21.4	27.1	11.7	17.6	6.3	16.2	15.2	11.7	22.5	19.7
15	17.5	24.2	27.0	22.0	13.3	5.4	15.0	12.3	5.7	18.6	13.5	18.2
16	14.2	20.2	26.1	21.5	16.3	16.5	8.6	21.2	16.1	15.1	16.1	14.1
17	23.6	24.4	26.1	27.9	19.5	8.8	18.9	15.7	12.5	17.0	14.3	17.9
18	23.5	21.7	27.7	27.6	25.6	23.2	11.1	19.3	13.8	24.3	5.7	16.5
19	19.2	22.7	25.2	26.8	20.4	17.5	18.9	7.9	16.8	11.5	11.2	18.7
20	21.9	25.6	24.4	27.2	13.6	21.4	22.3	13.6	14.2	11.9	14.8	16.8
21	23.0	24.3	25.8	24.0	17.5	9.5	17.5	12.0	14.7	12.9	16.8	10.3
22	24.1	22.3	23.6	27.4	14.6	10.9	5.3	3.7	13.3	18.2	14.1	15.9
23	20.2	19.7	19.0	25.8	12.1	5.7	17.1	15.6	12.1	23.2	16.4	21.8
24	17.4	20.5	22.0	23.9	16.1	9.6	18.5	22.3	20.6	17.3	11.8	20.5
25	18.6	23.3	22.4	25.6	19.6	3.6	13.1	24.5	17.5	12.1	10.8	19.7
26	22.4	24.2	26.9	28.9	20.9	14.5	13.2	18.6	16.7	9.9	16.7	16.9
27	23.3	26.0	25.3	28.0	20.8	25.2	15.9	16.8	20.0	15.6	16.1	10.4
28	18.2	23.1	25.8	24.3	18.9	12.8	18.5	22.9	24.6	12.5	18.2	16.5
29	21.9		23.2	23.5	19.0	12.3	13.7	20.3	24.4	19.3	5.4	13.3
30	23.6		7.0	14.2	22.9	15.9	16.4	20.8	19.0	18.5	18.1	18.5
31	23.6		23.4		21.0		5.2	12.5		9.6		17.8



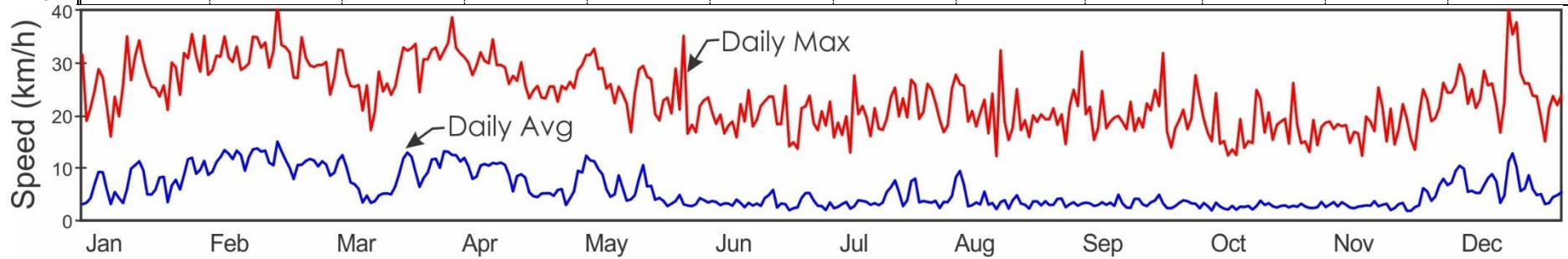
Monthly Average Total Daily Solar Radiation (Pyranometer)

	1984-2022		2023	
	Avg Daily Total (Mj/m ²)	Avg Daily Max. (J/m ² /s)	Avg Daily Total (Mj/m ²)	Avg Daily Max. (J/m ² /s)
January	18.2	1076.0	19.3	1173.6
February	20.0	1142.0	22.9	1211.5
March	20.7	1176.3	22.9	1249.8
April	19.2	1168.0	24.9	1214.3
May	15.6	1098.3	18.4	1225.4
June	14.0	1034.8	15.2	972.2
July	13.9	1024.2	14.1	999.8
August	14.2	1072.6	16.0	1057.2
September	14.8	1095.4	16.1	1145.6
October	14.1	1114.0	16.2	1185.0
November	12.9	1047.8	13.5	1033.9
December	15.0	1056.6	18.4	1130.0



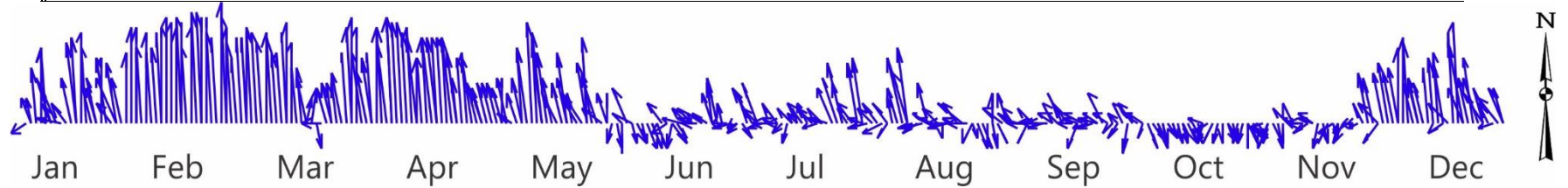
2023 Daily Average Wind Speed (km/h)

	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	3.1	31.5	8.7	27.7	11.3	29.5	13.1	33.7	4.2	26.4	3.1	16.8	2.8	17.2	257.6	3.5	16.8	3.1	21.6	3.3	19.5	2.5	14.3	6.7
2	3.4	19.0	9.3	28.6	10.6	30.1	12.4	38.6	5.5	25.2	4.2	21.8	2.8	20.7	267.1	3.5	18.0	3.4	24.8	3.2	27.6	3.5	17.8	7.9
3	4.3	21.4	11.1	31.3	8.5	23.9	12.4	32.8	9.4	28.5	3.9	22.8	2.0	18.0	288.7	4.6	25.1	2.8	21.8	2.3	23.0	2.6	18.6	6.7
4	6.9	24.6	12.0	31.2	9.1	27.1	11.2	31.8	9.1	29.6	3.4	23.4	3.4	22.6	310.9	8.2	27.7	3.2	32.1	3.3	19.2	3.0	18.8	7.2
5	9.2	28.8	13.4	35.0	11.4	32.5	11.9	31.1	12.3	31.4	3.7	20.6	2.3	15.8	265.1	9.4	25.9	3.4	20.2	2.7	16.7	3.5	17.4	9.4
6	9.1	27.1	12.7	30.9	12.4	32.3	10.4	30.0	11.4	31.5	3.5	18.4	2.6	18.6	232.7	6.8	25.6	3.2	21.6	1.9	15.1	2.7	18.3	10.4
7	5.9	21.9	11.7	30.1	10.2	28.1	7.9	27.6	11.2	32.6	2.9	20.1	3.1	16.3	207.8	2.7	18.8	2.8	15.3	3.4	24.2	3.5	17.9	9.8
8	3.1	16.0	13.3	33.0	7.2	25.6	8.3	29.4	9.7	28.8	3.2	16.6	3.5	19.8	301.0	2.9	20.8	2.9	17.5	2.7	14.6	3.0	18.1	5.4
9	5.4	23.5	12.4	28.6	6.9	25.4	10.4	32.0	8.8	29.0	3.2	18.0	2.3	12.9	337.4	3.4	17.9	3.4	24.6	2.2	15.1	2.5	14.8	5.7
10	4.3	19.8	9.5	29.1	6.0	25.7	10.7	30.3	5.9	25.1	2.8	18.8	2.7	27.6	301.8	3.0	20.5	3.0	17.5	2.1	12.4	2.3	16.9	5.3
11	3.3	25.6	12.1	29.9	3.4	20.9	10.4	29.9	4.5	25.9	4.0	15.8	3.8	20.2	314.9	5.5	23.0	3.4	18.8	2.8	13.5	2.6	16.6	5.2
12	6.0	35.0	13.5	34.9	4.7	25.7	10.9	34.4	5.0	22.3	3.3	22.1	3.7	21.8	319.3	3.0	16.6	2.8	19.6	2.1	12.5	2.7	12.3	6.7
13	9.8	26.7	13.7	34.8	3.3	17.2	10.8	29.5	8.6	25.4	2.5	18.8	3.5	19.6	307.1	3.3	24.1	4.9	19.9	2.6	19.3	2.9	19.7	8.1
14	10.5	31.3	13.1	32.9	3.7	20.7	11.0	29.5	6.2	24.0	3.4	24.7	3.0	16.0	260.2	2.1	12.2	3.2	18.7	2.6	13.8	2.8	18.8	8.8
15	11.3	34.2	13.3	33.8	4.7	28.3	10.5	29.1	3.7	22.2	2.8	17.9	3.3	21.3	304.7	3.5	32.3	2.5	17.4	2.8	15.1	3.7	17.0	7.4
16	9.6	30.2	11.0	29.1	5.1	24.5	8.6	25.9	4.0	16.8	3.2	19.2	2.9	17.5	283.3	3.9	18.8	2.4	22.5	2.1	14.7	2.7	25.3	3.4
17	5.0	27.5	10.5	32.2	5.1	26.0	5.5	27.5	4.8	24.2	2.8	21.8	3.4	17.2	280.0	2.3	15.3	4.1	17.0	2.8	24.8	3.0	21.6	4.7
18	4.9	25.4	15.0	41.1	5.0	23.9	8.4	26.5	7.9	28.7	4.3	22.7	5.4	19.3	327.6	3.8	17.6	4.1	19.5	3.8	23.1	3.2	15.0	11.1
19	5.9	25.1	13.2	33.3	6.5	25.5	8.8	30.1	10.5	29.4	4.9	23.5	6.3	23.5	338.6	4.8	24.9	3.0	17.7	2.9	16.7	2.0	21.2	12.8
20	8.2	23.6	11.6	33.0	9.0	29.4	8.2	25.7	6.5	27.3	5.8	23.5	7.6	25.2	344.3	3.2	17.2	2.7	22.2	3.3	20.5	2.4	14.4	10.1
21	8.3	25.7	10.0	32.0	11.8	32.9	5.4	23.2	6.6	26.9	2.5	18.3	5.4	19.8	336.3	3.0	19.1	3.5	20.9	2.7	15.4	3.1	17.2	5.6
22	3.5	21.0	7.9	27.2	12.9	32.3	4.6	24.6	3.9	20.3	3.2	18.4	2.8	23.2	306.0	2.2	15.8	3.8	24.8	2.5	18.2	3.3	22.1	6.1
23	6.6	30.0	10.5	27.1	12.1	32.7	4.4	25.6	4.3	19.0	3.1	25.6	3.8	19.6	312.8	3.6	20.0	4.9	21.8	2.8	18.8	1.8	19.3	8.6
24	7.7	29.1	10.6	34.8	9.2	33.6	5.1	23.4	3.7	22.8	1.9	14.1	7.5	26.7	348.2	3.6	18.7	3.3	31.8	2.9	19.3	1.8	15.5	6.0
25	5.9	23.9	11.3	30.9	6.4	24.4	5.2	23.2	2.7	23.3	2.3	14.9	8.0	25.8	351.4	2.9	20.1	2.4	16.8	2.5	14.6	2.5	13.4	4.8
26	8.6	31.8	11.7	29.5	8.1	30.6	5.2	25.5	3.2	20.4	2.5	13.7	3.4	19.3	283.4	3.6	19.2	2.3	13.9	2.8	26.1	2.9	20.1	5.0
27	11.6	30.8	11.4	29.2	9.1	30.7	4.7	25.5	3.7	28.9	4.3	21.3	3.7	20.6	262.2	3.0	19.2	2.7	17.5	2.6	18.2	6.1	24.9	3.1
28	11.9	35.4	10.3	29.6	11.6	32.5	5.8	22.6	4.9	21.1	5.2	21.7	3.5	25.9	302.6	3.0	21.3	3.3	19.1	3.2	14.7	5.6	23.1	3.3
29	8.9	31.2			11.7	32.9	6.0	25.6	3.1	35.1	5.2	23.7	3.4	24.9	312.8	4.1	18.2	3.8	21.0	2.7	15.0	3.7	18.9	4.5
30	9.6	28.3			10.0	30.6	2.9	24.9	2.8	16.5	3.8	18.4	3.7	22.4	247.9	4.1	20.1	3.6	17.4	2.4	13.0	4.5	19.5	4.8
31	11.3	35.1			13.1	32.2			2.7	18.2			2.4	19.2	214.7	2.5	14.5		2.4		19.1			5.3



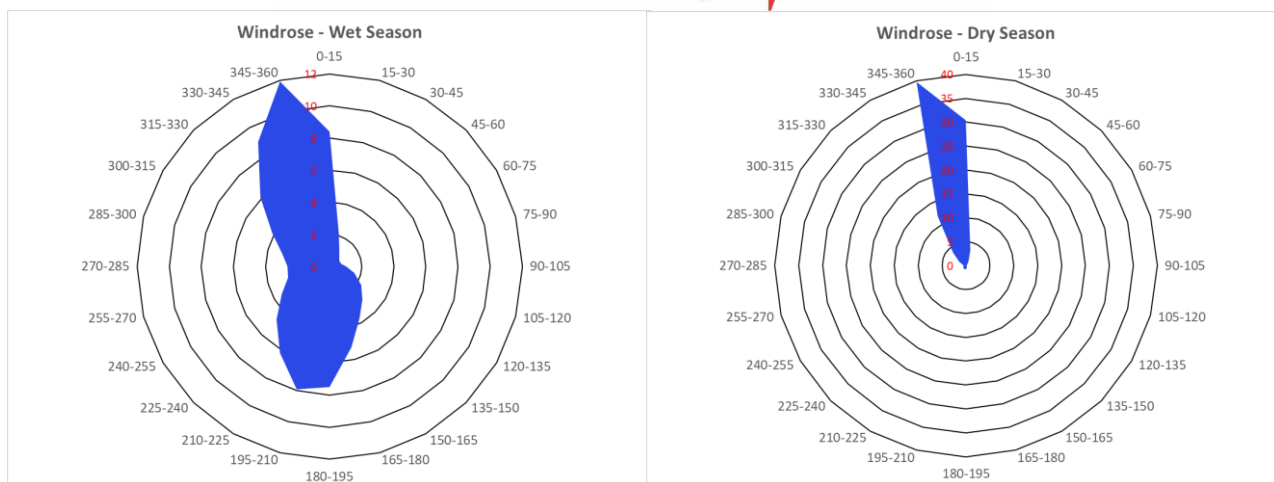
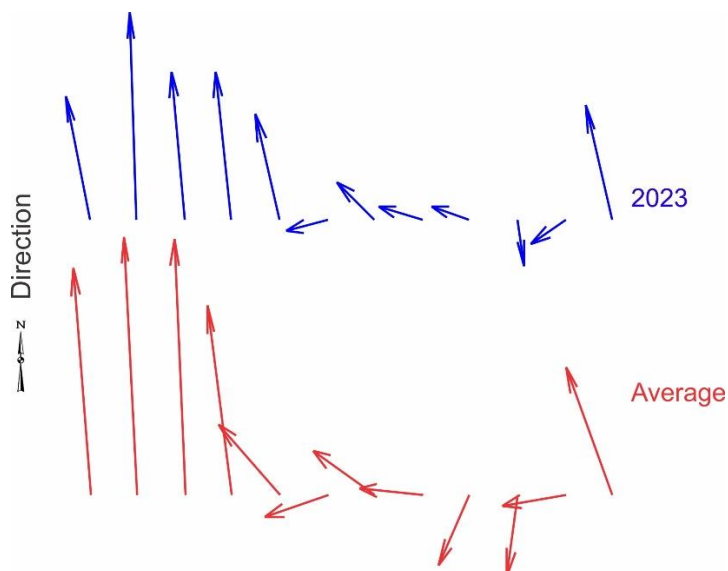
2023 Average Daily Mean Vector Wind Direction

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	246.1	353.7	356.8	355.8	332.1	153.3	257.6	309.7	313.2	294.4	248.2	345.4
2	346.7	356.7	353.5	355.2	348.2	141.7	267.1	334.6	280.9	298.1	211.6	349.8
3	321.9	357.1	354.9	356.9	352.9	144.0	288.7	332.7	264.7	215.0	206.2	342.5
4	353.7	360.0	353.1	355.5	349.3	152.3	310.9	343.0	216.1	148.7	140.7	346.8
5	357.2	358.6	356.9	354.3	355.7	153.9	265.1	352.7	308.5	130.3	163.0	356.5
6	353.0	358.9	357.2	353.6	355.0	313.1	232.7	336.3	273.7	137.9	177.0	356.7
7	338.4	359.3	357.0	355.2	352.3	240.2	207.8	262.1	265.9	160.9	302.8	354.6
8	321.9	358.5	349.3	355.7	348.5	183.9	301.0	250.5	260.6	160.3	324.0	338.1
9	322.6	357.9	352.4	353.5	348.9	134.5	337.4	262.0	273.5	136.1	282.4	346.2
10	274.2	353.5	342.6	353.4	338.8	140.1	301.8	297.5	297.5	158.5	265.3	335.4
11	312.0	357.9	2.4	353.8	324.5	276.7	314.9	334.3	320.5	164.5	265.7	341.0
12	345.9	358.4	10.0	354.2	344.7	311.0	319.3	286.6	300.5	136.5	236.5	348.6
13	353.3	358.2	164.3	355.2	351.0	281.3	307.1	299.4	319.7	176.2	300.8	356.8
14	354.3	358.0	268.8	353.3	338.3	305.2	260.2	182.0	313.6	150.6	282.8	355.9
15	358.4	359.0	341.3	353.0	340.3	272.5	304.7	257.1	265.1	143.7	203.2	351.4
16	356.9	356.9	347.0	351.0	318.9	287.5	283.3	268.1	281.8	159.5	161.3	251.4
17	340.1	355.2	343.7	346.8	316.2	296.1	280.0	284.9	221.3	200.2	208.9	300.8
18	339.9	0.4	342.2	352.6	348.8	332.8	327.6	310.3	287.0	281.6	243.3	354.3
19	341.2	359.4	345.3	350.6	354.1	346.5	338.6	297.4	257.9	248.0	159.1	355.9
20	356.2	356.7	354.8	350.7	340.5	338.2	344.3	269.5	253.1	218.8	197.9	345.1
21	348.3	355.4	355.6	345.4	330.5	335.7	336.3	217.3	279.4	195.2	212.7	320.8
22	316.1	351.5	357.6	341.9	296.2	271.9	306.0	168.3	287.7	179.0	250.2	344.3
23	328.6	355.5	358.0	334.7	338.2	261.4	312.8	154.0	324.7	138.6	273.8	348.9
24	343.6	357.2	349.2	342.5	348.2	258.8	348.2	156.4	296.0	139.7	274.7	333.6
25	338.6	359.0	344.8	338.6	207.4	235.9	351.4	169.2	245.1	159.7	262.4	320.5
26	358.5	356.9	349.1	343.5	159.1	139.0	283.4	358.7	214.4	193.9	319.6	336.4
27	359.4	355.8	349.6	344.3	178.1	339.1	262.2	165.0	300.6	200.9	346.9	319.8
28	0.4	355.9	357.0	355.5	334.9	323.9	302.6	147.7	324.8	168.6	343.6	261.7
29	356.6		357.1	343.5	288.6	334.7	312.8	299.9	200.2	147.9	226.7	311.2
30	354.0		350.0	292.6	159.5	299.2	247.9	330.6	319.5	148.3	300.3	342.9
31	357.3		356.2		146.6		214.7	300.8		142.0		328.3

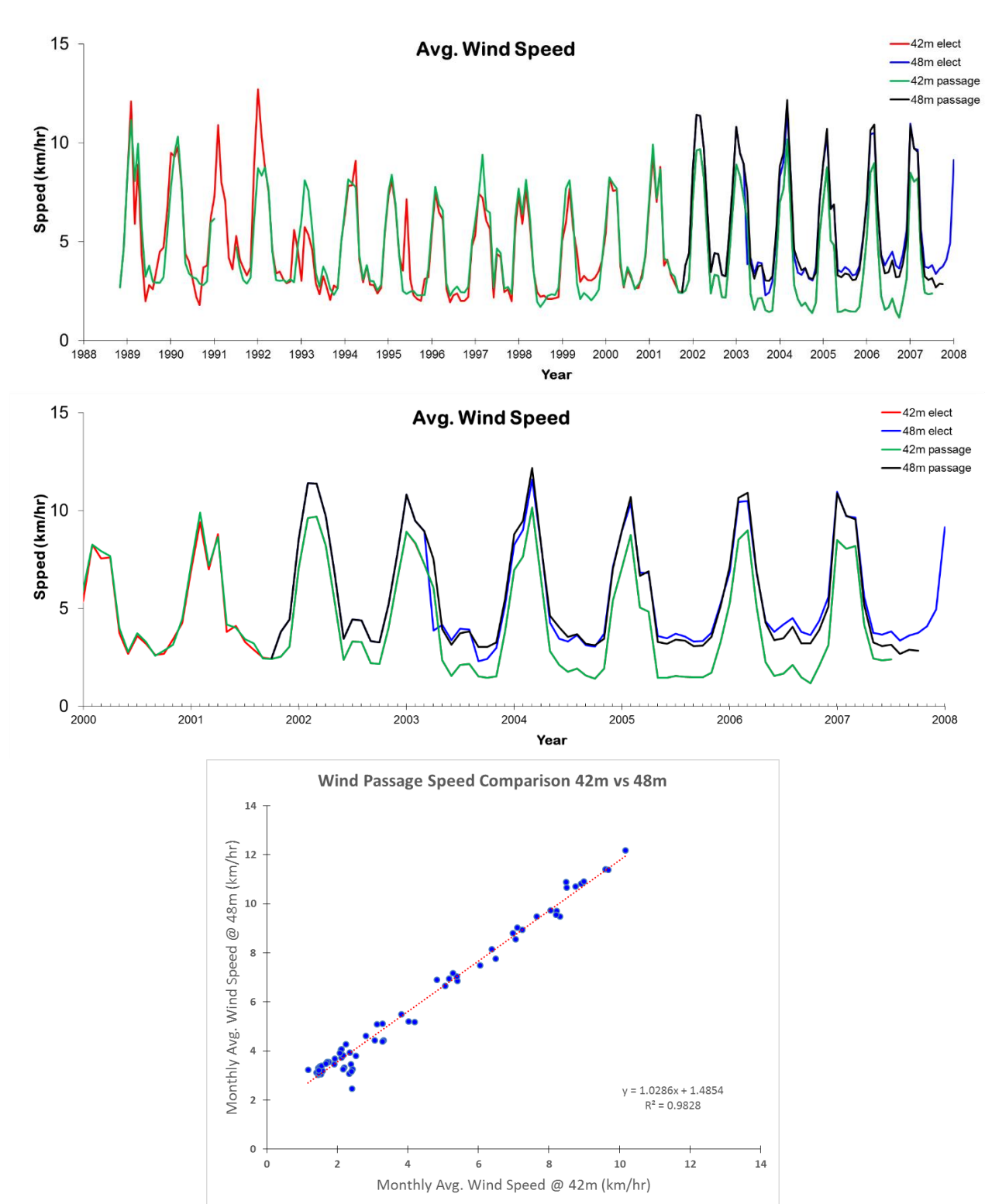


Average Monthly Wind Speed and Direction

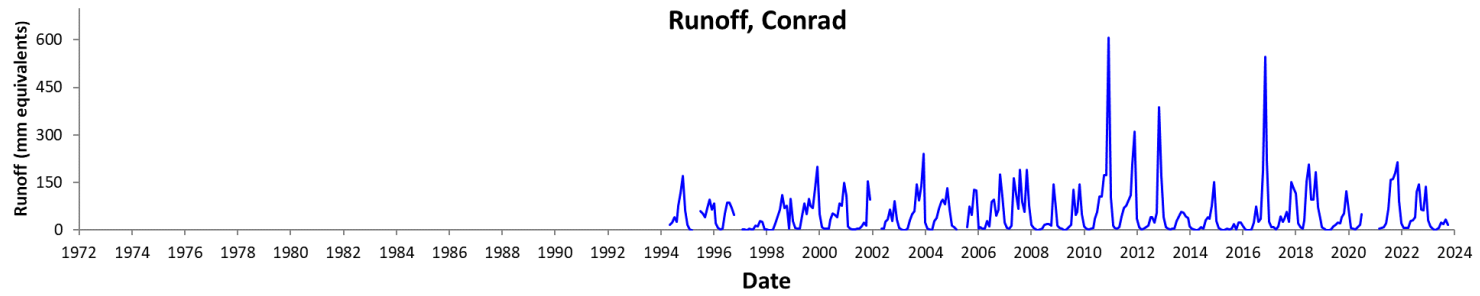
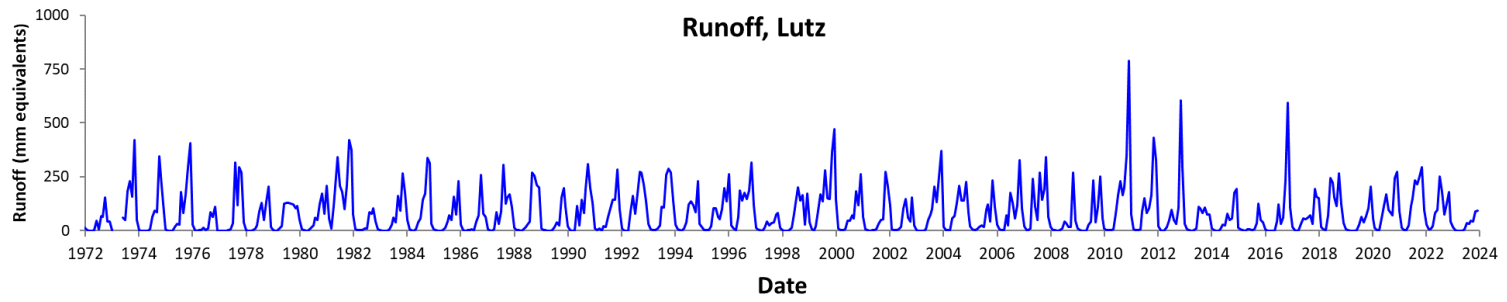
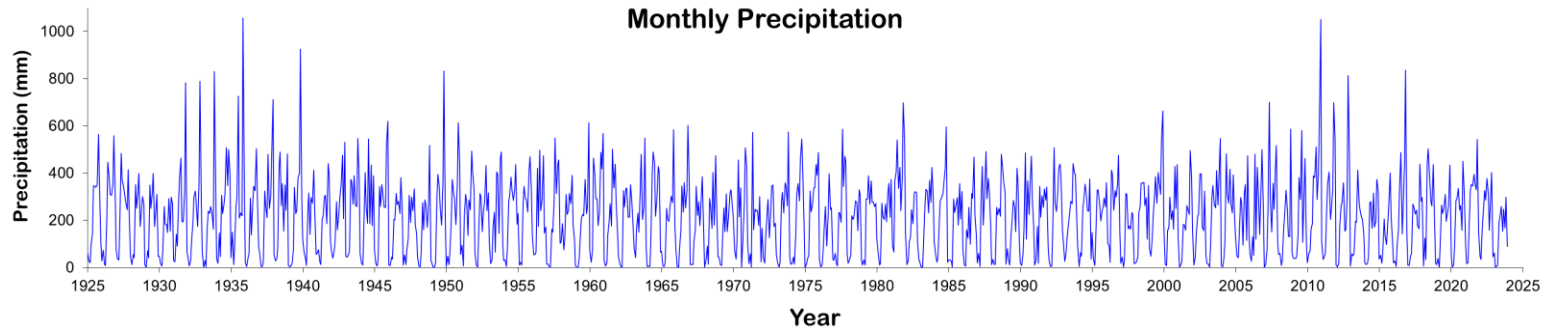
	Long-term Av.			2023		
	Speed	Max	Dir.	Speed	Max	Dir.
January	8.5	28.7	353.1	7.2	27.1	344.7
February	9.7	30.6	355.5	11.6	31.4	357.2
March	9.6	30.3	356.2	8.4	28.0	352.2
April	7.2	26.5	348.8	8.4	28.3	350.4
May	4.3	21.9	311.4	6.2	25.4	341.0
June	3.6	20.3	257.0	3.5	19.9	259.3
July	3.9	20.8	295.5	3.8	20.6	302.6
August	3.6	20.4	274.4	3.8	20.2	280.6
September	3.2	20.4	219.9	3.3	20.5	283.3
October	3.1	19.4	189.4	2.7	17.9	166.6
November	3.5	20.5	263.0	3.1	18.3	244.6
December	5.5	24.2	331.6	6.8	25.1	340.3



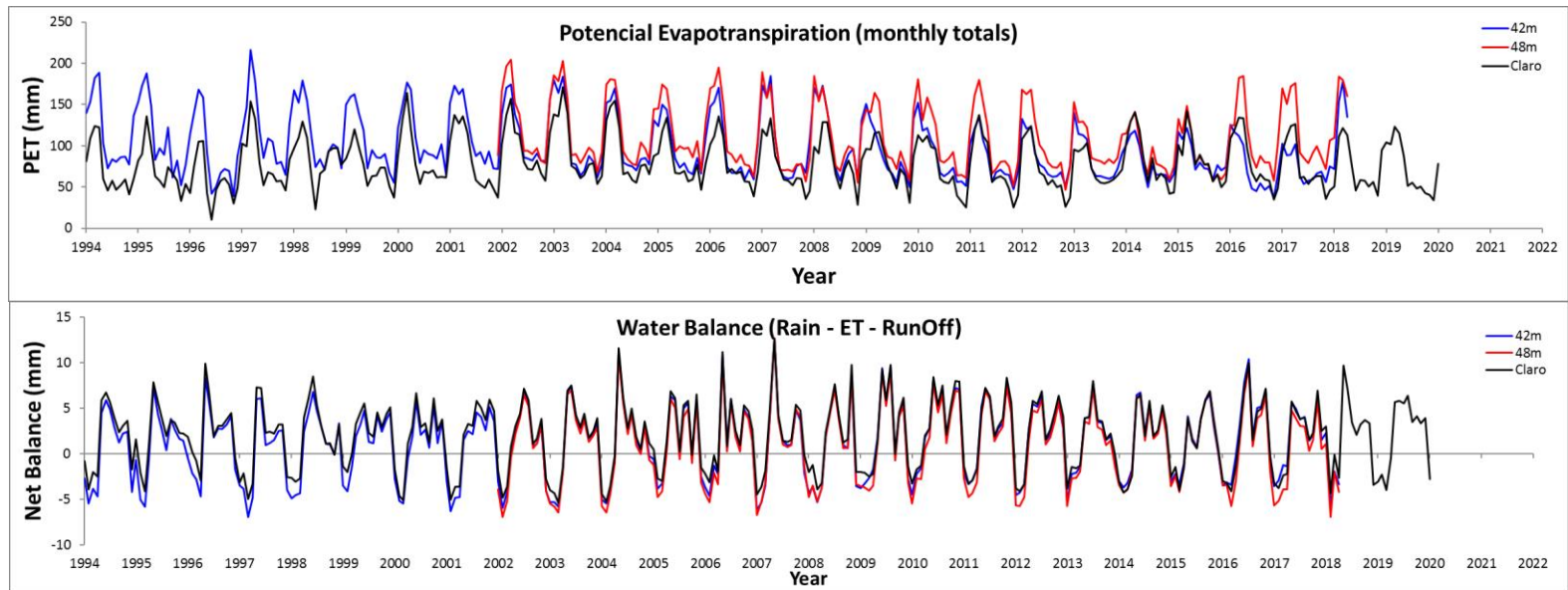
Comparison of Totalizing & Electronic Anemometers

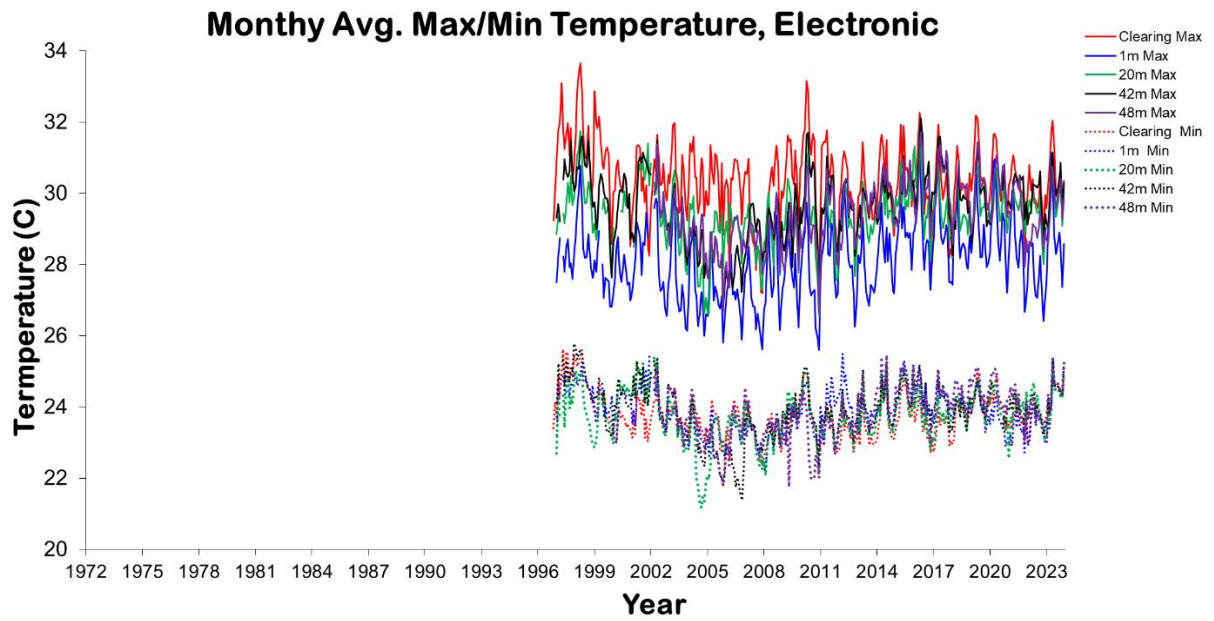
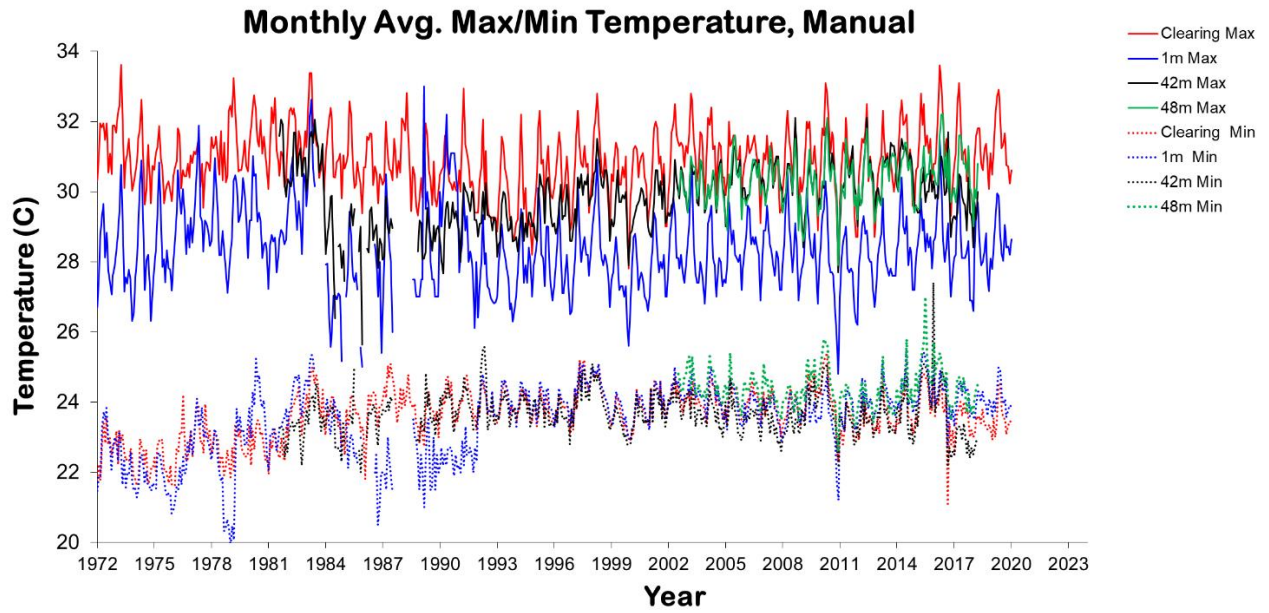


Long-term Monthly Averages/Totals

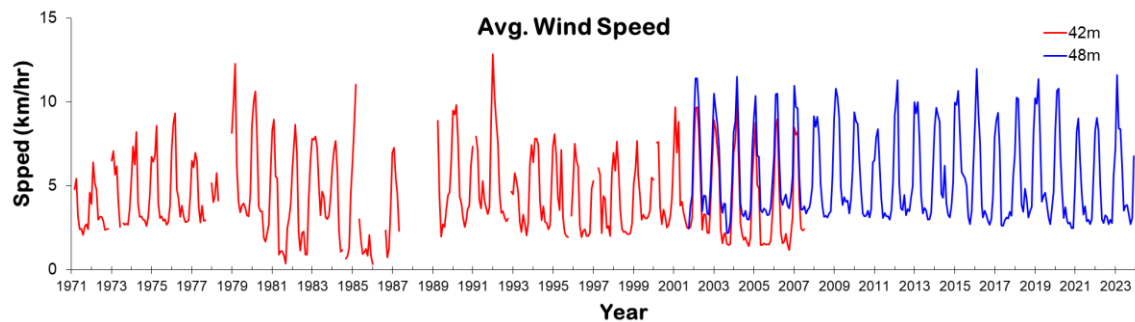
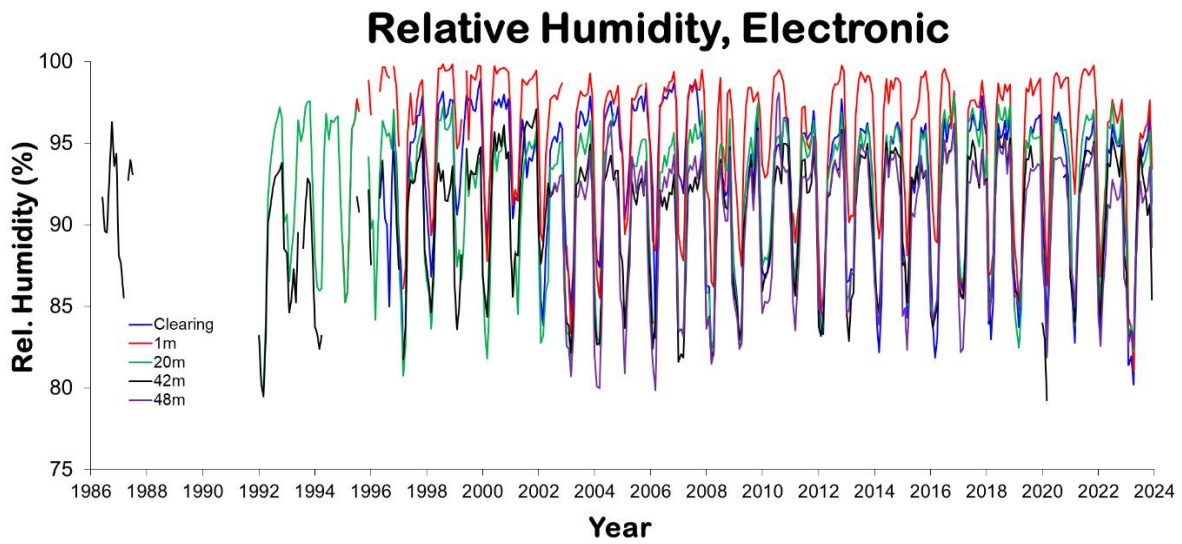
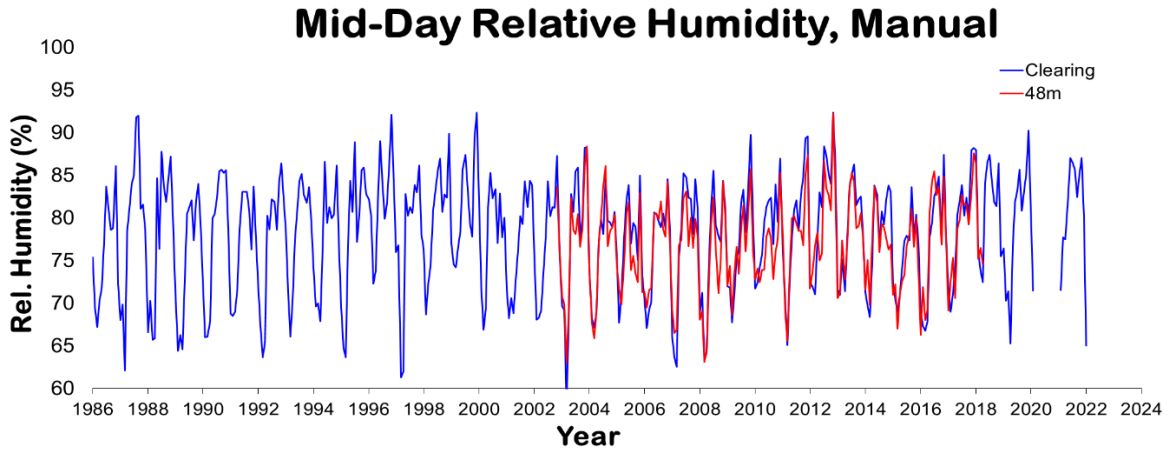
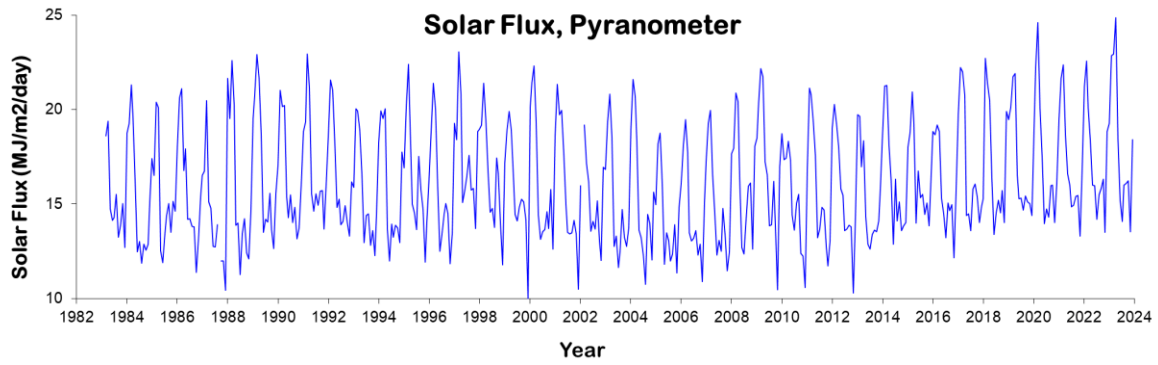


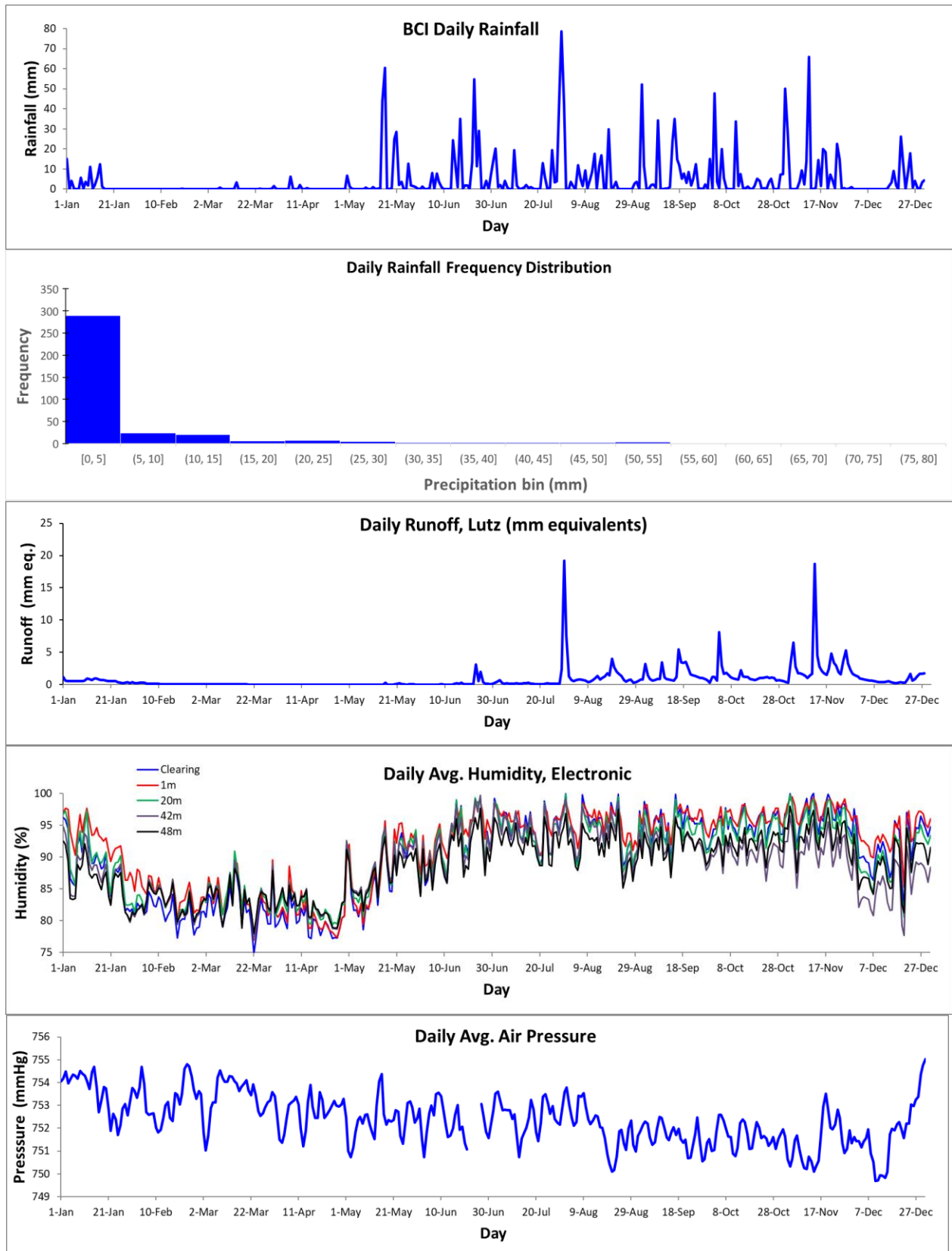
Long-term Monthly Averages/Totals



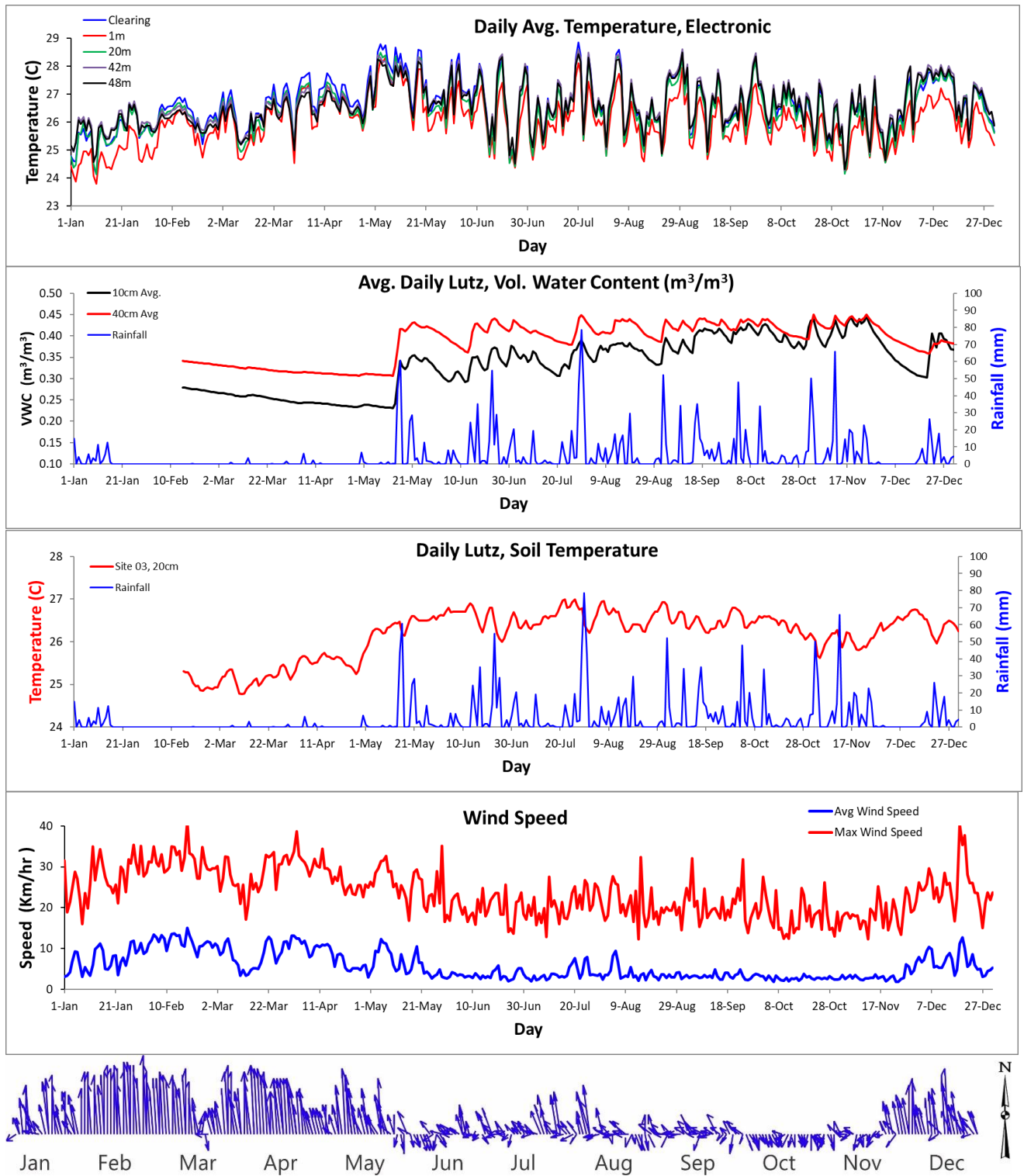


Long-term Monthly Averages/Totals



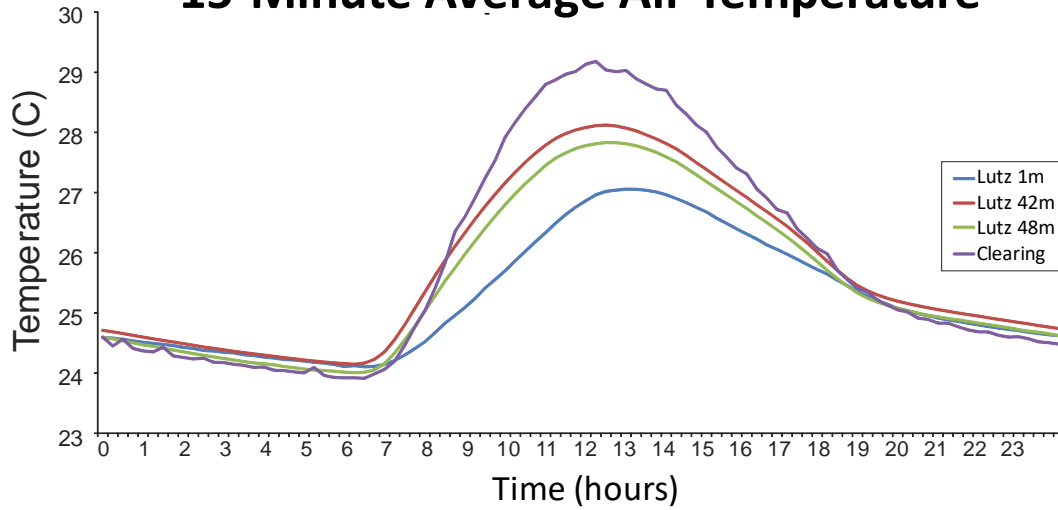


2023 Daily Averages/Totals

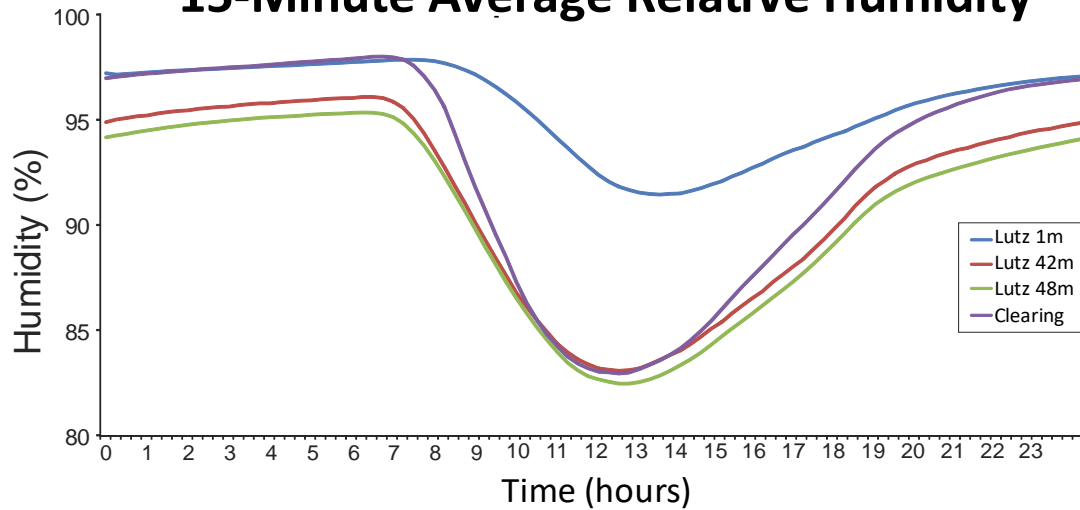


Long-term Hour Averages

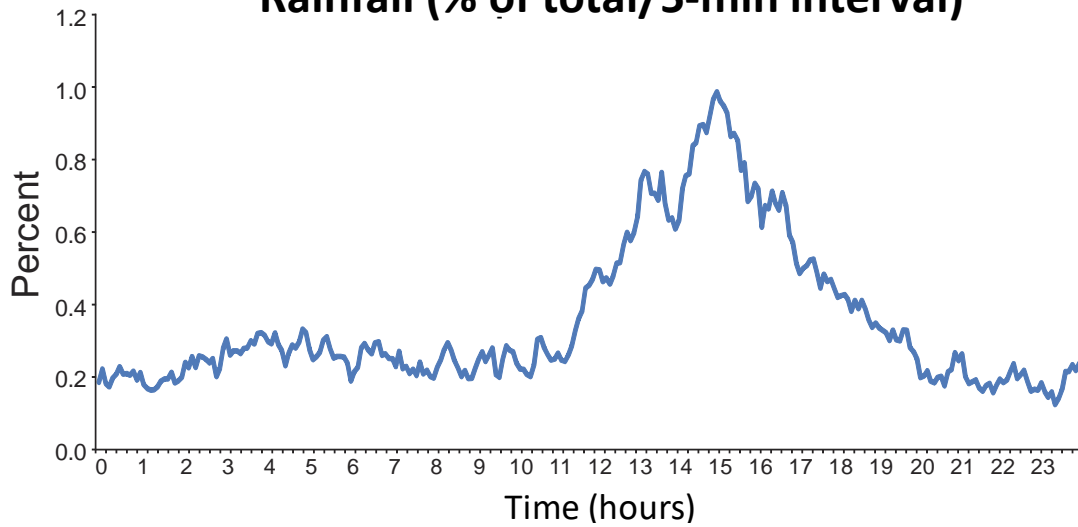
15-Minute Average Air Temperature



15-Minute Average Relative Humidity

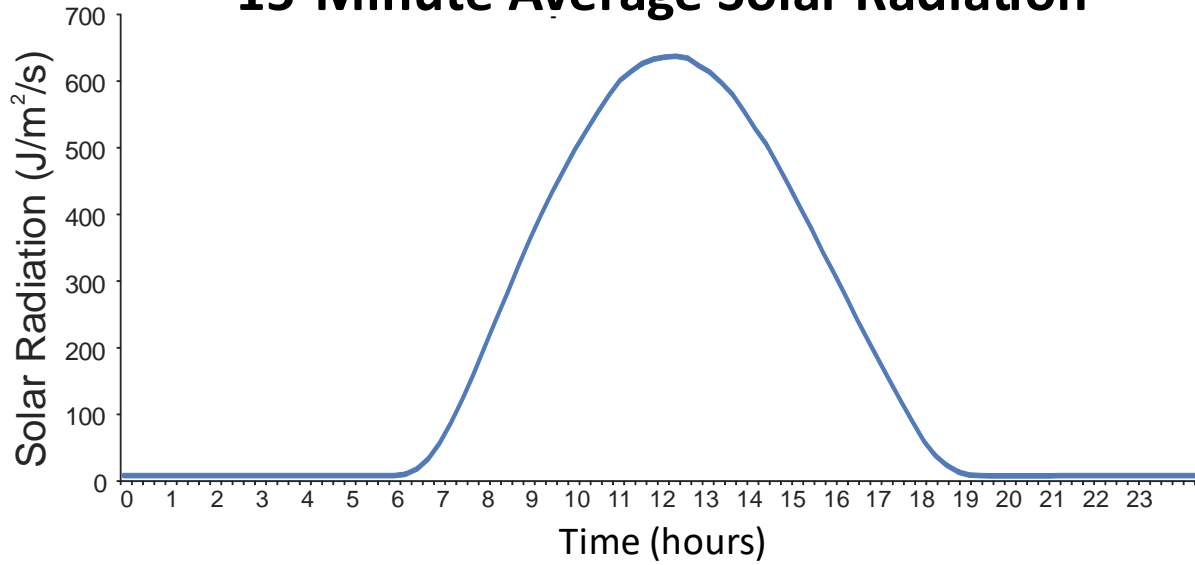


Rainfall (% of total/5-min interval)



Long-term Hour Averages

15-Minute Average Solar Radiation



15-Minute Average Wind Speed

