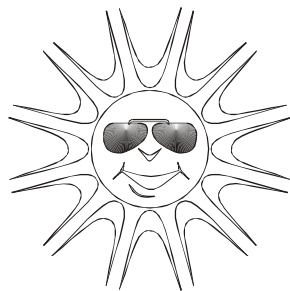




Smithsonian Tropical Research Institute

2019 Meteorological Summary for
the Parque Natural Metropolitano
Canopy Crane

Prepared by: Steven Paton



Introduction

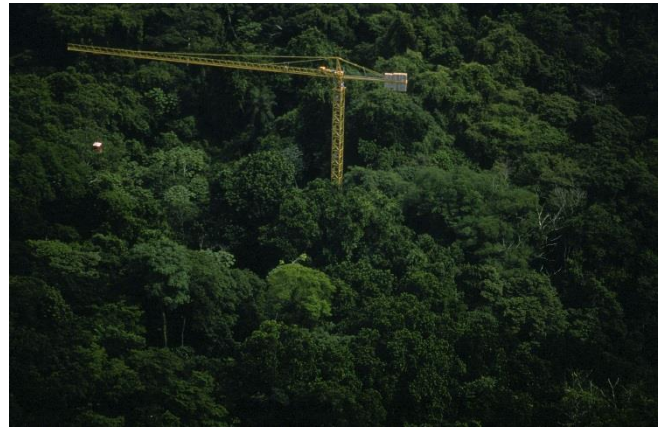
This is the 6th in a series of yearly reports summarising the data from the past year's Smithsonian Tropical Research Institute's Physical Monitoring Program on the Parque Natural Metropolitano (PNM) Canopy Access Crane. This report is not meant to be exhaustive in its coverage in that it summarizes 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 and downloadable data from the PNM and other research locations, can be obtained from:

biogeodb.stri.si.edu/physical_monitoring/research/metpark

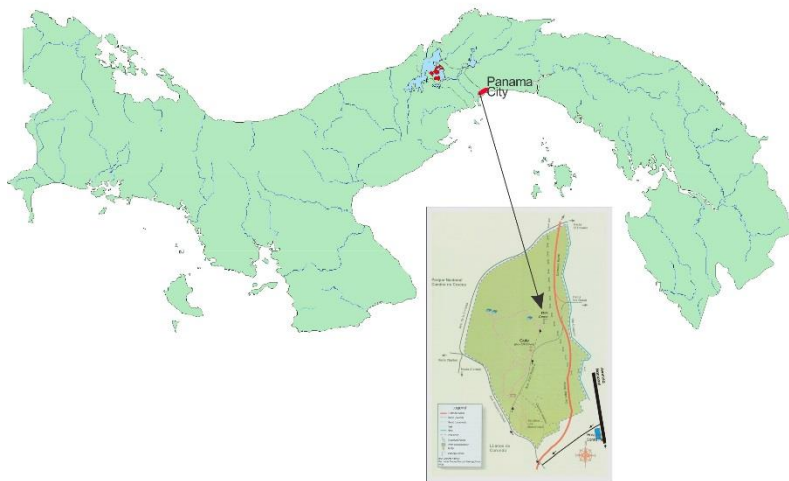
Setting

Established in 1992, the PNM canopy crane (8.994410° , -79.543000°) is located at the North Western edge of Panama City, at the eastern edge of the Parque Natural Metropolitano (Metropolitan Nature Park) and is surrounded by 80-year old, lowland semi-deciduous forest. The crane is 50 meters tall with a radius of 51 meters, and can reach approximately 80 species of trees and lianas.

The station receives an average of 1851.4 mm of rain per year. The meteorological year is divided



Republic of Panama



Parque Natural Metropolitano
Canopy Access Crane

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 210mm 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.

All data are collected using electronic sensors. Originally, all sensors were located at an instrument pack located approximately 25m above the ground (see photo below).



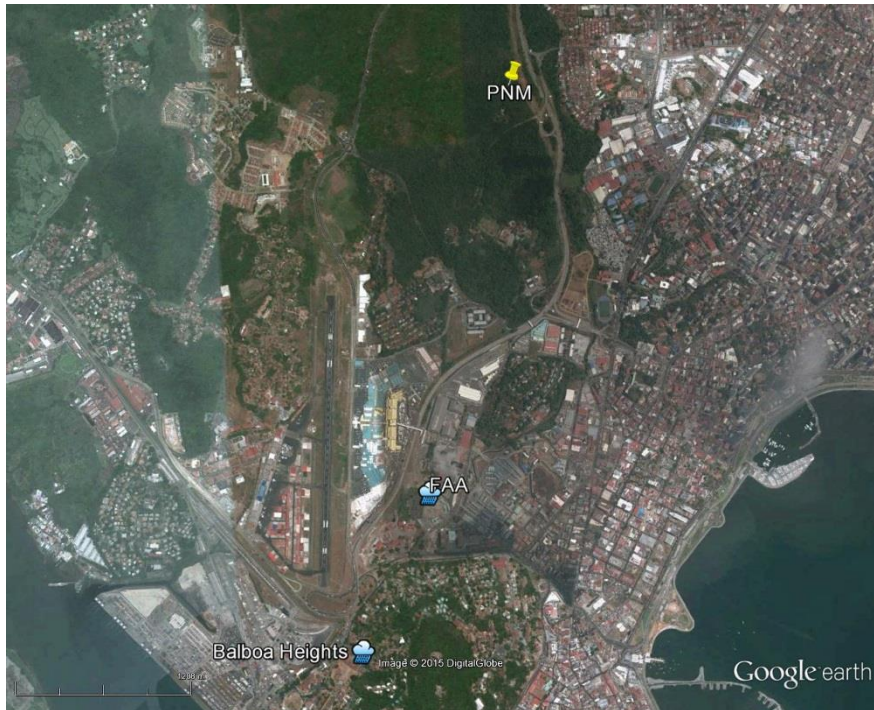
The Anemometer was eliminated in June 2008. The tipping bucket was moved to the top of the crane on March, 2009. In 2010, two pyranometer sensors were installed on the top of the crane to supplement the 25m measurements.

Data were originally collected hourly, but changed to every 15 minutes in June of 2005.

This report summarises the following data:

- Relative humidity
- Air temperature
- Rainfall
- Wind speed and direction
- Solar radiation

The Autoridad del Canal de Panamá (ACP) (Panama Canal Authority in English) maintains two nearby stations: Albrook Airbase (FAA) and Balboa Heights (HTS) – located 2.8 and 3.1km SSW of the PNM crane, respectively. Both stations record precipitation, while the HTS station also records wind, air temperature, relative humidity and solar radiation. This report summarizes the data from these stations.



Rainfall

Rainfall was collected by a tipping bucket rain gauge originally located at the 25m station, and then moved to the top of the crane in 2009. Tipping buckets generate ‘events’ for every 0.254 mm of rainfall recorded. There are several large gaps in the data. Missing data have been estimated using an average of the data from the two ACP stations. The r^2 between the monthly PNM rainfall and an average of the two ACP station’s rainfall is 0.909.

The daily rainfall data for 2019 are shown on page 6.



Page 7 shows the monthly totals for 2019. The graph on the same page compares this year’s monthly totals with the average monthly totals (\pm SD) for the period 1995 to 2017.

Page 8 shows yearly rainfall totals for all year since 1995. Time series graph and frequency histograms are presented for these data.

Pages 9 and 10 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. The tables and graphs on this page compare the maximum storm size and the average storm size and duration per month for the period 1995 to 2017 and for the year 2019.

Relative Humidity

Data were originally collected hourly at the 25m station (later every 15-minutes) by dataloggers attached to Viasala HMP temperature/humidity sensors. Since 2010, Campbell Scientific CS215 temperature/humidity sensors have been used.

The average monthly relative humidity data are shown in tabular and graphical form on pages 11.

Air Temperature

Data were originally collected hourly at the 25m station (later every 15-minutes) by dataloggers attached to Viasala HMP temperature/humidity sensors. Since 2010, Campbell Scientific CS215 temperature/humidity sensors have been used. The monthly average, maximum and minimum temperatures are shown in tabular and graphical form on page 12 to 14, respectively.



Solar Radiation

Global solar radiation has been measured at the 25m station (see photo at right) since Aug, 2007, and on the top of the crane boom (see photo at the top of the next page) since Mar. 2012 using two Li-Cor LI200SB pyranometers attached to dataloggers. 15-minute interval average intensity, maximum and minimum (W/m^2) were collected. On Apr. 12, 2018 the 25m sensor was discontinued. On June 14, 2016 one of the top sensors was replaced with a Kipp&Zonen SPLite2 pyranometer.



Page 15 shows the daily Global Radiation values from the top of the crane. Graphs of these data, plus the data from the 25m station are shown on Page 16. Pages 17-8 show the monthly average daily Global Radiation for both the 25m and crane top sensors.



Wind Speed and Direction

Data were collected hourly at the 25m station (later every 15-minutes) using Model 05103 Young Anemometers. No data have been collected since June 2008. The data are available on the associated Excel spreadsheet.

Times Series

In this section, graphs show the 2019 daily averages (pages 19-20) and monthly averages for the entire period of record (pages 21-22) for Humidity, Air Temperature, Rainfall, Wind Speed and Solar Radiation.

Daily Patterns

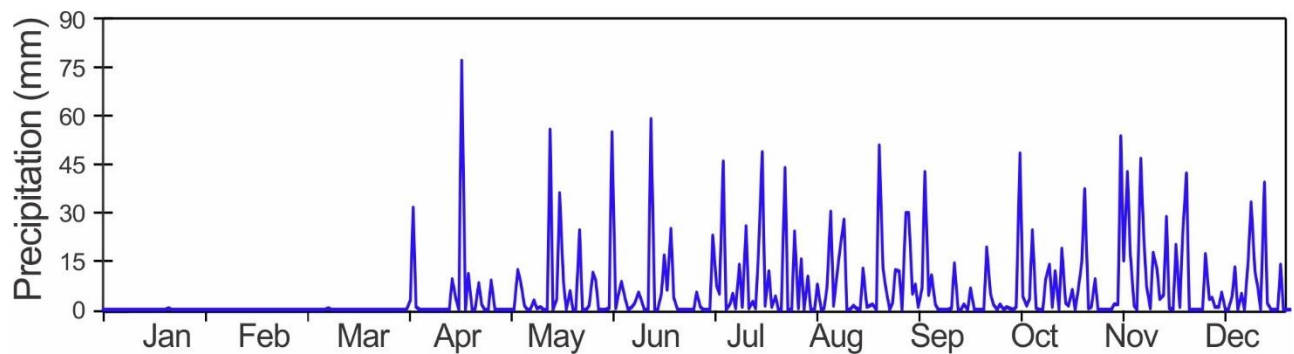
Pages 23-4 show the daily patterns for Humidity, Air Temperature, Rainfall, Wind Speed and Solar Radiation.

ACP Stations

The Autoridad del Canal de Panamá (ACP) (Panama Canal Authority in English) maintains two nearby stations: Albrook Airbase (FAA) and Balboa Heights (HTS). The stations are located at Lat/Long 8.968889°, -79.549444° and 8.959444°, -79.554167° respectively. Data were collected hourly. No information is available regarding instrumentation. A summary rainfall, wind speed and direction and air temp for these stations is shown on pages 26-32. Relative humidity, air pressure and solar radiation data were also collected at the FAA station, but not reported here due to obvious problems with the data (the data are, however, available in the associated Excel spreadsheet).

2019 Daily Rainfall (mm)

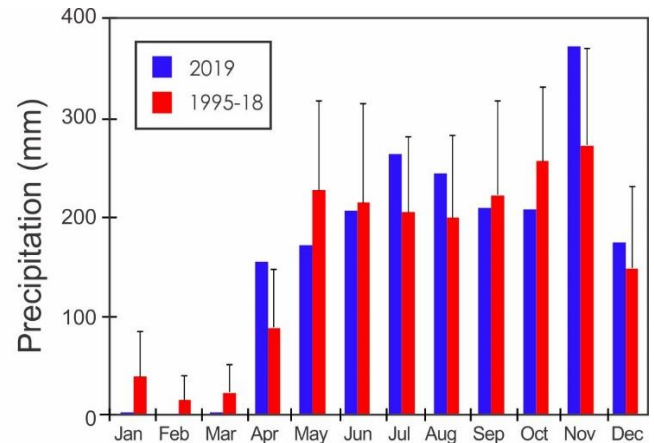
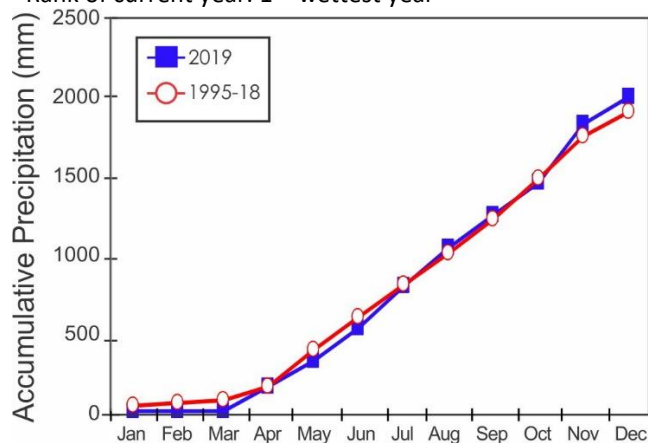
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	0.0	0.0	0.0	0.0	8.9	0.0	23.9	12.2	1.5	9.4	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	5.1	0.3	11.9	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.8	15.2	0.0	1.5	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0	0.0
5	0.0	0.0	0.0	2.8	0.0	0.3	0.0	9.9	30.0	0.5	0.0	17.0
6	0.0	0.0	0.0	31.2	0.0	54.6	0.0	0.0	4.8	0.3	0.0	3.0
7	0.0	0.0	0.0	0.5	0.0	0.3	22.9	0.0	7.6	0.0	1.5	3.6
8	0.0	0.0	0.0	0.0	12.2	4.6	7.1	7.6	0.8	0.8	1.5	0.5
9	0.0	0.0	0.0	0.0	8.6	8.4	4.8	0.0	6.4	48.3	53.3	0.5
10	0.0	0.0	0.0	0.0	1.0	3.3	45.7	0.3	42.4	3.8	15.0	5.3
11	0.0	0.0	0.3	0.0	0.0	0.0	0.0	6.6	4.3	1.3	42.4	0.0
12	0.0	0.0	0.0	0.0	0.0	0.5	1.5	30.2	10.4	3.0	17.3	0.0
13	0.0	0.0	0.0	0.0	2.5	1.8	4.8	1.3	1.5	24.4	1.3	3.8
14	0.0	0.0	0.0	0.0	0.3	5.3	0.3	11.7	0.0	0.3	0.0	13.0
15	0.0	0.0	0.0	0.0	0.8	2.5	14.0	19.1	0.0	0.0	46.5	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.5	27.7	0.0	0.0	23.1	4.8
17	0.0	0.0	0.0	0.0	0.0	0.0	25.7	0.0	0.0	9.1	7.1	0.0
18	0.0	0.0	0.0	9.1	55.6	58.9	0.3	0.0	0.3	13.7	0.3	15.5
19	0.0	0.0	0.0	3.1	0.0	0.0	2.3	1.3	14.2	0.5	17.5	33.0
20	0.0	0.0	0.0	0.0	3.0	0.0	0.3	0.3	0.0	11.9	12.7	11.7
21	0.3	0.0	0.0	77.0	36.1	4.6	17.3	0.0	0.0	0.0	3.3	6.9
22	0.0	0.0	0.0	0.0	8.6	16.8	48.8	12.5	1.5	18.5	4.3	0.0
23	0.0	0.0	0.0	10.9	0.0	5.8	1.0	0.8	0.0	2.0	28.7	39.1
24	0.0	0.0	0.0	0.0	5.6	24.9	11.7	1.0	6.6	1.0	0.3	2.0
25	0.0	0.0	0.0	0.0	0.0	3.6	0.8	1.5	0.0	5.8	0.0	0.0
26	0.0	0.0	0.0	8.1	0.0	0.0	3.8	0.0	0.0	0.0	19.8	0.0
27	0.0	0.0	0.0	1.5	24.4	0.0	0.0	50.5	0.0	5.6	0.5	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.4	0.0	14.7	22.9	13.7
29	0.0		0.0	0.0	0.0	0.0	43.7	6.4	19.3	37.1	42.2	0.0
30	0.0		0.0	8.9	1.3	0.0	0.0	0.0	4.6	0.3	0.0	0.0
31	0.0		0.0		11.2		0.0	2.0		0.8		0.0
	0.3	0.0	0.3	153.2	171.2	205.0	262.9	242.3	208.8	206.7	370.8	173.5



Monthly Rainfall (mm)¹

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
1995	0.0	2.5	61.7	73.0	319.1	377.5	237.8	175.7	490.2	266.2	179.6	141.5	2324.8
1996	155.2	51.2	64.1	123.3	384.4	178.5	133.2	188.3	99.5	218.3	335.8	101.2	2033.0
1997	129.0	17.1	2.4	7.3	102.0	189.5	135.0	140.9	344.5	230.8	272.3	0.0	1570.8
1998	0.5	3.8	0.0	73.7	373.4	279.4	198.1	172.7	230.8	158.4	211.1	222.9	1924.8
1999	57.6	33.7	87.2	69.8	187.3	189.3	115.4	0.0	182.3	258.6	297.7	222.9	1701.8
2000	19.5	44.0	7.5	90.6	122.3	251.2	231.3	118.2	214.7	276.9	191.3	146.3	1713.8
2001	23.5	0.4	1.1	50.8	233.5	254.0	149.9	88.9	236.2	264.2	236.2	218.4	1757.1
2002	100.9	0.6	22.8	117.4	96.2	136.6	197.6	197.4	137.7	281.3	210.7	34.8	1534.0
2003	0.0	21.7	8.9	186.0	223.6	147.2	135.9	125.3	103.6	219.6	222.9	152.0	1546.8
2004	4.4	0.0	11.6	79.9	177.0	140.7	221.0	170.2	355.6	408.9	221.0	52.8	1843.1
2005	35.5	0.0	11.0	68.7	225.5	172.1	202.7	192.3	403.2	66.0	76.2	61.0	1514.1
2006	17.8	2.5	67.2	81.5	133.2	137.2	294.6	266.7	106.7	223.5	241.3	233.7	1805.9
2007	20.8	0.0	7.6	143.8	264.4	148.7	112.9	208.5	144.0	259.0	223.0	196.0	1728.7
2008	35.0	44.0	8.0	8.1	76.1	237.9	240.8	365.0	141.0	291.9	534.3	43.1	2025.1
2009	7.6	10.7	36.8	41.9	193.1	222.4	323.2	204.6	220.8	326.0	251.4	57.6	1895.9
2010	25.7	6.8	67.6	67.8	220.1	389.2	324.6	275.9	185.2	303.1	209.5	312.1	2387.4
2011	101.5	102.1	53.8	177.2	300.3	117.9	375.2	272.2	171.0	433.3	377.8	184.1	2666.3
2012	0.3	2.5	17.3	54.2	222.6	172.7	110.2	111.4	258.6	323.8	376.5	285.0	1935.0
2013	0.0	0.8	1.0	12.7	252.0	171.2	133.7	358.4	273.3	268.5	170.8	158.4	1800.7
2014	63.5	6.1	7.6	19.5	402.0	143.8	179.2	164.2	203.8	213.4	230.2	189.3	1822.4
2015	20.0	0.0	0.0	44.2	164.7	141.4	193.1	277.5	208.9	242.4	226.2	62.7	1581.0
2016	18.0	0.5	0.0	143.7	350.5	208.7	161.1	163.6	134.1	263.9	408.0	131.7	1983.8
2017	1.3	0.0	9.4	52.0	201.5	160.8	130.5	291.6	253.5	172.2	306.8	203.7	1783.3
2018	107.7	1.3	0.5	235.2	249.9	562.1	295.7	182.6	214.6	208.0	404.1	96.5	2558.3
2019	0.25	0.0	0.25	153.2	171.2	205.0	262.9	242.3	208.8	206.7	370.8	173.5	1994.9
mean	37.8	14.1	22.2	87.0	225.8	213.4	203.8	198.2	220.9	255.4	271.4	147.2	1897.3
sd	45.7	24.2	27.4	59.4	90.5	100.5	75.5	83.0	95.5	74.5	98.2	82.0	307.7
min	0.0	0.0	0.0	7.3	76.1	117.9	110.2	0.0	99.5	66.0	76.2	0.0	1514.1
max	155.2	102.1	87.2	235.2	402.0	562.1	375.2	365.0	490.2	433.3	534.3	312.1	2666.3
Rank*	21	20	22	4	19	10	6	8	14	22	6	11	7

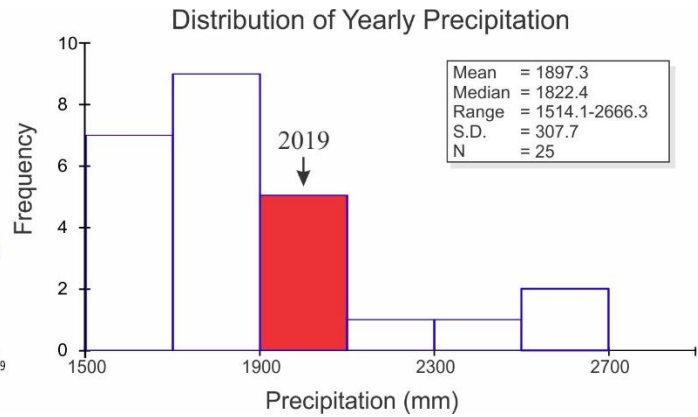
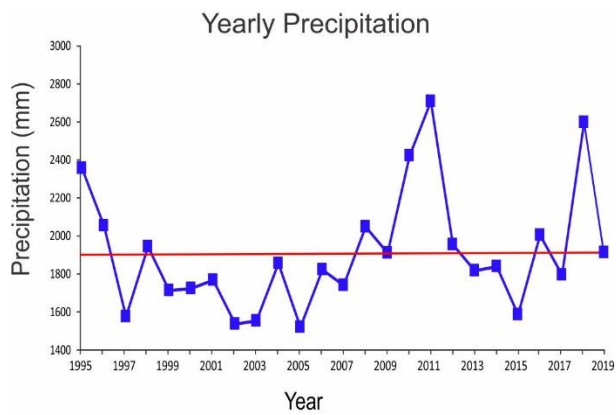
*Rank of current year. 1 = wettest year



¹ Monthly totals in green have been estimated from an average of the Balboa Heights and Albrook Airbase stations of the Panama Canal Authority

Yearly Rainfall (mm)

Year	Rain	Year	Rain	Year	Rain
1995	2324.8	2006	1805.9	2017	1783.3
1996	2033.0	2007	1728.7	2018	2558.3
1997	1570.8	2008	2025.1	2019	1954.9
1998	1924.8	2009	1895.9		
1999	1701.8	2010	2387.4		
2000	1713.8	2011	2666.3		
2001	1757.1	2012	1935.0		
2002	1534.0	2013	1800.7		
2003	1546.8	2014	1822.4		
2004	1843.1	2015	1581.0		
2005	1514.1	2016	1983.8		

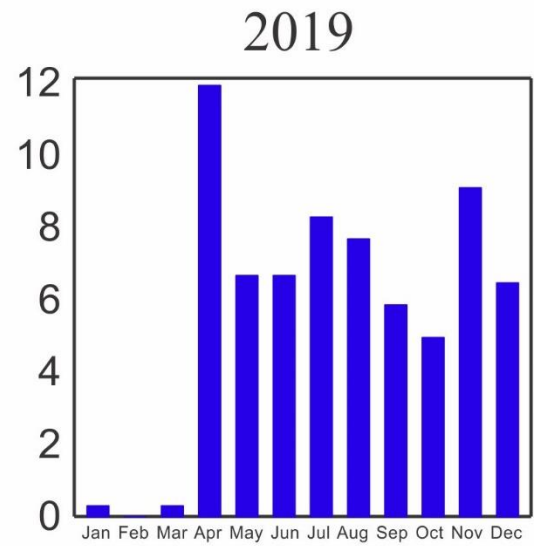
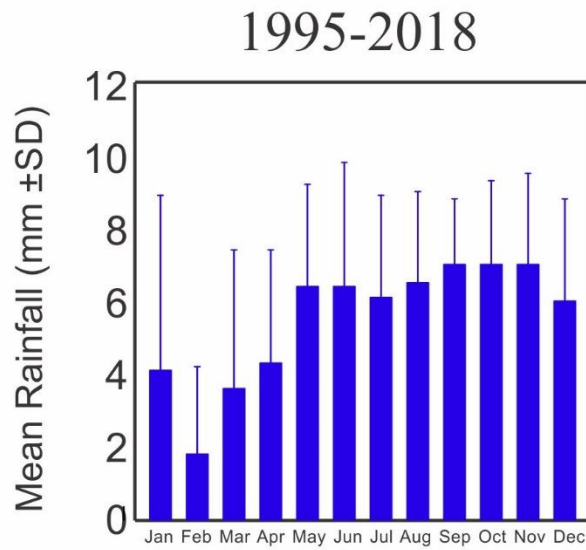


Storm Analysis

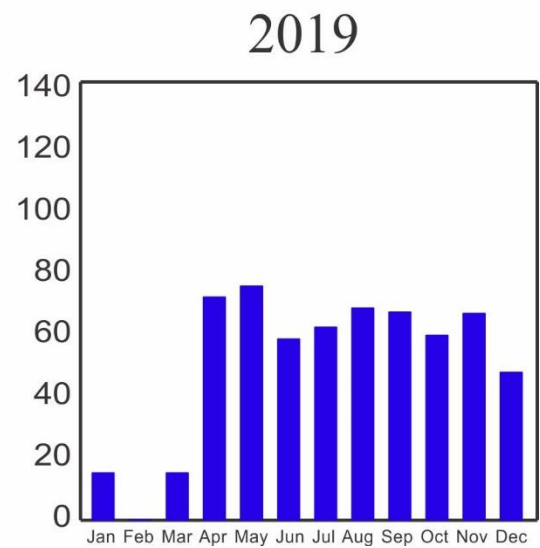
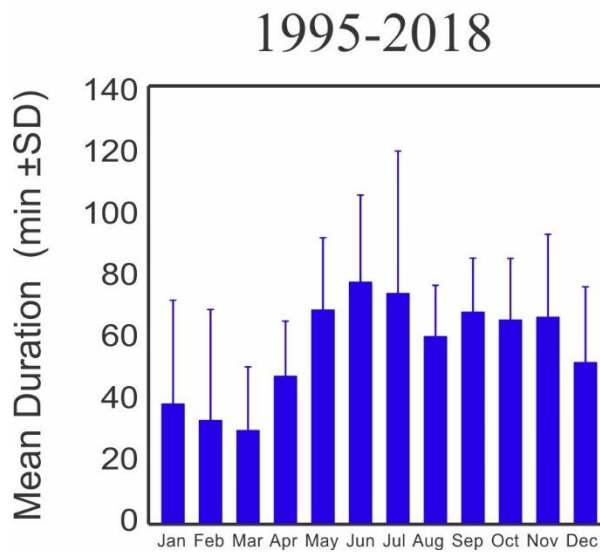
	Max. Rainfall per Storm (mm)			Storm Duration (min.)		
	1995-2018		2019	1995-2018		2019
	Mean	S.D.		Mean	S.D.	
January	11.3	10.8	0.3	38.0	33.3	15.0
February	5.3	9.4		32.7	35.6	
March	10.0	11.0	0.3	29.5	20.4	15.0
April	30.9	27.4	77.0	46.9	17.7	71.2
May	44.7	23.4	54.1	68.1	23.2	74.7
June	52.8	30.1	58.9	77.0	28.0	57.8
July	51.8	28.6	48.5	73.4	45.7	61.6
August	47.4	21.5	50.3	59.6	16.5	67.7
September	53.8	25.3	42.2	67.4	17.4	66.4
October	44.3	14.6	36.8	64.9	19.8	59.0
November	50.3	20.1	51.8	65.8	26.6	66.0
December	42.6	28.2	36.1	51.3	24.3	47.2

	Av. Rainfall per Storm (mm)		
	1995-2018		2019
	Mean	S.D.	
January	4.1	4.8	0.3
February	1.8	2.4	
March	3.6	3.8	0.3
April	4.3	3.1	11.8
May	6.4	2.8	6.6
June	6.4	3.4	6.6
July	6.1	2.8	8.2
August	6.5	2.5	7.6
September	7.0	1.8	5.8
October	7.0	2.3	4.9
November	7.0	2.5	9.0
December	6.0	2.8	6.4

Average Monthly Storm Size

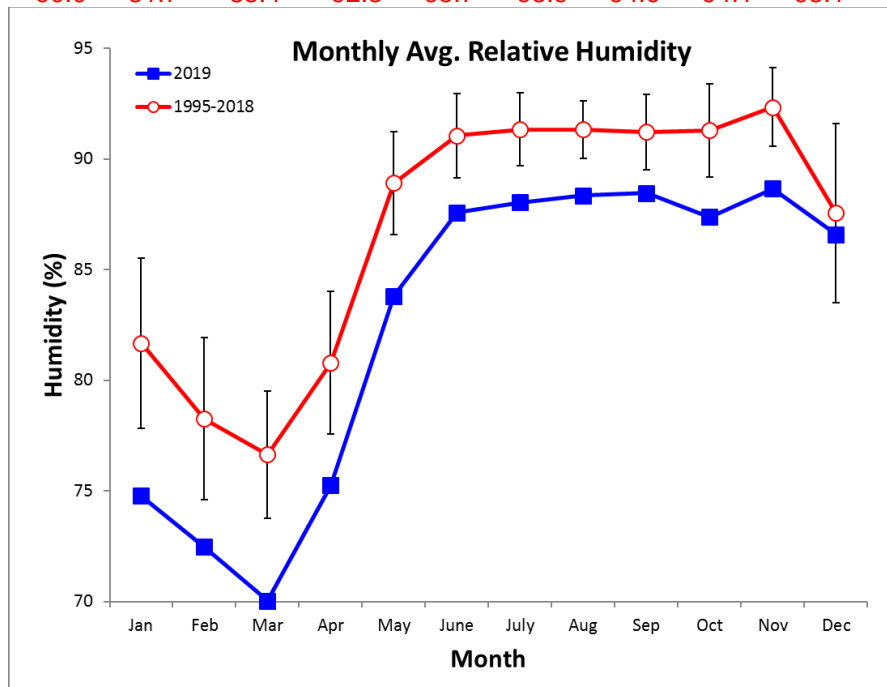


Average Monthly Storm Duration



Relative Humidity (%)

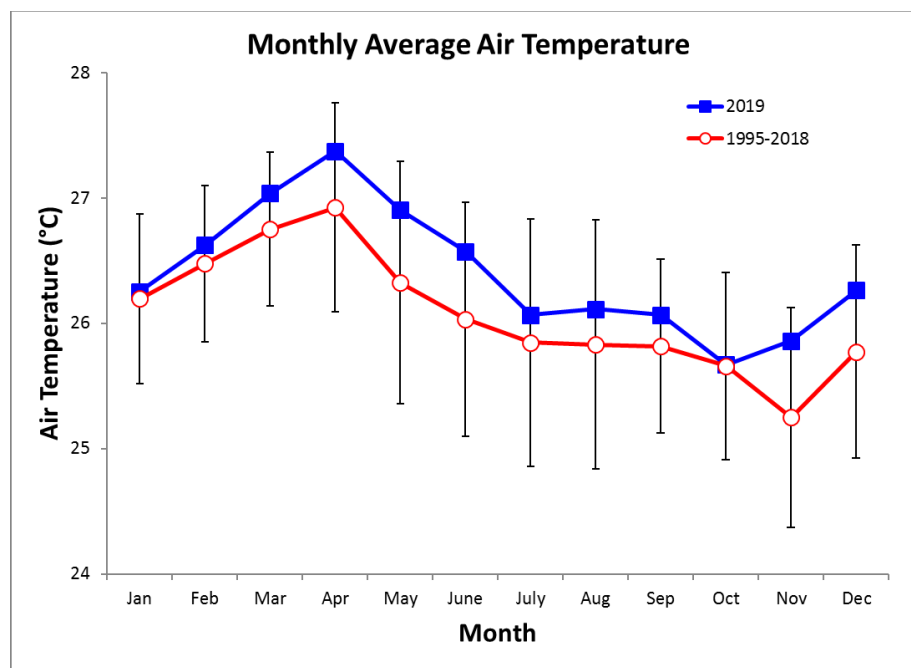
Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1995	91.0	90.0			91.3	91.3	92.2	90.8		92.6	92.8	89.7
1996	85.9	81.5	79.6	81.6	90.4	93.1	92.0	92.0	92.4	91.5	91.6	91.6
1997	83.4	81.0	75.7	78.9	85.2	90.4	89.9	90.4	93.1	92.1	91.8	80.6
1998	78.8	77.9	73.6						88.1	89.1	91.0	91.3
1999	81.5	78.5	77.3	82.8	91.9							
2000							92.3	91.4	91.1	92.5	89.9	88.1
2001	80.0	75.9	76.8		88.2	89.6	91.3	91.3	91.5	92.1	92.3	91.8
2002	84.3	77.7	77.5	80.4	84.9	90.1	91.4	92.1	91.6	92.6	91.8	84.0
2003	77.9	75.4	77.4	73.6	90.5	92.3	92.4	92.2	90.8	92.5	94.2	90.0
2004	80.5	76.9	75.3	81.2	90.4	91.4						82.1
2005	81.2	74.9	80.0	81.9	89.4	90.8	90.6	91.8	91.9			79.2
2006		75.5	77.0	83.4	89.5	90.0	88.7	90.8	91.1	89.0	92.0	88.7
2007				84.9	91.6	91.1	91.5	91.7	90.6	90.6	92.7	89.7
2008	79.5	80.4	76.7	78.0	87.3	92.6	93.1	91.7	89.0	90.3	94.1	83.9
2009	81.5	78.2	75.2	76.1	88.7	89.4	91.5	92.1	90.7	90.3	93.1	85.9
2010	80.7	81.6	81.7	85.4	87.9	92.7	93.8	91.3	90.5	93.1	92.7	91.2
2011	86.2	80.6	79.3	84.0	87.5	91.3	92.2	91.4	91.7	91.3	94.6	90.4
2012	79.6	77.4	75.8	84.0	90.3	90.8	93.3	92.4	93.8	93.2	95.0	92.4
2013	80.8	79.6	80.5	82.3	88.9	93.2	93.9	94.0	94.1	95.1	93.6	90.5
2014	84.9	80.6	79.2	82.3	90.0	93.0	90.7	92.0	92.5	92.2	92.2	90.5
2015	80.3	79.3	76.2	80.7	87.0	88.1	90.1	91.7	93.2	92.8	92.9	88.3
2016	80.5	76.5	76.3	80.0	91.1	90.3	90.9	89.5	89.9	90.1	91.9	86.9
2017	75.7	73.2	71.3	77.6	86.7	88.5	91.8	92.1	92.3	92.6	94.5	88.8
2018	88.0	74.8	73.5	82.5	92.3	95.7	88.2	88.2	88.5	85.6	88.2	79.3
2019	74.8	72.5	70.0	75.258	83.8	87.6	88.0	88.3	88.5	87.4	88.7	86.6
mean	81.7	78.3	76.6	80.8	88.9	91.1	91.3	91.3	91.2	91.3	92.3	87.6
sd	3.8	3.7	2.9	3.2	2.3	1.9	1.6	1.3	1.7	2.1	1.8	4.0
min	74.8	72.5	70.0	73.6	83.8	87.6	88.0	88.2	88.1	85.6	88.2	79.2
max	91.0	90.0	81.7	85.4	92.3	95.7	93.9	94.0	94.1	95.1	95.0	92.4



Avg. Monthly Temperatures (°C)

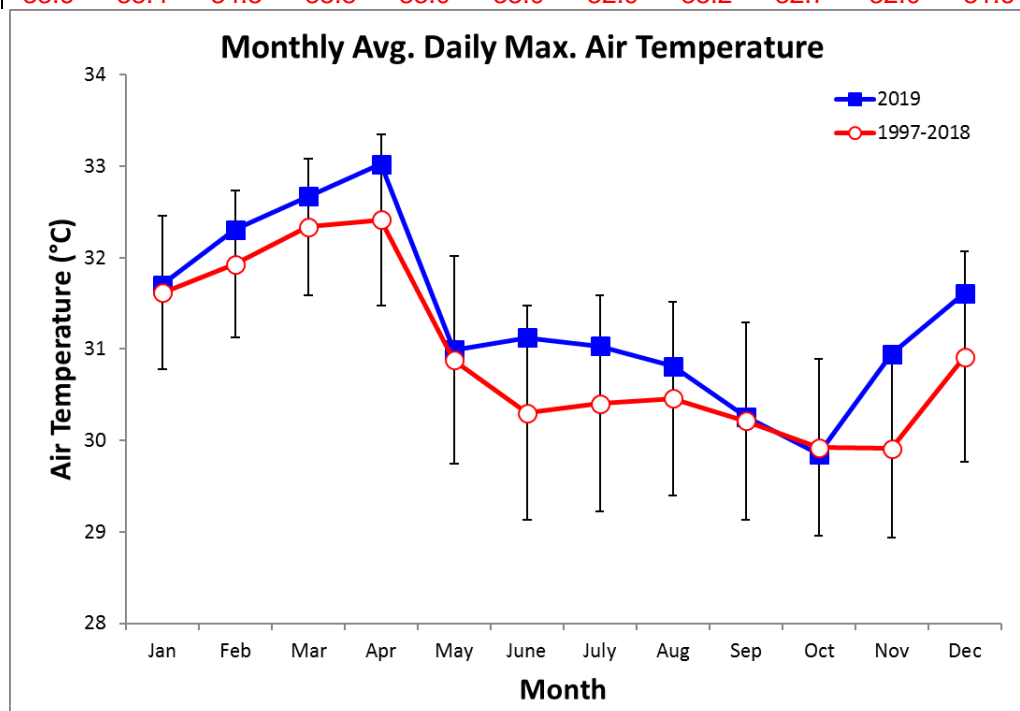
Monthly Average Temperature

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1995	27.2	27.2			27.0	27.2	26.7	27.0		26.4	26.6	26.6
1996	26.6	26.8	27.0	27.5	27.1	27.0	26.8	26.7	26.8	26.6	26.3	26.3
1997	26.4	27.2	26.9	27.5	27.9	27.4	28.0	28.0	27.2	27.3	25.9	26.9
1998	27.1	27.2	27.8						26.2	26.1	25.6	25.4
1999	26.0	25.7	26.2	26.5	26.0	25.6	25.6		25.4	25.3	25.3	25.4
2000	25.2	25.6	25.9	26.3	25.9	25.8	25.6	25.6	25.2	25.2	25.4	25.2
2001	25.5	25.8	26.0		26.0	26.1	25.5	26.3	25.3	25.5	24.4	24.8
2002	25.8	26.1	26.4	26.0	26.1	25.4	25.3	25.3	25.4	25.0	25.2	26.2
2003	26.4	27.0	26.7	27.9						25.2	25.2	25.6
2004	25.9	26.5	27.1									25.6
2005	25.7	26.2	26.5	26.7	25.1	24.7	24.7	24.0				25.6
2006		26.3	26.1	25.3	23.9	24.4	24.6	24.4	24.2	24.3	23.6	24.8
2007				26.0	24.6	25.2	24.9	24.6	25.0	24.8	23.9	24.6
2008	26.0	26.0	26.5	27.1	26.0	24.5	23.8	24.2	25.9	25.3	23.8	25.8
2009	26.1	26.4	26.7	27.3	26.2	25.9	25.7	25.3	26.0	25.6	25.0	26.6
2010	26.4	26.7	27.0	27.0	27.1	25.8	25.5	25.6	25.4	24.9	24.4	23.9
2011	25.2	25.8	25.6	25.7	26.1	25.7	25.3	25.6	25.3	24.7	24.4	24.8
2012	25.7	25.7	27.0	26.6	26.5	26.5	26.1	26.0	25.9	25.6	25.3	25.9
2013	26.8	26.7	27.2	27.6	26.7	26.4	26.2	26.0	26.1	25.8	25.9	26.3
2014	26.5	26.8	27.1	27.7	26.8	27.1	27.6	26.8	26.6	26.7	26.4	26.6
2015	27.3	27.3	27.5	28.1	27.6	27.8	27.2	27.0	27.0	26.9	26.6	27.9
2016	27.6	27.8	28.2	28.4	27.6	26.6	25.8	26.3	25.7	25.6	24.9	25.7
2017	25.9	26.2	26.8	26.9	26.3	26.0	25.8	25.7	25.9	25.8	25.0	25.4
2018	25.2	25.8	26.3	26.1	25.8	25.3	26.0	25.9	25.6	25.8	25.8	26.4
2019	26.3	26.6	27.0	27.4	26.9	26.6	26.1	26.1	26.1	25.7	25.9	26.3
mean	26.2	26.5	26.9	27.1	26.7	26.3	26.1	26.0	26.0	25.7	25.4	25.9
sd	0.7	0.6	0.6	0.8	1.0	1.0	1.0	1.0	0.7	0.8	0.9	0.9
min	25.2	25.6	25.6	25.3	23.9	24.4	23.8	24.0	24.2	24.3	23.6	23.9
max	27.6	27.8	28.2	28.4	27.9	27.8	28.0	28.0	27.2	27.3	26.6	27.9



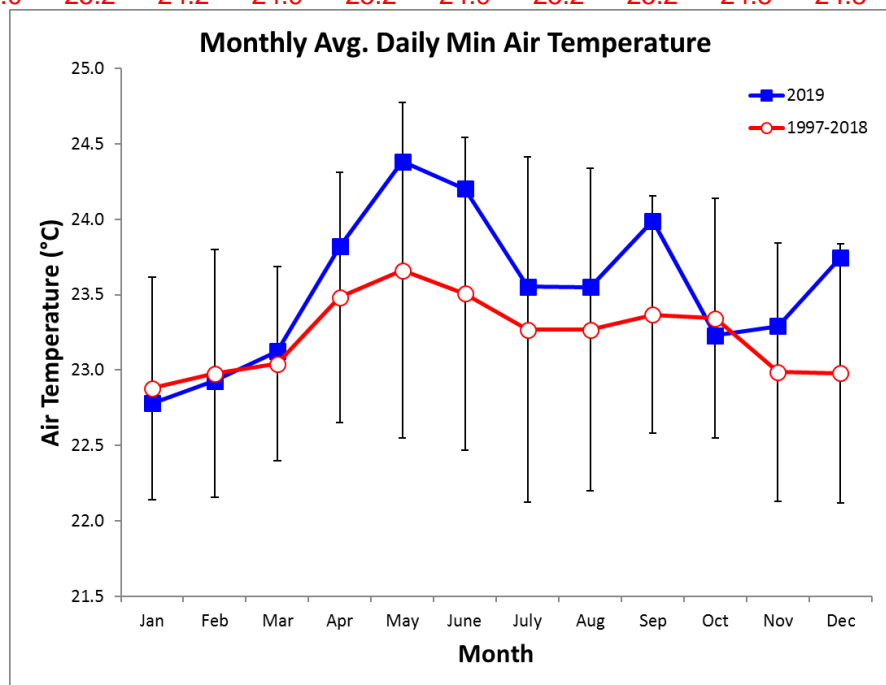
Monthly Average of Daily Maximum Temperature

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1995	31.2	30.2			31.6	30.7	30.9	30.9		31.1	31.2	31.8
1996	31.6	32.2	32.7	33.0	31.4	31.1	30.9	31.0	31.1	30.7	30.1	30.5
1997	32.3	32.5	32.5	32.7	33.0	31.7	32.9	33.2	31.9	32.0	30.1	32.1
1998	32.7	32.6	33.4						30.4	29.5	30.2	29.8
1999	31.1	30.6	31.5	31.2	29.9	29.6	30.1		28.9	28.7	29.8	29.8
2000	30.2	30.9	31.3	31.3	30.1	29.9	29.7	30.0	28.6	29.7	30.1	29.6
2001	30.6	30.8	31.3		30.0	30.4	29.9	30.5	28.9	29.3	28.7	29.3
2002	30.9	31.2	31.7	31.3	30.8	29.7	30.0	30.3	29.7	29.5	30.1	31.3
2003	31.7	32.2	31.7	33.7						29.7	30.4	30.4
2004	31.4	32.3	32.1									31.5
2005	31.2	31.8	32.5	32.2	29.7	28.4	29.4	29.2				31.6
2006		32.0	31.8	31.1	28.3	27.6	28.4	29.8	29.3	28.4	28.3	30.5
2007				31.4	29.7	29.7	29.8	28.7	29.6	28.7	28.7	29.8
2008	31.5	31.7	32.6	33.0	30.4	29.3	28.6	28.5	29.8	29.5	28.3	31.4
2009	31.6	31.7	32.3	32.9	31.3	30.3	30.4	30.2	31.1	30.3	29.4	32.0
2010	31.9	32.0	32.2	32.1	31.3	29.7	29.2	29.8	28.8	29.1	29.0	28.4
2011	30.9	32.1	31.5	31.3	30.7	29.9	29.6	30.1	29.9	28.8	29.1	30.0
2012	31.6	31.9	32.8	32.2	31.4	31.2	31.1	30.9	31.2	30.5	30.3	31.2
2013	32.4	32.6	32.5	33.6	31.5	30.7	30.9	30.6	30.2	30.4	31.0	32.0
2014	32.4	33.1	33.3	33.3	31.9	31.5	32.9	31.6	31.5	31.1	31.6	31.9
2015	33.1	33.1	33.1	33.8	32.8	33.0	32.2	32.2	32.7	32.0	31.3	33.5
2016	33.6	33.4	34.3	33.8	32.5	31.4	30.3	30.7	30.5	29.9	29.0	30.8
2017	31.4	31.9	32.5	32.2	30.4	29.7	30.2	30.2	29.7	30.1	29.7	30.3
2018	30.3	31.4	31.7	31.7	29.8	30.0	30.6	30.5	30.4	29.8	30.7	32.0
2019	31.7	32.3	32.7	33.0	31.0	31.1	31.0	30.8	30.3	29.9	30.9	31.6
mean	31.6	31.9	32.3	32.4	30.9	30.3	30.4	30.5	30.2	29.9	29.9	30.9
sd	0.8	0.8	0.7	0.9	1.1	1.2	1.2	1.1	1.1	1.0	1.0	1.2
min	30.2	30.2	31.3	31.1	28.3	27.6	28.4	28.5	28.6	28.4	28.3	28.4
max	33.6	33.4	34.3	33.8	33.0	33.0	32.9	33.2	32.7	32.0	31.6	33.5



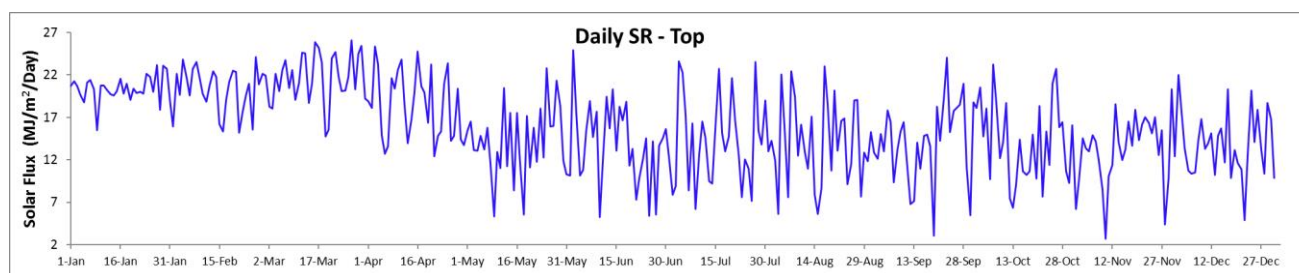
Monthly Average of Daily Minimum Temperature

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1995	25.0	25.2			24.4	24.9	24.4	24.4		24.2	24.4	24.2
1996	23.9	23.7	23.5	24.1	24.9	24.9	24.4	24.4	24.7	24.5	24.4	24.2
1997	23.2	24.1	23.1	24.1	25.2	24.8	25.2	25.2	24.8	24.8	23.7	23.5
1998	23.7	23.9	24.1						23.6	24.1	23.4	23.4
1999	23.0	22.8	22.9	23.7	23.7	23.5	23.2		23.2	23.3	23.3	23.4
2000	22.2	22.3	22.2	23.2	23.7	23.7	23.4	23.1	22.9	22.9	22.9	22.7
2001	22.2	22.4	22.4		23.6	23.4	23.1	23.9	22.9	23.3	22.2	22.3
2002	22.6	22.5	22.8	22.5	22.9	22.6	22.6	22.7	22.8	22.5	22.7	23.2
2003	22.8	23.4	23.1	24.2						22.5	22.8	23.0
2004	22.3	22.5	23.6									21.7
2005	22.1	22.4	22.5	23.0	22.0	21.8	21.5	21.2				21.7
2006		22.4	22.0	21.5	20.7	21.5	20.5	21.5	21.4	21.5	21.3	22.2
2007				22.7	21.7	22.3	22.3	21.9	22.2	22.6	21.7	21.9
2008	22.4	22.3	22.5	23.2	23.1	21.9	21.2	21.5	23.3	23.0	21.6	22.3
2009	22.8	22.9	22.8	23.4	23.4	23.0	23.3	22.9	23.4	23.1	22.9	23.5
2010	22.8	23.6	23.8	23.8	24.5	23.5	23.2	23.2	23.3	22.8	22.1	21.5
2011	22.1	22.1	22.0	22.4	23.2	23.4	22.9	23.0	22.8	22.5	22.4	22.3
2012	22.0	21.9	23.4	23.4	24.0	23.9	23.5	23.4	23.4	23.3	23.3	23.4
2013	23.1	22.9	23.8	24.1	24.0	23.9	23.7	23.4	23.6	23.5	23.3	23.3
2014	22.9	22.9	23.0	24.3	24.3	24.9	24.9	24.3	24.0	24.3	23.9	23.8
2015	23.8	23.7	23.6	24.7	24.7	24.9	24.6	24.5	24.5	24.4	24.2	24.9
2016	23.8	24.3	24.2	24.9	25.1	23.8	23.4	24.0	23.1	23.3	22.8	23.0
2017	22.2	22.4	22.9	23.6	23.8	23.5	23.4	23.2	23.5	23.7	22.8	22.7
2018	22.5	22.1	22.7	22.8	23.5	22.9	23.7	23.5	23.2	23.5	23.3	23.1
2019	22.8	22.9	23.1	23.8	24.4	24.2	23.6	23.6	24.0	23.2	23.3	23.7
mean	22.9	23.0	23.0	23.5	23.7	23.5	23.3	23.3	23.4	23.3	23.0	23.0
sd	0.7	0.8	0.6	0.8	1.1	1.0	1.1	1.1	0.8	0.8	0.9	0.9
min	22.0	21.9	22.0	21.5	20.7	21.5	20.5	21.2	21.4	21.5	21.3	21.5
max	25.0	25.2	24.2	24.9	25.2	24.9	25.2	25.2	24.8	24.8	24.4	24.9



2019 Daily Total Radiation (MJ m⁻² day⁻¹) - Top

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	20.7	16.0	21.9	19.0	15.5	10.1	12.3	14.3	12.8	18.8	6.2	12.5
2	21.3	22.2	18.3	18.1	16.5	24.9	7.9	11.9	12.1	18.1	9.7	22.0
3	20.6	19.7	18.1	25.3	13.2	17.5	8.9	5.7	15.1	20.6	14.6	17.6
4	19.6	23.8	22.2	23.2	13.1	10.1	23.6	22.1	13.0	14.8	13.4	13.3
5	18.8	21.7	20.1	14.9	14.9	10.8	22.3	14.7	17.8	18.0	13.0	10.7
6	21.1	19.6	22.6	12.7	13.3	15.4	17.2	7.6	16.5	9.7	14.9	10.3
7	21.4	22.7	23.8	13.6	15.8	18.9	8.4	22.4	9.4	23.3	14.2	10.5
8	20.3	23.5	20.4	21.6	11.6	14.7	16.3	19.5	13.3	18.7	11.9	14.2
9	15.5	21.7	22.6	20.4	5.4	17.7	6.2	12.5	15.3	12.2	8.5	16.8
10	20.7	19.8	19.0	22.6	12.9	5.3	12.7	16.1	16.4	14.1	2.7	13.3
11	20.8	18.9	21.1	23.8	11.1	11.9	16.5	13.0	11.1	18.7	10.1	13.9
12	20.2	20.7	24.7	18.3	20.5	19.4	14.6	10.9	6.8	7.4	11.4	15.1
13	19.7	22.4	24.5	14.0	11.2	15.7	9.5	17.1	7.2	6.4	18.5	10.2
14	19.6	21.8	18.7	16.7	17.5	20.3	9.2	7.9	14.0	9.1	14.1	14.8
15	20.1	16.2	21.0	20.1	8.4	13.1	15.6	5.7	11.0	14.4	12.0	15.7
16	21.5	15.3	25.9	24.7	17.5	18.2	22.7	8.7	14.8	10.6	13.3	11.7
17	19.8	19.1	25.2	20.7	11.5	16.7	15.2	23.0	15.0	10.2	16.5	20.3
18	21.0	21.2	23.4	20.0	5.6	18.8	13.0	18.5	13.6	10.6	13.7	9.9
19	19.0	22.5	14.8	16.4	17.1	11.3	14.8	10.7	3.1	15.0	17.9	13.2
20	20.4	22.4	15.6	23.3	11.1	13.3	21.6	20.2	18.3	9.8	14.3	11.6
21	19.9	15.2	24.0	12.4	15.8	7.3	16.7	13.1	14.2	18.3	16.2	10.9
22	20.0	17.8	24.7	14.8	11.7	9.9	12.6	16.6	19.1	7.6	17.0	4.9
23	19.8	19.6	21.8	15.4	18.1	12.1	7.6	16.9	24.0	15.4	16.3	12.5
24	22.2	20.9	20.1	21.0	12.2	14.6	12.1	9.2	15.3	11.4	15.1	20.2
25	21.8	15.5	20.2	23.4	22.8	5.4	10.9	11.5	17.8	21.0	17.0	14.1
26	20.0	24.1	21.8	14.3	16.0	14.1	7.2	19.0	18.1	22.7	12.6	17.9
27	23.2	20.9	26.1	14.9	16.0	5.5	23.5	19.0	18.5	15.9	15.5	13.2
28	17.9	22.1	20.3	20.4	21.3	13.7	15.4	7.6	21.0	16.4	4.4	10.3
29	23.1		24.5	14.4	18.3	14.5	13.8	12.8	11.2	10.7	9.8	18.7
30	22.7		25.4	13.7	11.9	15.6	19.0	11.8	5.5	9.3	20.3	16.7
31	19.0		19.2		10.3		13.0	15.2		16.1		9.9



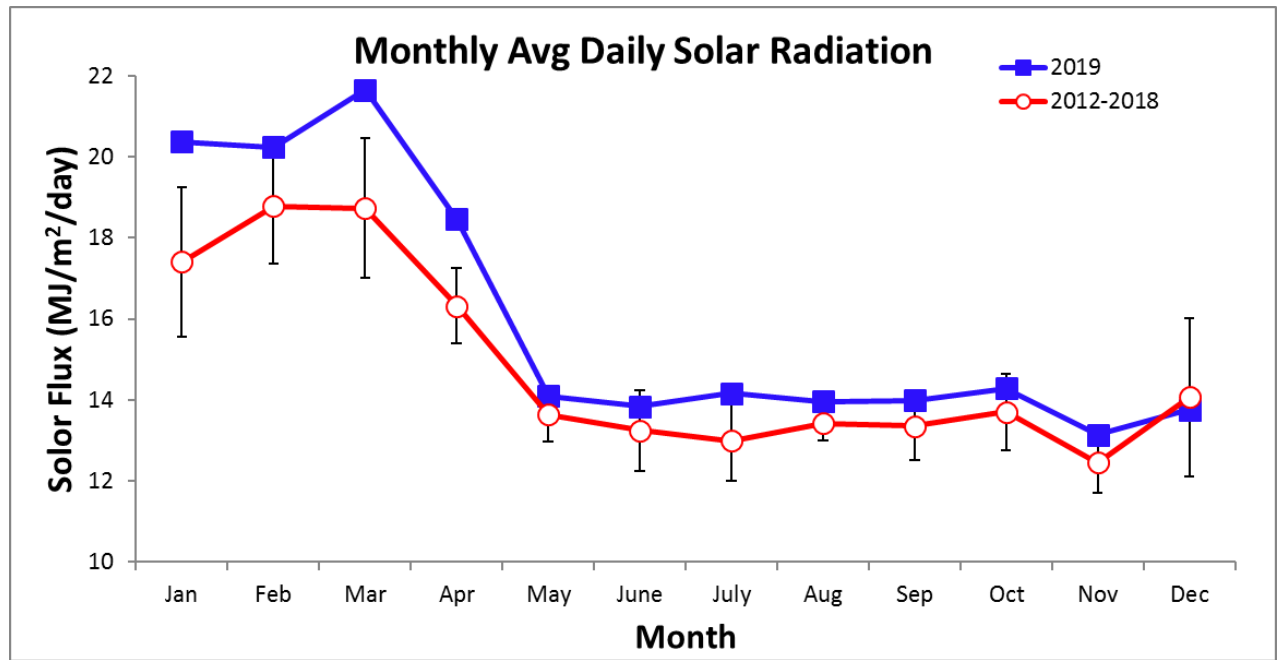
Monthly Average Total Daily Solar Radiation (MJ m⁻² day⁻¹)

Top Station

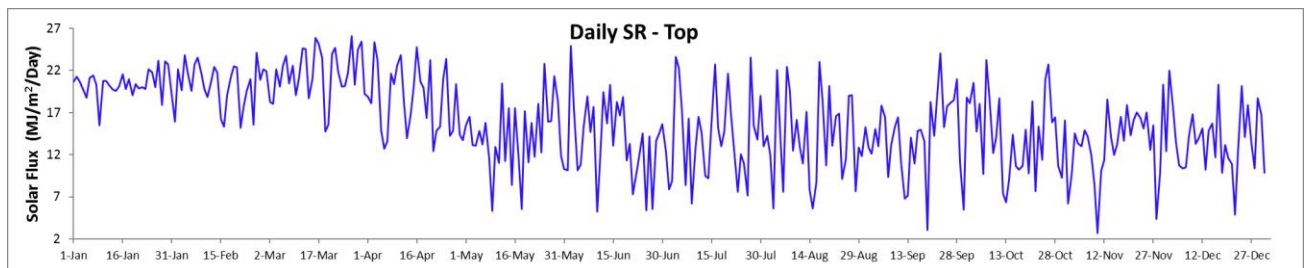
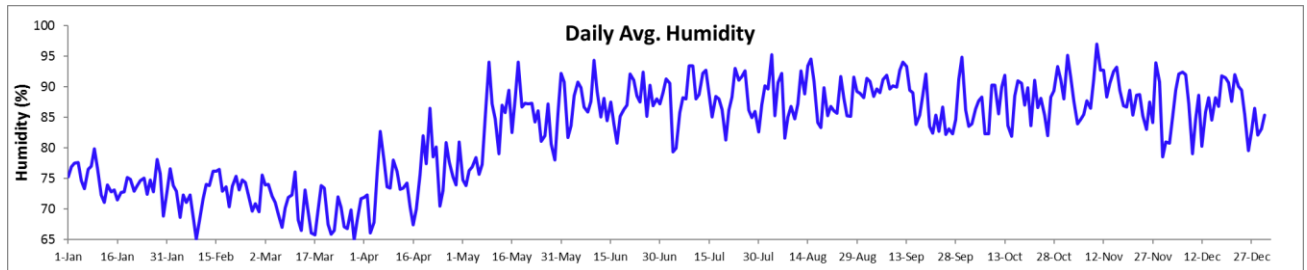
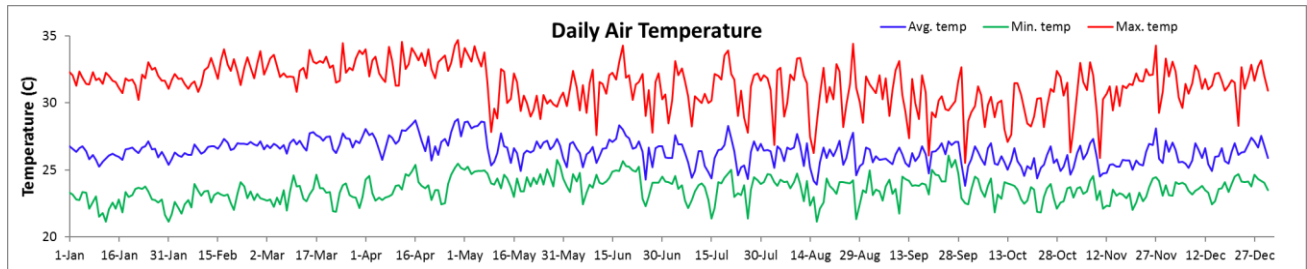
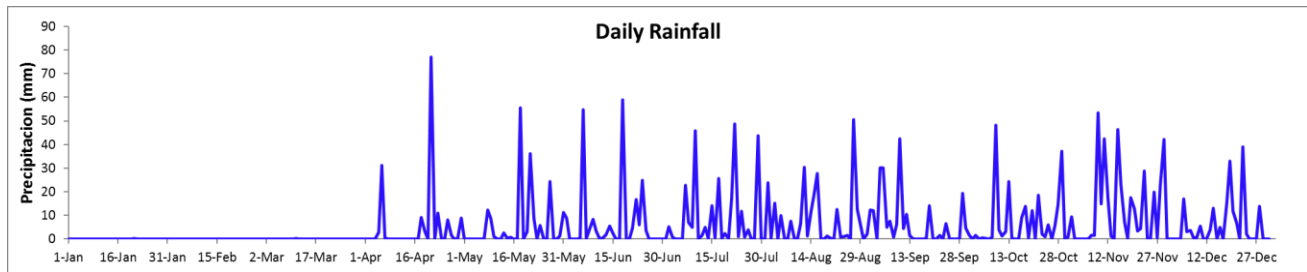
Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2012			18.8	15.7	13.5	13.4	11.5	13.3	12.1	12.6	11.3	12.0
2013	18.3	17.8	16.3	16.7	14.1	12.9	13.1	13.8	12.3	12.8	13.2	13.3
2014	16.9	18.2	19.0	15.7	13.0	11.6	13.4	12.7	13.2	13.1	12.5	12.3
2015	16.0	17.2	18.3	15.9	13.2	14.9	14.5	13.3	13.1	13.4	11.9	14.4
2016	17.3	17.5	16.7	15.8	12.7	13.6	12.4	13.8	13.9	14.5	11.7	14.2
2017	18.4	20.5	19.3	16.0	14.1	13.5	12.4	13.6	13.8	13.6	13.0	14.4
2018	14.7	20.0	19.9	16.2	14.5	12.3	12.6	13.0	14.4	15.4	13.0	18.3
2019	20.4	20.2	21.7	18.5	14.1	13.8	14.2	14.0	14.0	14.3	13.1	13.8
mean	17.4	18.8	18.7	16.3	13.6	13.2	13.0	13.4	13.4	13.7	12.5	14.1
sd	1.8	1.4	1.7	0.9	0.6	1.0	1.0	0.4	0.8	0.9	0.8	2.0
min	14.7	17.2	16.3	15.7	12.7	11.6	11.5	12.7	12.1	12.6	11.3	12.0
max	20.4	20.5	21.7	18.5	14.5	14.9	14.5	14.0	14.4	15.4	13.2	18.3

25 Meter Station (discontinued)

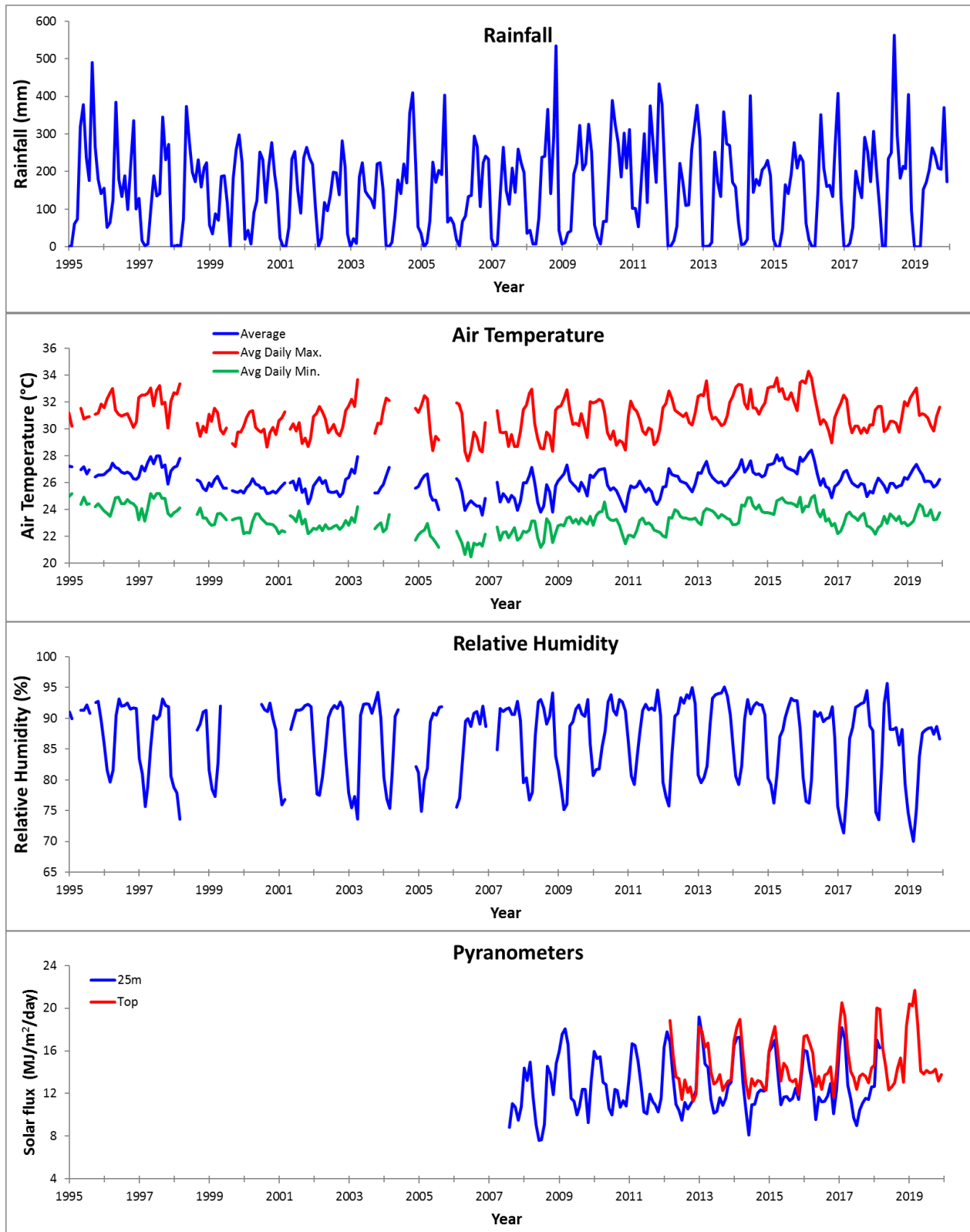
Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2007								8.8	11.0	10.7	9.5	10.8
2008	14.4	13.2	15.0	11.6	9.0	7.6	7.7	9.1	14.6	13.8	11.9	14.8
2009	16.0	17.6	18.1	16.6	11.5	11.3	10.0	10.7	12.4	12.4	9.3	13.2
2010	16.0	15.3	15.5	13.1	12.9	10.6	10.0	12.4	12.3	10.7	11.3	10.8
2011	13.5	16.7	16.5	15.1	12.8	10.3	10.1	11.9	11.2	10.9	10.3	11.6
2012	16.3	17.8	16.8	13.6	11.0	10.5	9.5	11.2	10.5	11.0	11.4	12.3
2013	19.2	17.6	14.8	14.5	11.4	10.2	10.3	11.6	10.9	11.6	12.7	13.1
2014	16.5	17.2	17.3	13.1	10.5	8.1	11.0	11.0	12.1	12.3	12.2	12.3
2015	15.9	16.4	17.0	13.9	11.0	11.7	11.7	11.3	11.6	12.5	11.5	13.9
2016	16.1	15.9	14.2	12.8	9.6	11.6	11.2	11.3	11.8	12.9	10.1	12.3
2017	16.4	18.2	17.1	12.8	11.5	9.7	9.0	10.5	11.1	11.6	11.4	12.6
2018	12.7	17.0	16.3									
mean	16.0	16.6	16.2	13.7	11.1	10.2	10.0	10.9	11.8	11.9	11.1	12.5
sd	1.5	1.5	1.3	1.4	1.2	1.4	1.2	1.1	1.1	1.0	1.1	1.2
min	13.5	13.2	14.2	11.6	9.0	7.6	7.7	8.8	10.5	10.7	9.3	10.8
max	19.2	18.2	18.1	16.6	12.9	11.7	11.7	12.4	14.6	13.8	12.7	14.8



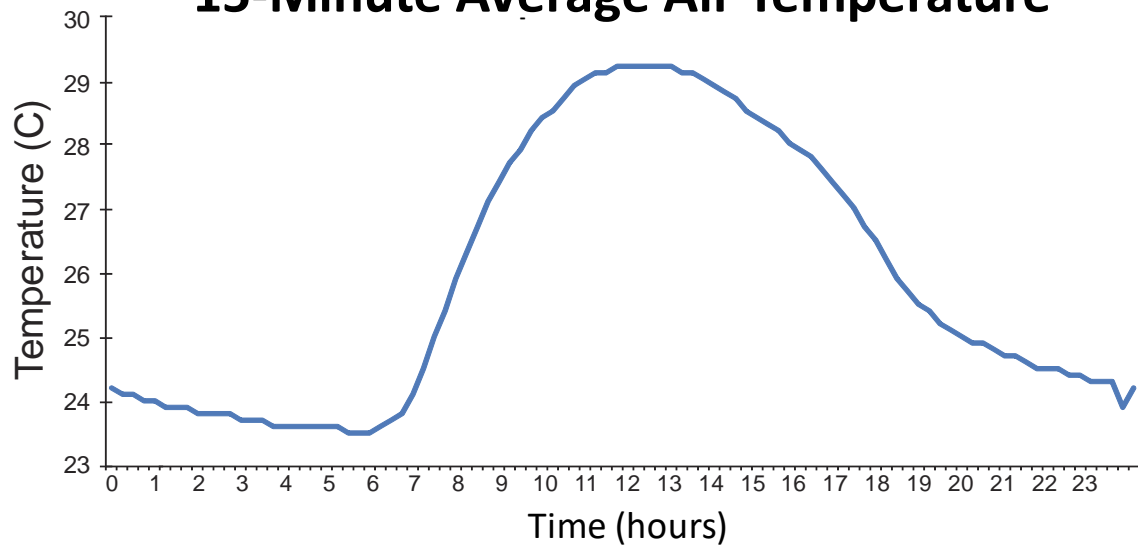
Time Series – Daily 2019



Time Series - Monthly



15-Minute Average Air Temperature



15-Minute Average Relative Humidity

