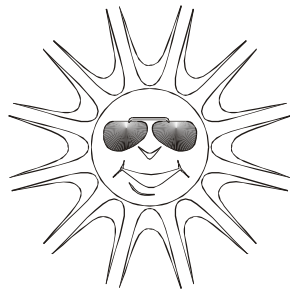




Smithsonian Tropical Research Institute

# 2019 Meteorological Summary for the Galeta Marine Island Laboratory

Prepared by: Steven Paton

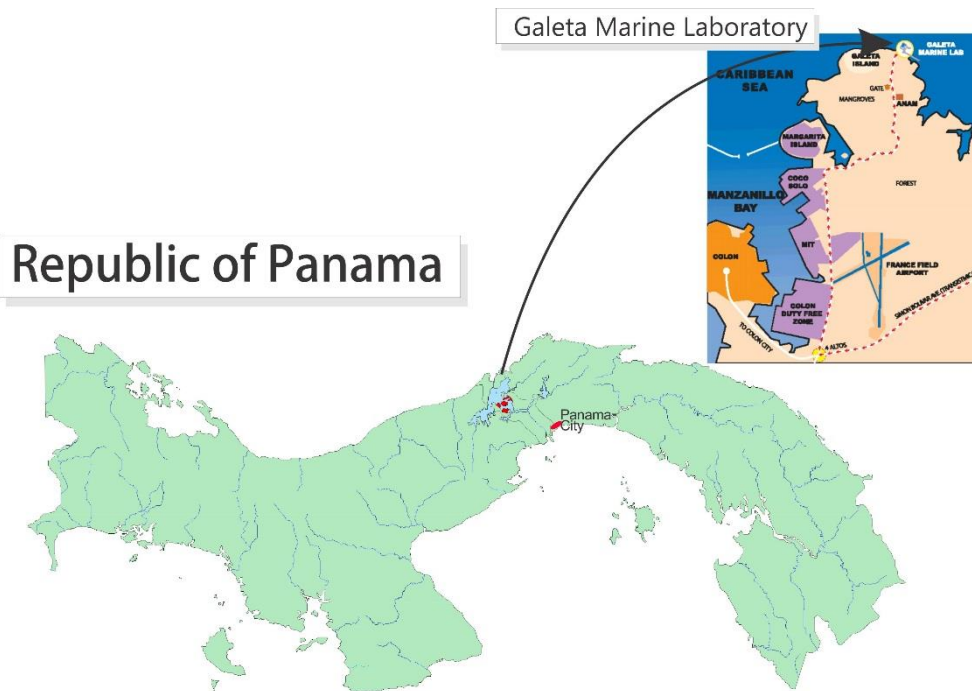


## Introduction

This is the 7<sup>th</sup> in a series of yearly reports summarising the past year's Smithsonian Tropical Research Institute's Physical Monitoring Program at the Galeta Island Marine Laboratory. 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 the Galeta and other research locations, can be obtained from: [http://biogeodb.stri.si.edu/physical\\_monitoring/research/galeta](http://biogeodb.stri.si.edu/physical_monitoring/research/galeta)

## Setting

Installed in 1974, the Galeta Island Marine Laboratory physical monitoring station (9.402742°, -79.860837°) is located approximately 6 km North East of the city of Colon. Established in the 1960's, The Galeta Island Marine Laboratory was the first marine laboratory established by STRI on the Caribbean coast of Panama. It was the site of an extensive study of the biological effects of a major oil spill.



The station receives an average of 2897.9 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 217mm of rain falls during the dry season. Relative humidity, air temperature, solar radiation, wind speed and direction, sea surface temperature (SST) all show marked seasonal differences.

All data are collected using electronic sensors. Sensors exist (or have existed) at five locations: Upstream, DownStream, and MidReef sensor platforms, on top of the laboratory building and a small tower on the Pier. This report summarises the following data:

<b>Pier</b>	Relative humidity Air temperature Rainfall Wind speed and direction Solar radiation SST
<b>Laboratory</b>	Solar radiation (1974 – 1981) Rainfall (1974 - 2007)
<b>MidReef</b>	Wind speed and direction
<b>Upstream</b>	Air temperature SST
<b>Downstream</b>	Solar Radiation (1982 – 2007) SST



Pier Tower



Mid-Reef site



UpStream Site



DownStream Site

## Rainfall

Rainfall was originally collected by a Stevens Type 'A' water level recorder with intake located on top of the laboratory building. Rainfall were recorded to paper charts and digitized at 1-hour intervals. In 1991 a digital encoder was added which recorded 1mm rainfall increments. In 2002, an electronic tipping bucket was installed on the pier. This device records rainfall in 0.254mm increments. Data were also manually recorded weekly using a plastic rain gauge.



Stevens Type 'A' water level recorder with intake located on top of the laboratory building



Tipping Bucket (left) and manual Rain gauge (right)

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

Page 7-8 show 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 1974 to 2018.

Page 8 shows yearly rainfall totals for all years since 1974. 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. 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 only as an estimate since tipping buckets will tend to underestimate the size of storms - larger storms will be more underestimated than smaller ones. Keeping this in mind, the tables and graphs



compare maximum and average storm size, and average storm duration per month for the period 2004 to 2018 versus 2019.

### Relative Humidity

Relative humidity data have been collected with a number of electronic Temperature/Humidity sensors: Viasala HMP 35, Viasala HMP45, and most recently Campbell Sci. CS215. Sensors have been located on the small tower on the Pier. Data are recorded at 15- minute intervals by dataloggers controlling the sensors. The average monthly relative humidity data are shown in tabular and graphical forms on page 11.



### Air Temperature

Shaded air temperature data is currently recorded using a Campbell Sci. CS215 electronic temperature/humidity sensor located on the small tower on the Pier. Data are recorded at 15-minute intervals by dataloggers controlling the sensors. Data have also been collected at the Up Stream station using a Hydrolab RT-125 Marine Thermometer connected to a datalogger and recorded at 1-hour intervals. Daily Max/min temperatures were also collected using Taylor Instruments Max/Min thermometers.

The monthly average temperatures from the electronic sensors are shown in tabular and graphical form on pages 12-14.

### Solar Radiation

From 1974 until 1981, Global solar radiation was measured on the roof of the laboratory building using a Moll-Gorczynski-type pyranometer. The sensor was destroyed by lightning in 1981 and in 1984 a Li-Cor LI200SZ pyranometer sensor was deployed at the reef flat Down Stream location. Sensors were connected to dataloggers and the data were recorded hourly.

From 2004 to 2016, Global solar radiation was measured on the Pier tower using Li-Cor LI200SB pyranometers attached to a datalogger recording total ( $\text{MJm}^{-2}$ ), maximum and minimum ( $\text{J m}^{-2} \text{ s}^{-1}$ ) radiation at 15-minute intervals. On Sept. 13, 2016 the Li-Cor pyranometers were replaced with Kipp&Zonen SPLite2 pyranometers.



Page 15 shows the Daily Global Radiation values. Pages 16 and 17 show total monthly Global Radiation.

### Wind Speed and Direction

Wind speed and direction were originally recorded at the MidReef site using an MRI Mechanical Weather Station model 1072 connected to a datalogger and recording at 1-hour

intervals. Anemometers were located on two cement pylons, located 10m from each other, and 3m above the surface of the reef flat.

From 1983 to 1992 and Omnidata sensors were used. These were replaced in 1992 with RM Young anemometers. Beginning in April of 2002, 15-minute interval average, maximum and minimum wind speed plus average wind direction have also been recorded by a Model 05103 Young Anemometer located on top of the Pier tower.

Page 18 shows average and maximum daily wind speeds from the Young Anemometer located at the top of the Pier tower. Page 19 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 20 shows the monthly average wind speed and monthly average directions for the year.



Upstream Anemometer



Pier Tower Anemometer

### Water Temperature

Water temperature was collected at the UpStream, DownStream and Tower Base sites. Reef site temperatures were initially measured using Hydrolab RT-125 thermometers connected to dataloggers. In 2007 these sensors were replaced with self-contained Hobo U22 Water Temperature Pro v2 probes. Temperatures were recorded hourly; changed to every 15 minutes in 2019. SST at the base of the Tower has always been measured using Campbell Sci. Model 107 temperature sensors at 15-minute intervals. Monthly average SST data are shown on pages 21-22.

### Times Series

Graphs showing the 2019 daily (Pages 25-6) and monthly averages for the entire period of record (Pages 27-9) for Relative Humidity, Air Temperature, Rainfall, Wind Speed, Solar Radiation and Water Temperature.

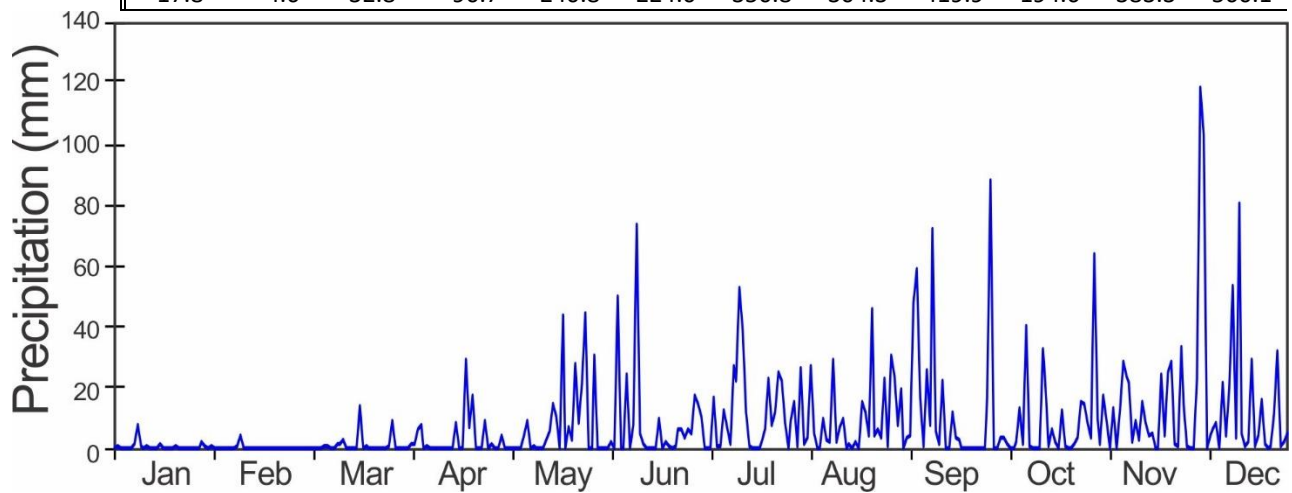
More details about how data were collected between 1974 and 1988 can be found in: Cubit *et al*, 1989. *Meteorology and hydrography of a shoaling reef flat on the Caribbean coast of Panama*. Coral Reefs 8:59-66.

### Daily Patterns

Pages 30 and 31 show the daily patterns for Relative Humidity, Air Temperature, Rainfall, Wind Speed and Solar Radiation.

## 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	4.1	0.0	14.7	0.8	8.1	0.3	64.3	0.0
2	0.8	0.0	0.0	0.0	0.0	0.0	10.4	26.7	19.3	0.0	9.7	0.0
3	0.0	0.0	0.0	1.8	0.0	0.0	0.3	1.3	0.0	3.3	1.3	23.4
4	0.0	0.0	0.0	1.3	0.0	2.3	0.0	3.6	3.8	3.6	17.8	118.6
5	0.0	0.0	0.0	6.1	0.0	0.3	0.0	27.4	4.6	1.8	8.9	103.4
6	0.0	0.0	0.0	7.9	0.3	50.3	16.5	5.1	47.8	0.0	0.0	0.3
7	1.3	0.0	0.5	0.0	0.0	0.0	1.0	0.0	59.4	0.0	13.5	4.1
8	7.6	0.5	0.8	0.8	4.6	0.0	0.5	0.0	16.8	2.5	0.0	6.6
9	0.5	4.1	0.3	0.0	8.9	24.6	12.4	10.2	0.5	13.5	13.0	8.6
10	0.3	0.0	0.3	0.0	0.0	0.3	7.4	3.0	26.2	1.8	28.7	0.0
11	1.0	0.0	1.5	0.0	0.5	7.9	1.8	2.3	8.1	40.4	23.6	21.3
12	0.3	0.0	1.3	0.0	0.3	73.4	26.9	29.5	72.1	0.8	21.8	4.1
13	0.0	0.0	2.8	0.0	0.0	4.8	22.6	2.3	5.6	0.0	2.0	20.1
14	0.3	0.0	0.0	0.0	0.0	1.5	53.1	7.4	1.5	0.3	9.1	53.3
15	1.3	0.0	0.0	0.0	2.8	0.0	39.1	10.2	22.4	0.0	2.8	3.6
16	0.0	0.0	0.0	0.0	5.8	0.0	11.7	0.3	0.0	32.8	15.2	80.8
17	0.3	0.0	0.0	8.1	14.7	0.0	0.5	1.8	0.3	22.6	8.4	4.8
18	0.0	0.0	14.2	0.0	10.7	0.0	0.0	0.0	11.7	1.0	4.1	0.8
19	0.0	0.0	0.0	0.0	0.0	9.9	0.0	2.5	3.3	6.4	4.8	2.5
20	0.5	0.0	0.5	29.0	43.9	0.3	0.0	0.0	3.0	2.3	0.3	29.5
21	0.0	0.0	0.0	6.9	0.3	2.5	2.0	15.2	0.0	0.0	0.0	0.8
22	0.0	0.0	0.0	17.8	7.4	0.5	6.4	12.2	0.3	12.7	24.6	4.1
23	0.0	0.0	0.0	0.3	3.0	0.0	22.9	4.1	0.3	0.5	4.6	16.0
24	0.0	0.0	0.3	0.0	27.9	0.8	7.6	46.2	0.0	0.0	25.1	1.3
25	0.0	0.0	0.0	0.0	8.6	6.1	11.7	4.1	0.0	0.0	29.0	0.3
26	0.0	0.0	0.0	9.4	21.6	6.1	25.1	6.6	0.0	1.8	1.3	0.8
27	0.0	0.0	1.0	0.3	44.7	3.3	22.6	3.3	0.0	3.8	0.5	11.4
28	2.3	0.0	9.4	1.3	0.0	6.4	8.6	23.4	0.0	15.8	33.3	32.0
29	0.8		0.0	0.0	0.0	5.1	0.3	1.0	16.5	14.7	15.0	0.8
30	0.0		0.0	0.0	30.7	17.8	9.4	30.5	88.4	8.4	0.8	2.0
31	0.8		0.0		0.0		15.2	23.6		3.8		5.1
	17.8	4.6	32.8	90.7	240.8	224.0	350.8	304.3	419.9	194.6	383.3	560.1



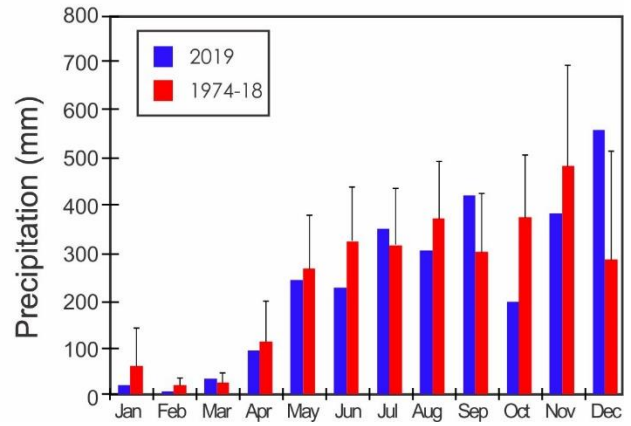
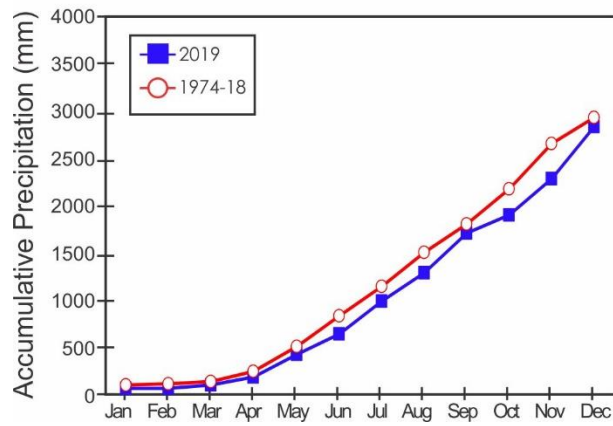
## Monthly Rainfall (mm)

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
1974	18.3	16.6	17.9	41.5	171.0	378.0	462.2	287.4	152.5	453.1	708.4	149.4	2856.3
1975	20.8	20.6	21.2	13.5	137.9	392.7	311.0	376.0	451.0	336.5	298.0	340.8	2720.0
1976	16.2	25.3	13.8	85.6	191.4	347.0	184.1	302.5	346.4	421.0	297.5	37.3	2268.1
1977	12.5	7.8	2.8	84.9	316.0	214.8	260.2	651.8	157.4	585.3	585.6	173.5	3052.6
1978	45.8	20.8	64.1	191.8	253.2	451.5	329.0	389.4	211.0	463.8	276.6	33.8	2730.8
1979	7.2	39.1	2.2	300.8	431.9	416.9	284.3	323.4	269.9	296.1	414.8	241.5	3028.1
1980	152.3	47.0	5.0	16.0	345.0	264.0	251.0	335.0	195.0	362.0	467.0	314.0	2753.3
1981	56.0	2.0	60.0	343.0	518.0	231.0	290.0	497.0	132.0	475.0	867.0	412.0	3883.0
1982	280.0	40.0	4.0	148.0	148.0	203.0	351.0	131.0	299.0	313.0	135.0	9.0	2061.0
1983	26.0	12.0	6.0	150.0	148.0	365.0	151.0	421.0	427.0	363.0	256.0	365.0	2690.0
1984	49.0	27.0	12.0	29.0	204.0	519.0	261.0	284.0	149.0	298.0	388.0	78.0	2298.0
1985	41.1	10.4	7.2	16.6	457.6	447.7	184.3	350.7	153.4	487.6	318.5	456.2	2931.3
1986	8.9	21.0	19.3	91.6	168.2	340.6	189.4	231.9	179.6	256.3	216.4	61.4	1784.6
1987	8.1	6.6	5.6	248.6	473.7	329.2	377.7	576.4	401.7	605.7	577.5	412.7	4023.5
1988	2.7	43.1	4.4	10.4	262.7	354.3	503.3	255.1	255.3	347.9	541.4	174.2	2754.8
1989	4.8	18.5	3.7	10.1	155.5	172.4	413.6	420.7	179.7	790.2	454.9	65.6	2689.7
1990	14.5	2.4	25.3	32.6	235.5	256.3	338.0	429.5	386.3	535.3	286.4	191.4	2733.5
1991	10.0	11.5	14.3	102.0	271.0	185.0	207.0	263.0	410.0	237.0	598.0	59.0	2367.8
1992	1.0	11.0	0.0	185.0	319.0	223.0	300.0	418.0	357.0	287.0	207.0	211.0	2519.0
1993	90.0	16.0	35.0	258.0	131.0	486.0	243.0	368.0	343.0	293.0	375.0	326.0	2964.0
1994	40.0	3.0	16.0	14.0	307.0	415.0	224.0	382.0	235.0	186.0	359.0	106.0	2287.0
1995	105.0	7.0	5.0	117.0	307.0	351.0	302.0	201.0	305.0	189.0	673.0	342.0	2904.0
1996	287.0	71.0	33.0	87.0	99.0	476.0	303.0	469.0	363.0	336.0	613.0	233.0	3370.0
1997	34.0	7.0	0.0	97.0	229.0	175.0	145.0	330.0	411.0	244.0	350.0	17.0	2039.0
1998	8.0	2.0	6.0	283.0	180.0	312.0	380.0	493.0	296.0	322.0	236.0	453.0	2971.0
1999	127.0	21.0	70.0	58.0	249.0	412.0	527.0	661.0	125.0	398.0	326.0	650.0	3624.0
2000	30.0	12.0	0.0	72.0	351.0	515.0	157.0	355.0	129.0	523.0	224.0	662.0	3030.0
2001	98.0	4.0	30.0	12.0	236.0	102.0	208.0	211.0	264.0	283.0	441.0	518.0	2407.0
2002	157.0	8.0	33.0	45.0	113.0	248.0	384.0	305.0	246.0	349.0	328.0	32.0	2248.0
2003	16.0	6.0	3.0	153.0	512.0	379.0	272.0	345.0	249.0	200.0	615.0	294.0	3044.0
2004	34.0	1.0	11.0	147.0	307.0	370.0	323.0	648.0	434.0	357.0	419.0	119.0	3170.0
2005	64.7	32.8	33.1	305.1	190.0	203.0	127.0	511.0	365.0	208.0	581.0	128.0	2748.7
2006	86.0	12.0	45.0	155.0	469.0	106.0	433.0	218.0	424.0	347.0	790.0	365.0	3450.0
2007	11.4	13.7	41.9	138.0	113.9	324.9	336.3	283.5	309.1	574.6	780.6	365.3	3292.9
2008	5.3	33.7	1.8	145.5	283.6	266.8	352.1	332.0	158.3	258.7	780.8	179.2	2797.6
2009	16.9	46.1	29.1	166.8	211.2	334.5	359.9	411.9	245.0	271.3	546.6	98.2	2737.7
2010	22.1	13.2	35.0	66.8	135.7	371.3	294.4	337.1	60.6	605.1	727.1	1193.3	3861.6
2011	390.5	19.8	29.9	111.9	222.4	296.7	385.9	253.8	371.9	330.8	964.1	441.8	3819.2
2012	19.8	3.5	71.1	114.7	236.0	282.2	370.0	250.0	445.8	397.8	899.4	427.4	3517.7
2013	7.9	32.2	56.1	14.7	311.4	317.2	362.5	550.6	206.1	333.2	214.5	213.7	2620.0
2014	32.5	14.2	48.2	103.1	396.6	610.3	100.8	395.7	277.7	488.8	439.1	358.2	3265.0
2015	37.1	10.7	6.1	47.5	160.0	93.7	220.0	479.3	650.5	493.5	408.7	98.8	2705.9
2016	31.0	18.0	10.2	57.9	280.4	397.3	543.0	319.0	466.1	464.6	864.6	279.4	3731.5
2017	23.4	10.4	35.6	23.9	285.7	280.2	556.9	380.0	355.1	314.7	355.6	740.0	3361.3
2018	96.8	10.9	43.4	51.3	438.9	435.6	619.5	357.1	530.6	300.2	592.1	43.7	3520.2
2019	17.8	4.6	32.8	90.7	240.8	224.0	350.8	304.3	419.9	194.6	383.3	560.1	2823.5
Mean	57.9	17.7	22.8	109.5	265.3	323.4	315.8	371.6	300.0	373.4	482.2	283.3	2923.0
sd	81.0	14.8	20.4	88.0	113.0	116.0	118.4	120.7	125.0	131.8	213.8	232.1	526.3
Min	1.0	1.0	0.0	10.1	99.0	93.7	100.8	131.0	60.6	186.0	135.0	9.0	1784.6
Max	390.5	71.0	71.1	343.0	518.0	610.3	619.5	661.0	650.5	790.2	964.1	1193.3	4023.5
Rank*	30	39	16	24	24	36	18	33	9	44	28	5	24

\*Rank of current year: 1 = wettest

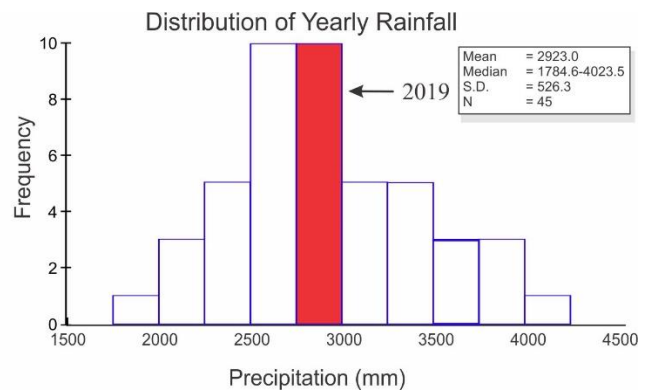
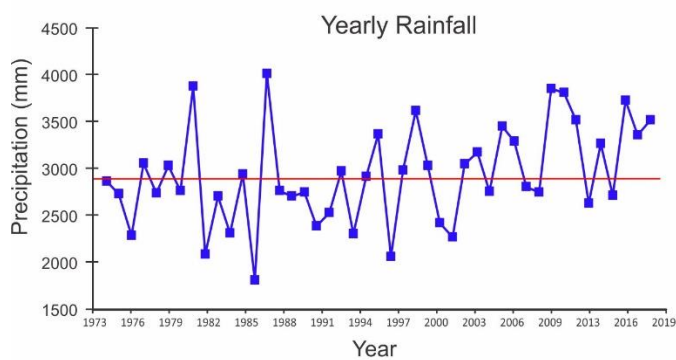
Note: Data in Purple estimated from ACP station Limon





## Yearly Rainfall (mm)

Year	Rain	Year	Rain	Year	Rain
1974	2856.3	1991	2367.8	2008	2797.6
1975	2720.0	1992	2519.0	2009	2737.7
1976	2268.1	1993	2964.0	2010	3861.6
1977	3052.6	1994	2287.0	2011	3819.2
1978	2730.8	1995	2904.0	2012	3517.7
1979	3028.1	1996	3370.0	2013	2620.0
1980	2753.3	1997	2039.0	2014	3265.0
1981	3883.0	1998	2971.0	2015	2705.9
1982	2061.0	1999	3624.0	2016	3731.5
1983	2690.0	2000	3030.0	2017	3361.3
1984	2298.0	2001	2407.0	2018	3520.2
1985	2931.3	2002	2248.0	<b>2019</b>	<b>2823.5</b>
1986	1784.6	2003	3044.0		
1987	4023.5	2004	3170.0		
1988	2754.8	2005	2748.7		
1989	2689.7	2006	3450.0		
1990	2733.5	2007	3292.9		

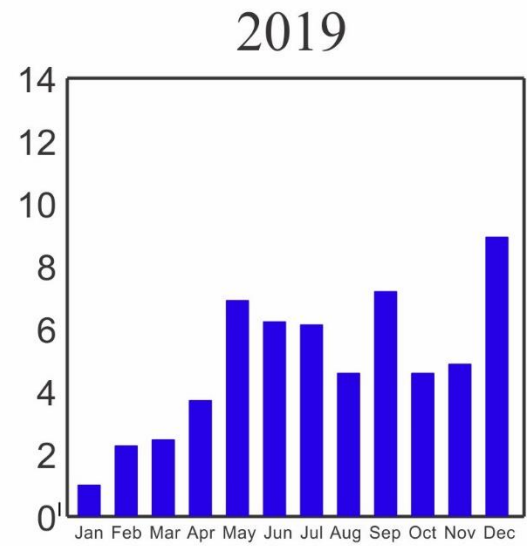
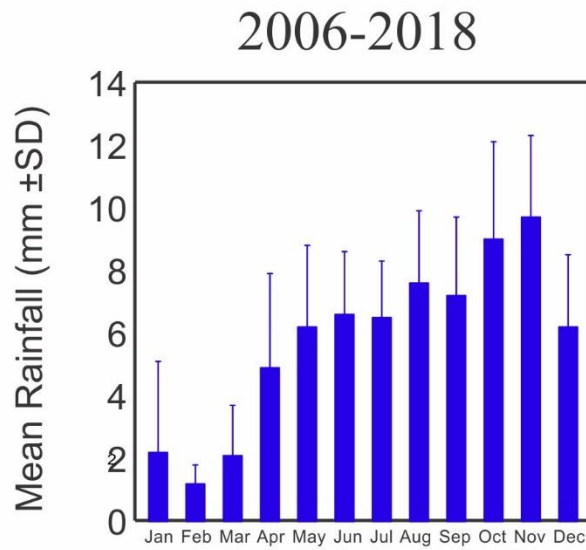


## Storm Analysis

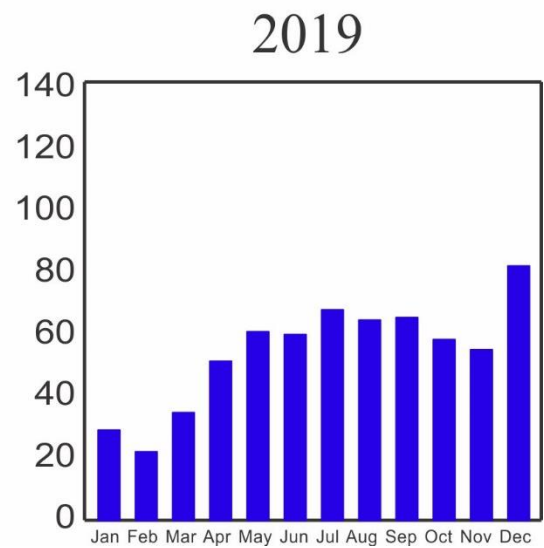
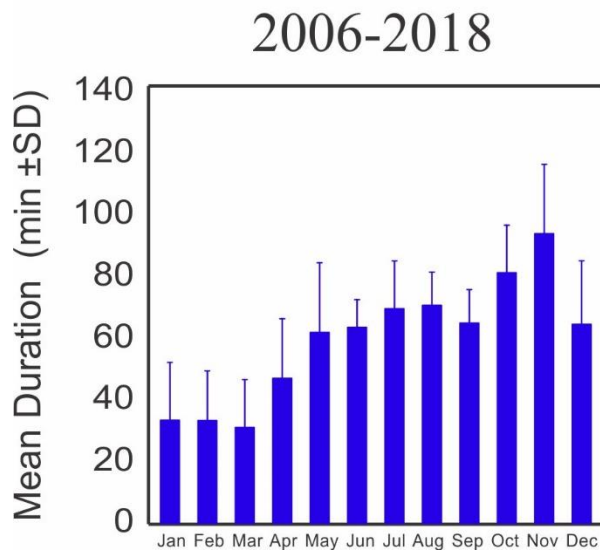
	Max. Rainfall per Storm (mm)			Storm Duration (min.)		
	<b>2006-2018</b>		<b>2019</b>	<b>2006-2018</b>		<b>2019</b>
	Mean	S.D.		Mean	S.D.	
<b>January</b>	17.4	23.8	<b>5.3</b>	33.2	17.3	<b>28.9</b>
<b>February</b>	4.8	3.5	<b>4.1</b>	32.3	14.8	<b>22.0</b>
<b>March</b>	13.7	10.7	<b>14.2</b>	31.6	14.5	<b>34.5</b>
<b>April</b>	40.2	32.9	<b>26.4</b>	46.9	17.7	<b>50.9</b>
<b>May</b>	58.1	24.7	<b>44.5</b>	62.5	21.0	<b>60.3</b>
<b>June</b>	72.6	38.5	<b>55.1</b>	64.6	9.8	<b>59.4</b>
<b>July</b>	58.4	24.9	<b>38.6</b>	70.8	15.1	<b>67.3</b>
<b>August</b>	81.0	40.0	<b>42.2</b>	68.3	10.5	<b>64.0</b>
<b>September</b>	71.6	37.0	<b>87.9</b>	63.7	10.5	<b>64.8</b>
<b>October</b>	76.5	29.7	<b>40.4</b>	79.0	14.3	<b>57.8</b>
<b>November</b>	106.5	50.2	<b>35.6</b>	89.1	22.4	<b>54.6</b>
<b>December</b>	72.7	65.8	<b>115.1</b>	61.8	22.0	<b>81.3</b>

	Av. Rainfall per Storm (mm)		
	<b>2006-2018</b>		<b>2019</b>
	Mean	S.D.	
<b>January</b>	2.2	2.7	<b>1.0</b>
<b>February</b>	1.1	0.6	<b>2.3</b>
<b>March</b>	2.0	1.5	<b>2.5</b>
<b>April</b>	4.5	3.0	<b>3.8</b>
<b>May</b>	6.5	2.5	<b>7.1</b>
<b>June</b>	6.8	2.0	<b>6.4</b>
<b>July</b>	6.9	2.1	<b>6.3</b>
<b>August</b>	7.6	2.1	<b>4.7</b>
<b>September</b>	7.2	2.3	<b>7.4</b>
<b>October</b>	8.8	2.9	<b>4.7</b>
<b>November</b>	9.3	2.6	<b>5.0</b>
<b>December</b>	6.6	3.5	<b>9.2</b>

## Average Monthly Storm Size



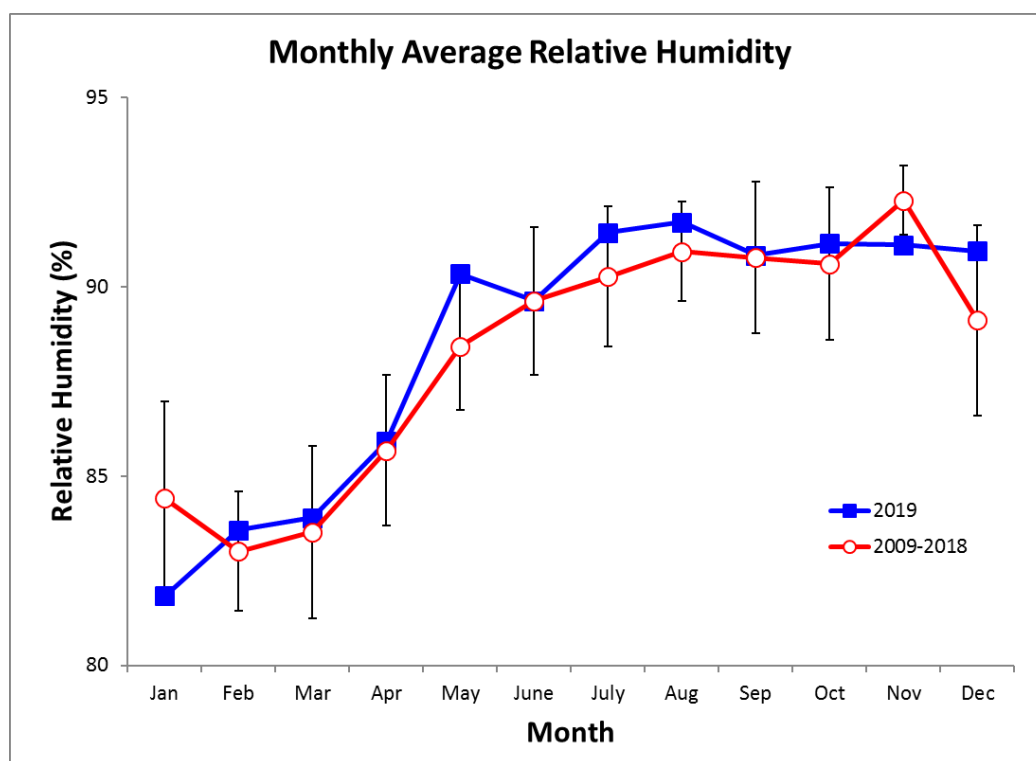
## Average Monthly Storm Duration



## Relative Humidity (%)

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2002				83.8	84.0	85.4	87.2	88.2	89.0	89.4	89.2	81.5
2003	79.4	80.2	79.3	81.7	88.8	87.3	88.4	88.5				
2004											88.6	83.9
2005	85.0	82.5	86.9	87.8	91.1	89.2	88.3	90.9	91.5	87.6	90.8	87.1
2006	87.2	84.6	86.1	87.3	90.9	89.6	91.9	90.9	91.7	90.4	91.8	89.6
2007	84.4	83.3	84.0		90.9	90.6	91.5	90.9	90.4	89.8	92.1	89.0
2008	82.9	82.6	79.1	78.6	81.0	88.0	90.6	89.1	86.5	85.7	91.5	83.9
2009	82.1	80.6	79.8	81.5	86.6	87.8	89.4	90.1	88.7	89.8	91.8	86.4
2010	83.1	84.6	85.4	86.7	87.0	89.3	89.6	91.5	87.9	91.6	91.2	89.6
2011	87.0	81.3	79.4	82.9	86.5	88.2	88.5	89.3	88.7	88.1	91.9	88.9
2012	82.8	82.4	84.5	85.8	88.3	87.2	89.5	89.9	89.5	89.2	92.8	91.4
2013	84.1	83.6	86.9	86.9	89.1	92.6	93.1	93.0	93.1	93.9	93.0	86.3
2014	82.5	82.4	82.3	86.8	89.5	92.6	90.8	92.5	92.8	92.6	93.4	92.1
2015	86.0	85.7	84.5	88.2	90.7	91.6	91.7	92.4	93.7	93.1	93.3	90.8
2016	84.2	81.2	83.1	84.5	87.5	89.4	91.1	90.4	91.3	90.3	93.5	89.3
2017	84.5	84.1	84.6	86.8	90.6	90.3	91.6	90.0	89.8	88.1	91.5	90.4
2018	90.5	83.8	84.4	86.6	86.8	87.5	86.4	89.6	92.4	88.9	91.7	84.0
2019	81.8	83.6	83.9	85.9	90.3	89.6	91.4	91.7	90.8	91.2	91.1	91.0
mean	84.4	83.0	83.5	85.7	88.4	89.6	90.3	90.9	90.8	90.6	92.3	89.1
sd	2.6	1.6	2.3	2.0	1.7	2.0	1.9	1.3	2.0	2.0	0.9	2.5
min	81.8	80.6	79.4	81.5	86.5	87.2	86.4	89.3	87.9	88.1	91.1	84.0
max	90.5	85.7	86.9	88.2	90.7	92.6	93.1	93.0	93.7	93.9	93.5	92.1

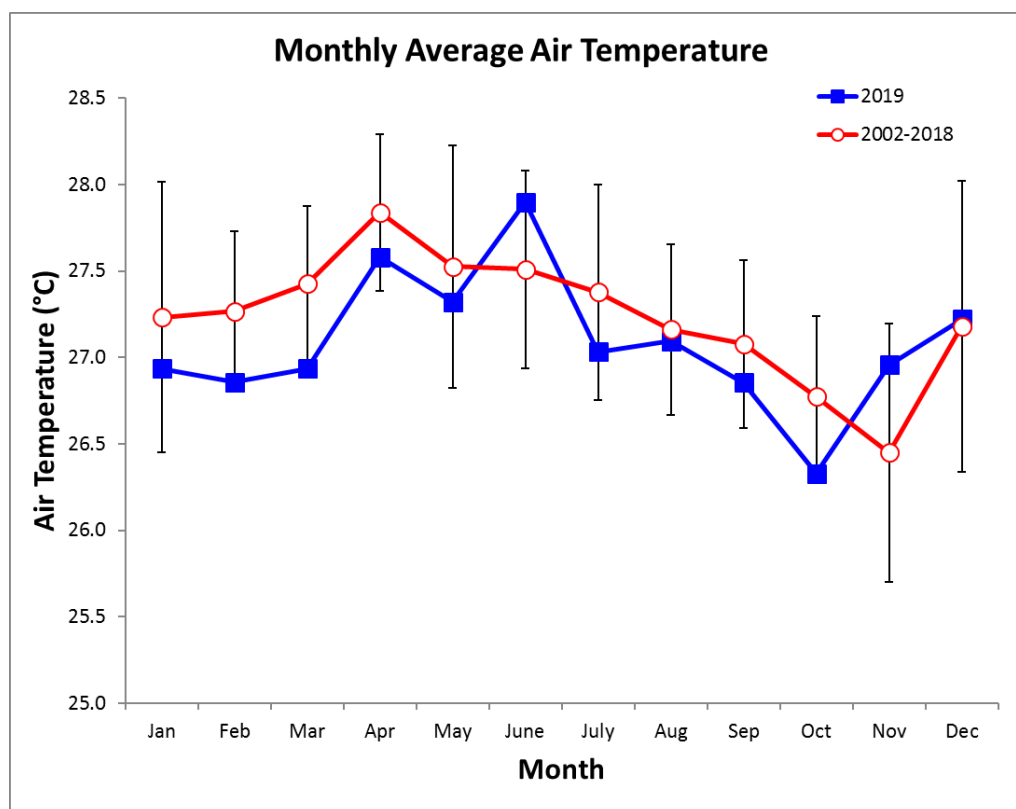
\* A sensor change at the end of 2008 resulted in significantly higher readings. Summary statistics only include data from 2009 onwards.



## Monthly Average of Daily Maximum & Minimum Temperatures (°C)

Monthly Average Temperature

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2002				27.9	28.1	28.0	27.7	27.6	27.4	27.0	26.9	27.9
2003	27.6	27.6	27.8	28.2	27.6	27.5	27.5	27.0				
2004											26.8	27.6
2005	27.2	26.9	27.6	27.9	27.2	27.6	27.9	27.1	26.7	26.8	26.3	27.1
2006	27.2	26.9	27.1	27.1	27.0	27.3	27.1	27.2	26.8	26.6	26.2	27.1
2007	27.3	26.9	27.1		26.4	26.9	26.6	26.2	26.4	26.0	25.7	26.7
2008	27.1	27.3	27.8	27.8	26.2	27.1	26.5	26.5	27.1	26.7	24.4	25.5
2009	25.2		26.7	27.6	27.9	27.4	27.8	27.5	28.0	27.2	27.0	28.1
2010	28.0	28.2	28.3	28.7	28.6	27.7	27.3	27.1	27.2	26.7	26.2	26.1
2011	26.9	27.2	27.3	27.4	27.6	27.4	27.2	27.1	27.0	26.4	26.1	26.7
2012	27.4	27.1	27.3	27.5	27.6	27.8	27.5	26.9	27.2	26.5	26.4	26.6
2013	27.2	27.1	27.2	27.8	27.4	26.9	27.0	26.6	26.8	26.7	26.9	27.8
2014	27.8	27.6	27.8	28.3	28.2	28.2	28.9	27.8	27.5	27.2	27.2	27.5
2015	28.2	27.9	27.8	28.4	28.5	28.7	28.3	28.3	28.1	28.0	27.8	29.0
2016	28.6	27.8	27.8	28.1	28.3	27.7	27.4	27.6	27.0	27.0	26.1	27.2
2017	27.2	27.2	27.5	28.0	27.4	27.4	27.2	26.8	26.8	27.1	26.0	26.4
2018	26.1	26.5	26.9	27.1	26.7	26.2	26.6	27.2	26.4	26.4	26.6	27.5
2019	26.9	26.9	26.9	27.6	27.3	27.9	27.0	27.1	26.9	26.3	27.0	27.2
mean	27.2	27.3	27.4	27.8	27.5	27.5	27.4	27.2	27.1	26.8	26.4	27.2
sd	0.8	0.5	0.5	0.5	0.7	0.6	0.6	0.5	0.5	0.5	0.7	0.8
min	25.2	26.5	26.7	27.1	26.2	26.2	26.5	26.2	26.4	26.0	24.4	25.5
max	28.6	28.2	28.3	28.7	28.6	28.7	28.9	28.3	28.1	28.0	27.8	29.0

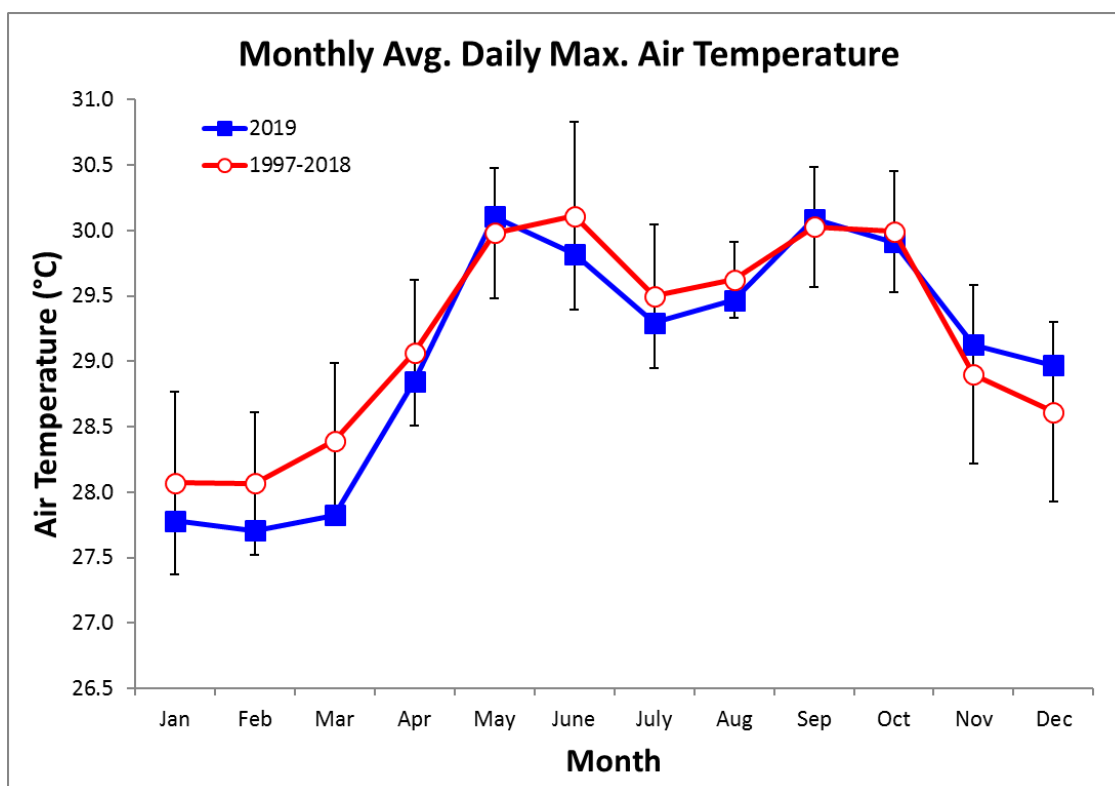




## Monthly Average of Daily Maximum Temperature

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2002				28.8	30.5	30.7	29.9	30.0	30.9	30.1	30.0	29.3
2003	28.5	28.6	29.7	30.3	30.4	30.9	29.9	29.7				
2004											28.7	28.9
2005	28.2	27.7	29.0	29.3	30.0	31.5	30.8	29.9	30.0	31.1	29.0	28.8
2006	28.3	27.8	27.8	28.3	29.5	30.1	29.4	29.5	29.4	29.8	28.9	28.8
2007	28.0	27.8	27.8		30.1	29.6	29.0	29.3	29.7	29.8	28.1	28.5
2008	27.9	28.3	28.9	28.8	29.5	29.6	29.4	29.8	30.7	30.2	27.3	27.3
2009	26.3		28.2	28.5	29.5	30.4	29.6	29.4	30.1	30.2	29.2	29.4
2010	28.9	29.2	29.4	30.0	31.0	30.5	30.2	30.3	30.8	29.4	28.7	27.5
2011	27.9	27.9	27.9	28.5	29.6	30.2	29.7	29.8	30.1	29.7	28.7	28.1
2012	28.0	27.7	27.9	29.2	29.9	30.3	29.1	29.5	29.6	29.4	28.1	28.0
2013	27.6	27.6	28.0	29.2	29.6	29.4	29.1	29.1	29.8	29.5	29.5	28.8
2014	28.5	28.3	28.6	29.1	29.7	29.7	29.9	29.7	30.0	30.0	29.4	28.8
2015	28.6	28.8	28.4	29.2	29.6	30.3	29.5	29.8	30.3	30.8	30.2	30.0
2016	29.3	28.4	28.5	29.5	30.7	30.5	29.3	29.8	29.8	30.3	29.0	28.8
2017	28.1	28.2	28.4	29.4	30.6	30.3	29.1	29.5	30.0	29.9	28.6	28.0
2018	27.2	27.0	28.1	28.4	29.5	28.3	28.4	29.3	29.4	29.7	28.9	28.7
2019	27.8	27.7	27.8	28.8	30.1	29.8	29.3	29.5	30.1	29.9	29.1	29.0
mean	28.1	28.1	28.4	29.1	30.0	30.1	29.5	29.6	30.0	30.0	28.9	28.6
sd	0.7	0.5	0.6	0.6	0.5	0.7	0.5	0.3	0.5	0.5	0.7	0.7
min	26.3	27.0	27.8	28.3	29.5	28.3	28.4	29.1	29.4	29.4	27.3	27.3
max	29.3	29.2	29.7	30.3	31.0	31.5	30.8	30.3	30.9	31.1	30.2	30.0

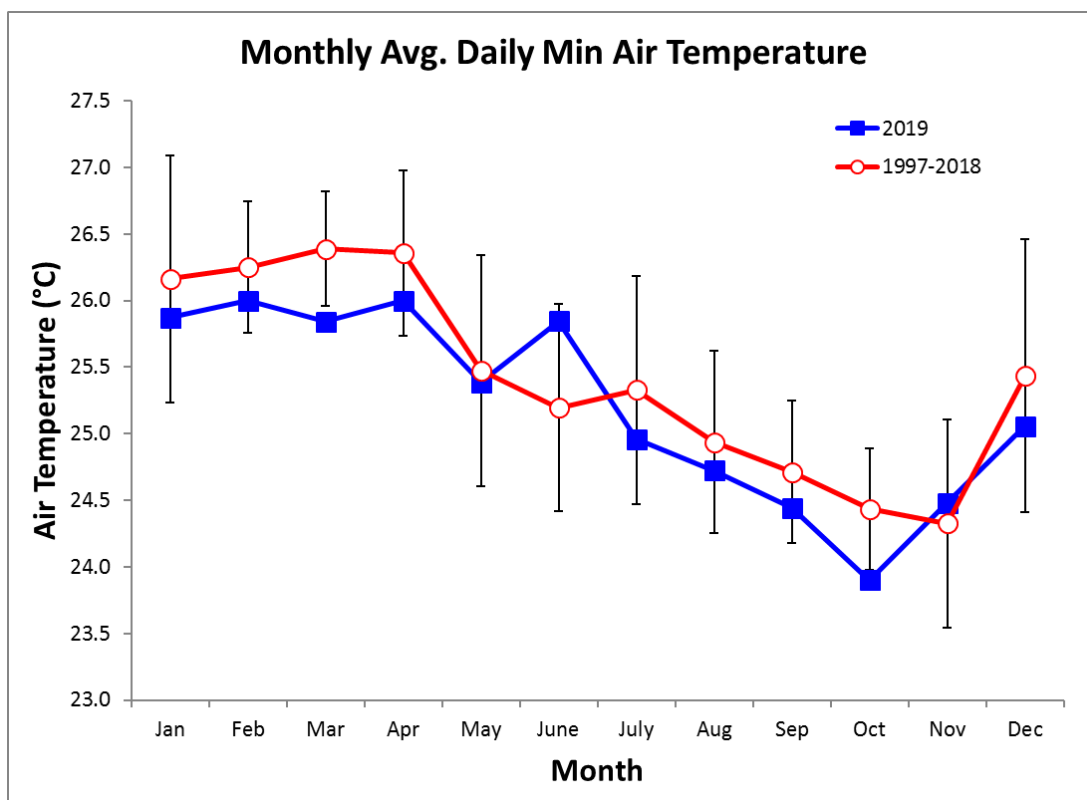
Values in green were calculated by using the monthly average of daily maximum, interval-average temperature values. In Mar. 2018 this was changed to averages of interval-maximum values.



## Monthly Average of Daily Minimum Temperature

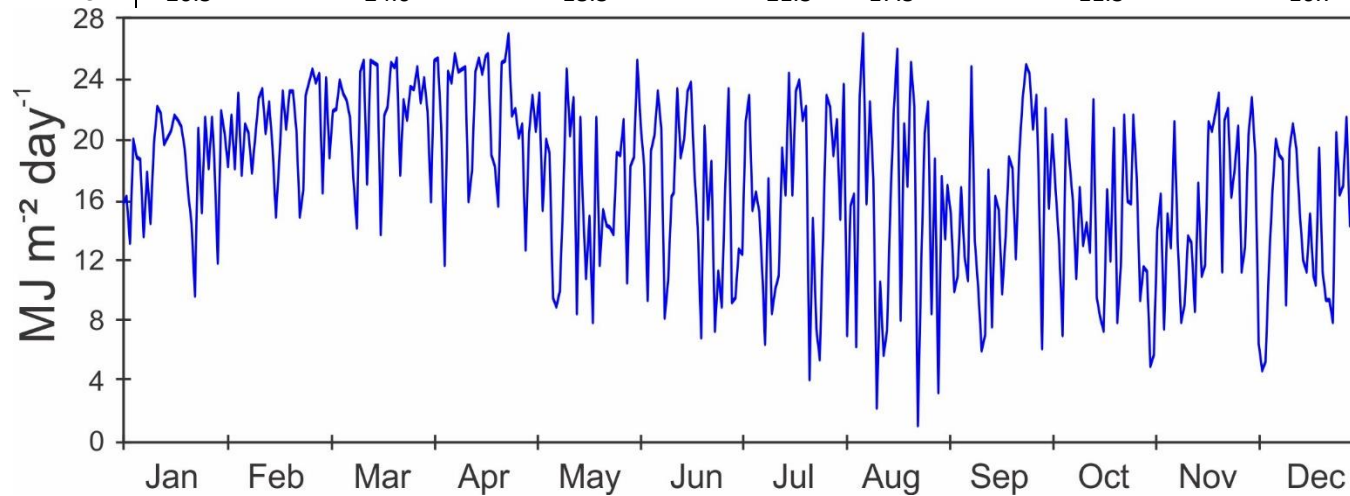
Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2002				26.3	26.2	25.8	25.7	25.6	24.7	24.6	24.4	26.3
2003	26.6	26.5	26.2	26.2	25.5	24.3	25.3	24.3				
2004											24.9	26.1
2005	26.0	25.8	26.1	26.2	25.1	25.1	25.3	24.8	24.4	24.3	24.2	24.9
2006	25.9	25.9	26.3	25.4	25.1	25.2	24.8	25.0	24.5	24.3	23.9	25.3
2007	26.5	26.0	26.2		24.2	24.5	24.6	24.0	23.9	23.7	23.8	24.5
2008	26.1	26.0	26.6	26.5	23.8	24.9	24.3	24.1	24.4	24.0	22.1	23.4
2009	24.0		26.0	26.3	26.2	24.8	25.7	25.4	25.8	24.9	25.2	26.7
2010	26.8	27.1	27.3	27.3	26.5	25.4	25.0	25.0	25.0	24.5	23.9	24.1
2011	25.4	26.2	26.2	25.7	25.4	24.9	24.9	24.7	24.6	24.3	24.1	25.4
2012	26.5	26.4	26.5	25.7	25.5	25.3	25.5	24.7	24.9	24.2	24.5	24.8
2013	26.5	25.9	26.0	26.9	25.5	24.7	24.9	24.3	24.6	24.4	24.6	26.1
2014	26.9	26.9	26.7	27.3	26.3	26.1	27.7	25.7	25.3	25.0	25.1	26.0
2015	27.4	26.9	27.0	27.4	27.2	27.3	27.0	26.7	25.9	25.6	25.8	27.8
2016	27.6	26.8	27.0	26.5	26.0	25.1	25.2	25.5	24.6	24.7	24.0	25.4
2017	25.8	25.4	26.4	26.6	25.0	25.0	25.1	24.5	24.4	24.6	23.9	24.8
2018	24.8	26.0	25.9	25.5	24.4	23.9	24.6	25.0	24.2	24.1	24.4	25.9
2019	25.9	26.0	25.8	26.0	25.4	25.8	25.0	24.7	24.4	23.9	24.5	25.1
mean	26.2	26.3	26.4	26.4	25.5	25.2	25.4	25.0	24.7	24.5	24.3	25.5
sd	1.0	0.5	0.4	0.6	0.9	0.8	0.9	0.7	0.5	0.4	0.8	1.1
min	24.0	25.4	26.0	25.4	23.8	24.3	24.3	24.0	23.9	23.7	22.1	23.4
max	27.6	27.1	27.3	27.4	27.2	27.3	27.7	26.7	25.9	25.6	25.8	27.8

Values in green were calculated by using the monthly average of daily maximum, interval-average temperature values. In Mar. 2018 this was changed to averages of interval-maximum values.



## 2019 Daily Total Radiation (MJ m<sup>-2</sup> day<sup>-1</sup>)

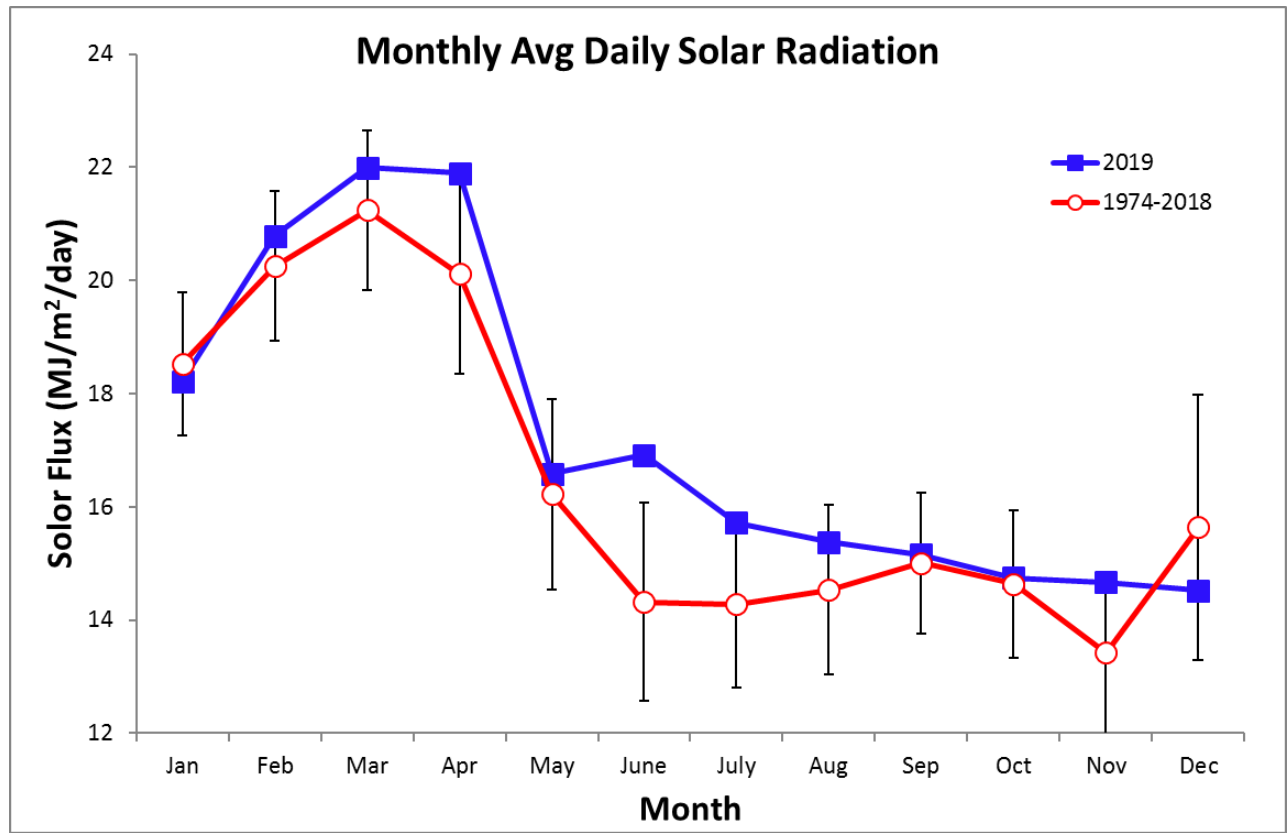
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	15.9	18.3	16.6	21.9	20.4	18.8	9.6	14.8	13.5	22.1	5.2	22.7
2	16.3	21.7	24.1	15.9	22.9	25.3	12.7	23.6	17.0	15.6	5.9	19.0
3	13.2	18.2	18.8	25.3	20.6	20.9	12.5	7.1	15.1	20.4	14.1	6.6
4	20.1	23.1	21.9	25.4	23.1	18.3	21.2	15.7	10.1	16.5	16.4	4.8
5	18.9	17.7	22.0	20.9	15.5	9.5	23.0	16.4	11.1	13.2	7.6	5.4
6	18.7	21.1	24.0	11.8	20.0	19.4	15.5	6.4	16.9	7.1	15.1	11.7
7	13.7	20.4	23.1	24.5	19.1	20.3	16.6	23.0	12.4	21.3	13.0	16.5
8	17.9	17.8	22.6	23.8	9.6	23.2	15.3	27.0	10.8	18.6	21.1	20.0
9	14.5	20.4	21.5	25.7	9.1	20.7	10.7	15.9	24.9	16.0	13.2	19.0
10	19.7	22.8	17.5	24.5	10.1	8.3	6.6	22.5	13.4	11.0	8.1	18.7
11	22.2	23.3	14.3	24.7	16.2	10.8	17.5	17.5	10.2	16.8	9.2	9.2
12	21.8	20.5	24.5	24.9	24.7	16.3	8.6	2.3	6.2	13.0	13.7	19.5
13	19.8	22.4	25.3	16.0	20.3	16.6	10.1	10.6	7.2	14.5	13.3	21.1
14	20.1	19.6	17.2	18.0	22.8	23.4	11.0	5.9	18.0	12.6	8.8	19.4
15	20.6	14.9	25.3	24.5	8.6	18.9	19.4	7.4	7.8	22.6	17.2	15.3
16	21.6	18.8	25.1	25.4	21.4	20.1	16.4	15.9	16.3	9.7	11.0	12.0
17	21.4	23.2	25.0	24.4	16.2	23.2	24.4	22.0	15.3	8.4	11.8	11.4
18	20.9	20.7	13.9	25.5	10.9	23.8	16.3	26.0	10.0	7.5	21.2	15.1
19	19.4	23.2	21.7	25.7	14.9	18.0	23.2	8.2	13.6	16.7	20.6	11.1
20	16.6	23.3	22.3	19.1	8.0	14.2	24.0	21.0	18.9	12.1	21.8	10.5
21	14.5	20.6	25.2	18.3	21.6	7.0	21.3	17.0	18.1	20.8	23.0	19.4
22	9.8	15.0	24.7	15.7	11.7	20.8	22.2	25.1	12.2	8.0	11.4	11.3
23	20.7	16.7	25.5	25.1	15.5	14.8	4.2	22.3	19.2	11.7	21.3	9.5
24	15.2	22.9	17.7	25.3	14.3	18.6	14.8	1.2	22.8	21.6	22.0	9.5
25	21.5	23.7	22.6	26.9	14.3	7.4	7.5	11.8	24.9	15.9	16.3	8.0
26	18.2	24.7	21.4	21.7	13.8	11.4	5.6	20.4	24.4	15.8	18.2	20.4
27	21.5	23.8	23.5	22.0	19.1	9.0	14.0	22.5	20.7	21.6	20.8	16.5
28	18.7	24.3	23.4	20.1	19.0	16.7	22.9	8.6	22.9	17.6	11.3	17.0
29	11.9		24.8	21.1	21.4	23.4	22.2	18.7	17.6	9.5	12.9	21.5
30	21.9		22.5	12.8	10.7	9.3	19.0	3.4	6.2	11.7	20.3	14.4
31	20.5		24.0		18.3		21.3	17.5		11.3		16.7



## Monthly Average Total Daily Solar Radiation (MJ m<sup>-2</sup> day<sup>-1</sup>)

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1974	20.9	22.6	24.7	23.0	19.9	17.0	12.8	16.0	16.4	15.5	13.5	19.1
1975	19.6	22.4	22.5	23.3	18.6	12.8	14.5	13.5	15.4	14.8	14.3	
1976	17.8	19.9	19.7						15.3	15.1	13.9	15.9
1977	18.0	18.1	18.9	17.8	15.2	12.7	14.0	14.5	15.4	15.8	15.4	18.8
1978	21.2	20.2	21.9	18.6	17.3	14.8	15.7	16.7	18.2	14.3	13.7	15.4
1979	17.8	21.2	23.1	16.6	17.3	15.6	15.2	16.0	15.8	14.9	14.0	14.9
1980	18.0	20.2	21.5	18.0	15.8							
1981												
1982												
1983					15.8	12.7	13.1	13.6	15.6	14.8	14.8	17.2
1984	18.6	19.2	21.0	21.7	15.9	12.5	13.0	13.2	16.5	13.2	15.3	14.8
1985	17.8	20.9	21.6	18.0	18.8	14.0	15.3	15.2	14.1	12.7	14.7	16.9
1986	16.7	17.7	21.2	15.7	15.4	12.5	12.3	13.1	13.6	12.5	13.0	15.8
1987	19.6	18.8	21.4	22.1	15.2	14.3	10.6	13.8	14.9	13.0	12.3	16.1
1988	19.8	20.3	22.9	21.3	18.0	13.3	14.0	12.9	15.5	12.8	13.7	16.9
1989	18.1	21.5	20.2	21.3	14.7	13.2	14.6	13.4	13.8	13.7	14.5	16.4
1990	19.6	19.1	22.4	22.1	13.9	14.0	16.3	15.1	14.8	15.3	12.6	15.9
1991	18.4	21.0	20.7	18.8	15.7	15.6	13.2	12.7	14.1	12.5	14.2	15.4
1992	15.8	19.9	19.6	18.6	16.9	12.2	14.8	14.0	12.4	13.6	12.0	14.4
1993	18.6	20.5	19.5	21.5	14.2	12.5	14.8	14.6	15.0	16.5	12.7	16.9
1994	18.1	20.9	22.2	21.5	15.1	15.2	15.1	18.3	15.7	15.9	12.3	14.5
1995	16.6	20.3	22.6	20.2	17.5	13.7	13.3	14.8	15.2	16.1	12.3	14.2
1996	20.2	20.1	23.6	21.9	17.4	16.9	18.3	18.6	15.4	16.7	13.6	18.5
1997	19.1	19.4	22.0	20.6	16.1	14.3	14.1	13.8	16.3	15.2	15.5	12.3
1998	18.8	18.5	21.3	19.9	17.1	13.9	14.0	14.3	14.7	14.4	13.1	11.0
1999	19.6	21.2	22.1	21.3	15.9	14.1	15.7	15.3	16.6	13.5	17.7	13.9
2000	19.4	20.7	20.9	21.6	18.4	17.7	15.1	15.3	15.3	15.8	13.6	12.3
2001	18.5	21.2	21.8	20.9	20.4	15.4	14.8	16.1	15.8	13.4	13.9	19.2
2002	19.0	20.3	22.5	20.8	13.4	13.8	13.1	14.1	16.4	16.2	14.0	12.9
2003	20.5	22.2	21.2	20.1	14.4	14.4	13.2	12.3	16.5	16.8	13.8	18.6
2004	17.9	20.7	21.1	18.9	14.4	16.6	16.4	14.3	13.8	16.2	14.0	18.0
2005	16.8	19.0	19.7	17.3	13.0	15.1	15.0	13.3	13.0	15.4	12.6	16.9
2006	17.8	19.0	19.8	18.0	14.3	14.9	13.9	14.7	12.9	14.2	11.6	15.8
2007	18.5	20.1	20.1	0.0	16.7	12.7	12.8	10.3	11.8	13.8	11.1	13.9
2008	18.5	19.0	22.0	21.2	15.9	12.5	12.3	15.1	16.9	16.1	12.3	18.4
2009	18.7	20.1	22.0	21.2	17.3	15.9	14.0	13.8	15.0	13.9	10.2	17.2
2010	17.6	17.2	17.6	19.1	15.9	14.0	14.5	13.6	14.6	12.4	11.3	8.1
2011	17.4	21.4	22.2	19.7	18.6	14.5	14.3	14.7	15.3	13.6	12.2	13.4
2012	20.0	20.9	19.7	18.8	16.9	16.5	14.2	14.2	14.5	13.9	10.8	14.9
2013	19.8	20.4	18.0	20.7	15.0	12.8	13.8	14.0	14.4	14.7	15.0	17.1
2014	17.8	20.5	20.9	18.7	17.0	9.2	17.4	14.7	14.4	12.8	14.2	14.5
2015	17.8	18.7	21.2	20.6	14.0	17.4	14.1	15.1	14.7	15.6	13.8	15.8
2016	18.3	19.4	20.3	20.6	16.4	15.5	12.0	13.9	13.7	15.8	12.3	15.7
2017	20.2	22.5	22.5	21.4	15.2	15.2	13.3	15.9	15.4	16.1	13.4	15.0
2018	15.4	23.2	21.4	19.7	16.3	12.8	15.5	16.3	15.5	15.7	13.7	19.6
2019	18.2	20.8	22.0	21.9	16.6	16.9	15.7	15.4	15.2	14.7	14.7	14.5
mean	18.5	20.3	21.2	20.1	16.2	14.3	14.3	14.5	15.0	14.6	13.4	15.6
sd	1.3	1.3	1.4	1.8	1.7	1.7	1.5	1.5	1.2	1.3	1.4	2.3
min	15.4	17.2	17.6	15.7	13.0	9.2	10.6	10.3	11.8	12.4	10.2	8.1
max	21.2	23.2	24.7	23.3	20.4	17.7	18.3	18.6	18.2	16.8	17.7	19.6

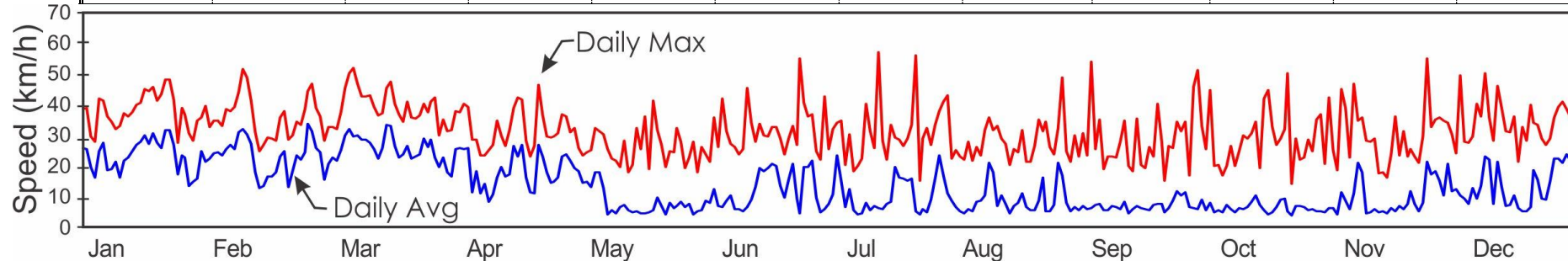
Data in Purple are from sensors on Laboratory Roof, Data in Green are from sensors on Reef Station. Other data are from the Pier Tower





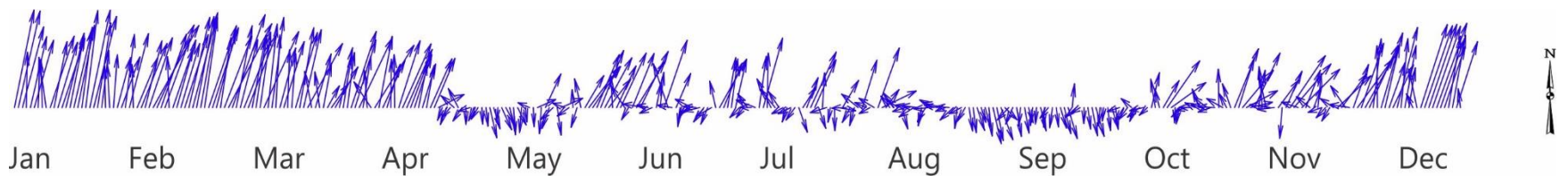
## 2019 Daily Average Wind Speed (km/h) – Pier Tower

	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	26.1	38.7	22.6	33.0	16.0	28.5	17.0	31.9	19.7	32.5	6.0	26.3	6.2	42.9	9.2	22.7	5.8	23.5	9.4	33.1	6.5	42.4	12.1	30.6
2	25.7	39.1	24.4	35.0	21.1	32.8	25.7	38.1	18.5	26.3	9.1	24.0	8.2	25.6	7.1	25.4	7.3	31.0	5.9	25.9	6.6	25.3	12.9	24.5
3	20.0	29.8	24.9	34.9	23.1	32.9	26.0	37.7	14.8	23.7	8.3	21.8	11.2	32.2	5.7	23.3	6.3	23.7	8.3	44.8	4.6	19.0	10.9	49.5
4	16.5	28.3	23.6	33.5	22.0	32.4	25.9	40.3	15.1	24.8	12.9	36.0	23.8	34.3	5.0	22.2	6.7	54.2	5.3	20.3	11.6	45.4	9.9	28.1
5	25.1	42.2	25.9	38.8	25.5	37.7	26.1	39.5	13.6	25.4	7.4	26.4	15.5	35.1	6.4	28.3	7.5	25.7	5.8	20.8	9.2	39.1	8.1	27.8
6	27.9	41.4	27.1	38.2	30.1	45.7	11.8	28.9	18.4	32.7	7.1	42.2	7.0	20.7	5.7	22.1	7.9	35.5	5.3	17.2	6.2	22.9	13.1	29.7
7	19.1	36.4	25.8	39.5	32.2	50.2	18.4	28.8	18.3	31.6	8.9	31.6	12.8	30.6	8.8	26.3	6.0	19.2	7.8	20.4	11.3	46.8	9.8	40.6
8	19.4	34.6	31.1	44.1	29.8	51.9	11.3	23.7	13.0	30.5	10.7	27.5	6.1	18.7	9.1	23.6	5.9	23.4	6.2	26.8	21.4	35.1	13.7	36.4
9	21.8	32.4	32.2	51.6	30.3	47.0	14.4	23.6	4.6	25.8	6.2	26.3	4.6	20.4	10.8	32.0	7.4	23.5	5.2	20.4	18.2	36.0	23.5	50.5
10	16.5	33.1	30.7	48.9	28.9	42.9	8.9	25.5	6.1	22.5	6.3	24.2	4.8	22.9	21.3	36.2	6.9	23.0	6.5	25.1	4.9	28.6	22.4	36.2
11	21.9	37.5	27.3	41.4	29.0	43.0	11.1	27.2	5.0	21.9	5.6	25.7	8.4	40.4	18.1	31.8	6.3	28.1	6.2	30.1	5.3	28.2	8.0	28.5
12	22.9	36.3	18.2	31.2	28.0	43.1	16.7	35.1	7.2	19.9	6.9	45.6	5.9	31.5	7.4	33.2	8.6	35.0	7.1	29.4	6.2	29.3	21.7	46.1
13	25.0	37.8	13.2	25.1	25.9	39.5	19.8	30.2	7.6	28.6	9.5	34.3	7.3	26.0	10.9	29.4	4.8	20.4	8.8	30.9	5.3	18.0	13.6	39.0
14	27.2	40.1	13.8	27.3	22.6	36.8	16.8	26.9	6.1	18.4	13.5	28.2	6.6	57.3	8.0	27.5	6.2	18.8	10.7	34.5	5.7	18.4	7.4	31.6
15	28.1	41.0	16.7	29.5	26.1	37.4	17.6	31.8	5.3	20.5	19.6	34.0	6.2	28.5	4.8	20.6	7.4	35.8	7.5	19.7	5.0	16.4	7.7	31.2
16	30.4	45.3	16.9	29.2	33.5	45.6	26.8	39.2	5.7	32.5	18.5	30.3	7.9	22.2	7.3	25.6	6.7	20.6	5.9	42.0	6.6	23.9	10.7	36.4
17	27.5	44.4	18.2	28.6	33.2	47.5	23.5	42.6	4.9	25.9	19.8	29.7	8.8	33.6	8.3	24.7	6.2	19.6	4.5	44.9	5.6	36.2	6.6	21.6
18	31.0	45.8	23.4	36.1	26.8	40.4	27.0	41.9	4.8	36.2	21.0	32.8	19.8	29.5	11.4	31.9	5.8	26.4	5.1	32.9	7.2	23.7	5.6	32.9
19	27.8	41.5	25.0	38.1	22.9	37.2	16.5	28.4	5.2	19.1	20.3	33.0	16.4	28.7	6.9	21.8	7.6	23.4	6.9	27.1	6.2	31.5	5.7	28.6
20	26.2	43.5	13.6	28.9	24.1	34.6	11.7	23.2	5.9	41.4	13.9	29.3	16.2	27.0	6.1	21.6	8.0	40.4	9.3	29.4	7.9	23.3	6.9	40.3
21	32.1	48.2	18.5	30.1	26.9	41.2	11.5	26.6	10.1	31.8	10.1	24.0	15.6	29.3	6.1	26.7	8.0	28.3	9.9	32.2	12.0	25.9	18.9	34.2
22	32.1	48.2	23.6	34.5	22.7	36.2	27.1	46.7	7.4	27.3	16.0	29.2	16.1	33.7	9.0	35.5	5.2	15.4	5.8	50.2	8.1	23.3	16.0	33.5
23	27.3	41.8	22.5	33.6	23.3	35.5	23.3	36.7	4.7	20.1	21.1	33.1	5.5	56.0	16.5	31.7	6.7	26.8	4.3	14.4	5.7	21.4	9.9	29.2
24	17.4	27.9	24.6	38.8	24.2	36.7	18.1	29.7	8.4	25.2	9.6	27.0	4.7	15.6	5.6	34.6	9.1	26.0	7.4	29.1	8.4	30.0	9.3	27.1
25	23.7	39.1	33.9	44.5	29.1	40.3	15.0	29.5	6.5	24.7	5.0	55.3	6.3	29.1	5.5	26.4	12.1	34.8	7.3	22.3	21.8	55.1	15.3	29.3
26	23.1	37.2	31.5	47.0	26.6	37.8	15.2	30.0	7.5	32.7	20.0	40.9	5.3	32.6	7.8	24.0	10.8	31.7	7.0	23.0	17.4	33.0	22.6	36.2
27	13.8	31.0	26.1	39.0	28.9	41.1	16.6	30.7	8.6	28.2	20.0	36.2	9.4	27.3	21.2	32.6	11.7	34.7	6.0	28.8	18.8	35.3	22.8	39.3
28	15.1	28.4	24.8	36.2	22.9	42.3	23.3	36.9	6.9	19.5	22.1	37.2	16.4	33.8	17.1	49.1	7.0	17.2	6.3	25.1	15.7	36.0	21.2	41.2
29	16.2	35.0			20.1	30.2	24.2	36.2	7.9	23.1	10.2	25.1	23.8	38.1	8.3	25.0	6.7	46.0	5.7	35.2	10.6	35.1	23.9	38.8
30	25.3	36.0			22.9	35.5	22.0	31.2	4.6	28.2	5.4	22.4	17.1	41.1	5.7	21.5	6.3	51.2	5.7	37.2	21.0	34.4	21.9	35.9
31	21.6	39.9			18.2	31.6			5.6	18.3			11.3	43.0	6.9	30.3			5.2	21.1			19.4	39.9



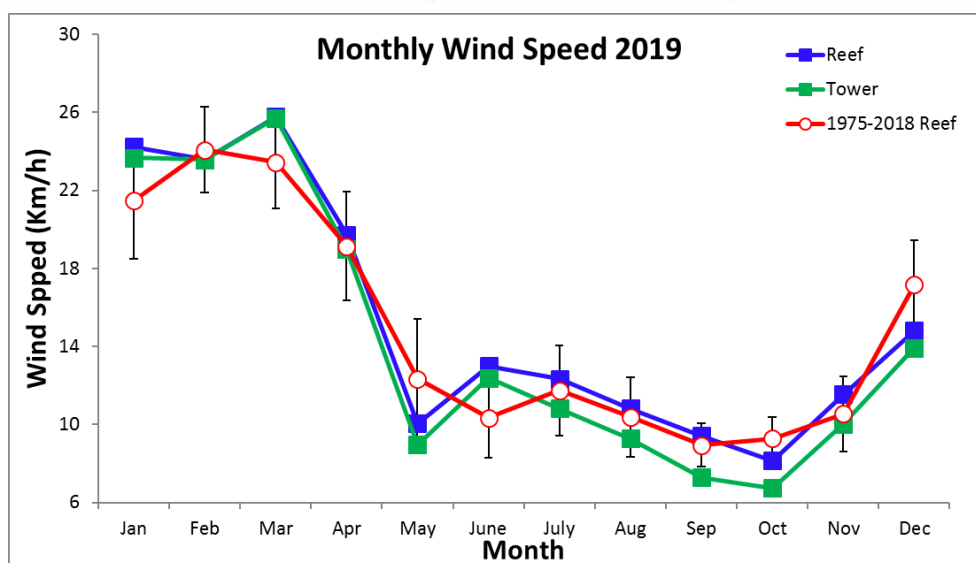
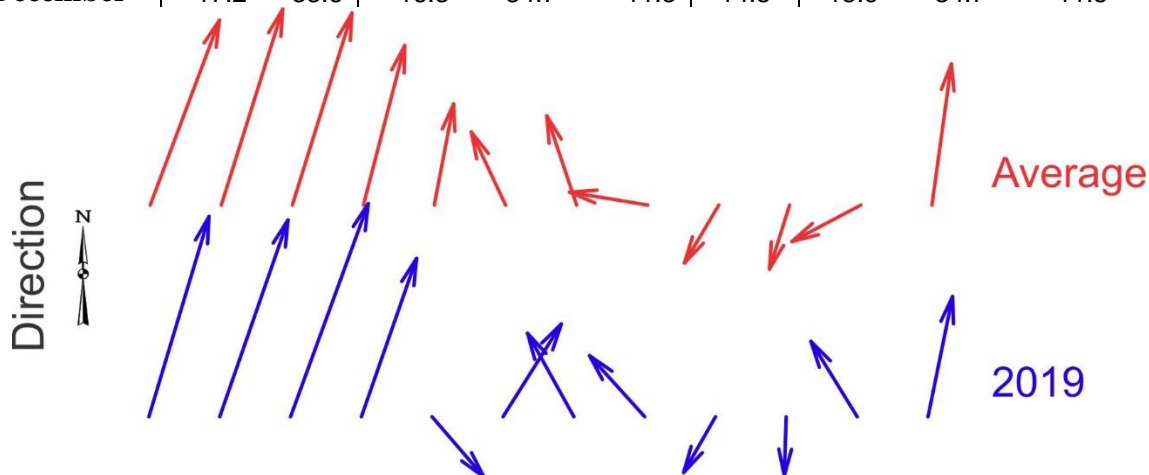
## 2019 Average Daily Wind Direction (°) – Pier Tower

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	23.3	24.5	357.4	6.1	30.3	176.9	252.8	308.8	295.2	166.3	242.5	15.5
2	26.3	26.8	27.8	23.8	26.5	73.9	17.1	314.5	157.6	190.0	261.2	353.0
3	18.2	20.5	23.1	15.0	16.8	186.5	8.4	249.7	258.2	164.8	238.6	340.6
4	15.9	16.7	24.1	19.1	24.8	35.3	27.4	206.1	276.6	155.3	19.4	274.7
5	10.3	19.5	26.0	39.7	15.2	207.5	332.5	252.1	247.1	190.5	346.1	265.5
6	21.9	17.3	19.5	343.7	33.9	237.7	275.5	227.2	274.1	186.5	339.3	48.9
7	355.5	11.2	21.8	24.0	32.7	167.6	33.2	152.0	196.1	159.7	41.9	187.1
8	11.1	10.7	16.0	349.0	71.5	74.3	190.7	44.8	221.2	183.7	46.7	33.8
9	21.4	17.8	15.1	15.5	208.6	282.9	216.7	29.9	266.4	229.8	64.8	45.9
10	7.3	20.8	12.3	40.2	207.2	245.1	241.7	34.9	289.8	191.1	184.0	52.3
11	28.0	13.2	27.5	47.9	231.8	355.0	287.7	34.2	275.9	170.7	195.3	281.6
12	33.7	11.0	26.4	40.5	300.6	204.3	272.6	152.1	280.2	155.5	242.0	56.5
13	25.8	357.4	21.1	18.6	321.7	341.3	260.9	5.4	255.5	158.8	260.4	30.5
14	25.2	355.2	13.0	13.6	225.7	42.3	226.4	258.3	272.5	155.9	270.6	297.0
15	23.3	6.4	30.3	11.4	180.1	49.0	212.0	194.3	237.9	8.1	286.9	29.8
16	20.2	21.8	38.2	26.6	257.7	45.9	249.6	178.2	190.6	239.2	331.0	8.6
17	13.1	29.0	28.2	25.1	212.2	32.9	341.0	97.0	251.6	246.4	279.8	256.6
18	20.8	10.7	16.4	35.9	220.6	31.3	40.2	42.2	221.7	181.0	296.9	234.9
19	19.1	21.6	21.3	13.1	176.5	39.9	32.1	268.0	167.7	169.5	256.5	221.2
20	9.9	357.1	31.2	353.8	170.7	49.8	14.4	219.8	169.0	163.1	271.6	293.8
21	16.9	32.1	30.4	314.7	160.9	354.3	11.2	201.5	154.1	156.4	359.1	58.1
22	18.9	31.6	16.2	43.7	155.6	35.4	19.3	297.7	153.9	186.9	289.8	49.0
23	21.8	20.9	12.7	15.9	188.1	35.7	235.7	25.3	155.4	190.0	320.4	313.6
24	1.5	26.9	12.0	35.5	146.0	316.1	226.3	285.5	170.6	170.2	332.0	275.9
25	19.5	40.3	34.9	25.0	140.6	220.2	312.6	249.4	160.6	155.2	31.8	28.2
26	23.7	34.3	9.5	0.8	157.7	31.5	270.7	291.5	164.1	170.3	25.9	47.9
27	2.9	27.9	11.4	358.9	174.3	43.4	284.2	28.4	150.3	258.1	51.7	27.9
28	357.6	28.8	4.7	25.8	142.8	37.1	11.9	72.5	122.8	222.9	70.6	40.9
29	347.7		21.9	34.2	186.8	276.4	23.1	47.9	233.8	227.7	81.3	35.1
30	27.2		25.1	33.9	170.5	278.4	2.0	309.1	213.2	299.2	35.5	10.2
31	16.8		2.9		284.9		323.2	311.9		213.0		359.9



## Average Monthly Wind Speed (km/h) and Direction (°)

	Long-term Av.					2019			
	Reef Avg.	Reef Max.	Tower Avg.	Tower Max.	Dir.	Reef Avg.	Reef Avg.	Tower Máx.	Dir.
January	21.5	35.1	22.3	38.1	18.5	24.2	23.7	38.1	16.7
February	24.1	34.1	23.4	36.3	19.2	23.6	23.6	36.3	19.1
March	23.4	32.5	23.3	39.2	17.0	25.8	25.7	39.2	20.0
April	19.1	30.9	18.6	32.6	16.3	19.0	19.0	32.6	19.2
May	12.3	27.3	11.2	26.4	11.6	10.0	9.0	26.4	139.5
June	10.3	26.5	9.3	31.3	248.4	13.0	12.4	31.3	32.1
July	11.7	27.4	10.6	31.8	337.3	12.3	10.8	31.8	331.1
August	10.4	26.6	9.1	28.0	282.6	10.8	9.3	28.0	318.0
September	8.9	25.4	7.7	28.8	207.4	9.4	7.3	28.8	209.5
October	9.3	25.4	7.8	28.8	195.4	8.2	6.7	28.8	181.8
November	10.5	28.2	9.3	30.6	240.0	11.5	10.0	30.6	328.6
December	17.2	33.6	16.3	34.7	11.3	14.8	13.9	34.7	11.5



## Average Monthly SST (C)

Reef, Upstream

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1975	26.8	26.7	27.5	27.8	28.6	28.6	28.2	27.7	28.4	28.1	27.8	26.2
1976	26.1	26.3	26.9	27.9	28.3	28.5	28.3	28.0	27.9	28.6	28.2	27.7
1977	26.9	26.9	27.0	27.6	29.2	28.6	27.7	27.9	28.1	28.1	27.6	28.1
1978	27.0	26.9	27.7	28.2	28.5	28.5	27.9	28.4	28.2	28.3	28.0	27.4
1979	26.7	26.8	27.3	27.7	28.8	28.7	28.5	28.3	28.4	28.4	27.9	27.3
1980	27.1	27.8	27.7	28.7	29.9	29.4	28.9	29.3	28.8			
1981												
1982												
1983												
1984				28.9	29.3	29.1	28.5	28.2	27.9	28.2	27.3	26.5
1985	25.8	26.3	27.1	28.5	29.2	29.1	28.9	28.7	29.3	28.9	28.5	28.0
1986	26.8	27.2	27.9	28.4	29.3	28.9	28.1	28.2	28.2	27.9	28.0	27.4
1987	27.1	27.2	28.1	28.0	28.6	29.0	28.4	28.3	28.4	28.2	27.9	27.8
1988	27.4	27.3	27.3	28.8	29.0	29.1	28.4	28.2	28.3	27.9	27.6	27.0
1989	26.4	26.0	27.0	27.6	28.3	28.1	27.8	27.7	28.1	27.9	27.7	27.3
1990	26.5	26.5	26.9	28.1	28.0	28.2	27.9	28.2	28.3	28.1	28.3	27.5
1991	27.3	26.9	28.0	28.7	28.4	29.0	28.7	28.2	28.4	28.4		26.8
1992	26.8	27.3	28.0	28.5	28.3	29.7	28.7	28.0	28.0	28.3	28.2	27.9
1993	27.3	27.2	27.9	29.1	29.4	29.2	28.5	28.4	28.0	28.4	27.6	27.4
1994	26.9	27.0	27.5	28.3	28.6	28.4	28.0	28.0	28.1	28.5	27.8	27.5
1995	27.2	27.3	28.3	28.9	28.9	29.3	28.7	29.1	29.1	28.4	28.0	27.4
1996	27.0	27.0	27.5	28.2	28.6	28.5	28.1	28.0	28.6	28.0	27.6	26.7
1997	26.9	26.9	27.2	28.0	28.1	28.8	28.5	28.5	28.4	28.4	27.7	27.8
1998	27.4	27.6	28.2	28.7	28.8	28.8	28.2	28.3	29.0	29.1	28.5	27.5
1999	27.2	27.0	27.4	28.1	29.1	29.0	28.4	28.5	28.4	27.9	27.2	26.4
2000	26.2	26.5	27.1	27.6			28.0	29.8	29.3	28.7	28.6	27.8
2001	26.9	26.7	27.4	27.7	28.9	28.9	28.1	28.6	28.7	28.9	27.4	27.6
2002	27.8	27.5	28.5	29.0	29.3	30.0	29.1	28.8	30.0	29.5	28.9	28.2
2003	28.2	28.3	28.8	29.8	29.1	29.3	28.9	29.0	29.9	29.8	29.3	28.1
2004	28.0	28.5	28.1	29.2	29.0	29.1	29.0	29.1	29.2	29.6	28.7	27.9
2005	27.5	27.4	29.3	29.6	29.6	30.4	30.4	29.7	29.5	29.3	27.9	27.3
2006	27.4	27.8	28.0	28.5	28.8	29.3	29.2	28.9	29.1			
2007	27.5	27.8	28.4	29.4	29.8	29.6	29.0	29.3	29.5	29.1	28.4	
2008		27.8	28.3	29.2	29.2	29.7				29.2	28.2	27.5
2009	27.2	27.0	27.6	28.8	29.2	29.8	29.0	29.0	29.5	29.2	28.3	28.4
2010	28.0	28.4	28.6	29.7	29.9	30.0	29.8	29.7	29.2	28.8	27.9	26.2
2011	27.1	27.8	28.1	28.9	29.9	29.9	29.5	29.5	29.8	29.1	28.4	27.5
2012	27.3	27.3	27.4	28.8	29.4	29.7	28.8	28.9	29.1	29.0	27.9	27.8
2013	27.8	27.8	28.0	29.0	29.1	29.0	28.9	28.9	29.3	29.4	29.2	28.6
2014	27.9	27.9	28.4	28.8	29.4	29.2	29.1	28.9	29.2	29.1	28.8	28.0
2015	27.7	27.9	28.0	28.9	28.9	29.7	28.8	28.9	29.3	29.9	29.7	28.8
2016	28.5	27.5	28.0	29.3	30.0	30.3	29.0	29.3	29.5	29.3	28.7	28.1
2017	27.7	28.1	28.2	29.2	29.9	29.8	29.1	29.5	29.8	29.6	29.2	27.8
2018	27.3	27.3	27.8	28.8	29.4	29.4	28.6	28.7	29.2	28.8	28.6	28.6
2019	27.6	27.7	27.9	29.0	29.6	30.0	28.9	29.3	29.3	29.5		
mean	27.2	27.3	27.8	28.6	29.0	29.2	28.6	28.7	28.8	28.7	28.2	27.6
sd	0.6	0.6	0.5	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
min	25.8	26.0	26.9	27.6	28.0	28.1	27.7	27.7	27.9	27.9	27.2	26.2
max	28.5	28.5	29.3	29.8	30.0	30.4	30.4	29.8	30.0	29.9	29.7	29.0

## Average Monthly SST (C)

Reef, Downstream

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1984					29.0	28.6	28.3	28.1	28.1	28.1	27.1	26.4
1985	26.5	26.7	27.0	28.2	28.8	28.5	27.9	28.0	28.7	28.3	27.7	27.4
1986	26.8	27.0	27.8	28.4	29.4	29.1	28.2	28.3	28.4	28.0	28.1	27.5
1987	27.2	27.3	27.9	28.1	28.9	29.5	28.5	28.4	28.5	28.3	27.8	27.7
1988	27.3	27.2	27.1	28.7	29.0	29.2	28.5	28.4	28.4	27.8	27.6	26.9
1989	26.4	26.0	27.0	27.6	28.3	28.1	27.9	27.8	28.2	27.8	27.6	27.1
1990	26.5	26.6	27.0	28.1	28.0	28.2	27.9	27.9	28.0	27.8	27.8	27.0
1991	26.9	26.5	27.6	28.2	28.2	29.3	28.9	28.4	28.6	29.0	28.1	27.1
1992	27.0	27.3	27.9	28.8	28.5	29.9	28.7	27.9	28.0	28.2	28.1	27.7
1993	27.2	27.3	27.9	29.1	29.8	29.6	28.7	28.8	28.2	28.7	27.8	27.5
1994	27.2	27.4	27.8	28.6	29.0	28.8	28.3	28.4	28.4	28.8	28.1	27.7
1995	27.4	27.5	28.5	29.3	29.4	29.7	29.2	29.5	29.7	28.9	28.3	27.7
1996	27.3	27.3	27.9	28.7	28.9	28.9	28.5	28.4	28.8	28.7	27.9	27.1
1997	27.3	27.3	27.6	28.5	28.7	29.4	29.1	29.2	29.0	28.9	28.3	28.2
1998	27.7	27.8	28.5	28.8	29.3	29.3	28.9	28.9	29.0	29.2	28.7	27.6
1999	27.3	27.1	27.5	28.2	29.0	28.9	28.5	28.6	28.8	28.4	27.9	
2000	26.2	26.4	26.9	27.9	28.5	28.6	28.2	28.3	28.5	27.9	27.5	26.7
2001	25.9	25.8	26.5	26.7			28.7	29.2	29.2	29.4	28.2	27.5
2002	27.8	27.7	28.0	28.8	29.4	30.1	29.1	28.8	29.5	29.3	28.8	28.1
2003	27.7	27.9	28.4	29.6	29.4	29.7	29.0	29.1	30.2	30.1	29.4	28.1
2004	27.7	28.2	28.3	29.4	29.3	29.7	29.2	29.1	29.5	29.3	28.2	27.9
2005	27.3	27.1	29.8	30.2	30.3	31.0	30.8	29.5	29.2	29.5	28.4	28.0
2006	28.1	27.6	28.0	28.9	28.8	29.1	29.0	28.7	28.7	28.2	27.8	27.3
2007	26.9	27.2	27.8	28.5			27.5	27.2	27.3	26.9	26.6	27.0
2008	26.7	26.9				28.8	28.4	28.3	28.9	28.7	28.1	27.3
2009	27.0	26.9	27.5	28.6	29.3	29.9	29.1	29.1	29.6	29.2	28.3	28.4
2010	28.0	28.4	28.7	29.8	29.8	30.1	29.8	29.9	29.4	29.0	28.1	26.4
2011	27.1	27.8	28.1	29.0	30.0	29.9	29.5	29.5	29.6	28.9	28.2	27.4
2012	27.4	27.4	27.6	29.0	29.7	30.1	28.9	28.9	29.1	29.0	27.9	27.7
2013	27.7	27.8	28.0	29.1	29.2	29.1	29.1	29.0	29.5	29.4	29.2	28.7
2014	28.0	27.9	28.3	28.8	29.4	29.2	29.1	28.9	29.2	29.0	28.8	28.0
2015	27.7	27.9	28.0	29.0	28.9	29.8	28.9	29.0	29.4	29.9	29.6	28.7
2016	28.4	27.8	28.3	29.8	30.2	30.5	29.0	29.4	29.5	29.3	28.7	28.1
2017	27.5	28.0	28.1	29.5	30.3	30.0	29.2	29.6	29.8	29.6	29.1	27.7
2018	27.2	27.1	27.8	28.8	29.8	29.6	28.8	28.9	29.3	28.9	28.7	28.4
2019	27.4	27.5	28.0	29.1	29.8	30.2	29.0	29.3	29.4	29.4		
mean	27.2	27.3	27.8	28.7	29.2	29.4	28.8	28.7	28.9	28.8	28.2	27.6
sd	0.6	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.7	0.6	0.6
min	25.9	25.8	26.5	26.7	28.0	28.1	27.5	27.2	27.3	26.9	26.6	26.4
max	28.4	28.4	29.8	30.2	30.3	31.0	30.8	29.9	30.2	30.1	29.6	29.0

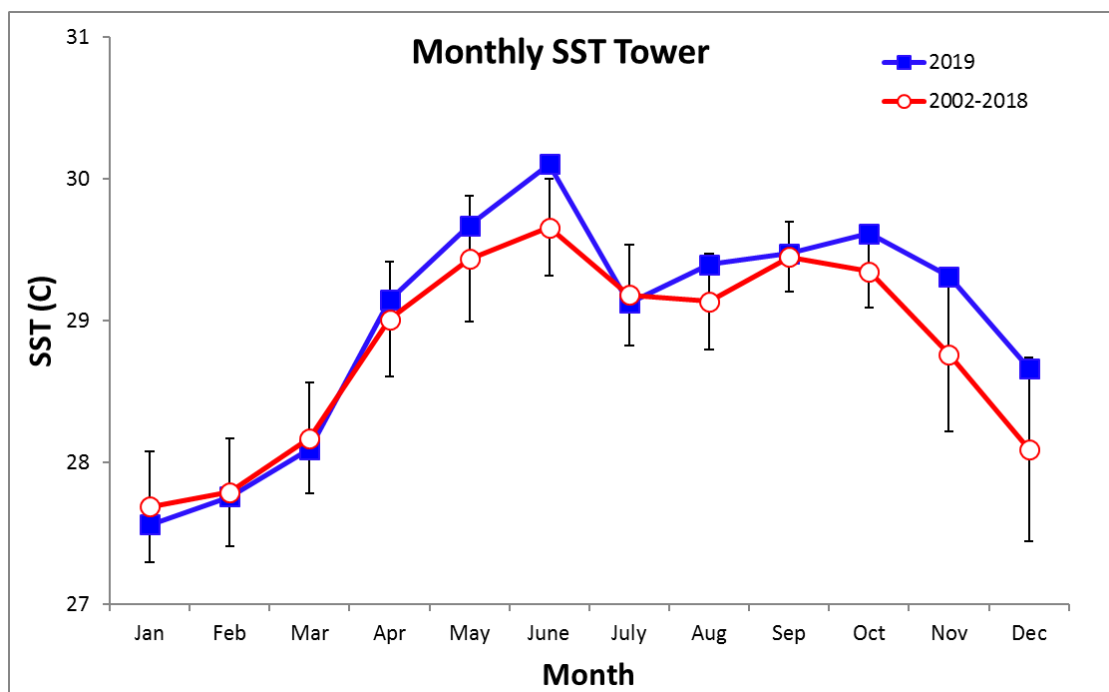


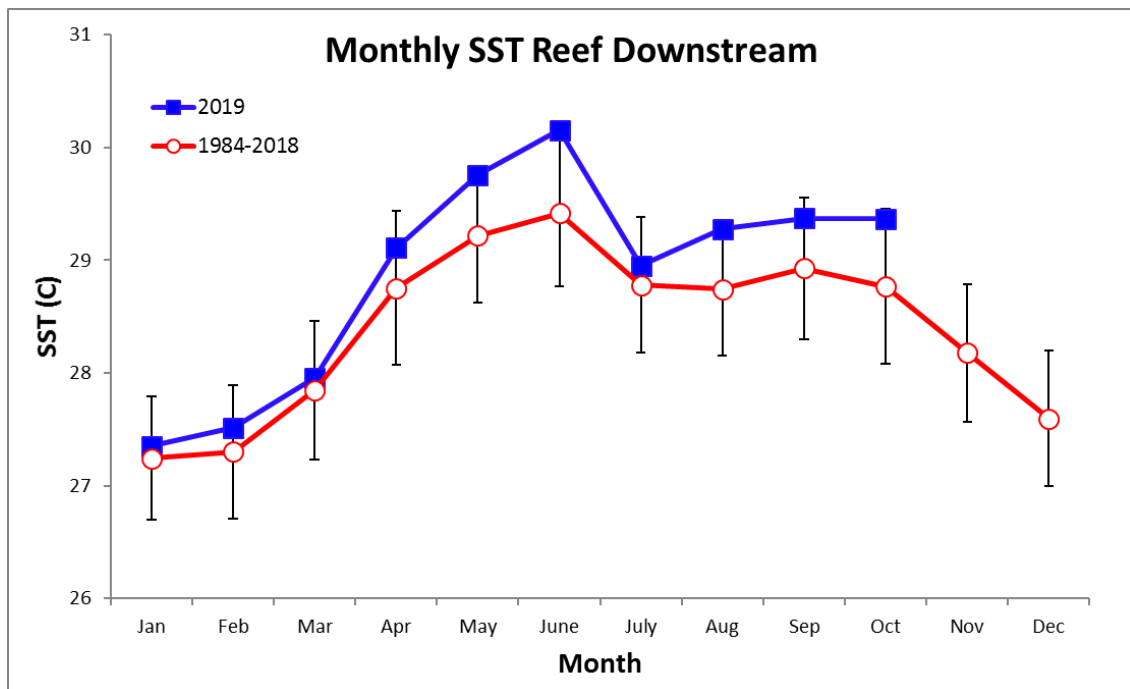
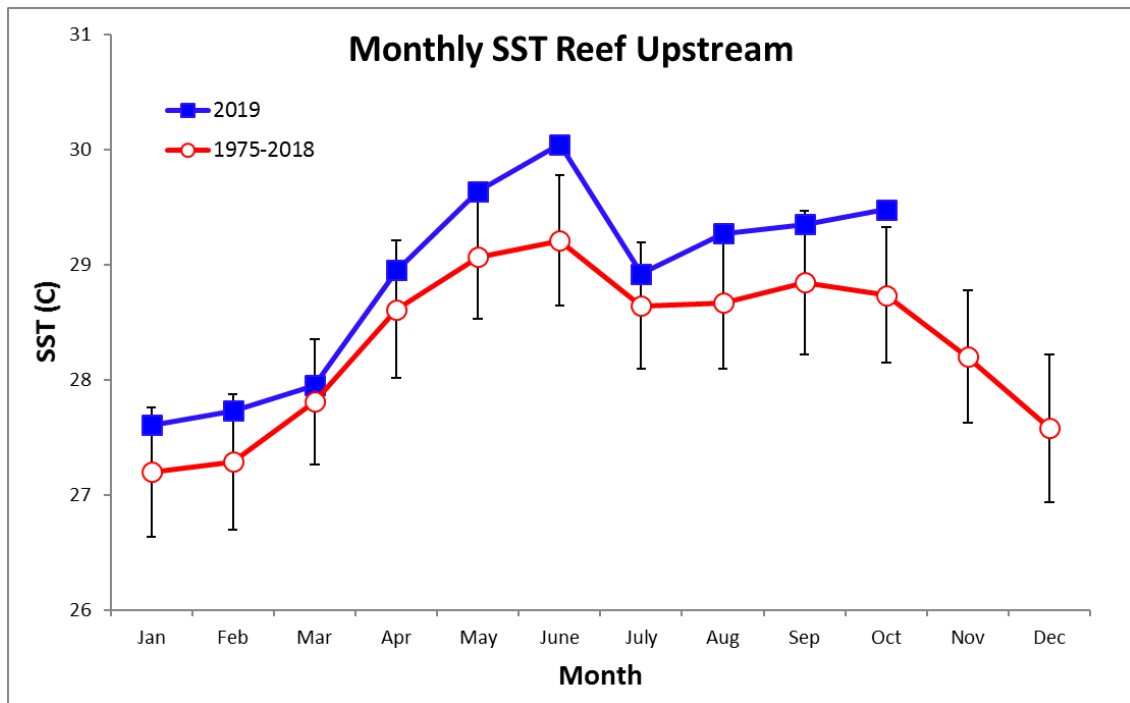
## Average Monthly SST (C)

Tower

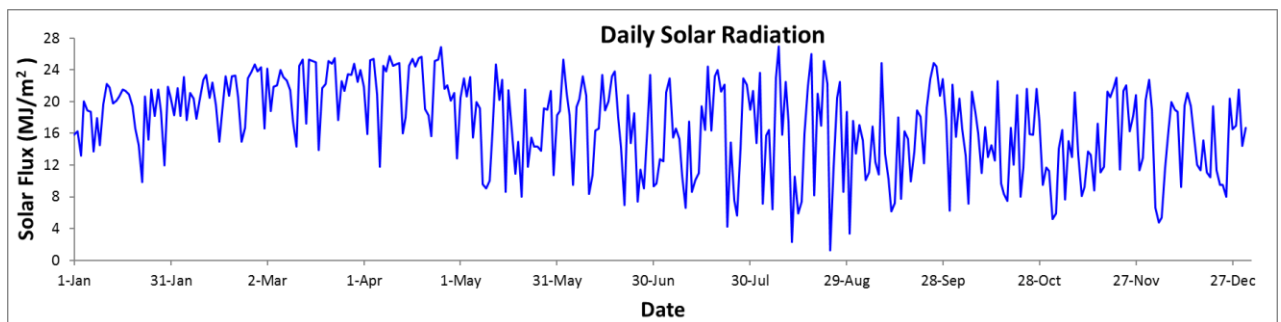
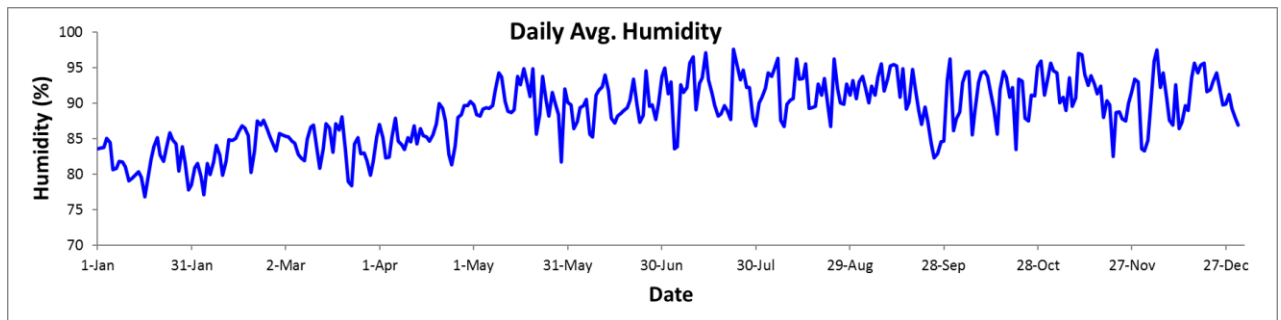
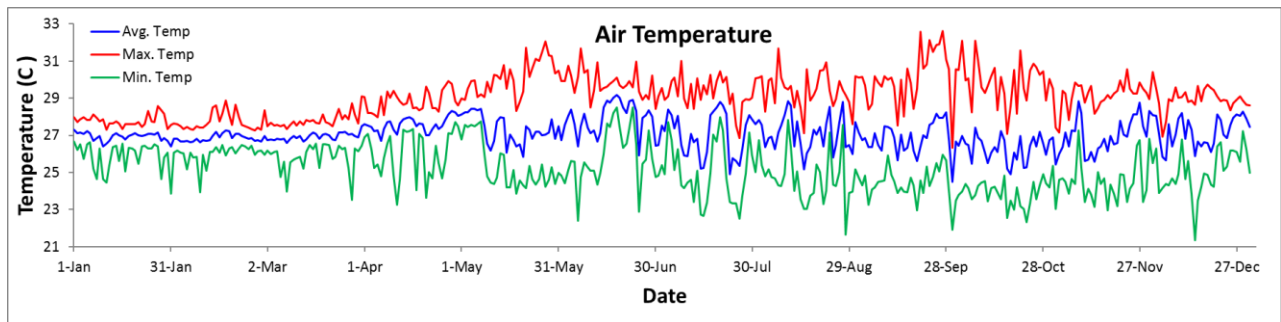
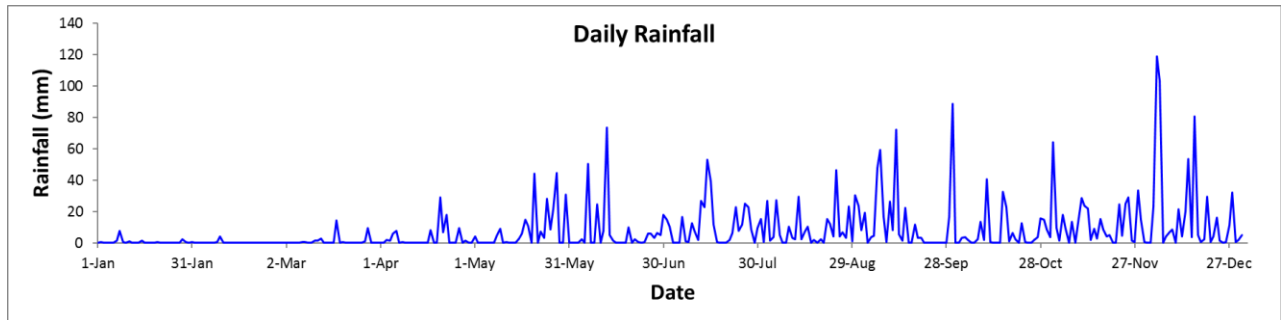
Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2002	27.8	27.7	28.0	28.8	29.4	30.1	29.1	28.8	29.5	29.3	28.8	28.1
2003	27.7	27.9	28.4	29.6	29.4	29.7	29.0	29.1	30.2	30.1	29.4	28.1
2004	27.7	28.2	28.3	29.4	29.3	29.7	29.2	29.1	29.5	29.3	28.2	27.9
2005	27.3	27.1	29.8	30.2	30.3	31.0	30.8	29.5	29.2	29.5	28.4	28.0
2006	28.1	27.6	28.0	28.9	28.8	29.1	29.0	28.7	28.7	28.2	27.8	27.3
2007	26.9	27.2	27.8	28.5			27.5	27.2	27.3	26.9	26.6	27.0
2008	26.7	26.9				28.8	28.4	28.3	28.9	28.7	28.1	27.3
2009	27.0	26.9	27.5	28.6	29.3	29.9	29.1	29.1	29.6	29.2	28.3	28.4
2010	28.0	28.4	28.7	29.8	29.8	30.1	29.8	29.9	29.4	29.0	28.1	26.4
2011	27.1	27.8	28.1	29.0	30.0	29.9	29.5	29.5	29.6	28.9	28.2	27.4
2012	27.4	27.4	27.6	29.0	29.7	30.1	28.9	28.9	29.1	29.0	27.9	27.7
2013	27.7	27.8	28.0	29.1	29.2	29.1	29.1	29.0	29.5	29.4	29.2	28.7
2014	28.1	28.0	28.2	28.8	29.3	29.2	29.1	28.8	29.1	29.0	28.7	27.8
2015	27.3	27.5	27.5	28.4	28.4	29.1	28.3	28.4	29.0	29.5	29.8	29.1
2016	28.5	27.9	28.5	29.6	30.2	30.3	29.1	29.4	29.6	29.5	28.9	28.4
2017	27.9	28.2	28.3	29.4	30.0	29.9	29.3	29.6	29.9	29.8	29.2	27.8
2018	27.3	27.3	27.9	28.9	29.5	29.4	28.8	29.0	29.5	29.1	28.8	28.5
2019	27.6	27.8	28.1	29.1	29.7	30.1	29.1	29.4	29.5	29.6	29.3	28.7
mean	27.7	27.8	28.2	29.0	29.4	29.6	29.2	29.1	29.4	29.3	28.7	28.1
sd	0.4	0.4	0.4	0.4	0.5	0.3	0.4	0.3	0.3	0.3	0.5	0.7
min	27.0	27.1	27.5	28.4	28.4	29.1	28.3	28.4	29.0	28.9	28.0	26.4
max	28.5	28.4	28.9	29.6	30.2	30.3	29.9	29.7	29.9	29.8	29.8	29.1

Note: Data in green are suspect. Unexpectedly low compared to long-term relationships with other stations

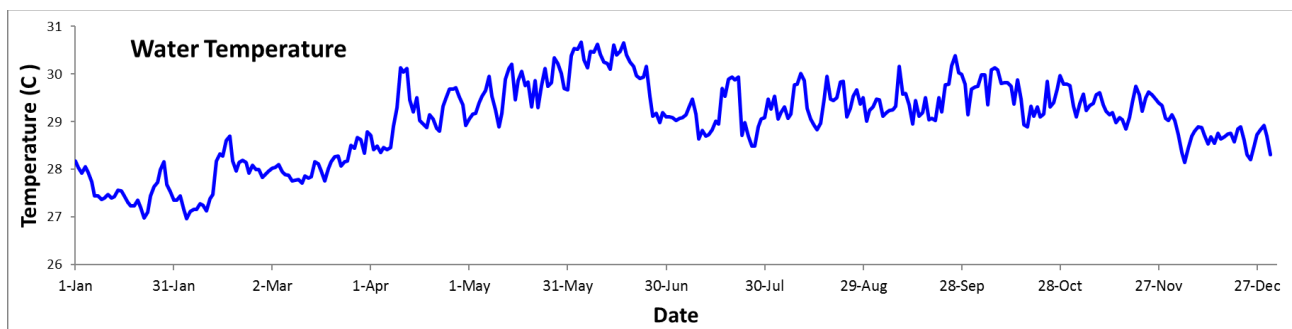
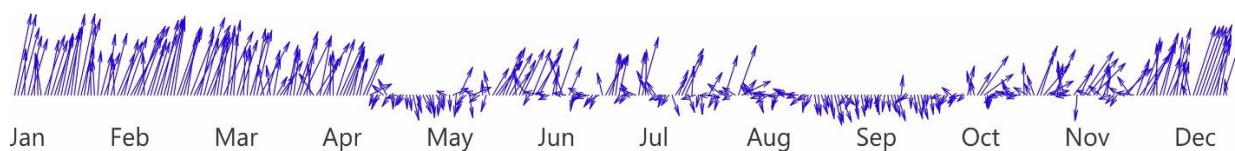
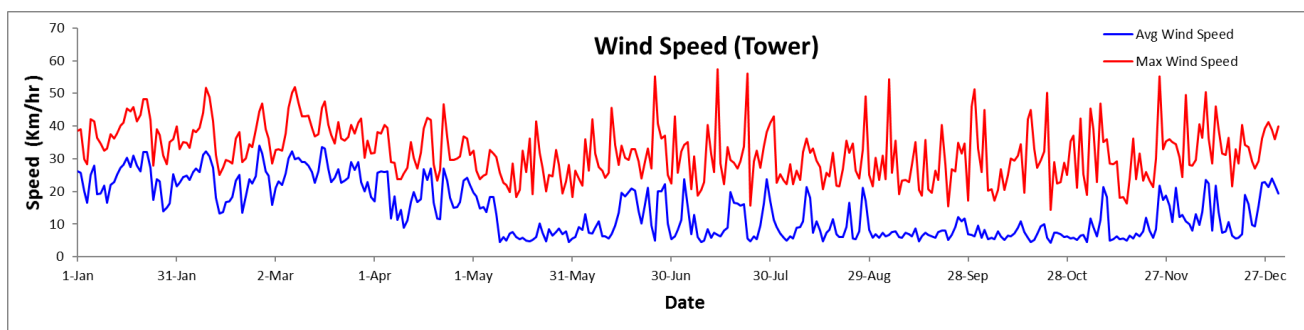
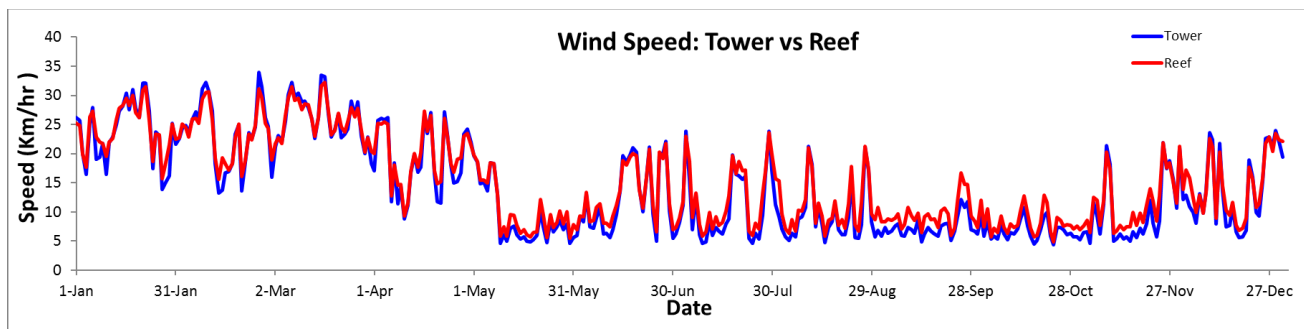




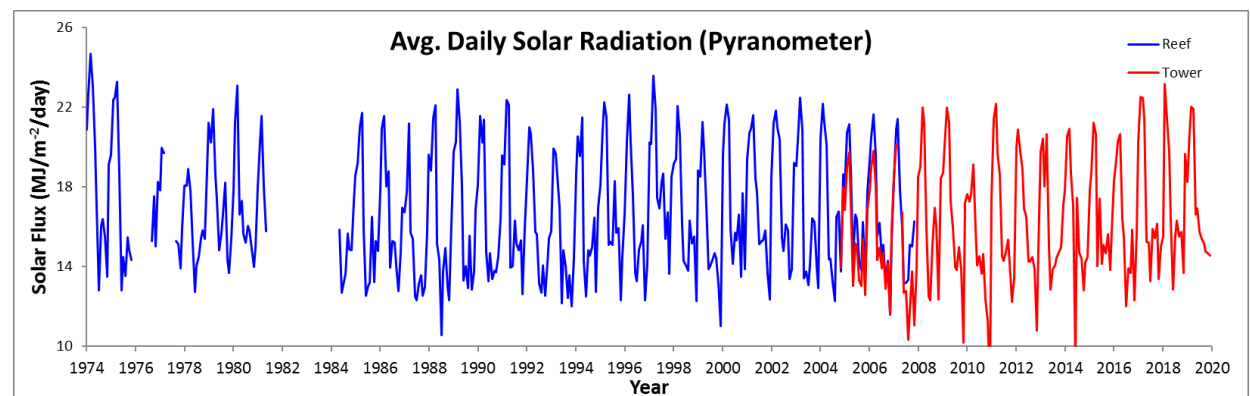
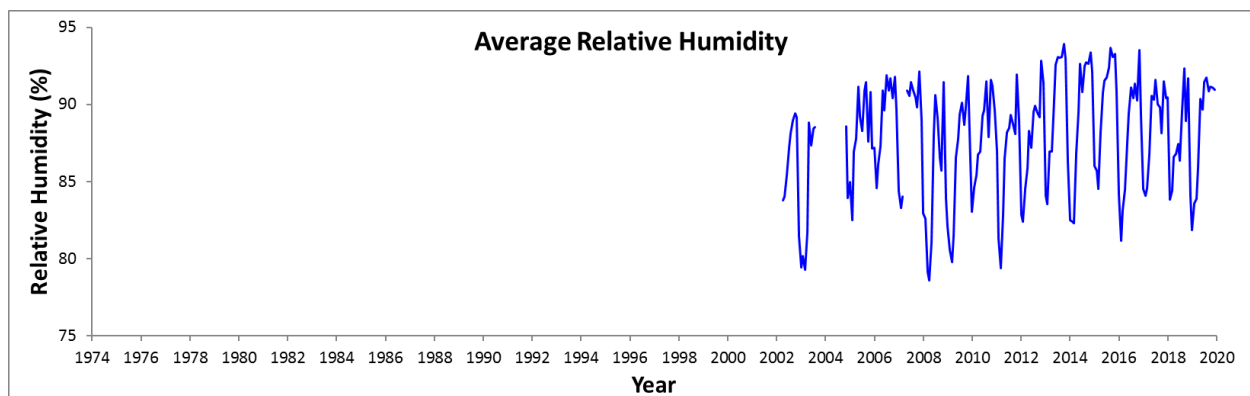
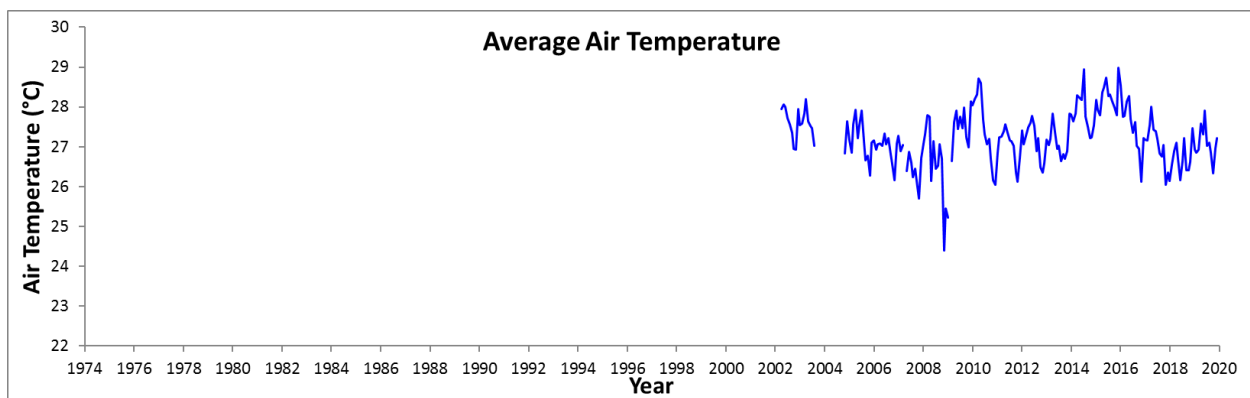
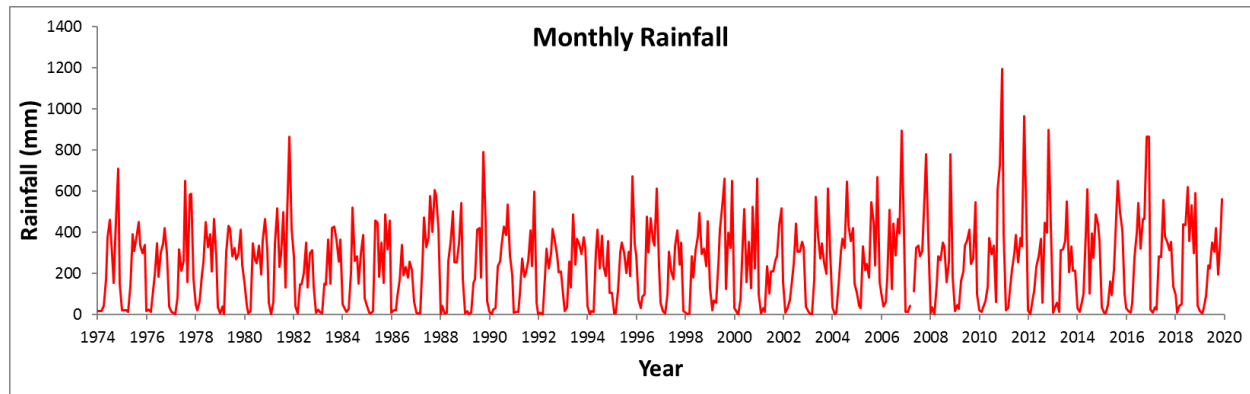
## Time Series – Daily 2019



## Time Series – Daily 2019

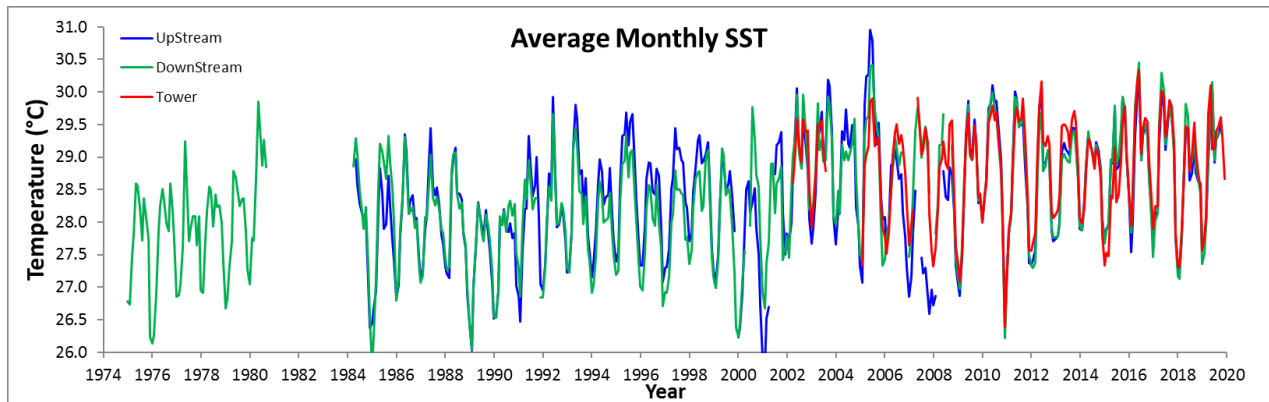
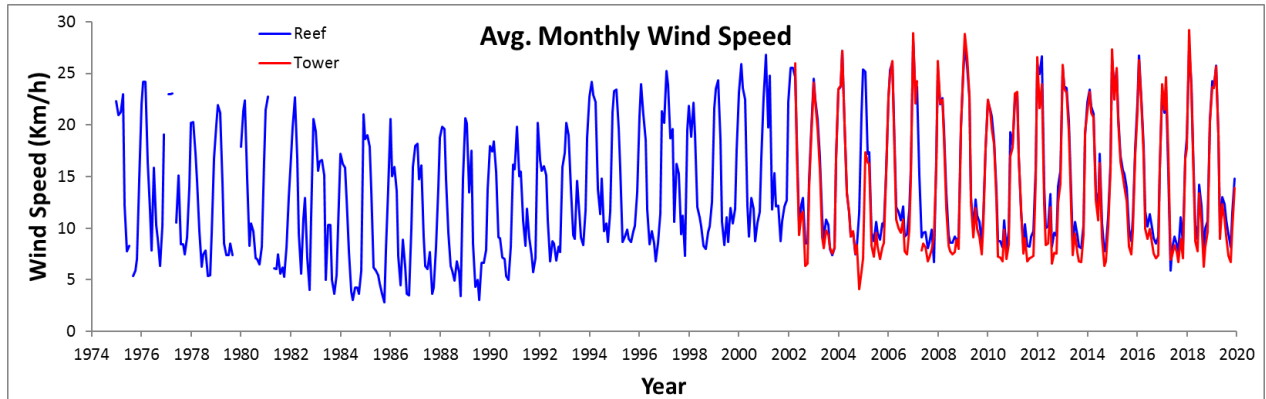


## Time Series - Monthly

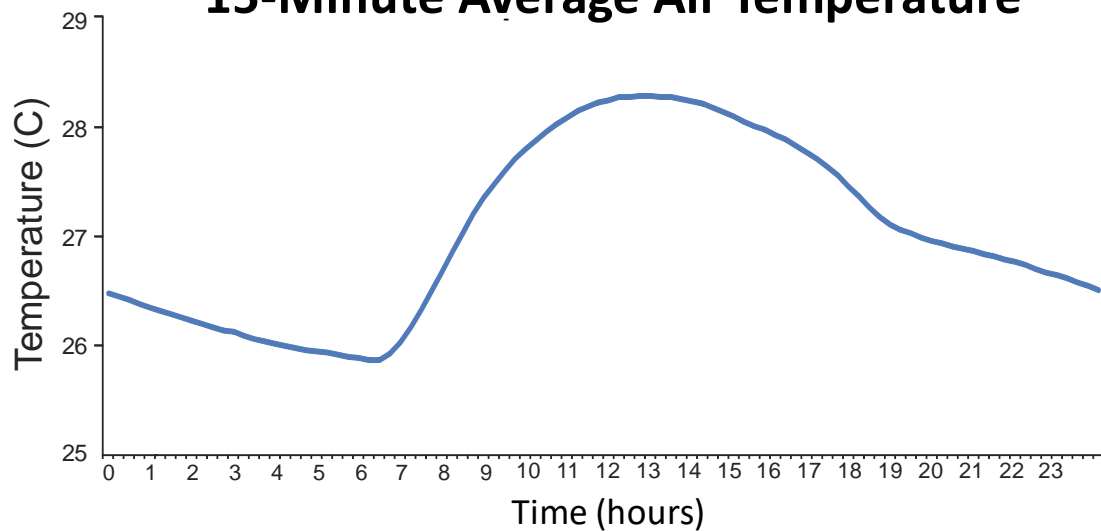




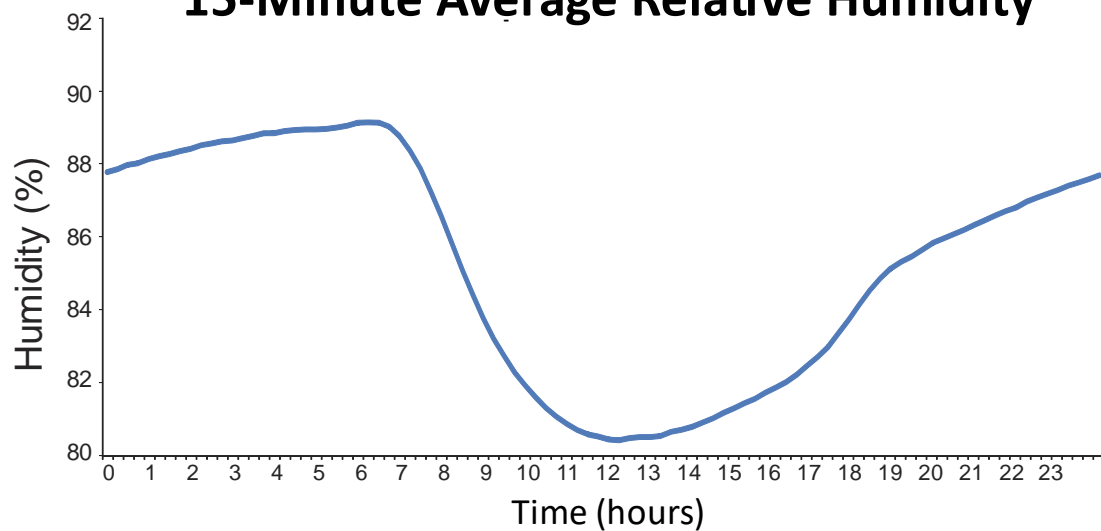
## Time Series - Monthly



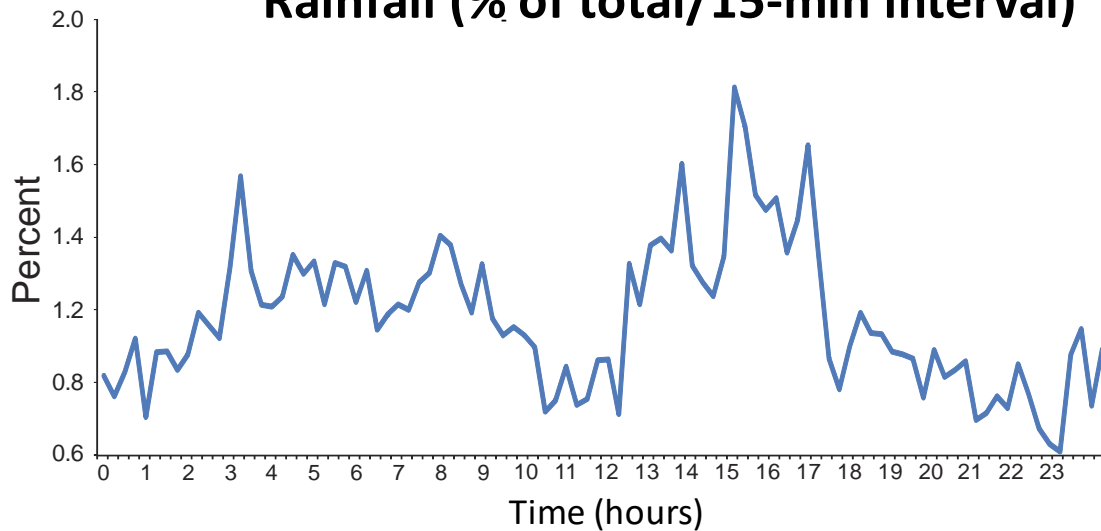
### 15-Minute Average Air Temperature



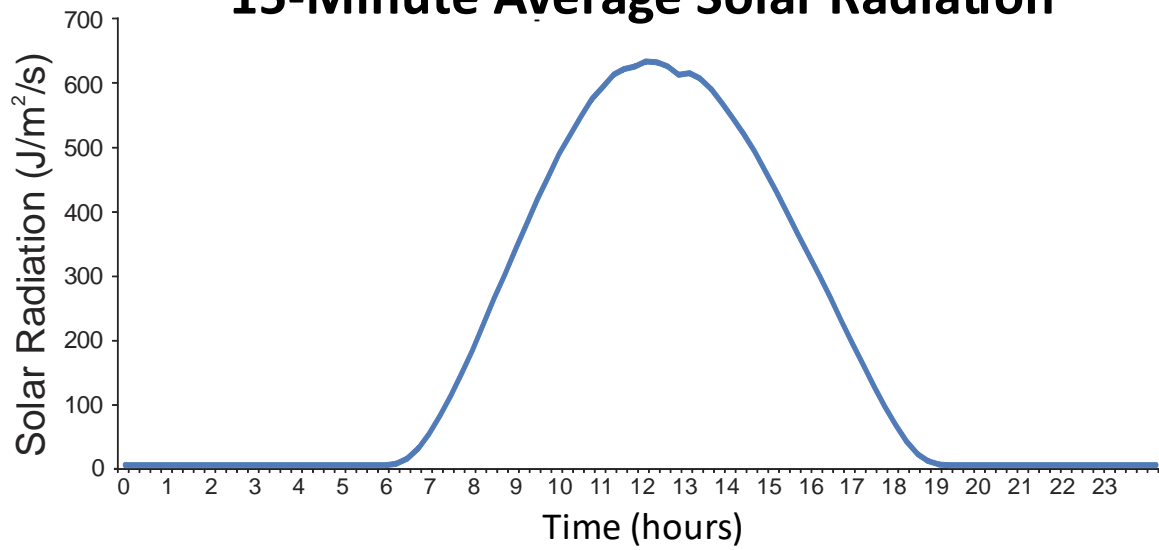
### 15-Minute Average Relative Humidity



### Rainfall (% of total/15-min interval)



## 15-Minute Average Solar Radiation



## 15-Minute Average Wind Speed

