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CLIMATOLOGY OF THE FREEMAN RANCH, HAYS COUNTY, TEXAS

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INTRODUCTION

Climatology is the scientific study of climate, the synthesis of weather. While weather is concerned with the conditions at a given place at a given time, climate is concerned with tendencies and variability of weather. A climatological description must address not only average conditions, but also the variability about that average including extremes. In describing the climate of an area we must address the primary controls of climate, described as climatic elements and their physical manifestation, climatic variables.

The primary controls of climate are radiation, Earth rotation, topography, nature of the underlying surface, and land/water distribution. The spatial and temporal distribution of solar radiation at the Earth's surface drives atmospheric processes. Receipt of solar radiation varies with season, latitude, and length of day. The inclination and parallelism of the Earth's axis of rotation define the seasonal distribution in receipt of solar energy as the Earth revolves about the Sun. The action of the daily rotation of the Earth on its axis interacts with this seasonal motion to produce a variable length of daylight hours throughout the year. Topography, especially slope and orientation influence the amount of surface area exposed to solar heating. In the Northern Hemisphere, south facing slopes will receive more radiation over the course of the year. Steep slopes receive incident radiation over a greater surface area, and hence at a lower net intensity per unit surface area, than shallow slopes or flat areas. The composition of the surface upon which solar radiation falls is another important control of climate. Different surfaces reflect and absorb solar radiation at different rates and hence heat up and cool down at different rates. Large bodies of water, or land areas that have high soil moisture content will heat and cool slower than dry or non-vegetated surfaces.

The effects of these primary controls are expressed in climatic elements. Climatic elements may be thought of as components of the climate; temperature, moisture, wind, and radiation. Any particular aspect of a climatic element is known as a climatic variable. For example, the average July temperature and the number of days in the month of February with at least 0.01 inch of precipitation are climatic variables. Each July would have a slightly different average temperature. They would tend to cluster about the mean, but information about extremes of this variable (very hot or very cold Julys) is also needed to fully describe the climate. Readers desiring additional information on the principles and applications of climatology should consult one of the many classic texts in the field. An abbreviated list of these is given in the Bibliography.

Good summaries of the overall weather conditions of south-central Texas are given in Earl and Kimmel (1995) and Norwine, et al, 1995.

The *Freeman Ranch Publication Series* consists of peer-reviewed research and interpretive monographs related to Southwest Texas State University's Freeman Ranch and the Texas Hill Country. James Kimmel and Richard Earl, editors.

DATA SOURCES

No long-term record of weather observations exists from the Freeman Ranch. Continuous precipitation and temperature data have been recorded only since December 1998. Therefore this climatic summary is based on observations from San Marcos (SM), New Braunfels (NB), Austin (AUS), and San Antonio (SAT). Observations from San Marcos and New Braunfels are taken as part of the National Weather Service (NWS) Cooperative Observer Program (COOP). COOP volunteers use NWS thermometers and rain gauges and record observations according to NWS procedures. Observations from Austin and San Antonio have been taken by NWS personnel and/or NWS trained contract observers and include a complete suite of weather observations taken at airport locations in the cities. All observations from NWS and COOP observers are forwarded to the National Climatic Data Center (NCDC) in Asheville, NC. NCDC performs quality control of the observations and certifies that the observations represent true conditions. NCDC also publishes a series of monthly and annual summaries of climatological variables calculated from the observations. Climatological normals representing average temperature and precipitation conditions for a 30 year defined period are published for selected stations. The current normals for Austin and San Antonio cover the period 1961 – 1990. Normals for San Marcos and New Braunfels cover the 1951 – 1980 time frame. In 1968 NCDC published the Climatic Atlas of the United States. This atlas mapped values of climatic variables for the normal period of 1931 - 1960. Maps of variability of climatic variables covered the entire period of record available at the time. NCDC has never updated this atlas to reflect the new data collected since its publication.

CLIMATIC DATA TABLES

Summary data for each month of the year is presented in the following tables. Appendix A includes definitions of terms and information on how various variables are calculated. Readers should consult any of the climatology texts listed in the Bibliography for additional details on these climatic variables.

Information on temperature is given in Table 1. This includes both measured and calculated variables such as degree-days. The annual temperature range is 60F° with summer highs in the low to mid 90s and winter lows near 40°F. Every month except December and January have recorded temperatures of 90°F or warmer, while freezing temperatures have been reported in all months from October through April. The need for supplemental heating is minimal given the relatively low value of 1887 annual heating degree days (HDD). There is a need for summer cooling however, given the annual cooling degree days (CDD) value of 2658. This need for supplemental cooling is further highlighted by the annual number of days in which the temperature exceeds 90°F (113) as opposed to the number of days in the year with freezing temperatures (36). The area has a long growing season as indicated by the high number of growing degree days (GDD base 50°F).

Table 2 gives climatic information on moisture conditions including precipitation and relative humidity. The area receives about 34 inches of rain annually spread over all months of the year. There is a slight preference for increased precipitation in September, associated with the decay of tropical systems. Rain falls on about 4 days each month. The area is subject to periodic drought and flood. Every month has recorded zero rain at least once, while monthly rainfall exceeding 10 inches has occurred in May, June, August, October, and November. The area is humid, with an average relative humidity of 67%. Summer nights can be especially sultry when humidities and air temperatures are both in the mid-70s.

Table 3 provides wind information. Southerly flow dominates the area, but following passage of a winter cold front the winds will briefly veer to the north. Average wind speed is about 9 MPH with slightly breezy conditions prevailing in the spring. Occasional gale force winds over 32 MPH have been recorded in all months of the year.

Table 4 contains information on a variety of radiation variables including azimuth angles for sunrise and sunset and noon solar elevation angles. The low latitude of the station is reflected in the noon solar elevation angle for June (83°) which contributes to the high summer heat load. Summer months are noted

for relatively clear skies and so receive high values of both hours of sunshine and incident solar radiation. Winter months are much cloudier.

HAZARDOUS WEATHER

The Freeman Ranch is potentially subject to a variety of hazardous weather events. Table 5 contains information on tornado occurrence in the (former) NWS TX-36 forecast zone. This zone incorporated all of Hayes County and a number of the surrounding counties. Climatological information on tornado characteristics cover the period 1950–1981. The greatest majority of these tornadoes are weak (F0 & F1) and relatively short-lived. Table 6 has a list of the 10 wettest and driest years in San Marcos while Table 7 lists those years in which meteorological drought has occurred. Meteorological drought is defined as a year in which less than 75% of the average rainfall occurs. Table 8 lists the 10 warmest and coldest years as measured by annual average temperature. Snow is a very infrequent occurrence (4 inches in February 1966 and 5 inches in March 1965), but freezing temperatures can be expected in every winter as shown in Table 1. Hurricanes making landfall along the Texas Coast have mostly dissipated in strength before reaching the area. The major impact from hurricanes is increased precipitation.

In October of 1998, severe flooding impacted parts of south-central Texas. Substantial flooding occurred in the Guadalupe River Basin which includes the Blanco River. Rainfall accumulations of 12 to 20 inches were recorded in the Freeman Ranch area. Slade and Persky (1999) provide additional information on the hydrologic consequences of this flood event.

CONCLUSIONS

The Freeman Ranch area is subject to a wide variety of conditions indicative of a humid sub-tropical climate. On occasion, drought may lead to semi-arid conditions with negative impacts on vegetation. This chapter provides tables of monthly values of means and extremes of climatic elements in the area. These tables should be used as a guide to expected conditions in the area for planning purposes. Researchers conducting meso- or micro-scale research at the complex should plan on taking measurements of meteorological parameters to support their programs. Assistance in selection of instrumentation and measurement methodologies is available from the author in the Department of Geography, Southwest Texas State University.

CLIMATIC DATA TABLES

TABLE 1. TEMPERATURE

J	F	M	A	M	J	J	A	S	O	N	D	Y	Units	Variable	Station
89	92	99	100	103	103	110	108	104	97	90	89	110	F	Ext Max	SM
60.8	65.2	72.8	79.8	85.1	91.4	95.0	95.5	89.8	81.8	70.8	64.0	79.3	F	Daily Max	SM
35.9	39.3	46.0	55.6	62.9	69.3	71.3	70.8	66.4	55.7	44.9	38.0	54.7	F	Daily Min	SM
48.4	52.3	59.4	67.7	74.0	80.3	83.2	83.2	78.1	68.8	57.9	51.0	67.0	F	Average	SM
6	5	17	30	42	51	56	57	42	31	17	15	5	F	Ext Min	SM
24.9	25.9	26.8	24.2	22.2	22.1	23.7	24.7	23.4	26.1	25.9	26.0	59.6	F	Range	SM
54.6	58.7	66.1	73.8	79.6	85.9	89.1	89.3	84.0	75.3	64.3	57.5	73.2	F	Avg Day	SM
42.1	45.8	52.8	61.7	68.5	74.8	77.2	77.0	72.3	62.2	51.4	44.5	60.9	F	Avg Nite	SM
523	369	218	55	0	0	0	0	0	48	240	434	1887	DegDays	HDD	SM
8	13	45	136	283	459	564	564	393	166	27	0	2658	DegDays	CDD	SM
110	147	325	539	752	917	1036	1035	850	589	277	131	6708	DegDays	GDD	SM
0	0	1	2	8	22	29	28	19	4	0	0	113	Days	Max>=90F	SM
12	7	3	0	0	0	0	0	0	0	4	10	36	Days	Min<=32F	SM

Source: NCDC Climatography of the United States No. 20

TABLE 2. MOISTURE

J	F	M	A	M	J	J	A	S	O	N	D	Y	Units	Variable	Station
2.00	2.93	1.84	3.29	3.68	3.56	1.77	2.31	4.52	3.61	2.23	2.01	33.75	Inches	Avg Precip	SM
4	4	3	4	5	4	3	3	5	4	4	4	47	Days	Precip	SM
6.63	7.55	5.24	7.59	10.89	22.96	8.01	11.02	8.73	25.31	13.00	7.03	25.31	Inches	Max Precip	SM
66.8	65.5	63.8	66.5	71.5	57.3	64.8	63.8	68.0	67.0	68.5	67.5	66.8	%	Avg RH	AUS
65.0	63.3	61.3	63.7	68.3	66.0	61.7	60.7	65.0	64.3	66.0	65.7	64.0	%	Avg Day	AUS
69.0	67.7	66.3	69.7	75.3	73.7	69.3	68.3	72.3	71.0	72.0	70.3	70.3	%	Avg Nite	AUS

Source: NCDC Climatography of the United States No. 20 and Local Climatological Data – Austin

TABLE 3. WIND

J	F	M	A	M	J	J	A	S	O	N	D	Y	Units	Variable	Station
S	S	S	SSE	SSE	S	S	S	S	S	S	S	S	Degrees	Avg Dir	AUS
9.7	10.2	10.8	10.5	9.6	9.1	8.3	7.9	7.9	8.1	9.0	9.2	9.2	MPH	Avg Speed	AUS
33	39	36	40	35	41	40	35	52	33	36	44	52	MPH	Max 1-min	AUS

Source: Local Climatological Data - Austin

TABLE 4. RADIATION

J	F	M	A	M	J	J	A	S	O	N	D	Y	Units	Variable	Station
279	347	417	445	541	612	639	585	493	398	295	256	442	Langleys	Solar Rad	SAT
148	152	207	221	266	302	331	320	261	242	180	160	2790	Hours	Sunshine	AUS
		729			845			731			614		Minutes	Daylength	SM
		60			83			60			37		Degrees	Max Elev	SM
		90			62			90			117		Degrees	SR Azim	SM
		270			297			270			243		Degrees	SS Azim	SM

Source: Climatic Atlas of the United States and US Naval Observatory

TABLE 5. Tornado Climatology: 1950 - 1981

Strength Fujita Scale	%
F0 & F1	58
F2 & F3	32
F4 & F5	3
UNK	8

Path Length Miles	%
0 - 1	44
1 to 10	30
10+	9
UNK	17

Path Width Yards	%
up to 500	66
500 - 1500	11
1500+	4
UNK	19

Source: NWS Forecast Office New Braunfels

TABLE 6. Ten Wettest and Driest Years in San Marcos

WETTEST		DRIEST	
Amount	Year	Amount	Year
58.51	1998	15.77	1917
52.24	1946	18.59	1939
51.49	1991	19.81	1909
49.63	1981	19.90	1963
48.65	1975	21.10	1950
48.41	1941	21.33	1910
47.92	1973	21.50	1988
47.46	1976	21.97	1924
47.37	1944	22.69	1916
46.57	1992	22.78	1948

Source: NCDC

TABLE 7. Meteorological Drought Years in San Marcos (Precip < 25.31 inches)

Amount	Year		Amount	Year
25.15	1943		21.97	1924
24.68	1915		21.50	1988
24.11	1912		21.33	1910
23.66	1911		21.10	1950
23.65	1925		19.90	1963
23.48	1906		19.81	1909
22.78	1948		18.59	1939
22.69	1916		15.77	1917

Source: NCDC

TABLE 8. Ten Coolest and Warmest Years in New Braunfels

COOLEST		WARMEST	
Temp	**Year**	**Temp**	**Year**
60.53	1940	75.38	1950
62.33	1976	72.14	1933
62.78	1985	71.87	1989
63.14	1979	71.24	1909
63.32	1970	71.06	1934
63.41	1903	70.97	1923
63.68	1926	70.61	1932
63.77	1960, 1942	70.43	1938
63.86	1959	70.43	1980
63.95	1906	70.34	1952, 1965, 1990

Source: NCDC

APPENDIX A: Glossary of Terms and Calculations

A1. Temperature

Average. The mean temperature for the month or day.
Average Day. The weighted mean temperature ((3Max + 1Min)/4) for daylight hours.
Average Nite. The weighted mean temperature ((1Max + 3Min)/4) for nighttime hours.
Daily Max. The highest temperature of the day.
Daily Min. The lowest temperature of the day.
Ext Max. The highest temperature recorded for that month.
Ext Min. The lowest temperature recorded for that month.
Range. The difference between the daily max and daily min.
CDD. Cooling degree days. The sum over all days of the month of the difference between the average temperature for the day and a base temperature of 65°F. CDD accumulate when the average is over 65°F.
HDD. Heating degree days. The sum over all days of the month of the difference between the average temperature for the day and a base temperature of 65°F. HDD accumulate when the average is less than 65°F.
GDD. Growing degree days. The sum over all days of the month of the difference between the average temperature for the day and a base temperature of 50°F. GDD accumulate when the average is over 50°F. Specific crops may use a different base temperature.
Max >= 90°F. The average number of days per month that the daily max is 90°F or warmer. A measure of hot days.
Min < = 32°F. The average number of days per month that the daily min is 32°F or cooler. A measure of days with freezing temperatures.

A2. Moisture

Average Precip. The mean amount of precipitation for the month. Frozen precipitation is included as water equivalent.
Precip days. The average number of days per month in which at least 0.01 inches of precipitation has occurred.
Max Precip. The highest precipitation amount recorded for that month.
Average RH. The mean relative humidity for the day.
Average Day. The mean relative humidity for daylight hours.
Average Nite. The mean relative humidity for nighttime hours.

A3. Wind

Average Dir. The mean wind direction for the month.
Average Speed. The mean wind speed for the month.
Max 1-min. The fastest wind speed observed over a one minute interval.

A4. Radiation

Solar Rad. The solar radiation (direct and diffuse) measured on a horizontal surface. One Langley/minute equals 698 Watts/m2 .
Sunshine. The mean number of hours of sunshine per month.
Daylength. The time between sunrise and sunset on the 17th of the month.
Max Elev. The noon altitude angle of the sun on the solstice or equinox.
SR Azim. The horizontal angle of the sun at sunrise on the solstice or equinox.
SS Azim. The horizontal angle of the sun at sunset on the solstice or equinox.

A5. Fujita Scale

The Fujita Scale measures the intensity of a tornado on the basis of wind speed as estimated from property damage.

Value	Strength	Wind Speed [MPH]
0	Weak	40-73
1		74-112
2	Strong	113-157
3		158-206
4	Violent	207-260
5		261-318

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