

CLIMATE AND ET: DO PLANT WATER REQUIREMENTS INCREASE DURING A DROUGHT?

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ABSTRACT

Municipalities, engineering consultants and State agencies use reference evapotranspiration (ET_o) data (directly and indirectly) for long-term water planning, for designing hydraulic structures, and for establishing regulatory guidance and conservation programs intended to reduce water waste. The use of ET_o data for agricultural and landscape irrigation scheduling is becoming more common in Texas as ET_o-based controllers and automation technologies become more affordable. Until recently, most ET_o data has been available as monthly values averaged over many years. Today, automated weather stations and irrigation controllers equipped with specialized instrumentation allow for real-time ET_o measurements. With the expected rise in global warming and increased frequency of extreme climate variability in the coming decades, conservation and efficient use of water resources is essential and must make use of the most accurate and representative data available.

BACKGROUND

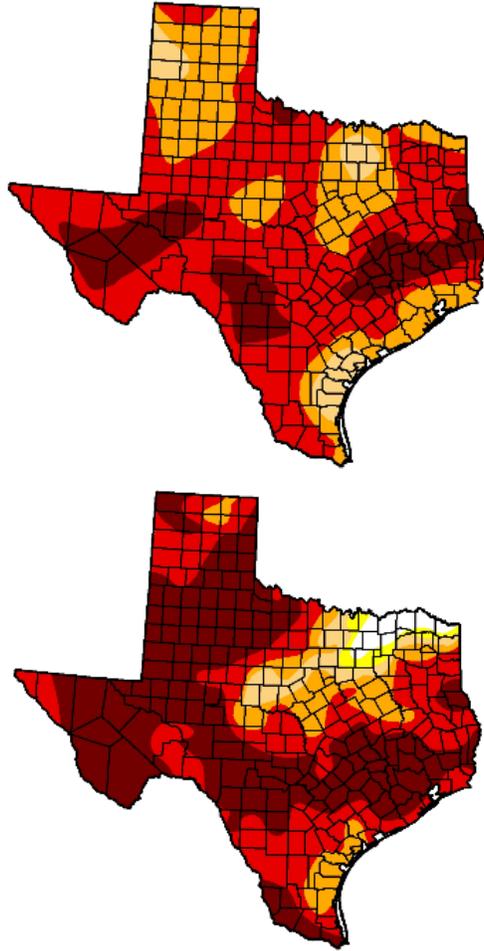
2011 marked the driest year on record in the State of Texas with over 81% of the state experiencing an exceptional drought by the end of August (See Figure 1). Compounding the lack of rainfall was record heat during the summer of 2011. Observations from the TexasET Network and Website (<http://TexasET.tamu.edu>) showed higher temperatures, lower relative humidity and higher wind speeds than typically experienced during the spring and summer months, resulting in 25% to 50% higher ET_o rates than historic averages during 2011. The implications are quite serious, as most current water planning and drought contingency plans do not take into consideration increases in ET during such periods, and irrigation planning and capacity sizing are based on historic averages of consumptive use.

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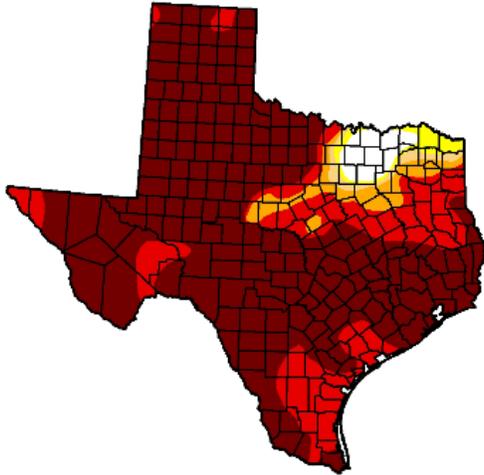
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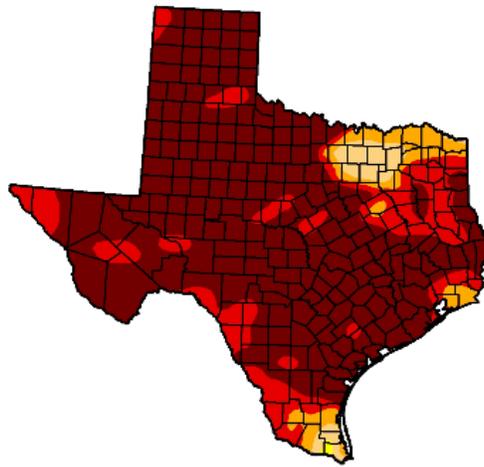
Figure 1. US Drought Monitor, Texas. April - August 2011



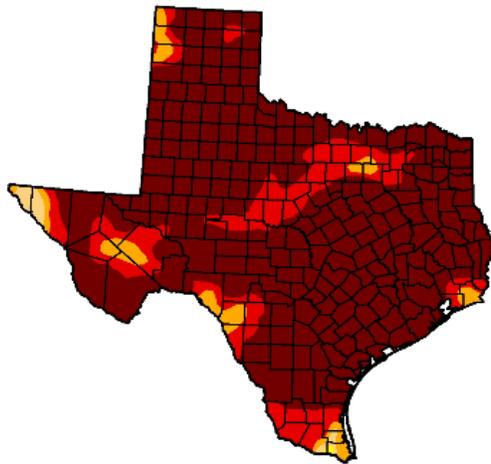
Week	Nothing	D0-D4	D1-D4	D2-D4	D3-D4	D4
April 26, 2011	0.00	100.00	100.00	94.97	70.42	17.16
Week	Nothing	D0-D4	D1-D4	D2-D4	D3-D4	D4
May 31, 2011	2.25	97.75	96.07	91.89	81.09	50.65



Week	Nothing	D0-D4	D1-D4	D2-D4	D3-D4	D4
June 28, 2011	2.68	97.32	95.71	94.52	90.82	72.32



Week	Nothing	D0-D4	D1-D4	D2-D4	D3-D4	D4
July 26, 2011	0.00	100.00	99.85	95.88	91.65	75.23



Week	Nothing	D0-D4	D1-D4	D2-D4	D3-D4	D4
August 30, 2011	0.00	100.00	99.92	99.01	95.04	81.08

TexasET Network & Website

The TexasET Network is a collaboration of 32 weather stations across the state used to calculate daily reference evapotranspiration, primarily for irrigation scheduling purposes. Daily ETo is calculated using the Standardized Penman-Monteith Equation which requires hourly weather readings of temperature, relative humidity (used to derive dew point temperature), solar radiation and wind speed. In addition to being able to view daily “real-time” ETo, the network makes available historical monthly averages of ETo data for 19 cities in Texas. These values are often used in water budgeting for irrigation and based on the number of years of record available for each city. Years of record for each city discussed in this paper are shown in Table 1.

Table 1. Historical Years of Record Used to Calculate Historic Monthly Averages on the TexasET Network Website					
	Brownsville	San Antonio	Lubbock	Dallas	Houston
Years of Data	79	54	89	26	31

ANALYSIS AND DISCUSSION

Five cities on the TexasET Network were chosen based on their location, size and/or requirement for seasonal irrigation. These cities include Brownsville, San Antonio, Lubbock, Dallas and Houston, Texas. Monthly total ETo was calculated for each city from 2008 to 2011 for the months for April through August as well as the 4 year average. The monthly ETo data per year, monthly average for the 4 year period and the historical monthly average for the years of record are shown in Tables 2-6.

Table 2. April Comparison of Total ETo Data					
	Brownsville	San Antonio	Lubbock	Dallas	Houston
2008	6.04	5.39	6.87	5.55	3.67
2009	5.88	5.53	6.68	6.29	3.68
2010	3.35	5.44	5.69	6.23	3.63
2011	6.33	7.83	8.03	7.16	4.55
4 Year Average	5.39	6.05	6.82	6.31	3.88
Historical Average	5.17	5.47	5.53	5.14	5.01
2011 Increase or Decrease from Historic Value	22%	43%	45%	38%	-10%

	Brownsville	San Antonio	Lubbock	Dallas	Houston
2008	6.77	6.97	7.79	7.38	4.71
2009	6.52	6.18	6.90	5.79	4.81
2010	3.81	6.95	7.42	7.21	4.91
2011	6.82	8.59	9.42	6.91	5.39
4 Year Average	5.93	7.17	7.88	6.82	4.96
Historical Average	6.03	6.47	6.93	6.21	6.11
2011 Increase or Decrease from Historic Value	10%	33%	36%	11%	-12%

	Brownsville	San Antonio	Lubbock	Dallas	Houston
2008	7.78	7.82	9.37	8.31	5.23
2009	8.75	8.23	7.69	6.04	6.01
2010	6.83	7.23	8.16	8.50	4.95
2011	7.08	10.1	11.31	10.14	6.11
4 Year Average	7.61	5.82	9.13	8.25	5.58
Historical Average	6.68	6.97	7.73	7.06	6.57
2011 Increase or Decrease from Historic Value	6%	45%	46%	44%	-7%

	Brownsville	San Antonio	Lubbock	Dallas	Houston
2008	6.09	6.80	7.09	10.81	5.46
2009	10.74	10.09	7.45	9.07	5.65
2010	6.44	7.23	6.13	7.94	4.50
2011	7.42	10.79	8.80	10.47	5.63
4 Year Average	7.67	8.73	7.34	9.42	5.31
Historical Average	6.68	7.31	7.31	7.40	6.52
2011 Increase or Decrease from Historic Value	11%	48%	20%	41%	-14%

	Brownsville	San Antonio	Lubbock	Dallas	Houston
2008	6.52	5.81	5.47	7.62	4.15
2009	8.85	9.57	7.09	9.00	4.80
2010	7.06	8.45	6.55	9.49	5.25
2011	7.34	9.89	7.66	10.48	5.79
4 Year Average	7.69	8.43	6.69	9.15	5.00
Historical Average	6.65	6.99	7.20	7.25	6.08
2011 Increase or Decrease from Historic Value	10%	41%	6%	46%	-5%

The percent increase (or decrease) in ETo during 2011 was calculated by dividing the measured total ETo for each month by the historical average monthly ETo for each city. This referred to as the “percent change” was graphed to show monthly increases (or decreases) in ETo compared to historical conditions (See Figure 2).

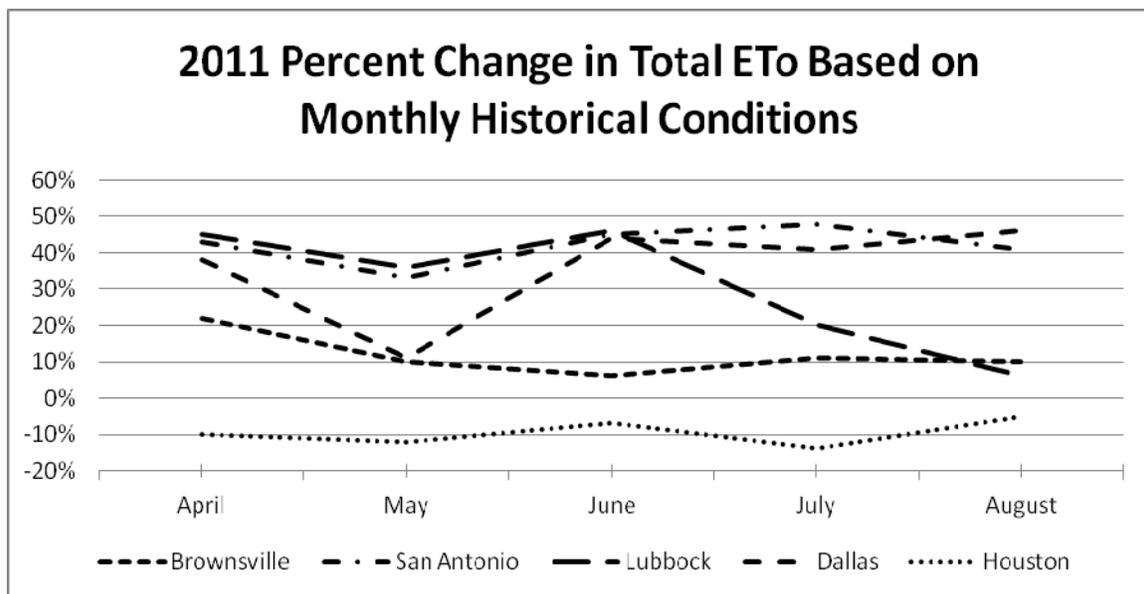


Figure 2.

SUMMARY AND CONCLUSIONS

Basic analysis of the ETo data obtained from the TexasET Network showed that ETo did increase dramatically across most of the state in 2011. Of the five cities evaluated:

- Four cities consistently showed an increase in ETo ranging from 6% to 48% from April to August,
- One of the evaluated cities consistently showed a lower ETo than the historical average, decreasing from -5% to -14%,
- June showed the greatest change in ETo with 3 cities having a percent change greater than 44%.

During the drought, the greatest change in ETo appeared the further north the city is located in the state and the further west, with the least amount of change in monthly ETo occurring along the coastal areas of the state. Further statistical analysis is needed to determine what climatic factors resulted in the significant increase in total ETo during the drought of 2011.

REFERENCES

TexasET Network and Website. Irrigation Technology Center, Texas AgriLife Extension Service. <http://TexasET.tamu.edu>. Accessed on September 16, 2011.

US Drought Monitor. Texas Drought Condition on August 30, 2011. <http://droughtmonitor.unl.edu>. Accessed on January 6, 2011.