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THE TEXAS HIGH PLAINS EVAPOTRANSPIRATION (TXHPET) NETWORK

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SUMMARY

Development, adoption and use of an evapotranspiration (ET) network system designed for irrigation scheduling entail the integration of several factors that include a simplified data acquisition approach, user understanding, multiple dissemination venues, user clientele education, resource support plus operational commitment by network personnel to maintain accurate meteorological and ET data. The Texas High Plains Evapotranspiration (TXHPET) network was developed with these factors in mind and continues to gain adoption by irrigated users to date. The TXHPET system, its development, use, output and operations are discussed.

INTRODUCTION

As irrigation continues to be the majority user of water (60%) in Texas (Texas Water Facts, 2008) and other states, increases in other water use sectors are typically dependent on transfers from the agricultural sector. Thus, agriculture is likely to continue to have to produce more with less water and depend more on conservation measures, technological advances and irrigation scheduling to optimize irrigation management. Conservation districts and other water governing agencies are increasingly embracing network based evapotranspiration (ET) requirements as the maximum allowable pumping for crops. Appropriate (high quality and location-specific) meteorological data are necessary for application of widely accepted standard ET models and calculations.

Numerous meteorological networks have been developed and are in existence today in the U.S. Most of these systems have differing primary objectives and targeted users. The purpose and scope of these networks vary in size and intent along with differing interrogation intervals. Some are large-scale climate based and can be used for varying purposes. Others are specific in nature and the data are controlled and restricted to the designated application or agency. Agriculturally based ET networks generally have the defined purpose of estimating crop ET within a particular region. Networks such as “school net” sites are basically teaching tools for students and for illustration of the variability of localized rainfall events and typically are not suitable for agricultural applications because of city and urban (siting) based parameter influences. Agricultural meteorological stations need to be representative of the environment they are located in with sensors conforming to standardized accuracy and placement (ASABE, 2004; Walter, et al., 2005). Data interrogation, processing, and transfers (uploads) must be consistent and timely for producer adoption and use. Sensor maintenance should be a priority issue of the network and adhered to for accurate, continuous quality assured and quality controlled data streams. Most importantly, ET computations should be scientifically based and documented adequately for comparison with the latest standardized ET equations.

METEOROLOGICAL STATIONS

Placement of ET weather stations should be a key component in the establishment of a successful and useful network station grid. Stations should be located in areas where irrigated agriculture is practiced. Additional considerations for placement involve known or anticipated topographical differences such as elevation. Station placement should be adequately “free” from biasing influences such paved roads, tree rows, valleys, large depression areas, potential water holding areas such as playas, lakes, large water holes, unpaved roads with dust potential, feedyard or other confined animal feeding operations, grain elevators, or other influences that may alter representative agriculturally based acquisition of meteorological parameters.

The number of stations within an ET network is not as important as their representation. The TXHPET network currently has 18 stations over an area representing more than 1.5 million irrigated acres. In the TXHPET network, representation in the Texas High Plains intensively irrigated areas typically ranges from to 900 to 1500 square miles per station. This figure can vary depending on the surrounding topography and prevailing upwind influences. Redundancy or overlap of weather stations is a good design consideration as data from adjacent units can be more easily estimated with redundant units. In many cases, redundancy cannot be determined until adequate data are acquired to indicate that it exists.

NETWORK DEVELOPMENT

Development of a regionally based ET network should involve a multi-disciplinary scientific based team as well as industry and commodity representatives. Additionally, large operation, progressive growers and crop consultants should be invited to provide valuable input in to the design and format of the output materials. Others that may be included are area agricultural agency representatives and governing water agency personnel. Early input is necessary as the crop consultants and large producers are the ones who will most likely use the outputs and they sometimes will have strong opinions as to how they want the data formatted for integration into their operations. Most producers and even many consultants do not want to spend time calculating values from equations each day. Most want a single value of daily ET to use in a straightforward, easy to understand irrigation scheduling checkbook type method or equivalent irrigation scheduling program. These desires have been learned by the development team of the Texas High Plains ET (TXHPET) network in the early 1990's. In addition, the following should be strongly considered:

1) Data must be accurate and scientifically based and supported.
2) Data must be timely (daily or more frequent depending on application goal).
3) Data must maintain integrity (through scheduled maintenance and timely repairs as needed).
4) Data must be comparative, calibrated and verified.
5) Data must be sustainable (with adequate resource support and allocation).
6) Data should conform to agriculturally based and scientific standards.

Initially, the TXHPET development team brought a group of producers to listen to their needs and they decided jointly that they wanted a single "fax sheet" of the ET data delivered on a daily basis whereby they could read a single crop value of ET for yesterday's conditions. After the initial design draft, the consultant and producer members rearranged much of the sheet to their liking to fit their needs. This involvement by the users virtually ensured that the data output format was what they wanted and not just what the science based members dictated. The single page fax file format is still in use today and contains data for cereal grain crop daily, 3-day, and 7-day ET's plus growing degree day heat units and average growth stage for short and long season crops with four dates of planting. Figure 1 illustrates the information in the TXHPET fax file format. Another file that is created daily and that has hourly formatted information for researchers and other related agricultural industry users is designated as an hourly file. A copy of this file in illustrated in Figure 2.

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                 Temperatures (F)
    Date     ETo  ---Air--  Soil Min  Prec. Growing Degrees Days (F)
             in.  Max  Min  2in. 6in.  in.  Crn Srg Pnt Cot Soy Wht
  07/16/08   .22   89   63   71   75  0.00   25  26   0  16  29   0
  07/17/08   .27   91   62   70   74  0.00   24  27   0  17  28   0
  07/18/08   .25   90   66   73   76  0.01   26  28   0  18  30   0
  10-day avg min soil temp   68   72  Wind  6.3  mph from 226 deg.

CORN       Short Season Var. Water Use    Long Season Var. Water Use
Seed  Acc  Growth    Day 3day 7day  Seas. Growth    Day 3day 7day  Seas.
Date  GDD  Stage     -----in/d-----  in.  Stage     -----in/d-----  in.
04/01 1860 Milk      .32  .32  .29  22.8  Blister  .32  .32  .29  22.5
04/15 1761 Milk      .32  .32  .29  20.4  Silk,    .32  .32  .29  20.2
05/01 1550 Blister   .32  .32  .29  16.1  14-leaf  .31  .31  .28  15.9
05/15 1379 Silk,     .32  .32  .29  12.7  14-leaf  .31  .31  .28  12.6

SORGHUM    Short Season Var. Water Use    Long Season Var. Water Use
Seed  Acc  Growth    Day 3day 7day  Seas. Growth    Day 3day 7day  Seas.
Date  GDD  Stage     -----in/d----   in.  Stage     -----in/d----   in.
05/01 1693 Flag      .23  .23  .21  13.8  Flag      .23  .23  .21  12.7
05/15 1521 Flag      .23  .23  .21  11.2  Flag      .23  .21  .18  10.3
06/01 1206 GPD       .20  .20  .18   7.7  5-leaf    .17  .17  .16   7.2
06/15  853 5-leaf    .17  .17  .16   4.2  4-leaf    .15  .15  .13   4.1

COTTON      North Plains Area Water Use   South Plains Area Water Use
Seed  Acc  Growth    Day 3day 7day  Seas. Growth    Day 3day 7day  Seas.
Date  GDD  Stage     -----in/d----   in.  Stage     -----in/d----   in.
05/01  894 1st Sqr   .24  .24  .22  10.4  1st Sqr  .24  .24  .22  10.0
05/15  868 1st Sqr   .24  .24  .22   9.6  1st Sqr  .24  .24  .22   9.3
06/01  727 1st Sqr   .24  .24  .22   6.6  1st Sqr  .24  .24  .18   6.3
06/15  513 Emerged   .12  .12  .11   3.5  Emerged  .12  .12  .11   3.5

SOYBEANS   Late Group 4-Var. Water Use
Seed  Acc  Growth    Day 3day 7day  Seas.
Date  GDD  Stage     -----in/d----   in.
05/15 1629 R_3       .26  .26  .23  12.8
06/01 1271 V-6       .20  .20  .18   8.3
06/15  917 V-4       .17  .17  .15   4.8
07/01  489 Emerged   .14  .14  .12   2.0

Fescue/Bluegrass lawn water use 0.24 inch
Bermuda grass lawn water use 0.18 inch
Buffalo grass lawn water use 0.12 inch
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Figure 1. Fax output format from the TXHPET network illustrating daily crop ET values for multiple crops and planting dates.

Station:ETTER, TX Long 102 deg 0 min Lat 36 deg 0 min
Date:07/18/08 Year/DOY:2008200 Elev: 1103 m   Bar. Corr: 12.5
Sunrise 545 Sunset 2003   Daylight time = 14 hours 18 minutes

Time	Rs	Ts2	Ts6	Tair	TDew	RH	AVP	VPD	WSpd	Wdir	SDd	PREC	BP	EToG	EtoA
CST	W/m^2	C	C	C	C	%	kPa	kPa	m/s	deg	deg	mm	kPa	mm	mm
100	0.0	25.0	26.6	23.2	16.3	65	1.85	1.00	2.2	202	15	0.00	-99.9	0.04	0.07
200	0.0	24.6	26.3	22.0	16.7	72	1.90	0.74	1.3	213	26	0.00	-99.9	0.02	0.03
300	0.0	24.1	26.0	20.5	17.0	81	1.94	0.46	0.7	311	9	0.00	-99.9	0.00	0.00
400	0.0	23.7	25.7	20.3	17.2	83	1.97	0.41	0.9	272	31	0.00	-99.9	0.00	0.01
500	0.0	23.3	25.3	20.4	17.2	82	1.97	0.43	1.5	208	15	0.00	-99.9	0.01	0.02
600	3.5	23.0	25.1	20.1	17.3	84	1.98	0.37	1.4	238	26	0.00	-99.9	0.01	0.02
700	36.8	22.8	24.8	20.3	17.4	83	1.99	0.40	1.7	214	13	0.00	-99.9	0.03	0.05
800	103.7	22.8	24.6	21.0	17.1	78	1.95	0.54	2.5	242	16	0.00	-99.9	0.10	0.13
900	220.4	23.1	24.4	22.1	17.2	74	1.96	0.70	2.9	258	13	0.00	-99.9	0.18	0.23
1000	443.6	24.0	24.3	24.2	17.1	65	1.95	1.07	3.5	256	13	0.00	-99.9	0.35	0.44
1100	727.5	25.9	24.4	27.2	16.6	52	1.89	1.72	2.9	250	16	0.00	-99.9	0.57	0.68
1200	883.6	28.7	24.8	29.1	16.8	48	1.92	2.12	2.8	234	21	0.00	-99.9	0.70	0.84
1300	992.2	31.0	25.5	29.9	16.9	46	1.93	2.29	3.8	202	20	0.00	-99.9	0.80	0.98
1400	996.1	33.2	26.4	31.0	16.2	41	1.84	2.64	3.9	192	20	0.00	-99.9	0.83	1.03
1500	905.7	34.5	27.4	31.3	14.5	36	1.66	2.90	3.7	207	23	0.00	-99.9	0.78	0.98
1600	760.0	35.2	28.3	31.7	14.0	34	1.61	3.08	4.2	203	19	0.00	-99.9	0.71	0.92
1700	388.6	34.8	29.0	30.9	13.4	34	1.54	2.93	3.7	213	19	0.00	-99.9	0.45	0.63
1800	147.6	33.1	29.5	27.7	15.7	49	1.80	1.94	4.4	184	27	0.00	-99.9	0.27	0.42
1900	71.8	31.2	29.5	25.2	17.3	61	1.98	1.24	4.4	175	12	0.00	-99.9	0.17	0.27
2000	14.7	29.7	29.2	24.9	16.7	61	1.91	1.24	3.4	176	11	0.00	-99.9	0.11	0.19
2100	0.0	28.5	28.8	24.0	16.7	64	1.90	1.08	3.6	188	40	0.00	-99.9	0.06	0.10
2200	0.0	27.5	28.4	22.7	17.1	71	1.95	0.80	2.8	310	21	0.00	-99.9	0.04	0.07
2300	0.0	26.7	27.9	20.6	17.4	82	1.99	0.44	3.3	295	17	0.00	-99.9	0.03	0.04
2400	0.0	25.9	27.5	19.6	17.8	90	2.04	0.23	2.8	248	18	0.25	-99.9	0.01	0.02
Sum	24.1 MJ											0.25		6.28	8.16
Avg		27.6	26.7	24.6	16.6	64	1.89	1.28	2.8	226	43		-99.9		
Max	1320.4	35.2	29.6	32.2	18.8	93	2.16	3.33	8.6				-99.9		
Time	1158	1531	1748	1523	1216	2345	1216	1458	1724				9999		
Min		22.7	24.3	19.1	11.8	30	1.39	0.16					-99.9		
Time		655	949	2358	1450	1457	1450	2345					9999		

Precipitation by 15 minute periods
2345 0.25

Figure 2. Hourly file output format of the TXHPET network containing hourly meteorological data and ETo values plus daily values.

While these file formats are simple for the producers and other agricultural users, researchers generally desire more options and advanced type outputs. Both can be programmed into the system but the main focus should be on the producer utilization; otherwise, it becomes cumbersome and more of research effort than a user product. The research parts of the system may be "hidden" from the general user as necessary to prevent confusion.

Rainfall at the respective network sites is possibly the least relevant ET parameter of the data set although it is one of the most monitored by users. Users should use site specific field rainfall in their irrigation scheduling method. The values recorded by the TXHPET network are frequently in question from both producers and researchers alike and large differences often result from highly variable precipitation events or even from common rain gauge problems, including plugged funnels and ports.

Development with an ET network is typically not complete but rather an ongoing process. Advances in the hardware and software change over time and most of this activity should be transparent to the user. Over time new interrogation instrumentation and data modules plus computational methods have replaced the initial and earlier methods of acquisition. Much of the original instrumentation and sensors are no longer available so upgrades are seemingly always forthcoming. Additionally, researchers are progressing to evaluate ET values on smaller (shorter) time scales for new future irrigation application systems with data interrogation times becoming shorter.

DISSEMINATION

Data and Calculated Values

Originally, faxing of the "fax sheet" was the main dissemination method during the 1990's. Since then, the TXHPET network has developed a web based listserv whereby growers can subscribe and change at their will which stations and the type(s) of files they want to receive through e-mail at around 05:00 each day. Although the fax mode of dissemination has been diminished in terms of requests using the fax mode, its primary replacement has been that of email. A few years ago, the TXHPET system created an ET network parameter data base whereby internet users can query the system and receive data in formats selected from several available formats, including on-line graphics options. A snapshot of the site is included in Figure 3 and the site can be accessed at http://txhighplainset.tamu.edu/. This addition has cut down significantly on the number of data formatting and processing requests network personnel had to deal with on a timely basis. Backup electronic data sites on other servers support duplicative data sets to assure data security and reliable access. Although the TXHPET system has been considered successful, the network team continues to listen to the needs of the clientele and propose new tools for integration into the network sites, including more automation of the data into user based tools as well as and including upgrading the crop growth models for adequate representation of current and progressive production agriculture.

TXHPET Use

The TXHPET network has kept statistics of use and downloads since its inception and has in recent years averaged about 300,000 pages of disseminated information per year. This past summer season, an additional 180,000 plus pages of crop ET downloads were noted indicating that as energy based pumping costs increased in 2008, users wanted more exacting ET

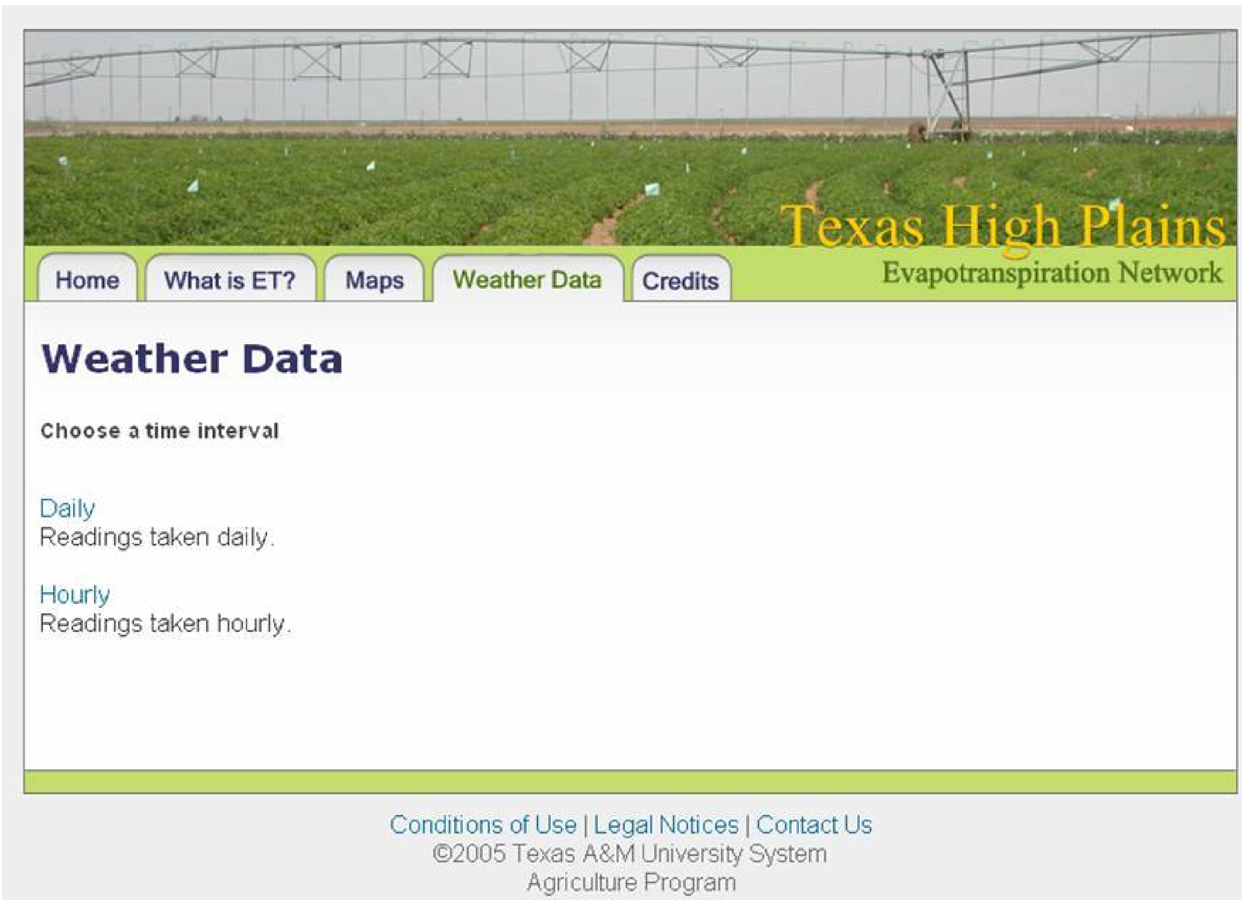

Figure 3. TXHPET network web page containing weather data selection.

data to assess and refine irrigation management practices. This also coincided with an enhanced extension education effort by the limited staff associated with the TXHPET network in the Texas High Plains. While the majority of users have been irrigated producers and crop consultants, others include farm managers, production consultants, seed production agronomists, agricultural engineers, researchers, extension specialists, water district managers and technicians, water planners and consultants, state agency regulators, design engineers and city water and parks superintendents. The highest priority network users are the producers as they are the ones who have the opportunity to conserve the greatest amount of water in the region. Also, most state water agencies appreciate the use of the network as it provides a sound basis for regional water planning efforts and documentable and consistent inputs into the groundwater availability model (GAM) used for future supply and demand planning.

FUNDING

The single most difficult challenge of operating an ET network, which has been experienced by others throughout the western U.S. is that of securing sustained funding for operations and maintenance. Development and upgrade dollars can be acquired but sustained funds for personnel are hard to secure. Operational attempts to sustain operations from sales of the data have proved unsuccessful for almost all ET based networks and only account for approximately 5% of the needed revenue annually.

CONCLUSION

A well developed and maintained ET network is essential for implementation of irrigation scheduling within an intensively irrigated region. The development of such a system should be an on-going effort whereby the interested parties, particularly the irrigated producers should provide input into future needs for integrated use of their operations. The network can also provide data for a variety of other interests that use the data for wise and efficient use of water resources.

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