CAN OKLAHOMA MESONET CUMULATIVE EVAPOTRANSPIRATION DATA BE ACCURATELY PREDICTED USING THREE INTERPOLATION METHODS?

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CAN OKLAHOMA MESONET CUMULATIVE EVAPOTRANSPIRATION DATA BE ACCURATELY PREDICTED USING THREE INTERPOLATION METHODS?

O. S. Walsh, J.B. Solie, and W.R. Raun

ABSTRACT

The Oklahoma Mesonet, an automated statewide system of 115 remote meteorological stations, provides observations through an interactive web site – www.mesonet.org. Precision sensing enables to estimate winter wheat grain yield potential mid-season which in turn has a potential to increase fertilizer use efficiency. Knowing cumulative evapotranspiration could help to improve the accuracy of yield potential prediction. We evaluated how well the evapotranspiration value of a chosen test station can be predicted from values of surrounding Oklahoma Mesonet stations using the Nearest Neighbor, Local Average, and the Inverted Weighted Distance methods. All three interpolation methods enabled to accurately predict the actual cumulative evapotranspiration value at the test Oklahoma Mesonet station. The Nearest Neighbor method is the easiest and the quickest interpolation method, it also proved the most accurate (R^2=0.98). Results of this paper underline the value of Oklahoma Mesonet weather data to Oklahoma crop producers for improved fertilizer use efficiency.

INTRODUCTION

Precision sensing techniques using optical active-light hand-held GreenSeeker™ sensor developed at Oklahoma State University (OSU) in conjunction with N-Tech Industries enable to estimate winter wheat grain yield potential (YP) mid-season. GreenSeeker™ sensors are used to measure crop canopy reflectance and calculate Normalized Difference Vegetative Index (NDVI). The YP predicted mid-season enables to generate accurate fertilizer topdress recommendations based on nutrient status of the crop. This approach has a great potential to increase fertilizer use efficiency because fertilizer rates are adjusted depending on the actual crop need. Evapotransipiration (ET) – is the total amount of soil water used for transpiration by the plants plus evaporation from the soil surface (Irmak and Haman, 2003). The crop ET indicates the amount of water utilized by the crop and its environment. Preliminary data analysis of winter wheat yield data collected from OSU long-term experiments combined with ET data obtained from Oklahoma Mesonet suggested that cumulative ET beginning 30 days prior to planting through first two to three months of the cropping season could be used to improve the accuracy of YP prediction in winter wheat (Dr. J.B. Solie and Dr. W.R. Raun, personal communication, 2009). The following question should be addressed if crop producers are to use Oklahoma Mesonet cumulative ET data to estimate winter wheat YP in their fields: what ET values can be used when a producer's farm is located between the Mesonet stations?

Approximately 115 Mesonet stations are located state-wide (Figure 1) within 20 to 30 miles of each other with at least one station situated in each of Oklahoma's counties (www.mesonet.org, 2008). Daily ET data is available to researchers and crop producers on the Oklahoma Mesonet site (http://agweather.mesonet.org/index.php/data/section/crop).

Interpolation is used to estimate unknown values based on measured surrounding values. Three interpolation techniques - Nearest Neighbor, Local Average and Inverse Weighted Distance – are commonly used for prediction of missing values that vary spatially. Nearest Neighbor method implies using the value of the nearest measurement to the unknown value to be estimated. If several values are located at the same distance, the average of those values is used. Local Average method entails using an average of all known values within a predetermined distance from an unknown value. Inverse Weighted Distance interpolation implies that all known values are weighted by the inverse of their distance from the missing value. The unknown value is interpolated by calculating the sum of the weighted values divided by the sum of the weights. The objective of this paper is to evaluate how well the ET value of a chosen test station can be predicted from known cumulative ET values of surrounding

Oklahoma Mesonet stations using the Nearest Neighbor, Local Average, and the Inverted Weighted Distance methods.

MATERIALS AND METHODS

The Mesonet station # 54 (KING) located 2.0 miles North East of Kingfisher, Kingfisher county, Oklahoma (35° 52' 49" N and 97° 54' 40" W) was chosen as a test station. This station was chosen for the following reasons. First (considering agronomy), Kingfisher county is located in the middle of the primary winter wheat growing area of Oklahoma. Second (considering geography and data point availability), the Kingfisher station is situated relatively far away from the Oklahoma state border, with multiple Mesonet stations on each side. Total of 14 OKLAHOMA MESONET stations were included in the analysis (Table 1). Using latitude and longitude provided at http://www.mesonet.org/, the distances from the Mesonet stations to Kingfisher station were calculated using software (Byers, 1997) available at: http://www.chemical-ecology.net/java/lat-long.htm. Cumulative ET data for period of four months (October 1 through January 31) for five cropping years (2003-2004 through 2007-2008) were included in the analysis using all three interpolation methods.

The Nearest Neighbor interpolation method implies predicting an unknown value by averaging the known values of the nearest neighbors. For the Nearest Neighbor interpolation, cumulative ET data from KING and three Oklahoma Mesonet stations within 30 mile radius were analyzed. The average value of cumulative ET for three nearest adjacent Oklahoma Mesonet stations surrounding KING was used to correlate with the value of cumulative ET for the KING station.

The Local Average interpolation method entails predicting a missing or unknown value by averaging all the known values within a specified radius. For the Local Average interpolation, cumulative ET data from KING and seven Oklahoma Mesonet stations within 40 mile radius were analyzed. The average value of cumulative ET for seven Oklahoma Mesonet stations surrounding KING (the nearest neighbors) was used to correlate with the value of cumulative ET for the KING station.

The Inverted Weighted Distance interpolation method also involves predicting an unknown or missing value by analyzing the neighboring known values within a certain radius. However, unlike with the Nearest Neighbor method, the known neighboring values are not simply averaged, but weighted based on their distance from the unknown value to be predicted. This approach implies that the importance (weight) of the nearby values is proportionate to their distance from the unknown value: the closer the known value to the missing value being predicted - the greater the weight that is assigned to its value. Then, the missing value is calculated as the sum of the weighted values divided by the sum of the assigned weights. For the Inverted Weighted Distance interpolation, cumulative ET data from KING and 14 Oklahoma Mesonet stations within 50 mile radius were analyzed. The stations located within 25 miles (MRSH, GUTH, and ELRE) from the test station were assigned the weight of 1, those located 25 to 37.5 miles from the KING station (WATO and LAHO) – the weight of 0.75, and, finally, those situated 37.5 to 50 mile radius – the weight of 0.5.

RESULTS AND DISCUSSION

Figures 2, 3, 4, 5, and 6 show the cumulative ET values for analyzed Oklahoma Mesonet stations located within 40 mile radius from the KING test station for five consecutive cropping seasons. The cumulative ET tended to be higher for WATO station in all five cropping seasons, while ET for all other stations were comparable within any given year. Temporal variability in cumulative ET was apparent when comparing cropping seasons. Specifically, cumulative ET values were lower for all Oklahoma Mesonet stations in 2004-2005 cropping season (ranging from 4.6 in to 5.7 in) (Figure 3), and relatively higher in 2005-2006 cropping season (8.5 in to 10.2 in) (Figure 4). Other three growing seasons had similar cumulative ET values for all evaluated Oklahoma Mesonet stations. It is important to notice that cumulative ET values were very similar for the KING station and SPEN station (located the farther away - 40 miles - compared to other Oklahoma Mesonet stations analyzed) for in four of five cropping seasons.

Figures 7, 8, and 9 show the relationship between the cumulative ET at KING Oklahoma Mesonet station calculated using known ET values obtained from Oklahoma Mesonet database (actual ET) and the cumulative ET values predicted using three interpolation methods - Nearest Neighbor, Local Average, and the Inverted Weighted Distance – respectably (interpolated ET).

The actual cumulative ET at KING was strongly correlated (R^2=0.98) with the cumulative ET determined using the Nearest Neighbor interpolation and ET data from three nearest neighboring Oklahoma Mesonet stations (MRSH, GUTH, and ELRE) (Figure 7). This shows that the missing or unknown cumulative ET value can be predicted with 98% accuracy using the Nearest Neighbor interpolation method.

The Local Average interpolation enabled to estimate the actual cumulative ET value with 97% accuracy. The actual cumulative ET at test station was strongly correlated (R^2=0.97) with the cumulative ET determined using the Local Average method and ET data for seven adjacent Mesonet stations (MRSH, GUTH, ELRE, WATO, LAHO, BREC, and SPEN) (Figure 8).

The actual cumulative ET at test station was also strongly correlated (R^2=0.89) with the cumulative ET value calculated with the Inverted Weighted Distance method using ET data for thirteen Mesonet stations within the 50 miles radius (MRSH, GUTH, ELRE, WATO, LAHO, BREC, SPEN, MARE, MINC, HINT, FAIR, STIL, and PERK) (Figure 9). This result indicates that using the Inverted Weighted Distance interpolation enables to predict an unknown cumulative ET value with 89% accuracy.

CONCLUSION

The analysis of data for 5 consecutive cropping seasons showed that if a crop producer wants to use Oklahoma Mesonet cumulative ET data for estimation of winter wheat YP, the cumulative ET value for his particular field could be accurately estimated using the known cumulative ET values of surrounding Oklahoma Mesonet stations. All three interpolation methods (Nearest Neighbor, Local Average, and the Inverted Weighted Distance) enabled to accurately predict the actual cumulative ET value at the test Oklahoma Mesonet station (KING). The analysis of cumulative ET data showed that the Nearest Neighbor interpolation method could be the most appropriate for prediction of an unknown cumulative ET value for a point located between the Oklahoma Mesonet stations. The Nearest Neighbor method is the easiest and the quickest interpolation method, but also proved the most accurate (R^2=0.98). Results of this paper underline the value of Oklahoma Mesonet weather data to Oklahoma crop producers for improved fertilizer use efficiency.

TABLES

Table 1. Mesonet station, station ID's and distance (in miles) to Kingfisher Oklahoma Mesonet station.

FIGURES

Figure 1. Location of Oklahoma Mesonet stations with ID's. Source: Oklahoma Mesonet, 2008. Oklahoma Mesonet. Overview. Available at: http://www.mesonet.org/. Last accessed: 01-19-2011.

Figure 2. Cumulative evapotranspiration values for the test station (KING) and for seven neighboring Oklahoma Mesonet stations (MRSH, GUTH, ELRE, WATO, LAHO, BREC, and SPEN) located within 40 mile radius, October 1 – January 31, for 2003-2004 cropping season.

Figure 3. Cumulative evapotranspiration values for the test station (KING) and for seven neighboring Oklahoma Mesonet stations (MRSH, GUTH, ELRE, WATO, LAHO, BREC, and SPEN) located within 40 mile radius, October 1 – January 31, for 2004-2005 cropping season.

Figure 4. Cumulative evapotranspiration values for the test station (KING) and for seven neighboring Oklahoma Mesonet stations (MRSH, GUTH, ELRE, WATO, LAHO, BREC, and SPEN) located within 40 mile radius, October 1 – January 31, for 2005-2006 cropping season.

Figure 5. Cumulative evapotranspiration values for the test station (KING) and for seven neighboring Oklahoma Mesonet stations (MRSH, GUTH, ELRE, WATO, LAHO, BREC, and SPEN) located within 40 mile radius, October 1 – January 31, for 2006-2007 cropping season.

Figure 6. Cumulative evapotranspiration values for the test station (KING) and for seven neighboring Oklahoma Mesonet stations (MRSH, GUTH, ELRE, WATO, LAHO, BREC, and SPEN) located within 40 mile radius, October 1 – January 31, for 2007-2008 cropping season.

Figure 7. The relationship between measured cumulative evapotranspiration at test station (KING) and the cumulative evapotranspiration for KING station calculated using the Nearest Neighbor interpolation method and evatranspiration data for three nearest neighboring Oklahoma Mesonet stations (MRSH, GUTH, and ELRE) located within 25 mile radius, October 1 – January 31, 2003-2004 through 2007-2008 cropping seasons.

Figure 9. The relationship between measured cumulative evapotranspiration at test station (KING) and the cumulative evatranspiration at KING station calculated using the Inverted Weighted Distance interpolation method and evatranspiration data for thirteen adjacent Oklahoma Mesonet stations located within 50 mile radius, October 1 – January 31, 2003-2004 through 2007-2008 cropping seasons.

Figure 8. The relationship between measured cumulative evapotranspiration at test station (KING) and the cumulative evapotranspiration for KING station calculated using the Local Average interpolation method and evatranspiration data for seven adjacent Oklahoma Mesonet stations (MRSH, GUTH, ELRE, WATO, LAHO, BREC, and SPEN) located within 40 mile radius, October 1 – January 31, 2003-2004 through 2007-2008 cropping seasons.

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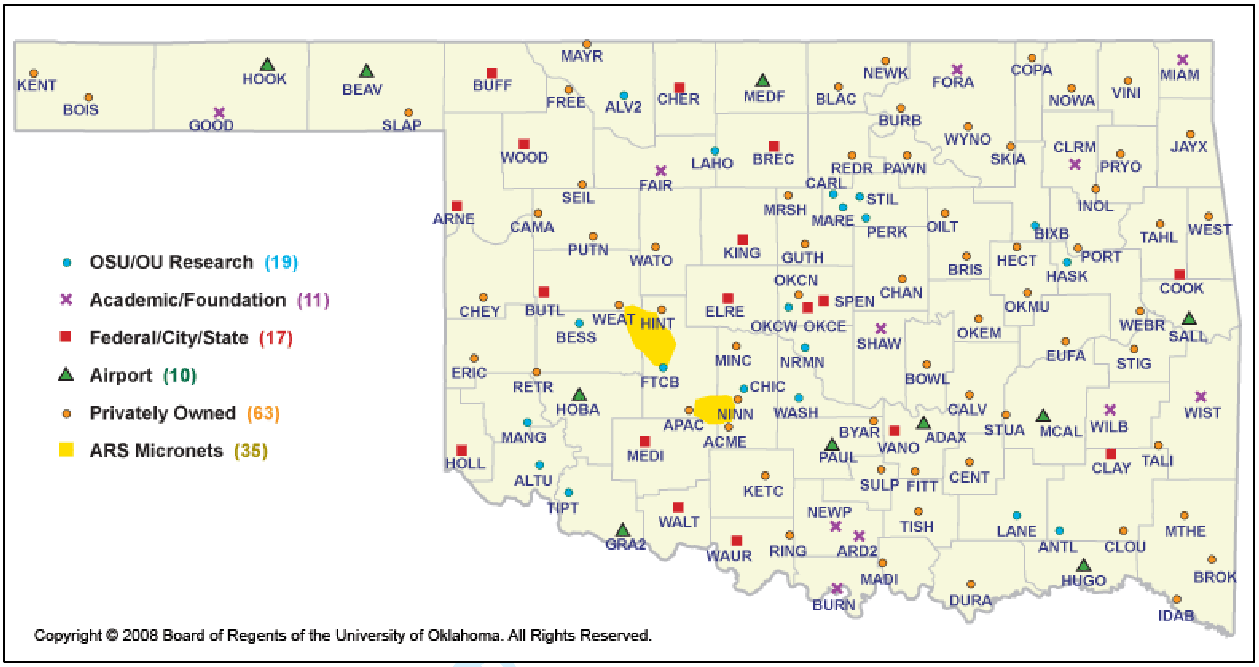
- www.mesonet.org. 2008. Oklahoma Mesonet. Overview. Available at: http://www.mesonet.org/. Last accessed: 05-11-2011.

	Mesonet station	Station ID	Distance from KING site, miles
1	Kingfisher	KING	-
2	Marshal	MRSH	24
3	Guthrie	GUTH	24
4	ElReno	ELRE	24
5	Watonga	WATO	35
6	Lahoma	LAHO	37
7	Breckingridge	BREC	39
8	Spenser	SPEN	40
9	Marena	MARE	41
10	Minco	MINC	42
11	Hinton	HINT	42
12	Fairview	FAIR	42
13	Stillwater	STIL	49
14	Perkins	PERK	49



OSU/OU Research (19)
Academic/Foundation (11)
Federal/City/State (17)
Airport (10)
Privately Owned (63)
ARS Micronets (35)
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BOIS
HOOK
GOOD
BEAV
SLAP
BUFF
MAYR
FREE
ALV2
CHER
MEDF
BLAC
NEWK
FORA
COPA
MIAM
NOWA
VINI
BURB
WOOD
LAHO
BREC
WYNO
SKIA
CLRM
PRYO
JAYX
FAIR
REDR
PAWN
CARL
SEIL
MRSH
STIL
INOL
ARNE
CAMA
MARE
PERK
OILT
BIXB
TAHL
WEST
PUTN
WATO
KING
GUTH
HECT
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BRIS
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OKCN
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CHEY
BUTL
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SPEN
OKMU
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HINT
BESS
OKCW
OKCE
SHAW
OKEM
WEBR
SALL
MINC
NRMN
EUFA
STIG
ERIC
RETR
FTCB
BOWL
CHIC
HOBA
WASH
CALV
WIST
NINN
APAC
BYAR
STUA
MCAL
WILB
MANG
ACME
VANO
ADAX
MEDI
PAUL
CLAY
TALI
HOLL
CENT
ALTU
SULP
FITT
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NEWP
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WALT
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GRA2
ANTL
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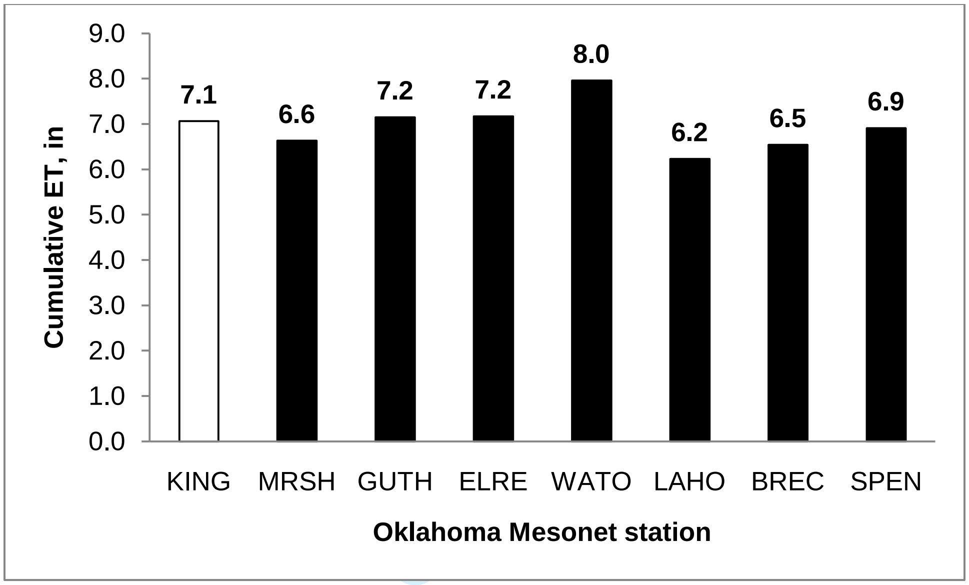
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Cumulative ET, in
7.1
6.6
7.2
7.2
8.0
6.2
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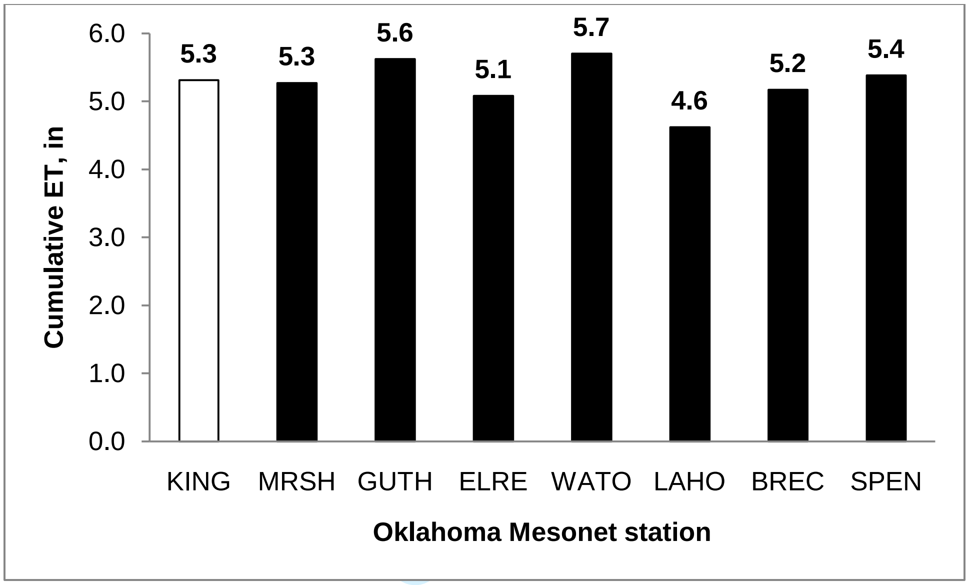
6.9
KING
MRSH
GUTH
ELRE
WATO
LAHO
BREC
SPEN
Oklahoma Mesonet station


Cumulative ET, in
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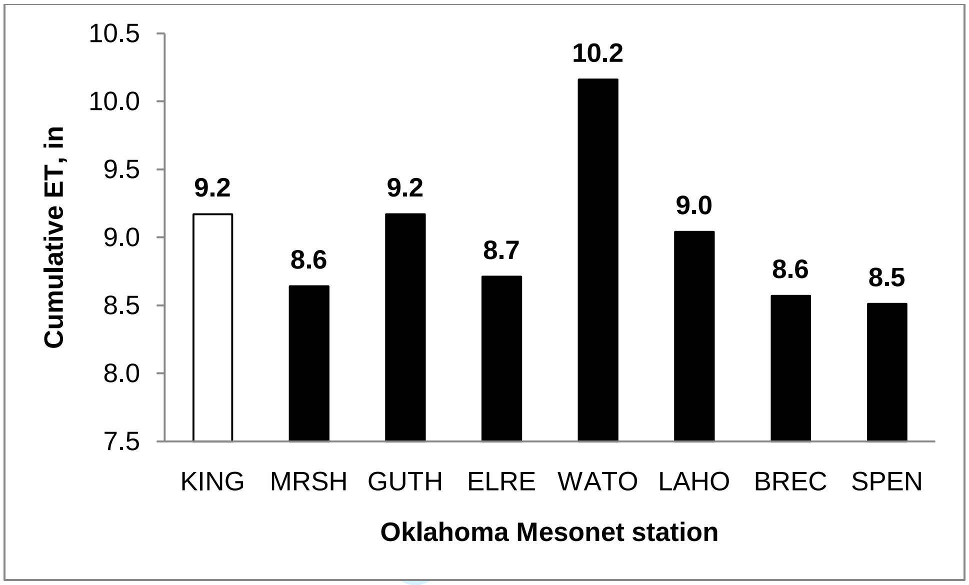
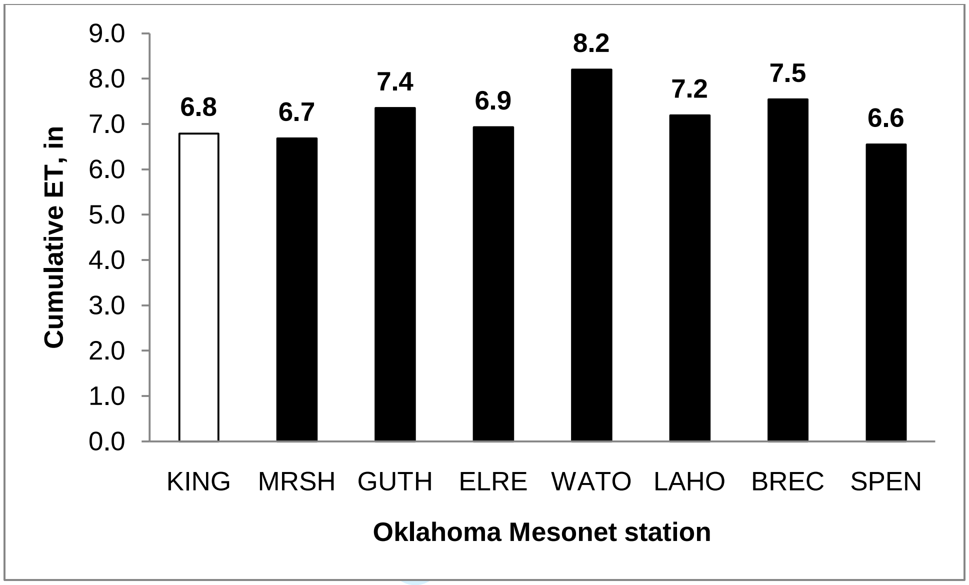
KING
MRSH
GUTH
ELRE
WATO
LAHO
BREC
SPEN
Oklahoma Mesonet station


10.5
10.0
9.5
9.0
8.5
8.0
7.5
Cumulative ET, in
9.2
8.6
9.2
8.7
10.2
9.0
8.6
8.5
KING
MRSH
GUTH
ELRE
WATO
LAHO
BREC
SPEN
Oklahoma Mesonet station


Cumulative ET, in
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KING
MRSH
GUTH
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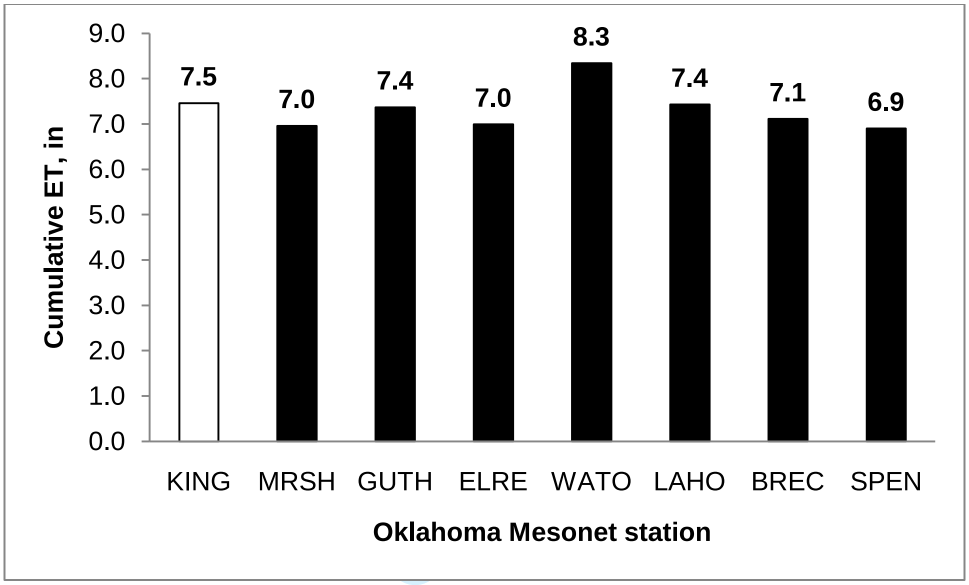
LAHO
BREC
SPEN
Oklahoma Mesonet station


9.0
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Cumulative ET, in
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KING
MRSH
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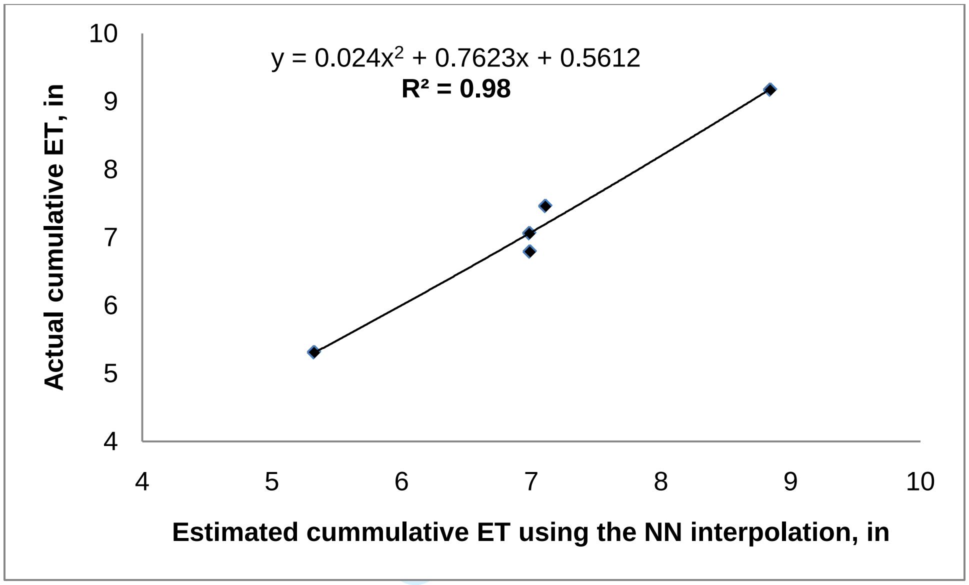
SPEN
Oklahoma Mesonet station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R² = 0.98
Actual cumulative ET, in
Estimated cummulative ET using the NN interpolation, in
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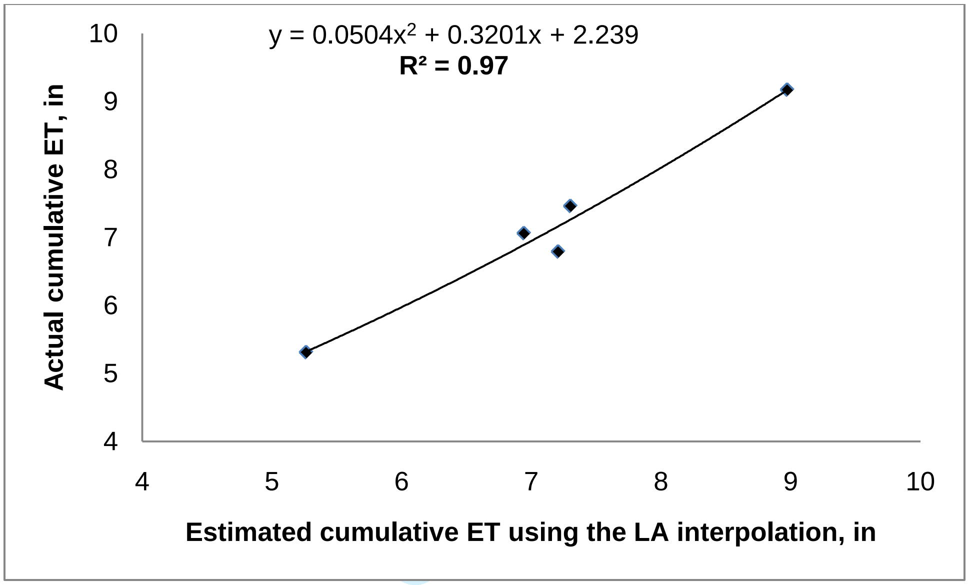
5
6
7
8
9
10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Estimated cumulative ET using the LA interpolation, in
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7
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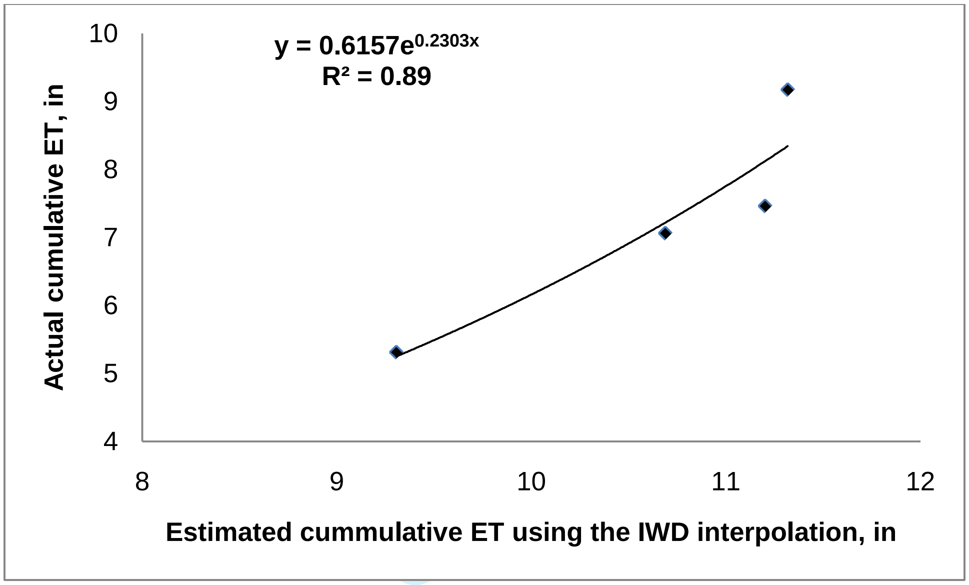
10


y = 0.6157e^0.2303x
R² = 0.89
Actual cumulative ET, in
10
9
8
7
6
5
4
8
9
10
11
12
Estimated cummulative ET using the IWD interpolation, in