THE PRESENTATION OF PRECIPITATION INFORMATION IN TELEVISION BROADCASTS: WHAT IS NORMAL?

Thomas E. Hagen[1,2]

Justin M. Glisan[1]

Anthony R. Lupo[1]

Eric M. Aldrich[1,3]

Patrick E. Guinan[1,4]

Patrick S. Market[1]

Neil I. Fox[1]

[1]Department of Soil, Environmental, and Atmospheric Sciences
University of Missouri-Columbia
Columbia, Missouri

[2]KSNT Channel 27
Topeka, Kansas

[3]KOMU - TV 8
Columbia, Missouri

[4]Missouri Climate Center
University of Missouri - Columbia
Columbia, Missouri

Corresponding Author: Dr. Anthony R. Lupo
Department of Soil, Environmental, and Atmospheric Sciences
302 E Anheuser Busch Natural Resources Building
University of Missouri - Columbia, Columbia, MO 65211
e-mail: LupoA@missouri.edu

Abstract

In a typical weather broadcast, observed precipitation information such as the daily amount that fell and the accumulated monthly total are shown and compared to the mean monthly average or "normal" precipitation. Such information, however, may not adequately describe whether or not that particular month is fairly typical for the time of year or truly an unusual occurrence. Here, it is shown that monthly average precipitation may not be representative of the typical value for a particular month at all. Thus, it is suggested that the presentation of precipitation information can be augmented with elementary statistical information, providing a more meaningful presentation of precipitation information without the need to explain the basis of such statistical information. A study of the climatological behavior of monthly precipitation values over a 118-year period for Columbia, Missouri is performed in order to provide the rationale for displaying "typical" precipitation ranges.

1. Introduction

Recently, two papers (Lupo et al. 2003; Holder et al. 2006) have demonstrated that statistical information could be used to augment daily temperature readings (e.g., maximum and minimum temperature) and be presented successfully in a three-to-five minute television weather segment. Both of these articles showed that simple information about the distribution and variability of daily temperature information could be included in a television graphic that uses the Tukey box plot (Tukey 1977) as its basis. These papers suggested that daily maximum and minimum temperatures could be compared, not only to the daily mean, but to some range of temperatures that would be considered as "typical" for that date, month, or season. Lupo et al. (2003) define a range for "typical" daily temperatures using values within one standard deviation (σ = 68%; rounded by Lupo et al. 2003 to a "70% range") from the 30-year normal, whereas Holder et al. (2006) defined their range using a smaller value than one standard deviation (50% range). Each paper showed that temperature data at their respective locations was normally (or near normally) distributed about the mean. Naturally, these graphics should be constructed such that they are appealing to the general public as well (see Holder et al., 2006 for an example).

Precipitation information would be much more difficult to incorporate using the same basis as that for temperature, since precipitation does not occur daily. Additionally, monthly precipitation data does not have a normal distribution (e.g. Stephenson et al. 1999; Guinan 2004). Moreover, precipitation may accumulate on only a handful of days within a month, and is generally tabulated monthly and then compared to a monthly averaged value. Television meteorologists make this comparison of the monthly accumulated precipitation to the monthly mean (or a fraction of the monthly mean by dividing the monthly total by the number of days in the month and assuming an equal amount should fall daily) using simple subtraction.

While this information may be meaningful to users, it does not provide more detail, or accuracy, regarding the statistical or historical context.

Generally, television meteorologists only comment on whether or not the month has been wetter or drier than normal, defined as the arithmetic mean. In the mid-west and plains states, viewers are very interested in this type of information since these areas have a strong agriculturally-based economy. Also, most television weather broadcasts are centered on the information that the broadest segment of the viewing public may be most interested in a day-to-day basis, which is mainly temperature and precipitation information and forecasts.

In the last 30 years, there has been a dramatic increase in the attention paid to weather and climate information such as severe weather (Del Genio et al. 2007), El Niño and La Niña events, and climate change, including global climate change (e.g., Changnon and Kunkel 1999; Kunkel et al. 1999). This has resulted in more than a five-fold increase in the television coverage of weather related events over that time period (e.g., Ungar 1999). As such, a broader segment of the public is interested in weather broadcasts and has become increasingly "weather-savvy" with regard to the information presented to them.

Thus, this short paper has two simple objectives. The first objective is to perform a short statistical study by examining monthly precipitation data, their means and distribution, and variations for the Columbia, Missouri area. The second objective is to demonstrate how such information can be incorporated into weather broadcasts in order to provide the public with a more informative presentation.

2. Data and Methodology

a. Data

The data used in this brief study are the monthly precipitation records for Columbia, Missouri from January

1890 to December 2007. These data were obtained from the Missouri Climate Center. This temporal period was chosen since this period provided a larger data set for the statistical analysis. Also, this 118-year period provides for a continuous record for the precipitation information, and, as such, there was no need to artificially fill in missing precipitation data. In this study, data from the Columbia region were chosen since the results found here could be incorporated into local weather broadcasts. Also, precipitation observations have been taken from the locale named above over the duration of the last 38-year period. Only one change in the instrumentation was made in 1996, when the Automated Surface Observation Station (ASOS) instrumentation was installed. However, the airport did change location around 1970. This station moved approximately 22 km south-southeastward, but there are no indications that this move resulted in significant changes in the precipitation climatology (not shown). Before 1970, precipitation records were synthesized from records taken at the Columbia Municipal Airport (1930 – 1969) and an observation station in Columbia, MO (1890-1951). Each of the previous stations was located within the city limits. Lastly, the precipitation data and the calculations used in this study carried units of inches since that is still the standard unit for precipitation measurements in the United States, and is still the standard unit for precipitation used in weather broadcasts.

b. Methods

The initial step required that the monthly precipitation information for the 118 year period, 1890 – 2007, was used to generate the statistics discussed here. Based on these monthly precipitation records, the average monthly precipitation values were generated for each month of the year, along with the standard deviations (Table 1). These were then tested in order to determine whether or not a normal or Gaussian distribution would best represent these data. Figure 1 shows a histogram generated for one month and binned in 0.5 inch intervals. Inspection would reveal that this distribution is not Gaussian, and thus another distribution was needed to fit to the data. The observed distribution was tested in order to determine if it followed a standard normal distribution at a statistically significant level, using the chi-square goodness-of-fit test (e.g., Neter et al. 1988). The statistical testing reveals that the observed distribution is not the same as (different from) the normal distribution at the 99% confidence level.

Comparing, however, the observed data to a gamma distribution for statistical testing reveals that the distributions are similar at the 95% confidence level. A gamma distribution was fitted using the standard
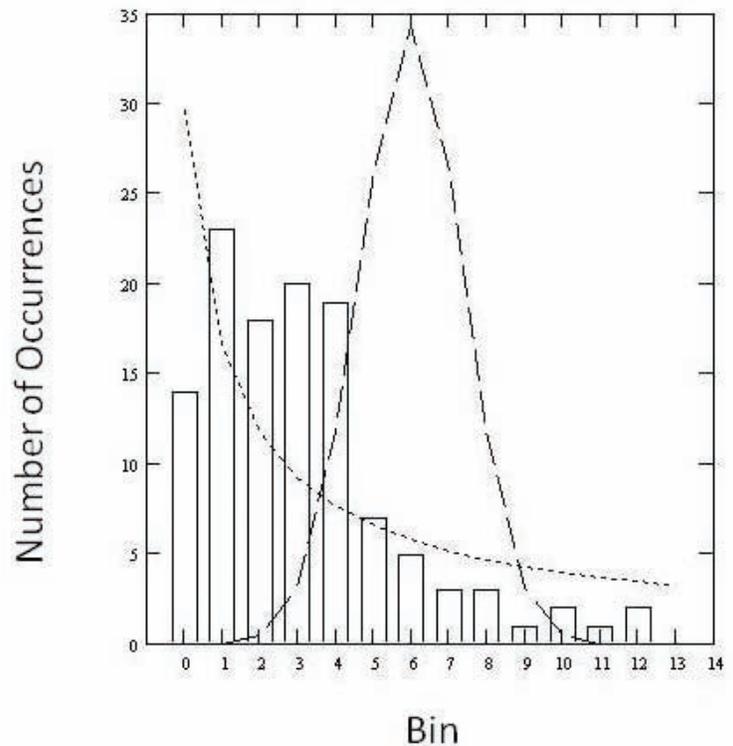

Fig. 1. Binned monthly precipitation amounts (bars) for each January from 1890 – 2007. The first bin on the left is monthly precipitation amounts from 0 – 0.50 inches, and each bin is successively 0.50 inches greater. The dotted line represents a fitted gamma distribution, while the long dashed line represents a normal or Gaussian distribution.

Month	Average Precipitation	Standard Deviation
January	1.85	1.38
February	1.88	1.19
March	2.93	1.68
April	3.87	2.08
May	4.77	2.32
June	4.49	2.56
July	3.50	2.16
August	3.76	2.42
September	4.14	2.83
October	3.01	2.03
November	2.48	1.79
December	2.00	1.31

Table 1. Calculated monthly average precipitation and standard deviations (inches) for the base period 1890 – 2007, using monthly precipitation data from the Columbia, Missouri Regional Airport.

parameters for the gamma probability density function following Guinan (2004) (see also Stephenson et al. 1999):

$$f(x,\alpha,\beta) = \frac{1}{\beta^\alpha \Gamma(\alpha)} x^{\alpha-1} e^{-\frac{x}{\beta}} \qquad (1)$$

where x represents a bin value, and α and β are parameters needed to calculate the distribution and are as follows:

$$\alpha = \frac{1}{4} A \left[1 + \left(1 + \frac{4A}{3} \right)^{0.5} \right] \qquad (2a)$$

$$A = \ln(\bar{x}) - \sum_{i=1}^{n} \frac{\ln(x_i)}{n} \qquad (2b)$$

$$\beta = \frac{\bar{x}}{\alpha} \qquad (2c)$$

where α controls the shape of the distribution (shape parameter), and β is the scale parameter. The parameter α controls whether the distribution takes on the form of a skewed normal distribution, or appears more like the tail of a normal distribution (see Fig. 1).

Table 2 shows the monthly values of α and β for our data set, which demonstrates that these parameters do vary significantly throughout the year. Values of α and (β) are relatively low (high) during the wettest months
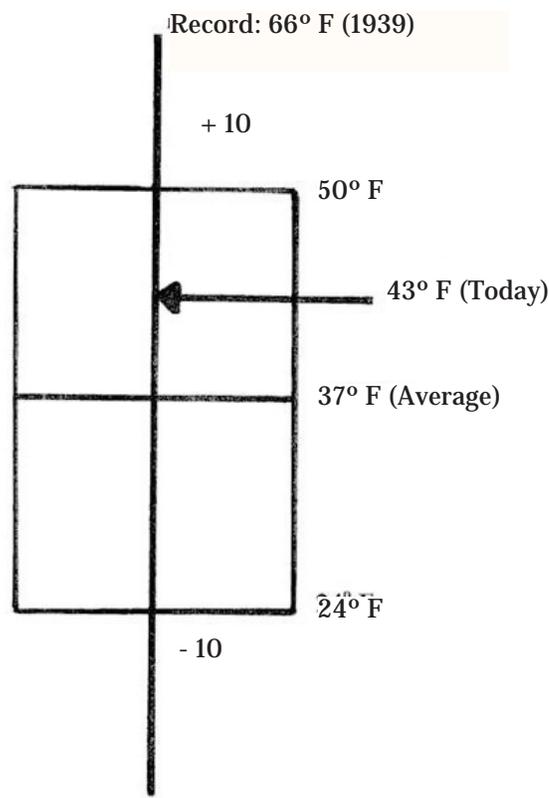
(April and May) when the distribution would be expected to extend farther along the abscissa. Our values here are not consistent with Guinan (2004), who used gamma distributions for two week periods to examine drought; but our values for α are more consistent with Stephenson et al. (1999). They studied the frequency and amounts of monsoonal precipitation events in India. Our winter month values for α and β were consistent with a study of precipitation frequencies from the University of Bergen in Norway (see http://www.uib.no/people/ngbnk/kurs/notes/node31.html).

Clearly, the Tukey box-plot (e.g., Fig. 2 – adapted from Lupo et al. 2003) which is typically based on normally distributed data would not be the proper basis for a precipitation graphic, and further discussion below will illustrate this point. Another strategy is proposed here which bases the graphic on the division of the observed data into quintiles. The new graphic is described in the next section. Using observed data allows for yearly adjustment of the values in Table 3, if necessary. Additionally, the gamma distributions were generated and tested versus the observed distribution using commercially available software such as spreadsheets and mathematical / statistical software.

High Temperature: January 4, 2002

Typical Temperature Range

Month	α (shape parameter)	β (scale parameter)
January	0.163	11.34
February	0.128	14.43
March	0.166	33.52
April	0.073	53.24
May	0.065	73.27
June	0.116	38.53
July	0.118	29.75
August	0.156	24.05
September	0.148	27.96
October	0.124	24.19
November	0.155	16.02
December	0.110	18.19

Table 2. Calculations of the monthly parameters for α and β from Equations 1 and 2 for the monthly precipitation for the base period 1890 – 2007, using monthly precipitation data from the Columbia, Missouri Regional Airport.

Fig. 2. Suggested templates for incorporating seasonal standard deviation information into weather graphics depicting daily temperature observations [adapted from Lupo et al. 2003 - a Tukey box plot (Tukey 1977)].

Month	First Quintile	Second Quintile	Third Quintile	Fourth Quintile	Record
January	0.82	1.22	1.91	2.48	6.87
February	0.90	1.40	1.97	2.50	6.80
March	1.51	2.41	3.04	3.72	10.09
April	2.16	2.86	4.21	5.07	11.69
May	2.89	4.05	4.94	6.21	13.34
June	2.35	3.30	5.02	6.71	14.86
July	1.70	2.69	3.72	4.97	12.14
August	1.45	2.80	4.08	5.83	10.19
September	1.75	2.99	4.33	5.79	13.34
October	1.37	2.17	2.86	4.38	13.44
November	1.00	1.64	2.49	3.81	10.42
December	0.99	1.46	1.94	2.72	7.82

Table 3. The calculated values for the maximum precipitation value (inches) for each quintile. The record value represents the top of the fifth quintile (100%).

3. Results and Graphical Depiction

a. Results and Discussion

Figure 3 shows the proposed template for a new graphic. The monthly precipitation data for any month could be classified as within the range of "normal" (20% of the data, the third quintile – Table 3). The second and fourth quintiles would represent below and above average rainfall for that month, respectively. The first and fifth quintiles could represent extremely dry and wet conditions, respectively. Finally, a record wet month could also be represented as extremely wet. Two strategies could be used in representing this kind of information, and these will be described below. Note also that the graphic could be color coded in a way that would be consistent with the color of land or the vegetation during dry or wet conditions, or colors that are associated with, for example, water (extreme wet). This suggested color scheme also corresponds roughly to the natural color spectrum, but alternative schemes could be experimented with and then implemented to better convey the information (e.g., Brewer 2005). Additionally, the graphic could be made more viewer-friendly by using a rain gauge image in a similar manner that Holder et al. (2006) showed the use of a thermometer in their temperature graphic (Fig. 4).

Probability Density Functions (PDF) for the entire 118-year period and for each month were tested as opposed to PDFs for individual days or seasons since precipitation is archived as monthly totals. Since precipitation does not occur every day, the daily precipitation information (for individual calendar days)
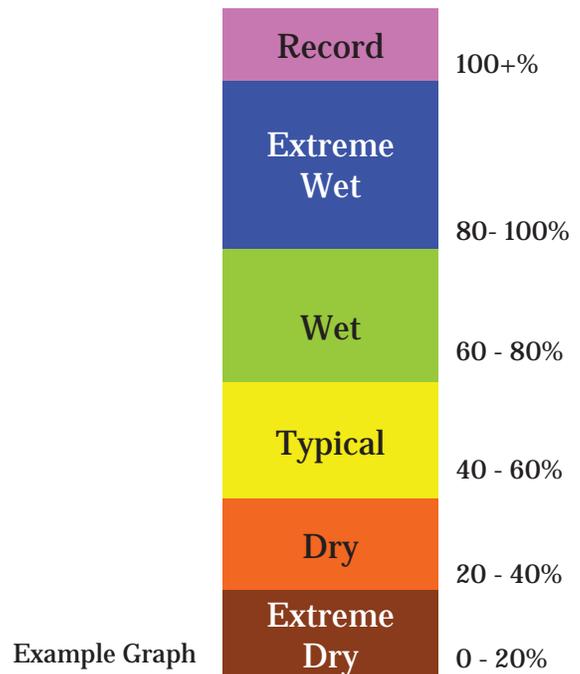

Fig. 3. A proposed sample template for a new precipitation amount graphic.

Fig. 4. A second proposed sample template for a new precipitation amount graphic with data from January 2005.

over a 30-year climatic averaging period would represent a small sample from which it might be difficult to obtain statistically meaningful results. Similar to temperature anomalies, precipitation anomalies for each month can be viewed as being produced by the cumulative impact of a set of random synoptic-scale disturbances guided by quasi-randomly generated large-scale flow regimes which may be strongly influenced by the underlying surface of the earth (e.g., Lupo et al. 2007 and references therein).

However, summer-season flow regimes may possess different kinematic and dynamic characteristics from winter-season flow regimes over North America. Data sets which are produced by two different forcing regimes, and which also produce clearly differing distributions (if analyzed separately) are called "mixed distributions" or "mixture distributions" (e.g., Wilks 2006). In order to minimize this problem of differing seasonal flow regimes, the data sets were analyzed monthly over the 118 year period. This same assumption does not preclude the use of seasonal statistical results instead of, or in addition to, the monthly data sets.

In displaying precipitation information, it would be useful to show some measure that represents a typical range of monthly values or the typical variability for a particular month. Most television broadcasts only show the monthly accumulated precipitation and compare this to the monthly mean total, or a portion of this value that depends on how much of the month has already past. However, when examining the gamma distributions for each month, it is revealed that the mean value is commonly near the top of the third quintile (compare Tables 1 and 3), or in the case of October – December (see Table 3) is at the top of this quintile or even into the fourth quintile. Then, the implication of comparing observed precipitation to the arithmetic mean is that in the fall, most months

will appear to the viewer to be dry (drier-than-normal), or conversely, an "average" month is actually one of the wetter months historically. Thus, comparing monthly precipitation to an average value is misleading.

Some television broadcasts show the record monthly high and low precipitation amounts, but typically only when the month approaches a record. These represent in a statistical sense (and loosely in a physical sense) the absolute range of the precipitation amounts that may be expected for a given location for a given month. Here, the graphic we chose (Figs. 3 and 4) is based on variability. Lupo et al. (2003) chose to use standard deviation (σ), which represents a measure of absolute variability in a data set (in their case, the 30-year daily temperature anomalies). For data set that is normally distributed, σ can be used to construct an interval (range) about the mean for which approximately 68% of the data points in a particular set of data should reside.

By using quintiles, we followed the method used by Guinan (2004), and the frequency of extreme events (1st and 5th quintile) will be similar to that of Lupo et al. (2003) or Holder et al. (2006), or would occur less than 50% of the time. Using January 2005 (Figs. 4 and 5) as an example would show that 5.94 inches of rain fell at the Columbia Regional Airport. This is shown in comparison to the monthly mean 1.85 inches and clearly depicts that January 2005 was extremely wet, occurring only 20% of the time, or once every 5 years; the range of which is 2.48 - 6.87 inches. This demonstrates also that January in this region of the country is usually quite dry. Over the course of a year, the astute viewer / weather observer would realize that winter in this region is the driest time of the year (Tables 1 and 3).
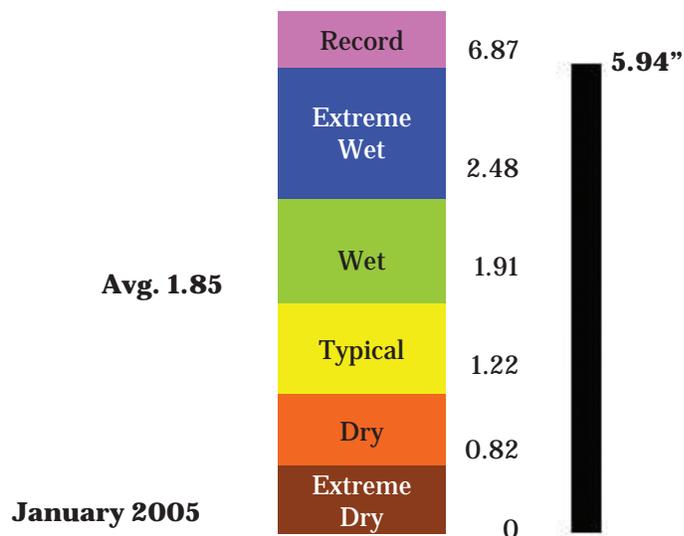

Fig. 5. The generic template from Fig. 3 with data from January 2005. All precipitation amounts are shown in inches.

b.   Application

In the previous section (3a), it was stated that two strategies could be used when applying this graphic. The first is to simply accumulate the daily precipitation data, and the regular viewer would watch the monthly precipitation increase versus the historical record. This method would be simple to apply and would not require daily maintenance of the graphic. The second strategy would involve identifying each of the quintile values on the right hand side of the plot and dividing these by the number of days in a month, and then tallying up the rain daily as well as "stretching" out (re-calculating) the numbers on the ordinate of the graph with each passing day. The latter is recommended, since this would account for the fact that months could become progressively drier or wetter during the month, or as shown in Figs. 6a-c for March 2005, the month stays extremely dry in spite of the occurrence of precipitation on two different occasions. Fig. 6a shows the graphic as it would appear on 10 March, and as no precipitation occurred during the next ten days, Fig. 6b shows the graphic as it would have appeared on 20 March. Finally, Fig. 6c shows the graphic as it would have appeared for the end of that month. Note that the numbers on the right side of the graphic grew progressively larger as the month progressed. Additionally, Figs. 7a-c shows an example during a month in which precipitation categories changed from a dry month early to a record wet month by mid-month.

Such information could be presented as in Fig. 6 and 7 without the need to explain to the general public the concept of standard deviations, quintiles, and other statistical concepts. A similar display to these figures, showing seasonal or annual means, could be considered as well for the presentation of this kind of information.
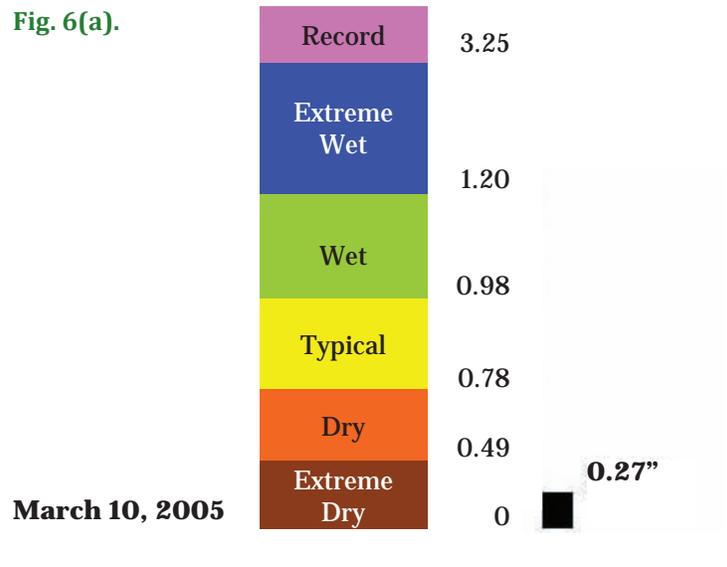
Fig. 6(a).

March 10, 2005

Fig. 6(b).

March 20, 2005

Fig. 6(c).

March 2005

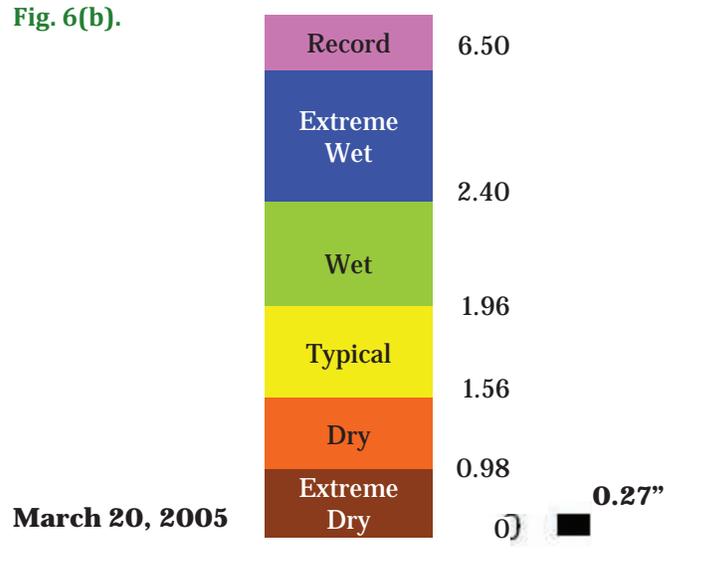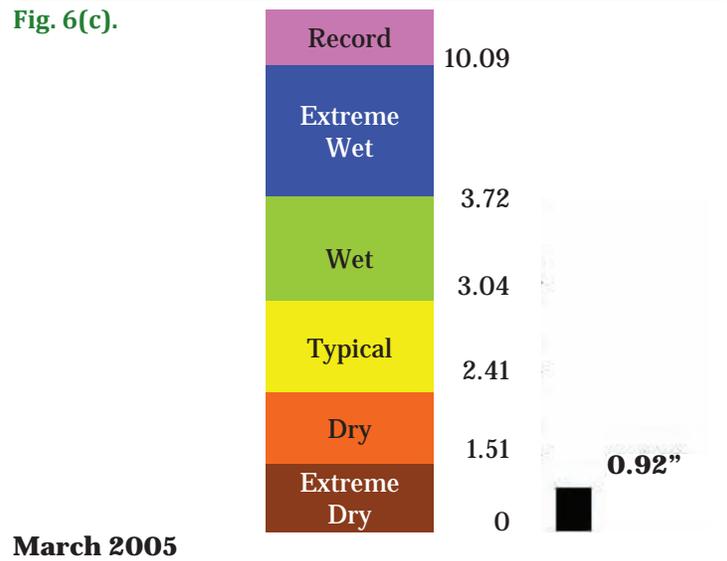**Fig. 6.** As in Fig. 5, except for March 2005. This figure shows a monthly progression for a) March 10, b) March 20, and c) the end of the month.
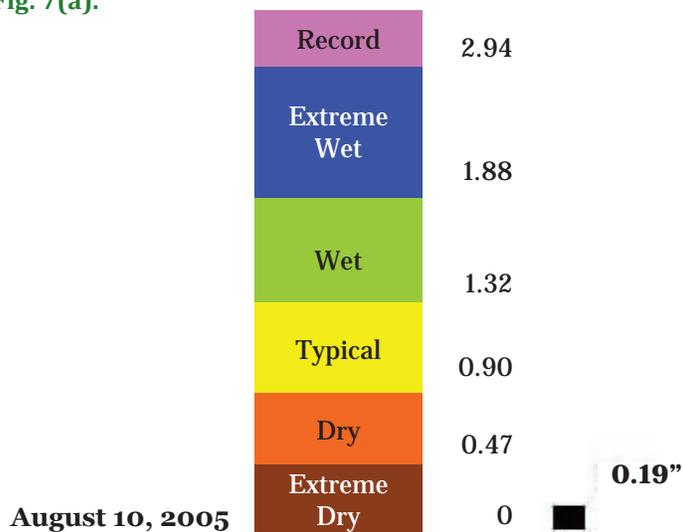
Fig. 7(a).

Record	2.94
Extreme Wet	1.88
Wet	1.32
Typical	0.90
Dry	0.47
Extreme Dry	0

0.19"

August 10, 2005

Fig. 7(b).

Record	5.88
Extreme Wet	3.74
Wet	2.64
Typical	1.80
Dry	0.94
Extreme Dry	0

6.24"

August 20, 2005

Fig. 7(c).

Record	9.10
Extreme Wet	5.83
Wet	4.08
Typical	2.80
Dry	1.45
Extreme Dry	0

Avg. 3.76

10.19"

August 2005

Fig. 7. As in Fig. 5, except for August 2005.
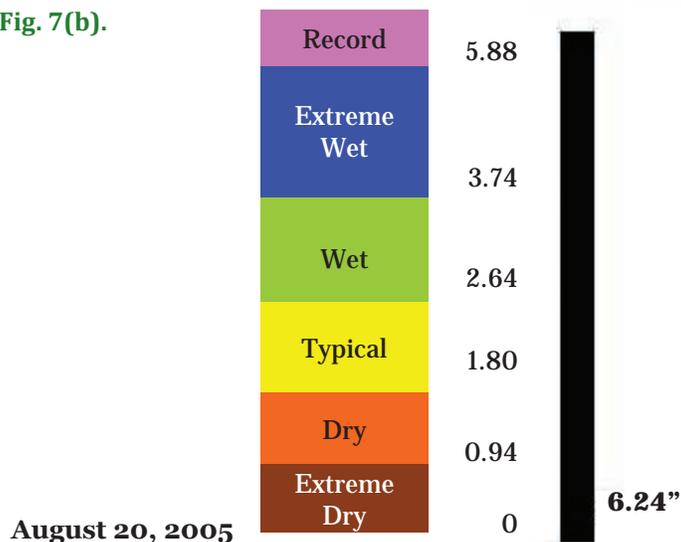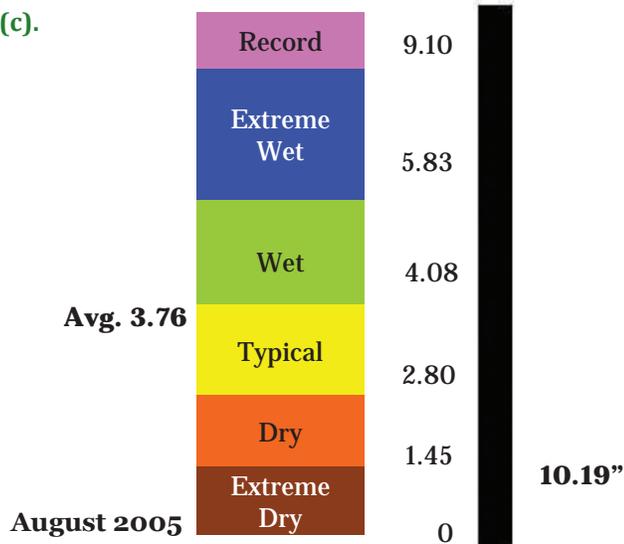
4. Summary and Conclusions

In this study, the statistical properties of the 118-year record (1890-2007) of monthly precipitation observations for Columbia, Missouri, were examined with the goal of providing more information about the representativeness of observed monthly precipitation amounts with respect to climatological means for presentation in television weather broadcasts. The data used in this study were obtained from the Missouri Climate Center and analyzed using standard statistical techniques. A 118-year period was chosen because the record for this time period has been continuous and is long enough to present a reasonable sample size for each month.

In general, it was found that maximum and minimum monthly precipitation in the 118-year period occurs during the warm and cold seasons, respectively. For each month, the data were fitted to a gamma distribution which provided a better match than a normal distribution as was used for the mean temperature values by Lupo et al. (2003) and Holder et al. (2006). Quintiles were then used as a measure of variability, and these were applied to the monthly samples. The third quintile was considered "typical", while the second and fourth quintiles were considered dry and moist, respectively. Together, these three quintiles constituted 60% of the observations. The first and fifth quintiles were considered extremely dry and moist, respectively.

This information was incorporated into routine television weather broadcasts at KOMU and KSNT, the NBC affiliates in Columbia, Missouri and Topeka, Kansas, respectively, beginning with the fall of 2007. Meteorologists and weather broadcasters created graphics that used the monthly climatological values of precipitation. Thus, the viewer will not only see how observed precipitation compared to that which is typical rather than the mean, but how representative these observations were within the historical context for this region. In an era when weather information is presented more and more often, information regarding a typical range for precipitation can be used to separate unusual monthly accumulations of precipitation from those that are more typical.

Authors

Thomas E. Hagen is a currently the morning meteorologist at KSNT-TV in Topeka, Kansas. His bright personality and involvement with the community has made him a popular and respected meteorologist in Northeast Kansas. A proud member of the AMS, he is pursuing his Certified Broadcast Meteorology Seal of Approval. Tom received his Bachelor's degree in Atmospheric Science from the University of Missouri-Columbia. This is Tom's first publication.

Justin M. Glisan is a Ph.D. candidate at Iowa State University. Prior to his arrival at Iowa State, he graduated from the University of Missouri (MU) where he earned both his BS and MS in Atmospheric Science. While at MU, his research aided in the understanding of persistent blocking flows and the development of a diagnostic for forecasting the onset and dissipation of large scale positive 500-hPa geopotential anomalies. These atmospheric flow features have been shown to cause substantial changes in both temperature and precipitation regimes, as detailed in his MS thesis "Two cases of extreme blocking over Europe and North America." As a PhD candidate at Iowa State, his research involves simulations and modeling of the Arctic using the Pan-Arctic WRF model. Specifically, this research will entail dynamical analysis of extreme and persistent features in both the present and future climate states and how their dynamics evolve temporally. Eventually, this work will include a DOE-funded coupled atmospheric/land-surface/sea-ice/ocean model in collaboration with research groups at Colorado, Washington, the Naval Post Graduate School, and the Arctic Region Supercomputing Center.

Anthony R. Lupo is a Professor and Chairman of the Department of Atmospheric Sciences in the Soil, Environmental, and Atmospheric Sciences at the University of Missouri. His research has been in the areas of large-scale atmospheric dynamics, climate dynamics, and climate change. His current teaching assignments include the dynamic meteorology sequence, the climatology sequence, and general circulation. He has been a Fulbright Scholar, studying climate change at the Russian Academy of Sciences in Moscow. He is also a contributing scientist and reviewer for both the United Nations (UN) World Meteorological Organization (WMO) Intergovernmental Panel on Climate Change (IPCC), and the Nongovernmental International Panel on Climate Change. He received his MS and Ph.D. degrees in Atmospheric Science from Purdue University in West Lafayette, IN. In service to the National Weather Association, Dr. Lupo is the co-editor of the National Weather Digest and serves on the Education Committee and the Publications Committee.

Eric M. Aldrich graduated from the Soil and Atmospheric Science Department in 2001 with a B.S. degree. He is currently the morning meteorologist with University of Missouri NBC affiliate in Columbia, MO, KOMU – TV8. He entered the M.S. program with Soil, Environmental, and Atmospheric Science in the fall semester of 2008. He is also an instructor with the department and has taught courses in Introductory Meteorology, Weather Briefing Lab, and Broadcast Meteorology. Eric also received the Best Weathercast Award for 2009 in Missouri.

Patrick E. Guinan attended the University of Illinois in Urbana-Champaign where he received a B.S. in physical geography in 1986 and an M.S. in atmospheric science in 1988. He came to the University of Missouri to continue his education in atmospheric science and serve as a climatologist with the Agricultural Experiment Station. Since 1996, he has been employed by the University of Missouri's Extension Commercial Agriculture Program as a climatologist. Pat received his Ph.D. in Soil, Environmental and Atmospheric Sciences in 2004 and, in addition to his Extension and campus activities as an Assistant Professor in Climatology, he serves as the State Climatologist for Missouri and Director of the Missouri Climate Center. Pat also maintains and operates the Extension Commercial Agriculture Automated Weather Station Network which consists of 29 automated weather stations in Missouri that monitor several environmental variables on a 5-minute, hourly and daily basis.

Patrick S. Market is an Associate Professor of Atmospheric Science at the University of Missouri-Columbia. He earned his BS in meteorology from Millersville University of Pennsylvania in 1994, and his MS and Ph.D. degrees from Saint Louis University in 1996 and 1999, respectively. Dr. Market's current teaching assignments include the synoptic meteorology sequence, mesoscale meteorology, and the daily forecasting practicum. His research explores issues in heavy rain and snow forecasting, including the occurrence of thundersnow, and the precipitation efficiency of mesoscale convective systems. In service to the National Weather Association, Dr. Market has served as a Council member, Co-editor of the National Weather Digest, a tape evaluator for the Broadcast Meteorology Committee, and a Co-Chair of the Weather Analysis and Forecasting Committee.

Neil I. Fox: Neil Fox is an Associate Professor in the Department of Atmospheric Sciences in the Soil, Environmental, and Atmospheric Sciences at the University of Missouri. His research focuses on radar meteorology, precipitation and nowcasting, as well as

studies of boundary layer winds. His current teaching assignments include radar meteorology, remote sensing, atmospheric physics and micrometeorology. He received an MPhil from Reading University and his Ph.D. from the University of Salford, both in the UK. Dr. Fox has previously served on the Remote Sensing Committee of the National Weather Association.

References

Brewer, C., 2005: *Designing Better Maps: A Guide for GIS Users*. ESRI press, 203 pp.

Changnon, S.A., and K.E. Kunkel, 1999: Rapidly expanding uses of climate data and information in agriculture and water resources: Causes and characteristics of new applications. *Bull. Amer. Meteor. Soc.*, 80, 821 - 83.

Del Genio, A.D., M-S. Yao, and J. Jonas, 2007: Will moist convection be stronger in a warmer climate? *Geophys. Res. Lett.*, 34, L16703, doi: 10.1029/2007GL030525.

Guinan, P.E., 2004: A seasonally adjusted index for projecting agricultural drought. Ph.D. dissertation. University of Missouri, 144 pp.

Holder, C., R. Boyles, P. Robinson, S. Raman, and G. Fishel, 2006: Calculating a daily normal temperature range that reflects daily temperature variability. *Bull. Amer. Meteor. Soc.*, 87, 769–774.

Kunkel, K.E., R.A. Pielke Jr., and S.A. Changnon, 1999: Temporal fluctuations in weather and climate extremes that cause economic and human health impacts: A review. *Bull. Amer. Meteor. Soc.*, 80, 1077 - 1098.

Lupo, A.R., E.P. Kelsey, E.A. McCoy, C.E. Halcomb, E. Aldrich, S.N. Allen, A. Akyuz, S. Skellenger, D.G. Bieger, E. Wise, D. Schmidt, and M. Edwards, 2003: The presentation of temperature information in television broadcasts: What is normal? *Natl. Wea. Dig.,* 27:4, 53 -58.

_____, _____, D.K. Weitlich, I.I. Mokhov, F.A. Akyuz, Guinan, P.E., J.E. Woolard, 2007: Interannual and interdecadal variability in the predominant Pacific Region SST anomaly patterns and their impact on a local climate. *Atmosfera,* 20, 171- 196.

Neter, J., W. Wasserman, and G.A. Whitmore, 1988: *Applied Statistics. 3d ed*. Allyn and Bacon Press. 2,029 pp.

Stephenson, D.B., K. Rupa Kumar, F.J. Doblas-Reyes, J.F., Royer, F. Chauvin, and S. Pezzulli, 1999: Extreme daily rainfall events and their impact on the ensemble forecasts of the Indian Monsoon. *Mon. Wea. Rev.,* 127, 1954 – 1966.

Tukey, J. W., 1977: *Exploratory Data Analysis*, Addison-Wesley. 688 pp.

Ungar, S., 1999: Is strange weather in the air? A study of U.S. national network news coverage of extreme weather events. *Climatic Change*, 41, 133-150.

Wilks, D. S., 2006: *Statistical Methods in the Atmospheric Sciences.* Academic Press, 627 pp.