Design of an Innovative Probability Plotting Position For a 73 Year Precipitation Data (1940-2012) of El Paso County, Texas, U.S.A

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Abstract

This research established a tridimensional probability plotting position, as a function of annual precipitation data, probability of occurrence and return periods. The study determined the gamma distribution to be the most suitable one fitting the data, using the Minitab computer program based on the value of the Anderson-Darling test, which turned out to be 0.271. Afterwards, this method constructed a probability graph going as a function of precipitation values, probability of occurrence and return periods. This novelty approach has an advantage over the traditional plotting positions methods, because it first identifies the right probability distribution and, on that graph constructs a probability plotting position, as a function of precipitation data, probability of occurrence and return periods. This task was done without relying on the traditional assigning of ranges to the data (that not always follow the normal distribution), and the use of empirical formulas. It is concluded that this approach is more precise and reliable than the traditional plotting positions methods, because it determines optimum estimates for return periods and occurrence probabilities that helps in the construction of prime hydraulic projects.

Keywords: Probability plotting positions formulas; Probability graphs; Anderson-Darling goodness of fit test; Minitab computer program; gamma continuous probability distribution; periods of return; probabilities of occurrence; precipitation data for El Paso County, Texas; Hazen, Cunnane, Weibull, Adamowski, Bloom, Gringorten, Beard probability plotting positions

1. Introduction

In this study applied statistics and graphical methods to establish a probability plotting position for the precipitation data of El Paso, Texas, U. S. A., which consisted in the processing of a sample data of 73 years (1940-2012). The study applied several statistical functions, as descriptive statistics to calculate measures of central tendency and measures of variability. It also calculated cumulative and density probabilities, to compute probabilities of precipitations. Too, the methodology attempted different probability graphs to calculate probability distributions that best fit the data, using the Minitab computer program which determines the right continuous probability distribution based on the value of the Anderson-Darling test. From there-on, this framework constructed a probability plotting position going as a function of precipitation values, periods of return or recurrence intervals (formula $T = 1/P$, where T is the return period and P is the probability of occurrence or the probability that an event of a specified magnitude will be equaled or exceeded during a one year period). In general, the period of return is an estimate of the likelihood of an event, such as a hurricane, tornado, earthquake, flood, storm, precipitation or a river discharge flow to occur.

Besides, the return period is a statistical measurement based on historic data denoting the average recurrence interval over an extended period of time (10, 20, 50, 100 years and so on).

This assessment is used in the evaluation of risk analysis, that is, to decide whether a hydraulic project should be allowed to go forward in a zone of a certain risk, or to design safely structures to withstand an extreme climatic event, with a certain return period.

Regarding plotting positions applied to hydrological problems, there are many studies written on the subject. For example, Ahmad ShukriYahoya et al. (2012), discuss the application of probability plotting positions for the Gumbel distribution. They also list several plotting positions as the Adamowski, Bloom, Cunnane, Gringorten, Hazen, Beard and so on. Also, M. De (2000) discusses a new unbiased plotting position formula for the Gumbel distribution, and affirms that the developed formula better approximates the exact position as compared to other existing formulae. Moreover, Looney et al. (1985) discuss the problem of choosing a plotting position to be used in constructing a normal probability plot. These investigators emphasize the choosing of a plotting position, so that the resulting graph is best able to identify departures from normality. Still further, Cunnane (1978) discusses his criterion for choosing plotting positions in his work entitled *Unbiased plotting positions A Review*. Furthermore, Quevedo (2013)in his book of statistical applications to hydrology (*Aplicaciones de Probabilidad y Estadística a Problemas de Hidrología. El Cambio Climático y sus Efectos en los Recursos Hidrológicos*) devised a methodology to construct a tridimensional probability plotting position going as a function of hydrological data, probability of occurrence and periods of return.

His method consisted in using the Minitab computer program, by first identifying the best continuous probability distribution representing the data (which in this case turned out to be the gamma distribution) and, from thereon, by constructing a probability plotting position. This unique approach has an advantage over the traditional plotting positions methods because, it first identifies the right continuous probability function and, then, by relying on this result, the procedure served to construct the probability plotting position, as a function of precipitation data, probabilities of occurrence and periods of return. This method did this task, without relying on the traditional allocation of ranges to the data (that not always fits the normal distribution, but some other continuous probability distribution as Gamma, Weibull, Lognormal, Gumbel, etc.), and the use of empirical formulas, to calculate the probabilities of occurrence and periods of return. However, the probability plotting position scheme presented in this research paper was designed to serve as a guide for the selection of any return period, by interpolating the precipitation data and the probability of occurrence. These probability plotting positions provide important information to the hydraulic and civil engineers in the construction of prime hydraulic structures, to minimize damages and risks, to protect the well-being of the public, in cases of extreme events caused by climatic changes brought about by the underway global warming.

Further, regarding periods of return, Ponce (2013) discusses the periods of return and the guidelines for the selection of appropriate return periods. For example, he says that for urban drainage of medium risk, a period or return of 25 to 50 years is appropriate. He also affirms that for levees of high risk, the period of return should be from 200 to 1000 years.

About precipitation data, the National Weather Service Weather Forecast Office gives information on rainfall events and all time heavy snowfalls events. Moreover, the National Weather Service Weather Forecast Office gives additional information on the historic precipitation data corresponding to the El Paso, Texas area.

2. Materials and Methods

The methodology used in this research was accomplished by using the values of the precipitation data shown in Table 1. This table shows the time, in years, starting from 1940 to 2012. It also shows the monthly values for each of the 73 years sample data and the cumulative precipitation values. The methods used here consisted in the application of statistical functions, as for example, descriptive statistics to calculate measures of central tendency (as the mean, median, quartiles, etc.) and measures of variability (as the variance, standard deviation, skewness, etc.) and confidence intervals for the mean and median, to check for the symmetry of the data. This information is shown in Figure 1. Further, the procedure consisted in calculating density probabilities (see equation 1 below) and cumulative probabilities (see equation 2 below) and the plotting these values, as shown in Figure 2 using the values of Table 2.The next step consisted in going through a trial-and-error procedure to identify the appropriate distribution, as the normal, lognormal, gamma, Weibull, Gumbel, etc. Then, the next phase involved the examining the smallest values of the Anderson-Darling (A-D) statistical function that identifies the best fitting distribution, which in this case turned out to be the gamma distribution, with an A-D value of 0.271, as shown in Figure 3.

The following step entailed the construction of the probability plotting position, as a function of precipitation data, probability of occurrences and periods of return, as shown in Figure 4. To do this task, the procedure consisted in modifying Figure 3, by manipulating the values and the positions of the graph axes.

For example, the technique encompassed the transposing the vertical axis (the one containing the probability values), for the horizontal axis (the one containing the precipitation data values). The next step consisted in reversing the probability values of the horizontal axis. Then and there, the next step consisted in manipulating manually the corresponding calculated periods of return (the reciprocal of the probabilities of occurrence). In this way, the upper horizontal axis was constructed. All these manipulations are explained in detail in the book of Quevedo (2013), where he applied probability and statistics to problems in hydrology to construct tridimensional probability plotting positions.

As said before, the gamma distribution was the tool used in this paper aimed to construct a probability plotting position. This gamma function can be broadly defined as a moderately skewed distribution and can be used as a workable model for climatic conditions as precipitations and can be used in risk calculations. There are different cases of gamma distribution. Thus, if the shape parameter has to be one, and the scale parameter equals the mean interval between the defined events then, the gamma distribution will be modified to an exponential distribution. Also, if the shape parameter is taken as the degree of freedom divided by 2, and if the scale parameter is taken as 2, then the gamma distribution is changed to chi squared distribution, etc.

The probability density function of the gamma distribution can be defined as:

$$f(x) = \begin{cases} \frac{x^{\alpha-1}e^{-x/\beta}}{\beta^{\alpha}\Gamma(\alpha)} x \geq 0 \\ 0 \end{cases} \quad (1)$$

Otherwise

Where α is the shape parameter, $\beta$is the scale parameter and Γ is the gamma function defined as:

$$\Gamma(\alpha) = \int_0^{\infty} x^{\alpha-1}e^{-x}\,dx \quad \text{for } \alpha > 0 \quad (2)$$

Similarly, the cumulative probability function of the gamma distribution is:

$$p = F(x;\alpha,\beta) = \frac{1}{b^{a}\,\Gamma(\alpha)}\int_0^{x} t^{\alpha-1}e^{-t/\beta}\,dt \quad (2a)$$

The *p*is the cumulative probability function of the gamma distribution, with historical shape parameters (α) and scale parameter (β) and where$\Gamma(\alpha)$ was already defined. In fact, the logic of the Minitab computer program uses equations (1) and (2) to calculate the cumulative and density probabilities as shown in Table 2.

3. Results

Figure 1 depicts the results of a mean annual precipitation value of 11.097 and standard deviation of 3.884. Moreover, as judged by the skewness value of 0.3574, the distribution is slightly tilted to the right. Likewise, the 95% confidence interval for the mean ($10.191 < \mu < 12.004$), says that the mean is contained in the interval, 95% of the time and 5% of the time off, and so on. In regard to the calculation of the density and cumulative probabilities of the gamma distribution, the results are shown in Table 2.The graphs corresponding to the values of Table 2 are shown in Figure 2. It can be seen that any probability value corresponding to any precipitation data can be easily calculated using Table 2. For example, if it is desired to calculate the probability for a precipitation of 13 inches, mathematically, the result is, $P(X = 13) = 0.076976$. Similarly, the probability for a precipitation of at least 8.45 inches this can be exemplified as $P(X \geq 8.45) = 0.7299$. Also, the probability of getting a precipitation, of no more than 20.16 inches, the result is $P(X \leq 20.16) = 0.9760$. Too, if it is desired to calculate the probability between 13.31 and 15.84 inches, of rain inclusive, it is written as $P(13.31 \leq X \leq 15.84) = 0.1400$, and so on. Here, however, we note that these probabilities can also be calculated by interpolation, using Figure 2 and Figure 3, though, with less precision.

Furthermore, through the use of the Minitab computer program, this research identified the best continuous probability distribution that fits better the precipitation data which, in this case, turned out to be the gamma distribution, with a resulting value of the Anderson-Darling goodness of fit test equal to 0.271. This value is the lowest one obtained after trying the normal, lognormal, Weibull, Gumbel, etc., distributions. As observed in Figure 3, the results show a 95% band confidence interval band, with historical shape and scale parameters equal to 7.921 and 1.401, respectively. This figure also shows an A-D value equal to 0.271 and a P-value > 0.250.

Still further, about the construction of the probability plotting position, the resulting graph is shown in Figure 4. This figure shows the graph using as base, the gamma continuous probability distribution going as a function of precipitation data, probability of occurrence and periods of return. For example, if it is desired to predict a period of return, for a precipitation of 10 inches, the resulting corresponding probability of occurrence is about 0.6 and the period of return is about 1.7 years, and so on.

4. Discussions and Conclusions

The methodology and the results obtained in this paper suggest that, before one attempts to establish the probability plotting position that goes as a function of meteorological or hydrological values, probability of occurrence and return periods, it is of utmost importance the identification of the best continuous probability distribution that best fits the data (as the Gamma distribution in this case). Once we accomplish this task, then, and only then, we are in a situation to establish, with precision, the appropriate probability plotting position, following the methodology explained in this document. This novelty approach has advantage over the traditional plotting positions methods, because it first identifies the right probability continuous distribution, and then constructs the ideal plotting position, without relying on the assigning of ranges to the data(that not always follow the normal distribution), and use of empirical formulas to calculate the probabilities of occurrence and periods of return. It is concluded that the forward-looking approach presented in this research, to construct probability plotting positions is more precise and reliable than the customary or traditional plotting positions methods. It is determined that the choice of the best probability distribution fitting the data is of paramount importance, in the construction of the probability plotting positions, to determine the optimum estimate for return periods and occurrence probabilities of the data, to be used for hydrological risk analysis. That is, to decide whether a hydraulic project should be allowed to go forward in a zone of a certain risk, or in the design of structures, to withstand extreme climatic conditions, to protect the welfare of people.

Using a speculative intellectualism, extreme climatic events are going to be more and more common, due to the indiscriminate burning of fossil fuels that generate greenhouse gases. The excessive emission of these air pollutants emitted to the troposphere, is causing the global warming and the consequential climatic distortions affecting precipitation patterns or hydrological resources. To confront these present or future adverse situations, engineers will have to indorse their design criteria in the construction of hydraulic works, on more precise probability plotting positions, in the design of hydraulics structures. Hydraulic and civil engineers will have to do this duty, to minimize damages and risks, to protect the well-being of the public, in cases of exceptional events caused by climatic changes, which in turn, cause unstable adverse effects of precipitation patterns and extreme climatic events.

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List of Figures and Tables

Table 1: Table showing the time-frame of the data starting from 1940 to 2012 and the monthly and annual precipitation values expressed in inches.

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dic	A. P. (in)
1940	0.61	0.45	0.01	0.03	0.6	1.22	0.78	0.68	0.28	0.7	0.85	0.24	6.47
1941	0.52	0.48	1.62	1.04	1.31	0.42	1.49	2.78	4.39	1.45	0.42	0.46	16.36
1942	0.14	0.52	0.01	1.11	0	0.35	0.89	3.99	0.78	1.25	0	1.24	10.29
1943	0.23	0	0.11	0	0.1	1.44	1.09	0.43	1.5	0	0.90	0.66	6.46
1944	0.43	1.16	0.07	0.01	0.33	1.11	1.44	2.09	0.49	0.85	0.63	0.47	9.08
1945	0.17	0.08	0.80	0.26	0	0.02	0.73	0.84	0.09	3.59	0	0.05	6.62
1946	1.05	0	0.04	0.45	0.71	0.17	0.72	0.98	1.36	0.41	0.15	1.05	7.07
1947	0.94	0.01	0.34	0.46	0.76	0.6	0.46	1.8	0.67	0.54	1.06	0.93	8.54
1948	0.71	1.33	0.27	0.69	0.78	0.96	1.07	1.22	0.14	0.47	0.01	0.88	8.53
1949	2.42	0.74	0.37	0.48	0.75	0.72	1.4	0.56	1.72	2.68	0.04	1.15	13.0
1950	0.77	0.50	0.30	0.43	0.61	0.54	3.68	0.89	1.5	0.65	0.17	0.10	10.16
1951	0.66	0.91	0.83	0.14	0.06	0.43	1.16	1.4	0.71	1.23	0.50	0.43	8.45
1952	0.37	0.86	0.88	1.47	1.04	1.29	1.25	1.15	0.23	0	0.63	0.79	9.95
1953	0.33	0.91	0.32	1.4	1.26	0.26	2.88	0.59	0.11	0.62	0.39	0.74	9.82
1954	0.5	0.09	0.26	0.51	1.15	0.22	0.62	2.59	0.67	0.83	0.25	0.30	7.99
1955	0.73	0.48	0.47	0	0.19	0.10	3.1	0.92	0.16	1.15	0.11	0.03	7.45
1956	0.36	0.48	0	0.01	0	0.83	0.65	0.82	0.29	0.22	0.31	0.65	4.63
1957	0.77	0.81	0.63	0.81	0.54	0.53	1.45	1.86	0.55	2.51	2.57	0.28	13.31
1958	1.15	1.21	1.94	0.83	1.18	1.64	1.32	1.38	4.45	1.70	0.53	0.07	17.40
1959	0.28	0.49	0.47	0.65	0.61	0.96	0.60	1.53	0.17	0.83	0.55	0.75	7.90
1960	1.26	0.90	0.41	0.13	0.23	1.11	2.56	0.98	0.27	1.12	0.50	2.42	11.91
1961	1.06	0.36	0.89	0.15	0.27	1.24	0.92	1.17	1.33	0.28	1.86	1.37	10.91
1962	0.98	0.98	0.44	0.68	0.38	0.98	2.94	0.25	3.14	1.28	0.59	0.53	13.17
1963	0.23	0.58	0.08	0.48	0.29	0.54	1.88	1.71	1.34	0.59	0.97	0.33	9.01
1964	0.44	0.29	1.24	0.94	0.44	0.02	0.64	2.06	1.22	0.31	0.28	0.80	8.69
1965	0.39	1.13	0.57	0.11	0.93	0.71	0.58	1.67	2.28	0.21	0.22	1.18	9.98
1966	0.77	0.80	0.23	1.39	0.63	3.12	0.96	3.27	1.19	0.40	0.14	0.51	13.42
1967	0.15	0.59	0.17	0.24	1.20	1.76	2.20	1.08	0.74	0.37	0.50	1.38	10.38
1968	1.26	1.34	1.12	0.88	0.98	0.45	3.89	3.67	1.12	0.26	2.03	1.08	18.07
1969	0.09	0.66	0.67	0.51	0.91	0.31	1.63	0.78	1.59	0.82	1.52	0.63	10.14
1970	0.02	0.60	0.45	0	0.39	1.16	1.82	1.81	1.07	1.37	0.26	0.32	9.27
1971	0.25	0.41	0.22	0.26	0.49	0.16	2.69	1.59	0.54	1.32	0.69	1.14	9.76

1972	0.99	0.13	0.41	0.18	0.43	1.59	1.30	2.84	3.08	1.98	1.09	0.82	14.83
1973	1.98	1.77	1.02	0.68	0.64	0.89	4.41	0.58	0.53	0.73	0.44	0.63	14.3
1974	1.48	0.44	0.12	0.56	1.1	0.68	2.28	2.15	7.19	2.15	0.99	1.03	20.16
1975	0.91	1.34	0.74	0.55	1.67	0.64	2.68	1.06	1.77	0.48	0.40	0.92	13.17
1976	0.59	0.55	0.61	0.46	1.66	1.29	2.50	0.60	1.75	1.41	1.01	0.84	13.27
1977	0.93	0.32	0.70	0.55	0.13	0.58	1.48	1.30	0.89	2.18	0.45	0.43	9.93
1978	0.83	0.74	0.25	0.24	1.39	0.96	0.34	1.84	3.65	1.95	1.49	1.09	14.76
1979	2.21	1.40	0.63	0.94	1.56	0.70	2.14	3.36	1.01	0.31	0.65	0.71	15.62
1980	0.66	1.09	0.83	1.2	0.15	0.43	0.55	1.64	3.27	0.84	0.77	0.14	11.58
1981	1.23	0.57	0.69	1.08	1.55	0.91	1.52	2.87	1.50	1.44	0.34	0.13	13.8
1982	0.42	0.58	0.35	0.56	0.69	1.08	0.71	0.60	2.11	1.49	1.27	3.65	13.51
1983	0.97	1.29	1.20	1.48	1.38	0.98	0.61	1.13	1.86	1.82	1.95	1.17	15.84
1984	0.90	0.77	0.93	0.4	0.92	1.87	0.77	3.13	1.01	3.92	1.57	1.61	17.80
1985	1.26	1.19	1.62	0.82	0.34	0.67	1.72	1.40	2.59	2.61	0.94	0.56	15.71
1986	0.17	0.69	0.47	0.73	1.19	4.02	2.18	1.89	1.07	1.49	2.90	1.79	18.58
1987	0.60	1.64	0.61	0.27	0.97	3.38	1.06	1.48	1.45	0.77	1.73	3.65	17.61
1988	0.53	0.77	0.92	0.89	0.33	0.52	3.64	2.83	1.74	1.08	1.03	1.01	15.3
1989	1.13	1.29	1.00	0.17	2.01	1.94	2.21	2.57	1.05	0.58	0.34	0.62	14.9
1990	1.62	0.91	1.26	1.04	1.30	0.66	2.50	2.48	3.42	0.95	1.88	1.40	19.41
1991	0.92	0.63	0.08	0.07	0.32	0.25	2.40	3.58	2.97	0.19	0.52	2.84	14.79
1992	1.51	0.19	0.58	0.29	2.61	0.34	0.69	1.21	0.77	0.51	0.38	0.98	10.06
1993	1.49	0.37	0	0.07	0.24	0.62	1.18	2.68	0.46	0.4	0.41	0.46	8.40
1994	0.03	0.28	0.43	0.15	1.34	0.48	0.97	0.34	0.46	0.69	0.51	1.22	6.90
1995	2.57	3.42	0.47	0.02	0.19	1.04	0.52	0.45	2.58	0.16	0.33	0.04	11.78
1996	0.12	0.12	0	0.47	0	1.97	1.85	1.6	1.76	0.20	0.15	0	8.23
1997	0.42	0.38	0.42	0.44	0.65	1.09	1.65	1.27	1.51	0.2	0.73	1.85	10.62
1998	0.37	0.13	0.19	0.01	0.10	0.28	1.67	1.01	0.04	2.2	0.32	0.27	6.58
1999	0.28	0	0.14	0.03	0.29	1.37	2.24	1.26	1.00	0.39	0	0.35	7.36
2000	0	0.06	0.07	0.11	0	2.27	1.02	0.17	0	0.98	0.80	0.17	5.65
2001	0.23	0.17	0.31	0	0.06	0.66	0.76	0.8	0.45	0	0.49	0.21	4.14
2002	0.10	0.83	0.01	0.01	0.04	0.27	2.15	0.59	0.29	1.51	0	1.55	7.35
2003	0	1.64	0.16	0	0	0.76	1.22	0.35	0.78	0.49	0.47	0.02	5.89
2004	0.47	0.21	0.60	1.66	0.5	1.12	1.06	1.90	1.59	0.75	2.18	0.34	12.38
2005	0.83	1.79	0.09	0.13	1.51	0.02	0.65	2.94	1.19	2.16	0	0.02	11.33
2006	0.04	0.23	0	0.01	0.18	0.4	3.25	4.11	3.60	1.22	0.01	0.04	13.09
2007	1.86	0.15	0.06	0.3	1.02	0.51	2.89	1.55	1.85	0.06	0.94	0.44	11.63
2008	0.12	0.07	0	0	0.28	0.09	6.4	2.92	1.84	0.49	0.14	0.22	12.57
2009	0	0	0.1	0	0.57	1.92	1.07	0.72	1.47	0.59	1.03	0.68	8.15
2010	0.88	1.23	0.04	0.69	0.08	1.22	1.55	1.22	1.19	0.24	0	0.13	8.48
2011	0	0.04	0	0	0	0.25	1.53	0.68	0.47	0.08	0.19	0.67	3.91
2012	0.68	0.05	0.15	0.22	0.69	0.22	1.54	1.29	1.42	0.14	0.10	0.04	6.54

A.P. = Annual precipitation in inches

Source: Printed with permission of Andrew Wilson (Texas Water Development Board).

Table 2: Table showing the cumulative and density probabilities and the precipitation values for the 73 precipitation year data derived from the Gamma continuous probability distribution.

Precip.	Cum.Prob.	Den.Prob.	Precip.	Cum.Prob.	Den.Prob.
3.91	0.00874469	0.012388	10.38	0.47345803	0.105202
4.14	0.01195667	0.015614	10.62	0.49854935	0.103832
4.63	0.02155622	0.023870	10.91	0.52836609	0.101722
5.65	0.05663315	0.045719	11.33	0.57031482	0.097894
5.89	0.0682827	0.051374	11.58	0.59446292	0.095249
6.46	0.10141153	0.064818	11.63	0.59921149	0.094692
6.47	0.10206087	0.06505	11.78	0.61328694	0.092968
6.54	0.10667094	0.066664	11.91	0.62527248	0.091416
6.58	0.10935586	0.067580	12.38	0.66685396	0.085441
6.62	0.11207732	0.068492	12.57	0.68284707	0.082898
6.90	0.13213232	0.074706	13.00	0.71722666	0.076976
7.07	0.14514075	0.078310	13.09	0.72409785	0.075717
7.35	0.16786095	0.083900	13.17	0.7301103	0.074594
7.36	0.16870091	0.084091	13.17	0.7301103	0.074594
7.45	0.17634548	0.085779	13.27	0.73749948	0.073189
7.90	0.21670828	0.093362	13.31	0.74041577	0.072626
7.99	0.22517129	0.094694	13.42	0.74831944	0.071077
8.15	0.24050152	0.096899	13.51	0.75465939	0.069811
8.23	0.24829471	0.097922	13.80	0.77431421	0.065745
8.40	0.26511447	0.099916	14.30	0.8054574	0.058864
8.45	0.27012388	0.100456	14.76	0.8311233	0.052774
8.48	0.27314228	0.100769	14.79	0.8327007	0.052387
8.53	0.27819346	0.101274	14.83	0.83478588	0.051873
8.54	0.2792067	0.101373	14.90	0.83838566	0.050979
8.69	0.29451796	0.102745	15.30	0.8577782	0.046028
9.01	0.32778349	0.105016	15.62	0.87190113	0.042271
9.08	0.33514813	0.105395	15.71	0.87565944	0.041249
9.27	0.35525555	0.106211	15.84	0.88092732	0.0398
9.76	0.40755469	0.106929	16.36	0.90018013	0.034339
9.82	0.41396928	0.106886	17.40	0.93087026	0.02504
9.93	0.4257192	0.106734	17.61	0.93595722	0.023421
9.95	0.42785352	0.106697	17.80	0.94027373	0.022027
9.98	0.43105351	0.106635	18.07	0.94596619	0.020161
10.06	0.43957677	0.106439	18.58	0.95541968	0.016985
10.14	0.44808245	0.106196	19.41	0.96767117	0.01271
10.16	0.4502057	0.106128	20.16	0.9760204	0.009674
10.29	0.46397062	0.10562			

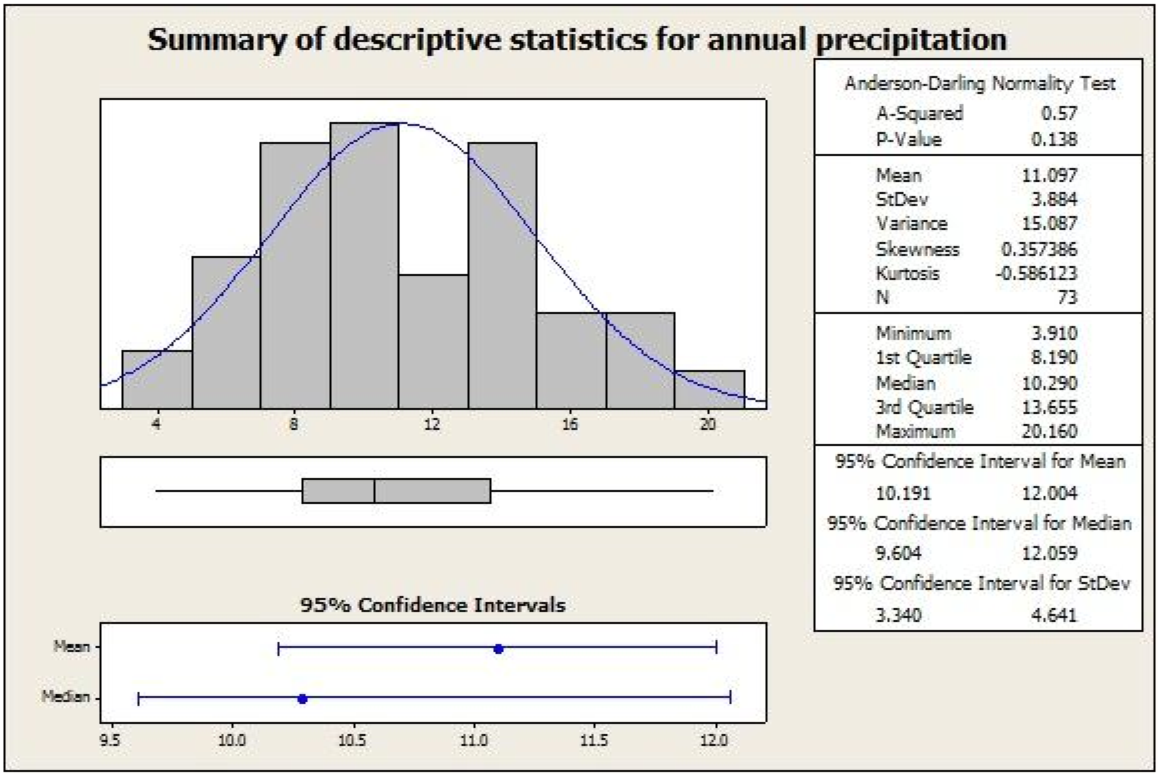

Figure 1: Graphshowing the results of the descriptive statistics and confidence intervals for the precipitation data.

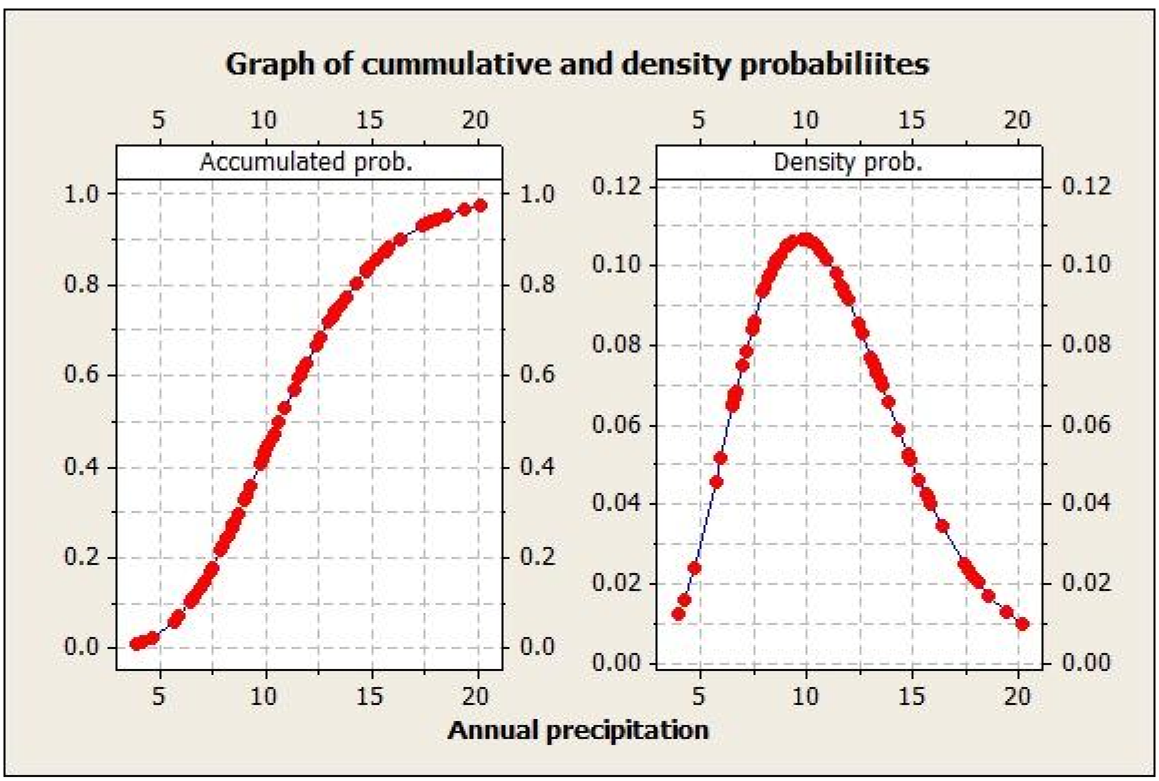

Figure 2: Figuresshowing the graphs of cumulative probabilities (left graph) and density probabilities (right graph) for the precipitation data derived from the Gamma continuous probability distribution.

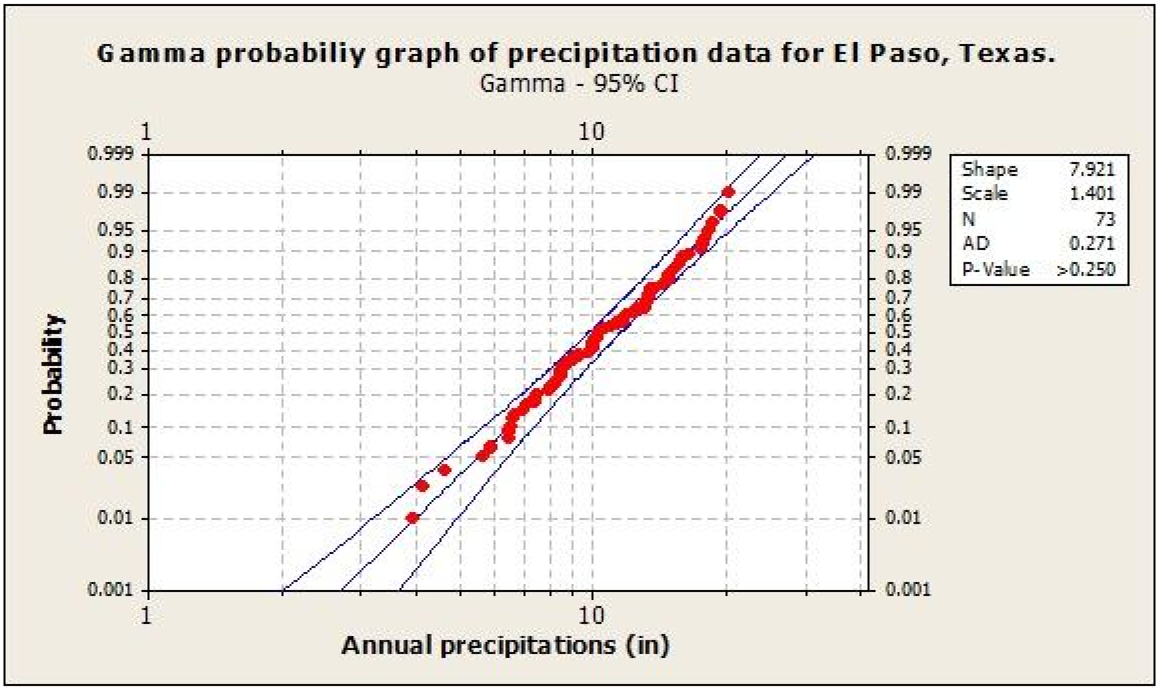

Figure 3: Figure showing the probability graph of the Gamma continuous distribution, going as a function of probability and annual precipitations (inches), with a value of Anderson-Darling (A-D) of 0.271, and shape and scale historical parameters of 7.921 and 1.401, respectively.

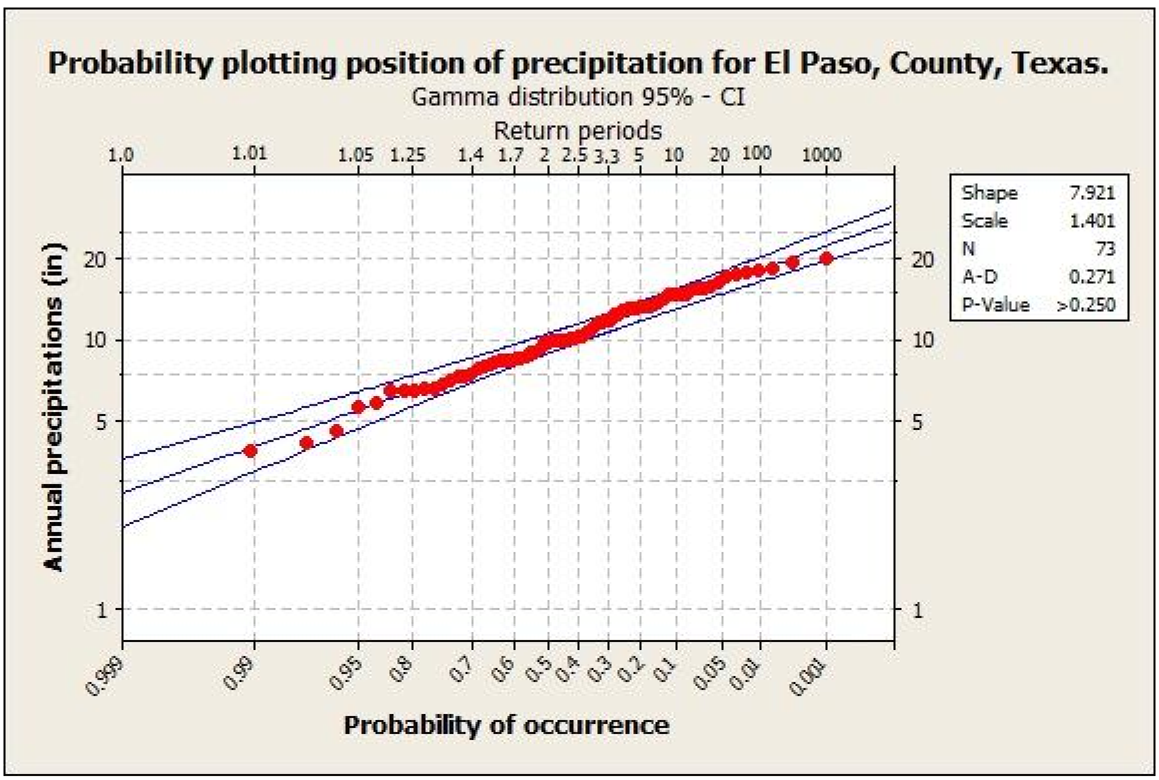

Figure 4: Graphshowing the probability plotting position using the values of the gamma distribution for data of El Paso County, Texas, going as a function of annual precipitation data (inches), probability of occurrence and periods of return, with a 95% confidence band interval. Period of sampling is 1940-2014.