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RESEARCH ARTICLE

ESTIMATION OF DRY SPELL IN MARATHWADA REGION BY USING DATA MINING TECHNIQUES

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ABSTRACT

Data Mining is an analytic process designed to explore data or big data in search of consistent patterns or systematic relationships between variables, and then to validate the findings by applying the detected patterns to new subsets of data .In this study use explorative data analysis (EDA) of data mining techniques that include basics statistics, time series & probability distribution for the study of dry spell in Marathwada region. This region situated between 170 -35 N and 200- 40 N latitude and 740 - 40 E and 780 – 15 E longitudes in Maharashtra state. In this region consist of eight districts such as, Beed, Hingoli, Jalna, Latur, Nanded, Osmanabad and Parbhani. The monthly dry spell data of 55 years (1960 to 2015) was used for study. The primary objectives of study firstly to investigate the general trends of dry spells, secondly to fitting the probability distribution &estimate the return period of dry spell. The result show that all selected metrological station of Marathwada region was increasing trend on basis of result of Mann-Kendall Test in this test statistics value is positive & p-value is less than the significant level alpha (0.05). Discrete probability distribution such as, Geometric , Neg. Binomial, D. Uniform and possion was used for study. Kolmogorov–Smirnov test (K-S) of goodness fit test was used to select best fit probability distribution on the basis of minimum value of test statistic. The result shows that Aurangabad, Beed, Latur, Parabhani & Hingoli it was fit possion distribution, Osmanabad & Nanded it was fit Dis.Unifrom distribution, Jalna it was fit Neg.Binmoial distribution. Maximum likelihood method was used to estimate the parameters of fitted probability distributions. Regarding estimation of return period of dry spell was used to fitting probability distribution and their parameter such as estimation of expected monthly 10 dry day in Aurangabad station by using passion probability distribution was very high (68%) occurs at every one year and 20 dry day was only 1.5 % of occurs of every 66.47 years .This result is also helpful to prediction and estimation of rainfall for farmers and agriculture department of the Government of Maharashtra for planning cropping pattern of the Marathwada region.

INTRODUCTION

Data Mining is an analytic process designed to explore data or big data in search of consistent patterns or systematic relationships between variables, and then to validate the findings by applying the detected patterns to new subsets of data. The ultimate goal of data mining is prediction - and predictive data mining is the most common type of data mining and one that has the most hydrology, science, engineering, and metrology and business applications. The process of data mining consists of three stages: (1) the initial exploration, (2) model building or pattern identification with validation/verification, and (3) deployment (i.e., the application of the model to new data in order to generate predictions). In this we have study dry spells of rainfall of Matathwada region by used two data mining techniques such as time series analysis & probability distribution techniques. Marathwada region consists of eight districts viz. Aurangabad, Beed, Hingoli, Jalna, Latur, Nanded, Osmanabad and Parbhani. The total area of the region is 64,798 sq. km. The entire region is situated at the height of about 300–650 meter. The highest peak at Aurangabad district is Surpal Nath (960 m). Dry deciduous forests, open scrub jungles and vast tracts of grasslands form the components of vegetation. Economy this region is depends upon agriculture productivity. Last five year Marathwada region is less rainfall affected region in Maharashtra. The present study is based dry spell rainfall data of Marathwada region of seven district (metrological station) of Maharashtra .The monthly dry spell data of 25 years (1990 to 2015) were collected from the IMD and Department of agriculture, Govt. of Maharashtra. The rainfall was measured in

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millimeter (mm). Dry spell can be defined as a sequence of dry days including days with less than a threshold value of rainfall. The objective of the present study is show the trend in dry spell and estimation the dry spell on bias of fitting of probability distribution in Marathwada region. Time series analysis techniques are help to show the trend such as decreasing or increasing in selected metrological station. Probability distribution models, we have used discrete uniform distribution; Geometric distribution,

Logarithmic series, Negative binomial distribution, Poisson distribution. The Kolmogorov Smirnov test for goodness of fit was employed as the significance test for every model, assuming the level of Significance as 5% (a =.05). The maximum likelihood estimator is used for estimation of parameter fitted probability distribution of selected metrological station. Estimation of dry spell or return period by using fitted probability distribution model. Knowledge of the distribution of dry spells during the monsoon period is essential for successful rained farming. It is also important to know the chances of occurrence of dry spells during the critical stages of the crops for deciding the sowing date, cropping pattern and planning for protective irrigation and intercultural operations. This result is also helpful to prediction and estimation of rainfall for farmers and agriculture department of the Government of Maharashtra for planning cropping pattern of the Marathwada region

Related Work

Many researchers have study of dry spell by using time series and probability distribution data mining techniques such as, C. T. Dhanya1 and D. Nagesh Kumar (2008) Data mining for evolution of association rules for droughts and floods in India using climate inputs. Fisher (1924) crop yield during a season mainly influenced by the distribution of rainfall rather than season total amount of rainfall. Dennet, 1987 &Sivakumar, (1992) Probability distributions are widely used in understanding the rainfall pattern and computation of probabilities. Racsko *et al*. (1991) proposed a model constituting two different geometric distributions. In the referred study, both the geometric distributions were separated according to the length of dry spells. Results of the works suggested that mixed distribution, including geometric one, could be promising in reproduction of long dry periods. Wantuch *et al*. (2000).

The first model exhibits good fitting for the dry spells and the latter one can be advised to employ for the wet periods. Jackson (1977) has emphasized that annual rainfall distributions are markedly skewed in semi-arid areas and the assumption of normal frequency distribution for such areas is inappropriate. Anagnostopolou *et al*. (2003) compared performances of Negative Binomial and Markov Chain models to analyze spell frequencies in 20 Stations in Greece using data from 1958 –1997. Lana *et al*. (2005) and Aghajani (2007) have also shown that compared to other models, Weibull model fitted well with the empirical frequency distributions of spell lengths for a number of selected stations. Galloy *et al*. (1982) used the Negative Binomial model for the treatment of dry spells. Wantuch *et al*. (2000)], it has been shown that the MC models although approximately replicate some statistical properties of the spells (wet or dry) of daily precipitation, usually overestimate very short dry sequences and underestimate very long dry sequences, and do not reproduce long term persistence. Simba Farai Malvern,etc(20120 Analysis of trends in dry spells during rainy seasons for masvingo airport and zakastations in masvingo province, Zimbabwe. Srinivasan (1958), who introduced a combination of geometric and logarithmic series (GMLSD), successfully fitted the sequence of wet days at Poona, India. These are related work

DATA AND METHODOLOGY

Study area and data collection

The present day Marathwada forms a revenue division of Maharashtra Geographically the region is situated between 170 -35 N and 200- 40 N latitude and 740 - 40 E and 780 – 15 E longitudes. The total geographically area of the region is 64525 square Kms. The land of Marathwada of region is flat with an evaluation ranging between 300 & 900 meters. Marathwada has extensive hilly ranges and sprats but these ranges neither provide water cultivation nor attract rains and hence are used form economic point of views. The present study is based dry spell rainfall data of Marathwada region of seven district (metrological station) of Maharashtra .The monthly dry spell data of 55 years (1960 to 2015) were collected from the IMD and Department of Agriculture, Govt. of Maharashtra.

Data mining techniques

Data Mining is an analytic process designed to explore data or big data in search of consistent patterns or systematic relationships between variables, and then to validate the findings by applying the detected patterns to new subsets of data. The ultimate goal of data mining is prediction - and predictive data mining is the most common type of data mining and one that has the most hydrology, science, engineering, and metrology and business applications. The process of data mining consists of three stages: (1) the initial exploration, (2) model building or pattern identification with validation/verification, and (3) deployment (i.e., the application of the model to new data in order to generate predictions).

Exploration is stage usually starts with data preparation which may involve cleaning data, data transformations, selecting subsets of records and - in case of data sets with large numbers of variables ("fields") - performing some preliminary feature selection operations to bring the number of variables to a manageable range (depending on the statistical methods which are being considered). Then, depending on the nature of the analytic problem, this first stage of the process of data mining may involve anywhere between a simple choice of straightforward predictors for a regression model, to elaborate exploratory analyses using a wide variety of graphical and statistical methods. In this study Explorative data analysis (EDA) data mining techniques is used . Computational exploratory data analysis methods include both simple basic statistics and more advanced, designated multivariate exploratory techniques designed to identify patterns in multivariate data sets.

Time Series Data Mining

There are two main goals of time series analysis: (a) identifying the nature of the phenomenon represented by the sequence of observations, and (b) forecasting (predicting future values of the time series variable). Both of these goals require that the pattern of observed time series data is identified and more or less formally described. Once the pattern is established, we can interpret and integrate it with other data (i.e., use it in our theory of the investigated phenomenon, e.g., seasonal commodity prices). Regardless of the depth of our understanding and the validity of our interpretation (theory) of the phenomenon, we can extrapolate the identified pattern to predict future events. In this we using the time series analysis to check the trend in dry spells of Marathwada region .Mann-Kendall Test for checking trend in time series.

Mann-Kendall Test for Trend

This test, usually known as Kendall's τ statistics, has been used in hydrology and climatology to test randomness against trend of hydrologic time series. As it is a rank-based procedure, it is robust to the influence of extremes and good test for skewed data. For any sample of n variables, Xi …. Xj the null hypothesis states that the sample is independent and identically distributed. The alternative hypothesis of a two-sided test is that the distributions of xi and Xj are not identical for all k, j ≤ n with i _= j. Test of interpretation based on the following hypothesis.

H0: the precipitation data follow there is no trend in the series
H1: the precipitation data there is a trend in the series.

The computed p-value is lower than the significance level α=0.05, one should reject the null hypothesis H0, and accept the alternative hypothesis H1. The Mann-Kendall test is based on test statistic S defined as follows.

$$S = \sum_{i=2}^{n} \sum_{j=1}^{i-1} \text{sign}(x_i - x_j)$$

Where the Xj are the sequential data values, n is the length of the time-series and Sign(Xi - Xj) is-1 for (Xi - Xj) < 0; 0 for (Xi - Xj) =0 and 1 for (Xi - Xj) >0 . The mean E[S] and variance V [S] of the statistic S may be given as follows.

E[S]= 0

$$\text{Var}[S] = \frac{n(n-1)(2n+5) - \sum_{p=1}^{q} t_p (t_p - 1)(2t_p + 5)}{18}$$

where tP is the number of ties for the pth value and q is the number of tied values. The second term represents an adjustment for tied or censored data. The standardized test statistic Z_K is computed as follows.

$$Z_K = \begin{cases} \frac{s-1}{\text{Var}(S)} & \text{if } s > 1 \\ 0 & \text{if } s = 0 \\ \frac{s-1}{\text{Var}(s)} & \text{if } S < 0 \end{cases}$$

A positive Z_K indicates an increasing trend, whereas a negative Z_K indicates a decreasing trend. To test for either increasing or decreasing monotonic trend at α significance level, the null hypothesis is rejected if the absolute value of Z is greater than Z1-α/2 where Z1-α/2 is obtained from the standard normal cumulative distribution tables. In this study the significance level of α = 0.01. Hipel & McLeod (1994) and McLeod *et al*. (1990) have used the Mann-Kendall trend test in the analysis of various types of environmental data.

Probability distribution

In this study different type of discrete probability distribution such as Geometric , Neg. Binomial, D. Uniform and possion were used probability models distribution for eight stations of Marathwada region. In the passion distribution and negative binomial distribution n & p, discreet uniform distribution a & b are parameter. Random is used to find estimation of parameter by using maximum likelihood estimator after using the probability distribution to check fitting probability distribution model in selected metrological station.

Fitting of the probability distribution

The goodness of fit tests measures the compatibility of a random sample with a theoretical probability distribution function. The results are presented in the form of interactive tables that help you decide describe your data in the best way. The goodness of fit test is designed to compare the sample obtained with the type of sample one would expect from the hypothesized distribution and to check whether the hypothesized distribution function fits the data in the sample The goodness of fit test is performed in order to test the following hypotheses.

H0: the precipitation data follow the specified distribution
H1: the precipitation data do not follow the specified distribution.

The goodness-of-fit tests have been conducted were several pervious researchers such as Kolmogorov-Smirnov test was used α (0.05) level of significance for the selection of the best fit probability distribution.

I.Kolmogorov-Smirnov Test

This test is used to decide if sample come from a hypothesized continuous distribution .It is based on the empirical cumulative distribution .Assume that we have a random sample x1, ---xi from some distribution with cumulative distribution function F(x).

The empirical cumulative distribution is denoted by.
Fn(x) = 1/n [Number of observation ≤ x].

Definition

The Kolmogorov-Smirnov test statistic (D) is a function of the greatest vertical distance between distribution functions, either hypothesized or empirical distribution functions. K-S test calculates the maximum difference between the hypothesized distributions $Z_{(i)} = F(x_{(i)}, \hat{-})$ and empirical cumulative distribution function $F_n(x_i)$ with x_i representing the ordered data

$$D^+ = \max_i (i/n - z_i)$$
$$D^- = \max_i [-(i-1)/n] \quad (1)$$
$$D^+ = \max_i (D^+, D^-)$$

Where x1 . . . xi are daily dry spell values of selected metrological station.

Estimation of Return period

Return period (T): interval is the average interval of time within which any extreme event of given magnitude will be equaled or exceeded at least once .The estimation of probability (x mm) of annual rainfall exceeded on average only once in T years. Probability of occurrence (p): is expressed as probability of that an (x mm) of annual rainfall of specified magnitude will be equaled or exceeded during a one year period(T).If n is the total number of values and m is the rank of a value in a list ordered descending magnitude (x1 > x2 > x3 ... > Xm), the exceeding probability of the m[th] largest value, Xm is

$$P(X \geq x_m) = \frac{m}{n} \quad (4)$$

(See Ramachandra Rao and Hamed, page 6-7). A given return level xT with a return period T may be exceeded once in T years. Therefore.

$$P(X \geq x_T) = \frac{1}{T} \quad (5)$$

If the probability model with CDF, F is assumed then on inverting.

$$F(x_T) = P(X \leq x_T) = 1 - P(X \geq x_T) = 1 - \frac{1}{T} \quad (6)$$

And get the general expression

$$\inf\{x_T : F(x_T) \geq 1 - \frac{1}{T}\} = F^{-1}(1 - \frac{1}{T}) \quad (7)$$

RESULT AND DISCUSSIONS

In this study present methodology was applied to eight selected metrological station of Marathwada region. In this region Jalna metrological station is most dry station have mean dry spell is 15.469 day. Coefficient of variation of Jalna station is 41.27 is less than other station so this station is more consistent. The distribution of dry spell was found to be positively skewed at selected metrological stations. Table1 show the descriptive statistics of dry spell in selected metrological station.

Table 1 Descriptive statistics of dry spell in selected metrological station

Station	Mean	StDev	CoefVar	Skewness	Kurtosis
Aurangabad	14.893	7.463	50.11	1.37	1.73
Jalna	15.469	6.367	41.27	1.09	1.95
Beed	13.857	7.362	53.13	1.26	1.82
Latur	14.125	6.777	47.98	1.52	3.14
Osmanabad	14.589	7.088	48.59	1.53	3.22
Nanded	15.089	7.174	47.54	0.88	1.37
Parabhani	15.429	6.944	44.9	1.09	1.24
Hingoli	15.054	7.154	47.52	1.31	1.86

Trend analysis result is used for the identification of time series changing points, a preliminary graphical inspection is highly instructive and meaningful. Figure (1) shows present the temporal changes of dry spell and the trend line in Aurangabad station. The linear regression model is used to estimate time trend of data. The regression trend lines are also given in the figure (1). All trend lines are significant at 5% level. According to the slope of trend lines Aurangababad increasing around 14.3 % dry day in Aurangabad metrological station.

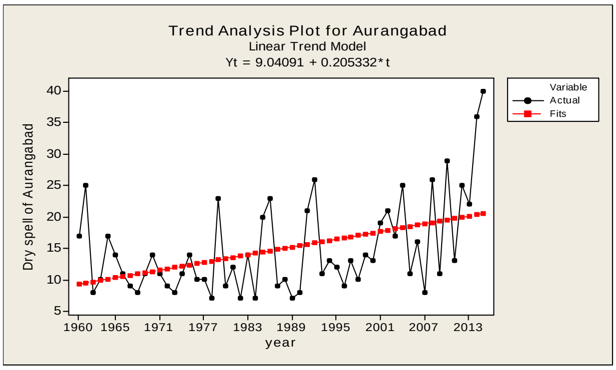

Fig 1show the Trend Analysis plot of dry spell in Aurangabad metrological station

Figure (2) shows present the temporal changes of dry spell and the trend line in Latur station. The linear regression model is used to estimate time trend of data. The regression trend lines are also given in the figure (2). All trend lines are significant at 5% level. According to the slope of trend lines Latur increasing around 11.1 % dry day latur metrological station.

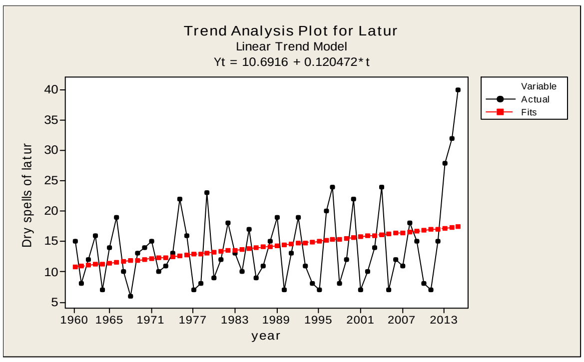

Fig 2 Show the Trend Analysis plot of dry spell in Latur metrological station

Mann-Kendall test for tend which is used for testing of trend such as increasing or decreasing. In this study 5% level of significant for testing. Mann-Kendall test statistic value is positive in the analysis of all selected metrological station have increasing trend & p-value is less than level of significance so reject the null hypothesis. The risk of rejecting the null hypothesis when it is true for all metrological station such as Aurangabad, Jalna Beed, Latur is , respectively, 3.6%, 2.1% , 1.8% and 3.8 % respectively. Table 2 show the Statistics of Mann-Kendall test for selected metrological station.

Table2 Statistics of Mann-Kendall test for selected metrological station

location	Mann-Kendall test statistic	p-value
Aurangabad	0.274	0.004
Jalna	0.203	0.032
Beed	0.187	0.047
Latur	0.195	0.039
Osmanabad	0.189	0.047
Nanded	0.209	0.036
Parabhani	0.254	0.42
Hingoli	0.192	0.045

The test statistic for Kolmogorov-Smirnov test, for each data set were calculate discrete probability distribution. The probability distribution was best fits on the basis of minimum value test statistics. In the Table (3) show that fitting of probability distribution of Kolmogorov-Smirnov test statistics

Table 3 Fitting of probability distribution of Kolmogorov-Smirnov test (K-S) statistics

location	Distribution Fit	K-S Test Statistic
Aurangabad	Possion	0.19187
Jalna	Neg.Binmoial	0.24231
Beed	possion	0.22517
Latur	possion	0.16273
Osmanabad	Dis.Unifrom	0.20758
Nanded	Dis.Unifrom	0.18182
Parabhani	possion	0.18166
Hingoli	possion	0.20993

Maximum likelihood method was used to estimate the parameter of fitted probability distribution. These values of the parameter were used to generate random numbers for each data set and the least square method was used for the dry spell analysis. The random numbers were generated for actual and estimated observations for all the 49years. The parameter of fitted probability distribution are presented in (table .4)

Table 4 parameter of best fitted probability distribution for metrological station

location	distribution fit	parameter
Aurangabad	possion	λ=12.326
Jalna	Neg.Binmoial	n=4 p=0.26731
Beed	possion	λ =11.616
Latur	possion	λ =9.6512
Osmanabad	Dis.Unifrom	a=-2 b=24
Nanded	Dis.Unifrom	a=-5 b=27
Parabhani	possion	λ =11.988
Hingoli	possion	λ =11.872

Estimation of return period of dry spell with the help of best fitted probability distribution was estimate for different return periods and probability (%) desired amount of monthly dry spells was expected at Marathwada region. Estimate of expected monthly dry day of > 4 dry day in Aurangabad station by using possion probability distribution was very high (99%) occurs every 1 year and >20 dry day was only 1.5 % of occurs of every 64.47 years. In the table (5) shows Estimation of return period of dry spells in Aurangabad metrological station.

Table 5 Estimation of return period of dry spells in Aurangabad metrological station

Probability of exceedance	Dry spell(Day)	Return period
0.99	4	1
0.96	6	1.03
0.86	8	1.15
0.68	10	1.45
0.46	12	2.17
0.25	14	3.88
0.11	16	8.3
0.046	18	21.6
0.015	20	66.47

CONCLUSION

The objective of this paper is to study the dry spell by using data mining techniques such as time series analysis and probability distribution. The descriptive statistics shows that highest average 12.5 day of dry spells was found in Jana metrological station this station is most dry station in the region. In time series we have use trend analysis to show all value of Mann-Kendall test for trend is positive and p-value is less than significance level alpha this result indicate that increasing trend in dry spell of all selected metrological station of Marathwda region. Discrete probability distribution was used to best fit probability distribution model to selected meteorological station on the basis of minimum value of Kolmogorov-Smirnov test for goodness of fit.

The result show that Possion distribution distribution was fit in Aurangabad, Beed, Latur, Parabhani & Hingoli metrological station, Dis.Unifrom distribution was fit in Osmanabad and Nanded metrological station. Maximum likelihood estimator was used to estimate the parameter of fitted probability distribution of station .Estimation of expected monthly greater 4 dry day in Aurangabad station by using possion probability distribution was very high (99%) occurs at every one year and 20 day was only 1.5 % of occurs of every 66.47 years The dry spell length is affected to loss of productivity for the region especially if it happens at the time of grain filling. The greatest risk of loss due to agricultural dry spells for the return period of one year is the Marathwada region. The last five year increasing dry spell of Marathwada region and decreasing agricultural production of this regions. This result is also helpful to prediction and estimation of rainfall for farmers and agriculture department of the Government of Maharashtra for planning cropping pattern of the Marathwada region.

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