HydroInformatics Project

Drought Analysis

Communicator: Venkat Koganti

Dataset

1. Drought Analysis:

   Data Given: Precipitation, Evapotranspiration, Runoff Data of Krishna RIver basin(1980-2012) from which data of stations near to the required stations was separated.

   Then the data is converted into monthly average format and used for further analysis.

   The analysis follows calculation of drought indices like SPI, SPEI, SRI.

Data Corrections

Missing data for precipitation is generated using average of that month over all the years.

$$m(i) = \sum p(i) \ \forall \ i \in \{1\text{-}11\}$$

Where m(i) is missing data value

p(i) is precipitation data of i^{th} month

Drought Analysis

Estimation of SPI:

We used Log-logistic distribution to fit a probability distribution of precipitation time series. The probability density function (pdf) (f(x)) and cumulative distribution function (CDF) (F(x)) of the three-parameter log-logistic distribution are given as follows:

$$f(x)=\frac{\beta}{\alpha}\left(\frac{X-\gamma}{\alpha}\right)^{\beta-1}\left[1+\left(\frac{X-\gamma}{\alpha}\right)^{\beta}\right]^{-2}$$

α,β,γ are scale,shape location parameters respectively.The Parameters are estimated using the L-moment procedure as follows:

$$\beta=\frac{2w_1-w_0}{6w_1-w_0-6w_2} \qquad \alpha=\frac{(w_0-2w_1)\beta}{\Gamma(1+1/\beta)\Gamma(1-1/\beta)} \qquad \gamma=w_0-\alpha\Gamma(1+1/\beta)\Gamma(1-1/\beta)$$

Where w_0, w_1, w_2 are the probability weighted moments calculated based on Sheng and Hashino (2007), as follows:

For r = 1,2,3

$$W_r = \frac{1}{n}\binom{n-1}{r}^{-1}\sum_{j=1}^{n-r}\binom{n-j}{r}x_j$$

Where n is sample size and X_j is ordered vector of observation in descending order.

Next, the cumulative distribution function of log-logistic distribution can be calculated with the estimate parameters of Pearson-III distribution.Using F(x) values SPEI is calculated as follows:

$$F(x) = \left[1 + \left(\frac{X-\gamma}{\alpha}\right)^{-\beta}\right]^{-1}$$

$$SPI = W - \frac{C_0 + C_1 W + C_2 W^2}{1 + d_1 W + d_2 W^2 + d_3 W^3}$$

Where W = √(-2ln(p)) for p<=0.5 where p is exceeding probability,P = 1-F(x).

If P>0.5, then P is replaced by 1- P and the sign of the resultant SPI is reversed. The constants are Co = 2.5515517, C1 = 0.802583, C2 = 0.010328, d1 = 1.432788, d2 = 0.189269, and d3 = 0.001308. The present study used the drought indices at 12-month accumulation time periods for the drought characterization over region.
After that Drought is classified based on spi values as follows:

SPI range	Drought Category
SPI≥2.00	Extremely Wet
2.00>SPI≥1.50	Very Wet
1.50>SPI≥1.00	Moderate Wet
1.00>SPI≥-1.00	Normal
-1.00≥SPI>-1.50	Moderate Drought
-1.50≥SPI>-2.00	Severe Drought
-2.00≥SPI	Extreme Drought

Weight scores are determined by considering the SPI intervals such that weight = 1 for Normal Drought(ND),weight = 2 for Moderate Drought(MD),weight = 3 for Severe Drought and weight = 4 for Extreme Drought.
Ratings are given based on Cumulative probability values:

CDF	Rating
(0.3-0.425)	4
(0.425-0.55)	3
(0.55-0.675)	2
(0.675-0.8)	1

Here we define some new terms to understand the sensitivity and depth of Drought analysis.

$$DRI = DHI * DVI$$

DRI: Drought Risk Index
DHI: Drought Hazard Index Where $DHI_i = \sum W_i * R_i$ where W,R are weight and rating
DVI: Drought Vulnerability Index(Population density)

For the calculation of Drought Risk Index we're trying to use the population data and the obtained DHI , but the problem is that the available population density data is in district scale but data present for DHI calculation is station wise,So we have clipped the data of two required districts from raster data of Afghanistan and interpolated over the two districts using Inverse distance interpolation.

Using the same methods which were used to find SPI, are used for analysis of SPEI and SRI. The only major difference is the distribution methods which are used to fit the data(For SPEI, log-pearson-3 distribution, For SRI GEV distribution).

After this, we have plotted the Krishna Basin risk maps by interpolating the calculated data over the region for which we have used the QGIS software.

Next, we have integrated the total project analysis into a web application which is developed using Python and Django framework.

Challenges

Major challenges faced during this project is while data extraction since the data is not in the required coordinates, hence we used interpolation techniques like nearest neighbour method, etc.

We have tried our best to Integrate the interpolation part through website but we were unable to succeed in that.

We have faced many problems in integration of Matlab to python

Future Scope

We can build the prediction model which is very much useful for future data analysis.

We can build risk maps by integrating the population density and drought hazard scores over Krishna river basin which are useful for risk assessment and mitigation methods.

We can add scope for addition of new or available data to the model in order to get exact results.

Contributions

We have divided the team into 4 groups:

Group 1: Data extraction and Data correction

Group 2: Matlab Codes

Group 3: Images and QGIS Interpolation

Group 4: Web Development