Stochastic time series analysis of hydrology data for water resources

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Abstract. The prediction to current publication of stochastic time series analysis in
hydrology and seasonal stage. The different statistical tests for predicting the
hydrology time series on Thomas-Fiering model. The hydrology time series of flood
flow have accept a great deal of consideration worldwide. The concentration of
stochastic process areas of time series analysis method are expanding with develop
concerns about seasonal periods and global warming. The recent trend by the
researchers for testing seasonal periods in the hydrologic flow series using stochastic
process on Thomas-Fiering model. The present article proposed to predict the
seasonal periods in hydrology using Thomas-Fiering model.

1. Introduction
The classical development of stochastic process to predict the seasonal periods in hydrology using
Thomas-Fiering Models. Especially for analyzing the hydrologic wide variation in the River flow
various month for different years. The time series analysis of the statistical region in hydrology from
River flow data, which is wide domain, statistics has significant as a powerful method for analyze
hydrology in time series. The contribution to predict the seasonal periods in hydrology River flow data
using Thomas-Fiering model. The time series analysis is used for building arithmetical models to
computation of statistics from River flow data using Thomas-Fiering model. The contribution of this
paper to predict the seasonal periods in hydrologic flow series of stochastic process using Thomas-
Fiering model.

2. Review of literature
The arithmetical model to expand synthetic hydrology records developing in time series analyze, to
forecast hydrology events notice in the missing data and continue records. The current trend time
series is homogeneous, fixed. Otherwise non-periodic is without continuation Adeloye and Montaseri,
[2].
A time series definitely have fixed data when its statistical properties do not different variation of time
origin. The first and second order moments depends only on time variation Chend and Rao, [2]. The
normally time series is fixed data stationary does not exit. The second order stationary is essentially
occur as fixed time series.
The earth’s rotation around the sun. Which is astronomical cycles due to period is normally time series Kite. To identify and quantify the periodicity in the hydrology or climatology time series, the time scale is to be considered less than a year (e.g., month or six months). In the hydrologic time series analysis, multiple comparison tests are still contemporary, while these tests are considered classical in the geotechnical field e.g., Phoon et al [3]. Climate change “is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level” (IPCC, Intergovernmental Panel on Climate Change. Higher temperatures could potentially increase evaporation rates at surfaces and transpiration by plants, which leads to a reduction in runoff Frederick and Major[5]. The environment change will accelerate the hydrology cycle with an increasing intensity of rainfalls and occurrence of maximum weather events Milly et al [8]. The consequences of this modification are manifold. The nearly 2.4 billion people lived in water stressed river basins and this number is supposed to rise in the futureArnell et al [7].

Despite the various impacts on river flow, today only a tiny number of rivers are protected by any sort of environmental flow management Richter et al, and according to current trends in riverine species loss, global warming, population develop and land-use change, freshwater ecosystems will remain threatened well into the future Vor’osmarty et al [6]. In order to assess changes in riverine species loss, global warming, population develop and land-use change, freshwater ecosystems will remain threatened well into the future Vor’osmarty et al [6].

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3 Method and Discussion

Applications

A linear auto regressive scheme which is probability of being a particular state in a given period is dependent on the actual state in the preceding time period. Which scheme are stochastic process.

\[ x_t - \mu = \alpha(x_{t-1} - \mu) + V_t \]

In which \( X_t \) is the dependent stationary stochastic series, \( \mu \) the mean, \( \alpha \) the auto regressive coefficient \( V_t \) is the independent stationary stochastic component.

Thomas-Fiering(1962) in above markov chain model from taken producing monthly flow rivers data into consideration one serial correlation level. This model is widely used to generate flow series for monthly or seasonal periods. In the concept always assume that the July flows are always dependent on June values.

\[ Q_{p,j+1} = Q_{av,j+1} + b_j(Q_{pj} - Q_{avj}) + t_p S_{j+1} \sqrt{1-r^2} \]

Where \( Q_{j+1} \) and \( Q_j \) are the advantage volumes during \((j+1)^{th}\) and \(j^{th}\) months respectively, \( Q_{av,j+1} \) and \( Q_{avj} \) the mean monthly discharge volumes during \((j+1)^{th}\) and \(j^{th}\) months respectively, \( S_{j+1} \) and \( S_j \) standard deviations for \((j+1)^{th}\) and \(j^{th}\) months respectively, \( r_j \) correlation between the \( j^{th}\) and \((j+1)^{th}\) months, \( t_p \) the random separately variate with zero mean and one variance, \( P \) the year, \( j \) the month, i.e., \( j = 1 \) stands for January and so on.

Time Series on T-F Model:
A time series is a sequence of Measurements of the same variables made over time. Usually the measurements are made at evently spaced times.

Monthly (or) yearly which is the problem in y-variable measures as a time series.
Here 'y' as global temperature, with measurements observed each year. Estimate that the values over time, 'y' subscript rather than 'i' i.e. $y_t$ means $y$ measured in time period $t$.

An auto regressive model is when value from a time series is regressed on previous values from that same time series.

First order stationary Markov model are known as Thomas Fiering model (Stationary)

$$X_{j+1} = \mu_X + \rho_j (X_j - \mu_X) + t_{j+1} \sigma_X \sqrt{1 - \rho_j^2}$$

Stationary with respect to mean, variance and lag-one correlation

Known sample estimates of $\mu_X$, $\sigma_X$, $\rho_j$ and Assume $X_1(= \mu_X)$

Generate value $X_1, X_2, X_3, \ldots$

First order Markov model with non-stationary, for stream flow generation.

$$X_{i,j+1} = \mu_{j+1} + \rho_j \sigma_{j+1} / \sigma_j (X_j - \mu_j) + t_{i,j+1} \sigma_{j+1} \sqrt{1 - \rho_j^2}$$

$\rho_j$ Which is one serial correlation among flows in $j^{th}$ month and $(j+1)^{th}$ month $t_{i,j+1} \sim N(0,1)$

### 4 Area and population of river basins in India

| River Basins          | Catchment | Length of River | Population |
|-----------------------|-----------|-----------------|------------|
|                       | Total (KM)| Density         | %          |
| All Basins            | Km2       | Million         | NO/km2     |
|                       | 3,191     | 932             | 282        |
|                       |           | 888             | 301        |
| Basins of the         |           |                 |            |
| Westerly flowing      |           |                 |            |
| Rivers                |           |                 |            |
| Indus                 | 321       | 48.8            | 140        |
| Narmada               | 99        | 17.9            | 160        |
| Sabarmati             | 22        | 6.0             | 521        |
| Basins of the         |           |                 |            |
| Easterly flowing      |           |                 |            |
| Rivers                |           |                 |            |
| Cauvery               | 81        | 32.6            | 389        |
| Ganga                 | 861       | 370.2           | 449        |
| Godavari              | 313       | 76.7            | 186        |
| Krishna               | 259       | 68.9            | 253        |

From the river basins in India we get total percentage $\frac{487}{7} \approx 69.5\%$. The flood flow of river monthly 7 years available data given here.
Table 2. Year data

| Sl. No | YEAR    | JUN | JUL  | AUG  | SEP  | OCT  | NOV  | DEC  |
|--------|---------|-----|------|------|------|------|------|------|
| 1      | 1979-80 | 54.60| 325.40| 509.50| 99.40| 53.50| 25.80| 12.50|
| 2      | 1980-81 | 220.78| 629.16| 591.32| 120.33| 43.33| 14.83| 8.41 |
| 3      | 1981-82 | 131.30| 538.89| 574.21| 151.06| 53.03| 19.49| 8.38 |
| 4      | 1982-83 | 100.19| 630.02| 702.07| 83.29| 32.45| 16.60| 6.80 |
| 5      | 1983-84 | 171.30| 444.30| 512.30| 211.00| 62.40| 24.00| 8.40 |
| 6      | 1984-85 | 147.80| 636.20| 293.50| 127.70| 79.70| 22.10| 10.10|

Year data (JUN from DEC 7 Month)

Table 3. Standard deviation and Log-one correlation

| Sl.No | Month | Mean | Standard Deviation | Log-one Correlation |
|-------|-------|------|--------------------|---------------------|
| 1     | JUN   | 107.45| 62.20              | 0.458               |
| 2     | JUL   | 476.5 | 145.7              | 0.154               |
| 3     | AUG   | 325.39| 126.53             | 0.169               |
| 4     | SEP   | 245.94| 77.65              | 0.365               |
| 5     | OCT   | 76.61 | 30.67              | 0.490               |
| 6     | NOV   | 32.99 | 13.26              | 0.798               |
| 7     | DEC   | 12.30 | 9.82               | 0.955               |
Figure 1.

Example

\[ X_{1,1} = \mu_1 = 107.45 \]
\[ \sigma_1 = 62.20 \quad \rho_1 = 0.458 \]
\[ \mu_2 = 476.5 \quad \sigma_2 = 145.7 \]

\[ X_{1,2} = \mu_2 + \rho_1 \frac{\sigma_2}{\sigma_1} (X_{1,1} - \mu_1) + t_{1,2} \sigma_2 \sqrt{1 - \rho_1^2} \]
\[ = 476.5 + 0.458 \frac{145.7}{62.20} (107.45 - 107.45) + 175.85 * 145.7 \sqrt{1 - 0.458^2} \]
\[ = 23252.64 \]
5. Conclusion
The current trend in stochastic process in time series analyze has been applied in various field such as hydrology, climatology, seismology. Based on Thomas-Fiering model which is stream flow of river flow data are the main hydrology resources followed by temperature and surface area water quantity, water resources development, which is significant the consideration of worldwide researchers for application in time series analysis of stochastic process in various techniques using Thomas-Fiering model. The performance of the seasonal periods in hydrology using Thomas-Fiering model have major focus of applied research field.

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