ijcrr
Vol 04 issue 02
Category: Research
Received on:05/12/11
Revised on:10/12/11
Accepted on:13/12/11

# HURST'S RESCALED RANGE ANALYSIS OF EARTH QUAKE OCCURENCES IN GUJARAT

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## ABSTRACT

Rescaled range analysis is a statistical methodology used to analyse long records of natural phenomena and to detect the presence or absence of trend in time series by finding Hurst component. Hurst exponent is an important measurement in fractal analysis, descriptions of rough images and signals. Basically this method is used to identify when the event is persistent i.e., the tendency to continue its current direction and also anti persistent i.e, the tendency to reverse itself or it is random and unpredictable. In this study, Hurst's rescaled range technique was applied to a time series composed of seismic events occurred in Gujarat for a period of 1973 to 2010.In this paper, we studied the earthquake cycles and the results infer that these have the behaviour of the so called "Joseph effect'': quiet years tend to be followed by quiet years and active years by active years. The Hurst exponent was found to be 0.469, which is nearly 0.5

## 1. INTRODUCTION

Earthquakes are caused by faulting; a sudden lateral or vertical movement of rock along a rupture (break) surface .There are two main causes of earthquakes. They can be linked to explosive volcanic eruptions or can be triggered by tectonic activity, with the latter being the cause of most earthquakes. Earthquake occurrence is one of the significant events in nature that causes both irretrievable financial and physical harm. The energy released from an earthquake is 10,000 times more powerful than the first atomic bomb.

Apparently the prediction of earthquake is really vital, to our security. In recent times, earthquake occurrence is analyzed by various mathematical techniques like Artificial Neural Network, Fractal dynamics, Cellular Automata Hurst exponent, etc.

The Hurst exponent H has broad applications for the studies on earth quakes, activities prior to geomagnetic storms, to ensure the stochastic nature of geomagnetic variations, fractal metrology for images, signals in time series analysis etc. Hurst component can distinguish a random series from a non-random series. Measurement of Hurst exponent can be applied in the power spectrum analysis, wavelet transforms, fractals and measurement of stochastic nature in time series analysis. Hurst exponent has been studied for various nonlinear processes in geophysics. In this paper, we employed Hurst's rescaled range technique to analyze the earthquake occurrences in Gujarat region.

Lomnitz, Mandelbrot and Wallis, used Hurst's method to study the earthquake cycles and found that these have the behaviour called Joseph effect.[1]. Quiet years turn to be followed by quiet years and active years by active years [2].This corresponds to a Hurst exponent greater than 0.5. However, Ogata and Abe obtained values of H of about 0.5, with data from Japan and from the whole world [3].This means that successive steps are independent, and the best prediction is the last measured value [4]. The best fit for our data set gives H = 0.469, which is nearly 0.5. This result is in agreement with the one obtained by Ogata and Abe.

## 2. HURST'S RESCALED RANGE TECHNIQUE

We provide a concise summary of Hurst's rescaled range method below. To calculate the Hurst exponent, one must estimate the dependence of the rescaled range on the time span of n observation [5]. A time series of full length N is divided into a number of shorter time series of length n = N,N/2,N/4...The average rescaled range is then calculated for each value of n. For a (partial) time series of length n, X1, X2...$X_n$, the rescaled range is calculated as follows:

1. Calculate the mean: m.
2. Create a mean-adjusted series: $Y_t = X_t - m$ for t= 1, 2..,n
3. Calculate the cumulative deviate series Z.
4. Compute the Range.
5. Compute the standard deviation S.
6. Calculate the rescaled range R (n)/S (n) and average over all the partial time series of length . Hurst exponent is estimated by fitting the power law to the data.

Hurst found that the observed rescaled range *(R/ S)* for many records in time is very well defined by the following empirical relation

$$R/S = (\tau/2)^H$$

Where *H* is the Hurst exponent, and τ is the time-span considered in the calculation. *H* describes the correlation between the past and future in the time series. For independent random processes with finite variances, the *H* value is 0.5. When *H* > 0.5, the time series is persistent, which means that an increasing trend in the past is indicative of an increasing trend in the future. Conversely, as a general rule, a decreasing trend in the past signifies a persistent decrease in the future. When *H* < 0.5, the time series is anti-persistent, which means that an increasing trend in the past implies a decreasing trend in the future and vice-versa. If H is more or less equal to 0.5 it indicates that the time series is random.

## 3. DATA ANALYSIS

Gujarat is located $23^0$ N and $72^0$ E in India. On 26 January 2001 an earthquake registering 7.9 on the Richter scale devastated Gujarat. It was the second largest recorded earthquake in India, the largest being in 1737, and was the worst natural disaster in India in more than 50 years. Hence in this paper an attempt is made to analyze the earthquake cycles of Gujarat. The earthquake data are obtained for a period of 1973 to 2010 for Gujarat from http;//neis.usgs.gov/neis/epic/epic global.html. The Hurst exponent value for 37 years was calculated using the rescaled range Technique. H was found to be 0.469 which is nearly 0.5.

## 4. CONCLUSION

In this paper we have shown how it is possible to measure the impact of information on the time series by using Hurst exponent H. Hurst exponent was calculated for earthquake occurrence in Gujarat region for 37 years and was found to be 0.469.This value suggests that the earthquake of Gujarat is chaotic in nature and hence predictability is not feasible for the region.

## 5. ACKNOWLEDGEMENT

We wish to thank the authors/editors of those journals from where the references to compile the manuscript are obtained.

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