STATISTICAL EVALUATION OF THE INFLUENCING EFFECTS OF GEOMAGNETIC STORMS ON GLOBAL EARTHQUAKE OCCURRENCES

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ABSTRACT

Earthquakes are tectonic events that take place within the fractures of the earth’s crust namely faults. Above certain scale earthquake can result in widespread fatalities and substantial financial loss. In addition to the movement of tectonic plates relative to each other, it is widely discussed that there are other external influences originate outside earth that can trigger earthquakes. These influences are called “Triggering effects”. The purpose of this article is to present a statistical view to elaborate if geomagnetic storms triggers earthquakes. As a model the research focuses on analysis at the global level using 37 years of historical data on geomagnetic storms and earthquakes collated from national and international resources. As the result of statistical analysis using spearman rank correlation technique the rank correlation coefficient was found to be −0.03 which indicates weak correlation. From this it is concluded that geomagnetic storms do not trigger earthquakes.

INTRODUCTION

Earthquakes are tectonic events that take place within the fractures of earth’s crust namely faults. In addition to the movement of tectonic plates relative to each other it is widely discussed that there are other external influences originate outside earth that can trigger earthquakes. These influences are called “Triggering effects”. Examples of such external event are lunar and solar eclipses, planetary alignment within the solar system and the influences of geomagnetic storms taking place in the sun. The most influential of these events is considered to be the extra ordinary solar activities influencing the earth’s geomagnetic field. The purpose of this article is to present a statistical view to elaborate if geomagnetic storm triggers earthquakes. As a model, the research focuses on the global occurrence presenting 37 years of historical data on geomagnetic storms and earthquakes collated from National and International resources.

Causes of earthquakes and geomagnetic storm and measurement methods

This section outlines the principles behind the occurrence of earthquakes and Geomagnetic storms.

Causes of earthquakes and measurement methods

In 1911, Professor Reid established the elastic rebound theory (1). A mathematical scale was required in order to obtain the data about the effects of these variations on the structures and Charles. F. Richter and Beno Gutenberg applied magnitude concept in 1930 (2). Among these Mb is calculated by taking the magnitude of p and s waves (Body wave magnitude), Md is calculated by using the durations of very small and close earthquakes. Ms is calculated by taking the magnitude of surface waves (surface wave magnitude) and Mw takes the seismic moment of the released energy (moment magnitude). These are the most used magnitude measures.

Causes for the occurrence of geomagnetic storms and measurement methods

The solar material, which accelerates as a result of the energy discharges occurring in the sun, “solar flares and prominences reaches earth from the gravitational field of the sun as different radiation forms and particles and it interacts with the magnetic field of Earth. In cases where these effects are dense, sudden changes occur in the magnetic field and they create the phenomenon which is called “geomagnetic storms”. Although different systems are used, one of the most important scales used in measuring this is Dst “Disturbance storm time”, indexes which have been recorded since 1973 (3). For the magnetic fields the changes in the Dst index are evaluated in five major groups. Weak storms - 30nt > DST > -50ntT, moderate storms -50nt> Dst> -100nt, strong storms -100nt> Dst> - 200 nt, Intense storms - 200 nt > Dst > -350nt, Heavy storms Dst > 350 nt
MATERIALS AND METHODS

Selection of study area and duration

Sources for the earthquakes data

In calculating the earthquake triggering effects the global occurrences are take into consideration starting from magnitude 2 to 9. The data set used in this study is based on 37 years of data collected from 1973 to 2010. The data is obtained from U.S. Geological survey (2005) Internet size for national earthquake information center USGS – NEIC, http://earthquake.usgs.gov/ eqcenter.)

Sources for the geomagnetic storm data

In this study data from NOAA, National Geophysics Data center, Internet site for space weather and solar events, http://www.ngdc. Noaa.gov/ which are constantly and regularly broad casted on the internet and globally acknowledged have been taken as basis.

Method

Correlation is a measure of association between two variables. The variables are not designated as dependent or independent. In this paper we used spearman correlation technique to find possible correlation between geomagnetic storms and earthquake occurrences. Spearman rank correlation is a technique used to test the direction and strength of relationship between two variables. In other words it is a device to show whether any one set of numbers has an effect on another set of numbers. It uses the statistics Rs which falls between -1 and +1

Procedure for using spearman rank correlation

1. State null hypothesis i.e., “There is no relationship between two sets of data.
2. Rank both set of data from the highest to the lowest.
3. Subtract the two sets of ranks to get the difference ‘d’
4. Square the values of ‘d’ to get $\sum d^2$
5. Add the squared values of ‘d’ to get $\sum d^2$
6. Use the formula Rs (or) $P = \frac{1-6\sum d^2}{n(n^2-1)}$

7. Where n is the number of ranks you have
8. If the Rs Value
   G Is -1 there is perfect negative correlation.
   G Falls between -1 and -0.5 there is strong negative correlation.
   G Falls between –0.5 and 0 there is weak negative correlation.
   G Is 0 there is no correlation.
   G Falls between 0 and 0.5 there is weak positive correlation.
   G Falls between 0.5 and 1 there is strong positive correlation.
   G Is 1 there is perfect position correlation between two sets of data.

If Rs value is ‘0’ the null hypothesis is accepted otherwise it is rejected. The spearman rank correlation coefficient for Geomagnetic storm and Earthquake data was found to be -0.03.

CONCLUSION

This preliminary study conducted using spearman rank correlation technique to know the relationship between Geomagnetic storms and Earthquake occurrences. The spearman rank correlation was found to be 0.03. This shows Very weak correlation. As a result of all these data, a hypothesis cannot be put forward which suggests that geomagnetic storms trigger earthquakes. However these results should not hinder the conduction of further research. A regional study on this subject can potentially provide new approaches.

References


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