



Do Solar Activities Cause Local Earthquakes? (New Zealand)

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ABSTRACT

The relationships between solar activities (sunspots, solar 10.7cm radio flux, solar irradiance, and solar proton events) and local earthquakes investigated in this paper. The geographical location of study is New Zealand area. All earthquakes data have been chosen for $M \geq 4$, from first of 1970 to Jun 2012. The study reveals the following conclusions: **1)** The total numbers of earthquakes strongly show annually an increasing in number of earthquakes in New Zealand from 42 years ago. **2)** The maximum earthquakes occur frequently around the minimum years of solar activities, **3)** The maximum earthquakes occurs in minimum years of sunspots number with a good correlation coefficient. **4)** The maximum earthquakes occur in the minimum solar 10.7 cm radio flux with strong correlation coefficient.

Key words: Astrophysics, solar activities, local earthquake, New Zealand

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INTRODUCTION

The Sun as an active and primary source of radiant energy to Earth is emitting a large radiation with a wide spectrum of wavelengths, which reaches the atmosphere of Earth. This radiation is including high energy and charge particles such as electrons and high energetic protons ($> 10 \text{ Mev}$). The effects of solar radiations and charge particles on earth and its atmosphere are known to a good extend and therefore expecting some affects on the geophysical processes of earth like earthquakes. Earthquakes not only cause by internal effects such as, subsidence, volcanic and/or tectonic effects, but can also be triggered by some other (external) effects. From 40 years ago, many authors in their studies have suggested about the different effects of solar activities in Earth and earthquakes. Simpson (1968) found that maximum quake frequency occurs at times of moderately high and fluctuating solar activity. Sytinskiy (1961) carried out a series of searches on the influence of solar activity on the earth seismicity. Ip (1976) carried out series of researches on the influence of solar activity on the earth seismicity. Zhang (1998) and Odintsov, Boyarchuk, Georgieva, Kirov, and Atanasov (2006) worked on the long period tendency in global earthquake geomagnetic activity and some simple relationships between solar activities and global number of earthquakes. However few studies such as Gousheva et al.

(2006) were considered for a country confined or local area earthquakes. Here, in this paper, we attempt to show that solar activities may have effect in earthquake events locally. For this reason we assume the following assumption.

1-The Earth is not a homogeneous isotropic object.

2-The earthquakes are not only caused by internal effects.

From the first assumption we find out different structure of plate tectonics and properties and therefore it is expected that different regions show unlike responses. From the second assumption also we find that internal effects such as subsidence, volcanic and tectonic effects are not the only reason of earthquake but also earthquakes can be triggered by some external effects such as cosmic rays (Dorman, 2004) magnetic field and solar activities. It is important to mention and remember that external effects are not stronger than internal effects certainly but these effects are not neglectable. The most active and well documented regions that affected by earthquake are Iran, Japan, Turkey, India, Australia, Italy, China, Indonesia, Philippines and New Zealand. In the previous our study we concentrated on Iran zone (Nikouravan, 2012) but here we consider and focused our study only on the New Zealand area. New Zealand is an island country located in the southwestern Pacific Ocean. The country geographically comprises two main landmasses that of the North and South Islands as well as numerous smaller islands and earthquake lines illustrated in Fig 1.

DATA

The Earth receives a total amount of radiation energy. The average incoming solar radiation is called the solar irradiance (SI) and all data are available freely and have been collected from historical total solar irradiance (TSI). Moreover, solar activities produce and emit very high energetic protons and these energies are equal and/or greater than 10 Mev. These charged particles arrive to Earth and enter the atmosphere over the polar region and much enhanced ionization is produced at altitudes below 100 km. These high energetic protons can penetrate the Earth's magnetic field and cause ionization in the ionosphere. To select Solar Proton events data, we used integral 5-minute averages for energies ≥ 10 Mev, given in Particle Flux Units (pfu). These data are available from issues of NOAA/SESC (2000) (Gerontidou, Vassilaki, Mavromichalaki, & Kurt, 2002). The time period of 1976-2010 which covering over 5 solar cycles 20, 21, 22, 23 and a part of 24, except 1996 and 2010 which is provided by the NASA. Moreover, all earthquake data also have been collected from IRIS for $M \geq 4$ and only for New Zealand zone.

LOCAL EARTHQUAKES (NEW ZEALAND)

Earthquakes are the result of a sudden release of energy in the Earth's crust that creates seismic waves. All earthquakes data have been collected for ($M \geq 4$) from 1st of January 1970 to 20th of June 2012. The total number of earthquake occurred in New Zealand area is 5327. Also, this is show that the numbers of earthquakes events are increasing from 42 years ago till now. (Fig 2)

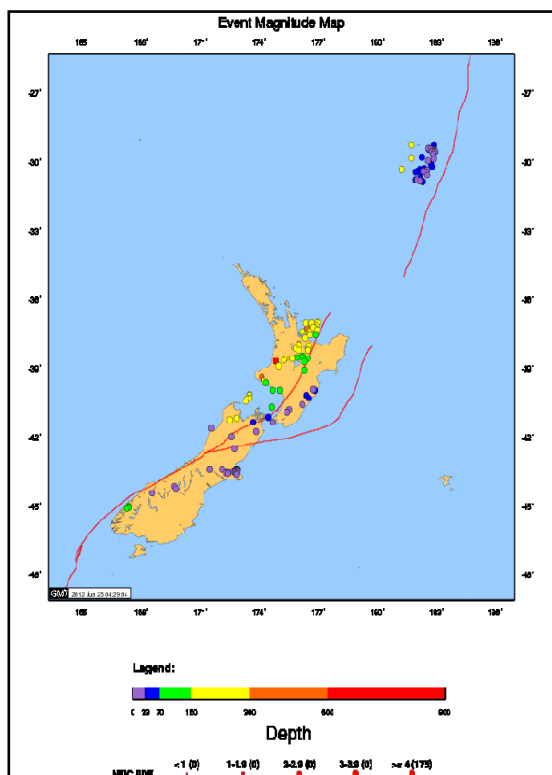


Figure.3 The figure show 289 numbers of earthquakes ($M \geq 4$) which have been updated based on data from the IRIS. (1st of January 2012-20th of June 2012) (IRIS)

SOLAR ACTIVITIES

The output of the Sun in all forms, light, solar wind, and energetic particles, is not constant. It varies with both time (seconds to centuries) and position on the Sun. These changes are called solar activity. Solar activities such as sunspots numbers, solar radio flux, solar Irradiance and solar proton events, show a periodic variation approximately with 11 years and considered in exact maximum and minimum years of sunspots. The exact values here are defined as accurate values of solar radio flux, solar Irradiance and solar proton events in the maximum and minimum years of solar activities. The variations of solar activities from 1970 to 2012 are shown in Figure 1.

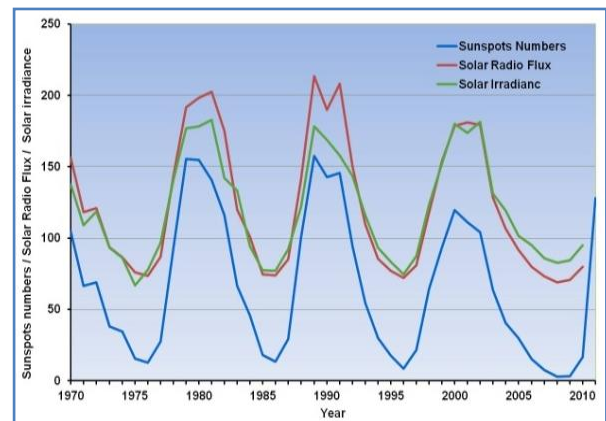


Figure.1 The variation of solar activities (1970-2010)

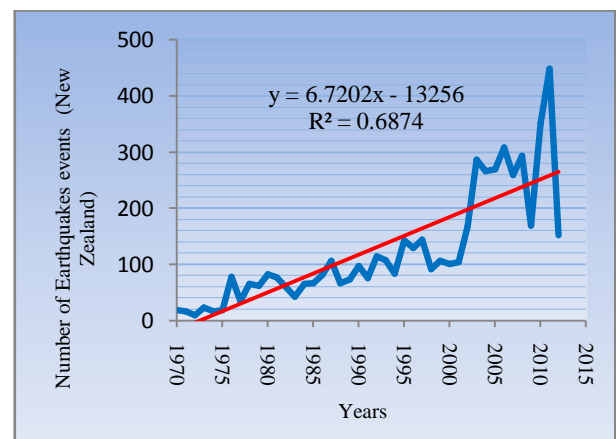


Figure.2 The variation of earthquakes with total number of 5327 events occurred from 1st of January 1970 to 20th of June 2012.

The location and seismic fault lines of this region is indicated in Fig3. This figure also shows 289 recorded earthquakes occurred in New Zealand only from first of Jun 2011 to 10 August 2011. The lines of earthquakes have also been demonstrated. Solar activities with its high emitting energy have large influence on the Earth magnetosphere which creates fluctuations known as geomagnetic storms. Here we pay special attention to periodic variation of, sunspots numbers, solar 10.7cm radio flux, solar irradiance and solar proton events (few data) with high energy (> 10 Mev) and earthquakes number. However our data is few

but these data are from 40 years ago. The results showed as below. The Fig4, show a strong and negative correlations

relationship between sunspots and number of earthquakes for $M \geq 4$.

Table.1 shows solar cycle period for minimum and maximum solar activities and total number of earthquakes events in each period

Period	Years		Sunspots		Solar Flux	Solar Irradiance	Solar Proton	Earthquakes M>4
	Started	Finished	Min	Max				
Cycle 18	1944	1954	4.4	151.6	702	1360.7617	-	0
Cycle 19	1954	1964	10.5	190.2	726	1360.8296	-	73
Cycle 20	1964	1976	12.6	105.9	734	1360.6678	12	78
Cycle 21	1976	1986	13.4	155.4	740	1360.7749	297	81
Cycle 22	1986	1996	8.6	157.6	720	1360.8329	0	129
Cycle 23	1996	2008	2.9	119.6	690	1360.8568	0	293
Cycle 24	2008	Not	-	128	-	-	-	0

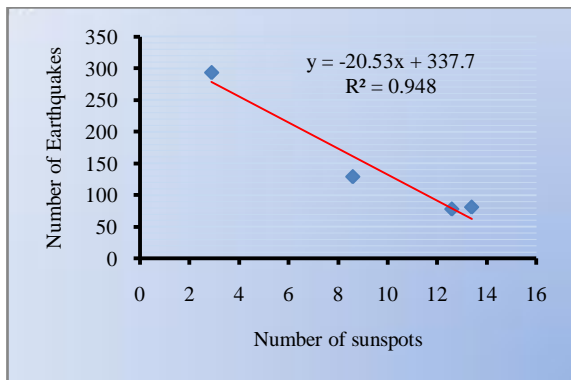


Figure.4 Correlation between number of sunspots and number of earthquakes from 1970 to 2012 for New Zealand

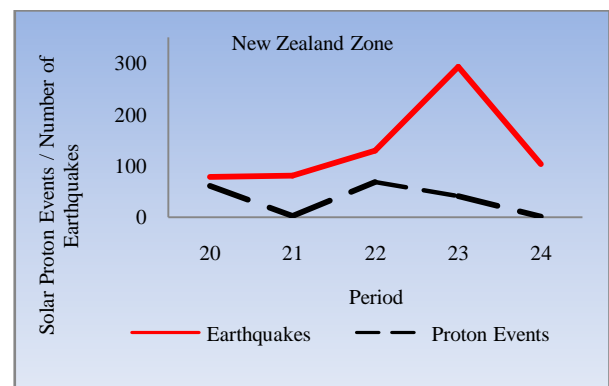


Figure.7 Annual variations between solar proton events (dotted black line) and number of earthquakes (solid red line)

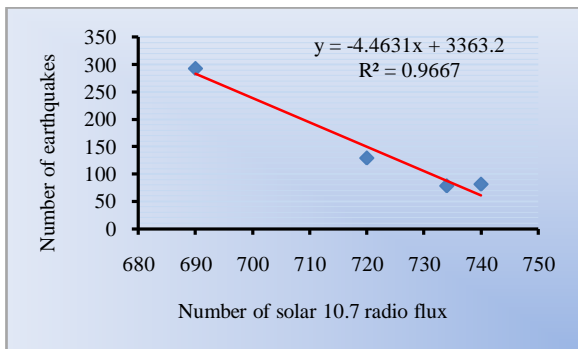


Figure.5 Correlation between number of Solar 10.7 cm radio flux and number of earthquakes from 1970 to 6 August 2011 for New Zealand

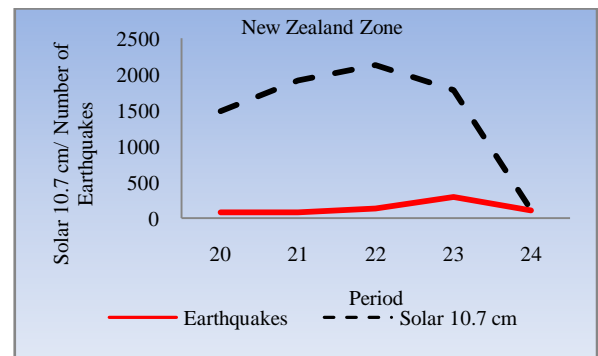


Figure.8 Correlation between number of solar 10.7 cm and earthquakes

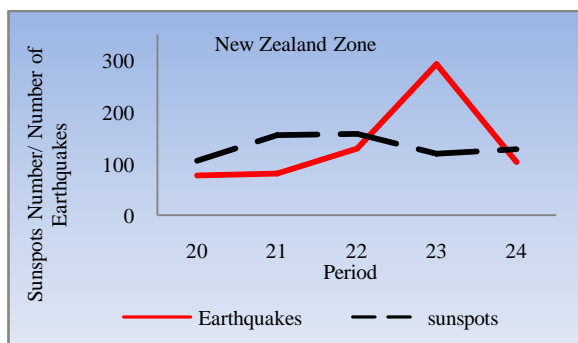


Figure.6 Annual variations between sunspots number (dotted black line) and the number of earthquake (solid red line)

CONCLUSION

With a quick look at the data it has been found that:

1-The total numbers of earthquakes for $M \geq 4$ from first of January 1970 to 20 Jun 2011, strongly show an increasing in number of earthquakes with coefficient $R^2 = 0.6874$.

2-The total number of earthquakes in the minimum and maximum years of solar activities is 654 and 602 respectively and the maximum earthquakes occur frequently around the minimum years of solar activities.

3-The maximum earthquakes from 1964 to 2008 occur in minimum years of sunspots numbers with very well correlation coefficient and $R^2 = 0.9482$.

4-The maximum earthquakes between 1964 and 2008, occur in the minimum solar 10.7 cm radio flux with a strong correlation and $R^2 = 0.9667$.

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