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RESEARCH ARTICLE

Relationship between Seismicity and Solar Activities during Solar Cycle 22

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Abstract

The relations between sunspot numbers and earthquakes ($M \geq 5$) and ($M \geq 8$), solar 10.7 cm radio flux and earthquakes, solar proton events and earthquakes, sunspots area and earthquakes during solar cycle 22, from 1986 to 1996 have been analyzed in this paper. It has been found that (1) there is an inverse relation between solar activity and earthquakes activity for $M \geq 5$ during solar cycle 22. (2) There is a direct relation between solar activity and earthquakes activity for $M \geq 8$ during the maximum of solar cycle 22 and an inverse relation between both at the descending phase of the cycle.

INTRODUCTION

Among all aforementioned natural phenomena, the earthquake is becoming a major phenomenon to damage the life and properties of the people and if no proper management and strategy are applied, a disaster will occur. Every particle has relation with each other to create a phenomenon like earthquake. Many scientists believe that the most naturally occurring earthquakes are related to the tectonic activities and volcanic eruption but, according to our assumption, Earth's External Effects (EEE) possibly is the cause for the occurrence of the earthquakes too as shown in figure (1) (Nikouravan B. et al., 2013).

Some scientists believe solar activity can cause earthquakes, volcanoes or extreme weather, where solar activity, as indicated by sunspots, radio noise and geomagnetic indices, plays a significant but by no means exclusive role in the triggering of earthquakes, also terrestrial solar flare effects which are the actual coupling mechanisms which trigger quakes appear to be either abrupt accelerations in the earth's angular velocity or surges of telluric currents in the earth's crust.

Many studies about the relation between solar activity and earthquake activity have come out. Generally, most of these studies studied the relation between the recurrent variation of sunspot numbers and earthquake activity. Sytinskiy (1961,1973,1998) carried out a series of searches on the influence of solar activity on the earth seismicity (Sytinskiy, 1979). Simpson (1968) found that maximum quake frequency occurs at times of moderately high and fluctuating solar activity (Simpson et al., 1968). Lursmanashvili (1972) &Ip (1976) carried out series of researches on the influence of solar activity on the earth seismicity (Lursmanashvili, 1972). Ip wrote about Chinese records on the correlation of heliocentric planetary alignments and earthquake activities. Forecasts were made on the basis of the correlation between the instants of occurrence of strong earthquakes and the time of passage of geo-active solar regions across the central meridian of the sun (Ip et al., 1976).

BijanNikouravan (2012) attempt to show that solar activities may have effect in earthquake events locally, his study is focused on exploring the relationships between solar activities such as sunspots numbers (SNs), solar 10.7 cm radio flux (SRF), solar irradiance (SI), solar proton events (SPEs) and local earthquakes for magnitude 4, in country confined local seismicity (New Zealand area) (Bijan N., 2012).

Nikouravan et al. (2012) studied the relationships between solar activities such as sunspots numbers (SNs), solar 10.7 cm radio flux (SRF), solar irradiance (SI), solar proton events (SPEs) and local earthquakes for magnitude ≥ 4, in country confined local seismicity (Iran area) and all earthquakes data chosen for M ≥ 4 from 1970 to 2010 (Nikouravan et al., 2012).
Dorman (2004) found 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 magnetic field and solar activities (Dorman et al., 2004) (Gerontidou et al., 2002).
NikouravanBijan (2013) published a paper which brings a new opinion that shows the fact of existence of solar cycles such as solar activity or solar winds as non-tectonic effects are comparable with seismic and tectonic processes which are very important. It reveals that the link between the sunspots and earthquakes has emerged and interprets the fact that the electric discharges on the sun which cause sunspots, also affect the earth's ionosphere. The ionosphere forms one "plate" of a capacitor, while the earth forms the other (Nikouravan B. et al., 2013).
Therefore, this paper concerned in studying the relation between different aspects of solar activities with the behavior of the earthquake activity during cycle 22 with an aim of exploring the relationships between solar activities and earthquakes activity using different analytical and statistical methods.

Data:

Solar cycle 22 was the 22nd solar cycle since 1755, when extensive recording of solar sunspot activity began. The solar cycle lasted 9.7 years. It began in September 1986 and ending in May 1996. The maximum smoothed sunspot number (monthly number of sunspots averaged over a twelve-month period) observed during the solar cycle was 158.5 (July 1989), and the minimum was 8. There were a total of 309 days without sunspots during this cycle (Kane, R.P., 2002).
Sunspots numbers (annual mean or yearly average) are taken from SIDC web site (Solar Influence Data Analysis Center), solar proton fluence(>100 MEV) data are taken from NOAA/NGDC (National Geophysical Data Center) web site , sunspots area data from Royal Observatory , Greenwich USAF/NOAA Sunspot Data site and 10.7 solar radio flux (yearly average observed flux) data were taken from Space Weather Canada (Natural Resources Canada) web site for a time period from 1986 to 1996.
Earthquake activity data had been collected from National Earthquake Information Center – NEIC / U.S. Geological Survey – USGS with magnitude (M ≥ 5) for the same time period. This solar cycle have 6249 total earthquakes number, 5450 earthquakes with M ≥ 5 , 677 earthquakes with M ≥ 6 , 116 earthquakes with M ≥ 7 and 6 earthquakes with M ≥ 8 .
Large earthquakes are one with M=8.1 took place on 1989 , 2 with M=8.2,8.3 took place on 1994 , 2 with M=8 took place on 1995 and one with M=8.2 took place on 1996. Table (1) illustrates the 6 huge earthquakes occurred during cycle 22 (from 9/1986 to 5/1996) their time, depth, magnitude, latitude and longitude.

Results and Discussion:

1- The relation between the solar activity and earthquakes number with M ≥ 5 during cycle 22.

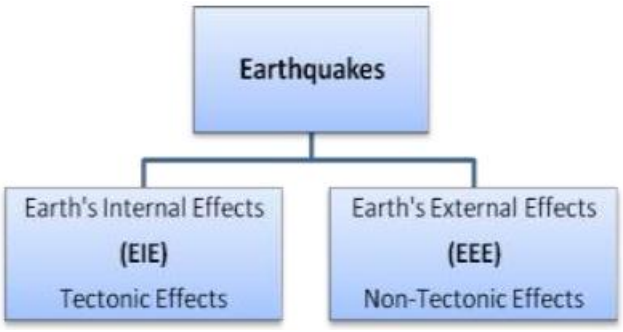
After analyzed the data used and applied some statistical methods we got the relation between sunspots number and earthquakes number with M ≥ 5 as shown in figure (2), which explained that the earthquakes number was minimum in 1989 where the sunspots number was maximum but it was maximum during the interval from 1990 to 1995 where the sunspots number was minimum.
The relation between GEOS proton influence >100 MEV and earthquakes number with M ≥ 5 illustrated in figure (3), which shown that during the period of 1988 , 1990 and 1993 the earthquakes number was maximum where the GEOS proton influence > 100 MEV was minimum but during 1989 , 1991 the GEOS proton fluence> 100 MEV was maximum where earthquakes number was minimum.
Figure (4) shows the relation between yearly average solar flux and earthquakes number with M ≥ 5 and shows that on 1987, 1990, 1994 the earthquakes number was maximum when the yearly average solar flux was minimum and on 1989, 1991 the yearly average solar flux was maximum but earthquakes number was minimum.
Figure (5) shows the relation between both observed , corrected sunspots area and earthquakes number with M ≥ 5 and shows that on 1987 , 1990 , 1992 , 1995 the earthquakes number was maximum when the sunspots area was minimum and on 1989 , 1991 the sunspots area was maximum but earthquakes number was minimum.

2- The relation between solar activity and earthquakes number with M ≥ 8 during cycle 22.

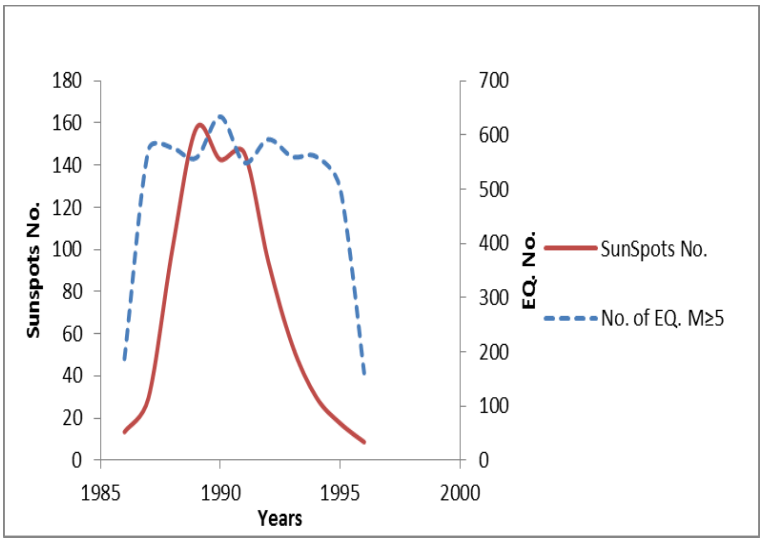
The international solar data : sunspots numbers (annual mean or yearly average) are taken from SIDC web site (Solar Influence Data Analysis Center) , solar proton fluence (>100 MEV) data are taken from NOAA/NGDC (National Geophysical Data Center) web site , sunspots area data from Royal Observatory , Greenwich USAF/NOAA Sunspot Data site and 10.7 solar radio flux (yearly average observed flux) data were taken from Space Weather Canada (Natural Resources Canada) web site for a time period from 1986 to 1996.
Earthquake activity data had been collected from National Earthquake Information Center – NEIC / U.S. Geological Survey – USGS with magnitude ($M \geq 8$) for the same time period.
Making some statistical analysis and drawing graphs show the relationship between the solar activity data and earthquakes number, we can see that:
Figure (6) shows the relation between sunspots number and earthquakes number with $M \geq 8$ and shows that on 1995 the earthquakes number was maximum when the sunspots number was minimum and on 1989 the sunspots number was maximum and also earthquakes number was maximum.
Figure (7) shows the relation between GEOS proton fluence> 100 MEV and earthquakes number with $M \geq 8$ and shows that on 1995 the earthquakes number was maximum when the GEOS proton fluence> 100 MEV was minimum and on 1989 the GEOS proton fluence> 100 MEV and earthquakes number were maximum.
Figure (8) shows the relation between yearly average solar flux and earthquakes number with $M \geq 8$ and shows that on 1995 the earthquakes number was maximum when the yearly average solar flux was minimum and on 1989 the yearly average solar flux and earthquakes number were maximum.
Figure (9) shows the relation between both observed, corrected sunspots area and earthquakes number with $M \geq 8$ and shows that on 1995 the earthquakes number was maximum when the sunspots area was minimum and on 1989 the sunspots area and earthquakes number was maximum.

Table (1) Huge earthquakes during cycle 22

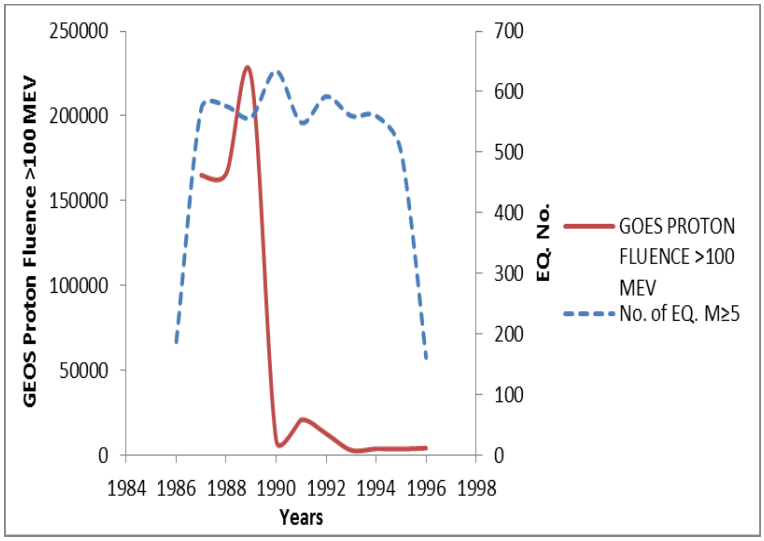
No.	Year	Month	Day	Hour	Min.	Depth	Magnitude	Latitude	Longitude
1	1989	5	23	10	54	1.7	8.1	-53.51	160.6
2	1994	6	9	0	33	635.4	8.2	-13.88	-67.53
3	1994	10	4	13	23	33.3	8.3	43.83	147.33
4	1995	7	30	5	11	40.5	8	-23.34	-70.27
5	1995	10	9	15	35	25.6	8	19.05	-104.21
6	1996	2	17	5	59	35.9	8.2	-0.92	136.98



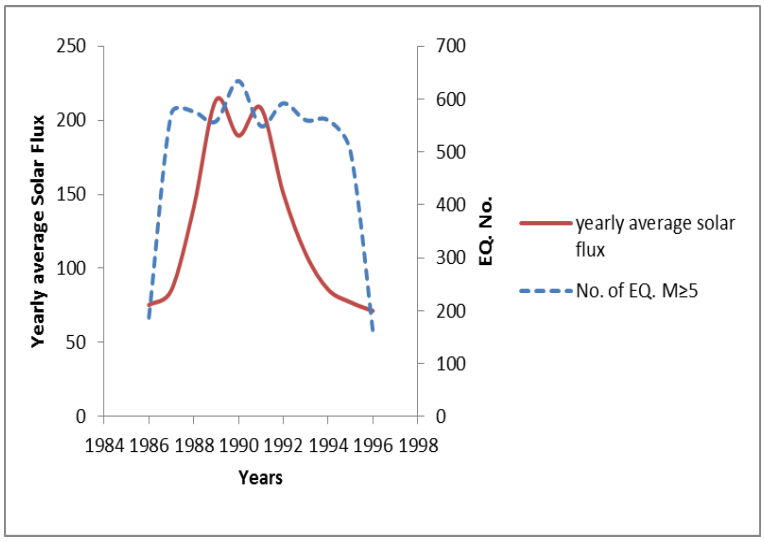
Figure(1)Classification of the earthquake's effects.



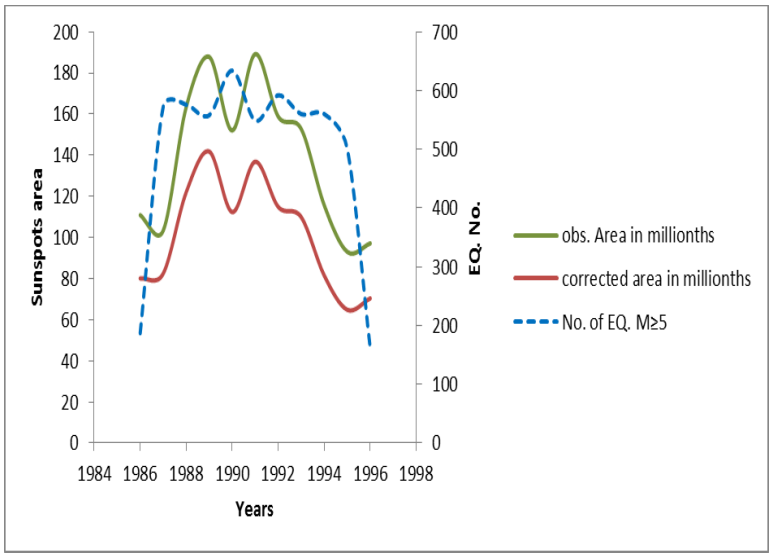
Figure(2)The relation between sunspots number and earthquakes number with M ≥ 5during cycle 22



Figure(3) The relation between yearly average solar flux and earthquakes number with M ≥ 5 during cycle 22



Figure(4) The relation between yearly average solar flux and earthquakes number with M ≥ 5 during cycle 22



Figure(5) The relation between both observed , corrected sunspots area and earthquakes number with M ≥ 5 during cycle 22

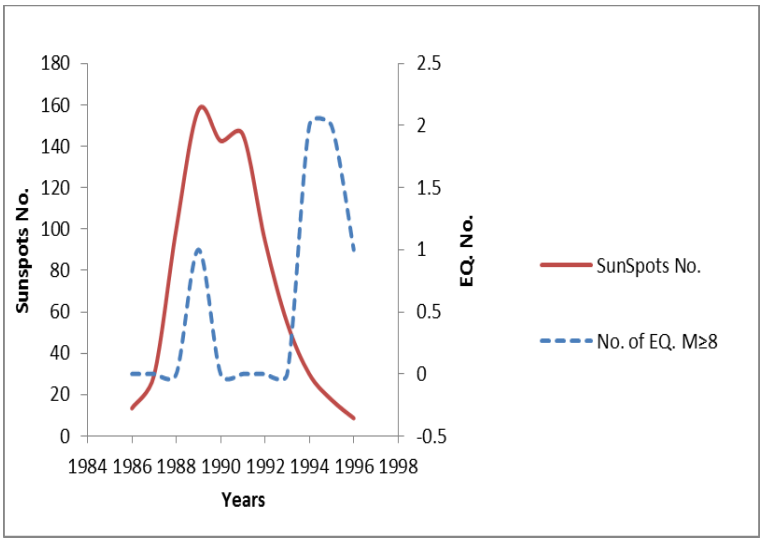
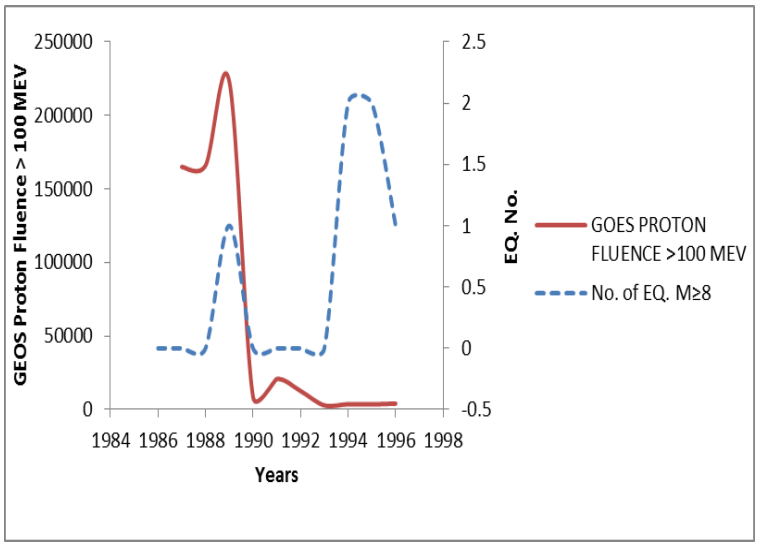
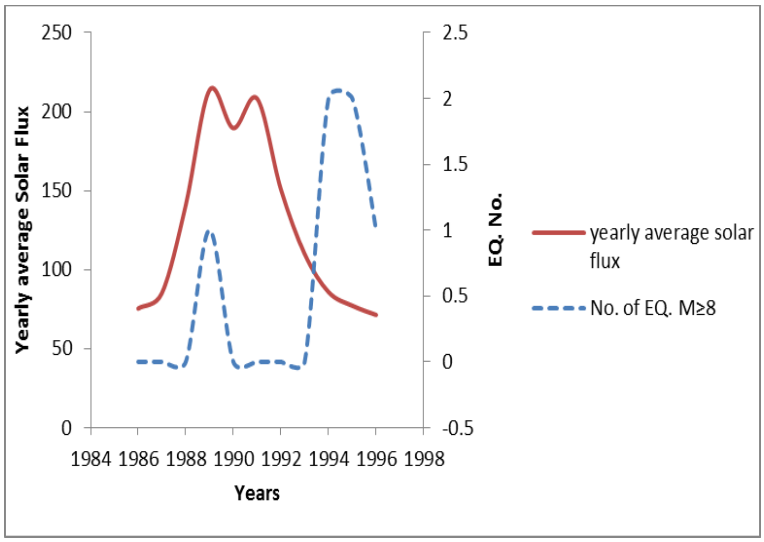


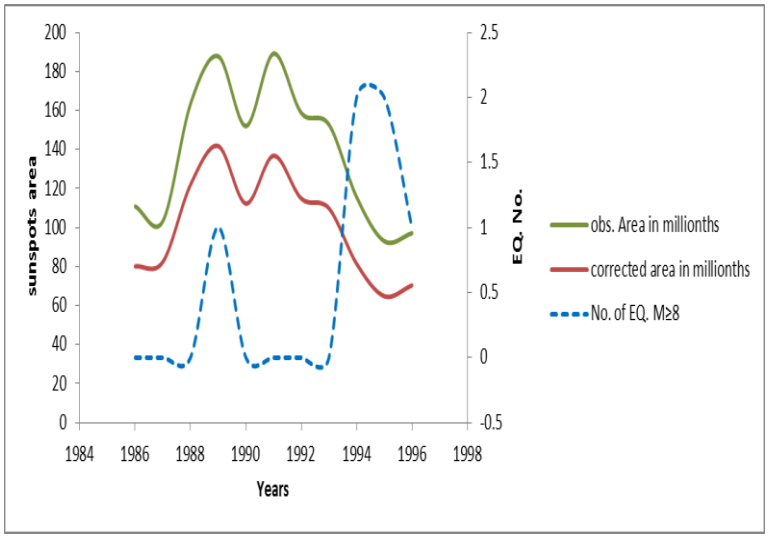
Figure (6) The relation between sunspots number and earthquakes number with $M \geq 8$ during cycle 22



Figure(7) The relation between GEOS proton fluence> 100 MEV and earthquakes number with $M \geq 8$ during cycle 22



Figure(8) The relation between yearly average solar flux and earthquakes number with M ≥ 8 during cycle 22



Figure(9) The relation between both observed , corrected sunspots area and earthquakes number with M ≥ 8 during cycle 22

Conclusion:

This paper illustrate the relation between sunspots number,solar 10.7 cm radio flux, solar proton events, sunspots area and earthquakes number with magnitude (M ≥ 5) and (M ≥ 8) during solar cycle 22 (from 1986 to 1996).
The above analysis and discussions can be concluded as follows:
From figures 2, 3, 4 and 5 we can see that:
-The maximum global earthquakes with M ≥ 5 occurred during the descending phase of the solar cycle 22 when the sunspots number, solar 10.7 cm radio flux, solar proton events and the sunspots area were minimum.
-The minimum global earthquakes with M ≥ 5 occurred around the maximum of the solar cycle 22 when the sunspots number, solar 10.7 cm radio flux, solar proton events and the sunspots area were maximum.
But, from figures 6, 7, 8 and 9 we can see:
-The maximum global earthquakes with M ≥ 8 occurred during the maximum of the solar cycle 22 when the sunspots number, solar 10.7 cm radio flux, solar proton events and the sunspots area were maximum.
-Also, The maximum global earthquakes with M ≥ 8 occurred during the descending phase of the solar cycle 22 when the sunspots number, solar 10.7 cm radio flux, solar proton events and the sunspots area were minimum.

During cycle 22 in the period from 1986 to 1996, all the maximum global earthquakes with magnitude ($M \geq 5$) occurred in the minimum of the cycle, so there is an inverse relation between solar activity and earthquakes activity for $M \geq 5$ during solar cycle 22.
But, all the global earthquakes only with magnitude ($M \geq 8$) occurred around the maximum and during the descending phase of the cycle, so there is a direct relation between solar activity and earthquakes activity for $M \geq 8$ during the maximum of solar cycle 22 and an inverse relation between both at the descending phase of the cycle.

References:

- BijanNikouravan, 2012, Do Solar Activities Cause Local Earthquakes? (New Zealand), IJFPS, Vol. 2, No.2, pp.20-23.
- BijanNikouravan, J. J. Rawal, RahmanSharifi, and Mahmoud Nikkhah, 2012, Probing relation between solar activities and seismicity, Vol.7 (24), pp. 3082-3088.
- Dorman, L. I., 2004, Cosmic rays in the earth's atmosphere and underground (Vol. 303): Kluwer Academic Pub.
- Gerontidou, M., Vassilaki, A., Mavromichalaki, H., & Kurt, V., 2002, Frequency distributions of solar proton events. Journal of atmospheric and solar-terrestrial physics, 64(5-6), 489-496.
- Kane, R.P., 2002, Some Implications Using the Group Sunspot Number Reconstruction, Solar Physics 205(2), 383-401.
- Lursmanashvili O.V., 1972, Possible influence of solar activity on the distribution of the earthquakes in the Caucasus, AkadNaukGruz SSR Soobshch, 65(2), 309-12.
- Lursmanashvili O.V., 1972, The regular changes in the internal andmagnitude of intense earthquakes in the Transcaucaus, AkadNaukGruz SSR Soobshch, 66(3), 581-3.
- NikouravanBijan, Pirasteh Saied, and MollaeeSomayeh, 2013, The effect of solar cycle's activities on earthquake: a conceptual idea for forecasting. Disaster Advances, Vol. 6 (4).
- Simpson, J. F., 1968, Solar activity as a triggering mechanism for earthquakes. Earth and Planetary Science Letters, 3, 417-425.
- Sytinskiy A.D., 1979, Relationship between strong earthquakes and solar wind parameters, Doklady of the Academy of Sciences of the USSR, Earth Sciences Sections, 2499(1-6), 12-14 .
- W.-H. Ip, 1976, Chinese records on the correlation of heliocentric planetary alignments and earthquake activities. Icarus, 29(3), 435-436.