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Influences of Solar Activities on Earthquakes during Different two Solar Cycles 22 and 23

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Abstract: *The Sun as a primary source of radiant energy is an active object to Earth as it emits a large amount of radiation with a wide range of wavelengths, and energetic charged particles which have severe effects on the man-made space systems, the earth's atmosphere and, its interior stability. In the last four decades, many researchers in their studies suggested different effects of solar activities on Earth and earthquakes. Yet, the relationship between the solar activity and earthquakes is still a subject of debate. Therefore, the present study will concern studying the relation between different aspects of solar activities with the behavior of the earthquake activity during two different solar cycles 22 and 23.*

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I. Introduction:

Scientists have been trying for many years to predict earthquakes in the short term. So, the exact trigger mechanism for earthquakes is not fully understood. Many scientists believe that the most naturally occurring earthquakes are related to the tectonic activities and volcanic eruption but this is not all that generates the occurrence of the earthquakes. Some link exists between sunspots and seismic activity such as earth's external effects. If this link exists, it may not be extremely weak as to be insignificant. Earth's external effects act as catalyst on Earthquakes. The study of this effect is an application of Astrophysics in Earthquake science.

Lursmanashvili et al. (1987) proved that the variations and position of the earth on its yearly orbit in correlation with the solar activity, Gui-Qing Zang (1998) concluded that the earthquake frequency in the minimum period of solar activity is closely related to the maximum annual means of sunspot numbers, the maximum annual means of solar 10.7 cm radio flux and solar proton events of a whole solar cycle, and the relation between earthquake and solar proton events is closer than others.

Odintsov, et al., (2006) studied the long period tendency in global earthquake geomagnetic activity and some simple relationships between solar activities and global number of earthquakes with magnitude equal and larger than 4 ($M \geq 4$). Sun not only have very serious effects on the earth atmosphere, but also affect the earth surface. As evidence are; low level clouds, ocean temperatures, land temperatures, tropospheric temperatures, and earthquakes (Courtillot et al., 2007). Khainand K., (2009) found that the periodicity of solar activity have an influence upon the periodicity of geodynamic processes, also, Tavares and Azevedo (2011) showed that in their study, there existed a correlation between the solar cycles and the earthquake activity. Nikouravan B. 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 $M \geq 4$ from 1970 to 2010.

Nikouravan B., et al. (2013) got that link exists between solar activity and seismic activity, this study effects is an application of Astrophysics in Earthquake science. Sara, S.K., et al. (2015) studied the relation between seismicity and solar activities during solar cycle 22. This paper concerned in studying the relation between different aspects of solar activities with the behavior of the earthquake activity during two different solar cycles 22 and 23 with an aim of exploring the relationships between solar activities and earthquakes activity. The relations between sunspot numbers, sunspot areas, solar 10.7 cm radio flux, solar proton events and earthquakes of ($M \geq 6$) and ($M \geq 7$) during the interval from 1986 to 2008 of our studied two solar cycles 22 and 23 have been analyzed.

II. Data used:

Our studied Solar cycle 22 was the 22 nd solar cycle since 1755, when extensive recording of solar sunspot activity began lasted 9.7 years, It began in September 1986 and ending in May 1996 and solar cycle 23 was the 23 nd solar cycle since 1755, when extensive recording of solar sunspot activity began, It lasted 12.6 years, began in May 1996 and ended in January 2008. 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 2008. Earthquake activity data had been collected from National Earthquake Information Center – NEIC / U.S. Geological Survey – USGS with magnitude ($M \geq 5$) for the same time period. The solar cycle 22 has 6249 total earthquakes number, 677 earthquakes with $M \geq 6$, 116 earthquakes with $M \geq 7$. The solar cycle 23 has 7141 total earthquakes number, 930 earthquakes with $M \geq 6$, 140 earthquakes with $M \geq 7$.

We divided the data into two categories according to the magnitude of earthquakes studied ($M \geq 6$ and $M \geq 7$) with corresponding solar data, and carried out some statistical analysis showing the relation between the solar activity and the corresponding earthquake activity during the two solar cycles 22 and 23.

III. Discussion:

Relationship between the solar activity and earthquakes number with M ≥6 during solar cycles 22 and 23.

The relation between solar activity and earthquakes number with $M \geq 6$ is shown in figures (1-a,b,c,d,e,f,g,h) during the period from 1986 to 1996 for cycle 22 and from 1996 to 2008 for cycle 23 respectively.

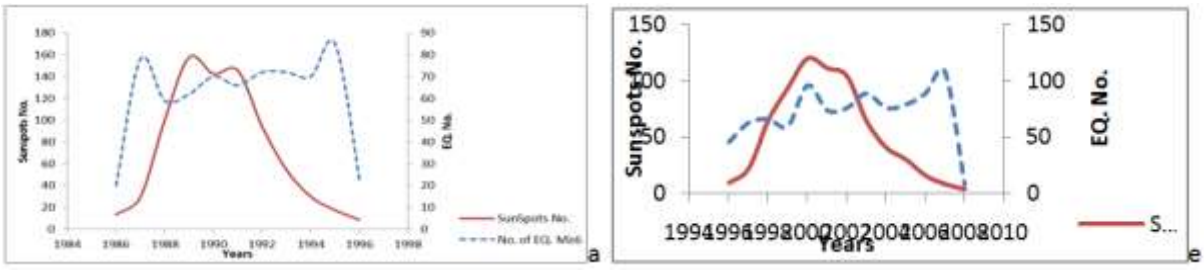
Figures (1-a,e) show the relation between sunspots number and earthquakes number with $M \geq 6$ for solar cycles 22 and 23 respectively, fig. (1-a) shows that on 1987, 1990, 1995 the earthquakes number was maximum when the sunspots number was minimum and on 1988, 1992 the sunspots number was maximum but earthquakes number was minimum. Figure (1-e) illustrates that on 2000 the sunspots number was maximum and also earthquakes number was maximum, on 2002 the sunspots number was maximum but earthquakes number was minimum, and on 2003, 2007 the earthquakes number was maximum when the sunspots number was minimum. Figures (1-b,f) show the relation between GEOS proton fluence > 100 MEV and earthquakes number with $M \geq 6$ for solar cycles 22 and 23 respectively, fig. (1-b) shows that on 1987, 1991, 1993, 1995 the earthquakes number was maximum when the GEOS proton fluence > 100 MEV was minimum and on 1989 the GEOS proton fluence > 100 MEV was maximum but earthquakes number was minimum. fig.(1-f) shows that on 2000, 2003 the earthquakes number and the GEOS proton fluence > 100 MEV were maximum and on 2007 the GEOS proton fluence > 100 MEV was minimum and earthquakes number was maximum.

Figures (1-c,g) show the relation between yearly average solar flux and earthquakes number with $M \geq 6$ for solar cycles 22 and 23 respectively, fig. (1-c) shows that on 1987, 1991, 1994, 1996 the earthquakes number was maximum when the yearly average solar flux was minimum and on 1988, 1990 the yearly average solar flux was maximum but earthquakes number was minimum. Figure (1-g) illustrates that on 2000 the earthquakes number and the yearly average solar flux were maximum and on 2007 the yearly average solar flux was minimum and earthquakes number was maximum.

Figures (1-d,h) show the relation between both observed, corrected sunspots area and earthquakes number with $M \geq 6$ for solar cycles 22 and 23 respectively, fig. (1-d) shows that on 1987, 1990, 1993, 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. Figure (1-h) illustrates that on 2000, 2003 the earthquakes number was maximum when the sunspots area was minimum and on 2007 the sunspots area and earthquakes number was maximum.

So, from figures (1-a,b,c,d) we can say that there is an inverse relation between solar activity and earthquakes activity for $M \geq 6$ during solar cycle 22.

From figures (1-e,f,g,h) for solar cycle 23, we show that the earthquakes was near the maximum of this cycle, there is a direct relation between the sunspots number, yearly average solar flux, GEOS proton fluence and earthquakes number and an inverse relation between the sunspots area and earthquakes number. Also, at this cycle's maximum and the descending phase of it there is an inverse relation between the sunspots number, yearly average solar flux, GEOS proton fluence and earthquakes number, but a direct relation between sunspots area and earthquakes number.



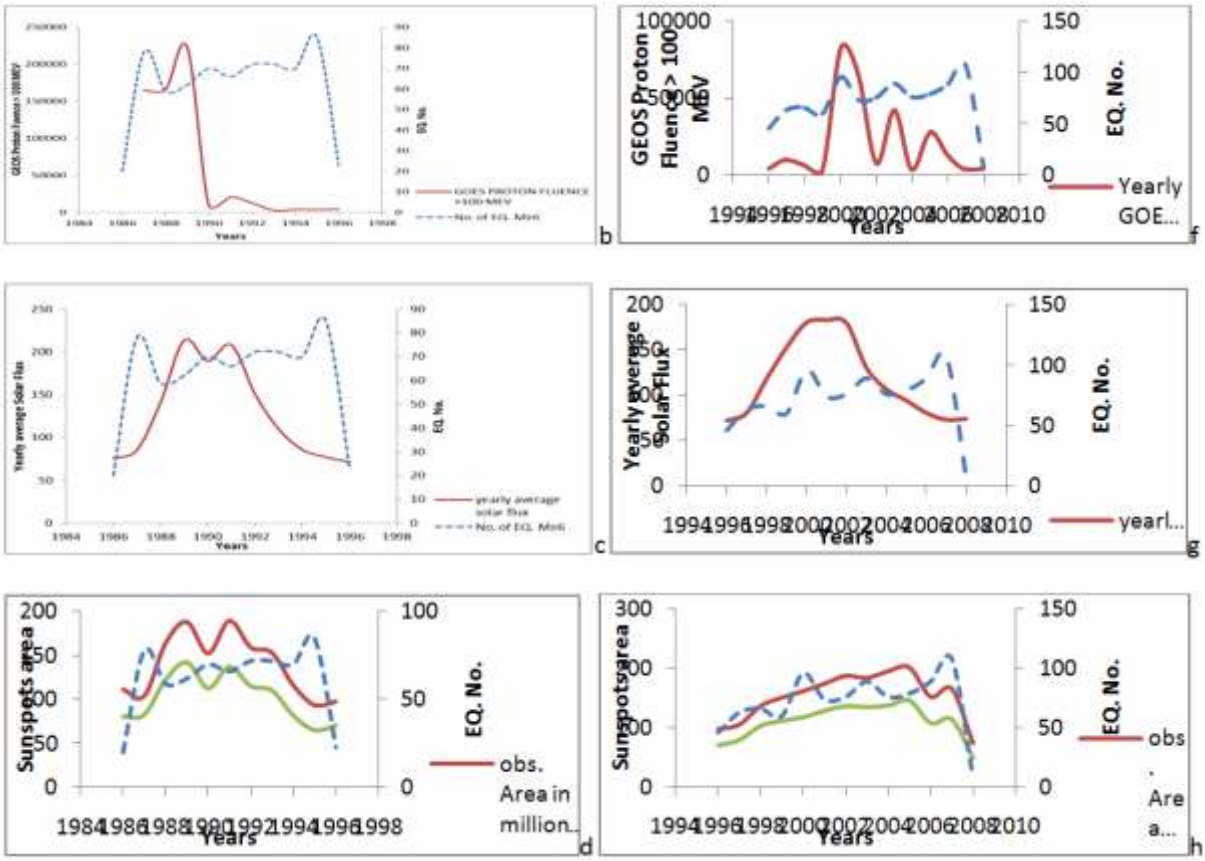


Fig.(1-a,b,c,d,e,f,g,h) The relation between the solar activity and earthquakes numbers with magnitude ≥ 6 during cycles 22 and 23, (a&e) the relation between sunspots number and earthquakes number, (b&f) the relation between GEOS proton fluence > 100 MEV and earthquakes number, (c&g) the relation between yearly average solar flux and earthquakes number,(d&h) the relation between sunspots area and earthquakes number).

Relationship between so lar activity and earthquakes number with M ≥ 7 during solar cycles 22 and 23.

The relation between solar activity and earthquakes number with M ≥ 7 is shown in figure (2-a,b,c,d,e,f,g,h) during the period from 1986 to 1996 for solar cycle 22 and from 1996 to 2008 for solar cycle 23 respectively. Figures (2-a,e) show the relation between sunspots number and earthquakes number with M ≥ 7 for cycles 22 and 23 respectively, fig.(2-a) shows that on 1987, 1990, 1995 the earthquakes number was maximum when the sunspots number was minimum and on 1989, 1991 the sunspots number was maximum but earthquakes number was minimum. Figure (2-e) illustrates that on 1997, 2004, 2007 the sunspots number was minimum and the earthquakes number was maximum and on 2000, 2003 the sunspots number was maximum but earthquakes number was minimum.

Figures (2-b,f) shows the relation between GEOS proton fluence > 100 MEV and earthquakes number with M ≥ 7 for cycles 22 and 23 respectively, fig.(2-b) shows that on 1987, 1991, 1995 the earthquakes number was maximum when the GEOS proton fluence > 100 MEV was minimum and on 1989 the GEOS proton fluence > 100 MEV was maximum but earthquakes number was minimum. Figure (2-f) illustrates that on 1999, 2007 the earthquakes numbers was maximum and the GEOS proton fluence > 100 MEV was minimum and on 2000 the GEOS proton fluence > 100 MEV was maximum and earthquakes number was minimum.

Figures (2-c,g) show the relation between yearly average solar flux and earthquakes number with M ≥ 7for cycles 22 and 23 respectively, fig.(2-c) shows that on 1987, 1991, 1994, 1996 the earthquakes number was maximum when the yearly average solar flux was minimum and on 1988, 1990 the yearly average solar flux was maximum but earthquakes number was minimum. Figure (2-g) illustrates that on 2000, 2002 the earthquakes number was minimum and the yearly average solar flux was maximum and on 1997, 2007 the yearly average solar flux was minimum and earthquakes number was maximum.

Figures (2-d,h) show the relation between both observed, corrected sunspots area and earthquakes number with M ≥ 7 for cycles 22 and 23 respectively, fig. (2-d) shows that on 1987, 1990, 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. Figure (2-h) illustrates that on 1997, 1999 the earthquakes number was maximum when the sunspots area was minimum and on 2007 the sunspots area and earthquakes number was

maximum. So, from figures (2-a,b,c,d) we can got that there is an inverse relation between solar activity and earthquakes activity for M ≥ 7 during solar cycle 22, also from figures (2-e,f,g,h) we can got that there is an inverse relation between all solar activity and earthquakes activity for M ≥ 7 during the solar cycle 23, but there is a direct relation between sunspot area and earthquakes number at the descending phase of this cycle.

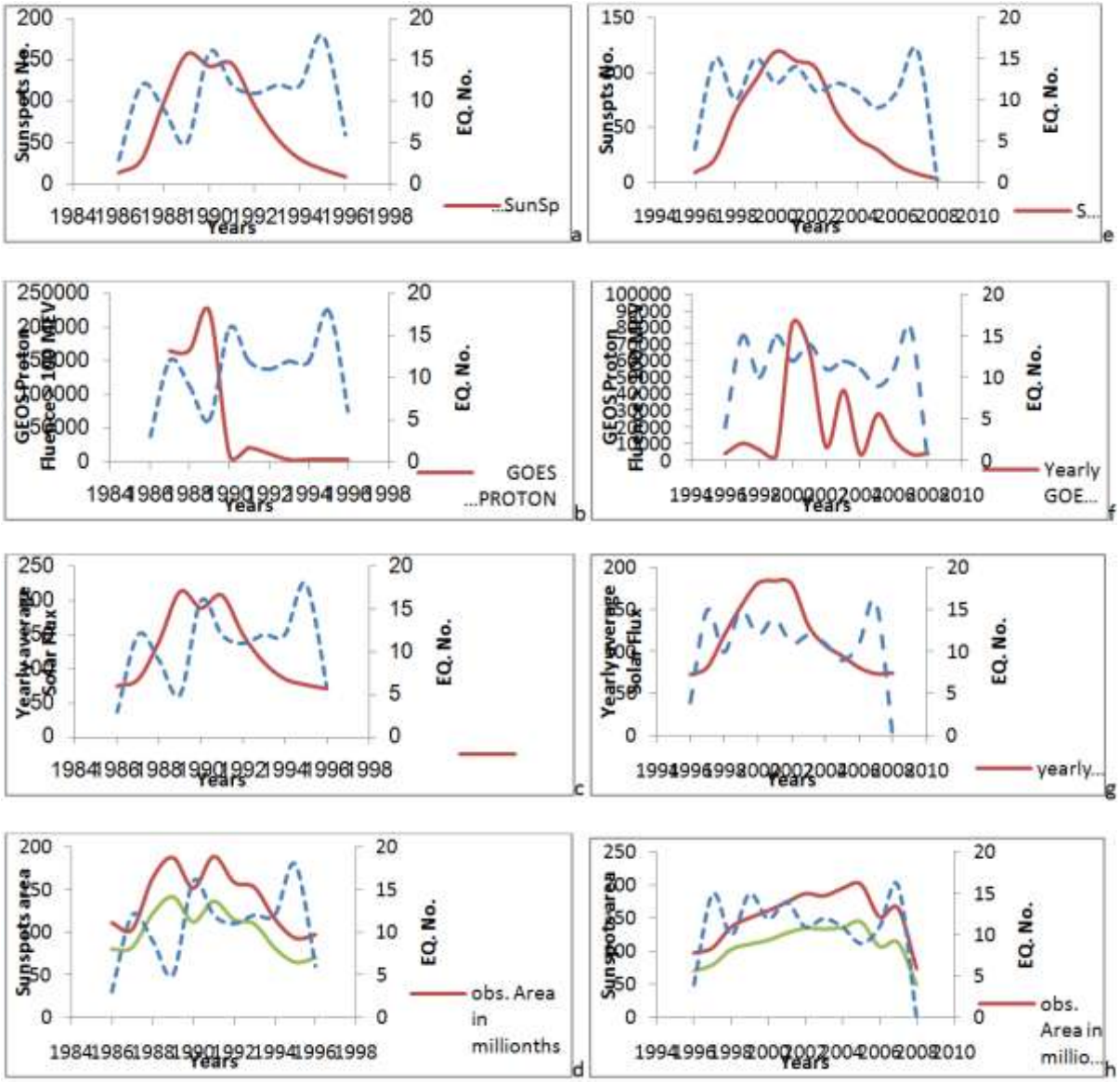


Fig.(2-a,b,c,d,e,f,g,h) The relation between the solar activity and earthquakes numbers with magnitude ≥ 7 during solar cycles 22 and 23, (a&e) the relation between sunspots number and earthquakes number, (b&f) the relation between GEOS proton fluence > 100 MEV and earthquakes number, (c&g) the relation between yearly average solar flux and earthquakes number, (d&h) the relation between sunspots area and earthquakes number).

IV. Conclusion:

Solar activities can influence the frequency of the earthquake activity. Generally, the earthquake activity is relatively more frequent around the minimum years of solar activity and is relatively less in the maximum years, i.e., around the time when the magnetic polarity in solar polar regions are reversed.

We note that during solar cycle 22, there is an inverse relation between solar activity parameters and earthquakes number with M ≥ 6, 7 during the maximum of the cycle.

Also, at the descending phase of the cycle there is an inverse relation between the solar activity parameters and earthquakes number with all magnitude ranges.

During the solar cycle 23, at the maximum of this cycle there is no clear relation between the solar activities and the earthquakes activity for all magnitude ranges. But, at the descending phase of this cycle there is an inverse relation between the solar activities and the earthquakes activity for all magnitude ranges.

Generally, the earthquake activity is relatively more frequent around the minimum years of solar activity and is relatively less in the maximum years, i.e., around the time when the magnetic polarity in solar polar regions are reversed. It reveals that the link between the Sunspots and Earthquakes has emerged and interprets the fact that the electric charges in the solar wind ionize the Earth's ionosphere. So from relationship between solar activities and earthquakes activity, we can investigate the possibility of prediction the earthquakes activity from the solar cycle prediction.

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