WOLF NUMBER RELATED TO M6+ GLOBAL SEISMIC ACTIVITY

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Abstract: In this study the potential relationship between solar activity and the number of earthquakes that have been recorded on a global scale between 2012 and 2018 is discussed. To obtain this result the daily number of sunspots (Wolf number; index parameter of solar activity in the photosphere) and the daily number of potentially destructive M6+ seismic event occurred on a global scale, were compared. The results of the study confirmed a close link between solar activity and the M6+ global seismic activity.

Keywords: *earthquakes 6+, solar activity, sunspots, cosmic rays, Wolf number*

1.0 Introduction

In the last fifty years, research on seismic forecasting has progressively focused its attention on phenomena of solar origin thanks to the availability of data provided by space missions dedicated to monitoring solar activity (the main ones: GOES, ACE, SOHO, SDO, DSCOVR) that allowed to carry out detailed studies on solar activity (electromagnetic activity) confirming several times that there is a close relationship between the phenomena of solar origin and terrestrial seismic activity; relationship that had already been observed at the beginning of the 20th century through simple optical observations of the solar surface: in 1919, the American astronomer Dinsmore Alter, observed for the first time a correlation between the number of sunspots and the number of seismic events recorded on a global scale (Dinsmore, 1920). More recently, a study conducted in 2006 showed the existence of a correlation between the total number of earthquakes recorded in the Mediterranean area and the number of sunspots grouped in the period from 296 AD to 1000 AD (Odintsov et al., 2006).
Solar activity and terrestrial seismic activity are two phenomena that have been correlated since the late 1960s (Simpson, 1968; Machado, 1973; Kalinin, 1974; Gribbin, 1974; Zhang, 1998; Edward, 2008; Afraimovich et al., 2008; Anagnostopoulos et al., 2010; Radovanovic et al., 2011; Nikouravan, 2012-2013; Shestopalov et al., 2014). The studies conducted by the authors, as early as 2012, had confirmed this type of correlation (Straser, 2011-2017; Cataldi et al, 2014-2019). Through this work it was confirmed that the solar activity has a significant impact on the seismicity of our planet and the monitoring of solar activity combined with the monitoring of terrestrial geomagnetic activity could be used as a global indicator that is able to suggest when is expected a resumption of M6+ seismic activity. The physical process of solar-terrestrial interaction also reveals a deep and intrinsic relationship between the EM dynamics of the inner solar system and the temporal occurrence of large geophysical events (Casati e Straser, 2013; Charvátová, 2010; Duma and Vilardo, 1998; Mazzarella and Palumbo, 1989; Sytinsky, 1987,1989).
Further studies that confirmed the relationship between solar activity, cosmic rays and seismicity for earthquakes of magnitude equal to or greater than 6 have been proposed by Choi e Maslov (2010) and Kovalyov (2015).
The studies conducted by the authors from 1 January 2012 to 31 December 2018 confirmed that the density of solar ionic flux is closely related to the M6+ global seismic activity (Cataldi et al., 2019).

2.0 Methods and Data

To realize this study the authors analyzed the temporal modulation of the daily number of sunspots provided by the *Sunspot Index and Long-term Solar Observations* (SILSO)[1] and the M6+ global seismic activity data provided by *United States Geological Survey* (USGS)[2] between 2012 and 2018: a total sample of 969 earthquakes (**Fig. 1**).

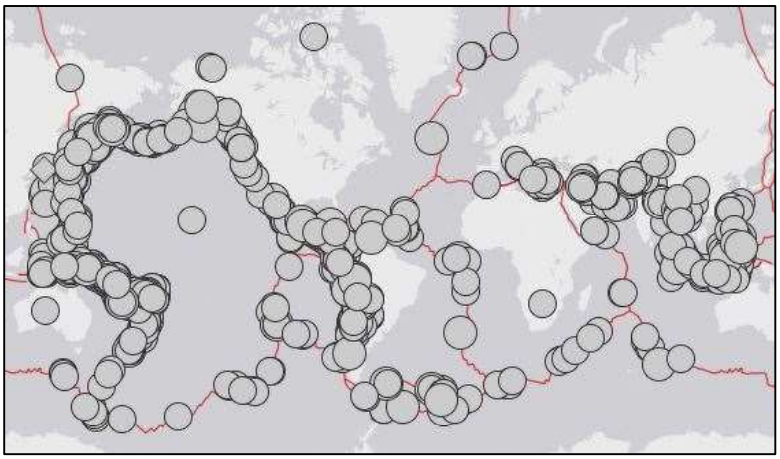

Fig. 1 – Planetary distribution of the M6+ seismic events recorded between 2012 and 2018. *Credits: USGS.*

The two types of data were subsequently divided by year; as visible in **Fig. 2-8**.

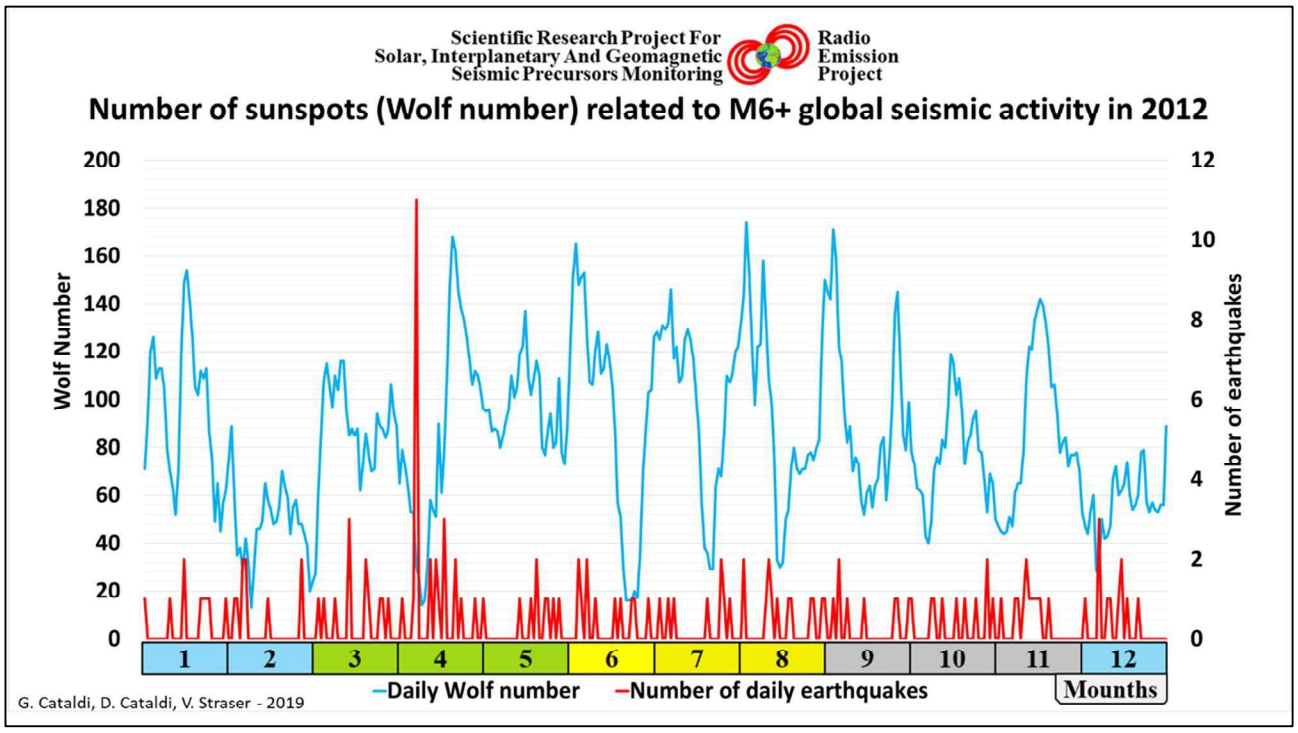

Fig. 2 – Daily number of sunspots related to the daily number of M6+ seismic events recorded on a global scale in 2012

[1] http://www.sidc.be/silso/datafiles
[2] https://earthquake.usgs.gov/earthquakes/

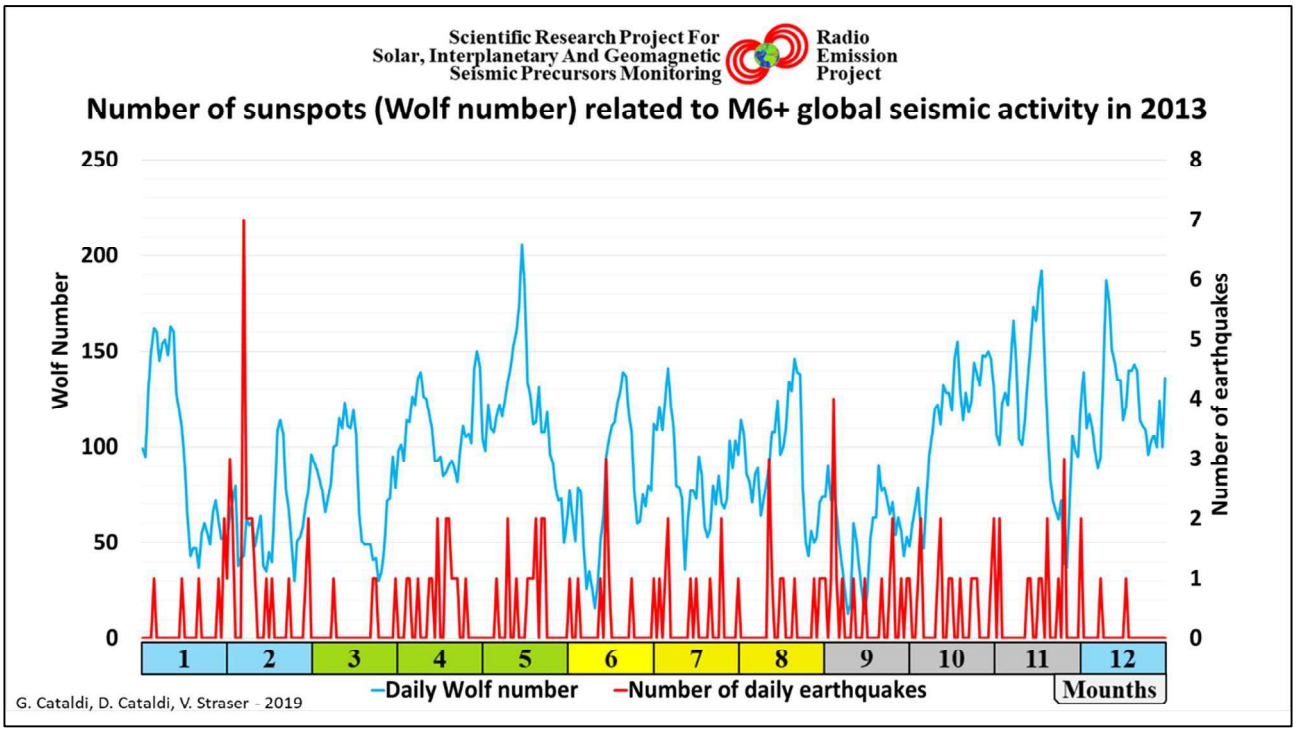

Fig. 3 – ***Daily number of sunspots related to the daily number of M6+ seismic events recorded on a global scale in 2013***

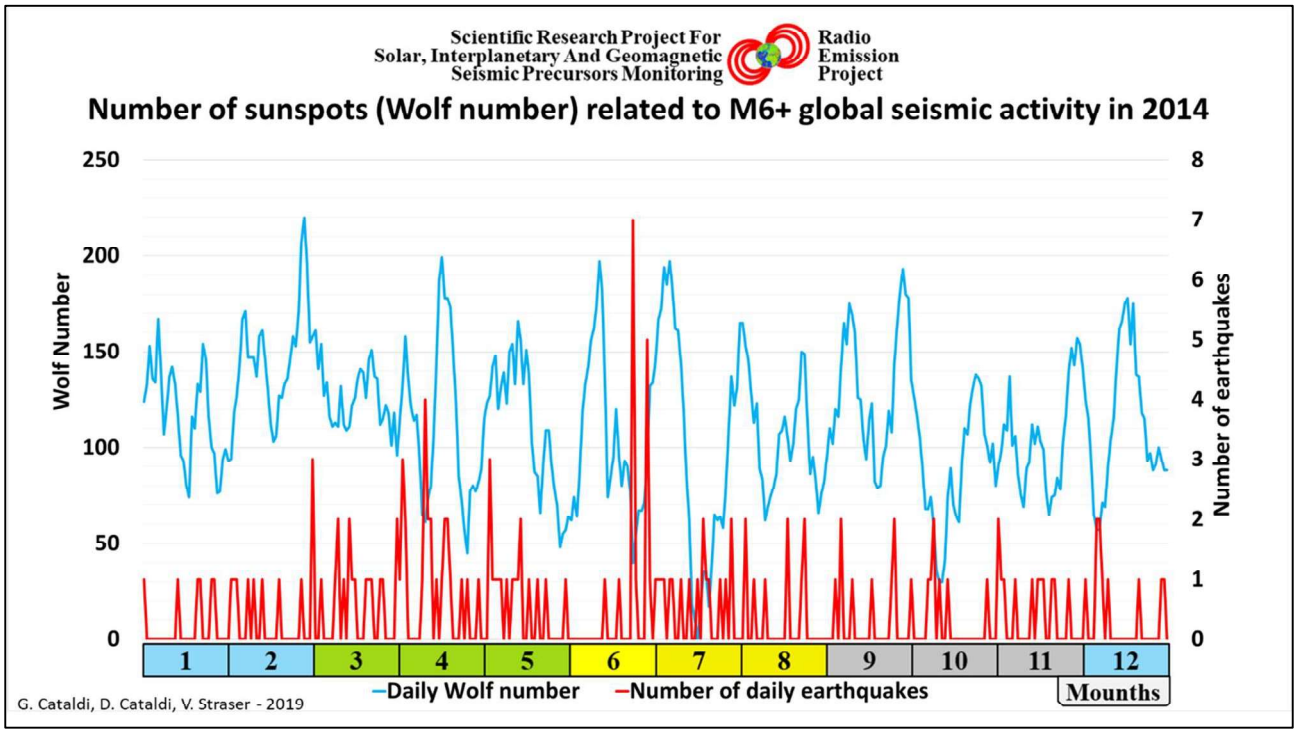

Fig. 4 – ***Daily number of sunspots related to the daily number of M6+ seismic events recorded on a global global scale in 2014***

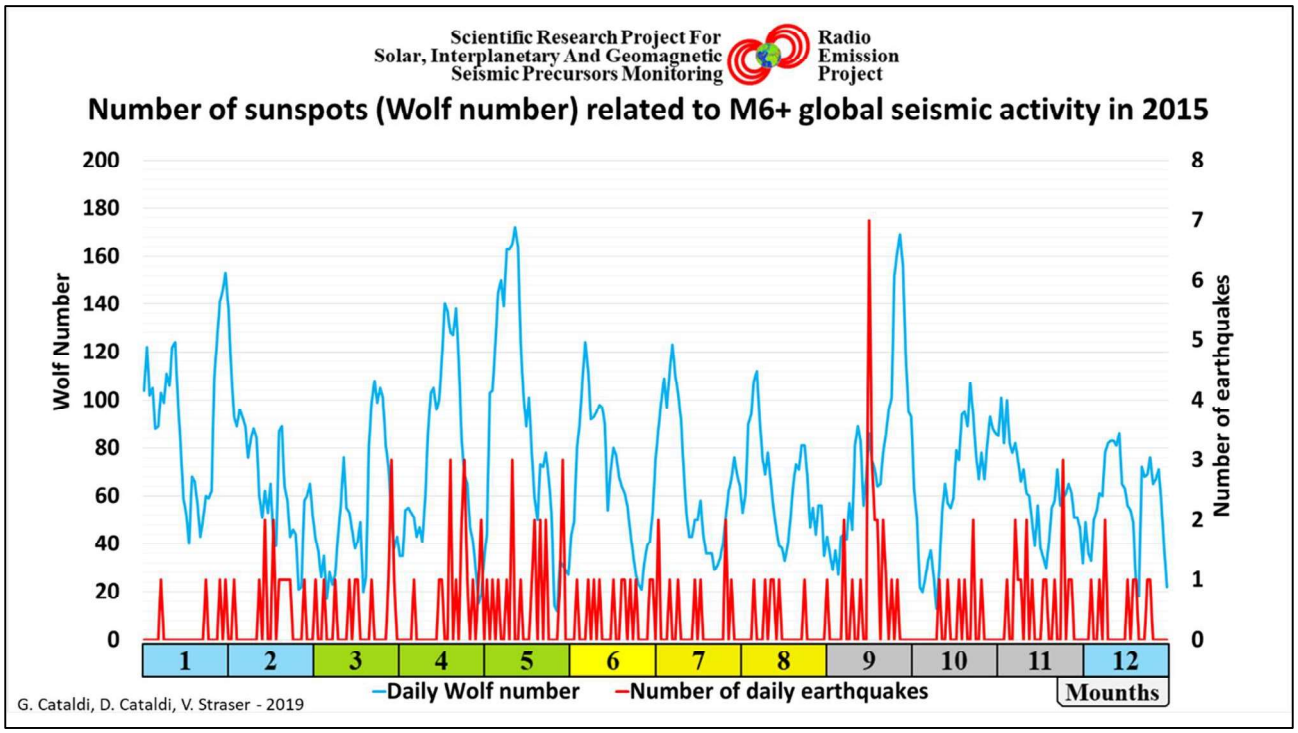

Fig. 5 – ***Daily number of sunspots related to the daily number of M6+ seismic events recorded on a global scale in 2015***

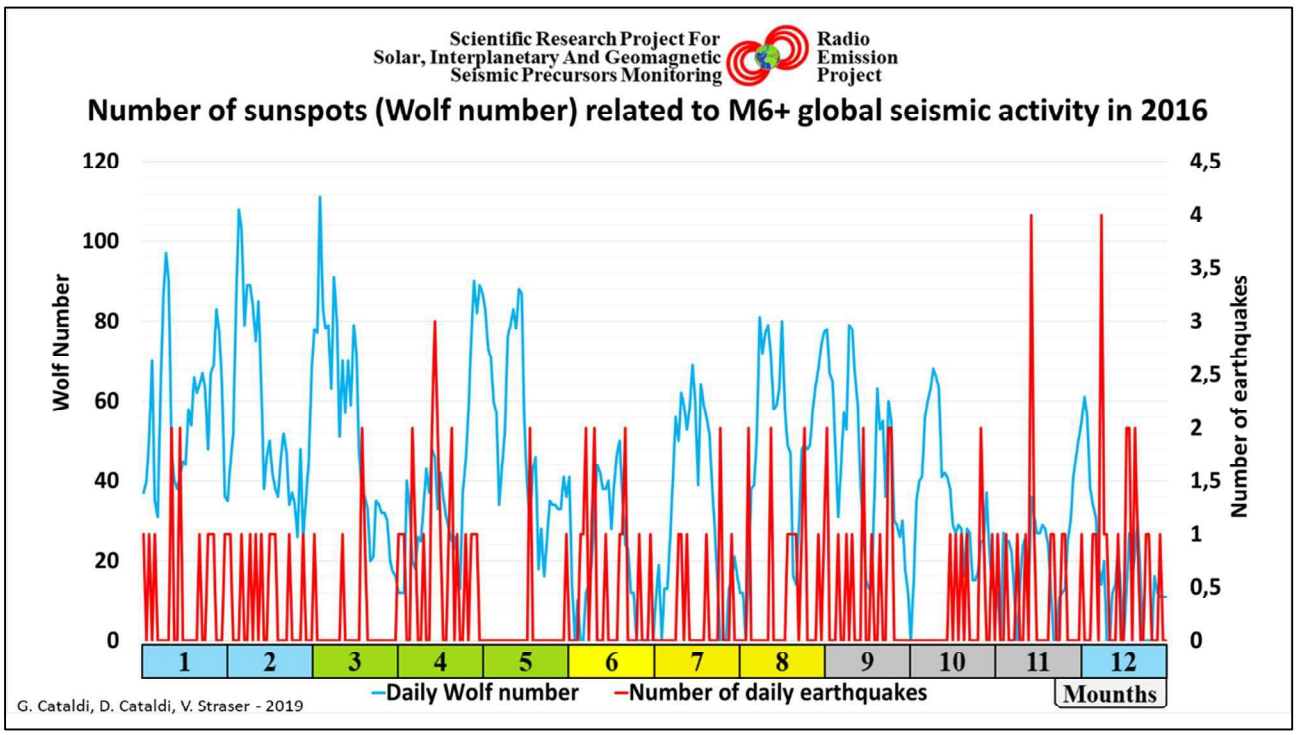

Fig. 6 – ***Daily number of sunspots related to the daily number of M6+ seismic events recorded on a global scale in 2016***

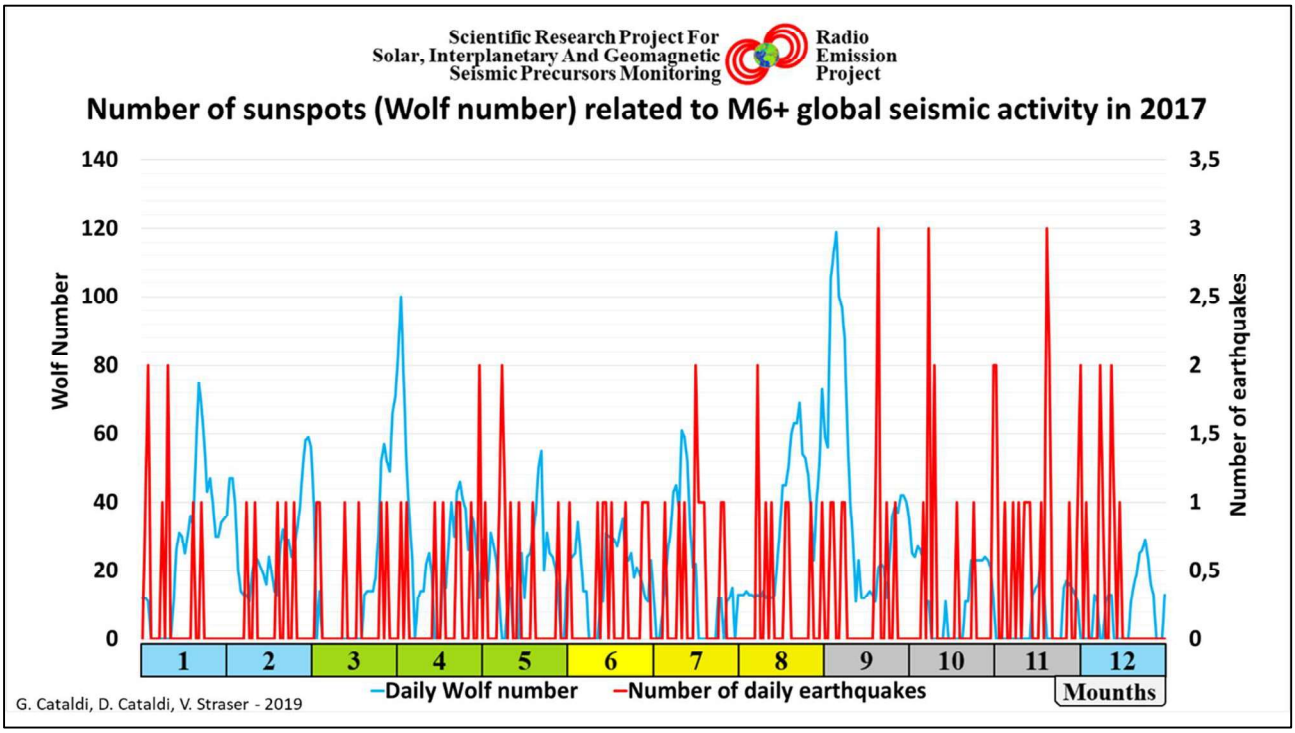

Fig. 7 – ***Daily number of sunspots related to the daily number of M6+ seismic events recorded ona global scale in 2017***

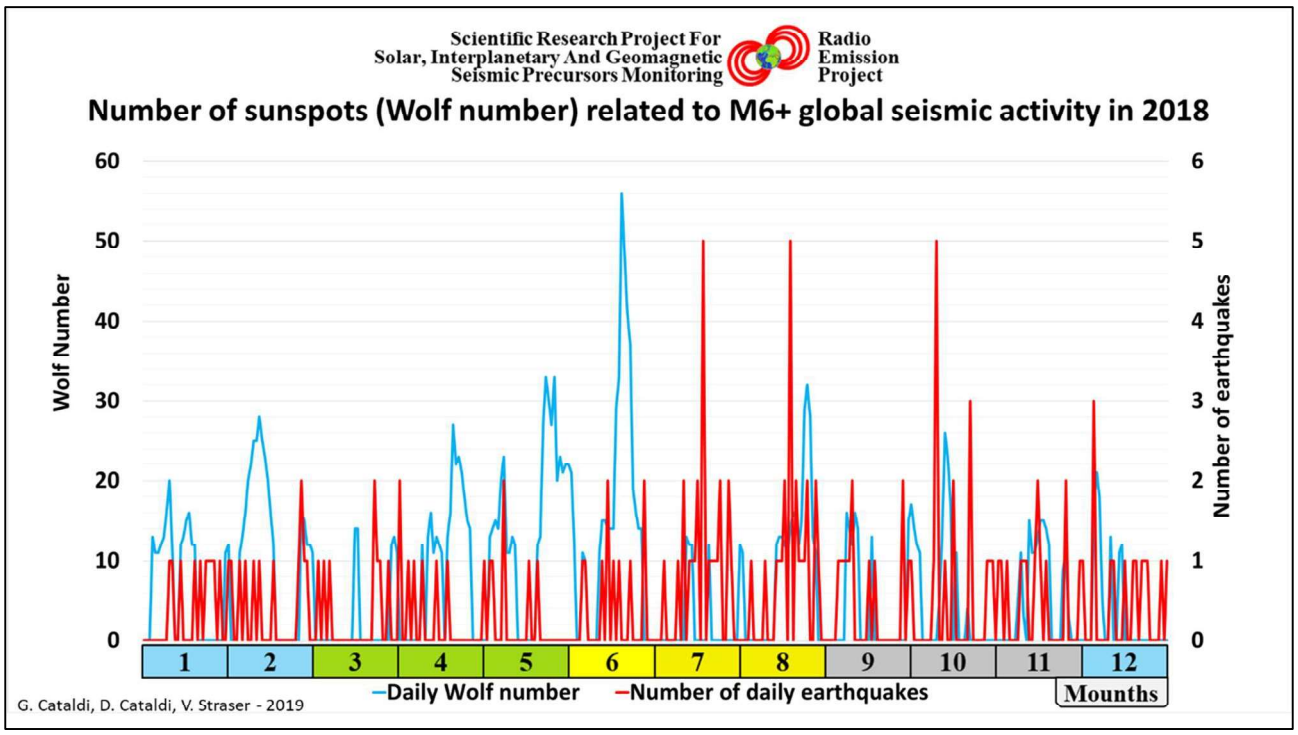

Fig. 8 – ***Daily number of sunspots related to the daily number of M6+ seismic events recorded on a global scale in 2018***

3.0 Discussion

Analyzing the data on the daily number of sunspots in relation to the daily number of M6+ seismic events that occurred on a global scale in the period from 2012 to 2018, is emerged that the two phenomena are significantly correlated: when the number of sunspots is at a minimum, the number of seismic events decreases or tends to decrease; while when the daily number of sunspots increases, we observe a higher number of seismic events per day, or a higher frequency of single seismic events that occur over the period (days) in which we observe the increase in solar activity.
This type of correlation seems to have a connection with the studies conducted by the authors over the last ten years. A correlation between the number of sunspots and the earth's global seismic activity could be explained by the presence of magnetic loops located above the sunspots: an electromagnetic phenomenon that determines a reduction in the speed of the solar ionic flow and an increase in its density. In fact, between 2012 and 2018, the authors have correlated the global seismic activity M6+ to the increases in the proton density of the interplanetary medium (near Earth) (Cataldi et al., 2019) and it has been observed that the increases in ionic density are greater of the interplanetary medium, the greater the number of potentially destructive earthquakes that are recorded on EarthThe reverse thing happens during the "solar minimum" even if, it should be reiterated, during a reduced solar activity, on average, less destructive earthquakes are observed but due to the formation of a greater number of solar coronal holes, a greater number of HSSW (High Speed Solar Wind) events are recorded: a phenomenon that has been correlated with potentially destructive high-magnitude seismic events (Sytinsky, 1987-1989).
Because the density of solar ionic flux is directly related to the M6+ global seismic activity (Cataldi et al., 2013-2018) and because the density of the solar ionic flux is directly connected to the electromagnetic activity present in the solar atmosphere, it's evident that by monitoring the electromagnetic phenomena present on the photosphere (sunspots) and in the solar corona (magnetic loops, flares, coronal holes) it's possible to have a prediction of the extent and direction of escape of the solar ionic flux that after a few days (2-3 days) will reach the Earth determining perturbations of the terrestrial geomagnetic field and determining a resumption of the M6+ global seismic activity. Respect to what has just been stated, the electromagnetic activity present in the solar atmosphere, therefore, is a phenomenon that can be considered as a Solar Seismic Precursor (SSP) precisely because it represents the substrate from which the solar ionic flux originates with the relative density variations related to the M6+ global seismic activity.

4.0 Conclusions

It is reasonable to hypothesize that there is a relationship between solar activity and earthquake activity for potentially destructive earthquakes, as shown in the graphs of **Fig. 2-8**. Solar activity, when the magnetic field is weakened, paves the way for cosmic rays that hit the Earth, causing an increase in entropy. The physical law that correlates solar, cosmic magnetism and seismicity has yet to be written, but we conclude that there is a close link between them, even if at present it is correct to say that there are "reasonable" elements of coincidence.

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