Space weather related to potentially destructive seismic activity that has been recorded globally between 2012 and 2023

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Abstract

The analysis of space weather has allowed the authors to understand the existence of a close correlation between variations in the solar proton flux (increases) and potentially destructive seismic activity (M6+) that has been recorded on a global scale since 2012. This study will present the results of twelve years of observations that the authors have conducted on solar activity and potentially destructive seismic activity that has been recorded on a global scale between 2012 and 2023.

Keywords: space weather, proton density, seismic precursors, potentially destructive seismic events, solar ion flux.

Introduction

Between January 1, 2012 and December 31, 2023, 1567 potentially destructive seismic events with magnitude (Mw) 6 or higher were recorded on our planet (Fig. 1). On average, about 131 seismic events are recorded per Year. During this period, the Earth was impacted by varying intensities of solar proton flux increases, which were followed by potentially destructive seismic events on a global scale. On average, each proton flux increase is followed by 2.87 strong seismic events (M6+), while approximately 99 hours pass on average between the start of the proton flux increase and the potentially destructive seismic events associated with it.

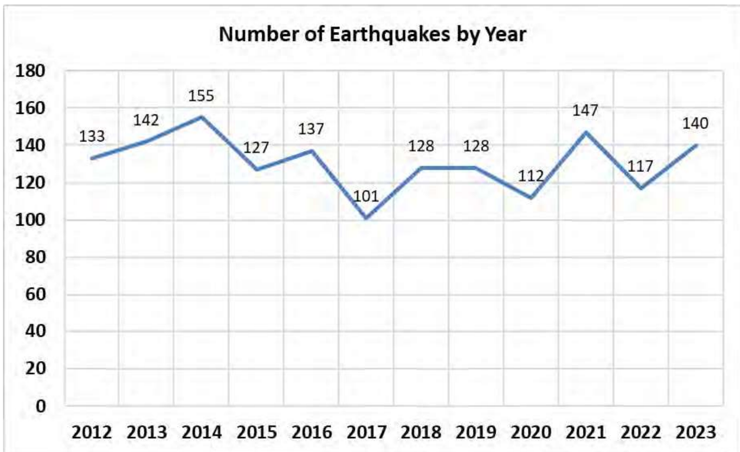

Fig. 1 – Distribution of potentially destructive seismic events (M6+) recorded on a global scale between 2012-2023*. In the chart at the top, the annual distribution of potentially destructive seismic events recorded on a global scale is visible. Credit: Radio Emissions Project.*

These are the results of the most extensive study ever conducted by man on space weather related to potentially destructive seismic activity [1-45].

Methods and data

This study analyzed 1567 destructive seismic events recorded globally between January 1, 2012, and December 31, 2023. The catalog on potentially destructive seismic activity (M6+) was provided by the USGS (United States Geological Survey), and the data on the M6+ activity to conduct this study were collected almost

in real time. However, it is possible that over longer time frames, some data have been updated or the number of potentially destructive seismic events has changed due to more precise analyses conducted on the energy released by the seismic events.
To determine whether there is a strong correlation between increases in solar ionic flux and potentially destructive seismic activity recorded on a global scale, the authors conducted a detailed analysis of the proton variation curve of the solar wind, utilizing data provided by two artificial satellites located in Lagrangian orbit:

a) Advanced Composition Explorer (ACE) Satellite;
b) Deep Space Climate Observatory (DSCOVR) Satellite.

More specifically, the data analyzed by the authors were the following:

ACE Satellite:

- differential proton flux 1060-1900 keV (p/cm^2-sec-ster-MeV);
- differential proton flux 761-1220 keV (p/cm^2-sec-ster-MeV);
- differential proton flux 310-580 keV (p/cm^2-sec-ster-MeV).

DSCOVR Satellite:

- proton density (p/cm^3).

Discussion

Studies conducted by the authors in 2011 on the characteristics of the solar wind have revealed that variations in the proton density of the solar wind are always correlated with an increase in potentially destructive seismic activity observed on a global scale. The variation of the interplanetary magnetic field (IMF), the magnitude of the dynamic pressure of the solar wind, or the temperature of the solar ionic flux, are not always events that can be correlated with a resurgence of global seismic activity M6+. For now, the only phenomenon that has proven to be reliable in the context of this type of correlation is represented solely by variations in the proton density of the solar ionic flux.

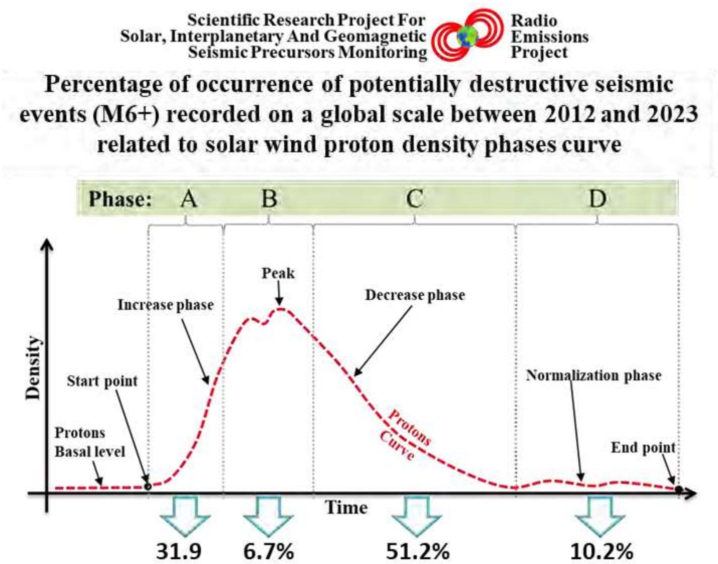

***Fig. 2 – Distribution of potentially destructive seismic events (M6+) recorded on a global scale with respect to the proton variation curve**. In the graph above the typical proton curve of a "gradual" type event has been reproduced. The authors divided the variation curve into four distinct phases to simplify the description in relation to the correlation data with the M6+ global seismic activity provided by the study. Credits: Radio Emissions Project.*

In the study conducted by the authors between 2012 and 2023 it was clarified that potentially destructive seismic events occurring on a global scale are distributed in different percentages along the proton variation curve (Fig. 2): most earthquakes (51.2%) are recorded during the reduction phase (phase C) of the proton density, while another large percentage (31.9%) occurs during the initial phase of increasing proton density (phase A). Therefore, more than 83.1% of potentially destructive seismic events are recorded while the density of the solar proton flux increases or decreases. Instead, 10.2% of potentially destructive seismic events are recorded during the stabilization phase of the proton density, a phase in which the proton density level will slowly return to pre-increase levels.

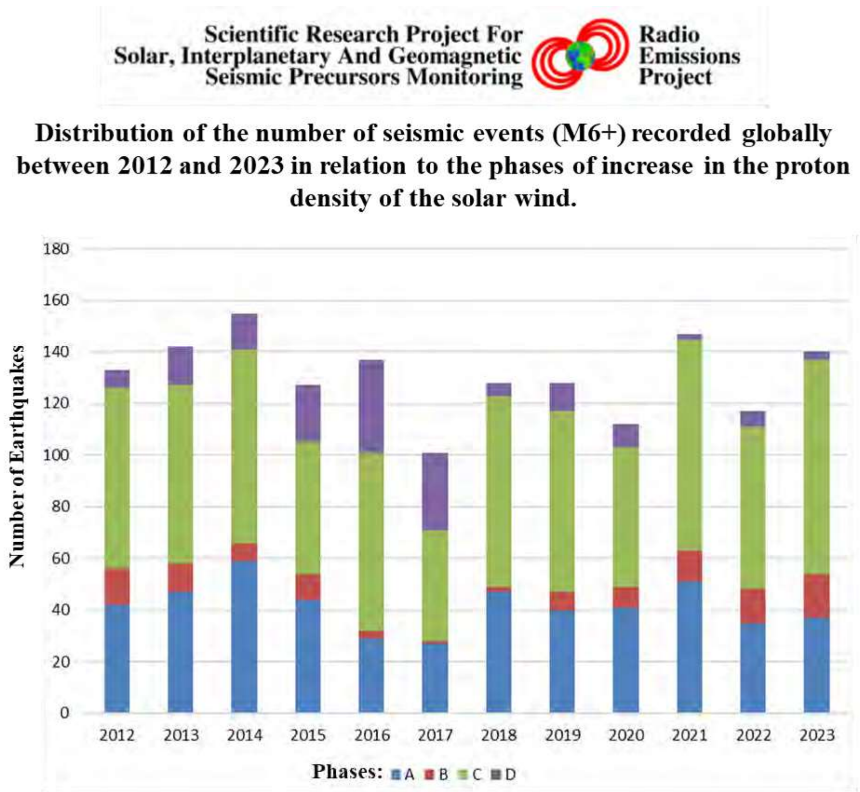

Fig. 3 – Distribution of the number of seismic events (M6+) in relation to the phases of increase in the proton density of the solar wind*. In the graph, it is possible to observe the distribution of potentially destructive earthquakes in relation to the characteristics of the proton variation curve visible in Fig. 2. Credits: Radio Emissions Project.*

Observing Fig. 3, it is possible to understand that the number of earthquakes correlated with the different phases of proton variation maintains a certain regularity over the years: phase C is the one during which more earthquakes occur compared to the other phases; phase A is the second in terms of the number of earthquakes; phase D is the third in terms of the number of earthquakes, and finally, phase B is the last in terms of the number of earthquakes. This suggests that most seismic events occur during a variation (increase or decrease) in the proton density of the solar wind, while the smallest number of earthquakes (16.9%) occurs when the variation curve does not show significant and prolonged oscillations.

As proposed by the authors, the reason could be traced back to a form of electromagnetic interaction as a seismogenic cause induced by the variation in the density of the solar ionic flux. This interaction might affect the superficial layers of the Earth's crust where the formation of electronic currents due to tectonic stress caused by geodynamics is possible. The formation of these electrical charges, being within the Earth's magnetic field (a magnetic field that is not static, but variable over time and influenced by the density of the solar ionic flux), could, through the Lorentz force, contribute to altering the static equilibrium of faults.

This would also explain why more potentially destructive seismic events are observed during phases A and C rather than during phases B and D (Fig. 2): when the intensity of the Earth's magnetic field is greater, the Lorentz force will also be greater. When the intensity of the Earth's magnetic field oscillates rapidly, the

Lorentz force will also exhibit rapid oscillations. All this would explain why an increase in global seismic activity M6+ is observed during a disturbance of the Earth's geomagnetic field.

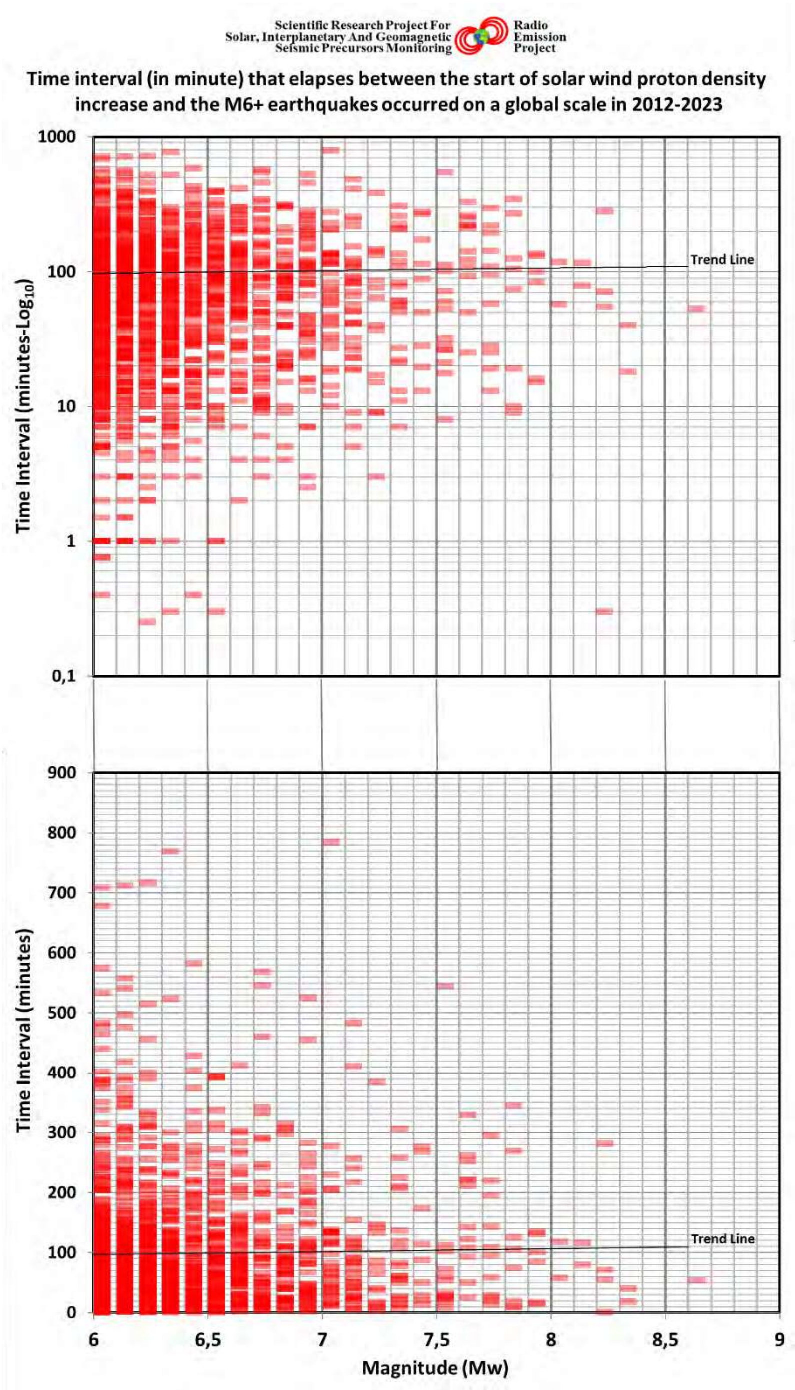

Fig. 4 – Distribution of time intervals. *In the chart above, it is possible to observe the distribution of time intervals recorded between the beginning of the protonic increase of the solar wind and the potentially destructive seismic events related to the ionic increase. The data sample used corresponds to 1,567 potentially destructive seismic events recorded on a global scale. Credits: Radio Emissions Project.*

The study also allowed for the measurement of so-called "time intervals" that occurred between the start of the protonic increase of the solar wind and the seismic events associated with it. On average, each increase in the solar ionic flux is followed by 2.87 potentially destructive seismic events; meanwhile, the average recorded time interval is equivalent to 99 hours (4.13 days) (Fig. 4). The start of the increase in the solar ionic flux has been identified as the baseline level that the density of the solar ionic flux assumes between phase D and phase A of the proton variation curve (Fig. 2).

Conclusions

The study conducted by the authors has confirmed that there is a close relationship between the increase in solar ionic flux and potentially destructive seismic activity (M6+) recorded on a global scale. The analysis of the proton variation curve of the solar wind, its temporal modulation, has made it possible to understand that the potentially destructive seismic activity recorded globally follows a specific distribution relative to the proton variation curve (Fig. 2), and this finding cannot be explained as a causal distribution of earthquakes. The authors have repeatedly proposed that the basis of this distribution is a form of electromagnetic interaction between the solar ionic flux and the potentially destructive seismic activity recorded globally (see previous chapter).

The observed phenomenon has predictive potentials that have never been observed in any other phenomenon of solar or terrestrial origin, and it is evident that it would be possible to use the data obtained by the authors within the framework of an innovative seismic prediction project, not based on statistical data.

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