New Concepts in Global Tectonics Journal
Volume 12, Number 3, September 2024

ISSN number; ISSN 2202-0039

Space weather linked to potentially destructive earthquakes between 2012 and 2023

Valentino Straser[1], Gabriele Cataldi[2] and Daniele Cataldi[2-3]

1: University of Makeni (Sierra Leone). valentino.straser@gmail.com
2: Radio Emissions Project, Solar and Terrestrial Interaction (I). ltpaobserverproject@gmail.com
3: Radio Emissions Project, Radio Direction Finding (I). daniele77c@hotmail.it

Abstract. The occurrence of earthquakes is not random, as confirmed by tectonic and geodynamic studies. However, their trigger mechanism, especially for tectonic earthquakes, involves many variables, including, among others, the influence of the Sun. This study presents the collection and discussion of data from 2012 to 2023, which compares solar activity with the occurrence of potentially destructive earthquakes, of magnitude equal to or greater than M6, considered on a global scale. The most significant clue from the study is constituted by the flow of solar protons which, corresponding to significant increases, show a potential relationship between potentially destructive geophysical events. The spatio-temporal analysis of proton increases, based on the discussion of 1567 events, has shown to have a close relationship with seismic events, especially for those of magnitude M6+.

***Key Word*:** space weather, proton density, seismic precursors, potentially destructive seismic events, tectonic plate slip rate.

Introduction

The Sun emits a constant stream of electrically charged particles (predominantly protons and electrons) into interplanetary space. A portion of these particles reaches Earth, interacting with the Earth's magnetosphere and disturbing the terrestrial geomagnetic field. The authors have monitored the density of the solar ionic flux and the potentially destructive seismic activity recorded on a global scale in the period from January 1, 2012, to December 31, 2023 (a total of 1567 earthquakes M6+, **Fig. 1**), and have found that there exists a close correlation between increases in the density of solar proton flux reaching Earth and potentially destructive seismic activity (M6+) recorded on a global scale (on average, 131 seismic events every month): in practice, all potentially destructive seismic events recorded on a global scale are always preceded by an increase in the proton density of the solar wind [1-45].

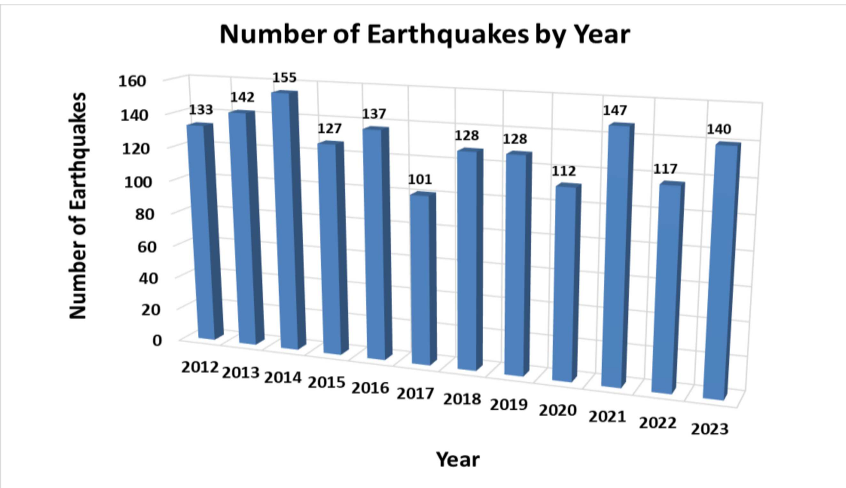

Fig. 1 Distribution of potentially destructive seismic events (M6+) recorded on a global scale between 2012-2023. In the chart above, the annual distribution of potentially destructive seismic events (M6+) recorded on a global scale between 2012 and 2023 is visible. Credit: USGS, Radio Emissions Project.

ISSN number; ISSN 2202-0039

Currently, it is not yet clear how variations in the density of the solar ionic flux manage to trigger a resurgence of potentially destructive seismic activity on a global scale (some hypotheses have been proposed by the authors, [19] [23]), but the authors aimed to verify the existence of a correlation also between the modulation of the solar ionic flux density and the rate of tectonic plate movement at the edges of which strong earthquakes originate. This work will present the results of this study.

Methods and data

To conduct the study, the authors analyzed the modulation of the solar ionic flux density (the proton density) and the potentially destructive seismic events (M6+) recorded between January 1, 2012, and December 31, 2023: it was calculated the average of the temporal deviations recorded between the start of the proton increase and the potentially destructive seismic events (M6+) related to it. The start of the proton increase was identified by considering the baseline level of the solar wind proton flux density that preceded each "gradual" increase, or the lowest density level detected between two gradual increases (**Fig. 2**) was taken as reference. The density level of the solar wind proton flux was provided by two artificial satellites located in the L1 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).

The "start point" visible in **Fig. 2**, precisely because it represents the moment when the increase in

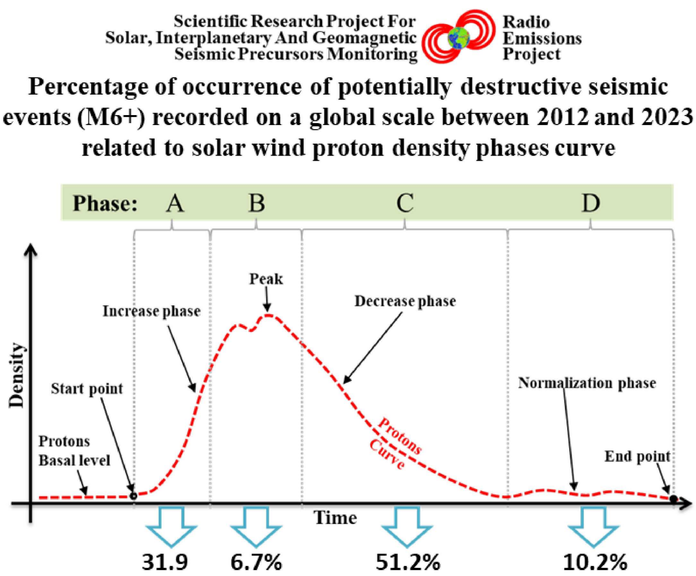

Fig. 2 Distribution of potentially destructive seismic events (M6+) recorded on a global scale with respect to the proton variation curve. In the graph above the typical proton curve of a "gradual" type event has been reproduced. The authors divided the variation curve into four distinct phases to simplify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

ISSN number; ISSN 2202-0039

the proton density of the solar wind begins, can be defined as the beginning of the interplanetary seismic precursor (ISP) represented by the entire curve of gradual increase in the proton density of the solar wind to which all potentially destructive earthquakes recorded on a global scale are related. The "start point" also corresponds to the moment when the calculation begins to quantify the time interval associated with the potentially destructive seismic event (or seismic events) that will be recorded subsequently.

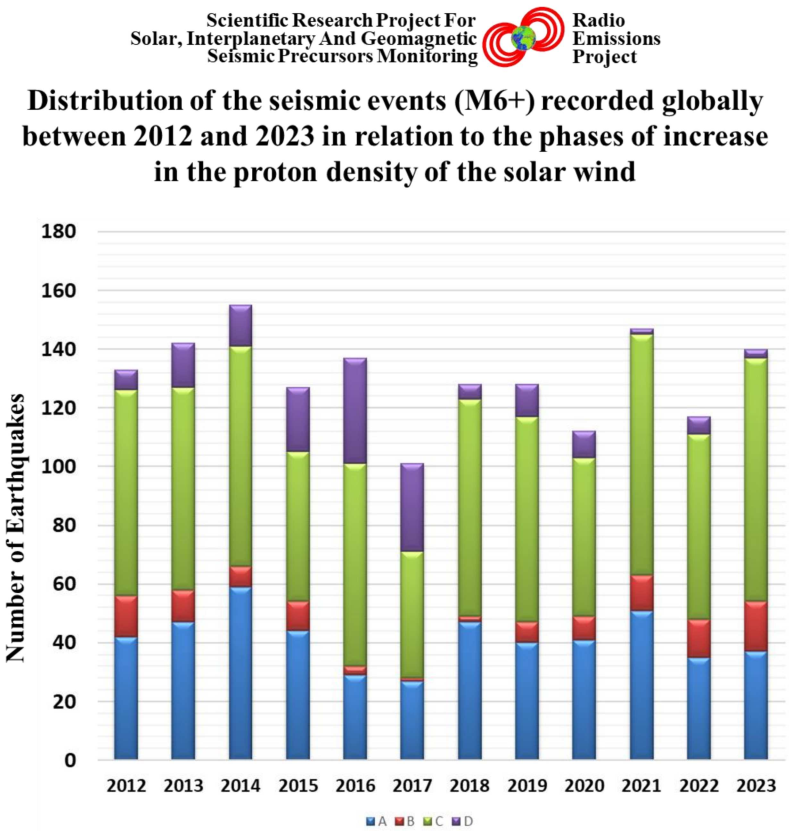

Fig. 3 Distribution of the number of seismic events (M6+) in relation to the phases of increase in the proton density of the solar wind. In the graph, it is possible to observe the distribution of potentially destructive earthquakes in relation to the characteristics of the proton variation curve visible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

The distribution of seismic events relative to the curve of proton increase visible in **Fig. 2** follows a proportion that the authors have divided into four distinct phases (**Fig. 3**). Below are the average data for this proportion (2012-2023):

- Phase A: 31.9% of potentially destructive seismic events recorded on a global scale occur during the phase of increasing proton density of the solar wind.
- Phase B: 6.7% of potentially destructive seismic events recorded on a global scale occur during the peak of the solar wind proton density (±6 hours).
- Phase C: The majority of M6+ seismic events (51.2%) recorded on a global scale occur during the phase of decreasing proton density of the solar wind.
- Phase D: 10.2% of potentially destructive seismic events recorded on a global scale occur during the final "stabilization" phase of proton density; this is the phase preceding the baseline level.

The proportion between phase A and C has remained unchanged between 2012 and 2023, while the proportion between phase B and D has experienced reversals over the years (**Fig. 3**). It is important to underline that 83.1% of potentially destructive seismic events recorded on a global scale between

ISSN number; ISSN 2202-0039

2012 and 2023 were registered during phases A and C of the solar wind proton increase curve, that is, during the increasing or decreasing phase. Meanwhile, during phases where the proton density did not undergo sudden increases or decreases, even at the maximum value reached (phase B) or in the "normalization" phase (phase D), 16.9% of potentially destructive seismic events were recorded. These data confirm that potentially destructive seismic activity recorded on a global scale is more closely related to sudden oscillations in the proton density of the solar wind (increases and decreases).

Subsequently, the average magnitude of potentially destructive earthquakes recorded in different countries between January 1, 2012, and December 31, 2023, was calculated. Data from those countries where only one potentially destructive seismic event was recorded between 2012 and 2023 were removed from the study. Moreover, two groups of countries were created, divided by Northern and Southern latitude:

- 46 countries located in the Northern Hemisphere (**Fig. 5**): Afghanistan, Alaska, Aleutian Islands, Barbados, Bolivia, Burma, California, Canada, China, Colombia, Costa Rica, El Salvador, Greece, Guatemala, Hawaii, India, Indian, Ocean, Iran, Italy, Japan, Kazakhstan, Kuril Islands, Mariana Islands, Marocco, Mexico, Micronesia, Mid-Atlantic Ridge, Myanmar, Nepal, Nicaragua, Northern East Pacific Rise, Northern Mid-Atlantic Ridge, Oregon, Pakistan, Panama, Philippines, Puerto Rico, Russia, Sandwich Islands, Sea of Okhotsk, Shetland Islands, Taiwan, Tajikistan, Thailand, Turkey, Venezuela.
- 43 countries located in the Southern Hemisphere (**Fig. 6**): Amsterdam Island, Argentina, Ascension Island, Balleny Islands, Banda Sea, Bouvet Island, Brazil, Bristol Island, Central East Pacific Rise, Central Mid-Atlantic Ridge, Chile, Drake Passage, East Pacific Rise, East Timor, Easter Island, Ecuador, Fiji, Indian Ridge, Indonesia, Kermadec Islands, Loyalty Islands, Macquarie Island, Mauritius, Molucca sea, New Caledonia, New Zealand, Pacific-Antarctic Ridge, Papua New Guinea, Peru, Prince Edward Islands, Santa Cruz Islands, Scotia Sea, Solomon Islands, South Georgia Islands, South Indian Ocean, South of Africa, Southern East Pacific Rise, Sumatra, Tonga, Vanuatu, Visokoi Island, Wallis and Futuna, Western Indian-Antarctic Ridge.

  The Central Mid-Atlantic Ridge has been included among the seismically active areas of the Southern Hemisphere because the wider oceanic crust fractures are associated with the South. Some countries located on the equator have been placed in the list of either the Northern or Southern Hemisphere in relation to the size of their surface area: if the larger surface area was located in the Northern Hemisphere, then the country was included in the list of countries in the Northern Hemisphere, and vice versa.

In the final phase of the study, the authors identified the rate of tectonic plate movement (slip rate) associated with each country included in the study: this phase was time-consuming as only for 70% of the countries included in the study were geodynamic data verified by the international scientific community available; about 10% of the countries were located in areas of the Earth's surface that are very complex from a geodynamic point of view, for which the calculation of the slip rate was the result of an average of the annual sliding data related to complex tectonic junctions; for 4 countries (Balleny Islands, Wallis and Futuna, Ascension Islands, Thailand), it was not possible to associate data on the rate of tectonic plate movement.

The slip rate data were provided by:

- USGS – United States Geological Survey;
- EPOS – European Plate Observing System;
- JAMSTEC – Japan Agency for Marine-Earth Science and Technology;
- UNAVCO – University NAVstar Consortium;
- Scientific Journals: Journal of Geophysical Research, Tectonics, Geology, Geophysical

ISSN number; ISSN 2202-0039

Journal International; Earth and Planetary Science Letters; Journal of Structural Geology;

- National and regional geological surveys: International Lithosphere Program (ILP), World Stress Map (WSM) Project, Global Earthquake Model (GEM) Foundation, Geoscience Australia, Centro Nacional de Prevención de Desastres (CENAPRED) – Mexico;
- University research projects: Global Earthquake Model (GEM), Southern California Earthquake Center (SCEC), Earthquake Research Institute (ERI) – University of Tokyo, Active Tectonics and Seismic Hazards Group – Arizona State University (ASU), Seismology and Geodynamics Group – ETH Zurich, Institute of Geological and Nuclear Sciences (GNS Science) – New Zealand;
- Search engines: Google Scholar, Web of Science, Scopus;
- Books [46-49].

All these data were statistically compared and divided by hemisphere (Northern or Southern latitude) to verify the existence of a statistically significant correlation between:

- The average of time intervals recorded between the start of each proton increase and the potentially destructive seismic event (or events) related to it.
- The average seismic magnitude recorded in a specific seismic district (the total sample of M6+ earthquakes used for this study was 1567).
- The average slip rate associated with a specific seismic district.

Discussion

The results of the study (**Fig. 4-6**) highlighted that:

a) Potentially destructive seismic events recorded between January 1, 2012, and December 31, 2023, are always preceded by an increase in the proton density of the solar wind [1-45].

b) The average temporal deviations recorded between the start of the proton increase and the potentially destructive seismic events associated with them are statistically correlated in a directly proportional manner to the average magnitude. The correlation index (r) between these two data series reaches a value of 0.03 for countries located in the Northern Hemisphere and 0.21 for countries located in the Southern Hemisphere. The authors have been able to ascertain for several years that higher magnitudes are correlated with higher proton increases and/or more intense geomagnetic disturbances [11] [15] [20] [32-35]. Typically, the ionic density of a high

Correlation Index (r)

Northern Hemisphere	Average Magnitude	Average Time Intervals
Slip Rate	-0.20	0.41
Average Time Intervals	0.03	

Southern Hemisphere	Average Magnitude	Average Time Intervals
Slip Rate	-0.19	0.001
Average Time Intervals	0.21	

Fig. 4 Correlation Index (r). In the charts at the top, the correlation index between the data series presented in Fig. 5 and 6 are visible. Credits: Radio Emissions Project.

ISSN number; ISSN 2202-0039

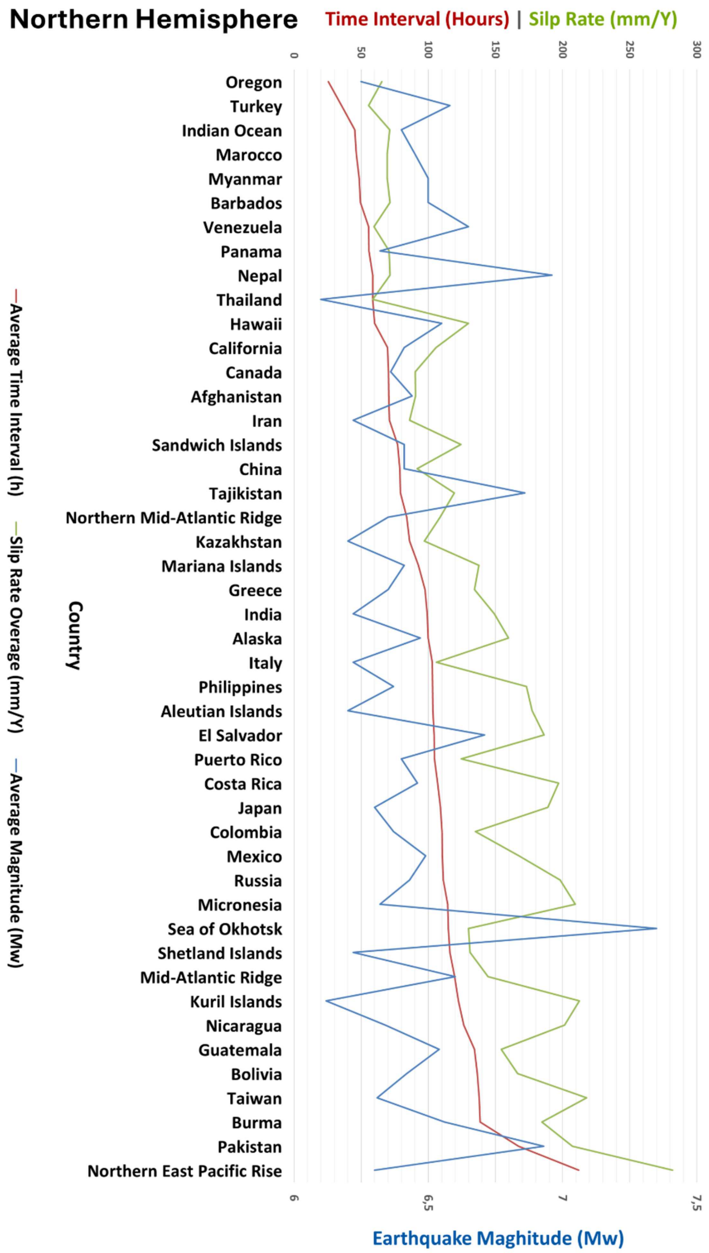

Fig. 5 Correlation study between average magnitude, time intervals, and slip rate of potentially destructive seismic activity (M6+) recorded on a global scale and in Northern hemisphere between 2012 and 2023. In the image on the side, it is possible to observe the average of the time intervals (in hours) calculated between the start of the proton increase of the solar wind and the potentially destructive seismic activity (M6+) recorded on a global scale between 2012 and 2023; the average magnitude of potentially destructive seismic events (M6+) recorded on a global scale between 2012 and 2023; the slip rate associated with the tectonic plates of the different countries considered in the study. The countries are ordered according to the average time interval recorded, in ascending order from top to bottom. Credits: Radio Emissions Project.

proton increase returns to baseline levels over longer periods compared to more modest proton increases, and this could partly explain why, on average, the magnitude of a potentially destructive seismic event is correlated with longer time intervals.

c) When we compare the sliding speed of tectonic plates or slip rate with the average magnitude of seismic events, we obtain a very similar negative correlation index for countries located in both hemispheres: these two data series are inversely proportional and reach a similar correlation

New Concepts in Global Tectonics Journal
Volume 12, Number 3, September 2024

ISSN number; ISSN 2202-0039

Fig. 6 Correlation study between average magnitude, time intervals, and slip rate of potentially destructive seismic activity (M6+) recorded on a global scale and in Southern hemisphere between 2012 and 2023. In the image on the side, it is possible to observe the average of the time intervals (in hours) calculated between the start of the proton increase of the solar wind and the potentially destructive seismic activity (M6+) recorded on a global scale between 2012 and 2023; the average magnitude of potentially destructive seismic events (M6+) recorded on a global scale between 2012 and 2023; the slip rate associated with the tectonic plates of the different countries considered in the study. The countries are ordered according to the average time interval recorded, in ascending order from top to bottom. Credits: Radio Emissions Project.

index (r) even when dividing the data based on Northern and Southern latitude. For countries located in the Northern Hemisphere, the correlation index is -0.20, for countries located in the Southern Hemisphere, the correlation index is -0.19. However, when comparing the average time intervals with the slip rates recorded for countries located in the Northern Hemisphere, we observe that there is a correlation index (r) equal to 0.41; the same type of correlation for

ISSN number; ISSN 2202-0039

countries located in the Southern Hemisphere is very low (r = 0.001).

Conclusions

We conclude that:

- The analysis of the solar wind proton variation curve and its temporal modulation follows a specific distribution relative to the proton variation curve. This result highlights that the distribution of earthquakes is not random and is comparable to the proton variation.
- This data allows us to hypothesize that there is a close relationship between the increase in solar ionic flux and potentially destructive seismic activity (M6+) recorded on a global scale.
- Therefore, it is conceivable that there could be a form of electromagnetic interaction between the solar ionic flux and potentially destructive seismic activity recorded globally.
- The outcome of this research, if confirmed, aims to be applied in an interdisciplinary context for the study of earthquake trigger mechanisms.

References

[1] Cataldi, G., D. Cataldi and V. Straser (2013): Variations of terrestrial geomagnetic activity correlated to M6+ global seismic activity. EGU (European Geosciences Union) 2013, General Assembly, Seismology Section (SM3.1), Earthquake precursors, bio-anomalies prior to earthquakes and prediction, Geophysical Research Abstracts, v. 15. EGU2013-2617, Vienna, Austria.

[2] Cataldi, G., D. Cataldi and V. Straser (2014): Earth's magnetic field anomalies that precede the M6+ global seismic activity. European Geosciences Union (EGU) General Assembly 2014, Geophysical Research Abstract, v. 16, EGU2014-1068, Vienna, Austria.

[3] Cataldi, D., G. Cataldi and V. Straser (2014): Variations of the Electromagnetic field that preceded the Peruvian M7.0 earthquake occurred on September 25, 2013. European Geosciences Union (EGU) General Assembly 2014, Geophysical Research Abstract, v. 16, EGU2014-1075, Natural Hazard Section (NH4.3), Electro-magnetic phenomena and connections with seismo-tectonic activity, Vienna, Austria.

[4] Rabeh, T., G. Cataldi and V. Straser (2014): Possibility of coupling the magnetosphere–ionosphere during the time of earthquakes. European Geosciences Union (EGU) General Assembly 2014, Geophysical Research Abstract, v. 16, EGU2014-1067, Vienna, Austria.

[5] Straser, V. and G. Cataldi (2014): Solar wind proton density increase and geomagnetic background anomalies before strong M6+ earthquakes. Space Research Institute of Moscow, Russian Academy of Sciences, MSS-14. 2014. Moscow, Russia, 280–286.

[6] Straser, V. and G. Cataldi (2015): Solar wind ionic variation associated with earthquakes greater than magnitude M6.0. New Concepts in Global Tectonics Journal, v. 3, no. 2, 140–154.

[7] Cataldi, G., D. Cataldi and V. Straser (2015): Solar wind proton density variations that preceded the M6+ earthquakes occurring on a global scale between 17 and 20 April 2014. European Geosciences Union (EGU) General Assembly 2015, Geophysical Research Abstract, v. 17, EGU2015-4157-2, Vienna, Austria.

[8] Cataldi, G., D. Cataldi and V. Straser (2015): Solar wind ion density variations that preceded the M6+ earthquakes occurring on a global scale between 3 and 15 September 2013. European Geosciences Union (EGU) General Assembly 2015, Geophysical Research Abstract, v. 17, EGU2015-4581, Vienna, Austria.

[9] Cataldi, G., D. Cataldi and V. Straser (2015): Solar wind proton density variations that preceded the M6,1 earthquake occurred in New Caledonia on November 10, 2014. European Geosciences Union (EGU) General Assembly 2015, Geophysical Research Abstract, v. 17, EGU2015-4167, Vienna, Austria.

[10] Straser, V., G. Cataldi and D. Cataldi (2015): Solar wind ionic and geomagnetic variations preceding the Md8.3 Chile Earthquake. New Concepts in Global Tectonics Journal, v. 3, no. 3, 394–399.

[11] Cataldi, G., D. Cataldi and V. Straser (2016): Solar activity correlated to the M7.0 Japan earthquake occurred on April 15, 2016. New Concepts in Global Tectonics Journal, v. 4, no. 2, 202–208.

[12] Cataldi, G.i, D. Cataldi and V. Straser (2016): Tsunami related to solar and geomagnetic activity. European Geosciences Union (EGU) General Assembly 2016, Natural Hazard Section (NH5.6), Complex

ISSN number; ISSN 2202-0039

modeling of earthquake, landslide, and volcano tsunami sources. Geophysical Research Abstract, v. 18, EGU2016-9626, Vienna, Austria.

[13] Cataldi, G., D. Cataldi and V. Straser (2017): SELF-VLF electromagnetic signals and solar wind proton density variations that preceded the M6.2 Central Italy earthquake on August 24, 2016. International Journal of Modern Research in Electrical and Electronic Engineering, v. 1, no. 1, 1–15. doi:10.20448/journal.526/2017.1.1/526.1.1.15.

[14] Cataldi, G., D. Cataldi and V. Straser (2017): Solar wind proton density increase that preceded Central Italy earthquakes occurred between 26 and 30 October 2016. European Geosciences Union (EGU), General Assembly 2017. Geophysical Research Abstracts, v. 19, EGU2017-3774, 2017, Vienna, Austria.

[15] Strase, V., G. Cataldi and D. Cataldi (2017): Solar and electromagnetic signal before Mexican Earthquake M8.1, September 2017. New Concepts in Global Tectonics Journal, v. 5, no. 4, 600–609.

[16] Cataldi, G., D. Cataldi and V. Straser (2017): Solar and Geomagnetic Activity Variations Correlated to Italian M6+ Earthquakes Occurred in 2016. EGU General Assembly 2017. EGU2017-3681, v. 19. Vienna, Austria.

[17] Cataldi, G., D. Cataldi and V. Straser (2019): Solar wind ionic density variations related to M6+ global seismic activity between 2012 and 2018. European Geosciences Union (EGU) General Assembly 2019, Geophysical Research Abstract, v. 21, EGU2019-3067, 2019, Vienna, Austria.

[18] Straser, V., G. Cataldi and D. Cataldi (2019): Namazu's Tail – RDF: a new perspective for the study of seismic precursors of Japan. Lulu Editore, 2019.

[19] Cataldi, G. (2020): Precursori Sismici – Monitoraggio Elettromagnetico. Kindle-Amazon, ISNB: 9798664537970. ASIN Code: B08CPDBGX9.

[20] Cataldi, G., D. Cataldi and V. Straser (2019): Wolf number related to M6+ global seismic activity. New Concepts in Global Tectonics Journal, v 7, no. 3, 178–186.

[21] Straser, V., G. Cataldi and D. Cataldi (2020): The space weather related to the M7+ seismic activity recorded on a global scale between 28 January and 25 March 2020. Acta Scientific Agriculture 4.12 (2020), 55–62.

[22] Cataldi, G., V. Straser and D. Cataldi (2020): Space weather related to potentially destructive seismic activity recorded on a global scale. New Concepts in Global Tectonics Journal. v. 8, no.3, 233–253.

[23] Cataldi, G. (2021): Radio Emissions Project – A new approach to seismic prediction. Kindle-Amazon, ISNB: 9798709593411.

[24] Cataldi, G., D. Cataldi and V. Straser (2021): Space weather and geomagnetic activity related to the Japan M7.1 earthquake recorded on February 13, 2021. New Concepts in Global Tectonics Journal, v. 9, no. 1, 16–23.

[25] Cataldi, G., D. Cataldi and V. Straser (2021): Space weather and geomagnetic activity related to the Chilean M6.7 earthquake recorded on February 3, 2021. New Concepts in Global Tectonics Journal, v. 9, no. 1, 3–9.

[26] Cataldi, G., D. Cataldi and V. Straser (2021): Space weather and geomagnetic activity related to M6+ global seismic activity recorded on February 7, 2021. New Concepts in Global Tectonics Journal, v. 9, no. 1, 24–30.

[27] Cataldi, G., D. Cataldi and V. Straser (2021): Space Weather and geomagnetic activity related to Ecuadorean M7.5 earthquake recorded on February 22, 2019. New Concepts in Global Tectonics Journal, v. 9, no. 2, 79–86.

[28] Cataldi, G., D. Cataldi and V. Straser (2021): Solar Activity and geomagnetic activity related to M6+ global seismic activity recorded on March 20, 2021. New Concepts in Global Tectonics Journal, v. 9, no. 2, 87–93.

[29] Cataldi, G., D. Cataldi and V. Straser (2021): Space weather and geomagnetic activity related to M6+ global seismic activity recorded on 3-4 March 2021. New Concepts in Global Tectonics Journal, v. 9, no. 2, 94–98.

[30] Cataldi, G.i, D. Cataldi and V. Straser (2021): Solar activity and geomagnetic activity related to M6.0 South Sandwich Islands region earthquake recorded March 14, 2021. New Concepts in Global Tectonics Journal, v. 9, no. 2, 99–105.

[31] Cataldi, G., D. Cataldi and V. Straser (2021): Space weather and geomagnetic activity related to the Vanuatu M6.3 earthquake recorded on March 20, 2019. New Concepts in Global Tectonics Journal, v. 9, no. 2, 106–111.

[32] Cataldi, G., D. Cataldi and V. Straser (2021): Space weather and geomagnetic activity related to M6+

ISSN number; ISSN 2202-0039

earthquakes recorded between 7 and 20 November 2017. New Concepts in Global Tectonics Journal, v. 9, no. 3, 137–144.

[33] Cataldi, G., D. Cataldi and V. Straser (2021): Space weather and geomagnetic activity related to M6+ earthquakes recorded between 12 and 15 April 2012. New Concepts in Global Tectonics Journal, v. 9, no. 3, 145–154.

[34] Cataldi, G., D. Cataldi and V. Straser (2021): Space weather and geomagnetic activity related to M6+ earthquakes recorded between 13 and 16 April 2016. New Concepts in Global Tectonics Journal, v. 9, no. 3, 158–163.

[35] Cataldi, G., D. Cataldi and V. Straser (2021): Space weather and geomagnetic activity related to M6+ earthquakes recorded between 17 and 19 July 2017. New Concepts in Global Tectonics Journal, v. 9, no. 3, 164–169.

[36] Cataldi, G., D. Cataldi and V. Straser (2021): Space weather related to M6+ earthquakes recorded on June 24, 2019. New Concepts in Global Tectonics Journal, v. 9, no. 3, 132–136.

[37] Cataldi, G., V. Straser and D. Cataldi (2021): Space weather related to M6.1 Indonesia earthquake recorded on June 3, 2021. New Concepts in Global Tectonics Journal. v. 9, no 4, 185–193.

[38] Cataldi, G., V. Straser and D. Cataldi (2021): Space weather related to M6.0 Tonga earthquake recorded on March 17, 2020. New Concepts in Global Tectonics Journal. v. 9, no 4, 206–214.

[39] Cataldi, G., V. Straser and D. Cataldi (2021): Space weather related to M8.2 earthquake recorded in Alaska on 29 July 2021. New Concepts in Global Tectonics Journal. v. 9, no 4, 194–205.

[40] Cataldi, G., E. Cavina, G. Cataldi and V. Straser (2022): Reverse migration of the wood pigeons and electromagnetic emissions, before the Mw 3.7 earthquake occurred in Visso-Macerata, Central Italy on October 18, 2021. International Journal of Social Relevance and Concern (IJSRC), v. 10, Issue 1, 24–40.

[41] Straser, V., D. Cataldi and G. Cataldi. (2022): Pre-seismic phenomena that preceded the M7.0 earthquake recorded in Acapulco (Mexico) on September 8, 2021. International Journal of Social Relevance and Concern (IJSRC), v. 10, Issue 1, 41–57.

[42] Straser, V., G. Cataldi and D. Cataldi (2022): Space weather related to M6+ potentially destructive seismic events recorded on a global scale between 13 and 16 March 2022. New Concepts in Global Tectonics Journal. v. 10, no. 1, 3–10.

[43] Straser, V., G. Cataldi and D. Cataldi (2022): Space weather related to M6+ potentially destructive seismic events recorded on a global scale between 2012 and 2021. New Concepts in Global Tectonics Journal. v. 10, no. 1, 11–21.

[44] Straser, V., D. Cataldi and G. Cataldi (2023): Weather events associated with strong earthquakes and seismic swarms in Italy. Advances in Geological and Geotechnical Engineering Research. v. 05, Issue 03, 39–54.

[45] Straser, V., G. Cataldi and D. Cataldi (2023): Magnitude of potentially destructive earthquakes recorded in Mexico correlated to the extent of the solar proton flux. New Concepts in Global Tectonics Journal. v. 11, no. 4, 261–266.

[46] Oreskes, N. (2003): Plate Tectonics: An Insider's History of the Modern Theory of the Earth. CRC Press, Taylor and Francis Group. Edition 1, eBook ISBN: 9780429498282.

[47] Kearey, P., K. A. Klepeis, and F. J. Vine (2009): Global Tectonics. Wiley-Blackwell, ISBN: 978-1-4051-0777-8.

[48] Segall, P. (2010): Earthquake and Volcano Deformation. Princeton University Press. ISBN: 9780691133027.

[49] Shearer, P. (2019): Introduction to Seismology. Cambridge University Press. doi:10.1017/9781316877111.