# Space weather related to M8.2 earthquake recorded in Alaska on 29 July 2021

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

(1) Radio Emissions Project (I). ltpaobserverproject@gmail.com
(2) Department of Science and Environment UPKL Brussel (B). valentino.straser@gmail.com
(3) Fondazione Permanente G. Giuliani - Onlus (I). daniele77c@hotmail.it

## Abstract

Between 26 and 29 July 2021 three seismic events of strong intensity were recorded on our planet: 1) M6.2 Indonesia earthquake recorded on July 26, 2021 at 12:09:06 UTC; 2) M8.2 Alaska earthquake recorded on July 29, 2021 at 06:15:47 UTC; 3) M6.1 Alaska earthquake recorded on July 29, 2021 at 06:19:25 UTC. From the analyzes conducted by the authors it was ascertained that these three potentially destructive seismic events were preceded by an important increase in the density of the solar ion flux which subsequently produced an increase in the Earth's geomagnetic field (max Kp = 4).

**Keywords**: proton density increase, seismic precursors, solar activity, M8+, Alaska earthquake, seismic prevision.

## Introduction

On 29 July 2021 at 06:15:47 UTC at South of the Alaska Peninsula an M8.2 earthquake was recorded (**Fig. 1**). The seismic epicenter was located near the subduction zone interface between the Pacific and North America plates. Earthquakes of this magnitude are common in the Alaska-Aleutian subduction zone, in fact on 22 July 2020 an M7.8 earthquake was recorded 62km away from the 29 July 2021 earthquake and an M7.6 earthquake on 19 October 2020, located in 145km West of the earthquake of 29 July 2021. Given the temporal and spatial proximity to the M8.2 earthquake of 29 July 2021, it is evident that the two major earthquakes of July and October 2020 were a premonitory shocks [54].

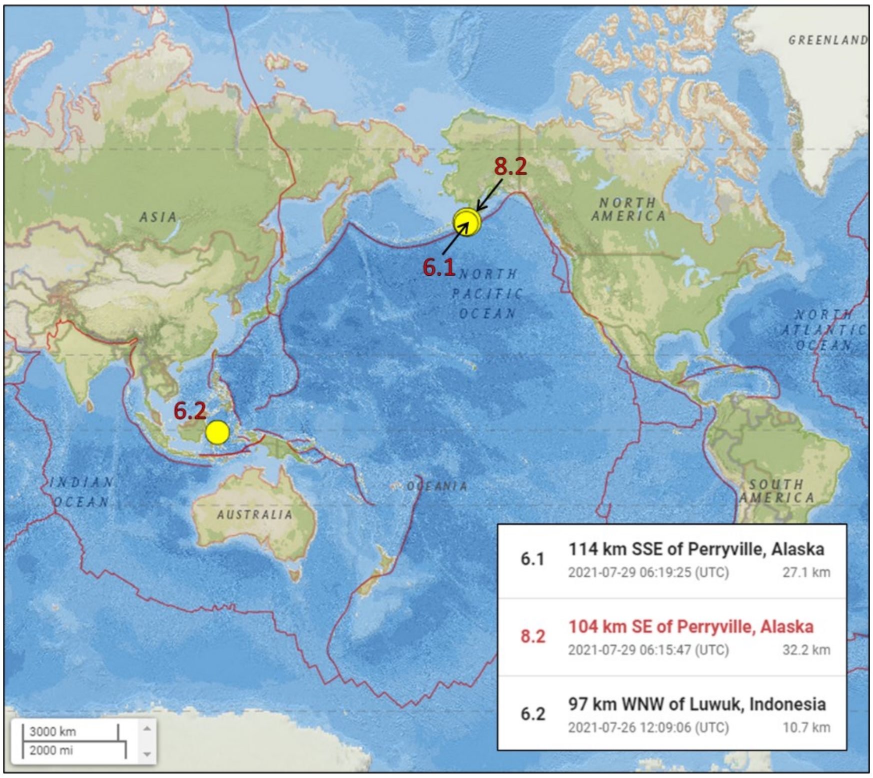


**Fig. 1 – Seismic epicenter of the M6+ seismic train recorded between 26 and 29 July 2021.** The image above shows the seismic epicenters (yellow circles) of the M6+ earthquakes recorded between 26 and 29 July 2021. The magnitude in red. Credits: USGS, Radio Emissions Project.

In fact, as can be seen through **Fig. 1**, the M8.2 earthquake was not the only earthquake recorded on July 29, 2021:

- M8.2 Alaska earthquake recorded on July 29, 2021 at 06:15:47 UTC;
- M6.1 Alaska earthquake recorded on July 29, 2021 at 06:19:25 UTC.

But that is not all. The authors wanted to verify if the M6+ seismic train which occurred in Alaska on 29 July 2021 was related to solar activity like all potentially destructive seismic events recorded on a global scale from 1 January 2012 to today [5-7] [9-15] [17-19] [21] [22] [25] [32] [39] [41] [43] [45-52]. Indeed, it has been established that solar activity and geomagnetic activity are closely related to M6+ global seismic activity [2-8] [13-15] [19] [21] [22] [25] [39] [41 ] [43] [45-52]: this type of correlation was observed for the first time by the authors between 2010 and 2011 during some studies conducted on environmental radiofrequency [1] [7] [31] [43].
Indeed, by analyzing the characteristics of the solar ion flux between 26 and 30 July 2021 it was possible to identify a solar wind proton density increase which started on 26 July 2021 at 07:30 UTC and ended on 30 July 2021. During this, three potentially destructive seismic events were recorded, of which only the last two are those recorded in Alaska (**Fig. 1 and 2**):

- M6.2 Indonesia earthquake recorded on July 26, 2021 at 12:09:06 UTC;
- M8.2 Alaska earthquake recorded on July 29, 2021 at 06:15:47 UTC;
- M6.1 Alaska earthquake recorded on July 29, 2021 at 06:19:25 UTC.

**Data analysis**

Between July 26, 2021 and July 29, 2021, the DSCOVR Satellite (located in Lagrangian orbit L1) detected a solar wind proton density increase which reached its maximum density (56.9 p/cm^3) on July, 2021 at 01:20 UTC (**Fig. 2**) causing an increase in the Earth's geomagnetic field between July 26, 2021 and July 29, 2021 (**Fig. 3**).

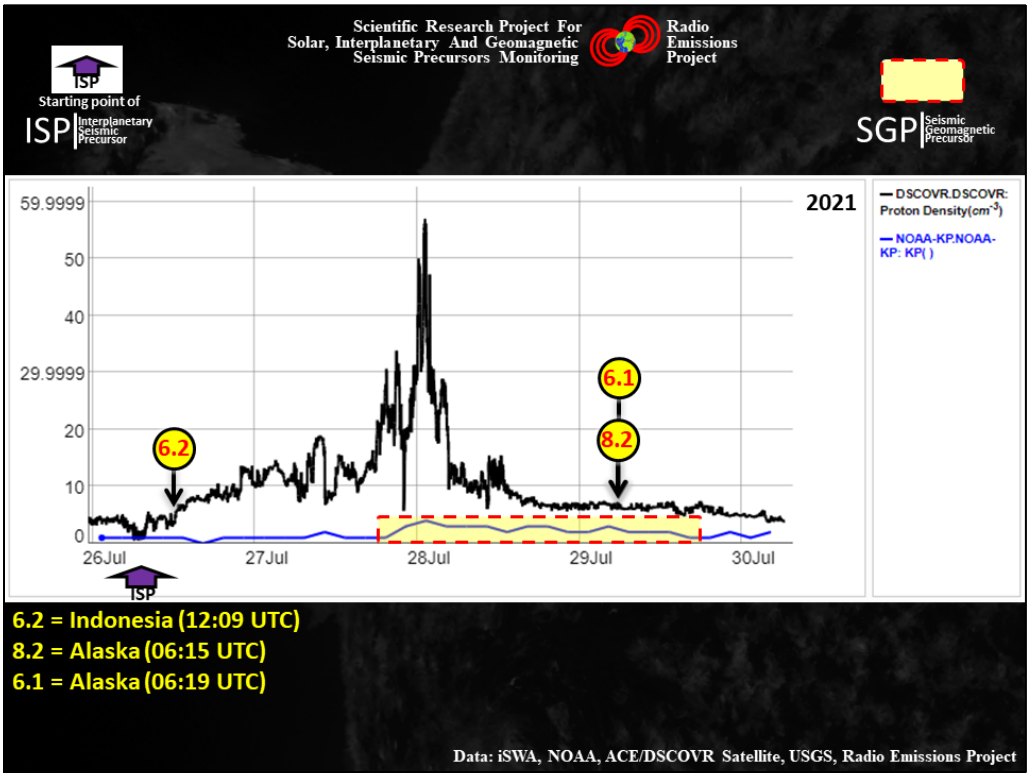


**Fig. 2 – Variation in solar ion flux and Earth's geomagnetic activity related to the M6+ earthquakes recorded between 26 and 29 July 2021.** The graph above shows the time marker of M6+ earthquakes recorded between 26 and 29 July 2021 (black vertical arrow). Analyzing the data in the graph it is evident that the M6+ earthquakes was preceded by a solar wind proton density increase (Interplanetary Seismic Precursor; black curve) and by Earth's geomagnetic field increase (Seismic Geomagnetic Precursor; blue curve highlighted by the yellow area) whose maximum value was recorded on July 28, 2021 (Kp = 4). The purple arrow indicates the start of solar wind proton density increase. Credits: iSWA, USGS, Radio Emissions Project.

The proton increase preceded the Indonesian M6.2 earthquake recorded on July 26, 2021 by 4.5 hours and the two earthquakes recorded in Alaska on July 29, 2021 by 71 hours. The geomagnetic perturbation instead began on July 26, 2021 at 16:30 UTC gradually increasing until it grows suddenly from 27 July 2021 at 19:30 and reaches the maximum increase on 28 July 2021 at 01:30 UTC (Kp = 4), and then gradually decreases between 28 and 29 July 2021 reaches Kp = 1 on 29 July 2021 at 16:20 UTC (**Fig. 3**).

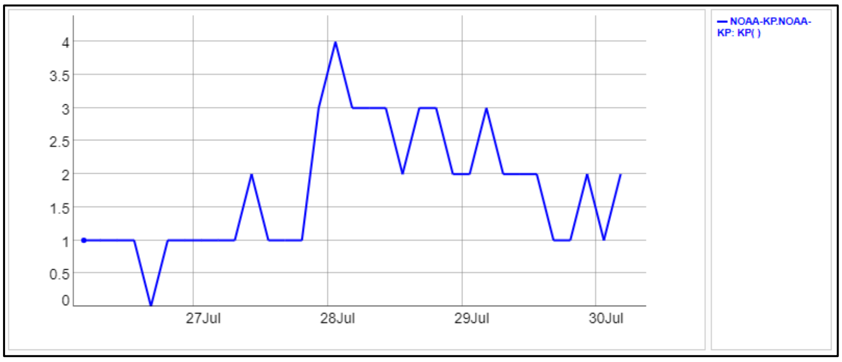


**Fig. 3 – Variation of Kp-index related to the M6+ earthquakes recorded between 26 and 29 July 2021.** The graph above shows the variation of Kp-index recorded between July 26, 2021 and July 29, 2021. Credits: iSWA, Radio Emissions Project.

On average, the time interval related to the proton increases of the solar wind and the potentially destructive earthquakes associated with them is about 105.9 hours (4.41 days) (**Fig. 4**). Furthermore, on average, a proton increase is correlated to 2.876 potentially destructive seismic events.

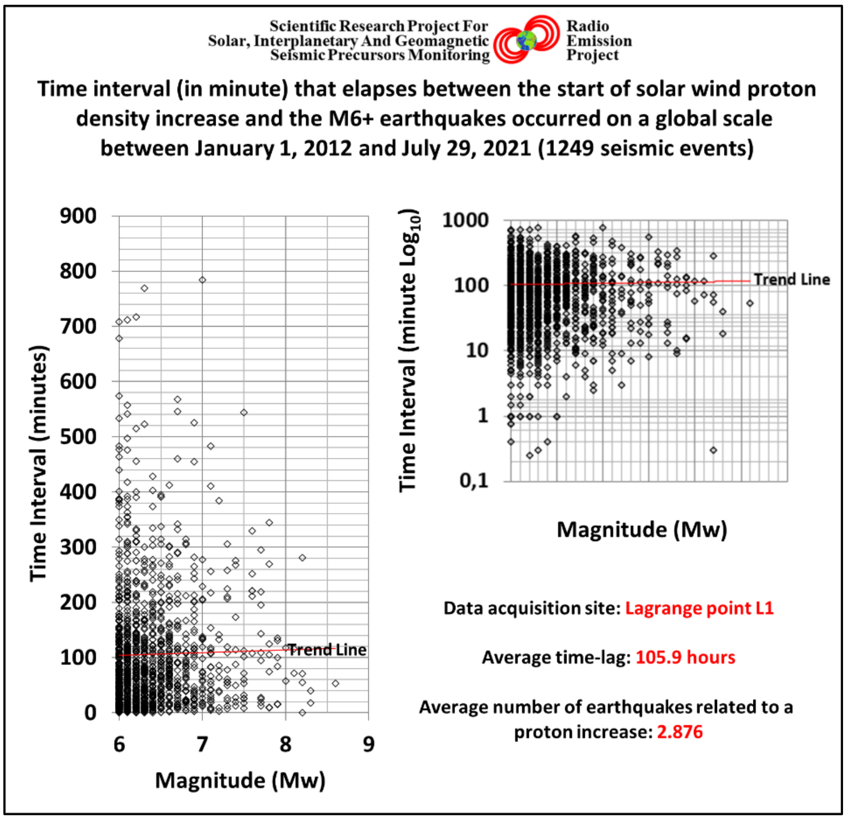


**Fig. 4 – Time intervals.** The graphs above show the distribution of the time intervals that elapses between the start of solar wind proton density increase and the M6+ earthquakes occurred on a global scale between January 1, 2012 and July 29, 2021. Credits: iSWA, USGS, Radio Emissions Project.

The increases in the proton density of the solar wind are therefore phenomena that always begin to manifest themselves before a potentially destructive seismic event. 31.87% of M6+ seismic events are recorded during the phase of increasing proton density; 5.23% of M6+ seismic events are recorded when the proton density reaches the maximum value; 49.57% of M6+ seismic events are recorded during the phase of reduction (or bending) of the proton density, while 13.33% of M6+ seismic events are recorded during the phase of adjustment of the proton density to basal values. It is interesting to underline that this proportionality is respected every year, that is also considering the time intervals recorded during a single year. This fact makes this type of correlation a phenomenon that cannot be explained by a simple statistical distribution. Further indications about the characteristics of the solar wind in the hours and days preceding the seismic train of 26-29 July 2021 can be observed through **Fig. 5** and **Fig. 6**.

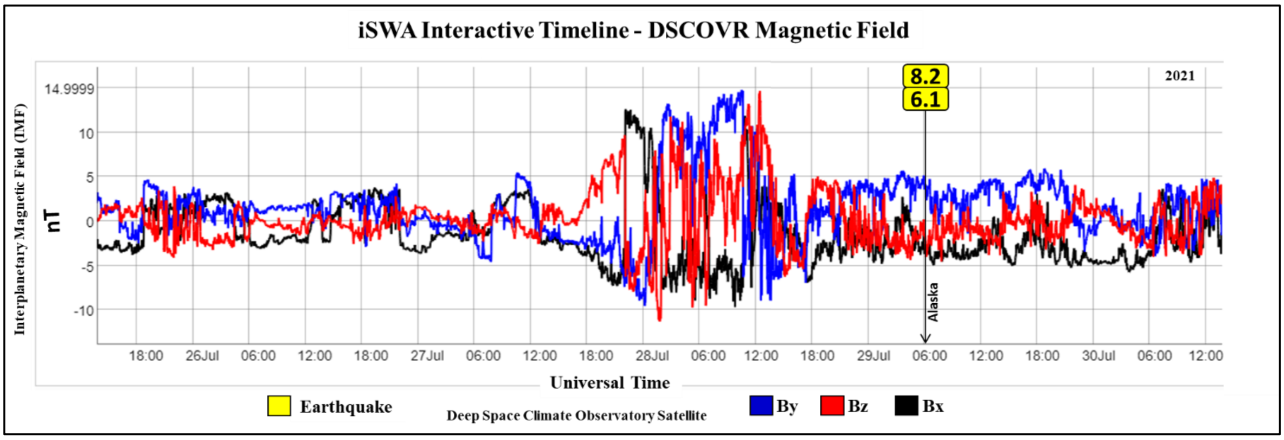


**Fig. 5 – Solar wind magnetic field perturbation correlated to M6+ Alaska earthquakes recorded on July 29, 2021.** The chart above shows the variation of the interplanetary magnetic field (IMF) recorded through the Deep Space Climate Observatory (DSCOVR) Satellite in orbit at L1 Lagrange point. The recording was done on 3 axes (By, Bx, Bz). Analyzing the variation curves it is evident that the M6+ earthquakes recorded in Alaska has been preceded by a perturbation of the interplanetary magnetic field (IMF) whose greater intensity was recorded between 27 and 28 July 2021. The long black vertical arrow represents the temporal marker of M6+ earthquake. Credits: iSWA, USGS, Radio Emissions Project.

In **Fig. 5** we observe an important perturbation of the interplanetary magnetic field that preceded the seismic train recorded in Alaska on 29 July 2021 by at least 36 hours: 1) M8.2 Alaska earthquake recorded on July 29, 2021 at 06:15:47 UTC; 2) M6.1 Alaska earthquake recorded on July 29, 2021 at 06:19:25 UTC.
This type of correlation was observed for the first time by the authors between 2010 and 2011 following some studies conducted by the authors on the variations of the Earth's geomagnetic field: variations that were monitored for a few months through environmental electromagnetic monitoring stations designed to study the Seismic Geomagnetic Precursors or SGPs. This technology, which in the future will make it possible to create the first electromagnetic monitoring system equipped with an RDF (Radio Direction Finding) system specifically designed to make crustal diagnosis [1] [7] [24] [26-31] [33-38] [40] [42-44] [53]. It should also be remembered that this electromagnetic monitoring system has made it possible, over the last ten years, to record the first "local" pre-seismic radio signals relating to the Italian territory in spectrographic format [16-18] [20] [31] [43]: a technology that had been obtained through the use of prototypes of radio receivers created as part of the "Radio Emissions Project" and through the use of 24-bit analog-to-digital converters (ADCs). Thanks to this system created by the authors it was possible to monitor a bandwidth of 30kHz with a resolution lower than 1mHz (1mHz = 0.001Hz): an exceptional result in the field of scientific research dedicated to seismic precursors of the electromagnetic type which until then it was made using electromagnetic monitoring systems capable of providing data with a much lower quality.

Apart from this, it is now clear that the solar ion flux, that is solar activity, is closely related to the M6+ global seismic activity. Also the variation of the solar wind speed is often correlated to the potentially destructive seismic activity: in **Fig. 6**, in fact, it is possible to observe an important variation of the solar wind speed whose apical value has overlapped, from the temporal point of view, at the time to the two major earthquakes were recorded in Alaska on July 29, 2021 (M8.2 and M6.1): the basal rate speed of solar ion flux stabilized at approximately 305-210 km/s; on July 27, 2021 at 18:00 UTC the speed starts to increase until it exceeds 500km/s on July 28, 2021 at 10:00 UTC. On July 29, 2021, at 03:45 UTC the solar ion flux reaches its maximum speed (574.2 km/s): 2 hours and 30 minutes later, are recorded the M8.2 and M6.1 Alaska earthquakes. The authors have observed this type of correlation several times over the past decade.

However, the most reliable seismic precursor remains the solar proton flux: this, unlike other phenomena of an electromagnetic nature analyzed by the authors between 2010 and 2021, always occurs before a potentially destructive seismic event following the distribution mentioned before **Fig. 5**.

The impact that the solar wind has on the Understanding why and how potentially destructive seismic activity is closely linked to solar activity would allow us to broaden our knowledge also on geomagnetism: in fact, since strong earthquakes are closely related to changes in the density of the solar ion flux, it is evident that there must be a form of electromagnetic interaction between the solar wind and the Earth's crust capable of altering the static balance of the faults. Understanding this mechanism will be the most important challenge that researchers will have to face in the field of scientific research dedicated to seismic prediction.

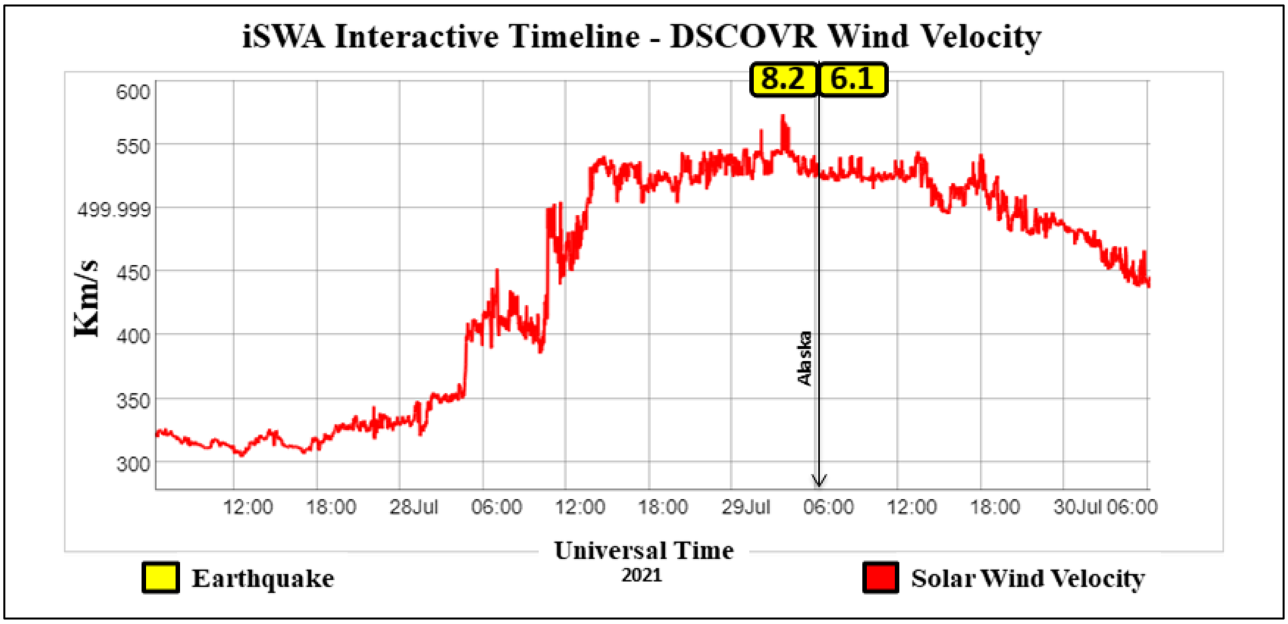


**Fig. 6 – Solar wind velocity correlated to M6+ Alaska earthquakes recorded on July 29, 2021.** The graph shows the variation of solar wind velocity recorded between 27 and 30 July 2021 by Deep Space Climate Observatory (DSCOVR) Satellite, in orbit at L1 Lagrange point. Analyzing the variation curve it is possible to understand that the two M6+ Alaska earthquakes was preceded by an increase of the solar wind speed. The black vertical arrow shows the temporal marker of the M6+ Alaska earthquakes occurred on July 29, 2021. Credits: iSWA, USGS, Radio Emissions Project.

The **Fig. 7** helps us to understand how significant this "impact" is on the geomagnetic level. In fact, all the data that have been presented so far have shown that between 26 and 29 July 2021 the Earth was reached by a fast and dense solar ion flux.

The Kp Index, in fact, had undergone an evident increase even if a very high level had not been reached (potentially destructive earthquakes are not always correlated to increases in Kp Index >4). This was partly confirmed by DST Index (**Fig. 7**): analyzing the variation curve of the DST Index it emerged that the two strong earthquakes recorded in Alaska (M8.2 and M6.1) occurred during a reduction of DST Index which reached the rank of "weak storm" 210 minutes later. This confirms that the solar ion flux has caused an important perturbation of the Earth's geomagnetic field. The DST Index began to decline significantly as of July 28, 2021 at 00:00 UTC. At 12:00 UTC the DST Index had reached the value of -25nT; then after a slight decline it returned to decrease and reached -31nT (a few hours after the recording of the two potentially destructive seismic events recorded in Alaska on 29 July 2021).

From the data exposed so far, it is possible to establish that the two strong earthquakes recorded in Alaska on 29 July 2021 were preceded by an increase in solar activity which produced some perturbations in the Earth's geomagnetic field. This type of correlation, as has already been mentioned, has been observed with respect to all seismic events that have a magnitude of not less than Mw 6.

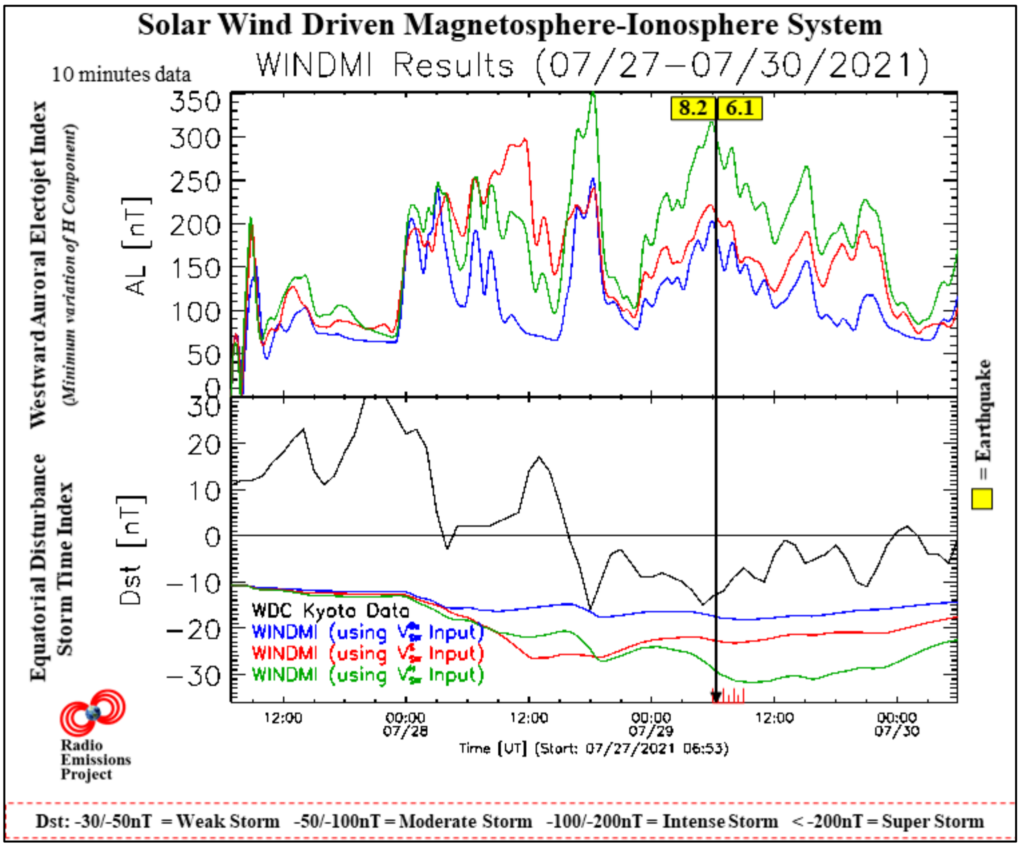


**Fig. 7 – Low-dimensional model of the energy transfer from the solar wind through the magnetosphere and into the ionosphere (WINDMI).** The picture shows the variation of the AL-Index (at top) and the DST-Index (at bottom) in the hours that preceded the M6+ Alaska earthquakes recorded on July 29, 2021. The DST-Index is a direct measure of the Earth's geomagnetic horizontal (H) component variation due to the equatorial ring current, while the AL-Index (Auroral Lower) is at all times, the minimum value of the variation of the geomagnetic H component of the geomagnetic field recorded by observers of reference and provides a quantitative measure of global Westward Auroral Electrojet (WEJ) produced by increased of ionospheric currents therein present. The WINDMI data analysis showed that the M6+ Alaska earthquakes recorded on July 29, 2021 was preceded by an increase of solar and geomagnetic activity. The black vertical arrow shows the temporal marker of the M6+ earthquake. Model developed by the Institute for Fusion Studies, Department of Physics, University of Texas at Austin. Credits: iSWA, USGS, Radio Emissions Project.

## Conclusions

We conclude that the three potentially destructive earthquakes recorded between 26 and 29 July 2021 occurred during an increase in the proton density of the solar wind that subsequently resulted in an increase in the Earth's geomagnetic field: the two earthquakes recorded in Alaska on July 29, 2021 occurred during a significant increase in the velocity of the solar wind and after an apparent perturbation of the interplanetary magnetic field (IMF): but it is not yet clear how an increase in solar ion flux density might have a connection with seismogenesis. The authors do not exclude that at the base there is a form of electromagnetic interaction able to alter the static balance in fragile zones subjected to tectonic stress.

## Credits

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