# Solar activity and geomagnetic activity related to M6+ global seismic activity recorded on March 20, 2021

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**Abstract**

On March 20, 2021, two potentially destructive earthquakes were recorded on our planet: Macquarie Island M6.1 earthquake, recorded at 05:19:31 UTC at a depth of 10 km; Japan M7.0 earthquake recorded at 09:09:45 UTC at a depth of 54 km. These two earthquakes were recorded after a solar wind proton density increase which subsequently generated a geomagnetic perturbation that reached the degree G1 (NOAA G Scale). This type of correlation was observed by the authors for the first time since 2011, while from January 1, 2012 to date it was possible to see that all potentially destructive seismic events that are recorded on a global scale are always preceded by a solar wind proton density increase which can subsequently produce a perturbation of the Earth's geomagnetic activity.

**Keywords**: solar activity, Earth's geomagnetic activity, seismic precursor, earthquake prevision, proton density increase.

## Introduction

On March 20, 2021, two potentially destructive seismic events have been recorded on our planet (**Fig.1**):

1) Macquarie Island M6.1 earthquake, recorded at 05:19:31 UTC at a depth of 10 km;
2) Japan M7.0 earthquake recorded at 09:09:45 UTC at a depth of 54 km.

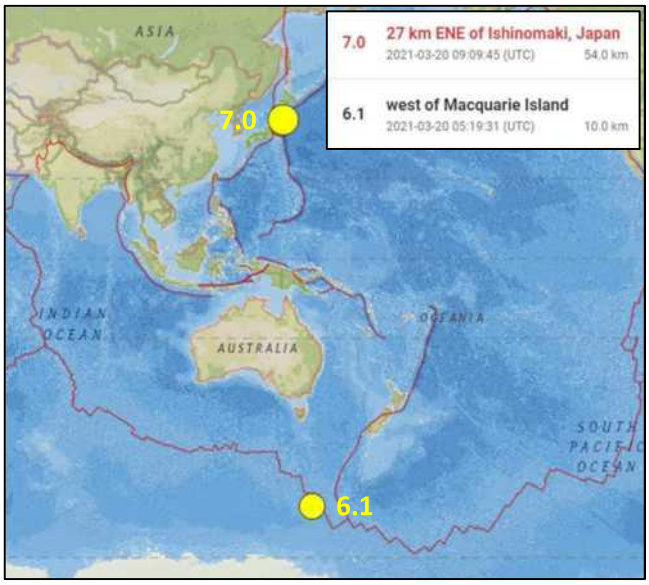


**Fig. 1 – Seismic epicenters of M6+ earthquakes recorded on March 20, 2021**.
Credits: USGS

The studies conducted by the authors from 2012 to today have shown that all the potentially destructive seismic activity that is recorded on our planet (M6+ global seismic activity) is always preceded by an increase in the solar ion flux [4] [5] [7- 24] namely by a solar wind proton density increase (Interplanetary Seismic Precursor ord ISP) which can produce important geomagnetic perturbations [1-3] [5] [6] [11] [13-15] [18] [20] [24] (Seismic Geomagnetic Precursor or SGP). This important result has been confirmed for

every single potentially destructive seismic event: a unique scientific achievement in the history of research dedicated to seismic prediction but which is not yet widely discussed within the international scientific community. In this paper the authors will present the results of this type of correlation obtained with respect to the M6+ seismic events recorded on a global scale on March 20, 2021.

**Data analysis**

The authors constantly monitor the conditions of space weather and geomagnetic activity to understand when a resumption of M6+ global seismic activity is expected. On March 18, 2021 at 22:46 UTC the DSCOVR Satellite (in Lagrangian orbit L1) started detecting a solar wind proton density increase (**Fig. 2**) which reached its maximum level (63.47 p/cm ^3) on March 20, 2021 at 03:58 UTC. At 04:10 UTC this increase quickly decreased and two seismic events of strong intensity were recorded within a few hours:

1) Macquarie Island M6.1 earthquake, recorded at 05:19:31 UTC at a depth of 10 km;
2) Japan M7.0 earthquake recorded at 09:09:45 UTC at a depth of 54 km.

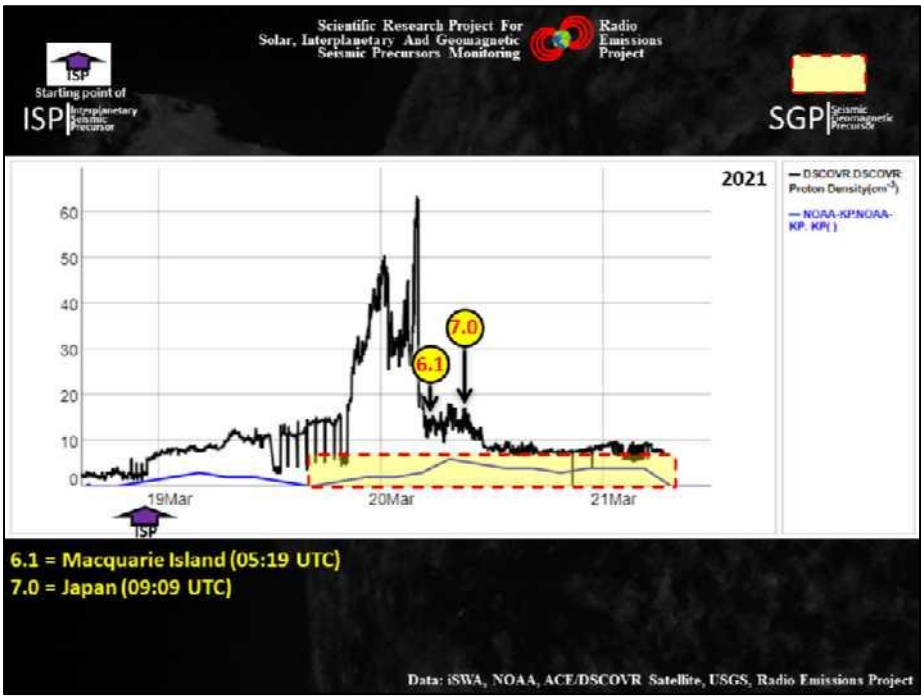


**Fig. 2 – Electromagnetic seismic precursors related to the M6+ earthquake**. The graph above shows the variation curve relating to the solar wind proton density increase (black line) and the variation curve of the geomagnetic activity (Kp Index; blue line) recorded between 18 and 21 March 2021. The area yellow highlights the geomagnetic increase (Seismic Geomagnetic Precursor or SGP) that preceded the M6+ global seismic activity that have been recorded on March 21, 2021. The solar wind proton density increase started on 18 March 2021 at … UTC (see purple arrow) and represents the Interplanetary Seismic Precursor (ISP) related to the M6+ earthquakes. Credits: USGS, iSWA, Radio Emissions Project.

Observing **Fig. 2** it is evident that the proton increase (Interplanetary Seismic Precursor or ISP) produced an increase in geomagnetic activity (**Fig. 2** and **3**) which preceded, in turn, the two M6+ seismic events (Seismic Geomagnetic Precursor or SGP). From a predictive point of view, therefore, we are faced with two phenomena of an electromagnetic nature (one of which is the consequence of the other) which can be monitored with enormous ease and which give us a certain time indication (on average within 108 hours) about when a resumption of M6+ global seismic activity can be expected. This seismic forecasting method is not able to identify the epicentral areas of potentially destructive earthquakes but it gives us the certainty that a resumption of M6+ seismic activity will take place on a global scale. Considering that this mechanism has been observed for every potentially destructive seismic event occurring from January 1, 2021 to date, the authors believe that this is an unprecedented scientific achievement and, as such, should find adequate recognition within the international scientific community

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**Fig. 3** – **Kp Index related to M6+ global seismic activity recorded on March 20, 2021.** The graph above shows the Kp Index curve recorded between 18 and 21 March 2021: it is clear that the M6+ global seismic activity earthquake was preceded by a geomagnetic increase that reached the degree of 6 (geomagnetic storm of G1 degree; NOAA G Scale), as indicated by the dashed red line. Credits: iSWA.

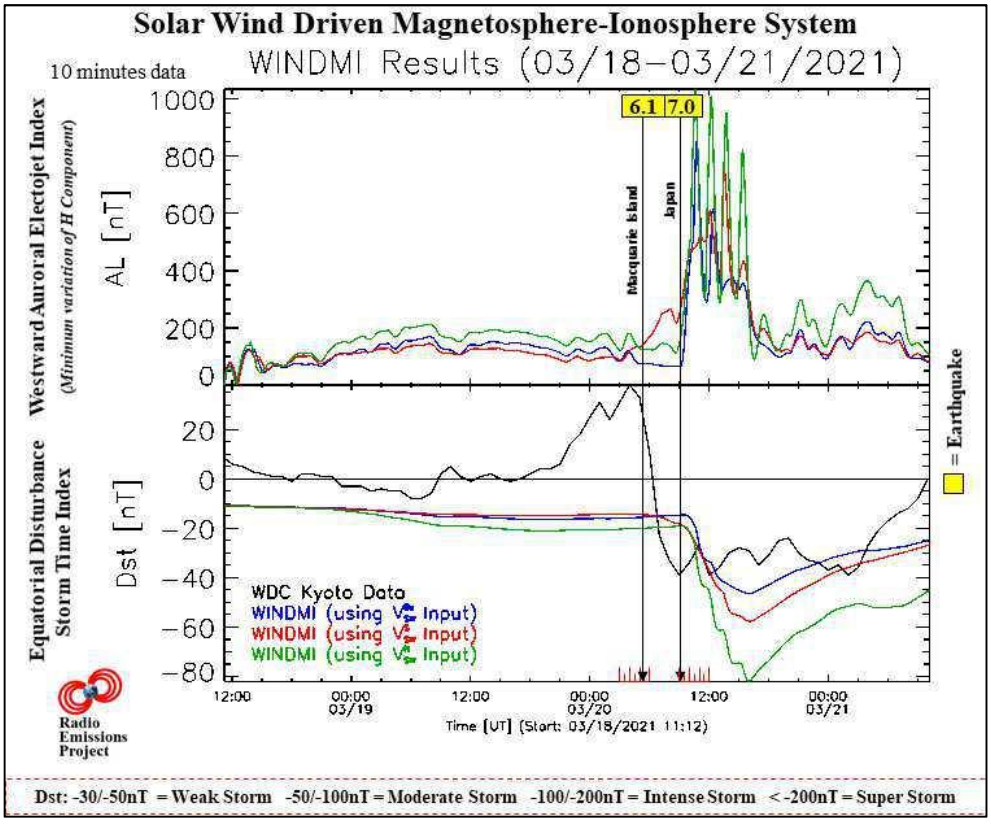


**Fig. 4 – Low-dimensional model of the energy transfer from the solar wind through the magnetosphere and into the ionosphere (WINDMI).** The picture shows the variation of the AL-Index (at top) and the DST-Index (at bottom) in the hours that preceded the M6+ global seismic activity recorded on March 20, 2021 (the time marker of the earthquake is indicated by a vertical black line). 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 Electroject (WEJ) produced by increased of ionospheric currents therein present. Model developed by the Institute for Fusion Studies, Department of Physics, University of Texas at Austin. Credits: iSWA, USGS, Radio Emissions Project.

Other interesting data come from the analysis of the "Low-dimensional model of the energy transfer from the solar wind through the magnetosphere and into the ionosphere (WINDMI)" (**Fig. 4**). Observing the graphs of Fig. 4 it is possible to understand that the two earthquakes were preceded by an increment of DST Index and AL Index: two indices used to have an indication of the entity of the geomagnetic perturbations induced by solar activity, i.e. by the solar ion flux. This data confirms that the two earthquakes were preceded by an

increase in the Earth's geomagnetic activity produced as a result of the coupling between solar activity (solar ion flux) and the Earth's magnetosphere, as shown in **fig. 2**. In fact, it was no coincidence that the two M6+ seismic events were recorded shortly before and shortly after the geomagnetic increase of G1 class (NOAA G Scale) (**Fig. 3**).

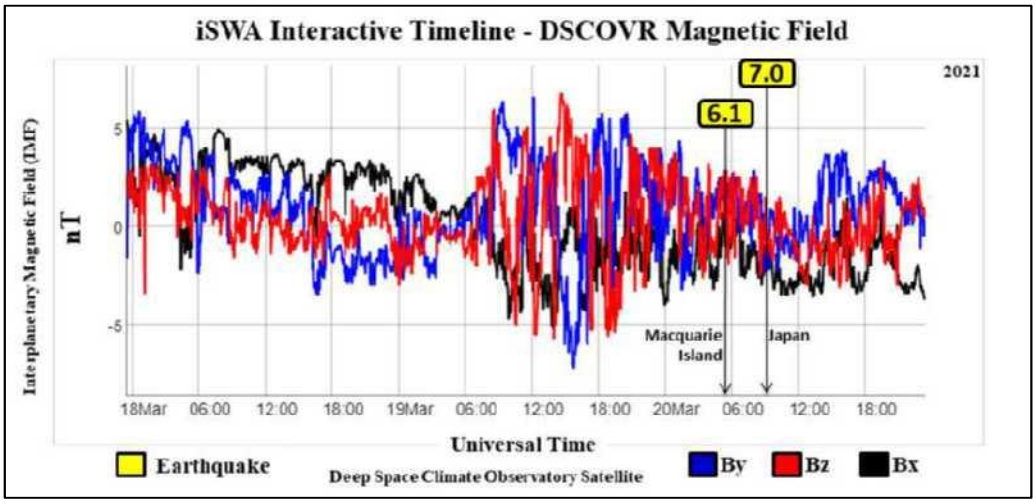


**Fig. 5 – Solar wind magnetic field perturbation correlated to South Sandwich Islands region M6.0 earthquake.** The chart above shows the variation of the interplanetary magnetic field (IMF) recorded through the Deep Space Climate Observatory (DSCOVR) Satellite in orbit at L1 Lagrange point. The recording was done on 3 axes (By, Bx, Bz). Analyzing the variation curves it is evident that the M6.0 earthquake occurred in South Sandwich Islands region on March 14, 2021 has been preceded by a perturbation of the interplanetary magnetic field (IMF) whose greater intensity was recorded between 02:30 UTC and 06:00 UTC of March 13, 2021. The long black vertical arrow represents the temporal markers of South Sandwich Islands region M6.0 earthquake recorded on March 14, 2021 at 12:05 UTC. Credits: iSWA, USGS, Radio Emissions Project.

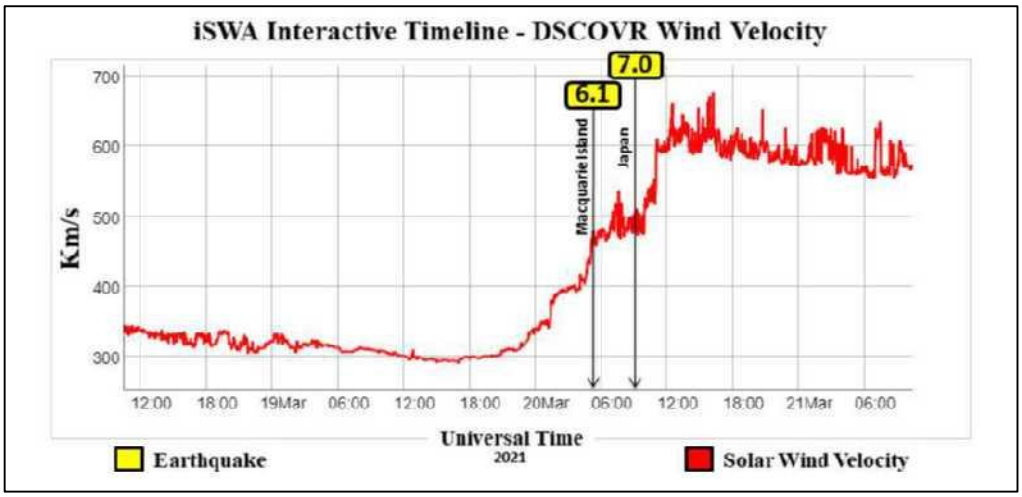


**Fig. 6 – Solar wind velocity correlated to M6+ global seismic activity recorded on March 20, 2021**. The graph shows the variation of solar wind velocity recorded between 18 and 21 March 2021 by Deep Space Climate Observatory (DSCOVR) Satellite, in orbit at L1 Lagrange point. Analyzing the variation curve it is possible to understand that the M6+ earthquakes was preceded by an increase of the solar wind speed. The black vertical arrow shows the temporal marker of the M6+ earthquakes occurred on March 20, 2021. Credits: iSWA, USGS, Radio Emissions Project.

Fig. 5 and 6 confirm what has been stated so far. Very interesting is the perturbation (Interplanetary Seismic Precursor or ISP) of Interplanetary Magnetic Field (IMF) highlighted many hours before the two M6+ seismic events recorded on March 20, 2021: 24 hours before Macquarie Island earthquake and 28 hours before Japanese earthquake. Also in this case, the speed of the solar wind has undergone an increase correlated to the M6+ seismic activity: the two seismic events analyzed in this work were recorded during a rapid increase in the solar ion flux which reached ~670 km/s 8 hours after the Japanese earthquake. This type

of correlation was observed for the first time by the authors in 2011 and allowed to focus attention on the density of the solar ion flux [4] [5] [7-24].

## Conclusions

Thanks to the enormous work that the authors have been carrying out since 2012, the conclusions should be taken for granted, however it should be reiterated that the M6+ global seismic activity is closely related to the solar activity and, more precisely, to the solar wind proton density increases that can subsequently determine of the important perturbations of the Earth's geomagnetic field. The authors were able to verify that every single M6+ seismic event is always preceded by solar wind proton density increase and this allows to establish with certainty when on Earth it is possible to expect a resumption of global M6+ seismic activity. What has been ascertained represents in all respects an important scientific achievement which, according to the authors, should be counted among the most important scientific discoveries of the century as it could (today) be used as a tool capable of predicting (with an average forewarning of 108 hours) when a resumption of M6+ seismic activity occurs on Earth. This tool has been tested by the authors for more than nine years and, unlike other methods, has always proved reliable.

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