

## Space weather and geomagnetic activity related to M6+ global seismic activity recorded on 3-4 March 2021

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### Abstract

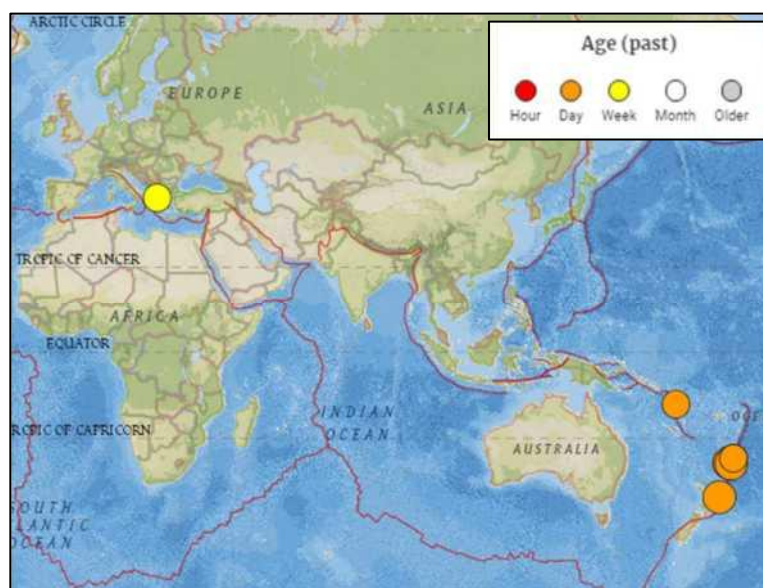
On 3-4 March 2021, seven M6+ seismic events were recorded on our planet: 1) Greece M6.3 earthquake, recorded on March 3, 2021 at 10:16 UTC; 2) New Zealand M7.3 earthquake, recorded on March 4, 2021 at 13:27 UTC; 3) Vanuatu M6.1 earthquake, recorded on March 4, 2021 at 16:53 UTC; 4) Kermadec Islands M7.4 earthquake, recorded on March 4, 2021 at 17:41 UTC 5) New Zealand 8.1 earthquake, recorded on March 4, 2021 at 19:28 UTC; 6) Kermadec Islands M6.1 earthquake, recorded on March 4, 2021 at 20:25 UTC; 7) Kermadec Islands M6.2 earthquake, recorded on March 4, 2021 at 23:12. The peculiarity that unites these potentially destructive earthquakes was the fact that they were recorded during a solar wind proton density increase that started on March 28, 2021 at 00:00 UTC and ended on March 5, 2021 at 00:00 UTC which caused a series of geomagnetic perturbations.

**Keywords:** proton density increase, seismic precursors, solar activity, geomagnetic activity, electromagnetic precursors.

### Introduction

Seven M6+ seismic events were recorded on our planet between 3 and 4 March 2021 (**Fig. 1**):

- 1) Greece M6.3 earthquake, recorded on March 3, 2021 at 10:16 UTC (depth = 10 km);
- 2) New Zealand M7.3 earthquake, recorded on March 4, 2021 at 13:27 UTC (depth = 20.8 km);
- 3) Vanuatu M6.1 earthquake, recorded on March 4, 2021 at 16:53 UTC (depth = 172.1 km);
- 4) Kermadec Islands M7.4 earthquake, recorded on March 4, 2021 at 17:41 UTC (depth = 55.6 km);
- 5) New Zealand 8.1 earthquake, recorded on March 4, 2021 at 19:28 UTC (depth = 19.4 km);
- 6) Kermadec Islands M6.1 earthquake, recorded on March 4, 2021 at 20:25 UTC (depth = 10 km);
- 7) Kermadec Islands M6.2 earthquake, recorded on March 4, 2021 at 23:12 (depth = 10 km).

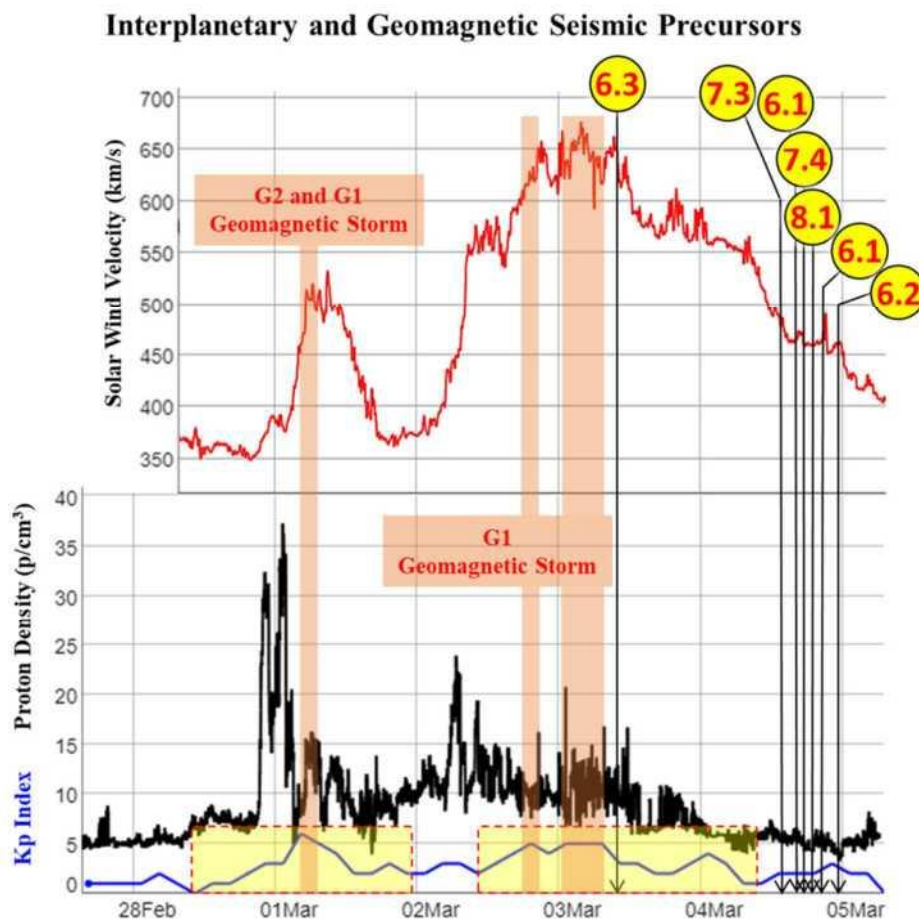


**Fig. 1 – Epicenter of the M6+ seismic events recorded between 3 and 4 March 2021.** The image above shows the map of the M6+ earthquake epicenter recorded between 3 and 4 March 2021. Credits: USGS, Radio Emissions Project.

Six of the seven earthquakes were recorded on March 4, 2021; while only one was recorded on March 3, 2021: it is a rare concentration of destructive seismic events of which very few precedents are known that occurred over the last ten years. In this paper, the authors will present the results of a correlation study that showed that these seven potentially destructive seismic events were preceded by a solar wind proton density increase and two increases in the Earth's geomagnetic activity. This type of correlation was observed by the authors since 2011 [1-24].

### Data analysis

This work served to demonstrate that the potentially destructive seismic activity that is recorded on our planet is always preceded by an increase in solar activity which determines an increase in the Earth's geomagnetic activity [1-24]. To confirm this trend, the authors analyzed the characteristics of the solar ion flux in the hours and days preceding the seven M6+ seismic events recorded between 3 to 4 March 2021: the results of this analysis can be seen in Fig. 2.



**Fig. 2 – Interplanetary and Geomagnetic Seismic Precursors related to M6+ earthquake recorded between 3 and 4 March 2021.** The graph above shows the classic correlation that exists between potentially destructive seismic events that are recorded on a global scale and solar and geomagnetic activity. The upper part of the graph (red curve; expression of the increase in solar activity) refers to the change in the speed of the solar wind recorded between February 28, 2021 and March 5, 2021. The lower part of the graph highlights the variation of solar wind proton density increase (black curve; expression of the increase in solar activity, started on February 28, 2021 at 00:00 UTC) and the variation of Kp Index (blue curve; expression of geomagnetic activity). The vertical black arrows represent the temporal markers of potentially destructive seismic events related to solar increase and geomagnetic increase: the increases in geomagnetic activity have been highlighted through the yellow and orange areas. The latter represents the time frame in which a geomagnetic storm of class G2 and G1 (NOAA G Scale) was recorded on our planet, corresponding to a Kp Index of 6 and 5. Credits: iSWA, USGS, Radio Emissions Project.

Thanks to the data provided by DSCOVR Satellite (placed in Lagrangian orbit L1), on February 28, 2021, at 00:00 UTC a solar wind proton density increase began to manifest itself which ended five days later, and exactly on March 5, 2021 at 00:00 UTC. Over this period of time it has undergone several fluctuations (Fig. 2):

1. on February 28, 2021 at 22:23 UTC the proton flow has reached a first peak of intensity ( $32.27 \text{ p/cm}^3$ );
2. on March 1, 2021 at 01:24 UTC the proton flow has reached a second peak of intensity ( $37.23 \text{ p/cm}^3$ );
3. on March 2, 2021 at 06:47 UTC the proton flux has reached the third peak of intensity ( $23.84 \text{ p/cm}^3$ ).

From a geomagnetic point of view, however, thanks to data provided by the National Oceanic and Atmospheric Administration (NOAA) it was possible to observe two increases in terrestrial geomagnetic activity which are superimposed on the general proton increase recorded between February 28, 2021 and March 5, 2021 (**Fig. 2**):

1. the first, reached a Kp Index of 6 on March 1, 2021 at 04:30 UTC (geomagnetic storm of class G2) and was recorded a few hours after the maximum proton increase peak (the second of the three increases; March 1, 2021 at 01:24 UTC);
2. the second, reached a kp Index of 5 between March 2, 2021 at 19:30 UTC and March 3, 2021 at 07:30 UTC (geomagnetic storm of class G1) and was recorded more than 12 hours after the third proton increment.

Exactly after the second geomagnetic increase of class G1 the seismic sequence of the seven potentially destructive earthquakes analyzed in this work began. The two intense geomagnetic increases that have rightly been superimposed on a series of solar wind proton density increases (secondary) have resulted in a typical global seismic trigger pattern related to solar activity [5] [7-12] [14-24]. The solar wind proton density increases, since they are phenomena of an electromagnetic nature related to M6+ global seismic activity have been classified by the authors as “Interplanetary Seismic Precursors” or ISPs; the same is true for geomagnetic increases produced as a result of one or more ISPs: the authors have classified these geomagnetic perturbations as “Seismic Geomagnetic Precursors” or SGPs. The first draft of this classification was made by the authors during 2012 [1].

## Conclusions

The M6+ seismic sequence recorded between 3 and 4 March 2021 was correlated to a series of electromagnetic phenomena of a solar nature (ISPs) and, subsequently, of a geomagnetic nature (SGPs) that the authors observed for the first time in 2010-2011. In this work they were presented only the data of a small part of the correlation study (which is still in progress) and which allowed the authors to correlate all M6+ seismic events occurring on a global scale to variations of solar wind proton density increases. This type of analysis will allow in the future to create a seismic forecasting method based solely on the monitoring of solar activity (and on the effects it has on the Earth’s geomagnetic field) and on environmental electromagnetic monitoring [20] [24].

## Credits

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