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Solar activity related to M6+ earthquakes recorded between 7 and 11 September 2024

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Abstract. Between 7 and 11 September 2024, two strong seismic events were recorded on our planet (M 6.0 earthquake recorded in Tonga on September 7, 2024 at 22:36 UTC; M6.3 earthquake recorded in Papua New Guinea on September 11, 2024 at 16:46 UTC). The analysis of solar activity has allowed us to establish that the two strong earthquakes were preceded by a proton increase in the solar ion flux.

***Key Word*:** space weather, seismic precursors, M6+, proton density, solar wind.

Introduction

As has been known for more than a decade thanks to the studies conducted by the authors on possible precursor signals, in particular on Electromagnetic Seismic Precursors (ESPs) of "local" and "non-local" origin [1-50], the potentially destructive seismic activity that is recorded on a global scale is always preceded by an increase in the ion density of the solar wind that hits the Earth [1-50].

This form of interaction (between the solar wind and the Earth's magnetosphere) has been known for decades; what was not known and that the authors have, instead, ascertained is that the density of the solar ion flux is strictly correlated to the M6+ global seismic activity, so much so that the authors have coined the term "Interplanetary Seismic Precursors" (ISPs) to refer precisely to the variations in the density of the solar ion flux that interact with the Earth's magnetosphere. In this case, ISPs are "non-local" seismic precursors since their interaction with the Earth's magnetosphere produces effects on a global scale (variations in the Earth's geomagnetic field) that can be studied from any point on the Earth's surface.

Between September 7 and 22, 2024, two strong seismic events were recorded on Earth (**Fig. 1**):

- M 6.0 earthquake recorded in Tonga on September 7, 2024 at 22:36 UTC;
- M 6.3 earthquake recorded in Papua New Guinea on September 11, 2024 at 16:46 UTC.

In this study the authors analyzed the characteristics of the solar wind density thanks to the data provided by the Advanced Composition Explorer (ACE) Satellite, located in Lagrangian orbit L1, to understand whether the two strong seismic events recorded between 7 and 11 September 2024 were preceded by an increase in the density of the solar ion flux; a correlation that has always been identified with respect to all potentially destructive seismic events recorded on a global scale from 1 January 2012 to today [1-50].

Method and Data

The data used for this study were provided by the iSWA – Integrated Space Weather Analysis System. In particular, the authors analyzed the modulation of the solar ionic flux with energy between 1060 and 1900 keV in the time frame between September 7 and 11, 2024 (**Fig. 2**). Solar ion flux data were provided by the Advanced Composition Explorer Satellite, placed in Lagrangian orbit L1. This data set was then compared with hourly data for M 6+ seismic events recorded on a global scale between 7 and 11 September 2024:

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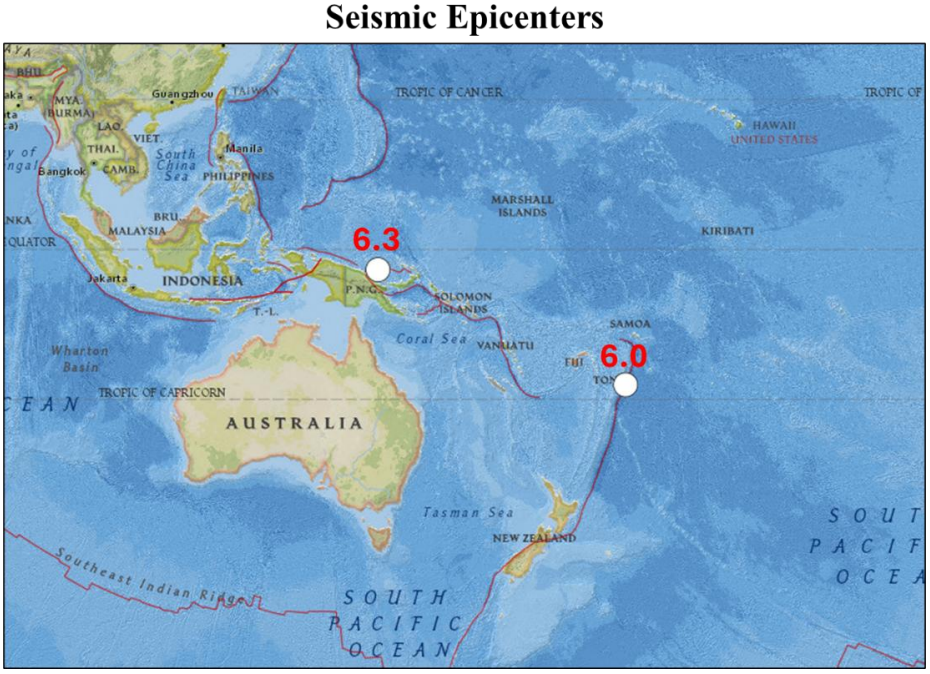

Fig. 1 Seismic Epicenters. The image above shows the seismic epicenters of two strong earthquakes recorded between September 7 and 11, 2024: M 6.0 earthquake recorded in Tonga on September 7, 2024 at 22:36 UTC; M 6.3 earthquake recorded in Papua New Guinea on September 11, 2024 at 16:46 UTC. Credits: USGS, Radio Emissions Project.

- M6.0 earthquake recorded in Tonga on September 7, 2024 at 22:36 UTC;
- M6.3 earthquake recorded in Papua New Guinea on September 11, 2024 at 16:46 UTC.

By analyzing the solar wind density recorded between 3 and 12 September 2024 (**Fig. 2**) it was possible to verify that every single M6+ seismic event recorded in this time frame (M6.0 earthquake recorded in Tonga on September 7, 2024 at 22:36 UTC; M 6.3 earthquake recorded in Papua New Guinea on September 11, 2024 at 16:46 UTC) was preceded by an increase in the proton density of the solar wind (Fig. 2). In practice, between 3 and 12 September 2024 two increases in the proton density of the solar wind were recorded, each of which was followed by a M 6+ seismic event. This clearly confirms the results of the authors' studies conducted since 2012 [1-50] and that is that the M6+ seismic activity recorded on a global scale is always preceded by an increase in the proton density of the solar wind.

This evidence also allows us to establish, with an average advance of 99 hours, when it is possible to expect a resumption of M 6+ global seismic activity [1-50].

The time intervals, expressed in hours (±30 minutes), correlated to the M6+ earthquakes recorded between 7 and 11 September 2024 were the following:

M6.0 earthquake recorded in Tonga on September 7, 2024 at 22:36 UTC ≈ 109

M6.3 earthquake recorded in Papua New Guinea on September 11, 2024 at 16:46 UTC ≈ 55

Discussion

Analyzing the variation curve of the proton density of the solar wind recorded between 3 and 12 September 2024 (**Fig. 2**), it is evident that the two M6+ seismic events recorded in the same time frame were preceded by a significant increase in the proton density of the solar wind that reached the Earth. This type of correlation has been ascertained by the authors since 2012 [1-50]. Currently, it is not possible to find an explanation capable of explaining this close correlation, but only hypotheses

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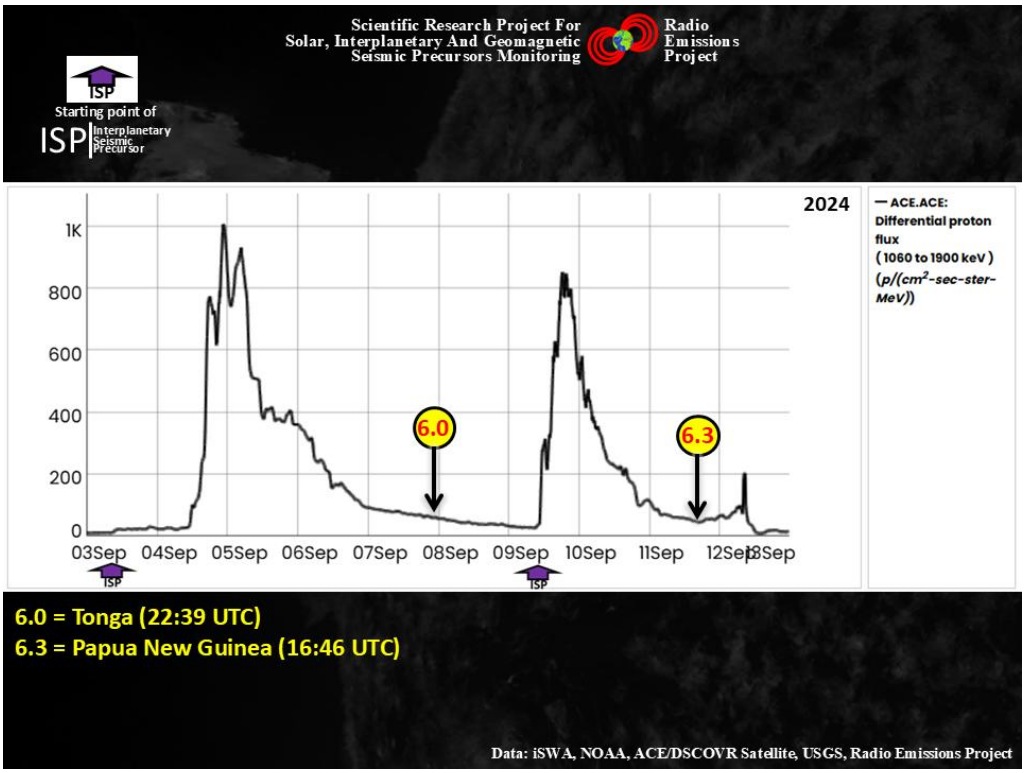

Fig. 2 M 6+ seismic sequence correlated to the protonic increase recorded between September 3 and 12, 2024. In the upper graph, the distribution of potentially destructive seismic events recorded between September 7 and 11, 2024, correlated to the increase in solar proton flux density recorded between September 3 and 12, 2024, is visible. The vertical black arrows identify the time markers of the potentially destructive seismic events recorded between September 7 and 11, 2024. Credits: iSWA, Radio Emissions Project.

can be developed. The authors believe that at the basis of this close correlation there must be a form of electromagnetic interaction that also affects the Earth's geomagnetic activity.

Conclusions

In conclusion, the authors confirm that every potentially destructive seismic event recorded on a global scale is always preceded by an increase in the proton density of the solar wind [1-50]. This close correlation between solar activity and M 6+ global seismic activity could be integrated into modern seismic forecasting methods to improve their reliability, at least on a global scale. This proposal has already been presented by the authors both in national (Italy) and international contexts, without however gaining much consensus.

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