THE GEOPHYSICAL COUPLING BEFORE EARTHQUAKES FROM MULTIPARAMETRIC STUDIES

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Abstract

The scientific debate on the existence of possible precursors before large earthquakes has been wide and brought to not univocal conclusions. One observable alone is clearly insufficient to provide indications on the criticality of the seismic fault status. In particular, it’s fundamental to investigate how critical is the accumulation of stress on a seismogenic fault and how we can predict an incoming earthquake. Considering that the Earth is a complex system in which the geo-layers (lithosphere, atmosphere and ionosphere) interact, it seems possible to understand better the Earth’s system if we study it as a whole. This requires an integration of observations and data from several sources and instruments, from ground data to remote sensing satellites. Despite the technical obstacles, several works have been done in this direction in the last years, and they seem to confirm firstly that the geo-layers show alterations (i.e., anomalies) before earthquake occurrence; secondly, it seems that several mechanisms of coupling are possible. This last point is the present research topic, as further clarifications are required.

In the presentation, several examples of couplings before the earthquakes will be shown; for example, the recent investigation of the Lushan (China) 2013 earthquake, which shows three possible couplings by different geophysical mechanisms at very different times before the earthquake (130 days, 45 days, and 2 weeks).

For the more recent seismic event, it is possible to investigate the ionosphere layer with the precious data from China Seismo Electromagnetic Satellite (CSES-01), by its instruments such as Langmuir probes and magnetometers. The integration of CSES and ESA Swarm data allows us to define better the ionospheric disturbances possibly related to earthquake occurrence. These cases include Mw = 7.5 Indonesia 2018, Mw = 7.6 Papua New Guinea 2019, Mw = 7.7 Jamaica 2020 or Mw = 7.8 Turkey 2023 earthquakes.

Finally, we are still far from predicting earthquakes but several steps toward a better understanding of the phenomena eventually associated with seismic events seem to be not far.

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ABSTRACT

Field Perturbations Detected by Swarm Three Satellite Constellation.

On 8 February 2023, two strong earthquake swarms occurred on the border between Turkey and Syria. The first, with magnitude of 7.6, was recorded at 7:54 AM (UTC) at 18:02 local time. The second, with magnitude of 7.8, occurred two hours later at 12:56 AM (UTC) at 02:54 local time. These events have been analyzed by previous techniques extracting several anomalies summarized in the following figure. A systematic analysis will be conducted after the last 30 days of the layers show anomalies.

1 - INTRODUCTION: WHAT IS LAIC?

Lithosphere–Atmosphere–Ionosphere–Coupling (LAIC) describes a series of possible phenomena which may overlap the earthquake triggering from the lower layers to the upper ionosphere. Several mechanisms for LAIC have been proposed, and they are generally correlated in a way that one event may trigger a second event, and so on. As multi-parametric investigations of earthquakes by Swarm has been conducted, we expect which coupling could trigger before specific event.

There are several proposed mechanisms for Lithosphere-Atmosphere-Ionosphere-Coupling (LAIC) (e.g.,


In conclusion, there seem to be more geophysical coupling before the earthquakes described by the different LAIC models. The reason for the differences could be that the different earthquake local characteristics and characteristics of different coupling mechanisms will be the subject of investigation in the near future research.

REFERENCES

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Papa New Guinea 2019: Two stages of acceleration

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In Marchetti et al. (2022), we investigated earthquake catalogue (for lithosphere), ground geomagnetic observatories, climatological data from atmospheric, GMN, and ionospheric data from Formosat-3/4 satellites. From Marchetti et al., 2023, we investigated earthquake catalogue (for lithosphere), ground geomagnetic observatories, climatological data from atmospheric, GMN, and ionospheric data from Formosat-3/4 satellites. From Marchetti et al., 2023, we investigated earthquake catalogue (for lithosphere), ground geomagnetic observatories, climatological data from atmospheric, GMN, and ionospheric data from Formosat-3/4 satellites.

2 - STATISTICAL INVESTIGATIONS OF SWARM AND CSES DATA

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3 - Mw 6.7 Lushan (China) 2013: three different couplings before the earthquake

Lushan (Qinghai) earthquake occurred on 21 April 2013 in a thrust fault mechanism on Longmenshan fault, the same area responsible of catastrophic Wenchuan earthquake of 2008 in Szechuan province of China. In the page of Zhao et al., (2013), the authors characterize the Lushan Earthquake as a megathrust earthquake, releasing energy of about 1200 km3 and vertical profiles of 300 m width (for swarms) searching for anomalies in the lower crust. These three possible couplings have been identified 190, 30-40 and 20-30 days before Lushan earthquake. The first one is a rapid coupling and it was established as the first stage of preparation of this earthquake and other publications identified a variation of Ab from SPI data in the same time. This last coupling could be described as a chain of phenomena according to models of Fukushima and Nishihara (2011).

In Marchetti et al. (2023), we investigated earthquake catalogue (for lithosphere), ground geomagnetic observatories, climatological data from atmospheric, GMN, and ionospheric data from Formosat-3/4 satellites. From Marchetti et al., 2023, we investigated earthquake catalogue (for lithosphere), ground geomagnetic observatories, climatological data from atmospheric, GMN, and ionospheric data from Formosat-3/4 satellites. From Marchetti et al., 2023, we investigated earthquake catalogue (for lithosphere), ground geomagnetic observatories, climatological data from atmospheric, GMN, and ionospheric data from Formosat-3/4 satellites.