



OUR PLANET FROM SPACE

SAFE AND LIMADOU PROJECTS: DISCOVERING FROM SPACE THE MYSTERIES OF THE PREPARATORY PHASE OF LARGE EARTHQUAKES

Could data provided by satellites improve our current knowledge of the phase preceding large earthquakes? This is the question that the SAFE (SwArm For Earthquake study) project coordinated by INGV (Istituto Nazionale di Geofisica e Vulcanologia) and the LIMADOU-Science project are trying to answer through the Swarm (ESA Magnetic Field Satellite Mission) and CSES (China Seismo-Electromagnetic Satellite) by means of data analysis of electromagnetic field and waves, plasma and particle perturbations of the atmosphere, ionosphere and magnetosphere induced by natural sources and anthropogenic emitters. The SAFE project is funded by the European Space Agency (ESA) and the LIMADOU- Science project is funded by the Italian Space Agency (ASI).

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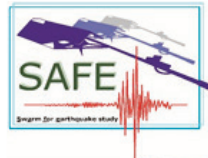
SAFE and LIMADOU projects: discovering the mysteries of the preparatory phase of large earthquakes from space

Could data provided by satellites improve our current knowledge of the phase preceding large earthquakes?

The SAFE (SwArm For Earthquake study) project

The SAFE project has been coordinated by the Istituto Nazionale di Geofisica e Vulcanologia (INGV) and funded by the European Space Agency (ESA). SAFE has analysed the electromagnetic data from sensors on board the three identical satellites of ESA Swarm constellation for 4,7 years of mission. In particular, the project has studied the coupling between lithosphere, where the earthquakes occur, and the above atmosphere and ionosphere. The goal is to capture the possible information exchanged among these three layers from space, on occasion of large earthquakes.

To achieve this scope, two different approaches have been considered. First, the study of single case studies, where the anomalies associated to the studied earthquakes resemble a linear dependence with earthquake magnitude, so supporting the statistical correlation with earthquakes and excluding a relationship by chance. The second approach is a worldwide point of view. We define the anomalies statistically in the whole



space-time interval of interest and use a superposed epoch and space approach to study the possible relation with earthquakes. We find some clear and significant concentrations of electron density and magnetic anomalies from more than two months to some days

before the earthquake occurrences. By investigating different earthquake magnitude ranges, not only do we confirm the well-known Rikitake empirical law, but we also give more reliability to the seismic source origin for many of the identified anomalies.



The LIMADOU-Science project

INGV is also currently joined another scientific project dedicated to the Lithosphere- Atmosphere-Ionosphere Coupling (LAIC) studies. The LIMADOU-Science project is funded by the Italian Space Agency (ASI) and is analyzing the data collected by the CSES (China Seismo-Electromagnetic Satellite) space mission

dedicated to monitoring electromagnetic field and waves, plasma and particle perturbations of the atmosphere, ionosphere and magnetosphere induced by natural sources and anthropogenic emitters. The INGV-team work is focused on the analysis of in-situ ionospheric anomalies occurring during the preparation phase of large earthquakes, in order to study possible pre- earthquake related processes affecting the ionosphere. This study is conducted following a multiparametric approach applied to both to atmospheric, satellite and ionosonde data data, taking into account also solar and geomagnetic conditions.

Thanks to this project, the first analysis of the ionospheric disturbances observed by CSES magnetic and electron density sensors during quiet geomagnetic time, associated with the preparation phase of the $M_w=7.5$ earthquake occurred in Indonesia on September 28th, 2018 has been carried out. By using different techniques, anomalies concentrated around 2.7 months before the mainshock have been found.

For more information about the SAFE project:
<http://safe-swarm.ingv.it/project/about-safe>

For more information about the LIMADOU project:
<http://cses.roma2.infn.it/>

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