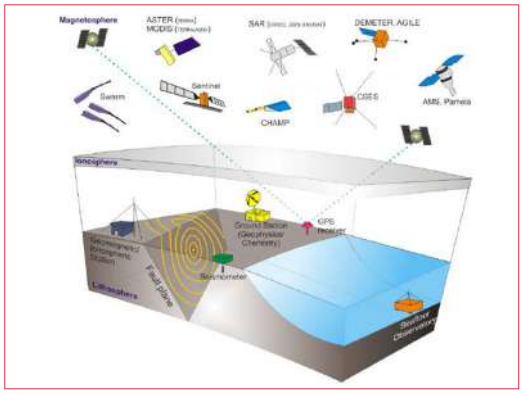
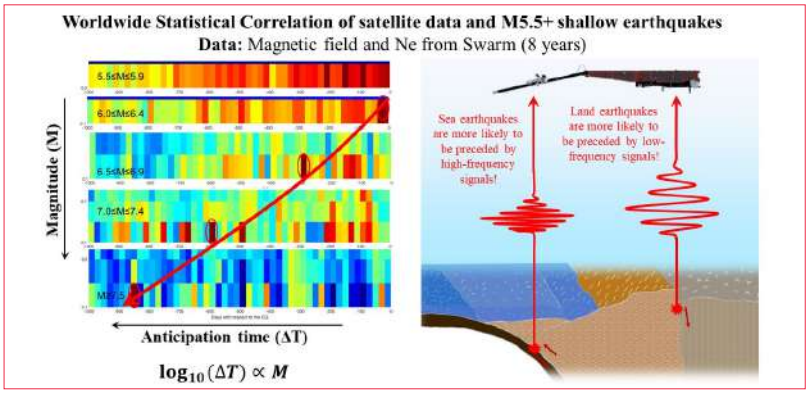
DISCOVERING FROM SPACE THE MYSTERY OF THE PREPARATORY PHASE OF LARGE EARTHQUAKES

Could data provided by satellites improve our current knowledge of the phase preceding large earthquakes? This is the question the COS-LAIC Group at INGV (Centro di Osservazioni Spaziali - Earth Space Observation Centre of the Istituto Nazionale di Geofisica e Vulcanologia) is trying to answer.

AN "INTERCONNECTED WORLD". LAIC | LITHOSPHERE | ATMOSPHERE | IONOSPHERE COUPLING

Scientific investigations have shown that before large earthquakes, often the Earth sends transitory signals, sometimes strong, but more often fleeting: they appear as electromagnetic emissions over a wide range of frequencies, variations in the local magnetic field and also multiform atmospheric and ionospheric phenomena. LAIC stands for Lithosphere-Atmosphere-Ionosphere Coupling, a comprehensive name for those synergetic different processes occurring across ground surface, atmosphere and ionosphere leading to anomalous variations associated with different preparation stages of large earthquakes.
Current Swarm (ESA Magnetic Field Satellite Mission), CSES (China Seismo-Electromagnetic Satellite), NOAA (National Oceanic and Atmospheric Administration) satellites and other past satellite missions provide useful data for analyses of electromagnetic field and waves, as well as plasma and particle perturbations in the atmosphere, ionosphere and magnetosphere, induced by natural sources and anthropogenic emitters.





LAIC
Methods and Models

The lithosphere–atmosphere–ionosphere interaction processes are of primary interest in seismo-ionospheric research for a deeper understanding of the preparation phases of large earthquakes.
Energy exchanges through heat, ground motion, electromagnetic emissions and perturbations are able to affect the ionospheric plasma parameters, electromagnetic field, ionospheric current, and energetic particles: so investigating the dynamics and electromagnetic environment via multi-parameter analysis from a variety of ground- and space-based detections (e.g. in situ – satellite - plasma parameters, ground motions, the geomagnetic and electromagnetic fields, infrared (IR) and radiofrequency (RF) emission, GNSS TEC, ionosonde, etc.) is mandatory.

Methods

COS-LAIC group considers, among the others, two different approaches:
1. Investigation of single case studies. The total number of anomalies associated with an earthquake are put in statistical correlation with its magnitude and occurrence and a confutation analysis is made to exclude a relationship by chance.
2. A worldwide point of view. We study the anomalies statistically in the whole space-time interval by using a "superposed epoch and space" approach to verify the possible relation with earthquakes: the concentrations of electron density and magnetic anomalies found time before and after the earthquake occurrences are promising and give more reliability to the seismic source origin for many of the identified anomalies. Moreover, by investigating different magnitude ranges, we confirm the Rikitake empirical law (i.e. the larger the earthquake magnitude, the longer the anticipation time of the precursor).

Models

The interaction among the different geolayers before large earthquakes is complex and comprises different possible phenomena. In general, it depends on the magnitude of the impending earthquake, because the energy released before its occurrence in the form of some precursory anomalies seems to scale with the magnitude. In addition, the region of earthquake preparation scales with magnitude, i.e. the larger the earthquake, the larger the preparation region (the so-called Dobrovolsky region).

Three possible «channels» of LAIC are expected, explained by three different models.

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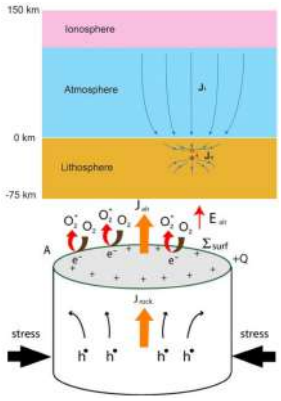
The LAIC study to comprehend the pre-earthquake phases

Investigation of the dynamics and electromagnetic environment via multi-parameter analysis from ground- to space-based detections is mandatory.

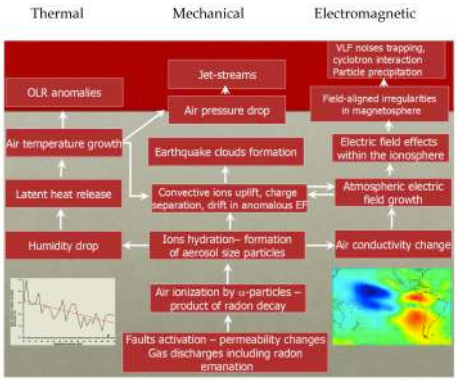
DYNAMO FROM STRESSED ROCKS (E.G. FREUND, 2011)

When crustal rocks are stressed, molecular links break, releasing electronic charge carriers, known as positive holes or p-holes, which can flow out of the stressed volume of rock. Such electric current generates magnetic field variations and low frequency EM emissions: these positive charges can lead to ionization of air at the ground–air interface able to produce IR and RF emission.



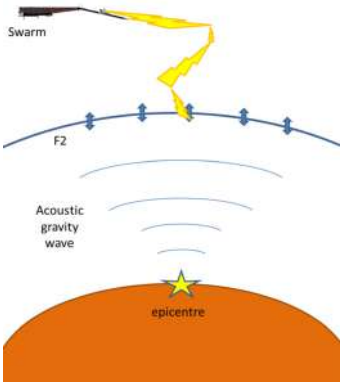
DYNAMO FROM INJECTION OF RADON AND/ OR CHARGED AEROSOLS (E.G. PULINETS AND OUZOUNOV, 2011)

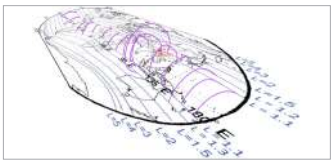
From the starting release of radon and/or charged aerosols, this model proposes a chain of processes that can explain the various types of variations in the different observables (electromagnetic, atmospheric, ionospheric, etc.) identified in the scientific literature.

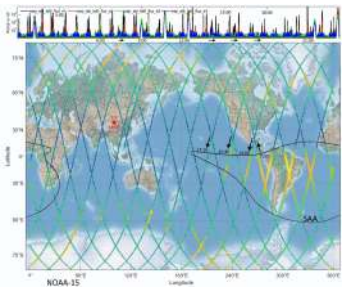


ACOUSTIC GRAVITY WAVES (AGW) (E.G. HAYAKAWA ET AL. JAE, 2011)

The generation of AGW (atmospheric gravity wave) is considered responsible for the transfer of the lithospheric perturbation to the ionospheric altitudes, through the atmosphere, leading to the anomalous variations in the ionospheric data.







The LIMADOU-Science+ Project

INGV COS-LAIC Group has recently joined the LIMADOU-Science+ project, a scientific project dedicated to LAIC studies and funded by the Italian Space Agency (ASI). By using different techniques, this project is aimed at analysing the data collected by the CSES space mission, which is dedicated to monitoring electromagnetic fields and waves, plasma and particle perturbations in the atmosphere, ionosphere and magnetosphere, induced by natural sources and anthropogenic emitters, with particular attention to Italian and Chinese territories: to the search for magnetic disturbances and electron density anomalies observed by CSES sensors during a quiet geomagnetic period, was also added the analysis of the precipitation of particles from the Van Allen radiation belts induced by emissions from below and associated with the preparation phase of large earthquakes (see the References for more information).

All the space-related INGV flyers are here!

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