Remote Sensing Applications in Detecting Electromagnetic Earthquake Precursors

Mostapha Harb[1,2], Fabio Dell'Acqua[1,2]

[1]*Dipartimento di Ingegneria Industriale e dell'Informazione - University of Pavia, Italy*

[2]*Aerospace Section – EUCENTRE, Pavia, Italy*

E-mail: fabio.dellacqua@unipv.it; mostapha.harb@eucentre.it

Introduction

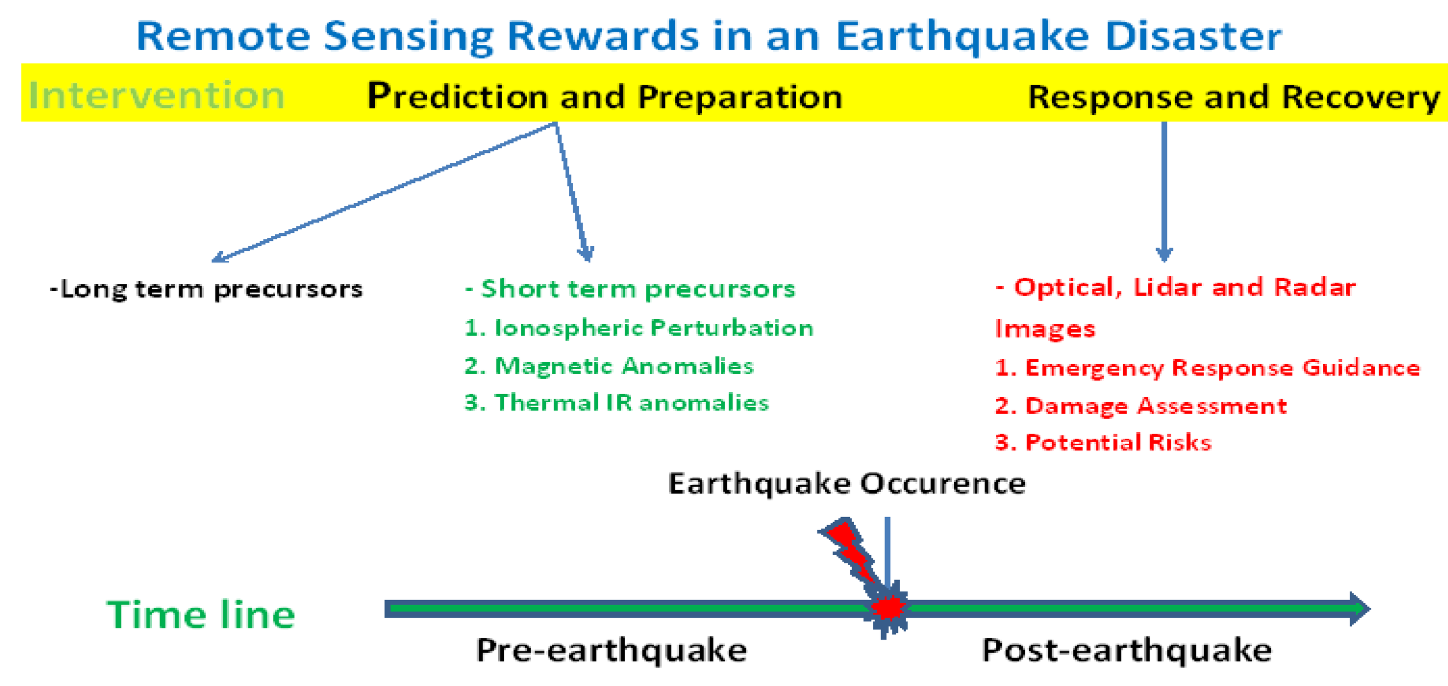
- **Objective**

This study is intended to highlight an emerging trend in the research field of quakes identification.

- **Seismic Hazards**

Earthquakes are particular among natural disasters for their enormous capability to kill, to damage, and to trigger other disasters.

Traditionally there has been a focus on rock and soil mechanics to develop a mechanical precursor system for earthquakes. But the instantaneous nature of the hazard prevented any breakthrough in short-term prediction of quakes.



List on the main remote sensing activities related to an earthquake event

Electromagnetic Precursors

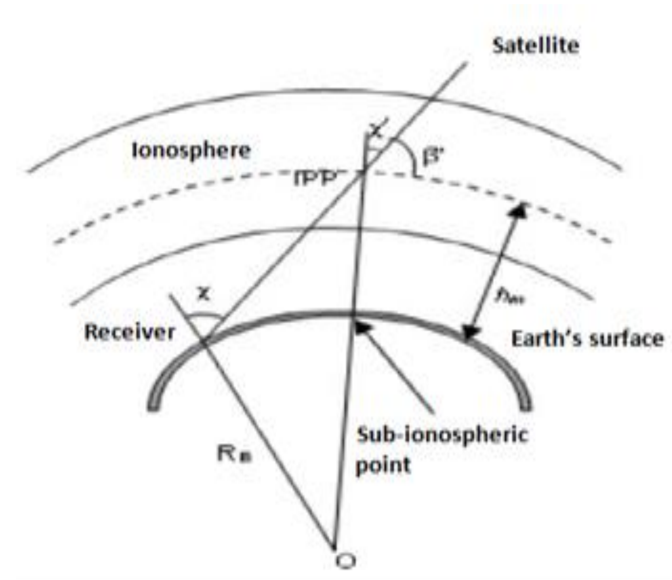
The unified approach towards studying earthquake precursors has witnessed a growing trend towards using "electromagnetic precursors" clues. The physical illustration of these clues is that the rocks' strain accumulation would generate electromagnetic manifestations through various mechanisms.

- **Ionospheric Perturbation**

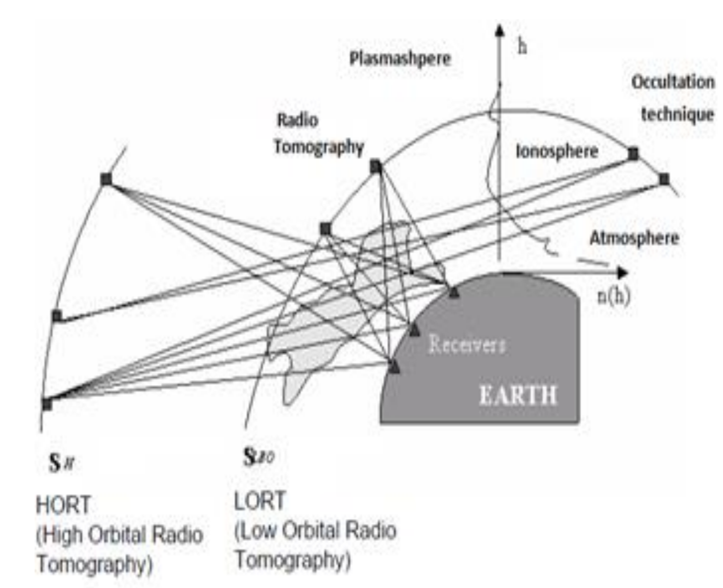
The first observation of distinctive perturbations in electron densities of the F region of Ionosphere was on March 1964, days before the Alaskian earthquake [1]. However, the variations were difficult to isolate due to the usual day-to-day variability of Ionoshpere that is affected by solar and magnetic activities.

The two main technologies used are:

1. **IGS Networks**, with GPS receivers on ground and satellites above the ionosphere.
2. **Ratio-tomography of the ionosphere (RTI)** perform by upper and lower satellites [3].



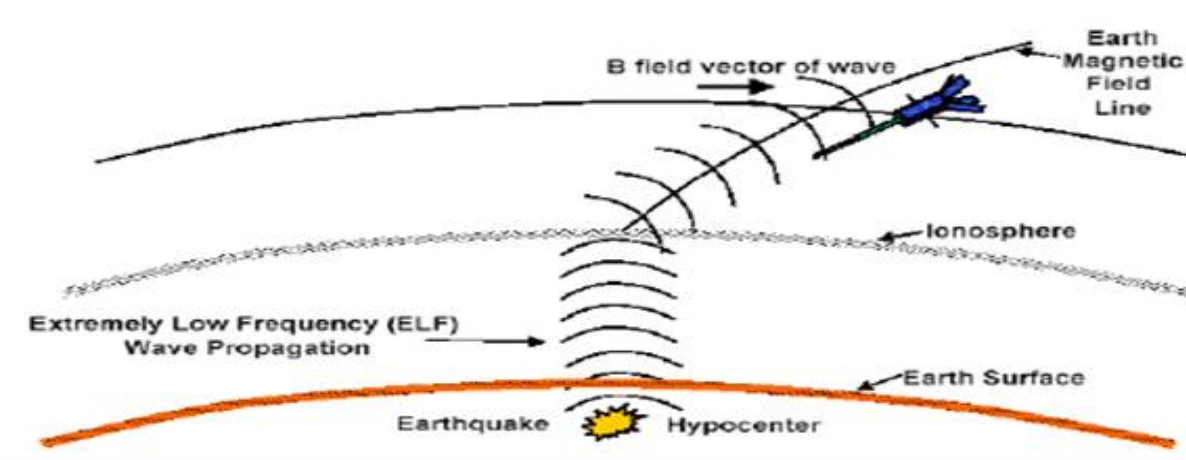
IGS Networks, (Mubarak et. al, 2009)



Ratio-tomography, (Freund et. al 2009**)**

- **Magnetic Anomalies**

In 1982, infinitesimal abnormalities (nTesla) were detected in Earth magnetic field satellite during a magnitude 5.4 EQ by Aureol 3 [4].The physical explanation points out that stressed rocks at the hypocentre release charges upon cracking. The free charges create large currents that slightly perturbate the Earth's magnetic field. The created disturbances are the source of the EM radiations with low frequencies ULF, ELF, and VLF.

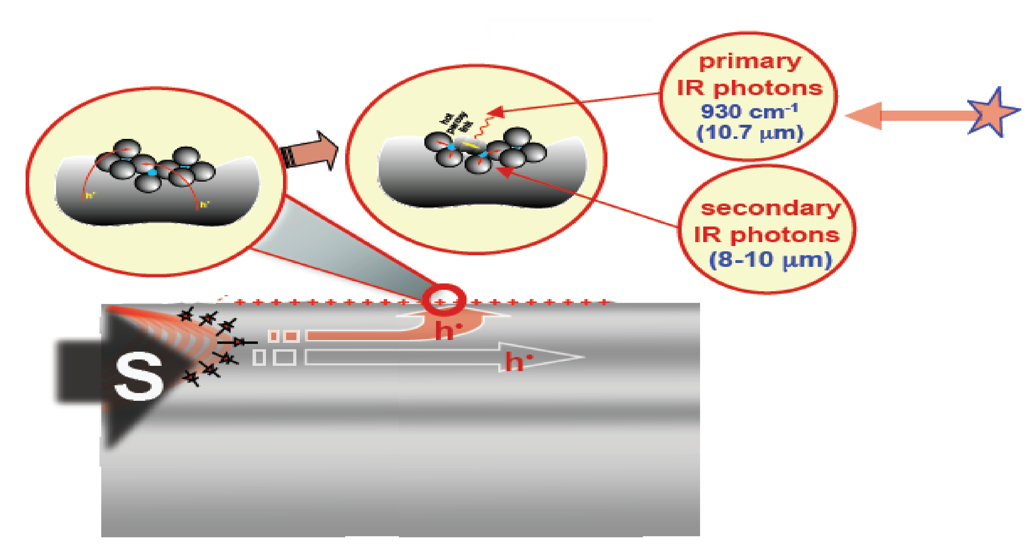


QuakeSat mission for monitoring ELF emissions, (Safaee et. al, 2004)

- **Enhanced Infrared Emission**

The thermal infrared anomalies in satellite remote sensing images before an earthquake were reported worldwide for approximately 25 years since 1988 [5]. The large rapidly changing areas of enhanced mid-IR emissions were linked to impending earthquake activity.

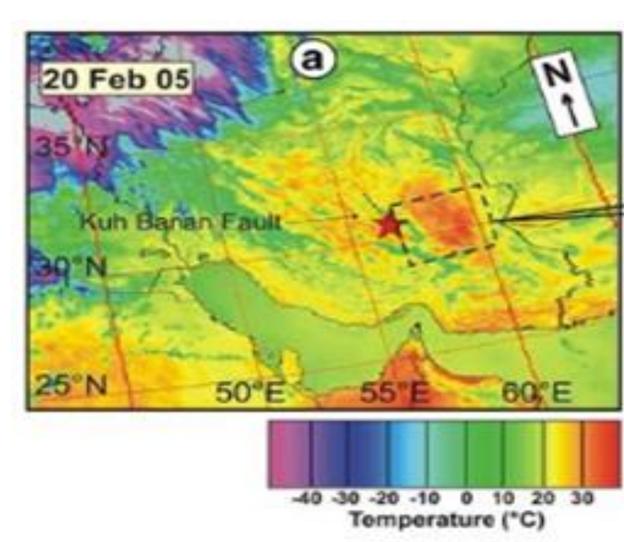
In 2002 a new promising physical explanation offered by the **p-hole theory** [6]. The theory extended the perception earthquake electromagnetic precursors and has reactivated researches on thermal anomalies as possible clues for quake prediction [7].



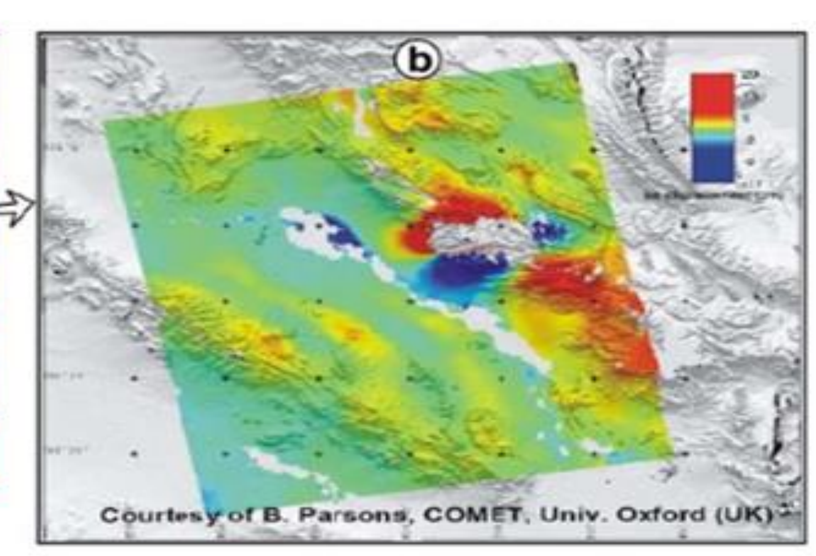
The micro process of surface TIR emission, (Freund et. al 2009**)**

Observations on Thermal Anomlies

After Bam earthquake 2003, two of the groups worked on remote sensing were [8,9]. The first group worked on the crust displacement field derived from InSAR image and other on tracking thermal anomalies from the daytime NOAA-AVHRR images of the region. Combining the two published results the maximum infrared emissions were observed from the area with the maximum crust displacement [10].



TIR anomaly from NOAA-AVHRR
(Choudhury et. al 2006**)**



Crust displacement field from InSAR
(Parsons et. al 2005**)**

Conclusions

The recent progress is expected to integrate efforts of different scientific fields (geology, seismology, meteorology, remote sensing…) in the establishment of information models for short-term earthquake prediction. Therefore recent researches would enhance correlation investigations of the related phenomenon measured by the various disciplines.

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