Monitoring electromagnetic signals related to earthquakes with satellites and ground-based magnetometer arrays

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Outline

• The ENIGMA magnetometer array within the frame of BEYOND Center of Excellence

• Electromagnetic (EM) signals related to earthquakes (EQs)
  – Ground-based studies
  – Satellite studies
A magnetometer array named ENIGMA (HELLENIC GeoMagnetic Array) is currently operated by the National Observatory of Athens (NOA). The array consists of three ground-based magnetometer stations located in Trikala (Klokotos), Attiki (Dionysos), and Lakonia (Velies). ENIGMA provides measurements for studying geomagnetic pulsations that result from the coupling of the solar wind with the magnetosphere. Ground-based magnetometers are particularly useful for understanding magnetosphere-ionosphere coupling physics.
• Ground magnetometers enable effective remote sensing of geospace dynamics and therefore their importance in space weather monitoring and research is indisputable.

• The ENIGMA network is used within BEYOND in an attempt to address the issue of earthquake predictability by studying electromagnetic signals attributed to the coupled lithosphere-atmosphere-ionosphere system as one of the most promising potential pre-seismic transients.
The old ENIGMA website

The Space Research and Technology Group operates the HelLENic GeoMagnetic Array (ENIGMA), an array of 3 ground-based magnetometer stations in the areas of Trikala (Kotokos), Attiki (Dionysos) and Lakonia (Yelkes) that provides measurements for the study of geomagnetic pulsations, resulting from the solar wind - magnetosphere coupling. ENIGMA is the first magnetometer station array that has ever operated in Greece and within a few years of operation has achieved to become a SuperMAG contributor.

SuperMAG is a worldwide collaboration of organizations and national agencies that currently operate more than 300 ground-based magnetometers. SuperMAG provides easy access to validated ground magnetic field perturbations in the same coordinate system, identical time resolution and with a common baseline removal approach. The purpose of SuperMAG is to help scientists, teachers, students and the general public have easy access to measurements of the Earth’s magnetic field.

Ground-based magnetometers have proven to be the workhorse of magnetosphere-ionosphere coupling physics. Ground magnetometers enable effective remote sensing of geospace dynamics and therefore their importance in space weather monitoring and research is indisputable.

The Earth’s Magnetic Field
The new ENIGMA website:
www.enigma.space.noa.gr
A new geophysical service offered by BEYOND

WELCOME TO ENIGMA

The Space Research and Technology Group operates the HELLEnic GeoMagnetic Array (ENIGMA), an array of 3 ground-based magnetometer stations in the areas of Trikala (Kokoto), Attiki (Diatysa) and Lakonia (Vilies) that provides measurements for the study of geomagnetic pulsations, resulting from the solar wind - magnetosphere coupling.
A new geophysical service offered by BEYOND

GEOMAG-02 instrument
A new geophysical service offered by BEYOND
A new geophysical service offered by BEYOND

For ENIGMA data request please contact with Dr. G. Balasis.
Geomagnetic data service offered by BEYOND
Geomagnetic data service offered by BEYOND
Geomagnetic data service offered by BEYOND
Geomagnetic data service offered by BEYOND
EM signals related to EQs: Proof of concept
Entropy analysis of Velies data around 23/11/2011 M5 EQ
Entropy analysis of Dionysos data around 23/11/2011 M5 EQ
ULF wave power features in the topside ionosphere revealed by Swarm observations


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Swarm Pc3: Apr 1st – June 15th 2014

“Swarm & Nepal EQ (25/4/2015)”
Geomagnetic data service offered by BEYOND
Geomagnetic data service offered by BEYOND
Swarm Pc3: Apr 1\textsuperscript{st} – June 15\textsuperscript{th} 2015

SWARM B Pc3 Wave Power

SWARM A Pc3 Wave Power
Swarm Pc3: Difference 2015 – 2014 (Waves)
Swarm Pc3: Difference 2015 – 2014 (Instab.)

SWARM-B Pc3 Difference in Wave Power (2015 - 2014)

SWARM-A Pc3 Difference in Wave Power (2015 - 2014)
Future work

• Perform a systematic study of ENIGMA data around large EQs occurred in Greece over the last 5 years or so.
  – Test alternative time series complexity measures as well.

• Perform a systematic study of Swarm data around strong EQs occurred all over the world after Swarm’s launch (11/2013).
  – Collaborate with A. De Santis (INGV, Italy) in ESA’s “SAFE” project.

• Analyze ENIGMA and Swarm data around EQs occurred in Greece during the Swarm lifetime.