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Initial operation results of the HellENIc GeoMagnetic Array (ENIGMA), a new magnetometer array in South-Eastern Europe

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Abstract

National Observatory of Athens (NOA) currently operates ENIGMA (HellENIc GeoMagnetic Array), an array of 4 ground-based magnetometer stations in the area of south-eastern Europe (central and southern Greece). The current stations are latitudinally equispaced between 30° and 33° corrected geomagnetic latitude. In the near future another station will be installed in Macedonia or Thrace, and there are plans for the installation of an additional station in Crete by the end of 2010.

Magnetic field measurements are essential for correlative satellite and ground-based studies of various magnetospheric phenomena (Schwingenschuh et al., 1996). The ENIGMA data combined with the magnetometer measurements performed onboard the Cluster satellites provide the unique opportunity to study the following scientific objectives (Schwingenschuh et al., 2000):

- Determine how Pi 2s are produced by substorms
- Determine how PC 3-4 magnetic pulsation energy enters the magnetosphere and propagates along magnetic field lines to low latitudes

1. Introduction

One of the primary research objectives assigned to ENIGMA (http://proteus.space.noa.gr/∼srtg/geomag.html) would be to compare ultra-low-frequency (ULF) wave observations in space made by ESA's Cluster mission (http://sci.esa.int/science-e/www/area/index.cfm?fareaid=8) and on the ground acquired by these mid-to-low-latitude ground-based observation sites of the Earth's magnetic field. Cluster has a high inclination orbit; insofar studies at high latitudes are more justified for direct interactions along the magnetic field lines. So, for a Cluster-ENIGMA study one has to expect some indirect, somehow related reactions with propagations perpendicular to the $\mathbf{B}$-field. The Cluster-ENIGMA study can serve as a pilot-study for the upcoming Swarm mission of ESA (http://www.esa.int/esaLP/ESA3QZJE43D_LPswarm_0.html). The Swarm constellation of spacecraft will allow, for the first time, the unique determination of the near-Earth field aligned currents, which connect various regions of the magnetosphere with the ionosphere and can be regarded as a complement to the Cluster mission.

We would like to combine measurements from Cluster and ENIGMA for the study of geomagnetic field line resonances (FLRs). The latter is a well-established phenomenon taking place in the Earth's magnetosphere (Vellante et al., 2004). It can be pictured as the formation of standing magnetohydrodynamic waves on magnetic field lines with fixed ends at the conjugate ionospheres. The excitation is believed to be caused by some compressional wave source. The aim of the ESA's Cluster mission (launched in 2000) is to study small-scale structures of the magnetosphere and its environment in three dimensions. To achieve this, Cluster is constituted of four identical spacecraft, carrying among other instruments fluxgate magnetometers, that flight in a tetrahedral configuration. ENIGMA is expected to eventually (late 2010) consisting of five or six mid-to-low-latitude ground-based observation sites of the Earth's magnetic field. We would like to stress that related studies of such kind are indeed rare up to practically non-existent.

This might be due to the fact, that FLRs in the in-

ner magnetosphere at low to mid-latitudes are known to be related to magnetospheric excitations that can be sensed in the outer parts of the magnetosphere, but the relation is - at least to present theory - not a direct one; it is a relation with mode conversions, wave transformations, energy and momentum transfers in one or several intermediate steps (Matthias Foerster, personal communication). The Cluster measurements represent in any case also only a limited region of the magnetosphere and the transformation processes, their efficiency, propagation characteristics etc. certainly depend on spatial and temporal relative positions of the in-situ observations and on ground.

2. Magnetic stations' details

The array in its present form consists of 4 stations (THL, KMI, DIO and VLI in Figure 1). In the near future another station will be installed in Macedonia or Thrace (e.g. NVR in Figure 1), and there are plans for the installation of an additional station in Crete by the end of 2010. The array will provide the potential for collaboration with the SEGMA array (http://soleterra.aquila.infn.it/staz_segma.asp?lang=en), since this new low-latitude magnetometer array practically starts where the SEGMA ends. The L-shell values of the 4 current stations are: 1.43 (THL), 1.40 (KMI), 1.38 (DIO) and 1.33 (VLI), while NVR will be 1.51 (Table 1). All the stations are equipped with state of the art variometers.

3. Summary and Conclusions

- The new European low-latitude magnetometer array will be providing measurements for the study of geomagnetic pulsations, resulting from solar wind - magnetosphere coupling.
- The array will eventually consist of 5 stations latitudinally equi-spaced between 31° and 36° corrected geomagnetic latitude. The particular spatial configuration is suitable for detecting FLR signatures, thus allowing the study of the dynamics of the inner magnetosphere.
- The array will provide the potential for collaboration with the SEGMA array.
- A Cluster-ENIGMA study can serve as a pilot-study for the foreseen ESA's Swarm mission.

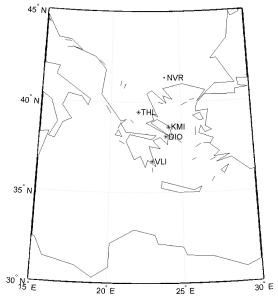

Figure 1: Geographic locations of magnetic stations.

Station Name	Station Abbreviation	Geographic Latitude (°)	Geographic Longitude (°)	Altitude (m)	Geomagnetic Latitude (°)	Geomagnetic Longitude (°)	L-shell value
Nevrokopi	*NVR*	41.35	23.86	595	35.63	96.61	1.51
Klokotos	*THL*	39.45	21.97	110	33.18	94.61	1.43
Kimi	*KMI*	38.63	24.1	160	32.37	96.52	1.40
Dionyssos	*DIO*	38.08	23.93	480	31.68	96.3	1.38
Velies	*VLI*	36.72	22.95	220	29.89	95.25	1.33

Table 1: Magnetic stations' details.

References

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