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"Combining ground-based and satellite magnetic data for investigating the Earth's magnetosphere"

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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 equi-spaced 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 2009. One of the primary research objectives assigned to ENIGMA is the study of geomagnetic field line resonances (FLRs). The latter is a well-established phenomenon taking place in the Earth's magnetosphere. It can be pictured as the formation of standing magnetohydrodynamic waves on magnetic field lines with fixed ends at the conjugate ionospheres.

Introduction

An interesting option in this field of research would be to compare ultra-low-frequency (ULF) wave observations in space made by ESA's Cluster mission 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 B-field. The Cluster-ENIGMA study can serve as a pilot-study for the foreseen ESA's Swarm mission. 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.

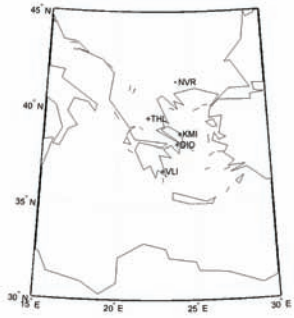
A study of magnetospheric excitations through combined analysis of satellite and ground-based geomagnetic measurements

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. 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. National Observatory magnetometer array is expected to eventually (late 2009) consisting of five 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 inner 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.

HellENIc GeoMagnetic Array (ENIGMA)

http://zitis.space.noa.gr/geomag/

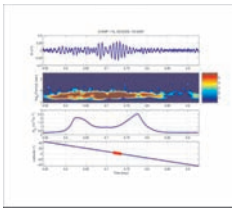


The array in its present form consists of 4 stations (THL, KMI, DIO and VLI). In the near future another station will be installed in Macedonia or Thrace (e.g. NVR), and there are plans for the installation of an additional station in Crete by the end of 2009.

The new low-latitude magnetometer array practically starts where the SEGMA ends (see below). 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).

Table 1: Magnetic stations' details.

Magnetospheric ULF wave recorded on board CHAMP satellite



The ground magnetometers will be providing measurements for the study of geomagnetic pulsations, resulting from solar wind magnetosphere coupling. The frequency of these oscillations depends on the field line length, the magnetic field strength and the plasma mass density along the field line. For a given field line, an increase of the field aligned plasma density corresponds to a decrease of the oscillation frequency. Field line resonance frequencies can be accurately determined by means of a cross-phase analysis of ground-based ULF wave measurements recorded at stations closely spaced in latitude. This enables monitoring of the temporal variations of the plasma mass density in the inner magnetosphere, which is a critical parameter in geospace storm dynamics and solar wind magnetosphere coupling in general.

South European GeoMagnetic Array (SEGMA)

http://sole-terra.aquila.infn.it/staz_segma.asp?lang=en

Three fluxgate magnetometers developed by the Space Research Institute of the Austrian Academy of Sciences in Graz (CHIMAG instruments) have been installed in Nagycenk/Hungary, Ranchio/Italy and in Castello Tesino/Italy. The main objective of this chain in Middle and Southern Europe - together with several magnetometers installed by the Dipartimento di Fisica of the University in L'Aquila named **SEGMA** (South European Geomagnetic Array) - is the study of field line resonances for space weather purposes. The L-shell values of the 4 SEGMA stations are 1.88 (NCK), 1.77 (CST), 1.65 (RNC) and 1.56 (AQU).

Other research topics of interest

Ionospheric Alfven resonator studies

Lithospheric field modeling

Electromagnetic induction studies: mantle conductivity

Geomagnetically Induced Currents (GIC) studies at low-latitudes?

References

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Vellante, M., et al. (2004), Ground/satellite signatures of field line resonance: A test of theoretical predictions, J. Geophys. Res., 109, A06210, doi:10.1029/2004JA010392.

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Vellante, M., M. Foerster, U. Villante, T. L. Zhang, and W. Magnes (2007), Solar activity dependence of geomagnetic field line resonance frequencies at low latitudes, J. Geophys. Res., 112, A02205, doi:10.1029/2006JA011909.

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 field-line resonance 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.