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SCIENCES DES STRUCTURES DE LA MATIÈRE
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THÈSE UNIQUE DE DOCTORAT ÈS SCIENCES PHYSIQUES

présentée par

ZAKA KOMENAN ZACHARIE

Pour obtenir le grade de **DOCTEUR ÈS SCIENCES**

**ETUDE DE LA DYNAMO IONOSPHERIQUE PERTURBÉE :
CARACTÉRISATION DE L'ELECTRODYNAMIQUE EQUATORIALE
A LA FIN D'UN ORAGE MAGNETIQUE ET MODELISATION DES
CHAMPS ET COURANTS ELECTRIQUES PERTURBES**

Soutenue publiquement le 11 Février 2010 devant la commission d'examen composé de :

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Based on 3 papers in
International Journals

Annales Geophysicae
JGR
Science Direct



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ASSAMOI**

They are now Professors or Associate Professors



**Jean-Pierre
ADOHI**

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**Vafi
DOUMBIA**

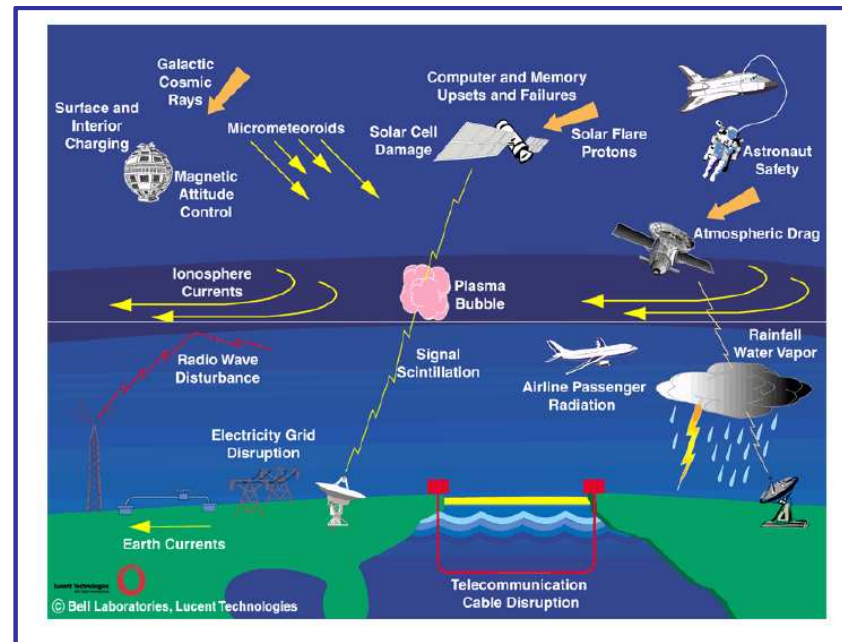
**Olivier
OBROU**

RESEARCH PROGRAM TRANSIENT VARIATIONS OF THE EARTH MAGNETIC FIELD DUE TO THE EXTERNAL IONOSPHERIC AND MAGNETOSPHERIC SOURCES

Our research program is part of the ISWI (International Space Weather Initiative) which deals with electromagnetism in the earth environment. The figure 1, below, illustrates the physical processes concerned by this program.

Our specific topic is ionospheric electric currents (shown in the middle of this figure) and their associated transient variations of the earth magnetic field and earth current.

Figure 1 : Physical processes –ISWI program



Importance of this field

With the development of space transmission, all the electromagnetic physical processes in the earth environment must be studied in order to understand their impacts on new technologies systems used in navigation as the GPS system.

- **Objectives of Proposed Research**

The earth magnetic field expression is given by :

$$\mathbf{B} = \mathbf{B}_p + \mathbf{B}_a + \mathbf{B}_e + \mathbf{B}_i$$

Where B_p is the main field, B_a the aimantation litospheric field, B_e the magnetic field related to the external ionospheric and magnetospheric sources and B_i , the ground field induced by the external sources (see figure 1). At the time scales of the year and smaller than the year, $DB_p \sim DB_a \sim 0$, and therefore the transient variations DB of the Earth's magnetic field is:

$$DB = DB_e + DB_i$$

We plan to study these transient variations of the earth magnetic field and the external sources at their origin by using the MAGDAS magnetometer network and other data sets (ionospheric parameters as electronic densities, ionospheric electric fields etc..). Figure 2 shows the world distribution of the MAGDAS network of magnetometers.

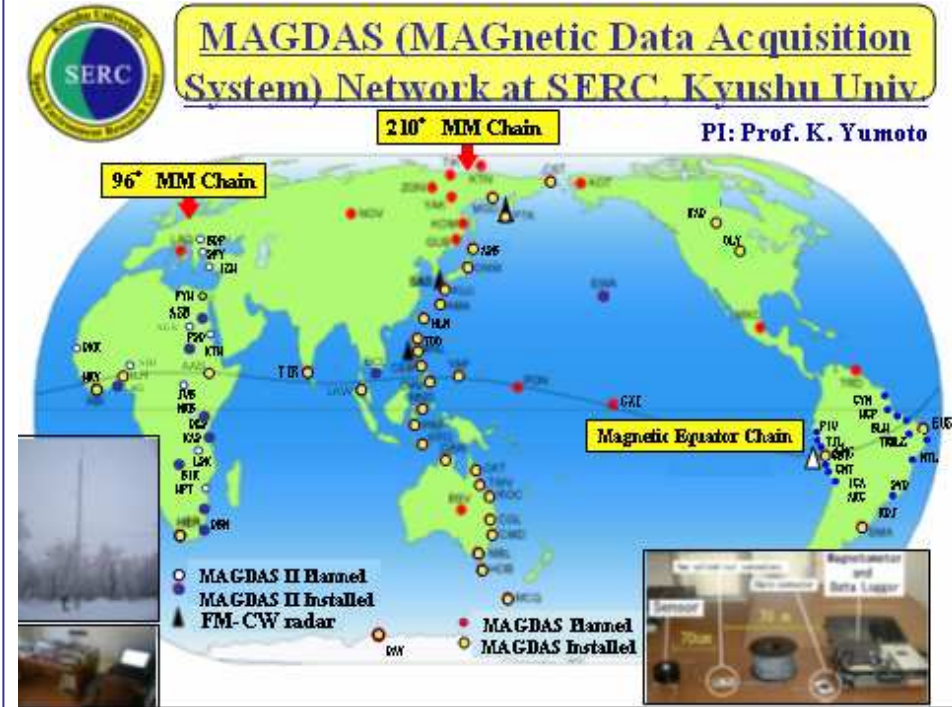


Figure 2: MAGDAS network

Our objective : to understand the transient variations of the earth magnetic field, resulting from physical processes at work in the earth environment mainly in the :

Ionosphere – conductive layer around the earth at the altitude from ~80 to ~ 500 km

Magnetosphere – cavity of the earth magnetic field.

- **Proposed Research Plan**

- **Determination of the geophysical context to understand the different magnetic field signatures :**

- Following the Biot and Savart law, the earth magnetic field integrates the signatures of all the current systems existing in the Ionosphere and the Magnetosphere. These current systems vary with solar activity and solar events such as flare, CME etc.... The sun is acting on the earth environment through solar radiations and solar wind (flow of solar particles).

- Therefore it is necessary to analyze solar data to know exactly the physical processes at work on the sun in order to interpret the transient variations of the terrestrial magnetic field.

- **Classification of the events**

- The events are organized in different classes by using solar events and also geomagnetic indices. The geomagnetic indices such as AL, AU, Dst, Am etc... allow_(permit) to understand the response of the Ionosphere and magnetosphere to the solar activity and the resulting solar events.

- **Data analysis**

- The data analysis will be conducted separately according the different classes (in each class*) in order to qualify each physical process. We will analyze the mean characteristics of each class and investigate further (analyze) specific cases in order to develop a data base for numerical simulations. In the following, these different classes are presented:

- Class of magnetic quiet days: this class deals with days which are under the main influence of the regular radiation from solar source (ionospheric dynamo)

- Class of solar flares: this class are related to strong emissions of radiations from the sun (ionospheric dynamo)

- Class of magnetic disturbed days: this class concerns days which are under the main influence of the solar wind source (solar wind /magnetosphere dynamo). This class will be split into different sub class related to the different type (kind) of perturbations (prompt penetration of the magnetospheric electric field, ionospheric disturbance dynamo...)
- etc...
- **empirical model for the regular variation**
- With the MAGDAS magnetometer network which records continuously the earth magnetic field, it is possible to establish a model of the regular variation of the earth magnetic field in the Asian sector as a function of solar cycle, season and local time. This model will be useful to study the magnetic disturbance.
- **numerical simulations for selected event**
- In the framework of my PhD, I carried out a simulation of a disturbance dynamo event with the TIEGCM (Thermospheric Ionospheric Electrodynamics General Circulation Model) model of NCAR (National Center for Atmospheric Research). The obtained results constitute an incentive for me to continue in order to contribute more to the improvement of the global circulation model.
- **Expected results and impacts**
- Geomagnetic transient variations result from those of external ionospheric and magnetospheric sources originating from solar activities. To predict the impact of the sun on the earth environment, it is then necessary to investigate geomagnetic variations in coordination with ionospheric data to approach the physical processes at work in the earth environment. The coming era dedicated to radiocommunications require a better knowledge of the sun-earth environment physical process to forecast eventual harmful event to ground and on-board radiocommunication systems and all the way improve their reliability.