The AGONET program
and space weather

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AGONET (Antarctic Geospace Observatory NETwork) is a network of Antarctic observatories devoted to measurements of geospace parameters which are important in the field of ionosphere-magnetosphere coupling. The AGONET program is conducted under the auspices of the Scientific Committee for Antarctic Research, an body of ICSU, the International Council of Scientific Unions, like SCOSTEP and COSPAR. SCAR full members are 25 national committees, 7 ICSU members and 7 associate members. AGONET was proposed to SCAR at the XXI meeting in Sao Paulo, in 1990, (Dudeney, 1990) and was endorsed formally in a recommendation to the international scientific community involved in Antarctica; support of the deployment of instruments and collection of data was requested from the participating bodies in each country.

The AGONET program is managed by the STAR Working Group (Solar-Terrestrial and Astrophysical Research) of SCAR (see web site **http://www.sprl.umich.edu/MIST/STAR**).

The AGONET observatories include those permanent stations where appropriate instrumentation is already in operation; other sites to uniformly cover an appropriate mesh are instrumented with automatic observatories which are already operated by several national programs (USA, UK, Japan); gaps exist that need to be filled.

Before entering the detailed description of the program, it is proper to outline the - scientific objectives to be addressed on the data that will be provided by such network of instruments.

The relevance of the AGONET program in the framework of space weather is: 1) in the possibility to conduct research on magnetosphere ionosphere interaction in conjugated regions, using differences between the two polar regions as a tool to better investigate the propagation of phenomena and their cause to effect relationship and 2) in the availability of monitoring sites which may be differently located with respect to the observable phenomena and may represent a vantage point from which to obtain information additional and complementary to that obtained in the northern hemisphere.

Scientific overview

The Earth's polar regions are very important for the study of magnetospheric phenomena in general and of ionosphere magnetosphere interaction in particular, because of the existence of the Earth's magnetic field. This is dipolar in the region close to the Earth's surface, up to a certain altitude; this implies that magnetic field lines emanating from low latitudes are closed and go from one end, say in the northern hemisphere at latitudes lower than 65 degrees, to the southern hemisphere at comparable latitudes. Magnetic field lines emanating from higher latitudes instead tend to go further from Earth, where they feel the distorting influence of magnetospheric currents; this causes such field lines to depart from the dipolar geometry and to extend away from Earth, in the Earth's magnetic tail, and directly into interplanetary space. Thus the magnetic field lines at high latitudes are connected to regions of the Earth's magnetosphere that are very far from the Earth's surface; the structure of such regions and the properties of the plasma that resides there, far from the Earth surface, can be studied through the investigation of the effects they cause at very low altitudes, close to Earth, in the ionosphere above the Earth's poles. The aurora borealis and australis are the best known examples of such interaction.

Why is it important to study the interaction between the ionosphere and the magnetosphere from a southern hemisphere perspective, namely in Antarctica ? After all the northern hemisphere polar region has been studied for a long time and to great detail, and satellite data have provided satellite to ground correlation capabilities and observations of both hemispheres from space. There are three orders of motivations to go and study magnetospheric phenomena from the Antarctic continent :

(1) Lanzerotti (1987) has produced a plot of the southern hemisphere mapped onto the northern hemisphere, or viceversa according to which hemisphere one wants to emphasize ; the mapping is done along the magnetic field lines, which means that positions mapped onto each other do not share geographic coordinates, but magnetic coordinates only, since the magnetic field is the organising structure for magnetospheric phenomena.

It appears clearly that while in the northern hemisphere we have an ocean surrounded by land, in the southern hemisphere we have a continent surrounded by ocean. This has the implication that studies in the North have been concentrated on the lower polar latitudes, 65 to 80 degrees in magnetic coordinates while less emphasis has been placed on higher polar latitudes, above 80 degrees.

(2) The southern magnetic pole is offset by 16 degrees with respect to the southern geographic pole, while the northern magnetic pole is only 11.5 degrees away from the northern geographic pole. This must induce larger daily modulations in magnetospheric effects, making their detection easier; also the southern region above 80 degrees magnetic latitude stays in the dark continuously for longer periods of time than in the northern hemisphere.

(3) The simultaneous observation of both hemispheres is necessary if studies of North/South asimmetry are to be conducted. Even if, to first order, simmetry is expected, close analysis of the scarce correlative data that exist shows that the two hemispheres are not mirror images of each other (Candidi and Meng, 1988). Also satellite data alone do not provide the detail necessary to such correlation, and the time resolution available with satellite data is not sufficient since polar satellites at appropriate altitudes observe each polar region for a few minutes once every 90 minutes.

Status of the **AGONET** program.

A basic set of instruments has been defined for a site to be of relevance to AGONET :

- magnetometer
- riometer
- VLF receivers
- optical instrumentation

Such a complement of instruments to variable degrees of sophistication is generally available at the AGONET stations.

As of 1998 the AGONET stations consist of the sum of several national arrays, from the largest ones provided by the USA, the UK, Australia, Russia, Japan, France to the individual stations provided by South Africa, Italy, Argentina, China and India on the Antarctic continent and, at lower magnetic latitudes, Chile and Brazil on the Antarctic peninsula.

The US program is centered on the two permanent stations, South Pole and McMurdo, and on the array of six Automatic Geophysical Observatories (AGO’s) deployed on the plateau roughly around the magnetic meridian sector which extend from the southern magnetic pole to the UK station at Halley Bay. This array of stations has been provided by the PENGUIN program (Polar Experiment Network for Geophysical Upper-atmospheric Investigation) of the University of Maryland, the Bell Laboratories, the University of New Hampshire, the Tohoku University, the Stanford University, the Dartmouth College and the University of California.

The second largest array is the British one, centered around the permanent station of Halley Bay, and consisting of four AGO’s which complete the PENGUIN meridional network. They are all operated by the British Antarctic Survey at Cambridge.

The National Institute for Polar Research of Japan operates the permanent station at Syowa.

Australia operates through the Australian Antarctic Division the permanent bases at Casey and Davis and through the Australian Geological Survey Organization the permanent station at Mawson and Macquarie Island.

Russia (AARI, IZMIRAN and with the help of University of Michigan) operates Mirny and Molodeznaya on the continent’s coast and Vostok on the high plateau, and services a line of automatic magnetometer along the traverse from Mirny to Vostok (Pionerskaya and Komsomoloskaya).

The Ecole et Obsevatories de Physique du Globe - CNRS of France operates the permanent stations at Dumont d’Urville on the continent and on several subantarctic islands (Port aux Francais, Ile Crozet, Ile Amsterdam).

Italy’s base at Terra Nova Bay is seasonal but is instrumented with automatic observatories which operate year round with data recording under the responsibility of Istituto Nazionale di Geofisica, Universita’ dell’Aquila and IFSI/CNR.

The coordinated geospace measurements supplied by the AGONET are collected at the Istituto di Fisica dello Spazio Interplanetario - CNR (Roma), where a data centre for data archiving and analysis has been created under the sponsorship of PNRA (National Antarctic Research Program): the ADAF (AGONet Data Analysis Facility). Furthermore, the data from numerous magnetometer Antarctic stations are available in real time through the INTERMAGNET program.

The ADAF system can be accessed through World Wide Web at the URL: **http://sunserv.ifsi.fra.cnr.it/~adaf** since March 1996. People who access the ADAF Home Page have the possibility to get a general description of the project and of the data sets archived at the data centre. Data set selection and plotting capabilities are provided to the authorized user (according to the Rules of the Road reported in the Home Page).

The ADAF facility provides the user with the capability of performing a simultaneous display of multiple data sets, so that data from the same instrument , coming from all the available stations can be analysed together giving a global perspective of the large scale magnetosphere ionosphere interaction phenomena; also, data supplied by different instruments, monitoring several related phenomena can be displayed together.

Behind the provision of multiple data sets plots, stack magnetograms on ADAF are available of the H, D, and Z geomagnetic field components of specific longitudinal and latitudinal chains of stations.

The magnetograms are available for the 30º Longitude (Ago P1 - South Pole - Ago P2 - A76), the 100º Longitude (Vostok - Davis - Mawson) and the 80º Latitude (Ago P1 - Ago P4 - Vostok - Casey - Dumont D'Urville - Terra Nova Bay - McMurdo) chain. While displaying the data in such a format ADAF performs, in real time, the conversion from the original reference systems (which may be different for each station) to a unique reference in order to display all the data in corrected geomagnetic coordinates (H: horizontal component toward geomagnetic North, defined by the Definitive/International Geomagnetic Reference Field (DGRF/IGRF) geomagnetic field model, D horizontal component toward East, Z vertically downward).

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