International Association of Geomagnetism and Aeronomy (IAGA)

IAGA Activities in Italy (2009-2010) (www.iagaitalia.it)

IAGA activities in Italy are currently developed by several universities as well as by mayor Scientific Institutions such as Istituto Nazionale di Geofisica e Vulcanologia (INGV), Istituto Nazionale di Astrofisica (INAF) and Consiglio Nazionale delle Ricerche (CNR).

The present document, organized on the basis of IAGA Divisions and Interdisciplinary Commissions, summarizes the principal achievements, the participation to international programs and the most relevant programs in which the Italian Scientific community is involved.

IAGA Community in Italy is organized according to the following scheme:

Italian Delegate: Prof. U. Villante, University of L'Aquila
Vice Delegate: Dr. L. Vigliotti, CNR – Istituto di Scienze Marine (ISMAR), Bologna

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After the tremendous earthquake that devastated the city of L'Aquila and its territory (April 6, 2009), the Italian IAGA community joined in a workshop on "Osservazioni elettromagnetiche e gravimetriche relative al sisma del 6 Aprile 2009 a L'Aquila" held in L'Aquila on April 26-28, 2010 (www.iagaitalia.it) and organized by the Consorzio "Area di Ricerca in Astrogeofisica".

DIVISION I:
“Internal Magnetic Field” (Coord.: L. Vigliotti)

A) Research groups involved in research activity:

The principal Italian groups involved in research activities related with IAGA Division I “Internal Magnetic Field” are:

1. Istituto Nazionale di Geofisica e Vulcanologia, INGV-Roma; (*T. Meloni; M. Chiappini, P. Palangio, L. Cafarella, P. De Michelis, F. A. De Santis, R,.Tozzi, L. Sagnotti, F. Florindo, F. Speranza, J. Dinares-Turell, P. Macrì, A. Venuti*.)
2. ALP - ALPINE LABORATORY OF PALEOMAGNETISM - Inter-Universitary Center for Rock Magnetism. University of Milano, Torino, Parma, Roma3, Siena and Urbino) (*G. Muttoni, E. Dallanave, G, Scardia, R, Lanza, L. Lanci E. Tema, E. Zanella, F. Cifelli, M. Mattei, M. Porreca*).
3. Department of Physics of the University of Bari; (*M. Loddo, Siniscalchi*)
4. Department of Physics of the University of Camerino; (*A. Schettino*)
5. University of Naples (*A. Incoronato*)
6. University of L’Aquila and Consorzio Area di Ricerca in Astrogeofisica (*U. Villante, M. Vellante, P. Francia, M. De Lauretis, E. Pietropaolo, A. Piancatelli, M. Piersanti*)
7. Istituto di Scienze Marine ISMAR-CNR, Bologna; (*L. Vigliotti*)
8. Istituto di Fisica dello Spazio Interplanetario/INAF, Roma. (*M. Laurenza, M. Storini*)

B) Scientific Report

During 2009-2010 the scientific activity carried out in the framework of the IAGA-Division-I (Internal magnetic Field) concerned several issues within different geophysical and Earth sciences disciplines.

Interdisciplinary studies concerning the registration of the Earth magnetic field and the magnetic properties of rocks and sediments were focused into four main subjects:

- Geodynamic reconstructions.
- Magnetic polarity and secular variation record of the magnetic field.
- Magnetic properties of rocks and sediments for environmental, climatic and volcanic reconstructions.
- Magnetic properties of minerals, rocks, atmospheric particulate and ice cores.

Geodynamic Reconstructions.
The research activities on geodynamic reconstructions of the Italian peninsula were focused on the Plio-Pleistocene sediments of the Crotone Basin, the Gorgoglione Flysch and Umbrian Apennine. Additional studies took into account the tectonic evolution of the Mediterranean area and in particular the subduction zone of the western sector of the basin. Paleomagnetic investigations were also carried out in the north-eastern sector of the Iranian plateau and South America to understand the arc formation of the bolivian and patagonic oroclines. These studies bring new experimental data that allow to constrain the reconstruction of the mechanisms of deformation and geodynamic evolution of orogenic chains.

Magnetostratigraphy and Secular Variations.
Reversal of the magnetic field was used as dating tool of Cenozoic sequences in sections with a relevant stratigraphic significance including the section of Montalbano Jonico that is candidate as *Global Stratotype Section and Point* (GSSP) for the Lower-Middle Pleistocene stage. New data were also obtained from sections in the Bellunese Basin, Monte Conero, Ager basin (Spain), pre-evaporitic sections in the Apennine and in several cores from the southern ocean where the paleomagnetic data allowed to establish a high resolution cronological framework necessary to recognize the influence of the orbital oscillation in the paleoclimatic history of the Antactic Ice-Cap.
An increasing number of studies was focused on the paleosecular variations (PSV) of the Earth magnetic field recorded by several marine (Adriatic and Jonian Sea; Sardinia Channel), lacustrine (lake Lungo, Fondi Lake) and terrestrial records (Stromboli Island; Boca do Rio, Portugal). The results indicate the possibility to obtain high resolution chronology of sedimentary sequences containing registration of earthquakes and even tsunami.

The paleointensity of the magnetic field during the last 3000 yr, was investigated by bayesian statistic with the aim to obtain an Italian reference curve. Four archeological sites from Greece were investigated in the framework of a collaboration with the Salonicco University. Magnetic properties of laterizi of roman and medieval times were measured together with ossidiane of Neolithic age to reconstruct the provenance and the commercial roads in the Mediterranean region during the ancient times.
Magnetic measurements were also applied to archeomagnetic investigations at Norba archeological Site (Lazio) and to classic sites inhabited by hominid in Puglia (Pirro Nord) and at Monte Poggiolo (Forli).

Environmental Magnetism.
Several studies utilized the magnetic parameters to investigate the paleoclimatic history recorded by marine and lacustrine sediments. Relationships between magnetic parameters and the climate were evidenced in cores collected at high latitudes of both hemispheres:

- Ross Sea (Antarctica) in the framework of the ANDRILL Project (http://www.andrill.org);
- Arctic region (Svalbard) in cores collected during the oceanographic cruises SVAIS and EGLACOM with the objective to reconstruct the margin evolution from the Pliocene to the recent-most deglaciation, and to define the changes in sedimentary architecture and seafloor morphology since the onset of glacial condition
- Canterbury Basin (New Zealand) in sediments drilled during the IODP leg 317. Jaime Dinares Turell (INGV Roma) partecipated as paleomagnetist to this Leg dedicated to reconstruct the sea-level change and the oceanographic circulation of the last 35 million years.

Applications of magnetic parameters to volcanic rocks aimed to investigate the emplacement temperatures and depositional mechanism of piroclastic units. Detailed analysis concerned the Permian Ignimbrite of Ore (Italy), the Holocenic deposits of Pantelleria and the ignimbritic deposits of Cappadocia (Turkey) as well as the explosive eruptions of Colima (Mexico). Magnetic parameters were used to identify tepra layers in Borehole Prad1-2 from the Adriatic Sea in the framework of the RESET project. and to reconstruct the chronology of volcanoclastic deposits of a volcanic field near Auckland (New Zealand).

Magnetic properties of minerals, rocks, atmospheric particulate and ice cores.
Measurements of magnetic properties were used to investigate the presence of atmospheric particulate and for monitoring the quality of the air in towns with high pollution. New procedures have been established in order to distinguish nanometric particles of iron oxides with very small grain size (<0.1 micron).
The presence of contaminant in red clay from northern Adriatic was also investigated by comparing the magnetic content recorded by concentration-related parameters (magnetic susceptibility, anysteretic and isothermal remanence) with the presence of heavy metals (Cr, Ar) within the sediments. The results indicate that magnetic measurements can offer a potential of use in geochemical, sediment transport and sediment provenance studies,
Other studies were carried out to explore the depositional models of turbiditic sequences (Marnoso-Arenacea Formation; Castagnola Formation) and even tsunami layers (Boca do Rio, Portugal) by using anisotropy of magnetic susceptibility.
Experimental results from mid-oceanic ridge basalt and lava samples demonstrate that it is possible to induce a large AMS to natural rock samples by using an IRM as predicted by the theoretical model.

The final results of the ANDRILL Project were presented to a workshop held in Erice (6-11 aprile 2010) in the framework of an International School of Geophysiscs and organized by the INGV (F. Florindo).

Search for ULF activity preceding earthquakes.
Geomagnetic measurements have been routinely conducted at SEGMA (South European GeoMagnetic Array, in cooperation with the Space Research Institute of Graz, Austria; http://sole-terra.aquila.infn.it/staz_segma.asp).

SEGMA is part of the global magnetometer network ULTIMA (Ultra Large Terrestrial International Magnetic Array http://www.serc.kyushu-u.ac.jp/ultima/ultima.html), an international consortium aimed to promote scientific cooperation in magnetospheric, ionospheric and atmospheric physics, facilitating data exchange and sharing**.**

The research activity was focused on the identification of ULF precursors of seismic events through the analysis of geomagnetic field measurements at the ground stations. Indeed, although debated, an interesting aspect of the ULF wave research is related to the possible identification of signals originated in the lithosphere before seismic events. In such context, in the framework of a collaboration with the Istituto Nazionale di Geofisica e Vulcanologia and the Space Research Institute of Graz (Austria), an analysis of the magnetic observations performed at L'Aquila during three months preceding the April 6, 2009 earthquake has been conducted, focusing attention on the possible occurrence of features similar to those identified in previous events. The results, presented at the IAGA 11th Scientific Assembly (August 23-30, 2009, Sopron, Hungary) do not show compelling evidence for any of the features which have been proposed as earthquake precursors.

Future programs.

Most of the research activity carried out in the 2010 will continue in the next biennium on classic topics of interest for applications of paleomagnetism to geodynamics, stratigraphy, study of changes in Earth's magnetic field in the geological past and even for the assessment of volcanic and seismic risk. With regard to applications to geodynamics, the research in paleomagnetism and magnetic anisotropy will be focused on key areas of the north-central Apennines and Calabria, and in the Andean chain, in particular in the mountain ranges of Colombia.

Magnetostratigraphic research will be continued on some sections from Conero, Malta, and Iberian peninsula, with the start of a new project focused on the Late Cretaceous. New studies are also expected in Bulgaria, with particular attention to the correlation of coeval European sections, and the cyclostratigraphic definition of the Paleocene. Will also continue research on sedimentary sequences taken from the peri-Antarctic margins with the planned publication of the final results for the ANDRILL project, the study of cores stored in the archive of the PNRA and sequences taken in the context of IODP leg 317, off New Zealand.

These researches will be critical for the development of an integrated stratigraphy at high resolution representing a reference for an accurate chronological framework necessary for the understanding of geological and climatic events of the past.

New studies will focus on the reconstructions of changes in Earth's magnetic field in the geological past and the use of secular variation (SV) for the dating of geological sequences and significant events of the past. They will complement the ongoing analysis on the various sedimentary cores taken off the eastern Sicily and the Adriatic Sea. Finally, further investigation of SV will be carried out on products from the volcanic island of Stromboli, Pantelleria and Azores.

Studies on pollution will include low-temperature hysteresis properties of atmospheric particulate, in an attempt to characterize the contribution of superparamagnetic particles of anthropogenic origin as well as the source of vehicular pollution, with analysis of magnetic properties of soils along roads with different levels of traffic.

New investigations are expected to include researches in the framework of the International Continental Drilling Program (ICDP) concerning the Lake Van in Turkey (**Project Paleovan** – L. Vigliotti, ISMAR CNR-BO) and the Lake Ohrid in Macedonia (Scientific Collaboration On Past Speciation Conditions in Lake Ohrid – **SCOPSCO -** INGV Rome, L. Sagnotti).

New magnetostratigraphic investigations include the study of a borehole drilled in the Iblei region representing a sequence that is a candidate for the *Global Stratotype Section and Point* (GSSP) of the Burdigalian (Lower Miocene). The INGV laboratory is expected to start measurements to reconstruct the absolute paleointensity of the magnetic field recorded by volcanic rocks in collaboration with the Scripps Institution of Oceanography of San Diego (USA). Future works on archeological sites will include the study of S. Vincenzo bronze age village at Stromboli in the framework of the multidisciplinary project **CARBRIDGE**.

Magnetic parameters as innovative means of monitoring sediment sources and properties will be used to characterize marine-coastal sediments from the north Adriatic region even to investigate the distribution of pollutants.

DIVISION II:
"Aeronomic Phenomena" (Coord.: B. Zolesi)

A) Research groups:

The principal Italian groups involved in research activities related with IAGA Division II "Aeronomic Phenomena" are:

1. Istituto Nazionale di Geofisica e Vulcanologia, Roma
2. Consiglio Nazionale delle Ricerche, Firenze
3. International Centre for Theoretical Physics, Trieste

1) Istituto Nazionale di Geofisica e Vulcanologia, Roma

Theoretical studies and systematic observations of the terrestrial ionosphere have been performed since 1936, year of foundation of the former Istituto Nazionale di Geofisica by Guglielmo Marconi. Presently, ionospheric vertical soundings are performed in two ionospheric observatories in Italy, Rome (41.8° N, 12.5° E) and Gibilmanna (37.9° N, 14.0° E), and one in the Italian Antarctic base M. Zucchelli. Considerable cooperation has been activated with the Argentinean colleagues to install and operate the Italian ionospheric station AIS in Tucuman (26.9° S, 294.6° E), Argentina. Concerning the ionosondes previously mentioned, during the next years major upgrades will be performed to increase their reliability and the possibility of full remote control. Regular ionospheric oblique soundings have been performed starting in November 2003 over radio link Inskip, UK (53.50°N; 2.5°W) , Rome, Italy (41.8°N; 12.5°E) and over the radio link Inskip, UK (53.50°N; 2.5°W) and Chania, Crete, Greece (35.70 N, 24.00 E) since April 2005. Recently a new oblique sounding continue monitoring has been established between Rome and Chania.

In the last years, due to the growing interest in real time ionospheric mapping and short term previsions, the need for immediate availability of good scaled data became more and more important. For this reason, together with the ionosonde, the INGV developed a computer program, called Autoscala, for the automatic scaling of critical frequency fo*F*2 and MUF(3000)*F*2 from ionograms. The main characteristic of Autoscala is that it is based on image recognition technique, and it can run without using information on polarization. Thanks to these characteristics, Autoscala can be applied to any kind of ionosonde. Autoscala was recently applied to the ionograms recorded by the Canadian Advanced Digital Ionosonde (CADI). The system was tested off-line using a wide number of ionograms recorded at different latitudes. The reliability of the produced data showed that CADI & Autoscala can be proposed as a real time ionospheric monitoring system, although the use of the Autoscala in equatorial regions should be carefully evaluated. Autoscala was extended with the addition of special routines for the automatic scaling of polar ionograms. The polar ionosphere is often characterized by strong D region ionizations, causing absorption events, and by the presence of irregularities that may cause rapid changes in both the amplitude and phase of radio signals. Blank ionograms are the manifestation of absorption events, while Z-ray and spread-F signatures on ionograms are the manifestation of ionospheric irregularities. Hence, new methods have been added to Autoscala to face these high latitude ionogram features.

In the last years continue the measurements provided by a network of GPS high rate sampling measurements, taken at 50 Hz, to investigate and the ionospheric irregularities causing scintillation, a scattering effect on the trans-ionospheric signals transmitted by GNSS satellites, installed in Arctic region (Svalbard Islands) and Antarctic. The experimental observations can provide information on the temporal and spatial evolution of irregularities of scale size ranging from hundreds of meters to few kilometres, typically embedded into bigger regions, commonly called patches. The understanding of the patchy ionosphere can be achieved with 3D plus time tomography reconstruction and through a proper modelling. INGV works on the original development of scintillation models; on the climatology of scintillations through the statistical analysis of the measurements acquired almost continuously during the last 6 years over both the poles; collaborate to the development of the ionospheric imaging over high latitude regions. Recently, another analytical tool, called GBSC (Ground Based Scintillation Climatology) has been realised at INGV to investigate long series of data on a statistical base to study the recurrent spatial and temporal features favouring scintillation occurrence. INGV is also working on another important issue for the understanding of the long-term variation of the ionosphere: the investigation of upper atmosphere secular trends, eventually connected to anthropogenic effects (greenhouse effect) and/or natural causes (next excursion or inversion of the geomagnetic field). The network has been further widened with two new installations in Tucumán, Argentina, and in Chania, Crete. The first site is particularly important due to its position very close to the equatorial ionospheric anomaly area, while the second can contribute to the knowledge of ionospheric phenomena of the Mediterranean region.

Regional and local ionospheric models have been studied as input data source for a real-time 3-D IRI modeling. The joint utilization of autoscaled data for F2 peak critical frequency foF2 and propagation factor M(3000)F2, coming from two reference ionospheric stations (Rome and Gibilmanna), the regional (SIRMUP) and global (IRI) ionospheric models, can provide a valid tool for obtaining a real-time three-dimensional (3-D) electron density mapping of the ionosphere. Preliminary results of the proposed 3-D model are shown by comparing the vertical electron density profiles given by the model with the ones measured at three testing ionospheric stations (Athens, Roquetes and S.Vito). Mostly at the solar terminator the vertical electron density profile extracted from the proposed 3-D model is more representative of the real conditions of the ionosphere than the electron density profile extracted from the IRI-URSI model. Best results were however obtained for S. Vito, and this is comprehensible considering that the ionospheric station of S. Vito is the test site closest to the input sites of Rome and Gibilmanna, and then it is the site where the assimilation process of the measured vertical electron density profiles is mainly perceived. In the next future, further additional tests are planned on periods geomagnetically disturbed and considering more than two reference ionospheric stations providing real time data as input for the model.

A software tool, called IONORT (ionospheric ray tracing), for HF ray-tracing calculation useful to determine the path of the HF radio wave propagation in the ionospheric plasma has been developed at the INGV. As others HF ray tracing computational algorithms, it numerically integrates at least 6 differential equations to determine the spherical coordinate of the points reached by the wave vector. The nucleus of the program is written in FORTRAN which the executive has been embedded in the Matlab which the input mask is friendly and the output graphics are easy to implement.
In this way the program exploits the input and output potentiality maintaining a good speed performance.

Measurements of the highest frequency reflected by the sporadic-E layer (foEs) recorded at the Rome ionospheric observatory, were considered in order to calculate the percentage of occurrence of sporadic-E layer with frequencies foEs greater than a given threshold value over Rome, and to establish possible influences of solar and geomagnetic activity on Es occurrence. The software COERENZA to calculate the maximum coherence times (MCT) of the ionosphere, on the base of power-height measurements of the radio signal collected at the Rome ionospheric observatory, was further improved. Some studies were carried out to establish the software parameters more appropriate for computing the MCT. At the same time software called STATISTICA was developed to analyse the outputs of COERENZA on a monthly base. An ionosphere forecasting empirical regional model (IFERM) to predict the state of the critical frequency of the *F2* layer (*foF2*) over Europe during moderate, disturbed, and strongly geomagnetic conditions, is under development. The IFERM model is based on 13 local forecasting models developed to predict *foF2* at 13 ionospheric observatories scattered in the European area. Hourly measurements of *foF2*, hourly quiet-time reference values of *foF2* ($foF2_{QT}$), and the time weighted accumulation hourly series derived from the geomagnetic planetary index *ap*, $ap(\tau)$, were considered for each observatory to develop the forecasting procedures. Hourly systematic measurements of the critical frequency of the F2 layer, foF2, recorded at the Rome (Italy, 41°.8′ N, 12°.5′ E) and Gibilmanna (Italy, 37°.6′ N, 14°.0′ E) ionospheric observatories, along with the hourly quiet time reference values of foF2, $foF2_{QT}$, were considered around the periods of minimum and maximum solar activity over the years 1976-2008, to study the ionospheric variability over Rome and Gibilmannna.

Crustal earthquakes with magnitude $6.0 > M \geq 5.5$ observed in Italy for the period 1979-2009 including the last one at L’Aquila on 06.04.09 were considered to check if the earlier obtained relationships for ionospheric precursors for strong Japanese earthquakes are valid for the Italian moderate earthquakes. The ionospheric precursors are based on the observed variations of the sporadic E-layer parameters (h’Es, fbEs) and foF2 at the ionospheric station Rome. Empirical dependencies for the seismo-ionospheric disturbances relating the earthquake magnitude and the epicenter distance are obtained and they have been shown to be similar to those obtained earlier for Japanese earthquakes but there are ionospheric anomalies not related to the earthquakes. They are not numerous, but their number is comparable and they are not distinguished from the ionospheric anomalies linked to the earthquakes.

Seasonal (Winter/Summer) and solar cycle NmF2 variations as well as summer saturation effect in NmF2 have been analyzed using Millstone Hill ISR daytime observations. A self-consistent approach to the Ne(h) modeling has been applied to extract from ISR observations a consistent set of main aeronomic parameters and to estimate their quantitative contribution to the observed NmF2 variations. It is shown that the summer saturation effect in NmF2 under high solar activity is not just reduced to O/N_2 or EUV flux solar cycle variations, but is determined by β. A new mechanism (qualitative) to explain the December anomaly in NmF2 is proposed.
Ionosonde observations at Rome and Gibilmanna (Sicily) for some months of 2006-2007 were analyzed in the connection with recent COSMIC NmE results. Italy was completely located in the NmE enhanced zone according to COSMIC observations for the periods in question. COSMIC-observed NmE values in the NmE enhanced zone do not coincide with NmE scaled from ionograms in accordance with the URSI Recommendations, but the IRI model correctly describes monthly median NmE contrary to the Chu et al. [2009] conclusion. Three-month averaged COSMIC NmE values turn out to be close to monthly median NmE corresponding to the blanketing frequency fbEs. A conclusion is made that sporadic E practically permanently existing during daytime hours in summer strongly contributes to NmE observed by COSMIC. Possible reasons for the occurrence of the NmE enhanced zones at middle latitudes are discussed.

2) Consiglio Nazionale delle Ricerche, Firenze

Objective of CNR team activity is the study of the variability of the ionosphere and of its interactions both with the near-Earth space (Space Weather) and with the inner parts of the Earth's environment (atmosphere and lithosphere). This work is two-folded: on the one hand the long lasting experience in experimental work and data analysis gives us the skill to work on our time series of data as well as to analysis the available worldwide data, mainly derived from GNSS. On the other hand theoretical effort has been put into understanding the dynamics of small scale irregularities producing radio scintillation, and the role of complexity in the Sun-Earth interaction. The two main research lines presently active are the scintillation analysis and the predictive Space Weather via information theory.
Scintillation are studied both by multi-scale (wavelet) analysis of the radio signal from GPS satellites crossing the ionosphere and collected with a sampling rate of 50 Hz, and observing the climatology of 1 minute scintillation indices. Space Weather is studied in order to produce "predictive" modelling by applying techniques of information theory to the relationship between proxies of different Space Weather phenomena, likely to be related in a non-linear way. Information theory techniques should allow determining causalities and response times in unclear interactions.

3) International Centre for Theoretical Physics, Trieste

The research activity of this group is oriented to the ionospheric modeling and data ingestion and assimilation to be applied to an original model for the electron density profile. Schools, courses and training activity are the aim of ICTP and of this group. In detail a new version of the 3D and time dependent NeQuick model of ionospheric electron density has been developed. The model is used to simulate ionospheric effects on GNSS operations and it has been adopted as the ionospheric corrections model for the European GALILEO satellite navigation system. The improved topside of the new version of NeQuick has been adopted as the default option for the IRI model of electron density. Research activities related to the IRI model and to the low latitudes ionosphere has been carried out in collaboration with groups of Argentina, Nigeria and Cote d'Ivoire. The investigation about the detection technique and the behaviour of ionospheric low latitude bubbles in collaboration with a group of the Universidad Complutense of Madrid, Spain, has continued. Research efforts are now devoted mostly to 3D and time specification of the electron density in the ionosphere using experimental data ingestion. In addition, a new research topic has been initiated using radio occultation techniques to determine the electron density distribution in the ionosphere.

B) Main scientific themes: Ionospheric Physics and Radio propagation

Ionospheric measurements and ionospheric monitoring is an important task of the Italian ionospheric teams since 1936. Ionospheric vertical and oblique soundings have been performed as routine activity or as special campaigns in Italy, in the Mediterranean area and in the Polar Regions. Applied studies to the ionogram autoscaling have been improved for real time management of the ionospheric results. Moreover the irregularities, causing scintillation, a scattering effect on the trans-ionospheric signals transmitted by GNSS satellites, are recently monitored by a network of GPS receivers in the polar regions. Then all the Italian ionospheric teams are active in theoretical studies on the morphology of the ionosphere , its variability and its interactions both with the near-

Earth space and with the inner parts of the Earth's environment, the temporal and spatial evolution of irregularities, the long-term variation of the ionosphere; also active on 3D ionospheric modeling and mapping. Finally tests on now casting models as well ray tracing technique and data ingestion and assimilation methods have been performed in the last 3 years.

C) Projects

DIAS: European Digital Upper Atmosphere Server, A European service for the specification and the prediction of the state of the ionosphere, funded by the *eContent* programme of the European Commission. Monitoring and forecasting is still active.

GIFINT (Geomagnetic Indices Forecasting and Ionospheric Nowcasting Tools), Pilot project of Space weather promoted and financed by European Space Agency ESA. Monitoring and forecasting is still active.

Rosa: a joint Italian-Indian project lead by ASI (Italian Space Agency) devoted to the production of the software for managing an occultation receiver space-born on the Oceansat-2 satellite and analysing its data.

COST Action ES0803: **Developing space weather products and services in Europe;** a four years European-international action devoted to study and spread results of Space Weather research.

GWSWF (GPS for Weather and Space Weather Forecast) Action Group endorsed by SCAR (Scientific Committee for Antarctic Research).

Original and Novel Solutions to Counter GNSS Ionospheric Scintillation Effects, endorsed by Royal Society (UK).

CIGALA (Concept for Ionospheric-Scintillation Mitigation for Professional GNSS in Latin America), funded by the European GNSS Supervisory authority within the 7th Framework Programme of the European Commission (started on February 2010, it will end on February 2012).

TRANSMIT (Training Research and Applications Network to Support the Mitigation of Ionospheric Threats), funded by the European Commission through a Marie Curie Initial Training Network (ITN) as part of the FP7 People Programme (started on February 2011, it will end on February 2015).

CALIBRA (Countering GNSS high Accuracy applications Limitations due to Ionospheric disturbances in BRAzil), submitted on December 2010 to the Call: FP7-GALILEO-2011-GSA-1-a (under revision).

ESPAS: Near-Earth Space Data Infrastructure for e-Science, The strategic goal of ESPAS is to make Europe a foremost player in the efficient use and dissemination of comprehensive near-Earth space environment information offered by institutions, laboratories and research teams all over Europe and world-wide which are active in collecting, processing and distributing scientific data. Duration 42 months.

SWING: Short Wave Critical Infrastructure Network based on New generation prediction Tools. The aim of the Project shortly named SWING is to establish the basis for a South European robust radio network, based on SW architecture and utilizing innovative ionospheric sounding techniques and real time signal processing and forecasting, to support Critical Infrastructure communications, both short and long range, in case of wide scale terroristic or attacks able to render useless Internet links. Under evaluation.

DIVISION III:
"Magnetospheric Phenomena" (Coord.: G. Consolini)

A) Research Groups

The principal Italian groups involved in research activities related with the IAGA Division III "Magnetospheric Phenomena" are:

1. Department of Physics of the University of L'Aquila,
2. Department of Physics of the University of Calabria,
3. Department of Physics of the University of Roma "Tor Vergata",
4. Department of Physics of the Third University of Roma,
5. Istituto di Fisica dello Spazio Interplanetario-Roma of the Istituto Nazionale di Astrofisica, Roma,
6. Osservatorio Astrofisica di Arcetri of the Istituto Nazionale di Astrofisica, Arcetri (Firenze)
7. Istituto Nazionale di Geofisica e Vulcanologia.

B) Scientific Report

The magnetospheric studies in Italy are mainly focused on the investigation of the interaction between the interplanetary solar wind and the planetary magnetospheres (mainly the Earth's magnetosphere), of the Earth's magnetospheric dynamics, of the processes responsible for the plasma transport in the magnetospheric regions, and of the Earth's magnetosphere-ionosphere coupling.

In what follows a resume of the main contribution of the Italian groups to the above themes is reported. These reported results are documented in the publication list.

a) In the framework of the interaction between the solar wind and the Earth's magnetosphere the studies focused on the link between the response of geomagnetic activity at high latitudes to solar wind turbulence, on the impact of interplanetary shocks on the terrestrial bow shock, on the reconnection topology inside Kelvin-Helmotz vortices at the magnetapause, and of high kinetic energy density jets in the Earth's magnetosheath. The results of such (statistical and/or case) studies evidenced i) the relationship between Alfvénic fluctuations and auroral activity, as monitored by the AE-index and pointed out that the storm dynamics is influenced by the internal magnetospheric dynamics; ii) a general agreement of the pressure pulse observed in the magnetosheath due to the impact of interplanetary shock waves (IS) with simulation results, the presence of a slowing down process of transmitted shock which is also accompanied by a secondary discontinuity; iii) the possible occurrence of a lobe reconnection occurring along an extended X-line instead of local reconnection sites within vortices generated by Kelvin-Helmotz instability; iv) the presence of high kinetic energy density jets, which are characterized by anomalously high values of the local magnetosonic Mach number and are not due to magnetic reconnection processes at the magnetopause, in the dayside magnetosheath. A possible origin of such jets could be that the indentation of the magnetopause is caused by an anti-sunward jet ramming into the magnetopause slightly equatorward of the northern cusp and that the northward–tailward jet is the result of its reflection at the deformed magnetopause. Most of these studies have been done analyzing data from recent interplanetary and/or magnetospheric missions (Cluster, Double Star,…)

b) The investigation of the role of turbulence and nonlinear processes in magnetospheric phenomena has mainly focused in the characterization of the turbulence itself. These studies evidenced that i) a large share of magnetic turbulence in the geospace environment is generated locally, as due for instance to the reflected ion beams in the ion foreshock, to temperature anisotropy in the magnetosheath and the polar cusp regions, to velocity shear in the magnetosheath and magnetotail, and to magnetic reconnection at the magnetopause and in the magnetotail; ii) spectral indices close to the Kolmogorov value can be recovered for low frequency turbulence when long enough intervals at relatively constant flow speed are analyzed in the magnetotail, or when fluctuations in the magnetosheath are considered far downstream from the bow shock; iii) for high frequency turbulence, a spectral index of the order of 2.3 or larger is observed in most geospace regions, in agreement with what is observed in the solar wind; iv) more studies are needed to gain an understanding of turbulence dissipation in the geospace environment, also keeping in mind that the strong temperature anisotropies which are observed show that wave particle interactions can be a source of wave emission rather than of turbulence dissipation; v) several spacecraft observations show the existence of vortices in the magnetosheath, on the magnetopause, in the magnetotail, and in the ionosphere, so that they may have a primary role in the turbulent injection and evolution. Furthermore, a novel approach based on the recent theoretical improvements in the information theory has been investigated and applied to some preliminary studies of the cross-coupling of different scales in several nonlinear magnetospheric processes.

c) Another relevant subject widely studied has been the proton acceleration mechanism in the Earth's magnetotail regions. In detail two possible acceleration mechanisms have been investigated: a) the cross tail electric field Ey (due to the large-scale coupling between solar wind and magnetosphere, along dawn-dusk direction) and b) the stochastic acceleration due to the electromagnetic fluctuations present in the magnetotail. These studies have been conducted by means of 2D test particle simulations, able to reproduce the interaction between charged particles and electromagnetic fluctuations and the constant dawn-dusk electric field, Ey, in the magnetotail current sheet. Results on the proton accelerations evidence the role that stochastic Fermi-like process plays, and, by varying the features of the electromagnetic fluctuations, along with the value of the normal magnetic component and other physical parameters, it has been shown to be possible to explain a range of energetic ion observations.

d) The study of the overall magnetospheric dynamics has been carried out by different approaches, dealing with the investigation of the magnetospheric/ionospheric response to solar wind changes by the geomagnetic indices, the observations of ULF waves in the magnetosphere, the monitoring of the plasmaspheric density and the magnetic perturbations produced by ionospheric and magnetospheric currents both at high and low latitudes. The main topics can be summarized as follows:

i) The research activity on ULF (f ~ 1 mHz-1 Hz) waves, developed in the framework of PNRA (Programma Nazionale Ricerche in Antartide), has been focused on the analysis of the geomagnetic measurements in Antarctica to investigate the transmission processes of upstream waves in the Earth's magnetosphere. A multi-station analysis of geomagnetic field measurements during a case event has been also conducted, showing simultaneous oscillations at discrete frequencies (f ~ 1.0, 1.3, 2.2 and 3.2 mHz), driven by fluctuations of the solar wind density, and clear evidence for the occurrence of resonant coupling between such modes and high latitude field lines.

ii) The analysis of SI events (Sudden Impulses) measured at geostationary orbit and on the ground and the comparison with theoretical models allowed to distinguish the contribution of magnetospheric and ionospheric current systems to the magnetospheric and geomagnetic perturbations.

iii) For what concerns the overall magnetospheric dynamics several studies based on both ground based magnetic measurements and spacecraft observations have been done with special emphasis to the nature of the magnetic perturbations measured at mid and high latitudes. In particular, a statistical analysis of low frequency pulsations at different Antarctic observatories situated along the same geomagnetic parallel has allowed to study the azimuthal propagation direction of the observed signals; the results have shown that the pulsations are originated preferably in two different regions: around local geomagnetic noon and around local geomagnetic midnight. Moreover, the analysis of the diurnal variation at high latitude was extended, including also northern hemisphere observatories; their position is interesting in that they are all situated within the polar cap, but at different distance from the polar cusp; the results have shown that the shape of the diurnal variation, as well its dependence on season and solar wind parameters is deeply influenced by the position of the station with respect to the auroral oval. Furthermore, the nature of magnetic perturbations produced by ionospheric and magnetospheric currents as recorded at high and mid latitude geomagnetic stations has been investigated. In particular, it has been studied the effect of these currents on geomagnetic data recorded both at Mario Zucchelli station in Antarctica and at L'Aquila in Italy. Part of these studies are supported by the PNRA (Programma Nazionale Ricerche in Antartide).

iv) Concerning the investigation of the internal magnetospheric regions and in particular the monitoring of the plasmaspheric density, in the framework of the INAF/ASI "Studi di Esplorazione del Sistema Solare" program, a software has been developed for the generation of images of daily dynamic cross-phase spectra between different station pairs of SEGMA. Images have been generated for the years 2003-2007. These images allow to visualize the daily pattern of the field line resonance frequency (FLR) at L = 1.61, 1.67, 1.71, 1.77, 1.83. It gives useful information on the ion fluxes between the ionosphere and the inner plasmasphere under different geomagnetic activity conditions. The images are available for the scientific community in the WEB site of SEGMA (URL: http://sole-terra.aquila.infn.it/cross-phase-spectra.asp). A data base with hourly values of the FLR frequencies at L =1.61 and 1.83, together with corresponding inferred equatorial plasma mass densities for the years 2001-2008 is also available at: http://sole-terra.aquila.infn.it/remote-sensing.asp. Moreover, in cooperation with the Physics Department of the University of Alberta (Canada), the temporal variation of the resonance frequency of the magnetospheric field lines (1.6 < L < 5.1) during the Hallowe'en 2003 geomagnetic storms has been investigated using data from the SAMNET, BGS, and SEGMA ground-based magnetometer arrays in Europe. Through inversion techniques, field line resonance frequencies have been converted into estimates of the equatorial plasma mass density. The results show a global rapid increase of the mass density immediately following the initial storm sudden commencement believed to be due to rapid ionospheric O+ outflow, and a decrease in the next two days probably due to two main causes: 1) plasmasphere erosion produced by the increased convection electric field, 2) increase of the recombination rate in ionosphere. The study has also allowed to monitor the recovery times of the plasma concentration in different regions of the plasmasphere.

e) Dealing with the study of the magnetospheric/ionospheric coupling the ionospheric effects of solar wind dynamic pressure pulses at the magnetopause, and the interhemispheric differences on the effects of magnetic reconnection in the ionosphere have the central topics. In particular, the different responses of northern and southern high latitude ionospheric convection to IMF rotations have been investigated using the Super Dual Auroral Radar Network (SuperDARN) measurements. The Italian community is indeed involved in the SuperDARN Network by a French-Italian co-operation (LPCE-CNRS and IFSI-Roma/INAF) to run the radar of the Kerguelen island (Southern hemisphere) and to install two radars in the French-Italian Dome C Antarctica Station. On the Italian side the participation to the SuperDARN project is financed by the Italian PNRA (Programma Nazionale Ricerche in Antartide).

f) A novel approach based on information theory quantities (delayed mutual information, transfer entropy, etc.) has been applied to investigated the possible coupling of different processes occurring in the Earth's magnetosphere.

On the experimental side, geomagnetic measurements have been routinely conducted at SEGMA (South European GeoMagnetic Array, in cooperation with the Space Research Institute of Graz, Austria; http://sole-terra.aquila.infn.it/staz_segma.asp) and in Antarctica (Terra Nova Bay, geom. lat. -80°, and Dome C, geom. lat. -89°). SEGMA is part of the global magnetometer network ULTIMA (Ultra Large Terrestrial International Magnetic Array http://www.serc.kyushu-u.ac.jp/ultima/ultima.html), an international consortium aimed to promote scientific cooperation in magnetospheric, ionospheric and atmospheric physics, facilitating data exchange and sharing.

Other experimental activities are related to the maintenance of geomagnetic measurements in several geomagnetic observatories both on the mainland (L'Aquila – AQU; Castello Tesino – CTS; Lampedusa) as well as in Antarctica ("Mario Zucchelli" Station - TNB; Dome Concordia). Furthermore, the Italian groups (INAF-IFSI) are also involved in the management of the SuperDARN radar of Kerguelen, installed in cooperation with the LPCE-CNRS of Orleans, France, and in the construction and management of two new radars in Antarctica at the Italian-French base of Concordia. These activities are funded by the Italian National Program for Antarctica Research (PNRA).
Furthermore, activities connected to the participation in some experiments of the next Bepi Colombo ESA – JAXA mission to Mercury have been done.

The principal national and international agencies supporting the activities of the Italian groups are the Italian Space Agency (ASI), The Italian National Program for Antarctica Research (PNRA) and the European Union (FP7 program).

C) Future Projects and Programs.

The main programs of the next two years are devoted to the continuation of the previous research activity based on the analysis of data collected by space missions and ground based geomagnetic observatories, on theoretical and modelling developments. Particular attention will be devoted to the following aspects:

(1) The interaction of solar wind structures with the magnetosphere, in particular regarding the role of the intermittent reconnection between the magnetopause field and the interplanetary magnetic field,

caused by Alfven waves embedded in the fast solar wind streams, and the influence of the magnetospheric and ionospheric current systems in the manifestation of sudden impulses of the magnetospheric and ground field.

(2) The generation and propagation mechanisms of ULF waves (1 mHz-1 Hz) in the magnetosphere, at low and Antarctic latitudes, in correspondence of different conditions of the interplanetary medium.

(3) The remote sensing of the plasma mass density in the plasmasphere through determination of the resonance frequency of geomagnetic field lines. This information, together with observations from a network of whistler receivers, will be used to create a dynamical model of the Earth's plasmasphere (FP7 PLASMON project).

(4) The investigation of geomagnetic pulsation propagation within the polar cap; up to now, observatories situated along the same geomagnetic parallel 80S were considered, and the study will be extended including also DomeC station, in order to address the question of the latitudinal propagation.

(5) The study of kinetic processes and dissipative structures in the near Earth plasmas. This activity is funded by European Union Seventh Framework Programme via the project GEOPLASMAS – Dissipative structures and kinetic processes in the near Earth plasmas, project number 269198, belonging to the funding scheme Marie Curie Actions – International Research Staff Exchange Scheme (IRSES), coordinated by University of Calabria (coordinator Gaetano Zimbardo) and including research groups from the IWF in Graz (Austria), the University of Saint Petersburg (Russia), the Tbilisi State University (Georgia), and the Space Research Institute in Moscow (Russia).

(6) The study of magnetic turbulence and complexity in dynamical processes from the MHD scales down to the kinetic ones.

(7) The investigation of the importance of the reconnection between the magnetopause field and the interplanetary magnetic field,

(8) The study of the low-latitude and the high latitude coupling of the dynamical processes occurring during the geomagnetic storms and substorms by means of novel approaches based of information theory. These studies will be in particular oriented to the understanding of strom-substorm relationship.

(9) The investigation of the topological feature of turbulent structures in the magnetospheric environment.

(10) The analysis of the cross-scale coupling of different processes via information theory.

On the side of experimental activities the following activities will be developed;

- upgrading of SEGMA instrumentation to provide real-time data accessibility;
- upgrading of the instrumentation for geomagnetic measurements in Antarctica;
- upgrading of the ground-based instrumentation in Antarctica. Installation of two SuperDARN radars at Dome C;
- continuation in the participation to the activities related with some experiments of the next ESA-JAXA Bepi Colombo mission to Mercury.

DIVISION IV:
"Solar Wind and Interplanetary Magnetic Field" (Coord.: R. Bruno)

Main goal of this division is to study the solar wind in its various aspects, from its generation low in the corona throughout its expansion into the heliosphere in order to gain a global view of the governing processes.
In Italy there are several groups working on this subject. Part of these groups belong to Universities, others are represented by Observatories and Institutes belonging to the National Institute for Astrophysics (INAF), others belong to National Institute for Geophysics and Vulcanolgy (INGV).
These groups are located, from north to south, at:

1. INAF – Osservatorio Astronomico di Torino, Turin
2. INAF – Osservatorio Astrofisico di Arcetri, Florence
3. Dip. di Astronomia e Scienza dello Spazio, Università di Firenze, Florence
4. Dip. di Fisica, Università di Roma Tor Vergata, Rome
5. Dip. di Fisica, Università di L'Aquila, Coppito, (AQ)
6. INGV - Istituto Nazionale di Geofisica e Vulcanologia, Rome
7. INAF – IFSI Istituto Fisica Spazio Interplanetario, Rome
8. INAF – Osservatorio Astronomico di Roma, Monte Porzio Catone (RM)
9. Dip. di Fisica, Università della Calabria, Rende (CS)
10. Dip. di Fisica e Astronomia, Università di Catania, Catania
11. INAF – Osservatorio Astrofisico di Catania, Catania

The main research themes are about:

- Solar Atmosphere Dynamics;
- Solar Magnetic Field Pattern and magnetic diffusion related to small scale photospheric processes;
- Active region formation, evolution and decay;
- Flares and erupting prominences
- Coronal Mass Ejections and magnetic helicity transport in active regions
- Origin of the solar wind and relation with coronal plumes
- Study of the wind originated in regions evacuated by coronal mass ejections or at the margins of active regions
- MHD turbulence in the solar wind: role and origin of coherent magnetic structures
- IMF influence on ionospheric scintillations at low-mid and high latitudes

The activity for the next two years will mainly follow the lines reported above with particular emphasis on the following topics:

- Chromosphere dynamics studies using SDO, HINODE and IBIS dopplergrams and magnetograms
- Active region formation, evolution and decay using multi-wavelength observations in order to study the details of the emergence of magnetic flux tubes in the solar atmosphere
- Flares and erupting prominences focusing on the reconnection process and on the possibility to confirm the thick target model
- Modeling the initiation mechanisms in CMEs and analysis of data obtained by the STEREO mission during the ascending phase of the next maximum of the solar cycle
- Study of models for solar wind intermittency in turbulence, including validation of their hypotheses;
- Description of dissipative/dispersive range of turbulence. Emphasis on where and how the energy is disspiated into heat;
- Study of the modulation of SEP impulsive events by solar wind turbulence and coherent dtructures;
- Spatial and temporal studies of magnetic helicity of flux tubes and magnetic clouds;
- Study of radial evolution of solar wind anisotropy in terms of Kpar and Kperp;
- Laboratory activities with the IFSI-LPC and further development of 3D space plasma sensor

In particular, some of the above groups are involved in national/international experimental programmes. Their activity within the next two year will focus on:

- Experimental projects (prototype of Fabry-Perot interferometer and wavefront forecasting for MCAO application, MOF application for space - SAFARI/NASA, HiRISE/ESA, and SolMex/ESA projects
- Phase A study for EST Heat Stop design, EST-MCAO design and simulation, and solar image compression algorithms and test the FPI and MCAO forecasting prototypes
- Study on the feasibility of the Broad-Band Imager, new detectors and planning of Data Acquisition and Control Package in the framework of EST Design Study
- *CIGALA* (Concept for Ionospheric-Scintillation Mitigation for Professional GNSS in Latin America), funded by the European GNSS Supervisory authority within the 7th Framework Programme of the European Commission (started on February 2010, it will end on February 2012);
- *TRANSMIT* (Training Research and Applications Network to Support the Mitigation of Ionospheric Threats), funded by the European Commission through a Marie Curie Initial Training Network (ITN) as part of the FP7 People Programme (started on February 2011, it will end on February 2015);
- *CALIBRA* (Countering GNSS high Accuracy applications Limitations due to Ionospheric disturbances in BRAzil), submitted on December 2010 to the Call: FP7-GALILEO-2011-GSA-1-a (under revision).
- ESA-Solar Orbiter, activities related to development and realization of SWA with science and instrument calibration; ESA-PDR in January 2012.

Funds

All the above activities have been totally or partially funded by:
MIUR/PRIN, INAF (PRIN-INAF- Scientific exploitation of the Interferometric BIdimensional Spectrometer (IBIS). Magnetic structuring of the lower solar atmosphere),
ASI (Esplorazione del Sistema Solare), MAE (Solar bidimensional spectropolarimetry with IBIS), the European Commission (EC) in the framework of FP6 and FP7.
PNRA (Programma Nazionale di Ricerche in Antartide);
ARCFAC V (European Centre for Arctic Environmental Research);
Royal Society (UK).
Regione Calabria, CNR Short Term Mobility Program.
European FP7 project: Marie Curie IRSES "Turboplasmas", 2011/2014
ASI contratto “Solar Orbiter ILWS-Supporto scientific alla realizzazione”.

Università di Roma Tor Vergata

Scientific report

Solar Atmosphere Dynamics.
The interplay between solar convective motions and solar magnetic structures is one of the critical outstanding issues of solar chromosphere dynamics and represents one of the basic topics of our research. We studied the evolution of various magnetic features associated to solar Active Regions and quiet Sun. In particular, we search for possible correlations between photospheric and chromospheric events examining the magnetic flux density evolution and waves propagation in the solar atmosphere. We coupled the IBIS dopplergrams from Fe I 617.3 and Ca II 854.2 nm lines and analyzed the correlation in between as a function of space and time. In particular, we were interested in the power associated to 3 minute and 5 minute waves.

Solar Magnetic Field Pattern.
We developed a new searching algorithm to find voids in high resolution magnetograms. The algorithm permits the investigation of spatially intermittent nature of magnetic field emerging when solar surface is observed at high spatial resolution. Actually, at these small scales, the connected patterns, forming magnetic network, show aligned or clustered magnetic features producing a highly branched and fractal pattern embodying magnetic elements. High resolution SOHO/MDI, Hinode/SOT and SDO magnetograms confirmed the presence of multiscale underdense (voids) magnetic regions.

Magnetic Diffusion Numerical Models.
Various small scale photospheric processes are responsible for spatial and temporal variations of solar emergent intensity. The contribution to total irradiance fluctuations of such small scale features is the solar irradiance background. Here we examine the statistical properties of irradiance background computed via a n-body

numerical scheme mimicking photospheric space-time correlations and calibrated by means of IBIS/DST spectro-polarimetric data. Such computed properties are compared with experimental results derived from the analysis of a VIRGO/SPM data. A future application of the model here presented could be the interpretation of stellar irradiance power spectra observed by new missions such as Kepler.

EST – European Solar Telescope.
We designed the heat stop for the 4-m European Solar Telescope EST. EST is an on-axis Gregorian telescope, equipped with a four-meter diameter primary mirror and primary focal length of about six meters. The heat stop, positioned at the primary focus, must be able to remove a heat load of 13 kW, while maintaining its surfaces very close to room temperature, to avoid the onset of seeing. In order to remove the heat, three configurations have been taken into consideration: 1) a flat 45° inclined heat rejecter, 2) a 45° conical heat rejecter and 3) a heat trap (made of a conical heat rejecter and a cylindrical heat absorber). All devices include an air removal system to avoid the formation of thermal plumes.
In the framework of the EST 4m class Solar Telescope we studied the performance of the MCAO using the LOST simulation package. We focus on two different methods to reduce the time delay error which is particularly critical in solar adaptive optics: a) the optimization of the wavefront reconstruction by reordering the modal base on the basis of the Mutual Information and b) the possibility of forecasting the wavefront correction through different approaches.

Solar Space Missions.
Advanced Astronomy for HELIophysics (ADAHELI) is a Small Mission to study the structure and fast dynamics of the low solar atmosphere. The ADAHELI Team successfully completed, in December 2008, the Phase A study awarded by the Italian Space Agency (ASI). During the period 2010-2011 we designed a Fabry-Perot Interferometer (FPI) prototype in order to investigate the possibility to realize a future space qualified version of FPI. In the framework of space instrumentation for spectroscopy we proposed MOF and FPI based instruments for SAFARI/NASA, HiRISE/ESA, and SolMex/ESA projects.

Funding Agencies 2010-2011.
During the 2010/2011 two-years period our research was pursued in the framework of international collaboration (THEMIS French-Italian telescope CNR-funded , USA-Italy “Two dimensional Spectro-polarimetry” project with IBIS at the DST/NSO telescope MAE-funded, The European Association for Solar Telescopes EAST, European Solar Telescope Project EU-FP7-funded), MIUR/PRIN, PRIN-INAF- Scientific exploitation of the Interferometric BIdimensional Spectrometer (IBIS) and ASI (Esplorazione del Sistema Solare).

Main research projects in 2011/2012.
The 2011-2011 research projects are primarily devoted to chromosphere dynamics studies (using SDO, HINODE and IBIS dopplergrams and magnetograms, and experimental projects (prototype of Fabry-Perot interferometer and wavefront forecasting for MCAO application, MOF application for space - SAFARI/NASA, HiRISE/ESA, and SolMex/ESA projects). Over the next two years, the Rome Tor Vergata Solar and Space Physics Team (link http://www.fisica.uniroma2.it/solare) will close the phase A study for EST Heat Stop design, EST-MCAO design and simulation, and solar image compression algorithms and test the FPI and MCAO forecasting prototypes.

Università di Catania
INAF - Osservatorio Astrofisico di Catania

Scientific report

The scientific goals of this group concern the study of the physical processes responsible for the formation and evolution of active regions, by means of a comparison between data obtained during observational campaigns involving instruments operating in several spectral ranges and the most recent models, and a study of the physical processes taking place in the various regions of the solar atmosphere during flares, erupting prominences and CMEs. A particular relevance has been given during the last two years to the european project concerning the Design Phase of the EST (European Solar Telescope).

EST European Solar Telescope.
EST is a pan-european project, presently in its Conceptual Design Study Phase, financed by the European Commission in the framework of FP7, involving 29 partners, from 14 different countries. The EST project is aimed at the realization of a 4-m class telescope, characterized by an optical design and a set of instruments optimized for extremely high resolution imaging and spectropolarimetric observations from near UV to NIR. EST will be four times larger than any existing high resolution solar telescope and it is designated with the highest priority among the ground-based, medium term (2016-2020) new projects in the ASTRONET Roadmap (Panel C). The EST instruments will measure fundamental astrophysical processes at their intrinsic scales in the Sun's atmosphere to establish the mechanism of magnetic field generation and removal, and of energy transfer from the surface to the upper solar atmosphere and eventually to the whole heliosphere. The conceptual Design Study started on February 2008 and will finish during 2011. EST will be operational at the same time as major ESA and NASA space missions aimed at studying solar activity. Our team has been involved in the Design Phase of the Broad-Band Imager and Detectors, as well as in the Data Acquisition and Control Package.

Active region formation, evolution and decay.
During the last two years we performed three multi-wavelength observational campaigns: two at the Swedish Solar Tower in the Canary Islands (2-10 September 2009, 14-25 July 2010), and one at the Dunn Solar Telescope in Sacramento Peak, New Mexico (16-24 October 2010). Aim of these campaigns was to study the emergence of magnetic flux tubes in the solar atmosphere and their interaction with the ambient magnetic field lines. Particular emphasis was also given to the detection of small magnetic elements, known as Moving Magnetic Features, that are generally observed during the decay phase of sunspots, in order to clarify their role in the magnetic field diffusion process. Using data obtained during a previous coordinated observing campaign (SST and HINODE data), we were able to single out a process of magnetic reconnection occurring in an emerging flux region. Finally, the analysis of data acquired with the Sunrise/IMaX mission allowed us to study a small-scale flux emergence event whose main characteristic was the presence of a reconnection process. This research has been carried out in cooperation with other teams belonging to the Research Training Network SOLAIRE, financed by the European Commission (EC) in the framework of FP6. Parts of this research were also carried out in cooperation with teams belonging to Rome and Arcetri Astronomical Observatories and to the Rome - Tor Vergata University. Moreover, the financial support of ASI (Esplorazione del Sistema Solare) and the MAE (Solar bidimensional spectropolarimetry with IBIS) projects is acknowledged.

Flares and erupting prominences.
We performed several multi-wavelength – multi-instrument studies of these very energetic phenomena, focusing our attention on the presence of reconnection processes and on the possibility to confirm the thick target model. To this aim, a comparison between the increase in emissivity in some spectral lines (Hα and Ly-α) and that obtained by some models has been carried out. In particular, we investigated the morphology and evolution of a solar flare in different wavelengths by using imaging data acquired by TRACE in Ly-α and by BBSO in white light and in Hα, to study the behavior of the pre-flare and impulsive phase of a flare occurred on 28 February 1999. The magnetic topology of the active region hosting the flare was analyzed using the photospheric magnetic field data provided by SOHO/MDI, extrapolating the photospheric magnetic field lines, and assuming a potential field. In order to determine the response of the solar chromosphere to the flare evolution, we used a Radiative MagnetoHydroDynamic (RMHD) code - developed by Carlsson & Stein (1992, 1997) and improved by Allred et al. (2005). The code allows to model a flare loop from its footpoints in the photosphere to its apex in the corona, and to add non-thermal heating in the lower atmosphere and soft X-ray radiation. Changing the flux of the non-thermal electron beam, it is possible to simulate three different kind of flares (faint, moderate and bright flares). The code allows to determine the dynamical response of the solar chromospheres to the energy injected in the form of non-thermal electrons during the flares and the evolution in time of the different parameters (temperature, density), in order to compare them with observational data. The data obtained by the simulations for the Ly-α and Hα lines were successively compared with the observations, indicating a good agreement between the two sets of results. This research has been carried out in cooperation with other teams belonging to the Research Training Network SOLAIRE, financed by the European Commission (EC) in the framework of FP6. Moreover, the financial support of ASI (Esplorazione del Sistema Solare) is acknowledged.

Coronal Mass Ejections.
By means of numerical simulations we investigated both emergence of magnetic flux and shearing motions along the magnetic inversion line as possible driver mechanisms for CMEs. The pre-eruptive region consisted of three arcades with alternating magnetic flux polarity, favoring the breakout mechanism. We compared the topological and dynamical evolution of the system when driven by the different boundary conditions. These simulations were

compared with CME data provided by the STEREO satellite. In particular, using STEREO and MDI/SOHO data, we studied a coronal mass ejection (CME) event, occurred in NOAA 11059 on April 3, 2010. We analyzed the CME evolution using data provided by SECCHI-EUVI and COR1 onboard STEREO satellites, and we performed a 3D reconstruction of the CME using the local correlation tracking – tie point (LCT-TP) method. Using MDI/SOHO line-of-sight magnetograms we also analyzed the magnetic configuration of NOAA 11059 and determined the magnetic helicity trend in the active region. This research has been carried out in cooperation with other teams belonging to the Research Training Network SOLAIRE, financed by the European Commission (EC) in the framework of FP6.

Magnetic helicity transport.
We studied the magnetic helicity trend in active regions generating halo coronal mass ejections and we found that the trend does not have a unique behavior, showing sometimes a sudden change in coincidence with the CME occurrence, while in others there is only a small decrease/increase after the event. In another work we compared the different techniques used so far to determine the horizontal velocity fields (necessary step to determine the magnetic helicity transport) in order to single out the most accurate method. Moreover, taking into account the importance of hexagonal cells in convection theories, we studied the motion of magnetic features into such a geometrical element and analyzed the results in terms of the accumulated magnetic helicity. We computed the emergence of a bipole inside the hexagonal cell and its motion from the centre of the cell towards its sides and its vertices, where the magnetic elements are considered to be sinking down. Multiple bipoles were also considered and phenomena such as cancellation, coalescence and fragmentation were investigated. We found that the most important process for the accumulation of magnetic helicity is the shear motion between the polarities. In another paper we investigated the magnetic helicity balance in an active region where a confined solar eruption occurred. This was done in order to verify a possible relationship between the filament expansion and the helicity transport at its footpoints. We aimed to verify if this variation on the helicity transport rate could be interpreted as a consequence of the magnetic torque unbalance due to the tube expansion. In contradiction to the expectations from Chae et al. (2003) model, the helicity injection after the eruption was positive. We offered the alternative interpretation that helicity injection resulted from torque of the opposite sign, generated as the filament lost its negative helicity through reconnection with its surroundings. This research has been carried out in cooperation with other teams belonging to the Research Training Network SOLAIRE, financed by the European Commission (EC) in the framework of FP6.

Main research projects in 2011/2012

In the next two years we will focus our attention on several topics listed below.

EST Design Study: in the next years the Catania team will continue to work on the feasibility of the Broad-Band Imager and the study of new Detectors, as well as on the planning of the Data Acquisition and Control Package for the EST project.

Active region formation, evolution and decay.
we will analyze the data acquired during the previous observational campaigns and we will perform other multi-wavelength observational campaigns in order to study the details of the emergence of magnetic flux tubes in the solar atmosphere, how they interact with pre-existing field lines and how they decay. The aspect of the emergence of new magnetic flux and of its interaction with previously emerged flux tubes will be investigated both theoretically and observationally in the framework of the ISSI team on Magnetic flux emergence and interaction (www.issibern.ch/teams/magneticflux/HOME.html). Moreover, particular emphasis will be given to the detection and study of small magnetic elements, known as Moving Magnetic Features, that are generally observed during the decay phase of sunspots, in order to clarify their role in the magnetic field diffusion process.

Flares and erupting prominences: we will continue the multi-wavelength – multi-instrument study of these very energetic phenomena, focusing our attention on the reconnection process and on the possibility to confirm the thick target model. To this aim, the comparison between the increase in emissivity in some spectral lines and some models will be continued.

Coronal Mass Ejections: we will continue the modeling approach to the study of the initiation mechanisms in CMEs and we will analyze data obtained by the STEREO mission during the ascending phase of the next maximum of the solar cycle, in order to compare the results obtained by the simulations with observational data.

The STEREO data will allow us to determine the 3D structure of the ejected plasma and eventually to determine the initial structure and characteristics of the erupting filament.
Magnetic helicity transport: We will study the magnetic helicity transport and accumulation in several active regions, using line of sight magnetograms, in order to investigate different situations that can trigger erupting filaments/flares/CMEs. We will analyze those situations characterized by opposite signs of magnetic helicity between the erupting filament and the whole active region.

Funding Agencies

These researches are carried out in collaboration with several national and international institutes, like for instance the Italian institutes financed by INAF (PRIN-INAF- Scientific exploitation of the Interferometric BIdimensional Spectrometer (IBIS). Magnetic structuring of the lower solar atmosphere), by ASI (Esplorazione del Sistema Solare), by MAE (Solar bidimensional spectropolarimetry with IBIS) and the nodes of the SOLAIRE Network, financed by the European Commission (EC) in the framework of FP6, as well as the institutes involved in the Design Phase of the European Solar Telescope (EST), financed by the EC in the framework of FP7.

Istituto Nazionale di Geofisica e Vulcanologia

Scientific report

IMF influence on ionospheric scintillations at mid-high latitudes.
INGV manages high frequency sampling GPS receivers deployed in Arctic (Svalbard Islands) and Antarctica (Mario Zucchelli and Concordia stations), which are capable to provide Total Electron Content (TEC) and ionospheric scintillations measurements to investigate the dynamics of ionospheric plasma. During disturbed conditions the TEC absolute and relative values reveal interesting insights about the mechanisms producing scintillation. A novel approach, called GBSC (Ground Based Scintillation Climatology), has been recently developed at INGV to investigate strong enhancements and steep TEC gradients under different Bz interplanetary magnetic field (IMF) conditions. Such type of study shows how the Bz conditions characterize the scintillations observed in the cusp and in the auroral boundaries ionosphere. In particular, what the GBSC reveals is the involvement of different scale sizes of the ionospheric irregularities, whose occurrence and dynamics are, in turn, strictly linked to the IMF climatology. Our results indicate as preferred sectors the auroral oval boundaries and cusp/cleft region where higher percentage of phase scintillations occurrence happen.

IMF influence on ionospheric scintillations at low latitudes.
In close collaboration with other institutions during the last two years INGV has been involved into scientific activities concerning equatorial and low latitudes ionospheric scintillations. These are characterized mainly by amplitude scintillations that occur, quasi-systematically, after sunset local time due to the reversal of the equatorial electrojet typical of the low latitude ionosphere. This well-known mechanism can be less or more effective in producing scintillations depending on the IMF conditions. The investigation is based on the data acquired in Vietnam (Hue and Hoc Mon), in Argentina (Tucuman) and in Brazil (Presidente Prudente). Thanks to the GBSC analysis a promising correlation between the position of the equatorial anomaly crests and of the South Atlantic Magnetic Anomaly and scintillation occurrence is under investigation.

Main research projects in 2011/2012

The study of the ionospheric scintillations will be crucial in the following projects:
CIGALA (Concept for Ionospheric-Scintillation Mitigation for Professional GNSS in Latin America), funded by the European GNSS Supervisory authority within the 7th Framework Programme of the European Commission (started on February 2010, it will end on February 2012);
TRANSMIT (Training Research and Applications Network to Support the Mitigation of Ionospheric Threats), funded by the European Commission through a Marie Curie Initial Training Network (ITN) as part of the FP7 People Programme (started on February 2011, it will end on February 2015);
CALIBRA (Countering GNSS high Accuracy applications Limitations due to Ionospheric disturbances in BRAzil), submitted on December 2010 to the Call: FP7-GALILEO-2011-GSA-1-a (under revision).

Funding Agencies

The conducted studies are included and partially supported by the following projects:
- Upper Atmosphere Observations and Space Weather, endorsed by PNRA (Programma Nazionale di Ricerche in Antartide);
- Experimental investigation to relate the presence of polar cap ionospheric features to HF signalling characteristics, endorsed by ARCFAC V (European Centre for Arctic Environmental Research);
- Original and Novel Solutions to Counter GNSS Ionospheric Scintillation Effects, endorsed by Royal Society (UK).

INAF - Osservatorio Astrofisico di Arcetri
Università di Firenze

Main research projects in 2011/2012

Observations from SOHO, HINODE, STEREO and other S/C will be used for the following studies:

- Origin of the solar wind within the first solar radius above the limb
- Study of the wind originated in a region evacuated by a coronal mass ejection
- Search, between 1.7 and 3 solar radii, for the wind which might originate from the margins of active regions
- Study of the link between coronal plumes and solar wind.

INAF-IFSI, Roma
Università della Calabria
Università di L'Aquila
CNR- LICRYL, INFM/CNR, Cosenza
INAF-Torino Astronomical Observatory

Scientific report

The activity of this group in the past two years has been focussed mainly on three different aspects related to space plasma physics:

1) Study of MHD turbulence in the solar wind
2) work related INAF-IFSI participation to ESA-Solar Orbiter and ESA-CrossScale projects
3) laboratory activity

Study of MHD turbulence in the solar wind.
The inertial range of turbulent cascade in solar wind has been analysed using Ulysses data during both Ecliptic and polar phases. Particular attention has been devoted to the study of the third order structure function. The linear scaling of the third order structure function (Kolmogorov's 4/5 law) is the only scaling in turbulence that can be rigorously obtained from the Navier-Stokes equation and represents a sort of boundary condition or "conditio sine qua non" for turbulence. Based on this premise, studies have been performed on the nature of the energy cascade, the relationship with the local parameters of the solar wind, and the large scale energy input.
Other studies have addressed the solar activity modulation of solar wind turbulence studied through the statistical analysis of the higher order moments of fluctuations.
Moreover, the properties of small scale anisotropy, as measured using advanced techniques for multipoint measurementes (Cluster data), have been investigated.
Intermittency properties of solar wind turbulence have been investigated with a new technique based on wavelet decomposition.
Particular attention has been put on magnetic helicity properties of coherent structures and their radial evolution analysed during a radial alignment between Earth and Ulysses occurred at the end of August 2007 seems to

confirm the invariance of this measurable. This study was performed within the framework of a Coordinated Investigated Program in occasion of the International Heliopspheric Year (IHY) 2007.
Other studies were devoted to the investigation of the link between the response of geomagnetic activity at high latitudes and solar wind turbulence. A robust relationship between Alfvénic fluctuations and auroral activity, as monitored by the AE index was found. On the contrary, the storm dynamics, as monitored by the SYM-H index, was found to be influenced by the intrinsic magnetospheric dynamics rather than by solar wind turbulence.

Work related to INAF-IFSI pariticipation to ESA-Solar Orbiter and ESA-CrossScale projects.
Our main interest in Solar Orbiter is related to the study of solar wind plasma within our active participation in the international consortium responsible for providing the plasma suite SWA. Most of the scientific work has been devoted to numerical simulation of the ion velocity distribution function that Solar Orbiter will encounter during its orbit and for different solar wind conditions. This study has been preliminary to the definition of the field of view of the two ion sensors PAS and HIS which are part of SWA plasma suite.
Moreover, the large amount of data produced by SWA make data compression a very important topic to analyse in order to choose the best algorithm to run on SWA-DPU. A remarkable amount of work has been dedicated to the study of the efficiency of different compression algorithms which have been tested on different particles velocity distribution functions. In particular we tested lossy and lossless compressors such as: semilog+ Hartmann Quad-Tree, JPEG 2000, RICE and, CCSDS-122-B1.
Similar numerical studies on electrostatic plasma analyzers were also performed within the context of our participation to phase A of ESA-Cross-Scale mission during the class M selection.

Laboratory activity.
During 2010 the refurbishing phase of IFSI-Large Plasma Chamber (LPC) successfully ended after three years within the ASI contract ESS (Esplorazione Sistema Solare). This activity refers to the upgrading of the vacuum system and the design and realization of a new s/w and h/w diagnostic system based on LabView and Langmuir Probes and Retarding Potential Analyser, respectively. This facility is particularly apt to perform plasma environmental tests for payloads and/or single components designed to operate in a low Earth orbit (e.g. ISS, sounding rockets, ...). During 2010, LPC has been used to perform various tests on ionospheric payloads related to the “Meridian” experiment of the Center for Space Science and Applied Research (CSSAR) of the Chinese Academy of Sciences (CAS).
Parallel to this activity, IFSI developed a quasi 3D ion plasma sensor apt to be flow on 3-axis stabilized S/C.

Main research projects in 2011/2012

During the following two years our activity will focus on the following topics:
- study of models for intermittency, including validation of their hypotheses;
- description of dissipative/dispersive range of turbulence: where and how is the energy dissipated into heat?;
- study of the modulation of SEP impulsive events by solar wind turbulence;
- spatial and temporal studies of magnetic helicity of flux tubes and magnetic clouds;
- study of solar wind anisotropy in terms of Kpar and Kperp;
- activities related to our participation in Solar Orbiter mission: science and instrument calibration;
- laboratory activities with the IFSI-LPC and further development of 3D plasma sensors.

Funding Agencies

Funds related to participation to space projects and data analysis from already flown space missions come from the Italian Space Agency. The first 12 month scientific contract with ASI for Solar Orbiter phase A started in October 2010. In 2011 there will be a second contract for phase B/C(D) and will last 48 months.
For some Institutes partial support comes from Regione Calabria, CNR Short Term Mobility Program.
Other funds come from European FP7 project: Marie Curie IRSES "Turboplasmas", 2011/2014.

DIVISION V:
"Geomagnetic Observatories, Surveys, and Analyses" (Coord.: A. Meloni)

GEOMAGNETIC OBSERVATORIES

Observatory	IAGA code	Latitude	Longitude	Elev (a s.l. m)
L'Aquila	AQU	42°23'N	13°19'E	682
Castello Tesino	CTS	46°03'N	11°39'E	1175
Mario Zucchelli	TNB	74°42'S	164°6'E	30
Concordia (*)	DMC	75°06'S	123°21'E	3200

Magnetic Observatories operated by INGV, Italy.
(*) in cooperation with France, IPEV

L'AQUILA GEOMAGNETIC OBSERVATORY

The Observatory started its activity in 1958 and published regular yearbooks from 1960 onwards; last published 2008. On April 6th 2009, L'Aquila and surroundings, were struck by a terrible M=6.2 earthquake that destroyed the city and killed 309 people. The Observatory, located near Preturo, ten km north-west from the city, was not severely affected by earthquake but the land on which the observatory buildings: a) absolute measurements, b) variometers, c) proton precession vector magnetometer, d) laboratory and e) general services, were built, will be given back to L'Aquila University (the original landlord) for new student housings. Reasonably this report will be the last referring to magnetic activities in Preturo. A new location for the new Observatory will be found.

Declination and Inclination measurements are carried out by means of an optical theodolite equipped with a fluxgate magnetometer. The horizontal and vertical intensities are determined associating the measured I value to the total field measurement from a proton precession magnetometer (PPM). A PPM for the measurement of F and a fluxgate magnetometer for the measurement of the H, D and Z component variations are used for time variations; both instruments have a 0.1 nT resolution; the original sampling rate is 1 Hz, then the data are filtered with a Gauss filter and recorded at 1 min.

Additional variometric systems are also working: two tri-axial fluxgate magnetometers, one with toroidal and the other with linear sensors, for the measurement of the H, D and Z variations. These systems are generally not used for the yearbook compilation but their data are used to check and, if necessary, integrate the measurements. L'Aquila is an INTERMAGNET Observatory and only for this observatory in Italy, K magnetic activity indices SSC, SFE and SI notifications are made.

CASTELLO TESINO GEOMAGNETIC OBSERVATORY

The Geomagnetic Observatory of Castello Tesino is located about fifty-five km East from Trento. The Observatory has been working almost continuously since 1964 as the Northern Italy magnetic Observatory. It works as an automatic Observatory and consists of three buildings, completely non-magnetic; a) laboratory for small repairs, b) absolute measurement equipments, and c) the automatic digital variometer system. Since some disturbance affected the Observatory variometer house, recently a new small wooden building was built at a safe distance, in order to avoid this problem. Two systems are currently working simultaneously. In the next few years the old hut will be abandoned.

Declination and Inclination measurements are carried out by means of an optical theodolite equipped with a fluxgate magnetometer. The horizontal and vertical intensities are determined associating the I value to the total field measurement made by a PPM. A PPM for the measurement of F and a fluxgate magnetometer for the measurement of the H, D and Z component variations are used for time variations; both instruments have a 0.1 nT resolution; the original sampling rate is 1 Hz, then the data are filtered with a Gauss filter and recorded at 1 min. Recently a recovery of several arrear yearbooks was accomplished. At this time all yearbooks from 1996 to 2007 were completed, as well as the very recent 2008-2009, were all regularly published as standard booklets.

TERRA NOVA BAY (MARIO ZUCCHELLI STATION)

During the 1986-87 austral summer a geomagnetic observatory was installed at the Italian Antarctic Mario Zucchelli Station. In the first years the measurements of the geomagnetic field were carried out only during summer expeditions. Since 1991 the recording was implemented with an automatic acquisition system operating through the year.

Declination and Inclination measurements are carried out by means of an optical theodolite equipped with a fluxgate magnetometer. The horizontal and vertical components are determined associating the I value to the total field measurement made by a proton precession magnetometer.

A proton precession magnetometer for the measurement of F and a fluxgate magnetometer for the measurement of the H, D and Z component variations are used for time variations; both instruments have a 0.1 nT resolution; the original sampling rate is 1 Hz, then the data are filtered with a Gauss filter and recorded at 1 min.

Additional systems are also working for the measurement of the H, D and Z variations. These systems are generally not used for the yearbook compilation but their data are used to check and, if necessary, integrate the measurements.

When absolute measurements are available (summer) results and hourly data are published on booklets (so far completed up to 2006-2007).

CONCORDIA

In 1994 France and Italy started a program for opening a permanent scientific station on the high East Antarctic plateau at Dome C at 3280 m asl. The national Antarctic Programs (IPEV and PNRA respectively) started logistic, technical and scientific activities at Dome C that were initiated with the realization of a summer camp. The permanent Base opened in 2005

The observatory is constituted by two shelters, a) variometer shelter and b) absolute measurements shelter, at a distance of about 300 m from the old field camp. Operations started regularly at the end of 2004. Variations of the Earth's magnetic field are monitored by a three-axis fluxgate magnetometer along three orthogonal vector components oriented with respect to the local magnetic meridian. The intensity of the field is measured by an overhauser magnetometer. Absolute measurements are performed during the whole year.

The flux-gate variometer, a suspended DMI magnetometer, and an Overhauser magnetometer operate for the acquisition of the geomagnetic field intensity and components time variations. The instrument sensors are located in a cave under the shelter in order to keep the sensors at a constant temperature (about -40°C). In the absolute shelter D, I, F absolute measurements are carried out according to standard observatory practice. Data quality and standard requirements have allowed the inclusion of Concordia as an INTERMAGNET Observatory.

GEOMAGNETIC STATIONS

Two Geomagnetic time varying stations are currently in operation in Italy.

Since the end of 2007 an electromagnetic field monitoring station has been in operation in at Duronia (Lat. 41°39’N, Lon. 14°28’E). The station was created in the framework of a project headed by the Abruzzo region. The main target was to create a network of stations to monitor the environmental electromagnetic signals in the Adriatic area, in the frequency band from 0.001Hz to 100kHz (ULF-ELF-VLF). The peculiarity of Duronia installation is the site low electromagnetic background noise and the low noise of the instrumentation. A target will also be the long-term monitoring of local magnetic field anomalies possibly related to the local geodynamical processes. After the 2009 L’Aquila earthquake Duronia station it was completed to include a full geomagnetic equipment to follow IAGA requirements. Starting from 2011 also Duronia will be operated to include absolute measurements and then made possible to become a full Magnetic Observatory.

By the end of 2007 magnetic field time variations are also recorded in Lampedusa Island South-West of Sicily (Lat. 35° 31’ N, Lon. 12° 32’ E). From the beginning of 2007 values of the Earth’s magnetic field were recorded quite regularly. A small stone building with a wooden roof, located within a natural reserve, in an area characterized by a low electromagnetic noise, host the magnetic instruments. Electric current is provided by photovoltaic cells and data transmission is achieved through GSM connection. The little hut hosts only the instruments electronic units; sensors are buried in thermally isolated shafts in the area in front of the building. Total intensity F is measured by an Overhauser magnetometer, while the variations of the magnetic field components H, D and Z are measured by a fluxgate vector magnetometer. Data acquisition is made through a device made on purpose at INGV to avoid the use of a personal computer.

MAGNETC SURVEYS

In order to complement the observatory measurements, for a better spatial knowledge of the geomagnetic field and its secular variation over Italy, a national magnetic network is active. The Italian repeat station network consists of 116 points. INGV has the task to make measurements and data elaboration. The measurements are generally carried out by means of Declination/Inclination theodolites and total intensity magnetometers; a gyroscope theodolite is used to check and establish new azimuth marks when necessary. The information on the more rapid time variations, both for the diurnal variation and for possible irregular perturbations, is taken at the two observatories L'Aquila, in central Italy, and Castello Tesino, in northeast Italy. Moreover, for selected areas, other temporary magnetic time recording stations, favorably displaced for having nearly a total coverage of the Italian territory, are installed during the survey. All magnetic repeat stations are represented in figure below together with the Observatories and temporary stations.

A full survey was planned for the 2010.0 date This most recent full survey was competed in November 2010 and consisted of 133 repeat stations, with 55 km average spacing, over Italy, and included also stations surveyed in Albania, Malta and Corsica. At this time data elaboration is completed and D, I and F magnetic element values on all stations and 1/2000,00 cartography for F, H, Z and D. All maps will be published together with a CD rom and interactive program to display maps and magnetic field values across all Italy.

Other Relevant Activities To Division V

GEOSTAR: As well known in the geophysical community there is a strong need of marine, in particular seafloor, measurements (we remember that around 2/3 of the Earth's surface is in fact covered by seas). In the view of improving the number of observing systems that would guarantee a complete coverage for a full global analysis of the geomagnetic field, at INGV the contribution in this direction is the continuing development of an automatic system called Geostar, that includes in one geophysical station seismic sensors and other devices. The station characteristics for the magnetic part are a) fluxgate magnetometer (built at INGV): resolution: 1.0 nT power, consumption: 2W, accuracy: 5-10nT, sampling: 6 values/min, b) Scalar Magnetometer (GEM System): resolution: 0.1nT, consumption: 1W, accuracy: 1nT, sampling: 1value/min.

ARM: (Antarctic Reference Model) Magnetic modeling provides scientific communities with updated information on magnetic field elements as the output of computer programs. ARM is a 3D model for the geomagnetic field over Antarctic regions. It is based on the Spherical Cap Harmonic Analysis and allows the computation of the main field and its secular variation over these regions from 1960 onwards. It's now updated to include year 2009.

Crustal magnetic field investigations. The study of tectonics can take important advantages by the use of magnetic field surveys that allow the determination of the crustal field contribution. We report here some recent contributions in this field. High spatial resolution aeromagnetic surveys were undertaken, especially at INGV, by the use of helicopter born magnetometry and data interpretation in volcanic magnetized areas. We report the most recent activities undertaken. At the Eolie islands archipelago, in the Tyrrhenian, surveys and studies were made on Salina island and Volcano island. Other measurements and studies were made on El Hierro (Canary isalnds) in cooperation with Spanish colleagues.

A group at the Università of Camerino has undertaken analysis and interpretation of marine and in particular devoted to the realization of kinematic models for the Mediterranean and the Atlantic.

"Interdisciplinary Commission on History" (Coord.: A. De Santis)

Main Activities

Among all initiatives of Education and Outreach for IAGA in Italy those which are worth mentioning are: the "Week of the Scientific and Technological Culture" organised and produced in a defined week of each year by many Italian Universities and Research Institutes and the 2011 "ScienzAperta" ("Open Science") by INGV with a series of outreach seminars.

IAGA Inter-Divisional Working Group on Education and Outreach 2007-2011
(member A. De Santis; see http://www.iugg.org/IAGA/iaga_pages/science/commissions.htm)

SCIENTIFIC PUBLICATIONS

DIVISION I:
“Internal Magnetic Field”

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DIVISION II:
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DIVISION V:
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