Resoconto di attività 2011-2014

Prof. U. Villante

Delegato Italiano IAGA

International Association of Geomagnetism and Aeronomy (IAGA)

IAGA Activities in Italy (2011-2014)

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

Division I: *(pag. 3)*	"Internal Magnetic Field" (Coordinator: Dr. L. Vigliotti – CNR - ISMAR, Bologna)
Division II: *(pag. 8)*	"Aeronomic Phenomena" (Coordinator: Dr. B. Zolesi – INGV - Roma)
Division III: *(pag. 13)*	"Magnetospheric Phenomena" (Coordinator: Dr. G. Consolini – INAF/IAPS, Roma)
Division IV: *(pag. 17)*	"Solar Wind and Interplanetary Magnetic Field" (Coordinator: Dr R. Bruno – INAF/IAPS, Roma)
Division V: *(pag. 21)*	"Geomagnetic Observatories, Surveys and Analyses" (Coordinator: Dr A. Meloni – INGV, Roma)
Interdivisional Commission: *(pag. 25)*	"History" (Coordinator: Dr A. De Santis – INGV, Roma)
Interdivisional Commission: *(pag.25)*	"Education and Outreach" (Coordinator: Prof. F. Berrilli – Università Tor Vergata, Roma)

Meetings of the Italian IAGA Community have been held on:

- October 2011 – IAGA/Italy General Assembly
- June 2013 – IAGA /Italy Meeting - Future Projects and Programs

As summarized in the following, the Italian IAGA Community organized several conferences and international schools.

The Italian IAGA Community also played a major role in the establishment of the National Group for Space Weather (Oct. 2013).

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

A) Institutions involved in research activity

1. Istituto Nazionale di Geofisica e Vulcanologia, INGV-Roma.
2.Centro Interuniversitario di Magnetismo Naturale (CIMaN-ALP ALPINE LABORATORY OF PALEOMAGNETISM University of Milano, Torino, Parma, Roma3, Chieti-Pescara and Urbino).
3. Department of Physics of the University of Bari.
4. Department of Physics of the University of Camerino.
5. University of Naples.
6. Istituto di Scienze Marine ISMAR-CNR, Bologna.
7. Istituto di Astrofisica Spaziale e Planetologia/INAF Roma

B) Scientific Report

B1) Main Scientific Themes

Interdisciplinary studies concerning the registration of the Earth magnetic field, magnetic properties of rocks/sediments and studies of the electromagnetic signal focused on different subjects including:

Magnetostratigraphy. Using Earth's magnetic field reversal as a method of dating rocks.

Earth's magnetic field. Structure and paleosecular variations of Earth's magnetic field from marine/lacustrine sediments and archaeological data (Archaeomagnetic dating).

Environmental Magnetism. Paleoclimatic and paleoceanographic reconstructions based on magnetic properties of sediments. Study of atmospheric particulate even trapped in the Antarctic Ice.

Tectonics. Tectonic evolution of the Mediterranean region as well as areas in other continents: Asia, Africa, South America.

Volcanology. Use of paleomagnetism and rock magnetism to understand volcanic processes

Sedimentology. Depositional patterns of turbidites rocks.

- **Paleomagnetism, Magnetic polarity and Secular Variation record of the magnetic field**

Paleomagnetic studies achieved important results in the reconstruction of the dynamics and timing of polarity reversals of the Earth's magnetic field. The study of Sagnotti et al. (2014) of lake sediments from the Basin of Sulmona showed that the transition of the magnetic polarity during the reversal would take place in a time comparable to that of human life. This study could have major implications not only for understanding the behavior of the Earth's magnetic field. With regard to the integrated stratigraphy and magnetostratigraphy, researches focused on several sections ranging in time from Cretaceous to Pleistocene. Some of them are candidates for the definition of different Global Stratotype Section and Point (GSSP). Early Miocene (Burdigalian) sections were studied in the Conero, Iblei as well as in oceanic cores. Additional GSSP focused on the Paleogene (Lutetian, Thanetian, Bartonian and Selandian) and in particular on stratigraphic series sampled at Gorrondatxe and Zumaia in the Basque countries (Spain). Additional studies on land took into account sections from the Anatolian Plateau (Turkey), New Zeland, the Piedmont Tertiary Basin and Pleistocenic sequences from the Padania Plain. Measurements on marine sediments include the upper part of the stratigraphic succession recovered in the IODP expedition 317 (Canterbury Basin).

Several investigations have been carried out on the paleosecular variations (PSV) of the Earth magnetic field recorded by sediments (Adriatic Sea, Ionian Sea, Barents Sea) and

volcanic rocks (Azores, Capo Verde, Pantelleria), with a re-evaluation of the Italian historical geomagnetic catalogue. The analysis of different cores from the Barents Sea, off the coast of Svalbard, has allowed the reconstruction of the Holocene PSV at high northern latitudes, providing important experimental constraints for models of the geomagnetic field, and allowing the development of an age model for detailed reconstruction of climatic variations. Magnetostratigraphic investigations include also classic sites inhabited by hominid in Puglia (Pirro Nord) and at Ceprano.

- **Environmental Magnetism**

  Magnetic parameters were used to investigate the paleoclimatic and paleoceanographic history recorded by marine and lacustrine sediments in different environments. Results have been obtained on sediments representing extreme climatic conditions such as greenhouse episodes during the Eocene-Paleocene and the Messinian salinity crisis, but also from young sediments. In the framework of the International Continental Drilling Program (ICDP) "Paleovan", 150 meters of Late Quaternary sediments collected at Site 5034 in the Lake Van (Turkey) were analyzed for a paleomagnetic/rock magnetic study carried out in collaboration with the University of Florida at Gainesville (USA).

  Magnetic data from Antartic and periantartic drillings have been summarized to reconstruct the climatic evolution of this region during the Cenozoic.

  Application to studies of environmental pollution, especially by particulate matter were carried out with the aim to determine the contribution of the ultrafine magnetic fraction (diameter less than 30 nm) in atmospheric dust, characterized by superparamagnetic properties.

  Electrical and electromagnetic methods were used in various geodynamic environments at different scales of investigation in Italy, Morocco and especially in volcanic areas. The targets focused on the continuous monitoring of the magnetotelluric field, development of techniques for the characterization of the magnetotelluric signal, study of the seismic-electromagnetic signals.

- **Geodynamic Reconstructions**

  With regard to applications to geodynamics, paleomagnetic and magnetic anisotropy were applied to reconstruct the tectonic evolution of the Italian peninsula, several Mediterranean regions and the Andes. Studies in the Crotone basin provided new original data for the geodynamic mechanisms responsible of the Plio-Pleistocene deformation of the Calabrian block. In the Andes region, new studies have been conducted in the Eastern Cordillera of Colombia to constrain the mechanisms for the genesis of this mountain chain. New paleomagnetic data were obtained from Paleozoic rocks in Sardinia as well as from the Neogene of Central Iran. The anisotropy of magnetic susceptibility was used to reconstruct the Pleistocenic deformation field in the upper valley of the Tiber.

- **Magnetic Properties of Rocks and Archeomagnetism**

  An increasing number of studies focused on the applications of magnetic parameters to volcanic rocks. The emplacement temperatures and depositional mechanism of piroclastic and volcanic units were analyzed to characterize different volcanic eruptions (Breccia di Commenda, Brown Tuff, Ferrar Dolerites, Pollena, Pompei, Colima, El Chichon).

  Archeomagnetic studies took into account furnaces found at Kato Achaia (Grecia), Fontanetto Po, Spilamberto, Portugal, and on ceramics from Skala Sotiros, Archontiko, Tempi, Paros, and Santorini (Greece). Studies for determination the firing temperature of ceramic artefacts were carried out in collaboration with the University of Bari and the Archaeological Office of different regions (Piemonte, Emilia-Romagna) and also the Canton of Bern in Switzeralnd. The origin and composition of Neolithic obsidian as well as Roman and Medieval bricks were investigated in collaboration with the National Institute of Metrological Research to

reconstruct the provenance and the commercial roads in the Mediterranean region during the ancient times.

Specific research of the remanent magnetization carried out by magnetic minerals of biogenic origin in marine sediments gave new insights on their influence in the acquisition and retention of the magnetic properties. Additional results focused on peculiar magnetic properties of different species of magnetotactic bacteria.

B2) Main Research Projects/Programmes

- Magnetic models and analyses in the Project "Magnetic Homing. PRIN
- Earth Magnetic Field measurements, Modelling and Seismicity – EM3S Italy-Albania. Bilateral project DS3F "Deep Sea and Subseafloor Frontier"
- Satellite, ground and seafloor measurement for earthquake pattern regnition". SAGA-4-EPR
- Paleomagnetic and Magnetic properties of the Lake Van sediments (PALEOVAN PROJECT; ICDP SITE 5034): Paleoclimatic and environmental reconstruction of the last 500000 years. Short-Term mobility" program.
- Acque di fusione glaciale, plumiti e morene recessionali allo sbocco della Fossa di Storfjorden durante la deglaciazione della Calotta Glaciale del Mare di Barents (MELTSTORM)
- Studio multidisciplinare dei sedimenti glaciomarini deposti nel Mare di Ross (Antartide) negli ultimi 50 Ka: informazioni sulle fluttuazioni dell'estensione dei ghiacci nel corso della transizione glaciale-interglaciale
- Rapporti Temporali tra Attività Vulcanica e Sedimentazione nell'Area McMurdo Sound - Ross Ice Shelf: Implicazioni Tettoniche e Paleoclimatiche. ANDRILL- ANtarctic DRILLing .
- Paleomagnetic Analyses of Drifting and Tectonic Rotations of Central Iran. Progetto nell'ambito del Consorzio internazionale DARIUS (2009-2011).
- Magnetostratigraphy and stratigraphy of Miocene to Present lacustrine basins in central Anatolia. Collaborative Research Project Vertical Anatolian Movement Project (VAMP), Progetto TOPOEUROPE (ESF) (2008-2012).
- Osservazioni di terreno e sperimentali per la stima della pericolosità vulcanicaValutazione della pericolosità vulcanica in termini probabilistici. Progetto Vulcanologico DPC-INGV. Task 2.
- Genesi e differenziazione dei magmi in relazione all'ambiente geodinamico ed alle caratteristiche petrologiche e geochimiche delle loro sorgenti: implicazioni per l'evoluzione del sistema convergente Africa-Europa. PRIN.
- Indagini ad alta risoluzione per la stima della pericolosità e del rischio sismico nelle aree colpite dal terremoto del 6 aprile 2009. FIRB.
- EPOS (European Plate Observing system) preparatory phase.
- CORIBAR-IT: Dinamica glaciale e deposizione associata all'ultimo ritiro glaciale del Mare di Barents nordoccidentale: un progetto a 5-nazioni per perforare l'Artico con il sistema MeBo. PNRA
- Reconstructing 2500 years of environmental change at the periphery of Rome: Integrating paleoecology and socioeconomic history to understand human response to climate.
- ROSSLOPE II: Dinamica sedimentaria passata ed attuale nel Mare di Ross: un approccio multidisciplinare allo studio della scarpata continentale. PNRA
- Il "GSSP" (Global Stratigraphic Section and Point) del Piano Burdigaliano: il tassello mancante all'intervallo Neogenico della Scala del Tempo Geologico
- The potential of AMS (Anisotropy of Magnetic Susceptibility) studies in polyphase deformed rocks.
- REGENA project "Holocene and Pleistocene recovery of geomagnetic secular variation in the North Atlantic (Azores and Cape-Verde archipelagos and Portugal mainland): Geomagnetic and volcanological implications". FCT Project (Portugal)
- MED-SUV (MEDiterranean SUpersite Volcanoes), FP7

- Project ENI Val d'Agri: subcontract with the Institute for the Methodologies for Environmental Analysis of the CNR (CNR_IMAA) of Potenza.
- Geochimica, geodinamica, e cinematica delle placche nel Mar Rosso. PRIN
- Integrated assessment of magnetotelluric and magnetospheric monitoring in seismic areas of L'Aquila and the Val d'Agri for the identification, quantification and interpretation of possible modifications of the electrical resistivity in the earth's crust

B3) Funding Agencies

- MIUR PRIN Magnetic models and analyses in the Project “Magnetic Homing”
- MIUR PRIN Valutazione integrata del monitoraggio magnetotellurico e magnetosferico nelle aree sismiche de L'Aquila e della Val d'Agri ai fini della identificazione, quantificazione e interpretazione di eventuali modificazioni della resistività elettrica nella crosta terrestre
- MIUR PRIN Geochimica, geodinamica, e cinematica delle placche nel Mar Rosso.
- Italian Foreign Office Bilateral project Italy-Albania 2012-2013.
- European Project DS3F “Deep Sea and Subseafloor Frontier” 2010-2012
- Italian Foreign Office SAGA-4-EPR Project of Excellnce Italy-China 2010-2012
- CNR “Short-Term mobility program” "Paleomagnetic and Magnetic properties of the Lake Van sediments (PALEOVAN PROJECT; ICDP SITE 5034): Paleoclimatic and environmental reconstruction of the last 500000 years"
- PNRA Acque di fusione glaciale, plumiti e morene recessionali allo sbocco della Fossa di Storfjorden durante la deglaciazione della Calotta Glaciale del Mare di Barents (MELTSTORM)
- PNRA Studio multidisciplinare dei sedimenti glaciomarini deposti nel Mare di Ross (Antartide) negli ultimi 50 Ka: informazioni sulle fluttuazioni dell'estensione dei ghiacci nel corso della transizione glaciale-interglaciale
- PNRA ANDRILL-ANtarctic DRILLing - Rapporti Temporali tra Attività Vulcanica e Sedimentazione nell'Area McMurdo Sound - Ross Ice Shelf : Implicazioni Tettoniche e Paleoclimatiche
- Provincia Autonoma di Bolzano - Alto Adige
- CNR. Progetto Bandiera RITMARE.
- NSF-USA
- ENI

B4) Organization of Conferences and Workshop of international relevance

Italian researchers from different institutions were convenors of important international conferences:

- M. Mattei (Roma-3) co-convenor of the J-V07 symposia “Using Paleomagnetism to Understand Volcanic Processes” IUGG, 2011, Melbourne, Australia.
- P. Macrì (INGV) Co-convener of the EMRP1 Open session on “Geomagnetism and Paleomagnetism” EGU General Assembly 2011, Vienna, Austria.
- L. Sagnotti (INGV) Convenor della sessione EMRP3.1 “Open session on Rock magnetism and Paleomagnetism”, EGU General Assembly 2014; Vienna, Austria.
- A. De Santis (INGV) Convenor session EMRP2.1 “Open Session on Geomagnetism“, EGU General Assembly 2014, Vienna, Austria.
- E. Tema (Università di Torino). Convenor della sessione EMRP3, “Archaeological material, volcanic rocks and sediments as past geomagnetic field recorders: New data, methods and applications.” EGU General Assembly 2014; Vienna, Austria.
- F. Florindo (INGV) Convenor sessione “Environmental Magnetism in Climate, Stratigraphy and Environmental Studies”. AGU, San Francisco, Dicembre, 2014.

- A. De Santis (INGV) co-organiser of the International Scientific Spring (ISS-2014), Islamabad (Pakistan) March 2014.

B5) Prizes

- G. Currenti (University of Catania) IAGA Medal at the IUGG meeting (Melbourne 2011)
- A. De Santis (INGV) has been appointed as Vice-President of the Earth Magnetism and Rock Physics (EMRP) Division of the European Geoscience Union (EGU) in the years 2012-2014.

C) Goals, priorities and plans for future activities

C1) Main Scientific Themes

- Development of an integrated network of research infrastructures, in particular rock physics labs, in the framework of the EPOS project
- Integrated magnetostratigraphy, as a high-resolution correlation and dating tool for marine and continental stratigraphic sequences even in sequences representing GSSP
- Paleomagnetism applied to geodynamics; new experimental data and insights for understanding the evolution of the central Mediterranean and the genesis of complex orogens
- Environmental magnetism as an original proxy for the reconstruction of paleoenvironmental and paleoclimatic changes, with particular emphasis on the Mediterranean and both polar regions
- Environmental magnetism, as an original tool to investigated particulate matter air pollution
- Reconstruction of paleosecular variation of the geomagnetic field for the Holocene and relative paleointensity for the Pleistocene. Application to correlation and dating of geologic events with implication for the evaluation of volcanic and seismic risks.

C2) Main Research Projects/Programmes

- European Plate Observing System (EPOS)
  Funding agency: European Community
- Studio multidisciplinare dei sedimenti glaciomarini deposti nel Mare di Ross (Antartide) negli ultimi 50 Ka: informazioni sulle fluttuazioni dell'estensione dei ghiacci nel corso della transizione glaciale-interglaciale
  Funding agency: PNRA
- NEXTDATA un sistema nazionale per la raccolta, conservazione, accessibilità e diffusione dei dati ambientali e climatici in aree montane e marine
  Funding agency: MIUR
- Indagini ad alta risoluzione per la stima della pericolosità e del rischio sismico nelle aree colpite dal terremoto del 6 aprile 2009
  Funding agency: MIUR
- Reconstructing 2500 years of environmental change at the periphery of Rome: Integrating paleoecology and socioeconomic history to understand human response to climate
  Funding agency: NSF
- ARctic: present Climatic change and pAst extreme events (ARCA) MIUR
- PRIN Geochimica, geodinamica, e cinematica delle placche nel Mar Rosso.
  Funding Agency: MIUR.

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

A) Institutions involved in research activity

1. Istituto Nazionale di Geofisica e Vulcanologia, Roma ;
2. Istituto dei Sistemi Complessi, Consiglio Nazionale delle Ricerche, Firenze
3. "Abdus Salam " International Centre for Theoretical Physics, Trieste.

B) Scientific Report

B1) Main Scientific Themes
Istituto Nazionale di Geofisica e Vulcanologia

- **HF and L-band ionospheric monitoring**

  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.

  Hourly systematic measurements of the critical frequency of the F2 layer, foF2, recorded at the Rome and Gibilmanna 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.

  Power Virtual Height measurements (PVH) of radio echoes reflected from the ionosphere acquired at the Rome ionospheric observatory have been used to study the multipath fading variations through time of the ionospheric channel on a temporal scale from 0.5 to 256 s.

  INGV is managing a network of high rate (50 Hz) sampling GNSS (Global Navigation Satellite Systems) receivers at polar, equatorial and mid-latitudes. The network now counts instruments in Antarctica (at Mario Zucchelli Station and at Concordia), in Arctic (at Svalbard Islands), in the Mediterranean area (lampedusa and Rome, Italy; Crete, Greece) and in Argentina (Tucuman). Through a network funded by different project INGV cooperates also to the operation of similar receivers in Brazil. Such observations are used to investigate the irregular behaviour of the ionosphere causing scintillation, a diffractive and refractive effect on the trans-ionospheric signals transmitted by GNSS satellites. INGV has achieved a robust expertise in modelling the scintillation and has activated several international collaborations in the field.

- **Ionospheric morphology and modelling**

  Unusual nighttime impulsive electron density enhancements that are rarely observed at low latitudes on a wide region of South America, under quiet and medium/high geomagnetic conditions, were analyzed. A detailed analysis of isoheight ionosonde plots suggests that traveling ionospheric disturbances (TIDs) caused by gravity wave (GW) propagation could play a significant role in causing the phenomenon both for quiet and for medium/high geomagnetic activity; in the latter case however a recharging of the fountain effect, due to electric fields penetrating from the magnetosphere, joins the TID propagation and plays an as much significant role in causing impulsive electron density enhancements. An atypical nighttime spread-F structure appearing on ionograms at or above the F2 trace, near the crest of the ionospheric equatorial ionization anomaly (EIA) region, was investigated. The phenomenon appeared to be the signature of MSTIDs propagating above or at F2-layer peak that generates an extra ionospheric structure just above or at the F2-layer, during nighttime. A

comparative study of spread-F signatures over five low-latitude sites was performed. The study confirmed that the dynamics and the physical processes responsible for these phenomena are actually complicated. In fact, the features that arise from the investigation are different, depending both on the longitude sector and on the hemisphere. A spread-F and GPS scintillation statistics of occurrence under the southern crest of the equatorial ionospheric anomaly was carried out. The most striking features coming from the study were a systematic correspondence between SSF (Strong Range Spread-F) and scintillations, and a possible correlation between S_4 and FSF (Frequency Spread-F) peaks at the terminator. Assuming that both ftEs and h'Es trends are influenced by the atmospheric tides, the height–time–intensity (HTI) technique was applied to deeply investigate how these waves control the Es dynamics. The HTI study, along with a fast Fourier transform analysis, show that a well-defined semidiurnal periodicity characterizes the Es layer dynamics most accurately in June and July, while in August and September the daytime semidiurnal periodicity becomes weaker and the role of the diurnal periodicity is consequently highlighted. The behavior of the critical frequency of the F2 region of the ionosphere (foF2) and the height of the maximum density of free electrons in F2region (hmF2) over Tucumán (26.91S, 294.61E), during the deep solar minimum occurred in 2008–2009. Data used were compared with those obtained at solar minimum observed in 1975–1976. An ionospheric service was implemented in the Mediterranean area around Nicosia (Cyprus) in terms of: plots in real-time of the ionospheric characteristics foF2 and fmin recorded by the digisonde installed at Nicosia; nowcasting and long-term maps of foF2, M(3000)F2, and MUF (with the transmitting point located at Nicosia) over a regional area around Nicosia.

A short-term ionospheric 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, as well as a short-term ionospheric forecasting empirical regional model to predict M3000F2 over Europe during not quiet geomagnetic conditions plus a method for foF2 short-term (1–24 h) forecast using both historical and real-time foF2 observations over European stations, EUROMAP model, has been developed. The predictions of M3000F2 are obtained correcting the monthly median field of M3000F2 with the Bradley - Dudeney formula that depends on the short-term predictions of foF2 provided by IFERM model. 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. A comparative study between the sporadic E layers over the ionospheric stations of Rome and Gibilmanna has been carried out using hourly systematic measurements of the highest frequency reflected by the *Es* layer (*foEs*) recorded during the period January 1976 - July 2008 at the Rome and Gibilmanna ionospheric observatories. Power Virtual Height measurements (PVH) of radio echoes reflected from the ionosphere acquired at the Rome ionospheric observatory have been used to study the multipath fading variations through time of the ionospheric channel on a temporal scale from 0.5 to 256 s A three-dimensional (3-D) IRI-SIRMUP-P (ISP) model of electron density of the ionosphere was developed and tested over several periods characterized by very disturbed geomagnetic conditions. The three-dimensional (3-D) electron density representation of the ionosphere computed by the assimilative IRI-SIRMUP-P (ISP) model was used in connection with IONORT (IONOspheric Ray-Tracing), a software application for calculating a 3-D ray-tracing in the ionospheric medium. For testing the reliability of IONORT-system, several comparisons between measured oblique ionograms over the radio link between Rome (41.8_N, 12.5_E) and Chania (35.7_N, 24.0_E), and synthesized oblique ionograms from the IONORT – system have been performed. In the framework of the project ESA Space Weather Network -IV3 project European ionosonde and neutron monitor services, two original software for the achievement of maps of foF2 and M3000F2 extending from 34°

N to 80° N in latitude and from -10° W to 40° W in longitude are under development. In the framework of the project CIFS (Cyprus Ionospheric Forecasting Service), long term and nowcasting maps of the maximum usable frequency (MUF) were generated over the east region of Mediterranean extending from 30° N to 40° N in latitude and from 20° W to 45° W in longitude. Studies concerning the effects of Small Scale Disturbance (SSD) on signal fading and coherence times of the ionosphere have been conducted on the basis of vertical ionospheric soundings at 3 MHz performed at the Rome ionospheric observatory. A short-term forecasting regional model (STFRM), based on the integrated geomagnetic index ap(τ) has been developed to predict M(3000)F2 over the European area during moderate, disturbed, and very disturbed geomagnetic conditions. The possible relationship between thunderstorms and the ionospheric sporadic E Layer over Rome has been investigated using the superposed epochs analysis. Studies about the possible influence of solar cycle on the critical frequencies of the mid-latitude sporadic E layer have been carried out using the Continuous Wavelet Transform technique, Fast Fourier Transform, and linear regression analyses. In order to obtain a three dimensional electron density mapping of the ionosphere up to three hours in advance, studies concerning the achievement of short term forecasting of electron density profiles over some stations located in European area are in progress.

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 new mechanism (qualitative) to explain the December anomaly in NmF2 is proposed. A new method has been developed to retrieve neutral temperature Tn and composition [O], [N_2], [O_2] from electron density profiles in the daytime mid-latitude F2-region under both quiet and disturbed conditions.
Other themes of main interest are: empirical and theoretical modeling of ionospheric scintillations to forecast and mitigate the ionospheric corruptions on GNSS signals; scientific understanding of the cause-effect mechanism leading from the ionospheric irregularities formation to the scintillation effects; structuring and accessibility of the ionospheric data for real-time and post processing use. The empirical and theoretical modeling of ionospheric scintillations is based on the experience matured on the analysis of the data owned by INGV and its partners. The modelling is addressed to forecast and to mitigate the ionospheric corruptions on GNSS signals. The experimental activity allowed to advance the scientific understanding of the cause-effect mechanism leading from the ionospheric irregularities formation to the scintillation effects. The significant amount of data collected since 2003 has been structured and made accessible to registered users via the eSWua Database: www.eswua.ingv.it.

Istituto dei Sistemi Complessi, Consiglio Nazionale delle Ricerche, Firenze
During the years 2010-2014 CNR's activity in the field of near-Earth space research has been concentrated mainly in the study of the dynamics of complex/irregular plasmas and near-Earth space imaging/observation. CNR team conducts the project named ISIS, ESA-CNR about the observation of the Earth's plasmasphere.

Abdus Salam " International Centre for Theoretical Physics, Trieste.
The Telecommunications/ICT for Development Laboratory (T/ICT4D) (formerly Aeronomy and Radiopropagation Laboratory) of the Abdus Salam International Centre for Theoretical Physics has concentrated its ionosphere research and applications work in the following lines: Earth and Mars Ionosphere modelling, data ingestion and assimilation in models, use of radio occultation for ionosphere characterization, lower latitudes ionosphere, ionosphere effects in GNSS operations at range and position domains. The work has been carried out in collaboration with groups of European and African universities.

B2/3) Main Research Projects/Programmes and funding Agencies

- CIGALA project "Concept for Ionospheric Scintillation Mitigation for Professional GNSS in Latin America" FP7, Collaborative projects, GALILEO 2008GSA, 2010-2012.
- ESPAS: "Near-Earth Space Data Infrastructure for e-Science" a FP7 project.
- Royal society Project: in collaboration with University of Nottingham and INGV funded by the Royal Society (UK): "Original and Novel Solutions to Counter GNSS Ionospheric Scintillation Effects", 2010-2012;
- Research Project IDIPOS "Italian Data Base Infrastructure for Polar Observation Science", funded by National Program of Antarctic Research (PNRA).
- Research Project 2009/B03 "Upper Atmosphere Observations and Space Weather", 2009-2012, funded by National Program of Antarctic Research (PNRA).
- SWING : (Short Wave Critical infrastructure Network based on new Generation prediction Tools) EU Directorate Justice,Freedom and Securety. 2012- 2013
- TELEDIFE :Training courses and Ionospheric radio propagation prediction; Minisistry of Italian Defense
- TRANSMIT project (Training Research and Applications Network to Support the Mitigation of Ionospheric Threats), 2011-2015, FP7 Marie Curie-ITN.
- MIMOSA, GINESTRA, MEDSTEC 2012-2013, ESA Alcantara initiatives to survey the ionospheric monitoring capabilities over South America, Africa, Asia.
- Funding Agencies : FP7, ESA, PNRA, Minisistry of Italian Defense.
- CALIBRA (Countering GNSS high Accuracy applications Limitations due to Ionospheric disturbances in BRAzil) FP7, 2012-2014.
- MIMOSA2, ERICA 2014-2016, Continuation of ESA Alcantara initiatives.
- MISW (Mitigation of space weather threats to GNSS services), FP7, 2014-2016.
- DemoGRAPE, PNRA, 2014-2016.
- CIFS ,Cyprus Ionospheric Forecasting Service, 2012-2014

B4) Organization of conferences and Workshop of international relevance

- M.Pezzopane as convenor of the session "S4: Space Weather effects on HF and trans-ionospheric radio wave propagation" at the 10th European Space Weather Week, Antwerp, Belgium, 18-22 November 2013.
- M.Pezzopane as member of the "Scientific Organizing Committee" of the session "C1.1: Recent Advances in Equatorial, Low- and Mid-Latitude Mesosphere, Thermosphere and Ionosphere Studies" at the COSPAR (Committee on SPAce Research) scientific assembly, Mysore, India, 14-22 July 2012.

B5) Prizes

- M. Pezzopane: 2013. First prize for the best communication presented at the XCIX National Congress of the Italian Physical Society, held in Trieste from 23 to 27 September 2013, Section 4a "Geophysics, Environmental Physics, Oceanography"; title of the communication "Unusual nighttime impulsive enhancements of electron density characterizing the low-latitude ionosphere: phenomenology and possible mechanisms of triggering".

C) Goals, priorities and plans for future activities

- The study of TEC and ionospheric scintillation will be further advanced to improve the scientific understanding and to increase the performance of the forecasting and mitigation modeling. The results of new studies on the ionospheric impact on the SAR observations and on the regional assessment of the polar scintillations will be presented in the next 2 years.
- Different spectral analyses will be employed to investigate the tidal and planetary wave periodicities imprinted in the following two main characteristics of the sporadic (Es) layer: the top frequency (ftEs) and the lowest virtual height (h'Es). Studies are planned to verify the

influence of the solar activity on the Es layer. The behavior of the ionospheric plasma in correspondence of the anomalous and prolonged minimum of solar activity between cycles 23 and 24 will be investigated.

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

A) Institutions involved in research activity

1. Institute of Space Astrophysics and Planetology of the Istituto Nazionale di Astrofisica (INAF-IAPS)
2. Istituto Nazionale di Geofisica e Vulcanologia
3. Department of Physics of the University of L'Aquila

B) Scientific Report

B1) Main Scientific Themes

Physics of the Magnetosphere.

The magnetospheric studies in Italy are mainly focused on 1) the interaction between the solar wind and the planetary magnetospheres (mainly the Earth's magnetosphere), 2) the Earth's magnetospheric dynamics, 3) the processes responsible for the plasma transport in the magnetospheric regions, and 4) the Earth's magnetosphere-ionosphere coupling.

During 2010-2011 a particular interest has been devoted to the study of acceleration plasma processes, such as magnetic reconnection, which are responsible for the enhancement of plasma transfer and transport in the inner magnetospheric regions, and to the study of ULF waves and pulsations, of the emergence of complexity and the role of turbulence and intermittence in the global magnetospheric dynamics. These studies are mainly based on magnetic field and plasma data recorded on-board of magnetospheric spacecrafts (e.g., CLUSTER, Geotail, Double-Star,....) and on ground-based geomagnetic and ionospheric observatories. Using data coming from Cluster and Double Star TC-1, it has been possible to study the interaction of the solar wind with the terrestrial magnetosphere. In particular, research has been performed concerning processes like reconnection, interaction of interplanetary shocks with the magnetosphere. Such research has been funded by ASI in the framework of the contract I/023/09/0 which ended in June 2012. Using detailed Double Star observations of proton distribution functions and magnetic field data around a Flux Transfer Event (FTE) at the terrestrial magnetopause, useful information on the FTE generation mechanism have been obtained. These observations have suggested that two X lines active at the magnetopause are probably the generation mechanism of the observed FTE confirming the Lee and Fu FTE model of multiple reconnection X lines rather than the patchy reconnection proposed in the Russell and Elphic model. In the last two years a detailed study of the magnetic and electric field fluctuations at the kinetic scale has been done. This study allowed to reveal the emergence of different scaling features at scales below the ion-inertial length during magnetic reconnection.

Special attention has been paid to the study of the magnetic storms and substorms, which are two important manifestations of the interaction between the solar wind and the Earth's magnetic field. The relationship between these two phenomena is a key point in the study of the Sun-Earth connection and despite numerous studies conducted over the past years, there are still problems that are not completely solved. In this context, during the period 2011-2012, the relationship between these two classes of magnetospheric phenomena has been studied through an approach based on the information theory. In detail, the dependence of the information transfer on the conditions of the solar wind has been investigated. It has been found that the flow of information between these two classes of magnetospheric phenomena depends on the global level of magnetic activity. The influence (in terms of information flows)

of substorms on storms is maximum in the case of moderate/intermediate geomagnetic activity level while the driving of storms by substorms seems to be less effective during intense magnetic storms. Furthermore, studying the multiscale features of some large geomagnetic storms by applying the empirical mode decomposition technique it has been shown that there is an increase of dynamical complexity and multi-scale properties for intermediate geomagnetic activity levels. This increase seems to reflect the influence of substorms to storms that is maximum during these periods. In contrast, during low and high geomagnetic activity levels, the geomagnetic field fluctuations seem to be a consequence of a very stochastic dynamics, similar to the global dynamics that characterize a Markovian nonequilibrium relaxation process.

Using geomagnetic field data collected on the ground, the magnetospheric dynamics has been investigated analyzing the low frequency geomagnetic pulsations and the daily variation of the Earth's magnetic field. In detail, the analysis of magnetic data collected by geomagnetic observatories placed at high latitude all located within the polar cap but at different distance from the auroral oval (Antarctic and Artic) has allowed analyzing the diurnal variation of the magnetic field. The results have shown that the diurnal variation strongly depends on the position within the polar cap, both regarding its shape and its dependence on season, solar wind and magnetospheric parameters. At the same time, a statistical analysis of low frequency (1-5 mHz) pulsations, at different Antarctic stations situated along the same geomagnetic parallel (80S) within the polar cap, has allowed to study the azimuthal propagation 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; they are interpreted in term of cusp-related and geomagnetic tail-related phenomena, respectively; these signals are well coherent between station spaced up to 5 hours in magnetic local time. The analysis, conducted also using data from Cluster and Geotail, has suggested that waves can transmit across the magnetopause flanks and tail lobes and, propagating along the outermost field lines, reach the ground at polar latitudes. The ULF magnetometer stations, which have allowed to achieve positive results on the dynamic magnetospheric studies, have been installed in a new area. Indeed, as responsible of the Work Package "Retrieval of equatorial plasma mass densities by magnetometer arrays and cross-calibration" an Italian group of researchers has participated to the activities connected to the FP7 Project PLASMON ("A new, ground based data-assimilative model of the Earth's plasmasphere - a critical contribution to Radiation Belt modeling for Space Weather purposes", 2011-2014). In the framework of this project, a new latitudinal array of 25 ULF magnetometer stations (EMMA) extending from Italy to Finland (including SEGMA) has been created. A code has been developed to deduce in quasi-real-time the equatorial plasma mass density at different L-shells using the field line eigen-frequencies automatically determined from the EMMA array and the real-time solar wind parameters from the ACE satellite which are necessary for modelling the magnetospheric field by the Tsyganenko model. Data coming from ULF magnetometer stations have been used to analyze the possibility that electromagnetic signals can precede the occurrence of an earthquake. In particular, everal papers have been dedicated to the possible occurrence of electromagnetic signals preceding the L'Aquila earthquake (6 April, 2009) mostly in the ULF range. The results do not show, in general, any clear evidence for ULF precursors.

In the year 2013 the INAF-IAPS group started an international collaboration in the framework of the actrivities connected to the FP7 Project STORM (Solar system plasma turbulence, observations, intermittency and multifractals) coordinated by Dr. Marius Echim of the BIRA-IASB (Brussels, Belgium). This project aims to investigate the relevance and the feaures of intermittent turbulence in several interplanetary and near-planetary environments, among which Earth's and planetary magnetosheaths from the magnetohydrodynamic scales to the kinetic ones. Furthermore, the project is also devoted to the analysis of the intermittent and

multifractal properties of short- and long-term magnetospheric dynamics as it results from the analysis of the features of geomagnetic inidces time series. Preliminary results (communicated to international meetings - papers in preparation) have clearly shown how the critical nature of the Earth's magnetosphere depends on the solar cycle.

The Italian community (INGV and INAF-IAPS groups) started a study of the turbulent and scale-invariance featuers of the magnetic field variations on short temporal and small spatial scales as observed by the novel ESA mission Swarm, lauched in the late 2013. The aim of these studies is the understanding of the influence of the different magnetospheric disturbances (magnetic storms and substorms) and currents on the ionospheric turbulence for a better understanding and modeling of the inner magnetospheic dynamics and magnetospher-ionosphere coupling. The first results, relative to the investigation of the high latitude scaling features of the horizonthal component of the magnetic field, allowed for the characterization the turbulent spectra as a function of the geomagnetic activity level (AE-index) in the polar regions.

Finally, the Italian community is involved in the studies concerning the global solar wind - magnetosphere - ionosphere coupling and the inter-hemispheric magnetic conjugacy. Such studies are performed throughout the measurements provided by the SuperDARN network. In relation to this activity, in late 2012 – early 2013 the Dome C East radar has been successfully installed in the framework of a French-Italian co-operation (LPC2E-CNRS and INAF/IAPS). The context of solar wind - magnetosphere - ionosphere coupling includes also the analysis of SI (Sudden Impulses) events, which have been measured both at geostationary orbit and on the ground. This analysis, allowing careful comparisons with theoretical models of the magnetospheric field representation, has been useful to distinguish the contribution of magnetospheric and ionospheric current systems to the magnetospheric and geomagnetic perturbations.

B2) Main Research Projects/Programmes

- **PNRA-PEA (U. Villante, resp.)**
  Title: ULF pulsations, magnetospheric dynamics and Space Weather aspects at polar latitudes (2011-2013).
- **FP7-SPACE-2010.2.3-1 PLASMON (M. Vellante, resp.)**
  Title: A new, ground based data-assimilative modeling of the Earth’s plasmasphere - a critical contribution to Radiation Belt modeling for Space Weather purposes (2011-2014).
- **FP7-SPACE-2012.2.1-01 STORM (M. Echim - BIRA, Brussels, Belgium-, resp., G. Consolini Italian group resp.)**
  Title: Solar system plasma turbulence: observations, intermittency and multifractals (2013-2015).
- **PNRA-PEA (L. Cafarella, resp.)**
  Title: Osservazioni di geomagnetismo ed elettromagnetismo in Antartide.
- **PNRA-PEA (M.F. Marcucci, resp.)**
  Title: Studio bipolare di fenomeni magnetosferici con SuperDARN ed osservazioni ottiche e magnetiche (2014-2016).

B3) Funding Agencies

- Italian National Programme for Antartica Research (PNRA)
- Italian Space Agency (ASI)
- European Commission (FP7-Space Call)

B5) Prizes

In the year 2011 Prof. Umberto Villante received the "Antonio Feltrinelli" Prize on Astronomy, Geodesy, Geophysics and applications, assigned by the Italian Accademia dei Lincei, for his relevant scientific activity in the field of interplanetary space and magnetospheric physics.

C) Goals, priorities and plans for future activities (next two years, max 1 page)

In these next two years the scientific activities of the previous period will continue. In particular, the Italian groups will devote to:

- The studies of the interaction of solar wind structures with the Earth's magnetosphere, with a special emphasis to the influence of the magnetospheric and ionospheric current systems in the manifestation of magnetic storms and substorms, as well as sudden impulses of the magnetospheric and ground field. Always in this framework a particular attention will be devoted to the investigation of the role of turbulence, intermittency and multifractal features of the geomagnetic disturbances and in situ satellite measurements (FP7 STORM project);
- The analysis of ULF waves (10-100 mHz) and geomagnetic pulsations in the solar wind, magnetosheath, magnetosphere, and at low and Antarctic latitudes. These studies will concentrate on the short and long term variations of the magnetospheric activity, through the analysis of long series of ULF magnetic measurements and geomagnetic pulsations, to investigate the possible influence on the different layers of the Earth’s atmosphere. This research will benefit of the data from the new geomagnetic station at Talos Dome;
- The remote sensing of the plasma mass density in the plasmasphere by 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);
- The study of plasma processes in the ionosphere conditioned to solar wind conditions. It is foreseen to install the second radar at Dome C, the Dome C radar North (Italian PNRA - project), which will fill existing gaps in latitudinal coverage of SuperDARN network in the Southern Hemisphere.
- The study of the turbulence features of the magnetic field in the framework of the magnetosphere-ionosphere coupling and as a function of the geomagnetic activity level.
- Investigation of the features of magnetic field fluctuations also in planetary magnetospheric envronments beyond the Earth's one, such as Mercury.

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

A) Institutions involved in research activity

- INAF-OATO (Turin) – studies of the extended corona and the origin, acceleration and transient perturbations of the solar wind. PI-role in ESA/Solar Orbiter-METIS instrument
- INAF-OAA & Astronomy Dpt. Univ. of Florence – studies of explosive phenomena, solar surface magnetism, solar instrumentation, and theory of the generation and transfer of polarised radiation in the solar atmosphere and the solar corona.
- INAF-IAPS (Rome) – studies related to solar wind plasma, solar energetic particles and cosmic rays; design and realization of plasma sensors; management of IAPS Large Plasma Chamber for ionospheric payloads plasma environmental tests; CoPI-role in ESA/Solar Orbiter-SWA(Solar Wind Analyzer) instrument
- INAF-OAR (Rome) – studies of solar irradiance; involved in the Conceptual Design Study of the EST; continuous management of the PSPT telescope (RISE project) for acquisition of photometric images of the whole Solar disk.
- INGV (Rome) – Space-Weather studies with particular emphasis on ionospheric perturbations following the IMF-solar wind coupling with the Earth's magnetosphere
- Physics Dpt., Univ. Roma Tor Vergata – studies of the dynamics of solar photosphere; involved in the Conceptual Design Study of the EST; leading role in a small space mission in response to ASI-Small Missions Program call; participation to space weather awareness programme.
- Physics Dpt., Univ. L'Aquila – studies related to the solar wind properties;
- Physics Dpt., Univ. Cosenza – theoretical studies on space plasma kinetic properties; solar wind data analysis and modeling;
- INAF-OACt & Physics Dpt., Univ. Catania – studies of solar active regions and eruptive phenomena with data analysis and modeling; involved in the Conceptual Design Study of the EST.

B) Scientific Report

B1) Main Scientific Themes

- **Solar Wind and MHD Turbulence in Space Plasmas**

  One of the central scientific interests of Division IV is the study of the solar wind and, more in general, the problem of MHD turbulence in space plasmas. In particular, the study has been devoted to the following topics: i) Statistical investigation of the MHD invariants of magnetic fluctuations in the interplanetary space, particularly within flux ropes, ii) radial evolution of density fluctuations intermittency during the expansion of the solar wind in the inner heliosphere, iii) radial evolution of the spectral break location between fluid and kinetic scales, iv) flattening of the spectral slope at proton scales moving from fast to slow wind, v) characterization of fluctuations within the kinetic regime as a function of wind speed and radial expansion, vi) study of the intermittency at proton scales.

  Other studies have been made on the possible role that turbulence and magnetic coherent structures advected by the wind have in the modulation of Solar Energetic Particles produced by impulsive events.

  Finally, the role of turbulence in solar wind heating has been evaluated estimating the energy transferred across the inertial range of the spectrum of the fluctuations to be dissipated at ion and/or electron scales. In addition, theoretical speculations, based on the available data, have been proposed about the nature of the fluctuations within the kinetic range.

Other studies have been conducted on reconnection events in the solar wind, l) model vs observations for turbulence transport in the solar wind, 2) study of twisted magnetic flux-tubes in the solar wind.

- **Participation in ESA-Solar Orbiter Mission**
  Within the participation to SOLAR ORBITER-SWA, the involvement is both managerial and scientific.
  INAF-IAPS is the Italian leading Institute, at Co-PI level, for the national participation in the Solar Wind Analyser (SWA) experiment on board Solar Orbiter. The project is now in phase C-D and INAF-IAPS is working on the provision of the common Data Processing Unit which will manage the whole plasma suite made of 4 sensors dedicated to protons, electrons and minor ions.
  Moreover, the related scientific activity mainly focusses on the use of numerical simulations apt to produce the ions and electrons velocity distributions for different solar wind conditions. The main goal is that of setting up the best measurement strategy to be adopted by SWA consistently with the DPU computational performances and the available telemetry.

- **Solar Photospheric Dynamics**
  Another important scientific themes is the dynamics of solar photosphere, particularly the convective regime present in the outer layers of the sun. This topic is tackled by means of experimental techniques, images analysis procedures and numerical simulations:
  Experimental techniques: realization of solar image acquisition systems based on CCD and CMOS detectors for panoramic Fabry-Pèrot based monochromators (IBIS@DST/NSO) and achievement of observational campaigns at various ground-based telescope often coordinate with spatial instrumentation.
  Image analysis: realization of automatic procedure of image segmentation (dynamic and optimal threshold, Medial Axis Transform, skeleton, spatial operators) and investigation of statistical tools for pattern analysis.
  Numerical simulation: realization of dynamical models of passive magnetic advection.
  Particular interest has been dedicated to estimate the possible contribution of the jets X to the solar wind. Mass flux has been evaluated after an accurate detrmination of the physical parameters. This study showed that jets, in particular blowout jets, are not sufficient for the solar wind. Also the contribution coming from the plumes has been estimated and, also in this case, an upper limit contribution, possibly of only 60%, has been determined.

- **Solar Energetic Particles**
  Efforts have been devoted to study the acceleration and propagation of solar energetic particles (SEPs) in the interplanetary space as well as their interaction with the Mercury's environment. Moreover, the general features of the cosmic ray modulation, such as most of the step-like decreases and the Gnevyshev Gap phenomenon, have been investigated through non stationary data processing methods (e.g., empirical mode decomposition and wavelet analyses) in association with the variability of solar activity and the interplanetary magnetic field. The same analyses have been applied to the photospheric magnetic field data to understand the spatio-temporal dynamics of the solar magnetic field.

- **Space Weather**
  This research, mainly performed by means of GPS sampling measurements at 50 Hz, allows the study of the ionospheric irregularities causing scintillation on the trans-ionospheric signals transmitted by GNSS satellites. The experimental observations can provide information useful for purely scientific advancements and for improve the predicting capabilities for Space Weather purposes. As a matter of fact, the original development of scintillation models needs to characterize the ionosphere also as function of the interplay between IMF-solar wind and ionosphere. Another topic on which this Division is working on is about 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).

B2) Main Research Projects/Programmes

- SOLAR ORBITER: Supporto Scientifico per la Realizzazione degli Strumenti METIS e SWA_DPU. The related ASI contract for phase A-B1 ended in September 2011. The new contract for phase B2-C1 started in May 2012 and will last 3 years.
- EST: European Solar Telescope Conceptual Design Study financed by the European Commission
- SPARC: Space Awareness for Critical Infrastructure: European Commission - Directorate-General Home Affairs
- BEPI-COLOMBO: BepiColombo (SIMBIOSYS, ISA, PHEBUS, MEA, MIXS, SIXS) – The related ASI contract for phase B2/C will end in June 2013
- GRAPE (GNSS Research and Application for Polar Environment) Expert Group funded by SCAR (www.grape.scar.org)

B3) Funding Agencies

- European Commission: FP7 and Directorate-General
- ASI: Italian Space Agency
- SCAR: Scientific Committee for Antarctic Research

B4) Organization of Conferences and Workshop of international relevance

- EWASS2012 Symposium 8 - The Sun: new tools and ideas in observational solar astrophysics
- EWASS2012 Special Session 11 - From solar physics to astrophysics: the Sun as Rosetta stone for understanding astrophysical processes
- SOC-5th Earth-Sun-Exploration conference, hold in January 2013
- Co-Chair of Solar Wind XIII-2012-Session II – "The dynamical behavior of the interplanetary medium throughout the heliosphere, including large- and small-scale structures, the evolution of disturbances, dissipative processes, including turbulence, and energetic particles";
- Chair of Solar Wind XIV-2015-Session II "Solar wind (quiescent and transient) evolution: processes, structures, waves, and turbulence"
- ISSS course on: "Frontiers of Space Science: from Solar Activity to NEOs" held in L'Aquila, (17 – 22 April 2011) directed by F. Berrilli, A. Celletti (University of Roma "Tor Vergata"), E. Flamini (ASI) and D. Mueller (ESA).
- ISSS course on: "Astrophysical and Space Plasmas" held in L'Aquila, (2 – 7 September 2012) directed by A. Ferrari (CIFS, Torino & University of Torino), M. Tavani (INAF-IAPS & University of Roma "Tor Vergata"), B. Coppi (M.I.T., Cambridge , USA), R. Rosner (University of Chicago, USA)
- ISSS Course on: "Towards a Deeper Understanding of the Sun and the Heliosphere with Solar Orbiter – The first Solar Orbiter School" directed by R. Bruno (INAF-IAPS), E. Antonucci (INAF-OATO) and D. Mueller (ESA), L'Aquila, 22-25 Sept. 2014
- Science Working Team of the Solar Orbiter mission organized by European Space Agency, L'Aquila 25-27 Sept. 2014

B5) Prizes/Recognitions

- D. Telloni (INAF-OATO) received the Second Edition (2011) of Premio Ferraro Award, for the best PHD thesis on MHD studies in astrophysical or laboratory plasmas
- The Minor Planet Center (MPC) under the auspices of the IAU Division III designates the asteroid 7918 = 1981 EJ22 with the name Berrilli.

C) Goals, priorities and plans for future activities

- SOLAR ORBITER: the ASI scientific contract “Supporto Scientifico per la Realizzazione degli Strumenti METIS e SWA_DPU nelle fasi B2-C1” started in May 2012 and will end in May 2015. A new contract is expected to start afterwards to last another three years, covering the delivery phase of SWA FM to ESA. In the meantime, the scientific team supports the industry during the production of the required deliverables.
- BEPI-COLOMBO: recently, because of financial difficulties, ASI decided not to support further activities related to Bepi-Colombo not having a PIship or CoPIship involvement in this program. Despite that, the scientific collaboration on energetic particles will continue as much as possible on the simulation of the propagation of SEPs in Mercury’s magnetosphere as well as of the flux of secondary particles produced by interaction with the planetary surface. In addition, evolution of SEP events of different intensities will be studied for the correlation between the observations of the SEP radiation monitor, designed for the LISA Pathfinder mission, and the particle fluxes charging the gravitational sensor test masses.
- STORM(FP7): Solar system plasma Turbulence: Observations, inteRmittency and Multifractals. This project will use large datasets instead of focusing on particular events, to advance the understanding of fundamental processes such as the turbulent energy transfer, the intermittent turbulence and multifractals in astrophysical plasmas.
- SOLARNET(FP7): High Resolution Solar Physics Network: is the solar successor of OPTICON, and start in April 2013. Main objectives are to provide access to European Solar telescopes and instruments, and to develop data pipelines and innovative instrumentations such that science-ready data is easily available for users of the ACCESS program.
- MISW(FP7): Mitigation of space weather threats to GNSS services (2013-2015)

DIVISION V:

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

1) GEOMAGNETIC OBSERVATORIES

In Italy, for the years of concern, INGV has taken care of activities of 6 magnetic observatories:

Observatory	IAGA code	Latitude	Longitude	Elev. (asl 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
Duronia	DUR	41°39'N	14°28'E	918
Lampedusa	LMP	35°31'N	12°32'E	33

All observatories are operated by INGV except (*) in cooperation with PNRA and (**) in cooperation with PNRA and France, IPEV.

- **L'AQUILA**

On April 6th 2009, L'Aquila and surroundings, were struck by a very bad M=6.2 earthquake that destroyed the city and killed 309 people. This 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, was asked back by L'Aquila University (the original landlord) for new student housings. L'Aquila was an INTERMAGNET Observatory and for this observatory, K magnetic activity indices, SSC, SFE and SI notifications were made. As now we are still waiting for an official request for moving out, but standard INTERMAGNET activity was interrupted.

The Observatory started its activity in 1958 and yearbooks from 1960 onwards were published; last published as now is 2009. Today the main observatory in central Italy is located in Duronia, but a complete system is still running in the buildings of this old geomagnetic observatory. Observations are made by means of an Overhauser magnetometer for the measurement of the field intensity F and a fluxgate magnetometer, for the measurement of H, D and Z component variations. The instruments have a 0.1 nT resolution; original sampling rate is 1 Hz, then the data are filtered with a Gauss filter and recorded at 1 min.

- **CASTELLO TESINO**

The Observatory of Castello Tesino (Northern Italy) is located about fifty-five km East from Trento. It has been working almost continuously since 1964. It works now 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. After a trial period, the old house was finally left in April 2012. In the same period the power supply was converter from AC 220 V to DC 12 V in order to improve the quality of measurement systems. Two systems are currently working simultaneously in the new wooden building.

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 measurements made by the scalar magnetometer . The geomagnetic field is recorded by means of two parallel systems, each constituted by a proton precession magnetometer (Overhauser GEM-GSM90) for the measurement of the total magnetic field intensity F and a tri-axial fluxgate magnetometer (LEMI-017) for the measurement of the H, D and Z component variations. The 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. At this time all yearbooks from 1996 to 2013 were completed, all regularly published as standard booklets. From 2010 yearbooks are not printed but are available on the website of INGV.

At this time the yearbooks from 1996 to 2013 are available on the INGV website (http:// roma2.rm.ingv.it/en/facilities/geomagnetic_observatories) where the monthly bulletins are also available.

- **TERRA NOVA BAY (MARIO ZUCCHELLI STATION)**

This Observatory was installed during 1986-87 austral summer at the Italian Antarctic Mario Zucchelli Station. In the first years geomagnetic field measurements 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.

When absolute measurements are available (summer) results, including hourly mean data, are published on pdf booklets (so far completed up to 2010-2011). Results are available at INGV website: http://roma2.rm.ingv.it/it/risorse/banche_dati/32/dati_osservatorio_di_stazione_mario_zucchelli/46/annuari.

- **CONCORDIA (CONCORDIA STATION)**

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 station 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.

- **DURONIA**

Since the end of 2007 an electromagnetic field monitoring station has been in operation 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 was completed to include a full geomagnetic equipment to follow IAGA requirements. On August 28, 2012 Duronia has been accepted as an INTERMAGNET Magnetic Observatory (IMO).

- **LAMPEDUSA**

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 two fluxgate vector magnetometers. Data acquisition is made through a device made on purpose at INGV to avoid the use of a personal computer. Data can be found in the INGV website (http://roma2.rm.ingv.it/it/risorse/osservatori_geomagnetici) where the monthly bulletins are also available.

2) GEOMAGNETIC STATIONS

Three geomagnetic time varying stations were in operation in Italy in the time period.

A geomagnetic station was installed in Cittareale (Lat. 42.62° N - Long. 13.16° E , 960 m asl) on 23 March 2011 and from that time has been recording continuously three components plus scalar intensity of the geomagnetic field. Its objective is not only just geomagnetic but also to eventually detect any anomaly associated with earthquakes, the place of installation being a seismic area with some frequent seismicity.

Another magnetometric system (formed by a couple of vectorial and scalar magnetometers) is running aboard of the seafloor GEOSTAR-class cabled Observatory (called NEMO-SN-1) which was deployed on 9 June 2012, 25 km offshore Catania (Sicily) (Lat. 37.54765oN, Lon. 15.3975oE, 2010 m depth). Data are streaming on the web through Catania harbor centre of INFN (National Institute of Nuclear Physics). The objective of the magnetic instruments is twofold: a) the magnetic monitoring of the seafloor environment in order to extend the national land network to the sea, b) to assist the other geophysical and oceanographic monitoring in order to check if there are magnetic anomalies eventually associated to extreme events typical of this area such as Etna volcanic eruptions and earthquakes.

Recently, a new multiparametric station including magnetic measurements was set up in Varese Ligure (La Spezia). Currently, the magnetic measurements have been recently analyzed and the results can be considered acceptable.

3) MAGNETC SURVEYS

The spatial variation of the geomagnetic field and details on local secular variation over Italy, is achieved by means of a national magnetic network of measuring points. This

complements the observatory network. The Italian repeat station network consists of more than 110 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 Italian geomagnetic observatories (Duronia, Castello Tesino and Lampedusa). Moreover, for selected areas, other temporary magnetic time recording stations, properly displaced to have nearly a total coverage of the Italian territory, are installed during the survey. The last full survey was made for the 2010.0 date. It was competed in November 2010 and consisted of 131 repeat stations, with 55 km average spacing, over Italy, and included also stations surveyed in Albania, Malta and Corsica. After data elaboration was completed a 1/2000,00 cartography for F, H, Z and D was realized. All maps are now published together with a CD rom and interactive program to display maps and magnetic field values across all Italy. A partial survey was made for the 2012.5 date. This most recent partially survey, that was completed in December 2012, consisted of 25 repeat stations and D, I and F magnetic element values on all stations have been obtained. Data compared with the 1/2000,00 cartography for F, H, Z and D are published together with a CD rom and interactive program to display maps and magnetic field values across all Italy. Now INGV is working at the measurements for the 2015.0 magnetic network, with field activities on repeat stations. This phase will be completed in 2015 and will lead to the 2015.0 magnetic elements absolute values, secular variation models and updated maps.

4) OTHER ACTIVITIES RELEVANT TO DIVISION V

Geomagnetic Regional Reference Models: As well known magnetic modeling provides scientific communities with updated information on magnetic field elements as the output of computer programs. They are based on updated measurements taken in the region under modelling. An analytical expression, a second order polynomial, in latitude and longitude for the field elements was determined and coefficients for 2010.0 with average secular variation over the period 2005-2010, were obtained for Italy. Moreover the new maps for Italy, for D, F, H and Z at the epoch 2010.0, were also produced. ARM (Antarctic Reference Model) 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. Another regional model with similar characteristics of ARM has been developed to model the geomagnetic field of Southern Italy and Albania (including the confining sea) since 1990. Both models ARM and this latter model have been now updated to include year 2010 with prediction to 2012.

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. During the recent cruise MAVA2011, performed on the R/V Urania, a new magnetic dataset was obtained from seamounts Vavilov and Marsili. At the Eolie islands archipelago, in the Tyrrhenian, surveys and studies were made on Salina island and Volcano island. In the Tyrrhenian Sea, in the marine facing on Panarea and Stromboli islands, an high resolution magnetic survey (PANSTR12) was carried out using an Italian Navy ship and marine magnetometers with Overhauser effect sensors.

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.

"Interdivisional Commissions on History and on Education and Outreach" (Coord.s.: A. De Santis, F. Berrilli)

As mentioned in the IAGA website, the Interdivisional Commission on History encourages historical research by scientists as well as professional historians of science - into the history of geophysics. It encourages historical sessions and presentations at IAGA meetings, and the preservation of IAGA's history. The Interdivisional Commission on Education and Outreach has become an autonomous interdivisional commission from the former from IAGA 2013 Assembly in Merida (Mexico). In this report they are considered merged together because they were in this way till 2013.

A) Institutions involved in research activity

- Istituto Nazionale di Geofisica e Vulcanologia (INGV)
- Consiglio Nazionale delle Ricerche (CNR)
- ISPRA
- University of Tor Vergata
- Department of Civil Protection (DPC)

B) Activity Report

B1) Main Themes

- INGV Open day ("Open Science for Open minds") 21 May 2011. Exhibits on Geophysics, Geomagnetism and Paleomagnetism.
- SCIENZA APERTA ("Open Science") 2012 -2014 (all INGV centers). In particular: different Exhibits on Geomagnetism and Paleomagnetism (INGV, Rome) and Geomagnetic Prospection (INGV, Catania)
- SHINE! (Scientist are Humans - Interactive Night of Entertainment) Sept. 2012-2014. Outreach Events, seminars, museums, exhibits in 24 Italian cities. INGV participated with initiatives in all INGV centers.
- Realization of Podcast: "Stromboli: a small volcano but a great natural laboratory" by INGV – Catania. This Podcast shows the magnetic monitoring of Stromboli volcano. 2012.
- Series of seminars given by INGV researchers (Dep. Rome 2) on Space Weather, Ionospheric Physics at the University La Sapienza, Rome Dec. 2012- Jan. 2013.
- Visits of school pupils/students/teachers in 2012-2014 at INGV: around 5000 people every year visited seven INGV centers, among which the main were Rome, Naples and Catania Centers.
- During the outreach event "Under another optics" the telescope in carbon fiber built during the Stage in heliophysics at Tor Vergata was presented April 6, 2013, in the High School of Ceccano (FR).
- Laboratory of Solar Physics at University of Tor Vergata Stages 2011, 2012, 2013, 2014, for teachers and students from secondary schools. The laboratory section of the stage was executed in two phases (weeks): i) First phase aims was the realization of a keplerian telescope and low-cost acquisition system. During this week students were introduced to astronomical techniques used to safety collect and acquire solar light; ii) Second phase aims was the realization of a low-cost instrument to analyse sunlight extracting information about the solar spectrum, solar irradiance and Sun. http://www.stageatorvergata.it/home

B3) Funding Agencies

- University and Research Ministry (MIUR)
- Italian National Programme for Antartica Research (PNRA)

- Italian Space Agency (ASI)
- European Commission (FP7-Space Call)
- Piano Lauree Scientifiche (PLS)

B5) Prizes

- Edmund Optics (EO), a provider of optical components for industry and academia, has announced the winners of its 2013 Higher Education Global Grant Program. The awards are given in recognition of outstanding undergraduate and graduate optics programs in science, technology, engineering, and mathematics at non-profit colleges and universities worldwide. Third-place European recipient is Università degli Studi di Roma "Tor Vergata" (Italy), submitted by Luca Giovannelli. The award was presented for developing a Fabry-Pérot Capacitance Stabilized Etalon (CSE), based on a monolithic approach, optimized for a satellite application.

C) Goals, priorities and plans for future activities

- Promotion and Initiatives on History of Geomagnetism and Aeronomy, as well as in Education and Outreach will continue during the next two years, repeating in particular the positive experience of SCIENZA APERTA (“Open Science”) and SHINE!. Some of the main centers of INGV will be again open to school visits, especially in Rome with three visits/week from October of each year to June of the next.
- Laboratory of Solar Physics at University of Tor Vergata Stages 2015-2016 for teachers and students from secondary schools. For these laboratories is planned the realization of solar radiotelescopes for education and connection with solar activity. More detailed and updated information can be found on the web (e.g. http://www.stageatorvergata.it/home or https://www.fisica.uniroma2.it/~solare/english/).

SCIENTIFIC PUBLICATIONS

DIVISION I:
"Internal Magnetic Field"

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