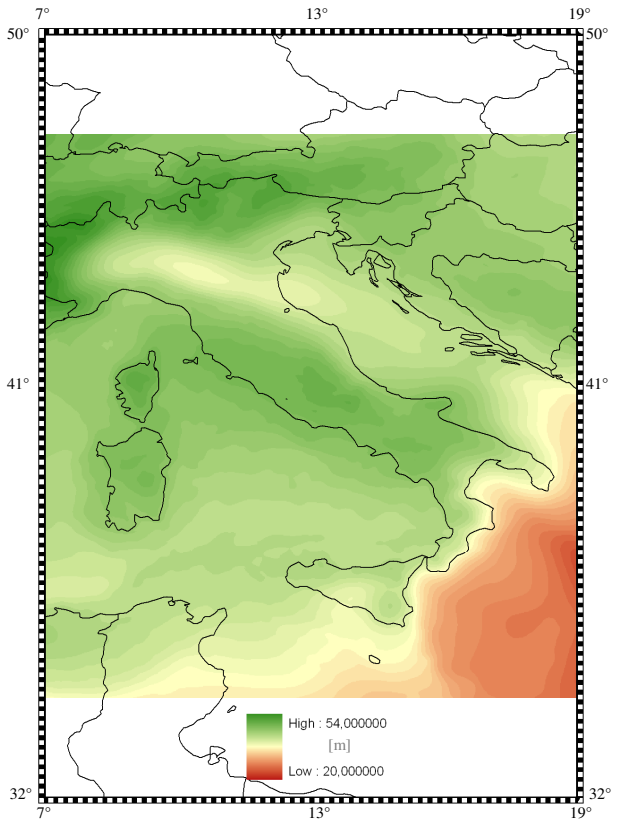

ITALIAN GEODETIC RESEARCH ACTIVITIES IN THE PERIOD 2011-2013

IAG REPORT

BY F. SANSÒ
ITALIAN DELEGATE TO IAG

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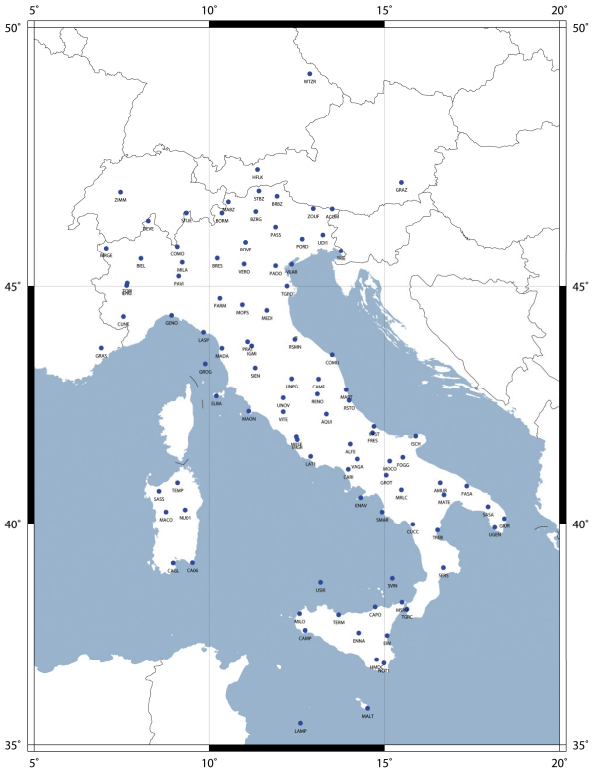

International Association of Geodesy (IAG) by Fernando Sansò

Activities in Italy (2011-2013)

Short summary
The report is organized by 4 IAG_Commissions, the Inter-Commission Committee on Theory and the Services.
For each of them we report: name, contact persons, participants to structures, scientific reports, bibliography.

Note: the geodetic Community is organizing a IAG-Italy website (http://w3.dicea.uniroma1.it/iag-i/) which is starting now its activity and will hopefully monitor the relevant projects in real time.

Structures:

Commission 1 (Reference Frames)

Contact persons
A. Caporali
G. Bianco
R. Maseroli
L. Biagi

Participants to IAG Structures

JWG 1.1 on ties of Space Observations
P.Sarti (Chair)
C. Abbondanaza
G. Bianco
L. Vittuari

WG 1.4.2 on celestial reference frames
V. Tornatore

Italian Institutions
ASI
IGM
CNR
Universities (PoliMi, PoliTo, UniBo, UniRoma, UniPg, UniPd)

Summary
Activities related to the establishment and maintenance of the Terrestrial Reference Frame, from both the instrumental and the theoretical point of view.
Particularly relevant is the participation of ASI to the various IAG Services. Also the theoretical discussion on the relation and simultaneous modelling of deformations of the Earth surface and of the variation of the Earth orientation parameters in a terrestrial system is relevant.
The implementation of a national reference system into the ITRS has been object of intensive work and Projects of National Interest.

Scientific Reports

Activities of A. Caporali in Geodetic Projects, 2011-2013

1) As Chairman of the CEGRN Consortium (Central European Geodynamics Research Network): Geokinematic investigations in Central Europe using long term data (1994-2011) from epoch and permanent GNSS stations.

2) As Secretary of EUREF IAG Reference Frame Sub-Commission for Europe, integrated in the Sub-Commission 1.3, Regional Reference Frames, under Commission 1 – Reference Frames: Maintenance of the European Reference System and its realizations. Processing standards for GNSS data. Relation to IGS, EuroGeographics and National Mapping and Cartographic Authorities in Europe.

3) As member of the Thematic Working Group 1 (Coordinate Reference Systems) and 2 (2D and 3D geographic grids) of the INSPIRE EU Directive/Annex 1: preparation of the Implementing Rules.

4) As member of the Processing Group of the Rete Dinamica Nazionale (RDN) of IGMI (Istituto Geografico Militare Italiano): maintenance of the RDN at regular intervals.

5) As responsible of the GPS network of the Regione Veneto: maintenance of the 26 GNSS permanent network, alignment to RDN/ETRS89, weekly network adjustment with Bernese 5.0 and IGS/EPN processing standards, analysis of Time Series

6) As member of the NSPR Project (Network of Permanent GPS stations): weekly computation and adjustment of the network of 400+ GNSS stations in Italy, representing a densification of the RDN. Weekly SINEX files are sent to EUREF for combination and stacking with the EPN normal equations, for densification of the ITRF2008 in Europe.

7) Support to IAG SC1.3 - WG1 Integration of dense velocity fields into the ITRF by sending SINEX files of the Italian network to EUREF for combination and stacking with the EPN normal equations, for densification of the ITRF in Europe.

8) Geophysical modelling of the inferred velocities, correlation of the areas of high strain with structural geology, historical seismicity.

Activities of R. Maseroli in Geodetic Projects, 2011-2013

1) Revision and new determination of the Italian Dynamic Network (RDN), finalized to the possible estimation of the crustal movements, and to the updating of the coordinates.

2) Computation of the geopotential, the dynamic heights and the normal heights of all data of the Italian high precision levelling lines (about 20000 benchmarks), through measures of gravity estimated on the basis of the model ITALGEO2005 italian geoid.

3) New determination of some Italian high precision levelling lines (about 1000 km) and updating of the heights.

4) densification of the points GPS + levelling (about 100 points), for the future improvement of the Italian model of geoid.

5) Realization of a certified national net NRTK, for the dissemination of the real time GNSS

corrections.

Activities of L. Biagi in Geodetic Projects, 2011-2013

Politecnico di Milano has lead a project, funded by Italian Ministry of University, named
"The new Italian geodetic reference frame: continuous monitoring and use in environment management". The project started in 2008 and ended in 2012. As a matter of fact, the Italian reference frame (denominated national dynamic network, in Italian Rete Dinamica Nazionale, RDN) had been established in 2008, by using one month of data (last two weeks of 2007, first two weeks of 2008) of 100 national permanent GPS stations and presented and approved by the EUREF structure as complying with international standards: in 2008 the RDN solution was officially published in the website of Istituto Geografico Militare. This was accomplished by IGM Institute in cooperation with Politecnico di Milano and other centres.
In the following years, the problem arose of establishing a proper methodology and praxis to manage and monitor the national reference frame. Meanwhile permanent GNSS networks have been developed at different scales and for different purposes. Therefore, the funded project aimed at:
1) reconducting all this activity to a unitary point of view under the theoretical and practical concept of geodetic reference frame,
2) establishing the national reference frame (NDN) on the basis of a continuous time ("monitoring") solution leading in this way the Italian community to a level finally compatible with the international reality of developed countries,
3) providing a number of documents of the type "certificate", to be used by regional authorities in particular for the economically sensitive item of RTK positioning services,
4) providing the first answers to a strategic question, namely whether , how and, in case, when a homogenized structure for positioning services at national level has to be created.

In particular, the following researches have been completed in the years 2011-2012.
1. Analysis of the status of RDN, definition of a protocol for those permanent stations that would be accepted in the network and creation of a data base for the project.
2. Computation of the solutions of RDN over the time span between 2008 to 2012, with different SW of international relevance.
3. Implementation of a rational experiment to prove or disprove the feasibility of an RTK positioning service at national level.
4. Analysis and solution of the problem of framing a sub-network into a larger network, overcoming some incorrect current practices.
5. Investigation of the problem of time series prediction of the coordinates of individual stations, assessing a specific stochastic prediction model for each of them.
6. Set up of an optimal predictor of the deformation pattern accounting for the spatial correlation structure of the network.

Activities of G. Bianco in Geodetic Projects, 2011-2013

The ASI Space Geodesy Center "G. Colombo" (CGS) has contributed to the IERS Technique Centers (ILRS, IVS, IGS/EUREF) since the beginning of the Service activities both as fundamental station and analysis center.
The ILRS Governing Board recognized ASI/CGS' continuous and rigorous contribution and appointed it as one of the official ILRS Analysis Centers (ACs) when the ILRS AC structure was finalized (2004). In June 2004 the CGS was selected by the International Laser Ranging Service (ILRS) as its primary Official Combination Center (CC) for station coordinates and Earth Orientation Parameters.
ASI/CGS is an official IVS Station, Data Center and Associate Analysis Center since the beginning

of the service (1999).
ASI/CGS is operating as EUREF Local Analysis Center (LAC) since 1996, producing since then the requested solutions for the European reference frame densification and tropospheric applications. More recently (2009), ASI-CGS became also an European Permanent Network (EPN) Regional Broadcaster for the dissemination of Real Time orbit and clock corrections as well as observation streams. Since 2012 ASI/CGS is contributing to the EUREF Technical Working Group.
In January 2012 a GNSS receiver has been installed at the CGS in the framework of the IGS Multi-GNSS (M-GEX) experiment.
ASI/CGS has been participating since 1999 to many GPS Meteorological projects (COST 716, MAGIC, TOUGH, E-GVAP) and is presently participating to E-GVAP III (2009-2013, contribution to the operational meteorology) as Analysis Center and Combination Center and is now involved in the COST Action ES1206.
In January 2010 ASI/CGS has been appointed as GGOS Coordination Office.
Information on the CGS and some of the analysis results are available at the CGS WWW server GeoDAF (Geodetic Data Archiving Facility, http://geodaf.mt.asi.it).

SLR Data Analysis

ILRS Activities

In the years 2011-2013, the ASI/CGS has been involved in the ILRS activities, mainly in support of the reference frame maintenance and under the coordination of the Analysis Working Group. Due to its double role of Analysis Center and Combination Center, ASI/CGS provides both its single AC solution and the combined product of the 8 ILRS ACs, whenever requested. Main projects are:

- **Official ILRS Products**: Weekly and Daily site position and Earth Orientation Parameters obtained using LAGEOS and ETALON data. The solutions provide the weekly coordinates of the worldwide SLR tracking network and the daily EOPs as the ILRS contribution to the USNO Rapid Service.
- **ITRF maintenance**: long term time series of site coordinates and EOPs computed according to the requirements of the IERS inter-technique Combination Centers
- **IERS Pilot Project** to evaluate the impact of non-tidal atmospheric loading at the observation level.
- **Pilot Project on Weekly orbits:** satellite ephemerides for Lageos and Etalon, preliminary periodic evaluation/comparison of the ACs weekly orbits in order to produce a combined official product.
- **Station qualification:** ASI/CGS is one of the ACs designated by the AWG to validate the data from new or upgraded sites or after an earthquake.
- **Bias monitoring:** routine activity carried out to compute data corrections whenever the biases are not reported by the station, in close contact with the station engineers.

IERS contribution: production of EOP time series regularly carried out as ASI/CGS operational EOP series:

ETRUSCO-2 Project: characterization and validation of the optical performance of satellite Laser Ranging Arrays under laboratory-simulated space conditions.

ASI/CGS internal projects:

The ASI/CGS SLR analysis activities extend beyond the accomplishment of its role within ILRS/IERS and were addressed in the following main application fields:

- **Reference Frames:** annual generation of multi-year solutions from Lageos I and II data, used as a benchmark for global network coordinates/velocities EOPs, satellite ephemerides and accelerations, station biases
- **Gravity**: long term time series of low degree Earth's geopotential coefficients and geocenter.

VLBI Data Analysis

IVS Activities

In the years 2011-2013, the ASI/CGS has been involved in the following IVS projects:

- **Session Earth Orientation Parameter Series:** Time series of X pole, Y pole, UT1, Xp rate, Yp rate, UT1 rate, dpsi, and deps.
- **Terrestrial Reference System (TRF):** Set of station positions, velocities, and correlations
- **Celestial Reference System (CRF)** Set of right ascension and declination for sources
- **Tropospheric Parameters:** Regular submission of tropospheric parameters for all VLBI stations observing in the IVS R1 and R4 sessions the results are available on the IVS products ftp sites.
- **Daily Solution Files** Pre-operational submission for each 24-hour session to provide earth orientation and site positions, the covariance matrix of the estimates and decomposed normal equations.

IERS Contribution Regular submission to the IERS EOP operational series of R1 and R4 session EOP estimates

ASI/CGS internal projects:

- **Global VLBI Solutions:** Every year, global VLBI solutions are produced, including all the observation sessions since 1979 onwards. The estimated parameters of the global solution are:
  - Celestial Frame: right ascension and declination as global parameters for 637 sources
  - Terrestrial Frame: Coordinates and velocities for 92 stations as global parameters
  - Earth Orientation: Unconstrained X pole, Y pole, UT1, Xp rate, Yp rate, UT1 rate, dpsi, and deps.

GPS Data Analysis

EUREF/IGS Activities

In the years 2011-2013, the ASI/CGS has been involved in the EUREF activities, mainly in support of the reference frame maintenance. Main projects:

- **Official EUREF Products**:
  EPN Final weekly product: site coordinates and tropospheric parameters using IGS Final products, now covering a European sub network of 41 sites, 2-week latency
  EPN Rapid daily product: site coordinates using IGS Rapid products, now covering a European sub network of 41 sites, 1-day latency
  EPN NRT hourly product: site coordinates using IGS Ultra-Rapid products, now covering a European subnetwork of 41 sites, 1-hour latency
- **EPN Real Time Analysis:** ASI-CGS is an EPN Regional supporting the dissemination of RT orbit and clock corrections and observation streams. It contributes directly to the data stream with 3 RT GNSS stations.
- **EPN Reprocessing:** Reprocessing the EPN Network from 1996 onwards.

IERS contribution: Pre-operational submission to the IERS EOP operational series of GPS daily EOP estimates

GNSS Meteorology Activities

In the years 2011-2013, the ASI/CGS has been involved in the GNSS-Met activities as E-GVAP Analysis Center and Combination Center.

- **Official E-GVAP Products**:
  NRT ZTD estimates: every hour, 15m ZTD estimates with a 1h45m latency for an European network of more than 200 sites are produced;
  NRT ZTD combined estimates: every hour, the 15m ZTD estimates from the contributing E-GVAP Analysis Centers are combined and made available to the project, using a

combination SW developed at ASI-CGS.

Quality Control: on hourly basis AC bias w.r.t. the combined solutions are computed providing a quality indicator for each solution.

ASI/CGS GNSS-Met activities in support of NWP applications, nowcasting and forecasting of severe weather events will continue, in the following years, within the framework of E-GVAP phase III and of the EU COST Action "Advanced Global Navigation Satellite Systems tropospheric products for monitoring Severe Weather Events and Climate" (GNSS4SWEC).

ASI/CGS internal projects:

The ASI/CGS GPS analysis activities extend beyond the accomplishment of its role within EUREF and E-GVAP and were addressed in the following main application fields.

- **Reference Frames:** annual generation of multi-year solutions of site coordinate and velocity of a GNSS network covering the central Mediterranean area.
- **Zenith Tropospheric Delays (ZTD) Residual Fields:** hourly generation of ZTD residuals fields covering the central Mediterranean area.

Multi-technique Data Analysis

COL Working Group: submission of requested weeks (CONT-08 and -11 campaigns) for SLR solutions in the form of NEQ SINEX and participation to the WG activity.

ASI/CGS internal projects:

- **Gravity**: long term time series of degree 2 Earth's geopotential coefficients variations obtained from SLR and VLBI EOP estimates, through excitation functions and time/frequency comparison with Angular Atmospheric and Oceanic Momenta components (from IERS dedicated sub-bureaus).
- **EOP excitation functions** Regular production of the daily geodetic excitation functions from the ASI/CGS estimated EOP values for IERS (SLR, VLBI), since 2006.
- **Geodetic solution combination** Realization, implementation and testing of combination algorithms for the optimal merging of global inter- and intra-technique solutions and of regional (e.g. Mediterranean) solutions to densify tectonic information in crucial areas.

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Commission 2 (Gravity Field)

Contact persons R. Barzaghi
M. Reguzzoni
I. Marson
C. Braitenberg

Participants to IAG Structures

SC 2.3 Dedicated Satellite Gravity Missions
F. Migliaccio

SC 2.4f Gravity and Geoid in Antartica
A.Capra

SC 2.6 Gravity and Mass Displacements
C. Braitenberg

JWG 2.1 Techniques and metrology for absolute gravity
A.Germak
F. Coren

JWG 2.2 Absolute gravity
D. Iacorone
A. Germak

JWG 2.3 Assessment of GOCE models
R. Barzaghi

JWG 2.4 Interpretation of Tibet, Xinjiang and Siberia
C. Braitenberg

JWG 2.8 Inversion of gravity with solid Earth coupling
C. Braitenberg

Italian Institutions

OGS
INGV
CNR
Universities (PoliMi, UniTs, UniTn)

Summary
A lot of work has been done in conjunction with ESA structures and NGA and the item of global and local modelling of the gravity field, in particular to estimate local geoids including the new data sets coming from the Goce mission. Also the GOCE Italy project has been developed, with several geophysical and geological and oceanography applications.

Scientific Reports

Activities of R. Barzaghi and M.Reguzzoni in Geodetic Projects 2011-2013

- **Gravity field estimation using satellite and ground based data**

Ground based gravity data have been combined with satellite data to get an improved estimate of any functional of the anomalous potential T. GOCE T_{zz} observations available at ESA have been combined with radaraltimetry and gravity anomalies at ground level using collocation. In performing the collocation estimate an improved covariance fitting procedure has been devised and applied. In this way an integrated estimate of the geoid has been obtained and tested versus available GPS/leveling data. The performed tests in the Central Mediterranean area have provided reliable estimates.

- **Deflection of the vertical estimation**

Deflection of the vertical estimation has been performed based on gravity data. This allowed a proper reduction of observed zenith and azimuth angles measured in a precision traverse for estimating reference point coordinates in the Gran Sasso Laboratories. These reference points on the Borexino, Icarus and LVD experiments have been used in the context of international experiments aiming at re-estimating the neutrino velocity based on neutrino beams from CERN.

- Height datum problem

The global height datum problem, that is the determination of biases of different height systems at global scale, has been revised and one solution has been proposed. In this approach height anomalies derived from GNSS ellipsoidal heights and biased normal heights have been compared with height anomalies derived from an anomalous potential which combines a satellite-only model up to degree 200 and a high-resolution global model above 200. Numerical tests have been devised to prove the effectiveness of this method and an error budget has been performed. Also, at local level, GOCE data has been used to unify the Italian and Swiss geoids in the framework of the HELIDEM project. Further studies are ongoing

- **Satellite geodesy**

Analyses on satellite gravity missions have been performed with particular attention to the data analysis of the GOCE mission for gravity global and local model estimation and for geophysical applications.

- **Aerogravimetry**

This research aims at local gravity field modelling taking advantage of GOCE data for the low frequency part of the field and improving the acceleration estimation by the nowadays available GNSS constellations.

- **Crustal deformation laboratories**

The network of stations with underground deformation measurements in North-eastern Italy is maintained. The three stations house tiltmeters and extensometers, including the famous Grotta Gigante „Long-base Pendulums“ in the Trieste Carst. This station has an exceptionally long continuous data series of near to 50 years. The research includes free oscillations of modern mega-earthquakes compared to the historic Chile 1960 event. Further the underground hydrology is studied through the induced tilt signals.

- GOCE observations for the detection of natural resources.

GOCE has revolutionized the knowledge of the gravity potential field in remote areas. The studies include sensitivity analysis of GOCE for geologic structures relevant for oil and mineral exploration. Methodological aspects are studied to define the best way to extract the geological

signal from the GOCE observations using either the on-track gradient observations or the derived global gravity models. Software has been developed, including the modelling of tesseroids and for the inversion of the crustal density inhomogeneities. The methods have been applied to Africa, South America and Alps, demonstrating the huge leap ahead that GOCE has delivered for the use of potential methods in exploration in remote areas.

- **Funded projects**

In the following, the main funded projects related to gravity researches are briefly described:

GOCE-HPF (High-level Processing Facilities): funded by the European Space Agency (ESA), it involves European university and research centers with the final aim of producing Level 2 GOCE data and estimating a global model of the Earth gravitational field. Politecnico di Milano is responsible for the model by the space-wise approach and it is now computing global grids of gravity gradients at mean satellite altitude that should have a higher local content than the one of the spherical harmonic coefficients.

GEMMA (GOCE Exploitation for Moho Modeling and Applications): co-funded by ESA-STSE and ASI, the main goal of the project was to map the crust-mantle discontinuity (Moho) all over the world and in key regions by means of GOCE data. The obtained Moho is also based on ETOPO1 and a 1°x1° sediment model for the shallowest layers. The crust is divided into geological provinces, each of them characterized by its own relation between density and depth. The GEMMA Moho is freely available and delivered with the support of a Web Processing Service (WPS).

GAL (Galileo for gravity): funded by the European Community, it is a project of aero-gravimetry based on the joint used of positioning techniques, such as GPS, EGNOS and in particular Galileo systems, inertial measurement units (IMUs) and satellite gravity data and global models derived by the GOCE mission for the estimation of low frequency part of the gravity field; the proposed solution does not make use of on board gravimeters.

VIKING (Very Improved KINematic Gravimetry): funded by ENI, it is a project with the aim of improving performances of airborne kinematic gravimetry in terms of accuracy and spatial resolution of the retrieved local gravity field; this is done by fully exploiting the current state of the art satellite technology (GNSS multi-constellations), IMUs, on board gravimeters and innovative processing strategies.

DPC 2012-2013: in the framework of the seismological projects of INGV, activities have been performed to enhance the Italian ground gravity database with the low frequency information coming from the GOCE mission; this has been done for the Po Plain area. The final aim of these activities was to investigate the crustal velocity and density 3D modelling in the Po Plain, with the support of GOCE satellite gravity data too.

Activities of C.Braitenberg in Geodetic Project 2011-2013

1) Crustal deformation laboratories

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Commission 3 (Earth Rotation and Geodynamics)

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Participants to IAG Structures

SC 3.5 Tectonics and Earthquake Geodesy
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JSG 3.1 Gravity and height change intercomparaison
S. Zerbini

Italian Institutions

ASI
CNR
INGV
OGS
Universities (PoliMi, UniBo, UniMi, UniMo, UniRoma)

Summary

Most of the activity in the framework of Commission 3 is related to geodynamics and deformation analysis. Particular attention has been devoted to the combination of different techniques in the analysis of post seismic deformation.

Scientific reports

Activities of S.Zerbini in Geodetic Projects 2011-2013

Application of space techniques to geodesy and geodynamics. Study of regional and local deformations of the Earth's crust, in particular, monitoring, interpreting and modelling short- and long-term vertical motions by means of the Global Positioning System (GPS), other space techniques and by high precision terrestrial gravimetry. Study of sea-level fluctuations in relation to climate variability and change. Study, by Principal Components Analysis, of temporal and spatial variability of GPS station positions and of key hydrological variables. Integration of techniques, GPS and InSAR in particular, including study of wet tropospheric path delay.

1) Member and past chair of the "Tectonics and Earthquake Geodesy (WEGENER)" Steering Committee. WEGENER is sub-commission 3.5 of IAG Commission 3.

2) Member of the Working Group for the internationalization of Research of the Italian Ministry of Education, University and Research.

3) Chair of the EGU Vening Meinesz Medal Committee.

4) Member of the Executive Committee of GGOS.

5) Member of the Science & Technology Committee of GEO representing IAG.

6) Member of the Editorial Board of the Journal of Geodynamics.

7) Member of the GEO Supersites SAC, representing WEGENER.

Activities of R.Devoti in Geodetic Projects 2011-2013

Tectonic geodesy and geodynamics
INGV is hosting a nationwide GPS network (RING) dedicated specifically to the monitoring of current crustal deformation in Italy. The data are daily transferred to the central archive in Grottaminarda (ring.gm.ingv.it). Different analysis groups at INGV process routinely the GPS data of the RING network and other permanent networks in the Italian region, currently producing solutions of over 600 sites every day using basically three different approaches: Gamit, Bernese, Gipsy. The time series are the fundamental products that allow researchers to study the kinematics of the region, to discriminate the plate boundaries and to recognize the active deforming regions. These studies suggest important clues and significant advances in seismic hazard investigations and current tectonic mechanisms.

Geodetic observations at fault scale or regional scale
To study the seismic cycle at the fault level, it is useful to observe the co-, post- and inter-seismic deformations in limited areas across the active faults. Typical observations include GPS and leveling data, classical terrestrial methods. Alternatively, in small regions interested by volcanic activity the geodetic monitoring is crucial for source analysis and danger warning. INGV is managing numerous campaign networks or small permanent networks dedicated to local tectonic and/or volcanic active processes. These applications often require a real time analysis and real time alert response.

InSAR ground deformations and comparison with GPS
Interferometric SAR measurements are currently processed at INGV and interpreted to study the coseismic and interseismic deformations occurring in different places on the Earth surface. The integration and comparison of InSAR and GPS results may enhance the picture of the ongoing deformation by exploiting the strengths of both techniques, high spatial resolution and high time resolution respectively.

Combination of geodetic solutions at the normal equation level
Geodetic solutions (coordinates and/or velocities) are usually obtained from different processing methods or different observation techniques. The combination of such solutions at the normal equation level allow to integrate all the solutions rigorously in a unique reference frame. This procedure is fundamental in terrestrial reference frame construction, geodetic validation processes and buildup of large network velocity solutions.

High rate GPS observations for seismic events
The capability of high rate GNSS observations allow to study the direct ground shaking during an Earthquake. At INGV a number of studies have been carried out since the L'Aquila earthquake in 2009 and consequently the RING network has been configured such as to enable the archiving of high rate observations in case of seismic events on the Italian territory.

Activities of **A.Capra** in Geodetic Projects 2011-2013

The geodetic activity performed was principally devoted to Antarctic geodetic surveying for geodynamics purposes. Within this research Capra is the Responsible of two projects:

1) Geodetic Observatory in Northern Victoria Land
2) Geodetic Observations for northern Victoria Land monitoring

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Commission 4 (Positioning and Applications)

Participants None

Italian Institutions

IGM
CNR
Universities (all Engineering Schools)

Summary
The activities for the framework of Commission 4 are various and range from the study of GPS applications to real time positioning, to navigation, to the use of SAR for ground movements monitoring. A particular mention has to be done for the application of a stand alone GPS to reconstract seismic waveform. Also the development of a free ware navigational software (GoGPS) which is developed under an international cooperation.

Scientific Reports

Activities of A.Manzino in Geodetic Projects 2011-2013

Local responsible of the Politecnico di Torino for the PRIN 2008 project with a title " The new Italian geodetic reference system: continuous monitoring and applications to the management and control of the territory."

Local responsible of the Politecnico di Torino for the Italy-Switzerland Interreg project HELI-DEM (HELvetia – Italy Digital Elevation Model) related to the unification of the reference systems and the creation of a single digital model of heights.

Responsible for GNSS NRTK network managed by Politecnico di Torino and coordinator of the project for the creation of new GNSS Regione Piemonte network for RTK positioning.

Local coordinator of the project "Quality Control of GNSS positioning within NRTK networks".

Activities of S.Gandolfi in Geodetic Projects 2011-2013

PNRA – Research program for Antarctic Research
(Operative Unit Geodesy): Studies on Geodynamic and Post Glacial Rebound (PGR) of the Victoria Land (Antarctica). These studies are carried out by means of space geodetic techniques and in particular using GNSS. In order to perform correct results interpretation, several methods, approaches and data processing software packages have been used.

(Operative Unit Glaciology): In this contest the geodetic activities are regarding two main aspects. First of all studies on surface deformation of the plateau, by means of GNSS technologies) in correspondence of two deep drilling sites useful for the dynamic of the two areas. The second aspects regard all the geodetic activities required for the localization of geophysics survey such as GPR. In particular in this field a lot of studies have been carried out in the Precise Point Positioning field for static and kinematic surveys.

GNSS Precise Point Positioning
The research is oriented to the definition of the best models and methods, including the framing aspects using regional reference network, for high accurate positioning. This research try to focus also the impact of the windows time observation to the final accuracy. All these tests have been carried out using GIPSY OASIS II.

PRIN 2010.
In the field of National Program PRIN2010 the geodetic activities are relating to the possibility to realize a prototype of autonomous GNSS permanent station. This prototype constitute the first step for the establish a CORS (Continuously Operating Reference Stations) for Emergency.

Activities of M.Crespi in Geodetic Projects 2011-2013

Main research topics
GPS Seismology: VADASE
GPS Meteorology: inter-comparison of water vapor estimation approaches
Digital Surface Models generation from high resolution optical and SAR satellite imagery

GPS Seismology: VADASE
VADASE (Variometric Approach for Displacements Analysis Stand-alone Engine) is a new approach to estimate coseismic displacements in a global reference frame in real-time based on a single GPS station technique and on standard GPS broadcast products (orbits and clocks). Since it does not require either additional technological complexity or a centralized data analysis, in principle it can be embedded into the GPS receiver firmware, thereby providing a significant contribution to tsunami warning systems.
The effectiveness of VADASE was tested on several earthquakes, including the last extremely strong one occurred in Japan on March 11, 2011 (VADASE supplied the first worldwide solution for the displacements at two IGS site (MIZU, USUD) and, at first, was presented at IUGG 2011 General Assembly in Melbourne.
In the last two years it was extended to Galileo and Glonass, refined and thorough compared on real observations with four renown software, used as reference, following different approaches (APP-PPP and CSRS-PPP, Bernese and TRACK), with an agreement at 1-2 cm level, quite close to the agreement between the reference software.
It was also successfully tested using observations simulated by Spirent simulators, thanks two cooperations with DLR (German Aerospace Agency, Oberpfaffenhofen, Germany) and CATEC (Centro Avanzado de Tecnologías Aeroespaciales, Sevilla, Spain).
Moreover, thanks to a cooperation with Leica Geosystems AG (Heerbrugg, Switzerland), VADASE was implemented onboard a GR10 GNSS receiver and tested.
A new cooperation with NCKU (National Cheng Kung University, Taiwan) has been recently started for a possible application of VADASE to the real-time GNSS network managed by the Department of Earth Science.

GPS Meteorology: inter-comparison of water vapor estimation approaches
The research was developed within an international cooperation with the Universidad Nacional de La Plata (La Plata, Argentina) and the Universidad Nacional de Cuyo (Mendoza, Argentina), partially funded by the Italian Foreign Ministry and the Argentinean Science and Technology Ministry. The goal was the inter-comparison of different approaches to estimate the atmospheric water vapor (WV) both over land and over sea: ground-based approach using GNSS observations, satellite-based approach using radiometer observations acquired in the Jason-1 mission, and model-based using the ECMWF meteorological model.
The comparison was at first focused on GNSS-Jason-1 WV estimations comparison along the South America coastline (where both the techniques may supply results), considering some GNSS sites

included in SIRGAS network, and the focus was both to point out the comparison problems and to assess the agreement level, depending latitude, time of the day and season of the year. A dedicated software was implemented in order to softly manage the extremely huge data-base coming from Jason-1.
Secondly, a comparison between SIRGAS and IGS WV estimations in the same GNSS site was developed, in order to point out possible significant inconsistencies; then, a comparison between SIRGAS and ECMWF model estimations in the GNSS site was started, with the aim to design an integration strategy to improve regularly WV estimations all over South America.

Digital Surface Models generation from high resolution optical and SAR satellite imagery
The research was developed within the international project *Evaluation of DEM derived from TerraSAR-X data* leaded by Prof. Uwe Soergel (Leibniz University Hannover, Germany) and supported by DLR, a second international project *Influence of sensor orientation method, number and distribution of ground control points, image acquisition incidence angles, and strip length on the horizontal accuracy of WV2 satellite orthoimages* leaded by Dr. P. Astrand (Joint Research Center European Commission, Ispra, Italy), an international cooperation with Dr. T. Toutin (Canada Center for Remote Sensing, Ottawa, Canada) and the national project *On the exploitation and validation of COSMO-SkyMed interferometric SAR data for digital terrain modelling and surface deformation analysis in extensive urban areas* leaded by R. Lanari and supported by ASI (Italia Space Agency).
A rigorous model to orientate optical and SAR imagery coming from different sensors and a tool for Rational Polynomial Coefficients generation (based on the rigorous model itself) were implemented in SISAR package, tested and successfully compared with other models.
Moreover, an original image matching strategy for Digital Surface Models (DSMs) generation from both optical and SAR imagery (in this case according to a radargrammetric approach) was implemented, tested and compared with other approaches.
A particular concern was devoted to radargrammetric DSMs generation from high resolution SAR imagery acquired by COSMOSkyMed, TerraSAR-X and RADARSAT-2, focusing the filtering for image enhancement and the comparison with interferometric generated DSMs in view of a future integration.

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Awards

2012 ESNC (European Satellite Navigation Competition) – VADASE included into the "Success Stories"

2012 Italian Association of Professors in Geomatics – Best Ph.D. Thesis (Ph.D. student: Gabriele Colosimo – Supervisor: Mattia Crespi) - topic: VADASE approach for GNSS displacement monitoring

2013 ESNC (European Satellite Navigation Competition) – VADASE testimonial of the 2013 competition as Success Story (http://www.galileo-masters.eu)

2011 Italian Association of Professors in Geomatics – Best Ph.D. Thesis (Ph.D. student: Francesca Pieralice – Supervisor: Mattia Crespi) - topic: imagery orientation models for radargrammetry with

high resolution SAR satellite sensors
2012 Google – Grant for Google Summer of Code – Ph.D. Student: Andrea Nascetti, Ph.D. Gabriele Colosimo - topic: orthophotos from high resolution SAR satellite imagery within open-source Optik software

Patent
2012 International patent for VADASE supported by the University of Rome “La Sapienza”
2013 Italian patent for matching strategy for optical and SAR high resolution satellite imagery supported by the University of Rome “La Sapienza”

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Summary

Two events are worth to be mentioned in this framework: the publication of an intensive theoretical book of physical geodesy by Springer; the organization of a new Hotine-Marussi Symposium on Geodetic Theory in Rome on June 2013.

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The main IGeS scientific activities in the period 2011-2013 have been related to two research areas: the methods for merging local geoid estimates; the analysis of the global height datum. Both problems are strictly related to the IGeS mission that is focussed on local/regional geoid estimation and evaluation. Theoretical solutions to the two problems have been devised and tested on numerical examples in order to prove their feasibility. Furthermore, the support activity on geoid computation continued. IGeS has co-operated with the Centre for Geodesy and Geodynamics of Nigeria in giving a training course on geoid estimation theory and geoid estimation software. IGeS also was supporting the computation of the geoid in the San Paolo state in Brazil. Finally, IGeS web site was totally renewed and the local geoid solution database was improved by adding new local solutions (namely the Switzerland geoid, the French geoid, the new European EGG2008 geoid and the US geoid). Geoid Schools were also planned and organized. The next one will be held in October 7th-11th, 2013 at the Universidad Tecnica Particular de Loja in Loja, Ecuador.

International VLBI Service

G. Tuccari

For more details see the web site: www.iag-aig.org and "The Geodesist's Handbook 2012" (JoG No.10, Vol.86, Oct.2012).

List of Acronyms

ASI	Agenzia Spaziale Italiana
IGM	Istituto Geografico Militare
CNR	Consiglio Nazionale delle Ricerche
INGV	Istituto Nazionale di Geofisica e Vulcanologia
OGS	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale
PoliMi	Politecnico di Milano
PoliTo	Politecnico di Torino
UniBo	Università di Bologna
UniRoma	Università di Roma "La Sapienza"
UniPg	Università di Perugia
UniPd	Università di Padova
UniTs	Università di Trieste
UniTn	Università di Trento
UniMo	Università di Modena