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GEODESY
Italian research activity (1991-1994) report to IAG

INTRODUCTION

During the last 4 years, Italy has experienced a remarkable development of geodetic works. Primarily the most classical objectives of geodesy have been pursued with the most modern instruments; a large, dense reference network has been established and surveyed by GPS; a reference gravimetric network of absolute stations connected by highly precise relative measurements is almost completed.

Beyond that, all the fields of geodesy have been tackled by various institutions and research groups in the universities: the impression is that the italian geodetic community is growing and, in spite of the everyday fight for subsistence, it will contribute also in the future to the development of this discipline.

GPS POSITIONING

Geodetic networks*

The Istituto Geografico Militare, Florence, has finished its five year campaign (IGM95) determining the GPS coordinates of the first order Italian network.

The Direzione Centrale del Catasto Italiano (Ministry of Finance) began in 1991 the densification of the cadastral network, starting from to small area. In 1994 the GPS first order net has been initiated, regarding about one third of the whole Italy, devided into three groups of provinces in Southern, Central and Northern Italy. Within 1997 the whole territory will be covered.

Almost all the Universities have worked with GPS in geodetic or cadastral positioning for specific problems, like hydraulic plants, rail construction, terrestrial support in aerophotogrammetry.

Most of geodetic GPS has been done for detecting soil movements, both local (landslides and subsidence) and tectonic ones. The latter have been done both on the prominent tectonic features and on a European as well as Intercontinental base like the Mediterranean area, by participating to a number of international campaigns.

Some Universities have participated to geodetic GPS campaign in Antarctica mainly for

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study tectonic and vulcanic deformations. Moreover a 39 point GPS network has been established in Nepal and Souther Tibet in the framework of the EV-KZ-CNR Project.

Kimematic GPS with geodetic accuracy have been done at experimental level to precisely determine aerial as well as terrestrial and marine vehicle trajectories.

Navigation and road survey by Differential GPS has been tested in various environmental conditions, both in town centres and in intercity roads, as support to Transport Information Systems.

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The IGM95 Project*

The realization of the GPS network in the frame of IGM95 Project is expected to provide a precise and reliable frame on the whole territory:

- to be used for research purposes;

- to support the geodetic and topographic operations using GPS differential positioning.

The main targets of the Project, which is scheduled to be operationally concluded in 1995, can be summarized as follows:

- determination of the 3D coordinates of over 1000 points with respect to the satellite frame; most of them are being chosen to coincide with the points of the fundamental triangulation network (Roma M. Mario '40 System);

- over 400 of the above points will be tied to the fundamental levelling network;

- the astronomical latitude and longitude of over 200 of the above points will be determined with the method of equal heights.

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* by L. Surace (Istituto Geografico Militare, Direzione Geodetica Firenze).

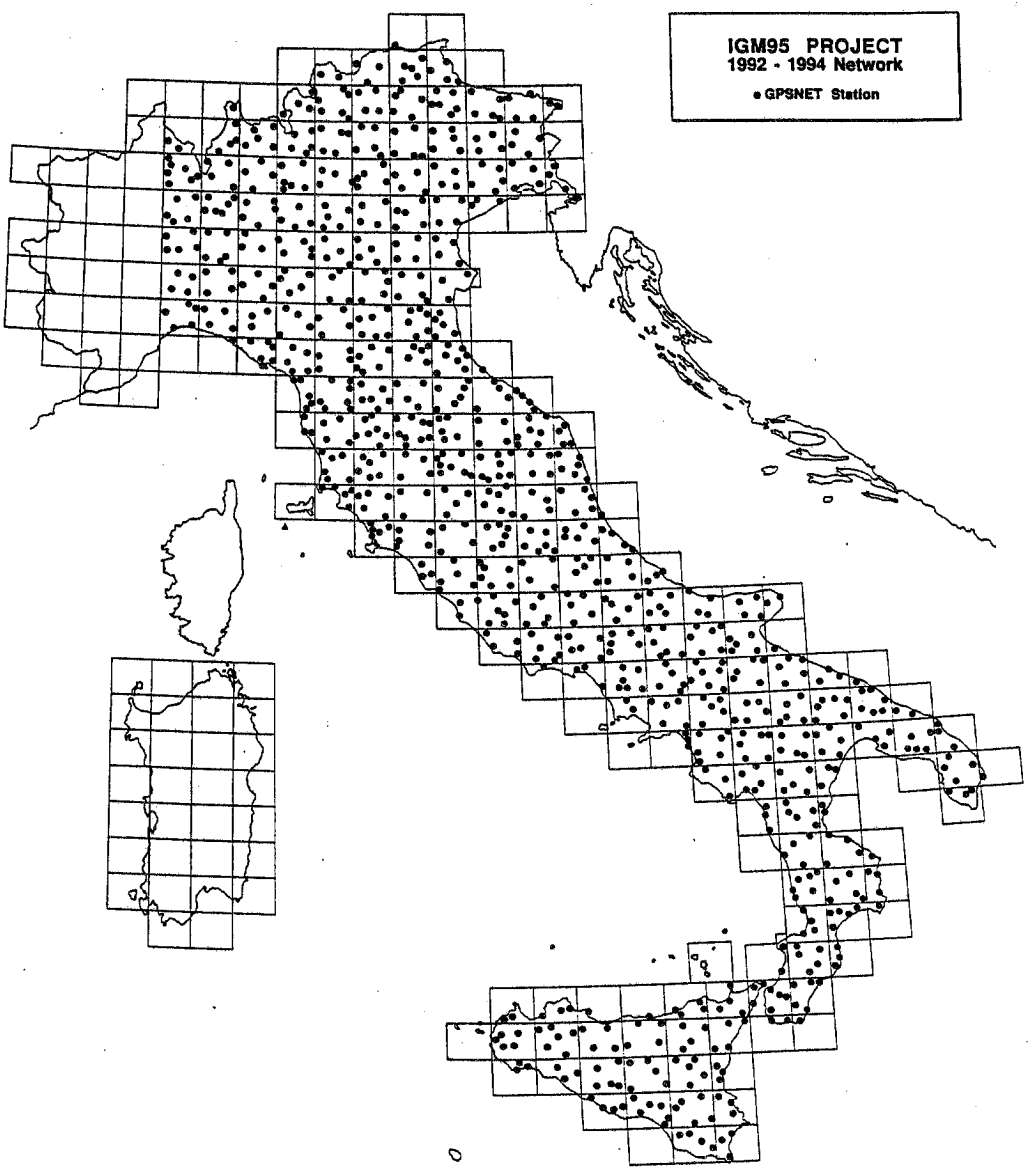

Fig. 1 - GPSNET network observed in the period 1992-1994.

For practical purposes, the network points are being placed, as much as possible, in easily accessible sites (with a mean density of 4 points per 1:100000 sheat, i.e. 1 point/400 km^2).

The Project has been articulated in three sub-project; GPSNET, GEOTRAV and ASTRONET.

GPSNET is the main one and deals with the implementation of the new net and its connections to the fundamental trigonometric one, while GEOTRAF does the same with the fundamental levelling lines (anyway, both sub-project make reference to the one and same GPS network). No GPS measurements are involved in ASTRONET, which is to collect vertical deflection data to be used together with gravimetric and topographic data for a better determination or control of a local geoid.

The WGS84 (relative) coordinates of the 927 points of the network relevant to the parts observed up to the end of 1994 (covering all of the national territory with the exception of north-western part of Italy and Sardinia; see Fig. 1) have been preliminarly determined with an average precision better than 3 cm in the three coordinates: over 50% of the network points have been linked to pre-existing trig-points and about 34% have been directly connected to benchmarks of the fundamental levelling net (Fig. 2).

The astronomical coordinates of 220 points have also been determined (Fig. 3), most of them belong to the GPS network.

As done in the preceding years, four to five points per session at the same time will be GPS-measured, realizing elementary sub-networks to be connected each other generally through two common points. A further GPS receiver will be dedicated to the connections of the GPS network to the levelling lines. Five to six Trimble 4000 SSE GPS receivers will be used. The astronomical latitude and longitude observations (about one per 1:100000 sheet) will be performed using a Wild T2002 theodolite and the Time Digitizing Unit (TDU) developed by ETH of Zurich.

This year the IGM95 network will be completed covering the regions Sardinia, Piemonte, Valle d'Aosta and, partially, Liguria. It is expected to monument and GPS-observe, in total, over 200 points, using 11 Trimble 4000 SSE receivers, and to connect about 50% of them to the fundamental levelling net, while, as usual, astronomical determinations will be executed throughly.

At the end of 1995, when all the field data is collected, the final block adjustment in WGS84 will be started.

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Space Geodesy*

The Space Geodesy Centre (CGS) "G. Colombo" of the Italian Space Agency (ASI) is located in southern Italy, about ten kilometres east of the town of Matera. The CGS was born in 1983, following the signature of a Memorandum of Understanding on Solid Earth studies between NASA and the CNR/PSN (now ASI). The Centre is managed by ASI, while operational activities are entrusted to Nuova Telespazio.

At the CGS several operational projects are routinely carried out, including Satellite Laser

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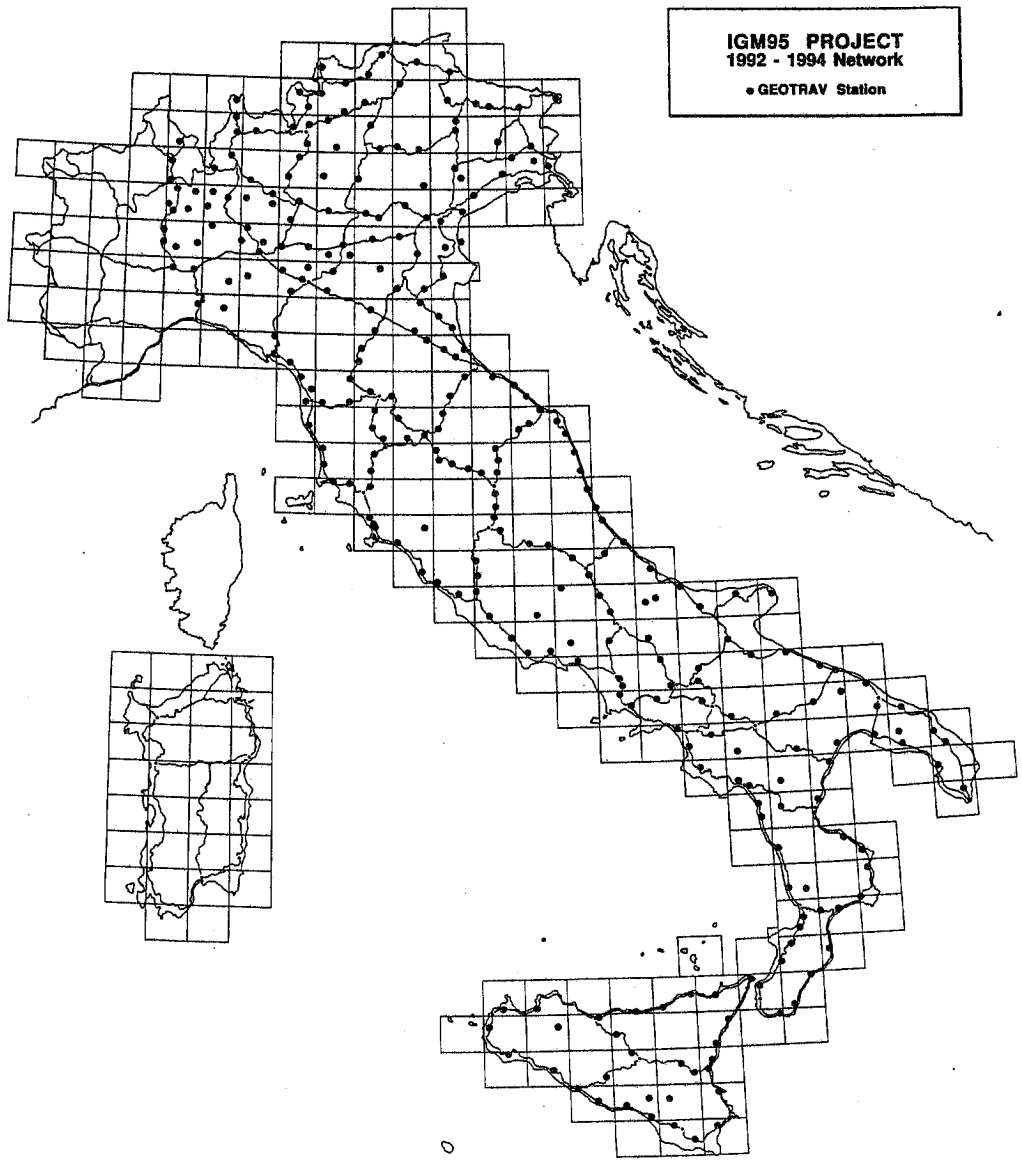

Fig. 2 - GEOTRAV network observed in the period 1992-1994.

Ranging (SLR) to artificial satellites equipped with laser reflectors, Very Long Baseline Interferometry (VLBI) observations of extragalactic radio sources, and Global Positioning System (GPS) observations as IGS core station.

Moreover, a significant amount of work, devoted to scientific studies in the field of Space Geodesy, is carried out by a team of ten analysts under ASI supervision.

The SLR data analysis team (established in 1985), consists of 4 analysts and has been routinely providing several reliable geodetic products. The latest SLR global solution, named CGS93, recovers, by analysing 10 years of LAGEOS-1 tracking data, 1) a global plate motion model (comparable with the most recent geological models, as the NUVEL1-A), 2) a regional model for Mediterranean area (where the global prediction fails), 3) daily earth rotation parameters (on which dedicated analyses and interpretation are in progress), 4) dedicated studies to assess the validity of the present models for the non-gravitational effects (Rubincam's, Yarkowsky's, Yarkowsky-Schach's, etc.) on the LAGEOS'orbit, as recovered from estimated 15-day along-track residual acceleration time series. The available LAGEOS-2 data have been also analysed, especially in the frame of estimation of earth rotation parameters and residual along-track accelerations, as in previous 3) and 4).

The VLBI data analysis team, consisting of 2 analysts, started its activity more recently (1991). Up to now the attention has been focused on the analysis of the data collected within the Europe Campaign project. The next major step is going to be a joint global solution with the SLR and GPS teams to compare the different Reference Frames adopted by the different techniques.

The GPS data analysis team is composed by 4 analysts and started its activity in 1991.

The main effort in these years has been devoted to a detailed study of GPS data analysis issues, in order to be able to develop a dedicated system capable of state-of-the-art results from GPS data analysis. This project, which has been called HIPPOS (HIghly Precise POsitioning Service) is now approaching the end of the first phase which will allow data analysis of real GPS data for Geodesy and GPS satellite Precise Orbit Determination (POD), as well as data analysis of simulated GPS data for Low Earth Orbit (LEO) POD and LEO real time navigation. This particular objective in the work of GPS team did not prevent to perform data analysis of regional as well as global GPS networks using already available S/W systems.

From the technological point of view, many activities are under way. First of all, a new, state-of-the-art laser ranging observatory is under construction, which will be capable of millimetre level precision on all available targets, including the moon; it will be operational within 1997 at the CGS. Major upgrades are being done on the VLBI station, including the replacement of the current receiver with a new one based on the most recent international VLBI standards. Two PRARE (Precision RAnge and Range-rate Experiment) ground stations are being put into operation. A "zero-order" network made of 6 high-performance geodetic GPS receiver is being established by installing them at the main geodetic sites in Italy. This network will be remotely managed from the CGS and will be operational within the summer of 1995. Finally, the CGS GEODAF (GEOdetic Data Archiving Facility) is being established at the CGS in order to provide the scientific community with a powerful on-line database of space data from the major space geodetic techniques.

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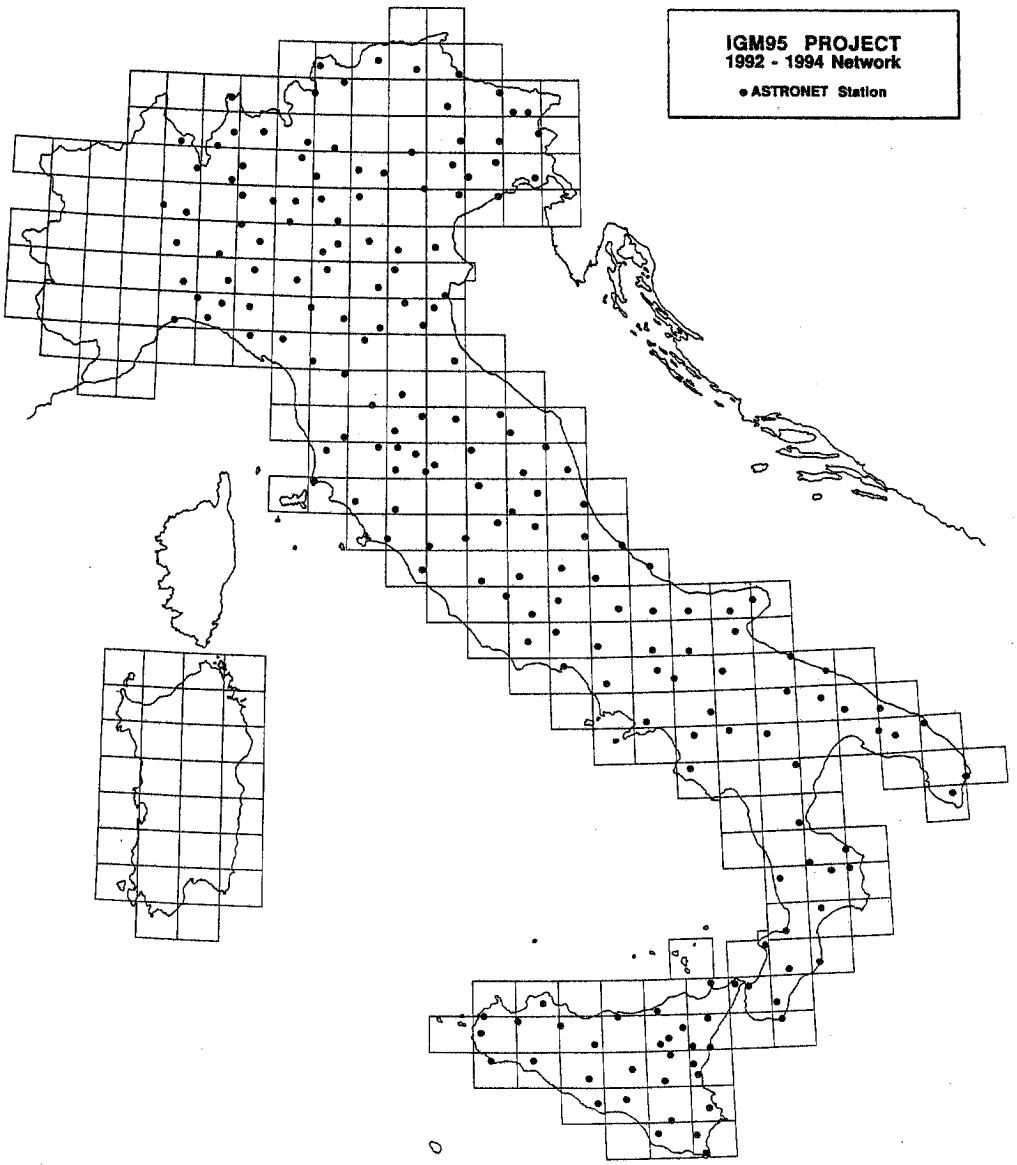

Fig. 3 - ASTRONET network observed in the period 1992-1994.

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GRAVITY FIELD*

Several projects concerning the gravity field have been developed by Italian researchers in the framework of national and international projects. The main research topics can be identified in instrument development, geodetic metrology, fundamental physics, microgravimetry, land and marine gravity. Italy is situated in an important area from the geodynamic point of view. It is therefore not surprising that several projects deal with crustal deformation studies, where gravity, and particularly absolute gravimetry, plays an important role. Motion of masses and changes of density within the earth crust due to short term phenomena like volcanic activities and exploitation of geothermal fields have attracted the interest of several researchers. Data acquisition on land has been limited to specific projects, mainly associated to deep reflection seismics, but interesting projects on marine gravimetry (surface and bottom) have been performed in unsurveyed areas. Finally several researchers are involved in theoretical studies on inversion interpretation and continuation of gravity data.

Instrument development

It is a long term project which started in the '70ies with the development of a transportable absolute ballistic gravity meter of the rise-and-fall type by Istituto di Metrologia G. Colonnetti (IMGC) and is still underway with substantial improvements both in the throwing mechanism and in the timing electronics. In the last few years a new absolute gravimeter also based on

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the rise-and-fall method has been developed at the University of Trieste. Essentially the new instrument features a more precise throwing mechanism and a more accurate measurement of the space. The precision of these instruments is expected to be of the order of 1 μGal.

Geodetic metrology

Absolute gravimetry has been extensively employed in Italy in the framework of several national projects, both for purposes of geodetic metrology (gravity datum and scale) and for crustal deformations studies. Some 15 new absolute sites have been established, with an accuracy of about 3 μGal, to study crustal deformations at VLBI and SLR sites (national project supported by Italian Space Agency) and in volcanic area (Vesuvio, Vulcano, Ischia, Pantelleria), and to study sea level fluctuations. In the framework of an International Project funded by the European Community, the italian absolute gravimeter has been employed in France, Italy and Greece to realize, together with GPS, a reference frame to study the real fluctuations of the sea level. In 1994 a project to establish a zero order gravity network in Italy has been initiated. It is entirely based on absolute sites tied together by means of at least four LaCoste-Romberg Mod.G gravity meters. Several LCR Mod. D and one Scintrex will also be employed.

Fundamental physics

The Department of Physics and INFN of the University of Bologna installed in 1991 a GWR superconducting gravimeter in a dismissed nuclear plant near Bologna (Italy), in the frame of an experimental program meant to verify the validity of the Newton's law over distance of the order of 10-100 m. The calibration factor was determined adopting a method which consists in moving an anular mass of about 273 kg placed around the meter; the statistical accuracy of the method results to be 0.2 %. The comparison between the superconducting and an absolute gravity meter, performed in May 1994 by the Istituto di Metrologia G. Colonnetti of Torino (Italy), gave a factor which agrees on a rather satisfactory way with the previous one.

Microgravimetry

The assessment of volcanic risk and the study of gravity variations associated with the exploitation of geothermal fields are the two main targets of medium term microgravity projects.

Osservatorio Vesuviano di Napoli is costantly studying the variations of gravity field and crustal deformation in the active volcanic areas of Campi Flegrei, Ischia, Vulcano, Vesuvio and Pantelleria by means of repeated observations of microgravity networks and continuous recording of the gravity field on the Vesuvio. ENEL and University of Trieste have established a medium term project to monitor subsidence and gravity variations on all the geothermal fields, in Tuscany and Latium, currently under exploitation. The Project was initiated in 1985 and is still underway. More limited appear the projects to study gravity variations in seismic areas (mainly in Friuli, Northern Italy).

Land and marine gravimetry

Few local land gravity surveys have been performed on the Alps, Apennines and volcanic islands with the purpose of structural studies. More important are the researches performed by Osservatorio Vesuviano and Osservatorio Geofisico Sperimentale di Trieste in marine gravimetry.

The first has recorded some 900 new sites with the sea bottom La Coste Romberg model HG gravity meter in the Gulf of Napoli and around volcanic islands in that area. Main purposes of the research are studies of volcanic structures.

The second has acquired some 3000 km of surface marine gravity data on the Ross Sea in Antarctica and some 2000 km of gravity profiles in the Mediterranean sea. A new Bouguer gravity map of Ross Sea has been produced and analysed.

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The international Geoid Service: first two years of experience*

The International Geoid Service started the activity in 1993.

The work done

According to the IGeS by laws we have been in charge of:

a) collecting, archiving and making available to the scientific community data sets relevant in geoid computation apart from gravity data sets which are the natural field of work of the Bureau Gravimetrique International,

b) collecting and validating softwares for geoid computation,

c) training third parties in the use of the above software i.e. running international schools on the determination of the geoid,

d) participating to international projects relevant for the worldwide knowledge of the geoid.

a) Data collection: the largest experience we had in this field has been the one related to the determination of the geoid in the Mediterranean area: basically we are now organizing standard databases for digital terrain models, gravity anomalies on a 5'x5' grid covering the Mediterranean area, to which we have to add with the same resolution a gravimetric geoid and a stationary sea surface topography for the same area (Fig. 4).

Another data set we are currently preparing is a documented library of existing global geopotential models.

This field of action is by far the most difficult for us and it is easy to predict that only at medium term (e.g. in 5 years) we will be able to reach a status qualifying IGeS as a worldwide recognized data centre.

b) We have at present, coming from different sources, softwares to:

b1) manipulate global models to produce functionals of T1 first or second derivatives of T, in both spherical or ellipsoidal coordinates;

b2) produce (residual) terrain corrections to various kind of functionals of T both using exact formulas or approximate formulas computed by FFT;

b3) compute collocation solutions according to different philosophies, including the so-called Fast collocation solutions for gridded data;

b4) compute Stokes solutions with several algorithms, including FFT solutions.

c) A first international school has been organized in Milan from October 10 to 14, 1994; the courses have been given by 5 teachers (F. Sansò, R. Rapp, C. C. Tscherning, R. Forsberg, M. Sideris) to 34 students coming from 17 countries. Lectures have generally be followed by numerical exercises with computers.

A general assessment of the school done by the students evidenced their obvious desire of having more time for practical exercises; my own evaluation is that, considering that it was a first issue, the school has been excellent.

Lecture notes will be published and available at IGeS in 1995.

d) The main projects into which IGeS has had a part are:

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by F. Sansò (D.I.I.A.R., Politecnico di Milano, P.zza Leonardo da Vinci, 32, Milan).

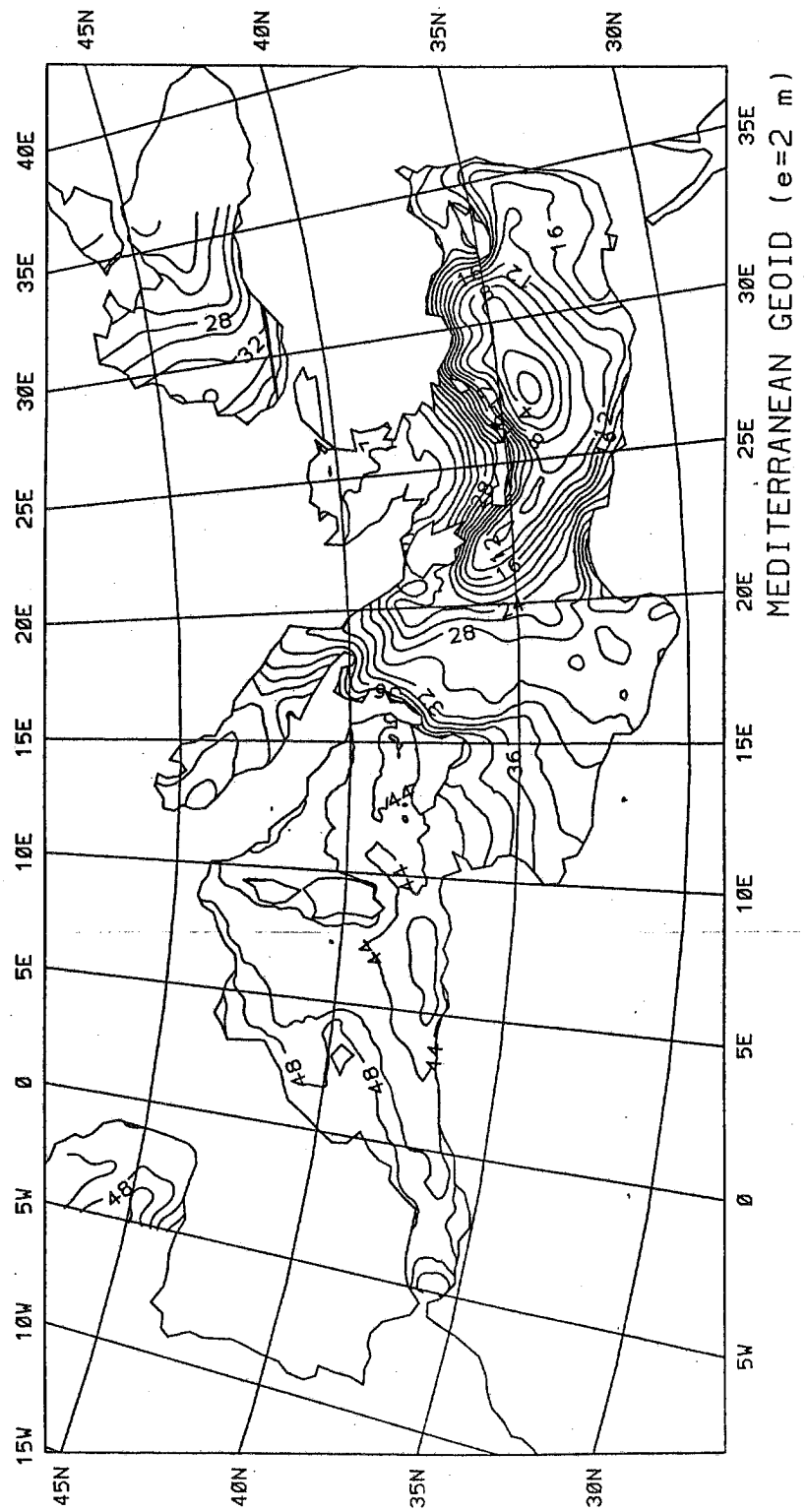

Fig. 4 - Mediterranean geoid.

d1) the GEOMED project, aiming at producing a gravimetric geoid and a SST for the Mediterranean, which has been concluded in September 1994;

d2) the ARISTOTELES project, followed by STEP project, to which IGeS has contributed by several simulations based on the concepts of a spacewise data reduction.

Moreover IGeS has had a small cooperation with the Hannover Group computing the new European Geoid, by comparing different types of solutions.

To be added to this activity there is the organization and issue of an IGeS Bulletin of which already 2 numbers have been published; the Bulletin is distributed in 250 copies, for the moment free of charge.

Future plans

Let us review the plans for the future of IGeS, considering only those which are considered as feasible in the next 4 5 years:

a), b) it seems difficult to be able to predict now what data and softwares will be collected in the next years; what is essential is that both the data and the software will be archived in a national library which should be made available on-line, on the IGeS main computer. Also the library should be advertised and updated on IGeS Bulletin, starting from N. 5 at the end of 1995;

c) the next course of the IGeS International School on the Determination and Use of the Geoid will be given in 1996.

Candidate sites for the school are Brazil and Indonesia. A choice will be made after Boulder, also depending on the available support;

d) projects which are currently under organization and to which IGeS intends to participate are:

d1) GEOMED2, the gravimetric geoid and SST of the Mediterranean with improved data sets (particularly altimetric data sets);

d2) analysis of Space Gradiometric Missions, whatever the International Community will pursue;

d3) Italgeo '95; the recomputation of the Italian gravimetric geoid in Italy.

To these we could maybe add the participation, though with minor impact, to the validation of the forthcoming global model computed cooperatively by DMA and NASA with the scientific support of the Ohio State University.

To this activity we have to add the publication of IGeS Bulletin N. 3, on which this report is to appear, and of the special issue IGeS Bulletin/BGI Bulletin d'Information containing the scientific documentation of a large number of very recently computed geoids.

As a small sample of the work done we add here the final map of the geoid in the Mediterranean, as well as our bibliography concerning only the Geomed and the Aristoteles projects.

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THEORY AND METHODOLOGY*

A number of theoretical results has been obtained by the group working at the "Politecnico di Milano", mainly in support of a more practical activity in different fields: regional geoid computation; for the refinement of the national geoid and for a first computation in the whole Mediterranean area); space geodesy; for the processing of altimeter data and for the design of gradiometric missions); GPS data processing; inverse problems in gravimetry.

The main topics which have been investigated are the following:

- Geoid computation: a new numerical procedure, called Fast Collocation, has been established, that allows to process simultaneously a large amount of data from areas of the order of 10°x10°, in order to obtain a high resolution geoid; it has been tested in the Western Mediterranean area, with satisfactory results (Barzaghi and Bottoni, 1993).

- GPS data processing: a new statistical approach (of Bayesian type) to the treatment of phase ambiguities has been analysed. New algorithms for data processing based on this approach have been defined and its implementation in a software for scientific use is being carried out (Betti et al., 1992, 1993).

- use of GPS in geodesy: the discrepancies between gravimetric and GPS-levelling geoid have been investigated and procedures to integrate GPS-levelling and gravimetric data in future geoid computations have been studied (Benciolini et al., 1991; Crespi et al., 1993).

- radar altimetry: a rigorous theoretical framework for the rank-deficiency problem has been established (Barzaghi et al., 1994).

- global gravity model analysis: new results have been obtained on the use of discrete Fourier

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analysis in the determination of spherical harmonic coefficients in the expansion of the disturbing gravity potential (Albertella et al., 1992, 1993; Albertella and Sacerdote, 1994).

- geodetic boundary-value problems: an optimal linear estimation theory for continuous fields has been formulated and used for boundary-value problems for data affected by noise (Barzaghi and Sacerdote, 1993; Crespi et al., 1993); furthermore, a new type of geodetic problem, including downward continuation to a simple reference surface, has been formulated and discussed (Sansò and Sona, 1994).

- inverse problems in gravimetry: methods to integrate and invert gravimetric and seismic data (or other kinds of geophysical information) have been studied (Barzaghi, 1994; Barzaghi and Sansò, 1994).

- inverse problems in cartography: interpolation methods for the recovery of transformation laws between different cartographic representations; analytical developments and numerical procedures for conformal and equivalent maps (Sacerdote, 1992; Marana and Sansò, 1994).

At the University of Rome theoretical investigations have been carried out on the following topics:

- determination of athmospheric models for the study of electromagnetic wave propagation in distance measurements (Caputo, 1994).

- relations between spectral features of topography and rheological behaviour for the study of crustal deformations (Caputo, 1993).

At the University of Trento contributions have been given in various topics on numerical methods for geodetic data analysis, in particular:

- use of finite elements, with a hybrid norm criterion, for smoothing and interpolation of data distributed in 2D (Benciolini, 1992).

- proposals for the applications of the multiresolution analysis in geodesy (Battha et al., 1994; Benciolini, 1994).

At the University of Udine new investigations have been carried out on the following topics:

- geometric properties of the gravity fields. In particular, new results have been obtained on generalizations of Clairaut's theorem, connecting the geometric flattening of the Earth to the variations of vertical derivatives of different orders of the gravity potential (Bocchio, 1994).

- hypothesis testing tecniques for quality control in GIS, particularly by use of non-parametric statistics. In recent times the attention has been focused especially on bootstrap methods (Crosilla, 1992, 1993; Crosilla and Pillirone, 1994a, 1994b).

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GEODYNAMICS*

Since 1990 the Department of Physics of the University of Bologna, the Istituto Nazionale di Geofisica, Rome and other Italian and foreign institutions have been contributing to set up the Tyrgeonet project with the purpose of performing GPS geodetic surveys in Italy and its surrounding regions in the central Mediterranean area.

The goal of the project is to quantify the present day strain field of the area located between France, Tunisia, Greece, Albania, Croatia, Slovenia and central Europe, presently subjected to active geodynamical processes due to the collision between the European and African plates. A network of 50 sites has been established in the area and since 1990 seven campaigns have been successfully performed.

The long term program of activities has the following characteristics:

- a large number of observation sites are measured, in order to outline the complex structural

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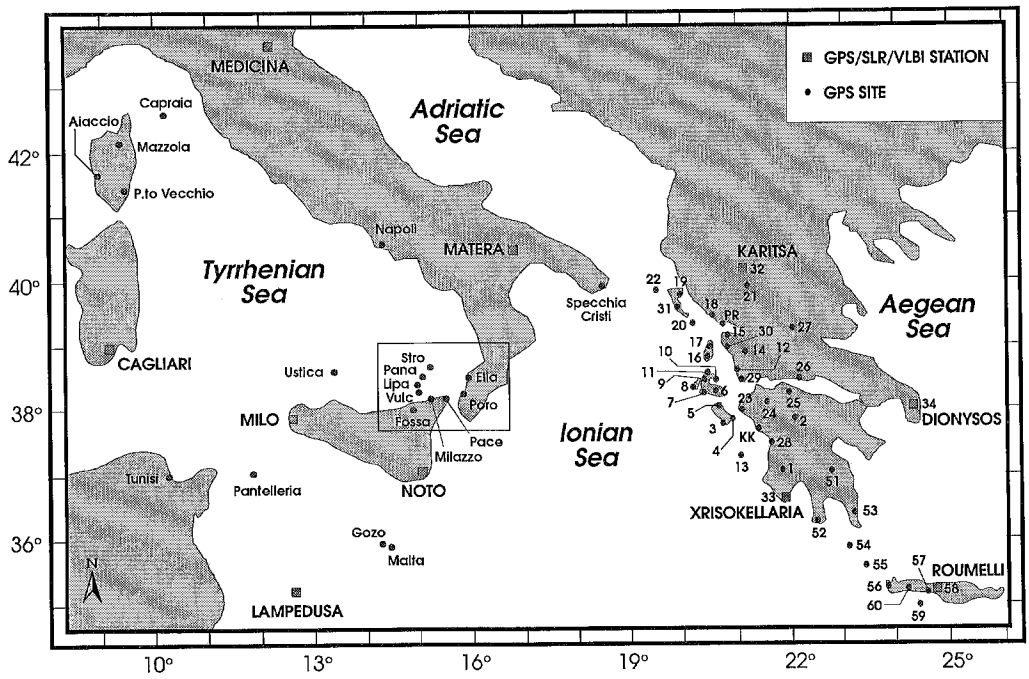

Fig. 5 - The WHAT-A-CAT network.

and tectonical features of the Italian peninsula.

- the local geodetic networks, already established in the past in some of the most relevant italian seismic areas are inserted in the general scheme of Tyrgeonet. This strategy was followed in order to separate the local movements from the regional ones.

For all the campaigns, the GPS observation data of SLR and V.L.B.I stations of Matera, Grasse, Wettzell, Punta Samenta (Cagliari) and Basovizza, Medicina and Noto were used. The data analysis is performed by the Bernese software using the precise ephemerides (CODE and NGS) and the ITRF reference frame.

After five years of surveys, the results obtained do not show valuable deformations between the Tyrrhenian and the Adriatic part of the network, while a strong deformation field is confirmed in the Ionian area.

Besides Tyrgeonet other GPS projects are currently carried out both in the Italian peninsula and abroad.

In 1993 a group of Institutions from France, Italy and Switzerland established and measured a GPS network in the West Alpine arc in the zone bordering Italy and France. The network, named Alps network, consists of 58 observation sites. The goal of the project is the evaluation of the present day crustal motion in this part of the European area which is currently subjected to a moderate tectonic activity,while in the geologically recent past has undergone strong deformations following the building and arching of the Alps.

Among the local GPS networks recently established in Italy, is that one located in Southeastern Sicily where a Md=5.1 earthquake struck the area between Catania and Siracusa during december 1990. This area, characterized by a complex tectonic setting, experienced in 1693 one of the greatest earthquake occurred in the whole Mediterranean area (M=7.5 estimated). The area has been already subjected to geodetic investigations by means of levelling surveys, that detected an active crustal dynamics.

The Dipartimento di Georisorse e Territorio, University of Udine remeasured, every year

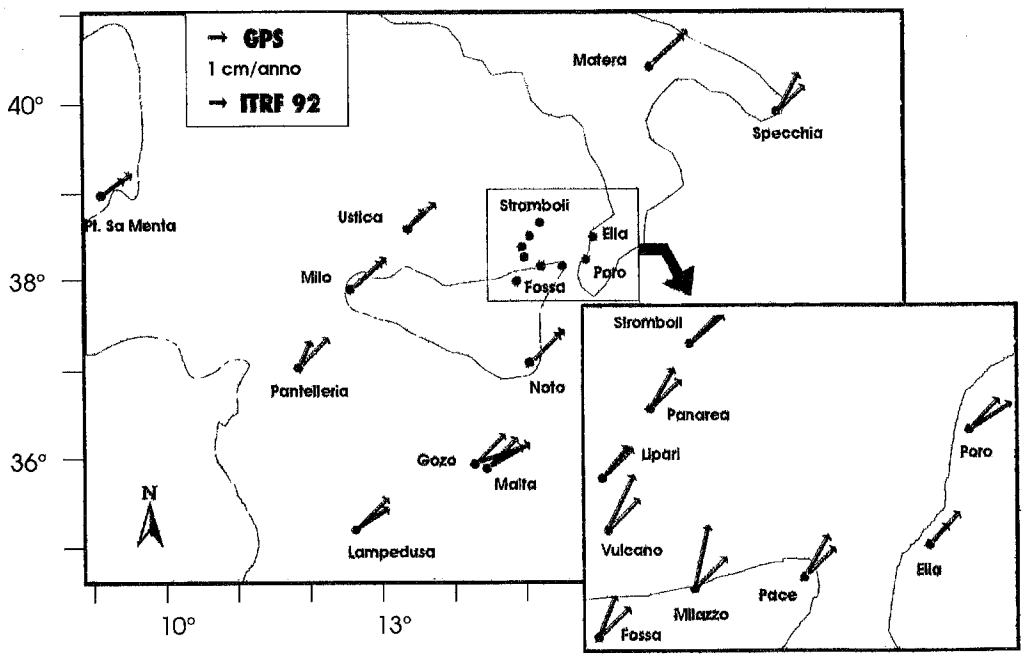

Fig. 6 - GPS derived velocities and ITRF92 predictions.

or every two years, with high precision classical geodetic instruments and GPS, the geodetic networks of Caneva, Gemona and Fella-Gail (Friuli seismic area in the northern part of Italy) and Travale (central Toscana), in order to monitor the ground displacements. These works have been carried out in collaboration with the Universities of Karlsruhe (D), Ljubljana (SLO) and Trieste, the CNR laboratories of Pisa and Venice and the OGS of Trieste.

In 1992 the height of Mount Everest was remeasured for the first time from both Tibet and Nepal sides with two indipendent methods: trigonometric levelling and GPS. The work was promoted by Prof. A. Desio and the Ev-K2-CNR Commitee with the collaboration of the Universities of Trieste, Padova and the National Bureau of Surveying and Mapping of Bejing (China).

In the frame of the Ev-K2-CNR project, supported by the Italian National Research Council, a GPS network has been established and measured in 1991 by a group of Italian Institutions in the Eastern Nepal area.

The network, that consists of 24 observation sites, plans to evaluate the present day active deformation in this part of the Himalayas due to the collision between the Indian and the Asiatic plates.

The West Hellennic Arc tectonics and Calabrian Arc tectonics (WHAT-A-CAT) GPS network

The Department of Physics of the University of Bologna under the coordination of Prof. Susanna Zerbini has been working since 1986 in the establishment, realization and measurement of a large network encompassing the southern Mediterranean from Sardinia as far as western Greece and including the island of Crete (Fig. 5). The objective of the WHAT-A-CAT-GPS project is to monitor recent crustal movements and deformations in the region of the Tyrrhenian, Pelagian and NE Ionian Sea. This endeavour has started as a collaboration between the University of Bologna and the Deutsches Geodätisches Forschungsinstitut (DGFI), Munich, Germany, by

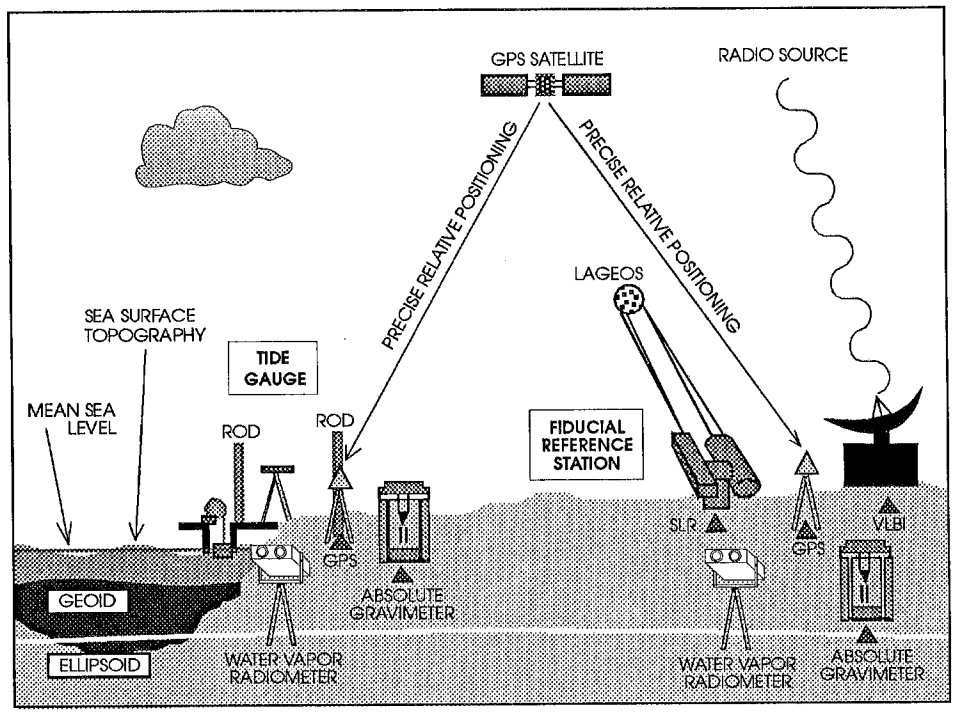

Fig. 7 - Schematic of th SELF approach.

establishing a network in the southeastern Tyrrhenian Sea covering four of the Aeolian Islands, northeastern Sicily and southwestern Calabria. This network was then extended in the Central Mediterranean to an area defined by the Punta Sa Menta, Lampedusa and Matera stations. In 1989 the first GPS campaign in the Hellenic Arc was carried out jointly by the National Technical University of Athens, Greece and by the ETH, Zürich, Switzerland, In 1990 the two projects joined into the common WHAT-A-CAT project (Kahle et al., 1993; Kahle et al., 1994). Since then three major GPS campaigns have been performed in 1990, 1992 and 1994. The GPS results for this large regional network will be tied to global scale through the Satellite Laser Ranging (SLR) stations of the WEGENER/MEDLAS network present in the area.

The analysis of the GPS data has been performed for the two networks separately and for the entire WHAT-A-CAT network. The results obtained so far are briefly outlined in the following. The analysis of the three joint campaigns, the last on took place in September 1994 and involved 43 stations, is presently being completed.

As far as the Calabrian Arc portion of the network is concerned, the results obtained so far (Fig. 6; Kaniuth et al., 1994) indicate that the regional velocity field follows, generally speaking, the north-eastward motion of the Eurasian plate. There seem to be, however, indications of a larger north component of the stations on the west side of the Straits of Messina and of a more eastward oriented drift of the islands of Malta and Gozo compared to the ITRF (International Terrestrial Reference Frame) solutions.

Sea level fluctuations: geophysical interpretations and environmental impact (SELF project)

The SELF project has been developed and realized in the framework of the European Union Programme on Climatology and Natural Hazards (Environment) and involves four member states (Germany, Greece, Italy, United Kingdom), Switzerland and Poland. Coordinator of the project is Prof. Susanna Zerbini, Department of Physics, University of Bologna. The objectives of the

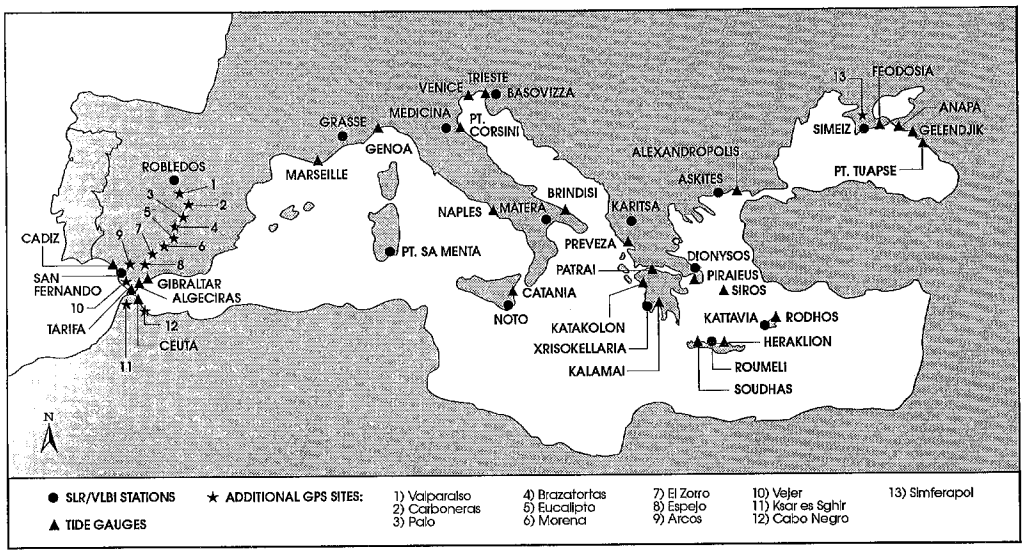

Fig. 8 - The SELF network.

project are: to select, in the Mediterranean region, fiducial reference stations belonging to the International Earth Rotation Service (IERS) network and well established tide gauges and to provide GPS links between the SLR/VLBI fiducial stations and the tide gauges; to improve GPS measurements procedures by using Water Vapor Radiometers (WVR) to minimize the error associated with the determination of the vertical component; to perform absolute gravity measurements both at fiducial sites and tide gauges to monitor, with an independent system, vertical surface elevation changes; to perform in selected areas of the Mediterranean Basin observations of geologic sea level markers of the past; to collect, analyze and interpret tide gauge data; to develop realistic models for tidal loading and tectonics in the Mediterranean region; to define corrections for the Earth's surface deformation due to exogenic causes and to study long-term variability of relative sea level. In Fig. 7 the schematic of the measuring approach is described, while Fig. 8 illustrates the SELF network which encompass the entire Mediterranean basin from the Straits of Gibraltar ad far as the Black Sea.

Besides coordinating the project, the italian contribution to this endevor has been mainly in the GPS, absolute gravity and geology fields. As a matter of fact, the italian team had the responsability to connect the tide gauges, in Italy and France, by GPS links, and to carry out the relevant analysis and interpretation of data; to determine absolute gravity at the french, italian and greek stations and to study the geologic markers of the past on selected coastal and shallow submarine areas of the Aeolian Islands Archipelago (Southeastern Tyrrhenian) with both field and oceanographic surveys.

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