

**SPANISH NATIONAL COMMITTEE
OF GEODESY AND GEOPHYSICS**

NATIONAL REPORT

1999-2002

Presented to the
XXIII General Assembly of the
International Union of Geodesy and Geophysics
Sapporo, Japan
July 2003



Introduction
Members of the Spanish National Committee
Association Reports

INTRODUCTION

This report has been elaborated by the Comisión Española de Geodesia y Geofísica (CEGG), which is the International Union of Geodesy and Geophysics (IUGG) adhering organization. CEGG administer the Spanish National Committee for the IUGG, whose current membership is presented below.

The main goal of this report is to summarize the research activities on Geodesy and Geophysics carried out in Spain during the years 1999-2002. This activities are presented in the form of reports elaborated by the Associations.

However, other activities has been carried out by the CEGG during the last four years as, for example, the joint organization of two Spanish-Portuguese

Assemblies on Geodesy and Geophysics: the first one held in Lagos (Portugal) in 2000, and the second held in Valencia (Spain) in 2002. These Joint Assemblies proved very fruitful in establishing scientific cooperations for the study of the Iberian area.

MEMBERS OF THE SPANISH NATIONAL COMMITTEE OF GEODESY AND GEOPHYSICS

The current membership of CEGG is:

President:

Albero Sereno Álvarez
Director General del Instituto Geográfico Nacional
General Ibáñez de Ibero, 3
28003 Madrid
Tf: 34-91-5979410
Fax: 34-91-5979753
e-mail: asereno@mfom.es

Vice-President:

Ricardo Vieira Díaz
Consejo Superior de Investigaciones Científicas
Instituto de Astronomía y Geodesia
Facultad de Ciencias Matemáticas
Ciudad Universitaria
28040 Madrid
Tf:34-91 3944586
Fax: 34-91 3944615
e-mail: vieira@iagmat1.mat.ucm.es

Secretary General:

Jesús Gómez González
Subdirección General de Geodesia y Geofísica
Instituto Geográfico Nacional
General Ibáñez de Ibero, 3
28003 Madrid
Tf: 34-91-5979460
Fax: 34-91-5979616
e-mail: jggonzalez@mfom.es

NATIONAL CORRESPONDENTS OF THE ASSOCIATIONS

IAG

Miguel Sevilla de Lerma
Instituto de Astronomía y Geodesia
Facultad de Ciencias Matemáticas

Universidad Complutense
28040 Madrid
Tf:34-91-3944582
Fax:34-91-3944615
e-mail: sevilla@iagmat1.mat.ucm.es

IASPEI

Antonio Roca Adrover
Servicio Geológico de Cataluña
Instituto Cartográfico de Cataluña
Parque de Montjuic s/n
08038 Barcelona
Tf: 34-93-5671510
Fax: 34-93-5671568
e-mail: roca@icc.es

IAVCEI

Ramón Ortiz Ramis
Museo Nacional de Ciencias Naturales.
Dpto. de Volcanología
José Gutiérrez Abascal, 2
28006 Madrid
Tf:34-91-4111328
Fax: 34-91-5644740
e-mail: ramon@mncn.csic.es

IAGA

Alicia García García
Museo Nacional de Ciencias Naturales.
Dpto. de Volcanología
José Gutiérrez Abascal, 2
28006 Madrid
Tf:34-91-4111328
Fax: 34-91-5644740
e-mail: aliciagg@mncn.csic.es

IAMAS

Manuel Gil Ojeda
Instituto Nacional de Técnica Aeroespacial
Ctra. Torrejón-Ajalvir Km. 4,5
28820 Torrejón (Madrid)
Tf: 34-91-5201564
Fax: 34-91-5201317
e-mail: gilm@inta.es

IAHS

Emilio Custodio Gimena
Instituto Geológico y Minero de España
Ríos Rosas, 23
28003 Madrid

Tf: 34-91-3495962
Fax: 34-91-3495817
e-mail: e.custodio@itge.mma.es

IAPSO

Juan José Dañobeitia Canales
Instituto de Ciencias de la Tierra Jaume Almera
Luis Solé i Sabaris, s/n
08028 Barcelona
Tf: 34-93-4095410
Fax: 34-934110012
e-mail: jjdanobeitia@ija.csic.es

ASSOCIATION REPORTS

The following reports summarizes the research carried out in Spain during the quadrennial 1999-2002.

- Section 1:** IAG (page 5)
 - Section 2:** IAGA (page 65)
 - Section 3:** IAHS (page 95)
 - Section 4:** IAMAS
 - Section 5:** IAPSO (page 97)
 - Section 6:** IASPEI (page 117)
 - Section 7:** IAVCEI (page 144)
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**COMITÉ ESPAGNOL DE GÉODÉSIE ET GÉOPHYSIQUE
SPANISH COMMITTEE OF GEODESY AND GEOPHYSICS**

NATIONAL REPORT ON GEODESY

FOR

1999 - 2002

IUGG XXIII GENERAL ASSEMBLY

PREFACE

This report outlines some Spanish activities in Geodesy for the period 1999 to 2002. It has been prepared for submission to the International Association of Geodesy (IAG) on the occasion of the XXIII General Assembly of the International Union of Geodesy and Geophysics in Sapporo, Japan, June 30 - July 11, 2003. It is issued on behalf of the Spanish Committee of Geodesy and Geophysics

In the report the main activities in Geodesy developed in Spain in the period 1999-2002 by different Institutions are presented. This Institutions in alphabetic order are.

- 1.- Hydrographic Institute of the Navy. (Instituto Hidrográfico de la Marina).
CADIZ
- 2.- Institute of Astronomy and Geodesy (Instituto de Astronomía y Geodesia),
MADRID.
- 3.- Institute Cartographic of Catalonia (Instituto Cartográfico de Cataluña).
BARCELONA.
- 4.- National Geographic Institute (Instituto Geográfico Nacional). MADRID.
- 5.- Royal Institute and Observatory of the Navy. (Real Instituto y Observatorio de
la Armada). San Fernando. CÁDIZ.
- 6.- Valencian Cartographic Institute (Instituto Cartográfico Valenciano).
VALENCIA

The information provided by the Institutions has been incorporate in the Report, and due to the quantity and diversity of works done these has been resumed, giving for each Institution a list of the activities followed by the list of papers published in the period.

Madrid, June, 2003

Miguel J. Sevilla
(IAG Spanish National Correspondent)

1. HYDROGRAPHIC INSTITUTE OF THE NAVY

INSTITUTO HIDROGRÁFICO DE LA MARINA
Plaza San Severiano, 3
11007 CÁDIZ (SPAIN)
Tel.: (34) 956 599 406, Fax.: (34) 956 275358

Introduction

The Instituto Hidrográfico de la Marina, located in Cádiz, was established by law dated 30th December 1943, as an organization within the Navy. A later Law on arrangement of Cartography (7/1986) specified the responsibilities of the Instituto, its task being the information and maintenance of basic Nautical Cartography.

The aim of the Instituto is to look after the safety of navigation, in the sense of collecting and diffusing information on the sea and the coast, and to foster the development of Nautical Sciences. To achieve this goal, the Instituto has six main responsibilities:

- Hydrographic surveys and studies on submarine relief in Spanish coastal and maritime areas, as well as other areas assumed in compliance of its agreement with the International Hydrographic Organization (IHO), where it represents the Government of Spain.
- Systematic observation and study of tides and currents, temperatures and acoustic and electromagnetic propagation in seawater, meteorology and, in general, any physical feature which may affect navigation.
- Development of Nautical Charts, books and documents as aids to navigation, and their printing and distribution.
- Collection of data and news on alterations in the environment, aids to navigation or dangers to the same, which will be disseminated as Notices to Mariners, for the updating of nautical charts and publications.
- Determination of features and specifications of nautical instruments used on board Navy vessels, certification and validation of them.
- *Carrying out geodetic and hydrographic works of interest for the Navy*, as well as research programmes assigned by the Navy Research and Development Directorate.

Maintenance of the Hydrographic Control Network

The *Hydrographic Control Network (RCH)* is a geodetic network used to control the positioning during a hydrographic survey. It is composed of geodetic stations called **RCH stations**. Currently, this network comprises some 1200 stations. The coordinates of these stations, as well as some other relevant data, are included in the so-called *RCH station report*, which is filed and stored in a database by the IHM *Sección de Fotogrametría y Geodesia* (Geodetic and Photogrammetric Section).

RCH station coordinates are determined by means of *moving geographic positions* using two kinds of procedures: Conventional Procedures, by measurement of angle field and/or distance, reduction of them to the ellipsoid and solution of the so-called **main geodetic problems**, also known as *Direct Problem* and *Inverse Problem*; and Spatial Technique Procedures, using the

satellite positioning system named *Global Positioning System, GPS*, which allow for the output of coordinates in system *ETRS89*.

RCH will be based on the stations of the ***Conventional Geodetic Network, ROI*** and ***National Geodetic Network by Spatial Techniques (REGENTE)***, established by the *National Geodetic Institute (IGN)*, or on *RCH* stations from surveys antedating current work in progress.

Measurement of field of distance and/or angle, to obtain the features of the ellipsoid used in the solution of the *main geodetic problems*, are carried out using several techniques like Polygonal, Radiation, Triangulation and Trilateration.

Transformation parameters from ED50 to WGS84 in the Spanish coast

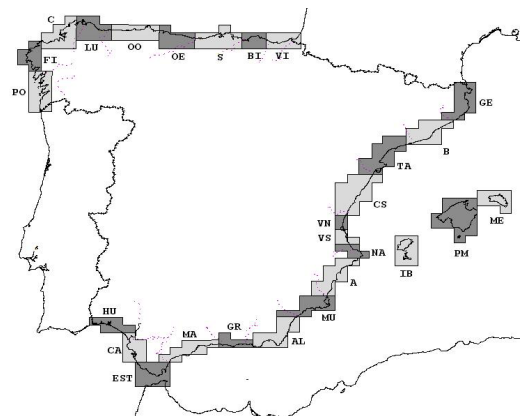
The simultaneous presence of datums ED50 and WGS84 force any cartographic production or positioning system to work on data referred to any of the two datums and produces a final result in just one of them. The current trend in production at the *Instituto Hidrográfico de la Marina* is to publish nautical cartography referenced to WGS84 datum, which is necessary for the generation of ENC (Electronic Navigational Chart).

Also, Hydrographic surveys are carried out under WGS84. The quality of final products relies on the quality of the transformations of items from one datum to the other, which has prompted a study on the most efficient methods of transformation. This study includes a number of observation cruises with GPS receivers to generate double sets of coordinates for the calculation of transformation parameters. The Instituto Hidrográfico de la Marina has finished these cruises, started in 1993.

The distribution of the areas which parameters are computed for is done on a province level along the whole Spanish peninsular coast, and at the island level for the Balearic Islands. Within each province, those sheets in the National Topographic Map scale 1:50000 inside its demarcation are selected. This set of selected sheets form a zone for the computation of parameters.

To cover the needs of the IHM regarding transfer of geographic files of nautical cartography in ED50 system into WGS84 datum, each chart has been assigned one province or island zone of parameters.

More general parameters have been computed for those nautical charts that, due to scale, comprise more than one province or island zone. Consequently, each nautical chart in the IHM Cartographic Project has been assigned specific transformation parameters.



Zones distribution, Molodensky 7 parameters model

A small statistical survey has been carried out to know the performance of the parameters on the limits of each zone with regards to the contiguous zone, resulting in mean discrepancies of 36 cm in longitude, 47 cm in latitude y 186 cm in height.

Publications:

Millán, J., (2002): Parámetros de transformación ED50 a WGS84 en el litoral español

2. INSTITUTE OF ASTRONOMY AND GEODESY (MADRID)

(Including Dep. of Astronomy and Geodesy. UCM)

FACULTAD DE CIENCIAS MATEMÁTICAS
UNIVERSIDAD COMPLUTENSE
28040 MADRID (SPAIN)

Tlf. ++ 34 91 394 45 86, ++ 34 91 394 45 82; Fax. ++ 34 91 394 46 15

URL: <http://www.mat.ucm.es>

SUMMARY OF Results description

Gravimetry and inverse problem (A. G. Camacho et al.):

Data reduction (tidal correction, instrumental sensibility, marine data) - Fit of traverses (drifts, recording jumps, scale adjustment, data quality) - Terrain corrections from digital models - Fit of regional trends (robust methods) - Covariance analysis and least squares prediction of gravity anomalies - Gravity inversion (non linear inversion, exploratory methods, inversion of noisy data with blunders, fit of linear trends, fit of models with positive and negative density contrasts, optimal balance between smoothness and fitness, 3-D models, graphical presentation of 3-D models) - Reduction of absolute observations.

APPLICATION WORKS: Mainly gravimetric studies of: - Archaeological rests (buried walls, Palaeolithic caves and crypts). - Karstic structures. - Volcanic areas: - Canary Islands Azores Islands - Deception Island (Antarctic)

Geodetic boundary value problems (J. Otero et al.)

The mathematical analysis, from theoretical and practical points of view, of some boundary value problems is one of the topics of Physical Geodesy. In the theoretical respect a new existence and uniqueness of solutions theorem has been obtained for the scalar Molodensky boundary problem (Otero and Sansò 1999). The theory and analysis of free boundary value problems has attained certain popularity in Geodesy in the last 20 years, being considered as a sort of reference theory providing a sound scientific background to the problem of determining the figure of the earth and its gravity field. In this framework an effort has been done to come to a solution of the most relevant problem, namely the so-called scalar geodetic boundary value problem (introduced by Sacerdote and Sansó in 1985), under the most general conditions of regularity of the boundary values. In this paper we give a result that, in the authors' opinion, seems to be the most natural and somehow a point of arrival of all the work done in the field. In fact the basic theorem proven in this paper guarantees a solution for the (modified) scalar geodetic boundary value problem in spherical coordinates under the conditions that the gravity g and that the potential v belong to the Hölder spaces H_α and $H_{1+\alpha}$, respectively.

A comparison between various approaches to solve some classical geodetic boundary problems, including Sansò's change of boundary method and the analytical continuation method, has been carried out in (Otero and Auz 2002). From the basic idea of the Molodensky shrinking we propose an alternative variational approach to solve some linear geodetic boundary problems. We show that the variational approach solution and the solution by analytical continuation are formally the same. The essential difference is that no use of downward analytical continuation is made in the variational approach. Rather, upward harmonic continuation from the Bjerhammar sphere is what is needed to explain the terms of the derived series. In this way the Morych-Moritz's solution could be now correctly interpreted. In addition, this upward harmonic continuation allows that one can guess some linking between the change of boundary method and the variational approach, and this relation is also studied in this paper.

The precision that can be obtained with the actual satellite positioning techniques justifies the assumption that the earth surface is known. Therefore nowadays the GPS-gravimetric boundary problem has become very relevant being one of its applications the determination of geopotential numbers (the physical measure of height above sea level). This is a non-linear and oblique derivative problem. In (Auz and Otero 2002) once the problem is linearized we solve it by means of Sansò's change of boundary method leading to a series solution avoiding a downward analytical continuation. The first order solution is compared with the gradient solution given previously by Moritz (2000). Using a Taylor expansion both results are shown to be formally the same.

Direct geodetic problem and UTM coordinates (J. Otero et al.)

Both in the determination of the latitude in the direct geodetic problem, and in the obtaining of the geodetic coordinates from the UTM coordinates we are led to solve a similar non linear equation. In (Bermejo and Otero 2002) we propose to use the Newton iterative method for solving both problems. Numerical examples show its fast convergence and accuracy. In (Bermejo and Otero, 2000) the maximum angular distortion for the UTM projection in finite approximation is analyzed. This maximum angular distortion is computed along parallels south, center and north of the Iberian Peninsula and along meridians close to the central meridian.

Time series analysis methods (J. Otero et al.)

Time series methods are of basic importance for the analysis of geodetic and geophysical time-dependent and large data sets. In (Otero and Sevilla 2002) we sketch the theoretical foundations of some stationary processes more frequently used, like moving average, autoregressive and ARMA processes. In addition, we give two examples quite different: the first one is a series of ellipsoidal heights obtained from GPS observations in Lanzarote's permanent station; the second, is a series of orthometric heights corresponding to the leveling network of Milan's Cathedral.

Theory of geodetic linear models (J. Otero)

The paper (Otero, 2000) is a contribution to the theory of geodetic linear models with rank deficiency equal to 1: we give the pseudoinverse matrix of the design matrix (which is of incidence type), and making use of the Gauss-Markov theorem we obtain the BLUE of the parametric functions associated to the rows of the design matrix (the true values of the observed magnitudes). This BLUE is interpreted as a weighted mean of all of its possible uncorrelated determinations using pairs of observations including the direct measurement.

Deformation modeling and interpretation of observations (J. Fernández Torres et al.)

Deformation models has been developed and improved for faulting and volcanic loading (see e.g., Charco et al., 2001; Fernández et al., 1999c; Yu et al., 1999; 2002).

The topography effect on the theoretical computations has been study (Folch et al., 2000; Charco et al., 2002) as well as the rheological properties and shape of the intrusion effects (Folch et al., 2000, Fernández et al., 2001). Deformation and gravity changes produced by volcanic loading has been modelled using different theoretical models and the Genetic Algorithm techniques for inversion.

Applying geodetic techniques to monitoring activity involves interpretation using deformation models. Usually gravity change data and displacement data are interpreted separately. Fernández et al. (2001) show, using modeling of deformation and gravity change data in Campi Flegrei, Italy, Mayon Volcano, Philippines, and Long Valley Caldera, California, USA, that this can lead to incorrect interpretations. Also, in the traditional style it can be difficult, if not impossible, to interpret the data coherently or correctly in terms of the

characteristics of the intrusion or the deflation derived from the gravity changes with purely elastic models, as in the case of Mayon Volcano, Phillipines. The results obtained show that displacements and gravity changes must be interpreted together whenever possible and that elastic-gravitational models can be a far more appropriate approximation to problems of volcanic load in the crust than the more commonly used purely elastic models. Therefore it is necessary to change the philosophy normally used to interpret geodetic observations, improving the possibility of predicting future eruptions. Also the combination of displacement and gravity changes is found to be especially effective in constraining the possible characteristics of the magmatic intrusion as well as the rheology of the medium surrounding it. Tiampo et al. (2000) model the second inflation period at Long Valley caldera, California using a genetic algorithm technique and high quality geodetic measurements of elevation changes and baseline extensions. They compare two source inversions for both spherical Mogi point sources and the finite prolate ellipsoid of Yang and Davis. A sensitivity analysis for the genetic algorithm is performed based upon synthetic data set inversions on similar sources in order to better constrain the areal location, orientation, and volume of the potential sources.

Volcano monitoring: designing and observation. (J. Fernández Torres et al.)

The geodetic monitoring system in Tenerife, Canary Island, has been theoretically studied by Fernández et al. (1999) and Yu et al. (2000), arriving to the conclusion that it should be changed and extended to cover the full island for volcano monitoring purposes. A clear choice should be a global GPS network. In this context, two research projects were trying to demonstrate the feasibility of using Synthetic Aperture Radar Interferometry, InSAR, for operational decision-making support purposes at a volcanic risk scenario such as the Canary Islands and to define a monitoring system for volcanic hazard in Spain that includes the operative use of InSAR techniques (Carrasco et al., 2000, Fernández et al., 2002, Romero et al., 2002). The results has shown that InSAR is an useful technique for volcano monitoring in Canary Islands. On Tenerife island, two deformations were detected outside the usually observed area, and located in the region where the most recent eruptions on the island have occurred (Fernández et al., 2002). Due to the very poor spatial coverage of the geodetic volcanic monitoring previously performed on the island, that deformation had not been observed before with any other observational technique, and very probably would never be detected without using an observational technique such as InSAR, or any other appropriately distributed to cover the full island. However, it must be stressed that in some areas of the island there is such dense vegetation that InSAR cannot be used to monitor ground displacements, at least in the radar frequency employed by the ERS-1 and ERS-2 satellites used in this study. Therefore previous results made necessary the design and observation of a GPS network in the island for volcano monitoring in combination with other techniques, validation of the deformations detected by InSAR. Rodríguez-Velasco et al. (2002) and Gonzalez-Matesanz et al. (2002) describe the designing, observation methodology, results and interpretation of the GPS surveys conducted in Tenerife. The results has allow to define a new geodetic monitoring system for the full Tenerife island combining InSAR and GPS.

Continuous observation of gravity has been done in Tenerife and Lanzarote islands and the tidal results has been interpreted (Arnosó et al. 2000, 2001).

A design of the geodetic monitoring for the full Canary Island has been done with base on the theoretical and observational results (Fernández and Luzón, 2002).

Cartographic projection (M. J. Sevilla and J. A. Malpica)

Study of some elastic properties of the projections with the Second Order Theory of Chovitz. This lead to give a new projection within the azimuthal ones which yields a minimum for the elastic deformation energy. The application of strain criteria in map projections is proposed by Dermanis et al; since this approach gives cumbersome formula it is used the second

order Chovitz theory to facilitate the study. This approach is sufficient for most applications on a small scale. At the same time it is studied the difference between direct formulae and formulae obtained using second order theory.

Geopotential model for the north-east Atlantic (M. J. Sevilla et al.)

A new geopotential model tailored to gravity data in the north-east Atlantic was developed. The new geopotential model (FCUL96B), completed to degree and order 360, has been calculated using a new set of 30' x 30' mean free-air gravity anomalies obtained from several ocean gravimetric missions since 1975 to 1990. The calculation of the tailored model was based on the OSU91A coefficient set, that was used as a start model. The comparison of EGM96, OSU91A and FCUL96B, with altimetric data obtained from ERS1 and TOPEX, reveals a better accuracy of the FCUL96B model. In this area EGM96 geopotential model reveals a better fit to the gravity field than OSU91A but not as good as the tailored model FCUL96B. From the results we obtained, we verify that a tailored model can provide a superior reference surface for local and regional solutions, if the gravity data used in the tailoring process was improved in quality or in density.

Satellite altimetry (M.J. Sevilla et al.)

ERS-1 satellite altimetry data corresponding to the second multidisciplinary phase of the satellite, have been used over a zone in the North Atlantic during fifteen months of mission. They have been corrected of all modelled effects. A data validation has been done using criteria related with the observed and average statistical values. Mean arcs are obtained from a year to take out the seasonal effects. After getting them, crossover points between ascending and descending arcs are determined. Residual differences are adjusted by least-squares. Two parameters are obtained for every arc. The mean sea surface obtained with the adjusted residuals is tested over Canary Islands region with a gravimetric geoid.

Satellite altimetry from Geosat (18 months) and ERS-1 (10 months) geodetic missions provide data with a very dense coverage, allowing a very detailed recovery of the gravity field. Stacked data from TOPEX/Poseidon (6 years in a 10 day repeat cycle), ERS-2 (4 years in a 35 day repeat cycle) and Geosat ERM (2 years in a 17 day repeat cycle) are used to define a precise reference frame where the previously mentioned data are adjusted.

The effect of the sea surface topography is reduced by fitting each profile of the sea surface height to the corresponding profile of the EGM96 geoid undulation. A remove-restore procedure is used to obtain residual sea surface heights eliminating the contributions of the low (with the global geopotential model EGM96 as reference field) and high (the effect of the topography/bathymetry is computed using the RTM correction with the local accurate bathymetric model AZDTM98 and global JGM95E) frequencies to the sea surface heights. A validation procedure is then applied, comparing each value with an estimation obtained using least squares collocation. A cross-over adjustment using bias and tilt parameters is followed by the estimation by least squares collocation of a dense grid of residual geoid undulation using the validated data. Finally an efficient method based on Fast Fourier Transform is used to obtain the residual gravity anomalies by inversion of the mentioned grid. After adding the contributions to the gravity anomalies from the global geopotential model and from the topography/bathymetry, the result is compared with adjusted gravity data obtained by gravimetric surveys.

High precision bathymetry and geoid computation (M. J. Sevilla et al.)

The effect of a new detailed regional terrain model on geoid computation has been studied. A new detailed bathymetric model around Azores Islands has been constructed based on new ocean depth information obtained from echo soundings during ship surveys. These bathymetric data were merged with high precision height data on land producing a new terrain model (AZDTM98) with 1'x1' resolution on sea and 20''x20'' on land. Global digital terrain model JGP95E was compared with AZDTM98 model. Sea and land gravity data covering the area was merged with satellite derived gravity anomalies for geoid computation. Least squares collocation was used for geoid estimation according to the remove-restore technique using EGM96 geopotential model and RTM method. Two geoid solutions were obtained from AZDTM98 and JGP95E models and compared with 134 GPS stations on land and with ERS-1 and ERS-2 altimetric data on sea. From this comparison it was found, on sea, a slight improvement for AZDTM98 model after the removal of the trend surface, reaching the level of 5 cm in the difference between the two models. The new detailed bathymetric/altimetric data did not improve the geoid solution as it was expected.

Gravity and Mean Sea Surface and geoid (M. J. Sevilla et al.)

In the last years, several data sets and gravimetric, bathymetric, mean sea surface models have appeared globally or just for the Mediterranean Sea. Analysing them it is possible to see that there are significant discrepancies between the models provided by different authors or organisations. We present such differences and conclude the most representative choice in our opinion, for the Mediterranean area.

In geodetic and oceanographic studies generally, some reference surfaces are needed. These surfaces must represent as much as possible the gravity field of the Earth and the height/bathymetry systems. In the last years, several gravimetric, bathymetric, and mean sea surface models have appeared. Analyzing them it is possible to see that there are significant discrepancies between the models provided by different authors or organizations; there are also differences between the models and data obtained by independent measurements. We present the analysis of such differences and determine the most representative choice of models, in our opinion, for the Canary Islands region.

Gravimetric and altimetric data are used to assess an estimation of the sea surface topography in the Western Mediterranean Sea. This is a complex area from different points of view, due to the presence of several islands, coastal lines, shallow waters and a peculiar hydrologic equilibrium due to its proximity to the Atlantic water exchange area. Firstly, a gravimetric geoid was computed using the least-squares collocation (LSC) procedure with the classical remove-restore technique. We also present a local mean sea surface generated from repeat ERS-1 altimeter data fitted to TOPEX. We chose this satellite because it offers a better spatial resolution than the TOPEX data. The time span used in the computations is one year. This is a useful interval for averaging out the regular seasonal variations, which are very large in this area. We present the comparisons between the gravimetric geoidal heights and the adjusted sea surface. This is a way to obtain a rough estimation of the sea surface topography (SST) since we also include the errors in the two surfaces and other oceanic signals. The differences obtained are physically reasonable with a mean of 17 cm and standard deviation (s.d.) of 39 cm. A significant similarity is observed between the features reproduced by these differences and the bathymetry in the area, suggesting some sort of correlation between both magnitudes for the studied region. If we accept such correlation, the SST may be described as a function of depth. This procedure lets us filter out the short wavelength part of the geoid from the first SST estimation.

A mean sea surface model is used as the frame of reference in processing altimeter data. This work focuses on ascertaining the extent to which results depend on the different mean sea surface models used. In particular, we have analyzed the results from the OSU95MSS and the CLS SHOMv.98.2 models in an area in the North Atlantic Ocean comprising the Canary and Azores Islands. Special attention has been paid to data editing and several criteria were

proposed. The amount of detected data is quite small because we used a well corrected data set. However, it was enough to show important relations between the applied criteria and the kind of area. Therefore we analyzed the best way to apply these criteria according to the areas where the points have been found. Singular areas related to several factors have been detected by all the suggested criteria. In particular, rough sea bottom features, dynamic circulation, and amphidromic points of the tidal waves, among others. As a result of this analysis, we have not considered it appropriate to remove all the detected points. Two time-averaged and corrected mean sea surfaces were determined in the test area.

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3. INSTITUTE CARTOGRAPHIC OF CATALONIA (BARCELONA)

INSTITUT CARTOGRÀFIC DE CATALUNYA (ICC)
Parc de Montjuïc, s/n.
08038 – BARCELONA (SPAIN)
Tif. ++ 34 935 671 500
Fax. ++ 34 935 671 567
URL: <http://www.icc.es>

1. SPGIC: Sistema de Posicionament Geodèsic Integrat de Catalunya

Since 1991, the *Institut Cartogràfic de Catalunya* (ICC) has been working on the SPGIC project (Integrated Geodetic Positioning System of Catalonia), based on sparse geodetic networks, the knowledge of the geoid and GPS. SPGIC may be defined as a set of geodetic permanent stations, networks, procedures, regulation data, communications, software, hardware and technical advice for the purpose of high-precision local positioning in Catalonia.

1.1 XU: Xarxa Utilitària de Catalunya

The objective of the XU is to have a modern and accessible geodetic network. Modern because XU is a three-dimensional network, where horizontal and vertical components are computed at the same time. Accessible because the distribution of its points adapts to user necessities and technology. In order to know the description, location, coordinates and information associated with each one of the XU vertices, for each point a file with all the information is generated. These files can be consulted and printed free of charge through Internet (<http://www.icc.es/ressenyas/homeang.html>).

Until the end of 2002, XU has observed 2138 points with GPS technology. In the next years the ICC try to finalize the implantation of the XU with about 2000 additional points, at the rate of about 250 points per year. The density of the XU depends on the difficulty of ROI access and on the dynamics of the territory.

1.2 XdA: Xarxa d'Anivellació

In a high dynamical territory, like Catalonia, the conservation of the leveling network can become a difficult task. In order to densify the NAP (*Nivelación de Alta Precisión*) network from the *Instituto Geográfico Nacional* (IGN) the ICC is leveling since 1998 the Xda network. Other objectives of the Xda are the aim to obtain a more homogenous coverage and to improve the conservation of the leveling points in Catalonia. The permanent GPS stations (CATNET) are also being leveled as part of the Xda project. At the end of the 2002, 456 km have been measured, continuing its observation at the rate of 100 km annual. Xda assures a precision 1mm by square root of level km.

Since a part of the leveling signals are located in optimal sites for the GPS measures, the Xda facilitates the precise determination of geoid profiles. These profiles are useful for the evaluation of the precision of the geoid and for its later improvements.

1.3 Tidal gauge stations

Since 1990, the ICC has been storing data from the tidal gauge station l'Estartit and has been collaborating with other institutions in Spain.

1.4 GPS permanent stations

One of the kernels of SPGIC project is the network of GNSS permanent stations that the ICC has implanted on Catalonia (CATNET). The network was conceived mainly to offer a public service of GPS data. Its main client is the own ICC, for the necessities of kinematic positioning of its airplanes. The network was designed from an initial triangle (corresponding to the three ends of the Catalan territory) and has been densified progressively towards the interior. Throughout 1999, the first phase of this densification was completed with a network of 8 stations (5 of them members of the EUREF Permanent Network, EPN). From year 2000 the second phase of this densification is under deployment. Ending with a total of 14 stations in 2004. The coverage provided by a set of 14 stations will allow implementing systems of RTK positioning in real time in a robust form, since the mean distance between stations will be of 70 km.

We can distinguish two types of stations: geodynamics, in which the point is materialized with a structure of great robustness anchored in the subsoil and that is going to allow to us to use its data for studies of cortical deformations; and non-geodynamic, with one structure that guarantees the stability of the antenna in the long term although not at the mm level. All the stations implemented during the first phase belong to the geodynamic type whereas in the second phase they are going away combining geodynamic stations with non-geodynamic stations.

By reasons for redundancy the data can be downloaded to ICC by two different ways via modem or via satellite using VSAT (Very Small Aperture Terminal) network. Since 1999, VSAT technology is considered as the main telecommunications system to the GPS stations, covering at the present time 7 of the total of 10 stations. This implantation is made jointly with the Unit of Geology that has implanted it in its new seismic network.

1.4.1. GeoFons

The GeoFons service, initiated in 1995 and at the moment through Internet, have been extended and improved, offering now the following products:

- Observations of CATNET network. RINEX standard format has been adopted for all GPS files, as a standard product.
- Geoid, datum transformation parameters, XU coordinates, etc.
- Reviews of the XU points.
- Software of free distribution created by ICC.

Daily, the files of GNSS data of stations AVEL, BELL, CREU, GARR, EBRE, ESCO, LLIV, MNTC and PLAN are available in the network, as much in form of hour-files at a rate of 15 seconds, like in daily-files at a rate of 30 seconds. In addition, VSAT system offers to the users hour-files at 1-second rate for AVEL, BELL, CREU, EBRE, GARR, LLIV and PLAN stations after few minutes to complete the hour in course. This capacity will be extended to the rest of stations according to these are incorporating VSAT system. The availability online of the hour-files is of 30 days, although also service is offered off-line under order to geofons@icc.es. Access to the GeoFons service is free of charge through anonymous FTP (<ftp.icc.es>). More information can be found in <http://www.icc.es>.

1.4.2. RASANT

Since 1995 the ICC is offering the RASANT service consisting in the transmission of RTCM SC-104 code corrections via Radio Data System (RDS). Its operative phase initiated at the beginning of 2001 with the installation of the Integrity Monitor System, according to standards RSIM. This system allows a continuous monitoring of the state of the broadcasting and the quality of the transmitted corrections.

1.4.3. CATNET-IP

The use of Internet and the present facilities for movable devices to access Internet, as well as their capacity to transmit data continuously, make this way of data transfer very suitable to offer several differential positioning services. With this goal and led by the BKG (*Bundesamt für Kartographie und Geodäsie*) within the EUREF-IP project, the ICC has started a test phase of the service CATNET-IP, based on a station installed in the ICC.

The service works under the concept of client-servant. The servant gathers the data of a GPS receiver and makes available for the clients, via TCP/UDP ports, the generated data. The IANA (Internet Assigned Numbers Authority) has reserved ports 2001 and 2003 for the transmission of differential GPS data by Internet. Thus the client applications, in fixed platforms or movable, select a servant through its connection to Internet and connect its client application. For more information about this project and for unloading sample software, one can visit the following Internet site, http://igs.ifag.de/euref_realtime.htm

1.4.4. CATPOS

The ICC is developing a public positioning service, free of charge, CATPOS, which provides GPS users of coordinates at centimetre level (up to 10 cm depending on the quality of the data) from the network of permanent stations CATNET.

It offers a positioning system based on double frequency static GPS data, in RINEX format and using Internet technology. After making a GPS observation in a point, the user must fill in a questionnaire, which sends his observation file to the ICC. Then an automatic process is activated based on the Bernese Processing Engine (BPE) of the Bernese Software Package v.4.2. Each file will be processed with respect three CATNET stations. The selected stations are chosen considering the distance, number of observations, operatively, etc. The position associated to the data will be given back to the user via electronic mail in few minutes.

1.5. GeoCat: Geoide de Catalunya

Geoid determination is still one of the main activities of the geodetic research. Since the determination of the geoid of Catalonia, UB91, in 1991, the situation has been improved sensibly:

- There are new global gravity field models (EGM96, EGG97, GPM98), which have improved considerably the OSU89 model used in UB91 determination.
- Combined GPS/levelling observations in XU-XdA points.
- New DTM determination of Catalonia.
- Points with observed deflections of the vertical.

It has been detected and corrected an absolute offset of 80 cm observed in the UB91 geoid. Also in some projects, several areas with great gradient disturbances have been detected.

There are plans for a new determination of a precise Catalan geoid by using GRAVSOFT software. GRAVSOFT is a FORTRAN package that allows the determination of the gravity field, specially the determination of local geoid models using the well-known remove-restore technique.

The ICC has collaborated in some projects about sea level measures based on GPS buoys:

- CATALA: absolute calibration of the altimeter Topex Poseidon. In this project, 2 GPS buoys have designed and built. Each buoy consists of a floating system to lodge a choke ring antenna for the precise study of the sea surface. The ICC has participated in the

GPS observation campaign in the zone of Llafranc. It has made the assembly and the control of a reference station in the zone. It has built and observed with GPS a leveling benchmark in the port of Llafranc in order to equip with precise height a tide gauge located in this port.

- CRAC: development of a system of geocentric measures of the sea level (FEDER 2FD97-0588). The ICC has participated in two observation campaigns with the GPS buoys defined in the CATALA project.

2. High precision positioning

Within the frame of the PotSis (Potencialitat Sísmica del Pirineu Oriental) project for measuring crustal movements in the eastern Pyrenees the, PotSis'99 campaign has been carried out. The campaign was done from 28 June 2000 until 2 July 2000 with 11 receivers GPS (3 Trimble 4000 SSI, 1 Trimble 4000 SSE and 7 AshTech Z-xii3), antennas choke Ring and permanent station CATNET of Llivia (LLIV). The PotSis point in Llivia has been connected with the CATNET station LLIV, so continuous GPS data are obtained for this study. The Bernese software package v.3.5 has been used order to calculate the GPS baselines using final IGS precise orbits and data from the nearest EUREF permanent stations. The resulting network has been adjusted using GeoTeX/ACX and a precision of 3,5 in planimetry and 5 mm in altimetry have been obtained for the 24 points of the PotSis network.

3. GEOVAN

Land Based - Mobile Mapping Systems (LB-MMS) is a technique for compiling cartographic information from a mobile vehicle. With the objective to develop its own LB-MMS the ICC has developed the project GEOVAN. GEOVAN is based on the orientation and positioning subsystems and allows a flexible integration of different kinds of sensors (digital cameras, lasers...). The system is equipped with a structure where the sensors are rigidly attached, so it is possible to transfer the orientation computed by the GPS/IMU to the Earth observation sensors. Initially GEOVAN integrates two digital cameras in order to form oriented stereoscopic models.

5. GeoTeX: Geodèsia, Teledetecció i Xarxes

The GeoTeX system is a general geodetic and photogrammetric point determination system, which is able to deal with any type of geometric functional model.

The automatic error detection during the computation allows, together with the dynamic implementation and memory allocation of the new version of the AdIL format, ACX to be a robust and operative system for any kind of project. During this period, it has been continued the development and implementation of new mathematical models and new tools to transform data.

6. Public service

The ICC is collaborating with l'Escola d'Enginyeria Tècnica Topogràfica de la Universitat Politècnica de Barcelona (UPC) and Departament d'Enginyeria de Geodèsia, Cartografia i Fotogrametria, Universitat Politècnica de Valencia on several student diploma projects.

The Col·legi Oficial d'Enginyers Tècnics en Topografia de Catalunya i Balears, the Geomatics Institute and the ICC organized the IV Setmana Geomàtica de Barcelona (Sitges, 3-6 April, 2000).

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4.- NATIONAL GEOGRAPHIC INSTITUTE. MADRID

INSTITUTO GEOGRÁFICO NACIONAL
General Ibañez de Ibero, 3
28003 MADRID, (SPAIN)
ph.: 34 91 597 9768
fax: 34 91 597 97666
e-mail: adalda@mfom.es

1. REFERENCE SYSTEMS

1.1 REGENTE

Aiming the set of an unified European cartography, it is indispensable the coordinate conversion of National Geodetic Reference Frames to the ETRF89 Frame. Such a determination requires the knowledge of coordinates in both systems in a very high number of stations uniformly distributed, should this number be higher if the irregularities in the local Frame increase.

In the case of Iberian Peninsula and archipelagos, the IGN decide to fix the problem by REGENTE Project (Spatial technique National Geodetic Network), consisting of setting up a dense GPS high precision network with coincident stations to ROI (Third Order Geodetic Network) and some benchmarks of High Precision Levelling Network. The mean density was fixed to one station per MTN sheet (National Surveying Map) scale 1:50,000, that is, one station per 300 km².

REGENTE will be perfectly linked to the ETRF89 reference network, thus IBERIA95 and BALEAR98 which stations are REGENTE points as well. REGENTE Canarias (Canary Islands) was leaned, as reference station, on Maspalomas (VLBI and IGS station).

Objectives

With REGENTE Project the following objectives are reached:

- Implementation, observation and co-ordinate determination, for entire Spain, of a three-dimensional basic class C network, with an absolute precision better or equal than 5 cm.
- Obtainment of precise transformation parameters between reference system of National Geodetic Network, ED50, and that of REGENTE, ETRF89.
- To ease valid data to debug Spanish geoid of centimetre precision. REGENTE project is supported with relative Lacoste-Romberg gravimetric observations in every point.
- To ease support to the high number of GPS technique users, so that any national point could be inside a maximum circle of 15 km. with centre in a REGENTE station.

REGENTE points have to fulfil the following requirements:

- Belong to the National Geodetic Network, or VLBI or SLR.
- Common features to a GPS station: easy vehicle access, open horizon above 10°, enough distance from elements, which might cause multipath or interferences.
- As REGENTE is a three-dimensional network with observed ellipsoidal heights referred to GRS80 and should perfectly be linked to National Geodetic Network ED50, which heights are referred to sea level, it has been established that more than 10 percent of points should have orthometric height, with sub-centimetre precision, through the link to the High Precision Levelling Network, NAP.
- Whenever the requirements of a GPS station are fulfilled, the Laplace points will be included in REGENTE and the second order astronomical stations.
- Each point of IBERIA95 and its extend BALEAR98, belong to REGENTE.

- To serve as a reference frame for local networks used for geodynamic.

In the same way, 12 points have been included in Canary Islands REGENTE net. Its fundamental point is the VLBI station of Maspalomas, in Gran Canaria.

Realization

The mark and observation tasks which begun in 1994 reached two thirds of the project in 1998, and kept on through the period concerning this report till their end in 2001.

Definite structure

REGENTE consists of around 1078 stations in the Iberian Peninsula and Balearic Islands, one per MTN sheet (National Surveying Map) scale 1:50,000, which implies a mean distance of 20 to 25 km between stations. In the Canary Islands, REGENTE Canarias, REGCAN95, consists of 72 stations delivered in seven islands with a maximum of 21 in Tenerife, and being 5 the minimum in every minor islands of El Hierro and La Gomera.

1.1 GPS Reference Station Network (ERGPS)

Introduction.

Since its in 1991 the International GPS Service (IGS), more than 220 permanent stations operate continuously with double frequency GPS receivers with the objectives: to better, extend and define the International Reference Frame (ITRF); study of terrestrial Geodynamics; determination earth rotation variations and pole coordinates; processing and distribution of precise orbits.

It was the IAG sub-commission for Europe, EUREF, which decided the set and control of the permanent European GPS Network, by forming a densification called EUREF Permanent Network (EPN).

The Spanish network, ERGPS.

Since March 1998 when the National Geographic Institute begun the installation of permanent stations on national territory, 16 ERGPS form the current network, which is fully operative and ten of them serve data to IGS and EUREF for definition of World and European Frames, respectively.

The link of Yebes permanent station (YEBE) to the telescope by high precision geodetic observations and its integration in IGS makes possible the transference from VLBI observations to the network, being its kernel of IGN analysis.

The ERGPS already installed are located in:

- ALAC - Tide-Gauge of Alicante (IGN).
- ACOR - Tide-Gauge of La Coruña (IGN).
- YEBE - Observatorio Astronómico de Yebes (IGN).
- ALME - Observatorio Geofísico de Almería (IGN).
- VALE - Universidad de Valencia.
- MALL - Instituto Español de Oceanografía de Mallorca.
- MALA - Observatorio Geofísico de Málaga (IGN).
- CANT - Escuela de Ingenieros de Caminos, Canales y Puertos (Univ. Cantabria).
- SONS - Observatorio Sismológico de Sonseca (IGN).
- CACE - Universidad de Extremadura en Cáceres.
- RIOJ - Observatorio Geofísico de Logroño (IGN).
- LPAL - Observatorio Astronómico Roque de los Muchachos (Inst. Astrofísico de Canarias).
- CEUT - Autoridad Portuaria de Ceuta.
- HUEL - Universidad de Huelva.

- VIGO - Instituto Español de Oceanografía de Vigo.
- ALBA - Universidad de Albacete.

The following table shows the data availability dates, the belonging network to EUREF or IGS and the hourly transfer data in "near real time" (nrt < 10 minutes).

ERGPS	Datos	EUREF	IGS	Nrt
ALAC	04 / 98	X		
ACOR	01 / 99	X		
YEBE	05 / 99	X	X	X
ALME	12 / 99	X		
VALE	12 / 99	X		X
CANT	03 / 00	X		X
MALA	03 / 00			
MALL	05 / 00	X		X
SONS	12 / 00			
CACE	12 / 00	X		X
RIOJ	04 / 01			
LPAL	05 / 01	X		
CEUT	07 / 01	X		
VIGO	09 / 01			
HUEL	12 / 01			
ALBA	09 / 02			

Table 1 – ERGPS

Network.

ERGPS Objectives.

- Obtainment of very precise coordinates and velocity field in all points of the network.
- Contribution to new definition of Global Reference Systems (ITRFxx).
- To belong to European Network of permanent stations (European Reference Frame).
- To use raw continuous data for Geodynamical, Tropospheric, Ionospheric studies.
- To provide GPS users, publicly, data for geodetic, cartographic, surveying and positioning works in general.

Data flow.

Data generated from ERGPS are daily recorded and sent automatically to IGN Central facilities in Madrid (Euref Local DATA Centre) by INTERNET network or phone lines. Data transmission is carried out by ADSL line for stations which had only pone line.

IGN processes raw data, checks quality and arranges the next sub products for the scientific community and itself, incide the analysis step.

Data are sent automatically by internet to EUREF Regional Data Centre in Frankfurt (Germany), and arranged in a public access IGN data server.

Acknowledgment.

We acknowledge collaboration to all public institutions which collaborate in installing and maintain the National Permanent Station Network.

1.1 GPS permanent network processing by IGN: Analysis Centre of EUREF

Introduction.

Actually, 16 stations form the National GPS Station Network (ERGPS) of IGN. Most of them are integrated in EUREF or IGS, and keep the organisation of EPN, that could be sum up in:

- *Local Data Centres (LDC)*. They receive the data of all stations of a local network and distribute them to the users.
- *Regional Data Centres (RDC)*. They save all EUREF stations data, and even IGS.
- *Local Analysis Centres (LAC)*. They process a subnetwork of EUREF stations. Now there are 16 LAC's in Europe.
- *Regional Analysis Centre (RAC)*. Coordinates the global processing, combining and linking the different sub networks of LAC, offering weekly results in SINEX format to be sent to IGS. Nowadays this task is carried by Bundesamt für Kartographie und Geodäsie (Germany).

Together with the station data management, the main EPN product is the weekly estimate of station coordinates. This is the so called "EUREF combined solution", based on combination of solutions given by the LACs. They process their sub networks following a specific rules. The weekly combined solution is formed after removal of constraints made by LACs, adjusting the global solution to the International Terrestrial Reference Frame (ITRF) fixing a selected station set, which are updated monthly from ITRF velocity fields.

Thus, each EPN station is processed by at least three LACs. These solutions, both LACs and weekly combined solution, are available through anonymous ftp://igs.ifag.de/pub/EUREF/products/(GPS week) or <ftp://epncb.oma.be/pub/product/combin>

IGN, Local Analysis Centre of EUREF.

Since the first week of September (GPS WEEK 1130) and after the tests made when introducing our solution into the final combined European solution with satisfactory results, the IGN geodetic department has become an EUREF Analysis Centre, processing an Iberian network with a total of 23 permanent stations. The three letter acronym used is IGE.

Processing is done by Bernese Processing Engine BPE 4.2, as an automatic procedure. Weekly solutions are reported in SINEX format (Solution INdependent EXchange format), together with a weekly SUMMARY of results and seven troposphere parameter files (one per week day) corresponding to a special project of estimation of troposphere parameters (zenith path delays) of EUREF.

The processing strategy carried out by IGN fulfils the last recommendations of LAC's workshop which took place in Warsaw, to which all LAC's since GPS week 1130 (2nd September 2001), date of official joining of IGE as Analysis Centre of EUREF.

Processing strategy.

The Bernese Processing Engine (BPE) module allows, through chaining scripts, automatically achieve fulfil in an optimal way all processing, which, step by step, would be tedious. Almost all LACs used Bernese software for their sub network analysis. Platforms where BPE is run in IGE are Unix and Linux.

The main processing rules, following EUREF general specifications are:

Pre-processing: phase by using triple differences in baseline mode. Most of cases the cycle slips are simultaneously fixed by different linear combinations of L1 and L2. If a cycle slip are not fixed, the bad data are removed and new ambiguities are fixed.

Basic observable: of course, phase carrier. Code is only used to synchronize receiver clocks.

Elevation mask : 10 degrees.

Data interval to fix ambiguities : 60 s.

Data interval of final processing: 180 s.

Modelled observable: double differences and ionosphere free linear combination.

Phase antenna centre calibrations: corrections to phase centre dependent of elevation for different types of antennas, according to IGS calibrations.

Troposphere: a priori Saastamoinen model and estimation of ZPDs (zenit path delays) with 1 hour interval for each station by Dry-Neill function. Besides this generates troposphere files already quoted for a special project of troposphere parameter estimation.

Ionosphere: not modelled in final solution, ionosphere removed by forming free ionosphere combination with L1-L2.

Orbits and ERP's (Earth Rotation Parameters) and final IGS precise orbits.

Other parameters: planet ephemerides DE200, JGM3 potential model and GOT99 ocean loading and tide model (last recommended by IGS).

Removal rule: none during parameter estimation. Outliers are marked when pre-processing.

Constraints: only YEBE (0,1 mm), network kernel, weekly updated coordinates with ITRF2000 velocities, coming from VLBI. Radiotelescope vector VLBI-GPS perfectly determined.

Troposphere: hourly estimation of ZPD's for every station.

Ionosphere: not estimated.

Ambiguities: QIF strategy (Quasy Ionosphere Free) for ambiguity resolution for every baseline. These fixed ambiguities are introduced into the final solution.

Satellite clocks: drifts are not estimated, but removed by forming double differences.

Receiver clocks: drifts estimated during pre-processing using code measurements.

2. MAINTENANCE OF GEODETIC NETWORKS

Maintenance of the third order geodetic network (ROI)

During 2000, 2001 and 2002 the ROI maintenance that concerns to disappeared points due to different causes (public constructions, urbanizations and so on) has been carried out, where a new mark must be placed, the observation and compute the new coordinates.

- In 2000 the network was densified in Segovia province with 33 new station marks.
- In 2001 17 station marks were repaired in Ávila province.

- In 2002 46 station marks were repaired Cáceres province.

3. A PUBLIC SERVICE. Geodetic Data Server (SERDAG)

Origin of project

From the following elements:

- *Geodetic Data*: coming from field observations (old or new), with a new structure in digital format and Data Base storage.
- *IGN or external Users* (technicians, enterprises and state national and international Institutions) who need this data for their work.
- *Technological Advance*: which serve Observations and allow a new way to deliver data.

IGN Geodetic Department, is forced to develop a tool to give service that users demand: The Geodetic Data Server would like to put available to any user the records included in Geodetic Department data bases through searchers via Internet with an easy, quick and friendly access.

Data Bases: development

From ROI (Third Order Geodetic Network), begun in 1994 the development of the structure of future Data Bases under Microsoft Access®.

Development Phases:

- Best structure study (tables, fields, data...)
- Design of and relationships between tables, queries, display forms and printed reports only for internal works.
- Base creation with study and design steps.
- Available data loading (old and new observations) and links to similar elements to those data (photographs, drafts...)

This last step is being execute continuously and updates Data Bases with new observation records.

Data Bases: types

From this structure, the following Data Bases have been elaborated:

- **Territorial information.** Data coming from “Consejo Superior Geográfico” needed for territorial record linking.
- **Geodetic Network (ROI).** ED50 and WGS84 coordinates, angle observations, station sheet, photo, sketch... of geodetic points.
- **Gravimetric Network.** Geographic and Gravimetric data, reseñas, topographic correction ...
- **New Levelling Network.** Data from nails that form the levelling lines and branches. It includes Bases from *CANARIAS* and *INTERREG-II*. Now the Spanish Network is being reobservation phase.
- **Tide-Gauge Network.** *Being developed.* **Special works.** *AENA* and *TUNEL PIRINEOS*.

Data Bases: GPS Permanent Stations

They are special data that are not organized in a Data Base. They are stored in files structured by: Station coming from (out of 20 that form the network); date and hour interval of observation (full day or hour window); Time Interval (in seconds) between observations (every 5 or 30 s); and Type of values contained as Observations or Navigation Data.

SERDAG Tool

Application physically placed in a Server and consists of several Web pages and programs that, through inquires sent by a customer via Internet, looks for geodetic data in copies of the data bases and delivers them in order in a specific way.

It is fully complete with:

- A set of information pages about features and record type of Data Bases.
- Utility tools for data management.

The server is structured in the following components:

- *Geodetic Data Bases*: Copy from originals and only read property.
- *Permanent GPS station Data Files*: Records formed daily with raw data delivered by the stations.
- *Applications*: Programs and utilities developed to ease user's work with data provided. They are specific of each base and others are shared.
- *Customer Data Bases*: For user registration that ask for data and control of receivment.

Data Server: It is the main task made by th Server. Basically consists of:

- *Program*: Program code developed in VisualScript. It is in charge to deal with Data Bases and their formulars arrived from customers and data sent as a result of a search.
- *Web pages*: HTML and DHTML code. It is the element for the Program to connect to customer.

Component Organization

In order to implement the Main Page, different components are delivered in two levels:

General Information. Explain every Data Base, its records, utility to be given and linked applications.

Searchers. Specific for each Data Base. Facilitate access to its records through múltiple options.

SERDAG. It gives access to main page which reports briefly about Data Bases.

- **General Information.** Contains all general information level.
- **Geodesy in the World.** Special Section that includes addresses and links in Internet where to find more geodetic data.
- **Data searchers:** Permanent GPS Stations; Geodetic Network; Levelling; Network; Tide-Gauge Stations; Gravimetric Network

1. SPECIAL WORKS

1.1. Coordinate determination in WGS84 system of "VILSPA1" antenna and calibration tower in spatial facilities of Villafranca Del Castillo (ESA)

By request of European Spatial Agency was done october 1999 with:

Objetives

The aim of this work was to obtain WGS84 system coordinates to 15 m antenna named VILSPA1 and two calibrating antennas, placed in a metallic tower of about 40 m height. The following procedure:

Realization

First a GPS six point network was observed, with double Trimble 4000 SSE frequency receivers. These points are:

"REF1", "REF2" and "REF3", around VILSPA1 antenna;

"VILA2", near SATAN antenna

"VILA3BIS", in station main building terrace. New point due to "VILA3" disappearance.

"Doppler Este", named 5582 in spanish national GPS REGENTE network.

Observation time varied between 2h 08m the lowest and 3h 04m the highest, with a 15 s interval measurement and a elevation mask of 15°.

Secondly from three references were got the eight points (coordinates) of the structure of the antenna., through bisection with Wild T2 theodolites and distance measurements with Wild Distomat DI-3000, to determine the geometric centre.

In third place, from VILA2 and VILA3BIS, two antennas were radiated and the pointing triangle placed in calibration tower by a Wild T2 and Will Distomat DI-3000 distance meter.

Processing

Vector processing of GPs network was done with GPSurvey Trimble Navigation software, using 5582 point as fiducially, already quoted as REGENTE network point, which is defined in WGS84 system.

Afterwards an adjustment of those resultant vectors was made with Geolab software, obtaining finally the WGS84 ellipsoidal coordinates of the rest 5 points.

From the three point coordinates called REF1, REF2, and REF3, a least squares adjustment of the angle and distance observations for the determination of the eight structure points of VILSPA1 was made. A least squares adjustment of the three calibration tower points was also made.

These last ones were also processed with Geolab software.

1.1. High precision levelling and GPS tasks for National Airports And Aerial Navigation (AENA).

The Geodetic Department of Instituto Geografico Nacional carried out in 1999 a GPS campaign for transfer geometric orthometric height to **twenty four** airports in the Iberia Peninsula, other **three** airports in the Balearic Islands, and one in the city of Melilla. In Canary Islands airports a high precision levelling network (NAP) was done, due to the small distance between AENA signal chosen in each airport and the corresponding NAP line of the isle.

Objective

To give orthometric height with a better precision than 0.10 m, to the levelling networks built by AENA in their 36 airports.

Methodology

With support on REGENTE and in two benchmarks of High Precision Levelling Network of IGN (NAP) closer to the airport, the observed network was completed with two signals of the levelling network established by AENA inside each airport. This methodology was applied to 24 peninsular airports, 3 in the Balearic Isles and 1 in the city of Melilla.

Processing

UIT the specific compensation in each airport within the frame of REGENTE, ellipsoidal coordinates (WGS84) to AENA point network are given, the knowledge of orthometric and ellipsoidal heights in the close levelling marks (NAP), allows to determine an mean geoid undulation value above WGS84 ellipsoid, valid for any point at the airport not lower than a 0.05 m precision. In the isles, given the actual uncertainty in th precise determination of mean sea level (as a consequence of the limited observation time of tide gauges installed, or lack of them), the uncertainty was increased to 0.10 m.

The precise geoid knowledge in every airport facilitates greatly the use of GPS observations in them, allowing ellipsoidal height conversion to orthometric (and vice versa) within the assigned precision to the geoid undulation.

3.3 Vertical deviation determination in millimetrical radioastronomic observatory of Pico Veleta

In July 2000 the necessary tasks to determine vertical deviation, the angle between ellipsoid normal and geoid normal at the same point placed for this purpose in Pico Veleta, were carried out.

In order to obtain the vertical deviation in a point the suitable relationships between astronomical coordinates Φ, Λ, H and geodetic coordinates φ, λ, h referred to a certain ellipsoid.

Astronomical and geodetic coordinates differ in vertical deviation (ξ and η components) and orthometric and ellipsoidal heights, in an N value known as geoid undulation.

Astronomical coordinates must be referred to an inertial reference system, thus in XXIIIth IAU General Assembly, which took place in august 1997 in Kyoto, it was decided to adopt a new conventional celestial reference system, which axes were defined by IERS Celestial Reference System (International Earth Rotation Service), and its materialization would be the ICRF (International Celestial Reference Frame) epoch J2000.0 which mean ecuatorial coordinates are determined by VLBI (Very Long Base Interferometry) observations of extragalactic radio-sources.

ICRS pole is consistent to FK5, with an uncertainty of FK5 position related to mean J2000.0 pole is around 50 mas. Right ascension origin of FK5 has a displacement from ICRS of -22.9 mas.

Similarly, geodetic coordinates have a global reference system, ITRS (International Reference Terrestrial System) of IERS and which materialization is ITRF (International Terrestrial Reference Frame) with GRS80 associated ellipsoid, which coincides for our sake with WGS84 GPS system ellipsoid.

Thus the procedure for astronomical and geodetic coordinates is:

Methodology

A pillar near the observatory was build, so that geodetic and astronomical observations were made.

Geodetic observations

In order to obtain geodetic coordinates a double frequency Trimble SSi receiver was continuously used recording from 12th July till 14th July in astronomic pillar.

Simultaneously a double frequency receiver Trimble SE for geodetic point “Cañadillas” (belongs to REGENTE network) and ROI geodetic point “Veleta”.

Finally the GPS Reference Stations of IGN in Malaga and Almeria were used, which continuously record generating 24 hours data.

Astronomical observations

To obtain astronomical coordinates a Wild T4 theodolite were used from 14th to 18th July and FK5 star were observed. To determine the longitude with Mayer method were used eleven sets with a minimum of eight stars each observed set, amounting a total of 90 stars. To determine the latitude with Sterneck Method was used. a total of 127 stars were observed, delivered in three sets.

Processing Geodetic Observations

GPS network vector processing was executed with Trimble GPSurvey software, using control points as Malaga, Almeria and REGENTE point “Cañadillas”, already quoted as belonging to REGENTE point. All of them are defined in WGS84.

After that, an adjustment of those values with Geolab software was done, obtaining as result the WGS84 ellipsoidal coordinates for IRAM Observatory point and the ROI Veleta point.

Astronomical Observations

Processing of astronomical observations for longitude and latitude determination, has been executed with updated to J2000.0 Mayer and Sterneck software by Prof. Miguel Sevilla from UCM University.

4.4. Canary islands geoid determination through GPS and levelling.

Introduction.

GPS wide use by geodetic and surveying community for coordinate determination in engineering and surveying applications outstands the importance of surface geoid knowledge. Thus for example, the difference between ellipsoidal (h) GPS WGS84 obtained height and orthometric height could reach 10 cm/km in the Canary Islands, which indicates not validity in obtaining GPS or orthometric height differences without a knowledge of a reliable geoid. Although the geoid is a physical surface, its practical use with GPS has a geometric meaning ($h=H+N$).

Besides, in cartographic, surveying civil engineering or even navigation applications, the ellipsoidal altitude do not has a real meaning, so WGS84 system substitution instead of traditional reference systems should live with geoid referred height.

Precision levelling and GPS in Canary Islands.

In 1997 the Geodetic Department of IGN, through a subscribed treaty between CNIG and “Consejería de Política Territorial del Gobierno de Canarias”, dealt with the task of constructing and observing the high precision height networks in all islands of the archipelago. In autumn of that year begun observation in eastern isles (Gran Canaria, Fuerteventura and Lanzarote), with a total of 575 kilometres double high precision levelling. In 2000, observation was completed in western islands (Tenerife, La Gomera, El Hierro and La Palma) with another 600 kilometres.

At the same time, through GPS observations with double frequency receivers and rapid static method WGS84 coordinates to almost all height network points were given, with 2 cm RMS error in vectors, and gravity values.

Geoid determination.

The practical geoid undulation knowledge combining precise levelling and GPS observations does not present any problem, because $N=h-H$, obtaining a RMS error in N determination, $s^2_N = s^2_H + s^2_h = \pm 0,03$ meters, which shows validity of the method.

In this way levelling points and geodetic points were processed (REGCAN, ROI and 4° order) the geoid undulation with respect to WGS84 reference ellipsoid, in the three eastern isles, establishing a quality control by kriging crosscorrelation, to reject possible mistaken data or with not enough precision.

Extension to all undulation values to all surface was build with a regular net of points covering the whole extension of each isle, of 500x500 meters, extrapolating the undulation value with an mathematical way.

Model obtainment.

Kriging has been the used estimator. The samples are weighted and a law to each sample is attributed; these weights are calculated to get a minimum in estimation variance, considering geometrical features of the sample, in that refers to shape, dimensions and relative data positioning, those estimated and those that could be estimated.

To minimize the estimate variance and the application equations of kriging to a sample, it is necessary to know before its change and its defining equation and shape. This function is called experimental variogram, which is adjusted to a mathematical model to introduce into the equations afterwards. The present work every isle experimental variogram is determined in eight plane directions, 45°.

Once calculated and drawn, experimental variograms in eight directions, a test to prove isotropy must be done, that is, all are statistical images of the same underlying variogram (shape and parameter values). Thus, all can be then sum up in a mean variogram and to fit to a mathematical curve (spherical, power, gaussian, etc) which will be introduced in the kriging equations. Then geoid models have been determined by different way for the three islands, called GPSNIV.

Combination with gravimetric geoid

This method has a weaker precision when extrapolated values are far away from points of height network. For this reason, a second model using shape of a gravimetric geoid was used, combining it with undulation values obtained from height networks. CANGEO97 was the chosen model (M. J. Sevilla), made by “Facultad de Ciencias Matemáticas UCM” with data bases from IGN, GEOMED, Bureau Gravimetrique International and DMA, and a proven quality. Eventually, a scaling was done, extrapolating differences encountered in levelling networks. Process can be summed up into the following steps:

- Construction of a regular point net (500x500 meters).
- N_{CANGEO} values were given to points of regular net and to height network points.
- Obtainment of $N_{\text{OBSERVED}} - N_{\text{CANGEO}}$ difference in the network.
- Extrapolation by kriging of point differences of regular net.
- Obtainment in regular net of corrected undulation values ($N_{\text{CANGEO}} + \text{dif}_{\text{KRIG}}$).

Advantages for this method are evident as geoid tendency in far regions from height network and while extrapolating through kriging the differences encountered and not N value, so the variance of kriging is lower (40 times).

Finally, practical exploitation of final model (CANGEO97 scaled) is carried out by a program which makes a bicubic interpolation from introduced coordinates over 16 points of net and gives N and vertical deviation components.

Conclusion.

The exposed method is an excellent procedure to obtain the geoid with better than 0.03 metros, useful to develop GPS all tasks with orthometric altitudes needed.

To get the high precision levelling observation of height networks in western islands of archipelago has permitted geoid obtainment in the rest of isles, giving a save frame to determine orthometric heights with GPS and validating a procedure to extend it in future to the rest of Spanish territory in REDNAP.

1.1. Coordinate determination in radiobeacons from “Puertos Del Estado”

State Institution “Puertos del Estado” wanted to increase the radioelectric aids to navigation operating in the spanish coast by establishing a DGPS National Network (Differential Global Positioning System). The DGPS service facilitates a greater precision for navigation (about 10 meters) in every atmospheric condition, complementando the actual radio navigation techniques through traditional radio beacons, and even improvement of actual precision with aid of ship

radars. The coverage area of DGPS service will include a 100 km region parallel to the peninsular and insular littoral.

The Technical Department of Maritime Signals of State Institution "Puertos del Estado" has planned a radioelectric coverage to establish the National DGPS, selecting 17 places of existent or proposed radio beacons in the actual Maritime Signal Plan.

The National Geographic Institute, by its Geodetic Department has collaborated in precision coordinate provision to different DGPS stations installed by "Puertos del Estado". Thus, in 1999, processing were made in two of them: Estaca de Bares and Finisterre, in Cantábrico, and in 2002, six more points (Cabo San Sebastián, Salou, Castellón, Llobregat, Cala Figuera and Mahón), and in north Mediterranean.

Each of the radio beacons consists of 4 GPS antennas (two of double frequency and two of one frequency). Single frequency antennas are integrity monitors (IM1 and IM2), while the main ones, the double frequency are reference stations (RS1 and RS2). This four antenna's group is comprised in less than 3 meters between them.

To give coordinates to these stations, GPS permanent stations from National Geographic Institute in La Coruña (ACOR), Mallorca (MALL) and from ICC, EBRE, all of them belonging to EUREF permanent station network and ITRF97 coordinates. Processing with Bernese 4.2 software was done (Astronomical Institute University of Berne), using precise ephemerides from International GPS Service (IGS) and ITRF97 EUREF station coordinates at the observation epoch. Final results were transferred to ETRS89 from ITRF97 (Boucher-Altamimi equations).

The main process features are:

- Pre-processing: phase by using triple differences in baseline mode. Most of cases the cycle slips are simultaneously fixed by different linear combinations of L1 and L2. If a cycle slip are not fixed, the bad data are removed and new ambiguities are fixed.
- Basic observable: Of course, phase carrier. Code is only used to synchronize receiver clocks.
- Elevation mask : 10 degrees.
- Data interval to fix ambiguities : 60 s.
- Data interval of final processing: 180 s.
- Modeled observable: double differences and ionospheric free combination.
- Phase antenna centre calibrations: corrections to phase center dependent of elevation for different types of antennas, according to IGS calibrations.
- Troposphere: Saastamoinen a priori model.
- Ionosphere: not modelled in final solution, ionosphere removed by forming free ionosphere combination with L1-L2.
- Orbits and ERP's (Earth Rotation Parameters): ERP's and final precise orbits from IGS.
- Ambiguities: QIF strategy (Quasy Ionosphere Free) to fix ambiguities for every baseline. These fixed ambiguities are introduced into final solution.
- Satellite clocks: drifts are not estimated, but removed forming double differences. Receiver's clocks: drifts estimated during post-processing using code measurements.

Once determined RS1 antenna coordinates, a second Trimble GPSurvey 2.35 pre-processing was done, in order to calculate each IM1,IM2 and RS2 radio beacon coordinates. Data used for this second processing have been 2 hours with a data interval of 1s., enough for such a baseline length (lower than 3 m.) in each radio beacon, introducing IGS precise ephemerides. Choosing any day for every group of antennas, data from 1:00 to 3:00 UTC have been processed, so that tropospheric and ionospheric perturbation is lowest at night.

1. GRAVIMETRY

1.1. Absolute

Since the first absolute measurements of gravity in Spain (J. Barraquer 1877 and 1882) no absolute measurements have been performed till 1989, when Finish Geodetic Institute (FGI) measured in Valle de los Caidos and University of Madrid with JILAG 5. During the last decade of twentieth century, BKG of Germany also performed absolute measurements in Alicante, Granada, Ceuta, Tarifa, and San Fernando with FG5#101.

In 2000 the National Geographic Institute of Spain (IGNE) has purchased a new free fall absolute gravity device by Micro-G Solutions named FG5#211 in order to observe a zero order gravity network in peninsular Spain and at least one point in every island (Balearic Islands and Canary Islands). Also another A-10 absolute gravity meter (10 microgal accuracy) for the first network observation has been purchased in 2001. These networks will serve for geodetic (supporting the new High Precision Levelling Network) and geodynamic purposes.

In 2001 nine stations have been observed by FG5#211 of IGNE: The first station was observed in the library of the National Astronomic Observatory of Madrid, three points at the BIPM during ICAG2001 absolute gravimeter comparison, the Laboratory of gravimetry in the IGN facilities, two points in the CEM (Spanish Center of Metrology in Tres Cantos, Madrid), Geophysical Center of Sonseca (Toledo) and Geophysical Observatory of San Pablo de los Montes (Toledo).

During 2002 absolute stations in Geophysical Observatory of Santiago de Compostela, Geophysical Observatory of Logroño, Geophysical Observatory of Málaga, Geophysical Observatory of San Pablo de los Montes (Toledo), El Miracle (Lleida), Astronomical Observatory of Fabra (Barcelona), Ebro Observatory (Tarragona), El Puig Monastery (Valencia), and Valle de los Caidos (Madrid, IAGBN station) have been observed by FG5#211 of IGNE.

1.1. Relative and UEGN2002

Links between absolute stations and many other densification ones for the REDNAP project have been made. IGNE contributed to the *European Unified Gravity Network (UEGN2002)* sending data from all absolute values known in Spain, as well as relative raw observations.

1. Development of the ED50-ETRS89 datum transition

Introduction

As results of the recently finished REGENTE (National Geodetic Network using Spatial Techniques) have provided us a double set of ETRS89-ED50 coordinates used to prepare a range of transformation techniques. The challenge is to absorb the heterogeneous behaviour of ED50 as a consequence of observational methods evolution, the different calculation for the network, etc. Our purpose is to obtain a single transformation as simple and efficient as possible. In addition, it will be desirable to develop the capability of absorbing local datum changes in shape and form.

Three main techniques have been evaluated: “7 conformal transformation”, “real and complex polynomials” and “minimum curvature surface distortion modelling”. In all those were be used the data of 911 REGENTE points.

6.1. The Methods:

7 parameter conformal transformation

Using the common formulae to this method, three sets of parameters have been obtained in order to keep residuals under 2m. The Iberian Peninsula is divided in two zones: northwest ($41^{\circ}30'N < \varphi < 43^{\circ}50'N$ y $9^{\circ}25'W < \lambda < 4^{\circ}30'W$) and rest . A third set has been computed for Balearic Islands. The 99% of residuals of the adjust were less than 0.99m in the first one, an less than 1.5m in the second one.

Polynomial transformation

Polynomial regression has been used in the past trying to absorb the heterogeneous behaviour of classical networks. The chosen method for Iberian Peninsula has been “progressive elimination”, because is excellent to avoid exclusion of significant variables. The results of this method give us a powerful tool to achieve cartography transformation at mid scales such as National Topographic Map 1:25.000 produced in this institution. The 99% of residuals of the adjust were less than 0.93m when real polynomials were used, and less than 0.60m if complex polynomial is used.

Distortion modelling

There are several methods used in some countries to model such distortion: Least Squares Collocation, Minimum Curvature Surfaces, Multiple Regression, Local Affine Transformation on Delaunay triangulation (Rubber Sheeting), etc. Australia and Canada have applied Collocation and North America Minimum Curvature Surfaces (MCS).

Details about calculation of distortion fields is widely explain in geodetic literature. We have built two grids covering mainland Spain with 105” of interval and 100” for Balearic Islands. The format chose is NTV2 (National Transformation Version 2), used in Canada and Australia. Such format has the advantage of being used by a large number of software applications.

Test of the obtained grids

In order to test the several methods (Least Squares Collocation, Rubber Sheeting and Minimum Curvature Surfaces) we have created 3 grids, one for each method. The grid was generated using REGENTE monuments (30 Km average distance). For testing the grid a recalculation of the third order network (1400 monuments) was used. The results shows accuracies between 14-18 cm (95%)

Statistics	E _{TEST}	N _{TEST}
# points	1400	1400
Average	0.00	-0.01
Std Dev	0.07	0.05
Max	0.24	0.19
Min	-0.25	-0.25
Range	0.49	0.43
95%	0.13	0.11
99%	0.16	0.13

Table 1. points below 25cm. Least Squares Collocation

Estadísticas	E _{TEST}	N _{TEST}
# puntos	1395	1395
Media	0.00	-0.00
Std Dev	0.05	0.05
Max	0.23	0.22
Min	-0.24	-0.24
Rango	0.48	0.46
95%	0.10	0.09
99%	0.13	0.12

Table 2. points below 25cm. Rubber-Sheeting

Estadísticas	E_{TEST}	N_{TEST}
# puntos	1400	1400
Media	0.01	0.02
Std Dev	0.05	0.05
Max	0.24	0.22
Min	-0.24	-0.24
Rango	0.48	0.46
95%	0.10	0.10
99%	0.13	0.12

Table 3. points below 25cm. Minimum Curvature Surface

6.2. Conclusions

There is no simple way of making datum transformation using standard conformal procedures since the existence of distortion component is difficult to absorb. Modelling the distortion is the best way to perform the datum change.

However, depending on the specialisation level of the user of this transformation a more specific product need to be prepared. An executable software, web page with Java/Asp components, OCX/DLL tools for developers and grid files in NTV2 format will be built. The NTV2 format was developed by the Geodetic Survey Division, Geomatics Canada and it has been implemented in many software packages. The gridding using minimum curvature technique is easy to achieve and gives us the optimal performance in the transformation. The NTV2 format also provides multiple subgrids of different intervals and let us obtain successive grids as the network is being readjusted in ETRS89.

1. RECORD (Radio Broadcasting of GPS Differential Corrections)

The RECORD project intends to broadcast GPS differential corrections through RDS non-audible sub-carrier (Radio Data System) of Radio Nacional de España (RNE) broadcasting stations.

The code differential GPS correction, obtained from pseudodistance observable smoothed with phase, is available in RTCM SC104 format. Further on, it is analysed and compressed in RASANT 2.6 format (Radio Aided Satellite Navigation Technique). It is in this format in which it is sent to RNE, who send it incorporated to the FM signal broadcasted. A FM/RDS/RASANT receiver decompresses and provides the original RTCM SC04 corrections, which are integrable in most GPS receivers.

Since middle of 1997, the IGNE in cooperation with RNE has made several tests to broadcast differential GPS corrections, as requested by quite a lot of users, to manage fleets, to control special public services (burning forests, ambulances, public transport, traffic, and so on.). To do that, the IGNE uses software licenced by LVA of NordRhein-Westfallen, under agreement of exclusive use by IGNE and RNE as free official public service.

The main objective of setting up DGPS/RASANT system (named RECORD) is establishing and implementing a public service to terrestrial positioning available to Spanish community of GPS users with usual criteria of precision, integrity and availability in this kind of systems.

The given service by DGPS/RASANT system will be based upon broadcasting RTCM differential corrections in RASANT format through sub-carrier not audible RDS of RNE broadcasting stations.

The attainment of the objective establishes on a basis of formalization of technical cooperation agreement between IGNE and RNE subscribed to that motive, thus differential corrections will be broadcasted by FM broadcasting stations of the "Red Técnica de Difusión" of RNE. This corrections will be delivered following international accepted formats (RTCM and UIT's

Recommendation nr. 823), compressed in RASANT format, with free access to all users who have a FM/RDS/RASANT receiver.

Precision given by this system will be better than 5 m 2dRMS (95% of probability). In more restrictive conditions concerning to distance to correction generating point and data availability, the system will reached about 1 m precisions.

The DGPS/RASANT system consists of stations DGPS/RASANT and a Control Centre. The DGPS stations that will work in redundant mode by double reference receiver will have the tasks:

- RTCM differential correction generation, evaluation and compression to RASANT format.
- Data deliver to RDS net server of RNE through phone line point to point, optical fibre link or equivalent.
- Working Integrate Monitoring in each station DGPS by decoding RASANT format to RTCM by a FM/RDS/RASANT receiver.
- Observable store setting up a GPS Database.

On its own, the control centre placed in the IGNE facilities in Madrid, will have the following tasks:

- To assure intercommunication with DGPS stations.
- To monitor and control DGPS parameter, assuring system homogeneity.
- To integrate metric precision controls in future peripheral stations.
- To download daily, or by request, of GPS information towards the Spanish National GPS Reference Station Network.

The fact of being in the peninsular periphery inside a radius of 500 km and positions obtained during the period 1997/98 guarantees that the first part of the network set up will be deal with one control centre and two reference stations, one in Madrid (IGNE) and the other in Sta. Cruz de Tenerife (Geophysical Centre of Canary Islands of the IGNE).

Integrity monitoring tests are being made during 1999-2000. For this reason a triple GPS equipment (2RS+IM) has been set up in IGNE facilities, assuring correction's reliability, continuity and integrity for Canary Islands and Peninsula. A fourth GPS equipment in Prado del Rey facility to reinforce the array is also working.

The equipments have been set up in Tenerife similar to that in Madrid station and connected to IGNE Control Center in Madrid through RDSI (TCP/IP).

During 1999 a GPS receiver in broadcasting station of Palma de Mallorca has been installed to get an independent solution for the Balearic Islands region apart from that of the peninsula. This solution is available for RNE2 broadcasting stations (Radio Clásica) of Alfabia and Pollensa.

A remote monitoring service is being installed from Prado del Rey by RNE, in which data and audio broadcasting are verified. IGNE has equiped different regional departments with FM/RDS/RASANT+GPS receivers to get a redundant monitorization.

Digital Audio Broadcasting (DAB) tests have been carried out for the transmission of real time differential phase corrections with excellent results. As long as the technology will be utilised massively this stage of the project is still not operational (RECORD-2)

Digital radio allows a more effective use of the spectrum holding seven programs in one frequency. The PAD (Programme Associated Data) associates data to each program but is space limited for our purposes. The data channel no associated to audio (NPAD) can hold more bandwidth. In this channel is where the tests have been done.

Such tests were done at RNE headquarters, broadcasting the RTCM phase and code differential corrections, that is type 1, 2, 3, 18 and 19. The data was received at a Grundig Dab200 connected to a laptop computer that output the corrections into a test GPS. Several GPS receivers were test: single frequency, double frequency with and without "on the fly" ambiguity resolution option activated. Both GPS, generator and receptor, used in this test shared the same antenna, and the delay observed was about 2 - 4 seconds.

The last part of the project consists on transmitting RTCM over internet (RECORD-3). The BKG has developed all the software (client and server side) for this purposes. The first GPS station included in EUREF-IP is Madrid. This station is located at IE09 monument (ETRS89 class B network) and consist on tree GPS: Integrity monitor+double reference station. Nowadays Madrid station is broadcasting RTCM messages (1,2,3,16,18 and 19) which allows RTK positioning in all Madrid metropolitan area.

In the future some stations of ERGPS will be included in the project although it depends on ERGPS manager objectives. Even if it is not possible GPSL1 mapping reference stations (Córdoba, Coruña and Burgos) will be included as soon as possible.

7 NEW SPANISH HIGH PRECISION LEVELLING NETWORK. REDNAP PROJECT

Between 1997 and 2000, National Geographic Institute of Spain established the High Precision Levelling Network in the Canary Islands. Besides, during 1999 and 2000 replacements and reobservations of High Precision Levelling Network in the Pyrenees spanish zone (INTERREG-2 Project) with an important network length increase in that region, from around 1000 to 1500 kilometers of linear development.

Both tasks, Canary and Pyrenees levelling served as sample for REDNAP Project (High Precision Spanish Levelling Network) which begun to be implementes in 2001 and will end hopefully in 2007, covering the rest of spanish peninsular territory an Balearic Islands. This network is linked to the North Pyrenaic Network, tasks being developed towards South and West with a 2400 and 2500 year rate. All together, in 2008 Spain will have a new network which will cover all peninsular and insular territory with an amount of 17500 kilometers NAP lines

SUMMARY of REDNAP

ZONE	MONUMENT DATE	OBSERVATION DATE	NUMBER OF LINES	KM
CANARIES	1997	1997-2000	15	1000
PYRENEES	1999	1997-2000	29	1411
1	2001		38	2440
2	2002		29	2404
3	2003 (in execution)	2004 (programmed)	29	2400
4	The rest till 17500 km is programmed between 2004 and 2007			
5				
6				
7				

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5.- ROYAL INSTITUTE AND OBSERVATORY OF THE NAVY. (SAN FERNANDO)

REAL INSTITUTO Y OBSERVATORIO DE LA ARMADA (ROA).

Cecilio Pujazón s/n

11100 San Fernando (Cádiz). SPAIN.

Phone: +34-956-599285.

Fax: +34-956-599366.

E_mail: geofisica@roa.es

The “Real Instituto y Observatorio de la Armada en San Fernando” (ROA), is a Navy Institution working on geodesy since its foundation on the mid XVIII century. Nowadays, the work on this area is mainly concentrated in Satellites Laser Ranging (SLR) and Global Positioning System (GPS) applications.

1. Satellites Laser Ranging (SLR).

Installed on the top of the main building, under a dome, ROA has a SLR station successively improved since 1968. During the period 1999-2002, the station has been upgraded in the following items:

- Implementation of a Compensated Single Photon Avalanche Diode C-SPAD as detector for nighttime tracking.
- New reception system able to use a C-SPAD as well as a photomultiplier as a detector.
- Developing of a new azimuth motor control system to improve the pointing on the satellites.
- General adjust of the laser bench and associated electronic equipment.
- Replacement of the calibration system for a new internal, avoiding refraction effects during calibrations.
- Implementation of the active-passive laser mode, with 50 picosecs and 40 mjoules.
- Substitution of the all electrical power lines by new ones, improving the ratio signal-noise.
- Redesign and implement new electronic circuit boards.
- Main and secondary mirrors periodical repairs.

The above mentioned modifications have been partially funded by the following research projects:

- “Automatic Geophysical Station” (MN-8302), Spanish Defence Ministry Research Programs.
- “An optimization of the precision for the laser observations on artificial satellites” (ESP97-1816-C04-01), from the National Program for Space Research, Comisión Interministerial de Ciencia y Tecnología (CICYT), I+D Spanish National Plan.
- “Daylight tracking on artificial satellites by laser telemetry” (ESP2001-4514-PE), from the National Program for Space Research, ‘Ministerio de Ciencia y Tecnología’ of Spain.

A brief tracking statistics for the 1999-2002 period are:

- 1999:

SATELITE	N.ECOS	N.PASOS
AJISAI	318262	336

STELLA	91393	270
ERS-1	78277	206
ERS-2	68155	194
LAGEOS-1	99607	231
LAGEOS-2	99648	167
GFO-1	38984	127
STARLETTE	146418	256
WESTPAC	1736	44
TOPEX	219356	258
SUNSAT	17221	78
BEC	72484	135
GEOS	1044	1
TOTALES	1252585	2303

2000:

SATELITE	N.ECOS	N.PASOS
AJISAI	788942	558
STELLA	189438	357
ERS-2	119889	281
LAGEOS-1	203553	218
LAGEOS-2	214530	214
GFO-1	84964	187
STARLETTE	277746	426
WESTPAC	3543	31
TOPEX	586429	434
SUNSAT	12953	76
BEC	452368	488
CHAMP	15144	58
TOTALES:	2949499	3328

2001:

SATELITE	N.ECOS	N.PASOS
AJISAI	359086	317
STELLA	63068	156
ERS-2	37877	107
LAGEOS-1	72072	118
LAGEOS-2	74525	105
GFO-1	30906	70
STARLETTE	123794	239
WESTPAC	260	12
TOPEX	264360	246
BEC	159573	231
CHAMP	13863	56
TOTALES:	1199384	1657

2002:

SATELITE	N.ECOS	N.PASOS
LAGEOS 1	97373	249
LAGEOS 2	74263	174
AJISAI	324485	434
STARLETTE	70906	264

TOPEX	193292	287
STELLA	54258	192
ERS2	64885	258
CHAMP	6437	36
JASON	75844	173
GFO	46610	151
BEC	151851	324
REFLECTOR	15281	137
GRACE A	6107	25
GRACE B	5717	39
METEOR 3	1029	29
TOTALES:	1188338	2772

2. GPS geodetic activity.

The ROA GPS geodetic activity came from the middle 80's. During that period ROA has participated in several field campaigns, among which highlights the Spanish Antarctic research campaigns (1987, 88, and so on). It's worth to be mentioned the GPS geodynamic net deployed by ROA in 1994, monumenting several sites south Spain-north Africa, and having a first observation field campaign during that year. This network has been mainly established in order to study the geodynamic evolution of the Ibero-Maghrebian region, that is south Spain, Gulf of Cadiz, Alboran sea and north Morocco, region crossed by the Eurasia-Africa plate boundary. During 1994 a Cadiz Bay GPS net was also established to study mean sea level variations and oceanographic circulations in that bay.

During the period 1999-2002, the main GPS geodetic activities carried out by ROA have been:

GPS field campaigns:

- Collaboration with the University of Porto (Portugal) in October 1999 episodic GPS TANGO-99 campaign, carrying out observations at Monte Hacho, in Ceuta, at Tarifa, and at San Fernando for a 72 hours coverage period.
- Collaboration with the University of Porto (Portugal) in October 2000 episodic GPS TANGO-00 campaign, carrying out observations at Monte Hacho, in Ceuta and at San Fernando for a 72 hours coverage period.
- Collaboration with the University of Porto (Portugal) in October 2001 episodic GPS TANGO-01 campaign, carrying out observations and at the Geographic National Institute of Spain geodetic Monument VS8 located at Monte Hacho, in Ceuta, and at San Fernando for a 72 hours coverage period.
- "Cuateneo-2002" GPS episodic campaign. Organized by the San Fernando Observatory and the University of Barcelona, covering the Cuateneo GPS Network at Murcia and Almeria provinces, end of September, beginning of October 2002. We had the collaboration of University of Cadiz students.

GPS permanent network:

A new GPS permanent station was included in the San Fernando Observatory GPS permanent network. It is located at the 'Observatorio de la Cartuja', in Granada, Spain. It is controlled from San Fernando via Internet, since March 2001. The equipment deployed at that stations is:

- TRIMBLE 4700 receiver.
- TRIMBLE Geodetical antenna.
- Computer.
- UPS + electrical line protection.
- Internet access

GPS at the Spanish Antarctic Base:

Also, a GPS permanent station was deployed at the Spanish Antarctic Base Juan Carlos I, located at Livingstone Island in the Southern Shetland Islands. It is controlled by the Base team during the base activity period: November-March, collecting the data at the local computers, The data are sent to San Fernando, when the team is coming back to Spain. The equipment deployed at the stations is:

- TRIMBLE 4000 SSi receiver.
- TRIMBLE Geodetical antenna.
- Computer.
- UPS + electrical line protection.

All the GPS data coming both the field campaigns and permanent stations, are processed by using the GIPSY-OASIS II software (Jet Propulsion Lab.).

The above mentioned GPS activities have been funded by the following research projects:

- “Automatic Geophysical Station” (MN-8302), Spanish Defence Ministry Research programs.
- “Focal mechanism, crustal deformations, seismotectonics and seismic risk in southern Spain” (AMB97-0975-C02-02), from the National Program for Environment Research, Comision Interministerial de Ciencia y Tecnología (CICYT), I+D Spanish National Plan.
- “GPS Permanent Station at the Spanish Antarctic Base Juan Carlos I” (ANT98-1805-E), from the National Program for Environment Research, Comision Interministerial de Ciencia y Tecnología (CICYT), I+D Spanish National Plan.
- “Meteorological Applications of Global Positioning System Integrated Column water vapor measurements in the western Mediterranean (PL972065). European Comision DGXII/D Fourth Framework Programme. Theme 3, Area 3.3.1.
- “An optimization of the precision for the laser observations on artificial satellites” (ESP97-1816-C04-01), from the National Program for Space Research, Comision Interministerial de Ciencia y Tecnología (CICYT), I+D Spanish National Plan.
- “GPS campaign at the Cuateneo Network (Almeria – Murcia)” (REM2000-3014-E/RIES), from the ‘Ministerio de Ciencia y Tecnología’ of Spain.
- “Earthquakes and Crustal Deformation at Southern Spain: Seismic Hazard Applications” (REM2000-0777-C02-02), from the National Program for Space Research, ‘Ministerio de Ciencia y Tecnología’ of Spain.

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6.- VALENCIAN CARTOGRAPHIC INSTITUT. VALENCIA

Edificio Institutos 2, UPV
Avda. de los Naranjos s/n
46022 VALENCIA (SPAIN)
Tel.: (34) 96 387 77 10
Fax.: (34) 96 387 97 98

Geodetic projects.

Geodetic, topographic applications, cartographic production and civil engineering projects need a robust infrastructure for their realisation. The Cartographic Institute of Valencia (ICV) has developed several works in this field to fulfil geodetic positioning requirements in the Comunidad Valenciana:

As we know, ETRS89 Datum is accepted as the standard European System of many geodetic and cartographic works. One of the main tasks is the solution for Datum transformation to determine local parameters that fit better the Comunidad Valenciana and the connection of the Fourth Order Geodetic Network with other European Networks like Iberia95 and REGENTE in the Iberian Peninsula. In future, this project will conclude with the adoption of ETRS89 as the Mapping System for the Comunidad Valenciana.

Another point to consider is the maintenance of the Fourth Order Geodetic Network in this area (1521 points). The cooperation between the Institute and de City Councils of the Comunidad Valenciana is decisive in this work. The City Councils inform about the integrity of the geodetic network.

Finally, it is necessary to emphasize the development and update of geodetic tools, that are carried out. For example, geodetic software, coordinates transformation utilities, tools and interface for visualization and diffusion of the geodetic information for the final user.

POLITECHNICAL UNIVERSITY OF VALENCIA.

DEPARTMENT OF CARTOGRAPHIC ENGINEERING, GEODESY AND PHOTOGRAMMETRY.

1 GEODESY

1.1 HIGH-PRECISION LOCAL AND URBAN NETWORKS

The development of this project is focus on two networks, one in Sagunto (Valencia) and the other one in San Miguel de los Reyes' monastery. Climatological conditions are taken into account in the observations. Little displacements have been originated in the points of the networks in order to check the compensation and outlier detections models, apply deformation theory under development and improve precision and reliability based on new error figures theory.

1.2 LOCAL TERRESTRIAL CRUST MOVEMENTS

Two different hill displacements have been studied: Gestalgar and Puebla de Arenoso. The movements in Puebla del Arenoso have been studied with GPS observations. The movements in Gestalgar have been studied with classical observations.

2 GPS

2.1 RASANT

A GPS differential correction station have been developed and located in the building of the Department of Cartographical Engineering, Geodesy and Photogrammetry (Polytechnical University of Valencia), which is a very useful tool for topographical and geodetic applications.

2.2 SOCRATES PROJECT: REAL TIME PURSUIT AND LOCATION OF VEHICLE FLEETS

GPS, MSM-SMS and Rfid Icode have been used simultaneously, the application is supported on digital cartography that can be consulted through Internet. Rfid (Radio Frequency Identification) is a label system that use electronic elements (TAG's) fixed over the objects to identify. This project is a very useful tool for transportation companies.

2.3 GPS AND REFERENCE FRAMES

A new adjustment of the fourth order geodetic network of the Valencian Community is under development in collaboration with Cartographical Institute of Valencia (ICV). This network in related to REGENTE reference frame (ITRF).

3 GRAVIMETRY

3.1 EARTH-TIDE PARAMETERS OBSERVATION AND DETERMINATION IN VALENCIA

Gravity Earth-Tide observations in Valencia have been analyzed in order to obtain accurate amplitude and phase-difference for the principal tidal waves. The observations have been carried out with the Lacoste&Romberg gravimeter D-203 equipped with electrostatic feed-back system. The data have been digitally recorded since February 2001 with 60 seconds of sampling interval covering a total number of 302 days (434.600 observations). The recorded data have

been edited and processed with ETERNA 3.32 Earth-Tide data processing package using the Hartmann and Wenzel tidal potential catalogue.

Finally new tidal parameters for Q1, O1, M1, K1, J1, OO1, 2N2, N2, M2, L2, S2 and M3M6 wave groups are computed for Valencia witch could be of great interest for gravity and geodetic reductions.

(More info <http://www.upv.es/unigeo/>).

3.2 GRAVITY NETWORK OF VALENCIA PROVINCE

A new gravity network has been established in Valencia Province to meet the increased requirements of Geophysics, Geology, Geodynamics and Geodesy. The net comprises 21 stations. It has been measured with high precision using 2 Lacoste&Romberg gravimeters between 1999 and 2000, using 1 IGSN71-Station and about 190 relative gravity meter observations. Corrections are applied for Earth-Tides, polar motion, vertical gradient and air pressure. special investigations have been focus on the least-square adjustment with new observations equations. The final adjustment showed a mean standard deviation of 0.018 mGal.

(More info <http://www.upv.es/unigeo/>).

4 LOCAL HIGH-PRECISION GEOID MODEL FOR VALENCIA REGION

High-resolution and high-precision geoid has been computing for Valencia Region, ranging from 37° N to 41° N in latitude and 2° W to 1° E in longitude. The EGM96, complete to degree and order 360, and the GPM98cr, complete to degree and order 720, have been testing, combined with more than 3000 land and marine gravity data and 25m X 25m DTM to generate geoid model. The remove-restore technique was adopted. Second-Helmert condensation reduction has been using for the computation of terrain effects. The contribution of the local gravity data to geoid has been evaluating by least-square prediction and numerical solution of Stokes integral with planar Kernel. The indirect effect of up to second order has been considering. Finally 12 GPS/levelling-derived geoidal heights will be used for local fitting of the geoid witch is essential for a good utilization of GPS for height determination.

(More info <http://www.upv.es/unigeo/>).

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NATIONAL REPORT ON GEOMAGNETISM AND AERONOMY
FOR
1999-2002

Alicia García
IAGA National Correspondent
Dpt. of Volcanology, MNCN-CSIC
Madrid, Spain

Introduction

This report outlines the progress reached in Spain during the period 1999-2002 in Geomagnetism and Aeronomy. Although there are no many teams working on Geomagnetism and Aeronomy, they are very active groups. The main topics are the following:

In the Dpt. of Volcanology (CSIC), the research is focusing in Active Volcanism, so the structure of volcanic edifices from aerial, land and marine data and the study of volcanomagnetic signals are the main searches.

EM exploring methods, to characterize, control and monitoring environmental problems, and MT surveys, applied to model the structures, are carried out by the Dpt. of Geodynamics and Geophysics of Barcelona Univ.

There are several groups and laboratories working on Paleomagnetism:

Dpt. of the Earth Physics (Complutense Univ. of Madrid)

Jaume Almera Inst. (Barcelona, CSIC)

Volcanological Inst. of Canary I. (CSIC)

Faculty of Marine Sciences (Vigo Univ.)

Burgos Univ.

Zaragoza Univ.

The topics are related to block rotation studies, magnetostratigraphy, archaeomagnetism, and, more recently, on environmental magnetism.

Magnetospheric phenomena are studied by Barcelona Univ. and Institute of Spatial Studies of Cataluña. Also in Solar-Terrestrial relationships, the Ebro Observatory has traditionally studied the perturbations of the geomagnetic field due to solar activity. In the last decade they have also studied the SF magnetic effects and eclipses.

Geomagnetic observatories: Services and Analysis

- San Pablo de los Montes (SPT) in Toledo and Güimar (GUI) in Tenerife I. Instituto Geografico Nacional (IGN). It is the responsible of the secular stations network and the Spanish magnetic charts.
- San Fernando. Real Instituto y Observatorio de la Armada (ROA, Cadiz)
- Ebro Observatory. (Roquetes, Tarragona), it is also responsible of the Livingston I. Spanish Antarctic Observatory (LIV) from 1996.

With the support of the Spanish Ministry of Science and Technology, the study of geomagnetic variations of external origin and the regional model of internal field and its secular variation has been developing (Ebro Observatory and Dpt. of Volcanology). The Spanish program of Antarctic research has supported the installation and operation of the Spanish Antarctic Observatory (Ebro Observatory and Dpt. of Volcanology), thus permitting to analyze the magnetic anomaly of the region to reach a better understanding of the regional tectonics and to obtain a model for the Reference Magnetic Field for the Antarctic Continent.

The ROA team, besides the geomagnetic observatory, is the responsible entity of all the marine surveys carried out by the Spanish Army.

The investigation of the Ionosphere (INTA, Ebro Observatory and UCM) is carried out by means of several projects financed by the Spanish and European Programs and trough international cooperations between CSIC and Bulgarian and Czech Sciences Academies and others.

Thanks are due to the different Groups which provided the information outlined in this report.

Alicia García. IAGA National Correspondent

INSTITUTO GEOGRÁFICO NACIONAL

Sección de Geomagnetismo

General Ibáñez Ibero, 3

28003 MADRID. SPAIN.

Tf: +34 91-5979521

Fax: +34 91-5979616

1. AREAS OF RESEARCH

- **Magnetic Observatories (San Pablo de los Montes (SPT); Güimar (GUI))**
- **Spanish repeat station program - (Mainland, Balearic Islands and Canary Archipelago).**
- **Geomagnetic maps - all components and secular variation.**
- **Geomagnetic annuaries.**
- **Aeromagnetism - confection and interpretation.**

2. SCIENTIFIC PROJECTS

- Collaboration since 1997, of the IGN's magnetic observatories in the INTERMAGNET project. The data of San Pablo de los Montes (SPT) and Güimar (GUI) observatories (minute by minute) are send to the Intermagnet project: (1998, 1999, 2000 already sent, recorded in CD).
- **Communication system between Livingston Island and the Ebro Observatory (1999).**
- **Complementary development of the software for San Pablo de los Montes, Güimar and Geomagnetic Central of Madrid.**
- **Collaboration in the OERSTED Project.**
- **Studies of the diurnal variation correlation between a distant station (Menorca) and San Pablo de los Montes.**
- **Geomagnetic analysis of the zone responsible of the 1999 Mula (Murcia) seismic sequence.**
- **Geomagnetic study of Galicia (in collaboration with seismic studies).**
- **Conditioning of the San Pau and San Onofre hermitages and installation and acquisition of equipments for the geomagnetic station in Horta de San Juan (Tarragona). (Agreement between IGN and Ebro Observatory).**

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- Anuarios de Geomagnetismo de San Pablo de los Montes y Güimar (1998, 1999, 2000)
- Anuarios de Geomagnetismo, Observatorios de San Pablo y Güimar. Años 1995-1996-1997.
- Mapa aeromagnético de la Península Ibérica: (IGN, 2000).

INSTITUTO NACIONAL DE TÉCNICA AEROESPACIAL

Estación de Sondeos Atmosféricos “ El Arenosillo”

21130 Mazagón (Huelva). Spain

Tf: +34 959 208 855

Fax: +34 959 208 857

1.-AREAS OF ATMOSPHERIC RESEARCH

- **Evolution of the ozone total content, aerosol, tropospheric ozone and ultraviolet radiation study in middle latitude, using Dobson spectrophotometer, CIMEL, DASIBI 1008, Brewer spectrophotometer and Yankee radiometer.**
- **Evolution of the lower and upper ionosphere study in middle latitude, using Digisonde 256 and Absorption Meter A3 and following the ITU recommendations, The European Space Agency (ESA) and the Action COST271**
- **Ionospheric Channel Characterization for HF Communications.** This type of transmissions keeps his application as much in the Civil field (Civil Protection Links, Communication between Embassies, Cooperation in Natural Catastrophes as Military (Tactical Communications Alternatives to the Satellite in Emergency Situations)
- **Ionospheric Parameter Measures and Data Base Creation.** International Campaigns Participation (ITU-R 222 1/3).
- **Effects of the Ionosphere over Satellite_Satellite and Satellite_Earth Links (ITU-R 226 2/3).** Electronic Density Profiles Application calculated from Ionospheric Parameters get in Digisonde 256, for Validation of Measures of the Total Electron Content (TEC) provided by GNSS (Global Navigation Satellite Systems).
- **Ionospheric Prediction.** Long-term trends of Ionospheric Parameters. Long-term changes in the Ionosphere and his relation with the Geomagnetic Activity. Nowadays there is a permanent interest related with the problem of the global changes in the Terrestrial Atmosphere because of Anthropogenic Impact.

- Variability in the Ionosphere associated to irregulars events produced in the Sun-Earth system. (Geomagnetic Storms, Solar Flares,...), and his application to the Atmospheric Prediction.

1.-SCIENTIFIC PROJECTS

- Project COST238 PRIME of UE: “Prediction and Retrospective Ionospheric Modelling over Europe”. From 1991 to 1994.
- Project COST251 IITS of UE: “Improved Quality of Ionospheric Telecommunication System Planning and Operation”. From 1995-1999
- Spanish Project CICYT (TIC 97/0787-CO2): “Ionospheric Communications Link with Spread Spectrum INTA (El Arenosillo)-La Salle(Universidad Ramón Llull)” in collaboration with La Salle School of Engineering, Polytechnical School of La Rabida (Huelva University) and INTA, from 1997 to 1999.
- Spanish Project Special Action CICYT (TIC99-1284-E): “Ionospheric Link with Spread Spectrum INTA (El Arenosillo)-La Salle(Universidad Ramón Llull)”. From 1999 to 2000.
- Project COST271 of UE “Effects of the upper atmosphere on terrestrial and Earth-space communications”. From 2000-2004.
- Spanish Project CICYT (BTE 2000-0825): “Ionospheric variability; interaction between neutral and ionised atmosphere. Ionospheric model over Iberian Peninsula INTA (el Arenosillo)- Observatorio del Ebro. From 2001-2004.
- In addition to this research task, this Station sends its ionospheric data to the following Data Centers every year:
 - World Data Center A (Boulder, USA)
 - World Data Center C1 (Slough, UK)
 - World Data Center C2 (Tokio, Japan)
 - European Data Center (Trieste, Italy)
 - Besides, foF2 and M(3000)F2 data are daily sent to the RAL (Chilton, UK) and to the Space Research Centre (Warsaw, Poland).

3.DOCTORAL THESIS

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Marín, D., Long-term changes in the Ionosphere and their relation with the Geomagnetic Activity, Complutense University, Madrid, 2003.

4. PUBLICATIONS

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De la Morena B.A., J.M. Vilaplana and E.S. Kazimirovsk, The Climatology of radiowave absorption in south-west Spain, Proceedings VIII Asamblea Nacional de Geodesia y Geofísica, Univ. Complutense, Madrid,1999

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De la Morena B.A. and E.S. Kazimirovsky, The experimental investigation of the lower ionosphere response to forcing from above and below, Scientific Report INTA 1995, J. Torres and B.A. de la Morena Ed's, El Arenosillo, 1999

Alberca, L. F., E. Kazimirovsky, B. A, de la Morena, J. G., Solé, and J. M., Vilaplana, The applicability of fmin-parameter for the study of radio wave absorption in the lower ionosphere, Anales de Física. Vol 93, No. 2, 83-92, 1999

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Miró G., M. Herráiz, B.A. de la Morena, T.L. Gulyaeva, D. Marín, Round-The-World Propagation of the Ionospheric Disturbances at Low Middle Latitudes, COST251TD(99)003 "COST 251/Workshop On "Procedures and Testing of the Models for Ionospheric Telecommunications Application", R. Hanbaba and B. A. de la Morena Ed's, Huelva, pp 169-174, 2000

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D. Marín, A.V. Mikhailov, B.A. de la Morena, M. Herriz, Long- term hmF2 trends en the EuroAsian longitudinal sector on the ground-base ionosonde observations. Ann. Geophysicae, Volume 19, Number 7, 2001.

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D.Buresova, J. Lastovicka, D. Altadill, G. Miró. Daytime electron density at the F1 region in Europe during geomagnetic storms". *Annales Geophysicae*, 20 (7), pp. 1007-1021, 2002.

MUSEO NACIONAL DE CIENCIAS NATURALES (CSIC)

Grupo de Geomagnetismo; Dpto. de Volcanología

José Gutiérrez Abascal, 2

28006 MADRID SPAIN.

Tf: +34 914111328

Fax: +34 915644740

1. AREAS OF RESEARCH

- **Volcanomagnetism: Magnetic surveys at Deception Volcano (South Shetland I., Antarctica)**
- **Magnetic networks for volcano monitoring. Design of the new magnetic sensors.**
- **Structural models from aeromagnetic and marine magnetic data.**
- **Correlations between seismic, electromagnetic and magnetic anomalies in active volcanic areas**

2. SCIENTIFIC PROJECTS

- SANARIS (Satellite network for natural Risks). 1999-2000. UE , Main investigator: A García.
- DECVOL (Crossdisciplinary study of Deception volcano, Antarctica), 1999-2000 MCyT; Main Investigator: A. García
- e-Ruption (A Satellite Telecommunication and Internet-Based seismic Monitoring System for Volcanic Forecasting and Risk Management). 2002-2004; UE, Main Investigator of CSIC (Spain): A. García
- Monitoring of volcanic activity in Timanfaya volcano (Lanzarote I., Canary I.). Correlations between temperature variations, seismic activity and electromagnetic perturbations. 2002-2005; MCyT. Main Investigator: R. Ortiz

3. PUBLICATIONS (only papers related to Magnetism)

Araña, V., Camacho, A.G., García, A., Montesinos, F.G., Blanco, I., Vieira, R., Felpeto, A (2000) Internal structure of Tenerife (Canary Islands) based on Gravity, Aeromagnetic and Volcanological data. *Journal of Volcanology and Geothermal Research*. Vol 103: 43-64

Abella, R.; Zlotnicki, J.; García A. (2000). Volcanomagnetismo. In: Curso Internacional de Volcanología y Geofísica Volcánica, ed: Astiz M, García A, Ortiz R; Serie Casa de los Volcanes nº7, printed by servicio de Publicaciones del Cabildo de Lanzarote (Canary I. Spain): 325-340

Tárraga, M.; Abella, R.; Ortiz, R.; García, A.; Astiz, M.M.(2000) Seguimiento de la actividad volcánica: estaciones multiparamétricas y Sistemas de comunicaciones. In: Curso Internacional de Volcanología y Geofísica Volcánica, ed: Astiz M, García A, Ortiz R; Serie Casa de los Volcanes nº7, printed by servicio de Publicaciones del Cabildo de Lanzarote (Canary I. Spain): 243-264.

Tárraga, M.; García, A.; Ortiz, R.; Abella, R.; Peña, J. (2001). SANARIS Project: A Satellite Network for Natural Risk Monitoring. Natural Hazards Vol. 23: 417- 429

Blanco-Montenegro, I.; Torta, J.M.; García, A.; Araña, V. (2003). Analysis and Modeling of the aeromagnetic anomalies of the volcanic island of Gran Canaria (Canary Islands). Earth and Planetary Science Letters, Vol.: 206: 601-616.

OBSERVATORI DE L'EBRE, Geomagnetic Department.

Horta Alta, 38

43520 ROQUETES (Tarragona). SPAIN.

Tf.: +34 977500511

Fax.: +34 977504660

1. AREAS OF RESEARCH

- **Regional modeling of the magnetic field, its secular variation, and the equivalent ionospheric currents responsible of some geomagnetic variations, using spherical cap harmonic analysis.**
- **Geomagnetic observatories: Instrumentation, practice and analysis.**
- **Rapid magnetic variations.**
- **Geomagnetic field studies on the South Shetland Islands and Antarctic Peninsula region.**

2. SCIENTIFIC PROJECTS

- Satellite communication system between Livingston Island and Ebro observatories, and development of methodologies to monitor the geomagnetic and ionospheric activity in the Spanish Station region. CICYT: ANT98-0886. Main investigator: L.F. Alberca.
- Solar-Terrestrial and Geophysical Studies in Antarctica from geomagnetic and GPS Data. REN2000-0833-C02-01/ANT, Main Investigator: J.M. Torta.
- **Conditioning of the San Pau and San Onofre hermitages and installation and acquisition of equipments for the geomagnetic station in Horta de San Juan (Tarragona). (Agreement between IGN and Ebro Observatory).**

3. PUBLICATIONS

- De Santis, A., M. Chiappini, J.M. Torta, R.R.B. von Frese. Development of an improved geomagnetic reference field of Antarctica, *Annali di Geofisica*, 42, 265-270, 1999.
- Torta, J.M., L.R. Gaya-Piqué, J.G. Solé, I. Blanco, A. García, A new geomagnetic observatory at Livingston Island (South Shetland Islands): implications for future regional magnetic surveys, *Annali di Geofisica*, 42, 141-151, 1999.

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- De Santis, A., J.M. Torta, F.J. Lowes, Spherical cap harmonics revisited and their relationship to ordinary spherical harmonics. *Phys. Chem. Earth – Part A*, 24, 935-942, 1999.
- Gaya-Piqué, L.R., J. M. Torta, B.J. Casas, J.J. Curto, E. Sanclement, J.G. Solé, D. Altadill, A. Ugalde, A. De Santis, E.M. Apostolov, J. Merino, L.F. Alberca, A. García, Livingston island geomagnetic Observatory. 1999 and 1999-2000 Survey Bulletin. Publication of Ebre Observatory. *Miscelania* 43, 67 pp., 2000.
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- Torta, J.M., Variaciones geomagnéticas de origen ionosférico en días de calma. *Tendencias Actuales de investigación de la ionosfera*. Ed. B. de la Morena, M. Herraiz. *Física de la Tierra*, 12, 205-222, 2000. ISSN 0214-4557.
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- Curto, J.J., E. Sanclement, Leveling error corrections to D-measurements in DI-flux magnetometers, *Contributions to Geophysics & Geodesy*, *Geophys. Inst. Slov. Acad. Sci.*, 31, 111-117, 2001.
- Torta, J.M., L.R. Gaya-Piqué, J.C. Riddick, C.W. Turbitt, A partly manned geomagnetic observatory in Antarctica provides a reliable data set. *Contributions to Geophysics & Geodesy*, *Geophys. Inst. Slov. Acad. Sci.*, 31, 225-230, 2001.
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- Blanco-Montenegro, I.; Torta, J.M.; García, A.; Araña, V., Analysis and Modeling of the aeromagnetic anomalies of the volcanic island of Gran Canaria (Canary Islands). Earth and Planetary Science Letters, 206, 601-616, 2003.

OBSERVATORI DE L'EBRE, Ionospheric Department

Horta Alta, 38

43520 ROQUETES (Tarragona). SPAIN.

Tf.: +34977500511

Fax.: +34977504660

1. AREAS OF RESEARCH

- **Monitoring of the main ionospheric parameters obtained by vertical sounding and its variability.**
- **Study of the dynamic coupling of the mesosphere-thermosphere-ionosphere by tides and planetary waves.**
- Study of the solar and geomagnetic forcing on the ionosphere.

2. SCIENTIFIC PROJECTS

- Integration of a GNSS permanent receiver as an ionospheric and tropospheric monitor tool. Application to navigation system based on space techniques. UPC - Observatori de l'Ebre. CICYT: TIC97-0993-C02-01. 1997-1999, Main investigator: M. Hernández-Pajares.
- Ionospheric physics. Study of the ionospheric parameters and their impact on terrestrial and Earth space communication. Cooperation Program Poland-Spain. 1998-2000, Main Investigator: L. F. Alberca.
- Influence of the solar activity on the Mesosphere-Thermosphere-Ionosphere system. Coupling and energetic. Consejo Superior de Investigaciones Científicas – Bulgarian Academy of Sciences. Ministry of Foreign Affairs: International Cooperation project 2001BG0012. 2001 – 2002, Main investigator: D. Altadill and E. M. Apostolov.
- Effects of the upper atmosphere on terrestrial and Earth-Space communications EACOS COST271, Observatorio del Ebro – EU, 2000 – 2004, Main investigator: B. Zolesi.
- Ionospheric variability; interaction between the neutral atmosphere and the ionized atmosphere. Ionospheric model above the Iberian Peninsula. Consejo Superior de Investigaciones Científicas. MCYT BTE2000-0825, 2001 – 2004. Main investigator: D. Altadill.

- Effects of Meteorological, Solar and Anthropogenic Origin on the Ionosphere. Consejo Superior de Investigaciones Científicas – Academy of Sciences of the Czech Republic. MCYT International Cooperation project 2003CZ0007. 2003 – 2004, Main investigator: D. Altadill and J. Lastovicka.

3. PUBLICATIONS

- Lastovicka, J., D. Pancheva, D. Altadill, E. A. Benediktov, J. Boska, J. Bremer, M. Dick, K. Igarashi, P. Mlch, B. A. de la Morena, Z. T. Rapoport, V. A. Vyakhivev, B. O. Vugmeister, X. Zhang, and B. Zolesi, Ionospheric measurements during the CRISTA/MAHRSI campaign: their implications and comparison with previous campaigns, *Annales Geophysicae*, Vol. 17, No. 8, 1040-1052, 1999.
- Altadill, D., J. G. Solé, and E. M. Apostolov, Gravity wave type disturbances observed in the ionosphere during solar eclipse of 11 August 1999, *Bulgarian Geophysical Journal*, Vol. XXV, No. 1-4, 43-50, 1999.
- Alberca, L.F., G. Juchnikowski, S. Kouris, A.V. Mikhailov, G. Miró, B. de la Morena, P. Mukhtarov, D. Pancheva, J.G. Solé, I. Stanislawska, L. Villanueva, T. Xenos, Comparison of various foF2 single station models for European area, *Acta Geophysica Polonica*. Vol XLVII, N°1, 77-91, 1999.
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REAL INSTITUTO Y OBSERVATORIO DE LA ARMADA (ROA).

Cecilio Pujazón s/n

11100 SAN FERNANDO (Cádiz). SPAIN.

Phone: +34 956599285.

Fax: +34 956599366.

1. AREAS OF RESEARCH.

- Magnetic observatory.
- Periodic Bulletins.
- Secular variation.
- Field and marine surveys.
- Magnetic anomalies.
- Development of magnetic equipment.
- Tectonics. Geodynamics.

2. SCIENTIFIC PROGRAMS.

- ***Antarctic Research Program : -***

DECVOL [CICYT- ANT99-1428-E].

A seismic crisis, along 1998-1999 austral summer, at Deception island (Bransfield Strait, Antarctica), where Spanish Base “Gabriel de Castilla” is installed, motivated the performance of a fast volcanic risk evaluation. Spanish Antarctic Program organized a multi-disciplinar campaign called DECVOL. Different Spanish Institutions were involved: National Natural Science Museum, Spanish Hydrographic Institute, Cadiz University, Complutense University of Madrid, and the R.O.A. Three sub-programs were carried out: Volcanism, Geodynamics and Marine Geophysics. The latter one was led by the ROA.

GEODEC-MAR [CICYT-REN2000-0551-C03-03 ANT]

This project, funded by Spanish Science and Technology Ministry (MCyT), pursue a deep crustal structure knowledge at SW Bransfield strait area, by the use of different geophysical techniques: Geomagnetism, Earth gravity field, Seismic refraction and bathymetry. A 30 day Antarctic cruise was carried out during 2001-

2002 austral summer. Actually all the above acquired information is being analyzed and interpreted.

- “Automatic Geophysical station” (MN-8302).

The main objective of this project, funded by the Spanish Defense Ministry, is to develop an automatic station able to acquire and transmit several geophysical parameters from different geomagnetic, seismic and meteorological sensors. In the geomagnetic side, those sensors could be installed at a fixed point on land or on a mobile platform for marine surveys. Under this project, a three components variographic station has been developed, based on fluxgate sensors, and tested at remote sites controlled by radio/phone modem.

- “Spanish Exclusive Economic Zone Project” (SEEZ).

THE SEEZ PROJECT HAS AS MAIN AIMS: THE ESTABLISHMENT OF THE SPANISH EXCLUSIVE ECONOMIC ZONE CARTOGRAPHY; AND THE ACQUISITION OF GEOPHYSICAL PARAMETERS WHICH CHARACTERIZE ITS MARINE SOIL AND SUBSOIL.

Due to the extension of the SEEZ (more than 1.2 million square kilometers) and its inherent complexity, it was essential to fix a framework for any exploration program to take place. It has been decided to develop it during one month every year (without any defined end as of yet), mainly using the Spanish Research Vessel "Hespérides" as scientific platform.

The project kicked-off on July 1995, establishing as an initial geographical frame the Balearic Sea and Gulf of Valencia, and went on for the following two years (1996, 1997). It was necessary to perform two additional Campaigns (1999 and 2000) to end the survey of the area.

Since 1996, the ROA has actively participated in the SEEZ. Its Geophysical Department is in charge of the Geomagnetic data collection and treatment, as well as the preparation of Total Force magnetic anomaly maps.

All the geomagnetic data acquired, during this first part, has been reduced and stored as database. Seven scalar magnetic anomaly maps have been prepared and published. Six maps [scale of 1:200.000], and another of the entire area [scale of 1:500.000].

During 1998, 1999 and 2000, the SEEZ Project concentrated its effort at Canary Islands. In order to end with this geographical frame, it has been necessary to perform two additional campaigns on October 2001 and 2002. From August 2001 onwards the Project is working at Galicia Bank.

- **Collaboration with other scientific programs**

On request of different Spanish research programs [TASYO: MAR9802-09 and PARSIFAL: MAR1998-1837-CE], ROA has collaborated as responsible of acquisition, processing and analysis of the geomagnetic data. Geomagnetic anomalies maps, as well as complementary scientific studies are actually on course.

3. PUBLICATIONS

Geophysical Annals: Seismic, Geomagnetic and Meteorological Observations. Real Instituto y Observatorio de la Armada. 1999, 2000, 2001 and 2002. Edited by Spanish Defense Ministry.

M. Catalán, M. Pardo, J.A. Marín, J. Martín, R. Alvarez, P. Herranz, J.L. Sanz: “Descripción de los levantamientos magnéticos realizados en la campaña Zona económica exclusiva (años 1995, 1996 y 1997)”. Proceedings de I ASAMBLEA HISPANO-PORTUGUESA DE GEODESIA Y GEOFÍSICA. (en CD-ROM). 2000

M. Catalán, J. Martín Davila: “On technical aspects concerning the Geomagnetic surveying at Balearic sea and Valencia Trough: ZEEE Project”. “Contributions to Geophysics and Geodesy”. Geophysical Institute. Slovak Academy of Sciences. Vol. 31/1, 2001, pp. 263-272.

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Grupo de Trabajo ZEE, 2001: Mapa geomagnético del Mar Balear y Golfo de Valencia (1:500.000). Ministerio de Ciencia y Tecnología - Instituto Español de Oceanografía. I.S.B.N.: 84-931926-9-4 N.I.P.O.: 406-01-007-7

UNIVERSITAT DE BARCELONA
Departament de Geodinàmica i Geofísica

Martí Franqués s/n
08028 BARCELONA. SPAIN

Tf: 93- 4021386

Fax: 93-4021340

1. AREAS OF RESEARCH (concerning geomagnetism and geoelectricity)

- Magnetotelluric surveys: Regional studies
- Electromagnetic methods applied to Hydrogeology
- Treatment and reduction of magnetic anomalies from oceanographic campaigns
- Modeling and interpretation of oceanic magnetic anomalies.

2. SCIENTIFIC PROJECTS

- Perfiles de magnetotelúrica en el suroeste de la Península Ibérica: Zona Surportuguesa, Ossa Morena y Centroibérica. MCYT nº BTE2000-0583-C02-02. (2001-03).
- Geodinámica del borde de placas Scotia/Antártica y paleoceanografía del agua Antártica profunda. Desarrollo de cuencas oceánicas.(SCAN 2000). CICYT ANT 99-0817(2000-2002).
- Tomografía geoléctrica: Desarrollo para la caracterización de acuíferos, CICYT REN2002-4538-C02-01(2002-05).
- Caracterización geológica de alta resolución en 3D de la zona central de Tenerife: implicaciones en recursos hidrogeológicos y en evaluación de riesgos naturales. CICYT-UNER nº 1FD97-1121 (1999-00).

3. PUBLICATIONS

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UNIVERSITAT POLITÈCNICA DE CATALUNYA

Group of Astronomy and Geomatics (gAGE/UPC)

Jordi Girona, 1-3. Mòdul C-3, Campus Nord

08034 BARCELONA. SPAIN

Tf: +34 93 401 6029

Fax: +34 93 401 5981

1. AREAS OF RESEARCH

- Ionospheric determination with Global Navigation
- Satellite Systems (GNSS)
- Precise GNSS Navigation
- GNSS Integrity for Civil Aviation

2. SCIENTIFIC PROJECTS

- Improvement of tomographic models to estimate the ionospheric electron density from GNSS occultation data.
- Combination of ionosonde and ground GPS data to extend the vertical profiles.
- Improvement of Global TEC maps computation.
- Generation of very accurate differential ionospheric corrections in real-time for subdecimeter navigation in Wide Area Differential GPS networks (UPC patent in 1999).
- Generation of new algorithms for instantaneous subdecimeter navigation with the help of ionospheric corrections with new GNSS systems of three frequencies (Galileo and Modernized GPS). European Space Agency Patent in 2002.

3. PUBLICATIONS (selected journals since 2000)

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- Colombo O., Hernandez-Pajares M., J.M. Juan, J. Sanz, Wide-Area, carrier-phase ambiguity resolution using a tomographic model of the Ionosphere, *Navigation*, 49(1), p.61-69, 2002.
- Orus R., M. Hernandez-Pajares, J.M. Juan, J. Sanz and M. Garcia, Performance of direct TEC models to provide ionospheric corrections, *Journal of Atmospheric and Solar Terrestrial Physics*, 64(18), 2055-2062, 2003.
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- Hernandez-Pajares M., J.M. Juan, J. Sanz, O. Colombo, Application of ionospheric tomography to real-time GPS carrier-phase ambiguities resolution, at scales of 400-1000 km and with high geomagnetic activity, *Geophysical Research Letters*, V.27, No.13, 2009-2012, 2000.

UNIVERSIDAD COMPLUTENSE DE MADRID

Paleomagnetism Group

Departamento de Física de la Tierra

Facultad de Ciencias Físicas

28040 MADRID. SPAIN

Tf: 91-3944396

Fax: 91-3944398

1. AREAS OF RESEARCH

- Paleomagnetic rotations and crustal deformation in Iberia.
- Mesozoic evolution of Iberia from paleomagnetic data.
- Jurassic and Triassic magnetostratigraphy.
- Environmental magnetism.
- Archaeomagnetism.
- Tectonics of the Trans-Mexican Volcanic Belt (Mexico).
- Remagnetization processes in limestones.
- Magnetic properties of extraterrestrial material

2. SCIENTIFIC PROJECTS

- Descripción y origen de las reimanaciones de sedimentos mesozoicos de Iberia (Cordilleras Béticas y Sistema Ibérico). Implicaciones tectónicas BTE2002-00854. MCYT. 2003-2006. Investigador Principal: M.L. Osete.
- Archaeomagnetic applications for the rescue of cultural heritage (AARCH). HPRN-CT-2002-00219. UNIÓN EUROPEA. 2002-2005. I.P. M.L. Osete. Coordinadora C. Batt (Univ. Bradford).

- Refinamiento de la Primera Curva de Variación Secular del Campo Geomagnético de Madrid. Aplicación a la datación de yacimientos arqueológicos (Ampliación del proyecto 06/008/1998) 06/0036/2000. Comunidad Autónoma de Madrid. 2001.I.P. M.L. Osete.
- Evolución Cinemática de la Placa Ibérica durante el Mesozoico a partir de datos paleomagnéticos PB98-0834. CICYT. 2000-2002. I.P. M.L. Osete.
- Paleomagnetic and Magnetostratigraphic study of the Mesozoic cover in the Iberian margin of the Tethys (Betic Cordillera and Iberian Ranges). DGICYT. PB95-0921. 1996-1999.
- Network for Mineral Magnetic Studies of Environmental Problems (MAG-NET). European Union. PL97-0892. 1998-2001.
- Palaeomagnetic dating. Establishment of a Secular Variation Curve for Madrid. Comunidad de Madrid. 06/0080/98. 1990-2001.
- Big Sources of Earthquakes and Tsunami in SW Iberia. European Union. PL97-1147. 1997-2000.
- Magnetic properties of marine sediments from Cádiz Gulf. Burgos University. 1998-99.

3. PUBLICATIONS

- Cresta S, Goy A, Ureta S, Arias C, Barron E, Bernad J, Canales ML, Garcia-Joral F, Garcia-Romer E, Gialanella PR, Gomez JJ, Gonzalez JA, Herrero C, Martinez G, Osete ML, Perilli N, Villalain JJ. The Global Boundary Stratotype Section and Point (GSSP) of the Toarcian- Aalenian boundary (Lower-Middle Jurassic). *Episodes*. 24(3). 166-175. 2001.
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Volcanics from the Eastern Segment of the Mexican Volcanic Belt. *Tectonophysics*, 318. 217-233. 2000.

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- Núñez, J.I.; Osete, M.L. Estudio arqueomagnético del horno cerámico bajoimperial del sector G. In: *Excavaciones arqueológicas en la villa romana del Puente Grande (Los Altos de Ringo Rango, Los Barrios, Cádiz)*. Ed.: Universidad de Cádiz. ISBN 84-7786-753-4. 407-413. 2002.
- Osete, M.L.; Villalaín, J.J.; Osete, C. y Gialanella, P.R. Evolución de Iberia durante el Jurásico a partir de datos paleomagnéticos. *Geotemas*. 1 (1). 117-119. 2000.
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- Ruiz-Martínez, V.C.; Osete, M.L. y Sopeña, A. Propiedades magnéticas de sedimentos del Triásico Medio-Jurásico Inferior de la Cordillera Ibérica Occidental. *Geotemas*. 1 (1). 131-135. 2000.
- Villasante, V.; Osete, M.L.; Gervilla, F. y García-Dueñas, V. Rotaciones dextrales en el complejo ultrabásico de Ronda. Nuevos datos paleomagnéticos. *Geotemas*. 1 (1). 137-140. 2000.
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REPORT OF ACTIVITIES OF THE HYDROLOGY SECTION OF OF THE SPANISH COMMISSION OF GEODESY AND GEOPHYSICS FOR THE PERIOD 1999-2002

Year 1999

The Spanish Commission of Geodesy and Geophysics was created officially on March 25th 1999, according to the Spanish Official Register (BOE) of 03-04-1999. The Spanish Commission of Geodesy and Geophysics has a consultative nature and encompasses the following Sections: Geodesy; Seismology and Physics of the Earths Interior; Geomagnetism and Aeronomy; Vulcanology; Meteorology and Atmospheric Sciences; Physical Sciences of the Oceans; Hydrology and Applied Geophysics. Each Section corresponds with one of the International Associations forming the International Union of Geodesy and Geophysics (IUGG), being the corresponding to the Section of Hydrology the International Association of Hydrological Sciences (IAHS). Every Section has a maximum of ten members, including a President and a Secretary. The latter are elected among the ten members and act as the link with the Executive Committee and all the Centres and Institutions related with their field.

Year 2000

Current members of the Hydrology Section include: Dr. Andrés Sahuquillo Herráiz, Dr. Emilio Custodio Gimena, Dr. Javier Samper Calvete, Dr. Teodoro Estrela Monreal, Dr. Juan A. Mintegui Arreguá, Dr. Daniel Sempere Torres, Dr. Antonio Pulido Bosch, Dr. Francesc Gallart, Dr. Lucila Candela Lledó and Dr. Juan Vicente Giráldez Cervera. Dr. Andrés Sahuquillo and Dr. Javier Samper were elected as president and secretary of the Section, respectively. They maintained during this year various contacts among themselves as well as with the Spanish Commission of Geodesy and Geophysics.

Year 2001

The main activity of the Hydrology Section in this year consisted on organizing and preparing the Hydrology Session of the III Spanish-Portuguese Assembly of Geodesy and Geophysics to be held in Valencia on February 2002. Dr. Teodoro Estrela acted as chairman and organizer of the Session on Hydrological Sciences.

Year 2002

The Hydrology Section got together met on February 6th at the Polytechnic University of Valencia during III Spanish-Portuguese Assembly of Geodesy and Geophysics. The following members attended the meeting: Dr. Sahuquillo, Dr. Custodio, Dr. Samper, Dr. Estrela, Dr. Mintegui, Dr. Sempere, Dr. Pulido and Dr. Gallart. Dr. Candela and Giraldez apologized for their absence. Main topics of the meeting were related to the scientific activities of the Section, ways to strength the links with IAHS, participation in preparation of the National Research Program of the Ministry of Science and Technology, creation of a web page, and other topics. Dr. Custodio was elected as substitute President and Dr. Estrela as substitute Secretary.

The Hydrology Session of the III Spanish-Portuguese Assembly of Geodesy and Geophysics took place on February 7th, 2002. The main topics of the session were Basin Management and Contamination. There were two invited lectures, one by Dr Joaquin Andreu from the Polytechnic University of Valencia on Decision Support Systems and another one by Dr Javier Ferrer from the Júcar Basin authority on Hydrology and Water Management in the Júcar basin. In addition, a total of 27 papers were presented, including 21 oral presentations and 6 posters.

National Report on Physical Oceanography 1999-2002

1. Introduction.

This report lists and describes the main Spanish interests and activities in Physical Oceanography for the period 1999-2002. Although for this period the European and national specific programmes on Marine Sciences had been already (or near to be) terminated and the Marine Research was integrated in programmes of wider multidisciplinary scope, the Spanish oceanographic research kept its pace and increased its scientific output. In particular, because the push given by the aforementioned programmes during the nineties kept its inertia, and the incorporation of graduates to the different institutions maintained its rate. In other aspects, the interdisciplinary character of Oceanography became more evident and operational oceanography became a more familiar term.

In this report the main research areas and objectives of the different Spanish institutions will be described as well as the major projects they have been involved in this quadrennial period. A list of publications is given at the end of the report.

2. Institutions.

Instituto Canario de Ciencias Marinas (ICCM)

Grupo de Oceanografía Operativa y Descriptiva. (GOOD).

Ctra. Taliarte s/n.

Apdo. Correos 56

35200 Telde (Las Palmas de G. Canaria)

España

Tel: 34 928 133312

Fax: 34 928 132908

www.ieo.es

Its main research interests are:

1.- The study of long-term series in the Eastern Central Atlantic. (Upwelling area between the Canary Islands and Cape Blanc. European Station for Time-Series in the Ocean Canary Islands. ESTOC. Local studies close to the islands).

2.-Development of instrumentation and methodologies for oceanographic observations. (Telemetry applications for the observation of oceanographically interesting parameters. Moored and adrift instrumentation developments to make observations in the ocean.).

Institut de Ciències del Mar (ICM-CMIMA)

Passeig Marítim de la Barceloneta 37-49

08003 BARCELONA

España

Tel: 93 2309512

Fax:93 2309555

CMIMA belongs to the “Consejo Superior de Investigación Científica. Its main lines of work have been linked to the Mediterranean circulation, in particular in the Western Basin, and satellite imagery. Presently they are also working in operational oceanography related project and the Antarctic.

Instituto Español de Oceanografía (IEO)

Avd. de Brasil, 31
28020 Madrid
España
Tfno: 91 4175411
Fax 91 5974770
www.ieo.es

IEO finances its own programme related to the particular sectors it has been charged with, in particular fisheries. IEO also looks for funds in the Spanish, national or regional, agencies as well as in the European ones, within the frame of their work programmes.

The IEO programme related to Physical Oceanography is part of the “Area de Medio Ambiente Marino y Protección Ambiental”, whose priority lines for the reported period were:

1.- Study of the temporal variability and trends in the oceanographic conditions and biological communities. Several time series sections around the Iberian Peninsula and the archipelagos are sampled monthly or quarterly. Time series are actually some 10 years long. Those made in the Mediterranean are in the process of integration in the water masses monitoring implemented by the International Council for the Exploration of the Mediterranean Sea and in the European operational oceanography project “Mediterranean network to assess and upgrade Monitoring and forecasting Activities in the region”.

2.- Study of the relations between physical processes and living marine resources.

Besides, IEO has been partner or coordinator of other national or European funded projects related to: the circulation and dynamics in the Mediterranean (Alboran Sea and Balearic channels); North Atlantic Eastern Boundary currents; heat, freshwater and nutrients fluxes in the subtropical N. Atlantic and their mechanisms; climate variability of the ocean; preparation of atlas, satellite imagery, etc., and WOCE projects.

IEO is the Spanish representative in the Intergovernmental Panel (IOC) of GOOS (Global Ocean Observing System) and in GLOSS (Global Observing Sea Level System) that incorporates 3 tide gauges of the IEO network. IEO is also one of the Spanish agencies member of EuroGOOS.

Instituto Mediterráneo de Estudios Avanzados (IMEDEA).

Grupo de Oceanografía Física (GOI_FIS).

CSIC-Univ. Illes Balears
C/ Miquel Marqués 21
07190 Esporles (Islas Baleares)

España
Tfno: 34 971 611716.
Fax: 34) 971 611761

The research in GOI-FIS has a predominant interdisciplinary character. They deal with problems related to marine dynamics at different scales. From the large one (numerical simulation of Mediterranean basin circulation) until littoral dynamics (beaches, public works, etc.) through mesoscale (Balearic, Alboran seas). Several incursions in operational oceanography have been also made.

Important results have been obtained respect to the relation between the mesoscale physical processes and biochemical ones. These processes have been approached from two main viewpoints: 1) the critical influence of the sampling strategy and posterior calculation of fundamental dynamic variables (vorticity, etc.), and 2) the biological repercussions of this mesoscale dynamics.

Laboratori d'Enginyeria Marítima (LIM/UPC)

Universitat Politècnica de Catalunya

c/ Jordi Girona, 1-3
Campus Nord-UPC, mòdul D-1
08034 Barcelona
Tfno.: 93 401 6468
Fax: 93 401 1861
E-mail: info.lim@upc.es
Web: <http://lim-ciirc.upc.es>

LIM/UPC carries out basic and applied research projects in the following fields: coastal and estuarine hydrodynamics, maritime environment climate and quality, oceanographic physics and engineering, coastal morphology, harbour and coastal engineering, and coastal zone management. It has at present a solid infrastructure and the equipment and scientific material it needs to undertake its projects effectively, and in turn to offer these facilities to other institutions or entities.

Puertos Del Estado (PE)

Avda del Partenon 10
Campo de las Naciones
28042 Madrid
España
Tfno. 91-5245500
Fax 91-5245504

The main activities of PE have to do with operational oceanography. They maintain and exploit several buoy networks: Deep-water buoy network, coastal network, tide gauge network and current meter network. Data is used for assimilation into operational systems: operational forecasting of waves and sea level around the Spanish waters; implementation of autonomous wave propagation models on Harbour authorities; development of tide gauge pilot Station to test new technologies and development of routines for automatic data control and exploration.

PE is one of the Spanish agencies member of EuroGOOS.

Universidad de Cádiz (UCA)
CASEM, Departamento de Física Aplicada
11510 Puerto Real (Cádiz)
España
Tfno: 956 01 60 76
Fax: 956 01 60 79
E-mail: miguel.bruno@uca.es

The staff of Physical Oceanography at the University of Cádiz (Spain) is integrated into the Department of Applied Physics. There are three main research lines.

1.- The hydrodynamic of bays and estuaries is centered at the Bay of Cádiz and in the Guadalquivir river (Spain), focusing the interest in the tidal wave propagation, sediment dynamic and its influence on tidal propagation, sea-air interaction and the numerical modeling of all these processes.

2.- The altimetry satellite. The improvement of the orbit of altimetry satellites and the application of altimetry on the southern ocean the Earth, mainly in the Antarctic. In addition the water masses recognition and dynamic of the Bransfield Strait are subject of interest.

3.- The dynamic of the Strait of Gibraltar. The numerical modeling of the tidal waves at Gibraltar is one of our first goals. The study of internal waves (classical bore and internal lee waves) and their consequences on biological processes is also carried on nowadays. There is some extentions of the numerical models towards the Alboran Sea and the Gulf of Cádiz.

Universidad de Málaga (UMA)

ETSI Telecomunicacion

Campus De Teatinos S/N
29071 Malaga
España
Tfno. 952 13 27 21
Fax 952 13 14 50

Its main lines of research are the study of the exchange of water through the Strait of Gibraltar and its variability at different temporal scales, and the circulation in the adjacent regions: Alboran Sea and Gulf of Cádiz.

Universidad de Las Palmas de Gran Canaria. (ULPGC)
Campus Universitario de Tafira
31017 Las Palmas de Gran Canaria.
España
Tfno.: 928454500
Fax: 928452922

The main interests of ULPGC have been in the study of the N. Atlantic Western and Eastern Boundaries, upwelling, coupling of biological and physical processes, diapycnal mixing, effect of islands on the circulation and the Antarctic.

3. Projects.

(Title of the project and acronym, if exists, are given. Source of funding- institutional, national or European- is indicated. A very short description of the project is given if the title is not self-explanatory. Acronyms of Spanish participant institutions in the project are also shown.)

Corriente de Contorno Oriental – Canarias (CORICA). Nal. Study of the Canary C. IEO and ULPGC.

Development of a Real Time in situ Observing System in the North Atlantic Ocean, by an array of Lagrangian Profiling Floats (Gyroscope). Eur. European contribution to Argo pilot experiment. IEO, ULPGC and CMIMA.

Proyecto Piloto sobre Circulación Regional, Escenario Ambiental y Distribución Larvaria del Atún Rojo y Especies Afines en Aguas de las Islas Baleares (TUNIBAL). Inst., IEO. Circulation and Red Tuna environment conditions. IEO

Permanent Moorings in the Eastern Boundary Current (FONDEBC). Inst., IEO. IEO, ULPGC

European Station For Time Series In The Ocean (ESTOC). IICM, If Meereskunde-Kiel, U. Bremen and IEO. Idem.

Estudio Interdisciplinario de Inestabilidades de Mesoescala y su Interacción con la Circulación Local, Regional y Global en el Mediterráneo Occidental. (INTERMESO). Nal. Mesoscale unstabilities and their interaction with local, regional and global circulation. Universidad Islas Baleares IMEDEA and CMIMA

Observation and Modelling of Eddy Scale Geostrophic and Ageostrophic Circulation (OMEGA). Eur. IMEDEA, CMIMA, UMA.

Series históricas de datos oceanográficos. Inst., IEO. Times series sections. IEO.

NORALBORAN. Nal. Circulation in the Alborán Sea. IEO.

Mediterranean network to asses and upgrade Monitoring and forecasting Activities in the region (MAMA). Eur. IEO, IMEDEA, CMIMA.

Mass Transfer and Ecosystem Response (MATER). Eur. UMA, IEO, UIB, CMIMA.

MEDAR - MEDATLAS II. Making of a Mediterranean Atlas. Eur. IEO, PE, IMEDEA.

Wind and Salinity Experiment (WISE). Eur. Effect of sea state on L band emission. Phase of scientific definition of the mission SMOS(SoilMoisture and Ocean Salinity). CMIMA, ICM, U.Politènicade Catalunya, U. València.

IN SITU DATA ACQUISITION AT "CASABLANCA" SITE DURING THE EUROSTARRS CAMPAIGN (EUROSTARRS).EUR. DEVELOPMENT OF A GPS BUOY FOR A VERY HIGH GEOCENTRIC DETERMINATION OF THE SEA LEVEL, AND USE IT IN MEASUREMENTS SIMULTANEOUS TO ERS-2 SATELLITE.

SOFT: Satellite-based Ocean Forecasting. Eur.Evk3-2000-00561. IMEDEA.

ESEAS (European Sea Level Service) -RI: Sea Level Service – Research Infrastructure. Eur. IEO, PE, IMEDEA.

Estudio multidisciplinar de la dinámica de un cañón submarino y su repercusión sobre la ecología del margen continental del Mediterráneo Noroccidental (CAÑONES). Nal. Submarine canyons dynamics and ecology. IMEDEA

Relación entre procesos físicos y biogeoquímicos asociados a sistemas hidro-dinámicos de mesoescala en el Mar de Alborán (BIOMEGA). Nal. IMEDEA.

Influencia de las zonas inundables de marisma en la hidrodinámica de los estuarios. Nal. Estuaries hydrodynamics. Universidad de Cantabria, Universidad de Cádiz, IEO

Canary Islands Azores Gibraltar Observation (CANIGO). Eur. Interdisciplinary study of the region . IEO, ULPGC, UMA, ICCM.

Remolinos/meandros de mesoescala en la parte central del estrecho de Bransfield: identificación y acoplamiento físico-biológico (BREDDIES). Nal. Eddies and meanders in the Bransfield Strait. ULPGC, Instituto de Ciencias Marinas de Biología, Universidad de Vigo

Flujo de carbono en la región canaria: acoplamiento entre exportación costera y demanda oceánica (COCA). Nal. carbon flux in the NW African upwelling. ULPGC, IMEDEA.

Dinámica, interacción y efectos biológicos de filamentos remolinos y estelas (FRENTEs). Nal. Study of NW African Upwelling filaments on the leeward side of the Canary I. ULPGC.

Hindcast of 44 years of waves, atmosphere and sea-level on the Mediterranean Sea. (HIPOCAS). Eur. PE

Assimilation of satellite data into wave models. Enviwaves. Eur. PE.

Circulation prediction for the Macaronesian Marine Zone, PREVIMAR.. Eur. ICCM-GOOD.

Changes in the Saharan Dust storms during the last 50 years and its impact in the Canary Islands, CALIMA. Nal. ULPGC, ICCM-GOOD.

Carbon and Nutrient Fluxes to the north of the Canary Islands, FLUCAN . Nal., ULPGC, ICCM-GOOD

Atlantic Network of Interdisciplinary Moorings and Time Series for Europe, ANIMATE. Eur. ICCM-GOOD.

Monitoring for the management of the Canary Islands coastal zones, using telemetry and analyses “in situ”, SAC-Canaries . National Commission of Aerospace Activities (CONAE), Argentina. ICCM-GOOD.

Experimental Network for Surveillance, Control and Marine Observations in the Canary Islands, R.E.D. A.C.O.M.A.R. Canarias.Nal. ICCM-GOOD

Fluxes Across Narrow Shelves. The Ebro delta case (FANS). Eur. LIM/UPC.

Rationale for Integrated Coastal Area Management (RICAMA). Eur. LIM/UPC.

Scour around coastal structures (SCARCOST), Eur. LIM/UPC.

Coastal study of three-dimensional sand transport processes and morphodynamics (COAST 3D). Eur. LIM/UPC.

YOYO 2001: Ocean odyssey. Eur. LIM/UPC.

Preparation and integration of analysis tools towards operational forecast of nutrients in estuaries of European rivers (PIONEER). Eur. LIM/UPC.

Mediterranean forecasting system pilot project (MFSPP). Eur. LIM/UPC.

Development and implementation of novel imaging velocimetry techniques suited to large-scale hydraulic facilities (HYDRIV). Eur. LIM/UPC.

Environmental design of low crested coastal defense structures (DELOS). Eur. LIM/UPC.

Basis and tools for a more suitable development (ECOSUD). Eur. LIM/UPC.

Circulación y distribución de masas de agua en el Golfo de Cádiz. Procesos físicos de mesoescala. Nal. UMA, UCA.

Estudio de la circulación y batimetría en el entorno de la corriente circumpolar. Nal. UCA.

Análisis de la variabilidad temporal de los flujos hidrodinámicos en el sistema Golfo de Cádiz-Estrecho de Gibraltar-Mar de Alborán mediante un modelo numérico en coordenadas ajustadas al contorno del dominio (GEMA-II). Nal. UCA

Estudio del comportamiento dinámico del Atlántico Ibérico-Mar Mediterráneo-Canarias utilizando técnicas de teledetección. Integración y validación de datos obtenidos por altimetría y radimetría. Nal. UCA

Estudio de la circulación y batimetría en el entorno de la corriente circumpolar. Nal. UCA.

Los altímetros como instrumentos oceanográficos : Dinámica del Océano Atlántico Ibérico y Cuenca del Mediterráneo. Nal. UCA.

Analysis of the inverse barometer algorithm applied to ERS-1/2 and ENVISAT altimetric measurements using a global ocean model. Eur. UCA

4. Publications.

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Nacional Report on Seismology and Physics of the Earth Interior

INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

Sapporo, Japan, July 2003

The progress reached for the period 1999-2003 in the field of Seismology and Physics of the Earth Interior for the research Spanish community is outlined in this report. Thanks to the cooperation of the heads of different organizations in Seismology in Spain we produced this report in which main trends in Seismological Research are described.

Dr. Antonio M. Posadas

President of the Seismology and Physics of the Earth Interior Sub-Committee

Geodesy and Geophysics Spanish Committee

Universidad Complutense de Madrid
Facultad CC. Físicas, Universidad Complutense 28040 Madrid (Spain)
Phone: 34 913945190
Fax: 34 913944398
E-mail:

1. Areas of research:

Seismicity, seismic sources, seismotectonics and seismic risk
Seismic profiles
Broad-band network

2. Scientific Programs

Mecanismo de los terremotos, deformaciones de la corteza, sismotectónica y riesgo sísmico en el Sur de España.

Comisión Interministerial de Ciencia Tecnología, 1997-2000

Universidad Complutense de Madrid, Real Observatorio de la Armada (San Fernando, Cádiz)

Prof. A. Udías

Estación de banda ancha de Mahón

Comisión Interministerial de Ciencia Tecnología, 2000-2001

Universidad Complutense de Madrid, Real Observatorio de la Armada (San Fernando, Cádiz)

Prof. A. Udías

Terremotos y deformación cortical en el sur de España. Aplicación al riesgo sísmico

Dirección General de Enseñanza Superior e Investigación Científica, 2001-2003

Universidad Complutense de Madrid, Real Observatorio de la Armada (San Fernando, Cádiz)

Prof. E. Buforn

Estación sísmica de banda ancha de Ceuta

Dirección General de Investigación, Ministerio de Ciencia y Tecnología, 2002-2003

Universidad Complutense de Madrid, Real Observatorio de la Armada (San Fernando, Cádiz)

Prof. E. Buforn

Seismic hazard scenarios for a seismic risk integrated evaluation

(Funded by the Spanish Ministry of Science and Technology (REN 2001-1674/RIES. 2002-2003)

Site characterization for different seismic scenarios. Practical application and evaluation at the Ratones Mine area” (Funded by ENRESA, 2001- 2002)

3. Publications:

M. Bezzeghoud y E. Buforn. Source parameters of 1992 Melilla (Spain, Mw=4.8), 1994 Alhoceima (Morocco, Mw=5.8) and 1994 Mascara (Algeria, Mw=5.7) earthquakes and seismotectonic implications. *Bull. Seism. Soc. Am.* 89, 359-372, 1999

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Herraiz, M., G.de Vicente, R. Lindo, J. Giner, J.L. Simón, J.M. González Casado, O. Vadillo, M.Rodríguez- Pascua, J.I. Cicuéndez, A. Casas, L. Cabañas, P. Rincón, A. Cortés, M. Ramírez y M. Lucini, 2000, "Recent (Upper Miocene to Quaternary) and present tectonic stress distributions in the Iberian Peninsula", *Tectonics*, 19, 4, 762-786.

UNIVERSITY OF ZARAGOZA, Sciences B, Physics of the Earth
Pedro Cerbuna 12, 50009 Zaragoza, Spain
Phone: + 34 976 761139
Fax: + 34 976 761140
E-mail: badal@unizar.es

1. Research Areas

- 1.1. **Surface waves, forward and inverse modelling, elastic, anelastic and anisotropic media, 3-D imaging of Earth structures and seismic tomography, wide-angle seismic profiling.**
- 1.2. **Simulation of seismic wave fields.**
- 1.3. **Earthquake magnitude classification, earthquake impact scenarios, vulnerability of populations to seismic hazard.**

2. Scientific Programs

- 2.1. Title: Seismic modelling of tectonic areas
Coordinator and principal researcher: José Badal
Institution: DGICYT, Coordinate Project PB95-0777
Dates: 23.12.1996 – 23.12.1999
- 2.2. Title: Crustal structure and site response of the medium
Coordinator and principal researcher: José Badal
Institution: DGES, Coordinate Project PB96-0139
Dates: 01.10.1997 – 01.10.2000
- 2.3. Title: Shallow seismic velocity structure
Participant Researcher: José Badal
Institution: Dirección General de Investigación, Ministry of Science and
Technology, Project REN2000-1740-C05-03

Dates: 29.12.2000 – 28.12.2003
- 2.4. Title: Seismic tomography of Earth structures
Principal Researcher: José Badal
Institution: Dirección General de Investigación, Ministry of Science and
Technology, Project REN2000-1740-C05-04

Dates: 29.12.2000 – 28.12.2003
- 2.5. TITLE: WIDE-ANGLE SEISMIC PROFILING AND MAPPING OF LOVE AND
RAYLEIGH WAVE GROUP VELOCITY
Principal Researcher: José Badal
Institution: University of Zaragoza, Project 225-152

Dates: May 2003

3. Publications (in well-ranked international journals, period 1999-2003):

Elena Samardjieva, Gonzalo Payo and José Badal, 1999. Magnitude formulae and intensity-magnitude relations for early instrumental earthquakes in the Iberian region, *Natural Hazard*, **19**, 189-204.

X. Lana, O. Casellas, J. A. Canas, J. Badal, L. Pujades and M. D. Martínez, 1999. Anelastic structure of the Iberian peninsula obtained from an automatic regionalization algorithm and stochastic inversion, *Tectonophysics*, **304**, 219-239.

F. J. Sabadell, F. J. Serón and J. Badal, 1999. A domain decomposition method for elastic wave propagation based on Huygens' principle, *Phys. Chem. Earth (A)*, **24**, 235-239.

M. D. Martínez, X. Lana, J. Badal, J. A. Canas and L. Pujades, 1999. Simulated annealing in 3-D seismic modelling and elastic structure of the Mediterranean basin, *Phys. Chem. Earth (A)*, **24**, 253-260.

F. J. Serón, F. J. Sabadell, J. Badal and J. M. Martín, 1999. Modelling techniques for volumetric reconstruction of Earth structures, *Phys. Chem. Earth (A)*, **24**, 261-268.

F. J. Sabadell, F. J. Serón and J. Badal, 2000. A parallel laboratory for simulation and visualization of seismic wavefields, *Geophysical Prospecting*, **48**, 377-398.

J. Badal, E. Samardjieva and G. Payo, 2000. Moment magnitudes for early (1923-1961) instrumental Iberian earthquakes, *Bull. Seism. Soc. Am.*, **90**, 1161-1173.

M. D. Martínez, X. Lana, J. Olarte, J. Badal and J. A. Canas, 2000. Inversion of Rayleigh wave phase and group velocities by simulated annealing, *Phys. Earth Planet. Inter.*, **122**, 3-17.

M. D. Martínez, X. Lana, J. A. Canas, J. Badal and L. Pujades, 2000. Shear-wave velocity tomography of the lithosphere-asthenosphere system beneath the Mediterranean area, *Phys. Earth Planet. Inter.*, **122**, 33-54.

J. Badal, F. J. Sabadell and F. J. Serón, 2000. An attempt at 3-D imaging of a small domain (Almeria, southern Spain) using a POCS algorithm, *Phys. Earth Planet. Inter.*, **122**, 67-77.

F. J. Serón, J. I. Badal, F. J. Sabadell, 2001. Spatial prediction procedures for regionalization and 3-D imaging of Earth structures, *Phys. Earth Planet. Inter.*, **123**, 149- 168.

M. D. Martínez, J. A. Canas, X. Lana, J. Badal, 2001. Objective regionalization of Rayleigh wave dispersion data by clustering algorithms: an application to the mediterranean basin, *Tectonophysics*, **330**, 245-266.

M. Chourak, J. Badal, V. Corchete, F. J. Serón, 2001. A survey of the shallow structure beneath the Alboran Sea using Rg-waves and 3-D imaging, *Tectonophysics*, **335**, 255-273.

J. Badal, F. Serón, F. Gómez, U. Dutta and N. Biswas, 2002. Delineation of soils by high-frequency Rayleigh waves and spatial prediction, *64th EAGE Conference, Extended Abstracts Book* (ISBN 90-73781-20-5), Volume 1, D-26.

E. Samardjieva and J. Badal, 2002. Estimation of the expected number of casualties caused by strong earthquakes, *Bull. Seism. Soc. Am.*, **92**, 2310-2322.

M. Chourak, V. Corchete, J. Badal, F. J. Serón and F. Gómez, 2003. Imaging of the near-surface shear-wave velocity structure of the Granada Basin (southern Spain), *Bull. Seism. Soc. Am.*, **93**, 430-442.

M. Chourak, V. Corchete, J. Badal, F. J. Serón and F. Gómez, 2003. 3-D Shallow Seismic Velocity Structure of the Betics and Neogene Basins (southern Spain) from Rg waveform inversion, *Phys. Earth Planet. Inter.* (accepted).

Department of Geotechnical Engineering and Geosciences
C/ Jordi Girona 1-3, UPC-Campus Nord. D-2. 08034 Barcelona. Spain
Phone: +34 93 401 72 50
Fax: +34 93 401 72 50
E-mail: luis.pujades@upc.es

1. Areas of research:

Applied Geophysics and Geophysical tomography
Earthquake Engineering

2. Scientific Programs

Main projects in national programs:

Seismic risk analysis: hazard, soil effects and vulnerability.
AMB98-0558 (1998-2000)

Seismic risk: seismological and earthquake engineering aspects.
REN2000-1740-C05-001 RIES. (2000-2003)

Development and application of advanced procedures to obtain seismic risk scenarios.

REN2001-24184-C04-01 RIES (2001-2004)

Main projects in european programs

An advanced approach to earthquake risk scenarios with applications to different European towns (RISK-UE).

EESD-ENV-99-2 (JO 1999/C330/10).

3. Publications:

1999

Lana, X., Caselles, O., Canas, J.A., Badal, J., **Pujades, L.G.** and M.D. Martínez (1999). Anelastic Structure of the Iberian Peninsula obtained from an automated regionalization algorithm and the stochastic inversion. *Tectonophysics*, **304**. 219-239. ISSN: 0040-1951.

Martínez, M.D.; Lana, X.; Badal, J.; Canas, J.A. and **L.G. Pujades** (1999). Simulated annealing in 3-D Seismic Modelling and Elastic Structure of the Mediterranean Basin. *Phys. Chem. Earth (A)*, **vol. 24. N. 3**. pp. 253-260. ISSN: 1464-1865

2000

Pérez Gracia, M.V.; Canas, J.A.; **Pujades, L.G.**; Clapés, J.; Caselles, J.O.; García, F. and R. Osorio (2000) GPR survey to confirm the location of ancient structures under the Valencian Cathedral (Spain). *Journal Of Applied Geophysics*. **43**-167-174. ISSN: 0926-9851.

Martínez, D.; Canas, J.A.; Lana, X. and **L.Pujades** (2000). Estructura de la litosfera en el margen Ibérico-mediterráneo. *Revista Internacional de métodos numéricos para cálculo y diseño en la Ingeniería*, **Vol. 16, Nº 1**, 3-32. ISSN: 0213-1315.

Martínez, M.D.; Lana, X.; Canas, J.A.; Badal, J. and **L.G. Pujades** (2000) Shear-wave velocity tomography of the lithosphere-asthenosphere system beneath the the Mediterranean area *Phys, Earth Planet., Int.* **122 (2000)** 33-54.

2001

Alfaro, A.; Pujades L.G.; Goula, X.; Susagna, T.; Navarro, M.; Sánchez, J. And J.,A. Canas (2001). Preliminary Map of Soils's Predominant Periods in Barcelona Using Microtremors. *Pure and Applied Geophys.* **158**, 2499-2511.

2002

Bonett R.L., **Pujades, L.G.** y J.E. Hurtado (2002) Generación de acelerogramas artificiales compatibles con un espectro de respuesta. Aplicación a eventos recientes en Colombia y España. *Revista Internacional de Métodos Numéricos para Cálculo y Diseño en Ingeniería.* Vol. **18, 2**, 297-308. ISSN: 0213-1315

Ugalde, A.; Vargas C.A.; **Pujades L.G.** and J.A. Canas (2002). Seismic Coda attenuation after the $M_w=6.2$ Armenia (Colombia) earthquake of 25 January 25, 1999. *J. Geophys. Res., VOL. 107, NO. B6, ESE 1-1,11.* ISSN: 0148-0227.

Benavent, C.; **Pujades, L.G.** y F. López Almansa (2002). Design Energy Input Spectra for Moderate seismicity Regions. *Earthquake Engineering and Structural Dynamics.* **Vol. 31-5:** 1151-1172. Mayo 2002. Online ISSN: 1096-9845 Print ISSN: 0098-8847.

Vargas C.A., Pujades, L.G. Ugalde, A. Y J.A. Canas (2002). Estado de deformación y esfuerzos en el territorio Colombiano. *Revista de la academia colombiana de ciencias exactas, físicas y naturales.* **Vol. XXVI N. 100.** pp. 373-391. Septiembre, 2002. ISSN-0370-3908.

2003

Benavent, C.; Akiyama, H.; López-Almansa, F.; **Pujades, L.G.** and L.Bozzo (2003). Ultimate Earthquake Resistance of Gravity-Load Designed RC Buildings in Low to Moderate Seismicity Regions. *Earthquake Engineering and Structural Dynamics* (Submitted, March 2002). Online ISSN: 1096-9845 Print ISSN: 0098-8847.

González-Drigo R., Pujades L.G., Caselles O., Canas J.A. y M.V. Perez-Gracia (2003). Coda-Q analysis and scattering and intrinsic attenuation in Southern Iberian Peninsula. *Bull. Seism. Soc. Am.* ISSN: 0037-1106 (Submitted).

Vargas C.A., Ugalde, A. Pujades L.G., and J.A. Canas (2003). Spatial variation of Coda-Wave attenuation in Colombia. *Geophys. J. Int., (Submitted).* ISSN: 0956-540X.

Real Instituto y Observatorio de la Armada (ROA)
c) Cecilio Pujazón s/n. 11100 San Fernando (Cádiz)
Phone: +34 956 599285
Fax: +34 956 599366
E-mail: mdavila@roa.es; pazos@roa.es;

1. Areas of research:

Seismic Instrumentation and Seismic nets.
Crust and upper mantle structure.
Seismicity and Seismotectonics.

2. Scientific Programs

Mecanismo de Terremotos. Deformaciones de la corteza, sismicidad y riesgo sísmico en el Sur de España. CICYT -AMB97-0975-02-02. 1997-2000 (C)

Estación Geofísica Automática. Subdirección Gral. Tecnología Investigación (Minist. Defensa) (MN8302). 2001-2004 (C).

Reconocimiento y Evaluación Rápida de la Actividad Volcánica de la Isla Decepción: Geofísica Marina. CICYT-ANT99-1428-E. 1999-2000 (C).

Terremotos y Deformación cortical en el Sur de España: aplicación al riesgo sísmico. MCyT: REN2000-0777-C02-02. 2000-2003 (C).

Estudio del complejo volcánico de Isla Decepción y su entorno a partir de técnicas de Geofísica Marina. MCyT: REN 2000-0551-C03-03 ANT. 2000-2003 (C).

Workshop "Working Group of European Geoscientist for the Stablishment of Networks for Earth Science Reasearch" (WEGENER). PGC2000-2406-E. 2000-2001 (C).

3. Publications:

Autores: M. Catalán M., J. Martín Davila.

Título: On technical aspects concerning the Geomagnetic surveying at Balearic sea and valencia Trough: ZEEE Project.

Ref. revista Libro:

Clave: A Volumen: Páginas, inicial: 263 final: 272 Fecha: 2001

Editorial (si libro): Slovak Academy of Sciences.

Lugar de publicación: Revista "Contributions to Geophysics and Geodesy". Geophysical Institute. Slovak Academy of Sciences.

Autores: S. Van der Lee, F. Marone, M. van der Meije, D. Giardini, A. Deschamps, L. Margheretti, P. Burkett, S. Solomon, P.M. Alves, G. Chouliaras, C. Chiarabba, A. Eshwedhi, H. Gashut, M. Herak, R. Ortiz, J. Martin Davila, A. Ugalde, J. Vila, K. Yelles.

Título: New seismographic data from Eurasia-Africa plate boundary region.

Ref. revista Libro:

Clave: A Volumen: Páginas, inicial: 645 final: 646 Fecha:
2001
Editorial (si libro):
Lugar de publicación: Revista "Eos, Transactions, American Geophysical Union", vol. 82, núm. 51.

Autores: M. Catalán M., J. Martín Davila.
Título: New database and magnetic anomaly sheets of the Balearic sea and Valencia Trough. [The Spanish Exclusive Economic Zone Project].
Ref. revista Libro:
Clave: A Volumen: Páginas, inicial: 433 final: 435 Fecha:
25/09/2001
Editorial (si libro):
Lugar de publicación: Revista "Eos, Transactions, American Geophysical Union", vol???, núm???

Autores: A. Carbó, A. Muñoz, J. Martín, M. Catalán, A. García.
Título: Análisis de nuevos datos gravimétricos marinos en el entorno de la Isla Decepción (Islas Shetland del Sur, Antártida).
Ref. revista Libro:
Clave: A Volumen: Páginas, inicial: 189 final: 197
Fecha: 2001
Editorial (si libro):
Lugar de publicación: Revista de la Sociedad Geológica Española, vol 14 (núm. 3-4).

Autores (p.o. de firma): A. Udías, E. Buforn, **J. Martín Davila**, W. Hanka, A. Pazos.
Título: Broad Band stations network ROA/UCM/GFZ in South Spain and Northern Africa.
Ref. revista Libro:
Clave: A Volumen: Páginas, inicial: 173 final: 177 Fecha:
2001
Editorial (si libro):
Lugar de publicación: Seismological Research Letters, vol 73, núm. 2.

Autores (p.o. de firma): J. Martín Davila, J. Gárate, A. Pazos, M. Catalán, A. Udías, M. Berrocoso, W. Hanka, E. Buforn, P. Pérez, J. Prián, J. Quijano, J.A. Peña, J. Gallego, G. Muñoz-Delgado, S. Van der Lee.
Título: The Royal Naval Observatory in San Fernando (ROA) Seismic (SP, LP, VBB) and Geodetic (GPS) nets deployed South Spain- North Africa Region.
Ref. revista Libro:
Clave: A Volumen: Páginas, inicial: Fecha: 2001
Editorial (si libro): Ministerio de Defensa.
Lugar de publicación: Boletín ROA núm. 03/2001: "Workshop on the Geodynamics of the Western Part of Eurasia - Africa Plate Boundary (Azores- Tunisia)".

Autores (p.o. de firma): M. Becker, S. Zerbini, T. Baker, B. Bürki , J. Galanis, J. Garate , I. Georgiev, H.-G. Kahle, V. Kotzev, V. Lobazov , I. Marson, M. Negusini, B. Richter, G. Veis and P. Yuzefovich

Título: Assessment of height variations by GPS at Mediterranean and Black Sea coast tide gauges from the SELF projects. En 'Global and Planetary Change' Elsevier Science B.V.

Ref. revista

Libro:

Clave: A Volumen: 34 (1-2) (2002) Páginas, inicial: 5 final: 35 Fecha: 2002

Editorial (si libro):

Lugar de publicación: Elsevier Science B.V. Ámsterdam

Autores (p.o. de firma): T. van Eck, C. Trabant, A. Heinloo, B. Dost, R. Sleeman, F. Goutbeek, W. Hanka, E. Carenno, M. Tome de la Vega, S. Mazza, A. Mandiello, M. Ollivieri, G. Chouliaras, N. Melis, A. Deschamps, W. Lenhardt, N. Horn, M. Baer, J. Schweitzer, M. Zivcic, G. Mocnik, K. Solomi, J. Zednik, J. Kivisilla, G. ROult, M. Granet, K. Stammler, A. Shapira, M. Russi, G. Costa, P. Wiejacz, E. Buforn, A. Pazos, M. Aktar, D. Kalafat

Título: Towards a Virtual European Broadband Seismograph Network

Ref. revista / Libro: ORFEUS NEWSLETTER

Clave: R Volumen: 4 N°1 Páginas, inicial: final: Fecha: May 2002

Editorial (si libro): Lugar de publicación: <http://orfeus.knmi.nl>

Autores: A. Pazos, M.J. González, G. Alguacil.

Título: Non-linear filter, using the wavelet transform, applied to seismological records

Ref. Revista: Journal of Seismology (Accepted).

Department of Applied Physics. University of Almeria. 04120-Almeria. Spain.

Phone: +34 950.015601

Fax: +34 950.015477

E-mail: aposadas@ual.es

1. Areas of research:

Seismicity

Numerical Methods to evaluate Seismic Response

Seismic Microzonation

2. Scientific Programs

1. Microzonación sísmica en áreas urbanas del sureste de España

CICYT

01-Agosto-1997 *hasta* 30-Septiembre-1999

Posadas Chinchilla, Antonio Miguel

2. Determinación empírica de las características del movimiento sísmico del suelo en áreas urbanas.

Ministerio de Fomento. Instituto Geográfico Nacional.

01-Enero-1997 *hasta* 31-Diciembre-1998

Posadas Chinchilla, Antonio Miguel

3. Riesgo sísmico y volcánico en España: Estudio de la aplicación de nuevas técnicas geofísicas de vigilancia e interpretación

CICYT

01-Diciembre-1999 *hasta* 30-Noviembre-2001

Luzón Martínez, Francisco

4. Aproximación estocástica al peligro sísmico de la Península Ibérica y zonas sismogénicas singulares

MCYT

01-Noviembre-2001 *hasta* 31-Octubre-2004

Posadas Chinchilla, Antonio Miguel

5. Evaluación del comportamiento de los edificios en áreas urbanas del sureste de España.

CICYT

01-Enero-2000 *HASTA:* 31-Diciembre-2002

NAVARRO BERNAL, MANUEL

6. ESTRUCTURA CORTICAL DEL SUR DE ESPAÑA

DGES

01-Enero-1987 *HASTA:* 31-Diciembre-1999

CORCHETE FERNÁNDEZ, Víctor

Proyecto: *Modelización numérica del movimiento del suelo debido a la propagación de ondas sísmicas*

Investigador Principal: Dr. Francisco Luzón Martínez
Financiación: D.G.E.S.I.C. (Acción integrada hispano-francesa) (HF1999-0129)
Período: 2000-01
Puesto: Investigador Principal

Proyecto: *Determinación y modelado de efectos sísmicos locales en cuencas sedimentarias del sur de España.*

Investigador Principal: Dr. Francisco Luzón Martínez
Financiación: C.I.C.Y.T. REN2002-04198-C02-02/RIES .
Período: 2002-05
Puesto: Investigador Principal

3. Publications

Autores: Torcal, F.; Posadas, A.; Chica, M.; Serrano, I.
Título: Application of conditional geostatistical simulation to calculate the probability of occurrence of earthquakes belonging to a seismic series.
Año de publicación: 1999
Volumen: 139
Página inicial: 703 *Página final:* 725
Revista: Geophysical Journal International
Factor de impacto: 1.366 *Puesto:* 8
ISSN: 0956-540X *CLAVE:* A

Autores: F. Luzón; F.J. Sánchez-Sesma; A. Gil; A. Posadas; M. Navarro
Título: Seismic response of 3D topographical irregularities under incoming elastic waves from point sources
Año de publicación: 1999
Volumen: 24
Página inicial: 231 *Página final:* 234
Revista: Physics and Chemistry of the Earth
Factor de impacto: 1.248 *Puesto:* 10
ISSN: 0031-9201 *CLAVE:* A

Autores: Torcal, F.; Posadas, A.; Serrano, I.
Título: Simulating a seismic series using geostatistical and stochastic methods. Application to the seismic series in the Alboran Sea (June 24, 1997-?).
Año de publicación: 1999
Volumen: 139
Página inicial: 726 *Página final:* 742

Revista: Geophysical Journal International
Factor de impacto: 1.366 *Puesto:* 8
ISSN: 0956-540X *CLAVE:* A

Autores: Sotolongo, O.; Antoranz, C.; Posadas, A.; Vidal, F.; Vázquez, A.;
Título: Lévy flights and earthquakes.
Año de publicación: 2000
Volumen: 27
Página inicial: 1965 *Página final:* 1968
Revista: Geophysical Research. Letters.
Factor de impacto: 2.516 *Puesto:* 6
ISSN: 0094-8276 *CLAVE:*
A

Autores: Posadas, A.; Hirata, T. ; Vidal, F.; Correig, A
Título: Spatial and temporal seismicity patterns using mutual information. Application to southern Spain earthquakes.
Año de publicación: 2000
Volumen: 122
Página inicial: 269 *Página final:* 276
Revista: Physics of the Earth and Planetary Interiors
Factor de impacto: 1.248 *Puesto:* 10
ISSN: 0031-9201 *CLAVE:*
A

Autores: Navarro, M.; Enomoto, T.; Sánchez, F.J.; Matsuda, I.; Iwate, I.; Posadas, A.; Luzón, F.; Vidal, F.; Seo, K.;
Título: Surface soil effects study using short-period microtremor observations in Almería city, Southern Spain
Año de publicación: 2001
Volumen: 158, 12
Página inicial: 2481 *Página final:* 2487
Revista: Pure and applied geophysics
Factor de impacto: 0.728 *Puesto:* 13
ISSN: 0033-4553 *CLAVE:*
A

Autores: Posadas, A.; Morales, J.; Vidal, F.; Sotolongo, O.; Antoranz, C.;
Título: Continuous Time Random Walks and seismic series.
Año de publicación: 2002
Volumen: 6
Página inicial: 61 *Página final:* 67
Revista: Journal of Seismology
Factor de impacto: 0.754 *Puesto:* 12
ISSN: 1383-4649 *CLAVE:*
A

Autores: Posadas, A.; Hirata, T.; Vidal, F.;
Título: Information theory to characterize spatio-temporal patterns seismicity in Kanto region
Año de publicación: 2002
Volumen: 92
Página inicial: 600 *Página final:* 610
Revista: Bulletin of the Seismological Society of America
Factor de impacto: 1.231 *Puesto:* 11
ISSN: 0037-1106

CLAVE:
A

Autores: Hirata, T.; Posadas, A.; Ogawa, A.; Harada, Y.;
Título: A probabilistic cellular automaton model for developing spatio-temporal patterns
Año de publicación: 2002
Volumen: 17
Página inicial: 19 *Página final:* 29
Revista: Forma. Society for Science on Form.
Factor de impacto: *Puesto:*
ISSN: 0911-6036

CLAVE:
A

Autores: Sotolongo-Costa, O.; Posadas, A.
Título: Gouge earthquakes
Año de publicación: 2002
Volumen: 19 (1)
Página inicial: 15 *Página final:* 18
Revista: Revista cubana de Física
Factor de impacto: *Puesto:*
ISSN: 0253-9268

CLAVE:
A

30. *Autores:* Luzón, F.; Ramírez, L.; Sánchez-Sesma, F.; Posadas, A.M.;
Título: Propagation of SH elastic waves in Deep Sedimentary Basins with Oblique Velocity Gradient
Año de publicación: 2003
Volumen: 38 (1)
Página inicial: 11 *Página final:* 23
Revista: Wave motion
Factor de impacto: 0.688 *Puesto:* 14
ISSN: 0165-2125

CLAVE:
A

AUTORES (p.o. de firma): Navarro, M.; Enomoto, T.; Sánchez, F.J.; Matsuda, I.; Iwate, I.; Posadas, A.; Luzón, F.; Vidal, F.; Seo, K.;
TÍTULO: Surface soil effects study using short-period microtremor observations in Almería city, Southern Spain
AÑO DE PUBLICACIÓN: 2001
VOLUMEN: 158, 12
PÁGINA INICIAL: 2481 *PÁGINA FINAL:* 2487
REVISTA: Pure and applied geophysics
REF. REVISTA: 0033-4553 *CLAVE:* A

AUTORES (p.o. de firma): F.J. Alcalá-García, J. Espinosa, M. Navarro, F.J. Sánchez
TÍTULO: Propuesta de división geológica de la localidad de Adra (provincia de Almería). Aplicación a la zonación sísmica
AÑO DE PUBLICACIÓN: 2002
VOLUMEN: 15
PÁGINA INICIAL: 55 *PÁGINA FINAL:* 66
REVISTA: Revista Sociedad Geológica España
REF. REVISTA: *CLAVE:* A

AUTORES (p.o. de firma): A. Alfaro, L.G. Pujades, X. Goula, T. Susagna, M. Navarro, J. Sanchez, A. Canas
TÍTULO: Preliminary Map of Soil's Predominant Periods in Barcelona Using Microtremors
AÑO DE PUBLICACIÓN: 2001
VOLUMEN: 158
PÁGINA INICIAL: 2499 *PÁGINA FINAL:* 2511
REVISTA: Pure and applied geophysics
REF. REVISTA: 0033-4553 *CLAVE:* A

AUTORES (p.o. de firma): M. Navarro, F.J. Sánchez, M. Feriche, F. Vidal, T. Enomoto, T. Iwatate, I. Matsuda, T. Maeda
TÍTULO: Statistical estimation for dynamic characteristics of existing buildings in Grnada, Spain, using microtremors. *Publicado en el libro* Structural Dynamics. Eurodyn 2002. Vol. 1
EDITORIAL: A.A. Balkema Publishers
LUGAR DE PUBLICACIÓN: Netherlands
AÑO DE PUBLICACIÓN: 2002
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AUTORES (p.o. de firma): T. Enomoto, K. Kuriyama, M. Navarro, T. Iwatate
TÍTULO: Site-Effects evaluation by H/V spectra comparing microtremor with strong motion records observed at ground surface and basement using borehole. *Publicado en el libro* 12th European Conference on Earthquake Engineering
EDITORIAL: Elsevier Science
LUGAR DE PUBLICACIÓN: Londres
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PÁGINA INICIAL: *PÁGINA FINAL:*

AUTORES (p.o. de firma): F.J. Sánchez, M. Navarro, J.M. García, T. Enomoto, F. Vidal

TÍTULO: Evaluation of seismic effects on building structures using microtremor measurements and simulation response. *Publicado en el libro* Structural Dynamics. Eurodyn 2002. Vol. 2

EDITORIAL: A.A. Balkeman Publishers

LUGAR DE PUBLICACIÓN: Netherlands

AÑO DE PUBLICACIÓN: 2002

PÁGINA INICIAL: 1003 *PÁGINA FINAL:* 1008

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CLAVE: CL

1. Seismic response of 3D topographical irregularities under incoming elastic waves from point sources. Luzón, F., Sánchez-Sesma, F.J., Gil, A., Posadas, A.M. and Navarro, M.. *Phys. Chem. Earth, Part A*, (1999). Vol. 24, nº3, pp. 231-234.
2. Medidas de microtremores en la ciudad de Almería a lo largo de cortes geológicos. F.J. Sánchez, M. Navarro, T. Enomoto, A. Posadas, F. Vidal y F. Luzón. "100 años de observaciones sismológicas en S. Fernando". *Bol. R. Inst. Obs. Arm.* (1999). Vol. 5, pp.97-104.
3. Propagación de ondas, producidas por fuentes explosivas, en una cuenca sedimentaria irregular. Z. Al Yuncha y F. Luzón, "100 años de observaciones sismológicas en S. Fernando", *Bol. R. Inst. Obs. Arm.* (1999). Vol. 5, pp.241-250.
4. On the horizontal to vertical spectral ratio in sedimentary basins. Al Yuncha, Z. and Luzón, F., *Bull. Seism. Soc. Am.* Vol. 90, 4, pp.1101-1106. (2000).
5. Surface soil effects study using short-period microtremor observations in Almería city, southern Spain. Navarro, M., T. Enomoto, F.J. Sánchez, I. Matsuda, T. Iwatate, A.M. Posadas, F. Luzón, F. Vidal and K. Seo. *Pure and Applied Geophysics* ,158,pp. 2481-2497. (2001).
6. Detection of surface displacement produced by the 1993 Adra earthquake (Mb=5.0), South Spain, using radar interferometry. Romero, R., F. Luzón, J. Fernández and D. Carrasco. *Bol. R. Inst. Obs. Arm.* Vol. 3, 2 pp. (2001).
7. A numerical experiment on the horizontal to vertical spectral ratio in flat sedimentary basins. Luzón, F., Z. Al yuncha, F.J. Sánchez-Sesma and C. Ortiz-Alemán. *Pure and Applied Geophysics*, 158, pp 2451-2461. (2001).
8. InSAR Volcano and seismic monitoring in Spain. Results for the period 1992-2000 and possible interpretations. J. Fernández, R. Romero, D. Carrasco, F.

- Luzón and V. Araña. *Optics and Lasers in Engineering*, 37(2-3), pp 285-297. (2002).
9. -3D Seismic Response of the deep basement-structure of the deep basement structure of the Granada basin (Southern Spain). A.S. Gil-Zepeda, F. Luzón, J. Aguirre, J. Morales, F. J. Sánchez-Sesma, and C. Ortiz-Alemán. *Bull. Seism. Soc. Am.*, Vol. 92, (6), pp. 2164-2176. (2002).
 10. Estimation of local site effects during earthquakes: an overview. Francisco J. Sánchez-Sesma, Víctor J. Palencia and Francisco Luzón. *ISSET Journal of Earthquake Technology*. Vol 39 (4). (2002).
 11. Propagation of *SH* elastic waves in deep Sedimentary Basins with an Oblique Velocity Gradient. F. Luzón, L. Ramírez, F. J. Sánchez-Sesma and A. Posadas. *Wave Motion*, Vol. 38 (1), pp.11-23. (2003).

Geological Survey of Catalonia (*Servei Geològic de Catalunya*)

Institut Cartogràfic de Catalunya

Parc de Montjuïc - 08038 Barcelona

web: <http://www.icc.es>

1. Research areas

Seismic Network

Earthquake catalogues

Seismic zonation

Local Effects / Microzoning

Vulnerability and Civil Defense plans

3. Publications

1999

-Gimenez, J., Goula, X. y Suriñach, E. (1999) Cuantificación de deformaciones recientes mediante datos de nivelación. *1er Congreso Nacional de Ingeniería Sísmica*. Murcia. pp 129-138.

- Catalán, A., Roca, A. y Goula, X. (1999). Predicción espectral de la acción sísmica a partir del modelo de Brune modificado. *1er Congreso Nacional de Ingeniería Sísmica*. Murcia. pp 177 -189.

-Chávez, J., Goula, X., Roca, A., Mañá, F., Presmanes, J.A. y López- Arroyo, A. (1999) Escenarios de daños sísmicos en Cataluña. *1er Congreso Nacional de Ingeniería Sísmica*. Murcia. 299 - 307.

-Susagna, T., Goula, X. y Roca, A. (1999). Catálogo de sismicidad : Vol I del Atlas Sísmico de Catalunya. Procc. *1er Congreso Nacional de Ingeniería Sísmica*. Murcia. pp 109-117.

- Secanell, R., Goula, X., Susagna, T. Fleta, J. y Roca, A. (1999). Mapa de zonas sísmicas de Catalunya. *Ier Congreso Nacional de Ingeniería Sísmica*. Murcia. pp. 251-259.
- Cid, J., Figueras, S., Fleta, J., Goula, X., Susagna, T. y Amieiro, C. (1999). Zonación sísmica de la ciudad de Barcelona. *Ier Congreso Nacional de Ingeniería Sísmica*. Murcia. pp 263 -271.

- Figueras, S., Cid, J., Goula, X., Susagna, T. y Roca, A. (1999). Calibración de métodos de modelización de efectos locales: Euroseistest (Grecia). *Ier Congreso Nacional de Ingeniería Sísmica*. Murcia. pp 279 - 287.

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- Goula, X.(1999) Sismologia. Aplicació a la construcció La Punxa, núm. 29, pàg. 44-47. *Col·legi d'Aparelladors i Arquitectes Tècnics de Girona*. pp 161-166.

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- Roca, A., Goula, X. i Susagna, T. (1999) Zonación sísmica a Diferentes Escalas. *Microzonación Física de la Tierra*, núm. 11, pp 203-236.

- Goula, X., Olivera, C., Fleta, J., Grellet, B., Lindo, R., Rivera, L. A., Cisternas, A. i Carbon, D.(1999): Present and recent stress regime in the eastern part of the Pyrenees. *Tectonophysics*, núm. 308, pp 487-502.

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2000

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- Roca, A., Goula, X., Olmedillas, J. C., Olivera, C., Susagna, T., Figueras, S. i Fleta, J. (2000) Nueva red sísmica de Cataluña con sensores de banda ancha y comunicación vía satélite en tiempo real. *2ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Portugal, 8-12 de febrer de 2000 pp 207-208.

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2ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica. Portugal, 8-12 de febrer de 2000 pp 155-156.

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T. Susagna, T., X. Goula, and A.Roca. (2001).A new macroseismic catalogue for Catalonia.In: The use of historical data in natural hazard assessment. Ed. T. Glade, P. Albini, F. Frances. Kluwer Academic Publishers. pp 71-79

González, M., Susagna, T., Goula, Roca, A., Safina, S. (2001). Una primera evaluación de la vulnerabilidad sísmica de edificios esenciales: hospitales y parques de bomberos. Proc: 2º Congreso Ibero Americano de Ingenieria Sísmica. Madrid, 16-19 Octubre 2001. 8 pp. CDRom.

Chiroiu, L. , Goula, X., Roca, A., Susagna, T., Barbat, A., Pujades, L. (2001).El método del espectro de capacidad aplicado a la evaluación de daños sísmicos. Proc: 2º Congreso Ibero Americano de Ingenieria Sísmica. Madrid, 16-19 Octubre 2001. 10 pp. CDRom.

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Cid, J., Susagna, T., Goula, X., Chavarria, L., Figueras, S., Fleta, J., Casas and Roca, A, (2001) Seismic zonation of Barcelona based in preliminary site specific response spectra. Pure and Appied Geophysics, 158, 2559-2577.

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Goula, X., Jara, J A, Susagna, T., Roca, A. (2001). A New Broad-Band Seismic Network with Satellite Transmission in Catalonia (Spain). Orfeus Newsletter, Vol 3, no1, (<http://orfeus.knmi.nl/newsletter/vol3no1/catalonianet.html>)

Goula, X, Fleta, J., Castellote, M. and Tércens, A. (2001) Present deformation and seismic potentiality in the Eastern Pyrenees. Workshop on the Geodynamics of the western part of Eurasia-Africa plate boundary. Extended abstracts book. San Fernando, May 31-June 2.

Castellote, M., Fleta, J., Giménez, J., Goula, X., Soro, M., Suriñach, E., Talaya, J., and Tércens, A. (2001) The Cuateneo GPS network to quantify crustal deformations in the SE of the Iberian Peninsula. Workshop on the Geodynamics of the western part of Eurasia-Africa plate boundary. Extended abstracts book. San Fernando, May 31-June 2.

Fleta, J., Santanach, P., Goula, X., Martínez, P., Grellet, B. i Masana, E (2001). Preliminary geologic, geomorphologic and geophysical studies for the paleoseismological analysis of the Amer fault (NE Spain). Netherlands Journal of Geosciences / Geologie en Mijnbouw 80 (3-4): 243-253.

Goula, X. (2001). Gestió del risc sísmic a Catalunya. 1es Jornades del CRECIT, La Gestió dels Riscos Naturals, Andorra 13 i 14 setembre 2001.

2002

Susagna, T., Goula, X., Fleta, J. y Roca, A. (2002). Análisis de riesgos en el plan de protección civil ante el riesgo sísmico en Cataluña. Cien años de sismología en Granada. 8-11 Octubre 2002, Granada, 4pp. CD Rom.

Tapia, M., Susagna, T., Goula, X. y Figueras, S. (2002). Reducción de ruido en profundidad a partir de registros Broadband. Cien años de sismología en Granada. 8-11 Octubre 2002, Granada, 4pp. CD Rom

Tapia, M., Susagna, T., Goula, X. y Irizarry, J. (2002). Atenuación del movimiento del suelo en Cataluña. Cien años de sismología en Granada.8-11 Octubre 2002, Granada, 4pp. CDRom

Instituto Geográfico Nacional

Subdirección General de Geodesia y Geofísica

C/General Ibáñez Ibero, 3, 28003 Madrid

Phone: 34 91 5979509

Fax: 34 915979758

e-mail: sismologia@mfom.es

1. Areas of research.

Seismicity, Broad-Band network, Strong-motion network, Array, Seismic Hazard, Seismic Building Code

2. Scientific Programs

Red Sísmica Digital Española de Banda Ancha (RESIDE).
Ministerio de Fomento. 2000-2003

Regular Update of seismic hazards maps through thermal space observations. 1998-2000

UE (ENV4-CT98-0741)

Dr. E. Carreño

Earthquake parameters and standardized information for a European-Mediterranean bulletin. 2000-2002

UE (EVR-CT-2000-40006)

Dr. E. Carreño

Developing existing earthquake data infrastructures towards a Mediterranean-European rapid earthquake data information and archiving network. 2000-2005

UE (EVRI-1999-00006)

Dr. E. Carreño

3. Publications

2000

J.M. Tordesillas, E. Carreño and F. García (2000). Análisis de acelerogramas de movimientos fuertes del suelo. Universidad Politécnica de Valencia.

E. Carreño, B. Bravo, A. Suárez, J. M. Tordesillas (2000). Registro y análisis de movimientos fuertes del suelo. Física de la Tierra. Ed. Complutense

2001

E. Carreño, C. López, A. Villamayor, F. Gracia, A. Alonso, E. Ruiz (2001). Estación Sísmica de Sonseca. Descripción general. Universidad Complutense de Madrid, Consorcio de Compensación de Seguros.

J. M. Martínez Solares (2001). Los efectos en España del terremoto de Lisboa (1 de noviembre de 1755). Monografía nº 19. Ministerio de Fomento. Instituto Geográfico Nacional.

J. Rueda, J. Mezcua (2001). Sismicidad, sismotectónica y peligrosidad sísmica en Galicia. Public. Técnica nº 35. Ministerio de Fomento. Instituto Geográfico Nacional.

2002

J. M. Martínez Solares, J. Mezcua (2002). Catálogo sísmico de la Península Ibérica (880 a.C.-1900). Monografía nº 18. Ministerio de Fomento. Instituto Geográfico Nacional.

J. M. Martínez, A. Rigo, L. Louis, R. Capote, J.L. Hernández, E. Carreño, M. Tsige (2002). Caracterización geológica y sismotectónica del terremoto de Mula (febrero de 1999, Mb:4.8) mediante la utilización de datos geológicos, sismológicos y de interferometría de RADAR (INSAR). Boletín Geológico y Minero. 113.(1).

2003

J.M. Tordesillas, M. López, E. Carreño, C. López, J.M. Martínez, R. Capote, L. Castro, M. Tsige. (2003). Interferometría de RADAR(INSAR) y su aplicación a la sismotectónica. Public. Técnica nº 41. Ministerio de Fomento. Instituto Geográfico Nacional.

RESEARCH GROUPS AND ORGANIZATIONS ON VOLCANOLOGY IN SPAIN

Fields of interest

1. Mineralogy and petrology of volcanic rocks
2. Geochemistry of volcanic rocks
3. Radioactive isotopes and geochronology
4. Experimental petrology
5. Stable isotopes
6. Geochemistry of fluids
7. Volatile and fluid inclusions
8. Volcanogenetic mineralization
9. Geothermal resources
10. Volcanism and tectonic setting
11. Explosive volcanism and pyroclastic deposits
12. Eruptive mechanism
13. Volcanic hazard
14. Geophysical structural studies
15. Physical modeling of volcanic processes
16. Geophysical surveillance of active volcanoes
17. Geochemical surveillance of active volcanoes
18. Other

CSIC. Departamento de Volcanología, Museo Nacional de Ciencias Naturales Madrid
Report contributor: Ramon Ortiz
E-mail: ramon@mncn.csic.es

Topics of specific research:

Volcano monitoring; Volcano Hazards and management of volcanic crisis.
Volcano seismology. Electromagnetical phenomena in volcanoes. Petrology,
Geochemistry of volcanic rocks. Stable Isotopes.

Methods and techniques:

Numerical methods for eruption forecasting, instrumentation development
(hardware and software). Volcanis and society

Fields of interest 1, 2, 3, 5, 12, 13, 14, 15, 16

Geographical area:

Canary Islands (Spain). South America Volcanoes (Mexico, Chile, Ecuador),
Deception Island (Antarctica), Stromboli (Italy)

CSIC. Departamento de Geología, Museo Nacional de Ciencias Naturales Madrid
Report contributor: José María Cebriá Gómez
E-mail: cebria@mncn.csic.es

Topics of specific research:

Geochemical modelling of igneous processes. Cenozoic volcanism Iberian Peninsula. Geochemical signature of the sublithospheric component of the Cenozoic European Volcanic Province.

Methods and techniques:

Electron probe microanalysis. Neutron activation. Mass spectrometry

Fields of interest 1, 2, 3, 5, 10

Geographical area:

Canary Islands. Cenozoic Volcanic Province of Europe

CSIC. Departamento de Geología, Museo Nacional de Ciencias Naturales, Madrid

Report contributor: José López-Ruiz

E-mail: lopezruiz@mncn.csic.es

Topics of specific research:

Geochemical modelling of igneous processes. Cenozoic volcanism Iberian Peninsula. Geochemical signature of the sublithospheric component of the Cenozoic European Volcanic Province.

Methods and techniques:

Electron probe microanalysis. Neutron activation. Mass spectrometry

Fields of interest: 1, 2, 3, 5, 10

Geographical area:

Canary Islands. Cenozoic Volcanic Province of Europe

CSIC Institute of Astronomy and Geodesy (CSIC-UCM). Research Group: “Geodetic and Gravimetric techniques applied to Volcanology”

Report contributor: Ricardo Vieira Díaz

E-mail vieira@iagmat1.mat.ucm.es ricardo_vieira@mat.ucm.es director.iag@csic.es

Topics of specific research

Terrestrial and space geodetic techniques applied to deformation control in volcanic regions. Mathematical modelization Instrumentation: development of instrumentation for geodynamics studies.

Methods and techniques

High precision EDM geodetic networks. High precision levelling geodetic networks. Gravimetry and microgravimetry. Short distance deformations: tiltmeter and extensometer. Software development for all geodetic and geodynamic applications.

Fields of interest 10, 13, 14, 16

Geographical area

CSIC Instituto de Astronomía y Geodesia, CSIC-UCM

Report contributor José Fernández

E-mail jose_fernandez@mat.ucm.es

Topics of specific research

Geodetic volcano monitoring, deformation modeling

Methods and techniques

Terrestrial and space geodetic techniques, theoretical models, inverse problem

Fields of interest 10, 13, 14, 13, 14, 15, 16

Geographical area

Canary Islands (Spain), Mayon Volcano (Philippines), Merapi (Indonesia), Long Valley Caldera (USA), Galapagos (Ecuador), Usu (Japan)

CSIC Institute of Earth Sciences "Jaume Almera" (Barcelona). Group of Volcanology

<http://www.wija.ija.csic.es/gt/volca/>

Report contributor: Joan Marti

E-mail: joan.marti@ija.csic.es

Topics of specific research

Physical volcanology, volcanic risk assessment and management, magma physics, dynamics of collapse calderas.

Methods and techniques

Experimental petrology, numerical modelling, analogue modelling, GIS, field geology

Fields of interest 1, 2, 4, 10, 11, 12, 13, 15

Geographical area

Tenerife, Flegraean Fields, Vesuvius, Central Andes

CSIC Instituto de Ciencias de la Tierra Jaume Almera

Report contributor Alicia Felpeto

E-mail: aliciaf@mncn.csic.es

Topics of specific research

Numerical modeling of eruptive processes. Assessment of volcanic hazard & risk

Methods and techniques

Geographical Information Systems. Implementation of numerical models.

Fields of interest 13, 14, 15

Geographical area

Canary Islands, Azores Islands, Andes

CSIC Departamento de Petrología y Geoquímica. Universidad Complutense. Instituto de Geología Económica. CSIC-UCM

Report contributor: Eumenio Ancochea

E-mail: geodec@geo.ucm.es

Topics of specific research:

Volcanic complexes, Volcano stratigraphic succession, Submarine volcanism, Subvolcanic intrusions, Dykes swarm

Methods and techniques: Geochemical and petrological techniques

Fields of interest 1, 2, 3, 10, 13, 18

Geographical area:

Oceanic Island, Spanish peninsula, Morocco, Central and South America

University of Catalonia (UPC). Department of Geotechnical Engineering and Geosciences Technical

Report contributor: Marcel Hürlimann

E-mail marcel.hurlimann@upc.es

Topics of specific research

Volcano instability, Volcanic hazard,

Methods and techniques

Numerical modeling, geomechanical laboratory test, GIS

Fields of interest 15

Geographical area

Canary Islands

Universidad de La Laguna. Dpto. Edafología y Geología..

Report contributor: Juan Coello Armenta

E-mail: jcoello@ull.es

Topics of specific research:

Gases and groundwater.

Methods and techniques

Detectors and analysis systems of gases and water.

Fields of interest 1, 2, 3, 6, 18

Geographical area:
Canary Islands

Universidad de La Laguna. Departamento de Edafología y Geología.
Report contributor; Francisco Hernán Reguera
E-mail fhernan@ull.es

Topics of specific research
Volcanic complex, volcanostratigraphy, genetic model of volcanic islands.

Methods and techniques
Petrology and geochemistry

Fields of interest 1, 2, 3, 10, 13, 18

Geographical area
Canary Islands, Iberic Peninsula, Cabo Verde

Universidad de La Laguna. Departamento de Edafología y Geología.
Report contributor Candelaria Martín Luis
E-mail mcmartin@ull.es

Topics of specific research
Volcanic gases, tectonics

Methods and techniques
Gases analysis

Fields of interest 6, 10, 13

Geographical area
Canary Islands

Universidad de La Laguna. Research Group: Grow and emersion of Oceanic Islands:
(Other members from Huelva, Salamanca and Barcelona Universities).
Report contributor: Ramón Casillas Ruiz
E-mail: rcasilla@ull.es

Topics of specific research
Submarine volcanism. Ultraalkaline and carbonatitic magmatism. Hypoabissal and plutonic systems in Oceanic Islands. Relationships betewen the magmatism and regional lithospheric stress. Grow and emersion of Oceanic Islands.

Methods and techniques

Geological Sampling. Rock and mineral geochemistry. Isotopic Geochemistry. Paleontological methods. Sedimentological analysis. Stress-strain relationships analysis.

Fields of interest 1, 2, 3, 5, 10

Geographical area:

Canary Islands (Basal Complex of La Palma. La Gomera and Fuerteventura).

Universidad de La Laguna. Departamento de Edafología y Geología

Report contributor: Julio de la Nuez Pestana

e-mail jnuezpes@ull.es

Topics of specific research

Submarine volcanism, hydromagmatism, geochemistry of volcanic rocks.

Methods and techniques

Gas analysis, geochemistry, mineralogy of volcanic rocks.

Fields of interest 1, 2, 6, 10, 13

Geographical area

Canary Islands

University of Las Palmas de Gran Canaria

Report contributor: Francisco José Pérez Torrado

E-mail fperez@dfis.ulpgc.es

Topics of specific research

Volcanic magnetostratigraphy. Volcaniclastic deposits

Methods and techniques

Magnetostratigraphy. Geological cartography. Geochemical, mineralogical and petrological

Fields of interest 1, 2, 10, 11, 18

Geographical area

Canary Islands

Universitat de Barcelona / Institut d'Estudis Catalans

Report contributor: Antoni M. Correig Banchar

E-mail ton.correig@am.ub.es

Topics of specific research:

Time-Sequence analysis, modeling natural dynamical systems

Methods and techniques:

Temporal and Spectral analysis. Time-Sequence analysis, analysis and transmission of information in RT systems

Fields of interest: 15, 16

Universidad de Cádiz. Laboratorio de Astronomía y Geodesia. Facultad de Ciencias. Campus de Puerto Real. 11510 Puerto Real (Cádiz)

Report contributor: Manuel Berrocoso Domínguez.

E-mail: manuel.berrocoso@uca.es

Topics of specific research:

Geodetic network for geodynamical monitoring. Deformation models in active volcanoes. Determination of the experimental geoid in active areas. Design and development of multidisciplinary information systems scientific support. Statistical and analytical signal processing.

Methods and techniques:

Observations of GPS satellites. Geometrical and geodetic levelling. Relative gravimetric levelling. Applications ArcGis and Bernese. Signal processing using wavelets.

Fields of interest: 15, 16, 18

Geographical area:

Deception Island (Antarctica)

Universidad Complutense de Madrid. Departamento de Análisis Geográfico Regional y Geografía Física

Report contributor: David Palacios

E-mail davidp@ghis.ucm.es

Topics of specific research

Hydro-volcanic processes. Catastrophic erosion processes in stratovolcanoes. Glacial-volcanic interactions

Methods and techniques

Climatic monitoring. Ground temperature monitoring. Lahar sediment analysis. Sediment dating. SIG modelling

Fields of interest 3, 13, 18

Geographical area

The Cascades (USA), Mexican and Peruvian glaciated stratovolcanoes

Universidad de Huelva
Report contributor. Emilio Pascual
E-mail pascual@uhu.es

Topics of specific research

Petrology and geochemistry of igneous rocks in the Hercynian Iberian Massif
Paleovolcanology and related VMS deposits in Southern Iberia and other world-class mining districts

Methods and techniques

Field exploration, petrography, major- and trace-elements and isotope geochemistry

Fields of interest 1, 2, 3, 8, 10, 18

Geographical area

Iberian Pyrite Belt (Spain). Skelleftea (Sweden)

Universidad de Huelva
Report contributor: Carlos Fernández
E-mail fcarlos@uhu.es

Topics of specific research

Tectonic controls on volcanic growth. Structural evolution of volcanoes.
Geological history of the Canary archipelago: transition from the submarine to the subaerial stage.

Methods and techniques

Geological mapping, structural analysis (geometric description, stress inversion methods, strain measurements), theoretical study of the rheological behaviour of magmas.

Fields of interest 10, 15

Geographical area

Canary Islands

Universidad de Huelva. Grupo de investigación de la Universidad de Huelva.
Departamento de Historia II.

Report contributor: M Eugenia Petit-Breuilh
E-mail mepetit@latinmail.com petit@uhu.es

Topics of specific research

Latin American History of eruptions (XVI-XX). Volcano cronology

Methods and techniques

Historical and geographical analysis

Fields of interest 13, 18

Geographical area
Latin America

Universidad de Granada
Report contributor Jesús Ibañez
E-mail ibanez@ugr.es

Topics of specific research
Volcano seismology
Methods and techniques
ARRAY application in volcano seismology.

Fields of interest: 15, 16

Geographical area
Canary Islands (Spain) Vesuvius, Etna, Stromboli (Italia), Deception Island (Antarctica), Azores (Portugal)

Alcala University. Physic Dep.
Report contributor Miguel Ramos Sainz
E-mail miguel.ramos@uah.es

Topics of specific research
Geothermal and permafrost interaction
Methods and techniques
Geothermal gradient measures. Micrometeorological studies

Fields of interest: 9, 11, 14, 15

Geographical area
Decepcion Island (Antarctica)

Centro Geofísico de Canarias. Instituto Geográfico Nacional
Report contributor: María José Blanco
E-mail: mblanco@ign.es

Topics of specific research:
Seismic volcano monitoring. Geophysical monitoring. Volcanic hazard.

Methods and techniques
Seismology (seismic stations, seismic arrays), geomagnetism

Fields of interest: 14, 15, 16

Geographical area
Canary Islands

Instituto Español de Oceanografía Report contributor: Juan Acosta
E-mail: juan.acosta@md.ieo.es

Topics of specific research:

Submarine geomorphology of volcanic areas

Methods and techniques:

Multibeam echosounders, high resolution seismic reflection, direct methods as sampling, photograph, and submarine video.

Fields of interest 10, 13, 18

Geographical area
Canary Islands, Balearic Islands

Gobierno de Canarias. Area de Laboratorios y Calidad de la Construcción. Universidad de La Laguna
E-mail lhergut@gobiernodecanarias.org jrlosada@ull.es

Topics of specific research

Volcanic Rocks Mechanics. Volcanic Soils Mechanics. Igneous Petrology

Fields of interest 18

Geographical area
Canary Islands

Gobierno de Canarias. Consejería de Educación, Cultura y Deporte
Report contributor: Angeles Llinares
E-mail marrerollinares@hotmail.com

Topics of specific research

Education programs in volcanic and seismic risk.

Fields of interest 18

Geographical area
Canary Islands

Casa de los Volcanes. Lanzarote
Report contributor Joaquin Naveran
E-mail orly2000@terra.es

Topics of specific research

Education programs in volcano. Permanent Exhibition of volcanoes.

Fields of interest 18

Geographical area

Canary Islands

INDRA Espacio

Report contributor Daniel Carrasco

E-mail dcarrasco@indra.es

Fields of interest 16

Topics of specific research:

SAR Interferometry, application of INSAR for volcanic risk monitoring

Methods and techniques:

INSAR

Geographical area

Canary Islands, Ecuador

Instituto Tecnológico de Energías Renovables (ITER) División de Medio Ambiente

Report contributor: Nemesio M. Pérez

e-mail nperez@iter.rcanaria.es

Topics of specific research:

Difuse degasification in volcanic active systems

Continuous geochemical monitoring in active volcanoes

Geophysical monitoring of volcanoes

Hidrology of volcanic islands

Geochemical prospecting of geothermal resources

Optical sensors for volcanic emissions

Methods and techniques:

COSPEC, OP-FTIR, ICP-OES, mass spectrometry, electrostatic alpha spectrometry, ionic chromatography, gas microchromatography,

Fields of interest 5, 6, 9, 13, 16, 17, 18

Geographical area

Canary Islands,, Cabo Verde, Azores, El Salvador, Nicaragua, Costa Rica, Japan, Papua New Guine, Ecuador

Universidad Complutense de Madrid. Departamento de Geofísica y Meteorología
Facultad de Físicas.

Report contributor: Rafa Abella
e-mail rafa_abella@fis.ucm.es

Methods and techniques:
Volcanic seismology, instrumentation

Temas de interés específico
Seismology, volcanomagnetism

Fields of interest 12, 13, 15, 16

Geographical area
Antartica, Chile, Canaria, Azores, Italy
