COMITÉ ESPAGNOL DE GÉODÉSIE ET GÉOPHYSIQUE
SPANISH COMMITTEE OF GEODESY AND GEOPHYSICS

NATIONAL REPORT ON GEODESY

FOR

2003 - 2006

IUGG XXIV GENERAL ASSEMBLY

PREFACE

This report outlines some Spanish activities in Geodesy for the period 2003 to 2006. It has been prepared for submission to the International Association of Geodesy (IAG) on the occasion of the XXIV General Assembly of the International Union of Geodesy and Geophysics in Perugia, Italy, 2-12 July, 2007. 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 2003-2006 by different Institutions are presented. These Institutions in alphabetic order are.

1. Astronomy, Geodesy and Cartography Laboratory. Facultad de Ciencias. Universidad de Cádiz, Puerto Real. CÁDIZ
2.- Institute of Astronomy and Geodesy (Instituto de Astronomía y Geodesia), (UCM-CSIC). MADRID.
3.- Institute Cartographic of Catalonia (Instituto Cartográfico de Cataluña). BARCELONA.
4.- Microgeodesia Jaén Research Group. Universidad de Jaén. JAEN
5.- National Geographic Institute (Instituto Geográfico Nacional). MADRID.
6.- Royal Institute and Observatory of the Navy. (Real Instituto y Observatorio de la Armada). San Fernando. CÁDIZ.

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, 2007

Miguel J. Sevilla
(IAG Spanish National Correspondent)

1. ASTRONOMY, GEODESY AND CARTOGRAPHY LABORATORY

Departamento de Matemáticas. Facultad de Ciencias .Campus de Puerto Real
Universidad de Cádiz. 11510 Puerto Real (Cádiz) SPAIN
Tlf. 0034 956 01 64 73, 0034 956 01 62 87; Fax. 0034 956 01 62 88
URL: http://www2.uca.es/grup-invest/geodesia/
e-mail: geodesia@uca.es

People at the Laboratory

		Research Interest
Manuel Berrocoso Domínguez	Ph.D. in Mathematics	Astronomy, Geodesy, Cartogrpahy
María José González Fuentes	Ph.D. in Mathematics	Mathematical Analysis
Alberto Fernández Ros	Ph.D. in Mathematics	Astronomy, Geodesy, Cartogrpahy
María Eva Ramírez Rodríguez	MsC in Mathematics (DEA)	Astronomy, Geodesy
Alejandro Pérez Peña	MsC in Mathematics (DEA)	Spatial Geodesy
José Manuel Enríquez de Salamanca	MsC in Mathematics (DEA)	Astronomy, Geodesy
Cristina Torrecillas Lozano	MsC (Geodesy and Cartography Engineer)	Geodesy, Cartography
Raúl Páez Jiménez	MsC in Mathematics (DEA)	Spatial Geodesy
Alfonso Lorenzo Moya	Postgraduate Students (Mathematics)	Astronomy
Alberto Sánchez Alzola	Geodesy and Cartography Engineer	Geodesy, Cartography
Juan Antonio Fernández Prada	Postgraduate Students (Mathematics)	Geomatics
Columba Fernández Muñoz	Postgraduate Students (Mathematics)	Geomatics
Bismarck Jigena Antelo	Geodesy and Cartography Engineer	
Amós de Gil Martínez	Superior Studies (Ministry of Defence)	

Research interests

1. Design and development of GNSS geodetic network and its applications.

    - Establishment of a geodetic reference frame for South Shetland Islands, Bransfield Sea and the Antarctic Peninsula (RGAE geodetic network).
    - Establishment of geodetic networks in Deception Island: REGID geodetic network, RENID levelling network and REGRID gravimetric network.
    - Design and development of the Andalusian GPS Positioning Network (RAP network)
    - Establishment of a geodetic network on Tenerife Island to control its volcano-tectonic (TEGETEIDE-GEO network).
    - Establishment of a levelling network to control the deformation of the volcanic complex TEIDE-Pico Viejo (TEGETEIDE-NIVEL network)

2. Determination of volcanic and tectonic deformation models.

    - Application of the RGAE geodetic network to determine the tectonic deformation occurring in the South Shetland Islands, Bransfield Sea and the Antarctic Peninsula.
    - Monitoring of the volcano-tectonic activity in Deception Island and its environment and volcanic deformation models determination.
    - Determination of tectonic deformation models for Andalusia and the North of Africa.
    - Volcano-tectonic deformation models for Tenerife Island and Teide-Pico Viejo volcanic complex.
    - Real time monitoring of the volcanic activity on Deception Island and in the Teide-Pico Viejo volcanic complex.

3. Determination of experimental geoids

    - Determination of geophysical and geodetic experimental models in volcanic areas (Deception Island and Teide-Pico Viejo volcanic complex).
    - Geoid determination in Cádiz Bay for seaside areas delimitation.

4. Cartography: Technical and scientific information systems and remote sensing.

    - Design and development of a multidisciplinary system of scientific support (SIMAC). An application of Deception Island.
    - Maps Server development and Web Client.
    - Design and elaboration of an information system for universities management (SIGUCA), by means of free software and web client.
    - Quality control for the toponimy of cartographic series.
    - Satellite images for multispectral sensors. Using of panchromatic images for cartography update.

Publications (Papers and Book Chapters)

M. E. Ramirez, Y. Jiménez, M. J. González, M. Berrocoso, M. Sánchez-Francisco (2006)**. A new data analysis technique in the study of mutual even lightcurves.** Astronomy & Astrophysics, 448, pp. 1197-1206.

C. Torrecillas, M. Berrocoso, A. García (2006). **The Multidisciplinary Scientific Information Support System (SIMAC) For Deception Island.** En: Fütterer DK, Kleinschmidt G, Miller H, Tessensohn F (eds): Antarctica: Contributions to global earth sciences. Springer-Verlag, Berlin Heildelberg New York, pp 397-402.

M. Berrocoso, A. García, J. Martín-Dávila, M. Catalán- Mogollón, M. Astiz, M. E. Ramírez, C. Torrecillas, J. M. Enríquez de Salamanca. **Geodynamical studies in Deception Island from 1999 (DECVOL AND GEODEC PROJECTS).** En: Fütterer DK, Kleinschmidt G, Miller H, Tessensohn F (eds): Antarctica: Contributions to global earth sciences. Springer-Verlag, Berlin Heildelberg New York, pp 283-288.

M. Berrocoso, A. Fernández-Ros, C. Torrecillas, J. M. Enrique de Salamanca, M. E. Ramírez, A. Pérez-Peña, M. J. González, R. Páez, Y. Jiménez, A. García-García, M. Tárraga, F. García-García (2006). **Geodetic Research on Deception Island.** En: Fütterer DK, Kleinschmidt G, Miller H, Tessensohn F (eds): Antarctica: Contributions to global earth sciences. Springer-Verlag, Berlin Heildelberg New York, pp 391-396.

M. Berrocoso, Y. Jiménez, J. M. Enríquez-Salamanca, M. E. Ramírez (2006). **Analysis and comparison of the different mathematical techniques for the establishment of physical reference frames and its application to Deception Island (Antarctica).** Proceedings of the International Conference on Computational and Mathematical Methods in Science and Engineering, CMMSE 2006 Madrid, 21–25 September 2006, pp. 121-124.

M. Berrocoso, M. E. Ramírez, A. Fernández-Ros, Y. Jiménez (2006). **Crustal deformation model in volcanic areas. An application to Deception Island Volcano (South Shetland Islands, Antarctica).** Proceedings of the International Conference on Computational and Mathematical Methods in Science and Engineering, CMMSE 2006 Madrid, 21–25 September 2006, pp. 116-120.

M. Berrocoso, M. E. Ramírez, A. Fernández-Ros (2006). **Deformation models for the Deception Island.** En: Sansó F, Gil AJ (eds). **Geodetic Deformation Monitoring: From Geophysical to Engineering Roles,** IAG Symposium Jaén, Spain, March 7-19, 2005. Series: International Association of Geodesy Symposia , Vol. 131, ISBN-10: 3-540-38595-9, ISBN-13: 978-3-540-38595-0.

M. Berrocoso, M. E. Ramírez, Y. Jiménez, S. García-López, V. Pérez-Martín y C. Navarro (2005). **Conceptos básicos sobre Sistemas de Representación Terrestre y Cartografía.** En: M. Berrocoso (Coordinador)**. Aplicación de Sistemas de Geolocalización.** Servicio de Publicaciones de la Universidad de Cádiz. ISBN-10: 84-9828-052-4, ISBN-13: 978-84-9828-052-4.

M. Berrocoso, A. Pérez-Peña, R. Páez, A. Fernández-Ros, M. Boyano (2005). **El Sistema de Posicionamiento Global.** En: M. Berrocoso (Coordinador)**. Aplicación de Sistemas de**

Geolocalización. Servicio de Publicaciones de la Universidad de Cádiz. ISBN-10: 84-9828-052-4, ISBN-13: 978-84-9828-052-4.

S. García-López, R. Páez, J. A. Fernández-Prada, C. Torrecillas, C. Fernández-Muñoz (2005). **Conceptos básicos sobre Sistemas de Información Geográfica y Cartografía.** En: M. Berrocoso (Coordinador)**. Aplicación de Sistemas de Geolocalización.** Servicio de Publicaciones de la Universidad de Cádiz. ISBN-10: 84-9828-052-4, ISBN-13: 978-84-9828-052-4.

C. Torrecillas, F. J. Sánchez-Díaz, R. Páez, A. Pérez-Peña (2005). **Estado actual de la Red Andaluza de Posicionamiento (RAP).** En: XVII Congreso Internacional INGEGRAF – ADM, Sevilla. ISBN: 84-96377-41-5.

F. J. Sánchez, C. Torrecillas (2004). **Diseño de la Red Andaluza de Posicionamiento.** Mapping. ISSN: 1131-9100. Madrid.

M. Berrocoso, J. Martín, M. Catalán-Morollón, A. García, M. Astiz (2003). **El proyecto GEODEC: Un estudio multidisciplinar de la actividad geodinámica de la isla Decepción (Islas Shetladn del Sur, Antártica).** Proceedings de la III Asamblea Hispano-Portuguesa de Geodesia y Geofísica. Páginas 766-769. Universidad Politécnica de Valencia. Valencia.

C. Torrecillas, M. E, Ramírez, A. Pérez-Peña, J. M. Salamanca, M. Berrocoso (2003). **El sistema de información multidisciplinar de apoyo científico (SIMAC).** Páginas 799-801. Universidad Politécnica de Valencia. Valencia.

A. Fernández-Ros, M. E. Ramírez, A. Pérez-Peña, M. Berrocoso (2003). **Establecimiento de un modelo de deformación de la isla Decepción (Antártica) a partir de observaciones GPS**. Proceedings de la III Asamblea Hispano-Portuguesa de Geodesia y Geofísica. Páginas 330-333. Universidad Politécnica de Valencia. Valencia.

F. J. Sánchez, C. Torrecillas (2003). **Las infraestructuras de datos espaciales**. Mapping. ISSN: 1131-9100. Madrid.

Books and monographies

M. Berrocoso, J. M. Salamanca (2006). **El potencial gravitatorio.** Servicio de Publicaciones de la Universidad de Cádiz. ISBN-13: 978-84-9828-044-9. ISBN-10: 84-9828-044-3. Depósito Legal: CA-361/06. Cádiz.

M. Berrocoso (Coordinador) (2005). **Aplicación de Sistemas de Geolocalización**. Servicio de Publicaciones de la Universidad de Cádiz. ISBN-10: 84-9828-052-4. Cádiz.

M. Berrocoso, J. M. Enríquez de Salamanca, M. E. Ramírez, A. Pérez-Peña (2004). **Notas y Apuntes de Trigonometría Esférica y Astronomía de Posición.** 248 pág. Servicio de Publicaciones de la Universidad de Cádiz. ISBN: 84-7786-651-1. Cádiz.

M. Berrocoso, M. E. Ramírez, A. Pérez-Peña, J. M. Enríquez de Salamanca, A. Fernández-Ros, C. Torrecillas (2004). **El Sistema de Posicionamiento Global.** 175 pág. Servicio de Publicaciones de la Universidad de Cádiz. ISBN 84-7786-642-2. Cádiz.

M. J. González-Fuentes, M. E. Ramírez, M. Berrocoso (2004). **Del Análisis de Fourier a la Teoría de Wavelets.** 95 pág. Servicio de Publicaciones de la Universidad de Cádiz. ISBN: 84-96274-49-7. Cádiz.

García-Silva, C., Gárate, J., Martín-Dávila, J., Pérez-Peña, A. (2006). **Análisis de las series temporales efectuadas por el roa en el marco del proyecto ESEAS-RI**. Proceedings de la V Asamblea Hispano-Portuguesa de Geodesia y Geofísica (ISBN 84-8320-373-1). Páginas 330-333. Comisión Española de Geodesia y Geofísica (Ministerio de Medio Ambiente). Madrid

Pérez-Peña, A. (2005). **Cálculo de vectores desplazamiento en el Sur de España-Norte de África deducidos a partir de las observaciones GPS.** Boletín ROA (ISSN: 1131-5040). Páginas 1-117. Ministerio de Defensa. San Fernando (Cádiz).

Conferences and meetings attended

CONFERENCE ON MATHEMATICAL METHODS IN SCIENCE AND ENGINEERING (MADRID, 21-25 SEPTIEMBRE 2006)

Analysis and comparison of the diferent mathematical techniques for the establishment of physical reference frames and its application to Deception Island (Antarctica). M. Berrocoso, Y. Jiménez, J. M. Enríquez-Salamanca and M. E. Ramírez

Crustal deformation model in volcanic areas. An application to Deception Island Volcano (South Shetland Islands, Antarctica). Manuel Berrocoso, María Eva Ramírez, Alberto Fernández-Ros and Yolanda Jiménez

VII SYMPOSIUM DE ESTUDIOS ANTÁRTICOS (GRANADA, 18-20 SEPTIEMBRE 2006)

Diseño, desarrollo, objetivos y estado actual de las redes geodésicas establecidas en la Antártida durante las campañas antárticas españolas. M. Berrocoso, M. E. Ramírez, A. Fernández-Ros, C. Torrecillas, J. M. Enríquez-Salamanca, A. Pérez-Peña, R. Páez, Y. Jiménez, M. J. González-Fuentes, A. García-García, M. Tárraga, F. García-García, A. Sánchez-Alzola

Modelos de deformación volcano-tectónicos en la isla Decepción. M. Berrocoso, M. E. Ramírez, A. Fernández-Ros, A. Sánchez-Alzola, A. Pérez-Peña

Determinación de la superficie física de referencia para la isla Decepción a partir de observaciones GPS, medidas de nivelación y medidas gravimétricas. M. Berrocoso, Y. Jiménez, J. M. Enríquez-Salamanca, M. E. Ramírez.

Diseño, metodología y desarrollo de un Sistema de Información Multidisciplinar de Apoyo Científico (SIMAC) para la isla Decepción (Antártida). M. Berrocoso, C. Torrecillas

Actualización del mapa topográfico Isla Decepción 1:25.000 y nuevos productos cartográficos para la isla Decepción. M. Berrocoso, C. González-Bielsa, R. Páez, A. Sánchez-Alzola, S. García-López, C. Torrecillas

Aplicaciones de la Cartografía Espacial de Precisión a estudios científicos en la isla Decepción. M. Berrocoso, R. Páez, A. Sánchez-Alzola, C. González-Bielsa, C. Torrecillas

XII CONGRESO NACIONAL DE TECNOLOGÍAS DE LA INFORMACIÓN GEOGRÁFICA (GRANADA, SEPTIEMBRE-2006)

La Red Andaluza de Posicionamiento. M. Redondo, C. Torrecillas, M. Berrocoso, R. Páez.

CONGRESO "The EUREF 2006 Symposium of the IAG Commission 1 - Reference Frames, Subcommission 1-3a Europe (EUREF)" (RIGA (LETONIA), JUNIO-2006)

The RAP Net: a geodetic positioning network for Andalusia (South Spain), M. Berrocoso, R. Páez, A. Sánchez-Alzola, M. E. Ramírez, A. Pérez-Peña, Y. Jimenez, A. Hermosilla, M. Redondo

XIII ASAMBLY OF WEGENER (NIZA, 4-7 SEPTIEMBRE 2006) Sesión especial: "PERMANENT GPS NETWORKS IN EUROPE AND THE MEDITERRANEAN: DEVELOPPMENT, ANALYSIS AND INTERPRETATION"

A permanent GPS network for Andalusia (Spain). M.Berrocoso, R.Páez, A.Sánchez-Alzola, A.Pérez-Peña, A.Hermosilla, M.Redondo, J. Gárate

WORKSHOP "TIME SERIAL DATA IN VOLCANOLOGY: METHODS OF ANALYSIS" dell 26 al 30 de junio de 2006, Puerto Real (Cádiz)

Series geodésicas en dos volcanes activos: Decepción (Antártida) y Teide-Pico Viejo (Islas Canarias). M. Berrocoso.

Aplicación de la teoría wavelets a las series temporales en Volcanología. M. E. Ramírez.

Series geodésicas en Volcanología. M. E. Ramírez, A. Sánchez, R. Páez

CONGRESO DE LA EUROPEAN GEOSCIENCES UNION (VIENA, ABRIL-2006)

Using ASTER-TIR space image for the monitoring of the volcanic activity in Tenerife Island (Spain). Manuel Berrocoso, Alicia García, Santiago García, Yolanda Jiménez, Raul Páez, Alberto Sánchez-Alzola.

Determination of a physical reference frame for Deception Island (Antarctica). M. Berrocoso, Y. Jiménez, J. M. Salamanca, M. E. Ramírez, A. Sánchez-Alzola, R. Páez

Horizontal deformation models in Deception Island Volcano from GPS surveying. Berrocoso, M., Ramírez, M. E., Fernández, A.

A positioning Network for Andalusia (Spain), Ramirez, M.E. for the RAP Team: M. Berrocoso, R. Paez, A. Sanchez-Alzola, M. E. Ramírez, A. Perez-Peña, J. A. Fernandez-Prada, A. Hermosilla, M. Redondo, J. Gárate, C. Garcia-Silva, A. J. Gil

Plate boundary deformation at the strait of gibraltar area from gps episodic surveys and CGPS: preliminary results. J. Gárate, J. Martín-Davila, A. Pérez-Peña, C. García-Silva

NTRIP SYMPOSIUM AND WORKSHOP (FRANKFURT, FEBRERO-2006)

The Andalusian Positioning Network. M. Berrocoso, R. Páez, A. Hermosilla, M. E. Ramírez, A. Sánchez-Alzola, J. A. Fernández-Prada, A. Pérez-Peña, M. Redondo.

ASAMBLEA HISPANO-PORTUGUESA DE GEODESIA Y GEOFÍSICA (SEVILLA, ENERO-2006)

La Red Andaluza de Posicionamiento. M. Berrocoso, D. Fernández-Bruna, J. A. Fernández-Prada, J. Gárate, C. García-Silva, A. J. Gil, A. Hermosilla, Y. Jiménez, R. Páez, A. Pérez-Peña, J. Peñafiel, M. E. Ramírez, M. Redondo, A. Sánchez-Alzola, F. J. Sánchez-Díaz, C. Torrecillas

Estudios geodésicos para el control de la actividad volcánica del complejo Teide-Pico Viejo. M. Berrocoso, J. Doniz, A. García-García, S. García-López, C. García-Silva, C. Guillén, J. A. Fernández-Prada, C. Fernández-Muñoz, Y. Jiménez, R. Ortíz, R. Páez, A. Pérez-Peña, M. E. Ramírez, C. Romero, U. Ruiz, A. Sánchez-Alzola, C. Torrecillas

Análisis de series temporales efectuado por el ROA en el marco del proyecto ESEAS_RI. C. García-Silva, J. Gárate, J. Martín-Davila, A. Pérez-Peña.

INTERNACIONAL SYMPOSIUM ON GEODETIC DEFORMATION MONITORING: FROM GEOPHYSICAL TO ENGINEERING ROLES (MARZO-2005)

Southern Spain-Northern África displacements from CGPS observations. J. Gárate, J. Martin Dávila, A. Pérez-Peña, C. García Silva.

XVII CONGRESO INTERNACIONAL INGEGRAF – ADM (SEVILLA, JUNIO-2005)

Estado actual de la Red Andaluza de Posicionamiento (RAP). C. Torrecillas, F. J. Sánchez-Díaz, R. Páez, A. Pérez-Peña.

GRAVITY, GEOID AND SPACE MISSIONS (IAG INTERNATIONAL SYMPOSIUM) (OPORTO, AGOSTO-SEPTIEMBRE 2004)

Determination of an experimental geoid for Deception Island. M. Berrocoso, J. M. Enríquez-Salamanca, Y. Jiménez, A. Fernández, C. Torrecillas, M. E. Ramírez, M. J. González-Fuentes, A. Pérez-Peña, R. Páez, M. Tárraga, A. García-Garcia, M. Tárraga, F. García-García, R. Soto.

IV ASAMBLEA HISPANO PORTUGUESA DE GEODESIA Y GEOFÍSICA (Figueira da Foz, Febrero 2004)

Investigaciones geodésicas en la isla Decepción. M. Berrocoso, A. Fernández-Ros, C. Torrecillas, J. M. Enríquez-Salamanca, M. E. Ramírez, M. J. González-Fuentes, R. Soto, A. Pérez-Peña, R. Páez, M. Tárraga, A. García-García, F. García-García

Medidas gravimétricas en la isla Decepción, Shetland del Sur. M. Berrocoso, F. García-García, A. Fernández-Ros, M. Tárraga, A. García-García, C. Torrecillas, M. E. Ramírez, J. M. Enríquez-Salamanca

El sistema SIMAC para la isla Decepción. Estado actual. C. Torrecillas, M. Berrocoso

Modelos de deformación para la isla Decepción. A. Fernández-Ros, M. Berrocoso

El potencial gravitatorio generado por una esfera multipreñada. J. M. Enríquez-Salamanca, M. Nicasio, M. Berrocoso

La red geodésica REGID y la red de nivelación RENID para el control geodinámico de la isla Decepción. M. Berrocoso, A. Fernández-Ros, C. Torrecillas, J. M. Enríquez-Salamanca, M. E. Ramírez, M. J. González-Fuentes, R. Soto, A. Pérez-Peña, R. Páez, M. Tárraga, A. García-García, F. García-García

Series temporales para las estaciones GPS del Observatorio de la Armada en San Fernando. J. Gárate, J. Martín-Davila, M. Berrocoso

Proyecto TEDESE: principales resultados. J. Martín-Davila, E. Bufforn, J. Gárate, A. Pazos, A. Udías, W. Hanka, M. Berrocoso, A. Pérez-Peña, C. García-Silva

Red geodinámica del observatorio de San Fernando: resultados preliminares a partir de campañas episódicas. A. Pérez-Peña, J. Gárate, J. Martín-Davila, M. Berrocoso, C. García.

EUROPEAN GEOPHYSICAL SOCIETY. XXVIII GENERAL ASSEMBLY (NIZA, ABRIL 2003)

Cuateneo network: preliminary results after first reobservations. J. Gárate, J. Martín, E. Suriñach, M. Berrocoso, A. Pérez-Peña, J. Talaya

TEDESE project: preliminary results. E. Bufforn, J. Gárate, J. Martín-Davila, A. Pazos, A. Udias, A. Pérez-Peña

9º INTERNACIONAL SYMPOSIUM ON ANTARCTIC EARTH SCIENCES (ISAES IX) (POTSDAM, SEPTIEMBRE 2003)

DECVOL and GEODEC projects. M. Berrocoso, A. García-García, J. Martín-Davila, M. Catalán-Morollón, M. Astiz, M. E. Ramírez, C. Torrecillas, J. M. Enríquez-Salamanca

Geodetic research en Deception Island. M. Berrocoso, A. Fernández-Ros, C. Torrecillas, J. M. Enríquez-Salamanca, M. E. Ramírez, A. Pérez-Peña, R. Páez, M. J. González-Fuentes, M. Tárraga, F. García-García

Multidisciplinary scientific information support system (SIMAC) for Deception Island, South Shetland Islands, Antarctica. M. Berrocoso, C. Torrecillas, R. Páez, M. E. Ramírez, J. M. Enríquez-Salamanca, A. Fernández-Ros, A. Pérez-Peña, M. J. González-Fuentes

JORNADAS CIENTÍFICAS 250 AÑOS DE ASTRONOMÍA EN ESPAÑA (1753-2003) (SAN FERNANDO, SEPTIEMBRE 2003)

Estudio del eclipse de Europa por el satélite Io ocurrido durante la campaña PHEMU'97. M. E. Ramírez, M. Berrocoso, M. J. González-Fuentes, Y. Jiménez-Teja, M. Sánchez-Francisco

Msc and *Grade Dissertations*

J. M. Enríquez de Salamanca (2003). **Acerca del potencial gravitatorio.** Tutor de investigación: M. Berrocoso. Trabajo de Investigación. Programa de Doctorado: "Matemáticas: Astronomía". Universidad de Cádiz.

A. Pérez-Peña (2003). **El Sistema de Posicionamiento Global (GPS) y su aplicación en el estudio de la Deformación Geodinámica existente en el Sur de España**. Tutor de investigación: J. Gárate. Trabajo de Investigación. Programa de Doctorado: "Matemáticas: Astronomía". Universidad de Cádiz.

M. E. Ramírez (2003)**. Del Análisis de Fourier a la Teoría Wavelets. Aplicación al estudio de las curvas de luz.** Tutor de investigación: M. Berrocoso. Trabajo de Investigación. Programa de Doctorado: "Matemáticas: Astronomía". Universidad de Cádiz.

R. Páez (2006). **La Red Andaluza de Posicionamiento.** Tutor de investigación: M. Berrocoso. Trabajo de investigación. Programa de Doctorado: "Astronomía, Geodesia y Geofísica". Universidad de Cádiz.

Y. Jiménez (2006). **Determinación del geoide en la Isla Decepción (Antártida).** Tutor de investigación: M. Berrocoso. Trabajo de investigación. Programa de Doctorado: "Astronomía, Geodesia y Geofísica". Universidad de Cádiz.

A. Sánchez-Alzola (2005). **Seguimiento de acumulaciones nubosas y determinación de sus trayectorias en series temporales de imágenes satélite.** Proyecto Fin de Carrera I. Geodesia y Cartografía. Director: A. Ureña.

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
E-mail: secras@mat.ucm.es URL: http://www.mat.ucm.es

SUMMARY OF RESULTS DESCRIPTION

Report of activities: R. Vieira, F. G. Montesinos, J. Arnoso, E. Vélez and M. T. Benavent.

Laboratory of Geodynamics of Lanzarote

In the period from 2003 to 2006 in the Laboratory of Geodynamics of Lanzarote we have continued the researches about the local geodynamic, interaction between solid earth-ocean-atmosphere, earth and ocean tides, sea level change and deformation that we have been developing during the last 20 years in Lanzarote Island (Canary Islands).
Through the national projects *REN2001-2271 & UCM2005-910505*, international projects *MAC/2.3/A7 &* 03/*MAC/2.3/A4*, corresponding to the *INTERREG IIIB* call, and the international collaborations with the Institute of Seismology (Prof Cai Weixin, China Earthquake Administration), Bulgarian Academy of Sciences (Prof Angel Venedikov) and the Royal Observatory of Belgium (Dr. Michel Van Ruymbecke) , an important improvement have been done in order to guarantee the quality and precision of the observations, the conditions of the laboratory in relation with its connectivity to internet, and the software development for the signal analysis.
The *Geodynamic Control Network of Lanzarote* was designed selecting 33 points covering the entire island. In each station, gravimetry, GPS, vertical gravity gradiant and microsismic observations have been done.
Annually, the *Levelling Network of Jameos del Agua* is observed to control the vertical movements of the permanent GPS station and the reference mark of the tide gauges, in order to study the sea level variations in relation with the local geodynamic and the possible oceanographic implications of the Global Change.

Gravimetry and inverse problem.

Study of gravity inverse problem, by means of three dimensional model of crustal structures. Development of optimization techniques based on genetic algorithms and non linear approachs. Application to detection of cavities, archaeology, civil engeeneering, volcanic areas, and study of natural hazards. Analysis of gravity field. Joint interpretation with other geophysics techniques (mangetism, seismic).
Gravimetric calibration lines. Gravimetric networks. Establishmet of networks to control of natural hazards (Lanzarote, Fuerteventura, El Hierro y Tenerife) and gravity network of reference (Guipuzcoa, Spain)
Main Zones of research: in Canarian Archipélago (Tenerife, Lanzarote, Fuerteventura, La Gomera, Gran Canaria, El Hierro and La Palma) and Azores (Pico, Faial, Sao Jorge, Sao Miguel, Terceira, Flores y Corvo).
In the year 2005, the Institute of Astronomy and Geodesy (CSIC-UCM) in collaboration with the Bureau Gravimetrique International, the Internacional Center of Earth Tides, the Observatoire Royal de Belgique and the Casa de los Volcanes of Lanzarote, has organized, in Lanzarote Island (Canary Islands), the second Summer School on Microgravimetris Methods. The first one took place in the University of Louvain, in Belgium, in the year 2003.

We have developed in the Institute of Astronomy and Geodesy, a new system for the measurement of the verticals gravity gradients. The objective of this is to raise and to lower smoothly and in a controlled form a gravitymeter Lacoste&Romberg type G and in this way to determine the vertical gravity gradient in that point. The system is light, easily detachable and transportable to can operate in field. The prototype, in its last version, was presented in the "Summer School on Micro-Gravimetric Methods: static and dynamic aspects" celebrated in Lanzarote (Canary Islands) on October, 2005, co-organizated by the International Gravimetric Bureau, the International Earth Tides Center and the Institute of Astronomy and Geodesy.
We have also developed and built, a second prototype for automatic determination of the gravity gradient, with a measure range of up to 60 cm. This new prototype has been designed to use with any type of relative gravimeter working under laboratory conditions.

Earth Tides (R. Vieira, Vélez, E., Arnoso, J.)

1.- Observation. During the period 2003-2007, has been continued taking of data in two of the modules of observation of the Laboratory of Geodynamics of Lanzarote (LGL). In the Cueva de los Verdes, to the north of the island, has been continued the series of measurements begined in 1987 with the gravimeter Lacoste Romberg nº 434. In this place we have, at the present time more of 10 years of observation of the three components of earth tides, of oceanic tides and of meteorological parameters. Equally from 1999 we have a geodesic GPS station.
Likewise, in the module of observation of the LGL located the National Park of Timanfaya, to the south of Lanzarote, have been continued, in collaboration with the Real Observatory of Belgium, the observations of gravity tides, begun in the year 2001.
2.-Analysis. We have improved, and enlarged with new options, the software for analysis of temporary series, VAV (Venedikov, Arnoso, Vieira). During these years we have organized two international seminars, in Madrid and Cádiz, on the use and applications of this program, the second of them mainly dedicated to the analysis of oceanographics data.
At the present time it is proceeding to a revision of the data and the realization of new análisis, with the program VAV, of the 25 stations of gravity tides, observed, from 1973, by the Institute of Astronomy and Geodesy.

Monitoring Crustal Movements (M. J. Sevilla, L. García and J. Zurtuza)

In order to obtain real sea level variations a permanent GPS station has been installed near the tide gauges in Lanzarote island. The goal of this GPS station is to measurement vertical crustal movements in order to obtain absolute sea level variations removing these movements from tide gauge data. The results obtained are the evaluation of the altimetric links and levelling campaigns, and the comparison of the levels of different measurements. The GPS antenna is located in the top of a building and the geodetic control network has been designed and installed around it, to study the stability of the monument and building and to monitoring the possible movements of the crust respect to the sea level. The control net consists of 12 well signalled bench marks and it has been observed since year 2000 till 2006 by means of classic levelling techniques and GPS campaigns. The levelling observations allow a higher precision in the vertical component and it is known that the vertical movements are very important in the records of the tide gauges; while the GPS allows to have a control in the three components.
Also, a real GPS network located in Guipúzcoa has been used to monitor a simulated deformation via the Procrustes solution, which is compared with the Helmet's datum transformation classic approach.
Finally the region of Chelif (ex-El Asnam), situated in the North West of Algeria, is of an exceptional interest for the study of crustal motion which is related to the region seismic activity. The realised tests have focused on the horizontal movements determination and their errors on the strain tensors from periodic observations. The operation was stretched over a two year campaign of classical geodetic observations The evaluation and simultaneous representation of these deformations and their errors are made by the method of Monte Carlo that allows simulating a great number of series of measures

GPS investigations. New Software (J. Zurutuza and M. J. Sevilla)

Accurate GPS vector determination is nowadays one of the major problems in modern geodesy. Most of the errors are modelled either to smooth atmospheric effects or to remove biases, like clock offsets. The network design criteria and the vector processing solutions are based in distances to the reference stations and in the time span of the vectors involved in the sessions. Thus, the final solutions are computed accurately and the residuals show the quality of the computations. What is not usual to be taken into account in the final vector computation is the bearing of the vector to be processed, as the cut-off angle is considered fixed. The work deals with the variation on the final solution due to the different cut-off angles, and still more important, to the bearing of the vector in high precision GPS vector determination. If in the future, the IGS starts to distribute orbits that are created using the ANTEX file, this elevation-angle dependency should diminish

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

It is considered the isoparametric representation in the sense of O'keefe for the local transformation of one surface in another. Then one of the surfaces is consider being a plane, therefore only one metric tensor is necessary to represent the properties of the transformation or final projection of the surface into the plane. Using Chovitz development to the second order for the metric tensor a matrix is proposed summing up the more important properties of the cartographic projection. Then it is easy to generate a infinite number of cartographic projections provides a method for the synthesis and unification of the different projections.

Geopotential model for the north-east Atlantic (Catalao J. C. and M. J. Sevilla)

A new gravimetric geoid was determined for the North-East Atlantic between Iberian peninsula, Azores archipelago and Canary Islands (ICAGM05). The main purpose of this geoid surface is to establish the connection between the existing vertical reference systems in Azores, Canary and Madeira islands and Iberia (Portugal and Spain). Several data sources were included for the gravity field determination: 113382 terrestrial free-air anomalies, 533918 shipborne anomalies and 653395 altimeter derived gravity anomalies from KMS02 model. A new digital terrain model (ICADTM05) with a resolution of 500m was constructed from the compilation of altimetric data. A programme for marine gravity data validation and adjustment is prepared—VALDAMA. The aim of the programme is to provide a complete user-friendlysy stem for marine gravity data validation and adjustment that enables the user to define all intervening parameters.

Satellite altimetry (M. J. Sevilla and Rodriguez Velasco)

Actual studies related to calibration of altimeters involves the use of GPS buoys and the determination of absolute bias in just purely geometric sense. Doing so it seems to be avoided the estimating a marine geoid or the mean sea surface.
However, this is not at all true. Firstly we need the cross track geoid gradient in order to account the difference in the distance between the altimeter ground track and the position of the point to use in the comparison. In the second hand, an accurate estimation of the surface slope is also needed for linking offshore altimetric data and coastal tide gauges.
This is the followed method used to process the Spanish/French JASON-1 calibration campaign, IBIZA 2003. This campaign took place in June 9^{th}-17^{th} , 2003. The area, close to a big island and in a singular place from a dynamic point of view, has a complex local geoid and mean sea surface around. For this reason, we have developed some comparisons and correlations between results from this campaign data and some previous results about geoid and mean sea surface in the area, completely independent (in time, and in type of employed data – gravimetry or altimetry from another satellite -). The compared surface have been some mean sea surface models over the area and local marine geoids,

built up from gravimetry and altimetry of ERS ESA satellite, with a higher spatial resolution. The result of such studies is presented in this work.

High precision geoid computation (M. J. Sevilla and J. C. Catalao.)

In 1993, the Instituto Português de Cartografia e Cadastro (now Instituto Geográfico Português) started a new gravimetric project, to perform a more precise and accurate gravity field model in Portugal mainland. With this new gravity data and with a new Digital Terrain Model (obtained from the 1:50 000 cartography) a new gravimetric geoid model was constructed
In the Iberian Peninsula the Ibergeo95 geoid was published in 1995. From then on have appeared new geopotential models, new digital terrain models and new and precise data of gravity anomalies. With all these resources has been proceeded to calculate a new geoid, IBERGEO_2006, more precise than the previous one, although it has been used the same methodology that demonstrated to be extremely useful. In this new geoid computation has been used the following data types: a) the Combined Gravity Field model EIGEN-CG03C complete to degree and order 360, b) a set of 209.752 validated free air gravity anomalies covering the Iberian Peninsula and surrounding regions, c) a digital terrain model of mesh side 200x200 meters and e) GPS data in levelling points provided by the Geographical Institutes of Spain and Portugal. The final reference heights surface have been compared with those data GPS points resulting a standard deviation of 1.3 centimeters (6 cm. in interpolation) and a relative precision of 0.62 ppm.

Gravity survey in Guipúzcoa (M. J. Sevilla, J. Zurutuza, F. G. Montesinos and E. Vélez)

In the historical territory of Guipúzcoa, a new gravity network has been settled down. The network will be the reference for the future gravity related geodetic tasks. The network has eleven stations with a maximum distance between two consecutive stations of about 20 km. Also, it is connected with the absolute gravity station of the IAG in Madrid by means of a round trip itinerary with gravity measurements in Madrid, Aranda del Duero, Miranda de Ebro and Donostia with distances between stations of about 150 km. This last station of Donostia has been considered as reference station for the itineraries that configure the net of Gipuzkoa. To obtain the gravity values in the 11 stations, three round trip itineraries have been performed, where the starting and closing measure is the station of Donostia.
The used instrument has been a gravimeter LaCoste & Romberg model GRAVITON-EG-1194. The relative precision of this gravimeter is in the order of the 4 or 5 μGal, that together with the absolute gravity value of the station of the IAG in Madrid, which is known with an absolute precision of $\pm 9.0 \times 10^{-8}$ ms^{-2}, guarantee a final precision of 10 μGal. The coordinates of the stations have been determined by GPS in the WGS84 system

BIBLIOGRAPHY

Arnoso, J.; Benavent, M.; Vieira, R.; Kalinina, A.; Gorbatikov, A.; Volkov, V.: Efectos oceánicos en observaciones de marea terrestre de inclinación en Lanzarote. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España), Pub. UPV, CL ISBN 84-9705-297-8. Volumen I, pp. 250-255. 2003.

Arnoso, J.; Vieira, R.; Vélez, E.; Cai Weixin; Tan Shiling: Análisis de observaciones de marea de extensión en Lanzarote. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España), Pub. UPV, CL ISBN 84-9705-297-8. Volumen I, pp. 244-249, 2003.

Arnoso, J., Benavent, M., Ducarme, B., Vieira, R.: Comparación de Modelos Oceánicos de Marea en las Islas Canarias (España). *Proceedings 4ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Figueira da Foz (Portugal), pp. 521-522. 2004

Arnoso, J., Benavent, M. Ducarme, B., Montesinos, F.: Ocean tide loading model in the Canary Islands Region. *Journal of Geodynamics*, ISSN 0264-3707 Clave: A Volumen: 41(1-3) Páginas, 100-111 2006 (online version, 2005)

Auz Gómez, A.; Otero Juez, J.: Solución gradiente del problema de contorno GPS-gravimétrico. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España), Pub. UPV, CL ISBN 84-9705-297-8. Volumen I, pp. 190-193, 2003.

Benavent, M., Arnoso, J., Sevilla, M. J., Vieira, R.: Influencia de la Elasticidad de la tierra en las Funciones de Green en el Cálculo de la Carga Oceánica". *Proceedings 4ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Figueira da Foz (Portugal), pp. 525-526. 2004.

Benavent, M., Arnoso, J., F. G. Montesinos: Computation of surface displacements, tilt and gravity variations due to ocean tide loading. *Física de la Tierra*, vol. 17, pp. 97-112 (ISSN: 0214-4557). 2005

Bermejo Solera, M.; Otero Juez, J.: El método de Newton aplicado a la resolución del problema geodésico directo y a la obtención de las ecuaciones inversas de la proyección UTM. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísic*a, Valencia, (España), Pub. UPV, CL ISBN 84-9705-297-8. Volumen I, pp. 129-133. 2003.

Bermejo, M., Otero, J.: Minimum conformal mapping distortion according to Chebyshev's principle: a case study over peninsular Spain. *Journal of Geodesy*, vol. 79, pp. 124-134. 2005

Blanco, I., Montesinos, F. G., García, A., Vieira, R.: Caracterización magnética de la estructura de la corteza en Lanzarote a partir del análisis conjunto de las anomalías magnéticas y gravimétricas. Proceedings *4ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, 491. 2004

Blanco, I, Montesinos, F. G., García, A., Vieira, R., Villalaín, J.: Paleomagnetic determination of Lanzarote from magnetic and gravity anomalies: implications for the early history of the Canary Islands. *Journal of Geophysical Research*, Solid Earth, vol. 110, B12102, doi:10.1029/2005JB003668. 2005

Calvão, J.; Sevilla, M. J.: Ulitização de anomalias da gravidade obtenidas por inversão de dados altimétricos para o aperfeiçoamento da batimetria. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España), Pub. UPV, CL ISBN 84-9705-297-8. Volumen III, pp. 1658-1661. 2003.

Camacho, A.; Vieira, R.; Ortiz, E.; Montesinos, F. G.: Investigación gravimétrica para estudio arqueológico en la Cueva de Maltravieso (Cáceres). *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España), Pub. UPV, CL ISBN 84-9705-297-8. Volumen III, pp. 1779-1782. 2003.

Capitaine, M. Folgueira and J. Souchay. Earth rotation based on the celestial coordinates of the celestial intermediate pole I. The dynamical equations. *Astronomy and Astrophysics.* 445. 347-360. 2006

Catalão, M.; Vasconcelos, J.; Kol, H.; Sevilla, M. J.: Geóide em Portugal-novos resultados. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España), Pub. UPV, CL ISBN 84-9705-297-8Volumen I,pp.185-189, 2003.

Catalao, J.C, Vasconcelos, M., Kol, H., Sevilla, M.J.: Geóide em Portual novos resultados". Actas da *III Conferéncia Nacional de Cartografia e Geodesia*, Ed. Lidel, nº de págs. 10. Lisboa, 2003.

Catalao, J. C. and M. J. Sevilla: Inner and minimum constrain adjustment of marine gravity data. *Computers & Geosciences*, Vol. 30, pp. 949-957. Elsevier. 2004

Catalao, J., M. J. Sevilla y J. Calvao: Icagm05- Geoide no Atlántico Nordeste (Iberia-Canarias-Azores). *5ª Asamblea Hispano Portuguesa de Geodesia y Geofísica*. Sevilla 30 enero a 3 febrero de 2006. CD. Cambridge Univ Press ISBN 84-8320-373-1. 2006

Charco, M.; Fernández, J.; Tiampo, K. F.; Yu, T.-T.; Jentzsch, G.: Efecto de la topografía en las deformaciones y variaciones de gravedad producidas por una intrusión magmática en la corteza. Aplicación al volcán Mayon, Filipinas. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen II, pp. 741-745. 2003.

Charco, M.; Luzón, F.; Fernández, J.: Desplazamientos y esfuerzos producidos por una intrusión magmática en la corteza. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen II, pp. 794-798. 2003.

Charco, M., Fernández, J., Tiampo, K.F., Battaglia, M., Kellogg, L., McClain, J., and Rundle, J.B.: Study of volcanic sources at Long Valley Caldera, California, using gravity data and a genetic algorithm inversion technique. *Pure and Applied Geophysics*, vol 161, nº 7, 1399-1413, DOI: 10.1007/s00024-004-2511-8. 2004.

Charco, M., Tiampo, K. F., Luzón, F., Fernández, J.: Modelling Gravity changes and crustal deformation in active volcanic areas. Física de la Tierra", vol. 17, pp. 129-146 (ISSN: 0214-4557). 2005

Charco, M., Fernández, J., Luzón, F., and Rundle, J. B.: On the relative importance of self-gravitation and elasticity in modelling volcanic ground deformation and gravity changes. *Journal of Geophysical Research*, 111, B03404, doi:10.1029/2005JB003754. 2006.

Cerdeño, M. L., Hernández, C., Rodríguez-Caderot, G., Folgueira, M.: Novedades culturales y metodológicas en la necrópolis de Herrería (Guadalajara). *Novedades Arqueológicas Celtibéricas*, pp. 43-62, Ed.. Museo Arqueológico Nacional. 2004.

Diaz, G., J. I .Díaz and J. Otero: On an oblique boundary value problem related to the Backus problem in Geodesy. Nonlinear Analysis: *Real World Applications.* Vol. 7. 147-166. 2006.

Ducarme, B., A. P. Venedikov, J. Arnoso,, R. Vieira: Determination of the long period tidal waves in the GGP superconducting gravity data *Journal of Geodynamics*, ISSN 0264-3707: Vol. 38, n. 3-5, pp. 307-324, Ed. Elsevier. 2004.

Ducarme, B., Van Ruymbeke, M., Venedikov, A. P., Arnoso, J., Vieira, R.: "Polar motion and non tidal signals in the superconducting gravimeter observations in Brussels" *Bull. d'Inform Mareees Terrestres*. Bruxelles. Nº 140, pp. 153-1171. 2005.

Ducarme B., Venedikov A.P., de Mesquita A.R., De Sampaio França C.A., Costa D.S., Blitzkow D., Vieira R., Freitas S.R.C.: New analysis of a 50 years tide gauge record at Cananéia (SP-Brazil) with the VAV tidal analysis program. IAG Symposia, 130, Vol 130. 453- 460. 2006

Ducarme, B., Venedikov, A. P., Chen X.D., Arnoso, J., Sun H. P., Vieira, R.: Global analysis of the GGP superconducting gravimeters network for the estimation of the polar motion effect on the gravity variations. *Journal of Geodynamics.*Vol.: 41. 334-344. 2006.

Ducarme, B., Venedikov, Arnoso, Vieira, R.: Aanalysis and prediction of ocean tides by the computer program VAV. Journal of Geodynamics. Vol. 41. 119-127. 2006

Fernández, J.; Luzón, F: Sistema de vigilancia geodésica en las Islas Canarias. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen II, pp 751-755. 2003.

Fernández, J., Yu, T-T, Rodríguez-Velasco, G., González-Matesanz, Romero, J ., Rodríguez, G., Quirós, R., Dalda, A., Aparicio, A., Blanco M. J.: New geodetic monitoring system in the volcanic island of Tenerife, Canaries, Spain. Combination of InSAR and GPS techniques, *Journal of Volcanology and Geothermal Research*, nº 124: 241-253. 2003.

Fernández, J., Rundle, J.B.: Postseismic Viscoelastic-Gravitational Half Space Computations: Problems and Solutions. *Geophys. Res. Lett.*, 31, 29 L07608, DOI:10.1029/2004GL019654. 2004

Fernández, J.,: (**Guest Editor**). *Pure and Applied Geophysics*, vol 161, nº 7, Topical Issue "Geodetic and geophysical effects associated with seismic and volcanic hazards.", ISSN 0033-4553, pp. 1301-1611. 2005

Fernández, J.: Geodetic and geophysical effects associated with seismic and volcanic hazards. Introduction. *Pure and Applied Geophysics*, vol 161, nº 7, 1301-1303, DOI: 10.1007/s00024-004-2505-6. 2005

Fernández, J., F. J. González-Matesanz, J. F. Prieto, A. Staller, G. Rodríguez-Velasco, A. Alonso-Medina and M. Charco: GPS Monitoring in the N-W part of the Volcanic Island of Tenerife, Canaries, Spain. Strategy and results. *Pure and Applied Geophysics*, vol 161, nº 7, 1359-1377, DOI: 10.1007/s00024-004-2509-2. 2004

Fernández, J., Romero, R.; Carrasco, D., Tiampo, K. F., Rodríguez-Velasco, G., Aparicio, A., Araña, V., González-Matesanz, F. J.: Detection of displacements in Tenerife Island, Canaries, using radar interferometry. *Geophysical Journal International*, Vol. 160, pp. 33-45. doi: 10.1111/j.1365-246X.2005.02487.x. 2005

Fernández, J., Tiampo, K. F., Rundle, J. B., Jentzsch, G.: On the interpretation of vertical gravity gradients produced by magmatic intrusions *Journal of Geodynamics*, 39/5, 475-492. doi:10.1016/j.jog.2005.04.005. 2005.

Fernández, J. Charco, M., Rundle, J. B., Tiampo, K. F.: A revision of the FORTRAN codes GRAVW to compute deformation produced by a point magma intrusion in elastic-gravitational layered Earth models. Computers & Geosciences, 32/2, 275-281. doi:10.1016/j.cageo.2005.06.015. 2006

Folgueira, M. y Souchay, J.: Free Polar of a triaxial and elastic body in Hamiltonian formalism: Application to the Earth and Mars. *Astronomy and Astrophysic*s. Vol. 432, pp. 1101-1113. 2005.

Gambi, J., Zamorano, P., Romero, P., García del Pino, M. L.: A theorem for rigid motions in Post-Newtonian celestial mechanics, *Revista de la Real Academia de Ciencias*, Serie A, Mat., vol. 97 (1): 113-118. 2003.

García, L.; Cano, M. A.; Ortiz, E.; Sevilla, M. J.: Determinación de coordenadas provisionales en la estación GPS permanente de Lanzarote. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8 Volumen I, pp. 76-80. 2003.

García-Cañada L. and M. J. Sevilla: Monitoring crustal movements and sea level in Lanzarote. Geodetic Monitoring: from Geophysical to Geodetic Roles *IAG Springer Series*, vol. 131. pp. 160-165. Springer Verlag. 2006.

Gil, E., de Toro, C.: Improving tide-gauge data processing: A method involving nidal frequencies and inverted barometer effect. *Computer & Geosciences*, 31, 1048-1058. 2005

Gil, E., de Toro, C.: New determinations of the Ages of Tide in the North Atlantic Ocean. *Marine Geodesy*, nº 28, pp. 231-249. ISDN: 0149-0419. 2005

Gil, E., de Toro, C.: Non-linear processes in shallow waters. Influence on local observed mean seal leve". *Física de la Tierra*, Vol. 17, pp.77-96 (ISSN: 0214-4557. 2005

González-Matesanz, J.; Fernández, J.; Prieto, J. F. Staller, A.; Rodríguez-Velasco, G., Alonso-Medina, A.: Vigilancia GPS en la isla de Tenerife: metodología y resultados. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen I, pp. 306-309. 2003.

Gorbatikov, A. V., Kalinina, A. V., Volkov, V. A., Arnoso, J., Vieira, R., Vélez, E.: Results of analysis the data of microseismic survey at Lanzarote Island, Canary, Spain. "Geodetic and geophysical effects associated with seismic and volcanic hazards". *Pure and Applied Geophysics*. Vol. 161 nº 7 , 1561-1578. 2004

Gottsmann, J.; Wooler, L.; Martí, J.; Fernández, J.; Camacho, A. G.; Gonzalez, P. J.; García, A.;y Rymer, H. New evidence for the reawakening of Teide volcano. *Geophysical Research Letters*, vol. 33, L20311, doi:10.1029/2006GL027523, 2006

Gottsmann, J.; Camacho, A. G.; Tiampo, K.; Fernández, J.: Spatiotemporal variations in vertical gravity gradients at the Campi Flegrei caldera (Italy): a case for source multiplicity during unrest. *Geophys. Jour. Int.* 167, 1089-1096, Doi: 10.1111/j.1365-246X.2006.03157.x, 2006

Hayes, T. J., Tiampo, K. F., Rundle, J. B., Fernández, J. B.: Gravity changes from a stress-evolution earthquake simulation of California. Journal of Geophysical Research, 111, B09408, doi:10.129/2005JB004092. 2006

Kalinina, A.V., Volkov, V.A., Gorbatikov, A.V., Arnoso, J., Vieira, R., Benavent, M.: Seismo-Tilt observations in Geodynamic Observatory Cueva de los Verdes, Lanzarote. Pure and Applied Geophysics. Vol. 161, nº 7, 1579-1594. 2004.

Malpica, J. A. y M. J. Sevilla: Estudio de las proyecciones cartográficas con el desarrollo hasta el segundo orden del tensor métrico. *5ª Asamblea Hispano Portuguesa de Geodesia y Geofísica*. Sevilla 30 enero a 3 febrero de 2006. CD. Cambridge Univ Press ISBN 84-8320-373-1

Martinez-Benjamin, J.J., M. Martinez-Garcia, S. Gonzalez Lopez, A. Nunez Andres, F. Buill Pozuelo, M. Espino Infantes, J. Lopez-Marco, J.Martin Davila, J. Garate Pasquin, C. Garcia Silva, P. Bonnefond, O. Laurain, A.M. Baron Isanta, M. A. Ortiz Castellón, J. Talaya Lopez, B. Perez Gomez, E. Alvarez Fanjul, G. Rodriguez Velasco, D. Gomis, M. Marcos, Y. Menard, G. Jan, E. Jeansou, F. Lyard, and L. Roblou:: Ibiza Absolute

Calibration Experiment: Survey and Preliminary Results. *Marine Geodesy* (ISSN: 0149-0419 on line: 1521-060X). Vol: 27 N3-4. Ed. Taylor&Francis. 2004

Martínez Benjamin, J. J., Martínez García, M., Ortiz Castellón, M. A., Rodríguez Velasco, G., Martín Dávila, J., Pasquín, J. G., Bonnefond, P., Pérez Gómez, B., García Silva, C.: "Calibration altimeter sites at Cape of Begur and Ibiza Island". *Física de la Tierra*, vol. 17, pp. 33-45 (ISSN: 0214-4557). 2005.

Merbah, A.; Sevilla, M. J.; Yelles-Chaouch, A.: Análisis de movimientos altimétricos de la región sísmica de Chlef por el método de Monte Carlo. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen I, pp. 334-338. 2003.

Merbah, A., Yelles-Chaouch, A., Sevilla, M. J., García, L., Meghraoui, M.: Deformations associated with El Chelif earthquake of 10.10.1980: Vertical movements determinations. *Chaiers du Centre Européen de Géodynamique et de Séismologie*, vol. 23, pp. 165-158 (ISBN 2-9599804-6-8). 2004.

Merbah, A., Gourine, B., Sevilla, M. J.: Evaluation et interprétation des déformations horizontales et de leurs erreurs sur un réseau de surveillance sismique *Proceedings of FIG Working week 2005* and GSDI-8 Pharaohs to Geoinformatics, pp. 16-21. 2005.

Montesinos, F. G.; Vieira, R.; Camacho, A. G.: Estudio gravimétrico en la "Catedral Vieja" de Cádiz mediante algoritmo genético. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen III, pp. 1783-1788. 2003.

Montesinos, F.G., Camacho, A.G., Nunes, J.C., Oliveira, C.S.and Vieira, R.: A 3-D model for a volcanic crater in Terceira Island (Açores). Correlation with geology and seismic anomalies. *Geophys. J. Int*.. Vol. 154. 393-406. 2003.

Montesinos, F.G., Arnoso, J., Vieira, R., Benavent, M.: Estudio gravimétrico en El Hierro (I. Canarias): Resultados preliminares. Proceedings *4ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, 359-360, 2004

Montesinos, F. G., Arnoso, J., Benavent, M.: New study of the local gravity field of El Hierro (Canary Islands), *Física de la Tierra*, vol. 17, pp. 113-127 (ISSN: 0214-4557). 2005

Montesinos, F. G., Arnoso, J., Vieira, R.: Using a genetic algorithm for 3-D inversion of gravity data in Fuerteventura (Canary Islands), *International Journal of Earth Sciences*, Vol. 94, 2, pp. 301-316.(ISSN 1437-3254). 2005

Montesinos, F. G., Arnoso, J., Benavent, M. y Vieira, R.: The crustal structure of El Hierro (Canary Islands) from 3-D gravity inversion. *Journal of Volcanology and Geothermal Research* Vol. 150. 283-299. 2006.

Montesinos, FG., Vieira, R., Benavent, M., Arnoso, J., Estudio estructural de la Isla de La Palma mediante inversión gravimétrica. Primeros resultados. Cambridge University Press Congreso: *V Asamblea Hispano-Portuguesa de Geodesia y Geofísica* Pub. Electrónica. ISBN 84-8323-73-1. 2006.

Nunes, J.C., A.G. Camacho, Z. Franca, F. G. Montesinos, M. Alves, R. Vieira, E. Vélez, E. Ortiz: Signature of Crustal Volcano-Tectonic Structures of Pico Island (Azores) based on Gravity Anomalies Journal of Volcanology and Geothermal Research 156, 1-2 :1 55-170. DOI:10.1016/j.jvolgeores. 2006.

Nunes, J.C., Camacho, A.G., Franca, Z., Montesinos, F.G., Alves, M., Vieira, R., Velez,E. y Ortiz, E. Gravity anomalies and crustal signature of volcano-tectonic structures of Pico Island (Azores) *Journal of Volcanology and Geothermal Research*, 156, 55-70, 2006

d'Oreye, N., Kervyn, F., and the SAMAAV team: InSAR study of active African volcanoes: preliminary results of the SAMAAV project. In: Proceedings of the Xith International Congress for Mathematical Geology, "Quantitative Geology from multiple sources". Liège, Belgium, September 3-8, 2006. S04-07, 8 pp. (CD). (SAMAAV team includes J. Fernández) 2006

Otero, J.; Sevilla, M. J.: Análisis de series temporales de observaciones GPS en la estación permanente de Lanzarote. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España),) Pub. UPV, CL ISBN 84-9705-297-8 Volumen I, pp. 81-85. 2003.

Otero, J. and A. Auz: A formal comparison between Marych-Moritz's series, Sansò's change of boundary method and a variational approach for solving some linear geodetic boundary value problems. *International Association of Geodesy Symposia, Vol. 127* (Ed. F. Sansò), Springer-Verlag, Berlin-Heidelberg, pp: 226-233. 2004

Otero, J.: Best conformal map projections. "*Oberwolfach Reports*" (OWR, ISSN 1660-8933), European Mathematical Society. 2004.

Rodríguez Velasco, G.; Romero, R.; Yu, T.-T.; González-Matesanz, J.; Quirós, R.; Dalda, A.; Carrasco, D.; Fernández, J.: "Introducción de técnicas espaciales a los sistemas de vigilancia geodésica en Tenerife (Islas Canarias)". *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen II, pp. 746-750. 2003.

Rodríguez-Velasco, G.: Estudios sobre geoides terrestres y marinos. (ISBN: 84-669-1618-0. Dep. Legal: M-21215-2004). Ed. Universidad Complutense de Madrid. 2004.

Rodríguez Velasco, G., Sevilla, M. J., Martínez Benjamín, J. J.: Analysis of Gemid and Sea Level in the Area of the JASON-1 Calibration Campaign, IBIZA 2003. *Física de la Tierra*, Vol. 17, pp 61-76. (ISSN: 0214-4557). 2005.

Romero, P.; Gambí, J. M.; García del Pino, M. L.: Laser Ranging Satellite utilizando una Descripción Covariante Post-Newtoniana y Sistemas Localmente Inerciales. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8Volumen I,pp. 163-164. 2003.

Romero, P.; Gambí, J. M.; Patiño, E.: "Mantenimiento de Estación Norte/Sur para el Satélite Español Amazonas". *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8Volumen I, pp. 153-154, 2003.

Romero, R., Carrasco, D., Fernández, J., Martínez, A., Moreno, V., Araña, V.: Results from DECIDE-VOLCANO Project. Application to Canary Islands and Ecuador. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen I, pp. 310-314. 2003.

Romero, R., Carrasco, D., Araña, V., Fernández, J.: A new approach to the monitoring of deformation on Lanzarote (Canary Islands): an 8-year radar perspective. *Bulletin Volcanology*, nº 65:1-7. 2003.

Romero, R., and J. M. Gambi: Optimal control in the East/West station-keeping maneuvers for geostationary satellites. *Aerospace Science and Technology* 8, 8 ,729-734. 2004.

Romero, P., Gambi, J. M., **Patiño, E., Antolin, R**.: Optimal Station-Keeping for Geostationary Satellites with Electric Propulsion Systems under Eclipse Constrains. Progress in Industrial Mathematics at ECMI 2006, SERIES: Mathematics in Industry, `Springer-Verlag, Vol 11,` 2006

Romero, P., J.M: Gambi, E. Patiño: Station keeping manoeuvres for geostationary satellites using feed-back control techniques. *Aerospace Science and Technology* Vol. 10, n8, doi 10.1016 /j.ast2006.08.003, 2006.

Gambi, J. M., García del Pino M. L., Romero, P., Salas M. Post-Newtonian Covariant measurement formulation in Space Geodesy. Progress in *Industrial Mathematics at ECMI* 2006, SERIES: Mathematics in Industry, Springer-Verlag, Vol 11. 2006

Sánchez, F. J.; Sevilla, M. J.: Métodos de Análisis y Validación de Datos Gravimétricos. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8Volumen I, pp. 194-198. 2003.

Sevilla, M. J.: Modelos Digitales del Terreno 1:200.000 y Modelos de Transformación en la Península Ibérica. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8Volumen I. pp.45-49. 2003.

Sevilla, M. J.; García, L.; Ortiz, E.: Red de Apoyo de la Estación GPS permanente de Lanzarote. 3ª *Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen I, pp. 292-296. 2003.

Sevilla, M. J.; Ortiz; E.; García, L.: Enlace Altimétrico GPS-Mareógrafos en la estación permanente de Lanzarote. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen I, pp. 339-343. 2003.

Sevilla, M. J.; Rodríguez Velasco, G.: Análisis del modelo de geopotencial de muy alto grado, GPM98 en las Islas Canarias. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen I, pp. 261-265. 2003.

Sevilla, M. J.; Sánchez, F. J.: Gravimetría, Altimetría y Nivel Medio del Mar en el Norte de África. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen I, pp. 256-260. 2003.

Sevilla, M. J. "Ajustes con constreñimientos. *Publicaciones del IAG*, nº 198. pp.1-43. 2003.

Sevilla, M. J. Actualización de Cálculos Astronómicos I.A.G. ISBN 84-87488-08-0. 190 páginas. CSIC-UCM. *Instituto de Astronomía y Geodesia*. Madrid. 2003

Sevilla, M. J.: Modelización en Física y Astronomía. *Gaceta de la RSME* Vol 8.1, pp 20-22 Madrid. 2005

Sevilla, M. J. Ajustes de redes libres. Modelos matemáticos singulares. Publicaciones del Instituto de Astronomía y Geodesia. Nº 200, (82 páginas). (UCM-CSIC). Madrid 2005.

Sevilla, M. J.- IBERGEO_2006: Nuevo geoide centimétrico de la península Ibérica. *Topografía y Cartografía* Vol. XXIII nº 135. pp. 3-10. Madrid 2006.

Sevilla, M. J., J. Zurutuza y E. Vélez. Red gravimétrica del territorio histórico de Guipúzcoa. *V Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Procedings Instituto Nacional de Meteorología. Ed.: Cambridge University Press. ISBN: 84-8323-73-1 Clave: A. 2006.

Sevilla, M.J., E. Vélez y J. Zurutuza: Red Gravimétrica del territorio histórico de Guipúzcoa. *5ª Asamblea Hispano Portuguesa de Geodesia y Geofísica*. Sevilla 30 enero a 3 febrero de 2006. CD. Cambridge Univ Press ISBN 84-8320-373-1

Sevilla, M. J.: IBERGEO_2006. *5ª Asamblea Hispano Portuguesa de Geodesia y Geofísica*. Sevilla 30 enero a 3 febrero de 2006. CD. Cambridge Univ Press ISBN 84-8320-373-1.2006

Sevilla M. J. y L. García: Estabilidad de la red de apoyo GPS en Lanzarote como resultado de cinco campañas de observación. *5ª Asamblea Hispano Portuguesa de Geodesia y Geofísica*. Sevilla 30 enero a 3 febrero de 2006. CD. Cambridge Univ Press ISBN 84-8320-373-1.2006

T**iampo, K.F., Fernández, J., Jentzsch, G., Charco, M., and Rundle, J.B.:** New results at Mayon, Philippines, from a joint inversion og gravity and deformation measurements. *Pure and Applied Geophysics*, vol 161, nº 7, 1433-1452, DOI: 10.1007/s00024-004-2513-6. 2004

Tiampo, K.F., Fernández, J., Jentzsch, G., Charco, M., and Rundle, J.B.: Inverting for the parameters of a volcanic source using a genetic algorithm and a model for magmatic intrusion in elastic-gravitational layered Earth models. *Computers & Geosciences*, 30/9-10 pp. 985-1001. 2004

Tiampo, K.F., J. Fernández, G. Jentzsch, M. Charco, C. Tiede, C. Gerstenecker , A. Camacho, and J.B. Rundle.:. Elastic-gravitational modeling of geodetic data in active volcanic areas. In: *Recent Res. Devel. Geophysics*, 6. Edit. Research Signpost, Recent Research Developments in Geophysics, 6, 37-58. 2004

Tiede, C., Tiampo, K. F., Fernández, J., Gerstenecker, C.: Deeper Understanding of Non-Linear Geodetic Data Inversion Using a Quantitative Sensitivity Analysis. *Nonlinear Processes in Geophysics*, Vol. 12, pp. 373–379. 2005

Tiede, C., A. G. Camacho, C. Gerstenecker, J. Fernández, and I. Suyanto: Modeling the density at Merapi volcano area, Indonesia, via the inverse gravimetric problem *Geochem. Geophys. Geosyst.*, 6, Q09011, doi:10.1029/2005GC000986. 2005.

Vélez, E.; Vieira, R.; Arnoso, J.; Cai Weixin; Jiang Jun; Tan Shiling: Desarrollo de tecnología y software aplicado a la investigación en geodinámica de una zona volcánica activa. Cooperación Hispano China en el Laboratorio de Geodinámica de Lanzarote. *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen II, pp. 784-787. 2003.

Vélez, E. y Vieira, R.: Nuevos resultados en las observaciones del nivel del mar en el Laboratorio de Geodinámica de Lanzarote. "*V Asamblea Hispano-Portuguesa de Geodesia y Geofísica* – Procedings" Instituto Nacional de Meteorología. Ed.: Cambridge University Press. ISBN: 84-8323-73-1 Clave: A. 2006

Venedikov, A., Arnoso, J., Vieira, R: A program for tidal data processing. *Computer and Geosciences*. Edit. Pergamon, Elsevier, vol 29, nº , pp. 487-502. 2003.

Venedikov, A.P., Arnoso, J., Vieira, R.: New version 2003 of the program VAV for tidal data processing: *Computers and Geosciences*. 2004

Venedikov, , A., Arnoso, J., Vieira, R.: New version of program VAV for tidal data processing. *Computer and Geosciences*, nº3º, pp. 667-669. 2005.

Vieira, R.; Arnoso, J.; Vélez, E. J.: La observación de variaciones del nivel del mar en el Laboratorio de Geodinámica de Lanzarote (LGL). *3ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*, Valencia, (España) Pub. UPV, CL ISBN 84-9705-297-8. Volumen III, pp. 1603-1607. 2003.

Vieira, R., Cai Weixin: Volcano and crustal deformation. *Seismological Press*. ISBN-5028-2639-4/P.1232. Beijing, pp. 1-170. 2005.

Vieira, R. , Valbuena, J. L., Vélez, E.: GRAVIGRAD, a new system for the measurement of the vertical gravity gradien. *V Asamblea Hispano-Portuguesa de Geodesia y Geofísica – Procedings* Instituto Nacional de Meteorología. Ed.: Cambridge University Press. ISBN: 84-8323-73-1. Clave: A. 2006.

Vieira, R., E. Vélez. The three laboratories of geodynamics of Lanzarote. *Electronic Special Publication* of the Bureau Gravimetrique International. "2006 School on Microgravimetric methods". ISBN92-990017-1-5. Paris. France. CD.Vol.1. 2006.

Vieira, R.,Vélez E., Arnoso, J., Montesinos F.G. Geodetical and Gravimetric investigations of the Institute of Astronomy and Geodesy (CSIC-UCM) in the project "VULCMAC: Vulcanism in the Macaronesia"Editor: Cambridge University PressCongreso: *V Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Pub. Electrónica. ISBN 84-8323-73-1 2006.

Vieira, R, M. J. Sevilla, E. Vélez y F. G. Montesinos: Actividad del Instituto de Astronomía y geodesia con motivo de la llamada "Crisis del Teide" (2004-2005). *5ª Asamblea Hispano Portuguesa de Geodesia y Geofísica*. Sevilla 30 enero a 3 febrero de 2006. CD. Cambridge Univ Press ISBN 84-8320-373-1

Wadge, G., Parsons, B.E. and EVINSAR Science Team: Achieving the EVINSAR objectives with TERRASAR-L. Proceedings of the Fringe 2003 workshop, 1-5 December, 2003, ESA/ESRIN, Italy (JUNE 2004), LACOSTE H. (ED.) *ESA SP-550 // CD-ROM*. (EVINSAR Science Team includes to J. Fernández) 2004

Zhelev, Z., Petrova, T., Montesinos, F.G., Vieira, R., Arnoso, J., Camacho A.: Some Preliminary Results of the Analysis of the Lanzarote (Canary Islands) Gravity Anomaly with Elementary Sources. Annual Journal of the University of Mining and Geology, "St. Ivan Rilski", Sofia, 2004.

Zurutuza, J. and **M. J. Sevilla:** Cálculos precisos GPS: soluciones diarias y productos añadidos. *Mapping* nº 107, pp. 1-10. 2006

Zurutuza, J. and **M. J. Sevilla:** Deformations monitoring by integrating local and global reference systems. Geodetic Monitoring: from Geophysical to Geodetic Roles *IAG Springer Series*, vol. 131. pp. 48-55 Springer Verlag. 2006

Zurutuza, J. S. Hilla, T. Soler y M. J. Sevilla: Sobre la influencia del ángulo de corte y el acinut en el procesamiento GPS de alta precisión. *5ª Asamblea Hispano Portuguesa de Geodesia y Geofísica*. Sevilla 30 enero a 3 febrero de 2006. CD. Cambridge Univ Press ISBN 84-8320-373-1. 2006

3. INSTITUTE CARTOGRAPHIC OF CATALONIA (BARCELONA)

INSTITUT CARTOGRÀFIC DE CATALUNYA (ICC)
Parc de Montjuïc, s/n.
08038 – BARCELONA (SPAIN)
Tlf. ++ 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/ressenyes/homeang.html).

Until the end of 2006, XU has observed 3304 points with GPS technology. In the next years the ICC try to finalize the implantation of the XU 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. Has been started the procedures to review the XU points in order to update the information present at web, since there are many points destroyed each year and others that suffer changes on its surrounding area. The goal is to keep all points updated every 10 years.

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 2006, 927.7 km have been measured. 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

The CATNET network has 14 reference stations tracking the GPS constellation continuously. The network was conceived mainly to offer a public service of GPS data. The network was designed from an initial triangle (corresponding to the three ends of the Catalan territory) and has been increasing its density progressively towards the interior. The coverage provided by a set of 14 stations made possible the installation of a VRS systema capable to offer RTK positioning throurough Catalonia. The system was set in operation on January 2006 as a free of charge public service..

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.

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 11 stations. This implantation is made jointly with the Unit of Geology that has implanted it in its new seismic network.

The different services are available through internet, so the roving users need a GPRS connection to its ISP provider in order to get access. The protocol used is NTRIP , RTCM SC-106 standard for GNSS data dissemination. ICC has been collaborating in the project EUREF-IP in order to promote the use of NTRIP protocol and assist in its development.

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, MATA and PLAN,SORI,REUS,CASS,SBAR,ICCW are available in the network, as much in form of hour-files at a 1 sec and 15 seconds epoch-rate, and daily-files at a rate of 30 seconds.. 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 services provided by the CATNET network for real time positioning through internet are grouped under this category. The services are available at the ICC's Caster catnet-ip.icc.cat at the 8080 port.

DGPS: Broadcasting of the classical DGPS RTCM 2.1 pseudo range corrections. There is one source linked to each station reference stations.

CODCAT : Interactive service for improved code correction based on Virtual reference stations. It can reach decimetric precissions depending on the quality of the receiver used.

RTKAT: Interactive service for RTK positioning based on Virtual reference stations, allowing centimeter precision. The use of such services improves the consistency on the rover performance both for init time and precision when compared with single station RTK.

CATNET_WEB: This component is a web interface were the users can have access to the reports showing the performance of the whole system , and get RINEX data from a single station or a Virtual Station generated ant the user keyed in coordinates.

1.5. WARTK-EGAL

Under the EU program Galileo Joint Undertaking, ICC participates together with the Universitat Politècnica de Catalunya (UPC) as the project manager, the Finish Geodetic Institute, Pildo (Aerospatial company, Spain) and IFEN (Germany) , in the project WARTK.EGAL, (Wide Area RTK based on EGNOS and Galileo: Technical feasibility study). This project is a demonstrator for the UPC developed algorithms for the Wide area GNSS enhancement, to show the feasibility to operate a pan-european positioning service based on Galileo , using the RIMS stations of this system as reference stations, and using EGNOS channels to broadcast the solution to the final users.

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.
- …

During this period 55 points have been measured from combined networks leveling and GPS to have undulations along the Xda network. A test for 24 points have been measured for trigonometric links between leveling and Xu network in order to provide orthometric precise heights to the whole reference frame.

Its under development the works for a new geoid determination using the GRAVSOFT, updated gravimetric data, and a complete set of undulations measurements along the leveling network.

2. High precision positioning

POTSIS : On 2006 a new measurement campaign was done on the Pyrenees network. During this period the calculations of past campaigns was refined and homogenized in order to minimize systematic errors.

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.

During this period several demonstration and test campaigns for road inspections and urban cataloge were done. The system has been improved by installing 6 color cameras an a Terrestrial Laser.

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.

During this period have been done works to improve the performance of the system. Those task were mainly devoted to the dynamic memory managing and also the inclusion of new models.

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.

7. Publications

Baron, A., Talaya, J.: Utilización de enlaces de latencia media (>5s) para RTK ; Proceedings de la 5a Setmana Geomàtica de Barcelona. Febrer 2003.

Cabré, M., Térmens, A., Moysset, M., Soro, M., Ortiz, M. À., Talaya, J.: XdA: Red de nivelación de Cataluña; Proceedings de la 5a Setmana Geomàtica de Barcelona. Febrer 2003.

Parareda, C., Bosch, E., Térmens, A., Ortiz, M. À., Talaya, J.: CATNET: Servicios de posicionamiento de alta precisión y su integración en las nuevas tecnologías de la información; Proceedings de la 5a Setmana Geomàtica de Barcelona. Febrer 2003.

Soro, M., Térmens, A., Ortiz, M. À., Talaya, J.: XU: Red utilitaria de Cataluña ; Proceedings de la 5a Setmana Geomàtica de Barcelona. Febrer 2003.

4. MICROGEODESIA JAÉN RESEARCH GROUP

Grupo de Investigación MICROGEODESIA JAÉN
Universidad de Jaén
Dpto. de Ingeniería Cartográfica, Geodésica y Fotogrametría
Escuela Politécnica Superior de Jaén
Campus Las Lagunillas s/n, Edif. A3
23071 JAEN (SPAIN)
Tlf: +34 953 212 467
Fax: +34 953 212 855
e-mail: ajgil@ujaen.es
URL: http://coello.ujaen.es/investigacion/webmicro/

1.- Introduction

The "MICROGEODESIA JAÉN" research group was set up in 1997 in the Department of Cartographic, Geodetic and Photogrammetric Engineering of the University of Jaén. It is mainly focused on Geometrical and Physical Geodesy applications and in the period 2003-2006 carried out research on the following areas:

- Geodetic monitoring of surface deformation and its application to natural disaster hazards
- Determination of the Earth figure.
- Surface displacement monitoring in olive trees sloping areas affected by erosion.
- Geodetic networks and GPS.
- Positioning and navigation services based on permanent GNSS networks with RTK applications.

The group actively works collaboratively with various government agencies, cartographic institutes and other academic partners. In the period 2003-2006 we were engaged on several projects and contracts related to:

- Technical advice on Geodesy and Surveying.
- Establishment of high precision local networks to monitor ground movements of dams, walls and landslides.
- Establishment of 1D, 2D and 3D classical and GNSS networks for Geodesy and related applications.
- High precision determination of local and regional geoid models.
- Geodesic methodology for precise agriculture

In 2005, we organised and hosted the *International Symposium on Geodetic Deformation Monitoring: from Geophysical to Engineering Roles. ISGDM2005, March, 17-19*, sponsored by IAG (International Association of Geodesy) (http://www.ujaen.es/huesped/gdeforma). This symposium covered the following topics:

- Mathematical and Statistical Models for Crustal Deformation Analysis.
- Deformation Monitoring from GPS and InSAR data: Analysis and Geophysical Interpretation.
- Geodetic Monitoring of Movements in Civil Engineering.
- Integration of Spatial and Terrestrial Techniques in Deformation Studies.
- Geodynamical Applications of Gravimetric Observations.
- Gravity and Structure of the Earth's Interior.
- Present-day Geodetic Instrumentation for Deformation Monitoring.

The scientific committee consisted of Prof. Fernando Sansò (Politecnico di Milano, Italy), Prof. A. Dermanis (Aristotle University of Thessaloniki, Greece), Prof. E. Brückl (Vienna University of Technology, Austria), Prof. H. Henneberg (University of Zulia, Venezuela) and Prof. Antonio J. Gil (University of Jaén, Spain).

Recently, in September 2006, a collection of 36 peer-reviewed papers presented at the Symposium have been published in the book: *Geodetic Deformation Monitoring: From Geophysical to Engineering Roles IAG Symposium Jaén, Spain, March 7-19,2005.* Series: International Association of Geodesy Symposia, Vol. 131, Springer, edited by Fernando Sansò and Antonio J. Gil.
(http://www.springer.com/east/home/geosciences/geophysics?SGWID=5-10008-22-173674905-0)

2.- Research Projects

Quantifycation of tectonic processes in the South of Spain and the North of Africa.
Funding: Consejería de Innovación, Ciencia y Empresa de la Junta de Andalucía.
Participanting teams:University of Granada, University of Jaén.
2006-2008. 169.400 Euros.
PI: Francisco González Lodeiro (University de Granada).

Current tectonic activity in Balanegra fault and its relation to big folds.
Funding: DGI. Acción Complementaria CGL2004-0167-E.
Participating teams: University of Granada, University of Jaén, University of Alicante and Instituto Andaluz de Ciencias de la Tierra.
2005-2006. 11.000 euros.
PI: Jesús Galindo Zaldívar (University of Granada).

Geometric analysis of basement of the Guadix-Baza basin (Betic Cordillera).
Funding: DGI. Acción Especial BTE2001-5230-E.
Participating teams: Instituto Andaluz de Ciencias de la Tierra, University of Jaén, University of Granada and University of Alicante.
2003-2004**.** 17.725,29 Euros.
PI: Carlos Sanz de Galdeano (Instituto Andaluz de Ciencias de la Tierra).

3.- Main Contract Research

Innovative Concepts for High Accuracy Local Geodetic Networks (GEOLOCALNET)
(RESEARCH AND DEVELOPMENT ACTIVITIES, 6TH FRAMEWORK PROGRAMME, CALL NUMBER 2423, AREA 3 – Innovation and International Initiatives Innovation by Small and Medium Enterprises)
Funding: GALILEO JOINT UNDERTAKING (ESA – EC)
2005-2006.

Quality control of ground control points of 1/20,000 flight for the generation of the 1/5.000 Andalusia Digital Ortophoto.
Funding: Empresa Pública para el Desarrollo Agrario y Pesquero de Andalucía S.A.
2003 – 2004

4.- Publications

Books

- Geodetic Deformation Monitoring: From Geophysical to Engineering Roles. IAG Symposium Jaén, Spain, March 7-19,2005. Series: International Association of Geodesy Symposia , Vol. 131. Sansò, Fernando; Gil, Antonio J. (Eds.). 2006, XII, 306 p., 233 illus., Hardcover. ISBN: 978-3-540-38595-0

International Journals

- A. J. Gil, J. Galindo, M.J. Borque, L. Marín, P. Ruano, C. Sanz de Galdeano. Geodetic deformation monitoring in Zafarralla fault and Sierra Tejada antiform (Spain): Status Report . Acta Geodynamic. Geomater. Vol: 2. 25-28. Czech Republic. 2005.
- Lacy, A. J. Gil, G. Rodríguez-Caderot. A method for the ionospheric delay estimation and interpolation in a local GPS network. Studia Geophysica et Geodaetica. ISSN: 0039-3169. Vol: 49. 63-84. Prague. 2005.
- Ramos M.I., Feito F.R., Gil A.J. Towards high precision digital elevation model. Journal of WSCG. ISSN: 1213-6972. Vol: 12. 145-148. Pilsen, Czech Republic. 2004.

- E.B. Blázquez, A. J. Gil, G. Rodríguez-Caderot, M.C. Lacy, J.J. Ruiz. ANDALUSGEOID2002: The New Gravimetric Geoid Model of Andalusia (Southern Spain). Studia Geophysica et Geodaetica. ISSN: 0039-3169. Vol: 47. 511-520. Prague. 2003.
- J. Galindo-Zaldívar, A. J. Gil, M. J. Borque, F. González-Lodeiro, A. Jabaloy, C. Marín-Lechado, P. Ruano and C. Sanz de Galdeano. Active faulting in the internal zones of the central Betic Cordilleras (SE, Spain). Journal of Geodynamics. ISSN: 0264-3707. Vol: 36/1-2. 239-250. 2003.
- Ruiz A.M., Ferhat G., Alfaro P., Sanz de Galdeano C., Lacy M.C., Rodriguez- Caderot G., Gil A.J. Geodetic Measurement of Crustal Deformation On Nw-Se Faults Of The Betic Cordillera, Southern Spain, 1999-2001. Journal of Geodynamics. ISSN: 0264-3707. Vol: 35. Pp: 259-272. 2003.
- Lacy, F. Sansó, G. Rodríguez-Caderot y A. J. Gil. The Bayesian Approach applied to GPS Ambiguity Resolution. A mixture model for the discrete-real ambiguities alternative. Journal of Geodesy. ISSN: 0949-7714. Vol: 76 (2). 82-94. 2002.

National Journals

- Ruiz Morales M. Una comunicación de J. Mendoza y Ríos a la Royal Society en Junio de 1812, dando cuenta de un estudio geodésico realizado por J. Rodríguez. Biblio 3W. Revista Bibliográfica de Geografía y Ciencias Sociales. 1138-9796. Vol: -. Pp: 1-?. Barcelona. 2005.
- Ruiz Morales M. Dos eclipses observados por Antonio Ulloa en el año 1748. Astronomía. Vol: -. 83-87. Madrid. 2005.
- Ruiz Morales M. Los primeros trabajos del Instituto Geográfico. Mapping: Revista de Cartografía, Sistemas de Información Geográfica, Teledetección y Medio Ambiente. 1131-9100. Vol: 103. Pp: 6-17. Madrid. 2005.
- Ruiz Morales M. Laussedat y la Academia de Ciencias de España (I). Topografía y Cartografía. 0212-9280. Vol: -. Pp: 27-35. Madrid. 2005.
- Ruiz Morales M. Cartas de Carlos Ibáñez de Ibero al francés Aimé Laussedat. Mapping: Revista de Cartografía, Sistemas de Información Geográfica, Teledetección y Medio Ambiente. 1131-9100. Vol: -. Pp: 60-70. Madrid. 2005.
- Borque M.J., Gil A.J., Alfaro P. Nivelación de alta precisión a lo largo de la costa entre La Marina y Torrevieja (Alicante) para controlar movimientos tectónicos verticales. Geotemas. 1576-5172. Vol: 7. Pp: 135-141. Madrid. 2004.
- Peláez J.A., Gil A.J., Álvarez J., López D., Rodríguez A., Rodríguez-Caderot G., Métodos astrogeodésicos como control de geoides gravimétricos. Datum XXI. 1696-7941. Vol: -. Pp: 10-16. Madrid. 2004.
- Galindo J., Gil A.J., Borque M.J., González F., Jabaloy a., Marín C., Ruano P., Sanz de Galdeano C., Desarrollo simultáneo reciente de pliegues y fallas en las Cordilleras Béticas: la falla de Zafarraya y el pliegue de Sierra Tejada. Geotemas. 1576-5172. Vol: 6. Pp: 147-150. Madrid. 2004.
- Sanz de Galdeano C., Galindo J., López A. C., Alfaro P., Delgado J., Marín C., García F. J., Borque M. J., Gil A. J., Anomalías gravimétricas y magnéticas en la cuenca de Guadix-Baza: primeros resultados. Geotemas. 1576-5172. Vol: 6. Pp: 195-198. Madrid. 2004.
- Ruiz Morales M. Aimé Laussedat y el comienzo de la Fotogrametría en el Instituto Geográfico. Datum XXI. 1696-7941. Vol: -. Pp: 4-12. Madrid. 2004.
- Ruiz A. M., Gil A. J., Alfaro P., Sanz de Galdeano C., La falla activa de Padul. Medidas geodésicas para controlar su deformación. Investigación y ciencia. 0210-136X. Vol: -. Pp: 32-34. Barcelona. 2004.
- Ruiz Morales M. El mejor cartógrafo andalusí y su paradójica descripción del Reino de Granada. Topografía y Cartografía. 0212-9280. Vol: -. Pp: 39-41. Madrid. 2004.
- Ruiz Morales M. Aportaciones del General Ibáñez e Ibáñez de Ibero a las ciencias geográficas. Datum XXI. 1696-7941. Vol: -. Pp: 4-16. Madrid. 2003.

Conferences

- Peláez, J.A., Gil, A.J., Sanz de Galdeano, C., Martínez Solares, J.M., and Galindo Zaldívar, J. 2006. A plausible 'geodetic scenario' for the 1884 Arenas del Rey earthquake. 5ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica. 30 Enero - 3 Febrero, Sevilla, 2006

- Ramos M. I., Gil A. J., Feito F. R., García-Ferrer A., Cruz J. L. ¿Se mueven los olivos? XII Simposium Científico-Técnico EXPOLIVA 2005. Jaén (España). 2005.
- Ramos M. I., Gil A. J., Feito F. R., García-Ferrer A., Cruz J. L. Geodetic control of the present tectonic deformation of the Betic Cordillera. International Symposium on Geodetic Deformation Monitoring: from Geophysical to Engineering Roles. ISGDM2005. Jaén (España). 2005.
- Ramos M. I., Feito F. R., Gil A. J. Consecuencias de la erosión en el olivar en pendiente. I Congreso de la cultura del olivo. Jaén. 2005
- Ramos M. I., Feito F. R., Gil A. J. Analysis of slope to study erosion. International Cartographic Conference. ICC2005. A Coruña (España). 2005.
- Peláez J. A., Gil A. J., Álvarez J., López D., Núñez E., Rodríguez A., Rodríguez-Caderot G. Two checking astrogeodetic geoid profiles in southern Spain. 4ª Assembleia Luso-Espanhola de Geodesia e Geofísica. Figueira Da Foz (Portugal). 2005.
- Galindo J., Gil A. J., Borque M. J., Marín C., Ruano P., Sanz C. The Zafarraya fault in the frame of the active tectonic structures of the Central Betic Cordillera (southern Spain). Cost-Action 625
- Camerino (Italia). 2004.
- SanJosé J. J., Blázquez E. B., Atkinson A. D. J. The Argüalas rock glacier analysis in the period 1991-2000. 4ª Assembleia Luso-Espanhola de Geodesia e Geofísica. Figueira Da Foz (Portugal). 2004.
- Lacy C., Rodríguez-Caderot G., Gil A. J. Precise point positioning using undifferenced GPS observations. 4ª Assembleia Luso-Espanhola de Geodesia e Geofísica. Figueira Da Foz (Portugal). 2004.
- Lacy C. The bayesian detection of discontinuities in a linear regression: a GPS application. EGS-AGU-EUG Joint Assembly. Niza (Francia). 2003.
- Ramos M. I., Gil A. J., Feito F. R. Estudio de deslizamiento de ladera en olivar con pendiente. XI Simposium Científico-Técnico EXPOLIVA 2003. Jaén (España). 2003.
- Peláez J. A., Gil A. J., Sanz de Galdeano C., Rodríguez-Caderot G. Constraints on the design of a geodetic network for the control of a normal fault: an application to the Granada fault. 3ª Assembleia Luso-Espanhola de Geodesia e Geofísica. Valencia (España). 2003.
- Gil A. J., Rodríguez-Caderot G., Ruiz M., Sanz de Galdeano C., Alfaro P., Ruiz A. M., Ferhat G., Lacy C., Biagi L., Garrido M. S., Blázquez E. B. Actividades geodésicas de control de deformaciones en el sector central de la Cordillera Bética en el período 1999-2001. 3ª Assembleia Luso-Espanhola de Geodesia e Geofísica. Valencia (España). 2003.
- Blázquez E. B., Gil A. J., Rodríguez-Caderot G., Lacy C., Ruiz J. J. A gravimetric geoid in Andalusia: Results and precision estimates. 3rd Meeting of the International Gravity and Geoid Commission (3). Thessaloniki (Grecia). 2003.

5.- NATIONAL GEOGRAPHIC INSTITUTE

INSTITUTO GEOGRÁFICO NACIONAL (IGN)
Centro de Observaciones Geodésicas
General Ibañez de Ibero, 3 28003 MADRID, (SPAIN)
Tlf.: ++ 34 91 597 9768 Fax: 34 91 597 97666 URL: http://www.ign.es

1. GEODETIC NETWORKS

1.1 R.O.I. in ETRS89

The adoption of ETRS89 as official Geodetic Reference System in Spain has important consequences and changes in all the geodetic, topographic and cartographic works. The National Geodetic Network by Space Techniques (REGENTE) constitutes the frame on which these works must be carrying out. The density of this class C network is one geodetic point each sheet of the National Topographic Map scale 1/50,000, totalizing more than 1100 stations in the whole country (an average density of one by each 450 km^2).

The general characteristics and conditions that this network fulfils (precision better than 5 cm, good accessibility, cleared horizon, etc) make the density of the network enough to support for any geodetic, topographic or cartographic works in any zone of Spain. Nevertheless, the National Geodetic Network of Inferior Order (ROI) –included REGENTE stations- with coordinates in ETRS89 system, can be used for less precision-demanding works or whenever it is needed to have greater geodetic densification in a zone.

The ROI is constituted by about 11.000 geodetic points in all Spain (density of one bench mark every 45 km2) with coordinates in ED50 Geodetic Reference System and an average precision of 0.2 m in horizontal coordinates and 0.3 m in altimetry in this system. The precision of the network partly results from lack of a sufficiently dense network of superior order to base on. This network was mainly observed during years 80's and 90's by means of triangulation, measuring three angle's series with the horizon method.

Re-computation of all the ROI has been made in ETRS89 system constraining to the REGENTE network and including classic angular observations and GPS (this last one in the regions that have carried out a re-observation of the ROI with GPS: Balearic Islands, Catalonia, Navarre, Basque Country and Valencia). After thorough revision and quality control of the observables included in the process, a joint adjustment of all the network has been made. In order to make the complete adjustment of ROI in ETRS89 127.000 azimuth directions, 67.000 zenith angles and 7.000 GPS vectors have been used, weighting the observables suitably by calculation blocks.

The results are the coordinates in ETRS89 system of those of the 9.850 remaining geodetic vertices of the ROI that are not included in REGENTE network. The obtained precision depends on the available observables in each zone. In the regions with GPS, the resulting error ellipses (95% confidence) are usually constant of 2 cm in planimetry and 3 cm in altimetry of relative precision, whereas in the classic observable zones, where only angular measurements are available, the precision is variable depending on the visuals in each geodetic point, with an average magnitude of 8 cm in planimetry and 14 cm in altimetry (relative precision).

1.2 REGENTE

The computation of the last set of coordinates of REGENTE was carried out in 2003.

Aiming at the set of an unified European cartography, it is essential to transform the current National Geodetic Coordinates into the ETRF89 Frame. Such a determination requires to know the coordinates of a geodetic subset in both systems with a very high number of stations and uniformly distributed, but with a bigger density of points in those areas where the distortion of the old network is higher.
In the case of Iberian Peninsula and archipelagos, the IGN decided to solve the problem through 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 belonging to the 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 km^2.
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).
With REGENTE Project the following objectives are reached:

- Implementation, observation and coordinate 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 centimetric precision. REGENTE project is supported with relative Lacoste-Romberg gravimetric observations in every point.
- To 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: good approach itinerary for off-road vehicle, open horizon above 10^o, 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.
- Finally, 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.

1.3 GPS Reference Station Network (ERGPS)

ERGPS is the GNSS Permanent Network of the Geodetic Observations Centre of the National Geographic Institute of Spain. The installation of the first station was carried out in March 1998. Currently, ERGPS is constituted by 19 stations. All of them accomplish the requirements to be a station of the EUREF Permanent Network (EPN).
The main objectives of this network are:

- To obtain precise coordinates and velocities of the points.
- One of them (YEBE) is an IGS station contributing to the definition of the International Terrestrial Reference Systems ITRS.
- 16 of them are stations of the EPN contributing to all projects that affect at this Network and

to the definition of the European Terrestrial Reference Systems ETRS.

- To collaborate in other scientific projects, like Geodynamical, Meteorological or Geophysical projects.
- To participate in the last Real Time Projects (Euref-IP).
- Providing public and free Rinex 1 second hourly data through a public ftp server with the next address: ftp://ftp.geodesia.ign.es

IGN Permanent GNSS stations Network.

ERGPS	Instalation date	IGS	EUREF	EUREF-NRT	EUREF-IP	Public data 1 second
ALAC	Abr - 98		X	X	X	X
ACOR	Sep - 98		X	X	X	X
YEBE	May - 99	X	X	X		X
ALME	Dic - 99		X	X	X	X
VALE	Ene - 00		X	X	X	X
MALA	Mar - 00		X	X	X	X
CANT	Mar - 00		X	X	X	X
MALL	May - 00		X	X	X	X
CACE	Dic - 00		X	X	X	X
SONS	Dic - 00				X	X
RIOJ	May -01		X	X	X	X
LPAL	May - 01		X	X	X	X
CEUT	Ago - 01		X	X	X	X
VIGO	Sep - 01		X	X	X	X
HUEL	Dic - 01				X	X
ALBA	Jun - 02				X	X
COBA	Abr - 04		X	X	X	X
ZARA	Abr - 06		X	X	X	X
SALA	Jun - 06				X	X

The link of Yebes permanent station (YEBE) to the telescope through 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.
GPS sites that fulfill the recommendations of the IGS have been selected for the installation of these permanent stations as far as monumentation, location, stability, durability, etc..
The ERGPS already installed are located in:

- ALAC: Tide Gauge of Alicante.
- ACOR: Tide Gauge of A Coruña.
- YEBE: Observatorio Astronómico de Yebes.
- ALME: Observatorio Geofísico de Almería.
- VALE: Universidad Politécnica de Valencia .
- MALL: Instituto Español de Oceanografía de Mallorca.
- MALA: Observatorio Geofísico de Málaga.
- CANT: Escuela de Ing. Caminos, Canales y Puertos de Santander (Universidad de Cantabria).
- SONS: Observatorio Sismológico de Sonseca.
- CACE: Universidad de Extremadura en Cáceres.
- RIOJ: Observatorio Geofísico de Logroño.
- LPAL: Observatorio Astronómico Roque de los Muchachos.
- CEUT: Puertos del Estado.
- HUEL: Universidad de Huelva.
- COBA: Universidad de Córdoba.
- ALBA: Universidad de Castilla-La Mancha, Campus de Albacete.
- ZARA: Instituto Nacional de Meteorología en Zaragoza.
- SALA: Aeropuerto de Matacán.
- VIGO: Instituto Español de Oceanografía de Vigo.

1.4 EUREF-IP Project in ERGPS Network.

Within the EUREF frame, the BKG (Bundesamt für Kartographie und Geodäsie) developed a new technique of registry and interchange GNSS data, as well as the derived product diffusion, as for example the transmission of differential corrections in real time. All it has been made on the basis of free code of GNU (General Public License), in particular the one of Internet-radio. Most of the activity in this field is carried out through the dissemination of GPS data (DGPS) in form of differential corrections for precise positioning. The transmission of differential corrections between the reference remote receiver (BASE) and rover is standardized according to proposal of the Radio Technical for Commission Maritime Services, Special Committee 104, RTCM-SC104. RTCM format includes messages with correction to the pseudo-distances and time variation of these. It contains in addition corrections to the phase measures. 18-21 messages are for RTK (Real Time Kinematics) positioning for application in receivers that admit this technique. The “base station” must be distanced a few tens of kilometres (20-30 km) so that the correction is effective. This technique allows reaching centimetric precisions in real time. NTRIP (Networked Transport of RTCM via Internet Protocol) is the new technology and protocol to transfer data GNSS (for example corrections RTCM) by means of Internet network or cell telephony. NTRIP Software has been developed within EUREF under free GNU

license and most of topographic GPS receivers incorporate it like stantdard for the reception of RTK corrections. Almost all stations of ERGPS network are transmitting RTK corrections. The client program with the name "GNSS Internet Radio" available for several platforms (Linux, Windows or Windows EC) can be unloaded in order to get the data of one station of the IGN, the IGNE caster must be chosen, whose IP address is 80.38.104.84 (port 80).

1.5 IGE, Analysis Centre.

IGE as a Local Analysis Centre of EUREF

Since the first week of September of 2001 (GPS WEEK 1130) and after the tests made introducing our solution into the final combined European solution with satisfactory results, the IGN geodetic department became a EUREF Analysis Centre. The three letters acronym used is IGE.

Processing was done by Bernese Proccessing Engine BPE of Bernese 4.2 under UNIX platform in an automatic procedure. Weekly solutions were 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.

In these four years several topics have changed. The software currently used is Bernese 5.0. under LINUX. The current number of stations that are processed is 39. The processing strategy have changed in these years with new and better models, using new values at processing, using Absolute Antenna Phase Centre Variations, changing to the current Reference System for orbits at the processing epoch etc …. Furthermore, the products provided by IGE to EUREF have been increased with daily SINEX. Nowadays IGE collaborate with EUREF in a new project for near real time processing with Bernese 5.0, such project consists on the daily processing with Rapid Ephemeredes using the same strategy that in weekly processing.

IGE Processing Network for EUREF

IGE as a Analysis Centre

Following almost the same strategy used for EUREF, the IGE Analysis Centre is processing and Iberian Network with stations of the area which provide public data. These stations have not to be EPN stations. The name of this network is IBERRED. As a result of this process IGN is making a Time Series analysis of the coordinates for Monitoring and Geodynamical studies.

1.6 Maintenance of geodetic networks.

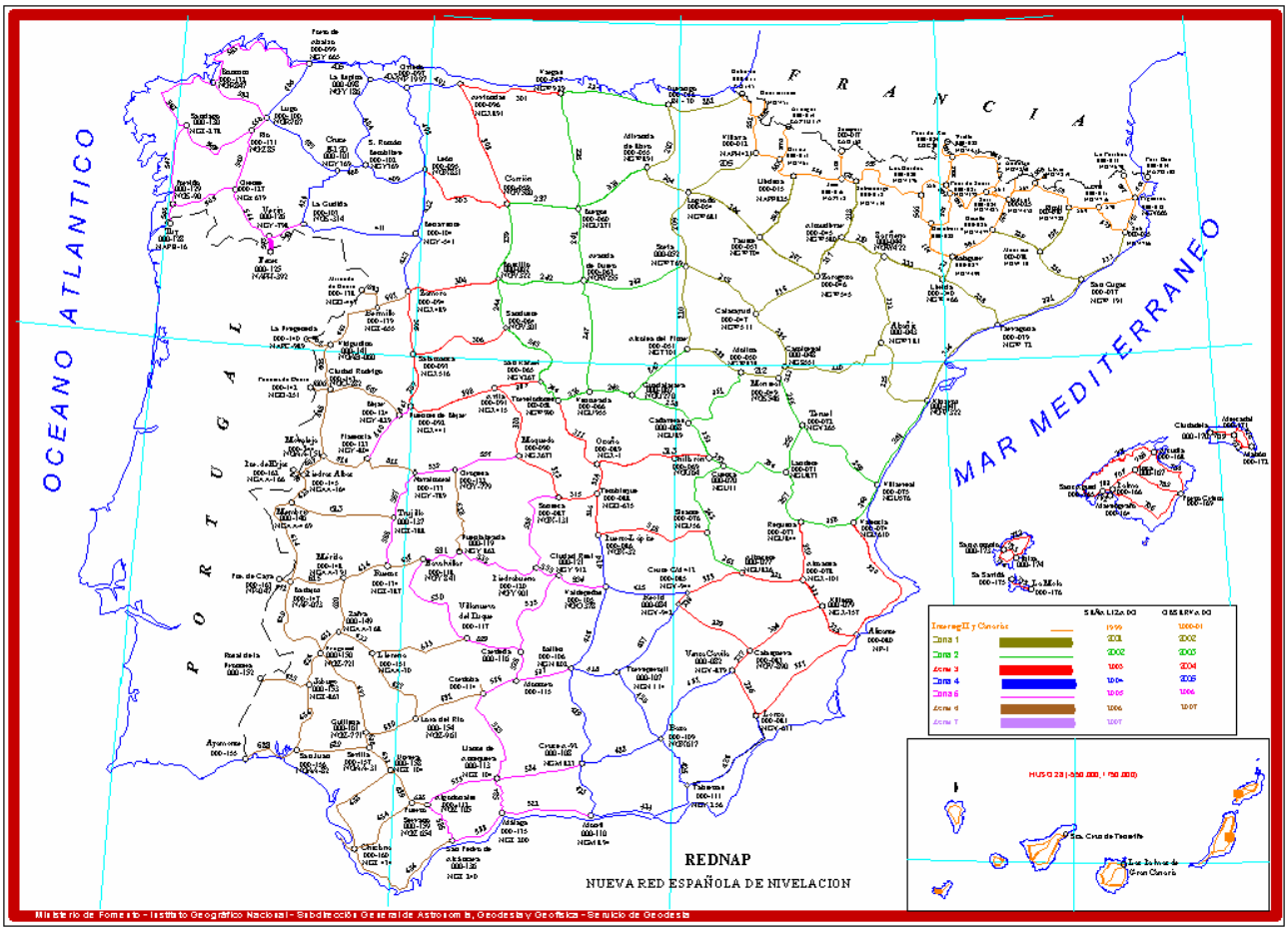
During these years the ROI maintenance that concerns to disappeared points due to different causes (public constructions, urbanizations and so on) has been carried out. New marks have been built and new coordinates of these ones have been computed.
Some equipments of the ERGPS network have been replaced, communication and quality problems have been resolved and new locations and stations have been set during these four years.

2. New Spanish National High Precision Levelling Network (REDNAP)

The Instituto Geográfico Nacional of Spain (IGNE), by its Geodesy Department, is carrying out since 2001 the establishment of a New High Precision Levelling Network (REDNAP Project). In the period 2003/2007 this project has implemented 102 new levelling lines covering 7.900 kilometres in the northwest, centre and southeast part of Spain, 9.500 levelling marks have been monumented as well. Three observation campaigns have been carried out in 2004, 2005 and 2006. Currently, the last observation campaign in the Iberian Peninsula is being carried out.
The REDNAP Project has been expanded to the Balearic Islands in 2007 in order to complete the Spanish High Precision Levelling Network. This project will be definitely finished in 2008 covering the Spanish national territory, mainland and islands, with 257 high precision levelling lines, 18.200 kilometres and more than 20.000 marks.

Summary of REDNAP (2003/2007)

ZONE	MONUMENT DATE	OBSERVATION DATE	NUMBER OF LINES	**LENGTH (KMS)**
3	2003	2004	29	2400
4	2004	2005	25	2420
5	2005	2006	35	2700
6	2006	2007(in execution)	42	2800
7(Balearic)	2007**(in execution)**	2007/08(programmed)	15	600



REDNAP Network

3. ABSOLUTE GRAVITY

The very first scientific task in Spain from the gravimetric point of view reported to the Int. Assoc. of Geodesy Commission was J. Barraquer´s work. His first measurements with Repsold's absolute pendulum were made in 1882 in the National Astronomic Observatory of Madrid, although he had performed some previous tests in 1877 in the old facilities of IGC. Eight years later, several gravimetrists of IGN carried out observations of the absolute gravity network. A new site was observed by P. Cebrián and F. de la Rica in Valladolid in 1901, which was never published before, possibly due to its higher standard error. Corrections were found by Helmert and measured by Kühnen and Furtwängler (1906), which refined Barraquer´s measurements, though, the deviations from actual values amount to 10 miliGal and more (Torge, 1989; Rodríguez, 2005).

A total of nine stations including Madrid was the very first absolute gravity set of points in Spain. The first relative measurements with Von Sterneck Pendula were performed by Dr. Oscar Hecker (Potsdam Geodetic Institute) in his travel through the Atlantic Ocean (Potsdam, Rio de Janeiro, Lisbon, Madrid) in 1901. The relative network observed by many other spanish gravimetrists (Sans Huelin, 1946) of around 210 stations were linked to Potsdam by Hecker´s value, allowing the first Bouguer and free air anomaly maps ever in Spain (1924). Between 1897 and 1989 no absolute gravity measurement is reported in Spain.

Observations provided by LaCoste & Romberg gravity meters during the sixties and the early seventies, resulted in a new set of fundamental stations in Spain inside the IGSN71 frame, called

RGFE73. The IGSN71 network (Morelli, 1974) allowed gravity values with mean errors around 0.025 miliGal at the best sites. This network along with its less accurate densification, named RGFE73, is still in use.

In the time period 1989-2003, Mäkinen and Vieira observed in Valle de los Caídos and Madrid with the JILAG-5 absolute gravimeter (Vieira, 2002). Owing to De Maria and Marson (1995, 1995a), Cerutti and De María (1992), some stations were observed by IMGC in Barcelona (Fabra Astronomical Observatory, 1995), Spanish Center for Metrology in Tres Cantos (Madrid, 1992) and Las Mesas Geophysical Observatory (Tenerife, Canary Islands, 1995) with the IMGC absolute gravimeter. Thanks to BKG, by means of the SELF I and II projects, some stations were observed and even repeated with FG5 absolute gravimeters : Valle de los Caídos (Finnish Geodetic Institute, FGI, and IAG); Tarifa, Ceuta, Alicante, San Fernando, Granada (Wilmes and Falk, 2003, BKG).

Absolute gravity stations are divided into two sub-networks (figure 1): the zero order network and the first order network.

Absolute gravity sites

3.1 Zero order network

More than 35 sites have been occupied from 2001 until 2006, including those of the intercomparisons for the zero order network, i.e. FG5 observations. Some sites have already been re-occupied, allowing thus the beginning of the time series. All results must be considered in the frame of the international absolute intercomparisons and carefully observed in the future to detect outliers. All observation and processing protocols are similar to those performed in the above mentioned intercomparisons and the World Gravity Standards (Boedecker, 1988).

Most stations, placed in geophysical or astronomical observatories, have a strong well founded pier without any metallic reinforcement bar. Piers are usually connected to bedrock to reduce instrumental

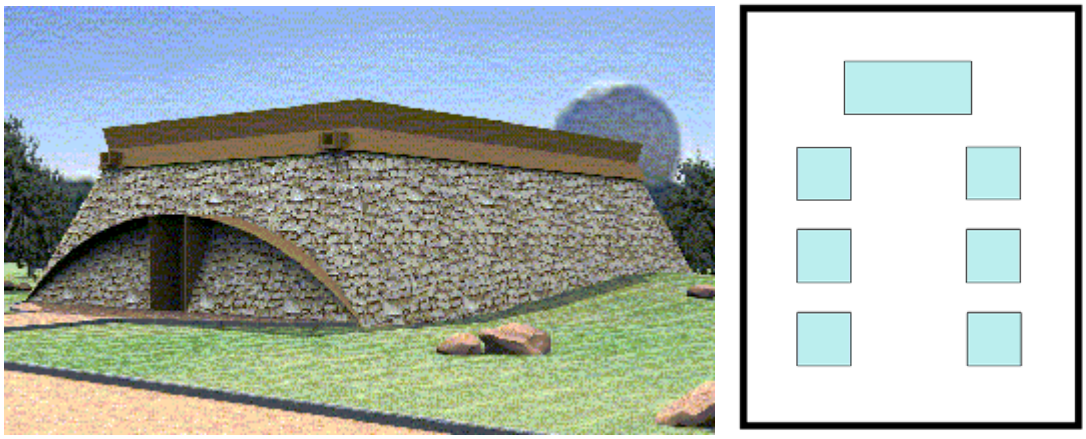
vibrations. Seismically quiet sites far from cultural and industrial noise bring up low scattered observations. In those cases where no such facilities were found, a special selection of old well founded buildings (abbeys, old churches, universities, etc) were chosen. Thus, examples such as Geophysical Observatory of Santiago de Compostela, Geophysical Observatory of Logroño, Geophysical Observatory of Málaga, Geophysical Observatory of Almería, Geophysical Observatory of San Pablo de los Montes (Toledo), El Miracle Cluster (Lleida), Astronomical Observatory of Fabra (Barcelona), Ebro Observatory (Tarragona), El Puig Monastery (Valencia), and Valle de los Caídos (IAGBN station) already observed, point up a quietness and very long permanence qualities.

The station Astronomical Observatory of Madrid is located in the library of the main facility building of "Observatorio Astronómico Nacional", inside the "Parque del Retiro" in Madrid. The measurement was made in the pillar where Mr. Joaquin Barraquer placed the Strasser clock for his 1882 absolute gravity determination, which is about 1 meter to the west of the pier where he made the measurements with the Repsold Pendulum. The station is placed on a granite outcrop around 1.8 m deep in the ground. There is a IGSN71 point next to these piers (MADRID-A).

Since 1933 the Gravity Laboratory of IGN in Madrid is a fundamental point, where an IGSN71 core station Madrid-C and absolute piers coexist in the same room.

The geological stability and low noise (far from big roads) of the San Pablo de los Montes and Sonseca sites in “Montes de Toledo”, in the Sistema Central Mountain Range, allows to join geodetic, magnetic, seismological and gravity instruments in the same site. Two piers are set up to measure gravity.

Yebes Astronomical Observatory is a special facility for combining top quality techniques (VLBI, GPS and absolute gravity) also at the same site. The facility is supposed to have seven pillars for absolute gravity intercomparison and a superconducting gravity meter pier. The building is almost finished.



Project of Yebes absolute gravity site with seven piers.

An easily accessible eccentric at every station will be set up to facilitate direct value of gravity. Some eccentrics were already measured.

Before absolute measurements, true gravity gradient observations were made to introduce the best possible gradient in the absolute gravity formula and to translate the absolute value from effective height to the floor, see for instance Niebauer et al. (1989, 1995) and also Francis and Van Dam (2003). A LaCoste & Romberg, Model G, gravimeter with analogue feedback system was used to develop this task. At least 24 hours of measurements were made in every station to obtain the final absolute value, 24 set of a hundred drops per set, namely about 2400 drops. The starting fringe was 30 in all cases,

and the number of fringes were 600, namely a million and a half time-distance pairs. To obtain the final results, the g software processing tool from Microgsolutions Inc. (Niebauer et al., 2002) has been employed.

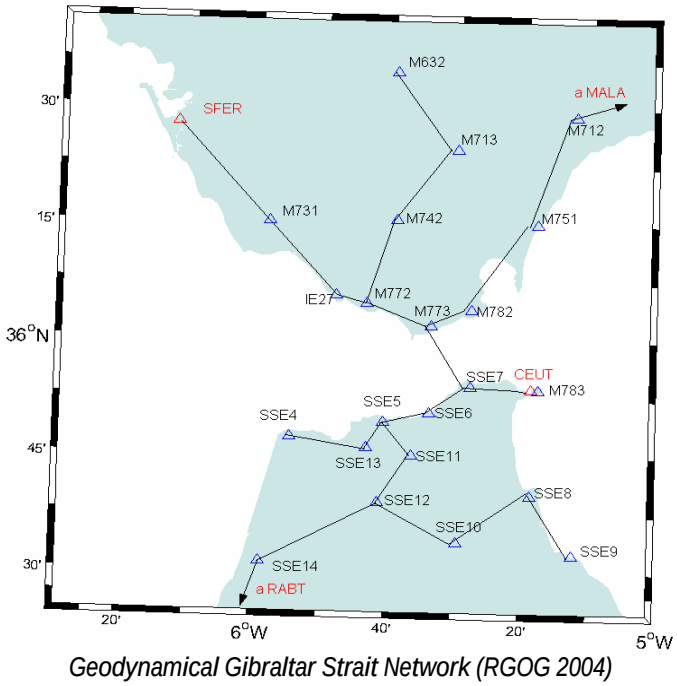
3.2 First order network

Around forty (40) sites have been occupied with the A10 gravimeter as the first order network (figure 1). Most of these sites have also a concrete pier to obtain a good stability, sharing accelerometer sites. Also the main entrance of churches and cathedrals are stable buildings and considered as sites. Measurements of gradient were carried out to translate the 0.7 m nominal height value to the floor datum. All stations were processed identically as the zero order stations.
Gravity stations in Spain are then divided in two first classes:
CLASS A: absolute station with gravity rate
Precision ±1,1 microGal and accuracy ±3 microGal
CLASS B: absolute station without gravity rate
Subclass B1: Precision ±3 microGal and accuracy ±5 microGal
Subclass B2: Precision ±5 microGal and accuracy ±10 microGal

4. SPECIAL WORKS

4.1 Gibraltar Strait GPS Network (RGOG 2004)

The construction of permanent communication system between the African and European continents through Gibraltar Straits has been one of the objectives of the cooperation between Spain and Morocco in the last years. For the construction of this system of permanent communications the necessity of a geodynamic study of the area is obvious, since Gibraltar Strait in an area of confluence of different tectonic plates. The geodetic techniques have demonstrated to be essential for the accomplishment of this type of studies.

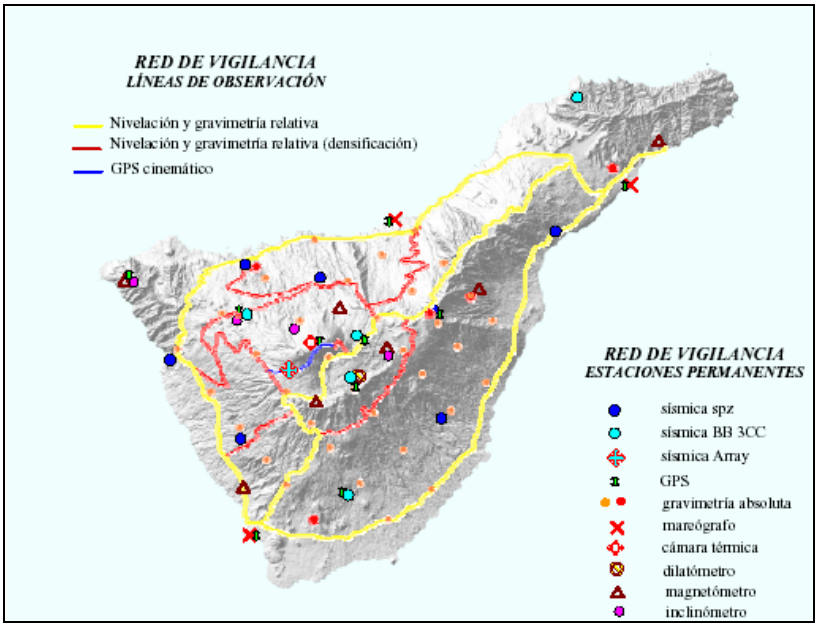


Geodynamical Gibraltar Strait Network (RGOG 2004)

In 2004 this collaboration was continued. It was agreed to make as GPS synchronized observation of whole network (both sides of the Strait) simultaneously for five days at interval of 8 hours per day . This set of points forms the Geodesic Network of Geodynamic Observations of the Straits of Gibraltar (RGOG). The net has a new configuration with respect to the observation of 1989, since it includes new points (in Morocco) that were not included in previous campaigns, because of the new name taken RGOG 2004. In October 2004 the Spanish and Moroccan national geodesic agencies observed a five days GPS campaign of 22 points.

4.2 Tenerife Volcanic Monitoring System Project

Several seismic movements affected Tenerife Island, the biggest of the Canary Islands, year 2004. The Spanish Government decided to develop a Volcanic Monitoring System basic project. The development of this basic project is carrying out to observe, monitor and communicate possible volcanic activities in Tenerife Island and also to determinate associated risks.
In this basic project seismic, geodetic and geophysical data sub-systems and the broadcasting of these data have been taken into account to determine the instrumental systems for observation and analysis of those phenomena linked to volcanic activity that could appear.
Next figure shows infrastructures, instrumentation and seismic, geodetic and geophysical facilities that have been projected to install in the next two years.



Tenerife Volcanic Monitoring System

4.3 Referencing of Space Tracking stations

Referencing of space tracking stations consists of the use of the more precise geodesic techniques in order to get the most exact definition of the space position of the axes of the antennas of these ones. In this type of work it is necessary to use classic geodesic instrumentation (theodolites) as well as of space geodesy instrumentation (GPS). Until this moment the IGN has collaborated in the referencing of stations for different institutions. On one hand with INTA-NASA in stations located in Maspalomas (Great Canary) and Robledo de Chavela (Madrid) and on the other hand with the European Space Agency (ESA) in the referencing of stations in Villafranca del Castillo (Madrid). In addition there is a

continuous collaboration with the Astronomical observatory Nacional (OAN) in the referencing of its stations.

Four Space Tracking Antennas in Villafranca del Castillo were observed in 2003. The antennas that were observed are VIL-1, TS-1, MARECS and EXOSAT. At this work classic geodesic instrumentation (theodolites) like of space geodesy instruments(GPS) were used. 23 points place close the antennas, six or five of them around each one were observed with GPS. Afterwards, four marks (placed at both sides of each antenna) were observed from the GPS points with classic geodesic instrumentation (theodolites) in six different positions. Finally, the obtained set of coordinates for each antenna were adjusted with the least-squares algorithm in order to get the cross points between horizontal and vertical axes.

BIBLIOGRAPHY

David Riaño, Emilio Chuvieco, Sonia Condés, Javier González Matesanz. Generation of crown bulk density for Pinus sylsestris from LIDAR. 23rd EARSel Annual Symposium 2003. . Seleccionado como Special issue en Remote Sensing Environment. European Association of Remote Sensing Laboratories, Gent, Belgium, 77-81. 2-5 Junio 2003

González-Matesanz, F.J., Dalda-Mourón, *A.* Modelos De Transformación Entre Ed50 Y Etrs89. 5ª Setmana Geomàtica de Barcelona. Institut de Geomàtica, Barcelona, Program and Abstracts. 2003

J. Fernández, F. J. González-Matesanz, J. F. Prieto, G. Rodríguez-Velasco, A. Staller , A. Alonso-Medina, and M. Charco. GPS MONITORING IN THE N-W PART OF TENERIFE, CANARY ISLANDS. European Geophysical Society. American Geophysical Union of European Union of Geosciences Joint Assemby. EGS-AGU-EUG, Niza, Francia, . 6-10 Abril 2003

J. Fernández, G. Rodríguez-Velasco, J. González-Matesanz, J. F. Prieto, R. Romero, A. Staller, M. Charco, A. Alonso-Medina, T.-T. Y*u.* Geodetic monitoring system in Tenerife, Canary Islands, using InSAR and GPS. Strategy and results. Time-variable deformation and gravity fields: theory, observations and modelling. . International Association of Geodesy (IAG), Section IV: Theory and Methodology, Special Study Group 4.189: Dynamic theories of deformation and gravity fields, Casa de los Volcanes, Lanzarote, Canary Islands, Program and Abstracts, pag. 12. 18-21 Febrero 2003

J. Fernández, G. Rodríguez-Velasco, J. González-Matesanz, J. F. Prieto, R. Romero, A. Staller, M. Charco, A. Alonso-Medina, T.-T. Yu. Geodetic monitoring system in Tenerife, Canary Islands, using InSAR and GPS. Strategy and results. 2nd Meeting Special Study Group 4.189: Dynamic theories of deformation and gravity fields. International Association of Geodesy (IAG), Section IV: Theory and Methodology. Workshop: Time-variable deformation and gravity fields: theory, observations and modelling, Casa de los Volcanes, Lanzarote, Canary Islands, . 18-21 Febrero 2003

Weber, Georg, Gonzalez-Matesanz*, Javier.* EUREF-IP for Wireless GNSS/DGNSS,Example Implementation in Madrid. EUREF 2003 Symposium of the IAG Subcommission for Europe (EUREF). Subcomisión EUREF de la Asociación Geodésica Internacional para Europa, Toledo, Spain, Program and Abstracts. 4-7 Junio 2003

Fernández, J., González-Matesanz, Prieto, J.F., Rodríguez-Velasco, G., Staller, A., Alonso-Medina, A*., Charco, M.* Control con GPS de la zona noroeste de la isla de Tenerife. 4ª Asemblea Hispano Portuguesa de Geodesia y Geofisica. Comisión Nacional de Geodesia y Geofísica. Secçao Portuguesa das Unioes Internacionais Astronómica e Geodésica e Geofísica, Figueira da Foz, Portugal, Program and Abstracts pp. 531-532. 3 - 7 Febrero 2004

González-Matesanz, F.J, Quirós, R., Cano M., Dalda, *A.* Posicionamiento GPS en tiempo real a través de internet. EUREF-IP. Congreso nacional de Topografía y Cartografía Topcart 2004. Ilmo. Colegio oficial de ITT, Madrid, Program and abstracts. Noviembre 2004

González-Matesanz, F.J, Quirós, R., Cano M., Dalda, A. y Sanchez, J. El cambio de datum ED50-ETRS89. Métodos y resultados. Congreso nacional de Topografía y Cartografía Topcart 2004. Ilmo. Colegio oficial de ITT, Madrid, Program and abstracts. Noviembre 2004

Priego, E., González-Matesanz, F.*J.* Catalogación de las estaciones de referencia GPS en España. Congreso nacional de Topografía y Cartografía Topcart 2004. Ilmo. Colegio oficial de ITT, Madrid, Program and abstracts. Noviembre 2004

Gonzalez-Matesanz, F.J., Quiros R., Cano, M. y Dalda, A. Euref-ip. towards an integrated GPS+internet positioning service. International Cartographic Conference. , A Coruña, Program and abstracts 44. Julio 9-16

Berné, J.L., Capilla, R., Cañas, A. Fernández, R., Gonzalez-Matesanz, F.J.,Malpica, J.*A.* Test de evaluación de transición de Datum en cartografía regional de Valencia. 5ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica. Comisión Nacional de Geodesia y Geofísica. Secçao Portuguesa das Unioes Internacionais Astronómica e Geodésica e Geofísica, Sevilla, . 30 de enero a 3 de febrero

Fernández, J., Yu, T.-T., Rodríguez-Velasco, G., Gonzalez-Matesanz, F.J., Romero, R., Rodríguez, G., Quirós, R., Dald*a, A., Aparicio, A., and Blanco, M.J.*, 2003. New Geodetic Monitoring System in the Volcanic Island of Tenerife, Canaries, Spain. Combination of InSAR and GPS Techniques. Journal Volcanology and Geothermal Research, 124/3-4, 241-253.

Fernández, J., F. J. González-Matesanz, J. F. Prieto, A. Staller, G. Rodríguez-Velasco, A. Alonso-Medina and M. Charco, 2004. GPS Monitoring in the N-W part of the Volcanic Island of Tenerife, Canaries, Spain. Strategy and results. Pure and Applied Geophysics, vol 161, nº 7, 1359-1377, DOI: 10.1007/s00024-004-2509-2. (también publicado en libro)

Fernández, J., Romero, R.; Carrasco, D., Tiampo, K.F., Rodríguez-Velasco, G., Aparicio, A., Araña, V., González-Matesanz, F*.J., 2005.* Detection of displacements in Tenerife Island, Canaries, using radar interferometry. Geophysical Journal International, 160, 33-45. doi: 10.1111/j.1365-246X.2005.02487.x.

Fernández, J., F. J. González-Matesanz, J. F. Prieto, A. Staller, G. Rodríguez-Velasco, A. Alonso-Medina and M. Charc*o*, 2004. GPS Monitoring in the N-W part of the Volcanic Island of Tenerife, Canaries, Spain. Strategy and results. ISBN 3-7643-7044-0. Birkhäuser Verlag, Basel-Boston-Berlin. Reprint de Pure and Applied Geophysics (PAGEOPH), vol 161 (2004), nº 7, 1359-1377

Gonzalez-Matesanz, F.J.,Malpica, J.A. Quasi-conformal mapping with genetic algorithms applied to coordinate transformations. Computer and Geosciences., Marzo 2006

González-Matesanz, F.J., Dalda, A. Malpica, J.A. A range of ed50-etrs89 datum transformation models tested on the Spanish geodetic network. Survey Review.2006

Quirós, R., Cano, M. A., Sobrino, J. A. S., Valdés, M.: "National Report of Spain: Spanish national Reference Station Network (ERGPS)". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 29. EUREF Publication No.12. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Ponta Delgada 2002. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2003. ISBN 3-89888-873-8 pp 290.

Quirós, R., Cano, M. A., Sobrino, J. A. S., Valdés, M.: "National Report of Spain: New Local Analysis Centre:IGE". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 29. EUREF Publication No.12. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Ponta Delgada 2002. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2003. ISBN 3-89888-873-8 pp 291.

Quirós, R., Barbadillo, A.., Cano, M. A., Sanz, M., Sobrino, J. A. S.: "National Report of Spain: REGENTE project finished". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 29. EUREF Publication No.12. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Ponta Delgada 2002. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2003. ISBN 3-89888-873-8 pp 292.

Quirós, R., Fraile, J., Bendala, F., Valdés, M., Sobrino, J. A. S.: "National Report of Spain: SERDAG Project". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 29. EUREF Publication No.12. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Ponta Delgada 2002. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2003. ISBN 3-89888-873-8 pp 293.

Barbadillo, A., De La Cruz, F., Quirós, R.: "National Report of Spain: REDNAP Project". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 29. EUREF Publication No.12. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Ponta Delgada 2002. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2003. ISBN 3-89888-873-8 pp 293.

Dalda, A., González-Matesanz, F. J.: "National Report of Spain: Development of the ED50-ETRS89 datum transition". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 29. EUREF Publication No.12. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Ponta Delgada 2002. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2003. ISBN 3-89888-873-8 pp 295.

Dalda, A., Rodríguez, E., Núñez E., Fernández M.: "National Report of Spain: Zero Order Gravity Network of Spain". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 29. EUREF Publication No.12. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Ponta Delgada 2002. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2003. ISBN 3-89888-873-8 pp 296.

Quirós, R., Lozano, L., Cano, M. A., Sobrino, J. A. S., Valdés, M.: "Estado actual del procesamiento de redes GPS en el IGN". *4ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Figueira da Foz (Portugal). 3-7 febrero 2004.

González-Matesanz, F. J., Weber, G., Celada, J., Dalda, A., Quirós, R.: "El proyecto EUREF-IP. Resultados con GPRS". *4ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Figueira da Foz (Portugal). 3-7 febrero 2004.

García-Cañada, L., Sevilla, M. J., Núñez, A., Cano, M. A.: "Estado actual del procesamiento de redes GPS en el IGN". *4ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Figueira da Foz (Portugal). 3-7 febrero 2004.

Fernandez, J., González-Matesanz, Prieto, J. F., Rodríguez-Velasco, G., Staller, A., Alonso-Medina, A. Charco, M.: "Control con GPS de la zona Noroeste de la isla de Tenerife". *4ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Figueira da Foz (Portugal). 3-7 febrero 2004.

Celada, J., González-Matesanz, F. J., Dalda, A., Quirós, R., Vivas-White, P.: "Nueva web de cálculos geodésicos del Instituto Geográfico Nacional". *4ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Figueira da Foz (Portugal). 3-7 febrero 2004.

González-Matesanz, F. J., Dalda, A., Quirós, R., Celada, J., Sobrino, J. A. S.: "Predicción de diferencias entre ED50 y ETRS89". *4ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Figueira da Foz (Portugal). 3-7 febrero 2004.

Sobrino, J. A. S. et al.: "Spanish National Report". *EUREF 2004 Symposium*. Bratislava (Chequia). 2-6 June 2004.

Valdés, M. et al.: "Spanish National Report". *EUREF 2005 Symposium*. Bratislava (Chequia). 1-4 June 2005.

Rodríguez Pujol, E., M. Fdez. Villalta, E. Núñez (2004) "Red gravimétrica absoluta de orden cero de España". IV Asamblea Hispano-Portuguesa de Geodesia y Geofísica: Comunicación. Febrero, Figueira da Foz (Portugal).

Rodríguez Pujol, E., M. Fdez. Villalta, E. Núñez (2004) "Red gravimétrica absoluta de primer orden de España". E. Rodríguez, M. Fdez. Villalta, E. Núñez. IV Asamblea Hispano-Portuguesa de Geodesia y Geofísica: Comunicación. Febrero, Figueira da Foz (Portugal).

Rodríguez Pujol, E., M. Fdez. Villalta, E. Núñez (2004) "Observaciones absolutas de la gravedad en el Pico Veleta (Granada)". E. Rodríguez, M. Fdez. Villalta, E. Núñez. IV Asamblea Hispano-Portuguesa de Geodesia y Geofísica: Comunicación. Febrero, Figueira da Foz (Portugal).

Rodríguez Pujol, E., M. Fdez. Villalta, E. Núñez (2004) "Resultados de Intercomparaciones de gravímetros absolutos". E. Rodríguez, M. Fdez. Villalta, E. Núñez. IV Asamblea Hispano-Portuguesa de Geodesia y Geofísica: Comunicación. Febrero, Figueira da Foz (Portugal).

Quirós, R., , Sobrino, J. A. S., Cano, M. A., Valdés, M.: "National Report of Spain: Spanish national GPS Reference Stations Network (ERGPS)". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 33. EUREF Publication No.13. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Toledo 2003. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2004. ISBN 3-89888-885-1 pp 283.

Barbadillo, A., De La Cruz, F., Quirós, R.: "National Report of Spain: REDNAP Project". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 33. EUREF Publication No.13. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Toledo 2003. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2004. ISBN 3-89888-885-1 pp 284.

Dalda, A., Rodríguez, E., Núñez E., Fernández M.: "National Report of Spain: Zero Order Absolute Gravity Network of Spain". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 33. EUREF Publication No.13. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Toledo 2003. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2004. ISBN 3-89888-885-1 pp 285.

Dalda, A., González-Matesanz, F. J., Celada, J.: "National Report of Spain: RECORD (Radio Broadcasting of GPS Differential Corrections". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 33. EUREF Publication No.13. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Toledo 2003. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2004. ISBN 3-89888-885-1 pp 286.

Dalda, A., González-Matesanz, F. J.: "National Report of Spain: Development of the ED50-ETRS89 datum transition". Mitteilungen des Bundesamtes für Kartographie und Geodäsie. Band 33. EUREF Publication No.13. Report on the Simposium of the IAG Subcomission for Europe (EUREF), held in Toledo 2003. Verlag des Bundesamtes für Kartographie und Geodäsie. Frankfurt am Main 2004. ISBN 3-89888-885-1 pp 289.

Valdés, M., Dalda, A., Quirós, R.: "Red Geodésica de Observación Geodinámica del estrecho de Gibraltar 2004". 5ª *Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Sevilla (España). febrero 2006.CD ISBN 84-8320-373-1.

Rodríguez Pujol, E., Fdez. Villalta, M.: "Red de gravimetría absoluta en España". 5ª *Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Sevilla (España). febrero 2006.CD ISBN 84-8320-373-1.

Rodríguez Pujol, E., Fdez. Gil, A J.: "Determinaciones Absolutas de la Gravedad en Jaén". 5ª *Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Sevilla (España). febrero 2006.CD ISBN 84-8320-373-1.

Mena, J. B., Dalda, A.: "Digitalización de datos antiguos registrados por el Mareógrafo de Alicante". 5ª *Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Sevilla (España). febrero 2006.CD ISBN 84-8320-373-1.

Barbadillo, A., De la Cruz, F.: "Nueva Red Española de Nivelación de Alta Precisión. Proyecto REDNAP". 5ª *Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Sevilla (España). febrero 2006.CD ISBN 84-8320-373-1.

González-Matesanz, F. J., Malpica J. A. Dalda, A.: "Aplicación de los Algoritmos Genéticos en un problema de transformación de Sistemas de Referencia mediante polinomios conformes por trozos". 5ª *Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Sevilla (España). febrero 2006.CD ISBN 84-8320-373-1.

Cano, M. A., Talaya, J., Termens, A., Quirós, R., Revuelta, L., Sobrino, J. A. S.: "Ajuste de la Red Geodésica de Orden Inferior R.O.I. de Cataluña en ETRS89". 5ª *Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Sevilla (España). febrero 2006.CD ISBN 84-8320-373-1.

García-Asenjo, L., González-Matesanz, Hernández, D..: "Crs++ Software libre para la gestión de Sistemas de Referencia Coordenados". 5ª *Asamblea Hispano-Portuguesa de Geodesia y Geofísica*. Sevilla (España). febrero 2006.CD ISBN 84-8320-373-1.

Quirós, R., Cano, M. A., Sobrino, J. A. S., Valdés, M.: "El Servidor FTP de la Red de Estaciones Permanentes del IGN". Topografía y Cartografía. Band 29.Vol XIII- nº 128 Mayo-Junio 2005. ISSN 0212-9280 pp 42-46.

Rodríguez Pujol, E, Fernández de Villalta, M, Núñez Maderal (2003). "Red gravimétrica de orden cero y primer orden en España., E. Actas de la 5ª Setmana de Geomática, Barcelona. 2003. En CD.

Rodríguez Pujol, E. (2004) "Absolute Gravity Network in Spain". Gravity, Geoid, and Satellite Missions (GGSM2004). Poster and paper in CD. September, Oporto (Portugal).

Rodríguez Pujol, E. (2005). "Medidas gravimétricas en Madrid y en España". Artículo de Divulgación. Anuario del Observatorio Astronómico 2005. Dirección del Instituto Geográfico Nacional. Ministerio de Fomento.

Rodríguez Pujol, E.(2005)."Absolute Gravity Network in Spain". *Física de la Tierra* 17, 147-163.

Rodríguez Pujol, E. (2005). "Absolute Gravity Network in Spain". EUREF Publication Symposium Viena. Poster and paper

6.- 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: jgarate@roa.es, mdavila@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 2003-2006, the station has been upgraded in the following items:

. • Main and secondary mirrors were delivered to be recoated at Nice Observatory in February 2003. They were recovered in May 12th, but they should be sent again back to Nice, because some problems in the recoating. Finally they were successfully reinstalled in the beginning of September.
. • A complete refurbishment of the tracking station facilities was made during the summer of 2003.
. • Redesign and implement new electronic circuit boards.
. • A new CCD camera with light intensifier was located on the telescope in order to make easier the tracking of low/medium satellites.
. • A new continuous diaphragm was installed to replace the old one, allowing a more accurate satellite tracking.
. • The old photomultiplier was decommissioned, because it was becoming worse. Since it is not as precise as the CSPAD detector, and it is not easy to find replacements, we decide to decommission it.
. • A new rack with the laser control system and the time measurement device was mounted. A set of three interval counters (SR620i) was installed in order to make a more accurate time measurements, allowing intercomparison among these devices.
. • One of the counters was carried out to the Herstmonceaux SLR facility in the UK, in order to calibrate it against the set of counters of that station.
. • The barometer was calibrated with respect a master which was delivered from the UK, and travelled around the SLR stations in Europe

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

. • "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.
. • "Laser Tracking on GNSS satellites (GPS, Galileo…)" (ESP2004-4598), from the National Program for Space Research, 'Ministerio de Educación y Ciencia' of Spain.

A brief tracking statistics for the 2003-2006 period are:

2003:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	22	12			4	1			1	1	16	12
Lageos 2	17	1			7	6			1	0	4	7
Ajisai	26	12			53	28			3	14	48	31
Starlette	27	10			18	14			0	10	16	16
Topex	38	5			19	1			2	9	28	24
Stella	16	5			5	0			1	7	15	4
ERS2	18	7			24	16			1	6	9	12
Champ	0	0			2	0			0	0	2	3
Jason	19	1			9	0			1	3	9	11
GFO	7	3			12	12			0	7	16	8
BEC	28	8			15	2			4	7	31	20
Reflector	6	2			0	0			0	0	0	0
GRACE A	1	2			0	0			1	0	0	2
GRACE B	2	0			1	2			0	0	0	2
Meteor 3	0	0			2	2			0	0	0	0
Larets											5	6

Number of successful tracking in 2003

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	7497	5242			934	106			104	26	3934	1372
Lageos 2	7051	690			3984	1663			317	0	871	1447
Ajisai	26847	8940			77121	25161			2739	7993	34141	31537
Starlette	9191	4099			4519	2519			0	2335	6205	4381
Topex	32258	6380			14014	860			1502	3521	19816	11220
Stella	6138	1833			1041	0			223	1569	5305	409
ERS2	4181	744			8436	4738			86	773	988	4365
Champ	0	0			109	0			0	0	215	100
Jason	7997	112			3680	0			364	870	2485	3677
GFO	1406	256			3004	4102			0	1814	2471	1503
BEC	21149	5081			7212	698			1647	3390	11613	12224
Reflector	296	81			0	0			0	0	0	0
GRACE A	40	347			0	0			896	0	0	105
GRACE B	284	0			145	664			0	0	0	71
Meteor 3	0	0			106	45			0	0	0	0
Larets											559	365

Number of successful echoes in 2003

2004:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	10	15	12	10	14	21	11	16	20	6	15	13
Lageos 2	13	18	11	7	0	1	11	7	23	16	16	5
Ajisai	22	52	27	7	54	12	42	48	24	24	63	9
Starlette	18	13	14	22	7	52	11	23	17	14	42	15
Topex	12	13	25	24	3	36	35	29	10	18	35	34
Stella	4	4	1	15	0	0	2	2	4	3	0	0
ERS2	7	7	7	9	25	33	31	28	19	12	13	21
Champ	1	1	1	3	1	7	2	2	9	0	3	1
Jason	6	5	18	20	3	26	22	24	3	7	30	33
GFO	3	8	0	3	12	14	0	1	24	7	10	11
BEC	9	30	16	27	5	59	21	30	30	15	44	13
GRACE A	1	7	0	0	2	10	9	1	0	1	3	6
GRACE B	2	5	1	1	5	9	8	1	0	1	7	8

Larets	6	4	3	7	9	11	10	14	10	6	8	18

Number of successful tracking in 2004.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	2381	7829	4612	1870	6306	6883	10947	16611	11509	3342	4331	38501
Lageos 2	5117	9644	7124	1370	0	1301	3535	5222	14254	6582	6129	965
Ajisai	20148	76301	43632	4987	142801	17288	77951	117467	15972	29728	82976	18224
Starlette	6022	5722	6510	12147	3682	15991	4117	9680	7362	7546	25031	3761
Topex	13361	13973	33581	31945	6183	54097	47286	33277	16168	18228	41450	40328
Stella	1722	1780	15	0	0	0	559	1452	1539	670	0	0
ERS2	2403	1389	918	2491	20045	29823	21322	16482	6767	2692	3537	7487
Champ	423	95	53	783	130	2591	835	368	3339	0	388	71
Jason	3685	2575	10972	14181	1580	21763	18910	21002	2924	1510	12349	17093
GFO	388	3502	0	2352	9253	10823	0	294	22672	1427	2509	4263
BEC	4864	27724	9912	27537	3698	65930	14727	31193	27979	13220	29937	13627
GRACE A	150	940	0	0	107	2422	3767	115	0	21	300	775
GRACE B	646	1413	21	109	759	2272	3485	90	0	22	804	1650
Larets	646	1313	632	1976	1772	2641	2003	3914	2249	983	2529	3559

Number of successful echoes in 2004.

2005:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	7	15	3	7	15	24	34	18	45	32	33	12
Lageos 2	4	17	1	23	30	14	10	0	20	18	39	20
Ajisai	37	68	7	55	44	10	63	29	21	30	41	6
Starlette	35	14	8	15	9	45	11	17	27	13	30	4
Topex	7	35	19	28	8	44	31	20	14	18	12	2
Stella	0	0	0	2	1	1	0	0	3	2	0	0
ERS2	18	18	3	23	23	31	27	19	28	16	8	8
Champ	2	0	0	1	4	0	0	0	5	6	0	1
Jason	4	24	15	23	3	34	26	16	3	22	14	12
GFO	8	22	5	12	11	2	2	4	26	9	10	1
BEC	30	16	17	7	39	25	32	27	20	36	11	22
GRACE A	1	0	0	1	3	6	0	0	5	3	3	0
GRACE B	2	0	1	2	10	5	0	0	7	6	1	2
Envisat	13	25	9	21	27	24	36	17	29	18	19	10
GP-B	2	2	0	12	7	0	5	0	15	6	10	3
Larets	12	16	7	13	12	13	16	7	17	8	12	8

Number of successful tracking in 2005.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	3088	5026	233	3304	11507	12164	33958	26022	64308	37345	25382	2113
Lageos 2	1163	3592	62	11845	20960	8003	4517	0	22887	18292	29512	9652
Ajisai	43493	124550	11769	97394	95068	6517	131558	49735	16511	30827	63864	8345
Starlette	16463	5022	3085	6596	5966	24163	4291	10062	16409	6121	17517	975
Topex	7319	35600	28352	41870	4246	64604	55592	34705	19419	16457	9649	1410
Stella	0	0	0	487	48	67	0	0	3717	992	0	0
ERS2	6029	6212	1321	14447	15650	23968	23167	12985	12638	5273	4452	2220

Champ	327	0	0	124	866	0	0	0	360	2003	0	185
Jason	766	8977	10758	20182	1617	26118	18787	11892	400	14093	3919	4458
GFO	10525	20812	1464	4541	6542	987	365	3692	18071	3556	4260	1730
BEC	26521	19128	6751	5987	45906	21191	36895	24411	13358	29585	6810	21414
GRACE A	251	0	0	181	1425	2453	0	0	1027	598	825	0
GRACE B	1448	0	481	372	3101	1966	0	0	1104	2207	334	276
Envisat	4595	6677	3914	12787	2279	19443	27562	13079	16271	8682	8002	2817
GP-B	270	175	0	2910	1984	0	2498	0	4543	1082	4014	2226
Larets	3257	3941	1294	2375	3112	4175	6018	1641	6612	1694	2364	2096

Number of successful echoes in 2005.

2006:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	10	15	21	18	16	7	3	4	4	2	13	13
Lageos 2	10	8	2	1	13	16	29	27	16	5	4	5
Ajisai	29	28	2	36	30	14	59	22	10	50	29	26
Starlette	19	4	6	19	9	25	3	38	24	15	50	13
Stella	0	0	0	0	0	0	0	0	1	0	3	1
ERS2	5	5	9	20	21	22	29	26	19	23	16	19
Champ	1	6	0	1	2	7	0	1	3	7	8	0
Jason	5	7	13	11	14	17	30	6	8	22	13	9
GFO	7	8	6	3	0	1	8	28	11	8	12	18
BEC	2	21	24	13	39	9	4	4	35	16	37	22
GRACE A	0	0	3	5	3	0	1	7	5	6	2	1
GRACE B	0	0	1	4	3	0	4	8	7	8	3	3
Envisat	7	10	11	18	24	23	27	30	16	19	21	21
GP-B	0	2	0	8	14	0	0	0	0	0	0	0
Larets	3	5	6	8	6	9	17	20	13	17	12	9

Number of successful tracking in 2006.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	2441	3453	14401	17162	20144	5465	474	2940	3535	725	13166	5377
Lageos 2	2369	1340	837	17	11317	8718	45381	47652	10618	8817	571	1150
Ajisai	49782	35024	536	55190	47191	18000	165899	63391	9591	102968	61671	32684
Starlette	9789	2454	1911	11013	5983	12035	1158	27799	11228	11712	39176	5397
Stella	0	0	0	0	0	0	0	0	389	0	319	1433
ERS2	2658	1383	3264	8825	14463	15281	22996	23511	8649	18997	8949	7168
Champ	54	1203	113	30	237	2558	0	131	408	1256	3334	0
Jason	266	3190	4453	11804	12918	9958	41760	11709	2857	23258	8546	6976
GFO	4100	2423	2555	1352	0	45	6453	28403	3883	6108	7740	10972
BEC	318	12540	32901	9870	45311	7587	51246	3545	36603	16629	52044	23846
GRACE A	0	0	614	2176	1156	0	74	2089	664	2930	849	83
GRACE B	0	0	63	1137	821	0	869	1596	1818	2302	815	434
Envisat	2553	3655	3350	10160	15365	19765	27621	27693	6285	10938	12984	10402
GP-B	0	70	0	2932	9967	0	0	0	0	0	0	0
Larets	1609	788	2585	2002	1771	3872	3762	5869	2769	5152	3836	2726

Number of successful echoes in 2006.

On the other hand, since June 7th, 2004, until June 11th, ROA organized the 14th LASER RANGING WORKSHOP, held in San Fernando. About 120 people involved in the International Laser Ranging Service attended the meeting. A proceedings volume was issued, including the main topics developed during the workshop. Presentations shown at the workshop, as well as papers related, are available through the ILRS web page (ilrs.gsfc.nasa.gov)

2. GPS geodetic activity.

During this period ROA has organized several field surveys, in the Andalusian Region in order to complete the GPS Geodetic Network, getting data files at Cordoba, Castillo de Segura, Malaga and Almeria. The set of data files is going to be used in the development of a Ph. D. which is scheduled to be presented during the year 2007.

The Cuateneo Network, installed by the Catalonian Cartograpich Institute, and the University of Barcelona was also revisited in 2006. "Cuateneo-2006" GPS episodic survey was organized by the San Fernando Observatory in collaboration with the University of Barcelona, covering the Cuateneo GPS Network at Murcia and Almeria provinces. We had the support of University of Cadiz students to perform the observations at field. The survey was carried out in September 2006, and was funded by the '*Ministerio de Educación y Ciencia*' of Spain through the action CGL2004-21666-E

Furthermore some new Continuous GPS stations were added to the ROA CGPS Geodetic Network. In the beginning of 2003 a new CGPS was installed at Alboran Island, and, in February 2005, another CGPS was installed at Velez de la Gomera, in the Northern African Coast. The aim was the densification of the Observatory GPS permanent network with geodynamic purposes.

The Observatory has also participated in the EU funded researching Project ESEAS-RI, devoted to implement the infrastructure to study the Mean Sea Level evolution around the European Coasts. The main idea of the GPS contribution was to decontaminate tide gauge measurements from tectonic effects on their bench marks. Data analysis of a set of CGPS stations all around the European coast were carried out. Vertical displacements were obtained, and their trends were applied on tide gauge records. In the same project frame, a new CGPS was installed in Ceuta in order to implement the Dual- CGPS concept. The idea is to compare CGPS data records from the equipment collocated with the tide gauge, with those recorded at a CGPS located in the main land. In this way one could get local effects on the CGPS located on the piers, and so make corrections over these effects.

In June 2003, a Jason satellite radar altimeter calibration field survey was performed at the surroundings of Ibiza Island. It was an indirect calibration, by making GPS measurements of the sea level, while sailing in the neighbourhood of a satellite cross track. In this way comparison between the mean sea level we got for the area, and altimetry measurements made from the satellite radar are availables.

All the GPS data coming both the field campaings 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.
. • "Earthquakes and Crustal Deformation at Southern Spain: Seiemic Hazard Applications" (REM2000-0777-C02-02), from the National Program for Space Research, 'Ministerio de Ciencia y Tecnología' of Spain.
. • "Escenarios realistas de riesgo sismico en España" (REN2003-05178-C03-02), from the National Program for Research, 'Ministerio de Ciencia y Tecnología' of Spain.

3. Publications:

Gárate, J.; Martín Davila, J. La Geodesia Espacial, una herramienta de futuro. 'Revista Española de Física' vol. 17, 33--38 Real Sociedad Española de Física. Facultad de Ciencias Físicas. Universidad Complutense de Madrid. Madrid Spain.

Martinez Benjamin, J.J.; Gonzalez, S.; Nuñez, A.; Bullí, F.; Lopez-Marco, J ;Martín Davila, J.; Garate, J. et al (2004) Ibiza Absolute Calibration Expeiment: Survey and Preliminary Results. 'Marine Geodesy' vol. 27, 657--681 Taylor & Francis. Filadelfia (USA)

Martinez Benjamin, J.J.; Martinez, M.; Ortiz, M.A.; Rodríguez, G.; Martín Davila, J.; Garate, J. et al (2005). Calibration Altimeter Sites at Cape Bagur and Ibiza Island. 'Física de la Tierra' vol. 17, 33--45 Universidad Complutense de Madrid. Madrid Spain.

Khazaradze, G., Suriñach, E., Gárate, J., and Davila, J. M. (2005): Crustal Deformation in Eastern Betics, Spain . 'Terra Nostra' vol.5 n.1 64—65. Madrid Spain**.**

Martín Davila, J.; Gárate, J.; Pazos, A.; Catalán, M. (2006): La Geofísica en el Real Instituto y Observatorio de la Armada en San Fernando. 'Física de la Tierra' vol. 18, 119--135 Universidad Complutense de Madrid. Madrid Spain.

Gárate, J., Martín Davila, J., Suriñach, E., Berrocoso, M., Pérez-Peña, A.., Talaya, J., (2003) CUATENEO Network: preliminary results after first reobservation. *European Geophysical Society. XXVi General Assembly* Nice (France)

Martínez-Benjamín, J. J., Martínez, M., Núñez. A., Ortiz, M. A., Talaya, J., Perez, B., Martín Davila, J., Gárate, J., Vigo-Aguiar, M. I., Rodríguez, G. (2003) JASON 1 CALVAL 2003 Campaign at the Ibiza Island area.. *European Geophysical Society. XXVi General Assembly* Nice (France)

Gárate, J., Martín Davila, J., García Silva, C. (2004) Contribución del Observatorio de San Fernando al proyecto europeo ESEAS-RI.. *4ª ASAMBLEA HISPANO-PORTUGUESA DE GEODESIA Y GEOFÍSICA* Figueira da Foz (Portugal)

Gárate, J., Martín Davila, J., Berrocoso, M., Pérez-Peña, A. (2004) Red Geodinámica del Observatorio de San Fernando: Resultados preliminares a partir de campañas episódicas. *4ª ASAMBLEA HISPANO-PORTUGUESA DE GEODESIA Y GEOFÍSICA* Figueira da Foz (Portugal)

Gárate, J., Martín Davila, J., Berrocoso, M. (2004) Series temporales para las estaciones GPS del Observatorio de la Armada en San Fernando. *4ª ASAMBLEA HISPANO-PORTUGUESA DE GEODESIA Y GEOFÍSICA* Figueira da Foz (Portugal)

Gárate, J. Martín Davila, J., Berrocoso, M., Pérez-Peña, A., Garcia Silva, C. (2004) Time series for Southern Spain – Northern Africa GPS permanent Network. *European Geosciences Union. 1st General Assembly* Nice(France)

Martínez Benjamin, J.J., Martín Davila, J., Gárate, J., Bonnefond, P., Rodriguez, G,, Pérez, B., Ortiz Castellon, M.A., Talaya, J., Gonzalez, S., Nuñez, A. (2004) IBIZA 2003 Jason-1 IBIZA 2003 Campaign and Preliminary Results. *European Geosciences Union. 1st General Assembly* Nice(France)

Gárate, J. Martín Davila., J. Quijano. M., Belza, C. (2004) San Fernando SLR: status and future objectives. *14th International Workshop on Laser Ranging* San Fernando (Spain)

Vigo-Aguiar, I., Ferrándiz, J., Gárate, J., Martín Dávila,J., García D. (2004) Determination of the Site Position at the SLR Tracking Station (7824). *14th International Workshop on Laser Ranging* San Fernando (Spain)

Gárate, J. Martín Davila., J. (2004) San Fernando Observatory GPS network: time series. *XII Asamblea General. Proyecto WEGENER* Tangier (Morocco)

Martín Davila., J.; Guitart, A.; Palomo, C.; Carbó, A.; Catalán, M.; Villarubia, J.; Acosta, J.; Muñoz Martín, A.; Marín, J.A.; Herranz, P.;Gárate, J.; Muñoz, A.; Gómez, M.;J de Andrés.J.R. (2004) Spanish Economic Exclusive Zone (ZEEE) Project: Almost 10 years of marine systematic surveys at Valencia Trough and Balearic Sea (Western Mediterranean), Canary Islands and Bank of Galicia (NW Iberian Peninsula). *XII Asamblea General. Proyecto WEGENER* Tangier (Morocco)

Khazaradze, G.; Suriñach,E.; Gárate, J. Martín Davila., J., Fleta,J.; Goula, X.; Soro, M. Térmens, A. Giménez, J. (2004) Present-day Crustal Deformation in Eastern Betics (SE Spain) inferred from two observations of the CuaTeNeo GPS network. *XII Asamblea General. Proyecto WEGENER* Tangier (Morocco)

Gárate, J. Martín Davila., J. Garcia Silva,C. (2004) ROA Preliminary Results for the ESEAS GPS Network. *Workshop on Observing and Understanding Sea Level Variations.* Malta (Malta)

Khazaradze, G., Suriñach, E., Gárate, J., and Davila, J. M. (2005) Active deformation in eastern Betics (SE Spain) inferred from GPS measurements and numerical modelling. *European Geosciences Union General Assembly* Wien (Austria)

Gárate, J.; Fernandes, R.M.S.; Bos, M.S. (2006) Efectos de la Carga de Marea Oceánica en la Costa Atlántica de la Península Ibérica.. *5ª ASAMBLEA HISPANO-PORTUGUESA DE GEODESIA Y GEOFÍSICA* Seville (Spain)

Gárate, J.; Martín Davila, J.; Garcia Silva, C.; Perez Peña, A (2006) Análisis de Series Temporales efectuado por el ROA en el marco del proyecto ESEAS-RI. *5ª ASAMBLEA HISPANO-PORTUGUESA DE GEODESIA Y GEOFÍSICA* Seville (Spain)

Berrocoso,M.; Fernandez-Bruna,D.; Fernandez-Prada, J.A.; Gárate, J.; Garcia Silva, C.; Gil, A. ; et al. (2006) La red Andaluza de posicionamiento. *5ª ASAMBLEA HISPANO-PORTUGUESA DE GEODESIA Y GEOFÍSICA* Seville (Spain)

Gárate, J.; Martín Davila, J.; Perez Peña, A. (2006) Plate Boundary Deformation at the Strait of Gibraltar Area from GPS episodic surveys and CGPS: preliminary results. *European Geosciences Union General Assembly* Wien (Austria)

Berrocoso, M.; Paez, R.; Sanchez-Alzola, A.; Perez-Pena, A.; Hermosilla, A.; Redondo, M.; Gárate, J. (2006) A Permanent GPS Network for Andalusia (Spain). *XIII Assembly of the WEGENER project*. Nice (France)