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

NATIONAL REPORT ON GEODESY

FOR

2007 - 2010

IUGG XXV GENERAL ASSEMBLY

PREFACE

This report outlines some Spanish activities in Geodesy for the period 2007 to 2010. It has been prepared for submission to the International Association of Geodesy (IAG) on the occasion of the XXV General Assembly of the International Union of Geodesy and Geophysics in Melbourne, Australia, June 27 to July 8, 2011. 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 2007-2010 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. Cartographic Institute of Valencia. Department of Geodetic Projects, Valencia.
3. Department of Astronomy and Geodesy, Facultad de Ciencias Matemáticas Universidad Complutense, MADRID.
4. Department of Cartographic, Geodesic and Photogrammetric Engineering (DICGF) - Cartography Geodesy and GPS. VALENCIA
5. Institute Cartographic of Catalonia. BARCELONA.
6. Institute of Astronomy and Geodesy, (UCM-CSIC), MADRID.
7. Institute of Geomatic. Castelldefels, BARCELONA.
8. Microgeodesia Jaén Research Group. Universidad de Jaén, JAEN
9. National Geographic Institute (Instituto Geográfico Nacional). MADRID.
10. 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, April, 2011

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://lagc.uca.es/; http://rap.uca.es/; http://siguca.uca.es/;
e-mail: geodesia@uca.es; *lagc@uca.es*

People at the Laboratory

		Research Interest
Manuel Berrocoso Domínguez	Ph.D. in Mathematics	Astronomy, Geodesy, Cartography
María José González Fuentes	Ph.D. in Mathematics	Mathematical Analysis
Alberto Fernández Ros	Ph.D. in Mathematics	Astronomy, Geodesy, Cartography
Alejandro Pérez Peña	Ph.D. in Mathematics (DEA)	Spatial Geodesy
Cristina Torrecillas Lozano	MsC (Geodesy and Cartography Engineer)	Geodesy, Cartography
Raúl Páez Jiménez	MsC in Mathematics (DEA)	Spatial Geodesy, Cartography
Alberto Sánchez Alzola	Geodesy and Cartography Engineer	Geodesy, Cartography
Bismarck Jigena Antelo	Geodesy and Cartography Engineer	Spatial Geodesy
Amós de Gil Martínez	Superior Studies (Ministry of Defence)	Geodesy
Gonzalo Prates	MsC (Geodesy and Cartography Engineer)	Geodesy, Cartography
Luis Miguel Peci Sánchez	Computer Engineer	Spatial Geodesy
Antonio Cruz	Computer Engineer	Spatial Geodesy

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.

<u>Publications (Papers and Book Chapters)</u>

Autores: A. Fernández-Ros, M. Berrocoso, M. E. Ramírez
Título: Volcanic deformation models for Deception Island (South Shetland Islands, Antarctica)
Fecha de publicación: 2007
Referencia: A. Cooper, C. Raymond, and the 10th ISAES Editorial Team (eds): Antarctica: A Keystone in a Changing World.
Contribución número: 094
ISSN: 0196-1497 **DOI:** 10.3133/of2007-1047 **ISBN (CD-ROM):** 1-411-31788-2
Editorial: U. S. Geological Survey and The National Academics
Lugar de Publicación: Santa Barbara (California)

Autores: M. E. Ramírez, M. Berrocoso, A. Fernández-Ros, M. J. González
Título: GPS time series analysis from Deception Island Volcano (South Shetland Islands, Antarctica)
Fecha de publicación: 2007
Referencia: A. Cooper, C. Raymond, and the 10th ISAES Editorial Team (eds): Antarctica: A Keystone in a Changing World.
Contribución número: 102
ISSN: 0196-1497 **DOI:** 10.3133/of2007-1047 **ISBN (CD-ROM):** 1-411-31788-2
Editorial: U. S. Geological Survey and The National Academics
Lugar de Publicación: Santa Barbara (California)

Autores: M. Berrocoso, J. M. Enríquez de Salamanca, M. E. Ramírez, A. Fernández-Ros, B. Jigena
Título: Determination of a local geoid for Deception Island
Fecha de publicación: 2007
Referencia: A. Cooper, C. Raymond, and the 10th ISAES Editorial Team (eds): Antarctica: A Keystone in a Changing World.
Contribución número: 123
ISSN: 0196-1497 **DOI:** 10.3133/of2007-1047 **ISBN (CD-ROM):** 1-411-31788-2
Editorial: U. S. Geological Survey and The National Academics
Lugar de Publicación: Santa Barbara (California)

Autores: M. Berrocoso, A. Fernández-Ros, M. E. Ramírez, J. M. Salamanca, C. Torrecillas, A. Pérez-Peña, R. Páez, A. García-García, Y. Jiménez-Teja, F. García-García, R. Soto, J. Gárate, J. Martín-Davila, A. Sánchez-Alzola, A. de Gil, J. A. Fernández-Prada, B. Jigena
Título: Geodetic Research on Deception Island and its Environment (South Shetland Islands, Bransfield Sea and Antarctic Peninsula) During Spanish Antarctic Campaigns (1987–2007)
Fecha de publicación: 2008
Referencia: A. Capra, R. Dietrich (Eds.): Geodetic and Geophysical Observations in Antarctica.
Páginas: 97-124
ISBN: 978-3-540-74881-6
Editorial: Springer-Verlag
Lugar de Publicación: Berlin

Autores: M. E. Ramírez, M. Berrocoso, M. J. González, A. Fernández-Ros
Título: Crustal Deformation Models and Time-Frequency Analysis of GPS Data from Deception Island Volcano (South Shetland Islands, Antarctica)
Fecha de publicación: 2008
Referencia: Donner, R. V., Barbosa, S. M. (Eds.): Nonlinear Time Series Analysis in the Geosciences. Applications in Climatology, Geodynamics and Solar-Terrestrial Physics.
Series: Lecture Notes in Earth Sciences
Volumen: 112/2008 **Páginas:** 245-272
ISSN: 0930-0317 **DOI:** 10.1007/978-3-540-78938-3 **ISBN:** 978-3-540-78938-6
Editorial: Springer-Verlag
Lugar de Publicación: Berlin

Autores: C. Torrecillas, M. Berrocoso
Título: Diseño, metodología y desarrollo de un Sistema de Información Multidisciplinar de Apoyo Científico (SIMAC) para la isla Decepción (Antártida)
Fecha de publicación: 2008
Referencia: Proceedings del Congreso Internacional de Ingeniería Geomática y Topográfica y IX Congreso Nacional TOP-CART
Páginas: 1-5
ISBN (CD-ROM):
Editorial: Universidad Politécnica de Valencia
Lugar de Publicación: Valencia

Autores: M. Berrocoso, A. Fernández-Ros, A. Pérez-Peña
Título: Tectonic deformation for South Shetland Islands and the Antarctic Peninsula by means of GPS observations in Geodynamic Network RGAE
Fecha de publicación: 2008
Referencia: M. Leppe, C. Gimpel, L. F. Leiva (eds): Antártica y Sudamérica. Ciencia en el Año Polar Internacional.
Páginas: 391-394
ISBN-13: 978-956-7046-03-4
Editorial: Instituto Antártico Chilena
Lugar de Publicación: Valparaíso (Chile)

Autores: M. R. Arias, A. Serrano, R. Benítez, M. Berrocoso
Título: Thermometric network for volcanic monitoring at Deception Island, Antarctica
Fecha de publicación: 2008
Referencia: M. Leppe, C. Gimpel, L. F. Leiva (eds): Antártica y Sudamérica. Ciencia en el Año Polar Internacional.
Páginas: 447-450
ISBN-13: 978-956-7046-03-4
Editorial: Instituto Antártico Chilena
Lugar de Publicación: Valparaíso (Chile)

Autores: M. Berrocoso, M. R. Arias, A. Serrano, A. Fernández-Ros, A. de Gil, C. Torrecillas, J. A. García
Título: Geodetic and thermometric monitoring of the volcanic activity at Deception Island (Antarctica): VOLTEDEC Project (2005-2008)
Fecha de publicación: 2008
Referencia: M. Leppe, C. Gimpel, L. F. Leiva (eds): Antártica y Sudamérica. Ciencia en el Año Polar Internacional.
Páginas: 382-384
ISBN-13: 978-956-7046-03-4
Editorial: Instituto Antártico Chilena
Lugar de Publicación: Valparaíso (Chile)

Autores: A. Carmona, M. Berrocoso
Título: Una primera experiencia sobre la impartición de "Astronomía" en el contexto docente del Campus Andaluz Virtual
Fecha de publicación: 2009
Referencia: J. I. Aguaded-Gómez, A. Infante-Moro (Directores): Buenas prácticas de teleformación en las diez universidades andaluzas.
Páginas: 319-327
ISBN: 978-84-9745-219-9
Editorial: Netbiblo, S.L.
Lugar de Publicación: Oleiros (La Coruña)

Autores: A. Pérez-Peña, J. Martín-Davila, J. Gárate, M. Berrocoso, E. Buforn
Título: Velocity field and tectonic strain in Southern Spain and surrounding areas derived from GPS episodic measurements
Fecha de publicación: 2010
Referencia: Journal of Geodynamics 49 Issues 3-4
Páginas: 232-240
DOI: doi:10.1016/j.jog.2010.01.015
Editorial: Elsevier.

Autores: M. Berrocoso, J. Carmona, A. Fernández-Ros, A. Pérez-Peña, R. Ortiz, A. García
Título: Velocity Kinematic model for Tenerife Island (Canary Islands, Spain): Geodynamic interpretation in the Nubian plate context
Fecha de publicación: 2010
Referencia: Journal of African Earth Science
Páginas: En prensa
DOI: 10.1016/j.jafrearsci.2010.04.007
Editorial: Elsevier.

Conferences and meetings attended

Autores: M. Berrocoso, R. Páez, R, A. Fernández-Ros, A. Sánchez-Alzola, A. Pérez-Peña, J. Gárate
Comunicación: Calculation and adjustment method of the RAP network to refer it to ITRF frame and quality checking of the coordenates obtained
Congreso: EUROPEAN GEOSCIENCES UNION GENERAL ASSEMBLY
Tipo de Congreso: Internacional

Lugar de celebración: Viena
Fecha: Abril, 2007
Tipo de la presentación: Poster

Autores: M. E. Ramírez, M. Berrocoso, M. J. González-Fuentes, A. Fernández-Ros
Comunicación: Crustal deformation models and time - frequency analysis of GPS data from Deception Island Volcano (South Shetland Islands, Antarctica)
Congreso: EUROPEAN GEOSCIENCES UNION GENERAL ASSEMBLY
Tipo de Congreso: Internacional
Lugar de celebración: Viena
Fecha: Abril, 2007
Tipo de la presentación: Oral (CONFERENCIA INVITADA)

Autores: A. Fernández-Ros, M. Berrocoso, M. E. Ramírez
Comunicación: Deformation models and volcanic source location for Deception Island Volcano (South Shetland Islands, Antarctica)
Congreso: EUROPEAN GEOSCIENCES UNION GENERAL ASSEMBLY
Tipo de Congreso: Internacional
Lugar de celebración: Viena
Fecha: Abril, 2007
Tipo de la presentación: Poster

Autores: M. Berrocoso, M. E. Ramírez, A. Fernández-Ros, A. Pérez-Peña, A. Sánchez-Alzola
Comunicación: Tectonic deformation in South Shetland Islands, Bransfield Sea and Antarctic Peninsula environment from GPS surveys
Congreso: EUROPEAN GEOSCIENCES UNION GENERAL ASSEMBLY
Tipo de Congreso: Internacional
Lugar de celebración: Viena
Fecha: Abril, 2007
Tipo de la presentación: Poster

Autores: M. Berrocoso, J. M. Enríquez-Salamanca, Y. Jiménez, B. Jigena
Comunicación: Geodesic and geophysical models for Deception Island (Antarctica)
Congreso: EUROPEAN GEOSCIENCES UNION GENERAL ASSEMBLY
Tipo de Congreso: Internacional
Lugar de celebración: Viena
Fecha: Abril, 2007
Tipo de la presentación: Poster

Autores: M. Berrocoso, A. García-García, J. A. Fernández-Prada, M. E. Ramírez, A. Sánchez-Alzola, A. Fernández-Ros
Comunicación: Crustal deformation models for Tenerife Island (Canary Island, Spain)
Congreso: EUROPEAN GEOSCIENCES UNION GENERAL ASSEMBLY
Tipo de Congreso: Internacional
Lugar de celebración: Viena
Fecha: Abril, 2007
Tipo de la presentación: Poster

Autores: M. Berrocoso, A. Fernández-Ros, M. E. Ramírez
Comunicación: Volcano deformation models an source location for Deception Island (South Shetland Islands, Antarctica)
Congreso: IUGG XXIV General Assembly (IAVCEI)
Tipo de Congreso: Internacional
Lugar de celebración: Perugia (Italia)
Fecha: Julio, 2007

Tipo de la presentación: Poster

Autores: M. Berrocoso, García-García Alicia, Fernández-Ros Alberto, Sánchez-Alzola Alberto, Fernández-Prada Juan Antonio, Ramírez María Eva
Comunicación: Volcano-tectonic deformation models for Tenerife Island (Canary
Spain)
Congreso: IUGG XXIV General Assembly (IAVCEI)
Tipo de Congreso: Internacional
Lugar de celebración: Perugia (Italia)
Fecha: Julio, 2007
Tipo de la presentación: Poster

Autores: M. Berrocoso, Ramirez Eva, González-Fuentes María José, Fernández-Ros Alberto
Comunicación: Deformation models and GPS time series analysis from Deception Volcano(South Shetland Islands, Antarctica)
Congreso: IUGG XXIV General Assembly (IAVCEI)
Tipo de Congreso: Internacional
Lugar de celebración: Perugia (Italia)
Fecha: Julio, 2007
Tipo de la presentación: Poster

Autores: M. Berrocoso, M. E. Ramirez, A. Fernández-Ros, A. Pérez-Peña, A. Sánchez-Alzola
Comunicación: TECTONIC DEFORMATION IN DECEPTION VOLCANO AND YOUR ENVIRONMENT FROM GPS SURVEYS (1990-2007)
Congreso: IUGG XXIV General Assembly (IAG)
Tipo de Congreso: Internacional
Lugar de celebración: Perugia (Italia)
Fecha: Julio, 2007
Tipo de la presentación: Poster

Autores: M. Berrocoso, R. Páez, A. Fernández-Ros, A. Sánchez-Alzola, A. Pérez-Peña, A. de Gil, A. Hermosilla, M. Redondo, J. Gárate
Comunicación: THE ANDALUSIAN POSITIONING NETWORK: DESING, DEVELOPMENT, CALCULATION AND ADJUSTMENT METHOD AND SERVICES
Congreso: IUGG XXIV General Assembly (IAG)
Tipo de Congreso: Internacional
Lugar de celebración: Perugia (Italia)
Fecha: Julio, 2007
Tipo de la presentación: Poster

Autores: M. Berrocoso
Comunicación: La Red Andaluza de Posicionamiento
Jornadas: NUEVAS TECNOLOGIAS: NUEVOS SENSORES TERRESTRES Y AEROTRANSPORTADOS: APLICACIÓN A LA ORDENACION DEL TERRITORIO organizado por STEREOCARTO
Tipo de Congreso: Nacional
Fecha: Diciembre, 2007
Tipo de la presentación: Oral (CONFERENCIA INVITADA)

Autores: M. Berrocoso
Comunicación: Aplicaciones Científicas del Sistema GNSS
Curso de Verano: INGENIERÍA DE SATÉLITES. APLICACIONES. ESCENARIO ACTUAL Y FUTURO organizado por la Universidad Politécnica de Madrid y dirigido por A. Pérez Yuste
Lugar de celebración: La Granja de San Ildefonso (Segovia)
Fecha: Julio, 2007
Tipo de la presentación: Oral (CONFERENCIA INVITADA)

Autores: M. Berrocoso, M. E. Ramírez, A. Fernández-Ros, A. Pérez-Peña, and J. M. Salamanca
Comunicación: Tectonic deformation models for South Shetland Islands, Bransfield Strait and the Antarctic Peninsula from GPS surveys
Congreso: 10th International Symposium on Antarctic Earth Sciences (IX ISAES)
Tipo de Congreso: Internacional
Lugar de celebración: Santa Barbara (California)
Fecha: Agosto-Septiembre, 2007
Tipo de la presentación: Poster

Autores: A. Fernández-Ros, M. Berrocoso and M. E. Ramírez
Comunicación: Volcanic deformation models for Deception Island (South Shetland Islands, Antarctica)
Congreso: 10th International Symposium on Antarctic Earth Sciences (IX ISAES)
Tipo de Congreso: Internacional
Lugar de celebración: Santa Barbara (California)
Fecha: Agosto-Septiembre, 2007
Tipo de la presentación: Poster

Autores: M. E. Ramírez, M. Berrocoso, A. Fernández-Ros, and M. J. González
Comunicación: GPS time series analysis from Deception Island Volcano (South Shetland Islands, Antarctica)
Congreso: 10th International Symposium on Antarctic Earth Sciences (IX ISAES)
Tipo de Congreso: Internacional
Lugar de celebración: Santa Barbara (California)
Fecha: Agosto-Septiembre, 2007
Tipo de la presentación: Poster

Autores: C. Torrecillas, M. Berrocoso
Comunicación: Diseño, metodología y desarrollo de un Sistema de Información Multidisciplinar de Apoyo Científico (SIMAC) para la isla Decepción (Antártida)
Congreso: Congreso Internacional de Ingeniería Geomática y Topográfica y IX Congreso Nacional TOPCART
Tipo de Congreso: Nacional
Lugar de celebración: Valencia
Fecha: Febrero, 2008
Tipo de la presentación: Oral

Autores: A. Perez-Peña, J. Garate, J. Martin Davila, M. Berrocoso
Comunicación: Deformation model in South of Spain and North of Africa region from GPS episodic surveys
Congreso: EGU General Assembly 2008
Tipo de Congreso: Internacional
Lugar de celebración: Viena
Fecha: Abril, 2008
Tipo de la presentación: Poster

Autores: M. Berrocoso, A. Fernández-Ros, A. Sánchez-Alzola, A. de Gil
Comunicación: Deformation models for Deception volcano (Antarctica) obtained with classical and spatial geodetic techniques
Congreso: IAVCEI General Assembly
Tipo de Congreso: Internacional
Lugar de celebración: Reykjavík
Fecha: Agosto, 2008
Tipo de la presentación: Poster

Autores: M. Berrocoso, J. M. Enrique de Salamanca, B. Jigena, A. Fernández-Ros
Comunicación: Geodetic and Geophysics Frame for the Deception Volcano
Congreso: IAVCEI General Assembly
Tipo de Congreso: Internacional

Lugar de celebración: Reykjavík
Fecha: Agosto, 2008
Tipo de la presentación: Poster

Autores: M. Berrocoso, A. Fernández-Ros, A. Pérez-Peña
Comunicación: Volcanotectonic deformation models in Deception volcano and its environment (1990-2008)
Congreso: IAVCEI General Assembly
Tipo de Congreso: Internacional
Lugar de celebración: Reykjavík
Fecha: Agosto, 2008
Tipo de la presentación: Poster

Autores: M. Berrocoso, A. García-García, A. Fernández-Ros, A. Pérez-Peña, J. Carmona, A. Sánchez-Alzola
Comunicación: Volcanotectonic deformation models for Tenerife Island from observations GPS at geodynamical TEGETEIDE network
Congreso: IAVCEI General Assembly
Tipo de Congreso: Internacional
Lugar de celebración: Reykjavík
Fecha: Agosto, 2008
Tipo de la presentación: Poster

Autores: M. Berrocoso, A. Fernández-Ros, A. Pérez-Peña
Comunicación: Tectonic deformation for South Shetland Islands and the Antarctic Peninsula by means of GPS observations in Geodynamic Network RGAE
Congreso: IV SIMPOSIO LATINOAMERICANO SOBRE INVESTIGACIONES ANTÁRTICAS Y VII REUNIÓN CHILENA DE INVESTIGACIÓN ANTÁRTICA
Tipo de Congreso: Internacional
Lugar de celebración: Valparaíso (Chile)
Fecha: Septiembre, 2008
Tipo de la presentación: Oral

Autores: M. R. Arias, A. Serrano, R. Benítez, M. Berrocoso
Comunicación: Thermometric network for volcanic monitoring at Deception Island, Antarctica
Congreso: IV SIMPOSIO LATINOAMERICANO SOBRE INVESTIGACIONES ANTÁRTICAS Y VII REUNIÓN CHILENA DE INVESTIGACIÓN ANTÁRTICA
Tipo de Congreso: Internacional
Lugar de celebración: Valparaíso (Chile)
Fecha: Septiembre, 2008
Tipo de la presentación: Poster

Autores: M. Berrocoso, M. R. Arias, A. Serrano, A. Fernández-Ros, A. de Gil, C. Torrecillas, J. A. García
Comunicación: Geodetic and thermometric monitoring of the volcanic activity at Deception Island (Antarctica): VOLTEDEC Project (2005-2008)
Congreso: IV SIMPOSIO LATINOAMERICANO SOBRE INVESTIGACIONES ANTÁRTICAS Y VII REUNIÓN CHILENA DE INVESTIGACIÓN ANTÁRTICA
Tipo de Congreso: Internacional
Lugar de celebración: Valparaíso (Chile)
Fecha: Septiembre, 2008
Tipo de la presentación: Oral

Autores: A. García, R. Ortiz, M. Berrocoso, J. Vila
Comunicación: Configuring an automatic volcanological observatory able to operate in unattended areas: the example of Deception
Congreso: ESC Working Group "Earthquakes and Volcanoes" Annual Workshop 2008 co-sponsored by the IASPEI/IAVCEI Inter-Association Commission on Volcano Seismology

Tipo de Congreso: Internacional
Lugar de celebración: Managua y León (Nicaragua)
Fecha: Septiembre, 2008
Tipo de la presentación: Oral

PH. D. Thesis

Título: Modelización de movimientos y deformaciones de la corteza terrestre mediante observaciones de los satélites del Sistema de Posicionamiento Global
Doctorando: Alberto Fernández Ros
Universidad: Cádiz
Facultad: Ciencias
Fecha: 7 de marzo de 2007
Calificación: Sobresaliente cum Laude por Unanimidad

Título: Modelización de la deformación superficial en áreas volcánicas mediante la teoría de wavelets. Aplicación al volcán Decepción.
Doctoranda: María Eva Ramírez Rodríguez
Universidad: Cádiz
Facultad: Ciencias
Fecha: 4 de mayo de 2007
Codirectores: Manuel Berrocoso Domínguez y María José González Fuentes
Calificación: Sobresaliente cum Laude por Unanimidad (Suplemento Europeo)

Título: MODELIZACIÓN DE LAS DEFORMACIONES CORTICALES EN EL SUR DE ESPAÑA Y NORTE DE ÁFRICA A PARTIR DE OBSERVACIONES DE SATÉLITES GPS.
Doctorando: Alejandro Pérez Peña
Universidad: Cádiz
Facultad: Ciencias
Fecha: 15 de junio de 2007
Codirectores: Jorge Gárate Pasquín y José Martín Davila
Calificación: Sobresaliente cum Laude por Unanimidad

Msc. And Grade Dissertations

Alberto Sánchez Alzola (2007). El control de la actividad volcánica de la isla Decepción y del complejo volcánico Teide-Pico Viejo a partir de redes de nivelación. Tutor de Investigación: M. Berrocoso. Programa de Doctorado "Astronomía, Geodesia y Geofísica". Universidad de Cádiz.

Juan Antonio Fernández Prada (2007). La red geodésica TEGETEIDE y su aplicación para la obtención del modelo de deformación tectónica para la isla de Tenerife. Tutor de Investigación: M. Berrocoso. Programa de Doctorado "Astronomía, Geodesia y Geofísica". Universidad de Cádiz.

Bismarck Jigena Antelo (2007). Primera aproximación a la determinación del geoide experimental de la Bahía de Cádiz. Tutor de Investigación: M. Berrocoso. Programa de Doctorado "Astronomía, Geodesia y Geofísica". Universidad de Cádiz.

Alfonso Lorenzo Moya (2007). Integración de sensores meteorológicos en el Círculo Meridiano del Real Instituto y Observatorio de la Armada. Tutor de Investigación: M. Berrocoso. Programa de Doctorado "Astronomía, Geodesia y Geofísica". Universidad de Cádiz.

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(The information of this Institution has been remitted by M. Berrocoso)

2. CARTOGRAPHIC INSTITUTE OF VALENCIA

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a) Working areas and research

Levelling rings
GNSS Networks and services
Geodetic Densifications
Promoting ETRS89 adoption
GNSS-DInSAR combination.
PPP analysis
Cooperation in educational projects

b) Projects and scientific tasks

1. Levelling rings

As a first approach, the GNSS Reference Stations of the Cartographic Institute of Valencia (ICV) have been connected to the Spanish High Precision levelling network (REDNAP) during 2009-2010. The "Marker points" of some of the GNSS stations have now orthometric heights. The tasks performed include the observation with high precision geometric levelling method combined with trigonometric data, and computations with interpolation of gravity data or new gravity measurements.

The works are being developed because it is highly recommended in spatial geodesy the establishment of "tie" measurements between materializations of high precision geodetic techniques, furthermore consistent regional solutions provide qualitatively better performance and results to final users. According to this idea, the ICV is carrying out levelling works in order to connect its geodetic networks with REDNAP-2008 network, of the National Geographic Institute of Spain (IGN-Spain).

The new levelling points of the levelling rings are also being determined with static GNSS techniques for integration in the 4th-order geodetic network of Valencia. This set of points is very useful as control points to check the geoid models.

2. GNSS Reference Station Network of Valencia

The establishment of the GNSS Reference Station Network of the Region of Valencia (ERVA Network), has meant the achievement of different objectives. For example: research about technological tools and resources for the improvement of productivity in Geodesy and Topography; densification of the European Terrestrial Reference System, ETRS89, in the land of Valencia and enlargement of the current geodetic infrastructure. All the establishment of the network was completely done by the ICV.

The GNSS Network begun to provide real-time corrections and post-processing data in 2005. Since then, the network has been completed with more stations, providing redundancy of services, and cooperating with other existing GNSS networks of neighbouring regions. Nowadays, the GNSS CONTROL CENTER in Valencia in the Cartographic Institute of Valencia is connected to 16 stations.

Available services include:

-Rinex data files GPS+GLONASS, of own stations at 30 second daily, hourly data files at 1 second and 5 second. All of them are available with FTP and http.

-Real Time Kinematic (RTK) Network solution and RTK corrections from individual stations in RTCM format, with Networked Transport of RTCM via Internet Protocol (NTRIP).

Both services, (real time and RINEX data), are duplicated in two public servers.

2.1. Advanced analysis and applications.

In the last years different analysis and research works have been carried out so far in the ICV:

-GNSS Network Monitoring in the control center of the ICV.

-Analysis series in different frames with GAMIT software: ETRF2000-ETRF2005.

-Own development of software for daily quality check. The plots of the daily quality check are available in the webpage of the ICV.

Current services are being widely used by professionals and with scientific purposes. Since 2007, BORR station is accepted in EUREF network, and it is providing RINEX files and streaming RTCM data to EUREF-IP project. These data are also provided to the National Geographic Institute of Spain, which acts as Data Center.

Furthermore, hourly RINEX files of all stations are available for applications like Eumetnet GPS water vapour programme for meteorology, EGVAP. Several institutions and universities are downloading files for advanced applications and research.

Other services:

-Implementation of Real time Streaming of geodetic transformations, such as frame transformations, Datum GRID FILES, and geoid undulations: The standard format for real time corrections Radio Technical Commission for Maritime Services, RTCM 3.1, contains the data fields for geodetic transformation transport and real time computation of orthometric heights by received geoid undulations via internet protocol. These parameters can be generated dynamically by a GNSS data center, encapsulated in RTCM messages and finally, they can be broadcast to the rover location so they are centrally administered by the GNSS Control center and the same frame transformations and geoid model are available to all users in the field.

The implementation of transformation, preparation of grids, parameters and encapsulation following the standard RTCM format using NTRIP protocol, has been done by the ICV. Test field campaigns were done to describe the real performance and usefulness of these RTCM 3.1 geodetic transformation messages.

-GLONASS Real time streaming in Network RTK solutions: In 2006, the ICV begun to provide GPS Network RTK solution. But some GPS receivers are being replaced with GPS+GLONASS equipment since 2009. The capability has also been improved with the GPS+GLONASS Network RTK solution as a new service for ERVA network. It provides an optimal constellation and improves initialization time at user's side.

3. Fourth Order Geodetic Network of Valencian Community

Following the strategy of initial maintenance of the fourth order passive network, autonomic GNSS campaigns were carried out for the adoption of ETRS89 Datum. The set of points, form a three-dimensional block with more than 1000 points, are connected to the REGENTE CLASS C-IGN network and include the last campaigns. A set of control measurements have been done, to check the results and consistency in ETRS89, by means of the real time kinematic services of the GNSS reference station network. Between 2007-2010, annual works of restoration and re-observation of destroyed points have been done.

In addition to these campaigns, some of the points of the fourth order network are part of the new leveling rings of the Cartographic Institute of Valencia, and have orthometric height. In the rest of the network, it has been adopted the EGM2008-REDNAP (IGN-Spain) geoid model, as a solution for the vertical reference system referred to mean sea level.

Finally, double set of coordinates in ETRS89 and ED50 of this network, have been very helpful for quality control of the National Transformation grid file, (*sped2et.gsb -NTv2*). It has helped to detect anomalous residuals and errors in grid generation due to the use of ROI points with errors in the calculation of the grid. The task of the quality control of the national grid file in the area was requested to the ICV.

4. Promoting the adoption of ETRS89 and maintenance of the passive networks

The ICV is promoting the adoption of ETRS89 between users, enterprises and agencies in the area, since the establishment of ETRS89 as official Geodetic Reference System. As a public organism, the ICV has made periodic training courses in order to help to update knowledge of professionals.

Several tasks have been conducted to provide information by letters to the councils of the Valencian Community about the tools and ETRS89 available results. The purpose of the campaigns was also having a feedback from the municipalities on the status of all passive networks. The ICV sent circulars with information about the fourth order network, the letters also included links to download the national network ROI and REGENTE after an agreement with IGN. Information received from the municipalities helps to keep the geodetic databases updated and lead a suitable maintenance policy.

5. Research tasks in the ICV

-GNSS –DINsar combination: Processing of Geodetic Measurements for *Persistent scatterers* method.

The objective of this work, developed in 2010, is the detection and mapping of ground subsidence related to human activities using differential interferometry techniques (DInSAR) over a period of seven years (2003-present) using a small perpendicular baseline (< 500 m) interferogram approach. The attention is put on the harbor area of Valencia City, the part of the city that has suffered several changes in the last 25 years.

In the analysis it have been used seven year ENVISAT archive of 21 Advanced Synthetic Aperture Radar ascending and descending images from 2003 to present, and available TERRASAR-X strip-map images in that period. GNSS measurements on the harbor area for validation process have been used. The GNSS processing has been done in the Cartographic Institute of Valencia, in order to have series and results for Persistent Scatterers method.

-Precise Point Positioning analysis

Precise Point Positioning (PPP) analysis and simulations have been done in order to advance in the knowledge of the technique for GNSS positioning. Less investment in reference station installations

are necessary with the PPP technique, although GNSS network infrastructure still will be necessary for a lot of applications and generation of products for PPP. The analysis includes:

-Determination of accuracy based on the available precise GNSS orbit and clock products.

-Determination of initialization time as phase ambiguities converges and the solution reaches its optimal precision.

On the one hand, the tests have been done for real time case study. It has been used stream solutions that contain products (clock and orbits), provided from EUREF's Real-time Analysis project, and the IGS Real-time Pilot Project. Real-time applications needs to broadcast orbit and clock information under standard format messages (RTCM through NTRIP), so an analysis of these products and their actual standardization for real-time applications is needed.

The ICV has set up a simulation control unit, which is working 24 hours, using the infrastructure and architecture of the control center of the GNSS network. The streams that contain analysis centers orbits and clocks are applied in real time to the stream of reference stations. It allows analysing several parameters in the continuous stream: availability of analysis centers real time orbits and clocks, percentage of gaps and outages during continuously tracking period, convergence and initialization time. Finally, the use of GPS+GLONASS products in Real time PPP is being analysed in order to determine the significant impact on convergence time.

On the other hand, the institute has participated in the drafting of the proposal funded by the Ministry of Science and Innovation (MICINN) of the Department of Cartographic Engineering of the Polytechnic University of Valencia about the study of the PPP technique. This research project was recently granted.

In the frame of this project, the ICV is cooperating with the Polytechnic University of Valencia in the performance of post-processing tasks in the PPP technique.

6. Cooperation and educational projects

There is a collaborative agreement for educational cooperation program between the Generalitat Valenciana, through the Valencian Cartographic Institute, and the Polytechnic University of Valencia.

Students in the last years of the degree can apply for a training grant and make degree's final investigation work in this institution. In this cooperation program, the ICV trains students of the university. There are two opportunities every year in order to apply for grants in the department of geodesy of the ICV, the students have the opportunity to develop a research and development job related to GNSS and geodesy in the institute, or simply they can have work experience in this area. Universities that have signed the Cooperation agreement with the ICV, can offer this kind of grants to geodesy students.

In 2010, the ICV received a "BANCAJA foundation" award for one Geodesy project developed in the frame of its cooperation projects.

c) Publications and events organizations.

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(The information of this Institution has been remitted by R. M. Capilla)

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Research lines

Cartographic projections.
Earth Tides.
Gravimetry and inverse problem.
GPS investigations.
Monitoring Crustal Movements.
Satellite orbit Control.
Relativity and Geodesy.

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(The information of this Institution has been remitted by P. Romero)

4. DEPARTMENT OF CARTOGRAPHIC, GEODESIC AND PHOTOGRAMMETRIC ENGINEERING (DICGF) - CARTOGRAPHY GEODESY AND GPS

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SUMMARY OF RESULTS DESCRIPTION (2007-2010)

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1. Research interests

GNSS: Navigation.

Positioning and navigation services based on permanent GNSS networks with RTK applications. Geodetic surveying with GNSS. Geodetic networks and GNSS. Analysis and optimization of Precise Point Positioning technique (PPP).

Research has been done in the field of GNSS & INS integration: publications and a patent under development are the most representative outcomes.

There have also been some contributions to the adjustment theory and procedures for error testing (as it can be seen in publication list below).

Some new proposals have been made for optimizing GNSS positioning capabilities under different assumptions: application of global robust estimation has been proven to be useful for mitigating multipath effects, as well as for avoiding the ionospheric delay in the single frequency case. Further, the classical approach of ambiguity functions has proven to be strengthened by the use of global optimization algorithms.

PPP technique analysis is actually carrying out based on time convergence solution, repeatability, IGS products, different software processing and GPS+GLONASS constellation, both in static and kinematic mode, postprocessing or real time.

A new line research has been integrated, a research project about EGNOS (European Geoestationary Navigation Overlay Service) to improve his accuracy using VRS (Virtual Reference Station) differential corrections phase applied to emergency medical helicopters

Technical advice on Geodesy and Surveying

A Trajectory Surveying System has been specifically developed for monitoring beach areas. A VRS real-time kinematic GPS receiver and an Inertial Measurement Unit had been integrated on a small all terrain vehicle (QUAD). The surveying system is controlled by means of a rugged computer and especially developed software. This method offers high productivity (5 Ha /h) with an acceptable level of accuracy (better than 10 cm). Continuous system improvement is part of the research contract which is described in more detail in the corresponding section.

Deformation monitoring in building and civil engineering such as building control in the Ricardo Tormo Circuit, Pinedo sewage treatment plant, *Lonja* Silk Trade structural control, etc.

Terrestrial Reference Systems and/or Frames

DICGF has cooperated with some of the responsible regional institutions (Valencian Cartographic Institute, Asturias Principality) for the computation of ETRS89 coordinates of their active networks. As it can be seen in the publication list section, methodology and results were presented in the Symposium IAG Subcommission for Europe (EUREF).

Instrumental calibration and sensor integration

A calibration baseline facility has been established at the UPV campus (November 2007). Each of the 7 pillars of this Heerbrugg-type baseline consist in two stainless steel cylinders, with an air chamber in between them, a double forced-centering mechanism and reinforced concrete foundations.

This geodetic infrastructure was certified as a calibration baseline by the Spanish Metrology Center (Centro Español de Metrología, CEM) and it is currently used for geodetic instrumental verification in accordance with ISO standard No. 17123.

DICGF is also member of the AEN/CTN 82/SC 2 – GT7, Spanish counterpart of ISO TC172/SC6 - Optics and optical instruments/ Geodetic and surveying instruments. Related with this research field, some activities can be mentioned such as the organization of the 15th ISO TC172/SC6 meeting and the organization of the Technical Conference “La normalización en el sector del instrumental geodésico y topográfico”, which were held in the UPV campus in April 2009.

Compact integration of GSM-19 magnetic sensor with high-precision positioning by RVS GNSS technology has been developed.

Physical geodesy

High-precision and high-resolution gravimetric geoid model has been developed for the Community of Valencia under research contract with the Valencian Cartographic Institute. The geoid determination is based on remove-restore technique following Stokes-Helmert procedure. EIGEN-CG03C global geopotential model, more than 13000 gravity observations and more than 100 25x25 Km digital elevation files from DEM of the SGE with 25x25 meters resolution have been used.

High-precision geoid model determination in small areas have been studied based on remove-restore technique applied to GPS/levelling observations. A case study in Doñana national park has been developed.

The analysis and ability for local geoid computations of the new global geopotential models based on CHAMP, GRACE and GOCE solutions are one of the main goals of this research area, with special emphasis on high degree geopotential models such as EGM2008.

2.- Research Projects

Next generation in positioning, navigation and sensor positioning. Analysis and optimizacion of Precise Point Positioning technique (PPP)

The main goal of this project, funded by the Spanish Science Ministry, is to advance in the knowledge and implementation of the Precise Point Positioning technique (PPP) as a potential technique for positioning and navigation with GNSS. No reference station data is necessary making the technique applicable e.g. for airborne high accuracy GPS positioning with InSar, LIDAR or geophysical sensors in remote areas such as Greenland, Northern Canada and the Northen parts of Scandinavia.

Research in static and real-time characteristics of PPP will be done in order to develop potential improvements those guarantee accuracy in the results (centrimetric in absolute and decimetric for real-time applications).

Development of an architectural information system for automatic modelling documentation and multimedia diffusion of cultural heritage.

This project, funded by the Spanish Science Ministry, involve the integration of multispectral imagery, laser scanner data and spatial positioning sensors (GPS/INS), looking for optimum return and cost. The project focuses on developing an information system to automate the processes of acquisition, processing, and plotting spatial data and is especially useful for architectural heritage inventories and conservation tasks.

3.- Main Contract Research

Beach-dune monitoring system in the Devesa de L'Albufera coastal area. This research project is funded by the Valencian City Hall since 2005. It is a long time research project which involves geodetic reference frame control, reference frame transformations, GPS-RTK surveying techniques and LIDAR data processing. Previous geodetic works and initial results were presented in the Journal of Coastal Research in 2005. Some geodetic problems and the adopted solution were also presented in the

V Asamblea Hispano-Portuguesa de Geodesia y Geofísica, held in Sevilla (Spain) in January, 2006. Analisis and conclusions for the 2005-2010 period will be shortly presented.

A satellite navigation system to emergency medical helicopters. This is a research project to improve the EGNOS (European Geoestationary Navigation Overlay Service) accuracy to apply in low visibility conditions for emergency medical helicopters. We use EGNOS improved with VRS (Virtual Reference Station) into ABAS (Aircraft-Based Augmentation) to increase the accuracy and integrity

High-precision and high-resolution gravimetric geoid model for the Community of Valencia. This research contract is supported by the Valencian Cartographic Institute.

Software applications improvements for surveying and civil engineering. This research project is funded by APLITOP S.L. It deals with specific problems with geodetic reference frames and their transformations and GPS localization jobs to local reference systems.

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QUINTANILLA, I, GARRIGUES, P; QUESADA, N; ANQUELA, A, GARRIDO, N. go to the europeanhiger education area. international congress on geomatics education in europe. VARSOVIA

6. Other Academic Activities

Organization of the International Congress on Geomatics and Surveying Engineering and IX Congreso Nacional de Topografía y Cartografía (TOPCART), Valencia, Spain, February 18-21, 2008.

Organization of the 15th ISO/TC 172/SC 6 Geodetic and surveying instruments meeting, Valencia, Spain, April 22-24, 2009.

Editorial Board Member of ASCE Journal of Surveying Engineering, since 2008.

(The information of this Institution has been remitted by J. L. Berné)

5. INSTITUTE CARTOGRAPHIC OF CATALONIA

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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.cat/eng/Home-ICC/Inici/Geodesia/Xarxa-Utilitaria).

Until the end of 2010, ICC has observed 3935 points with GPS technology. All main cities of Catalonia have already XU deployed, and now the goal is to deploy one benchmark at every municipality. With the widespread use of GNSS RTK Real time services and their acceptance by the surveyor community the need of a proper instrumental calibration and check arises as a key factor on a daily basis procedure. With this density ICC provides the capability to request a calibration to the surveyors without compromising the efficiency of the field task. The procedures to review the XU points in urban areas have been carried out together with the quality control procedures for 1:1000 cartography production. The goal is to keep all points updated every 10 years. The procedures for rural benchmark reviewing are under study

1.2 XdA: *Xarxa d'Anivellació*

Following the works carried out by the REDNAP adjustment provided by the IGN , ICC has done the observation of a leveling line and gravimetry of 10 Km to reach the tidal gauge station of Barcelona Harbor. The processing works of this line are underway.

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 15 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 15 stations made

possible the installation of a VRS system able to provide RTK positioning thorough 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.

During 2009-2010 the communications systems were upgraded in order to allow the future upgrade to GNSS receivers and allocate the increased data throughput needed. The system chosen is a Wimax system provider witch offers 1Mbps IP links symmetrically, instead of the 10Kbps Satellite link previously used. This has been possible thanks to the deployment of such broadband IP services at remote areas of Catalonia.

During the period 2007-2010 the CATNET services provided an average of 35.000 hours of real time services and 40.000 hours of RINEX epochs to 440 registered active users every year.

CATNET stations participate in international networks as IGS and EUREF reaching the higher grades of performance as reference stations for ITRF and ETRF determination. Also participates in several international projects as IGS-RT, EUREF-IP and provides real time streaming of raw data to development groups, from several CATNET stations.

1.4.1. GeoFons

The GeoFons service, initiated in 1995, has been providing 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.

During the 2010, 2043 users downloaded more that 78 GB of data, mainly consisting of RINEX observations.

1.4.2. RASANT

The RASANT service has provided a valuable service improving the GPS positioning in Catalonia for 15 years. It has made possible to reduce the autonomous GPS positioning error from hundred meters to a metric precision in real time throughout the territory. The discontinuation of selective availability (SA) in May 2000 and the entry of the EGNOS service in October 2009 have made the availability of the RASANT service a not significant improvement for the autonomous GPS positioning. Taking into account these assessments, the RASANT service has been disconnected on January 1st 2011.

1.5. GeoCat: *Geoide de Catalunya*

The publication by the National Geospatial-Intelligence Agency of the EGM2008 gravity model, the leveling REDNAP network publication by the National Geographical Institute and the ICC interest in upgrading UB91 geoid model adjusted for leveling, did raise the concern for the ICC to analyze the goodness of this gravimetric model in Catalonia.

The ICC carried out in 2008 a campaign to measure the ellipsoidal height in more than 250 points of the REDNAP in Catalonia using the service RTKAT, Network RTK from CATNET network. Whit these measurements obtained a direct measurement of the geoid undulation referred to the Spanish altimetry datum. These undulations were compared with those obtained with the corresponding gravimetric models. The result showed that once the offset is compensated, due to the diverse reference potential used, the RMS obtained was 4cm and the maximum error of 13 cm. This result improves almost 3 times the obtained with the former gravimetric model so the ICC decided to adopt the EGM2008 with a correction of 595mm as its reference geoid model.

2. ETRS89 Adoption.

According to the INSPIRE Directive 2007/2/EC the “Real Decreto 1071/2007” was published establishing the ETRS89 system (European Terrestrial Reference System 1989) as the official geodetic reference system in Spain, whose framework is materialized by REGENTE network and its densifications. Based on an agreement established between the ICC (Cartographic Institute of Catalonia) and the IGN (National Geographical Institute of Spain), we calculated a single set of coordinates of the ETRS89 ROI network (Network of Lower Order) in Catalonia, which are a densification of REGENTE frame.

From a geodetic point of view, strictly speaking, the methodology necessary and sufficient to address a change of reference system is the three-dimensional similarity transformation. Assuming that the change of reference system needs to be applied in a two-dimensional space (as might be the case of cartography, if there is no change on elevation datum), the methodology proposed previously can be simplified to a two-dimensional similarity transformation.

The use of two-dimensional similarity transformation avoids an important part of the calculations, it is not necessary to switch between geographic and UTM coordinates, or between systems of geodetic and geocentric coordinates. All this avoids the use of Taylor series expansions and calculations on the surface of the ellipsoid, because of their complexity, may differ when they are processed by different algorithms used in diverse software, affecting the result and final accuracy of the process. In addition, the two-dimensional similarity transformation avoids the use of the geoid models and eliminates the orthometric height calculations.

Moreover the four parameters of the two-dimensional similarity transformation are expressed for direct application in the UTM projection. Consequently, it can be applied to the coordinates of the elements to transform. The two-dimensional similarity transformation can be applied in most CAD and GIS systems, and which can be decomposed into two translations, a rotation and a scale factor.

To calculate the parameters have been chosen 683 points of the ROI network, as they are available in both systems ED50-ICC adjustment and ETRS89, and have a homogeneous distribution in the territory.

To estimate the error that the two-dimensional similarity transformation can produce to the cartography we studied the database of control points used in the aerial triangulation of 1:1.000 scale projects. This database consists of 15,000 points distributed throughout Catalonia, whose coordinates are expressed in ED50-ICC. On one hand, these points have been transformed to ETRS89 by an LSA on the new reference frame ETRS89/SPGIC and these are the coordinates that are now used for aerial triangulations in ETRS89. On the other hand, in order to know the divergence introduced by the two-dimensional similarity transformation mapping, this control points have transformed using the transformation and compared to the LSA result. The result showed that this transformation is valid for all the geo-information produced by the ICC for scales 1:1000 and smaller for the whole territory.

With this validation work approved by the CCCC (Comissió de Coordinació Cartogràfica de Catalunya), regulatory commission that coordinates the efforts in mapping and geo-information production at the Administration of the Generalitat de Catalunya and local authorities, this transformation has been formalized as the official for products and services made by the ICC in Catalunya.

With the goal of leading the reference system transition in Catalonia, the ICC is developing a communication plan and support. This plan covers aspects of information to the user community, training for different professional profiles for the correct processing of their products in a manner consistent with the conditions of ICC, and support for change through tools and technical advice. One of the main tasks indentified was the communication to different manufacturers and software developers in the geo-information environment. For this purpose and for a proper communication the transformation has been registered at the OGP geodetic database. The transformation and its parameters can be found at the EPSG Geodetic Registry under the EPSG code: 5166, type 'Coordinate Transformation', named "ED50 / UTM zone 31N to ETRS89 / UTM zone 31N (1) ". Further information and results can be found at the geodesy site of the ICC web www.icc.cat.

Publications

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C. Parareda, Miquel Soro, E. Bosch, A. Termens: "Un año de experiencias con el servicio RTKAT." 7 Setmana Geomàtica. Barcelona . 20-23 Febrer 2007,

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Bosch,E. ;"CATNET, Experience and Outlook" Trimble GNSS Network Operator Seminar. Barcelona, 29 - 30 May 2007.

(The information of this Institution has been remitted by J. Talaya)

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- Benavent Merchan, Mª Teresa (UCM)
- Charco Romero, María (CSIC)
- Fernandez Torres, José (CSIC, Acting Director)
- Folgueira López, Marta (UCM)
- Garcia Pallero, José Luis (UCM)
- Gonzalez Camacho, Antonio Jesús. (CSIC)
- Gonzalez Montesinos, Fuensanta (UCM)
- Martin Hernández, Adriana María (UCM)
- Otero Juez, Jesús (UCM)
- Rodríguez Velasco, Gema (UCM)
- Sevilla de Lerma, Miguel Jesús. (UCM, Vice-Director)
- Vieira Díaz, Ricardo (CSIC)

Research Lines

- Development of new geodetic software
- Earth tides
- Theoretical modelling
- Earth rotation
- Geodesy applied to geological and anthropogenic hazards
- Gravimetry, microgravity and inverse gravimetric problem
- Satellite altimetry
- Space geodesy (including GPS, InSAR and optical methods)

Publications

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(The information of this Institution has been remitted by J. Fernández)

7. INSTITUTE OF GEOMATIC

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1. AREAS OF RESEARCH

The Institute of Geomatics, among other disciplines, does research in the integration of any available sensor for local geodetic applications both in their geometric and physical aspects. Over the past ten years, the Integrated Geodesy and Navigation unit (GIN) has developed theoretical, software development, hardware integration and educational capabilities, through the realization of applied research projects and continuous education programmes. The GIN unit has a record of cooperation with other academic groups, with private companies and with public administration at the international level, with partners in Europe and the Americas .

More specifically, the GIN unit does research on static and kinematic point and gravity field determination. This includes, for instance, precise positioning and navigation with INS/GPS or INS/Galileo, LiDAR and imaging sensor orientation and calibration, and kinematic INS/GPS gravimetry among other topics.

The technologies currently used by GIN are satellite navigation, inertial sensing and digital image/ranging sensing. Its methods are those of geodesy which, in turn, are based on redundant measurements, deterministic and stochastic modelling, statistical testing, signal analysis, numerical analysis and algorithmic design. The combination of these technologies and methods results in a research capacity beyond geodesy. For instance, radiometric sensor calibration, multi-sensor matching and multi-sensor data fusion have recently entered the GIN agenda.

2. SCIENTIFIC PROJECTS

GIN's research and teaching is organized along lines driven by the evolution of technology, the geoinformation community needs, the institutional and industrial markets and the GIN expertise and vision. Current and recent drivers have resulted in the following activity areas:

(1) precise and robust integrated navigation,
(2) precise and robust kinematic positioning and trajectory determination,
(3) precise and robust sensor orientation and calibration,
(4) new platforms and paradigms for high-resolution geodata acquisition.

A few representative projects related to the above four areas are uVISION [MITyC, CIDEM] for geodata acquisition with unmanned aerial vehicles (UAVs) (1,2,3 and 4); IADIRA [6FP/GJU/GSA] for INS/Galileo deeply integrated architectures (1), SARVant-INS [OrbiSat] for UAV-based Synthetic Aperture Radar (SAR) remote sensing (1,2), IEGLO [7FP/GSA] for EGNOS/Galileo receivers (1), GeoLandModels [TRACE/MICINN] for airborne LiDAR and digital camera integration (3), GeoTRAM [TRACE/MICINN] for railway surveying (2,3) and the courses "Sensor orientation: precise trajectory and attitude determination with INS" (1,2) and "Sensor orientation: calibration and block adjustment" (3). Analogously, a number of SW and HW tools have been developed for in-house research use or under contract for private companies giving the GIN group a remarkable independent data acquisition and data processing capacity.

3. PUBLICATIONS

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(The information of this Institution has been remitted by I. Colomina)

8. MICROGEODESIA JAÉN RESEARCH GROUP

Grupo de Investigación MICROGEODESIA JAÉN
Universidad de Jaén
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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 2007-2010 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.
- Application of radar interferometry to monitor ground deformation

2.- Research Projects

- APLICACIÓN DE LA INTERFEROMETRÍA RADAR DE SATÉLITE (INSAR Y PSINSAR) Y LOS SISTEMAS GLOBALES DE NAVEGACIÓN POR SATÉLITES (GNSS) EN ESTUDIOS DE DINÁMICA LITORAL PRESENTATIONEN EL SUR Y ESTE DE LA PENÍNSULA IBÉRICA
  Funding: MICINN AYA2009-10209 (Subprogram ESP)
  Participanting teams: Univ. Jaén, Univ. Porto, Univ. Tec. Delft, Univ. Complutense Madrid.
  Period, from: 01/01/2010 to: 31/12/2010. Budget: 36.300 Euros
  Principal Investigator: Antonio J. Gil (Univ. Jaén)

- CUANTIFICACIÓN DE LA DEFORMACIÓN ACTUAL EN LA CORDILLERA BÉTICA MEDIANTE UNA NUEVA OBSERVACIÓN GPS DE LA RED PENINSULAR DE ORDEN CERO (IBERIA95) EN SU SECTOR MÁS MERIDIONAL
  Funding: MICINN Complementary action CGL2008-05155-E/BTE
  Participanting teams: Univ. Jaén, Univ. Granada, Univ. Alicante
  Period, from: 04/06/2009 to: 03/10/2010. Budget: 15.000 Euros
  Principal Investigator: Antonio J. Gil (Univ. Jaén)

- APLICACIÓN DE LAS TÉCNICAS GPS EN TRABAJOS ARQUEOLÓGICOS. ARQUEOGPS.
  Funding: DGI. Complementary action. ESP2006-28465-E
  Participanting teams: Univ. Complutense Madrid, Univ. Jaén
  Period, from: May 2007 to: May 2008. Budget: 6.000 Euros
  Principal Investigator: Gracia Rodríguez Caderot (Univ. Complutense Madrid)

- APPLICATION OF SATELLITE RADAR INTERFEROMETRY IN STUDIES OF COASTAL DYNAMICS (SOUTHERN SPAIN)
  Funding: EUROPEAN SPACE AGENCY - CAT1 PROPOSAL ID: 7629
  Funding: EUROPEAN SPACE AGENCY - CAT1 PROPOSAL ID: 3963
  Participanting teams: Univ. Jaén - Univ. Porto – Univ. Tec. Delft – Univ. Silesia

Period, from: 2010 to: 2011. Budget: (Reproduction costs)
Principal Investigator: Antonio M. Ruiz (Univ. Jaén)

- DEFORMATION MONITORING OF THE PADUL FAULT (BETIC CORDILLERA, SOUTHERN SPAIN) USING RADAR INTERFEROMETRY (INSAR)
  Funding: EUROPEAN SPACE AGENCY - CAT1 PROPOSAL ID: 3963
  Participanting teams: Univ. Jaén - Univ. Porto – Univ. Tec. Delft
  Period, from: 2006 to: 2008. Budget: (Reproduction costs)
  Principal Investigator: Antonio M. Ruiz (Univ. Jaén)

- EVALUATION OF ACTIVE DEFORMATIONS IN THE BETIC REGION
  Funding: EUROPEAN SPACE AGENCY - CAT1 PROPOSAL ID: 3858
  Participanting teams: Univ. Jaén - Univ. Porto – Univ. Tec Delft
  Period, from: 2006 to: 2008. Budget: (Reproduction costs)
  Principal Investigator: Luisa Bastos (Portugal)

- APLICACIÓN DE LA INTERFEROMETRÍA RÁDAR DE SATÉLITE (INSAR) PARA EL CONTROL DE DEFORMACIONES EN EL SECTOR CENTRAL DE LA CORDILLERA BÉTICA.
  Funding: DGI. Complementary action. ESP2006-28463-E
  Participanting teams: Univ. Jaén
  Period, from: June 2007 to: December 2008. Budget: 9.200 Euros
  Principal Investigator: Antonio Miguel Ruiz Armenteros (Univ. Jaén)

- GEOCIENCIAS EN IBERIA: ESTUDIOS INTEGRADOS DE TOPOGRAFÍA Y EVOLUCIÓN 4D (TOPOIBERIA).
  Funding: MEC (CONSOLIDER-CSD2006-00041).
  Participanting teams: Instituto Jaume Almera (CSIC) and 10 teams (UCM, UGR, UPC, UB, IGME, UJA,…)
  Period, from: October 2006 to: September 2012. Budget: 4.500.000 Euros
  Principal Investigator: J. Gallart (IJA-CSIC) (Coordinator); PI UJA team: Antonio J. Gil

- SERVICIOS DE POSICIONAMIENTO Y NAVEGACION BASADOS EN REDES DE ESTACIONES PERMANENTES GNSS CON APLICACIONES TIEMPO REAL (RTK).
  Funding: MEC. Proyecto de I. ESP2006-10113
  Participanting teams: Univ. Jaén
  Period, from: October 2006 to: December 2009. Budget: 47.610 Euros
  Principal Investigator: Antonio J. Gil (Univ. Jaén)

- CUANTIFICACIÓN DE PROCESOS TECTÓNICOS DE CONVERGENCIA, ESCAPE Y LEVANTAMIENTO, EN EL SUR DE ESPAÑA Y NORTE DE ÁFRICA. PROPUESTA DE UN MODELO TECTÓNICO. (Research project of excellence)
  Funding: Junta de Andalucía Ref. 00327
  Participanting teams: Univ. Granada, Univ. Jaén
  Period, from: January 2006 to: December 2008. Budget: 169.400 Euros
  Principal Investigator: Francisco González Lodeiro (Univ Granada)

- INVESTIGACIONES GEODÉSICAS, GEOFÍSICAS Y DE TELEDETECCIÓN EN LA ISLA DECEPCIÓN Y SU ENTORNO (PENÍNSULA ANTÁRTICA-ISLAS SHETLAND DEL SUR)
  Funding: MEC. Proyecto de I. CGL2005-07589-C03-01/ANT
  Participanting teams: Univ. Cádiz, Univ. Jaén, Univ. Valencia, Natural Sciences Museum
  Period, from: 31-December-2005 to: 31-December-2008. Budget: 249.900 Euros
  Principal Investigator: Manuel Berrocoso (Univ. Cádiz)

- ANÁLISIS DE LA EROSIÓN EN EL OLIVAR TRADICIONAL
  Funding: Diputación Provincial de Jaén. Instituto de Estudios Giennenses (IEG)
  Participanting teams: Univ. Jaén
  Period, from: November-2009 to: November-2011. Budget: 5.000 Euros
  Principal Investigator: Mª Isabel Ramos Galán (Univ.Jaén)

- Application of satellite radar interferometry in studies of coastal dynamics (southern Spain)
  Funding: EUROPEAN SPACE AGENCY - CAT1 PROPOSAL ID: 7629
  Budget: (Reproduction costs)
  Participanting teams: UNIV. JAÉN - UNIV. PORTO - UNIV. TEC DELFT - UNIV. SILESIA
  Period, from: 2010 to: 2011
  Principal Investigator: ANTONIO M. RUIZ (Univ. Jaén)

- Application of satellite radar interferometry in studies of coastal dynamics (southern Spain)
  Funding: EUROPEAN SPACE AGENCY - CAT1 PROPOSAL ID: 7629
  Budget: (Reproduction costs)
  Participanting teams: UNIV. JAÉN - UNIV. PORTO - UNIV. TEC DELFT - UNIV. SILESIA
  Period, from: 2010 to: 2011
  Principal Investigator: ANTONIO M. RUIZ (Univ. Jaén)

- Coastal dynamics and stability of water defense structures monitoring by satellite radar interferometry (northern Portugal)
  Funding: EUROPEAN SPACE AGENCY - CAT1 PROPOSAL ID: 8111
  Budget: (Reproduction costs)
  Participanting teams: UNIV. JAÉN - UNIV. PORTO - UNIV. TEC DELFT - UNIV. SILESIA
  Period, from: 2010 to: 2012
  Principal Investigator: JOAQUIM JOAO SOUSA (Univ. Porto)

- Nuevos algoritmos para el futuro sistema GNSS multifrecuencia
  Funding: MEC. Ref. AYA2008-02948
  Participating teams: Univ. Jaén, Univ. Complutense Madrid, Politecnico di Milano (Campus Como), Univ. Ljubljana
  Period, from: 2009 to: 2011. Budget: 14000 €
  Principal Investigator: M. Clara de Lacy (Univ. Jaén)

- Gestión de información urbana tridimensional
  Funding: Junta de Andalucía. Ref. P07-TIC-02773
  Participating teams: Univ. Jaén
  Period, from: 2008 to: 2012. Budget: 327568,14 €
  Principal Investigator: Francisco F. Feito (Univ. Jaén)

3.- Publications

- J. A. Armenteros, A. J. Gil (2010) A methodology for creating RTK positioning coverage maps via a radio modem link to CORS stations. Survey Review. ISSN: 0039-6265 DOI: 10.1179/003962610X12747001420744. Vol. 42, 318: 406-411

- Carlos Marín-Lechado, Jesús Galindo-Zaldívar, Antonio J. Gil, María Jesús Borque, María Clara de Lacy, Antonio Pedrera, Angel Carlos López-Garrido, Pedro Alfaro, Francisco García-Tortosa, Maria Isabel Ramos, Gracia Rodríguez-Caderot, José Rodríguez-Fernández, Ana Ruiz-Costán, Carlos Sanz de Galdeano-Equiza (2010) Levelling Profiles and a GPS Network to Monitor the Active Folding and Faulting Deformation in the Campo de Dalias (Betic Cordillera, Southeastern Spain). Sensors ISSN: 1424-8220 doi:10.3390/s100403504. Vol. 10: 3504-3518

- J. J. Sousa, A. M. Ruiz, Ramon F. Hanssen, L. Bastos, A. J. Gil, J. Galindo-Zaldívar, C. Sanz de Galdeano (2010) PS-InSAR processing methodologies in the detection of field surface deformation - study of the Granada basin (Central Betic Cordilleras, Southern Spain). Journal of Geodynamics ISSN: 0264-3707 doi:10.1016/j.jog.2009.12.002. Vol. 49: 181-189

- B. Moreno , S. Radicella, M. C. de Lacy, M. Herráiz, G. Rodríguez Caderot (2010) On the Effects of the Ionospheric Disturbances on Precise Point Positioning at Equatorial Latitudes.(DOI 10.1007/s10291-010-0197-1). GPS SOLUTIONS. Online article.

- J. Giménez , M.J. Borque, A. J. Gil, P. Alfaro, A. Estévez, E. Suriñach (2009) Comparison of long-term and short-term uplift rates along an active blind reverse fault zone (Bajo Segura, SE Spain) Studia Geophysica & Geodaetica. ISSN: 0039-3169. doi 10.1007/s11200-009-0005-y Vol. 53: 81-98

- GARCÍA BALBOA, J.L, RUIZ ARMENTEROS, A.M., CRESPO ALONSO, M. Y RAMOS GALÁN, M.I. (2009) Aplicación del aprendizaje cooperativo para el desarrollo de competencias transversales en la materia de topometría de la titulación de Ingeniería técnica en Topografía. En: Métodos y herramientas innovadoras para potenciar el proceso de aprendizaje del alumno en el EEES. ISBN: 978-84-936853-4-8. Pag: 581-592. Servicio de publicaciones de la Universidad europea Miguel de Cervantes. Valladolid. Colección Scholaris

- RAMOS GALÁN, M.I., CRESPO ALONSO, M., RUIZ ARMENTEROS, A.M Y GARCÍA BALBOA, J.L (2009) Aplicación del aprendizaje cooperativo para el desarrollo de competencias transversales en la materia Topografía y Construcción de la titulación de Ingeniería técnica Industrial. En: Métodos y herramientas innovadoras para potenciar el proceso de aprendizaje del alumno en el EEES. ISBN: 978-84-936853-4-8. Pag: 203-209. Servicio de publicaciones de la Universidad europea Miguel de Cervantes. Valladolid. Colección Scholaris

- M.I. Ramos, F.R. Feito, A.J. Gil, J.J. Cubillas (2008) A study of spatial variability of soil loss with high resolution DEMs: A case study of a sloping olive grove in southern Spain. Geoderma ISSN: 0016-7061 doi:10.1016/j.geoderma.2008.08.015 Vol. 148 (11-12

- J. GALLASTEGUI, J.A. PULGAR, J.M. GONZÁLEZ-CORTINA, J. GARATE, J. MARTIN DAVILA, G. KHAZARADZE, A.J.GIL, A.M. RUIZ, I. JIMENEZ-MUNT, C. AYALA, J. TELLEZ, G. RODRÍGUEZ-CADEROT, P. AYARZA Y F. ÁLVAREZ-LOBATO (2008) Despliegue de estaciones GPS permanentes en el marco del proyecto Topo-Iberia. GEO-TEMAS (Proceedings del VII congreso geológico de España, Las Palmas de Gran Canarias). Vol. 10. Pag: 1543-1545.

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- De Lacy, M.C., A. J. Gil, G. Rodriguez-Caderot, B. Moreno (2008) A method to estimate the Ionospheric bias by using the new GNSS frequencies: an analysis of its theoretical accuracy in a PPP context. Física de la Tierra ISSN: 0214-4557 Vol. 20: 133-150

- M. Chersich, M. Fermi, M.C. De Lacy, A.J. Gil, M. Osmo, R. Sabadini, B. Stopar (2008) Perspective of Galileo in Geophysical Monitoring: The Geolocalnet Project .DOI 10.1007/978-0-387-47524-0_29. Book: Satellite Communications and Navigation Systems ISBN: 978-0-387-47522-6. 369-385. Springer

- M. C. de Lacy, M. Reguzzoni, F. Sansò, G. Venuti (2008) The Bayesian detection of discontinuities in a polynomial regression and its application to the cycle-slip problem (DOI 10.1007/S00190-007-0203-8) Journal of Geodesy, Vol. 82(9): 527-542

- C. Sanz de Galdeano, J. Delgado, J. Galindo-Zaldívar, C. Marín-Lechado, P. Alfaro, F.J. García Tortosa, A.C. López- Garrido, A.J. Gil. (2007) Anomalías gravimétricas de la cuenca de Guadix-Baza (Cordillera Bética, España). Boletín Geológico y Minero ISSN: 0366 - 0176 Vol. 118, 4763-774

- J. Galindo-Zaldívar, A.J. Gil, C. Sanz de Galdeano, S. Shanov, D. Stanica (2007) Monitoring of active tectonic structures in central Betic Cordillera (Southern Spain). Acta Geodynamica et Geomaterialia ISSN: 1214 – 9705. Vol. 4, 1 14519-29

- M.I. Ramos, A.J. Gil, F.R. Feito, A. García-Ferrer (2007) Using GPS and GIS tools to monitor olive tree movements. doi:10.1016/j.compag.2007.03.003. Computers and Electronics in Agriculture. ISSN: 0168-1699 Vol. 57, 2135-148

- P. Alfaro, F.J. García Tortosa, J. Delgado, C. Sanz de Galdeano, J. Galindo-Zaldívar, A.C. López Garrido, C. López Casado, L. Gibert, J.A. Peláez, C. Marín, A.J. Gil, M.J. Borque. La falla activa de Baza (2007) La Cuenca de Guadix-Baza. Estructura, tectónica activa, sismicidad, geomorfología y dataciones existentes ISBN: 8-496-85636-4. Pag: 155-175. Ed. C. Sanz de Galdeano y J.A. Peláez. Granada

- J. Delgado, J. Galindo-Zaldívar, C. Marín, C. Sanz de Galdeano, P. Alfaro, F.J. García Tortosa, A.C. López Garrido, A.J. Gil (2007) Los mapas gravimétricos de la cuenca de Guadix-Baza: campaña y elaboración de datos Libro: La Cuenca de Guadix-Baza. Estructura, tectónica activa, sismicidad, geomorfología y dataciones existentes ISBN: 8-496-85636-4. Pag: 97-99. Ed. C. Sanz de Galdeano y J.A. Peláez. Granada

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4.- Contributions to conferences

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- Joaquim J. Sousa, Antonio M. Ruiz, Ramon F. Hanssen, Luisa Bastos, Antonio J. Gil, Jesús Galindo-Zaldívar, Carlos Sanz De Galdeano
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5.- Committees and international representation

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(The information of this Institution has been remitted by A. M. Ruiz (A. J. Gil))

9. NATIONAL GEOGRAPHIC INSTITUTE

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1. GEODETIC NETWORKS

New Geodetic Reference System in Spain: ETRS89.

On august 2007, a law was published adopting ETRS89 (European Terrestrial Reference System 1989) as the new legal Geodetic Reference System for all type of works of geodesy, mapping, surveying and any other works involving geographic referencing.The Royal Decree 1071/2007 set up the geodetic reference system on which to compile all the geographical information and official maps, allowing full integration of geographic information and Spanish official mapping with other European countries and navigation systems.

ETRS89 system is adopted as official geodetic reference system in Spain for geographical referencing and mapping in the area of the Iberian Peninsula and Balearic Islands. In the case of the Canary Islands, REGCAN95 system was adopted, wich is equivalent to ITRF93 epoch 1994.8. Both systems have associated the GRS80 ellipsoid and realised by the framework of the National Geodetic Network through Spatial Techniques (REGENTE) and their densifications.

Respecting to the Altimetric Reference System, the R.D. 1071/2007 set the Spanish High Precision Levelling Network (REDNAP) as the legal frame for the realization of the system, taking as reference height the records of mean sea level in Alicante for the Peninsula and local tide and references for each of the islands. The origins of the references are defined and published by the Directorate General of the National Geographic Institute (IGN).

In order to reach the transition from ED50 to ETRS89 conveniently, IGN has published a set of tools that facilitates the change between coordinates. The tools are based on a regular grid of parameters depending on the area the user is working on.

This grid have been computed taking into account the double set of coordinates in both systems of REGENTE network (about 1100 points with ETRS89 coordinates well known, 5 cm of precision) and National Geodetic Network (about 9800 points more). A minimum curvature surface algorithm has been used to model the differences between both geodetic reference systems.

The law establishes a maximum available period to publish and compile cartography in the old system (1st January, 2015). Also from 1st January, 2012 no cartography in the old system ED50 wouldn't inscribe in the Central Cartography Registry neither in the National Cartographic Plan.

1.1 Computation of new orthometric heights in the National Geodetic Network (ROI).

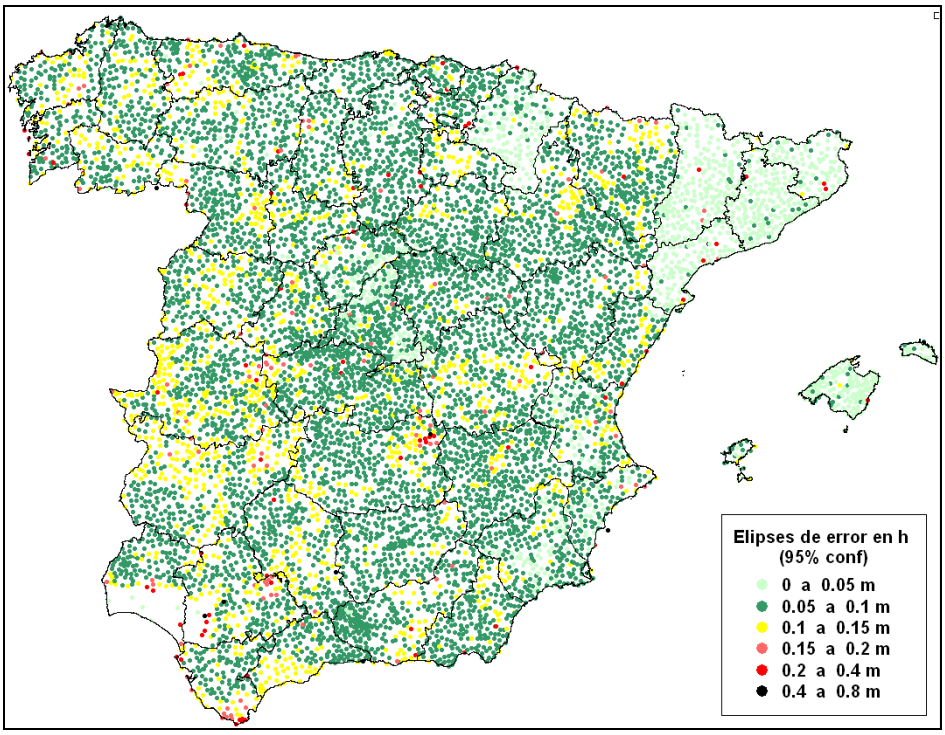
The adoption of ETRS89 as official Geodetic Reference System in Spain has important consequences and changes in all the geodetic, topographic and cartographic works. The National Geodetic Network by Space Techniques (REGENTE) constitutes the frame on which these works must be carried out. The density of this class C network is one geodetic point per sheet of the National Topographic Map scale 1/50000, totalling 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 Spain. Nevertheless, the National Geodetic Network of Inferior Order (ROI) –included REGENTE stations- is more dense, and it's constituted by about 11000 geodetic points in all Spain (density of one bench mark every 45 km2). 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.

In 2007 a re-computation of all the ROI has been made in ETRS89 system constraining to the REGENTE network and including classic angular observations and GPS, including 127.000 azimutal directions, 67.000 zenital angles and 7.000 GPS vectors, weighting the observables suitably by calculation blocks.

Additionally to this computation, in 2009 a new adjustment was carried out in order to provide to these points orthometric heights consistents with the new High Precision Levelling Network (REDNAP) and the geoid model EGM08-REDNAP, mentioned above. Through the values of deviation of the vertical provided by the model, zenithal angles (referred to the geoid) were transformed into vertical angles respect the ellipsoid, because computation had to be done in Cartesian reference system components. The final equation system was composed of almost 200.000 observations to solve 42.000 parameters. As in the previous global adjustment, the network was constrained to REGENTE coordinates, also in ellipsoidal heights.

Concerning the final precision obtained in altimetry is represented by a mean standard deviation in the adjustment of 4.5 cm and a mean vertical vector error (95% confidence) of 8.8 cm for those geodetic points where only angular observations were available. 81% of the geodetic points have a vertical vector error less than 10 cm. In the case of 1222 vertex with GPS observables, the resulting average standard deviation was 1.2 cm and the average error vector of 2.3 cm (95% confidence). In the next picture the spatial distribution of the vector errors is shown.



Vertical vector errors in the adjustment.

1.2 GNSS Reference Station Network (ERGNSS)

ERGNSS 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, ERGNSS is constituted by 33 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.
- Two of them (YEBE and LPAL) are IGS stations contributing to the definition of the International Terrestrial Reference Systems ITRS.
- 23 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 one second hourly data through a public ftp server with the next address: ftp://ftp.geodesia.ign.es

IGN Permanent GNSS stations Network.

In the last four years most of these stations have been upgraded to be able to track GLONASS satellite signals. New stations that have been placed are:

- Aranda de Duero. EDAR Aranda. **(ARDU).**
- Ceuta Port **(CEU1).**
- Observatorio Meteorológico de Izaña **(IZAN).**
- León Aeroport, Agencia Estatal de Meteorología **(LEON).**
- Tarifa Port **(TARI).**
- Agencia Estatal de Meteorología. Teruel **(TERU).**
- For Teide Volcano **TN01** to **TN06.**
- Yebes Astronomical Observatory, Guadalajara **(YEB1).**
- Ayuntamiento de Zafra **(ZAFR).**

ERGNSS	Instalation date	IGS	EUREF	EUREF-NRT	EUREF-IP	GLONASS	Public data 1 second
ACOR	sep-98		X	X	X		X
ALAC	abr-98		X	X	X	X	X
ALBA	jun-02		X	X	X	X	X
ALME	dic-99		X	X	X		X
ARDU	jul-09					X	X
CACE	dic-00		X	X	X		X
CANT	mar-00		X	X	X		X
CEU1	may-07		X	X	X		X
COBA	abr-04		X	X	X		X
HUEL	dic-01		X	X	X		X
IGNE	may-00					X	X
IZAN	may-08		X	X	X	X	X

LEON	mar-07		X	X	X	X	X
LPAL	may-01	X	X	X	X	X	X
MALA	mar-00		X	X	X	X	X
MALL	may-00		X	X	X	X	X
RIOJ	may-01		X	X	X		X
SALA	jun-06		X	X	X	X	X
SONS	dic-00		X	X	X	X	X
TARI	may-10					X	X
TERU	mar-08		X	X	X	X	X
TN01	may-07						X
TN02	may-07						X
TN03	nov-07						X
TN04	ago-08						
TN05	ene-10						
TN06	jun-10						
VALE	ene-00		X	X	X	X	X
VIGO	sep-01		X	X	X		X
YEB1	may-09					X	X
YEBE	may-99	X	X	X	X		X
ZFRA	nov-11					X	X
ZARA	abr-06		X	X	X		X

IGN Permanent GNSS stations Network availability.

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 the kernel of IGN analysis.

For real-time applications a Professional NTRIP Caster (http://ergnss-ip.ign.es) working on TCP ports 8080 and 2101 has been developed with RTCM2.3 and RTCM3.x data streams for each GNSS station. To get access to RTCM data streams through this server you need to submit by e-mail to buzon-geodesia@fomento.es next pdf document (ftp://193.144.251.14/documentos/registro_cliente.pdf).

1.3 IGE, Analysis Centre.

IGE as a Local Analysis Centre of EUREF

The IGN geodetic department became a EUREF Analysis Centre since the first week of September of 2001 (GPS WEEK 1130). The three letters acronym used is IGE.

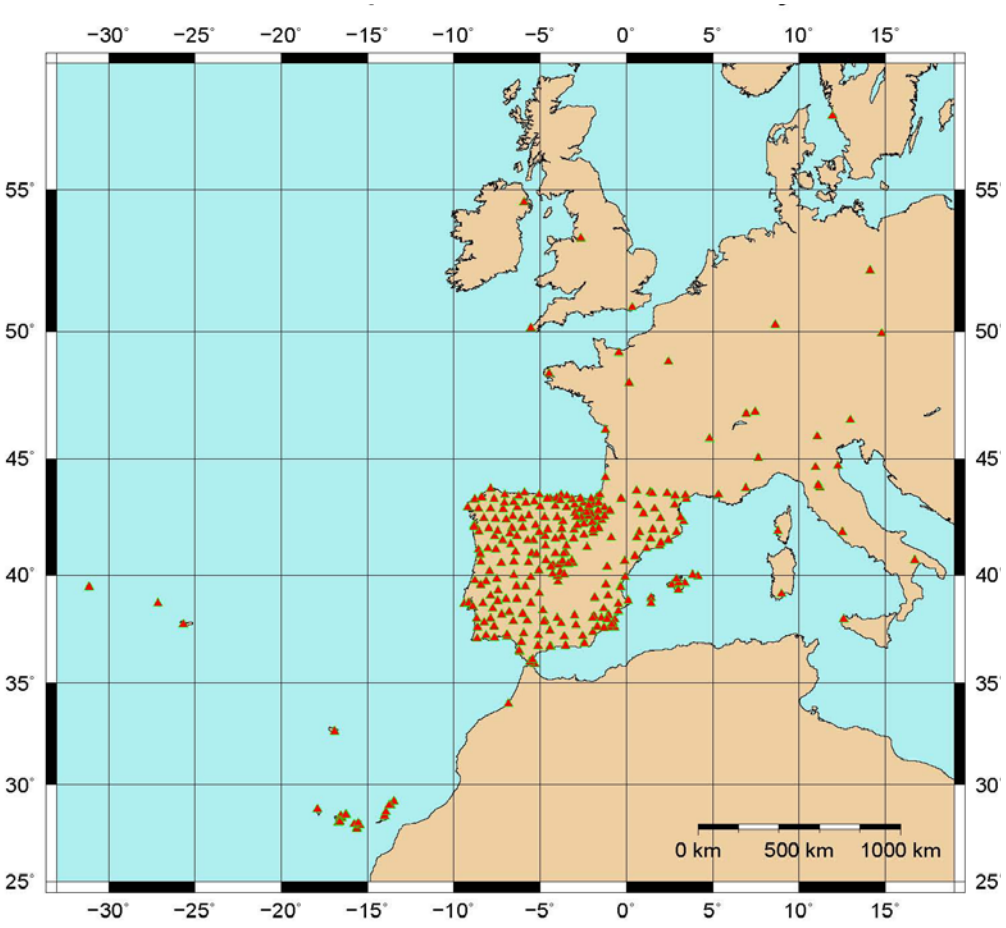
Currently, the processing is done by Bernese Processing Engine BPE of Bernese 5.0 under LINUX platforms in an automatic procedure. Weekly and daily solutions are reported in SINEX format (Solution Independent Exchange format), together with a weekly SUMMARY of results and seven troposphere parameter files (one per day of the week) corresponding to a special project of estimation of troposphere parameters (zenith path delays) of EUREF processed with precise IGS products. Additionally, we are collaborating sending daily solutions processed with rapid IGS products. The current number of EPN stations that are

processed is 61. 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. Also, IGE is participating in the re-processing activities of EUREF with a sub-network of around 100 EPN stations.

IGE Processing Network for EUREF

1.4 IGE as a Analysis Centre of E-GVAP and E-GVAPII projects

IGE Analysis Centre has begun the collaboration with AEMET, the Spanish Meteorological Institution, in E-GVAP since March 2009. During this time the number of stations have grown up and the strategy have been re-adapted. We are currently processing about 300 stations, but some of them do not provide hourly data on time. The processing is done by Bernese Processing Engine BPE of Bernese 5.0 under LINUX platforms in an automatic procedure. The processing consists of two phases, a daily process with the objective of getting precise coordinates and an hourly process to get zenith total delays. The first process is done with double differences strategy using final IGS products and at the end making a weekly combination. We are dealing with the huge number of stations clustering the network. The hourly process is done using the precise coordinates from the first process, with double differences strategy and using ultra rapid IGS products. Finally, the 12 last hours are combined.



IGE Processing Network for E-GVAP-II and IBERRED project

1.5 IGE as Iberian Analysis Centre

Following almost the same strategy used for EUREF, the IGE Analysis Centre is processing an Iberian Network with stations of the area which provide public data. Currently we are processing about 300 stations. 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.

2. National High Precision Levelling Network (REDNAP).

The Instituto Geográfico Nacional of Spain is carrying out since 2001 the establishment of a New High Precision Levelling Network (REDNAP Project), already finished in 2008, consisting on about 17.000 kilometres of levelling lines composed by about 22.000 benchmarks.

Once the main project finished in 2008, during the 2008-2010 period, this network have been densified and new additional lines have been observed as well as its extension to the Balearic Islands. This REDNAP densification project consist on 3.300 kilometres, which currently more than 2.000 kilometres have been already observed, including in 2009 a lot of links to the network of GNSS permanent stations and tide gauges.

Also in 2010 two lines were observed in the area of Gibraltar Strain, one in the European side and the other one in the African continent (Ceuta), wich support a common altimetric reference for the Geodetic Network of Geodynamic Observations of the Gibraltar Strait (RGOG), linked to tide gauges on both sides of the Strait and the Moroccan Levelling Network in the African border.

The REDNAP densification project will be ended in the next 2012, being in this way an homogeneous and precise levelling network composed of a total of 20.000 kilometres of lines and 30.000 benchmarks.

High Precision Levelling Network of Spain (REDNAP).

Respecting to the relative gravimetric observation during this period (2007-2010) in the REDNAP project, a total of 3.500 benchmarks were observed and 20 new gravimetric fundamental points were set up in order to observe the gravimetric itineraries.

3. EGM2008-REDNAP geoid model.

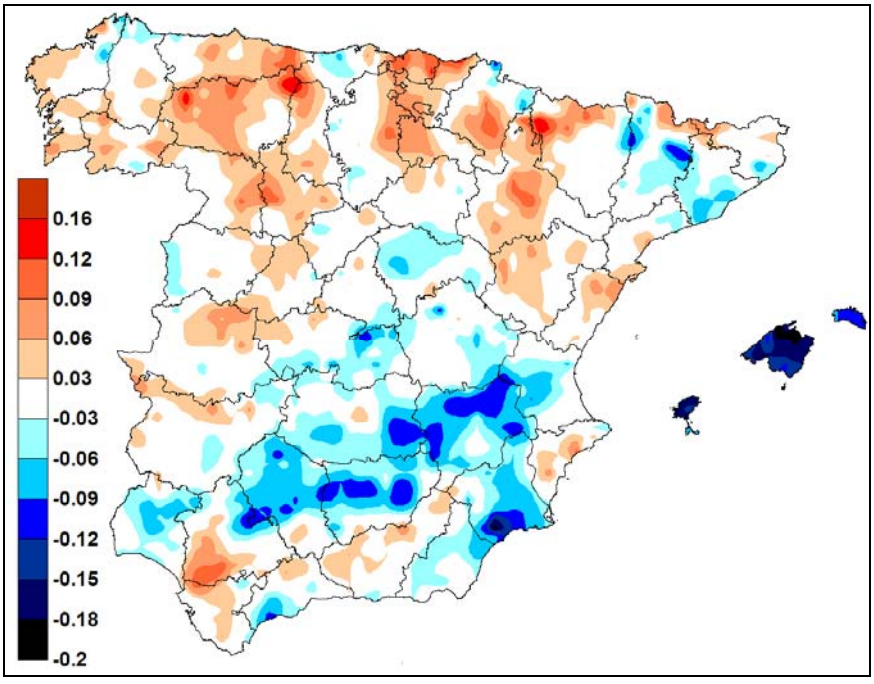
Obtaining orthometric heights (referred to mean sea level) from GPS techniques require to use series of points with well known altitude or having a geoid model with enough accuracy. IGN has recently published the new geoid model EGM08-REDNAP, adapting the global gravimetric geoid model EGM2008 to the vertical reference frame in Spain given by the Spanish High Precision Levelling Network (REDNAP), whose origin is the mean sea level of the Mediterranean in Alicante.

EGM2008 was published by the National Geospatial-Intelligence Agency (NGA) EGM Development Team, being the most complete and accurate global model obtained so far.

In short, it can be said that it has taken the "overall" of the gravity model and it has moved and adjusted to a great number of REDNAP benchmarks covering the country. Thus the resultant surface cannot strictly named geoid, but "vertical reference surface", because it is used to convert ellipsoidal heights into orthometric heights, supportting all types of jobs of surveying, mapping, geodesy and positioning in general.

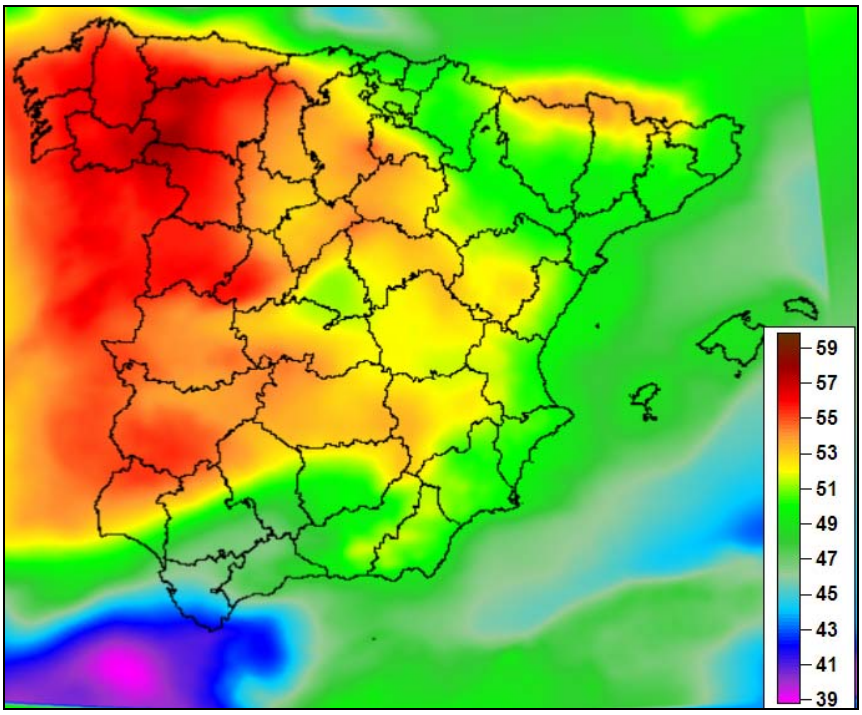
The technique involved the direct observation of the geoid undulations at most of the points of REDNAP. This network currently consists of about 25000 benchmarks on main roads along 18000 kilometres. GNSS observation on these signals, which have a very precise orthometric height, provide ellipsoidal heights, although not so precises (rms ~ 3 cm). This direct observation of the geoid undulation has been made in nearly 18.000 points, but an exhaustive debugging, computation and analysis of data, the number of available points (in order of precision) were more than 13.000 benchmarks, which have been used to build a "corrective surface" over EGM2008 original gravity model in order to adapt it to the national vertical reference surface materialised by REDNAP.

The mean difference between observed and model undulations has a value of -0.561 m, due to the low mean sea level of the Mediterranean. After subtracting this adopted constant value, a surface of corrections in order to adapt the gravity model to the vertical reference surface was computed and to a 1' x 1' regular grid. Different algorithms were tested, resulting the most effective, given the irregular distribution of the data (linear along the main roads), the minimum curvature surface algorithm.



Correction surface applied to EGM2008 (-0.561 m).

Applying this corrections surface to the gravity model, the final model named EGM08-REDNAP was obtained, given by a regular grid of geoid undulations spaced every minute in latitude and longitude (nearly half a million points).



EGM2008-REDNAP geoid model.

In order to check the quality and accuracy of the final model, 188 REDNAP benchmarks located in levelling lines that originally didn't participate in the preparation of the model, were observed with GPS, following more strict observation methodology in terms of accuracy than the 13000 points previously used. In this set of points a standard deviation and an equivalent average difference of 3.8 cm was obtained comparing undulations observed and given by the final model (absolute accuracy). Also relative accuracy of the model between signals of 2 parts per million (ppm) was computed.

REDNAP-EGM08 model is available in public FTP server and also accessible from the website of the IGN. The model can be downloaded in ascii format and also for direct use with GPS receivers (Leica, Topcon and Trimble formats) or GeoLab format for its use with this software.

Also through a tool named Geodetic Applications Programme (PAG), the users can obtain geoid and vertical deflection components in Spain. This software has many other utilities, such as transformation between ED50 to ETRS89, transformation of coordinates (geographic, UTM, geocentric), search on map and access to all national geodetic infrastructure, access to GNSS data of IGN permanent stations network, etc.

In 2012, a densification REDNAP project will be finished, with 3200 kilometres more of levelling lines, so additional data will be available to a new computation of EGM08-REDNAP surface.

4. ABSOLUTE and RELATIVE GRAVITY

Absolute gravity stations are divided into two sub-networks (figure 1): the Zero Order Network and the First Order Network.

Absolute gravity sites

Zero Order Network

The Zero Order Network consists of 30 sites observed from 2001 until 2010 in the Iberian Peninsula with the FG5 gravity meter. 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.

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.

First Order Network

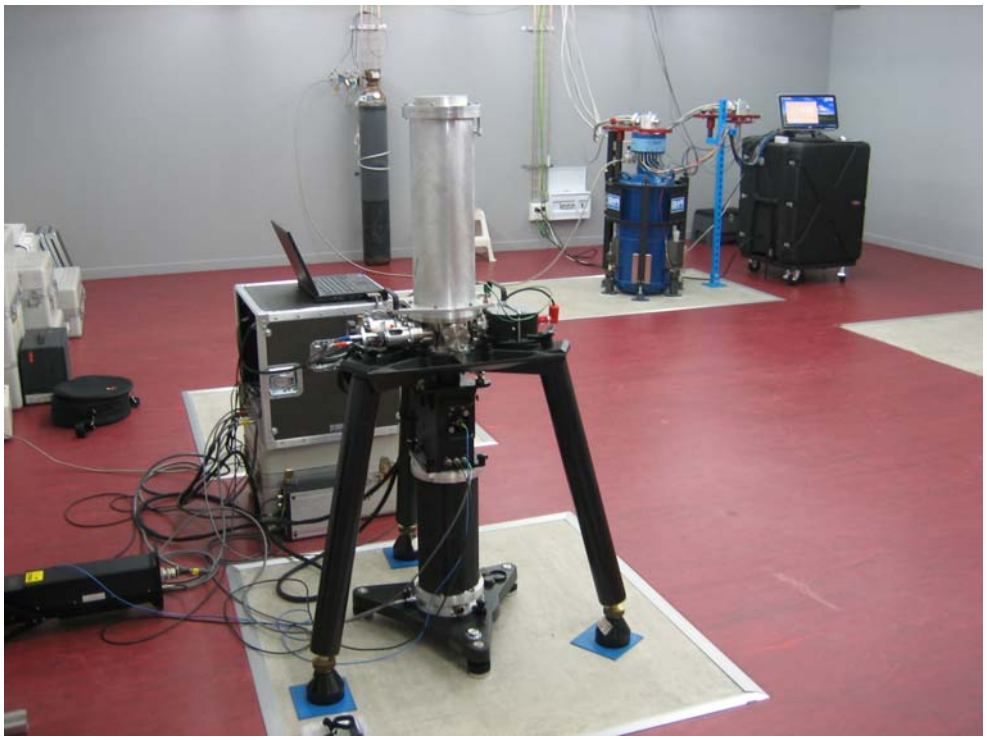
The First Order Network consists of 44 sites observed from 2003 until 2010 in the Iberian Peninsula and the Balearic Island (Majorca, Minorca and Ibiza) with the A10 gravity meter (figure 1). Most of these sites have also a concrete pier to obtain a good stability, sharing accelerometer sites. Also the 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 Pavilion at Yebes

In 2008 the IGN started a new project at the Yebes Astronomical Observatory endowing it

with new facilities for combining top quality techniques (VLBI, Laser ranging, GPS and continuous gravity measurement) at the same site. To this end, in 2008, is designed and built a pavilion of gravimetry in the outbuildings Yebes Observatory. The pavilion, designed to reach a high-quality, has a dual-chamber with seven pillars of measurement, which allows simultaneous measurement and inter comparison of gravimetric instrumentation. It has been also installed instrumentation for environmental conditions measurement (weather station, measuring the water table, measurement of soil moisture ...). In this pavilion, in May 2010, has been installed the newly acquired Gravimeter Superconductor (SG) launched in the world of superconducting gravimetry. The new SG has been made by G.W.R Company and it is now installed in one of the gravity meter pier. The new SG is being calibrated with one of the IGN´s absolute FG5 instrument.

The SG opens a wide range of new possibilities for study, allowing research in seismology, geodesy, geomagnetism, volcanology, VLBI or GPS, and to measure the acceleration of gravity in real time, continuously and with high resolution, which was unattainable until now. At present, data from the Superconducting Gravimeter of Yebes, is integrated in many projects, as GGP (Global Geodynamics Project) and the IRIS (Incorporated Research Institution for Seismology).



Indoors Gravity Pavilion. To the left is the absolute gravimeter FG5 of the IGN, the simultaneous measurement of the SG is required for the control of superconducting gravimeter drift during the first months of registration.

Continuous relative gravimeters

In 2009, the IGN acquire a relative continuous gravimeter for continuous earth tides

registration. The instrument, a gPhone, from Micro-g-Lacoste Company, has been installed in Tenerife for volcano monitoring proposes.

5. SPECIAL WORKS

5.1 Gibraltar Strait GPS Network (RGOG 2004)

Geodetic Network of Geodynamic Observation of Gibraltar Strait (RGOG).

In 2010 a new campaign was done in the RGOG network. The main objetive in this campaign was the link in terms of ortometric heights between both sides of the Gibraltar Strait through many techniques in order to compare results and fix a realistic value.

These techniques include classical observations of reciprocal and simultaneous cenital angles, combination of GNSS data with many local geoid models and high precision levelling networks from tide gauges using mean sea level references on both sides of the Strait. The results by comparing the three different techniques had a good agreement and a common altimetric reference was set up for both sides.

Also in this campaign a new GNSS permanent station was installed in the area, in Tarifa tide gauge and a network of stations in the area are also being continuously monitorized in real time.

5.2 Tenerife Volcanic Monitoring System Project

Geodetic Network to Tenerife, Volcanic Monitoring System Project

Tenerife is an island with active volcanoes. For this reason the Spanish Government decided to develop a Volcanic Monitoring System project in 2004 after several seismic movements affected the island that year.

The Spanish National Geographic Institute is developing a network to monitor the island, using different techniques: geodetic, seismic, geochemical and geomagnetic techniques. Due to volcanic process, land movements can occur at different spatial and temporal scales. The measurement of these possible deformations can be useful precursors to active volcanoes. So, it is necessary to have a geodetic network covering the whole island, which uses land and space techniques. Apart from REGCAN network (REGENTE Canary Island) and the National High Precision Levelling Network (REDNAP), permanent GPS stations and tide gauges, GPS periodic campaigns and InSAR techniques has been used in the last years.

Continuous GPS

A permanent GPS network of about 11 sites is being installed in order to control ground deformation on the whole island. Nowadays there are 7 GPS stations working in the island, some of them close to Teide volcano. Some stations are located at the coast next to a tide gauge. Next figure shows the Continuous GPS stations installed in Tenerife (CGPS in red and

CGPS with Tide Gauge blue).

Data are sampled every second and downloaded hourly in two analysis centres at Centro Geofísico de Canarias (CGC) in Tenerife and Centro de Observaciones Geodésicas (COG) in Madrid. In these centres quality is checked using TEQC software and data are processed together with IGS and EUREF stations around the area using the Bernese Processing Engine (BPE) of Bernese 5.0 software.

Processing is carried out in the Analysis Centre IGE. The strategy depends on the type of movement expected in the deformation monitoring. In the case of volcano monitoring the deformation is expected to be slow or not present during quiescence periods. Nevertheless ground movements of increasing magnitude can occur in the hours to days prior to a magma intrusion. This is why two strategies are being used to process GPS data:

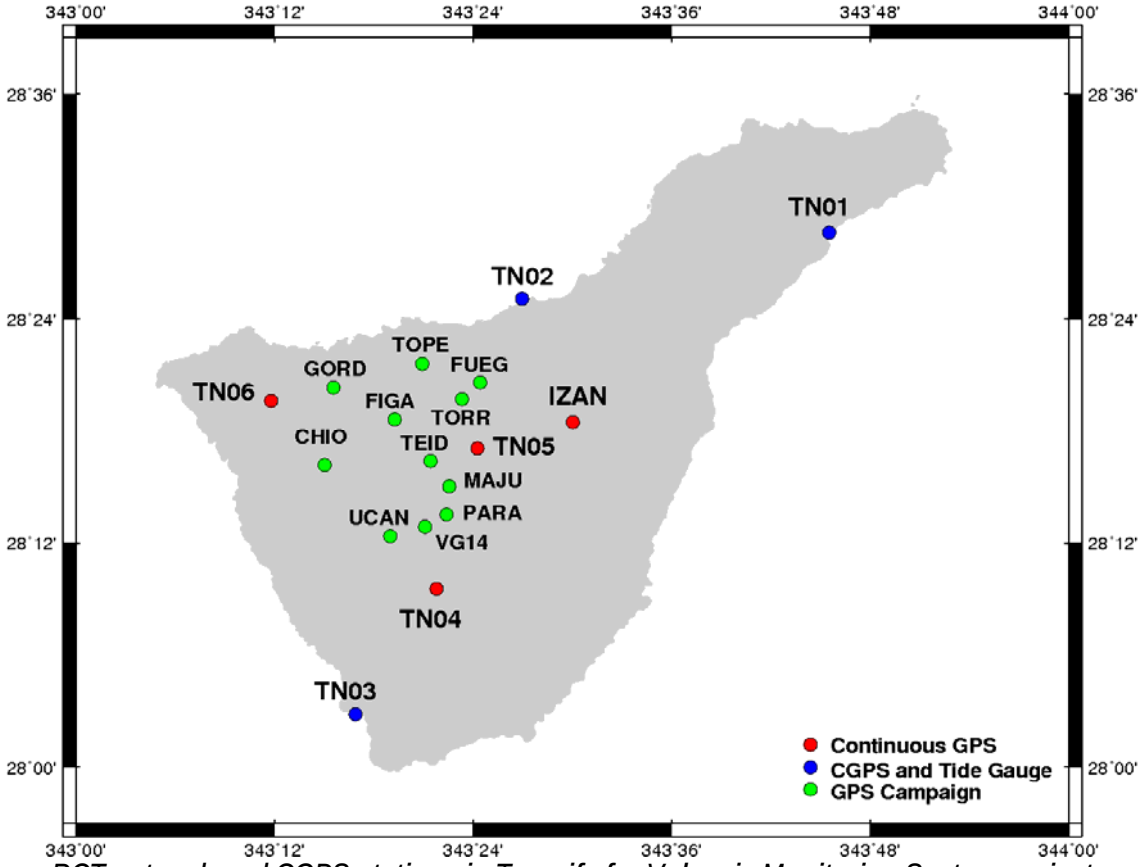
- Rapid processing mode occurs with minimum delay (the day after) in static sessions of a day in length using ultra-rapid orbits.

- Post-processing mode with static sessions of a day in length to measure slow deformation, such as a constant rate, using precise orbits and Earth rotation parameters to improve the quality of the solution.

The network solution is connected to the ITRF2005 through some IGS core stations. In this way, daily solutions are reported in SINEX files and coordinate time series from our stations in ITRF2005 are obtained to control ground deformation associated with volcanic activity in Tenerife.

GPS campaigns

A GNNS high density network has been created adding 11 points to the permanent GPS network (green points in next figure). This new network, called RCT (Red de Control del Teide), is observed twice per year since May 2009. In each campaign simultaneous GPS observations of half of the network are carried out for two days with an interval of 5 hours per day. The other half of the network is observed for another two days, 5 hours per day too. There are three points in common in all the observations (PARA, TEID and FUEG) apart from the continuous GPS stations.



RCT network and CGPS stations in Tenerife for Volcanic Monitoring System project

Computation of the RTC network has been made in REGCAN95 and ITRF2005 system, using Bernese software v.5.0. The solutions obtained for each campaign are compared with previous ones to detect any possible deformation that could be taken place.

InSAR

SAR Interferometry technique (InSAR) can detect changes in the position of the Earth's surface using two radar images of the selected area taken from approximately the same position in space but at two different epochs. Basically, an interferogram shows the phase difference between the two radar signals. So, if a deformation has occurred between the two passes there will be a change in the total length of the return signal of the second image, regarding to the first one. This is showed in the interferogram as a pattern of certain fringes.

Because of the area covered by radar images is typically 100 km2, this method allows to measure deformations over large areas, being a complementary technique to GPS. Moreover, there are radar images available since 1992 to date what makes possible the study of the deformation processes in the past. However, the real-time monitoring is not possible with this technique as the radar acquire a new image every 35 days.

Currently, as we are involved in a Category-1 ESA Project, we have 25 radar images of Tenerife between 2003 and 2010 which we are processing. In the near future we have planned

to use advanced InSAR methods (PSI) to improve the results.

5.2 The 2009 local ties survey at San Fernando Naval Observatory

A local ties survey in the San Fernando Naval Observatory (ROA: Real Observatorio de la Armada) was carried out by the Instituto Geografico Nacional de España (IGNE) team during the summer of 2009. A SLR station (SFEL) contributing to the International Laser Ranging Service (ILRS) and a Continuous GPS receiver (SFER), contributing to the International GNSS Service (IGS) are collocated at ROA since 1996. Another CGPS receiver (ROAP) was installed a couple of years ago to contribute to the IGS Time Transfer Experiment.

The objective of the survey was to verify old values, modifying them as needed and, to complete the information linking not only these three reference points together but also linking them with other points to allow further reviewing: there are a number of survey monuments and pillars within the observatory to be used as reference marks for the local ties determination through terrestrial connections.

But local ties determination at ROA is actually complicated due to the situation of the main points. The SLR station is located inside a closed dome at the top of the Observatory main building while the intermediate reference marks are placed at the main terrace. It means that there are large height gradients, and it is also difficult to get a direct line of sight from the reference points located at the terrace to the SLR telescope reference point. Furthermore, to look for the telescope axis cross point is not an easy task due to the reduced dimensions of the SLR telescope dome. And last, but not least a background of scattered buildings of very different heights and large trees that hinder the visual intermediate between them seem to be not the best scenario to ensure uncertainty improvements.

Finally, despite the difficulty, the local ties were successfully calculated and sent to IERS for the new ITRF2008 in SINEX format.

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(The information of this Institution has been remitted by M. A. Cano (A. Dalda))

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

REAL INSTITUTO Y OBSERVATORIO DE LA ARMADA (ROA).
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The "Real Instituto y Observatorio de la Armada en San Fernando" (ROA), is a Naval institution working on geodesy from its foundation on the mid XVIII century. Now, activities on this area are focused in Satellites Laser Ranging (SLR) and Global Positioning System (GPS) measurements and 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 2007-2011, the station has been upgraded, partially funded by the Spanish Government through the following research projects:

• "Laser Tracking on GNSS satellites (GPS, Galileo…)" (ESP2004-4598), from the National Program for Space Research, 'Ministerio de Educación y Ciencia', until the end of 2008.

• "Satellite Laser Ranging automating and accuracy improving" (AYA2009-11896), from the National Program for Space Research, 'Ministerio de Ciencia e Innovación', from the beginning of 2010.

The most important goal of the first research action was reached in May 2007. Since then, the SLR station is able to track successfully High Earth Orbiter Satellite, with a semi major axis of about twenty thousand kilometers. The most of this kind of satellites equipped with retro reflectors are those included into the Global Satellite Systems. Besides the GPS-35 and GPS-36, all of the *Glonass* Constellation satellites have got mirrors to be tracked by the SLR Technique, as well as the *Giove* satellites, prototypes of the upcoming *Galileo* European Navigation System.

Since 2010, January 1st, the second research action is going on. We are developing a new movement control system. The objective we are expecting to reach is a significant improvement in the tracking accuracy. First steps have been made, and promising results are expected.

A brief tracking statistics for the 2007-2010 period:

2007:

Satélite	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC
Lageos 1	15	14	24	19	40	35	37	17	14	30	33	17
Lageos 2	16	17	37	17	13	2	20	11	21	32	29	14
Ajisai	44	11	39	53	32	54	68	7	32	76	34	65
Starlette	28	9	39	20	20	61	17	16	18	32	61	15
Stella	1	0	2	0	7	17	10	2	6	12	18	22
ERS2	12	4	25	23	29	35	34	13	12	18	13	10
Champ	2	6	6	0	2	7	14	0	3	1	5	7
Jason	12	11	30	3	34	33	35	0	15	29	29	14
GFO	15	11	15	0	5	10	28	13	8	20	32	17

BEC	19	21	23	42	15	76	26	15	26	40	68	23
GRACE A	2	1	7	1	6	9	9	1	3	0	1	3
GRACE B	1	1	11	2	5	11	16	4	3	2	5	12
Envisat	11	10	28	20	33	37	31	16	14	19	22	13
Larets	8	7	13	9	12	24	16	7	13	8	12	10
ANDE-P	0	0	0	1	0	2	1	1	0	0	1	0
ANDE-A	0	0	0	0	0	3	0	0	0	0	1	0
TerrasarX	0	0	0	0	0	0	2	0	2	12	17	14
Glonass95	0	0	0	0	0	2	3	3	1	6	5	3
Glonass99	0	0	0	0	6	0	0	1	0	3	1	0
Glonass102	0	0	0	0	2	2	2	0	0	2	7	5
Etalon-1	0	0	0	0	0	0	1	0	0	0	0	0
Etalón-2	0	0	0	0	0	0	1	0	0	0	0	0
TOTAL	186	123	299	210	261	420	371	127	191	342	394	264

Number of successful tracking in 2007

Satélite	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC
Lageos 1	8245	8391	14413	12722	44343	33034	41401	19173	8753	28358	31889	14099
Lageos 2	8033	9684	34534	15307	26544	1697	18059	12187	15836	29657	34841	8692
Ajisai	77243	10736	42908	85396	34469	114553	149601	11941	43551	96128	30301	83228
Starlette	13882	3452	17657	11060	10795	46169	6968	9871	5847	18541	43418	6174
Stella	830	0	619	0	2802	8940	5998	2530	2839	4782	7156	9289
ERS2	4106	2293	10374	9979	24441	26573	29176	10364	4854	5250	5493	3625
Champ	320	1206	946	0	438	1532	5546	0	546	114	1481	2563
Jason	4024	6877	23681	1200	42541	33827	37835	0	6794	17273	17119	6521
GFO	5008	3432	3912	0	491	3687	25875	8218	2625	8258	21191	4249
BEC	17480	22378	13778	33051	7104	106553	19345	23586	26257	34776	69804	13797
GRACE A	257	81	4046	310	2098	1985	1986	101	862	0	15	304
GRACE B	230	113	2704	439	2462	4527	7146	1425	874	324	375	1495
Envisat	4199	4985	9966	7688	30718	32248	23949	11315	6162	7263	6989	5115
Larets	1964	1110	3183	1715	5292	7182	5912	2603	2681	1274	2565	2366
ANDE-P	0	0	0	85	0	227	93	16	0	0	469	0
ANDE-A	0	0	0	0	0	821	0	0	0	0	67	0
TerrasarX	0	0	0	0	0	0	76	12187	383	5138	10384	9057
Glonass95	0	0	0	0	0	248	309	674	25	614	2580	276
Glonass99	0	0	0	0	3597	0	0	273	0	175	194	0
Glonass102	0	0	0	0	391	360	113	0	0	111	481	135
Etalón-1	0	0	0	0	0	0	9	0	0	0	0	0
Etalón-2	0	0	0	0	0	0	22	0	0	0	0	0
TOTAL	145821	74738	182721	178952	238526	424163	379419	126464	128889	258036	286812	170985

Number of successful echoes in 2007

2008:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	15	7	5	8	18	32	39	26	31	30	32	7
Lageos 2	5	7	10	29	24	40	23	3	4	15	27	7
Ajisai	62	24	64	57	17	98	73	6	61	51	27	14
Starlette	60	17	41	34	12	82	15	38	22	24	52	4
Stella	17	8	13	17	12	24	22	4	9	12	18	22
ERS2	12	4	25	23	29	35	34	13	12	11	19	7
Champ	4	5	5	0	5	2	9	3	0	5	5	0
Jason-1	36	8	22	14	36	50	17	9	32	22	24	4
Jason-2	-	-	-	-	-	-	3	11	34	21	28	5
GFO	17	10	13	7	3	34	33	16	12	2	2	-
BEC	61	13	54	24	41	57	49	40	14	59	25	13
GRACE A	4	4	3	4	10	19	7	0	3	8	7	0

GRACE B	7	3	3	5	11	15	13	0	4	9	10	1
Envisat	23	10	18	22	31	40	36	25	19	24	20	4
Larets	10	6	13	15	11	21	22	13	16	14	15	1
ANDE-P	1	-	-	-	-	-	-	-	-	-	-	-
TerrasarX	14	5	4	2	0	1	4	0	3	9	18	5
Glonass95	2	0	2	-	-	-	-	-	-	-	-	-
Glonass99	1	1	5	5	4	2	2	3	2	5	0	0
Glonass102	3	3	3	0	2	1	0	0	0	6	7	1
Glonass109	-	-	-	-	-	1	0	0	0	5	6	0
TOTAL	354	135	303	266	266	554	401	210	191	332	342	95

Number of successful tracking in 2008.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	7844	5864	1457	5884	17579	42427	32125	29671	26133	15391	13728	1171
Lageos 2	425	3384	7347	29547	30837	55595	18629	891	3690	7637	13127	1757
Ajisai	91562	19359	86826	113310	9300	180001	126445	10196	97729	81852	34227	15545
Starlette	35229	9927	18075	24858	5430	48948	6287	39723	18965	15138	28240	2135
Stella	10523	3397	7680	14301	8275	17334	29240	3547	3610	3071	13997	3107
ERS2	8545	5612	6986	15388	13734	28188	24290	18625	9768	6722	9116	2337
Champ	670	600	943	0	1838	730	4569	2580	0	461	1128	0
Jason-1	16502	5011	14893	12120	33874	44107	17747	5581	11305	6997	9926	1149
Jason-2	-	-	-	-	-	-	726	7354	16666	6981	14399	1335
GFO	5465	2162	4086	958	844	24481	20442	8522	2778	42	1263	-
BEC	81151	4851	60574	21825	66462	55923	81993	69523	11324	79492	18889	14696
GRACE A	1403	948	374	759	2196	7760	4345	0	361	1866	1211	0
GRACE B	941	809	570	1026	2369	6062	3995	0	239	1539	1990	18
Envisat	6140	4183	6469	11011	19061	35481	28699	21280	7448	9014	7308	1755
Larets	1686	1287	2038	3955	3744	7797	6223	5495	5865	5118	3187	542
ANDE-P	23	-	-	-	-	-	-	-	-	-	-	-
TerrasarX	8700	2572	236	288	0	63	384	0	121	5021	12539	2793
Glonass95	186	24	-	-	-	-	-	-	-	-	-	-
Glonass99	37	7	366	318	238	69	213	413	150	240	0	0
Glonass102	364	206	198	0	178	17	0	0	0	412	438	17
Glonass109	-	-	-	-	-	10	0	0	0	825	209	0
TOTAL	277396	70203	219118	178952	215959	554993	406352	223401	215882	247819	184922	48357

Number of successful echoes in 2008.

2009:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1			22	20	28	17	8	0	4	17	6	8
Lageos 2			3	5	13	31	26	36	22	18	10	4
Ajisai			77	42	50	93	21	20	81	57	43	57
Starlette			43	31	38	50	9	50	25	44	52	9
Stella			20	16	20	22	17	11	13	29	11	13
ERS2			21	23	40	33	26	30	26	31	23	7
Champ			8	11	3	7	10	10	10	4	5	3
Jason-1			7	30	44	37	7	31	17	36	16	10
Jason-2			14	30	45	37	10	32	33	36	13	13
BEC			26	46	70	36	47	4	74	36	57	35
Grace A			8	9	13	2	3	7	4	10	10	6
Grace B			5	9	15	6	4	10	8	10	16	9
Envisat			17	30	42	38	30	36	30	31	26	14
Larets			11	11	21	19	18	20	19	17	16	8
Ande-P									3	1	0	0
Ande-C									3	1	3	1
Blits									0	3	4	1

Goce									1	5	12	9
TerrasarX			1	6	6	10	2	0	8	16	18	12
Etalon1			1	0	0	0	0	0	0	0	0	0
Glonass115					1	6	8	10	6	10	10	3
Glonass102			4	3	4	0	0	0	2	4	2	4
Glonass99			4	3								
Glonass109			4	2	2	1	1	1	1	8	5	2
TOTAL			296	327	455	445	247	308	390	424	358	228

Number of successful tracking in 2009. Mirrors were recoated in January and February

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1			12047	11672	16237	8872	2400	0	1860	11867	1906	700
Lageos 2			1061	1321	4592	20805	14532	25429	15021	12891	1638	521
Ajisai			150046	49874	62844	158708	31963	26007	109019	83186	41591	77550
Starlette			23127	18603	19010	20205	2877	28116	6766	21013	22722	3623
Stella			10096	9111	13268	15541	15058	6185	4798	12046	3153	4086
ERS2			8586	10498	17948	25456	16808	17133	6216	11474	6658	2796
Champ			1199	5671	1508	3328	3288	1447	4736	1213	1018	693
Jason-1			3774	14492	27741	26802	1924	18856	4782	23712	5827	2937
Jason-2			8269	16457	37468	30073	3762	20872	11345	19311	6723	3570
BEC			27061	50211	60944	36827	77188	1619	53757	42640	41113	35682
Grace A			1728	1463	3932	125	1678	691	631	1528	4417	1894
Grace B			1218	1034	4931	714	800	85	1249	1909	4345	3402
Envisat			6014	11034	22946	22139	19464	18792	7424	9772	8031	3109
Larets			3816	2477	4591	6532	4911	3822	2313	2909	3011	1714
Ande-P									195	67	0	0
Ande-C									469	73	252	20
Blits									0	100	99	12
Goce									64	1302	3038	2220
TerrasarX			40	1515	608	1627	731	0	1214	9178	8172	7431
Etalon1			12	0	0	0	0	0	0	0	0	0
Glonass115					87	1355	2157	1912	538	2301	1511	107
Glonass102			185	88	252	0	0	0	67	122	34	122
Glonass99			203	349								
Glonass109			771	96	42	115	10	20	16	793	223	56
TOTAL			259253	205966	298949	379224	199551	170986	232480	269407	165482	152245

Number of successful echoes in 2009. Mirrors were recoated in January and February

2010:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	5	6	8	7	37	28	32	13	15	13	6	8
Lageos 2	1	4	14	13	12	3	5	6	14	22	13	6
Ajisai	17	22	47	19	75	77	16	45	76	26	39	27
Starlette	22	10	27	24	32	52	11	29	18	18	13	9
Stella	11	5	8	7	24	21	18	14	15	15	13	12
ERS2	11	6	12	33	32	32	21	22	18	16	15	8
Champ	4	2	3	3	9	0	4	2	2			
Jason-1	13	10	10	27	47	27	5	20	23	25	16	5
Jason-2	7	13	8	24	50	27	14	29	36	23	17	12
BEC	22	22	20	45	29	72	14	33	48	33	37	13
Grace A	4	0	4	4	1	8	6	6	3	10	3	1
Grace B	4	1	3	9	0	10	8	4	11	16	6	1
Envisat	10	4	9	14	36	31	32	22	23	14	16	5
Larets	4	2	5	4	15	13	10	9	10	11	8	7
Blits	1	0	0	2	0	2	1	0	1	0	2	0
Ande-C	0	0	1									

Proba2			1									
Goce	5	1	0	0	0	1	0	0	1	5	4	4
Cryosat 2				1	8	20	16	10	2	15	19	6
TerrasarX	8	4	4	2	8	7	0	0	4	6	8	3
TandemX						0	2	1	10	14	13	4
Glonass102	2	2	0	0	0	0	0	0	0	0	0	0
Glonass109	0	0	1	0	0	0	0	0	2	3	1	1
Glonass115	2	0	0	0	2	9	6	1	1	4	1	0
Glonass120				2	0	0	2	0	2	0	0	0
TOTAL	153	114	185	239	409	420	207	256	333	274	250	132

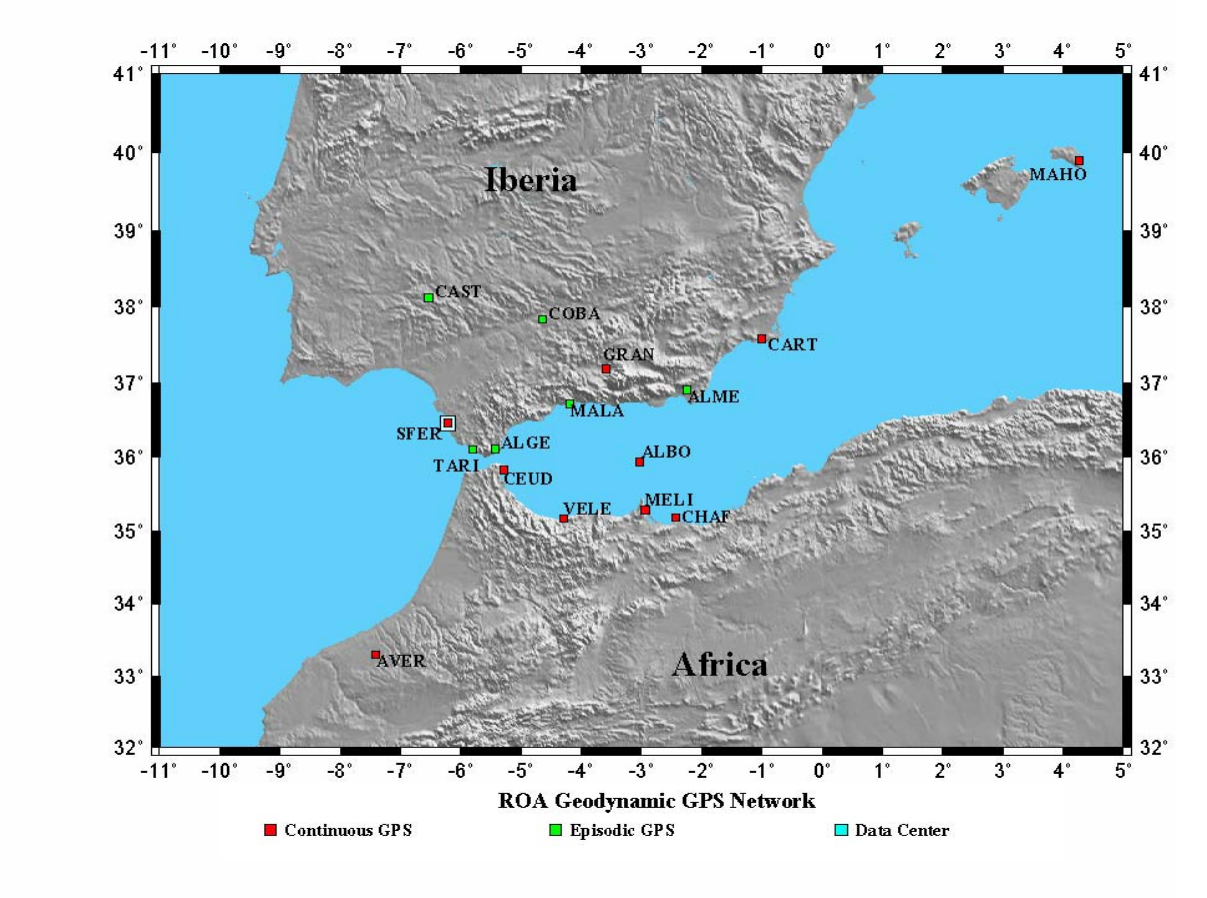
Number of successful tracking in 2010.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lageos 1	570	1009	3118	3429	20899	15944	20605	2815	6896	4851	999	610
Lageos 2	128	864	5093	2692	12151	709	1181	2104	6142	9973	2271	2158
Ajisai	13127	18990	43182	15008	108854	103922	6996	55799	83516	24481	38039	22728
Starlette	7277	4738	7829	6959	10946	19270	2678	13068	5130	8779	17862	2183
Stella	2944	1794	2414	2004	9651	7634	10076	7321	7274	5687	6698	1598
ERS2	4890	1372	3091	1802	19938	15637	15499	8274	4916	4680	4321	812
Champ	1486	275	472	591	2318	0	1529	123	104			
Jason-1	2913	3576	3798	7093	29063	10503	3751	11627	11390	16829	3690	2638
Jason-2	2829	3374	3143	6455	30403	16722	9485	11494	12255	17916	5649	3218
BEC	13675	14067	7003	23069	16495	65742	6617	36011	26891	26590	38243	4414
Grace A	610	0	580	887	76	2496	988	730	541	4597	897	49
Grace B	233	77	788	1561	0	2097	915	419	1481	4461	470	39
Envisat	2936	406	1778	3317	17156	15866	22365	10278	6907	3869	3197	928
Larets	747	565	489	609	2922	3176	2193	1790	1878	1937	1997	754
Blits	35	0	0	40	0	62	62	0	56	0	104	0
Ande-C	0	0	75									
Proba2				180								
Goce	896	140	0	0	0	24	0	0	63	1187	1517	415
Cryosat 2				38	4979	8734	6914	1552	2267	3393	7591	2329
TerrasarX	2648	848	808	110	533	600	0	0	332	1006	1843	593
TandemX						0	111	156	1383	2906	2753	1024
Glonass102	42	28	0	0	0	0	0	0	0	0	0	0
Glonass109	0	0	32	0	0	0	0	0	160	70	14	12
Glonass115	43	0	0	0	291	2822	226	22	7	471	18	0
Glonass120				75	0	0	119	0	303	0	0	0
TOTAL	58029	52123	44693	75919	286675	291960	112310	163583	179865	143683	138173	46502

Number of successful echoes in 2010.

2. GPS geodetic activity.

The main contribution to Geodesy by using GPS is the ROA CGPS Geodetic Network. In 2007, November 7th, a new permanent receiver was installed in Chafarinas Islands. It is a group of three small islands located in front of the Moroccan coast, not far from the Algerian border. It was not possible to automate the downloading process yet. Data files are recovered quarterly by the ROA staff. Anyway the station is working properly, and the data process is made without further problems.



As a results of the collaboration with the Scientific Institute of Rabat (ISRABAT), in 2008, June 3rd, a CGPS was installed at the Averroes Observatory, close to Casablanca (Morocco). Its data files are recovered daily through the Internet. It is remarkable that the CGPS is collocated with a Very Broad Band seismic device to gain the synergies of both instruments.

In 2009 January 29th, the CGPS at the Alboran Island was relocated at the island Lighthouse. The new position is safer than the old one, because it can be attended by the island crew. Data files are recovered through the corporative web in a daily basis, although the receiver is easily accessible to download high rate data files if needed.

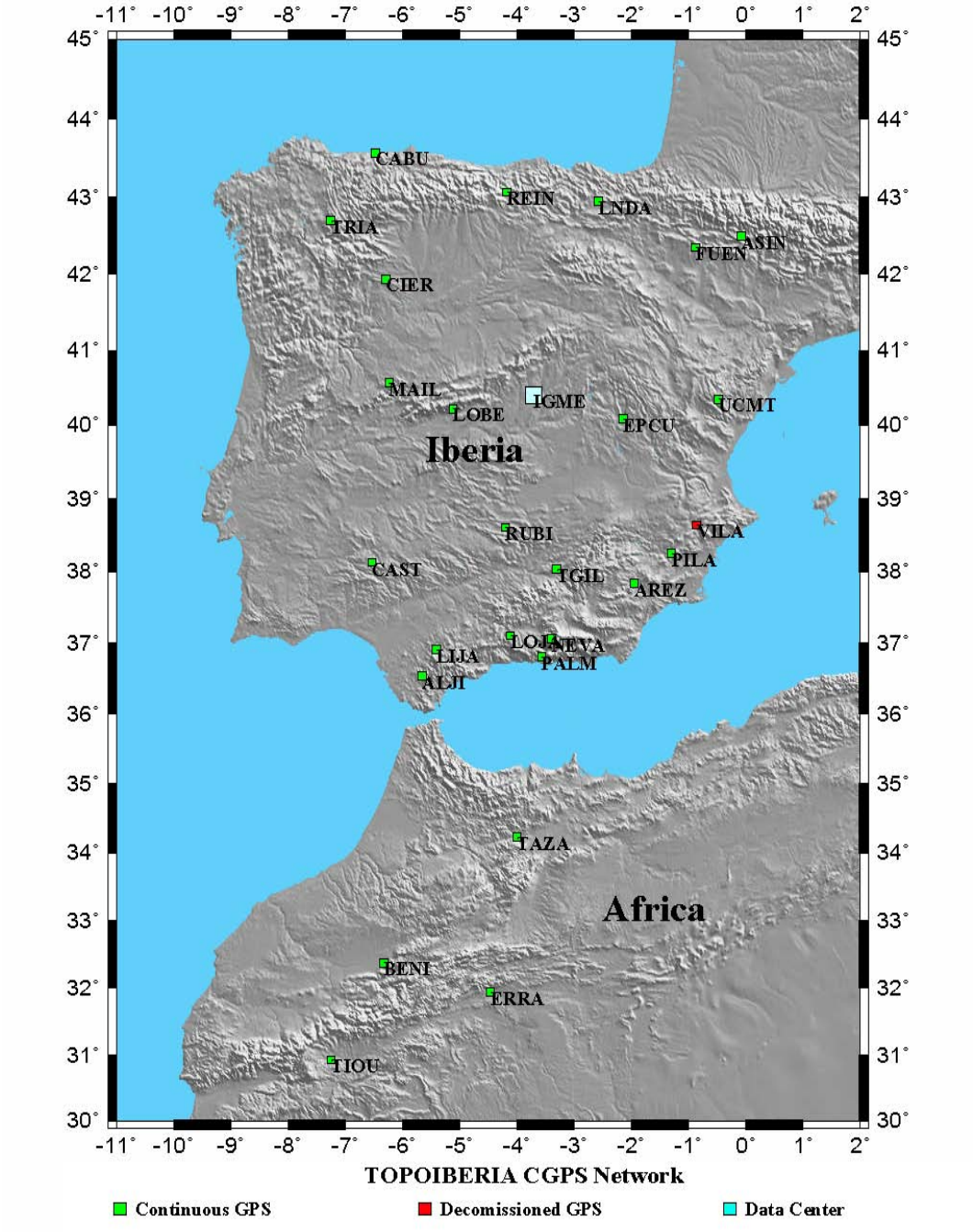
Furthermore, a CGPS was installed in April 2010 at the Spanish Navy Rota Naval Base main pier, in order to research the ocean tide loading behavior on the Atlantic Ocean Coast. As it is a temporally CGPS station, it is not included in the sketch, nor in the CGPS network.

On the other hand, ROA is contributing to the Research Project:" *Geociencias en Iberia: Estudios integrados de topografía y evolución 4D. "TOPO-IBERIA". CONSOLIDER-Ingenio*" Ref. CSD2006-00041. ROA is leading the GPS working group. A new 26 CGPS network has been installed in the Region. Up to 22 was placed in the Iberian Peninsula, but 4 additional equipments were mounted in Morocco in order to study Northern Morocco and Southern Spain region as a tectonic unit. The implementation of the network started in March 2008, after a preparative period including the instrumentation election and purchasing, and the network design, which took into account the relevant topography events, and the already existing CGPS high quality networks.

CGPS stations responsibilities were distribute among the different groups contributing to the project: University of Barcelona, CSIC- Jaume Almera Earth Science Institute, University of Jaen, Complutense University at Madrid, Geological and Mining Institute of Spain, University of Oviedo, and University of Salamanca as well as ROA. We have to acknowledge the above mentioned

ISRABAT collaboration in the CGPS stations located in Morocco. Data collection is still going on. Data files are archived at the Mining Institute of Spain, working as Project Data Center.

There are three different analysis groups integrated in the Working Group: University of Barcelona, University of Jaen and ROA. Each group analyzes data files by using different software: GAMIT, BERNESSE and GIPSY, respectively. ROA acknowledge Jet Propulsion Laboratory for the software license. Different approaches are also used: network solution as well as Precise Point Positioning.



A significant event on the routinely data acquisition was the stolen of one of the receivers, marked in red in the sketch. But it was more important the anomalous behavior shown by some of the antennae, which had to be replaced, while they were delivered to the manufacturer to be fixed. Time

series for the damaged places had to be delayed, and the whole network processing was affected.

After more than two years of data for the most of the stations, preliminary results from positioning time series are achieved. Exhaustive and detailed results are expected during the coming months.

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. • "Geociencias en Iberia: Estudios integrados de topografía y evolución 4D. "TOPO-IBERIA". CONSOLIDER-Ingenio" Ref. CSD2006-00041. Spanish Government 'Ministerio de Ciencia e Innovación' CONSOLIDER Research Program.
. • "Riesgo de Terremotos y Tsunamis en España" (CGL2006-10311-C03-02/BTE). Spanish Government 'Ministerio de Ciencia e Innovación' Research Program

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(The information of this Institution has been remitted by J. Gárate)