National Report of Spain

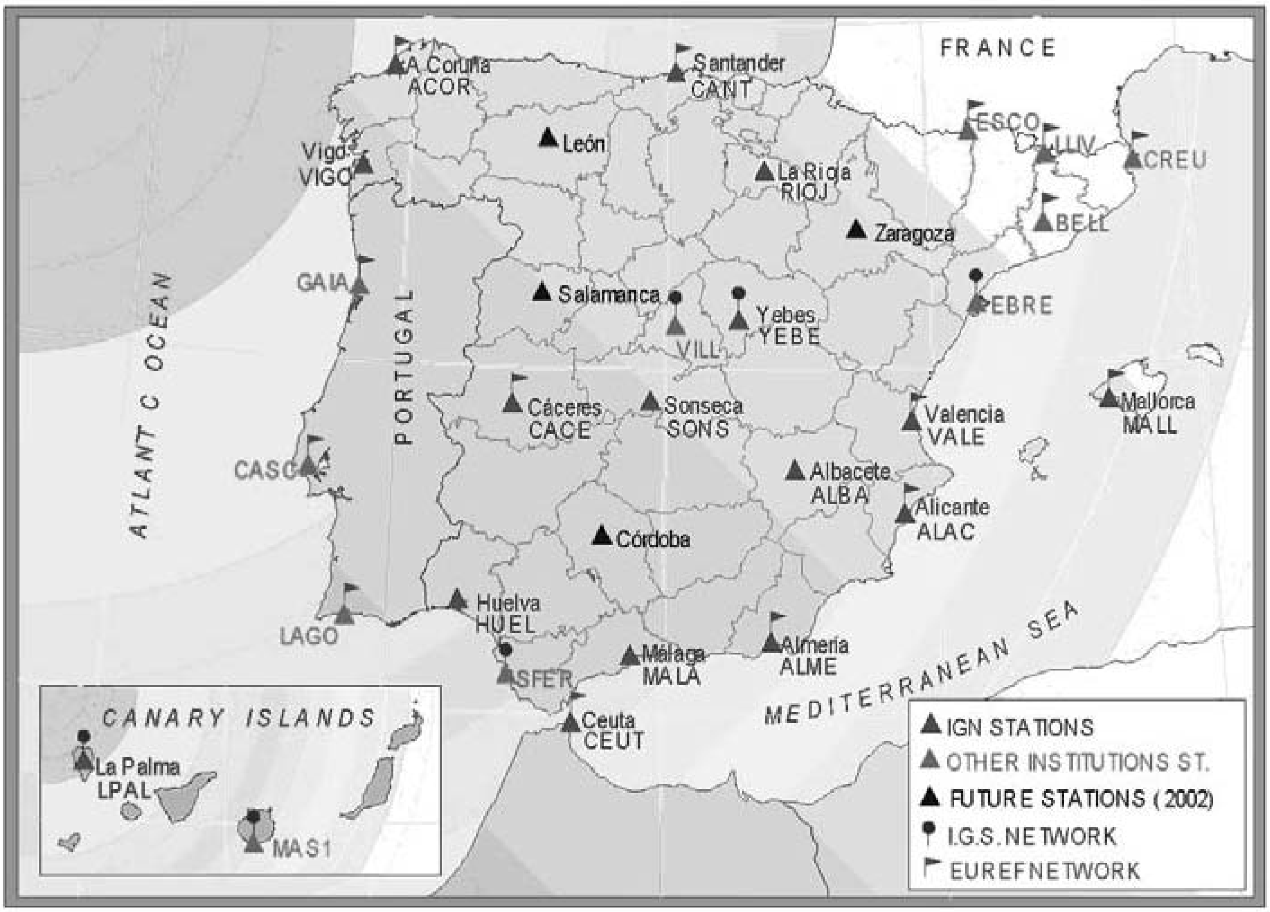
Spanish National GPS Reference Stations Network (ERGPS)

R. QUIRÓS, M. A. CANO, J. A. S. SOBRINO, M. VALDÉS[1]

The Instituto Geográfico Nacional of Spain (IGNE), by its Geodesy Department, is carrying out since 1998 the establishment of a GPS Reference Station Network of Spain (ERGPS) delivered all around Spain which allows millimetric coordinate results, as well as velocity fields in a Global Reference System (ITRFxx), serving as support for another geodetic networks and for technical and scientific works. Most of these stations are being integrated in EUREF Permanent Station Network.

The main objetives of ERGPS are:

- High precision coordinate results and velocity field for all points of the network, covering all Spanish territory.
- Global integration of geodetic data.
- To provide GPS users with data for surveying, cartographic, mapping, geodetic and positioning works which require a high precision differential GPS work.
- To contribute to the new Global Reference Systems (ITRFxx).
- To became EUREF permanent network stations and contribution to its reference frame (European Reference Frame) as well as its definition in Spain.
- Generally speaking, to supply with continous data in geodynamic, atmospheric, ionospheric, tropospheric, mean sea level and any other related scientific studies.



[1] R. Quirós, M. A. Cano, J. A. S. Sobrino, M. Valdés, Instituto Geográfico National, rquiros@mfom.es, macano@mfom.es, jassobrino@mfom.es, mvaldes@mfom.es

IGNE installed March 1998 its first ERGPS station in the tide gauge of the Harbour of Alicante. It was integrated in EUREF Permanent Network (EPN) in 1999 (ALAC). Today fourteen more stations have been installed in:

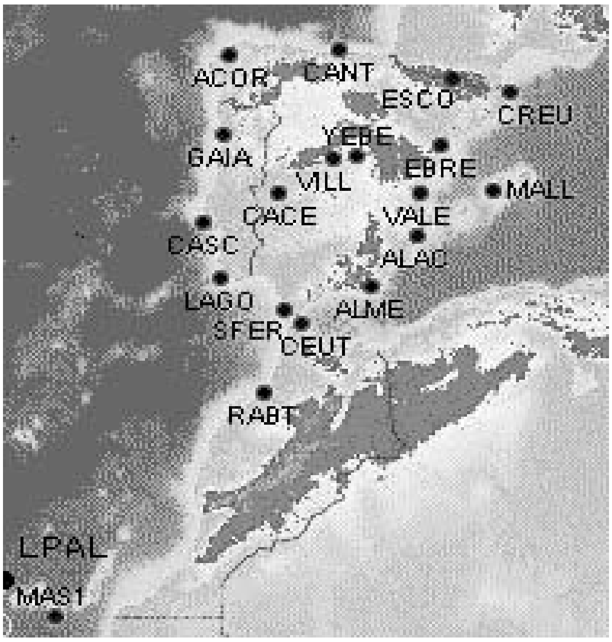
– Tide gauge of Alicante (ALAC), Mar 1998.
– Tide gauge of La Coruña (ACOR), Sept 1998.
– Astronomical Observatory of Yebes (YEBE), May 1999, IGS network and provide nrt hourly data.
– Geophysical Observatory of Almería of IGN (ALME), Dec 1999.
– Politechnical University of Valencia (VALE), Jan 2000, nrt hourly data.
– University of Cantabria, Santander (CANT), Mar 2000, nrt hourly data.
– Geophysical Observatory of Málaga of IGN (MALA), Mar 2000.
– Spanish Oceanografic Institute in Palma, Balearic Islands (MALL), May 2000, nrt hourly data.
– Sysmological Observatory of Sonseca of IGN (SONS), Dec 2000.
– University of Extremadura, Cáceres, (CACE), Dec 2000.
– Geophysical Observatory of Logroño, IGN (RIOJ), Apr 2001.
– Astrophysical Institute of Canarias, Roque de los Muchachos Observatory in La Palma, Canary Islands, (LPAL), May 2001.
– Ceuta's Port Authority, (CEUT), Aug 2001, in the African Plate.
– Spanish Oceanografic Institute in VIgo (VIGO), Sep 2001.
– University of Huelva (HUEL), Dec 2001.
– University of Albacete (ALBA), May 2002.

It is planned to install four more stations in the 2002, completing the planned whole Spanish GPS Reference Station Network (ERGPS), which will consist of 20 stations.

New Local Analysis Center: IGE

R. Quirós, M. A. Cano, J. A. S. Sobrino, M. Valdés[2]

Since the first week of September (1130 GPS week), the Spanish IGN has started to process an EUREF subnetwork solution, becoming an EUREF Local Analysis Center (IGE). This subnetwork consist of 20 stations in the Iberian Peninsula, Africa, Canary and Balearic Island. The processing is carried out with Bernese Processing Engine, BPE v. 4.2, in a complete automated process.



The strategy of processing is carried out following the rules and recommendations set up by the International GPS Service and the EUREF Technical WG since September 2001.

At the same time, IGE contribute to the Special Project Troposphere Parameter Estimation, submitting daily tropospheric files of the ZPD's with hourly estimation.

The process is carried out constraining (0,1 mm) only to YEBE station, which belong to the IGS network and it's integrated in the IVS network of VLBI stations. Nowadays IGN-E has 15 GPS permanent stations, but just 10 stations are integrated in IGS or EUREF network. Consequently, IGE carry out another process with the whole IGNE-E network, including other IGS stations in Spain. According to this, an analysis of the time series produced is made by IGE in order to monitor and detect strange behaviours of the stations and research about geodynamics.

[2] R. Quirós, M. A. Cano, J. A. S. Sobrino, M. Valdés, Instituto Geográfico National, rquiros@mfom.es, macano@mfom.es, jassobrino@fom.es, mvaldes@mfom.es

REGENTE Project finished.

R. QUIRÓS, A. BARBADILLO, M. A. CANO, J. REGIDOR, M. SANZ, J. A. S. SOBRINO[3]

In order to establish a unified european cartography, it is essential a conversion of coordinates of National Reference Systems to ETRF89, which is possible through determination of transformation parameters from one to the other frame. Such a determination requires the knowledge of both types of coordinates in a high number of stations regurlarly arranged, and this number must be higher as the irregularities of present Local Frame arise. At the same time, GPS users needed precise coordinates for support their surveying and cartographic works.

IGNE decided to solve the problem in the Iberian Peninsula and archipelagos through REGENTE Project (Red Geodésica Nacional por Técnicas Espaciales, REGENTE), which consists of a dense high precision GPS network that coincide with National Geodetic Network points and NAP levelling stations. Mean density is fixed in one station per sheet of MTN (National Surveying Map) scale 1:50.000, i.e., one station every 300 km^2.

REGENTE is perfectly linked to ETRF89 european reference network, thus IBERIA95 and BALEAR98 stations are also REGENTE stations. REGENTE for Canary Islands is linked to VLBI Maspalomas station as ITRF93 reference station.

Objectives

The main objectives of REGENTE are:

- Implementation, observation and coordinate determination of a basic tridimensional geodetic First Order Network for Spain with an accuracy of 5 cm or better.
- Obtainment of precise transformation parameters between National Geodetic Network, ED-50, reference system and REGENTE, ETRF89.
- To provide with qualified data for the refined centimetric spanish geoid and precise determination of gravimmetric peninsular geoid scale (M.SEVILLA et al.).
- To support the high number of GPS users. Thus any point in spanish land is within a maximum radius of 15 km. circle, with a station of REGENTE as center.

Structure

REGENTE consist of 1078 stations in Peninsula and Balearics, one every sheet of National Topographic Map, MTN, at scale 1:50.000, which implies a mean distance of 20-25 km.

Stations fulfil the following requirements:

- To belong to the National Geodetic Network or a VLBI or SLR station.
- GPS station normal requirements: easy vehicle access, free horizon above 10º, and far from multipath or interference objects.
- More than a 10% of REGENTE stations (ellipsoidal GRS80 heights) have also high precision orthometric height through NAP (High Precision Levelling Network), in order to be linked to National Geodetic Network ED-50, which has heights linked to mean sea level.
- Laplace stations and astronomical second order stations are included in REGENTE if GPS station requirements are fulfilled.
- IBERIA95 and BALEAR98 extensions belong also to REGENTE.
- To serve as a reference frame for local networks for geodynamic or geophysic control related to faults and tectonic plates.

Data field

Two different sessions have been observed at each station (3 hours, 15 sec data interval, 15º mask elevation) at different time (morning and afternoon), in order to observe in a different satellite constellation. 9 sites and 2 NAP are simultaneously observed at each session, forming the 11 sites a single computing block. Three of these stations are common to the previous block and other three more are common to the next one.

Development

Field works of REGENTE begun in 1994 and the complete project have finished in 2001, providing a precision GPS network in Spain (better than 5 cm), necessary and essential for all the exposed purposes.

[3] R. Quirós, A. Barbadillo, M. A. Cano, J. Regidor, M. Sanz, J. A. S. Sobrino, Instituto Geográfico National, rquiros@mfom.es, abarbadillo@mfom.es, macano@mfom.es, jregidor@mfom.es, msanz@mfom.es, jassobrino@mfom.es

SERDAG Project

R. QUIRÓS, J. FRAILE, F. BENDALA, M. VALDÉS, J. A. S. SOBRINO[4]

The main objectives of the SERDAG (Geodetic data server) project is to implement the necessary applications in order to query the Geodetic data base of the Instituto Geográfico Nacional.

These applications consist in WEB pages and a group of useful server programs. These programs hold a query client service in Internet at the same time .This data base continuously must be updated.

A Dataserver (SERDAG) will provide these and other geodetic data to public users through web page of Instituto Geográfico Nacional. Other type of data will include the whole Geodetic Network (12000 points) with its coordinates and general information, the REGENTE Network (1100 GPS points), Precise Levelling Network, etc.

REDNAP Project

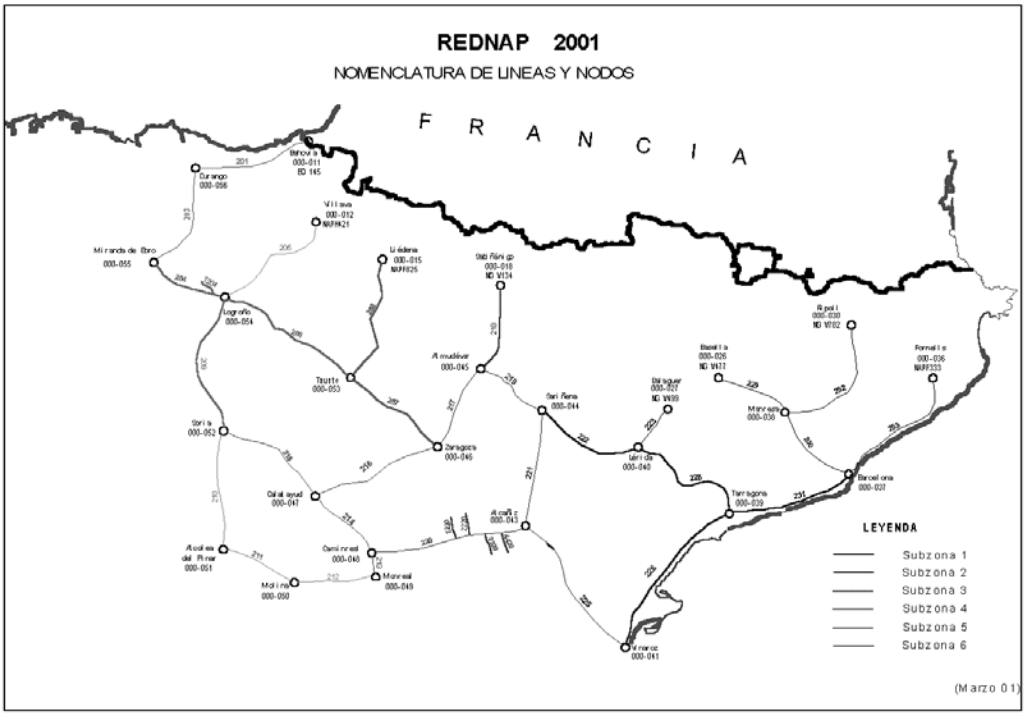
A. BARBADILLO, F. DE LA CRUZ, R. QUIRÓS[5]

Since 2001 the IGNE is carrying out the REDNAP Project in order to establish a new High Precision Levelling Network in Spain, replacing the former network (forty to seventy years old), which is actually destroyed in a big rate. Last year, about 2500 bench-marks along 2400 kilometres were monumented in the Northeaster part of Spain, bordering to the Pyrenees (Interreg II Project). Geometric levelling, gravimetric and GPS campaigns are being carried out in 2002. Simultaneously to the gravimetric observation, all the point are observed by GPS in order to establish an High Precision Geoid. The REDNAP Project will be ended in 2007 in the Peninsula and the following year in the Balearic Islands.

[4] R. Quirós, J. Fraile, F. Bendala, M. Valdés, J. A. S. Sobrino, Instituto Geográfico National, rquiros@mfom.es, jfraile@mfom.es, fbendala@mfom.es, mvaldes@mfom.es, jassobrino@mfom.es

[5] A. Barbadillo, F. de la Cruz, R. Quirós, Instituto Geográfico National, abarbadillo@mfom.es, fcruz@mfom.es, rquiros@mfom.es

NUEVA RED ESPAÑOLA DE NIVELACIÓN



Development of the ED50-ETRS89 datum transition

A. DALDA, F. J. GONZÁLEZ-MATESANZ[6]

Introduction

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

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

7 parameter conformal transformation

Using the common formulae to this method, three sets of parameters have been obtained in order to keep residuals under 2m. The Iberian Peninsula is divided in two zones: northwest (41º30’N<n<43º50’N y 9º25’W<8<4º30’W) and rest . A third set has been computed for Balearic Islands. The 99% of residuals of the adjust were less than 0.99m in the first one, an less than 1.5m in the second one.

Polynomial transformation

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

Distortion modelling

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

We have used MCS to model distortion in the ED50 network over Iberian Peninsula. This method was initially developed by BRIGGS (1974) and it is based on minimizing the total curvature over a grid. The idea comes from mechanical engineering and elasticity theory. Let’s consider a thin plate in equilibrium where every force actuates perpendicular to it and no shear forces. The 99% residuals of this transformation are below 5cm for the whole territory at the REGENTE points. We have built two grids covering mainland Spain with 105” of interval in a common format called NTV2 (National Transformation Version 2), used in Canada and Australia. Such format has the advantage of using a large number of software applications, being compatible with them.

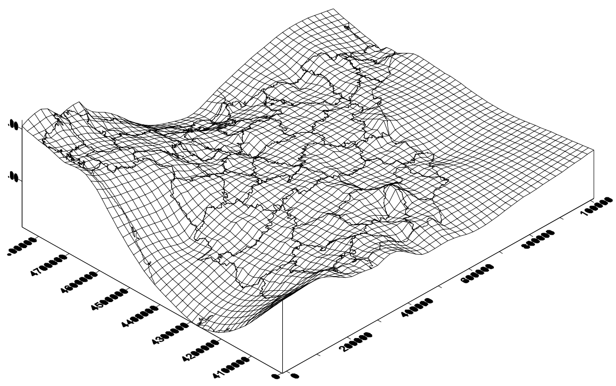


Figure 2. East distortion

Test of the MCS grid obtained

In order to test the reliability of this transformation a part of the Spanish network (fig. 3) have been readjusted in ETRS89 (over 1400 points) and the results have been compared with the transformation given by the MCS created with REGENTE points (about 10% of the whole network). The residuals of the test were less than 13cm for the 1400 points with 19 outliers (all of these below 50 cm)

Conclusions

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

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

[6] A. Dalda, F. J. González-Matesanz, Instituto Geográfico National, adalda@mfom.es, fjgmatesanz@mfom.es

Zero Order Absolute Gravity Network of Spain

A. DALDA, E. RODRÍGUEZ, E. NÚÑEZ, M. FERNÁNDEZ[7]

Summary

Since the first absolute measurements of gravity in Spain (J. Barraquer 1877 and 1882) no measurements have been performed until 1989. The IGN of Spain has purchased recently the FG5 # 211 absolute gravimeter and a new more precise network called Iberian Absolute Gravity Network (IAGN, REGA Project in Spain) will be deployed in the next few years in order to improve the present accuracy.

The very first network

The very first scientific task in Spain from the gravimetric point of view, reported to the IAG Commission, was Barraquer's work. Now it has been 120 years since his measurements in the National Astronomic Observatory of Madrid were made.

Eight years later Antonio los Arcos and Príamo Cebrián also measured absolute values of gravity following Barraquer's method. They choose *Pamplona* (October 1892), *La Coruña (August and September 1893)* and *Barcelona* (November and December 1893); only Antonio Los Arcos did observations in *Observatory Astronomic de San Fernando* (October and December 1894), and finally Rafael Aparici and Arturo Misfut in *Valencia* (Autumn 1895), Eduardo Escribano in *Granada* (1897) and Príamo Cebrián and Felipe de la Rica in *Valladolid* (1901). This made a total of eight stations, including the National Astronomic Observatory of Madrid. We also celebrate 101 years since the first relative measurements with Von Sterneck Pendulums that were made by Dr. Oscar Hecker in his travel through the Atlantic Ocean (Potsdam, Rio de Janeiro, Lisbon, and Madrid) in 1901.

The new network

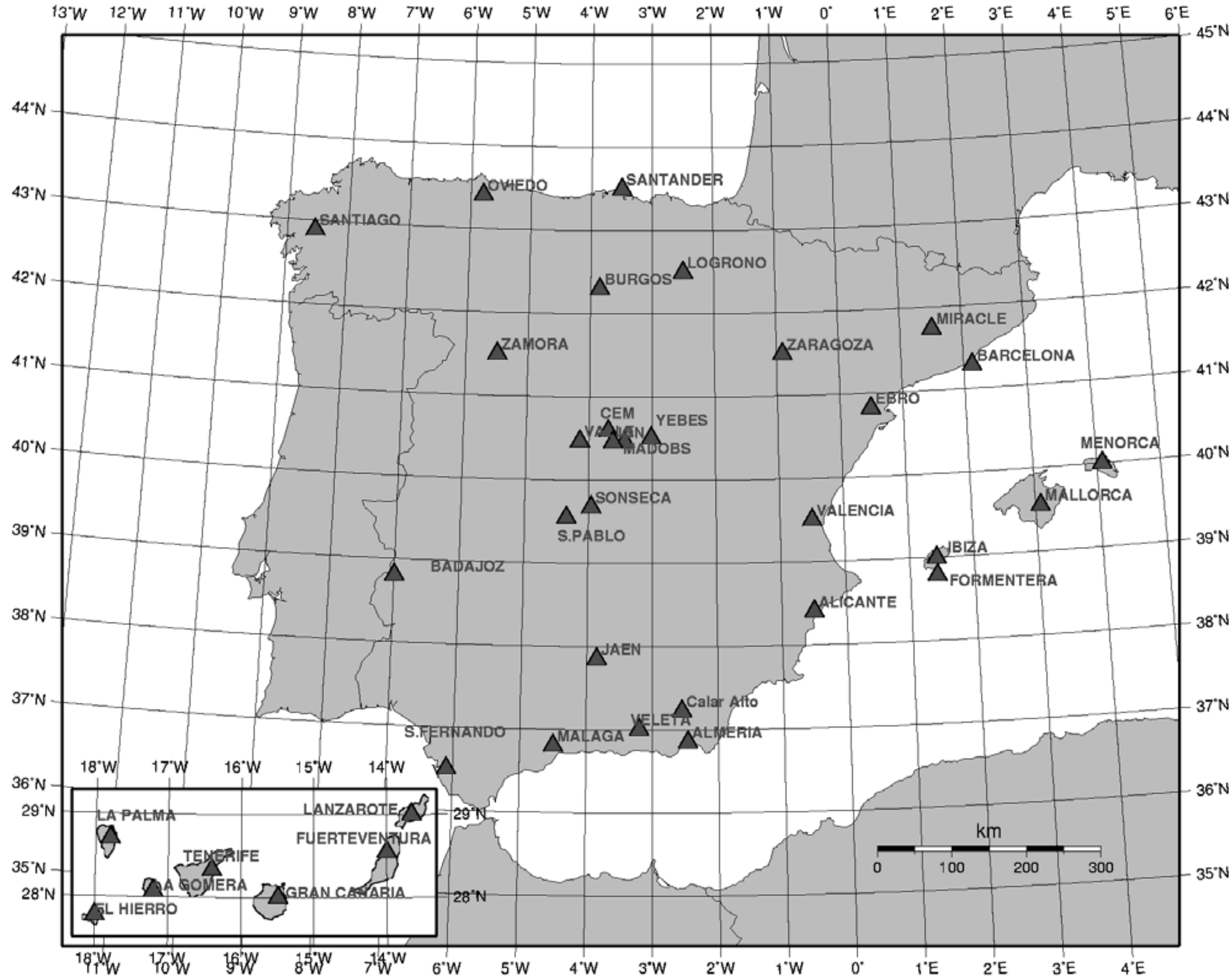
The National Geographic Institute of Spain (IGNE) has purchased a new free fall absolute gravity device by Micro-G Solutions named FG5#211, in order to observe a new absolute gravity network (IAGN), red triangle stations shown in map, and at least one point in every island (Balearic Islands and Canary Islands).

This network will serve for geodetic (supporting the new High Precision Levelling Network) and geodynamic purposes, among others. The breakout point for this enterprise was the ICAG2001 (International Comparison of Absolute Gravimeters) which took place in Sévres (Paris) July 2001, where the FG5#211 worked with the expected 1 microgal precision.

It would be desirable that these and more proposed stations fulfill the international standards of the International Absolute Gravity Base-Station Network (IAGBN) and all our efforts are focused on driven to that purpose so that this work could be widely accepted and useful for the scientific community.

The first stations already observed are Madrid IGNE, Madrid CEM, Madrid Astronomical Observatory, Valencia, Sonseca, San Pablo de los Montes, and Logroño and the next projected stations are shown in map. To those, some stations observed by other Europeans and Spanish institutions should be added: Valle de los Caídos (FGI and IAG); Tarifa, Ceuta, Alicante, San Fernando, Granada (BKG); Barcelona, and Las Mesas Observatory (Canary Islands).

[7] A. Dalda, E. Rodríguez, E. Núñez, M. Fernández, Instituto Geográfico National, adalda@mfom.es, erodriguez@mfom.es, enmaderal@mfom.es, mfvillalta@mfom.es



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