



PORTUGAL

**SECÇÃO PORTUGUESA DAS UNIÕES INTERNACIONAIS
ASTRONÓMICA E GEODÉSICA E GEOFÍSICA
(SPUIAGG)**

**INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS
(IUGG)**

NATIONAL REPORT

2003 – 2006

**PRESENTED TO THE XXIV GENERAL ASSEMBLY
OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS**

HOLD AT PERUGIA, 2 – 3 JULY 2007

NATIONAL REPORT OF PORTUGAL

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PRESENTED TO THE XXIV GENERAL ASSEMBLY
OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

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Preface

It is my pleasure to report the technical and scientific progresses reflecting very intensive and large use of the improved technical facilities in all domains of the Associations's Activities.

The increasing participation of national specialists in Conferences, Symposia and General Assemblies where the visibility of the Portuguese community was highlighted, can be seen as a positive result of the large collaborative efforts developed in the period 2003-2006.

The support of the Association's Correspondents to prepare the National Report for the 2003-2006 period, was a valuable input, namely the IAG (International Association of Geodesy), IASPEI (International Association of Seismology and Physics of the Earth's Interior), IAGA (International Association of Geomagnetism and Aeronomy) and IAPSO (International Association for the Physical Sciences of the Ocean). They produced wide practical informations about the developments covering many scientific subjects and challenges, that could be addressed by global remote sensing and modern information technologies.

The seismic hazard assessments, based upon networks of continuously operating Global Positioning System (GPS) receivers and SAR interferometry, during this last period the Portuguese Scientific Community justify the efforts to use the geodetic techniques to study the crustal movements, associated to the seismic activity and dynamic crustal displacements.

The implementation of the marine geophysics research is contributing to a better understanding of the tectonic and tectonophysics structures, in southern areas of Portugal, where the seismic hazard related to the activity expressed during historical periods by impressive reports, such as the 1755 earthquake, continues to be the main objective of projects funded by national agencies or financed in the framework of EU programs.

In the domain of the physical sciences of the ocean more projects were implemented on the influence of the transport of sediments, their dynamics, their course and respective consequences. Monitoring is increasing and more and more data is being collected.. The amount of project reports issued by the different Portuguese Institutions involved and the numerous publications are clear demonstration of the progresses achieved.

The concentration in the problems and implications of the biological production are continuous source of interest and the Centers dedicated to the biology of the oceans maintain a steady amount of publications treating those subjects.

More and more people are developing analytical methods to the mathematical representation of phenomena, becoming the mainstream with several important and innovative works in progress or recently concluded. Predictive models were implemented and tested.

Finally it is with great pleasure that the improvement of post-graduate academic degrees continue to pursue in the Portuguese Universities, thanks to the support received from the Portuguese Scientific Agencies and European Union.

Professor Dr. Luis Alberto Mendes-Victor, President of SPUIAGG

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Coordinated by

**Eng. João Manuel Agrida Torres,
National Correspondent of IAG**

1 – INTRODUCTION

The present report contains the information about the work carried out in Portugal in the field of Geodesy, covering the period 2003-2006.

Each one of the following chapters is dedicated to the institutions (governmental agencies, universities and research centres), who reported relevant geodetic work:

- *Instituto Geográfico Português* (Portuguese Geographic Institute) - report by Eng. Maria Helena Kol;
- *Instituto de Investigação Científica Tropical* (Tropical Science Research Institute) - report by Dr. Paula Santos;
- *Laboratório Nacional de Engenharia Civil* (National Laboratory of Civil Engineering) – report by Prof. João Casaca and Dr. José Nuno Lima;
- *Faculdade de Ciências da Universidade de Lisboa* (Faculty of Sciences of the University of Lisboa) – report by Prof. João Catalão;
- *Centro de Investigação em Ciências Geo-espaciais e Departamento de Matemática Aplicada da Faculdade de Ciências da Universidade do Porto* (Geo-Space Sciences Research Center and Department of Applied Mathematics of the Faculty of Sciences of the University of Porto) – report by Prof. José Pereira Osório;
- *Observatório Astronómico Prof. Manuel de Barros da Universidade do Porto* (Astronomical Observatory Prof. Manuel de Barros of the University of Porto) – report by Dr. Luisa Bastos.

It must also be mentioned the personal contribution to the work within the IAG structure, namely:

- João Agria Torres (*SPUIAGG*) as President of EUREF, the Regional Reference Frame Sub-commission for Europe of Commission 1 – Reference Frames.

2 – INSTITUTO GEOGRÁFICO PORTUGUÊS

2.1 – INTRODUCTION

The Instituto Geográfico Português (IGP) is an organism created in 2002, resultant of the union of the former Portuguese Institute of Cartography and Cadastre and the former Portuguese Centre for Geographical Information.

IGP is the organisation responsible for the establishment and maintenance of the national geodetic reference frames. In its works are included:

- geodetic network;
- high precision levelling;
- tide gauges;
- gravimetric network;
- vertical deflection points’;
- GPS permanent network;
- calibration baselines.

2.2 – POSITIONING

2.2.1 – Geodetic Network - Mainland

In 2004 the observation with GPS of the second order network in Portugal mainland was completed. The following standards were used to observe the 2nd order network:

- 4-5 double frequency GPS receivers;
- 2 hours sessions;
- 15 seconds epoch interval;
- 10 degrees elevation mask;
- occupation of two 1st order points in each session.

The figure 1 shows the trig points of the mainland network already observed with GPS.

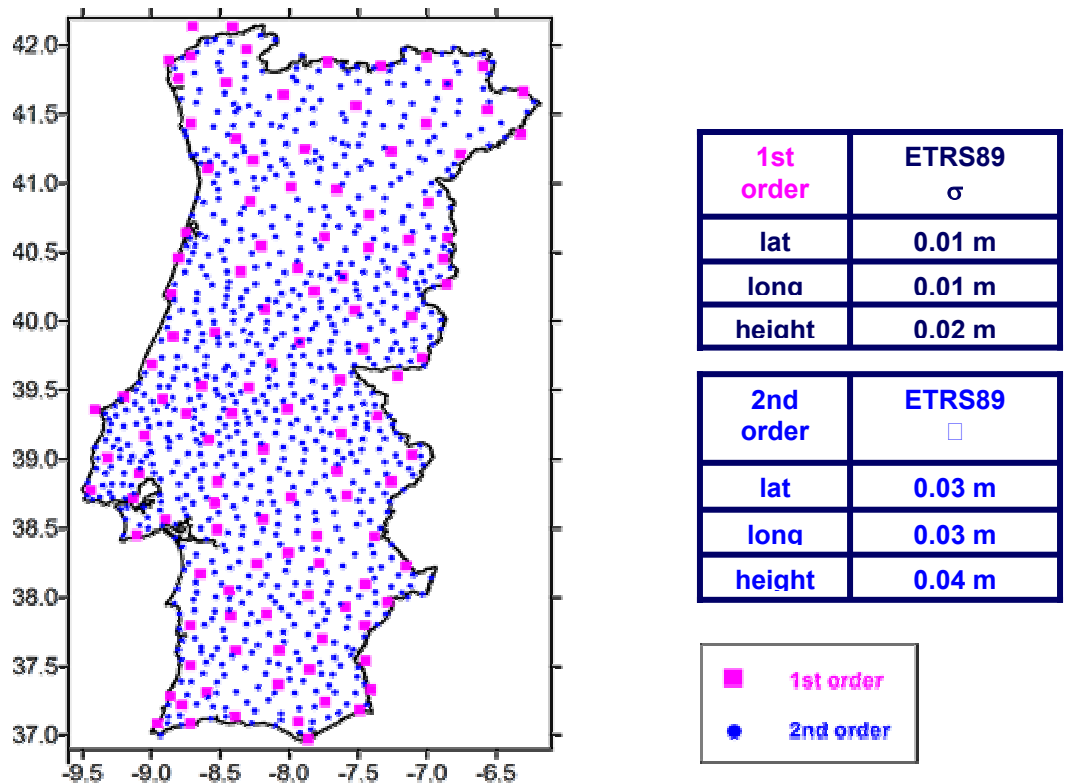


Figure 1 – Mainland Geodetic network observed with GPS until the end of 2004.

2.2.2 – Geodetic Network - Madeira

The Geodetic network of Porto Santo island, in Madeira Archipelago - figure 2 - was measured with GPS during October 2004. A total of twenty monumental geodetic points defines the Porto Santo network. This field campaign also includes the realization of reciprocals and simultaneous zenithal observations to improve precision in the height. The preliminary computation shows results (for ITRF93) better than 2 centimetres (at 95% of confidence level) for the coordinates. Local Datum (Base SE) coordinates were also computed, using the same set of observations. The Geodetic Network has already been adjusted for Base SE coordinates, with the same precision as the ITRF93 coordinates.

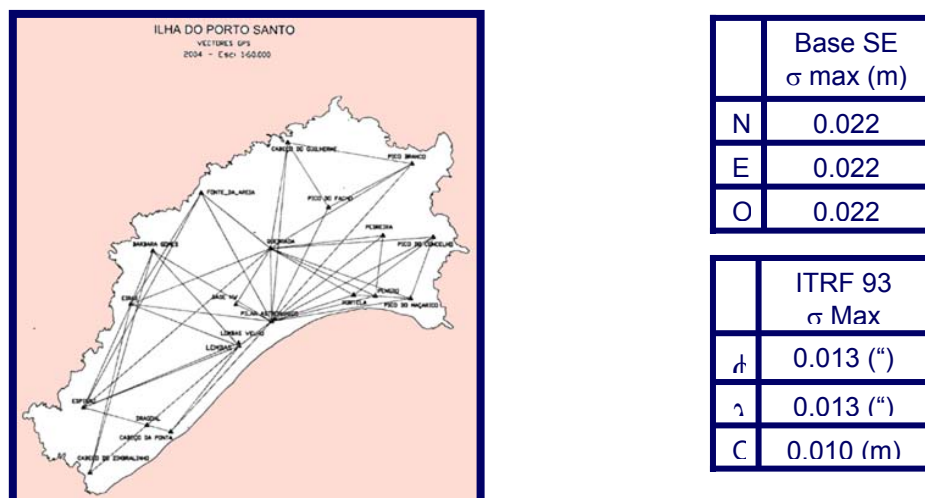


Figure 2 – Porto Santo Island Geodetic network observed with GPS.

2.2.3 – Geodetic Network - Azores

The Geodetic network of Corvo and Flores islands, in Azores Archipelago - figure 3 - was measured with GPS during July 2005. A total of six monumental geodetic points defines the Corvo network and a total of thirty tree monumental geodetic points defines the Flores network. The preliminary computation shows results (for ITRF93) better than 4 centimetres in Corvo and 2 centimetres for the coordinates of Flores (at 95% of confidence level). Local Datum (Observatório) coordinates were also computed, using the same set of observations.

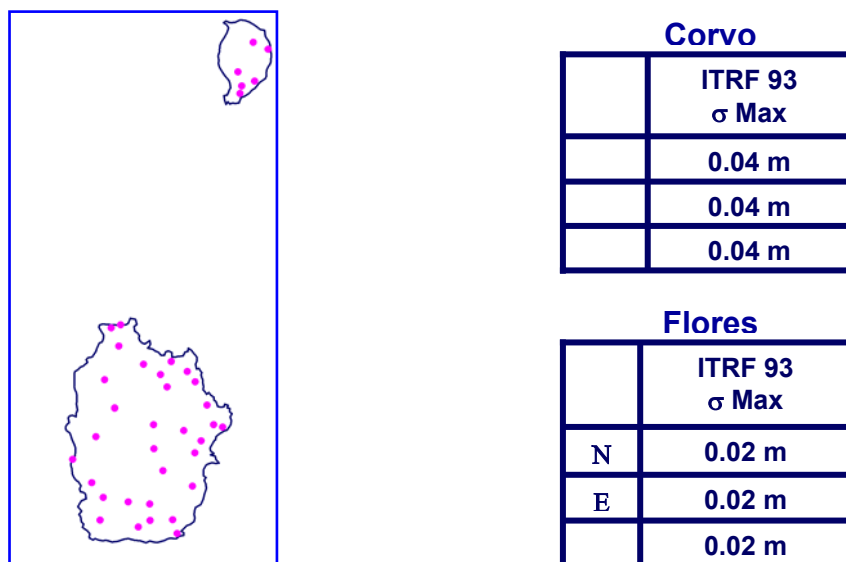
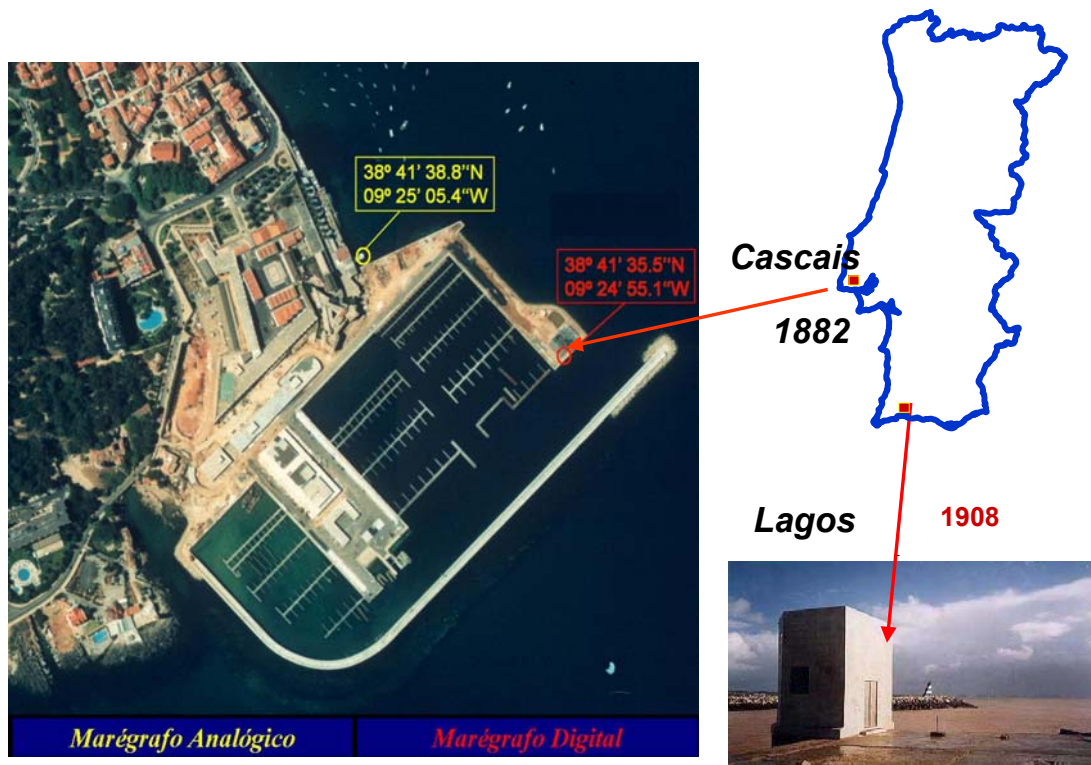


Figure 3 – Corvo and Flores Islands Geodetic network observed with GPS.

2.3 – Tides Gauges

IGP is responsible for two floating tide gauges, at Cascais and Lagos, working since 1882 and 1908, respectively. The Cascais tide gauge is the reference for the mainland ordnance datum.



In 2003, due to the technological innovations and for a better service to the scientific community, IGP acquired 2 new acoustic tide gauges, in order to replace the floating tide gauges systems. These new systems will work simultaneously with the older ones for at least one year. In that way we assure a better quality of the data and also the continuity of the secular series.



2.4 – Vertical Deflection Points’ Network

A network of about 130 vertical deflection points’ was observed with a prismatic astrolabe and a Wild T4 theodolite until mid 1980s.

In 1998 a project for the re-observation and densification of this network was started in a co-operation with ETH-Zürich (Swiss Federal Institute of Technology Zurich). The first work was the re-observation of 25 stations with the Zenithal Camera of ETH-Zürich. In the subsequent year another 28 points were observed with the ICARUS automatic system.

In 2000, following a protocol between IGP and FCUL, a special densification campaign along the central part of Portugal was launched. During this campaign the ICARUS system has been put in operation together with a GPS Palissade receiver, for timing purposes. In the year 2001 another 11 stations were observed.

In 2004 in field campaign performed by Dr. Beat Bürki and Dr. Anna Müller of ETH in cooperation with IGP, 17 points were measured with the new digital Zenith Camera system DIADEM.

Figure 4 shows the distribution of the vertical deflection points’ network and the methods of observation. The stations related with the FCUL specific work are not indicated.

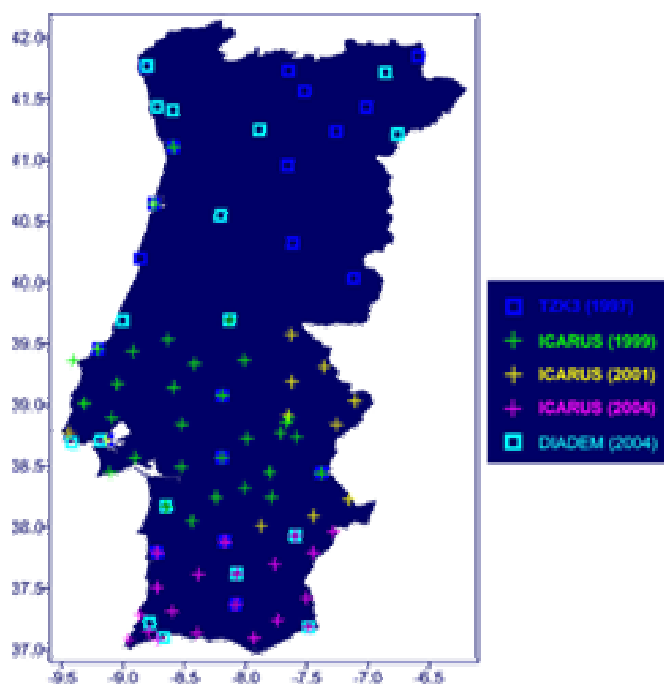


Figure 4 – Astronomical observations in Portugal Mainland.

2.5 – GPS Permanent Network

The first GPS permanent station was installed in 1997 in Cascais near the tide gauge. In the beginning of 2000 three more stations started to work: two near the tide gauges of Lagos and Leixões, and the other in Ponta Delgada, Azores. All these 4 stations are included in the EUREF GPS Permanent Network. The Ponta Delgada station also belongs to the International GPS Service Network.

The project of the GPS permanent network continued in the subsequent years with the installation of 5 other stations: Beja and Mirandela in 2001, Melriça and Funchal (Madeira Archipelago) in 2002, IGP in 2006. The configuration of the present GPS permanent network is shown in figure 5.

All the data regarding these 9 stations can be obtained at the anonymous ftp of IGP: <ftp://ftp.igeo.pt/pub/gpsdata/>.



Figure 5 – GPS Permanent Network.

2.6 – DETERMINATION OF THE GRAVITY FIELD

2.6.1 – Gravimetric Network

The gravimetric network of Portugal mainland consists of more than 6500 points, measured with LaCoste & Romberg relative gravimeters, and has a density of about one point per 25 km². In 1994 Dr. J. Mäkinen of the Finnish Geodetic Institute (FGI) had determined the absolute value of gravity in Gaia and Mértola, with the JILAg-5 absolute gravity meter.

In 2003 Dr. Mäkinen came again to Portugal to perform an absolute gravity survey, this time with FGI's new FG5 #221 absolute gravimeter. The Gaia and Mértola stations were re-measured, and a new point was measured in Cascais, in the same building of the GPS permanent station and near the tide gauge. The present state of the gravimetric network is shown in figure 6.

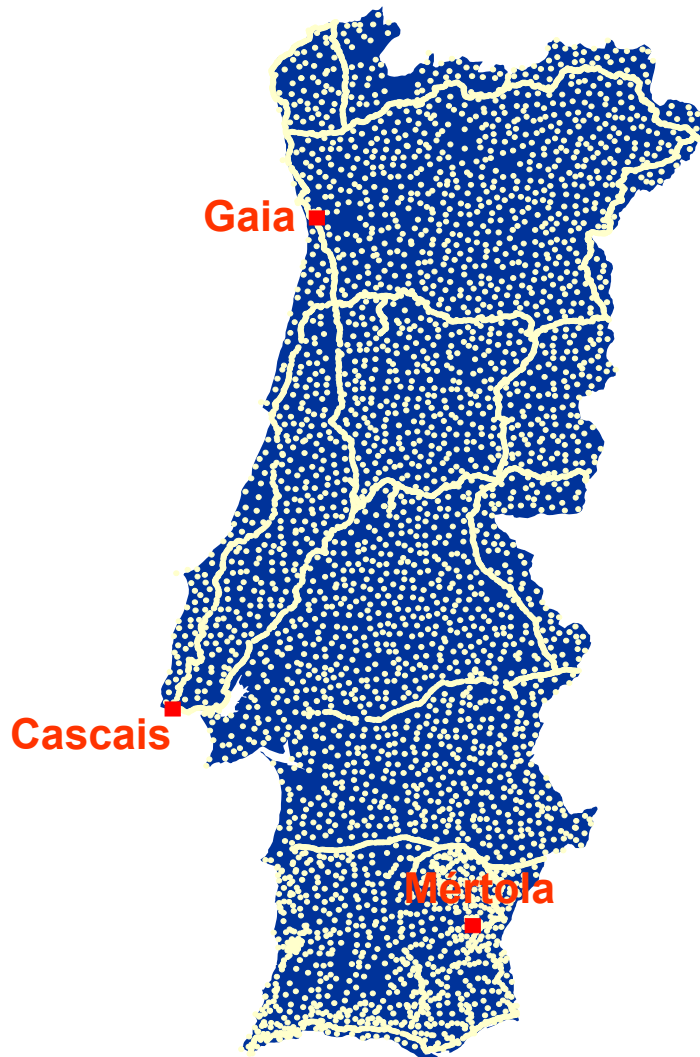


Figure 6 – Gravimetric network of Portugal mainland.

2.6.2 – Geoid Model - GPS on Levelling Bench Marks

In a joint project of IGP, FCUL and the Instituto de Astronomía y Geodesia de la Universidad Complutense de Madrid (Spain), a new gravimetric geoid model was developed. The first results were first presented at the 3rd Hispano-Portuguese Assembly of Geodesy and Geophysics, held in Spain in 2002.

In 2006, IGP promoted a GPS campaign with observations on 80 levelling bench marks, to complete the full coverage of the country, since that only exists 26 measurements. The main goal of this project was to adjust and validate the Portuguese gravimetric geoid model and also to contribute to the EUVN_DA project.

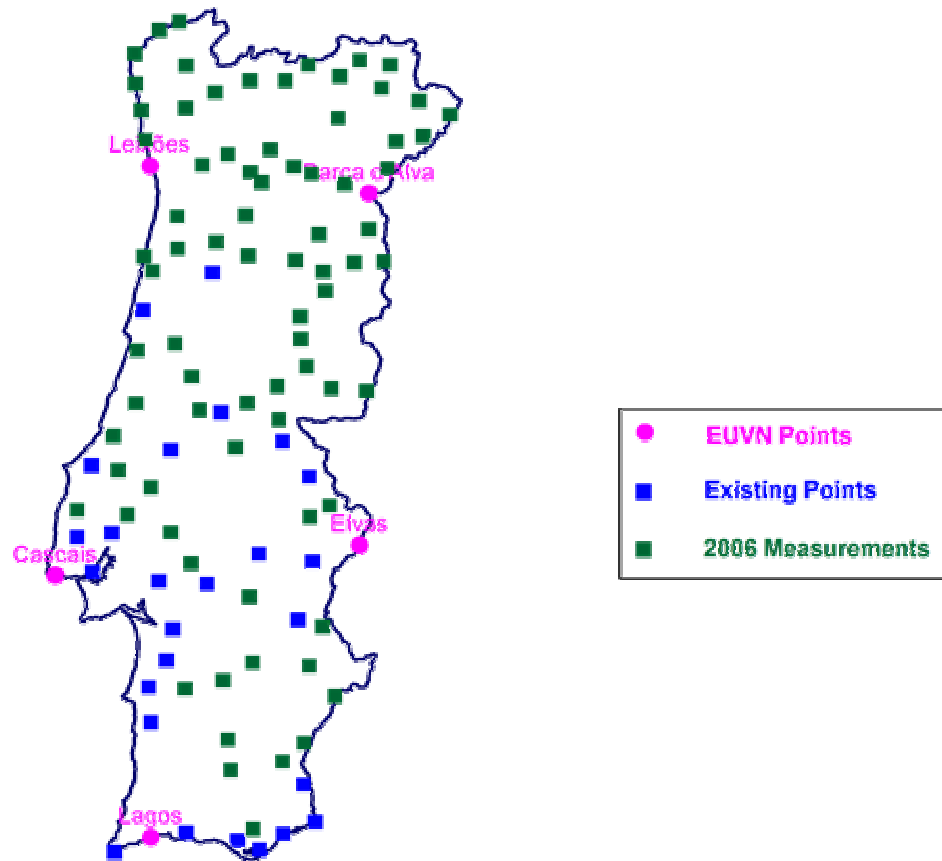


Figure 7 – GPS on levelling bench marks in Portugal mainland

2.7 – HUMAN AND MATERIAL RESOURCES

The human resources of the Department of Geodesy of IGP are five surveying engineers and six surveying technicians. The equipment consists on:

- 2 LaCoste & Romberg, model G gravimeters;
- several dual-frequency GPS receivers;
- several geodetic levels;
- several optical-mechanics theodolites (astronomy, geodesy and surveying);
- several computers;
- Bernese GPS software;
- GPS software;
- gravimetry adjustment and computation software;
- triangulation adjustment and computation software;
- levelling adjustment and computation software;
- geodetic astronomy adjustment and computation software;

2.8 – PUBLICATIONS

- Kol, H., Vasconcelos, M., Botelho, H. - **Rede Nacional de Estações GNSS de observação Contínua – Um projecto ao serviço de cidadão**. Comunicação realizada no ESIG 2006 - IX Encontro de utilizadores de informação geográfica, Oeiras, Portugal, 15 a 17 de Novembro de 2006.
- Silva, A, Crisóstomo, G., Freire, E., Costa, F. - **Reflexões sobre a variação do Nível do Mar em Portugal**, 1ª Conferência Lusófona sobre o Sistema Terra, Lisboa, 22-24 de Março de 2006.
- Crisóstomo, G., Kol, M. H., Vasconcelos, M. – **Marégrafos do IGP - Acústicos vs. Analógicos**, IV Conferência Nacional de Cartografia e Geodesia, Lisboa, Março 2005.
- Catalão, J., Kol, M. H., Sevilla, M. J., Anes, J. – **IAGM04 - Geóide Centimétrico no Atlântico Nordeste (Ibéria – Açores)**, IV Conferência Nacional de Cartografia e Geodesia, Lisboa, Março 2005.
- Vasconcelos, M., Casaca, J. - **A Transformação de Coordenadas Geodésicas entre o Datum 73 e o ETRS89 por Predição Espacial**, IV Conferência Nacional de Cartografia e Geodesia, Lisboa, Março 2005.
- Vasconcelos, M., Martins, C., - **Rede Geodésica Nacional: Estado Actual; Competências; Informação de Cidadania**, GisPlanet 2005, Lisboa, Portugal.
- Crisóstomo, G., Vasconcelos, M., Kol, H. – **Novo Sistema de Aquisição de dados Maregráficos do IGP**, Resumos da 4ª Assembleia Luso Espanhola de Geodesia e Geofísica, Figueira da Foz, Fevereiro 2004.
- Ribeiro, H., Martins, C., - **Automatização das Estações Permanentes GPS do IGP**, Resumos da 4ª Assembleia Luso Espanhola de Geodesia e Geofísica, Figueira da Foz, Fevereiro 2004.
- Martins, C., Ribeiro, H., - **Observação da Rede Geodésica de 2ª Ordem com GPS**, Resumos da 4ª Assembleia Luso Espanhola de Geodesia e Geofísica, Figueira da Foz, Fevereiro 2004.
- Vasconcelos, M., Casaca, J. - **Análise Estatística das Coordenadas da Rede Geodésica Portuguesa**, Resumos da 4ª Assembleia Luso-Espanhola de Geodesia e Geofísica, Figueira da Foz, Fevereiro 2004.
- Gonçalo C. Crisóstomo, Kol, H., Vasconcelos, M., - **Referencial Altimétrico Nacional**, XXI Assembleia DIGSA, Lisboa, 22-26 de Novembro de 2004.
- Vasconcelos, M., Casaca, J., - **Using Residuals for Improving the Accuracy of Coordinate Transformation**, Simpósio EUREF 2004, Bratislava, Eslováquia, 2 a 5 de Junho de 2004. (a publicar).

3 – INSTITUTO DE INVESTIGAÇÃO CIENTÍFICA TROPICAL

3.1 – INTRODUCTION

The origin of the Tropical Science Research Institute (IICT) dates from 1883 when a “Cartography Commission” was created to promote the scientific study of the ancient Portuguese colonies in Africa and to establish the basis for their scientific occupation. It was the first Portuguese institution devoted, in a permanent way, to develop scientific research in the tropics.

Geodesy is one of the scientific areas covered by the activities of IICT. The geodetic work in Africa (Angola, Mozambique, etc.) and in Asia was started more than 100 years ago. A systematic and well-organized acquisition of geodetic data on the ground and its adequate mathematical treatment has been carried out for many decades.

3.2 – RESEARCH & DEVELOPMENT PROJECTS

3.2.1 – Geodetic Network of Mozambique

This project has three main objectives. The first one is to update the classical geodetic triangulation of Mozambique with GPS. The second is to conclude two lines of the geometric levelling network of Mozambique. The third objective is to develop research studies with all geodetic data from the ex-Missão Geográfica de Moçambique.

Activities:

- Integration of the GPS observations in Mozambique Geodetic Network;
- Digitalisation of geodetic data field books to build a digital database.
- Adjustment of the classical terrestrial network of Mozambique in ITRF

3.2.2 – Geodetic Network of Angola

The objective of this project is the development of research studies with all geodetic data from the ex-Missão Geográfica de Angola

Activities:

- Observation of Luanda network with GPS
- Estimation of Bursa –Wolf parameters between Camacupa datum and ITRF for Luanda

3.3 – HUMAN AND MATERIAL RESOURCES

The human resources are two Researchers (PhD equivalent) .

The equipment consists on:

- 3 dual-frequency GPS receivers (Trimble 4000).
- 1 C/A code GPS receiver (Trimble Pathfinder Pro XL).
- 1 Gravimeter LaCoste & Romberg G.
- 2 Theodolite Total Stations
- Several optical-mechanics theodolites (Astronomy, Geodesy and Surveying)
- Several Geodetic Levels.
- 1 Portable Computer
- Several Pentium Computers
- Bernese GPS Software Version 4.2
- GPSurvey Software (Trimble)
- Gravimetry Adjustment and Computation Software (LaCoste & Romberg)
- Gravimetry Adjustment and Computation Software (Finnish Geodetic Institute)
- Triangulation Adjustment and Computation Software
- Levelling Adjustment and Computation Software
- 1 Calcomp Plotter
- 1 Desk Scanner

3.4 – PUBLICATIONS

- Faria, B.V.E.,Fonseca, J.F.B.D., Heno, S.I.N, Lázaro, Clara, d’Oreye, N. ,Ferreira, Barros, I.Santos, P., bandomo, Z, day, S.J., Osório J. PBaio, M., Matos, J. L** “Multi-parameter monitoring of Fogo island , Cape Verde” . Journal of Volcanology and Geotthermal Research. 2003, 125 , p 39 – 56.
- Lázaro, Clara, Santos, Paula, Lima, J.Nuno, Heleno, Sandra N., Barros, Inocêncio, Matos João, Baio, Miguel, Fonseca , João F.B.D.–** “Detection of subsurface magma movements in Fogo Volcano, Cape Verde, trough Microgravity observations. Proceedings of III Assembleia Luso-Espanhola de Geodesia e Geofísica, Valencia, Spain, 2003. tomo II, pp 720-722
- Lima, J.N., Heleno, S.I.N., Fonseca, J.F.B.D.,** - “Establishment of a GPS control network in FogoVolcano, Cape Verde”. Proceedings of III Assembleia Luso-Espanhola de Geodesia e Geofísica, Valencia, Spain, 2003. tomo I pp 114-117
- Lima, J.N., Lazaro, C., Santos, P., Heleno, S.I.N., Fonseca, J.F.B.D.,** - “GPS and microgravimetry for Fogo Island volcano control”. Proceedings of III Assembleia Luso-Espanhola de Geodesia e Geofísica, Valencia, Spain, 2003. tomo I pp 297-300
- Lima, J.N.–** “O GPS na observação geodésica de Barragens – Resultados do 1º ensaio”. Laboratório Nacional de Engenharia Civil, Relatório 157/05 - NGA/DBB, Lisboa 2005
- Lima, J.N.–Henriques, Maria João, casaca, João –** “ Monitorização de estruturas com GPS”. Livro das actas da IV conferência Nacional de Cartografia e Geodesia, Lisboa 2005, Cartografia e Geodesia 2005, Lidel pp 597-605.
- Lima,J.N., Casaca,J., Henriques,M.J. –** “Accuracy of Displacement Monitoring at Large Dams with GPS”. Presented at the International Symposium on Geodetic Deformation Monitoring: From Geophysical to Engineering Roles, Jaen, 2005, International Association of Geodesy Symposia, Vol. 131, Springer-Verlag Berlin Heidelberg 2006, pp 239 – 243.
- Lima, Nuno, Santos, Paula e Barros, F. Frias de -** Instrumentos Geodésicos e Astronómicos utilizados nas Antigas Missões Geográficas, “O Domínio da Distância”, Comunicação e Cartografia, IICT 2006, pp 165 – 170.
- Santos, Paula, Lima, J.N. –** “Observação do troço Buzi-Zimuala com GPS para a conclusão do ajustamento da Rede Geodésica de Moçambique” Livro das actas da IV conferência Nacional de Cartografia e Geodesia, Lisboa 2005, Cartografia e Geodesia 2005, Lidel pp 587-596.
- Santos, Paula, Lima, J.N., Quembo, J.L. –** “Adjustment of the Classical Terrestrial Geodetic Network of Mozambique tied to ITRF”, 5th FIG Regional Conference for Africa - Accra, Ghana, March 2006 (<http://www.fig.net/accra/>).
- Santos, Paula, Lima, Nuno e Barros, F. Frias de -** Atribuições das Missões Geográficas instituídas pela Comissão de Cartografia, “O Domínio da Distância”, Comunicação e Cartografia, IICT 2006, pp 171 – 189.
- Santos, Paula, Barros, Frias de e Lima, Nuno -** Catálogo dos Teodolitos usados nas Missões Geográficas da antiga Comissão de Cartografia, “Comissão de Cartografia - Catálogos”, IICT 2006, pp 3 – 27.

4 – LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

4.1 – R&D PROJECTS IN THE DOMAIN OF APPLIED GEODESY

Project: Geodesy Applied to the Observation of Engineering Works.

Abstract: The project, integrated in the Programmed Research Plan (Plano de Investigação Programada - PIP) of LNEC, includes a set of R&D activities developed with the aim of supporting the improvement and the updating of the important contribution provided, in a regular basis by the Applied Geodesy Centre (Núcleo de Geodesia Aplicada – NGA), to the monitoring of large engineering works (dams, bridges, etc.). The proposed project has a remarkable incidence in the engineering works observation activity, carried out in the Departments of Dams, Structures and Geotechnics. The geodetic observation activity plays an important role in the observation of engineering works, that doesn't exempt a constant renewal of the measuring equipment, operative methods, and methods and models for the treatment of the observations. The central purpose of this project consists on the study and improvement of the geodetic methods to the observation of large engineering works, essentially at two levels:

- i) equipments for geodetic observation (including a GNSS permanent station and multi-pillar baseline in LNEC campus)
- ii) methods and models for the treatment of the observed data and quality evaluation of measurements and results.

4.2 – ORGANIZING A IAG/FIG SIMPOSIUM

LNEC and the “Local Organizing Committee” are organizing the symposium “Measuring the Changes”, to be held in Lisbon, Portugal, from 12 to 15 May 2008 at LNEC Congress Center. “Measuring the Changes” (<http://measuringchanges.lnec.pt>) is integrated in the activities of IAG and FIG and combines the 4th IAG Symposium on Geodesy for Geotechnical and Structural Engineering with the 13th FIG Symposium on Deformation Measurements and Analysis.

The symposium will consist of both oral and poster presentations in three days, plus a one-day technical tour. The topics include Monitoring Static and Dynamic Deformations of Engineering and Geotechnical Structures, Multi-Sensor Systems, Automation of Monitoring and Warning Systems and Applications in Geotechnical, Structural Engineering and in Geosciences at Local and Regional Scales.

Local Organizing Committee of “MEASURING THE CHANGES”

Maria João Henriques – President (LNEC)
Rui Manuel Fernandes (UBI)
José Nuno Lima (LNEC)
João Agria Torres (SPUIAGG)
Manuela Vasconcelos (IGP)

4.3 – PRESENTATIONS, ARTICLES AND OTHER R&D PUBLICATIONS IN THE DOMAIN OF APPLIED GEODESY

Henriques,M.J., Casaca,J. – Monitoring Displacements at Large Dams by Means of Precision Traverses. Presented in FIG Working Week 2003, Paris, 2003.

Henriques,M.J., Casaca,J.– Quality Control of a Large Dam Geodetic Monitoring System. Presented in 1st FIG International Symposium on Engineering Surveys for Construction Works and Structural Engineering. Nottingham, 2004.

Casaca,J., Henriques,M.J. – Geodesia Aplicada à Monitorização de Barragens. Presented at the 4ª Assembleia Luso Espanhola de Geodesia e Geofísica, Figueira da Foz, 2004.

Casaca,J., Henriques,M.J. – O Princípio de Fermat e a Refracção Vertical. Presented at the Congresso de Métodos Computacionais em Engenharia, Lisboa, 2004.

Henriques,M.J., Santos,R., Silva,A., Coelho,J. – A Ambientação de Equipamento de Observação Geodésica. Presented at the IV Conferência Nacional de Cartografia e Geodesia. Lisboa, 2005.

Henriques,M.J., Casaca,J. – A Importância do Quadro de Referência nos Sistemas de Observação Geodésica de Grandes Barragens. Presented at the IV Conferência Nacional de Cartografia e Geodesia, Lisboa, 2005.

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- Lima,J.N., Henriques,M.J., Casaca,J.** – Monitorização Geodésica de Estruturas com o GPS. Presented at the IV Conferência Nacional de Cartografia e Geodesia, Lisboa, 2005.
- Casaca,J., Henriques,M.J.** – The Impact of Vertical Refraction at Local Three-dimensional Engineering Control Networks. Presented at the International Symposium on Geodetic Deformation Monitoring: From Geophysical to Engineering Roles, Jaen, 2005.
- Lima,J.N., Casaca,J., Henriques,M.J.** – Accuracy of Displacement Monitoring at Large Dams with GPS. Presented at the International Symposium on Geodetic Deformation Monitoring: From Geophysical to Engineering Roles, Jaen, 2005.
- Casaca,J., Henriques,M.J.; Fonseca,A.M., Lima,J.N.,** – A Geodesia Aplicada à Medição de Deslocamentos em Grandes Barragens. Presented at the Seminário: Barragens - Tecnologia, Segurança e Interação com a Sociedade, Lisboa, 2005.
- Caldeira,L., Casaca,J., Serra,J.B., Henriques,M.J., Lima,J.N.** – A Utilização do GPS em Sistemas de Aviso e Alerta em Grandes Barragens de Aterro. Presented at the XIII Congresso Brasileiro de Mecânica dos Solos e Engenharia Geotécnica, Curitiba, 2006.
- Lima,J.N., Henriques,M.J., Casaca,J., Coelho,J.** - Medição de Deslocamentos Superficiais em Barragens de Aterro com o GNSS - Presented at the 4as Jornadas Portuguesas de Engenharia de Estruturas, Lisboa, 2006.
- Casaca,J., Henriques,M.J.** – Uncertainty in Convergence Measurements made by Motorized Tacheometers in Tunnels. Presented at the 12th FIG Symposium on Deformation Measurements and Analysis the 3rd IAG Symposium on Geodesy for Geotechnical and Structural Engineering, Baden, 2006.

5 – FACULDADE DE CIÊNCIAS DA UNIVERSIDADE DE LISBOA

5.1 – PROJECTS

Project: **KARMA**

Title: Kinematics And Rheological Modelling of the Nubian-Eurasian plate boundary in the Azores

Principal Investigator: João Catalão

Principal Research Unit: Laboratório de Tectonofísica e Tectónica Experimental - LATTEX

Period of activity: 1/Jun/2005 to 31/12/2008

Goals: The main goal of KARMA is to derive a cinematic model for the Azores plate boundary and to design a comprehensive model for the Eurasia/Nubian plate boundary, valid at the "segment scale", able to incorporate the main conclusions of a series of detailed and complementary approaches supplied by other geophysical projects operating in this area. This will be achieved by the development of an integrated technique, based on SAR interferometry, GPS surveys, continuous GPS observations and rheological modelling, to evaluate inter-seismic, co-seismic and post-seismic deformation. This will allow a reassessment of seismo-tectonics both in-land and offshore.

Project: **ESA - Project C1P 3149**

Title: Ground deformation of Azores islands based on INSAR, corner reflectors and GPS

Principal Investigator: João Catalão

Principal Research Unit: Laboratório de Tectonofísica e Tectónica Experimental - LATTEX

Period of activity: 1/Jun/2005 to 31/12/2008

Goals: The main objective of this project is to test the applicability of the corner reflectors to overcome short term decorrelation of SAR images pairs. To reach this objective we proposed to install in Faial island 6 corner reflectors.

DISPLAZOR, STAMINA and SARAÇORES projects, mentioned in the last report (1999-2002) have already ended in 2005.

5.2 – Papers published in International Journals (with referees)

Catalão, J., J.M. Miranda, N. Lourenço (2006), "Deformation associated with the Faial (Capelinhos) 1956 eruption. Inferences from 1937-1997 geodetic measurements". *Journal of Volcanology and Geothermal Research*, Vol 155, 3-4, 151-163. doi:10.1016/j.jvolgeores.2006.03.028.

Catalão, J., (2006) "Iberia-Azores Gravity Model (IAGRM) using multi-source gravity data". *Earth, Planets, Space*, 58, 277–286, 2006.

Catita, C., K.L.Feigl, J. Catalão, J.M.Miranda, L.M.Victor (2005) "Time series analysis of SAR data applied to the study of the co-seismic deformation of the 9th July 1998 Pico-Faial (Azores) earthquake" *International Journal of Remote Sensing*, Vol. 26, No 13, 10 July 2005, 2715-2729.

Catalão, J. and M.J. Sevilla (2004), "Inner and minimum constraint adjustment of marine gravity data". *Computers and Geosciences*, Vol. 30, Issues 9-10 pp. 949-957, DOI: 10.1016/j.cageo.2004.06.004

Navarro, A., J. Catalão, J.M. Miranda and R. M.S. Fernandes (2003) "Estimation of the Terceira island (Azores) main strain rates from GPS data". *Earth, Planets and Space*, Vol. 55 (10), pp. 637-642.

Antunes, C., R. Pail, J. Catalão (2003) "Geoid determination by point mass method". *Studia geophysica et geodetica*, Vol. 47, pp. 495-509.

Mendes, V.B. and E.C. Pavlis (2004). "High-accuracy zenith delay prediction at optical wavelengths". *Geophysical Research Letters*, Vol. 31, L14602, doi:10.1029/2004GL020308.

5.3 – Communications to International Meetings (with Publication of Extended Abstract or Publication of Communication on Acta Book)

Antunes, C., 2004. Linear formulation of the gravity space approach for local geoid determination. *Proceedings of the 1st Workshop on International Gravity Field Research*, Graz, Austria, May 8-9. Eds. Bruno Meurers and Roland Pail, Österreichische Beiträge zu Meteorologie und Geophysik, Heft 31, Vienna 2004, p. 79-85.

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Hulley, G., E.C. Pavlis, V.B. Mendes, and D.E. Pavlis (2005). "Multiwavelength refraction modeling improvements for SLR observations" Proceedings of the 14th International Laser Ranging Workshop, June 7 - 11, 2004, San Fernando, Cadiz, Spain, Boletín ROA No. 5/2005, J. Garate, J. M. Davilla, C. Noll and M. Pearlmann (Eds), Real Instituto y Observatorio de la Armada, San Fernando, Spain, pp. 301-309.

**5.4 – Communications to National Meetings
(With Publication of Extended Abstract or Publication of Communication on Acta Book)**

Catita, C., J. Catalão, M. Miranda, L.M. Víctor (2004). O sismo de 9 de Julho de 1998, Pico-Faial (Açores): deformação co-sísmica observada a partir de interferometria radar. *Actas da III Conferência Nacional de Cartografia e Geodesia in December of 2002, Aveiro, Portugal*. Lidel, Edições Técnicas, pp. 243-250.

Prates, G. e V.B. Mendes (2004). "Análise de estratégias de processamento de dados GPS." *Actas da III Conferência de Cartografia e Geodesia*, 5-6 de Dezembro, Aveiro, Lidel – Edições Técnicas, Lda, pp. 97-102.

Mendes, V.B., J. Madeira, J. Pagarete, G. Prates, A. Trota, P. Elósegui (2004). "Estabelecimento de uma rede GPS de controlo de deformações no Faial, Pico e S. Jorge." *Actas da III Conferência de Cartografia e Geodesia*, 5-6 de Dezembro, Aveiro, Lidel – Edições Técnicas, Lda, pp. 127-131.

Rodrigues, R., V.B. Mendes, A. Trota, J.L. Gaspar e P. Amaral (2005). "Aplicação da técnica GPS no estudo da deformação dos sistemas vulcano-tectónicos da ilha graciosa (Açores)." APMG 2005, 4.º Simpósio de Meteorologia e Geofísica da Associação Portuguesa de Meteorologia e Geofísica, 6.º Encontro Luso-Espanhol de Meteorologia, 14 - 17 Fevereiro 2005, Sesimbra, pp 122-126.

**5.5 – Communications to National and International Meetings
(Without Publication of Extended Abstract or Publication of Communication on Acta Book)**

Calvão, J. (2006). "Generation of a high resolution grid of gravity anomalies by inversion of altimetric data from Geosat, Topex/Poseidon, ERS-1/2 and Jason-1 in the Azores region". Presented at the ESA meeting "15 Years of Progress in Radar Altimetry", 13-18 March, Venice

Catita, C., J. Catalão, M. Miranda, L.M. Victor, R.M. Fernandes (2005). Cinemática e deformação das ilhas do Faial e Pico (Açores). IV Conferência Nacional de Cartografia e Geodesia, Março de 2005, Centro de Congressos do LNEC, Lisboa.

Antunes, C., 2003. "Linear formulation of the gravity space approach on local geoid determination". 1st Workshop International Gravity Field Research, Graz, Austria, May 8-9.

Antunes, C., 2004. A combined linear formulation of the boundary-value problem in the gravity space applied to local geoid determination. IAG International Symposium - Gravity, Geoid and Space Missions - GGSM2004. Porto, Portugal, Aug. 30th - Sept. 3th.

Antunes, C. 2006. "Problema Combinado de Fronteira na Abordagem do Espaço Gravidade ". 5ª Assembleia Luso-Espanhola de Geodesia e Geofísica, Sevilla, Espanha, Fev 28 – Mar 3.

Sousa, C. e Catalão, J. (2006) "A integração do sistema GPS/INS para a monitorização da linha de Costa do Litoral do Algarve." In: IX Encontro de Utilizadores de Informação Geográfica, 15-17 Novembro 2006, Tagus Park, Oeiras, publicado em CD-ROM, 11 páginas.

Catalão, J., Sevilla, M.J., Calvão, J. (2006), "ICAGM – Geóide no Atlântico nordeste (Ibéria – Canária - Açores)". In: Proceedings of V Assembleia Luso Espanhola de Geodesia e Geofísica e Coordenador da sessão Geodesia - "?????", realizada em Sevilla, Fevereiro 2006. ISB 84-8320-373-1.

Catalão, J., H. Kol, M. J. Sevilla, J. Anes (2005), "IAGM04 – Geóide centimétrico no Atlântico Nordeste (Ibéria – Açores)". IV Conferência Nacional de Cartografia e Geodesia, Sessão, LNEC, Lisboa, Março 2005.

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- NAVARRO, A., J. CATALÃO e J.M. MIRANDA (2005). Estimação das taxas de deformação e de rotação local da ilha da Terceira com base em observações GPS. Comunicação apresentada na IV Conferência Nacional de Cartografia e Geodesia, 10 e 11 de Março de 2005, LNEC.
- Catalão, J., J.Fernandes and L. Bastos (2004), "Mapping Multi-source Gravity Data using Optimal Interpolation". IAG International Symposium: Gravity, Geoid and Space Missions - GGSM2004. Sessão 5 - Topographic data bases and gravity modeling. Porto, 2004.
- Catalão, J., H. Kol, M. J. Sevilla, J. Anes, (2004), "Towards a cm-geoid for the North-East Atlantic (Iberia – Azores)". IAG International Symposium: Gravity, Geoid and Space Missions - GGSM2004. Sessão 3 - Regional geoid modeling. Porto, 2004.
- Mäkinen, J., L.Bastos, P. Baptista, J. Catalão,H. Kol,R. Vieira, (2004) "Absolute gravity measurements in the Azores and in the Iberian Peninsula". IAG International Symposium: Gravity, Geoid and Space Missions - GGSM2004. Sessão 7 - Terrestrial gravity instrumentation, networks, and geodynamics. Porto, 2004.
- Catalão, J.; Catita, C.; Miranda, J.M.; Pinto, J. (2003), "Reanalysis of the deformation associated with Capelinhos eruption (Faial island, 1958) from geodetic data". XXVIII General Assembly of the EGS, Session G12; Vol. 5, 8604, 6-11 April, Nice, France.
- Feigl, K., Retina Team (J. Catalão) (2003), "Mechanical coupling between earthquakes, volcanos and landslides". XXVIII General Assembly of the EGS, Session G12; Vol. 5, 04677, 6-11 April, Nice, France.
- NAVARRO, A., J. CATALÃO, R. FERNANDES, M. MIRANDA, L. BASTOS (2003). The Terceira Island (Azores) crustal deformations from GPS data. Geophysical Research Abstracts, Vol. 5, 10082, European Geophysical Society 2003.
- Mendes, V.B., I. Fortes, and P. Elósegui (2003). "Accuracy assessment of IGS zenith tropospheric delays." Presented at the AGU 2003 Fall Meeting, 8-12 December, S. Francisco, CA. (Eos Trans. AGU, 84(46), Fall Meet. Suppl., Abstract G51B-0026).
- Rodrigues, R., P. Amaral, A. Trota , J.L. Gaspar e V. B. Mendes (2004). "Implementação de uma rede geodésica na ilha Graciosa (Açores) para avaliação da actividade sismovulcânica." Apresentada na 4ª Assembleia Luso-Espanhola de Geodesia e Geofísica, Figueira da Foz, 3-7 de Fevereiro de 2004 (Livro de Resumos: pp. 627-628).
- Pavlis, E., V.B. Mendes, D.E. Pavlis, and G. Hulley (2004). "Atmospheric refraction modeling improvements in satellite laser ranging" European Geosciences Union 1st General Assembly, Nice, France, 25 - 30 April 2004, Geophysical Research Abstracts, Vol. 6, 04206, 2004.
- Trota, A., R. Rodrigues, P. Amaral, J.L. Gaspar, and V. B. Mendes (2004). "GPS continuous observations at S. Miguel and Terceira islands (Azores). Preliminary results" Tenerife, International Symposium "Reducing Volcanic Risk in Islands". Tenerife, 1-7 June 2004.
- Hulley, G., E.C. Pavlis, V.B. Mendes, and D.E. Pavlis (2004) "Validation of atmospheric refraction modeling improvements in satellite laser ranging." Presented at the AGU 2004 Fall Meeting, 13-17 December, S. Francisco, CA. (Eos Trans. AGU, 85(47), Fall Meet. Suppl., Abstract G31A-0784).
- Hulley, G., E.C. Pavlis, V.B. Mendes, and D. E. Pavlis (2005). "Improved atmospheric refraction modeling for Satellite Laser Ranging: Model validation." EGU General Assembly, 24 – 29 April 2005, Vienna, Austria (Geophysical Research Abstracts, Vol. 7, 05693).

6 – CENTRO DE INVESTIGAÇÃO EM CIÊNCIAS GEO-ESPACIAIS E DEPARTAMENTO DE MATEMÁTICA APLICADA DA FACULDADE DE CIÊNCIAS DA UNIVERSIDADE DO PORTO

6.1 – MAIN AREAS OF ACTIVITY IN GEODESY

The activity at the Geo-Space Sciences Research Centre (CICGE) and Applied Mathematics Department, Faculty of Sciences, University of Porto, in the area of Geodesy and related fields, is organized around four main domains:

Satellite Positioning and Navigation
Satellite Altimetry
Remote Sensing and Image Processing
Geographical Information Systems

In the period covered by this report, 2003-2006, the activity was carried out, in all those domains and their applications, through research projects financed by national as well as international organizations. Some of the results from such activity are given in the annexed list of publications.

The two Masters Degree Courses, in Satellite Positioning and Navigation and in Remote Sensing, continue to be offered. The MSc Thesis produced during the same period are also included in the list.

Also in the list, are the PhD Thesis, already finished, whose research work was conducted under the supervision of elements of the Research Centre, within the area of geodesy and related fields.

Finally, it is also to be mentioned the organization of some International Meetings under the responsibility of members of the Centre.

6.2 – PUBLICATIONS

2003

Joao F.B.D. Fonseca, Bruno V.E. Faria, Nuno P. Lima, Sandra I. N. Heleno, Clara Lazaro, Nicolas F. d'Oreye, Ana M. G. Ferreira, Inocencio J.M. Barros, Paula Santos, Zuleyka Bandomo, Simon J. Day, Jose P. Osorio, Miguel Baio, Joao L.G. Matos, 2003, "Multiparameter Monitoring of Fogo Island, Cape Verde, for Volcanic Hazard Mitigation", *Journal of Volcanology and Geothermal Research* 2605, pp. 1-18.

Nekrassov A. 2003, Airborne measurement of the sea surface wind vector by a microwave radar altimeter at low speed of flight. *IEICE Transactions on Electronics*, 2003, Vol. E86-C, No. 8, pp. 1572-1579.

André R. S. Marçal, Janete Borges, 2003, AVHRR Rectification Using Orbital Navigation and Image Matching, *Image and Signal Processing for Remote Sensing VIII*, edited by Sebastiano B. Serpico, *Proceedings of SPIE Vol. 4885*, 13-21.

Lima, José Nuno, João Agria Torres, Maria Helena Kol, 2003, "Geo-responsabilização: o que podemos esperar da nossa infra-estrutura geodésica e em que condições a podemos utilizar?", *Actas da III Conferência Nacional de Cartografia e Geodesia, Cartografia e Geodesia, Lidel, Lisboa 2003*, pp 395-405.

Lázaro, C., P. Santos, J. N. Lima, S. N. Heleno, I. Barros, J. Matos, M. Baio e J.F. B. D. Fonseca, 2003, "Detecção de movimentos sub-superficiais de magma no Vulcão do Fogo, Cabo Verde, através das observações de microgravimetria", *Proceedings da 3ª Assembleia Luso-Espanhola de Geodesia e Geofísica, Tomo II, Valência, Espanha*, pp 720-722.

Lima, J. Nuno, S.I.N. Heleno, J. F. B. D. Fonseca, 2003, "Estabelecimento da Rede GPS para o controlo do Vulcão do Fogo, Cabo Verde", *Proceedings da 3ª Assembleia Luso-Espanhola de Geodesia e Geofísica, Tomo I, Valência, Espanha*, pp 114-117.

Lima, J. Nuno, Clara Lázaro, Paula Santos, S.I.N. Heleno, J.F.B.D. Fonseca, 2003, "GPS e microgravimetria no controlo do Vulcão da Ilha do Fogo", *Proceedings da 3ª Assembleia Luso-Espanhola de Geodesia e Geofísica, Tomo I, Valência, Espanha*, pp 297-300.

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Fernandes M. J., L. Bastos and M. Antunes, 2003, Coastal Satellite Altimetry – Methods for Data Recovery and Validation, Proceedings of the 3rd Meeting of the International Gravity & Geoid Commission (GG2002), 302-307, Tziavos, I. N. (Ed.), Editions ZITI.

Fernandes M. J and M. Antunes, 2003, Eight Years of Satellite Radar Altimetry in The Northeast Atlantic – Proceedings 3ª Assembleia Luso-Espanhola de Geodesia e Geofísica, Vol I, 226-230, Garcia F. and Valero, J.(ed.), Editorial UPV.

Fernandes M. J., 2003, Satellite Altimetry Data Recovery In Coastal Regions – Proceedings 3ª Assembleia Luso-Espanhola de Geodesia e Geofísica, Vol I, 231-235, Garcia F. and Valero, J.(ed.), Editorial UPV.

Alexandre Gomes, André R. S. Marçal, 2003, Land cover revision through object based supervised classification of ASTER data, ASPRS 2003 Annual Conference Proceedings, May 2003, Anchorage, Alaska, CD-ROM, 9 pp.

Gonçalves, J., 2003. Orientation of SPOT stereopairs with a SAR image for DEM extraction. Proceedings of the Annual Conference of the American Society of Photogrammetry and Remote Sensing (CD-ROM).

Borges, J., Costa, J., Marçal, A., 2003, Classificadores e Máquinas de Suporte Vectorial em Imagens Multi-espectrais, Actas da JOCLAD 2003: X Jornadas de Classificação e Análise de Dados, 36-41.

Fernandes, M. J., L. Bastos, F. Leite, 2003, Integration of Multisensor Gravity anomalies, IUGG2003, Sapporo, Japan, June 30 – July 11.

Lázaro, C e M. J. Fernandes, 2003, Synergistic Use of Near-Real Time Radar Altimetry And ATSR-2 Data For Ocean Circulation Studies Around Cape Verde, IUGG2003, Sapporo, Japan, June 30 – July 11.

Barbosa, S. M., Silva, M. E., Fernandes, M. J., 2003, Time series analysis of sea level data, SPRUCE VI, Lund, June, 2003.

Barbosa, S. M., M. J. Fernandes and M. E. Silva, 2003, Non linear estimation of eustatic trends from European tide gauge records, EGS-AGU-EUG Joint Assembly, Nice, France, 6 – 11 April.

Lázaro, C e M. J. Fernandes, 2003, Ocean Variability Around Cape Verde Archipelago from Near Real Time Satellite Altimetry and SST Images, EGS-AGU-EUG Joint Assembly, Nice, France, 6 – 11 April.

Lima, J. Nuno, 2003, “GPS e Gravimetria para o controlo de deformações do Vulcão da Ilha do Fogo”, Livro dos resumos do I Encontro Nacional de Geodesia Aplicada, Laboratório Nacional de Engenharia Civil, Lisboa, pp 142-143.

Silva, M. C. G. Q. L., "Uso sinérgico de altimetria radar e imagens ATSR-2 em tempo real para a caracterização da circulação oceânica na região de Cabo Verde, Tese de Mestrado, Março 2003.

Meneses, M. A. S., “As Redes Neurais na Análise de Tráfego com o GPS”, Tese de Mestrado, Maio 2003.

Castanheira, M. J. L, “Detecção de Alterações da Cobertura do Solo no Vale do Alto Tâmega através de imagens de satélite Landsat TM e ETM+”, Tese de Mestrado, Outubro 2003.

Gomes, J. A. F., "Classificação supervisionada de imagens ASTER segmentadas em objectos. Aplicação prática na actualização da cartografia de ocupação do solo da região do Vale do Sousa", Tese de Mestrado, Dezembro 2003.

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Meneses, A., Osório, I., 2004, “Urban Traffic Flow Prediction by Using GPS and Neural Networks Theory”, Proceedings of the ION Annual Meeting, San Diego, USA, January 2004, 974-981.

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André R. S. Marçal, Alexandra Nunes, Janete Borges, 2004, AVHRR data processing for near real time applications, Remote Sensing for Environmental Monitoring, GIS Applications, and Geology III, edited by Manfred Ehlers, Hermann J. Kaufmann, Ulrich Michel, Proceedings of SPIE Vol. 5239, 542-550.

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- Janete Borges, André R. S. Marçal, Joaquim P. Costa, 2004, Comparison of three supervised classification methods for deriving land cover maps from ASTER satellite images, Proceedings of the 1st Workshop on Pattern Recognition for Remote Sensing, Kingston, UK, CD-ROM, 4pp.
- Alexandra Nunes, André R. S. Marçal, 2004, Atmospheric correction of high resolution multi-spectral satellite images using a simplified method based on the 6S code, Proceedings of the Remote Sensing & Photogrammetry Society Annual Conference – “Mapping and Resources Management”, Aberdeen, Scotland, UK, CD-ROM, 9pp.
- Pereira, Z., Morgado, A. M., Pereira, L. G., 2004, "Comparison of different approaches to create architectural archives", *IntArchPhRS Istanbul*, Vol 35, Part B5: 552-557.
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- Gonçalves, J., 2004, "Analysis of SAR image geo-location accuracy for mapping", *SAR Image Analysis, Modelling and Techniques VI*, Eds. Francesco Posa, Proceedings of SPIE Vol. 5236, 190-199.
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- Bastos, L., P. Tomé, T. Cunha, M. J. Fernandes, S. Cunha, 2004, Avaliação do desempenho de um sistema GPS/INS para gravimetria aérea, *Actas da 3ª Conferência Nacional de Cartografia e Geodesia*, Aveiro, Portugal, 5 – 6 Dezembro 2002, 113-114, Lidel.
- Teodoro, Ana Cláudia, M. Joana Fernandes, 2004, A detecção remota como um instrumento de planeamento urbano: caso da Área Metropolitana do Porto (AMP), *Actas da 3ª Conferência Nacional de Cartografia e Geodesia*, Aveiro, Portugal, 5 – 6 Dezembro 2002 , 205-214, Lidel.
- Leite, F. B. D, Morujão, L. Bastos and M. J. Fernandes, 2004, Estimação da acelerações usando medidas de fase GPS, *Actas da 4ª Assembleia Luso-Espanhola de Geodesia e Geofísica*, 509-510, Figueira da Foz, Portugal, 3-7 de Fevereiro de 2004.
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- Barbosa, S. M, M. J. Fernandes and M. E. Silva, 2004, Sea Level change from Cascais tide gauge data, *Actas da 4ª Assembleia Luso-Espanhola de Geodesia e Geofísica*, 659-660, Figueira da Foz, Portugal, 3-7 de Fevereiro de 2004.
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- Alexandra L. Nunes, André R. S. Marçal, 2004, Correção atmosférica de imagens AVHRR para a produção de índices de vegetação, *Actas da III Conferência Nacional de Cartografia e Geodesia*, LIDEL, 161-169.
- Ana Cláudia Teodoro, André Marçal, Veloso Gomes, 2004, Discriminação de sedimentos e padrões de rebentação a partir de diferentes imagens de satélite, *Actas da III Conferência Nacional de Cartografia e Geodesia*, LIDEL, 170-178.
- André R. S. Marçal, 2004, Distribuição de imagens de satélite de Portugal para aplicações em tempo real, *Actas da III Conferência Nacional de Cartografia e Geodesia*, LIDEL, 225-234.
- Teodoro, A.C., Marçal, A.R.S., Gomes, F.V., 2004, Determinação da concentração de Sedimentos Suspensos Totais (SST) na zona de rebentação a partir de imagens de satélite, *Actas da 4ª Assembleia Luso-Espanhola de Geodesia e Geofísica*, Figueira da Foz, 3-7 Fevereiro 2004, 685-686.
- Teodoro, A.C., Almeida, C. Marçal, A., Gomes, F.V., 2004, Quantificação de sedimentos na zona costeira com recurso a técnicas de detecção remota: Integração dos resultados num Sistema de Informação Geográfica (SIG), *Actas do Encontro Nacional de utilizadores de SIG 2004*, CD-ROM, 10 pp.

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- Santos, Z., Morgado, A. M., Gonçalves, J. A., 2004. Elaboração de um arquivo arquitectónico inserido num modelo tridimensional urbano. ESIG Proceedings, Lisbon: 12 pgs publicado em CD.
- Lima, José Nuno, João Agria Torres, Maria Helena Kol, "Geo-responsabilização: o que podemos esperar da nossa infra-estrutura geodésica e em que condições a podemos utilizar?", Actas da III Conferência Nacional de Cartografia e Geodesia, Cartografia e Geodesia, Lidel, Lisboa 2004, pp 395-405.
- Fernandes, M. J., Lázaro, C., Santos, A. M. P., Oliveira, P., 2004, "Oceanographic characterisation of the Cape Verde region using multisensor data". Envisat & ERS Symposium, Gotenburg, 6-10 September 2004 (submetido para publicação).
- Osório, I., 2004, GNSS applications at Centro de Investigação em Ciências Geo-Espaciais, UN/USA International Meeting on the Use and Applications of Global Navigation Satellite Systems, Viena, Austria, 13-17 December.
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- Osório, J. P., "Sistemas de Referência Internacionais", Jornadas de Engenharia Topográfica, Guarda, Maio 2004.
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7 – OBSERVATÓRIO ASTRONÓMICO PROF. MANUEL DE BARROS DA UNIVERSIDADE DO PORTO

7.1 – INTRODUCTION

Presently the main areas of research at the Astronomical Observatory of the University of Porto (OAUP) are essentially satellite positioning and navigation, with applications in geodynamics, coastal zones monitoring and mobile mapping, and airborne gravimetry.

The most relevant activities in the period 2003-2006 had been:

- Implementation of a Database and Analysis Center (GEODAC) in the scope of the activities of the Inter Commission Project of the International Association of Geodesy, WEGENER (in collaboration with the University of Delft and the University of Beira-Interior). In the scope of this project, systematic processing of an Iberian GPS network (including some GPS stations located in Northern Africa) is carried out.
- Implementation of algorithms for analysis of the spatial and temporal correlations in GPS time. These algorithms are being implemented successfully in the analysis of permanent networks in the scope of GEODAC.
- Implementation of algorithms for estimating trends (in GPS time series) with realistic error bars. A new method was developed which is an order of magnitude faster with no loss of accuracy in case there are no data gaps. When there are gaps in the data the new method still produces good results while retaining its gain in speed. Further improvement in the estimation of the trend in GPS data was done by removing the environmental effect of atmospheric loading.
- Development of the program CARGA. This program, developed in collaboration with other European institutions, allows the calculation of loading effects. It is being applied to the analysis of permanent GPS networks and also in international projects involving the study of tides using gravimetric observations.
Results of CARGA were compared with the values of the Special Bureau for Loading (SBL) which is part of the International Earth Rotation Service (IERS). Discrepancies were found not only between our results and theirs but also among the several sets of values available at the SBL. This led to a deeper investigation of the numerical accuracy of atmospheric loading computations.
- Maintenance of permanent GPS stations in the Azores region for geodynamic studies.
- Development of algorithms based on GPS/INS integration for airborne gravimetry.
- Reobservation of the absolute gravimetric station located in the grounds of the Astronomical Observatory (in collaboration with the Finnish Geodetic Institute).
- Monitorization of the coastal zone using space techniques for vulnerability and risk assessment.
- Implementation of a Mobile Mapping system based on the integration of GPS measurements with data from dead-reckoning sensors and video systems for acquisition of image.

The following list of publications and communications, resulting from the developed activities, expresses the main results achieved.

7.2 – COMMUNICATIONS AND PUBLICATIONS (2003-2006)

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PORTUGAL

**SECÇÃO PORTUGUESA DAS UNIÕES INTERNACIONAIS
ASTRONÓMICA E GEODÉSICA E GEOFÍSICA
(SPUIAGG)**

**INTERNATIONAL ASSOCIATION OF SEISMOLOGY
AND PHYSICS OF THE EARTH'S INTERIOR
IASPEI**

NATIONAL REPORT

2003 – 2006

**PRESENTED TO THE XXIV GENERAL ASSEMBLY
OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS**

HOLD AT PERUGIA, 2 – 3 JULY 2007

Coordinated by

**Prof. Dr. Luis Alberto Mendes-Victor,
National Correspondent of IASPEI**

1 – INTRODUCTION

When we try to sum up the main spots of the activities performed since 2003, the International Conference of the 1755 Lisbon Earthquake was undoubtedly the best one. The high quality of participants and of the lectures on the 6 Themes, defined by the Scientific Council of the Conference, was emphasized by the majority of the around 300 attendees and are reflected in the Book of Proceedings.

The Portuguese seismic community was called to participate in the ESC G. A. in Potsdam (2004) and Geneva (2006) as well as in the Santiago do Chile IASPEI General Assembly (2005), presenting very interesting papers, reported in the bibliography of the Institutions included in this set.

Furthermore, participating in several European meetings to clarify the research advancement of the knowledge on Tsunami Risks around the euro-mediterranean areas, and with the UNESCO, in the framework of the IOC, some projects were designed already and proposed to be partially financed by the European Union, being approved with wide involvement of Portuguese scientific groups.

The continuity of regular meetings (every two years) of Spanish and Portuguese specialists on Geodesy and Geophysics was assured in Portugal (Figueira da Foz -2004) an in Spain (Sevilla - 2006) where large number of seismic papers have demonstrated the improvement on networking.

The Working Group 6 of the Sub-Commission F of the ESC, approved in the Potsdam Assembly- "Potential Very Large Earthquake Disasters in the European - Mediterranean Region" was able to organize a preparation meeting in Obidos -Portugal at the end of November 2005 in order to define the call for the First Workshop included in the program of the Geneva 2006 ESC .

It is worthwhile to refer the extraordinary progress on the seismic networking improvement (mostly Broadband and Ocean Bottom Seismograph -OBS stations), in the main land and Açores and, in what concerns OBS, along the coastal portuguese areas

DEPARTMENT OF SEISMOLOGY AND GEOPHYSICS OF THE INSTITUTO DE METEOROLOGIA REPORT

1. Introduction

The work developed by the Department of Seismology and Geophysics of the Instituto de Meteorologia is compiled in the following paragraphs, where the core activities were the ones related with the seismic monitoring and watch.

2. Seismic network

2.1 Mainland Portugal and Madeira archipelago

At the beginning of 2003, the seismic network in this area was composed by 14 telemetric enhanced SP digital stations, 4 analogue telemetric SP stations and 1 VBB station, MTE, belonging to GEOFON and operated by IM at his facilities (Manteigas).

There are two enhanced SP stations at Madeira archipelago, and twelve at Mainland Portugal. Those stations are equipped with three component short-period sensors (flat velocity response from 5 sec to 40 Hz) and digitizers with 120 dB of dynamic (96 dB of resolution). All digital stations were remotely accessed through public telephone lines.

The network is equipped with automatic acquisition and data retrieval software, running on a Solaris platform, which retrieves the data to a waveform database from where it is manually analysed.

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On 2005, a major effort was carried out in order to upgrade the quality and reliability of data communications links. Between 2005 and 2006, six of the enhanced short-period stations were equipped with VSAT communication infra-structure, which increase significantly data availability.

At the same time, IM introduced significant improvements in the Portuguese seismic network through a modernization project of the National Seismic Network (MODSISNAC). Since July 2006, seven new broadband stations have been installed on the mainland, connected in real-time by VSAT to the IM headquarters, in Lisbon. All of the new stations are equipped with very broadband sensors (3 Guralp 3T, 3 Guralp 3ESPCompact and 1 STS-2), strong-motion sensors (6 Guralp 5T and 1 Kinometrics Episensor) and 24 bit digitisers (6 Guralp DM24 and 1 Quanterra Q330).

IM has adopted the SEISCOMP system (GEOFON, Potsdam) as the standard for data acquisition. Some of the older SP stations have already been integrated into the new acquisition system, and efforts are being made in order to integrate the remaining ones. Up to the end of 2006, data from 17 seismic stations are concentrated at a central computer at IM, including available regional stations operating in real-time (RT) (MTE, from GEOFON with support from IM; EVO, from Évora University; MORF from Lisbon University, with support from IM) and part of the SP network. Also, data from other regional stations is being obtained from the ORFEUS Data Centre, using AutoDRM protocol.

All data is processed and analysed using SEISAN (Havskov & Ottemöller, 2005), complemented with software developed at IM.

With the availability of near real-time data, automatic processing is now possible.

All the phase data for local, regional and distant earthquakes, together with the computed hypocenters, are published in monthly preliminary bulletins, and is available in the Web.

Waveform data from two of the VBB stations (PESTR and PVAQ) is sent to ORFEUS and IRIS/DMC in real-time, where it is made available to the community.

2.2 Azores

Twelve three-component stations constitute the digital network: 9 of them equipped with enhanced short-period seismometers (flat velocity response from 5 sec to 40 Hz) and 3 with short-period sensors (flat velocity response from 1 Hz to 80 Hz) and digitizers identical to the ones in Mainland Portugal. The stations transmit segmented data through UHF radio links and conventional telephone lines. Most of the data from the Central group is concentrated at a central recording facility located at Horta (Faial island), from where it is sent to the main installation of IM in Ponta Delgada, San Miguel Island, where the remaining data (one station from Central Group, four from Eastern Group and 2 from the Western one) is received.

On 2005, another digital enhanced short period station was installed at central part of S. Miguel.

The communication system for CMLA station, which belongs to IDA/IRIS and is locally maintained by IM, was improved since mid 2006. It is now based on an Internet connection, and data was also integrated into SEISCOMP acquisition system.

Major plans exists to upgrade the regional network, introducing broadband seismometers and strong-motion sensores, high resolution digitisers and real-time communications using VSAT links. SEISCOMP will also be adopted, and older stations will be integrated into a common acquisition system.

All the phase data for local, regional and distant earthquakes, together with the computed hypocenters, are published in monthly bulletins within the framework of the SIVISA (Azorean Seismic Surveillance Network) protocol.

3. Geomagnetic campaigns

Since late 2005 IM is again responsible for the geomagnetic monitoring in the portuguese territory.

A major project is to install e geomagnetic observatories, in Madeira, Azores and Mainland. This project is still waiting for financial support.

During the reporting period, IM performed several geomagnetic campaigns in the national territory, surveying a network of repeating stations. The acquired information was used to monitor and study the magnetic field, and also to obtain information required by the aviation.

4. Participation in projects

CTBTO – Comprehensive Test Ban Treaty Organization – On 1999, IM has been chosen by the PTS to be the local partner for the operation and maintenance of two IMS stations: one T-Phase hydroacoustic station and one Infrasound array, both in Azores islands. IM, who has performed the site survey for the installation of the T-Phase hydroacoustic station, and was the responsible for its installation, on 2004. This Station was certified in 2005, and since then IM is operating and maintaining it.

IRIS/IDA – Since 1996, IM is the local responsible for the operation and maintenance of the CMLA station, which belongs to the San Diego University. On mid 2006, significant improvements have been introduced, namely on the data transfer process which is now done through a stable Internet connection to San Diego.

GEOFON – Since 1997, former Divisão de Sismologia, now Departamento de Sismologia e Geofísica, has been cooperating with the Potsdam GFZ in the operation of a very broadband station at Manteigas, Portugal, and belonging to the GEOFON network. On 2006, significant improvements in the data transference system have been introduced.

Participation in several national projects, mainly founded by the Science and Technology Foundation (FCT): DISPLAZOR - Tectonic, volcanic and landslide displacement monitoring at Faial, Pico and S. Jorge (Azores) using GPS; SHELT – seismic hazard Seismic hazard evaluation of the lower Tagus Valley; GEOALGAR – Geodynamic control and seismic characterization of the Algarve Region; SISMOTECTO – development of a geophysical database for Portugal Mainland; MASHA – Multi-scale approach for seismovolcanic hazard investigation in the Azores; “SEISMIC SOURCES AND STRONG MOTION PREDICTION”; SEISMIC TOMOGRAPHY OF THE ALGARVE CONTINENTAL LITHOSPHERE; COMICO – Contribution for the Seismic Risk Mitigation for 3 Major Cities in Azores, NEAREST – Integrated Observations From Near Shore Sources of Tsunamis. Towards an Early Warning System, MODSICNAC – Modernization of the National Seismic Network.

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- "Sistema de Monitorização dos Sismos e Tsunamis e os investimentos associados - um levantamento de necessidades", Workshop 'Risco Sísmico e os Tsunamis', Instituto de Meteorologia, 31 de Maio de 2005, apresentação oral, co-autoria Senos, M.L.
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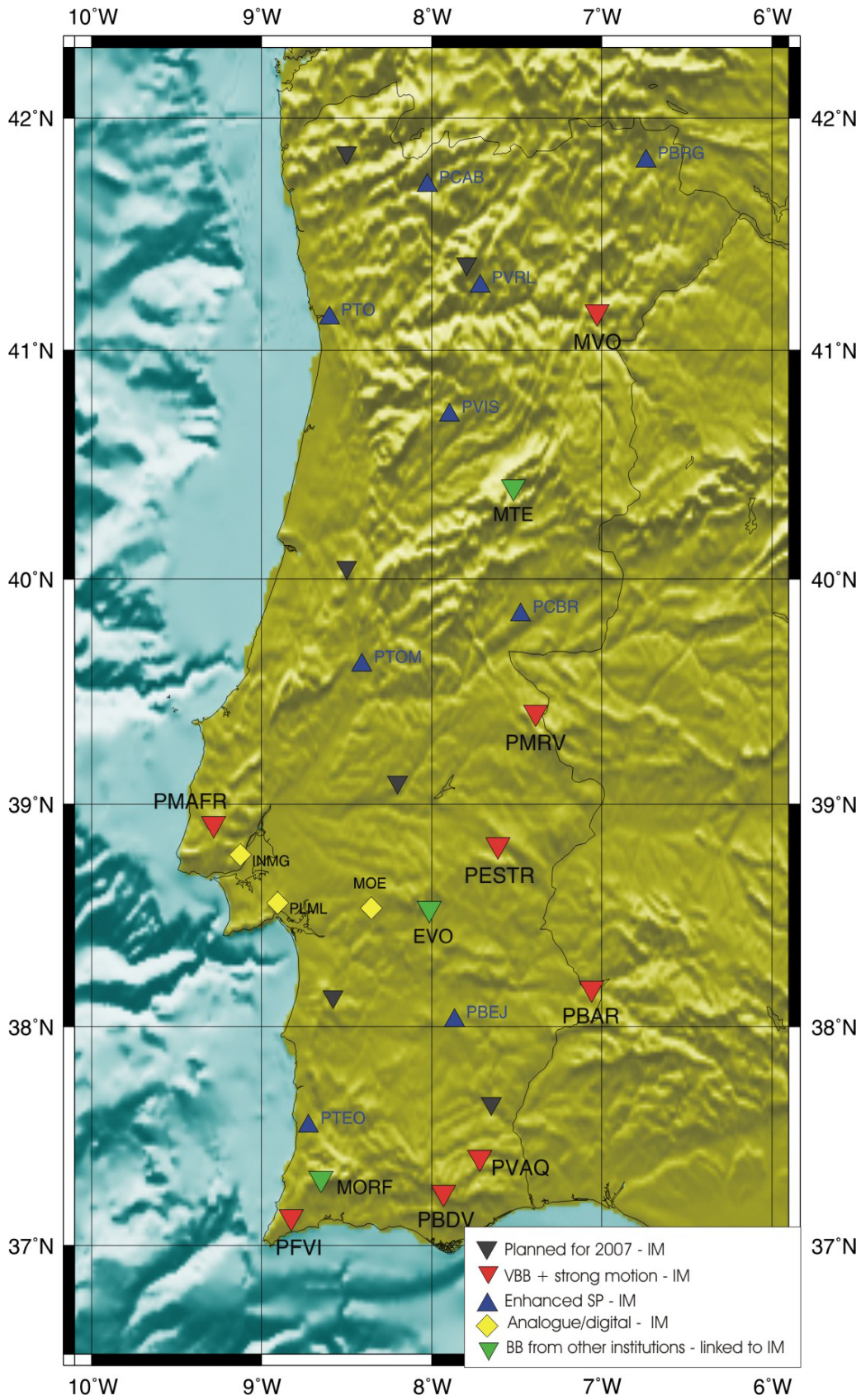


Figure 1 - Portugal Mainland Network - 2006

Centre of Geophysics of the University of Lisbon

1 – INTRODUCTION

During the 2003-2006 period several activities were developed by the seismologists of the CGUL (Centre of Geophysics of the University of Lisbon). One important activity was involvement on the organization (co-organized by several institutions) of the International Conference on the "250th Anniversary of the 1755 Lisbon Earthquake". This conference was chaired by Professor Luis Mendes Victor, and took place in Centro Cultural de Belém and in the Rectorate of the Lisbon University, from 1-4 November 2005. The Opening Ceremony, on the 1st November, was followed by five invited lectures given by national and international experts on seismology, history and seismic engineering. In the following days, the participants attend special and invited lectures, as well as, oral presentations and posters, distributed in the different topics:

- Social and economic disfunctions of communities exposed to earthquakes (philosophical, historical, scientific and technological impacts, etc.);
- Urban Planning facing natural hazards, information, training and warning;
- Propagation and local effects on the seismic destruction;
- How to build earthquake resistant buildings under environmental geological constraints;
- New approaches to the seismogenesis of the 1755 earthquake: Source
- Mechanism, Tsunami Simulation, Induced Seismicity;
- Global Response to Large Earthquakes.

The conference had about 200 hundred participants and, in particular, most of the relevant seismologists for all over the world interested in historical seismicity.

The research work developed by the seismology group of the CGUL is described in the following paragraphs.

2 – SEISMIC AND TSUNAMI HAZARD ASSESSMENT

In the aim of seismic hazard assessment studies, the investigation on attenuation models for SW Iberia were developed conducting to the definition of an attenuation law for the whole country, taking into account historical and instrumental seismicity.

Studies related with the statistical distribution of the seismicity in Portugal mainland and adjacent Atlantic region, were also developed. A database of all the information related with the natural seismicity is under construction.

The study of the historical seismicity contributes for a better assessment of the seismic hazard. CGUL is involved on the study of the source parameters estimation for Iberian historical earthquakes developed in the aim of a Portuguese-Spanish collaboration. For the 1909 Benavente earthquake, a review of the macroseismic data were performed in order to identify the existence of site effects as well as of anisotropy on the seismic propagation. The identification of site effects in Lisbon town during the 1st November 1755 earthquake was also investigated, based on a new analysis and interpretation of the macroseismic information.

CGUL is also concerned with the monitoring of actual seismicity in some particular sites, in the aim of different research projects: during one year CGUL installed three portable seismic stations in Algarve close to Portimão fault. Seismic monitoring on the Foz Côa Natural Park was also conducted with one single station, during 2 years, and the events were detected using spectrogram analysis.

Seismic hazard assessment was estimated for some particular sites in Portugal in the Lower Tagus Valley region and in the Algarve (south Portugal). Studies concerning the estimation of strong ground motions were also developed for different sites in Portugal.

In the aim of COMICO project, seismic hazard studies are being developed for the three main towns of the Azores Archipelago. A review of the historical seismicity of S. Miguel, Terceira and

Faial Islands were performed. A first estimation of the seismic hazard for the town of Angra do Heroísmo (Terceira Island) was performed. Several problems were identified: (i) the time extension of the seismic information (only 500 years) is too short to determine recurrence intervals with accuracy; (ii) geologic investigation of the inland seismic sources revealed the evidence of major shocks occurred in the past, but not observed during these last 500 years; (iii) the identification of the main seismogenic zones may be biased due to the small amount of data.

The study of tsunamis in the Morocco coast was developed in the framework of bilateral agreement between Portugal and Morocco. Numerical modelling techniques for source evaluation using Okada's equations and non linear shallow water model, Swan (Mader, 1988) for tsunami propagation were used to study the 26 May 1975.

Tsunami hazard assessment was a major topic during 2005 as a consequence of the Sumatra 26 December tsunami. CGUL actively participated in national and international initiatives to devise a common strategy for hazard assessment and risk mitigation. Research was developed towards the study of the 1722 Tavira (Algarve, Portugal), 1761 Iberian and 1693 Calabrian historical tsunamis.

In the framework of TRANSFER and NEAREST projects the process of revision and update of the Portuguese tsunami database, part of the European tsunami catalogue, ETC, was implemented.

Tsunami run up and inundation pilot studies are under development for the Algarve area with selected test sites Sagres – Lagos and Ria Formosa.

The CGUL has an active participation and commitment in the implementation of NEAMTWS – North East Atlantic and Mediterranean Tsunami warning System – UNESCO. The First Session of the Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North Eastern Atlantic, the Mediterranean and connected Seas (ICG/NEAMTWS) confirmed that a European-North African TWS is urgently needed as the Atlantic Ocean, including the Mediterranean, is the second largest source of tsunamis around the globe. Given the short geographical distances between possible sources and coastal target regions of an impact (i.e. in the Mediterranean), a regional TWS for Europe has to rely on a dense net of seismic stations to provide timely forecasts and warnings. The ICG decided to have an initial tsunami warning system in place by end of 2007.

3 – SITE EFFECTS ESTIMATION USING MICROTREMORS

Between 2003 and 2006, the use of microtremors in site characterization was investigated, as a complementary method to the more classical approaches. Some results were presented in the 2nd International Conference on Site Characterization (ISC'2), (Porto, Portugal, September 2004).

Microtremor surveys based on ambient vibration measurements were performed for several towns in the Azores Archipelago: Angra do Heroísmo (Terceira Island), Ponta Delgada (S. Miguel Island) and Horta (Faial Island). The interpretation of the results was performed taking into consideration the surface geological formations of the towns. For the town of Angra do Heroísmo correlation between the results and the damage distribution observed during the January 1, 1980 earthquake, were also investigated.

Included in a Portuguese-French collaboration and, in the framework of the COMICO project, the study of the shallow structure under Ponta Delgada town was initiated, based on the analysis of continuous record of ambient vibrations (Shapiro and Campillo, 2004: Emergence of Rayleigh waves from correlations of the ambient seismic noise). The analysis of the correlograms, obtained without filtering, only reflect the presence of a low frequency noise, probably induced by the sea. Between 0.8 and 2 Hz we have been able to retrieve a good Green function. At a frequency band of 2 – 4 Hz the noise reveals, mainly, human activity. Computation of the Rayleigh wave group velocities is now under way. This first analysis showed the need to identify and localize the noise source. This can be done with the installation of a small seismic array (5 to 8 stations), to record noise continuously for 8 to 10 days. This experiment will be implemented very soon.

4 – SEISMIC RISK ON LAGOS HISTORICAL CENTRE

The project concerning the seismic risk on Lagos historical centre “RSCHL - Risco Sísmico no Centro Histórico de Lagos”, has been developed during 2003 and concluded in 2004. The final workshop, in November 2004, was opened to the civil community. The work developed during the whole project involved the seismogenesis, the geological setting, the seismic hazard estimation and the characterization of subsurface geology. In order to design probable seismic scenarios, the building stock was classified in terms of typologies; seismic scenarios were presented in terms of building damages and social damages (homeless people and deaths). The social and economical contexts of the seismic risk were also outlined in order to contribute for the development of an emergency plan. CGUL participated in almost all tasks. Some of the results were presented in national and international meetings in 2003, 2004 and 2005.

The work developed under this project was compiled in a text book published in 2006. Two master thesis were also developed in the framework of this project.

5 – BUILDING SEISMIC BEHAVIOUR

Ambient Vibration Tests (AVT) are non destructive dynamic tests and are considered quite useful to characterize the dynamic behaviour of a structure excited by low amplitude vibration. In the framework of Caravela project, ambient vibration tests were conducted in order to identify the natural frequency of Nossa Senhora do Carmo church, in Lagos historical centre. Simultaneously, a finite element model (FEM) of the structure was developed, and the natural frequency was evaluated. The same methodology, AVT and FEM, was applied to the Portuguese Telecom Tower, in Lisbon. Natural frequencies, mode shapes and damping ratios were computed and checked against.

The collection of microtremor data on different types of buildings was performed in Ponta Delgada and Angra do Heroísmo towns, in the aim of COMICO project. The natural frequencies (in the longitudinal and the transversal directions), as well as the damping, were determined for each building. Taking into account the physical parameters of each building (type and material of construction, date of construction, number of floors, salient elements, etc.), the vulnerability curves were estimated, following a methodology developed in the European project Risk-UE. The results were presented in national and international meetings.

In order to estimate the contribution of the soil seismic response on the building seismic behaviour and, in particular, on the seismic intensity evaluation, a simple theoretical modelling will be developed. Results are expected during the next years.

6 – MANTLE TOMOGRAPHY AND SEISMIC ANISOTROPY

The Azores archipelago occupies a lateral branch of the Mid-Atlantic Ridge near the triple junction of three large tectonic plates, the North American, the Eurasian and the African plates. The tectonic setting is even more complex because of the existence of the Azores hotspot and hotspot-ridge interaction. However, the hotspot origin at depth as a plume and its lateral extent are controversial subjects. High-resolution tomographic models, through the mapping of low-velocity and anisotropy anomalies, can provide an important hint to evaluate the depth and lateral extent of plumes when they exist. We have made a review of the Azores deep seismic structure, as seen as on the most recent global and regional studies. Those models have been interpreted using a fluid mechanics framework (Silveira et al., 2006).

Later this same study has been extended to the Indo-Atlantic “box”. Using recent fluid mechanics results as a framework, we reinterpret the images of the Indo-Atlantic mantle obtained from global and regional tomography studies together with geochemical, geological and paleomagnetic observations to unravel the pattern of convection in the Indo-Atlantic “box” and its temporal evolution over the last 260 Myr. Laboratory experiments have shown that superswells, long-lived hotspot tracks and traps may represent three evolutionary stages of the same phenomenon, i.e. episodic destabilization of a hot, chemically heterogeneous thermal boundary layer, close to the bottom of the mantle. When scaled to the Earth's mantle, its recurrence time is on the order of

100–200 Myr. At any given time, the Indo-Atlantic box should contain 3 to 9 of these instabilities at different stages of their development, in agreement with observations. The return flow of the downwelling slabs, although confined to two main « boxes » (Indo-Atlantic and Pacific) by subduction zone geometry, may therefore not be passive, but rather take the form of active thermochemical instabilities (Davaille et al., 2005).

At this larger scale, we continue our study of the Atlantic deep structure by investigating the lithospheric thickening in anomalous areas. For young sea floor, the relationship between depth and root square of age is valid but Calcagno and Cazenave (1994) have shown fluctuations of the order of 100-150 m/Ma for older sea floor. In order to investigate the thermal structure beneath the lithosphere and asymmetrical subsidence observed in the Atlantic we have determined a new high resolution model of the Atlantic Ocean. This model is now being used to determine the lithosphere thickness and cross-correlation along tectonic corridors.

The several broadband stations of the Memorandum of understanding COSEA, located in Azores archipelago, have offered an opportunity to study seismic anisotropy beneath that area. To test a prediction of the anisotropy of the upper mantle beneath the Azores archipelago, we measure splitting of the waveforms of SKS and SKKS. Splitting observations have often, but not universally, indicated a fast axis parallel to the plate motions (Vinnik et al., 1992). Our preliminary SKS splitting measurements beneath CMLA seem to contradict this result, and the average anisotropy must be small if it exists at all. During March 2004, the CGUL has received Professor Lev Vinnik from the Physics Institute of Moscow. He collaborate with our group, namely with our master student Iolanda Morais, on seismic anisotropy. We confirmed the absence of the S phases beneath São Miguel island (CMLA/IDA seismic station). The lack of splitting can have different explanations: a) presence of multiple layers with different anisotropy directions with a null effect; b) presence of a vertical flow or c) an isotropic medium at the SKS scale. (Morais et al., 2005).

Due to its geographical location, seismic stations installed on the Azores islands are very sensitive to the noise induced by oceanic storms. These storms are responsible for the contamination of most of the teleseismic records and explain the high noise level in the body wave frequency band. During 2006, we started a study of the Azores shallow crust, using ambient seismic noise, developed under a Portuguese-French collaboration. A preliminary analysis of the noise cross-correlation revealed that the source of the long period seismic noise is mainly induced by oceanic storms and it is located in the South hemisphere during summer (South Indian and South Pacific) and on North hemisphere (North Atlantic) during winter.

The Variscan Iberian Massif covers a large area of central and western Iberia. A better characterization of mantle anisotropy is important, not only at this part of the Iberian Peninsula, as well to provide new insight in mantle anisotropy below this class of orogens. The Geofon VBB seismic station MTE (Manteigas), located in the western part of the Peninsula, offers an excellent opportunity to study seismic anisotropy. Path-integrated anisotropy can be estimated most readily from shear waves that enter an anisotropic region with a known polarization, as it is the case of the SKS and SKKS. Splitting observations in orogenic regions have often, but not universally, indicated a fast axis parallel to the orogeny, which is consistent with collisional shortening of the mantle root (Silver, 1996). We have performed a SKS splitting search beneath MTE (Manteigas) seismic station. The measurements indicated a fast axis parallel to the E-W direction, which can probably be related to the orogen that induced collisional shortening of the mantle root. The measurements indicated a fast axis parallel to the E-W direction, which can probably be related to the orogen that induced collisional shortening of the mantle root.

7 – STUDY OF THE AFRICA-IBERIA PLATE BOUNDARY

2004 saw a great improvement on the knowledge of the active structures in the SW Iberian margin, thanks to several oceanographic cruises dedicated to detailed bathymetric coverage of the seafloor. One of the cruises, the most important one, was part of the MATESPRO project. The others were performed in coordination with Portuguese scientists, under the ESF-Euromargins project SWIM. The preliminary interpretation points to the existence of very long lineaments in the Gulf of Cadiz area that are interpreted as a consequence of Eurasia-Africa convergence. These structures seem to over-print the postulated accretionary wedge that has been associated with a retreating subduction zone in the same area, by French researchers. The full dataset has been

interpreted using the large collection of MCS profiles available in the area, from academic sources and oil companies.

During 2005 the Gulf of Cadiz area was investigated by two oceanographic cruises where Portuguese seismologists participated actively in the framework of SWIM project: the DELSIS cruise (chief scientist Marc-Andre Gutscher), dedicated to the investigation of the front of the accretionary wedge using high-resolution seismics and coring; and the SWIM2005 cruise (chief scientist Nevio Zitellini), exclusively dedicated to the completion of the MB coverage in Southern Portugal, offshore Algarve, near the Coral Patch ridge. In 2006, the SWIM-2006 cruise (chief scientist Eulalia Gracia) was dedicated to the investigation of the Horseshoe Abyssal Plain high-resolution seismics and MCS. The bathymetric compilation in the Gulf of Cadiz, sponsored by SWIM, saw an improvement in 2006 with the inclusion of data provided by IFREMER.

Given the extensive geophysical and geological data base already collected in the Gulf of Cadiz, Portuguese seismologists are now at a turning point that could allow to develop quantitative modelling on: stable plate kinematics; strain from geodetic observations, seismic strain and the geologic strain. For the modelling we are applying two main approaches: i) estimate a regional smooth strain model; ii) make a Neotectonic modelling based on a thin-shell approach. By doing this, SWITNAME project will contribute to the better knowledge of the active structures and we will be able to estimate, through modelling, the activity and recurrence of the larger identified faults. This will be a major contribution to authorities, civil protection agencies, engineers and land planners in their efforts to mitigate the Geological Risks by preventive actions.

Portuguese seismologists collaborate with geodesists in the interpretation of GPS observations in southern Iberia and northern Africa (Fernandes et al., 2007).

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Viegas, G., L. Matias e P. Teves Costa, 2003. Modelação do Movimento Forte do Solo no Campo Próximo, 3º Simpósio de Meteorologia e Geofísica da APMG, Aveiro, 10-13 Fev, 4p.

Earthquake Engineering and Seismology Group at IST

Short description of activities, facilities and research interests.

The Group comprises 12 PhD researchers and several PhD and MSc students and its main research areas are:

- Seismology, Active Tectonics and Volcanology studies - Study of the active tectonic of the Lower Tagus Valley, satellite interferometry applied to the active tectonics of the Greater Lisbon Area, and volcano monitoring (Fogo volcano, Cape Verde).
- Earthquake engineering - Seismic vulnerability assessment, analysis and design of structures and lifelines – new seismic analysis procedures, reinforced concrete underground structures, base isolation, structural seismic modification, precast reinforced concrete structures, heritage constructions, and general seismic vulnerability assessment procedures (existing building stock and Very Important Structures).

The Group is actively involved in national and EU funded projects, in close cooperation with other European research institutions working on these fields, and in several consultancy works to the private sector and public entities. The Group operates one broadband seismographic station in the Lower Tagus Valley near Lisbon (TAGUSNET), and a network of accelerographs distributed in Mainland Portugal and Azores islands. For its activities the Group uses the experimental facilities of the Laboratory for Structures and Strength of Materials, which include a reaction wall able to withstand a 4000 kN.m moment, the facilities of the Laboratory of Computational Mechanics. At the end of 2006 the Ministry of Science, Technology and Higher Education created the National Geophysical Network (RNG), in which ICIST participates with two new seismological infrastructures to be deployed in 2007: Network NAVIGATORS (very broad band seismology in the Azores-Gibraltar region) and SEISNETg (accelerometric instrumentation of Mainland Portugal and Azores). IST, the host institution of the ICIST, is a member of the FDSN, a foreign affiliate of IRIS, a member of EMSC. One of the researchers of the Group (Joao Fonseca) represents Portugal in the Board of Directors of the ORFEUS Consortium.

List of research projects of the last 2 years

Identification: POCI/ECM/59306/2004 FCT project
Name: DIMSIM
Researchers: Prof. Rita Bento

Identification: POCI/CTE-GIN/58095/2004 project
Name: RISCO SISMICO
Researchers: Prof. Carlos Sousa Oliveira
Objective: seismic risk assessment in Portugal

Identification: PRAXIS/CEG/2531/95 FCT project
Name: PERCAS
Researchers: Prof. Carlos Sousa Oliveira
Objective: strong-motion instrumentation in the Azores

Identification: FP6 Project
Name: NERIES
Local contact: Prof. Carlos Sousa Oliveira
Objective: coordination of seismological research at European level

Identification: FP6 project
Name: LESSLOSS
Researchers: Prof. Carlos Sousa Oliveira, Mário Lopes and Luis Guerreiro
Objective: Seismic risk mitigation

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Identification: CONC/REEQ/1121/2001
Name : SEISNETg
Principal Investigator : Prof. Carlos Sousa Oliveira
Objective: strong-motion instrumentation of West Iberia and Azores

Identification: GMES Project
Name: TERRAFIRMA (Service Level Agreement, Phase 2)
Contact person: Prof. Joao Fonseca
Objective : Permanent scatterer interferometry applied to Active Tectonics

Identification: POCTI/32730/CTA/2000 FCT project
Name: ALERT
Researchers: Prof. Joao Fonseca
Objective: design of a multi-parametric alert level label for volcanic emergencies in Fogo Island, Cape Verde

Identification: POCTI/32720/CTA/2000 FCT project
Name: TAGUSNET
Researchers: Prof. Joao Fonseca
Objective: broad band instrumentation of the Lower Tagus Valley

Identification: POCTI/CTA/194/2004 FCT project
Name: RESISTE II
Researchers: Prof. Joao Fonseca
Objective: broad band instrumentation of the Lower Tagus Valley

Identification: POCTI/CTA/48252/2002 FCT project
Name: TAGUS2
Researchers: Prof. Joao Fonseca
Objective: study of the seismotectonics of the Lower Tagus Valley

Identification: CONC-REEQ/194/2001
Name : NAVIGATORS
Principal Investigator : Prof. Joao Fonseca
Objective: Very broad band instrumentation of the Azores Gibraltar Region

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Guerreiro, MC; Craveiro, A; Branco, M - The Use of Passive Seismic Protection in Structural Rehabilitation, 8, 121-132, Wiley Interscience Progress Structural Engineering Materials, 2006

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Proença, JMSFM; Branco, FAB - Case studies of vibrations in structures, Revue Européenne de Génie Civil, Vol. 9/1-2, pp.159-186, Lavoisier, 2005

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- 6.1 Oliveira, C. S., Roca, A. and Goula, X (eds.), Assessing and Managing Earthquake Risk, Geo-scientific and Engineering Knowledge for Earthquake Risk Mitigation: developments, tools, techniques, Springer Geotechnical, Geological, and Earthquake Engineering Series, Vol. 2, 2006, ISBN: 978-1-4020-3524-1

Papers in Proceedings (International): 32 papers presented in 2005-2006.

Papers in Proceedings (National): 3 papers presented in 2005-2006.

Internal Scientific Reports (of which a member is 1st author): 17 reports presented in 2005-2006.

PORTUGAL

**SECÇÃO PORTUGUESA DAS UNIÕES INTERNACIONAIS
ASTRONÓMICA E GEODÉSICA E GEOFÍSICA
(SPUIAGG)**

**INTERNATIONAL ASSOCIATION OF GEOMAGNETISM AND AERONOMY
IAGA**

NATIONAL REPORT

2003 – 2006

**PRESENTED TO THE XXIV GENERAL ASSEMBLY
OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS**

HOLD AT PERUGIA, 2 – 3 JULY 2007

Coordinated by

**Prof. Dr. Jorge Miguel Miranda,
National Correspondent of IAGA**

1 – INTRODUCTION

1.1 Overview

During the 2003-2006 period Geomagnetism had a large development in Portugal. Several sub-areas have been addressed, particularly AMS studies and rock mineralogy, MT and marine magnetics as a tool for ridge research and fundamental topics concerning the magnetic field of the Earth.

Laboratory means developed both in Porto and Lisbon Universities even if the National Magnetic Observatory still does not meet international standards.

2 – MARINE MAGNETICS AND MT

Marine magnetic methods are a major topic of research in Portugal, particularly associated with Mid-Atlantic Ridge research. After ISO-3D experiment, that allowed the development of sensors and methodology for controlled source EM studies, we organized a major sea operation on Saldanha Massif, to study the differences in crustal structure associated with different geological environments where hydrothermal vents have been found. Most of the work will be organized in the framework of SEHAMA project, in cooperation with NERC (UK, National Oceanographic Center). A new attempt to process and interpret high resolution marine magnetic data concerning hydrothermal vents south of Azores was made (Miranda et al., 2003) focused on the separation between regional and local anomalies at the intra-segment level. Magnetization variations across the Mid-Atlantic Ridge were also addressed.

2 – MAGNETO-TELLURIC RESEARCH

Several AMT soundings were carried out in Azores (Terceira Island) in the scope of the projects STAMINA and VAMEM. In the scope of the VAMEM project two permanent electromagnetic arrays were installed in the Terceira Island. One of these arrays is already installed and is working in a experimental way. Several magneto-telluric soundings have been carried out in the SW Iberia in cooperation with Barcelona University.

The continuous monitoring of the electric field in a submarine cable installed in Ria de Aveiro has been carried out during 2003-2006. This installation seeks to study the correlation between water transport in Aveiro Ria and telluric signals measured in a cable crossing the RIA and on land in a array of electrodes. Research in anisotropic media, as well as, in applied geophysics was developed in the scope of the cooperation with international and national teams (Pek et al., 2003, 2004; El-Qady et al., 2003; Sultan et al. 2005; Menezes et al., 2005; Almeida et al. 2005).

Magnetotelluric techniques combined with other geophysical approaches were also developed by Evora University focused on the structure of the Ossa Morena Xone.

3 – AMS AND PALEOMAGNETIC RESEARCH

During the last four years the main research topics were dedicated to: (a) Evaluation of the causes of temporal and spatial variability of Natural Remanent Magnetisation (NRM) along Saldanha Massif (Mid-Atlantic Ridge) for posterior correlation with the geological framework and distance to the ridge axis; (b) Flow and propagation of magma along thick Jurassic dykes and the effects of such intrusive processes on the magnetic properties of host sedimentary rocks, which are still poorly understood. Therefore, an exhaustive study of rock magnetic and petrography analyses was performed on dolerite rocks collected along several sections across the Fom Zguid (FZD - Southern Morocco) and Messejana-Plasencia (MPD - Iberia) dykes, complemented with several sections across the sediments hosting the FZD. At Oporto University several studies concerning AMS of granites have been developed with focus on petrophysics.

4 – STUDIES OF THE MAIN FIELD

Basic research on the non-uniqueness of main geomagnetic field determined by surface intensity measurements (the Backus problem) were developed by Alexandra Pais at the University of Coimbra, in cooperation with Institut de Physique du Globe de Paris.

5 – LABORATORY AND OBSERVATORY FACILITIES

5.1 COIMBRA MAGNETIC OBSERVATORY

The Geophysical Institute of the University of Coimbra (Instituto Geofísico da Universidade de Coimbra - IGUC), founded in 1864, is in charge of the single Portuguese geomagnetic observatory. The data-series are uninterrupted until today and, in these 140 years, have been the support for countless research studies, both in Portugal and abroad. Presently research is organized on the the Centre for Geophysics of the University of Coimbra (CGUC), taking advantage of the infrastructural facilities that are granted by IGUC. Monthly magnetic bulletins are prepared and diffused through the web (<http://www.uc.pt/iguc/magnet.htm>).

5.2 ROCK MAGNETIC LABORATORIES

The Lisbon University Laboratory of Rock Magnetism now manages a group of high quality devices that include:

- Magnetometer JR6, AGICO Inc;
- Alternating Magnetic Field Demagnetizer LDA-3A, AGICO Inc;
- Anhyseretic Magnetiser AMU-1A, AGICO Inc;
- Magnetic Susceptibility Meter - KLY2.1, AGICO Inc;
- Furnace Apparatus CS23, coupled to KL2.1, AGICO Inc;
- MINISPIN - Portable Rock Magnetometer Magnetometer, Molspin Inc;
- Flux magnetometer, MAG-01H, Bartington Instruments Ltd;
- Thermal Demagnetizer (Home Made);

This set of instruments is made available for the whole scientific community and can be used for standard AMS, Magnetic Mineralogy and (basic) Paleomagnetic studies. A similar infrastructure also exists in Porto University Geophysical Institute.

5.2 LABORATORY FOR EM STUDIES

At Lisbon University, the Electromagnetic Lab operates two magnetotelluric stations - one in the frequency range of 180 to .01 Hz- and another one from 8000Hz to 4000 s. This equipment have been used in crustal and shallow studies, as well as, for teaching at graduation level and post-graduation level. Available is also a magnetometer (3-components fluxgate) for observations of the geomagnetic field variations. This equipment is mainly devoted to electromagnetic monitoring studies. The laboratory has a small unit for resistivity and capacity measurements on samples. This equipment has been used in some environmental studies as a complement of geo-electric surveys.

4 – PUBLICATIONS

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PORTUGAL

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HOLD AT PERUGIA, 2 – 3 JULY 2007

Coordinated by

**Dr. Sara Loureiro Almeida,
National Correspondent of IAPSO**

1 – INTRODUCTION

1.1 Overview

This report concerns the scientific activity that took place in Portugal, in the sea related areas, between 2003 and 2006.

The analysis of the projects seems to indicate an increase in multidisciplinary projects, involving multiple areas, with partners from several institutions in different countries. The goal still being a better knowledge of the surrounding ambient, the climate changes and its repercussions, and the supplying of this data/knowledge to all interested be, be it the scientific community, the decision makers or the public in general.

Another point that emerges is a more pronounced investment in projects concerning the aid to decision makers in logistical processes in the occurrence of natural disaster. Another aspect is the existence of more modelling and prevision modelling projects with and without the integration of real time data.

We endeavour to identify some of the institutions that operate on the study of the Ocean as well as the main projects that initiated, or ended, in the period under consideration.

2 – PROJECTS

A list (partial) of projects, from different institutions, within the scope of the report:

ECOIS (Estuarine COntribution to Inner Shelf dynamics) where are involved, as partners: Instituto Hidrográfico, IPIMAR, CIIMAR (University of Porto) and University of Minho to study the contribution of the Northern rivers Douro and Minho towards the hydrodynamics of the adjacent continental platform.

NICC (Northwest Iberian Coastal Currents) where are involved as partners: CIIMAR (University of Porto), IPIMAR, Instituto Hidrográfico, and University of Minho to study the Northern rivers Douro and Minho so as to better understand the Winter dynamic process on the Norwest Iberia coast.

EUROSTRATAFORM - EUROpean Margin STRATA FORMation (2002 to 2005). National partners of this project were: Instituto Hidrográfico and Instituto Superior Técnico (Univ. Técnica de Lisboa). The project was to define and model the sedimentary processes and their forcing conditions operating on the European continental margin. It involves following the sediment from its origin in rivers to its deposition on deltas, shelf, canyons and open slopes, and how it then progresses to the deep-sea.

PROFIT - Interdisciplinary study of oceanographic processes underlying the phytoplankton dynamics in the Portuguese upwelling system. Partners are IPIMAR e CESAM (University of Aveiro) and they use of satellite data and numerical models to achieve their goals.

CLIMAAT - Clima e Meteorologia dos Arquipélagos Atlânticos – With several partners as Obs. Environmental from Açores, Regional Admnistrations, Regional Direc. Science Technology and Maritime Transport, Centro de Geofísica (Univ. of Lisboa), Inst. de Meteorogia, Inst. Hidrográfico and Univ. of Açores, aims to stablish the scientific cooperation to study the maritime and coastal climate.

HERMES - Hotspot Ecosystem Research on the Margins of European Seas. National partners are: Instituto Hidrográfico e CESAM (Univ. of Aveiro). HERMES is an international, multidisciplinary research programme, which brings together expertise in biodiversity, geology, sedimentology, physical oceanography, microbiology and biogeochemistry to investigate Europe's deep marine ecosystems and their environment.

DYNCOASTAL (Physical and Biogeochemical Dynamics of Coastal Countercurrents: A Study Case in Algarve Luff) with participants from Univ. Lusófona, CIMA (Univ. Algarve), Inst. Hidrográfico, IPIMAR, Hidromod. The nature of the research is the physical and biogeochemical characterisation of the coastal countercurrent off Algarve luff, to investigate the physical driving mechanism for the formation of the coastal countercurrent.

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ATOMS (Acoustic Tomography Ocean Monitoring System) which participants are CINTAL and CIMA from University of Algarve and Inst. Hidrográfico. This project aims at developing an integrated system for large-scale ocean monitoring, using acoustic tomography.

NEMEDA - Networking to Mitigate the Effects of Dinophysis in Aquaculture (2003-2005) with coordination from National University of Ireland it has as partners IPIMAR and other 5 institutions from France, Ireland and Spain. The butt is to create a network of involved people: the experts, the users and the decision makers, on the effects of Dinophysis in Aquaculture, and to formulate a wider research project on the behaviour patterns of the Dinophysis.

AMAZING - A multi-sensor analysis and interpretation system for the coastal zone remote sensing. Partners: Instituto de Oceanografia (University of Lisboa) and IPIMAR. Along the contribution to a better interpretation of sea satellite data, this project intends to investigate the bio-physical interaction on the sea surface as well as to create algorithms to use in the interpretation

SIMCLAVE - Studying the impact of the climate change in the Portuguese coastal waters - the Aveiro costal ecosystem. Partners: CESAM (University of Aveiro) and IPIMAR.

SIG-POLLUTION - Computer Systems to Manage Contingency Plans to Limit Marine Pollution (2003 to 2005) who's responsible was the Instituto Superior Técnico (Univ. Tec. Lisboa). This GIS system will improve the answering capabilities on the occurrence of hydrocarbon spillage or any other substance dangerous to the environment.

Advanced numerical modellation on the interaction of non-linear waves on coastal structures – (2002 to 2006). CIMA (Univ. Algarve) and Instituto Superior Técnico (Univ. Tec. Lisboa).

HIPOCAS - Hindcast of Dynamic Processes of the Ocean and Coastal Areas of Europe -Duration (2000 to 2004) with responsibility from Instituto Superior Técnico (Univ. Tec. Lisboa). The objective was to obtain a 40-year hindcast of wind, wave, sea-level and current climatology for European waters and coastal seas for application in coastal and environmental decision processes.

3 – CENTRES AND INSTITUTIONS

INSTITUTO NACIONAL DE INVESTIGAÇÃO AGRÁRIA E DAS PESCAS - INIAP (IPIMAR)

Av. Brasília – Algés,
1400 Lisboa, Portugal
Phone: +351 21 301 08 14
Fax: +351 21 950 117
url: <http://ipimar-iniap.ipimar.pt/>

DEPARTAMENTO DE AMBIENTE AQUÁTICO

Director: Dr^a Graça Cabeçadas

e-mail: gc@ipimar.pt

DEPARTAMENTO DE RECURSOS MARINHOS

Director: Dr^a Graça Pestana

e-mail: gpestana@ipimar.pt

INSTITUTO HIDROGRÁFICO

Director Técnico: CFR EH Carlos Ventura Soares

Rua das Trinas, 49

1249 – 093 Lisboa

Phone: +351 210 943 000

Fax: + 351 210 943 299

e-mail: dirtecnica@hidrografico.pt

url: <http://www.hidrografico.pt/hidrografico/>

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INSTITUTO DE OCEANOGRRAFIA
Faculdade de Ciências da Universidade de Lisboa
Coordenador Científico: Profª Doutora Isabel Ambar
Campo Grande
1749 – 016 Lisboa
Phone: + 351 217 500 000
Fax: + 351 217 500 009
e-mail: iambar@fc.ul.pt
url: <http://www.io.fc.ul.pt/>

INSTITUTO SUPERIOR TÉCNICO
Av. Rovisco Pais
1049-001 Lisboa, Portugal
Phone: +351 218 417 000
Fax: +351 218 499 242
<http://www.ist.utl.pt/>

DEPARTAMENTO DE MECÂNICA, SECÇÃO DE AMBIENTE E ENERGIA
Coordenador: Prof. Doutor Ramiro Neves
e-mail: ramiro.neves@ist.utl.pt
<http://www.maretec.mohid.pt>
UNIDADE DE ENGENHARIA E TECNOLOGIA NAVAL
Coordenador: Eng. Carlos Guedes Soares
e-mail: guedess@mar.ist.utl
ur.: <http://mar.ist.utl.pt/uetn/>

UNIVERSIDADE DOS AÇORES
Coordenador Científico: Prof. Doutor Ricardo Serrão Santos
Departamento de Oceanografia e Pescas
9901-862 Horta, Açores, Portugal
Phone: + 351 292 200 400
Fax: + 351 292 200 411
e-mail: ricardo@notes.horta.uac.pt
url: <http://www.horta.uac.pt/>

UNIVERSIDADE DE AVEIRO
Campus Universitário de Santiago
3810 – 193 Aveiro
Phone: +351 234 370 200
Fax: + 351 234 429 290
[url:http://www.ua.pt/](http://www.ua.pt/)

CENTRO DE ESTUDOS DO AMBIENTE E MAR (CESAM)
Prof. Doutor Casimiro Adrião Pio -DEPARTAMENTO DE AMBIENTE E ORDENAMENTO
e-mail: Casimiro@ua.pt
Prof. Jesús Dubert - DEPARTAMENTO DE FÍSICA
e-mail: jdubert@fis.ua.pt
<http://www.cesam.ua.pt/>

UNIVERSIDADE DO ALGARVE
Campus das Gambelas,
8005-139 Faro, Portugal
Phone: +351 289 800 900 / +351 289 800 100
Fax: +351 289 818 353

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CENTRO DE INVESTIGAÇÃO MARINHA E AMBIENTAL (CIMA)

Coordenador Científico: Prof. Doutor Tomasz Boski

e-mail: cima@ualg.pt

url: <http://www.ualg.pt/cima/>

CENTRO DE CIÊNCIAS DO MAR (CCMAR)

Coordenador Científico: Prof. Doutor Adelino Canário

e-mail: ccmar@ualg.pt

url: <http://www.ualg.pt/ccmar/>

UNIVERSIDADE NOVA DE LISBOA

CENTRO DE MODELAÇÃO ECOLÓGICA - INSTITUTO DO MAR (IMAR)

Coordenador Científico: Prof. Doutor João Pedro Salgueiro Gomes Ferreira

e-mail: asc@mail.fct.unl.pt

URL: <http://www.ci.uc.pt/imar>

UNIVERSIDADE DO PORTO

CENTRO INTERDISCIPLINAR DE INVESTIGAÇÃO MARINHA E AMBIENTAL (CIIMAR)

Coordenador Científico: Prof. Doutor João José Oliveira Dias Coimbra

Rua dos Bragas, 177

4050-123 Porto, Portugal

Phone: +351 223 401 800

Fax: +351 223 390 608

e-mail: cimar@cimar.org

URL: <http://www.cimar.org/>

4 – PUBLICATIONS

For the different institutions/centres above, we will list part of the work done, during 2003-2006, which can be showed through papers, articles in conferences or thesis presented for Phd's, MsC ou BsH. This list is never updated ...

IPIMAR

THESIS:

CEREJO, Marta I. H. - Contribuição para a monitorização de algas tóxicas na ria de Aveiro – ciclo anual de sucessão fitoplanctónica e modelização da dispersão de microalgas. MsC in Ciências das zonas costeiras, Departamento de Biologia, Universidade de Aveiro.

PAPERS:

MOITA, M. T. [et. al.] – A Bloom of *Dinophysis acuta* in a thin layer off NW Portugal. African Journal of Marine Science 28(2). 2006, p. 265-269.

Co-authors: SOBRINHO-GONÇALVES, L.; OLIVEIRA, P. B.; PALMA, S. and FALCÃO, M.

ARÍSTEGUI, J. - Oceanography and Fisheries of the Canary Current/Iberian Region of the Eastern North Atlantic, Chapter 23 in The Sea. The Global Coastal Ocean: Interdisciplinary Regional Studies and Syntheses, Vol. 14, A. R. Robinson and K. H. Brink, eds, Harvard University Press, Cambridge, MS, USA.. 2006, p. 877-931.

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- Co-authors: ÁLVAREZ-SALGADO, X. A.; BARTON, E. D.; FIGUEIRAS, F. G.; HERNÁNDEZ-LEÓN, S.; ROY, C. & SANTOS, A. M. P.
- SANTOS, A. M. P.; FIÚZA, A. F. G. & LAURS, R. M. - Influence of SST on catches of swordfish and tuna in the Portuguese domestic longline fishery. *International Journal of Remote Sensing*, 27(15). 2006, p. 3131-3152.
- SANTOS, A. M. P. - Vertical distribution of the European sardine (*Sardina pilchardus*) larvae and its implications for their survival. *Journal of Plankton Research*, 28(5). 2006, p. 523-532, doi:10.1093/plankt/fbi137.
- Co-authors: RÉ, P.; SANTOS, A. & PELIZ, A.
- SANTOS, A. M. P. - GLOBEC Portugal: an overview from the past a view into the future. *GLOBEC International Newsletter*, 12(1). 2006, p. 7-31.
- SOBRINHO-GONÇALVES, L. & Moita, M. T. -. Copepod grazing on a toxic *Dinophysis acuta* thin layer bloom. *GLOBEC International Newsletter*, April 06, 12 (1). p. 11-12.
- SANTOS, A. M. P. - Cascais Watch: a lighthouse into the future. *GLOBEC International Newsletter*, April 06, 12 (1). p. 22-23.
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