First Mini Seismology Seminar

Geophysical Centre of Évora 2010

Seismolitos - Seismotectonics and Processes of Lithospheric Deformation

Internal Geophysics/Seismology

Wednesday, February 10th 2010

University of Évora, Colégio L. Verney, Anf. 1

Program

14:30 – 14:40	**Hugo Silva**	Opening Session
14:40 – 15:00	**Bruno Romeira** *Prémio Gulbenkian 2009*	Nonlinear dynamics and chaos: applications to physics and optical communications **(Invited talk)**
15:00 – 15:10	**Ekaterina Zadonina**	Slip distribution, coseismic deformation and Coulomb stress change for the 12 May 2008 Wenchuan earthquake & Influence of model parameters on synthesized high-frequency strong-motion waveforms
15:10 – 15:20	**Ricardo Torres**	Construction of a 3D Model of the Lower Tagus Basin
15:20 – 15:30	**Augusto Furtado**	Confirmation of the 3D Structure model using ambient-noise measurement for lower Tagus Basin
15:30 – 15:40	**Rubén Santos**	Modulation of active tectonic processes through displacement theory
15:40 – 15:50	**Nuno Pereira Santos**	Fronteira Astronomical Observatory: observations of transiting extrasolar planets
15:50 – 16:00	**João Pedro Rocha**	Imaging 3D seismic velocity along the seismogenic zone of Algarve region (southern Portugal)
16:00 – 16:30		Discussion

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Nonlinear dynamics and chaos: applications to physics and optical communications

Since the discovery, in 1963 by Edward Lorenz, of what is now known as the butterfly effect [1], chaos became an essential research topic in physics and mathematics. It then expanded into biology, chemistry, engineering, and more recently into information and social sciences. The study of chaos is a part of a larger program of study of so-called ‘strongly’ nonlinear systems. Within the context of physics, examples of such systems are the fluid turbulence (e.g. whether), planetary motion, electronic circuits, heartbeat, brain waves, and several other real life examples.

The signatures of chaos include erratic, noise-like fluctuations and extreme sensitivity to application of small perturbations to the system’s initial conditions [2]. In this seminar the essence of chaotic phenomena in physical systems is discussed and a general overview of chaos applications in science and technology is also presented.

Of particular interest is the application of chaos theory in modern telecommunications to improve information security. During the last decade there has been growing interest in commercial and industrial applications of new types of optical chaotic communication networks, which could improve substantially the security of nowadays software encryption techniques [3].

In recent work developed by the University of Algarve research group in collaboration with the Universities of Glasgow and Seville, the authors have demonstrated a novel optoelectronic chaos emitter based on a laser diode (LD) circuit integrated with a nanoelectronic resonant tunnelling diode (RTD) nonlinear oscillator, the RTD-LD chaotic system [4-6]. In a chaos communication fibre-link, such a system takes advantage of the combination of RTD and LD strong nonlinear dynamics, leading to substantial reduction of transmitter and receiver circuits’ complexity and less restrictive operation conditions. Based on this novel chaos emitter, chaos-based secure communication systems using RTD-LD systems will be discussed and compared with recently proposed chaotic communications.

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Slip distribution, coseismic deformation and Coulomb stress change for the 12 May 2008 Wenchuan (China, M_w7.9) earthquake

The May 12, 2008 Wenchuan earthquake (Mw7.9) took place at the transition between the mountainous chain of Shan and the basin of Sichuan along the Longmen Shan Fault zone (31.1ºN, 103.3ºE; USGS). With a magnitude of 7.9 and a depth of ~19 km the earthquake produced a 300-km-long fault rupture. It was the largest earthquake recorded in the region during the last centuries. It claimed more than 69,000 lives, induced widespread destruction over the region and raised concern about seismic hazard and source characterization for the Sichuan province. In the frame of our study, we selected 40 broadband waveforms (IRIS Consortium, USA) with good quality and satisfactory azimuthal coverage. Body waveforms were prepared for inversion using Kikuchi and Kanamori's method [1] to obtain the spatiotemporal slip distribution of a finite rupture model (length=300 km, strike=229º, dip=33º, width=60 km). The slip distribution model obtained was used to determine the coseismic deformation and the stress change distribution using the Coulomb 3.0 software [2]. Our coseismic deformation results was compared with data from GPS stations located near the fault rupture. Results show that directions of coseismic deformations are consistent with GPS observations close to the fault. Finally, we compare aftershock hypocenters that occurred during one month after the main shock with the Coulomb stress changes caused by this shock in the region. We observed that most aftershocks are located along the main fault plane without any noticeable clustering in the areas of increased stress. Our results suggest the rupture of the 2008 Wenchuan earthquake was essentially unilateral, from SW to NE (N49E), covering a 260km length and with duration about 105 sec. The strongest moment release occurred about 85km from the hypocenter, ~30sec after the start of the rupture. Motions are dominated by thrust mechanism, but the superficial section of the second half of the rupture also shows a significant strike-slip component.

Influence of model parameters on synthesized high-frequency strong-motion waveforms

Waveform modeling is an important and helpful instrument of modern seismology that may provide valuable information. However, synthesizing seismograms requires to define many parameters, which differently affect the final result. Such parameters may be: the design of the grid, the structure model, the source time functions, the source mechanism, the rupture velocity. Variations in parameters may produce significantly different seismograms. We synthesize seismograms from a hypothetical earthquake and numerically estimate the influence of some of the used parameters. Firstly, we present the results for high-frequency near-fault waveforms obtained from defined model by changing tested parameters. Secondly, we present the results of a quantitative comparison of contributions from certain parameters on synthetic waveforms by using misfit criteria. For the synthesis of waveforms we used 2D/3D elastic finite-difference wave propagation code E3D [3] based on the elastodynamic formulation of the wave equation on a staggered grid. This code gave us the opportunity to perform all needed manipulations using a computer cluster. To assess the obtained results, we use misfit criteria [4] where seismograms are compared in time-frequency and phase by applying a continuous wavelet transform to the seismic signal.

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Construction of a 3D Model of the Lower Tagus Basin

The goal of the research plan is to contribute to an improved assessment of the seismic hazard in the Lower Tagus Basin, in order to achieve that, we propose the introduction of realistic methods on the prediction of ground motion produced by moderate to large earthquakes in this area. This process involves the establishment of a structural 3D model and the evaluation of seismic potential of the faults in the studied area. The method employed involves modeling based Finite difference Methods (FDM) and Spectral-element Methods (SEM) [1], done on a massive parallel computing system.
There is already a 3D velocity model (SWIBMOD2006 model and VFGEN program [2]) and a methodology for wave propagation of the SW of Portugal which is based on the Finite difference method.
The work i'll be doing is based in the program SPECFEM3D [3], which is a program that simulates southern California seismic wave propagation. This program is based upon the spectral-element method (SEM) and includes effects due to lateral variations in compressional-wave speed, shear-wave speed, density, a 3D crustal model, topography and bathymetry.
I will collaborate in the development of the 3D model of the lower Tagus basin based on data collected by the National Institute of Engineering, Technology and Innovation (INETI), according to the method implemented in SPECFEM3D. With that model we will be able to construct scenarios for seismic strong ground motion in the studied region. We also hope to contribute to a better understanding of the sedimentary and tectonic evolution of the Mesozoic Lusitanian and Cenozoic Lower Tagus Basins. The research has a collaboration with the Laboratory of Modeling and Imaging in Geosciences, University of Pau, France and can possible be a thesis of my future Master research.

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Confirmation of the 3D Structure model using ambient-noise measurement for lower Tagus Basin

In recent years, ambient-noise measurements have been increasingly used to map the thickness of sediment fill in sedimentary basins in the context of seismic hazard assessment. In contrast to “active” seismic methods (e.g., refraction, reflection, or surface-wave), which use an artificial source such as an explosive charge or hammer blow to excite a seismic response from the subsurface, the H/V method called Nakamura’s technique 1989 is a “passive” method that uses three-component measurements of ambient seismic noise (microtremors induced by wind, ocean waves, industrial machinery, cars and trains, etc.) to determine and evaluate a site’s fundamental seismic resonance frequency. The ratio of the averaged horizontal-to-vertical frequency spectrum is used to determine the fundamental site resonance frequency, which can be interpreted using regression equations to estimate sediment thickness and depth to bedrock. The H/V method has been used for microzonation studies to predict site response to earthquake seismicity (e.g. Nakamura, 1989; Konno and Ohmachi, 1998) and as a method to estimate unconsolidated sediment thickness, map the bedrock surface, and infer fault locations (e.g., Lane et all., 2008; Ibs-von Seht and Wohlenberg, 1999).

The aim of this study is the confirmation the Lower Tagus Basin structure model by comparing the theoretical amplification curves and observed: the first, obtained from synthetic data generated from a velocity model and the latter by applying the H/V method. We will use a single, broad-band three-component seismometer to record ambient seismic noise. For computation of the spectral ratios using Nakamura’s technique (1989) we will use the JSESAME software developed within the European project SESAME (http://sesame-fp5.obs.ujf-grenoble.fr) or Geopsy software (http://www.geopsy.org/). The synthetic data will be generated from the E3D program.

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Modelação de processos tectónicos activos através de deslocamentos co-sísmicos - GNSS e InSAR

O objectivo deste trabalho é dar a conhecer o tema em estudo, tendo como título "Modelação de processos tectónicos activos através de deslocamentos co-sísmicos - GNSS e InSAR".

Numa primeira fase, pretende-se escolher zonas de estudo, onde ocorreram recentemente processos tectónicos. Mas, para escolhermos estas zonas, temos de satisfazer os seguintes aspectos: O processo tectónico ocorrido tem de ter grande magnitude; Os deslocamentos co-sísmicos têm de ser mesuráveis com técnicas geodésicas; Os dados para determinar os deslocamentos co-sísmicos têm de estar disponíveis. Os processos tectónicos que podem provocar deslocamentos mesuráveis são, por exemplo, a erupção de um vulcão [1], um sismo de grande magnitude próximo da superfície [2], entre outros. Desta forma, e nesta fase, existem três zonas candidatas a serem estudadas: Haiti, sismo de 12 de Janeiro de 2010, M7.0; L'Aquila, sismo de 5de Abril de 2009 às 7:00, M6.3; Wenchuan, sismo de 12 de Maio de 2008, M7.9. Todos estes sismos foram de grande magnitude, tendo provocado deslocamentos e rupturas, na superfície terrestre. Assim sendo, pretende-se reunir os dados geodésicos necessários para a determinação dos deslocamentos provocados por estes sismos. As primeiras técnicas geodésicas, que eram utilizadas neste tipo de monitorização eram a triangulação, a trilateração, o nivelamento geométrico e o nivelamento trigonométrico [3]. Estas técnicas revelaram-se morosas e exigentes, no que concerne aos recursos humanos, em parte devido às metodologias de observação utilizadas. Com a evolução tecnológica foram desenvolvidas novas técnicas de posicionamento, tais como, o GNSS (Global Navigation System by Satellite) e o SAR (Synthetic Aperture RADAR). Permitindo, obter a informação relativa à superfície terrestre, de uma forma rápida e precisa. Assim sendo, para este trabalho, decidiu-se usar dados GPS e/ou SAR, dependendo da sua disponibilidade. No caso dos dados GPS, existem diversos tipos de redes materializadas por estações permanentes (por exemplo, IGS - International GNSS Service, EUREF, entre outras redes GNSS). Desta forma, podemos descarregar esses dados em qualquer momento, no entanto, estas redes em determinadas regiões, não são suficientemente densas para determinarmos o campo de deformação com uma boa resolução. Relativamente aos dados SAR, podemos aceder-lhes através do portal da ESA, onde existe um conjunto de dados SAR, gratuitos para a comunidade científica. Depois, de obtermos esses dados, podemos processá-los, de forma a determinar os deslocamentos na superfície, provocados pelo respectivo sismo e assim, poderemos modelar o processo de ruptura que provocou esses deslocamentos (Problema Inverso). A modelação do processo de ruptura será desenvolvido numa fase posterior.

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Recent developments in the observation and analysis of extrasolar planets transit light curves

The Transit Project of the Geophysics Center of Évora (CGE), in collaboration with the Center of Astrophysics of the University of Porto (CAUP), as two main objectives: I) Establish a scaling-law to the mass-radius relationship of low-mass extrasolar planets, based on work of [1]; II) Photometric follow-up of transiting extrasolar planets, using the Astronomical Observatory of Fronteira, Portugal.

We will present recent results from the mentioned follow-up campaign and also new developments in the light curve fitting to experimental data. This new fitting model is also already being improved to take into account elliptical orbits (current version assumes circular orbits) using the model proposed by [3]. However, even assuming simplistic orbits, the current model, based on work of [2] provides quite accurate results (comparing with professional data) as long the real orbit is quite circular, and takes into account the star limb-darkening as proposed by [4].

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Imaging 3D seismic velocity along the seismogenic zone of Algarve region

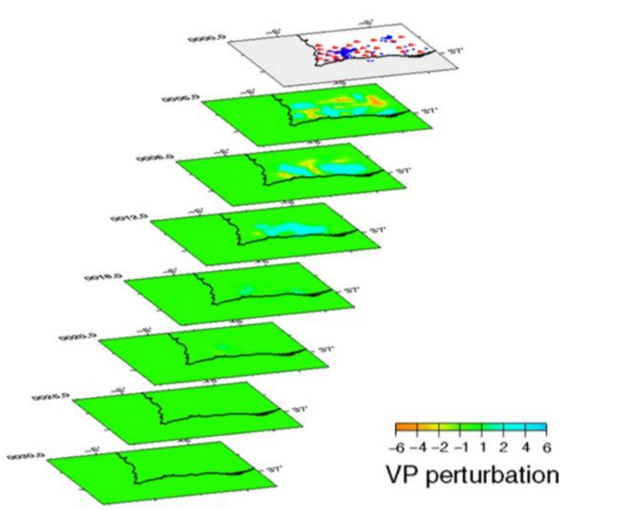

Fig. 1 – Velocity changes of P waves (VP Perturbation) in the first 15 km deep of the continental crust of Algarve region (southern Portugal).

The present seismic tomographic study is focused around Algarve region, in South of Portugal. To locate the seismic events and find the local velocity structure of epicentral area, the P and S arrival times at 38 stations are used. The data used in this study were obtained during the Algarve campaign which worked from January/2006 to July/2007. The preliminary estimate of origin times and hypocentral coordinates are determined by the Hypoinverse [1] and HypoDD [2] programs. Linearized inversion procedure was applied to comprise the following two steps: 1) finding the minimum 1D velocity model using Velest [3] and 2) simultaneous relocation of hypocenters and determination of local velocity structure. The velocity model we have reached is a 10 layer model which gave the lowest RMS, after several runnings of eight different velocity models that we used “*a priori*”. The model parameterization assumes a continuous velocity field between 4.5 km/s and 7.0 km/s until 30 km depth. The earth structure is represented in 3D by velocity at discrete points, and velocity at any intervening point is determined by linear interpolation among the surrounding eight grid points. A preliminary analysis of the resolution capabilities of the dataset, based on the Derivative Weight Sum (DWS) distribution, shows that the velocity structure is better resolved in the West part of the region between the surface to15 km. The resulting tomographic image has a prominent low-velocity anomaly (Fig. 1) that shows a maximum decrease in P-wave velocity in the first 12 km in the studied region. We also identified the occurrence of local seismic events of reduced magnitude not catalogued, in the neighborhood of Almodôvar (low Alentejo). The spatial distribution of epicenters defines a NE-SW direction that coincides with the strike of the mapped geological faults of the region and issued from photo-interpretation. Is still expectable to refine the seismicity of the region of Almodôvar and establish more rigorously its role in the seismotectonic picture of the region. This work is expected to produce a more detailed knowledge of the structure of the crust over the region of Algarve, being able to identify seismogenic zones, potentially generators of significant seismic events and also the identification of zones of active faults.

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