Call for Grants from the
Lisbon Doctoral School on Earth System Science

EARTHSYSTEMS

An University of Lisbon PhD program supported by IDL (Instituto Dom Luiz), MARE, Center for Statistics, and IPMA (Portuguese Institute for the Ocean and Atmosphere)

The EARTHSYSTEMS FCT-Doctoral Program

The EARTHSYSTEMS program gathers a multidisciplinary group of geophysicists, meteorologists, oceanographers, geodesists, geologists, geochemists, biologists and statisticians, based at the University of Lisbon (UL) and at the Portuguese Institute for the Atmosphere and Ocean (IPMA), with a common interest in Earth processes: their control of Climate in different time scales; their influence on natural resources distribution and characteristics; their effect on major natural hazards; and their impact on sustainable development. The proposed program emphasizes a quantitative, mathematically based, approach to Earth Science, merging students and researchers from different disciplines, and aiming to contribute to the development of cutting-edge ideas and tools for Earth System analysis and modelling.

PhD students supported by the EARTHSYSTEMS grants, will be enrolled in one of the three PhD Programs at the University of Lisbon: Geophysical and Geoinformation Sciences, Geology, or Marine Sciences, depending on their background and research interests. The EARTHSYSTEMS site lists a set of possible research projects in each of those areas.

Selection of 8 EARTHSYSTEMS PhD students for the 2016 Edition

Details on the call, including a list of proposed research topics, can be found at http://idl.ul.pt/node/403. Applications must be sent to clee@fc.ul.pt until the 30th September 2015. Each candidate must submit a detailed CV, a motivation letter explaining his/her research interests, with a selection of 2 of the proposed research topics, and up to two supporting letters from former professors. A short list of at about 16 candidates will be interviewed through skype (a skype address must be given). The selection committee will be constituted by Fernando Santos (IDL, Geophysicist), Pedro Viterbo (IPMA, Meteorologist), Filipe Rosas (IDL, Geologist) and Ana Amorim (MARE, Biologist). Results will be given in early November, with the program starting on January 2016.
EARTHSYSTEMS 2016-1
PhD in Geophysics and Geoinformation Sciences

Optimal alarm systems for extreme fires in the Iberian Peninsula

Supervision
K. F. Turkman (Centro de Estatística Aplicada da Universidade de Lisboa)
José M. C. Pereira (Centro de Estudos Florestais da Universidade de Lisboa)
Carlos da Camara (Instituto Dom Luiz)

Abstract
Wildfires, particularly in the Iberian Peninsula, are a relevant public policy issue due to the significant economic and social damage they cause. Most wildfires are extinguished upon ignition and do not have significant effects. However, some wildfires go out of control, causing large damages.

Therefore, one is often concerned to forecast the onset of a possible extreme wildfire and its subsequent evolution both in space and time. Large fires tend to occur under specific, relatively uncommon synoptic meteorological conditions acting on large spatial scales and typically involving variable combinations of high temperatures, low humidity and strong winds (e.g. Pereira et al. 2005); however, small scale spatial variations, such as terrain and fire prone vegetation distribution are also very important factors affecting large fire regimes. All these variables are spatio-temporal dynamic fields, evolving in space and time and wildfires are a random response to these underlying drivers (de Zea Bermudez et al. 2009; Pereira et al. 2013). Therefore, it is difficult to separate the study of wildfires from the study of these evolving fields, but the study of such input-output complex random systems are in infancy and it is more common to use ad-hoc empirical models with some degree of physical plausibility in the form of exploratory variables are often employed. Other alternative is to use deterministic dynamic models to integrate physical reality and plausibility in the model, at the cost of ignoring the random fluctuations. Our approach will be to employ, empirical dynamic random models.

A good alarm system should make as few false alarm as possible and at the same time should minimize the probability of missing an event (e.g. Turkman and Turkman, 1986, 1990). The construction of the alarm system fundamentally depends on constructing a sound model that links the fire size process to the multivariate explanatory variables. There are no analytical expressions for the operating characteristics; therefore, construction of the alarm system depends on good, sound numerical methods.

We propose to construct an on-line alarm system to predict the event of extreme fires at different spatial and temporal scales, exploring the relationships between space-time cluster of severe fire events with synoptic patterns (e.g. blocking highs) and long-term signal (e.g. sea surface temperature and soil moisture). The work will rely on the longest (49-years) high-resolution regional climate simulation available driven by reanalysis data spanning from 1959 to 2007 and covering the entire Iberian Peninsula, allowing estimation of fire danger indices at the hourly level, which have proven to be especially useful for fire prevention in Mediterranean Europe (DaCamara et al. 2014). The reliability of the database for this type of studies has been established by Gomez-Navarro et al. (2011).
Particular attention will be devoted to the validation of the alarm systems over Portugal making use of the Portuguese Rural Fire Database (Pereira et al. 2011). The alarm systems, once implemented, can be a very valuable tool in the organization of fire fighting capacity and allocation of resources.

References

Dynamics of the Azores Current

Supervision
Alvaro Peliz

Objectives
Understand the transport amplification of the Azores Current (AzC) on the West, and the behavior of the flow across the Mid-Atlantic Ridge (MAR)
Understand the nature and evolution of the AzC cyclonic rings
Characterize the AzC in the frame of recent oceanic zonal jet theories

Motivation and summary
The nature of the Azores Current has interested oceanographers studying the North Atlantic circulation for it is a sharp zonal jet crossing the subtropical gyre, where the circulation is expected to be meridional. Recent theories about its possible connection to the Mediterranean Outflow (MO) help in explaining its location but fail in explaining its transport (1, 2). Recently, (3) show that the Azores Current may result from the joint effect of two planetary beta plumes; the one induced by the MO plus that driven by localized wind-curl on the Gulf of Cadiz and the obtained transport is closer to the observed figures. However, an important question remains unanswered; if the current is generated on the east, why does the transport increases to the west as the observations (4) seem to show? Also, what happens to the flow on the west of the Mid-Atlantic Ridge? Some of the questions may be associated with a deficient knowledge of the mesoscale structure of the flow. In particular, the AzC is known for its large cyclonic rings. However, the reason for the dimension of such eddies is not clear (5). Where/when do they form and how they dissipate? Do they cross the MAR? Advances in satellite altimetry enabled the characterization of other zonal jets in the Pacific mid-latitudes (6), and new explanations for their dynamics based on eddy-mean flow interactions are being proposed. The dynamics of the Azores current should be revisited in the context of these theories.

Methodology
The study will be based on numerical models of different degrees of realism. It is suggested to conduct high-resolution process-oriented simulations of an AzC like jet to address specific questions like: the generation of AzC, mesoscale structure, origin of the cyclonic rings and their evolution, interaction of the zonal jet with topography, diagnose the eddy-mean flow interactions. The zonal structure of the current, the fate of the AzC and rings on the MAR should be addressed with more realistic basin scale eddy resolving models.
References


(3) Peliz and Kida (in prep), “The formation of the Azores Current due to the Mediterranean overflow and localized wind stress curl over the Gulf of Cadiz”


EARTHSYSTEMS 2016-3
PhD in Geophysics and Geoinformation Sciences

Processes and Changes in the Canary-Iberian Upwelling System

Supervision
Alvaro Peliz, Pedro Miranda

Summary
The evolution of the upwelling-favourable winds and of the SST upwelling-driven response in the Canary-Iberian Margin has been in the centre of debate in recent years [1,2,3,4,5]. The motivation for most studies is to understand whether the upwelling intensity is responding to climate change. The existing studies are however inconclusive and even contradictory (e.g., from a clear rapid increase reported in [2] to a small reduction reported in [1]), and hint into area dependent rates of responses [1,2,4,5].

It is proposed to extend the model system developed in [6] to the Iberian-Canary system to produce half-century simulations, yet preserving the coastal eddy resolutions for consistent representation of the upwelling dynamics. The main directions of research will be: i) Assess the importance of external (non-atmospheric/remote) variability in the upwelling system; ii) Understand the relevance of resolving submesoscale structure on the dynamics of crossshelf exchange; iii) Investigate the impact of Atmosphere-Ocean feedbacks on upwelling patterns iv) generate indicators of effective upwelling activity; v) Assess the evolution of the system forcing and response in the context of existing scenarios.

References
4 Relvas P., J. Luis, A.M.P. Santos (2009) Importance of the mesoscale in the decadal changes observed in the northern Canary upwelling system, Geophysical Research Letters, 36.
Quantifying the fire impact on Net Primary Production in Tropical Africa

Abstract

Biosphere plays an important role in the climate system, controlling the cycle of carbon. Additionally, the activity of ecosystems is particularly sensitive to climate variability (Ciais et al., 2003, Gouveia et al., 2008). The regional changes observed in temperature, radiation and precipitation in recent decades seems to have caused an increase in global Net Primary Productivity (NPP), increasing CO2 fixation by the ecosystems (Nemani et al., 2003). Fire is the main agent of disturbance in the global terrestrial ecosystem (Bowman et al., 2009), affecting the net carbon balance both directly and indirectly, throughout the biomass burning that introduces carbon in the atmosphere (van der Werf et al., 2010) and the carbon loss by burned and died vegetation (Amiro et al., 2010). The spatio-temporal patterns of fires on a global scale are also related to climate variability such as El Niño (LePage et al., 2008) and extreme events on regional scales (Pereira et al., 2005), looking significantly affect the regional balance of CO2 (Bond-Lamberty et al., 2007). Quantifying the impact of fire on global carbon balance is required to better understanding the carbon dynamics and their changes (Running, 2008).

Tropical forests and savanas contribute with about 60% of the terrestrial NPP (Field et al., 1998), however the frequent clouds and biomass-burning aerosols may lead to misleading interpretations (Samanta et al., 2011).

The emergence of new platforms, sensors and satellites has arisen remarkable efforts to develop more sophisticated methods and algorithms. There are several remote sensing datasets available that can be used to derive vegetation proprieties. Currently the major NPP databases correspond to two distinct datasets– NASA-CASA project and GPP/NPP MODIS covering the periods 1982-1998 and 2000 to present, respectively. MODIS is certainly a strong tool for remote monitoring of tropical forests. However, there is a few number of ground observations to evaluate NPP MODIS accuracy in tropical areas. Recently, more focused validation studies on tropical regions indicate that MODIS17 NPP does not perform well in modeling field-measured tropical NPP (Samanta et al. 2010).

The driving behind this work is related to the need to enhance the knowledge on fire impacts on vegetation dynamics and carbon cycle. This project intends to contribute to a detailed characterization of LSA-SAF/VP, including the Fraction Vegetation Cover (FVC), Leaf Area Index (LAI), Fraction of Absorbed Photosynthetic Active Radiation (FAPAR) and NDVI. The availability of other Vegetation Parameters, among the NDVI, is expected to improve the quality of new NPP dataset, as saturation of NDVI in closed canopy was found as one of the main reasons of NPP MODIS lack of accuracy. The add value of using FVC or FAPAR will be assessed.

In this project the NPP CASA algorithm will be adapted to LSA SAF/VP in order to develop a new NPP database over Africa (NPP LSA-SAF). This dataset will be compared with the available datasets (CASA and MODIS). Special attention
will be devoted to Africa tropical areas. In particular, the NPP LSA-SAF will be used to analyze the impact of large fires in vegetation dynamics in order to assess their direct and indirect contribution to the carbon balance in the short and medium/long term.

References


EARTHSYSTEMS 2016-5
PhD in Geophysics and Geoinformation Sciences

Development of an Agriculture Drought Risk Model for the Iberian Peninsula: a neural network approach

Supervision
Ana Russo and Célia M. Gouveia

Abstract
The Iberian Peninsula is recurrently affected by drought episodes and therefore by its associated adverse effects, which range from severe water shortages to economic and social losses. Prolonged intense drought episodes are also responsible for the most negative impacts on vegetation, such as losses in crop yields. Even a short-term drought may have a severe impact on agriculture if occurring at a critical crop growth stage, leading to the need for a continuous monitoring of vegetation stress and for reliable estimates of the drought impacts. This need is reinforced because of the observed tendency towards a drier Mediterranean for the period 1970-2010 in comparison with 1901-70. A close relationship between crop yield and water stress is well known and crop yield may be viewed as a reliable indicator of agricultural drought. However, the relationship between crop yield and water stress varies from crop to crop, making assessment and prediction a complex task. Furthermore, the response of yield depends on the environmental conditions during the growing season as well as during antecedent periods. Additionally, the time scale of the variables employed in the agricultural drought risk assessment is critical, as well as the weather conditions at a given time will have differential effects on crop yield, either beneficial or detrimental, depending on plant types and growth stage in the life cycle at that time.

Drought risk management includes four analytical components – hazard, exposure, vulnerability, and risk. Drought hazard analysis consists of selecting an appropriate hydro-meteorological index to describe intensity, spatial and temporal characteristics. Most studies related to drought analysis and monitoring systems have been conducted using either the Palmer Drought Severity Index (PDSI) (Palmer, 1965), based on a soil water balance equation; or the Standardised Precipitation Index (SPI; McKee et al., 1993), based on a precipitation probabilistic approach; and the recently proposed Standardized Precipitation Evapotranspiration Index (SPEI) based on the simultaneous use of precipitation and temperature fields (Wu et al., 2004). SPI has the advantage of combining a multi-scalar character. In order to monitor the agricultural impact of droughts, drought indices that are using evapotranspiration data seems to have better results than those drought indices solely based on precipitation (Naramsimhan and Srinivasan, 2005). Remote sensing data allows analysing vegetation activity and estimating different biophysical parameters such as the area index, the vegetation biomass, the net primary production, photosynthetic activity etc. A number of studies have used remote sensing data to determine the impact of droughts (Gouveia et al., 2009). Vulnerability analysis captures the damage or loss suffered at the joining of exposure and hazard and represents the resiliency to exposure. It is connected to the ability of the exposed skill to predict, tolerate, and recover from the damaging effects of droughts. Vulnerability could be estimated using statistical relationships between coarse resolution drought hazard and the historical crop production losses. The probabilistic approach of drought risk assessment usually results from a frequency analysis of the gaps between water demand and availability during the crop season, building appropriate drought vulnerability models, and deriving loss exceedance curves and return period losses for selected crops.
Drought forecasting is a critical component of drought risk management. Various tools and methods for drought forecasting have been suggested and tested in different regions over the last decades. The recent decade has seen a wide application of a statistical technique known as Artificial Neural Networks (ANN) to a myriad of environmental applications and also to the prediction of drought events and severity (Morid et al., 2007).

This PhD plan aims at developing a Risk Model for Agricultural Drought using ANN through the prediction of quantitative values of drought indices, namely SPI and SPEI. The forecasts will be attempted using different combinations of meteorological variables, drought indices in preceding months and climate indices like Southern Oscillation Index (SOI) and North Atlantic Oscillation (NAO) index. After the model is constructed it should be able to assess in real time the agricultural risk associated with crop yields losses at critical phenological stages before the crop is planted and at critical stages during the growing season. The model will provide information about potential agricultural risk on dryland crop yield such that decision makers will have enough time to implement strategies to reduce risk potential. This information is also expected to be assist farmers in deciding whether to purchase crop insurance.

References

EARTHSYSTEMS 2016-6
PhD in Geophysics and Geoinformation Sciences

Weather extremes in a Changing Climate: Variability, Mechanisms and Societal Impacts

Supervision

Margarida L. R. Liberato (IDL & UTAD), Alexandre Ramos (IDL) and Joaquim G. Pinto (Department of Meteorology, University of Reading, UK)

Part of the proposed work may be performed at the University of Reading, UK

Objectives

Understand the variability and trends of weather extremes under recent climate conditions
Ananalyse large-scale dynamics and physical mechanisms leading to extremes affecting Europe
Characterize projections of extreme events and expected societal impacts in Western Europe

Abstract

Extreme weather events lead to costly societal impacts. There is growing evidence that anthropogenic climate change may alter the likelihood of occurrence these extreme events. As human population increases and the economic development progresses, the risk associated with weather-driven natural hazards also increases. Therefore, resulting socioeconomic losses from natural hazards have risen in recent decades and will continue to rise in the future. Reducing population’s vulnerability requires understanding extreme events in a changing climate.

In the Euro-Atlantic extratropical region, extreme windstorms are one of the most costly natural hazards. During recent winters, south-western Europe witnessed major damage from winter storms such as Klaus (January 2009), Xynthia (February 2010), Gong (January 2013) and Stephanie (February 2014). These storms underwent explosive development at unusual low latitudes, along the edge of the dominant North Atlantic storm track and affected the Iberian Peninsula with uncommon intensity (Liberato et al. 2011; 2013; Ludwig et al., 2014). Pinto et al. (2012) provided evidence that the increased risk of occurrence of windstorm-associated losses projected for the XXI century can be largely attributed to changes in the meteorological severity of the events. Additionally, factors such as changes in the cyclone paths and in the location of the wind signatures relative to highly populated areas are also important to explain the possible changes in estimated losses.

On the other hand, in the Iberian Peninsula, extreme precipitation events during the winter months have been associated with major socio-economic impacts such as flooding, landslides, extensive property damage and human casualties. These events are usually associated with low pressure systems over the North Atlantic (e.g. Liberato et al. 2012; Liberato and Trigo 2014). Precipitation extremes have also been studied by Ramos et al. (2014) who developed a method to rank precipitation events for the entire Iberia and several sub-domains, taking into account both the
intensity of the precipitation and its spatial extent. However further assessment of the physical mechanisms leading to the occurrence of such extreme episodes is still needed.

Recent results suggest that even if the total number of cyclones is expected to decrease, the number of extreme cyclones over Western Europe may actually slightly increase in association with an intensified and eastward extended polar jet toward Europe (e.g., Pinto et al., 2009). Accordingly, shorter return periods for extreme windstorms and associated losses have been estimated for Western Europe (Della-Marta and Pinto, 2009; Pinto et al., 2012). Thus, research on high impact events occurring on the western Iberia region and associated dynamical mechanisms and variability is of utmost importance. Namely it allows improved understanding of the occurrence of such extreme events, contributing to enhance forecast and prevention of severe meteorological hazards.

In this research the candidate will be studying mid-latitude North Atlantic extreme storms’ variability and its links to large-scale dynamics through diagnosis, modelling physical processes and related impacts on south-western Europe. The candidate will participate in the assessment of extratropical North Atlantic cyclone variability and trends under recent and future climate conditions. The candidate will also study its linkages to associated wind and precipitation extremes. The analysis will also include the analysis of the detailed structure and dynamics of selected case studies both for recent and future climate conditions. In particular, the UPSCALE high-resolution climate model experiments performed with the HiGEM GCM (Shaffrey et al., 2009) at various resolutions will enable an adequate evaluation of the dependence of the possible climate signal in terms of wind and precipitation extremes from model resolution. The case studies will be supported by regional climate modelling at 3-7 km resolution.

References


EARTHSYSTEMS 2016-7

PhD in Geophysics and Geoinformation Sciences

Mesoscale structure and coherent eddies between the Mid-Atlantic Ridge and the Iberian Margin (Iberian Basin).

Supervision

Álvaro Peliz (IDL), Bernard Le Cann (Laboratoire de Physique des Océans(LPO), CNRS-Ifremer-UBO, Brest)

Part of the proposed work may be done at LPO, Brest.

Summary

The Mid-Atlantic Ridge (MAR) at the midlatitudes marks a sharp transition in the level of Eddy Kinetic Energy (EKE) with high values in the western side (Fig 1) and low EKE on the east. This contrast is associated with a much larger eddy population on the western side associated with the Gulf Stream system. On the eastern side of the MAR, the highest EKE site is associated with the Azores Current eddy field (e.g., Barbosa Aguiar, 2011). Another spot of higher EKE is found north of the Azores promontory (fig 1a), but the nature and formation of the mesoscale structures that originate such relatively high values of EKE is unknown. Further east of the MAR, over the Iberian Abyssal plain, the EKE values detected with altimetry (corresponding to structures with sizes above ~50 km) diminishes significantly although the eddy activity is still significant as observed by Le Cann et al. (2005). At those longitudes, the observed eddies seem to be associated with the presence of time-mean zonal jets (see the special issue on the Pomme project: http://onlinelibrary.wiley.com/doi/10.1002/jgrc.v110.C7/issuetoc).

Near the Iberian margin, the mesoscale field is dominated by ocean margin processes (e.g., Peliz et al, 2003, 2005) on the upper ocean and by the Mediterranean outflow eddies at the intermediate levels (Barbosa-Aguier et al, 2013). These are relatively small eddies hardly detected by the altimetric signal and thus not represented in the mean EKE field of Fig. 1.

Despite the numerous studies a systematic characterization of the mesoscale field and coherent eddies in the deep sea zone between the MAR and the Iberian margin (the Iberian Basin) is still to be done. It is proposed to extend the modeling study described in Teles-Machado et al (2015) to the whole Iberian Basin and beyond the MAR, to produce equilibrium solutions of the circulation and mesoscale field. The model mesoscale structure and individual eddies will be compared with sea surface anomalies derived from altimetry ARGO floats, and with a database of surface and intermediate drifters maintained by B. Le Cann at LPO; e.g., Le Cann et al., 2005).

The study will concentrate on several main topics: The characterization of the eddy field and nature of coherent eddies east of the Mid-Atlantic Ridge; the reason for the strong gradients in EKE across-MAR (do coherent eddies cross the ridge system? How do they dissipate?), the nature of the eddies and zonal jets observed in the deep Iberian basin (Pomme area); what is the origin of the jets, how do they compare with the their Pacific counterparts, what is the role of coherent eddies in the jets structure.
Figure 1: Eddies and eddy properties east of the MAR: Mean Eddy Kinetic Energy a) and coherent eddies derived from altimetry data (Barbosa-Aguiar et al 2011), and eddies observed with in situ drifters (Le Cann et al, 2005).

References:


EARTHSYSTEMS 2016-8

PhD in Geophysics and Geoinformation Sciences

**Fine resolution studies of upwelling dynamics near sharp topography: cross-shelf transports**

**Supervision**

Álvaro Peliz (IDL), Xavier Capet (LOCEAN, Université Pierre et Marie Curie, Paris)

*Part of the proposed work may be done at LOCEAN, Paris.*

**Summary**

Upwelling is fundamental for many ecosystems on ocean margins for it provides a steady source of nutrients to the euphotic layer to feed the lower level of the trophic chain. Upwelling circulation is however very complex especially near sharp topography and the positive impacts of nutrient influx can be balanced by the offshore export of enriched waters. Favorable sites for biological enrichment over the shelf depend thus on a tradeoff between the influx of subsurface waters from the deep ocean and the export of enriched waters by the upwelling circulation: in other words it depends on the cross-shelf exchange.

Significant differences between upwelling sites arise from differences in topography and stratification, and wind intensity and curl (e.g., Marchesiello and Estrade, 2007).

In zones where the alongshore topographic variations are small the upwelling circulation matches the conceptual models for two-dimensional across-shore circulation. In zones where the alongshore topographic variations are significant, the upwelling circulation becomes highly three dimensional (e.g., Oke, et al 2002). The coastal flow near capes may even reverse during relaxation periods and flow against the winds, modifying the vertical cross-shore flow structure (e.g., Gan and Allen 2002).

The presence of submarine canyons may accelerate significantly the upwelling of deeper water onto the shelf and dramatically change the 3D structure of circulation (Allen S. E. and X. Durrieu de Madron, 2009). The joint effect of canyons and other topographic features, such as capes and head-lands, modulates, sometimes dramatically the onshore movement of upwelled water and favors the formation of stationary coastal upwelling centers (Kampf, 2009, Ndoye et al , 2014).

Near sharp topographies the upwelling cross-shore circulation and the associated Lagrangian pathways are very complex (Peliz et al., 2007, Oliveira et al., 2009). Yet this complexity needs to be understood and incorporated in upwelling representations, e.g., when investigating their evolutions as a consequence of anticipated global changes.

It is proposed a study of transport processes with a focus on sites of complex topography having the Western Portugal (Fig 1) as a primary study case. The study will be based on semi-idealized and realistic simulations with the Regional Ocean Modeling System. Lagrangian analyses will be an important methodological tool. Submesoscale processes responsible for vertical exchanges close the coast will also be considered.
Figure 1: This SST image reveals the major alongshore discontinuity present in the upwelling system at ~ 38.5N offshore of Lisboa. Understanding the dynamical and ecological role of such discontinuities is a major challenge of modern Oceanography.

References

EARTHSYSTEMS: Lisbon Doctoral School on Earth System Science, PhD Projects

EARTHSYSTEMS 2016-9

PhD in Geophysics and Geoinformation Sciences

Current and foreseeable future effects of extreme weather events on low energy buildings

Supervision

Guilherme Carrilho da Graça and Pedro Soares

Summary

In 2013 IPCC released an assessment report on climate change based on the predictions of the most advanced Earth System Models, including new emission scenarios and, particularly, looking for recent and near future climate change (up to the mid of the century). This report provides information on a timescale that is appropriate for decision makers in many sectors, namely in the buildings and energy sectors, and indicates that there is substantial economic potential for mitigation of global greenhouse gas emissions over the coming decades. In the short and medium term (until 2030) this mitigation should be based in technological development, namely, in the buildings sector, where energy efficiency plays a crucial role.

In addition to the climate change context, the continuous increase in global energy demand is also making building energy efficiency a top government priority. In response to this challenge the building design and research community is starting to develop highly efficient buildings that use passive and renewable energy systems. The ultimate goal is to design buildings that, on an annual basis, draw from outside sources an amount of energy that is less than the exported energy from onsite renewable energy sources, i.e., Net Zero Energy Buildings (NZEB).

Indicators are used to rate climate severity and building efficiency. The existing European building energy ratings are based on total energy consumption, as opposed to the capability of a building to maximize the available climate potential (an essential feature of any NZEB). The climate indicators that are currently in use were developed in the 70's and 80's and have a narrow focus that makes them unsuitable for NZEB and passive building design analysis. In this context, simple indicators that can clearly identify the best climates, and the buildings that achieve optimal interaction with a given climate, will have a significant impact in building energy demand reduction.

This research project proposes to develop climate indicators that focus on climate statistics, from mean to extremes and climate PDFs, which have a relevant impact in NZEB and passive buildings. The indicators focus on dynamic effects that influence building climate performance (BCP), such as the statistical distribution of sequences of warm and cold days, the simultaneous occurrence of overheating conditions and consistent wind patterns (that may allow for ventilative cooling), and the night-time temperature after warm days (that allows the building to flush accumulated heat). This analysis framework is applicable to different types of building and geographic locations. This project will focus on office buildings in the Mediterranean region.

The Mediterranean region has been identified as one of the most vulnerable to climate change, due to consistent warming and losses of precipitation found in CMIP5 ensemble, and to an increase of inter-annual variability. Iberia, in the western border of the European Mediterranean sector, is expected to experience large changes in its climate, and, being characterized by large gradients of temperature and rainfall, constitutes a challenge for regional climate
modeling. The high-resolution output of regional climate models (RCM) will allow for spatial characterization of the climatic indicator, through a weighted measure depending on temperature, relative humidity, global and diffuse radiation and wind, at the surface. The assessment of the climate change impact on this climate indicator, and subsequently in the building indicator will be performed, using the RCM results of the future simulations for the periods 2021-2050 and 2051-2070.

The outcomes of the proposed work are the BCP analysis framework, the mapping of CI for the Mediterranean region and the identification of the best combined strategies that, in each climate, can be used to increase BCP for a typical office building. The analysis will be performed for current and future climate (30 years), allowing for a clear diagnostics of the effects of climate change on NZEB and passive buildings.

References


EARTHSYSTEMS 2016-10
PhD in Geophysics and Geoinformation Sciences

Imaging the Cape Verde hotspot structure

Supervision
Graça Silveira, Susana Custódio, Pierre Arroucau

Summary
Within this work, the student will develop an anisotropic model for the crustal and upper mantle structure beneath the Cape Verde by joint inversion of body waves (receiver functions) and surface waves (dispersion curves from ambient noise cross-correlation). She/he will perform a systematic search to identify and locate volcanic tremor, which will then be compared with local seismicity and crustal structure.

Hotspots and related structures in the mantle are of major interest to understand the dynamics of the Earth and the modes of heat transfer within the planet. Recently, while investigating the crust, upper mantle and mantle transition zone of the Azores (Silveira et al, 2010) and Cape Verde (Vinnik et al, 2012) hotspots by seismic P and S receiver functions, evidence for crustal underplating in those regions was found. This is often inferred as a by-product of plume-lithosphere interaction (for example Leahy and Park, 2005). To better understand this issue, a detailed image of the crust and upper mantle beneath Cape Verde, with better lateral resolution, is still missing and further research on that area should be carried out. The setup of such models, able to image the inner earth structure with better resolution, depends critically on our ability to solve the inverse problem using different seismic datasets.

Ambient noise tomography recently became a very popular tool to study the crustal and upper mantle Earth structure. It can be applied to regions with sparse, inhomogeneously distributed, or even non-existent seismicity, and produces reliable measurements at periods below 10 seconds that are particularly difficult to obtain using earthquakes or explosions due to scattering and attenuation (e.g. Silveira et al., 2013). Surface-wave dispersion obtained from ambient noise cross-correlations, enables measurements at shorter periods and paths not allowed when using surface-waves generated by earthquakes. On the other hand, receiver functions allow mapping the main inner earth discontinuities. But, while surface-wave are sensitive to absolute wave speed averages, receiver functions are mainly sensitive to vertically integrated travel times. To overcome such ambiguity, we will use a joint inversion methodology to determine the velocity structure of Cape Verde with high resolution.
The candidate will also have the opportunity to detect and locate volcanic tremor. Volcanic tremor is typically associated with the movement of fluids inside volcanic conduits and fissures, and therefore will provide information on the locations of active fluid motion.

In this study we will use data recorded during two temporary deployments, namely from 2002 to 2004 (Lodge and Helffrich, 2006; Helffrich et al., 2010) and 2007 to 2008 (Vinnik et al., 2012; Vales et al., 2014).

Methodology, including relevant references


Generation of the empirical Green’s functions generated by cross-correlating seismic ambient-noise records. To improve the seismic ambient noise signal extraction a phase cross-correlation (Schimmel, 1999), followed by a time-frequency domain phase weighted stack (Schimmel et al., 2011) will be applied. The dispersion measurements (group and phase velocities) will be computed for each station pair by using the S-transform and the multiple filter technique, for comparison. 2D inversion of the dispersion measurements, including azimuthal anisotropy. 3D joint inversion of the receiver functions and the dispersion measurements using a self-adaptive method, solved in a Bayesian framework (Bodin et al., 2009).

Detection and location of volcanic tremor using automated waveform analysis techniques.

References


Schimmel, M., Stutzmann, E., Gallart, J., Using instantaneous phase coherence for signal extraction from ambient noise data at a local to a global scale, Geophys. J. Int., 184, 494-506, doi: 10.1111/j.1365-246X.2010.04861.x


EARTHSYSTEMS 2016-11

PhD in Geophysics and Geoinformation Sciences

Determination of Earthquake Sources in Real-Time by combining GNSS and Seismic data

Supervision

Rui Fernandes, Susana Custódio (IDL), Yoaz Bar-Sever (JPL)

Part of the proposed work will be done at SEGAL, University of Beira Interior, Covilhã and possibly at JPL, USA

Summary

The use of GNSS (Global Navigation Satellite Systems) observations, in particular GPS, has been incorporated in early warning systems, complementing other geophysical sensors, due to their high precision, sensitivity to the longest-period bands, and capability to measure absolute displacements.

The spatial pattern, magnitude, and timing of permanent displacement of GPS stations can be inverted for earthquake sources in order to predict the 3D displacement field (Blewitt et al., 2009). Custódio et al. (2009) and Page et al. (2009) also demonstrated the capabilities to integrate GPS and seismic data to invert for earthquake sources.

One of the major limitations to perform such inversion in real time is the uncertainty of the estimated GNSS displacements. However, such uncertainties have been reduced in recent years using dedicated global networks and improved orbits. Solutions provided in the framework of the Great Alert project (http://www.gdgps.net/products/great-alert.html) show the capabilities already available.

We propose in this PhD programme to develop methodologies to integrate GNSS solutions computed using precise point positioning strategies (with JPL support) with seismic observations in real-time in order to locate and characterize the earthquake source accurately in the minimum period of time. Such methodologies will be tested using real data and a complete prototype of a system for Azores (where the major seismic hazard occurs in Portugal) will be designed and evaluated using synthetic data.

References


EARTHSYSTEMS 2016-12
PhD in Geophysics and Geoinformation Sciences

Understanding the Makran Subduction Processes using Space-Geodetic Data

Supervision
Rui Fernandes, Miguel Miranda (IDL), Mohammad Mokhtari (IIEES, Iran)

Part of the proposed work will be done at SEGAL, University of Beira Interior, Covilhã

Summary
The Makran subduction area is one of the poorest understood tectonic systems in the Earth. It is caused by the subduction of the southeast part of the Arabia tectonic plate in the Eurasia tectonic plate. The eastern tip is also part of the Triple Junction with the India tectonic plate. A particular feature is the seismic distinctive behavior between the western and eastern segments (approximately defined by the political boundary between Iran and Pakistan). The magnitude and number of events in the eastern segment is higher in the eastern segment, as can be observed by the existing catalogues and the destructive events in the recent past (like the 1945 earthquake that originated a large tsunami). The western segment has less seismicity, even if two very recent events (magnitude larger than 5) occurred last May. This suggests this segment can be locked raising the probability that a tsunamiic earthquake can occur in the near future directly affecting the coasts of Iran and Oman. In order to analyze the mechanisms that affect the neo-tectonics of this plate boundary, it is fundamental to rigorously compute motion solutions for points located on the deforming zone and on the stable part of the bordering tectonic plates.

This project has the following goals:

a) Previous and acquired GNSS (Global Navigation Satellite Systems) observations in Makran will be used to compute the current present-day strain rate field for this region. New methods will be developed and applied to reduce the noise in motions derived from campaign observations.

b) On a continental scale, geodetic and geophysical data will be inverted to derive a unique model of the angular velocities for the plates bordering Makran. This model and the estimated velocity fields will be used to constrain the present-day kinematics of these plates in the area of study, allowing us to refine their boundaries and to identify possible independent tectonic units.

c) Finally, it will evaluated the seismic and tsunami hazard by extending the conclusions obtained from the geodynamic analysis and by integrating as much as possible the existing geophysical data.

References


EARTHSYSTEMS 2016-13
PhD in Geophysics and Geoinformation Sciences

New approaches to tsunami hazard assessment

Supervision
Maria Ana Baptista, Miguel Miranda

Summary
Deterministic and probabilistic tsunami hazard assessment methods are strongly constrained by geophysical a priori on the maximum credible earthquake source or on a definition of a small set of tsunami sources that is supposed to be representative of the whole set of possible sources, to dramatically reduce the computation effort. However, the identification of an obvious fault plane, common to most earthquakes, is not straightforward outside active subduction zones. Examples are the Gulf of Cadiz, in the North East Atlantic, that was the place of past transatlantic tsunamis (Baptista and Miranda, 2009), and the Eastern Mediterranean (Necmiğlu and Özel, 2013), an active seismic zone with a complex geometry. In both areas, there is no unique compilation of earthquake source parameters that covers all possible tsunamigenic sources and thus the number of different possible scenarios can be huge.

Most of the methods developed so far to simulate tsunami generation, propagation and run-up that have been used for hazard studies, are intensive on computing. Most of the models solve the non-linear shallow water equations, and some simplifications are often made to the physics of tsunami generation and propagation. Some approaches have been developed to accelerate the computation of synthetic tsunami waveforms. One of the most promising approaches is based on the concept of statistical emulation of tsunamis (Sarri et al., 2012); this approach has particular application to efficiently construct probability-of-loss-exceedance curves. Recently it was also shown that the use of empirical Green functions provides a method for fast computation of tsunami waveforms (Miranda et al., 2014) allowing a more comprehensive statistical evaluation of tsunami hazard by combining a large synthetic earthquake catalogue with forward tsunami modeling, for a given set of points of interest located on critical places along the coast.

The availability of high quality LIDAR data for the coasts of Portugal provides an excellent opportunity to test these approaches, and to reassess tsunami hazard estimations, up to now only developed for a small number of locations. The research program will include:

1. Methods for determination of synthetic earthquake catalogues;
2. Alternative methods for fast computation of synthetic tsunami waveforms;
3. Relationship between estimated LSW wave heights and run-up;

References
EARTHSYSTEMS 2016-14
PhD in Geophysics and Geoinformation Sciences

Site conditions proxies for seismic hazard and risk studies and building codes

Supervision
Paula Teves Costa and Pierre-Yves Bard

Part of the proposed work may be done at Institut des Sciences de la Terre, Observatoire de Grenoble, France

Objectives
The main objective is to look for alternative proxies allowing improving the way to account for site effects in building codes and seismic hazard studies. To search for the most adequate parameters that reflect the soil seismic behaviour for studies at varying scales and precision levels. The end product should be recommendations for the "optimal" site proxies for use in building codes, microzonation studies, or hazard and risk studies at various scales.

Motivation and summary
Heterogeneities in the subsoil materials and irregular surface or underground geometry significantly change the propagation of seismic waves, resulting in localized, complex interference patterns and significant to large amplification, and partly conditioning the distribution of damages in moderate to large earthquakes. These complex effects can be predicted using numerical simulation and 2D and 3D models; however, as the model complexity increases, the possibility of extrapolating the results of particular case studies to a general application decreases significantly, and so does also the capacity of the common geophysical or geotechnical investigation techniques to constrain the models with the required precision.

When considering site-specific studies, this is reflected in the difficulty to translate the current knowledge on site effects into expressions that could be generally applicable in building codes and in GMPE (Chávez-García and Faccioli, 2000; Chávez-García, 2007). Many equations for the prediction of ground-motion parameters (PGA, PGV) and response spectral ordinates have been published in recent years both for the entire Euro-Mediterranean and Middle Eastern region as well as for individual countries within this region (Bommer et al., 2010; Douglas et al., 2014). In general, in these GMPE the soil effect is introduced by the conjugation of one or two parameters, and considering a small number of site categories (e.g., soft soil, stiff soil and rock). This simple categorization is not enough to take into account the diversity of existing site effects and it is necessary to look for improved proxies (or groups of proxies) to introduce in the GMPE in view to reduce the within event variability linked to soil conditions. The site categorization is also taken into account in the design actions defined in the Eurocode 8. In this code the site classification is mainly based on VS30 values. However many authors argued that this parameter is not enough, or even not adequate, to be an indicator of site seismic amplification (Castellaro et al., 2008; Cadet et al., 2012; Deras et al., 2015). The implications of a soil classification based in other and/or complementary parameters must be investigated.
Methodology

To fulfill the main objective, the different methods currently used for site characterization will be compiled and their respective performance critically reviewed, on the basis of the two recent major accomplishments (NGAW2 in the US, Bozorgnia et al., 2014; RESORCE for Pan-European data, Douglas et al., 2014). Compilation of observed site effects, with an emphasis on the Euro-Mediterranean area, to build an extensive data base with measured site amplification and the corresponding metadata (site conditions, characteristics of earthquake recordings, analysis methods, etc.). Site-specific studies using weak-motion recordings will be also compiled. The observed site amplifications will be compared to the predictions by most recent GMPEs, and also to more advanced prediction equations that will be derived from the so constructed specific data base taking into account the most recent alternative propositions (for instance, Cadet et al., 2012; Pitilakis et al., 2013).

A similar literature survey will be performed about the results obtained with numerical simulations in 1D, 2D or 3D underground structures. Complementary 1D and 2D modelling can be performed to help identifying the most relevant parameters to be taken into account (fundamental frequency $f_0$, shallow velocity $V_{S30}$, average sediment velocity $V_{Smean}$, geometrical parameters: thickness, valley width, distance to edge, ...)

Finally, the respective advantages of each proxy will be discussed in view of the way they can be measured, and/or the way they can be approximated by other approaches.

References


Unravelling the nature and origin of Ocean Anoxic events: an environmental magnetic approach

Summary

Oceanic Anoxic Events (OAEs) are one of the most abrupt climatic changes during the Cretaceous, leading to widespread ocean anoxia and mass extinction. It is marked by the worldwide deposition of black shale deposits, which are important petroleum source rocks (Jenkyns, 1980). Despite more than three decades of intensive investigations, the cause and origin of OAEs still remain under debate. Basically, two models are proposed: the productivity model and the ocean stagnation model. The productivity model suggests that the high accumulation of organic carbon associated with OAEs was the result of increased ocean surface productivity due to the interaction of several factors, such as increased nutrient input from the continent, accelerated hydrogeological cycle associated to warmer climate and volcanic activity (e.g. Kerr, 1998; Leckie et al., 2002). The global stagnation model suggests that organic carbon-rich black shale was the result of enhanced preservation, due to ocean stratification and inhibition of deepwater circulation (e.g. Demaison and Moore, 1980). Submarine volcanism associated with hydrothermal activity has been recently invoked to explain ocean anoxia by decreasing oxygen levels or introducing enormous quantities of biolimiting metals within hydrothermal plumes (Kerr, 2005).

Here we propose to apply environmental magnetism coupled to geochemical and mineralogical proxies to referenced OAE sections worldwide (Portugal, Europe, North Africa...) in order to unravel paleoenvironmental changes during OAE’s and evaluate the contribution of massive volcanism. Iron oxides and sulphides are excellent indicators of environmental conditions (pH and Eh) and source sediment (aeolian, detrital, bio-chemical) but their potential has never been applied in details to OAE’s. Sulphur isotopic composition also provides information about the potential volcanic origin of the OAE signature. High-resolution magnetic and geochemical profiles, as well as the identification of the magnetic mineralogy provide a unique opportunity to unravel environmental and climate changes associated to these events and the contribution of large igneous province.

Keywords: Oceanic Anoxic Events, magnetism, volcanism, global climate changes.

References

EARTHSYSTEMS 2016-16

PhD in Geology

Multi-elemental and isotope geochemistry of metapelites from the Volcano-Sedimentary Complex (Iberian Pyrite Belt, Portugal): unravelling fingerprints of different sources, sedimentary environments and exhalative-hydrothermal activity

Supervision

António Mateus (FCUL, IDL)

Summary: The recent revitalisation of exploration surveys in the Iberian Pyrite Belt (IPB) renewed the interest in deepening the systematic study of sequences forming the Volcano-Sedimentary Complex (CVS) and usually hosting the typical polymetallic massive sulphides of this world-class metallogenic province. The genesis of these mineral resources is confined to a short period of time (≈2-3 Ma) and is not simply related to the volcanic sequences, existing inclusively examples where this connection is groundless. The project aims the characterisation of lateral and vertical facies variation recorded by pelites in several key sections of CVS by means of intensive use of mineral chemistry and multi-elemental/isotope geochemistry. On the basis of this study, useful indicators for the recognition of different sources, sedimentary environments and exhalative-hydrothermal activity are expected; all these will have impact on the definition of mineralogical and geochemical guides to be used in exploration surveys over IPB.

Motivation: The Iberian Pyrite Belt (IPB), including ≈2500 Mt of polymetallic massive sulphides distributed by ca. 90 known deposits in Portugal and Spain, is one of the world’s most important metallogenetic provinces of its type [1, 2]. These deposits have quite varied dimension and metal content and are mostly hosted in sequences forming the Volcano-Sedimentary Complex (CVS) of Upper Famennian to Upper Visean age. Their economic importance is historically indisputable and, at present, the four active mining centres (Neves-Corvo, Aljustrel, Las Cruces, Aguas Teñidas) have a strong impact on regional/national GDP, ensuring as well a significant part of the Cu produced in EU. The intensification of exploration activities in IPB, especially from 2006 onwards, brought new life to old issues that, not abandoned during the investment breaks between the mid-90s and 2004, regained relevance. Indeed, multidisciplinary studies conducted in the last two decades largely contributed to significant advances in the IPB knowledge, particularly with regard to: (i) understanding the factors that directly and indirectly conditioned the architecture, formation and evolution of the basin that gave rise to IPB [3, 4]; (ii) consideration of physical volcanology features in the interpretation of CVS and consequent clearance criteria useful for spatial reconstruction of volcanic centres and associated mineralisation [5, 6]; (iii) detailed lithostratigraphy based on systematic palinology and absolute geochronology, and consequent definition of the time interval in which ore-forming systems have been developed [7, 8]; (iv) characterisation of possible sources of metals and fluids involved in the metallogenic process, making use of multi-elemental and isotopic data [9-11]; and (v) proposition of hybrid genetic models, for most cases between systems of volcanogenic affiliation (VMS) and exhalative-hydrothermal processes in sedimentary settings (SEDEX) [3, 12]. In spite of these advances, several critical questions remain open, namely those regarding vertical and lateral facies variations in CVS, which determine the organisation of local stratigraphic columns and provide decisive elements for the location of metallogenic systems of economic significance; therefore, their relevance in the design of new exploration surveys cannot be discarded. Some promising steps in this direction have been done in the last
two years by reference to the results obtained for the Albernoa Polygon (≈713 km² granted to EPOS for mineral exploration since the end of the year 2012) based on high-resolution and integrated processing of geological, mineralogical/geochemical and geophysical data [13, 14]. These results fully justify the broadening of the research carried out so far in other sectors of the IPB and the revisiting of existing geological models, leading to their refinement. The historical record show clearly that improvements in conceptual models were decisive in the discovery of Neves-Corvo in 1977 [15], Lagoa Salgada in 1992 [16], Las Cruces in 1994 [17] and, more recently (February 2014), the success of exploration programs undertaken by the AVRUPA consortium in the Alvalade permit [18].

**Objectives:** The main goals of the proposed research plan are the:

1. Analysis of the main factors that determine the lateral and vertical facies organisation of pelite sequences in selected CVS stratigraphic columns to be also comprehensively sampled;
2. Petrography and detailed mineralogical characterisation of representative sets of pelite rocks;
3. Multi-elemental and isotope (Sr, Nd and Pb systems) characterisation of pelites;
4. Determination of mineralogical, geochemical and isotopic indicators able to discriminate the sources of fundamental constituents and evaluate critical variables in sedimentary environment analysis and/or subsequent geological evolution;
5. Data/information provided to enrich the reasoning behind the processes of deposition and/or accumulation of sulphides; and
6. Identification of potentially useful guides/criteria to the conceptual design of new exploration surveys in IPB.

The field work and re-logging surveys, in addition to sampling, will be developed together with the research team involved in the mineral exploration program at the Albernoa Polygon since 2013. The infrastructure needed for the planned activities is available at FCUL, allowing the accomplishment of petrography and mineralogy studies and part of lithogeochemistry work. Additional analytical means not available in FCUL, particularly those looked-for complementary lithogeochemistry data and isotope characterisation, will be provided by laboratories of national and foreign institutions with which there is consolidated scientific cooperation. The costs of field and analytical work will be fully supported by funds allocated to the EPOS-FCUL cooperation.

**References**


EARTHSYSTEMS 2016-17

PhD in Geology

Provenance studies in (palaeo)tsunami deposits

Supervision

Pedro J. M. Costa (IDL and Departamento de Geologia), César Andrade (IDL and Departamento de Geologia)

Summary

The main objectives of this program are to investigate relationships between (palaeo)tsunami sediments and their sources and to focus in the hydrodynamic interpretation of tsunami investigating run-in and backwash interaction. These purposes will be achieved through the application of sedimentological techniques that will contribute to a better understanding of transport paths, erosional and depositional mechanisms affecting sediments transported by tsunami waves.

The successful candidate will study tsunami sediments from different locations (Portugal, Scotland, Spain, United States, Indonesia and Japan). The multi-proxy approach will be based in textural, microtextural, compositional and tomography\((micro)\)stratigraphy studies. Furthermore, empirical tests may be conducted to assess correlations determined through the analysis of field and laboratory data.

The programme will benefit from the support of R&D projects “Will climate change in the Arctic increase the landslide-tsunami risk to the UK?” financed by NERC-UK Arctic Program (PI – Dr. Sue Dawson), “Eventos de oleaje extremo en el area atlantica ibero-magrebi: el registro geologico de tsunamis y ciclones durante el Holoceno” financed by the Plan Estatal de Investigación Científica y Técnica y de Innovación of the Spanish Government (PI - Dr. Javier Lario).

Objectives

1- To establish provenance\(\)parental relationships between tsunami sediments and their sources.
2- To investigate tsunami run-in and backwash interactions.
3- To conduct high resolution sedimentological analysis in tsunami deposits aiming the development of innovative techniques (e.g. microtextural, compositional, tomography, etc.).
4- To conduct empirical tests to link field and laboratory findings (e.g. wave tank or wind tunnel).
5- To contribute to the development of sedimentological criteria to recognize palaeotsunamis.
EARTHSYSTEMS 2016-18
PhD in Geology

Elemental microanalysis and isotopic composition of minerals forming polyphase assemblages in W(-Sn) quartz lodes of the Panasqueira Mine (Portugal); identification of metallogenic markers and new exploration guides

Supervision
António Mateus (FCUL, IDL)

Summary: The risk of supply puts tungsten in a relatively limited set of raw materials considered critical, stimulating the reappraisal of metallogenic provinces with recognised potential. The Portuguese segment of the Central Iberian Zone (CIZ) is part of one of these provinces, not being unfounded the expectations for new discoveries and being necessary to reassess old mining centres according to new scientific and technological paradigms. This project focuses on the Panasqueira Mine and intends to study the compositional and isotopic variability of mineral phases included in the complex assemblages that form distinct quartz lode sets observed in different areas of the mineralising W(-Sn) system. The information obtained will allow to revisit the existing genetic model for this world-class productive system, providing useful data regarding: (1) factors that affect its relative enrichment in certain metals; and (2) new guides for exploration surveys targeted at similar ore-forming systems in CIZ.

Motivation: Tungsten is one of the 21 raw materials identified as critical for EU [1], deserving similar classification in several other studies on determinant factors of growth of various world’s economic regions. This qualifier primarily reflects the increased risk of supply of the future market, which need to be reduced by diversifying the set of producers and/or increasing the production quota of countries other than the hegemonic China (~82% of ~73000t produced worldwide in 2011). The existing potential in Europe, particularly in the Central Iberian Zone (CIZ) and equivalent geotectonic areas, is high, yet poorly investigated in the light of modern concepts; the (re)start of mining in Barruecopardo and Los Santos (Spain) [2, 3], as well as the pilot exploitation works at Hemerdon Ball (UK) and Tabuaço (Portugal) [4, 5] are good examples of how much can still be done on this matter.

The beginning of a sustained growth cycle of the European W production will need: (i) improvements of the existing exploration models, making them more robust in methodological and scientific terms and able of providing new discoveries in depth and in geological settings different than conventional ones; and (ii) overcome the weaknesses that the steep decline in trade prices performed between the mid-80s and 2006 amplified, determining the closure of many mines, and mostly based on the difficulty of exploit and process relatively low grade ores (sometimes presenting complex compositional matrices) often distributed unevenly in lode systems (occasionally including brecciated bodies) with discontinuous and variable geometry. Therefore, the detailed and systematic chemical and isotopic characterisation presented by minerals included in polyphase assemblages supporting the W(-Sn) ores in CIZ represents one of the main lines of research to be undertaken. In this context, the Panasqueira Mine emerges as a natural selection, not only due to the unique characteristics of its ores, but also because of questions that remain open concerning the role played by the hydrothermal activity related to ENE-WSW and N-S fault zones in the metallogenic process evolution. The starting point for further research in Panasqueira is truly challenging, given the outstanding
contributions of numerous works done by several authors (from 1943 to 2014 [6-20]) on: (i) the distribution and content of mineralised quartz lodes and their relationship with the greisen-granite dome or other hidden igneous bodies; (ii) the hydrothermal alteration halos and metalliferous enrichment mechanisms; (iii) the composition and origin of the fluids involved in the metallogenic process; (iv) the age of the main mineralising events; and [v] the specific composition of some of the main mineral phases and their respective distribution at the mine scale. Still, structural, geochemical and mineralogical accumulated evidence demonstrates that it is necessary to revisit and refine the proposed genetic models, often favouring simple magmatic-hydrothermal affiliations around the greisen-granite dome.

**Objectives:** The main purpose of this PhD project is to characterise the compositional and isotopic variability of critical mineral phases included in the polyphase assemblages that form the W(-Sn) lode systems at the Panasqueira Mine. It is intended particularly to document minor and trace constituents of these mineral phases (using DRX, FTIR, EPMA, LA-ICP-MS, micro-PIXE and eventually syncrotron), in addition to the respective isotopic (multisystem Pb, Sr, Nd, Re) signatures, exploring the possibility of that information serve as an indicator of: (1) different sources of metals; and/or (2) the involvement of different fluid types; and/or (3) the involvement of processes responsible for late changes in the system with implications in the (re)distribution and/or enrichment of some chemical elements. Additionally, the information collected will confine, at least for some of the mineral phases, the age and the physicochemical conditions under which the ores were formed, complementing the results of previous works based on less comprehensive sampling plans. The expected results will allow further development of new guides/criteria to be used in exploration surveys aiming at similar ore-forming systems in CIZ, particularly along the Segura-Panasqueira-Góis belt.

The planned studies will include all the different types of mineral assemblages so far recognised at the mine scale, so that a 3D representative sampling program will be developed by collecting 30 to 50 specimens of wolframite, cassiterite, tourmaline, topaz, mica, chalcopyrite, sphalerite, pyrrhotite, arsenopyrite, apatite and carbonates in different quartz lode sets observed in various areas of the mine; several samples of fluorite and galena may be added to the list. Sampling work at Panasqueira will be developed together with the geologists of Sojitz Beralt Tin and Wolfram, and will take place in different stages with appropriate extension to the fulfillment of objectives specifically outlined. The geological reconnaissance and sampling of similar ore-forming systems in the Segura-Góis belt will be spread into various surveys whose timing and duration will be set according to the pre-existing geological knowledge, accessibility and other logistical conditions.

A significant part of the proposed work will be developed together with the team involved in the R&D project NewOreS – Development of New models for the genesis of Rare Metal (W, Nb, Ta, Li) Ore deposits from the European Variscan Belt and valorization of low grade and fine grained ore and mine tailings. This translational research project, approved under the ERA-MIN Joint Call on 2014 Sustainable supply of raw materials in Europe, started in February 2015 and will last for three years. The key infrastructure required to accomplish the planned activities exists in FCUL and allows completion of petrography and production of mineral concentrates in addition to XRD, FTIR and EPMA studies. Additional analytical means not available in FCUL, especially those needed to obtain additional data on mineral chemistry (LA-ICP-MS, micro-PIXE) and all the analyses of radiogenic isotopes, shall be provided by laboratories of partner institutions in NewOreS (Univ. Lorraine and Orléans) and/or laboratories of national and foreign entities with which there is a consolidated scientific cooperation. Activities will be funded by NewOreS and, if necessary, by other ongoing R&D projects.

**References**

EARTHSYSTEMS 2016-19
PhD in Geology

The effects of non-ideality of solid-solutions in oscillatory zoning phenomena and incorporation of metals

Supervision
Mário A. Gonçalves (FCUL, IDL) and Manuel Prieto (U Oviedo)

Partner Institution
Part of this work may be developed at the Faculty of Geology, University of Oviedo

Objectives: To extend a model for non-ideal solid-solution growth using a cellular automaton to simulate natural pattern formation (oscillatory zoning) and provide an explanatory framework for the distribution coefficients obtained experimentally. The project will combine modelling and solid-solution – aqueous solution growth experiments.

Motivation and summary: Solid solutions are mixed crystals where pairs of ions substitute for each other in the same structural position and have an important role in deciphering and understanding past growth environments as well as sequestering harmful ions, making them useful for technological applications in reactive and retention barriers. However, the mechanisms that control both the growth and incorporation of ions are still unsettled and debated, especially the interplay between the thermodynamic parameters that characterize these systems and its intrinsic kinetics. Besides, the effects of non-ideality of solid solutions in these processes were poorly studied. Approaching the problem from a modelling and experimental perspective is important to achieve a better understanding of the system’s mechanistic.

Methodology: The project involve the development of an extended version of a cellular automaton written in Matlab that successfully simulates pattern formation in solid-solution – aqueous solution systems. This model is limited to ideal solid solutions, but can be improved to incorporate non-ideal regular solid-solutions. Given the capabilities of the computer code PHREEQC, it is possible to link the current built-in aqueous activity model into PHREEQC such that it might be possible to deal with much more complex solution compositions. Concurrently, crystallization and growth experiments with non-ideal regular solid-solution systems will be performed using porous silica gel tubes that allow ions to counter-diffuse and achieve high supersaturation rates. Standard mineral characterization techniques will be performed: SEM, Electron Microprobe, and X-Ray Diffraction with state-of-the-art equipment. Solution gel composition will be determined by ICP-OES. The work will be developed jointly in FCUL and UOviedo (for both part of the experiments and characterization techniques).

References
EARTHSYSTEMS 2016-20

PhD in Geology

**Study of scaling laws relating dissolution rates of minerals and their surface area and reactivity**

**Supervision**

Mário A. Gonçalves (FCUL, IDL) and Manuel Prieto (U Oviedo)

**Partner Institution**

Part of this work may be developed at the Faculty of Geology, University of Oviedo

**Objectives:** Provide a model that properly scales different laboratory measured dissolution rates studying its relation to the surface area and surface reactivity of minerals. These parameters affect deeply the experimental results and their transferability towards similar experimental conditions in the laboratory and in the field.

**Motivation and summary:** Surface area of minerals is a parameter that still eludes researchers on how to properly assess its influence on the analysis of macroscopic dissolution experiments. Common practice normalizes reaction rates to surface area in order to compare and transfer reaction rates between different experiments. This normalization assumes a simple linear relationship with the measured rates, which is far from being true. This proposal is based in a methodology whose aim is to improve our understanding on how microscopic surface structures control macroscopic dissolution rates, and how they can be properly taken into account in a unifying macroscopic model. Its outputs can be far-reaching, because they will focus on carbonate and sulfate minerals with indisputable influence in the deeper understanding of the major cycles of their elements.

**Methodology:** The procedure is critically centered in the selection of mineral grains (with different symmetries and surface reactivity) whose sizes fall within a very narrow range of dimensions, ensuring that the uncertainty in the assessment of the surface area is minimal. These minerals will be used in conventional dissolution kinetic experiments with mildly acidic to near-neutral solutions at ambient temperature and in equilibrium with the atmosphere, using a continuously stirred flow-through reactor, taking into consideration the minimization of grain communition. Reaction progress is followed by means of titration techniques and ICP-OES analyses. If required, advanced techniques such as AFM with a fluid cell and synchrotron based surface analysis can be performed.

**References**


EARTHSYSTEMS 2016-21

PhD in Geology

High-resolution Late Pleistocene –Holocene calcareous nannofossils record related to the depositional evolution of the SW Portuguese margin

Supervision

Mário Cachão (IDL, FCUL), Cristina Roque (IDL, EMEPC)

RATIONAL: The SW Portuguese margin depositional evolution, since the Late Pleistocene, has been controlled by climatic changes and associated paleoceanographic modifications, sea-level fluctuations, and by the succession of different sedimentary regimes dominated mainly by hemipelagic, contouritic and mass movement processes. However, is still unknown how: i) these controlling factors affect different physiographic domains (i.e. continental shelf, continental slope, deep basin) during a certain time interval, and ii) the physiographic domains and respective depositional environments evolved through time. A complex interplay of paleoceanographic and taphonomic mechanisms may have imprinted upon the microfossil (Coccolithophore) record clues of climate and paleoceanographic changes. Together with mass movement events all acted as controlling processes of the SW Portuguese margin deposition, during the Late Pleistocene-Holocene.

OBJECTIVE AND WORK PLAN: The main objective of this doctoral proposal is to better understand the paleoceanographic and taphonomic evolution of the SW Portuguese margin during the Late Pleistocene-Holocene, with particular focus on the role played by mass movement events (e.g. slides, slumps, debris flow). It will use the already available dataset: a) 3 gravity cores retrieved from the SW Portuguese margin along a E-W transect, representative of different physiographic environments (i.e. external continental shelf, continental slope and deep basin); b) high-resolution measurements, obtained at 1 cm-scale, of sediments physical properties using GEOTEK multisensor core logger and X-ray computed tomography scanning (CT-scan); c) high-resolution measurements, obtained at 1 cm-scale, of sediments chemical properties using ITRAX-XRF.

A high-resolution analysis using complementary methodologies will be performed on those gravity cores during this PhD project, consisting of:

i) Calcareous nannofossil analysis: includes sample preparation (Random Settling procedure) and identification of nannolith assemblages, both autochthonous and reworked, using a petrographic polarizing optical microscope along a high-resolution sample interval;

ii) Sedimentological analysis: includes visual core description, grain size determination, carbonates and organic matter each centimeter depth and mineralogical observation at binocular microscope (at selected levels);

iii) Physical and chemical properties measurements analysis. This will be a complementary analysis of the last two (i) and (ii). It includes the study of: a) natural gamma radiation, gamma density, p-wave velocity, magnetic susceptibility, electrical resistivity, color reflectance and high-resolution digital X-ray radiography profiles, b) chemical elements in the range Si-U profiles and c) X-ray computed tomography scanning (CT-scan).
EARTHSYSTEMS 2016-22
PhD in Geology

Exhumation of anatectic complexes through shear zones

Supervision
Telmo M. Bento dos Santos (LNEG and IDL), João Mata (IDL)

Summary
Although, major shear zones have often been associated with the exhumation of anatectic complexes [e.g.: 1], this relationship has rarely been studied for their petrological and geochemical features, as well as their thermochronological evolution [e.g.: 1-2]. This has hindered the understanding of the interdependence between deformation, metamorphism, magmatism and exhumation at high thermal flux orogenic shear zones.

The Central Iberian Zone, located in the axial domain of the Iberian Variscan Belt [3], is intersected by several important shear zones associated with important anatectic complexes with abundant syn- and late-post-tectonic granite intrusions, such as the Figueira de Castelo Rodrigo – Lumbrales Anatectic Complex [4] and the Porto-Viseu Metamorphic Belt [5]. These are target areas of this PhD proposal, due to the outstanding quality of their lithological exposure that allows the characterization of the interference patterns between the structures associated with the different variscan tectonometamorphic events and a comparative petrological, geochemical and isotopic analysis of lithotypes from different crustal levels.

Acquisition of new petrological, geochemical and geochronological data will allow to better precise the timing and conditions of the Variscan deformation, metamorphism and granite plutonism, as well as to define the tectonometamorphic factors responsible for the formation, evolution and exhumation of the anatectic complexes through their respective shear zones. Innovative and quantitative methods of thermochronology and petrological modelling will allow quantifying the duration of the deformation events, the cooling rates of the anatectic complexes, to perform an innovative spatial-temporal characterization of the Central Iberian Zone and to present a consistent geodynamic model for the Iberian Variscan Belt.

This PhD will lead to an increased knowledge regarding: a) the structure, geometry, functioning and evolution of shear zones; b) the interdependence between temperature and deformation during the exhumation of anatectic complexes; c) the ages and duration of events and processes linked to deformation, metamorphism and the geodynamic evolution of orogenic belts; d) genesis and evolution of anatectic complexes and their implications in mass and heat transfer in orogenic belts; and e) the interaction of different geochemical reservoirs (e.g.: upper/lower crust interaction) during orogenic events.

In summary, this project will answer some fundamental questions regarding the formation and evolution of shear zones and their role in the exhumation of anatectic complexes.
References


EARTHSYSTEMS 2016-23
PhD in Geophysics and Geoinformation Sciences

Submarine landslide-induced tsunami: A comprehensive method to model the whole source-to-coast process.

Supervision
Pedro Terrinha (IDL/IPMA/FCUL), Rachid Omira (IDL/IPMA)

Motivation and summary:
Submarine mass-failures (SMFs) are a major cause of tsunami. They are phenomenon almost impossible to observe and instrument. Therefore, numerical modeling is seen as one of the key ways forward, both for understanding the landslides themselves and for the prediction of the induced tsunamis. Up-to-date, most developed numerical models suffer limitations related to the use of limited sediment rheologies. These limitations significantly affect the tsunami generation and therefore introduce unquantifiable uncertainty to hazard assessment. In this project we propose to investigate the SMF-induced tsunami potential in order to fill the gaps in the tsunami hazard from non-seismic sources. It will focus on a better characterization of the tsunami from a better understanding of the SMF body movement. Within this project, the following key questions will be addressed:

i) How the type of SMFs, the rheology of the sediments involved, the geotechnical parameters, and the marine environments (slope, water depth...etc) control the SMF behaviour and motion?

ii) How to constrain the tsunami generation characteristics from the landslide physical parameters?

iii) How better model the SMF-induced tsunami propagation in both deep and shallow water for appropriate estimates of tsunami impact?

To accomplish these objectives, a multidisciplinary methodology will be applied for SMFs case-studies in the NE Atlantic region. It will incorporate detailed geomorphological and geotechnical analyses, numerical modelling of the coupling of the SMF movement and the tsunami wave generation, and numerical modeling of the SMF-induced tsunami coastal impact.

Workplan:

a) Perform a review of the past-events documented submarine landslide. Generate a database with all the information related to SMFs occurred in different marine environments.

b) Analysis of the SMFs behaviour and characteristics (from the database generated in a)) to better understand and characterize the behaviour of SMFs. This will include an evaluation of the type of the SMFs, identification of geotechnical parameters, and associate to each SMF type a rheological model.

c) Coupling SMF movement and the tsunami generation by constraining the tsunami generation from comprehensive SMF rheological and physical parameters (evaluated in b)) and taking into account the effects
of marine environment. Case-studies of SMF past-events in the NE Atlantic will be considered.

d) Modelling tsunami propagation and coastal impact considering the initial conditions—tsunami generation—(calculated in c)). The propagation will be performed considering the Boussinesq dispersive terms. SMF-induced tsunami impact will be addressed for site-specific coastal areas of the NE Atlantic.

References


EARTHSYSTEMS 2016-24

PhD in Geology

Record of mass movement processes in southwest Iberia margin and implications for geohazards assessment

Supervision

Pedro Terrinha (IDL/IPMA/FCUL), Cristina Roque (IDL/EMEPC)

The proposed work will be done at the Portuguese Institute for the Sea and Atmosphere and University of Lisbon.

Motivation and summary:

Landslides and other types of mass movement deposits play an important role in shaping the continental margin and can also be a source of important information on i) the occurrence of past large to mega earthquakes in recent geological times for which historical catalogue or reports are not available, ii) important climatic events or iii) evolution of slope instability associated with sedimentary loading. Tsunamis have in very recent historical times changed the course of societal concerns and economics, such as the 2013 tsunami that hit the coast of Japan or the 2004 of Samatia, Indonesia. The West Portuguese Margin and specifically the Lisbon coastal region were struck by large tsunamis in the recent past. Apart from large earthquakes landslide triggered tsunamis is a source of concern. Recent work on the southwest Iberia has reported the existence of important landslides from the shallow continental shelf (Noiva et al., 2014; Terrinha et al., 2015) through the continental slope (Terrinha et al., 2003) to the deep sea (Lo Iacono et al., 2012). Recent work on the SW Iberia margin based on IODP 339 drilling has shown the contribution of a variety of sources for mass movement deposits that are believed to respond to a complex modification of the Pliocene-Quaternary environmental conditions of internal and external geodynamic origin (Hernández-Molina et al., 2014).

This work will be a quantitative contribution for the characterization of the source, type and timing of mass movement deposits on the southwest Iberia Margin.

Workplan:

a) This work will be based on the thorough study of the stratigraphy, physical and geotechnical properties of sedimentary cores, multibeam bathymetry and reflection seismic profiles. The student will participate and coordinate the acquired data and lab results.

b) Production of a morphotectonic model aiming at characterizing the continental slope environmental conditions, both from literature review and inspection of multibeam bathymetry and reflection seismic data.

c) Sedimentological description and interpretation of physical and geotechnical properties of sedimentary cores.

References:

Lo Iacono, Claudio, Eulàlia Gràcia, Filippo Zaniboni, Gianluca Pagnoni, Stefano Tinti, Rafael Bartolomé, Douglas G. Masson, Russell B. Wynn, Nuno Lourenço, Manuel Pinto de Abreu, Juan José Dañobeitia, and Nevio Zitellini. Large, deepwater slope failures: Implications for landslide-generated tsunamis. Geology, October 2012; v. 40; no. 10; p. 931–934; Data Repository item 2012262 |doi:10.1130/G33446.1


EARTHSYSTEMS 2016-25

PhD in Geology

Climate change influence on biodiversity, function and services of Portuguese lagoons

Supervision

Manel Leira and Conceição Freitas

Summary

Coastal lagoons are valuable areas of extreme variability, diversity and multifunctionality that provide a variety of goods and services which are essential to the human wellbeing. Lagoons are classified under the EU Habitats Directive (92/43/EEC) as a priority habitat (Annex 1: 1150 Coastal Lagoons). Coastal lagoons are unique habitats, inhabited by specialised euryhaline species that must be able to tolerate great, often daily fluctuations in salinity caused by tides, floods and storms. They are among the most productive ecosystems and simultaneously among the most modified and threatened coastal environments, compromising the associated goods and services, which endangers their ecological functions and conservation (Airoldi and Beck 2007). Main threats for this transitional waters come from both land based inputs from physical alteration (infill/drainage), agriculture, recreation and land runoff, as well as marine based inputs such as the disposal of dredged spoil and accidental and unlawful spillages. Furthermore, changes as a result of climate change (e.g. rising sea levels, increased flood and storm events) are also predicted to have a significant impact on these ecosystems in the near future. As ecosystems within coastal lagoons are changed, lost or degraded, their capacity to deliver services to satisfy human wellbeing is changed, threatening the overall ability to sustainably support human society.

Understanding the long term trajectories of provisioning and regulating ecosystem services are important to anticipate future societal requirements. In order to fully examine the pressure and ecological responses in these unique ecosystems tools and strategies are required to identify baseline reference conditions, natural variations and historical pressures to inform future policies on sustainable management of lagoon systems and recovery of degraded habitats in the context of the IPCC predicted warmer climates of the future. Palaeoecological data can provide a ‘reference condition’ for assessing long term change and specifically data directly relevant to the implementation of policy directives (Leira et al. 2006). The importance of a historical perspective to aid our understanding of current day ecology is essential, particularly given the lack of long term monitoring data for these systems. In any single region, biodiversity elements have emerged and declined with environmental pressures appearing and disappearing over time. Different patterns materialize depending on the length of the timescale explored. It is therefore imperative that significant drivers/pressures and ecological responses are examined at different timescales. Sediments represent temporal integration of allochthonous (catchment) and autochthonous (lagoon) inputs to the system. Major shifts in catchments and/or lagoon conditions are registered as lithological, geochemical and fossil signatures in the sediment profile. Palaeoecological methodologies provide an important opportunity to examine comprehensive timescales which are essential to underpin current knowledge of biodiversity and ecological change. Palaeoecology multidisciplinary studies have been successfully applied to coastal
environments by using a wide range of sediment proxies (e.g. Cearreta et al. 2003, 2007; Freitas et al. 2008), permitting inference of development and change of these coastal water systems over time.

The project has three main aims: (1) to contribute to reinforce the theoretical background linking climate changes to coastal lagoon responses in Portugal; (2) to test the expected relationships with already existing data; (3) to evaluate the actual influence of climate changes on the portuguese lagoons, in comparison with human activity induced changes.

References


Cearreta A., Cachão M., Cabral C.M., Bao R. and Ramalho, M.D.J. 2003 Lateglacial and Holocene environmental changes in Portuguese coastal lagoons 2: microfossils multiproxy reconstruction of the Santo André coastal area. The Holocene 13, 447-158.


PhD in Geology

**Histovariability of selected elements of dinosaur skeletons: evolution, paleobiology, paleoecology and Climate change during the Late Jurassic.**

*Supervision*

Mário Cachão (IDL, FCUL) + Francisco Ortega (Facultad de Ciencias, UNED, Madrid)

**RATIONAL:** The Lusitanian Basin is recognized by its rich and diverse Upper Jurassic (Kimmeridgian-Tithonian) paleofauna, namely dinosaurs both endemic forms and others shared with North America (Morrison form.) and Africa (Tendaguru). The identification of long term trends on the thermometabolic life history and physiology of specific taxonomic groups can provide information on survival ratios or on proneness to extinction due to climate change. Bone paleohistology is currently a potent descriptive and analytical tool that have provided interesting results about the paleobiology of extinct groups namely adaptation of organisms to conditions characterized by chronic resource limitations, either cyclic or casuistic.

**OBJECTIVE AND WORK PLAN:** The main purpose is to apply to the Paleontology of Vertebrates notions related to bone growth strategies developed for analogous extant groups with similar trophic levels. The histology of hard tissues (bones, teeth) is used as a tool to reconstruct physiology and life history of certain groups and their response to paleobiogeography and climatic variability. The aim is focused on explaining short-term (annual) variability related to growth and energy availability itself connected to changes in biome characteristics. It is also intended to evaluate the intra and interspecific histovariability of dinosaurs along the stratigraphic range of the Upper Jurassic as a proxy of events of long term severe and non-cyclic climate change.

Results from histological samples of dinosaurs from the Lusitanian Basin will be compared with those obtained from distinct paleobiogeographic realms (e.g. Morrison, Tendaguru).

i) Obtain histological samples by the least destructive means possible, namely by perforating the nucleus transverse to the diaphysis of long bones (humerus and femurs preferentially) and transversal cuts of ribs of dinosaurs from the osteological collection of the ALT-SNH Torres Vedras laboratory of Vertebrate Paleontology;

ii) Production of polished thin sections for observation under reflective light with cross pollars;

iii) Study of synchronous sauropods (Lourinhasaurus, Lusotitan e Turiasaurus), theropods Allosaurus, Ceratosaurus, Torvosaurus) and Thyreophore and Ornithopods from several Portuguese locations;

iv) Image processing with specific software (Bone Profiler + Image J) to quantify and statistically compare histological profiles and production of data matrixes with paleobiological, paleoclimatic and trophic parameters.
EARTHSYSTEMS 2016-27

PhD in Geology

Storm deposits in sandy coastlines: sedimentary record and morphodynamic modelling

Supervision

Pedro J. M. Costa (IDL and Departamento de Geologia), César Andrade (IDL and Departamento de Geologia)

Summary

Several palaeotempestology studies, including some that are supported by the comparison with modern analogues, have confirmed that sandy overwashed layers in the sedimentary column landward of overtopped barriers provide reliable proxies of storm events. Contemporaneous storm deposits in locations of the North Atlantic seaboard (Portugal, Scotland and the United Sates) will be studied to further comprehend the relative intensity of erosional and depositional processes. Sedimentary techniques (e.g. textural, microtextural and heavy minerals) will be applied to understand the sedimentary interplay during storm-induced flooding. The data obtained will help validating results from erosion, inundation and sedimentation numerical models (e.g. XBeach and Delft3D).

Results are expected to improve understanding of typical sedimentological\morphological responses to storm events, contributing to develop predictive tools relevant to coastal hazard definition (e.g. inundation paths, limits, etc.).

Objectives

The main objectives of this project are:

1. Contribute to the definition of sedimentological signatures of storm deposits in clastic coastal systems;

2. Apply textural, microtextural and mineralogical methods in the study of contemporaneous storm deposits from Portugal (e.g. Storm of February 2014), Scotland (e.g. Storm of January 2005) and United States (e.g. Hurricane Sandy);

3. Monitor the depositional and erosional patterns (and their spatial distribution) associated with a storm event in sandy coastlines;

4. Test state of the art modelling tools, such as using Delft 3D and XBeach;

5. Combine research on the geological impact of modern storm events together with inundation and morphodynamic models to provide tools for (palaeo)tempestology research;

6. Contribute to the improvement of coastal management of hazard.
EARTHSYSTEMS 2016-28

PhD in Marine Sciences

Seasonal and interannual variations in chlorophyll concentration (Chl) and primary productivity (PP) in the subtropical Northeast Atlantic.

Supervision

Vanda Brotas (MARE-FCUL), Igor Bashmachnikov (MARE-FCUL), Carolina Sá (MARE-FCUL)

Objectives

Chlorophyll a (Chl) is the key pigment responsible for photosynthesis, present in all phytoplankton cells. Chl is thus a proxy for phytoplankton biomass, directly correlated to PP. Chl is also an Essential Climate Variable (ECV), which can be monitored by satellite Earth Observation (EO). The goal of the study is to determine the major physical and biological mechanisms which govern the observed interannual variations in the satellite derived Chl and PP in the subtropical NE Atlantic. The present proposal aims to verify the relative importance of 3 possible mechanisms: seasonal and interannual variations in wind mixing intensity and ocean surface heat budget, advection and upwelling due to long-period Rossby waves and variation in the zooplankton grazing pressure.

Motivation and summary

The worldwide concern on climate change and on its effects on environmental quality of human populations has given phytoplankton research a much wider and universal scope. Due to its photosynthetic activity, oceanic phytoplankton accounts for almost 50% of total carbon sequestration, playing a major role on carbon cycle (Brotas et al., 2013). Satellite remote sensing of ocean colour has been a powerful tool to estimate phytoplankton biomass at synoptic temporal and spatial scales, particularly since 1997 with SeaWiFs.

Furthermore, Chlorophyll concentration (Chl) and primary productivity (PP) are important environmental indicators, used for fishery forecasting and evaluation of the environmental state of ocean ecosystems.

In oligotrophic waters Chl and PP are mainly controlled by the intensity of vertical mixing in the upper ocean, by vertical motions at the base of the mixed layer (upwelling/downwelling) and by zooplankton grazing activity.

Variations in intensity of regional atmospheric patterns, often expressed in terms of atmospheric indices (like the North Atlantic Oscillation Index (NAOI)), are claimed to be one of the most important factors controlling Chl dynamics at the seasonal and interannual scales (Ueyama and Monger, 2005; Levy et al., 2005; Henson et al., 2009; Zhai et al., 2013). Direct correlation between Chl the NAOI are generally low and insignificant (Barton et al., 2003), but this is due to the interannual variation of the Chl being dominated by various natural cycles (0.5-year, 1-year, 2-year, 4-year and longer), which show different response to the corresponding cycles in the NAOI (Bashmachnikov et al., 2013). In particular, it was hypnotised that high correlation between the NAOI and Chl for the 4-year cycle results from the direct effect of the atmosphere on intensity of vertical mixing in the upper ocean (Bashmachnikov et al., 2013), while on average low correlations for the 0.5- and 2-year cycles result from the direct atmospheric forcing
being overlapped with the delayed response to moving upwelling/downwelling zones formed by forced oceanic Rossby waves (Cipollini, 2003). Biological control of the seasonal phytoplankton cycles by zooplankton is another important factor that should be taken into account (Bahamon and Cruzado, 2003; Piontkovski et al., 2006).

Methodology

The study region is the NE Atlantic. The study will be based on 17 years of satellite derived Chl data (1998-2014), zooplankton (ESTOC, 1994-2003), combined with oceanographic (AVISO altimetry and SST, etc.) and atmospheric (wind, heat fluxes, etc., obtained from observations and global/regional models) data-sets. The data-sets are subject to cross-correlation, cross-spectral and cross-wavelet point-wise analysis. EOF (Empirical Orthogonal Functions) analysis of spatial distribution of the Chl concentrations and PP will also performed. Stationary and moving convergence/divergence zones will be obtained. Band-pass filtered Hovmoller diagram analysis will be used in order to outline characteristics of moving wave structures.

For obtaining up-to-date ocean colour data, the PhD project will be linked to the on-going Ocean Colour – Climate Change Initiative (OC-CCI), an ESA project (http://www.esa-oceancolour-cci.org). OC-CCI will provide ocean colour data, as composite images taken from various remote-sensing satellites, e.g., SeaWiFS, MODIS-Aqua and MERIS. The PhD student will have the opportunity to work with highly regarded oceanographers and remote sensing scientists.

The PhD candidate will have a broad range of multidisciplinary interests. Preferably with a mathematical/computer sciences/geophysical background. During the PhD, he/she will be trained in laboratory methodologies.

References


PhD in Marine Sciences

An ecosystem-based approach to the management of the pelagic fish resources in the Portuguese continental waters

Supervision
Alexandra Silva (IPMA), Henrique Cabral (MARE, FCUL), Marta Coll (IRD, France)

Summary
Sardine (Sardina pilchardus), an economically and socially important fishery resource, has shown a drastic decline in the past few years in the Portuguese coast in parallel with an increase of chub mackerel (Scomber colias). The complementary spatial distribution and inverse correlation between their recruitments suggests a species replacement dynamics driven by climatic variation possibly associated with the intensification of biotic relationships such as predation and competition. Such evidence points to the need to develop ecosystem-based models for a robust fisheries management of the pelagic fish resources in the Portuguese waters, following the new worldwide trend for marine resources management.

Different ecosystem-based modeling approaches such as whole ecosystem models (e.g. Ecopath with Ecosim) or minimum realistic models (e.g. GADGET) will be tested and their performance evaluated and compared. Differences in modeling approach performances will also be tested concerning the study area contemplated. Different scenarios in terms of climatic predictions and fishing effort strategies will also be presented.

Key references
EARTHSYSTEMS 2016-30

PhD in Marine Sciences

Spatial and temporal scale effects on indicators of marine ecosystems health and value

Supervision

Henrique Cabral (MARE, FCUL), Stéphanie Pasquaud (MARE, FCUL)

Summary

In the last decade a large number of marine ecosystems ecological quality or health indices have been proposed and applied worldwide. Some of these indices were developed under legal frameworks such as the Water Framework Directive or the Marine Strategy Directive but even in these domains a wide diversity of methodological approaches and practice have been implemented. Although they are useful indicators for management purposes, there are still several aspects concerning their use that need further research, namely the spatial and temporal scale effects.

This thesis will focus on such effects by using a broad range of indices, of different nature (e.g. ecosystem health, water quality, ecosystem goods and services), and evaluating their performance and sensitiveness at different spatial (from a few km to hundreds km) and temporal scales (from months to decades).

Key references


EARTHSYSTEMS 2016-31

PhD in Marine Sciences

Methodological perspectives relative to ecosystem-based approach to management of marine ecosystems

Supervision

Henrique Cabral (MARE, FCUL)

Summary

Ecosystem-based approach to management have been pointed out as a way of ensuring sustainability in exploited populations and ecosystems. Relevant policies, such as fisheries common policy, water framework directive, marine strategy directive and marine spatial planning highlighted the need and urgency for the use of such approaches. However, in practical terms there is a lack of scientific information on how this approach could be applied.

In this thesis several methodological perspectives will be evaluated and compared, and applied to different marine ecosystems (from estuaries to continental shelf environments). Ecopath and other trophic web modelling methods will be used, as well as neural networks. Regional, ecosystem and habitat dimensions will also be tested when comparing models performance. Practical recommendation of the methodological approach to adopt in the implementation of different policies and monitoring programmes will be proposed.

Key references


