Call for Grants in the

Lisbon Doctoral School on Earth System Science

EARTHSYSTEMS 2018

A University of Lisbon/FCUL PhD program supported by IDL (Instituto Dom Luiz), Mare, 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.

8 PhD students Fellowship(s) for is open at the EARTHSYSTEMS FCT - Doctoral Program - PD/143/2012 , financed by National Funds (Orçamento de Estado do Ministério da Educação e Ciência) and when eligible, from European Social Fund funds through the Operational Programs for the 2014-2020 programming period of Portugal 2020, namely the Thematic Operational Program of Human Capital, the Northern Regional Operational Program, in accordance with the provisions of the Specific Regulation applicable under the following conditions:

1. **Scientific Area**: ...Earth and Atmospheric Sciences

2. **Requirements for admission**: National citizens, or other citizens members of the EU countries

Others citizens outside the EU holders of valid residence permits or beneficiaries of long-term resident status, under the terms of Law No. 23/2007, 4th July, with changes done under Law No. 29/2012, of 9th August;

Applicants must hold an MSc degree, or equivalent, at the time of submission of the application

Academic degrees awarded by non-Portuguese institutions will only be accepted if recognized by the Portuguese Government, through the "Direção Geral do Ensino Superior, or by any Portuguese Public University, according with applicable laws, namely Decree-Law 341/2007, 12th October, and Decree-Law 283/83, 21 June.
Applicants which have already received an FCT funded Grant for the same purpose are not eligible for financial support.

Factors preferred:
Students with a degree, at the MSc level, in any topic of Earth Sciences (Meteorology, Oceanography, Solid Earth Geophysics, Geodesy, Geology), or in Marine Sciences, and students coming from other science degrees, such as Biology, Environmental Sciences, Physics, Mathematics or Engineering, willing to pursue research in Earth System Science

Students will be selected by a multidisciplinary committee, considering 3 main criteria: academic CV, a motivation letter, and a personal interview. The CV must include not only the final marks in degrees completed, but also a list of marks in individual courses, and a list of publications if they exist as well as a scan of all the diplomas + certificates. The motivation letter must indicate the preferred area of work, with reference to at least 3 of the proposed research topics, ordered by preference. The absence of any of the requested documents automatically implies the exclusion of the applicant

The committee will interview a selected number of candidates: twice the number of places offered. The assignment of research topics will then be negotiated with each of the selected students. Note that because this is a multidisciplinary program the selection of candidates will rank the candidates in separate lists, aiming to recruit a mix of students in the different areas of research (Atmospheric Science, Oceanography, Solid Earth Geophysics, Geodesy, Geology, Marine Biology), working with different supervisors, all the candidates must select more than 2 topics with different supervision.
The Painel for this call are: Pedro Miranda (Professor-FCUL), Pedro Ré (Professor-FCUL) , Rui Taborda (Professor-FCUL), Luís Matias (Professor-FCUL, Cristina Catita (Professor-FCUL)

3. **Legislation framework**: Statute of the Scientific Research Fellowship, in accordance with Law 40/2004, of 18 August, as amended and republished by Decree-Law No. 202/2012 of 27 August, and as amended by Decree-Law No. 233/2012 of 29 October and by Law No. 12/2013, of January 29, and Decree-Law No. 89/2013 of 9 July; And also by the FCT, I.P. Fellowships Regulation, in force (http://www.fct.pt/apoios/bolsas/docs/RegulamentoBolsasFCT2015.pdf) and **FCiências.ID** Fellowship Regulation, as approved on 23rd February 2017.

If you believe you want to pursue a research career in Earth System Science at the University of Lisbon, check our research topics at http://idl.ul.pt/node/403, and send your CV, a motivation letter, and at least two supporting references, to earthsystems@fc.ul.pt until 5th

Janurary 2018. Grants are due to start on the 1st March 2018. Candidates who have not yet obtained their academic degree by the closing date of the call will be eligible provided they declare, in the letter of motivation, that it will be awarded by January 5th, 2018. If this condition is not fulfilled, the grant will not be awarded.
Grants offered by the EARTHSYSTEMS program abide to the rules and values set by FCT (www.fct.mctes.pt). These grants are intended for individuals who meet the requirements set forth in Article 30, paragraph 1, of Decree Law nº 74/2006, of March 24, as amended by Decree-Law No. 107/2008 of June 25, and 230/2009 of September 14, and 115/2013 of August 07 and it's holds for one year, renewable for up to a total of four years, and cannot be awarded for periods of less than six consecutive months.

4. **Place of work**: The work will be developed at Faculdade de Ciências da Universidade de Lisboa under the scientific guidance of all the proposed Supervisor

In the case of research projects which require that part of its work plan is developed in a foreign institution, the attribution of the corresponding financial support is only possible for students with a permanent and main residence in Portugal, independent of nationality. Such requirements must be written in the call.

5. **Fellowship duration**: This position is initially opened for 12 months and will begin on March 2018. The fellowship contract may be renewed not more than 48 months, in accordance with the provisions of Regulation of Research Fellowships from the Foundation for Science and Technology, I.P.

6. **Monthly allowance**: The fellowship amounts to € 980 according to table values of the fellowships awarded directly by the FCT, IP. (http://www.fct.pt/apoios/bolsas/valores).
The fellowship holder will have a personal accident insurance and, if not covered by any social protection scheme can ensure the right to social security through adherence to the voluntary social insurance scheme, pursuant to Código dos Regimes Contributivos do Sistema Previdencial de Segurança Social.
The fellowship will be paid monthly by bank transfer.
(add, where applicable, other financial components, periodicity and method of payment of fellowship (fellowships)).

7. **Selection method**: Candidates will be assessed by the quality of their CV (40.%) and Motivation letter 20% and interview 40.%) (Curriculum evaluation, interview, tests of knowledge, other; indicate the values assigned to each method and its percentage weight).

NOTE*: If EU non residents are predicted to apply to the fellowship, an interview (via skype is acceptable) should be included in the selection procedure as, otherwise, a non EU candidate that does not have a Portuguese resident visa to whom no interview was conducted will not be eligible. (see Regulation of Research Fellowships from the Foundation for Science and Technology, I.P.*

8. **Selection Committee**: Pedro Miranda (Professor-FCUL), Pedro Ré (Professor-FCUL) , Rui Taborda (Professor-FCUL), Luís Matias (Professor-FCUL, Cristina Catita (Professor-FCUL)

9. **Publication/notification of results**: The results of the selection process will be communicated via email to all candidates, and the list of approved applicants will be available at http://idl.ul.pt/node/403. In the case of an unfavorable award decision (i.e. for applicants not selected to receive grants), the applicant has a period of 10 days after disclosure, to be heard by the Selection Committee, by request of a preliminary hearing, following the rules set by the Portuguese "Código do Procedimento Administrativo". The final decision may be appealed to the Directive Board of the FCT, within 15 days after the respective notification.

10. **Deadlines**: This call for applications is open from 04 December 2017 to 5th January 2018

Application: Applications may be sent via e-mail to earthsystems@fc.ul.pt , by attaching the following documents: A CV must include not only the final marks in degrees completed, but also a list of marks in individual courses, and a list of publications if they exist as well as a scan of all the diplomas + certificates. And the motivation letter *other documents considered relevant*

Publication/notification of results: The results of the selection process will be communicated via email to all candidates, and the list of approved applicants will be available at http://idl.ul.pt/node/403. In the case of an unfavorable award decision (i.e. for applicants not selected to receive grants), the applicant has a period of 10 days after disclosure, to be heard by the Selection Committee, by request of a preliminary hearing, following the rules set by the Portuguese "Código do Procedimento Administrativo". The final decision may be appealed to the Directive Board of the FCT, within 15 days after the respective notification.

EARTHSYSTEMS 2018- 1

PhD in Geophysics and Geoinformation Sciences

Azores Current Dynamics

Supervision

Alvaro Peliz (IDL)

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

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(2) Lamas L., A. Peliz, I. Ambar, A Barbosa Aguiar, N Maximenko , A Teles-Machado (2010). Evidence of time-mean cyclonic cell southwest of Iberian Peninsula: The Mediterranean Outflow-driven beta-plume?. Geophysical Research Letters, 37, doi:10.1029/2010GL043339
(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"
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EARTHSYSTEMS 2018- 2

PhD in Geophysics and Geoinformation Sciences/ PhD in Marine Sciences

Modelling the physical mechanisms that drive microalgae proliferations (MoPhy)

Supervision

Alexandra Silva (IPMA), Alvaro Peliz (IDL)

Objectives

The work will be focus on modelling fine-scale coastal processes associated with the evolution and transport of algae proliferations (blooms) – hindcast events, improve resolution of coastal (inshore) processes and understand the physical–biological interactions.

More specific objectives are to understand the nature and evolution of the relevant physical structures and mechanisms driving the transport and evolution of algal proliferations along the Portuguese coast – trigger and development conditions at fine spatial scales. Understand the connection between bloom dynamics (transport and maintenance) and the main modes of atmospheric/oceanographic variability. In detail:

i) Identify and delimit the relevant frontal structures along the south coast of Portugal - Characterize the seasonality and persistence of these structures and the main differences between the western and eastern parts of Algarve;

ii) Determine the impact of the presence and persistence of the northern Gulf of Cadiz inshore counter-current in algal blooms

iii) Identify the main coastal currents and jets associated with bloom transport along the west coast of Portugal – characterize the seasonality, persistence and velocity of these mechanisms.

iv) The influence of frontal structures, eddies, filaments on cross-shore transports and bloom evolution.

Motivation and summary:

Algae proliferations are typically complex phenomena that require examination of the horizontal distribution and vertical accumulation of cells throughout the water column, at appropriate space and time scales. As planktonic-living organisms, microalgae dynamics is primarily linked to the variability of oceanographic mechanisms ruling aquatic systems. Estimating the variability of these physical processes and associate those to relevant harmful events will contribute to the development of forecasting capabilities to warn of impending harmful algal blooms (HABs) in

oceanic/coastal areas (Silva et al., 2016), which have important economical consequences, for example, regarding to aquaculture activities and tourism. The diversity of harmful algae species and their impacts present a significant challenge to those responsible for management of coastal resources and the protection of public health (Anderson et al, 2011). Numerical models of atmospheric-ocean dynamics can supplement the mechanisms that produce blooms by identifying dispersal/concentration processes and regional advection patterns (in particular along the inner shelf). Models have the potential to document long-term patterns and changes in the sea, to detect infrequent events that previously went unobserved, and to make predictions or forecasts about these and other phenomena that directly affect human populations and marine ecosystem (Pinto et al., 2016). Results will greatly improve our ability to provide accurate forecasts of oceanographic and biological events and will contribute to the design and development of a regional model system to support economical activities affected by specific HABs), for example giving location and transport pathways information to the aquaculture industry.

Methodology

Relevant past algae-events will be selected from the National Monitoring Program of HABs database, in order to train the model system and evaluate its performance (good skill at reproducing observations). This will be used to tune the system and move towards an operational model for forecasting events (e.g. cells are introduced as passive particles and bloom transport is then predicted using hydrographic modelling with passive particle-tracking techniques, biological sub-model)

It is suggested to conduct high-resolution process-oriented simulations to address specific questions like the origin, structure and meandering of the physical mechanisms (currents, tides, stratification, river runoff, winds and large-scale forcing from the open ocean), its seasonality and persistence and associated biological interactions.

To develop the modeling system it will be used the Regional Oceanic Modeling System (ROMS)/Weather Research and Forecast (WRF) (Peliz et al., 2013) and Tracmass (Corell et al., 2012). The study will be based on numerical models of different degrees of realism.

The candidate should have a background in physical oceanography or similar field (geophysical sciences, meteorology) and programming skills.

References

Anderson, D M, Cembella, A D and Hallegraeff, G M (2012) Progress in Understanding Harmful Algal Blooms: Paradigm Shifts and New Technologies for Research, Monitoring, and Management. Annu. Rev. Marine. Sci., 4: 143-176.

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EARTHSYSTEMS 2018- 3

PhD in Geophysics and Geoinformation Sciences

Circulation of heat content anomalies in the North Atlantic Ocean in a coupled ocean-atmosphere system

Supervision

Ana Machado and Emanuel Dutra (IDL)

Objectives

- Participate in the development of a climate simulation using the Earth System Model EC-EARTH
- Describe the heat content decadal variability in the North Atlantic Ocean, with especial focus on the subpolar gyre and Eastern North Atlantic
- Study the main drivers of the heat content anomalies, their propagation to remote regions and their impacts on the ocean circulation and atmosphere.

Motivation and summary:

The last decade hiatus in global warming (1,2) and the possibility that oceans may be storing more heat (2) confirms the need for a better understanding of the role of ocean circulation on climate. The subpolar North Atlantic is known to be subjected to strong decadal variability, and the mechanisms driving this variability are not completely understood. Over the last two decades there was a reversal in the climatic trends in the North Atlantic (3), at around 2005 the heat content started to decrease, with a marked cooling observed in the period of 2005 to 2015 (4). This reversal in the trend seems to result from a weaker advection of heat by the ocean circulation and not by anomalous local heat fluxes (4). To better understand the importance of the ocean on the Earth's climate it is essential to understand the mechanisms that lead to the formation of these anomalies and to understand how they propagate and the impacts they have on remote regions.

Methodology

The candidate will mainly work in the development and analysis of a climate simulation using the Earth System Model EC-EARTH at 1º resolution. This simulation will take part of the CMIP6 (5). The performance of the model over the North Atlantic will be analyzed, and its ability to simulate the average circulation, and the development of heat content anomalies in the subpolar gyre and eastern Atlantic.
The pathways of the anomalies will be estimated in the outputs of the model simulation, using adjoint tracer integration to simulate their propagation from the formation regions and/or a lagrangian analysis. Both the adjoint tracer integration and the lagrangian analysis can be initialized on different instants, with opposing anomalies, to infer differences in the propagation.

References

(1) Trenberth, K.E., and J.T. Fasullo (2013): An apparent hiatus in global warming? Earth's Future, 1, 19-32, doi:10.1002/2013EF000165
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EARTHSYSTEMS 2018- 4

PhD in Geophysics and Geoinformation Sciences

Exploiting new satellite observations for improving weather forecast models

Supervision

Emanuel Dutra (IDL), Isabel Trigo (IPMA), René Orth (MPI, Jena)

Abstract

Processes occurring at the land surface are known to have an impact in weather and climate variability in a wide range of timescales, from hours to millennia, making land surface models a required component of both weather and climate prediction systems. Of special relevance is the role of land surface processes involving vegetation and soil water in the amplification of extreme weather and climate anomalies, such as the extreme hot summers in Europe in 2003 and 2010 episodes (Fischer et al. 2007) that, despite their limited duration, may have long lasting effects in natural ecosystems.

Earth Observations (EO) and the advances in retrieval algorithms brought high spatial and temporal resolution observations of key land-surface characteristics such as the land surface temperature (LST). However, the emergence of EO products has not been fully explored by the weather and climate communities to constrain their models. Most of land surface related EO data is used to validate, but not in data assimilation or to constrain and develop models. A clear example is the LST which, despite its quality, is not assimilated in any global operational numerical weather prediction model. This can be partially due to scientific and technical challenges involved in model optimization and data assimilation in complex models, which can imply redesign of the model structure and high computational costs. In the case of the LST, a striking barrier is the large systematic errors amongst models and EO data on the diurnal range in some biomes (e.g. semi-arid).

The primary objective of this work is to address the following question: What is the added value of using EO LST data in model development and data assimilation? The work will be based on two hypotheses:(i) models must represent key processes related to the observed EO variable and (ii) parameter estimation is paramount to constrain the conceptual models. The frontier-research work will use the state-of-the-art European Center for Medium-Range Weather Forecasts (ECMWF) numerical weather prediction model and the EC-EARTH climate model to develop and test the hypotheses presented, together with the newly available Land-SAF EO data.

References

Fischer, E.M., S. Seneviratne, D. Luthi, and C. Schär (2007), Contribution of land-atmosphere coupling to recent European summer heat waves, Geophysical Research Letters, 34(6).

Orth, R., E. Dutra, and F. Pappenberger, 2016: Improving Weather Predictability by Including Land Surface Model Parameter Uncertainty. Monthly Weather Review, 144, 1551-1569.

Orth, R., E. Dutra, I. F. Trigo, and G. Balsamo, 2017: Advancing land surface model development with satellite-based Earth observations. Hydrol. Earth Syst. Sci., 21, 2483-2495.

Trigo, I. F., S. Boussetta, P. Viterbo, G. Balsamo, A. Beljaars, and I. Sandu, 2015: Comparison of model land skin temperature with remotely sensed estimates and assessment of surface-atmosphere coupling. J. Geophys. Res. Atmos., 120, 2015JD023812.

EARTHSYSTEMS 2018- 5

PhD in Geophysics and Geoinformation Sciences

Estimation of meteorological fire danger with use of an ensemble prediction system and data assimilation

Supervision

Ricardo Trigo (IDL), Isabel Trigo (IDL, IPMA)

Abstract

On average, circa 65 thousand fires affect the European Union every year, the vast majority occurring in the southern European countries with a Mediterranean climate. These fires are responsible for burning roughly half a million hectares and leading to estimated annual losses of 2 billion euros (JRC, 2014). Moreover, a few large fires have recently led to unusual high number of deaths and homeless people, further stressing the impact such episodes can still impinge in the developed societies of Western Europe (e.g. more than 60 fatalities in Greece 2007 and Portugal 2017). Multiple indices have been developed with the aim of evaluating fire danger based on meteorological variables. Adopted by EFFIS, the Canadian-based Fire Weather Index (FWI) has shown to be particularly useful to assess fire danger in the Mediterranean region (DaCamara et al. 2014). Forecasts of meteorological fire danger are performed with resource to numerical weather predictions (NWP). However, NWP carries associated uncertainties due to several factors such as uncertainty in the initial conditions and unavoidable simplification in the model equations. The chaotic nature of the atmosphere magnifies these uncertainties, restricting the temporal extent of the NWP. One way to assess the range of the uncertainty is the use of Ensemble Prediction Systems (EPS). The European Centre for Medium-Range Weather Forecasts (ECMWF) EPS is a set of a control plus 50 forecasts initialized with small deviations on the initial conditions and based on a model which is close, but not identical, to the best estimation of the model equations (ECMWF 2012). The spread of the ensemble provides therefore an estimate of the forecast uncertainty. The use of EPS allows to create early warning systems for extreme weather conditions (Legg and Mylne, 2004). Furthermore, in the short-range timescale, the assimilation of observations from ground stations, weather radar and satellite can be used to improve the resolution and accuracy of prior forecasts. We propose to develop of a methodology to estimate the meteorological fire danger with an associated degree of uncertainty provided the meteorological variables uncertainty given by the ECMWF EPS from which a medium-range early warning system for wildfires can be derived. We also aim to test an assimilation system for the region of Portugal to generate state of the art high spatio-temporal resolution forecasts, and to compare its outcome with fire danger based on ensemble forecasts. The approach based on highresolution weather forecasts will include a series of sensitivity studies to test the impact of

assimilating a set of observations (e.g., conventional, ASCAT-winds, ASCAT soil moisture, clear-sky radiances, hyperspectral radiances) on the variables that are most relevant in the assessment of meteorological fire risk, namely near surface wind, air temperature and humidity,

References

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EARTHSYSTEMS 2018- 6

PhD in Geophysics and Geoinformation Sciences

A fire ecological index based on fire-productivity relationship over Mediterranean ecosystems

Supervision

Célia M. Gouveia and Ana Bastos (Laboratoire des Sciences du Climat et de l'Environemment, LSCE, France)

Abstract

Global ecosystems' activity is particularly sensitive to climate variability (Ciais et al., 2003, Gouveia et al., 2008). The regional changes observed in temperature and atmospheric CO2 in recent decades have caused an increase in global Net Primary Productivity (NPP), enhancing CO_2 fixation by vegetation (Nemani et al., 2003), and being associated with the global greening (Zhu et al., 2016). Fire is assumed as the main agent of disturbance in the global terrestrial ecosystems (Bowman et al., 2009), affecting the net carbon balance both directly and indirectly, introducing carbon in the atmosphere from biomass burning (van der Werf et al., 2010) and resulting in decreased photosynthetic capacity and increased emissions from decomposition of dead vegetation (Amiro et al., 2010). The spatio-temporal patterns of fires on a global scale are also related to climate variability, namely the El Niño (LePage et al., 2008) and extreme events at regional scales (Pereira et al., 2005), that affect the regional balance of CO_2 (Bond-Lamberty et al., 2007).
Recent works have pointed that the maximum of fire activity is observed at intermediate levels of aridity/productivity and decreases to arid as well as to productive ecosystems (Pausas & Bradstock, 2007; van der Werf et al., 2008). This feature indicates that in moist and productive regions, fuel is highly available and fire activity may be driven by drought frequency. On the other hand, in less productive and arid ecosystems, fires are fuel limited (Pausas & Bradstock, 2007). Pausas and Ribeiro (2013) analyzed the sensitivity of fire to high temperatures using monthly MODIS fire activity and monthly maximum temperature and showed that while in high-productivity ecosystems fire is more sensitive to high temperatures, in low-productivity ecosystems fire activity is not driven by warm periods, being mainly limited by low biomass. Pausas and Ribeiro (2013) also stressed that fire activity in arid ecosystems should be less sensitive to warning and more sensitive to fuel. The increase in fuel may be linked with changes in land use and management and withthe increased efficiency of photosynthesis under higher atmospheric CO2 concentrations. Gouveia et al. (2012) performed an analysis of vegetation dynamics and fire selectivity during the extreme drought year of 2005 in Iberian Peninsula and they also showed that fires tended to occur in pixels presenting lower vegetative and water stress conditions during spring and early summer months, stressing the role of fuel availability in fire occurrence and impact on the Iberia. Additionally, a vegetation condition assessment, based on 30

years of NDVI over Iberia performed by Gouveia et al. (2016), suggested a widespread land improvement with few hot spots of land degradation.
The emergence of new remote-sensing platforms, sensors and satellites has motivated remarkable efforts to develop more sophisticated methods and algorithms for increasingly diverse uses. Several currently available remote sensing datasets allow deriving vegetation productivity. Currently one of the most relevant Net Primary Production (NPP) database corresponds to the GPP/NPP MODIS product (MODIS17) covering the period from 2000 to present at annual basis. Additionally, Dry Matter Productivity (DMP) represents the overall growth rate or dry biomass increase of the vegetation, expressed in kgDM/ha/day. DMP is directly related to NPP (in $gC/m^2/day$) but its units are customized for agro-statistical purposes. It is possible to scale DMP to NPP following a single equation (Atjay et al., 1979). DMP was produced since 1999 using SPOT/VEGETATION with 1km spatial resolution and since June 2014 is produced using PROBA-V with 300m spatial resolution on a decadal basis. Presently, the Land Surface Analysis Satellite Applications Facility (LSA SAF) is developing a new product for Gross Primary Production (GPP) based on Meteosat Second Generation (MSG) data at a decadal basis.
The motivation behind this work is to develop a new fire ecological index (FEI) based on satellite data that integrates information about both vegetation productivity and climate variables with impact on soil conditions, namely using land surface temperature (LST) and Evapotranspiration (ET). Fire prediction based on accumulated biomass could be part of pre-fire-season suppression strategies, allowing fire managers to take proactive actions towards areas that are most likely to be affected by fire (e.g. thinning, litter removal). Therefore, this new index is expected to present an add value when integrated in fire risk models.
In this project the NPP MODIS algorithm will be adapted to LSA SAF GPP in order to develop a new NPP database for Mediterranean Europe (NPP LSA-SAF). This dataset will be compared with the available datasets (MODIS and PROBA-V). Fire Active data from VIIRS and MSG will be used to characterize fire activity. Fire Radiative Power will be used with the aim to characterize fire intensity. The relation between fire activity and vegetation productivity will be assessed using NPP-MODIS, DMP-PROBA-V and NPP-LSA-SAF. The impacts of temperature and water demand during spring and summer months on vegetation productivity will also be assessed for the main biomes to identify areas with different pyro-geography and fire drivers. For specific biomes and based on the obtained relationships a new fire ecological index will be developed. The FEI will be validated using information from key severe fire seasons in recent records, namely 2003 and 2017 in Portugal and 2007 in Greece, among others.

References

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EARTHSYSTEMS 2018- 7

PhD in Geophysics and Geoinformation Sciences

Assessing Fire Meteorological Danger in forested areas of Mozambique

Supervision

Carlos C. DaCamara (IDL), José M. C. Pereira (ISA, University of Lisbon)

Abstract

Linking climate, humans and vegetation, fire is a phenomenon whose activity is conditioned by natural and anthropogenic factors (LePage et al. 2008). Natural factors include topography, vegetation cover and prevailing weather conditions, which are linked to several atmospheric mechanisms working at different temporal and spatial scales (Pereira et al. 2005; Trigo et al. 2006). The ignition and spread of wildfires is in turn related to the local and daily scales, in particular to extreme weather conditions (DaCamara et al. 2014; Trigo et al. 2016).

The aim of the work to be performed is to model meteorological fire danger in order to reduce the prevalence of fire in plantations, natural forests and inhabited areas of the Zambezia Province of Mozambique. The work will comprise the following three main activities: 1) characterizing the fire regime and the effect of climate on fire risk; 2) developing models of meteorological fire danger; and 3) contributing to setting up a system to disseminate information about fire activity and meteorological fire danger.

Historical information about active fires and burned areas as obtained from satellite will be used to characterize fire regimes and uncover relationships between fire regime and climate, vegetation and social factors (Pereira et al. 1999; Amraoui et al. 2013; Pereira et al. 2015). The role of meteorological conditions on fire occurrences will be disclosed by means of composite analysis of relevant variables over periods characterized by anomalous positive or negative fire activity (i.e. severe and mild years). Differences between composites will be analyzed in terms of changes in susceptibility of vegetation to fire (Amraoui et al. 2015). Finally, the roles of long- and short-term components on fire meteorological danger will be assessed by developing statistical models of the spatial and temporal distributions of fire activity and burned areas (Pereira et al. 2013; Sousa et al. 2015; Silva et al. 2016).

Developed models will then form the basis of a system to assess meteorological fire danger in Mozambique. The system will be incorporated in a website designed to provide the user community with relevant real-time information on fire activity and meteorological fire danger in Mozambique that will allow adopting the adequate measures to mitigate fire damage.

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EARTHSYSTEMS 2018- 8

PhD in Geophysics and Geoinformation Sciences

Convective phenomena at high resolution over Europe and the Mediterranean

Supervision

Pedro M M Soares (IDL), Christoph Schär (ETH)

Part of the proposed work may be done at ETH, Zurich, Switzerland.

Abstract

In Europe and in the Mediterranean, severe weather events are frequently related with extreme convective precipitation (Ducrocq et al. 2014). Convection may occur over homogeneous plains, orographic regions and in response to land/sea or urban/rural contrasts. The consequences of extreme convection are diverse, from heavy rainfall, flash floods, short-lived windstorms to hail or lightnings. Some studies point out to a significant increase of convective activity and extreme precipitation due to climate change (Kendon et al 2014; Soares et al 2017). In a changing climate our main tools for understanding the future evolution of the climate system, in response to the increasing concentrations of greenhouse gases, are global and regional climate models. Global Climate Models (GCMs) are able to simulate the global circulation of the atmosphere and ocean, their decadal to centennial variability, and also to reproduce synoptic scale weather (Randall *et al.* 2007). Yet, GCMs reveal deficiencies when representing sub-grid scale processes, namely, convection and surface-atmosphere-ocean interactions, which greatly modulate the regional and local climates. Regional climate models (RCMs) constitute an increasingly sophisticated method to overcome these limitations, since they are able to capture physically consistent regional and local circulations (Giorgi and Mearns 1991; Laprise 2008; Soares et al. 2012; Soares et al. 2017). In the last decade, the RCM resolutions used for large simulation domains, often encompassing full continents, have increased greatly. Example of this evolution, is the increase from the 50km used in the PRUDENCE project covering Europe to the 25km of ENSEMBLES and the 0.11^{o} of the World Climate Research Program Coordinated Regional Downscaling Experiment (CORDEX) over Europe. In fact, the EURO-CORDEX, sub-set of CORDEX, comprehends the largest set of RCM simulations over a continent (Europe) at two resolutions, a coarser at 0.44^{o} and a finer at 0.11^{o}. The EURO-CORDEX simulations have recently started to be extensively evaluated (Kotlarski et al. 2014; Prein et al. 2016; Soares et al. 2017). These evaluations showed important gains but also no added value was identified for specific variables and regions.

Motivated by model's shortcomings related to the use of physical parameterizations, namely for convection, and enabled by the increasing computational power available, a number of modelling exercises within the so-called convection-permitting regime are emerging (e.g. Ban et al. 2014).

Commonly, these studies show promising results regarding the diurnal cycle of precipitation, the sub-daily precipitation and extremes. This is decidedly relevant in regions of complex orography or surface heterogeneous areas (urban) where precipitation is highly convective.

Recently, the Flagship Pilot Study "Convective phenomena at high resolution over Europe and the Mediterranean" was approved as an initiative supported by the WCRP CORDEX and GEWEX-GASS international program. In its framework, an unprecedented number of convective permitting simulations will be performed covering a common European domain. IDL will contribute to this effort performing the compliant simulations and participating in the diverse packages devoted to the detailed analysis of the simulations. The current PhD proposal wants to be at the core of the Flagship proposal. The general aim of the PhD is to investigate present and future convective extremes, and the related processes using the results of the models at a convection permitting resolution over selected sub-regions of Europe and the Mediterranean. The PhD will be focused in: 1) a detailed physical-processes analysis of the convective systems, 2) the study of the transition from shallow to deep convection over land, 3) the analysis of the diurnal cycle of convection and precipitation, 4) the characterization of the added value of the Flagship simulations, and 5) investigate future convective extremes.

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EARTHSYSTEMS 2018- 9

PhD in Geophysics and Geoinformation Sciences

European Precipitation in a changing climate: a broader view through multi-climate models and multi-statistical methods

Supervision

Pedro M.M. Soares (IDL), Ricardo Trigo (IDL) and Douglas Maraun (University of Graz)

Part of the proposed work may be done at University of Graz, Austria.

Abstract

Multi-model ensembles are increasingly used for climate change assessment, from global (IPCC 2013) to regional scales (Cardoso et al 2013, Soares et al 2015, Soares et al 2017, Christensen and Christensen 2007; van der Linden and Mitchell 2009). Regional Climate Model (RCM) ensembles enable the understanding and characterization of uncertainties, which have different origins, and thus increase confidence in future projections (Hawkins and Sutton 2009). Useful information at the local and regional scales under climate change scenarios can also be obtained by combining statistical downscaling (SD) with the output from global climate models (GCMs) or from RCMs (Fowler et al 2007; Maraun et al 2010; Maraun et al 2017). Nevertheless, important issues arise: 1) the distinction between the GCMs and the RCMs errors, 2) the selection and weighting of ensemble members for climate change assessment, 3) the eventual drawbacks associated with the different RCM performance and the observed relationships, which may not persist, and in a changing climate, 3) the suitability of bias correction methods to downscale climate model results for impact studies.

The PhD proposal will use state-of-the art dynamical and statistical downscaling approaches and focus on the following core problems:

(1) The evaluation of downscaling approaches is crucial in order to understand and potentially reduce uncertainties. This evaluation will be focused in the representation of relevant physical processes, significant to the hydrological cycle, from synoptic scale circulations to land surface interactions.

(3) A key requirement for regional climate change scenarios is the correct representation of climate change trends. Depending on the variable considered and region of the globe assessed, internal climate variability might completely mask climate change trends until the mid.21st century (Deser et al, 2012; Maraun, 2013b). Therefore, the representation of recent observed trends by GCMs and RCMs will be analysed, in addition to the detection of the temporal horizons for which random climate fluctuations preclude the provision of robust climate change information.

(4) A comparison of GCMs and RCMs/SDs will provide new insight into the added value by the latter methods. This added value assessment will be based on both process analysis and surface statistics to characterize the quality of RCMs/SDs to describe all relevant parameters of the precipitation distribution, including the mean and variability but with particular emphasis on

higher percentiles and extreme values. This will allow to assess the added value of downscaling to correctly represent local/regional trends, and equally important, to disentangle effects of internal variability from forced trends.
(5) The development of a novel statistical approach for spatially coherent downscaling of European precipitation, since many hydrological models require input with the correct spatial structure across the catchment. The multi-site statistical downscaling limitations will be analysed, and alternatives based on emerging network-based approaches will be explored. The probabilistic network models are suitable for building multi-site and multi-variable downscaling methods by jointly modelling both large-scale predictors and predictands, and assess uncertainty.
This proposal will contribute to describe the mechanisms associated to mean and extreme precipitation in present and future climates over Europe, and to disentangle the overload of information from multiple downscaling and multiple climate simulations and provide useful precipitation information for climate change assessment studies for many sectors (hydrology, energy, agriculture, forest, etc). It will use results from the EURO and MED-CORDEX RCMs and from the online statistical downscaling portal that has recently been provided by the VALUE COST action (http://www.value-cost.eu).

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EARTHSYSTEMS 2018- 10

PhD in Geophysics and Geoinformation Sciences

Land-Atmosphere-ocean in West African eastern boundary current system - coupled global to regional modelling

Supervision

Rita M Cardoso (IDL), Pedro MM Soares (IDL), Álvaro Semedo

Part of the proposed work may be done at IHE Delft Institute for Water Education, Netherlands.

Abstract

The ocean circulations called “eastern ocean boundary currents” (Iberia-Canaries and Benguela in the Atlantic) play an important role in the regional and global climate systems through enhanced land-atmosphere-ocean interactions. Eastern ocean boundary currents are cold equatorward ocean currents, located along the eastern flank of the ocean gyres, which transport cold water into the subtropical areas, contributing to the redistribution of heat between high and low latitudes. In summer, the contrast between the cold oceanic waters and the warm land is intensified through atmosphere-ocean interactions and the synoptically driven equatorward along coast winds are responsible for upwelling processes, resulting in lower sea surface temperatures (SSTs) at the coast. These lower SSTs increase the thermal contrast between the ocean and land that are responsible for baroclinic structures at the coast that drive coastal low-level jets (CLLJ) and low inland moisture transport (Soares et al. 2014; Semedo et al. 2016). Often the presence of coastal topography further enhances this process. In southwestern Africa, the Benguela upwelling regime on the western coastal areas of South Africa, Namibia and Angola is one of such systems and are within the driest and most arid areas of the planet (Warner 2004). Potential changes in this upwelling regime under climate change will be of crucial importance to ocean productivity and fisheries along these coastal areas. Moreover, the rich biodiversity of the Namib Desert depends largely on the inland penetration of fog as a source of water, and the formation of such fog events in turn depend on the location of upwelling patterns. High-resolution and coupled Regional Climate Models (RCMs) are needed to project the effects of regional climate change on the prevailing southeasterlies that blow along the west coast of southern Africa, and to understand how such changes may impact on the formation of upwelling zones and fog. In fact, the more realistic simulation of African west-coast upwelling may be important towards reducing the significant biases most Global Climate Models (GCMs) exhibit in simulating SSTs along the African west coast.
The dominating biome in Southwestern Africa is the African savannahs, where complex tree-grass interactions are shaped by fire and land-use. It is believed that under future climate change rising CO2 levels and increasing temperatures may favor trees over grassed in the savannah, leading to bush encroachment at the expense of biodiversity and grazing potential. Moreover, land use/land cover change (LUC) has been recognised as a main driving force of regional and global climate

change (Pielke et al 2011, Mahmood et al 2014), modifying locally land surface properties (e.g., surface albedo, Bowen ratio, and roughness) that control the land-atmosphere mass, energy and momentum exchanges. The impact of these changes depends on the scale and nature of land cover changes. However, the influence of this change in climate is still relatively unknown (Davin et al 2008). Ducroudré et al (2012) observed that, for a number of variables, LUC has an impact of similar magnitude but of an opposite sign, to increased greenhouse gases and warmer oceans.
This proposal aims at robustly identify the magnitude of the contributions due to the variety of feedbacks between the coupled land-atmosphere-ocean system in southern Africa, including LUC. The last generation of global climate simulations contributing to CMIP6 will be evaluated against observations, focusing on water and energy land/atmosphere fluxes, and common atmospheric variables. These will serve as boundary conditions for coupled RCM simulations over southwestern Africa. The high-resolution RCM results will include LUC for the historical and future simulations. Additionally, the RCM simulation results will provide scenarios for the location and strength of the upwelling and coastal circulations as well as the magnitude of the changes in biomass.The current proposal will be part of the inter-comparison efforts linked to the Flagship Pilot Study “Coupled regional modelling of land-atmosphere-ocean interactions over western-southern Africa under climate change” an initiative supported by the WCRP CORDEX and GEWEX-GASS international program.

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EARTHSYSTEMS 2018- 11

PhD in Geophysics and Geoinformation Sciences

Estimation of forest vertical structure from multifrequency dual-pol polarimetric SAR interferometry.

Supervision

João Catalão (IDL), Giovanni Nico (IAC-CNR, Bari)

Part of the proposed work will be done at IAC-CNR, Bari.

Abstract

Accurate estimation of forest parameters such as the total vegetation biomass, tree height or vertical structure in global scale has long been an important goal within the remote sensing community (Sarabandi and Lin, 2000). Recent improvements on radar microwave remote sensing with new polarimetric missions operating in X, C and L bands, and upcoming P-band BIOMASS mission, bring new insights to the radar remote sensing of vegetation.

The interferometric decorrelation in vegetated land surfaces has been recognized as an opportunity to measure vegetation depth and extinction. The combination of interferometry with polarimetry enhances the estimation of the vertical structure by providing additional degrees of freedom (Neuman et al., 2010). Papathanassiou and Cloude (2001) proposed an approach based on interferometric coherence using the random volume over ground scattering model to infer forest height and ground topography. These authors have considered a parameter that accounts for attenuation through the volume and is a function of the extinction coefficient and the random volume thickness. The major problem affecting this approach is the loss of interferometric coherence with time due to temporal decorrelation affecting more severely higher frequencies (C band). In fact, microwave higher frequencies (X and C bands) are highly sensitive to the dielectric properties of the scattering objects that makes them useless for monitoring the forest. Nevertheless, Santoro et al. (2011) have demonstrated that estimates of forest GSV (growing stock volume) can be retrieved from C-band if a large stack of SAR images is available. This is no longer a limitation, as long as Sentinel-1 mission has a 6 days revisiting time. The availability of high temporal resolution C-band SAR data contributes to enhance the data quality by significantly reducing the speckle and improving the interferometric coherence. This allow the exploitation of pixel-based approaches, with improved spatial resolution at the parcel level rather than at regional level.

In this study the forest vertical structure and biomass estimates will be evaluated for high temporal and high spatial resolution C band SAR acquired from Sentinel1A/B by assessing the accuracy of structure and biomass estimates over a variety of vegetated land surfaces as montado, sparse forest or dense forest. In order to sample a diversity of vegetated land surfaces we will combine the

structure estimation with field work at Companhia das Lezirias where soil moisture sensors are already installed and tree height and biodiversity measures have been made in the past 20 years in 15 spot areas of 1ha each.

The algorithm to develop in this study are based on coherent tomography approach proposed by Cloude and Papathanassiou (2008), that will be fine-tuned to include dual-pol polarimetric data acquired by Sentinel-1A/B and TerraSAR-X and Quad-pol SAR data acquired by ALOS PALSAR. Furthermore, the use of interferometric coherence as a means to estimate the canopy volume will be investigated (Koskinen et al. 2001). The use of Tandem TerraSAR-X and ping-pong Cosmo-Sky-Med SAR images, both in X band, will be investigated as a means to reduce the impact of interferometric coherence on the estimation of vegetation parameters. The algorithm will be tested and evaluated over local scales for the purpose of detailed refinement and further upscale to swath -wide scales.

The specific objectives of the proposed study are: a) Combine SAR interferometry and polarimetry for estimating the vertical structure of vegetated surfaces; b) Evaluate the use of ancillary data such as canopy laser altimeter for enhancement or validation of the parameter estimation, c) Develop forest models based on interferometric coherence information to discriminate ground and forest canopy contributions; d) Map vegetation height through the combined use of multi-frequency SAR interferometry and polarimetry.

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PD F
FCT PhD
PROGRAMMES

EARTHSYSTEMS 2018- 12

PhD in Geophysics and Geoinformation Sciences

Visualization and extraction of geophysical information from Earth Observation data using data science techniques

Supervision

João Catalão (IDL), Giovanni Nico (IAC-CNR, Bari), Marco Quartulli (Vicomtech, San Sebastian)

Part of the proposed work will be done at IAC-CNR, Bari and Vicomtech, San Sebastian)

Abstract

The huge amount of Earth Observation (EO) data currently acquired by the European Space Agency and other National Space Agencies is requiring new tools for the visualization of information and the synergetic survey of data and opening new perspectives on the use falsification/validation of current theories about different phenomena occurring on land, atmosphere and oceans. As a further approach, theory could be built starting in a data-driven way. In both cases, data science techniques are needed for the advanced statistical analysis of multidimensional data and the definition of features to be used in the retrieval and survey of the information. The aim of these research topic is to develop statistical tool for data visualization and analytics, as well as for the mining of huge databases containing both EO data, model output and ancillary information. Three application domains will be explored, atmosphere for the study weather events (with emphasis on extreme ones not correctly forecast by Numerical Weather Models), oceans (with emphasis on sea surface heights, temperatures, salinity, wave currents and relevant information for climate studies), and land (with emphasis on different geological phenomena causing terrain deformation).

The specific objectives of the proposed study are: a) define and extract statistical features from Sentinel-1/2/3 data (also using other EO data), in-situ measurements and relevant numerical models; b) develop algorithms for data mining, analytics and visualization based on statistical features; c) build a database of EO data, in-situ data and models for one or more application.

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EARTHSYSTEMS 2018- 13

PhD in Geophysics and Geoinformation Sciences

Seismicity and structure of the Monchique Alkaline Complex, Southwest Portugal

Supervision

Marta Neres (IDL, IPMA), Susana Custódio (FCUL, IDL), Pedro Terrinha (IPMA, IDL)

Abstract

The Monchique Alkaline Magmatic Complex (MAC) in SW Portugal is a well-exposed alkaline complex (syenites, gabbros, dykes and breccias) belonging to the Late Cretaceous magmatic province of West Iberia (72.7 ± 2.7 Ma). It emplaced in the Paleozoic metamorphic basement (Miranda et al, 2009), and isotope and mineral studies show that it originated from sub-lithospheric magma extraction.

The development of the seismic network during the last two decades showed that the most active cluster of earthquakes in West Iberia is located under Monchique, comprising 12% of all earthquakes recorded between 1996 and 2013 (1802 out of 12 726 events) by the mainland seismic network. These earthquakes usually have very low magnitudes (<2) (Custódio et al, 2015). The causes of this active seismicity have not yet been directly addressed. The proximity to the plate boundary and the fact that the intrusion–host rock boundary represents a rheological contrast are usually argued to be important factors. This project will address the following questions:

- What is the sub-surface structure of the Monchique intrusion?
- What is the role of structures inherited from the magmatic emplacement or from later deformation in the localization and dynamics of earthquakes?
- Is there a relationship between the recorded seismicity and the emission of noble gases (radon)?

The project includes field, laboratory and computational work, enabling the acquisition of competences on different geophysical methods. The PhD candidate will be involved in several multi-disciplinary tasks, and the main focus of the work plan may be adapted depending on his/her interest and background. The results are expected to be published in ISI journals, including a final joint and regional interpretation of all acquired data. The main tasks to be accomplished are the following:

Terrestrial magnetic and gravimetric data:

- Acquisition and processing of magnetic and gravimetric data covering the Monchique intrusion and surrounding region.
- Mapping of magnetic and gravimetric anomalies of the surveyed area and structural interpretation (e.g. magmatic zonation, identification of faults).
- 2D and 3D modeling of the sub-surface structure of the Monchique intrusion, constrained by magnetic and gravimetric data (e.g. Portal et al. 2016).

Marine magnetic data:

- Processing and interpretation of offshore magnetic data recently acquired along the SW coast of Portugal.
- Integration of these new data with data from previous surveys (e.g. Neres et al, 2016) to cast light into the possibility of a structural link between Monchique and other large magmatic intrusions of similar age, namely Sines and Sintra magmatic complexes, and the recently studied offshore Guadalquivir intrusion (Neres et al., submitted).

Anisotropy of magnetic susceptibility:

- Field sampling for anisotropy of magnetic susceptibility (AMS) analyses aiming at inferring the magma flow and emplacement of the Monchique complex as done for other intrusions on the west Portuguese coast (e.g. Neres et al, 2014).

Seismic data:

- Processing of existing seismic data for the calculation of focal mechanisms and for the study of the spatio-temporal clustering of earthquakes using advanced methodologies (Custódio et al., 2015).
- Participation in the deployment of a dense seismic network, for acquisition of high-resolution seismic data, which will allow the development of tomographic studies, in collaboration with IDL and IPMA.

Soil emission of noble gases:

- Investigation of a possible relationship between the emission of noble gases (in particular radon) and seismicity (e.g. Ghosh et al, 2009).

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EARTHSYSTEMS 2018- 14

PhD in Geophysics and Geioinformation Systems

Late Pleistocene continental shelf evolution and tsunami records on the south Portuguese continental shelf

Supervision

Maria Ana Baptista (IDL, FCUL, ISEL), Teresa Drago (IDL, IPMA), Pedro Silva (IDL, ISEL)

Abstract

The identification of high-energy deposits associated with tsunami events is crucial to assess paleoseismology, tsunami hazard, and processes of sedimentation. Despite much has been learned through instrumental and historical records of tsunamis, is still necessary to improve our understanding of tsunamis effects, their recurrence and magnitude to mitigate the hazards from future tsunamis (e.g., Baptista and Miranda, 2009). Accordingly, it is mandatory to go further back in the temporal window, which is only possible by sedimentary record study.

Common for all the tsunami-induced deposits are the characteristic properties of “event deposits”, i.e., episodic occurrence and unusually high-energetic transport processes compared to the autochthonous background deposition. The recognition of palaeotsunami deposits and reconstruction of the generating events depends solely on the interpretation of the sedimentary record, based upon a group of textural, paleontological, magnetic and geochemical data that has been used by many authors over recent years.

Concerning the Iberian margin, many onshore studies on tsunami deposits have been published since the 1990s, while in the offshore zones or in shallow-shelf areas the studies are recognized to be scarce (Dawson & Stewart, 2007; Chagué-Goff *et al.*, 2017).

Despite the ability of continental shelf sediments in providing more continuous records than continental records, the identification of tsunami deposits in marine environments is an interesting scientific challenge. Sedimentary hiatus promoted by the removal of the superficial layers by tsunami waves, abrupt increase of the terrigenous inputs brought by the backwash waves (e.g. Abrantes *et al.*, 2008) and diagenesis, are some of the mechanical and chemical processes that should be taken into account. Therefore, when searching for tsunamigenic layers is necessary to look for abrupt changes of the sedimentary regime as for the existence of anomalous sedimentological, magnetic and geochemical signatures in the sedimentary record regarding the existence of allochthonous sediment.

In the ambit of this purpose, were already collected several gravity cores in the southern Portuguese continental shelf and conducted several analyses, namely, grain-size, carbonates, organic matter, magnetic parameters, geochemical and dating (Silva et al., 2013; Lopes et al., 2015; Drago et al., 2016). Results allowed the identification of "anomalous levels" but a further step must be taken with major and better existing data exploitation, complemented by new data, as X-ray, computed tomography scanning and sand mineralogical composition detailed analysis.
Accordingly, this project intends to: 1) identify and characterize sedimentary levels associated to high-energy events; 2) determine their periodicity, 3) place them in the continental shelf environmental evolution, and 4) evaluate the effects of post-event sedimentary recover and the post-depositional sedimentary changes. With this PhD project, the student will gain valuable skills in various areas of the Earth Sciences and will benefit from a very considerable data series (obtained during ASTARTE FP7- European project) beyond the instrumental facilities of IDL (Lisbon) and IPMA (Lisbon and Tavira).

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PD F
FCT PhD
PROGRAMMES

EARTHSYSTEMS 2018- 15

PhD in Geology

Long-lived, granite-related ore systems: what factors rule the development of distinct mineral assemblages and/or contrasting grades?

Supervision

António Mateus (FCUL, IDL)

Abstract

Granite-related mineral deposits are a major global resource for a large number of elements, some of them playing a crucial role in advanced technological solutions, but also considered critical in face of the envisaged supply risks. Deposits that form part of the granite-related ore systems include lodes, breccias and skarns enriched in W-Sn-F(-P)-bearing mineral associations, besides pegmatite-hosted mineral assemblages incorporating Li-Cs-Be-Ta(-P) and/or Nb-Y-F(-Sn). Numerous examples of such deposits exist in the Central-Iberian Zone, forming a world-class province that comprises several well-defined belts where different mineralization styles coexist. However, many aspects supporting the links between the mineralized structures, their multiphase mineral infillings and relation to magma-derived fluid components are poorly understood. In addition, little is known about the behavior of many of the ore-forming elements during partial melting of crustal rocks to form granitic magmas; is it the composition of the starting materials, the melting conditions, or segregation processes that rule the redistribution of the ore-forming elements as melts form? So, the search for linkages between granite melts composition/evolution and mineralization types (including valuable co- or byproducts, besides the prevailing element association), as well as for the adequate conditions to sustain long-lived magmatic-hydrothermal systems, must continue. Also of most interest to mineral exploration endeavors are: (i) why some granite systems are heavily mineralized whilst other nearby and apparently similar systems host no more than faint mineralization or are barren; (ii) whether any aspects (mineral/textural, chemical, structural) of outcropping granites can be used to predict the presence of concealed mineralization; and (iii) which attributes and/or factors should be considered to infer which mineralization types and what grades may be present. The identified knowledge gaps will be addressed through detailed assessment of the available geological and geochemical information, complemented by field-work and sampling of selected mineralized and barren systems, and their parent granites, distributed throughout the Segura-Góis belt (Central-Iberian Zone). The existent geological and geochemical data will be reprocessed and reinterpreted, following the procedures already tested for the Panasqueira area [1]. New field data will complete the existing information to pursue an integrated geological interpretation of the entire belt on the basis of harmonized criteria. Collected samples will be comprehensively characterized in terms of their mineral textures and

compositions, as well as multi-element geochemistry; the analytical work will be undertaken using various facilities, including at least electron microprobe, (micro-)XRD, XRF and ICP-MS.

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EARTHSYSTEMS 2018- 16

PhD in Geology

Relating petrogenesis and duration of magmatism with mineralization in the Neves-Corvo VMS deposit (Iberian Pyrite Belt)

Supervision

Jorge Relvas (IDL), Rita Solá (LNEG)

Motivation

The Iberian Pyrite Belt (IPB) is one of the largest volcanogenic massive sulphide provinces in the world and includes giant world class volcanic-hosted massive sulphide (VMS) deposits such as Neves-Corvo, currently in operation for Cu, Zn and Pb. The deposit, with seven massive orebodies hosted in a volcanic sedimentary complex (VSC) has in some places, unusually high Cu and Sn contents.

The orebodies occur mainly at the top of the lower VSC sequence, either in the felsic volcanic rocks or in the black shales, suggesting a strong genetic relationship between ore-forming process and the volcanic activity. However, relationships between volcanism and VMS genesis in the IPB are still a matter of debate (e.g. Valenzuela et al., 2011 and references therein).

The particular geochemical characteristics of mineralization in Neves-Corvo, namely the Sn and Cu enrichments and late anomalous Cu-enrichment, imply the involvement of additional metal sources possibly magmatic, in the ore-forming system that took place at different times, under different thermochemical constraints (e.g. Gaspar, 2002; Relvas et al., 2006).

The available zircon U-Pb ages suggest that felsic magmatism associated with the Neves-Corvo VMS deposit lasted for at least 14 Ma with two distinct volcanic events with a small gap between them (e.g., Albardeiro et al., 2017). The mineralization is considered an episodic event coincident with the older volcanic event (~360 Ma) and the palinological age of enclosed black shales (Late Strunian miospore biozone LN, 360.7 ± 0.7 Ma -362 Ma, Matos et al., 2011 and references therein). The possible metalogenetic relationship of the younger volcanic activity (~350 Ma) with mineralization is unclear.

Therefore an approach relating the nature and age of magmatism linked with geochemical characteristics of the mineralization in Neves-Corvo will be particularly relevant for ongoing and future massive sulphide ore exploration because VMS deposits and related hydrothermal systems are generally coeval and coincident with primarily felsic volcanic sequences.

Objectives

i) Determine the time-span of volcanism in Neves-Corvo related with mineralization;

ii) Improve detail stratigraphic correlations at local scale within the sulfide mineralization (massive ore lenses and stockworks);

iii) Characterise the mineralization, namely the Sn and Cu enrichment and late anomalous Cu-enrichment and try to link the different thermochemical constraints of ores, with a specific volcanic event/episode;

iv) Characterise the metal sources (likely magmatic) in the ore-forming system throughout time;

v) Contribute to the scientific research and knowledge base of VMS deposits and evaluate the potential of new sulphide ore deposits of the mining region of Neves-Corvo.

Workplan

a) Field work and sampling – It will be focused on drill hole logging to be undertaken in key-areas of ore bodies, where the main goals will be the detailed characterisation of the VSC facies, hydrothermal alteration zonation and mineralized structures and tectonic features. This approach will sustain the correct rock sampling programs for geochronology, petrography, and lithogeochemistry studies.

b) VMS characterization- It has a multidisciplinary approach, and pretends to characterise physical aspects of volcanism closely related with massive sulphides (e.g. proximal vs distal, effusive vs explosive, volcanic facies: breccias, hyaloclastites, etc.), petrographic and geochemical features of sampled volcanics, as well as, to characterise specific ore mineralized rocks by paragenesis determination and microanalyses and isotopic studies.

c) U-Pb zircon ages and isotopic studies (e.g. Hf in zircon) of selected sampled volcanic rocks in key-areas in order to define primary ages. Information of inherited zircon ages, if available, will give information about the age and nature of the sources.

d) Interactive modelling studies integrating available geological, geophysical and geochemical data for definition and constraint of chronostratigraphic horizons and geological-structural models favourable to the massive sulphide mineralisation prospect.

This work will be developed close together with the EXPLORA project (LNEG) research team in cooperation with SOMINCOR – Lundin Mining since 2016.

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EARTHSYSTEMS 2018- 17

PhD in Geology

Deciphering the geochemical and mineralogical mechanisms of dolomitization processes in sedimentary and metassomatic environments

Supervision

Mário A. Gonçalves (FCUL/IDL), José Mirão (UÉvora/HERCULES Lab)

HERCULES Lab will provide complementary access to experimental facilities.

Abstract

The formation of primary dolomite as opposed to the dolomitization of calcium carbonates is still a major conundrum for the understanding of Earth processes, especially regarding the global sedimentary Mg budget as revealed by the lack of significant sedimentary dolomites is the geological record in the last tens of million years. This gave rise to the well-known “dolomite problem”, but to this day experimental approaches have systematically failed in precipitating dolomite at ambient conditions, unless some very specific conditions are met which seldom exist in nature[1,2]. The unsuccessful attempts to crystallize dolomite is often attributed to kinetic factors, while for calcites there is a limited incorporation of Mg in their structure, depending on Mg activity[1]. However, there is also ample geological evidence that dolomites are the result of late replacement mechanisms whose details are debatable, including the now much accepted coupled dissolution precipitation mechanism with porosity generation.[3,4,5] As a matter of fact, the molar volume of the reaction that substitutes calcite by dolomite is negative, and thus dolomites are important in the characterization of the porosity in carbonate reservoirs, with implications for the evolution of sedimentary basins including their suitability as hosts for hydrothermal ore deposits generated by basin-scale hydrodynamics and fluid flow.

The proposed theme addresses the problem by choosing two distinct environments with known dolomitization processes: the Lusitanian Basin (LB), a thick (circa 5 km deep) Mesozoic sedimentary sequence developed after the first stages of the opening of the Atlantic, and Paleozoic dolomitized marbles associated with metavolcanic rocks in the Ossa Morena Zone (OMZ). Recently, it has been demonstrated that dolomitic rocks in the LB have a rather complex history with frequent dedolomitization reactions, posing other challenges like the fate of Mg[6]. For this purpose, dolomitization fronts will be sampled and differentiated as being diagenetic, associated to faults, or due to metassomatism. These environments will be mineralogically studied in detail and microscopically characterized at the interfaces, combined with a careful characterization of their chemical signatures, especially trace elements and including stable isotopes, to pinpoint their differences and elucidate on their mechanisms of formation. Therefore, this project will involve

the use of electron microscopy techniques (Env-SEM with EDS and Electron Microprobe), micro x-ray diffraction, LA-ICP-MS, micro-FTIR, and IR Mass Spectrometry. Additional techniques may be used, depending on results and need for deepening of the problem.

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EARTHSYSTEMS 2018- 18

PhD in Geology

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

Supervision

Mário A. Gonçalves and Manuel Prieto (U Oviedo)

Part of the work will be developed in the U Oviedo.

Abstract

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.[1] 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.[2] 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.

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.[3] 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,[4] 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.[5-7] 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).

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EARTHSYSTEMS 2018- 19

PhD in Geology

The role of successive contractional and extensional deformation events in the structural evolution of the continental crust: the natural example of the Évora Massif (Iberian Variscan belt).

Supervision

Ícaro Dias da Silva (IDL), Manuel Francisco Pereira (IDL), José Brandão Silva (IDL)

Abstract

Significant progress is being made in the research of orogenic contractional and extensional tectonics in the Iberian Variscan belt (Martínez Catalán et al., 2014; Díez Fernández et al., 2016; Díez Fernández and Pereira, 2016; Dias da Silva et al., 2017). However, many doubts continue to exist and more studies are needed in domains where data collection is facilitated by the good quality of outcrops, like the Évora Massif (EM) located in the Ossa-Morena Zone (Iberian Variscan belt).

The aim of this proposal is to study the interplay of successive contractional and extensional deformation events that are recorded in a domain of the EM that is still little known. The work plan to be carried out in a key-area of the EM will be complementary to the activities plan of a post-doc fellowship in progress (Ícaro da Dias da Silva) and will have the support of two international scientific projects in which Ícaro da Dias da Silva, M. Francisco Pereira and José Brandão Silva (IDL researchers) collaborate.

Previous investigations demonstrated that the EM represents a dome-like structure during an intra-orogenic extensional regime (Pereira et al., 2009; 2012). In the northern domain of this dome-like structure the footwall composed by high-temperature/low pressure rocks (gneiss-migmatitic complex) contacts, through a major detachment, with the hanging-wall that experienced lower-metamorphic grade conditions. The hanging-wall block is characterized by a strong flat-lying foliation S2 associated to top-to-ESE tectonic transport. The intensity of D2 extensional deformation overprinted previous structures that formed most probably during a contractional deformation event (D1) that reached high to intermediate pressure metamorphic conditions (M1). This older deformation event (D1) it has been interpreted to be related to an early-Variscan continental collision, which led to obduction of subducted continental and oceanic crust (Rosas et al., 2008), is still poorly known in this part of the Iberian Variscan belt and should be further understood. Synchronously with the high-temperature / low-pressure metamorphic event M2, the hanging-block was intruded by mafic and felsic magmas during two main pulses: at ca. 340 and

ca. 320Ma (Lima et al., 2012). Both the hanging-wall and the footwall blocks of the EM were affected by a contractional deformation event D3. D3 deformation was responsible for: i) upright folding, ii) brittle-ductile strike-slip shearing, and iii) the development of a slaty cleavage under low-grade metamorphic conditions.

On the basis of structural and metamorphic data, this study will attempt to discriminate, in the hanging-block of the EM, between the D2 intra-orogenic extensional tectonics related to formation of the dome-like structure interposed between two contractional events.

In this proposal the PhD student must has to fulfill geological mapping in high- to low-grade metamorphic terranes, with the aim of complement the ongoing work (field surveys, petrographic, geochemical and geochronological studies).

The results that will be achieved in this study can represent a significant advance in the geological knowledge of this domain of the Iberian Variscan belt. They are important because they will: i) contribute to a better understanding of the interplay of distinct deformational regimes in the structural evolution of the continental crust of an ancient mountain chain; by knowing the successive events of deformation that led to a certain architecture of the continental crust we will be able to decipher the complex cartographic patterns of the metamorphic and magmatic rocks; ii) update the Geological Map of Portugal (scales 1/50,000, 1/200,000 and 1/500,000); iii) contribute to improve the knowledge of the geology of the region that is fundamental for future studies of mineral exploration, ornamental rocks and to help plan territorial planning; and iv) be used to prepare papers to be published in peer-review indexed journals and in communications of national and international meetings.

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EARTHSYSTEMS 2018- 20

PhD in Geology

Petrological evolution of the exhumed lower crust –mantle boundary in Northern Morocco: a geochemical and thermochronological approach

Supervision

Telmo Bento dos Santos (IDL) and José Francisco Santos (University of Aveiro)

Part of the work will be performed at the University of Aveiro

Abstract

The exhumation of lower crustal rocks along major shear zones is common [e.g.: 1], yet a highly debated subject. Less common is the exhumation of upper mantle rocks along such structural discontinuities. However, this is the case of the Southern Rif Shear Zone (SRSZ), an important shear zone that separates two major geodynamic domains in Northern Morocco: a) The Rif, to the North, mostly composed of Miocenic sedimentary units, and b) the Western Meseta, to the South, mostly composed of Paleozoic metasedimentary units, correlated with the Iberian Variscan Belt [2]. Associated to the SRSZ, and exhumed by its activity, is a large high grade metamorphic belt composed of abundant granulite and amphibolite facies rocks and an exotic sequence of igneous mafic and ultramafic rocks, representative of the upper mantle [3].

Several lines of evidence suggest that this shear zone is coeval and correlated to the tectonic events that formed the Betic Cordillera in Spain [2]. Although the SRSZ's activity exposed those rocks making them very accessible for study and they are well preserved, comparative petrological, geochemical and isotopic studies on this lower crust – mantle boundary segment are still to be performed, inhibiting the full characterization of this important testament of the infra-crustal conditions of the pre-Alpine geodynamics and the description of the activity and exhumation along the SRSZ. This project will, therefore, be developed in two main axis and objectives: 1) the characterization of the petrological and geochemical evolution of the exposed lower crust – mantle boundary igneous and metamorphic rocks; and 2) the definition of the P-T-t evolution of the studied rocks within the exhumation process and the overall geodynamics of the Variscan and Alpine events.

Workplan

In order to achieve Main Objective 1, it will be required to:

a) Perform field work and sampling in the Moulay Yacoub region with detailed geological mapping and structural and stratigraphic analysis of significant sections;

b) Obtain information on the petrographic, petrological, lithogeochemical and isotopic nature of the rocks associated to the SRSZ;

c) Perform geochemical analysis and modeling of the physical-chemical conditions during the formation and evolution by fractional crystallization of the different igneous rocks and metamorphic evolution of all other lithotypes [as in 4];

d) Integrate the obtained data in order to understand the petrological evolution and interaction between deep lithospheric reservoirs.

In order to achieve Main Objective 2, it will be required to:

e) Use the data obtained in the previously mentioned tasks;

f) Perform a comprehensive microstructural and regional macrostructure analysis, allowing the depiction and characterization of the deformation events that affected the region and their relationships to the activity of the SRSZ;

g) Qualitatively and quantitatively characterize the relationship between deformation and metamorphism (mineral assemblages, chemistry and geothermobarometry) during the main stages of the Variscan and Alpine events;

h) Obtain geochronological data of the rocks associated to the SRSZ using robust isotopic systems (U-Pb, Sm-Nd, Rb-Sr and Ar-Ar) and thermochronological integration in order to determine the duration of the tectonometamorphic events and the exhumation rates related to the SRSZ's activity [as in 1];

i) Build petrological and geochemical models for the exhumation activity of the SRSZ, to constrain the Alpine geodynamic evolution of Northern Morocco and to compare it to the Iberian analogue of the Betic Cordillera.

Additionally, this PhD will lead to an increased knowledge regarding: a) the structure, geometry, functioning and evolution of shear zones; b) the interaction of different geochemical reservoirs (e.g.: heat and mass transfer along the lower crust/mantle boundary) during orogenic events; and c) the understanding of heat and fluid transfer along shear zones, which is paramount to accurately depict the water flow pattern in the region's thermal spas.

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EARTHSYSTEMS 2018- 21

PhD in Geology

Geochemistry and P-T-t constraints on the HP rocks of the Ossa-Morena Zone: insights into the geodynamic evolution of the Iberian Variscan Belt

Supervision

Telmo Bento dos Santos (IDL), Rita Solá (LNEG)

Abstract

Eclogites and associated high-pressure (HP) rocks are formed in subduction zones from the metamorphic transformation of basic (usually oceanic crust) protoliths (e.g.: Maruyama et al., 1996). Therefore, HP rocks are important testimonies of both the original oceanic crust and of the orogenic context in which they were formed, providing crucial evidence for understanding the processes related to the formation and evolution of both the protolith and the HP rocks itself, namely subduction to mantle depths and subsequent exhumation to the crust.

Although it is well known that exhumation of HP rocks must occur at a very fast rate (e.g.: Ernst, 2006) in order to HP rocks survive metamorphic retrogression and remain preserved, the processes and context of exhumation through the subduction channel, as well as the geochemical evolution during prograde metamorphism (e.g.: the H_2O content and trace element patterns during HP metamorphism) are often poorly constrained. This is the case for the Ossa-Morena Zone (OMZ) HP rocks.

HP rocks such as eclogites and blueschists have long been recognized in the S and SW sectors of the Ossa-Morena Zone (e.g.: Safira, Alvito, Viana do Alentejo, Portel and Serpa) (e.g.: Fonseca, 1997; Leal, 2001; Moita et al., 2005). However, if their geological significance can easily be traced to a subducted slab in an active margin setting followed by exhumation during the Variscan Orogeny, much harder is to constrain their P-T-t evolution and to place them temporally and spatially in terms that can be understood regarding the overall framework of the Ossa-Morena Zone. Their geodynamic significance within the variscan orogenic events is still a subject of discussion, because significant amounts of information regarding their P-T-t evolution, timing and rates, as well as petrological and geochemical evolution, is still lacking.

Therefore, a two-fold plan will try to cover the following objectives: 1) understand the petrological, geochemical and isotopic nature of the HP rocks of the Ossa-Morena Zone, their formation mechanisms, timing and P-T-t evolution; 2) constrain their evolution within the framework of the Ossa-Morena Zone and its boundaries, as well as the connections to the amalgamation of the Iberian Variscan Belt.

Workplan

In order to achieve these objectives, it will be required to:

a) Perform field work and sampling in the S and SW sectors of the OMZ, including detailed geological mapping and structural analysis of key outcrops;

b) Obtain information on the petrographic, petrological, lithogeochemical and isotopic nature of the OMZ HP rocks;

c) Perform geochemical analysis and modeling of the physical-chemical conditions during the formation and evolution of the igneous protoliths and the metamorphic evolution;

d) Depict and characterize the deformation events that affected the region and the relationship between regional deformation and observed metamorphic evolution;

e) Qualitatively and quantitatively characterize the relationship between deformation and metamorphism (mineral assemblages, chemistry and geothermobarometry) during the main stages of the Variscan events;

f) Constrain the P-T-t metamorphic evolution and exhumation of the HP rocks by monazite/zircon petrochronology and pseudosections (as in Rubatto & Hermann, 2007).

g) Obtain geochronological data of the HP rocks using robust isotopic systems (U-Pb, Sm-Nd, Rb-Sr and Ar-Ar) and thermochronological integration in order to determine the duration of the tectonometamorphic events (as in Bento dos Santos et al., 2010);

h) Build petrological and geochemical models for the exhumation activity during the variscan orogenic events and to constrain the geodynamic evolution of the OMZ.

i) Integrate the data into global databases to contribute to an increased knowledge on the structure, geometry, functioning and evolution of ancient exhumation channels during collision events.

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EARTHSYSTEMS 2018- 22

PhD in Geology

Modelling shoreface morphodynamics: unveiling the links between coastal and continental shelf sedimentary dynamics

Supervision

João Cascalho (IDL, FCUL), Teresa Drago (IDL, IPMA)

The proposed work will be performed at IPMA Tavira and IDL, Lisbon.

Abstract

Beaches artificial nourishment is one of the solutions increasingly used nowadays to reverse the erosion that affects a large part of the worldwide sandy coasts, included the Portuguese ones. This nourishment is directly related with the sediment dredging from the continental shelf up to 30 m depth and its subsequent deposition on the beach. Although this nourishment has constituted (in many cases) an adequate solution to avoid erosion, there are some reported situations related to intensive sand extraction from inner shelf that has created serious morphological impacts (Degrendele et al., 2002). Moreover, it is known that the inner shelf recovery from the negative morphological impacts derived from the sand extraction is intimately related with the shoreface dynamics. In order to understand the influence of these dynamics on the sedimentary recovery of borrowing sites after the sand extraction, the PhD will develop a holistic model of the shoreface based on the knowledge of physical and geological shoreface processes. More particularly, the PhD project will aim to: 1) understand the dominant oceanographic circulation patterns; 2) evaluate seabed morphological and sedimentary changes and 3) define the sediment transport patterns. This multidisciplinary study will rely on field data, already acquired and to be acquire in the scope of the PhD, as ADCP's data (current and waves), multibeam data, sediment sampling and grain size analysis, coated sand with fluorescent paint experience and modelling analysis using SWAN 3rd generation model. The case study is the "borrow site" related with the Praia das Belharucas (Algarve, Portugal) sand replenishment already developed by local management authorities and the results will support near future decisions concerning coastal management.

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EARTHSYSTEMS 2018- 23

PhD in Geology

Using the morphology of insular shelves as a key for understanding the geological evolution of volcanic islands: Madeira and Porto Santo Islands

Supervision

José Madeira (IDL and Departamento de Geologia da Universidade de Lisboa) and Rui Quartau (Instituto Hidrográfico)

Introduction

Shelves from volcanic ocean islands result from the competition between two main processes, wave erosion that forms and enlarges them and volcanic progradation that reduces their dimension (Quartau et al., 2010, Ramalho et al., 2013). In places where erosion dominates over volcanism, shelf width can be used as a proxy for the relative age of the subaerial volcanic edifices and reconstruction of their extents prior to erosion can be achieved. The morphology of the shelf (namely the absence/presence of fresh lava flow morphologies and several types of erosional, depositional, and tectonic features) integrated with the analysis of the coastline morphology allow us to better constrain previous geological interpretations of islands' evolution (Quartau et al., 2014, 2015).

This project aims to improve our understanding of the geological evolution of the islands of Madeira and Porto Santo by combining a comprehensive geomorphological analysis of the islands' submarine edifices with the geological subaerial field evidence (Brum da Silveira et al.2010; Ramalho et al., 2015).

Methodology

To achieve the project's aim, the candidate will have the opportunity to interpret geological and geophysical data with a worldwide unprecedented coverage and resolution, including subaerial (geomorphology and geology) and submarine datasets (multibeam bathymetry, high-resolution seismic reflection profiles and sediment samples) from the Madeira archipelago. Subaerial datasets include high-resolution digital elevation models (DEM's) and the geological mapping of Brum da Silveira et al. (2010). Submarine datasets are from the SEDMAR project (Sedimentary environment of the Madeira archipelago) run by the Instituto Hidrográfico. Methodologies will include:

1. Geomorphological analysis of the subaerial islands (based on DEM's and geological maps) to derive coastline evolution.
2. Mapping of geomorphic markers of submarine shelves using multibeam bathymetry and seismic reflection profiles. Morphologic parameters on the shelf of these islands such as shelf width and erosional shelf break depth will be quantified. Mapping of the spatial distribution of submarine volcanism and landslide deposits on the shelf and slopes will also be performed. The geomorphological analysis and the inferences that can be made based on task 1 will serve to assess the age of shelf initiation and shelf incision rates, vertical movements of the islands, and the gross volumes of volcanic progradation and flank collapses.
3. Reconstruction of the sedimentary history of the shelf and slope of islands. Seismic profiles and sediment samples (box cores) on the shelf and slopes of the islands (collected during the project SEDMAR) will be used to derive sedimentary processes (including landslides) and long-term sedimentation rates in these areas.
4. Creation of conceptual models of shelf evolution by the analysis and interpretation of the data gathered in the above steps and relate them with the islands' evolution.

Supervisor's scientific background

Rui Quartau is a Researcher at the Instituto Hidrográfico. His research up to date has focused on studying how marine erosion, volcanic progradation, sedimentation and submarine landslides contributed to the development of insular shelves on reefless volcanic islands, by using field and marine data coupled with numerical modelling.

José Madeira is a Professor at the University of Lisbon. He is a senior researcher working on the geology of volcanic islands for 36 years, and co-author of the geological map of Madeira.

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EARTHSYSTEMS 2018- 24

PhD in Geology

Transport and depositional processes associated to megatsunami inundation

Supervision

Ricardo Ramalho (IDL), José Madeira (IDL), Raphaël Paris (LMV, OPG Clermont-Ferrand)

Part of the proposed work will be done at Clermont-Ferrand, France, and fieldwork in Cape Verde.

Abstract

Megatsunamis triggered by volcanic island flank collapses are probably amongst the most extreme of natural disasters. They are powerful agents of geomorphological change, capable of inundating near-field coastlines up to several kilometres inland and up to several hundreds of meters in elevation (Ramalho et al. 2015; Paris et al. 2017). However, owing to the scarcity of deposits attesting to their extreme inundations, little is still known about megatsunami sediment transport capabilities, what flow regimes characterise these events, and what depositional conditions govern the formation of deposits. Moreover, due to our incomplete knowledge of megatsunami transport and depositional mechanisms, our capability to unequivocally identify megatsunami deposits is still in its infancy (Paris et al., in review). This is where the exceptional geological record of the Cape Verde Islands may prove crucial. Owing to the lateral collapse of Fogo volcano at ~73 ka, the archipelago was impacted by one of the largest collapse-triggered tsunamis known from the geological record, as attested by conglomeratic deposits on several of the islands (Ramalho et al. 2015; Paris et al. 2011,Paris et al., in review).

The overarching goal of this PhD project is to use this tsunami's deposits to unravel some of the most enigmatic aspects of tsunami transport and deposition, and in the process advance our capability to unequivocally identify megatsunami deposits. To achieve this the research will employ a fine-scale sedimentological approach, designed to characterise in high detail key tsunami deposits in Cape Verde – exploring aspects such as internal organisation or stratification, bedding, lateral and longitudinal continuity of the structures and variations of macrotexture (e.g. grain size, sorting), microtextural analysis (e.g. development of downward clastic dykes injected in the substratum, traction carpets at contact with the substratum), morphometry of the clasts (e.g. roundness), sediment provenance, distribution of the petrographic facies, type and concentration of bioclasts and lithics, etc – and to provide usable quantitative information about megatsunami inundation and megatsunami transport and deposition processes. The different methods used to achieve this goal include petrology of the clasts, geochemical analyses of the matrix, image analysis of the microstructures (e.g. X-ray tomography), and palaeontology (characterization and

abundances of bioclasts). Parameters such as number and type of flows, flow regime, maximum and minimum run-up will be inferred for each locality and quantitative approaches that use hydrodynamic numerical solutions to boulder and sediment transport will be used to estimate local minimum flow depths and velocities (e.g. Nandasena et al. 2011). These parameters will be integrated in a comprehensive GIS database, which will help provide boundary conditions and validation criteria for tsunami inundation scenarios. The PhD will be integrated within the research frame set by R. Ramalho's FCT-funded project IF/01641/2015 MEGAWAVE.

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EARTHSYSTEMS 2018- 25

PhD in Geology/Volcanology and Natural Hazards

Volcanic hazard at hydraulically-charged Ocean Island Volcanoes – the case of Flores Island (Azores)

Supervision

Ricardo Ramalho (IDL), Armand Hernández (IDL)

Part of the proposed work will be done at Barcelona and Bristol, with fieldwork in the Azores.

Abstract

The interaction of ascending magmas with groundwater at near-surface levels may produce violent explosive eruptions, which carry an enormous hazard potential (Mastin et al. 2004). This is so because magma-water mixing ensures rapid heat exchange and extensive magma fragmentation, maximizing the violence of these eruptions. Phreatomagmatic interaction is, in fact, the most important mechanism capable of turning relatively mild basaltic volcanism into a highly hazardous force, generating violent explosions that affect large areas and produce tall volcanic plumes that cause large-scale disruption of air space (Németh and Cronin, 2011; Németh et al. 2012). Accordingly, hydraulically-charged ocean island volcanoes – such as Flores Island in the Azores – constitute some of the volcanic environments with higher hazard potential, yet one that is often underrated or overlooked.

Flores Island is a small ocean island volcano famous for its scenic landscape with abundant volcanic craters and lakes, perennial streams and high waterfalls. On account of the fact that the island did not experience any eruption since settlement, volcanic hazard is generally considered as low. However, the geological record of Flores shows that widespread monogenetic volcanism occurred as recent as 2-3 ka, being responsible for the creation of numerous cones and lava flows, and more importantly of some of the largest maars and tuff rings of the archipelago (Azevedo et al. 2006). The volcanic hazard potential of Flores therefore should not be underestimated, and the possibility for future highly-explosive phreatomagmatic eruptions should be properly considered.

Flores island edifice is generally saturated with groundwater, experiencing over 1660 mm of mean annual rainfall, with upland areas receiving in excess of 3000 mm/yr. However, the Azorean rainfall regime displays a strong seasonal cycle and large inter-annual variability (Hernández et al. 2016) and these changes in precipitation are of particular concern as precipitation, or a significant lack of it, can be responsible for huge changes in groundwater levels. Moreover, the Azores Archipelago is frequently crossed by tropical storms (or even cyclones), which are capable of dumping huge amounts of rainfall on the islands, further contributing to groundwater variability. Thus, studies of the long-term rainfall variability are required to better understand their impact on

potential magma/water interactions and the triggering of highly-explosive eruptive phases. Moreover, Flores constitutes the ideal case study to investigate the interaction between climate variability and phreatomagmatic volcanism.

This project aims to study the recent volcanic record of Flores Island in order to evaluate its hazard potential and, more importantly, to investigate how the hazard potential of small-volume monogenetic eruptions is amplified by environmental controls such as rainfall variability. The project will use detailed geological mapping, coupled with fine-scale tephro-stratigraphy techniques, in order to reconstruct the sequence of recent volcanic events and their magnitude, particularly those leading to the formation of the numerous maar-diatreme and tuff ring structures of the island. Crucially, the project will capitalize on the existence of several drill-core sequences in the framework of the PaleoModes project (CGL2016-75281-C2, Spain), recently collected on several of Flores' lakes, and which provide a rich record of volcanic ash layers that can be correlated with deposits on land. Moreover, lakes are excellent sensors of climatic changes and the reconstruction of the main climatic phases through the studied sequence would help to establish the role of the water-saturated subsoil changes in volcanic hazards. This coupled "onshore-offshore" study will provide a uniquely detailed picture of the recent volcanism of Flores Island, providing useful information on magmatic processes and on the volcanic hazard potential of the region (e.g. see Eisele et al. 2015). More generally, the project will provide useful insights onto the volcanic hazard potential of hydraulically-charged island edifices, with valuable lessons applicable to other settings.

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EARTHSYSTEMS 2018- 26

PhD in Geophysics and Geoinformation Sciences

Submarine landslides in the NE Atlantic: Slope stability and tsunami hazard assessment.

Supervision

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

Motivation and summary:

Submarine landslides constitute a widely recognized source of marine geo-hazards. They have the potential to generate significant morphological changes and in some cases they can destroy large offshore infrastructures, particularly communication cables. Tsunamis generated by large underwater landslides are known to have a large impact on coastal areas, particularly near-shore. Their importance as contributors to tsunami hazard has been recognized over the last 20-30 years, but they are seldom considered in the evaluation of quantitative tsunami hazard or in the design of tsunami warning strategies.

In the NE Atlantic, the occurrence of submarine landslides is widely recognized (Terrinha et al., 2003). Some of these landslides were tsunamigenic with large coastal impact as demonstrated recently by Omira et al. (2016). The pre-conditioning and triggering mechanisms of submarine landslides in the NE Atlantic, mainly consisting of moderate to high magnitude seismicity, post-glacial isostatic rebound and tectonic driven gravity instability (Masson et al., 2006), still persist favoring the occurrence of future large failures. In this project we propose to investigate submarine landslide-induced tsunami hazard in the NE Atlantic region. Within this project, the following key questions will be addressed:

i) What are the major submarine mass-failures, their characteristics, and their spatial distribution in the NE Atlantic?
ii) What are the mechanisms that cause the mass failure?
iii) What is the interaction between active seismic zones and failure potential of submarine landslides?
iv) How can we estimate the relationship between landslide size and time recurrence?
v) What is their tsunamigenic potential?
vi) What was the past tsunami effect of Submarine Mass Failure on NE Atlantic coasts and what can be predicted for the future?

To answer to these questions, a multidisciplinary methodology will be applied for submarine landslide events in the NE Atlantic region. It will incorporate detailed geomorphological and geotechnical analyses, slope stability analysis, coupling of the landslide dynamics and the tsunami wave generation, numerical modeling of the submarine landslide-induced tsunami propagation and coastal impact.

Workplan:

a) Characterization, size and distribution of submarine mass-failures in the NE Atlantic area: Perform geomorphological analysis and interpretation of available seismic reflection profiles to build a database of major underwater landslides in the NE Atlantic region.

b) Slope failure potential and recurrence rates: slope stability analysis is often based on relationships between landslides and earthquakes. Slope failure potential and conditions under the earthquake loading will be investigated through the pseudo-static method (ten Brink et al., 2009) that considers a homogeneous landslide body material. This analysis will allow establishing a relationship between the size of the landslide and the critical earthquake peak ground acceleration (PGA) necessary to initiate it. Recurrence rates of the submarine landslides will be inferred from the recurrence of the triggers (earthquakes).

c) Modeling the whole source-to-coat tsunami process: coupling submarine landslide dynamics and the tsunami generation for landslide case-studies in the NE Atlantic (from (a)) and for the future instable slopes (from (b)). Modeling the tsunami propagation in the deep-ocean and coastal impact for site-specific coastal areas of the NE Atlantic.

d) Time-independent and –dependent tsunami hazard assessment: The time-independent tsunami hazard assessment will consider the major submarine landslide sources (from (a)) to estimate the worst-case impact. The time-dependent hazard assessment will account for the contribution of a large number of landslide scenarios and their recurrence (from (b)) to estimate the probability of tsunami impact occurrence within a given exposure time.

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EARTHSYSTEMS 2018- 27

PhD in Geology

The role of high fluid pressure sediments in geologic processes along the Eurasia-Africa plate boundary

Supervision

Pedro Terrinha (FCUL-IPMA-IDL), Umberta Tinivella (OGS, Trieste), Marta Neres (IPMA, FCUL, IDL),

Abstract

The Eurasia-Africa plate boundary has been investigated for understanding the nature of the plate boundary, generation of large earthquakes and tsunami, methane hydrate production, large landslides, distribution of seismicity and constitution of the oceanic lithosphere.

Recent work indicates that fluid circulation affects the whole oceanic sediment column down to the oceanic basement along the SWIM plate boundary transform faults (Hensen et al., 2016). Various authors have shown the occurrence of large scale landslides on both sides of the Eurasia-Africa plate boundary prone to have caused tsunamis (e.g. Terrinha et al. (2002), ten Brink et al. (2009), Lo Iacono et al (2012) and Omira et al. (2016). However, the internal structure of these landslide deposits is still to be unraveled, which is crucial for understanding the failure mechanism and thus the landslide capacity of generating tsunamis.

This project aims at understanding the distribution of seismic units containing high pressure interstitial fluids, their relationship with faults and with the plate boundary and the internal structure of landslides and their relationship with seismicity distribution and other environmental parameters (e.g. sea floor slope, constitution, currents…). This will be attempted by producing high quality seismic images of selected areas of the region of the Eurasia-Africa plate boundary encompassing the Madeira-Tore Rise, the Hirondelle-Gorringe seamounts and the Tagus and Horseshoe Abyssal Plains. This process involves seismic processing focalized to improve seismic imaging and extract information about petrophysical properties of the main structures. The seismic processing scheme will be selected looking at the quality of the data. In any case, a true amplitude approach will be adopted in order to preserve the relative amplitude of the main reflections, as required to improve the interpretation. In order to discriminate a reflection mainly caused by lithologic or fluid change, specific algorithms, such as pre-stack migration and amplitude versus offset, are necessary to extract more information from seismic data. For example, the use of the pre-stack time migration can be used as a tool to detect negative velocity anomaly areas that could be associated to overpressure condition. The relationship with the deep structure of the crust and upper lithospheric mantle will be tested by modeling magnetic and gravimetric anomalies.

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EARTHSYSTEMS 2018- 28

PhD in Geology

The Tagus River Delta landslide: sedimentary processes and trigger mechanisms

Supervision

Pedro Terrinha (FCUL-IPMA-IDL), Carlos Ribeiro (Univ. Évora), Miguel Caetano (IPMA)

Abstract

Tsunamis changed the course of societal concerns and economics. Submarine landsliding is the second most important cause of tsunamis. Quantification of the environmental parameters controlling submarine landslides has been recently updated (ten Brink et al., 2009) and examples of deep water landslides off Portugal were recently recognized (Omira et al., 2016).

Project TAGUSDELTA showed that half of the frontal part of the Tagus River delta located off Lisbon collapsed between 8 and 13 ky BP. A 10km long, 4.5km wide landslide has an area of ~45km2 and a volume of ~0.9km3. 33km2 of shallow gas bearing sediments at the delta front were also mapped. The shallow gas and the Tagus Delta Landslide (TDL) areas are almost mutually exclusive neighbours. Most of the shallow gas is known to occur from seafloor to 10m depth below sea floor. Part of the gas trapped in depth is overpressured, hence reducing the friction conditions in the delta front and creating the ideal conditions for landsliding.

The trigger mechanism of the TDL is not known. It could be related with a seismic event or with a non-seismic trigger mechanism related with gas escape, gravity instability of the delta frontal lobe sediments facilitated by pore fluid migration or a meteo-tsunami. The occurrence of shallow gas raises the following questions: i) What is the nature and origin of the gas? Microbial shallow gas or thermogenic gas originated from deep hydrocarbons of the rift basin? ii) Is the overpressured area significant? What is the mitigation strategy to lower the odds of landslide occurrence?

Determining the nature and origin of the trapped shallow gas, mapping the fluid escape structures, search and map ongoing gravity instability structures like slumps, recent landslides or tensile cracks will guide us towards future research directed to mitigate the effects of gas bursts, or pore pressure build up and foster the societal preparedness towards landslide triggered tsunamis.

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EARTHSYSTEMS 2018- 29

PhD in Geology

Carbon sequestration in mafic and ultramafic rocks: lessons from natural systems

Supervision

Vitor Magalhaes (IPMA), Pedro Terrinha (FCUL-IPMA-IDL), Carlos Ribeiro (Univ. Évora)

Abstract

Direct measurements of atmospheric CO_2 concentration and paleo reconstructions clearly indicate a rise in carbon emissions due to human activity, fossil fuel burning and land clearing (IPCC, 2014). This can be one of the most harmful and long lasting human impacts on our planet. The urgency to mitigate the anthropogenic CO_2 release and consequent climate changes is an imperative and incentives to decouple CO_2 emissions and economic growth are increasing not only by reducing the CO_2 emissions (Obama, 2017) but also by searching for efficient and safe methods of capturing and storing carbon (IPCC, 2014 and as defined by EU Climate action Directives).

The best method for carbon sequestration is in the form of mineral carbonation, as it allows the maximum storage capacities with the longest residence times, in the order of million years and is the least risky CO_2 storage option. The most efficient mechanisms and rates of mineral carbonation occur through the reaction of CO_2-bearing fluids with silicate minerals in peridotite and basalt rocks and the subsequent precipitation of Carbon as carbonate minerals. This process occurs naturally in: (i) ultramafic-hosted hydrothermal vents, (ii) in ultramafic mantle rocks tectonically exposed at the seafloor, (iii) in basalts, (iv) in ophiolite ultramafic rocks, (v) in serpentinite mud volcanoes and (vi) associated with travertine formation at high alkaline springs from the meteorization of ultramafic rocks. All these systems occur on the offshore Portugal, in the EEZ, and also in Portugal mainland and in the Azores and Madeira Islands and platforms.

Within this project, the mechanisms and rates of the mineral carbonation reactions will be investigated in natural systems. The formation of authigenic carbonates associated with the Marianas serpentinite mud volcanoes (IODP Exp 366 samples). This approach will allow the characterization of the physical and chemical conditions that promote the spatial decoupling between the hydration/serpentinization reactions of the ultramafic minerals from the authigenic carbonates precipitation reactions (carbonation). Such knowledge is of crucial importance for an efficient and economically reliable in situ CO_2 storage by mineral carbonation. Besides these main objectives, within this project we will also evaluate the natural CO_2 storage processes and capacity in both offshore and onshore Portugal associated with ultramafic and basaltic rocks.

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EARTHSYSTEMS 2018- 30

PhD in Geology

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

Supervision

Manel Leira (IDL) and Maria da Conceição Freitas (IDL)

Abstract

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.

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EARTHSYSTEMS 2018- 31

PhD in Geology

Paleoenvironmental evolution of Morocco lagoons and estuaries

Supervision

Maria da Conceição Freitas (IDL)

Abstract

The identification and characterization of forcing factors of past coastal change is essential to building up reliable models of paleoenvironmental evolution, lagoons and estuaries providing privileged conditions for these studies given their transitional nature and potential to keep continuous and undisturbed sedimentary record. The existing body of knowledge at European scale suggests that barriers formed in middle Holocene in response to deceleration of sea level rise rate. Portuguese studies suggest that, since this time onwards, a suite of site-specific to regional borne forcing of coastal evolution (e.g. changes of sediment source and budget, periodic or aperiodic variation of chemical and physical attributes of the basin's water, variation of the exchange mass rates between the backbarrier basin and the ocean, anthropogenic influence) overwhelmed the eustatic control and these influences must be decoupled to fully understand the driving reasons and patterns and rates of coastal response.

Sea-level and paleoenvironmental studies carried out in the Portuguese coast and shelf delivered a substantial amount of data and an empirical model has already been well established.

This proposal aims to develop a model of Late-glacial to present environmental changes focused on the Atlantic Morocco coast to compare with the Iberian one. It is founded in interpretation of the sedimentary record and inferred responses of estuaries/lagoons to external forcing and uses a wide-range suite of integrated multidisciplinary methods to assess relative contributions of global/local and natural/anthropogenic forcing. Undisturbed and continuous cores (already exisent) will be analyzed for sedimentology and geochemistry, proxies that must be coupled with paleoecological indicators to establish the succession of facies. The ultimate goal is to access the applicability of the iberian model to a wider coastal façade. Such models are of fundamental importance to support forecasts of future evolution of these coastal systems, particularly within the context of the ongoing Global Change, including its impacts in local ecosystems, with direct use in sound policies of management of coastal zone.

EARTHSYSTEMS 2018- 32

PhD in Geology

Climate change, sea-level rise and risk of inundation of high intertidal areas

Supervision

Maria da Conceição Freitas (IDL)

Abstract

One major consequence of the expected increase in temperature related with climate change is sea-level rise and one main associated impact is inundation of low-lying areas. Among these, estuarine margins stand out in terms of vulnerability and importance due to their widely recognized ecological values and multiple uses of social-economical nature. Modeling salt marsh responses to future scenarios of sea-level change is a challenging task. Previous work in Tagus and Sado estuaries suggests that the morphological and sedimentological dynamics of each salt marsh expansion is site specific in function of sediment budget and geomorphological framewok. Thus, the evolution of marsh surfaces will be contrasting across the estuarine domain and between estuaries, although impacted by similar oceanographic forcing.

The motivation of this project is: (1) to understand the behavior of salt marshes in the last century, already in a context of positive eustatism; (2) to characterize the spatial variation in sedimentation rates within the estuary and compare with other estuarine results; (3) to model response scenarios of estuarine marshes to sea-level rise projected until the end of the 21st century.

The essential research question addressed is: how will high intertidal depositional environments of Sado estuary evolve in the near future in response to the projected rise in sea-level?

Specific aims include:

- To determine the main past evolutionary patterns of natural/re-naturalized margins of the Sado estuary (sedimentation/erosion) at a century time-scale;

- To assess, in sedimentation-dominated areas, changes in marsh volume and surface;

- To characterize the relation between sediment budgets and sea level changes;

- To determine the response of high intertidal estuarine margins to future changes in sea level.

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EARTHSYSTEMS 2018- 33

PhD in Geology

Sedimentological imprints of Holocene extreme events in south and south-west Portugal

Supervision

C. Andrade (IDL) and Pedro Costa (IDL)

Abstract

The understanding of extreme events (tsunami and storm) depositional signatures and their preservation potential in coastal sedimentary sequences is until the present moment poorly documented. Numerous extreme event sedimentological studies have mainly focused on contemporaneous tsunamis and in low latitude (i.e. hurricane prone) areas, especially in back-barrier environments on siliclastic coasts (Switzer and Burston, 2010). However, Andrade et al. (2004), Matias et al. (2008) and Costa et al. (2011, 2017) demonstrated that recent and historical events left a stratigraphically distinct record of overwash sand layers or boulder accumulations in the sediments of alluvial plains, dunes, coastal marshes and lagoons in Portugal.

Despite the different generation mechanisms, storms and tsunamis can produce similar sedimentological imprints because both result from a brief coastal inundation with high overland flow velocities, making their differentiation a very difficult task. However, presently, there is a need for more rigorous assessment of hazards posed by tsunamis and storms due to its potential societal costs. Therefore the reliability of the geological record is fundamental in areas where these events are less frequent, like the SW and S Portuguese coasts. This study is therefore particularly timely because present and future climatic change could potentially increase the risk posed by storms and by landslide-generated tsunamis in the North Atlantic.

The main aim of this project is to produce high-resolution analysis of extreme events that affected the SW and S Portuguese coasts during the Holocene. With this purpose their sedimentological imprints will be studied in great detail using a wide range of non-destructive techniques (e.g. LIDAR, GPR, CT-scans, x-rays imaging, etc.) and other more conventional approaches (grain-size, micromorphology, heavy minerals, foraminifera, geochemistry, microtextures, etc.). Departing for the pre-event geomorphological conditions, and based in the compilation of wide range of field data, it will be possible to reconstruct past events including 2D profiles of palaeotopography, sediment particle distributions and hydrodynamic conditions. Thus, this PhD project will contribute to a better definition of Holocene storm and tsunami recurrence, to their differentiation and to a more accurate evaluation of their intensities in the Portuguese coast.

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EARTHSYSTEMS 2018- 34

PhD in Geology

Tsunami sediment transport modelling – contributions to the understanding of Holocene events in the North Atlantic

Supervision

Pedro Costa (IDL) and Sue Dawson (University of Dundee, Scotland)

Part of the proposed work will be done in Dundee, Scotland, with fieldwork in the Algarve (South Portugal) and Shetland (Scotland).

Abstract

Palaeotsunami research depends on the recognition and characterization of tsunami deposits in coastal sedimentary environments, allowing event dating and reconstruction of inundation distances and run-up (Dawson, 2004). Recent sedimentological studies, conducted in the aftermath of the tsunami that impacted the coast of Japan, raised a series of scientific questions in relation to the source and preservation of these deposits and the recognition of inundation far beyond the sedimentological inland limits (e.g. Chagué-Goff et al., 2011). These developments are of fundamental importance to accurately understand sediment transport associated with tsunami events. This is of particular relevance along the Atlantic coasts of Europe, where lithostratigraphic studies are the key to the determination of tsunami risk (Dawson, 2004).

The most important tsunamis to impact the European Atlantic seaboard were the Storegga tsunami (8200 yrs cal BP) and the Lisbon AD 1755 tsunami that mainly affected the coasts of Scotland and Portugal, respectively. The overall aims of this program are to contribute to a better knowledge of these major events and provide tools for better management of coastal areas across the North Atlantic. The successful PhD candidate will study these events in cooperation with research project (NERC-UK Arctic Program – "Will climate change in the Arctic increase the landslide-tsunami risk to the UK?") and using sediment samples previously collected (accessible through the lithodatabase of the Departamento de Geologia da Universidade de Lisboa). in addition, the candidate will apply a multidisciplinary methodology encompassing empirical (i.e. sedimentological and age-chronology analysis) and numerical modelling methods (i.e. regressive and forward sedimentation models – Delft 3D and the Tsunami Sedimentation Model) with the aim to reconcile the discrepancy between the historical and sedimentological record of tsunamis (e.g. Bondevik et al., 2005; Costa et al., 2012, 2017). Modelling will also allow a better understand the processes involved in tsunami erosion, transport and deposition.

Work will also focus on high resolution sedimentological analysis in samples already retrieved from selected study sites (e.g. Scotland - Scatsta Voe, Basta Voe, Mid Yell Voe and Whale Firth; and Portugal - Martinhal, Barranco, Boca do Rio, Alcantarilha and Salgados). This work will provide reliable tools to validate identification of different inundation phases.

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EARTHSYSTEMS 2018- 35

PhD in Geology

Geotechnical characterization of volcanic soils of Cape Verde: methods of ground improvement for large dams' and buildings foundations

Supervision

Isabel Fernandes (IDL), Akos Torok (UTE, Budapest)

Part of the proposed work will be done at UTE, Budapest.

Abstract

The volcanic rocks that outcrop in the Island of Cape Verde exhibit specific geotechnical characteristics which influence the performance of the foundations of large constructions. These rocks typically show marked heterogeneities (Potro & Hürlimann, 2007) with compact rocks forming layers with pumitic deposits and pyroclastic materials of diverse thickness. In consequence, there is a strong variability of permeability, strength and deformability (Gonzalez de Vallejo et al., 2007; Rodríguez-Losada et al., 2007). On the other hand, the layers of rock are irregular and show intense alteration, mainly at the surface and along the main discontinuities, which imprints the characteristics of weak rock (ISRM, 1978; Cai et al., 2004; Thomas et al., 2004; Rodríguez-Losada et al., 2007) up to 30 m in depth and, in extreme cases, the formation of caverns and subsidence due to the piping by the water percolation. The alteration of these materials originates abundant clay minerals which can swell and produce high deformability to the large constructions foundations (Hernández- Gutiérrez et al., 2010). In consequence of these difficult conditions, it has been verified that for some dams built in the Islands show permeable foundations and water tightness problems in the areas covered by the reservoirs as well as insufficient bearing capacity. Traditionally these sites would be abandoned but the current practice is to modify the engineering properties of those soils to meet the design specifications (Makusa, 2012). Soil stabilization aims at improving soil strength and increasing resistance to softening by water through bonding the soil particles together, water proofing the particles or combination of the two (Sherwood, 1993). The improvement methods of soils and rock masses include variable techniques that need to be adapted to the particular local conditions (Makusa, 2012; Cardoso, 2016). The most common refer to the replacement of volumes of ground material by other materials with better mechanical properties namely rock boulders and/or concrete. Other methods include the execution of additional structures of support, the injection of grout to fulfill the voids, discontinuities and caverns, the use of jet grouting and the deep mixing methods. However, the soil-cement mixtures comprising stabilizing agents such as fly ash, lime and pozzolanas, the viscosity of the grout or the use of synthetic products are still not developed in what concerns the volcanic materials. Also compaction/consolidation, which is quite useful for large buildings

foundations to avoid settlements, drainage, heating and vibroflotation, have a number of advantages and limitations concerning specific lithologies and ground conditions.

The present project aims the characterization of Cape Verde volcanic soils and rocks from the geologic and geotechnical point of view in order to define the adequate method of treatment and improvement to be applied in future dams and large building construction in the country. The study includes both laboratory tests, some of which will be carried out at the laboratories of Budapest University of Technology and Economics, and in situ tests. As case studies, two dam sites will be studied as well as the foundation of a large governmental building. In order to compare different volcanic environments, Salineiros dam in Cape Verde will be compared with Pico da Urse dam, in Azores, Portugal.

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EARTHSYSTEMS 2018- 36

PhD in Marine Sciences

Physical-biological processes and the seeding of Harmful Algal Blooms in W Iberia

Supervision

Ana Amorim (MARE-FCUL), Luis S.Quaresma (IH), Paulo Oliveira (IPMA)

Abstract

Dinoflagellate blooms in upwelling areas are characterized by a high long-term (decadal) and short-term (upwelling cycle) irregularity despite their recurrence. Knowledge on the autecology and bloom dynamics of HAB species, namely the dinoflagellate *Gymnodinium catenatum*, has progressed enormously in the last decades. *G. catenatum* produces a group of neurotoxins responsible for the human Paralythic Shelfish Syndrome (PSP) and is responsible for enormous losses in the shellfish industry in Portugal and worldwide. It has a life-cycle that alternates between a planktonic vegetative stage and a benthic resting stage (cyst). In the Iberian upwelling system very little is known on the origin of the seed population and the factors that trigger the initiation of *G. catenatum* blooms. Cysts with viable cell contents are very scarce in coastal sedimentary basins (e.g. marinas, estuaries, coastal lagoons) and on the Iberian shelf even after bloom periods (Amorim et al., 2001, Artigas et al., 2008). Cyst dormancy period is very short: 6-10 days (Bravo & Andersen, 1994). Once mature, cyst germination may occur 24h after a temperature shift. Cysts from Iberian bottom sediments show high viability. Other toxic and potentially toxic species with life-cycles including cysts with distinct physiology, such as *Protoceratium reticulatum*, *Lingulodinium polyedrum* and *Alexandrium minutum*, occur in Iberian coastal waters.

On-going research using numerical Lagrangian models indicate, for certain periods in the year, a high probability of transport of cysts from bottom sediments to the euphotic layer where the environmental conditions favour population development (Quaresma et al 2007, Amorim et al. 2014). Building from these preliminary results, the current doctoral research project will test the hypothesis of internal waves and bottom currents being physical mechanisms capable of resuspending cysts from muddy sediments where viable cysts occur. The ultimate goal will be to feed forecasting systems for HAB outbreaks in West Iberia. Research on the physical parameters will be combined with dinoflagellate life-cycle transition properties in the development of a biophysical model.
The project has a transdisciplinary approach and the selected candidate will develop skills in physical oceanography and marine biology. The methodological approach will include in situ observations, satellite imagery, numerical modeling, sediment bottom characterization and phytoplankton and dinoflagellate cysts analyses. Research will be developed and supported within research projects involving the co-supervisors.

Results from the proposed work are expected to improve predictability of HABs in Iberia and other upwelling regions contributing to the sustainable management of marine resources.

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EARTHSYSTEMS 2018- 37

PhD in Marine Sciences

Improving the use of dinoflagellate cysts as indicators of global change: untangling climate change and eutrophication

Supervision

Ana Amorim (MARE-UL), Pedro Pinho (CE3C-UL)

Abstract

The XXth century has seen major environmental changes with regional and global impact on the earth biophysical system. Many of these changes are now recognised as being triggered by anthropogenic activities associated with land use (e.g. nutrient loading through urbanization and agriculture) and climate change. However, these two global change drivers (climate change and eutrophication) co-ocurr in space, making it difficult to descriminate the relative contribution of each driver on the observed changes in ecosystems.

In the marine realm, coastal ecossystems are among the most productive systems but also the most impacted by human activities. Looking back into the history of environmental changes using phytoplankton microfossils as proxies is one of the most promissing approaches to the understanding of environmental change. Dinoflagellate cysts are now well established as ecological indicators with changes in cyst assemblages, and certain morphological traits, responding to temperature, salinity or nutrient loadings (Dale, 1996, Bringué et al. 2014, Jansson et l. 2014).

In W Iberia, studies using dinoflagellate cysts have identified a major environmental shift at a regional scale, characterized by a many fold increase in productivity, increased dominance of the species *Lingulodinium polyedrum* and changes in the functional structure of the community characterised by increased dominance of autotrophs (Ribeiro et al. 2016). These changes were related to climate variability (NAO and warming) but nutrient loading was hypothesized to interact and eventually magnify some of these changes.

Here, we propose to improve the use of dinoflagellate cysts as indicators of the effects of global change. To do so we need to untangle the effects of climate from those of cultural eutrophication. This will be done by investigating the present day nutrient loadings (emphasis in nitrogen) along the portuguese coast and how these are reflected in dinoflagellate cyst assemblages and functional diversity. The ultimate goal will be to know the present, refine our interpretation of the past and contribute to predicting the future.

To achieve these goals, a stratified sampling startegy will be applied. Surface sediment samples will be collected in the portuguese coast along nutrient and temperature gradients. Potential

nutrient loadings will be determined by looking at land-use (focusing on agriculture and urban areas) in the river-basin influencing the most each sampling point. Temperature will be characterized using in situ data from available data sets and satellite imagery analysis. The collected sediments will be analysed for dinoflagellate cysts, nitrogen and carbon. Dinoflagellate cyst assemblages will be studied by standard palynological methods (Amorim and Dale, 2006, Ribeiro et al. 2016) to allow future comparison with the sub-fossil record.

To explore the possible relations between temperature, nitrogen and dinoflagellate cysts, multivaritate methods, based on community and functional diversity analysis, will be carried out. The most promising indicators (variables associated to dinoflagellate species) will be modeled, in order to understand which is the interaction between climate and eutrophication, and to make predictions of the dinoflagellate's response under scenarios of climate change.

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EARTHSYSTEMS 2018- 38

PhD in Marine Sciences (Biology)

Vegetation-flow interactions in salt marshes under storm surges: resilience and flood risk reduction

Supervision

Isabel Caçador (MARE, FCUL)

João M. Dias (CESAM, UA)

Carina L. Lopes (MARE, FCUL & CESAM, UA)

Abstract

Salt-marshes provide a large number of ecosystem services and among the most important is their role as buffers protecting coastal communities during storms. Although there is consensus about its importance on flood protection, is scarce the number of studies focused on the quantitative assessment of salt marsh communities value for flood risk reduction as well as on the salt-marsh resilience under storm surges. In fact, it is still unclear how resistant salt marshes are to extreme storms and whether they can survive to multiple events without collapsing. These issues are of great importance once by quantifying the economic value of natural defences and their resilience, they can be more effectively included in risk models and in the definition of coastal management strategies.

Attending this, the main aim of this thesis is to investigate, by one hand, the influence of salt marshes on flood risk reduction, and by the other hand, the influence of storm surges on the stability of salt marsh communities, in two contrasting estuarine systems (Tagus Estuary and Ria de Aveiro). This work will include field campaigns, exploitation and application of remote sensing techniques and development and application of dedicated high resolution numerical models.

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EARTHSYSTEMS 2018- 39

PhD in Marine Sciences (Biology)

Risk of introduction of non-indigenous species in estuarine systems: pathways/vectors pressure and habitat suitability

Supervision

Paula Chainho (MARE, FCUL)

José Lino Costa (MARE, FCUL)

Gordon Coop (CEFAS, UK)

Abstract

Non-indigenous species (NIS) are a major threat to global biodiversity, with significant ecological and economic impacts. Risk assessment is useful to identify species that are likely to become invasive and cause significant negative impacts, pathways and vectors with higher risk of facilitating the introduction of NIS and areas which are more likely of being invaded. These assessments provide the appropriate support for decision-making processes, such as management policies and regulations.

This thesis will determine if there are areas with different risk levels of introduction of NIS in estuarine systems, having vector effect (i.e. shipping, aquaculture and trade of living organisms) and habitat suitability as predictor variables. The Tagus estuary will be used as a case study. An integrated model will be developed to predict the potential NIS distribution in different estuarine areas with different introduction risk levels using available information on habitat suitability for selected NIS case studies.

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EARTHSYSTEMS 2018- 40

PhD in Marine Sciences (Biology)

Assessment of anthropogenic impacts on the European Eel in Portugal

Supervision

Isabel Domingos (MARE, FCUL)

Bernardo Quintella (MARE, FCUL)

Abstract

The drastic decline in the European eel (*Anguilla anguilla*) recruitment, that occurred in the late 1980's across the distribution range, and reached minimum values in 2000, led to the urgent need to take actions to revert this trend. The European Commission, issued a plan for the recovery of the population (Regulation EC 1100/2007) that obliged all member states to adopt measures to reduce anthropogenic mortality and increase escapement of spawners to the sea. The species is of high ecological, cultural and economic importance throughout its continental range but it is 'Critically Endangered' (IUCN, 2014) and is listed in the Convention on Migratory Species and Convention on International Trade in Endangered Species of Wild Fauna and Flora.

The present thesis will focus on developing new methodologies to assess the effects of anthropogenic impacts on the population dynamics of the species. Particular emphasis will be drawn to the most critical stages of the European eel life cycle.

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