EARTHSYSTEMS 2017-1
PhD in Geophysics and Geology

Unraveling the nature and origin of the Paleocene-Eocene Thermal Maximum (PETM): an integrated environmental magnetic approach

Supervision

Eric Font (IDL), Thierry Adatte (ISTE, Lausanne)

Part of the proposed work will be done at ISTE, Lausanne.

Abstract

A gradual increase in Earth’s surface temperatures, marking the transition from the late Paleocene to early Eocene (~56Ma), represents an extraordinary warming event known as the Paleocene-Eocene Thermal Maximum (PETM). Both marine and continental sedimentary records during this critical period revealed evidences of massive injection of isotopically light carbon, which may have triggered the global warming event. The PETM events led to major species extinctions in deep marine benthic foraminifera, and favored the diversification of planktic foraminifera and modern mammal continental species. Common explanation for the benthic extinction at the PETM is an initial stage of climate warming due to North Atlantic Igneous Province volcanism (NAIP), which may have triggered methane release from ocean sediments causing global warming and ocean acidification. Understanding how and when these rapid climate change leads to extinction and evolutionary diversification is critical to assess the risk of current climate warming on species populations and humans in the coming decades.

Here we propose to conduct an integrated study of reference PETM sections worldwide by coupling rock magnetic methods to geochemical and mineralogical approaches, in order to unravel the nature and origin of the paleoenvironmental changes that took place during the PETM. Since iron oxides (ex. magnetite) contained in sediments are very sensitive to changes in seawater chemistry (pH and Eh), rock magnetic analysis generally provide precious information about environmental acidification or anoxic events triggered by volcanism (Font et al., 2014). However, such approach has never been tested yet in the case of the PETM. Magnetic analyses are conducted at the Rock Magnetism Laboratory of the IDL, under the supervision of Dr. Eric Font. Part of the work plan including geochemical and mineralogical analysis can be carried out at the Institute of Earth Sciences, University of Lausanne, Switzerland, under the co-supervision of Dr. Thierry Adatte. Dr. Thierry Adatte will provide an impressive sample collection of sedimentary sections spanning the PETM boundary from Spain, Tunisia, Ouzbekistan, India, Egypt, England, etc.

References

EARTHSYSTEMS 2017-2
PhD in Geophysics and Geoinformation Sciences

Diagnostics of the atmospheric low-frequency potential predictability under global warming effect using Global Earth System Models Simulations

Supervision
Carlos Pires (IDL), Pedro Matos Soares (IDL)

Abstract
Low-frequency potentially predictability (PP) both of the surface temperature, precipitation in certain target areas (e.g. Europe) and of large-scale atmospheric indices at timescales from months to years will be assessed throughout the XX and XXI centuries using different analyses datasets like the extended centennial ERA 20C reanalysis (1899-2010) and also state-of-the-art Earth system simulations and predictions from the model of the EC-Earth Consortium (Hazeleger and Bintanja 2012) for different future scenarios: RCP4.5 and RCP8.5 (2010-2100), giving an hint of the sensitivity of PP to global warming, following previous studies from the proponents of this study (Soares et al. 2015).

The PP concept was introduced by Boer (2004) and was applied in the context of climatic models by Boer and Lambert (2008). The PP quantifies the fraction of long-term variability that may be distinguished from the internally generated unpredictable natural ‘noisy’ variability at the timescale of interest. Different PP assessing metrics will be tested namely the signal to noise ratio and information theory measures, properly accounting for non-Gaussian distributed predictable signals (Pires and Ribeiro 2016; Pires and Perdigão, 2012, Bocquet et al. 2010). PP variability of monthly, seasonal and yearly timescales along the XX and XXI will be addressed in a continuously time varying fashion.

Tests for the attribution of PP variability will be performed in order to identify certain predictability sources sought in the fields of sea surface temperature (e.g. El-Niño), large-scale moisture, stratospheric links and nonlinear resonances (Pires and Perdigão, 2015). For that, the tele-connection maps and other diagnostics at different lags will be calculated.

In order to physically understand the effect of global warming effect on PP, namely on the decadal change of the SST patterns (DelSole et. al. 2014) we will run an intermediate complexity model (the Community Climate System Model, version 4 (CCSM4) with different frozen forcings, taken from the different warming scenarios.

We hope that the above studies contribute to evaluate the sources of monthly, yearly and decadal sources of meteorological predictability, which undoubtedly will be useful on many human activities.
References


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EARTHSYSTEMS 2017-3
PhD in Geophysics and Geoinformation Sciences

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

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

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

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

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

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

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

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

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

References


EARTHSYSTEMS 2017-4
PhD in Geophysics and Geoinformation Sciences

Modelling the physical mechanisms that drive microalgae proliferations (MoPhy)

Supervision
Alexandra Silva (IPMA), Alvaro Peliz (IDL), A.Miguel Santos (IPMA)

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**


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 SMF 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-coast 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.

References:


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

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.

References


Future wave climate change under global warming – Ensemble projections

Supervision

Pedro Miranda (IDL/FCUL), Alvaro Semedo (IDL/EN), Øyvind Breivik (Met.no/U. Bergen)

Part of the proposed work will be done at Met.no and University of Bergen, in Norway.

Abstract

The ocean is a critical component of the Earth’s climate system. The extent to which the ocean drives the atmospheric climate is dependent on the exchange of radiation, heat, mass, momentum, and water across the air-sea interface. Many observational (Harris 1966; Grachev and Fairall 2001; Smedman et al. 2009) and modelling (Hanley et al. 2008; Sullivan et al. 2008) studies have shown that wind-waves at the ocean surface (henceforth simply called “waves”) significantly modulate these exchanges. Waves are also of major importance since they play a significant role in many engineering and environmental issues, both in the open ocean and coastal zones, providing a considerable contribution to coastal sea level extremes and flooding. Waves are also a key factor in determining rates of coastal erosion and sediment budgets. In the open ocean, waves represent a major hazard for any offshore operation or structure, or to maritime transportation and shipping activity. On the other hand waves are also important due to their modulation of the exchange of momentum, heat, and mass across the air-sea interface, and this modulation is sea state dependent (Högstrom et al. 2009; Semedo et al. 2009). The wave effect propagates trough the ocean mix layer and marine atmospheric boundary layer (Thorpe 2004, Belcher et al. 2012). It has been argued that the wave contribution to the coupled ocean-atmosphere climate system is not negligible; hence the study of this contribution and the study of the impact of changes in future climate on the global wave climate (from the climatic and practical point of view) are paramount.

The impact of a warmer climate on the future global ocean wave climate has recently drawn attention to the scientific community. Upon the work of Mori et al. (2010) several other wave climate projections followed (Hemer et al. 2012b; Semedo et al. 2013, Fan et al. 2013), all under the Coordinated Ocean Wave Climate Projection (COWCLIP; Hemer et al. 2012a) project, and based on CMIP3 (Coupled Model Inter-comparison Project, phase 3) greenhouse-gas emission scenarios. In spite of the variability of these studies, as shown in Hemer et al. (2013), most of them were mentioned in the recent Fifth Assessment Report (AR5) of the United Nations Intergovernmental Panel on Climate Change (IPCC) regarding the impact of climate change on future wave climate. Nevertheless, more coherent future wave climate projections (dynamical and statistical), based on CMIP5 and future CMIP6 GCM (global climate model) runs are needed.

This proposal will use a set of CMIP5 and CMIP6 EC-Earth (Hazeleger et al. 2010) runs to drive the wave model WAM (with 10 m winds and sea ice coverage). These dynamic wave climate projections will be the core of a seamless ensemble, where statistical wave climate projections will be added, aiming the study of the impact of climate change on future wave climate in a more coherent manner, and allowing the assessment of the associated uncertainty. The analysis of the projected changes for the end of the 21st
century, on the wind sea and swell patterns (following the Semedo et al. 2011 method), as well as on the wave energy flux, besides the usual wave heights and periods (and mean wave directions) approach, will also be pursuit.

This study will be carried on under the COWCLIP framework, with a strong link to the Norwegian Meteorological Institute (Met.no) and to the University of Bergen, in Norway, where the student is expected to spend part of the PhD time. The COWCLIP community is supported by the JCOMM (Joint Technical Commission for Oceanography and Marine Meteorology).

References


Impacts of water scarcity on energy generation: Mexico and Portugal case studies

Supervision

Carla Silva (IDL), Ignacio Contreras (México)
Part of the proposed work will be done at Universidad Autonoma de Sinaloa, Mexico.

Abstract

The relationship between climate change and water resources is a hot topic. Due to the large amount of water required to cool electricity generation plants, and in light of the predicted future increase in energy consumption for the coming years, water withdrawals associated with power and biomass generation must be taken into consideration (IEA 2012; Baker et al. 2014; Liu et al. 2015). Different Geographical locations, with different climates, imply different fresh water needs, different endogenous biomass and different electricity plants. Future horizons, 2050 and beyond, will deal with COP21 success or failure. This will produce different water impacts that may be simulated via CLIMWAT and CROPWAT (Land and Water Development Division 2015) (Doria et al. 2007). Water impact will affect passenger transportation systems via biofuel and electricity inputs. Biofuel comes from biorefinery (Silva et al. 2015). Electric vehicles have higher water needs than other conventional technologies due to the powerplants existing in the electricity generation mix (Silva 2011). In this thesis the Mexican electricity generation system as well as Jatropha curcas and Moringa Oleifera (da Silva et al. 2010) endogenous biomass to biodiesel will be studied. Within Portugal, electricity generation system as well as carob and Topinambur biomass to hydrogen and ethanol will be studied. Wastewater potential to withdraw fresh water will be assessed (Gouveia et al. 2016).

References


EARTHSYSTEMS 2017-9
PhD in Geology

**Physically based landslide hazard assessment at regional scale**

**Supervision**
Fernando M.S.F. Marques (Instituto Dom Luiz, Departamento de Geologia da FCUL)

**Abstract**
Landslides are slope processes which occur in a very wide range of geological and geomorphological conditions, and are also a major natural hazard, causing considerable life and economic losses. The increased awareness of landslide hazards in the last decades supported the development of different quantitative methods for landslide susceptibility and hazard assessment, following statistical or physically based approaches.

The statistically based methods have received the larger part of the research efforts, and in the current state of development, they are very efficient tools for landslide susceptibility assessment at basin or regional scale of analysis, and tend to provide good results with much less effort in the production of the base information data required than the physically based methods.

However, the physically based methods, in spite of requiring base data which is more difficult to obtain, have advantages which include: 1) the possibility to assess the earthquake triggered landslide susceptibility in regions where seismicity has long recurrence periods and, in consequence, there is no possibility to build inventories of earthquake triggered landslides for application of statistical methods; 2) to enable the construction of process based landslide alert systems; 3) to contribute with base data relevant to support engineering works, namely providing field based data on soil and rock mass strength.

In spite of these advantages, the physically based methods have received much less attention of the scientific community, with several problems in data acquisition and modelling still requiring significant improvements for their efficient application. In fact, there is need to produce advances in the physically based landslide susceptibility and hazard assessment at regional scale, addressing critical aspects as the assessment and mapping of potentially unstable soil thickness for shallow landslides, hydrological and hydrogeological data acquisition and modelling, assessment and spatial distribution of strength parameters, lateral effects on the performance of the infinite slope model for translational landslides and the setting up of analysis methods to model circular, deep seated landslides.

This thesis is intended to produce advances in physically based landslide hazard assessment methods, addressing the more critical problems that emerge on their application performance and reliability, including field, laboratory and modelling work to perform on selected study areas for which preliminary studies have already been undertaken.
Key references


EARTHSYSTEMS 2017-10

PhD in Geology

Large landslides in mainland Portugal: causes, dating and paleoactivity of triggering factors

Supervision

Fernando M.S.F. Marques (Instituto Dom Luiz, Departamento de Geologia da FCUL)

Abstract

Large landslides (volume displaced larger than 10^6 m^3) are high magnitude, low time frequency events, triggered by exceptional external factors, like heavy rainfall, floods, rapid snowmelt, volcanic eruptions or earthquakes. Their large size and low time frequency leads to a poor understanding of their causes and no awareness of the magnitude of the natural hazards involved. Further, due to their exceptional character, they are not included in current landslide hazard study methods.

Present knowledge on large scale slope instabilities is still far from satisfactory namely on: space distribution; causes and triggering factors; dating of start and reactivation; type and velocity of movement; influence of geological, structural or tectonic features; hydrogeological factors; particular geomechanical mechanisms; premonitory evidences of future instability and early warning indicators of failure; hazard assessment; anthropogenic influences.

In mainland Portugal, the available information is extremely limited, even at the lower level of large landslide identification and general characterization, making this subject particularly relevant in terms of hazard assessment.

Some large landslides contain a number of features favorable for the assessment of the triggering factors: their large displaced masses tend to last with minor changes during long time, enabling a constraint of failure conditions, based on the assessment of landslide geometry, geotechnical properties of materials and ground water levels. Failure can be modeled, with slope stability analysis methods, to derive ranges of values for the magnitude of the triggering factors most likely involved, that include static (rainfall, floods) and dynamic (large earthquake) actions. Finally, dating will provide the link with an external factor peak of activity.

This thesis is aimed to study a selected group of large mainly late Holocene landslides that affected various geological formations, occurred in a broad range of geomorphological conditions and fulfill, at least partially, the requirements to enable a complete analysis and the assessment of the triggering factors. The landslides to study are good examples of large movements of deep seated complex and earth-flow types. The multidisciplinary studies to perform include the determination of the geometry of the landslides, measurement of geotechnical properties, static and dynamic failure back analysis, and dating, in order to identify peak activity events of the external triggering factors of the landslides and to assess the ranges of magnitude required to start the movements. For those landslides triggered by earthquake shaking, the completion of the studies will provide indirect palaeoseismological data. The latter is particularly important in Portugal, where the two main sources of large earthquakes, the lower Tagus valley and the SW offshore of Portugal, are not accessible to direct palaeoseismological studies.
Key references

EARTHSYSTEMS 2017-11
PhD in Geophysics and Geoinformation Sciences

Earthquakes and lithospheric structure of the Gloria fault

Supervision
Susana Custódio (FCUL, IDL), Luis Matias (FCUL, IDL), Frank Krueger (Univ. Potsdam), Josep Batlló (ICGC, Barcelona)

Part of the proposed work may be carried out at Univ. Potsdam, Germany, and at ICGC, Barcelona.

Abstract
The Gloria fault is a major oceanic plate boundary fault, which accommodates strike-slip motion and links the Azores triple junction to the oblique convergent boundary between Iberia and NW Africa. This fault has hosted some of the largest strike-slip earthquakes in the oceanic domain, notably the 1941 M8.3 earthquake. In 1975, a M8.1 earthquake hit the intraplate region south of the Gloria fault, in the intersection between an old transform fault and the Madeira-Tore rise. In spite of its seismotectonic relevance, the Gloria fault has remained poorly studied, due mostly to its remote location in the north Atlantic. However, a recent Ocean Bottom Seismometer (OBS) array deployed slightly north of the Gloria fault has shown that the fault is seismically active and frequently generates small earthquakes.

The proposed work plan aims at studying the earthquakes and lithospheric structure of the Gloria fault. The main tasks proposed are:

1. Historical instrumental earthquakes. Seismological study of instrumental earthquakes in the Gloria fault domain and its aftershocks, using historical instrumental data and state-of-the-art methodologies, in order to infer earthquake rupture properties.

2. OBS-detected earthquakes. Accurate location of small earthquakes in the Gloria fault, using OBS data and array methodologies. In particular, special attention will be given to earthquake depth resolution, which can provide insights into the rheological depth profile of oceanic lithosphere.

3. Seismic wave scattering. OBS data has shown that the seismic waves generated by local and regional events in the Gloria fault domain are strongly scattered. The proposed work will address whether the strong scattering is related to the particular nature of the oceanic crust in this domain. The scattering will be quantified and its source will be located.

4. Seismic anisotropy. OBS data has indicated that the lithosphere in the Gloria fault domain is anisotropic. We will investigate the nature of this anisotropy and the possibility that the apparent “anisotropy” is due to a sub-crustal low velocity layer that thickens from the array towards the Gloria fault.

5. Geodynamic interpretation. The results obtained will be interpreted in a geodynamics framework, together with other geophysical data, including high-resolution bathymetry, magnetic data, gravimetric data, etc. Particular attention will be given to seismogenic processes in oceanic lithosphere and to the relationship between earthquake rupture and the particular properties of the lithosphere and fluid circulation.
Applicants are expected to have a strong background in Physics, Math and Earth Sciences and good programming skills.

**Figure 1.** Seismicity of the Azores–Iberia region. Earthquakes recorded instrumentally since 1996 are shown by small brown dots. Historical earthquakes reported by the SHARE European Earthquake Catalogue – SHEEC – with magnitudes larger than 5.5 are shown by circles whose radii correspond to the magnitude of the earthquakes (Stucchi et al., 2013). The earthquakes with magnitudes equal to or larger than 7.0 are labelled with year of occurrence and magnitude. The plate boundaries of the global plate tectonics NNR-MORVEL56 model are shown by dark blue lines (DeMets et al., 2010; Argus et al., 2011). The surface projection of potentially active faults compiled on the SHARE database are shown by red rectangles, the surface trace of the faults is marked by a thick red line (Basili et al., 2013; Vilanova et al., 2014). The SHARE faults in western Iberia are underlain by the original fault traces proposed by Cabral (2012) (green) and Duarte et al. (2013) (blue). The topography in background is taken from the global SRTM30+ model, obtained from satellite altimetry and ship depth soundings (Smith and Sandwell, 1997; Becker et al., 2009). (Figure taken from Custódio et al, 2016)

**References**


**EARTHSYSTEMS 2017-12**

PhD in Geophysics and Geoinformation Sciences

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

**Supervision**

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

**Abstract**

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

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

**Key references**


Seismicity and structure of the Monchique Alkaline Complex, Southwest Portugal

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) emplaced in the Paleozoic metamorphic basement (Miranda et al, 2009). 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?
- How do hypocenters distribute within the intrusion?
- What is the role of structures inherited from the magmatic emplacement or from later deformation in the localization 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 the ROCHEL magnetic survey (Neres et al, 2016) will cast light into the possibility of a structural link between Monchique and two other large magmatic intrusions of similar age – Sines and Sintra magmatic complexes.

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 precise relocation of hypocenters, and calculation of focal mechanisms, using advanced methodologies (Custódio et al., 2015). Seismic data already acquired will be used for this task.
- 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).

References


EARTHSYSTEMS 2017-14

PhD in Geophysics and Geoinformation Sciences

Integrating multiple earth observation sensors to improve predictions of climate change impacts on ecosystems

Supervision
Pedro Pinho (cE3c), João Catalão (IDL), Pedro Miranda (IDL)

Abstract

Climate change is one of the key problems threatening the functioning of earth systems (Heavens, et al, 2013). To tackle these problems, besides measuring climate change variables (e.g. temperature changes) one must also measure its effects in ecosystems (Branquinho, et al, 2015). Because vegetation is the support for all ecosystems, it is a logical target of most studies relating climate change to ecosystem functioning. In order to study vegetation response to climate, current earth observation system provide a wide range of options, but when using a single satellite system, one faces trade-offs in the information obtained. For example, by selecting a satellite with high spatial resolution one obtains data with poor temporal resolution, hindering the possibility of looking at the effects of precipitation changes in vegetation phenology (Ramos, et al, 2015).

In order to overcome this problem, we propose to explore the potential to integrate data from different earth observation systems, aiming at compensating each system weak point, in order to boost information quality. This will be done by combining the information from multispectral and radar sensors, in order to relate changes in vegetation status (both over space and over time) to climatic changes.

For that, this plan proposes to make use of the following earth observation systems: (i) Sentinel-1 (radar sensor with 4 m and 12 days resolution); (ii) Sentinel-2 (multispectral sensor, with 10-60 m and 10 days resolution); and (iii) MODIS (multispectral, 250-1000 m and daily resolution). For the areas and time periods selected, the historical and concurrent climate will be determined from the reanalysis of the European Centre for Medium-Range Weather Forecasts. This will be done in areas with a spatial climatic and ecosystem transition, especially along dryland areas, which will be identified with the support of the project ChangeTracker (PTDC/AAG-GLO/0045/2014).

Data analysis will model the changes in vegetation status and trends using concurrent and historical climate data, taking into account local conditions (topography and land-cover). This model will
then be validated by information derived from airborne sensors (EUFAR platform, if available) and field measurements (for example sampling annual vegetation).

By doing so this projects will identify the main climatic drivers of vegetation change under climate change conditions, and to forecast vegetation response to the anticipated climate over each region.

References


EARTHSYSTEMS 2017-15
PhD in Marine Sciences

Bloom dynamics of Gymnodinium catenatum 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 Paralytic Shellfish 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 (Figueroa et al., 2008).

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 (Amorim et al. in prep.). Physical processes that maybe associated with this transport are, for instance, internal waves known to occur off Iberia (Quaresma et al. 2007)

In this doctoral research project we propose to investigate in situ re-suspension processes and the associated oceanographic features to refine the model of input of benthic cysts to the pelagic realm. The physical parameters will be combined with G. catenatum life-cycle transition properties in the development of a biophysical model. Results from this research are expected to improve predictability of G. catenatum blooms in Iberia leading to a better management of marine resources in Iberia.

References


EARTHSYSTEMS 2017-16

PhD in Geology and Geophysics

Investigating the Tagus river delta landslide complex and its implications to tsunami hazard

Supervision

Pedro Terrinha (IDL, IPMA), Carlos Ribeiro (Univ. Évora) and Miguel Caetano (IPMA, Lisbon)

Abstract

Tsunamis have in very recent historical times changed the course of societal concerns and economics, such as the 2011 tsunami that hit the coast of Japan or the 2004 of Sumatra. The Portuguese coast and specifically the Lisbon coastal region were struck by large tsunamis in the recent past. The most well known for their tragic effects were the 1755 Great Lisbon and the 1531 earthquake triggered tsunamis. Less known historical seismic tsunamis occurred in 1969 AD, 1941 AD, 1909 AD, 1344 AD, 382 AD and 60 BC.

Apart from large earthquakes, other sources for tsunamis are known like meteo-tsunamis and landslide triggered tsunamis. The previous project TAGUSDELTA (3D high-resolution seismic stratigraphy of the Tagus Delta – imaging of tsunami and earthquake evidence for natural hazards) showed that half of the frontal part of the Tagus River delta collapsed in the Recent geological past. A 10km long, 4.5km wide area containing landslides was mapped using 2D and 3D seismics (Noiva et al., 2014 mission report online, Noiva et al., 2014; Terrinha et al., submitted). An age between 8ky and 13ky for Tagus Delta Landslides (TDLs) was proposed based on the calibration of seismic profiles with core data (Abrantes et al., 2008).

The occurrence of shallow gas raises the various problems, some of which will be addressed in this project:

i) What is the nature and origin of the gas? Is this microbial shallow gas or is it thermogenic gas originated from deep hydrocarbons of the Mesozoic Lusitanian rift basin?

ii) How much overpressed is the gas in depth? This strongly depends on its origin as shallow or deep gas and whether the gas is trapped within sediments or continuously flowing out of the system.

In order to answer these problems multibeam bathymetry will be acquired, processed and interpreted and gas bearing sediments will be collected and analyzed. The results will be used for the IPMA (Instituto Português do Mar e da Atmosfera) and IDL tsunami modelling group to assess the tsunami hazard.

The PhD candidate will be involved in a) detailed interpretation of 60 multichannel seismic reflection lines across the TDLs with the aim of understand the sedimentation dynamics of the Tagus delta, b) collecting and processing multibeam data on the delta and sediment/gas sampling and processing and c) integrate the tsunami modelling team and last but not least, in the integration of these data producing papers and his/her PhD thesis.

The analytical work will be carried out at the IPMA and Univ. Évora laboratories. The seismic interpretation will be carried out at the IPMA, Lisbon.
References


Terrinha, Pedro, Henrique Duarte, João Noiva, Carlos Ribeiro, Pedro Brito, Maria Ana Baptista, Miguel Miranda, Vitor Magalhães, Cristina Roque, Rachid Omira and Tagusdelta cruise team * (Marcos Rosa, Paulo Alves, Francisco Teixeira). The Tagus River delta (off Lisbon, Portugal) as a repository of landslides. Implications on trigger mechanisms, tsunami hazard and neotectonics. Submitte
EARTHSYSTEMS 2017-17
PhD in Geophysics and Geoinformation Sciences

Long Bone Intraspecific Variability in Dinosaur Faunal Assemblages of Upper Jurassic of Portugal as Response to Climate Change. A Morphometric Approach.

Supervision
Mário Cachão (IDL) & Luis Rodrigues (CCV_Lagos)

Abstract
Objectives:
The aim of this study is through morphometric and shape analysis methods to interpret important information over the paleoecology, functional morphology, evolution, ontogeny, sexual dimorphism, phylogeny, taphonomy, and reconstruction of dinosaurs.

Motivation and summary:
Paleoclimatic conditions, tectonism and continuous eustatic sea level fluctuations in the Jurassic are the driving forces behind the conditions that allowed the rich Portuguese terrestrial vertebrate fauna. Large-scale tectonic processes and therefore occasional opening-closing of epicontinental seaways and global environmental changes urged dinosaurian dispersion. Comparison between the Western United States and Portugal supports similar climate between these Late Jurassic terrestrial ecosystems thus sustaining migrating dinosaurs in exploration of new territories. The Middle–Late Jurassic sea-level fall in the Lusitanian Basin is also recorded within the Iberian and other peri-Atlantic regions and matches a transgressive to regressive change in eustatic sea-level curves, indicating that it is related to a global event. Changes in continental ice and water storage, brought about by change in atmospheric composition as well as sediment supply due to sea level changes, have created rich fossiliferous sites subjected to various taphonomic impacts. The studied materials have been subjected to constant environmental and diagenetic processes. Therefore, investigation is crucial on the taphonomic conditions and comparison in-between long bones with geometric morphometric approaches. Through that we aim to define the extent of intraspecific variability.

Methods:
Morphometric analyses are commonly implemented on the fossil record, to analyse and understand shape, developmental changes in form, correlations between ecological factors and shape, and for evaluating quantitative-genetic parameters of shape. Morphometrics can be used to quantify traits of evolutionary significance, and by identifying changes in the shape, infer ontogenetic stages, function or evolutionary relationships. Shape analysis is widely used in ecology and evolutionary biology.
The data from the vertebrate faunal assemblages of Upper Jurassic will be analyzed using morphometric techniques. Landmarks associated with articular surfaces and muscle attachments will be digitized from photographs of the long bones. Those differences in shapes and sizes will be then attributed to intrinsic or extrinsic, ante mortem or post mortem, factors respectively.

References


EARTHSYSTEMS 2017-18

PhD in Micropaleontology

Paleoecology and paleoceanography of calcareous nannofossils during the Quaternary.

Supervision

Mário Cachão (IDL)

Abstract

Produce SST and nutrient transfer functions for calcareous nannoplankton Quaternary main common species based on work produced on the Atlantic Ocean and around Iberia (e.g. Cachão & Moita, 2000; Cachão et al. 2000; Alday et al., 2006; Narciso et al., 2006, Guerreiro et al., 2013, 2014, 2015).

Validate these transfer functions with recent and fossil data from available water column filters, sediment traps, surface sediments and core tops and Quaternary core sediments.

References


Cachão, M., Moita, T., 2000: Coccolithus pelagicus, a productivity proxy related to moderate fronts off Western Iberia, Marine Micropaleontology, 39(1/4): 131-155. DOI: 10.1016/S0377-8398(00)00018-9; WOS: 000088058100010


Azores Current Dynamics and Eddies near the Mid-Atlantic Ridge

Abstract

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.

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

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. Finally, model results shall be compared with Altimetry and drifting bouy data.
References

(3) Peliz and Kida (in prep), “The formation of the Azores Current due to the Mediterranean overflow and localized wind stress curl over the Gulf of Cadiz”
EARTHSYSTEMS 2017-20

PhD in Geology/Oceanography/Marine Sciences

Is the Earth currently in a global tidal maximum? 500 Ma of coupled tectonic and tidal modelling

Supervision

João Duarte (Univ. Lisbon, IDL), Mattias Green (Bangor University, UK)

Summary

It is known that Atlantic-type oceans can open and close: the so-called Wilson cycle. However, the impact of such cycles on oceanic tides has never been explored. The aim of this work is to model tectonic plate’s motion and oceanic tides over a complete Wilson cycle, and associated supercontinent cycle of 500 Ma. The tidal modelling will be used to monitor changes in tidal amplitude and resonance over the entire lifetime of the Atlantic from its inception in the late Triassic ~200 Ma to its eventual closing in ~300 Ma. The models results will confirm or deny the existence of a “Super-tidal” cycle associated with a Wilson cycle. The implications of this work are global and, therefore, large scale oceanographic consequences will be explored. For example, changes in tidal dissipation that could alter the meridional overturning circulation of the Earth.

Objectives

The primary objective of this work is to test the following hypothesis:
Is the Atlantic Ocean currently in a tidal maximum? Does the Atlantic have a perfect shape and size to allow tidal resonance and hence high amplitude tidal waves causing the large modern day tides? If not, when, in the future or past, will the Atlantic be at an optimum size for maximum tidal resonance to occur?

This main objective can be divided into smaller, partial objectives:
1. To create a coupled numerical tidal-tectonic model of an entire supercontinent cycle spanning from the late Triassic 200 Ma in the past through the modern day to 300 Ma in the future.
2. To closely analyse the changes in tidal amplitude and resonance on two scales:
   a. In the Atlantic Ocean from its opening, progressive widening and eventual closing in a classical Wilson cycle.
   b. Over the entire Earth as the planet moves from the dispersal to the reformation of a supercontinent in a classical supercycle.
3. To investigate the existence or non-existence of a “Super-tidal” cycle associated with a Wilson cycle.
4. To investigate the implications of the existence of a “Super-tidal” cycle. Possible implications can be divided into two sub-categories: deep ocean and continental shelf. The main changes that could occur are:
   a. The global energy budget of the ocean leading to strengthening or weakening of the MOC.
   b. The energy input to the continental shelf changing aspects of sediment dynamics such as turbidity,
nutrient mixing and rate of deposition of sediment on the continental slope leading to differences in deposit formation.

**Tasks**

The work involved with this project can be divided into several tasks which will be completed either in tandem or as a prerequisite to another. The tasks are as follows:

1. Collation and organisation of current literature and data.
2. Tectonic modelling using Gplates.
4. Tidal modelling using the Oregon state University Tidal Inversion System (OTIS).
5. Implications and hypothesis confirmation/rejection.

**Literature**


EARTHSYSTEMS 2017-21
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.

References
EARTHSYSTEMS 2017-22

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), Rita M. Cardoso (IDL) and Douglas Maraun (University of Graz)

Part of the proposed work may be done at University of Graz

Abstract

The use of multi-model ensembles is increasingly used for climate change assessment, from global (IPCC 2013) to regional scales (Soares et al 2012, Cardoso et al 2013, Soares et al 2015, 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). Information on regional climate change 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). Nevertheless, important issues arise: the distinction between the GCMs and the RCMs errors, the selection and weighting of ensemble members for climate change assessment, and the eventual drawbacks associated with the different RCM performance and the observed relationships, which may not persist, and in a changing climate.

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. Until the mid-21st century, random internal climate variability might completely mask climate change trends (Deser et al, 2012; Maraun, 2013). 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 precipitation, from mean to extreme. Assess the added value of downscaling to correctly represent local/regional trends, and 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).

References
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EARTHSYSTEMS 2017-23

PhD in Geology

Deciphering the geochemical and mineralogical mechanisms of dolomitization 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 in 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, 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). Dolomitization fronts will be sampled and differentiated as being diagenetic, in close association with 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.

References

EARTHSYSTEMS 2017-24

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. However, the mechanisms that control both the growth and incorporation of ions are still unsettled and debated, especially the interplay between the thermodynamic parameters that characterize these systems and its intrinsic kinetics. Besides, the effects of non-ideality of solid solutions in these processes were poorly studied. Approaching the problem from a modelling and experimental perspective is important to achieve a better understanding of the system’s mechanistic.

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

References

EARTHSYSTEMS 2017-25

PhD in Geology

The role of wave erosion, sea-level and vertical movements in the evolution of volcanic islands: Insights from the geological record and modelling

Supervision

Rui Quartau (IDL and Instituto Hidrográfico), Rui Taborda (IDL and Departamento de Geologia) and Alan Trenhaile (University of Windsor)

Part of the proposed work might be done at the University of Windsor

Motivation

The ultimate fate of volcanic ocean islands is to be drowned. Drowning is essentially conditioned by subsidence in edifices standing in young lithosphere and in fast-moving plates like the Hawaii or by marine erosion that truncates stable edifices located in old lithosphere and in mid-plate stationary swells like Cape Verde. Several processes interplay, thus competing for the survival or decay of islands. The size (height and diameter) of the island, subaerial erosional processes, mass wasting, wave energy conditions and amplitude of the eustatic change, sedimentation/coral reef growth, post-erosional volcanic activity, and vertical movements are all factors conditioning the lifetime of an island (Ramalho et al., 2013). From all of these, marine erosion is one of the most important factor for island destruction since it is responsible for the development of insular shelves that initiate as soon as volcanism wanes. Shore platforms formed during stable sea-level by wave erosion evolved into insular shelves during the Quaternary with surf migrating landwards and seawards with changing sea-level (Quartau et al., 2010; Quartau et al., 2014) In settings where islands are stable or subsidence is occurring, wave erosion will promote their destruction and in uplifting settings it will oppose island growth (Quartau et al., 2016). Therefore, to understand the role of wave erosion and vertical movements in maintaining islands above sea level, is the main aim of this project.

Methodology

This project aims to study the coastal evolution of islands of two reefless archipelagos (Madeira and Azores) by combining a comprehensive geomorphological analysis of the island edifices with numerical modelling. To achieve the project’s aim, the candidate will use three distinct but complementary approaches: (1) Geomorphological analysis of the coastlines, insular shelves and slopes of the islands to provide a gross quantification of wave erosion and vertical movements processes (e.g., Quartau et al., 2014) (2) Use that gross estimation as initial inputs to a coastal erosion numerical model (Trenhaile, 2001) to calibrate it; By adopting the values that best simulate in the numerical model the present-day coastal morphology of the islands (cliff height, shelf gradient, shape, width, and depth of the shelf break, Quartau et al., 2010), the range of rates of these processes will be determined; and (3) Apply the range of rates
determined by the model to predict future coastal evolution and the time missing for the drowning of the islands in these archipelagos.

The successful candidate will have the opportunity to interpret data with a worldwide unprecedented coverage and resolution, including subaerial (geological and geophysical) and submarine datasets (multibeam bathymetry and high-resolution seismic reflection profiles) from the Azores and Madeira archipelago. The candidate will also develop strong skills in numerical modelling under the supervision of two experienced coastal modelers (Taborda & Ribeiro, 2015; Trenhaile, 2001), by applying a coastal erosion numerical model to quantify for the first time the role of wave erosion and vertical movements in controlling the survival of volcanic ocean islands.

**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.

Rui Taborda is a professor at the University of Lisbon. He is a senior researcher in coastal and marine geology with experience in sediment transport modeling, computational methods in geology and sea level changes. Rui has also a wide experience in the coordination of R&D and consultancy projects.

Alan Trenhaile is a Professor of Geomorphology in the University of Windsor, Canada. His primary interests are concerned with coastal development and in particular, rock and cohesive clay coasts, including the processes that are presently operating on them, their rates of erosion, mathematical modelling, inheritance from periods when sea level was similar to today’s, and the effect on these coasts of climate change. Alan is a worldwide recognized coastal geomorphologist, with a proven track record of reference books that are considered the bibles of Coastal Geomorphology.

**References**


The link between climate and Land use changes (LUC) has been investigated using RCMs in different regions of the world (Pielke et al. 2011, Mahmood et al. 2014) and can have an impact in regional climate as important as greenhouse gas emissions (de Noblet-Ducoudré et al. 2012). Nevertheless, no coordinated attempt to robustly identify the magnitude of contribution of LUC to the mitigation or enhancement of climate change has been previously attempted. Firstly, it is essential to quantify the contribution of land use to the present climate through the use of RCMs forced by reanalysis and through sensitivity studies to different LUC scenarios. The results from the RCM simulations will be evaluated against observations, focusing on water and energy land/atmosphere fluxes, and common atmospheric variables. Secondly, the contribution of LUC to climate change enhancement/mitigation will be investigated through the downscaling of two climate scenarios. The results will be part of the inter-comparison efforts linked to the Flagship Pilot Study LUCAS (Land Use & Climate Across Scales) initiative supported by the WCRP CORDEX and GEWEX-GASS international program.

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EARTHSYSTEMS 2017-27
PhD in Geology

Modelling subduction invasion of the Atlantic Ocean

Supervision
Filipe Rosas (Univ. of Lisbon, IDL) and Nicolas Riel (Univ. of Durham)

Part of the proposed work might be done at the University of Durham

Motivation
The main motivation of the present PhD project is to understand how is subduction initiated in a pristine passive margin (in general), and how is this happening nowadays in the margins of the Atlantic Ocean (in particular). Subduction initiation can be seen as the missing link of the Wilson cycle, since it corresponds to a stage of its evolutions that is not presently observed in nature (McKenzie, 1977; Cloetingh et al., 1989; Mueller and Phillips, 1991; Stern, 2004; Duarte et al., 2013).

To address this central conundrum of modern day Plate Tectonics (op. cit.), we propose to look at the Atlantic Ocean as a case study since it corresponds to a place where subduction has already been initiated – both in the Antilles and South Scotia arcs – and may initiate? along the Gibraltar Arc in the complex (diffuse) plate boundary between Eurasia and Nubia (in NE Atlantic, Terrinha et al., 2009; Duarte et al., 2013).

This last critical site (Gibraltar arc - Gulf of Cadiz region, offshore SW Iberia and NW Morocco), has recently been proposed as a place where subduction initiation would be starting to occur (Duarte et al., 2013), induced by the propagation of the arc-thrust lithospheric failure to the West Iberian Margin (WIM), under the ongoing NW-SE regional convergence between Eurasia and Nubia (op. cit.).

Taking all this into account, we propose a comparative study of the geodynamic evolution of the three mentioned main sites along the Atlantic margins: where subduction has already started (Antilles and Scotia arcs) and where it may start (Gibraltar arc). Geodynamic and geological constrains will serve as input to perform 3D numerical modelling of each of these different cases, but having as a common main background the key problem of subduction initiation.

Methodology
3D finite-element numerical modelling using “Underworld” software. The models will be achieved using the open source code “Underworld”, which has been developed by the computational geodynamics group at the Monash University (Australia). Underworld is a thermo-mechanical code using parallel particle-in-cell based finite element methods. This code is specifically designed for large-scale and long-term geodynamic simulations in 3D space. The main advantages of using such a numerical code are: the inbuilt complex stress and strain-dependent rheologies (from non-newtonian to brittle), the quantification of stress (besides strain and strain-rates) and the excellent parallel scalability on large 3D simulations.
References


EARTHSYSTEMS 2017-28
PhD in Geophysics and Geoinformation Sciences

Application of short term forecasting to model predictive control of indoor environment

Supervision
Guilherme Carrilho da Graça (IDL) e Pedro Ferreira (DI-FCUL)

Abstract
Students spend significant time in classrooms that often have low IAQ. As several studies found a link between low IAQ and reduced learning performance [1, 2], current classroom ventilation standards recommend an indoor-outdoor CO2 concentration differential of less than 700ppm. Achieving these airflow rates with mechanical ventilation systems increases energy consumption and maintenance costs. In many climates, a well-designed natural ventilation (NV) system can provide adequate IAQ with no running costs. The motivation for increased NV use is clear: mechanical ventilation fan energy consumption is comparable to indoor lighting, with power densities in the range 5-15W/m2 [3]. Further, the average energy consumption of a mechanical cooling system has similar magnitude (or up to twice as much in hot and humid climates), compounding an HVAC related energy consumption of 50%-60% of total building energy consumption [4,5]. In light of these numbers a successful NV cooling system could halve the total energy consumption of a typical school building located in a warm or mild climate.

Difficulties arise from the intense use of classroom spaces that creates a constant need for fresh air and (most of the year) cooling. As NV systems have limited cooling capability and in warmer days may have no cooling capacity at all, passive cooling must be provided by the building internal mass (heavy walls and floors exposed to the indoor air), that, ideally, should be pre-cooled during the night using NV. For passive cooling strategies to work, direct solar gains must be minimized, thereby avoiding overheating. Satisfying this requirement and the need to maximize use of daylighting can be challenging: overly restrictive shading can lead to insufficient daylight levels, while maximizing daylight can result in excessive solar gains.

The optimal performance of passive cooling strategies that use NV and building thermal mass is highly dependent on system control due to the complex interactions between the systems and the delayed response of the thermal mass. Indoor conditions can be influenced by control actions from the previous day, and, conversely, control actions can impact the building performance in the next day. ANN based MPC can explore the complex interaction between these systems as it selects optimal control actions based on their predicted outcome over a prediction horizon. This research will present one of the first applications of this approach to a building with fully passive systems.

The use of MPC in a limited cooling capability and slow response scenario requires accurate prediction of system response in a time frame of several hours up to one day. The effectiveness of the strategy can be improved by combining short-term ANN predictions, mid-term weather forecasts [6] and upcoming class schedule. Examples of automatic control actions that may result from taking into account the combined predicted information are: a cooler outdoor temperature triggering an actuation on the shading to increase passive heating by solar gains; or delaying ventilation in warm outdoor periods with no upcoming
room occupation; and adjusting the amount of nighttime pre-cooling of the room based on the expected next day occupation. The ANN MPC strategy will continuously identify the most successful control actions to maintain the room indoor conditions during the occupied hours. A temperature range defined using the adaptive thermal comfort model will be used (for the Lisbon climate, the 80% acceptability range is approximately 18-28°C) [7]. Indoor air quality will be assessed using CO2 as a tracer gas with a target value of 700ppm above outdoor. Daylighting variability will be within 300-1000 lux.

The ANN-MPC control strategy will be developed off-line in appropriate computing facilities, being the resultant operational system implemented in a distributed platform composed of low-cost small micro-controllers and computers installed in three identical south facing classrooms in the University of Lisbon. Each room will be equipped with electrically operated windows and external shading systems. The rooms have a 4 meter floor to ceiling height and an inclined seating arrangement, allowing for the use of buoyancy driven NV. In each room the indoor conditions will be monitored using two CO2 sensors along with two air and three room surface temperature sensors. In each moment room occupation will be monitored using an image processing based people counter (continuously monitoring students coming into and out of each room). The three rooms (A, B and C) will be in normal use throughout an academic year using three different control approaches. Room A will be manually operated by the teaching staff controlling window and shading system position. Room B will use an automated rule based traditional automatic control strategy. Room C will be controlled by the ANN MPC strategy developed in this work. Local weather conditions will be obtained from the UL campus weather station and class schedules will be provided by the UL information system. Comparison between the indoor environmental quality (air, temperature and daylight) of the three rooms will allow for a simple assessment and fine tuning of the control strategy developed in this research.

References

Dynamics of phytoplankton through remote sensing in coastal systems

Supervision
Ana C. Brito (MARE-FCUL), Vanda Brotas (MARE-FCUL),

Summary
More than 45% of the Human population now lives on only 10% of the available area, the coastal zone (Crossland et al., 2005). In addition, agriculture in the catchment and the consequent increase in nutrient pressure leads to an accelerate growth of algae, the occurrence of Harmful Algal Blooms (HABs) and a decrease in the environmental quality of coastal ecosystems. Achieving the sustainability of the marine environment is probably one of the most important challenges for both marine science and society. Changes in phytoplankton dynamics, which is at the base of food webs in the North-East Atlantic, have already been identified by several authors (see Richardson and Schoeman, 2004; and reference therein). These may have significant impacts on the fisheries industry, which in 2009 was worth 6.6. billion EUR Catches (http://eurostat.ec.europa.eu/). 75% of these catches were caught in the North-East Atlantic, although these catches were declining compared to previous years. Recognizing the importance of the marine ecosystems, the European Union released the Marine Strategy Framework Directive (MSFD) in 2008 with the aim of ensuring a Good Environmental Status (GES) across Europe's marine environment by 2020. However, the assessment of the environmental quality of ecosystems is difficult and time-consuming, especially in oceanic waters given the extensive area and access constraints. This is particularly important in a Europe that is currently dealing with a severe economic crisis. Therefore, cost-effective methods to differentiate the phytoplankton community based on satellite observations are being developed for this region (e.g. Brotas et al., 2014; Brito et al., 2015; Sá et al., 2015). In these demanding times, when Human pressure on the coastal zones is continuously growing and a global change in the general climatic pattern is now widely accepted, several research questions arise.

The objectives of this project will be to: 1) develop a remote sensing tool to distinguish the different phytoplankton groups using satellite data; 2) investigate the phytoplankton anomalies in the North-East Atlantic (NEA); 3) assess how can remote sensing contribute to the evaluation of environmental quality under the OSPAR and Marine Strategy Framework Directive (MSFD).
The end of this project expects a major contribution expected towards understanding phytoplankton communities and eutrophication in the North-East Atlantic, and towards the implementation of the MSFD.

References


EARTHSYSTEMS 2017-30
PhD in Marine Sciences

Water Quality Indexes for Estuarine Waters: assessment of temporal and spatial variability

Supervision
Ana C. Brito (MARE-FCUL), Vanda Brotas (MARE-FCUL), Marta Rodrigues (LNEC)

Summary
Estuarine ecosystems are some of the most threatened in the world (Howard and Marino 2006). Their susceptibility is related to the high anthropogenic pressure on the coastal zone, as well as global climate changes, i.e. sea level rise and temperature increase. European policies, such as the Water Framework Directive (WFD), have highlighted the need to develop metrics and indexes for the assessment of environmental quality in these coastal systems. However, this has been rather difficult due to the complexity of estuarine ecosystems. They have a high temporal variability, from diurnal, tidal and seasonal to inter-annual due to hydrological parameters, which are strongly linked with climatic factors. Additionally, they also have strong spatial heterogeneity due to their geomorphology, hydrodynamics and natural physico-chemical gradients. Remote sensing and 3D modelling that allow studying estuaries with high temporal and spatial resolution are therefore keys for the development of such indexes.

This study will be focused on the Tagus estuary, which is one of the largest estuaries in Europe. Data from an on-going monitoring programme, in action since 1999, did not show any significant change in the physico-chemical parameters (Brito et al., 2015), and a strong link between hydrological conditions and inter-annual variability of environmental parameters and phytoplankton biomass was established (Gameiro et al., 2007, Gameiro and Brotas, 2010). However, a decrease in chlorophyll a concentrations in the last decade was reported (Brito et al., 2015). This was associated with a shift in the phytoplankton community that could be caused by increased shellfish grazing due to the invasive Ruditapes philippinarum. A preliminary set of metrics to assess ecological quality of the Tagus based on phytoplankton was already proposed (Brito et al., 2012), however, there is the need to integrate the spatial and temporal dynamics of this system, as well as to consider the implications of different scenarios of climate change. Results obtained through the on-going monitoring programme will be integrated with Sentinel 2 satellite data. In-situ sensors and 3D biogeochemical model ECOSELFE (Rodrigues et al., 2009) implemented in the scope of the FCT UBEST Project will also be incorporated in the full database. The integration of in-situ, satellite data and results from 3D simulations will set the basis to evaluate the effects of anthropogenic pressure and to investigate how estuarine systems react to climate change.
References


EARTHSYSTEMS 2017-31

PhD in PhD in Geophysics and Geoinformation Sciences

Tsunamis from source to coast

Supervision

Maria Ana Viana Baptista, Utku Kanoglu, Jorge Miguel Miranda

Summary

In spite of the recent advances in tsunami warning and forecast tools and capabilities it is of utmost importance to enlarge our knowledge about the sources and triggers of tsunami events in complex geological environments, such as diffuse plate boundary environments, and in near source conditions. Most of the approaches developed so far are increasingly effective in the case of subduction areas, but are less effective in the case of diffuse plate boundaries domains. Current studies characterize the tsunami hazard using deterministic (Heidarzadeh, 2009; Baptista et al., 2011; Wijetunge, 2014) or probabilistic approaches (Sarri et al., 2012; Omira, 2015). These approaches use seismic hazard, geological or historical evidence of past tsunami events or tsunami catalogues. These studies indicate differences between tsunami hazards in discrete or diffuse tectonic settings. After determination of tsunami source, the non-linear shallow water (NSW) models are used to model tsunami propagation and inundation (Titov et al., 1995; Liu et al. 1998), Tinti et al., 2013). However, high resolution inundation modelling is time consuming and currently in use only for farfield events in TWS (Bernard and Titov, 2015). Tsunami early warning needs: quick tsunami detection and, quick and accurate source estimation. Most operational TWS use pre-computed scenario databases. Estimation of the seismic source uses w-phase inversion (Duputel et al. 2011) whereas tsunami source estimation uses joint inversion of various data sets (space geodetic data or tsunami waveforms through deep ocean measurements) Melgar and Bock (2015). It is proposed to review operational systems and existing methodologies, and to develop new approaches to be used in tsunami early warning systems. This thesis contributes to: (a) a better characterization of the tsunami hazard in diffuse plate boundary domains, (b) a better understanding of the tsunamigenesis in these conditions, (c) the development of new methods for quick run-up estimation and (d) implementation of these methods in operating systems.

The main goals of these study are:

1: The real-time evaluation of tsunami source in near-shore conditions, namely the implications of the fast evaluation of seismic sources and the limitations of the use of half-space elastic deformation approach to compute the co-seismic deformation. Recent tsunamis will be analysed involving both seismic, mareographic and DART data.

2: Fast evaluation of tsunami impact, namely a review of methods to forecast inundation parameters based on NSW estimation; use of inundation scenario databases; use of statistical simulators; the use of regularized extreme learning machine algorithms; new approaches on the combination of 2D numerical based on NSW or combining pre-calculated empirical Green’s functions + 1D analytical solution for inundation.
EARTHSYSTEMS: Lisbon Doctoral School on Earth System Science, PhD Projects

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EARTHSYSTEMS 2017-32

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 2017

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-occur in space, making it difficult to discriminate the relative contribution of each driver on the observed changes in ecosystems.

In the marine realm, coastal ecosystems 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 promising 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 al. 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 strategy 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) to allow future comparison with the sub-fossil record.
To explore the possible relations between temperature, nitrogen and dinoflagellate cysts, multivariate methods, based on community and functional diversity analysis, will be carried out. Afterwards, the more 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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