MECC 2013 - International Conference and Advanced School Planet Earth, Mathematics of Energy and Climate Change

Portugal, 21-28 March 2013

Keynote Speakers
Thematic Sessions
Advanced School
Book of Abstracts
Conference Schedule

Welcome letter to the participants of the President of CIM

The International Center of Mathematics CIM is a partner institution of the International Program Mathematics of Planet Earth 2013 (MPE 2013).

To this extent, CIM is organizing the following CIM-MPE events:

http://sqig.math.ist.utl.pt/cim/mpe2013/

- MECC 2013 - International Conference and Advanced School Planet Earth, Mathematics of Energy and Climate Change, 21-28 March 2013.

- DGS 2013 - International Conference and Advanced School Planet Earth, Dynamics, Games and Science, 26 August to 7 September 2013.

The first two volumes of the CIM Series in Mathematical Sciences published by Springer-Verlag will consist of selected works presented in the conferences Mathematics of Planet Earth (CIM-MPE). The editors of these first two volumes are Jean Pierre Bourguignon, Rolf Jeltsch, Alberto Pinto and Marcelo Viana. If you would like to submit a review article, please send it by email to aapinto@fc.up.pt and to info.mpe2013@sqig.math.ist.utl.pt until 31 of December of 2013.

CIM thanks all CIM-MPE events sponsors.

CIM thanks and wishes all keynote speakers, thematic session organizers, invited speakers and participants a fruitful meeting.

Alberto Adrego Pinto
CIM President

Venues

The International Conference, 25-27 March 2013 will be hosted in Calouste Gulbenkian Foundation (FCL), Lisbon, Portugal.
Rooms: Auditório 2, Auditório 3, Sala 1, Sala 2.

The Advanced School, 21-23 March and 27-28 March 2013 will be hosted at Faculdade de Ciências, Universidade Lisboa (FCUL), Lisbon, Portugal.
Rooms: Anfiteatro 3.2.15, Edifício C3.

Proceedings of the CIM series

The first two volumes of the CIM Series in Mathematical Sciences published by Springer-Verlag will consist of selected works presented in the conferences Mathematics of Planet Earth (CIM-MPE).

Proceedings editors:
- Jean Pierre Bourguignon, IHES, Paris, France
- Rolf Jeltsch, ETH, Zurich, Switzerland
- Alberto Pinto, INESC-TEC, University of Porto, Portugal
- Marcelo Viana, IMPA, Rio de Janeiro, Brazil

Submission: If you would like to submit a review article, please send it by email to aapinto@fc.up.pt and to info.mpe2013@sqig.math.ist.utl.pt until 31 of December of 2013.

Sponsors

These activities are enthusiastically supported and co organized by the Portuguese Society of Mathematics (SPM), the Portuguese Society of Statistics (SPE); the Portuguese Society of Operational Research (APDIO); UECE-Research Unit on Complexity and Economics; CEMAPRE-the Centre for Applied Mathematics and Economics; INESC-TEC Instituto de Engenharia de Sistemas e Computadores do Porto - Tecnologia e Ciência; CEAUL-Centro de Estatística e Aplicações, UL; CMAL-UNL-Centro de Matemática e Aplicaões, UNL; CMAF-UL-Centro de Matemática e Aplicaões Fundamentais, UL; ISR-Institute for Systems and Robotics, Lisbon; IDL-UL-Instituto D. Luís, UL; IN+ -Centro de Estudos em Inovação Tecnologia e Políticas de Desenvolvimento; ISEG-Instituto Superior de Economia e Gestão; Instituto de Telecomunicações; FCT - Fundação para a Ciência e a Tecnologia; Ciência Viva; FCUL-Faculdade de Ciências da UL e FCG-Fundação Calouste Gulbenkian.

Organization: CIM Direction

Local organization committee:

Paulo Mateus (President), IST; Alberto Pinto, FCUP; Pedro Baltazar, IST; Abdelrahim Mousa, FCUP; Renato Soeiro, FCUP; Bruno Neto, FCUP; Filipe Martins, FCUP; João Coelho, FCUP; Joana Becker, FCUP.

Keynote Speakers

New methods for the direct conversion of heat to electricity suggested by geometry (Pedro Nunes Lectures)
Richard James
University of Minnesota, USA.
March 25th, 10:30-11:30, Auditorio 2

Surface-atmosphere coupling by internal waves and its role on global climate
Pedro Miranda
Universidade de Lisboa, Portugal.
March 25th, 11:45-12:45, Auditorio 2

From penguins to Polar Bears: The role of Mathematics in addressing key research questions in Polar Science
José Xavier
Universidade de Coimbra, Portugal.
March 25th, 14:15-15:15, Auditorio 2

Photovoltaic dye sensitized solar cells: paving the way to commercialization
Adélio Mendes
Universidade do Porto, Portugal.
March 25th, 15:30-16:30, Auditório 2

Technology and the Future Bioeconomy (video lecture; public lecture)
David Zilberman
University of California, Berkeley, USA.
March 25th, 17:00-18:00, Auditório 2

Influence of Climate Change on Extreme Weather Events
Richard L. Smith
University of North Carolina, USA.
March 26th, 09:00-10:00, Auditório 2

Global Change, Energy, Sustainability and Crises
Filipe Santos
Universidade de Lisboa, Portugal.
March 26th, 10:30-11:30, Auditório 2

Network Formation in Surfactant Driven Systems: Energy conversion on the nanoscale
Keith Promislow
Michigan State University, USA.
March 26th, 11:45-12:45, Auditório 2

Resource-aware data mining
João Gama
Universidade do Porto, Portugal.
March 26th, 14:15-15:15, Auditório 2

Information theoretic learning: from diagnosis to wind power prediction
Vladimiro Miranda
Universidade do Porto, Portugal.
March 26th, 15:30-16:30, Auditório 2

The Challenges of Melding Data and Models in Climate Research (video lecture)
Christopher K. R. T. Jones
University of North Carolina, USA.
March 26th, 17:00-18:00, Auditório 2

Reducing CO2 Emissions: Technology, Uncertainty, Decision Making and Consumer Behavior
Inês Azevedo
Carnegie Mellon University, USA;
March 27th, 09:00-10:00, Auditório 2

Biofuels for Food Crops (public lecture)
Andrew Schmitz
University of Florida, USA.
March 27th, 10:30-11:30, Auditório 2

Sustainable Initiatives in Energy and Materials (public lecture)
Carlos Aragão
Universidade Federal do Rio de Janeiro, Brasil;
March 27th, 11:45-12:45, Auditório 2

Thematic Sessions

The role of statistics of extremes in society
Organizer: *Ivette Gomes*
University of Lisbon

Speakers:
-Manuela Neves, UTL, *"Geostatistical Analysis in Extremes"*.
-Isabel Fraga Alves, FCUL, *"Max-stability at Work (or not): modeling annual or monthly maxima for daily rainfall data"*.
-Ivette Gomes, FCUL, *"Resampling-Based Methodologies in Statistics of Extremes: an Environmental Application"*.
March 25th, 10:30-11:30, Auditório 3

Non-equilibrium statistical mechanics: kinetics, chemistry and coagulation
Organizer: *Maria da Conceição Carvalho*
Department of Mathematics and CMAF, University of Lisbon

Speakers:
- Ana Jacinta Soares, Univ. Minho, *"Kinetic approach to chemically reacting systems"*.
- Filipe Carvalho, I.P.V.C., *"A kinetic approach to the steady detonation waves for a four component gas undergoing a reversible bimolecular chemical reaction"*.
- Fernando Pestana da Costa, Univ. Aberta, *"Smoluchowski's coagulation system and related models"*.
- Rafael Sasportes, Univ. Aberta, *"The "cluster eating" coagulation system"*.
March 25th, 10:30-12:45, Sala 1

Statistical modelling of environmental data
Organizer: *Raquel Menezes*
Department of Mathematics and Applications Minho University

Speakers:
-Tiago A. Marques, University of St Andrews, Scotland, *"Estimating animal density from passive acoustic sensors"*.
-Luís Margalho, ISEC, Portugal, *"Modelling environmental monitoring data coming from different surveys"*.
-A. Manuela Gonçalves, Univ. Minho, *"Detection of changes in time series based on the informational approach - an application to water quality monitoring"*.
March 25th, 10:30-11:30, Sala 2

Mathematical Modeling and Numerical methods for environmental problems
Organizer: *Stéphane Louis Clain*
Centro de Matemática, Universidade do Minho

Speakers:
-Jorge Figueiredo, Universidade do Minho, *"Travelling waves modelling using a MOOD based finite volume method: application to tsunami's simulation"*.
-Christophe Berthon, University of Nantes, *"Easy well-balanced schemes for shallow-water models and extensions"*.
March 25th, 11:45-12:45, Auditório 3

Island Biogeography and Ecological Modeling
Organizer: *Paulo A. V. Borges*
University of Açores

Speakers:
-Luis Borda Água, *"The relative abundance of languages: neutral and non-neutral dynamics"*
-João Miguel Ferreira, *"The MacArthur and Wilson Island Biogeography Model - opportunities for modeling"*
-Paulo A. V. Borges, *"Macroecological patterns and ecological processes"*
March 25th, 11:45-12:45, Sala 2

Human activity in a dynamical planet
Organizer: *Carlos Ramos*
Departamento de Matemática, Centro de Investigação em Matemática e Aplicações, Universidade de Évora

Speakers:
-Carlos Ramos, Universidade de Évora, *"On evolutionary dynamics and its applications"*.
-António Domingos Heitor da Silva Reis, Universidade de Évora, *"Scaling laws of street networks — the dynamics behind geometry"*.
-Mouhaydine Tlemcani, Universidade de Évora, *"Modelling of social dynamical system"*.
March 25th, 14:15-15:15, Auditório 3

Stochastic dynamics
Organizer: *Patrícia Gonçalves*
CMAT University of Minho and PUC RIO

Speakers:
-Anabela Cruzeiro, IST, UTL, *"On stochastic variational principles"*.
-António Pacheco, IST, UTL, *"Comparing population sizes via the level crossing ordering"*.
-Fernanda Cipriano, FCUL, *"Inviscid limit for 2D stochastic Navier-Stokes equations"*.
-Maria João Oliveira, Universidade Aberta, *"Glauber dynamics in the continuum (via generating functionals approach)"*.
March 25th, 14:15-16:30, Sala 1

Traffic flow and fire modelling and simulation
Organizer: *Silvio M.A. Gama and João Emílio Almeida*
FCUP/CMUP and LIACC

Speakers:
- João Emílio Almeida, LIACC, *"Modelling and Simulation of Pedestrian Emergency Evacuation Dynamics"*.
- Rosaldo Rossetti, FEUP, *"NetLogo implementation for Crowd Evacuation"*.
- António Leça Coelho, LNEC, *"Buildings' Fire Development and Evacuation Modelling"*.
- Teresa Grilo, FCUP, *"On the optimal control of flow driven dynamic systems"*.
- Sílvio Gama, FCUP, *"Single lane car-following model: theory and numerics"*.
March 25th, 14:15-16:30, Sala 2

Sustainability and new energies
Organizer: *João Paulo Almeida*
Polytechnic Institute of Bragança

Speakers:
-José A. C. Silva, IPB, *"Porous Solids for Biogas Upgrading and CO_2 Sequestration"*.
- Paulo Brito, IPB, *"Modelling and simulation of biodiesel production processes"*.
- Vicente Leite, IPB, *"Processing Renewable Energy for a Sustainable Planet"*.
March 25th, 17:00-18:00, Sala 1

Energy Transfer and Management
Organizer: *José Luis dos Santos Cardoso and Mário Gonzalez Pereira*
UTAD

Speakers:
- Amadeu Borges, UTAD, *"Numerical Study of Anaerobic Digestion Process"*.
- Liliana Caramelo, UTAD, *"The Atmospheric Water Vapor Transport through Iberia Peninsula"*.
- Mário Gonzalez Pereira, UTAD, *"Mathematics of Energy and Climate Change: from the solar radiation to the impacts of regional projections"*.
- Norberto Gonçalves e Marco Naia, UTAD, *"A mathematical approach: Mass and energy propagation in periodic phenomena in the atmosphere"*.
- Paulo Alexandre Cardoso Salgado, UTAD, *"Forecasting of wind power generation - A collaborative multi-model approach "*.
March 26th, 10:30-12:45, Auditorio 3

Statistics of the Internet
Organizer: *Antonio Pacheco Pires*
Instituto Superior Técnico, UTL

Speakers:
- Nelson Antunes, Univ. Algarve, *"Estimation of Flow Duration from Sample Traffic"*.
- Paulo Salvador, Univ. Aveiro, *"Multiscale Internet Statistics: Unveiling the Hidden Behaviors"*.
- M. Rosário Oliveira, IST, UTL, *"Robust Feature Selection and Robust PCA for Internet Traffic Anomaly Detection"*.
- Mário A.T. Figueiredo, IST, UTL, *"Network Inference from Co-Occurrences"*.
March 26th, 10:30-12:45, Sala 1

Modeling Sustainability in Operations Management and Logistics
Organizer: *Tânia Pinto Varela*
Instituto Superior Técnico, UTL

Speakers:
- Bruna Mota, IST, *"A step towards supply chain sustainability"*.
- Florinda Martins, ISEP, *"Sustainable chemical processes: objectives and processes optimization"*.
- Nelson Martins, UNL, *"Greener Profits with Supply Chains - A Meta-heuristic approach for the Bi-Objective Design and Planning of Supply Chains"*.
- Ricardo Mateus, IST, *"Sustainable water supply management through reduction and control of water losses"*.
March 26th, 10:30-12:45, Sala 2

Control of diseases and epidemics
Organizer: *Delfim F. M. Torres*
CIDMA-Center for Research and Development in Mathematics and Applications Department of Mathematics, University of Aveiro

Speakers:
-Cristiana J. Silva, University of Aveiro, *"Optimal control of a tuberculosis model"*.
-H. Sofia Rodrigues, IPVC, *"Dengue in Madeira Island"*.
-Delfim F. M. Torres, University of Aveiro, *"Fractional calculus in epidemiology"*.
-Semu Mitiku Kassa, Addis Ababa University, Ethiopia, *"Optimal Self-Protective Measures in Controlling Infectious Diseases of Human Population"*.
March 26th, 14:15-16:30, Auditório 3

Dynamical models
Organizer: *Alberto Adrego Pinto*
FCUP

Speakers:
- Nico Stollenwerk, FCUL, *"Newly and re-emerging diseases in a rapidly changing world: the case study of dengue fever re-entering and newly enterning in Europe "*.
- Alberto Adrego Pinto, FCUP, *"BHP Universality and Energy Prices"*.
- João Passos Coelho e Paulo Vasconcelos, FCUP, *"A model of carbon assimilation and allocation in Douro vineyards"*.
March 26th, 14:15-15:15, Sala 1

Extreme Value Models
Organizer: *Margarida Brito*
FCUP/CMUP

Speakers:
- Margarida Brito, FCUP, *"Characterization of turbidity extremes behaviour"*.
- Susana Barbosa, FCUL, *"Extreme value analysis of environmental radon gas concentration from high-frequency measurements"*.
- Ricardo Cruz, FCUP, *"Automatic fitting of loss models and risk evaluation"*.
- Alexandra Ramos, FEP, *"Extremal dependence in river floods"*.
- Laura Cavalcante, FCUP, *"Modelling of extremal earthquakes"*.
- Maria Eduarda Silva, FEP, *"Persistent time series and extreme events"*.
March 26th, 14:15-16:30, Sala 2

Solar radiation
Organizer: *Miguel Centeno Brito*
Instituto Dom Luiz/Faculdade de Ciências da Universidade de Lisboa

Speakers:
-Ricardo Aguiar, LNEG, *"Practical uses of stochastic methods for solar radiation time series"*.
-Tomás Fartaria, Universidade de Évora, *"Simulation and computation of diffuse and albedo shadow losses of solar radiation in a photovoltaic field with 1-axis trackers"*.
-Maria João Rodrigues, ADENE, *"geoSOL - a georeferencied web based platform for solar sytems management"*.
March 26th, 17:00-18:00, Auditório 3

Renewable Energies
Organizer: *João Gama*
LIAAD, INESC TEC Universidade do Porto

Speakers:
-Ricardo Bessa, Universidade do Porto, *"Non-Gaussian Modeling of Wind Power Forecasts"*.
-Carlos Ferreira, Universidade do Porto, *"Predicting Ramp Events with a Stream-based HMM framework"*.
March 26th, 15:30-16:30, Sala 1

Advanced School

Compatibility, hysteresis and the direct conversion of heat to electricity
Richard James
University of Minnesota, USA.
March 21th, 09:00-13:00, Anfiteatro 3.2.15, Edifício C3, FCUL

Economic Foundations of Climate Smart Agriculture and **The Economics of Payment for Ecosystem Services** (video lectures)
David Zilberman
University of California, Berkeley, USA.
March 21th, 14:30-16:30 / March 22th, 14:30-16:30, Anfiteatro 3.2.15, Edifício C3, FCUL

Functionalized Energies: Higher order models of complex systems
Keith Promislow
Michigan State University, USA.
March 22th, 09:00-13:00, Anfiteatro 3.2.15, Edifício C3, FCUL

Comparing climate mitigation options using carbon abatement supply curves
Inês Azevedo
Carnegie Mellon University, USA;
March 27th, 14:30-18:30, Anfiteatro 3.2.15, Edifício C3, FCUL

Climate Statistics
Richard L. Smith
University of North Carolina, USA.
March 28th, 09:00-13:00, Anfiteatro 3.2.15, Edifício C3, FCUL

Adaptation to climate change: options, planning, constraints and uncertainties
Filipe Santos
Universidade de Lisboa, Portugal.
March 28th, 14:30-18:30, Anfiteatro 3.2.15, Edifício C3, FCUL

Book of Abstracts

Keynote Speakers

New methods for the direct conversion of heat to electricity suggested by by geometry
(Pedro Nunes Lectures)
Richard D. James [1]
[1] University of Minnesota, USA
March 25th, 10:30-11:30, Auditorio 2

There are enormous reservoirs of energy stored on earth at small temperature difference, such as the temperature difference between ocean ($\sim$ 0 C) and ambient (-40 to -20 C for most of the year) in the arctic, the heat focused by solar-thermal mirror arrays, and man-made sources like the waste heat from power plants and computers. New families of so-called multiferroic materials are emerging that offer the possibility of extracting energy from these vast sources. They have phase transformations but, unlike water to steam, they involve a change of crystal structure. Perhaps the most critical problem for devices based on these materials is the ability to pass back and forth through the phase transformation many, many times. We argue that this "materials problem" is essentially a problem of geometry. Solutions of this problem are leading to new materials that have significant promise for energy conversion.

Surface-atmosphere coupling by internal waves and its role on global climate
Pedro M. A. Miranda [1]
[1] Universidade de Lisboa, Instituto Dom Luiz (Laboratório Associado), Portugal
March 25th, 11:45-12:45, Auditorio 2

Internal waves in the atmosphere constitute one of the main mechanisms of atmosphere-globe coupling contributing in a sizable way to the global budget of atmospheric angular momentum. While internal waves exist in a wide range of horizontal scales, most of the momentum fluxes are associated with mesoscale waves with wavelengths between a few and about 100 km, scales which are not well represented in most global climate models. Because of that, internal waves need to be parametrized in those models. Current parametrization schemes assume homogeneous flow (constant wind and constant stability). However, recent results, based on analytical approaches, show that the flow may be driven to high drag states in some heterogeneous flows, responding to variations of wind speed with height in the lower layers or to the structure of atmospheric stability, in ways that may be used for parametrization purposes, and that are well reproduced in explicit simulations at high-resolution. A review of these results will be presented together with some evaluation of its relevance in the real atmosphere.

From Penguins to Polar Bears: The role of Mathematics in addressing key research questions in Polar Science
José Xavier [1,2]
[1] Institute of Marine Research, University of Coimbra, Portugal
[2] British Antarctic Survey, NERC, Cambridge, UK
March 25th, 14:15-15:15, Auditorio 2

Can the Polar Regions help us understand how planet Earth deals with climate change? The Arctic and the Antarctic are among the regions that are most susceptible to rapid ocean warming and acidification, two of the most pressing effects of global climate change. Furthermore, these Polar Regions holds a diverse range of unique terrestrial and marine ecosystems. Characterized by extreme environmental conditions, it provides habitats for highly adapted and specialized organisms and communities, making them highly attractive to test unique scientific hypothesis. The use of mathematical sciences has been playing a central role to help us addressing all these issues. This presentation aims to highlight the use of mathematics in the most recent research work focused on polar marine ecosystems, specifically on assessing the effects of climate change in marine biodiversity, determine how top predators are able (or not) to cope with climate change (such as penguins, polar bears, albatrosses and seals), review the models on marine food webs to predict future changes in the Polar regions and illustrate how education and outreach on polar subjects can be used to boost information sharing and science communication in schools, with the general public and in policy making worlwide.

Photovoltaic dye sensitized solar cells: paving the way to commercialization
Adélio Mendes [1,*], L. Andrade [1]
[1] LEPAE - Department of Chemical Engineering, Faculty of Engineering, University of Porto
[*] mendes@fe.up.pt
March 25th, 15:30-16:30, Auditório 2

The interest in dye-sensitized solar cells (DSC) has been increasing and few companies are now working hard to make this new technology available soon; EFACEC is a major national technological company deeply involved in the development of DSCs. Sealing these cells is still an issue and despite significant progresses; for example Sanyo considers this as the main obstacle for their fully commercialization. Recently, the authors developed a laser-assisted glass sealing, leak free, resistant to heat shock and cheaper to implement. They also developed a new glass substrate exhibiting a significant higher electrical conductivity and a larger effective area for solar conversion. Besides, the authors replaced the 10-nm platinum counter-electrode of DSCs by a carbon nanostructured layer that ended to be more efficient and almost as much transparent as the platinum counter-electrode.

Technology and the Future Bioeconomy (video lecture; public lecture)
David Zilberman [1], Eunice Kim, Scott Kaplan, Jeanne Reeves, and Sam Kirshner Supported by EBI and Cotton Inc.
[1] University of California, Berkeley, USA.
March 25th, 17:00-18:00, Auditório 2

Sustainable development could not be achieved unless the use of nonrenewable resources is replaced by renewable resources. That means that the bioeconomy that relies on the biological processes and the production of living organisms to produce food, energy, and chemicals plays a major role in the economy. The transition to the bioeconomy means that agriculture should be expanded so that biorefineries will become an important part of the industrial economy, and biofuel and green chemistry will become major sectors of the economy. The transition to the bioeconomy is tricky because increased production of biofuel may affect the availability of food. Therefore, it is essential to increase food productivity and food systems through improved practices. Governments need to develop systems that will enable a high rate of innovation. While private-sector investment will be crucial for the expansion of the bioeconomy, pubic-sector investment in R&D and development of products that serve the poor and population in developing countries will be essential for the bioeconomy to meet its potential.

Influence of Climate Change on Extreme Weather Events
Richard L. Smith [1]
[1] University of North Carolina, USA.
March 26th, 09:00-10:00, Auditório 2

The increasing frequency of extreme weather events raises the question of to what extent such events can be attributed to human causes. This talk will discuss an approach to these issues based on extreme value theory, incorporated into a Bayesian hierarchical model for combining climate models runs and the observational record. We illustrate the method with examples related to the European heatwave of 2003, the Russian heatwave of 2010, and the Texas/Oklahoma heatwave and drought of 2011. This is joint work with Michael Wehner (Lawrence Berkeley Lab).

Global Change, Energy, Sustainability and Crises
Filipe Duarte Santos [1]
[1] University of Lisbon, Portugal
March 26th, 10:30-11:30, Auditório 2

The period between World War II and the Western financial and economic crisis of 2008-2009 has been called the Great Acceleration. Although the development paradigm of the Great Acceleration has lifted hundreds of millions of people out of poverty and improved the quality of life of many more it is very probably unable to lead to a sustainable development. There are at present four main groups of unsustainability drivers. The first group includes the increasing inequalities in wealth, hunger and extreme poverty; the second regards the present global unsustainability of the energy systems; the third is climate change and the fourth includes the increasing food insecurity in many regions, loss of biodiversity, water scarcity and, more generally, the increasing scarcity of natural resources. The cost of natural resources, including fossil fuels, has been rising at an aggregate average value of 7% a year since 2000. It is estimated that if it increases above 9% a point will be reached where the growth generated by the economy is entirely used up in obtaining enough resources to run the system. All these four groups are strongly interconnected and to address them requires an integrated approach. We are facing a systemic challenge to our human development model. If we fail to implement at the global level a new paradigm the likelihood of recurrent financial, economic and environmental crisis will increase. Instead of being forced into an unknown path by multiple crises, leading probably to stagnation or de-growth in the more industrialized countries, we should implement a new development model based on the principles of social equity, poverty eradication, a green economy and an environmental protection policy that respects the planetary boundaries. This program requires an agreed timetable to eliminate poverty, to tackle global inequality, to produce national green economy roadmaps, to develop relevant metrics to measure societal and environmental wealth, beyond GDP and macroeconomics, to mainstream ecosystem values into financial institutions, national planning and corporate accounting, to improve energy efficiency and increase the share of renewable energy globally.

Network Formation in Surfactant Driven Systems: Energy conversion on the nanoscale
Keith S. Promislow [1]
[1] Michigan State University, USA
*kpromisl@math.msu.edu
March 26th, 11:45-12:45, Auditório 2

Amphiphilic systems form network structures which are central to many types of energy conversion mechanisms, include polymer-electrolyte membrane fuel cells, dye-sensitized solar cells, and Lithium ion batteries, not to mention those that drive organic life. These systems are formed by mixing a solvent with a hydrophobic polymer that has been functionalized by attaching pendant charge (acidic) groups. The competing effects of hydophilicity and hydrophobicity lead to fine-scale

morphology whose size is limited only by molecular constraints. The resulting energy landscape supports a rich array of network morphologies, including bilayers, pore, and micelle dominated structures. We present a reformulation of the classical Cahn-Hilliard type energy, based upon an unfolding of an energy proposed by De Giorgi. We derive sharp interface reductions, discuss the bifurcation structure of the system, and extensions to multi-component systems.

Resource-aware data mining

João Gama [1]
[1] University of Porto, Portugal

March 26th, 14:15-15:15, Auditório 2

The phenomenal growth of mobile and embedded devices coupled with their ever-increasing computational and communications capacity presents an exciting new opportunity for real-time, distributed intelligent data analysis in ubiquitous environments. In these contexts centralized approaches have limitations due to communication constraints, power consumption (e.g. in sensor networks), and privacy concerns. Distributed online algorithms are highly needed to address the above concerns. The focus of this talk is on distributed stream mining algorithms that are highly scalable, computationally efficient and resource-aware. These features enable the continued operation of data stream mining algorithms in highly dynamic mobile and ubiquitous environments.

Information theoretic learning: from diagnosis to wind power prediction

Vladimiro Miranda [1]
[1] INESC TEC and University of Porto, Portugal

March 26th, 15:30-16:30, Auditório 2

Information Theoretic Learning (ITL) introduced a new paradigm in model development, by proposing a manageable way of dealing with the information content of data. It is largely based on adopting Renyi's generalized definition of Entropy - namely its quadratic form which, coupled with Parzen windows estimates for probability density functions, results in expressions that are easy to interpret and to convert in algorithmic form. The talk will describe how these still novel principles were adopted at INESC TEC in a number of applications in the power systems domain. First of all, one will refer to the application of ITL to the training of neural networks, replacing the old fashioned Minimum Square Error (MSE) criterion by a Maximum Entropy Error (MEE) criterion or Maximum Correntropy Criterion (MCC). The successful application of MCC to building systems to perform short term wind power forecasting (up to 72 hours ahead) will be described, with reference to ARGUS PRIMA (Prediction Intelligent Machine), developed for ANL (USA). Then, ITL will be used to enrich (the densification trick) sets, so that the training of neural networks may be done only with virtual data and all real data saved to the validation process. This technique allows the development of models when in the presence of scarce data. Its merits will be described through an application to power transformer incipient fault diagnosis. Finally, one will show how the application of ITL concepts, namely Mutual Information coupled with a Cauchy-Schwarz similarity measure for probability density functions, allowed the improvement in the training of autoencoders. The technique demands splitting in half the autoassociative neural networks and maximizing information flow with unsupervised training of their first half. The success of the technique is illustrated with its application in the problem of power system state estimation, when one does not have information on the network topology because signals on switch status are missing in the control center. The relevance of these principles to models dealing with renewavle resources will be highlighted.

The Challenges of Melding Data and Models in Climate Research

Christopher K. R. T. Jones [1]
[1] University of North Carolina, USA

March 26th, 17:00-18:00, Auditório 2

Data assimilation (DA) is the process by which observational data and output from models based on physical laws are balanced to obtain optimal information. The mathematical underpinnings will be explained and the use of DA in climate prediction discussed. DA is particularly important in estimating the state of the ocean for initializing climate models and the challenges of ocean DA will be a focus of this lecture.

Trade-offs in Climate Mitigation Strategies: Assessing the Regional Variations in the Health, Environmental, and Climate Benefits of Wind and Solar Generation Across the United States

Inês Azevedo [1]
[1] Carnegie Mellon University, USA
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March 27th, 09:00-10:00, Auditório 2

There is a growing interest in reducing emissions from electricity generation in the United States. Renewable energy and energy efficiency and conservation are typically among the suggested solutions. Both supply- and demand-side interventions will displace energy and emissions from conventional generators. However, there is large uncertainty on which generators are being displaced by these interventions. I will present the first systematic calculation of marginal emissions factors (MEFs) for the U.S. electricity system. I will show how marginal emissions factors for CO2, NOx, SO2 and PM2.5 can be applied to estimate climate, environmental and health benefits from displaced emissions from wind and solar, highlighting regional differences. Depending on location, combined health, environmental and climate benefits from wind or solar range from about $10 to $100 per megawatt-hour. The key conclusion of this work is that the sites with the highest energy output not always yield the greatest social benefits. This work has been co-authored with K. Siler-Evans, M.G. Morgan and J. Apt. Funding from this work comes from Climate and Energy Decision Making (SES-0949710), through a cooperative agreement between the National Science Foundation and Carnegie Mellon University.

Biofuels for Food Crops (public lecture)

Professor Andrew Schmitz [1]
[1] University of Florida, USA
March 27th, 10:30-11:30, Auditório 2

Biofuel production in the United States has increased rapidly since 2000. The majority of this biofuel production comes from corn, with roughly 25 to 30 percent of the US corn crop being used for ethanol production. Ethanol production is encouraged by US government direct and indirect subsidies. This has created significant controversy because it removes corn from the food chain, thus driving up food prices. In a benefit-cost framework, one can show that the benefit-cost ratio from government policies to encourage ethanol production can exceed one but, within this framework, it is important to understand the key drivers that lead to this result. Two important components are the impact of ethanol production on gasoline prices and the use of distillers grain in livestock production.

Sustainable Initiatives in Energy and Materials (public lecture)

Carlos A. Aragão de Carvalho Filho [1]
[1] Universidade Federal do Rio de Janeiro, Brasil
March 27th, 11:45-12:45, Auditório 2

We review a number of initiatives developed at the Brazilian National Center for Research in Energy and Materials (CNPEM) aimed at obtaining materials and energy in a sustainable way.

Thematic Sessions

The role of statistics of extremes in society

Organizer: *Ivette Gomes*
University of Lisbon
March 25th, 10:30-11:30, Auditório 3

Geostatistical Analysis in Extremes

M. Manuela Neves [1,*]
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Classical statistics of extremes is very well developed in the univariate context, for modeling and estimating parameters of rare events. However such rare events often present a temporal aspect, a spatial aspect or both. Whenever rain, snow, storms, hurricanes, earthquakes, etc. happen the analysis of extremes is of primordial interest. Classical geostatistics, widely used for spatial data, is mostly based on multivariate normal distributions that are inappropriate for modeling tail behavior. The analysis of spatial extreme data lies at the intersection of two statistical areas: extreme value theory and geostatistics. A variety of statistical tools have been used for the spatial modeling of extremes, including Bayesian hierarchical models, copulas and max-stable random fields. A recent and very good survey is Cooley et al. (2012). Theory of max-stable processes can be seen as an extreme value analogy of Gaussian processes. Two different characterizations have been proposed in Smith (1990) and Schlather (2002). The purpose of this talk is to review and to apply max-stable processes in a practical context of modeling rainfall. First steps in an exploratory analysis of extreme precipitation data were presented in Neves and Prata Gomes(2011).
Acknowledgments: Research partially supported by National Funds through FCT—Fundação para a Ciência e a Tecnologia, project PEst-OE/MAT/UI0006/2011, and PTDC/FEDER, EXTREMA.

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[2] Neves, M. M. and Prata Gomes, D. "Geostatistics for spatial extremes. A case study of maximum annual rainfall in Portugal". *Procedia Environmental Sciences, Spatial Statistics 2011, Elsevier* 7, 246-251, 2011.

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Max-stability at Work (or not): modeling annual or monthly maxima for daily rainfall data

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When we are dealing with meteorological data there are two situations that matters to differentiate: the case of data set concentrated around the average, with no disastrous consequences for the society; on the other hand, the case of data away from the central distribution, that can have a very negative impact and which it is important to quantify. Typically, one is interested in the analysis of maximal observations and records over time, since these entail the negative consequences. The rainfall is a good example of this: the engineering structures associated with extremal precipitation levels, need to be constructed to withstand the extremal behavior of this process; for example, a reservoir must be able to store the amount of rain expected to fall in some specific location. EVT is the theory of modeling and measuring events which occur with very small probability, which has proved to be a powerful and useful tool to describe atypical situations that may have a significant impact in

many application areas, where knowledge of the behavior of the tail of a distribution is of main interest. The classical result is the Gnedenko theorem ([2]). It establishes that there are three type of possible limit distributions (max-stable) for maxima of blocks of observations, which are unified in a single representation – the GEV distribution. The second theorem in EVT is the so called Pickands-Balkema-de Haan theorem ([3], [1]). Loosely speaking, it allows us to approach the GP distribution to the excesses of high thresholds – POT approach – for distributions in the domain of a GEV distribution. For rainfall data, we will play with these results to estimate return level associated with the $T = 1/p$-year return period, for p small.

Supported by PEst-OE/MAT/UI0006/2011 and EXTREMA-FCT/PTDC/MAT/101736/2008.

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Resampling-Based Methodologies in Statistics of Extremes: an Environmental Application

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Resampling methodologies have recently revealed to be very fruitful in the field of *statistics of extremes*. We first mention the importance of the *generalized jackknife* (GJ), detailed in Gray and Schucany (1972), in the reduction of bias, and used recently in the field of extremes by Gomes *et al.* (2012). We next refer the relevance of the *bootstrap* (Efron, 1979) in the estimation of a crucial parameter in the area, the number k of top order statistics involved in the estimation of tails. Together, these two resampling procedures enable the obtention of reliable semi-parametric estimates of any parameter of extreme or even rare events, like a *high quantile*, the *expected shortfall*, the *return period* of a high level or the two primary parameters of extreme events, the *extreme value index* (EVI) and the *extremal index*. In order to illustrate such topics, we consider the GJ EVI-estimator in Gomes *et al.* (2012), associated to the simplest class of *minimum-variance reduced-bias* (MVRB) estimators of a positive EVI introduced and studied in Caeiro *et al.* (2005). An application of these methodologies to the analysis of an environmental data set, related to the number of hectares, exceeding 100 ha, burnt during wildfires recorded in Portugal during 14 years (1990-2003), is undertaken.

Acknowledgments: Research partially supported by National Funds through FCT—Fundação para a Ciência e a Tecnologia, project PEst-OE/MAT/UI0006/2011, and PTDC/FEDER, EXTREMA.

[1] Caeiro, F., Gomes, M.I. and Pestana, D.D. Direct reduction of bias of the classical Hill estimator. *Revstat* **3**:2, 113-136, 2005.

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Non-equilibrium statistical mechanics: kinetics, chemistry and coagulation

Organizer: *Maria da Conceição Carvalho*
Department of Mathematics and CMAF, University of Lisbon
March 25th, 10:30-12:45, Sala 1

Kinetic approach to chemically reacting systems

Ana Jacinta Soares [1]
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In the kinetic theory, the state of a chemically reacting system can be described by mathematical models based on the Boltzmann equation. The presence of the chemical reaction induces some new features which lead to interesting problems. Some of them are related to the structure and properties of the model, non-equilibrium effects influencing the solution behavior, and different engineering applications involving chemically reacting systems. In this talk, we introduce some problems arising in this context and present some work in progress.

A kinetic approach to the steady detonation waves for a four component gas undergoing a reversible bimolecular chemical reaction

Filipe Sampaio de Carvalho [1]
[1] CMAT, University of Minho and Polytechnic Institute of Viana do Castelo

The steady detonation waves are analyzed starting from the framework of the Boltzmann equation for an earlier stage of the chemical reaction, when the gas is far from equilibrium. Here we consider a four component gas undergoing a bimolecular chemical reaction of type $A_1 + A_2 \rightleftharpoons A_3 + A_4$ and adopt elastic hard-spheres and reactive modified line-of-centers cross sections. After obtaining the corresponding reactive Euler equations and the reaction rate, which is dependent on the reaction heat and the activation energy, we study the steady detonation wave and present some numerical results.

Smoluchowski's coagulation system and related models

Fernando Pestana da Costa [1]
[1] Universidade Aberta and CAMGSD-IST

Coagulation equations are mean field models of cluster growth based on the mass action law of chemical kinetics. They occur very often in the scientific literature (in Chemistry, Colloidal Science, Physics, Astrophysics, etc.) and its mathematical study has seen remarkable advances in the last quarter century. In this talk I will provide a very brief introduction to some of the results and problems in this area, with emphasis in those about the dynamic behaviour of solutions.

The "cluster eating" coagulation system

Rafael Sasportes [1]
[1] Universidade Aberta

We consider a coagulation model, first introduced by Redner, Ben–Avraham and Krapivsky in 1987, whose main feature is that the reaction between a j–cluster and a k–cluster results in the creation of a $|j-k|$–cluster, and not, as in Smoluchowski's model, of a $(j+k)$–cluster. We prove existence and uniqueness of solutions under reasonably general conditions on the coagulation coefficients, and we also establish differenciability properties and continuous dependence of solutions. Some interesting invariance properties are also proved. Finally, we study the long–time behaviour of solutions, and also present a preliminary analysis of their scaling behaviour.
This is a joint work with Fernando Pestana da Costa and João Teixeira Pinto.

Statistical modelling of environmental data

Organizer: *Raquel Menezes*
Department of Mathematics and Applications Minho University
March 25th, 10:30-11:30, Sala 2

Estimating animal density from passive acoustic sensors

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Estimating population density or abundance is a frequent requirement for the effective conservation and management of wild species. In particular it might be necessary to estimate density over time and space to understand how climate change might be impacting the distribution of species/populations.

In this talk I will present an overview of the blooming field of passive acoustic density estimation: the detection of natural sounds produced by the animals to estimate their density and abundance [1]. An emphasis will be given to the fact that due to the nature of data collection, these are especially well suited for estimating changes over time.

A case study based on the estimation of Blainville's beaked whales at an underwater US navy range in the Bahamas [2] will be presented. The example is particularly interesting because just 10 years before this study this species was considered rare/absent in the area, underlining the importance to account for species detectabiity on animal surveys.

While the examples used are based on cetaceans, the methods involved might be applied to other aquatic as well as to terrestrial sound producing species.

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Modelling environmental monitoring data coming from different surveys

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In Europe, since 1990, a survey on environmental monitoring has been taking place every five years, using moss samples to study the distribution of heavy metal concentration,resulting on the identification of statistical association of several heavy metal concentrations in mosses. With this work, we propose an extension of an existing spatio-temporal model, introduced in Høst et al. (1995), allowing for prediction at unsampled locations and in the presence of covariates related to each country specificities, when separately modelling the spatial mean field, the spatial variance field and the space-time residual field. Moreover, this model allows to estimate an interpolation error, as an accuracy measure, derived dependently on the case study. Results obtained by this methodology for the most recent available survey, are compared with results obtained with no temporal information, namely when Ordinary Kriging, according to the definition in Cressie (1993), is used to derive

illustrative prediction maps based only on the most recent data. While assessing interpolation errors, we conclude that the monitoring specificities of each country and the information of preceding surveys allow for more accurate prediction results.

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Detection of changes in time series based on the informational approach - an application to water quality monitoring

A. Manuela Gonçalves [1,*], Lara Teixeira [2], Marco Costa [3]

[1] [2] DMA - Departamento de Matemática e Aplicações, CMAT - Centro de Matemática, Universidade do Minho, Portugal

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The number of studies using change-point methods to detect a change in the behavior of meteorological and hydrological series has been increasing. In this study, the Schwarz Information Criterion (SIC) is applied in order to search a change-point in the time series of surface water quality variables. The time series are relative to Dissolved Oxygen, a water quality variable measured monthly, since January 1999 to December 2011, in eight monitoring sites. The application of change-points analysis allowed detecting change-points in both the mean and the variance in the eight observation series under study. Time variations in environmental data are complex and they can hinder the identification of the so-called change-points when traditional models are applied to this type of problems. In this study, as the series of observations present intrinsic environmental data proprieties such as seasonality and non-stationarity, it is proposed an alternative approach for the application of the change-point analysis by taking into account this data structure. As the assumptions of normality and independence of the applied methodology are not present in some time series, a simulation study is carried out in order to evaluate the methodology's performance when applied to non-normal data series and/or with time correlation.

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[2] Gonçalves, AM, Costa, M Predicting seasonal and hydro-meteorological impact in environmental variables modelling via Kalman filtering. *Stochastic Environmental Research and Risk Assessment.* (doi: 10.1007/s00477-012-0640-7), 2012.

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Mathematical Modeling and Numerical methods for environmental problems

Organizer: *Stéphane Louis Clain*
Centro de Matemática, Universidade do Minho
March 25th, 11:45-12:45, Auditório 3

Travelling waves modelling using a MOOD based finite volume method: application to tsunami's simulation

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Tsunami is an extreme geophysical phenomenon with considerable impacts on populations and human structures. Numerical simulations of such an event is a challenging task since one has to simulate travel waves for long distances and during long lapses of time (thousands of time steps) in a sea that stays, at a large scale, basically at rest. Moreover, large topographic variations, from the deep ocean zone to the near coastal areas, must be taken into account to correctly compute the speed wave. In this work we present a simulation of the Tsunami wave propagation in the framework of the shallow water problem with varying bathymetry using a high-order finite volume numerical scheme based on the Multi-dimensional Optimal Detection (MOOD) introduced in [4]. Such a method allows to preserve the wave shape and amplitude throughout the simulation without significant numerical diffusion. On the other hand, the numerical scheme is designed to respect the "C-conservation" property, a key issue to avoid the formation of small oscillations in the unperturbed sea areas.

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Easy well-balanced schemes for shallow-water models and extensions

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To accurately approximate the solutions of the shallow-water flows over a non-flat topography, some properties coming from the steady states must be preserved at the numerical level. The schemes able to recover the steady states (at rest) are said well-balanced. In this work, we present an easy way to enforce any finite volume scheme to be well-balanced. The suggested technique comes from a suitable reformulation of the PDE's which gives a relevant source term discretisation. Moreover, the approach is proved to be robust and easily extends to high-order approximations in order to perform accurate simulations.

In fact, the adopted shallow-water scheme can be extended to approximate more sophisticated model like the two layer shallow-water model which governs two superposed layers of immiscible fluids with different constant densities, over a bottom with non flat topography. We propose to extend the above technique [1] to approximate the solutions of the model under consideration. The benefits of this approach are twofold. In one hand, the resulting scheme turns out to be very easy to be implemented. Indeed, we obtain a relevant way to couple two Saint-Venant models associated with each layer. Despite the work by Bouchut-Morales [2] where splitting tentativeness are shown to fail, we here obtain fairly good approximations even if very severe regimes are considered. In the second hand, the scheme is proved to be well-balance preserving and layer height positive preserving. Several numerical experiments are performed and give improved results. For instance, considering lock-exchanged layers, the suggested method produces expected approximations while standard or sophisticated splitting approaches failed (see [2]).

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Island Biogeography and Ecological Modeling

Organizer: *Paulo A. V. Borges*
University of Açores
March 25th, 11:45-12:45, Sala 2

The relative abundance of languages: neutral and non-neutral dynamics

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Credible estimates predict that upwards of 90% of the nearly 7,000 languages could go extinct this century[1], a prospect with profound cultural, socioeconomic, and political ramifications. Despite its importance, we still have little predictive theory for language dynamics and richness. Several hypotheses invoke cultural and environmental mechanisms to explain the number of languages in language families and different geographic regions of the world[2]. More critical to the language extinction problem, however, is to understand the dynamics of the number of speakers of languages, the dynamics of language abundance distributions (LADs). Here we show that LADs can be understood as an equilibrium or disequilibrium between stochastic rates of origination and extinction of languages. Many regional LADs are very similar to the bell-shaped distributions of relative species abundance predicted by neutral theory in ecology[3]. The hypothesis of neutral language dynamics yields a particularly good fit in Africa, Papua New Guinea, Laos, and many island archipelagos of Polynesia. However, neutral theory does not fit some regional LADs, which can be explained if the number of speakers has grown systematically faster in some languages than others, due to cultural factors and other non-neutral processes. The LADs for Asian countries illustrate non-neutral processes in language dynamics. Only two LADs, for Australia and the United States, deviate from a bell-shaped pattern. These deviations are due to the documented higher, non-equilibrium extinction rates of low-abundance languages in these countries.

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[3] S. P. Hubbell, In *The Unified Neutral Theory of Biodiversity and Biogeography. Princeton University Press, NJ.*, 2001.

The MacArthur and Wilson Island Biogeography Model - opportunities for modelling

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A central question in ecology is what determines biodiversity. One perspective, known as neutral theories, is that the dominant processes are random, either at a species level or at an individual level. MacArthur and Wilson theory of island biogeography is a neutral theory at a species level that incorporates the fundamental processes of immigration, extinction and speciation.

We revisit this theory by considering in detail how to incorporate the process of the creation of new species adequately. This way we obtain a dynamical model for the species richness in the form of a discrete deterministic equation with a time lag.

The model makes several predictions both for the equilibrium and the time evolution of the number and kind of species present on an island. With time lag the evolution of the number of species present in the island towards equilibrium can show a rich behaviour, from a monotonic increase to a damped oscillatory behaviour. We present some preliminarily results obtained by applying this model to a geological evolving island as well as some open mathematical questions.

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Macroecological patterns in Azores: looking for modeling opportunities

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Here we address a list of questions based on long-term ecological and biogeographical studies performed in the Azores, a remote volcanic oceanic archipelago composed by nine islands. The target group are arthropods, and the main habitat Laurisilva, the Azorean native forest. Diversification of Azorean arthropod species is affected by island age, area and isolation. However, results obtained for over a decade show that distinct groups are differently affected by these factors, which has lead to the extreme diverse distribution patterns currently observed. Spatial distribution of arthropods in each island may be interpreted as caused by a typical "mass effect", with many species following a "source-sink" dynamics. Truly regionally rare species are those that are habitat specialists, many of them being threatened endemic species. Although various endemics persist as sink populations in human-made habitats (e.g., exotic forests), more than half of the original endemic forest arthropods may already have vanished or may eventually be driven to extinction in the future. Those species which have evolved in and are mainly found in native forests, have been dramatically affected by hitherto unrecognized levels of extinction debt, as a result of extensive destruction of native forest. We argue that immediate action to restore and expand native forest habitat is required to avoid a future of disastrous extinctions of a biologically unique fauna with an unique evolutionary history.

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Human activity in a dynamical planet

Organizer: *Carlos Ramos*

Departamento de Matemática, Centro de Investigação em Matemática e Aplicações, Universidade de Évora

March 25th, 14:15-15:15, Auditório 3

On evolutionary dynamics and its applications

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We discuss a mathematical setting appropriate to deal with complex systems in which different hierarchies coexist and can be naturally described. Our underlying objective is to include human activity in the global planet dynamics, so that in further developments we can understand, measure and control its impact. The mathematical methods used are mainly based on dynamical systems, graph theory and operator algebras.

[1] Ramos, Carlos; Riera, Marta. Evolutionary dynamics and the generation of cellular automata. In *Grazer Math. Ber.* Iteration theory (ECIT '08), Page 219-Page236, 2009.

[2] Correia Ramos, C.; Martins, Nuno; Nascimento Baptista, A. Dynamics on certain sets of stochastic matrices. *Nonlinear Dynam.* 65 (2011), no. 3, 301–310.

Scaling laws of street networks — the dynamics behind geometry

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Cities are very complex systems that have developed in time under the influence of multiple factors (politics, social structure, defense, trade, etc). Even though the relative weights of these factors seem to vary very much from city to city, some features have been noticed that are common to all cities. For example, it has been verified that cities possess self-similar structures that repeat over a hierarchy of scales. This provided the basis for many authors to claim that many aspects of cities allow a fractal description. This observation, however, does not explain why cities do share this architectural similarity. Idealists would claim that, as cities are complex man-made systems this common aspect springs from the congenital ideas of beauty and harmony shared by mankind. On the other hand, Constructal theory considers that dynamics is behind the geometry, such that geometry evolves just as the envelope of underlying dynamic processes. The Constructal law first put forward by Bejan states that "for a finite-size system to persist in time (to live), it must evolve in such a way that it provides easier access to the imposed (global) currents that flow through it".

Cities are living systems in the sense that they have proper "metabolism" driven by the activities of their inhabitants, are open to flows of goods and people and evolve in time. Lanes, roads, streets, avenues constitute the vascular network of cities. As with every living system, city networks have evolved in time such as to provide easier and easier access to flows of goods and people. Street networks of today's cities tell the old story of the dynamics of the past. From the ancient to the newest district we can observe the development of streets of decreasing flow resistance, or, said another way increasing access for people and goods. The street networks of the old parts of today's cities are fossils that testify to the past dynamics of the city.

The distributions of street lengths and nodes follow inverse-power distribution laws. That means that the smaller the network components, the more numerous they have to be. In addition, street networks show geometrical self-similarities over a range of scales. Based on these features many authors claim that street networks are fractal in nature. What we show here is that both the scaling laws and self-similarity emerge from the underlying dynamics, together with the purpose of optimizing flows of people and goods in time, as predicted by the Constructal Law. The results seem to corroborate the prediction that cities' fractal dimension approaches 2 as they develop and become more complex.

Modelling of social dynamical system

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We present a mathematical model of a social dynamic. Different situation defined by initial conditions, polities and interactions inside the population are considered. The time series resulting from the simulation are processed with digital signal processing tools used in dynamical systems with

complex behaviour. The model's results are compared with known patterns like usually known from real situations.

[1] Caldeira B., Silva H.G., J.F. Borges, M. Tlemçani, and M. Bezzeghoud, Chaotic behavior of seismic mechanisms: experiment and observation. *Annals of Geophysics*, 55, 1, 57-62, (2012)

[2] Mouhaydine Tlemçani and Sara Fernandes, Analysis of a nonlinear discrete dynamical system, signal coding and reconstruction, Difference equations and applications. *Proceedings of the 14th International Conference* (ICDEA2008)pp. 307–314 (2009)

Stochastic dynamics

Organizer: *Patrícia Gonçalves*
CMAT University of Minho and PUC RIO
March 25th, 14:15-16:30, Sala 1

On stochastic variational principles

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An overview of stochastic variational principles is presented, with special emphasis on those related to hydrodynamical equations.

[1] A.B. Cruzeiro, M.Arnaudon, Stochastic Lagrangian flows and the Navier-Stokes equation. http://gfm.cii.fc.ul.pt/people/abcruzeiro/abc-marnaudon-2012-11-08.pdf

Comparing population sizes via the level crossing ordering

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Stochastic Ordering is an important area of Applied Probability that can be used effectively in qualitative comparisons of random variables, random vectors, and stochastic processes. In addition, it may be used to investigate the impact of parameter changes in important performance measures of stochastic systems, avoiding exact computation of those performance measures. In this talk we address the level crossing ordering, proposed by A. Irle and J. Gani in 2001 [1], which compares stochastic processes in terms of the times they take to reach high levels (states). More precisely, a process X is said to be slower in level crossing than process Y if it takes X stochastically longer than Y to exceed any given level.

After introducing some motivation for the use of the level crossing ordering, we present tailored sufficient conditions that we have derived for the level crossing ordering of (univariate and multivariate) Markov and semi-Markov processes. We then present tailored sufficient conditions for the comparison of birth-and-death processes with catastrophes modelling population sizes. Our analysis highlights the benefits of properly using the sample path approach, which compares directly trajectories of the compared processes defined on a common probability space. This approach provides, as a by-product, direct algorithms for the simulation of stochastic processes ordered in the level crossing ordering sense. In the case of continuous Markov chains, we resort additionally to the powerful uniformization technique, which uniformizes the rates at which transitions take place in the processes being compared.

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Inviscid limit for 2D stochastic Navier-Stokes equations

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We consider stochastic Navier-Stokes equations in a 2D-bounded domain with the Navier with friction boundary condition. We establish the existence and the uniqueness of the solutions and study the vanishing viscosity limit. More precisely, we prove that solutions of stochastic Navier-Stokes equations converge, as the viscosity goes to zero, to solutions of the corresponding stochastic Euler equations.

[1] Bessaih, H., Flandoli, F.: *2-D Euler equation perturbed by noise.* In *NoDEA Nonlinear differ. equ. appl.* 6, Page35-Page54, (1999).

[2] Bessaih, H., Millet, A.: *Inviscid large deviation principle and the 2D Navie Stokes equations with a free boundary coondtition.* In *SIAM J. Math. Anal.* 44, No. 3, Page1861-Page1893, (2012).

[3] Clopeau, T., Mikelic, A., Robert, R.: *On the vanishing viscosity limit for the 2D incompressible Navier-Stokes equations with the friction type boundary conditions.* In *Nonlinearity*, 11, Page1625-Page1636, (1998).

[4] Kelliher, J. P.: *Navier-Stokes equations with Navier boundary conditions for a bounded domain in the plane.* In *SIAM J. Math. Anal.* 38, No. 1, Page210-Page232, (2006).

[5] Lions, P-L.: *Mathematical topics in fluid mechanics.* Vol. **1**. The Clarendon Press Oxford University Press, New York (1996).

[6] Lopes Filho, M. C., Nussenzveig Lopes, H. J., Planas, G.: *On the inviscid limit for two-dimensional incompressible flow with navier friction condition.* In *SIAM J. Math. Anal.* 36, No. 4, Page1130-Page1141, (2005).

Glauber dynamics in the continuum (via generating functionals approach)

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We construct the time evolution of Glauber dynamics for a spatial infinite particle system in terms of generating functionals. This is carried out by Peano-type approximations in a scale of Banach spaces, leading to a local (in time) solution which, under certain conditions, may be extended to a global one.

[1] Finkelshtein, D. L., Kondratiev, Yu. G., Oliveira, M. J., Glauber dynamics in the continuum via generating functionals evolution. *Complex Anal. Oper. Theory* 6 (4), 923–945, 2012.

Traffic flow and fire modelling and simulation

Organizer: *Silvio M.A. Gama and João Emílio Almeida*
FCUP/CMUP and LIACC
March 25th, 14:15-16:30, Sala 2

Modelling and Simulation of Pedestrian Emergency Evacuation Dynamics

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Pedestrian dynamics in emergency situations has become increasingly important and got the attention of both researchers and practitioners [1]. Various attempts have been made to model the behaviour of crowds in emergency situations for the validation of buildings and public environments in general. In the last decade a lot of effort was taken to enhance models and simulators. Different social simulation models exist and are used, such as the Social Forces and Magnetic Models, among others. Meanwhile, data for the validation of such models is scarce, due to the amount of time and means needed. Fire drills are a possible approach but hardly recreating the truly panic conditions, and people tend to take them not seriously.

To overcome the aforementioned issues, Serious Games (SG) have a set of features that might overcome this problem. SG offer engagement to their players and provide training to real life situations. The proposed approach consists in recreating a fire drill in a 3D environment using SG. Another goal is to collect data for later analysis. This data is of a great value, to help the validation and verification (V&V) process of existing or new emergency pedestrian simulators, as well as for the calibration of such models.

Preliminary work has led to the development of a prototype using Unity3D game engine [2], that can be used as a virtual fire drill training tool, but also as a collective behaviour analysis instrument that might give better insight into social aspects and interactions involved whenever crowds are forced to evacuate under elevated anguish and emotional distress.

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NetLogo implementation for Crowd Evacuation

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Issues related to crowd evacuations have become extremely important and gained the attention both of practitioners and public authorities. Understanding the dynamics and the emerging behaviour of the crowd during evacuation is a challenge under any circumstances. By creating a synthetic population it is possible to employ agent-based modelling (ABM) techniques to build artificial laboratories [1] for experimentation in-vitro. ABM relies on the modelling of micro level entities and dynamics. The observed global behaviour of the system emerges as the result of these micro level dynamics. Such an approach represents a unique way of testing theories and models of crowd behaviour in various "what-if" scenarios.

In their common environment pedestrians tend to show some basic attributes.The basic principle is the "least effort principle", which means everyone tries to reach their goal as fast as possible spending the least amount of energy and time. Observations made for crowds in emergency situations feature typically the same patterns [2].

Within this context, an agent-based implementation of a crowd evacuation scenario using NetLogo [3], a platform that permits rapidly the creation of simulation prototypes, will be discussed.

Although the model may appear to be simplistic, its conceptualisation encompasses many aspects of the observed system in the real world. As such, we are able to observe typical emerging behaviour patterns during evacuation situations, namely arching, clogging and other herding phenomena

Our aim is to show that models developed using NetLogo, albeit simple can be expanded and adapted for fire safety experts to test various scenarios and validate the outcome of their designs.

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Buildings' Fire Development and Evacuation Modelling

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Buildings' fire modelling requires knowledge from various domains and techniques, with a high level of complexity, from exact sciences such as physics and mathematics, as well as from social sciences, such as psychology and sociology [1]. This communication will verse two distinct areas for building?s fire risk modelling: fire development modelling and pedestrian dynamics in emergency evacuation. On the topic of fire development modelling there are three different approaches: two-zone fire models; Computer Fluid Dynamics (CFD) and stochastic models. Concerning the topic of buildings' evacuation and pedestrian dynamics, some of the existing techniques will be addressed, specifically the ones that aim to reproduce with some degree of realism the movement of pedestrians in emergency situations. Mathematical techniques enabling both a macroscopic and microscopic analysis of the pedestrian movement will be described [2]. On the other side, some behavioural models of the reasoning process of the building's occupants shall be presented, with a detailed focus on each of the evacuation phases, from the fire detection and alarm until reaching a safe exit . At last, since all these models present some uncertainty level, techniques to deal with this issue will also be referred.

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[2] Pinto, Nuno, Coelho, A.L.; al - Characterization of movement on vertical circulations. Building Simulation . Volume 5, number 4, December 2012.

On the optimal control of flow driven dynamic systems

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The objective of this work is to develop a mathematical framework for modeling, control and optimization of dynamic control systems whose state variable is driven by interacting ODE's and

PDE's. This framework should provide a sound basis for the design and control of new advanced engineering systems arising in many important classes of applications, some of which encompass gliders, [2], and mechanical fishes, [1].

Underwater gliders are highly efficient, winged autonomous underwater vehicles (AUVs) which locomote by modulating their buoyancy and their attitude. The applications include long-term, basin-scale oceanographic sampling and littoral surveillance, among others, which is very important in oceanographic observation. For mechanical fishes we want to modeling the fish-like behaviours and mimic the body motion of carangiform fish.

The research effort has been focused in gaining insight by applying necessary conditions of optimality for Couette flow driven dynamic control systems which can be easily reduced to problems with ODE dynamics. In particular, the minimum time control problem of moving a particle between two given points driven by certain classes of simple flows have been solved by using the maximum principle, [3].

[1] J. Liu e H. Hu, "Biological inspiration: From carangiform fish to multi- -joint robotic fish", *Journal of Bionic Engineering*, Vol. 7, (2010), pp. 35-48

[2] N. Mahmoudian, J. Geisbert e C. Woolsey, "Dynamics and control of underwater gliders I: Steady motions", Virginia Center for Autonomous Systems, Technical Report No. VaCAS-2007-01 (2009)

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Single lane car-following model: theory and numerics

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Understanding and simulating the dynamics of traffic flow in large urban centers and motorways is nowadays an important issue: besides improving the traffic flow, this also helps to minimize the effects of pollution and global warming.

There are several traffic flow models. Probably the most simple and popular of these models is the car-following model. This microscopic model is one dimensional and has been developed by many researchers (see, for instance, [1, 2, 3]).

The aim of this talk is to extend this model to vehicle overtaking. Some theoretical and numerical results of ongoing work will be presented.

[1] M. Bando, K. Hasabe, A. Nakayama, A. Shibata, Y. Sugiyama. Dynamical model of traffic flow congestion and numerical simulation. In *Phys. Rev. E* 51(2), 1035-1042, 1996.

[2] Sadeq Al-nasur, Pushkin Kachroo. A microscopic-to-macroscopic crowd dynamic model. In *IEEE Intelligent Transport Systems Conference*, Toronto, Canada, September 17-20, 606-611, 2006.

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Sustainability and new energies

Organizer: *João Paulo Almeida*
Polytechnic Institute of Bragança
March 25th, 17:00-18:00, Sala 1

Porous Solids for Biogas Upgrading and CO_2 Sequestration

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The reduction of CO_2 and CH_4 emissions to atmosphere is a matter of great concern nowadays since both gases can contribute significantly to the so-called greenhouse effect that describes the trapping of heat near earth´s surface by gases in the atmosphere. At the same time CO_2/CH_4 separations are of interest in treating gas streams like landfill gas, biogas and coal-bed methane. Accordingly, there is a need to investigate on this topic and that can be done with improved efficient technologies to separate or remove CO_2 and CH_4 from exhaust gases. Two recent reviews discuss this matter with great detail concerning the use of adsorbents (porous solids) based technologies to handle CO_2 capture and CO_2/CH_4 separations [1, 2]. Biogas is mainly composed by CH_4 (60 to 70%) and CO_2 (30 to 40%) and to obtain a high energy content CO_2 needs to be separated from CH_4. For this purpose a variety of solid physical adsorbents have been considered including molecular sieve zeolites and a new class of adsorbents named Metal-Organic Frameworks (MOFs). The technology for biogas upgrading using adsorbents is called Pressure Swing Adsorption (PSA). With this technique, carbon dioxide is separated from the biogas by adsorption under elevated pressure. The adsorbing material, is regenerated by a sequential decrease in pressure before the column is reloaded again, hence the name of the technique. In this work, we will present sorption equilibrium, kinetic and fixed bed data of CO_2, CH_4 in MOF-508b and zeolite 13X at 303, 323 and 343 K and partial pressures up to 4.5 bar. These data are fitted with appropriate isotherm models. At the same time single, binary and ternary breakthrough curves were measured to provide required data to develop and validate a mathematical model based on the LDF approximation for the mass transfer, which could be used in the implementation (simulation) of a cyclic adsorption processes (PSA) for the purification of biogas and CO2 sequestration.

[1] G. Férey, C. Serre. T. Devic, G. Maurin, H. Jobic, P. L. Llewellin, G. Weireld, A. Vimont, M. Daturi, J. S. Chang, Why hybrid solids capture greenhouse gases?, *Chem. Soc Rev.* 40 (2011) 550-562.

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Modelling and simulation of biodiesel production processes

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One can state that the application of the scientific method generally implies the construction of some kind of model which allows an easier way of dealing with and interpreting the complexity of the physical world. On the other hand, for millennia the mathematical language has proven to be an ideal code for the creation of these physical models of reality. Thus, much of the scientific process may encompass the tasks of mathematical representing the physical data (modelling), and then solving the obtained mathematical models (simulation) in various conditions. Here, we follow this two step process in order to study specific systems regarding chemical industrial processes for the production of biodiesel. Biodiesel is an alternative fuel to the conventional petrochemical fuels, and can be used as a total or partial substitute of petrodiesel in compression-ignition internal combustion

engines. It consists in a mix of alkylic esters usually synthesized by a transesterification reaction of triglycerides present in natural oils or fats, from vegetable or animal sources. We model and simulate biodiesel base-catalysed transesterification production processes in steady-state mode, using the simulation package UNISIM Design. This is a high level computational application that includes a user-friendly graphical interface which permits the building of industrial flowsheets through the connection of suitable unit operations, since it already comprises steady-state and evolutive general models for the most common industrial processes and the respective energy and mass connective streams. Hence, we present a simulation study including the synthesis, the biodiesel purification and the glycerol recovery processes, in order to prove the package suitability for mathematical representing these systems [1].

[1] Novais, M., Tristão, P.; *Simulação e optimização de processos de produção de biodiesel através do UNISIM DESIGN*, Renewable Energies Engineering Project, ESTiG/IPB, 2012.

Processing Renewable Energy for a Sustainable Planet

Vicente Leite

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Nowadays, and in the next decades, the number of systems based on electricity will grow up, and the consumption of electrical energy will strongly increase. Indeed, it is expected that more than 60% of all energy consumption will be converted and used as electricity [1]. This is the reality of developed and developing countries where there is an additional and urgent need of reducing CO_2. On the other hand, if we look at the planet as a whole, we find that there are extreme inequalities in access to electrical energy. Indeed, it is estimated that 1.4 billion people are living without electricity and according to the Organization for Economic Cooperation and Development (OECD), the electrification rate in Africa, in 2008, was 40% and less than 80% in the world. Consequently, it is mandatory to change from conventional to renewable energy sources and, on the other hand, promote the access to electricity for a huge part of the planet. In this way, we are witnessing a wide-spread integration of renewable sources in distribution networks and their dissemination in standalone systems, all over the world, either in small houses or islands and isolated regions. In fact, the electrical power technology is changing rapidly with the integration of a large number of dispersed generation units based on renewable and non-renewable sources are being installed everywhere [1, 2]. In this context, a powerful and flexible technology is needed, at reasonable prices, in a big part of the world aiming to promote the access to electricity. On the other hand, in developed regions, the efficiency of the technology used in power generation, transmission/distribution and end-user equipment has to be continuously improved and suitably designed for every application. In all cases, the gross electricity, as it is produced by different renewable sources, needs to be processed and integrated in order to be available in a suitable form for the transmission and the end-user. The Power Electronics, being the technology of efficient conversion of electric power, plays an important role in the above-mentioned scenario [1]. This paper describes how this technology, supported by advanced control algorithms, is enabling the access to energy to many people all over the world in a sustainable way, and describes the change from the traditional centralised power systems to a new paradigm, where more and more dispersed generation units based on renewable sources are being integrated in the power systems. The paper also describes how the electricity generated by different renewable sources can be integrated and processed in the context of a remote sustainable house, or in a developed power system, with the same quality of the electricity. Thus, even under a scenario of increasing consumption and growing access to the electricity by many people, it is possible to think of a more sustainable world, from a small house to the entire planet.

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[2] J. M. Guerrero, F. Blaabjerg, T. Zhelev, K. Hemmes, E. Monmasson, S. Jemei, M. P. Comech, R. Granadino, J. I. Frau, Distributed Generation: Toward a New Energy Paradigm, *IEEE Industrial Electronics Magazine*, vol.4, no.1, March 2010, pp. 52–64.

Energy Transfer and Management

Organizer: *José Luis dos Santos Cardoso and Mário Gonzalez Pereira*
UTAD
March 26th, 10:30-12:45, Auditorio 3

Numerical Study of Anaerobic Digestion Process

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Anaerobic digestion is gaining favour in both industrial and agricultural applications as an environmentally acceptable energy producing process. However, the highly complex dynamics of the process has led to many failures being reported, especially during the start-up phase, and several process control problems have led to issues of reliability and prevented its wider use. The development of numerical models can lead to automated digester control, thus improving process performance and reducing reliance on skilled operators.

Our work used the ADM1 and AM1 models, implemented in *MATLAB®*. The AM1 model characterizes the anaerobic digestion process in a basic form, since it considers only two stages of anaerobic degradation (hydrolysis and methanogenesis) and the methane formation only by the acetoclastic methanogenisis bacteria [1]. The ADM1 model utilizes five stages of anaerobic degradation (disintegration, hydrolysis, acidogenesis, acetogenesis and methanogenisis) and five inhibition functions, and contemplates the temperature influence [2].

Although the two models differ considerably in terms of complexity, the results showed great similarity, but the AM1 model estimates higher biogas flow than the ADM1 model, at close to 27%. Both models give excellent pH values for the anaerobic digestion process, and indicated high COD removal, with the AM1 model showing 79% COD removal and the ADM1 model 88%. The sensitivity analyses demonstrated that a pH below 6 lowers the production of biogas, insofar as a pH of 6 produced a fall of biogas flow close to 19% and a pH of 5.5 caused a 74% decline in biogas production. Higher influent flow led to a fall in the quality of biogas, diminishing the methane percentage and significantly reducing COD removal.

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The Atmospheric Water Vapor Transport through Iberia Peninsula

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The transport of water substance in its many forms and through many stages constitutes the hydrological cycle and is a consequence of the conservation of water substance (Peixoto and Oort, 1992). The kernel of this cycle is the evaporation of moisture in one place and the precipitation in other places. To maintain precipitation, water vapor must be supplied through the divergence of water vapor from its sources to sink regions. In this sense, water vapor transported by the atmospheric circulation is one of the most important processes in water cycle. On the other hand, the water cycle is a crucial part of the energy cycle through the evaporative cooling at the surface and latent heating of the atmosphere, as atmospheric systems play a primary role in moving heat upward. About 85% of atmospheric energy is derived from the release of latent heat in precipitation (Chen et al., 1995). Atmospheric water vapor is one of the contributors to the greenhouse effect and, in recent decades, as pointed out by the 2007 report of Intergovernmental Panel on Climate Change, the total column water vapor over global oceans has increased by $1.2 \pm 0.3\%$ per decade from 1988 to 2004.

A detail description of water cycle as well as its mathematical formulation is presented by Peixoto and Oort (1992). In this work, we examine a quantitative description of one part of water cycle, atmospheric water vapor transport, using the equations presented and discussed in previous work. Thus, the characteristics of the water vapor transport over Iberia Peninsula were investigated, for 1964-2004 period. Datasets used in this study were derived from the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) four time daily reanalysis data on a $2.5^o \times 2.5^o$ grid. Variables used included the specific humidity, meridional and zonal winds at eight levels (1000, 925, 850, 700, 600, 500, 400 and 300 hPa). Results will be present.

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Mathematics of Energy and Climate Change: from the solar radiation to the impacts of regional projections

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This presentation will focus on the natural and anthropogenic drivers of climate change and on the assessment of potential impacts of regional projections for different scenarios of future climate. Internal and external forcing factors of climate change are associated to changes in the most important processes of energy transfer with influence on the energy balance of the climate system. The role of the solar activity, regular variations in the orbital parameters of the Earth and the radiative forcing which comprises the changes in the chemical composition of the atmosphere and the characteristics of the radiative processes that occur in the atmosphere and on the surface Earth will be discussed. Recent evidences of climate change and the general characteristics climate models used in climate projection will be presented. Finally, some cases study of potential impacts of regional climate change projections in Portugal, namely in forest fire regime (changes in the statistical distribution

of the values of burned area) and in the statistical distribution of extreme rainfall intensity and its impacts in the design of retention basins and storm water drainage infrastructures.

A mathematical approach: Mass and energy propagation in periodic phenomena in the atmosphere

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The observation of phenomena with spatial periodicity in the atmosphere have been observed in different atmospheric layers. In the lower atmosphere, the phenomena reveals at a certain level that has its influence in the meteorology. These phenomena arise from the balance of the driving force with the gravitational force generating atmospheric gravity waves with wavelengths of tens to thousands of kilometers and periocidades ranging from minutes to hours.

The gravity waves reveal a nonlinear mathematical even if their description are consistent with the basic equations of the dynamics of the atmosphere. The treatment follows the standard treatment of linearization of the equations from a basic state of the atmosphere. This mathematical treatment proves to be important in order to know the influence in simulations of climate change scenarios due to the transport of mass and energy beetwen different layer of the atmosphere.

Forecasting of wind power generation
- A collaborative multi-model approach -

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Over the last decade there has been a rapid growth in wind generated electricity. The worldwide installed wind power capacity has increased from a total nameplate capacity of 24.3 GW to 238,351 GW in 2011, and the industry is set to grow by at least another 40 GW in 2012 (Global Wind Energy Council,2012). The increased incidence of wind power in an energy network causes an increase of the unpredictability factor of energy production. Thus, it is difficult to predict the wind power production value, as well as its maximal or minimal values and their occurrence instants. The cause of this problem is that the wind velocity and its orientation are considered as one of the most difficult meteorological parameters to forecast. This is a result of the complex interactions between large scale forcing mechanisms such as pressure and temperature differences, the rotation of the earth, and local characteristics of the surface. The forecasting technique employed depends on the available information and the time scale in question.

Wind power forecasting methods can be used to plan unit commitment, scheduling and dispatch by system operators, and maximize profit by electricity traders. Because wind power is weather dependent, it is variable and intermittent over various time-scales. This point makes very difficult to forecast the power which will be injected in the distribution network, which hinders the management of the networks of power centrals, in the fragile energetic balance between the production and the consumption of energy. There may also be problems in energy transportation system that connects wind farms, often placed far from the centres of consumption. A good forecast of the produced power is, therefore, very important. So, the accurate forecasting of wind power is recognized as a major contribution for reliable large-scale wind power integration. This demand of prediction accuracy motivates researchers to propose accurate short-term forecasting models of wind power.

The wind power forecast should be based on the actual wind signal forecast or on the output power of the wind turbines. Huge research is being carried out for obtaining good wind speed forecasting systems. Several mathematical models which hybridize weather forecasting models and

statistical techniques have been proposed in the literature (Alexiadis,at al., 1998)(Xiaochen Wang, at al., 2011). Also, in many cases, these systems use statistical down-scaling processes including auto-regressive models (Ergin Erdem and Jing Shi, 2011), artificial neural networks (Nahi Kandil, at al., 2006) or support vector machines (J. Zhou, J. Shi and Gong Li, 2011) as a final step to improve the wind speed forecasting of the system.

This work proposes a new kind of short-term forecasting model, based on a hierarchical structure, which combines distinct models. These are results of an identification process that, from analysis of historical time series of wind velocity, finds pattern sequences of wind velocity data. Wind data collected on chosen meteorological stations are the main inputs for the learning process. The values of wind speeds from the previous hours are grouped into clusters according to their similarity together with a bank of Kalman filter that uses each of the clusters as an input to forecast the power production of an wind park one hour ahead. A new learning method for a short-term wind speed forecasting, that uses a bank of Kalman filter approach, is proposed to predict the power production on wind parks. The test of this new forecast scheme, jointly with the proposed identification method, has shown excellent results in the task of short term wind velocity prediction. In this way, it is an alternative and effective method that can help to predict in real-time the wind energy produced, allowing to make a good planning and managing of the balance between consumption and production over the power grid.

[1] In *Global Wind Energy Outlook 2012*, 2012. Global Wind Energy Council.

[2] M.C. Alexiadis, P.S. Dokopoulos, H. Sahsamanoglou and I.M. Manousaridis Short-term forecasting of wind speed and related electrical power In *Solar Energy* 63(1), 61-68, 1998. Global Wind Energy Council.

[3] Xiaochen Wang, Peng Guo and Xiaobin Huang. A Review of Wind Power Forecasting Models. In *Energy Procedia* 12, 770-778, 2011.

[4] Ergin Erdem and Jing Shi. ARMA based approaches for forecasting the tuple of wind speed and direction. In *Applied Energy* 88, 1405-1414, 2011.

[5] Nahi Kandil, ReneÂ´ Wamkeue, Maarouf Saad and Semaan Georges. An efficient approach for short term load forecasting using artificial neural networks. In *Electrical Power and Energy Systems* 28, 525-530, 2006.

[6] Junyi Zhou, Jing Shi and Gong Li. Fine tuning support vector machines for short-term wind speed forecasting In *Energy Conversion and Management* 52, 1990-1998, 2011.

Statistics of the Internet

Organizer: *Antonio Pacheco Pires*
Instituto Superior Técnico, UTL
March 26th, 10:30-12:45, Sala 1

Estimation of Flow Duration from Sample Traffic

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The flow duration distribution is an important metric to the network operator for traffic prediction and accounting but also arguably from the viewpoint of the user. The inversion problem of recovering the flow duration distribution from sampled traffic is addressed here under several sampling methods. A theoretical framework for the inversion problem is developed using a probabilistic flow model. In this framework, direct equations for the distributions of sampled flow quantities are derived based on the distributions of original flow characteristics. The inversion of these equations provides estimators for the flow duration distribution. Additionally, we develop an asymptotic analysis that directly estimates the flow duration distribution tail in terms of the sampled flow quantities

under the various sampling schemes. This analysis is also extended to the flow size distribution tail. Finally, the adequacy of the results to estimate the flow distributions is checked against two Internet traces. This talk is based on the works [1, 2, 3].

[1] N. Antunes and V. Pipiras, "Inverting flow durations from sampled traffic," in *Proc. 24th International Teletraffic Congress*, Krakow, Poland, 4-7 Sept. 2012

[2] N. Antunes and V. Pipiras, "Estimation of flow distributions tails from sampled traffic," in *Proc. IEEE Statistical Signal Processing Workshop*, Ann Arbor, USA, 5-8 Aug. 2012.

[3] N. Antunes and V. Pipiras, "Probabilistic sampling of finite renewal processes," *Bernoulli*, vol. 17, pp. 1285–1326, 2011.

Multiscale Internet Statistics: Unveiling the Hidden Behaviors

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Nowadays, the Internet can be seen as an ever-changing platform where new and different types of services and applications are constantly emerging. Consequently, novel and more complex communications paradigms have emerged where the corresponding network traffic results from multiple simultaneous Internet interactions. This growing traffic complexity together with the emergence of highly stealth attacks creates a major challenge for network operators in improving resources utilization, network performance, service personalization and security. Moreover, the network operators are limited by legal and technical constrains when analyzing the confidential/protected traffic data. These constrains together with the need for optimizing the users' quality of experience lead to an increasing need for new ways of unveiling the hidden behaviors of users, applications, services and networks, based only on low level traffic statistics.

A new network analysis paradigm must be applied where the multiscale dynamics of traffic must be captured, analyzed, characterized, modeled and if possible predicted. The concept behind this approach is the fact that Internet traffic is generated and shaped by several events and mechanisms occurring in different time scales. High timescale events are associated with human behaviors and actions. Service and high level network mechanisms events such as the establishment of traffic sessions and the corresponding control mechanisms (traffic shaping), originate mid-range timescale components. Protocol and low level network mechanisms, such as packets arrivals and queuing, are mapped to very low timescale events. All these mechanisms and events are correlated since the traffic of any Internet application is generated by user requests and controlled by service daemons and traffic control mechanisms, influencing how packet arrivals will occur.

This talk will present some results of applying this multiscale analysis to Internet traffic generated by different users accessing different Internet services. The presented results include a multiscale analysis based on wavelet transforms applied to several traffic metrics, such as the number of transmitted bytes and packets. The analysis of the energy variation at different scales allows the creation of bi-dimensional behavior descriptors, in terms of the energy variation at a specific timescale. These descriptors allow the differentiation and identification of users, applications and services behaviors.

Robust Feature Selection and Robust PCA for Internet Traffic Anomaly Detection

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Robust statistics is a branch of statistics which includes statistical methods capable of dealing adequately with the presence of outliers. In this paper, we propose an anomaly detection method that combines a feature selection algorithm and an outlier detection method, which makes extensive use of robust statistics. Feature selection is based on a mutual information metric for which we have developed a robust estimator; it also includes a novel and automatic procedure for determining the number of relevant features. Outlier detection is based on robust Principal Component Analysis (PCA) which, opposite to classical PCA, is not sensitive to outliers and precludes the necessity of training using a reliably labeled dataset, a strong advantage from the operational point of view. To evaluate our method we designed a network scenario capable of producing a perfect ground-truth under real (but controlled) traffic conditions. Results show the significant improvements of our method over the corresponding classical ones. Moreover, despite being a largely overlooked issue in the context of anomaly detection, feature selection is found to be an important preprocessing step, allowing adaption to different network conditions and inducing significant performance gains.

Network Inference from Co-Occurrences

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Inferring network structures is a central problem arising in many fields of science and technology, including communication systems, biology, sociology, and neuroscience. In this talk, after briefly reviewing several network inference problems, we will focus on that of inferring network structure from "co-occurrence" observations. These observations identify which network components (e.g., switches, routers, genes) co-occur in a path, but do not indicate the order in which they occur in that path. Without order information, the number of structures that are data-consistent grows exponentially with the network size. Yet, the basic engineering/evolutionary principles underlying most networks strongly suggest that not all data-consistent structures are equally likely. In particular, nodes that often co-occur are probably closer than nodes that rarely co-occur. This observation suggests modeling co-occurrence observations as independent realizations of a random walk on the network, subjected to random permutations. Treating these permutations as missing data, allows deriving an expectation?maximization (EM) algorithm for estimating the random walk parameters. The model and EM algorithm significantly simplify the problem, but the computational complexity still grows exponentially in the length of each path. We thus propose a polynomial-time Monte Carlo EM algorithm based on importance sampling and derive conditions that ensure convergence of the algorithm with high probability. Finally, we report simulations and experiments with Internet measurements and inference of biological networks that demonstrate the performance of this approach.

The work reported in this talk was done in collaboration with Michael Rabbat (McGill University, Canada) and Robert D. Nowak (University of Wisconsin, USA).

Modeling Sustainability in Operations Management and Logistics

Organizer: *Tânia Pinto Varela*
Instituto Superior Técnico, UTL
March 26th, 10:30-12:45, Sala 2

A step towards supply chain sustainability

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Sustainability is usually perceived by industry practitioners as a constraint, rather than a competitive advantage. The awareness of the continued population growth and the limited availability of resources are pressing policy makers to create legislation that can somehow contain or reverse the overall impact of human activities on the planet. Therefore, firm managers are realising that taking the lead in sustainable behaviour could bring important benefits. Including these concerns in supply chain design is challenging since the field of sustainability is broad, many times subjective and with unclear boundaries. Hence, very few works have been performed in analysing simultaneously the three pillars: economic, environmental and social performance. A particularly significant gap is found in quantitatively evaluating social impact. This work aims to be a step forward in filling these gaps.

A generic multi-objective optimization methodology was developed for decision support in the design and planning of sustainable supply chains. The objectives are the minimization of cost and environmental impact and the maximization of social benefit. It is based on the model developed by Salema et al., 2010 [1], which allows the representation of supply chains with forward and reverse flows. The environmental impact is assessed through the introduction of ReCiPe 2008, a LCA methodology. A social indicator was developed, which prefers the creation of employment in less developed regions, so as to move people to these regions from overpopulated ones, increasing life quality in both places. The epsilon-constraint method is used to draw a Pareto curve, allowing the analysis of the necessary trade-off between the three objectives.

The model was tested through a case study of a company that specializes in battery production and distribution. The results showed that it was possible to improve both economic and environmental performances and that, at very little additional costs for the company, a significant enhancement in social benefit could be obtained.

[1] Salema I., Barbosa-Póvoa A., Novais A. Simultaneous design and planning of supply chains with reverse flows: A generic modelling framework. In *European Journal of Operational Research* 203(2), 336-349, 2010.

Sustainable chemical processes: objectives and processes optimization

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Nowadays chemical processes face several challenges due to increasingly instable prices and markets, scarcity of raw materials, environmental problems such as climate change, safety regulations, and sustainability issues arising from the different stakeholders and from society. Chemical companies must produce products with quality and low prices and simultaneously have environmental, safety, sustainability concerns. However as companies are in a global very competitive market they must also have flexible and robust processes in order to be able to effectively respond to the market changes and demands and maintain simultaneously their economic, environmental, social performance without major fluctuations. Chemical processes optimization, considering economic and environmental concerns, can be very complex optimization problems since they often are MINLP problems. To add more objectives such as robustness, safety, etc. can highly increase the difficulty and complexity of those optimization problems in spite of the potential increase in achieving sustainable chemical processes. However these other objectives can be considered in a sequential approach. In this work this sequential approach was used in analysing the robustness of a process using flexibility, operational (purity and flow rate of a product stream), economic (Net Present Value) and environmental (Global Potential Environmental Impact) criteria and considering as external uncertainties feed flowrate and product purity. Solutions obtained by stochastic optimization of three topologies of the HDA (benzene production by non catalytic toluene hydrodealkylation) process were studied. The optimizations considered four different objective functions, two of the net

present value (NPV) type, one of them including environmental costs and two of the global environmental potential impact (GPEI) type and two optimization algorithms: SA (simulated annealing) and TS (Tabu search).

Greener Profits with Supply Chains - A Meta-heuristic approach for the Bi-Objective Design and Planning of Supply Chains

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The main focus of the design and planning of supply chains has been economic. Traditionally such problems have been approached individually and mono-objectively functions considering the cost minimization or the profit maximization have been studied. However, currently society is achieving a higher level of awareness towards environmental sustainability and cost or profit are not the unique concern due to the high environmental impact that supply chains structures and operation may cause. Supply Chains should therefore be designed and planned reflecting these additional issues. This however leads to the need of using multi-objective approaches that often result into more difficult problems to solve. The most common approaches to these problems have been focused on the use of mathematical programming models ([1]). Unfortunately, these models when applied to real problems might become intractable. New solutions approaches should therefore be explored. This presentation explores a simulated annealing (SA) methodology for the design and planning of supply chains, where both economic and environmental objectives are taken into account, simultaneously. The algorithm defines the location of all entities, respective capacities and all flows between entities, while the profit maximization and environmental impacts minimization are performed. A LCA methodology is used for the environmental impacts modelling while the supply chains design and tactical decisions are modelled through a RTN based approach extended to the supply ([2]).

[1] Papageorgiou, L. G. "Supply chain optimisation for the process industries: Advances and opportunities." In *Computers and Chemical Engineering* 33(12), 1931-1938.

[2] Pinto, T., A. Barbosa-Povoa and A. Q. Novais. "Design of Multipurpose Batch Plants: A Comparative Analysis between the STN, M-STN, and RTN Representations and Formulations." In *Industrial and Engineering Chemistry Research* 47(16), 6025-6044.

Sustainable water supply management through reduction and control of water losses

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As there can be no life, without water, there is no sustainable development without a sustainable water management. Water management should be socially, environmentally, and economically sustainable so that not only the actual but also future generations can still enjoy it as a resource to meet their own needs. Over the last years, Portugal has been taken important steps toward ensuring universal access to clean water and sanitation services. Now that this social goal is almost completely achieved, water supply utilities are shifting the focus toward better management practices. Water losses account for more than forty per cent of all water used in Portugal and thus present an enormous potential for efficiency improvement. Several economic and environmental sustainable strategies and practices are presented showing how major Portuguese water supply utilities are controlling and reducing their water losses.

Control of diseases and epidemics

Organizer: *Delfim F. M. Torres*
CIDMA-Center for Research and Development in Mathematics and Applications Department of Mathematics, University of Aveiro
March 26th, 14:15-16:30, Auditório 3

Optimal control of a tuberculosis model

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We propose and analyze an optimal control problem where the control system is a mathematical model for tuberculosis (TB) with two control functions. The controls represent the treatment of early latent individuals with anti-TB drugs (e.g., treatment of recent contacts of index cases) and the prophylactic vaccination of the persistent latent individuals. Our aim is to minimize the number of active infected individuals with the lowest possible cost. We provide theoretic and numerical results for the optimal solution and show that the controls can reduce the basic reproduction number R_0 from $R_0 > 1$ to $R_0 < 1$.

[1] M. G. M. Gomes, P. Rodrigues, F. M. Hilker, N. B. Mantilla-Beniers, M. Muehlen, A. C. Paulo and G. F. Medley. Implications of partial immunity on the prospects for tuberculosis control by post-exposure interventions. *Journal of Theoretical Biology* 248 (2007), 608–617.

[2] C. J. Silva, D. F. M. Torres. Optimal control strategies for tuberculosis treatment: a case study in Angola. *Numer. Algebra Control Optim.* 2 (2012), no. 3, 601–617.

Dengue in Madeira Island

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Dengue is a vector-borne disease and 40% of world population is at risk. Dengue transcends international borders and can be found in tropical and subtropical regions around the world, predominantly in urban and semi-urban areas. In this work, a model for Dengue disease transmission, composed by mutually-exclusive compartments representing the human and vector dynamics, is studied. The data is from Madeira, a Portuguese island, where an unprecedented outbreak occurred in October 2012.

[1] H. S. Rodrigues, M. T. T. Monteiro and D. F. M. Torres. Dengue in Cape Verde: vector control and vaccination. *Math. Population Studies* 2013, in press.

[2] H. S. Rodrigues, M. T. T. Monteiro and D. F. M. Torres. Insecticide control in a dengue epidemics model. *AIP Conf. Proc.* 1281 (2010), no. 1, 979–982.

[3] H. S. Rodrigues, M. T. T. Monteiro, D. F. M. Torres and A. Zinober. Dengue disease, basic reproduction number and control. *Int. J. Comput. Math.* 89 (2012), no. 3, 334–346.

Fractional calculus in epidemiology

Delfim F. M. Torres[1,*], Shakoor Pooseh[1] and Helena Sofia Rodrigues[1,2]

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We propose the use of fractional calculus (calculus with non-integer order derivatives) in epidemiology. A model for dengue, that differs from the classical one by using nonlinear differential equations of fractional order, is considered. Using data from the 2009 outbreak that occurred in the Cape Verde islands, we show that our model is capable of providing numerical results that agree with the real data.

[1] Shakoor Pooseh, Helena Sofia Rodrigues and Delfim F. M. Torres. Fractional derivatives in Dengue epidemics. *AIP Conf. Proc.* 1389 (2011), no. 1, 739–742. DOI:10.1063/1.3636838

Optimal Self-Protective Measures in Controlling Infectious Diseases of Human Population

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Most of the existing epidemiological models assume unchanged individual behavior during outbreaks of infectious diseases. Public health education and informal communication can impact on perceptions of disease threat, which could result in influencing behavior of individuals to take any possible self-protective measures. On the other hand, all kinds of available protective measures may not be 100% efficient in protecting individuals from getting infected by the disease. These two determinant factors influence the epidemiological dynamics of a disease [1]. Moreover, it also gives a better information in how to intervene in controlling the disease. Cost of implementing combinations of the intervention mechanisms also play a role in combating the epidemics of a disease. Controlling the epidemics with minimum possible cost is the best alternative that a public health planner wants to know.

In this talk a mathematical model for infectious disease epidemics that takes the human learning behavior into account and with pharmaceutical treatment will be presented. It will be indicated that behavior modification by the population has a significant impact on the dynamics of the disease. Moreover, using an optimal control theory a best possible combination of efforts in controlling a disease will be discussed.

[1] Semu M. Kassa and Aziz Ouinhou, Epidemiological models with prevalence dependent endogenous self-protection measures, *Mathematical Biosciences* 229 (2011), 41–49.

Dynamical models

Organizer: *Alberto Adrego Pinto*
FCUP
March 26th, 14:15-15:15, Sala 1

Newly and re-emerging diseases in a rapidly changing world: the case study of dengue fever re-entering and newly enterning in Europe

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We revisit the parameter estimation framework for population biological dynamical systems, including Bayesian approach and model selection in simple analytic examples. Then we develop the computational framework for application to more complex and more realistic models.

When it comes to complex models like multi-strain dynamics to describe the virus-host interaction in dengue fever, even most recently developed parameter estimation techniques, like maximum likelihood iterated filtering, come to their computational limits. The subtle interplay between possible chaotic dynamics and dynamical noise are investigated, and applications mainly to influenza and dengue fever are shown.

Implications for predictability in such complex scenarios are discussed. Even though large fluctuations prevent long term prediction in most cases, short term predictability can be achieved in noisy data.

BHP Universality and Energy Prices

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We consider the α re-scaled energy source (ES) daily positive returns $r(t)^\alpha$ and negative returns $(-r(t))^\alpha$ that we call, after normalization, the α positive fluctuations and α negative fluctuations, respectively. We use the Kolmogorov-Smirnov statistical test as a method to find the values of α that optimize the data collapse of the histogram of the α fluctuations with the truncated Bramwell-Holdsworth-Pinton (BHP) probability density function. Using the optimal $\alpha's$ we compute analytical approximations of the probability distributions of the normalized positive and negative energy source (ES) daily returns $r(t)$. Since the BHP probability density function appears in several other dissimilar phenomena, our results reveal a universal feature of energy source prices.

A model of carbon assimilation and allocation in Douro vineyards

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Carbon plays a key role in the life of living beings and also in climate changes. What is the amount of greenhouse gases produced and consumed by the plants? Is it possible to produce wine with zero carbon emissions? We will show a model of the behaviour of Carbon in the different structures of a vine, based on reference [1]. Some results from this model will be shown after calibration and validation with real data collected in the Douro vineyards region that is UNESCO World Heritage Site.

[1] Wermelinger, B., Baumgärtner, J., Gutierrez, A.P. A demographic model of assimilation and allocation of carbon and nitrogen in grapevines *Ecological Modelling, 53 (1991) 1-26* 1990;

Extreme Value Models

Organizer: *Margarida Brito*
FCUP/CMUP
March 26th, 14:15-16:30, Sala 2

Characterization of turbidity extremes behaviour

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The statistical analysis of risk events requires, in many situations, the analysis of a small amount of data consisting of very large or small values. An adequate modelling of these extreme values provides an important basis for risk evaluation and management.

We consider here, one of the key parameters for indicating the quality of drinking water, the turbidity. Turbidity values may be very different when measured at different locations. The levels of this parameter may also show big fluctuations in samples taken from the same location at different times in a year. Here, a series of turbidity measurements taken at the entrance of a water treatment plant is analyzed and we focus our study on the turbidity extremes behaviour.

Two models are presented, derived using two different approaches, both taking into account the flow of the river where the water treatment plant is located. Relevant characteristics of the upper tail of the turbidity distribution, conditioned to the flow, are investigated with the help of these models. The values obtained are compared and the temporal dependance of the data is also investigated.

Extreme value analysis of environmental radon gas concentration from high-frequency measurements

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The radon gas is a naturally occurring radioactive noble gas ubiquitous in natural (soil, groundwater, air,...) as well as in indoor environments. It is generated by radioactive decay from radium within mineral grains of uranium bearing materials such as natural rocks or concrete. From the solid grains radon can move into the air-filled or water-filled pores of the porous media and further migrate via diffusion and/or advection to the atmosphere. In closed and poorly ventilated environments the exhalation of radon from porous media (rocks, soils, concrete,...) into the atmosphere is a serious health hazard due to the carcinogenic effects of the inhalation of its short-lived decay products such as polonium and bismuth (e.g. [1]). The analysis of extreme values of radon concentration is therefore of particular interest as very high radon concentrations require protective and mitigation measures. In this work extreme radon values are analysed from both a block maxima and a peaks-over-threshold perspective (e.g. [2]) using very high-frequency (1-minute) time series of gamma radiation.

[1] B. Veloso, Barbara, J. R. Nogueira, M. F. Cardoso, Lung cancer and indoor radon exposure in the north of Portugal - An ecological study. *Cancer Epidemiology* 36, Page 26-32, 2012.

[2] S. Coles. *An Introduction to Statistical Modeling of Extreme Values*. Springer-Verlag, London, 2001.

Automatic fitting of loss models and risk evaluation

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In this work, our main goal is to design an automatic fitting of distributions to a wide array of data from natural disasters, in order to predict and investigate the ongoing damages. We develop a technique to map statistical models to clusters of data; we will thus fit instances of one or more of several classical distributions that better match the data. Through automatic processes we will use common risk theory computations to estimate the necessary capital to face possible disaster scenarios, within a certain confidence. These processes are produced from previous models where the occurrences of disasters in time come from a memoryless distribution, while damages come from a random number generator based on the previously modelled distribution.

Extremal dependence in river floods

Alexandra Ramos
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Ramos and Ledford (2009) constructed a flexible parametric joint tail model that accommodates asymptotic dependence, asymptotic independence and asymmetry within a single straightforward parsimonious parameterisation. Using this parametric model, we analyse short-range temporal dependence within stationary time series, characterising the extremal behaviour of the series. Recently, to characterise the extremal behaviour of a stationary time series, attention has been given to the within-cluster behaviour of the extremes of a series, which is determined by the short-range temporal dependence. Most of its characterization has been done based on the assumption of Markovianity of the time series, as the class of dth-order Markov chains is sufficiently general and tractable.

We consider here joint tails of the distribution of two consecutive pairs (X_i, X_{i+1}) of a first-order stationary Markov chain being modelled by the joint tail model described in Ramos and Ledford (2009). Applying this modelling approach to hydrological data, we examine successive flood peaks, which requires the joint estimation of the extremal temporal dependence structure as well as the tail of the marginal distribution. In particular, we are interested in studying the strength of extremal dependence in the upper joint tail and the heaviness of the tails.

[1] Ramos, A. and Ledford, A. A new class of models for bivariate joint tails. *Journal of the Royal Statistical Society*, Series B, 71 (1), 219-241, 2009.

Modelling of extremal earthquakes

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Natural hazards, such as earthquakes, affect the lives of thousands of people at all levels. The study of the earthquake characteristics and properties is an important question of global interest. We focus on the study of the tails of the seismic moment distributions. The Extreme Value Theory is used to estimate the tail parameters by the POT approach. We propose to estimate the tail index and high order quantiles using geometric-type estimators (see, for instance, [1] and [2]).

A statistical analysis is carried out for a particular case, in which a catalog of seismic data is considered. In this analysis we combine two approaches, namely an exploratory oriented analysis, where the question of independence is addressed with a special attention, and an inferential study.

We investigate the tail behaviour of this data; tail index and high order quantiles estimators are, in particular, derived.

The obtained results are discussed and compared with other studies in earthquake data (see, for instance, [3] and [4]).

[1] Brito, M. and Freitas, A.C.M. (2003). Limiting behaviour of a geometric estimator for tail indices. *Insurance: Mathematics and Economics* 33, 221–226.

[2] Brito, M. and Freitas, A.C.M. (2006). Weak convergence of a bootstrap geometric-type estimator with applications to risk theory. *Insurance: Mathematics and Economics* 38, 571–584.

[3] Corral, A. (2006). Dependence of earthquake recurrence times and independence of magnitudes on seismicity history. *Tectonophysics* 424, 177-193.

[4] Pisarenko, V.F. and Sornette, D. (2003). Characterization of the frequency of extreme events by Generalized Pareto Distribution. *Pure and Applied Geophysics* 160, 2343-2364.

Persistent time series and extreme events

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Many natural records such as river flows, temperature records and ECG, exhibit long-term persistence characterized by autocorrelation functions that decay hyperbolically implying that the autocorrelations are not summable. An alternative characterization is given in the frequency domain by a spectrum that is unlimited near the origin. These time series are called long-memory. This type of phenomena also occurs in internet traffic and stock market volatility data. There are several parametric and non parametric approaches to estimate the long memory or persistence characteristic in a time series. The most well known parametric model for long memory time series relies on fractional differencing and is the ARFIMA model. The non parametric approaches widely used in the literature are the Hurst coefficient, Detrended Fluctuation Analysis (DFA) and wavelet variance. In this work, the interest lies in the effect of long-memory on the statistics of extreme events, in particular the mean return interval and the distribution function of the return intervals. The effect on clustering of both small and large return intervals is investigated in synthetic as well as observed data.

Solar radiation

Organizer: *Miguel Centeno Brito*
Instituto Dom Luiz/Faculdade de Ciências da Universidade de Lisboa
March 26th, 17:00-18:00, Auditório 3

Practical uses of stochastic methods for solar radiation time series

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Observed climatic and weather time series data are essential for building models of natural systems as well as of man-made systems. However, observed data are not always the best choice for many real world applications, including themes so diverse as climate change impact assessment, system engineering, insurances, regulations and other public policies. Indeed there are many technical, operational and financial constraints to data acquisition. The problems include missing and spurious values, parameters never monitored for a region, records too short and/or obtained at a spatial and time resolution not adequate.

Rather than dealing directly with messy observed data, often it is much faster and useful to prepare synthetic data sets via statistical and stochastic methods (validated by observed data). Then there the spatial and time scale is chosen, there are no gaps or missing data, and the full set of parameters required is available. Other bonus include no data protection rights and the possibility of creating datasets representative of an entire region or of a long period - very useful for running software fast or for characterizing a large area defined by administrative, not climatic or geographical, criteria.

In this talk an example of this approach will be provided, together with various actual uses. It refers to the assembling of Reference Meteorological Years (RMY) for the regulations and software supporting the implementation in Portugal of the Energy Performance of Buildings European Directive (Directive 2010/31/EU, a.k.a. EPDB).

The statistical and stochastic methodologies used are outlined. Practical uses of these standard RMY are illustrated with the help of regulations transposing the EPDB, of governmental schemes of incentives to solar energy, and of official software for assessing solar system performance and thermal balances of buildings.

Simulation and computation of diffuse and albedo shadow losses of solar radiation in a photovoltaic field with 1-axis trackers

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Raytracing methods are presented to simulate and compute shadow losses for diffuse solar radiation and albedo in a PV field, which can be implemented with any raytracing software. The methods are simple and precise and can be used to calculate losses for a very large number of trackers. Two methods were developed, one for diffuse radiation and another for albedo shadow losses. Two case studies were performed, using these methods and their results compared with those of a commercial software both to illustrate and validate their application.

[1] J.A. Duffie and W.A. Beckman. *Solar Engineering of Thermal Processes*. John Wiley & Sons, 2006.

[2] E. Lorenzo, L. Navarte, and J. Muñoz. Tracking and back-tracking. *Prog. Photovolt: Res. Appl.*, 19:747-753, 2011.

[3] F. Martínez-Moreno, Muñoz J., and E. Lorenzo. Experimental model to estimate shading losses on pv arrays. *Solar Energy Materials and Solar Cells*, 94:2298-2303, 2010.

[4] L. Navarte and E. Lorenzo. Tracking and ground cover ratio. *Prog. Photovolt: Res. Appl.*, 16:703-714, 2008.

[5] O. Perpiñán. Cost of energy and mutual shadow in a two-axis tracking pv system. *Renewable Energy*, 43:331-342, 2012.

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geoSOL - a georeferencied web based platform for solar sytems management

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geoSOL is a modular web-based platform that provides for an advanced geo-referenced tool for managing information of solar installations, both solar thermal (ST) and photovoltaic (PV), connected to a consumption point. This product-service is pioneer and innovative as it embeds: educational, institutional and regulatory information; mapping of solar potential in urban areas (roofs and façades); registry and mapping of installed solar systems; certification of solar installations; forecasting of solar thermal and electric production based in real-time and/or inferred data. geoSOL is a multi-stakeholder tool, with different values pertaining to different actors. From the political decision making point of view, geoSOL provides for an integrated observation system delivering

energy-policy indicators that allow for monitoring of in-force policies, while allowing for simulating future energy policy scenarios, namely targets and strategies, preferable areas and types of incentives. With respect to market actors, previledged access to business information on the potential for "selling" solar systems is possible, which helps to define commercialization and communication strategies, to the end user, to whom all this information is available to make an informed decision on the acquisition process. The whole concept of the geoSOL platform is tested and validated in Portugal, though it is designed to be made available and straightforwardly transposed to other countries realities. The modularity of the platform is an added value that allows customized packages in accordance with client requirements.

Renewable Energies

Organizer: *João Gama*
LIAAD, INESC TEC Universidade do Porto
March 26th, 15:30-16:30, Sala 1

Non-Gaussian Modeling of Wind Power Forecasts

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Presently, wind power forecast is highly important in Europe, where the growing penetration of wind power generation has reached heavy percentages (in the range of 5% to 20%) in some countries, like Germany, Spain, Denmark. For instance, in Portugal by the end of 2011, around 20% of the total generation was from wind power. During the last fifteen years, research on wind power forecast has been conducted to reduce the forecast error and expand the forecasting products (e.g., probabilistic forecasts, scenarios, ramps). Presently, the power system operator uses forecasts in their daily operation, embedded in decision-making processes.

It is well known that the wind speed versus power curve of a wind turbine is highly nonlinear, and this transformation of wind speed to wind power changes the statistical properties of the errors. The wind power forecast error distribution exhibits a non-Gaussian shape with high skewness and excess of kurtosis. The presence of non-Gaussian distributions has motivated research for "distribution free" statistical learning techniques and decision-making algorithms. This talk discusses the use of cost functions from Information Theoretic Learning (ITL) to fit neural networks and produce point forecasts [1,2], and the use of conditional kernel density estimators to generate non-parametric probabilistic forecasts [3]. The importance of not assuming Gaussian errors in decision-making problems (such as setting the operating reserve [4]) is briefly discussed.

[1] R.J. Bessa, V. Miranda, J. Gama, "Entropy and correntropy against minimum square error in offline and online three-day ahead wind power forecasting", In *IEEE Transactions on Power Systems* 24, 1657-1666, 2009.

[2] R. Bessa, V. Miranda, A. Botterud, J. Wang, "Good or bad wind power forecasts: a relative concept", In *Wind Energy* 14, 625-636, 2011.

[3] R.J. Bessa, V. Miranda, A. Botterud, Z. Zhou, J. Wang, "Time-adaptive quantile-copula for wind power probabilistic forecasting", In *Renewable Energy* 40, 29-39, 2012.

[4] M.A. Matos and R.J. Bessa, "Setting the operating reserve using probabilistic wind power forecasts", In *IEEE Transactions on Power Systems* 26, 594-603, 2011.

Predicting Ramp Events with a Stream-based HMM framework

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The motivation for this work is the study and prediction of wind ramp events [2] occurring in a large-scale wind farm located in the US Midwest. In this paper we introduce the SHRED framework, a stream-based model that continuously learns a discrete HMM model [1] from wind power and wind speed measurements. We use a supervised learning algorithm to learn HMM parameters from discretized data, where ramp events are HMM states and discretized wind speed data are HMM observations. The discretization of the historical data is obtained by running the SAX [3] algorithm over the first order variations in the original signal. SHRED updates the HMM using the most recent historical data and includes a forgetting mechanism to model natural time dependence in wind patterns. To forecast ramp events we use recent wind speed forecasts and the Viterbi algorithm [1], that incrementally finds the most probable ramp event to occur.

We compare SHRED framework against Persistence baseline [2] in predicting ramp events occurring in short-time horizons, ranging from 30 minutes to 90 minutes. SHRED consistently exhibits more accurate and cost-effective results than the baseline.

[1] L.R. Rabiner. A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition. In *Proceedings of the IEEE* 77(2), 1989.

[2] C. Ferreira, J. Gama, V. Miranda and A. Botterud. A survey on wind power ramp forecasting. In *Report ANL/DIS* 10-13, Argonne National Laboratory, 2010.

[3] J. Lin, E. Keogh, S. Lonardi and B. Chiu. A Symbolic Representation of Time Series, with Implications for Streaming Algorithms. In *8th ACM SIGMOD Workshop on Research Issues in Data Mining and Knowledge Discovery*, San Diego, CA, 2003.

Advanced School

Compatibility, hysteresis and the direct conversion of heat to electricity
Richard James
University of Minnesota, USA.
March 21th, 09:00-13:00, Anfiteatro 3.2.15, Edifício C3, FCUL

Most of the power produced on earth relies essentially on the phase transformation between water and steam. But there are other phase transformations that could serve the same purpose. They may have advantages with regard to convenient temperature regimes, simplicity of the device, elimination of the electrical generator, ease of capturing natural sources of heat, efficiency or power density. In this lecture series we examine the possibility of using so-called martensitic phase transformations in solid materials. The production of energy requires that the transforming material goes back and forth through the phase transformation many, many times, but this rarely happens. In martensitic materials, after a few cycles, the transformation temperature may have migrated, and the materials often fatigue or crack, and there may be too much hysteresis. We identify a particular problem of geometry whose solution profoundly affects the reversibility of the transformation, and therefore its potential use for energy conversion. This problem of geometry has deep links to the study of the calculus of variations and partial differential equations that we explain.

Economic Foundations of Climate Smart Agriculture and **The Economics of Payment for Ecosystem Services** (video lectures)
David Zilberman
University of California, Berkeley, USA.
March 21th, 14:30-16:30 / March 22th, 14:30-16:30, Anfiteatro 3.2.15, Edifício C3, FCUL

Climate change will reduce productivity in warm regions and increase it in cold regions. The aggregate effect of climate change on prices and production would be significant and may be negative if adjustment is slow, but the regional effect could be drastic. Producers can adapt to climate change by changing crops and varieties by introducing new technologies but, sometimes, the best approach is migration. We will identify policies that will allow easier adaptation to climate change and the characteristics of strategies that will reduce the cost of adaptation and actually improve the well-being in various locations. A key element of and effective adaptation strategy is investment in research and development that would lead to new technological options and a regulatory framework that would allow quick adoption of effective technologies. We will identify the features of models that are able to quantify effectively the impact of climate change and develop policies to address it. Smart policies were based on continuous assessment of economic conditions to identify the optimal timing to introduce climate-change adaptation strategies.

The ecosystem provides crucial services of regulation and sustainability to the economy, but these services may be stopped when land-use changes are introduced. Thus, land owners need incentive to conduct operations that would enhance the provision of environmental services. We will investigate the alternative strategies to provide multiple types of ecosystem services. We will develop principles to target resources most effectively to obtain ecosystem services. We will also assess the impacts of the ecosystem services on the economy. In most cases, payment for ecosystem services may not necessarily benefit the poor, but they may be pro poor if the poor receive most of the payment and will not negatively affect the price of food. We will consider several case studies.

Functionalized Energies: Higher order models of complex systems
Keith Promislow
Michigan State University, USA.
March 22th, 09:00-13:00, Anfiteatro 3.2.15, Edifício C3, FCUL

In classical amphiphilic mixtures a scarce surfactant phase lowers the free energy of a mixture of a solvent phase and a hydrophobic phase by residing partially inside of and partially outside of the ambient solvent. Amphiphilic systems seek to maximize interface subject to the steric constraints imposed by molecular arrangement of the surfactant molecules which load the interface. While molecular considerations prevent the surfactant phase from being spread-out too thin, energetic considerations discourage the surfactant from accumulating too thickly at the interface. The surfactant phase is typically a small bi-phasic molecule, with a polar head group which desires a hydration sphere of solvent molecules and a 'greasy' or 'hydrophobic' tail which mixes poorly with solvent. Surfactant molecules arise in a wide variety of important applications, from detergents which form a layer at water-grease interfaces, helping to break them up, to lipid bilayers which form the essential membrane structures in organic life, to polymer electrolyte membranes in which polar, or "functional", groups, are tethered to hydrophobic polymer backbones. In this latter application the solvent is the scarce minority phase, and is imbibed by the polymer electrolyte matrix, forming a complex network structure with dominant length-scales ranging from 1-4 nanometers.

We will prevent an overview of classical phase separation models, starting with the Cahn-Hilliard free energy and its gradient flows. We will motivate, both experimentally and mathematically, a family of higher-order free energies which elegantly reformulate the Cahn-Hilliard free energy. We will derive sharp interface reductions, and investigate competition between bilayer and pore structures. Models of electrostatic energy in high-density salt solutions will be presented, as well as their applications to ion transport and effective Poisson-Nernst-Plank equations. Finally we will discuss extensions to multi-component polymer systems with various degrees of functionalization.

Comparing climate mitigation options using carbon abatement supply curves
Inês Azevedo
Carnegie Mellon University, USA;
March 27th, 14:30-18:30, Anfiteatro 3.2.15, Edifício C3, FCUL

Should policy makers pursue energy efficiency, renewables, carbon capture and sequestration, or more natural gas as means to reduce greenhouse gas emissions? How can we go about comparing strategies that will save different amounts of greenhouse gas emissions, have different lifetimes and costs? One way to compute and display this information in a way that is easy to be used by policy makers and the public are carbon abatement supply. In this advanced course, you will learn what these course are, and we will go over hands on examples for a couple of climate mitigation interventions. We will discuss the benefits and limitations of carbon abatement curves.

Climate Statistics
Richard L. Smith
University of North Carolina, USA.
March 28th, 09:00-13:00, Anfiteatro 3.2.15, Edifício C3, FCUL

In this course, I will survey a number of areas of statistical methodology that are used in studying climate data. Statistical techniques include time series analysis, spatial statistics and extreme value theory. The applications discussed will cover some or all of the following: (a) Estimate trends and their statistical significance in climatic time series; (b) Reconstructing temperature time series

from paleoclimatic data; (c) Estimating probabilities of extreme climatic events; (d) Human health consequences of climate change.

Adaptation to climate change: options, planning, constraints and uncertainties
Filipe Santos
Universidade de Lisboa, Portugal.
March 28th, 14:30-18:30, Anfiteatro 3.2.15, Edifício C3, FCUL

Recent results from various research projects (mostly on-going) on climate change impacts, adaptation and uncertainties will be presented and discussed in an interactive way with the participants. The research projects to be presented are:

- **CIRAC** - Floods and Flood Risk Maps in Climate Change Scenarios

  Start date: 2010 — End Date: 2013

  CIRAC project will study the medium and long-term vulnerabilities of the Portuguese territory to flooding, thus providing information for planning and decision support and reducing the vulnerability of society to these phenomena. The project will produce for continental Portugal, flood areas and flood risk maps in the short, medium and long term, taking into account climate change scenarios, identifying and characterizing the potential impacts / damage to the areas considered most vulnerable.

- **2-FUN** - Full-chain and UNcertainty Approaches for Assessing Health Risks in Future ENvironmental Scenarios

  Start date: 2007 — End Date: 2011

  Stands for Full-chain and UNcertainty Approaches for Assessing Health Risks in FUture ENvironmental Scenarios" and aims to provide decision-makers with state of the art tools to analyse the current and future trends in environmental conditions and pressures that may lead to health problems.

- **C2 JI UNCERT** - CIRCLE - J.I. on Climate Uncertainties

  Start date: 2011 — End Date: 2014

  Climate change and climate adaptation policy developments represent a set of decision-making frameworks (e.g. international policy commitments, risk management planning and strategic investment decisions) that have to process and incorporate a wide range of uncertainties associated with these scientific outcomes. In order to account for decision makers' perspectives and support better informed decisions, this growing - and sometimes controversial - knowledge about the climate system, climate change and associated uncertainties, has to be communicated in a clear and useful way. This is a great challenge for both researchers and policy-makers working on climate change and climate adaptation policy development and a challenge.

- **VA-4D** - Visual Analysis of 4-Dimensional Fields, Processes

  Start date: 2011 — End Date: 2012

  The main goal of this project is to build a conceptual model for an intelligent Visual Analysis tool for large 4-Dimensional fields (VA-4D). The visual analysis tool will be a decision support system targeting different users and contexts, with five demonstration scenarios acting as source of requirements, conceptual abstractions, and also as demonstrators. The tool will support, in a user-friendly visual way, the exploration of complex (including uncertainty in data) and/or large data sets in different formats from standard 2D (slices), 3D (volume rendering) and even 4D (volume analysis along time) to geometrically transformed displays, dense pixel displays, etc. We have implicitly included different levels of stakeholders at the various stages of the project.

Conference Schedule

Keynote Speakers

Room: Auditório 2

	March 25th	March 26th	March 27th
9:00-10:00	Opening	Richard L. Smith University of North Carolina	Inês Azevedo Carnegie Mellon University
Coffee Break			
10:30-11:30	Richard James University of Minnesota (Pedro Nunes Lectures)	Filipe Santos Universidade de Lisboa	Andrew Schmitz University of Florida (public lecture)
Break			
11:45-12:45	Pedro Miranda Universidade de Lisboa	Keith Promislow Michigan State University	Carlos Aragão Univ. Federal do Rio de Janeiro (public lecture)
Break			
14:15-15:15	José Xavier Universidade de Coimbra	João Gama Universidade do Porto	
Break			
15:30-16:30	Adélio Mendes Universidade do Porto	Vladimiro Miranda Universidade do Porto	
Break			
15:30-16:30	David Zilberman University of California (video lecture; public lecture)	Christopher K. R. T. Jones University of North Carolina (video lecture)	

Thematic Sessions

Room: Auditório 3

	March 25th	March 26th
10:30-11:30	*The role of statistics of extremes in society* Manuela Neves Isabel Fraga Alves Ivette Gomes	*Energy Transfer and Management* Amadeu Borges Liliana Caramelo Mário Gonzalez Pereira
Break		
11:45-12:45	*Mathematical Modeling and Numerical methods for environmental problems* Jorge Figueiredo Christophe Berthon	*Energy Transfer and Management* Nuno Afonso Moreira Norberto Gonçalves e Marco Naia Paulo Alexandre Cardoso Salgado
Break		
14:15-15:15	*Human activity in a dynamical planet* Carlos Ramos António Heitor Reis Mouhaydine Tlemcani	*Control of diseases and epidemics* Cristiana J. Silva H. Sofia Rodrigues
Break		
15:30-16:30		*Control of diseases and epidemics* Delfim F. M. Torres Semu Mitiku Kassa
Coffee Break		
17:00-18:00		*Solar radiation* Ricardo Aguiar Tomás Fartaria Maria João Rodrigues

Room: Sala1

	March 25th	March 26th
10:30-11:30	*Non-equilibrium statistical mechanics: kinetics, chemistry and coagulation* Ana Jacinta Soares Filipe Carvalho	*Statistics of the Internet* Nelson Antunes Paulo Salvador
Break		
11:45-12:45	*Non-equilibrium statistical mechanics: kinetics, chemistry and coagulation* Fernando Pestana da Costa Rafael Sasportes	*Statistics of the Internet* M. Rosário Oliveira Mário A.T. Figueiredo
Break		
14:15-15:15	*Stochastic dynamics* Anabela Cruzeiro António Pacheco	*Dynamical models* Nico Stollenwerk Alberto Adrego Pinto João Passos Coelho
Break		
15:30-16:30	*Stochastic dynamics* Maria João Oliveira Fernanda Cipriano	*Renewable Energies* Ricardo Bessa Carlos Ferreira
Coffee Break		
17:00-18:00	*Sustainability and new energies* José A. C. Silva Paulo Brito Vicente Leite	

Room: Sala2

	March 25th	March 26th
10:30-11:30	*Statistical modelling of environmental data* Tiago A. Marques Luís Margalho A. Manuela Gonçalves	*Modeling Sustainability in Operations Management and Logistics* Bruna Mota Florinda Martins
Break		
11:45-12:45	*Island Biogeography and Ecological Modeling* Luis Borda Água João Miguel Ferreira Paulo A. V. Borges	*Modeling Sustainability in Operations Management and Logistics* Nelson Martins Ricardo Mateus
Break		
14:15-15:15	*Traffic flow and fire modelling and simulation* João Emílio Almeida Rosaldo Rossetti António Leça Coelho	*Extreme Value Models* Alexandra Ramos Susana Barbosa Laura Cavalcante
Break		
15:30-16:30	*Traffic flow and fire modelling and simulation* Teresa Grilo Sílvio Gama	*Extreme Value Models* Ricardo Cruz Margarida Brito Maria Eduarda Silva

Advanced School

Room: Anfiteatro 3.2.15, Edifício C3, Faculdade de Ciências da Universidade de Lisboa

	March 21st	March 22nd		March 27th	March 28th
9:00-11:00	Richard James	Keith Promislow			Richard L. Smith
Coffee Break					
11:30-13:00	Richard James	Keith Promislow			Richard L. Smith
Break					
14:30-16:30	David Zilberman (video lecture)	David Zilberman (video lecture)		Inês Azevedo	Filipe Santos
Coffee Break					
17:00-18:30				Inês Azevedo	Filipe Santos