UCD Earth Sciences Institute

Earth & Natural Sciences PhD Programme 2011

Strand 1:

Earth and Computational Climate Modelling

Project Descriptions (v8)

Please Note:

While every effort has been made to ensure that the information contained within this document is accurate, it is possible for errors and omissions to have occurred. It is strongly recommended that potential students make contact with the Principal Investigators directly, should they have any questions about the projects.

Introduction

The ENS PhD Programme

The global change in climate and energy supplies will have a major impact on the island of Ireland, on how our economy evolves and the need for measures to protect our environment.

UCD is harnessing its considerable resources to address the challenges by developing an Earth Sciences Institute (ESI). The proposed ENS PhD programme building on the concept that energy and environment are co-dependent, draws on the unique range of disciplines and technologies of UCD, ESI and its partners to create new programmes in Earth and Natural Sciences education. The proposed ESI PhD programme will create a cohort of graduates with a strong background in Energy and Environmental studies, imbued with the innovation and entrepreneurial skills to develop an emerging green technology sector. In addition to a core of postgraduate students specialised in key elements of earth sciences, the programme will impact across a wide range of undergraduate and graduate programmes. It is only by influencing the collective skills of future graduates emanating from a range of disciplines that we will as a society adapt to the national and global challenges and opportunities in agriculture, energy, food, forestry, green technology, land resources, nanoscience and water.

This Strand – Earth Systems Science and Computational Climate Modelling – aims to train Earth Scientists in the disciplines needed to propose quantitative and innovative solutions to rapidly emerging climate challenges.

A total of 10 Projects are offered with 10 positions for PhD candidates within this Strand. Students in this Strand will be housed at UCD, TCD or NUIG.

Strand Keywords: mathematics, computational science, geology, geophysics, glaciology, atmospheric physics, hydrology, geochemistry, thermochronology.

Information

The Application Process

Please read the following section very carefully. It is of the utmost importance that all the relevant documents are submitted as part of a single email application. Incomplete applications will not be reviewed.

If you have any specific questions about the project or the application, please contact the Principal Investigator directly (details are available in this booklet).

Applications should be emailed to both the Principal Investigator for the specific project and to ens_phd@ucd.ie. The subject line should contain the word “Application” followed by the project number followed by the applicant’s name (e.g. Application MOD 1 Joe Bloggs).

Mislabeled applications may not be processed.

All applications must include the following documents:

1. A completed Application Cover Form (download)
2. A complete Curriculum Vitae
3. A Letter of Motivation outlining your interest in the specific project
4. Certified copies of academic transcripts

and, where appropriate,

5. Evidence of proficiency in English

All documents should be typeset or scanned, as appropriate. Please provide PDF format documents where possible.

Please note that all elements of the application must be included in one email. It will not be possible to process incomplete applications and we will not be in a position to collate applications sent in separate emails.

Failure to include all of the documentation listed above will result in your application being rejected.

Applications received before **13 May 2011** will receive full consideration, and the positions will remain open until filled.

Project MOD 1

Real-time determination of the properties of deep (remote) *in situ* earth fractures

Principal Investigator: **Professor Christopher Bean** (UCD) – chris.bean@ucd.ie
Collaborators: **Sergei Lebedev** (DIAS); **John McCloskey** (UU)

Fractures play critical roles in a wide range of earth science problems and have been very widely studied. However most studies of fracture *properties* are confined to observing fractures that are currently exposed on or are very close to the earth's surface while many earth processes that are of interest take place several hundred metres to kilometres beneath the surface. Forensic seismic measurements open a window to the determination of these *in situ* rock fracture properties, deep below the surface. As seismic waves pass through fractures they are modified in amplitude, frequency and propagation speed, leaving 'characteristic signatures' on the waves which pass through the fractures. Furthermore, temporal changes in these fracture properties can be used to determine important related parameters, such as the temporal evolution of stress and fluid flow in the earth (e.g. beneath volcanoes even prior to visible inflation, in CO_2 sequestration reservoirs, in unstable land masses prior to land-slides etc.). A key determinable fracture parameter is its stiffness which can acts as a proxy for how fluids flow through the fracture and for fracture strength. However a key challenge is to better understand how fracture stiffness scales in space and to develop a methodology for remotely detecting fracture population stiffness and its temporal evolution, from seismic data. In this work we will address this problem by making field seismic measurements of wave propagation across fractures of different scale sizes from the sub-metre scale through to the 100s km scale. Field scale measurements will be undertaken in disused quarries, intermediate scale measurements in underground tunnels on Teide volcano Tenerife and the 100s km scale measurements using a new broadband seismic array ('Ireland array'), in collaboration with the Dublin Institute for Advanced Studies (DIAS). Field observations will be complemented by high-end computational simulations of seismic waves in fracture populations and fracture-fracture stress transfer interaction modelling in collaboration with the University of Ulster, at Coleraine. The impact will be an improved understanding of deep (remote) *in situ* fracture properties (and their time evolution) for a wide range of earth system applications.

There is one studentship available in this Project and will be based at UCD

Project MOD 2

Modelling the thermal structure of onshore Ireland and its offshore basins

Principal Investigator: **Dr David Chew** (TCD) - chewd@tcd.ie
Collaborators: **Professor Goeff Clayton** (TCD); **Professor Stephen Daly** (UCD); **Ray Scanlon** (GSI)

Our knowledge of the thermal structure of the Irish crust and lithosphere remains very incomplete. This project will constrain and model the thermal evolution of the Irish mainland and key portions of the offshore basins. Project outputs include characterizing regions of high heat flow (onshore) for geothermal target assessment, and establishing the timing of basin inversion (offshore) for petroleum exploration studies. This multidisciplinary project is closely linked with a UCD application. These projects contribute to three interdisciplinary research themes: monitoring/modelling surface/sub-surface heat & fluid flow; modelling geothermal power; sub-surface energy extraction. There will be close collaboration between the TCD group (regional-scale thermal history modelling) and the UCD team (characterizing a key target area for geothermal exploration).

This project will involve collection of rock samples for thermal-history analysis followed by thermal history modelling. Onshore sampling of escarpments will be reinforced with deep boreholes provided by the Geological Survey of Ireland (GSI) (co-applicant Ray Scanlon) to allow near-vertical thermal history profiles to be developed. Offshore sampling will utilize petroleum-exploration boreholes. Thermal history analysis will be undertaken in TCD, the only such facility in Ireland. Low-temperature thermochronology will be undertaken in the SFI-funded fission-track laboratory (PI) with organic maturation studies (vitrinite reflectance) overseen by co-applicant Prof. Geoffrey Clayton. U-Pb analysis of apatite samples will be undertaken in UCD (co-applicant Prof. Stephen Daly). Combined, these data will constrain the thermal history of the selected packages of rocks from 120oC-60oC to constrain the palaeogeothermal gradient in the upper 1-3 km of the crust. The thermochronology data will be modelled using a Bayesian framework to yield fully non-linear estimates of the uncertainty on the inferred thermal histories and the palaeotemperature gradient over time. Finally 2D and 3D temperature-history models of the Irish mainland and offshore will be produced and integrated with th GSI 3D-visualization suite.

Thermal-history models of the Irish onshore will characterize regions of high heat flow for geothermal target assessment. Low-temperature thermal history analysis is ideal for studying the development of sedimentary basins as the 120 °C - 60 °C temperature range contains the hydrocarbon maturation window. Knowledge of the thermal history has important implications for the prospectivity of petroleum system including trap breaching and the probability of encountering effective top-seals; the timing of source maturation and the quality of reservoir rocks.

There is one studentship available in this Project and will be based at TCD

Project MOD 3

Modelling of joint patterns within multi-layered rock masses

Principal Investigator: **Dr Conrad Childs** (UCD) **–** conrad@fag.ucd.ie
Collaborators: **Professor John McCloskey** (UU)**; Dr Martin Schopfer** (UCD)**; Professor John Walsh** (UCD)

One of the responses of the uppermost part of the earth's brittle crust to uplift and associated extension is the formation of populations of fractures within rock masses, which together form what are referred to as joint systems. This project will investigate the nature of the processes and factors which control the 3D growth and geometrical properties of joint systems within multilayered sequences, a long-standing issue in structural geology and many application areas. Despite their significance in controlling both the strength and flow properties of rocks, existing models of joint systems are relatively simple. However, recent work by the Fault Analysis Group using a Discrete Element Modelling (DEM) approach has, for the first time, provided a mechanical rationale for the basic scaling properties of joints. Near regular joint spacing, which scales with layer thickness, can be shown to be related to a combination of mechanical properties and conditions, including layer and layer-interface properties, confining pressure and pore fluid pressure. The proposed project will extend existing modelling capability into 3-D, providing a basis for investigating the broader range of processes and factors controlling the 3D growth and geometrical properties of joint systems within layered sequences. Modelling results will be linked to detailed descriptions of the 3-D geometry of joint systems contained within the Carboniferous limestones of the Burren and the Carboniferous sandstones of Donegal/Sligo (Mullaghmore sandstone), together representing some of the best exposures of joint systems in Ireland and rocks which form a substantial part of the near surface of Ireland. The 3-D modelling will permit a variety of fundamental questions to be confronted for the first time, including:

- (i) Do multi-directional joint patterns form in 3-D stress fields?
- (ii) Do joint patterns show the emergence of systematic joints and cross-joints?
- (iii) Are joint patterns developed in folded layers directly related to fold geometry?
- (iv) Is layer-parallel slip more prominent in the jointing of 3-D folded layers?

Any improvement in our understanding of the geometry and growth of joint systems is important in a wide variety of application areas which depend on a knowledge of the structure and strength of rock volumes. These range from engineering applications, such as tunnelling and dam construction, through to the extraction of natural resources in mining and other industries, into the many application areas where the fluid flow characteristics of jointed rock volumes are important, for example groundwater supply, oil production and subsurface waste disposal.

There is one studentship available in this Project and will be based at UCD

Project MOD 4

Biomineralisation and Isotope Proxies for Environmental Change

Principal Investigator: **Dr Quentin Crowley** (TCD) **–** crowleyq@tcd.ie
*Collaborators***: Dr Andrew Jackson** (TCD)**; Frank McDermott** (UCD)

Cold water coral reefs along the Irish continental margin are part of the largest barrier reef system on the planet and are crucial to better understanding the effects of environmental change.

Biomineralisation refers to the processes by which organisms form minerals. As a process, biomineralisation (e.g. aragonitic corals and fish teeth, otoliths and bones) is crucially important for providing substrate materials which underpin most quantitative climate, environmental and ecosystem proxy reconstructions. Isotope signatures preserved in biomineralisation (e.g. $\delta^{11}B$, $\delta^{18}O$, $\delta^{44}Ca$, $^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$) may potentially act as high-resolution proxy signals for environmental conditions (e.g. water temperature, salinity, ocean circulation, pH, Eh), diet and trophic level. Consideration must be given, however, to the so-called "vital effects "on biomineralisation which some organisms exhibit, such that these environmental signals can be suppressed or eliminated.

Biomineralisation may also provide materials suitable for isotope dating. For instance, $^{230}Th/^{234}U$ dating of corals has been shown to be an exceptionally useful chronometer in the late Quaternary and provides some of the finest high-resolution archives of marine conditions.

In this interdisciplinary project we propose to investigate key aspects of species specific and ecosystem specific isotope pathways and isotope fractionation. This will focus on deep sea coral-echinoid-fish ecosystems from modern Irish waters. The project will also test the utility of novel isotopes in species specific biomineralisation from a palaeo-oceanographic perspective. Analytically, a combination of modern mass spectrometry (CF-IRMS, ICP-MS, SIMS, TIMS) and imaging (e.g. SEM, synchrontron) techniques will be utilized.

Main aspects of the proposed research include:

- Measurement of biomineralised isotope records from modern deep sea coralechinoid-fish ecosystems in Irish waters.
- Use of culture experiments in which organisms are grown in the presence and absence of specific biochemical inhibitors to investigate biochemical pathways responsible for unpredictable $\delta^{11}B$ and $\delta^{44}Ca$ fractionation in corals and echinoids.
- Development of fossil fish teeth as a U-series chronometer.
- Investigation of $\delta^{11}B$, $\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$, $\delta^{4}4Ca$ fractionation and behaviour of Useries isotopes in echinoids.
- Testing the validity of $^{143}Nd/^{144}Nd$ from fossil fish teeth from the Atlantic sediments as a proxy for ocean circulation during the Palaeocene-Eocene thermal maximum.
- Evaluation of the role of aragonite to calcite transitions in controlling the closed system integrity of coral for U-series dating.

There is one studentship available in this Project and will be based at TCD

Project MOD 5

Numerical modelling of Ocean-Land coupling: Assessing ocean wave energy potential from land based observations

Principal Investigator: **Professor Frederic Dias** (UCD) **–** frederic.dias@ucd.ie
*Collaborators***: Professor Christopher Bean** (UCD); **Koen Verbruggen** (GSI)

Wind, and atmospheric pressure driven ocean gravity waves, generate pressure changes on the seafloor. In turn these pressure fluctuations generate seismic waves, which are recorded on seismological stations across the globe. This “background” seismic noise (microseisms) had traditionally been regarded as a nuisance, however there have been two significant, recent discoveries: (i) for near coastal seismic stations (when calibrated against ocean wave buoys) these microseisms can be used to determine ocean wave heights, and (ii) theoretical and methodological advancements in seismology means that microseisms can now be used as an imagery tool (using “noise correlation” techniques, which have revolutionised seismic imagery over the past 5 years). Transfer functions for ocean wave height to seismic excitation have been derived empirically, and there is now a need for a deeper understanding of how sea bed pressure fluctuations (a) vary in space and time, and (b) couple to the sea floor.

In theory, microseism “noise imagery” requires a uniform distribution of noise sources, a condition not satisfied in the physical world, so a deeper understanding of this limitation is required for real-world applications. In this work we will combine the expertise of the PI and co-PI’s to develop better estimates of spatio-temporal pressure fluctuations on the seabed and consequent microseism noise generation for the near-Atlantic, offshore Ireland, using high resolution bathymetric maps and seafloor properties (co-PI, Verbruggen). The lead-PI has several codes that can be used to compute spatio-temporal pressure fluctuations on the seabed. For example, the WSIM code solves the full Euler equations in the presence of a free surface and arbitrary bathymetry but its computational cost restricts it to a few wave lengths. However, since it is anticipated that nonlinear effects will not play an important role, codes solving the linearized Euler equations could possibly be used over large (100s sq km) areas. These pressure fluctuations will be used as “sources” in seismic wave simulation codes (co-PI, Bean) to propagate these disturbances into on-land synthetic seismic stations5. These recordings will then be used to (i) help develop real ocean wave-to-seismic transfer functions and (ii) look at spatial heterogeneity of seismic noise characteristics and its effects on noise “correlation imagery”. Impacts of this work will be in wave energy potential quantification from land-based seismic stations and in new seismological imagery techniques for sub-surface structure, a prerequisite for other energy related work (geothermal, compressed air energy storage etc).

There is one studentship available in this Project and will be based at UCD

Project MOD 6

A Laplace Transform Integration Scheme for Climate Modelling

Principal Investigator: **Professor Peter Lynch** (UCD) **–** peter.lynch@ucd.ie
*Collaborators***: Dr Tasman Crowe** (UCD); **Ray McGrath** (Met Éireann)

Climate model simulations play a central and crucial role in a wide range of climate change investigations. Simulations consume vast amounts of computational resources. It is very important that we ensure that the numerical schemes used to integrate the equations in these models are accurate and efficient.

Two different approaches are employed to model the advection processes that are of primary importance in atmospheric dynamics: Eulerian and semi-Lagrangian schemes. Most climate models use semi-implicit schemes to circumvent the numerical instability that can arise when long time-steps are used.

However, stability is achieved at a cost: the gravity-wave components are artificially slowed down, introducing a loss of accuracy. Gravity waves are functionally important in a number of climate contexts, for example the Madden-Julian oscillation in the tropics, and the quasi-biennial oscillation (Kelvin waves). Another problem arises when semi-implicit and semi-Lagrangian schemes are combined. Flow over orography can result in a spurious resonance that contaminates the simulation.

The Laplace transform scheme has been shown to solve both of the problems associated with the semi-implicit scheme. The scheme has been tested extensively in a shallow water model.

The Laplace transform scheme was formulated some time ago but the idea was, in certain respects, ahead of its time: application to grid-point models involves a significant computational overhead. The time is now right for application of the technique to climate models.

We now have several leading models that use the spectral technique and the non-hydrostatic equations (for example, the IFS code of ECMWF and the HARMONIE model). In spectral models, the computational overhead in negligible and the Laplace transform scheme is computationally competitive with the semi-implicit scheme but brings significant advantages in terms of accuracy.

Moreover, non-hydrostatic models have a rich spectrum of normal mode solutions, including acoustic waves that require careful numerical treatment. The excellent filtering properties of the Laplace transform scheme make it ideal for these models.

We propose to implement the scheme in two state-of-the art models, the regional model HARMONIE (Google: "Mesoscale model HARMONIE") and the IFS global model code of the European Centre for Medium-Range Weather Forecasts (www.ecmwf.int). The PhD student will work in close collaboration with the climate modelling group in Met Éireann.

The outcome will be a regional and a global model suitable for climate simulations that is efficient and accurate. It will provide guidance on future climate conditions for use in a wide range of applications and across a range of disciplines.

There is one studentship available in this Project and will be based at UCD

Project MOD 7

Storms as future geohazards in Irish coastal environments: a multi-proxy investigation of the Holocene record and the potential ecological impact of future events.

Principal Investigator: **Dr Patrick Orr** (UCD) **–** partrick.orr@ucd.ie
Collaborators: **Dr Peter Haughton** (UCD); **Professor Bruce Osborne** (UCD)

The frequency and magnitude of extreme weather events including storms will increase in the next few decades. Many such extreme storm events (ESEs) in the North Atlantic will make landfall over Ireland. Their impact, exacerbated by rising sea levels, will be particularly severe on costal ecosystems. The effects, in addition to the risk of infrastructure and life, include reconfiguration of hydrodynamic systems (changing the chemistry, quality and/or volume of suficial and groundwater) and modification of biotic community structure, including the nature of emergent vegetation cover; the last may reduce the ability of coastal wetlands to act as natural loci for carbon sequestration. Flooding coupled with soil drying has also been associated with enhanced emissions of nitrous oxide, methane and carbon dioxide. In Ireland (as globally), low lying areas, those most at risk from ESEs, are often major population centres and/or loci for marine-based economic activity.

The historical record of ESEs in Ireland covers the past 150 to 200 years. This is insufficient to assess either the magnitude of, or which areas are most at, risk. This problem is essentially global and, in response, the discipline of "palaetempestology" has emerged in the past decade. Pioneering studies in the 1990s confirmed the potential of the Holocene sedimentary record of western County Mayo, Ireland, as a source of such data but highlighting the difficulties in discriminating between the sedimentary signal resulting from ESEs and other sources (notably Aeolian and fluvial processes). Various sedimentological, geochemical and biological proxies have now been developed to "fingerprint" deposits from ESEs in Holocene (and older) sediments. We propose a multi-disciplinary re-investigation of the potential ESE record preserved in the Mayo sections. Two complimentary strands, each with one PhD student, pool the expertise of researchers from the UCD School of Geological Sciences and the UCD School of Biological and Environmental Sciences and the Geological Survey Ireland.

Stand 1 will integrate data from sampling and analysis of cores into GPS-based topographical models and 3D sub-surface imaging via ground-penetrating radar, led by GSI researchers Michael Sheehy and Ray Scanlon; chronology of events will be determined by absolute dating methods. Analysis of the lithology and microfossil content (systematic palaeontology and taphonomy) of candidate ESEs will be used to identify ESEs. The evolution of the sedimentary system, including the impact of ESEs on its structure is thus reconstructed in a three-dimensional spatial and temporal context. In strand 2, the spatial distribution and relative importance of key ecosystems (salt march, machair, sand dune and grassland) is assessed and laboratory cultured as microcosms, subjected to the simulations of flooding, and their response, including generation of greenhouse gases, monitored. Synthesis between the two strands using 2D and 3D models allows the future bio-sedimentological response of sedimentary systems to climate change to be modeled.

There is one studentship available in this Project and will be based at UCD

Project MOD 8

The impact of climatic and oceanographic changes on geohazards in the Rockall Trough

Principal Investigator: **Dr Patrick Shannon** (UCD) **–** p.shannon@ucd.ie

Collaborators: **Dr Sarah Benetti** (UU)**; Dr Aggeliki Georgiopoulou** (UCD)**; Dr Peter Haughton** (UCD)**; Professor Sebastian Krastel** (Leibniz Institute for Marine Sciences, Kiel, Germany)**; Dr Jonathan Turner** (UCD)

The Rockall Trough, west of Ireland, has the potential to provide a unique understanding of the relationship between geohazards, sediment transport, oceanographic processes and climate change. Submarine landslides are considered a geohazard with tsunamigenic potential. The underlying controls that lead to slope failure, the recurrence interval, localisation, style of failure and resedimentation processes are still poorly understood. Largescale submarine landslides, triggering turbidity currents, occurred ~15 ka in the Rockall Trough, during a phase of deglaciation and rapid climate change.

Project objectives include:

- Determination of failure recurrence interval: Correlation and dating of the failure-induced resedimented deposits (distal turbidites and debrites) shed from the Rockall Trough margins.
- Assessment of climate change impact on slope failure and ocean current-driven sediment transport: Sedimentological, geochemical and geochronological analysis and integration of core and high resolution swath bathymetry and seismic reflection data.
- Geohazard risk analysis: Analysis of links between mode of failure and tsunami genesis; role of pore pressure and sediment type (e.g. weak layers or overpressured sands) in sediment failure; role of climatically-induced sea-level fluctuations in slope instability.

This multidisciplinary project, including seismic stratigraphy, sedimentology, oceanography and geohazard assessment, will be addressed by integration of seismic, bathymetric, backscatter, and core data. 32 piston cores from the Irish sector of the deep Rockall Trough and slope were collected during a research cruise in 2010 led by one of the UCD PIs. Preliminary interpretations suggest that significant coarse sediment was emplaced on the deep basin floor by turbidity and bottom currents. Distinct sources for these sediments have been tentatively identified. Backscatter and shallow seismic data, together with other older shallow cores, are available for this project.

The student will be exposed to: seismic stratigraphic techniques, multibeam and backscatter interpretation, grain-size analyses, physical Multi-Sensor Core Logger, ITRAX geochemical core scanning and micropalaeontological dating. The student will spend time working in UCD and the University of Ulster on the core and multibeam data and the Leibniz Institute of Marine Sciences in Kiel working on the seismic data.

This interdisciplinary project addresses several of the priority research areas. It has the potential to make an international impact on improving understanding of (a) interplay of climate change, submarine slope stability and oceanographic circulation, (b) effects on coral communities at the headwall of the RBMF, (c) geohazard and tsunamigenic assessment and (d) reservoir analogues for hydrocarbon reservoirs, gas storage and carbon sequestration.

There is one studentship available in this Project and will be based at UCD

Project MOD 9

Discrete Element Method (DEM) modelling of the kinematic evolution of submarine landslides

Principal Investigator: **Professor John Walsh** (UCD) **–** john@fag.ucd.ie
Collaborators: **Dr Mike Long** (UCD) **Dr Martin Schopfer** (UCD)**; Koen Verbruggen** (GSI)

Large-scale gravitational collapse is a common mass wasting process in the evolution of the Earth's continental margins, including the European Atlantic margin where numerous large-scale submarine failures have been recognized from the southwest coast of Ireland to northern Norway. One of these events, the Storegga slide, affected an area of 95,000 km^2 (i.e. larger than Ireland) and caused a tsunami which decimated Scottish coastal settlements and extended 80 km inland. Recognizing and understanding these extraordinary submarine landslide events is important because of: (i) the hazards they, and associated large-scale tsunamis, present to people and crucial offshore/onshore infrastructure, (ii) the essential constraints they provide for general landslide processes, and (iii) their close relationship to offshore oil and gas reserves. This project will contribute to each of these issues by performing state-of-the-art numerical modelling of submarine landslide processes, underpinned by excellent observational constraints (3-D seismic and well data, supplemented by mechanical property data) from the Atlantic Margin.

This project will utilize Discrete Element Method (DEM) modelling to investigate the emplacement behaviour of large-scale offshore landslide complexes. DEM simulates the deformation, faulting and fragmentation of rock masses, and is widely used in the mining and geotechnical industries: its application to the geosciences is on the increase and has been pioneered by UCD. The project will be approached in two phases, 2D and 3D (using proprietary software PFC-2D© and PFC-3D©). Key geometric and mechanical variables thought to influence the development of submarine landslides will be systematically examined including: [i] the interrelationship between, and the slopes of, the bathymetry and geological layering; [ii] the impact of erosion or oversteepening adjacent to potential emergent slide surfaces, [iii] mechanical properties and anisotropies of the slide body, [iv] frictional properties of potential slide interfaces, including the effects of pore fluid over-pressure and dynamic friction.

An initial 2D phase will constrain the basic initiation and evolution of submarine landslides for the key variables. The more computationally robust and demanding 3D approach will develop further insight into the initiation and kinematic evolution of submarine landslides by considering lateral (out-of-plane) deformation of the landslide body. Emphasis will be given to a suite of models investigating the impact of key variables on the development and final architecture of natural submarine landslides. An additional set of models will attempt to reproduce the main features of a small selection of submarine landslides defined from the analysis of high quality multibeam, 3D seismic and well data.

There is one studentship available in this Project and will be based at UCD

Project MOD 10

Cleaner Air – A Warmer Europe?

Principal Investigator: **Professor Colin O Dowd** (NUIG) **–** colin.odowd@nuigalway.ie

The European Commission, under the Clean Air For Europe (CAFÉ) initiative and the Thematic Strategy on Air Pollution, aims to reduce excess mortality rates and mitigate against reduced life span across Europe resulting from air pollution. Specific targets are set for air pollution exceedence levels,, reduced mortality rates, and increased life span by 2020. These targets are developed with the best economic cost in mind and through Integrated Assessment Modelling (conducted at IIASA, Austria). While clean air is good for public health, it appears that it is bad for greenhouse-gas warming. It is estimated that aerosol (particulate matter) haze and cloud layers have off-set the greenhouse-gas warming by 50% over the last century and estimates, using a global climate model suggests accelerate rates of global warming to the tune of 0.3-0.4°C per decade over the next 2 decades or so.

We propose to quantify in impact on European scale warming rates, with particular focus on Ireland, of current air pollution targets. The climate scenario will be 2020 and it will be evaluate using the REgional MOdel with Tracer Extension (REMORE). REMOTE is a regional climate model based on the global climate model ECHAM4 and further developed to include atmospheric composition. Specifically, it contains an updated version of the atmospheric chemistry module RADM2 with 163 chemical reactions in the gas phase including a wide range of hydrocarbon degradation reactions, aqueous phase chemical reactions, aerosol-cloud microphysics interactions, advanced aerosol formation, transformation and dynamics (M7 – seven mode modal model capable of handling natural and anthropogenic, primary and secondary aerosol species). In nutshell, this is the state of the art regional climate model with atmospheric composition and has been developed over the last six years in NUIG (following the licensing of the basic bulk model from MPIMeteorology).

The PhD programme will implement new emission scenarios based on emission inventories, associated to particular economic storey lines, from both IIASA and TNO-MEP. The impact of cleaner air over Europe on European-scale temperature increases will evaluated using REMOTE at the 0.25° grid scale. Boundary conditions will come from the global ECHAM5 model. This work is, in principal, interdisciplinary, cutting across economics, transport, industrial development, health, physics, chemistry etc., and compliments thematic areas such as renewable energies and could be adjusted to be more interdisciplinary in practice.

There is one studentship available in this Project and will be based at NUIG