UNIVERSITÀ
DEGLI STUDI DI TRIESTE

Rettorato e Direzione Generale
Sezione Ricerca e Dottorati
Ripartizione Dottorati

LAST REVISED 30 gennaio 2014

DOCTORAL PROGRAMME IN EARTH SCIENCE AND FLUID MECHANICS

NOTE: This attachment provides only partial information. Exhaustive information, including how to register for the selection, is published in the Admission Announcement posted in the web page http://www2.units.it/dottorati/ >> Admission Announcement

Deadline for online application	**12th February 2014 h.11:30 a.m. CET**

PROGRAMME CODES AND DETAILS

SUBJECT AREA:
- main area: 04
- other areas: 01; 08; 02; 09

MACRO RESEARCH FIELDS:
- main area: 04/A
- other areas: 08/A; 02/A; 09/A

SCIENTIFIC DISCIPLINARY SECTOR:
- main area: ICAR/01
- other areas: GEO/02; GEO/03; GEO/04; GEO/05; GEO/06; GEO/07; GEO/08; GEO/10; GEO/11; GEO/12; ING-IND/06; MAT/05; MAT/07; MAT/08; FIS/06; GEO/01

DOMAIN EUROPEAN RESEARCH COUNCIL:
- PE

ERC PANELS:
- main area: PE10
- other areas: PE1; PE8

Information on the codes can be found online at the address: http://www.units.it >> Research >> Doctorates >> Admission >> Admission Announcement and relative attachments - Board of Examiners - Eligible Candidates/Merit list>> Research codes

RESEARCH FIELDS:
1. Environmental fluid mechanics, fluid mechanics in industrial and technological processes, and in biological systems
2. Solid and fluid earth geophysics and geology
3. Mathematical methods and modeling in fluid mechanics and in geophysics, differential equations and inverse problems

LOCATION: Trieste
- ORGANIZING DEPARTMENT: Dip. di Matematica e Geoscienze

OTHER DEPARTMENTS: Dipartimento di Ingegneria e Architettura

NON-ACCREDITED PARTICIPATING INSTITUTIONS:
- Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS)
- International Centre of Theoretical Physics (ICTP)

Legge 241/1990 - Responsabile del procedimento: Elena Ferraro

DURATION: 3 anni
OFFICIAL LANGUAGE: inglese

ADMISSION INFORMATION

TOTAL NUMBER OF PLACES AVAILABLE:..**1**

RESEARCH GRANT:

- [cod D/8] funded by the Dipartimento di Ingegneria e Architettura with resources provided by the **"SEDITRANS" Sediment transport in fluvial, estuarine and coastal environment** Programme (Grant agreement no: 607394 - Call identifier: FP7-PEOPLE-2013-ITN - Implementation mode: Multi-ITN) within FP7..1

  Title of the research project: Large Eddy Simulation modeling for real-scale suspended sediment transport in river and estuarine flows

  Full description of the project

  The present project is focused on modelization of suspended sediment transport in Large eddy simulation of estuarine and river flows. In the project the student will implement literature models for suspended sediment transport in large eddy simulation tools available at the laboratory of Environmental and Industrial Fluid Mechanics of the University of Trieste. The models will be first tested in application at low Reynolds number, and successively further developed to operate in simulations at large values of Re, where the wall-modelling approach is used. Finally, in cooperation with the research group of EPFL, the model will be calibrated and used for the study of a specific case of relevance in river hydraulics

  Scientific Disciplinary Sector/ i.e. subject area: ICAR/01

  Scientific Director/Supervisor: Prof. Vincenzo Armenio

  Duration of the grant:36 months

  The grant is paid monthly for a total annual amount of € 44,734.65 if the grant holder is married, otherwise it amounts to € 41,513.76, gross of national insurance contributions to be paid by the grant holder, and it covers mobility expenses.

  NOTE: applicants have to comply with EU Marie Curie actions requirements, namely:

  1 at the deadline date for applications candidates must prove that they have not spent more than twelve months in Italy either as residents or for work or study reasons in the previous three years;

  2 candidates must have carried out research activity on a full-time basis or equivalent within four years after degree conferment.

ACADEMIC QUALIFICATION REQUIRED: see Announcement (art. 2 – Requirements)

1 Italian Master's Degree "Laurea Specialistica/Magistrale" or Degree awarded prior to approval of Ministerial Decree D.M. n. 509 of 3 Novembre 1999, updated with D.M. n. 270 of 22 October 2004, n. 270, (or a qualification corresponding to a Master's -second level- degree);

2. an equivalent foreign academic qualification awarded abroad;

3 an academic qualification awarded abroad which is considered to be equivalent to the Italian degree that allows the holder to undertake Ph.D. studies for duration, level and area of study.

DEADLINE FOR COMPLETION OF DEGREE: see what is foreseen above (point 2 specifying EU Marie Curie actions requirements)

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ASSESSMENT CRITERIA: qualifications (project included)

- MAXIMUM FINAL SCORE (the final score is based on the sum total of marks obtained in the interview plus the points given for qualifications and publications):..........100/100
  MINIMUM FINAL SCORE REQUIRED:..70/100
  WEIGHTING OF THE QUALIFICATIONS:
  "Integration to application" (unless this form is presented, qualifications and publications CANNOT be assessed by the Examining Board):
  a. a detailed curriculum vitae et studiorum: 30/100
  b. full copy or abstract of the MA thesis in Italian or English (Italian MA theses may be from "Laurea vecchio ordinamento" or "Laurea specialistica/magistrale"): 40/100
  c. Submit the research project using the form that can be downloaded from the following link http://www.units.it >> Ricerca >> Research Doctorate >> Admission Procedure >> Application Forms >>Research Project (Doctoral Courses in Neural and cognitive sciences and Earth Science and Fluid Mechanics): 30/100
     Project assessment shall take into account:
     1 the value of the Research Project in relation to set objectives
     2 the quality of the Research Project with specific attention to adopted methodology and chronogram of activities

  DEADLINE FOR SUBMITTING QUALIFICATIONS AND PUBLICATIONS AND PROJECT :.. 12/02/2014
  QUALIFICATIONS AND PUBLICATIONS MAY BE SUBMITTED (art. 5.1.4 of the Ph.D. Announcement):
  - as an attachment to the online admission application (upload)
  - only for publications that are voluminous or not available in electronic format, as long as they are listed in the form "Integration to application" (digital format preferable): : Send a zip file to: eifm.adm@units.it by the 12/02/2014

  NOTE: reference letters only must be emailed directly by the signer to: eifm.adm@units.it
  subject: Letter concerning: Surname Name
  Emails must be received by and no later than midnight (Italian time) of 12 February 2014

CEFR LEVEL: B2

GENERAL INFORMATION

CHAIR: Prof. Vincenzo Armenio - Dipartimento di Ingegneria civile e architettura - Università degli Studi di Trieste - tel. 040/5583472 fax 040/572082 e-mail armenio@dica.units.it

VICE: Prof. Pierpaolo Omari – Dipartimento di Matematica e Informatica – Università degli Studi di Trieste – tel. 040/5582619 - e-mail omari@univ.trieste.it

WEB SITE: http://phdfluidmechanics.appspot.com/

EDUCATIONAL AIMS Earth sciences and fluid mechanics form a set of disciplines that, while presenting independent aspects and issues, intersect and interface in a very large class of problems.

The earth sciences study the structure, the physical and the chemical properties and the evolution of our planet, with instruments ranging from direct surveys on the ground and in the laboratory to the most advanced methods in the field of remote sensing, geophysics, petrophysics and geochemistry. By studying the current conditions, facing the reconstruction of complex processes, such as crustal deformations or migration of fluids within the solid matrix of rocks and sediments, with important implications in the field of resources and the prevention of natural hazards.

The methods used include advanced techniques of non-invasive diagnostics based on natural fields (potential methods) or on the propagation of electromagnetic or seismic waves, spectroscopic techniques for the study of geological materials, numerical modeling techniques for the reconstruction and the study of evolutionary models of the subsurface and the surface of our planet.

Important implications of these studies can also be found in recent developments in terms of climate. Over a large part of these issues there are important connections with the field of fluid mechanics, particularly in the area of fluid geo-resources (water, oil) and contamination.

Fluid mechanics studies the properties and the behavior of fluids, that is, liquids, gases, plasmas, and more generally of substances whose molecules have no fixed positions in space but can move relative to each other with different relative speeds. It involves physical phenomena of relevant complexity and has a broad range of applications. Most environmental systems involve the dynamics of water and gases that is described in terms of fluid mechanics, such as, e.g., diffusion of pollutants, or issues of marine and atmospheric meteorology. Similarly, biological systems are regulated by transport and dispersion of elements or species in water, air, and blood. Many industrial problems are concerned with fluid processes: for instance in transportation applications, or in processes where chemical-fluid dynamic interaction is expected.

The fundamental laws upon which this discipline is based are generally expressed by partial differential equations, often nonlinear and highly complex: their study requires the application of various methods of advanced mathematics and is a research field of high theoretical and practical relevance. Mathematics appears therefore to be a tool of fundamental importance for the study of these disciplines.

In turn, the study of issues related to earth sciences and fluid mechanics poses new problems, opens up new perspectives and provides incentive and opportunity for the development of new methods of research in mathematics, with particular emphasis to modeling issues, qualitative aspects of the theory of differential equations, numerical and computational methods for their quantitative treatment.

The Doctorate School in Earth Science and Fluid Mechanics (hereinafter referred to as ESFM) is aimed at the advanced training of students in the field of fluid mechanics, applied mathematics and earth sciences, with particular reference to the topics described above. It promotes the theoretical and applicative formation of students, through the investigation of scientific themes developed in the research groups belonging to the departments involved in the PhD and through international collaborations that provide the possibility to attend some training projects at qualified research facilities abroad.

With regard to fluid mechanics, the processes that involve the study of the motion of fluids and their transport properties, dispersion and mixing in environmental and industrial settings, are addressed in particular, as well as their interaction with the solid elements. Topics of thermodynamics and microphysics on a large scale are also studied.

In the field of earth sciences, the main objective is the transfer of knowledge on advanced methods of investigation with applications to the study of composition, structure, stratigraphy and evolution of our planet, from the close surface up to the deep structures and to the characteristics at the global scale. The techniques of analysis, modeling and inversion of geophysical data are an important part of the program and integrate with the tools of direct investigation and laboratory in the fields of geochemistry, geology and geomorphology, petrophysics and mineralogy / petrology.

The study of mathematical models of interest for fluid mechanics and earth sciences, both from the theoretical and the computational point of view, is a relevant part of the program as well.

The PhD course EFSM represents the evolution and the expansion of an existing center of excellence at the University of Trieste, the Doctoral School Environmental and Industrial Fluid Mechanics (hereinafter referred to as EIFM), which, for years, has been evaluated as a class A school, with regard to quality and internationalization. The extension of the doctoral program represents a completion and an enhancement of the previous structure, both in terms of subjects, and of personnel involved. Strengths of this PhD program are: the interdisciplinary nature of the scientific program and the presence in the academic board of mathematicians, physicists, geologists and engineers, with a high scientific profile, who operate in complete synergy in the understanding of physical problems and in the knowledge of mathematical and computational models; the presence of three institutions interacting with each other, the University of Trieste (hereinafter referred to as Units), the International Centre of Theoretical Physics (hereinafter referred to as ICTP) and the National Institute of Oceanography and Geophysics (hereinafter referred to as OGS), (among these institutions a formal cooperation agreement, approved by Units on 03.26.2013, was signed); the collaborations with foreign research institutions, the creation of a strong link between national and international research institutions and companies operating in the city of Trieste, in Friuli-Venezia Giulia and in the region Alpe-Adria; the absence in the region of doctoral programs that address similar issues.

The program aims to prepare students to pursue different careers in research,

teaching and in the industrial use of high technologies in the above mentioned areas. The final dissertation must be original, must represent the state of the art in the chosen field and should contain material for the publication of scientific papers in international journals of the field included in the ISI or SCOPUS catalog. The students will be in contact with several local and international environments and gain a considerable experience in both theoretical and applied problems of earth scences and fluid mechanics. In addition, the students will develop familiarity and competence in the use of more advanced tools (both modeling and experimental) for the analysis of complex physical systems, which will be of great use for future activities in public or private research centers or for any work in companies with high technological content.
All students must follow a program of courses in order to achieve good skills in the chosen research field. In particular "core courses" and "research-based courses" are offered. The core courses must provide the tools for understanding the physical phenomena involved and will focus on topics of mathematics and fluid mechanics or geophysics. The research-oriented courses will include research-based geophysics, geophysical fluid dynamics, physics and modeling of turbulence, physical oceanography, dynamics of the lower atmosphere, advanced mathematical methods for the study of qualitative properties of nonlinear differential equations of interest in fluid mechanics and geophysics. There will also be periodic seminars delivered by experts, to which students are expected to attend. The seminars will be organized in three periods. The seminars of the first period (January-April) will be handled by teachers of Units and will be held at the University; seminars in the second period (May-August) will be handled by OGS and will be kept there, the seminars of the third period (September-December) will be handled by ICTP and kept there. This will make it possible for students to attend on a monthly basis seminars held by researchers from different scientific communities, in which problems of earth sciences, mathematics and fluid dynamics are addressed and solved using different and complementary approaches and points of view.
The following lines of research are proposed as a possible topic of doctoral thesis

<u>Sediment transport and deposition in oceanic glacial environment</u>

Sediment transport from land masses to the marine and lacustrine environment occurs through a variety of processes of interaction between the atmosphere, the hydrosphere, and the cryosphere.
Oceanic sedimentation is relevant to society because the bottom of the oceans is becoming used for seabed installation, deployment of cables and pipelines, and foundations and anchors of platforms. Understanding of the mechanisms of accumulation and erosion of seabed sediments is vital to the correct planning and safety of such infrastructures. In particular, sediment mass transport represents the most important threats, not only for manufacts, but also for coastal settlements, because submarine landslides may cause tsunamis.

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Due to the increasing antropization of arctic regions, including the Arctic ocean, and the prospects for offshore economic activity, sediment transport via ice streams on polar continental shelves, and deposition on continental slopes need to be addressed with the same level of detail as the low-latitude sedimentary systems included in the deep sea fan sedimentary system models.

Depending on the projects associated with the study program, students will have an opportunity to experience data collection, data analysis in the laboratory, and perform modeling of sediment transport in the marine environment combining oceanographic and glaciological data contributing the development of novel sedimentary models for polar continental margins.

Underground fluid injection

A sustainable development requires developing technologies for a safer use and storage of energy, while protecting our environment. Underground fluid injection includes some key applications:

- permanent CO2 storage in geological formations;
- temporary methane gas storage for a seasonal duration;
- injection of brine to enhance the oil and gas production;
- geothermal production of power from hot deep rocks.

These applications require integrating time-lapse geophysical surveys and reservoir simulation, allowing for multi-phase fluids and time-varying permeability, geomechanical link of fluid pressure and rock strength via the induced microseismicity, geological and geochemical constraints, and advanced 3D modelling and imaging of seismic data.

Fluids in marine sediments

Different types of fluid and gas escape-related features and associated seismic anomalies(i.e. pockmarks, mud volcanoes, carbonate mounds, Bottom Simulating reflectors, etc.) have been identified in various sedimentary basins around the world. Seep occurrence and distribution is mostly controlled by vertical and lateral changes in sediment properties, whereas their morphological expression on the sea bed is conditioned by flux rates and concentration, sediment type, oceanographic conditions. Under particular conditions the migration of shallow gas through marine sediments can cause the precipitation of methane-derived calcium carbonate. An additional, fundamental role in the control of natural fluid migration within sedimentary sequences is that of gas hydrates and their stability through time in response to changing pressure and temperature conditions.

Students involved in this research topic will have the opportunity to analyze several types of geophysical data in order to identify and to characterize fluid/gas occurrence within the sediments and their migration ways to the surface, recognizing the seismic features related to gas presence. In addition, the research topic will include an introduction about the theoretical models that describe the seismic velocity versus gas content in marine sediments in order to analyze the geophysical data from different points of view.

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Microseismicity recognition and analysis in underground gas storage and geothermal exploitation activities

A number of human activities may cause earthquakes either induced by the activity itself or by activating pre-existing faults. These activities include for instance mining, dams, oil exploration and extraction, geothermal energy exploitation, or underground gas storage. Monitoring the microseismicity level down to very low magnitude values (i.e . between 0 and 1) has been recently acknowledged as a fundamental element for verifying the ongoing activity and preventing dangerous earthquakes.

OGS is committed in seismic monitoring of underground gas storage (for instance the Collalto Seismic Network, web: rete-collalto.crs.OGS.it, is the first italian seismic network built up under strong government prescriptions) and geothermal exploitation, therefore it has both the technological/scientific background and, more important, a wide dataset to support a research project in this topic.

Microseismicity records typically display a very low signal-to-noise ratio, and methods for the recognition of very weak events, their localization and the estimation of other attributes (e. g. magnitude, focal mechanism, …) need to improve the standards usually adopted for traditional networks. Therefore, there is a need of improving the technology of the seismic monitoring system –this includes: seismic network, communication systems, acquisition and processing of seismological data- as well as of developing new processing methods for the analysis of microseismic signals and improving the knowledge of the processes linking microseismicity to induced stresses and fluid transport.

We propose the following research lines:

- new methods for microseismic signal analysis, based on computationally intensive signal/noise separation techniques.
- Improving methods for automatic recognition and analysis of weak events, as for instance array processing. In this respect we include also possible improvements of the seismic network technology.
- studying the reciprocal relationships and space-time correlation between microseismicity and fluid pressure/transport within the reservoir.

Lagrangian studies in marine ecosystems

The development of numerical models able to evaluate responses of marine ecosystems to the surrounding environment, also considering adaptive and evolutive features, is fundamental to derive a more realistic assessment of the short-term and long-term effects of natural and anthropogenic forcings and of effectiveness of management policy. Many marine organisms can be represented, in first approximation, as mutually interacting particles moving in a fluid which, depending on the organisms' size, has viscous or turbulent characteristics. However, to follow the spatial-temporal evolution of a great number of organisms that mutually interact and evolve in time (lagrangian paradigm) still poses a technological, computational and scientific challenge.

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High-performance computing and innovative algorithms able to exploit the cutting-edge computing infrastructures represent a powerful approach to solve such a challenge, allowing researchers to look for innovative parameterizations of marine ecosystem.

Development of coupled models for biogeochemistry studies in Mediterranean Sea

Biogeochemistry modelling for the Mediterranean Sea at OGS has mainly adopted an off-line coupling strategy with an ocean general circulation model (OGCM), using, for different international and national projects, physical forcings (temperature, salinity, short-wave radiation, current velocity) provided by external partners. Aim of the present research theme is to adapt the OGCM MITgcm model to the Mediterranean Sea and then develop the coupling with the biogeochemical model BFM in order to obtain a new numerical tool to be used both for operational and climatic studies.

Multiscale analysis of ocean dynamics

Using in-situ observations from mobile autonomous platforms such as drifters, floats and gliders in concert with remote sensing data (HF radars, satellite images, etc.) we are exploring and studying the ocean dynamics at several scales, from the inertial/tidals currents, the mesoscale variability of the upper ocean, and the circulation and trends in water mass properties over decades, both in the open ocean/sea and in coastal environments. Some of these activities are related to fundamental oceanographic and climate research, others are connected to practical applications such as the monitoring of pollutant dispersion (in particular the observations of oil spills) and search-and-rescue operations.

Long-term variability of the Mediterranean circulation belt

From both in situ and satellite observations climatic variability of the Mediterranean circulation will be studied. Different sub-basins will be studied separately or from the point of view of their possible interaction and feedback. Possible impact of atmospheric and climatic conditions in shaping the Mediterranean circulation belt will be considered. Special attention will be paid to transient events on decadal or centennial scales (EMT, WMT).

Non-linear differential equations to model fluid injection for hydraulic fracturing

Unconventional resources such as oil and gas, extracted from shales, started to be rentable after the use of stimulation techniques that increase the formation permeability. The so-called “fracking” or hydraulic fracture stimulation is based on high-pressure fluid injections in boreholes to generate fractures and microcracks. The related induced seismicity can be used to locate these high permeable flow paths and obtain the permeability tensor. The whole process requires the understanding of how the pressure field around the well evolves with the injection rate and how permeability is modified as a function of pressure. This leads to non-linear differential equation for the pressure. The physics of fluid diffusion in anisotropic porous media is based on Biot’s theory of

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poroelasticity. Diffusion and elastic strain can be uncoupled fully, being a good approximation in many situations. In the linear case, we simulate the diffusion in inhomogeneous media using a time-domain spectral explicit scheme and pseudospectral methods to compute the spatial derivatives. Moreover, a realistic situation can be achieved with a fractional derivative, replacing the first-order time derivative in the classical diffusion equation. It implies a time-dependent permeability tensor having a power-law time dependence, which describes memory effects and accounts for anomalous diffusion. After the pressure field is established, microseismic field are emitted and recorded at the surface and nearby wells. The emission time depend on the type of source, i.e., tensile and shear, and the data processing on the basis of the pressure solution can give information about the fractured zone and magnitude of the permeability (tensor) components of the shale. The same technique can be applied to CO_2 monitoring problems related to storage in depleted reservoirs.

Earthquake Mechanics and continental tectonics

Earthquake cycle and continental tectonics studies exploit techniques in seismology, geodesy, remote sensing, tectonics and numerical modeling. These techniques are all needed, and none is sufficient on its own, for a realistic quantification of the earthquake hazard.

We invite applicants who are interested in using or integrating these techniques to study all the stages in the earthquake cycle (coseismic, preseismic, postseismic, and interseismic) and all the scales of active continental deformation ranging from the temporal and spatial variability of slip rates in individual earthquake fault zones to the kinematics and dynamics of vast continental regions. Studies that assess the mechanical properties of faults and the rheology of the lower crust and lithospheric mantle are encouraged. Assessing these properties is one of the current challenges in the dynamics of the continents, because they control the temporal and spatial distribution of surface strain at all length and time scales.

Capillary surfaces

In fluid mechanics capillarity is the ability of a liquid to flow in narrow spaces without the assistance of, or in opposition to, external forces. It occurs because of inter-molecular attractive forces between the liquid and the solid surrounding surfaces. More in general, capillarity is the set of phenomena due to interactions between the molecules of a fluid and of another material, which can be a solid, a liquid or a gas, on their separation surface (interface), said capillarity surface. From the mathematical point of view these phenomena are governed by highly nonlinear partial differential equations, which exhibit various peculiarities: the possible lack of existence or uniqueness of solutions, their general lack of regularity, their possible discontinuous dependence on boundary data, the possible breaking of symmetry. The study of these equations, which involve the mean curvature operator, is a classical subject, but still of great actuality, due to the large number of open problems, having a great interest even from the point

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of view of applications. Their analysis requires the use of sophisticated tools of advanced mathematics: geometric measure theory, variational methods in spaces of functions of bounded variation, non-smooth analysis techniques, combined with other typical tools of nonlinear analysis (critical points theory, topological degree, bifurcation methods).

The proposed research concerns the study of the existence, the multiplicity, and the qualitative properties (such as regularity and stability) of solutions of the capillarity equations, on bounded or unbounded domains, which appear as sub-critical points (not necessarily minimizers) of the functional representing the mechanical energy of the system.

Navier-Stokes equation

One important mathematical model for the motion of a viscous fluid is the so called Navier-Stokes equation. Starting from the pioneering work of J. Leray in the 30's of the last century, the study of the N.-S. equation has become one of the central subjects in the theory of partial differential equations and it has been attacked with the more sophisticated tools of the functional analysis. Nevertheless the theory of N.-S. equation is far to be completely understood and this is suggestively confirmed by the inclusion of this problem in the set of the "millennium problems" proposed by the Clay Mathematical Institute in the year 2000.

Some important tools in the study of N.-S. equation are related to Fourier analysis and more generally to the theory of pseudo and para-differential equations, and to harmonic analysis. In this setting, making use of the concept of generalized solutions (weak, mild, strong, etc.) which are element of more and more precise functional spaces (Sobolev, Besov, BMO etc.), many interesting results has been recently obtained.

The proposed research concerns existence and uniqueness for mild solutions to the N.-S. equation in various different situations e.g. in domains with boundaries, in infinite domains, with non isotropic viscosity, in presence of the action of the Coriolis force, when initial data are given in Besov spaces of negative index or in BMO spaces or which are fast oscillating.

Inverse problems in geophysiscs and fluid dynamics

The inverse gravimetric problem consists in detecting the earth's mass density, or its inhomogeneities, from measurements of its gravitational field. From a pure mathematical point of view, it is nothing else than the inverse problem for Newtonian potential, which is a well-known underdetermined ill-posed problem. For the purpose of this application, a relevant issue is to take into account machanical constraints and additional geophysical information (known for the earth's structure) in order to reduce, or possibly eliminate, the underdetermination of the inverse problem.

Recent results of stability in the determination of immersed bodies in stationary fluids are available. Such techniques can be extended to non-stationary models for the determination of immersed bodies or unaccessible river beds, from

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measurements taken on the fluid's surface.

The dynamics of blood's circulation has been extensively developed, from the modeling and the computational points of view. Various questions arise in the identification of parameters, not directly accessible to measurements, for which the inverse problems methods may provide a solution.

Numerical climate models with time delays

Some global climate processes can be modeled by partial differential equations with time delays. Wanting to study the evolution of the average temperature observed in a given place and over a certain period around a given time, we obtain a reaction diffusion equation by using an energy balance and a diffusion model for the horizontal flow of heat on the earth's surface. However, this equation must be taken into account the extension of the continental ice-shields, whose expansion or recession depends from the history of the average temperature over tens of thousands of years. This explains the presence of time delays in the model. The numerical solution of such a problem of evolution involves substantial additional difficulties, compared to the numerical solution of a classical partial differential equation, since the solution to be computed at a given time instant depends on the solution already computed at previous time instants. All this makes non-trivial the development, the analysis and the implementation of numerical methods.

Development and application of state-of-art models for the analysis of turbulence in fluids.

Analytic solutions of the Navier-Stokes equations (NSE) cannot be obtained but in simple idealized cases, where they can be linearized. In more general cases, where non linear effects lead to turbulence, numerical simulations are suited for the solution of the NSE. Within the present Ph.D. program, numerical techniques for the direct numerical simulations (DNS) and large eddy simulations (LES) of turbulent field are developed and applied to cases where turbulent mixing plays an important role. Specifically this regards problems of natural (Rayleigh-Benard) as well as forced convection, problems of stable stratification (either in confined or in open environments) problems of aeroelasticity for civil and industrial engineering, problems of external aerodynamics in incompressible regime, and problems of river and coastal hydraulics.

Development and application of state-of-art models for inter-facial problems

The interdisciplinary character of the present Ph.D program introduces a new class of problems being central to the project itself. Specifically, the skills and knowledge of solid earth mechanics from one side and fluid mechanics from the other side are here integrated to study new classes of problems characterized by a strong interdependence between the solid phase and the fluid phase. This requires the development and the application of novel inter-facial techniques able to connect the equations governing the solid phase dynamics with those governing the fluid phase, through the proper implementation of boundary

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conditions. This concerns exchange of momentum, mass and heat between the tho phases. Moreover the interdisciplinary competences allow the analysis of transport and contamination of fluids in porous media, as well as the study of geothermal processes as well as erosion processes.

Development and test of analysis, processing and inversion methods for Ground Penetrating Radar data with application to high-resolution studies

Ground Penetrating Radar (GPR) is the geophysical technique that provides the highest resolution about near surface structure and characteristics (approx. z≤50 m). In the framework of the PhD course, students will work with state-of-art hardware and software tools at the development, test and application of original methods for GPR data acquisition, processing and inversion, with particular reference to multi-fold techniques.

Development and test of analysis, processing and inversion methods for reflection seismic data with application to crustal studies

Reflection seismics is the highest resolution geophysical tool for the exploration of the Earth's Crust. Seismic attributes, AVO analysis, full waveform inversion, seismic interferometry are some of the research topics that will lead to the enhancement of our subsurface knowledge, with application to sectors ranging from the identification and extraction of natural resources to the study and the prevention of natural hazards. Students will develop and test original methods with applications to the study of complex seismic datasets.

Development and test of analysis, processing and inversion methods with application to non-destructive testing

Geophysical methods share the same physical and mathematical basis of several non-destructive testing (NDT) methods. Nonetheless, challenging NDT problems can greatly benefit from the application of advanced geophysical tools, in the experimental (measurement) phase and in data analysis and inversion, with specific reference to ultra-sonic surface and body waves. Students will work in cooperation with advanced industrial labs at the implementation and test of innovative measurement and analysis methods.

Basin geophysical studies in the Mediterranean and Antarctic areas

Ultimate goal of the research activity on such subject is the comprehension of structure, stratigraphy and evolution of the Earth's Crust at basin scale. Students will learn how to analyze large amounts of geophysical data to gain insight into geological conditions at depths reaching the Moho discontinuity. Advanced interpretation methods will be further exploited to understand geological processes leading to the present stratigraphic and structural conditions.

Geophysical exploration for geothermal energy

In the framework of the PhD course on Geothermal Energy, the students will perform research activities in the field of geophysical exploration, assessment and monitoring of geothermal resources, with specific reference to seismic and magnetotelluric methods for the identification of reservoirs and for the non-invasive pre-drilling characterization of geothermal systems.

Ultra high-resolution geophysical studies of reservoir analogues

Reservoir analogues offer a unique opportunity to study the characteristics of deep reservoirs in a controlled and calibrated environment. The students will work on selected test sites with integrated geophysical methods (basically seismics and GPR) to gain new knowledge about key subsurface features of crucial interest for the exploitation of georesources, such as water, heat, hydrocarbons

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