Università di Genova | **DICCA** Ph.D. PROGRAM IN CIVIL, CHEMICAL AND ENVIRONMENTAL ENGINEERING

PhD Program in Civil, Chemical and Environmental Engineering
Curriculum in Fluid Dynamics and Environmental Engineering

June 2025 Call, XLI cycle - Starting date: November 1 st 2025

The research projects submitted for the admission to the PhD program must be prepared in accordance with one of the projects listed in this file, which are organized by general thematics. Click on the Thematic you are interested in to see the full list of projects.

Ph.D. Program in Civil, Chemical and Environmental Engineering
dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it

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Projects in Fundamentals of Fluid Mechanics

Project: Macroscopic modelling of nanofiltration flows

Link to first page

Ph.D. Program in Civil, Chemical and Environmental Engineering
dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it

***Thematic*: Fundamentals of Fluid Mechanics**

Project: Macroscopic modelling of nanofiltration flows

Keywords: porous membranes, nanoscopic filtration, homogenization, molecular dynamics

Brief Description: With nanofiltration flows, we refer to the transport of a fluid through porous structures (membranes) with pore diameters on the order of a few nanometers or less. These flows are critical to a wide range of advanced technologies, including water purification, desalination, osmotic power generation, and targeted drug delivery.

Traditionally, progress in these fields has been driven by trial-and-error procedures. However, predictive modeling of nanoscale flows holds the potential to enable systematic and formal design processes. At such small scales, classical hydrodynamics, based on the Navier-Stokes equations, can qualitatively capture flow behavior at the membrane scale, but lacks quantitative accuracy1. Conversely, kinetic theory and molecular dynamics simulations can provide quantitatively accurate descriptions of flow through individual membrane pores, but are computationally unfeasible for simulating entire membrane systems.

The objective of this project is to establish a formal link between these two approaches and develop a predictive model for nanofiltration flows. To achieve this, a two-step procedure is proposed. First, a novel unified continuum model is derived to describe confined nanoscale flows. In the second step, this model is upscaled to the membrane scale.

The primary technical tool to achieve this purpose consists of a multi-scale homogenization technique extended to treat the different physics at play, from the smallest to the largest scale of the problem[2].

Referent: Giuseppe Zampogna, giuseppe.zampogna@unige.it

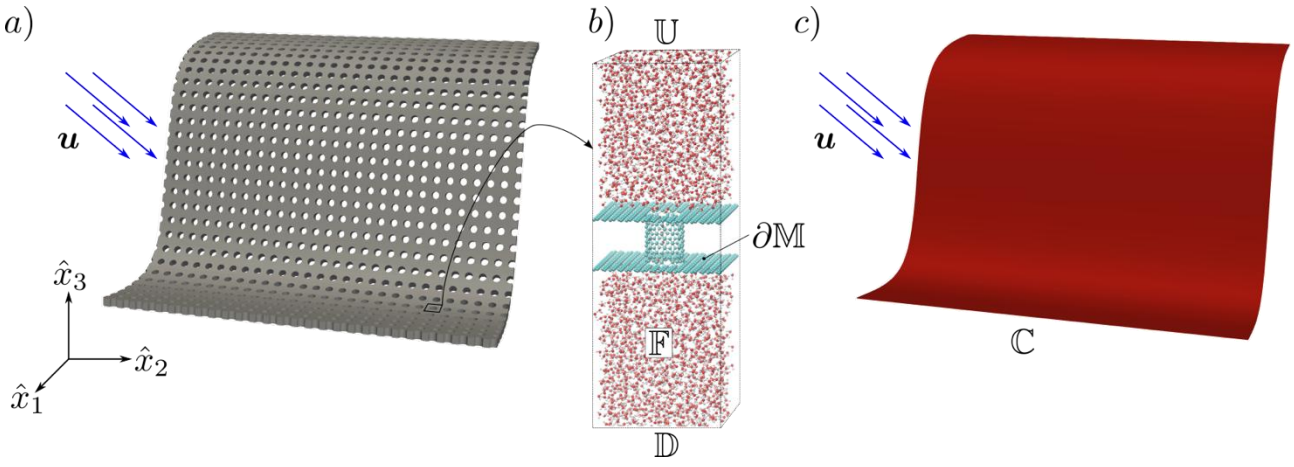

Figure: Typical homogenization workflow. a) Fluid flow across a membrane modeled with nanoscopic details. c) Macroscopic flow description, where the membrane is replaced by a smooth, homogeneous surface. b) Zoom in on a microscopic elementary cell, the fundamental working unit used in homogenization to transition from (a) to (c).

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dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it

References:

1. **Kavokine, N., Netz, R., Bocquet, L. 2021, Annual Review of Fluid Mechanics, 53:377-410.**
2. **Zampogna, G.A., Ledda, P.G., Wittkowski, K., Gallaire, F. 2023, Journal of Fluid Mechanics, 970:A39.**

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Ph.D. Program in Civil, Chemical and Environmental Engineering
dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it

Projects in Environmental Fluid dynamics, morphodynamics and climate changes

Link to first page

Ph.D. Program in Civil, Chemical and Environmental Engineering
dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it

***Thematic*: Projects in Environmental Fluid dynamics, morphodynamics and climate changes**

Project: Coastal Flooding hazard under present conditions and in the framework of future climate change

Keywords: Coastal flooding; Wave storm; Extreme levels; Climate Change

Brief Description:

Coastal erosion and coastal flooding are the main hazards for the management of the coastal zone and could pose many disruptions to different human production activities. A detailed knowledge of the processes and on the intensity of the phenomenon is crucial to provide managing authorities and institutions, and economic stakeholders, the necessary information and scenarios for decision making and policies development. The research projects will develop a methodological approach suitable for the definition and estimation of extreme levels of coastal flooding due to different physical processes such as wave run-up and set-up, storm surge and long-term sea-level variation due to climate change. The research activities will consist in developing a suitable numerical model suite for the description of wave storms in the coastal region, giving insight into wave run-up and set-up processes, the characterization of storm surge levels and the use of sea level variation projections under different Shared Socioeconomic Pathways (SSPs) for mid and end of the century (2050 & 2100). After developing a wide dataset of metocean forcings the analysis of flooding processes will be carried out through the employment of process based numerical models, having as the final objective of the project the evaluation of return levels for coastal inundation areas along the coastline of the Mediterranean Sea with specific attention to hot spots with respect to coastal infrastructures, lowlands and populated areas.

Referent: Giovanni Besio, giovanni.besio@unige.it

Relevant links: meteocean.science

Link to the list of projects

Università di Genova | **DICCA** Ph.D. PROGRAM IN CIVIL, CHEMICAL AND ENVIRONMENTAL ENGINEERING

***Thematic*: Environmental Fluid Dynamics, Morphodynamics and Climate Changes**

Project: Machine Learning for MeteOcean applications: clustering of sea storm data

Keywords: Big Data Analysis, MeteOcean, Climate analysis

Brief Description:
The characterization of MeteOcean forcings is crucial for the analysis of different applications in the offshore and coastal region like the design of infrastructures, the evolution of accretion/erosion in the coastal region or the analysis of the fate of contaminants in the coastal region and in the open ocean. The PhD project has the scope to develop an algorithm for a statistical analysis of historical data concerning metocean variables (waves, wind, pressure, sea level, currents) dedicated to the extraction of characteristic scenarios to be used in numerical simulations. The feature identification will be based on different types of algorithms to test their reliability and their power in reproducing meteocean forcings to be used in coastal/offshore applications. Techniques based on CNN and LSTM will be employed on a long time series of variables to extract different characteristic time series able to represent the climatic variability of predefined locations along the world coastline.

Referent: Giovanni Besio, giovanni.besio@unige.it

Relevant links: meteocean.science

Link to the list of projects

Università di Genova | **DICCA** Ph.D. PROGRAM IN CIVIL, CHEMICAL AND ENVIRONMENTAL ENGINEERING

***Thematic*: Environmental Fluid Dynamics, Morphodynamics and Climate Changes**

Project: Machine Learning for time series forecast of Meteocean variables

Keywords: MeteOcean forecast, Machine Learning, Field Observation

Brief Description:
Real time forecasting is fundamental for maritime operations and for coastal risk alert systems. The project has the scope to implement different algorithm based on Machine Learning approach to develop time-series forecast of metocean variables (mainly ocean waves) based on field measurements obtained using wave buoys installed along the Italian coastlines. The calibration, optimization and validation of this type of tool will enhance the provision of real time forecast for the short-term period (6-12-24-48 hours) at specific locations and the system will be tested in different areas to understand the reliability and the performance level of the different algorithms for different metocean conditions.

Referent: Giovanni Besio, giovanni.besio@unige.it

Relevant links: meteocean.science

Link to the list of projects

***Thematic*: Projects in Environmental Fluid dynamics, morphodynamics and climate changes**

Project: Revolutionising Micro/Nanobubble-based Treatment Process for Micropollutant Removal in Estuarine and Coastal Environments

Keywords: micro/nanobubble flotation, water treatment, particle aggregation, salinity

Brief Description:
Quest. The equilibrium of aquatic ecosystems in estuarine and coastal environments is particularly sensitive to the presence of micropollutants (such as pharmaceuticals, PFAS, surfactants, plastic and rubber additives), that easily escape the traditional wastewater treatments and, even at very low concentrations, have adverse effects on the ecological environment. Indeed, wastewaters are the main source of micropollutants, which are almost impossible to be detected and removed once they reach the oceans. Nowadays, the most effective strategy to remove the micropollutants is based on the activated carbons that, due to their negative charge, allow them to attract polarised compounds. However, such techniques are expensive and the increasingly restrictive limits of micropollutant concentration imposed on urban wastewaters by European "zero pollution action plan" (Green Deal), require more sustainable processes to be identified.
Aims. The present project aims to deliver a high-efficiency treatment solution with minimal environmental impact, specifically designed to protect and restore sensitive aquatic ecosystems. The project explores the possibility to exploit the physical and chemical properties of micro/nanobubbles, eventually combined with other electrochemical approaches, to separate (by floatation) and remove targeted micropollutants (e.g., PFAS, pharmaceuticals). The removal can be obtained by adsorption or by oxidation (e.g. by using ozone micro/nanobubbles). The effects of the salinity characterising the estuarine and coastal areas will be also considered.
Objectives and Methodology. The objectives of the project are (i) identifying experimentally the micro/nanobubble-based treatment process to aggregate and separate the targeted micropollutants, and (ii) modelling the evolution and the interaction between micropollutant and micro/nanobubble distributions, using the Population Balance Equations. The values of the model parameters will be possibly quantified by means of the Direct Numerical Simulation of the micro/nanobubble-micropollutant interactions when the ambient flow is turbulent.
Moreover, (iii) focus will be also directed toward optimizing system performance, evaluating environmental sustainability through Life Cycle Assessment (LCA) methodology, and assessing scalability for broader application in water management. Finally, the project will benefit from the collaboration with the company COGEDE that is specialised in the design and manufacture of wastewater and slurry treatment plants. Therefore, field experiences are also planned.

Referents: Marco Mazzuoli, marco.mazzuoli@unige.it and Erica Gagliano, erica.gagliano@unige.it

Relevant links: https://www3.dicca.unige.it/~markom/home/clean_coast.html

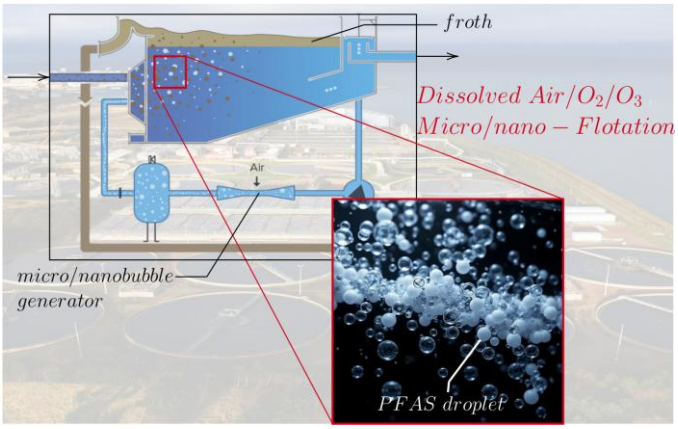

Figure: Sketch of the micro/nano-flotation device.

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Ph.D. Program in Civil, Chemical and Environmental Engineering
dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it

Projects in Hydrodynamics and Morphodynamics of Rivers, Coasts, Estuaries and Lagoons

Link to first page

Ph.D. Program in Civil, Chemical and Environmental Engineering
dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it

Thematic: **Projects in Hydrodynamics and Morphodynamics of Rivers, Coasts, Estuaries and Lagoons**

Project: Hydrodynamics performances and stability of artificial reefs

Keywords: Nature Based Solution, Artificial Reefs, Physical experiments

Brief Description:
Submerged artificial reefs (AR) are becoming increasingly popular, as they combine shore protection with environmental restoration. Compared to traditional boulders typically used for submerged breakwaters, AR are characterized by more complex shapes and higher porosity, providing habitats for fishes to nest and shelter from predators (see for instance Figure 1). If built with eco-friendly materials, AR offers additional surface for biofouling, supporting the marine food chain and enhancing the growth of algae and marine fauna. Moreover, the advent of 3D printing allows the construction of aesthetically appealing structures, raising interest in diving and ultimately supporting local activities. Despite being beneficial for a variety of reasons, the hydraulic performances of AR remain relatively unexplored. While the body of literature has steadily increased through the past recent years, most research focus on specific models and shapes without providing a comprehensive overview. Moreover, they mainly investigate the effect of AR on wave propagation, i.e., how they reduce transmitted wave height, reducing in turn flooding and erosion. By contrast, little research has assessed the stability of such porous blocks, which are particularly vulnerable to uplift and must be therefore properly engineered to withstand wave-induced stresses. In this framework, the proposed Ph.D. research aims to conduct an extensive experimental campaign to explore the stability of different AR depending on several features, such as weight, porosity, roughness, etc. Experiments will be carried out at the wave flume of the Enrico Marchi laboratory at DICCA, with the opportunity to conduct additional research at the Universidad de la Republica Oriental de Uruguay. The experimental design will follow a Design of Experiments approach, and the data collected will be analysed through dimensional analysis. The final goal is to derive general parametric formulas to preliminary assess AR stability and hydraulic performances.

Referent: Giovanni Besio, giovanni.besio@unige.it

Relevant links: meteocean.science

Link to the list of projects

***Thematic*: Projects in Hydrodynamics and Morphodynamics of Rivers, Coasts, Estuaries and Lagoons**

Project: Modelling Posidonia Oceanica effects on coastal hydrodynamics

Keywords: Numerical modeling, Posidonia Oceanica, Nature Based Solution

Brief Description:
Posidonia Oceanica meadows represent an important asset for the coastal region because they provide different types of eco-system services, ranging from nurseries to carbon capture. In the last years climate change has affected the characteristics of wave storms especially in the Mediterranean Sea, changing the impacts along the nearshore region either in terms of coastal risk (erosion and flooding) and in terms of forcings on the eco-system. One of the effects of this kind of change resulted in the uprooting of different Posidonia meadows in the Northern Tyrrhenian Sea, either natural one or transplanted ones. With the present project we would like to shade a light about possible survival of Posidonia meadows to highly energetic wave storms in specific sites along the nearshore region of the Tyrrhenian Sea comparing numerical modelling results with field observations. Furthermore, a preliminary assessment of a guideline for transplantation site analysis will be developed based on past experience of transplantation projects that suffered plant eradication during strong storm events. Finally, a mix of Deep Learning techniques and numerical modelling results will be employed to develop a forecasting tool for survival probability of transplantation projects.

Referent: Giovanni Besio, giovanni.besio@unige.it

Relevant links: meteocean.science

Link to the list of projects

***Thematic*: Projects in Hydrodynamics and Morphodynamics of Rivers, Coasts, Estuaries and Lagoons**

Project: Evolution and morphodynamic equilibrium of river deltas

Keywords: Sediment transport, morphodynamics, rivers, deltas, channel network

Brief Description:
River deltas are transitional environments of great economic and ecological value which are widely spread along the coasts of the Earth. Knowledge of the morphodynamic equilibrium of deltaic channel networks is thus of great importance not only for better understanding the response of these systems to autogenic and allogenic controls, but also for management purposes and for assessing the resilience of deltas to changes in external factors, either of natural or anthropogenic origin.

Delta formation is driven by a balance between the constructive forces of water and sediment discharge and the destructive forces of waves and tides. Increasing water discharge, sediment discharge and drainage basin area enhance the probability of a river to form a delta. Conversely, increasing wave height and tidal range counteracts delta formation (Caldwell et al., 2019).

Changes in the intensity and frequency of riverine flooding and storms associated with future climate alterations are likely to dramatically increase the exposure to flooding of a large amount of people living on deltas (Edmonds et al., 2020). Similarly, reductions in sediment flux consequent to changes in land management practices and dam construction, as well as groundwater and hydrocarbon extraction impact strongly delta biogeophysical functioning and affect the long-term sustainability of these landscapes (Tessler et al., 2018; Dunn et al., 2019).

In this PhD project we intend to build up a mechanistic model of tidally dominated delta channel networks in which water and sediment fluxes transported by the various delta branches are connected together through a localized treatment of bifurcations/confluences.

The development of this model will allow us to answer two main research questions. The first addresses how the delivery of water and sediment to a delta can be affected by the tidal forcing and by the network structure of deltaic channels. The second question this project wants to answer concerns the formative discharge that has to be used to estimate the possible equilibrium altimetric configuration of lowland deltas. Finally, the numerical model will be applied to the case study of the Po River Delta where river bed surveys performed at different years are available.

Referents: Michele Bolla Pittaluga, michele.bollapittaluga@unige.it and Nicoletta Tambroni, nicoletta.tambroni@unige.it

Link to the list of projects

Università di Genova | **DICCA** Ph.D. PROGRAM IN CIVIL, CHEMICAL AND ENVIRONMENTAL ENGINEERING

***Thematic*: Projects in Hydrodynamics and Morphodynamics of Rivers, Coasts, Estuaries and Lagoons**

Project: Vulnerability and resilience of tidal environments to climate change

Keywords: Sea level rise, saltmarshes, ecology, lagoon, morphodynamics

Brief Description:
Tides, storms, rising sea level due to climate change and sediment availability are the main features governing the dynamics of tidal environments such as estuaries and lagoons. In particular, concerns about an increasing sea level and the related ability of tidal environments to maintain their intrinsic characteristics have deserved a considerable attention in the last years. One of the issues that this project aims to study is the stability of saltmarshes under different environmental conditions by means of the formulation of proper process-based analytical and numerical models. Ecological implications, such as those related to the growth of halophytic vegetation and the role of benthic biofilms on bed erosion, are considered, as possible natural risk mitigation of coastal and tidal environments.

Referent: Nicoletta Tambroni, nicoletta.tambroni@unige.it

Relevant links: Tambroni, N., Seminara, G. A one-dimensional eco-geomorphic model of marsh response to sea level rise: Wind effects, dynamics of the marsh border and equilibrium (2012) 117 (3).

https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2012JF002363

Link to the list of projects

Università di Genova | **DICCA** Ph.D. PROGRAM IN CIVIL, CHEMICAL AND ENVIRONMENTAL ENGINEERING

Thematic: Projects in Hydrodynamics and Morphodynamics of Rivers, Coasts, Estuaries and Lagoons

Project: Experimental observations on tidal bifurcations stability

Keywords: tidal channels, experiments

Brief Description:
Tidal networks are characterised by bifurcating channels. While the issue of bifurcation has been extensively studied in the riverine literature, the case of tide-influenced bifurcation remains less understood. Some theoretical approaches have addressed river bifurcation under weak tidal influence of small amplitude, while numerical simulations have been carried out to investigate the morphological evolution of bifurcations in deltas influenced by tides. The project wishes to experimentally investigate the evolution of a fully tidal-influenced bifurcation in a laboratory model of a straight tidal channel with varying width.

Referent: Nicoletta Tambroni, nicoletta.tambroni@unige.it

Link to the list of projects

Projects in Hydrology and Water Resources Management

Project: Improvements in the accuracy of atmospheric precipitation measurement using disdrometers

Project: Short-duration rainfall event in actual and future climate scenarios

Project: Hydrologic modeling of nature-based solutions (NBS) at different spatial scales

Link to first page

Ph.D. Program in Civil, Chemical and Environmental Engineering
dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it

Thematic: Hydrology and Water Resources Management

Project: Improvements in the accuracy of atmospheric precipitation measurement using disdrometers

Keywords: Precipitation, Measurement, Accuracy, Drop size distribution, Wind

Brief Description:
Accurate and reliable precipitation measurements play a key role in a wide range of applications like flash-flood forecasting, water resources management, and climate change projections and mitigation policies. However, in-situ measurements of liquid precipitation have experienced little conceptual innovation for many decades now. Although prone to instrumental and environmental biases, rain gauge measurements are the most trusted forcing variables of hydrological models. Precipitation measurement biases of catching and non-catching gauges were investigated in previous projects through numerical simulation and wind tunnel tests, showing that their assessment and correction require detailed knowledge of the rainfall microphysical characteristics, typically expressed through the drop size and velocity distribution (DSVD).

The research project aims to fill knowledge gaps in various aspects of precipitation measurements and their use in hydrological modelling and climate studies. It focuses first on assessing the accuracy of disdrometer measurements with respect to wind effects and instrumental factors. Then, since the collection efficiency of traditional catching gauges is controlled by the DSVD through the catch ratios associated with monodisperse rainfall events, the corrected DSVD will be used to derive adjustments for measurements obtained from traditional catching gauges. Real world data from field test sites in Italy and abroad will be analysed to compare adjusted to reference precipitation.

Open issues related to the role of free-stream turbulence (inherent to the natural wind) on disdrometer measurements will be addressed together with the local turbulence generated by the bluff-body behaviour of the instrument. A modelling chain accounting for both advection of drops by turbulent wind and wind disturbance nearby disdrometers will be developed.

Results will allow to assess the impact of using corrected rainfall intensity and DSVD data on estimating measurement biases due to environmental conditions, improving statistical analysis of rainfall time series at climatological scales, investigating joint rain and wind climatology features at selected test sites, deriving extreme rainfall event statistics and trends.

Referents: Arianna Cauteruccio, arianna.cauteruccio@edu.unige.it and Luca G. Lanza, luca.lanza@unige.it

Link to the list of projects

***Thematic*: Hydrology and Water Resources Management**

Project: Short-duration rainfall event in actual and future climate scenarios

Keywords: sub-hourly extreme rainfall, IDF curves, climate change impact

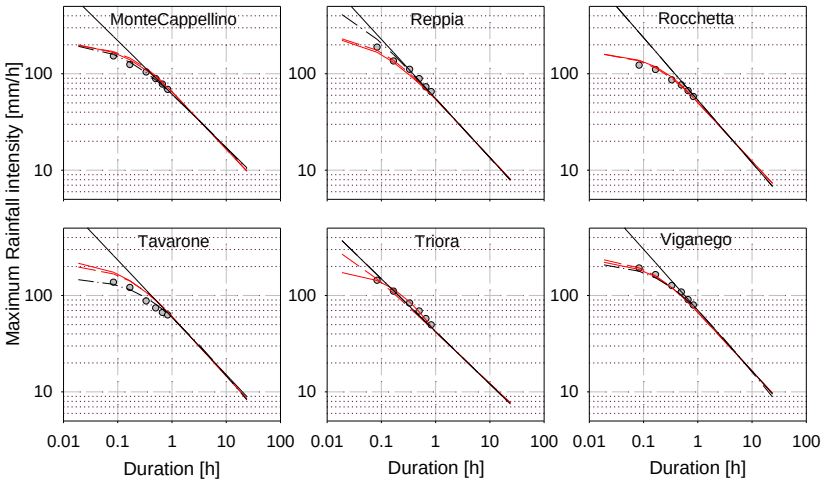
Brief Description:
The characterization of high intensity and short-duration rainfall events is crucial in small-catchment the field of hydrology and in urban hydrology. However short-duration rainfall data are rarely available and generally the length of the sub-hourly data series is significantly lower with respect to the long-duration ones. The aim of the present research is to investigate the transition in the scaling regime of rainfall from sub-daily to sub-hourly timescales in order to improve the capability of the Intensity Duration Frequency curves to provide reliable estimate of the short-duration design storm depth.

Furthermore, in the framework of a climate adaptation approach the estimates of extreme rainfall intensities from sub-daily to sub-hourly timescales in future climate scenarios are needed to tackle the design of resilient urban drainage systems.

Finally explore options for combining gauge, radar data into gridded sub-daily products to add to existing merged products as a key resource for the climate modelling community to validate model outputs.

Referent: Ilaria Gnecco, ilaria.gnecco@unige.it and Anna Palla, anna.palla@unige.it

Figure: Comparison between different IDF equations and the empirical quantile assessed for selected short-duration rainfall at 10-years return period.



Link to the list of projects

***Thematic*: Hydrology and Water Resources Management**

Project: Hydrologic modeling of nature-based solutions (NBS) at different spatial scales

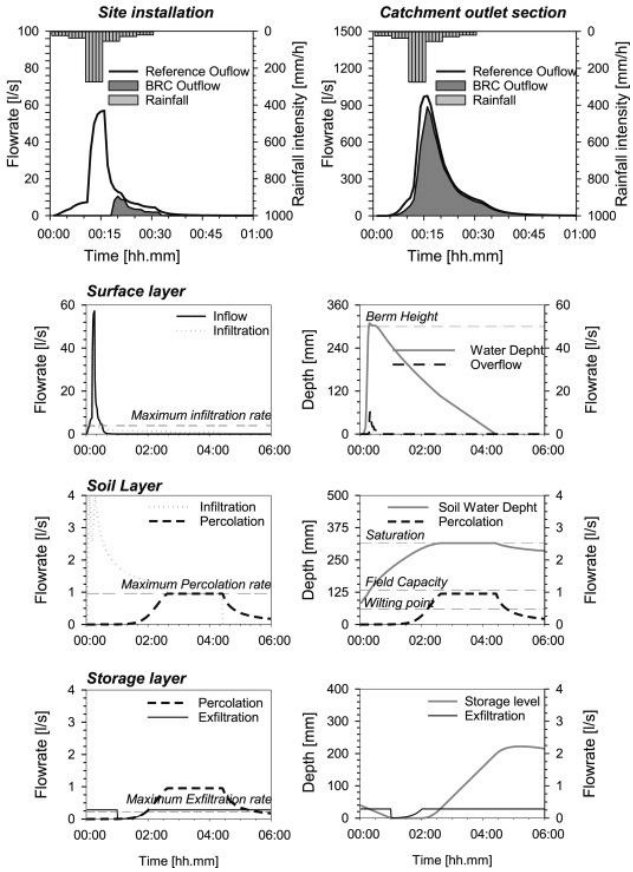
Keywords: Engineered porous media, soil water retention capacity; effective impervious area

Brief Description:
Extensive field and laboratory research has demonstrated the effective performance of nature based solutions (NBS) in urban stormwater control at the site scale or system scale/laboratory; however, there is a noticeable gap in understanding the effectiveness of NBS at the scale of urban areas. To fill this gap, modelling approaches may significantly improve the comprehension of NBS performance in urban catchment, as conducting monitoring studies on this scale requires considerable time and resources.

The aim of the research is to predict the effectiveness of NBS when translating beyond the commonly evaluated site scale to the urban residential settlements.

Referent: Anna Palla, anna.palla@unige.it and Ilaria Gnecco, ilaria.gnecco@unige.it

Figure: The hyetograph and hydrographs simulated at the single installation (top-left) and at the outlet section (top-right). Comparison between the inflow and outflow at each layers (left side) and the corresponding depths and imposed threshold (right side).



Link to the list of projects

Università di Genova | **DICCA** Ph.D. PROGRAM IN CIVIL, CHEMICAL AND ENVIRONMENTAL ENGINEERING

Projects in Biological Fluid Dynamics

[Project: Fluid flow in the retinal tissue and formation of macular oedema]

[Project: Predictive approaches in targeted drug delivery: a homogenization-based perspective]

[Project: Fluid and nutrient adsorption by the inner wall of the intestine]

Link to first page

Ph.D. Program in Civil, Chemical and Environmental Engineering
dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it

***Thematic*: Biological Fluid Dynamics**

Project: Fluid flow in the retinal tissue and formation of macular oedema

Keywords: fluid flow, macular oedema, retinal permeability, mathematical modelling, experimental measurements

Brief Description:

The retina is a thin and highly specialised multilayered neural tissue, located at the back of the eye. Macular oedema (MO) is a complication of many retinal diseases, and it consists in fluid accumulation in the central region of the retina (the macula). MO can cause severe visual impairment and can possibly lead to blindness. Fluid content in the retinal tissue is tightly regulated and depends on mechanical and osmotic pressure differences between the retinal tissue and blood, as well as on water transport across the membranes separating the retina from other tissues: the hyaloid on the vitreous side (inner side) and the retinal pigment epithelium (RPE) on the choroidal (external) side. The RPE is known to actively transport fluid from the retina to the choroid, thus contributing to keep the retina in the physiological hydration state. Very little is known concerning the fluid mechanics of the retina and its relationship with the occurrence of MO. Ruffini et al. [1] proposed a mathematical model of fluid flow in the retinal tissue and formation of macular oedema. In their work they highlight the difficulties encountered in parametrising the model, due to lack of experimental data. Several measurements exist on the mechanical properties of the retinal tissue (e.g. [3,4]) but only few researchers have attempted to measure the hydraulic permeability of the tissue, and the few existing measurements are highly contradicting [5,6]. Aim of the preset research project is to improve the model proposed in [1] by accounting for effects that were neglected in the original model, such as spatial variability of the retinal thickness, tissue anisotropic elasticity, tissue adhesion with the RPE,... The model will be informed by laboratory measurements that will be taken on ex vivo pig retinas. The work will be carried as a collaboration between the University of Genoa and the Politecnico di Milano.

Bibliography

[1] Daruich, A. et al. Mechanisms of Macular Edema: Beyond the Surface. Progress in Retinal and Eye Research 63, 2018.

[2] Ruffini, A. et al. A Mathematical Model of Interstitial Fluid Flow and Retinal Tissue Deformation in Macular Edema. Investigative Ophthalmology & Visual Science 65, no. 11, 2024.

[3] Belgio, B. et al. Towards an In Vitro Retinal Model to Study and Develop New Therapies for Age-Related Macular Degeneration. Bioengineering 8, no. 2, 2021.

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[5] Antcliff, R.J. et al. Hydraulic Conductivity of Fixed Retinal Tissue After Sequential Excimer Laser Ablation: Barriers Limiting Fluid Distribution and Implications for Cystoid Macular Edema. Archives of Ophthalmology 119, no. 4, 2001.

[6] Fatt, I & Shantinath, K. Flow Conductivity of Retina and Its Role in Retinal Adhesion. Experimental Eye Research 12, no. 2. 1971.

Referents: Rodolfo Repetto, rodolfo.repetto@unige.it and Federica Boschetti, federica.boschetti@polimi.it

Link to the list of projects

***Thematic*: Biological fluid dynamics**

Project: Predictive approaches in targeted drug delivery: a homogenization-based perspective

Keywords: porous membranes, homogenization, phoresis, osmosis, nanocarriers

Brief Description:

Targeted drug delivery is an advanced approach in nanomedicine aimed at transporting therapeutic agents to specific organs or tissues. This strategy is particularly significant in the treatment of malignant tumors. Among various targeted delivery techniques, the use of porous nanocarriers1 has gained considerable attention due to their capacity for controlled and localized release of therapeutic compounds.

A critical aspect of effective therapy lies in the precise control of nanocarrier motion. These carriers typically operate through phoretic mechanisms, wherein their movement is driven by gradients in chemical concentrations (diffusiophoresis), light (photophoresis), or temperature (thermophoresis).

This project proposes the development of a multiphysics modeling framework capable of predicting the dynamics of nanocarriers under such stimuli. The goal is to enable the optimization of nanocarrier structure and surface chemistry to achieve the desired transport behavior.

Given the scale separation between the nanocarrier dimensions and their internal pore structures, multiscale homogenization techniques offer a promising avenue for deriving effective continuum models that capture the essential physics at both micro- and macro-scales2.

The expected outcomes of this project are i) a theoretical and computational predictive model for simulating fluid flows and nanocarriers motion in confined environments, and ii) a systematic design methodology to tailor the nanocarrier transport for specific applications.

Referent: Giuseppe Zampogna, giuseppe.zampogna@unige.it

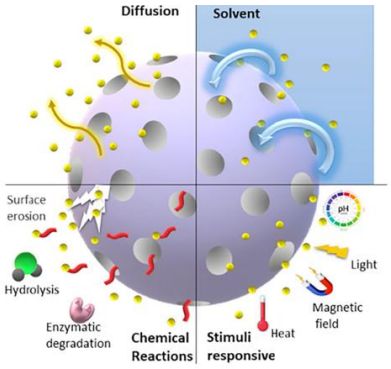

Figure: Typical porous nanocarrier and the several mechanisms at play[1].

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1. **Çitoğlu, S., Duran, H. 2024, Nano Select, 5:2300099.**
2. **Zampogna, G.A., Ledda, P.G., Wittkowski, K., Gallaire, F. 2023, Journal of Fluid Mechanics, 970:A39.**

Link to the list of projects

***Thematic*: Biological Fluid Dynamics**

Project: Fluid and nutrient adsorption by the inner wall of the intestine

Keywords: peristaltic fluid, nutrient adsorption, fluid structure interaction

Brief Description:
The inner wall of the intestine has a complex multiscale structure. In particular villi are present, the role of which is to increase the surface area available for nutrient exchanges between the fluid in the intestine and the wall tissue. The presence of villi increases by several folds the intestine wall area, where adsorption of nutrients can take place. Fluid flow in the intestine is primarily produced by peristaltic motion of the wall and the flow is laminar. Various authors have attempted to model the process of nutrient adsorption at the intestine wall and found that several factors contribute to the efficacy of the process, including unsteadiness of the flow and deformation of the villi (both active or passive) [e.g. 1-3]. However a complete understanding of the mechanics of the adsorption process is still not available.

In the present project we propose to use an in-house made numerical code, developed to model fluid-structure interaction processes. Such a model will be coupled with an advection diffusion equation for nutrient transport and suitable adsorption conditions at the intestine wall. This will allow us to carry our three-dimensional simulations of the flow in the intestine and of its interactions with the villi dynamics. Aim of the project is to explore the complex interaction between fluid motion and villi dynamics to understand its role on nutrient adsorption.

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Referents: Rodolfo Repetto, rodolfo.repetto@unige.it and Stefano Olivieri, stefano.olivieri@unige.it

Link to the list of projects

Projects in Geomatics

Project: Geospatial analysis of energy production from renewable sources in urban environment

Link to first page

Ph.D. Program in Civil, Chemical and Environmental Engineering
dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it

Thematic: Projects in Geomatics

Project: Geospatial analysis of energy production from renewable sources in urban environment

Keywords: renewable energy sources, spatial analysis and planning, urban environment, GIS,

Brief Description:
Urban environments employ considerable amounts of energy, mostly coming from distant power plants, with high costs related to production, transformation and transportation infrastructures and processes. However, it is possible to use or adapt part of the existing infrastructures and features that characterize such an environment to meet, at least in part, its energy needs. In this case, it makes sense to take into account the implementation of small plants distributed over the urban area for the exploitation of renewable sources, and simultaneously, to asses the conditions for optimal use.

In this regard, among the different elements, it is important to assess:

- **real energy needs related to the different functions that are carried out in an urban area, also depending on the size and "specialization" (e.g. settlements predominantly industrial, or tourism-oriented settlements, etc.).**
- **possible methods of energy production based on some specific features of the urban area (i.e., sun hours, wind, biomass availability, etc.)**
- **most suitable locations for the setting of production facilities, also considerign the infrastructure already in place, the various constraints affecting a densely man-made environment (cultural, safety, etc.), and the costs of their implementation, management and maintenance**
- **possible energy users or users clusters, in order to optimize spatial relationships and consequently transportation costs between production and use sites**
- **social implications related to the presence of production facilities and increased availability of energy**

Thus, a cross-disciplinary and multidisciplinary analysis is configured, with a view to applications in different contexts

Referents: Paola Salmone, paola.salmona@unige.it and Bianca Federici, bianca.federici@unige.it

Relevant links:

Molnár G., Ürge-Vorsatz D., Chatterjee S., 2022. Estimating the global technical potential of building-integrated solar energy production using a high-resolution geospatial model, Journal of Cleaner Production, Volume 375, 134133, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2022.134133.

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Resch, B.; Sagl, G.; Törnros, T.; Bachmaier, A.; Eggers, J.-B.; Herkel, S.; Narmsara, S.; Gündra, H., 2014. GIS-Based Planning and Modeling for Renewable Energy: Challenges and Future Research Avenues. ***ISPRS Int. J. Geo-Inf. 3*****, 662-692. https://doi.org/10.3390/ijgi3020662**

Link to the list of projects

Ph.D. Program in Civil, Chemical and Environmental Engineering
dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it

Other Projects

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Ph.D. Program in Civil, Chemical and Environmental Engineering
dottorato.dicca@unige.it
+39 010 3352303
Via Montallegro 1, 16145 Genova
Coordinator: roberta.massabo@.unige.it