



Pole for Doctoral Studies
Center for Doctoral Studies Sciences, Technologies, and Medical Sciences

ANNOUNCEMENT OF DOCTORAL THESIS DEFENSE



Ms. BEL HAJJAM Rafia

**Will present their research work with the aim of earning a
Doctorate**

Doctoral program: Mathematical Sciences, Physics, and New Technologies
Discipline: Mathematics
Specialty: Numerical Analysis

**On 28/03/2026 at 12H00 at Professor Hassan Benejiba's meeting
room, Department of Biology, Faculty of Sciences of Tetouan,
UAE
Under the Theme**

**From stratified Navier-Stokes to depth-averaged shallow water
models: advanced computational methods for 2D and 3D
hydrodynamic simulations**

Front of the jury composed of :

First Name & Last Name	Establishment	Designation
Pr. FERRAHI Bouchaib	FS of Tetouan, UAE	President
Pr. BOUZELMATE Arij	FS of Tetouan, UAE	Reviewer
Pr. ESSOUFI El Hassan	FST of Settat, UH1	Reviewer
Pr. YAKOUBI Driss	De Vinci Research Center of Paris, France	Reviewer
Pr. EL ANJOURI EL AMRANI Mofdi	FST of Tangier, UAE	Examiner
Pr. EL MOÇAYD Nabil	UM6P of Benguerir	Examiner
Pr. SEID Mohammed	University of Durham, United Kingdom	Co-Supervisor
Pr. YEBARI Naji	FS of Tetouan, UAE	Supervisor

Host Research Structure: Numerical Analysis and Nonlinear Analysis

Abstract



Understanding and predicting hydrodynamic processes in natural and urban environments requires a coherent integration of physical modeling, mathematical formulation, and numerical approximation. This thesis addresses the numerical modeling of free-surface flows across a range of spatial and physical scales, from depth-averaged Saint-Venant equations to three-dimensional hydrostatic Navier-Stokes formulations for stratified flows.

Starting from the governing equations of fluid motion, the work focuses on their numerical implementation under realistic assumptions, with particular attention to nonlinear advection, stratification effects, and complex geometrical configurations. Core contributions focus on improving the treatment of open boundary conditions, both horizontally and vertically, constructing physically consistent initial states, and accurately representing complex bathymetry and built environments. These aspects are shown to play a central role in the realism, stability, and predictive capability of hydrodynamic simulations.

The proposed modeling framework is applied to two physically distinct hydrodynamic configurations. The first involves riverine flood propagation, where unsteady free-surface simulations are coupled with probabilistic descriptions of extreme precipitation to predict inundation in urbanized floodplains, enabling physically consistent and uncertainty-aware flood mapping. The second concerns density-driven circulation in a geometrically constrained strait, where tidal forcing, stratification, and complex bathymetry control exchanges between water masses, allowing analysis of layered thermohaline flows and exchange dynamics critical for understanding circulation, mixing, and ecosystem processes.

By bridging governing equations, advanced numerical schemes, and practical modeling constraints, this work demonstrates how mathematically grounded hydrodynamic models can reproduce complex flow behavior while remaining applicable to operational and practical studies. The results highlight the potential of numerical modeling to support risk assessment, improve predictive capability, and contribute to the understanding and management of complex hydrodynamic systems.

Keywords : *Numerical modeling; Computational fluid dynamics; Saint-Venant equations; Navier-Stokes equations; Free-surface flows; Density-driven circulation; Finite element method (FEM); Flood risk assessment; Urban flooding; Ocean circulation; Strait of Gibraltar; Oued Martil; TELEMAC-2D; TELEMAC-3D.*