PHD THESIS PROPOSAL

COASTAL EROSION : FLUID MOTION AND SEDIMENT TRANSPORT

PhD Advisors : Julien Chauchat, MCF, HDR, (Univ. Grenoble Alpes, GINP, LEGI - UMR 5519)
Maria Kazakova, MCF (Univ. Savoie Mont Blanc LAMA - UMR CNRS 5127)

Starting Date : 1st October 2021

Duration : 3 years

Location : Laboratoire de Mathématiques de l'Université Savoie Mont Blanc
Campus Scientifique, 73376 Le Bourget du Lac, France

Research project In the context of climate change, the risks of flooding and coastal erosion are increased by numbers of extreme weather events. In France, for example, erosion affects a quarter of the metropolitan coasts. It is therefore essential to develop reliable, accurate and operational models to describe these phenomena. The key issue is to connect on the one hand, the coastal hydrodynamics and on the other hand the processes of sediment transport. The study of the mathematical and physical aspects of such a coupling is the main axis of the thesis.

The first objective of the project is the integration of the wave breaking description into a hyperbolic model of very high resolution for wave propagation. The property of hyperbolicity is important to allow a significant gain in terms of numerical resolution and to guarantee improved dispersive properties. This part of the study should eventually lead to the construction of a new model able to capture the breaking phenomena in the simplified 1D and 2D shallow water context. Numerical simulations will be performed to validate the model using experimental data and field observations. The mathematical analysis of the new numerical schemes (energy and positivity preserving, well-balanced properties, boundary conditions) will be carried out in order to ensure the robustness and the stablility of the numerical method. First of all, a solitary wave propagation predicted by the new model will be compared with experiments on the wave propagation in a channel. After that, 2D comparisons will be performed in the case of rip current experiments. Several data were obtained in LEGI (Grenoble) on the channel of 36m and on the multidirectional wave basin 30m×30m (LHF facility, France).

The second question concerns the inclusion of sediment transport and evolution of the bottom within the hydrodynamic model. In order to take into account the morphodynamic evolution, two equations must be solved in addition to the water wave model : a sediment mass conservation equation, the Exner equation, and an equation for the average suspended concentration. There are two difficulties in implementing this approach that need to be addressed : the non-linear couplings between the equations and the choice of closures. Different strategies will be proposed and validated by comparison with experimental results. Another major obstacle to morphodynamic modelling of sandy beaches lies in the prediction of the wave breaking, this point is at the core of this research project and will be accurately studied in the first part. The validation of the morhohydrodynamical model will be based on comparison with different experimental configurations from the solitary waves propagation over a fine sand beach in a channel to experiments on sediment transport and beach profile evolution induced by bi-chromatic wave groups.

The implementation will be performed on the base of the computational software TOLOSA (tolosa-project.com), with support of the TOLOSA project team. The performance of this platform and the precision of the hydrodynamic description provided by the new model will allow long-time simulations which are in the scope of interest for morphodynamic evolution.

Requirements

- Master degree (or equivalent) in applied mathematics
- Solid background in Theory of PDE, Numerical methods and Numerical analysis
- Initial skills in programming : Fortran/C++
- Background in mechanics of solids and fluids will be an advantage

Potential applicants are encouraged to send us :

- CV
- motivation letter
- recommendations or references (if possible)

Contacts : maria.kazakova@insa-rouen.fr, julien.chauchat@univ-grenoble-alpes.fr