Six month internship offer on Numerical methods for urban flood modeling

Education level: Second year of Master’s degree or equivalent.

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Context: The internship will take place at J.A. Dieudonné laboratory of University Côte d’Azur and as a part of ANR project Top-up. Top-up is an interdisciplinary project that aims to integrate high-resolution urban topography within the free surface flow simulations. Urban floods produced by exceptional precipitations may cause large damages both in terms of life losses and property destruction. This issue is of a special importance for the city of Nice and its surroundings. Numerical modeling can be used to predict, anticipate and control the floods by helping to size and position protective systems including dams, dikes or rainwater drainage network. The major challenges in numerical modeling of urban floods is that the small impervious structural features (like buildings, concrete walls, cars, etc.) significantly affect the flow. In order to include those small structures in the hydraulic simulations two major ingredients are requested:

1) high-resolution topographical data sets;
2) efficient numerical algorithms.

The motivation of the project comes from the observation that the second ingredient is still somewhat missing. The difficulty comes from a large contrast between a typical length of the simulation domain (10-100km) and the size of the relevant structural features, which in many cases have to be represented at metric or infra-metric scales. In other words the physical process that has to be simulated involves multiple scales, some of which are likely to be unresolved by the computational mesh. The project aims to address this challenge by using Domain Decomposition [2] and Multi-scale [3] numerical methods, that can be studied and implemented within a single framework.

Objectives: The internship will focus on the difficulties resulting from the geometrical complexity of the urban environment. Therefore we will consider a simplified flow model. The evolution of the water elevation $u(x,t)$ will be described by a linear heat equation

$$\partial_t u - \Delta u = f \quad \text{in} \quad \Omega \setminus \Omega_s.$$  

From the numerical perspective the difficulty comes from the fact that the flow equation has to be solved in a perforated domain $\Omega \setminus \Omega_s$, where $\Omega_s$ represents the area occupied by the buildings, and may contains a very large number of sub-regions. The final objective of the internship is to implement, evaluate (and probably improve on) some classical Domain Decomposition and Multi-scale...
numerical methods for equations (1), and using realistic topographical data provided by Métropole Nice Côte d’Azur. To this end the intern will be lead to explore different domains of Scientific Computing, including mesh generation, numerical linear algebra, and numerical analysis. The internship mainy focuses on the implementation of the existing numerical methods, however there is also an opportunity to perform a theoretical analysis of those methods.

**Duration and salary** : The internship duration is 6 month, the salary will be about 600 € per month. It also worst mentioning that the internship can be followed by a PhD.

**Requirements** : We are looking for a candidate with a solid background in numerical methods for PDE. The internship will require a decent amount of algorithm implementation, the candidate should therefore have some basic programming skills.

**References**

