About the research centre or Inria department

The Inria Sophia Antipolis - Méditerranée center counts 37 research teams and 9 support departments. The center's staff (about 600 people including 400 Inria employees) is composed of scientists of different nationalities (250 foreigners of 50 nationalities), engineers, technicians and administrators. 1/3 of the staff are civil servants, the others are contractual. The majority of the research teams at the center are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Six teams are based in Montpellier and a team is hosted by the computer science department of the University of Bologna in Italy. The Center is a member of the University and Institution Community (ComUE) "Université Côte d'Azur (UCA)".

Context

Flooding as a major source of disaster. Floods represent a major cause for human casualties, infrastructural damage and financial losses all over the world. In continental urban areas, urban flooding may arise as a result of intense rainfall over urbanized/nearly impermeable areas, or river flooding. In nearshore urban areas, flooding may result from storm surges or tsunami waves. The conjunction of climate change and urbanization trends is expected to increase the frequency and severity of flood-induced disasters.

The actors and stakeholders include insurance/reassurance companies, urban planners and municipal/conurbation authorities, civil protection authorities and rescue services (police, ambulance, firemen brigades, etc.), forecasting and warning (meteorological services).

Hydraulic models as decision-making support tools. Flood models (especially two-dimensional models) can be used at the three stages of the flood crisis. Before and after the crisis, they can be used to assess and map the flood risk, thus providing information to the stakeholders of the pre-and post-crisis stage. During the crisis, they can help in forecasting the extent and severity of the flood in urban areas.

However, the use of such models in practice is hampered by two factors: (i) the considerable amount of data and manpower needed to build and operate them on the scale of an entire urban area, (ii) their computational efficiency, when simulating one second often requires more than one second computational time.

Upscaling allows the above two factors to be minimized to a large extent. Upscaled urban flood models are obtained from small scale models by solving the governing equations "on the average" over coarse computational grids that contain both water and built areas. Such models allow the computational time to be reduced by several orders of magnitude compared to high-resolution models. If deemed necessary, the result of the fast-running upscaled models can be used to run models on a finer scale over certain areas of interest. Upscaled models have arisen as very recent research results. The team LEMON aims to turn these upscaled models into engineering software products such as SW2D, developed by Vincent Guinot (LEMON & University of Montpellier); this software shall be used by the hydraulic engineering community in a near future to address some of the needs of the various stakeholders.

Main objectives

This PhD thesis focuses on the coupling of shallow water models at various scales, possibly including anisotropic porosity. The main objective is to allow for the simulation of urban floods at various resolutions and numerical costs, while smoothing the numerical interactions.

Prior to practical implementation, however, two major research issues must still be addressed in terms of model development:

- **Upscaled model improvement.** Upscaling the flow equations raises two challenging issues: (i) account accurately for the wave propagation properties

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**General Information**

- **Theme/Domain**: Earth, Environmental and Energy Sciences
- **Town/city**: Montpellier
- **Inria Center**: CRI Sophia Antipolis - Méditerranée
- **Starting date**: 2018-09-01
- **Duration of contract**: 3 years
- **Deadline to apply**: 2018-04-15

**Contacts**

- **Inria Team**: LEMON
- **Recruiter**: Rousseau Antoine / antoine.rousseau@inria.fr

**The keys to success**

The PhD will start in September 2018 for a 3 years period and will take place in Montpellier, in the Inria research team LEMON, under the co-supervision of Antoine Rousseau (INRIA Montpellier, team LEMON) and Vincent Guinot (University of Montpellier and team LEMON).

The candidate is expected to have a master degree in applied mathematics, with a strong background in partial differential equations and scientific computing. A good knowledge of computational languages (C++, Fortran) is also required. Finally, knowledge in free surface hydraulics and/or fluid dynamics, and more generally a personal taste for modeling aspects of environmental sciences, will clearly be a plus.

**Conditions for application**

**Defence Security**

This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST). Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

**Recruitment Policy**

As part of its diversity policy, all Inria positions are accessible to people with
resulting from the anisotropy of the urban geometry, (ii) accounting accurately for energy dissipation mechanisms that occur on the subgrid scale. Previous research conducted by the partners indicates that upscaling the energy dissipation mechanisms leads to very unusual models (fourth-order tensor formulations, energy loss driven by non-equation-of-state models). The first part of this research line will consist in improving these models. The benchmarking data sets developed in the first research lines will also help in validating the proposed upscaled models.

- **Scale coupling.** Before the results of an upscaled model can be used for smaller scale simulations, the issue of scale coupling must be addressed. Assuming indeed that a satisfactory upscaled flood model is available and properly parameterized, what is the degree of compatibility between its large-scale simulation results and the simulation results obtained at a smaller scale? A typical use of porosity models will be to run fast simulations with a coarse cell resolution over wide areas and use their simulation results to interpolate initial and boundary conditions for refined models, operating at a much smaller scale over shorter time intervals. However, the large scale and small scale models are simulated using different equations, their simulation results can be expected not to be fully consistent with each other. The use of porosity parameters raises more complexity to the partial inconsistency between models of different scales, which is a new issue for research. Nudging techniques also allow conditions on the flow variables to be enforced at specific pilot points located inside the small scale models. However, despite enforcing such compatibility conditions for the flow variables, the small-scale simulation results still may turn out to differ significantly from the large scale ones. In such a case, the incompatibility between the two scales must be addressed.

### Assignment

**Assignments:**
With the help of Vincent Guinot and Antoine Rousseau, the recruited person will be taken to allow for the simulation of urban floods at various resolutions and numerical costs, while smoothing the numerical interactions.

**For a better knowledge of the proposed research subject:**
A state of the art, bibliography and scientific references are available at the team publication page (see in particular the “shallow water, porosity” keywords.

### Work program
1. Literature review for open boundary conditions and domain decomposition (M12)
2. Research of perfectly absorbing conditions for shallow water models with porosity. Numerical tests in 1D (M18)
3. DDM algorithms embedding optimized boundary conditions applied in a 2D case (M24)
4. Multi-scale modelling of urban flood with various 2D shallow water models (M36)

### Main activities

Main activities (5 maximum):

- Propose new multi-scale coupling techniques in the framework of upscaled shallow water models
- Develop programs/applications/interfaces of the platform SW2D
- Write scientific papers
- Present the work to partners and colleagues

Additional activities (3 maximum):

- Write documentation
- Co-advise interns on the project

### Skills

Mandatory:

- partial differential equations
- scientific computing (C++, Python)
- hyperbolic systems theory

Optional:

- domain decomposition and/or multi-scale techniques
- Fortran
- urban floods modeling

### Benefits package

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

**Remuneration**

Duration: 36 months
Location: Sophia Antipolis, France
Gross Salary per month: 1982€ brut per month (year 1 & 2) and 2085€ brut/month (year 3)