Offre n°2024-07351

PhD Position F/M Advancing Flood Modeling: Integrating High-Order Numerical Methods with Sub-Cell Limiting Techniques for Accurate Urban Flooding Prediction

Le descriptif de l'offre ci-dessous est en Anglais

Type de contrat : CDD

Niveau de diplôme exigé : Bac + 5 ou équivalent

Fonction : Doctorant

A propos du centre ou de la direction fonctionnelle

The Inria center at the University of Bordeaux is one of the nine Inria centers in France and has about twenty research teams.. The Inria centre is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative SMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute...

Contexte et atouts du poste

- Project **RESCUER HORIZON-MSCA-2022-DN 101119437**
  Resilient solutions for Coastal, Urban, Estuarine and Riverine environments
- The position also involves travels to other partners (secondments) as declared in the Grand Agreement

This project takes place within ongoing collaborations between the Inria CARDAMOM team and UNIVPM (Universita Politecnica delle Marche), AAU (Aalborg Universitet) and BRGM.

Mission confiée

Assignments :

Strategic planning to mitigate the effects of floods, induced within an urban environment by either heavy rainfall or other sources related to river and sea actions, is crucially important due to its paramount importance for people (e.g., pedestrian), objects, and structures. The only non-destructive way to assess these dangers is by advanced flow modeling techniques, which allow accurate forecasts of the hydrodynamics in urban areas.

The objective of this PhD is to develop a modeling framework for urban flooding simulations that integrates precise representations of topography and built structures using the Discontinuous Galerkin (DG) numerical method. Ensuring high-resolution descriptions of both coastlines and structures, with accuracies of maybe less than a meter, is crucial for accurately depicting flooding dynamics. The primary challenge lies in managing complex and irregular bathymetric data represented by polynomials on unstructured grids. This framework must effectively handle interactions between irregular bathymetric data and flooding fronts (wet/dry transitions), potentially incorporating non-submerged floating structures. A well-balanced scheme is imperative to avoid spurious and non-physical waves arising from numerical discretization-induced bathymetric variations.

The idea is to explore sub-cell models and sub-cell resolution strategies combined with some nonlinear numerical method. For example one avenue of exploration lies in the usage of sub-cell approximations that may allow to construct well balanced schemes preserving the high resolution see for eg [1]. Further more the integration of sub cell techniques can be instrumental in maintaining water positivity around wet/dry areas [2].

It is known that high order DG methods may produce spurious oscillations in the presence of discontinuities or steeply varying gradients, i.e. Gibbs phenomenon a possible way to treat this is the sub cell nonlinear approximations for the topography to avoid these spurious oscillations.

Furthermore, the integration of individual cell models could be extended to deal with friction phenomena and adapting to the presence of floating structures, allowing an integrated simulation framework that captures a

variety of real-world scenarios [3,4].

The implementation will be carried out within the UHAINA codebase [5], a phase-resolving free surface wave model. UHAINA is built on the Aerosol platform, offering extensive capabilities such as arbitrary high-order finite element discretizations, hybrid meshes, and an advanced programming environment optimized for performance and high-performance computing (HPC).

Anticipated outcomes include improvement on academic tests, and applications in operational context to realistic events benefiting from BRGM'experience in the matter, and experiments from other partners benefiting from consortium data

The resulting numerical scheme will be applied to a case study of urban flooding, with comparisons made against experimental data provided by UNIVPM.

[1] A. Meister and S. Ortleb. A positivity preserving and well-balanced DG scheme using finite volume subcells in almost dry regions. Appl. Math. Comp., 272:259–273, 2016.

[2] Haidar, Ali and Marche, Fabien and Vilar, Francois. A posteriori finite-volume local subcell correction of high-order discontinuous Galerkin schemes for the nonlinear shallow-water equations. Journal of Computational Physics,452:110902,2022.

[3] Edwige Godlewski, Martin Parisot, Jacques Sainte-Marie, Fabien Wahl. Congested shallow water model: on floating body.*SMAI Journal of Computational Mathematics*, 2021, 6, pp.227-251.

[4] U. Bosi, C. Eskilsson, A.P. Engsig-Karup, and M. Ricchiuto,A spectral/hp depth-integrated model for nonlinear wave body interaction,*Comp. Meth. Appl. Mech. Eng.* 348, pp. 222-249,2019

[5] Filippini, A. G., De Brye, S., Perrier, V., Marche, F., Ricchiuto, M., Lannes, D., & Bonneton, P. (2018, May). UHAINA: A parallel high performance unstructured near-shore wave model. In *Journées Nationales Génie Côtier-Génie Civil* (Vol. 15, pp. 47-56). Editions Paralia.

Collaboration :

The recruited PhD student will collaborate with colleagues in CARDAMOM team and with collaborators in UNIVPM (Universita Politecnica delle Marche), AAU (Aalborg Universitet) and BRGM.

Principales activités

- Development of sub-cell models within the DG framework , preserving the WB, control positivity and keeping the high resolution.
- Examining sub- cell polynomial approximations for the topography.
- Developing sub-cell models for friction and floating structures.
- Participation on dedicated laboratory tests that will be executed at UNIVPM to study the local hydrodynamics generated in correspondence of irregularities, such as building openings, courtyards, block porosity, obstacles.
- Verification and validation of the produced code with standard benchmarks and the above experimental data.

Additional activities:

- Participate in the training activities as described in the Grand Agreement.

Compétences

Technical skills and level required : The candidate must have a master degree in applied mathematics and scientific computing. Knowledge in programming (C, C++, Fortran or Python) will be highly appreciated.

Languages : English at good working level.

Relational skills : The candidate must be able to work in an international environment involving multiple collaborators, and be willing to travel.

Avantages

- Subsidized meals

- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of partial teleworking and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social security coverage

Rémunération

remuneration calculated according to the "MSCA Doctoral Networks 2022" scale

Informations générales

- **Thème/Domaine :** Schémas et simulations numériques
- **Ville :** Talence
- **Centre Inria :** Centre Inria de l'université de Bordeaux
- **Date de prise de fonction souhaitée :** 2024-09-01
- **Durée de contrat :** 3 ans
- **Date limite pour postuler :** 2024-05-17

Contacts

- **Équipe Inria :** CARDAMOM
- **Directeur de thèse :**
  Kazolea Maria / maria.kazolea@inria.fr

A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

Attention: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

Consignes pour postuler

- Applicants must be doctoral candidates, i.e. not already in possession of a doctoral degree at the date of recruitment.
- Mobility rule: researchers must not have carried out their main activity (e.g. work, studies) in the host country for more than 12 months in the 3 years immediately before their recruitment date.

The list of documents required to apply is as follows:

 a CV containing web links to publications and master's thesis (if applicable),

 a covering letter describing, in particular, interest in the subject as well as a description of the master's work (or equivalent) ;

 a transcript of marks for the last 2 years;

 at least one letter of recommendation from the supervisor of the master's course (or equivalent) sent directly by the author to the future thesis supervisor.

Sécurité défense :
Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

Politique de recrutement :
Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.