European Center for Research and Advanced Training in Scientific Computing (www.cerfacs.fr)

Development of Immersed Boundary Methods for urban applications

Position: Post-doctoral position starting on October 1, 2014 for a duration of 2 years

Context

The air quality and the urban microclimate depend on the particular meteorological situations, the characteristics of pollutants emissions and all the elements constituting a city. The study of these phenomena using modeling and computation can be a helpful guide for policymakers. The goal of the postdoc is to develop a tool to answer questions relating to urban planning over large areas such as the city of Toulouse, with a realistic cost in terms of computation time. The proposed methodology will explicitly take into account the buildings, routes and other sort of structures to simulate the flow and quality of the air in a high-resolution atmospheric model.

This will be done in collaboration with the Aviation and Environment team at CERFACS which is interested in the modeling of complex flows in the fields of geophysics and climate, and TURBAU team at CNRM, which focuses on the interactions between turbulent flows and heterogeneous surfaces, particularly in cities. This expertise has been recognized through the participation in major international programs in high-performance computing such as PRACE in Europe and INCITE in the United States. The post-doc will benefit from the results of EUREQua project leaded by CNRM and the University of Mirail in collaboration with ORAMIP (the agency air quality in the Toulouse region) whose purpose is to produce indicators of environmental quality in the Sud-Rocade neighborhood of Toulouse by combining aspects of urban microclimate, air quality and noise with the sociological aspects.

Description

In order to study the effects of local micro-climate or the dispersion of pollutants, one must first model numerically the dynamical properties (mean wind, turbulence, heat flow) of an urban flow in the presence of obstacles. In a conventional atmospheric model, the time required to generate a mesh that "follow" the edges of each element is a limiting factor in terms of cost in computation time. In addition, the grids following the bounary of the computational domain cannot represent obstacles whose shape varies abruptly from the ground (for example buildings perpendicular to ground)

The objective of this post-doc is to implement and test an immersed boundaries method (IBM) in the atmospheric model Meso-NH, which is jointly developed by CNRM and the Laboratoire d'Aerologie, for the study of the flow in a complex urban environment urban. The principle of this method is to represent obstacles in the flow-field by changing the model equations or the boundary conditions in such a way that the flow moves around an obstacle. This method has the advantage of using Cartesian grids that can be easily generated, and can therefore be used on large computational domains at lower cost in computation time.

The current version of Meso-NH already contains a simplified formulation of IBM where a source term in the form of drag force has been added to the model equations to represent the presence of a vegetation layer. The first task of the pot-doc will be to develop a more complex formulation of the present IBM method that is adapted to treat urban environments. Both approaches will be evaluated in academic flows that have been published in the literaure (e.g. the flow behind a cylinder and around a Gaussian hill).

Once the code has been validated, a study of the structure of winds and fine-scale turbulence (1m resolution) will be conducted to characterize the flow and the dispersion of pollutants in the Sud-Rocade neighborhood of Toulouse. For the validation of this study the urban data of the Systèmes d'Information Géographiques as well as the meteorogical and experimental data of NO2 from the EUREQua campaign will be used. This validation step will be useful to show the interest of using the IBM approach for the study of urban environment at very high resolution: modeling of any sort of obstacles to the to airflow and the dispersion of pollutant, while maintaining a good eficiency in terms of computational time. Finally, the results of the study will be combined with the interdisciplinary data issued from the EUREQua campaign to provide indicators of environmental quality.

Requirements

- Strong background in Computational Fluid Dynamics or Atmospheric Sciences with focus in numerical modeling
- Demonstrated experience in computer programming, knowledge of parallel programming is an asset
- Strong oral / written communication skills in English
- Ability to communicate in French is an asset

Salary: around 2500 euros / month

How to apply

Please send

- motivation letter
- curriculum vitae
- names and contacts of two referees

to the contacts below. Applications will be evaluated starting on 1st July 2014 and until the position is filled.

Contacts

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