Postdoctoral position

Uncertainty quantification applied to air quality simulation at urban scale

July 2017

Context and objective

Air quality simulations at urban scale are a key tool for the evaluation of population exposure to particulate matter and gaseous air pollutants. The simulations are however subject to high uncertainties that originate from various sources, and especially from the input data such as traffic emissions and meteorological data. The quantification of the resulting uncertainties is an important topic, in particular in the context of the assimilation of observational data. Quantifying the uncertainties is a challenging task because of the complexity and high computational cost of the involved numerical models. The objective of the post-doctoral position is to quantify the uncertainties in the complete simulation chain, which includes a dynamic traffic assignment model, an emission model and an atmospheric dispersion model at urban scale.

Method

The proposed approach relies on three main steps:

1. The meta-modeling of the computationally intensive parts of the simulation chain. The traffic assignment model and the atmospheric dispersion model both need to be replaced with a meta-model (or surrogate model) that essentially reproduce their behaviors, but at much lower computational cost.

2. Probability density functions (PDFs) are associated to all the uncertain inputs, at every step of the simulation process, e.g., traffic demand for traffic assignment, composition of the vehicle fleet for emission estimation, and meteorology for the atmospheric dispersion. The propagation of the uncertainties in the complete simulation chain is then carried out, using the meta-models.

3. The results are compared to observations, mainly pollutant concentrations at air quality monitoring stations, and possibly traffic observations at loop counters. A calibration is then required to determine the best PDFs for the inputs that lead to the best uncertainty quantification.

Meta-models have already been designed and implemented for both the traffic assignment model (based on LADTA, a dynamic traffic assignment model) and the atmospheric dispersion model (based on SIRANE, an urban air quality model). The traffic emissions can be computed with the Pollemission software. The complete chain is therefore available, although it may require additional work for a consistent uncertainty propagation.

The calibration is the most challenging task, and will require to find efficient algorithms that can minimize various probabilistic scores. Bayesian inference is one strategy. Another strategy would be the minimization of ensemble scores like the variance of the rank histogram.

Case study

The work will be carried out with existing simulation models and their meta-models for a rich case study in the metropolitan area of Clermont-Ferrand (France). In this case study, a one-year simulation can be run with an hourly step, and hourly traffic and air pollution observations are available for the calibration. The results of the simulation chain are pollutant concentrations down to street resolution; see Figure 1.

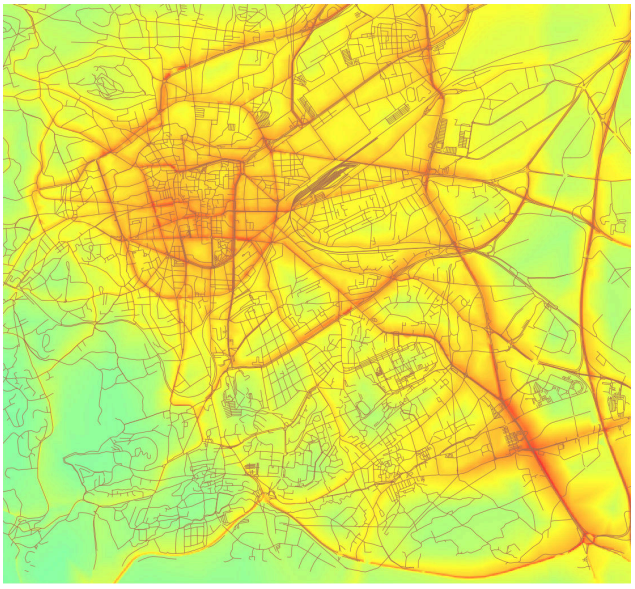

Figure 1: Hourly map of concentrations of nitrogen dioxide as computed by an urban air quality model over Clermont-Ferrand (France). The objective of the post-doctoral position is to quantify the uncertainties associated with such maps.

Research team

The post-doctoral position will take place at the Inria Paris research center, in the project-team ANGE. The work will be conducted in the framework of the ANR project ESTIMAIR. This project involves the SME NUMTECH (urban air quality), École des Ponts ParisTech (traffic modeling) and École centrale de Lyon (atmospheric dispersion model). The post-doctoral position will be supervised by Vivien Mallet (Inria research scientist and leader of the project ESTIMAIR).

Conditions and contact

Expected profile: PhD in applied mathematics or geosciences, with interest in numerical simulation
Starting date: October 2017
Duration: 11 months
Salary: at least 2110 euros net per month (health insurance included)
Localization: Inria Paris

- Address: 41 rue du Charolais, Paris (12e arrondissement)
- Within walking distance of gare de Lyon (RER A and D, subway 1 and 14), Montgallet (subway 8) et Dugommier (subway 6)

Contact: Vivien Mallet, vivien.mallet@inria.fr, 01 80 49 41 24 (from abroad: +33 1 80 49 41 24)