Rapid Response Modelling for Assessment of Pollution and Toxic Releases in Complex Urban Environments

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Background: Understanding the localised dispersion mechanisms in urban areas is of great importance both in the identification and mitigation of recurring pollution hotspots and in the design and implementation of effective emergency response actions in the case of a toxic release. Indeed, recent research suggests that short-term peak exposures to pollutants may have a major effect on our health and the natural environment.

To address these issues, we therefore seek to develop the tools to support effective air quality management and rapid response to air quality emergencies. This necessitates the implementation of a model that is able to adequately capture spatial and temporal variabilities of urban emission dispersion patterns. Unfortunately, current models are either excessively computationally expensive, or fail to capture the detailed variability of such problems and as a result, such analyses are performed infrequently with consequent limitations on our ability to plan and implement effective response strategies.

The aim of this project is to develop a highly efficient but detailed air pollution model that can provide a rapid environmental risk assessment, in relation to the specific requirements of human exposure to pollutants released on a regular basis or in an emergency response situation. The proposed work will improve the existing models by (1) using a cutting edge adaptive mesh turbulence model that has the potential to greatly enhance the accuracy of future air pollution models, by being able to simultaneously resolve city scale flows, the aerodynamic effects of individual buildings and even smaller obstacles like vehicles; and (2) model reduction in which the high-fidelity turbulence model is projected onto a reduced space so that the simulations can be performed computationally quickly. The reduced order model will, in many situations, reduce the computational cost of the turbulence model by orders of magnitude which would mean that the model may be used more interactively to determine the impacts of pollutant sources, or for data assimilation, or used to guide placement of measurements/instruments that aim to achieve a picture of the air flows, pollution concentrations and sources. This model may then offer tangible advantages in situations where previously computationally fast (but not always accurate) Gaussian plume models might have been used and would thus, if successful, be a very important development.

The project will leverage >120 person years of previous research and code development at ICL, allowing such a challenging project to be realistically achieved. The deliverables of the PhD research are (1) Domain decomposition techniques for forming reduced order model (ROM); (2) Non-intrusive domain decomposition techniques based on hyper reduction with variable parameters; (3) demonstrate the capability of the new subgrid ROM.

Novelty: The specific technologies (representing a new strategic research direction in reduced air pollution model) that distinguish this project are the subdomain reduced order model, computation efficiency capability, use with adaptive mesh resolution, and non-intrusiveness based on local subdomains. This new hyper reduction method will improve the computational efficiency of air pollution modelling drastically. The method can also be extended in the future to sensitivity analysis and uncertainty qualification.

The Candidate The successful candidate should have a good mathematical background and a good degree/diploma in an appropriate field such as earth science, physics, mathematics, computer science or engineering. Good written and spoken communication skills are essential.

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