New generation data assimilation and rapid response models for urban flooding

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Background: The combined effect of population growth and industrialisation in the UK means that coastal land areas are increasingly occupied by multiple user groups with diverse and competing needs (e.g. environmental, tourism, industrial). An important aspect of climate change is the increased likelihood of storms, and hence storm-surges and flooding, and this will have obvious impact upon low lying areas susceptible to diverse risks. There is thus an increased need to improve predictions (especially over a wide range of spatial scales - metres to many kilometres) and assess their impact, thereby helping policy makers, rescue services and scientists involved with ocean, climate change and risk reduction strategies. It is now generally recognised that the next generation of flooding models will be based on unstructured mesh technology as they are currently the only feasible way of resolving the important range of scales in coastal and urban regions.

The overall aim of this project is to develop an ultra-fast modelling software tool for modelling and forecasting and emergency management of interactions of urban pluvial, fluvial and coastal flooding. The proposed reduced order model (ROM) will include our newly developed advanced numerical methods and have the capability of reducing the CPU time by a factor of 100 ~ 10 3 while maintaining accuracy similar to the high fidelity model. The computational speed of this unique framework will enable rapid and fully nonlinear data assimilation (constraining models with measurements), uncertainty analysis, real-time interactive use (e.g. prediction of flooding in emergency situations), management (real-time flow monitoring/analysis etc.) and better informed decision-making. The predictive modelling will have the following features: 1) enable adaptive resolution of spatially and temporally distributed flooding interactions whilst providing measures of model error and sensitivities of the interactions field to changes in input data/parameters. 2) be highly implicit so very large time steps can be taken if desired, 3) equipped with efficient data assimilation algorithms for real-time exploitation of incoming information.

Novelty:

- **(1)** A unique combination of ROM and unstructured and adaptive mesh flooding modelling that will provide a fast yet accurate surrogate model for combined flooding and sewer systems, and thus allowing real-time operation;
- **(2)** A unique predictive modelling capability combining with ROM with EnKF and fully nonlinear Bayesian filters (data assimilation, optimization of sensors and experiments, uncertainty analysis, control).
- **(3)** Goal-based error measures for optimisation and quality control of ROM as well as for the full model entirely based on ensembles.
- **(4)** First use of adaptive meshing for combined flooding and sewer systems, within a data-driven framework supported by efficient assimilation capabilities.
- **(5)** Use of an oil and gas reservoir model (IC-FERST) for flooding modelling (developing Floodity) using analogy between the physics.

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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