Development of Risk-Based Investment Decision Making Tools in Water Framework Directive Studies.

WATER INFRASTRUCTURE AND RESILIENCE WIRe

EPSRC Centre for Doctoral Training

Philippa Mohan[1], Alma Schellart[1], Simon Tait [1], Chris Digman[2]

[1] The University of Sheffield, [2] Stantec

Significance of the Work

Regulation such as the Water Framework Directive (WFD) aims to protect and restore the ecological conditions of UK rivers. Currently the water industry spends upwards of tens of millions on water quality modelling and design frameworks for potential solutions in line with such regulation. Construction of solutions can be in the billions depends on the required outcomes. There are predictions that the cost will increase in future AMP cycle due to the current interest in storm overflows. Understanding the impact of uncertainty in these water quality models provides investment decision-makers more knowledge when considering solutions and hence a potential reduction in cost.

Aims: Project Overall

1. To develop a statistically based tool, which quantifies uncertainties in sub-models, and how uncertainty translates between models when applied in integrated catchment modelling.
2. To investigate the role of personal risk adverseness in terms of investment decision-making strategies.

Outcome: Project Overall

This allows the development of a tool, which incorporates model uncertainty into an objective investment decision-making strategy. It is the idea that this framework would be applied to a range of different catchments to evidence the potential cost variation of investment decision for WFD compliant solutions.

Background: Project Overall - Uncertainty

There is consensus that sources of uncertainty can be categorised into three categories: model parameter and input data; calibration process; and the model structure (see Tscheikner-Gratl *et al.,* 2019). Sensitivity analysis is the most established method in the literature of identifying the impact on uncertainty from model parameters (Wainwright *et al*. 2014). Primarily the literature on the calibration process and uncertainty has a focus the effectiveness of the calibration and verification process, with a lack of understanding of how uncertainty in measured calibrated data impact a model's predictive ability (see Brighenti *et al.,* 2019). The uncertainties from the model structure is a reflection on how well the model represents process in the natural system (Mustafa *et al.,* 2020). Uncertainty from model structure is often acknowledge but ignored and is sometime unknown as it can come from conceptual errors, accuracy of formula used and boundaries established in the method.

Methodology: Current Work

Rainfall estimates and associated uncertainty from the geostatistical work carried out by M. Muthusamy (Ph.D), were applied to a hydraulic network model in Infraworks of a small urban catchment, which was approximately 60km away from the area the rainfall was collected from and was believed to have similar climatic characteristics. The network model simulated three different rainfall events, with varying intensities. Peak flow rates were simulated in 5 pipes located at approximately 100, 500, 1000, 1500 and 2500 m from the most upstream end of the network, for 2, 5, 15 and 30 minutes temporal resolution and at the upper and lower 95% interval of the areal average rainfall intensity (AARI) for all three rainfall events.

Results and Discussion: Current Work

- Figure 1 shows short time intervals can also lead to large uncertainties. Shorter time intervals are of greater interest in urban hydrology
- Figure 2 illustrates the effect of the 95% prediction intervals on the range of peak pipe flows which could all be expected as true. For pipes 2, 3 & 4 for the 2 & 5-minute intervals, the 95% rainfall prediction interval leads to maximum of +37% and -32% changes in predicted peak in pipe flows. For comparison CIWEM (2017) recommends a 'green' confidence score when simulated peak pipe flow is between +25% and -10% of observed peak flow

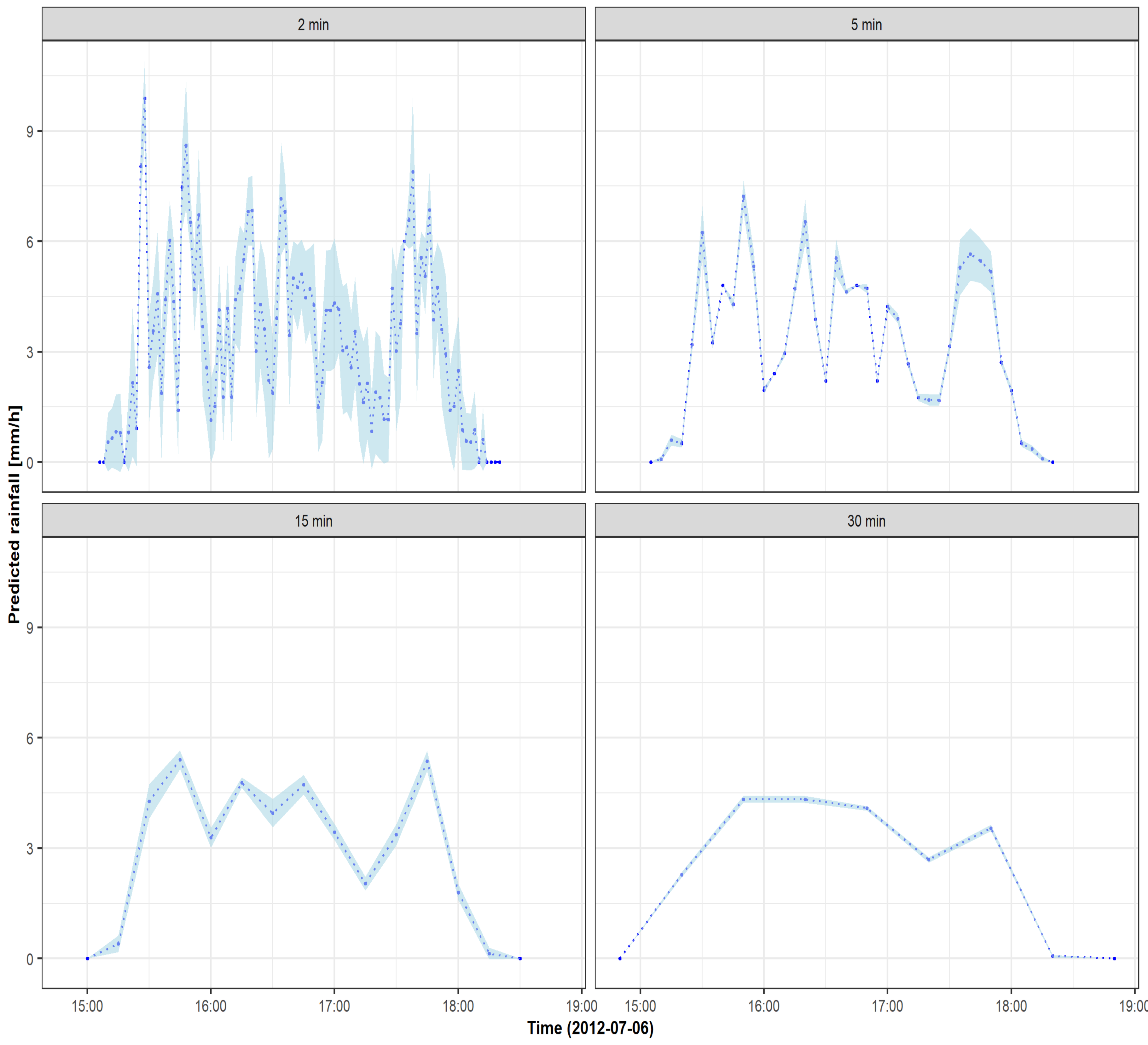

Figure 1; Predictions of AARI (indicated by points) together with 95 % prediction intervals (indicated by blue ribbon) for rainfall event 7 (Muthusamy created)

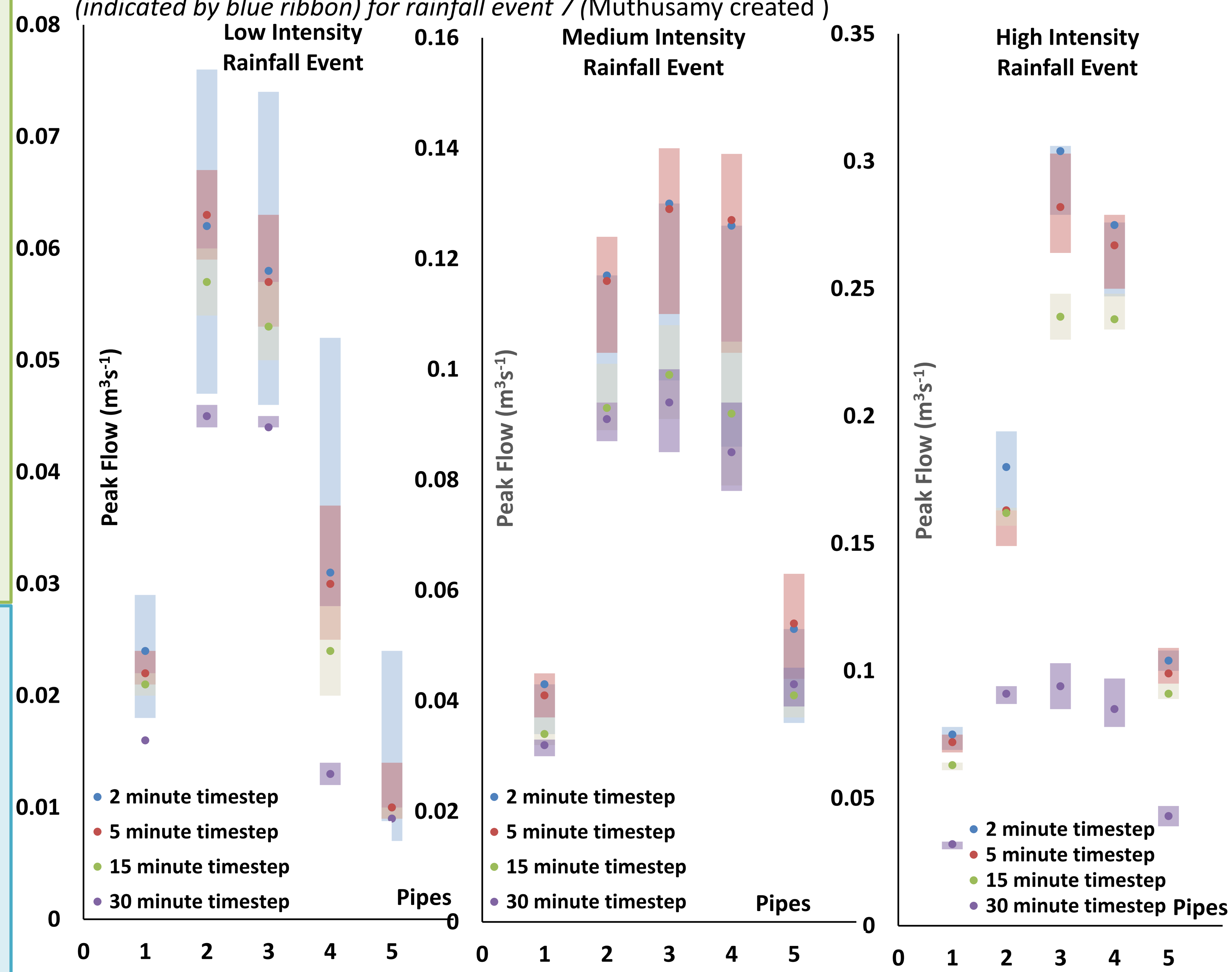

Figure 2; Peak flow at five pipes for 3 different rainfall events at time-steps 2, 5, 15 and 30 minutes. Point shows the predicted rainfall and shaded area is range from % predicted interval

Conclusions and Future Work

1. Currently work show that the effect of spatial rain gauge placement and temporal frequency of measurements collected do have influence on urban hydraulic models
2. Plans to build on this work include using a Monte Carlo simulation to find a probabilistic way of incorporating the spatial-temporal uncertainty around rain gauge into urban hydraulic models.
3. Future work will then look on the influence of personal risk adverseness when considering the effect of uncertainty on the assessment of WFD studies.
4. Finally a tool, which incorporates model uncertainty into an objective investment decision-making strategy will be made.

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www.cdtwire.com

For further information: pcmohan1@sheffield.ac.uk

Postal Address: Department of Civil and Structural Engineering S10 2TN

Stantec

The University Of Sheffield.

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