Pluvial flood forecasting in urban data-scarce regions: Influence of rainfall spatiotemporal data (in)accuracy on decision-making

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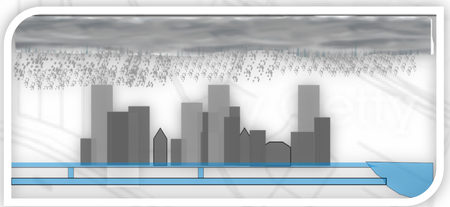
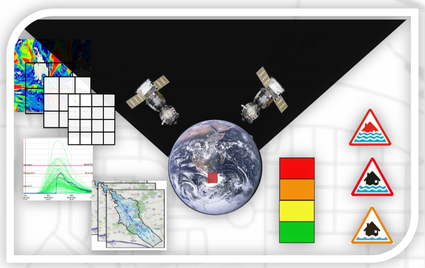
Introduction

Urban pluvial flooding refers to flooding from high-intensity rainfall which exceeds the design capacity of sewer networks and urban drains, inundating streets and low-lying areas.





Hybrid solutions such as Flood Forecasting (FF), anticipatory actions and advancements in hydro-meteorological forecasting techniques have been proposed to reduce impacts and disruptions by supporting decision-makers in issuing warnings and taking response.

Problem Description & Research Objective

- Decision making under uncertainty is a challenge
- Several sources of uncertainty exist down the FF chain (Fig. 1)
- Ensemble forecast can support probabilistic risk-based decision making
- However at the city scale there are challenges in accurately representing correct rainfall spatial and temporal patterns
- In data-scarce regions additional challenges persist due to a lack of high resolution forecast and observed rainfall and spatial data.

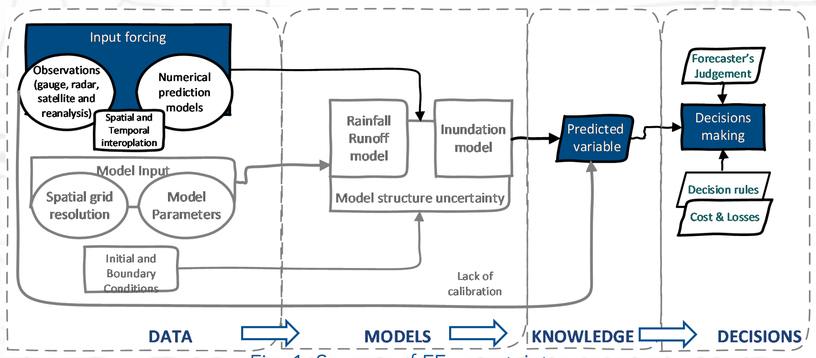
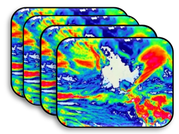


Fig. 1. Sources of FF uncertainty

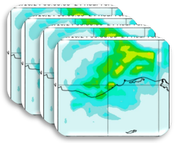
This research accepts there will be inaccuracies in the forecast and aims to evaluate the influence of uncertainty propagation from NWPs using ensembles and meteorological downscaling, not on forecast quality but rather on the ability to make decisions (forecast value).

Methodology

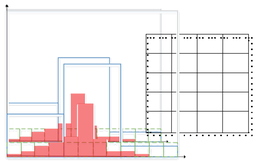
Downscaled Meteorological Forecasting



Initial and Boundary conditions Global Ensemble Atmospheric Models (GEFS & ECMWF)



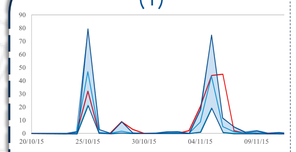
Limited Area Dynamically downscaled WRF model Nested Domains

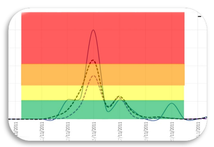


Pre-processing Global Precipitation Measurement data (GPM data)

Probabilistic Flood Forecast Approaches

(1)





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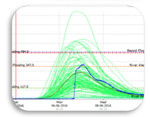
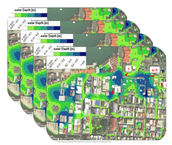




(1) Rainfall threshold method and (2) calibrated real-time Storm Water Management Model (SWMM) simulation

Decision Model

(1) Bayesian Decision Model

$$a_B(x) = \underset{a \in A}{\operatorname{argmin}} \int_{\Omega_y}^{y} U[a,y] f\{y|I\} dy$$

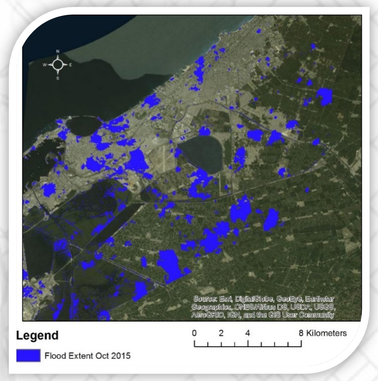
Optimal decision $a_B(x)$
Expected value , $E\{U[a,y]|I\}$
Utility function , $U[a,y]$
Predictive density , $f\{y|I\}$ (Savage, 1954)

(2) $\frac{Cost}{Loss} Ratio$

(Murphy, 1993)

Sensitivity Analysis and value of information analysis

Case study



Alexandria in Egypt and its neighbouring regions experienced heavy rainfall in a short duration in October and November 2015, which resulted in a major flood. (Fig. 2). Early warning systems and flood forecasting have been proposed as measures but the city continues to be challenged by data limitations

Fig. 2. : Flood map of Alexandria on October 26, 2015 from LANDSAT-8 images. (Bhattacharya et al. 2018)

Anticipated Limitations

- Limitations in the number of historical events, availability of impact data and damage functions
- While other sources of uncertainty exist, considers rainfall data input uncertainty at this time
- Assesses normative decision frameworks only

Conclusions & Future research

Much of the scientific literature addresses the prediction problem independent of the decision-making problem. The research aims to understand the interdependences of the flood forecast and decision-making chain in order to facilitate better decisions given the quality of available data.

The next phase of this research will consider the data, model, knowledge and decision-making inter-dependencies of a "data-rich" case study.

References

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