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Climate and change: simulating flooding impacts on urban transport network

Maria Pregnolato, Alistair Ford, and Richard Dawson
School of Civil Engineering and Geosciences,Newcastle University, Newcastle upon Tyne, UK

National-scale climate projections indicate that in the future there will be hotter and drier summers, warmer and wetter winters, together with rising sea levels. The frequency of extreme weather events is expected to increase, causing severe damage to the built environment and disruption of infrastructures (Dawson, 2007), whilst population growth and changed demographics are placing new demands on urban infrastructure. It is therefore essential to ensure infrastructure networks are robust to these changes.

This research addresses these challenges by focussing on the development of probabilistic tools for managing risk by modelling urban transport networks within the context of extreme weather events. This paper presents a methodology to investigate the impacts of extreme weather events on urban environment, in particular infrastructure networks, through a combination of climate simulations and spatial representations. By overlaying spatial data on hazard thresholds from a flood model and a flood safety function, mitigated by potential adaptation strategies, different levels of disruption to commuting journeys on road networks are evaluated. The method follows the Catastrophe Modelling approach and it consists of a spatial model, combining deterministic loss models and probabilistic risk assessment techniques. It can be applied to present conditions as well as future uncertain scenarios, allowing the examination of the impacts alongside socio-economic and climate changes.
The hazard is determined by simulating free surface water flooding, with the software CityCAT (Glenis et al., 2013). The outputs are overlapped to the spatial locations of a simple network model in GIS, which uses journey-to-work (JTW) observations, supplemented with speed and capacity information.
To calculate the disruptive effect of flooding on transport networks, a function relating water depth to safe driving car speed has been developed by combining data from experimental reports (Morris et al., 2011) safety literature (Great Britain Department for Transport, 1999), analysis of videos of cars driving through floodwater, and expert judgement.
A preliminary analysis has been run in the Tyne & Wear (in North-East England) region to demonstrate how the analysis can be used to assess the disruptions for commuter journeys due to flooding and will be demonstrated in this paper. The research will also investigate the effectiveness of adaptation strategies for extreme rainfall events, such as permeable surfaces and roof storages for buildings. Multiple scenarios (from the every-day-rainfall to the extreme weather phenomena) will be modelled, with different rainfall rates, rainfall durations and return periods. The comparison between the scenarios in which no interventions are adopted and those improved by one of the adaptation option will be compared to determine the cost-effectiveness of the solution considered.

Integrating spatial analysis of transport use with an urban flood model and flood safety function enables the investigation of the impacts of extreme weather on infrastructure networks. Further work will develop the analysis in a number of ways (i) testing a range of flood events with different severity and frequency, (ii) exploration of the influence of climate and socio-economic change (iii) analysis of multiple hazard events and (iv) consideration of cascading disruption across different infrastructure networks.