



Multivariate spatial analysis of a heavy rain event in a densely populated delta city

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Delta cities account for half of the world's population and host key infrastructure and services for the global economic growth. Due to the characteristic geography of delta areas, these cities face high vulnerability to extreme weather and pluvial flooding risks, that are expected to increase as climate change drives heavier rain events. Besides, delta cities are subjected to fast urban densification processes that progressively make them more vulnerable to pluvial flooding. Delta cities need to be adapted to better cope with this threat. The mechanism leading to damage after heavy rains is not completely understood. For instance, current research has shown that rain intensities and volumes can only partially explain the occurrence and localization of rain-related insurance claims (Spekkers et al., 2013). The goal of this paper is to provide further insights into spatial characteristics of the urban environment that can significantly be linked to pluvial-related flooding impacts.

To that end, a study-case has been selected: on October 12 to 14 2013, a heavy rain event triggered pluvial floods in Rotterdam, a densely populated city which is undergoing multiple climate adaptation efforts and is located in the Meuse river Delta. While the average yearly precipitation in this city is around 800 mm, local rain gauge measurements ranged from approx. 60 to 130 mm just during these three days. More than 600 citizens' telephonic complaints reported impacts related to rainfall. The registry of those complaints, which comprises around 300 calls made to the municipality and another 300 to the fire brigade, was made available for research. Other accessible information about this city includes a series of rainfall measurements with up to 1 min time-step at 7 different locations around the city, ground-based radar rainfall data (1 Km² spatial resolution and 5 min time-step), a digital elevation model (50 cm of horizontal resolution), a model of overland-flow paths, cadastral maps describing individual location and types of buildings, and maps on categorical socioeconomic statistics (1 Ha of spatial resolution).

On the basis of the quality and availability of the mentioned information, spatial and temporal units of analysis will be discussed and defined. Aggregation of single occurrences for binary variables will be performed, while simple interpolations or averages will be used in case of continuous or categorical data. To determine spatial clustering within each variable, Nearest Neighbor Distance and Spatial Autocorrelation tests will be carried out. When appropriate, the Getis-Ord G_i^* test will be used to identify single variable clusters. Finally, with the purpose of inferring possible associations between the available spatially distributed variables, a Mantel test will be applied to variables with a probed non-random spatial pattern. The results of this paper will allow to determine if the environmental characteristics described by the available data can provide additional explanation of the variability of rain-related damage in a delta city which is willing to become climate-proof.