Analysis of pluvial flood damage based on data from insurance companies in the Netherlands

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Abstract

Insurance databases form a promising data source that can be used to improve pluvial flood damage estimations. This paper describes the key characteristics of an insurance database on water related damages to private buildings and content in the Netherlands that has been made available for research. The paper presents preliminary results of a case study where insurance data are explored to find relationships between rainfall characteristics and pluvial flood damage. The results show that variations in damage are partly related to rainfall characteristics. More research on rainfall characteristics and other explanatory variables of flood damage is needed to capture the processes causing damage.

Introduction

Intense localised rainfall may generate overland flows and pooling in urban areas, causing damage to buildings, infrastructure and inconvenience to people. This happens when rainfall overloads the urban drainage system, or is for some reason unable to enter the urban drainage system. This process is commonly known as pluvial flooding. Some severe cases show the catastrophic consequences of pluvial flooding. In the summer of 2007 the City of Hull (UK) suffered from severe pluvial flooding, causing damage to over 8600 houses and 1300 premises [2]. Similarly, in several parts of the Netherlands, intense rainfall in autumn of 1998 caused damage to 2470 houses, 1220 premises and 350 governmental agencies [4]. However, not only severe events cause damage. The cumulative damage of smaller flood events over the lifetime of urban drainage systems can be considerable [8]. This is particularly true for lowland areas where pluvial floods have relatively high occurrence frequencies and small flood depths (<20 cm).

Damage data on pluvial flooding are scarce and therefore flood damage estimations are subject to large uncertainties. Freni et al. [3] argue that the main bottleneck in quantitative flood damage estimation is related to data availability. Damage models are affected by uncertainty related to the collected data and to the structure of the adopted functional relationships. Insurance databases are a promising source of flood damage data. The drawback of this source is that access to data is difficult due to privacy rules. Based on a questionnaire, only 4 out of 48 insurance companies in Germany were willing to provide data [1]. The Association of British Insurers presently only aggregates national damage data and does not hold local damage data [5].

Recently, a database containing information on pluvial flood damage has been made available for research by the Dutch Association of Insurers. This paper describes the key characteristics of the database. The paper presents preliminary results of a case study in the Netherlands where the usage of damage data is explored. The damage data are used to study correlations between rainfall characteristics and observed damage.

Insurance damage data in the Netherlands

Background

In the Netherlands, private persons and companies can insure their property and content for water related damages. Homeowners can insure both their property and their content. Renters can only insure their content; while the landlord is responsible for property damage. Companies can insure their commercial premises and goods.

Table 1 summarizes the three causes of water related damages that are covered by property and content insurances. Damage around or in the building is only covered if damage was unforeseen. It is, for example, the property owners' responsibility to close windows and doors and to properly maintain the building. Damage due to flooding from sewer systems or regional watercourses was included in nearly all insurance policies after 2000 following an advice issued by the Dutch Association of Insurers [6]. Damage due to flooding from sewer systems or regional watercourses should be directly and solely related to local extreme rainfall for a claim to be accepted. Flooding from rivers, sea or groundwater is not commonly insured in the Netherlands and therefore if pluvial flooding coincides with other flood types, the damage is not insured. In addition, the rainfall event should have a minimum intensity to be considered as 'extreme'. The Dutch Association of Insurers defined 'extreme' rainfall when rainfall intensity is higher than 40mm in 24 hours, 53mm in 48 hours or 67mm in 72 hours [6]. The intensities are related to rainfall events with occurrence frequencies once every 3 to 7 years. The reasoning behind this is to prevent reoccurring claims of damaged buildings that are built on very vulnerable locations; they are by no means related to minimum water system requirements. However, it is unclear how and to what extent fulfilment is examined by the insurance companies.

Database of damage to private buildings and content

There are two kinds of insurance databases available that contain data on pluvial flood damage: 1) a database of damage to commercial premises and goods and 2) a database of damage to private buildings and content. The first database is less suitable for research as it contains data from a limited number of insurance companies and data is stored in different database structures, making it hard to analyse the data as a whole. The second database is more extensive than the first one; the number of damage records in the database cover around 20-30% (on average for every year) of the damage records of all insurance companies in the Netherlands. The data are systematically stored in a data warehouse environment (using SAS 9.2 software). This study will therefore focus on the second database. The database does not record property damage of rented properties, as this is part of the database of damage to commercial premises and goods.

Table 1: Different causes of water damage covered by property and content insurances.

	Water related damages	Examples of causes	Responsible for flood management	Pluvial flooding as defined in this paper
1	Damage around or in building	breach of a water pipe inside a building rainfall leaking through a roof water flowing from garden into a building	Homeowner	no
2	Damage due to sewer flooding	sewer surcharge inside a building water on the street flowing into a building	Municipality	yes
3	Damage due to flooding from regional watercourses	overflowing of watercourses causing water to enter a building	Water board	yes

Table 2: Variables in property and content database of the Dutch Association of Insurers.

Damage records	Policy holder records
claimed damage	policy holder location
damage paid out	insured sum of property
date damage occurred	insured sum of content
damage cause	property details
policy identification key	start and end date policy
	policy identification key

Two different records can be distinguished: 1) damage records and 2) policy holder records. The most relevant variables in both records are listed in table 2. The records can be linked using a unique policy identification key. The claimed damage is based on the replacement values of materials and objects. In most cases the damage paid out by insurance agencies equals the claimed damage, except in cases that do not fulfil the policy conditions, then the damage paid out is 0. No or only limited information is provided in the records about the damage cause; in case of content damage four groups are distinguished: 1) water pipe leakage, 2) rainfall, snow or meltwater, 3) rest group and 4) cause unknown. The first group is the only damage cause that is clearly defined, while the other three are subject to different definitions by different insurance companies and are therefore treated as one. Group 2, 3 and 4 contain damage related to failure of urban drainage systems and failure of building elements such as leakage of roofs and building apertures. In case of property damage no subcategories exist.

Table 3 summarizes the key characteristics of the database. Information on content and property damage and policies are available from 1992 to 2009 (17 years) and 1986 to 2009 (23 years) respectively. The database contains on average 1.8 million content policies per year and 0.8 million property policies per year. These numbers are corrected for those policy records that are only valid for a part of the year. The policy records include multiple entries for cases where people moved to a new address and did not change insurance agency. The damage records are checked on errors and inconsistencies: duplicate records, damage records with no or zero damage (not paid out by insurance agency) and records without (valid) identification key or location have been removed. The damage values are corrected for inflation according to Statistics Netherlands [7]. 52% of the content damage claims are related to water pipe leakage and are thus not of interest for this study. The values related to the property claims also contain cases of damage due to water pipe leakage that are not distinguished separately in the database. The average content claim (not related to water pipe leakage) is 799 euro. The average property claim is a higher, namely 1098 euro, with half of the claims smaller than 582 euro. The damage data is therefore non-symmetrically distributed. The average damage per year is 7.5 million euro for content damage (excluding water pipe leakage) and 17.8 million euro for property damage (including water pipe leakage).

Table 3: Key characteristics of water damage in database of Dutch Association of Insurers.

Record type	Period	Total number of policies in millions per year	Total number of claims	Total damage [million euro]	Damage per year [million euro/year]	Mean [euro]	Median [euro]	St dev [euro]	P10 [euro]	P90 [euro]
Content	1992-2009	1.8	174324[a]	137[a]	8.1[a]	785[a]	401[a]	1458[a]	115[a]	1708[a]
			160406[b]	128[b]	7.5[b]	799[b]	408[b]	1501[b]	111[b]	1743[b]
Property	1986-2009	0.8	372959	409	17.8	1098	582	2181	157	2391

[a]Categorized as 'water pipe leakage' | [b]Categorized as 'rainfall, snow or meltwater', 'rest group' or 'cause unknown'

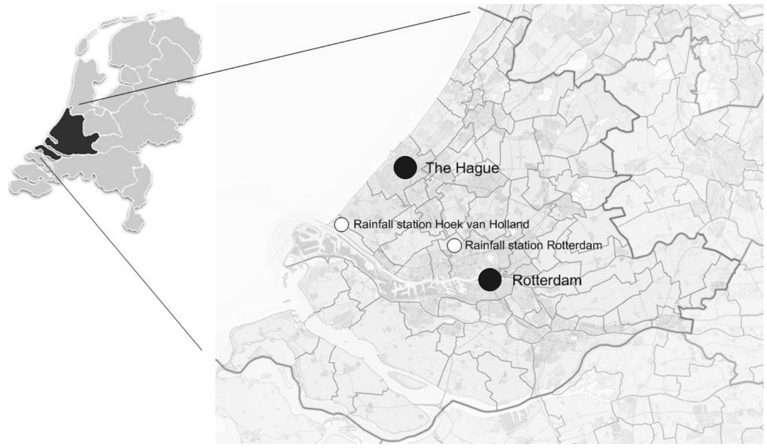

Figure 1: The province of South-Holland and the locations of the rainfall stations.

Case study: pluvial flooding summer 2004, South-Holland

Case study description

During the summer of 2004 the southwest and north of the Netherlands suffered from pluvial flooding. The average rainfall volume of the months June, July and August was 328 mm, with maxima ranging from 50-80 mm/day, as recorded by 300 rainfall stations of the Royal Netherlands Meteorological Institute. The case study focuses on the province of South-Holland, which is located in the western part of the Netherlands (figure 1). The total surface area of South-Holland is 3400 km^2 of which 600 km^2 is water. 73 cities are located in the area with a total of 3.5 million inhabitants and 135000 businesses. The largest cities are Rotterdam (611000 inhabitants) and The Hague (494000 inhabitants). The maximum rainfall volume for the month August 2004 in South-Holland was measured by a rainfall station in Maasland, which was 325 mm/month. This station also measured the maximum daily rainfall intensity of 67.1 mm/day on 13 August 2004. Local rainfall overloaded sewer systems. Local newspapers recorded cases of flooding of streets, gardens, kitchens, basements and crawl spaces. The case study presents preliminary results where insurance data are explored to find relations between rainfall characteristics and damage in South-Holland during the summer of 2004.

Methods

Damage data was selected for the period of 1 July 2004 to 30 September 2004 for the province of South-Holland. The summer of 2004 was selected because of the large number of intense rainfall events that occurred in only a few weeks. In addition, after 2000 nearly all insurance companies included flooding from sewer systems and regional watercourses in their policy conditions [6]. The selection encompasses 679 property claims and 381 content claims. 31% of the content claims are related to water pipes leakage and these records are therefore excluded in this study. It is assumed that similar percentage of the property records is also related to water pipe leakage. The total property damage per day is multiplied with a factor 0.69 to correct for water pipe leakage. The records were summarized per day (92 days in total). For every day, the total damage (sum of content and property damage), the average damage per content and property claim, the total number of claims (sum of content and property claims) were calculated. Rainfall characteristics were obtained from measurements of two rainfall stations of the Royal Netherlands Meteorological Institute; one located in the north of Rotterdam and the other one near the coast at Hoek van Holland (see figure 1). The two stations recorded for every day the maximum hourly rainfall intensity (mm/hour) and the daily rainfall volume (mm/day).

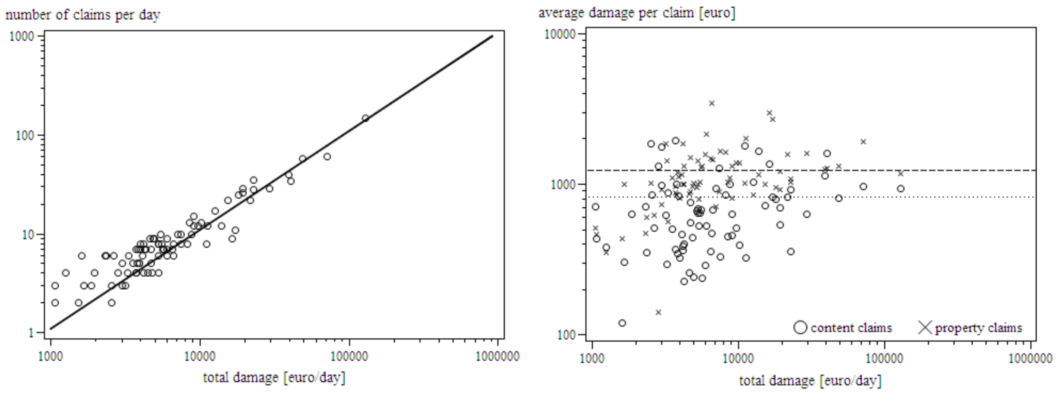

Figure 2: The number of claims per day versus the total damage per day (left) and the average content/property damage per day versus the total damage per day (right). Dotted line is mean content damage (817 euro), dashed line is mean property damage (1229 euro).

Results and discussion

Figure 2 shows the number of claims per day as a function of the total damage per day (left) and the average content and property damage per claim (per day) as a function of the total damage per day (right), where every data point represents a day. The number of claims increases linearly for increasing total damage with a coefficient of determination R^2 of 0.96. Days with total damages <10000 euro show more variation in the number of claims than days with total damages >10000 euro. A possible explanation for this is that days with larger total damages are based on more claims and therefore the average damage per claim is less affected by outliers in the data. The average content and property damage show no clear relation with the total damage. The standard deviations of the average content and property damage per day is 416 euro and 553 euro, respectively. Figure 3 shows the total damage per day (euro/day) as a function of the maximum hourly rainfall intensity (mm/hour). There is no clear relation between total damage and hourly rainfall intensity for rainfall intensities <5 mm/hour (left). Even for days without rainfall the total damage varies between 1000 and 30000 euro. This can be explained by 1) damage records in the database that are not directly linked to rainfall and 2) damages that are linked to rainfall that was not recorded by the rainfall stations that recorded hourly rainfall intensities. For days with rainfall intensity >5 mm/hour (right figure) a number of days shows a relation with rainfall; these days have damages between 30000 and

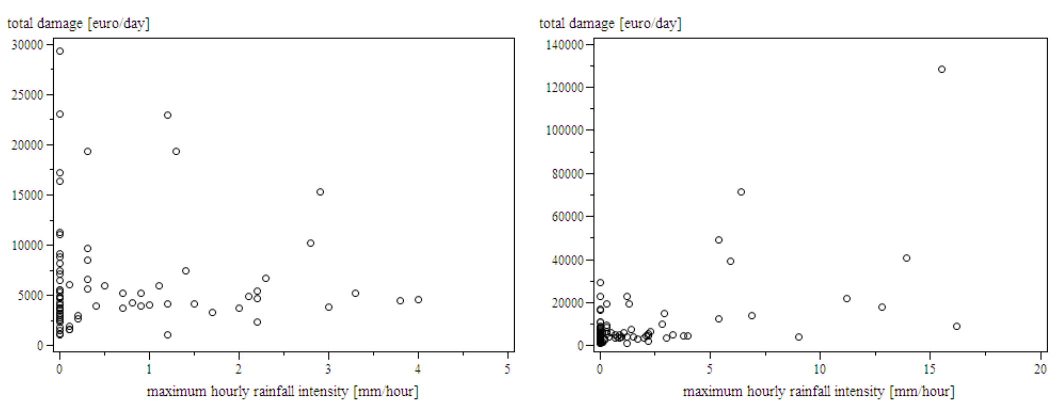

Figure 3: Total damage of a day (euro/day) as function of the maximum hourly rainfall intensity of a day (mm/hour) for Hoek van Holland. Similar rainfall characteristics were measured for Rotterdam. The left figure zooms in on rainfall intensity <5 mm/hour.

120000 euro/day. The variations in damages between days can be explained by 1) the fact that the rainfall stations are not representative for the whole area and 2) other explanatory factors besides rainfall that affect damage, such as building properties, the local functioning of the urban drainage systems and topographical characteristics.

Conclusion and recommendations

- Preliminary results for a case study in the Netherlands and one summer season of damage and rainfall data show that part of the damage records can be related to rainfall characteristics, although a clear relation with rainfall could not be formulated for this case study.
- The total water related damage is strongly related to the number of claims. It is unclear whether the average damage of a claim correlates with the total damage.
- Variations in damage can not only be explained by rainfall characteristics and therefore it is recommended to also study other explanatory variables, such as buildings properties and characteristics of the urban drainage system.
- It is unknown to what extent damages recorded in the database are caused by flooding from sewer systems and regional watercourses. It is recommended to carry out additional interviews with damage experts to estimate the relative contributions of different causes to water damage.
- Future studies should narrow the spatial scales in such a way that local rainfall data can be more directly linked to local claimed damages. For this time series of several years of damage observations and rainfall characteristics should be used to make the data analysis statistically sound.

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