A damage model for heavy rainfall?
A spatial analysis of rainfall damage data using C-band weather radar images

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September 5, 2013
Risks of heavy rainfall

- local (pluvial) floods
- short
- frequent
- few decimeters of water (particularly true in flat areas)
- hardly any casualties (idem)
Water-related damage in 2011*

<table>
<thead>
<tr>
<th>Country</th>
<th>Population</th>
<th>Total damage</th>
<th>Related to rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Netherlands</td>
<td>16.7m</td>
<td>332m</td>
<td>136m</td>
</tr>
<tr>
<td>Denmark</td>
<td>5.5m</td>
<td>894m</td>
<td>800m</td>
</tr>
<tr>
<td>Sweden</td>
<td>9.1m</td>
<td>410m</td>
<td>n/a</td>
</tr>
<tr>
<td>Norway</td>
<td>4.7m</td>
<td>234m</td>
<td>n/a</td>
</tr>
</tbody>
</table>

*) figures are in Euros and related to residential buildings only; definition of water-related damage may vary between countries
Flood damage estimation

To estimate damage of a single element (e.g. building) or a spatially aggregated unit (e.g. neighbourhood)

- Traditional damage model: flood depth, building class $\rightarrow \mathbb{E}$
  - Poor 1-on-1 relationship between flood depth and damage
- For pluvial flooding in flat areas, ‘flood depth’ is not meaningful
  - Only a very small range of flood depths
  - We cannot reliably predict flood depths (yet)
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The many factors contributing to rainfall damage

- Building-related properties
- Socio-economic factors of insured household
- Rainfall characteristics
- Local topographic features
- Drainage system characteristics

Heavy rainfall damage to residential buildings
The many factors contributing to rainfall damage

Heavy rainfall damage to residential buildings

- Rainfall characteristics
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See e.g. Cheng (2012), Zhou et al. (2013), Spekkers et al. (2013), Einfalt et al. (2012), Climate Service Center (2013)
1. Insurance database of Dutch Association of Insurers

- Insurance for private property and content
- Claims are related to heavy rainfall: sewer floods, roof leakages, etc.
- Data cover 30% of the insurance market, 1986–2011
- Spatially aggregated unit: neighbourhood level

2. KNMI C-band weather radar

- 1998–2012
- Covering the entire land surface
- 1-km spatial resolution (2.5-km before 2009)
- One image every 5 minutes
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At radar pixel level

- Maximum intensity
- Mean intensity
- Volume
- Duration

At neighbourhood level

- Claim ratio
- Total damage
- Average damage
Pearson correlations based on 150 days of data

<table>
<thead>
<tr>
<th></th>
<th>Claim ratio*</th>
<th>Total damage*</th>
<th>Average damage*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum intensity</td>
<td>0.38</td>
<td>0.21</td>
<td>0.12</td>
</tr>
<tr>
<td>Mean intensity</td>
<td>0.25</td>
<td>0.17</td>
<td>-</td>
</tr>
<tr>
<td>Volume</td>
<td>0.26</td>
<td>0.16</td>
<td>-</td>
</tr>
<tr>
<td>Duration</td>
<td>0.06</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*) damage variables were log-transformed
Conclusions and future work

- Spatial match, but no clear rainfall thresholds
- More intense rainfall results in more claims, not higher claims → implications for damage modelling
- Multivariate analysis: include topographic, socio-economic, building-related factors → rainfall thresholds?