Predicting present and future coastal flood risk in North East Wales

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North East Wales

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Previous flooding
5th December 2013

Peak Offshore Conditions
skew surge = 0.88m
sea level = 5.43m AOD
Hs = 4.58m
Tm = 6.58s
direction = 285°

Damage
• 170 homes flooded
• 400 people evacuated
• 4 casualties
• 5 electrical fires

2013 flood maps didn’t include the threat from overtopping
New Study
**Method**

Multi-variate statistical analysis of water levels and offshore wave and wind conditions. Produce Monte Carlo sample representing 10,000 years.

**Inundation Modelling**

Wave Transformation modelling & emulation

10,000 years of inshore waves

**Overtopping**

Calculate return periods

**Inundation Modelling**

[Image source: www.bbc.co.uk]
Statistics
Multi-variate statistical analysis

Marginal Modelling: Hs, Tm, wind speed and skew surge

Describe the distribution of each variable independently

Empirical distribution of ‘everyday’ conditions

Generalised Pareto Distribution

Distributions were fitted so as to replicate the physical limits of this location:

- Wind speed upper end point: bottom of hurricane scale (33 m/s)
- Wave height & period upper end point: consistent with British Standard nomograph
Multi-variate statistical analysis

Dependence Modelling

Find the relationship between variables
Used the Heffernan & Tawn dependence model

<table>
<thead>
<tr>
<th>Hs</th>
<th>Skew Surge</th>
<th>Tm</th>
<th>Wind Speed</th>
</tr>
</thead>
<tbody>
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<td></td>
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</tbody>
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- Hs
- Skew Surge
- Tm
- Wind Speed
Multi-variate statistical analysis

Monte Carlo sample

Create a Monte Carlo sample of offshore conditions with the same properties as the observed data. This sample represents 10,000 years.
Future Risk: changing offshore climate

- Waves are fetch limited
- Future wave and wind climates were not changed
- Sea level rise applied before waves were transformed into the nearshore

<table>
<thead>
<tr>
<th>Epoch</th>
<th>2017</th>
<th>2067</th>
<th>2092</th>
<th>2117</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSL increase (m)</td>
<td>0</td>
<td>0.41</td>
<td>0.71</td>
<td>1.08</td>
</tr>
</tbody>
</table>
Numerical Modelling
Wave Transformation Modelling

- SWAN
- Spatially varying water level grid
- ‘Calibrated’ against RADAR observations
Wave Emulation

- Offshore dataset represents 10,000 years includes 172,342 events
- Simulated 800 events with SWAN
- Used emulators to transform the remaining events into nearshore conditions
Wave Overtopping

- Split coastline into 32 sections with similar defence and wave characteristics
- Calculated overtopping using Neural Network
- Calibration against flood history: hindcast
Wave Overtopping: Hindcast

Image: google.co.uk
Wave Overtopping: validation
Inundation Modelling

- TUFLOW and Flood Modeller (ISIS) coupled
- 2D finite difference – 1D river model
- 5m grid
- Run for 3 tidal cycles
- Varying offshore water levels
- Overtopping inflows
Simulation of 5th Dec 2013
Using the results to manage flood risk
Managing coastal flood risk

- Study results will be used to update NRW flood warning and alert thresholds and areas.

- The study outputs will also be used inline with Planning Policy Wales to prevent inappropriate development on the flood plain.
Coastal Hazard Maps
Questions?
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