Real-time modelling of surface water flooding hazard and impact at countrywide scales

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What is the Natural Hazards Partnership?

Natural Hazards Partnership
Delivering coordinated assessments, research and advice on natural hazards for governments and resilience communities across the UK

Real-time Hazard Impact Model: Surface Water Flooding
Surface Water Flooding

- **Surface Water Flooding (SWF)**
  - Major hazard with ~4 million properties at risk in England alone (EA, 2009)

- **Summer 2007 floods**
  - £3 billion insurance payouts
  - 55,000 properties flooded, ~36,000 due to SWF
  - National infrastructure impacts
    - 140,000 homes *without clean water* for 17 days
    - 42,000 homes *without power* for 24 hours
    - 10,000 people trapped on M5
  - Pitt Review commissioned
  - Flood Forecasting Centre & Scottish Flood Forecasting Service formed
Surface Water Flooding Alerts: Approaches

- Rainfall-based alerts (current practice)
  - Uses national rainfall-thresholds and broad soil moisture & urban effects
  - Supports FFC Surface Water Decision Support Tool (Spreadsheet)
  - Feeds in to FFC daily Flood Guidance Statement
Surface Water Flooding Alerts: Approaches

- **Rainfall-based alerts (current practice)**
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- **Localised runoff thresholds (ongoing NHP developments)**
  - G2G distributed hydrological model *converts rainfall to runoff*
  - G2G *soil moisture conditions influence surface runoff production*
  - Scientific advances to improve *national SWF hazard footprint*
  - G2G already used by FFC & SFFS so “quick win” potential

- **New impact assessments (ongoing NHP developments)**
  - Use existing national datasets on *property, infrastructure & population*
  - Case studies show potential for *real-time hazard and impact forecasts*
Uses spatial datasets on **terrain, soil/geology, land-cover**

Responds to **spatial variation of rainfall input**

Used **operationally across Britain at a 1km 15 min resolution**

Moore et al., IAHS Publ. 305 (2006)  
Price et al.; Cranston & Tavendale, Water Management (2012)
Factors affecting G2G runoff production

- **Soil properties**
  - (for each HOST class)

- **Terrain/slope**
  - Steep slopes → Shallow storage
  - Shallow slopes → Deep storage

- **Soil Moisture Deficit**
  - (modelled)

- **Urban/Suburban coverage**
  - Increase runoff (by decreasing soil depth)

- **Gridded rainfall**
G2G runoff alerts for surface flooding

- National rainfall-thresholds
  - Based on Extreme Rainfall Alert method
  - Uses FEH 30 year return period rainfalls “averaged” across 8 UK cities

- **G2G runoff production** affected by:
  - Rainfall amount **plus**
  - Urban/suburban coverage
  - Soil and geology properties
  - Antecedent soil moisture conditions

- Prototype runoff threshold exceedances seem **more targeted**
SWF Case Study: 2-3 August 2011

- 2-3 August 2011 event
  - FFC identified event with SWF impacts
  - Peak radar accumulations of 40-60mm near York and Goole
  - Reports of flooding at Thorne and York
  - Goole badly affected including a residential home

- End-to-end case study to produce first SWF impact maps
  - Note uses radar-rainfall and not forecasts
  - Good first step guiding future development
SWF Case Study: 2-3 August 2011

- Evolution of rainfall and surface-runoff accumulation maps
- Reported flood locations highlighted (FFC data)
**SWF Case Study: rainfall vs surface-runoff**

1h rainfall totals
- >30mm
- >25mm

1h runoff totals
- >8.5mm
- >7mm

**Thorne**
- ERA Threshold Crossed
- G2G Threshold Not Crossed

**Thorne**
- ERA Threshold Not Crossed
- G2G Threshold Crossed

**17:00**
- Heavy rain
- Low runoff %
- Pixel becomes saturated

**18:00**
- Moderate rain
- High runoff %
- Saturated

SMD recovers
Example SWF impact output

- Impact Summary over time-frame of event

Dringhouses (York)
At Risk Within High Hazard Area:
- 152 residential dwellings
- Home to 354 people
Vulnerable People
- 85 potentially requiring assistance
Vulnerable Locations
- none identified
Transport
- York-South Railway Line

Camblesforth / Brayton (peak 6pm)
At Risk within High Hazard Area:
- 0 dwellings affected
Infrastructure
- Drax Power Station

Goole (peak 5pm)
At Risk within High Hazard Area:
- 3105 residential dwellings
- Home to 7211 people
Vulnerable People
- 1730 potentially requiring assistance
Vulnerable Locations
- Goole Hospital (82)
- 1 School (109)
- 2 Care homes (42)
Transport
- Goole to Hull Railway Line

Hazard Rating

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SWF Impact Modelling approach

- Ensemble rainfall forecasts (MO)
  - Hazard Footprint
    - Based on G2G surface runoff
  - Impact Library (HSL)
- National Receptor Dataset (EA)
- Other impact datasets...
- Hazard Impact Outputs
  - Updated Flood Map for Surface Water UFMfSW (EA)
  - National Population Database (HSL)
Impact Library

- Pre-calculate 1km Impact Library, using uFMfSW scenarios (e.g. 30yr, 1hr storm) and national datasets on population and receptors
- Criteria based on defined set of flood impacts
  1. Danger to life
  2. Damage to Buildings
  3. Disruption of Key Sites and Infrastructure
  4. Disruption of Transport
  5. Disruption of Communities
- Evidence-based approach for impact assessment methodology
- 1km impact output and regional summary
- Link impact and likelihood to Flood Risk Matrix used by EA/FFC
Link G2G Hazard Footprint to impact

- Calculate G2G surface runoff accumulations
- Exceeds UFMfSW “net rainfall” scenario?
- Use Impact Library to assess impact
Probabilistic impact products

Proof-of-concept hazard impact forecast system:

- Regional impact summary for each ensemble member
- Summarise for time, space & uncertainty
- Reporting by County/Authority
- Combine impact and likelihood to calculate risk
Case study

- Proof-of-concept outputs (26-28 June 2012)
- Compared to “actual” risk as assessed by FFC
- Impact forecasts show promise

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<tr>
<th>Forecast Origin</th>
<th>Darlington</th>
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<th>Northumberland</th>
<th>Tyne and Wear</th>
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**Region** | **Post Event Impact Level** | **Forecast Likelihood**
--- | --- | ---
Northumberland | Significant | Medium
Tyne and Wear | Severe | Medium
Summary and Next Steps

- **Proof-of-concept NHP Hazard Impact Model for SWF shows potential for nationwide application**
  - Supported by positive feedback from SEPA of similar system trialled during Commonwealth Games (earlier talk 2-9S)

- **Targeted improvements to methodology**
  - Runoff-production, impact datasets, impact calculations, ...
  - Explore closer links to high-resolution inundation modelling

- **Further case studies and validation**
  - Historical SWF footprint and impact data scarce

- **Presentation of outputs key for end-users**

- **Near-operational end-to-end trial by FFC in 2015**