Real-time hazard impact modelling for surface water flooding: some UK developments

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Session B1: Flood Hazard Mapping

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2 Health & Safety Laboratory
3 FLOODFORECASTINGCENTRE, a working partnership between Environment Agency and Met Office
4 Environment Agency

What is the Natural Hazards Partnership?

Natural Hazards Partnership (NHP) Scope

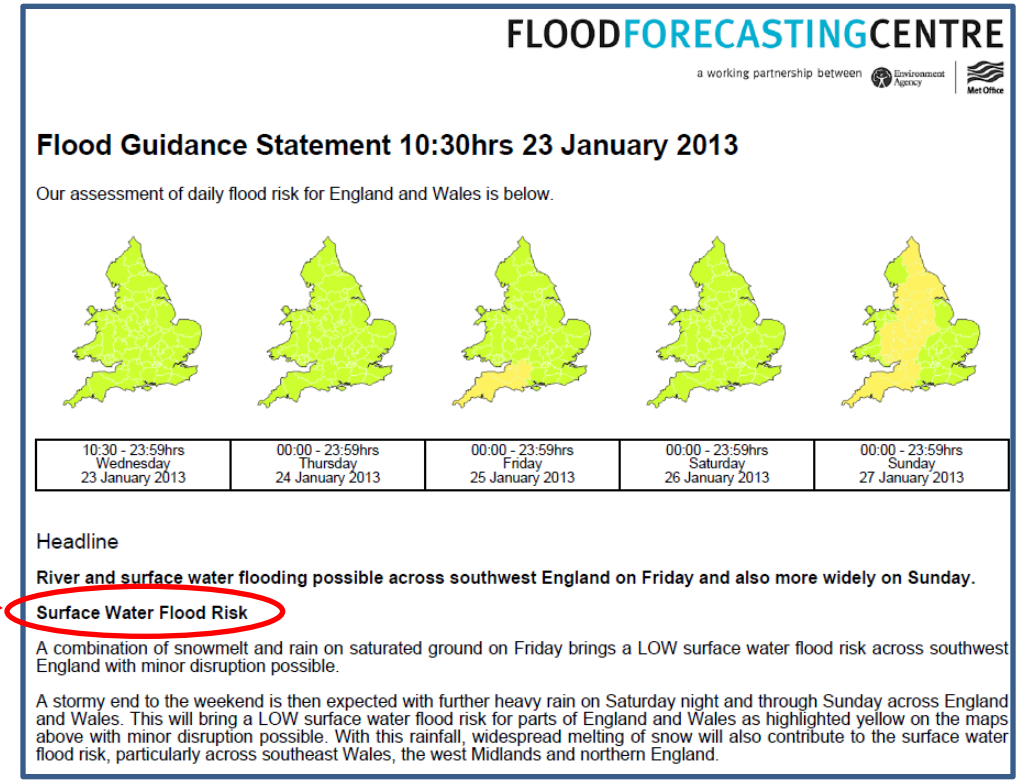
- Resilience
- Natural Hazards including their **impact**
- Fast tracking world class science into services
- Timescales of 0-5 years
- UK and in those countries affecting UK citizens
- Governments and responder community
- Public good
- Non commercial
- **Hazard Impact Model**: Surface Water Flooding

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)
  - Extreme Rainfall Alert. Uses national rainfall-thresholds
  - Supports FFC Surface Water Decision Support Tool (Spreadsheet)
  - Feeds in to FFC daily Flood Guidance Statement



FLOODFORECASTINGCENTRE

a working partnership between Environment Agency | Met Office

Flood Guidance Statement 10:30hrs 23 January 2013

Our assessment of daily flood risk for England and Wales is below.

10:30 - 23:59hrs Wednesday 23 January 2013	00:00 - 23:59hrs Thursday 24 January 2013	00:00 - 23:59hrs Friday 25 January 2013	00:00 - 23:59hrs Saturday 26 January 2013	00:00 - 23:59hrs Sunday 27 January 2013

Headline

River and surface water flooding possible across southwest England on Friday and also more widely on Sunday.

Surface Water Flood Risk

A combination of snowmelt and rain on saturated ground on Friday brings a LOW surface water flood risk across southwest England with minor disruption possible.

A stormy end to the weekend is then expected with further heavy rain on Saturday night and through Sunday across England and Wales. This will bring a LOW surface water flood risk for parts of England and Wales as highlighted yellow on the maps above with minor disruption possible. With this rainfall, widespread melting of snow will also contribute to the surface water flood risk, particularly across southeast Wales, the west Midlands and northern England.

Surface Water Flooding Alerts: Approaches

- Rainfall based alerts (current practice)
  - Extreme Rainfall Alert. Uses national rainfall-thresholds
  - Supports FFC Surface Water Decision Support Tool (Spreadsheet)
  - Feeds in to FFC daily Flood Guidance Statement
- 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 information (ongoing NHP developments)
  - Use national datasets on property, infrastructure & population
  - Potential for real-time hazard and impact forecasts

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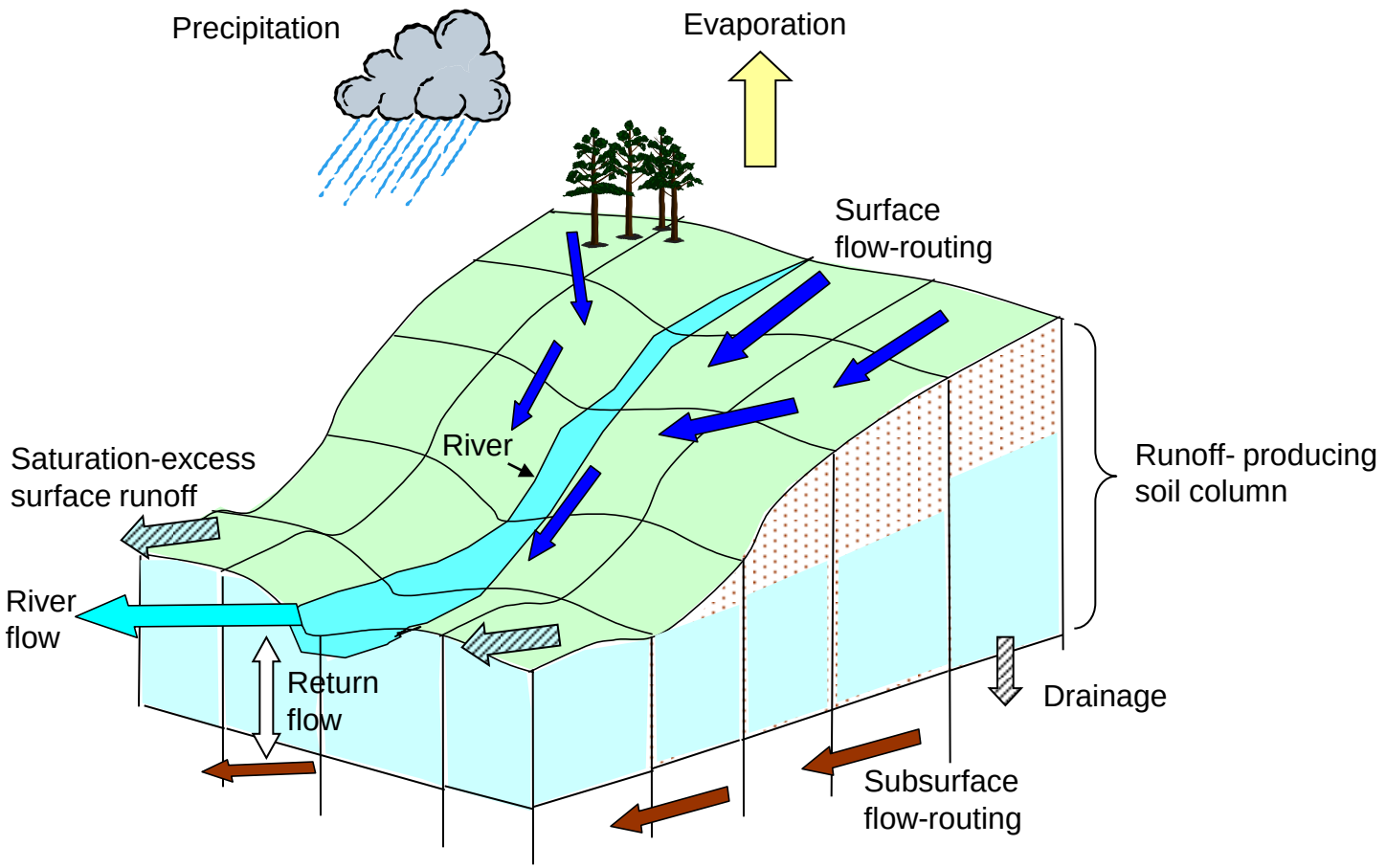
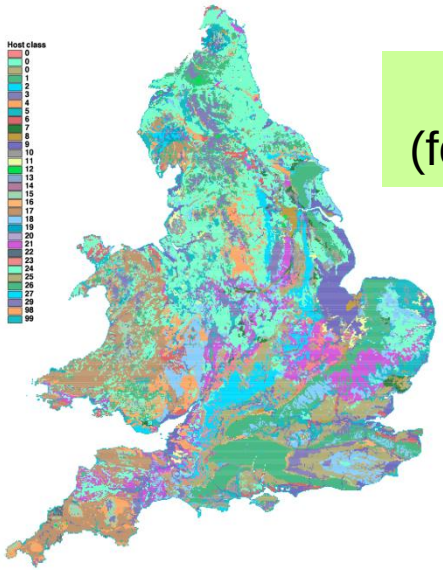
Grid-to-Grid (G2G) Distributed Model



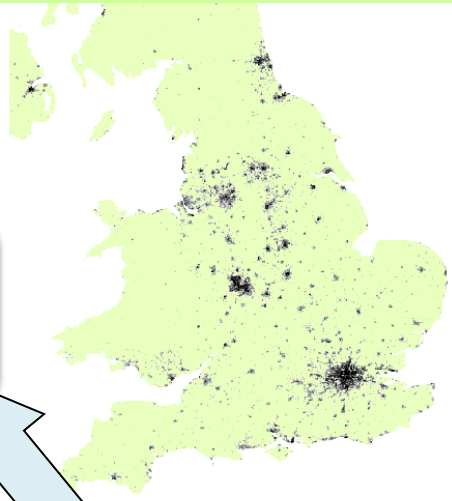
- Uses spatial datasets on terrain, soil/geology, land-cover
- Responds to spatial variation of rainfall input
- Already used countrywide by FFC and SFFS

Factors affecting G2G runoff production



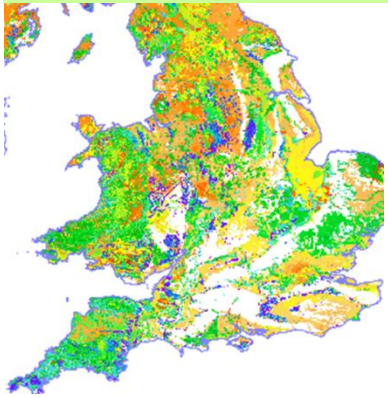
Soil properties
(for each HOST class)

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



G2G Runoff Production

Soil Moisture Deficit
(modelled)

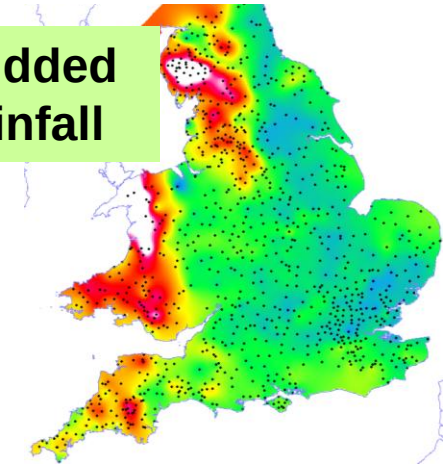


Terrain/slope

Steep slopes → Shallow storage

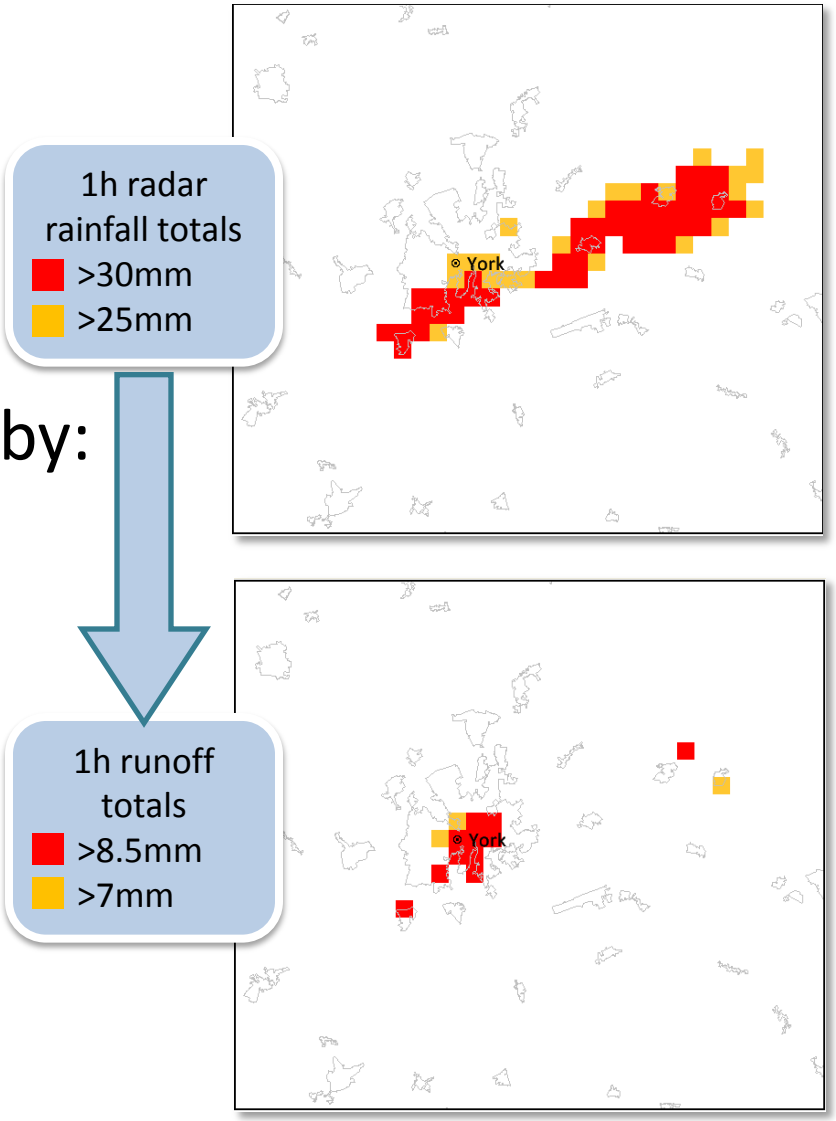
Shallow slopes → Deep storage

Gridded rainfall



G2G runoff alerts for surface flooding

- Extreme Rainfall Alerts (ERA)
  - National rainfall-threshold based method
  - Based on 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**



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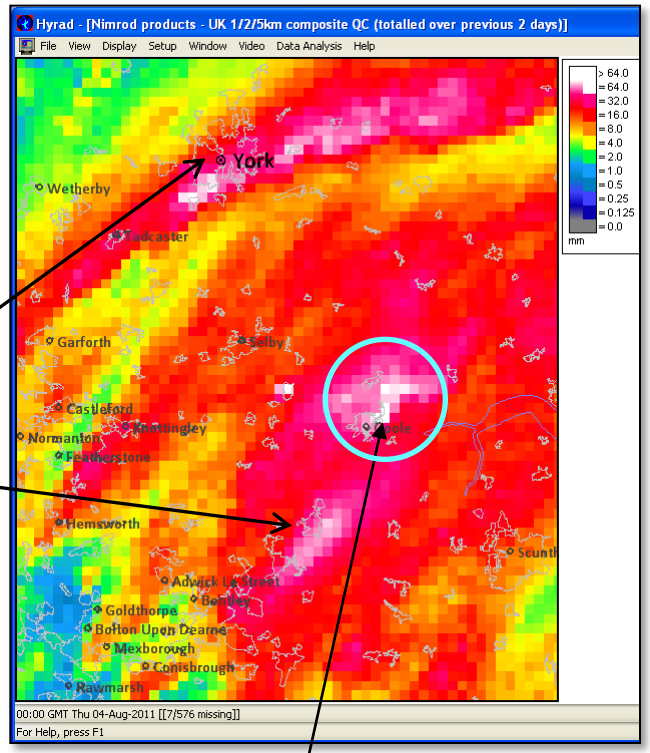
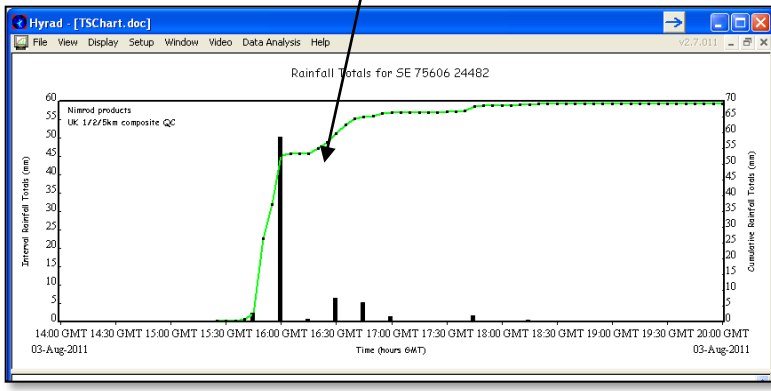
SWF Case Study – 2-3 August 2011

- 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 sample SWF impact maps
  - Note uses radar-rainfall and not forecasts
  - Good first step, further development ongoing





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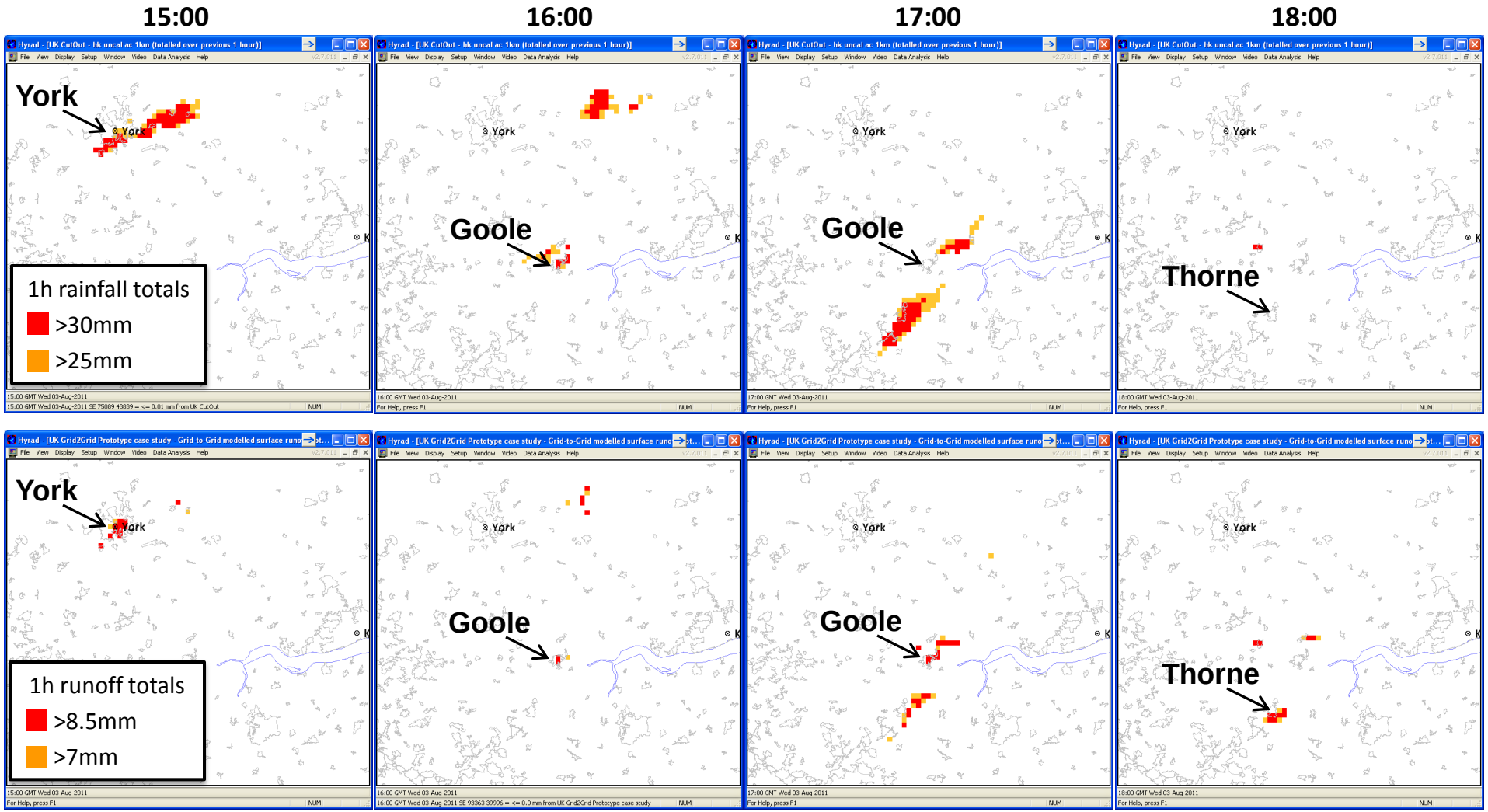
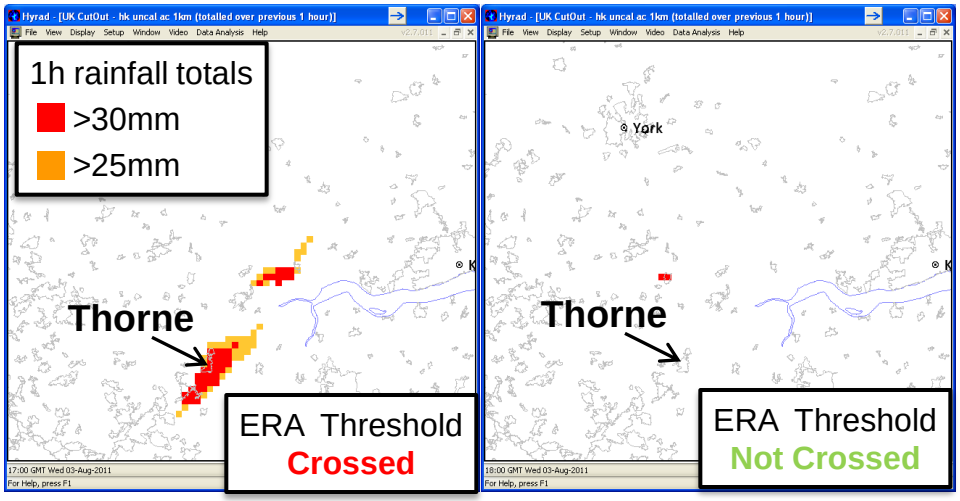
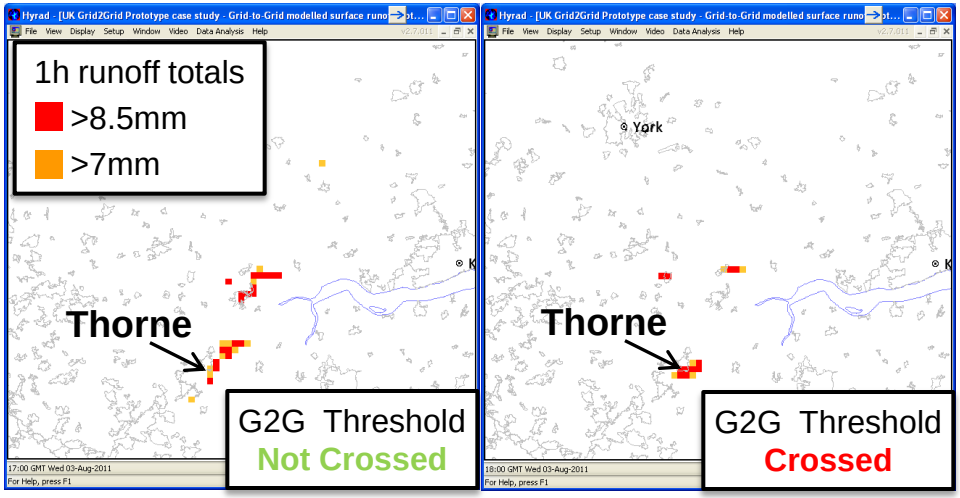
SWF Case Study of 2-3 August 2011

- Evolution of rainfall and surface-runoff accumulation maps
- Reported flood locations highlighted (FFC data)

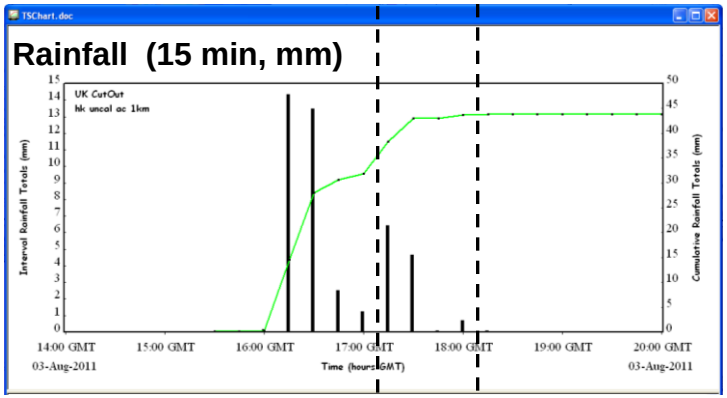


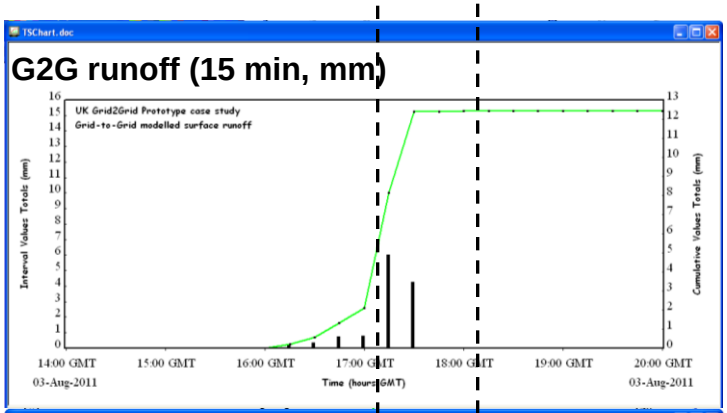
SWF Case Study: rainfall vs surface-runoff

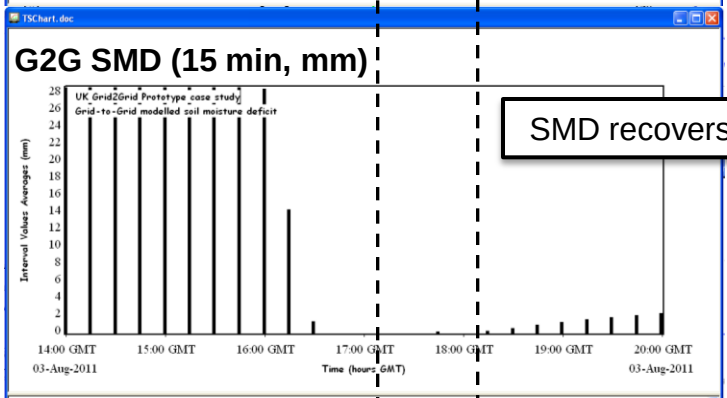




17:00 18:00







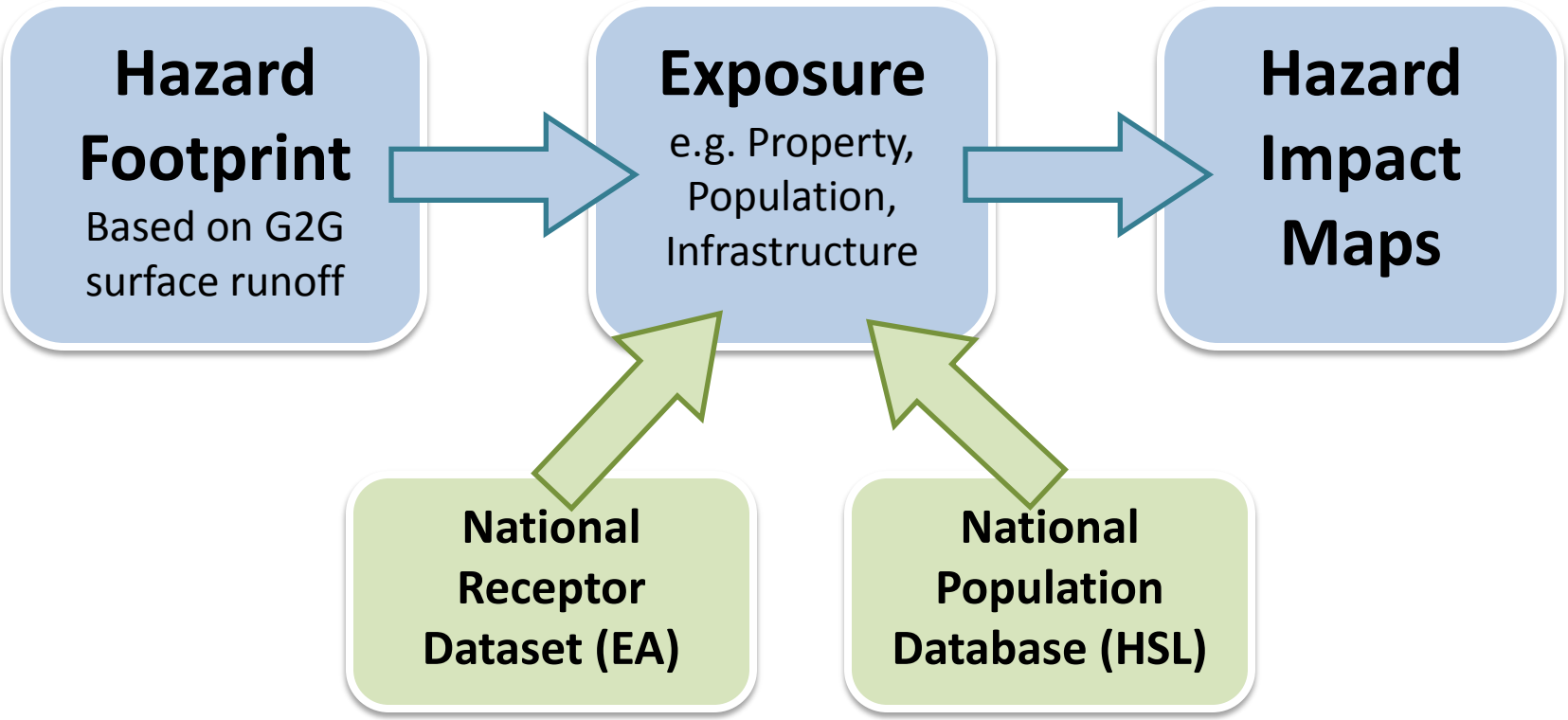
17:00

Heavy rain
Low runoff %
Pixel becomes saturated

18:00

Moderate rain
High runoff %
Saturated

Impact modelling approach

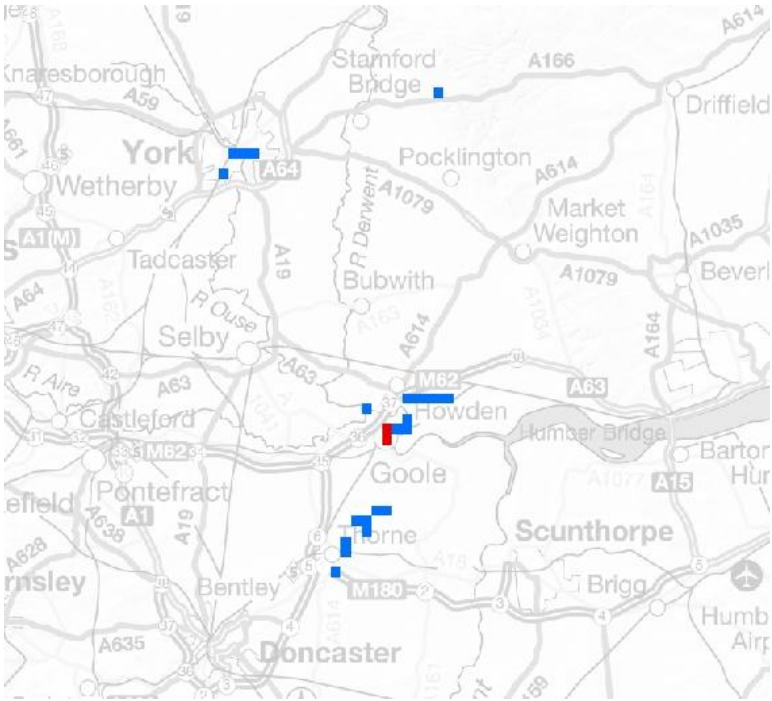


Hazard Footprint using G2G

- Prototype G2G runoff thresholds derived using a few case studies (similar to rainfall threshold approach)

Duration	1 h	3 h	6 h
Low G2G threshold	7 mm	13.5 mm	19 mm
High G2G threshold	8.5 mm	16 mm	23 mm

- Two types of footprint considered
- **High-hazard footprint**
  - Pixels where **all high thresholds** have been crossed
- **Low-hazard footprint**
  - Pixels where **any of the low thresholds** have been crossed

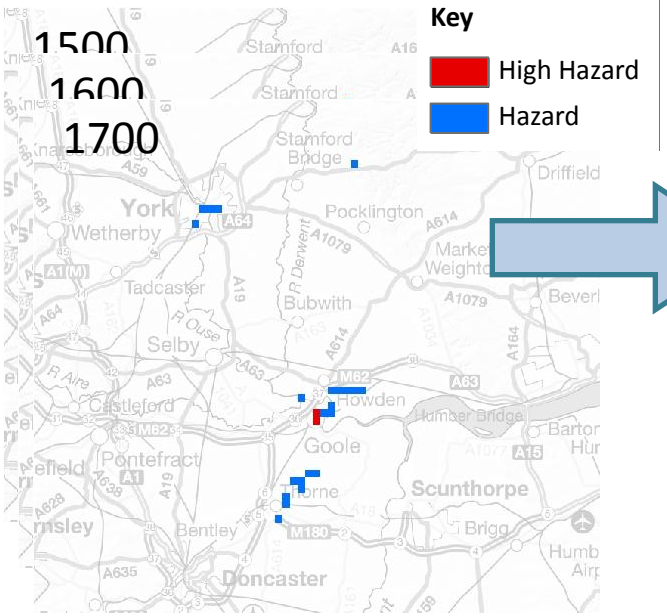


Dataset examples

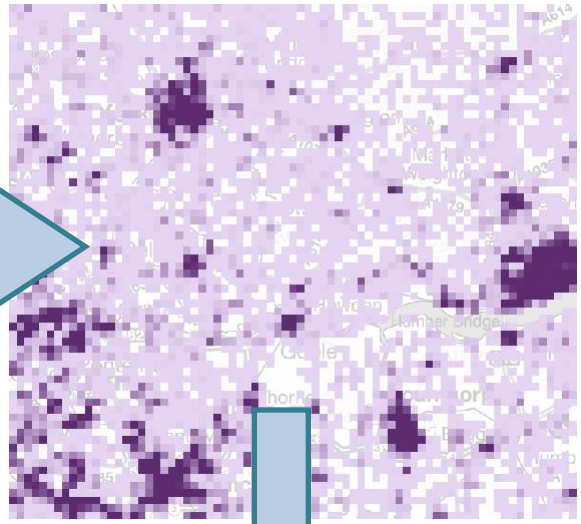
- **Day time population scenario (09:00-17:00)**
  Residential day time term-time + Care homes + Hospitals + Schools + Prisons + Workplaces
- **Night time population scenario (17:00-09:00)**
  Residential night time + Care homes + Hospitals + Prisons
- **Vulnerable population, as above except**
  (i) residential population that are over 75 or long-term sick
  (ii) workplace population removed
- **Vulnerable locations** (e.g. Schools and hospitals in NPD)
- **National Receptors Database**
  (i) Housing (dwellings bulk class description)
  (ii) Retail (Shop/Store and Retail bulk class descriptions)
  (iii) Road and railway information from the Transport layer

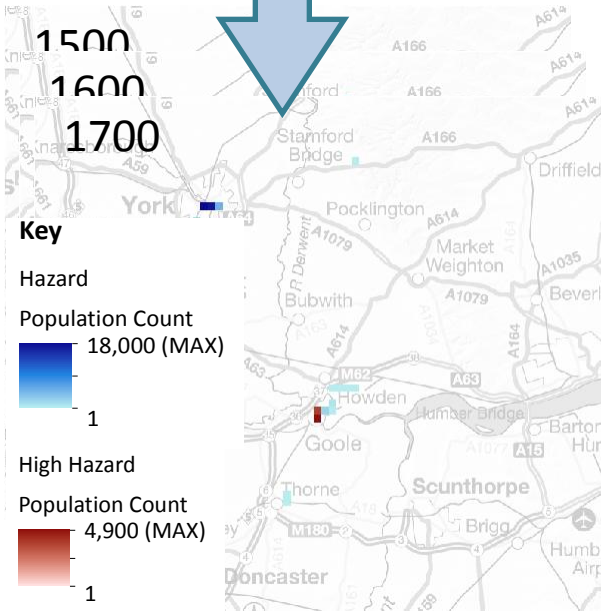
Population impacts

Hazard footprint

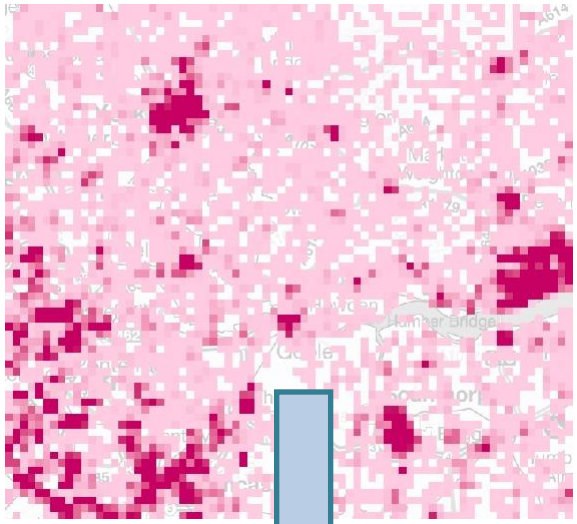


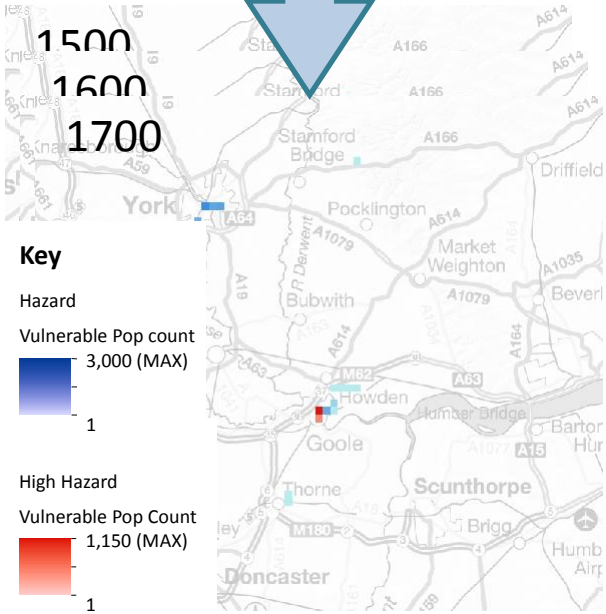
Population





Vulnerable Pop.





Hazard impact maps

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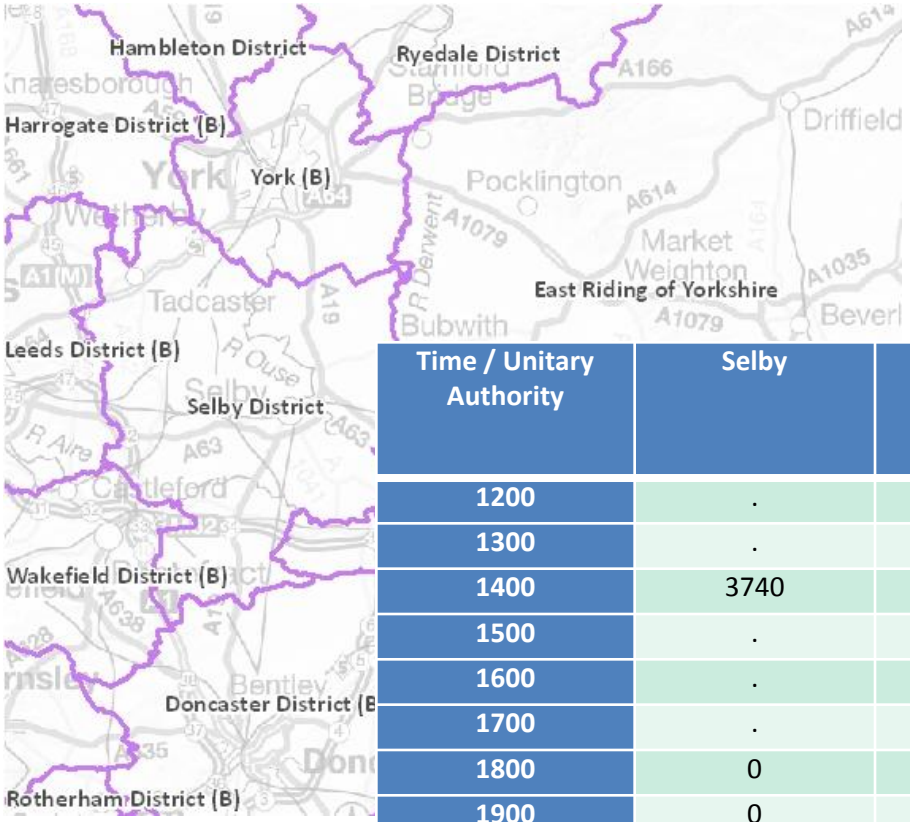
Regional summaries

Unity authorities



Time / Unitary Authority	Selby	East Riding of Yorkshire	York	Doncaster	Ryedale
1200	.	.	.	.	.
1300	.	.	.	.	.
1400	3740	.	.	.	.
1500	.	.	68215	.	6
1600	.	8547	46344	.	4
1700	.	11328	41682	30	.
1800	0	4782	13735	3259	.
1900	0	13399	3259	2864	.
2000	0	9614	3259	.	.
2100	0	9614	.	.	.
2200	0	5	.	.	.
2300	0	.	.	.	.
0000	.	.	.	.	.

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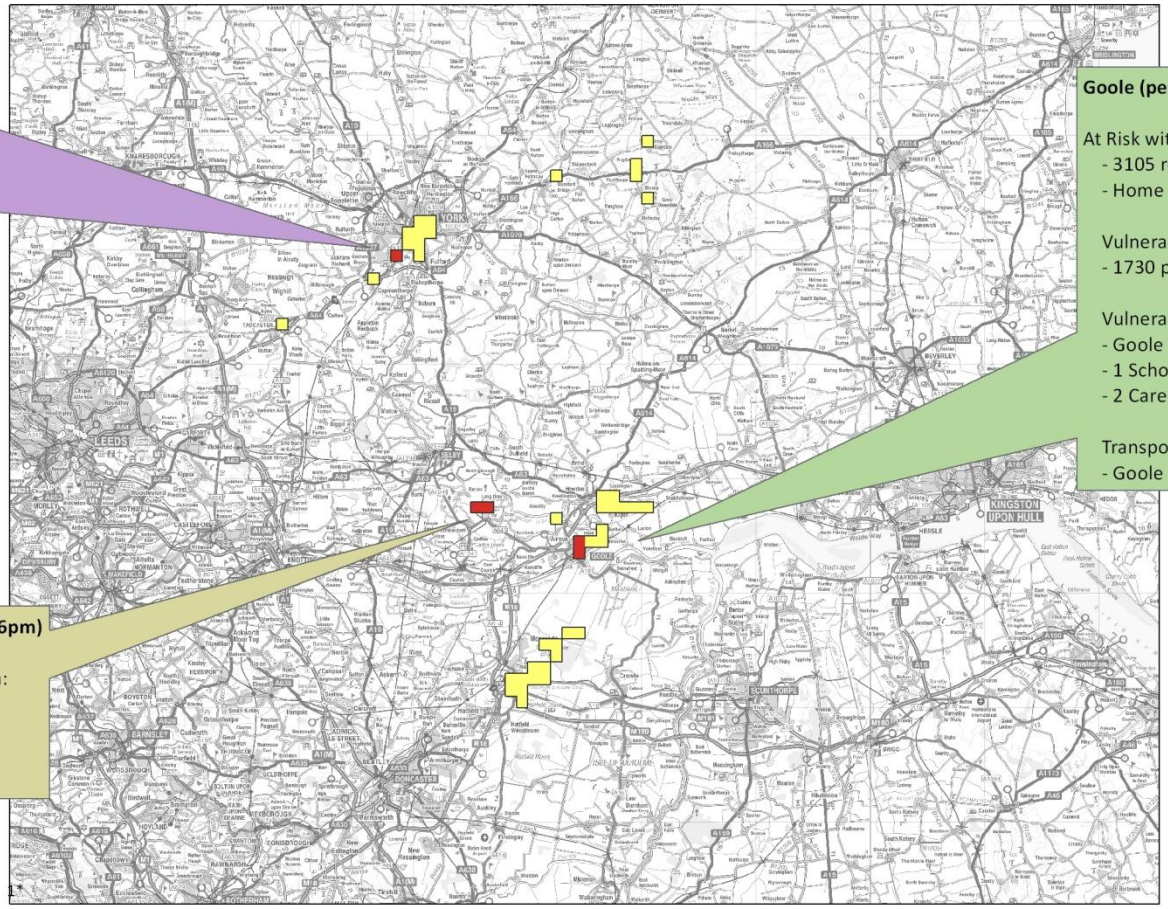
Note. '0' indicates the Local Authority has flooding, but no population expected. '.' indicates that no hazard was identified in the Local Authority.

Summaries over a time period

- Hazard footprint pooled over the timeframes of the event
- Summary of impacts in contiguous high hazard areas



Next steps

- Targeted improvements to methodology
  - Runoff-production, vulnerability datasets, ...
- Use of latest Met Office rainfall forecast products
  - High-resolution deterministic and probabilistic products
- Mapping of surface water flooding impacts (with HSL)
  - Aim to move from static to dynamic maps of hazard and impact
  - Presentation of results, local, regional and national
- Further case studies and validation
  - Historical surface water flooding data scarce and sporadic
  - Link to other initiatives, e.g. Hazard Impact Database (KCL)
- Near-operational trial by FFC in 2014