An assessment of the probability of extreme flood flows from a national perspective: evidence supporting the National Flood Resilience Review

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What is the chance of an extreme flood event occurring anywhere in the country in the next 10 years?
Conventional methods assess the likelihood of “local” extremes
Extreme flood events have distinct, coherent patterns

- January 2008
- Summer 2007
- December 2015

**Flooding Properties in Worst Hit Areas**

- Leeds: 130 homes
- Ryedale: 67 homes
- Bradford: 20 homes
- North Gloucester: 40 homes
- Omagh: 130 homes
- Earby: 55 homes
- Liverpool: 25 homes
- Lichfield: 200 homes
- Bridgnorth: 14 homes
- South Shropshire: 20 homes
- Wyre Forest: 154 homes
- Wychavon: Five homes
- Norfolk: 100 homes

**Record figure when circled**
- Exceptionally high flow
- Notably high flow
- Above normal
- Normal range
- Below normal
- Notably low flow
- Exceptionally low flow
Joint probability model

1. Observed data standardised onto a common scale

Each point is a concurrent observation

Flow at river gauge X

Flow at river gauge Y
Joint probability model

2. Model the probability that each gauge (Yn) is extreme when gauge X is extreme, with residuals retained as coherent sets

Model for “Y extreme | X extreme”
Joint probability model

2. Create conditional models for a set of 916 gauges selected for data quality and record length, over 7-day sampling intervals.
Joint probability model

3. Monte Carlo simulation to generate many possible, spatially coherent events
Dependence structure in extreme river flows

Flow data plotted on a standardised scale

Black:
Observations

Red:
Simulated events representing 10,000 years of synthetic “observations”
Dependence structure in extreme river flows

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Why the extremal dependence matters

Annual probability of at least one “event” (locally extreme river flow) somewhere in E&W
Results

**y-axis**
Chance of extreme river flow event occurring at a gauge somewhere in England and Wales in a period of 1, 10 or 25 years

**x-axis**
Relative level of extremes that is being used to define “extreme event” at any location
Results

**y-axis**
Chance of extreme river flow event occurring at a gauge somewhere in England and Wales in a period of 1, 10 or 25 years

**x-axis**
Relative level of extremes that is being used to define “extreme event” at any location

There is nearly an 80% probability (0.78) in any one year that at least one river gauge somewhere in E&W will experience an extreme flow, even though the chance of seeing that extreme flow at any one specific location is only 1-in-100 (1%)
Results

**y-axis**
Chance of extreme river flow event occurring at a gauge somewhere in England and Wales in a period of 1, 10 or 25 years

**x-axis**
Relative level of extremes that is being used to define “extreme event” at any location

CEH calculated the percentage of NRFA stations with data from 1971 to 2012 in which the at-site 1/100 AEP flow was exceeded in any given year, first for 900 stations and then for 289 stations with pooled FEH estimates of the 1/100 AEP flows.
Expected spatial scale

**y-axis**
Number of river gauges expected to experience a flow that is at least as extreme as the value defined on the x-axis in any one flood event (assuming that the flood event affects at least one such gauge).

**x-axis**
Relative level of extremes that is being used to define “extreme event” at any location (one-in-X chance of observation at any gauge, in any year).

If a flood event includes a flow that has 1% (1/100) AEP locally, then we expect, on average, six gauges to experience flows as extreme flows (or worse) in the same event.

How many river gauges should we expect to experience extreme flows in **any one event** (up to 7 days apart, here)?
Conclusions

• We quantified the “hydrological risk” of extreme river flows at a national level

• There is a 78% chance in any year that at least one river gauge will experience an extreme flow of 1 – in – 100 annual probability (or worse)

• In most places, flood defences could not contain a peak flow this high

• On-going research is examining the statistical uncertainty and influence of climatic variability on this analysis