Flood frequency quantification for ungauged sites using continuous simulation: a UK approach

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Principle of continuous simulation for national river flood frequencies

- Flow and rainfall data
- Rainfall-runoff model
  - Time series of river discharge; flood frequency curves
- Catchment properties
  - Relating of catchment properties and model parameters

**SPATIALLY GENERALISED FLOOD FREQUENCY ESTIMATION**
for use at ungauged sites

- Long term rainfall
- Optional climate change information

**TEMPORALLY GENERALISED FLOOD FREQUENCY ESTIMATION**
to cover high recurrence interval floods
Example of structure of parameter-sparse rainfall-runoff model
Examples of continuous simulation for the River Findhorn, Scotland:
left - time series; right - flood frequency curves derived from the time series
[‘PDM’ and ‘TATE’ are runoff models]
Some sources of catchment properties
Example equations for prediction of the three parameters (crm etc) of a runoff model from catchment properties (DPLBAR etc)

\[
\begin{align*}
\text{crm} &= -0.44 + 0.018 \times \text{DPLBAR} + 0.0090 \times \text{SMDBAR} + 0.71 \times \text{HOSTP} & R^2 &= 0.80 \\
\text{csm} &= 0.013 - 0.0023 \times \text{HOSTSPR} + 0.0042 \times \text{FIELDc} - 0.13 \times \text{URBCOMPX} + 0.099 \times C & R^2 &= 0.56 \\
\text{cfr} &= 3.01 - 8.5 \times 10^{-4} \times \text{AREA} - 1.1 \times \text{HOSTBFI} - 0.22 \times \text{ATANB} + 0.36 \times \text{CVATANB} & R^2 &= 0.69
\end{align*}
\]
Demonstration examples of modelling to high recurrence interval floods with gauged and ungauged cases: with and without climate change
Continuous simulation proof-of-concept

100-year flood estimates across Britain for sites treated as if ungauged
• Larger sample of catchments
• More exploration of generalisation approaches
• Estimation of uncertainties
Catchments modelled using hourly data (left) and daily data (right)
Objective function $[O_1 \text{ and } O_2]$ values (high good in these cases) for two model parameters [crm and csm]: top using hourly data directly; bottom left using daily data; bottom right using daily converted to hourly.
Predictive success for three model parameters (crm, csm, cfr): left column, enlarged sample; right column, small initial sample.

Comparison of parameter value calibrated for each catchment (horizontal axis) and value determined from spatial generalisation procedure (vertical axis)
Spatial generalisation approaches

- Pooling group concepts
- Physiographic regions
- Geographical regions
- One country-wide homogeneous ‘region’
- Weighted averages
- Univariate linear regression
- ‘Sequential’ regression
- Increasing effort
Performance (low values of $S$ better) of spatially-generalised results for a runoff model parameter ($f_c$) for range of numbers of catchment properties (CD) in predictive equation:

A. effect of number of ‘similar’ catchments used
B. effect of some ‘distance’ weighting schemes
Predictive success of three spatial generalisation approaches
Quantification of uncertainties in flood risk assessment

![Graph showing flood peak discharge versus recurrence interval with median simulated, 90% approx. conf. interval, 95%, observed PoTs, and fitted GPD lines.]
Generate catchment properties for site

Derive model parameters from established relationships between parameters and catchment properties

Long rainfall time series (observed or generated)

Run rainfall-runoff model with derived parameters over long periods to derive long flow time series

Guidance from any historic or other flood information

Continuous simulation flood frequency: outline procedure for ungauged site

FLOOD FREQUENCY ESTIMATION TO HIGH RECURRENCE INTERVALS

Flood management in light of estimates and uncertainty
Wallingford, January 2003
~3% annual exceedance probability
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