Flood Risk Forecasts for England and Wales: Production and Communication

Jon Millard
UEF 2015: Quantifying and Communicating Uncertainty
What is the FFC?

- Successful partnership between the Met Office and Environment Agency.
- Remit to forecast for all natural sources of flooding.
- Operational since April 2009 delivering 24/7 services.
- Combine staff expertise in hydrometeorology to provide improved and new services.
- Works across organisations to act as a trusted advisor for responders.
- Seeks to introduce new science and continually improve services for customers.
The Environment Agency and the Met Office should work together, through a joint centre, to improve their technical capability to forecast, model and warn against all sources of flooding.

The Met Office and the Environment Agency should issue warnings against a lower threshold of probability to increase preparation lead times for emergency responders.
Sources of Uncertainty

Uncertainties in Flood Forecasts

4 main areas of uncertainty;

Precipitation and hydrological response

Impacts

Communication & Understanding

Use of ensembles to attempt to model the spread in possible solutions.

Use of flood risk matrix to try and clearly communicate the uncertainties.
Production
Coarse precipitation ensembles

Broad scale precursors; warm, moist, unstable conditions, persistence of frontal bands.
Coastal - Strategic requirement for an early trigger to increase awareness (especially East Coast).

Coastal Decider – identifying when spring tides and specific weather regimes which are associated with large surges and/or large waves coincide (using ECMWF mslp ensemble forecasts).
Current project
• Developing surge and wave climatology by regime
• Linking weather regimes to past surge and wave events
• Quantifying surges and waves according to regime and anomaly (difference in mslp from idealised regime)

See Rob Neal’s presentation on Wednesday.
Coastal forecasting
CS3x MOGREPS-G driven surge ensemble forecasts to day 6

Immingham

[Graph showing surge predictions with various lines indicating different models and observations over time.]
High resolution precipitation models

Post processed MOGREPS-UK (2.2km, convection permitting, 12 members / 24 members if time lagged)
Surface Water flood forecasting using MOGREPS-UK probabilities of exceeding standard 10 and 30 year return period thresholds combined with SMD (antecedent conditions) and urbanisation value to produce FGS aligned output.

<table>
<thead>
<tr>
<th>10 year return periods</th>
<th>30 year return periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 mm / hour</td>
<td>30 mm / hour</td>
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<tr>
<td>30 mm / 3 hours</td>
<td>40 mm / 3 hours</td>
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<tr>
<td>40 mm / 6 hours</td>
<td>50 mm / 6 hours</td>
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**Short Range Forecasting**

**Surface Water Flooding Decision Support Tool**

<table>
<thead>
<tr>
<th>ID</th>
<th>County / Unitary Authority</th>
<th>Blue Square (%)</th>
<th>Blue Sq. Category</th>
<th>Met Hazard Description</th>
<th>Weight</th>
<th>10Yr Max Prob. Excd.</th>
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<th>SMD</th>
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<tr>
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Short Range Forecasting

Fluvial modelling using CEH Grid to Grid Hydrological Model. Forecasting percentage of ensemble members exceeding return period thresholds.
Short Range Forecasting

Fluvial modelling using CEH Grid to Grid Hydrological Model. Forecast point hydrograph outputs – short range ensembles (MOGREPS-UK 36 hour rainfall input)
Short Range Forecasting

Coastal forecasting  ECMWF Wave ensemble forecasts

MO Wave ensemble forecast (trial) and CS3x surge ensemble
Assigning Flood Risk

- Flood risk determined using a probabilistic approach
- **Hydrometeorologist employs a subjective analysis of:**
  - NWP models (deterministic and ensemble)
  - Guidance from the Met Office chief and deputy chief forecaster
  - Raingauge & radar data
  - Hydrological modelling - grid based rainfall/runoff – routing (G2G)
  - EA regional flood forecasting team's catchment rainfall/runoff - routing models
  - Pre-determined rainfall depth-duration thresholds (esp rapid response / surface water impacts)
  - Conference with EA flood forecasting teams (catchment sensitivity, defence condition and deployment, etc)
Communication
Medium Range Forecasting

Strategic briefing documents – uncertainty in words

The purpose of this short briefing note is to explain the coastal flood risk over the period 20-23 February 2015.

- A period of high spring tides begins on Wednesday 18 February and will reach their highest levels during the weekend of 21 – 22 February. An area of low pressure is expected to develop to the west and track across England and Wales on Friday (20 Feb) and remain over the North Sea on Saturday (21 Feb). It has the potential to cause strong to near gale force winds on coasts in the south and southwest of England on Friday, slackening slightly through Saturday.

- On Friday 20 February the combination of high astronomic tides and waves brings a medium likelihood of MINOR flooding impacts to parts of the northwest and north-east coasts, parts of the South Wales coast, parts of the Severn and Wye estuaries and the coast of Cornwall.
Flood Risk Matrix

Forecasting the likelihood of different levels of impact to give an overall flood risk.

Identical to the NSWWS matrix (so they should be the same for pluvial flooding event forecasts).

NOTE: The risk colours are not a progressive ready-steady-go system indicating the likelihood of flooding. They take account of the impact and the likelihood of flooding to highlight an overall flood risk.
## Communication Impact Table

### FLOOD IMPACTS TABLE

to be used by FFC (FGS), EA and Met Office (weather alerts / warnings of heavy rain) as an optional link on websites

<table>
<thead>
<tr>
<th>Minimal Impacts</th>
<th>Minor Impacts</th>
<th>Significant Impacts</th>
<th>Severe Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical impacts</strong></td>
<td><strong>Minimal disruption</strong></td>
<td><strong>Minor disruption</strong></td>
<td><strong>Significant disruption</strong></td>
</tr>
<tr>
<td></td>
<td>- Generally no impact, however there may still be</td>
<td>- Localised flooding of land and roads – risk of aquaplaning</td>
<td>- Flooding affecting properties and parts of communities</td>
</tr>
<tr>
<td></td>
<td>- Isolated and minor flooding of low-lying land and roads</td>
<td>- Localised flooding could affect individual properties</td>
<td>- Damage to buildings/structures is possible</td>
</tr>
<tr>
<td></td>
<td>- Isolated instances of spray/wave overtopping on coastal promenades</td>
<td>- Individual properties in coastal locations affected by spray and/or wave overtopping</td>
<td>- Possible danger to life due to fast flowing/deep water/wave overtopping/wave inundation</td>
</tr>
<tr>
<td></td>
<td>- Little or no disruption to travel although wet road surfaces could lead to difficult driving conditions</td>
<td>- Localised disruption to key sites identified in flood plans (e.g. railways, utilities)</td>
<td>- Disruption to key sites identified in flood plans (e.g. railways, utilities, hospitals)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Local disruption to travel – longer journey times</td>
<td>- Disruption to travel is expected. A number of roads are likely to be closed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

**Likelihood:**
- Very Low < 20%
- Low 20% < 40%
- Medium 40% < 60%
- High > 60%
Assigning Flood Risk

Level of FLOOD RISK is assigned on a county by county basis:

- **A**
  - High Likelihood × Very Low Impact = **VERY LOW OVERALL FLOOD RISK**

- **B**
  - Low Likelihood × High Impact = **MEDIUM OVERALL FLOOD RISK**

Customer’s response

Customer’s response
Flood Guidance Statement 10:30hrs Thursday 01 January 2015

Our assessment of daily flood risk for England and Wales, working with flood forecasting teams in the Environment Agency and Natural Resources Wales, is below.

General overview of flood risk

Rain will become persistent and heavy today over high ground in the north of England and across west Wales. This leads to a LOW risk of river flooding in Cumbria and parts of north-west Wales, as rivers are expected to exceed their banks. In other parts of the north and west of England and Wales today, despite the rainfall, the overall flood risk remains VERY LOW.

Assessment of flood risk

Rivers

Rain will become persistent and heavy over the high ground of both the north of England and the west of Wales during today with river levels expected to rise. This gives a moderate likelihood of minor river flooding impacts for Cumbria and parts of north-west Wales, leading to a LOW river flood risk overall today (see Area of Concern map for details on locations). In other parts of north and west England and Wales there is a low likelihood of minor river flooding impacts today. Typical flooding impacts may include localised flooding of land and roads, some travel disruption, and possible flooding affecting isolated properties.

Elsewhere and at other times, the river flood risk is VERY LOW for the next five days, despite further rainfall over the weekend.

Surface water

Persistent, heavy rain over the high ground of both the north of England and the west of Wales today gives a low likelihood of minor impacts from surface water flooding. Consequently, the surface water flood risk here, and elsewhere, remains VERY LOW for the next five days, despite further rainfall over the weekend.

Coastal / tidal

The coastal flood risk remains VERY LOW for the next five days. Strong winds today and into Friday will develop large waves for the coasts of Wales and the west and south of England at times, but any impacts are expected to be minimal.

Groundwater

The groundwater flood risk is VERY LOW for the next five days.

© Crown, Met Office and Environment Agency 2015
92 per cent of 2013/14 Yellow FGS at day 3 showed significant impacts (low or very low likelihood).

**Flood Risk Matrix**

A and B are not the same ... waiting for Amber (medium flood risk) means important lead time is lost.

Communication of potential impacts is important rather than just overall flood risk.
Responder Training

Category 1 and 2 responders can find supporting documents and training tools on-line to help them understand the risk matrix, the FGS and what is meant by uncertainty.

“The FGS risk assessment comes with uncertainty, particularly at longer lead times. Discussing and understanding this uncertainty is a key part of decision making for strategic managers. Some key areas to explore in discussion are: uncertainty in the weather forecast driving the flooding, certainty on locations and timings, and certainty on impacts” (Joint Responder Training for Strategic Managers).

Depending on your role in flood response the potential impact level and likelihood of flooding may be just as relevant as the overall risk. So you need to take account of all three elements in your decision making.
Communication

Supporting Information and Actions
An FGS product is supported by supplementary actions and information, including;

National Flood Advisory Service telecons (NFAS) – ‘helps to ensure that emergency responders and government contacts receive consistent and timely information from the Met Office, FFC, Environment Agency and Natural Resources Wales and that key communication links are in place - especially when the flood requires a multi-agency response’ (Joint Responder Training).

For EA - National Operations Incident Management telecons (NOIMT)
For all - MO Civil Contingency Advisors
For all - FFC telephone consultancy service
Response
Use of the Flood Risk Matrix

2015 survey of responders using the FGS (1342 responses).

Responders were asked which element they focused on when using the matrix;

- 39% use all elements equally
- 22% focus on colour (Overall Flood Risk)
- 20% on impact
- 16% on likelihood
Communication

Use of the Flood Risk Matrix

What actions do you typically take when the Flood Guidance Statement forecasts very low or low likelihood of significant (yellow) or very low likelihood of severe (yellow) flooding at Days 3, 4 or 5?

- Take emergency action: 16%
- Ready resources: 26%
- Join-up with others: 19%
- Spread awareness: 46%
- Have detailed conversation: 60%
- General awareness / assurance: 80%
Communication

Use of the Flood Risk Matrix

“The statements are of too low a level of certainty over a wide spatial area. This means that if we responded to every warning which included our administrative boundaries we would have spent huge sums on false alarms. As emergency responders we cannot commit resources on the basis of this accuracy however we will be condemned for not deploying when one of the warnings actually results in flooding.”

Local Authority, neither satisfied or dissatisfied with FGS, sometimes uses matrix

Perceptions of impacts differ;
from person to person across different roles
between organisations across different scales
Communication

Challenges

• Improve forecast accuracy
• Increase understanding of uncertainty
• Improve responder training
• Improve responder action plans
Future Developments
Grid to Grid Hydrological Model

Provides G2G model with medium range rainfall ensembles, allowing probabilistic forecasting.

Allows objective estimates of flow probability for all five days of the Flood Guidance Statement. Informing not only the impact level but also likelihood.

A statistical method is used to increase the resolution of the MOGREPS-G rainfall ensemble model.
Surface Water Flooding - Hazard Impact Model

Project in conjunction with NHP, CEH, HSL and MO.

Structure of proposed operational system:

- **Impact Library** set up as database of pre-calculated impact information
- Presentation of impact data to inform flood advice
- Summarise for time, space & uncertainty
- Reporting by County/Authority – further information at 1km cell level
Coastal – Wave Ensemble & Input into CDST

MyWave Ensemble - Buoy Verification

Click on map or select from Buoy ID list below.

Domain: Atlantic (UK)
Buoy ID: Select a site
Field: Significant wave height (used for colour coding)
Field2: Wind speed

Colour coding uses: RMS, Abs. bias

Each location is colour coded using the RMS error derived from the most recent observations versus the ensemble mean.

Marker RMS colour key:
- <0.2m
- <0.4m
- <0.6m
- >0.6m
- No data

Consequences
- No Data
- Very Low
- Low
- Medium
- High

Wind Forecast (Beaufort)
Dynamic Customizable Web Page

Choose individual county and see specific flood risk information
Choose flood source
Questions...
Uncertainty

Flood Risk Matrix

most likely scenario? A

scenario with highest impact level? C

range of scenarios and likelihoods? ABC
Uncertainty

Customizable Thresholds

most likely scenario? A - cost averse responders / slowly developing events

scenario with highest impact level? C – risk averse responders / rapidly occurring events

range of scenarios and likelihoods? ABC – responders with multiple, varied actions
Answers?