Operational flood forecasting linked to different decision-making contexts

Steven Cole
(and many others)

CEEDS Seminar: Decision-making under uncertainty
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UK Centre for Ecology & Hydrology

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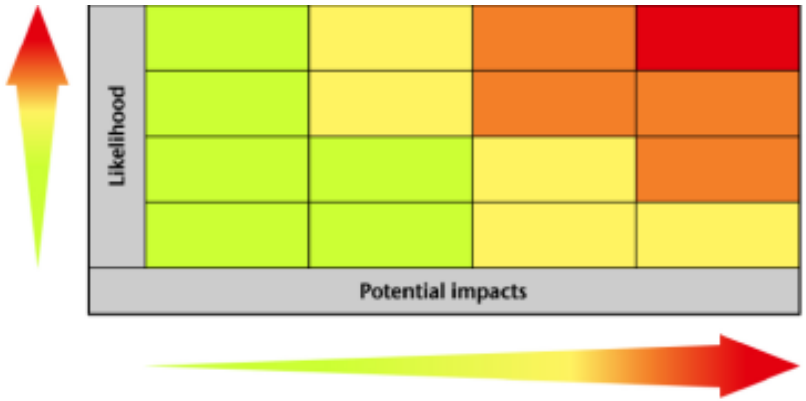
Motivation

- Typical questions a stakeholder might have to answer
  - Will it rain tomorrow? Will it flood?
  - How will storms and floods change in 50 years?
  - What does this mean for me? For my organisation?

- Need to acknowledge and account for uncertainty through risk-based approaches
  - Combine uncertainty and impact
  - Use a Risk Matrix
  - Make better, more informed, decisions



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Flood forecasting model chain

Inputs

Flood models

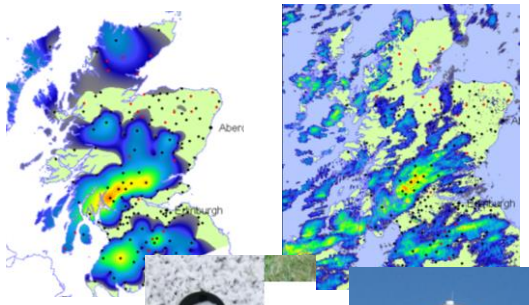
Outputs

Observation-based

Precipitation

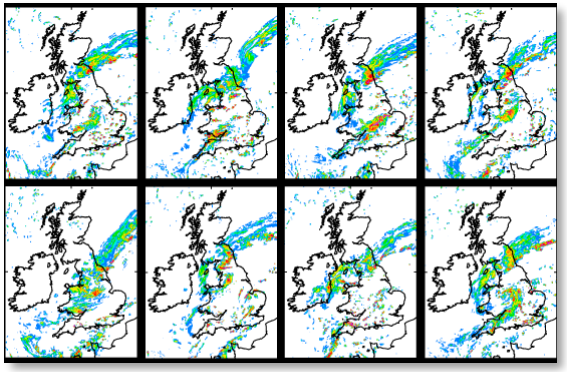
River Flows

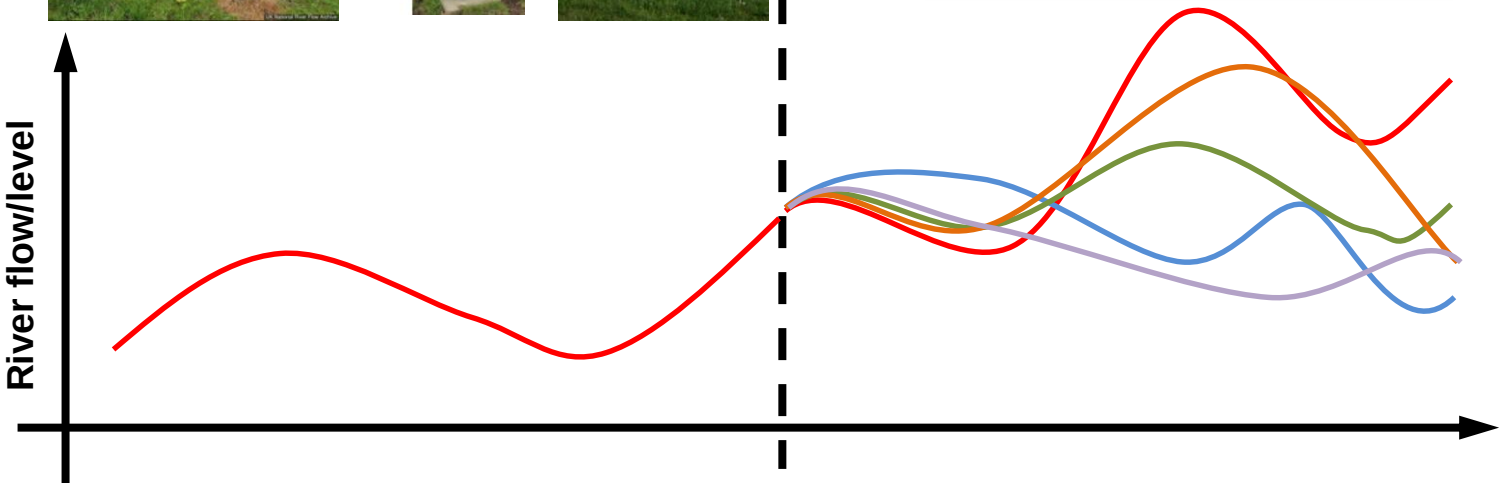
Potential Evaporation



Numerical Weather Prediction (NWP)

Deterministic and Ensemble





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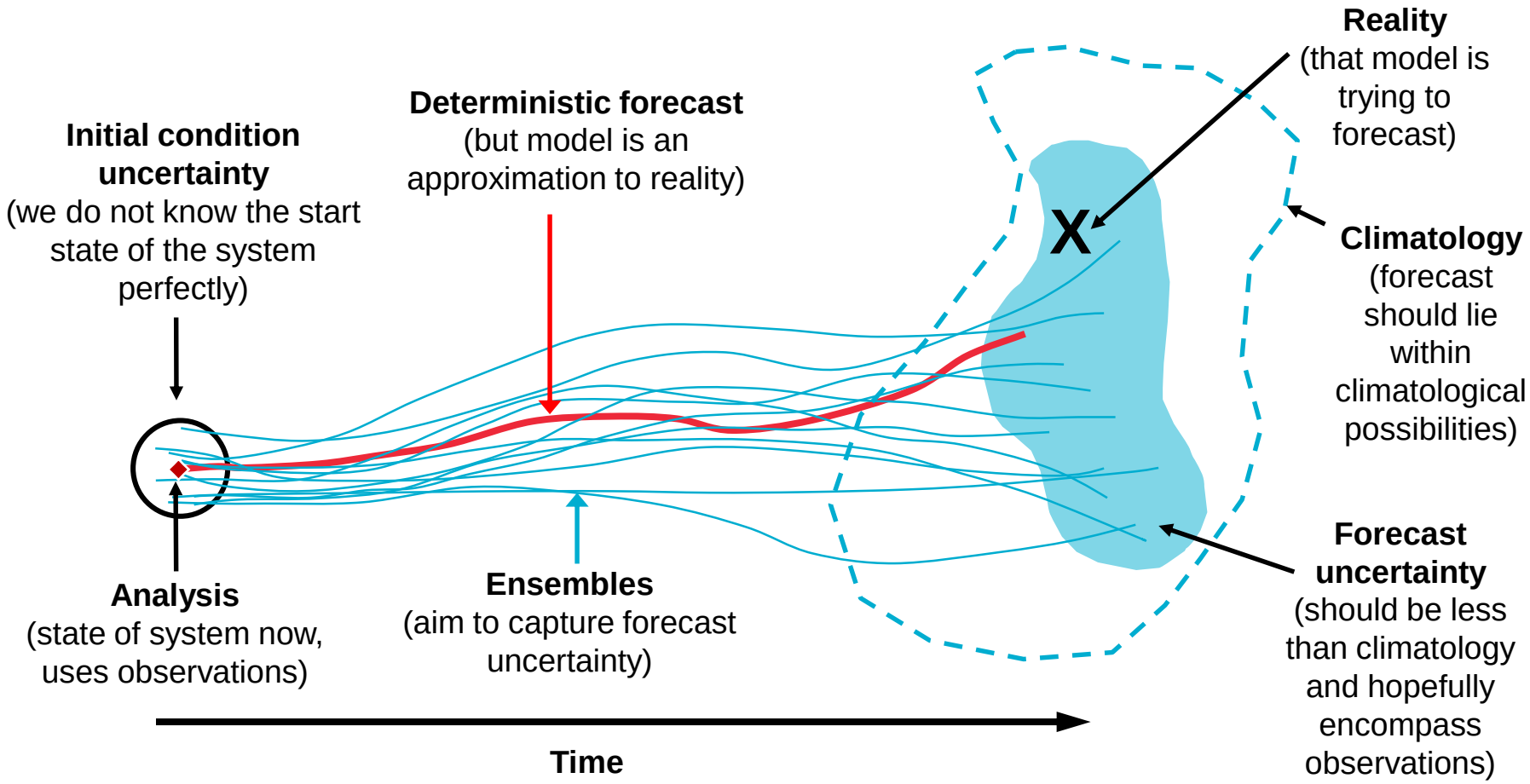
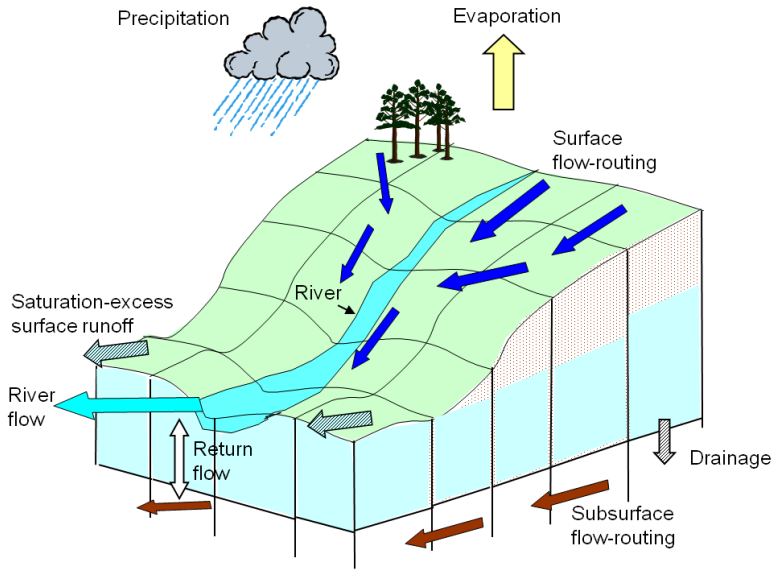
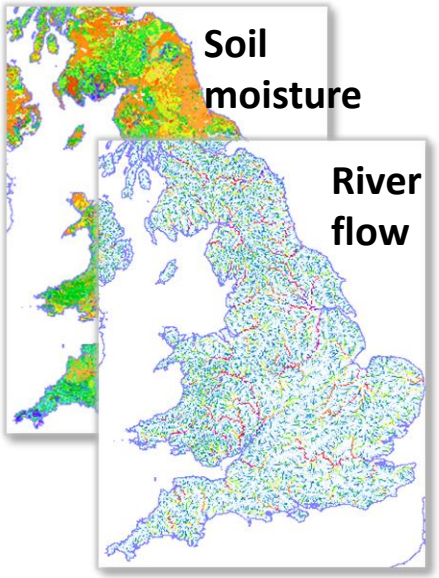
Forecast uncertainty – use of ensembles

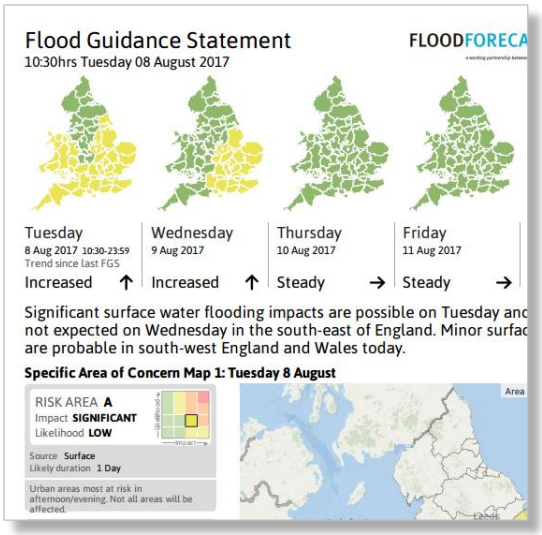
- What will the weather be like in the future?
  - We have complex mathematic models but they are uncertain
  - Capture this uncertainty using ensembles of forecasts



Grid-to-Grid (G2G) Hydrological Model







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a working partnership between Environment Agency | Met Office

Met Office | SEPA Scottish Environment Protection Agency | Scottish Flood Forecasting Service
Working in partnership

- G2G used operationally across Britain at a 1km, 15 min resolution
- Uses spatial datasets on terrain, soil/geology, land-cover
- Responds to spatial variation of rainfall input
- Probabilistic forecasts inform Flood Guidance Statements

Moore *et al.*, IAHS Publ. 305 (2006)

Price *et al.*; Cranston & Tavendale, Water Management (2012)

Rapid Response Catchments

- Rapid Response Catchments are typically small & ungauged
- Challenge to develop forecast/warning capability
- Needs rainfall forecast ensembles (~2km, 24h, 12 members)
- Case study experience (6-7 July 2012)

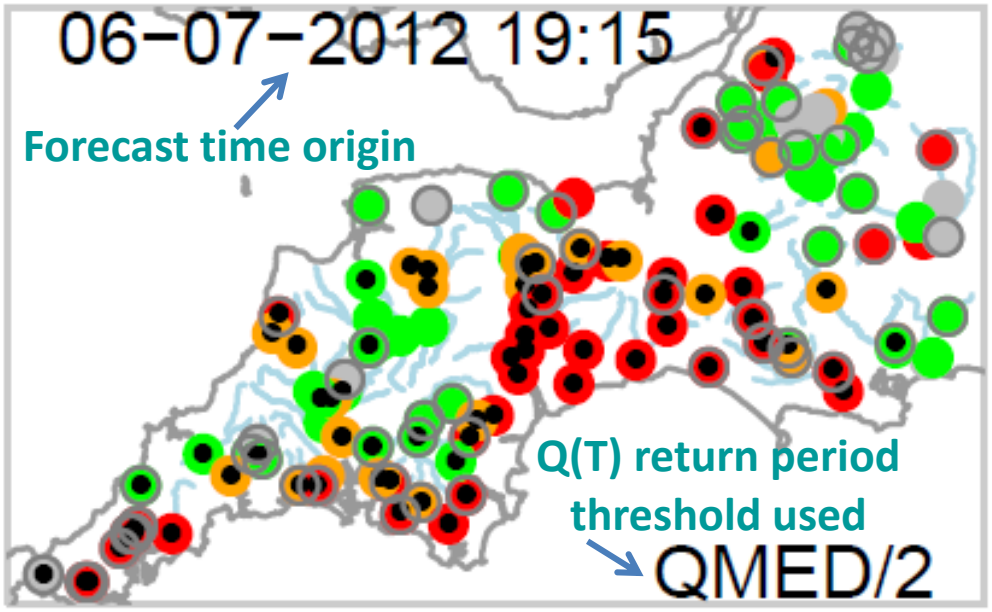
Met Office

Circles denote gauging stations

- ○ Solid outline: area <50km^2
- ● Observed flow exceeds threshold during forecast

Percentage of ensembles that exceeded the Q(T) threshold at some point during forecast

0 | 0-33% | 34-66% | >67%



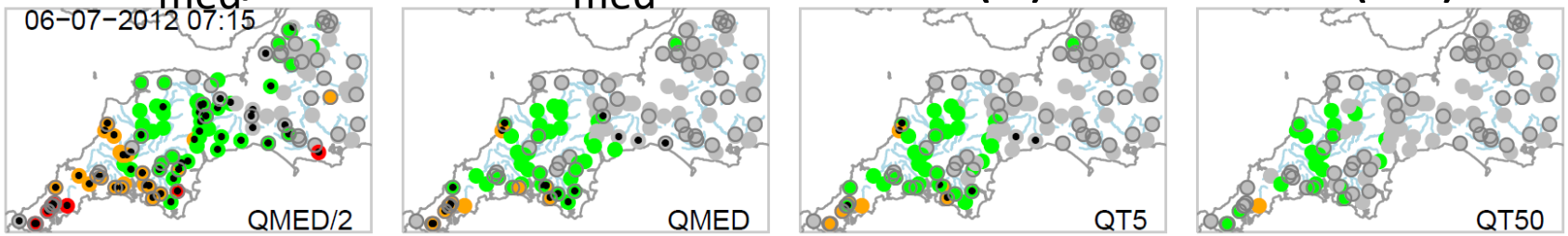
Case study: 6-7 July 2012

Threshold

Forecast Origin

06-07-2012 07:15

$Q_{med}/2$ | Q_{med} | Q(5) | Q(50)



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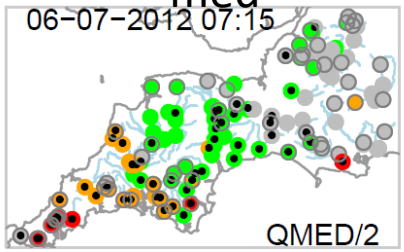
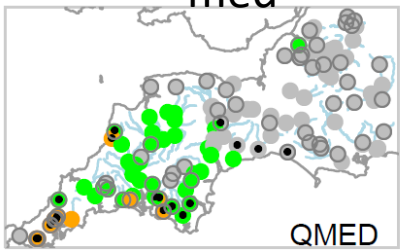
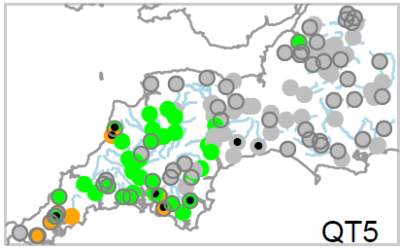
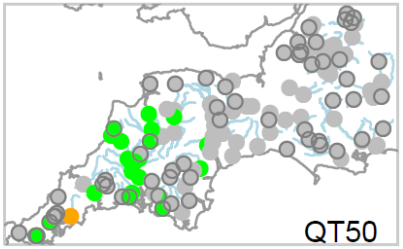
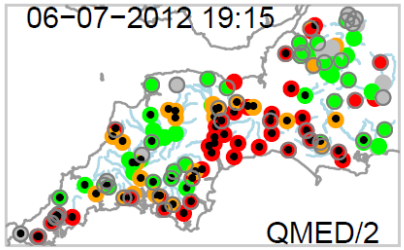
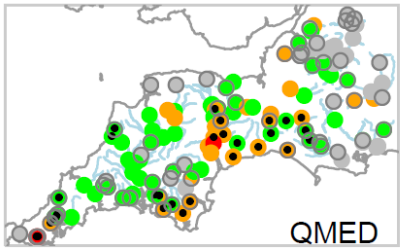
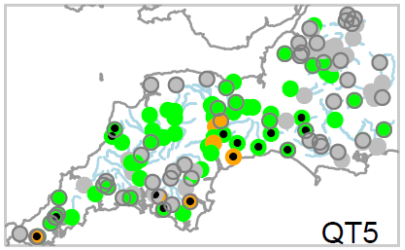
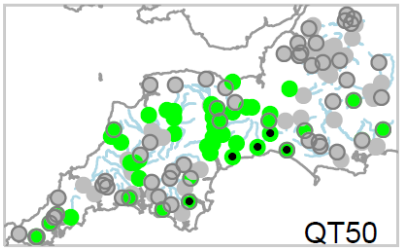
06-07-2012 07:15				
06-07-2012 19:15				

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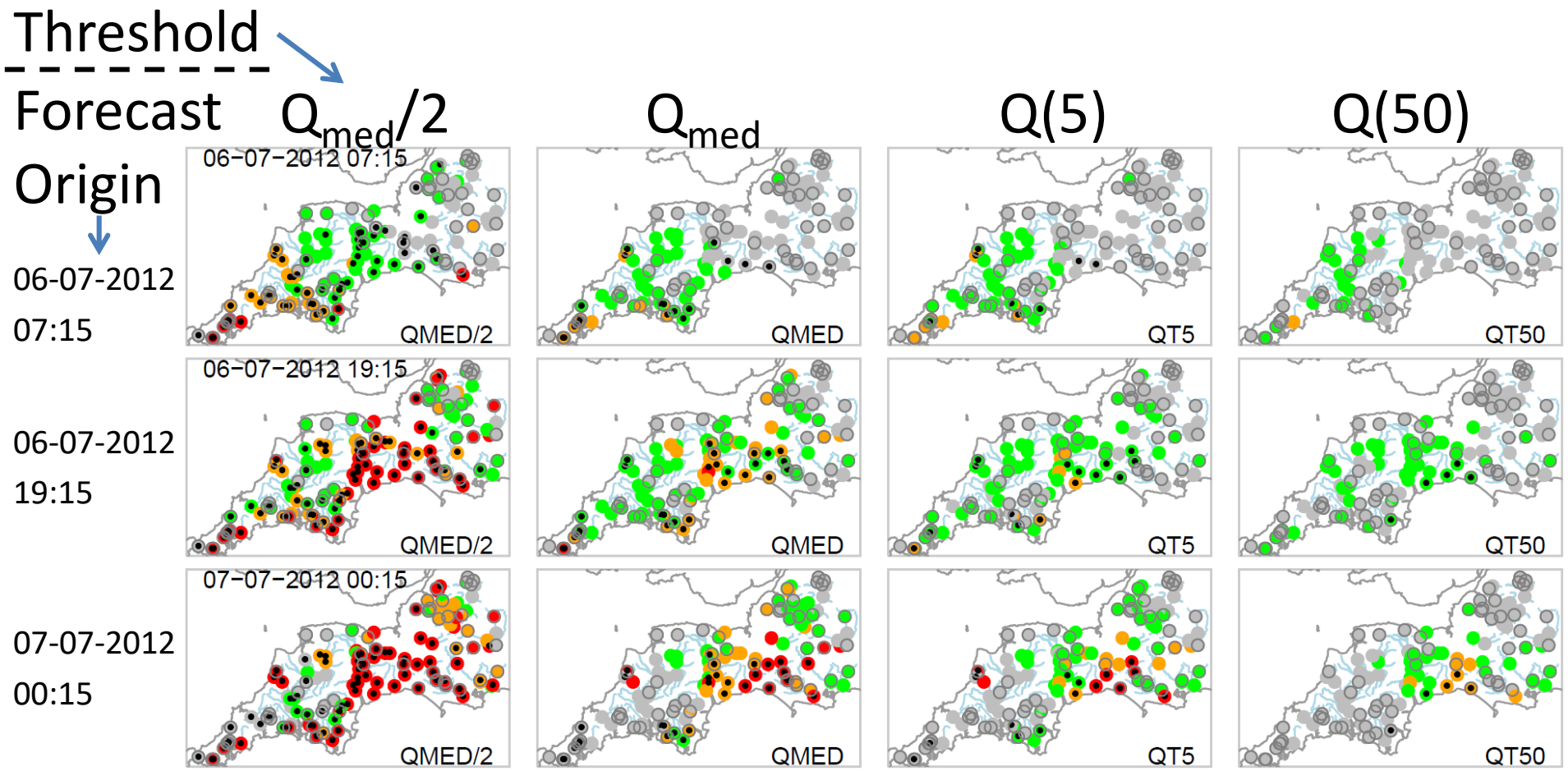

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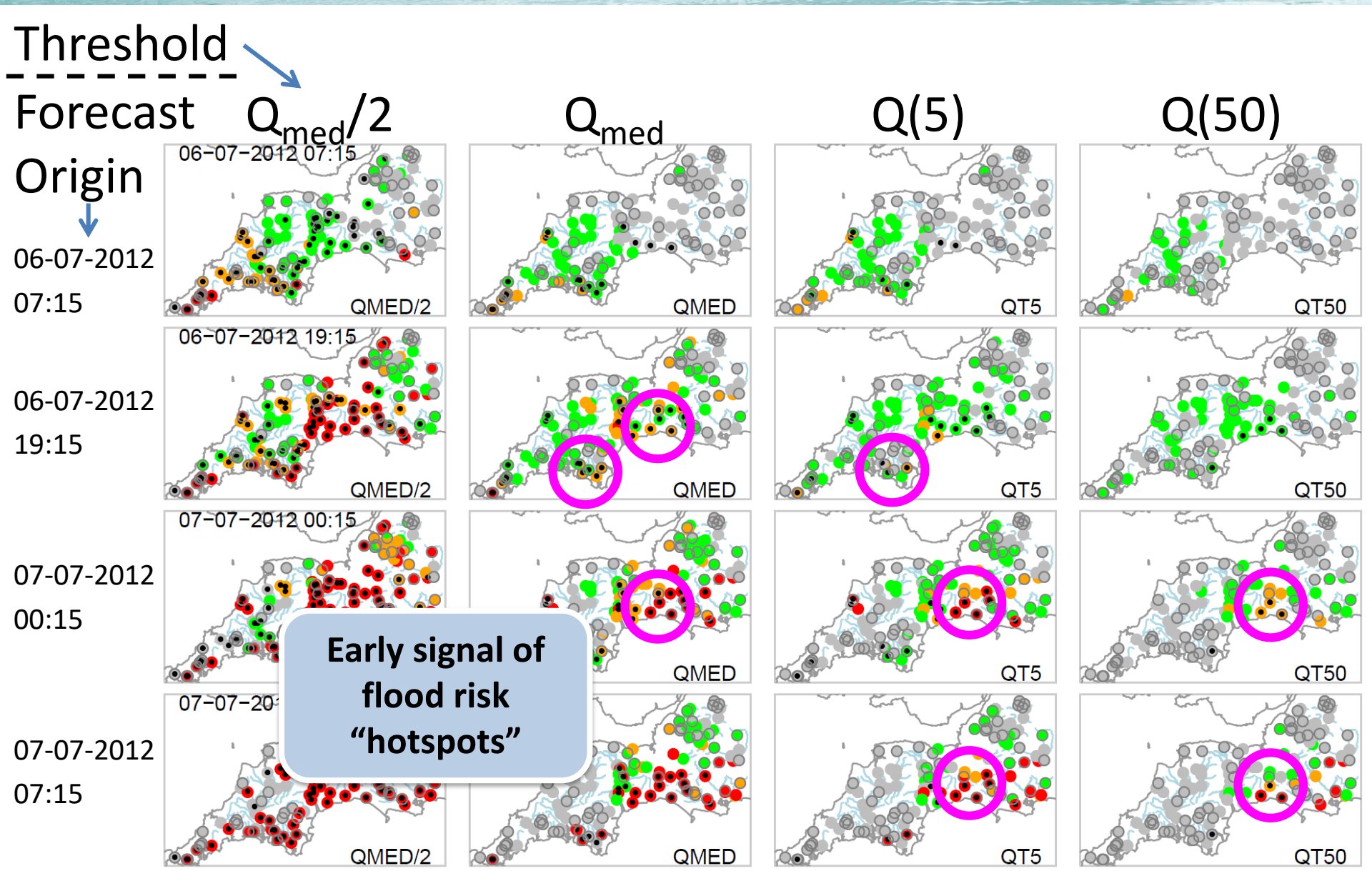
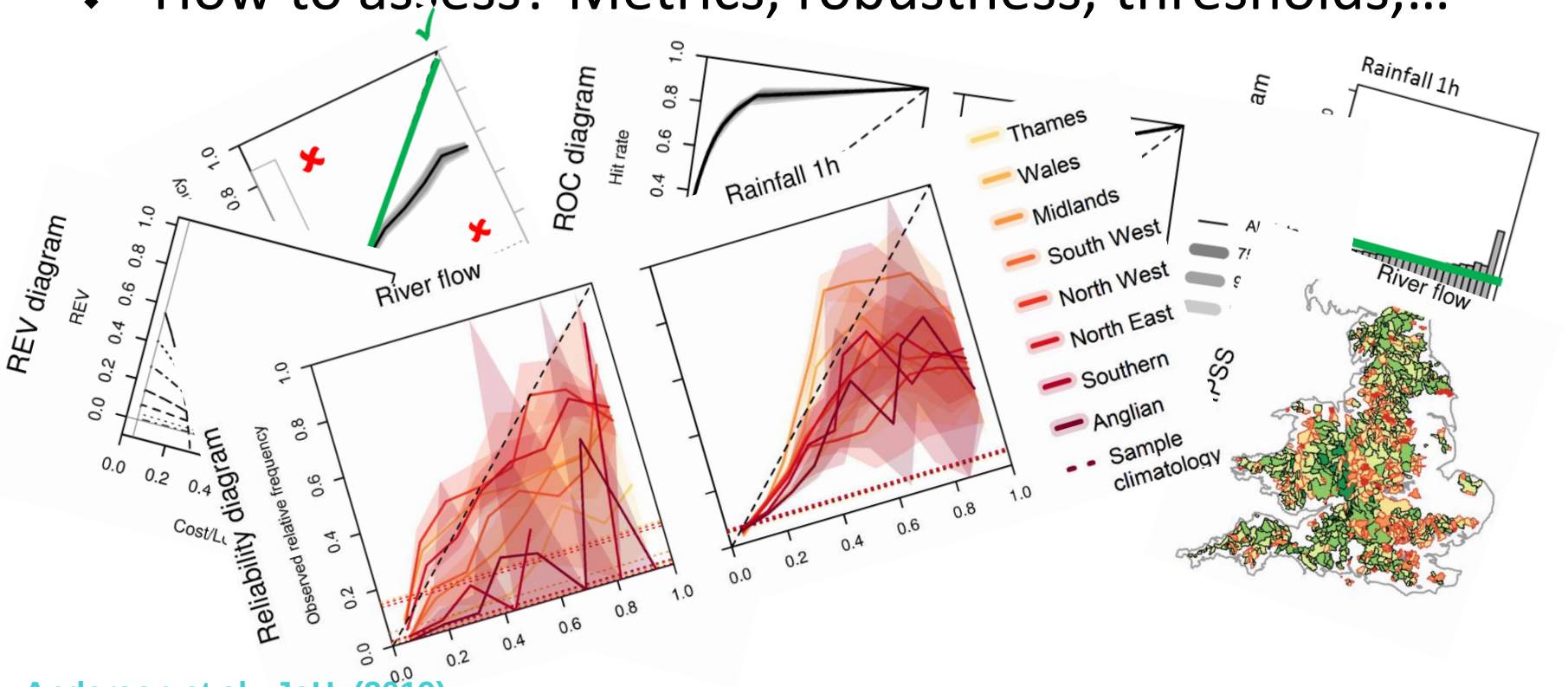


Rainfall & River flow Ensemble Verification

- Generally accepted that probabilistic rainfall and flood forecasts are needed BUT…
  - How well do forecasts perform? (ensemble verification)
  - How to assess? Metrics, robustness, thresholds,…



Anderson et al., JoH, (2019)

Rainfall & River flow Ensemble Verification

- Generally accepted that probabilistic rainfall and flood forecasts are needed BUT…
  - How well do forecasts perform? (ensemble verification)
  - How to assess? Metrics, robustness, thresholds,…
- Key is to be stakeholder and user focused:
  - Flood-producing events of interest.
  - What does this mean for *today's* forecast?
- UKCEH/Met Office project for Flood Forecasting Centre, Scottish Flood Forecasting Service, EA, SEPA

Anderson et al., JoH, (2019)

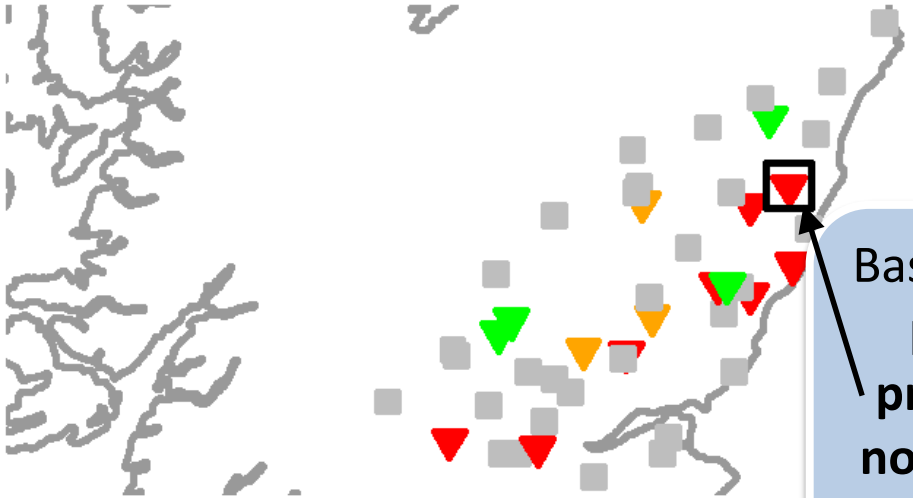
HEPEX blog: https://hepex.inrae.fr/verification-detail-matters/

Rainfall & River flow Ensemble Verification

What does this mean for today's forecast?

Day 1

Derive using >1 year of 5 day forecasts made 4 times a day



QT(2)/2

Based on historical performance, **probabilities are normally too high** at this location

Colours give probability of threshold crossing

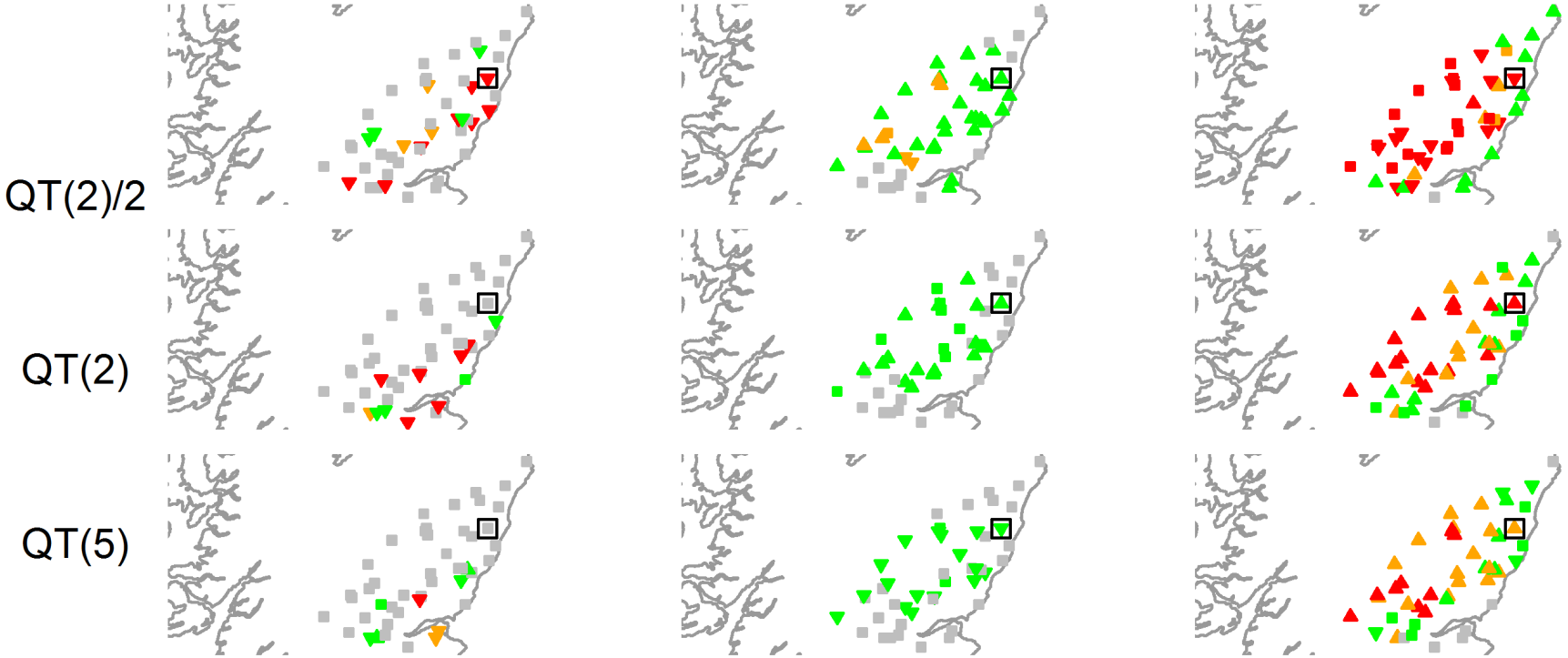
Red: 16 to 24 of members
Orange: 8 to 16 of members
Green: 1 to 8 of members

Symbols give suggested tendency from verification

△ Upwards triangle: possible underestimation
▽ Downwards triangle: possible overestimation
□ Square: no suggested trend
◆ Diamond: not enough data for a trend

Rainfall & River flow Ensemble Verification

What does this mean for today's forecast?



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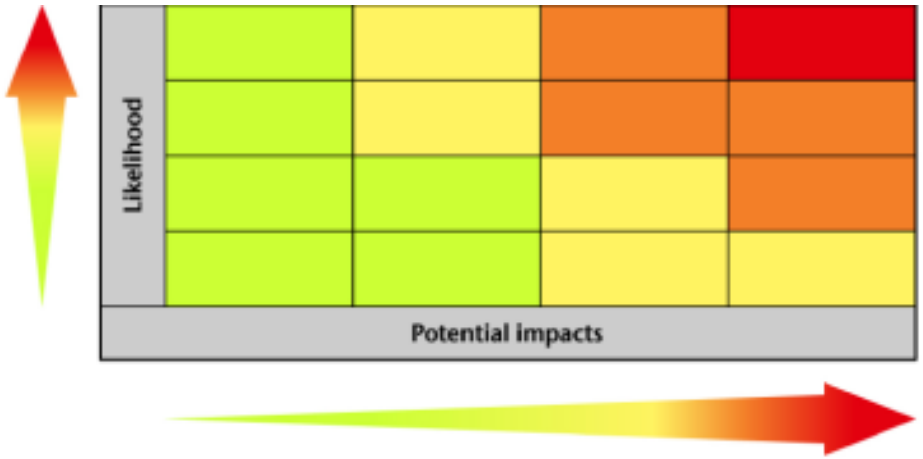
Impact-based Forecasting (IbF)

- Many operational weather and flood forecasting centres are moving to Impact-based Forecasting and Warning
- Supported and encouraged by World Meteorological Organisation (WMO)
- Commonly uses a Risk Matrix approach that combines uncertainty ***and*** impacts



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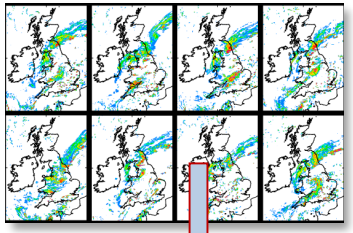
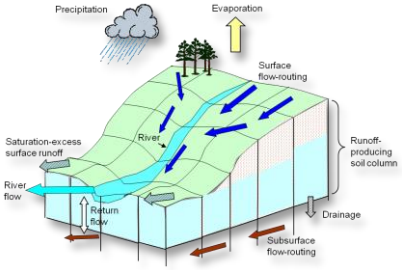
Impact-based Forecasting (IbF)

- Surface Water Flooding Hazard Impact Model (SWF HIM) developed by the Natural Hazards Partnership
- Builds on existing models & tools
- Operated by Flood Forecasting Centre over England & Wales

Rainfall ensembles (MOGREPS-UK)



Grid-to-Grid Hydrology

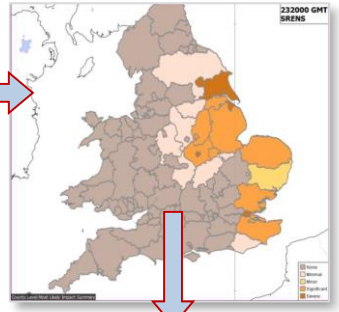


SWF Hazard Footprint

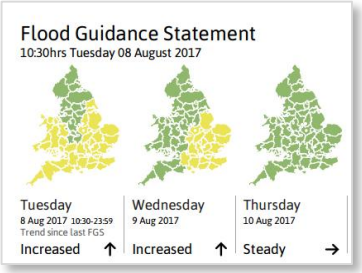
SWF HIM

Real-time SWF risk outputs

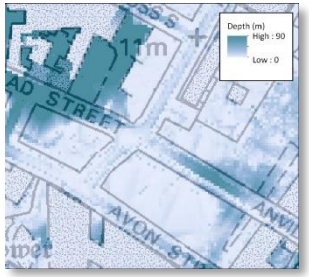
Visualisation



Dissemination

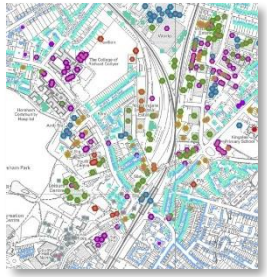


Impact Library



Updated Flood Map for Surface Water

National Receptor Database (NRD)



National Population Database (NPD)

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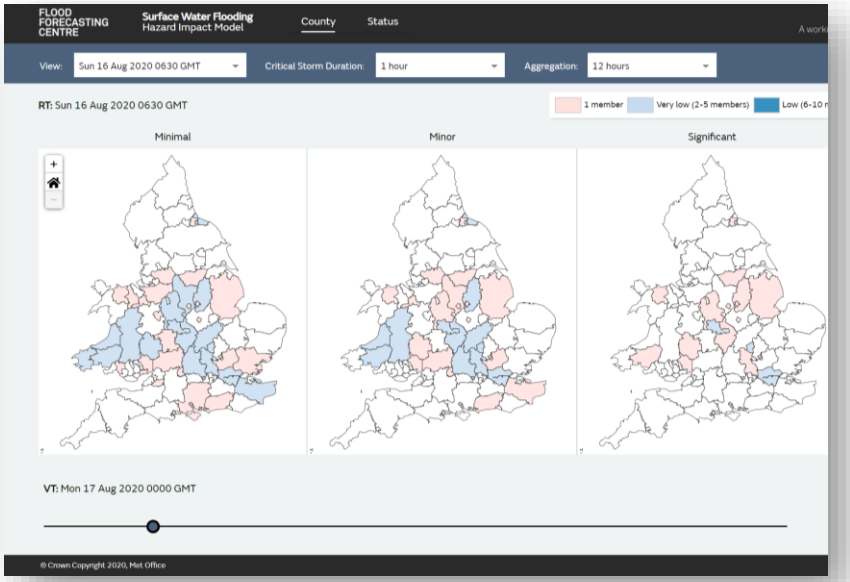
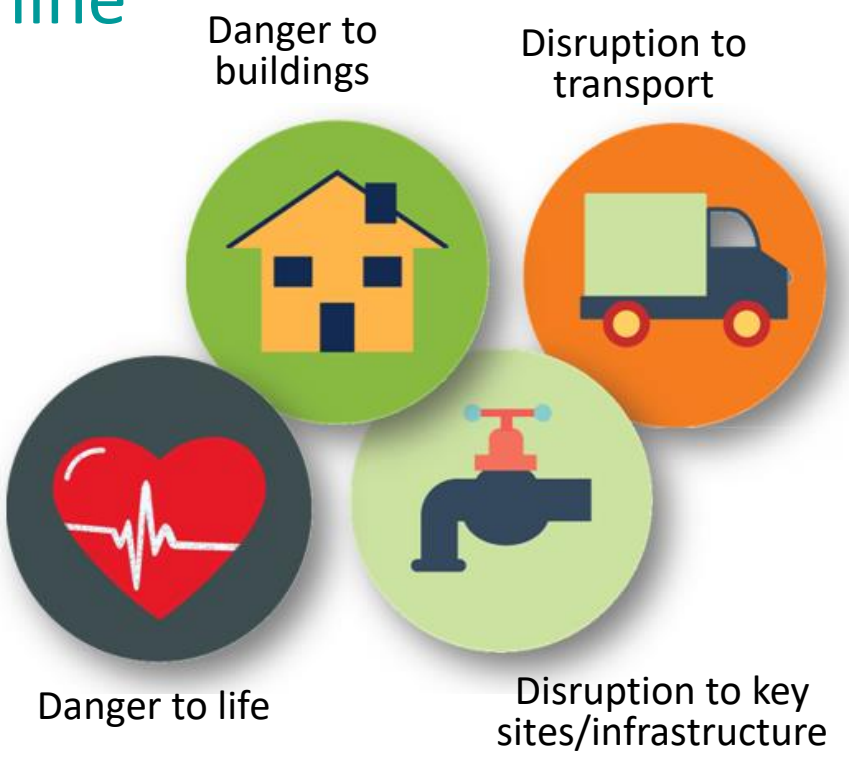
Impact Library and Visualisation

- Impact Library developed offline and accessed in real-time
- Four categories of disruption (impact criteria)
- Uses a Risk Matrix approach





- Operational since April 2020

Cole et al., Aldridge et al., FLOODrisk2016
www.naturalhazardspartnership.org.uk