

FLOODFORECASTINGCENTRE

a working partnership between



Environment
Agency

Met Office



Providing trusted guidance to help protect lives and livelihoods from flooding

Overview

- Introduction
- Flood Guidance Statement (FGS) & modelling approaches
- Flood Events: Examples
 - Cumbria & Lancashire 4/6 December, 2015 (Storm Desmond) 2015
 - Manchester, Leeds, York & Yorkshire 26/28 December, 2015 Boxing Day Floods
- Future Improvements & New Developments

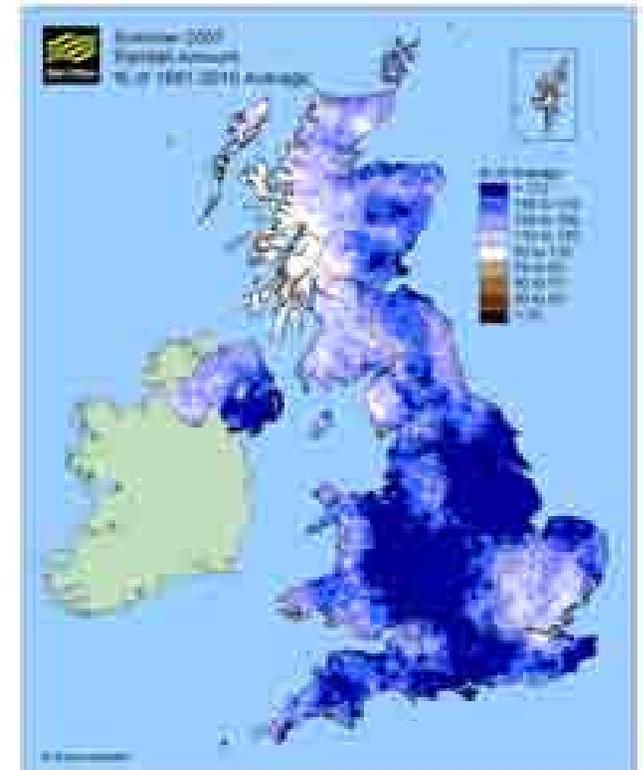
What is the FFC?

- ➔ Partnership between the Met Office and Environment Agency.
- ➔ Remit to forecast for all sources of flooding.
- ➔ Operational since April 2009 delivering 24/7 services.
- ➔ Combine staff expertise across disciplines in hydrometeorology.
- ➔ Works across organisations (MO/EA & Gov) to supply guidance to emergency services (Cat 1&2 responders, blue light services, CNI etc).
- ➔ Introduce new science and continually improve services for customers.

Why was the FFC set up? – the catalyst

- ➔ Inland flooding Summer 2007 – key trigger
- ➔ Record breaking rainfall amounts
- ➔ Severe flooding impacts
- ➔ Sir Michael Pitt recommended:

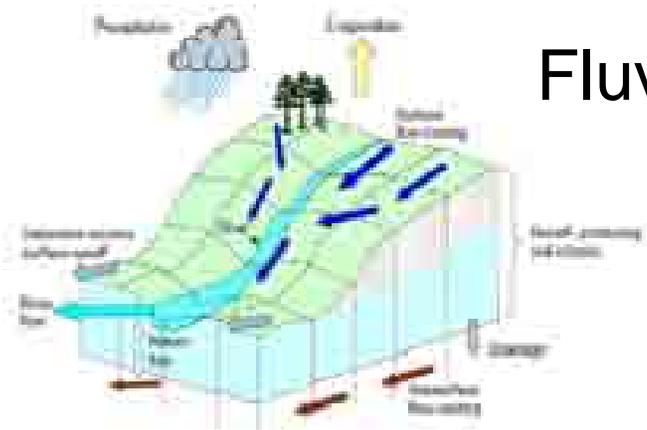
“The Environment Agency and the Met Office should work together, through a joint centre, to improve their technical capability to forecast, model and warn against all sources of flooding.”



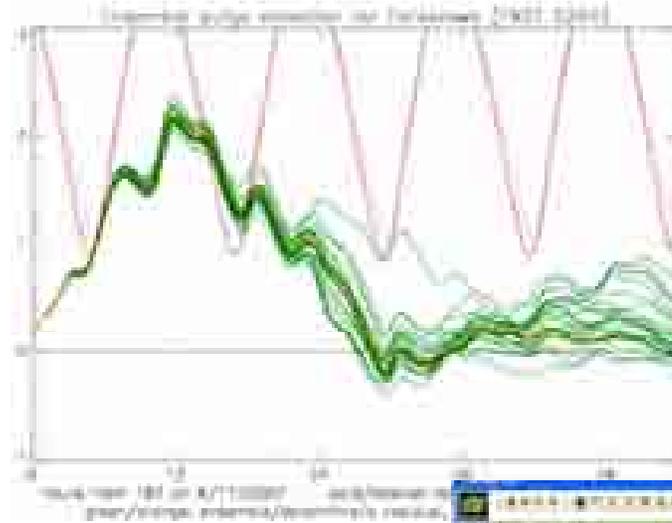
Timeline

- ➔ 2007 - summer flooding
- ➔ 2008 – Wet bench operating out of Ops Centre
- ➔ April 2009 - FFC set up as a pilot
- ➔ 2010 - permanent business case approved
- ➔ 2010/11 - prepare and train hydrometeorologists and rationalise services
- ➔ April 2011 - move from London to Exeter
- ➔ Nov 2011 - streamline services and staffing
- ➔ Summer / Autumn / Winter 2012 –widespread flooding
- ➔ 2013 / 14 – Winter flooding
- ➔ 2015 / 16 – Winter flooding

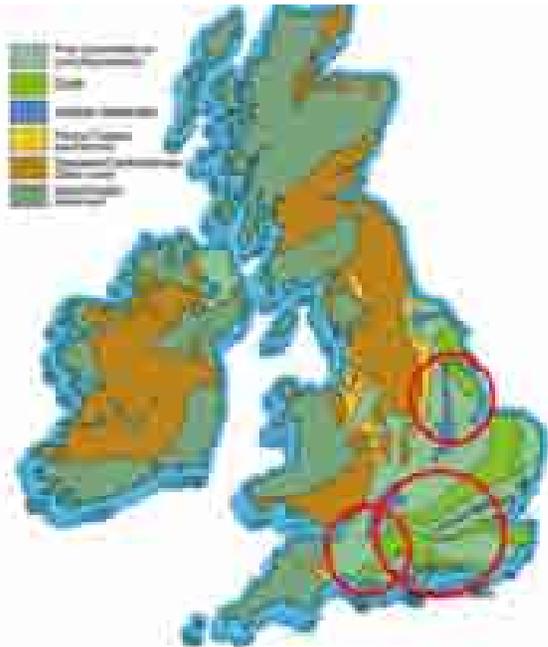
Sources of flooding & approaches



Fluvial



Coastal
UKCMF
(ensembles to
T+174)



Surface Water



Groundwater



Atmospheric models FFC use

UKV (Short Range)

- 1.5km resolution
- 120hr deterministic forecast
- 8 times per day



MOGREPS-UK

- 12 member ensemble
- 2.2km resolution
- 54hr probabilistic forecast
- 4 times per day



Euro4 (Medium Range)

- 4.4km resolution
- 66hr det. forecast twice/day
- 144hr det. forecast twice/day



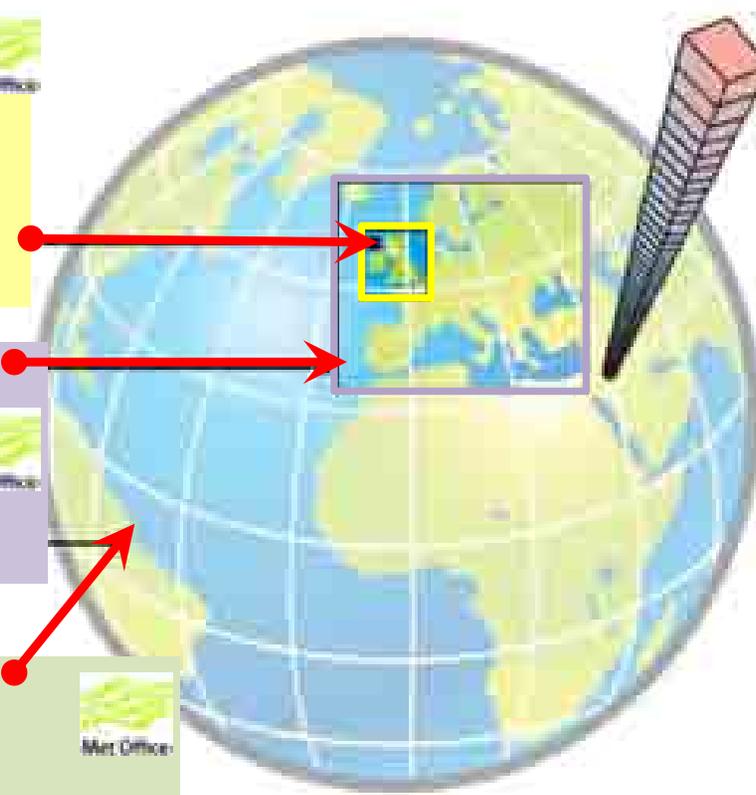
MOGREPS-G

- 12 member ensemble
- 4 times per day



Global Model

- 17km resolution
- 66hr det. forecast twice/day
- 144hr det. forecast twice/day



Models from other Forecast Centres

ECMWF



- Deterministic
- Medium range ensembles

National Weather Service (US)

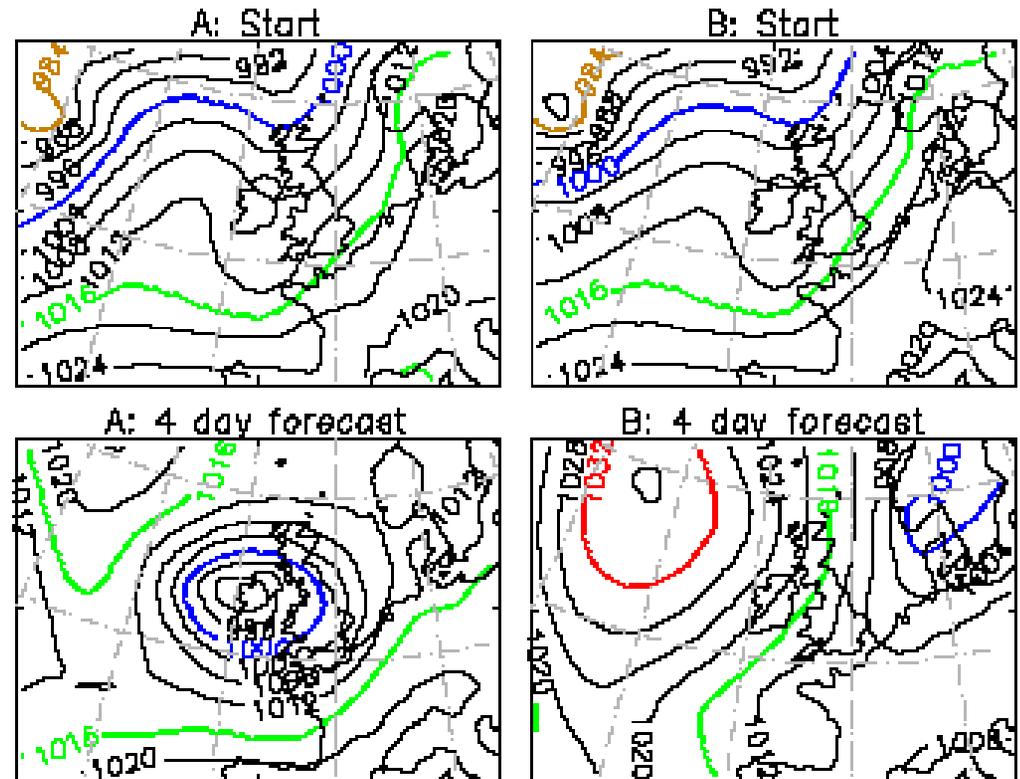


What is ensemble forecasting?

What is ensemble forecasting?

Forecasting Challenges

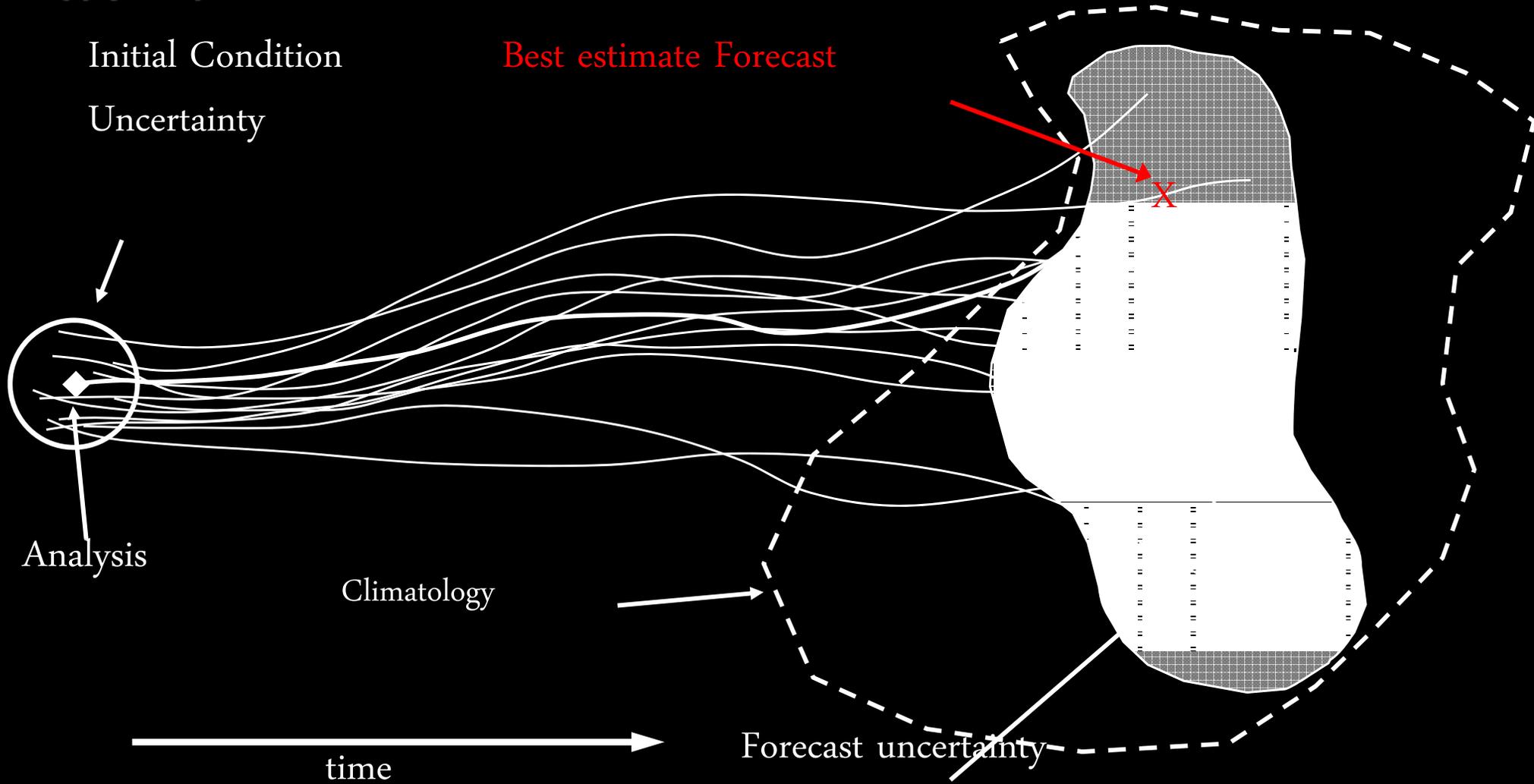
- Finer details generally have shorter predictability. For example, exact timing and spatial scale.....
- Beyond 3 days chaos becomes a major factor, with small errors in analysis & models, become large errors in forecast.
- Communicating the (un)certainty and potential impact - **risk**.





Dealing with Chaos...

Ensemble forecasting...

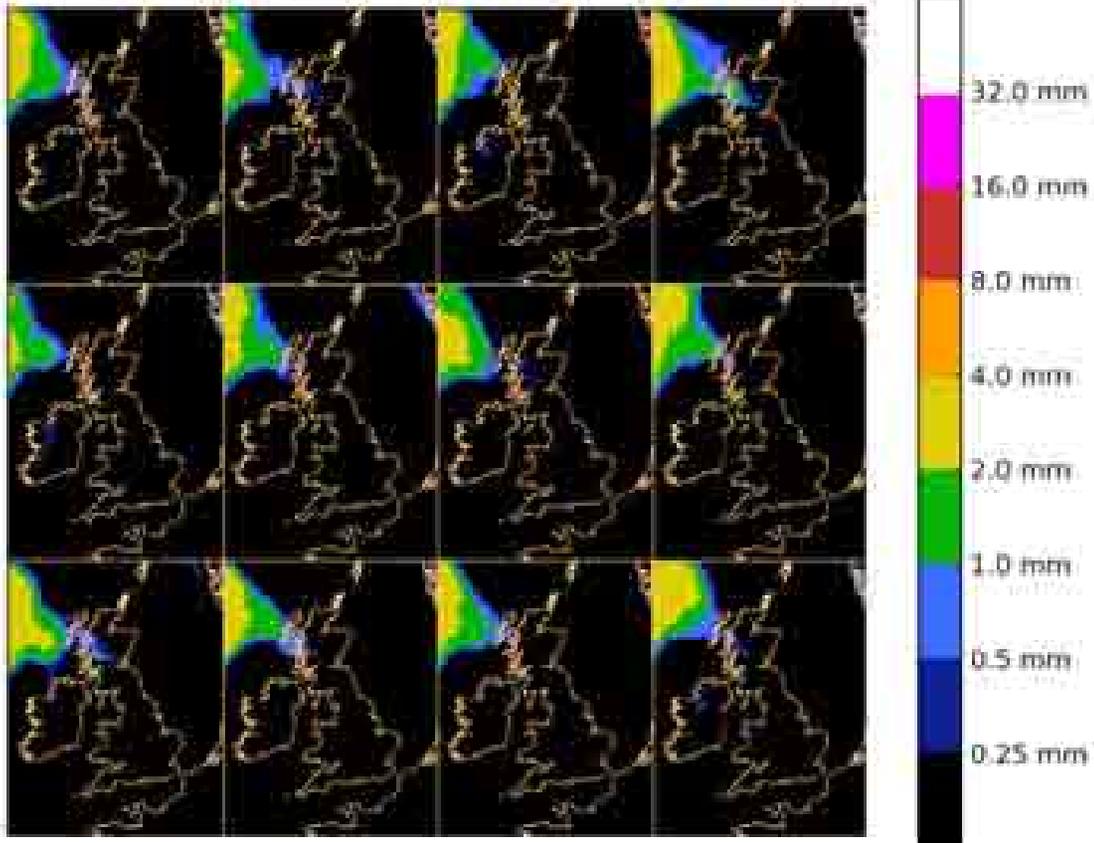


Storm Desmond Rainfall Accumulations

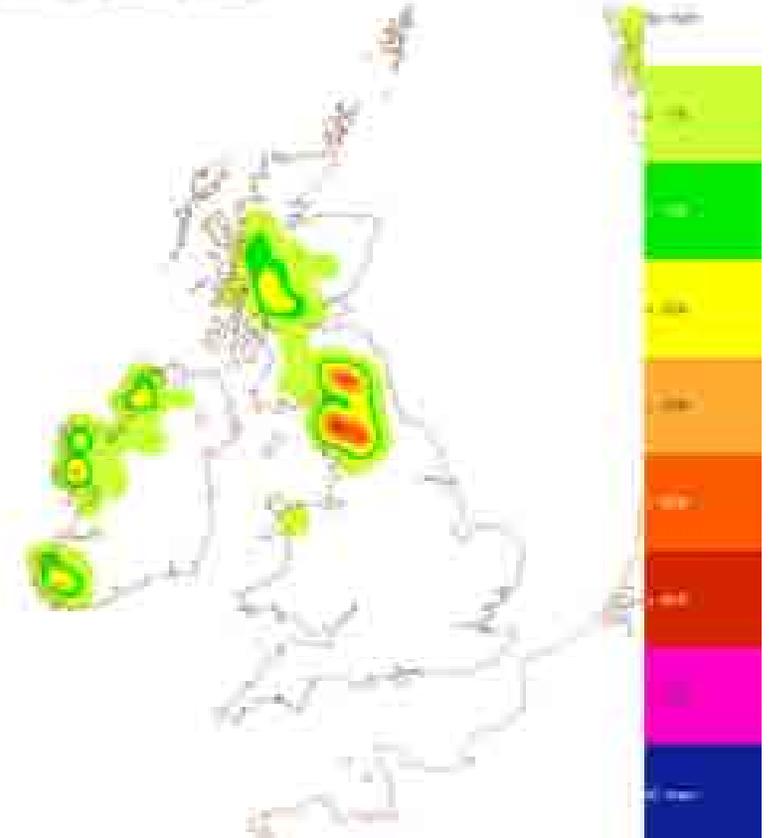
12 × 2.2km MOGREPS-UK hourly rainfall accumulation:

Probability 24 hour rainfall > 100mm. Valid for the period 2100 4th December to 2100 5th December' Gave a 12 to 36 hour lead time

M-UK 1 Hour Precip Accum. for period ending: 10Z 04/12/2015 T+1



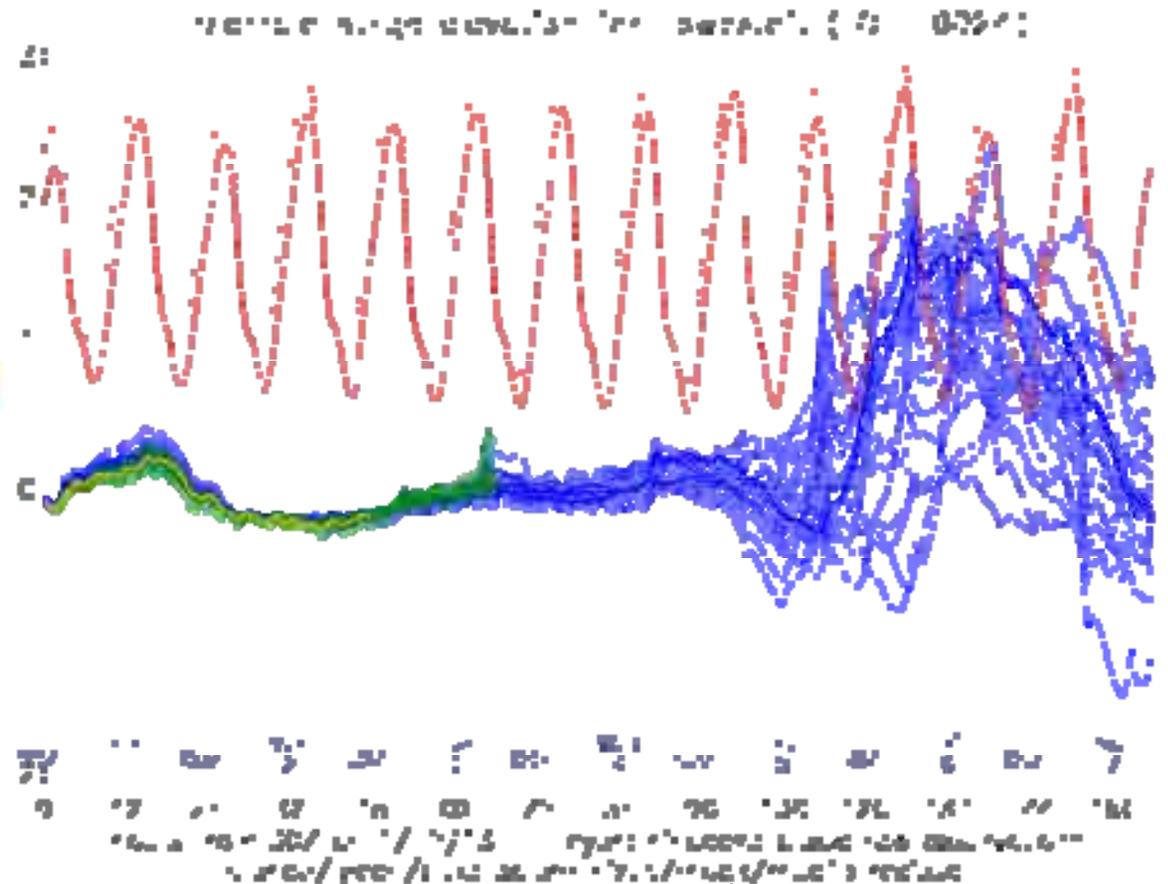
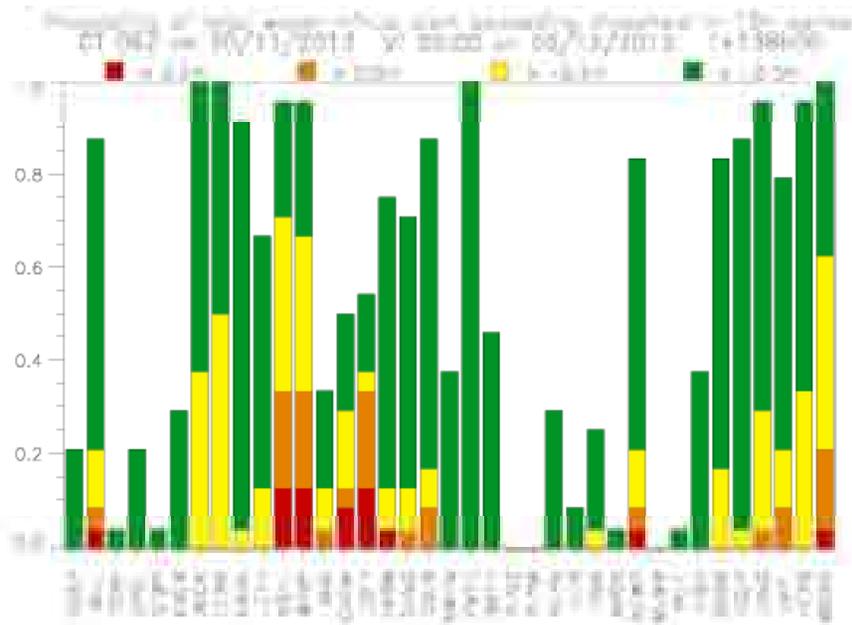
24 Hour Prob. Rainfall > 100mm



UK model accumulations up to 250mm; global all < 100mm.
Planning extended run length (UKV and MOGREPS-UK) on new HPC

Storm Surge Ensemble

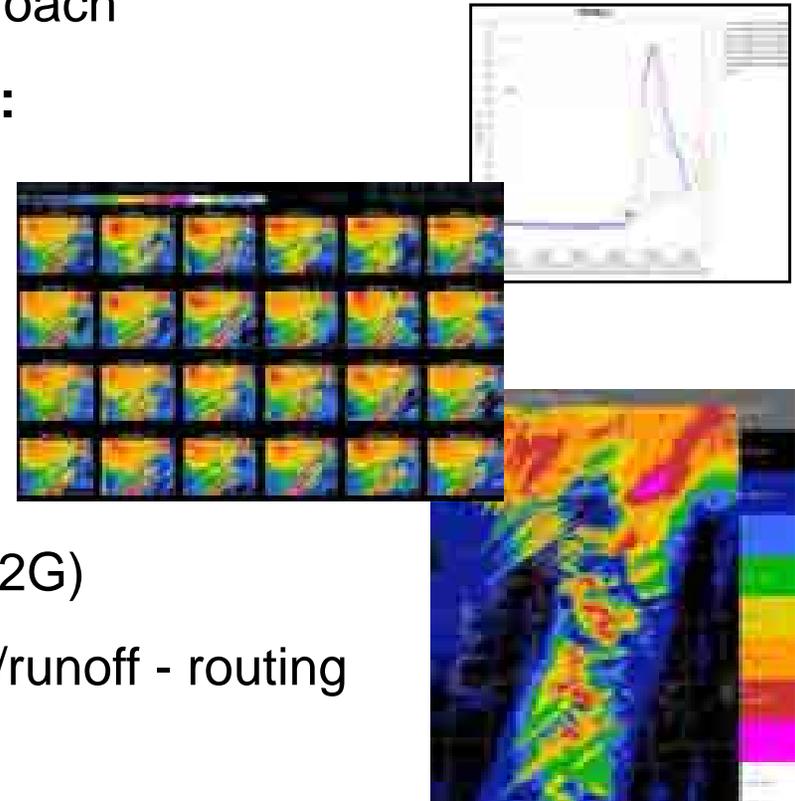
Surge model coupled to atmospheric ensemble



Lowestoft
(~5 day forecast)

Assigning & communicating flood risk

- ➔ Flood risk determined using a probabilistic approach
- ➔ **Hydrometeorologist employs an analysis of:**
 - NWP models (deterministic and ensemble)
 - Guidance from the Met Office chief and deputy chief meteorologists
 - Raingauge & radar data
 - Grid based rainfall/runoff - routing model (G2G)
- ➔ EA's flood forecasting team's catchment rainfall/runoff - routing models
- ➔ Pre-determined rainfall depth-duration thresholds (esp rapid response / surface water impacts)
- ➔ 09:45 Conference with EA forecasting teams



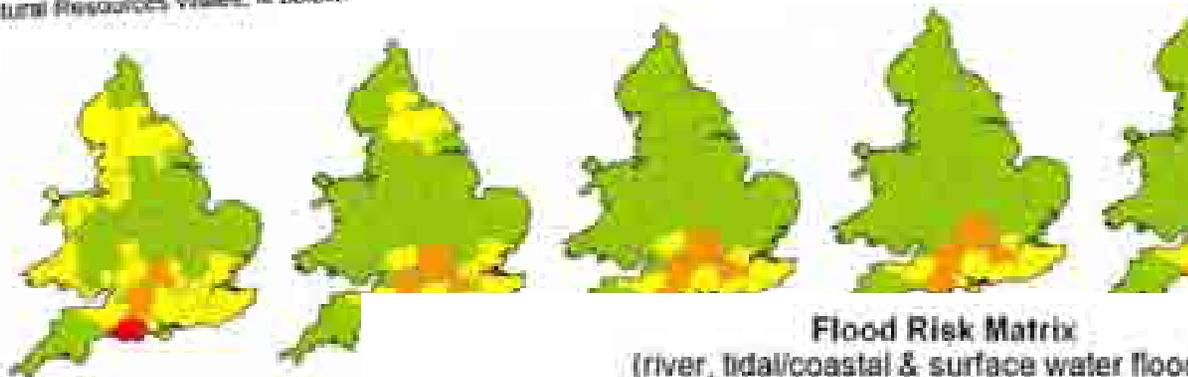
Flood Guidance Statement

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Flood Guidance Statement 10:30hrs Monday 06 January 2014

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



10:30 - 23:59hrs
Monday
06 January 2014 07

In Dorset, there is a **HIGH** and **MEDIUM** flood risk for risk from ongoing ground conditions in central southern

General overview of flood

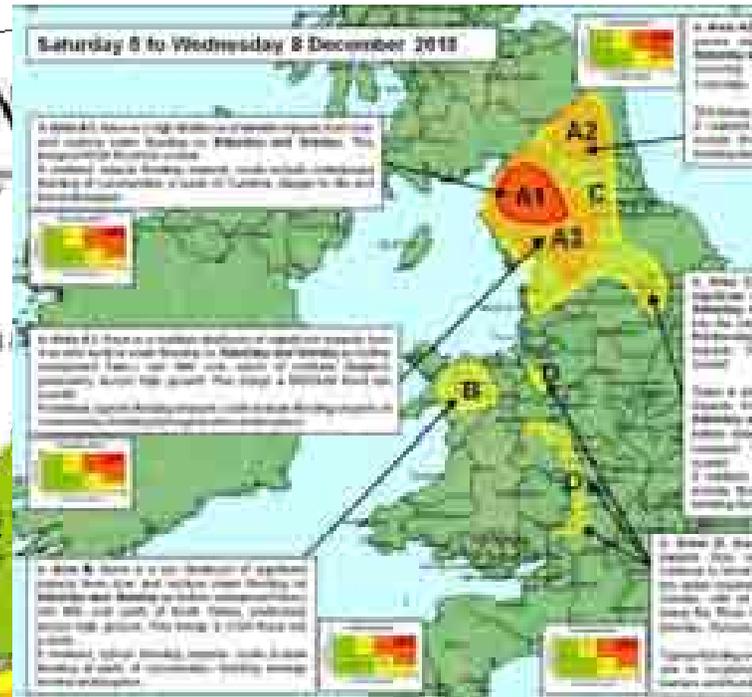
There is a **HIGH** overall flood risk impacts from coastal flooding in medium likelihood of significant

Flood Risk Matrix
(river, tidal/coastal & surface water flooding)

Likelihood	High				
	Medium		✓		
	Low				
	Very Low				✓
		Minimal	Minor	Significant	Severe
		Potential Impacts			

Overall Flood Risk

HIGH	
MEDIUM	
LOW	
VERY LOW	



Coastal

UK4

- Uses Global Model wind/pressure fields
- 2 day and 5 day forecast
- 4 times per



Wave ensemble

- Uses MOGREPS-G wind/pressure fields
- 6.5 day forecast
- 4 times per day



CS3X det. surge model

- Uses Global Model wind/pressure fields
- 2 day forecast
- 4 times per day



Surge ensemble

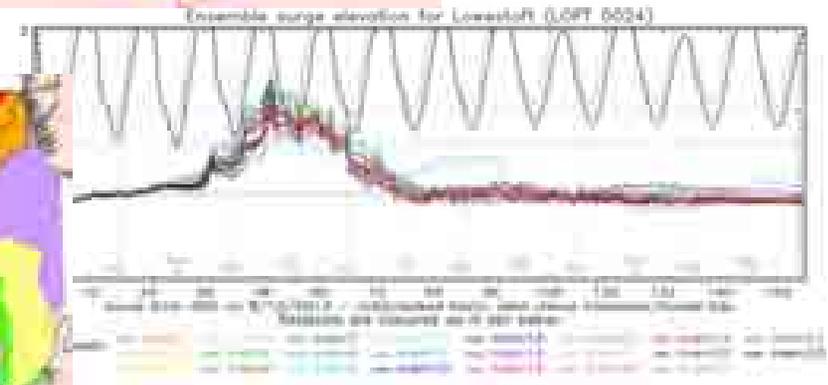
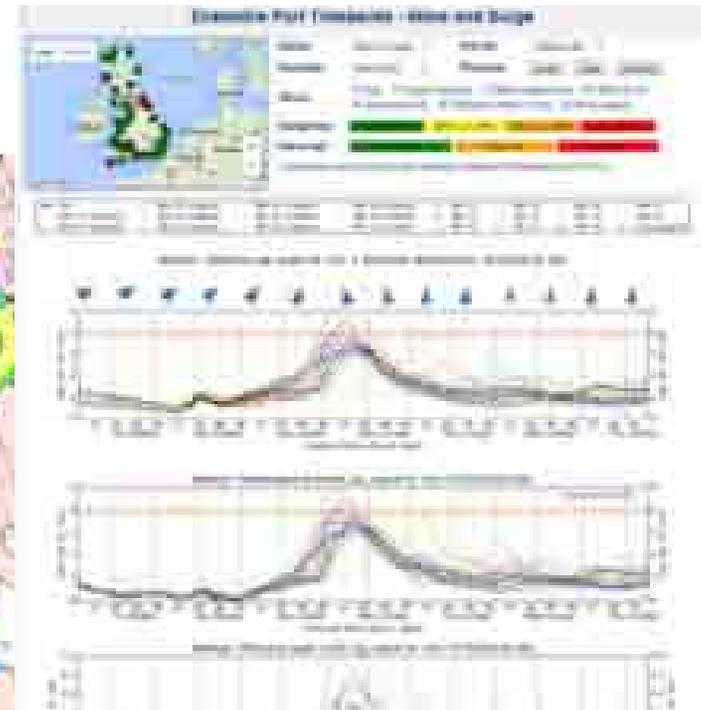
- Uses MOGREPS-G wind/pressure fields
- 6.5 day forecast
- 4 times per day



ECMWF



- Deterministic wave model
- Wave ensemble



Underpinning, science, systems & skills

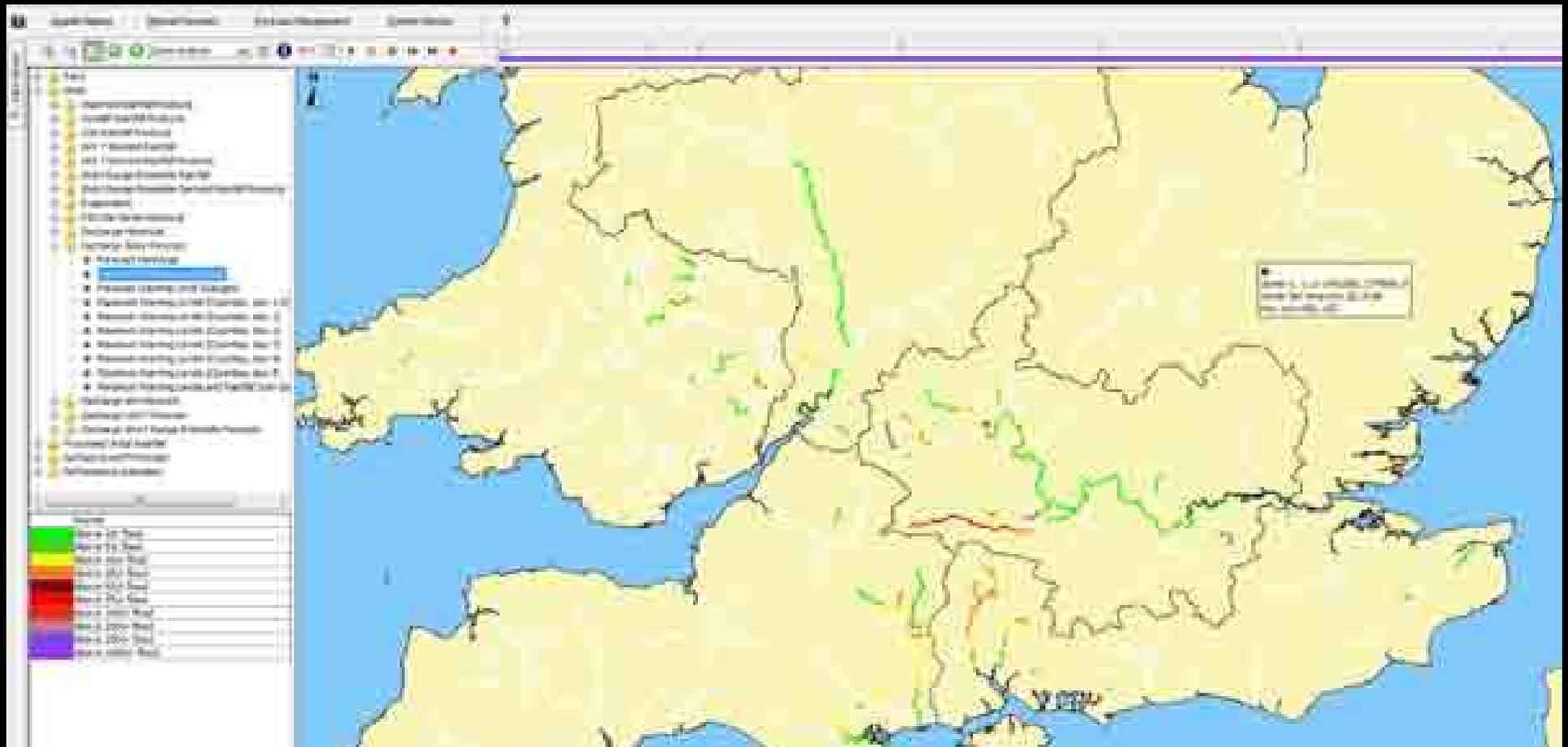
G2G: strengths & limitations

- Designed to work with gridded rainfall estimates, radar and NWP....);
- Forecasts everywhere! at 15 minute timesteps and at a 1km x 1km spatial resolution;
- Can provide flow forecasts for ungauged catchments....
- Performs less well in low relief, groundwater dominated catchments;



- **The challenge: to generate flows across whole of England & Wales (& Scotland) at 1km x 1km, using a distributed, grid-based, hydrological model, in an operational environment, to provide an overview of flood risk**
- **Very different from calibrating a model for a single catchment**

National Flood Forecasting System (NFFS) – Grid to Grid Hydrological Model



Flood info Timeline

Days 5 & 4

Day 3

Day 2

Day 1

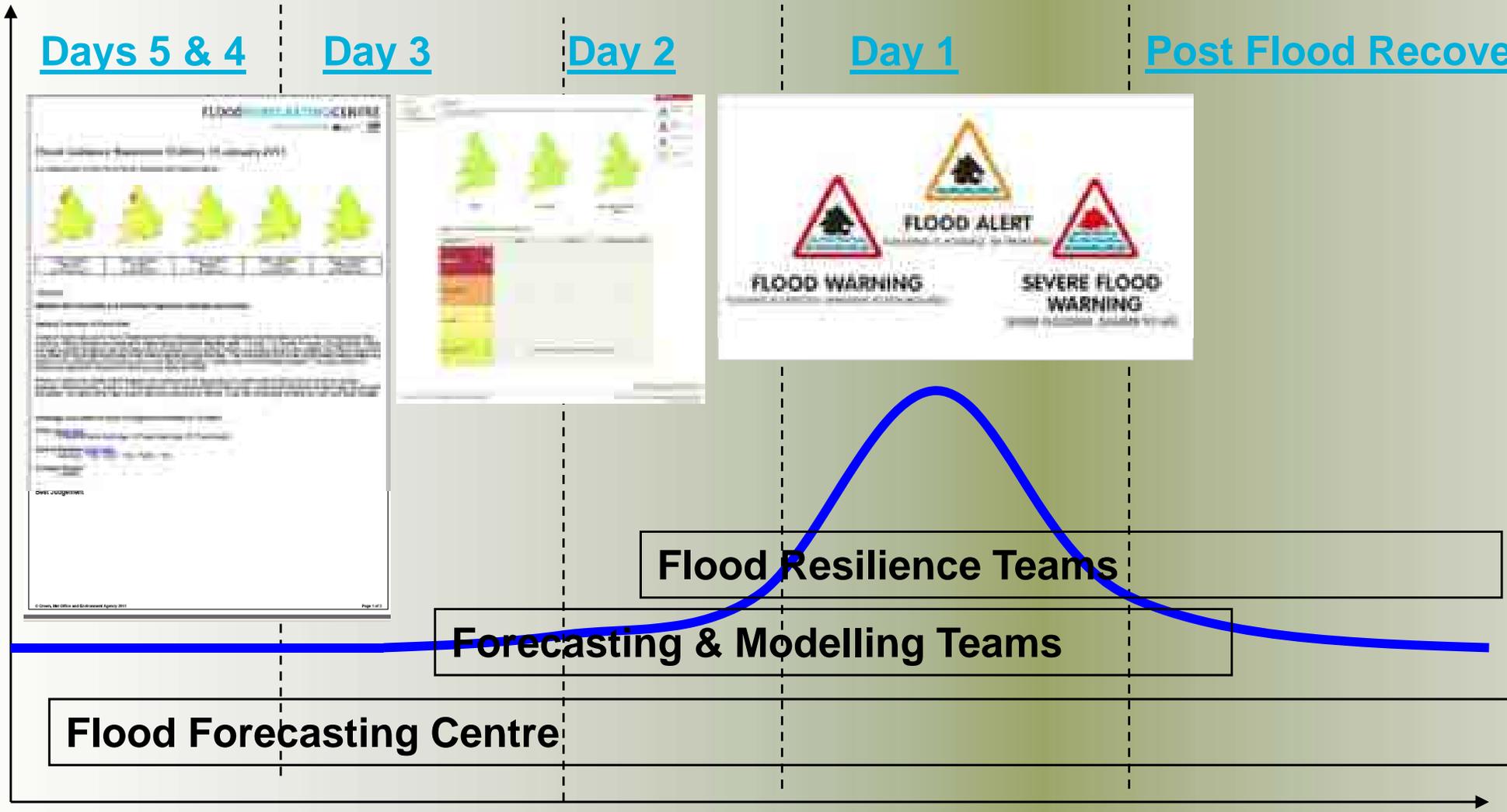
Post Flood Recovery



Flood Resilience Teams

Forecasting & Modelling Teams

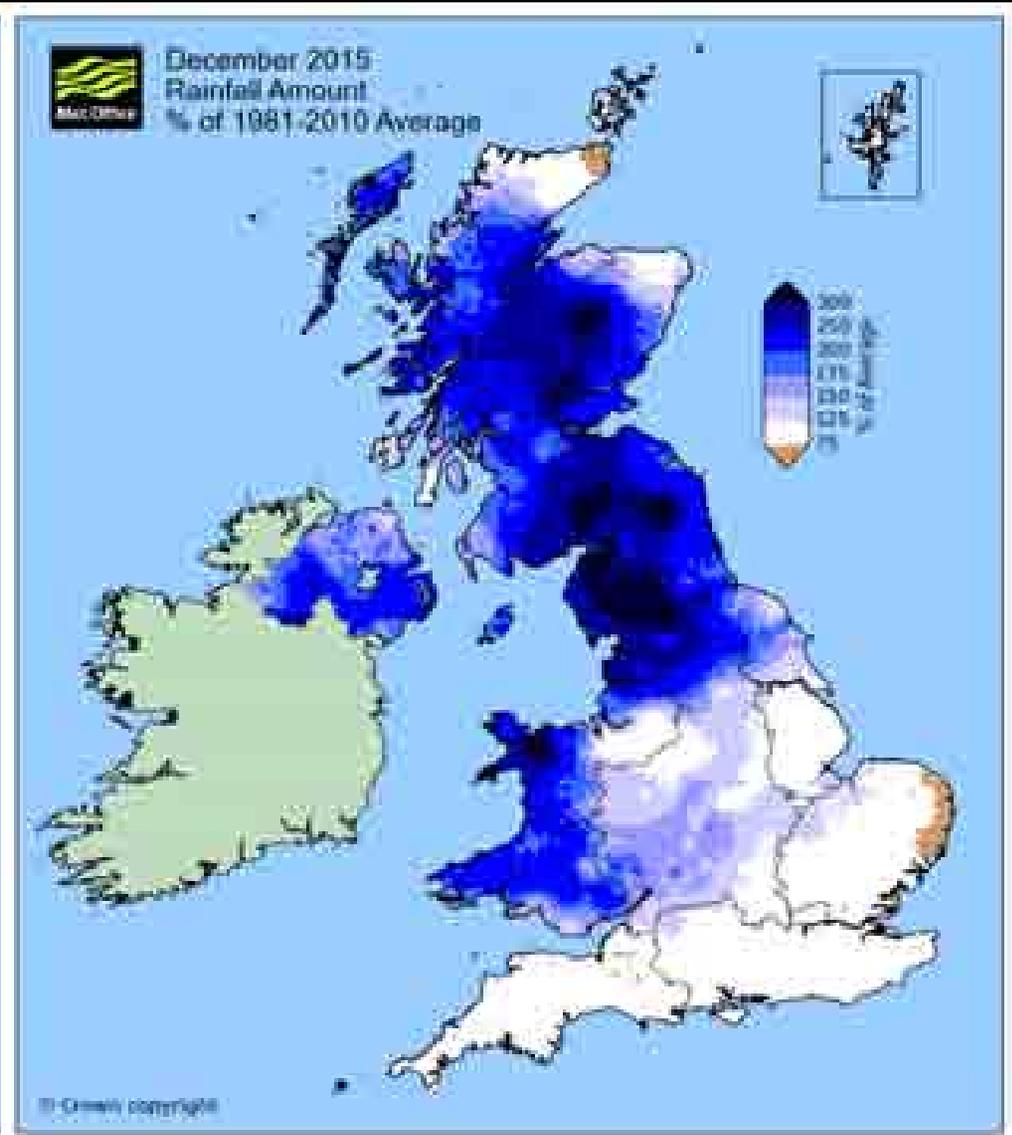
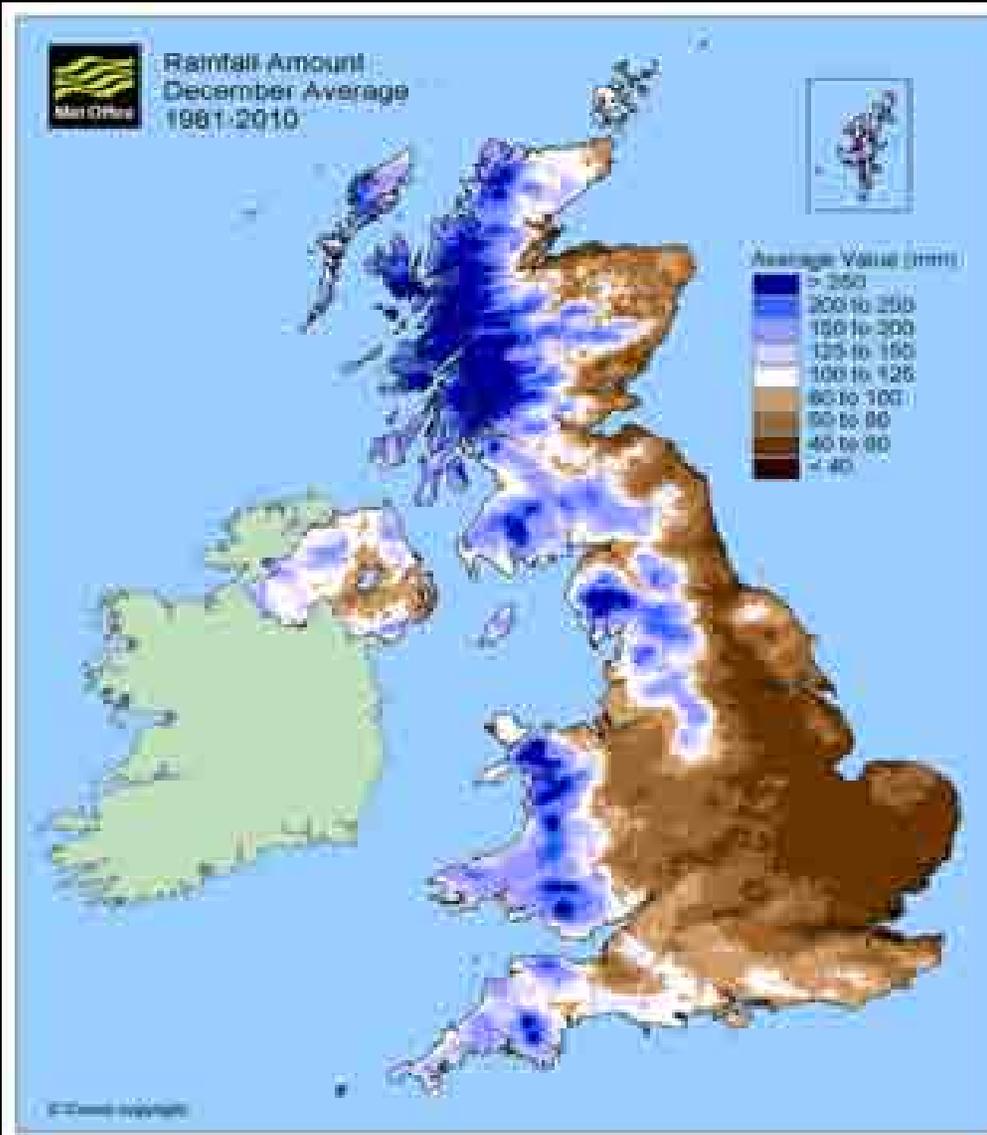
Flood Forecasting Centre



Winter 2015-16

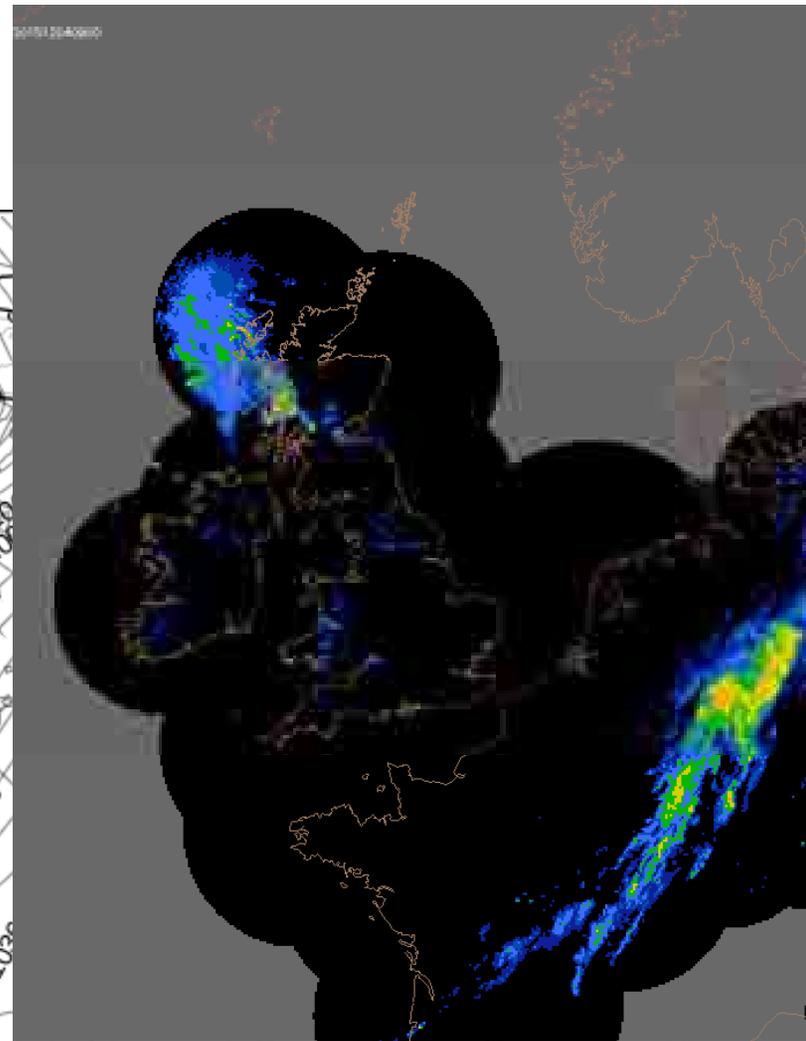
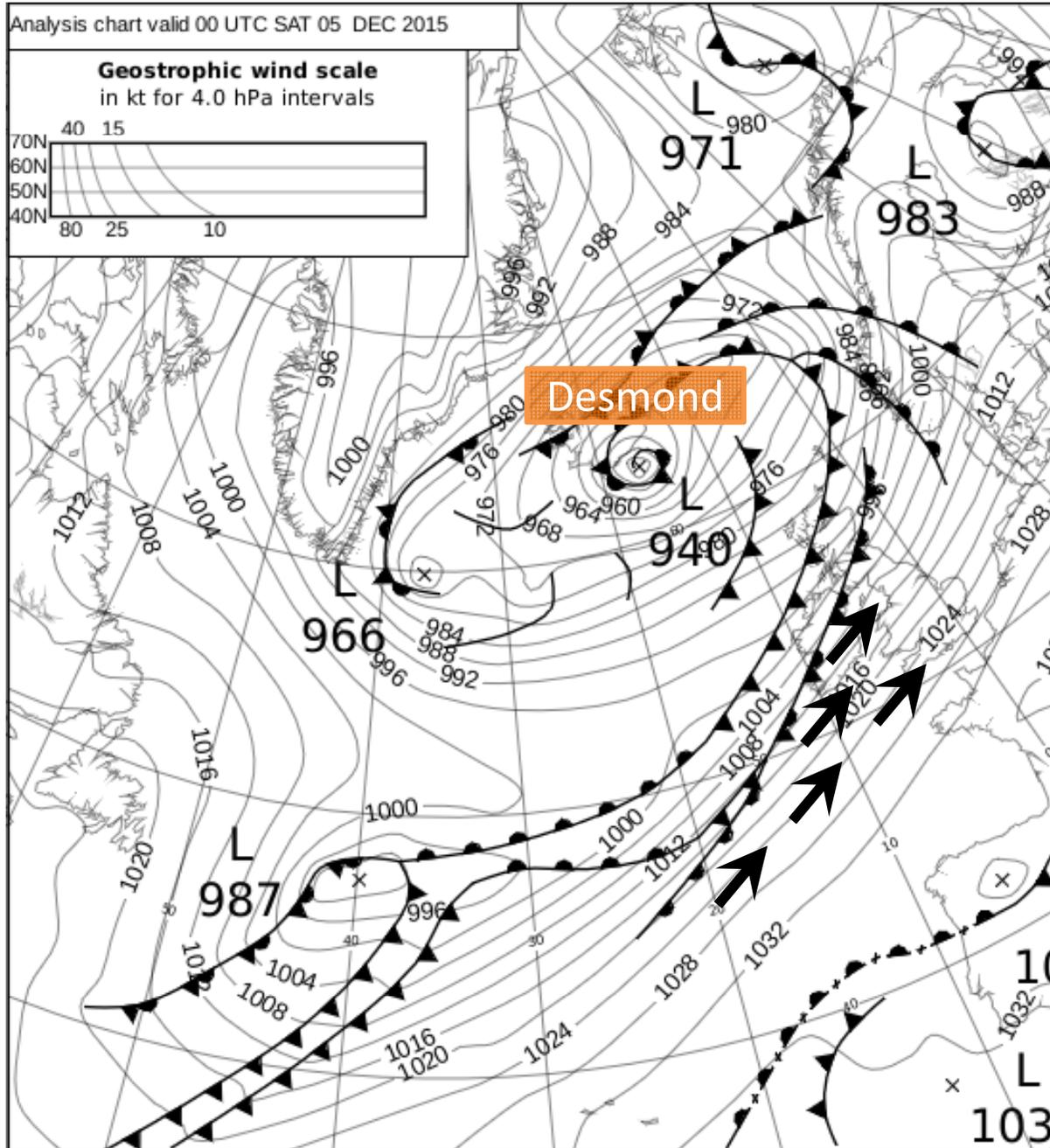
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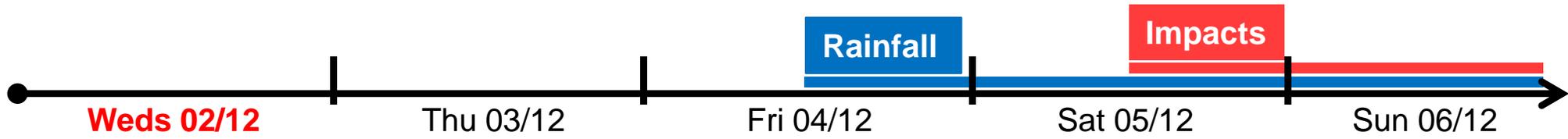
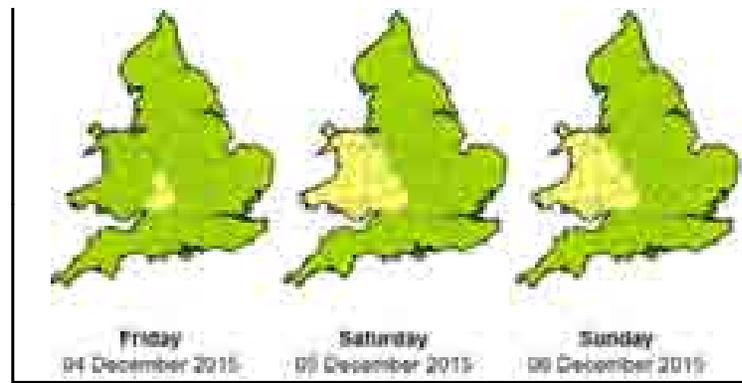


Storm Desmond

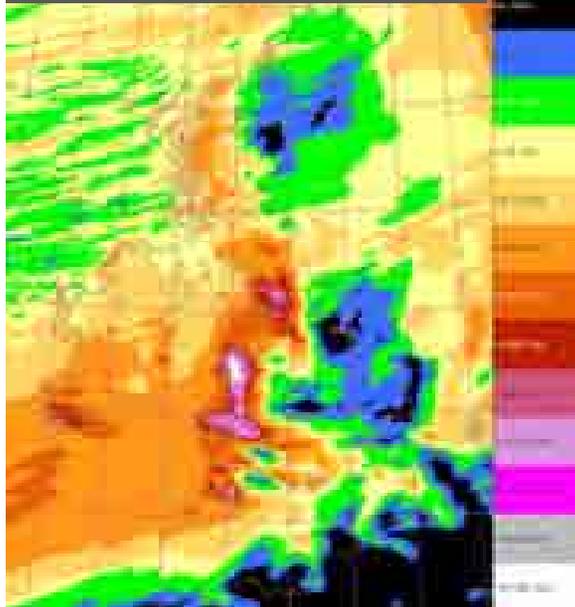
Extreme rainfall meteorology



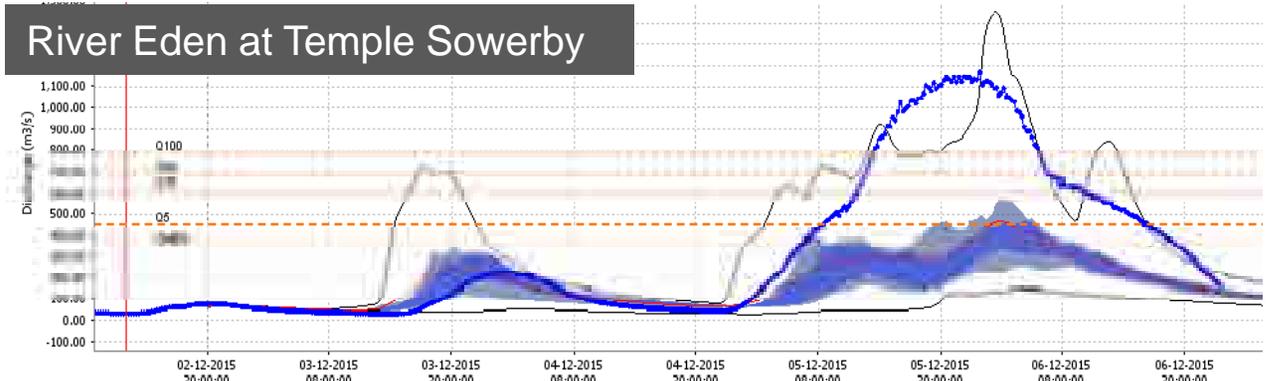
Desmond timeline



24hr hi-res totals for Sat



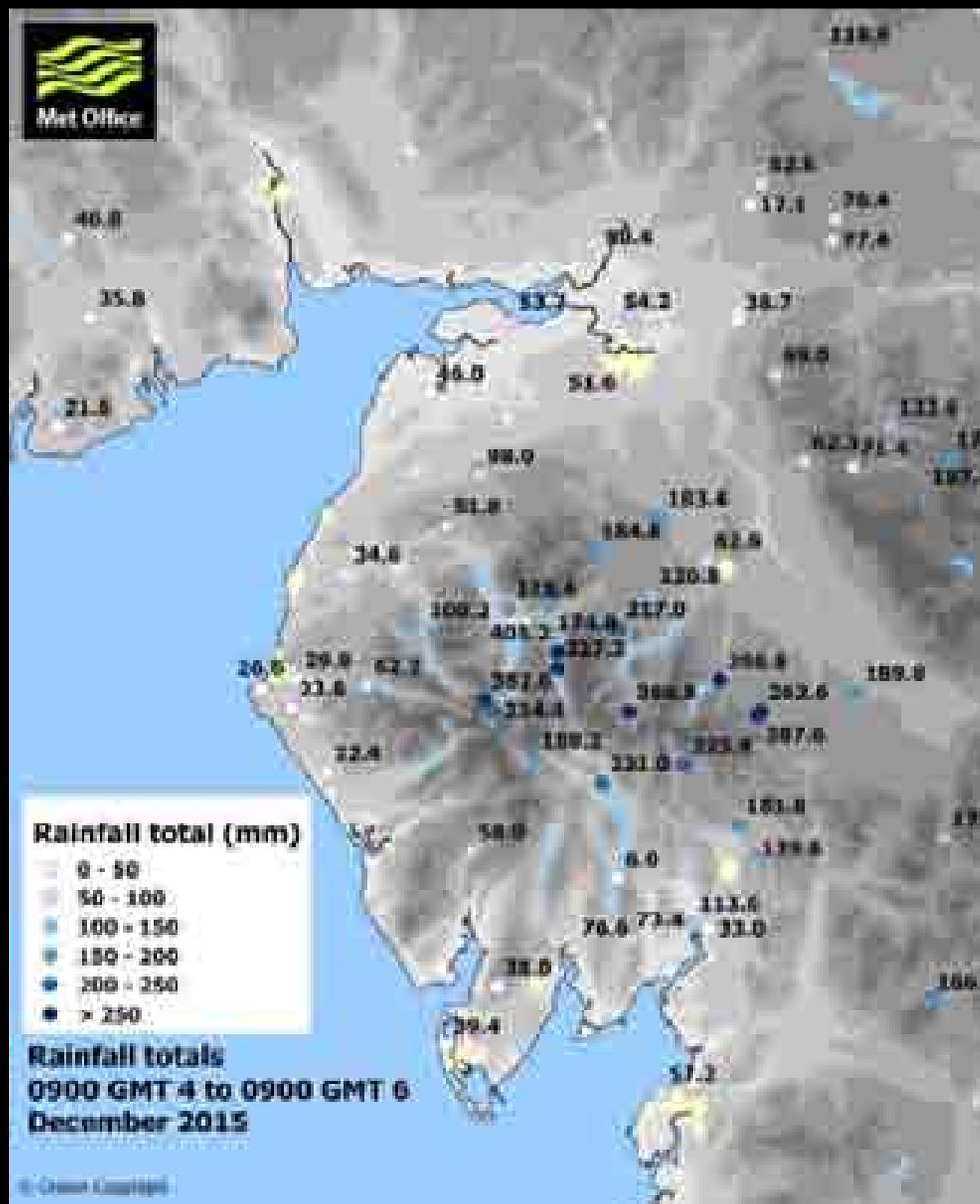
River Eden at Temple Sowerby



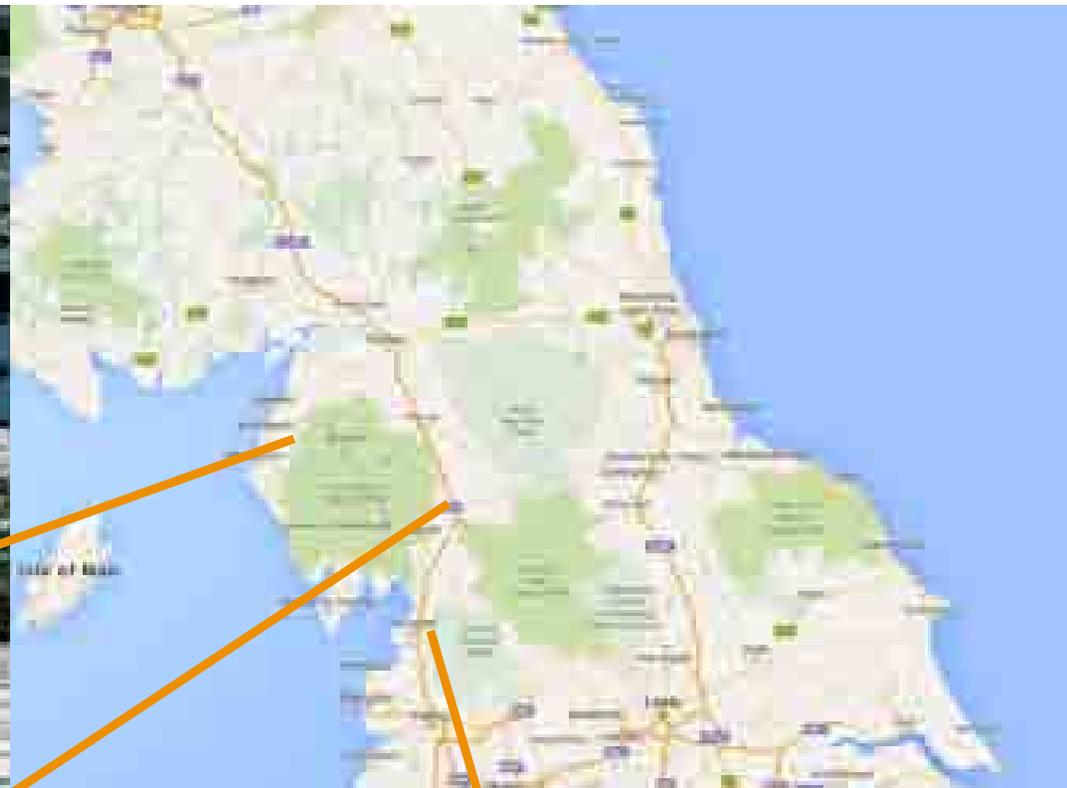
Storm Desmond rainfall observations
48hr Totals 4th-6th December, 2015
NW England

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Cockermouth



Appleby



Lancaster Primary sub-station

FGS summary of highest forecast flood risk for England and Wales for the 5/6 Dec 15

Target lead times forecasting Significant/Severe impacts

Day 2 (Surface water)

Day 3 (River)

FGS on Saturday 5 Dec (10:30; 15:00; 21:30) and Sunday 6 Dec (10:30; 15:30 & 21:30)

FGS on Friday 4 Dec (10:30)

FGS on Friday 4 Dec (15:30)

Flood Risk Matrix
(river, tidal/coastal, surface water & groundwater flooding)



Overall Flood Risk



FGS on Wednesday 2 Dec (10:30) – focus on Wales and west Midlands for Days 4/5

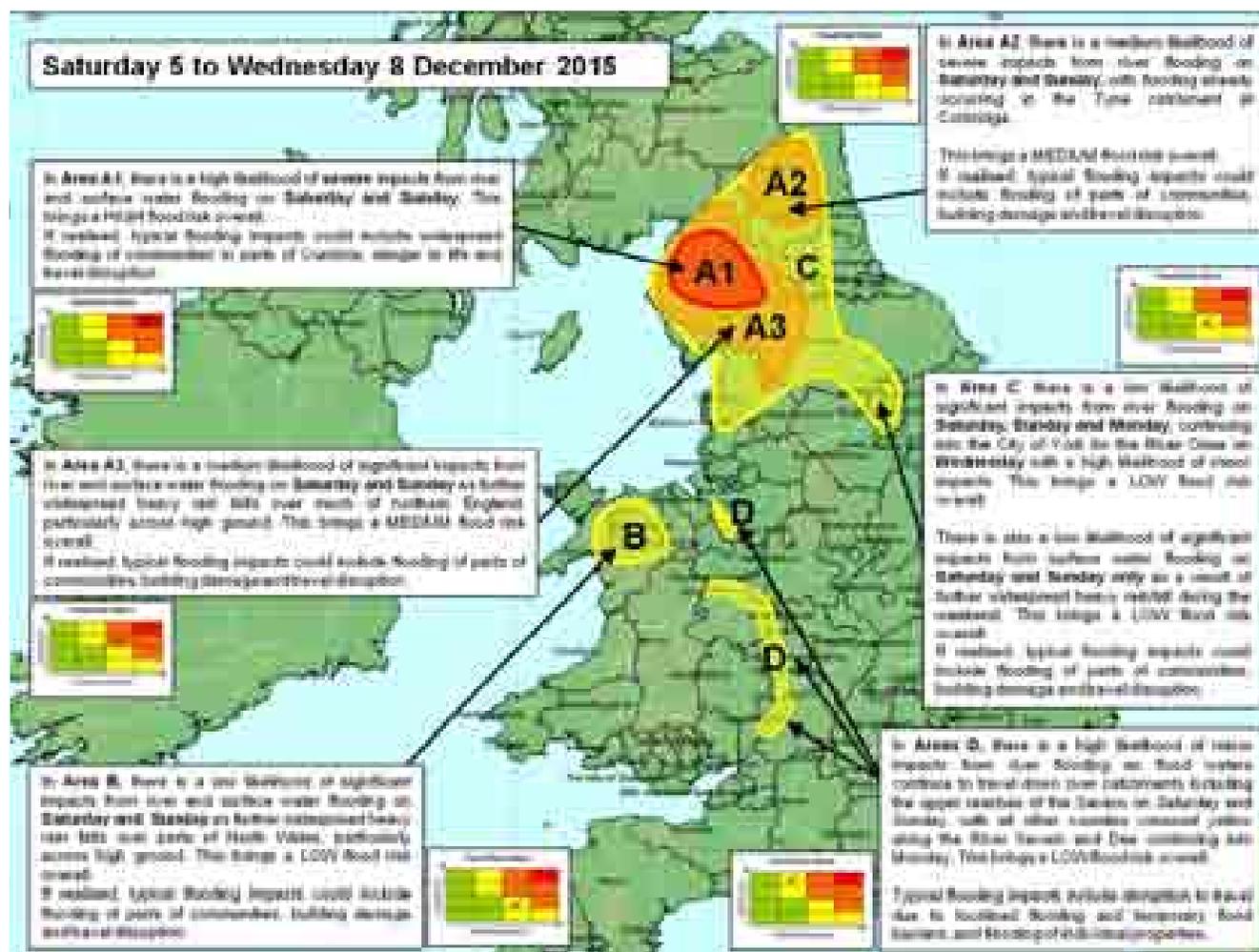
FGS on Thursday 3 Dec (10:30) – focus moves north into the north of England

FGS lead time for Cumbria for the 5/6 Dec 15 – from Wed/Thu Dec 2

Significant impacts from river and surface water flooding forecast for Cumbria for **Day 3** of the FGS (Saturday 5 Dec) and **Day 4** (Sunday 6 Dec) first indicated on the 10:30 FGS Thu 3 Dec 15, with severe impacts forecast on the 10:30 FGS Sat 5 Dec 15

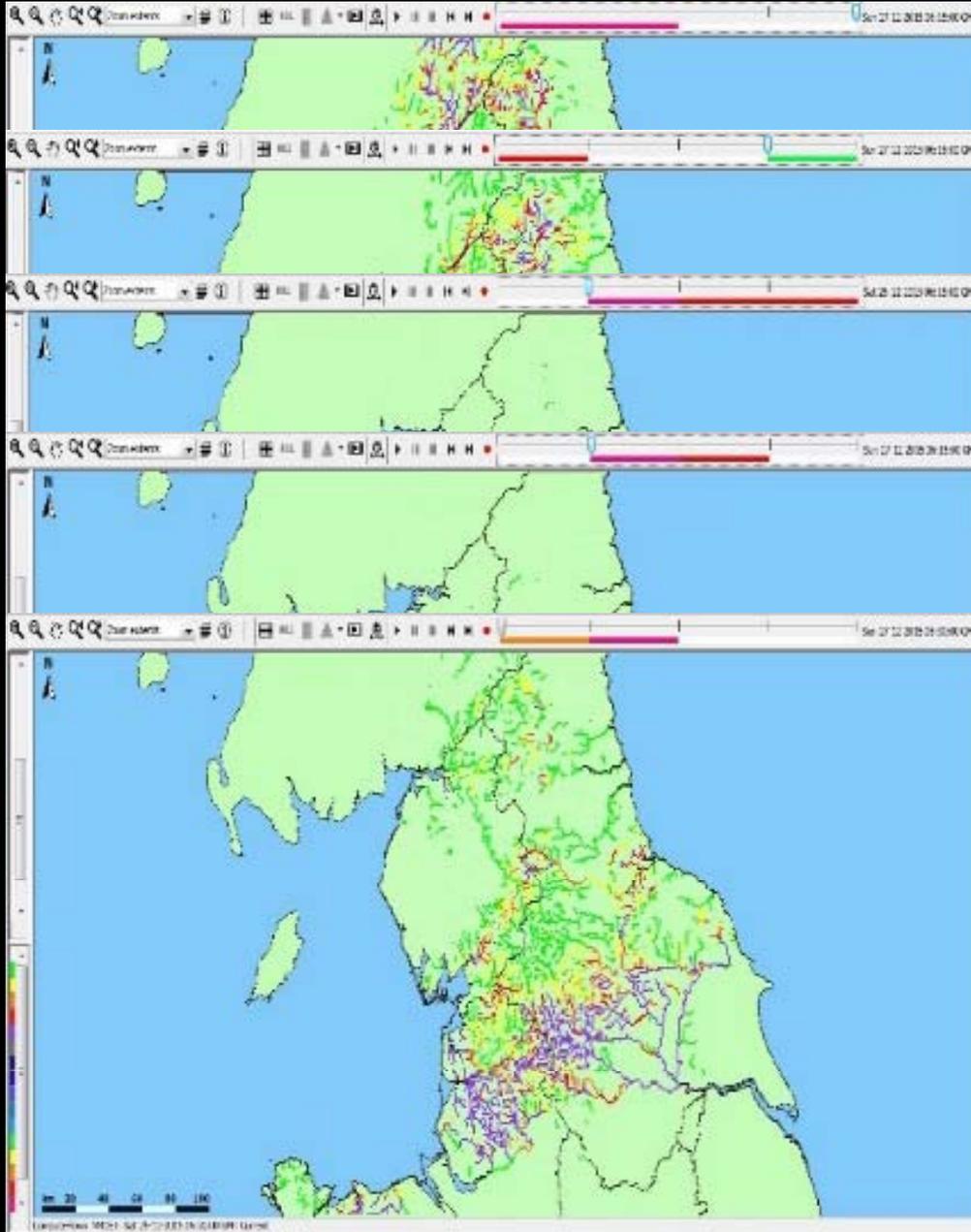
- First property flooding occurred in Cumbria from lunchtime on Saturday 5 Dec
- Significant impacts from Saturday afternoon (**FGS Day 3**; ~49 to ~53 hrs lead time)
- Severe impacts from Saturday evening / night – (**FGS Day 1**; ~8 hrs to ~12 hrs lead time)

Target lead times forecasting Significant/Severe impacts Day 2 (Surface water) and Day 3 (River)



Boxing Day floods

Deterministic G2G (0600 GMT) 22 - 26 Dec Return Period flows



Good broad scale pattern recognition

G2G deterministic discharge flows show consistent large flows ($>Q_{100}$)

Initially across parts of Cumbria

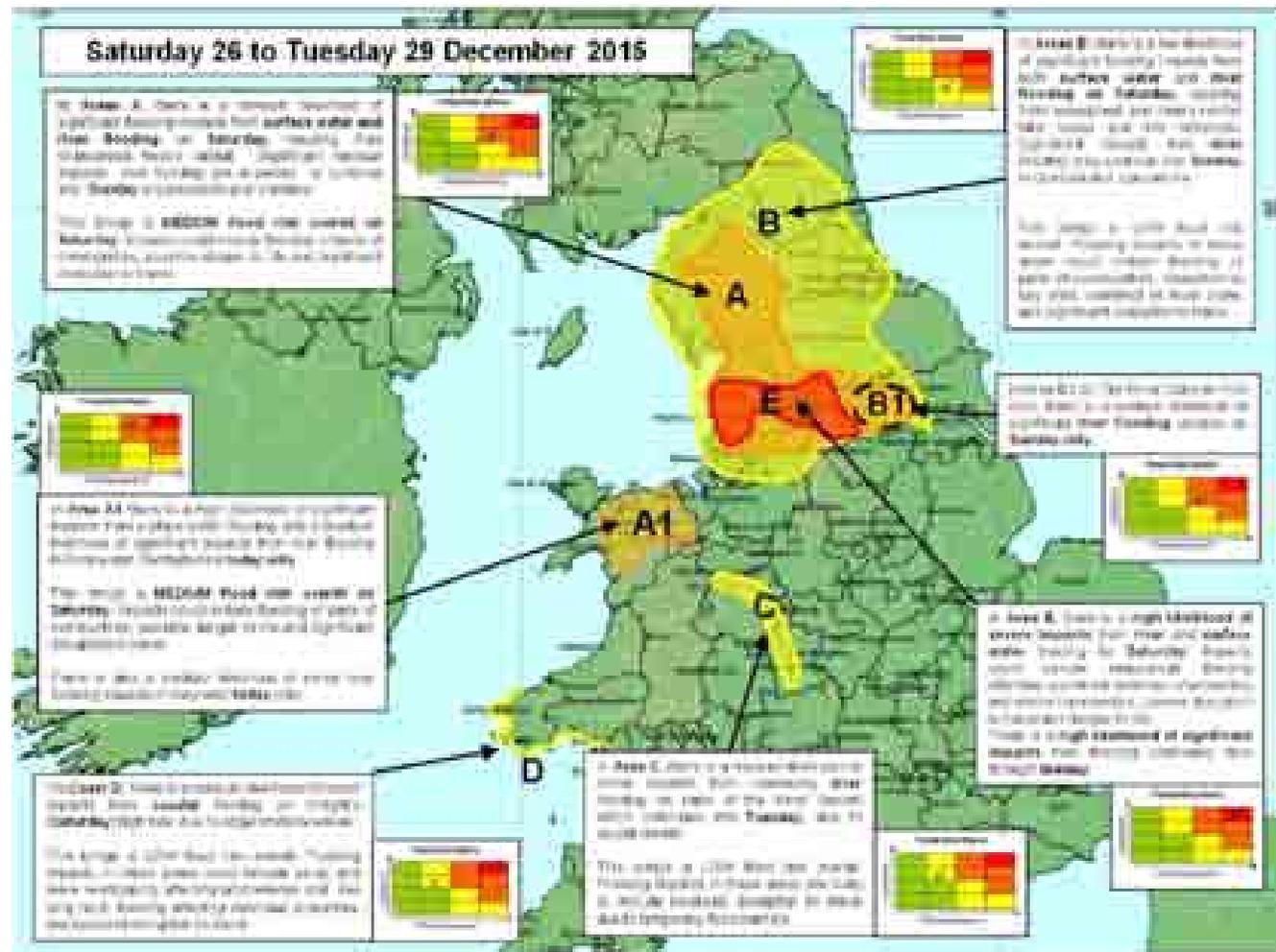
Shifted south into Lancashire and Greater Manchester

Normal
Above 2yr flood
Above 10yr flood
Above 25yr flood
Above 50yr flood
Above 100yr flood

Significant impacts from river and surface water flooding forecast for the north of England for **Day 5** of the FGS (Saturday 26 Dec 15) first indicated on the 10:30 FGS Tue 22 Dec 15, with severe impacts forecast from the 07:30 FGS Sat 26 Dec 15

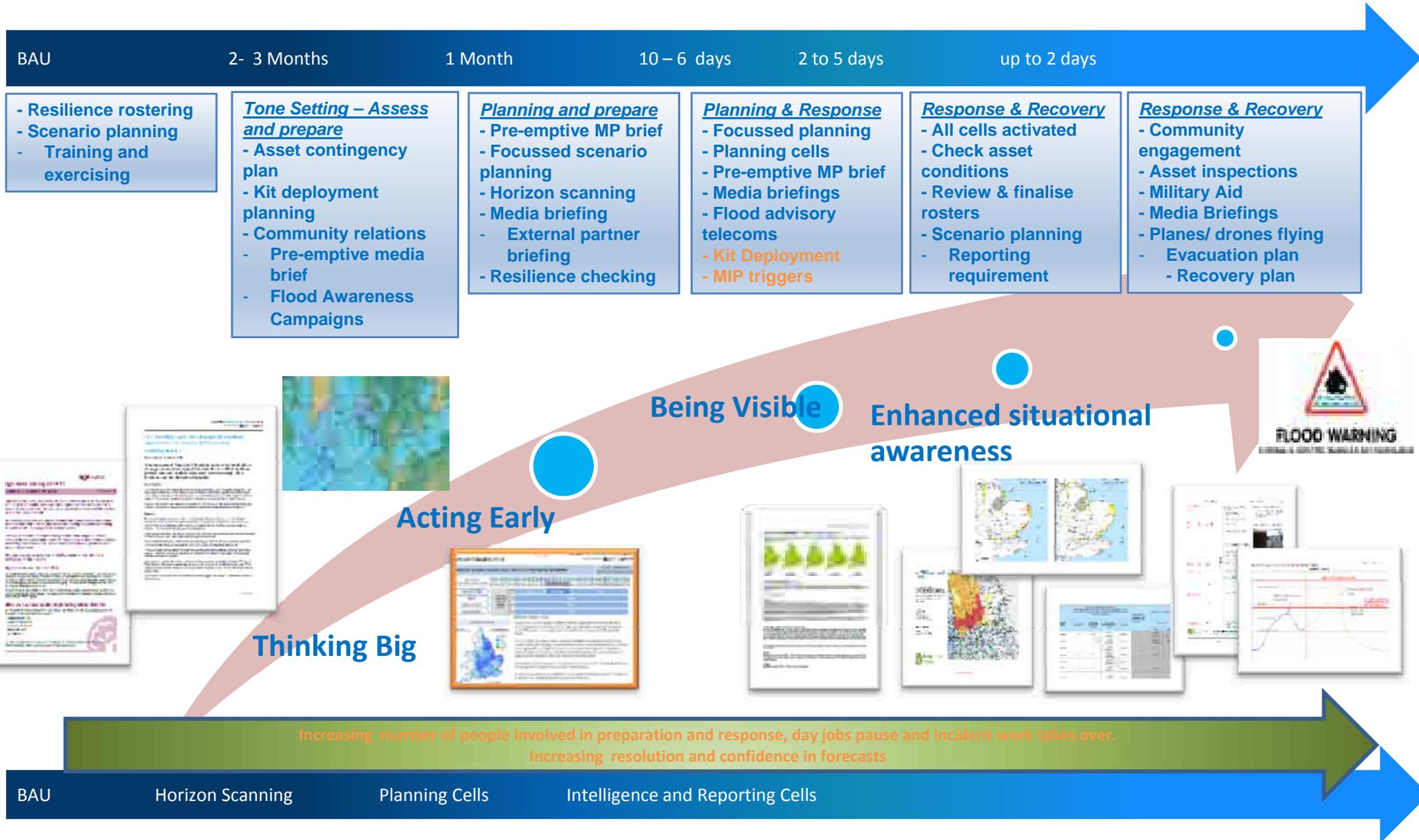
Target lead times forecasting Significant/Severe impacts Day 2 (Surface water) and Day 3 (River)

- First property flooding occurred during Saturday morning 26 Dec 15
- Significant impacts rapidly developed during Saturday morning (**FGS Day 5**; ~90 hrs lead time)
- Severe impacts from ~1000 GMT Saturday 26 Dec (**FGS Day 1**; ~2 hrs lead time)



**Longer lead times and 'nesting'
products**

The 'growing' - decision timeline



*Providing trusted guidance
to help protect lives and
livelihoods from flooding*

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Development of an operational, risk-based approach to surface water flood forecasting

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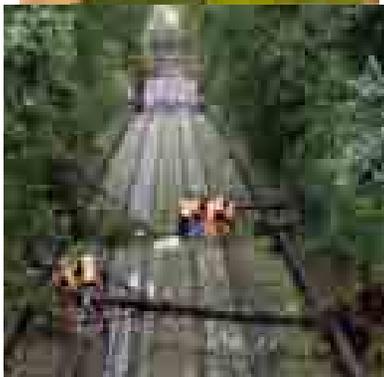


Surface Water Flooding (SWF)

- SWF major hazard in UK: ~4 million properties at risk
- Summer 2007 floods, major impacts
 - 55,000 properties flooded, ~35,000 due to SWF
 - 42,000 homes without power for 24 hours
 - 10,000 people trapped on M5
- Challenge to provide real-time “national” SWF guidance
 - Potentially complex modelling requirements in urban environments
 - Dominance of convective rainfall events that are hard to predict



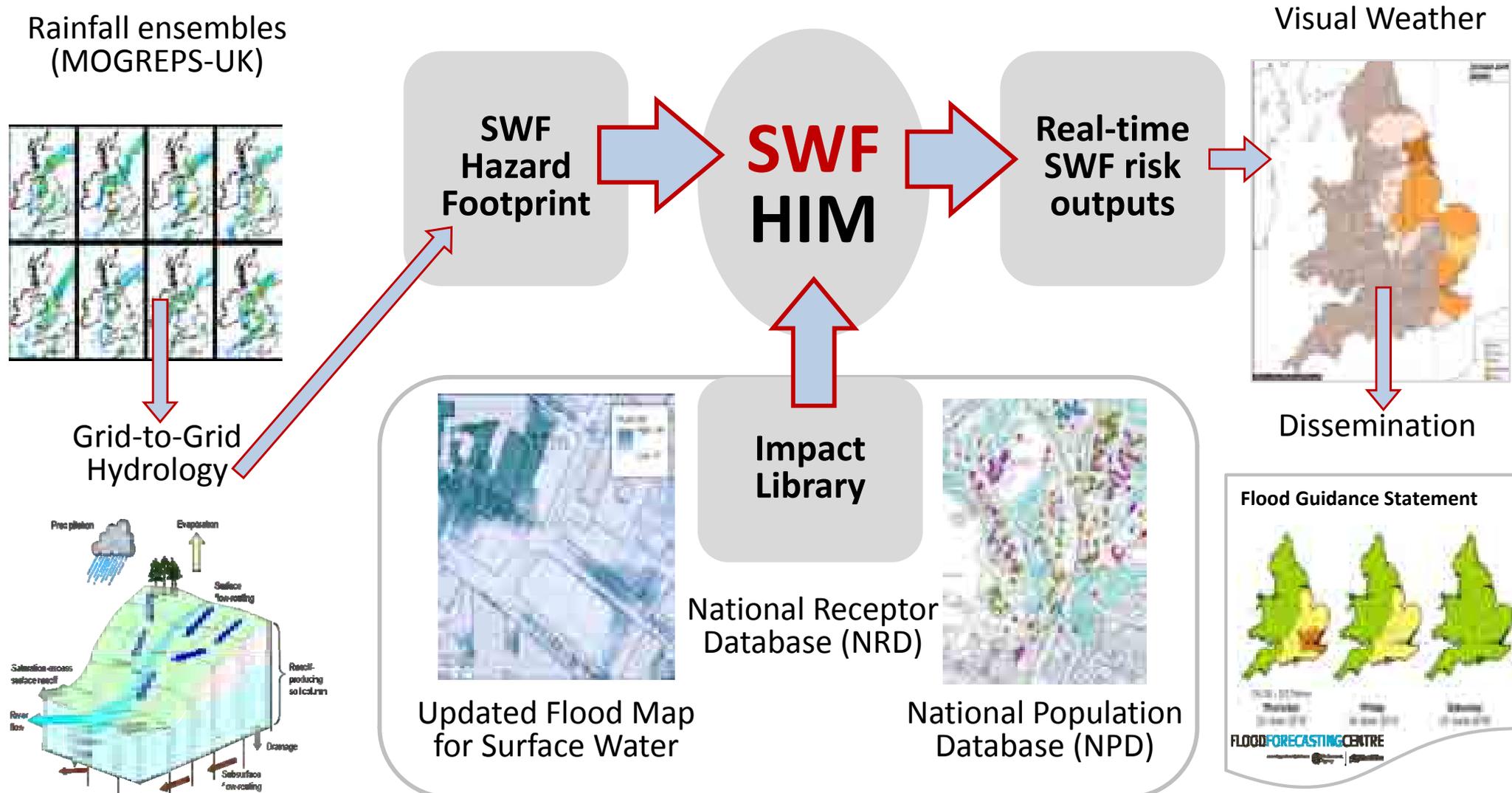
Hazard Impact Model (HIM) Risk Algorithm



$$\text{Risk} = \text{Hazard} \times \text{Vulnerability} \times \text{Exposure}$$

Surface Water Flooding HIM

SWF HIM innovation **builds on existing** models, data and tools



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