
EFAS ANNUAL MEETING 2022 — 27-28 SEPTEMBER

Surface Water Flooding Hazard Impact Model (SWFHIM)

Katie Egan (FFC Hydrometeorologist)

PROVIDING TRUSTED GUIDANCE TO HELP
PROTECT LIVES AND LIVELIHOODS FROM
FLOODING



**FLOOD
FORECASTING
CENTRE**

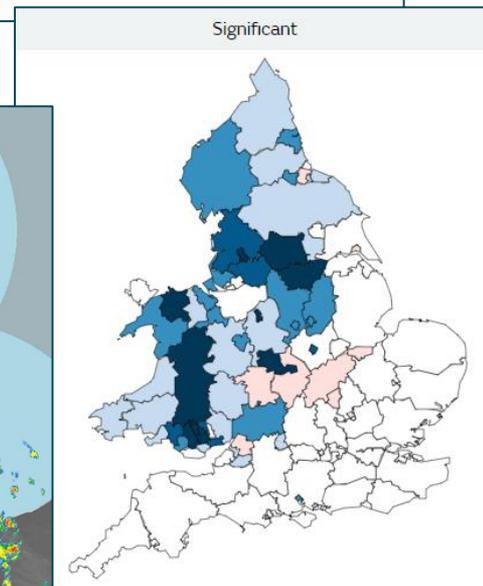
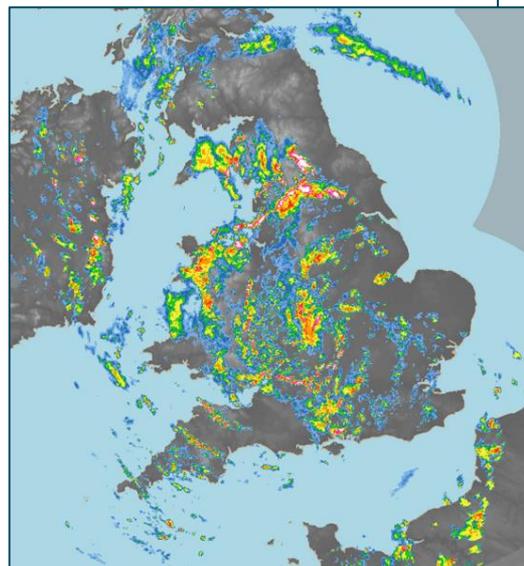
A working partnership between



SWFHIM

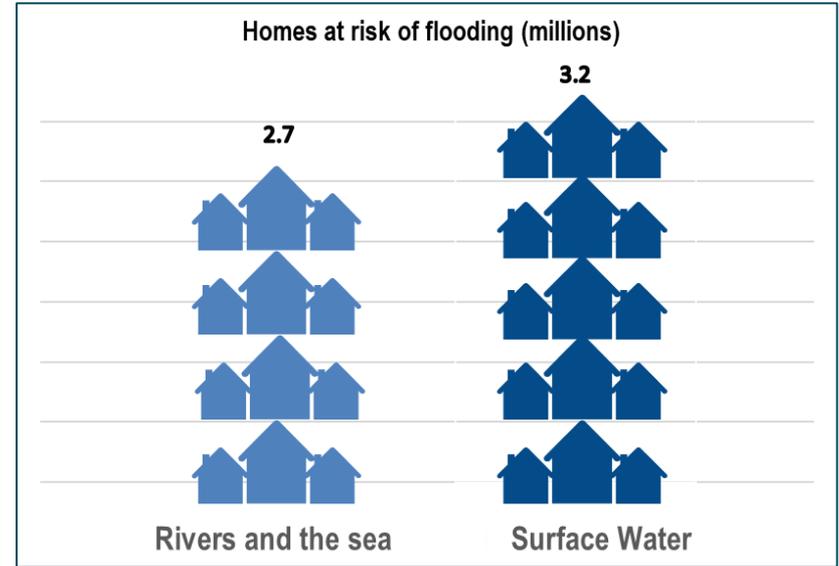
Contents

- Wider Context
- Technical Overview
- Operational Use
- Future Development



Surface Water Flooding

- 3.2 million homes in England at risk
- Included on the UK's national risk register
- Surface water flooding is challenging to forecast
- Responsibility for forecasting lies with the Flood Forecasting Centre (FFC)
- SWFHIM developed to support the FFC in forecasting surface water flood risk

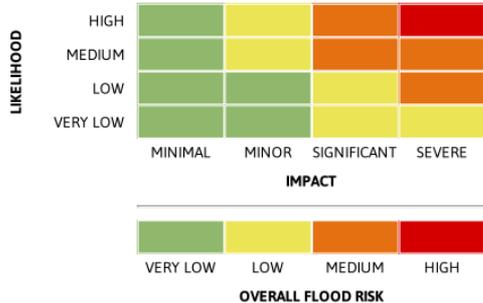


ENVIRONMENT AGENCY DATA ON HOMES IN ENGLAND AT RISK FROM RIVER, SEA, AND SURFACE WATER FLOODING

Flood Forecasting Centre

- Working partnership between the UK Met Office and the Environment Agency
- Support to category 1 and 2 responders primarily via the Flood Guidance Statement (FGS)
- Surface Water Flood Forecasts out to 5 days; focus and targets for 1-2 day lead time

Flood risk matrix



Summary of potential impacts

- MINIMAL**
Isolated and minor flooding of low-lying land and roads
Isolated spray/wave on coastal promenades
Little or no disruption to travel, but wet road surfaces
- MINOR**
Localised flooding of land and roads
Flooding affecting individual properties
Disruption to travel and key sites in flood plans
- SIGNIFICANT**
Flooding affecting parts of communities
Possible danger to life and damage to buildings/structures
Disruption to travel and key sites in flood plans
- SEVERE**
Danger to life, severe disruption to travel
Widespread flooding affecting whole communities
Widespread disruption or loss of infrastructure
Large scale evacuation of properties possible

Flood Guidance Statement

10:30hrs Wednesday 17 August 2022

FLOOD FORECASTING CENTRE

A working partnership between Environment Agency

Met Office



Wednesday 17 Aug 2022 10:30-23:59 Trend since last FGS Increased ↑	Thursday 18 Aug 2022 Steady →	Friday 19 Aug 2022 Steady →	Saturday 20 Aug 2022 Steady →	Sunday 21 Aug 2022 Steady →
---	-------------------------------------	-----------------------------------	-------------------------------------	-----------------------------------

Significant surface water flooding impacts are probable in parts of south-east England today (Wednesday). The surface water flood risk is MEDIUM.

Specific Areas of Concern Map 1: Wednesday 17 August 2022

RISK AREA A
Impact **SIGNIFICANT**
Likelihood **MEDIUM**

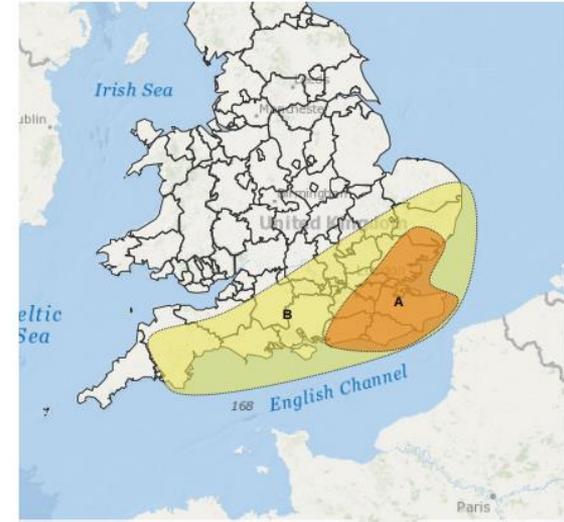
Source River Surface
Likely duration 1 Day

Heavy, slow moving showers/thunderstorms

RISK AREA B
Impact **SIGNIFICANT**
Likelihood **LOW**

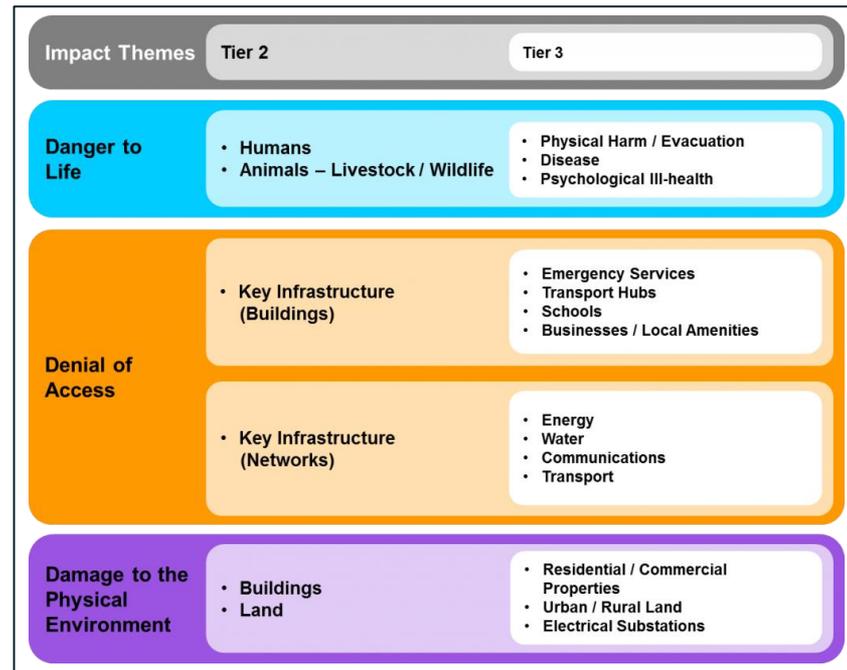
Source Surface
Likely duration 1 Day

Heavy showers/thunderstorms



SWFHIM Development

- Natural Hazards Partnership
- Collaboration of the UK Centre for Ecology and Hydrology, the Health and Safety Executive, the Environment Agency, the UK Met Office, and the Flood Forecasting Centre
- Hazard Impact Framework
- Four phases of development
- Peer review by Halcrow Group Ltd and JBA Consulting
- Operational since April 2020



NHP CLASSIFICATION OF IMPACTS
[HTTP://WWW.NATURALHAZARDSPARTNERSHIP.ORG.UK/SCIENCE-2/](http://www.naturalhazardspartnership.org.uk/science-2/)



SWFHIM – forecast output

- Surface water flood risk forecast (Eng & Wal)
- Based on the FGS Flood risk matrix and Hazard Impact Framework

Flood risk matrix

LIKELIHOOD	HIGH				
	MEDIUM				
	LOW				
	VERY LOW				
		MINIMAL	MINOR	SIGNIFICANT	SEVERE

VERY LOW	LOW	MEDIUM	HIGH

OVERALL FLOOD RISK

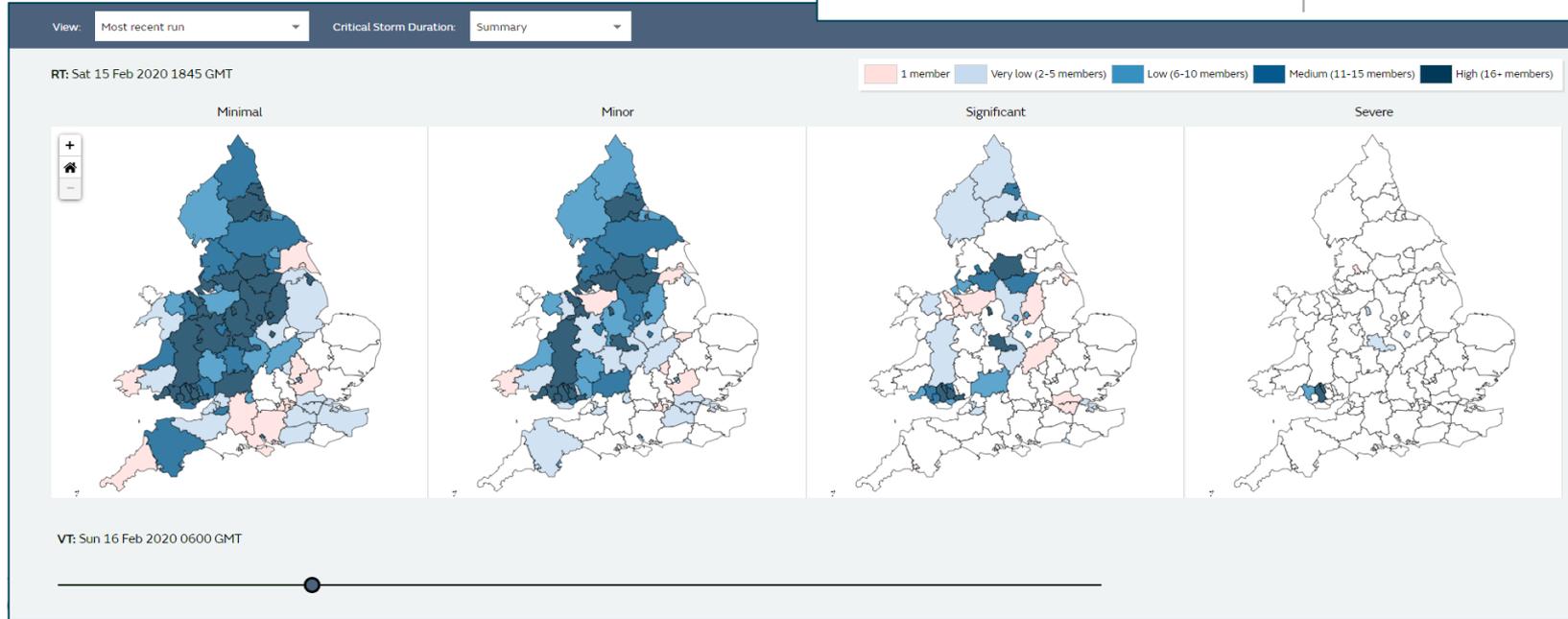
Summary of potential impacts

MINIMAL
Isolated and minor flooding of low-lying land and roads
Isolated spray/wave on coastal promenades
Little or no disruption to travel, but wet road surfaces

MINOR
Localised flooding of land and roads
Flooding affecting individual properties
Disruption to travel and key sites in flood plans

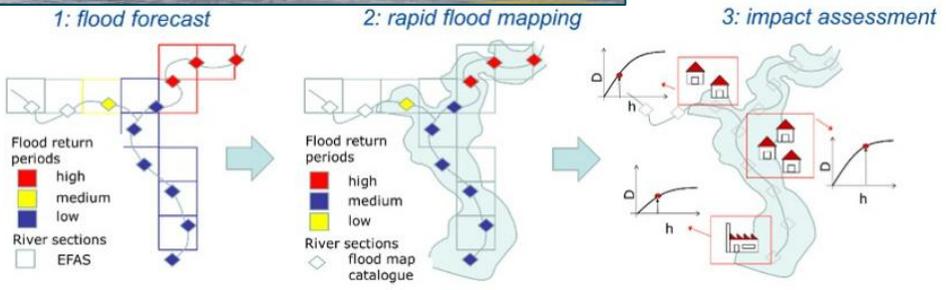
SIGNIFICANT
Flooding affecting parts of communities
Possible danger to life and damage to buildings/structures
Disruption to travel and key sites in flood plans

SEVERE
Danger to life, severe disruption to travel
Widespread flooding affecting whole communities
Widespread disruption or loss of infrastructure
Large scale evacuation of properties possible



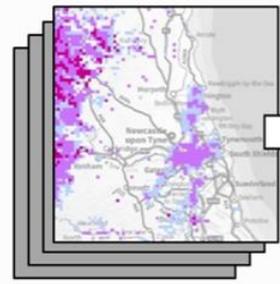
SWFHIM overview and parallels with EFAS

FLOOD FORECASTING CENTRE **Surface Water Flooding Hazard Impact Model**



G2G surface runoff maps for individual rainfall ensemble members

Colours represent runoff severity by return period



Pre-calculated Impact Library layers based on Environment Agency data

Layers of potential impacts, categorised by receptor type and return period



Final output impact severity layer for each ensemble member

Impacts are selected on a pixel-by-pixel basis from the Impact Library

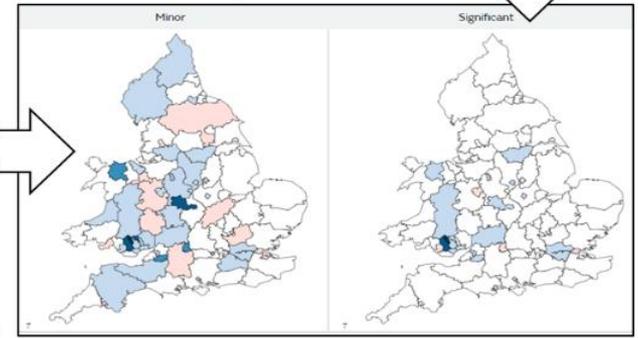


Flood Risk Matrix

Likelihood	High	Green	Yellow	Orange	Red
	Medium	Green	Yellow	Orange	Orange
	Low	Green	Green	Yellow	Orange
	Very Low	Green	Green	Yellow	Yellow
		Minimal	Minor	Significant	Severe

Potential Impacts

County flood risk maps

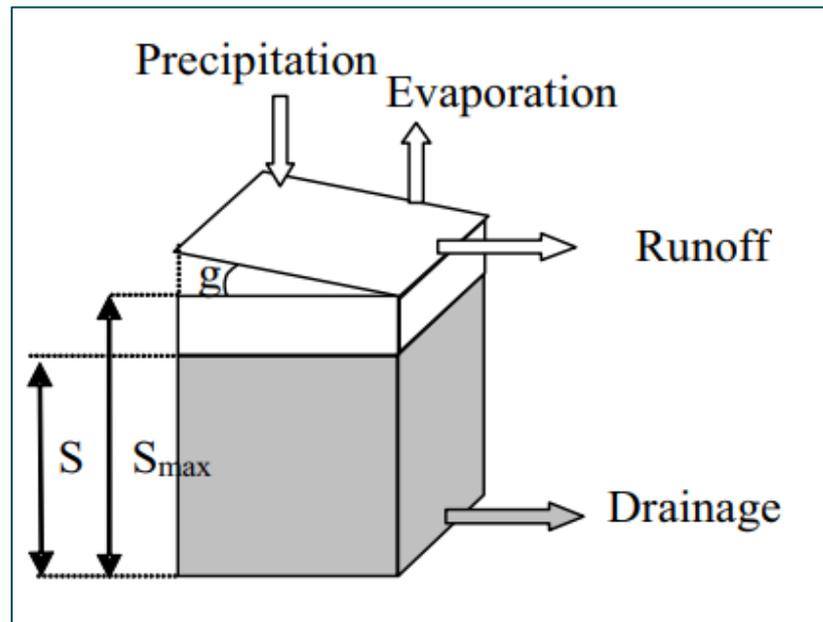


INPUT – SRENS and G2G

- Short Range Ensemble precipitation data (T+54; SWFHIM T+45/46)
- NOWCAST (T+7)/MOGREPS-UK
- 24 members; 2.2 km resolution
- 4 SWFHIM runs per day

- Grid-to-Grid (G2G)
- Probability distributed hydrological model
- Runoff production scheme

- Runoff
- 1 km resolution, 15 min timestep
- Summed to give longer durations (1, 3, 6 hr)

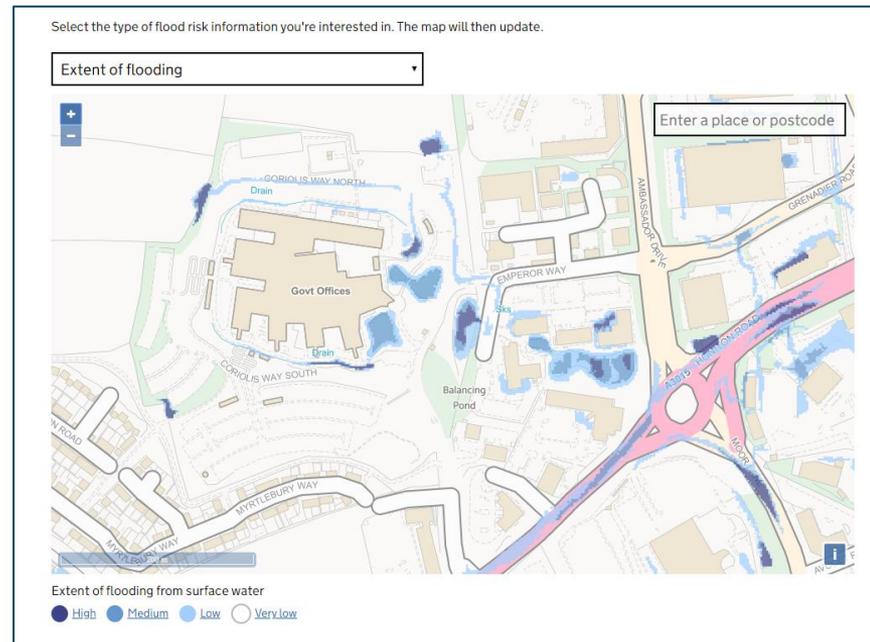


G2G SCHEMATIC FROM BELL ET AL., 2007: DEVELOPMENT OF A HIGH RESOLUTION GRID-BASED RIVER FLOW MODEL FOR USE WITH REGIONAL CLIMATE MODEL OUTPUT

Risk of Flooding from Surface Water Maps (Environment Agency Mapping)

- Detailed static risk mapping
- 9 effective rainfall scenarios (3 durations; 3 rainfall return periods)
- Jflow+ hydraulic model
- Flood depth, velocity, hazard rating
- 2 m resolution

- Equate G2G runoff to one of the 9 effective rainfall scenarios
- Creates a link to flood parameters



[HTTPS://FLOOD-WARNING-INFORMATION.SERVICE.GOV.UK/LONG-TERM-FLOOD-RISK/MAP](https://flood-warning-information.service.gov.uk/long-term-flood-risk/map)

Impact Library

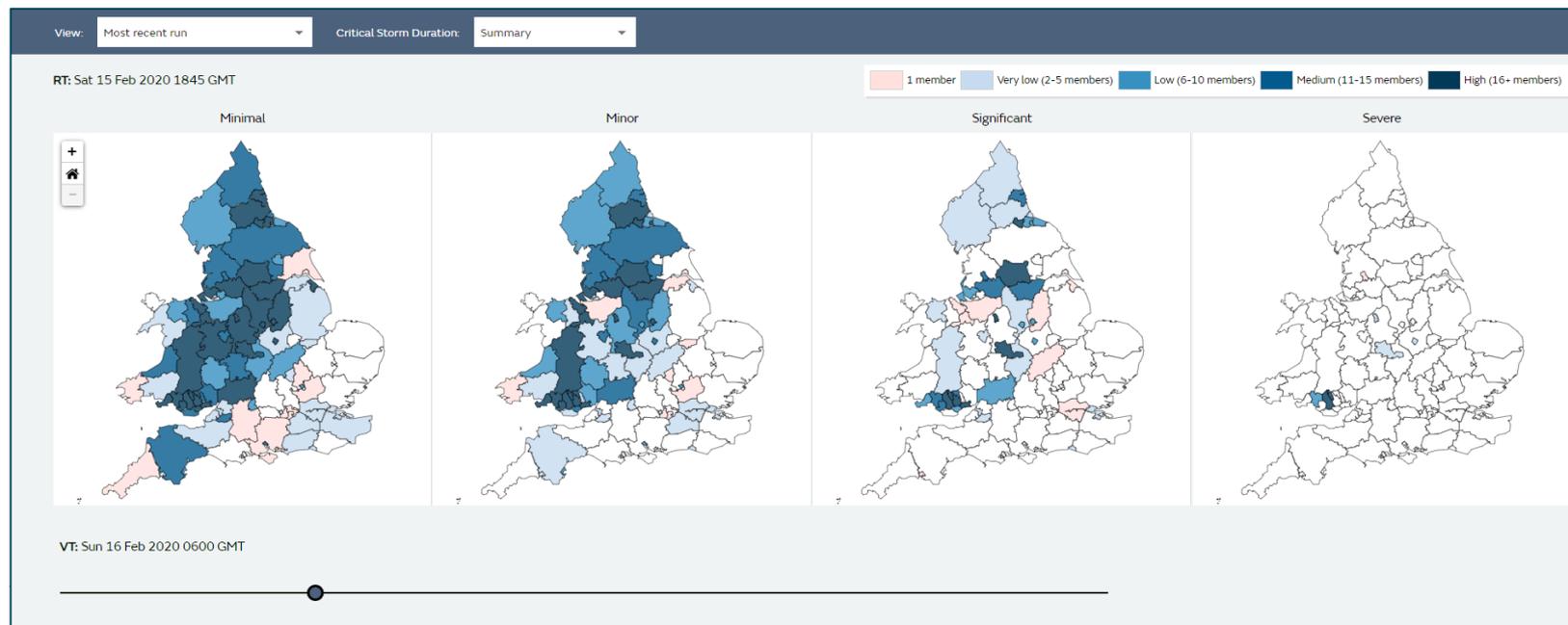
- Static catalogue
- Four impact types
- Flood parameters from RoFSW maps
- National Population Database
- National Receptor Database
- G2G runoff > Effective rainfall scenario
RoFSW Maps (maximum return period) > Lookup impact level in Library
- 1 km grid of maximum impact across flood types

Flood impact type	Threshold for flooding to occur	Impact Metric (per 1 km cell)	Data Source	Impact Detail			
Danger to Life	Hazard Rating \geq 1.25, or \geq 0.75 for vulnerable populations (such as children)	Count of people at risk	NPD	Day time population:	Day time term-time		
				Night time population:	Night time term-time		
Damage to Buildings	Water depth > 0.3 m (height of a typical property step)	Count of properties at risk	NRD	Residential Properties			
				Non-residential Properties			
Disruption of Key Sites and Infrastructure	Key Sites: Water depth > 0.3 m Key Infrastructure: Hazard Rating \geq 1.25 (denial of access)						
Disruption of Transport	Road or railway network flooded to a depth of 0.1 m over a distance of 10 m.						

Impact Criteria	Impact Severity Level			
	Minimal (1)	Minor (2)	Significant (3)	Severe (4)
Danger to Life (Count)	0	40	200	300
Damage to Buildings				
- Residential (Count)	0	5	30	100
- Non-Residential (Count)	0	1	10	30
Disruption of Key sites (Count)	-	0	1	2
Disruption of Infrastructure (Count)	0	1	2	4
Disruption of Transport				
- Trunk Roads and Motorways (metres)	0	150	500	1800
- Other Major Roads (metres)	0	500	1800	-
- Railways (metres)	0	300	950	-

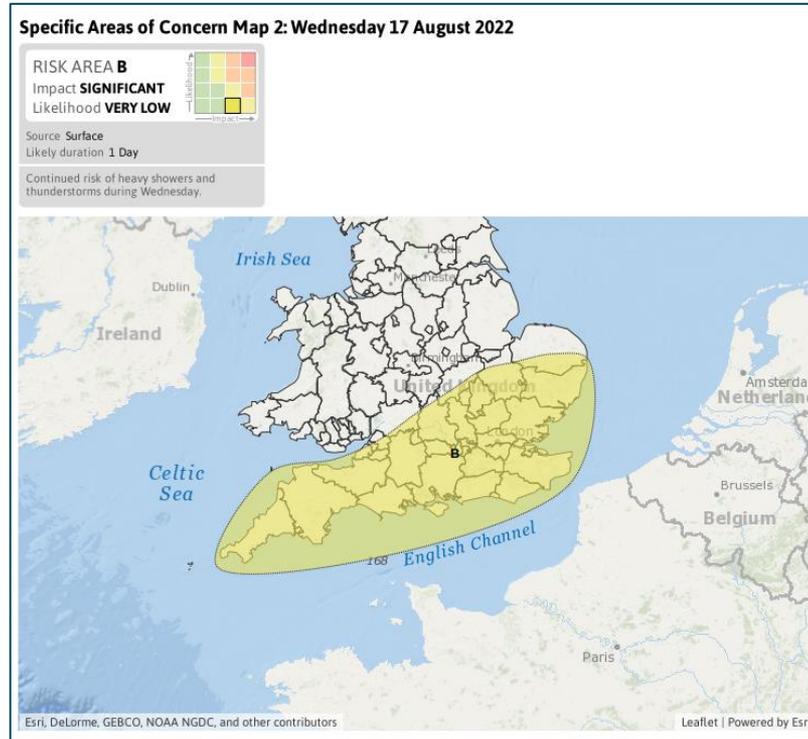
Upscaling and risk forecast

- 1 km gridded impacts upscaled to county level
- Likelihood from number of ensemble members

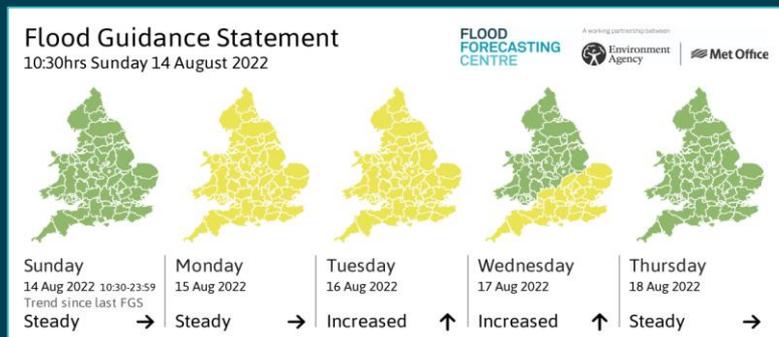


Operational Use

- ‘Tool’ in surface water flood risk assessment
- Considered in the context of other output and acknowledging uncertainty
- Objective assessment of impacts to help inform the FGS (days 1 and 2)



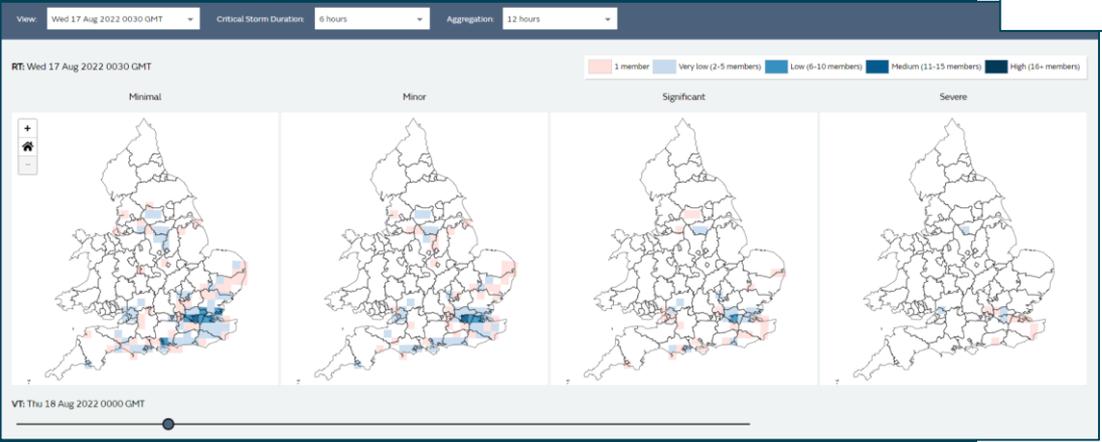
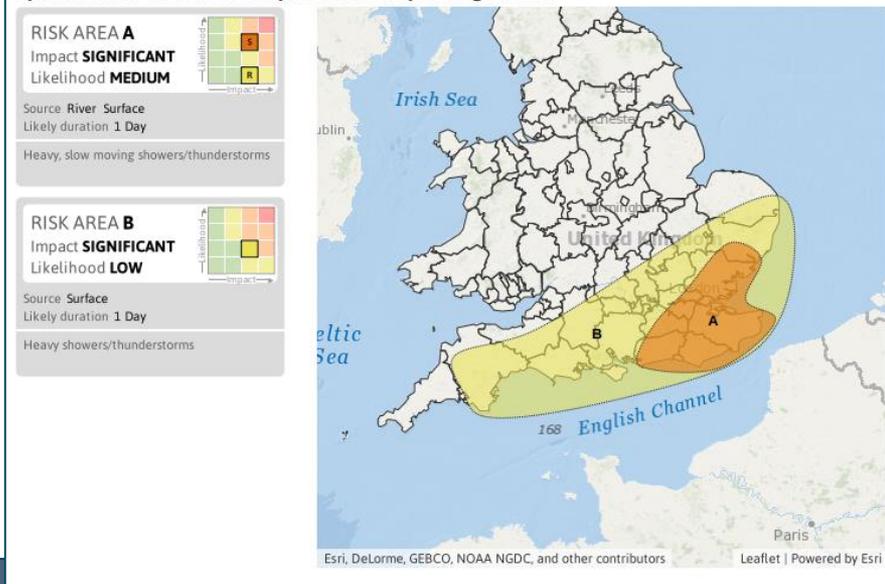
EXAMPLE OF ELEVATED SURFACE WATER FLOOD RISK ON THE FGS AUGUST 2022



Current and Future Development

- Lifecycle approach – ongoing scientific, technical and operational development
- Verification (subjective and objective) and operational learning
- Recent work with HSE (Health and Safety Executive) has introduced 20 km gridded output
- Future developments options under review

Specific Areas of Concern Map 1: Wednesday 17 August 2022



EXAMPLE OF ELEVATED SURFACE WATER FLOOD RISK ON THE FGS 17 AUGUST 2022 AND CORRESPONDING GRIDDED SWFHM OUTPUT

Questions?

FLOOD FORECASTING CENTRE

A working partnership between



Environment
Agency



Met Office

Email

ffcenquiries@environment-agency.gov.uk

Website

www.ffc-environment-agency.metoffice.gov.uk

© Crown Copyright 2019

Demonstration

<https://staging.swfhim.ffc.metoffice.gov.uk/County>

Email ffcenquiries@environment-agency.gov.uk
Website www.ffc-environment-agency.metoffice.gov.uk

View: Mon 21 Jun 2021 1230 GMT

Critical Storm Duration: Summary

Aggregation: 24 hours

RT: Mon 21 Jun 2021 1230 GMT

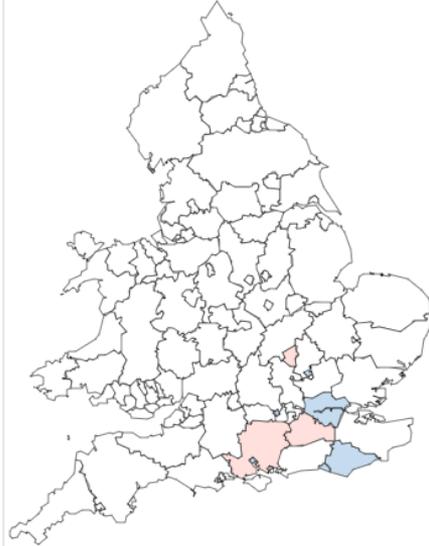
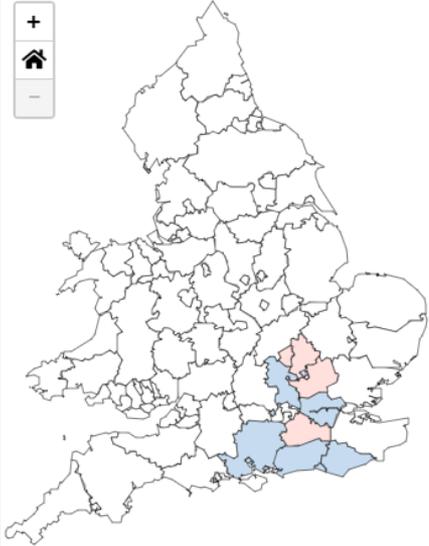


Minimal

Minor

Significant

Severe

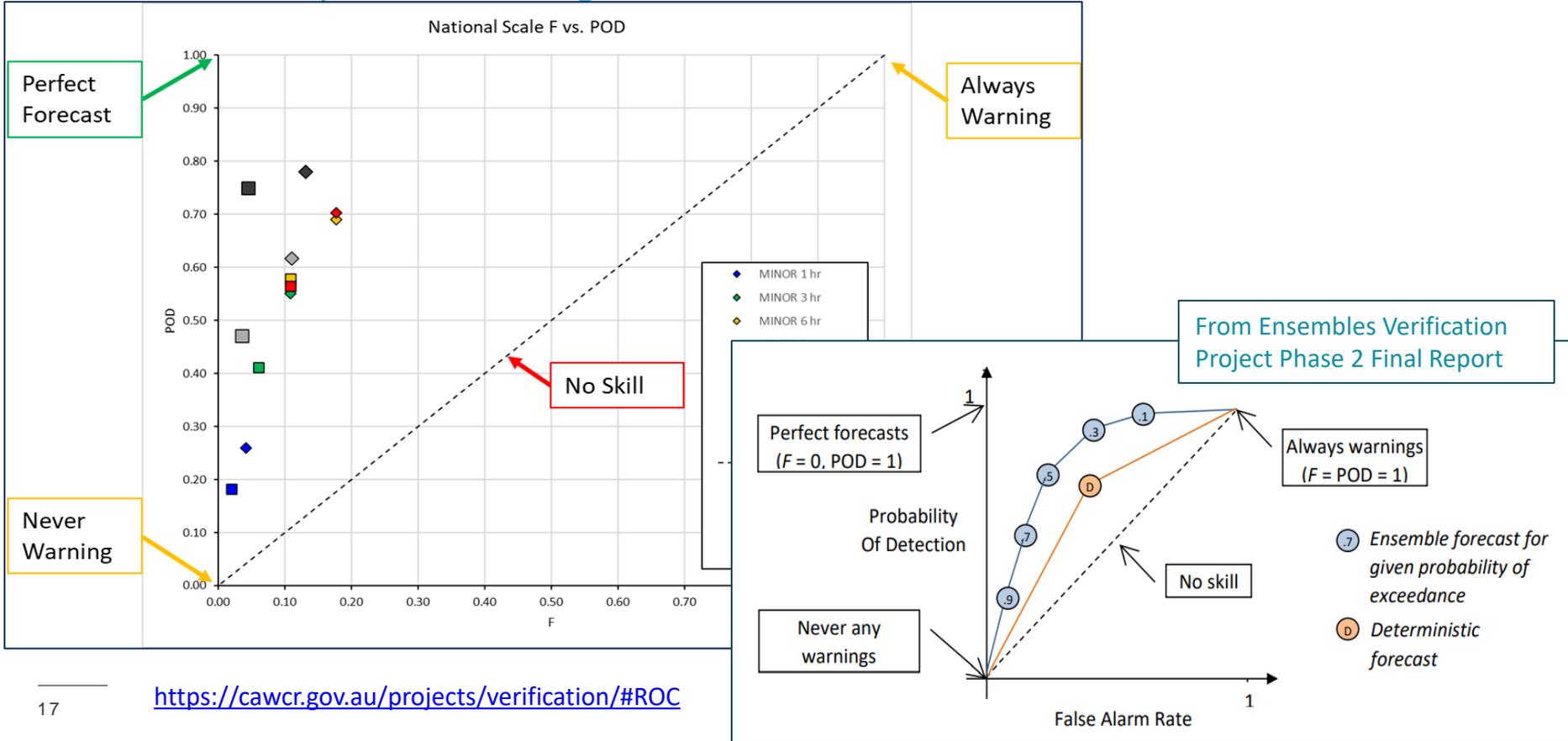


VT: Wed 23 Jun 2021 0000 GMT



Note FGS verification stats use a partial credit system

Results – Example 1 ROC diagram; F vs. POD



Impact Library

- Severity Level Thresholds
- Allocate severity levels in each grid square for the 9 original effective rainfall scenarios

Impact Criteria	Impact Severity Level			
	Minimal (1)	Minor (2)	Significant (3)	Severe (4)
Danger to Life (Count)	0	40	200	300
Damage to Buildings				
- Residential (Count)	0	5	30	100
- Non-Residential (Count)	0	1	10	30
Disruption of Key sites (Count)	-	0	1	2
Disruption of Infrastructure (Count)	0	1	2	4
Disruption of Transport				
- Trunk Roads and Motorways (metres)	0	150	500	1800
- Other Major Roads (metres)	0	500	1800	-
- Railways (metres)	0	300	950	-

