

Progress in Weather Forecasting – The User's Perspective

The Greatest Storm:

North Sea floods 1953
Impacts, forecasts &
developments

Charlie Pilling

Chief Hydrometeorologist

*with thanks Andrew Sibley, Dave
Cox, Helen Titley et al.*

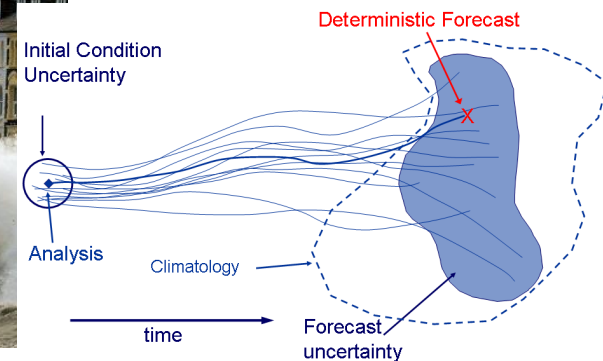


Structure

- ➡ 1953 impacts
- ➡ (Quick) comparison with Dec 2013
- ➡ **Developments & Tangible Benefits**
- ➡ **Dec 2013 to highlight key developments**
 - Science (NWP, deterministic, ensembles)
 - Cross discipline working
 - Guidance / Warnings (24/7)
 - Communication, Emergency Response etc

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

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



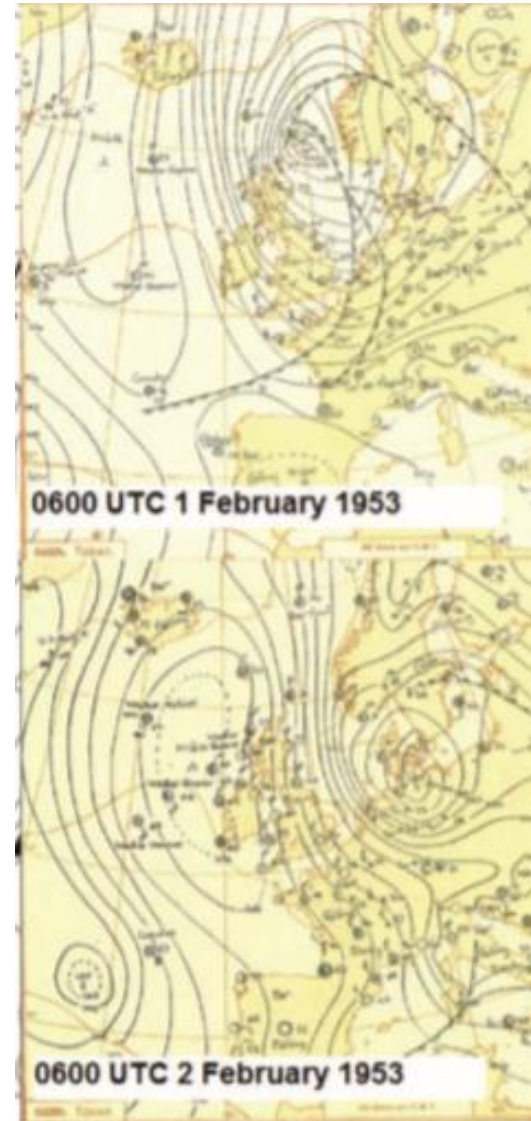
1953 Impacts

- More than 300 fatalities occurred in E England
- Over 800 deaths in the Netherlands
(Wolf and Flather, 2005)

<https://www.bing.com/videos/search?q=1953+flood&&view=detail&mid=FD22D86320EF6868A2B7FD22D86320EF6868A2B7&&FORM=VDRVRV>

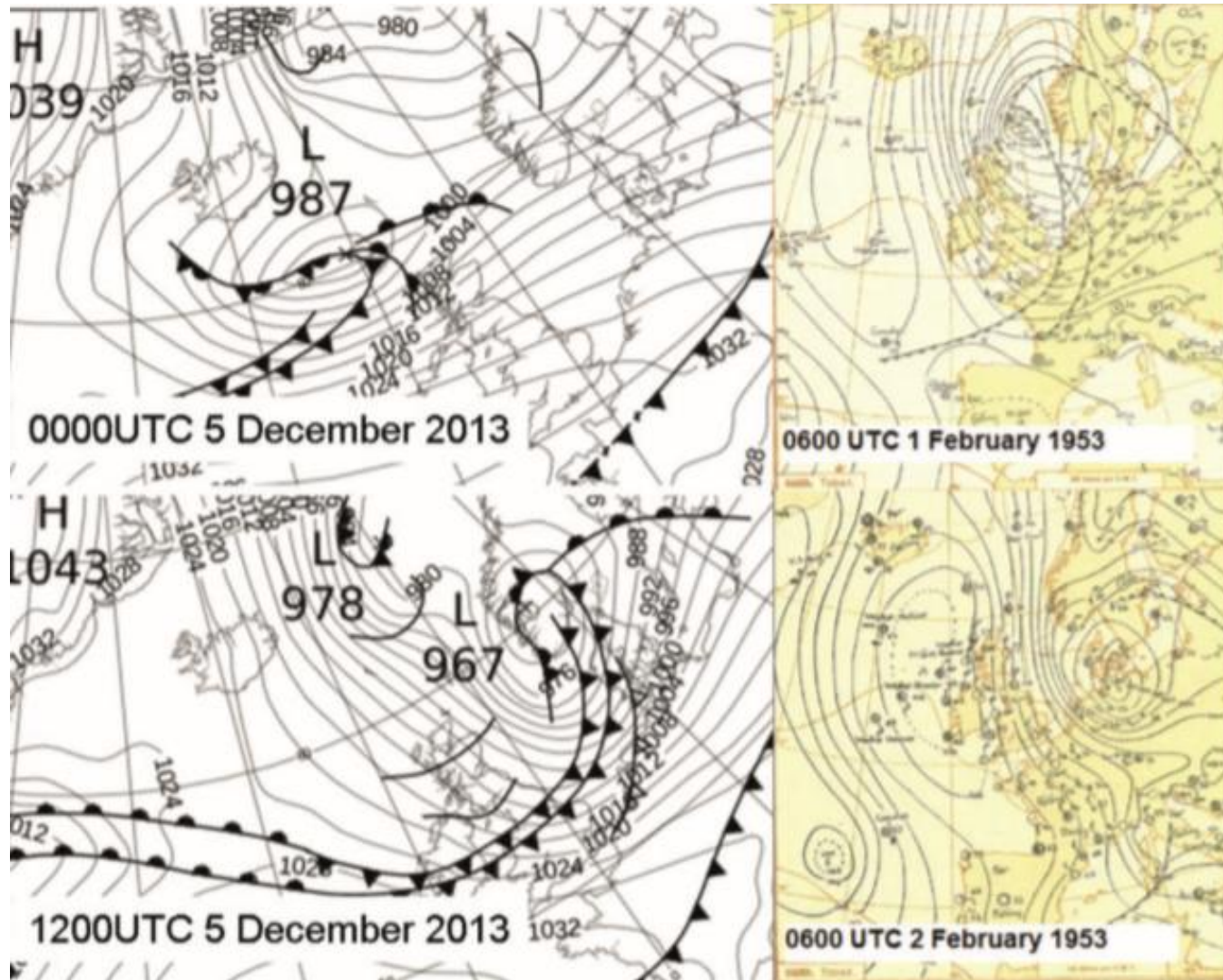
- Vulnerable and exposed
- 1200 breaches (England)
- Prefabricated homes
- Insufficient dykes (return periods)
- Harbours, transport, infrastructure
- Insufficient capacity and co-ordination for effective emergency response

<https://www.heart.co.uk/norfolk/news/local/east-anglia-storm-surge-worse-1953/>



Dec 2013

Feb 1953

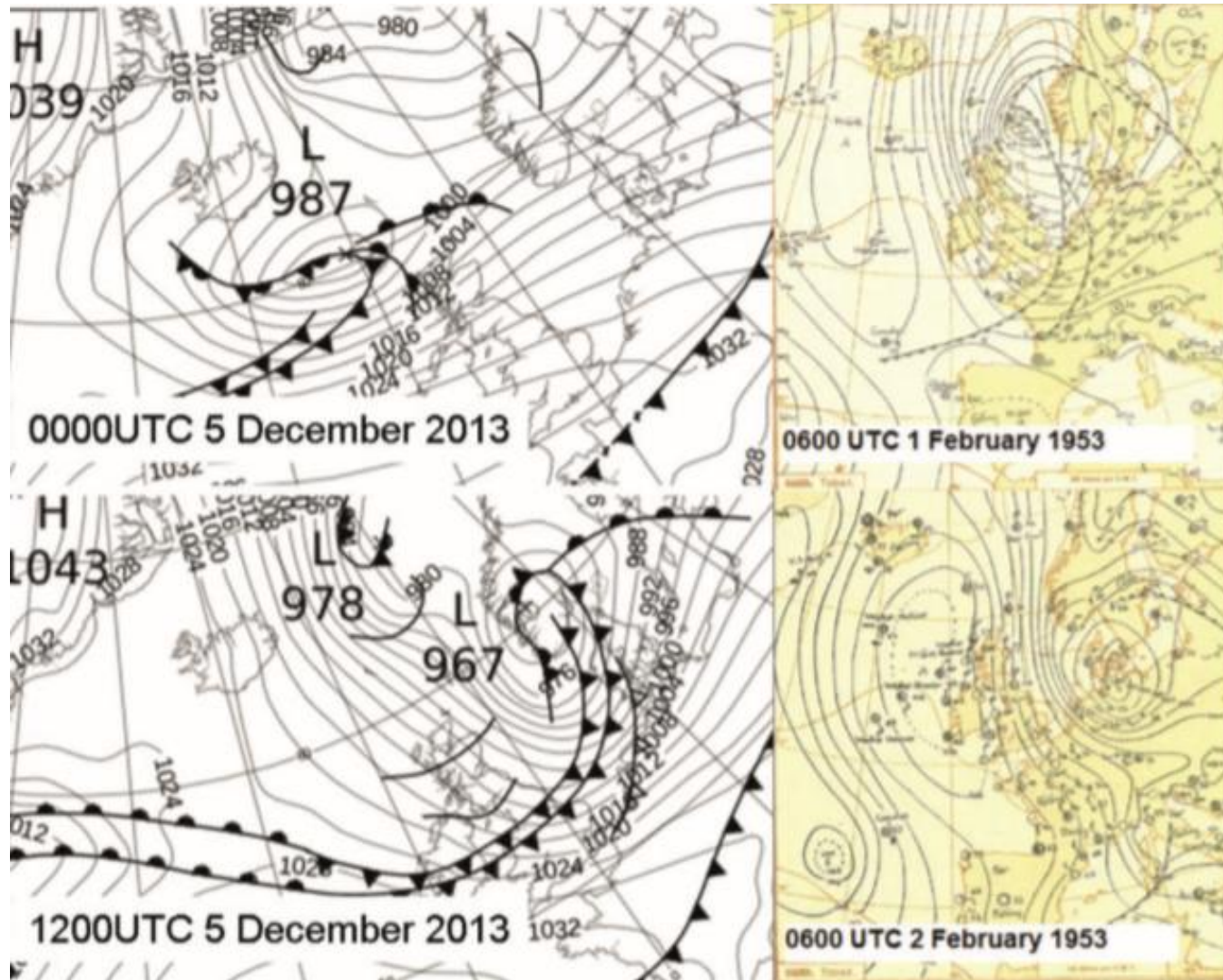


Comparison: Synoptic pattern and development of the February 1953 v's December 2013. (Note: difference in time steps 12h v's 24h; Sibley et al., 2015)

- ✓ Low pressure centre deepened to the S of Iceland and ran to N of Scotland
- ✓ Central pressures 967hPa (2013) & 964hPa (1953)
- ✗ Low centre of the 1953 event turned SE-ward as it deepened in the N. Sea; while the 2013 low pressure continued E-ward
- ✗ 2013 troughs of low pressure running southwards down the North Sea as the gradient wind veered Northerly direction
- ✗ Development of the 2013 event was much quicker, with the low centre running from 34°W to 8°E in 24h; compared with approx 48 hrs in 1953

Dec 2013

Feb 1953



✓ Maximum mean wind speeds and wave heights correlate reasonably well (wave heights 8–10m over the open sea in the Dec event, wind speeds > 50kn).

✗ December 2013 surge water levels were higher than those of the 1953 storm surge in more northern locations, but possibly slightly less further south.

✗ North Shields gauge, operational since 1947, recorded 3.97m OD(N) at 1615 UTC on 5 Dec 2013, compared with 3.56m at 1700 UTC on 31 Jan 1953 (Parsons and Frampton, 2014).

Comparison: Water levels

Tide levels for several events during the winter of 2013/2014 against tide records OD(N).

Ranking against historical records.

Many ports recorded their highest water level for over 50 years in 2013 ([next slide](#)). The return period for the 1953 at Lowestoft is estimated to be around 50 years, although rising sea levels will likely reduce the return period in coming decades (Wolf and Flather, 2005).

(Data is sourced from the British Oceanographic Data Centre (BODC) archive; Sibley et al., 2015)

Port	Observed Level OD(N) Source (BODC/EA) (rank)	First record / (years in record)	Continuous record since
5/6 December 2013			
North Shields (Tynemouth)	3.97m (1) (1953 = 3.56m)	1947 (60 years)	1978
Whitby (North Yorks)	4.32m (1)	1980 (35 years)	1980
Immingham (Humberside)	5.22m (1)	1953 (56 years)	1963
Lowestoft (Suffolk)	3.26m (1) (1953 = 3.35m visual estimate) Rossiter (1954) has 3.44m (11.3ft) in 1953)	1964 (51 years)	1964
Dover	4.76m (1)	1924 (65 years)	1958
Sheerness (North Kent)	4.10m (1)	1952 (48 years)	1965
Liverpool, Gladstone Dock	6.22m (1)	1991 (24 years)	1991
Portsmouth	2.83m (1)	1991 (24 years)	1991
Newhaven	4.27m (1)	1982 (30 years)	1991
3 January 2014			
Ilfracombe	5.70m (1)	1968 (41 years)	1977
Hinkley Point	7.45m (1)	1981 (27 years)	1990
Newport	8.03m (1)	1993 (22 years)	1993
Mumbles	5.73m (1)	1988 (24 years)	1997
Milford Haven	4.50m (1)	1953 (54 years)	1967
Fishguard	3.37m (1)	1963 (50 years)	1973
Barmouth	3.92m (1)	1991 (23 years)	1991
Newlyn	3.27m (6)	1915 (100 years)	1915
Plymouth	3.11m (5)	1987 (25 years)	1991
Weymouth	2.01m (3)	1991 (24 years)	1991
Portsmouth	2.76m (5)	1991 (24 years)	1991
4/5 February 2014			
Plymouth	2.93m (<10) (3.15m (rank = 1) was recorded 08:15 3 February 2014)	1987 (25 years)	1991
Weymouth	1.91m (<10)	1991 (24 years)	1991
14 February 2014			
Plymouth	3.12m (= 3)	1987 (25 years)	1991
Weymouth	2.00m (= 4)	1991 (24 years)	1991
Portsmouth	2.80m (2)	1991 (24 years)	1991

Comparison: 1953

2013

a working partnership between



Properties flooded	24,000	1,400 (10/12/2013)
Deaths	307	2 but not flood related
Agricultural Land	65,000 hectares	6,800 hectares
People evacuated	32,000	18,000
Infrastructure	2 Power stations 12 Gas Works 100 miles of roads 200 miles of rail	Major impacts at Immingham Port No power stations and major gas works/services affected Road and rail tbc
Flood Warnings	0	71 severe flood warnings Over 160, 000 warning messages sent directly to homes and businesses

Developments & Tangible Benefits

Following the 1953 disaster, effective monitoring, forecasting and warning systems were put into place, together with significant investments in North Sea flood defences. Hundreds of thousands of properties and around 2000 km² of agricultural land are now protected, including by the Hull and Thames Barriers

Early warnings of the 2013 event by the FFC & Environment Agency and excellent planning by regional responders, meant that despite significant coastal flooding, no fatalities occurred as a direct result of flooding.

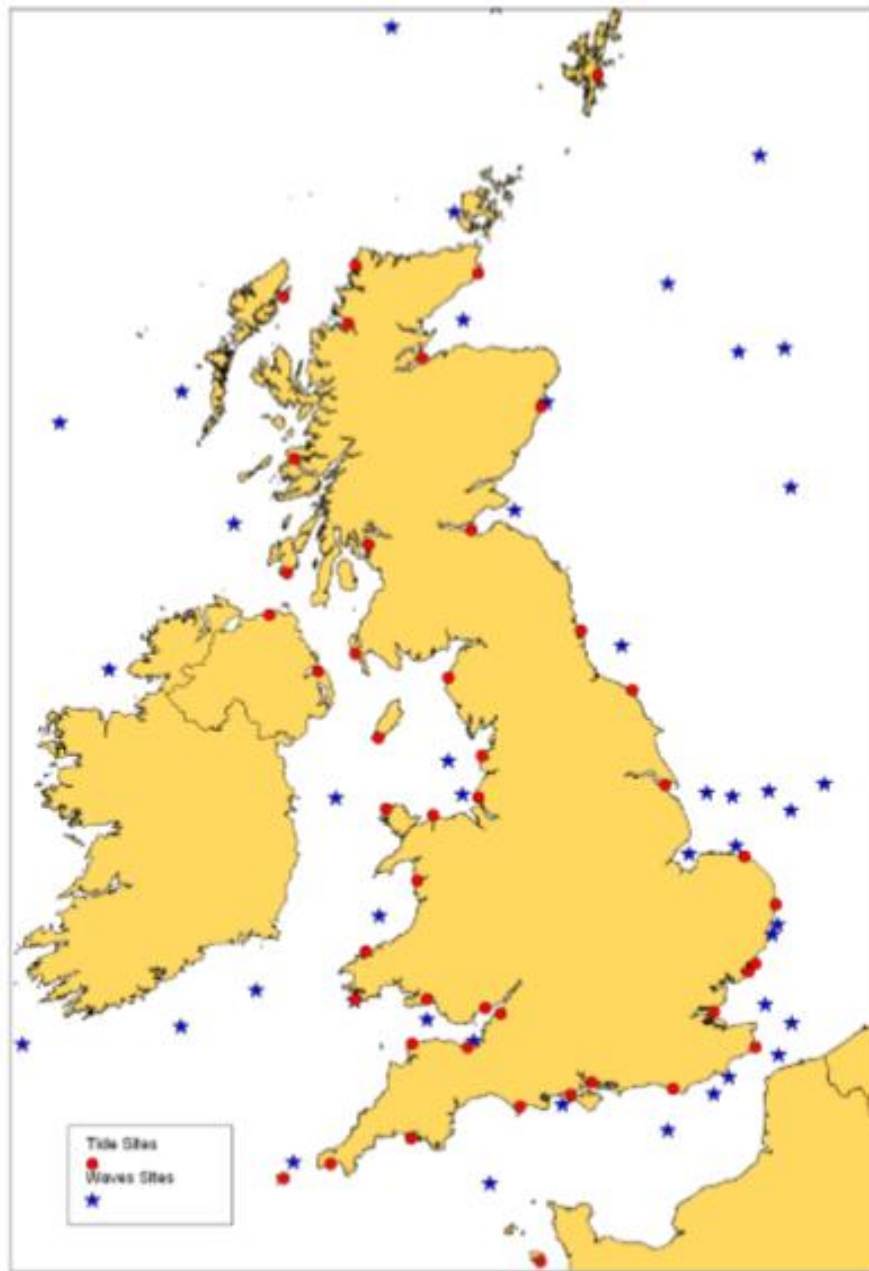
(Sibley et al., 2015)

More specifically:

Development of effective monitoring, forecasting and warning systems & defences

- ✓ Storm Tide Warning Service (STWS) was set up after the east coast flooding disaster of 1953, to provide warnings of impending high water levels & inundation
- ✓ UK Tide Gauge Network
- ✓ Joint UK Coastal Monitoring and Forecasting (UKCMF) and UK Coastal Flood Forecasting (UKCFF)
- ✓ Hard, structural defences & barriers, e.g. Thames Barrier, Hull Barrier
- ✓ In 1996, the Environment Agency took over the role of issuing flood warnings to the general public
- ✓ **Flood Forecasting Centre, 2008 (pilot)**, key role in National Strategic flood risk assessment and guidance
- ✓ Key partnerships & suppliers: Met Office, Environment Agency, Flood Forecasting Centre, National Oceanography Centre (NOC), Centre for Environment, Fisheries and Aquaculture Science (Cefas), British Oceanographic Data Centre (BODC)

Strategic monitoring network for
tide levels and wave heights



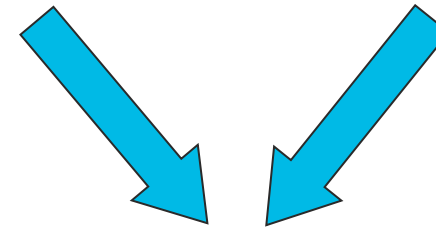
Flood Forecasting Centre

UK government's 'Pitt Review' key recommendation (6)

*"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."*

and

*"low probability of **severe events** at longer lead times"*



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“Providing trusted guidance to help protect lives and livelihoods from flooding.”

- Forecast national flood risk for Cat 1 & 2 responders in Eng & Wales
- Partnership between the Met Office and Environment Agency
- Operational since April 2009 delivering 24/7 services
- Forecast all natural sources of flooding, Flood Guidance Statement.....



Coastal



Surface water



Groundwater

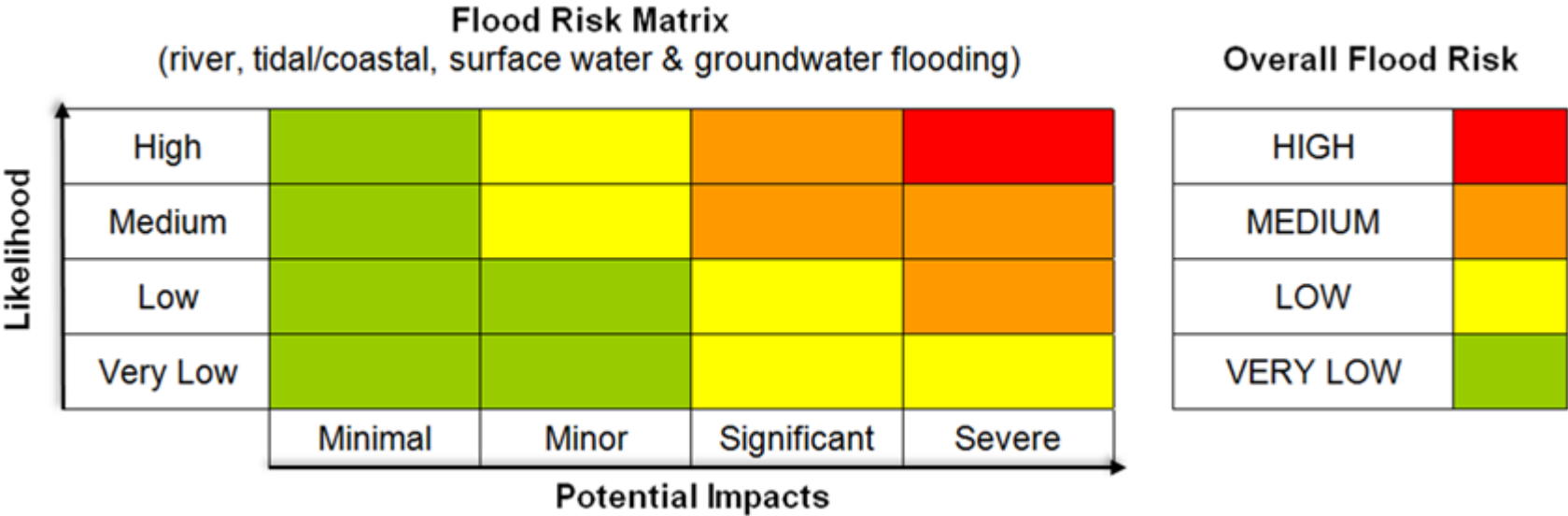


River

Flood Risk Matrix

Overall flood risk (and colour) = Likelihood x Impact

Not a simple traffic light system



Likelihood:

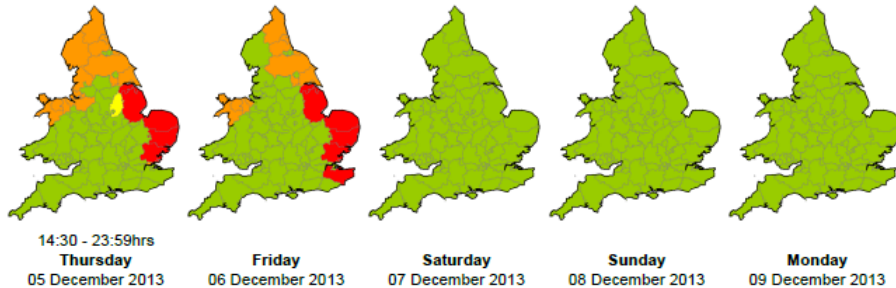
Very Low < 20% Low 20-40% Medium 40-60% High > 60%

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a working partnership between Environment Agency Met Office

Flood Guidance Statement 14:30hrs Thursday 05 December 2013

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.



Update: The coastal flood risk is now **HIGH (RED)** for Lincolnshire, East Anglia and Essex coast later today and into tomorrow and for Kent tomorrow. **MEDIUM** flood risk has also been extended into Friday for the north coast of Wales.

There is also a medium likelihood of significant coastal flooding impacts along much of the rest of the east coast of England today and tomorrow. Today only, there is also a medium likelihood of significant coastal flooding impacts along all of the north-west England coastline.

General overview of flood risk

Severe and significant impacts from coastal flooding are possible.

There is now a **HIGH** risk of flooding in parts of Lincolnshire, Norfolk, Suffolk and Essex today and tomorrow and also for Kent on Friday where the forecast surge is likely to lead to severe impacts - coloured red on the maps above.

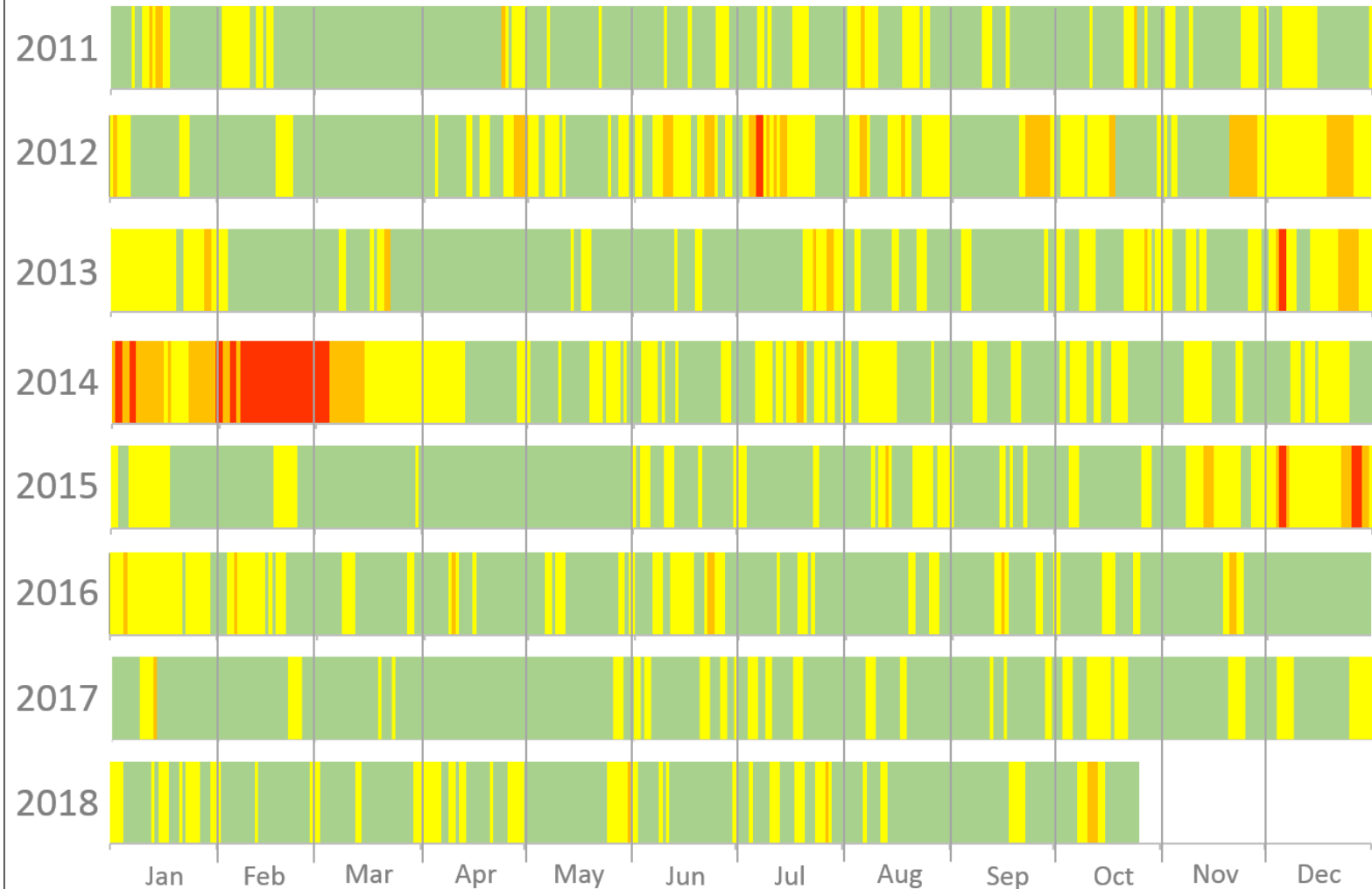
There is a medium likelihood of significant impacts from coastal flooding along all of the coastline in north-west England today. There is also a medium likelihood of significant coastal impacts along the north coast of Wales today and into tomorrow. This brings a **MEDIUM** overall flood risk in these areas, coloured amber in the maps above.

There is a medium likelihood of significant impacts from coastal flooding along the rest of the east coast of England today and tomorrow. This brings a **MEDIUM** overall flood risk in these areas, as coloured amber in the maps above.

There is also a very low likelihood of significant impacts from tidal flooding along the lower reaches of the River Trent in Nottinghamshire today. This brings a **LOW** overall flood risk, as coloured yellow in the maps above.

At all other times and places, the overall flood risk is **VERY LOW**.

'Barcode Calendar' of Forecast Flood Risk



So how did Dec 2013 unfold?

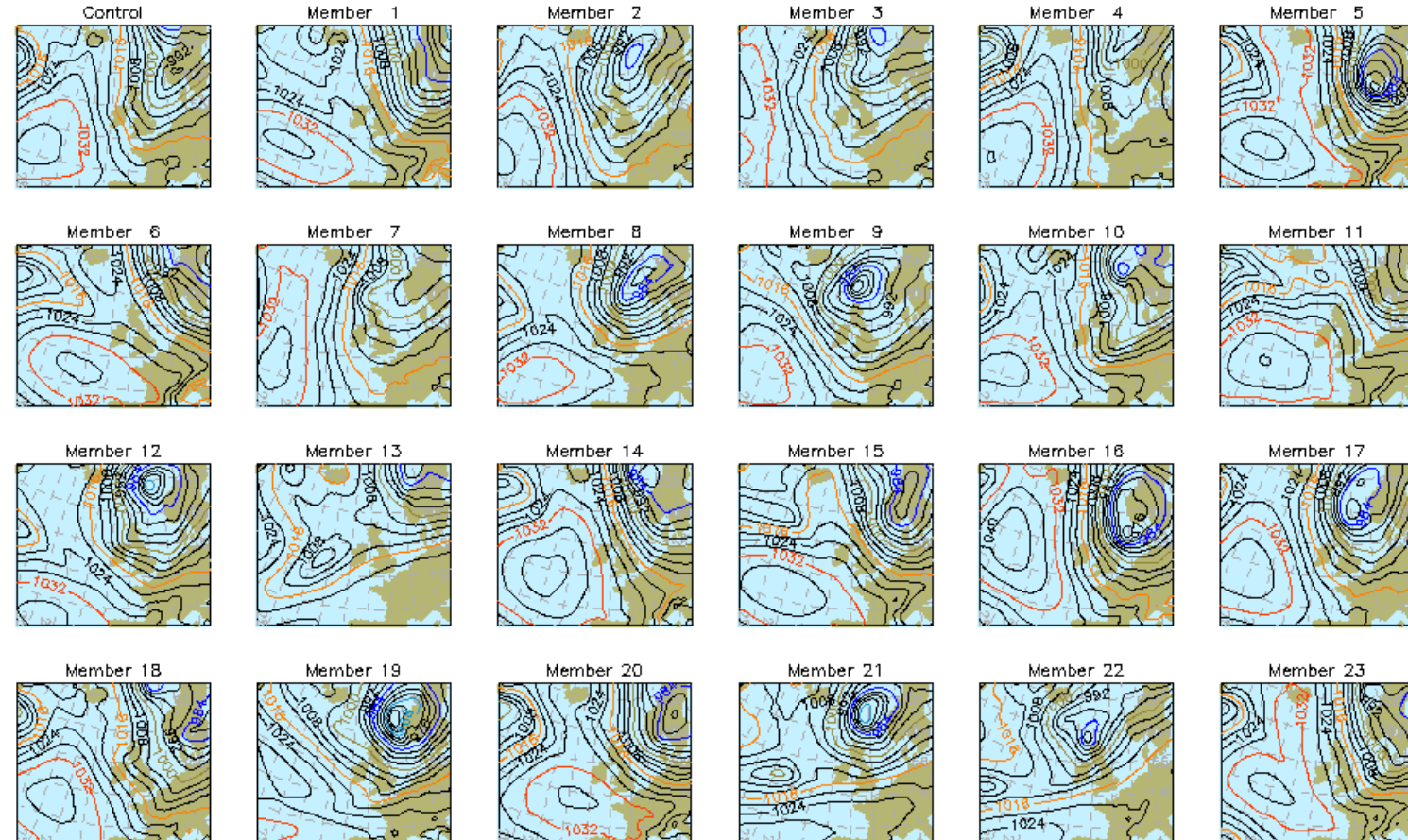
On the bench, communication, warnings, defences

Ensemble Prediction System
144hr (6 days) forecast
*Many members show a deep
low moving into the North Sea*

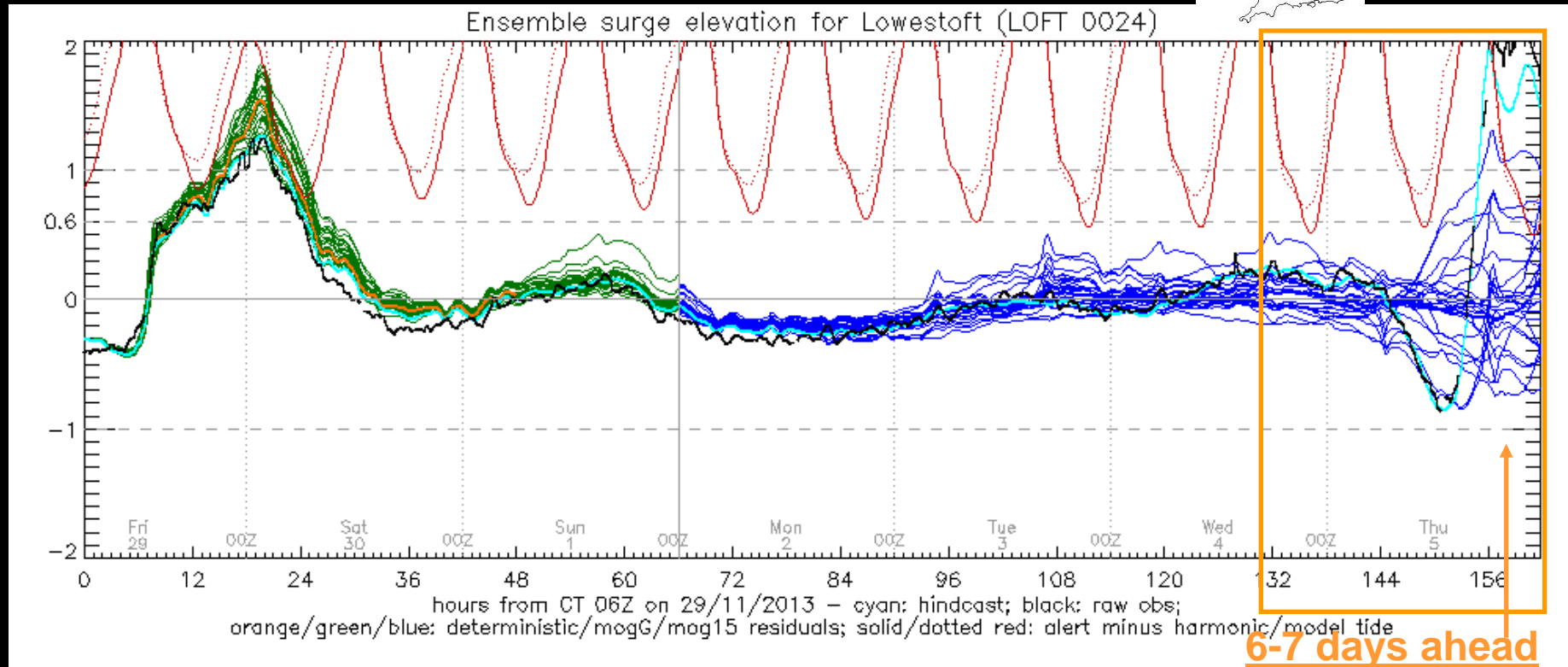
MOGREPS-15

PMSL (hPa)

T+144h DT: 00Z Sat 30/11/2013
VT: 00Z Fri 06/12/2013

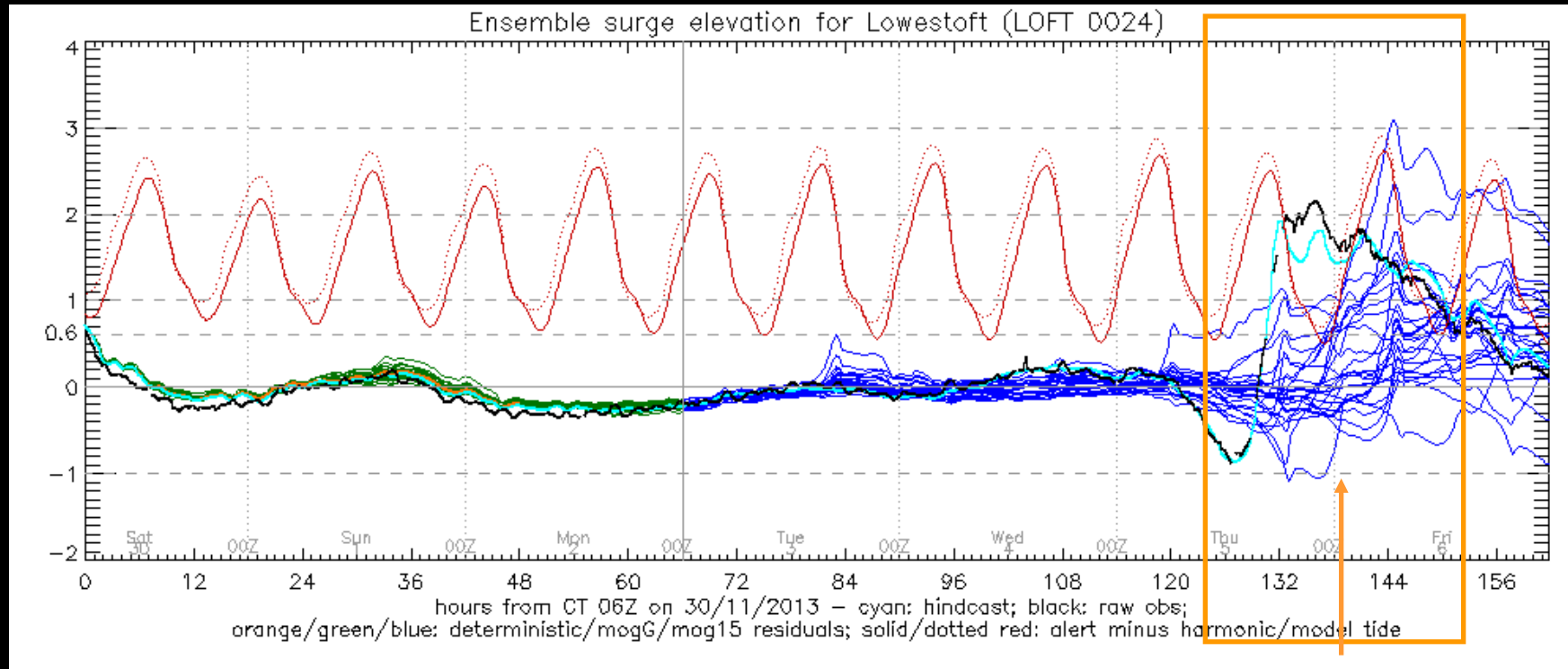


Predictability - Surge ensembles: 6-7 days lead time



- Several members show risk of alert level exceedance, but not by the magnitude shown by observations
- Clear increase in spread and uncertainty in ensemble from T+144 showing potential for extreme event
- Led FFC forecasters to first include in guidance to EA on *Fri 29th Nov*

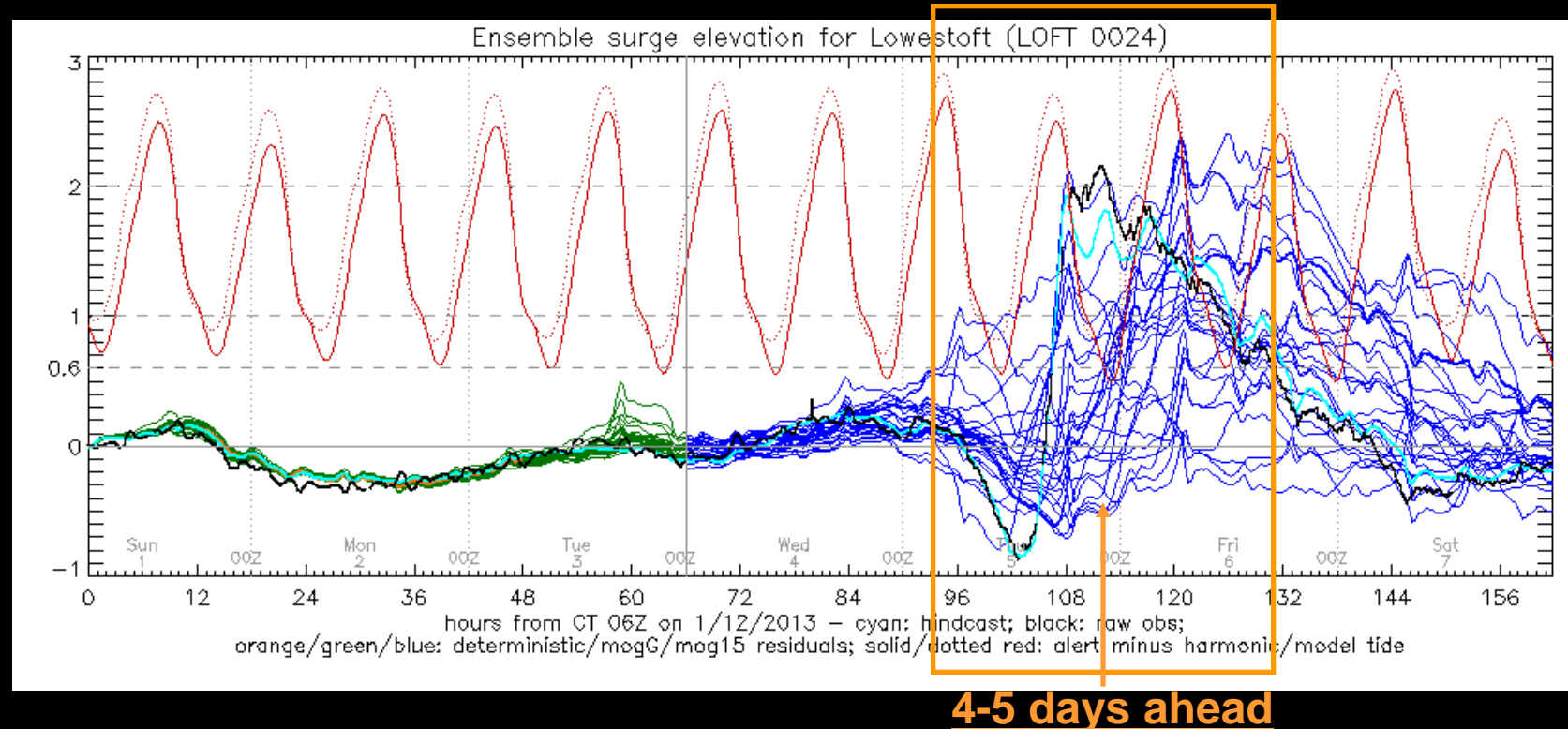
5-6 days ahead shows significant risk of period of dangerous surge activity



5-6 days ahead

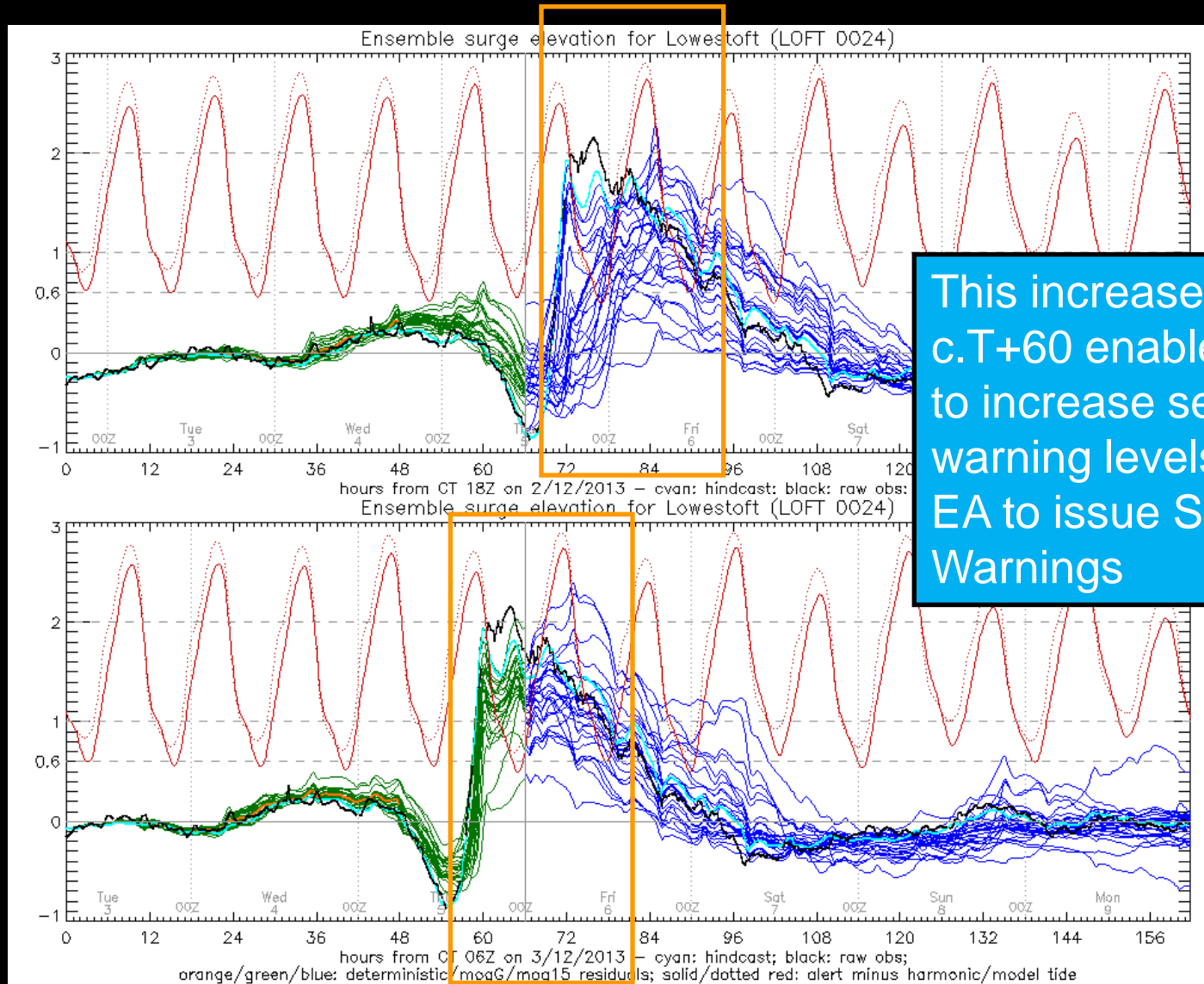
- Large variation in surge timing and magnitude from run to run
- Main surge activity forecast 12 hours later than subsequently observed
- One member is forecasting a 2.5m+ surge coincident with a high tide

4-5 days lead time



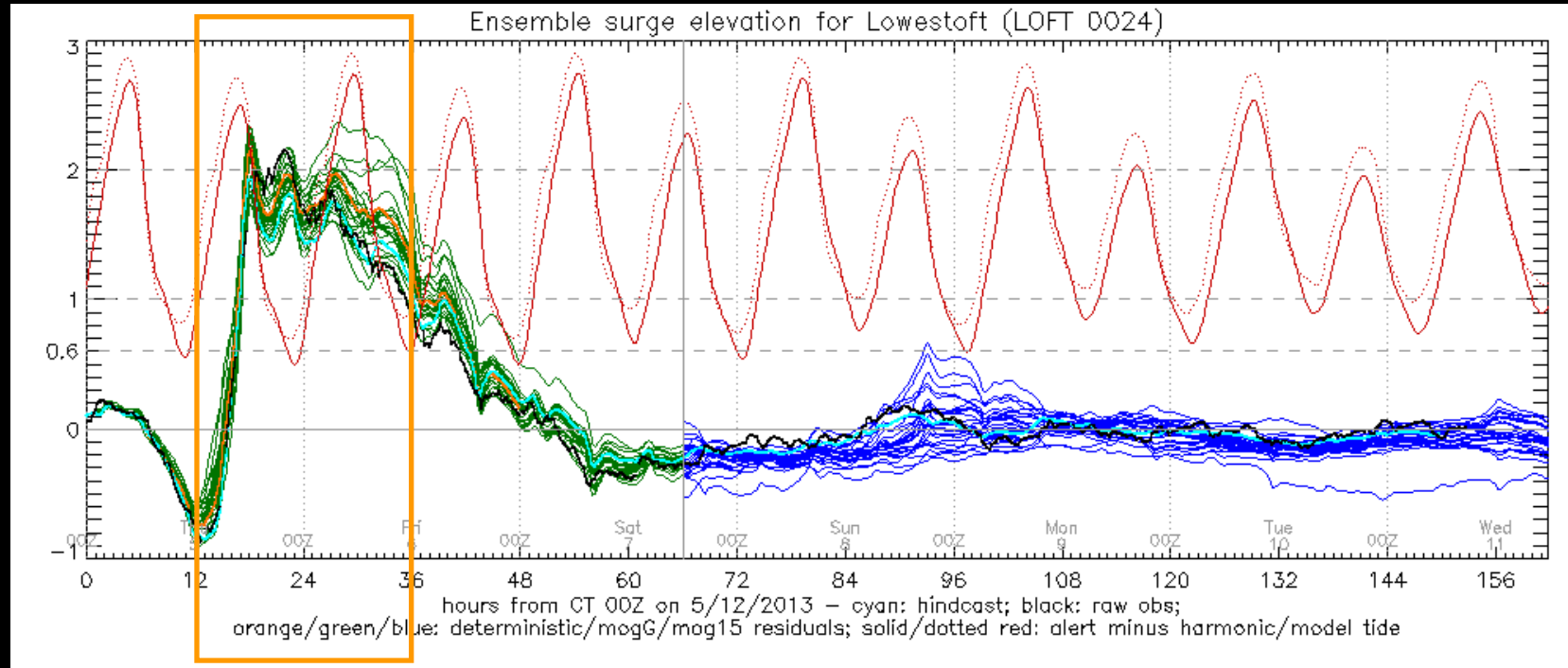
- Majority of members forecasting alert level exceedance at some point Thu-Sat – a very strong signal at this lead time
- Large uncertainty in magnitude and timing, showing importance of considering overall risk for the period, as considering one cycle only would underestimate overall risk
- FFC forecasters initiate National Flood Advisory Service teleconference on 1st Dec

Increase in signal strength at 2½ day lead time



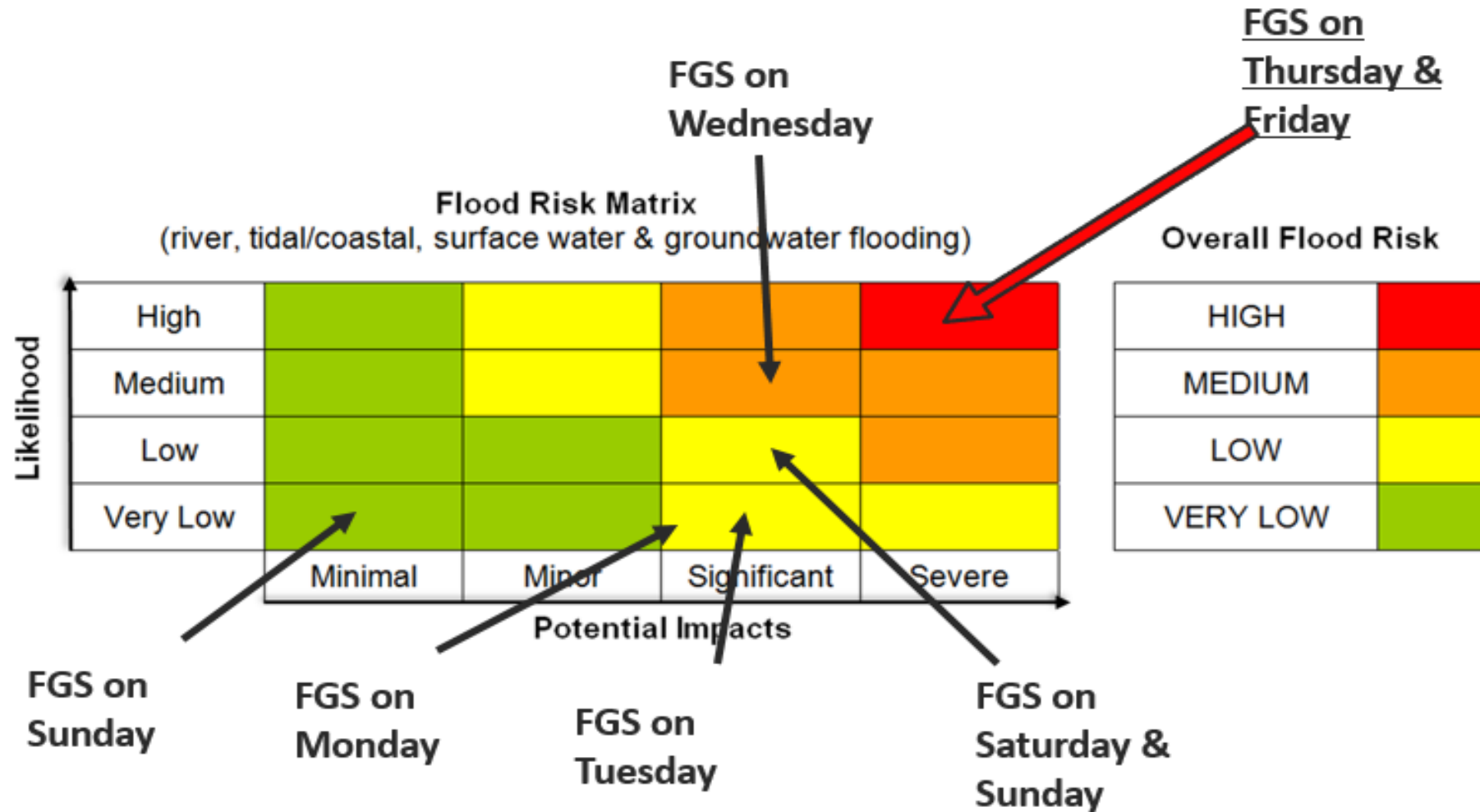
This increased confidence by c.T+60 enabled FFC hydromets to increase severity of the warning levels and enabled the EA to issue Severe Flood Warnings

Short range

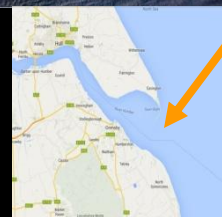


12-24 hours ahead

Communicating the flood risk - Flood Risk Timeline



Impacts 5-6 Dec



Summary of actions in 5/6 Dec event

Status	
	Severe Flood Warning Severe flooding. Danger to life
	Flood Warning Flooding is expected. Immediate action required
	Flood Alert Flooding is possible. Be prepared.



- Environment Agency issued 64 severe flood warnings
- Over 160,000 warning messages sent directly to homes and businesses
- 2,600 properties flooded, but 800,000 properties protected by flood defences including Thames Barrier (highest tide since completion in 1984)
- Mass mobilisation of emergency responders and emergency plans
- 18,000 people evacuated, and no deaths due to the storm surge
- Contrast with 1953 North Sea Storm Surge - no flood warnings, and 307 UK deaths

Preparation

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Sandwich, Kent – 6 Dec 2013

Communications

3,393
pieces of
national
and
regional
news
coverage



What creates a storm surge?

263 million – number of daily hits on UK
news websites to view the 316 flood articles

316 online news stories

14,539 mentions of
Environment Agency
across **social media**
and online

7,600 retweets
of messages
sent by all
Environment
Agency
accounts

44 separate
interviews with
EA
spokespeople



Boston, Lincolnshire – 5 Dec 2013



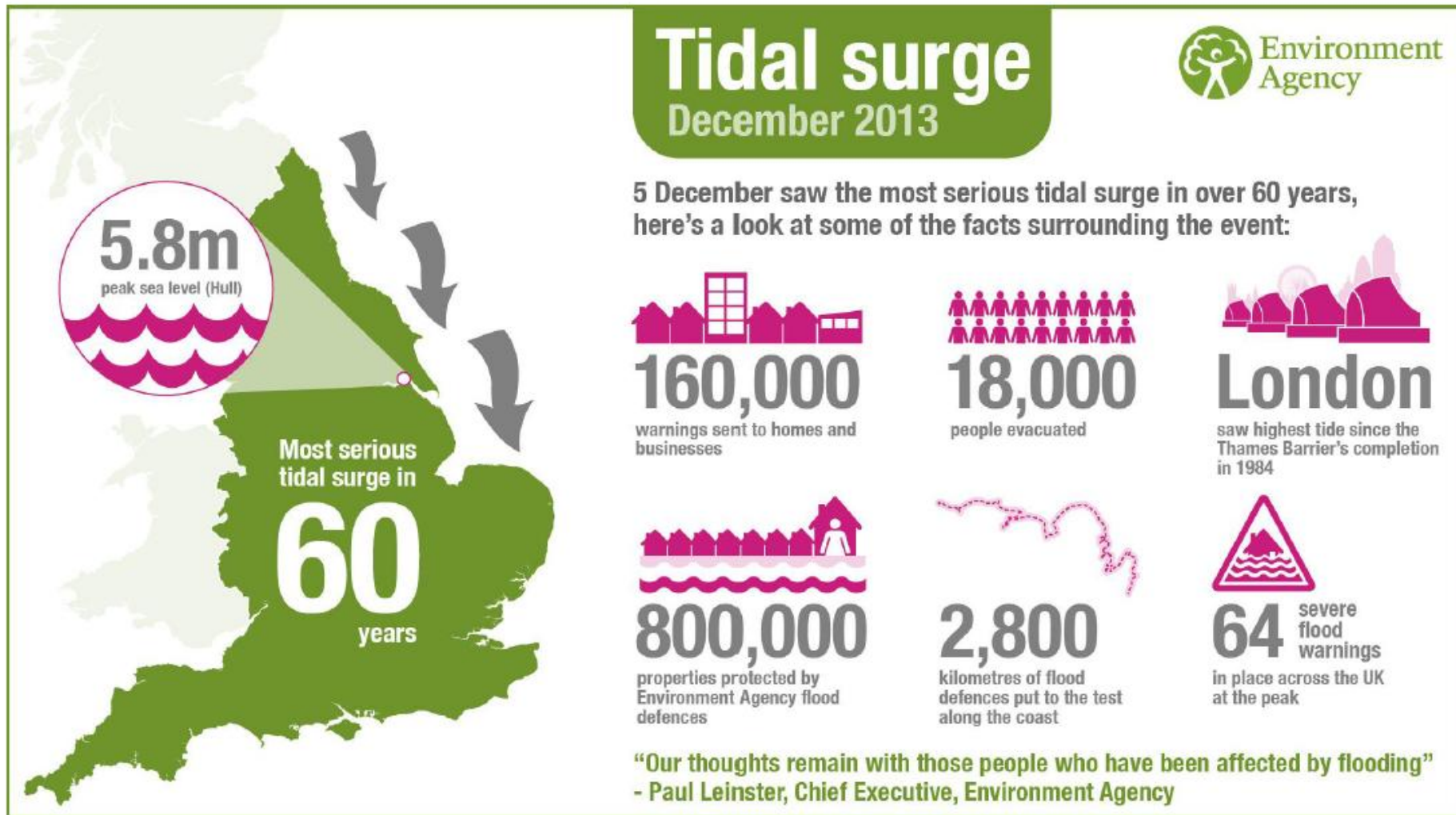
Humber Southbank – 6 Dec 2013 09:54 GMT



Keadby on Trent



Seal Sands, Billingham – 7 Dec 2013

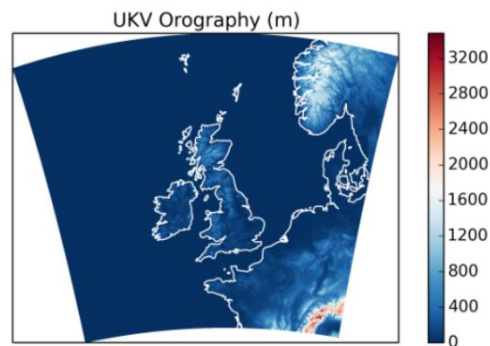
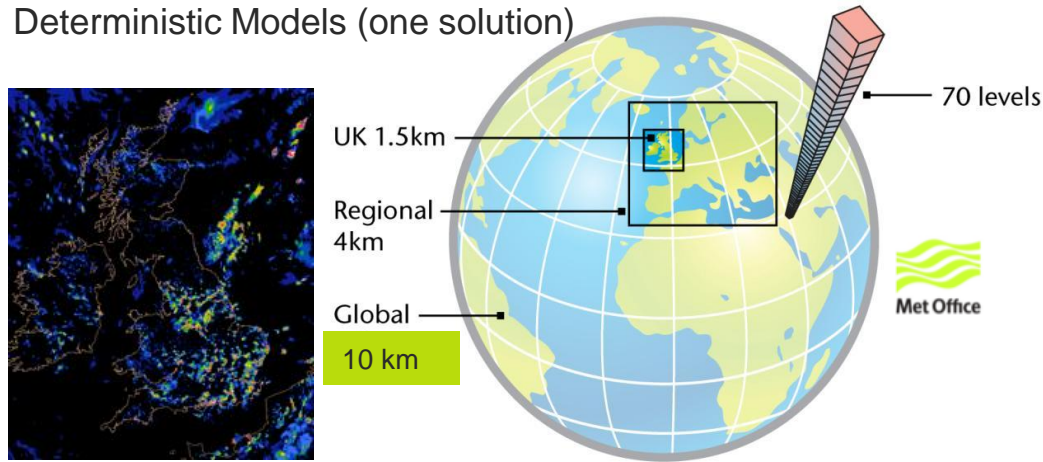


Feedback from 2013 coastal surge

- ‘Spectacular success – not a single fatality’ – **Kent County Council**
- ‘This was the largest national resilience deployment to date, 50 FRS teams mobilised from outside of the risk areas, including 20 high volume pumps’
‘We have complete faith in what you share – and we appreciate you sharing the uncertainty too. You are unfailing accurate. Embedding an officer with you was invaluable for this event’ – **Roy Harold, FRS**
- ‘Great, great effort from your team Crystal. This has been a big learning experience and probably saved the tax payer £1m next year by avoiding having to run a major coastal exercise’ - **David Lees, Defra**

Models – Deterministic and Ensemble Forecasts

Deterministic Models (one solution)



Models from other Forecast Centres



ECMWF

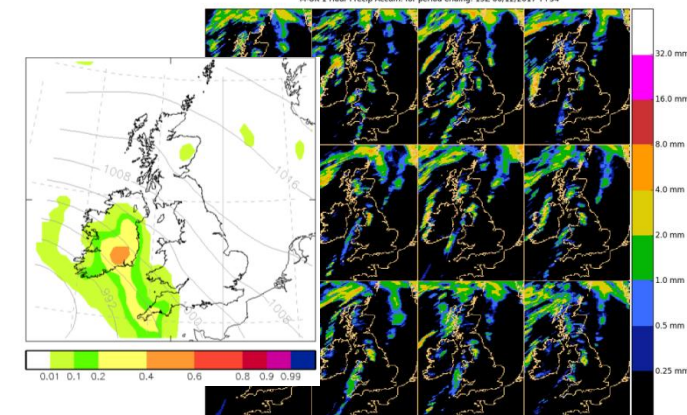
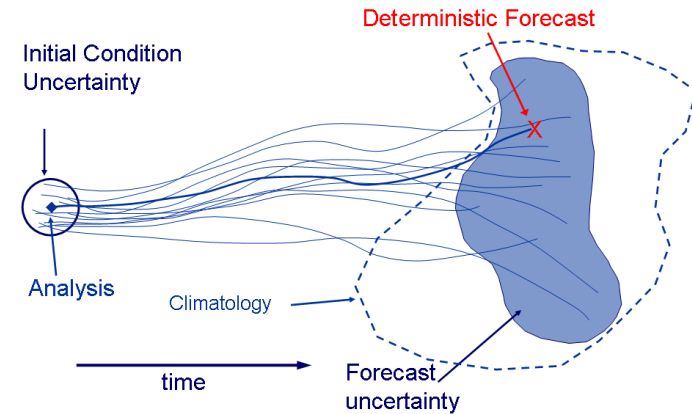
- Deterministic (9 km, 10 days)
- Medium range ensembles (18 km, 15 days)



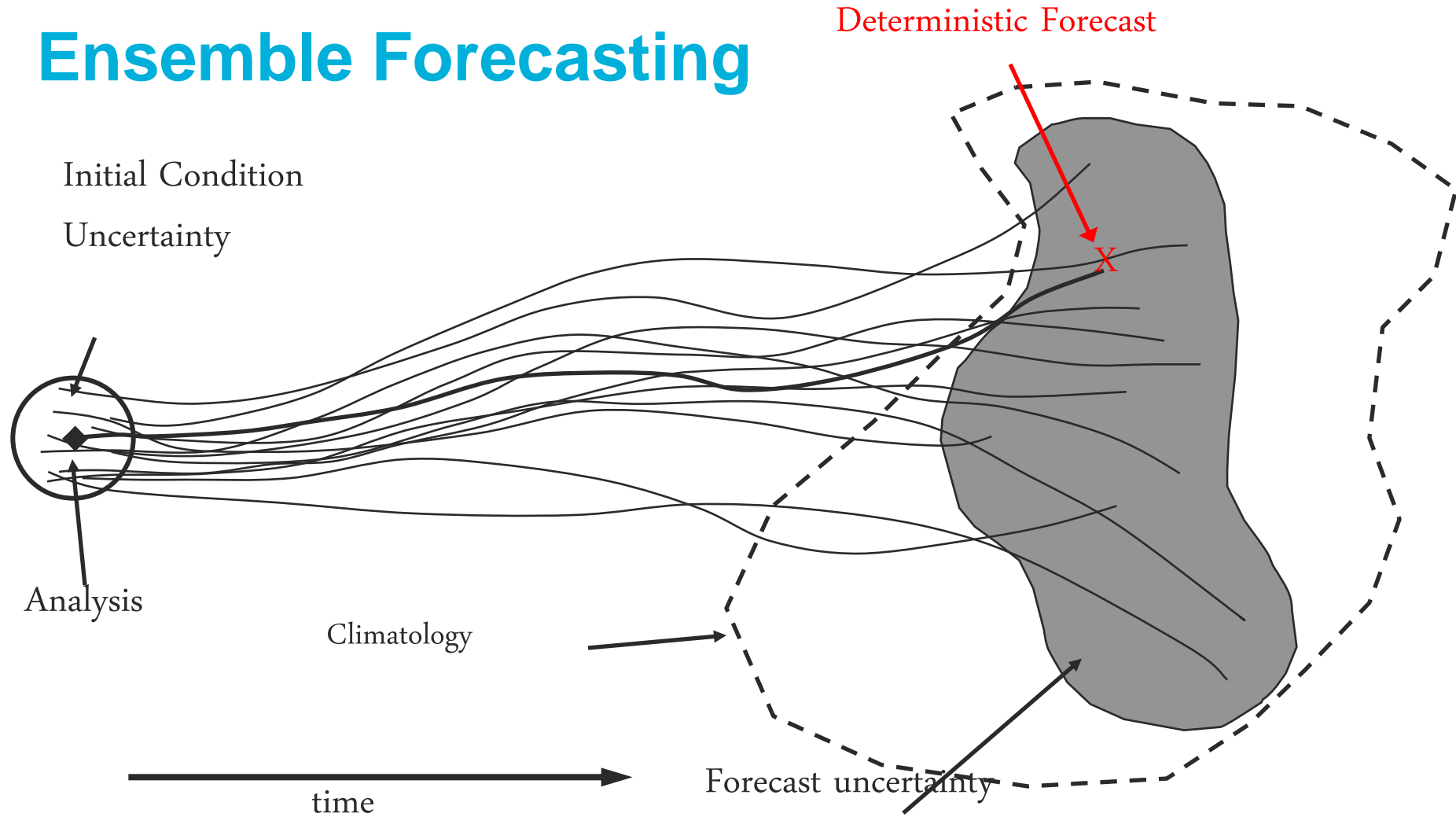
NCEP (US)

- Deterministic (13 km)
- Medium range ensembles (26 km)
- Both 16 days

Ensemble Models (probabilistic forecasts)



Ensemble Forecasting



Summary - Bringing it together

- Extreme, high impact events act as a trigger, catalyst for step changes.
- Cross discipline: science, operations, coordination, communication, ACTION.
- This work need to take place in 'peacetime' so that the country is best placed to respond.
- Communicating a complex situation
- Ongoing v's new flooding
- Adjustments for degraded defences
- Sharing intelligence e.g. infrastructure impacts
- Holding interest & key messages
- National flood emergency co-ordination



Thank You

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

Flood Outlook

Flood Outlook: 26 October – 26 November 2018

FLOODFORECASTINGCENTRE

a working partnership between  Environment Agency  Met Office

Headline: Low overall risk

Issued: 26 October 2018 (Next issue date: 16 November 2018)

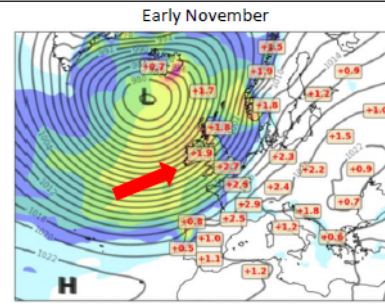
Day and date

Spring

F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M
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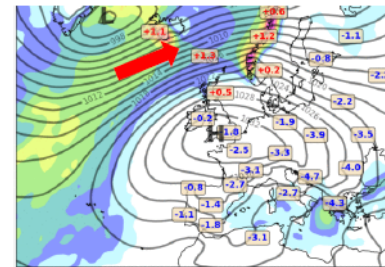
Flood Outlook: Current conditions and 3-month precipitation outlook

Weather Patterns



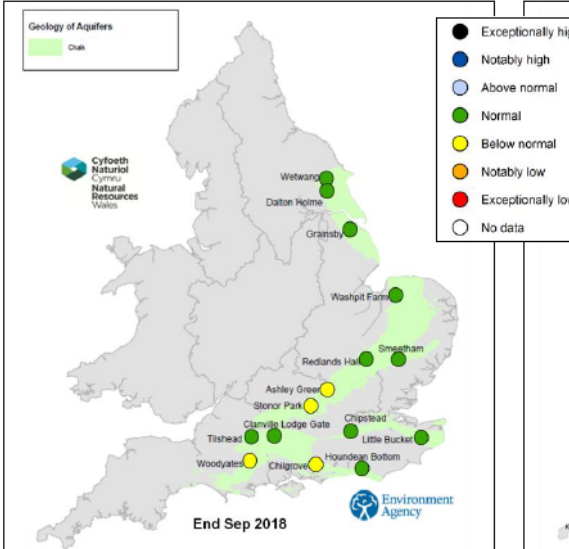
26 Oct 2

Late November



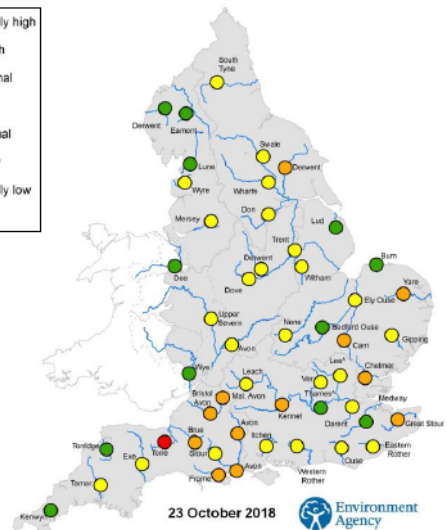
- Low pressure systems are likely to move close to the UK bringing periods of unsettled weather, strong winds and rain during late October into early November.
- There is evidence for conditions to become more settled weather higher pressure dominating from mid month onwards – though confidence is low.

Groundwater Levels



- Groundwater levels in England were largely normal for the time of year at the end of September.

River Flows



- River flows are mostly normal or below normal at the majority of sites in England and Wales.



Met Office

Three month UK Precipitation Outlook

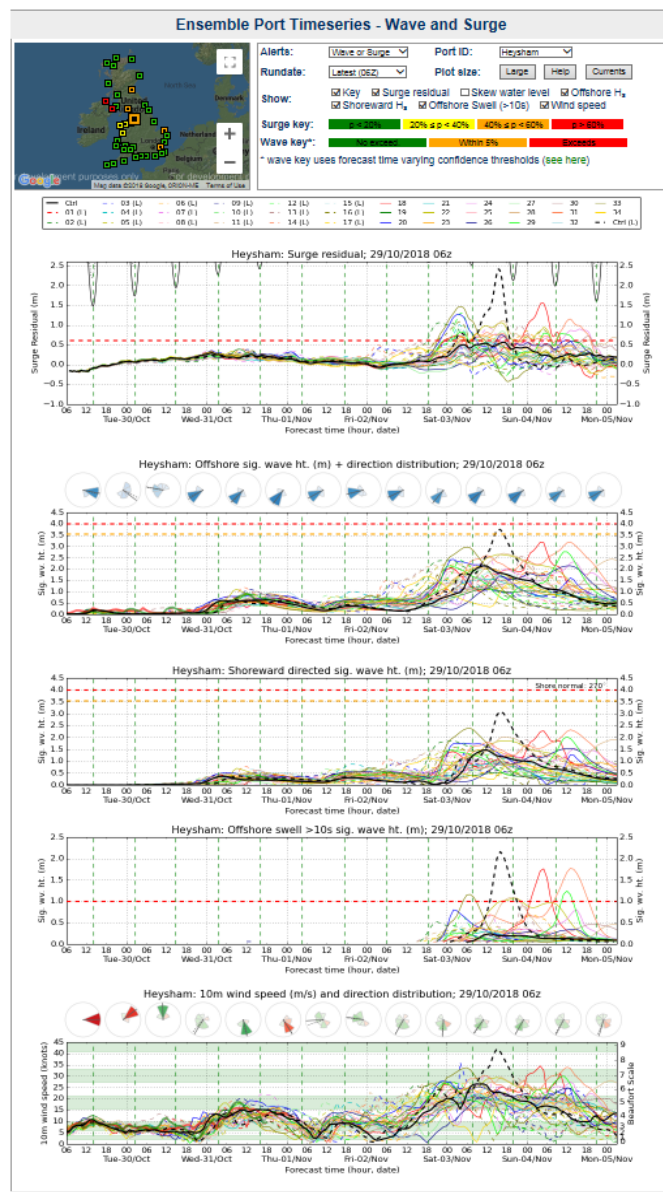
<https://www.metoffice.gov.uk/services/public-sector/contingency-planners>

For November, the chances of above- or below-average precipitation are approximately similar. For November-December-January as a whole, above-average precipitation is more likely than below-average precipitation. The probability that UK-average precipitation for November- December-January will fall into the driest of our five categories is between 10% and 15% and the probability that it will fall into the wettest of our five categories is around 25% (the 1981-2010 probability for each of these categories is 20%).

Forecasting Coastal Flooding

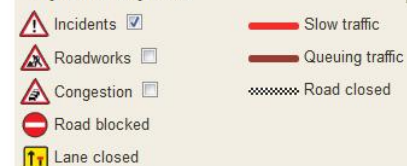
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Find

Key to traffic symbols



Incidents

Last updated: 26 Oct 2018, 8:40AM

Only some of the incidents shown on the map are listed below.
Zoom in for more details.

A226

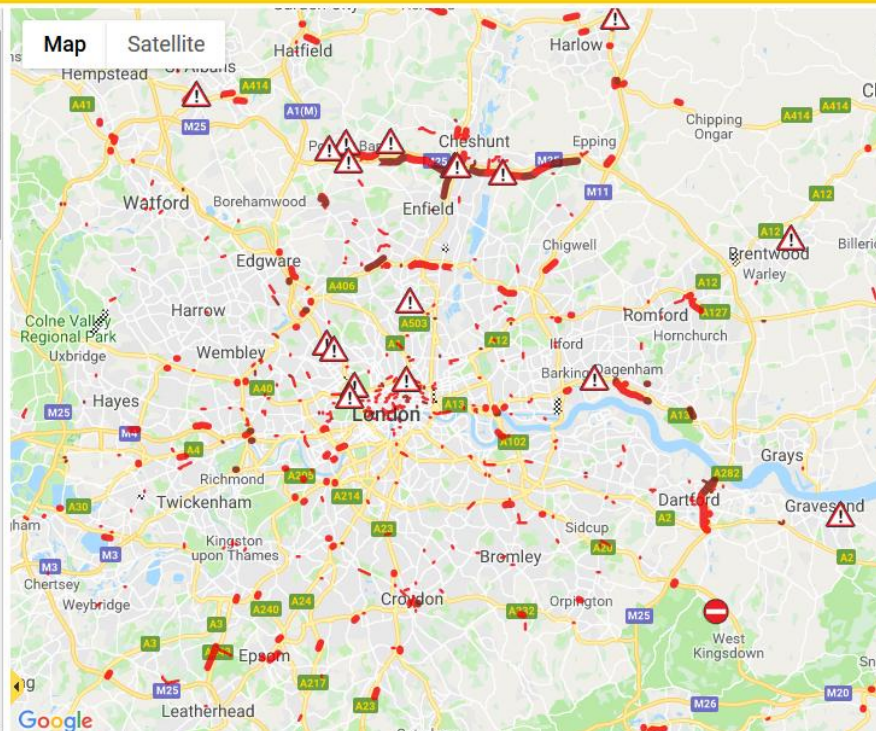
26 Oct 2018, 8:31AM (first reported)

Traffic signal failure on A226 Rochester Road near Denton Court Road. Approach with care. The temporary traffic lights in operation for electricity works, near to St John's Catholic Primary School are stuck on red.

A5

26 Oct 2018, 8:29AM (first reported)

One lane blocked and very slow traffic due to stalled car on A5














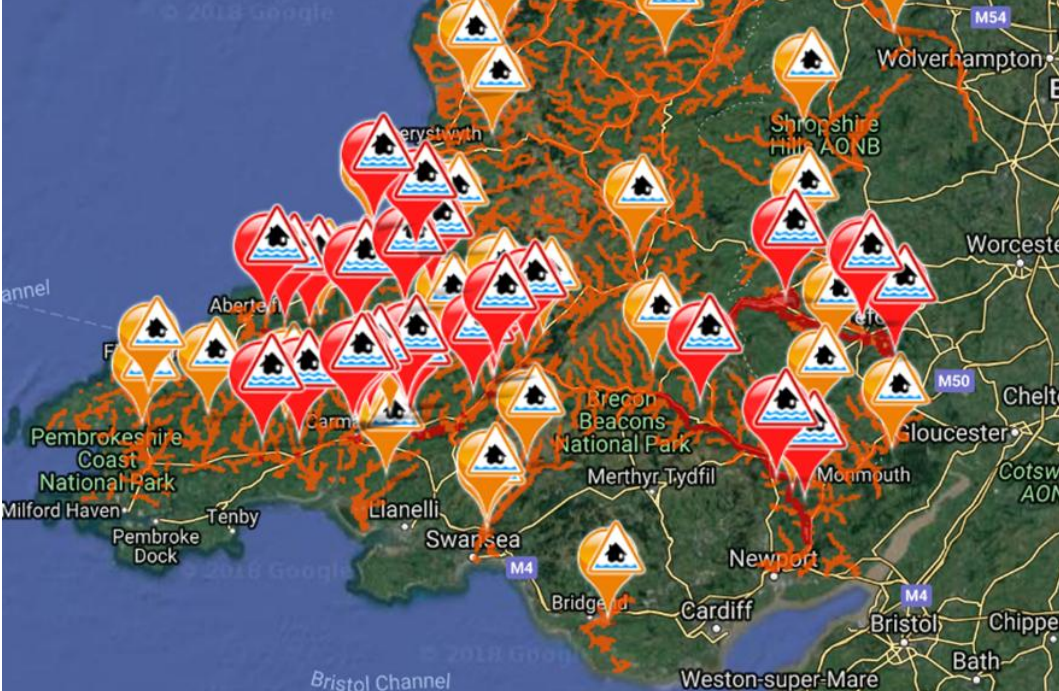
[Search all headlines](#)

News: 13 Oct 15:00

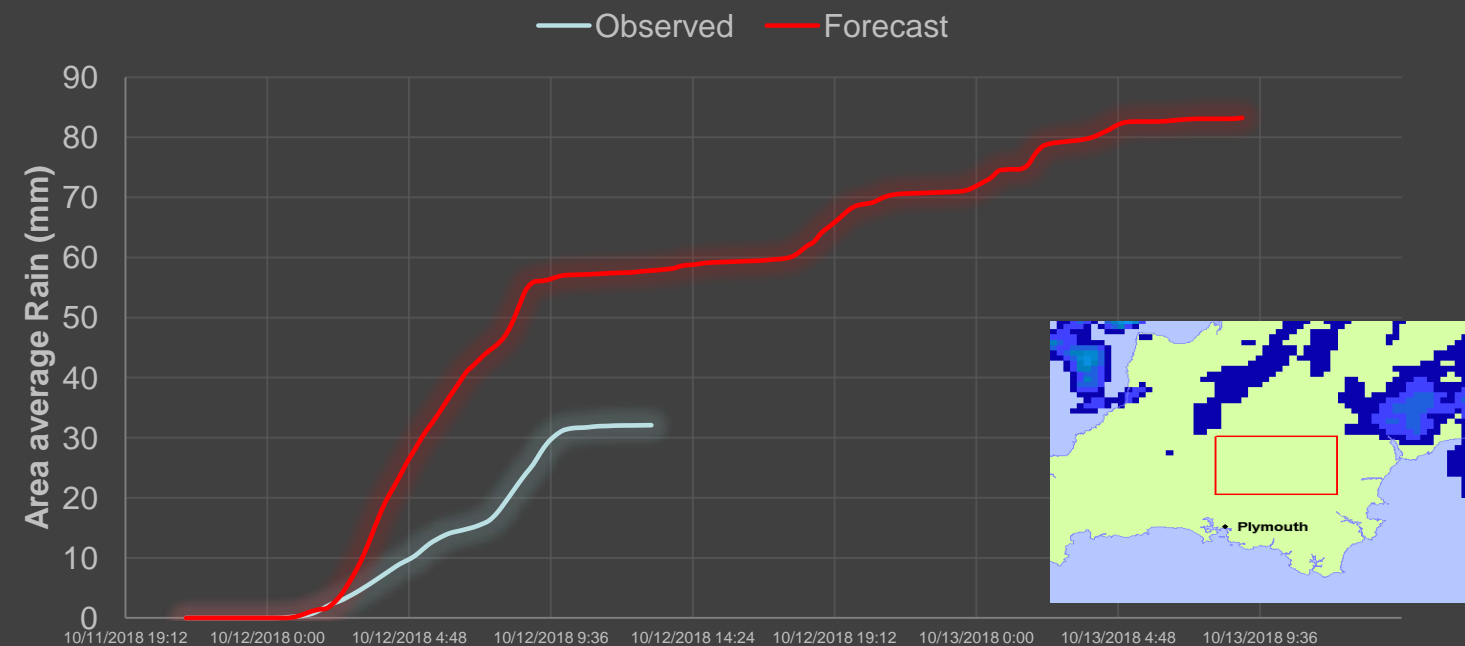
Latest News

In the last month

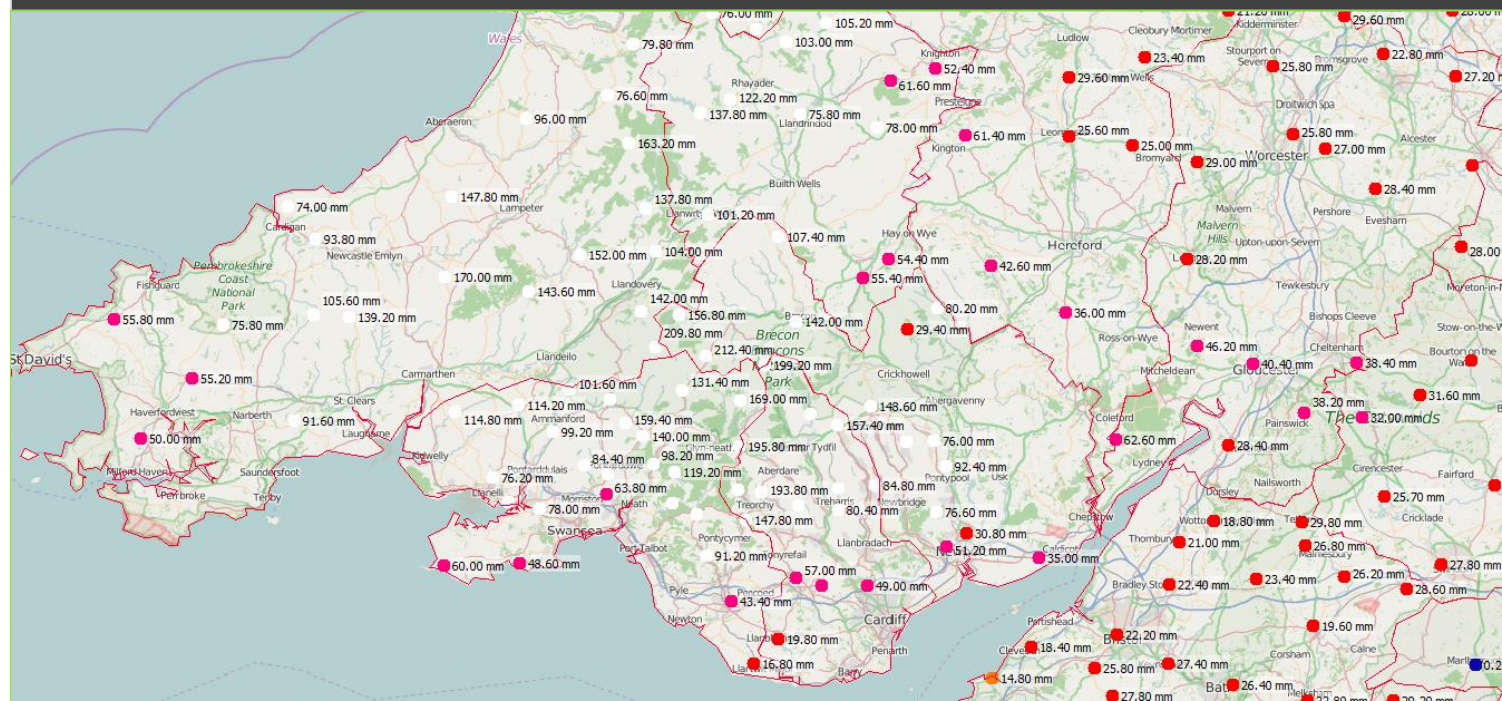
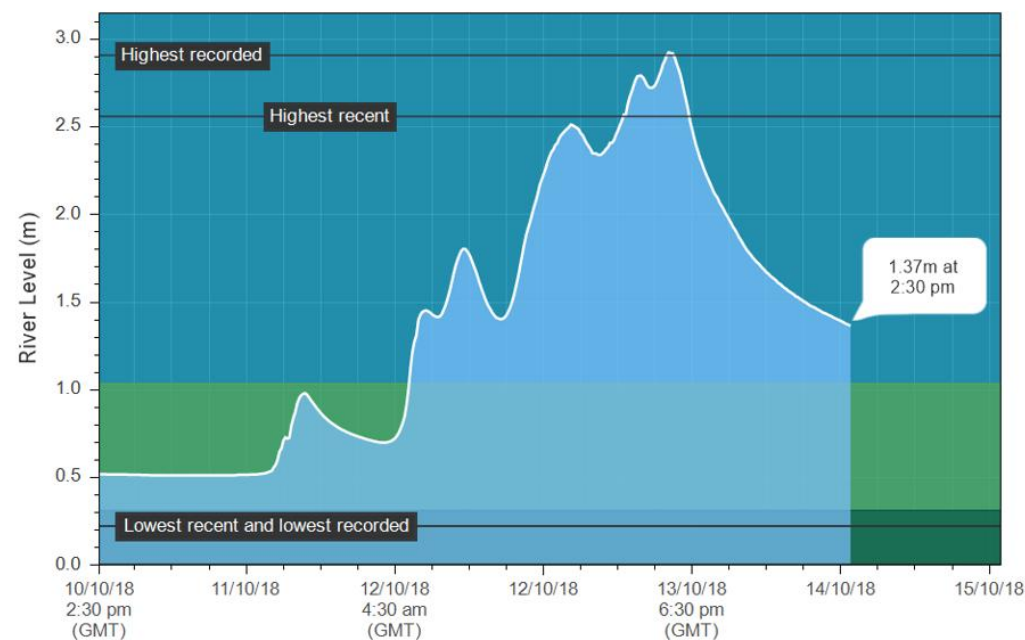
-  Storm Callum: **Flooding** in Cumbria The Carlisle News & Star ▾ 14:30 Sat, 13 Oct
-  **Flooding** closes stretch of M8 as heavy rainfall continues STV ▾ 13:43 Sat, 13 Oct
-  **Flooding** on Glasgow's M8 causes travel misery for drivers Glasgow Live ▾ 13:22 Sat, 13 Oct
-  Homes hit by **flooding** from Storm Callum BBC ▾ 13:09 Sat, 13 Oct
-  Video: Hasik, Dhofar sees rain and **flooding** on Saturday Times of Oman ▾ 12:04 Sat, 13 Oct
-  Indonesia flash **flooding** kills 21 BBC ▾ 11:50 Sat, 13 Oct
-  Hasik, Dhofar sees rain and **flooding** on Saturday Times of Oman ▾ 11:44 Sat, 13 Oct
-  Met Eireann issue weather warning for four counties and warn of possible spot **flooding**
-  Village where residents were told to evacuate homes sees 'worst **flooding** in 20 years' a Wales Online ▾ 10:59 Sat, 13 Oct
-  The Welsh town that's now an island after Storm Callum **flooding** Wales Online ▾ 09:59 Sat
-  **Flooding** as Storm Callum downpour continues ITV ▾ 09:30 Sat, 13 Oct
-  Weather: Storm Callum expected to bring more heavy rain and **flooding** to UK The Guardian



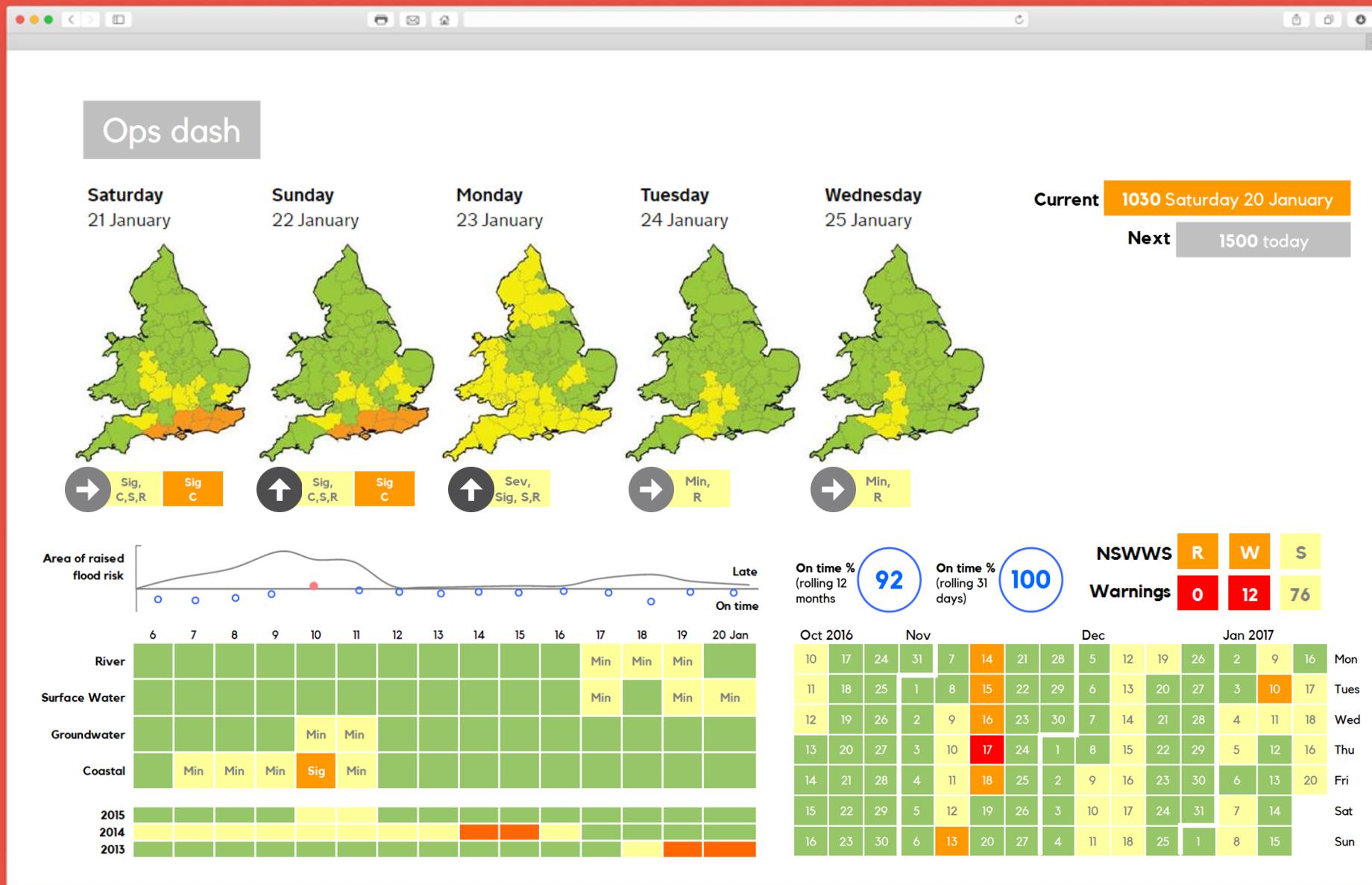
Dartmoor areal rain obs compared with 21Z Short Range Best Data



Gwili at Glan Gwili, Last retrieved value: 1.37m on 14/10/18 at 2:30 pm (GMT)

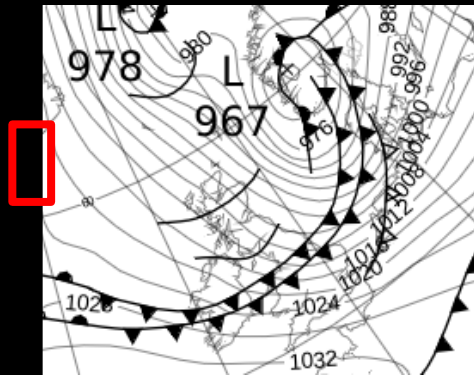


Operations dashboard

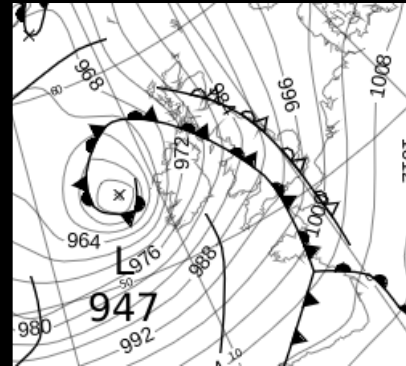


Overview of 2013/14 coastal flood events

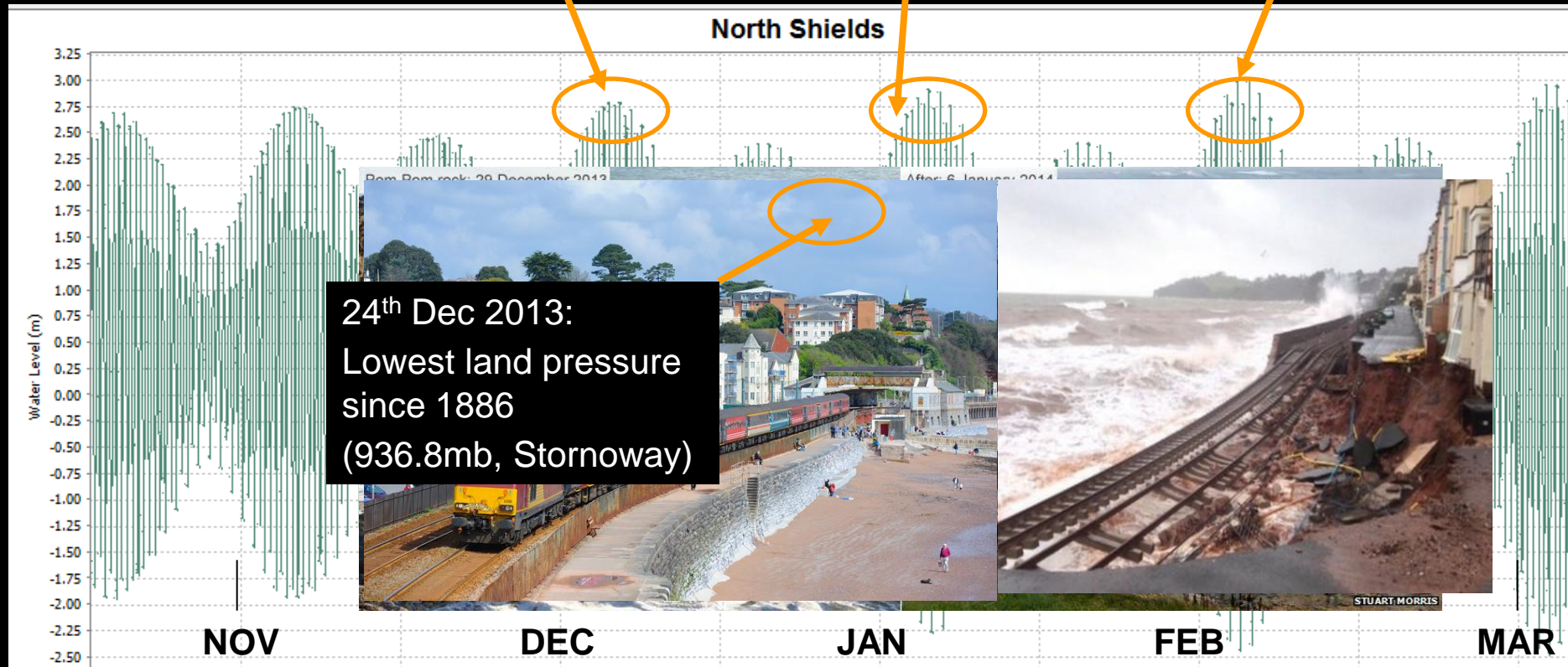
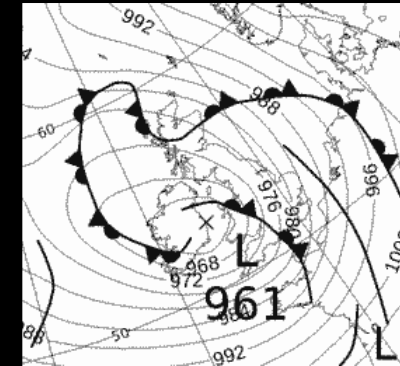
5-6th December 2013



3rd January 2014



4-5th February 2014



The FFC work closely with... (to deliver our products and services)

Met Office



- ➔ Guidance Unit
- ➔ National Severe Weather Warning Service (NSWWS) & Civil Contingencies Advisors
- ➔ Broadcast meteorologists (BBC / ITV)



Environment Agency (EA) & Natural Resources Wales (NRW)

- ➔ EA Centres and Natural Resources Wales MFDCs
- ➔ EA and NRW strategic/management teams
- ➔ National Flood Risk Systems
- ➔ Incident & Contingency Planning

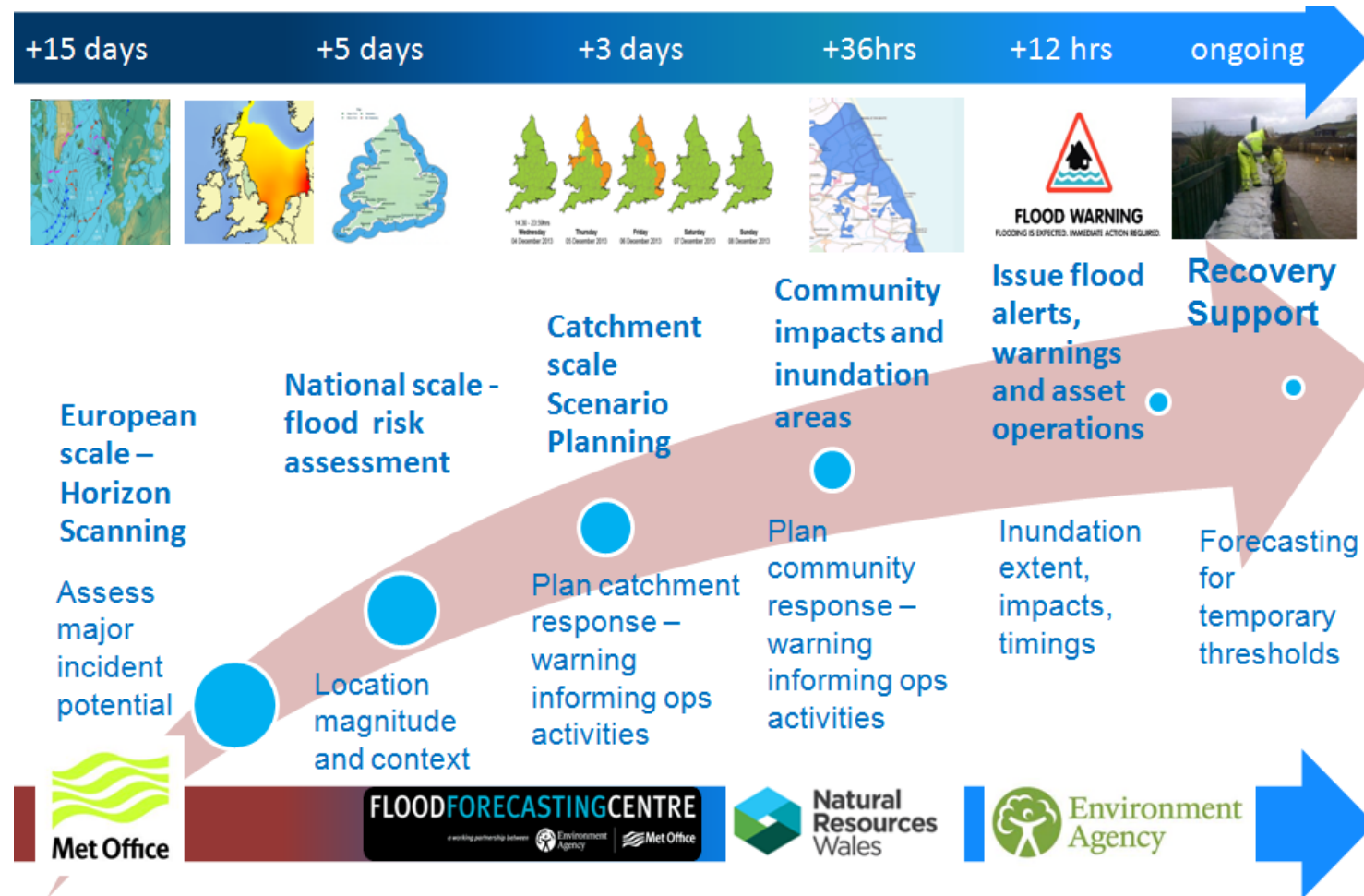


The FFC also work with SEPA and DARDNI for coastal issues



Where does the FFC fit?

Future Flood Incident Management Response



For the Environment Agency and Natural Resources Wales

- ➔ Hydromet Services: HG/ HRA / FMD
- ➔ Flood Guidance Statement
- ➔ Consultancy
- ➔ Flood Outlook

For Emergency Responders

- ➔ Flood Guidance Statement
- ➔ Advice and guidance
- ➔ Training material / exercises
- ➔ National Flood Advisory Service

For the Public

- ➔ Five Day Flood Risk Forecast

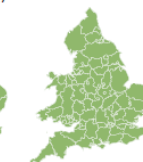
For UKCMF members

- ➔ Alerts and consultancy
- ➔ England, Wales & Northern Ireland

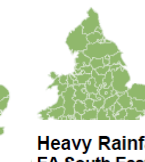
Flood Guidance Statement
10:30hrs Thursday 30 November 2017



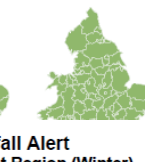
Thursday
30 Nov 2017 10:30-23:59
Trend since last FGS
Steady



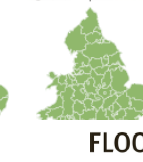
Friday
1 Dec 2017
Trend since last FGS
Steady



Saturday
2 Dec 2017
Trend since last FGS
Steady



Sunday
3 Dec 2017
Trend since last FGS
Steady



Monday
4 Dec 2017
Trend since last FGS
Steady

Heavy Rainfall Alert
EA South East Region (Winter)

Issued by the Flood Forecasting Centre on 08/01/15 at 06:08 GMT (06:08 local time)
Unique Alert Reference No. 1654_SOUTHEAST_413 Version 2

UPDATE

The overall flood risk is VERY LOW for the next five days.
Start of meteorological event: 1800 GMT on 07/01/15
End of meteorological event: 1400 GMT on 08/01/15

Summary of Alert Criteria Met

Assessment of flood risk

Coastal/Tidal

The coastal flood risk is VERY LOW for the next five days.
Strong winds and large waves may lead to some wind tides on Thursday and during Friday morning. However, only minor flooding is expected.

Rivers

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

Surface water

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

Groundwater

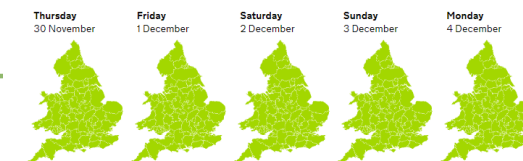
The groundwater flood risk is VERY LOW for the next five days.

5-day flood risk for England and Wales

Last updated at 10:30am on Thursday 30 November 2017

Forecast for Thursday 30 November 2017 to Monday 4 December 2017

The forecast flood risk across England and Wales for today and the next four days is very low.



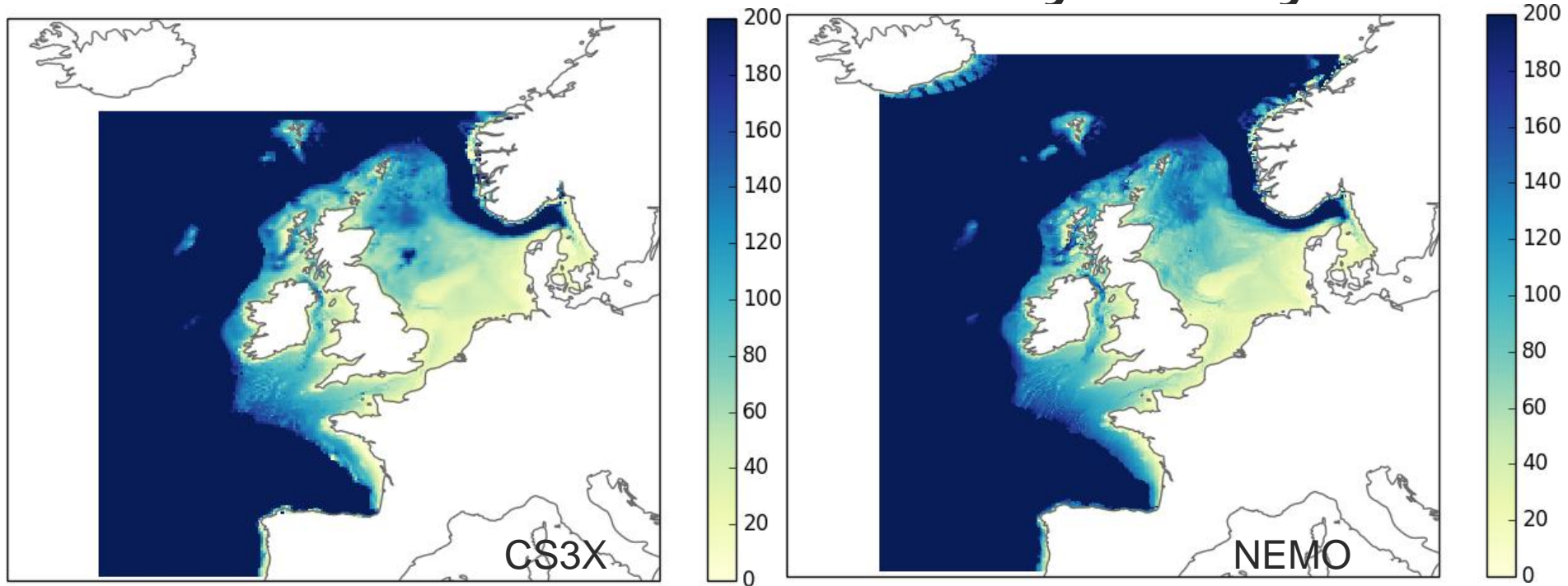
Coastal Flooding Dec 2013

- ➡ Largest East Coast flood since 1953
 - ➡ c1400 properties flooded
 - ➡ highest levels ever recorded in many areas
 - ➡ prolonged surge affecting three tides with strong winds and large waves
- ➡ Largest West Coast flood since 1987
 - ➡ c 400 properties flooded



- Benefits - communications
 - Communicating a complex situation
 - Ongoing v's new flooding
 - Adjustments for degraded defences
 - Sharing intelligence e.g. infrastructure impacts
 - Holding interest & key messages
 - National flood emergency co-ordination

CS3X vs NEMO – bathymetry



The Challenge

How can we make better use of data in a real-time operational environment to forecast floods?

3.

Flood impact identification

Real-time impact identification

Novel data sources

Automated assessment of impact severity