

*Impact based warning – does it work?
The Met Office's experience*

Mark Bevan

Senior Met Office Advisor (Civil Contingencies)



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Senior Met Office Advisor (Civil Contingencies)

- Joined the Met Office in 2003
- Background in Defence Forecasting, including reserve military service overseas
- Forecaster at 2012 Olympic Games and 2014 Commonwealth Games
- Now part of a team of 19 Advisors spread across the UK
- Liaison between the Advisor team and the Chief Operational Meteorologist in Met Office HQ
- Line manager for Advisors in south-west England and Wales.
- Provide Severe Weather advice to UK government, and lead on advice relating to Severe Weather Humanitarian Response overseas

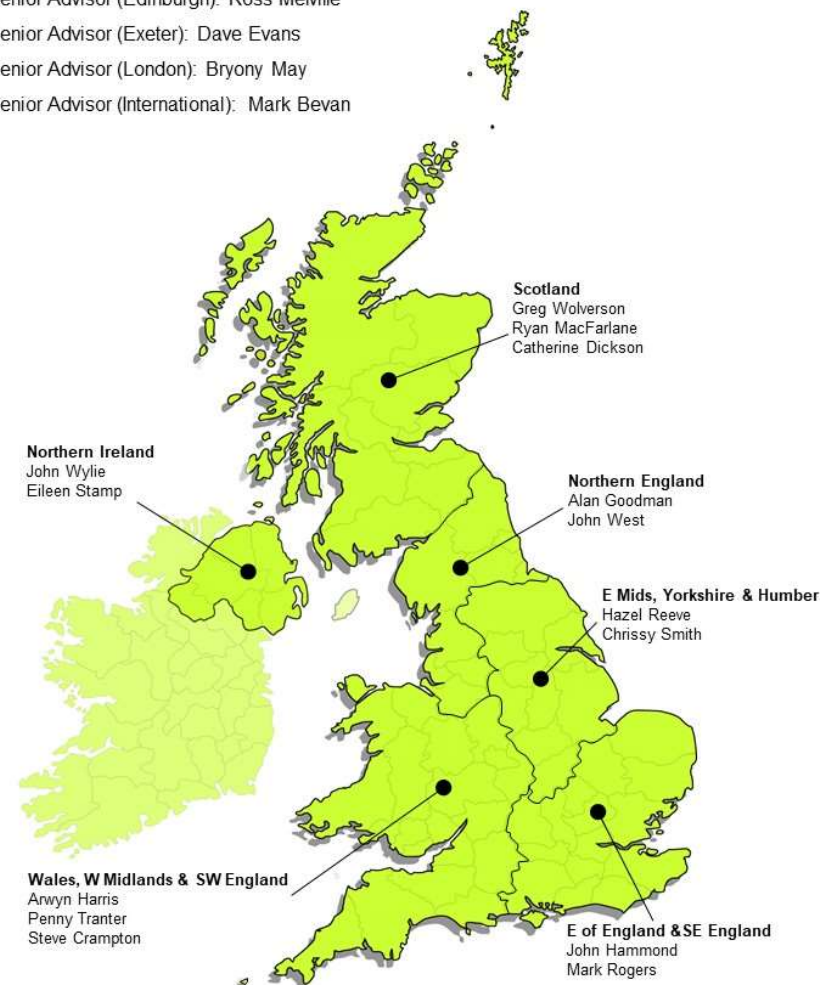
Head of Civil Contingencies: Will Lang

Senior Advisor (Edinburgh): Ross Melville

Senior Advisor (Exeter): Dave Evans

Senior Advisor (London): Bryony May

Senior Advisor (International): Mark Bevan



Content

- Introduction – UK Weather, what is severe?
- National Severe Weather Warning Service
 - why did we develop an impact based warning service?
 - development of the service (2009-2011)
 - current service
 - *Warnings Content*
 - *communicating the information*
 - *the Advisor service*
 - updating the service
- Questions

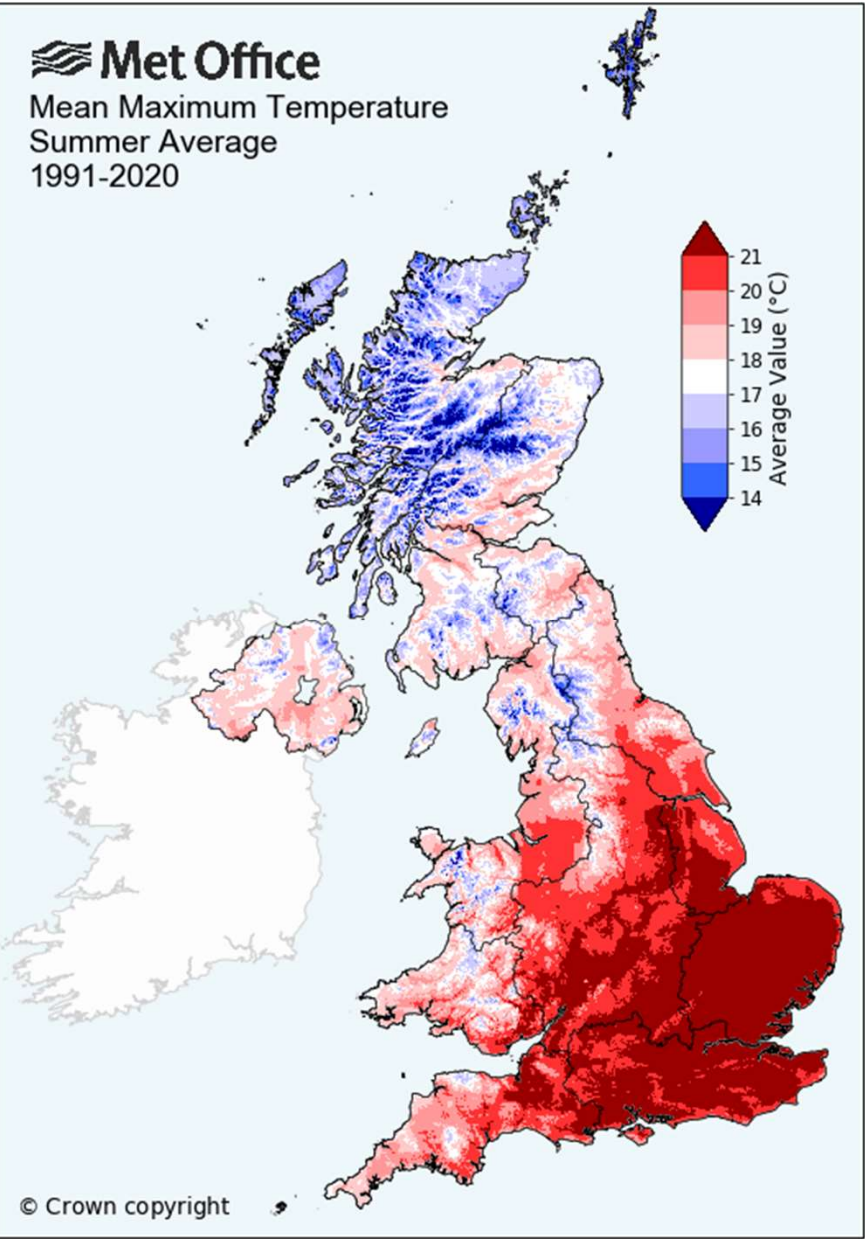


Weather in the UK



Met Office

Mean Maximum Temperature
Summer Average
1991-2020

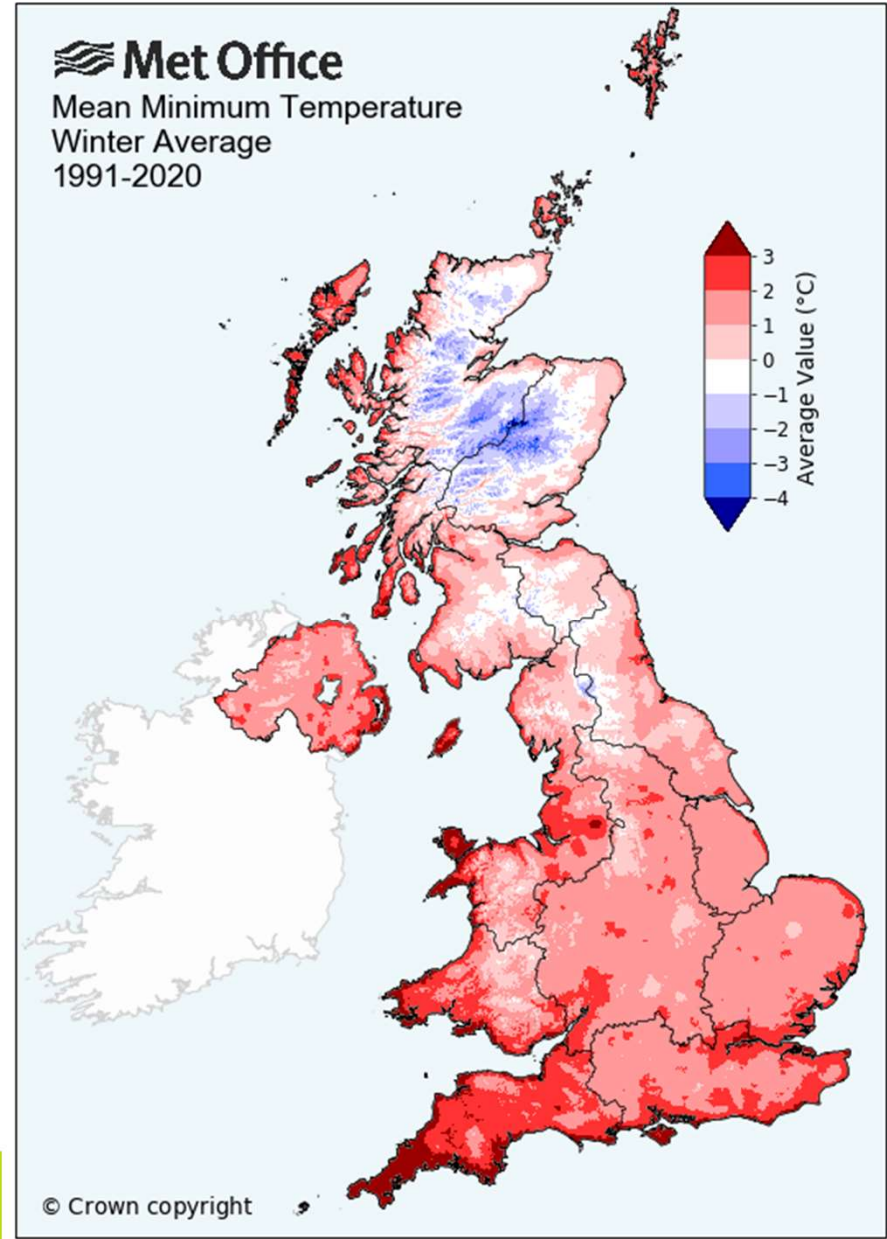


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Weather in the UK

Met Office

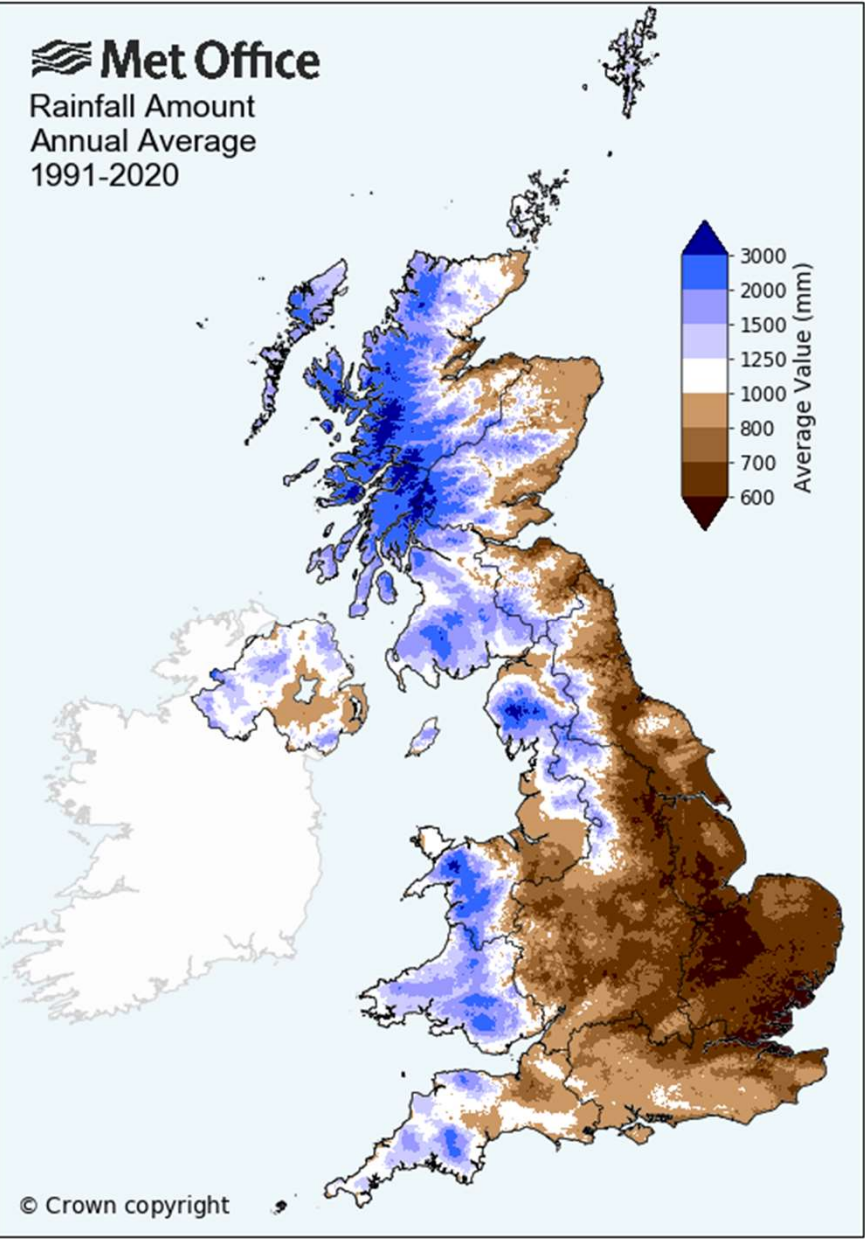
Mean Minimum Temperature
Winter Average
1991-2020



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Met Office

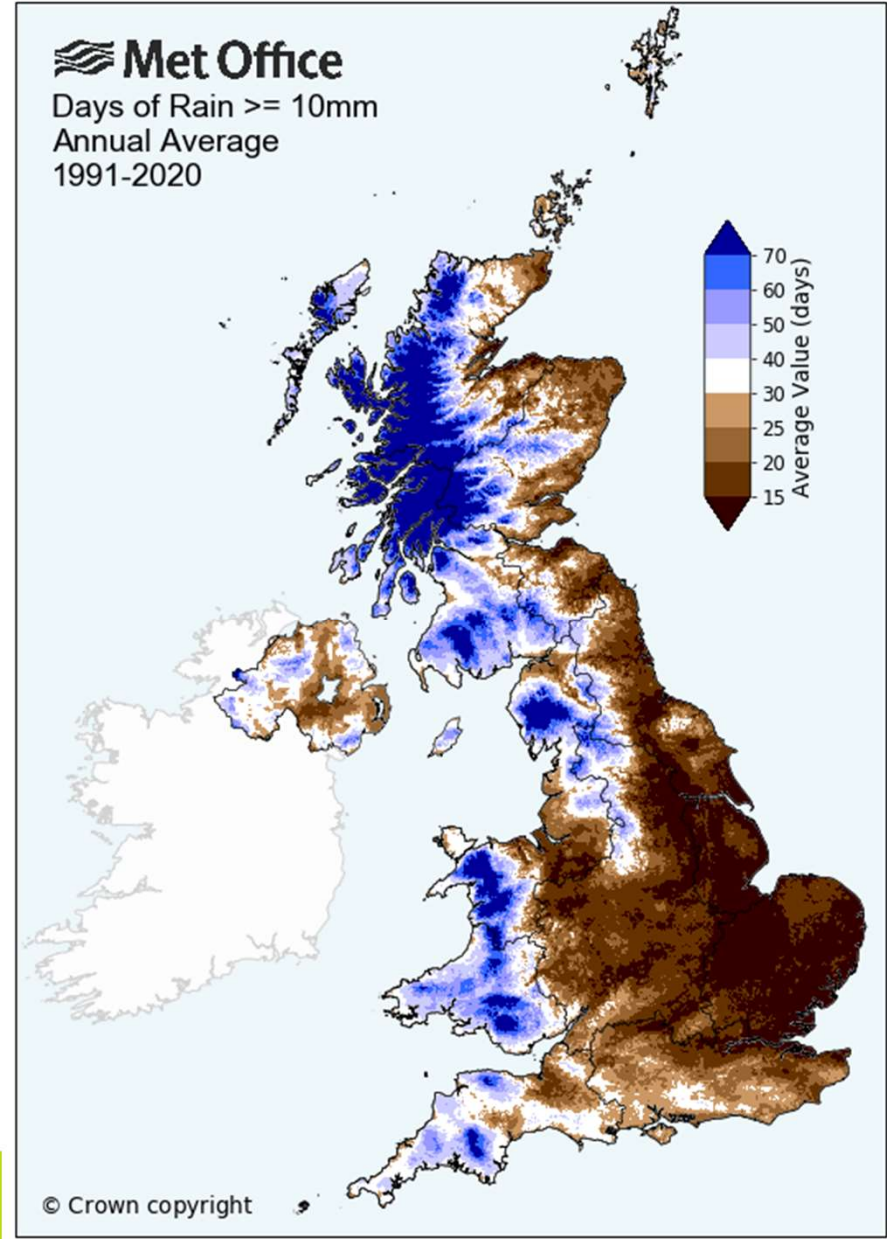
Rainfall Amount
Annual Average
1991-2020



Weather in the UK

Met Office

Days of Rain \geq 10mm
Annual Average
1991-2020



UK Weather Extremes

Highest daily maximum temperature records

| Country | Temperature (°C) | Date | Location |
|------------------|------------------|---------------|------------------------------|
| England | 38.7 | 25 July 2019 | Cambridge Botanic Garden |
| Wales | 35.2 | 2 August 1990 | Hawarden Bridge (Flintshire) |
| Scotland | 32.9 | 9 August 2003 | Greycrook (Scottish Borders) |
| Northern Ireland | 31.3 | 21 July 2021 | Castleberg (County Tyrone) |

Lowest daily minimum temperature records

| Country | Temperature (°C) | Date | Location |
|------------------|------------------|------------------|----------------------------|
| Scotland | -27.2 | 10 January 1982 | Braemar (Aberdeenshire) |
| Scotland | -27.2 | 11 February 1895 | Braemar (Aberdeenshire) |
| Scotland | -27.2 | 30 December 1995 | Altnaharra (Highland) |
| England | -26.1 | 10 January 1982 | Newport (Shropshire) |
| Wales | -23.3 | 21 January 1940 | Rhayader (Powys) |
| Northern Ireland | -18.7 | 24 December 2010 | Castleberg (County Tyrone) |

UK Weather Extremes

Highest 24-hour rainfall totals for a rainfall day (0900-0900 UTC)

| Country | Rainfall (mm) | Date | Location |
|------------------|---------------|------------------|--------------------------------------|
| England | 279 | 18 July 1955 | Martinstown (Dorset) |
| Northern Ireland | 159 | 31 October 1968 | Tollymore Forest (County Down) |
| Scotland | 238 | 17 January 1974 | Sloy Main Adit (Argyll & Bute) |
| Wales | 211 | 11 November 1929 | Lluest Wen Reservoir (Mid Glamorgan) |

The highest 24-hour total for any 24-hour period is 341.4 mm from 1800 UTC on 4th to 1800 UTC on 5th December 2015 at Honister Pass (Cumbria).

Highest gust speed records - by country (low-level sites)

| Country | Speed | Date | Location |
|------------------|---------------------|------------------|-------------------------------------|
| Northern Ireland | 108 knots / 124 mph | 12 January 1974 | Kilkeel (County Down) |
| England | 106 knots / 122 mph | 18 February 2022 | Needles Old Battery (Isle of Wight) |
| Scotland | 123 knots / 142 mph | 13 February 1989 | Fraserburgh (Aberdeenshire) |
| Wales | 108 knots / 124 mph | 28 October 1989 | Rhoose (Vale of Glamorgan) |

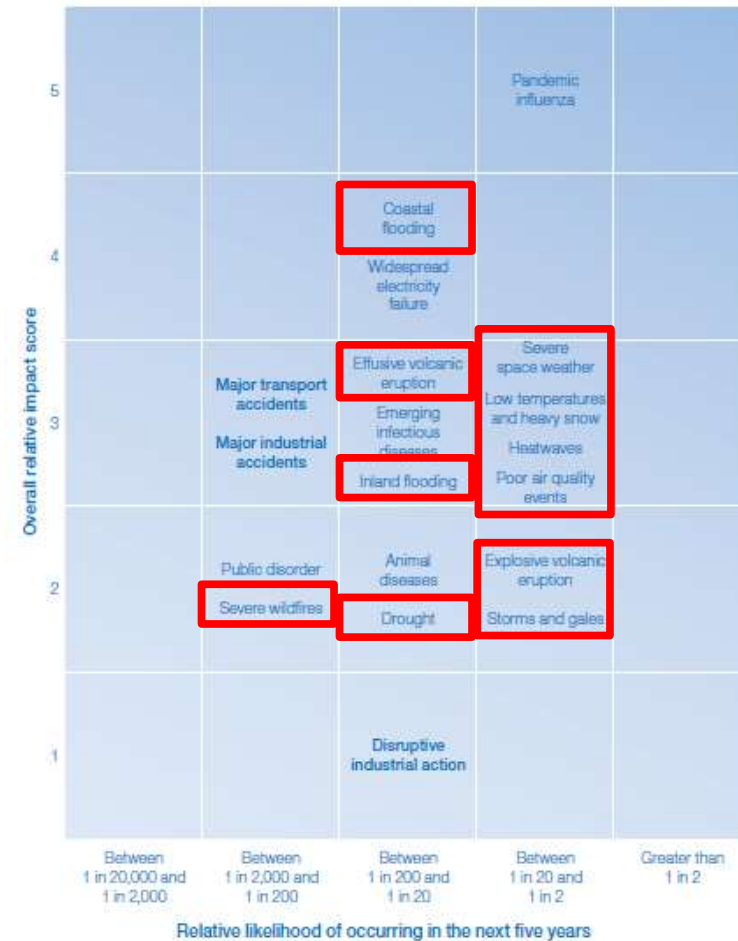
The highest gust speed from a high level site is 150 knots (173 mph) at Cairngorm Summit (1,245 metres AMSL) on 20 March 1986.



National Risk Assessment

Natural risks:

- Storms and gales
- Low temperatures and heavy snow
- Heat waves
- Drought
- Severe Wildfires
- Flooding (Coastal or Inland)
- Volcanic Eruptions
- Poor Air Quality
- Space Weather



The UK's **National Severe Weather Warning Service** (NSWWS)

History of NSWWS

1987 - Michael Fish's 'Hurricane' - 18 deaths, 15 million trees lost, hundreds of thousands of homes without power.

1988 - Government funded, meteorologically determined threshold based warning service begins



The original NSWWS 1988-2011

Severe gales/storms

Blizzards/drifts

Freezing rain/glazed frost/widespread icy roads

Heavy snow

Heavy rain

Widespread Dense Fog

Early warnings Issued when the forecaster had confidence that there would be “disruption” due to severe weather in the next 5 days.

Flash warnings When the forecaster had 80% or more confidence that there would be severe weather in the next few hours (up to 24 hours).

Emergency Flash Warnings These were issued with up to 24 hours notice (but usually much less than this) when extreme conditions were expected .

Motoring Unit Warnings There was a lower tier of warning aimed specifically at motorists. These gave warnings of rain, heavy enough to give spray and standing water, fog (visibility less than 200m), widespread ice, snow and wind.

The original NSWWS 1988-2011

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TOO COMPLICATED!

2009 – research undertaken into how to improve the warnings service:

- 12 public focus groups
- 7 responder workshops
- Media meetings

**‘Warning categories are too complex.
Needs to be simplified’**

**‘Weather warnings should only be
issued if severe weather is expected to
have an impact’**

2011 - Impact based NSWWS launched



So what is NSWWS?

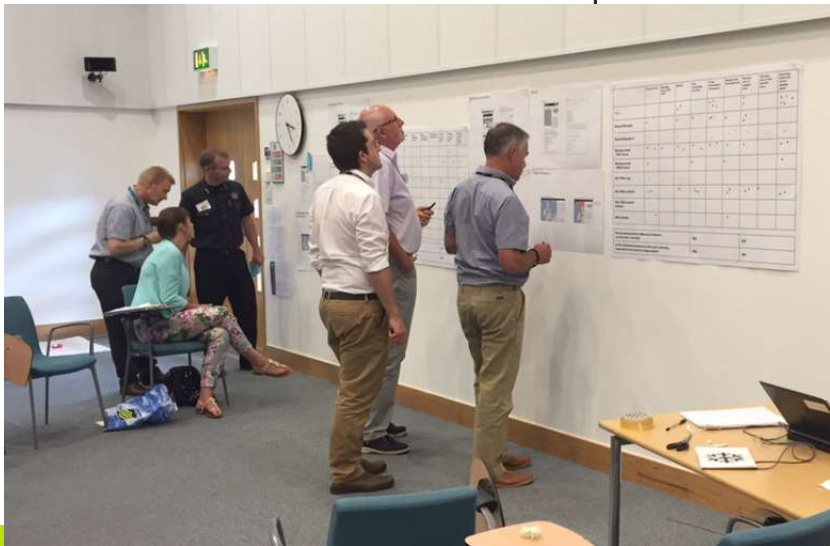
| | | | | | |
|------------|----------|----------|-----|--------|------|
| Likelihood | High | | | | |
| | Medium | | | ✓ | |
| | Low | | | | |
| | Very low | | | | |
| | | Very low | Low | Medium | High |
| Impact | | | | | |

- Impact based warnings service – providing warnings of **Rain, Wind, Snow, Ice, Fog, (Thunderstorm, Lightning and Heat added later)**
- Forecast provides an **Expected Level of Impact** and a **Likelihood of this Impact occurring** - from this we define a 'colour' to attach to the warning (Yellow, Amber or Red)
- **Thresholds** (for example 50 mm of rain in 12 hours) are **no longer used** to trigger warnings, but may form part of the decision process

Understanding Impacts

Emergency responders defined the levels of impact – ensures impacts in the warnings match their perceptions and pressures.

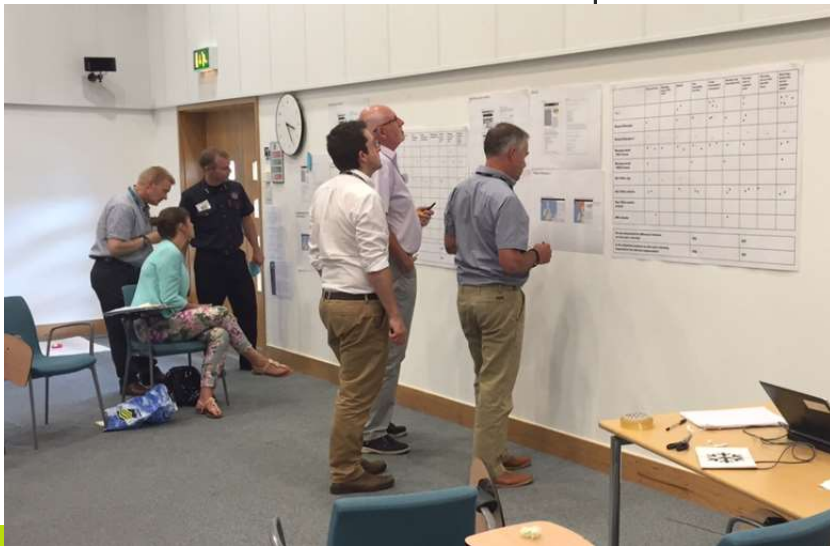
| Impact Levels for All Weather Types | | | |
|---|--|--|---|
| Very Low | Low | Medium | High |
| <p>On the whole, day to day activities not affected but some localised, small scale impacts occur</p> <p>A few transport routes affected.</p> | <p>Some short lived disruption to day to day routines in affected areas</p> <p>Incidents dealt with under 'business as usual' response by emergency services</p> <p>Some transport routes and travel services affected. Some journeys require longer travel times.</p> | <p>Injuries with danger to life</p> <p>Disruption to day to day routines and activities.</p> <p>Short-term strain on emergency responder organisations.</p> <p>Transport routes and travel services affected. Longer journey times expected. Some vehicles and passengers stranded.</p> <p>Disruption to some utilities and services.</p> <p>Damage to buildings and property.</p> | <p>Danger to life</p> <p>Prolonged disruption to day to day routines and activities</p> <p>Prolonged strain on emergency responders organisations.</p> <p>Transport routes and travel services affected for a prolonged period. Long travel delays. Vehicles and passengers stranded for long periods.</p> <p>Disruption to utilities and services for a prolonged period.</p> <p>Extensive damage to buildings and property.</p> |



Understanding Impacts

Emergency responders defined the levels of impact – ensures impacts in the warnings match their perceptions and pressures.

| Impact Levels for All Weather Types | | | |
|---|--|--|---|
| Very Low | Low | Medium | High |
| <p>On the whole, day to day activities not affected but</p> <p>'NORMAL WEATHER'</p> <p>affected.</p> | <p>Some short lived disruption to day to day</p> <p>'BUSY DAY'</p> <p>incidents dealt with under 'business as usual' response by emergency services</p> <p>Some transport routes and travel services affected. Some journeys require longer travel times.</p> | <p>Injuries with danger to life</p> <p>SHORT TERM STRAIN ON EMERGENCY SERVICES</p> <p>Transport routes and travel services affected. Longer journey times expected. Some vehicles and passengers stranded.</p> <p>Disruption to some utilities and services.</p> <p>Damage to buildings and property.</p> | <p>Danger to life</p> <p>PROLONGED STRAIN ON EMERGENCY SERVICES</p> <p>Transport routes and travel services affected for a prolonged period. Long travel delays. Vehicles and passengers stranded for long periods.</p> <p>Disruption to utilities and services for a prolonged period.</p> <p>Extensive damage to buildings and property.</p> |





Assessing the Risk

Location

Rural



Urban



Coastal





Assessing the Risk

Current
conditions





Assessing the Risk

Time of year



Assessing the Risk

Time of day / day of week



The Process

GATHER INTELLIGENCE

Forecast of 'severe weather'

Consult Civil Contingencies Advisors

Seek information from emergency responders & partner organisations

- Some questions to consider
- Forecast uncertainty?
- Impact uncertainty?
- Intensity of weather?
- Time of day?
- Time of year?
- Location? Rural or urban?
- What is 'normal' for the area?
- Local vulnerabilities?
- Recent conditions?

| | | | | | |
|------------|----------|----------|-----|--------|------|
| Likelihood | High | | ? | | ? |
| | Medium | | | ? | |
| | Low | | | | ? |
| | Very low | | | ? | |
| | | Very low | Low | Medium | High |
| Impact | | | | | |

Review Warning

Finalise and issue (or update) warning

Monitor weather / forecast & impacts

| | | | | | |
|------------|----------|----------|-----|--------|------|
| Likelihood | High | | | | |
| | Medium | | | | |
| | Low | | | ✓ | |
| | Very low | | | | |
| | | Very low | Low | Medium | High |
| Impact | | | | | |

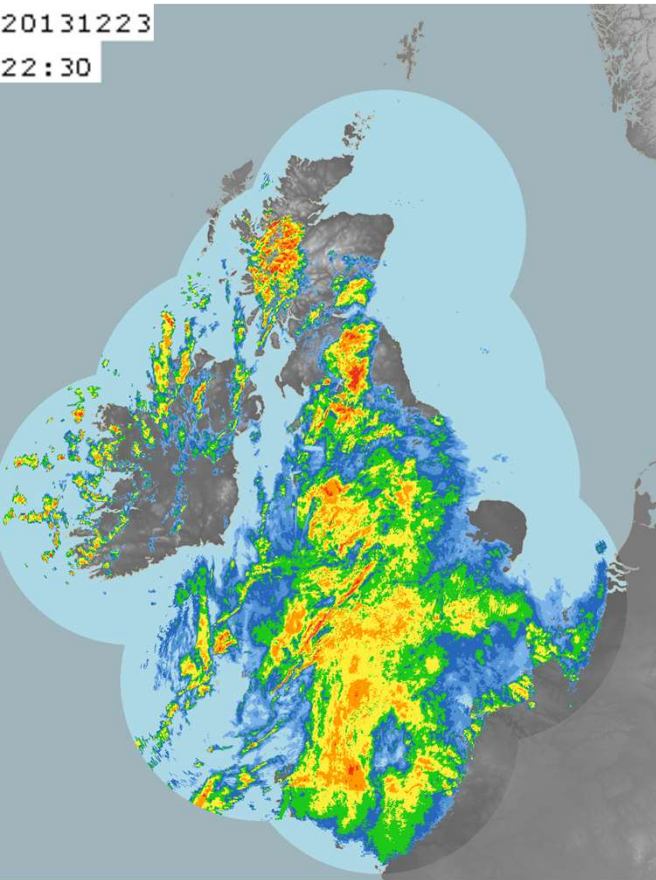
ISSUE

EVALUATE & UPDATE

- Some questions to consider
- Are the impacts as expected?
- Are the timings as expected?
- Are impacts within the warning area?

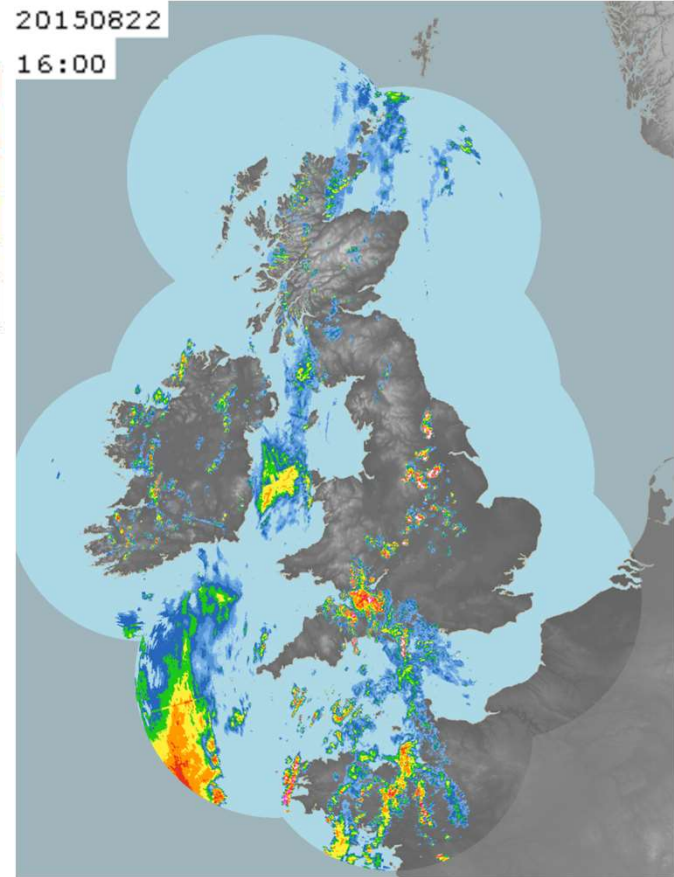
| | | | | | |
|------------|----------|----------|-----|--------|------|
| Likelihood | High | | | ? | |
| | Medium | | | ? | |
| | Low | | | ✓ | |
| | Very low | | | | |
| | | Very low | Low | Medium | High |
| Impact | | | | | |

What is the message?



Isolated medium impacts 20150822

| | | | | | |
|------------|----------|----------|-----|--------|------|
| Likelihood | High | | | | |
| | Medium | | | | |
| | Low | | | ✓ | |
| | Very low | | | | |
| | | Very low | Low | Medium | High |
| Impact | | | | | |



Convective



Dynamic



| | | | | | |
|------------|----------|----------|-----|--------|------|
| Likelihood | High | | | | |
| | Medium | | ✓ | | |
| | Low | | | | |
| | Very low | | | | |
| | | Very low | Low | Medium | High |
| Impact | | | | | |

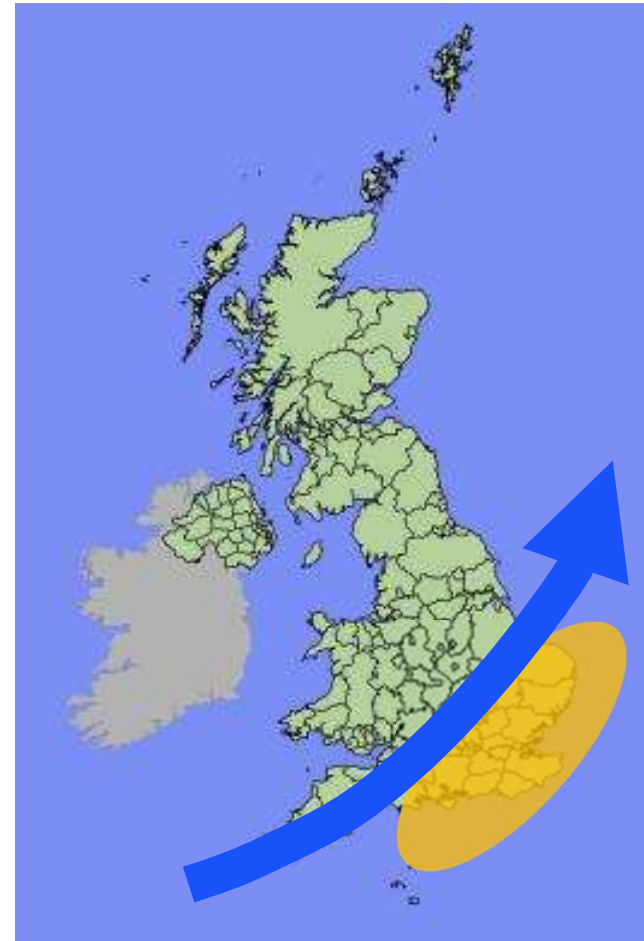
Widespread low impacts



Dealing with uncertainty - example

Here the model is suggesting that the track of the low pressure will be across central Southern England with the strongest winds across SE England.

| | | | | | |
|------------|----------|----------|--------|--------|--------|
| Likelihood | High | Green | Yellow | Orange | Red |
| | Medium | Green | Yellow | Orange | Red |
| | Low | Green | Green | Yellow | Orange |
| | Very low | Green | Green | Yellow | Yellow |
| | | Very low | Low | Medium | High |
| | Impact | | | | |

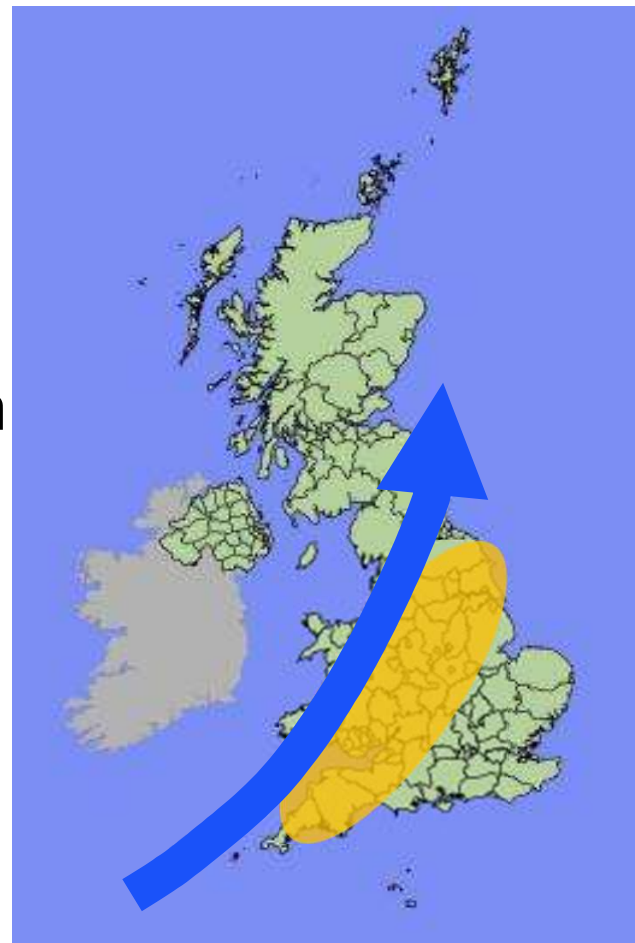




Dealing with uncertainty - example

However, this model is suggesting a track further northwest across Wales and northern England with the strongest winds across western and into northern England.

| | | | | | |
|------------|----------|----------|--------|-----------------------|--------|
| Likelihood | High | Green | Yellow | Orange | Red |
| | Medium | Green | Yellow | Orange with checkmark | Red |
| | Low | Green | Green | Yellow | Orange |
| | Very low | Green | Green | Yellow | Yellow |
| | | Very low | Low | Medium | High |
| | | Impact | | | |

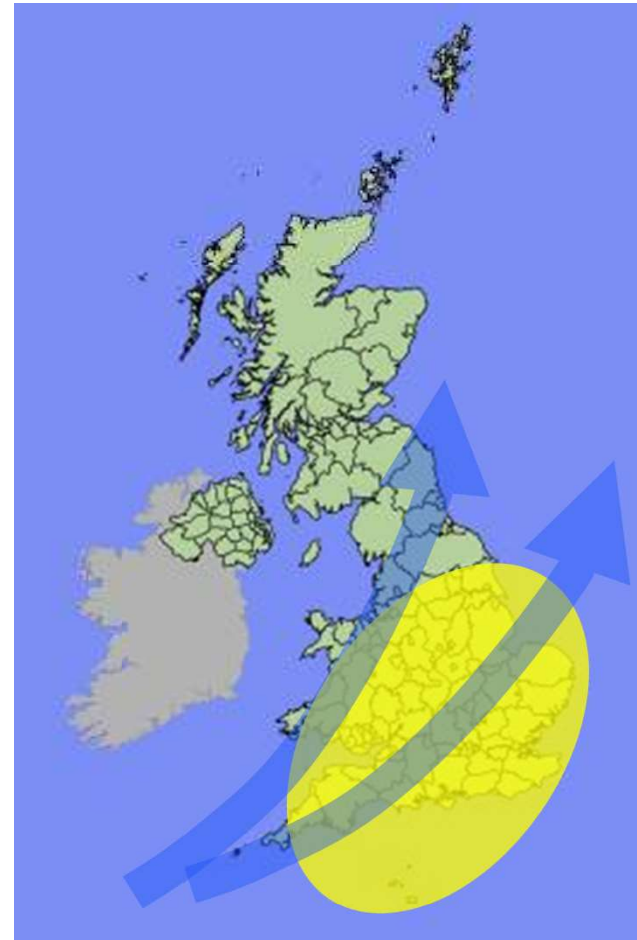




Dealing with uncertainty - example

Due to the uncertainty around the track a larger area may be covered by the warning with a lower likelihood.

| | | | | | |
|------------|----------|----------|--------|-----------------------|--------|
| Likelihood | High | Green | Yellow | Orange | Red |
| | Medium | Green | Yellow | Orange | Orange |
| | Low | Green | Green | Yellow with checkmark | Orange |
| | Very low | Green | Green | Yellow | Yellow |
| | | Very low | Low | Medium | High |
| | | Impact | | | |



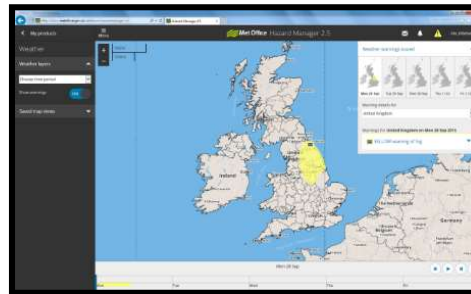


Where do the warnings go?

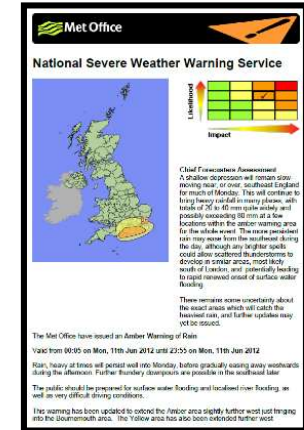
Television and Radio



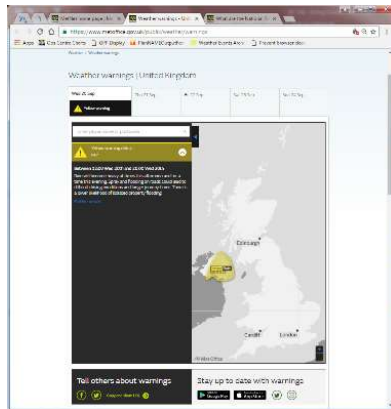
Hazard Manager web service for responders



Email



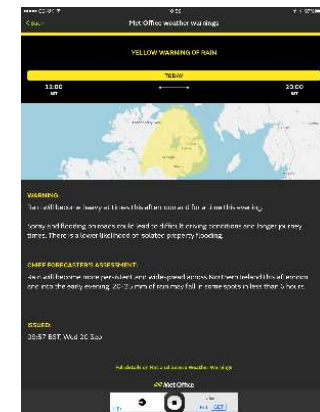
Public Website



Social Media



Mobile App



Video for responders

<https://youtu.be/3LPC-qDdl7M>

Does it work? – Verification of individual Warnings

All Amber and Red warnings are subjectively verified after the event.

Assess the warning in terms of: Impact Level (0-3)
Impact Timings (0-3)
Impact Location (0-3)

Impact information sought from: Responders
Media Reports
Social Media

Verification carried out internally then subject to external audit – rolling two year average.

Target of 72% of warnings scoring 6 or more (rising to 80% by 2020), with less than 20% scoring 3 or fewer.

Does it work? - Feedback

Feedback is regularly sought from both Emergency Responders and the Public



Responders surveyed every two years.
Met Office Advisors attend debriefs after
severe events



Public surveyed by telephone after
Amber or Red Warnings are issued

Does it work? - Feedback

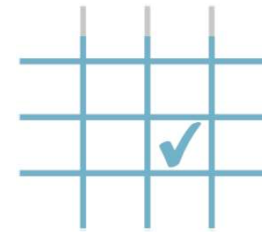
2017 survey of Emergency Responders – 1377 responders interviewed.



92% of Responders are satisfied with NSWWS



82% feel they get about the right number of warnings



86% say they use the weather impact matrix

Does it work? - Feedback

2017 survey of Emergency Responders – 1377 responders interviewed.

To what extent are you confident or not in your ability to use the National Severe Weather Warning Service weather impact matrix to assist you in making decisions?



Does it work? - Feedback

25% of responders made suggestions for improvements

I appreciate this is difficult but I feel there are **too many yellow warnings** which can neutralise the impact of the service. However, by their nature these will be more frequent..... Perhaps consider yellows as alerts or risk awareness raising whereas continue to provide warnings for amber or red scenarios.

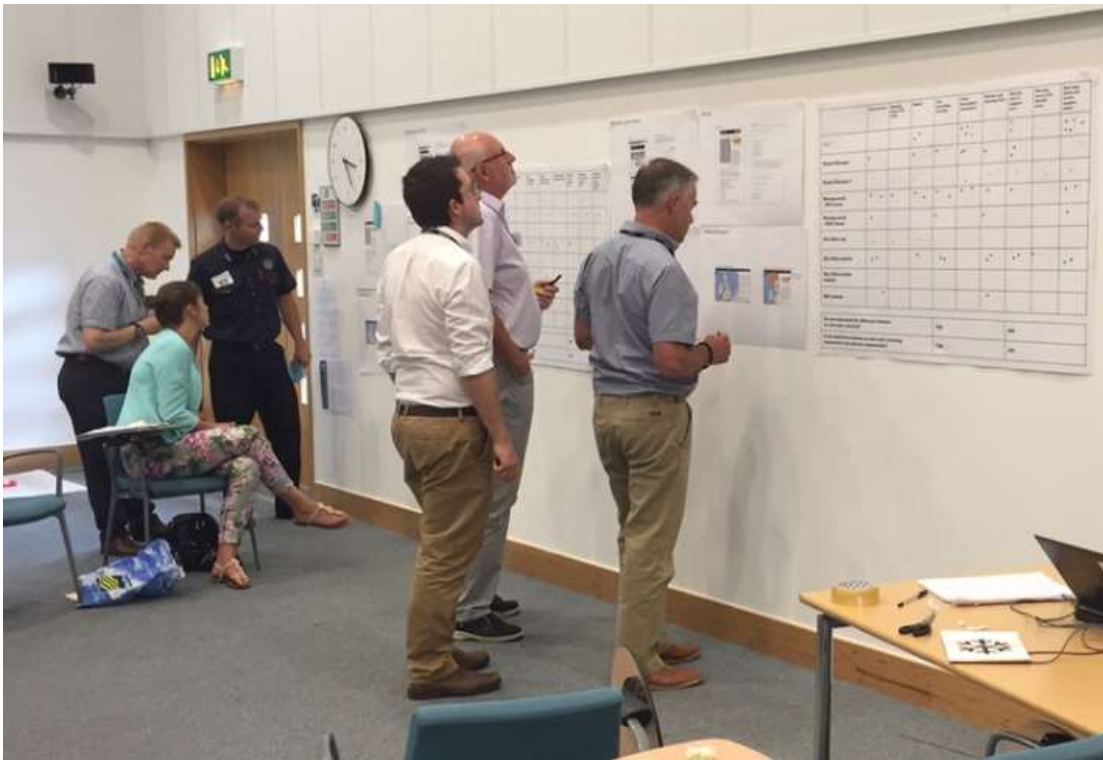
Make the **access** to the systems using a tablet easier, at the moment there seems to be **limited functionality** using a tablet or smart phone. Perhaps an app would be of benefit?

Fewer warnings. Seem to get far too many warnings when there is high wind or rain which is just normal winter weather.

If there was a way of making it **more regional** as the emails cover national information and I only need to see information relevant to my region.

Be more **locally specific**. This is why I usually wait for the Civil Contingencies Advisor to send it, rather than actively find and read it

2015 responder workshops



Ad-hoc public surveys post event



Warning overview

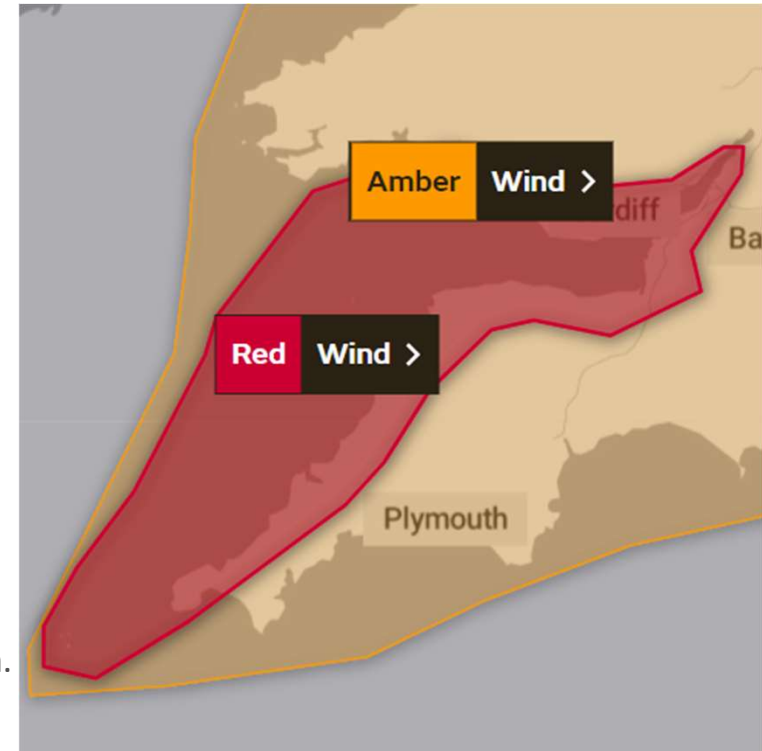
On Thursday the 17th of February a Red warning for wind associated with Storm Eunice was given from 07:00 until 12:00 on Friday 18th February.

The English local authorities covered were:

- Bristol, Cornwall, Forest of Dean, North Devon, North Somerset, Sedgemoor, South Gloucestershire, & Torridge.

The Welsh local authorities covered were:

- Bridgend, Caerphilly, Cardiff, Carmarthenshire, Monmouthshire, Neath Port Talbot, Newport, Rhondda Cynon Taf, Swansea, & Vale of Glamorgan.

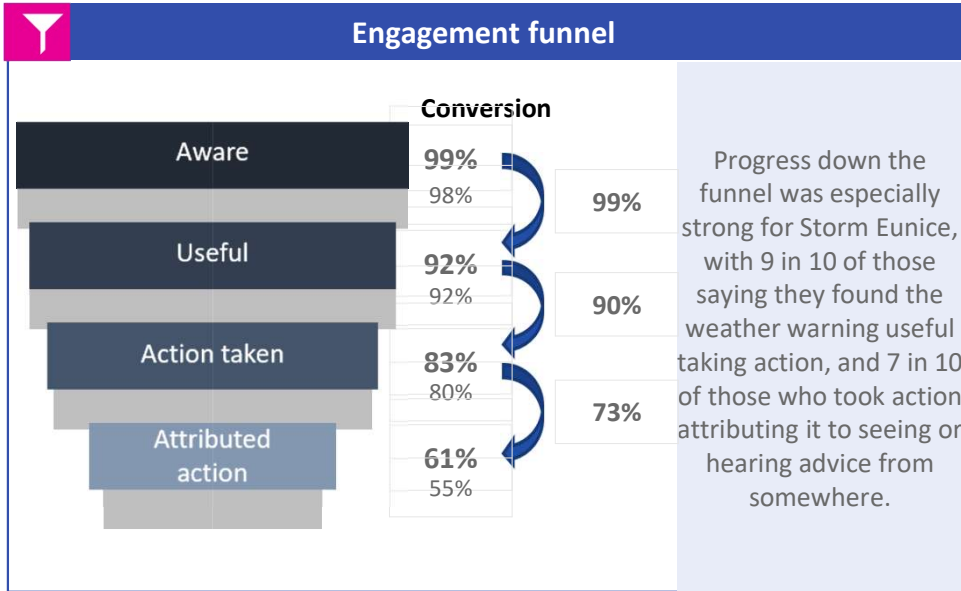


Storm 'EUNICE'

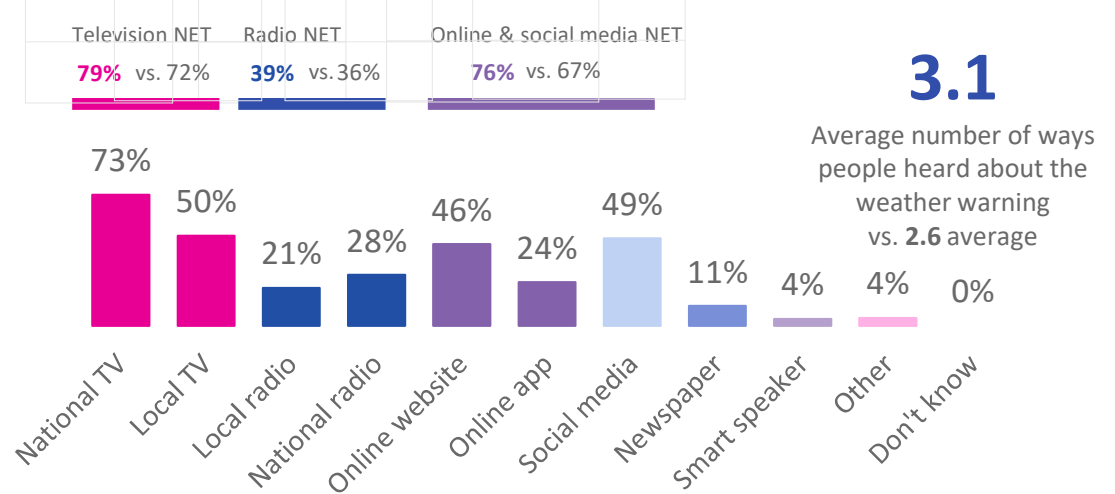
- Four deaths in the UK
- Winds reaching 106 knots
- Over a million properties without power, some for a number of days
- Major road and railway disruption
- Large coastal waves



Executive summary: Engagement & Key Observations

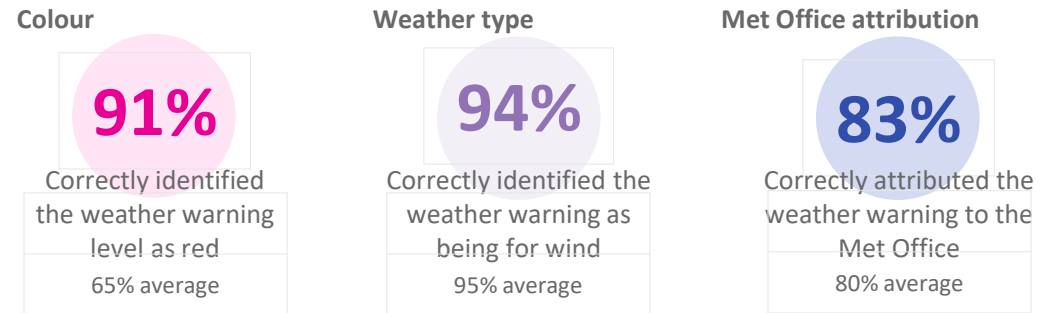


Where people saw it

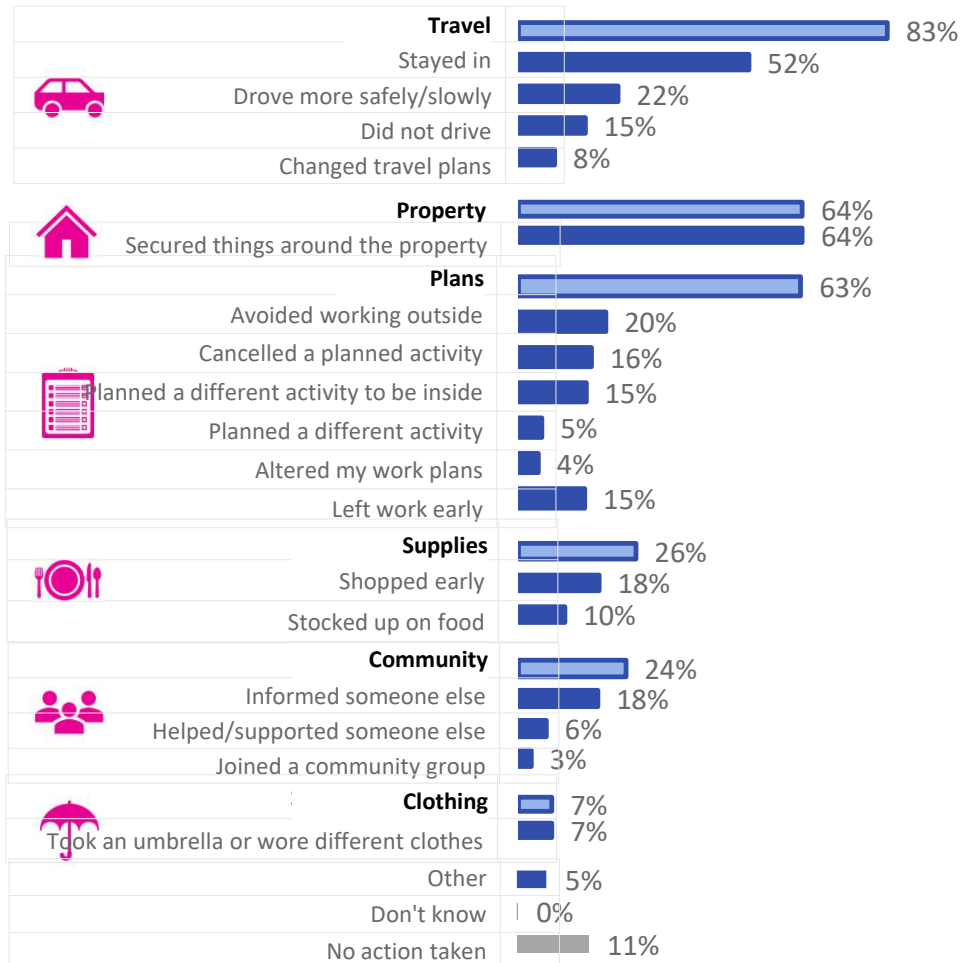


- ### Key observations
- Storm Eunice received widespread media coverage and was named quite early in advance. This led people hearing about the warning from a higher than average number of sources (3.1 vs. 2.6).
 - People were also more aware than usual of the particulars of the weather warning, such as the colour and the name of the storm. Just under 9 in 10 also took action in some form, with the highest action being to secure things around the property, followed by staying in.

Awareness of details



Almost 9 in 10 took action



89%

Of those who saw a weather warning took action

86% average



Analysis

Those aged 16-34 were more likely to have:

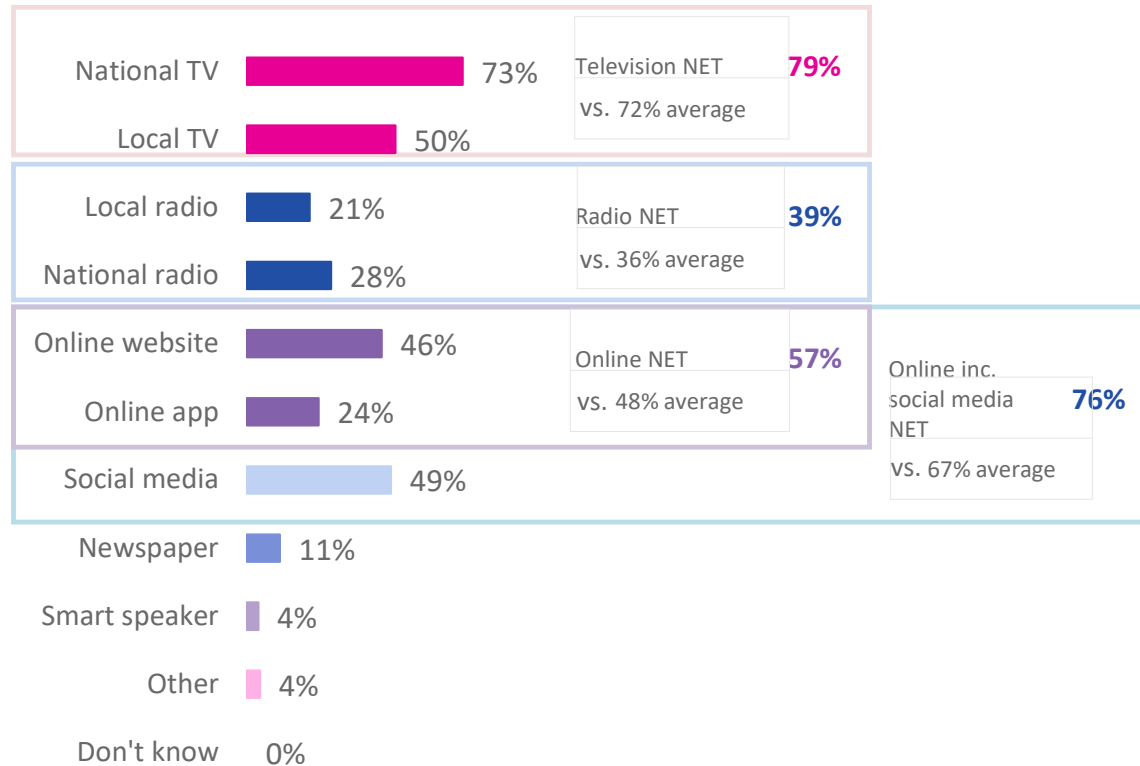
- Altered workplans
- Joined a community group
- Stocked up on food
- Taken an umbrella or wore different clothes

Those with children were more likely to have:

- Drove more safely/slowly
- Changed plans
- Undertaken a community focused activity

Different ages saw high variation in how they saw or heard about the weather warning

Where saw or heard about severe weather warning

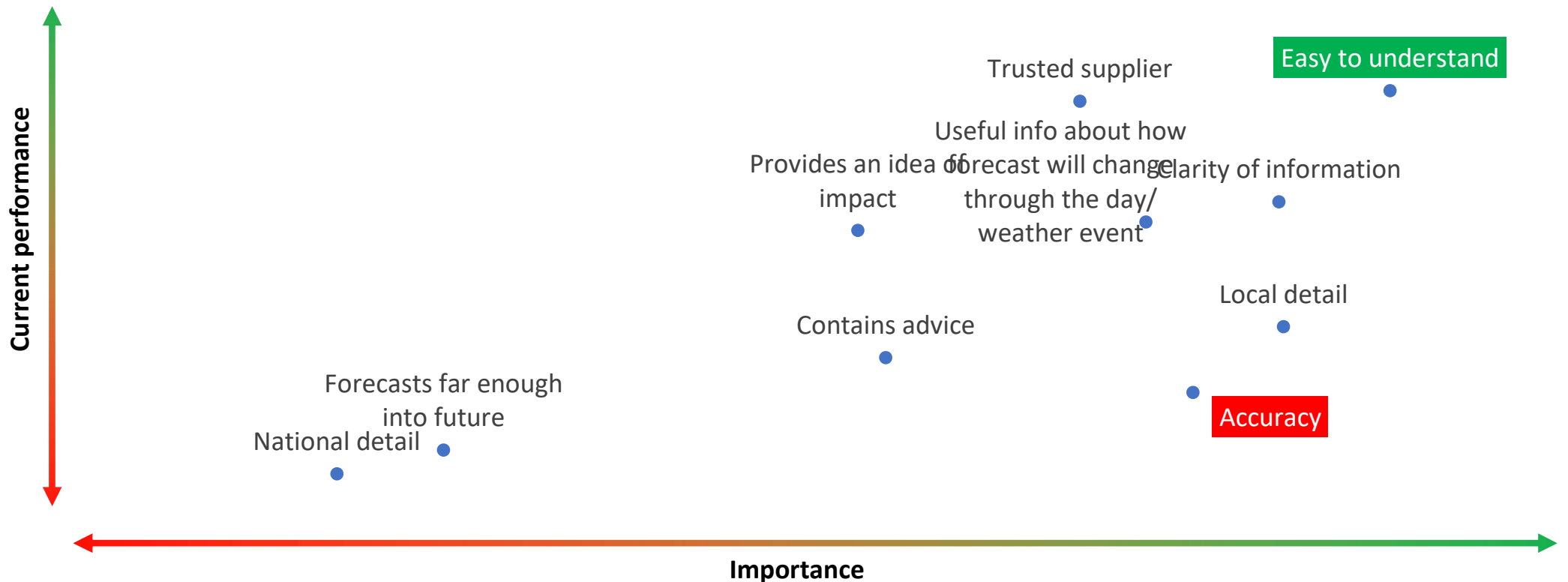


...
Analysis

- Those aged 55+ were significantly more likely to have found out about the weather warning from national TV (84%) or local TV (64%).
- Those aged 16-34 are significantly more likely to have found out about the weather warning from social media (66%).
- BAME respondents were also significantly more likely to have found out about the weather warning from social media (71%).
- Those in rented accommodation were significantly less likely to have heard about the weather warning on local radio (20%).
- Those who didn't take action were significantly more likely to have seen the weather warning in a newspaper (28%).

Ease of understanding is both seen as the most important aspect of weather warnings – and the current best performing

Weather warning priority matrix



Q09c. Please can you tell us how important or unimportant each of the following elements of a National Severe Weather Warning are?

Base: All respondents 518

Q09d. Thinking of where you last saw or heard a Severe Weather Warning, please can you tell us how well you feel the following elements of the National Severe Weather Warning are delivered? Base: All who saw weather warning 518

NSWWS – ‘Next Generation’

Research in 2015 led to:

- Extending the maximum warning lead time from 5 days to 7 days (in response to improved modelling and forecast capability)
- Add two new weather types to the scope of NSWWS – ‘Thunderstorm’ and ‘Lightning’
- Remove Weather Icons – use words to prevent misinterpretation
- Reduce meteorological jargon and emphasise impacts – use plain language
- Improve presentation of warnings – clarify overlapped areas during complex situations
- Improve communication in short lead time situations

Summer 2021

- Addition of ‘Extreme Heat’ as a weather type.

Addition of ‘Thunderstorm’ and ‘Lightning’ Warnings

Improve communication of severe convection – previously only option was to issue a ‘Rain’ warning.

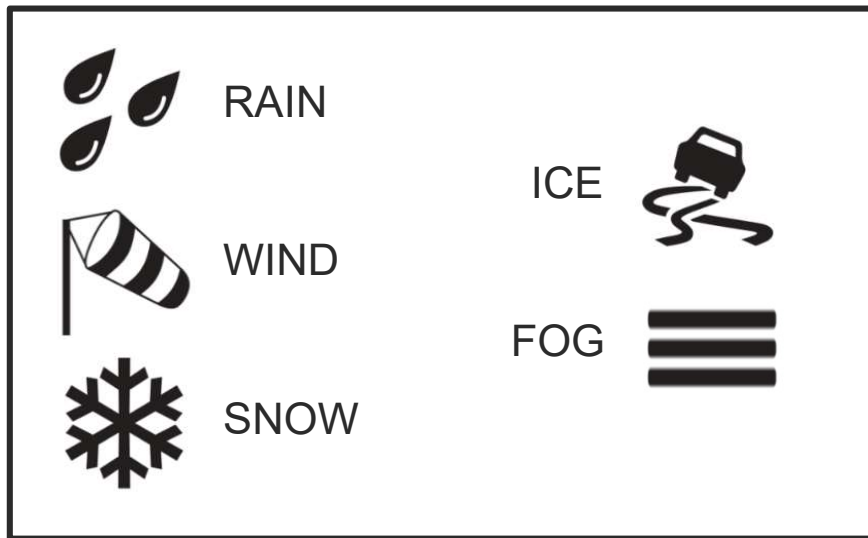
Public testing showed that ‘Thunderstorm’ was understood as a combination of Heavy Rain, Strong Winds, Hail and Lightning

So...

Thunderstorm warning – to be used when all thunderstorm hazards are present

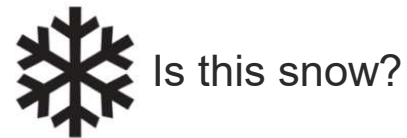
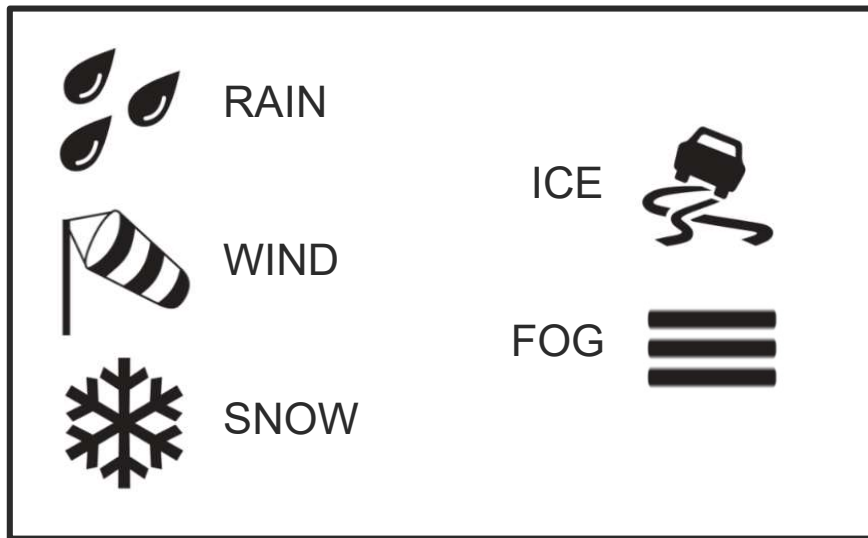
Lightning warning – for use when precipitation / wind is not expected to be a problem – for example elevated instability where lightning impacts on power networks are the main concern.

Remove Weather Icons – use words to prevent misinterpretation

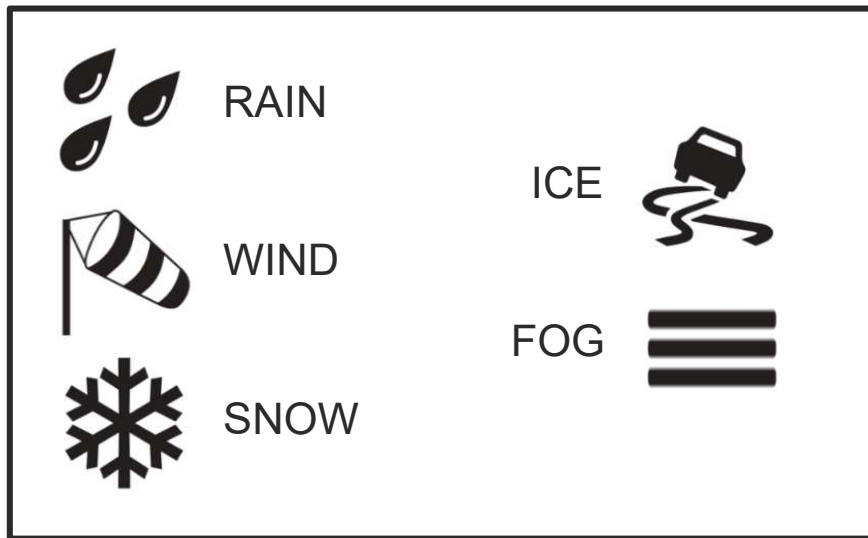


Public research showed that the audience did not always identify the weather type correctly from icons alone

Remove Weather Icons – use words to prevent misinterpretation



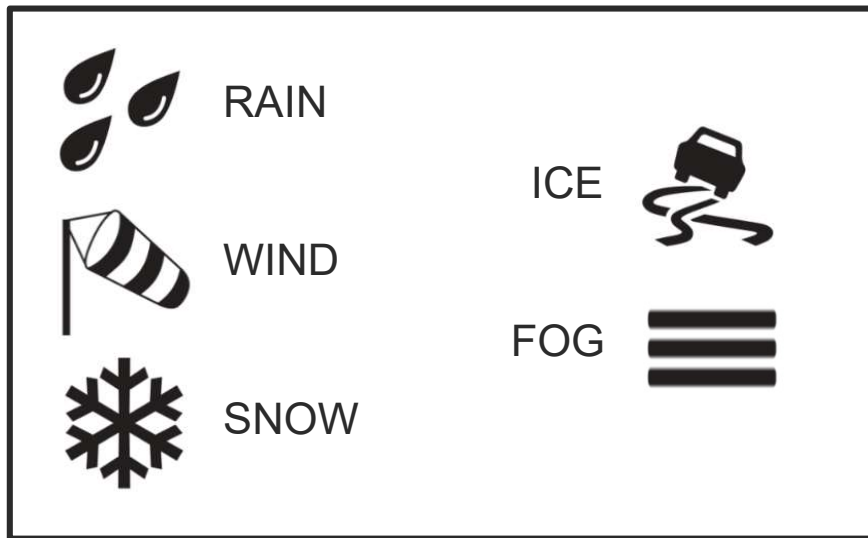
Remove Weather Icons – use words to prevent misinterpretation




Or ice? 

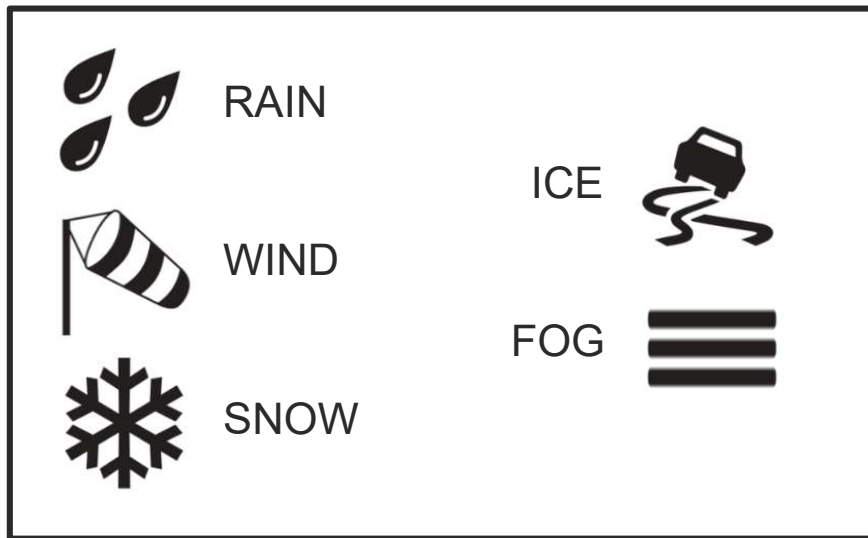


Remove Weather Icons – use words to prevent misinterpretation



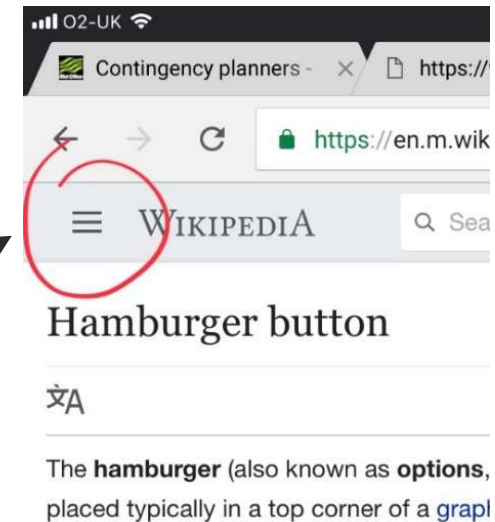
 Is this fog?

Remove Weather Icons – use words to prevent misinterpretation

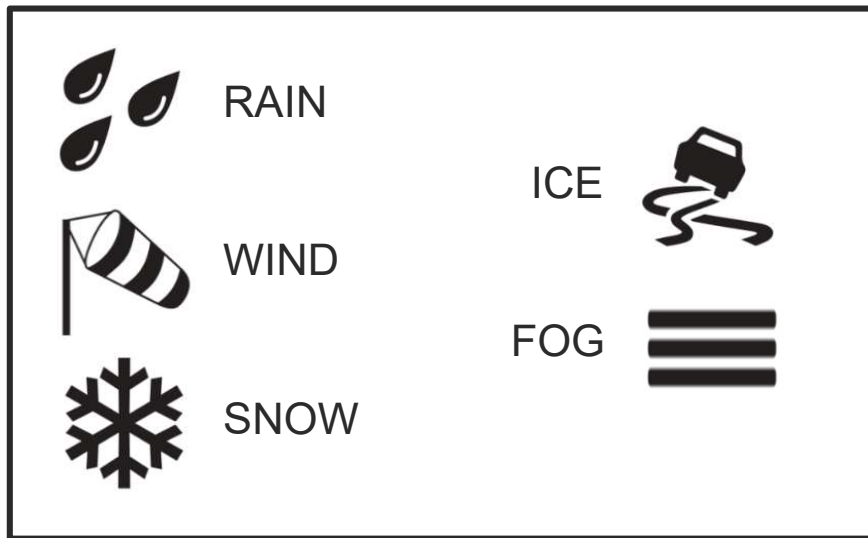


Is this fog?

Or a menu button?



Remove Weather Icons – use words to prevent misinterpretation



Icons are being replaced with plain text

RAIN

THUNDERSTORM

SNOW

ICE


LIGHTNING

FOG

Improve presentation of warnings

Met Office Weather Warning Overview: United Kingdom
Issued on Thu 12 Jan

Thu 12 Jan



Thu 12 Jan

Fri 13 Jan

Sat 14 Jan









Sun 15 Jan

Mon 16 Jan

Use the small maps above to select the weather warnings over the next five days. Click on your chosen region below for more details of current warnings in force.

| | | | |
|--|--|--|--|
| United Kingdom | | North West England | |
| Orkney & Shetland | | North East England | |
| Highlands & Eilean Siar | | Yorkshire & Humber | |
| Grampian | | West Midlands | |
| Strathclyde | | East Midlands | |
| Central, Tayside & Fife | | East of England | |
| Dumfries, Galloway, Lothian & Borders | | South West England | |
| Northern Ireland | | London & South East England | |
| Wales | | | |

Warnings:

| | | | | | | | |
|---|---|---|--|--|--|---|---|
|  Be aware |  Be prepared |  Take action |  Rain |  Wind |  Snow |  Ice |  Fog |
|---|---|---|--|--|--|---|---|

The Met Office has responsibility for providing weather warnings for the UK.

Coloured regions on the map show where severe weather warnings have been issued. When issued, the public are advised to take extra care. Further information and advice can be found on the: [Severe weather impact links](#) page.

Improve presentation of warnings

Met Office Weather Warning Overview: United Kingdom
Issued on Thu 12 Jan

Thu 12 Jan Thu 12 Jan Fri 13 Jan Sat 14 Jan Sun 15 Jan Mon 16 Jan

Use the small maps above to select the weather warnings over the next five days. Click on your chosen region for more details of current warnings in force.

| | | | |
|---------------------------------------|-------|-----------------------------|-------|
| United Kingdom | ⚠️ ❄️ | North West England | ⚠️ ❄️ |
| Orkney & Shetland | ⚠️ ❄️ | North East England | ⚠️ ❄️ |
| Highlands & Eilean Siar | ⚠️ ❄️ | Yorkshire & Humber | ⚠️ ❄️ |
| Grampian | ⚠️ ❄️ | West Midlands | ⚠️ ❄️ |
| Strathclyde | ⚠️ ❄️ | East Midlands | ⚠️ ❄️ |
| Central, Tayside & Fife | ⚠️ ❄️ | East of England | ⚠️ ❄️ |
| Dumfries, Galloway, Lothian & Borders | ⚠️ ❄️ | South West England | ⚠️ ❄️ |
| Northern Ireland | ⚠️ ❄️ | London & South East England | ⚠️ ❄️ |
| Wales | ⚠️ ❄️ | | |

Warnings: Be aware Be prepared Take action

The Met Office has responsibility for providing weather warnings for the UK. Coloured regions on the map show where severe weather warnings have been issued. When issued, the public are advised to take extra care. Further information and advice can be found on the: [Severe weather impact links](#) page.

Weather warnings | United Kingdom

Mon 16 Oct Tue 17 Oct Wed 18 Oct Thu 19 Oct Fri 20 Oct

⚠️ Amber warning ⚠️ Yellow warning

Enter place name or postcode

⚠️ Amber warning details
Wind

Between 15:00 Mon 16th and 22:00 Mon 16th

A spell of very windy weather is expected on Monday in association with ex-Ophelia. Longer journey times and cancellations are likely, as road, rail, air and ferry services may be affected as well as some bridge closures. There is a chance that power cuts may occur, with the potential for disruption to services, such as mobile phone coverage. Damage is likely, such as tiles blown from roofs, as well as waves around coastal districts with beach material being thrown onto coastal roads, sea fronts and properties. This leads to the potential for injuries and danger to life.

Further details

⚠️ Yellow warning details
Wind

Any questions?

Mark Bevan

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