Met Office

Deeper Discovery

# Winds of Change: Weather Hazards

## Storm Ulysses (1903) to present day

# Summary

In this session, we will explore how the UK has been impacted by different weather hazards over time, comparing extreme weather events of the past with those of today. Our focus will be on a significant UK weather event that happened over 120 years ago, called Storm Ulysses (1903), using modern day forecasting technology to analyse and understand its impact. We will compare this historical storm with more recent events and discuss how modern technologies and strategies reduce the risks from weather hazards.

By examining this historical event, we'll compare how weather observations were gathered in the early 20th century with the tools we use today. You'll gain a deeper understanding of what we mean by "extreme weather" and how advancements in meteorology have transformed our ability to predict and prepare for these events. We'll also explore what management strategies are in place today to keep people safe, including early warning systems, infrastructure, and emergency response.

## Objectives

- Define and explain what extreme weather and weather hazards are.
- Compare historical and modern weather data collection methods.
- Analyse the impacts of Storm Ulysses on human activity and compare it with the effects of more recent UK storms.
- Discuss the modern technologies and strategies we use to mitigate (reduce) the risks of extreme weather and protect communities.

This lesson will help you understand not just how weather impacts our lives but also how we've adapted and improved our ability to respond to these challenges. With today's technology, could we have managed Storm Ulysses better than people did in 1903? Let's find out!

### Time required

60-150 minutes

This lesson can be divided into two or more sessions, with a suggested break included. The content is scaffolded to provide additional explanations and concepts, while teachers who are more familiar with the concepts can select specific aspects of the lesson.

### Materials required

- Internet access for research and video
- Video discussion between Professor Ed Hawkins, Dr Catherine Ross (Library and Archive Manager at the Met Office) and Climate Scientist, Daisy Harley-Nyang
- Slide show

# Activity steps

## 01 What is meant by extreme weather and weather hazards?

15 minutes

Slides 2-4

To start, **show slides 2+3** and ask the group their initial thoughts on what they understand about the phrase extreme weather. What do they define extreme weather as? Use the pictures as prompts.

Take suggestions.

Discuss with the group what features link their suggestions. It is likely that they have considered one or more of size, location, timing or extent in their definition of extreme weather.

An extreme weather event can be:

- A rare event, so something that doesn't happen very often.
- Much larger or more intense than the weather that is normal for that place/location/time of year.

According to the Intergovernmental Government Panel on Climate Change (IPCC 2018), an extreme weather event is an "event that is rare for a specific place and time," like a storm or heatwave that's way beyond the normal range of past events. This usually means it falls near the highest or lowest 10% of past weather events measured there.

**Further reading**

Events can be extreme to one system, but not another. For example, a spell of very mild weather in the winter, where the temperatures experienced are what would usually be expected in early summer, may be pleasant for many people but could cause damage to ecosystems by impacting:

- Animal hibernation patterns – animals that hibernate may wake up prematurely and, if food sources like insects or plants are still scarce, this could threaten their survival.
- Bird migration – species might misinterpret mild weather as a signal to migrate too early, exposing them to food shortages and/or predators.

- Plants – those that require a sustained cold period may break dormancy too early and begin to bud or flower. Then, if another frost occurs, it could result in a weaker crop in the Spring.

**Show slide 4** - Some recent examples of extreme weather events in the UK that you may have witnessed or heard about on the news are:

1. **March 2018 - Beast from the East (Snow and Low Temperatures)**

**Impacts**

- **Transport** - Travel was disrupted, with roads closed and numerous road traffic collisions. Cars were stranded overnight on many roads in both Scotland and England. Rail services were cancelled, and air transport was severely disrupted. Thousands of schools across England, Wales and Scotland were closed, and many areas suffered power cuts. Isolated communities and farms across the North Pennines received supplies by helicopter.

2. **18th and 19th July 2022 - First ever red warning for extreme heat issued by the Met Office.**

**Impacts**

- **Transport** – Rail travel was severely disrupted as track buckled, leading to cancellations and warnings not to travel. Flights at Luton airport were suspended due to damage to the runway. Roads even melted in some areas, requiring sand to be spread on the road surface!
- **Health services** – The heat caused major stress for the NHS, with a surge in emergency calls and challenges for the elderly and vulnerable care services. Schools shortened their days.
- **Environment** – Multiple fires destroyed homes and property in areas such as Wennington and Milton Keynes, with fire services declaring a major incident. Some regions experienced power cuts and natural landmarks, such as Aysgarth Falls in Yorkshire, dried up due to the intense heat and lack of rain.

3. **1st-2nd November 2023 – Storm Ciaran**

**Impacts**

- **Transport** – This was heavily affected, with ferry services, flights and trains cancelled. The port of Dover was temporarily closed and many people were advised to work from home. Nearly 150,000 homes lost power, hundreds of schools closed and flooding caused rivers to overflow.
- **Environment** – High winds and heavy rain caused some cliffs to collapse in Dorset. Large waves swept vehicles out to sea and thousands of people lost their water supply after a power outage hit treatment plants in Surrey.

Meteorologists and Climate Scientists refer to occurrences such as those outlined above as extreme weather events. These are instances where weather conditions reach or even exceed the historical records for that specific location and type of event.

## What is a compound event?

10 minutes

When extreme events happen together or one after another, the impacts of these can increase. When this happens, it is called a **compound event**. For example, heavy rain and strong winds both happening together could cause more damage than either would on its own. Compound events may:

- **Happen over time**: If extreme weather events keep happen one after another, like a heatwave followed by a drought, they can be harder to recover from.
- **Involve pre-conditioning**: If an area is already vulnerable (such as a location that's already very dry before a drought) it can make the next extreme event more severe. If the same area keeps getting hit by extreme weather (e.g. repeated storms), the impacts increase in that location.

Essentially, the impact of compound events can be much more severe than isolated extreme events.

Definition of extremes - https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-11/ (11.2.1)

Tell the group that the Met Office provides monthly weather reports for the UK, including information on extreme weather.

## What do we mean by a weather hazard and what are the risks?

10 minutes

Discuss with the group - what do they think the definition of a 'weather hazard' would be? What do they understand about the meaning of the term 'weather hazard'? Tell the group that a weather hazard can be defined as a type of weather that could potentially cause damage to property, the environment and/or harm to people.

Examples of a weather hazard include:

- **Flooding** – Heavy rainfall can lead to flooding, as the excessive water causes rivers to overflow, groundwater to rise, or transport links to become inundated with water running off hard surfaces.
- **Heatwaves** – a period of sustained high temperatures can be dangerous to people's health and can lead to droughts and wildfires, for example.
- **Blizzards** – severe snowstorms with heavy snow and strong winds can make travelling dangerous and cause widespread power outages.

Can you think of any other weather hazards and their impacts? Ask the group to have a discussion in small groups and report back if you have additional time.

Tell the group there's 'risk' associated with all these kinds of events. When we talk about the risk related to weather hazards, we look at the chance of a dangerous event happening and how much it could affect a certain location or people. For example, what is the likelihood of a flood or a storm occurring and how serious would be the consequences if it did happen - how much damage could be caused to people, homes or the environment?

Risk is often understood as the potential for harm or damage resulting from a combination of three factors:

- **Hazard**: This refers to the natural event itself, such as heavy rainfall, a storm, or an earthquake.
- **Exposure**: This is the presence of people, property, and infrastructure in areas that could be affected by the hazard.
- **Vulnerability**: This is the susceptibility of the exposed elements to the hazard, influenced by factors like building quality, preparedness, and socio-economic conditions.

By considering these three factors together, we can better understand and quantify the risk associated with events such as floods, storms, and other extreme weather conditions. It helps us identify not just the likelihood of a hazard occurring, but also the potential impact it could have based on what is exposed and how vulnerable those elements are.

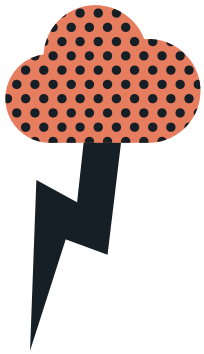
As mentioned earlier, heavy rainfall can lead to flooding. The risk of flooding can be higher in areas with a greater concentration of people and properties, and hard standing surfaces (causing run-off), compared to areas with more permeable surfaces and fewer people and properties

Weather hazards can happen anywhere. However, some environments are more susceptible than others. For example, which is the more vulnerable setting and why? (you can use equivalent examples, local to you)

- A tributary of the River Exe running through a small village such as Boscastle; or
- the River Exe running through the middle of the city of Exeter.

Most of the time there is a minimal risk as the rivers are not in flood.

You may have thought that the risk of flooding is greater in Exeter as it is a built up area, with a greater concentration of people and properties, and hard standing surfaces (causing run-off) but Exeter has had a lot of investment in flood defences, so although the hazard is there (it still rains and water levels increase), the likelihood of impact should have decreased significantly. However, villages, such as Boscastle in Cornwall sit on very flashy catchments but often have much less investment in them (as fewer people at risk).



Hazard risk is the probability of being affected negatively by these events. For example, people who live close to tectonic plate margins are at a higher risk of tectonic hazards, (such as earthquakes or volcanic eruptions) and people who live within the Tropics are at a higher risk of extreme weather events, such as tropical storms or droughts.

## 02 Weather observations and setting the scene for 1903.

10 minutes

Slides 5-7

**Using slides 5+6**. Tell the group that we're stepping back in time to explore how weather observations were recorded over a century ago. Let's start by setting the scene for the year 1903, a time when life, technology, and even the way people communicated weather information were very different from today.

First, let's touch on some important events of 1903 (**show slide 5**):

- In 1903, Edward VII was the King of the United Kingdom (UK). This was an era known for grandeur, technological advances and innovation, including early aviation and the expansion of our railway networks.
- 19 January 1903 – First transatlantic radio broadcast between United States and Britain.
- 15 February 1903 - First Teddy Bear went on sale.
- 17 December 1903 - The Wright brothers achieved the first flight, a breakthrough that changed transportation forever.

We'll be focusing on February 1903. This month is significant as the UK and Ireland experienced a major storm event that had a profound impact on people and communities.

**Show slide 7**. In the early 20th century, the daily recording of weather observations was slightly different from what we know today. In 1860, the Met Office (known then as the UK's Meteorological Department of the Board of Trade) founded by Admiral Robert FitzRoy, began recording and sharing daily weather reports. In 1861, FitzRoy established what is believed to be the world's first national forecasting system by using these reports to provide public storm warnings, to save lives at sea.

**Note** - if you'd like to learn more about Admiral Robert Fitzroy follow the links below-

Robert-Fitzroy and the early Met Office

Our history - Met Office

The storm that shaped the Shipping Forecast - Met Office

**Show slide 8**. By 1903, the Met Office was maintaining daily handwritten weather records. These records were based on observations from weather stations spread across the UK and mainland Europe, and each day's weather observations were transmitted to the London office by telegraph. These daily logs each spanned four pages of handwritten details , organised by stations across regions. You can see that the first page (shown on slide 6) presents a table showing weather observations for each station. The data presented starts with the prior evening's observations (on the left). The central columns provide data for the morning of the day on which the report is being issued and the right-hand section covers the full 24-hour period up to that day's readings.

These records play a key role in the story of the February 1903 storm we'll be examining.

## 03 Case study - Storm Ulysses.

10 minutes

Slides 10-12

In February 1903, an extreme weather event occurred that had significant impacts across the UK and Ireland, causing widespread destruction. This event was called Storm Ulysses.

**Show slide 10** – This provides some facts and figures about Storm Ulysses.

A scientist called Professor Ed Hawkins and his team at the University of Reading have been converting paper-based records into digital format (a process called digitising) **Show slides 11+12**, slide 11 shows the actual observation collected at different locations and slide 12 shows the modern reanalysis of those weather observations from Storm Ulysses. Using techniques similar to modern weather forecasting they have been able to more accurately assess the strength of Storm Ulysses' winds.

They have been able to establish that, across England and Wales, the peak windspeeds during storm Ulysses were similar to winds experienced in Storm Darragh between 6-7 December 2024. Ulysses is now confirmed to be an extreme storm event, even though it happened more than a century ago.

Tell the group that we know, from the reanalysis of Storm Ulysses, that it caused severe damage across the UK and Ireland, with some of the strongest winds ever recorded. You can see from the images and newspaper reports on **slides 13-18** just how destructive it was.

**The Science behind Storm Ulysses** - If you want to find out more about the research, please use these links to the scientific papers:

https://nhess.copernicus.org/articles/23/1465/2023/

https://esd.copernicus.org/articles/14/1081/2023/

**Note**: For a more in depth analysis of how the University of Reading digitized Met Office daily weather records -

https://centaur.reading.ac.uk/91043/1/gdj3.93.pdf

## 04 Storm Ulysses: Understanding historical storms with modern day warning systems.

20 minutes

Slide 20

Groupwork

Scientists have used the reanalysis model to re-run Storm Ulysses as if it was happening in the context of modern atmospheric conditions, in particular with the warmer sea surface temperatures (SSTs) we see today. This outputs have shown that it would have slightly stronger winds than before, but more importantly, it would be associated with approximately 25% more rainfall. This much additional rain would lead to serious flooding, landslides and other problems if the storm happened today.

Back in 1903, storms weren't given names the way they are today, by the Met Office or other meteorological organisations. Storm Ulysses got its name because it inspired a scene in a novel by the author James Joyce, called Ulysses:

> "O yes, J.J. O'Molloy said eagerly. Lady Dudley was walking home through the park to see all the trees that were blown down by that cyclone last year and thought she'd buy a view of Dublin."

Ask the group if they know why we name storms today? You can find the answer and more information here - https://www.metoffice.gov.uk/weather/warnings-and-advice/uk-storm-centre/index

Why might it be useful for the Met Office and other meteorological organisations to name storms? Give them a few minutes to discuss and share their thoughts. (The topic of conversation may move to discuss how the U.S. and other countries name storms like hurricanes, typhoons and tropical storms)

Tell the group that, although Storm Ulysses got its name from a literary reference, today storm names are selected differently. In fact, the Met Office takes public suggestions for storm names each season and works with the meteorological services from the Republic of Ireland and the Netherlands to define the list.

> **Note**:
> Would your students like to suggest a storm name? The Met Office allows public submissions for future storm names. You can find details on how to participate at the end of this activity.

## Research Task: Modern-day warning systems

15 minutes

Slide 20-21

Ask the group to work in pairs and, using the link to the Met Office webpage, research how today's weather warning systems work. As they are researching, ask the groups to think about how these systems can be used to reduce risk. Afterwards, get the group to share their findings. If you have time, they could present these as a poster, discussion or presentation.

With the group, discuss how the Met Office issues weather warnings and name storms that could cause significant disruption or damage. Weather warnings are issued via the National Severe Weather Warnings Service, which considers both the **impact** of the weather and the **likelihood** of those impacts. **See slide 20**.

**Show slide 21** watch Alex explain our warnings.

## Suggested end of session one

## Weather warnings task: Social and economic impacts

15 minutes

Slide 23-24

Groupwork

Tell the group that, now that they understand how these systems work, you want them to think about the **social, environmental and economic impacts** of an extreme weather event today.

**Using slides 23+24**, ask the group to look at the two Met Office weather warnings.

Split the group into two with each sub-group focussing on one weather warning.

Ask the question: What kind of **social, economic and environmental impacts could occur as a result of the weather described in your weather warning?**

Here are a few examples to consider:

- **Social impacts**: How might a storm/extreme weather disrupt people's lives or affect communities? Think about power outages, risks to life, property damage, and displacement. For example, a heatwave may affect the elderly more and could destroy crops on farmland, leading to increased food costs for people.
- **Economic impacts**: How would extreme weather affect jobs, transportation, businesses, and the local and national economy? Consider disruptions to travel, delays for employees, jobs, supply chain effects, and the overall financial cost.
- **Environmental impacts**: How would this affect animals and their habitats? Ecosystems can be affected by flooding, pollution and contamination, and altered landscapes due to flooding and strong winds.
- Are there any positive consequences? For example – heavy rain can refill reservoirs and rivers, especially in areas that have experienced a recent drought.

Remember, extreme weather can have multiple impacts. For example, travel delays don't just disrupt people's daily routines—they can also interrupt supply chains and business operations for many companies. Now that we understand more about social, economic and environmental impacts, do you think a storm like Ulysses would have the same impact today as it did in 1903?

After your discussion, look at the following reports to review your findings:

- Wind - Storm Isha and Storm Jocelyn 21-24th January 2024 - report
- Rain – Storm Dennis - report

## 05 Comparing then (1903) to the modern-day

15 minutes

Slide 21

Tell the group that, from newspaper reports and photos, we can see how much damage Storm Ulysses caused. But by reanalysing the data, scientists have been able to pinpoint where the strongest winds hit, confirming what we know from historical sources. The research Ed Hawkins and the wider University of Reading team have produced compares our current atmosphere with that of 1903. They mention that "our atmosphere is warmer and more humid, and so has more moisture in it." Storms have the potential to bring more rain than they did in the past. With rising sea levels, past storms would also cause more damage today due to higher storm surges around our coastlines.

**Task**: Ask the group if they can think of any other examples of differences there would be today? Think about what has improved/changed over the years, and how.

Some examples below:

**Weather Forecasting and Early Warning Systems**

**Then (1903)**

- Storm warnings could not be provided until very close to the event, leading to lack of preparation.
- Communications were via newspaper, word of mouth, or telegraph (often too slow or unavailable in isolated areas).
- Disaster response was reactive, rather than pro-active, with limited means of communication between emergency services.

**Now**

- Advanced satellites, radar systems and computer modelling provide highly accurate, real-time weather forecasts.
- Early warning systems – offering multiple days' notice of an extreme weather event.
- Communications – satellite, mobile phones, social media, and emergency broadcast systems reach wider audiences instantly.
- Community-based (local council) disaster education and training, to improve preparedness and response

**Infrastructure**

**Then (1903)**

- Many buildings, bridges, and other physical structures were constructed without taking extreme weather event considerations (such as high winds, heavy rainfall, or flooding) into account
- Minimal flood defences in place, or they failed under stress

**Now**

- Modern infrastructure and new building materials are designed to withstand specific weather risks.
- Green infrastructure, such as urban wetlands and green roofs, mitigates flooding and heatwaves.

Can you think of any other differences? Take suggestions.

## 06 Reflection

5 minutes

Take some time as a group to reflect on your findings and how modern-day technology can assist with our understanding of past weather events.

This kind of information is important for many organisations, from insurance companies to our emergency services, that need to understand the risks of extreme weather events. Although we tend to focus on recent records, adding historical data from storms like Ulysses gives a fuller picture of these risks, which can help these organisations better prepare for and minimise future storm impacts.

Our world is warming and, by understanding these past events, we can identify how risks are changing through time. The Storm Ulysses re-analysis, for example, has shown how that event would be more extreme if it happened today:

> "The reanalysis is beneficial for understanding the risks of extreme weather events as it showed that the winds experienced in some locations during Storm Ulysses would be rarer than once in 100 years. Having information about such a rare event provides valuable insight into the potential extra damage a similar storm could cause now and in the future" Prof Hawkins.

> "This study is a great example of how rescuing old paper records can help us to better understand storms from decades gone by. Unlocking these secrets from the past could transform our understanding of extreme weather events and the risks they pose to us today," Prof Ed Hawkins.

**Would you like to help us name a storm?**

Everyone is welcome to suggest names for future consideration via email to nameourstorms@metoffice.gov.uk
or through our online form.