Climate change and sea-level rise

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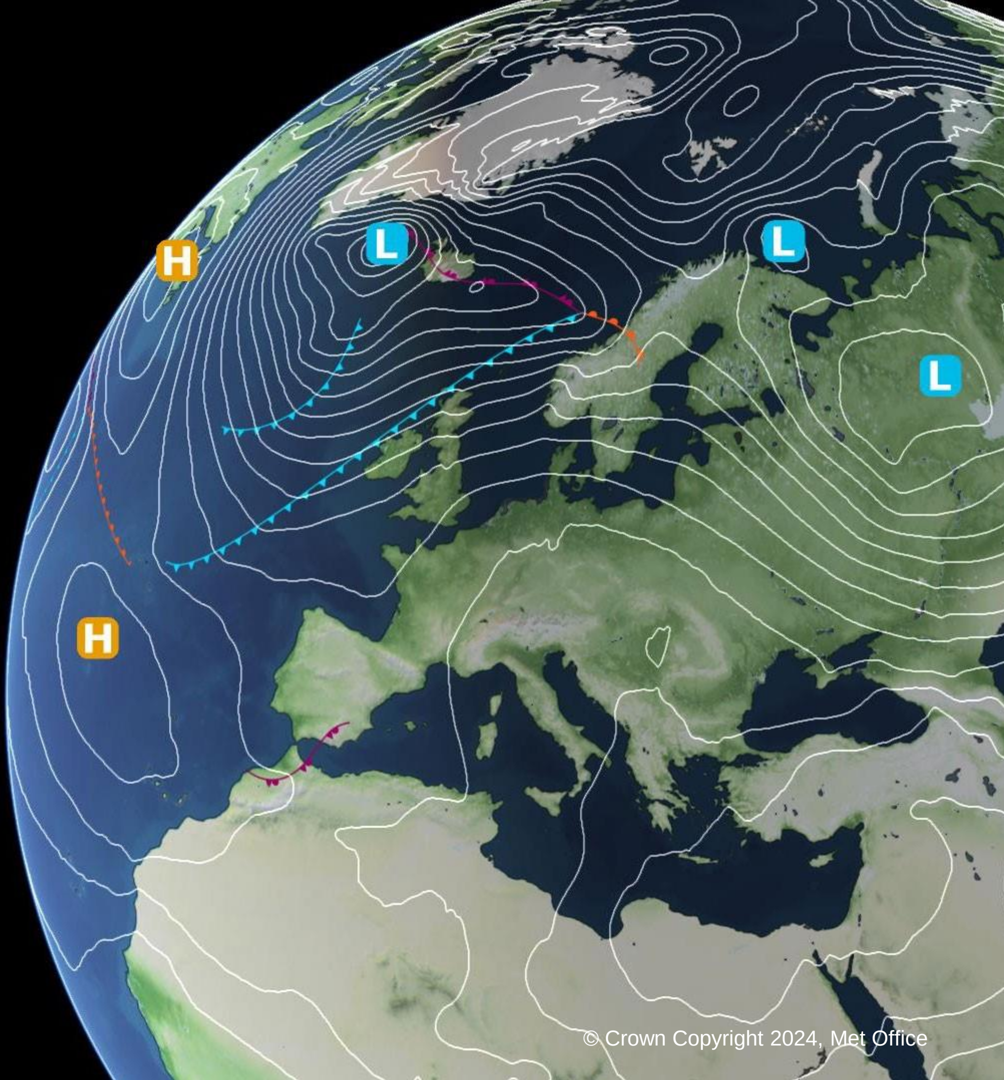
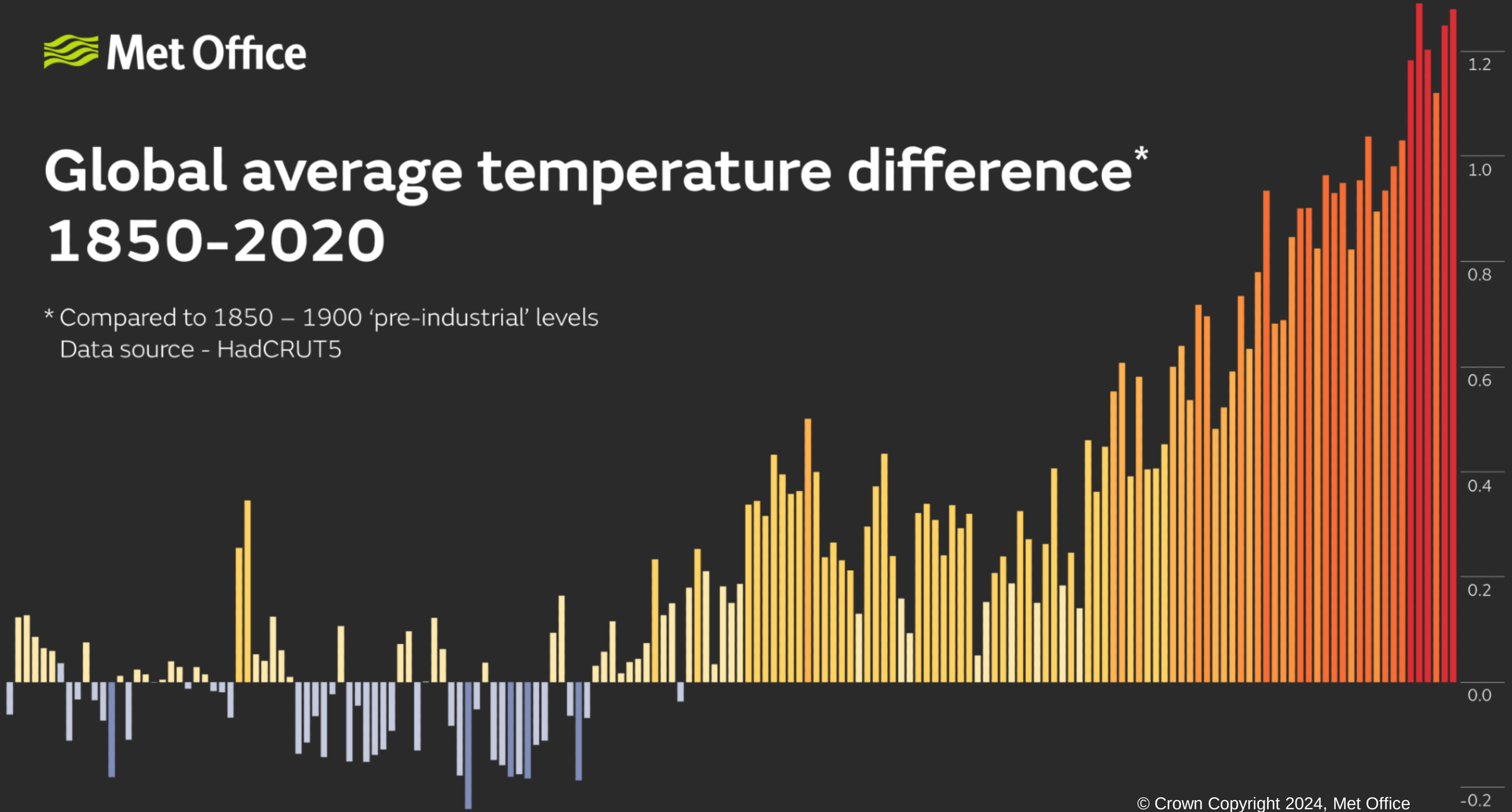
ONR NGO Climate Change Workshop
22 October 2024



Met Office

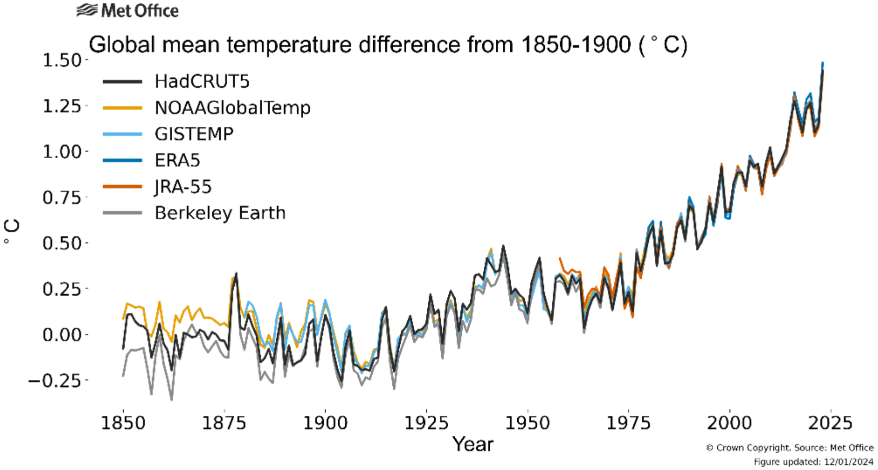
Global average temperature difference*
1850-2020

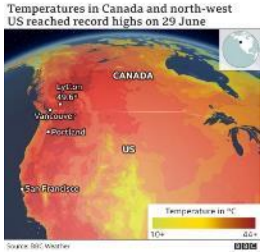
* Compared to 1850 – 1900 'pre-industrial' levels
Data source - HadCRUT5



Met Office

Global temperatures have risen by ~1.25°C

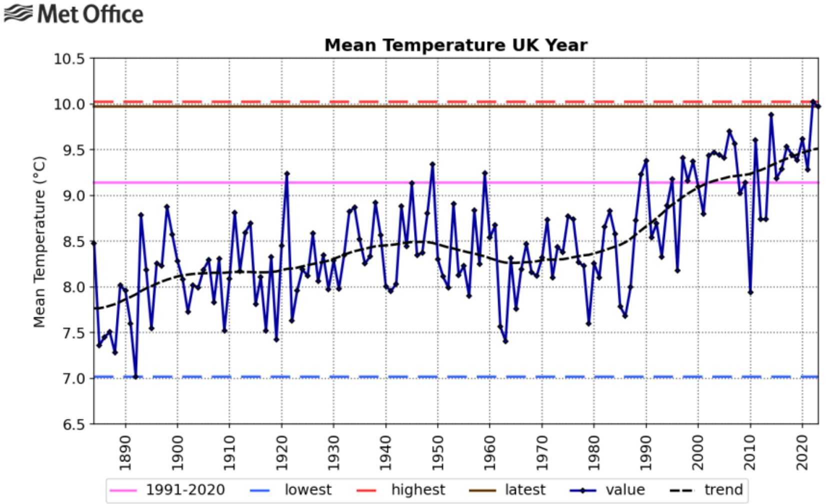


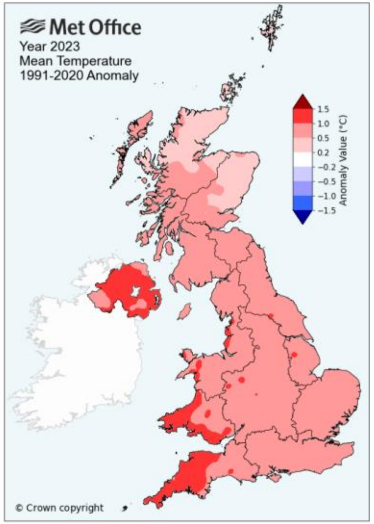


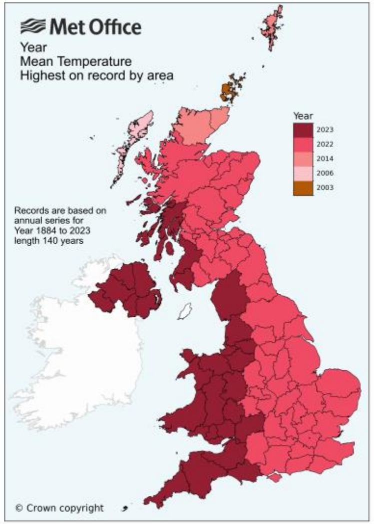
2023 was warmest year on record and the 10th year in succession that has equalled or exceeded 1.0°C above the pre-industrial period.

UK - 2023 temperatures

- UK's **second warmest** year on record (series from 1884)
- Central England **second warmest** year on record (series from 1659)
- 10 warmest years have all occurred this century, six in most recent decade
- Most recent decade, 2014-2023:
  - Warmest 10-year period for both UK and CET
- Most recent decade, 2014-2023:
  - 0.42°C warmer than 1991-2020
  - 1.25°C warmer than 1961-1990
- Warmest year in Ireland in series from 1900 (Met Éireann)

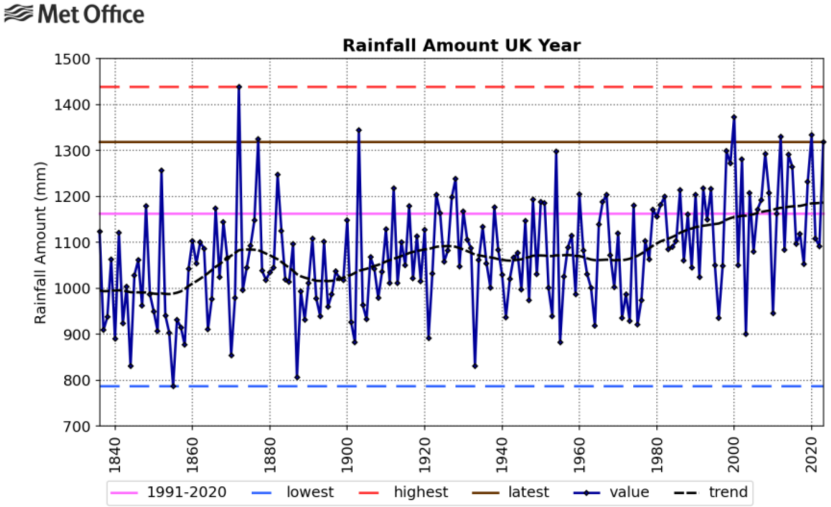


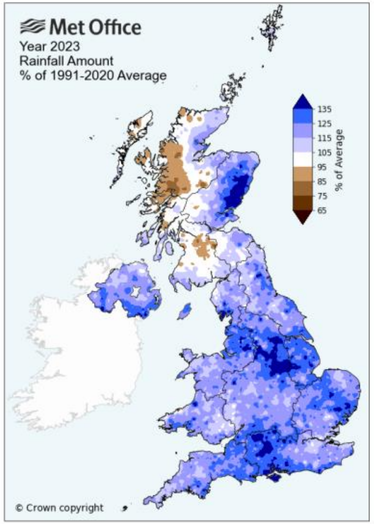


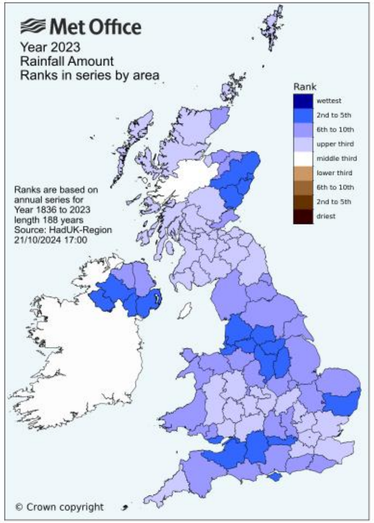


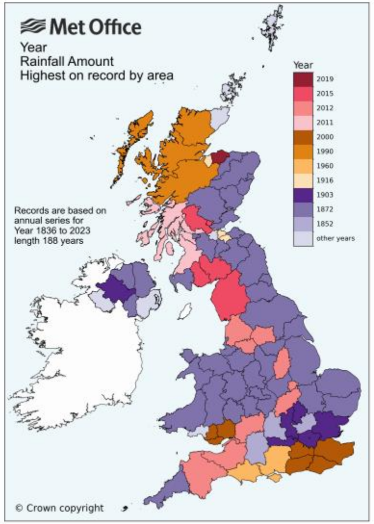
UK - 2023 rainfall

- UK’s **seventh wettest** year on record (series from 1836)
- 5 of 10 wettest years have occurred this century
- Most recent decade, 2014-2023:
  - 10% wetter than 1961-1990
- Most recent decade, 2014-2023:
  - Winters 24% wetter than 1961-1990
- Caution is needed interpreting trends over short periods since extreme years may strongly influence averages





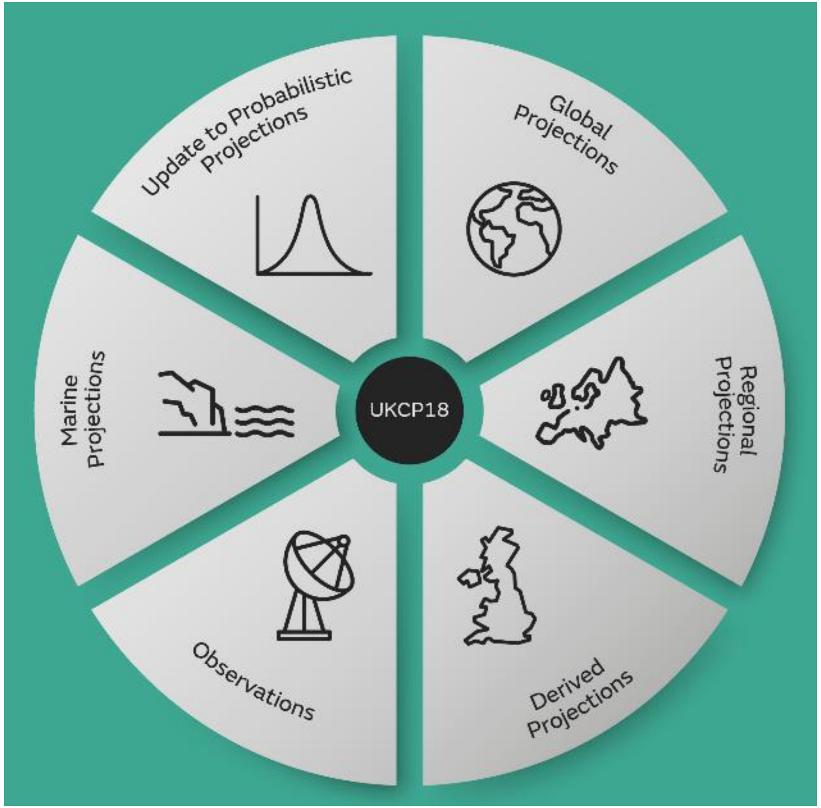




Headline results

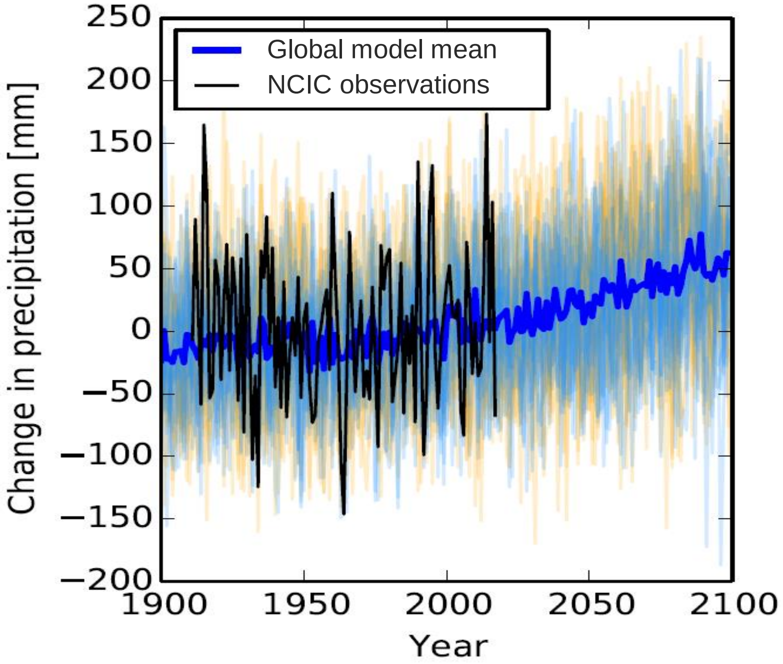
“a greater chance of warmer, wetter winters and hotter, drier summers”

“sea-level rise continues under all scenarios”



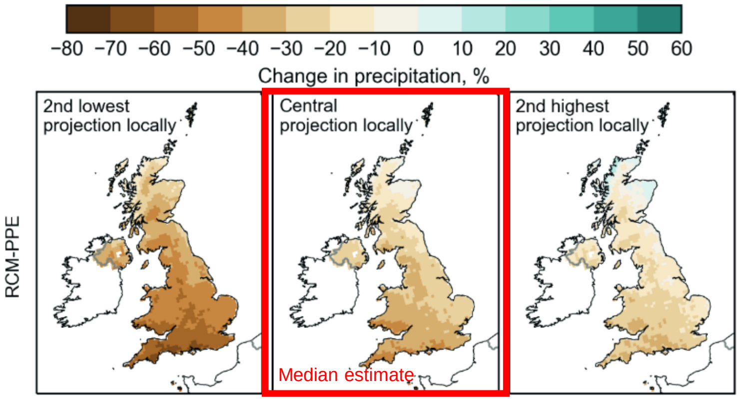
Global projections – UK mean precipitation change

- Winter precipitation is expected to increase significantly
  - We will still get some dry winters, but wet winters will become wetter
- Summer rainfall is expected to decrease significantly
  - But when it rains in summer there may be more intense storms

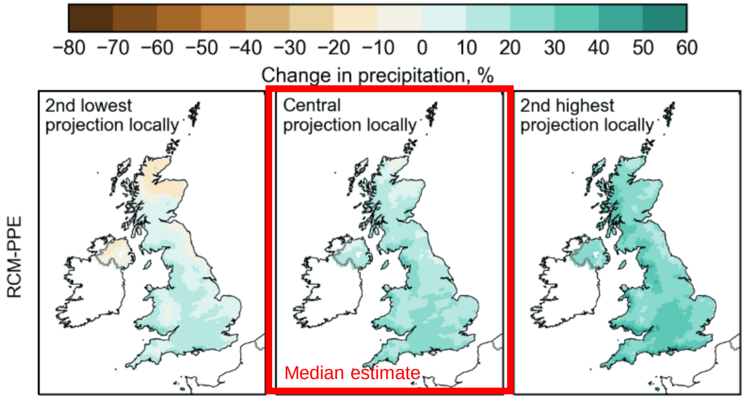


UK mean winter precipitation change.
Change is calculated relative to 1981-2000.

Regional projections – pattern of precipitation change



Summer precipitation change



Winter precipitation change

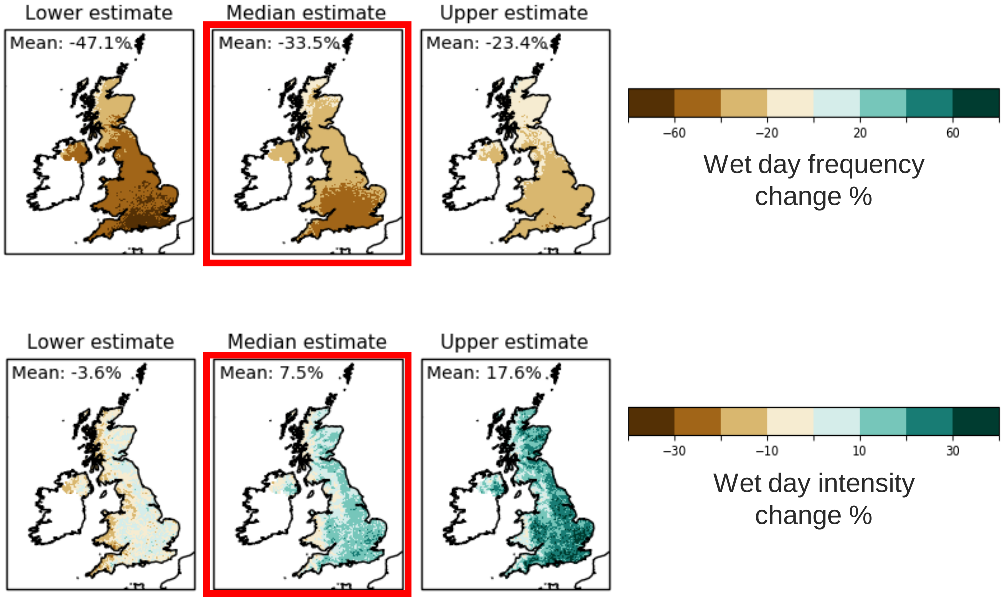
Spatial pattern of precipitation change to 2061-2080 (RCP8.5) shows detailed structure over the UK (compare S England and N Scotland). Change is calculated relative to 1981-2000.

Local projections – understanding frequency and intensity

Local (2.2km) projections for **summer** suggest **decreases in the frequency of wet days** but **increases in the intensity on wet days**

Wet days are defined as days with precipitation > 1 mm/day

However, for the most intense events the central estimate is for an increase of **25% by 2070**



Projected change to 2061-2080 (RCP8.5).
Change is calculated relative to 1981-2000.

Met Office

Global warming and future high-impact weather in the UK

	HOT WEATHER Extremely hot days, where temperatures exceed 25 °C, are likely to become much more frequent.	COLD WEATHER Very cold conditions, where temperatures fall below 0 °C, are likely to become less and less frequent.	HEAVY RAINFALL[2] Days of intense and prolonged heavy rainfall are likely to increase.	DROUGHTS Less frequent rainfall will increase occurrences of severe droughts[3].
+4 °C	37 days per year Value ranges between 32 and 46 days per year	12 days per year Value ranges between 9 and 20 days per year	11 days per year Value ranges between 10 and 13 days per year	146% more frequent
+3 °C	26 days per year Value ranges between 23 and 32 days per year	20 days per year Value ranges between 16 and 31 days per year	10 days per year Value ranges between 9 and 12 days per year	129% more frequent
+2 °C	18 days per year Value ranges between 15 and 22 days per year	34 days per year Value ranges between 27 and 44 days per year	9 days per year Value ranges between 8 and 10 days per year	86% more frequent
Present Day[1]	10 days per year Value ranges between 8 and 11 days per year	50 days per year Value ranges between 45 and 56 days per year	7 days per year Value ranges between 6 and 9 days per year	No change in frequency

These ranges represent the spread across simulations from the UKCP18 12km high resolution Regional Climate Model

Key: thermometer = 5 days, snowflake = 10 days, raindrop = 1 day, drought = 20%

[1] Present day values calculated for the period 2000 – 2017.

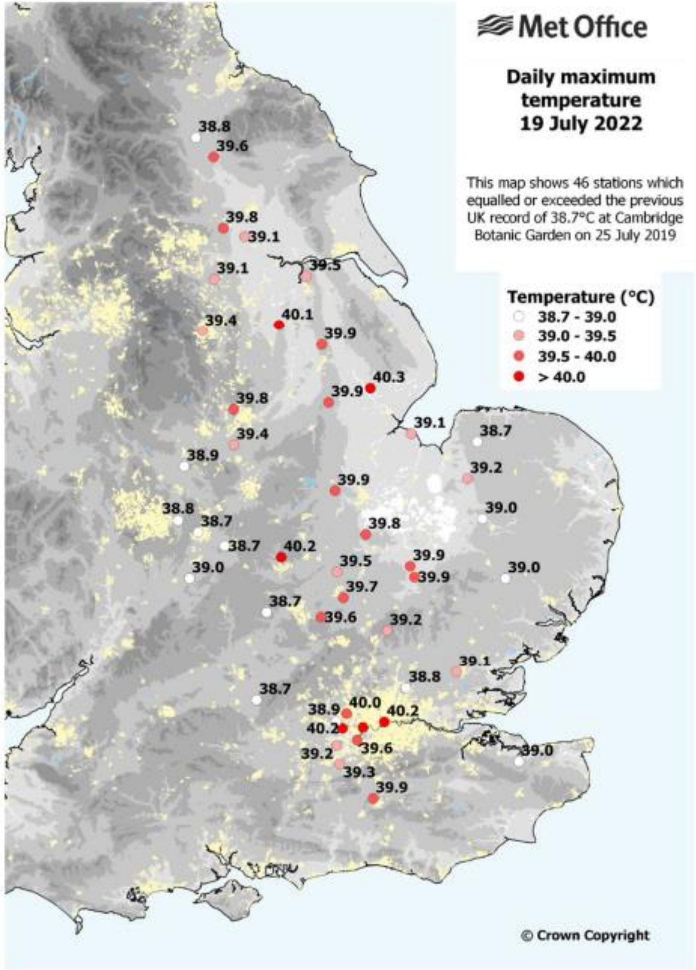
[2] The displayed values below are for England and Wales only.

[3] Severe droughts are defined here as droughts that are as severe or more severe than that of 2010-2012 drought, which had a 12-month period with accumulated rainfall deficit of 24% of the mean annual rainfall of the 1981-2000 period, i.e. 24% less rainfall than the average rainfall expected. We used the number of times this threshold was exceeded in the present day period (2000-2017) as a benchmark to compare frequency of exceeding the threshold in the future.

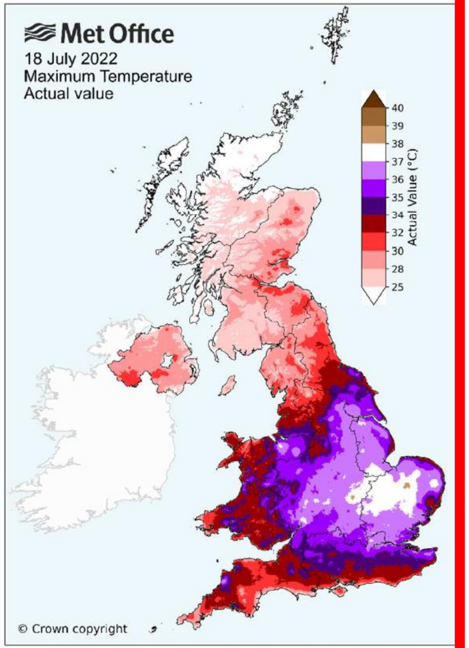
Met Office

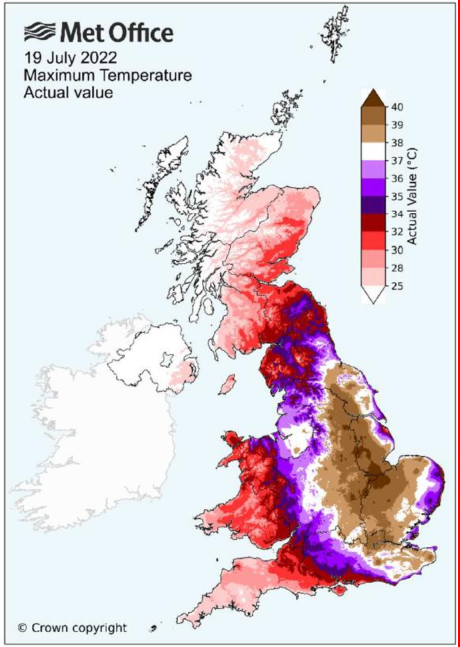
The July 2022 heatwave

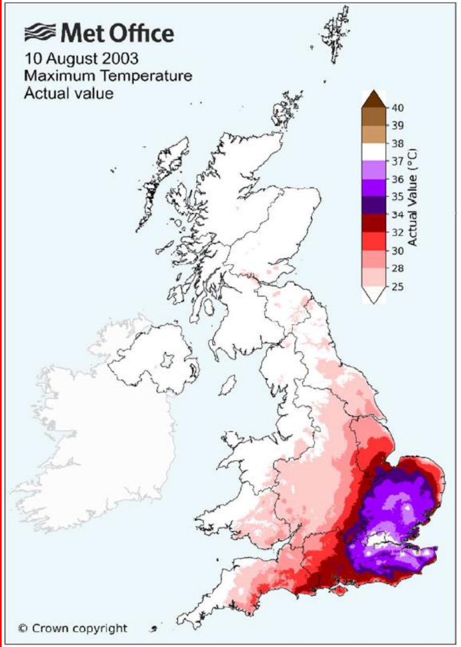
- Brief but unprecedented heatwave from 16 to 19 July 2022
- On 19 July, 40.3°C was recorded at Coningsby (Lincolnshire), setting a new UK temperature record by a margin of 1.6°C
- 40°C recorded for the first time in the UK
  - Seven stations at or above 40°C

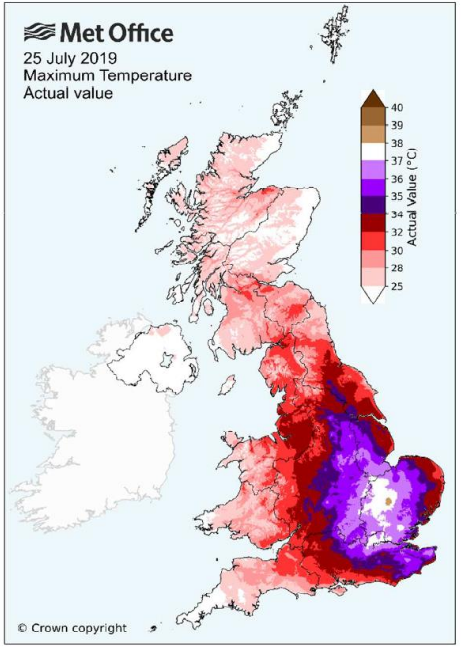


The July 2022 heatwave





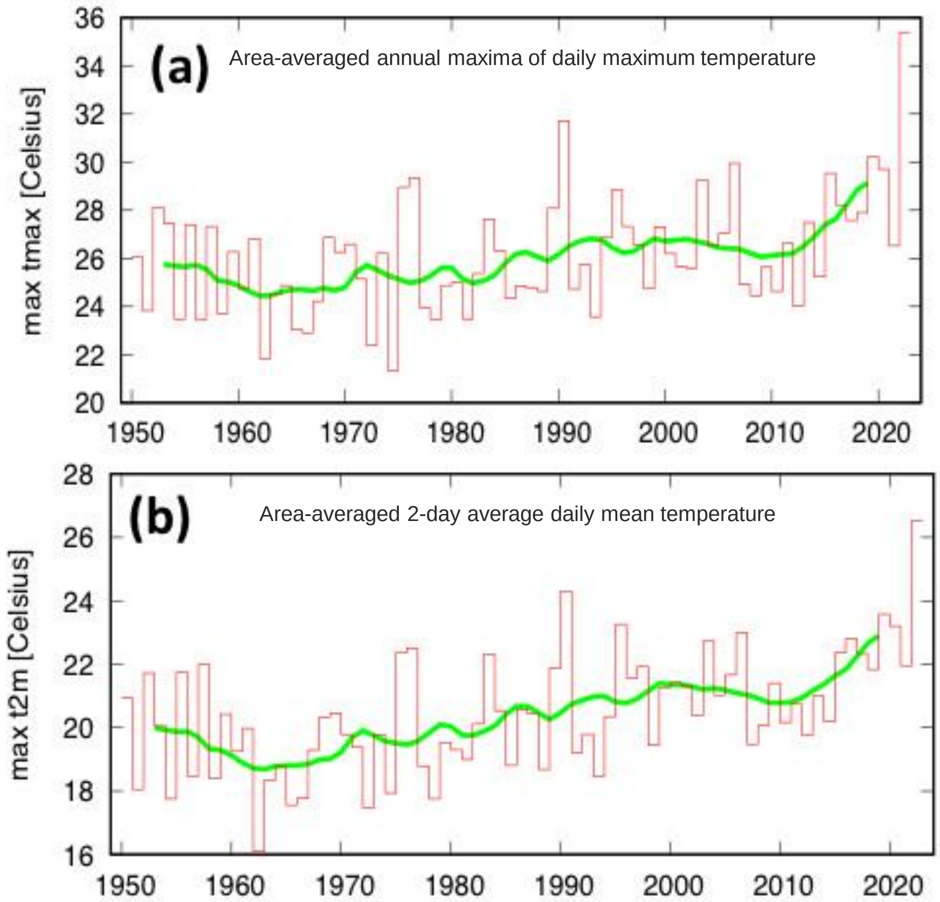




Met Office

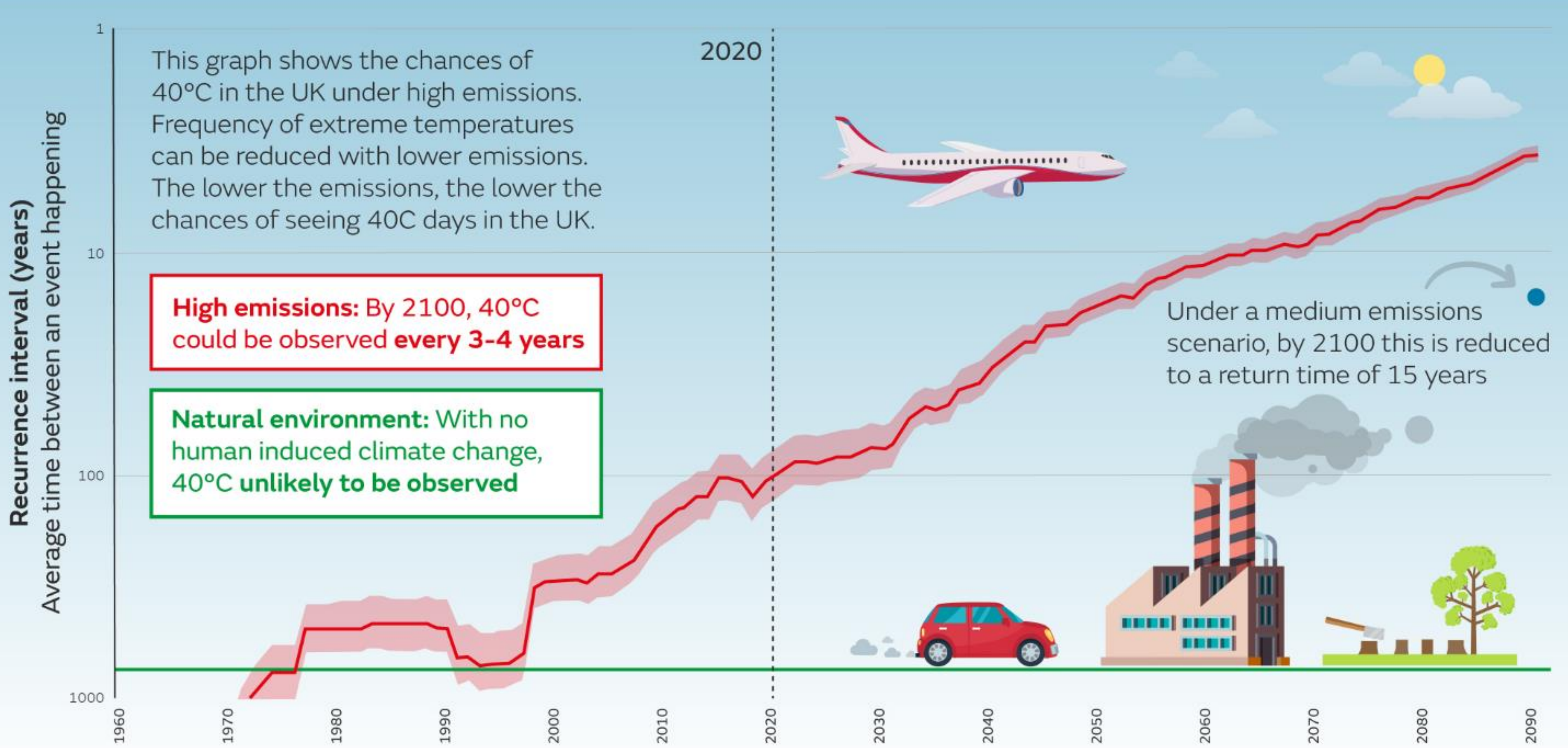
Attributing the event

- For the 1-day maximum temperatures over central England the return time is estimated at 1 in 1000 years in the current climate.
- The likelihood of observing such an event in a 1.2°C cooler world is extremely low and ‘almost impossible in a world without climate change’.
- The observational analysis shows that a UK heatwave as defined above would be about 4°C cooler in preindustrial times.
- It is important to highlight that all models systematically underestimate the observed trends. The model-derived results are thus almost certainly too conservative.
- Human-caused climate change made the event at least 10 times more likely.
- The discrepancies between the modelled and observed trends and variability also hinders confidence in projections of the future trends.



Source: World Weather Attribution (WWA)
https://www.worldweatherattribution.org/wp-content/uploads/UK-heat-scientific-report.pdf

Chances of seeing 40°C in the UK under a high emissions scenario



Source: Christidis et al. (2020)

Sea-level rise impacts and adaptation

Met Office

Why is sea-level rise important?

Sea-level rise is one of the most urgent climate threats, causing flood inundation, coastal erosion, shoreline retreat and saltwater intrusion. These impacts affect global shorelines, coastal infrastructure, and communities. About 10% of the world's population, roughly 770 million people, live in coastal areas less than 5 meters above the high tide line. A significant reduction in greenhouse gas emissions and effective adaptation action is needed to limit the risk from rising sea levels.

What is adaptation?

Adaptation is action taken to reduce the impacts experienced from climate change. Adaptation can take many forms across communities, regions, and countries; there is no "one-size-fits-all" solution. Adaptation can include building flood defences, redesigning communication systems, and restoring coastal habitats. Adaptation is a critical component of long-term responses to climate change to protect people, livelihoods, and ecosystems.

The map provides an example of an adaption option that has been implemented in each location, and many are considered across the globe.

US

Some US states, such as North Carolina, are building "living shorelines" from rocks, shells, and native plants to reduce coastal erosion while maintaining natural shoreline processes.

Arctic

As sea ice melts and sea level changes in the Arctic, new areas will be accessible and trade routes will open. Policy can be implemented to govern this.

UK

The UK invests in sea walls, flood barriers and levees to protect people and infrastructure from coastal flooding and erosion.

China

To make urban areas more resilient to floods, "sponge cities" absorb excess floodwaters, and release it slowly during drier periods.

South-East Asia

Rising seas make hurricanes and other storms more dangerous. Mangroves trap sediment and protect the coast against large waves and storm surges.

Pacific Islands

Saltwater intrusion damages crops and contaminates fresh water sources. To combat water and food insecurity, farmers are growing more salt tolerant crops.

Australia

Beaches and dunes are receding as sea level rises, so they are replenished with sand and grasses to minimise the impact of storm surges.

Scan the QR code to learn more about Looking North: the UK and the Arctic - GOV.UK (www.gov.uk)

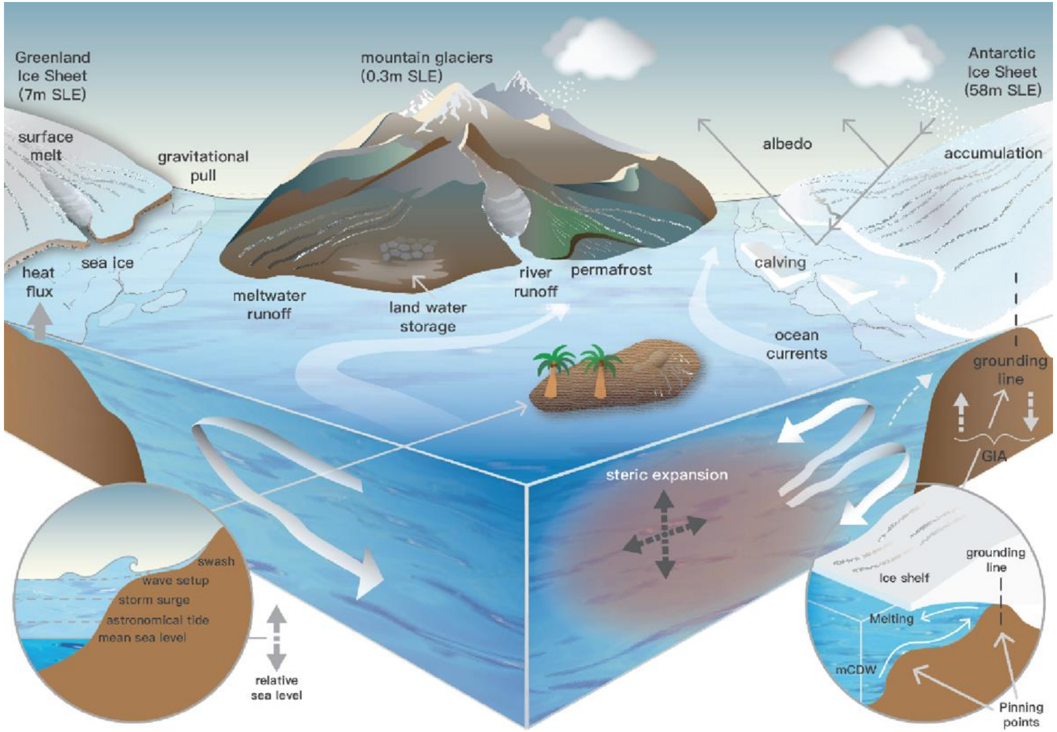
Scan the QR code to learn more about IPCC's Sixth Assessment Report (AR6)

Scan the QR code to learn more about UKCP18 sea-level projections

From global to local sea-level projections

Global sea levels are rising.

1. Thermal expansion
2. Melting ice sheets
3. Receding glaciers
4. Land water storage



Sea levels do not change uniformly.

1. Glacial isostatic adjustment (GIA)
2. Ocean density
3. Earth's gravity field, rotation, and shape of the ocean floor (GRD)

Source: Figure 9.2a in IPCC, 2021

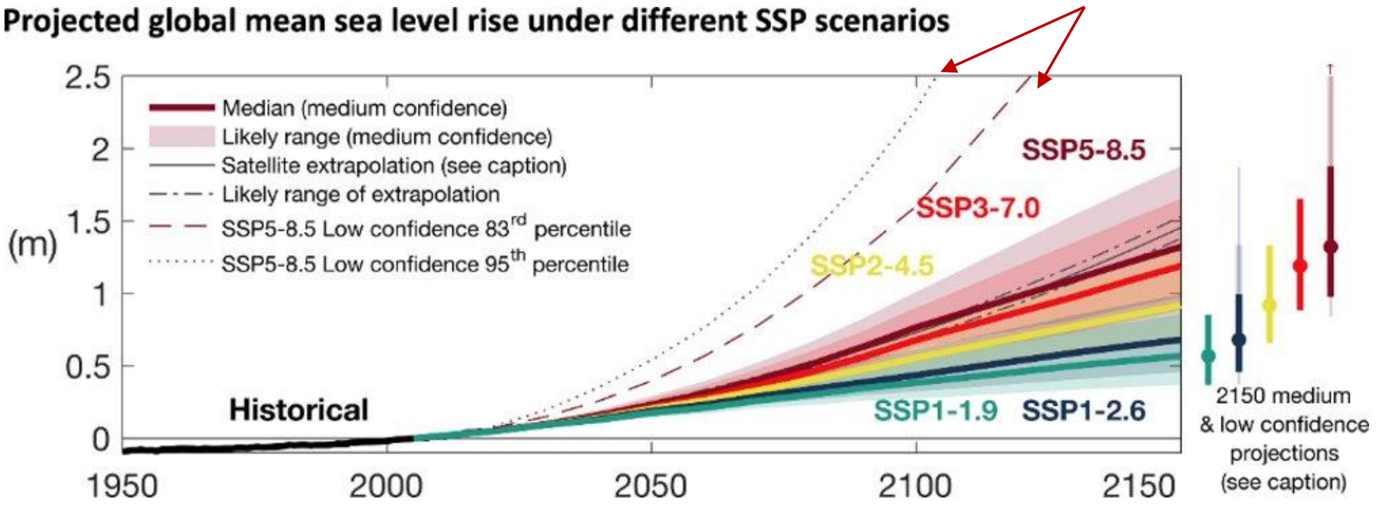
IPCC AR6 projections

Beyond 2050, projections are increasingly sensitive to emissions scenario, and it is virtually certain that sea level will continue to rise through 2100.

Relative to 1995-2014, the likely global mean sea level rise (*medium confidence*) by **2100** is projected to be:

- 0.32-0.62 m under the low emissions scenario (SSP1-2.6)
- 0.55-0.90 m under the high emissions scenario (SSP3-7.0)

High-end scenarios including ice sheet instability processes



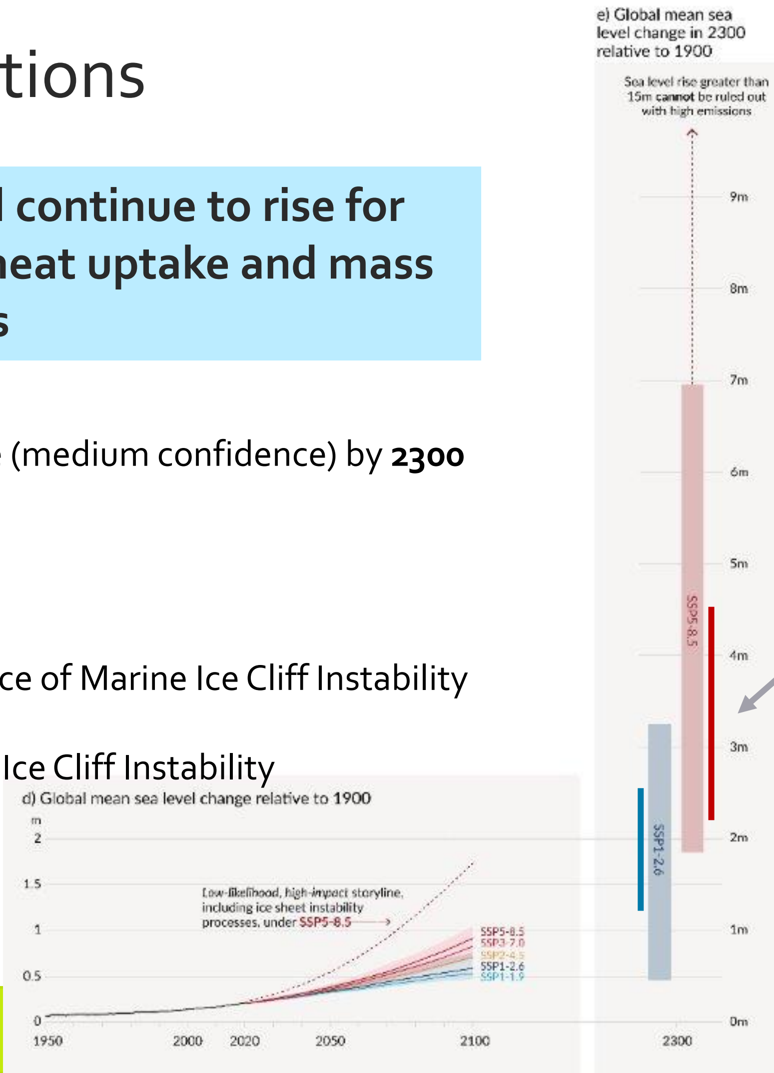
Source: IPCC AR6 WG1 Chapter 9

IPCC AR6 projections

Beyond 2100, global mean sea level will continue to rise for centuries due to continuing deep ocean heat uptake and mass loss of the ice sheets

Relative to 1995-2014, the likely global mean sea level rise (medium confidence) by **2300** is projected to be:

- between 0.3 m and 3.1 m under SSP1-2.6
- between 1.7 m and 6.8 m under SSP5-8.5 in the absence of Marine Ice Cliff Instability
- and by up to 16 m under SSP5-8.5 considering Marine Ice Cliff Instability



UKCP 2300 projections shown for comparison

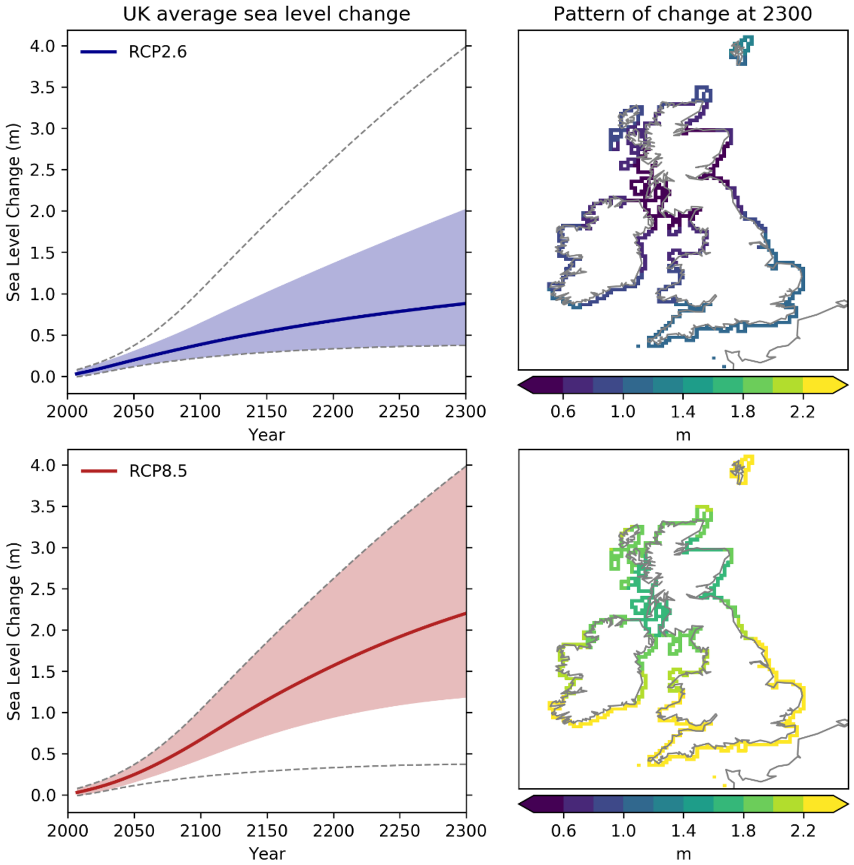
Source: IPCC AR6 WG1 Chapter 9

UKCP18 headline messages

UK coastal flood risk is expected to increase over the 21st century

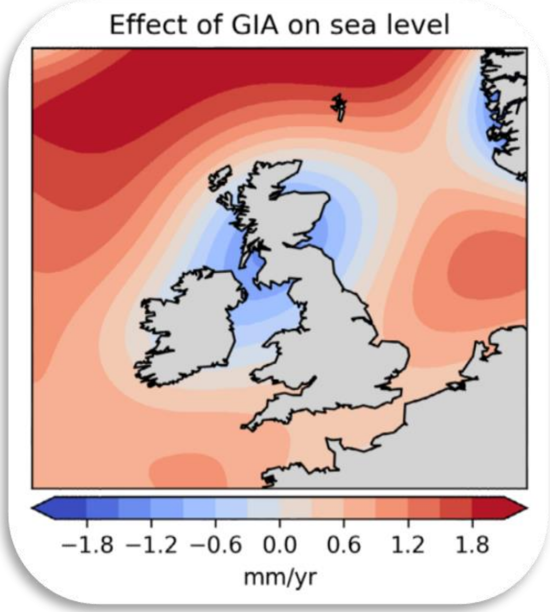
Exploratory, time-mean sea level projections to 2300 suggest that UK sea levels will continue to rise over the coming centuries

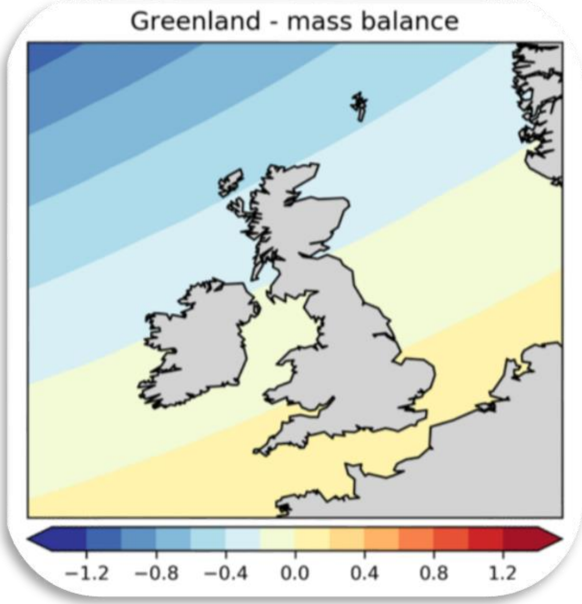
21st century projections of time-mean sea level change around the UK vary substantially

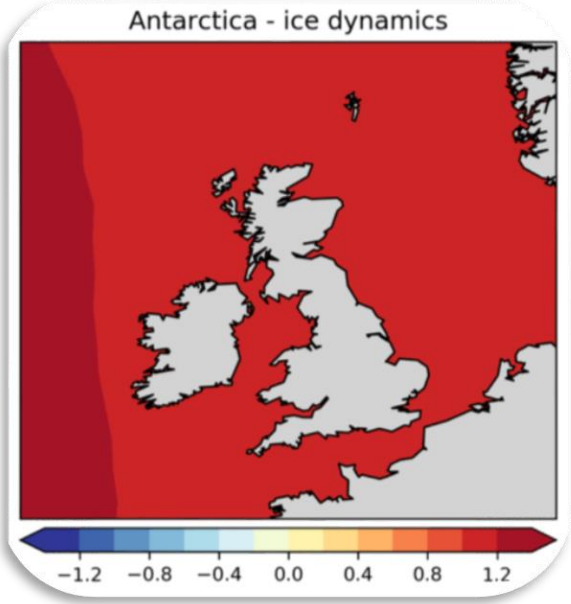


Source: UKCP18 Marine Report

UKCP18 sea-level projections

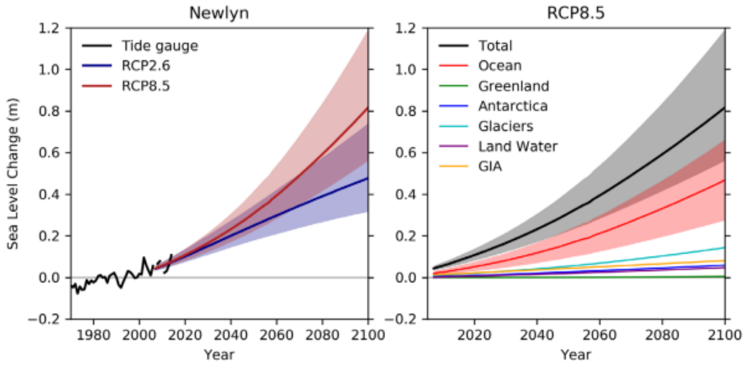






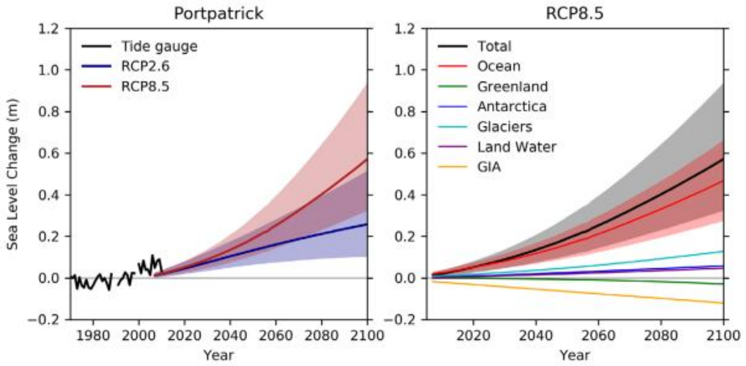
Source: UKCP18 Marine Report

UKCP18 sea-level projections



Newlyn in Southwest England has a total range of projected sea level rise at 2100 across all RCP scenarios of approximately 0.3 - 1.2m. The Greenland contribution to regional sea level is zero and GIA contribution is positive.

Portpatrick in Southwest Scotland has a total range of projected sea level rise at 2100 across all RCP scenarios of approximately 0.1 - 0.9m. Here, the Greenland and GIA contribution to regional sea level is negative.



Source: UKCP18 Marine Report

Projecting Future Sea Level (ProFSea)

Met Office

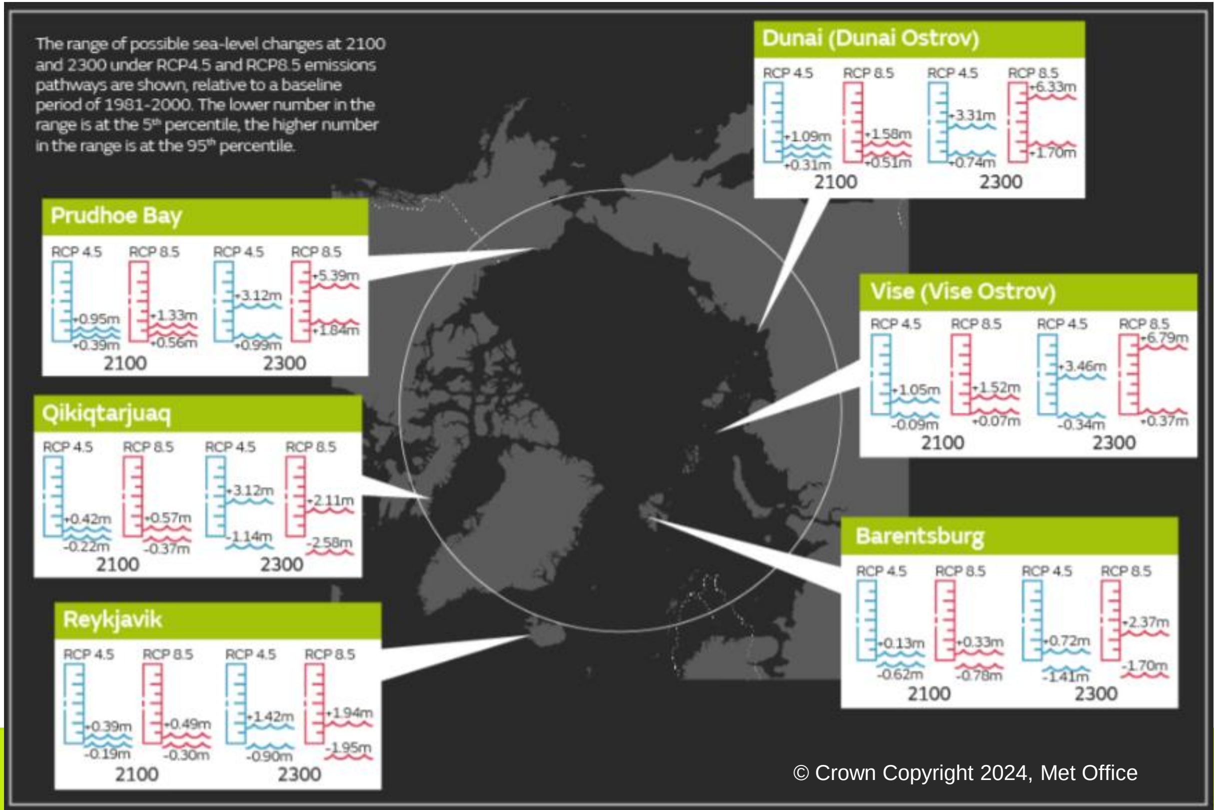
UK Research and Innovation

UK CLIMATE RESILIENCE PROGRAMME

The ProFSea tool can be used to generate local sea-level projections across the globe.

ProFSea generates global and local sea-level projections to 2100 and now 2300.

This tool is hosted on **GitHub** (https://doi.org/10.5281/zenodo.10255468) and involves running a series of Python based scripts.



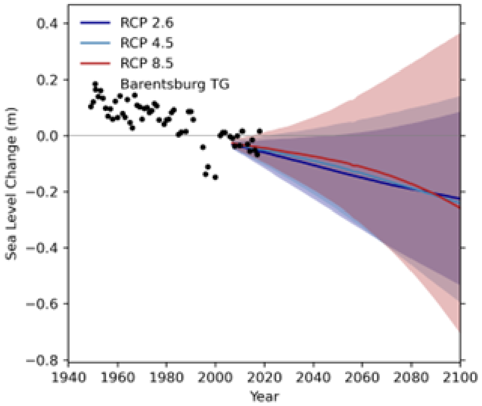
Perks & Weeks (2023), Palmer et al (2020)

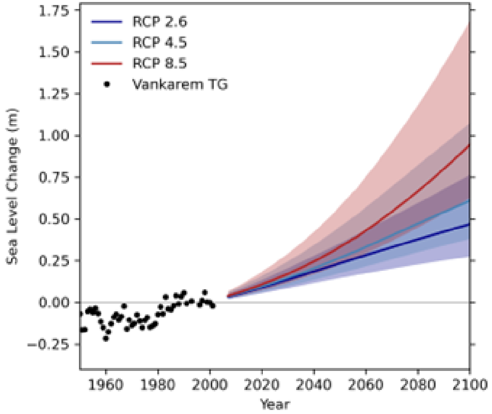
ProFSea in the Arctic Region

"Investigate how sea level change will affect port access. Work should aid military planners to understand access considerations for planning operations."

Arctic sea level changes can differ significantly from the global sea level rise trend and are highly dependent on location.

By 2100, sea level in **Barentsburg**, Norway will likely decrease.



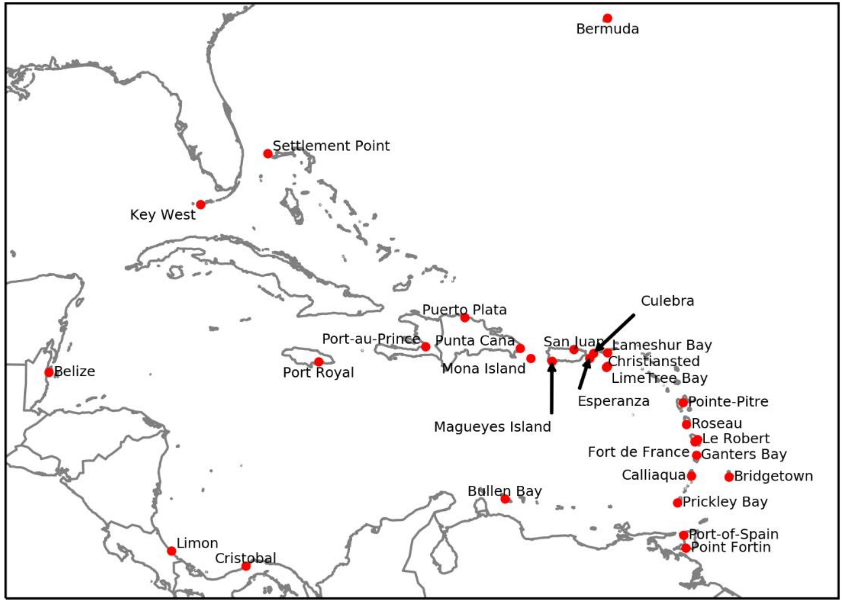


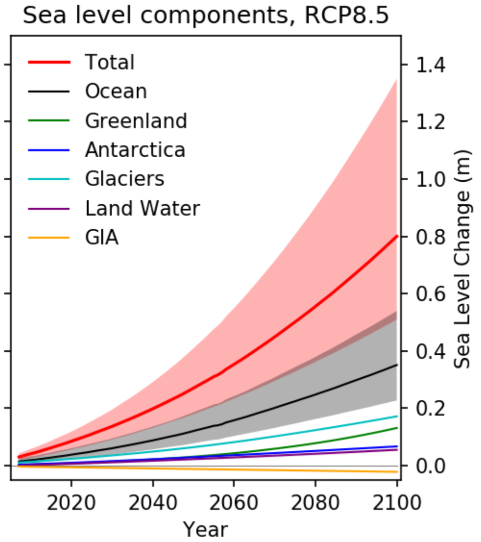
By 2100, sea level in **Vankarem**, Russia will almost certainly increase.

Munday et al. (draft), Perks & Weeks (2023), Palmer et al (2020)

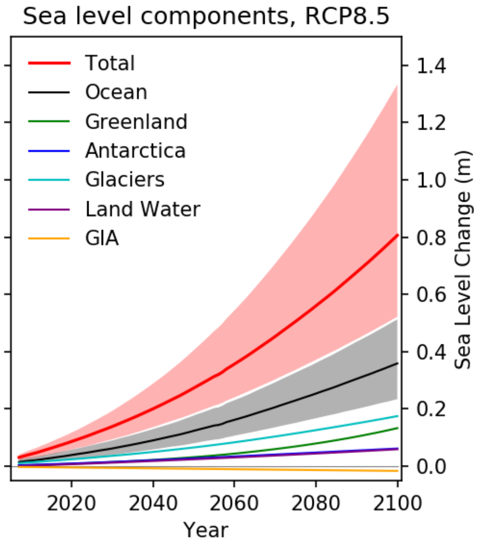
ProFSea in the Caribbean

“Generate sea-level projections for various locations in the Caribbean for Commonwealth Heads of Government meeting”





By 2100, sea level in **Belize** will likely increase.



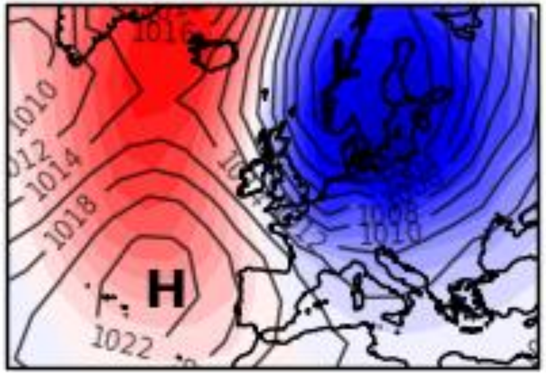
By 2100, sea level in **Port-of-Spain** will likely increase.

Coastal Resilience Demonstrator

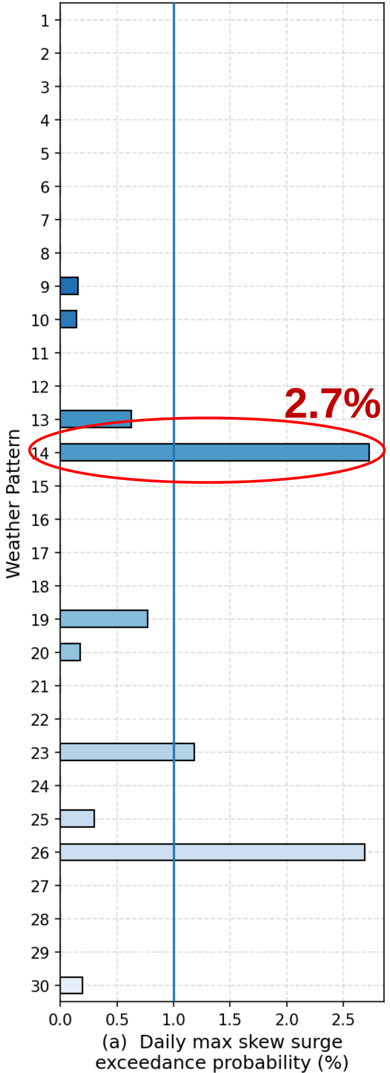
6th December 2013 Storm Xavier created the "'The biggest [coastal flood] event to impact the UK east coast for more than half a century."

The Met Office produced a set of 30 objectively derived daily weather patterns, which are typical of the main synoptic scale variability over large parts of Europe.

Pattern 14 of 30



Low over UK and North Sea
Higher storm surge risk



Perks et al. (2023), Neal et al. (2016)

Coastal Resilience Demonstrator

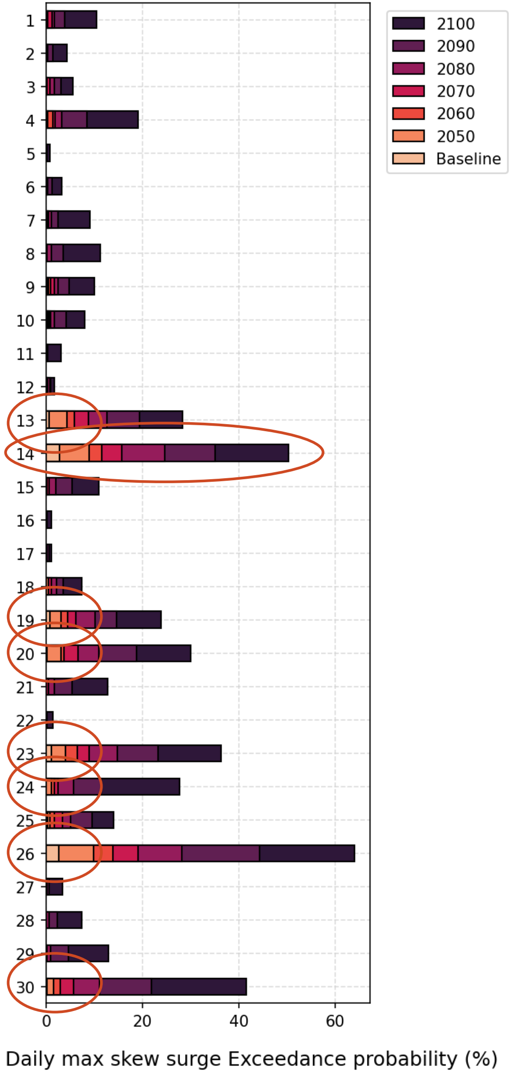
Met Office

Under sea level projections to **2050** (RCP8.5):

- **>8%** of events associated with WP14 exceed the warning threshold
- **8** number of weather patterns are considered a risk by 2050

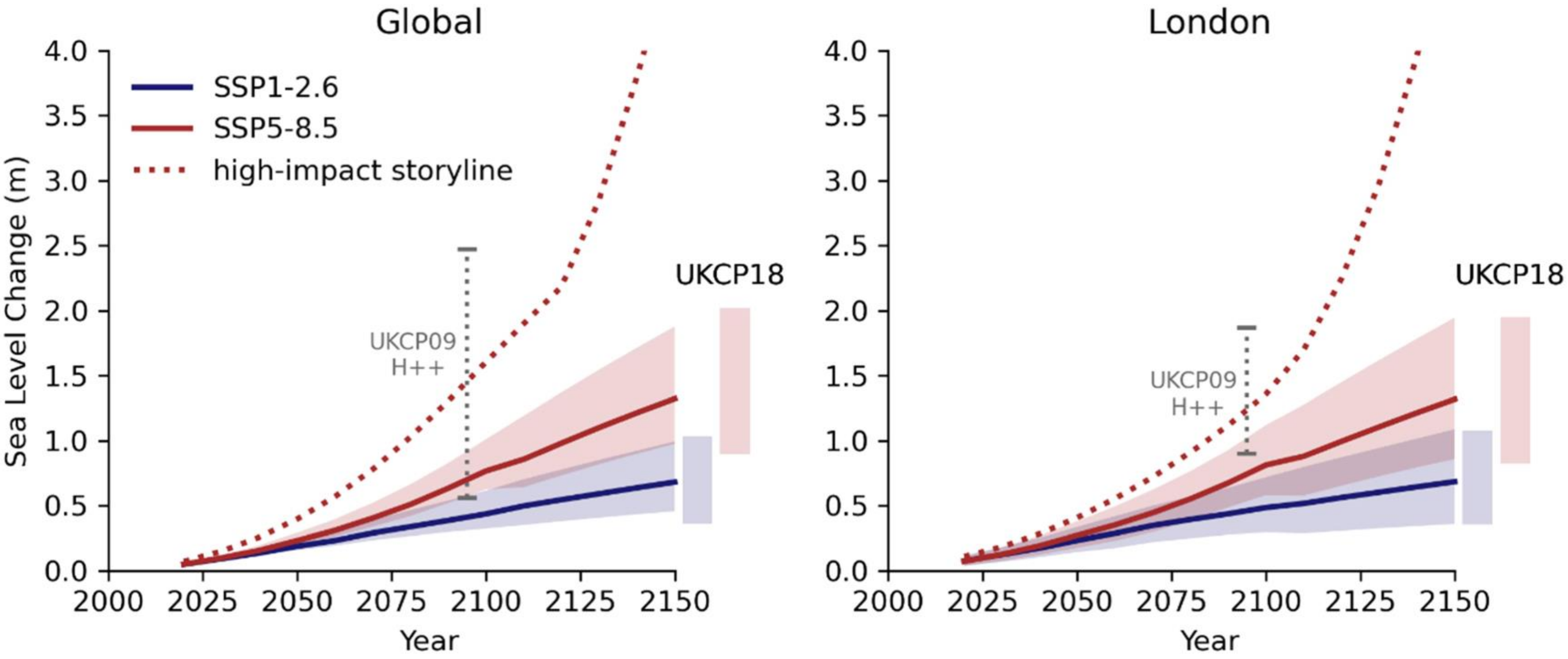
Under sea level projections to **2100** (RCP8.5):

- **>50%** of events associated with WP14 exceed the warning threshold
- **29** number of weather patterns are considered a risk by 2050



Perks et al. (2023), Neal et al. (2016)

UKCP18 vs AR6 sea-level projections



Weeks et al (2023)

Met Office

Key messages

- ✓ The world has warmed by about 1.2°C, leading to more extreme weather events
- ✓ The amount of future warming depends on future emissions
- ✓ The UK is expected to see:
  - ✓ warmer, wetter winters; hotter drier summers

- ✓ Sea levels do not change uniformly around the world
- ✓ The UK is expected to see:
  - ✓ greater sea-level rise in the south than in the north
- ✓ Sea levels will continue to change over the coming centuries, affecting coastal flood risk
- ✓ It is important to monitor sea-level and develop effective adaptation options
  - ✓ e.g. “early warning systems”

Met Office

For more information please contact

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