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Hadley Centre

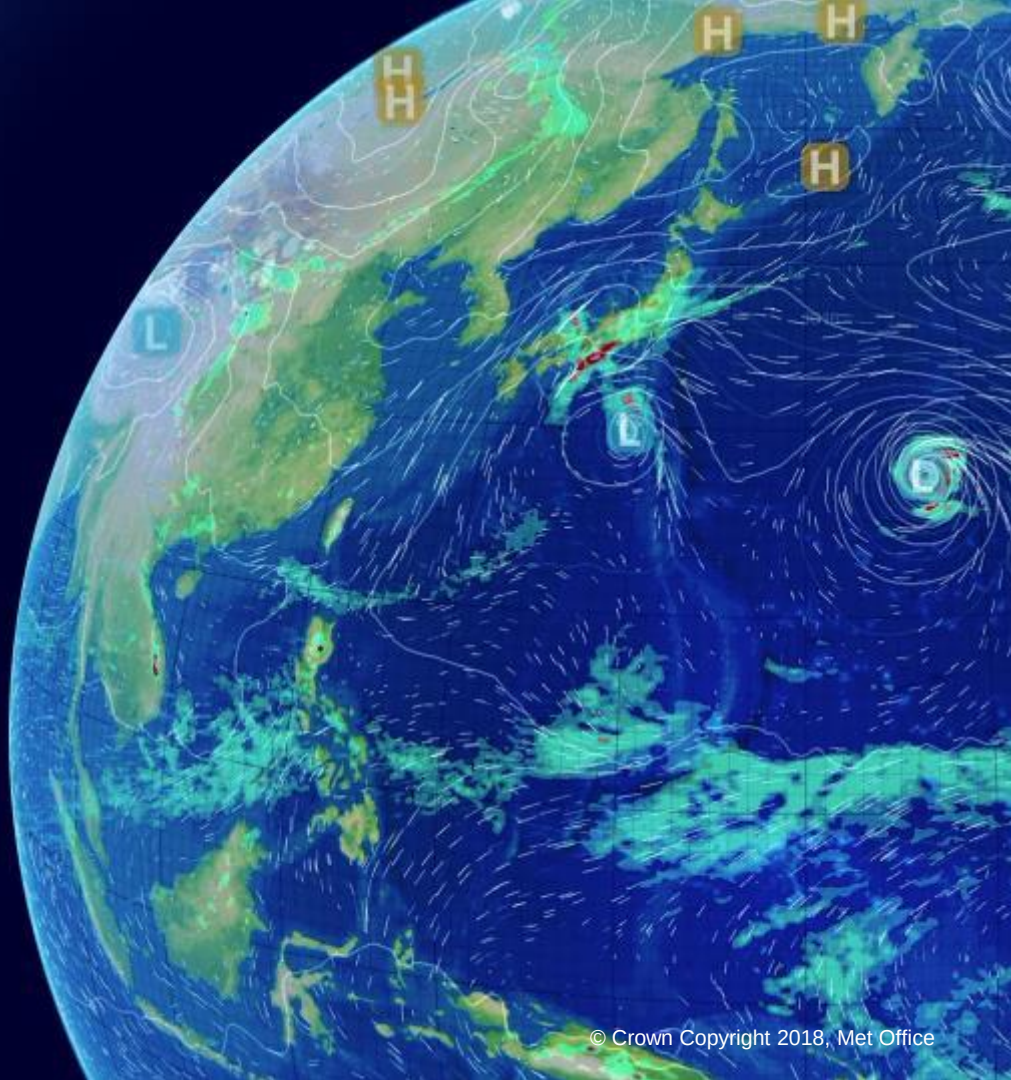
State of the UK Climate 2018

Mike Kendon

Met Office National Climate Information Centre

Thanks to:

Mark McCarthy, Dan Hollis, Tim Legg, Ian Simpson



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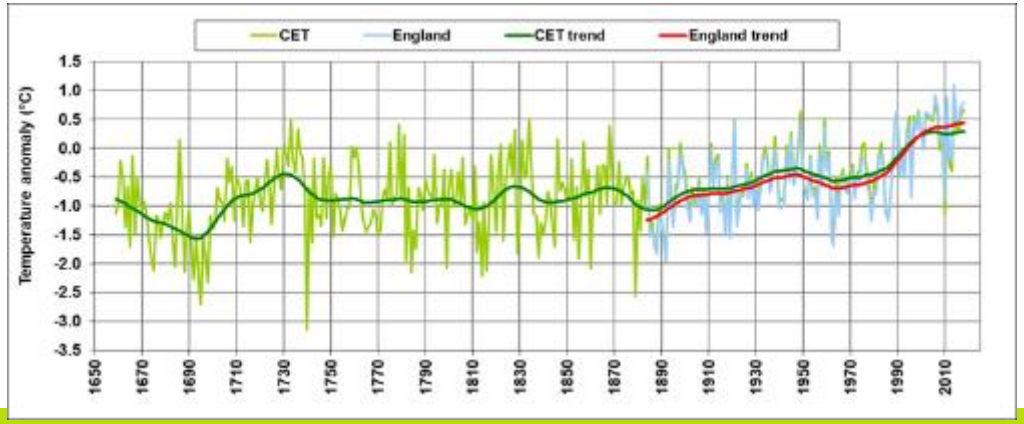
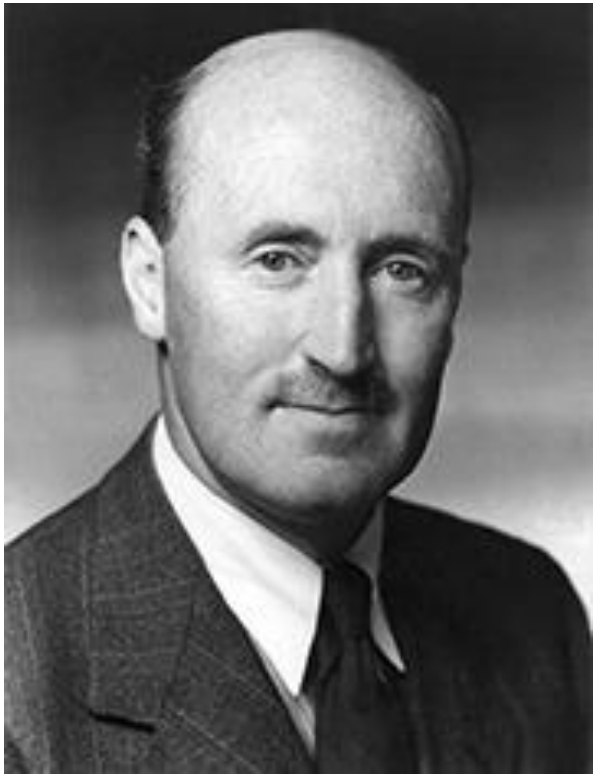
A great deal of needless romance has long been attached in Britain to the subject of snow. Our forefathers' memories must be discounted, for within four generations much of the population of these islands has moved downhill, southward, or into the larger towns where snow gives less trouble. When about 1929 I began working on the Pennines from Durham, and also skiing, I soon learnt to distrust the exaggerated stories, bad reporting and general lack of knowledge, and I set out to rationalise the available data. These were later discussed and mapped (Manley 1939, 1940, 1944 and 1947).

Gordon Manley on snow in Britain over the last 300 years





Gordon Manley
1902 to 1980

National Climate Information Centre

Our Vision

Authoritative source of UK climate monitoring information

Our Purpose

Helping government, the public and commercial customers:

- **National Memory**
  - UK climatological data products.
- **Weather and climate into context**
  - Climatological context of weather and climate events
- **UK Climate variability and change**
  - Enable society to understand and manage risks and opportunities from climate variability and change.

Early climate monitoring

I have often thought that if ſuch a Regiſter as this, or one that were better contriv'd, with the help of ſome Inſtruments that for exactneſs might be added, were kept in every County in *England*, and ſo conſtantly publiſhed, many things relating to the Air, Winds, Health, Fruitfulneſs, *&c.* might by a ſagacious man be collected from them, and ſeveral Rules and Obſervations concerning the extent of Winds and Rains, *&c.* be in time eſtabliſh'd, to the great advantage of Mankind. Whether you will think it worth the Royal Society's conſideration and promotion, I leave it to you. From this

A register of the weather for the year 1692, kept at Oates in Essex by Mr John Locke.
Proceedings of the Royal Society (1705)

Earlier still…

Nilometer
(1 Egyptian Cubit = 526mm)

Stage board on the River Exe, monitored by webcam

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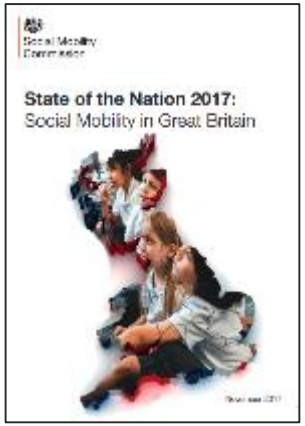
State of the …



Social mobility

Infrastructure

Health and social care

Citizens, government, business

Birds

Mental health

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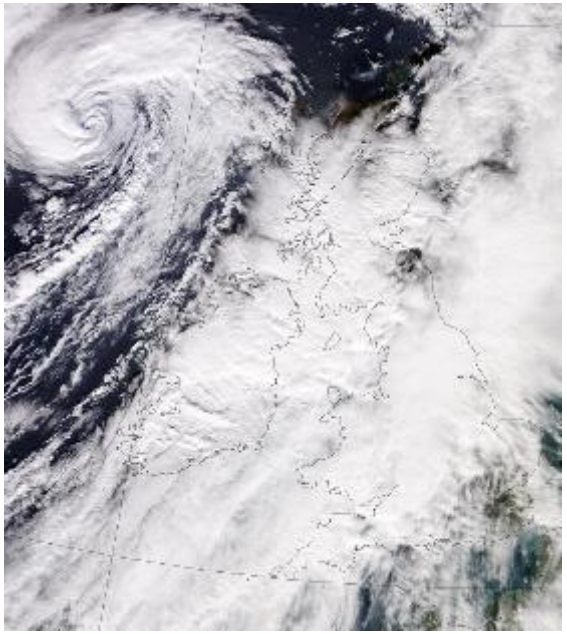
Monitoring the UK's climate

- Traceability
- Reproducibility
- Scientific Integrity
- Data
- Modern technology

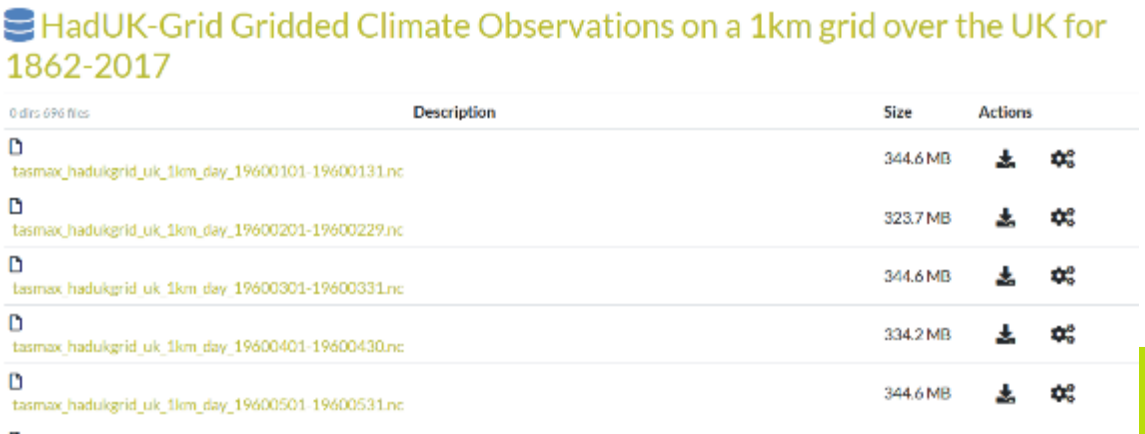
Lying snow in Exeter on 18 March 2018

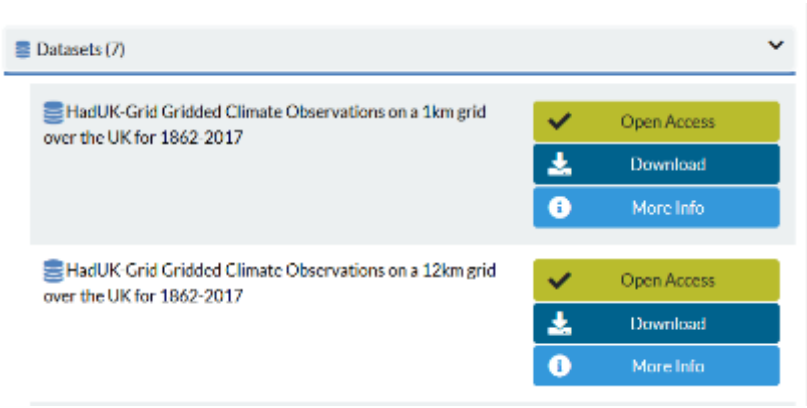


Visible satellite image of Storm Callum on 12 October 2018

State of the UK Climate

- Up-to-date assessment of UK climate trends, variations and extremes
- Based on climate quality datasets from UK land weather station network
- Internal review only 2014 to 2016
- External review 2017 onwards
- 2018 report – new 1km gridded dataset
- Open Access - [available via CEDA archive]





- Open Access
- 1km, 12km, 25km, 60Km grids
- 1862-2017
- Administrative regions, river basins, UK countries
- .nc format

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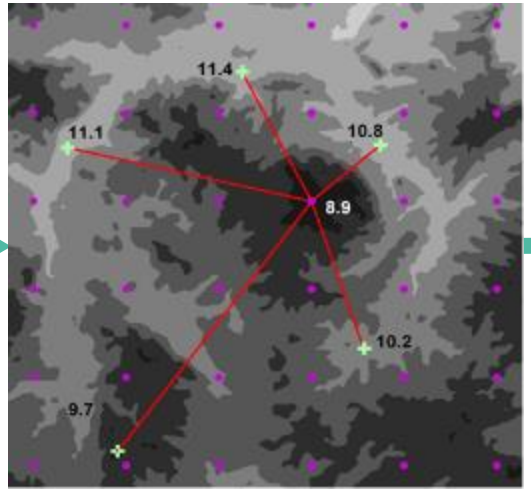
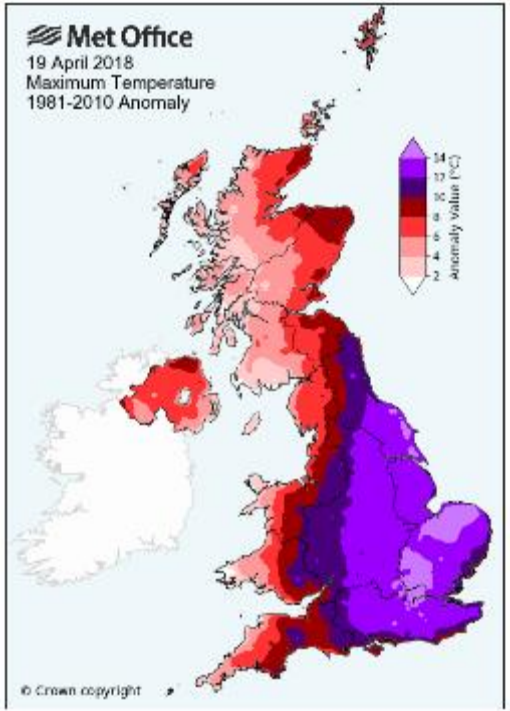
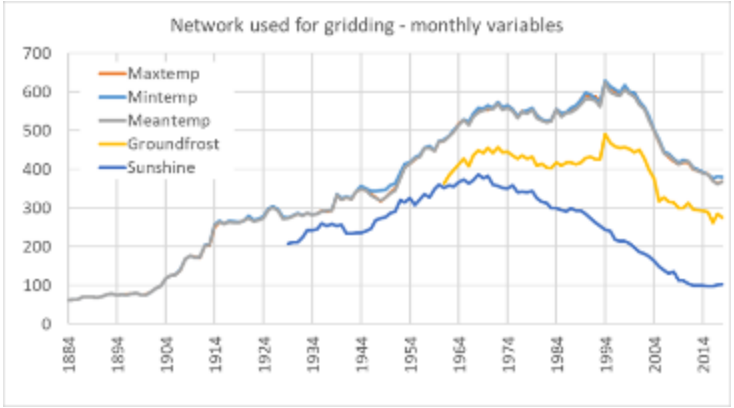
From observations to grids





Hollis, D., M. McCarthy, M. Kendon, T. Legg, I. Simpson, 2019: HadUK-Grid – A new UK dataset of gridded climate observations, Geoscience Data Journal, submitted.

How many stations?



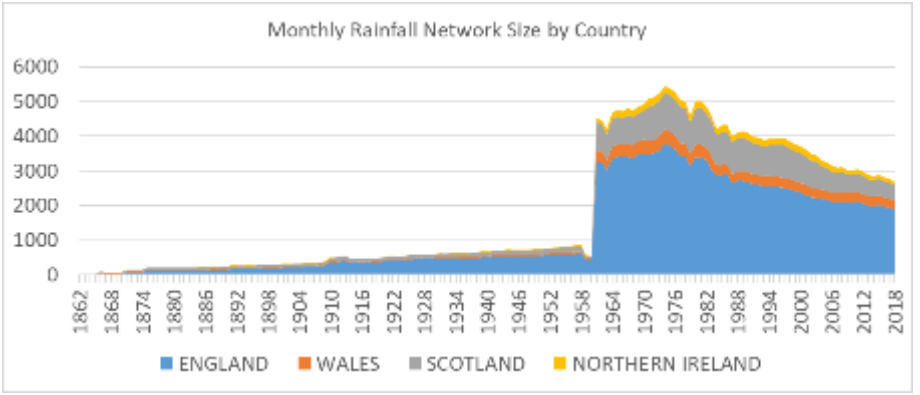
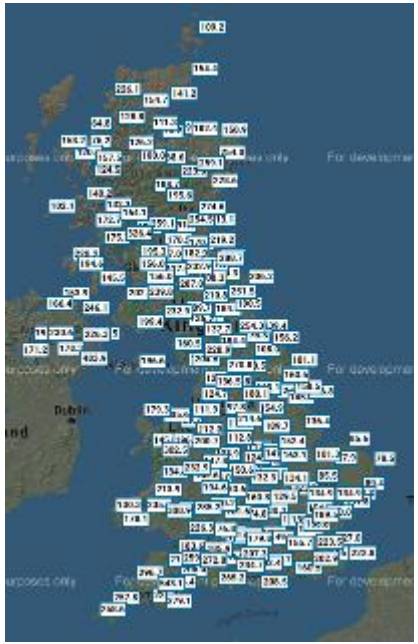


Table A1.2 Approximate total number of observations used for each variable

Climate variable	Number of years	Number of grids	Average number of stations per grid	Total number of station values
Monthly maxtemp	135	1620	360	580,000
Monthly rainfall	157	1884	1790	3,400,000
Monthly groundfrost	58	696	400	280,000
Monthly sunshine	90	1080	260	280,000
Daily maxtemp	59	21550	520	11,000,000
Daily rainfall	128	46750	1880	88,000,000

- Over 100 million observations used for HadUK-Grid_v1
- Midas database
- Digitized MWR DWR and British Rainfall

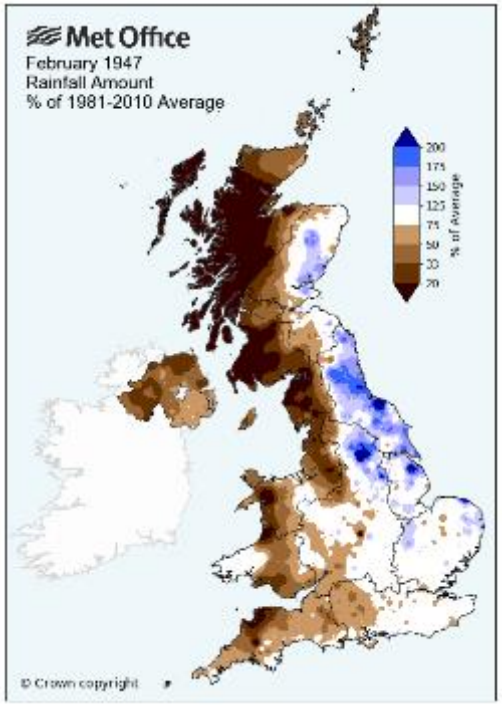
George Symons
1838 to 1900



Improved network coverage

Rainfall, February 1947, as per cent. of average

February 1947 anomalies – British Rainfall



February 1947 anomalies – HadUKGrid_v1

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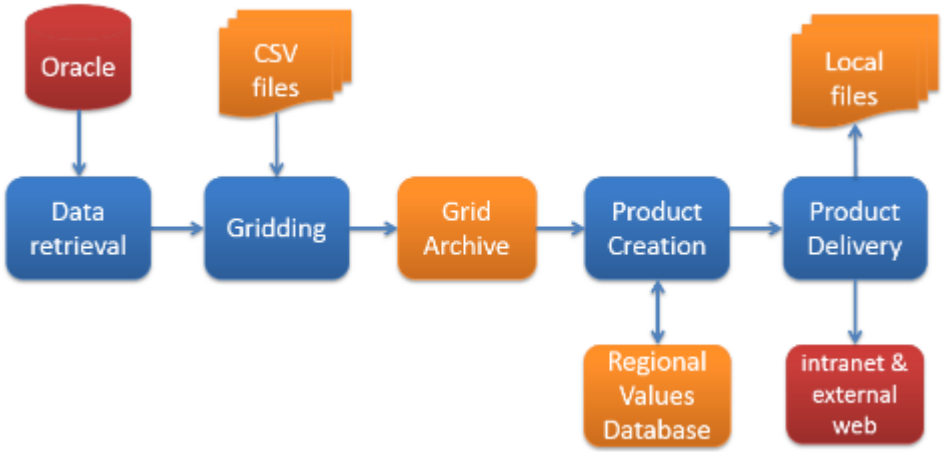
Climate Grid

- Software for creating national climate data products and services
- Portable, modular and traceable code base
- Toolkit for generation, exploration and visualisation of UK climate statistics



git

python

Iris 1.8

Python library for analysing and visualising meteorological and oceanographic data sets.

http://scitools.org.uk/iris/

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State of the UK Climate

- Summary statistics for year 2018 and most recent decade 2009-2018 against 1961-1990 and 1981-2010
- Key variables – temperature, precipitation
- Other variables – air and ground frost, energy demand and growing conditions, snow, sunshine, wind
- Near-coast sea-surface temperature and sea level rise (National Oceanography Centre)
- Atmospheric circulation (from reanalysis) and North Atlantic Oscillation (NAO) index
- Extremes and significant weather events
- Executive summary of key findings
- Annexes: methods, datasets, time-series, trends, uncertainty
- The report does **not** include attribution statements or future projections

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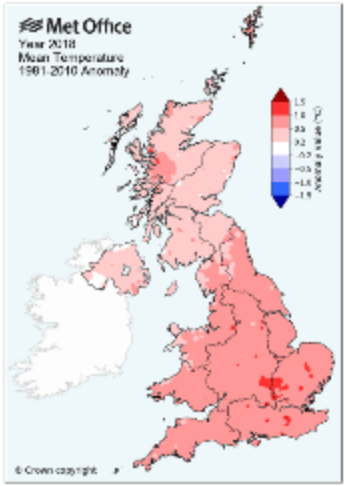
Temperature

- 2018 was seventh warmest year for the UK in a series from 1884



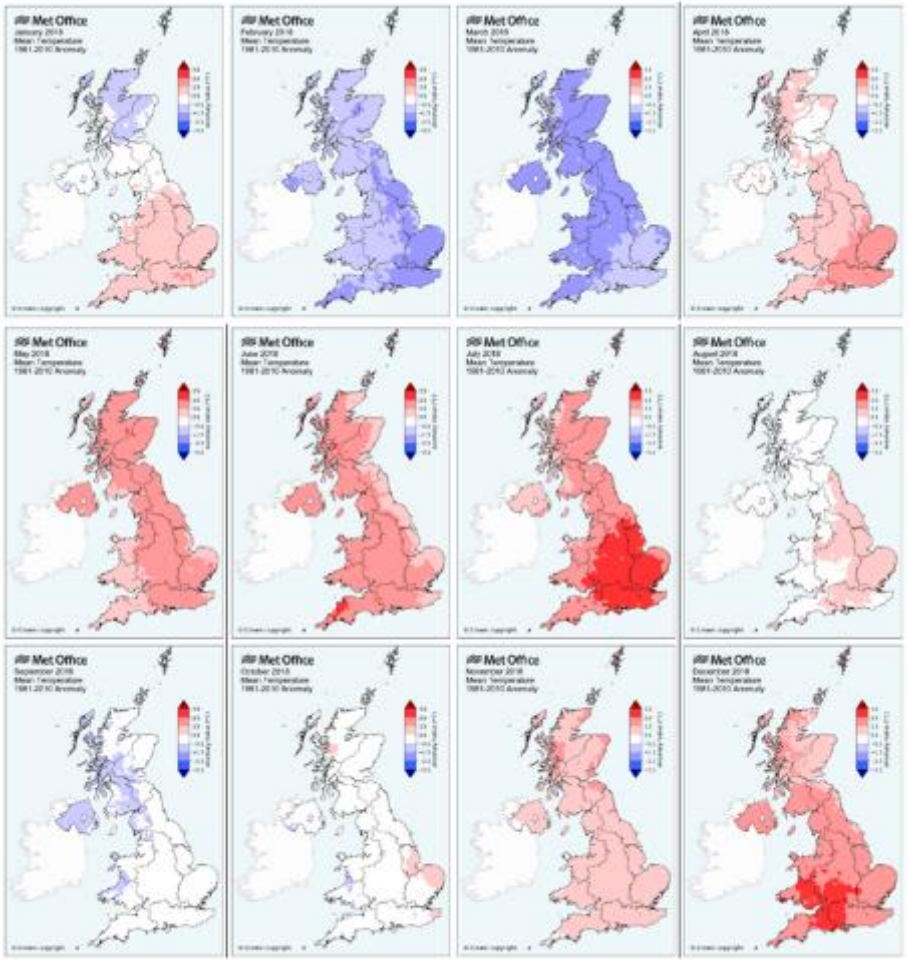


Figure 6: 2018 monthly average temperature anomalies (°C) relative to 1981-2010 average.

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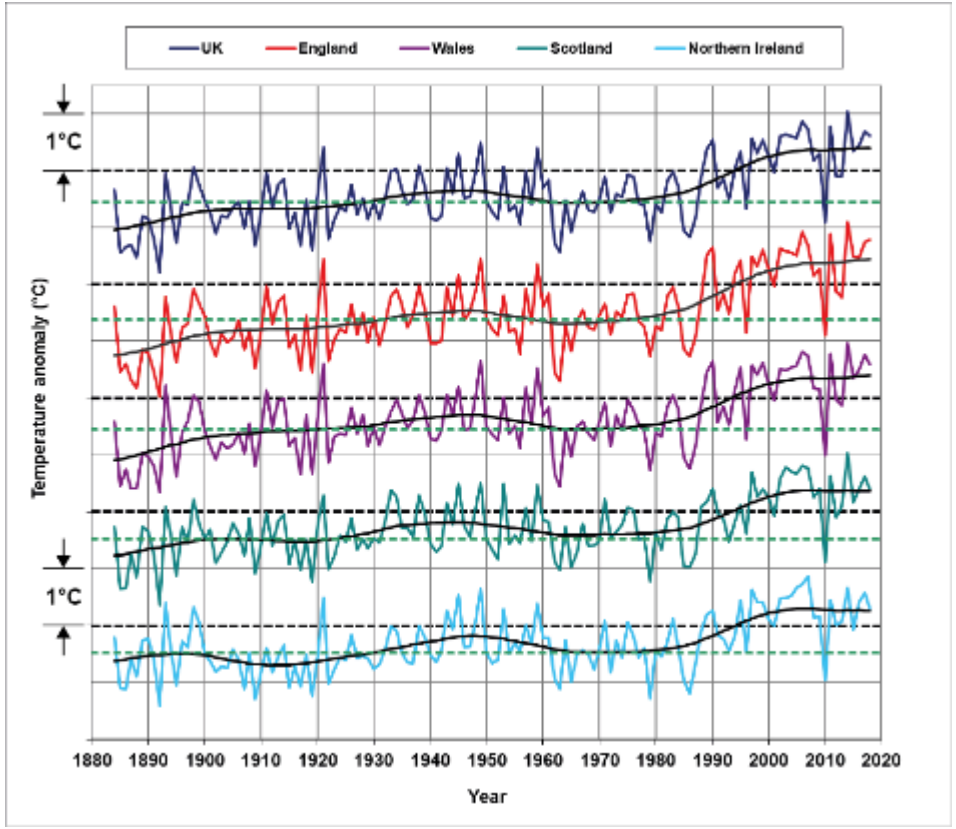
Temperature

- Top ten warmest years in series from 1884 have occurred since 2002
- The most recent decade (2009-2018) has been on average 0.3 °C warmer than the 1981-2010 average and 0.9 °C warmer than 1961-1990.

Area	1961-1990 average	1981-2010 average	2009-2018 average	2018
UK	8.3	8.8	9.2	9.5
England	9.0	9.7	10.0	10.4
Wales	8.6	9.1	9.4	9.7
Scotland	6.9	7.4	7.7	7.8
Northern Ireland	8.4	8.9	9.1	9.2



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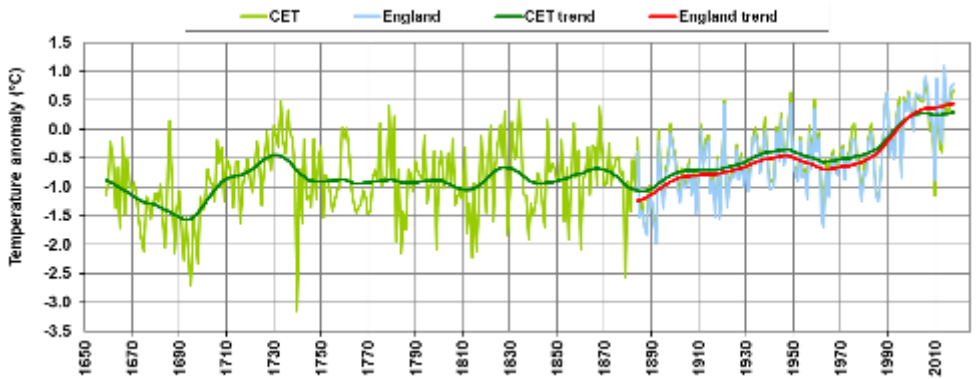
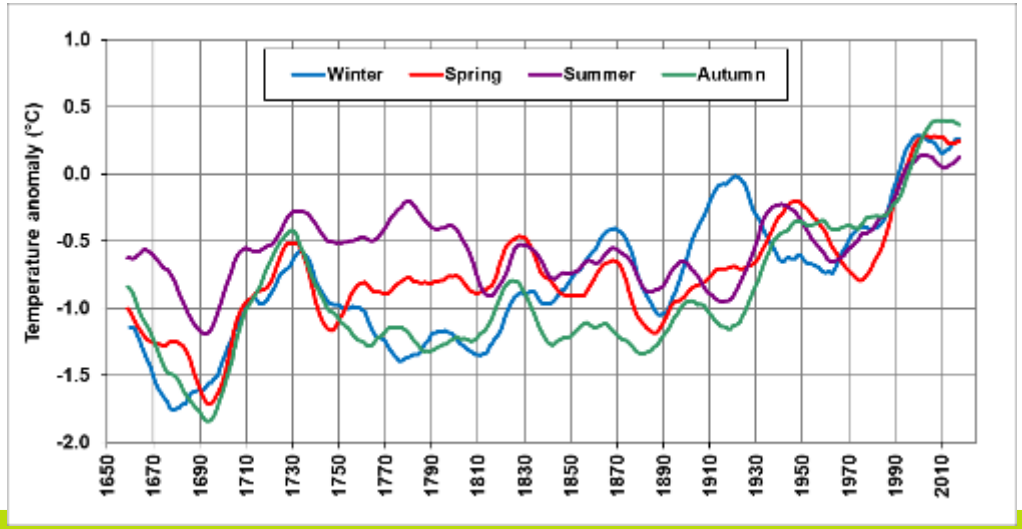
Temperature

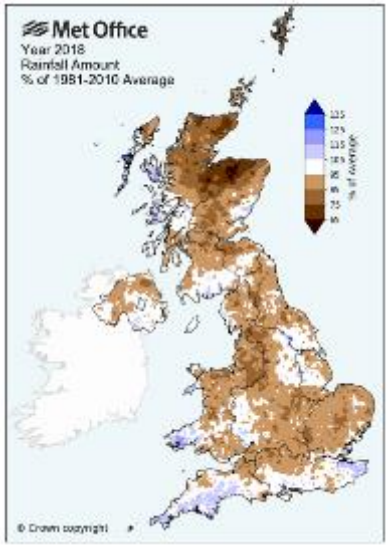
- The Central England Temperature series provides evidence that the 21st century so far has overall been warmer than the previous three centuries.





Precipitation

- 2018 precipitation was 92% of 1981-2010 average



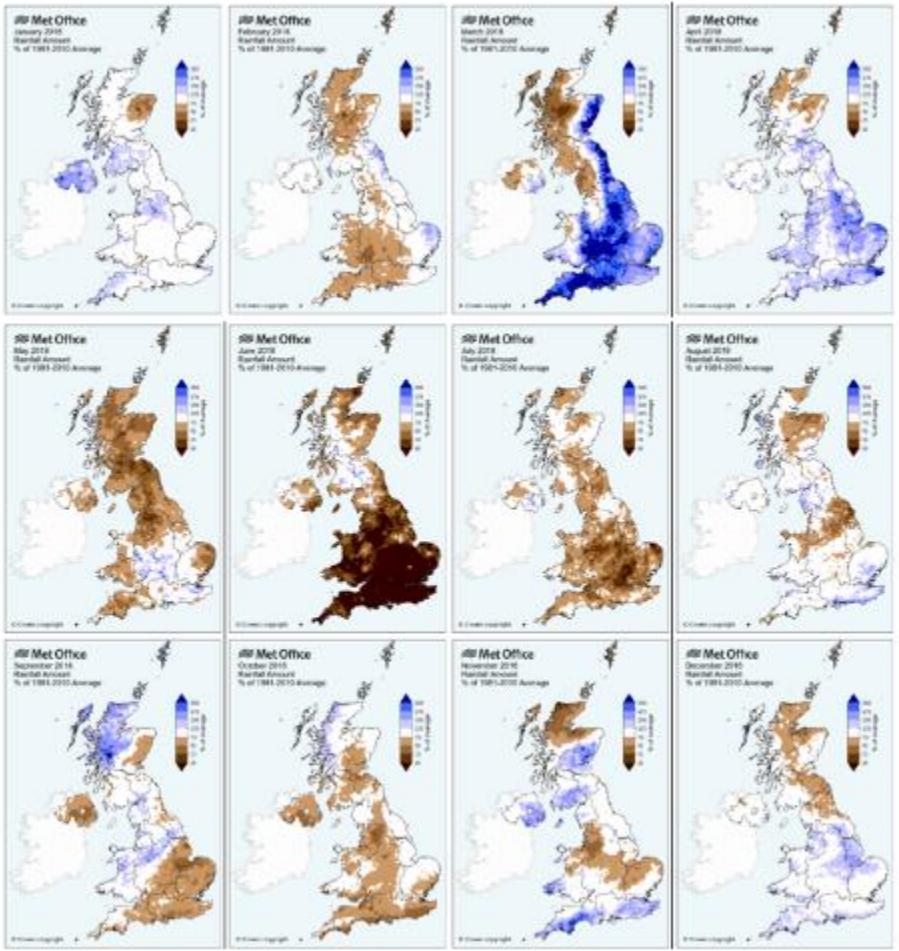


Figure 23: Rainfall anomalies (%) for months of 2018.

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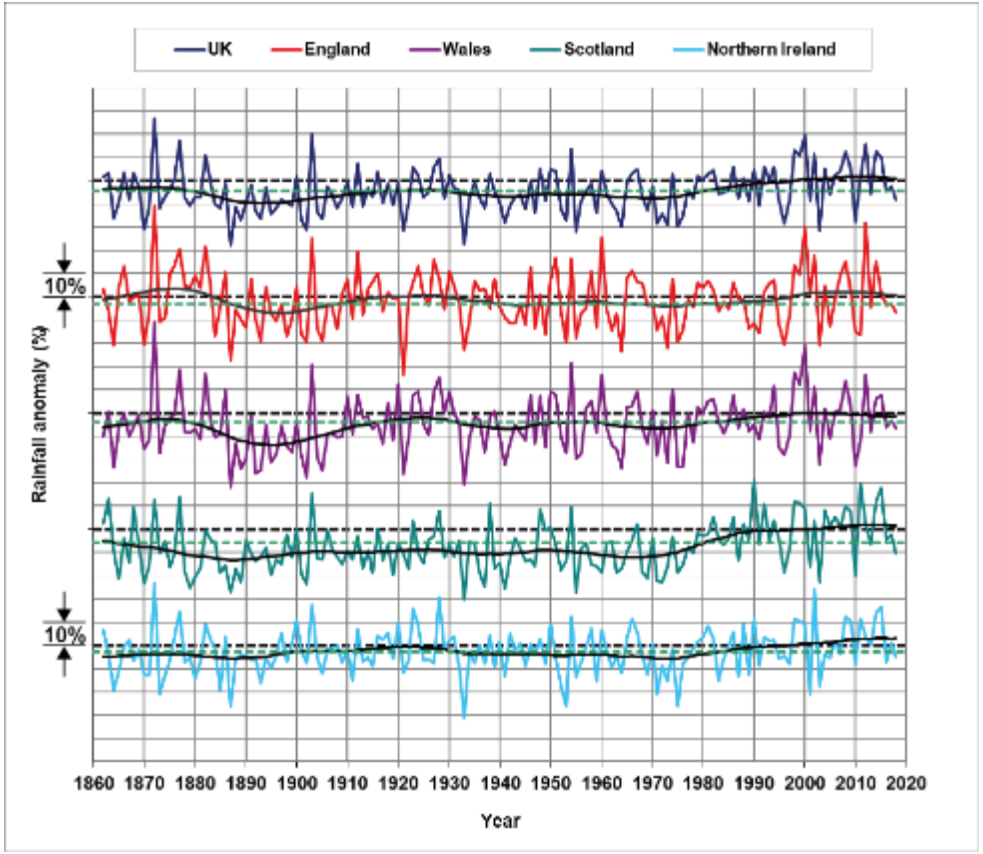
Precipitation

- Six of the ten wettest years for the UK in series from 1862 have occurred since 1998.
- For most recent decade (2009-2018) UK summers have been 11%/13% wetter than 1981-2010 and 1961-1990. UK winters have been 5% / 12% wetter.

Area	1961-1990 average	1981-2010 average	2009-2018 average	2018
UK	1100	1150	1158	1056
England	827	853	855	796
Wales	1402	1459	1421	1366
Scotland	1470	1562	1585	1398
Northern Ireland	1099	1133	1176	1076



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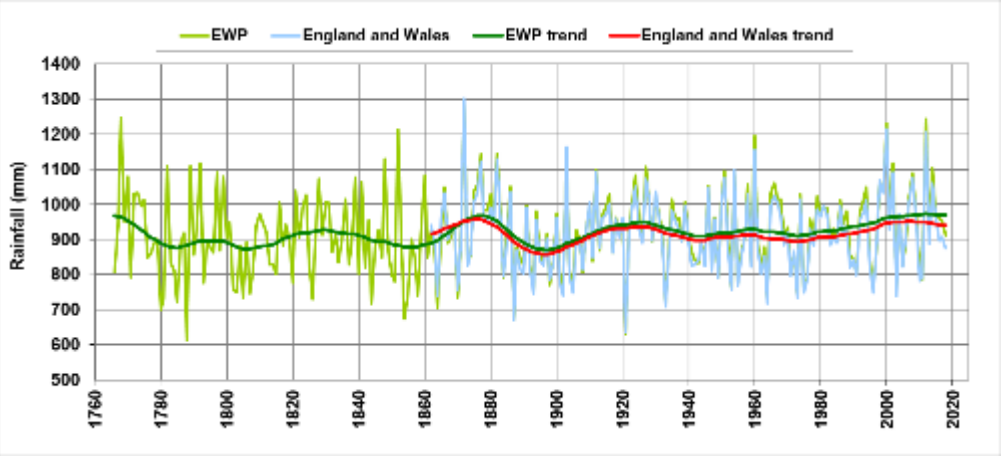
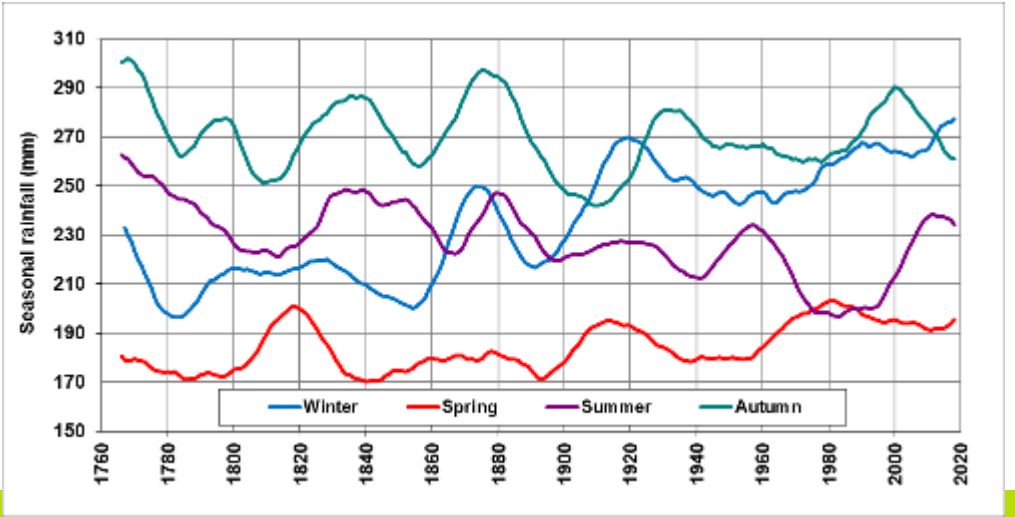
Precipitation

- England and Wales series shows large annual variability about stable long-term mean
- Notable fluctuations eg ‘long drought’ 1890 to 1910 and wet period in 1870s
- In 20th century winter rainfall has increased to be broadly equivalent to autumn rainfall
- Summer rainfall has declined but note sensitivity to start and end dates
- Uncertainties in EWP winter and summer series in the 18th and 19th centuries





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Key Findings

- Air and Ground Frost (falling)
- Heating/cooling degree days (falling/rising)
- Growing degree days (rising)
- Heavy rainfall (rising)
- Sunshine (increasing in winter/spring)
- Snow (declining)
- Wind (no clear signal)
- Coastal waters (warming)
- Sea level (rising)

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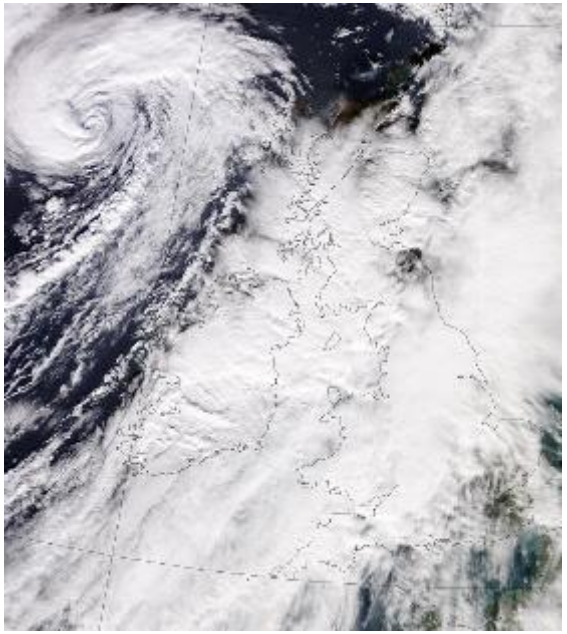
Monitoring the UK's climate

- Traceability
- Reproducibility
- Scientific Integrity
- Data
- Modern technology

Lying snow in Exeter on 18 March 2018



Visible satellite image of Storm Callum on 12 October 2018

Questions and feedback

- How would/do you use the report?
- What do you like and why?
- What do you dislike and why?
- Feedback to ncic@metoffice.gov.uk

Once in a lifetime ice-climbing challenge with an approach on skis?

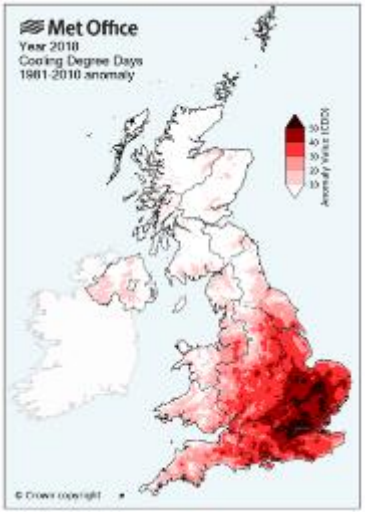
High Force, Upper Teesdale, frozen in winter 1963

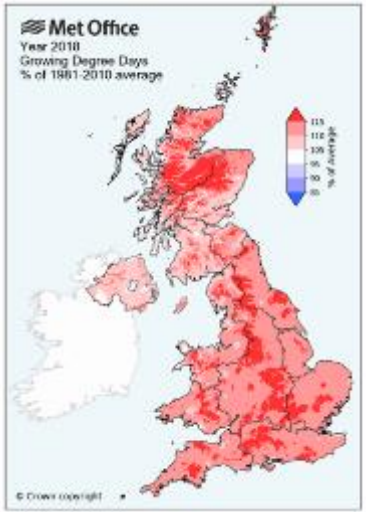
from http://www.northpennines.org.uk/

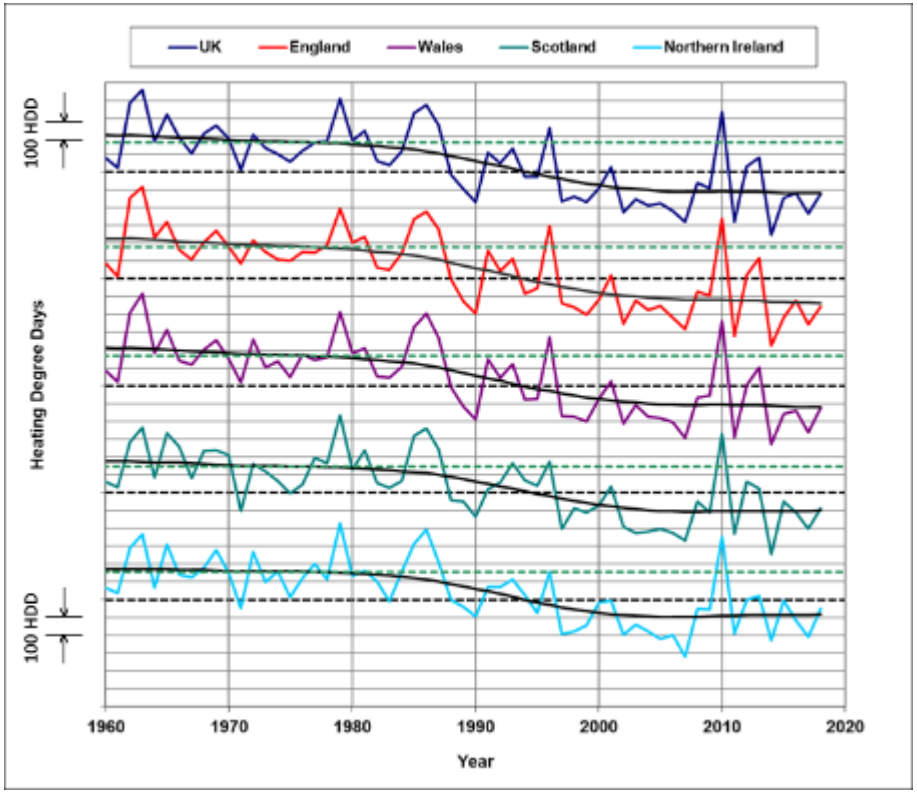
High Force frozen, 1963. Photo: Maurice Tarn

Degree Days

- HDD falling, GDD rising
- CDD third highest behind 1976 and 1995







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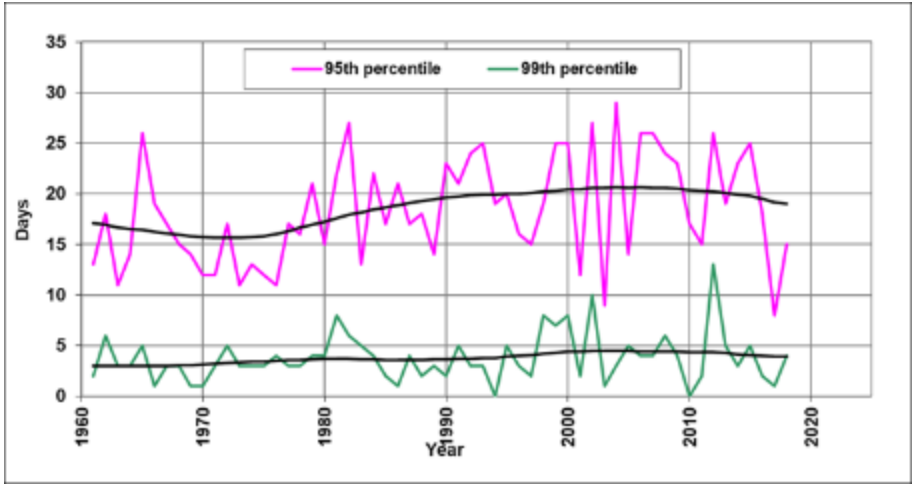
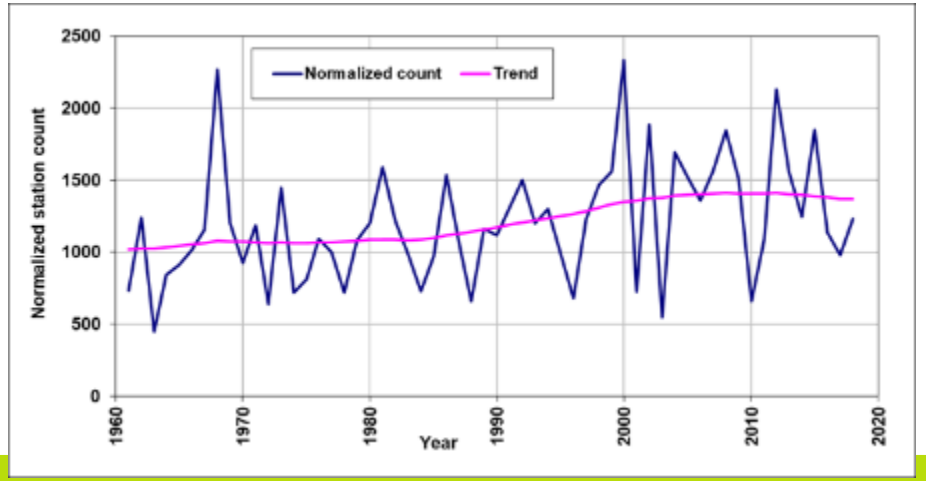
Heavy Rainfall

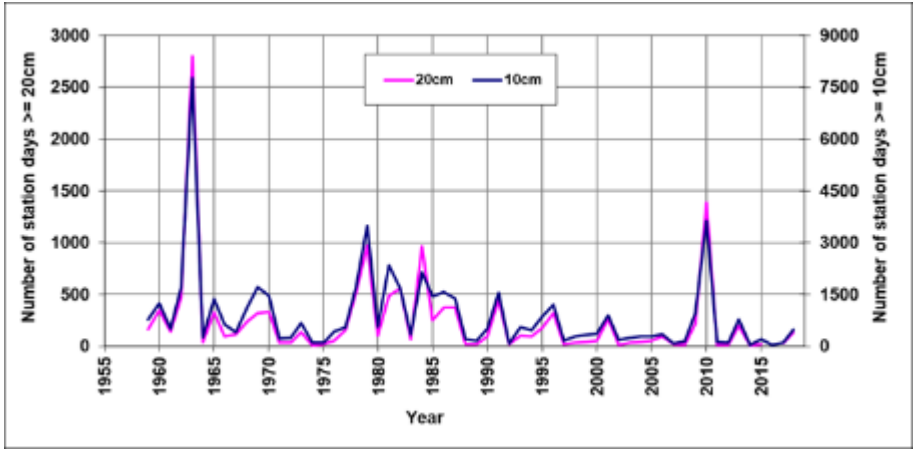
- Alternative metrics for heavy rainfall and rainfall intensity
- Adopt percentile and absolute threshold approaches
- Relatively short time-series with large annual variability
- Caveats are important
- Nevertheless, alternative metrics suggest an increase in heavy rainfall

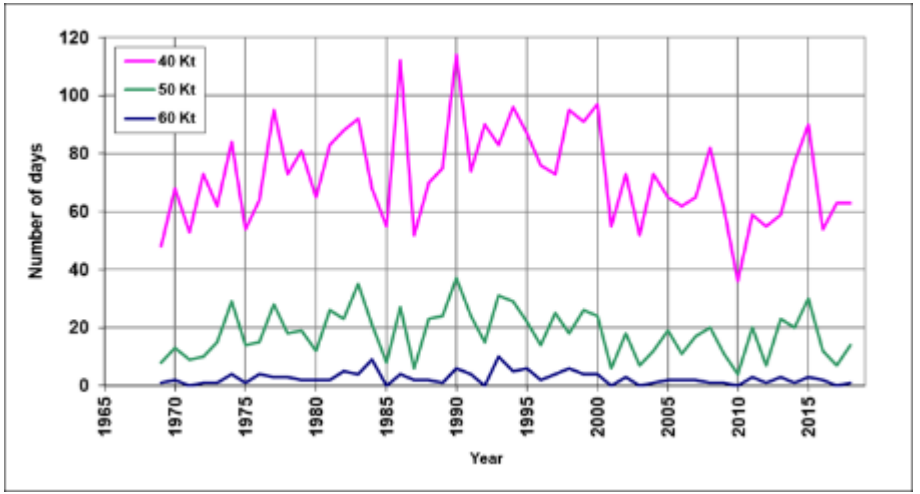




Snow and Wind

- Widespread and substantial snow events have occurred in 2018, 2013, 2010 and 2009
- Their number and severity has generally declined since the 1960s
- Ten named storms affected the UK in 2018
- There are no compelling trends in storminess over the last five decades

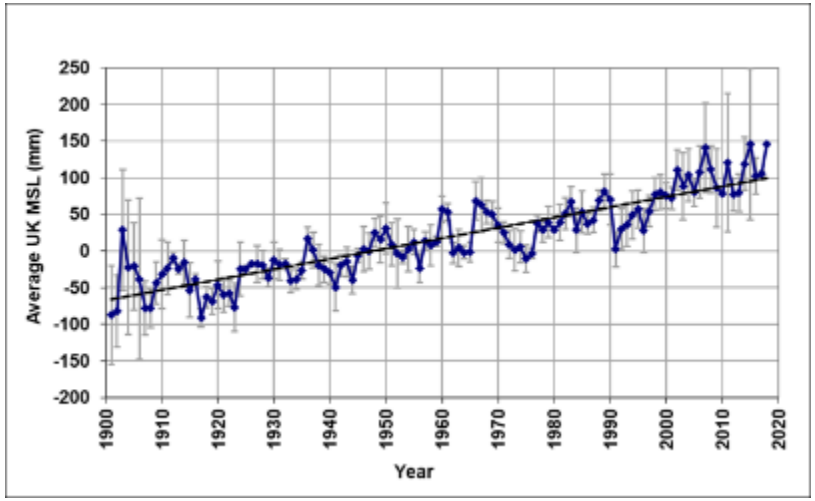


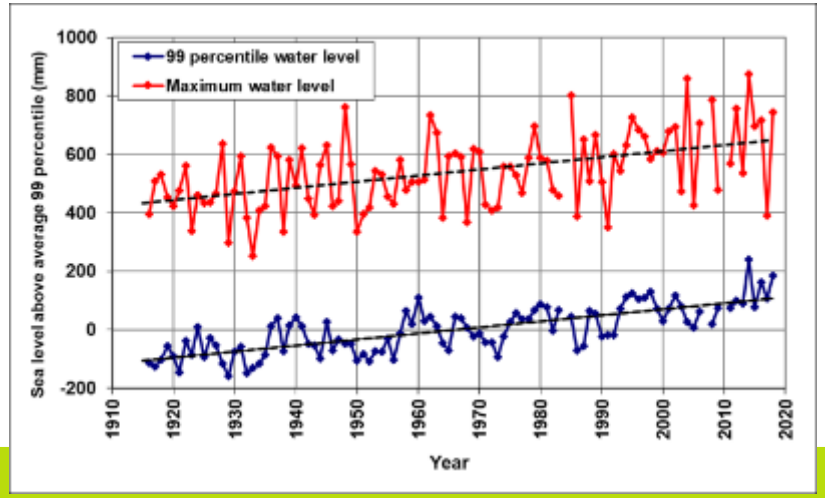


Sea Level

- Mean sea level around the UK has risen by approximately 1.4mm/yr from the start of the 20th century, excluding vertical land movement
- The 99th percentile water level at Newlyn, Cornwall for year 2018 was second highest in a series from 1916

Thanks to Svetlana Jevrejeva and Andrew Matthews, NOC





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Significant Weather

- Snow and low temperatures Feb-Mar 2018
- Exceptional warmth April 2018
- Warm, dry, sunny summer 2018
- Strong winds – Storm Ali
- Heavy rain across south Wales – Storm Callum

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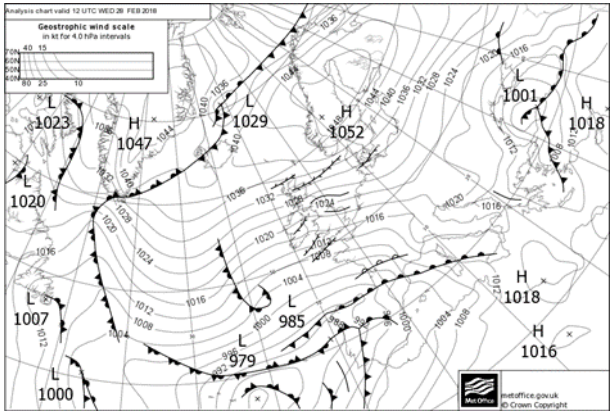
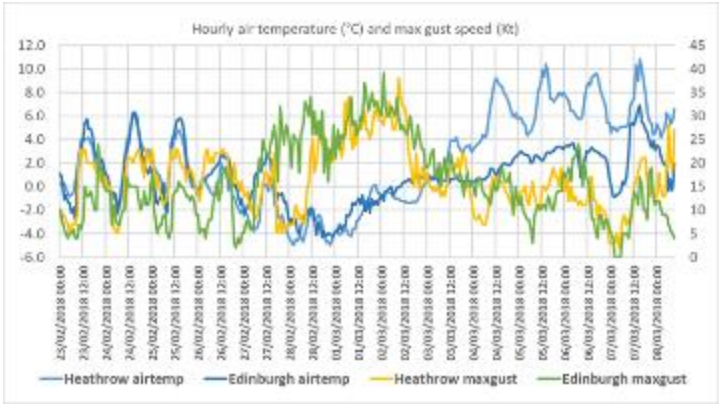
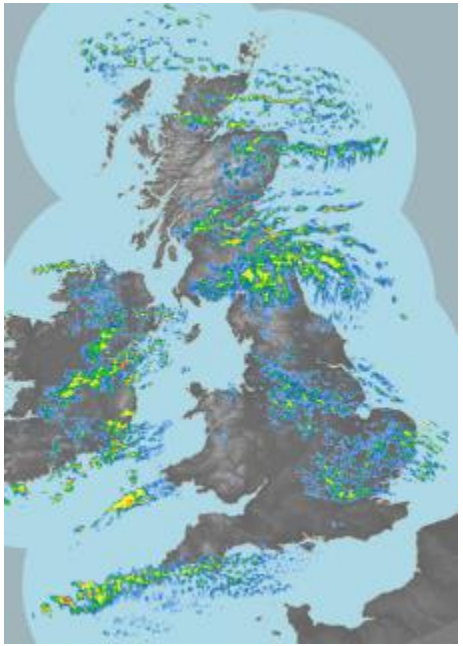
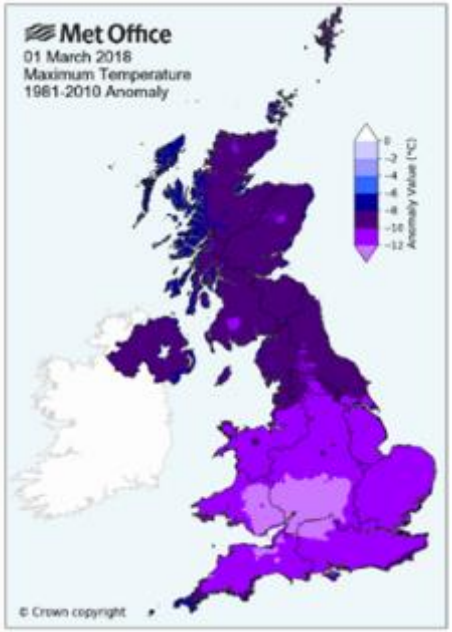
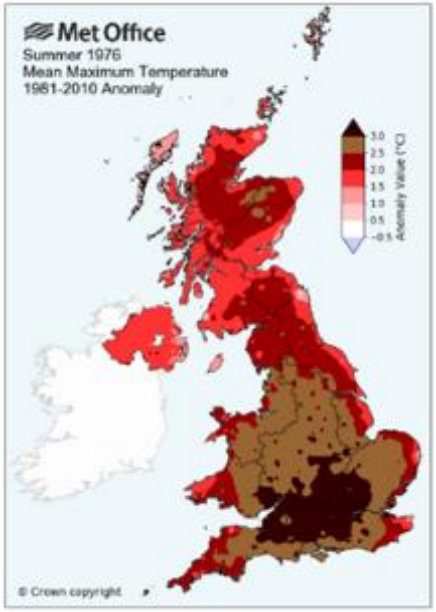


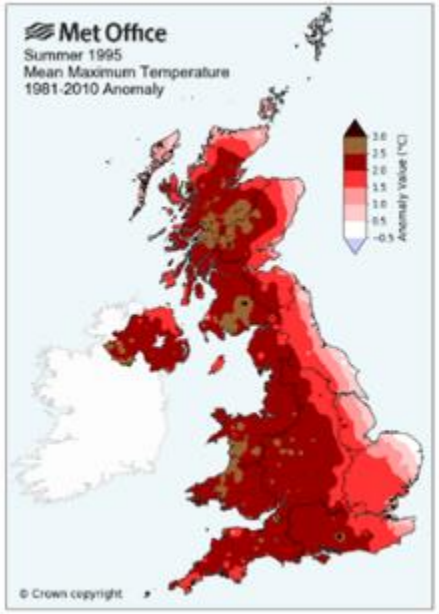


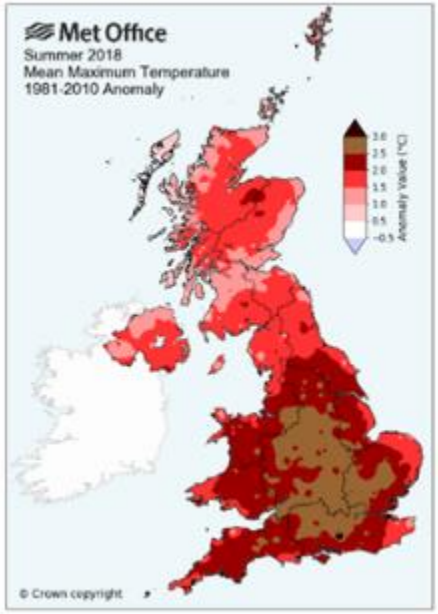


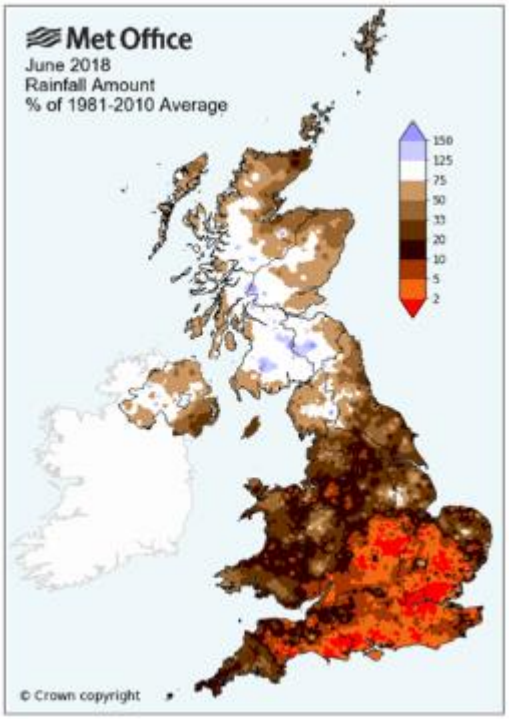


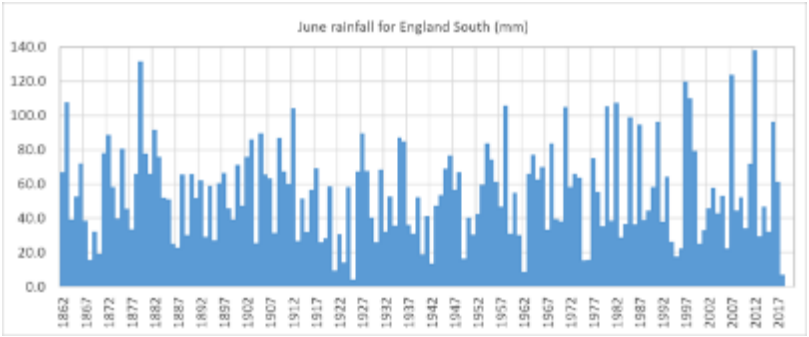
- Two Red Warnings for Snow
- Wind chill temperatures widely -10 °C
- New March record lowest maxtemp -4.7 °C
- Most significant severe winter weather since Dec 2010



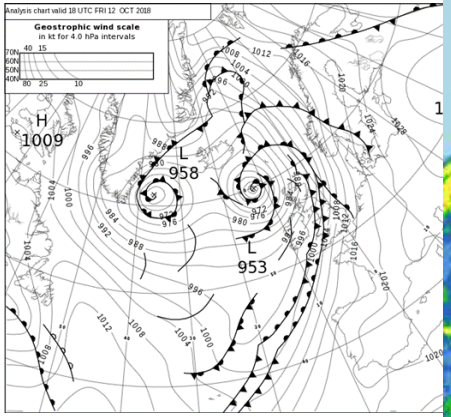


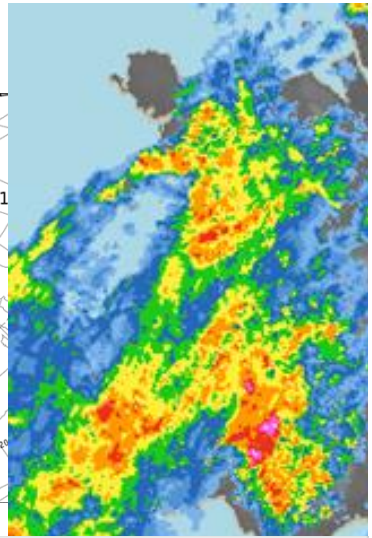


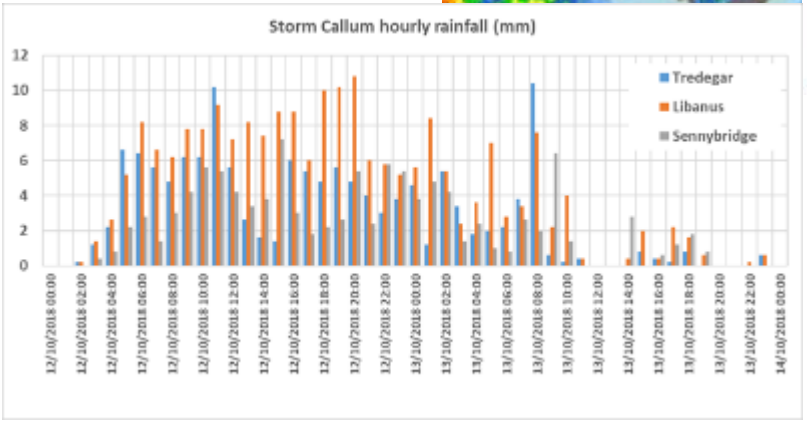


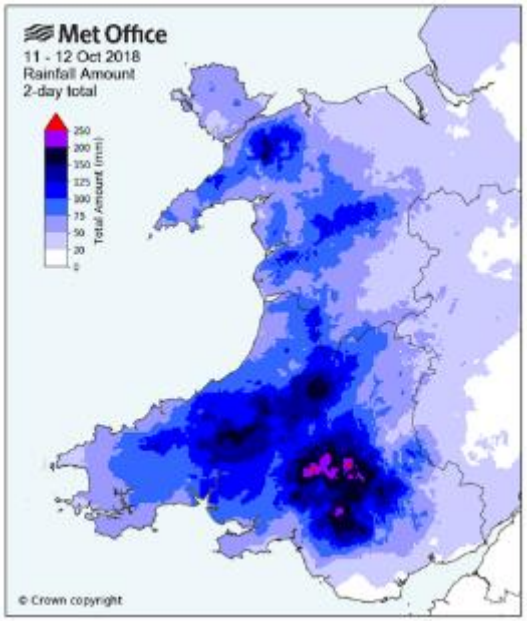


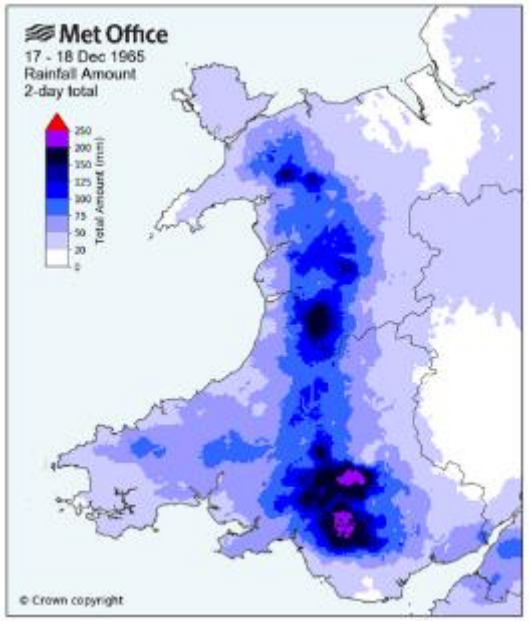
- UK's warmest summer since 2006
- UK's driest and sunniest summer since 1995
- Driest June for southern England since 1925











- 202mm in 34 hours at Libanus, Powys
- 200 to 250mm for 11 to 12 Oct 2018 across Brecon Beacons
- One of the most significant notable extreme rainfall events across South Wales in last 50 years

Atmospheric circulation

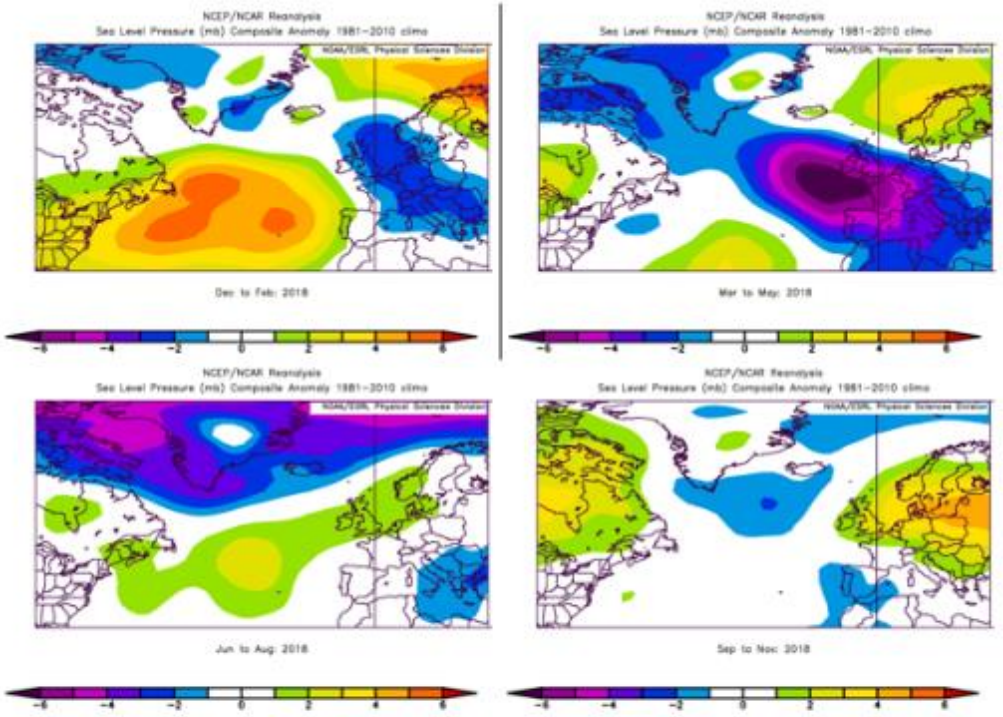
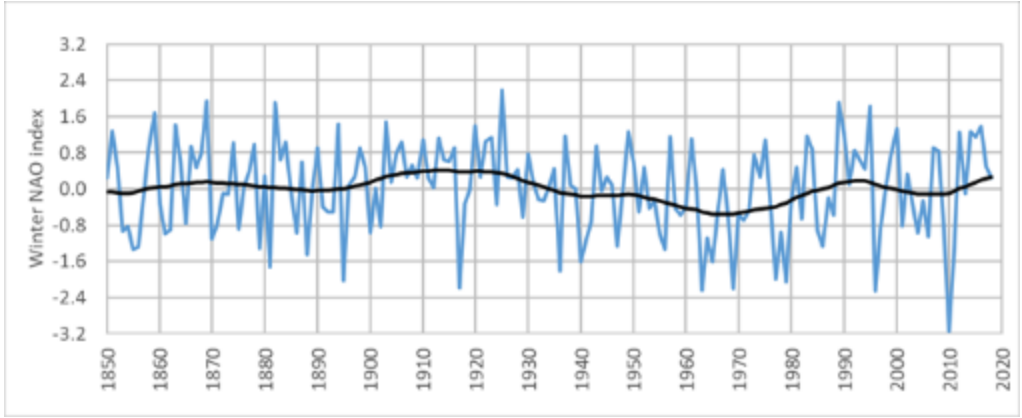


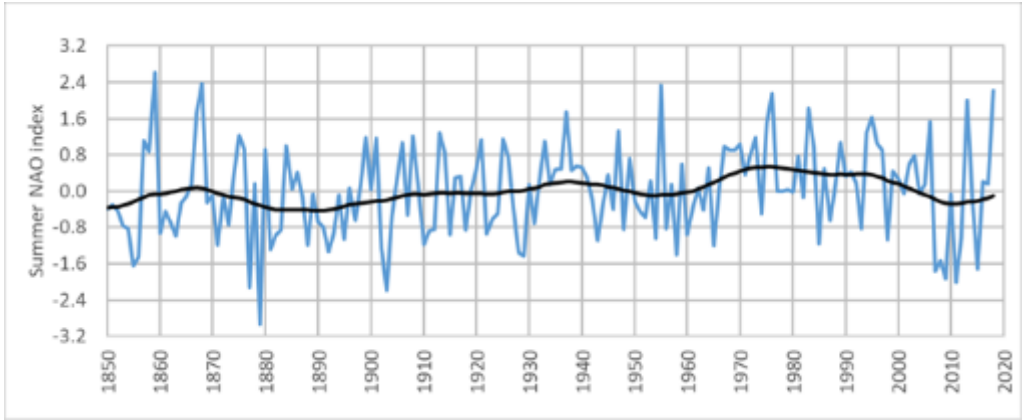
Figure 1: 2018 seasonal mean sea-level pressure anomalies (hPa, relative to 1981-2010 average). Winter refers to the period December 2017 to February 2018. Note that winter 2019 (December 2018 to February 2019) will appear in State of the UK Climate 2019. Images provided by the NOAA-ESRL Physical Sciences Division, Boulder, Colorado from their web site at http://www.esrl.noaa.gov/psd/

Met Office Hadley Centre

NAO index

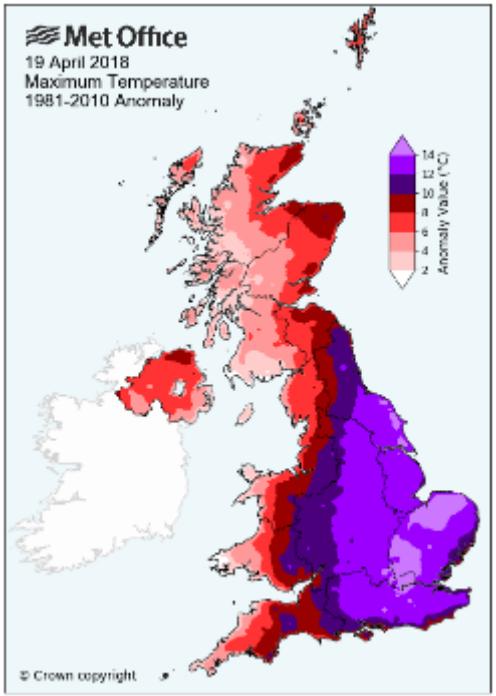
- Positive winter NAO associated with higher temperatures and higher rainfall
- Explains half variability in UK temperature and a quarter in UK rainfall
- Positive summer NAO associated with higher temperatures and lower rainfall
- Explains a quarter of variability in UK temperature and over a half in UK rainfall





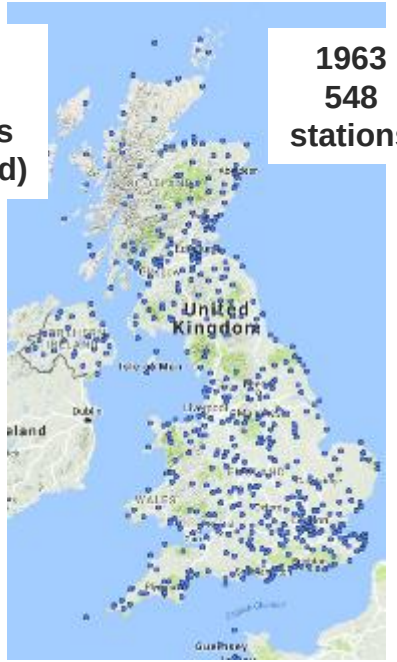
Gridding of climate data

- Ability to produce area-average values
- Largely unaffected by changes in weather station network
- Consistent series allowing comparisons in space and time
- Complete series with no gaps (which weather stations are prone to)
- Ability to produce maps and products (eg area-average or point values)
- Provision of data to users for other applications (eg hydrology, energy etc)



UK weather station network (automatic and manual)

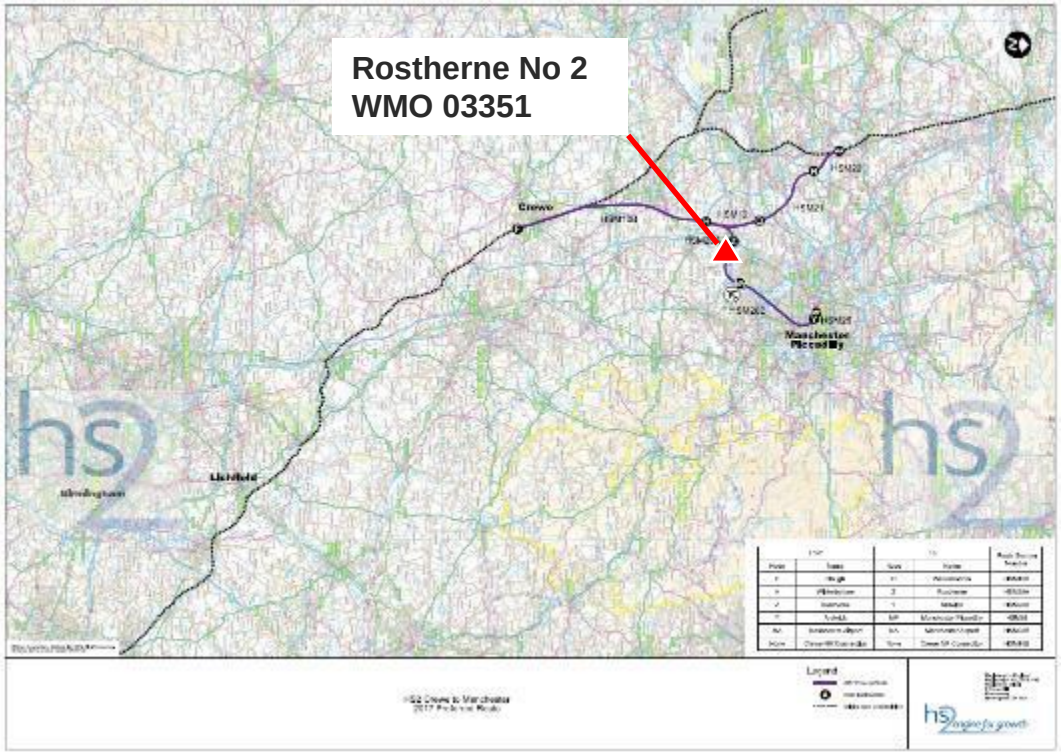
1947
120
stations
(digitized)



1963
548
stations

2018
416
stations

Why does the network change?



Observations priorities:

- Long-running stations
- Network coverage
- Quality of observations

but …

- Station exposure issues
- Lease agreement ends
- Change of land use
- Maintenance issues
- Access for power / comms
- Volunteer observer retires
- Etc …