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Climate Change Technical Report for Herefordshire

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Report information

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Disclaimer: This report represents the independent advice commissioned by Sustainability West Midlands and partners and not necessarily that of the funders.

About Sustainability West Midlands

Sustainability West Midlands (SWM) was established in 2002 as an independent, not-for-profit company and is the sustainability adviser for the leaders of the West Midlands.

Our vision is that the West Midlands is leading in contributing to the national target of net zero greenhouse gas emissions by 2050 whilst addressing health inequality and driving inclusive growth. We monitor the West Midlands Sustainability 2030 Roadmap which acts as a framework that all organisations based or operating in the region can use to help them make changes to their activities in the knowledge that they will contribute to wider regional ambition.

SWM's support our members and other local stakeholders in the public, private and third sectors to implement these changes by enabling them to demonstrate innovation and leadership and provide opportunities to collaborate and celebrate success.

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Contents

1 Introduction

Sustainability West Midlands (SWM) has been commissioned by Herefordshire Council to carry out the following:

- An analysis of how severe weather has impacted on the county over the last 15 years, who has been affected and how events have been dealt with.
- An analysis of how the climate is likely to change in Herefordshire up to the end of this century (this report).
- The development of a climate change risk register that sets out the key climate related risks the county is likely to face.
- The production of a climate change adaptation plan, aimed at providing a series of actions that should be considered for implementation by decision makers in Herefordshire, to ensure that the county's natural environment, people, infrastructure, buildings and businesses are prepared for the impacts of climate change. This is the primary output, informed by the previous analyses listed above.

The core objective is to ensure that Herefordshire can better manage, prepare for and respond to severe weather events and the increasing likelihood and intensity of these in future.

1.1 Purpose of this document

The purpose of this report is to analyse how the climate may change in Herefordshire in the next 70+ years, up to 2100. It uses the UK Climate Projections 2018 (UKCP18) to look at future projected trends, and other sources of data to determine how weather impacts, such as those documented in the accompanying Severe Weather Impact Assessment, may change in frequency and severity. Such impacts include heavy rainfall and subsequent flooding, heatwaves, droughts, storms and overall climatic variations. Various datasets are available in Excel format for any readers wishing to access more detail.

This report provides:

- A contextual overview of how the UK climate is changing
- An overview of UKCP18
- The findings of the above for Herefordshire

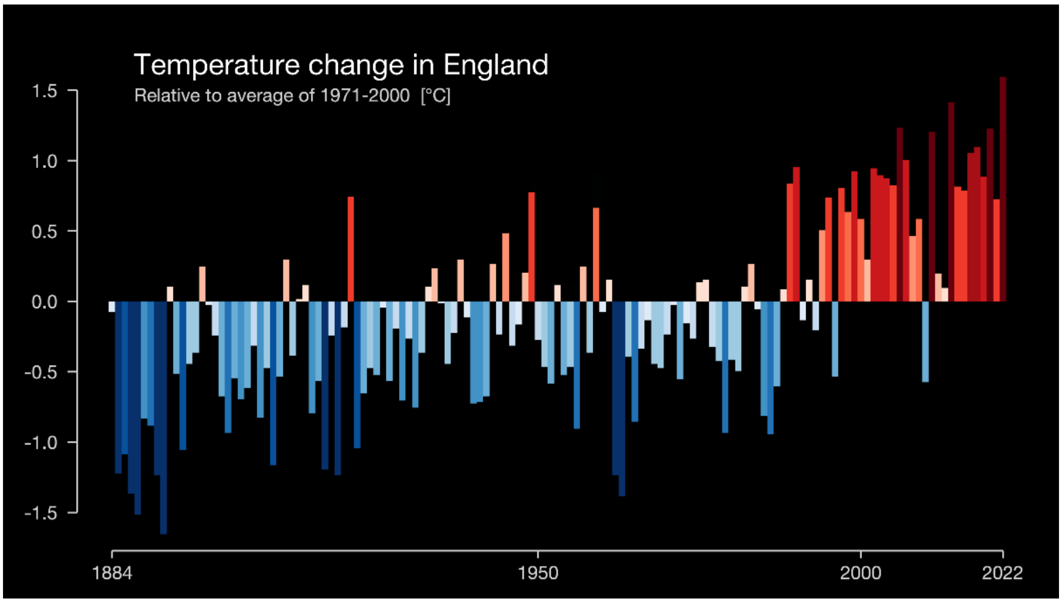
2 The Changing UK Climate

Weather data are collected and analysed by the Met Office using hundreds of weather stations scattered across the UK. Alongside climate modelling tools and satellite analysis, the Met Office can paint an accurate picture of weather observations and trends across the UK over many decades.

Through this analysis, it can therefore be observed that in the decade 2008-2017, the UK has been on average 0.3°C warmer when compared to the 1981-2010 average and 0.8°C warmer than 1961-1990. All of the top ten warmest years have occurred since 1990. Figure 1 illustrates the average temperature change across England very clearly.

Globally, July 2023 is thought to have been the hottest month ever in the 120,000 years since the Eemian interglacial period. Overall, the global climate has already warmed by around 1°C since the 1850s. In the UK 2022 was the warmest year on record, and the first year in which a temperature above 40°C (104F) was recorded.

Figure 1: Temperature change in England



Winters in the UK in the decade 2009-2018, have been on average 5% wetter than the period 1981-2010 and 12% wetter than 1961-1990. According to the Met Office, summers in the UK have also been wetter, by 11% and 13% respectively. However, very long-period natural variations are also seen in the longer observational record. These show periods in earlier parts of the historical record with similar levels of UK summer rainfall to 2009-2018, illustrating the importance of considering long-period natural variations.

However, it is clear through these observations that the UK's climate is changing already and the concept of 'climate change' is no longer 'something that may happen in future.' Nationwide observations and concurrent impacts show that the UK and Herefordshire need to be prepared for 'a new normal.'

3 Future Climate Projections

As summarised in the previous section, the global climate has already warmed by around 1°C since the 1850s, and further warming is expected in the future. The consequences of this globally are already being seen through impacts such as more extreme heatwaves and flooding events. The UK and Herefordshire will also be affected as warming continues.

This section outlines how the climate may change globally, nationally and in Herefordshire, depending on a range of scenarios.

3.1 Introduction to UKCP18

The UKCP18, developed by the Met Office and other scientific partners, is a set of tools and data that show how the UK climate may change in the future. It uses cutting-edge climate science to provide updated observations and climate change projections out to 2100. It also provides a user interface, allowing practitioners to interrogate future climate scenarios for specific locations of the UK to paint a clearer picture on how climate change could affect the area, helping to inform decision making and adaptation options, such as those outlined in the accompanying Herefordshire Climate Change Adaptation Plan.

3.2 Emissions scenarios

The extent of further warming we could avoid depends on our ability to cut greenhouse gas emissions. However, we now know that some further warming is already inevitable due to historical emissions. Beyond that, there are a range of different possible pathways of future warming, depending on how successful we are at cutting emissions on a global scale.

UKCP18 uses emissions scenarios, called Representative Concentration Pathways (RCPs), to provide a range of future climate scenarios for the UK, depending on our global efforts to reduce greenhouse gas emissions. RCPs are the emissions scenarios used by the world's leading climate scientists, such as the authors of the Intergovernmental Panel on Climate Change (IPCC) latest 5th Assessment Report.

RCPs specify the concentrations of greenhouse gases that would result in target amounts of radiative forcing at the top of the atmosphere by 2100, relative to pre-industrial levels. Four forcing levels have been set: 2.6, 4.5, 6.0 and 8.5 W/m2, as shown in Figure 2.

RCP	Increase in global mean surface temperature (°C) by 2081-2100
RCP2.6	1.6 (0.9-2.3)
RCP4.5	2.4 (1.7-3.2)
RCP6.0	2.8 (2.0-3.7)
RCP8.5	4.3 (3.2-5.4)

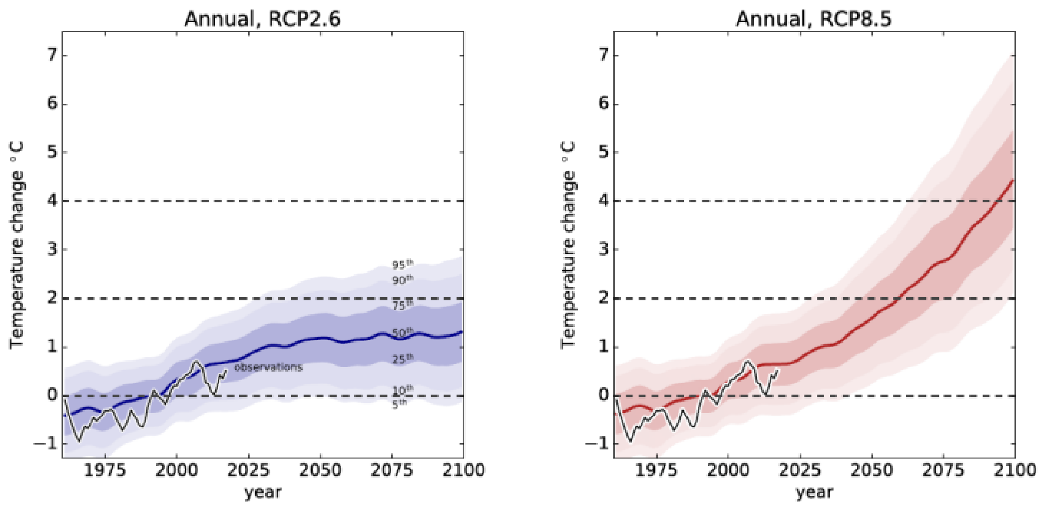
Figure 2: The increase in global mean surface temperature averaged over 2081-2100 compared to the pre-industrial period (average between 1850-1900) for the RCPs (best estimate, 5-95% range).

What this means in reality is as follows:

- RCP2.6 represents a future in which the world aims for and can implement sizeable reductions in emissions of greenhouse gases. Many studies show that following this scenario would give a sizeable chance of limiting global average warming to near 2°C above pre-industrial levels.
- RCP4.5 is described by the IPCC as an intermediate scenario. Emissions in RCP4.5 peak around 2040, then decline.
- RCP6.0 is also an intermediate scenario where emissions peak around 2080 then decline. The RCP6.0 scenario uses a high greenhouse gas emission rate and is a stabilisation scenario where total radiative forcing is stabilised after 2100 by employment of a range of technologies and strategies for reducing greenhouse gas emissions.
- In contrast, RCP8.5 represents a world in which global greenhouse gas emissions continue to rise. It is a potential future where the nations of the world choose not to switch to a low carbon future. The temperature increases associated with this are much higher than RCP2.6 and it is often used to illustrate a "worst case scenario".

The scenarios each follow different pathways. For example, in the RCP2.6 scenario, the fastest rate of change takes place in the near future. In the RCP8.5 scenario, the fastest rate of change occurs at the end of the century. However, there is a high degree of similarity between the scenarios over the next couple of decades, as shown in Figure 3.

Figure 3: UK temperatures, observed and projected, for RCP2.6 and RCP8.5



3.3 Spatial scale

UKCP18 uses a range of scales, the most suitable of which for this study are the probabilistic projections, which are set out in 25km grid squares and typically provide the most comprehensive range of potential future changes for key UK climate variables and global average temperatures. They are seen as the primary tool for assessments of the ranges of uncertainties in the UK's future climate, and are the scale and spatial resolution recommended for risk assessments at a more local level. For a given emissions scenario, they provide information on known uncertainties in future climate changes. The UKCP18 User Interface allows for the interrogation of a range of future climate scenarios within any of the 25km grid squares. We have analysed the grid squares that cover the majority of Herefordshire to identify future climate changes that may take place in the county.

Four of the 25km grid squares cover the majority of Herefordshire. For the purposes of this study they are referred to as A, B, C and D (see figures 4a and 4b). Their British National Grid (OSGB) coordinates are:

A. 337500.00, 262500.00
B. 362500.00, 262500.00
C. 337500.00, 237500.00
D. 362500.00, 237500.00

Figure 4a: The four 25km grid squares that cover the majority of Herefordshire, including the county boundary

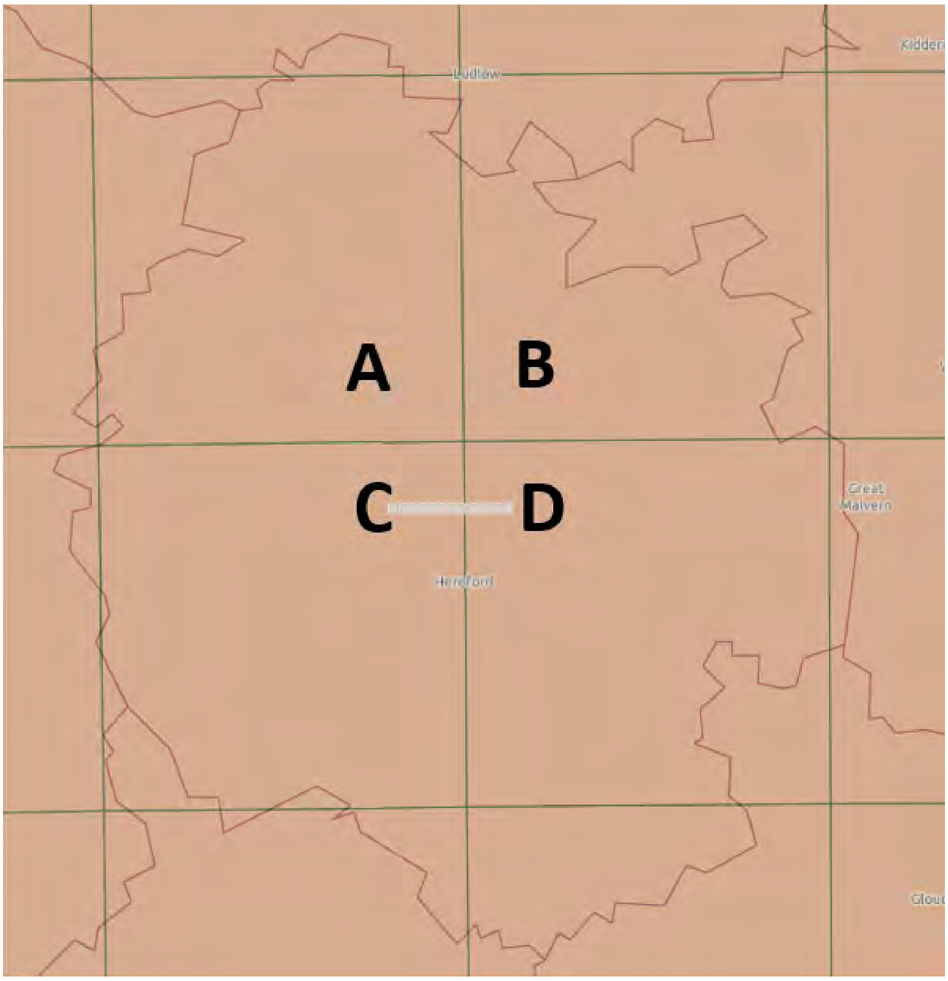
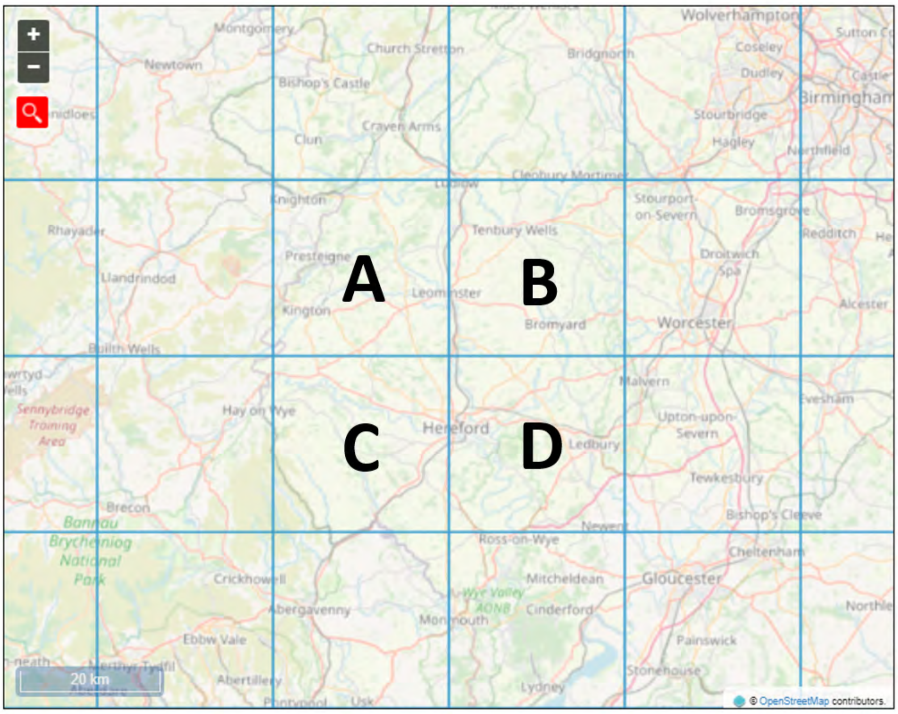


Figure 4b: The four 25km grid squares that cover the majority of Herefordshire, including the boundary layer map



3.4 Probability and Climate Projections

For each emissions scenario within each 25km grid square, probabilistic projections can provide local low, central and high changes, by using 5%, 50% and 95% probability levels. The probability levels show the probability of a change being less than the associated climate variable value. An example is provided in the box below.

If a temperature change is stated to be '2.5°C at the 95th percentile,' that means there is 95% probability that the actual temperature change seen will be less than 2.5°C. The 95th percentile is therefore usually used to demonstrate the extreme end of any scenario.

If a change is stated to be '+3mm of precipitation at the 50th percentile,' that means there is a 50% probability that the actual change in precipitation seen will be less than 3mm. The 50th percentile is therefore usually used to demonstrate the medium change in any scenario.

If a change is stated to be '0.7°C at the 10th percentile,' that means there is only a 5% probability that the actual change in temperature seen will be less than 0.7°C. The 5th percentile is therefore usually used to demonstrate the lowest/most conservative aspect of any scenario.

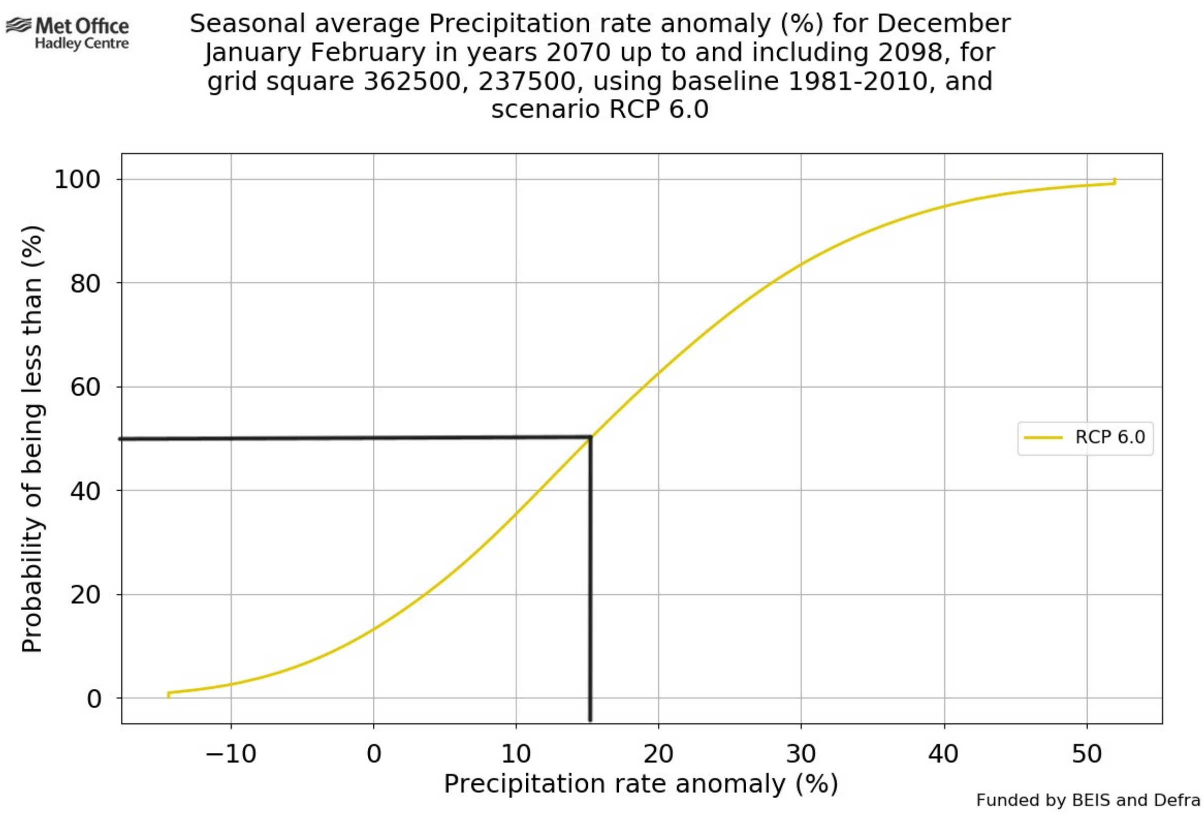
These probabilities can be generated via the UKCP18 User Interface, with outputs as Cumulative Distribution Functions (CDF) as data tables and graphs.

Figure 5 shows an example plot generated for:

- Herefordshire's Grid Square D (the south-east area)
- Scenario RCP6.0
- % change in precipitation
- During winter season
- For the 2080s (2070 – 2098)
- Compared to a baseline of 1981 -2010

It has been marked up to show the 50th percentile value which is +15.2% change. In other words, there is a 50% chance that winter precipitation will be less than 15.2% by the 2080s, and 50% chance it will be more than 15.2% compared to the 1981-2010 average in south-east Herefordshire. This level of detail allows decision makers to consider a range of possible scenarios, when one considers that it is possible to change each parameter of the above plot to suit. CSV files can also be generated showing exact values for every percentile.

Figure 5: Example CDF plot. Grid square D, % precipitation change in winter in 2080s (2070 – 2098), marked up with 50th percentile, generated from UKCP18 User-Interface



4 Key UKCP18 Findings for the UK

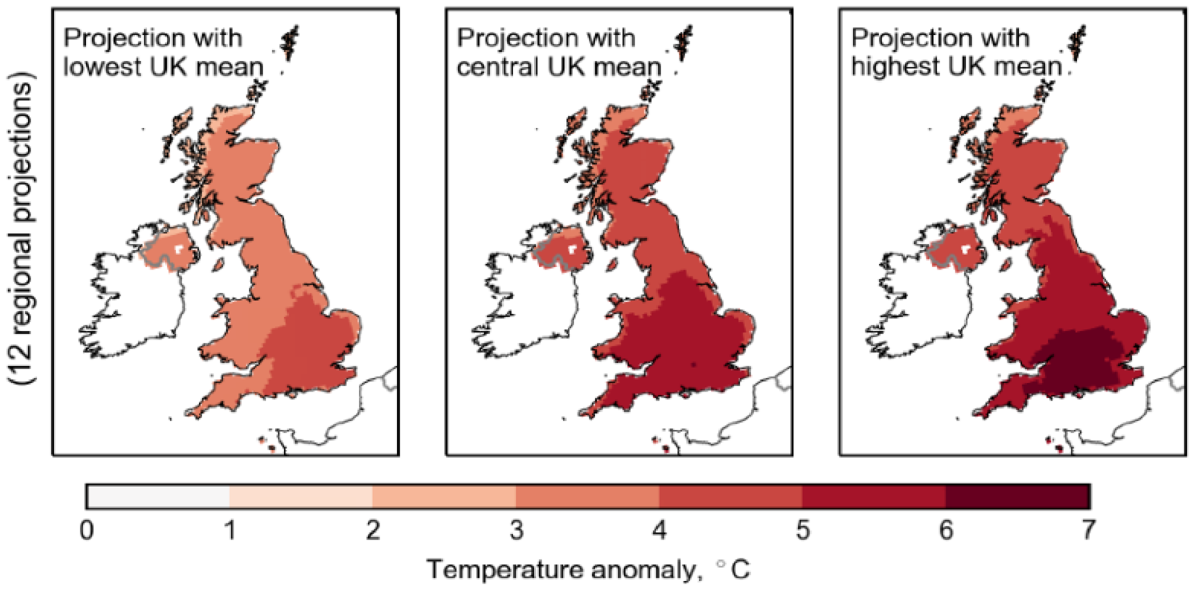
General climate change trends projected over UK land for the 21st century in UKCP18 show an increased chance of warmer, wetter winters and hotter, drier summers along with an increase in the frequency and intensity of extreme weather events.

4.1 UK Temperature Change

By the end of the 21st century, all areas of the UK are projected to be warmer, more so in summer than in winter.

Hot summers are expected to become more common. The summer of 2018 was the equal-warmest summer for the UK along with 2006, 2003 and 1976. Climate change has already increased the chance of seeing a summer as hot as 2018 to between 12-25%. With future warming, hot summers by mid-century could become even more common, with chances increasing further to around 50-60%. Figure 6 shows how temperature is projected to change across the UK depending on emissions levels.

Figure 6: Projected temperature change 2061 – 2080 under scenario RCP8.5



Hot spells, typically defined as maximum daytime temperatures exceeding 30°C for two or more consecutive days, are largely confined to the south-east UK in the present-day. By the 2070s, under a high emissions scenario, the frequency of hot spells increases, rising from an average of 0.2 occurrences per year in the present-day to 4.1 by the 2070s.

4.2 UK Precipitation Change

Overall in the UK, summers are likely to become drier and winters are likely to become wetter. However, rainfall patterns across the UK are not uniform and vary on seasonal and regional scales and will continue to vary in the future.

By 2070, in a high emission scenario, the range of change amounts to -45% to +5% in summer, and -3% to +39% in winter (where a negative change indicates less precipitation and a positive change indicates more precipitation). Figures 7a and 7b show how precipitation is projected to changes across the UK in summer (7a) and winter (7b) depending on emissions scenarios.

Figure 7a: Projected summer precipitation change 2061 – 2080 under scenario RCP8.5

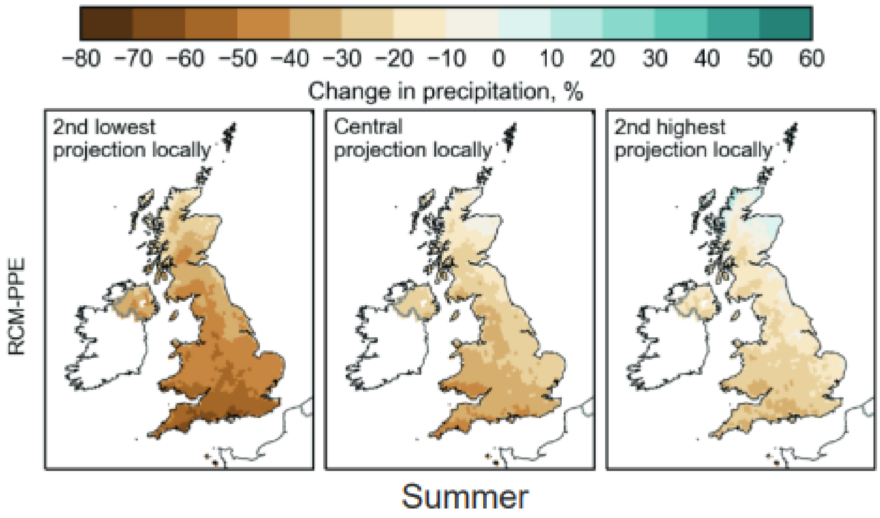
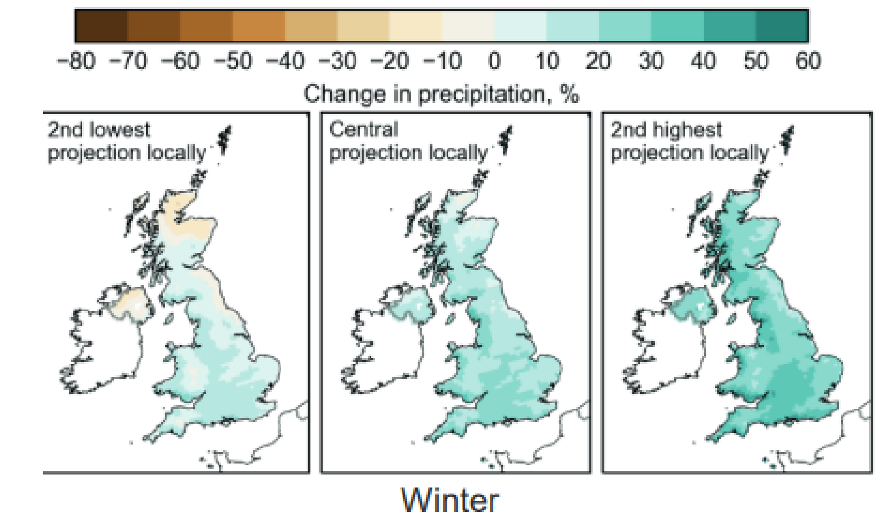


Figure 7b: Projected winter precipitation change 2061 – 2080 under scenario RCP8.5



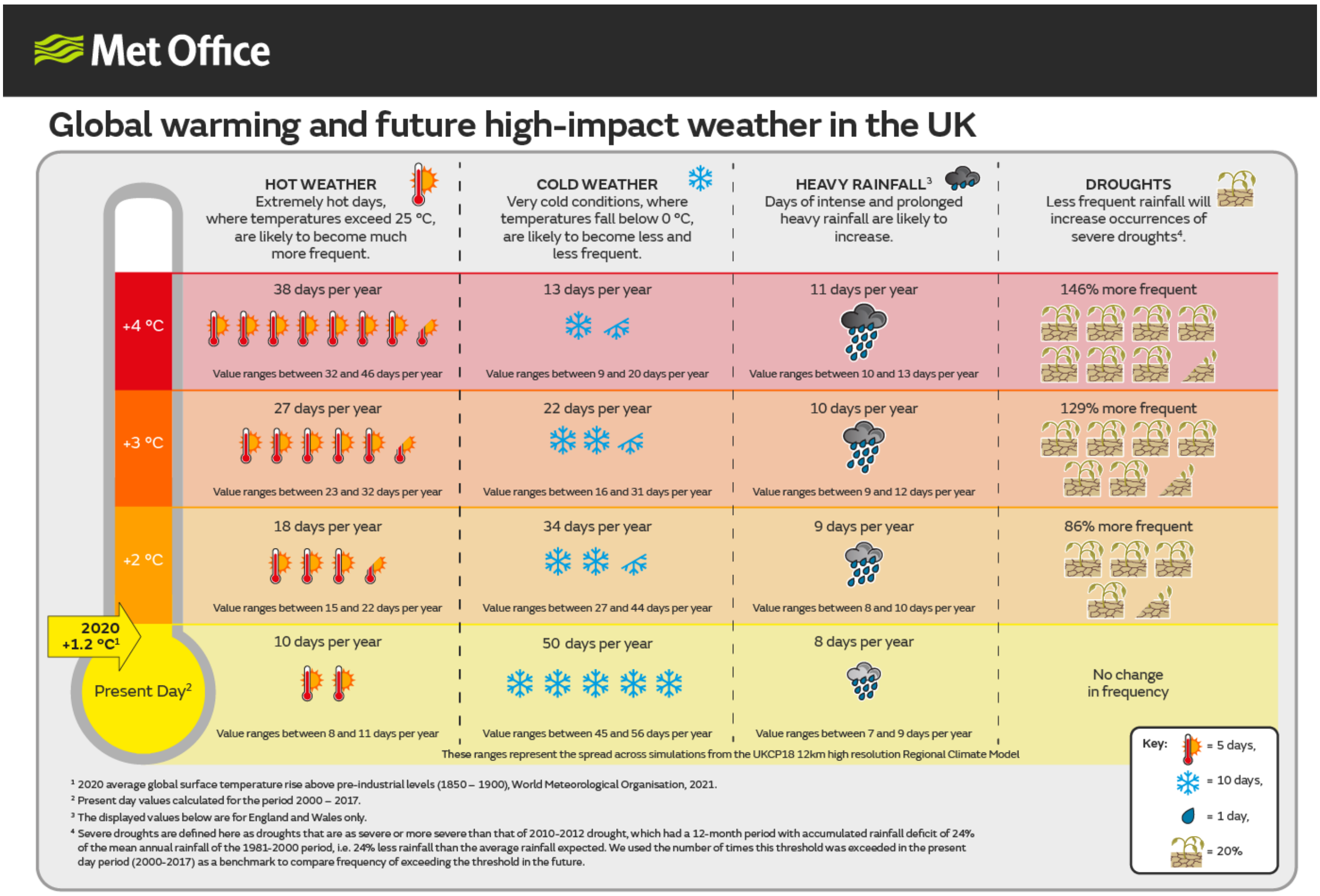
Future climate change is also projected to bring about a change in the seasonality of extremes. There may be an extension of the convective season from summer into autumn, with significant increases in heavy hourly rainfall intensity in the autumn.

4.3 UK High Impact Weather

High impact weather events such as extreme temperatures or rainfall can cause significant disruption affecting sectors such as health, transport, agriculture and energy. As the climate continues to change in response to human activities, the UK will be subject to different frequency, severity and duration of various climate hazards and high impact weather events.

A study has been undertaken drawing on the latest set of UK Climate Projections (UKCP18 12km regional climate model projections) to examine metrics relating to high impact weather and how these change with different levels of future global warming ranging from 1.5°C to 4°C above pre-industrial levels. These are summarised in Figure 8.

Figure 8: Projected change in high impact weather in the UK



Significant increases are expected in the frequency of extremely hot days and nights, with a UK average increase in hot days of between +5 and +39 days per year for 1.5°C to 4°C of global warming and extremely hot nights, which are currently rare, emerging as more common occurrences (Figure 9).

Whilst increases in the frequency of high daily temperatures and rainfall increase systematically, the frequency of very cold conditions (based on days where temperatures fall below 0°C) is shown to decrease by 10 to 49 days per year between 1.5°C and 4°C of warming (Figure 10).

Levels of daily rainfall are expected to increase across the country, with increases of days with high impact levels of rainfall occurring by +1 to +8 days per year between 1.5°C and 4°C of warming, suggesting that more frequent river flooding will have widespread severe impacts across the UK.

Average drought severity (based solely on rainfall deficit) is also projected to increase, especially so in the south and east of the UK, for three, six, 12 and 36-month drought indicators. The largest increases in severity were for the longer-term 12-month (-3 to +19%) and 36-month (+12 to +54%) droughts between 1.5°C and 4°C of warming. This suggests that for England and Wales, adaptation of water management practices can expect to be required to cope with increased severity of drought.

Figure 9: Increase in "Summer Days" and "Tropical Nights" per year under 1.5 - 4°C of warming, according to Hanlon et al. 2021.

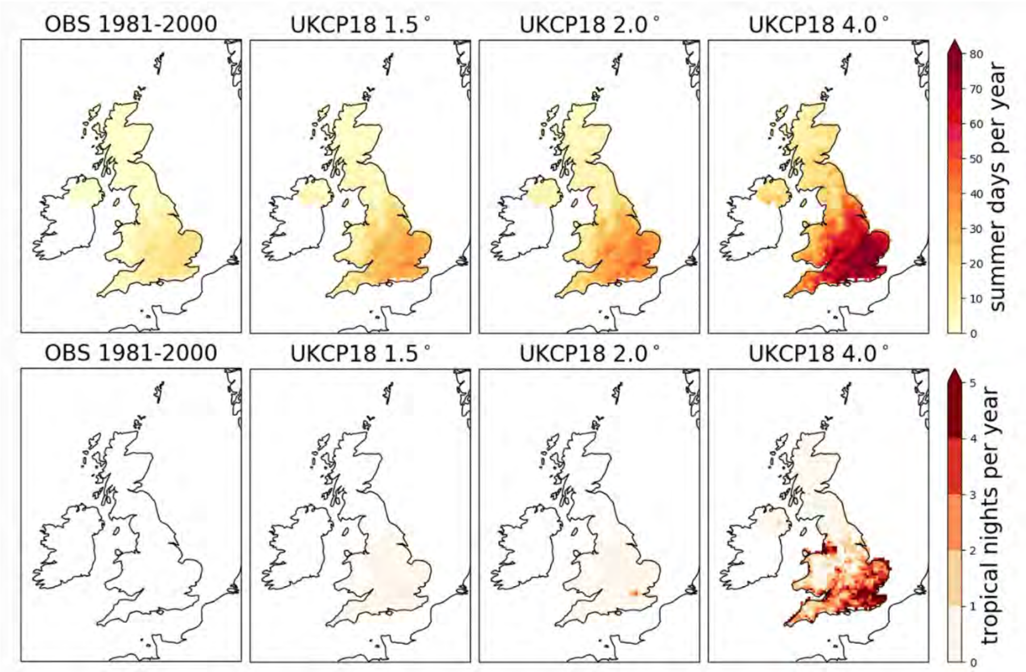
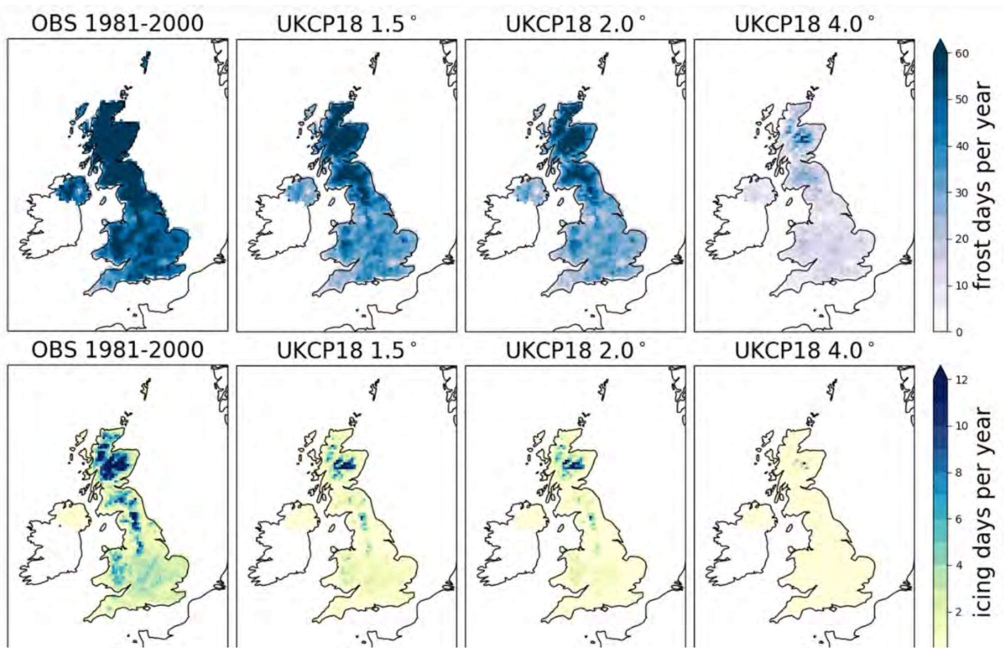


Figure 10: Decrease in "Frost Days" and "Icing Days" per year under 1.5 - 4°C of warming, according to Hanlon et al. 2021.



5 Key UKCP18 Findings for Herefordshire

The figures in the following section are (unless stated otherwise) mean values of the four 25km grid squares that cover the majority of Herefordshire, as outlined in Section 3.3. A detailed breakdown of the values for each of the separate grid squares can be provided in an accompanying data file, available upon request.

In preparing these results, consultation was carried out with the Met Office's Head of Climate Impacts Research on the most suitable range of scenarios to consider. It was advised to use the 5th, 50th and 95th percentile range within one single RCP (6.0) to illustrate low, medium and high scenarios.

RCP6.0 has been used to generate the scenarios for Herefordshire as it is one of the two intermediate stabilisation pathways (the higher medium) among the four representative concentration pathways. Globally, current emissions are tracking close to the higher RCP8.5 pathway, but estimates based on the assumption of current international agreements on greenhouse gas emissions suggest a median warming level in the region of 2.4-2.8°C, which corresponds with RCP6.0 (2.8°C).

5.1 Herefordshire Temperature Change

To examine projected temperature change in Herefordshire, the variable 'mean air temperature anomaly at 1.5m above the earth's surface' has been used. This is the mean temperature change expected against a given baseline value as measured at 1.5m above the earth's surface and is a standard climate variable used for comparisons and risk assessments.

Figures 11a and 11b show the results averaged across the four 25km grid cells for Herefordshire (a full breakdown for each grid cell is available in an accompanying data file upon request). The expected change is given in °C against a baseline of the mean temperature from 1981 – 2010. The potential resulting temperature is also presented (baseline + change).

Results are presented for the 2050s and 2080s for the mean annual, mean winter (Dec – Feb) and mean summer (Jun – Aug) temperatures.

Figure 11a: Summary results of temperature change for Herefordshire in the 2050s at RCP6.0, 5th, 50th and 95th percentile, generated via the Met Office UKCP18 User Interface

	Mean Annual Temperature	Mean Winter Temperature	Mean Summer Temperature
Observed Baseline 1981-2010 °C	9.66	4.25	15.54
2050s (2040-2069) Pathway RCP 6.0 **5th percentile:** Change in °C	0.26	-0.11	0.11
°C	9.92	4.14	15.65
2050s (2040-2069) Pathway RCP 6.0 **50th percentile:** Change in °C	1.17	1.02	1.51
°C	10.83	5.27	17.05
2050s (2040-2069) Pathway RCP 6.0 **95th percentile:** Change in °C	2.20	2.23	3.11
°C	11.86	6.48	18.65

Figure 11b: Summary results of temperature change for Herefordshire in the 2080s at RCP6.0, 5th, 50th and 95th percentile, generated via the Met Office UKCP18 User Interface

	Mean Annual Temperature	Mean Winter Temperature	Mean Summer Temperature
Observed Baseline 1981-2010 °C	9.66	4.25	15.54
2080s (2070-2099) Pathway RCP 6.0 **5th percentile:** Change in °C	0.91	0.18	0.86
°C	10.57	4.43	16.40
2080s (2070-2099) Pathway RCP 6.0 **50th percentile:** Change in °C	2.49	1.93	3.48
°C	12.15	6.18	19.02
2080s (2070-2099) Pathway RCP 6.0 **95th percentile:** Change in °C	4.16	3.84	6.28
°C	13.82	8.09	21.82

In summary:

- Annual temperatures are projected to increase by 0.3°C to 2.2°C by the 2050s and 0.9°C to 4.2°C by the 2080s.
- Winter temperatures are projected to change by -0.1°C to 2.2°C by the 2050s and 0.2°C to 3.8°C by the 2080s.
- Summer temperatures are projected to increase by 0.1°C to 3.1°C by the 2050s and 0.9°C to 6.3°C by the 2080s.

This level of change, particularly at the upper end of the range in summer, will have wide ranging impacts on health (heat stress), infrastructure and agriculture. More information on the impacts Herefordshire has already experienced is provided in the accompanying Herefordshire Impact Assessment which looks at how extreme weather has affected Herefordshire from 2008-2022. This will give an indication as to how the impacts reporting in this document may change over time.

5.2 Herefordshire Precipitation Change

To examine the projected precipitation change in Herefordshire, the variable ‘Precipitation Rate Anomaly %’ has been used. This is the % change in precipitation expected against a given baseline value and is a standard climate variable used for comparisons and risk assessments.

Figure 12 shows the results averaged across the four 25km grid cells for Herefordshire (a full breakdown for each grid cell is available in an accompanying data file upon request). The expected change is given as a % change against a baseline of mean precipitation levels from 1981 – 2010.

Results are presented for the 2050s and 2080s for the mean winter (Dec – Feb) and mean summer (Jun – Aug) precipitation.

Figure 12: Summary results of % precipitation change for Herefordshire in the 2050s and 2080s at RCP6.0, 5th, 50th and 95th percentile, generated via the Met Office UKCP18 User Interface

	Mean Winter Precipitation	Mean Summer Precipitation
2050s (2040-2069) Pathway RCP 6.0 **5th percentile:** % Change	-9.28	-37.79
2050s (2040-2069) Pathway RCP 6.0 **50th percentile:** % Change	+4.96	-11.43
2050s (2040-2069) Pathway RCP 6.0 **95th percentile:** % Change	+21.59	+14.65
2080s (2070-2099) Pathway RCP 6.0 **5th percentile:** % Change	-6.84	-54.43
2080s (2070-2099) Pathway RCP 6.0 **50th percentile:** % Change	+12.83	-26.79
2080s (2070-2099) Pathway RCP 6.0 **95th percentile:** % Change	+35.76	+3.38

In summary:

- Winter precipitation levels are projected to change by -9.3% to +21.6% by the 2050s and -6.8% to +35.8% by the 2080s.
- Summer precipitation levels are projected to change by -37.8% to +14.7% by the 2050s and -54.4% to +3.4% by the 2080s.

The large projected increase in winter precipitation may have impacts on flooding and infrastructure in Herefordshire. The likely decrease in summer precipitation, potentially halving by the 2080s, is likely to have extreme impacts on water availability, agriculture and biodiversity. More information on the impacts Herefordshire has already experienced is provided in the accompanying Herefordshire Impact Assessment which looks at how extreme weather has affected Herefordshire from 2008-2022. This will give an indication as to how the impacts reporting in this document may change over time.

5.3 Herefordshire High Impact Weather Changes

As with the UK as a whole, Herefordshire can expect to see significant increases in the frequency of extremely hot days and nights, plus more intense rainfall events and periods of drought.

Data on projected climate extremes can be used to understand the impacts on transport infrastructure, health, agriculture and energy demand. The Met Office has made available a range of data which allows analysis of various 'High Impact Weather Changes'. Those judged most relevant to Herefordshire and further examined in this report are:

- **Days above 25°C**, which indicate increased health risks, transport disruption and damage to infrastructure from high temperatures. This measure was formally known as the Annual Count of Summer Days and is the annual number of days where the maximum daily temperature is above 25°C. As the number of these days increases there are likely to be increased heat related illnesses, hospital admissions or deaths, transport disruption due to overheating of railway infrastructure, and overhead power lines also becoming less efficient.

- **Nights above 20°C.** These so called 'Tropical Nights' can indicate heat stress on health as high nighttime temperatures negatively impact the body's ability to recover and have relief from higher daytime temperatures.
- **Change in 'Annual Growing Degree Days'**. A Growing Degree Day (GDD) is a day in which the average temperature is above 5.5°C, which indicates whether temperature conditions are suitable for plant growth.
- **Drought Severity Index**, which is an indicator of agricultural and hydrological drought.

The Met Office tools allow all these measures to be modelled and mapped at various levels of global warming, rather than solely for a set period of time. Estimates based on the assumption of current international agreements on greenhouse gas emissions suggest a median warming level in the region of 2.4-2.8°C, so a 3°C change in global mean temperature scenario has been used for this analysis.

All mapping in this section has been generated via the Met Office Climate Data Portal service and the datasets are used under an open government licence.

5.3.1 Days above 25°C

The Annual Count of Summer Days is the number of days per year where the maximum daily temperature (the hottest point in the day) is above 25°C. It measures how many times (rather than by how much) the threshold is exceeded in a year. Note that the term 'summer days' is used to refer to the threshold and temperatures above 25°C outside the summer months and also contributes to the annual count.

An increase in the Annual Count of Summer Days indicates increased health risks from high temperatures. Impacts include:

- Increased heat related illnesses, hospital admissions or death for vulnerable people.
- Transport disruption due to overheating of railway infrastructure.
- Periods of increased water demand.

The Annual Count of Summer Days is calculated from the UKCP18 regional climate projections using the high emissions scenario (RCP8.5), the scenario in which greenhouse gas emissions continue to rise. Instead of considering future climate change during specific time periods (e.g. decades) for this scenario, the dataset is calculated at various levels of global warming relative to the pre-industrial (1850-1900) period. The world has already warmed by around 1.1°C (between 1850–1900 and 2011–2020), and this dataset allows for the exploration of greater levels of warming.

The following maps give an indication of the increase in days above 25°C that Herefordshire can expect to see with 3°C of global warming (Figure 13b) compared to a baseline of 2001 – 2020 (Figure 13a). The baseline scenario shows Herefordshire to have had mostly 10-30 days per year above 25°C during 2001-2020, and under 3°C of global warming . This is projected to increase to 30-50 days per year.

Figure 13a: Number of days exceeding 25°C in Herefordshire in the baseline period, 2001-2020

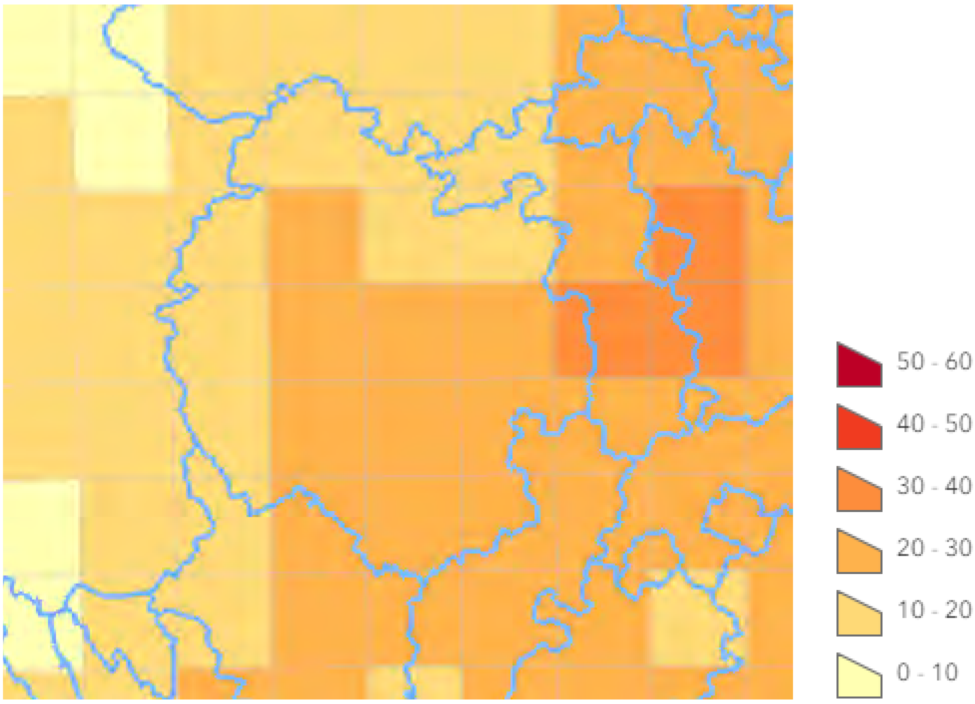
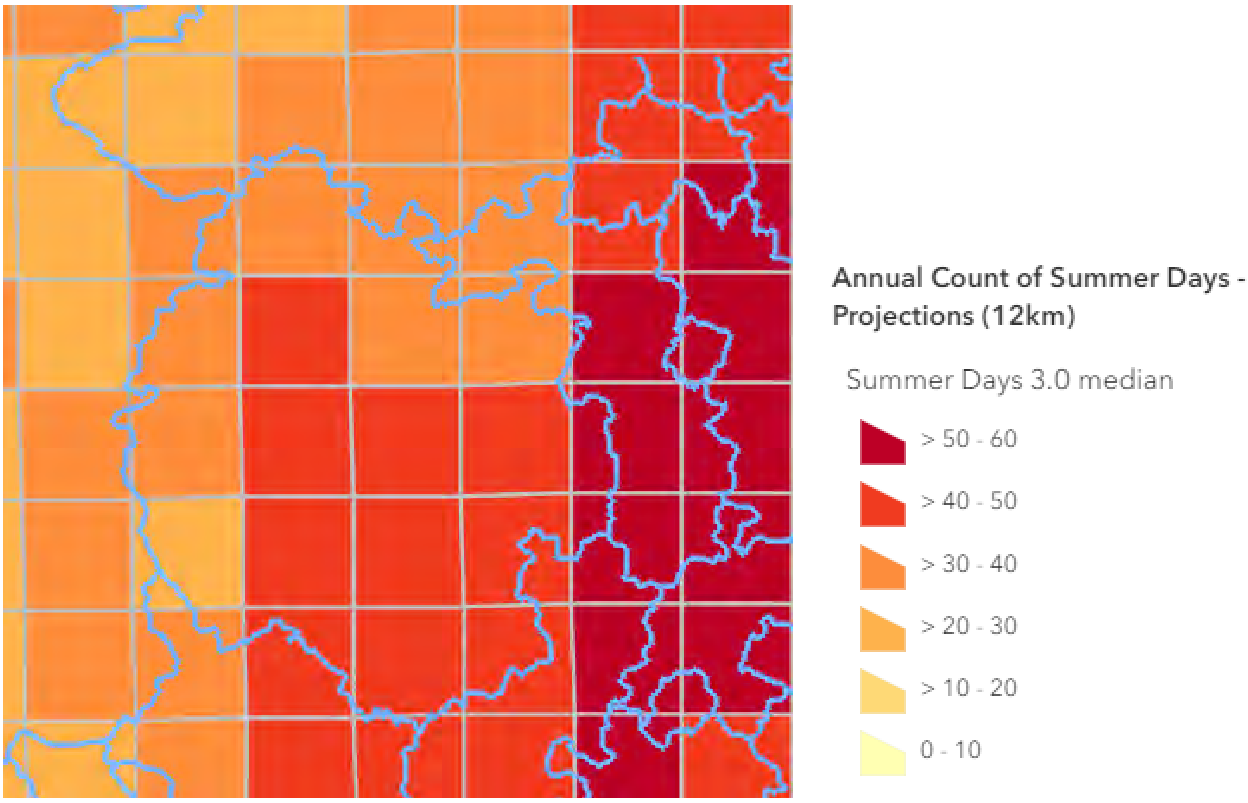


Figure 13b: Number of days expected to exceed 25°C in Herefordshire at 3°C of global warming



5.3.2 Nights above 20°C

The coolest part of the day usually occurs during the night. A Tropical Night is defined where the minimum daily temperature does not fall below 20°C.

The Annual Count of Tropical Nights is the number of days per year where the minimum daily temperature is above 20°C. It measures how many times (rather than by how much) the threshold is exceeded in a year. The results should be interpreted as an approximation of the projected number of days when the threshold is exceeded as there will be many factors such as natural variability and local scale processes that the climate model is unable to represent.

The Annual Count of Tropical Nights indicates increased health risks and heat stress due to high night-time temperatures. It is based on exceeding a minimum daily temperature of 20°C, i.e. the temperature does not fall below 20°C for the entire day. Impacts include:

- Increased heat related illnesses, hospital admissions or death for vulnerable people.
- Increased heat stress, as it is important that the body has time to recover from high daytime temperatures during the lower temperatures at night.

Figures 14a and 14b give an indication of the increase in Tropical Nights that Herefordshire can expect to see with 3°C of global warming under RCP8.5 (Figure 14b) compared to a baseline of 2001 – 2020 (which corresponds to 0.87°C warming above the pre-industrial period) (Figure 14a).

During the baseline period, Herefordshire experienced 0 to 0.1 days per year where the minimum daily temperature was above 20°C. However under 3°C of global warming this is projected to increase to 0.1 to 0.7 days per year.

Figure 14a: Number of nights not falling below 20°C in Herefordshire in the baseline period, 2001-2020

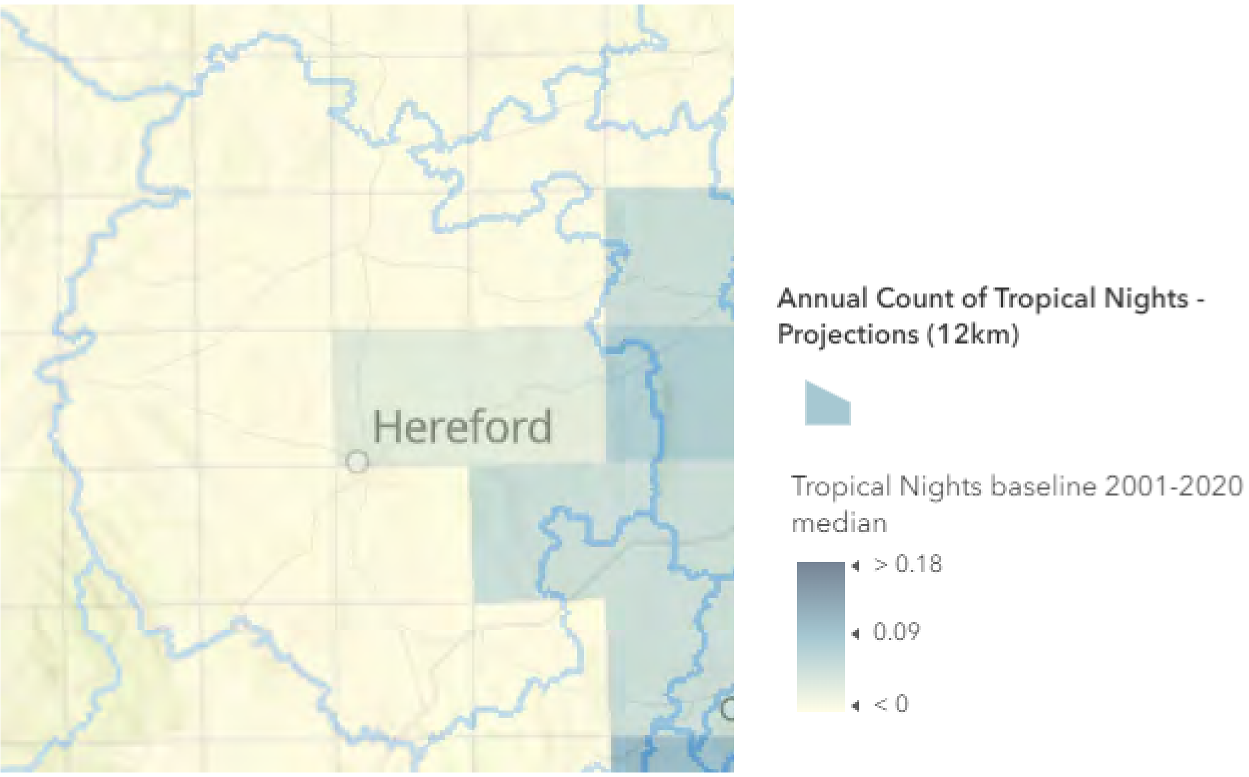
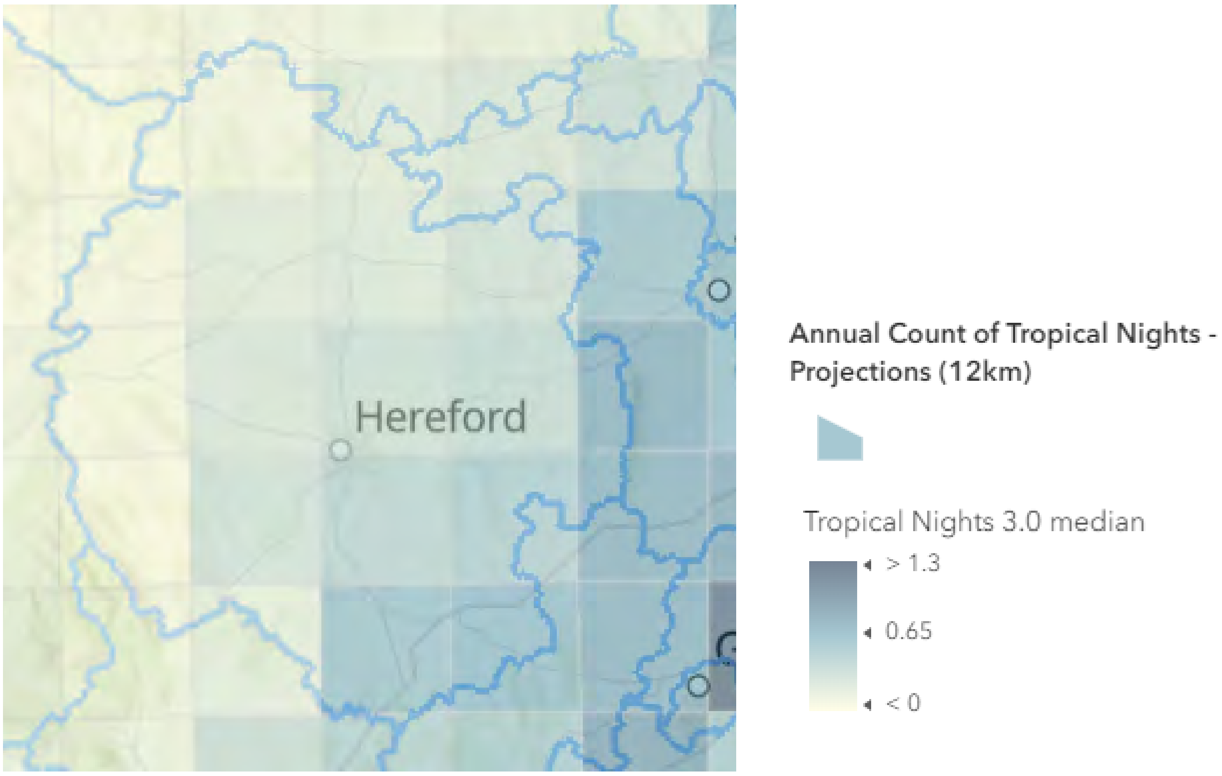


Figure 14b: Number of nights expected to not drop below 20°C in Herefordshire at 3°C of global warming



5.3.3 Annual Growing Degree Days

Annual Growing Degree Days (GDDs) is the annual sum of the number of degrees the daily average temperature is above 5.5°C.

GDDs indicate if conditions are suitable for plant growth. An increase in GDDs can indicate larger crop yields due to increased crop growth from warm temperatures, but crop growth also depends on other factors. For example, GDDs do not include any measure of rainfall, drought, sunlight, day length, wind, species vulnerability, or plant dieback in extremely high temperatures. GDDs can indicate increased crop growth until temperatures reach a critical level, above which there are detrimental impacts on plant physiology.

It is also important to note that it is the number of degrees (not number of days) above the threshold of 5.5°C that counts as a GDD. For example if the average temperature for a specific day is 6°C, this would contribute 0.5 GDDs to the annual sum. Alternatively, an average temperature of 10.5°C would contribute five GDDs. Given that the data show the annual sum of GDDs, this value can often be above 365.

Figures 15a and 15b give an indication of the increase in GDDs that Herefordshire can expect to see once it reaches 3°C of global warming (Figure 15b) compared to a baseline of 2001 – 2020 (which corresponds to 0.87°C warming above the pre-industrial period) (Figure 15a).

During the baseline period, Herefordshire experienced 1,500 – 2,500 GDDs per year. However, under 3°C of global warming this is projected to increase to 2,000 – 3,000 GDDs per year, providing an opportunity for increased agricultural output.

Figure 15a: Growing Degree Days in Herefordshire in the baseline period, 2001-2020

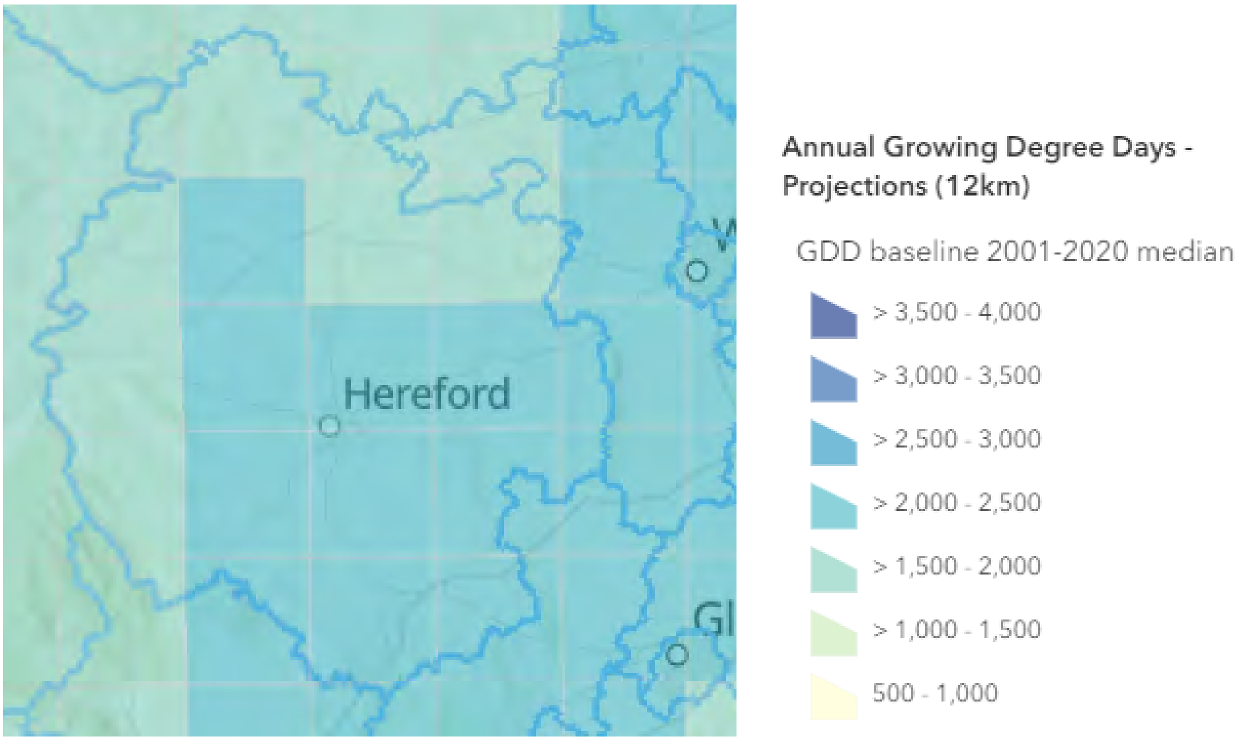
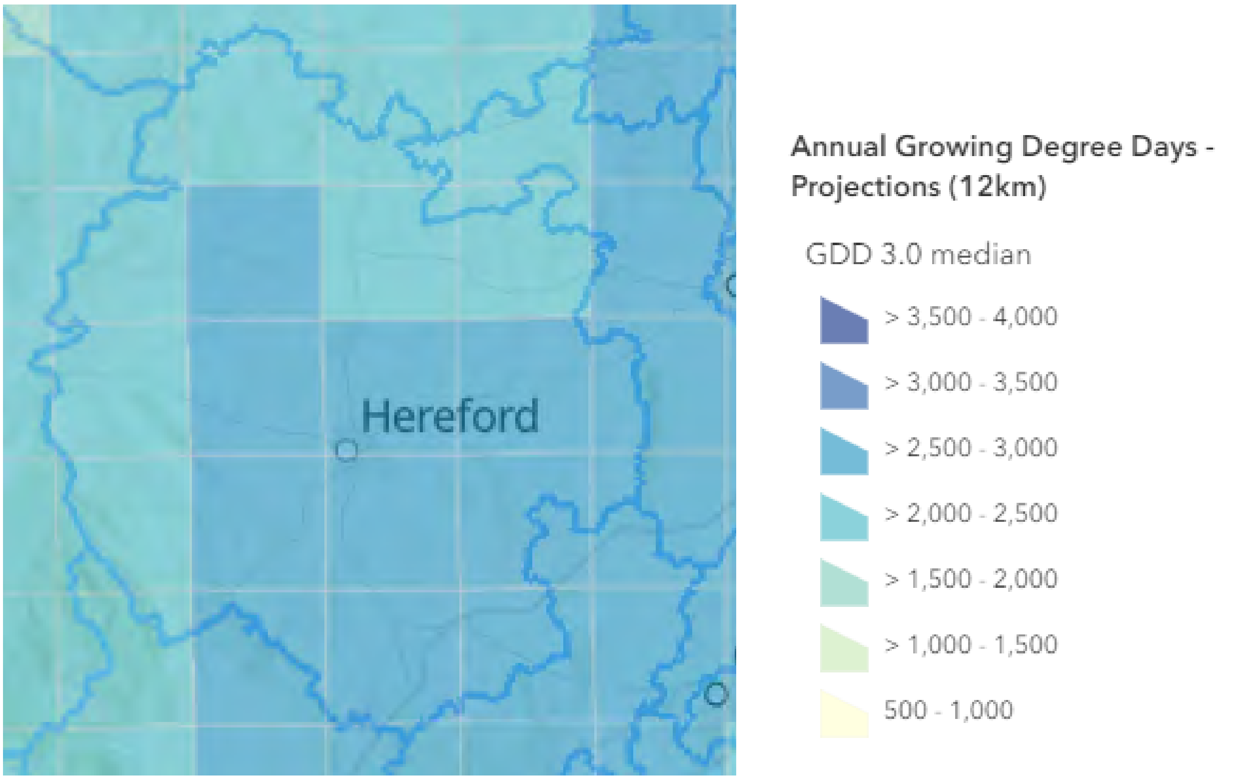


Figure 15b: Growing Degree Days in Herefordshire at 3°C of global warming



5.3.4 Drought Severity

The Drought Severity Index (DSI) is not threshold based. Instead, it is calculated with 12-month rainfall deficits provided as a percentage of the mean annual climatological total rainfall (1981–2000) for that location. It measures the severity of a drought, not the frequency.

12-month accumulations have been selected as this is likely to indicate hydrological drought. Hydrological drought occurs due to water scarcity over a much longer duration (longer than 12 months). It heavily depletes water resources on a large scale as opposed to meteorological or agricultural drought, which generally occur on shorter timescales of 3-12 months. However this categorisation is not fixed, because rainfall deficits accumulated over 12-months could lead to different types of drought and drought impacts, depending on the level of vulnerability to reduced rainfall in a region.

The DSI 12-month accumulations measure the drought severity. Higher values indicate more severe drought. The DSI is based on 12-month rainfall deficits. The impacts of the differing length of rainfall deficits vary regionally due to variation in vulnerability. Depending on the level of vulnerability to reduced rainfall, rainfall deficits accumulated over 12 months could lead to meteorological, agricultural and hydrological drought.

Figures 16a and 16b give an indication of the increase in DSI that Herefordshire can expect to see at 3°C of global warming (Figure 16b) compared to a baseline of 2001 – 2017 (which corresponds to approximate 0.8°C warming above the pre-industrial period) (Figure 16a).

During the baseline period, the DSI varies from only 5 to 10 across Herefordshire. However, under 3°C of global warming this is projected to increase to a range of 5 to 25, with the west of the county projected to be 20 to 25, which is likely to impact on agricultural output and water security.

Figure 16a: Drought Severity Index in Herefordshire in the baseline period, 2001-2020

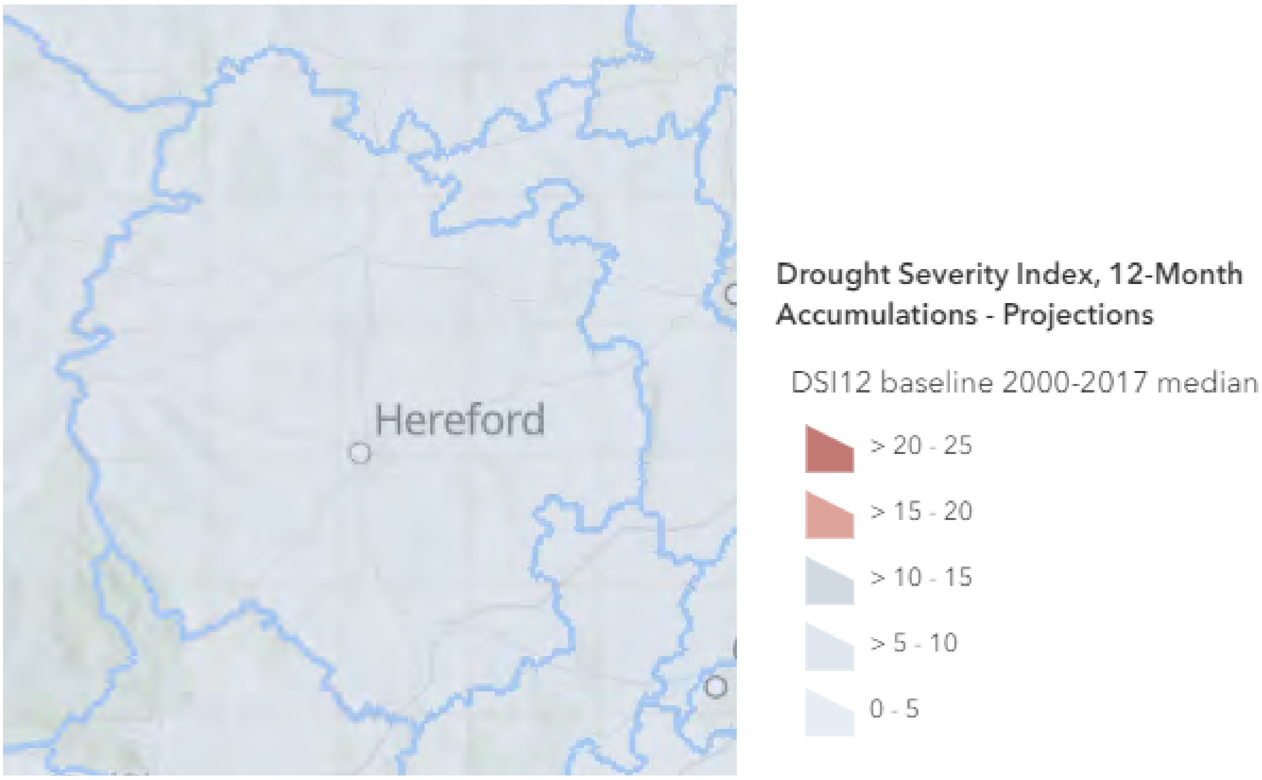
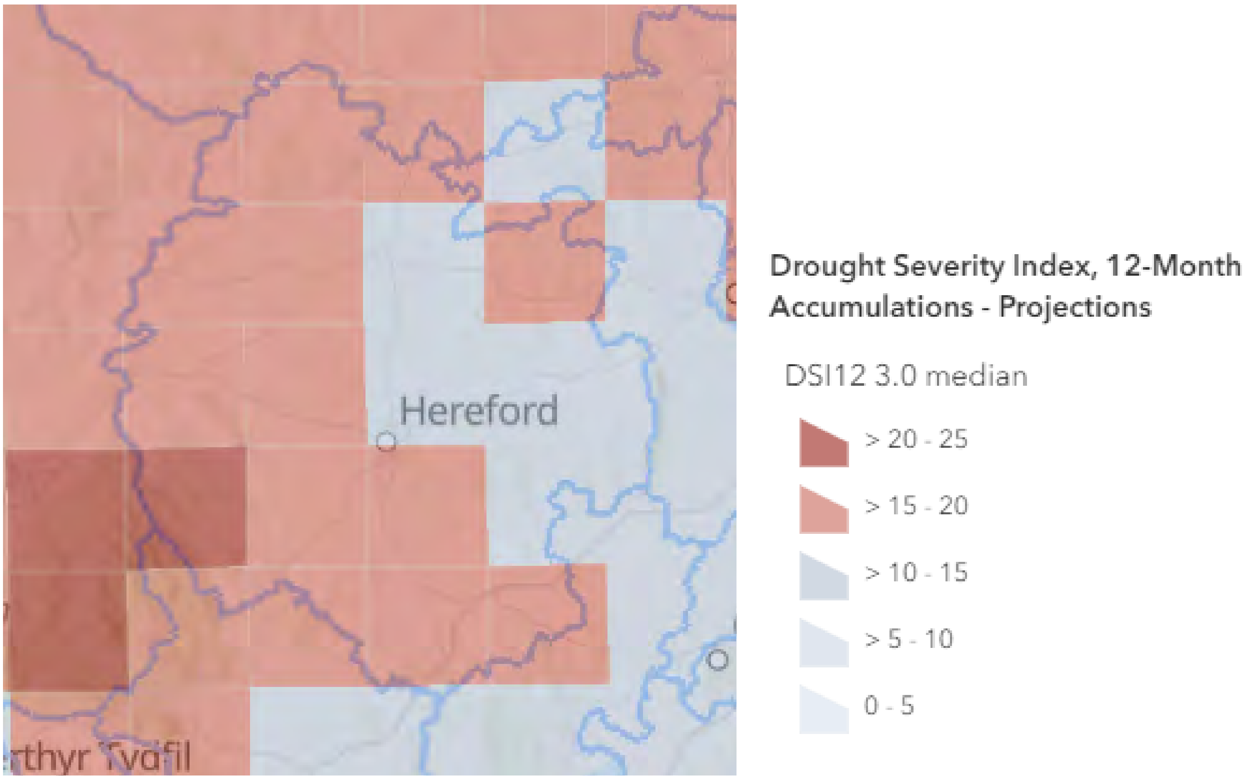


Figure 16b: Drought Severity Index in Herefordshire at 3°C of global warming



6 Summary

This section brings together the key data from Section 4 of this report to summarise what the expected climate changes are likely to be in Herefordshire, and outlines our closing remarks and next steps in light of this.

6.1 Climate change projections in Herefordshire

Figure 17: Summary results of temperature change for Herefordshire in the 2050s at RCP6.0, 5th, 50th and 95th percentile, generated via Met Office UKCP18 User Interface

	Mean Annual Temperature	Mean Winter Temperature	Mean Summer Temperature
Observed Baseline 1981-2010 °C	9.66	4.25	15.54
2050s (2040-2069) Pathway RCP 6.0 **5th percentile:** Change in °C	0.26	-0.11	0.11
°C	9.92	4.14	15.65
2050s (2040-2069) Pathway RCP 6.0 **50th percentile:** Change in °C	1.17	1.02	1.51
°C	10.83	5.27	17.05
2050s (2040-2069) Pathway RCP 6.0 **95th percentile:** Change in °C	2.20	2.23	3.11
°C	11.86	6.48	18.65

Figure 18: Summary results of % precipitation change for Herefordshire in the 2050s and 2080s at RCP6.0, 5th, 50th and 95th percentile, generated via Met Office UKCP18 User Interface

	Mean Winter Precipitation	Mean Summer Precipitation
2050s (2040-2069) Pathway RCP 6.0 **5th percentile:** % Change	-9.28	-37.79
2050s (2040-2069) Pathway RCP 6.0 **50th percentile:** % Change	+4.96	-11.43
2050s (2040-2069) Pathway RCP 6.0 **95th percentile:** % Change	+21.59	+14.65
2080s (2070-2099) Pathway RCP 6.0 **5th percentile:** % Change	-6.84	-54.43
2080s (2070-2099) Pathway RCP 6.0 **50th percentile:** % Change	+12.83	-26.79
2080s (2070-2099) Pathway RCP 6.0 **95th percentile:** % Change	+35.76	+3.38

Figure 19: Summary results of High Impact Weather changes, generated via Met Office Climate Data Portal

	Baseline - (2001 – 2020) 0.87°C warmed world	Future, if global temperatures rise by 3°C
Days per year above 25°C	10 – 30	30 – 50
Nights per year above 20°C	0 – 0.1	0.1 – 0.7
Annual Growing Degree Days	1,500 – 2,500	2,000 – 3,000
Drought Severity Index	5 – 10	5 – 25 (20 to 25 in west of county)

6.2 Closing remarks

The accompanying Severe Weather Impact Assessment outlines how the county has been affected by severe weather in the past 15 years. It is clear that such impacts could worsen over time, especially if the 'worst case climate change scenarios' outlined in this report play out. Flooding could become more intense and unpredictable, heatwaves and droughts more common and prolonged, and storms more extreme and damaging. However, the key message is to keep a watching brief on how the climate changes in Herefordshire, and how this may impact the county's ability to adapt over time.

Initially, the Herefordshire Climate Change Adaptation Plan will outline our recommendations as to how we believe the Council and its partners should commence its response to the projected changes in climate outlined in this report, and the potential knock-on effects that this will have on the likely impacts outlined in the Severe Weather Impact Assessment. Both should be continuously reviewed and monitored to ensure they remain fit for purpose, and the projections outlined in this report should be re-analysed should the Met Office release a new suite of projections over the next few years.

-END-