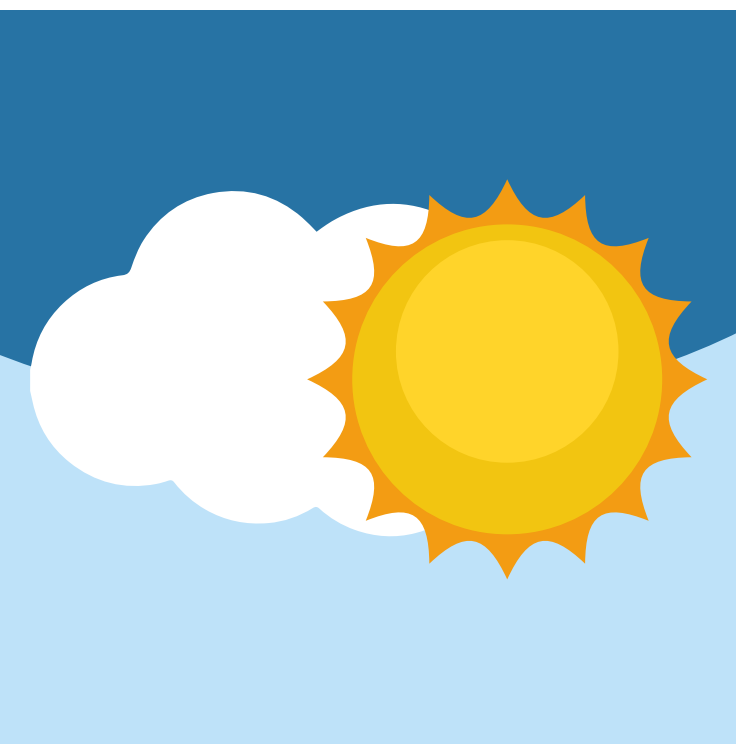


Climate Projections for Scotland

SUMMARY

Adaptation
Scotland

supporting climate change resilience



The Adaptation Scotland programme is funded by the Scottish Government and delivered by sustainability charity Sniffer

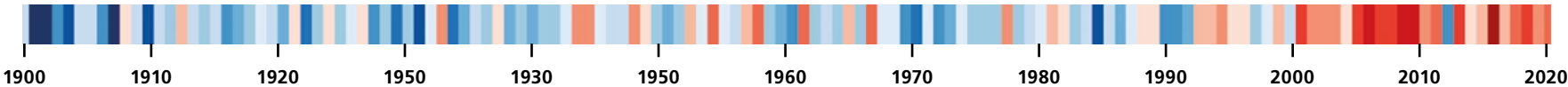
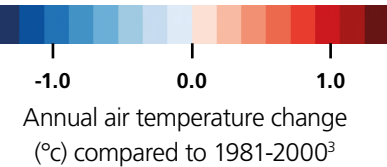


1. Climate Projections for Scotland – Summary

This summary provides an overview of the UK Climate Projections for Scotland. It is intended to help build common understanding – across local government, government agencies, and public bodies – of the future climate that Scotland will experience.

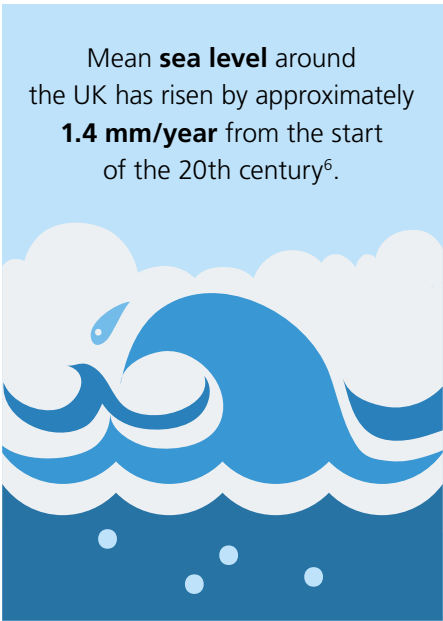
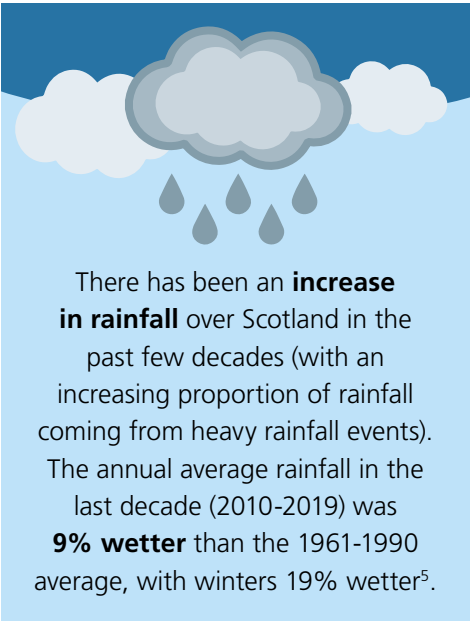
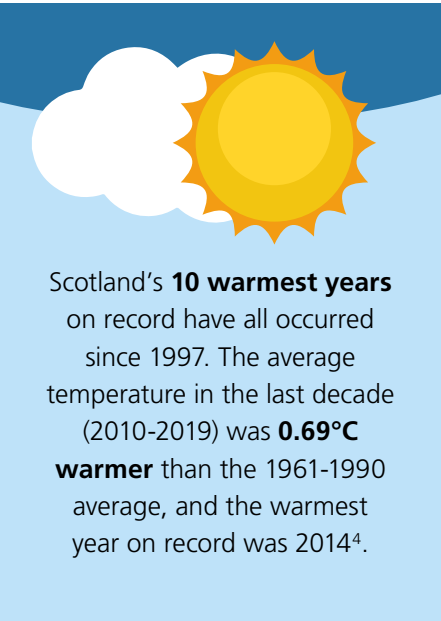
What are the UK Climate Projections?

The 2018 UK Climate Projections¹, produced by the Met Office Hadley Centre, provide up-to-date information about the potential future climate in Scotland. The projections provide a range of potential climate outcomes, based on a set of four pathways for greenhouse gas emissions: a low emissions scenario (RCP2.6); two medium emissions scenarios (RCPs 4.5 and 6.0); and a high emissions scenario (RCP8.5)².



How has Scotland’s climate changed?

Over the last few decades Scotland has experienced a warming trend, shifting rainfall patterns, and rising sea levels:



2. How will Scotland's climate change in the future?

The changes in climate that we are already experiencing are projected to continue and intensify:



Average temperatures will increase across all seasons



Typical summers will be warmer and drier



Typical winters will be milder and wetter



Intense, heavy rainfall events will increase in both winter and summer



Sea levels will rise



Reduced frost and snowfall



Weather will remain variable and may become more variable

The amount of change that occurs will depend on how successful we are in reducing greenhouse gas emissions globally.

What are low and high emission scenarios?

The following sections provide examples of projected changes in temperature, rainfall and sea level under both low and high emission scenarios.

Low emissions scenario

The low emissions scenario assumes sustained and rapid reductions in greenhouse gas emissions globally. The projections associated with the low emissions scenario represent the minimum level of climate change that we are likely to experience, and are shown in blue in the graphs and tables below.

High emissions scenario

The projections associated with the high emissions scenario outline more extreme changes that are projected if greenhouse gas emissions continue to increase and emission reduction targets are missed. They are shown in red in the graphs and tables below.

Low and high emissions scenarios are two of four potential climate outcomes included in the 2018 UK Climate Projections, medium low and medium high emissions scenarios are also available.

Scotland has already significantly reduced its greenhouse gas emissions⁷, and set a legally binding target to reach net-zero levels by 2045 at the latest⁸. However, the current global emissions trajectory remains closer to the medium-high emission scenario⁹. This underlines the importance of both further global efforts to reduce emissions and of adaptation policies and actions that take account of a range of emission scenarios.

What do the graphs show?

This summary includes graphs that show projected changes in climate for both low and high emission scenarios. The graphs or sections of graphs shown in blue show the low emissions scenario. The graphs or sections of graphs shown in red show the high emissions scenario.

The UK Climate projections provide a likely range of change. The dark, bold lines in the centre of the graphs show the central estimate (50th percentile) of projected change. The shading shows the wider range of change which is considered likely (10th – 90th percentile). Changes outside of this range are not impossible, but statistically unlikely based on our best understanding.

Although the graphs show a 'smooth' trend in the 50th percentile, individual years will continue to vary significantly year-on-year.

All of the graphs and data presented in sections 3 – 4 are *Probabilistic Projections* from the latest UK Climate Projections available at <http://data.ceda.ac.uk/badc/ukcp18/data/land-prob>



3. Winter



Scotland will experience warmer, wetter winters, with more intense rainfall events

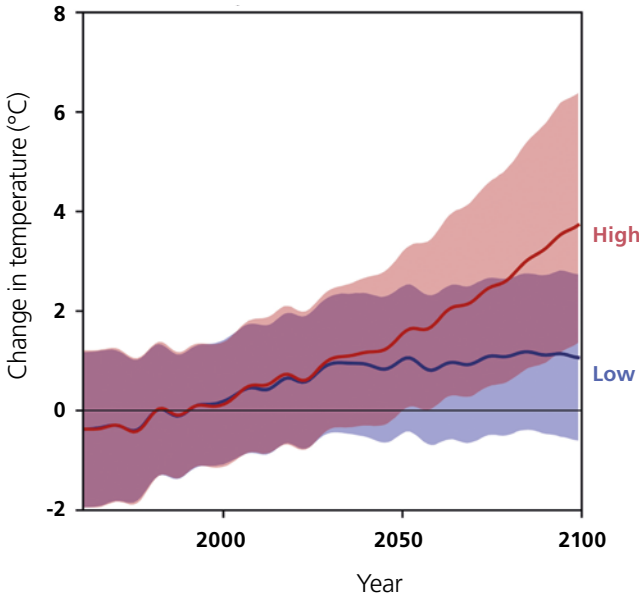
Temperature

- 

Winter temperatures are projected to increase.
- 

These changes do not mean that cold snaps and/or severe snowstorms can't or won't occur in the future. The 'Beast from the East' caused considerable disruption in early 2018, and similar cold/snow events remain a possibility despite the overall warming trend.

Scotland winter mean temperature compared to 1981–2000



The table on the right shows projected change in average winter temperatures for 2050 and 2080 under low and high emission scenarios. These figures are taken from the graph above.

The figures in **bold** are the central estimate (50th percentile). The figures below are the range of change that is considered likely (10th – 90th percentile).

Change in winter temperature (°C)

2050		2080	
Low Emission	High Emission	Low Emission	High Emission
1.0°C -0.5°C ↔ 2.5°C	1.5°C 0.0°C ↔ 3.2°C	1.1°C -0.5°C ↔ 2.7°C	2.7°C 0.6°C ↔ 4.9°C

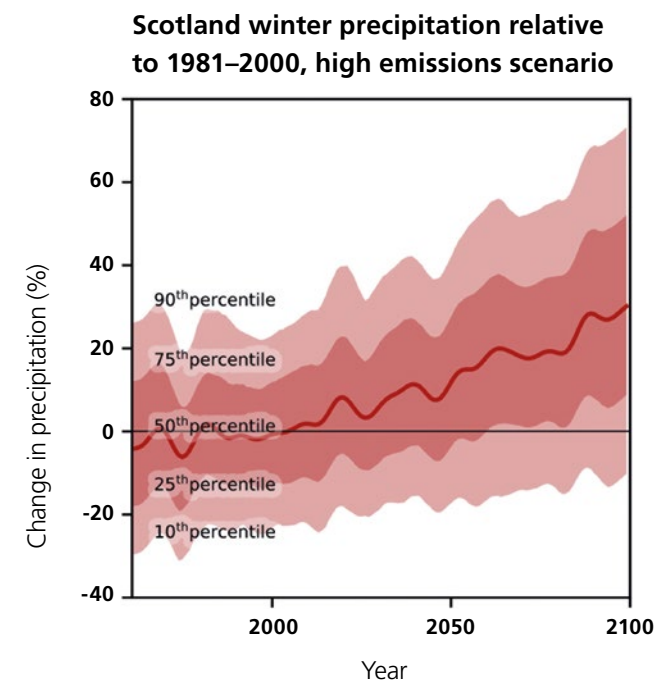
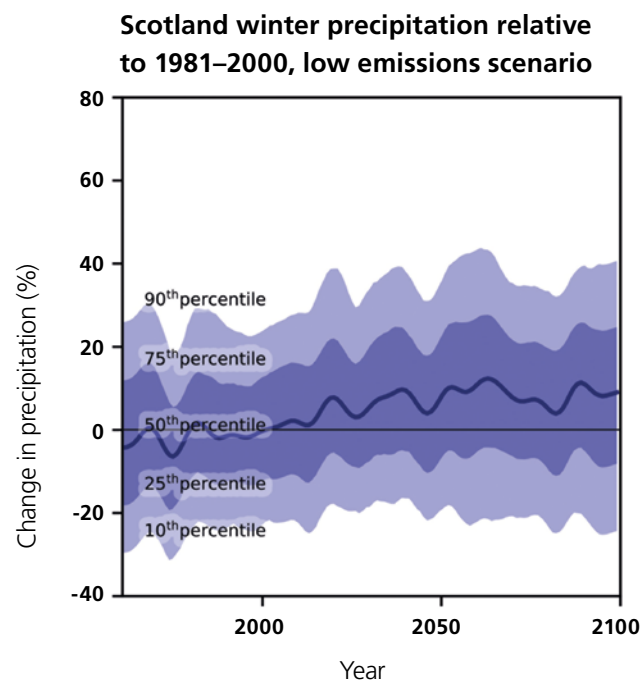
Rainfall



Winters are projected to become wetter, in terms of both the total amount of rainfall and the number of wet days. The increase is expected to be larger in western Scotland compared to the east. The intensity of rainfall on the wettest days is also expected to increase¹⁰.



The graphs on the right show projected change in winter rainfall over this century under a low (blue) and high (red) emission scenario.



The table on the right shows projected change in winter rainfall for 2050 and 2080 under low and high emission scenarios. These figures are taken from the graphs above. The figures in **bold** are the central estimate (50th percentile). The figures below are the range of change that is considered likely (10th – 90th percentile).

Change in winter rainfall (%)

2050		2080	
Low Emission	High Emission	Low Emission	High Emission
8%	12%	5%	19%
-19% ↔ 36%	-17% ↔ 42%	-24% ↔ 33%	-14% ↔ 56%

4. Summer



Scotland will experience hotter, drier summers, with greater extremes

Temperature

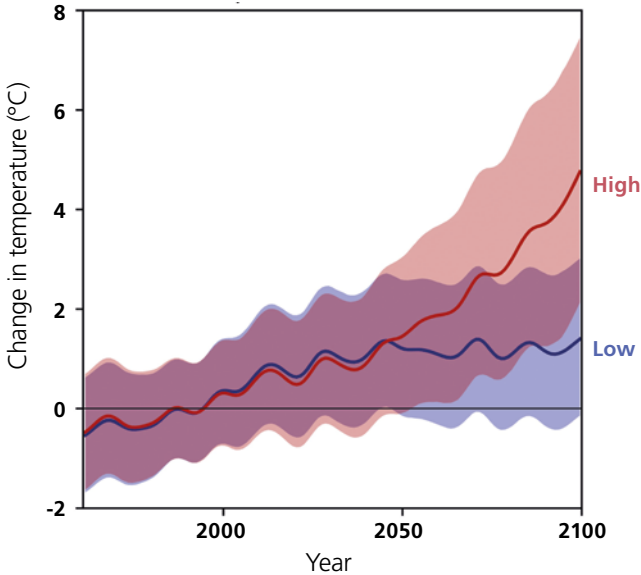


Although temperatures are projected to increase in both summer and winter, warming is expected to be greatest in summer.



Climate change has already increased the chance of seeing a summer as hot as the summer of 2018 to between 12 and 25%. With future warming, hot summers by mid-century could become even more common, near to 50%¹⁰.

Scotland summer mean temperature compared to 1981–2000



The table on the right shows projected change in summer by 2050 and 2080 under low and high emission scenarios. These figures are taken from the graph above. The figures in **bold** are the central estimate (50th percentile). The figures below are the range of change that is considered likely (10th – 90th percentile).

Change in summer temperature (°C)

2050		2080	
Low Emission	High Emission	Low Emission	High Emission
1.2°C	1.5°C	1.1°C	3.0°C
-0.2°C ↔ 2.6°C	-0.1°C ↔ 3.1°C	-0.4°C ↔ 2.6°C	0.8°C ↔ 5.3°C

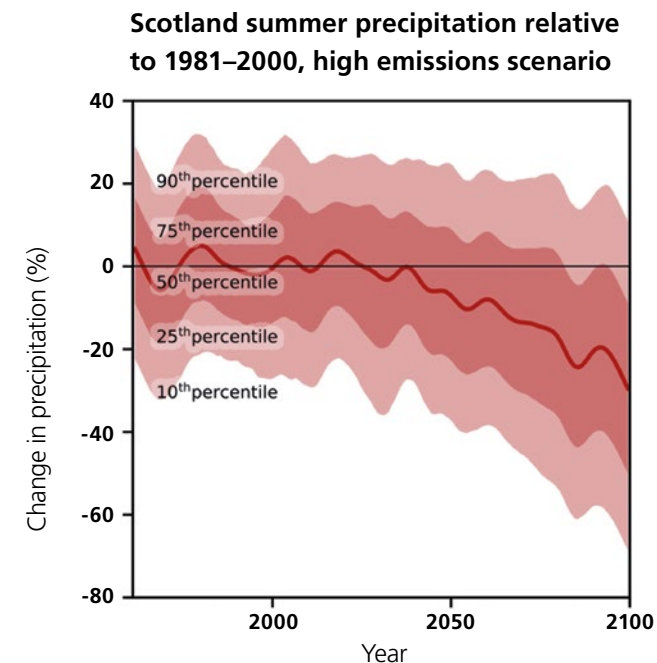
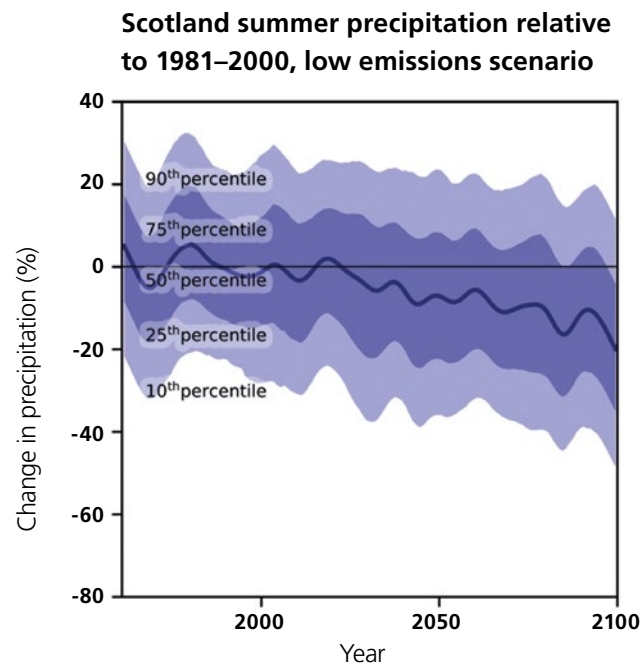
Rainfall



Summer rainfall is projected to decrease, although extreme downpours will be heavier despite the overall drying trend¹⁰.



The graphs on the right show projected change in summer rainfall over this century under a low (blue) and high (red) emission scenario. Summer rainfall decreases under both scenarios, with the greatest decrease projected under the high emission scenario.



The table on the right shows projected change in summer rainfall for 2050 and 2080 under low and high emission scenarios. These figures are taken from the graphs above. The figures in **bold** are the central estimate (50th percentile). The figures below are the range of change that is considered likely (10th – 90th percentile).

Change in summer rainfall (%)

2050		2080	
Low Emission	High Emission	Low Emission	High Emission
-7%	-8%	-11%	-18%
-36% ↔ 23%	-38% ↔ 24%	-40% ↔ 21%	-54% ↔ 21%

5. Sea level



Sea levels will continue to rise, increasing flooding and coastal erosion



Sea levels around the coast are projected to rise in the decades ahead. There are regional variations in projected sea level rise primarily due to vertical land movement caused by rebound from the last ice age.

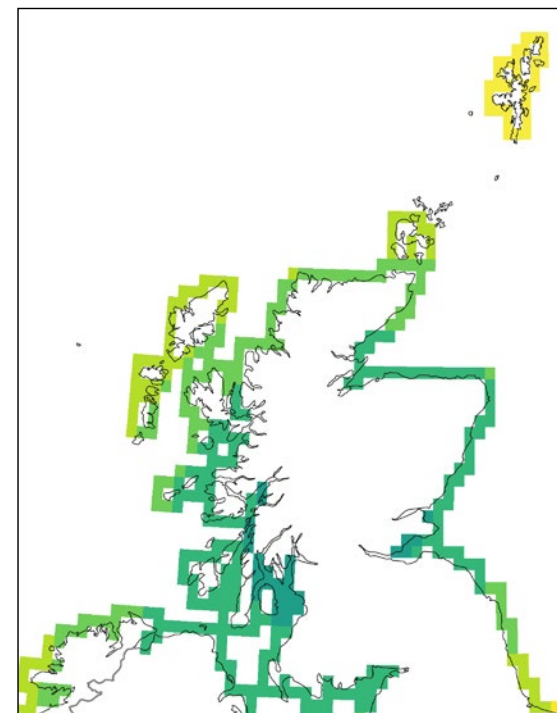


The maps on the right show median projected sea level rise around Scotland's coast by 2100 under low and high emission scenarios.

Median projected sea level change by 2100 for low emissions compared to 1981-2000



Median projected sea level change by 2100 for high emissions compared to 1981-2000



Sea level change (m)





The graphs on the right provide more detail and show sea level rise projections for Edinburgh, Stornoway, and Lerwick for high and low emission scenarios. The greatest projected sea level rise in Scotland occurs in the north, with the lesser projected increase in the central belt.

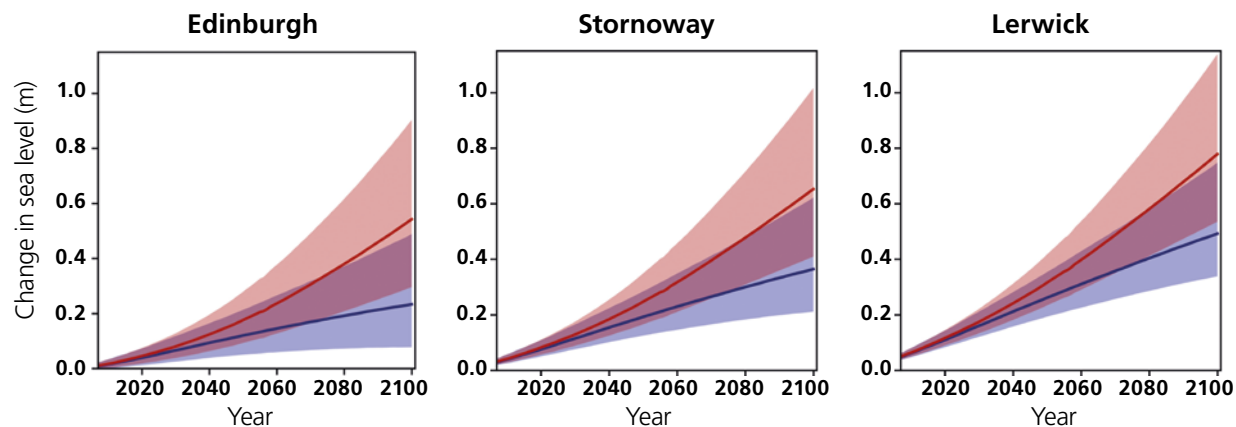
The table on the right shows projected sea level rise by 2050 and 2080 under low and high emission scenarios. These figures are taken from the graphs above. The figures in **bold** are the central estimate (50th percentile). The figures below are the range of change that is considered likely (5th – 95th percentile).

The sea level rise projections provided are considered the most likely range of change. However, the possibility of a sea level rise outside this range cannot be ruled out.

An estimated range for low probability, high impact sea level rise around the UK to 2100 was developed for the previous UK Climate Projections (UKCP09). This range is referred to as a H++ Scenario and is still valid. The low probability H++ absolute sea level rise estimate for the UK is 0.93m – 1.9m by 2100.

The Met Office recommends making use of multiple strands of evidence, including H++ scenarios when assessing vulnerabilities to future extreme water levels¹¹.

Change in sea level (m above 1981–2000 mean sea level)



Change in sea level (cm)

	2050		2080	
	Low Emission RCP 2.6	High Emission RCP8.5	Low Emission RCP2.6	High Emission RCP8.5
Edinburgh	12cm 5cm ↔ 21cm	18cm 9cm ↔ 28cm	19cm 7cm ↔ 37cm	38cm 21cm ↔ 62cm
Lerwick	26cm 19cm ↔ 35cm	32cm 23cm ↔ 42cm	40cm 28cm ↔ 58cm	58cm 41cm ↔ 82cm
Stornoway	19cm 13cm ↔ 28cm	25cm 17cm ↔ 35cm	30cm 18cm ↔ 48cm	48cm 31cm ↔ 72cm

6. Adapting to climate change – Scotland's response

Our response to the challenges of a changing climate is 'adaptation'¹². While the challenges we face from the impacts of climate change are significant, good adaptation can deliver both short-term benefits and progress towards long-term outcomes. This section goes beyond UKCP climate information and describes some of the climate impacts affecting Scotland. It also provides an overview of Scotland's response.

Impacts of climate change

The changes in climate described in this summary are causing widespread impacts which affect all of us. This includes increases in flood risk, coastal change, damage to buildings and infrastructure, and increased prevalence of pests and diseases in the natural environment.

Our understanding of these impacts is growing all the time, helping to inform Scotland's response and actions to adapt. Examples of more detailed impact information for flooding and coastal change are provided below. You can find out more about other climate impacts on the Adaptation Scotland website www.adaptationscotland.org.uk

Increased risk of flooding and coastal change

The last few years have seen numerous, widespread and significant flood events in Scotland, providing an indication of the conditions that we must adapt to.

- In Scotland, high river flow runoff has increased by over 20% and winter river runoff by nearly 45% over the last 4 decades¹³.
- Under a high emission scenario peak river flows for some Scottish river catchments could increase by more than 50% by the 2080's¹⁴.
- Projected increases in intense heavy rainfall events in both summer and winter will also increase the risk of extensive and significant river and surface water flooding.
- Analysis of Scottish tide gauges show that even the recent modest increases in mean sea level have resulted in more frequent flood events¹⁵.
- Sea level rise is thought to be a key factor in the increasing extent of coastal erosion identified across Scotland's soft, erodible shores¹⁶. Given uncertainties over future emissions and the environmental response, a precautionary approach is prudent.

Scotland's response

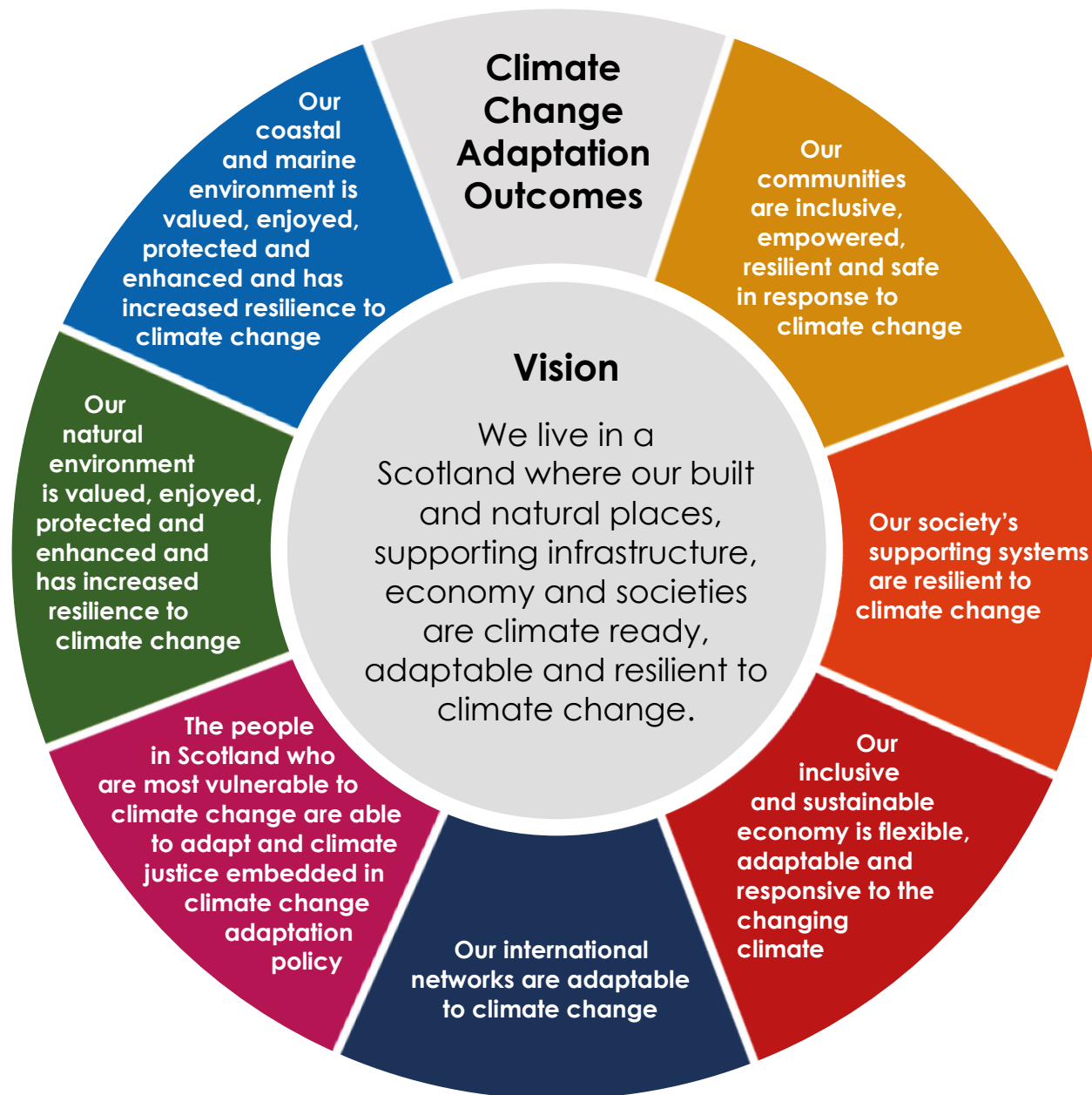
Developing a sound understanding of the challenge, including detailed analysis of the UK Climate Projections, is central to Scotland's adaptation response.

The UK Climate Projections are used, along with a wide range of evidence about the impacts of climate change, to create a UK Climate Change Risk Assessment (UKCCRA)¹⁷, this Assessment is required by the Climate Change Act 2008 and is updated every five years. The current Assessment was published in 2017 and so predates the UKCP18 projections. The next Assessment is due in 2022.

The Climate Change (Scotland) Act 2019¹⁸ requires the Scottish Government to use the findings of the UKCCRA to develop a statutory Scottish Climate Change Adaptation Programme (SCCAP)¹⁹. In September 2019, the Scottish Government published its second 5-yearly statutory adaptation programme. SCCAP2 sets out how the Scottish Government is responding to the main climate risks for Scotland – as identified in the UKCCRA and covering a range of global warming scenarios. In total, there are around 170 policies and proposals across Scotland.

The Programme is aligned with the UN Sustainable Development Goals²⁰ and Scotland's National Performance Framework²¹. The Scottish Government champions climate justice, and promotes a people-centred, human-rights approach to climate change adaptation.

The next SCCAP, which will respond to the priority risks identified for Scotland in the 2022 Risk Assessment, will be prepared for publication in 2024.



Endnotes

- 1 Read more about the climate projections on the MetOffice website <https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index> and about the Hadley Centre here <https://www.metoffice.gov.uk/weather/climate/met-office-hadley-centre/30-years-hadley-centre>
- 2 RPC is explained in this glossary https://www.ipcc-data.org/guidelines/pages/glossary/glossary_r.html
- 3 The 'climate stripes' for Scotland is based on UKCP Climate trends analysis done for this summary by the Met Office, 2020
- 4 Temperature data from UKCP Climate trends analysis done for this summary by the Met Office, 2020
- 5 Rainfall data from UKCP Climate trends analysis done for this summary by the Met Office, 2020
- 6 Mean sea level figures are from the UKCP 18 Science Overview Report (update April 2019) <https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/UKCP18-Overview-report.pdf> Pg 50, Met Office
- 7 This blog looks at the latest emissions figures for Scotland <https://www.climateexchange.org.uk/blog/how-is-scotland-progressing-towards-net-zero/>
- 8 <https://www.netzeronation.scot/> is a Scottish Government website that sets out what net-zero greenhouse gas emissions mean for Scotland and the actions people in Scotland can take.
- 9 The UNEP Emissions Gap Report 2019 finds that even if all unconditional Nationally Determined Contributions (NDCs) under the Paris Agreement are implemented, we are still on course for a 3.2°C temperature rise <https://www.unenvironment.org/resources/emissions-gap-report-2019>
- 10 You can read more about all the projections in the UK Climate Projections: Headline Findings (2019) <https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp-headline-findings-v2.pdf>
- 11 Read more about using H++ scenarios in this MetOffice fact sheet on sea level rise and storm surge <https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-fact-sheet-sea-level-rise-and-storm-surge.pdf>
- 12 The Intergovernmental Panel on Climate Change uses this definition of 'adaptation': "*adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities*", see the IPCC glossary <https://www.ipcc.ch/sr15/chapter/glossary/>
- 13 You can read the full paper by Jamie Hannaford 'Climate-driven changes in UK river flows: a review of the evidence' (2015), see pages 39, 29-48 <https://journals.sagepub.com/doi/10.1177/0309133314536755>
- 14 You can read the full paper by Alison Kay and colleagues 'Climate change impacts and peak river flows: Combining national scale hydrological modelling and probabilistic projections 2020', see figures 4 and 5 <https://www.sciencedirect.com/science/article/pii/S221209632030053X#!>
- 15 Read more about analysis of tide gauges in the paper 'Coastal Flooding in Scotland: A Scoping Study' by Ball, T., Werritty, A., Duck, R. W., Edwards, A., Booth, L. & Black, A. R., 2008 <https://discovery.dundee.ac.uk/en/publications/coastal-flooding-in-scotland-a-scoping-study>

- 16 Read more about sea level rise impact on soft erodible shores in this overview document from Dynamic Coast <http://www.dynamiccoast.com/files/reports/NCCA%20-%20National%20Overview.pdf>
- 17 Read about the climate risk assessment process and research here <https://www.ukclimaterisk.org/>
- 18 Read about climate change policy in Scotland here <https://www.gov.scot/policies/climate-change/> and the full Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 here <https://www.legislation.gov.uk/asp/2019/15/enacted>
- 19 The SCCAP is a statutory programme published every 5 years. Read the current programme here <https://www.gov.scot/publications/climate-ready-scotland-second-scottish-climate-change-adaptation-programme-2019-2024/>
- 20 The National Performance Framework is linked to the UN's Sustainable Development Goals: <https://www.undp.org/content/undp/en/home/sustainable-development-goals.html>
- 21 The Scottish Government works to a national outcomes set out in the National Performance Framework. See all the outcomes here <https://nationalperformance.gov.scot/>

Find out more and access advice and support

Partnership working is key to Scotland's adaptation response. This joint publication, produced through the Adaptation Scotland programme, is one of the many ways that the Scottish Government, the Met Office, key agencies and programmes are working together to respond. You can find out more about our work and access advice and support using the links below:

- **Met Office UK Climate Projections:**
www.ukclimateprojections.metoffice.gov.uk
- **Met Office Hadley Centre for Climate Science and Services:**
www.metoffice.gov.uk/weather/climate/met-office-hadley-centre/index
- **Scottish Government Climate Change Adaptation web pages:**
www.gov.scot/policies/climate-change/climate-change-adaptation/
- **SEPA's work on managing flood risk and water scarcity:**
www.sepa.org.uk
- **Historic Environment Scotland's climate change work:**
www.historicenvironment.scot/about-us/what-we-do/climate-change/
- **Nature Scot's climate action:**
www.nature.scot/climate-change
- **Dynamic Coast National Coastal Change Assessment:**
www.dynamiccoast.com
- **ClimateXChange climate change research:**
www.climateexchange.org.uk
- **Adaptation Scotland advice and support:**
www.adaptationscotland.org.uk

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Adaptation Scotland is a programme funded by the Scottish Government and delivered by Sniffer, Scottish Charity No SC022375, Company No SC149513.

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