

UK Climate Projections: Briefing report

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Foreword from Professor Robert Watson, Chief Scientific Advisor, Defra

That the world's climate is changing is irrefutable. The Intergovernmental Panel on Climate Change stated in its most recent Assessment Report that it is very likely that the changes we have seen and measured are the result of anthropogenic emissions of greenhouse gases. While there may be some opportunities to be gained from a changing climate, we expect the bulk of the changes associated with a warming world to be negative for our society, economic sectors and the natural environment. And because of the time lag in the climate system, even with the most ambitious mitigation efforts, we are locked in to a further amount of climate change over the coming decades. Governments across the UK have an obligation to put in place measures to ensure that the negative effects of this are minimised for the UK, as well as taking advantage of any opportunities.

In order for us to plan effectively for a changing climate, it is essential that we utilise the best evidence we have available. This is the purpose of the UK Climate Projections; the result of seven years of work by the Met Office Hadley Centre, UK Climate Impacts Programme and a body of over thirty contributing organisations. For the first time, the Projections use a peer-reviewed, cutting edge methodology to give a measure of the uncertainty in the range of possible outcomes; a major advance beyond previous national scenarios. While the new set of Projections is designed to give much more information to users than previous climate scenarios, the information is necessarily more complex. Alongside this report to summarise the science behind the Projections, there are four accompanying scientific reports with more detail, as well as a dedicated website to access the climate information, supported by extensive user guidance and training.

I am delighted to offer this new state-of-the-art climate information, both to support decision makers who need to plan adaptation strategies, and as a major contribution towards international efforts to improve our ability to model future climate.



R. T. Watson

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<http://ukclimateprojections.defra.gov.uk>

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The authors would like to thank the contributors and review groups to the four UKCP09 science reports on which this Briefing Report has been based.

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Discussions with Prof. Jonathan Rougier, University of Bristol, have encouraged us to adopt the methodology for the UKCP09 probabilistic projections.

Summary

This report provides a summary of the 2009 UK Climate Projections (UKCP09), consolidating for the general reader the scientific reports describing the methodology and some key projections of future climate change for the UK over the 21st century. The UKCP09 Projections provide a basis for studies of impacts and vulnerability and decisions on adaptation to climate change in the UK over the 21st century. Projections are given of changes to climate, and of changes in the marine and coastal environment; recent trends in observed climate are also discussed. Each will be treated separately in this summary.

Observed trends in UK climate

- Central England Temperature has increased by about 1°C since the 1970s; it is likely that global emissions of man-made greenhouse gases have contributed significantly to this rise.
- Sea level around the UK has risen by about 1 mm/yr in the 20th century; the rate of rise in the 1990s and 2000s has been higher than this.

Projections of climate change

- Projections of climate change take into account uncertainty due to natural variability and our incomplete understanding of the climate system and its imperfect representation in models. The projections do this by giving the probabilities of a range of possible outcomes, as estimated by a specific methodology.
- Probability in UKCP09 can be seen as the relative degree to which each climate outcome is supported by current evidence, taking into account our understanding of climate science, observations and using expert judgement.
- Probabilistic projections are given at a resolution of 25 km over land, and as averages over administrative regions, river basins and marine regions, for seven overlapping 30-yr periods, and for three future emissions scenarios.
- There is a cascade of confidence in climate projections, with moderate confidence in those at continental scale; those at 25 km resolution are indicative to the extent that they reflect large-scale changes modified by local conditions such as mountains and coasts. The confidence in the climate change information also depends strongly on the variable under discussion.
- Errors in global climate model projections cannot be compensated by statistical procedures no matter how complex, and will be reflected in uncertainties at all scales.
- The methodology developed for UKCP09 to convert climate model simulations into probabilistic estimates of future change necessitates a number of expert choices and assumptions, with the result that the probabilities we specify are themselves uncertain. We do know that our probabilistic estimates are robust to reasonable variations within these assumptions.

Some examples of projected seasonal and annual changes

We summarise in the box below some changes by the 2080s with Medium emissions, but stress that projections can be very different for other time periods and other emissions scenarios. Users should look at the time period appropriate for their decisions, and examine projections for all three emissions scenarios, to gain a full appreciation of changes to which they might have to adapt.

Summer, winter and annual mean changes by the 2080s (relative to a 1961–1990 baseline) under the Medium emissions scenario. Central estimates of change (those at the 50% probability level) followed, in brackets, by changes which are very likely to be exceeded, and very likely not to be exceeded (10 and 90% probability levels, respectively).

- All areas of the UK warm, more so in summer than in winter. Changes in summer **mean temperatures** are greatest in parts of southern England (up to 4.2°C (2.2 to 6.8°C)) and least in the Scottish islands (just over 2.5°C (1.2 to 4.1°C)).

- **Mean daily maximum temperatures** increase everywhere. Increases in the summer average are up to 5.4°C (2.2 to 9.5°C) in parts of southern England and 2.8°C (1 to 5°C) in parts of northern Britain. Increases in winter are 1.5°C (0.7 to 2.7°C) to 2.5°C (1.3 to 4.4°C) across the country.
 - Changes in the **warmest day of summer** range from +2.4°C (–2.4 to +6.8°C) to +4.8°C (+0.2 to +12.3°C), depending on location, but with no simple geographical pattern.
 - **Mean daily minimum temperature** increases on average in winter by about 2.1°C (0.6 to 3.7°C) to 3.5°C (1.5 to 5.9°C) depending on location. In summer it increases by 2.7°C (1.3 to 4.5°C) to 4.1°C (2.0 to 7.1°C), with the biggest increases in southern Britain and the smallest in northern Scotland.
 - Central estimates of **annual precipitation** amounts show very little change everywhere at the 50% probability level. Changes range from –16% in some places at the 10% probability level, to +14% in some places at the 90% probability level, with no simple pattern.
 - The biggest changes in **precipitation in winter**, increases up to +33% (+9 to +70%), are seen along the western side of the UK. Decreases of a few percent (–11 to +7%) are seen over parts of the Scottish highlands.
 - The biggest changes in **precipitation in summer**, down to about –40% (–65 to –6%), are seen in parts of the far south of England. Changes close to zero (–8 to +10%) are seen over parts of northern Scotland.
 - Changes in the **wettest day of the winter** range from zero (–12 to +13%) in parts of Scotland to +25% (+7 to +56%) in parts of England.
 - Changes in the **wettest day of the summer** range from –12% (–38 to +9%) in parts of southern England to +12% (–1 to +51%) in parts of Scotland.
 - **Relative humidity** decreases by around –9% (–20 to 0%) in summer in parts of southern England — by less elsewhere. In winter changes are a few percent or less everywhere.
 - **Summer-mean cloud amount** decreases, by up to –18% (–33 to –2%) in parts of southern UK (giving up to an extra +16 Wm^{–2} (–2 to +37 Wm^{–2}) of downward shortwave radiation) but increase by up to +5% (zero to +11%) in parts of northern Scotland. Changes in cloud amount are small (–10 to +10%) in winter.
- Projected changes in storms are very different in different climate models. Future changes in anticyclonic weather are equally unclear.
 - We have been unable to provide probabilistic projections of changes in snow. The Met Office Hadley Centre regional climate model projects reductions in winter mean snowfall of typically –65% to –80% over mountain areas and –80% to –95% elsewhere.
 - We make no assessment of how the urban heat island effect may change.
 - It is very unlikely that an abrupt change to the Atlantic Ocean Circulation (*Gulf Stream*) will occur this century.

Projected changes in daily climate

- UKCP09 provides synthetic daily time series of a number of climate variables from a weather generator, for the future 30-yr time periods, under the three emissions scenarios. These are given at 5 km resolution across the UK, the Isle of Man and the Channel Islands, but there is no climate change information additional to that at 25 km resolution.
- The Weather Generator is conditioned by change factors from the probabilistic projections; hence it must be used probabilistically by running at least 100 times.
- Analysis of results from the Weather Generator shows that increases in the number of days with high temperatures are found everywhere, particularly in southeast England, and reductions in the number of frost days are found, greatest where frost days are currently more frequent. Increases in the number of 10-day dry spells across the UK are found, more pronounced in southern England and Wales.

Projections of changes to the marine and coastal environment

- The range of absolute sea level rise around the UK (before land movements are included) is projected to be between 12 and 76 cm for the period 1990–2095 for the Medium emissions scenario.
- Taking vertical land movement into account gives slightly larger sea level rise projections relative to the land in the more southern parts of the UK where land is subsiding, and somewhat lower increases in relative sea level for the north. The land movements are typically between –10 and +10 cm over a century.
- Future projected trends in storm surge height are small everywhere around the UK, and in many places can be accounted for by natural variability. Consequently, changes in extreme sea level by 2100 will likely be dominated by increases in local mean sea level.
- Seasonal mean and extreme waves are generally projected to increase to the South West of the UK, reduce to the north of the UK and experience little change in the southern North Sea. Changes in the annual maxima are typically in the range –1.5 to +1 m.
- The shelf seas around the UK are projected to be 1.5 to 4°C warmer and ~0.2 practical salinity units (p.s.u.) fresher (lower salinity) by the end of the 21st century. The strength and period of summer stratification is projected to increase in the future.
- A wider range (known as H++) has also been developed for sea level rise and storm surges to be used for contingency planning and sensitivity analysis. The top of this range is considered very unlikely to be realised during the 21st century.

As our understanding, and our modelling and statistical capabilities, improve, it is very likely that projections will change in the future. The UKCP09 Projections are appropriate for decisions on adaptation to long-term climate change which need to be taken on the basis of current knowledge.

1 Introduction and purpose of this report

Climate is changing, both globally and in the UK. The Fourth Assessment Report (AR4) from the IPCC (Intergovernmental Panel on Climate Change) in 2007 said that “it is very likely that anthropogenic greenhouse gas increases caused most of the observed increase in global average temperatures since the mid-20th century”, and more recent research has increased confidence in this statement. Changes projected by climate models are likely to result in significant impacts on the UK. And, because of the inertia of the climate system, current global emissions, and those over the past few decades, have already committed us to future climate change which cannot now, in any practical sense, be avoided.

These three factors: the high likelihood that mankind has already begun to change the earth’s climate, the projections of significant impacts in the future, and the commitment to further change over the next few decades irrespective of any emission reductions in the short term, argue very strongly for a strategy of adaptation to minimise the consequences, and maximise the opportunities, of climate change. To adapt effectively, planners and decision-makers need as much good information as possible on how climate will evolve, and supplying this is the aim of the new projections of UK climate change in the 21st century, known as UKCP09. They are one part of a UK government programme of work to put in place a new statutory framework on, and provide practical support for, adaptation.

The projections have been designed as input to the difficult choices that planners and other decision-makers will need to make, in sectors such as transport, healthcare, water resources and coastal defences, to ensure the UK is adapting well to the changes in climate that have already begun and are likely to grow in future. The underlying projections are in the form of numerical data that can be explored and downloaded with a purpose-built User Interface; this can also be used to visualise the data in the form of maps and graphs.

The UKCP09 Projections are supported by several publications, primarily online, in particular:

- The climate of the United Kingdom and recent trends
- UK Climate Projections science report: Climate change projections
- UK Climate Projections science report: Marine and coastal projections
- UK Climate Projections science report: Projections of future daily climate for the UK from the Weather Generator

This report, and the science reports on which it is based, have been reviewed by the project Steering Group and User Panel. Reviewers’ comments have been taken into account in improving the report. The methodologies used to generate the UKCP09 Projections were reviewed by an international panel of experts.

This Briefing Report aims to summarise the information in the four reports, for those requiring a general awareness of UK climate change. It begins by summarising recent observed changes in UK climate, in Section 2. It next turns to projections of change, where a major improvement in UKCP09 is the way in which uncertainty is dealt with. Because this is done differently for climate variables (temperature, rainfall, etc.) than it is for those in the marine and coastal environment (e.g. sea level and waves) the Briefing Report also follows this separation. Thus Section 3 summarises the methodology used to quantify uncertainties in climate variables, Section 4 describes the information provided in the probabilistic projections, and Section 5 shows some example projections of changes in temperature and precipitation. Section 6 presents the same sort of summary for the marine and coastal environment.

Figure 1 summarises all the information, in different forms, available to support the projections. The process of developing UKCP09 has included consultation with both climate experts and potential users, through its Steering Group and Users’ Panel. Hence, the projections are designed to be aligned as closely as possible with what users need to support their assessments of risk and choice of adaptation measures.

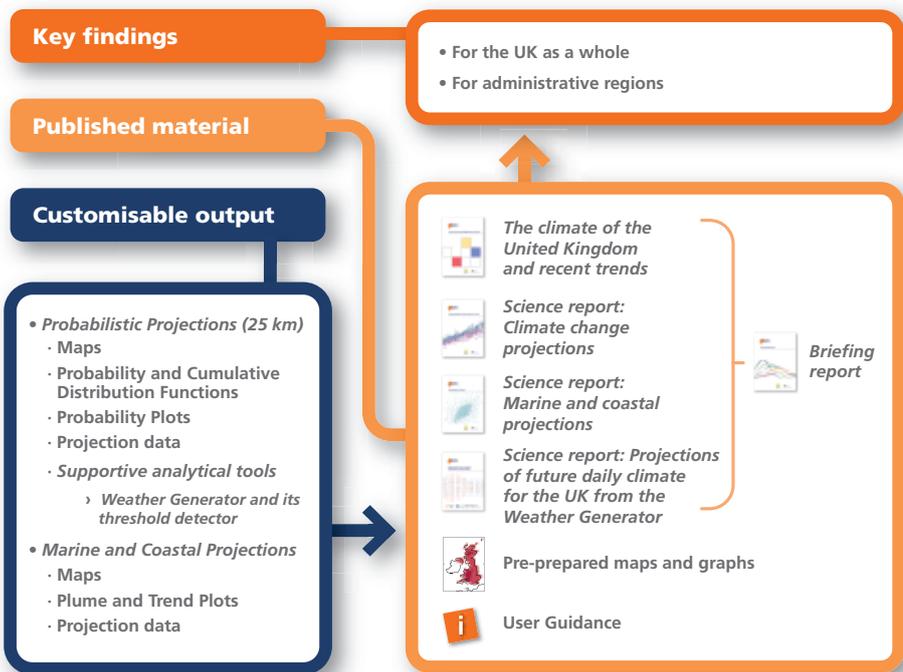


Figure 1: Information and publications supporting the UKCP09 projections. (Source: UKCIP)
The products described under **Customisable Output** are explained later in this report.