Department for Environment Food & Rural Affairs

Department for Business, Energy & Industrial Strategy

Met Office Hadley Centre

Environment Agency

UKCP18 Factsheet: Precipitation

This factsheet summarises the key information currently available on the UKCP18 projections over land for precipitation metrics. Read this before using any products as it describes the data availability, the key future climate changes (if any) that you should see and the caveats and limitations.

We recommend that you read the UKCP18 Science Overview (Lowe et al, 2018) to understand the different components of the projections. For a comprehensive description of the underpinning science, evaluation and results see the UKCP18 Land Projections: Science Report (Murphy et al, 2018).
Please note that the land projections consist of the following:

- **Probabilistic projections** that combine climate model data, observations and advanced statistical methods to simulate a wide range of climate outcomes for five emission scenarios (RCP2.6), RCP4.5, RCP6.0, RCP8.5 and SRESA1B).
- **Global (60km) projections** - a set of 28 climate futures at 60km grid resolution, showing how the 21st Century climate may evolve under the highest emission scenario, RCP8.5. The assess the uncertainty across different models from different modelling centres as well as the parameter uncertainty. It incorporates 15 members of the Met Office Hadley Centre model, HadGEM3-GC3.05 (PPE -15), and 13 other climate models selected from the climate models that informed the Intergovernmental Panel on Climate Change's 5th Assessment Report (CMIP5-13).
- **Regional (12km) projections** - a set of 12 high resolution projections at 12km (RCM-PPE) downscaled from the PPE-15 over the UK and Europe. They assess the uncertainty in the regional model parameters, as well as uncertainty in the large-scale conditions from the driving global model.
- **Local (2.2km) projections** – a set of 12 very high resolution projections at 2.2km (CPM-12) downscaled from the regional projections over the UK. They assess different local conditions given the uncertainty in the driving information.
- **Derived projections** – a set of climate futures for the UK at 60km grid resolution for a low emissions scenario, RCP2.6 and a global warming level of 2 °C and 4 °C. These have been derived from the global projections using statistical techniques.

Results overview[1]

- Observations show a high level of variability in precipitation from year to year, with a slight overall increase in UK winter precipitation in recent decades.
- Over land the projected general trends of climate changes in the 21st century are similar to UKCP09, with a move towards warmer, wetter winters and hotter, drier summers. However, natural variations mean that some cold winters, some dry winters, some cool summers and some wet summers will still occur.
- Rainfall patterns across the UK are not uniform and vary on seasonal and regional scales and will continue to vary in the future.
- For the probabilistic projections:
  - While the projections show a clear shift to higher probability levels of dry summers, they also suggest that the likelihood of individual wet summers reduces only slightly.
  - The projections show a pattern of larger increases in winter precipitation over southern and central England and some coastal regions towards the end of the century (Figure 1). Summer rainfall reductions tend to be largest in the south of England.
- For the UK the global projections show:
  - A good degree of consistency with the probabilistic projections in the winter.
  - A more complex behaviour in the summer: the ensemble mean of CMIP5-13 shows a smaller reduction - typically ~20% during the last decade of the 21st century - than the probabilistic projections. In contrast, the ensemble mean of PPE-15 is drier than the median probabilistic projections. Typically the PPE-15 is ~50% drier during the corresponding period.
  - More information on the differences between the PPE-15 and the CMIP5-13 precipitation projections can be found in the Science Overview report and Land Projections Science Report.
  - Further results for the Regional (12km) and Local (2.2km) projections can be found in the UKCP Local (2.2km) Factsheet

[1] More information will become available based on the results of the high resolution 2.2km climate model projections.

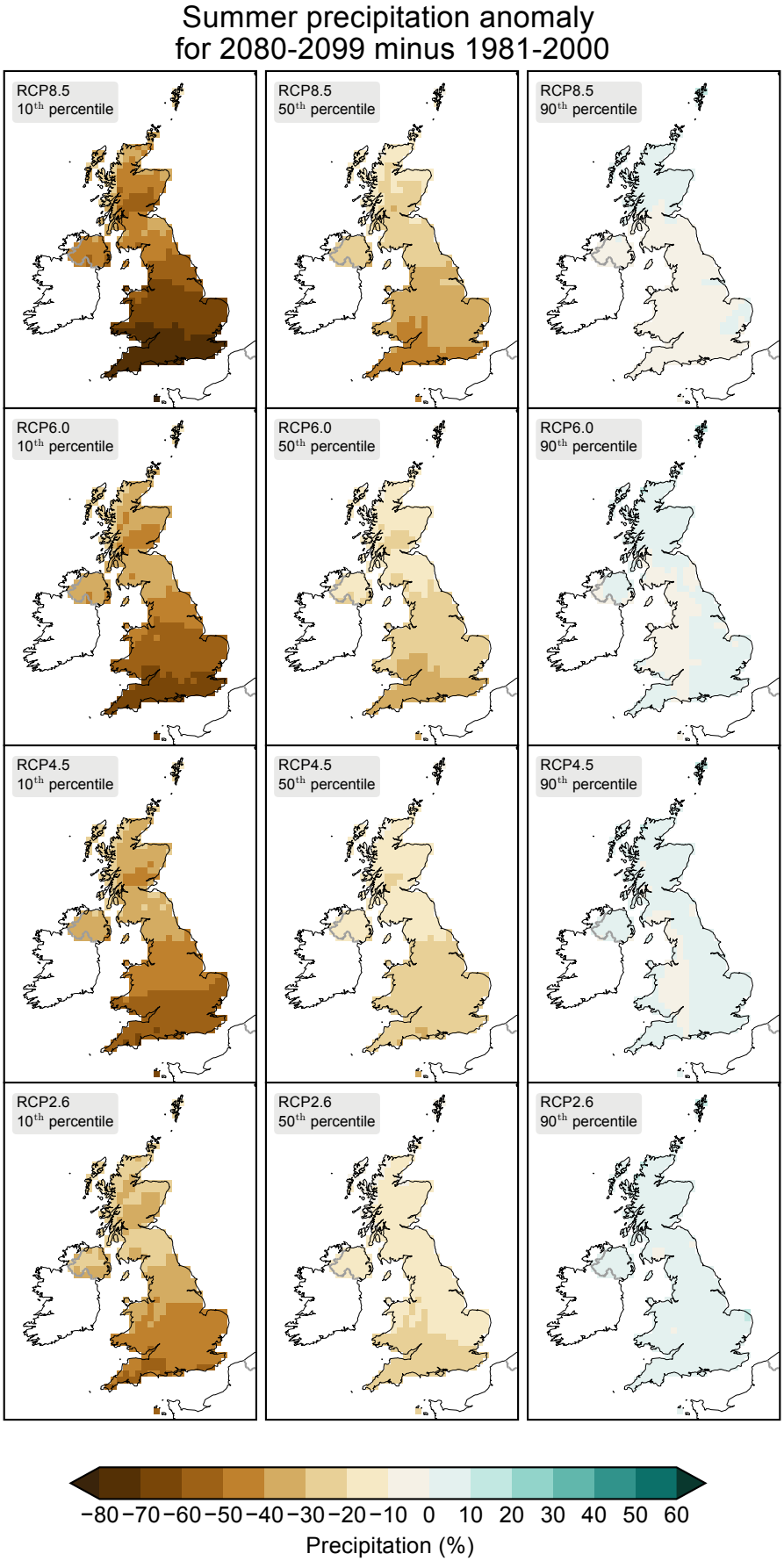

Figure 1. Projected changes in summer mean precipitation for the UK for 2080-2099 compared to 1981-2000 using the probabilistic projections. RCP2.6 is the lowest emissions scenario and RCP8.5 is the highest emissions scenario.

The importance of precipitation

Precipitation, both rainfall and snowfall, can cause significant societal and economic impacts on various timescales.

Short, intense rainfall events (e.g. thunderstorms) can lead to pluvial or surface flooding as surface run-off inundates small catchments and the urban landscape. Prolonged periods of excessive precipitation saturates soil, increasing the risk of fluvial or river flooding. Above average precipitation for long periods can ultimately lead to a raised water table, which can result in groundwater flooding in areas where the geological characteristics are favourable. In the UK and Europe, flooding is one of the most economically and socially disruptive natural hazards with impacts on transport, infrastructure and energy supply.

Information on precipitation variability and future change is also critically important in water resource management. Changes in precipitation patterns in the future – increases or decreases in totals on seasonal or multi-year timescales – have implications for major investment and planning decisions made by UK public and private sector organisations. Long periods of low rainfall, especially when combined with above average temperatures, can result in drought-like conditions with implications for water supply and agriculture.

What data are available and where can you find it?

You can find the data availability summarised in Table 1.

	Observations	Probabilistic projections	Global (60km) projections	Regional (12km) projections	Local (2.2km) projections	Derived projections
Precipitation variables near the surface	Amount, in mm per day	Amount, in mm per day	Amount, in mm per day	Amount, in mm per day	Amount, in mm per day	Amount, in mm per day
Geographical extent	UK	UK	UK Global	UK Europe	UK	UK
Spatial resolution	12km† 25km† 60km†	25km	60km	12km	2.2km (5km in OSGB)	60km
Temporal resolution	Daily Monthly	Monthly Seasonal Annual	Daily Monthly Seasonal Annual	Daily Monthly Seasonal Annual	Hourly Daily Monthly Seasonal Annual	Daily Monthly
Period of data	1960-2017 daily 1914-2017 monthly	1960-2100	1900-2100	1980-2080	1981-2000 2021-2040 2061-2080	1900-2100
Emissions scenarios	n/a	RCP2.6 RCP4.5 RCP6.0 RCP8.5 SRES A1B	RCP8.5	RCP8.5	RCP8.5	RCP2.6 2°C world 4°C world

Table 1: Summary of available precipitation variables for UKCP18. Data is provided in (i) the Ordnance Survey's British National Grid (OSGB) for UK areas and (ii) in the climate models' original grid for areas outside of the UK (see UKCP18 Guidance: data availability, access and formats). †based on observation network.

You can access the data and visualisations via the UKCP18 User Interface.

You can access the simulations and all other datasets via the CEDA Data Catalogue (http://catalogue.ceda.ac.uk) but note that this requires the technical skill to analyse large datasets.

How do the results compare to other models?

Figure 2 shows a like-for-like comparison of UKCP09 and UKCP18 for summer average precipitation over the Southeast England administrative region for the SRES A1B emissions scenario. It indicates substantial similarity between the distributions of the two sets of projections. Median summer precipitation changes both show reductions that grow through the century, accompanied by uncertainty ranges wide enough to encompass the possibility of an increase. By the end of the 21st Century UKCP18 displays a larger range of outcomes than UKCP09.

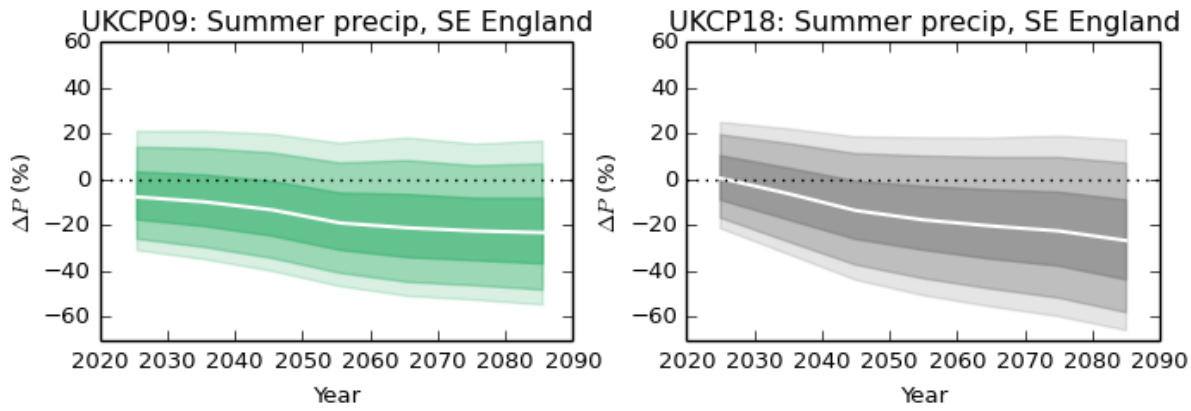

Figure 2: Probabilistic projections of summer average precipitation (%), ΔP, from UKCP09 (left) and UKCP18 (right), for the SRES A1B emissions scenario for the South East England administrative region. The white line shows the median (50th percentile) of the probability distribution and shading shows the 5th, 10th, 25th, 75th, 90th and 95th percentiles. Changes in 30-year averages are shown relative to the UKCP09 baseline of 1961-1990, for the seven overlapping future periods provided in UKCP09: 2011-2040, 2021-2050, 2071-2100 (based on Figure 2.6 of Murphy et al, 2018).

We have compared the probabilistic, global and regional land projections across the UK for the future. This shows a consistency in the increase in average winter precipitation for the high emissions scenario, RCP8.5, (see section 5.1 of UKCP18 Land Projections: Science Report). There are some differences found for the UKCP local (2.2km). See UKCP local (2.2km) Factsheet.

We have also compared the global and regional projections with observations[2] to understand how consistent they are. The PPE-15 and regional projections display systematic differences (bias) in winter precipitation from observations for the period 1981-2000 and show wet biases in both the PPE-15 and CMIP-13 in winter. The largest biases exceed 100% of the observed 1981-2000 value, these are more prevalent in the CMIP5-13 than in the PPE-15.

You may wish to consider adjusting the climate model data for the “biases” and apply bias-correction techniques before using UKCP18 data in your analysis. Further information on what bias correction is, common approaches and the caveats and limitations are described in the UKCP18 guidance on How to Bias Correct.

The comparisons presented in this factsheet show that there are similarities and differences between UKCP18 projections and other sources of data. The reasons for the differences are often complex and not easily summarised in this format of document. For further discussion of this topic and some of the explanations for the difference please refer to Section 2 of the Science Overview report (Lowe et al, 2018) in the first instance.

[2] We use a reanalysis dataset ERA-Interim (www.ecmwf.int/en/forecasts/datasets/archive-datasets/reanalysis-datasets/era-interim). It provides a comprehensive synthetic historical record of climate and is produced using observations and numerical models.

What do you need to be aware of?

Whilst the projections represent the latest scientific understanding and the results have been peer reviewed by independent experts, keep in mind the caveats and limitations of the projections. Although our understanding and ability to simulate the climate is advancing all the time, our models are not able to represent all of the features seen in the present day real climate. This means that when including the climate projections in your decision-making, consider how best to factor the capabilities and limitations of UKCP18. This should be informed by a thorough understanding of the consequences of different climate outcomes – perhaps including those beyond the ranges of uncertainty presented in UKCP18.

Precipitation is highly variable in both space and time and the interactions between this complex field and small-scale changes in terrain are required for a complete assessment of climate impacts. Many climate models cannot capture some of these processes responsible for precipitation, especially short duration local effects. The aggregate effect of the precipitation over a large area has to be calculated in order to maintain balance within the models, which can lead to some loss of information at smaller scale. The key messages provided in this guidance refer to total rainfall over a 3-month season and do not infer information about the intensity of individual rainfall events.

See UKCP18 Guidance: How to Use the Land Projections for further information on the caveats and limitations and appropriate use.

Where can I find more information?

For further information on UKCP18:

- Find a summary of the key results for precipitation from the UKCP18 website at https://ukclimateprojections.metoffice.gov.uk
- Download precipitation data from the UKCP18 User Interface at ukclimateprojections-ui.metoffice.gov.uk and the CEDA Data Catalogue at http://catalogue.ceda.ac.uk/uuid/c700e47ca45d4c43b213fe879863d589
- Find out more on the underpinning science from the UKCP18 Land Projections Science Report (Murphy et al, 2018).
- Find out more about the UKCP18 Derived Projections (Gohar et al, 2018) that provide results at the 60km scale over the UK for RCP2.6 and 2°C and 4°C worlds.

This document is citable as Maisey P, Fung F, Harris G, Lowe J, McSweeney C, Mitchell JFB, Murphy J, Rostron J, Sexton D and Yamazaki K. UKCP18 Factsheet: Precipitation. Met Office Hadley Centre, Exeter.

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