Probabilistic Projections Update: FAQs

Who is this document for?

This document is for anyone who has used or is planning on using the UKCP Probabilistic Projections that were released in 2018 and is a companion document to the science reports describing the original release (Murphy et al., 2018) and the updates outlined below (Harris et al, 2022), both available from the UKCP Science Reports page.

On 4 August 2022, we released an update to the UKCP Probabilistic Projections (v2022), replacing the dataset from November 2018 (v2018)*. The impact of the update will depend on your application and we explore an example case below.

This update does not affect any other UKCP Product, i.e. the Probabilistic Projections of Climate Extremes, UKCP Global (60 km), UKCP Regional (12 km), UKCP Local (2.2 km), Derived Projections or the Marine Projections. Further information about the UK Climate Projections can be found on our web pages and should you require any further assistance, you can contact us using the form at www.metoffice.gov.uk/forms/contact-us-ukcp18.

What are the Probabilistic Projections and why have they been updated?

The Probabilistic Projections are part of the suite of data products available as part of the UK Climate Projections and were released in November 2018. These consist of 3000 individual realizations of time-dependent climate change plus a corresponding set of probability distributions.

Five developments are included in the updated Probabilistic Projections, driven by feedback from users and investigations by the UKCP science team. Two developments correct software errors found following extensive investigation of the original results. One caused some inconsistencies between the maximum, minimum and mean daily temperature data. The second caused inconsistencies in how large-scale changes are translated into local changes in the Probabilistic Projections (i.e. the downscaling procedure), affecting all variables.

* Three datasets are mentioned in the technical report (Harris et al, 2022): "original" which refers to v2018, "new" which refers to v2022 as well as "updated" which refers to an interim dataset which does not include the downscaling fix. The interim dataset was produced for internal Met Office use to help quantify the impact of the improvements. In this guidance, we only reference the datasets that are available in the public domain, i.e. v2018 and v2022 or the "original" and "new".

We have also included three scientific improvements to the methodology that improve the utility of the data. These are:

- The statistical treatment of precipitation to avoid physically implausible values and improve the projections of dry- and wet-end extremes.
- Representation of annual and decadal variability which means that time-dependent changes in the probability levels for all variables develop more smoothly through the 21st century.
- Ensuring that average anomalies during the baseline period of 1981-2000 are precisely zero, in each of the 3000 realizations.

The combination of the improvements listed above means that all variables are modified to some degree. The size of the changes varies with variable, region, season and periods of interest, so the impacts will vary between users depending on their choices. An example use case can be found below.

As part of the continual review and improvement of UKCP data products and services, we have updated the UKCP Probabilistic Projections to correct these issues. Note that the improvements do not affect any other UKCP product, i.e. the UKCP Probabilistic Projections of Climate Extremes, UKCP Local, UKCP Regional, UKCP Global and the Derived Projections.

In more detail: the first software error was due to an indexing issue in one of our climate model datasets that offsets the seasonal cycle of maximum and minimum temperature data by one month. The second software error caused inconsistencies in how large-scale changes are translated into local changes in the Probabilistic Projections, affecting all variables. The error in the ‘downscaling procedure links global and regional climate model simulations to derive UK projections expressed on a 25 km grid. In some cases, this error also affected the projections provided for three sets of UKCP aggregated regions.

How does the Probabilistic Projections update affect the headline findings?

The qualitative statements in the Headline Findings document are not affected by the update: the UK is projected to have hotter, drier summers and warmer wetter winters. However, we have updated this to reflect the updated data values, namely statements:

3.1.2 on the range of summer and winter temperatures in 2070

3.1.3 on the increased chance of seeing a summer as hot as 2018

3.2.2 on the range of summer and winter precipitation changes in 2070

How different are the updated data compared to the original?

The Probabilistic Projections dataset provides data for national, administrative and river basin regions as well as 25 km grid cells. You can find monthly, seasonal and annual data as time series or 20-year and 30-year time horizons.

The differences between v2018 and v2022 depend on the location, variable of interest and greenhouse gas emissions scenario. As stated in the science report (Harris et al, 2022), the greatest differences between v2018 and v2022 are at the 25 km gridded data product, with the differences reducing for coarser spatial resolutions (i.e. administrative, river basin regions and national averages – see Table 1 for the differences for the high emissions scenario) and lower greenhouse gas emission scenarios.

Season	Mean variable	Difference
Summer	Temperature change*, median	0-0.1°C warmer (except Channel Islands, 0.1°C cooler)
Winter	Temperature change*, median	0-0.6°C colder
Summer	Precipitation change, median	Drier by 1-3% in England, Wales and Channel Islands Wetter by 1-2% in Scotland, Isle of Man and Northern Ireland
Winter	Precipitation change, median	Drier by 1-2% in England, Scotland, Wales and Channel Islands Wetter by 6-7% in Northern Ireland and Isle of Man
Summer	Precipitation change, dry extremes (10th percentile)	Wetter by 3-7% (except in Northern Ireland and Isle of Man, 3-4% drier)
	Precipitation change, wet extremes (90th percentile)	Wetter by 4-5% in Northern Ireland, Wales, Isle of Man and the Channel Islands Drier by 1-2% in England and Scotland
Winter	Precipitation change, dry extremes (10th percentile)	Wetter by 0-5% (except in Scotland, 1% drier)
	Precipitation change, wet extremes (90th percentile)	Drier by 2-4% (except in Northern Ireland and Scotland, 9-10% wetter)

Table 1 Summary of differences in projections at the end of the 21st century (2070-2089) between version 2022 in all UK country values for RCP 8.5 compared and version 2018 (v2022 – v2018) for a baseline of 1981-2000 based on Harris et al (2022) *differences in maximum, mean and minimum daily temperatures are similar.

In general, the summer temperature distributions are shifted to slightly warmer changes, and the winter distributions to slightly cooler changes. The intensities of extreme dry responses in summer are slightly reduced in the updated projections except for Northern Ireland and Isle of Man where 10th percentile drying is projected to increase slightly, from -41% to -44%.

You can find the differences in the values for country, administrative and river basin regions (i.e. aggregated regions) in a spreadsheet available on the UKCP web pages. In general, the smaller the spatial domain, the larger the differences that you will likely see. In the same way, the differences seen at the 25 km scale are similar or larger to those seen in the regional data quoted in Table 1. However, the differences can vary according to geographical location (see Figure 3.1.2 in Harris et al, 2022).

The Probabilistic Projections also include specific humidity, total cloud amount, sea-level pressure, total downward short-wave radiation at the surface, net downward short/long-wave radiation at the surface. Treatment of these variables has also been improved but the impacts can be significant at the 25 km spatial resolution; for example, for sea-level pressure the distribution has both shifted and increased in spread. If you have used these variables, we advise that you check the impact of v2022 on your analysis and decisions made based on it. However, the impacts of the developments on these variables are generally considerably smaller for the aggregated regions, because these were less strongly affected by the correction of the downscaling error.

What should I do if I've already used the original Probabilistic Projections?

The differences between v2018 and v2022 depend on the variable, the spatial resolution, the future time period and emissions scenario under consideration. Whether you should update your analysis depends on which data you used and the sensitivity of your analysis to changes at certain percentiles.

If you...

- Have only used temperature variables, we do not anticipate the need to update your analysis. This is because the differences between v2018 and v2022 are generally small (e.g. Table 1 and Figure 1) compared to the uncertainties captured in the distributions of possible outcomes. This applies to all spatial resolutions but as stated above, differences are greater as for finer spatial resolution.
- Have used precipitation for the aggregated regions and are sensitive to changes in dry and wet extremes (i.e. at and beyond the 10th to 90th percentile range), we recommend that you investigate further using v2022 using Table 1 and the Key Results spreadsheet. These will help you ascertain magnitude of the differences between v2018 and v2022 and assess whether you're sensitive to them.
- Have used precipitation at the 25 km resolution and are sensitive to changes in dry and wet extremes, we recommend that you investigate further with data from the UKCP User Interface and/or CEDA Archive. As noted above, the 25 km resolution data can show larger differences between v2018 and v2022 with the spread of the possible future outcomes also larger.
- Have used variables beyond precipitation and temperature at the 25 km resolution, we recommend that you investigate further with v2022 from the UKCP User Interface and/or CEDA Archive.
- Have just started or planning on conducting a new analysis, we recommend using v2022.

Which existing UKCP documents and datasets does the update affect?

The update only affects the UKCP Probabilistic Projections (excluding the Probabilistic Projections of Climate Extremes, which are not affected). Further details can be found in the Probabilistic Update Report, available from the UKCP Guidance and Science Reports webpage. The update does not affect any other dataset in the latest set of UK Climate Projections published since November 2018, i.e. the Probabilistic Projections of Climate Extremes, UKCP Local, UKCP Regional, UKCP Global or the Derived Projections.

On the existing documentation that includes the Probabilistic Projections:

- UKCP Headline Findings: the statements are not qualitatively different but the Probabilistic Projections' numbers have been updated.
- Key results spreadsheet on the UKCP web page: two versions are now available, one containing the v2022 and a second that compares v2018 and v2022.
- Key results plots on the UKCP web pages.
- Reports such as the UKCP18 Science Overview Report (Lowe et al, 2018) now include a note to indicate that the Probabilistic Projections have been updated.

All the above documents are available on the UKCP webpages. The CEDA Archive includes both the v2018 and v2022 UKCP Probabilistic Projections datasets. v2018 will not be removed from the CEDA Archive.

The existing guidance on the Probabilistic Projections still applies (Fung et al, 2018) and it's important to reiterate that the relative probabilities indicate how strongly the evidence from models and observations, taken together in our methodology, support alternative future climate outcomes. There is more evidence for outcomes near the centre of the distribution than in the tails, i.e. there is less confidence in the data at percentiles below the 10^{th} and above the 90^{th} percentiles. For example, you may find some large values in mean daily maximum temperatures are projected for a high emissions scenario (RCP8.5) by the late 21^{st} century in summer, compared to the 1980-2000 baseline. However, given that these values are above the 90^{th} percentile, there is less evidence for these outcomes than at the 50^{th} percentile. As described in Murphy et al (2018), the Probabilistic Projections "should be seen as a source of broad guidance that forms a useful starting point for risk assessments" and "the probabilistic format should not be misinterpreted as an indication of high confidence in the weight of evidence behind specific outcomes".

Use Case: Summary projections for cities – City Packs

Background

The City Pack uses the UK Climate Projections to provide local summaries of a city's future climate. City Packs have been co-developed by the Met Office with seven UK cities, including Exeter. This collaboration resulted in the co-delivery of three non-technical factsheets per city explaining how the climate of each city may change over the 21st Century. The factsheets were used to engage with a range of city stakeholders and to inform conversations and decision-making around city resilience to climate change. You can find further information on the City Packs at https://www.metoffice.gov.uk/research/approach/collaboration/spf/ukcrp-outputs.

Impact of Update

The City Packs include plots and statistics for temperature (maximum and minimum daily temperatures) and precipitation. Here we examine the impact of the Probabilistic Projections update for Exeter. The qualitative summary information in the City Pack for Exeter has not changed. However, there are some quantitative changes in the range -0.4ºC to +0.1ºC for temperature changes (see Table 2). Similarly for rainfall in Exeter, the largest differences are seen in the summer where there are changes of 3 – 7%.

	Values in v2022						Difference between datasets (v2022 – v2018)					
	2030s		2050s		2080s		2030s		2050s		2080s	
RCP 4.5: 50th percentile **RCP 8.5: 90th percentile** **As in City Packs**	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Summer Mean Temperature (˚C)	1.0	2.2	1.7	3.8	3.0	7.4	-0.01	0.00	0.01	-0.13	0.04	-0.43
Summer Maximum Temperature (˚C)	1.1	2.5	1.9	4.4	3.4	8.5	-0.19	-0.16	-0.18	-0.36	-0.04	-0.34
Winter Average Temperature (˚C)	0.7	1.6	1.1	2.6	1.7	4.5	-0.10	-0.20	-0.10	-0.25	-0.16	-0.28
Winter Minimum Temperature (˚C)	0.7	1.7	1.2	2.9	1.8	5.1	-0.06	-0.13	-0.04	-0.17	-0.06	-0.11
Annual Mean Temperature (˚C)	0.8	1.6	1.3	2.6	2.1	5.0	0.00	-0.08	-0.01	-0.09	-0.03	-0.29
Summer Rainfall Rate (%)	-8.0	-33.0	-15.9	-47.3	-23.9	-65.8	5.96	4.34	6.27	5.69	3.58	5.64
Winter Rainfall Rate (%)	5.1	18.8	8.2	26.9	14.4	46.7	-0.23	0.27	-0.71	0.72	-1.01	4.37

Table 2 Differences in updated (v2022) and old version (v2018) values in the Probabilistic Projections over Exeter compared to 1981 to 2000. Temperatures changes are rounded to the nearest 0.1 ºC and precipitation changes to the nearest 1%.

These magnitudes of difference between v2018 and v2022 of the dataset are almost indiscernible in time series showing the evolving probability distributions (see Figure 1).

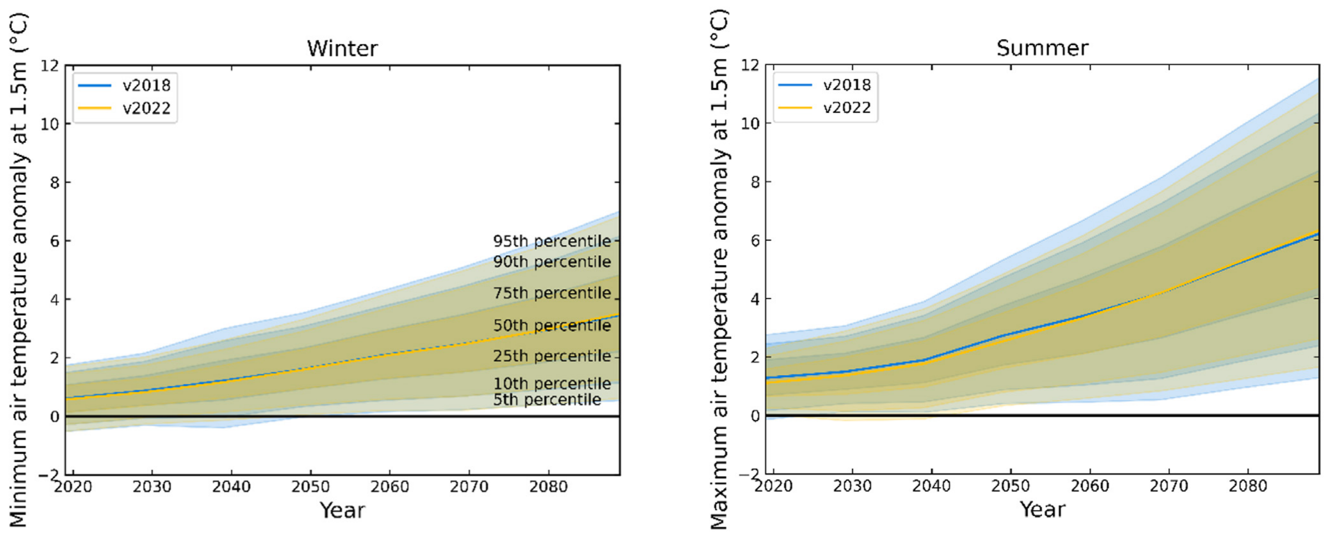

Figure 1 A comparison of v2018 and v2022 Probabilistic Projections of changes in winter minimum daily temperatures and summer maximum daily temperatures through the 21st century for Exeter, under RCP8.5 compared to a baseline period of 1981-2000.

For summer rainfall in four of the seven cities (London, Exeter, Bristol and Kirklees), the v2022 projections show reduced drying compared to v2018, (i.e. less negative). Exeter shows the greatest change with changes up to 7%. Belfast, Glasgow and Leeds show no such pattern with the sign of change between v2018 and v2022 depends on the time horizon and emissions scenario, but the differences all remain less than 7%. However, the overall message for all cities in both version of the data is that summers are projected to be drier.

For winter rainfall, all the cities are projected to see wetter winters at all time horizons in both versions of the data. London, Exeter, Bristol, Leeds and Kirklees have a mixture of increases and decreases when v2022 is compared to v2018, with differences being less than 5% in magnitude. Belfast and Glasgow show increases (i.e. the winters are projected to be wetter in v2022 compared to v2018), which reach 10-15% for the 2080s under RCP8.5 for the 90th percentile. This is mainly related correcting the downscaling error, which strengthens the links between the global and regional climate model data used to derive the probability distributions at the 25 km scale.

For coastal cities, the packs also include information about sea level rise but as stated earlier, the UKCP Marine Projections used here are not affected by the update.

The City Packs are being used primarily for engaging stakeholders (e.g. Local Authorities) and developing adaptation strategies and the overall messages about climate change remain consistent between v2018 and v2022. The modest changes to the details are expected to have little impact on their users.

Where can I get further information

For more information regarding this update, please refer to the UKCP website, particularly the Headline Findings and Key Results, the Probabilistic Update Report and the Climate Projections over Land maps page.

Should you require any further assistance, you can contact us using the form at https://www.metoffice.gov.uk/forms/contact-us-ukcp18.

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Fung F, Pirret JSR, Fuller EA, Harris GR, Murphy JM and Sexton DM, 2022. Probabilistic Projections Update – FAQs, Met Office.

References

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