3-month Outlook for UK contingency planning

User guidance

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Contents

For further details, see

http://www.metoffice.gov.uk/publicsector/contingency-planners

Met Office

The 3-month Outlook provides an indication of possible average temperature and rainfall conditions over the UK in the next 3 months. It is part of a suite of forecasts designed and produced on behalf of Government for use by contingency planners, and is one of several tools used in environmental risk planning by a number of different sectors. The 3-month Outlook should not be used in isolation. It is recommended that this is used in conjunction with other information provided by the Met Office for the contingency planning community, including shorter range forecasts (1-month, 15-day and 5-day) with more detailed information and weather warnings.

Background

Long-range outlooks are unlike weather forecasts for the next few days. The nature of our atmosphere is such that it is not possible to predict months ahead the precise weather for a particular day and place. At this longer range we have to acknowledge that many outcomes remain possible, even though only one can eventually occur. However, over the course of a whole season (or over a whole year or decade), factors in the global climate system (the atmosphere and oceans) may act to make some outcomes more likely than others. It is because of this that we can make long-range predictions, and the spread of possible outcomes provided in this outlook can be used to assess the likelihood and risk of particular events.

The skill of long-range outlooks varies with the time of year and with location, due to fundamental differences in how dependent local weather conditions are on global-scale atmospheric and oceanic processes at different times and in different regions of the world. Forecasts tend to be more skilful in the tropics than for mid-latitude regions. For example, our long-range forecasts are routinely used to predict inflow in water reservoirs in Africa. The UK is one of the most challenging regions for which to provide robust long-range information. This is because weather in the UK is dominated by the atmospheric circulation over the North Atlantic which is highly variable, and thus less predictable. In contrast, weather in the tropics is particularly dependent on slow variations of ocean conditions, such as El Niño, which are predictable months ahead.

The Met Office and our partners are continually improving all links in the forecast chain, from the model representation of key processes that affect UK weather to post-processing techniques that help decision-makers use all available information.

Long-range predictions

What is a climatology?

A ‘climatology’ represents the meteorological conditions (e.g. temperature, rainfall, sunshine) experienced across a particular region during the reference period, typically 30 years (e.g. 1971–2000[1]). The Met Office provides comprehensive UK and regional climatology information: http://www.metoffice.gov.uk/climate/uk/.

This can be expressed as an *average* – i.e. a ‘climatological average’ – which is simply the mean of all observations. Alternatively it can be expressed in a more comprehensive way, as the observation *distribution* within the period. This can provide users with probabilistic information for one or more specific outcomes in which they may have a particular interest. For example, a user may be interested in the occurrence of very cold winters, and has a temperature threshold by which they define a ‘very cold winter’. A user can count up the number of years in the climatological record in which mean temperature was below this threshold, and then convert this to a percentage – let’s say it comes out at 20%. It is then appropriate to state that the ‘climatological probability’ of a very cold winter (by the user’s definition) is 20%. Then, say, if the outlook for the upcoming winter were to indicate that there was a 30% chance of it being very cold (using the same definition), the user could state that the risk of that winter being very cold is ‘greater than normal’ or ‘higher than climatology’. Note that this does not imply that the event is likely (as the chance of occurrence is still less than 50%). Conversely, if the expectation for the upcoming winter being very cold had instead been 15%, we could have said that the chances were ‘lower than normal’ or ‘lower than climatology’.

What is a long-range prediction?

A long-range prediction is a forecast of the possible conditions averaged over a large region (e.g. country-wide) and over a specified period of time (e.g. 3 months).

Specifically, this outlook gives an indication of the possible conditions over the UK for the coming month and the coming 3-month period. This outlook does not indicate that these average conditions will prevail continuously, as the period is likely to contain a range of different types of weather. This outlook does not indicate that these average conditions will be the same over the whole region.

The 3-month Outlook is produced using output from the Met Office long-range prediction system, together with information from other leading international forecast centres, expert judgement of the current state of the atmosphere and oceans, and understanding of the influence of different factors on conditions in different regions. Long-range prediction systems are complex global forecast models of the atmosphere, which were originally developed for weather forecasting and, later on, linked to models of other Earth system components (oceans, sea-ice) and applied to climate prediction. During the last decade they have been used for monthly to seasonal prediction with the aim of providing risk information on climate variability up to a few months ahead.

How are long-range predictions produced?

We have all experienced how the weather can change dramatically in a short space of time – days that started with similar conditions in the morning can be completely different in the evening. This ability of the atmosphere to diverge rapidly from similar initial conditions (what scientifically is defined as chaos) makes long-range prediction very challenging, and a topic currently at the cutting-edge of science.

For weather forecasting, atmospheric conditions for the next few days are predicted by taking the latest observations from around the world to define the starting conditions. These are used in a comprehensive and complex dynamical global forecast model based on solving the fundamental physical equations of the atmosphere.

[1] The current baseline period of 1971-2000 is the international standard.

The same model employed for weather forecasting is used for long-range prediction, but with added complexity to represent the oceans, sea-ice and other important components of the Earth's climate system. In fact, it is thanks to these additional components that long-range forecasting is possible because the changes in the conditions of the oceans, sea-ice and land surface are much slower than changes in the atmosphere but can and do influence it. These changes at the surface can have a profound influence on the overlying atmosphere and affect the local and remote development of weather patterns.

However, because of the atmosphere's ability to diverge rapidly from similar starting conditions, one model simulation (i.e. a single forecast) is not enough. We need to complete an ensemble of simulations (multiple forecasts), each one of them representing the various interactions between the slow changing (oceans) and fast changing (atmosphere) components.

The aim for an ensemble of simulations is to capture, as well as possible, the uncertainties in the initial state (for example due to incomplete observations) and in the models themselves. An ensemble of simulations provides a set of outcomes from which it is possible to derive probabilities of the possible conditions affecting the region during the period of interest. Specifically, for this outlook the Met Office completes a total of 42 simulations for the coming months. Additional information such as forecasts from other centres and expert interpretation is then used to assess the likelihood of different outcomes.

What level of detail can be provided?

In general, the longer the forecast lead time, the less spatial and temporal detail can be provided in the outlook. Therefore, the 3-month Outlook does not aim to provide information for a particular location or a particular day. Instead, it aims to inform the user of the average weather conditions across a large area (e.g. the UK) over a 1-month or 3-month period. Taking such a long averaging period smoothes out the unpredictable influence of chaos and allows the effect of slower, more predictable fluctuations, (e.g. changes in the ocean temperatures) over the region of interest to be identified.

There are similar reasons for averaging over relatively broad geographical regions. The level of regional detail from long-range predictions is also affected by the resolution of the forecast model used – in the current prediction system, the highest model resolution we can afford is approximately 150 km grid boxes in the atmosphere (and the ocean as a 1° resolution grid)[2]. This imposes a limit on the amount of geographical detail we can provide with any confidence.

How accurate are long-range predictions?

Long-range predictions are routinely verified and the Met Office invests considerable effort and resources in analysing their skill. However, this is a complex issue.

Long-range predictions are inherently probabilistic and, therefore, it is not possible to say that a single prediction is 'right' or 'wrong'. This can be better understood if we think of a prediction for a football match in which Team-A is given a 70% chance of winning, Team-B a 20% chance of winning and the remaining 10% chance is for a draw. If Team-B wins the match, the prediction was 'right' because there was a 20% chance of that happening (we would anticipate this outcome 20 times out of 100 different matches played). But if Team-A wins, the prediction was also 'right' because there was a 70% chance of that happening… which takes us into the absurd situation that a single probabilistic forecast is always 'right'. Simply, there is no way of verifying a *single* probabilistic forecast.

However, probabilistic forecasts can be verified. But, to do it properly, a large number of predictions are needed, not just one. Because of the long time that it would take to accumulate real-time forecasts, long-range forecasting systems typically use a large set of predictions of past cases (referred to as 'hindcasts') to evaluate the skill of the system.

[2] There are plans to implement a system that will significantly enhance the skill and usefulness of forecasts which has resolution of approximately 60 km in the atmosphere and 1/4° in the ocean. Note that increasing the horizontal resolution by a factor of 2 equates to an increase in supercomputing costs by a factor of 10.

Of course, there is always a chance of one of the less likely outcomes in the outlook happening and this needs to be considered carefully when making decisions. For example, most people insure their home every year even if it is unlikely that the house will burn down. Decision-making in the face of uncertainty is complex, and the forecast information is not the only variable that needs to be taken into account – possible losses and costs are different for different users and also need to be evaluated.

The full benefit of any long-range outlook is only realised when they are used to guide decision-making over a longer period of time. Subjective verification of the accuracy of any single forecast is not possible.

What are the limitations?

Even with ‘perfect’ prediction systems and ‘perfect’ observations of the current state – neither of which are possible – the fundamental chaotic nature of the atmosphere will still affect the skill of predictions[3]. This means that probabilistic approaches will always be required for monthly predictions as well as those for longer timescales, and in interpreting the information provided.

These outlooks provide a view of possible changes in average conditions and do not by themselves indicate the risks of possible extreme weather. However, research so far indicates that there tends to be a relationship between the two. A high percentage for dry conditions, for example, would indeed indicate a higher-than-normal chance of drought. But if the chance of drought in a normal year is very small, it may still be unlikely. In this situation, drought should not be taken as a certainty but additional information should be considered (for example, the user’s possible losses and costs) for optimal decision-making.

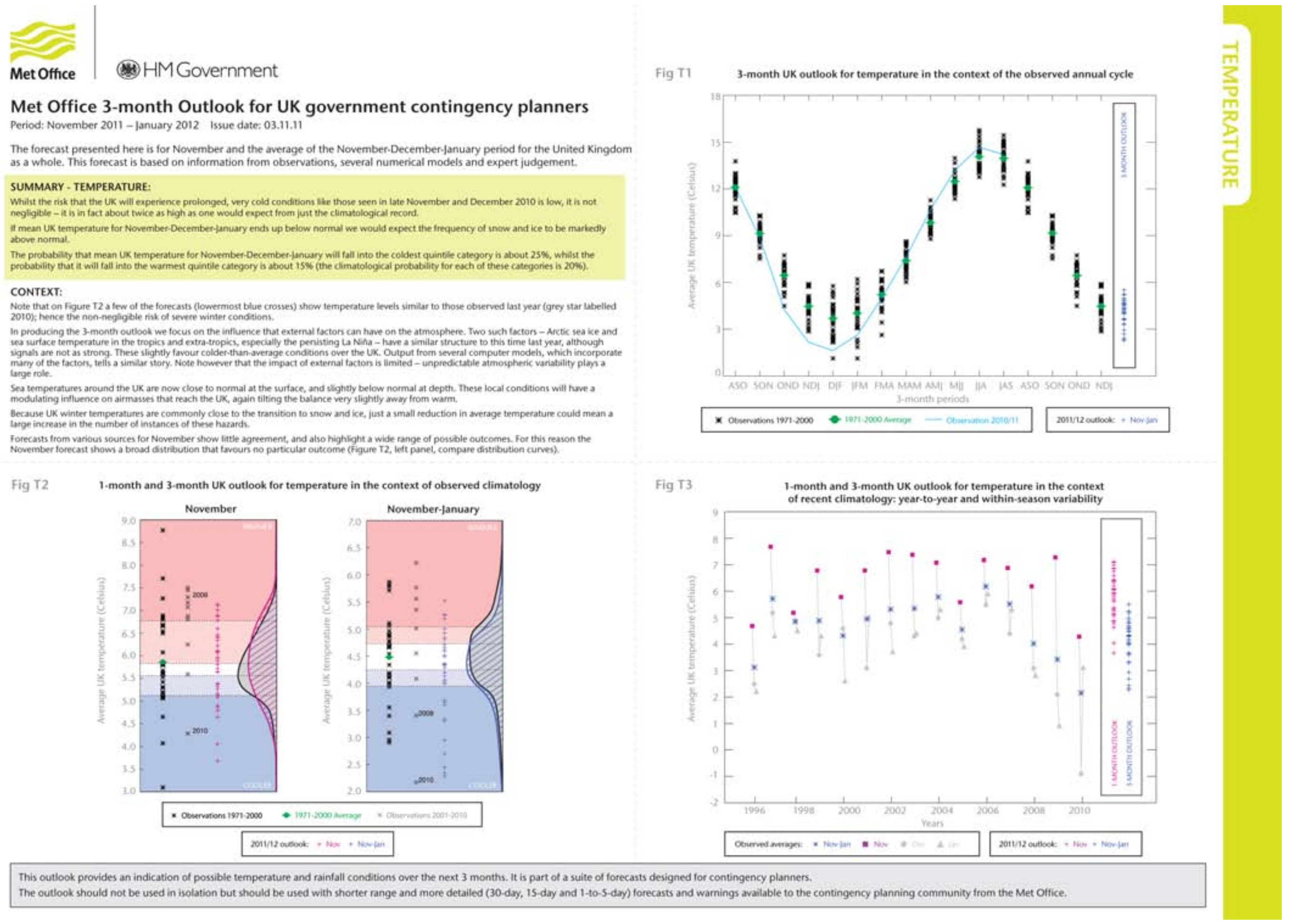
However, there are limitations to any prediction system. Model resolution is a critical factor in determining how well the model represents key processes and regional detail. Increasing model resolution is computationally expensive, however, so improvements can only be delivered within the constraints of available supercomputing power.

There are a number of important drivers that are expected to give rise to predictability (i.e. more confident forecasts) over mid-latitudes that are currently poorly represented in the models used for long-range predictions. These include land surface processes, the influence of Arctic sea-ice and atmosphere-ocean interactions. Research on long-range prediction is developing quickly, and the Met Office has implemented a flexible forecasting system to allow new science to be brought into our operational predictions as rapidly as possible.

[3] “*…one flap of a seagull’s wing may forever change the future course of the weather*”, Edward Lorenz (1963)

The 3-month Outlook – product guidance

The 3-month Outlook consists of three different graphical representations of the 1-month and 3-month average forecast for the UK, in the context of the long-term and recent climatology, together with a text description of the outlook and key messages. Outlook information is provided for average temperature and average precipitation (rain, snow, etc). Note that information provided for precipitation does not distinguish between occurrence of rain or snow for example. The differences between plots are only of emphasis and contextual climatological information – the outlook information is identical in all plots.



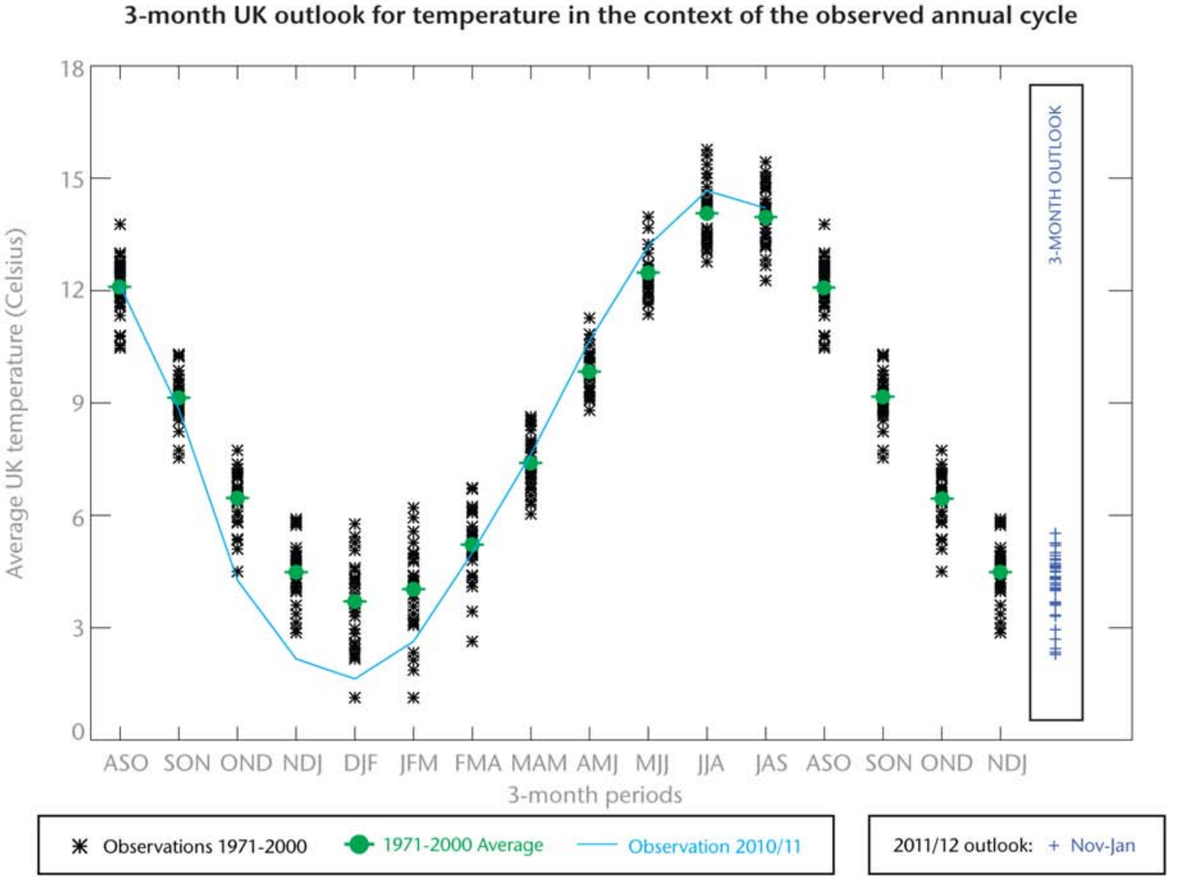
No part of the outlook should be taken in isolation, as each panel provides complementary information that should be used together to inform decisions.

The guidance below illustrates the sort of information provided in each graph (using temperature to illustrate their general content). *Note that the examples used here are for illustration purposes only.*

Outlook text

The outlook text provides the global context, a summary for the UK and any key messages, such as influencing factors and a commentary from an expert forecaster.

Figure T1

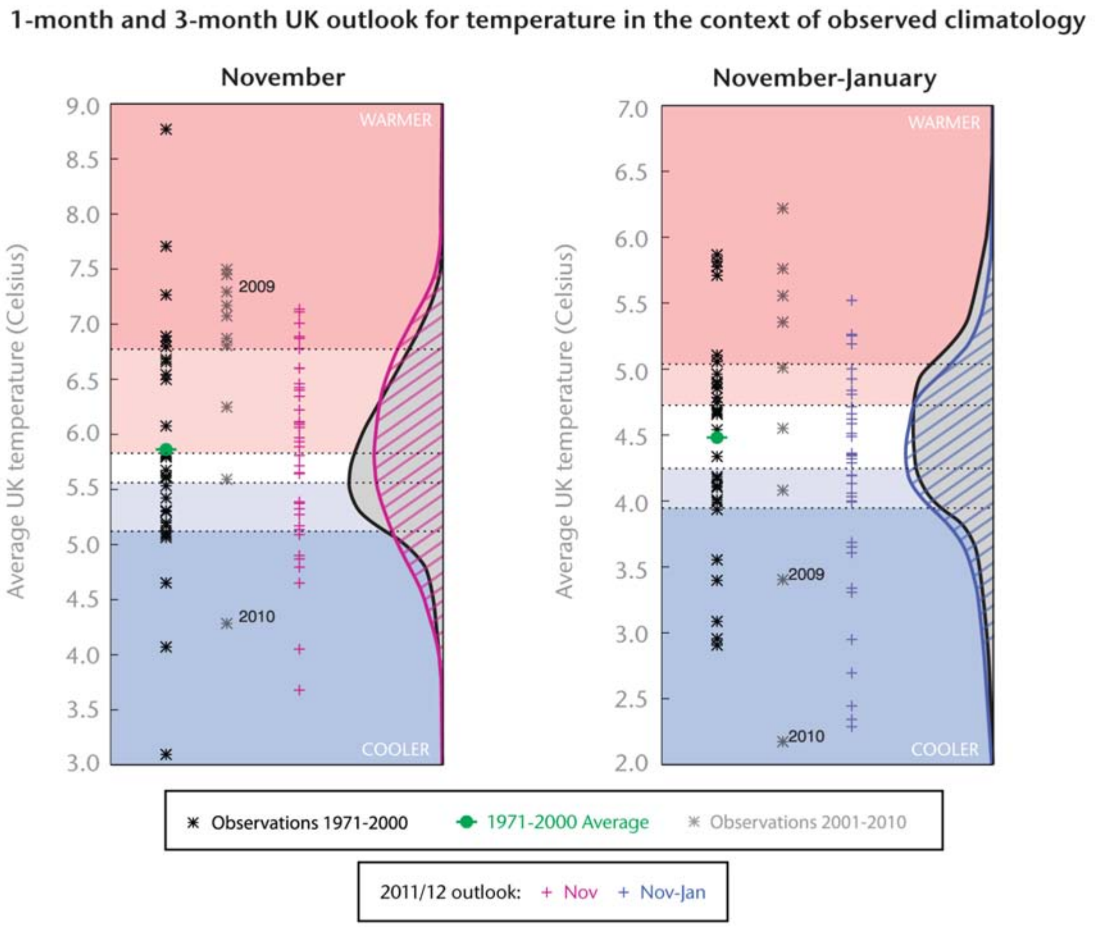


_T1_ shows the forecasts for UK average temperature over the next 3-month period in the context of relevant past observations.

- The vertical axis of the graph shows values for the variable represented (here, temperature in degrees Celsius). The horizontal axis shows time (here, the overlapping 3-month periods throughout the year). The symbols on the horizontal axis denote the period by the initials of the component months (e.g. JAS = July–August–September).
- Past observations are shown in two ways:
    - climatology for each year during 1971–2000 (black symbols) – observed temperatures over the reference period for each 3-month period during the year. The 30-year climatological mean is also shown (green circles).
    - values observed in the most recent twelve 3-month periods (coloured line) – to relate the forecast to the most recent past. Fifteen periods are shown to provide a full year's values for the recent past[4].
- There is a strong seasonal cycle in UK mean temperature, with the broadest range of year-to-year variations in winter and early spring.
- Outlook information shows the prediction for the average over the next 3-month period (here, for temperature) from each of the 42 'members' of the ensemble prediction, after expert modification. Each point represents an equally likely future scenario.

[4] In this example the most recent complete past period at the time of issue (November) is July-September.

Figure T2

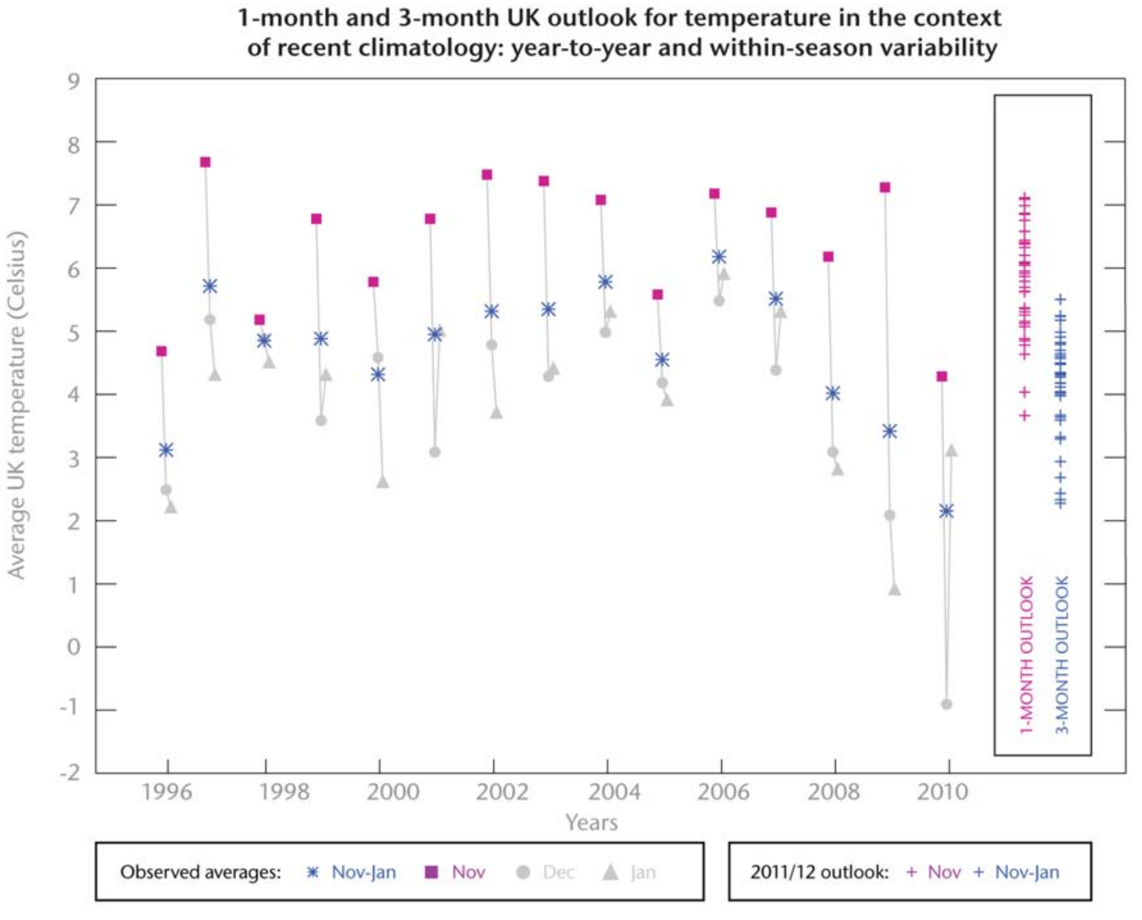


***T2* shows the outlook in the context of the observed UK climatology for the forthcoming month (left) and 3-month period (right).**

- Climatology information for 2 periods is shown:
    - long-term climatology 1971–2000 – the reference period (black symbols)
    - observations for the most recent period (2001–2010) (grey symbols)

  Differences between the 1971–2000 and 2001–2010 climatologies reflect long-term variability in the UK's climate (e.g. with warming temperatures over this period).
- The left-hand panel shows information relating to the coming month, the right-hand panel shows information relating to the coming 3-month period. Each coloured point (purple or blue) represents one of the ensemble member predictions – all the individual points are equally likely outcomes
- Both the forecast and observed reference climatology (1971-–2000) are also represented as continuous curves (coloured and black curves) – the probability density functions. These indicate the range of predicted outcomes, as well as the relative likelihood of different outcomes.
- The background shading indicates the quintile categories (well-below; below; average; above and well-above average temperature) of the reference (1971–2000) climatology. These are defined as equally likely (20% each) over the reference period.

Figure T3



***T3* shows the forecast for the coming month and 3-month period in the context of recent year-to-year variations of relevant 3-month mean and of individual months within the period.**

- Observations are shown for each month during the 3-month period of interest observed each year since1990. (Note that this period is shorter than and different from the reference period, and may not be representative of the full climatological variability possible).
- This sets the 1-month and 3-month outlook in the context of conditions observed in recent years, and emphasises that caution is required in using the 3-month average outlook as representative of the conditions predicted for individual months within the period.
- Outlook information shows the prediction for the average over the next 1-month and 3-month period (here, for temperature) from each of the 42 'members' of the ensemble prediction, after expert modification. Each point represents an equally likely future scenario.
- Note that for UK temperature, the strong annual cycle leads to significant inter-month temperature variations, generally larger than the spread of predicted 3-month averages.

WORKED EXAMPLE – *not real forecast, for illustration purposes only*
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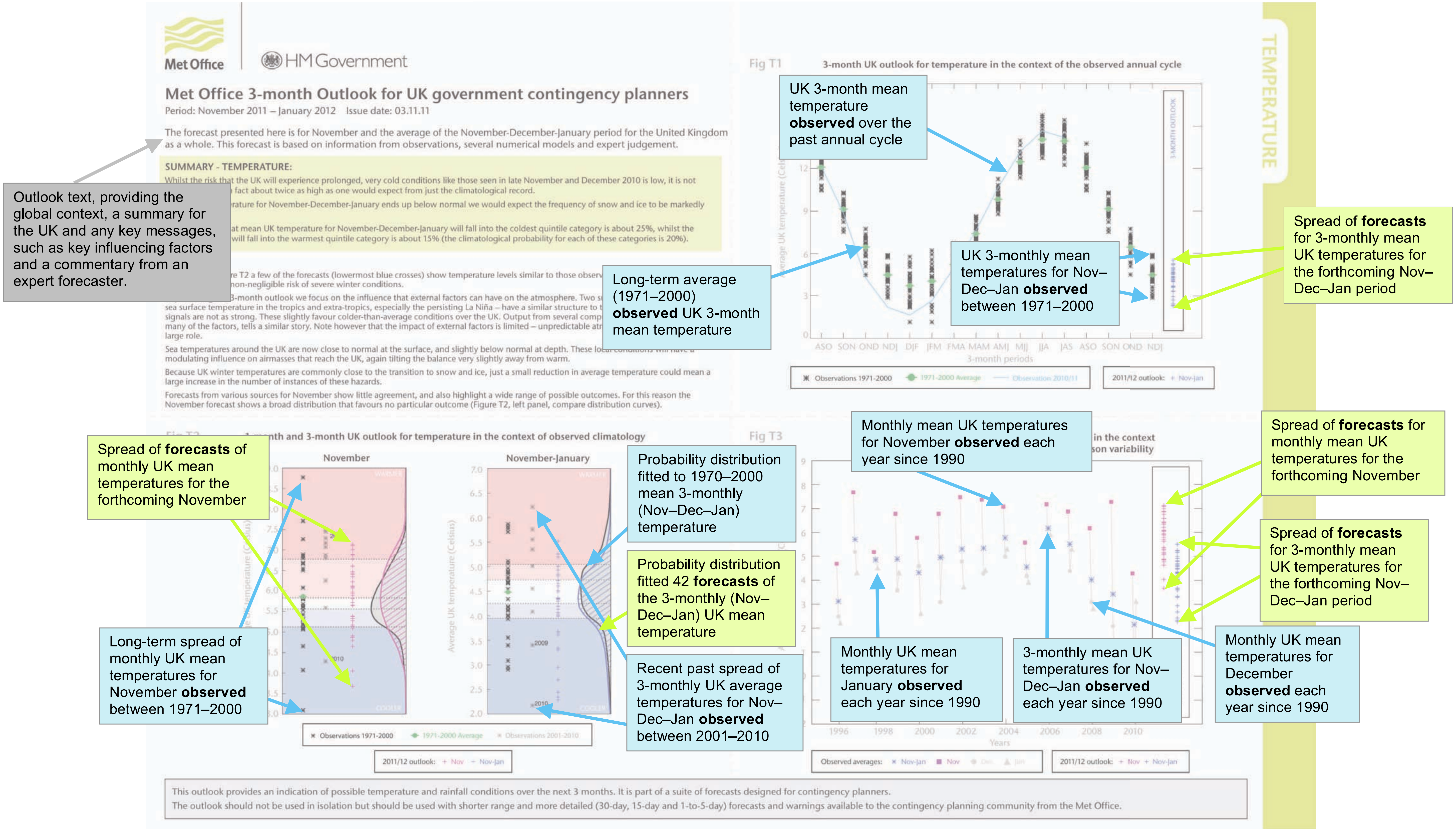

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