Figure 4.23 shows that the distribution of summer mean temperature moves to larger changes, and with correspondingly greater uncertainty, as the location of interest moves from N Scotland to Northern Ireland to Wales and finally to SE England; consistent with the geographical pattern of changes shown by the maps earlier in this chapter. The changes in the 25 km squares within the regions (Figure 4.24) show a similar progression as the regions themselves but some details are different.

4.4.6 How are PDFs affected by choice of mean or extreme variables?

Figure 4.25 shows that the most likely change in the summer-mean daily maximum temperature is greater than that in the summer mean temperature. The uncertainty in the warmest day of the summer is much greater than that in the summer-mean daily maximum temperature, which in turn is greater than that in the summer-mean temperature.

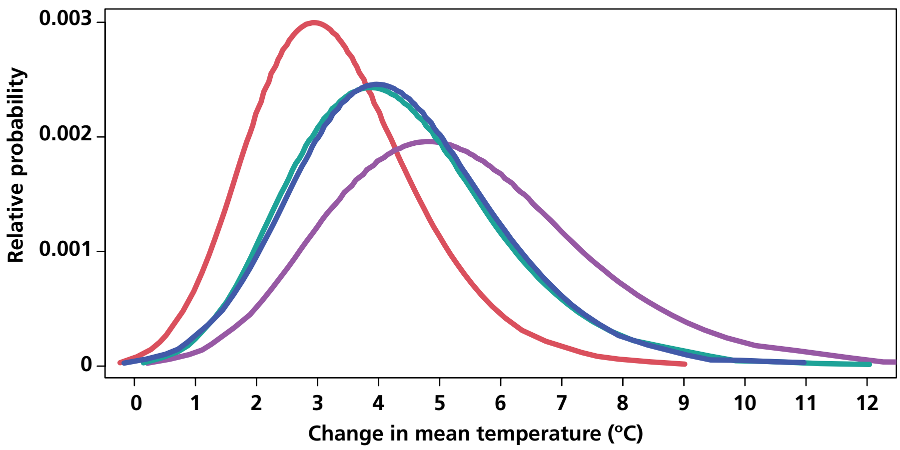

Figure 4.24: PDFs of change in the mean summer temperature by the 2080s under the High emissions scenario, for four 25 km grid squares including parts of Dorset (purple), Gwynedd (green), Shetland (red) and Co Antrim (blue).

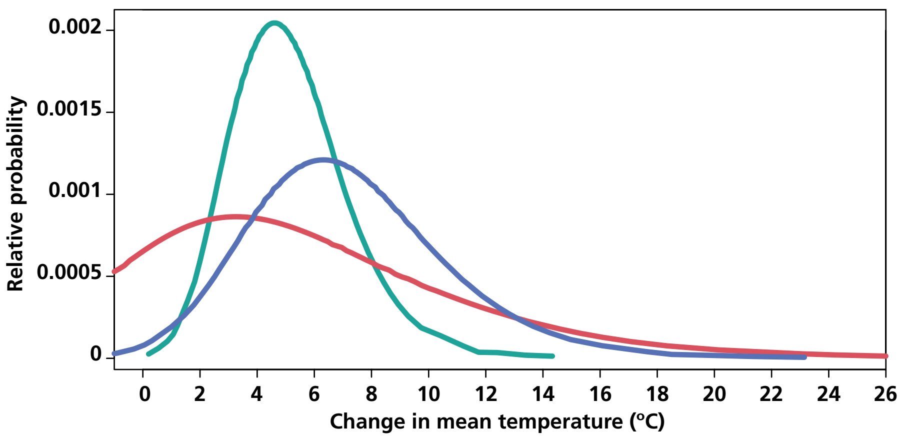

Figure 4.25: Comparison of the PDFs of change in summer mean temperature (green), summer mean daily maximum temperature (blue) and the warmest day of the summer (red) by the 2080s under the High emissions scenario, all for the administrative region of SW England.

4.4.7 How are PDFs affected by choice of climate change or future climate?

Users have the choice of seeing projections of some variables as climate change or as future climate. Climate change is that between the chosen time period and the 1961–1990 baseline 30-yr period. Therefore, we calculate projections of future change from model simulations by subtracting the simulated baseline period from the simulated future values. This reduces the impact of model bias on the projected change, though of course it does not guarantee that the projected change will be correct. Projections of absolute values for future climate variables are then obtained by adding the projected changes onto the observed baseline value.

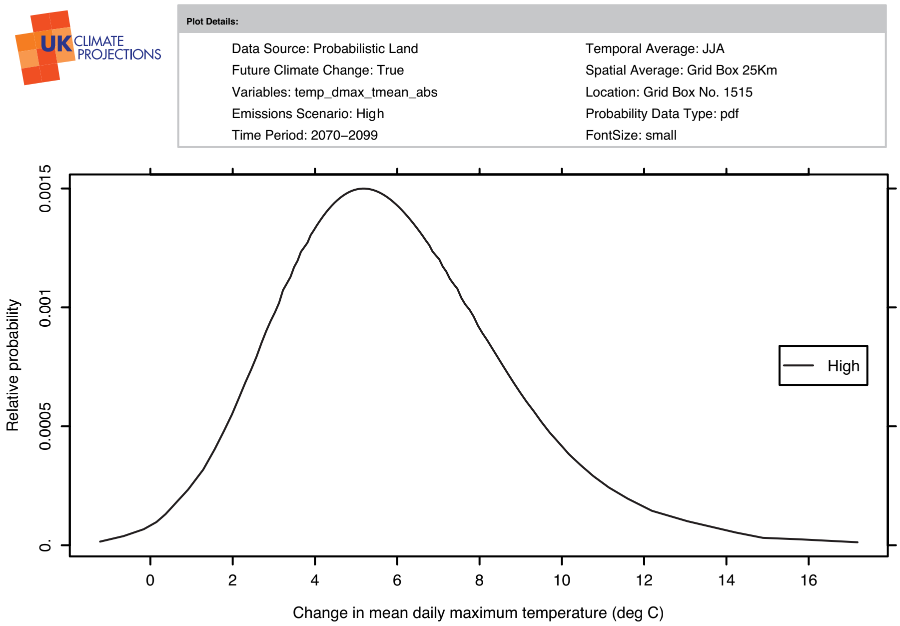

Figure 4.26: A PDF of the change in summer-mean daily maximum temperature, for a 25 km square in the East of England, by the 2080s under the High emissions scenario.

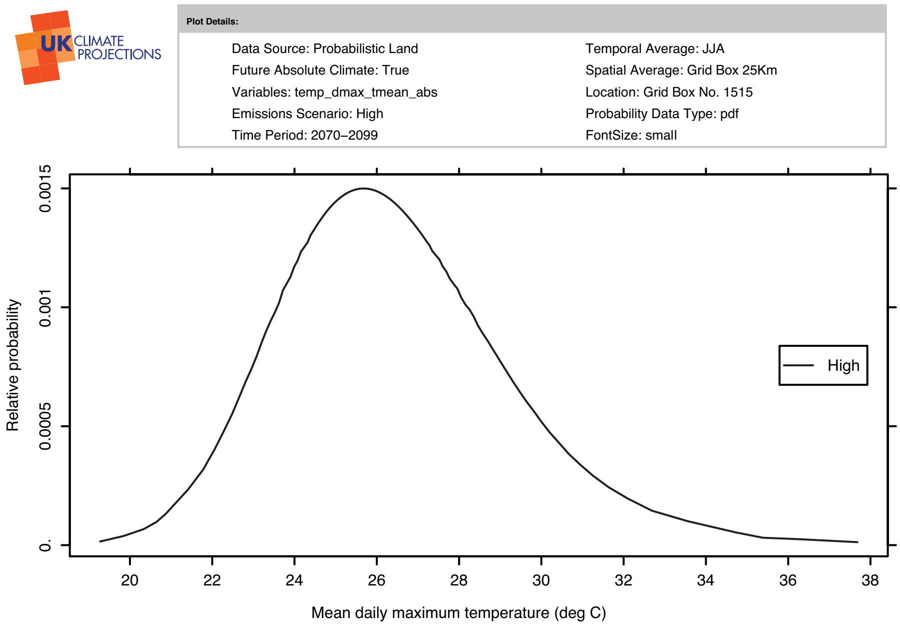

Figure 4.27: A PDF of the projected future summer-mean daily maximum temperature, for a 25 km square in the East of England, by the 2080s under the High emissions scenario.

Figure 4.26 shows a PDF of the change in summer-mean daily maximum temperature, for a 25 km square in the East of England, by the 2080s under the High emissions scenario. In Figure 4.27, this change has been added to the 1961–1990 observed summer-mean daily maximum temperature, to give a projection of the summer-mean daily maximum temperature for the 2080s. Note that the two PDFs have the same shape, but the future climate PDF in Figure 4.27 is shifted by about 20°C relative to the climate change PDF in Figure 4.26 — where 20°C represents the baseline summer-mean daily maximum temperature at that location.

4.5 Probabilistic projections changing with time

In addition to the PDF and CDF curves, the User Interface can be used to explore how projections change with time over the course of the century, using a "plume of probability". Essentially, this takes the values of change (for a certain quantity, location, emissions scenario, etc.) corresponding to the 10, 33, 50, 67 and 90% probability levels for each of the seven future time periods, and joins them together with straight lines. We show examples below of changes with time

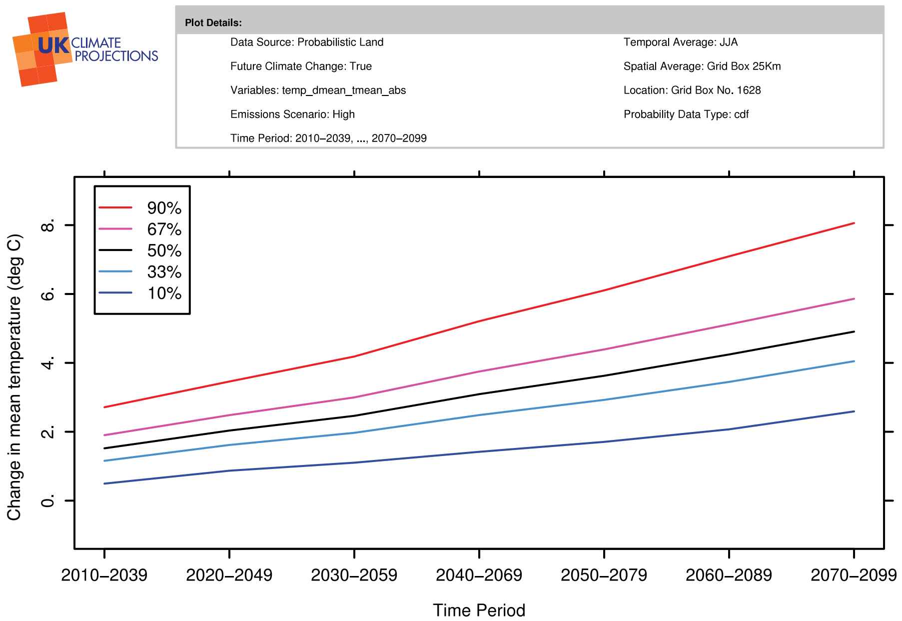

Figure 4.28: The progression from the 2020s to the 2080s of change in summer mean temperature under the High emissions scenario, for a single 25km grid square in Central London. Changes at probability levels of 10, 33, 50, 67 and 90% are indicated by different colours.

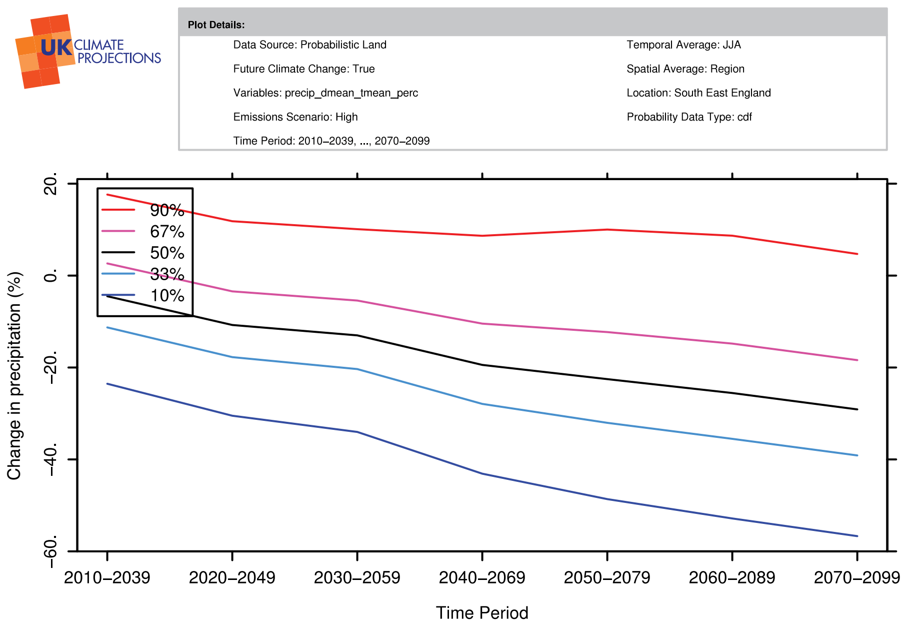

Figure 4.29: As Figure 4.24 but for changes in summer-mean precipitation.

summer mean temperature (Figure 4.28) and summer mean precipitation (Figure 4.29) for a 25 km square in Central London under the High emissions scenario. Thus the top line in Figure 4.28 shows how the temperature change that is very unlikely to be exceeded increases decade by decade through the century; the middle line shows how the central estimate increases with time, etc. This type of output can be provided by the User Interface for any variable, any emissions scenario and any location.

Plumes show that the width between the 10 and 90% probability levels is already substantial by the 2020s. In the case of precipitation (Figure 4.29), in particular, the width of the plume increases only modestly through the century. The main reason for this is that, at the scale of 25 km, natural internal variability is a big component of the overall uncertainty, and this does not increase with time. Plumes for larger areas (for example, administrative regions) will have a smaller component from natural variability, and do show more growth with time. This reflects the relatively larger components from model uncertainty, carbon cycle feedbacks, etc., which do grow with time. For even larger areas, for example Northern Europe, plumes are even more divergent (not shown here), reflecting the relatively even smaller component of overall uncertainty from natural internal variability at this larger spatial scale.

4.6 The joint probability of the change in two variables

The User Interface allows a calculation to be made, not just of the probability of change in a single variable, but of the joint probability of changes in (some, but not all) combinations of two variables. These can be used to explore specific impacts on targets (such as crops) which are vulnerable to changes in both variables. The User Interface can create plots of joint probability of changes in two variables, chosen by the user, such as that shown in Figure 4.30. This shows an example for two variables commonly used in combination, change in precipitation and that in mean temperature, in summer, by the 2080s under the High emissions scenario. Values of joint probability density are shown by the red contour lines, and have been multiplied by 1000 to make them more readable. So, referring to Figure 4.30, for a precipitation change of –50%, a simultaneous temperature change of 5°C is about 9 times more likely than a change of 1°C, as the joint probability densities are 18 and 2 respectively.

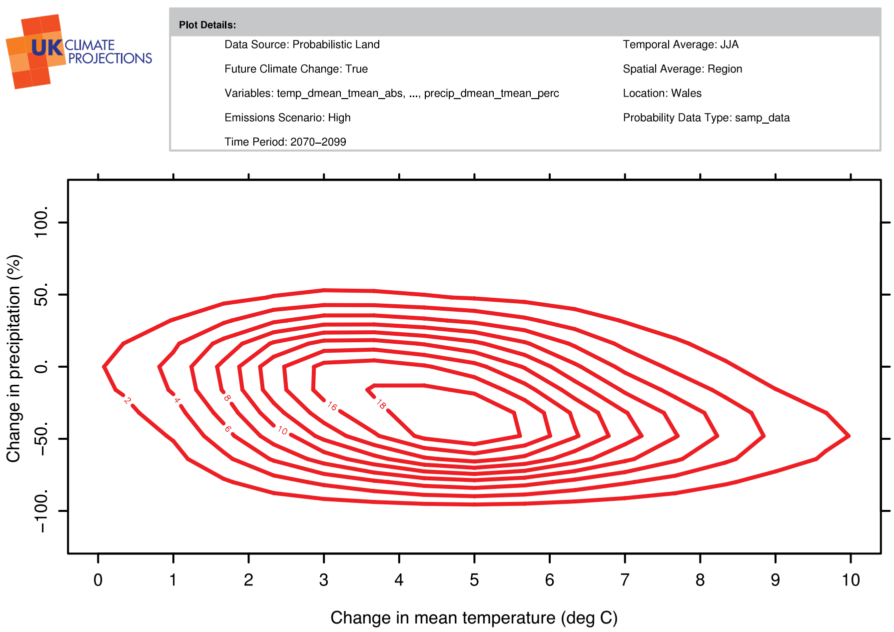

Figure 4.30: The joint probability distribution function of changes in summer-mean temperature and that in precipitation, by the 2080s under the High emissions scenario, for the administrative region of Wales. The red lines are contours of probability, multiplied by 1000, with units of per °C per %. (This plot is direct from the User Interface.)

Annex 4 describes the way in which data on the variables is held in batches in the User Interface. Users can explore joint probabilities among those variables in the same batch, but not between variables in different batches. Based on preferences expressed by users, efforts have been made to include within the same batch those variables for which joint probabilities are of particular interest.

4.7 Corresponding changes in global-mean temperature

We have included annual-mean, global-mean temperature as one of the variables for which we make probabilistic projections in UKCP09, although this data is not available from the User Interface. Changes to global mean temperature, for the three emissions scenarios and three future time periods, is shown in Table 4.8.

Table 4.8: The 10, 50 and 90% probability levels of changes to the global mean temperature (ºC), for all three emissions scenarios and three future time periods, as calculated by the UKCP09 methodology.

	2020s			2050s			2080s		
Emissions	10%	50%	90%	10%	50%	90%	10%	50%	90%
High	1.0	1.3	1.6	2.1	2.7	3.3	3.4	4.3	5.3
Medium	1.0	1.3	1.6	1.9	2.4	3.0	2.6	3.4	4.2
Low	0.9	1.2	1.6	1.6	2.1	2.6	2.0	2.6	3.4

4.8 Variables for which probabilistic projections cannot be provided

For certain variables (soil moisture, latent heat flux, and snowfall rate). it was not possible to provide probabilistic projections of future changes in UKCP09.

In the case of **soil moisture**, different definitions of this variable are used by different modelling groups, making it impossible to construct PDFs combining results from variants of Met Office models with those from other climate models. Without this key aspect of our methodology, it was not possible to provide probabilistic projections.

In the case of **latent heat flux** we found that projected changes from two of the alternative climate models were often well outside the range of the Met Office model variants (see Chapter 3, Section 3.2.10). In this situation, our method of combining results from the Met Office model variants and the alternative models could not be guaranteed to provide a robust indication of the probabilities of different outcomes, and hence PDFs were not provided.

In the case of **snowfall rate**, the models sometimes project small but non-zero values in the future, implying changes relative to the baseline climate that are close to the absolute lower bound of –100%. Under these conditions, statistical contributions to the uncertainties captured in the UKCP09 methodology were found to become unrealistically large, and hence probabilistic projections were not provided.

In the absence of a UKCP09 probabilistic projection for these three variables, there are three possible alternative sources of projections of transient changes during the 21st century:

- the 17-member ensemble of variants of the Met Office GCM,
- the 11-member ensemble of variants of the Met Office RCM,
- the ensemble of other global climate models, available from the PCMDI website.

Data from the first two (Met Office GCM and RCM variants) is available from the Climate Impacts LINK project, operated by BADC; see http://badc.nerc.ac.uk/data/link. Data from alternative global climate models can be accessed from the Program for Climate Model Diagnosis and Intercomparison (PCMDI), based in California, which has collected model output from simulations contributed by modelling centres around the world, as part of the Coupled Model Intercomparison Project (CMIP3) of the World Climate Research Programme. The CMIP3 multi-model dataset can be freely accessed for non-commercial purposes via http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php.

Each type of data has advantages and disadvantages. The data from other global climate models, and that from the 17-member Met Office GCM ensemble, is at a relatively coarse resolution. The Met Office RCM has a finer resolution (25 km) and hence provides more information on possible regional variations across the UK. The range of modelling uncertainties explored in the 17-member Met Office GCM ensemble, and the 11-member Met Office RCM ensemble, is not as wide as that explored in the variables for which probabilistic projections are provided in UKCP09. The RCM data is only available for the Medium emissions scenario.

In the case of snow, we recommend the use of changes from the 11-member Met Office RCM ensemble in the first instance. Changes by the 2080s in the winter mean snowfall rate, averaged over the 11-RCM ensemble are shown in Figure 4.31; typically there are reductions of 65–80% over mountain areas and 80–95% elsewhere. Chapter 5 gives details of the data available from the RCM ensemble, its advantages and limitations. Of course, users may wish to extend their analysis, and investigate the robustness of any adaptation decisions, using data from other global climate models. We have not looked at possible alternative projections of soil moisture and latent heat flux, although both are available from the 11-member Met Office RCM ensemble via LINK. It is recommended that users do not revert to UKCIP02 scenarios in isolation, for any of the variables that are not available in UKCP09.

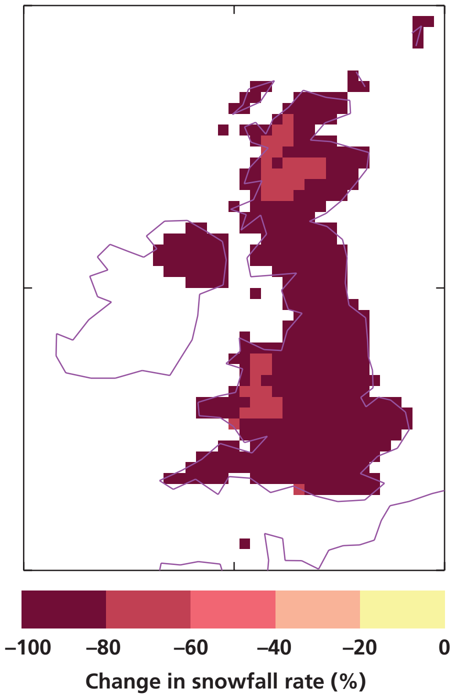

Figure 4.31: Percentage average changes in mean snowfall rate in winter, by the 2080s (relative to 1961–1990) under the Medium emissions scenario, averaged over the 11 members of the Met Office RCM ensemble.

5 Projections from the ensemble of regional climate models

This chapter describes data from an ensemble of eleven variants of the Met Office Regional Climate Model (HadRM3), run from 1950–2099 and used to dynamically downscale global climate model (GCM) results as part of the UKCP09 methodology. The daily RCM time series are not included as a UKCP09 product, and are therefore not accessible via the User Interface. However, RCM daily data may have advantages over that from the UKCP09 Weather Generator for some impacts studies, and is the only 25 km resolution data available over the seas around the UK, so has therefore been made available via the Climate Impacts LINK project. We describe here the RCM data, the advantages it may have for some users, and also its limitations — the main one being that it does not cover such a wide range of uncertainty as the UKCP09 probabilistic projections.

5.1 Regional climate models

A regional climate model contains the same representations of atmospheric dynamical and physical processes as in a global model. It is run at a higher horizontal resolution (in our case 25 km) but over a sub-global domain (typically 5000 km square), and is driven at the boundary of the domain by time series of variables (such as temperature and winds) saved from a GCM projection. Sea surface temperatures and sea-ice extents are also prescribed from the GCM, since HadRM3 (like most RCMs) does not include an interactive ocean component. The purpose of RCMs is to provide a high resolution climate projection consistent with its driving GCM projection at spatial scales skilfully resolved by the latter, but adding realistic detail at finer scales. This is the *downscaling* process referred to above. The advantages of projections from RCMs over those from GCMs are:

- RCMs simulate spatial contrasts in time-averaged climate at a scale much smaller than that of the driving GCM, in particular where there are significant regional influences arising from surface features such as mountains and coastlines (see Figure 5.1).

- The higher resolution of RCMs also allows improved representation of climate variability, particularly aspects associated with small scale meteorological processes. As a result, they can provide skilful (though not perfect) projections of regional climate extremes, such as localised intense precipitation events, which cannot be captured in GCMs.

- The higher resolution of RCMs allows small islands to be explicitly represented in the model.

- While RCM projections are designed to be consistent with their driving GCM projections at large scales, some types of climate impact, such as changes in river flow, are likely to be so strongly dependent on the fine scale detail that the use of downscaling, either based on RCM data or a statistical method, is essential for the generation of a credible assessment of future changes.

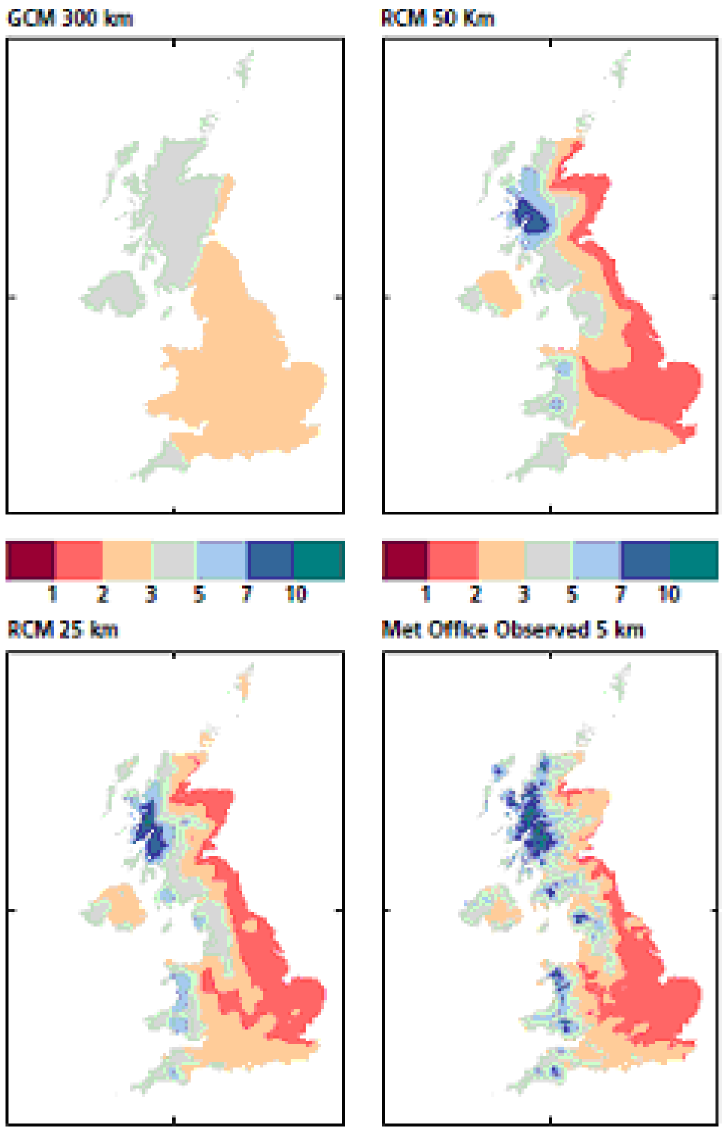

Figure 5.1: The distribution of winter precipitation over Britain (bottom right map) for 1961–2000, compared to simulations for the same period from a GCM (top left), and from two versions of the corresponding RCM at 50 and 25 km resolution, both driven with boundary conditions derived from analyses of observations. The GCM (inevitably) fails to resolve the observed spatial detail, whereas the RCM simulations show better agreement with increasing resolution.

General guidelines for applying RCM data can be seen in a report from the IPCC Task Group on Climate Impacts Assessments (Mearns *et al*. 2003). A key caveat is that while RCMs are now well established as skilful and sophisticated downscaling tools, they inevitably inherit all the uncertainties in large scale aspects of climate change present in their driving GCM simulations (see Annex 2), so the enhanced detail in their projections should not be taken to imply higher accuracy (see also Annexes 3 and 6). The same caveat applies to fine scale projections derived from the UKCP09 Weather Generator (see further discussion below).

5.2 RCM experiments

As mentioned above, and described in more detail in Chapter 3, transient (that is, continuous from 1950 to 2099) projections from GCM experiments were used as boundary conditions to drive transient regional climate model experiments. Only the Medium emissions scenario was used. Each RCM variant used parameter settings selected to be consistent with those used in the relevant driving GCM variant. In 11 RCM ensemble members this experimental design produced physically plausible simulations of detailed climate variability and change over the UK. In the case of an additional six ensemble members, however, the RCM simulations were found to be deficient in their simulations of storms and precipitation, because one of the parameter perturbations employed in the RCM failed to produce an impact consistent with that found in the driving GCM projections (details in Section 3.2.11). These members were therefore not used in the downscaling procedure for UKCP09, which was based on the remaining 11 RCM variants.

Daily data from 1950 to 2099 has been archived from each of these 11 variants, for a large number of variables (at the surface and at levels in the atmosphere) for 25 km grid squares over the domain shown in Chapter 3, Figure 3.8. Following interest from the user community, it was agreed to make this data available. This will be done via the Climate Impacts LINK project (http://badc.nerc.ac.uk/data/link), a Defra-funded activity operated by the British Atmospheric Data Centre, which allows access for research to a range of data from model experiments undertaken at the Met Office. Data accessed via LINK is not accompanied by extensive guidance.

Data from the RCM ensemble is also available as monthly and seasonal means. The RCM data can be used to create projections of climate change, by differencing averages for a future period from a reference period. This operation cannot be performed using the LINK website, but can be done offline once the data has been downloaded. Information on the use of this data is available in the UKCP09 User Guidance.

5.3 Advantages and disadvantages of data from the RCM ensemble

As described in the companion UKCP09 report *Projections of future daily climate for the UK from the Weather Generator*, daily data for future decades is also available from the Weather Generator, which is part of the UKCP09 projections. Why, then, should there be interest in using RCM data? Some reasons are:

1. The daily data from the 25 km model squares is coherent both spatially and temporally, in the sense that it arises from a model which produces dynamically and physically consistent simulations of the passage over the UK of a sequence of atmospheric weather systems. This means, for example,

that daily data from any number of squares (contiguous or otherwise) can simply be spatially aggregated by the user to form a physically plausible area average over any desired region. This could be, for example, a river basin or administrative region — although such averages are not provided as products. This is not the case for the output from the UKCP09 Weather Generator, which is designed to produce daily time series which are temporally consistent at individual locations, but not to produce daily time series which are physically coherent over a larger region.

2. It follows from point (1) that temporal sequences of, for example, daily temperature and precipitation over any set of 25 km squares can be used to study the impacts of the evolution of these variables when spatial consistency is required, for example when modelling flow in large river catchments.

3. Changes in long term averages of key variables are fed into the Weather Generator, which then generates characteristics of daily sequences, using a set of statistical relationships derived from present day observations and assumed not to change in the future. The influence of climate change feedback processes (see Chapter 2, Box 2.1) on characteristics of daily time series (for example runs of consecutive hot or dry days) therefore enters only through their effects on the input long term averages. Each of the RCM projections also accounts for effects of feedbacks on aspects of daily variability *not* explained directly by changes in the long-term average, subject of course to the uncertainties associated with climate model projections.

4. Each of the RCMs give a continuous time series of day-to-day data from January 1950 to December 2099 (see, for example, Figure 5.3). The UKCP09 probabilistic projections, however, give changes in *long term averages* of climate for particular 30-yr periods. This means that daily time series from the Weather Generator, fed by inputs from the probabilistic projections, will be typical of the average climate throughout the relevant period, but will not show any trend in climate change within that period.

5. There are a large number of variables available from the RCM ensemble, at many model levels over both land and sea (for details see the LINK website); the Weather Generator outputs a more restricted number of variables at the land surface only — although these are the ones most commonly used in impacts research.

The UKCP09 report *Projections of future daily climate for the UK from the Weather Generator* discusses the limitations of the Weather Generator in more detail.

On the other hand, the main disadvantages of RCM ensemble data are:

1. The 11 model variants do not sample the full range of changes in time-averaged climate expressed in the UKCP09 probabilistic projections. This is because the latter account for a wider range of process uncertainties, by sampling the full parameter space of the HadCM3 atmosphere model, while also catering for additional uncertainties arising from structural errors in atmospheric processes using alternative climate models, plus those arising from carbon cycle, sulphur cycle and ocean transport processes (see Chapter 3). The Weather Generator, however, can be run by selecting from a very large sample of possible changes in time-averaged climate covering the full range implied by the probabilistic projections.

Table 5.1 (opposite): Some characteristics of the data from the RCM ensemble and from the Weather Generator.

2. It follows from (1) above that users of RCM data should check projections of time-averaged climate change for variables of interest, to see where in the UKCP09 probability distributions they lie. An example is shown in Figure 5.2; this is for a specific variable and different variables and time periods will show different distributions of the 11 RCM variants within the probability distributions. Such an exercise can provide an assessment of the relative likelihood of the time-averaged changes in any given RCM projection, just as it can for any set of time-averaged changes selected to drive the Weather Generator. Note, however, that it would be unwise to assume that the corresponding daily time series possess the same relative likelihood. This is because limitations in current climate modelling capability, or in the statistical assumptions used in the Weather Generator, imply that projections of future changes in detailed regional variability cannot be assumed to carry the same level of credibility as corresponding projections averaged over long periods. In the case of the Weather Generator, the statistics of changes in variability (for a given set of time-averaged changes) can be sampled more robustly than in the case of the RCM, by running multiple realisations with different initial conditions. However the results are still conditional on the assumptions indicated above.

3. The RCM data are projections of simulated climate of the future, rather than ready-made projections of climate change. If the latter are required, then the user will need to difference data sets data for the two periods between which the change is required, for example 2060–2099 and 1990–1999. This does give the user the flexibility of using any number of different future time periods, and indeed baseline periods, of any length, rather than the 30-yr time periods and 1961–1990 baseline period used in UKCP09. As with all model data, that from the RCM will contain biases, due to systematic errors of various sorts — note that these biases will also affect projections from the weather generator. Creating projections of climate change by taking RCM differences as described above will remove the effect of historical model biases. This does not, of course, imply that the future values will then be error free, due to the uncertainty in modelling future changes themselves.

4. When using RCM data to drive models of climate impacts, the issue of model bias again needs to be considered. For example, in some cases the impacts model can be driven with daily data for both a future time period and a reference time period. The difference can then be taken as a plausible realisation of the impact of climate change. However, in other cases, the bias in the RCM may produce implausible results for the present climate from the impacts model, in which case a bias adjustment to the impacts by subtracting present from future may be inappropriate.

Table 5.1 shows some of the differences between the two types of daily data sets; that available from the UKCP09 weather generator, and that from the RCM ensemble.

Characteristic	RCM ensemble	Weather Generator
Geographic coverage?	Land and marine areas (see Chapter 3, Figure 3.8).	Land only. UK plus Isle of Man, but not Channel Islands.
Spatial Resolution?	25 km	5 km, but with no additional climate change information above projections at 25 km resolution.
Temporal resolution?	Daily	Synthetic daily data. No climate change information additional to that at monthly resolution in the probabilistic projections. Daily data is also disaggregated to hourly.
Continuous?	Yes, from 1950 to 2099.	7 standard UKCP09 30-yr time periods, plus 1961–1990.
Can users average daily time series from different grid squares to obtain time series for larger regions?	Yes, any number of grid squares can be averaged by users.	No, but users can configure the WG to produce time series for a single region of any size, up to a maximum area of 1000 km^2.
Temporal averaging?	Yes, can be done by users.	Yes
Consistency between variables?	Yes	Yes
Spatial coherence between grid squares?	Yes	No
Can a relative probability be attached to the projected daily time series?	No. Daily time series from particular RCM variants should be interpreted as plausible realisations, but are subject to additional modelling caveats which preclude the assumption that we can assign some level of probability to them, based on the corresponding changes in time-averaged climate.	No. Weather Generator time series are also subject to additional caveats, associated with their internal statistical assumptions. Again, they should be regarded as plausible realisations consistent with current knowledge, but should not be treated as results to which some level of probability can be attached.
Samples the UKCP09 probabilistic projections?	Partially. Designed to sample a range of possible responses, but not the full range expressed in UKCP09, for reasons explained above.	Yes: can be driven by prescribed climate changes sampled from the full range of possibilities captured in the UKCP09 probability distributions.
Projections of climate or climate change?	Daily climate, but with model biases in the historical simulations. Such biases can be empirically removed by expressing the future projections as changes relative to the model baseline climate, and then adding them onto an observed baseline. This does not guarantee that the projected changes are free from error.	Daily synthetic climate. Historical baseline simulations are generated using statistics based on observations, which should (by construction) reduce biases in their characteristics, though the extent to which this is achieved depends on the characteristics in question. Future simulations are obtained by prescribing change factors obtained from the UKCP09 probability distributions, giving future time series whose characteristics can be differenced relative to the historical simulations to obtain projected changes.
Variables?	Many, at several levels.	Nine surface variables.
Threshold analysis of daily data?	No tool provided, but can be done by users offline.	Yes, using UKCP09 User Interface Threshold Detector.
Visualisation of results?	None provided, but can be done by users offline.	Yes, using extensive capability in UKCP09 User Interface.
Emission scenarios?	Medium	Low, Medium, High

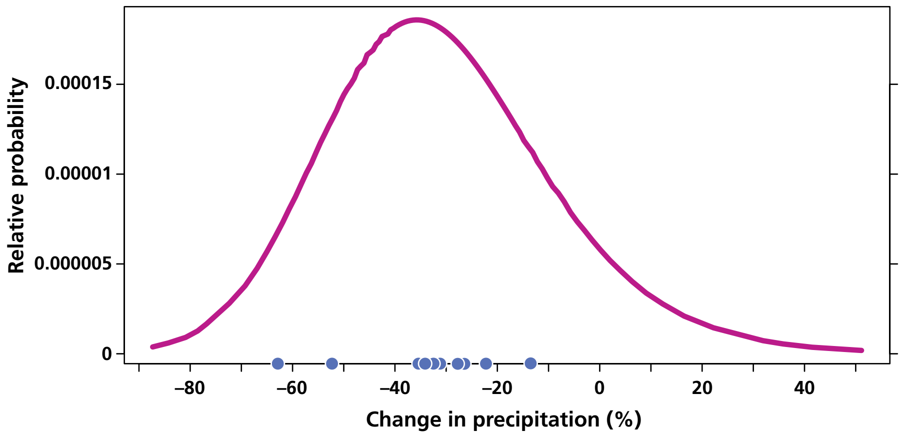

Figure 5.2: A UKCP09 probability distribution function, of change in mean summer precipitation at a 25 km square near Portsmouth, by the 2080s under the Medium emissions scenario. The added blue dots show the same change as projected by each of the 11 members of the RCM ensemble. Of course the PDF may well be quite different from the spread of RCM results, as the former includes information from other climate models and the effect of carbon cycle feedback, for example.

5.4 Examples of data from the RCM ensemble

Figures 5.3–5.5 show some results from the RCM ensemble; these are purely to illustrate the sort of data which can be accessed by the user, rather than to draw any conclusions about climate change. However, note that the LINK access does not provide any graphics capability, so these types of figures cannot be created online.

Figure 5.3 compares the simulated time series of summer (JJA) seasonal-mean daily maximum temperature from 1951 to 2099, from a 25 km grid square over Berkshire of each of the 11 RCM variants under the Medium emissions scenario. Figure 5.4 shows a similar set of time series of summer-mean precipitation for a grid square near Inverness; the large amount of *noise* due to natural variability is immediately apparent, showing that, despite a gradual reduction in summer precipitation through the 21st century, natural year-to-year changes remain larger than the projected climate change, even at the end of this period. Figure 5.5 shows maps of summer-average rainfall simulated by one RCM variant for two 30-yr periods, 1961–1990 and 2070–2099.

5.5 Some applications of RCM ensemble data

The RCM data has been used at the Centre for Ecology and Hydrology, Wallingford, to investigate changes in river flows over the course of the century. This is used as a worked example in the UKCP09 User Guidance to demonstrate the sort of application for which the RCM data might be appropriate. The data has also been used to drive the POL CSX model to estimate changes in the height of extreme water heights (storm surges); results from this are given in the companion UKCP09 science report *Marine and coastal projections*.

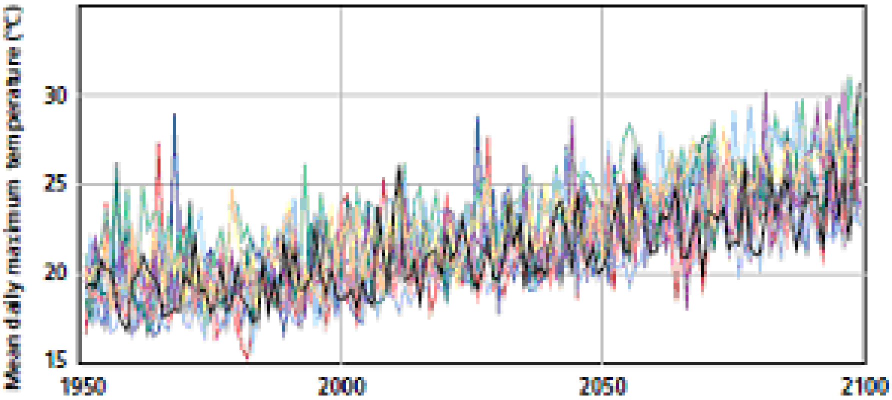

Figure 5.3: Simulated summer (JJA) seasonal-mean daily maximum temperature for a 25 km grid point in Berkshire, 1950–2099, under the Medium emissions scenario, from each of the 11 RCMs.

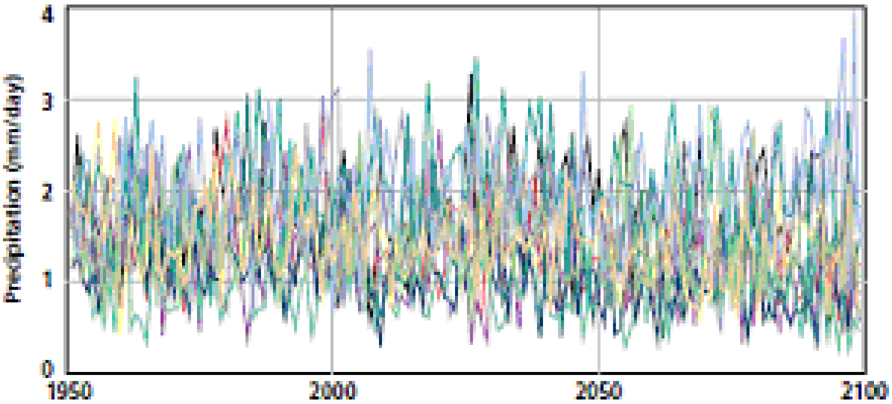

Figure 5.4: Simulated summer (JJA) seasonal-mean daily precipitation for the 25 km grid point near Inverness, 1950–2099, under the Medium emissions scenario, from each of the 11 RCMs.

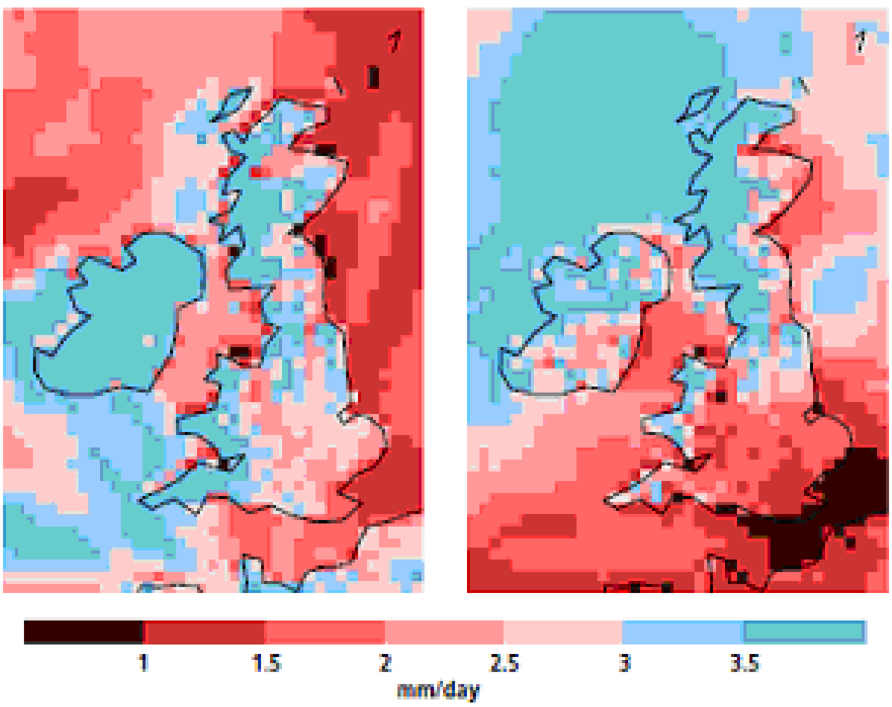

Figure 5.5: A map of summer (JJA) average precipitation (mm/day) from one member of the 11-member RCM ensemble, averaged over the period 1961–1990 (left) and over the period 2070–2099 under the Medium emissions scenario (right).

5.6 Reference

Mearns, L. O., Giorgi, F., Whetton, P., Pabon, P., Hulme, M. & Lal, M. (2003). Guidance on use of climate scenarios developed from regional climate model experiments. DDC of IPCC TGCIA. Available at: http://ipcc-ddc.cru.uea.ac.uk/guidelines/guidelines_rcm.html.

Annex 1: Emissions scenarios used in UKCP09

Each of the SRES emissions scenarios used in UKCP09 suggests a different pathway of economic and social change over the course of the 21st Century. Changes in population, economic growth, technologies, energy intensity, and land use are considered in the emissions scenarios. They do not assume any planned mitigation measures and cannot currently be assigned probabilities.

Rachel Warren, Tyndall Centre for Climate Change Research, UEA.

A1.1 Background

We need to make some assumptions about future emissions of greenhouse gases (and other pollutants) from human activities in order to make projections of UK climate change over the next century. Because we cannot know how emissions will change, we use instead a number of possible scenarios of these, selected from the IPCC Special Report on Emissions Scenarios (SRES) (Nakićenović and Swart, 2000). These correspond to a set of comprehensive global narratives, or storylines, that define local, regional and global socio-economic driving forces of change such as economy, population, technology, energy and agriculture — key determinants of the future emissions pathway. The scenarios are alternative conceptual futures to which no probabilities can be attached.

SRES emissions scenarios are structured in four major *families* labelled A1, A2, B1 and B2, each of which represents a different storyline. They are commonly shown as in Figure A1.1, in which the vertical axis represents the degree to which society is economically or environmentally oriented in the future, whilst the horizontal axis refers to the degree of globalisation. All scenarios are *non-interventionist*, that is, they assume that emissions will not be changed in response to concerns over climate change.

The A1 storyline describes a future world of very rapid economic growth, and a population that increases from 5.3 billion in 1990 to peak in 2050 at 8.7 billion and then declines to 7.1 billion in 2100. Rapid introduction of new and efficient technologies is assumed, as is convergence among regions, including large reductions in regional differences in Gross Domestic Product (GDP). Within the A1 family are three subgroups, referring to high use of fossil fuels (A1F1), high use of non-fossil energy sources (A1T) or an intermediate case (A1B).