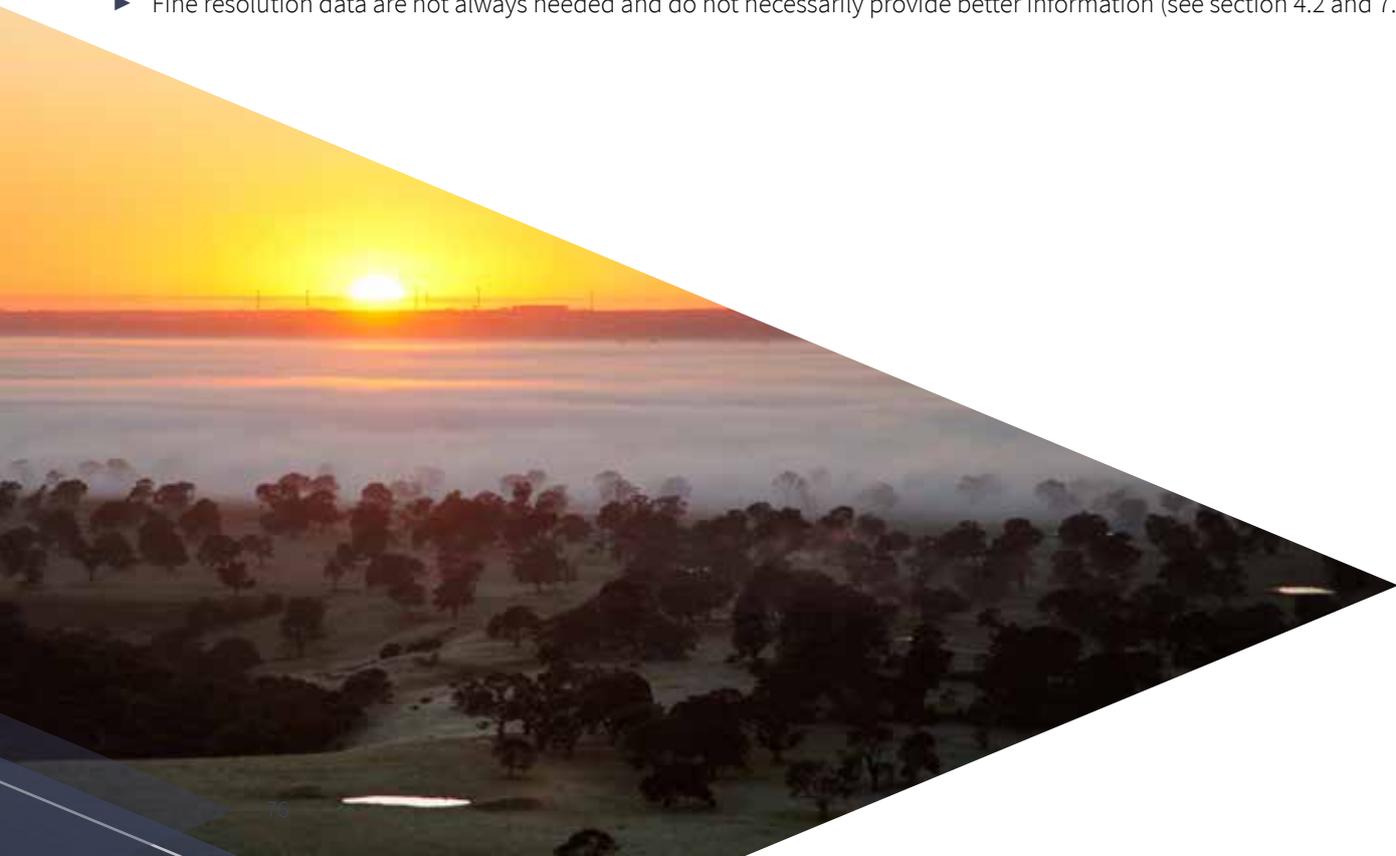


7. Guidelines for using Victoria's climate projections

Key messages

- ▶ Assessing the impact of future climate is complex – plan to allow adequate time for consultation and data collation (see section 7.2).
- ▶ You are likely to need advice and guidance from experts in the field (see section 7.5).
- ▶ Think carefully about the communication needs of your stakeholders – this can influence your choice of climate information (see section 7.1).
- ▶ In most cases, using just the mean or median climate projections will not be appropriate (see section 7.2).
- ▶ In most cases, use a method such as the Climate Futures approach to identify an appropriate subset of models to use in your assessment (see section 7.3).
- ▶ The VCP19 high-resolution data are high quality and add important value to the lower-resolution GCM data in some regions; nevertheless, if GCM results project a high-impact future that is not projected by the VCP19 data, the GCM results should be used unless there is a compelling reason not to.
- ▶ Ensure the ranges of projected change are adequately accounted for in your assessment (see section 7.3)
- ▶ There are multiple sources of uncertainty and there always will be. To deal with this, be sure to evaluate multiple emissions scenarios and explore the full ranges of plausible change from all available data sources (see section 7.3).
- ▶ There is no such thing as a 'most accurate' climate model or 'most likely' emissions scenario. All of the models included in Climate Futures produce climates that are physically plausible for a given emissions scenario. Instead, aim to use a representative subset of the available data (see section 7.3).
- ▶ The climate has always been naturally variable; this variability now occurs on top of climate trends; over short time scales, climate variability will be the largest influence on the climate we experience (see section 5.2.2).
- ▶ Be aware that future climate data have a range of limitations and take this into account (see section 4).
- ▶ Fine resolution data are not always needed and do not necessarily provide better information (see section 4.2 and 7.3).



7.1 Getting started

In this section, we provide brief guidance about using climate projections information for the purpose of impact, adaptation and vulnerability (IAV) assessments, as part of the broader response to climate change. The decision tree shown in Figure 61 can help determine which data and information from VCP19 and elsewhere might be useful for a given application.

As shown in Figure 61, not all applications will require access to detailed climate data sets. In addition to this technical report, VCP19 produced a regional report for each of the 10 regions (see Chapter 2) and a range of fact sheets. These are all available as PDF downloads from the VCP19 publications page of the *Climate Change in Australia* website⁹.

⁹ <https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/vcp19-publications/>

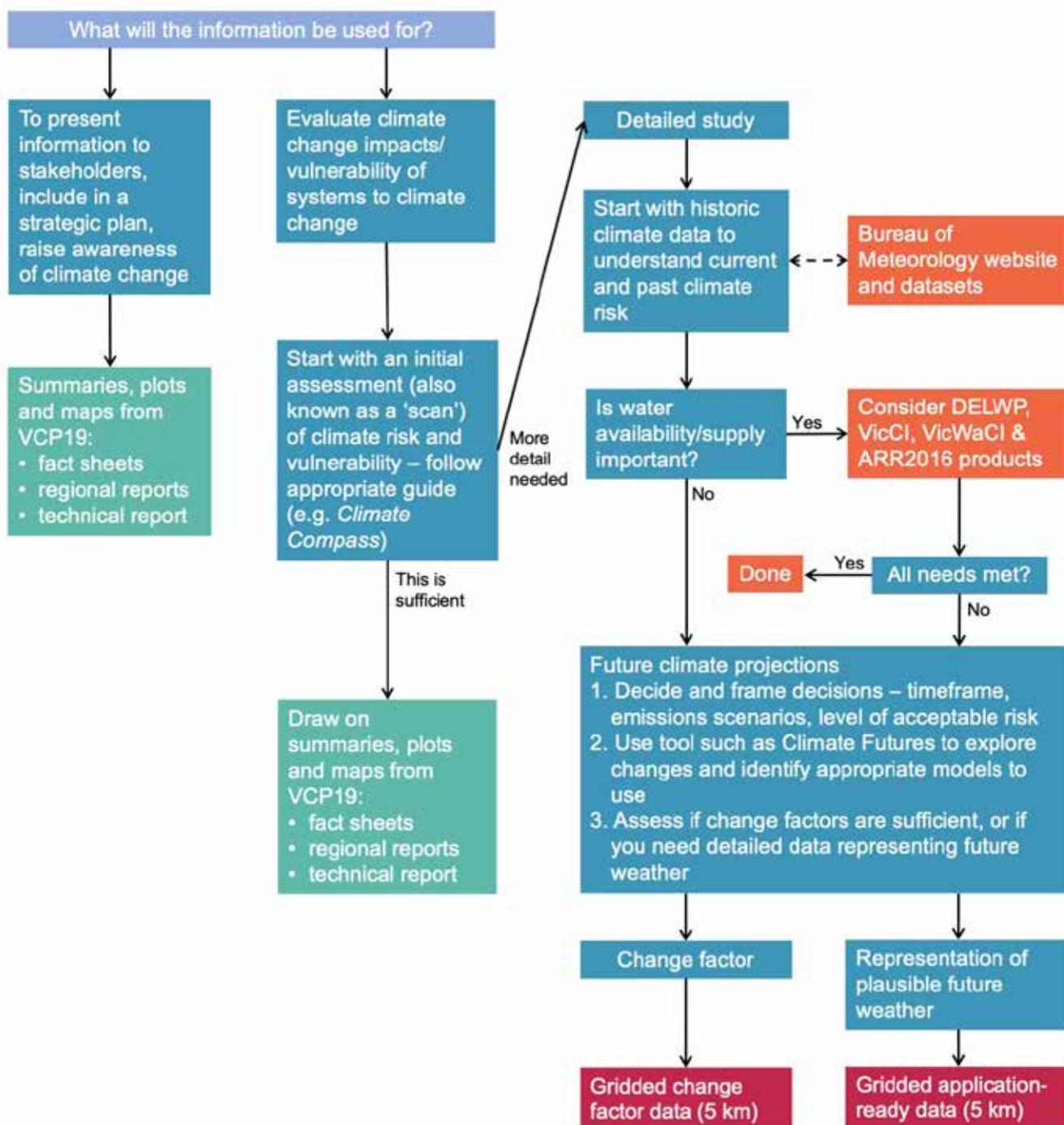


Figure 61. Decision tree for determining which climate data and information from VCP19 (and other sources) might be useful for an application.

7.2 Using climate projections in an impact assessment

Establishing plausible future climate conditions (scenarios or projections) is just one of many steps in knowing what climate change means to any application, and what to do in response. To assess the IAV aspects of future climate risk, we need to bring in other knowledge and information, and do further analysis.

Planning for managing future climate risk involves a combination of:

- ▶ ‘Top-down’ analysis – starting by constructing climate projections and feeding them into a chain of analyses such as applied models to understand what this change in the climate means to a downstream application (e.g. feeding rainfall and evaporation into a runoff model to assess changes in water availability and river flows). This top-down chain may include a downscaling step to provide regional insights in the projected changes. The VCP19 project included downscaling for this purpose.
- ▶ ‘Bottom-up’ analysis – assessing the vulnerability and resilience of systems, and pathways to reduce vulnerability and increase the capacity to cope or transform (without consideration of climate projections).

These two approaches can be combined to explore what climate change may mean for a given situation, and the scope and scale of response needed for different scenarios.

As projections of future climate include considerable uncertainties, a simple ‘predict then act’ framework is not suitable. Instead, we must consider the range of possibilities in four main respects:

- ▶ Natural climate variability
- ▶ Emissions scenarios
- ▶ How the climate may respond to increasing greenhouse gases (estimated from a range of models)
- ▶ Understanding the level of confidence that can be applied to each projection and/or model simulation.

Reducing these uncertainties is a global priority for climate research. Nevertheless, uncertainties due to climate variability and emissions uncertainty will always remain. This means impact assessments will always have to deal with a range of plausible future climates.

To deal with these uncertainties, impact assessments should:

1. consider the full range of plausible change as projected by all available climate modelling
2. evaluate multiple emissions scenarios (at least two)
3. account for natural climate variability (which will be superimposed over climate trends)
4. use an objective means (such as the Climate Futures approach described in section 7.3) to select a subset of data that is relevant to the assessment being undertaken.

In addition, some aspects of decision-making are specific to the application, including the time horizon and the tolerance for risk. There are also factors of political will, economic resources and social license to operate that must be considered.

7.2.1 Chain of actions

To pursue the top-down part of an IAV assessment, there are a few underpinning principles, and a chain of actions to follow:

1. Before using climate projections, it is important to do relevant background reading, identify relevant stakeholders and determine the appropriate level of stakeholder engagement.
2. Next, determine the need/s for climate change data and information.
3. Obtain appropriate information and/or data (use the decision tree in Figure 61).

The information from VCP19 and similar sources may be enough for basic purposes or raising awareness (the first branch in the decision tree), or it may be the start of further analysis. An initial assessment (sometimes called a ‘first pass assessment’ or ‘scan’) should be done before any detailed analysis. Following a scan, if more detailed information is needed then a detailed study can be scoped and carried out.

All IAV applications, including those in the water domain, should start with an assessment of past and future climate changes and the impact they have – this involves collecting and processing appropriate climate datasets from the Bureau of Meteorology, VCP19, CCIA and others, as well as data sets relevant to the application (e.g. databases of assets, networks and infrastructure).

Runoff, soil moisture and stream flow

VCP19 has not produced projections of runoff, soil moisture or stream flow. If these are required, the existing DELWP guidelines may be helpful (or mandatory in some cases). At the time of publication, the VicCI and VicWACI projects provided standardised datasets for managing water supply in Victoria (see <https://www.water.vic.gov.au/climate-change>). Like VCP19, these projects were based on a wide-ranging assessment of multiple sources of evidence (and align well with the VCP19 rainfall projections).

Contact DELWP Water and Catchments for further assistance (HCS.Team@delwp.vic.gov.au).

Once:

1. stakeholders are identified
2. the engagement plan is set
3. historical climate impacts and vulnerability are understood
4. the information needs are assessed
5. the initial scan is completed

then future climate datasets can be collected and climate projections constructed. This is where the Climate Futures tool and the VCP19 datasets may be useful, as described in the next section.

After climate projections have been constructed and used in applied analyses, the results should be interpreted and communicated via appropriate means, and the outcomes assessed. Then the cycle can be repeated, and the scan of needs can start again.

7.3 Constructing climate projections – the CSIRO Climate Futures framework

When using climate data sets for IAV assessment, there are four important requirements:

1. The data must be physically plausible, especially when data for multiple climate variables are being used – in other words, they could occur in the real world (this is referred to being ‘internally consistent’).
2. The data must be representative of the range of projections results.
3. The amount of data to be used must be manageable.
4. Information on likelihood or confidence is available.

One mechanism to satisfy these requirements is the Climate Futures framework¹⁰ (Whetton et al. 2012; Clarke et al. 2011). This allows the user to view, compare and select model outputs tailored to the needs of a specific application. The example Climate Futures matrix shown in Figure 62 shows the range of projected changes in winter temperature and rainfall for Gippsland around mid-century (2050s) under high emissions (RCP8.5). The spread of results from multiple climate models is shown on two dimensions divided into categories. The number of models within each category (or ‘climate future’) gives an indication of model agreement on that category.

¹⁰ <https://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-futures-tool/introduction-climate-futures/>

Climate Compass

The Climate Compass provides guidelines for the Commonwealth public service to manage the risks from a changing climate. Climate Compass describes the three classes of climate change impact assessment in detail:

- ▶ *Scan* – typical starting point, used to obtain a high-level sense of the climate risks that an area or responsibility is exposed to.
- ▶ *Strategy* – a deeper identification, assessment and treatment of risks (may follow a scan cycle).
- ▶ *Project* – a detailed assessment and operational plan for more focused work.

Climate Compass is available at <https://www.environment.gov.au/climate-change/adaptation/publications/climate-compass-climate-risk-management-framework>

Representative climate futures can then be selected, where key cases of interest are defined by the vulnerabilities of the application being considered. A representative model simulation from each key case can then be chosen and the data obtained. In the example matrix shown in Figure 62 (to inform a dairy productivity assessment), a hotter, drier climate is considered the worst case and a future that is less hot but wetter is considered the best available climate future

for this particular application. For another application, the situation is likely to be different.

The *maximum consensus* climate future (where there is the greatest model agreement) is also shown. Understanding where there is the maximum consensus among models is useful. In all circumstances, however, the higher impact but less likely *best* and *worst* cases should also be considered.

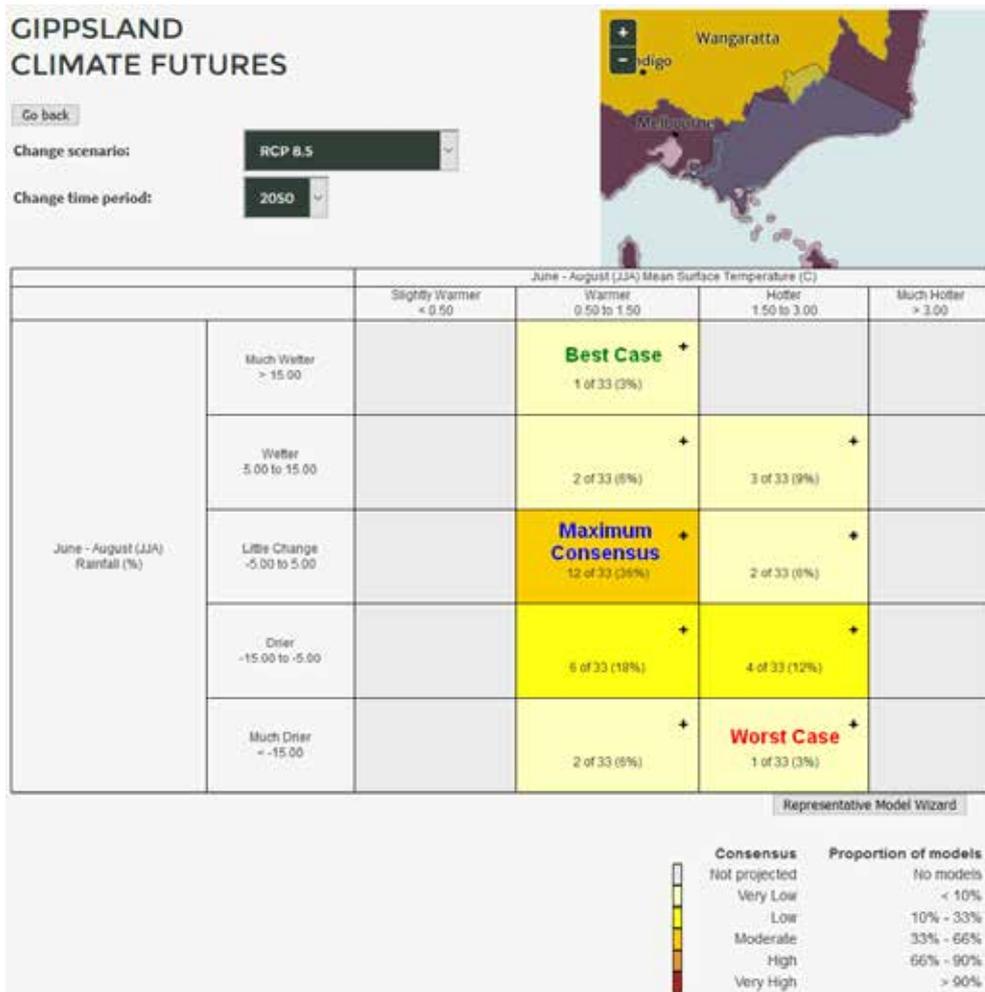


Figure 62. A Climate Futures matrix for Gippsland showing example 'key cases': best, worst and maximum consensus.

The following steps outline the procedure for creating a Climate Futures matrix, using the Climate Futures Toolkit on the *Climate Change in Australia* website. However, this process is complex so you may need to seek help. A good place to start is the *Climate Change in Australia* online training¹¹. You can also contact the CSIRO Climate Science Centre¹².

- ▶ Use the Detailed Projections Tool to generate a Climate Futures matrix to explore the range of change in terms of two classifying variables (because of the correlations among variables, temperature and rainfall are usually best classifiers). Populate the matrix with all the variables and seasons that are important to the impact assessment (e.g. winter rainfall and temperature, and summer minimum temperature are often important for the dairy sector).
- ▶ Use the information on projected changes to identify the ‘key cases’ that are important for the impact assessment. Commonly these are best case, worst case and maximum consensus (e.g. Figure 62). If needed, a simple sensitivity analysis (see section 7.3.1) can be useful to guide this step.
- ▶ Identify a representative model for each key case.
 - Rank the models using the Climate Futures Tool Representative Model Wizard
 - Follow the guidance on the Climate Futures matrix display to reject any models that have been identified as performing poorly for any reason in the region of interest. This is very important since you will be using data from a single model to represent the relevant key case.
- ▶ Obtain the data needed from each model. In many cases, the data will be available on *Climate Change in Australia*, including data from VCP19. However, once the representative models have been identified, the data from those models may be available from a range of sources (take care to ensure data from other sources are comparable to those used by Climate Futures).
- ▶ Input the data into the impact assessment.
- ▶ If using a risk management approach, use the information on model consensus (from the matrix) to guide the assessment of likelihood.

In VCP19, we present data from new high-resolution (5 km) modelling alongside previous modelling datasets – and highlight where the new data add useful insights. When assessing risk, it is important to consider the full range of plausible changes, especially if worst-case or other ‘low probability, high impact’ cases are important to manage or mitigate. The Climate Futures approach makes it easy to choose representative climate futures from across all available data sources.

For Victoria, we suggest using the VCP19 datasets in preference to the GCM datasets *in most instances* (this is because the VCP19 data have been shown to add value to the GCM results). However, if one of the key cases (as described above) is projected only by GCMs, we suggest the GCM results should be used unless there is a compelling reason not to. This is because it is generally more important to evaluate a plausible extreme case than it is to have higher spatial resolution.

A final consideration in model selection is the availability and usability of the necessary data. The range of climate variables and data formats available from GCMs and RCMs varies among models. GCM outputs and detailed dynamically downscaled data sets are available as described below. If other types of data are really needed (e.g. from weather generators or other forms of statistical downscaling), then this can be pursued. These methods, however, can be time-consuming and costly and require specialised skills to produce.

It is vitally important to understand the full range of plausible changes before undertaking a detailed assessment of risk. The Climate Futures approach facilitates this as well as providing a mechanism for objective selection of representative models to use.

¹¹ <https://www.climatechangeinaustralia.gov.au/en/climate-campus/online-training/>

¹² <https://www.climatechangeinaustralia.gov.au/en/support-and-guidance/contact/>

7.3.1 Sensitivity analysis

A sensitivity analysis is a good starting point in an impact assessment process and requires no detailed climate projection inputs.

A sensitivity analysis involves testing the effect of a spectrum of changes to a system – e.g. +1, +2, +3 and +4°C or -20, -10, +10 and +20% rainfall – to look for relationships, sudden changes or thresholds in response to climate changes. The results can in turn be used to define best and worst cases for use in Climate Futures.

For example, if a sensitivity test reveals a threshold of -20% in rainfall where a particular system must transform or face

failure, this can be explored as the worst case in Climate Futures. The chance of reaching this threshold under different RCPs and timeframes across the model range can then be explored.

7.3.2 Spatial analogues

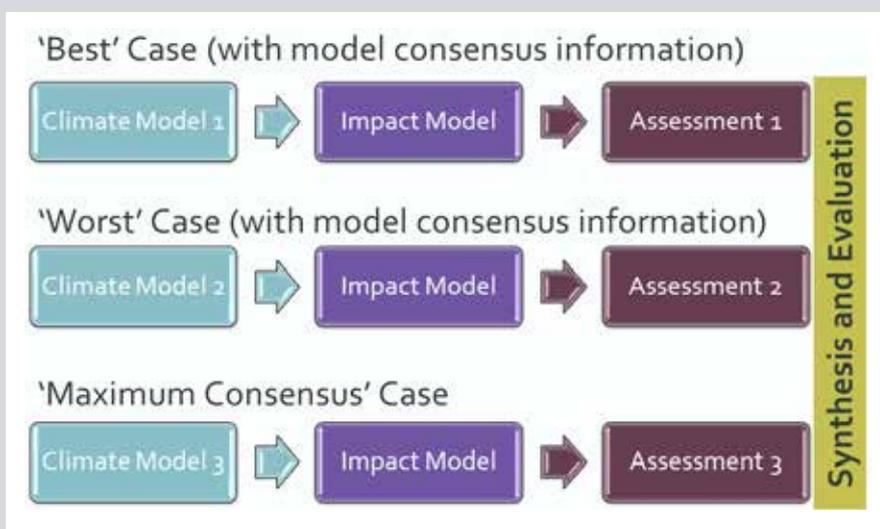
Spatial climate analogues can be another useful tool to start assessing what climate change means by looking at places that currently experience the climate that is projected to occur in the area in question, e.g. Melbourne’s climate becoming more like the current climate of Wangaratta.

A spatial climate analogues tool is available on the *Climate Change in Australia* website¹³.

¹³ <https://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-analogues/about-analogues/>

Key steps in developing climate scenarios and identifying data sources

1. Obtain/collate information on the sensitivity of the application to climate influences (e.g. crops are usually sensitive to rainfall, temperatures, evapotranspiration and solar radiation; particular seasons may be important); if necessary, do a simple sensitivity analysis.
2. Determine the type of data needed (e.g. change factors, application-ready daily time-series).
3. Define the key cases of interest, usually best case, worst case and maximum consensus. For example, a worst case for a cropping study is likely to be the hottest and driest future.
4. Generate Climate Futures matrices for the region of interest for all relevant time periods and at least two emissions scenarios (VCP19 data are available for RCP4.5 and RCP8.5); populate the matrix with all variables (and seasons) to which the application is sensitive.
5. Identify the key cases in each matrix.
6. Identify representative models for each key case. (Check the information on model skill; reject any models that demonstrated poor performance in the region of interest.)
7. In general, the VCP19 data should be used. However, if a key case climate future is populated by GCM data only, use the GCM data unless there is a compelling reason not to.
8. Obtain the necessary data from the identified representative models.
9. Complete an impact assessment separately for each case by using the data from the selected model (see figure). The results can then be synthesised and used to inform decision-making.



The 'key cases' approach to impact assessment (after Whetton et al. 2012)

7.4 Obtaining VCP19 high-resolution climate data

If the decision tree (Figure 61) recommends a detailed study, and other relevant decisions affirm this course of action, detailed data can be selected and downloaded. Data from VCP19 and host GCMs can be selected and then downloaded from the *Climate Change in Australia* website. This is best done directly from the results page when finishing a Climate Futures selection process. The Climate Futures Tool accounts for the VCP19 regions under ‘detailed projections’, and the Victorian regions can be accessed by selecting the option on the map as shown in Figure 63. It is also possible to access model data directly in netCDF format.

Most applications are sensitive to the biases inherent in climate model output. When obtaining data from the identified representative models (as described in section 7.3), all but the most expert of users should employ either relative change data or the application-ready future data. Both of these types of data are free of model biases and are available from VCP19 (see section 7.5).

In VCP19, application-ready data have been developed from all high resolution six models. This was done by applying the relative change signal from the climate models to an historical dataset. These datasets are explained in more detail in section 2.5. If in doubt, the application-ready

data are usually a more reliable and robust option to apply when using temperature, rainfall, relative humidity, evapotranspiration, wind speed and solar radiation. These application ready data sets have also been used to estimate future exceedances of a range of rainfall and temperature thresholds.

7.5 Further resources

The VCP19 pages of the *Climate Change in Australia* website contain additional resources for Victoria. Here you can access a range of climate projections tools and datasets to suit intermediate and expert users. You will also find guidance material and learning resources on climate science, data selection and impact assessment.

- ▶ <https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/victorian-climate-projections-2019/>

For observed data and analyses of climate trends, visit the Bureau of Meteorology Climate Data Online.

- ▶ <http://www.bom.gov.au/climate/data/>

General information on the *Victorian Climate Projections 2019* project is available on the Victorian Government’s climate change website.

- ▶ <http://www.climatechange.vic.gov.au/vcp19>

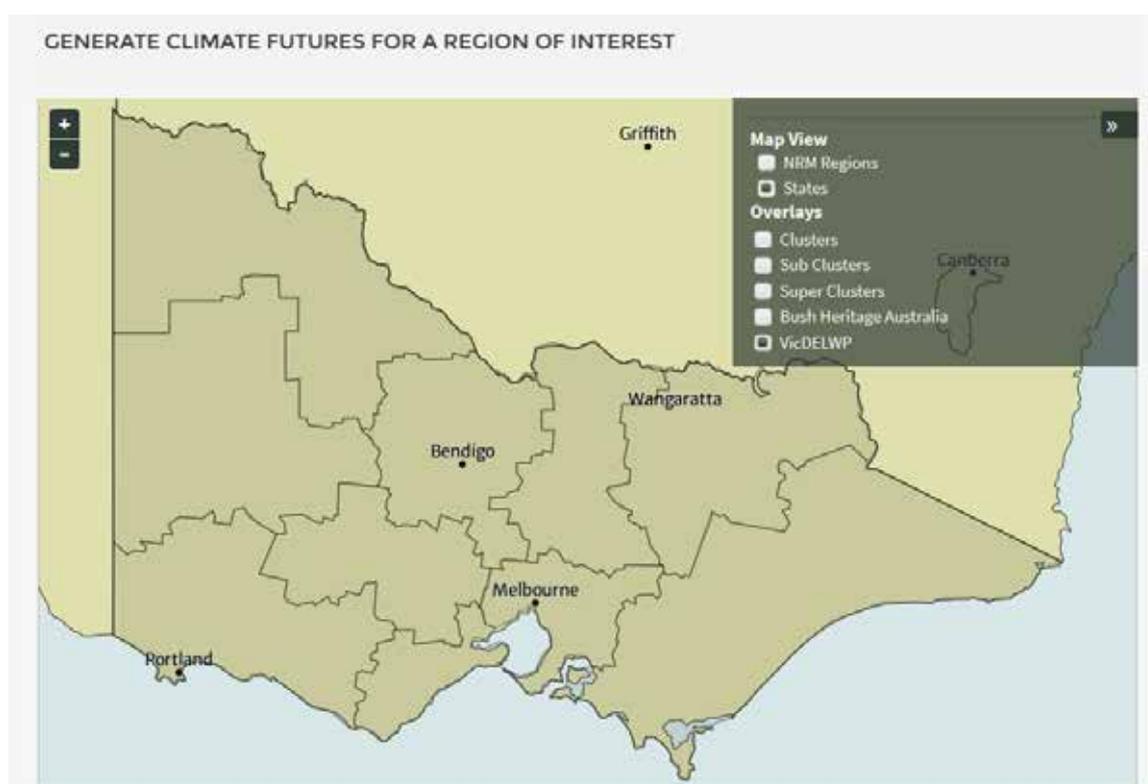


Figure 63. Example from the Climate Futures Tool on the Climate Change in Australia website, showing the VCP19 regions for Victoria.