



## Chapter 1 Introduction

This report is provided for researchers, public and private policy developers and the community at large to assess their respective exposure, risk and opportunities that may flow from regional climate change due to global warming. There is still much that we do not know, but this report provides the most up-to-date assessment of observed Australian climate changes and causes, and projections for 2030 to 2070. It supersedes earlier projections (CSIRO 2001) and builds on a greatly improved global scientific knowledge on this issue.

'Climate change' is defined by the IPCC as a change in the state of the climate that can be identified by changes in the mean (and/or the variability), and that persists for an extended period, typically decades or longer.

Since 1988 the scientific findings on atmospheric change and the potential for human induced changes in the Earth's climate have been reviewed and summarised by the Intergovernmental Panel on Climate Change (IPCC). Four major reports were issued (IPCC 1990; IPCC 1996; IPCC 2001 and IPCC 2007a). The Fourth Assessment Report on the physical science basis of climate change (IPCC 2007a) stated the following amongst its key conclusions:

- Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years.
  - Warming of the climate system is unequivocal as is now evident from observations of increases in global average air temperatures, widespread melting of snow and ice, and rises in global average sea level.
  - At continental, regional, and ocean-basin scales, numerous long-term changes in climate have been observed.
  - Palaeo-climate information supports the interpretation that the warmth of the last half century is unusual in at least the previous 1300 years.
  - Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations ... Discernible human influences now extend to other aspects of climate, including ocean warming, continental average temperatures, temperature extremes and wind patterns.
- For the next two decades a warming of about 0.2°C per decade is projected for a range of SRES emission scenarios.
  - Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century.
  - There is now higher confidence in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation, and some aspects of extremes and of ice.

In summary, the message is that global warming is real, humans are *very likely* to be causing it, and that it is *very likely* that there will changes in the global climate system in the centuries to come larger than those seen in the recent past. Future changes have the potential to have a major impact on human and natural systems throughout the world including Australia.

This report follows IPCC in its use of terms indicating likelihood. This is as follows: Virtually certain > 99% probability of occurrence, extremely likely > 95%, very likely > 90%, likely > 66%, more likely than not > 50%, unlikely < 33%, very unlikely < 10%, and extremely unlikely < 5%.

Each major IPCC report has produced global projections of climate change due to scenarios of greenhouse gas and aerosol emissions that become widely used until the time of the next IPCC report. As the science has improved, so have the breadth and detail of these projections. Projections of regional climate change for Australia have followed the major IPCC reports, providing regional detail consistent with the global projections produced by the IPCC (CSIRO 1992, 1996, 2001).

*Climate Change in Australia* is the latest such assessment. It is based upon international climate change research including the latest IPCC (2007a) conclusions. Moreover, it builds on a large body of climate research that has been undertaken for the Australian region in recent years. This includes research completed within the Australian Climate Change Science Program by CSIRO and the Australian Bureau of Meteorology in partnership with the Australian Greenhouse Office.

The purpose of this report is to provide an up-to-date assessment of observed climate change over Australia (Chapter 2), the likely causes (Chapter 3), global climate change projections (Chapter 4), regional projections for Australia (Chapter 5) and guidance on using projections in risk assessments (Chapter 6).

A number of major advances have been made over the previous statements about Australian climate change making this technical report the most comprehensive to date. Advances include:

- A detailed assessment of observed changes in Australian climate and likely causes, absent from previous statements.
- Projections are given for 23 climate variables and six ocean variables based on up to 23 climate models and up to six greenhouse gas and aerosol emission scenarios.
- For some climate variables, results are based on weighting of models according to their ability to simulate features of the present (1961–1990) Australian climate.
- For some climate variables, probability distributions have been assigned, allowing the presentation of median changes, 10th to 90th percentile ranges of uncertainty, and the probability of exceeding selected thresholds.
- A chapter on risk assessment, which provides guidance material for using climate projections in impact studies.
- socio-economic uncertainties associated with the current and future activities of humans
- scientific uncertainties associated with our understanding of how the Earth's major biophysical systems behave
- fundamental uncertainties associated with the behaviour of complex systems.

This report mostly deals with scientific uncertainties associated with projecting future climate change but also needs to consider socio-economic and complex systems uncertainties. Because of the substantial and complex uncertainties surrounding climate change, new concepts and specific uses of terminology have been developed for its management. Traditionally, characterisations of future climate have been described as scenarios, but as the types and uses of such characterisations grow, the terminology has become more detailed (Box 1; Carter *et al.* 2007).

This report describes characterisations of future climate that range from artificial experiments through to probabilistic futures. They are intended to provide a general overview of plausible climate change over Australia for general information, and are suitable for scoping exercises such as the identification of potential climate risks. For more applied purposes, further work will be needed to prepare climate change information that is fit for the purpose intended. Chapter 6 provides a general overview of how this may be achieved but it is also an area of active research that will continually be updated.

This technical report provides details of the national assessment and how it was developed, including references to the underpinning research. The report is aimed at researchers and informed experts. Supplementary material is available on the *Climate Change in Australia* website [www.climatechangeinaustralia.gov.au](http://www.climatechangeinaustralia.gov.au).

## Report context

Although our understanding of climate change has improved markedly over the past several decades and continues to improve, the issue is still beset by uncertainty. The sources of uncertainty are many and diverse but can be grouped into:

## Box 1.1: Definitions of future characterisations

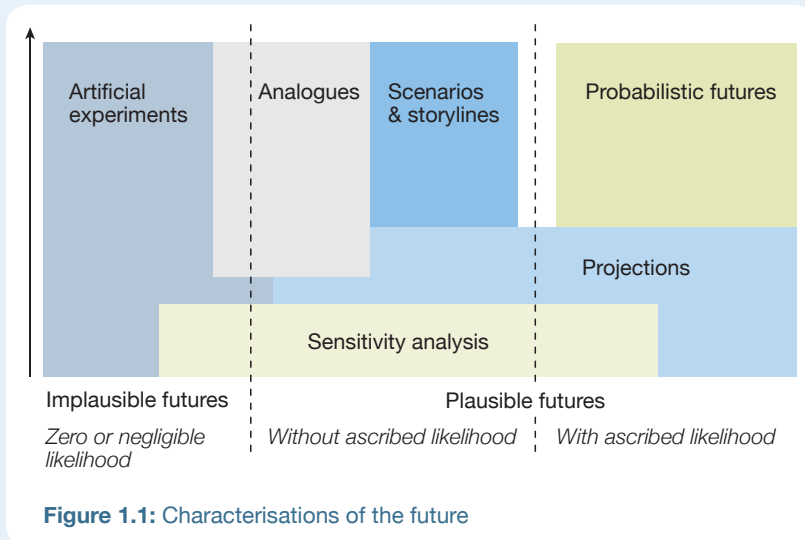


Figure 1.1: Characterisations of the future

Definitions have been developed by the IPCC for terminology relating to the use of climate information (Carter *et al.* 2007).

**Comprehensiveness** indicates the degree to which a characterisation of the future captures the various aspects of the socio-economic/biophysical system it aims to represent. Secondly, it indicates the detail with which any single element is characterised.

**Plausibility** is a subjective measure of whether a characterisation of the future is possible. Implausible futures are assumed to have zero or negligible likelihood. Plausible futures can be further distinguished by whether a specific likelihood is ascribed or not.

**An artificial experiment** is a characterisation of the future constructed without regard to plausibility (and hence often implausible) that follows a coherent logic in order to study a process or communicate an insight.

Artificial experiments range in comprehensiveness from simple thought experiments to detailed integrated modelling studies.

**Sensitivity analyses** employ characterisations that involve arbitrary or graduated adjustments of one or several variables relative to a reference case. These adjustments may be plausible (e.g. changes are of a realistic magnitude) or implausible (e.g. interactions between the adjusted variables are ignored), but the main aim is to explore model sensitivity to inputs, and possibly uncertainty in outputs.

**Analogues** are based on recorded conditions that are considered to adequately represent future conditions in a study region. These records can be of past conditions (temporal analogues) or from another region (spatial analogues). Analogues are plausible in that they reflect a real situation, but may be implausible because no two places or periods of time are identical in all respects.

A **scenario** is a coherent, internally consistent, and plausible description of a possible future state of the world (IPCC 1994; IPCC 2000). Scenarios are not predictions or forecasts (which indicate outcomes considered most likely), but are alternative images without ascribed likelihoods of how the future might unfold. They may be qualitative, quantitative, or both. A **climate scenario** is a description of a plausible future climate.

**Storylines** are qualitative, internally consistent narratives of how the future may evolve. They describe the principal trends in socio-political-economic drivers of change and the relationships between these drivers. Storylines may be stand-alone, but more often underpin quantitative projections of future change that, together with the storyline, constitute a scenario.

A **projection** is generally regarded as any description of the future and the pathway leading to it but is defined by Carter *et al.* (2007) as a model-derived estimate of future conditions related to one element of an integrated system (e.g. an emission, a climate, or an economic growth projection). Projections may be probabilistic, while scenarios do not ascribe likelihoods.

**Probabilistic futures.** Futures with ascribed likelihoods are probabilistic. The degree to which the future is characterised in probabilistic terms can vary widely. For example, conditional probabilistic futures are subject to specific and stated assumptions about how underlying assumptions are to be represented. Assigned probabilities may also be imprecise or qualitative.