

Models, scenarios and uncertainties

WHAT IS THE IPCC

THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

A scientific intergovernmental body set up in 1988 by the World Meteorological Organization and by the United Nations Environment Programme. In 2007, it was awarded the Nobel Peace Prize for "efforts to build up and disseminate greater knowledge about man-made climate change and to lay the foundations for the measures that are needed to counteract such change".

It provides information on climate change through reports based on the continually growing body of scientific evidence. The comprehensiveness of the content is achieved through the contributions of thousands of experts across all relevant disciplines and in all regions of the world including New Zealand.

DEVELOPING THE CLIMATE CHANGE MODELS

While the theory that human activity is influencing global climate had its beginnings in the 19th century, it took until the latter part of the 20th century for it to be fully developed. This was for two main reasons. Firstly, by the mid 1970s there was growing evidence of changes in atmospheric carbon dioxide and temperature. Secondly, the advance of computer technology enabled the development of complex models to test the theory. The results from the first computer model that showed the effects of a doubling of atmospheric carbon dioxide were published in 1975.

The science has developed rapidly since then. While model outputs contain many uncertainties, extensive work over the past decade has produced models that are increasingly skilful in simulating aspects of global climate.

FIGURE 1: MULTIPLE AND AVERAGE MODEL SIMULATIONS OF GLOBAL AVERAGE TEMPERATURE OVER THE PAST CENTURY, COMPARED TO OBSERVED TEMPERATURES

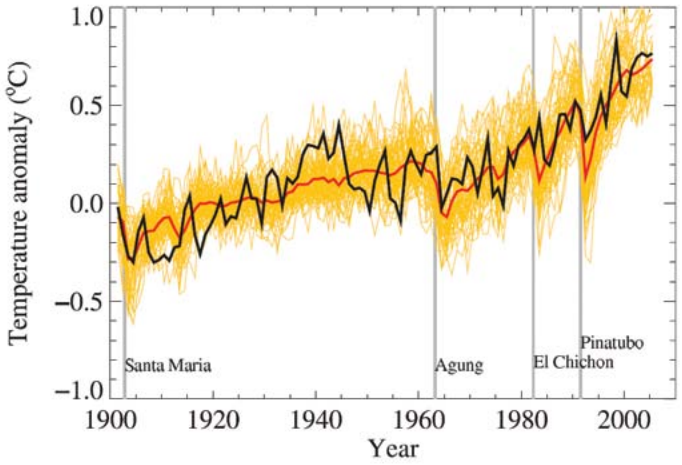


Figure 1 shows the consistency between model results (red line shows the average of 14 models and yellow line shows the range) and actual measured changes in global average temperature (black line). The vertical lines highlight the eruptions of the named volcanoes and their negative impact on global temperatures.

Source: IPCC 2007

MODELS OF FUTURE CLIMATE

The models' ability to represent past and present climate features gives us confidence in their simulations of future climate change. In practice, a range of models are used to simulate what are typically called climate change scenarios.

Climate change scenarios are not predictions or forecasts, rather they are plausible "pictures" of what climatic effects might arise on national and local scales. The scenarios try to take into account a range of possible changes in human population, economic factors, technological driving factors, and the resulting changes in greenhouse gas emissions.

Figure 2 illustrates the future possible different global temperature outcomes with associated ranges of uncertainty, dependent on different levels of greenhouse gas emissions.

"Farming and growing is about the need to be adaptable....If you're in the business of growing you're very reliant on the weather. You have no control, you have to farm with the weather, not against it. We will get the extreme weather events and suffer crop losses." Bay of Plenty kiwifruit grower

CLIMATE CHANGE SCENARIOS FOR NEW ZEALAND

The results from global climate models have been used for the last two decades to develop regional scenarios of climate change around the world. This information then provides a basis for identifying possible impacts on individual countries and for planning what responses might be possible or necessary.

Translating global model results to the New Zealand scale is not a simple task. It involves taking the very coarse global model data and combining it with knowledge of the climate around and within New Zealand (see Figure 3). Interpreting this information into plausible scenarios for New Zealand's regions involves a good deal of expert judgement. The possible climatic effects that might arise in New Zealand with scenarios of future climate are detailed in Fact Sheet 4, *Future New Zealand: Possible effects on our climate.*

SCENARIO UNCERTAINTIES

Given the complexity of the information, there are some resulting uncertainties associated with climate change scenarios.

SOURCES OF UNCERTAINTY AT THE GLOBAL SCALE

The two main sources of uncertainty associated with climate change models and scenarios, at the global scale, are:

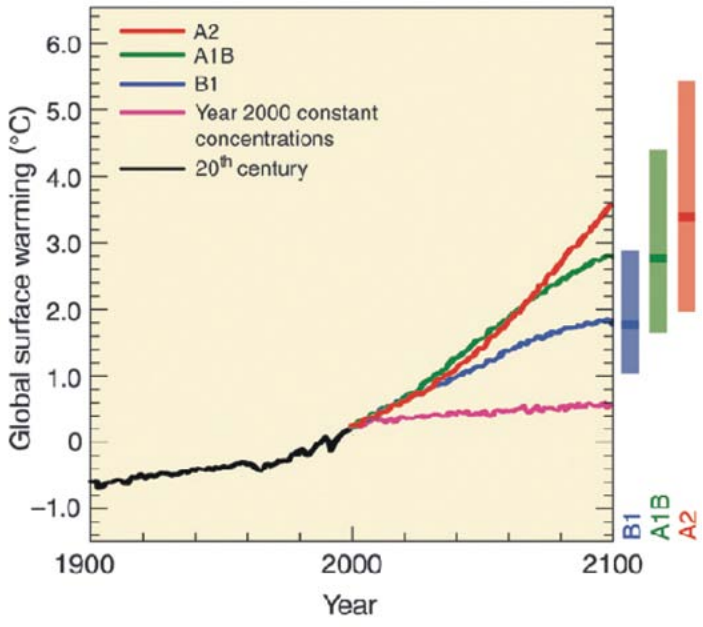
- Uncertainties within and between computer models developed by different research groups around the world. These uncertainties relate to different assumptions made about the multiple interactions and processes that exist in the global climate system.
- Uncertainties related to future emissions of greenhouse gases and the effects that these will have on the global climate system. The rate and magnitude of future emissions are dependent on human responses and there are uncertainties associated with different emissions 'pathways'.

SOURCES OF UNCERTAINTY AT THE NEW ZEALAND SCALE

Climate scenarios for New Zealand carry the uncertainties associated with the global scenarios, but also additional uncertainties associated with:

- How the natural variability in the climate of New Zealand will be affected by global changes and how sources of variability such as El Niño will change with global climate change.
- The difficulty in quantifying future climate change in New Zealand regions to a level of detail that can ensure accurate planning.

FIGURE 2: TEMPERATURE CHANGE SCENARIOS FOR THE 21ST CENTURY AND THEIR ASSOCIATED RANGES OF UNCERTAINTY



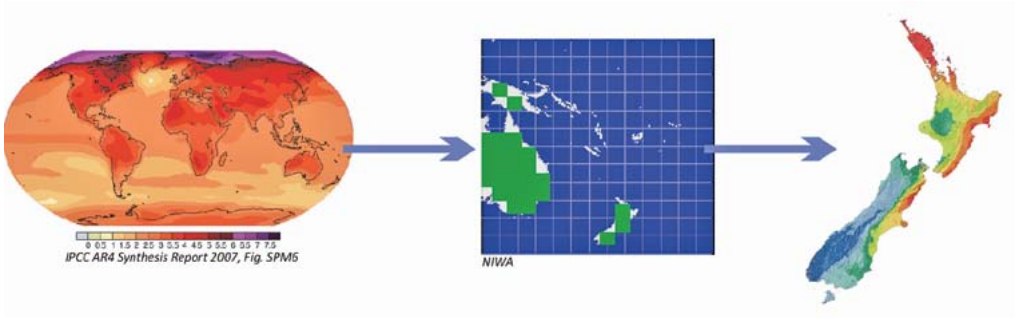
Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the global scenarios A2, A1B and B1. The magenta line is for an experiment where concentrations of GHG were held constant at year 2000 values. The bars to the right of the figure indicate the best estimate (solid line within each bar) and the likely range assessed for the three scenarios at 2090–2099 relative to 1980–1999. (Adapted from *IPCC Synthesis Report,* 2007, Figure 3-2)

IPCC SCENARIOS PORTRAY DIFFERENT FUTURES

For instance:

- A2 describes a very heterogeneous world with high population growth, slow economic development and slow technological change.
- The A1B storyline assumes a world of very rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies.
- B1 describes a convergent world, with the same global population as A1, but with more rapid changes in economic structures toward a service and information economy, and the introduction of cleaner and more resource-efficient technologies.

FIGURE 3: SCHEMATIC REPRESENTATION OF THE DOWNSCALING PROCESS



A global model result (left) is transformed using statistical techniques to create more regional detail (centre), and local climate knowledge to create a scenario of future climate for New Zealand (right).

INTERPRETING A REGIONAL SCENARIO

Given these uncertainties it is very important to be pragmatic when interpreting the scenarios presented for New Zealand. While they provide us with information on possible effects of climate change, over time, the science will evolve and natural and managed systems will respond in ways that cannot be foreseen.

For example, climate change scenarios for New Zealand consistently show a pattern of rainfall change that suggests wetter conditions on average in the west and drier conditions on average in the east. However, there will still be dry years in the west and wet years in the east, as well as changing variability between years, seasonal rainfall patterns and rainfall intensities.

When a climate change scenario says, "spring rainfall in Hawke's Bay is likely to be 13 percent less, but the range of possible change is –38 percent to +9 percent", what does this actually mean?

The scenario suggests an average decrease of 13 percent is the best estimate for future rainfall, but you should be aware that some of the models are suggesting a greater decrease (down to –38 percent), while others suggest an increase (up to +9 percent). Simply put, the odds are higher that there would be less rain in spring, than more.

In the short-term, what will matter most will be changes in variability between years, changes in seasonal rainfall patterns and distribution, and changes in rainfall intensities, all of which are uncertain. Variability in New Zealand's climate is detailed in Fact Sheet 2, *New Zealand's variable climate.*

FREQUENTLY ASKED QUESTIONS

HOW CAN NEW ZEALAND FARMERS MAKE FIRM DECISIONS WHEN THERE IS UNCERTAINTY?

Farmers and growers are already using different sources of climate information to make farm management and planning decisions. Most of this decision making is focused on the season ahead. When working with the weather, farmers constantly weigh up of the value and likely outcomes of day-to-day decision-making, while keeping in view the options that are part of long-term planning.

A sensible approach is to consider adaptation to climate change as part of what you might already be doing to increase your resilience. The Ministry of Agriculture and Forestry adaptation case studies provide some good examples of such an approach.

ISN'T NEW ZEALAND CLIMATE TOO VARIABLE TO PREDICT INTO THE FUTURE?

New Zealand climate in the future is likely to vary from year-to-year and decade-to-decade, just as it does at present. However, the science of climate change has confirmed that there is an underlying warming trend that may increasingly affect the variability of our climate. Climate change scenarios, while not predictions of future climate, use reasonable assumptions about current climate variability, as well as future conditions such as global economic, technological and political trends, to provide plausible indications of what changes in climate we might expect.

CAN WE BELIEVE THE MODELS?

There have been huge international efforts focused on developing and refining global climate models over the last three decades. These models have become increasingly sophisticated. There is also a growing body of evidence from scientific observation which is giving proof to results from the models.

A good test for the models is how well they represent the climate that has been measured. This has become possible as the signal of climate change has become more evident within recent decades. Figure 1 shows that the models represent past climate pretty well. However, the fact remains that it is not possible to model with 100 percent certainty how the climate might change in the future, particularly at the regional and local scale.

HOW WILL GREENHOUSE GAS EMISSIONS CHANGE IN THE FUTURE?

We cannot know with certainty how populations, economies, energy technologies and other social factors that influence greenhouse gas emissions will change in the future. The best we can do is to consider a range of plausible ways in which the world might develop.

Scenarios of future climate consider a range of possible emission scenarios – based on different levels of human activity and response. The IPCC emission scenarios give a range of global temperature change from about 1.5 °C to 6°C by 2100.

By reducing the rate at which we put greenhouse gases into the atmosphere, we may be able to slow the process of climate change. Further ways to reduce greenhouse gas emissions, such as carbon sequestration, will also help. International agreements, such as the Kyoto Protocol, aim to get countries to reduce emissions in order to minimise the effects of climate change.

WHAT ABOUT CLIMATE CHANGE IMPACTS IN A FUTURE CLIMATE?

In addition to the uncertainties described above, it is important to recognise that there are also uncertainties regarding the climate impacts themselves. Even if changes in climate could be accurately predicted, uncertainty would still surround the effects these changes would have on the environment and society.

Many factors contribute to this, including differences in crop variety, location, soil type, water availability, nutrient supply, pest and disease problems and management. Local knowledge, experience and observation are, in many cases, the best sources of information on possible impacts of climate change.

THIS FACT SHEET IS ONE IN A SERIES CALLED
INTRODUCTION TO CLIMATE CHANGE

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KEY REFERENCES

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Photo: Bob Zuur

FOR MORE INFORMATION

- For general information on climate change for land-based sectors visit the Ministry of Agriculture and Forestry website at **www.maf.govt.nz**
- For more information on climate change in New Zealand visit **www.climatechange.govt.nz** or the Ministry for the Environment's website **www.mfe.govt.nz**
- For a popular guide to the IPCC reports, visit the website of the United Nations Environment Programme **www.grida.no**