

# Introduction

*By Bruce Mapstone*

Climate change is one of the greatest ecological, economic, and social challenges facing us today. The scientific evidence that human activities are contributing to climate change is compelling, but society is increasingly seeking information about the nature of the evidence and what can be done in response to a changing climate. This book provides some of that much-needed information from some of Australia's leading climate scientists.

It is worth considering a couple of important distinctions. The terms 'weather' and 'climate' are frequently considered to be interchangeable, but weather and climate refer to different things. Weather is the brief, rapidly changing condition of the atmosphere at a given place and time, influenced by the movement of air masses. Climate, on the other hand, should more accurately be the term applied to the average weather conditions over longer periods of years to decades.

One may often hear mention of 'climate variability' and 'climate change' together. They are different facets of climate. Climate variability refers to the year-to-year variations, or noise, in the average conditions – meaning that consecutive summers, for example, will not all be the same, with some cooler and some warmer than the long-term average. Climate change refers to any long-term trends in climate over many years or decades, around which climate variability may be evident year on year. Hence, a single warmer or cooler year on its own is not sufficient evidence to assert that climate is changing, but systematic changes in average conditions over many years do provide evidence of a changing climate.

This book is based on rigorous peer-reviewed scientific literature to articulate how human activities affect our climate, what changes we have seen already, what further changes we can expect, and what we might do to reduce future changes and live with those that are now inevitable. The wealth of science behind this book reflects decades of research by researchers in Australia and internationally, including many from CSIRO.

Earth's climate has always changed, alternating between long periods of warm (interglacial) and cool (glacial) conditions, cycling over tens to hundreds of thousands of years. These changes are driven by both external influences and dynamics internal to the Earth system. Key external influences include fluctuations in the amount of energy emitted by the Sun, and changes in the Earth's orbit and axial tilt that affect the intensity and distribution of the Sun's energy across the Earth. Internal influences on climate include changes in the surface reflectivity due to the presence or absence of ice, changes in atmospheric composition of greenhouse gases, variations in ocean currents, drifting continents, the cooling effect of volcanic dust, and other geological processes.



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Gases in the atmosphere, such as carbon dioxide (CO<sub>2</sub>), methane, and water vapour, are essential to retain heat and keep the planet warm enough to sustain life – hence the reference to them as greenhouse gases. Solar energy warms the Earth's surface, which then radiates energy back through the atmosphere into space. The greenhouse effect is the process whereby greenhouse gases in the atmosphere absorb the radiation released by the Earth's surface and then radiate heat in all directions, including back towards the ground – adding to the heat the ground receives from the Sun. The surface of the planet would be more than 30°C cooler than it is now without this natural greenhouse effect, and life as we know it would not be possible.

Greenhouse gases also are stored in various forms in many parts of the Earth system. For example, carbon, in various forms, is stored in the oceans, in frozen tundra, in vegetation and soils, in limestone, and in hydrocarbons. Slight changes in the environment, especially in temperature and moisture, can lead to changes in the uptake and/or loss of greenhouse gases. Higher temperatures can lead to more CO<sub>2</sub> being emitted to the atmosphere due to feedback processes. This in turn causes further warming, and so on. Cooling reverses this feedback cycle, which is a major driver of the long-term fluctuations in climate in ways that are still the subject of intense research.

The Earth in the distant past has been both warmer and cooler than today. The Cretaceous Period (120 to 65 million years ago) was 5° to 7°C warmer than today and CO<sub>2</sub> concentrations were much higher. Cooling then occurred from the Tertiary Period to the Quaternary Period (2.5 million years ago). The past million years has generally seen a series of changes from major ice ages (glacial periods) to interglacial periods about every 100 000 years, and other variations with shorter periods.

So what makes the climate change we are now experiencing different? The modern climate is changing far more quickly than in the geological past. There is now strong evidence that recent rapid climate changes are driven largely by a range of human activities. Greenhouse gases are



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released into the atmosphere by burning fossil fuels, clearing forests, cement manufacture, and by many other industrial and agricultural activities, thereby increasing the amount of radiation trapped near the Earth's surface and driving accelerated warming. This process, called the enhanced greenhouse effect, is caused by a forced release of greenhouse gases from their terrestrial store into the atmosphere that has no precedent in history. The associated increases in global temperatures are changing fundamental climate processes. Some of those changes may be beneficial in some areas, but it is expected that most will cause more harm than good. Most of these human contributions to climate change have occurred over the last 200–300 years, following the agricultural and industrial revolutions.

Climate change due to human activities is superimposed on natural climate variability, and is sometimes masked by, and is sometimes exacerbating, natural processes.

Why should we care about climate change? Historical records of temperature show that although temperatures vary naturally between ice ages and warm periods there is no record of temperatures within human history ever having increased as rapidly as they have over the past 100 years. Many other aspects of the Earth's climate also have changed over the past century or more. Some regions have become wetter, while others have suffered increased periods of drought. Frosts have decreased, and heatwaves have increased, in many parts of the world. Mountain glaciers have shrunk and the sea level has risen.

Humans have responded and adapted to small variations in climate for thousands of years but now the changes are accelerating and humanity, more than ever before, is bound to lifestyles that are dependent on immensely complex infrastructure and agriculture for continued survival. Never before, for example, have there been around 150 million people living permanently within 1 m of existing sea level. Not everyone can easily relocate to avoid rising sea level and storm surges, as many cultures might have done in the past.



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Careful measurements tell us how our climate has been changing over the last 100 years. Judging how to respond to future changes, however, requires that we project what our future climate will be like. The most powerful available mechanism to make those future projections is by computer modelling of the Earth's climate system.

Scientific monitoring and analysis over many years – showing the links between human activities and terrestrial, marine, and atmospheric climate processes – are central to crafting the computer models that are most likely to provide us with reasonable projections of future climate. These projections allow us to infer many of the likely effects of climate change on the Earth's systems and humanity in general and, therefore, underpin our plans to both adapt to what is now inevitable change and mitigate, or reduce, even greater changes.

Climate change adaptation involves taking action to adjust to, or respond to, the effects of changes in climate, such as reduced rainfall or rising sea level. Climate change mitigation refers to actions that aim to reduce the amount of climate change, typically by limiting the future increases in concentrations of greenhouse gases in the atmosphere – either by reducing emissions from a wide range of our industrial and agricultural activities, or by increasing the amount of CO<sub>2</sub> taken up and stored in natural 'sinks' such as forests and soils. Actions that reduce greenhouse gas emissions in many cases also improve our preparedness for future climate change. Some of the ways in which we can adapt to various facets of expected climate change, or mitigate further change, are discussed in this book.

Humanity has learned to live with climate variability and will continue to do so in familiar ways. Modern climate change, however, represents many new challenges for this generation and for those to come. Climate change will mean that the underlying conditions that affect almost every aspect of our lives and the environment in which we live, and on which we depend, will become consistently different. Increasingly, it will influence the year-to-year variations with which we have become familiar. This book describes what the recent changes have been, what we understand future changes are likely to be, how those changes will affect us, and what we may need to do to live in a world different from anything we have experienced before.