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Excerpt
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# 1 Introduction

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## Introduction

A book about natural hazards in Australasia has been a long time coming. Most of the textbooks students and academics in the Southern Hemisphere are exposed to on the topic of natural hazards, and physical geography in general, have been developed by Northern Hemisphere researchers. Not surprisingly, Northern Hemisphere examples tend to be used and research ideas and thinking are mainly based upon work developed in Europe and North America using examples from those regions. While broadly useful, there are many instances when a Southern Hemisphere example would be far more relevant and informative for a student (or academic) based in Australasia. The most obvious example is the disjunct between hurricanes and tropical cyclones, rotating in opposite directions to each other and making explanations a little convoluted.

This book does not by any means attempt to be all encompassing, but it introduces students and academics to some of the vast wealth of data from the Australasian region. Many ideas and concepts about natural hazards on Earth have been developed in Australasia and yet they are seldom seen in textbooks because these have invariably been written with a Northern Hemisphere perspective. We hope some of the examples and observations made in this book will be notably different from previous offerings and that, even better, they may put an entirely new perspective on the issue of natural hazards in general.

## What is Australasia?

As a starting point, one of the initial issues when thinking about this book was the definition of 'Australasia'. What is it? What region does it actually cover? As with many things in science, the answer is not that simple. A simple internet search throws up myriad permutations, although there seems to be a chronology to the changing face of the region. A recent definition states:

> Australasia and associated regions together with the South Pacific Ocean and its islands make up about a sixth of the globe. The region is bounded to the north and northwest by Indonesia and South-east Asia, to the north by the islands of Micronesia, to the east by south America, to the south by the sub-Antarctic, and to the west by the Indian Ocean.
>
> (Rowe 2004, p. 139)

To get to this point, though, there has been some serious historical baggage. First, it is apparent that that fluctuating boundaries of Australasia through time reflect shifts in global power. Second, the fundamental building blocks of this region, namely Australia and New Zealand, indicate their shared histories. Third, in recent years the focus has shifted to recognise an 'oceanic' perspective and through this it appears that both Australia and New Zealand have a broader family in a new incarnation of Australasia (Mein Smith 2009).

Mein Smith's (2009) paper provides an excellent overview of the convoluted path that is the development of the concept of Australasia. Interestingly, the term 'Australasia' is older than the naming and claiming of Australia even though both are derived from the mythical *Terra Australis Incognita*. Even before Captain Cook's voyages, 'Australasia' had been used to refer to a region south of modern Indonesia. However, even by the time of Australian federation in 1901 it was still unclear what constituted the Australasian region – did it include all the British colonies in the 'southern seas' or just Australia and New Zealand?

This ambiguity remains today and is reflected in the difference between dictionary definitions in Australia and New Zealand. The *Concise Australian National Dictionary* defines Australasia as 'the Australian continent and neighbouring islands' – an Australia-centric point of view that includes New Zealand, New Guinea and the neighbouring islands of the Pacific. On the other hand, *The New Zealand Oxford Dictionary* simply defines 'Australasia' as New Zealand and Australia (Mein Smith 2009).

To cut a long story short, while Australasia will always have somewhat 'elastic' boundaries that drift along with shifts in political power the term will always be used to define some form of region of linked communities somewhere between the Antarctic and Indonesia. From the point of view of natural hazards we should not be surprised to see Indonesia included in the mix from time to time.

## What is a natural hazard?

Extreme events in nature are natural hazards, but not all extreme events are hazardous to people. According to Burton, Kates & White (1993), this is because all the natural events system – the range of earth, water and atmospheric processes – function largely independently of human activities (Burton el al. 1993). Conversely, Burton et al. (1993) point out that large parts of the human use system may be regarded as operating separately from natural events. Interaction between the two systems creates positive outcomes, resources, or 'negative resources' (that is, hazards). An extreme rainfall event may be a useful resource and a hazard at the same time. It is people who transform aspects of the physical system into resources and hazards. The conceptual relationship between resources and hazards is discussed in some detail in Chapter 2, 'Floods'.

In light of the above, it is not surprising there is no one definition for 'natural hazard'. This is possibly because so many people have given these events so much attention over so many years that it became necessary to decide on a definition. The following definition seems to fit the bill although, as with all things in science, it is open to debate: a natural hazard refers to a:

> [n]atural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
>
> (UNISDR 2009)

It follows that a natural disaster is a sudden or progressive natural hazard event that has an impact of such severity that it is beyond the capacity of the community to manage.

## Conceptual overview

The impact potential of a natural hazard is broadly set by natural forces, but this is not always a straightforward matter. In some cases, what initially is a natural resource can become a natural hazard. The best examples of this are the 'water hazards', namely floods and droughts. In the case of flooding, the culprit (rainwater) is also an invaluable climatic resource. Physical and social systems adapt to the climatic norm, but too much rain (flood) or too little rain (drought) are considered hazardous. A particular society adapts to rainfall conditions it usually encounters and expects. This forms the water resource that sustains entire communities, shown by the shaded zone in Figure 2.1 in Chapter 2. The outer edges of this zone mark impact thresholds beyond which there is damage caused by too much rainfall (flood) or too little (drought). Consequently, these hazards depend on society as well as on the magnitude of the physical event (flood or drought) itself. These relationships, with examples, are dealt with in some detail in Chapters 2 and 3.

When similar physical events are described as hazards, quite different features may become important. Generalising about the 'impact potential' of a natural hazard is not a simple matter. For example, rainstorms that would otherwise be harmless can cause flooding if there is high antecedent soil moisture. Likewise, medium intensity storms occurring in rapid succession can have an effect equivalent to one major storm event. The problem is there is no standard system for assessing the impact potential of natural hazards.

There are six key hazard event characteristics, or dimensions of natural hazard events, that relate to impact potential. These are magnitude, duration, spatial extent, speed of onset, frequency, and temporal spacing. These event characteristics have relevance in identifying and assessing impact potential and deciding on suitable responses. Magnitude is the 'size' or enormity of the hazard event. For example, the magnitude of a flood is the maximum height reached by the floodwaters, or the maximum discharge of water at some point in the river. Magnitude is an important characteristic for analysing hazards since only occurrences exceeding some given level of magnitude are considered hazardous, severe or disastrous.

Duration refers to the length of the period of occurrence, ranging from minutes or hours to several days, weeks or longer. A flood may persist for days or weeks; a drought may last for years. Spatial extent describes the size of the area affected. Rate or speed of onset refers to the length of time between first appearance of a hazard event and its peak. Frequency describes how often an event of a given magnitude may be expected to occur on average in the long-run average. Temporal spacing refers to the regularity of hazard occurrence; for example, tropical cyclones are seasonal, whereas thunderstorms, earthquakes and wind storms are generally random.

Hazard impact is a consequence of a natural event or process capable of causing loss. Loss or impact can involve people (death, disease, injury or stress), goods (property damage or economic loss), or the environment (loss of flora and fauna, pollution or loss of amenity value). But it is not always clear what exactly the data reveal. Take, for example, this hypothetical situation. The state of Victoria experiences by far the greatest number of bushfires each year out of all Australian states. Queensland experiences the greatest number of bushfires per square kilometre. South Australia experiences the greatest number of deaths per capita from bushfires. Where is the greatest bushfire threat?

Assessing impact involves taking into account all of these characteristics or facets of natural hazards. This is because the physical character of a hazard involves more than just magnitude. The physical significance of a hazard may be gained only by taking into account the combined effect of the hazard event characteristics. However, the relation between hazard event characteristics and social and economic impacts is not a straightforward linear function, since the degree of human preparedness is a crucial intervening consideration. The latter involves assessing risk, which is a combination of the natural event (magnitude, duration, frequency and other factors) and vulnerability of society to those events (social factors such as population growth, technology, land-use practices, environment degradation, government policies, hazard awareness and other factors).

A major focus of natural hazards research is on how society creates the conditions in which people face hazards differently. The key concepts are vulnerability, mitigation and resilience. Human vulnerability to a natural hazard is a function of susceptibility to loss – for example, the size and density of human populations and value of development, but more importantly the social and physical adjustments made to deal with the hazard. Mitigation involves measures taken in advance of a hazard event intended to decrease or eliminate its impact. Resilience is the social capacity to recover from a natural hazard event. The combined effects of vulnerability, mitigation and resilience determine the impact of and recovery from natural hazard events. These concepts, their application and examples for a variety of important natural hazards of Australasia are covered in the chapters that follow.

## Scope and plan of the book

Being the first of its kind, this book walks a fine line between trying to encompass every natural hazard we can think of to merely replicating Northern Hemisphere efforts but using Southern Hemisphere examples. However, there is, not surprisingly, a bias towards the two main characters of natural hazards in Australasia – climate and tectonics, or, if you will, storm/cyclones and earthquakes/volcanoes/tsunamis. It should be recognised that not all natural hazards happen in isolation; in fact the more research that is done, the more we realise how interconnected they are, although they are rarely discussed in this way in textbooks. We have attempted to address this issue by showing the interactions not only between humans and natural hazards, but also between one hazard and another. For example, large, earthquakes can cause tsunamis and landslides, and those landslides can cause river flooding and so on, and all of these are occurring within the landscape in which we live. Needless to say, the same could be said for climatic hazards – cyclones can cause flooding and landslides. Understanding such interconnectedness is important because it is too easy for us to simply read a chapter about earthquakes or storms and think about them in isolation. For example, the landslides we may experience as part of a period of heavy rain associated with an El Niño event may actually have been primed to fall following ground shaking caused by a large earthquake that occurred some decades earlier.

There are also natural hazards that have not been included as chapters in this book, and it could be argued that they warrant a chapter each. Examples are rip currents, tornadoes, hail and other small-scale storms. This simply confirms the difficulty we as editors had in selecting from the rapidly increasing amount of information on a variety of natural hazards. We believe, however, that the key natural hazards of Australasia have been well covered.

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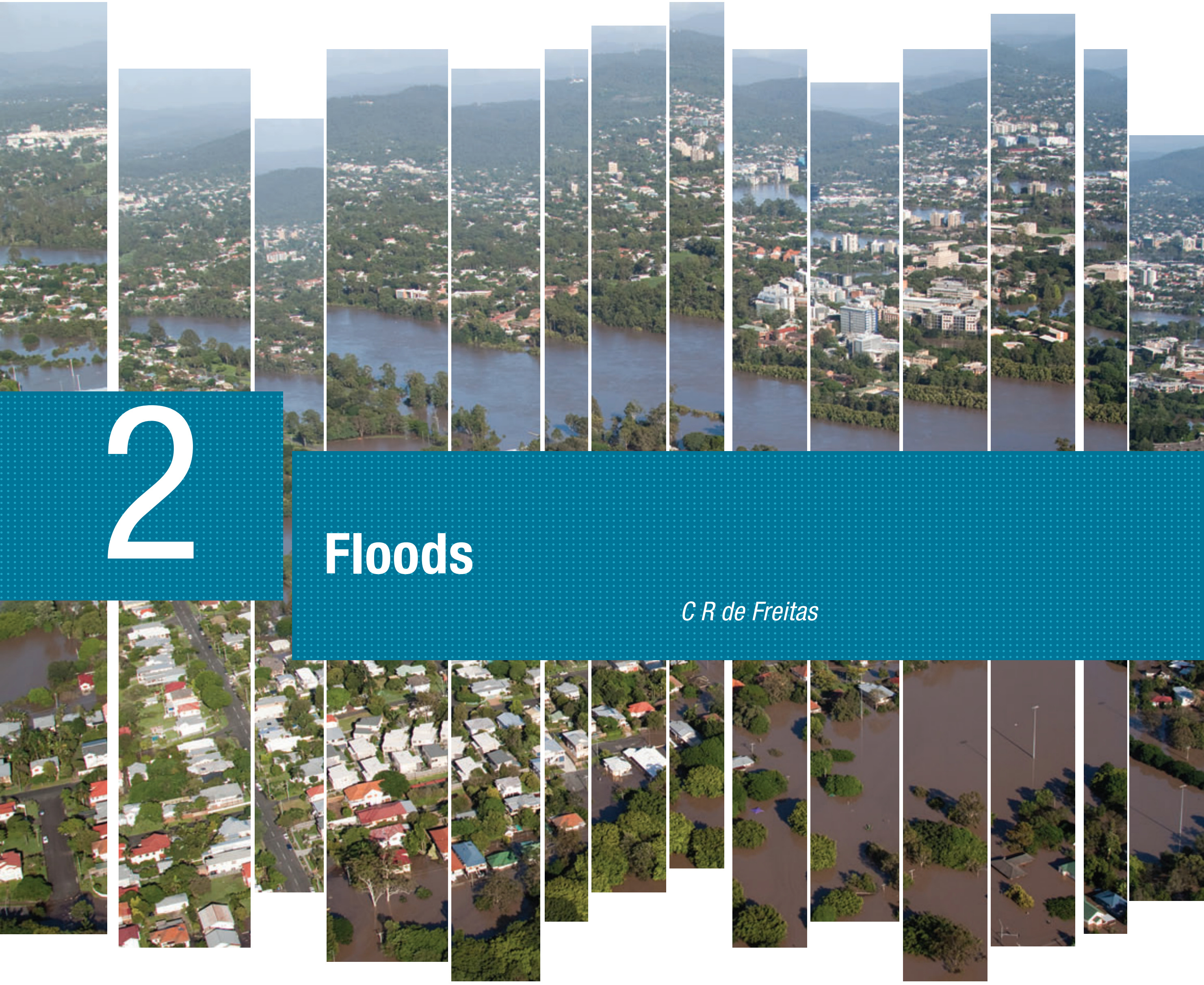

# 2 Floods

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## Learning objectives

- Identify different types of floods.
- Understand the physical nature of flooding.
- Understand the causes of floods.
- Become familiar with adjustments that can be made to minimise flood loss and damage.
- Know what is involved in multi-strategy flood hazard management.

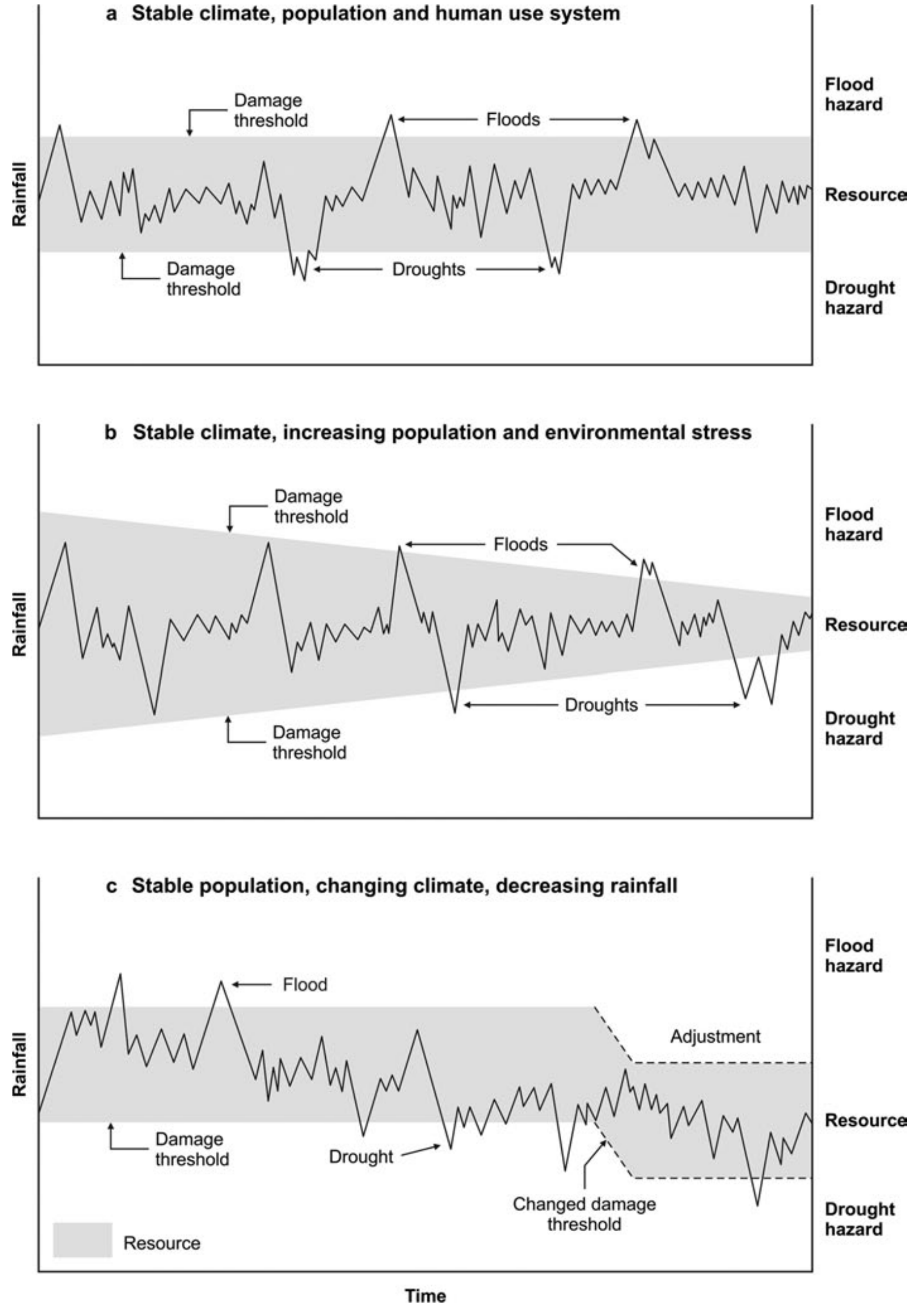
## Introduction and overview

The impact potential of a natural hazard is broadly set by natural forces. In the case of flooding, the culprit, rainwater, is also an invaluable climatic resource. Physical and social systems adapt to the climatic norm, but too much rain (**flood**) or too little rain (drought) are considered hazardous. Figure 2.1 shows this relationship schematically. The shaded zone in the figure identifies the resource on which a particular society or community has come to depend. The outer edges of this zone mark thresholds beyond which supply-side factors might be considered damaging. Impact or damage depends, therefore, as much on society as it does on the magnitude of the physical event (flood or drought) itself.

Flooding occurs in all climatic regions of Australasia. Unlike many other natural hazards, their frequency puts them high in importance on the list of natural hazards for most countries. A combination of factors is responsible, mostly but not entirely due to weather and climate. Heavy rainfall is implicated in causing a flood, but vulnerability to flood loss is generated by human action. Types of flood damage include injuries and loss of life, physical damage, income loss (including indirect losses), emergency costs, and social disruption. Measures for reducing the impacts of floods fall into one or more of five categories of response: avoidance, protection, regulation, relocation, compensation and education. **Watershed** and floodplain management is a multi-faceted approach that involves all of these categories of responses aimed at decreasing the effects of flooding.

When similar physical events are described as hazards, quite different features may become important. Take, for example, the urban snow hazard. The threshold for a crippling snowfall in Toronto, Canada, is higher than the threshold for the even colder Canadian city of Regina (de Freitas 1975). Therefore, a snow storm producing 20 cm of snow will cause much more disruption in Regina than in Toronto. This is because the physical character of a snowfall event involves more than just snowfall amount. The **snow water equivalent** and the air temperature and wind speed at the time of the snowfall event need to be considered alongside snow accumulation. To understand and explain the human response to snowfall and its impact, a number of other snowfall hazard event characteristics are also important (de Freitas 1975). This applies to all natural hazards. The physical significance of the flood event may be gained only by taking into account the combined effects of hazard event characteristics. Moreover, the relation between hazard event characteristics and social and economic impact is not a straightforward linear function, since the degree of human preparedness is a crucial intervening consideration.

**Figure 2.1** Rainwater is an invaluable climatic resource. Physical and social systems adapt to the climatic norm, but too much rain (flood) or too little rain (drought) are considered hazardous. The three figures show hazard and resource thresholds in relation to rainfall. The shaded zone in the figure identifies the resource on which a particular society or community has come to depend. The outer edges of the resource (shaded) zone mark thresholds beyond which supply-side factors might be considered damaging: (a) stable population and human use of the resource; (b) stable climate with increasing population and stress on the environment; and (c) stable population and with decreasing rainfall.




(Source: de Freitas 1994)

## Hazard event characteristics

There are six key flood hazard event characteristics, or dimensions of flood events: duration, spatial extent, magnitude, speed of onset, frequency, and temporal spacing. These event characteristics have relevance in identifying and assessing impact potential and deciding on suitable responses. Duration refers to the length of the period of occurrence, ranging from minutes or hours to several days, weeks or longer. A flood may persist for days or weeks; a drought may last for years. Spatial extent describes the size of the area affected. For example, this may be the **floodplain** of a river or an extensive area in the case of a regional flood.

Magnitude of a flood is the maximum **discharge** of river at a given point or the maximum height reached by floodwater. A 'flood' is not considered to have occurred until some predefined threshold of discharge is reached, typically the height at which water overtops the riverbank. Speed of onset is the time between the first signs of flooding and the flood's peak.

Flood frequency describes how often a flood event of given magnitude has occurred over an extended time period. Flood frequency is inversely related to magnitude. High magnitude floods usually have a low frequency of occurrence, but, because of human perception of these floods, frequency is related to flood impact. People are generally more aware of high frequency flooding and adjust accordingly; thus the impact of high frequency floods over the long term is low. Very low frequency events, while large in magnitude, are usually quickly forgotten because the time interval between them is lengthy. For this reason, communities are often not well prepared for high magnitude floods and suffer as a result. Temporal spacing refers to the sequence of hazard events. Some flooding shows a random time distribution, while others, such as summer monsoon flooding, are seasonal or cyclical.

## Types of floods and their causes

A flood may be defined simply as inundation by water of land not usually covered by water. There are a number of factors that cause floods, alone or conjointly. Different types of floods can have similar or the same causes. Intense storm rainfall with high rates of accumulation is the most common cause, but extended heavy rainfall can have a similar result. Other natural causes of flooding are landslides blocking **overland flow**, rapid snow melt combined with rainfall over an area covered by snow, and breakdown of ice dams.

Rainstorms that would otherwise be harmless can cause flooding if there is high antecedent soil moisture. Likewise, medium intensity storms occurring in rapid succession can have an effect equivalent to one major storm event. In the northern parts of New Zealand and coastal regions of south-eastern Australia, **extratropical cyclones** are often the cause of flooding, especially when their movement is impeded by blocking high pressure cells ('**blocking highs**' or 'blocking anticyclones'). For example, on 6 March 1988 what began as tropical cyclone Bola stalled for four days off the north-east coast of the North Island of New Zealand because its path towards the south-west was blocked by a large high pressure cell over the Tasman Sea. Four days of rain combined with high rates of rainfall intensity resulted in extensive flooding over large parts of the far north and east of the North Island. To illustrate the rainfall accumulation rates experienced, consider that some areas received over 100 mm of