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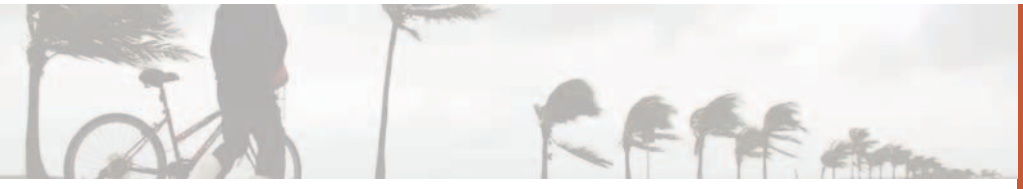

Global warming and climate change

1

Hurricane Wilma hit Florida's southern west coast on 24 October 2005.

THE PHRASE 'global warming' has become familiar to many people as one of the most important issues of our day. Many opinions have been expressed concerning it, from the doom-laden to the dismissive. This book aims to state the current scientific position on global warming clearly, so that we can make informed decisions on the facts.

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Is the climate changing?

In the year 2060 my grandchildren will be approaching 70 years old; what will their world be like? Indeed, what will it be like during the 70 years or so of their normal lifespan? Many new things have happened in the last 70 years that could not have been predicted in the 1930s. The pace of change is such that even more novelty can be expected in the next 70. It seems certain that the world will be even more crowded and more connected. Will the increasing scale of human activities affect the environment? In particular, will the world be warmer? How is its climate likely to change?

Before addressing future climate changes, what can be said about climate changes in the past? In the more distant past there have been very large changes. The last million years has seen a succession of major ice ages interspersed with warmer periods. The last of these ice ages began to come to an end about 20 000 years ago and we are now in what is called an interglacial period. Chapter 4 will focus on these times far back in the past. But have there been changes in the very much shorter period of living memory – over the past few decades?

Variations in day-to-day weather are occurring all the time; they are very much part of our lives. The climate of a region is its average weather over a period that may be a few months, a season or a few years. Variations in climate are also very familiar to us. We describe summers as wet or dry, winters as mild, cold or stormy. In the British Isles, as in many parts of the world, no season is the same as the last or indeed the same as any previous season, nor will it be repeated in detail next time round. Most of these variations we take for granted; they add a lot of interest to our lives. Those we particularly notice are the extreme situations and the climate disasters (for instance, Figure 1.1 shows the significant climate events and disasters during the year 1998 – one of the warmest years on record). Most of the worst disasters in the world are, in fact, weather- or climate-related. Our news media are constantly bringing them to our notice as they occur in different parts of the world – tropical cyclones (called hurricanes or typhoons), windstorms, floods and tornadoes, also droughts whose effects occur more slowly, but which are probably the most damaging disasters of all.

The last 30 years

The closing decades of the twentieth century and the early years of the present century were unusually warm. Globally speaking, the last 30 years have been the warmest since accurate records began somewhat over 100 years ago. Twelve of the 13 years 1995 to 2007 rank among the 13 warmest in the instrumental record of global surface air temperature that began around 1850, the

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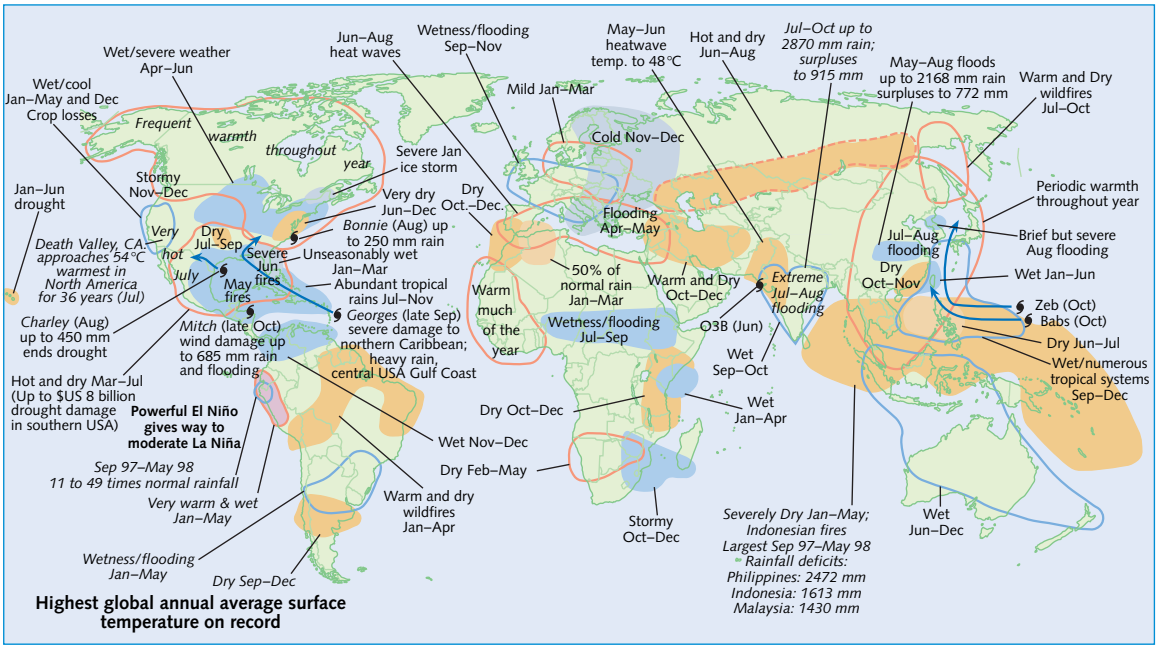

Figure 1.1 Significant climate anomalies and events during 1998 as recorded by the Climate Prediction Center of the National Oceanic and Atmospheric Administration (NOAA) of the United States.

years 1998 and 2005 being the warmest (different analyses disagree which is the warmer of the two). The Intergovernmental Panel on Climate Change in its 2007 Assessment[1] states:

> Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.

The period has also been remarkable (just how remarkable will be considered later) for the frequency and intensity of extremes of weather and climate. Let me give a few examples. An extremely unusual heatwave in central Europe occurred in the summer of 2003 and led to the premature deaths of over 20 000 people (see Chapter 7, page 215). Periods of unusually strong winds have been experienced in western Europe. During the early hours of the morning of 16 October 1987, over 15 million trees were blown down in southeast England and the London area. The storm also hit northern France, Belgium and the Netherlands with ferocious intensity; it turned out to be the worst storm experienced in the area since 1703. Storm-force winds of similar or even greater intensity but covering a greater area of western Europe have struck since – on four occasions in 1990 and three occasions in December 1999.

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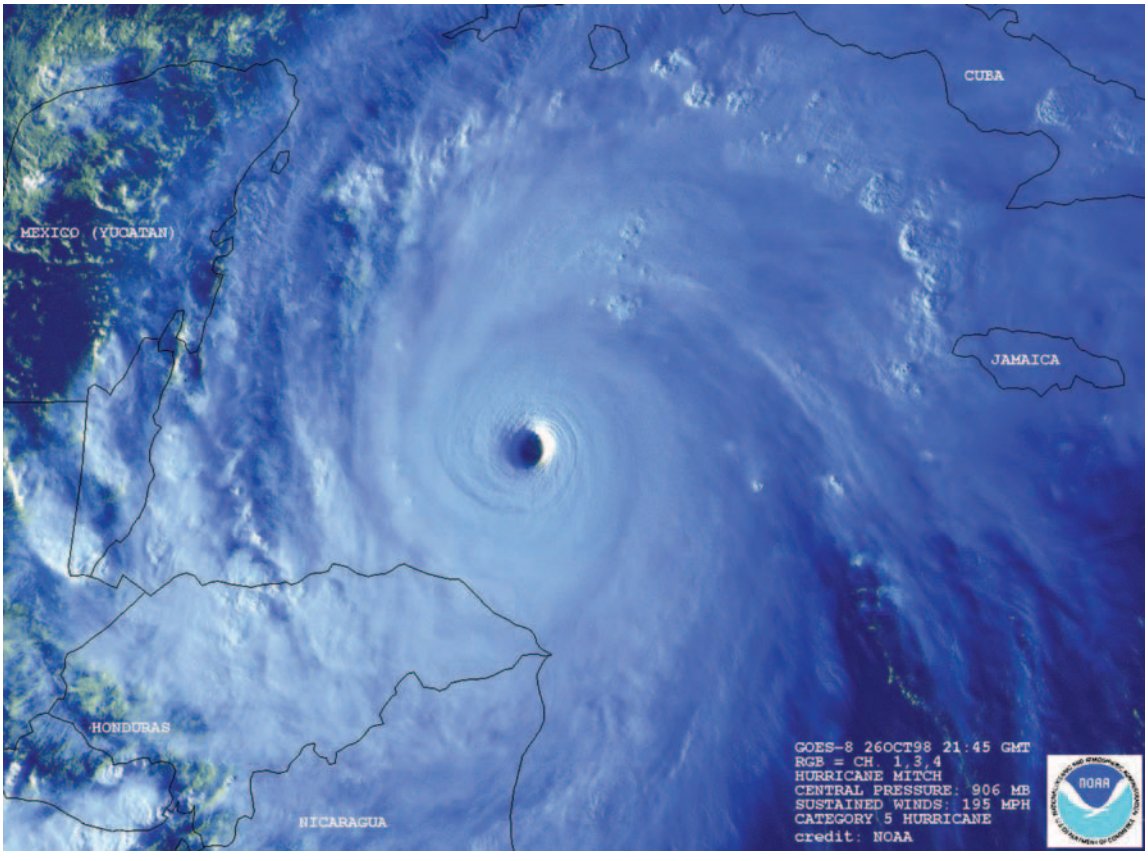

Hurricane Mitch was one of the deadliest and most powerful hurricanes on record in the Atlantic basin, with maximum sustained winds of 180 mph (290 km h^{-1}). The storm was the thirteenth tropical storm, ninth hurricane and third major hurricane of the 1998 Atlantic hurricane season.

But those storms in Europe were mild by comparison with the much more intense and damaging storms other parts of the world have experienced during these years. About 80 hurricanes and typhoons – other names for tropical cyclones – occur around the tropical oceans each year, familiar enough to be given names: Hurricane Gilbert caused devastation on the island of Jamaica and the coast of Mexico in 1988, Typhoon Mireille hit Japan in 1991, Hurricane Andrew caused a great deal of damage in Florida and other regions of the southern United States in 1992, Hurricane Mitch caused great devastation in Honduras and other countries of central America in 1998 and Hurricane Katrina caused record damages as it hit the Gulf Coast of the United States in 2005 are notable recent examples. Low-lying areas such as Bangladesh are particularly vulnerable to the storm surges associated with tropical cyclones; the combined

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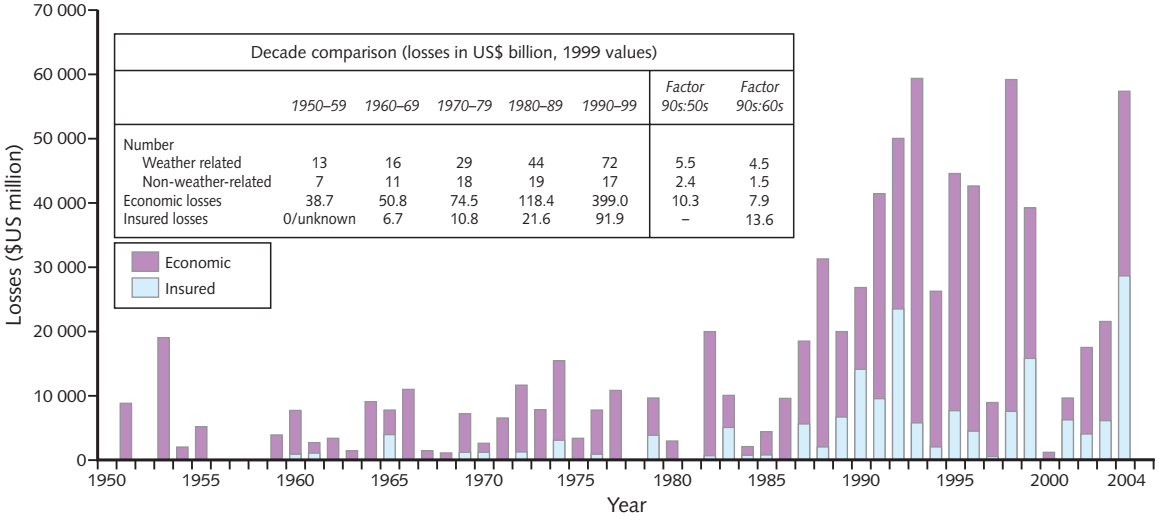

Decade comparison (losses in US$ billion, 1999 values)

	1950–59	1960–69	1970–79	1980–89	1990–99	Factor 90s:50s	Factor 90s:60s
Number							
Weather related	13	16	29	44	72	5.5	4.5
Non-weather-related	7	11	18	19	17	2.4	1.5
Economic losses	38.7	50.8	74.5	118.4	399.0	10.3	7.9
Insured losses	0/unknown	6.7	10.8	21.6	91.9	–	13.6

Figure 1.2 The total economic costs and the insured costs of catastrophic weather events for the period 1950 to 2004 as recorded by the Munich Re insurance company. For 2005, because of Hurricane Katrina in the USA the figures are off the page – over $US200 billion for economic losses and over $US80 billion for insured losses. Both costs show a rapid upward trend in recent decades. The number of non-weather-related disasters is included for comparison. Tables 7.3 and 7.4 in Chapter 7 provide some regional detail and list some of the recent disasters with the greatest economic and insured losses.

effect of intensely low atmospheric pressure, extremely strong winds and high tides causes a surge of water which can reach far inland. In one of the worst such disasters in the twentieth century over 250 000 people were drowned in Bangladesh in 1970. The people of that country experienced another storm of similar proportions in 1999 as did the neighbouring Indian state of Orissa also in 1999, and smaller surges are a regular occurrence in that region.

The increase in storm intensity during recent years has been tracked by the insurance industry, which has been hit hard by recent disasters. Until the mid 1980s, it was widely thought that windstorms or hurricanes with insured losses exceeding $US1 billion (thousand million) were only possible, if at all, in the United States. But the gales that hit western Europe in October 1987 heralded a series of windstorm disasters that make losses of $US10 billion seem commonplace. Hurricane Andrew, for instance, left in its wake insured losses estimated at nearly $US21 billion (1999 prices) with estimated total economic losses of nearly $US37 billion. Figure 1.2 shows the costs of weather-related disasters[2] over the past 50 years as calculated by the insurance industry. It shows an increase in economic losses in such events by a factor of over 10 in real terms between the 1950s and the present day. Some of this increase can be attributed

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Flooded McDonald's, Festus, Missouri in 1993. The spot where this photo was taken is nearly 1.5 miles (2.5 km) and 30 feet (9 m) above the river.

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to the growth in population in particularly vulnerable areas and to other social or economic factors; the world community has undoubtedly become more vulnerable to disasters. However, a significant part of it has also arisen from the increased storminess in the recent years compared with the 1950s.

Windstorms or hurricanes are by no means the only weather and climate extremes that cause disasters. Floods due to unusually intense or prolonged rainfall or droughts because of long periods of reduced rainfall (or its complete absence) can be even more devastating to human life and property. These events occur frequently in many parts of the world especially in the tropics and subtropics. There have been notable examples during the last two decades. Let me mention a few of the floods. In 1988, the highest flood levels ever recorded occurred in Bangladesh, and 80% of the entire country was affected; China experienced devastating floods affecting many millions of people in 1991, 1994–5 and 1998; in 1993, flood waters rose to levels higher than ever recorded in the region of the Mississippi and Missouri rivers in the United States, flooding an area equivalent in size to one of the Great Lakes; major floods in Venezuela in 1999 led to a large landslide and left 30 000 people dead; two widespread floods in Mozambique occurred within a year in 2000–1 leaving over half a million homeless; and in the summer of 2002 Europe experienced its worst floods for centuries. Droughts during these years have been particularly intense and prolonged in areas of Africa, both north and south. It is in Africa especially that they bear on the most vulnerable in the world, who have little resilience to major disasters. Figure 1.3 shows that in the 1980s droughts accounted for more deaths in Africa than all other disasters added together and illustrates the scale of the problem.

El Niño events

Rainfall patterns which lead to floods and droughts especially in tropical and semi-tropical areas are strongly influenced by the surface temperature of the oceans around the world, particularly the pattern of ocean surface temperature in the Pacific off the coast of South America (see Chapter 5 and Figure 5.9). About every three to five years a large area of warmer water appears and persists for a year or more. Because they usually occur around Christmas these are known as El Niño ('the boy child') events.[3] They have been well known for centuries to the countries along the coast of South America because of their devastating effect on the fishing industry; the warm top waters of the ocean prevent the nutrients from lower, colder levels required by the fish from reaching the surface.

A particularly intense El Niño, the second most intense in the twentieth century, occurred in 1982–3; the anomalous highs in ocean surface temperature

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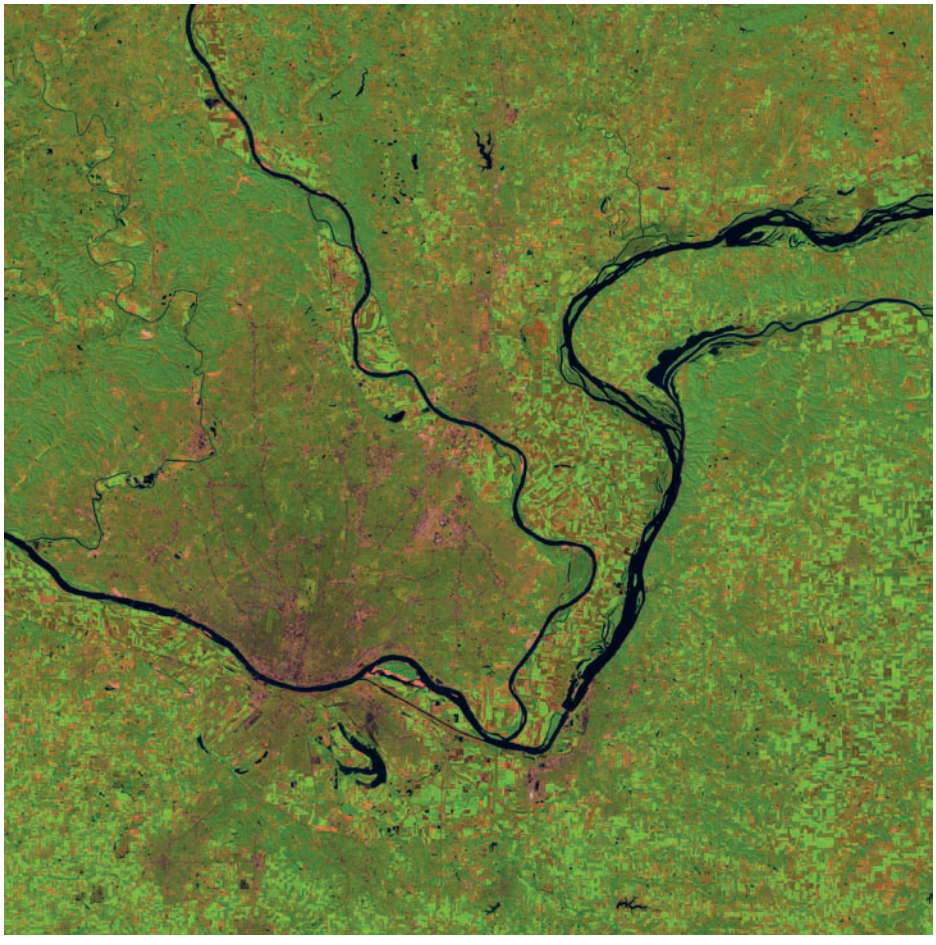

The Great Flood of 1993 occurred in the American Midwest, along the Mississippi and Missouri rivers from April to October 1993. The flood was among the most costly and devastating to ever occur in the United States, with $US15 billion in damages, and a flooded area of around 30 000 square miles (80 000 km^2). These images from Landsat-5 Thematic Mapper show the Mississippi near St Louis before and during the flood.

compared to the average reached 7 °C. Droughts and floods somewhere in almost all the continents were associated with that El Niño (Figure 1.4). Like many events associated with weather and climate, El Niños often differ very much in their detailed character; that has been particularly the case with the El Niño events of the 1990s. For instance, the El Niño event that began in 1990 and reached maturity early in 1992, apart from some weakening in mid 1992, continued to be dominated by the warm phase until 1995. The exceptional floods in the central United States and in the Andes and droughts in Australia and Africa

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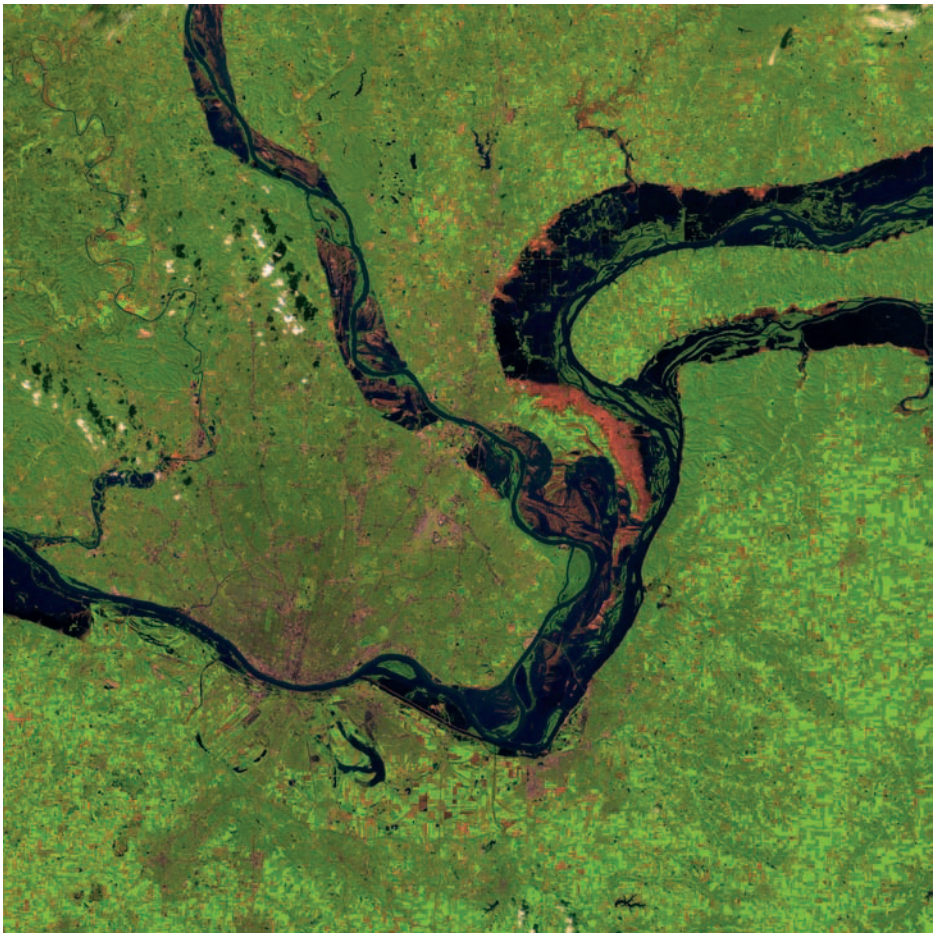

are probably linked with this unusually protracted El Niño. This, the longest El Niño of the twentieth century, was followed in 1997–8 by the century's most intense El Niño which brought exceptional floods to China and to the Indian sub-continent and drought to Indonesia – that in turn brought extensive forest fires creating an exceptional blanket of thick smog which was experienced over 1000 miles away (Figure 1.1).

Studies with computer models of the kind described later (in Chapter 5) provide a scientific basis for links between the El Niño and these extreme weather events; they also give some confidence that useful forecasts of such disasters will in due course be possible. A scientific question that is being urgently addressed is the possible link between the character and intensity of El Niño events and global warming due to human-induced climate change.

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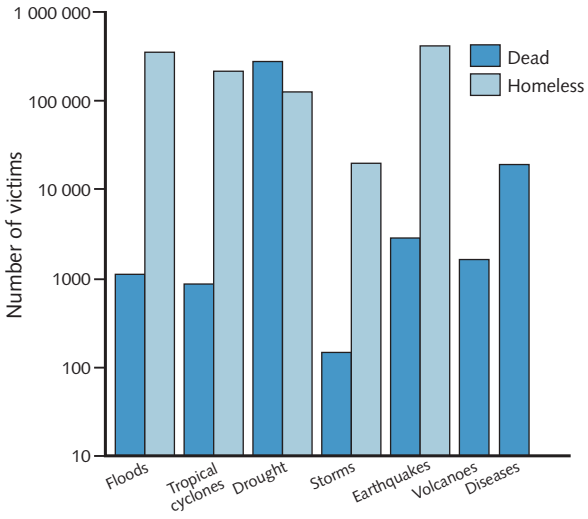

Figure 1.3 Recorded disasters in Africa, 1980–9, estimated by the Organization for African Unity. Note the logarithmic scale.

The effect of volcanic eruptions on temperature extremes

Natural events such as volcanoes can also affect the climate. Volcanoes inject enormous quantities of dust and gases into the upper atmosphere. Large amounts of sulphur dioxide are included, which through photochemical reactions using the Sun's energy are transformed to sulphuric acid and sulphate particles. Typically these particles remain in the stratosphere (the region of atmosphere above about 10 km in altitude) for several years before they fall into the lower atmosphere and are quickly washed out by rainfall. During this period they disperse around the whole globe and cut out some of the radiation from the Sun, thus tending to cool the lower atmosphere.

One of the largest volcanic eruptions in the twentieth century was that from Mount Pinatubo in the Philippines on 12 June 1991 which injected about 20 million tonnes of sulphur dioxide into the stratosphere together with enormous amounts of dust. This stratospheric dust caused spectacular sunsets around the world for many months following the eruption. The amount of radiation from the Sun reaching the lower atmosphere fell by about 2%. Global average temperatures lower by about a quarter of a degree Celsius were experienced for the following two years. There is also evidence that some of the unusual weather patterns of 1991 and 1992, for instance unusually cold winters in the Middle East and mild winters in western Europe, were linked with effects of the volcanic dust.

Vulnerability to change

Over the centuries, although different human communities have adapted to their particular climate, any large change to the average climate tends to bring stress of one kind or another. It is particularly the extreme climate events and climate disasters that emphasise the importance of climate to our lives and that demonstrate to countries around the world their vulnerability to climate change – a vulnerability that is enhanced by rapidly increasing world population and demands on resources.

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