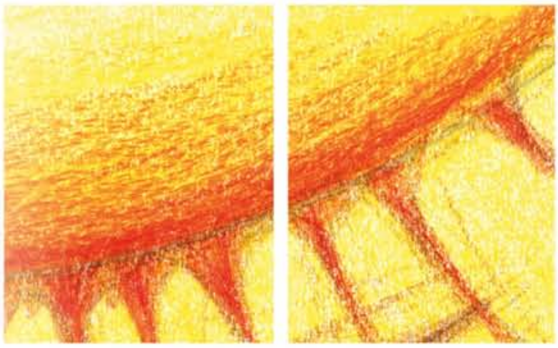
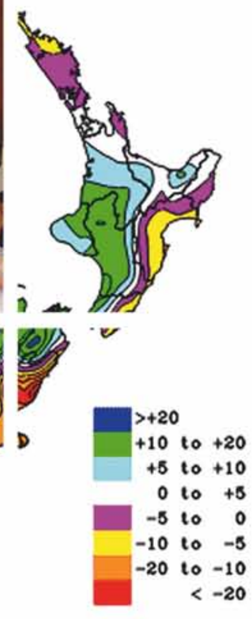
The Macro Change Picture

- Global Climate Change

Material in this chapter has been drawn from several sources. These include information drawn from an International Geosphere Biosphere Programme (IGBP) publication (see www.igbp.kva.se), and material produced by the National Institute of Water and Atmospheric Research (NIWA). Key sources of NIWA material are their website (see www.niwa.co.nz/ncc/clivar) and information prepared for the Climate Change Office (see www.climatechange.govt.nz/resources/local-govt/guidance.html).





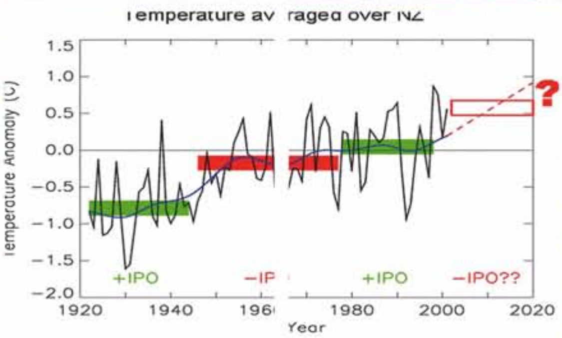


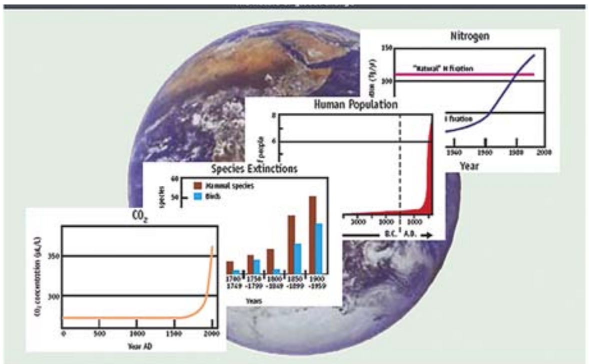
Photo courtesy of Ashburton District Tourism

Global change

‘Over the last two decades a new imperative has come to dominate environmental concerns. With a rapidly increasing understanding of the nature of Earth’s life support system, a growing awareness has emerged that human activities are exerting an ever accelerating influence on aspects of Earth System functioning upon which the welfare and the future of human societies depend’, from Steffen and Tyson (2001).

The changes resulting from human activities are unprecedented in their magnitude, spatial scale and pace. Principal drivers of change are population growth and increased economic wealth. Global population reached the six billion mark in the late 1990s and is projected to peak at nearly ten billion by the middle of this century. There are increasing impacts from economic activity around the world.

The nature of global change



Sourced from www.igbp.kva.se

The following are significant global changes identified by the International Geosphere Biosphere Programme (see Steffen and Tyson, 2001):

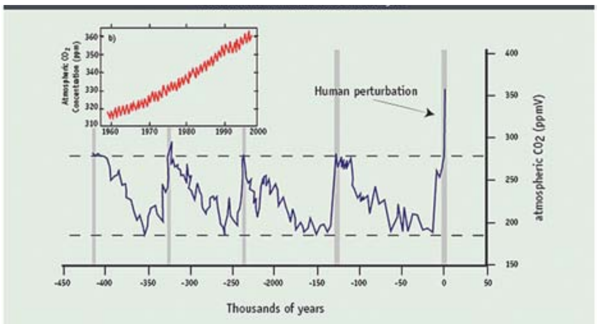
- In a few generations humankind is in the process of exhausting fossil fuel reserves that were generated over several hundred million years.
- Nearly 50 percent of the land surface has been transformed by direct human action, with significant consequences for biodiversity, nutrient cycling, soil structure and biology, and climate.
- More nitrogen is now fixed synthetically and applied as fertilisers in agriculture than is fixed naturally in all terrestrial ecosystems.
- More than half of all accessible freshwater is used directly or indirectly by humankind, and underground water resources are being depleted rapidly in many areas.
- The concentrations of several climatically important greenhouse gases, in addition to carbon dioxide (CO2) and methane (CH4), have substantially increased in the atmosphere.
- Coastal and marine habitats are being dramatically altered; 50 percent of mangroves have been removed and wetlands have shrunk by one-half.
- About 22 percent of recognised marine fisheries are overexploited or already depleted, and 44 percent more are at their limit of exploitation.
- Extinction rates are increasing sharply in marine and terrestrial ecosystems around the world.

Natural processes and cycles are being affected by these changes. Two very important ones are the carbon cycle and the natural greenhouse effect.

The carbon cycle

Carbon moves through the earth, living matter, water and the atmosphere. The amount of carbon that is actually being cycled is relatively small in comparison to the amounts that are stored. Principal stores of carbon are the atmosphere, forests, soils, the ocean and fossil fuels. Plants absorb carbon dioxide through photosynthesis. Some is returned to the atmosphere through respiration, but much remains stored in the plant biomass. Carbon is released naturally through decomposition or fire. There is also storage and release of carbon from the oceans.

The recent human influence on the carbon cycle



Sourced from www.igbp.kva.se

The Carbon Cycle

Analysis of a 420,000-year record from the Vostok ice core has revealed that levels of carbon dioxide in the atmosphere have fluctuated between ice ages, but within a consistent range. This long-term balance is now being influenced by the rapid release of carbon dioxide from the burning of fossil fuels and other activities such as deforestation.

The natural greenhouse effect

The **greenhouse effect** is a warming of the earth's surface and lower atmosphere caused by substances such as carbon dioxide and water vapour. These let the sun's energy through to the ground but impede the passage of energy from the earth back into space. Energy emitted from the sun ('solar radiation') is concentrated in a region of short wavelengths including visible light. Much of the short-wave solar radiation travels down through the Earth's atmosphere to the surface virtually unimpeded. Some of the solar radiation is reflected straight back into space by clouds and by the earth's surface. Much of the solar radiation is absorbed at the earth's surface, causing the surface and the lower parts of the atmosphere to warm.

The warmed Earth emits radiation upwards, just as a hot stove or bar heater radiates energy. In the absence of any atmosphere, the upward radiation from the Earth would balance the incoming energy absorbed from the Sun at a mean surface temperature of around -18°C. This is 33° colder than the observed mean surface temperature of the Earth. The presence of 'greenhouse' gases in the atmosphere accounts for the temperature difference. Heat radiation (infra-red) emitted by the Earth is concentrated at long wavelengths and is strongly absorbed by greenhouse gases in the atmosphere, such as water vapour, carbon dioxide and methane. Absorption of heat causes the atmosphere to warm and emit its own infra-red radiation. The Earth's surface and lower atmosphere warm until they reach a temperature where the infra-red radiation emitted back into space, plus the directly reflected solar radiation, balance the absorbed energy coming in from the sun. As a result, the surface temperature of the globe is around 15°C on average, 33°C warmer than it would be if there were no atmosphere. This is called the **natural greenhouse effect**.

Insert a simplified diagram illustrating the greenhouse effect (based on a figure in the 1990 IPCC Science Assessment).

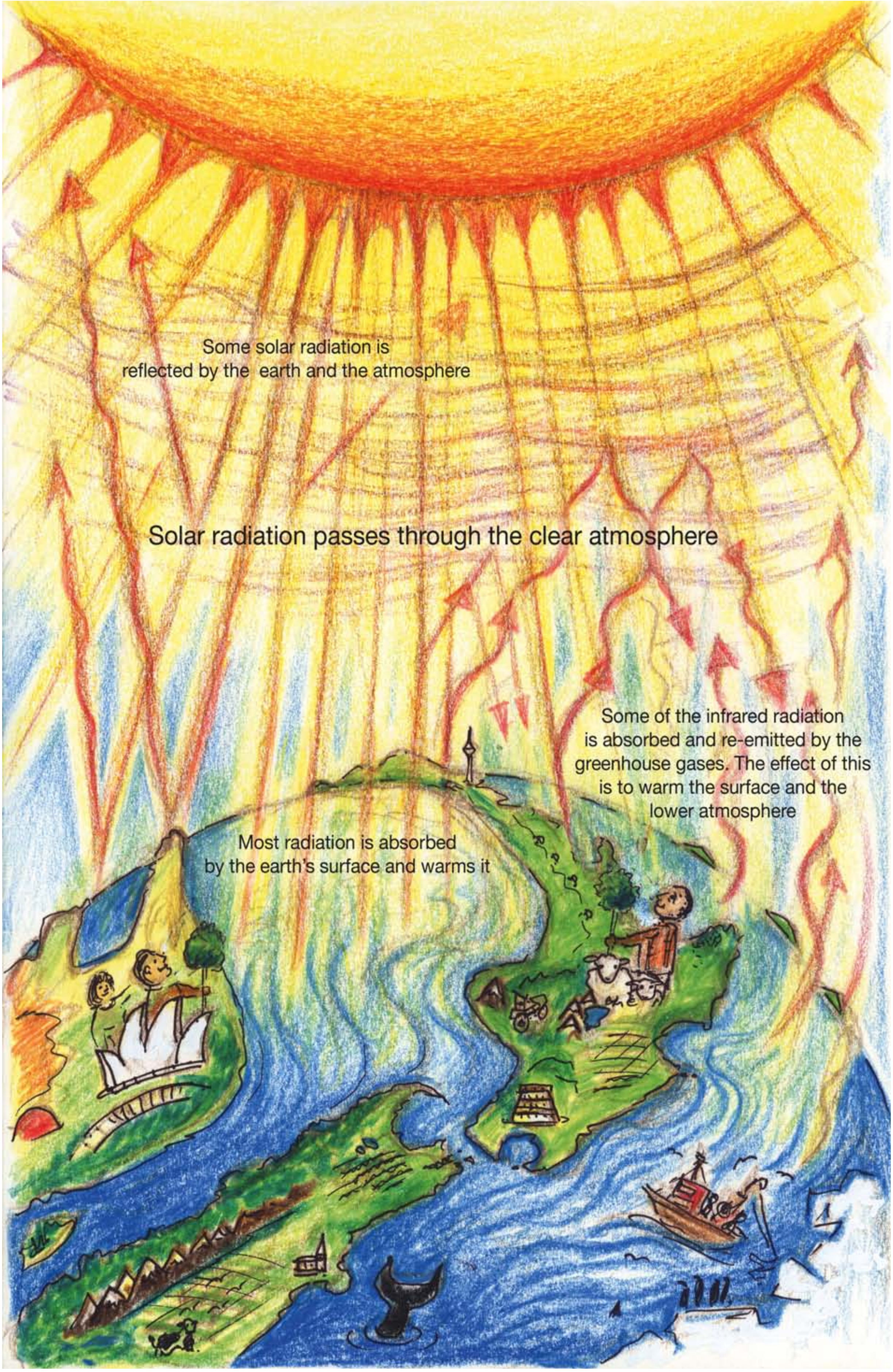
The effect of increased greenhouse gas concentrations

If extra amounts of greenhouse gases are added to the atmosphere, such as from human activities, they will absorb more of the infra-red radiation. The Earth's surface and the lower atmosphere will warm further until a balance of incoming and outgoing radiation is reached again. The emission of infra-red radiation increases as the temperature of the emitting body rises. This extra warming is called the **enhanced greenhouse effect**.

The magnitude of the enhanced greenhouse effect is influenced by various complex interactions in the earth-ocean-atmosphere system. For example, as the temperature of the earth's surface increases more water vapour is evaporated. Since water vapour is itself a strong greenhouse gas this is a positive feedback which will tend to amplify the warming effect of (for example) carbon dioxide emissions. Clouds tend both to cool the Earth because they reflect incoming sunlight, and to warm it by trapping outgoing infra-red radiation. The net result over the globe of clouds is a cooling, but it is still uncertain whether this overall cooling will increase or decrease as greenhouse gas concentrations increase. Heat is distributed vertically in the atmosphere by motion, turbulence and evaporation and condensation of moist air, as well as by the radiative processes discussed above.

Thus many processes and feedbacks must be accounted for in order to realistically predict climate changes resulting from particular greenhouse gas emission scenarios. These complications are the source of much of the debate which has occurred about the likely magnitude and timing of climate changes due to enhanced greenhouse gas emissions.

The Greenhouse Effect

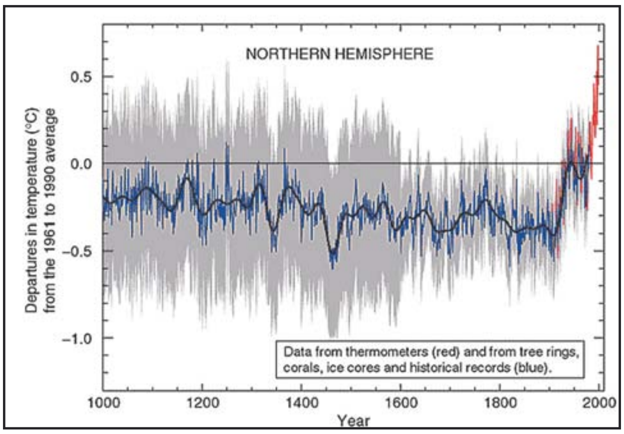


Past climate variations over New Zealand

The climate of the earth has changed many times over thousands of years, often with profound effects on human, animal and plant life. Information about past climate is obtained from piecing evidence together from various sources, including ice cores, fossil pollen, lake sediments, ocean sediment cores, loess deposits, glaciers, glacial deposits embedded within stalactites and stalagmites, tree rings, bore holes, and instrumental, written and oral records.

New Zealand temperatures have varied greatly over the past 150,000 years, largely through periods of glaciation and warmer periods between ice ages knows as interglacial periods. The Last Glacial Maximum was between 26,000 and 18,000 years ago, with New Zealand temperatures estimated to be 4 to 5°C below present day values. At this time, palaeovegetation patterns indicated enhanced westerly circulation over New Zealand.

During the Holocene (the current interglacial period which began about 14,000 years ago here), average annual temperatures for New Zealand appear to have fluctuated between about 10°C and 14°C (Salinger 1988). The warmest conditions of the present cycle occurred between 10,000 and 8000 B.P with temperatures about 1°C above the average experienced over the last couple of hundred years. This warmer climate was mild, with light winds and lush forests. The average temperature in the past three thousand years has remained within 1°C of the average temperature experienced over the last couple of hundred years (12°C) which is about 3°C below the global average.

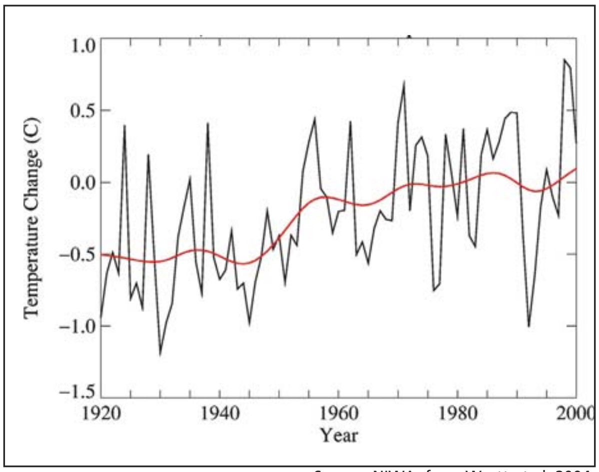


Over much of the last 1000 years there has been a cooling trend in the northern hemisphere. Over the last 150 years temperatures have been increasing at an unprecedented rate. Source: NIWA, from Wratt et al, 2004.

The period from 850 to 1850 AD was one of variable climate for New Zealand. From South Island mountain glacier records, cooler periods of climate occurred in the 11th century, early 12th century, mid 13th century, early 15th century, early 16th century, 17th and 18th centuries and the mid 19th century. Tree ring evidence (Salinger et al., 1994) shows cooler November to March periods in the 1760s, around 1790, and the early 1840s to early 1860s. These times correspond with periods when the glaciers had advanced (Fitzharris et al., 1992).

Recent and present climate

The development of recording instruments, which now range from farm rain gauges to satellite technology, has greatly enhanced understanding of our climate. New Zealand's climate is sometimes considered to be predictably unpredictable, but there are noticeable patterns of change and variation.



Source: NIWA, from Wratt et al, 2004.

In individual years, annual New Zealand-wide temperatures can deviate from the long-term average by up to 1°C (plus or minus). Despite these fluctuations, there has been a long-term increase of about 0.6°C between 1920 and 2000. Annual rainfall, too, can deviate from its long-term average, by about plus or minus 20 percent. Sea levels have risen by an average of 16cm between 1900 and 2000, with similar plus or minus 20 percent year-to-year variations.

Some of the shortest-term temperature fluctuations arise simply because of the natural variability in the weather and its random fluctuations or 'chaos'. However, other changes are associated with large-scale climate patterns over the Southern Hemisphere or the Pacific Ocean. There are a number of key natural processes that operate over time-scales of seasons to decades, particularly the El Niño-Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO).

The ENSO is a tropical, Pacific-wide oscillation that affects pressure, winds, sea-surface temperature (SST) and rainfall. In the El Niño phase, New Zealand usually experiences stronger than normal south-westerly airflow. This generally results in lower seasonal temperatures nationally with drier than normal conditions in the east of the country. The La Niña phase is essentially the opposite, usually creating more north-easterly flows, higher temperatures, and wetter conditions in the north and east of the North Island. Because the tropical Pacific SST anomalies persist for up to a year, there is some predictability in how ENSO oscillations affect New Zealand's climate. The ENSO cycle varies between about three and seven years with large variability in the intensity of individual oscillations.

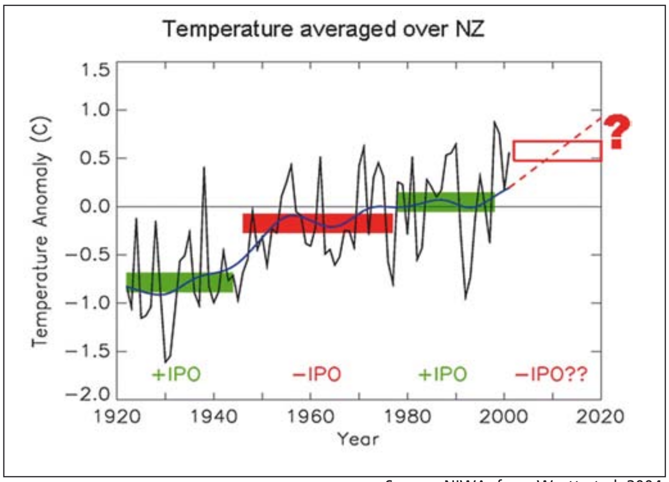
The IPO is another, recently identified, source of natural variability in climate. It has cycles that can last over several decades. Three phases of the IPO have been identified during the 20th century: a positive phase (1922–44), a negative phase (1946–77) and another positive phase (1978–98). Looking at the climate in these periods can give some guidance on future climate in the medium-term. In a positive phase, SSTs around New Zealand tend to be lower and westerly or south-westerly winds stronger. Temperatures in all regions are lower. In the negative phase, airflows from the east and north-east were observed to increase, as did temperatures in all regions. Conditions became wetter in the north of the North Island, particularly in autumn, and drier in the south-east of the South Island, particularly in summer. The increase in New Zealand temperatures around 1950 coincides with the change from positive to negative phase IPO at that time. Sea levels around New Zealand are also affected by the IPO. Particularly large increases in sea level have been associated with IPO transitions from the positive to the negative phase.

Natural climate patterns such as the IPO can, therefore, act either to suppress or enhance the effects of climate change over periods of up to two or three decades.

At this stage, it is uncertain to what extent the IPO can be accurately used to predict climate phases or patterns in future decades. More frequent natural climate variations, such as the ENSO, are also difficult to predict very far in advance. For this reason, it is not feasible to project natural variations over the next century. However, analysis of the latest sea temperature data suggests that another negative IPO phase may currently prevail. In this case, more La Niña (and less El Niño) activity could be expected, compared to the 1978–98 period, together with a period of higher temperatures.

Future climate

The natural variations described above will continue to impact on New Zealand climate in the future and will be superimposed on human-induced, long-term, climate change trends. Climate change is expected to shift the range of variability and, in some instances, to alter the patterns of variability. It will not remove this natural variability. Thus, the effects of climate change may be felt both through changes in long-term averages and in terms of the changed frequency and intensity of extreme events (such as heavy rainfall, storm surges, drought, or very high temperatures). In many instances, it is the extreme events that will have the greatest impacts and for which we need to be prepared. A small shift in the average climate can cause significant changes in the occurrence of extremes.



Source: NIWA, from Wratt et al, 2004.

Historical records show the national-averagetemperature can vary by up to about 1°C from year to year, and more than this on a seasonal timescale. Thus, the warmest individual years in the current climate have temperatures lying near the upper end of the projected average (climatological) warming for the 2030s. A current extremely hot year may be the norm by 2030 and a hot year in 2030 is likely to be outside the range of what is experienced today. Projected temperatures for the mid-to-high range of the 2080s are well outside the values experienced by New Zealand in the 20th century. A hot year in 2080 will be more extreme still. Likewise, the mid-range projected rise in sea levels of 30-50 cm by 2100 is higher than any year-to-year variations at present.

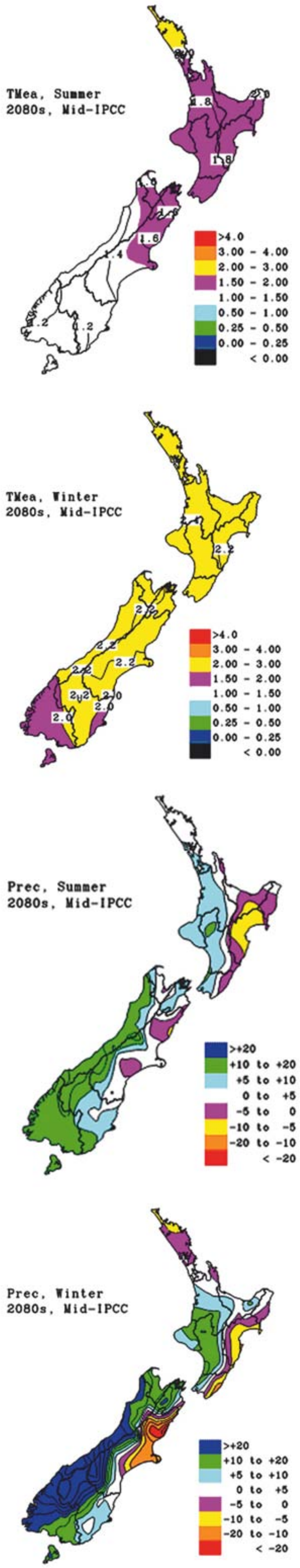
Similar comparisons can be made for rainfall, with climate change likely to bring wetter average conditions in the west and drier average conditions in the east. Seasonal anomalies today seem comparable to the projected average ranges for 2030. Areas that currently have water management issues could see present extremes such as water shortages become the norm by the 2030s depending on the direction of projected rainfall change for their region, and which emissions scenario and model simulation turns out to be the closest to reality. This will be particularly relevant for drought management in eastern New Zealand.

Average changes

Average global temperatures are projected to increase by between 1.4 and 5.8°C by 2100. The amount of increase will strongly depend on steps that are taken globally to reduce greenhouse gas emissions. The increase is expected to be less in New Zealand than the global average because of delayed warming of the oceans surrounding New Zealand.

Mid-range projections for New Zealand are for an increase in the annual average temperature of 0.5 to 0.7°C from 1990 to the 2030s, and 1.5 to 2.0°C from 1990 to the 2080s. There are likely to be greater increases in winter (meaning that the difference between winter and summer temperatures is expected to decrease) and in the north of the country (meaning the difference in temperature between the north and south is expected to increase).

Generally, a trend to drier conditions in eastern regions and wetter conditions in the west is expected. This means that the difference in rainfall between western and eastern regions is likely to further increase. Drought and flood risk are likely to increase in many parts of the country, both as a result of climate change and as a result of increasingly intensive human activity. Even if average rainfall decreases in some areas there will still be extreme rainfall events, with research suggesting the possibility of more intense rainfall events.



Projected changes in average precipitation (in %) and temperature (in °C) for the 2080s by season.
These maps are intended to illustrate broad geographical patterns of climate change within New Zealand. They should not be used as definitive predictions of climate change for specific geographical locations.

Source: NIWA, from Wratt et al, 2004.

Table 1: Main features of New Zealand climate change projections for 2030s and 2080s

Table 1 qualitatively summarises the main features of New Zealand climate projections and contains the best current scientific estimate of the direction and magnitude of change. The level of confidence in the projections is indicated in brackets (VH = very high, H = high, M = medium, L = low). A higher degree of caution should be employed where investment decisions are based on the 'low' confidence estimates. The figures provided are mid-range, based on a range of climate models and greenhouse gas emission scenarios. Changes in the return period of heavy rainfall events may vary between different parts of the country and will also depend on the rainfall duration being considered (for more detail see Section 2.2.4 of the source report, available from: www.climatechange.govt.nz/resources/local-govt/guidance.html).

Climate variable	Direction of change	Magnitude of change	Spatial and seasonal variation
Mean temperature	Increase (VH)	0.5–0.7°C by 2030s, 1.5–2.0°C by 2080s (M) *(Mid-range projections)*	Strongest warming in winter, tendency for slightly more warming in E and N
Daily temperature extremes (frosts, hot days)	Fewer low temperatures and frosts (VH), more high temperature episodes (VH)	Whole frequency distribution moves right	See source report page 27
Mean rainfall	Varies around country. By 2080s Taranaki, Manawatu-Wanganui, West Coast, Otago and Southland show increases; Hawke's Bay Gisborne, eastern Canterbury, eastern Marlborough show decreases (M)	Substantial variation around the country	Tendency to increase in S and W, decrease in N and E. Largest projected seasonal decreases in spring in N and E of North Island
Extreme rainfall	Heavier and/or more frequent extreme rainfalls, especially where mean rainfall increase predicted (M)	No change through to halving of heavy rainfall return period by 2030s; no change through to fourfold reduction in return period by 2080s (L)	Increases in heavy rainfall most likely in areas where mean rainfall is projected to increase
Snow	Snow cover decrease, snowline rise, shortened duration of seasonal snow lying (all M)		
Wind (average)	Increase in the mean westerly windflow across New Zealand (M)	By 2080s, could be from slight increase up to doubling of mean annual westerly flow (L)	
Strong winds	Increase in severe wind risk possible (L)	Little change up to double the frequency of winds above 30m/s by 2080s (L)	
Storms	More storminess possible, but little information available for New Zealand (L)		
Sea level	Increase (VH)	30-50 cm rise (New Zealand average) between 1990 and 2100 (H), accelerating the historical trend *(Mid-range projection)*	See *Coastal Hazards and Climate Change* publication (http://www.climatechange.govt.nz/resources/local-govt/coastal-hazards-may04/index.html)
Waves	Increased frequency of heavy swells in regions exposed to prevailing westerlies (M)	See *Coastal Hazards and Climate Change* publication	

Source: NIWA, from Wratt et al, 2004.

Projected changes and impacts in eastern regions

Changes in seasonal and annual temperature and precipitation are given below. These are accompanied by regional summaries of possible effects of climate change. It is important to be aware that prediction of regional changes in climate is much less certain than predictions of broader scale changes. The projected climate changes are based on the full range of Intergovernmental Panel on Climate Change emission scenarios and using a range of global climate models (see pages 11 and 12 of the source report for more details). So, a large part of the ranges given is due to uncertainty in the science but they also capture the range of variation within regions.

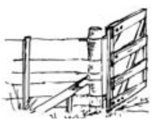
Bay of Plenty

	Summer	Autumn	Winter	Spring	Annual
Temperature °C 1990-2030s 1990-2080s	 0.0 to 1.2 0.3 to 3.8	 0.0 to 1.3 0.4 to 3.9	 0.4 to 1.6 0.8 to 4.2	 0.2 to 1.2 0.4 to 3.6	 0.2 to 1.3 0.5 to 3.8
Precipitation % (Tauranga) 2030s 2080s	 -10 to +4 -7 to +19	 -16 to +4 -18 to +15	 -5 to +7 -2 to +9	 -20 to +8 -41 to -3	 -9 to +2 -15 to +2

Source: NIWA, from Wratt et al, 2004.

Changes that might be expected to occur in Bay of Plenty include:

- Warmer winters, reduced frequency of frost inland and at higher elevations, and a longer growing season. Changes in crops grown will result over time with these changed conditions, with potential for more sub-tropical species. Hayward kiwifruit could become uneconomic in warmer parts of Bay of Plenty in 40 or 50 years without significant use of dormancy-breaking agents and other management practices.
- A greater tendency for drier average conditions, but the possibility of wetter average conditions in some areas. Even with lower average rainfall there is the possibility of more frequent and intense rainfall events.
- An increased risk of flooding could arise with any increase in intense rainfall events. There are obvious risks from flooding throughout the Bay of Plenty region, generally mitigated by comprehensive flood protection and river control schemes on major rivers and stopbanking of streams through towns (several in Rotorua). Any impacts from climate change will affect these schemes.
- A possibility of increased drought risk in coastal and eastern Bay of Plenty, which could contribute to reduced clover content in pastures and a higher incidence of sub-tropical species.
- Demand for water could increase. Many surface water resources have been over-allocated in the past and there are now limits on allocations in some stream catchments. This will therefore put extra demand to groundwater resources, particularly in the east. If conditions in the east are likely to be drier, available groundwater recharge may be lower. This may result in land use changes and consequent economic effects.
- New Zealand, and some overseas research, suggests that the higher temperatures and carbon dioxide concentrations expected over the next few decades will lead to a 10-20 percent increase in annual pasture yields in New Zealand. The extent to which these gains are realised in Bay of Plenty will depend strongly on changes in pasture composition and water availability. Along with the effects of on-going management changes these yield increases would arise from the combined effects of carbon dioxide fertilisation, higher temperatures, and any increases in precipitation. An issue will be an increased incidence of lower feed quality sub-tropical grasses such as paspalum and kikuyu. Other invasive sub-tropical grass species could also become a much greater problem.
- Other impacts are likely to include changes in animal health, pests, weeds and diseases. Changes in soil fertility and organic matter levels could also occur requiring management changes.
- There will be increased biosecurity challenges. If eastern Bay of Plenty were to become drier, animal pests such as rabbits could become more prevalent. More importantly, there will be potential for greater survival of a range of insect pests.
- Higher temperatures and changes in rainfall are likely to result in significant effects on the Rotorua and other lakes. This includes the possibility of increased eutrophication and frequency of algal blooms, particularly for shallow lakes, changes in lake levels with impacts on lake margins including wetlands, impacts on aquatic macrophytes and effects on trout numbers.



Hawke's Bay

	Summer	Autumn	Winter	Spring	Annual
Temperature °C 1990-2030s 1990-2080s	 -0.1 to 1.3 0.3 to 3.9	 0.1 to 1.3 0.5 to 3.8	 0.4 to 1.6 0.8 to 4.0	 0.2 to 1.3 0.5 to 3.3	 0.2 to 1.4 0.5 to 3.8
Precipitation % (Napier) 2030s 2080s	 -23 to +5 -25 to +21	 -27 to +1 -48 to +11	 -18 to +12 -43 to +23	 -23 to +9 -52 to -4	 -19 to +1 -32 to +3

Source: NIWA, from Wratt et al, 2004.

Changes that might be expected to occur in Hawke's Bay include:

- A longer growing season, and reduced frequency of frost. This will allow for earlier sowing of annual crops and potential for diversification. The wine industry will probably benefit and crops such as kiwifruit, citrus and avocados may become more economically viable. Irrigation demand could increase and availability of water could become a much greater issue.
- More frequent hot, dry, summer conditions and potential for more frequent heat waves and increased drought frequency and severity. These are often associated with El Niño episodes, as occurred through the 1980s and 1990s, which coincided with a positive phase of the Interdecadal Pacific Oscillation (IPO).
- The risk of fires in rural areas may also increase, with potentially severe effects.
- Decreased runoff into rivers and thus reduced river flows, on average. Runoff decreases of 10 to 40 percent could be experienced in eastern parts of Hawke's Bay. Uncertainty about rainfall changes in the western ranges means uncertainty about changes in runoff and river flows in the river catchments that extend back into the ranges.
- Security of water supply is likely to be the greatest issue for eastern North Island in the future, even if the worst effects of climate change are not realised. Drier average conditions, together with increased growth in demand for water, are likely to place increasing pressure on available water resources.
- Depending on changes to weather patterns, there could also be the possibility of an increase in frequency and intensity of high rainfall events. Together with drier average conditions, this could lead to increased problems with erosion and flooding.
- Changes in pasture composition are already evident in Hawke's Bay as a consequence of droughts experienced through the 1980s and 1990s. Ratstail has become more prevalent, particularly on drier northern slopes and management adjusted accordingly. An increase in such grasses is likely, with a continued decline in legumes. Clover is already absent in the summer-dry hill country of Hawke's Bay. There is also the likelihood of more subtropical weedy species. A number of undesirable grass species are already present in parts of Hawke's Bay, such as Chilean needle grass, the spread of which could be encouraged by warmer, drier, conditions.
- Changes to the range, identity and incidence of pest, weed and disease problems. Examples of what could be experienced with greater frequency include an increased incidence of facial eczema and viral pneumonia, and a rapid spread of Tasmanian grass grub in the last five or six years.

Nelson and Marlborough

	Summer	Autumn	Winter	Spring	Annual
Nelson					
Temperature °C					
1990-2030s 1990-2080s	0.0 to 1.2 0.2 to 3.4	0.1 to 1.2 0.3 to 3.6	0.3 to 1.6 0.7 to 3.8	0.1 to 1.2 0.4 to 3.3	0.1 to 1.3 0.4 to 3.5
Precipitation % (Nelson) 2030s 2080s	-16 to +1 -21 to +33	-10 to +4 -13 to +7	-3 to +15 -2 to +31	-11 to +4 -21 to +3	-7 to +2 -7 to +4
Marlborough					
Temperature °C 1990-2030s 1990-2080s	-0.2 to 1.3 -0.2 to 3.5	0.1 to 1.2 0.4 to 3.6	0.3 to 1.8 0.9 to 4.1	0.0 to 1.3 0.2 to 3.3	0.1 to 1.4 0.4 to 3.5
Precipitation % (Blenheim) 2030s 2080s	-8 to +4 -10 to +40	-9 to +3 -13 to +6	-5 to +15 -7 to +33	-12 to +4 -23 to +9	-5 to +3 -4 to +5

Source: NIWA, from Wratt et al, 2004.

Changes that might be expected to occur in Nelson and Marlborough include:

- A longer growing season, and reduced frequency of frost. This will generally be of benefit to fruit production and the wine industry. Water will be the key, however.
- The possibility of more frequent hot, dry summer conditions and potential for more frequent heat waves and increased drought severity and intensity. The effects of extended drought in coastal Marlborough are very evident, with serious wind erosion problems in some areas.
- The risk of fires in rural areas may also increase with potentially severe effects.
- Runoff decreases of around 40 percent could be experienced in eastern Marlborough, with the likelihood of decreases in other areas in the summer months. Depending on changes to weather patterns, there could also be the possibility of an increase in frequency and intensity of high rainfall events, which could lead to increased problems with erosion and flooding.
- Security of water supply is likely to be the greatest issue for Nelson and Marlborough in the future, even if the worst effects of climate change are not realised. In Tasman District, summer water resources are already fully allocated in the Waimea and Moutere catchments, and in the southern Motueka Plains. There was up to 60 percent water rationing in the 2000/2001 drought (a 30-year event) in some areas. This was well in excess of the planned security of supply, which allows for a 35 percent reduction in use during a one in 10 year drought. The southern side of the Wairau plain is an east coast catchment which is likely to be even more significantly affected than Nelson. Including thousands of hectares of grapes in the southern valleys this is already a water-short area where marginal water harvesting initiatives are becoming the only means of new development. This will be further compromised by any reduction in rainfall.
- Saltwater intrusion in coastal aquifers is already a problem in some areas and will become more of an issue.
- Changes in pasture composition may occur, with a trend already in coastal areas to hardier, less productive, species. A number of undesirable sub-tropical grass species are already present in parts of Nelson and Marlborough. Paspalum has already spread in parts of the eastern Nelson hills and is likely to become more widespread with warmer, wetter, average conditions. Species such as Chilean needle grass are a problem in parts of Marlborough, the spread of which could be encouraged with climate change. Increases in pasture yields may occur in wetter, inland areas.
- There could be increased problems with pests, weeds and diseases.

Canterbury

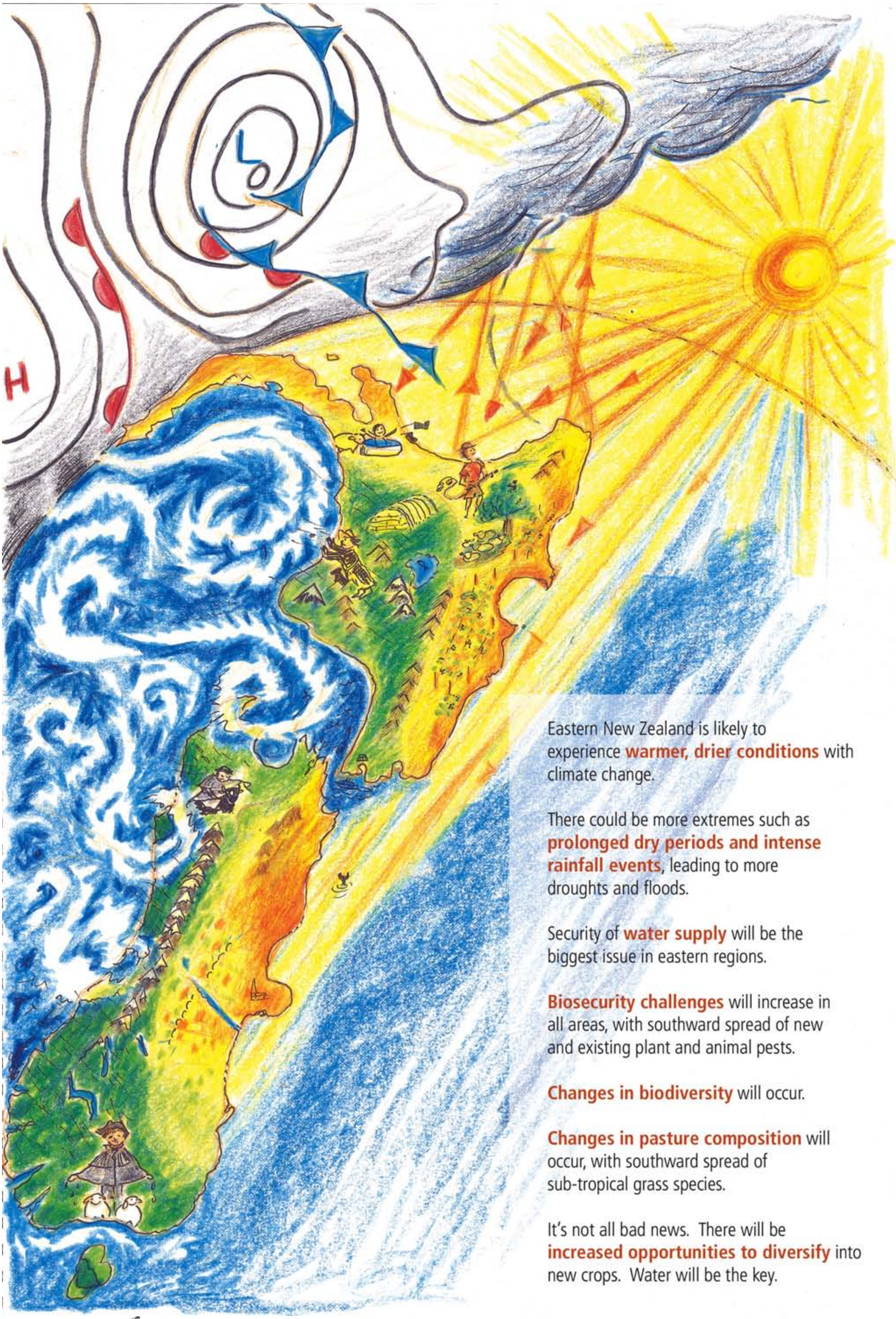
	Summer	Autumn	Winter	Spring	Annual
Temperature °C					
1990-2030s	-0.2 to 1.3	0.1 to 1.1	0.3 to 1.8	0.0 to 1.3	0.2 to 1.4
1990-2080s	0.0 to 3.3	0.4 to 3.5	0.8 to 3.9	0.3 to3.1	0.5 to 3.4
Precipitation %					
(Christchurch)					
2030s	-6 to +8	-20 to –1	-12 to +10	-11 to +4	-10 to +1
2080s	-12 to +38	-36 to +8	-28 to +9	-21 to 0	-17 to +4
(Hanmer)					
2030s	-16 to +5	-9 to +1	-15 to +11	-11 to +4	-12 to +3
2080s	-22 to +32	-17 to +5	-32 to +12	-21 to +3	-21 to +3

Source: NIWA, from Wratt et al, 2004.

Changes that might be expected to occur in Canterbury include:

- Warmer winters, reduced frequency of frost, and a longer growing season will increase opportunities for fruit and wine production, arable cropping and process vegetable production. Crops such as maize are already becoming increasingly viable. Higher temperatures will mean that it will be possible to sow crops earlier and they will generally reach maturity faster, depending on sowing time. Temperate crops may require higher N fertiliser inputs to maximise the expected benefits from higher carbon dioxide in the atmosphere, together with sufficient water. Availability of water will be the key.
- In the Canterbury plains, there is the likelihood of lower rainfall and increased evapotranspiration over the growing period, and possibly increased drought frequency and severity.
- Increased rainfall in the Southern Alps would lead to increased river flows in the principal rivers of the region.
- Security of water supply is likely to be the greatest issue for Canterbury in the future, even if the worst effects of climate change are not realised. Drier average conditions during the summer months, together with increased growth in demand for water, is likely to place increasing pressure on available water resources. There may be more water in the major rivers, but the capital costs of irrigation are likely to increase, with the likelihood of greater regulatory costs. More efficient water use will be required in irrigated systems, and improved water conservation practices will be necessary in dryland systems.
- On dryland the key agronomic issue is the marginal performance of perennial ryegrass on sunny aspects of downs and hills. It is still the basis of the pastoral industry, but it is suspected that it would take very little temperature change to make its persistence unacceptably low in large areas.
- There is no clear evidence of sub-tropical grass species becoming a problem, although there would be increased risk of invasive species establishing over time, particularly on dry, northern slopes in North Canterbury.
- Higher temperatures over time will increase the biosecurity risk for Canterbury region. Observed changes are already taking place, which are at least indicative of what could be expected with increasing frequency in coming decades. Two examples of increased presence could be banana passionfruit, a frost-tender plant which appears to be spreading and argentine ants which have managed to survive through two winters when previously not thought possible.
- Canterbury soils, which are already relatively low in organic matter, could be adversely affected with increased temperatures and will require careful management.

Projected changes and impacts in eastern New Zealand



Eastern New Zealand is likely to experience **warmer, drier conditions** with climate change.

There could be more extremes such as **prolonged dry periods and intense rainfall events**, leading to more droughts and floods.

Security of **water supply** will be the biggest issue in eastern regions.

Biosecurity challenges will increase in all areas, with southward spread of new and existing plant and animal pests.

Changes in biodiversity will occur.

Changes in pasture composition will occur, with southward spread of sub-tropical grass species.

It's not all bad news. There will be **increased opportunities to diversify** into new crops. Water will be the key.

A generalised scenario

In workshops and in-depth interviews with farmers a generalised scenario was used but consistent with the detailed information presented above. The scenario used was:

By 2050 conditions could be up to 1°C warmer on average in the east of New Zealand and possibly of the order of 10 percent drier on average. With a possible increased frequency of westerlies there could be a combination of more rainfall in the axial ranges of the North Island and in the Southern Alps, with drier average conditions further east. Drier average conditions and the possibility of more intense rainfall events, could increase drought and flood risk.

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Drought conditions in Marlborough

Flooding in the Bay of Plenty