



CLIMATE PROJECTIONS FOR NEW ZEALAND

Introduction

The climate is changing. All governments accept that further changes will result from increasing amounts of greenhouse gases in the atmosphere. Reductions of greenhouse gas emissions can slow the rate, but climate change cannot be prevented entirely. In New Zealand, changes in key climate parameters – such as temperature and rainfall – are already occurring. These changes will occur to differing extents in different parts of New Zealand throughout the 21st century and beyond.

This snapshot of climate projections for New Zealand summarises the main elements of a comprehensive technical report: *Climate Change Projections for New Zealand*. It updates the climate projections for New Zealand following the release of the Intergovernmental Panel on Climate Change (IPCC)'s Fifth Assessment Report in 2014. NIWA scientists used a supercomputer to produce climate projections for the New Zealand region on a 5 km grid, based on the results from coarser global climate models. They produced a report for the Ministry for the Environment which addresses possible changes in New Zealand's climate over the next 100 years, and is available in full at: www.mfe.govt.nz/node/21990

Current climate variability

New Zealand's climate varies naturally from year to year and from decade to decade. It is the combination of natural variation and human-induced long-term trends that will provide the climate extremes to which future New Zealand society will be exposed. Much of the natural variation is apparently random; however there are some cyclical elements.

In individual years, annual New Zealand-wide temperatures can deviate from the long-term average by up to 1°C (plus or minus). However, despite these fluctuations, there has been a long-term increase of around 0.9°C over the last century. Similarly, annual rainfall can deviate from its long-term average, by about plus or minus 20 per cent.

Key points

According to the 2016 climate projections, New Zealand will likely experience:

- > Higher temperatures, with an increase of about 0.7°C (low emissions scenario) and 1.0°C (high emissions scenario) by 2040 and about 0.7°C (low emissions scenario) and 3.0°C (high emissions scenario) by 2090. There will likely be slight gradients from north to south, and from east to west, with the greatest warming experienced in the northeast.
- > A change in rainfall patterns – increased summer rainfall in the north and east of the North Island, and increased winter rainfall in many parts of the South Island. Decreased spring rainfall in the north and east of the North Island, and in the south and east of the South Island.
- > Increased frequency of dry days for much of the North Island, and for some parts of the South Island. Increased frequency of heavy rainfall events over the South Island and some parts of the North Island.
- > Increased frequency and intensity of droughts over time, particularly under a high emissions scenario. The strongest increases are over the northern and eastern North Island and along the eastern side of the Southern Alps.
- > Some increase in storm intensity, small-scale wind extremes and thunderstorms is likely to occur. Ex-tropical cyclones will likely be stronger and cause more damage as a result of heavy rain and strong winds.
- > Increased northeasterly airflow in summer and stronger westerlies in winter, particularly in the south.
- > Increase in the number of hot days, and decrease in the number of frost days and snow days.

Future climate

What our climate looks like in the future depends on the future concentrations of greenhouse gases, and on how the global climate system will respond to these. Our projections are based on several different scenarios ranging from low to high emissions, and include different levels of emissions reductions. Future greenhouse gas concentrations depend on future emissions, which in turn depend on national and international policies, changes in population, economic growth, technology, and energy availability.

Because natural effects cause the New Zealand climate to vary from year to year, the changes are specified in terms of the average change for the twenty-year periods 2031–2050 (referred to in this snapshot as 2040), and 2081–2100 (similarly referred to as 2090), relative to the climate of 1986–2005 (1995).

Emissions scenarios

We consider four scenarios for New Zealand, which align with those in the IPCC Fifth Assessment Report. These pathways are known as Representative Concentration Pathways (RCPs)¹. The four pathways are abbreviated as RCP2.6, RCP4.5, RCP6.0, and RCP8.5, in order of increasing radiative forcing² by greenhouse gases at the end of this century. They are:

- > a low emissions, mitigation scenario (RCP2.6), in which global carbon dioxide emissions stop after 2080, after which some is actually removed from the atmosphere

- > a high emissions, business as usual scenario (RCP8.5)
- > two middle scenarios (RCP4.5 and RCP6.0) which represent futures where global emissions stabilise at different levels.

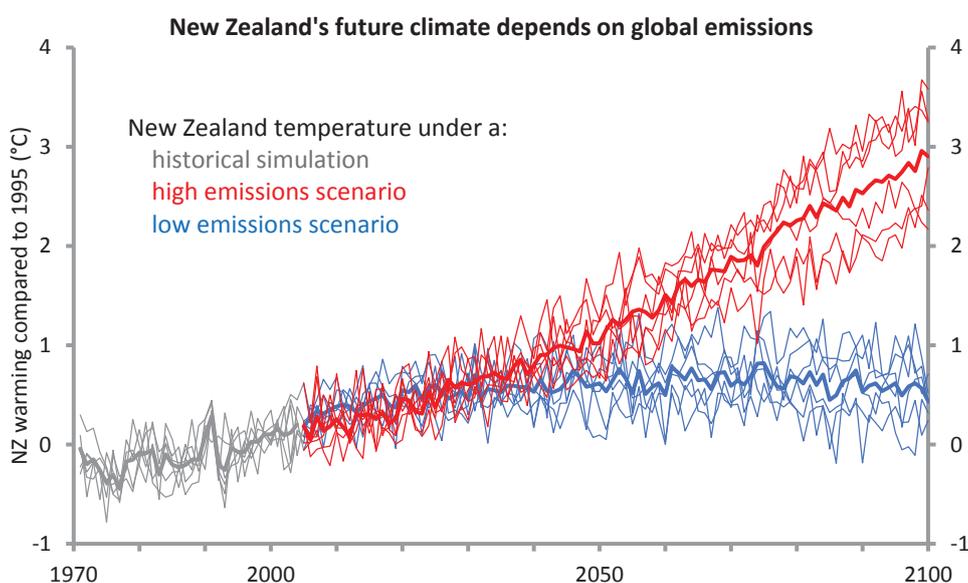
These differ from the scenarios used in the previous climate projections for New Zealand, which were based on the IPCC Fourth Assessment Report (2007). Notably, a new scenario is included which simulates success in limiting global warming to 2°C on pre-industrial levels, the internationally agreed limit. The Paris Agreement also recognises that limiting warming to 1.5°C (on pre-industrial levels) would significantly reduce climate change impacts.

Changes in temperature

According to the projections, by 2040 New Zealand temperatures will warm by about 0.7°C under the low emissions scenario (with an uncertainty range of 0.2–1.3°C) and by about 1.0°C (0.5–1.7°C) under the high emissions scenario, in relation to the 1995 baseline. By 2090, temperatures will increase by about 0.7°C (0.1–1.4°C) under the low emissions scenario and by about 3.0°C (2.0–4.6°C) under the high emissions scenario.

The pattern of annual average warming is expected to be fairly uniform across the country, with slight gradients from north to south and from east to west. The North Island is expected to experience slightly greater warming than the South Island. The warming is generally highest in summer and autumn and lowest in winter and spring.

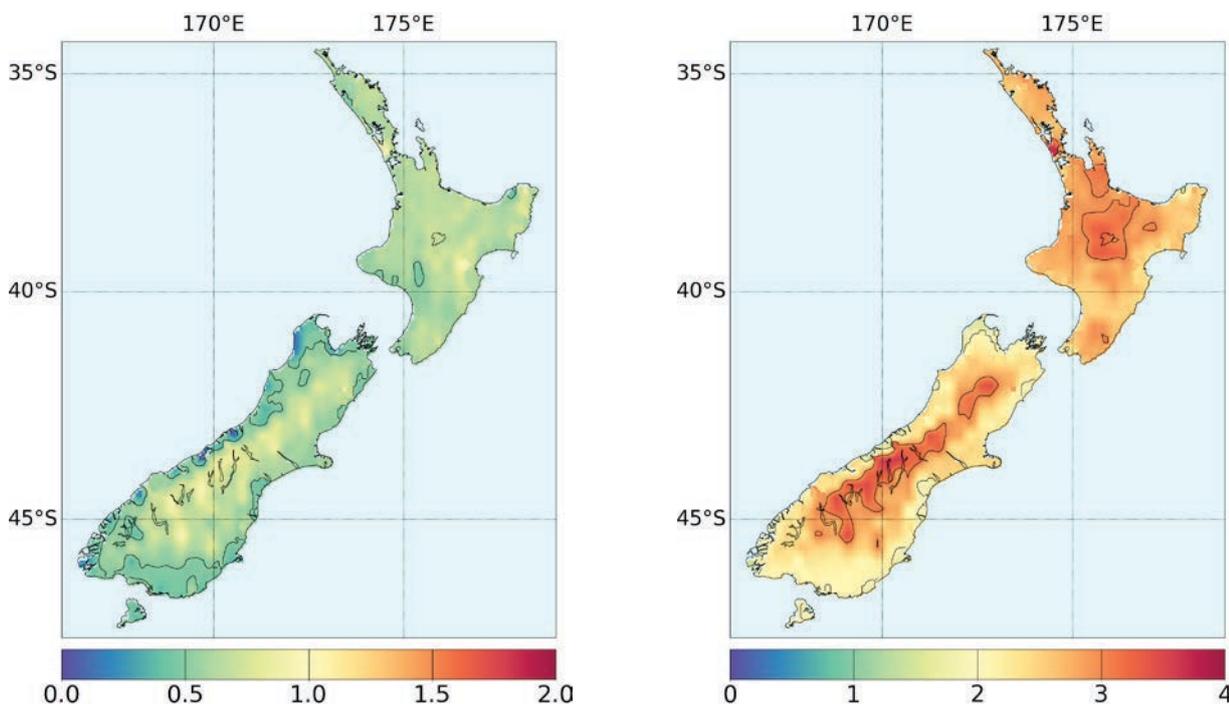
Figure 1: New Zealand's future temperature depends on global greenhouse gas emissions. The warming will probably lie between the red and blue bands, which represent the extreme high- and low- emissions scenarios modelled in the IPCC 5th Assessment Report (2014). Different models (thin lines) project different amounts of warming under the same scenario, and year-to-year variability will continue as in the past. The thick line shows the average for each scenario, as reported in these new projections.



1 The Representative Concentration Pathways (RCPs) are greenhouse gas concentration scenarios adopted by the IPCC for its Fifth Assessment Report. They describe four alternative futures, in which possible scenarios of human activities result in different concentrations of greenhouse gases in the atmosphere.
2 Radiative forcing is a measure of the energy absorbed and retained in the lower atmosphere.

Figure 2: Projected annual average temperature changes by 2090 under the RCP2.6 low emissions scenario (left) and the RCP8.5 high emissions scenario (right), relative to the 1995 baseline. Note the colour scales used are different for the two maps, in order to show each scenario more clearly.

Average change in temperature (°C) by 2090 under RCP2.6 (left) and RCP8.5 (right)



Projected changes in rainfall

Rainfall projections are highly variable by region and season. The overall pattern for changes in annual rainfall is a reduction in the north and east of the North Island, and increases almost everywhere else, especially on the South Island West Coast. It is *very likely*³ that for winter and spring there will be an increase in rainfall for the west of both the North and the South Island, with drier conditions in the east and north. For summer it is *likely* that there will be wetter conditions in the east of both islands, with drier conditions in the west and central North Island.

The largest rainfall changes by the end of the century will be for particular seasons rather than annually.

- > In spring, decreases for Northland, Auckland, and Bay of Plenty, and increases for Otago (Queenstown) and Southland.

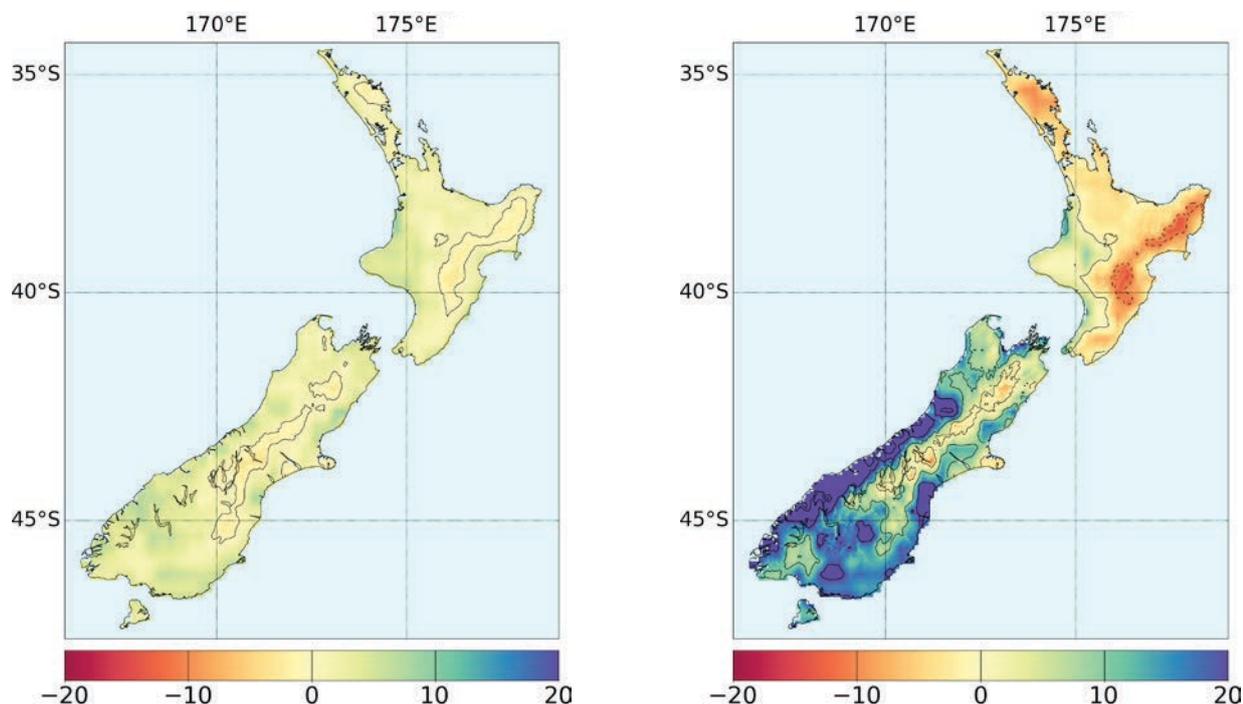
- > In winter, decreases for Waikato, Gisborne, Hawkes Bay and Canterbury (Christchurch and Hanmer Springs), and increases for Tasman-Nelson (Nelson), West Coast, Canterbury (Tekapo), Otago (Dunedin), Southland and Chatham Islands.

Changes in ocean and atmospheric circulation patterns projected by the models are consistent with the projected changes in rainfall. Mean sea level pressure is projected to increase over the North Island and east and south of the South Island in the summer season, resulting in more north-easterly airflow and more anticyclonic (high pressure) conditions, consistent with increased rainfall to the northeast. Pressures decrease south of New Zealand in winter, resulting in stronger average westerlies over central and southern New Zealand and increased rainfall in these regions.

³ IPCC terminology for indicating the assessed likelihood of an outcome or result: virtually certain 99–100% probability, very likely 90–100%, likely 66–100%, about as likely as not 33–66%, unlikely 0–33%, very unlikely 0–10%, exceptionally unlikely 0–1%. Additional terms (extremely likely: 95–100%, more likely than not >50–100%, and extremely unlikely 0–5%) may also be used when appropriate. Assessed likelihood is typeset in italics.

Figure 3: Projected annual average rainfall changes (%) by 2090 under the RCP2.6 low emissions scenario (left) and the RCP8.5 high emissions scenario (right), relative to the 1995 baseline.

Annual average change in rainfall (%) by 2090 under RCP2.6 (left) and RCP8.5 (right)



Extreme weather events

Natural variations in our climate will continue to affect the 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. Therefore, the effects of climate change may be felt both through changes in long-term averages and in the changed frequency and intensity of extreme events (such as heavy rainfall, high sea levels brought by storm surges, drought, or very high temperatures). It is this combination of underlying average climate, climate change trends, and natural variations that will provide the extremes that future New Zealand society faces. A small shift in the average climate can cause significant changes in the occurrence of extremes: generally, it is the extreme events that cause damage.

Intense rainfall is likely to increase in most areas, except for parts of Northland and Hawke’s Bay. Increases are small for the remainder of the North Island and larger for the

South Island, with the largest increases being seen in areas where average rainfall is also increasing, such as the West Coast. However, because increases in rainfall intensity do not necessarily imply an increase in annual rainfall totals, heavy rainfall events may increase even in areas where the average rainfall is projected to decrease, because the frequency of storm events may change.

There is a projected increase in the number of dry days for much of the North Island, and for high altitude inland regions in the South Island. The frequency of dry days is expected to decrease along both coasts of the South Island.

Drought frequency and intensity is projected to increase in magnitude in most areas of the country, except for Taranaki-Manawatu, West Coast and Southland. The strongest increases are observed over the northern and eastern North Island and along the eastern side of the Southern Alps, especially later in the century under the highest emissions scenario.

Other climate changes

Projections for other climate changes include:

- > increased frequency of high temperatures (days with temperatures of 25°C and above)
- > decreased likelihood of frost
- > higher snow lines and fewer snow days
- > possible increase in strong winds, particularly in eastern regions such as Marlborough and Canterbury
- > some increase in storm intensity, local wind extremes and thunderstorms. Ex-tropical cyclones will likely be stronger and cause more damage as a result of greater wind speeds and heavier rainfall.

Significance of climate change versus natural climate variability

What currently is an unusually warm year could be the norm in 30-50 years. In 30-50 years, an unusually warm year is very likely to be warmer than anything we experience at present.

Projected temperatures for the highest emissions scenario out to the end of the century are well outside the values experienced by New Zealand in the 20th century. Unless global emissions are significantly reduced, a hot year in 2090 will be more extreme still.

Summary of projected changes

Table 1 summarises the key findings of the source report. Numerical values refer to model averages.

Table 1: Main features of New Zealand climate change projections

Climate variable	Direction of change	Magnitude of change	Spatial & seasonal variation
Average temperature	Progressive increase with concentration. Only for RCP2.6 does warming trend peak and then decline.	By 2040, from +0.7°C [RCP2.6] to +1.0°C [RCP8.5]. By 2090, +0.7°C to +3.0°C. By 2110, +0.7°C to +3.7°C.	Warming greatest at higher elevations. Warming greatest summer/autumn & least winter/spring.
Minimum and maximum temperatures	As average temperature.	Maximum increases faster than minimum. Diurnal range increases by up to 2°C by 2090 [RCP8.5].	Higher elevation warming particularly marked for maximum temperature.
Daily temperature extremes: frosts	Decrease in cold nights (minimum temperature of 0°C or lower).	By 2040, a 30% [RCP2.6] to 50% [RCP8.5] decrease. By 2090, 30% [RCP2.6] to 90% [RCP8.5] decrease.	Percentage changes similar everywhere, but number of days of frost decrease (hot day increase) greatest in the coldest (hottest) regions.
Daily temperature extremes: hot days	Increase in hot days (maximum temperature of 25°C or higher).	By 2040, a 40% [RCP2.6] to 100% [RCP8.5] increase. By 2090, a 40% [RCP2.6] to 300% [RCP8.5] increase.	
Average rainfall	Varies around the country and with season. Annual pattern of increases in west and south of New Zealand, and decreases in north and east.	Substantial variation around the country, increasing in magnitude with increasing emissions.	Winter decreases: Waikato, Gisborne, Hawkes Bay and Canterbury. Winter increases: Nelson, West Coast, Otago and Southland. Spring decreases: Auckland, Northland and Bay of Plenty.

Climate variable	Direction of change	Magnitude of change	Spatial & seasonal variation
Daily rainfall extremes: dry days	More dry days throughout North Island, and inland South Island.	By 2090 [RCP8.5], up to 10 or more dry days per year (~5% increase).	Increased dry days most marked in north and east of North Island, in winter and spring.
Daily rainfall extremes: very wet days	Increased extreme daily rainfall, especially where mean rainfall increases.	More than 20% increase in 99th percentile of daily rainfall by 2090 [RCP8.5] in Southwest of South Island. A few % decrease in north and east of North Island	Increase in western regions, and in south of South Island. Decrease in extremes in parts of north and east of North Island.
Snow	Decrease.	Snow days per year reduce by 30 days or more by 2090 under RCP8.5.	Large decreases confined to high altitude or southern regions of the South Island.
Drought	Increase in severity and frequency.	By 2090 [RCP8.5], up to 50mm or more increase per year, on average, in July-June potential evapotranspiration deficit (PED).	Increases most marked in already dry areas.
Circulation	Varies with season.	Generally, the changes are only a few hectopascals, but the spatial pattern matters.	More northeasterly airflow in summer. Strengthened westerlies in winter.
Extreme wind speeds	Increase.	Up to 10% or more in parts of the country.	Most robust increases occur in southern half of North Island and throughout the South Island.
Storms	Likely poleward shift of mid-latitude cyclones and possibly also a small reduction in frequency.	(More analysis needed).	(See section 3.7 of full report).
Solar radiation	Varies around the country and with season.	Seasonal changes generally lie between – 5% and +5%. (See section 3.9.1 of full report.)	By 2090 [RCP8.5], West Coast shows the largest changes: summer increase (~5%) and winter decrease (5%).
Relative humidity	Decrease.	Up to 5% or more by 2090 [RCP8.5], especially in the South Island. (See section 3.9.1 of full report.)	Largest decreases in South Island in spring and summer.



FOR MORE INFORMATION:

- > about climate change impacts for New Zealand go to: www.mfe.govt.nz/climate-change/how-climate-change-affects-nz
- > about adapting to climate change go to: www.mfe.govt.nz/climate-change/adapting-climate-change
- > about the climate projections presented in this snapshot contact: info@mfe.govt.nz



New Zealand Government

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