Climate Change Assumptions for 2024–2034

Climate Change	The greenhouse gases we produce from most of our everyday activities are changing the climate and our environment. There is substantial scientific evidence that our climate has been and is continuing to change. Human-induced climate change, including more frequent and intense extreme events, has caused widespread adverse impacts beyond natural climate variability. The rise in weather and climate extremes has led to some irreversible impacts as natural and human systems are pushed beyond their ability to adapt. [1] 2022 was Aotearoa New Zealand's warmest year on record, surpassing the record set just the year before. The nationwide average temperature for 2022 was 13.76˚C (1.15˚C above the 1981-2010 annual average, and +0.20˚C above 2021). The top-four warmest years on record have now all occurred since 2016. It was also the warmest year on record in terms of maximum temperatures (+1.08˚C above average) and minimum temperatures (+1.22˚C above average). Data from NIWA's seven-station series that began in 1909 also shows that no months in 2022 were below average (more than 0.50°C below than the monthly average), and ten out of twelve months were above average (+0.51°C to +1.20°C above the monthly average) or well above average (>1.20˚C above the monthly average).[2]
Greenhouse gas emissions	In the year ended June 2021, total gross emissions of greenhouse gas emissions in Masterton District were 785,873 tCO2e (tonnes of carbon dioxide equivalent). [3] Agriculture is by far the largest emitting sector, representing 81% of total gross emissions. Most of this (62 of the 81%) came from enteric fermentation (methane released from the digestive process of sheep, cattle, and other ruminant animals). Other agricultural sources of emissions were unmanaged manure from grazing animals on pasture (9 of the 81%) and leaching and deposition from manure, urine, and fertiliser (6 of the 81%). Transport is the second largest emitting sector, representing 12% of total gross emissions. Almost all of this was from on-road petrol and diesel use (9 of the 12%) and off-road petrol and diesel use (1 of the 12%). Diesel for rail travel accounted for less than 0.1%. Other emissions were from stationary energy (4%) and waste (2%).

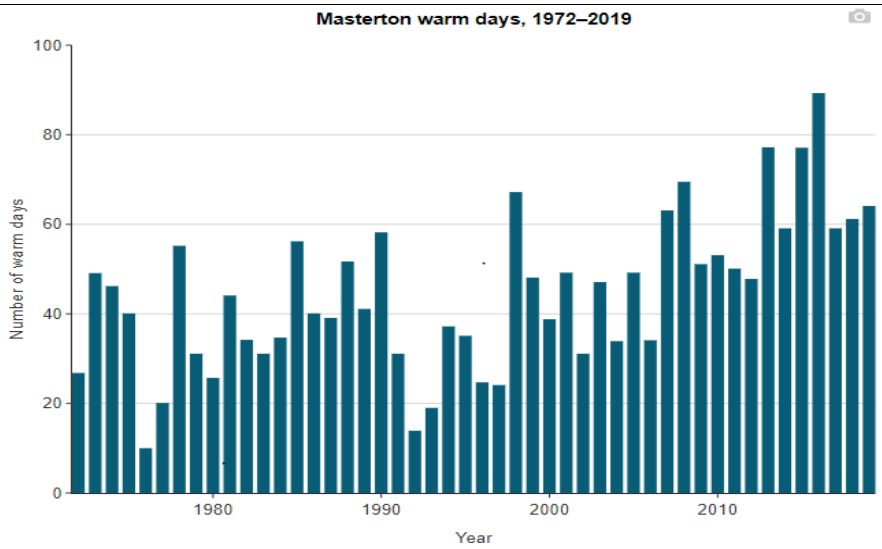
[1] IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA

[2] See https://niwa.co.nz/climate/summaries/annual-climate-summary-2022

[3] AECOMM, 2023: Masterton District Emissions Inventory 2021/22. For Greater Wellington Regional Council.

	Gross emissions decreased by 6% from 2018/19 levels, despite a population increase of 8%. It is likely that most of the decrease is explained by the impact of COVID-19 lockdowns.
Scenarios	The National Institute of Water and Atmospheric Research (NIWA) Climate Change Report is predicting that the Wairarapa Region is likely to warm significantly in the lifetime of the current generation. It is predicted that annual hot days (>25°C) may increase from 24 days currently to up to 80 days by 2090. For more see http://www.gw.govt.nz/assets/Climate-change-2/FINAL-WellNCC-projectionsimpacts.pdf We are using the NIWA modelled regional climate change projections (known as the Whaitua tables). The scenarios are expressed as a range, from lower emissions to higher emissions for a number of climate related parameters. https://www.gw.govt.nz/assets/Uploads/WhaituaClimateChangeprojectionsMarch2020.pdf All of the Wellington Region councils agreed to use these projections as the basis for the LTP 2024-2034 climate change assumptions. NOTE: It is not possible to reduce the mid-century warming, due to the amount of carbon dioxide already accumulated in the atmosphere. The projections for mid-century are already 'locked in'.
'Scenarios at Glance'– expressed as a range lower to high emissions[4] (for detail see the Whaitua tables)	
	For average annual temperatures projected lower range 0.7 °C warmer above present by 2040 and 1.2 °C warmer by 2090; and for higher range 1.0 °C warmer by 2040 and 3.0 °C warmer by 2090 above present. By 2040, up to 30 more hot days per year (>25°C) and by 2090 up to 80 more hot days for inland Wairarapa. **About a third of the warming predicted for mid-century has already happened in our region.** From *Our Atmosphere and Climate 2020* report https://www.mfe.govt.nz/sites/default/files/media/Environmental%20reporting/our-atmosphere-and-climate-2020-report.pdf

[4] Low - RCP4.5 mid-range scenarios where greenhouse gas concentrations stabilise by 2100.
High - RCP8.5 is a high concentration scenario where the GHG emissions continuing very high. In the light of new technologies and improvements it still remains a valid way to test the sensitivity of the climate variables.

	 Data source: NIWA National Climate Database from 30 climate stations. https://www.stats.govt.nz/indicators/frost-and-warm-days
	Rainfall will vary locally within the Wairarapa region. The largest changes will be for particular seasons rather than annually. Heavy/extreme rainfall is likely to increase especially for the end of century. The increased temperatures will have greater impact on the evapotranspiration. The predicted changes in temperature will make a significant difference to the hydrological systems and water availability meaning that it will get a lot drier even if the average rainfall doesn't change significantly.
	Up to 15 fewer frost days (below 0°C) by 2040; and up to 40 fewer frost days in inland Wairarapa by 2090.
	Change in the intensity of the wind: up to 3% increase by 2040 and up to 4% by 2090. Change in annual number of windy days: up to 4 days by 2040, and up to 12 days by 2090.
	Sea level rise: projected lower to higher range is 0.12 to 0.24 metres above present by 2040 and 0.12 to 1.75 metres by 2090.
Level of uncertainty	The level of uncertainty is low especially for the projections for mid-century. About a third of the warming predicted for mid-century has already happened in our region. The biggest uncertainty is the rate of future global GHG emissions, which are influenced by the human factor e.g. social, economic and environmental policies and development. The big unknown is the scale and pace of human actions. How much and how fast we change our behaviour will have an impact on the end of the century predictions, as well as whether policies, developments, and

	changing behaviour stabilize the climatic changes that are already in motion.
Risks	The greatest risk relates more to our readiness and willingness to respond, and to respond at a rate and to an extent that will reduce GHG emissions. Climate Change has the potential to increase the frequency and intensity of natural hazard events that already occur. Adaptation can help reduce our vulnerability and increase our resilience to natural hazards. Our efforts to mitigate the economic impacts of the COVID-19 pandemic provide us with an opportunity to base our recovery on a low carbon economy and to take consideration of equity and intergenerational impacts.
Financial and other implications	If we continue BAU – i.e. no action or action to reduce GHG emissions is too late – the warming trends already observed will continue. This will have far-reaching impacts on fresh water, biodiversity, productivity, and our resilience against increasing climatic changes and weather extremes: • Vulnerable infrastructure, supply chains, and lifelines • Coastal inundation • Saltwater intrusion to fresh water aquifers • Increase in human heat stress and impact on wellbeing • Stress on terrestrial and aquatic ecosystems and associated impacts on health and economy • Risk to water supply catchments • Water shortages becoming a norm • Energy, food, and other cost increases • Decrease in water quality impacts on biodiversity, recreation, and drinking water • Reduced soil fertility • Changes to timing of seasonal activities e.g. flowering, breeding • Increase in pests and diseases e.g. wasps, fruit flies • High stress on native species, extinction of some species • Ocean acidification, decline in fish population • Impacts on insurance and financial system. By thinking how each decision we make increases or decreases GHG emissions and contributes to the overall GHG emissions, and by acting now we are playing our part in meeting Aotearoa's carbon zero 2050 target. The following are the tools and methodologies that we are either progressing or considering: • Reducing carbon emissions • Embedding carbon emission considerations in our BAU • Energy efficiency and innovative approaches • Climate change adaptive planning framework • Water resilience • Work with other regional TAs and the regional council on getting the best and latest science and information • Engage with our community on adaptation.

	Carbon price: The Emissions Trading Scheme is the central government's main mechanism to reduce greenhouse gas emissions. Under the Scheme new NZUs (emissions units) are auctioned by the Government and there is a secondary market. Major emitters (except notably agriculture) must purchase NZUs to cover their current or future emissions. It is currently planned that agriculture will join the ETS in 2025. The current price for NZUs is about $70 per tonne (November 2023). The Climate Change Commission released data in 2021 indicating prices need to be over $138 per tonne by 2030 and over $250 per tonne by 2050 to encourage the required reduction in emissions to meet the Paris Accord obligations. A doubling of the carbon price within the term of this Plan and a quadrupling by 2050 will have cost implications for goods and services purchased by the Council, and could drive significant changes in the behaviour of our community and in their demands for Council services. For example in the Roading activity, fossil fuels are a significant cost factor for roads and footpaths, and higher fuel prices could result in a switch by many households to more active modes of transport and an increase in demand to accommodate walking and cycling, and for more devolved services. *Financial Implications:* If climate change results in changes that are more significant, or which continue to occur sooner than currently predicted, then this could place strain on some of Council's core infrastructure e.g. water supplies and our stormwater system. If infrastructure needs to be upgraded sooner than planned, then this may result in unbudgeted expenditure which could result in an increase in borrowing, the use of Council reserves or an increase in rates. The cost of doing nothing, or responding too late, will be greater, presenting risks for Council assets and service delivery, our economy and our community.
What are we doing to reduce that risk?	• Our Asset Management Plans and Infrastructure Strategy have considered the impacts of these assumptions on our infrastructure over the next 30 years. They consider the scenarios and they projections as a range, as expressed in the Whaitua tables. • Regional Climate Change Rosl Assessment • Regional Emissions Reduction Plan • Regional Food System Strategy • Participating in the National Climate Change Network • Developing an organisational carbon footprint • Focusing on energy efficiency • Increasing our EV fleet • Promoting waste minimisation • Implementing a corporate carbon emissions reduction plan • Implementing a community-focused climate action plan for Masterton District

PART 2A – Whaitua Tables

		Ruamāhanga Whaitua		Wairarapa Coast Whaitua		
	Scenarios	**2040**	**2090**	**2040**	**2090**	**Impacts**
Temperature and seasonality	**Average annual temperature**[5] will rise above present	+0.7°C to 1°C above present	+1.2°C to +3°C above present	+0.5°C to 1°C above present	+1°C to +3°C above present	• Increased human heat stress and mental health issues, rurally and in urban centres • Increased temperatures in urban centres due to human activities, large areas of concrete, buildings and vehicles • Increased risks of pests (such as wasps, rodents and fruit flies) and diseases (including risks to human health) and biodiversity losses • Reduced workplace productivity • Increased air pollution and seasonal allergies • Higher demand for drinking water at times when water is likely to be scarcer • Stress on ecosystems and associated impacts on health and economy • Range and habitat of native plants and animals will change- extinction of some species • Higher temperatures may allow for different crops to be grown. • Timing of seasonal activities such as flowering, breeding and migration will change.
	More very hot days (above 25°C) per year	Between 0 and 30 days increase	Between 0 and 80 days increase	Between 5 and 30 days in- crease	Between 15 and 60 days increase	
	Fewer frost nights (below 0°C) per year	Between 0 and 15 days reduction	Between 0 and 40 days reduction	Between 0 and 5 days reduction	Between 0 and 15 days reduction	
	Seasonal change in temperature	Maximum warming in autumn and summer for both whaitua. Least in winter for Ruamāhanga and least in spring for Wairarapa coast.				
Wind	**Change in the intensity of wind during windy days (>99th percentile of daily mean)**	0% to 3% increase	1% to 4% increase	0% to 3% increase	1% to 4% increase	• More frequent damage to trees, buildings and power lines • Will increase fire risk during hot, dry periods
	Change in annual number of windy days Extreme wind events are likely to increase	0 to 4 days increase	0 to 12 days increase	0 to 6 days increase	0 to 10 days increase	
Rainfall patterns and intensity	**Average annual rainfall**	5% decrease to 5% increase	0% to 10% decrease	5% de- crease to 5% in- crease	10% de- crease to 5% increase	• Increased prevalence of drought delivering urban and rural water shortages, and increased pressure on water infrastructure, including water storage • Saltwater intrusion on groundwater

[5] Uncertainty range: lower range for significant emissions reduction (Paris agreement targets met), and upper range for high emissions.

	Amount of rain falling during heavy rainfall days (> 99th per- centile of daily rainfall)[6]	0% to 10% increase	0% to 20% increase	0% to 15% increase	0% to 30% increase	• Decreased water quality and increased levels of toxic algae which impacts biodiversity, recreation and drinking water sources • Increased flooding, slips and landslides affecting land, houses, roads and other assets, public transport and rural productivity • Flood protection infrastructure Levels of Service reduced overtime • Impacted rural community due to reduced agricultural production • Reduced soil fertility • Regional parks negatively affected by both drought and flooding • Higher stress on indigenous ecosystems, plants and animals, especially with drought • Several fold increase in urban and rural wildfire risk – a particular concern for water supply catchments which may be rendered unusable for up to a year following a major wildfire
	Extreme rainfall magnitude: 6-12-hour duration, 100-year Average Recurrence Interval (normally used as reference for flooding design, referring to very extreme, infrequent rainfall events)[7]	8% to 12% increase	14% to 36% increase	6% to 12% increase	12% to 36% increase	
	Change in rivers mean annual flood discharge (MAF) Measures flood potential in the catchments	Between 20% de- crease and 40% increase depending on catchment	Between 20% de- crease and 60% in- crease de- pending on catchment	Between 20% de- crease and 20% in- crease de- pending on catchment	Between 20% de- crease and 60% in- crease de- pending on catchment	
	Change in rivers mean annual low flow discharge (MAL) Measures water shortage in the catchments	Decrease up to 60%	Decrease up to 80%	Decrease up to 60%	Decrease up to 80%	
	Change in annual growing degree days base 10 Measures potential for crop and pasture growth	Increase be- tween 0 and 300 GDD units	Increase be- tween 200 and 1000 GDD units	Increase between 0 and 300 GDD units	Increase be- tween 200 and 900 GDD units	
	Change in annual potential evapotranspiration deficit (mm) Measures drought intensity	Increase be- tween 20 and 120 mm	Increase be- tween 0 and 180 mm	Increase between 40 and 120 mm	Increase be- tween 40 and 160 mm	
	Changes in number of days of very high and extreme forest fire danger[8]	100% to 150% in- crease	100% to 150% in- crease	100% to 150% in- crease	100% to 150% in- crease	
Seal level rise and coastal hazards	**Seal level rise**[9]	0.12 to 0.24 metres above pre- sent	0.68 to 1.75 metres above pre- sent	0.12 to 0.24 metres above present	0.68 to 1.75 metres above pre- sent	• Increased coastal inundation with some areas to become permanently inundated • Saltwater incursion into freshwater habitats • Difficulty in obtaining insurance due to sea level rise and increasing frequency of flood events for community, business and central and local government
	More frequent storm surge (temporary raising of sea level during storms) more frequent and intense coastal flooding and coastal erosion					

[6] There is a large uncertainty in the range of changes due to model differences and emission scenarios. Changes against emission scenarios are not necessarily linear. Greater likelihood of increases in autumn, winter and spring

[7] Although the uncertainty in average rainfall range is high, extreme rainfall increases are more certain due to the increased amount of water vapour that the atmosphere can hold as it gets warmer (about 8% increase in saturation vapour per degree of warming).

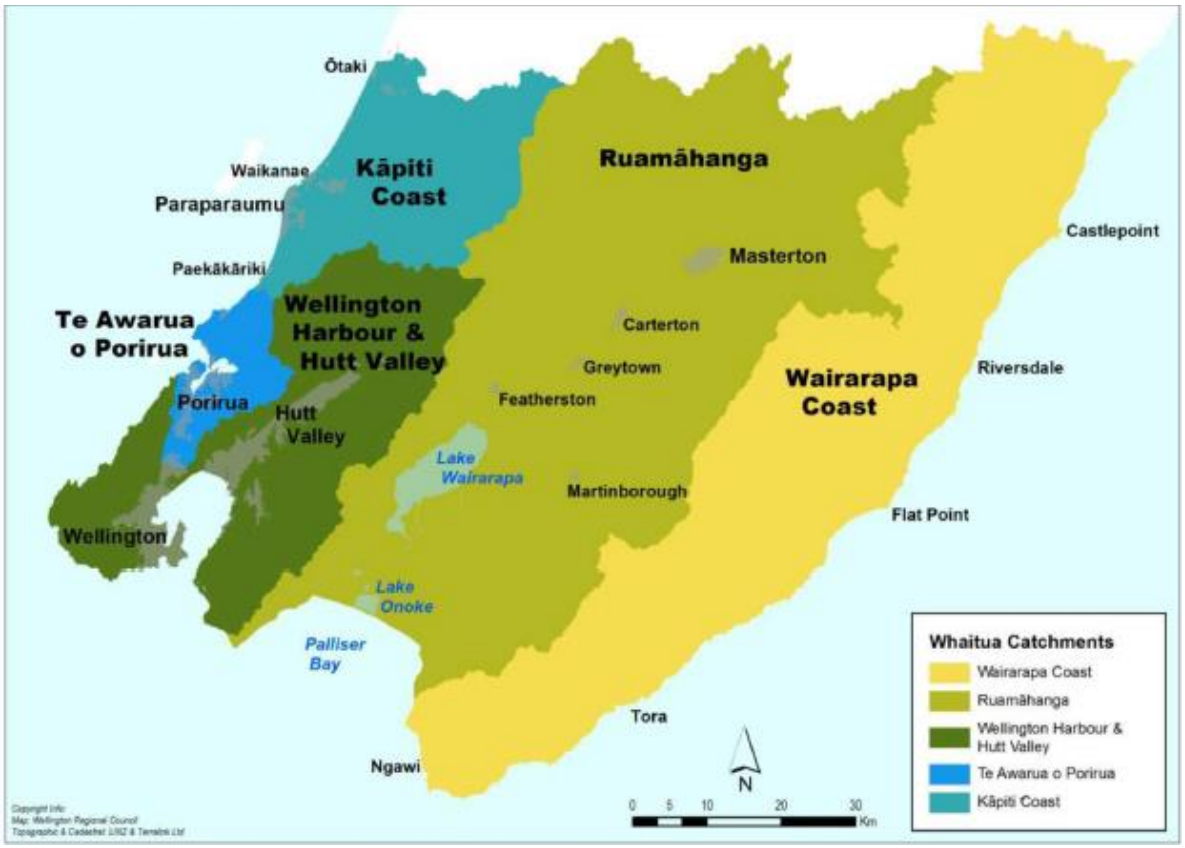
[8] These figures are given by IPCC model averages. Individual models can show much higher increases of up to 700%

[9] The projected sea level rise for 2090 is based on IPCC AR5 plus an estimated additional contribution from Antarctica, based on papers published in Nature in 2018. Note the difference between pre- sent and pre-industrial, as we have already had about 26cm of sea level rise so far.

More regular storm events in the fragile coastal environment may also mean faster and more significant coastal retreat. See the link below for climate change, sea level rise and storm surge maps for the Region:
https://mapping1.gw.govt.nz/gw/ClimateChange/

	Saltwater intrusion into coastal groundwater, and further upstream in rivers					
Oceanic changes	Acidification of the ocean General temperature rises of sea water. Marine heatwaves					• Altered marine ecosystems, particularly affecting hard shelled species • Extinction of some species • Changes to the range of species, location and abundance of fish and sea birds around NZ • Impacts on aquaculture and fishing industries • Reduced recreational benefits

Wellington Region Whaitua



http://www.gw.govt.nz/assets/Climate-change/GWRC-NIWA-climate-extremes-FINAL3.pdf

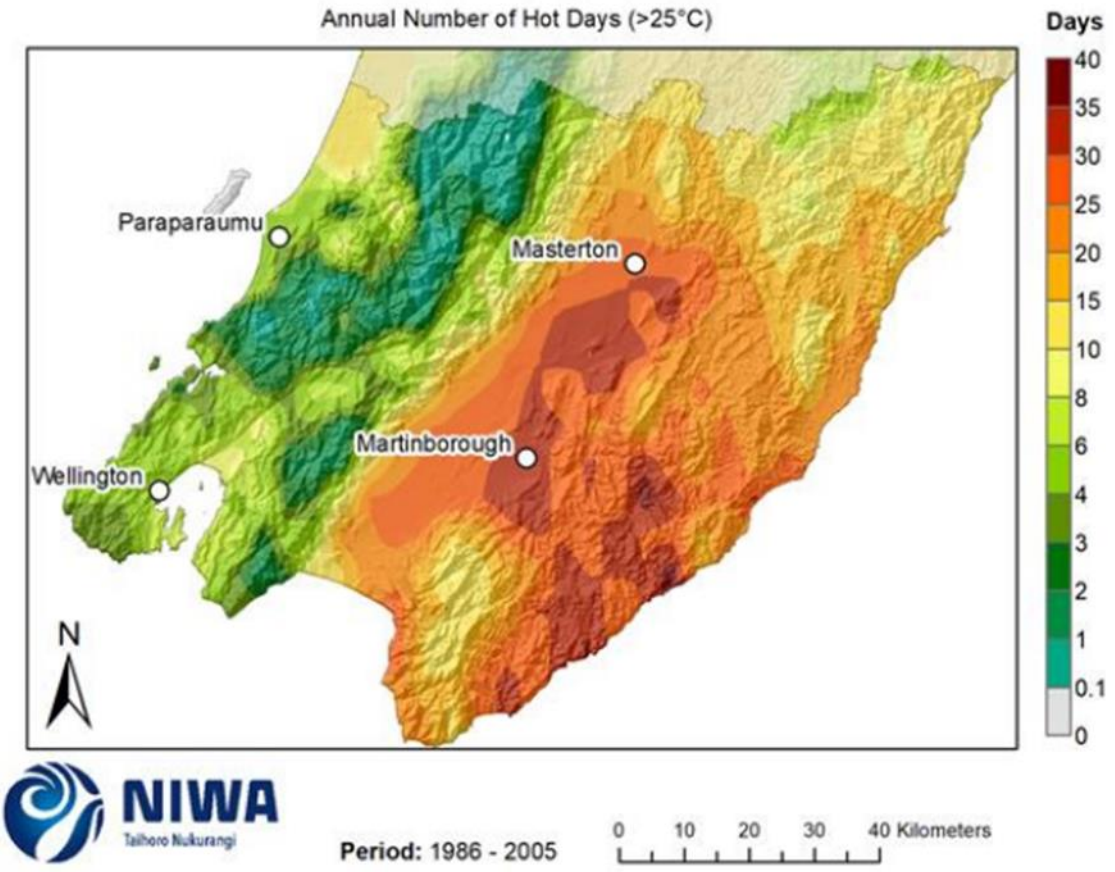


Figure 3-7: Modelled annual number of hot days (maximum temperature > 25°C), average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

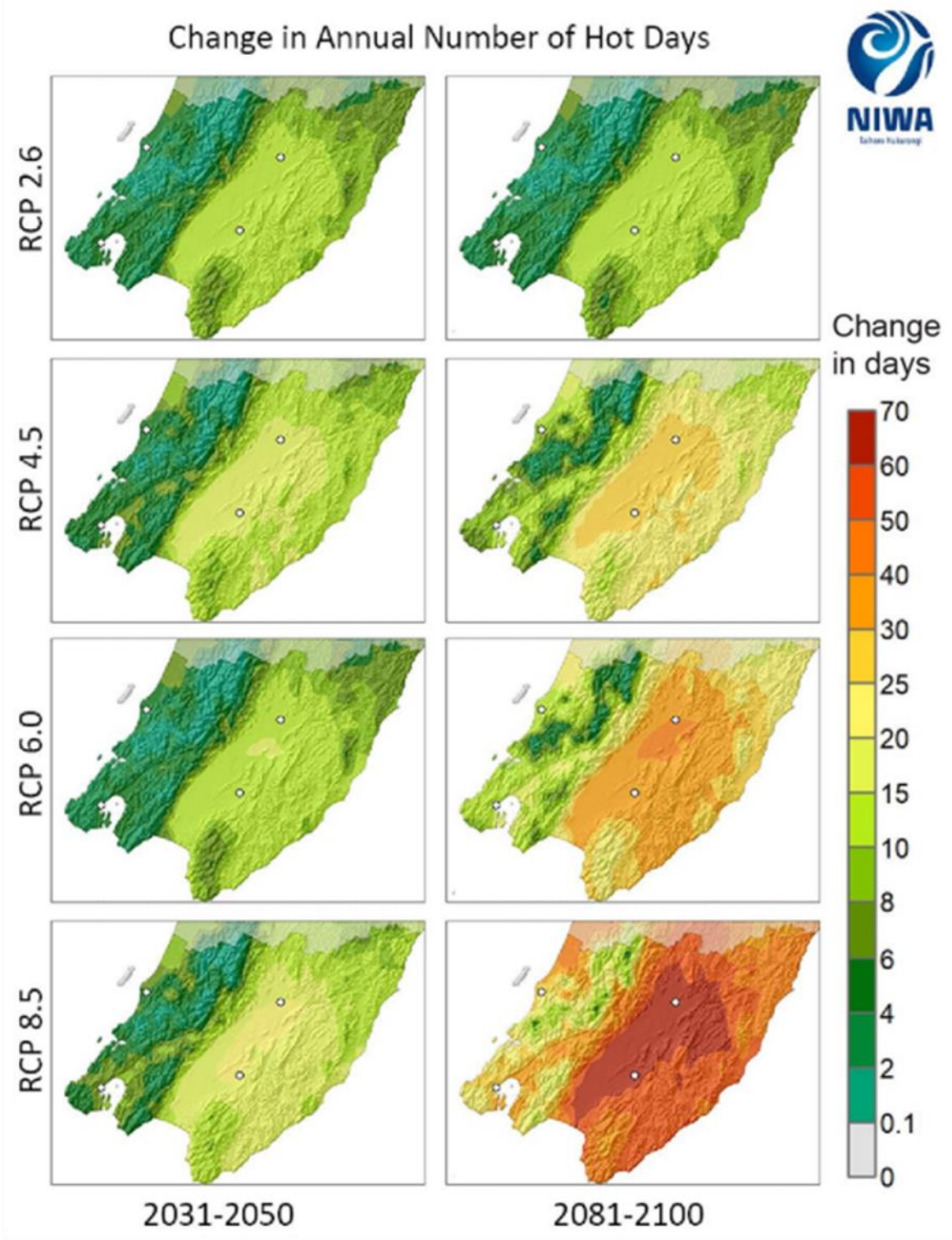


Figure 3-8: Projected annual hot day changes (max temperature > 25°C) at 2040 and 2090. Relative to 1986-2005 average, for four IPCC scenarios, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

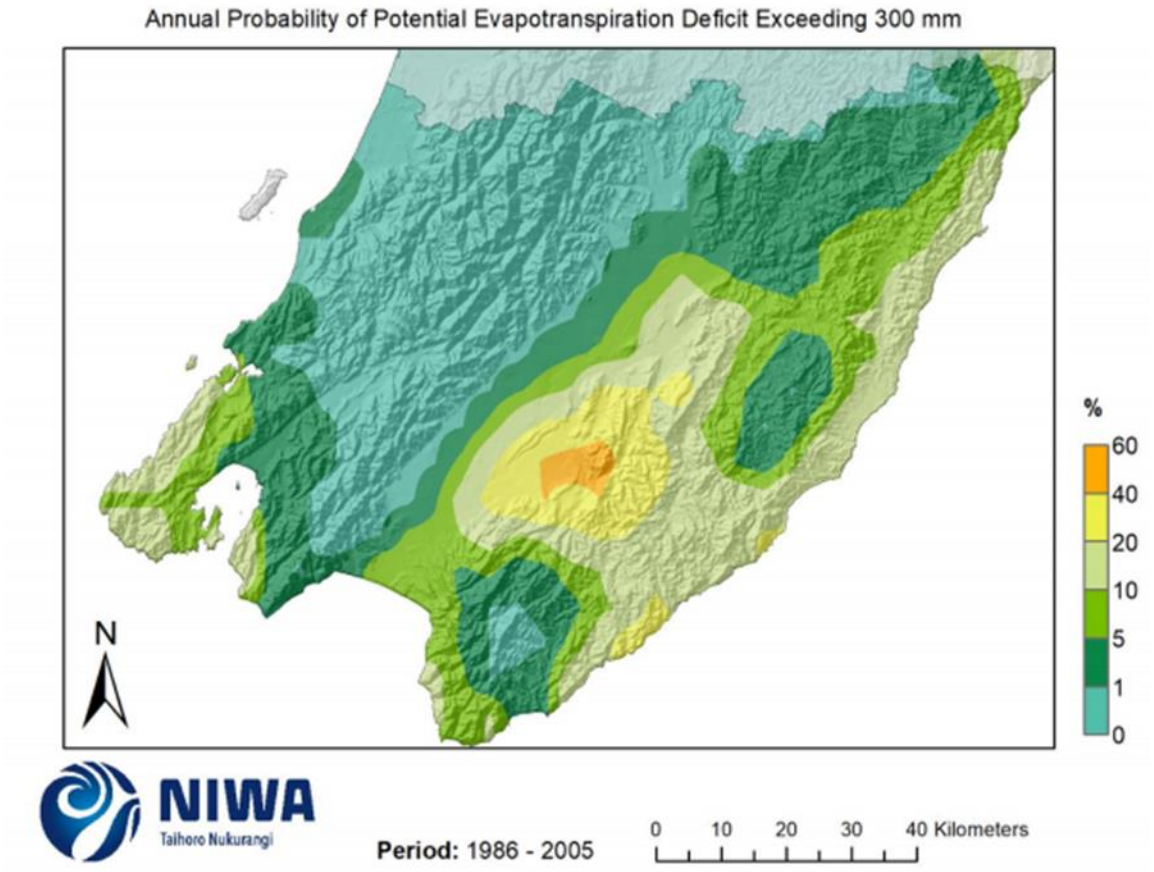


Figure 5-8: Modelled probability of Potential Evapotranspiration Deficit exceeding 300 mm in any year, average over 1986-2005. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.

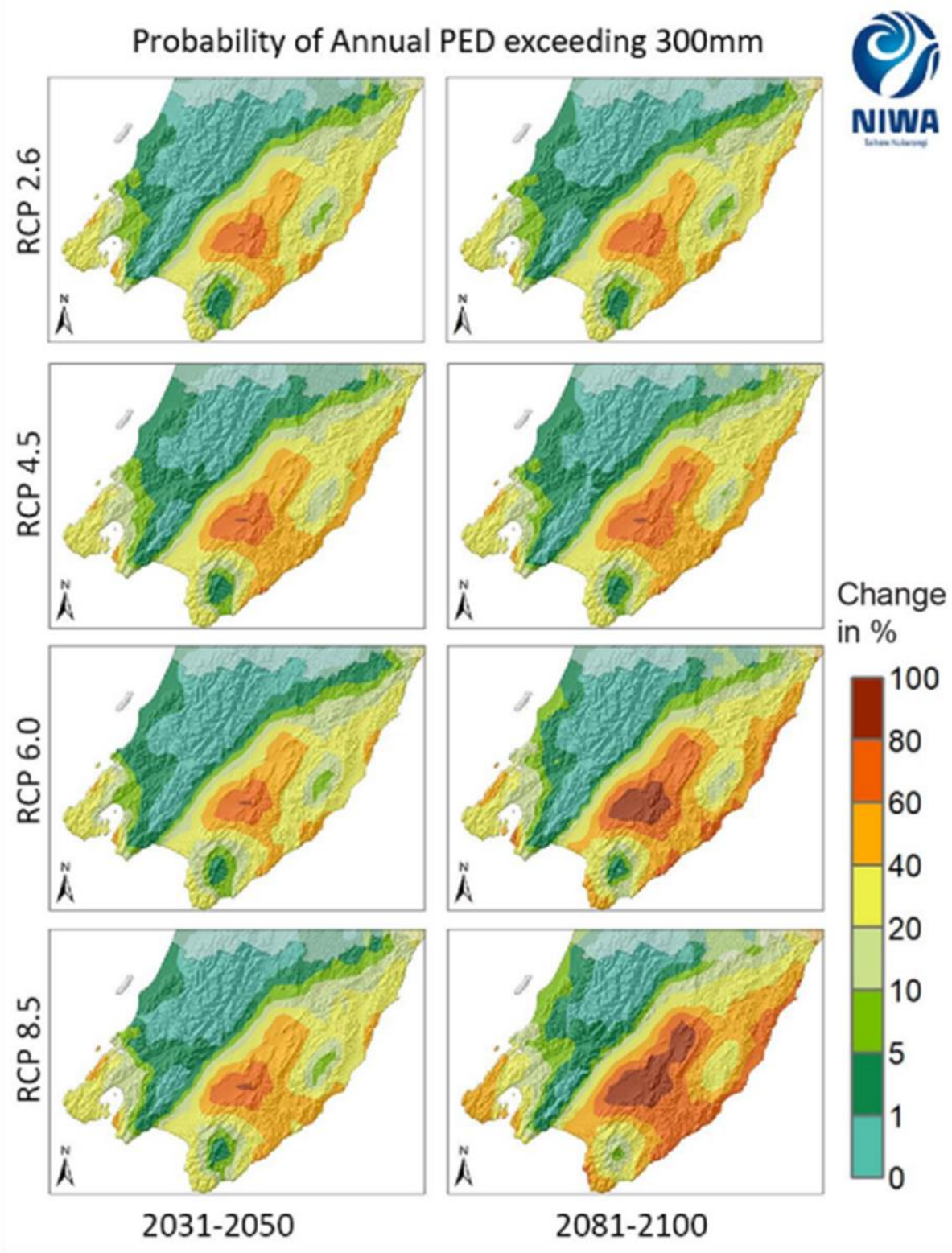


Figure 5-9: Projected probability of annual Potential Evapotranspiration Deficit exceeding 300 mm by 2040 and 2090. Relative to 1986-2005 average, for four IPCC scenarios, based on the average of six global climate models. Results are based on dynamical downscaled projections using NIWA's Regional Climate Model. Resolution of projection is 5km x 5km.