Zone 6: Regional snapshot of projected climate changes and hazards

Western and southern South Island (Te Wai Pounamu) – covers the West Coast, Fiordland, Southland and Stewart Island (Te Punga o Te Waka ā Māui) and includes the Southern Alps and southern lakes. Includes Canterbury and Otago.

Hazard	RCP 4.5	RCP8.5	Extra information
Higher mean temperatures: air and water	**2040:** Annual average air temp to increase 0.7-0.9˚C; Coastal sea-surface temps to increase ~0.8˚C (7% change).	**2040:** Annual average air temp to increase 1.3-1.4˚C; Coastal sea-surface temps to increase ~1.1˚C (8% change).	- Summer air temperature to warm the most; Spring air temperature the least. - Daily maximum air temperature is expected to increase faster than overnight daily minimum temperature.
	2090: Annual average air temp to increase 1.3-1.4˚C; Coastal sea-surface temps to increase ~1.2˚C (6.5% change).	**2090:** Annual average air temp to increase 2.8-3.1˚C; Coastal sea-surface temps to increase ~2.55˚C (19.5% change).	
Heatwaves: increasing frequency and magnitude	**2040:** Increase 0-20 more hot days/year (>25˚C). Highest in Central Otago; lowest in Fiordland.	**2040:** Increase 0-25 more hot days/year (>25˚C). Highest in Central Otago.	- No data available yet for *Heatwaves >25˚C (3 consecutive days)* or *Extreme Heatwaves* >30˚C *(3 consecutive days)*. - 40-100% increase in hot days (>25˚C) across New Zealand (RCP4.5, ~2050). - 40-300% increase in hot days (>25˚C) across New Zealand (RCP4.5, ~2100).
	2090: Increase 0-28 more hot days/year (>25˚C). Highest in Central Otago.	**2090:** Increase 0-50 more hot days/year (>25˚C). Highest in Mackenzie; lowest in Fiordland.	
More and longer dry spells and droughts	**2040:** 0-10 fewer dry days/year. Largest reduction on the West Coast. Increase in Potential Evapotranspiration Deficit (PED) of 0-50mm in most areas. Low river flow threshold reached later in the year for western and southern areas.	**2040:** Dry days/year and PED projections are the same as for RCP4.5. Low river flow threshold reached later in the year for West and South areas.	- The frequency of dry days (<1mm precipitation) increases with time and RCP. - ~10 more dry days/year in inland areas by 2090 (RCP8.5, ~2100). - Decrease of ~5% in relative humidity by 2090 (RCP8.5) - Climate drought severity is projected to increase in central areas (inland Otago), except for West Coast and Southland.
	2090: 0-5 fewer dry days/year in the East, 5-15 fewer dry days/year in the West, and 0-5 more dry days in the interior areas. Increase in PED of 0-50mm for most areas, 50-100mm increase for interior areas. Low river flow threshold reached later in the year for western and southern areas.	**2090:** 15-20 fewer dry days/year on West Coast. 5-15 more dry days/year for much of Southland and Otago. Increase in PED of 0-50mm for most areas, 100-150mm increase for interior areas. Low river flow thresholds to be reached later in the year for western and southern areas.	
Changes in climate seasonality with longer summers and short winters	**2040:** Warming greatest in summer and autumn. Warming least in winter and spring.	**2040:** Warming greatest in summer and autumn. Warming least in winter and spring.	- Spring and autumn frost-free land to at least triple by 2080 (RCP8.5, ~2100).
	2090: Warming greatest in summer and autumn. Warming least in winter and spring.	**2090:** Warming greatest in summer and autumn. Warming least in winter and spring.	
Increasing fire-weather conditions: harsher, prolonged season	**2040:** Increased fire risk. Increase in days with very high and extreme fire danger index from around 0-400%. *Seasonal Severity Rating*: Southland, increase of 50-100%. Lower South Island (excl. Queenstown), increase of 30-50%.	**2040: :** Increased fire risk. Increase in days with very high and extreme fire danger index. *Seasonal Severity Rating*: Coastal Otago, increase of >150%. West Coast areas, little to no change. *Very High + Extreme Fire Danger*: Southland, increase of >150%. Potential for significantly increased number of days of fire risk. West Coast areas show little to no increase.	- Fire season length to increase (RCP4.5 & RCP8.5, ~2100). - Fire season to start earlier and/or finish later (RCP4.5 & RCP8.5, ~2100). - Fire climate severity is likely to rise significantly with climate change in many parts of the country as a result of increases in temperature, wind speed and lower rainfall and/or humidity.
	2090: Increased fire risk. Increase in days with very high	**2090:** Increased fire risk. Increase in days with very high and extreme fire danger index.	

	and extreme fire danger index from around 0-700%. *Seasonal Severity Rating*: Southern South Island, increase of 40-100%. *Very High + Extreme Fire Danger*: Increasing high risk. Lower South Island, increase of >150%.	44-48 more days of fire risk. Dunedin has the highest projected increase of 207%. *Seasonal Severity Rating*: West Coast, increase of >30%. Most areas, increase. *Very High + Extreme Fire Danger*: Most areas, increase of >150%; West Coast areas, increase of 50%.	
Increased storminess and extreme winds and rainfall	**2040:** Extreme wind speeds increase up to 10%. Intensity of (ex)tropical cyclones projected to increase. Rainfall events see righthand column.	**2040:** Extreme wind speeds increase up to 10%. Frequency of extreme winds is likely to increase in winter and decrease in summer. Mean westerly flow of wind to increase ~20% in spring and ~70% in winter; decrease by ~20% in summer and autumn. Intensity of (ex)tropical cyclones projected to increase. Rainfall events see righthand.	- Increases in extreme wind (esp. for southern North Island). - Increases in rainfall intensity projected everywhere. - Moderately extreme daily precipitation (99th percentile of wet days) increases. Very extreme daily precipitation increases in frequency. - Short duration (1-in-100-year, 1hour duration) extreme rainfalls increase +13.6% for every 1˚C increase. Long duration rainfall events (1-in-2-year, 120hour duration) increase +4.8% for every 1˚C increase.
	2090: Poleward shift of mid-latitude and possible small reduction in frequency. The most severe ex-tropical cyclones are expected to be stronger. Intensity of (ex)tropical cyclones projected to increase. Rainfall events see righthand column.	**2090:** Poleward shift of mid-latitude and possible small reduction in frequency. The most severe ex-tropical cyclones are expected to be stronger. Frequency of extreme winds is likely to increase in winter and decrease in summer. Intensity of (ex)tropical cyclones projected to increase. Occurrence conditions conducive to storm development is projected to increase by 3-6%, relative to the period 1970-2000. Rainfall events see righthand column.	
Change in mean annual rainfall	**2040:** Small increase in annual rainfall. Larger increase in winter (e.g. +10% for Hokitika).	**2040:** Increase in annual rainfall of +5-15%. Largest increase in winter of >+20%.	- The largest rainfall changes by ~2100 will be seasonal rather than annually.
	2090: Increase in annual rainfall. Largest increase in winter (e.g. +16% for Hokitika and +19% for Queenstown).	**2090:** Annual rainfall increase (e.g. >+20% for West Coast). Increases in all seasons, especially in winter (>+40% in some areas).	
Reducing frost, snow and ice cover	**2040:** Decrease of 10-25 of frost days for most of South Island. Largest change in absolute snow amounts is along the Main Divide of the Alps. Greatest percentage change is at lower altitudes. Snowline elevation (exceeding 3 months): lifts from 1550m to between 1550 to 1750m. Overall decrease in snow duration for elevations below 2900m: 2000m the mean decrease is 6%; 1000m the mean decrease is 11%; below 1000m the mean decrease is 45%. Average maximum snow water equivalence significantly decreases at all elevations	**2040:** Decrease of 25-50 frost days for high elevations in Southern Alps.	- Much of NZ (outside of alpine areas) to become frost-free under RCP8.5, ~2100 scenario. - Number of frost days decrease is greatest in the coldest regions. - Snowline elevation, duration and snow water equivalence calculated under RCP6.0 scenarios. - No information about snow water equivalent/snow amounts is available yet from IPCC AR5 downscaling yet.

	except for over 2900m: 2000m the mean decrease is 9%; 1000m the mean decrease is 28%; below 1000m the mean decrease is 53%.		
	2090: Decrease of 10-25 of frost days for most the South Island and a decrease of 25-50 for high elevations in the Southern Alps. Largest change in absolute snow amounts is along the Main Divide of the Alps. Greatest percentage change is at lower altitudes. Snowline elevation (exceeding 3 months): lifts from 1550m to between 1700 to 2000m. Overall decrease in snow duration for elevations below 2900m: 2000m the mean decrease is 15%; 1000m the mean decrease is 31%; below 1000m the mean decrease is 76%. Average maximum snow water equivalence significantly decreases at all elevations: 2000m the mean decrease is 26%; 1000m the mean decrease is 57%; below 1000m the mean decrease is 82%.	**2090:** Decrease of 50-75 frost days for Southern Alps. Peak snow accumulation projected to decline by 32-79% at 1000m and 6-51% at 2000m. Snow days/year reduce by 30days or more.	
Increasing hail severity or frequency	- No information available on hail. MfE suggest a potential increase in storm intensity, local wind extremes and thunderstorms. - See also information above for *Increased storminess and extreme winds and rainfall*.		
River and flow changes in frequency and magnitude in rural and urban areas	**2040:** Mean annual flood occurrence slightly increases in most areas.	**2040:** Mean annual flood occurrence slightly increases in most areas; slightly decreases for northern Southland.	- Lower river flows in summer will raise water temperature and exacerbate water quality problems, such as increased algae growth (all RCPs and time frames). - No research yet on changes to large flood flows and return periods – highly uncertain at this point (all RCPs and time frames). - Increases in Mean Annual Flood occurrence affect most agricultural areas, with only slight reductions in other areas. Percentage increases tend to be greater for the more extreme RCPs (i.e. RCP8.5) and late century (i.e. ~2100).
	2090: Mean annual flood occurrence increases, particularly for Southland.	**2090:** Mean annual flood occurrence increases significantly, especially in the south and east of the region. Significantly large increases for much of Otago and Southland.	
Coastal and estuarine flooding: increasing persistence, frequency and magnitude	**2040:** 0.24m SLR	**2040:** 0.28m SLR; 0.37m under RCP8.5+ (allows for ice sheet instability).	- Rising sea levels are expected to cause salinization of groundwater and coastal wetlands. - Exposure to extreme storm tides will increase with further sea-level rise. - Extreme sea levels that are expected to be reached once every 100 years (on average) at present-day MSL, will occur at least once per year or more (on average) by 2050-2070 and will occur earlier in areas will smaller tidal ranges.
	2090: 0.55m SLR	**2090:** 0.79m SLR; 1.05m under RCP8.5+ (allows for ice sheet instability).	
Sea-level rise and salinity stresses on brackish and aquifer systems and coastal lowland rivers	**2040:** SLR trends as per above.	**2040:** SLR trends as per above.	- No information about projections for salinization of aquifers, except that this will increase under higher levels of SLR. - Changes to salinity will also depend on rainfall and runoff patterns.
	2090: SLR trends as per above.	**2090:** SLR trends as per above.	

<table>
<tr><td>Increasing coastal erosion: cliffs and beaches</td><td colspan="3">- Land subsidence will exacerbate the effects of SLR.
- Highly variable erosion, depends on geology, tidal range, geomorphology and exposure.
- Areas with small tidal range more sensitive to erosion than large tidal range. Eastern coasts more sensitive than western coasts.</td></tr>
<tr><td>Increasing landslides and coastal erosion</td><td colspan="3">- Increase in landslides and erosion with increasing rainfall intensity. Increased fire risk will exacerbate soil erosion.
- Increased risk of sheet erosion (exacerbated by increased rainfall and runoff)
- Bank erosion may increase with increasing river flows.
- Wind erosion may increase in susceptible areas, particularly in areas which will become drier and windier.</td></tr>
<tr><td rowspan="2">Marine heatwaves: more persistent high summer sea temperatures</td><td>2040: Southwest Pacific summer sea temperature (SST) increases by ~0.8˚C.</td><td>2040: Southwest Pacific SST increases by ~1.0˚C.</td><td rowspan="2">- Marine heatwaves projected to increase in frequency and intensity with ongoing atmospheric and ocean warming (i.e. RCP4.5 & RCP8.5 for ~2050 & ~2100).
- Proportional SST warming of 16-20% for most New Zealand marine areas.
- Warming lowest in southern waters.</td></tr>
<tr><td>2090: Southwest Pacific Sea SST increases by ~1.1˚C.
Tasman Sea SST exceeds ~3.0˚C.</td><td>2090: Southwest Pacific Sea SST increases by ~2.5˚C.
Tasman Sea SST exceeds ~3.1˚C.</td></tr>
<tr><td rowspan="2">Ocean chemistry changes: nutrient cycling and pH change</td><td>2040: pH: 7.98 for SW Pacific (decrease of 0.12).
No significant decrease in surface macronutrient concentrations and net primary production.
Particle flux change: -3.1%</td><td>2040: pH: 7.93 for SW Pacific (decrease of 0.18).
No significant decrease in surface macronutrient concentrations and net primary production.
Particle flux change: -6.7%</td><td rowspan="2">- Reduction in surface mixed layer depth, macronutrients, net primary production, chlorophyll-a. Reductions increase with time and RCP.
- Largest macronutrient declines in the eastern Chatham Rise and sub-Antarctic waters.
- Largest increase in dissolved iron in subtropical waters.</td></tr>
<tr><td>2090: pH: 7.98 for SW Pacific (decrease of 0.12).
Mixed layer depth to decrease by a mean of 6m. Significant decrease of surface macronutrient concentrations. Net primary production to decrease ~1.2%.
Particle flux change: -7.8%.</td><td>2090: pH: 7.77 for SW Pacific (decrease of 0.33).
Decreases in surface mixed layer depth (15%), macronutrients (7.5-20%), net primary production (4.5%), and particle flux (12%).
Particle flux change: -12.6%</td></tr>
<tr><td>International influences</td><td colspan="3">Findings from Royal Society report on Climate Change Implications for NZ (non-specific timeframes, region or RCP)
- All aspects of food security are potentially affected by climate change, including food access, utilisation, and price stability.
- Climate change over the 21st Century is projected to increase the displacement of people.
- Climate change can indirectly increase risks of violent conflicts in the form of civil war and intergroup violence by amplifying well-documented drivers of these conflicts such as poverty and economic shocks.
- The impacts of climate change on critical infrastructure and the territorial integrity of many states are expected to influence national security policies.
- While NZ agriculture could benefit from increasing global commodity prices in the long term, there are many negatives.
- We gain significant revenue from long-haul tourism which could be reduced if the acceptability of long-haul travel, and costs of fossil fuels, are affected by climate change.</td></tr>
<tr><td colspan="4">Useful resources:
Climate change projections for the Otago Region (Macara et al. 2019)</td></tr>
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