



Climate change impacts on water and wind in NZ energy modelling

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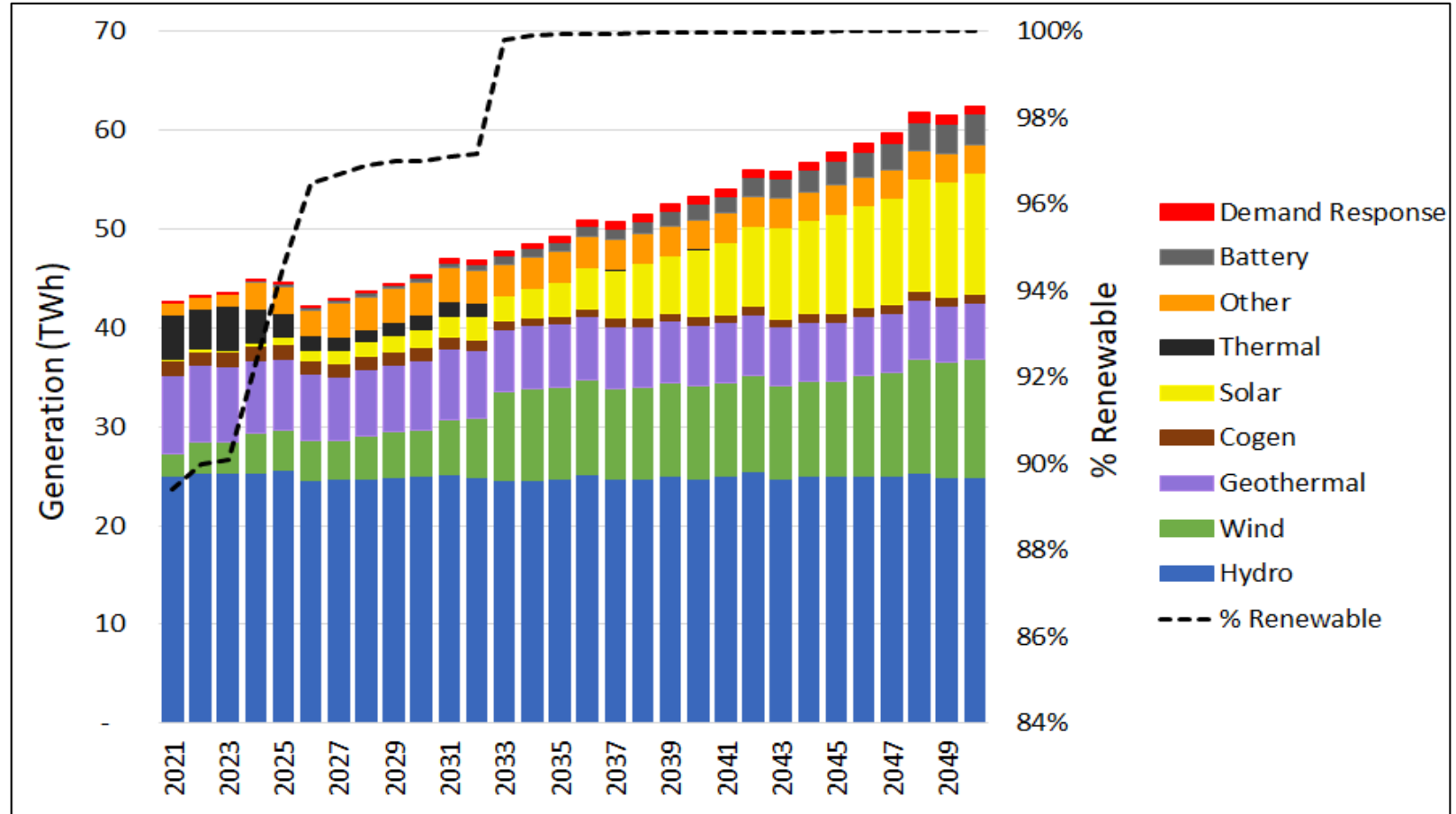
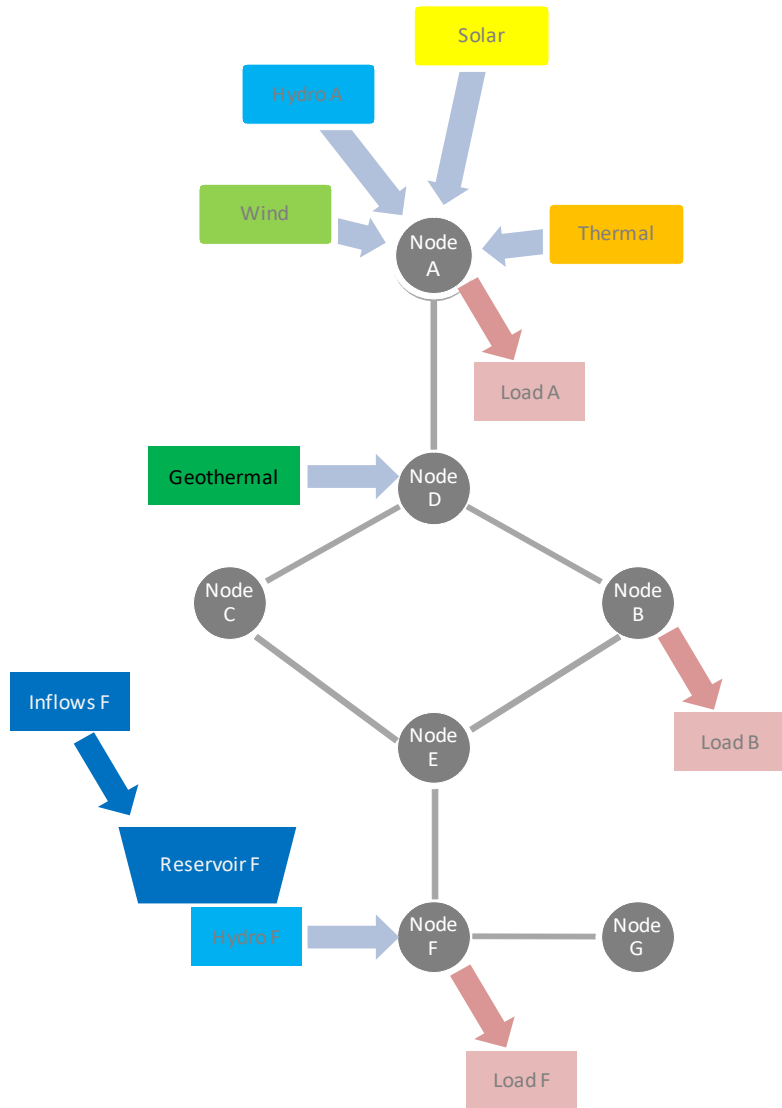
Collaborators: Dr Christian Zammit and Dr Richard Turner, NIWA;
Dr Michael Jack and Prof Janet Stephenson, University of Otago



Overview

1. Dominance of hydro inflows and storage in NZ electricity system modelling
2. Can we use historical hydro and wind records to represent variability in future energy modelling? - changes to hydro inflows and wind speeds over time
3. Future hydro inflows and wind projections
 - Mid-range emissions scenarios
 - High range emissions scenarios
4. Impacts on modelling from changes to wind and water – mid-range emissions, storage and spill impacts
5. Adjustments for energy modelling hydro inflow data, to incorporate climate change
6. High emission scenario hydro inflow modelling – initial results

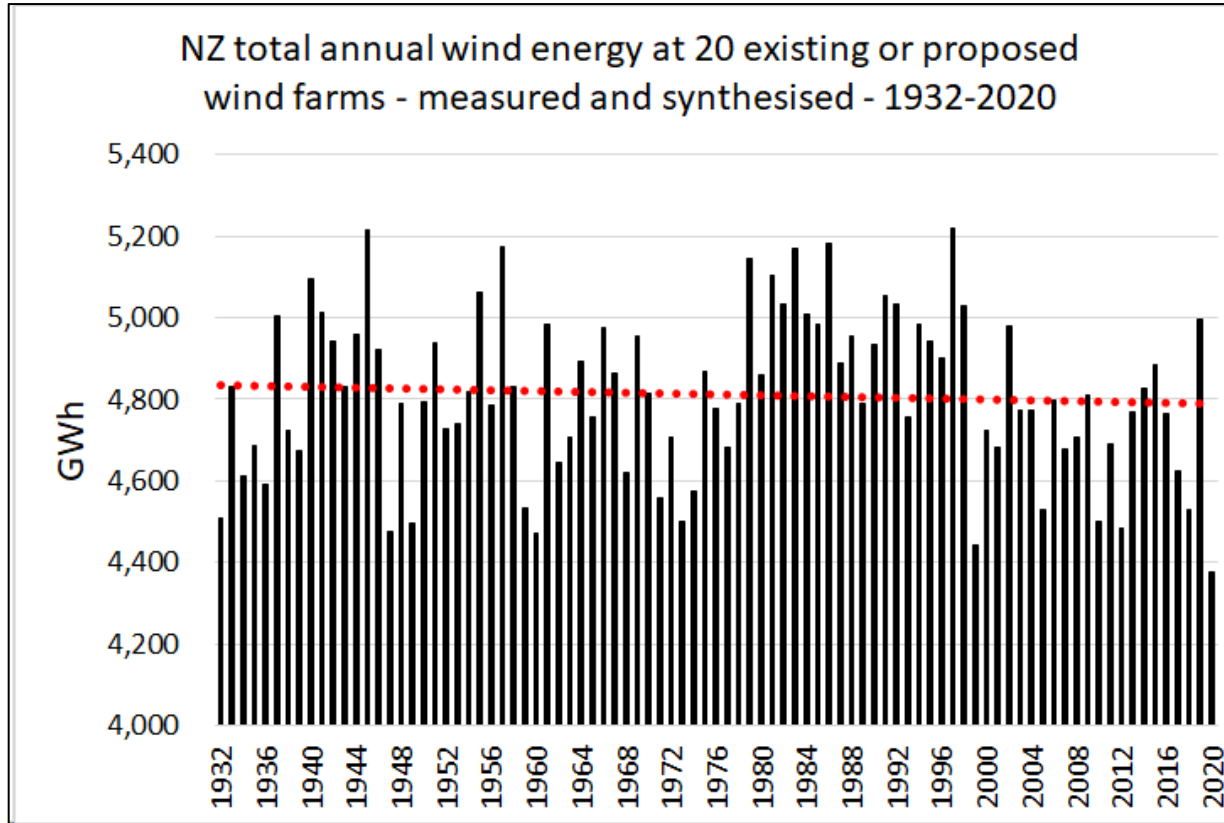
1. Dominance of hydro in NZ energy system modelling



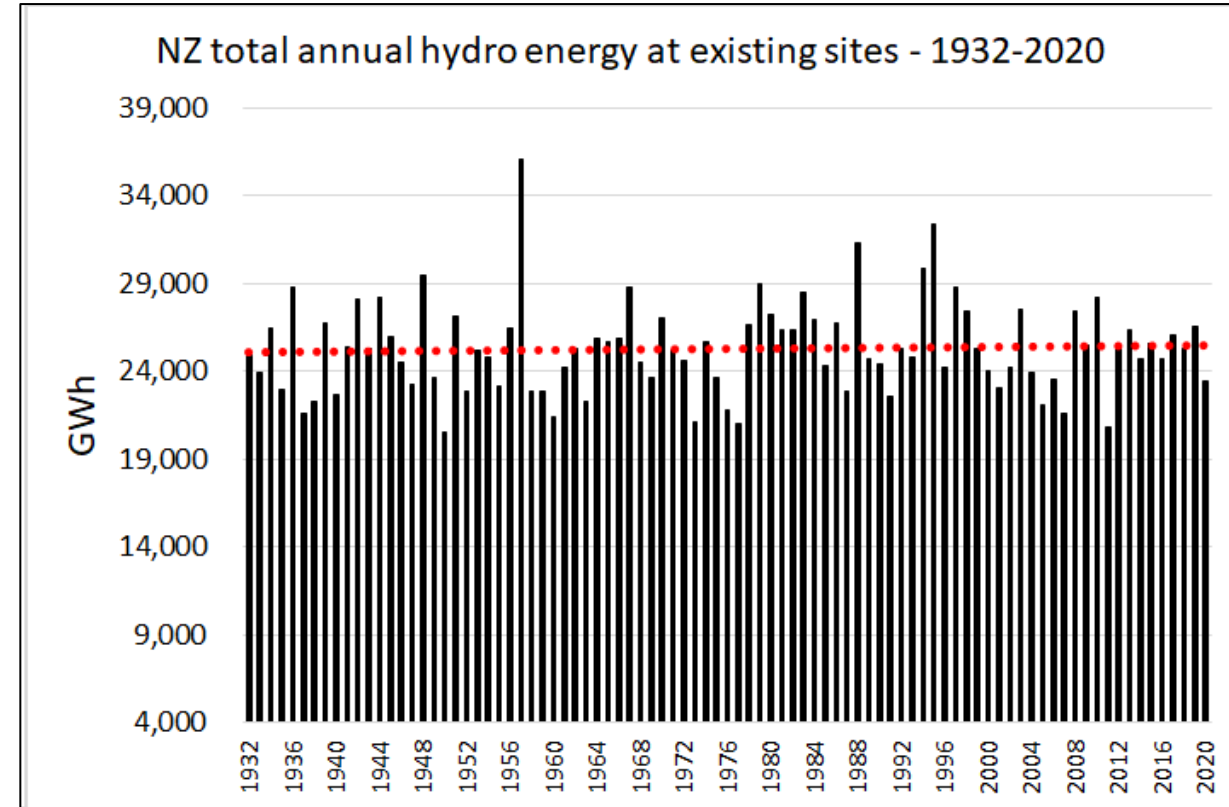
2. Can we use historical hydro and wind records to represent variability in future energy modelling?

- changes to hydro inflows and wind speeds over time
- Is the past a good model for the future?

2. Can we use historical hydro & wind records to represent variability in future modelling

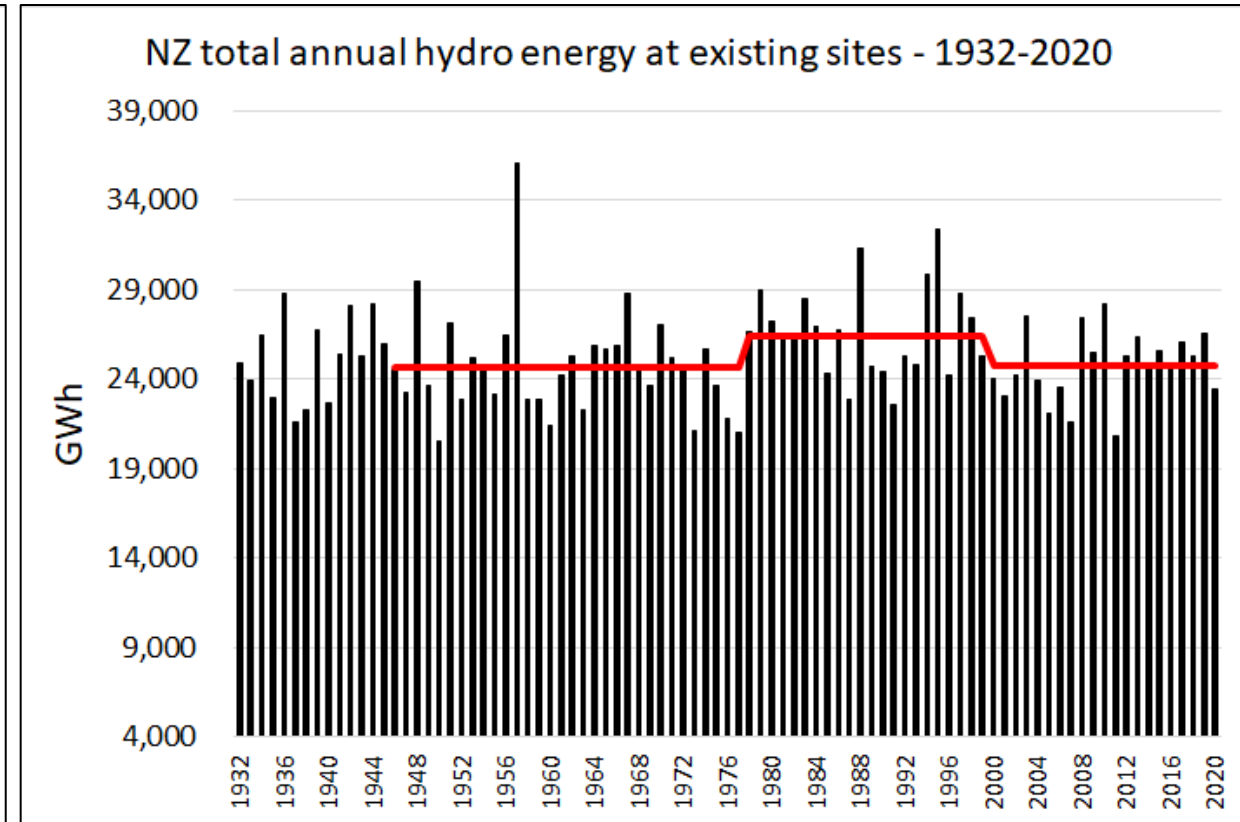
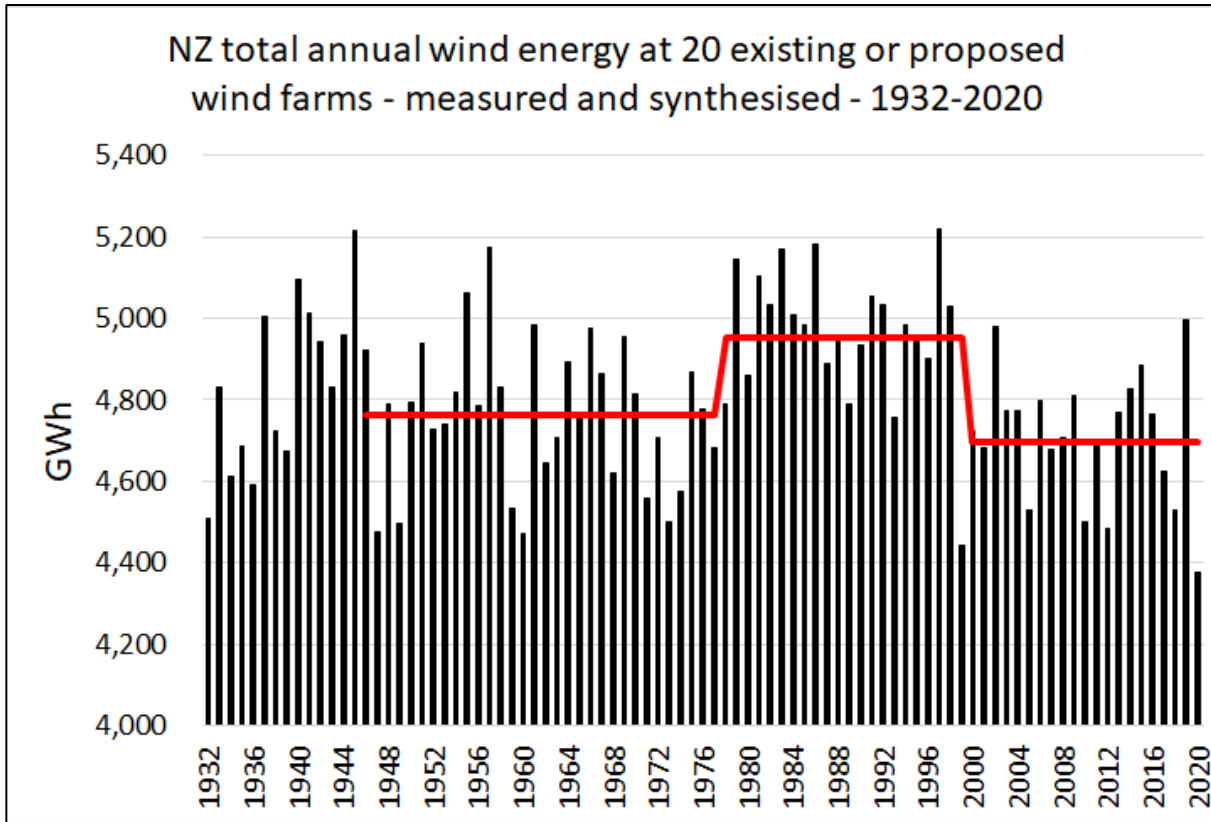


- 2% decrease in wind speed - long term linear trend
- Variability high, not significant



- 2% INCREASE - long term linear trend

2. Can we use historical hydro & wind records to represent variability in future modelling

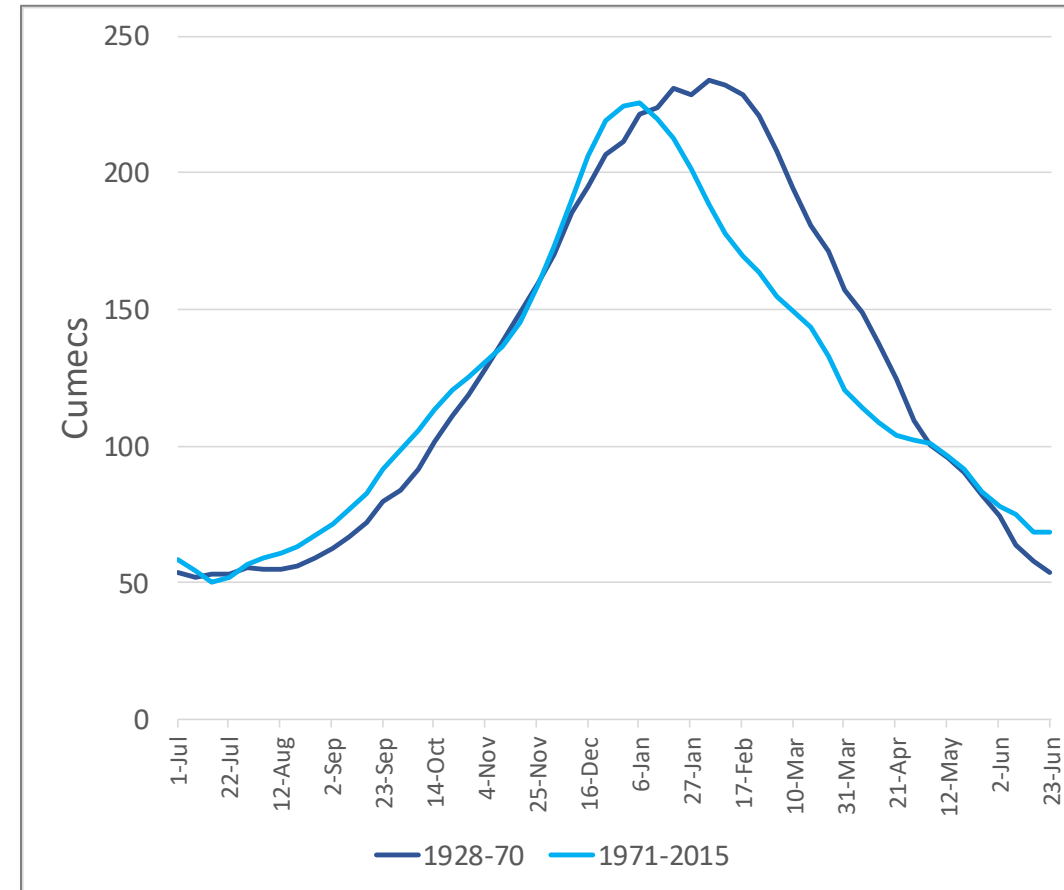
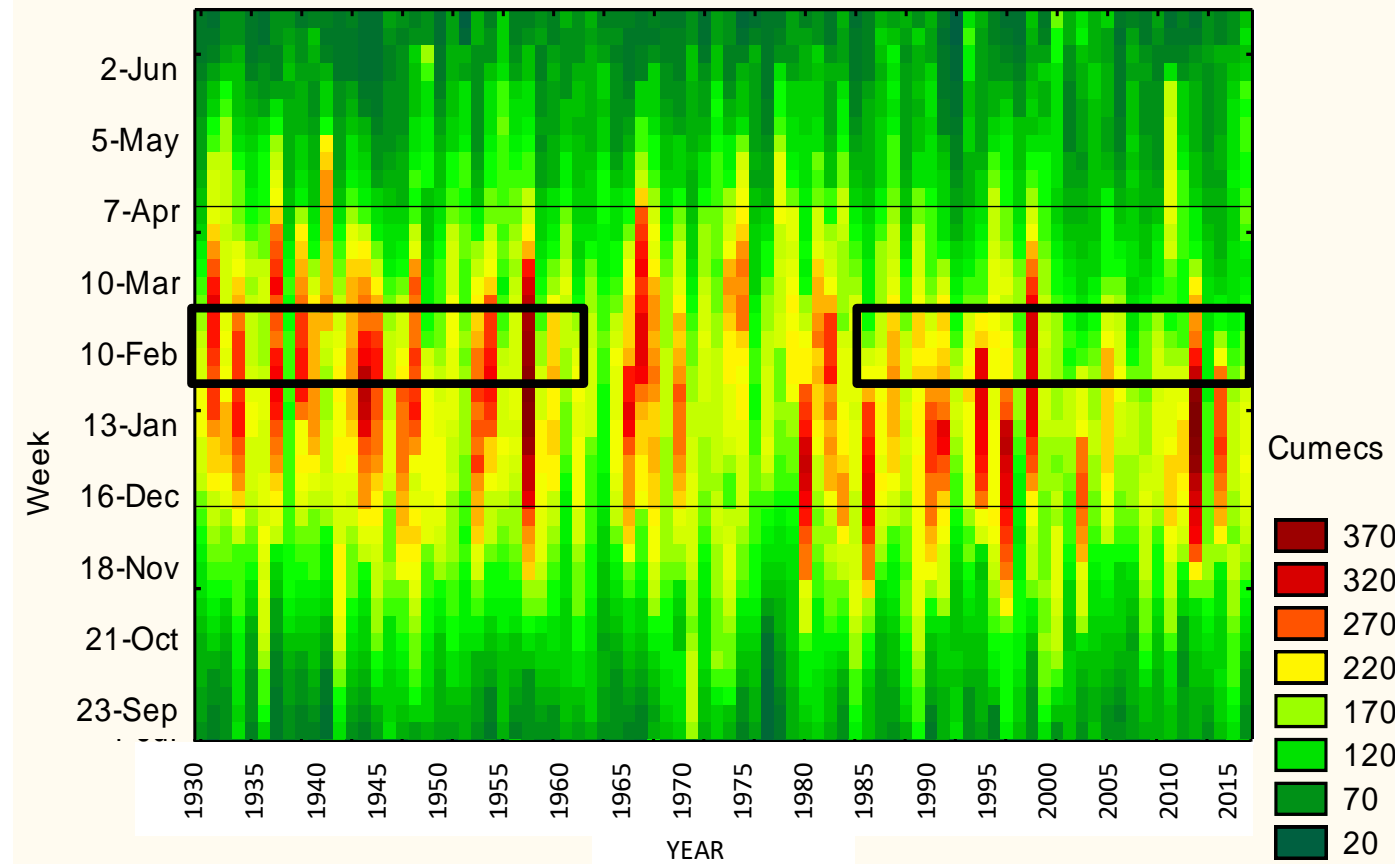


- 5% shift between different phases of the Inter-decadal Pacific Oscillation
- These are annual changes. What about seasonal shifts?

- 7% shift between different IPO phases

2. Can we use historical hydro & wind records to represent variability in future modelling

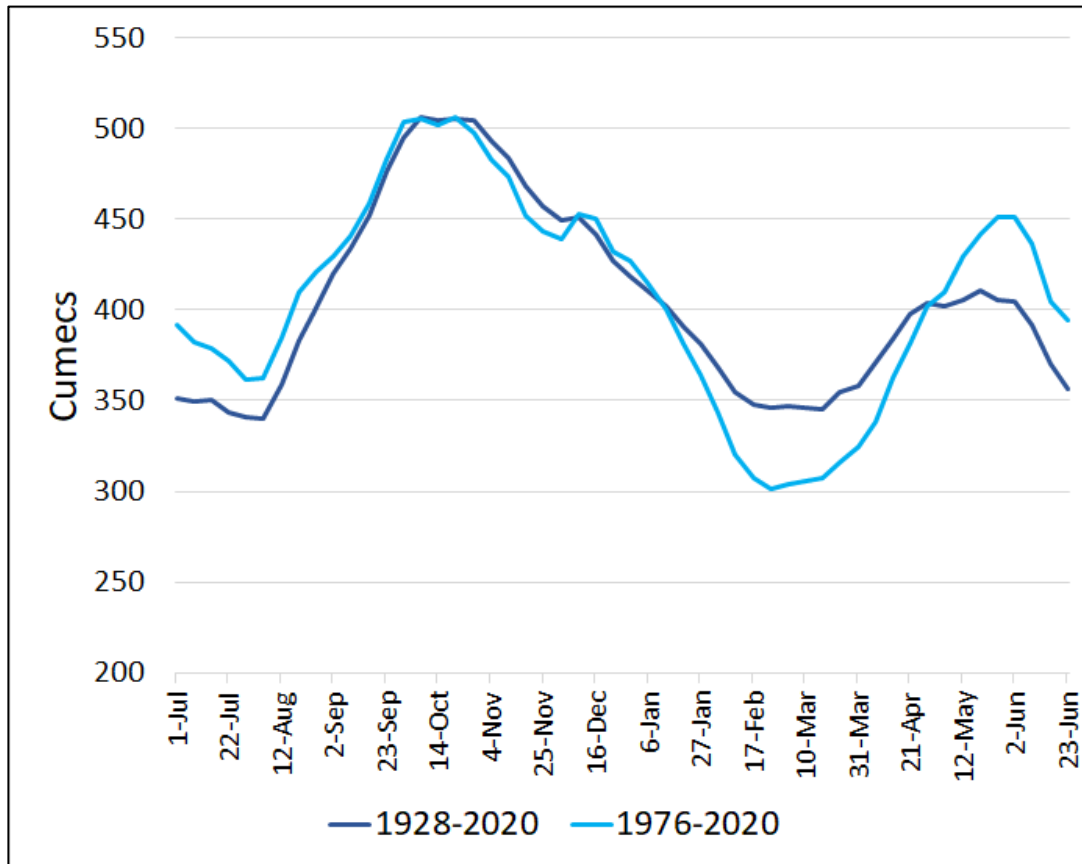
Smoothed Pukaki inflows over time



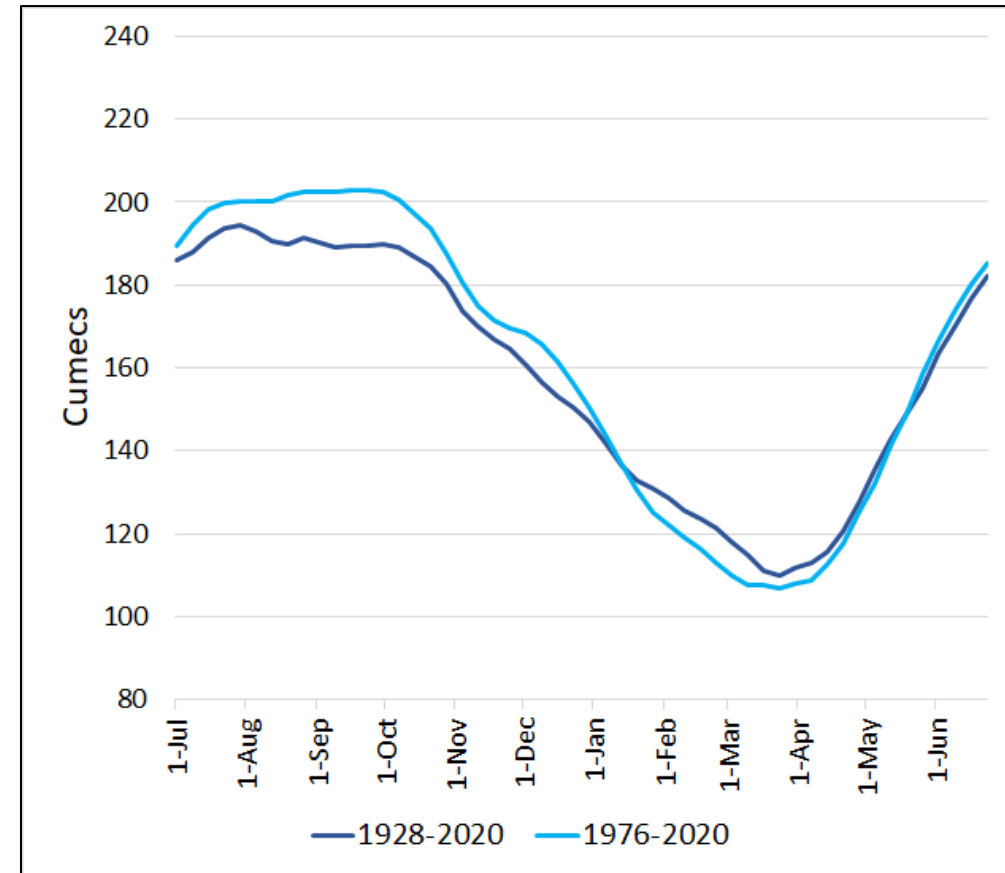
Lake Pukaki inflows 1928-1970 vs 1971-2015

- There is clear evidence that our climate has already changed considerably over the past century
- The climatological “normal” (best representation of “current” climate) is the average of the last 30 years

2. Can we use historical hydro & wind records to represent variability in future modelling



Manapouri catchment hydro inflows long term record vs recent past



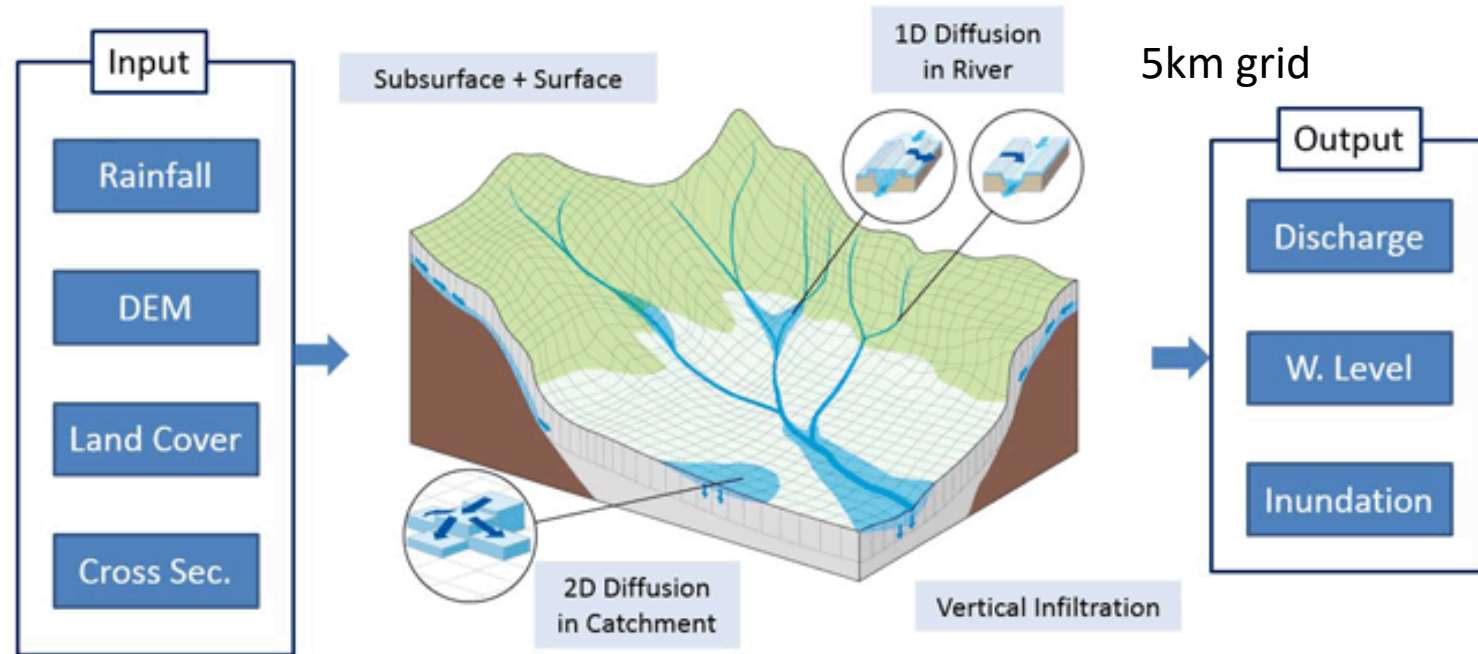
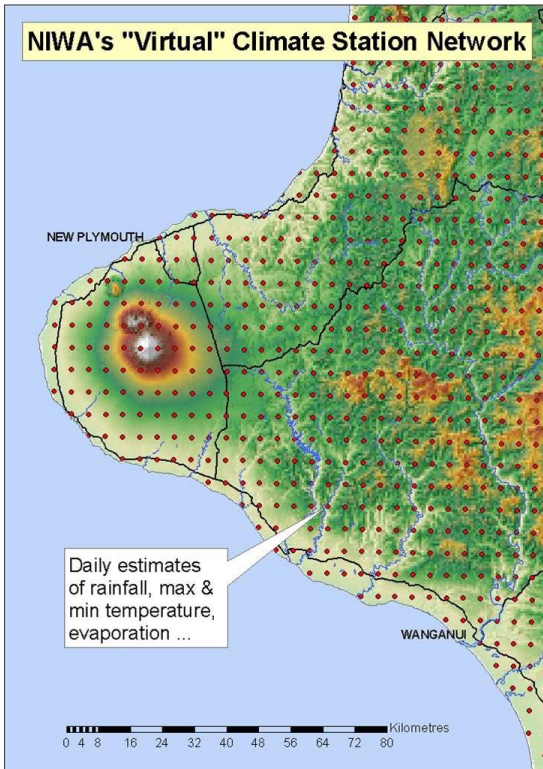
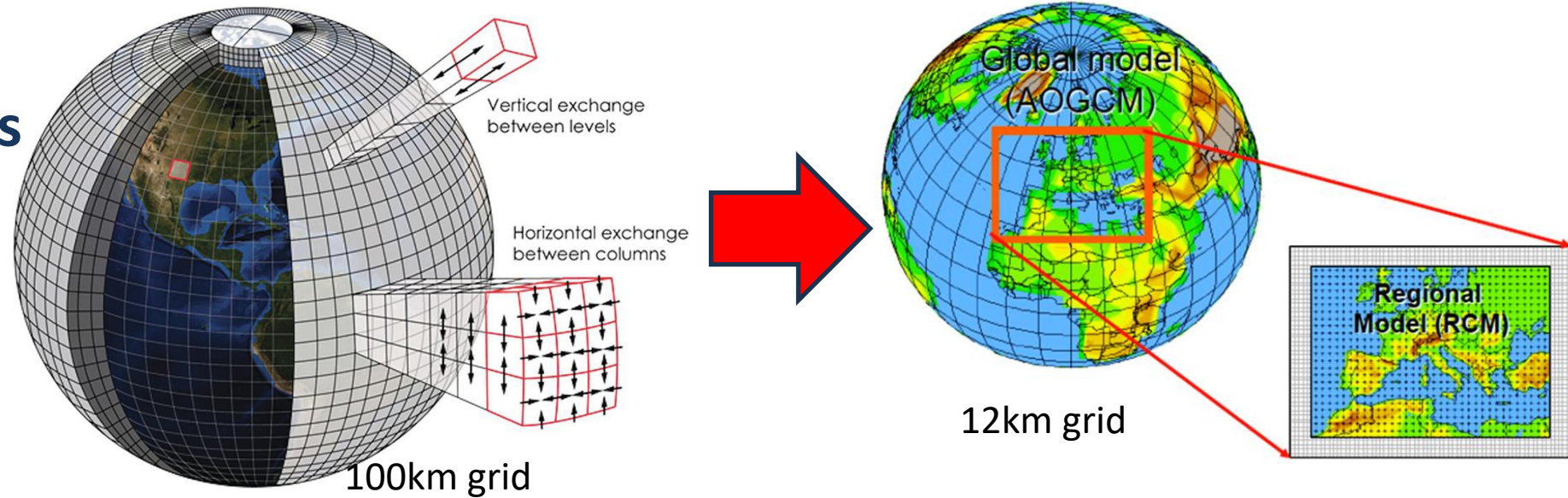
Waitako river hydro inflows long term record vs recent past

- So if we want to represent the very important volume of hydro inflows we can expect out to mid-century in our models, how should we adapt them for climate change?

3. Future hydro inflows and wind projections

- Mid-range emissions scenarios
- High range emissions scenarios

3. Future hydro and wind projections - climate models



3. Future hydro and wind projections – NIWA projections

| River | Mean flow | | | | | Flow extremes | | | Flow exceedance percentiles | | | | |
|------------|-----------|--------|--------|--------|--------|---------------|-----|------|-----------------------------|-----|-----|-----|-----|
| | Summer | Autumn | Winter | Spring | Annual | MALF | MAF | FRE3 | 5% | 25% | 50% | 75% | 95% |
| Wairoa | | | ↓ | ↓ | ↓ | ↓ | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| Hotoe | | | ↓ | ↓ | ↓ | ↓ | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| Waihou | | | | | | ↓ | | | | | | | ↓ |
| Waikato | | | | ↓ | | ↓ | | | ↓ | ↓ | ↓ | ↓ | ↓ |
| Rangitaiki | | | | | | ↓ | | | | | | | ↓ |
| Waipaoa | | | | | ↓ | ↓ | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| Waiaapu | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| Waiongana | | | ↑ | | | ↓ | | | | | | | |
| Manawatu | | | | | | ↓ | | | ↓ | ↓ | ↓ | ↓ | ↓ |
| Tukituki | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| Ruamāhanga | | | | | | ↓ | | | ↓ | ↓ | ↓ | ↓ | ↓ |
| Motueka | | | ↑ | | ↑ | | ↑ | ↑ | ↑ | ↑ | | | ↓ |
| Maitai | | | ↑ | | ↑ | | ↑ | | ↑ | ↑ | | | ↓ |
| Awatere | | | ↑ | | | | | | | | | | |
| Buller | | | ↑ | | ↑ | ↓ | ↑ | ↑ | ↑ | ↑ | ↑ | | |
| Haast | ↑ | ↑ | ↑ | ↑ | ↑ | | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| Rakaia | | | ↑ | | | | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| Clutha | | | ↑ | | ↑ | | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| Waiau | | | ↑ | | ↑ | | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| Mataura | | | ↑ | | ↑ | | ↑ | ↑ | ↑ | ↑ | ↑ | | |

North Island

South Island

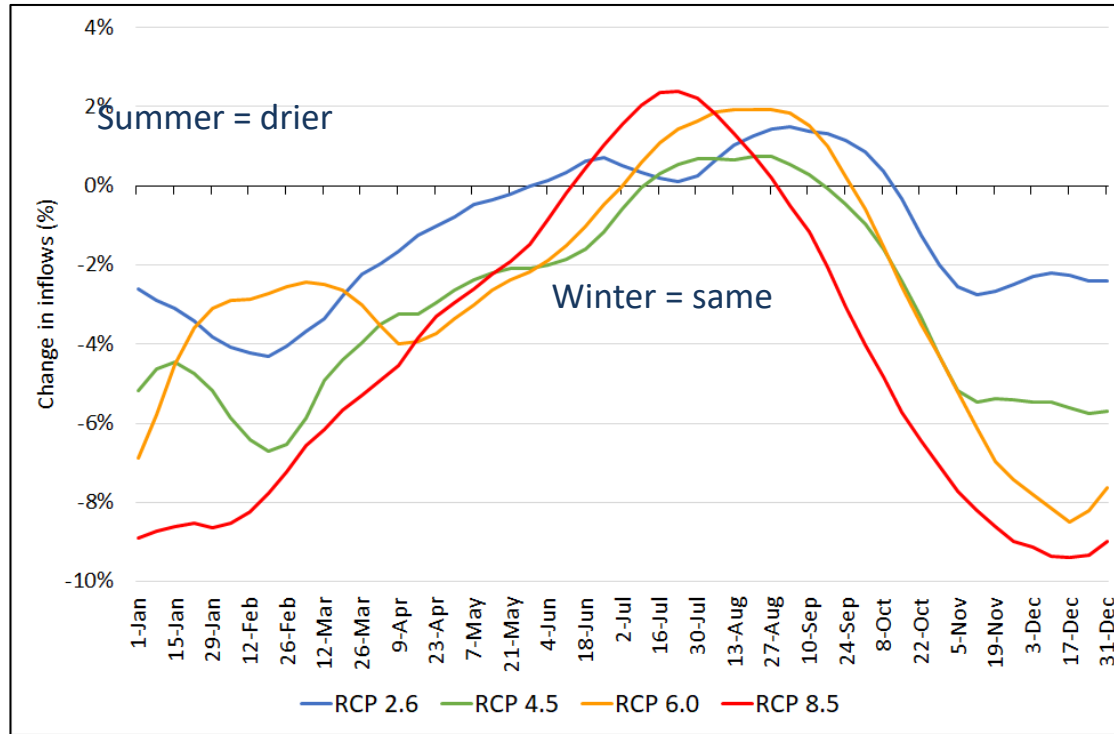
- Generally, we are expecting North Island river flows to get drier
- And South Island river flows to get wetter.
- 80% of NZ hydro electricity catchment inflows are in the South Island

Source: Collins, Montgomery & Zammit 2018, Table 1

Summary of the projected hydrological changes (direction indicated by the arrow/colour) for 20 rivers around NZ from now to mid-late century – mid-range emissions scenario.

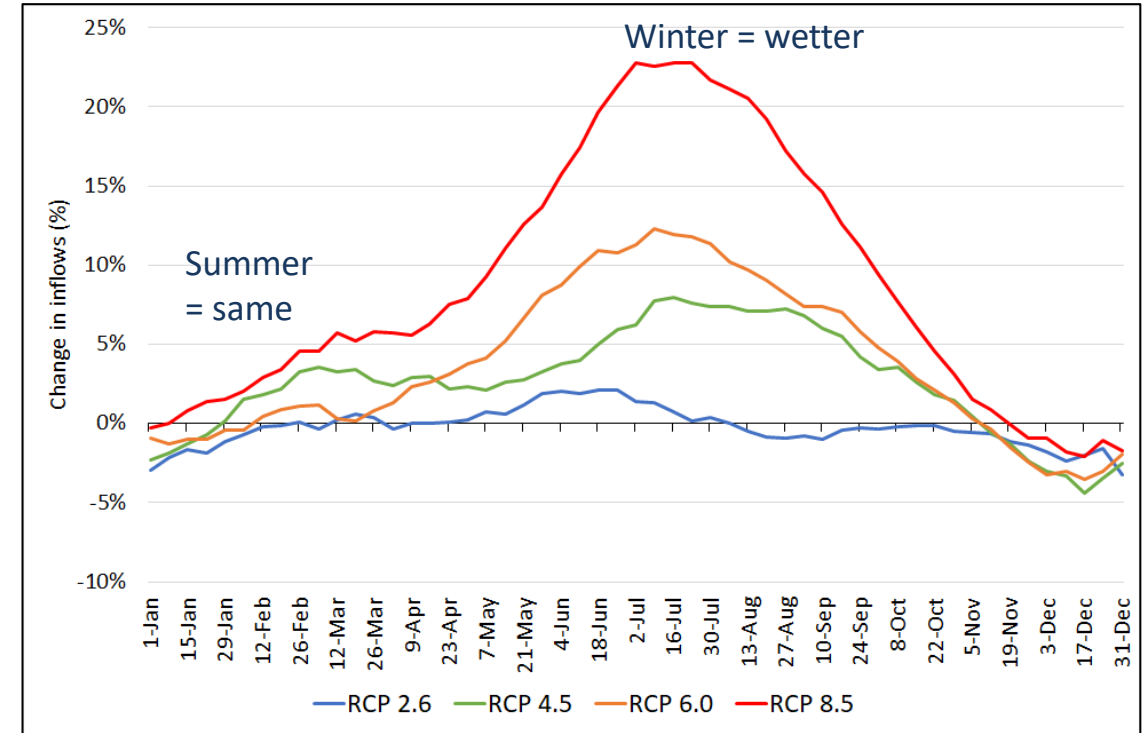
3. Future hydro and wind projections - Projected changes to hydro lake inflows by 2050 - all emissions scenarios

Waikato catchment projected weekly inflow changes 2020-2050 (%)



| RCP | Summer | Autumn | Winter | Spring | Annual |
|-----|--------|--------|--------|--------|--------|
| 2.6 | -3% | -1% | 1% | -1% | -1% |
| 4.5 | -6% | -3% | 0% | -3% | -3% |
| 6.0 | -5% | -3% | 1% | -3% | -3% |
| 8.5 | -9% | -4% | 1% | -6% | -4% |

Lake Pukaki projected weekly inflow changes 2020-2050 (%)



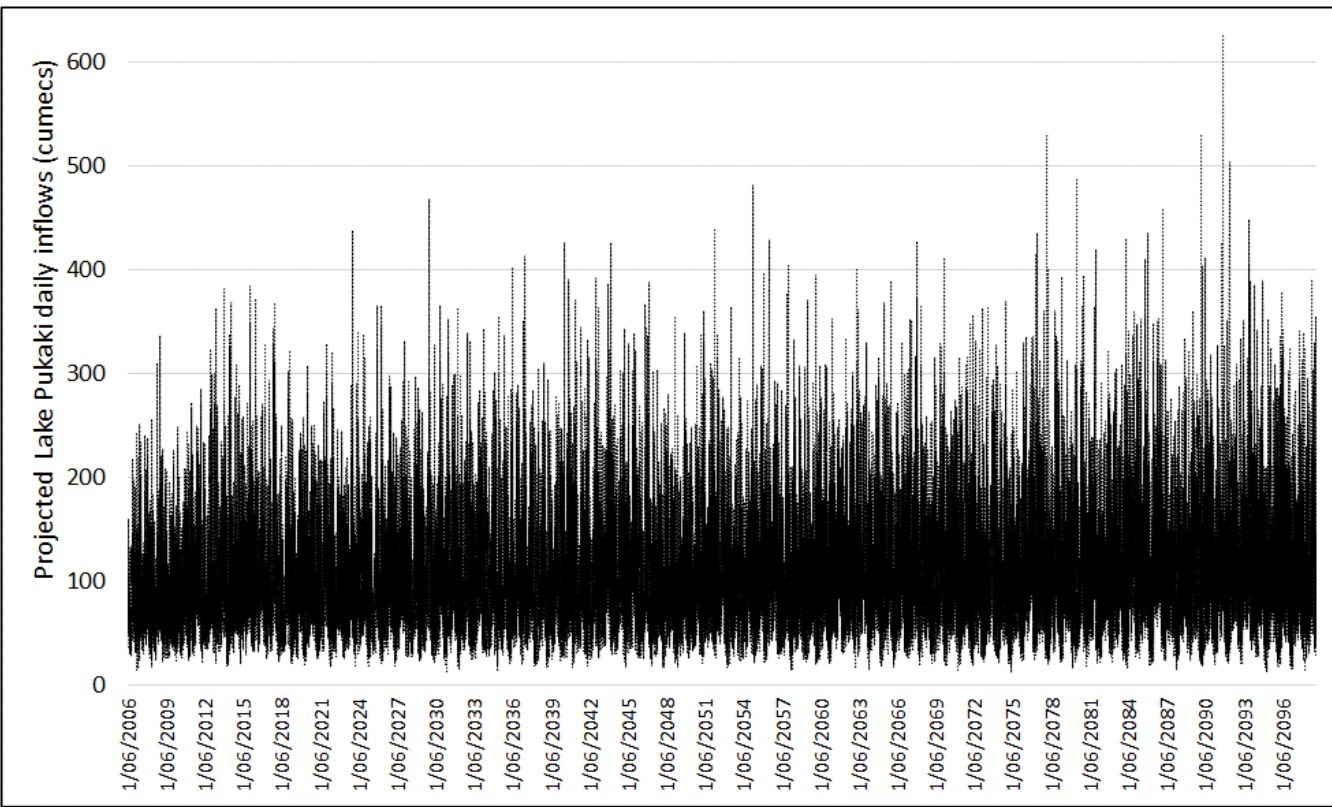
| RCP | Summer | Autumn | Winter | Spring | Annual |
|-----|--------|--------|--------|--------|--------|
| 2.6 | -2% | 0% | 1% | -1% | 0% |
| 4.5 | -1% | 3% | 6% | 2% | 3% |
| 6.0 | -1% | 3% | 10% | 2% | 4% |
| 8.5 | 1% | 8% | 20% | 7% | 9% |

Data source: Dr Christian Zammit, NIWA

3. Future hydro and wind projections – variability changes

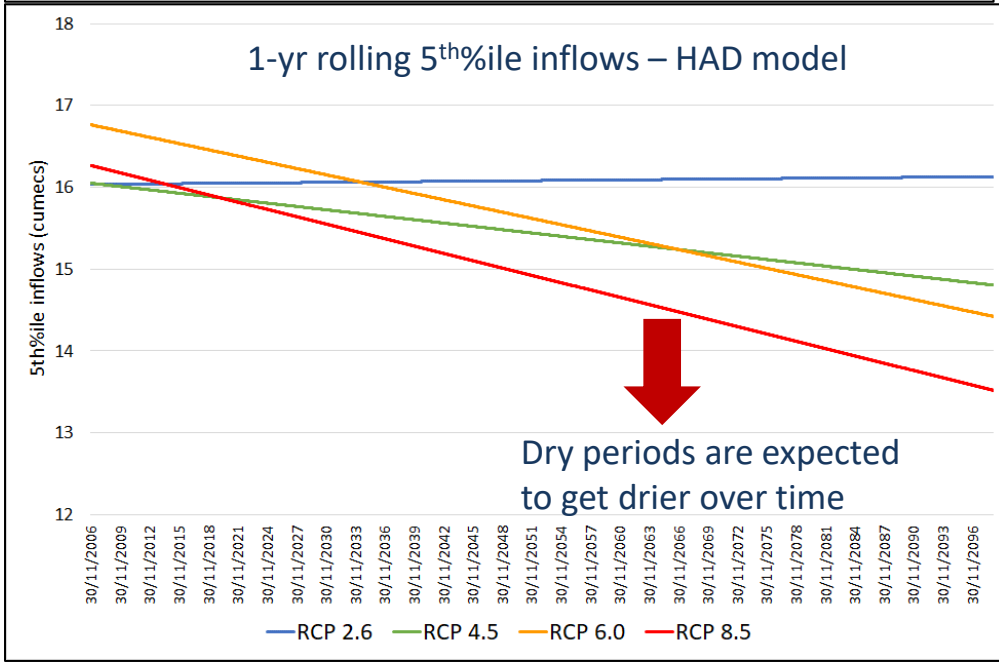
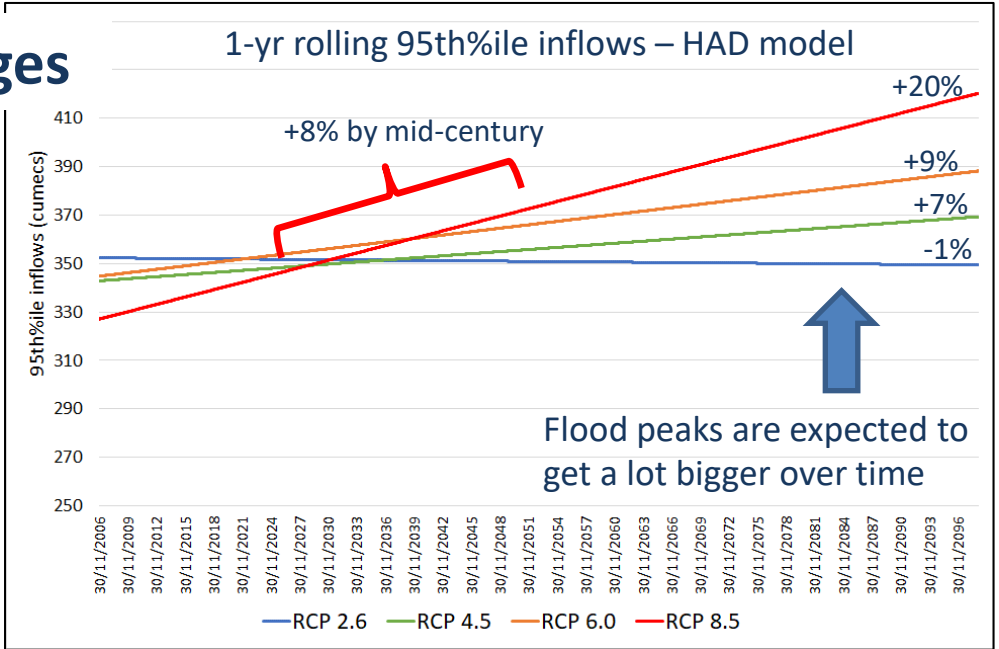
- Warmer air can carry more moisture, and circulation change are expected
- Result will be larger flood peaks in many areas

Lake Pukaki projected daily inflow changes 2006-2100



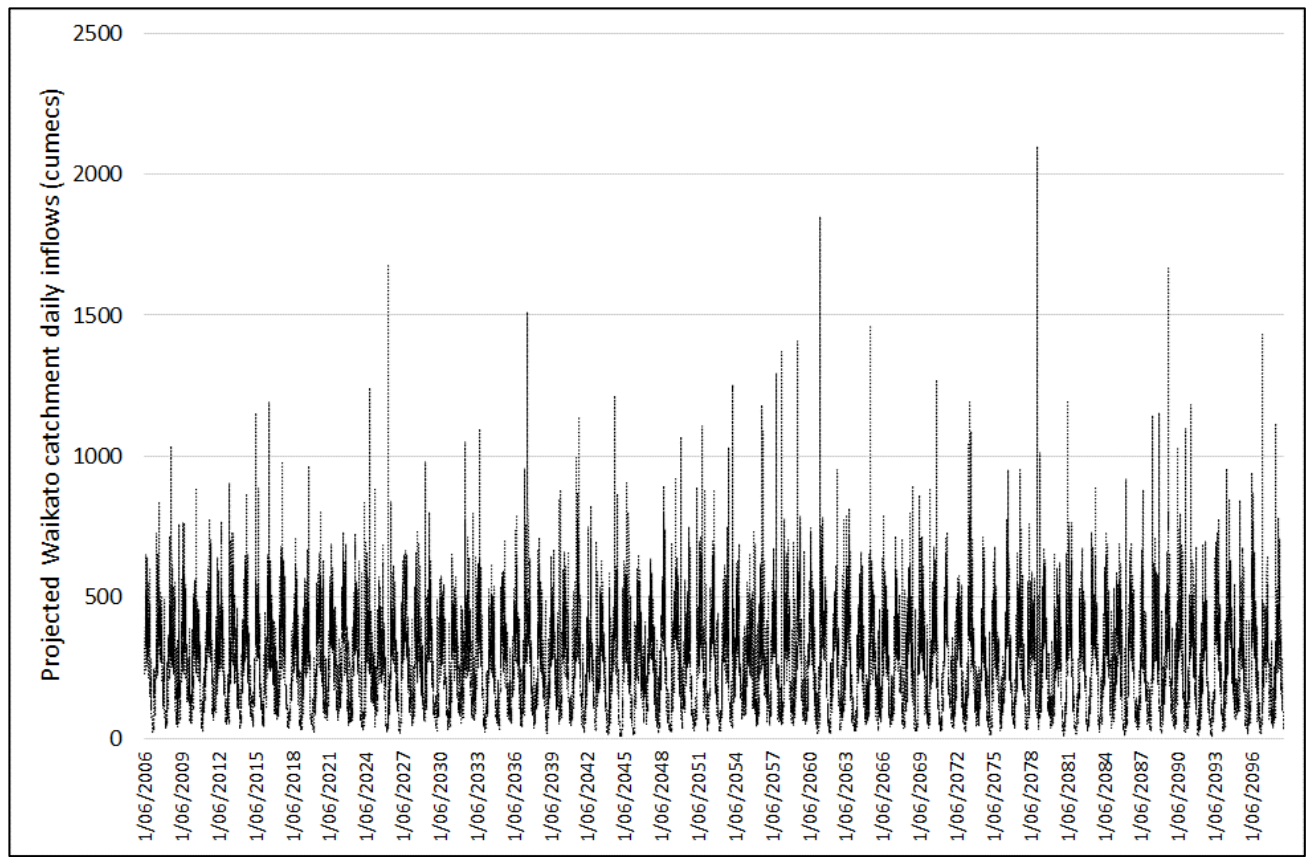
Projected daily Lake Pukaki inflows (RCP 8.5, average of 6 global models) 2006 - 2100

Data source: Dr Christian Zammit, NIWA



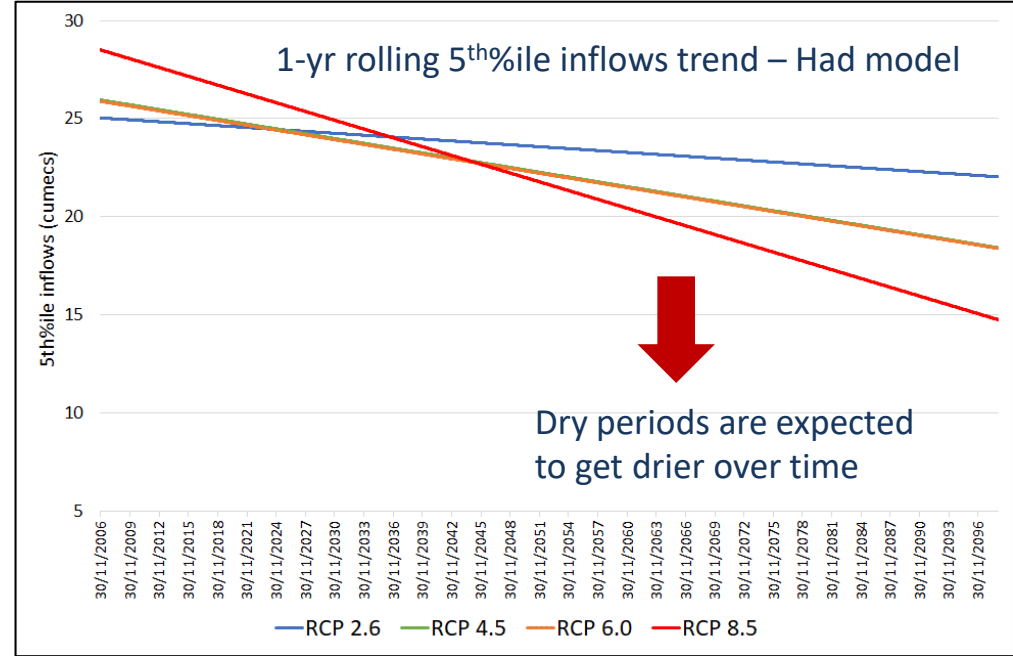
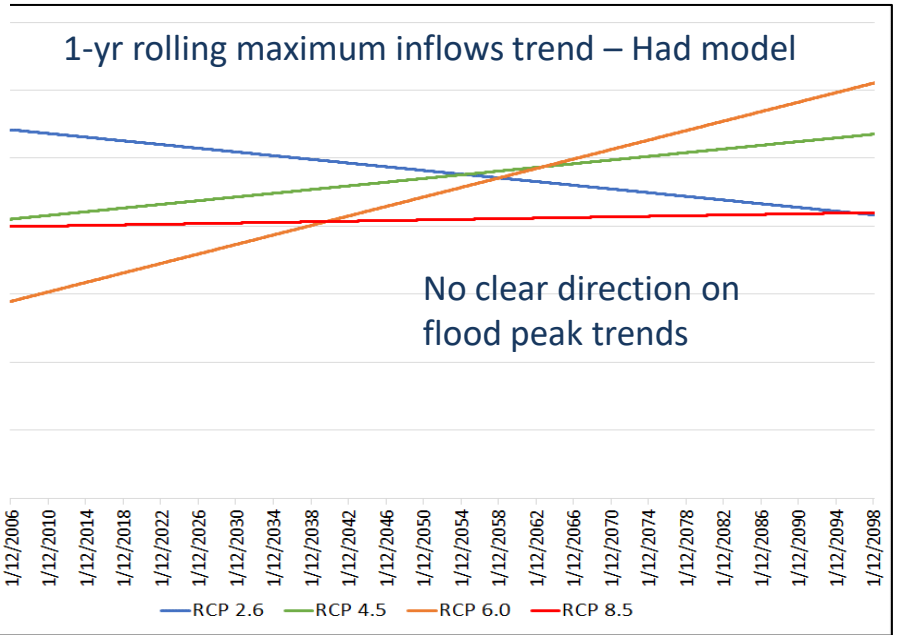
3. Future hydro and wind projections – variability changes

Waikato catchment projected inflow changes 2006-2100



Projected daily Waikato catchment inflows (RCP 8.5, average of 6 global models) 2006 - 2100

Data source: Dr Christian Zammit, NIWA

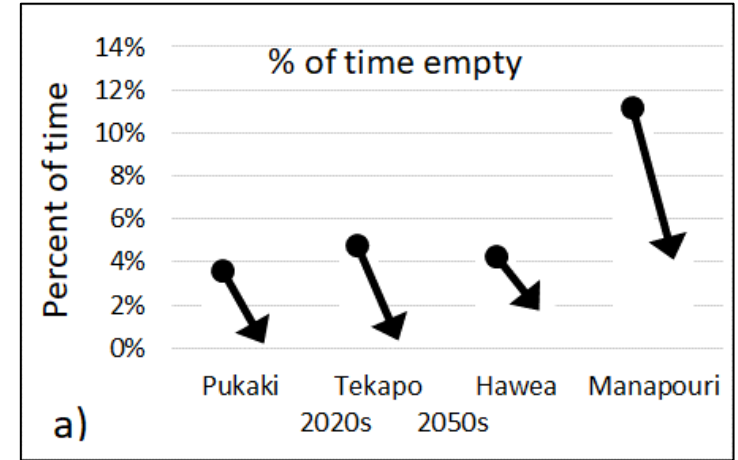
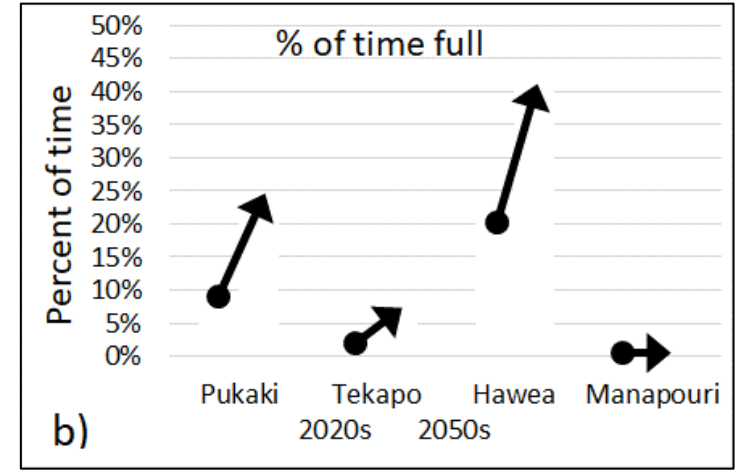
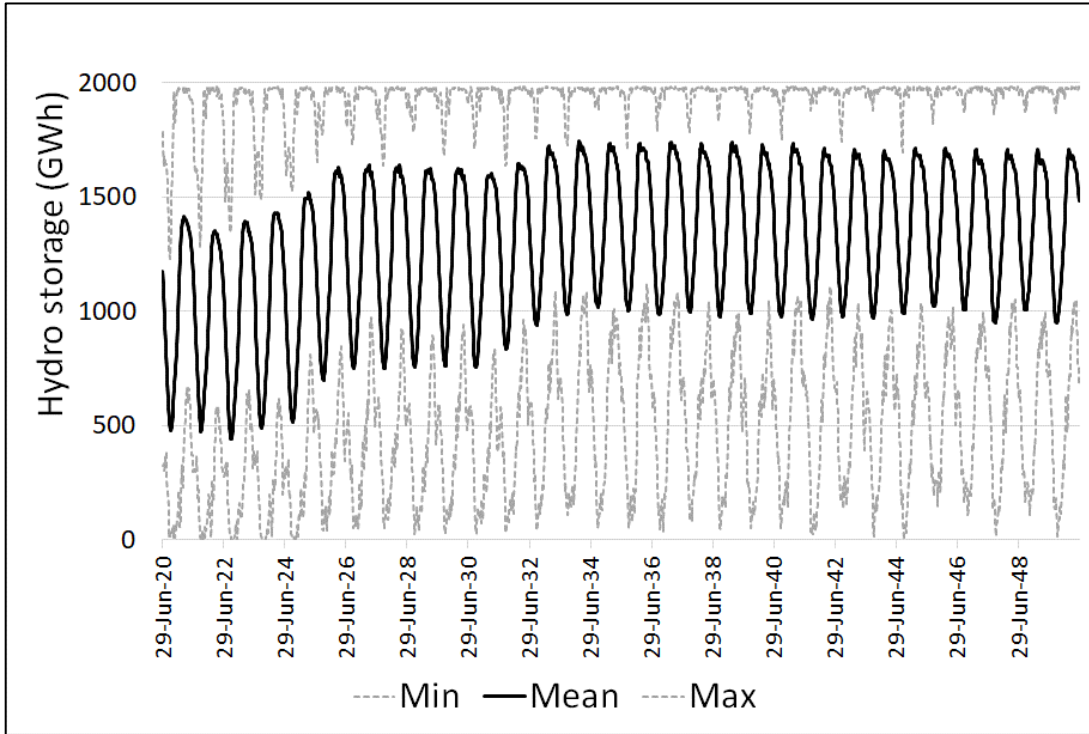


4. Impacts on modelling outcomes from changes to water

- Storage and spill impacts from mid-range emissions scenarios inflows

4. Impacts on modelling outcomes from changes to water – mid-range emissions - storage

- Combination of changes to inflows and 100% renewable (more intermittent) system
- Storage held higher, as a result of increased intermittency of generation (model avoids low storage) and increased inflows. More time spent at higher storage levels.
- But range of storage decreases as winter inflows increase significantly, so lakes spend more time full, less time empty.

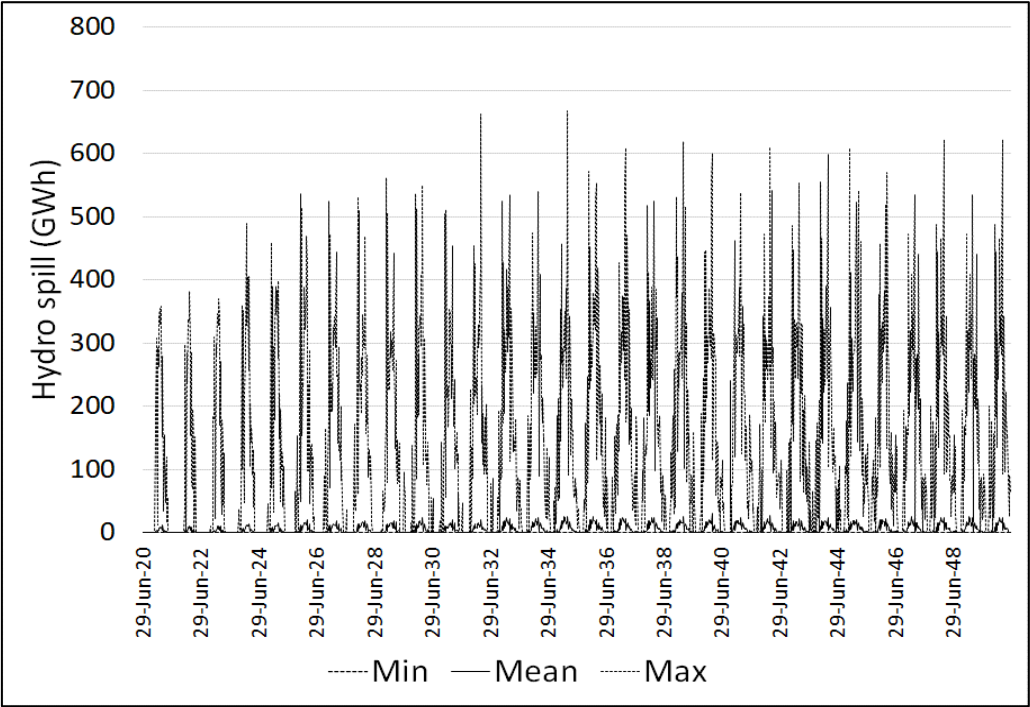


Lake Pukaki modelled weekly hydro storage 2020-2050 – min, mean, and max of 89 hydrological sequences based on past history, trended for climate change, and modified through hydropower scheme management.

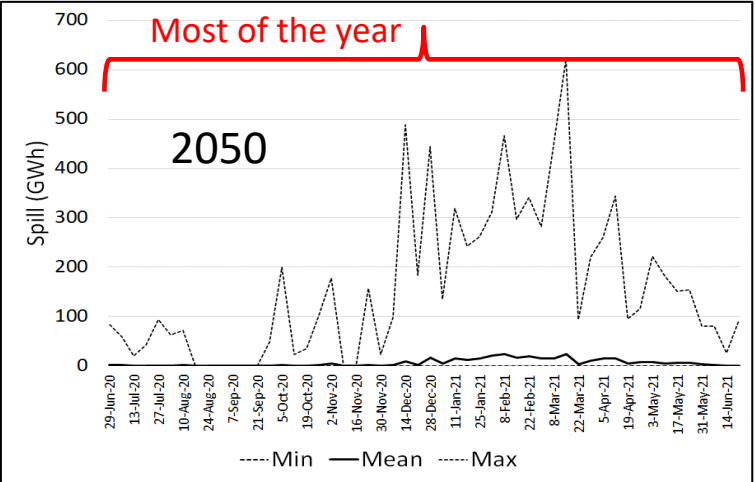
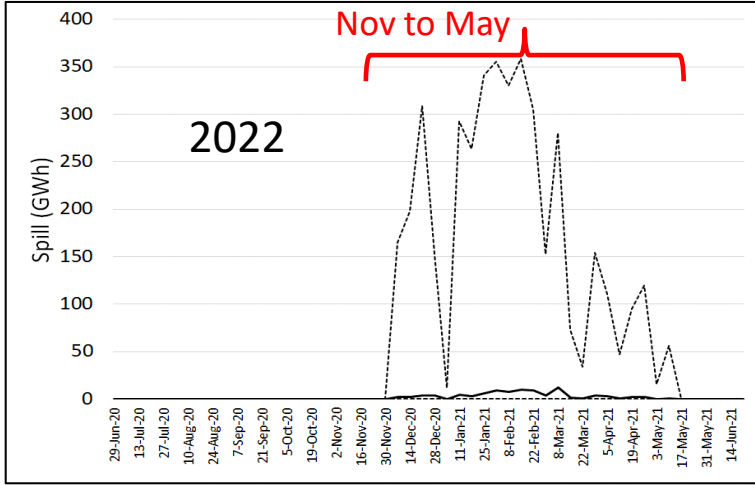
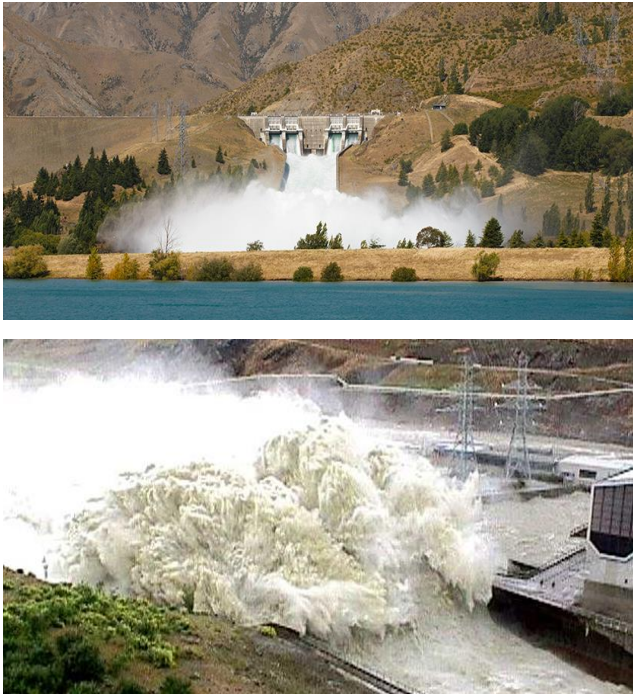
Percent of time at a) empty storage and b) full storage for Lakes Pukaki, Tekapo, Hawea, and Manapouri, for 2020 and 2050 (87 hydrological sequences).

4. Impacts on modelling outcomes from changes to water – mid-range emissions - spill

- As lakes are held higher in future, and flood peaks increase, the amount of water spilt (down spillways, and not generated with) is modelled to increase over time.
- As winter inflows increase, spill can occur at any time of the year, whereas in the past it has traditionally occurred in summer, when hydro lakes are at their highest.



Lake Pukaki modelled weekly spill 2020-2050 – min, mean, and max of 87 hydrological sequences based on past history, trended for climate change, and modified through hydropower scheme management.



Lake Pukaki modelled weekly spill for 2022 (top) and 2050 (bottom) – min, mean, and max of 87 hydrological sequences.

4. Impacts on modelling outcomes from changes to water – mid-range emissions - spill

| | 2020 | 2050 | % of generation 2020 | % of generation 2050 |
|----------------------|------------|-------------|-------------------------|-------------------------|
| Lake Pukaki & Tekapo | 133 | 500 | 1.8% | 6.0% |
| Lake Hawea | 56 | 117 | 1.5% | 3.1% |
| Lake Manapouri | 296 | 40 | 5.8% | 9.2% |
| Total | 485 | 1087 | 2.8% | 6.3% |

Modelled spill from major hydropower storage lakes in the Waitaki, Clutha, and Manapouri catchments for 2020 vs 2050, averaged over 87 hydrological sequences (GWh), and relative to current generation from that catchment, under a middle of the road emissions scenario.

- The increase in spill by 2050 (600GWh) is somewhat offset by the increase in annual inflows (430GWh) by this time.
- Initial work shows that future increased storage and spill is caused by changes to annual inflows, electricity demand, and increased renewables.

5. Adjustments for energy modelling hydro inflow sequences, to account for future climate change

Projected changes to hydro lake inflows by 2050 - annual

| LPCon region: | Manapouri | Clutha | Pukaki | Tekapo | GYM-RoR | ISL-RoR | KIK-RoR | BPE-RoR | Tongariro | Waikaremoana | BOP-RoR | Waikato |
|----------------|-----------|--------|--------|--------|---------|---------|---------|---------|-----------|--------------|---------|---------|
| RCP 2.6 | 1% | 0% | 0% | -1% | 0% | -1% | 1% | 0% | 0% | -3% | -2% | -1% |
| RCP 4.5 | 2% | 2% | 3% | 1% | 2% | 0% | 1% | -2% | -2% | -3% | -3% | -3% |
| RCP 6.0 | 4% | 2% | 4% | 2% | 3% | 0% | 0% | -1% | -1% | -3% | -3% | -2% |
| RCP 8.5 | 8% | 6% | 9% | 4% | 6% | 2% | 3% | -3% | -2% | -6% | -6% | -4% |

- RCP 4.5 “most likely” scenario
- Other RCPs still possible

Data source: Dr Christian Zammit, NIWA

Projected changes to hydro lake inflows by 2050 - seasonal

Data source: Dr Christian Zammit, NIWA

RCP2.6 – low emissions future

RCP8.5 – high emissions future

| LPCon region | Manapouri | Clutha | Pukaki | Tekapo | GYM-RoR | ISL-RoR | KIK-RoR | BPE-RoR | Tongariro | Waikaremoana | BOP-RoR | Waikato |
|--------------|-----------|--------|--------|--------|---------|---------|---------|---------|-----------|--------------|---------|---------|
| 1-Jul | 2% | 2% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 0% | 1% | 1% |
| 8-Jul | 1% | 1% | 1% | 1% | 0% | 0% | 1% | 0% | 0% | -1% | 1% | 0% |
| 15-Jul | 0% | 0% | 1% | 0% | 0% | 0% | 0% | 0% | -1% | -1% | 0% | 0% |
| 22-Jul | -1% | 0% | 0% | 0% | -1% | 0% | 0% | -1% | -1% | 0% | 1% | 0% |
| 29-Jul | -1% | -1% | 0% | 0% | -1% | 0% | 1% | 0% | 0% | 1% | 1% | 0% |
| 5-Aug | -1% | -1% | 0% | 0% | -1% | 0% | 0% | 0% | 0% | 1% | 1% | 1% |
| 12-Aug | -2% | -1% | -1% | -1% | -2% | 0% | 0% | 1% | 0% | 2% | 2% | 1% |
| 19-Aug | -2% | -2% | -1% | -1% | -2% | 0% | 0% | 1% | 1% | 2% | 3% | 2% |
| 26-Aug | -2% | -2% | -1% | -1% | -2% | 0% | 0% | 1% | 1% | 2% | 3% | 2% |
| 2-Sep | -1% | -1% | -1% | -1% | -1% | 0% | 0% | 1% | 1% | 2% | 3% | 1% |
| 9-Sep | -2% | -2% | -1% | -1% | -1% | -1% | 0% | 1% | 1% | 2% | 3% | 1% |
| 16-Sep | -2% | -2% | 0% | -1% | -1% | -1% | 1% | 1% | 1% | 2% | 3% | 1% |
| 23-Sep | -1% | -1% | 0% | -1% | -1% | 0% | 1% | 1% | 1% | 2% | 3% | 1% |
| 30-Sep | -1% | -1% | 0% | -1% | 0% | -1% | 1% | 1% | 2% | 2% | 3% | 1% |
| 7-Oct | -1% | -1% | 0% | -1% | 0% | -1% | 1% | 1% | 1% | 1% | 2% | 1% |
| 14-Oct | -1% | -1% | 0% | -1% | 0% | -2% | 1% | 1% | 1% | -1% | 1% | 0% |
| 21-Oct | 0% | -1% | 0% | -1% | 1% | -2% | 1% | 1% | 0% | -2% | -1% | -1% |
| 28-Oct | -1% | -1% | 0% | -1% | 1% | -2% | 1% | 0% | -1% | -4% | -2% | -2% |
| 4-Nov | 0% | -2% | -1% | -1% | 0% | -3% | 0% | 0% | -2% | -4% | -3% | -3% |
| 11-Nov | 0% | -1% | -1% | -2% | 1% | -3% | 1% | 0% | -1% | -4% | -3% | -3% |
| 18-Nov | 0% | -2% | -1% | -2% | 0% | -2% | 0% | 0% | -1% | -4% | -3% | -3% |
| 25-Nov | 0% | -2% | -1% | -2% | 0% | -2% | 1% | -1% | -1% | -5% | -3% | -3% |
| 2-Dec | 1% | -1% | -2% | -2% | 1% | -1% | 1% | -1% | -2% | -6% | -3% | -3% |
| 9-Dec | 0% | -2% | -2% | -3% | 0% | -2% | 1% | -1% | -1% | -7% | -3% | -3% |
| 16-Dec | 1% | -2% | -2% | -2% | 1% | -2% | 0% | -1% | -1% | -8% | -4% | -3% |
| 23-Dec | 0% | -2% | -2% | -3% | 0% | -2% | 0% | -1% | -2% | -8% | -4% | -4% |
| 30-Dec | 0% | -2% | -3% | -3% | 0% | -2% | 0% | -1% | -2% | -7% | -2% | -4% |
| 6-Jan | 1% | -2% | -2% | -3% | 0% | -3% | 0% | -2% | -2% | -6% | -2% | -4% |
| 13-Jan | 2% | -1% | -1% | -2% | 1% | -2% | 1% | -2% | -2% | -7% | -3% | -4% |
| 20-Jan | 1% | -1% | -1% | -2% | 1% | -1% | 1% | -2% | -1% | -7% | -3% | -5% |
| 27-Jan | 2% | -1% | -1% | -1% | 1% | -1% | 1% | -2% | 0% | -7% | -4% | -4% |
| 3-Feb | 2% | -1% | -1% | -1% | 1% | -2% | 1% | -2% | 1% | -8% | -4% | -4% |
| 10-Feb | 3% | 1% | 0% | -1% | 1% | -2% | 1% | -2% | 1% | -7% | -5% | -4% |
| 17-Feb | 3% | 0% | 0% | -1% | 1% | -2% | 2% | -2% | 1% | -7% | -6% | -4% |
| 24-Feb | 3% | 1% | 0% | 0% | 2% | -1% | 3% | -2% | 1% | -6% | -6% | -5% |
| 2-Mar | 3% | 1% | 0% | 0% | 2% | -1% | 2% | -2% | 1% | -6% | -6% | -4% |
| 9-Mar | 3% | 1% | 0% | 0% | 2% | -1% | 2% | -2% | 2% | -5% | -5% | -3% |
| 16-Mar | 4% | 2% | 1% | 0% | 2% | 0% | 2% | -1% | 2% | -4% | -7% | -3% |
| 23-Mar | 3% | 2% | 0% | 1% | 1% | 0% | 2% | -1% | 1% | -4% | -7% | -3% |
| 30-Mar | 3% | 1% | 0% | 0% | 1% | 0% | 2% | -1% | 1% | -3% | -6% | -2% |
| 6-Apr | 3% | 2% | 0% | 0% | 1% | 0% | 1% | -1% | 0% | -3% | -5% | -1% |
| 13-Apr | 2% | 1% | 0% | 0% | 1% | -1% | 2% | -1% | 0% | -3% | -6% | -2% |
| 20-Apr | 2% | 1% | 0% | 0% | 1% | 0% | 2% | -1% | -1% | -1% | -4% | -1% |
| 27-Apr | 2% | 1% | 0% | 0% | 1% | 0% | 2% | 0% | -1% | -1% | -3% | -1% |
| 4-May | 3% | 2% | 1% | 1% | 1% | 1% | 1% | 0% | -1% | -1% | -2% | 0% |
| 11-May | 3% | 1% | 1% | 0% | 1% | 0% | 0% | 0% | -1% | -1% | -2% | 0% |
| 18-May | 3% | 2% | 1% | 1% | 1% | 0% | 1% | 0% | 0% | -1% | -1% | 0% |
| 25-May | 4% | 3% | 2% | 2% | 2% | 1% | 1% | 0% | -1% | -2% | -1% | 0% |
| 1-Jun | 4% | 3% | 2% | 2% | 2% | 1% | 1% | 0% | 0% | -2% | 0% | 0% |
| 8-Jun | 3% | 3% | 2% | 2% | 1% | 1% | 1% | 0% | 0% | -1% | 0% | 1% |
| 15-Jun | 2% | 2% | 2% | 2% | 1% | 1% | 1% | 0% | 0% | -1% | 0% | 1% |
| 22-Jun | 2% | 2% | 2% | 2% | 1% | 1% | 1% | 0% | 1% | -1% | 1% | 1% |

| LPCon region | Manapouri | Clutha | Pukaki | Tekapo | GYM-RoR | ISL-RoR | KIK-RoR | BPE-RoR | Tongariro | Waikaremoana | BOP-RoR | Waikato |
|--------------|-----------|--------|--------|--------|---------|---------|---------|---------|-----------|--------------|---------|---------|
| 1-Jul | 20% | 13% | 23% | 13% | 13% | 10% | 11% | -1% | 6% | -3% | -3% | 2% |
| 8-Jul | 20% | 14% | 23% | 13% | 13% | 10% | 11% | 0% | 6% | -3% | -3% | 2% |
| 15-Jul | 19% | 13% | 23% | 13% | 13% | 10% | 10% | 0% | 7% | -3% | -2% | 3% |
| 22-Jul | 18% | 14% | 23% | 13% | 13% | 9% | 11% | 1% | 7% | -3% | -1% | 3% |
| 29-Jul | 17% | 13% | 22% | 12% | 12% | 9% | 10% | 1% | 6% | -2% | -1% | 3% |
| 5-Aug | 16% | 12% | 21% | 12% | 12% | 7% | 10% | 1% | 5% | -3% | -1% | 2% |
| 12-Aug | 15% | 11% | 21% | 11% | 11% | 6% | 9% | 0% | 5% | -3% | -2% | 1% |
| 19-Aug | 13% | 10% | 19% | 10% | 11% | 5% | 9% | 0% | 4% | -3% | -2% | 1% |
| 26-Aug | 10% | 8% | 17% | 9% | 10% | 4% | 8% | 0% | 3% | -3% | -2% | 0% |
| 2-Sep | 10% | 7% | 16% | 8% | 10% | 3% | 7% | -1% | 2% | -4% | -3% | 0% |
| 9-Sep | 9% | 6% | 15% | 7% | 9% | 2% | 7% | -1% | 1% | -4% | -3% | -1% |
| 16-Sep | 8% | 5% | 13% | 6% | 7% | 1% | 6% | -2% | 0% | -5% | -4% | -2% |
| 23-Sep | 7% | 5% | 11% | 5% | 7% | 0% | 5% | -2% | -1% | -5% | -5% | -3% |
| 30-Sep | 6% | 4% | 9% | 4% | 6% | -1% | 4% | -3% | -2% | -6% | -6% | -4% |
| 7-Oct | 7% | 4% | 8% | 3% | 6% | -1% | 4% | -3% | -3% | -7% | -7% | -5% |
| 14-Oct | 6% | 4% | 6% | 2% | 6% | -1% | 3% | -3% | -3% | -8% | -8% | -6% |
| 21-Oct | 6% | 3% | 5% | 1% | 5% | -1% | 3% | -3% | -4% | -9% | -9% | -6% |
| 28-Oct | 5% | 3% | 3% | 0% | 5% | -1% | 2% | -3% | -4% | -10% | -10% | -7% |
| 4-Nov | 5% | 3% | 2% | -1% | 5% | -1% | 2% | -3% | -4% | -11% | -10% | -8% |
| 11-Nov | 5% | 3% | 1% | -1% | 5% | -2% | 2% | -3% | -4% | -12% | -10% | -8% |
| 18-Nov | 5% | 3% | 0% | -2% | 4% | -2% | 1% | -3% | -4% | -12% | -10% | -9% |
| 25-Nov | 5% | 3% | -1% | -2% | 4% | -2% | 1% | -1% | -5% | -12% | -10% | -9% |
| 2-Dec | 5% | 3% | -1% | -2% | 4% | -2% | 0% | -2% | -6% | -12% | -9% | -9% |
| 9-Dec | 4% | 3% | -2% | -2% | 3% | -2% | -1% | -3% | -7% | -11% | -7% | -9% |
| 16-Dec | 5% | 3% | -1% | -2% | 4% | -3% | -1% | -4% | -7% | -11% | -7% | -10% |
| 23-Dec | 4% | 2% | -2% | -2% | 3% | -2% | -1% | -4% | -7% | -11% | -7% | -9% |
| 30-Dec | 4% | 3% | 0% | 0% | 4% | -2% | -1% | -3% | -8% | -10% | -7% | -9% |
| 6-Jan | 4% | 3% | 0% | 0% | 3% | -2% | -2% | -4% | -8% | -10% | -5% | -8% |
| 13-Jan | 5% | 3% | 0% | 0% | 3% | -3% | -2% | -4% | -9% | -10% | -5% | -8% |
| 20-Jan | 5% | 4% | 1% | 1% | 2% | -3% | -2% | -5% | -10% | -10% | -6% | -9% |
| 27-Jan | 5% | 4% | 2% | 0% | 2% | -3% | -2% | -5% | -10% | -10% | -7% | -9% |
| 3-Feb | 5% | 4% | 2% | 1% | 3% | -3% | -2% | -5% | -10% | -9% | -6% | -8% |
| 10-Feb | 5% | 3% | 3% | 1% | 3% | -2% | -2% | -5% | -9% | -9% | -8% | -9% |
| 17-Feb | 5% | 4% | 3% | 2% | 3% | -2% | -2% | -4% | -9% | -8% | -8% | -8% |
| 24-Feb | 5% | 3% | 5% | 2% | 4% | -1% | 0% | -3% | -8% | -8% | -9% | -8% |
| 2-Mar | 4% | 3% | 5% | 2% | 3% | -1% | 0% | -3% | -6% | -7% | -9% | -6% |
| 9-Mar | 4% | 3% | 6% | 3% | 4% | 0% | 0% | -3% | -6% | -7% | -9% | -6% |
| 16-Mar | 4% | 3% | 5% | 2% | 4% | 0% | 0% | -4% | -5% | -6% | -8% | -5% |
| 23-Mar | 4% | 3% | 6% | 3% | 5% | 0% | 1% | -4% | -5% | -6% | -9% | -6% |
| 30-Mar | 4% | 3% | 6% | 2% | 5% | 1% | 1% | -5% | -4% | -5% | -8% | -5% |
| 6-Apr | 4% | 3% | 6% | 2% | 5% | 2% | 1% | -5% | -4% | -4% | -7% | -4% |
| 13-Apr | 3% | 3% | 6% | 3% | 5% | 2% | 1% | -5% | -3% | -3% | -7% | -4% |
| 20-Apr | 4% | 3% | 8% | 3% | 5% | 2% | 2% | -6% | -3% | -3% | -7% | -3% |
| 27-Apr | 5% | 3% | 8% | 3% | 5% | 2% | 3% | -6% | -2% | -2% | -5% | -2% |
| 4-May | 6% | 4% | 9% | 4% | 5% | 3% | 3% | -6% | -1% | -3% | -5% | -2% |
| 11-May | 9% | 5% | 11% | 6% | 6% | 4% | 4% | -6% | -1% | -4% | -5% | -3% |
| 18-May | 10% | 7% | 13% | 6% | 6% | 5% | 4% | -6% | 0% | -4% | -5% | -2% |
| 25-May | 11% | 7% | 14% | 7% | 6% | 5% | 5% | -6% | 0% | -3% | -5% | -2% |
| 1-Jun | 13% | 9% | 16% | 8% | 7% | 6% | 6% | -5% | 2% | -3% | -4% | -1% |
| 8-Jun | 15% | 10% | 17% | 9% | 9% | 7% | 8% | -4% | 3% | -3% | -4% | 0% |
| 15-Jun | 17% | 11% | 20% | 11% | 10% | 8% | 8% | -3% | 4% | -3% | -4% | 0% |
| 22-Jun | 18% | 12% | 21% | 12% | 11% | 9% | 9% | -2% | 5% | -3% | -4% | 1% |

Projected changes to wind speeds by 2050 - seasonal

RCP2.6 – low emissions future

RCP8.5 – high emissions future

| LPCon region | White hill | FlatHill | MtStuart | Mahin erangi | West wind | Millcrk | HauNui | TeApiti | TeRere Hau | T1 | T2 | T3 | TeUku | Hurunui | MtMunro | Patea | Central Wind | Harap aki | Wood Hill | Pouto |
|--------------|------------|----------|----------|--------------|-----------|---------|--------|---------|------------|-----|-----|-----|-------|---------|---------|-------|--------------|-----------|-----------|-------|
| 1-Jul | 2% | 1% | 0% | 0% | 1% | 1% | 0% | 2% | 2% | 2% | 2% | 2% | 0% | 3% | 1% | -2% | -1% | 2% | 0% | 0% |
| 8-Jul | 1% | 1% | 0% | 0% | 1% | 1% | -1% | 2% | 2% | 2% | 2% | 2% | 0% | 3% | 1% | -2% | -1% | 1% | 0% | 0% |
| 15-Jul | 1% | 1% | 0% | 0% | 0% | 0% | -1% | 2% | 2% | 2% | 2% | 2% | 0% | 2% | 1% | -1% | -1% | 1% | 0% | 0% |
| 22-Jul | 1% | 0% | 0% | 0% | -1% | -1% | -1% | 2% | 2% | 2% | 2% | 2% | 0% | 1% | 1% | -2% | -2% | 1% | 1% | 1% |
| 29-Jul | 0% | 1% | 1% | 1% | -2% | -2% | -1% | 2% | 2% | 2% | 2% | 2% | 0% | 0% | 1% | -2% | -1% | 1% | 1% | 1% |
| 5-Aug | -1% | 0% | 1% | 1% | -2% | -2% | -1% | 2% | 2% | 2% | 2% | 2% | 0% | 0% | 1% | -2% | -1% | 0% | 1% | 1% |
| 12-Aug | -1% | 0% | 1% | 1% | -1% | -1% | -1% | 2% | 2% | 2% | 2% | 2% | 0% | 0% | 1% | -1% | -1% | -1% | 2% | 2% |
| 19-Aug | -1% | -1% | 1% | 1% | -1% | -1% | -1% | 1% | 1% | 1% | 1% | 1% | 2% | 1% | 1% | 0% | 1% | -1% | 2% | 2% |
| 26-Aug | -1% | 0% | 1% | 1% | -1% | -1% | 0% | 1% | 1% | 1% | 1% | 1% | 2% | 1% | 2% | 2% | -1% | 2% | 2% | 2% |
| 2-Sep | -2% | 0% | 1% | 1% | -2% | -2% | 0% | 1% | 1% | 1% | 1% | 1% | 1% | 0% | 2% | 1% | 1% | -1% | 2% | 2% |
| 9-Sep | -2% | 0% | 1% | 1% | -1% | -1% | 0% | 1% | 1% | 1% | 1% | 1% | 0% | -1% | 1% | 2% | 1% | -1% | 1% | 1% |
| 16-Sep | -2% | -1% | 1% | 1% | -2% | -2% | -1% | 1% | 1% | 1% | 1% | 1% | -1% | -1% | 1% | 1% | 0% | -2% | 1% | 1% |
| 23-Sep | -1% | 1% | 1% | 1% | 0% | 0% | 0% | 1% | 1% | 1% | 1% | 1% | 0% | 2% | 1% | 3% | 1% | -2% | 1% | 1% |
| 30-Sep | 0% | 0% | 1% | 1% | 0% | 0% | 0% | 1% | 1% | 1% | 1% | 1% | 1% | 3% | 1% | 3% | 1% | -1% | 2% | 2% |
| 7-Oct | -1% | -1% | 1% | 1% | 0% | 0% | 0% | 1% | 1% | 1% | 1% | 1% | 1% | 3% | 0% | 2% | 0% | -1% | 1% | 1% |
| 14-Oct | -1% | 0% | 0% | 0% | -1% | -1% | 0% | 1% | 1% | 1% | 1% | 1% | 0% | 2% | 0% | 2% | 0% | 0% | 1% | 1% |
| 21-Oct | -1% | 0% | 0% | 0% | -1% | -1% | 0% | 0% | 0% | 0% | 0% | 0% | -2% | 1% | 0% | 1% | -1% | 0% | 0% | 0% |
| 28-Oct | 0% | 0% | 0% | 0% | -1% | -1% | 0% | 0% | 0% | 0% | 0% | 0% | -1% | 1% | 0% | 1% | -1% | 0% | 0% | 0% |
| 4-Nov | -1% | 0% | 0% | 0% | 0% | 0% | -1% | 0% | 0% | 0% | 0% | 0% | -1% | 1% | 0% | 1% | -1% | 0% | 0% | 0% |
| 11-Nov | -2% | -1% | 0% | 0% | 0% | 0% | -1% | 0% | 0% | 0% | 0% | 0% | -1% | 0% | 0% | -1% | -2% | 0% | 0% | 0% |
| 18-Nov | -2% | -1% | 0% | 0% | 0% | 0% | 0% | -1% | -1% | -1% | -1% | -1% | -1% | 0% | -1% | -1% | -2% | 1% | 1% | 1% |
| 25-Nov | -2% | -1% | 0% | 0% | 0% | 0% | -1% | -1% | -1% | -1% | -1% | -1% | 0% | -2% | -1% | -1% | -2% | 0% | 1% | 1% |
| 2-Dec | -1% | 0% | -1% | -1% | 0% | 0% | -1% | -1% | -1% | -1% | -1% | -1% | -1% | -3% | -1% | -2% | -1% | -1% | 0% | 0% |
| 9-Dec | -1% | 1% | -1% | -1% | -1% | -1% | -2% | -1% | -1% | -1% | -1% | -1% | -1% | -3% | -1% | -2% | -1% | -1% | -1% | -1% |
| 16-Dec | 0% | 1% | -1% | -1% | -1% | -1% | -1% | -1% | -1% | -1% | -1% | -1% | -1% | -3% | -1% | -2% | -1% | -1% | 0% | 0% |
| 23-Dec | 0% | 1% | -1% | -1% | -1% | -1% | -1% | -1% | -1% | -1% | -1% | -1% | 0% | -3% | -1% | -2% | -1% | -1% | -1% | -1% |
| 30-Dec | 1% | 0% | -1% | -1% | 0% | 0% | -1% | -1% | -1% | -1% | -1% | -1% | -1% | -2% | -1% | -2% | -1% | -1% | 0% | 0% |
| 6-Jan | 1% | 0% | 0% | 0% | 0% | 0% | 0% | -1% | -1% | -1% | -1% | -1% | -1% | -3% | -1% | -3% | -1% | -1% | 0% | 0% |
| 13-Jan | 2% | 1% | -1% | -1% | 0% | 0% | 0% | -1% | -1% | -1% | -1% | -1% | 0% | -3% | -1% | -2% | 0% | -1% | -1% | -1% |
| 20-Jan | 3% | 2% | 0% | 0% | 0% | 0% | 0% | -1% | -1% | -1% | -1% | -1% | 0% | -1% | -1% | 0% | 1% | -1% | -2% | -2% |
| 27-Jan | 2% | 1% | 0% | 0% | 0% | 0% | -1% | 0% | 0% | 0% | 0% | 0% | -1% | -1% | 0% | 0% | 0% | -1% | -2% | -2% |
| 3-Feb | 2% | 1% | 0% | 0% | 0% | 0% | -1% | 0% | 0% | 0% | 0% | 0% | -1% | 0% | 1% | -1% | -1% | -2% | -1% | -1% |
| 10-Feb | 2% | 1% | 0% | 0% | 2% | 2% | 0% | 1% | 1% | 1% | 1% | 1% | -1% | 1% | 1% | 1% | 0% | -2% | -1% | -1% |
| 17-Feb | 4% | 2% | 0% | 0% | 3% | 3% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 2% | 1% | 1% | 2% | -1% | -1% | -1% |
| 24-Feb | 5% | 3% | 0% | 0% | 3% | 3% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 3% | 1% | 2% | 3% | -2% | -2% | -2% |
| 2-Mar | 4% | 2% | 0% | 0% | 2% | 2% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 3% | 1% | 2% | 3% | -2% | -2% | -2% |
| 9-Mar | 4% | 3% | 0% | 0% | 3% | 3% | 2% | 1% | 1% | 1% | 1% | 1% | 1% | 3% | 1% | 3% | 4% | -1% | 0% | 0% |
| 16-Mar | 4% | 2% | 0% | 0% | 4% | 4% | 3% | 1% | 1% | 1% | 1% | 1% | 2% | 5% | 1% | 4% | 5% | 0% | 0% | 0% |
| 23-Mar | 4% | 1% | 0% | 0% | 3% | 3% | 2% | 1% | 1% | 1% | 1% | 1% | 1% | 3% | 1% | 3% | 4% | 0% | 1% | 1% |
| 30-Mar | 3% | 1% | 0% | 0% | 3% | 3% | 2% | 1% | 1% | 1% | 1% | 1% | 2% | 2% | 1% | 2% | 4% | 0% | 0% | 0% |
| 6-Apr | 2% | 0% | 0% | 0% | 2% | 2% | 2% | 1% | 1% | 1% | 1% | 1% | 0% | 1% | 0% | 2% | 4% | 0% | -1% | -1% |
| 13-Apr | 2% | 0% | 0% | 0% | 1% | 1% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 1% | 3% | 1% | -1% | -1% |
| 20-Apr | -1% | -2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | -1% | -1% | 0% | 1% | 3% | 0% | 0% | 0% |
| 27-Apr | -2% | -2% | 0% | 0% | 2% | 2% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 3% | 1% | 1% | 1% |
| 4-May | 0% | -1% | 0% | 0% | 2% | 2% | 1% | 1% | 1% | 1% | 1% | 1% | 0% | -1% | 1% | 1% | 4% | 2% | 2% | 2% |
| 11-May | -1% | -1% | 0% | 0% | 2% | 2% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 1% | 3% | 1% | 1% | 0% | 0% |
| 18-May | -1% | 0% | 0% | 0% | 2% | 2% | 1% | 1% | 1% | 1% | 1% | 1% | -1% | -1% | 1% | 0% | 2% | 1% | -1% | -1% |
| 25-May | -1% | 0% | 0% | 0% | 3% | 3% | 1% | 1% | 1% | 1% | 1% | 1% | 0% | 1% | 1% | 1% | 3% | 1% | 0% | 0% |
| 1-Jun | 1% | 1% | 0% | 0% | 3% | 3% | 2% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 0% | 2% | 3% | 2% | 0% | 0% |
| 8-Jun | 2% | 1% | 0% | 0% | 3% | 3% | 2% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 2% | 2% | 0% | 0% |
| 15-Jun | 2% | 1% | 0% | 0% | 3% | 3% | 2% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 2% | 2% | 0% | 0% |
| 22-Jun | 2% | 2% | 0% | 0% | 2% | 2% | 1% | 2% | 2% | 2% | 2% | 2% | -1% | 1% | 2% | -1% | 0% | 1% | -1% | -1% |

| LPCon region | White hill | FlatHill | MtStuart | Mahin erangi | West wind | Millcrk | HauNui | TeApiti | TeRere Hau | T1 | T2 | T3 | TeUku | Hurunui | MtMunro | Patea | Central Wind | Harap aki | Wood Hill | Pouto |
|--------------|------------|----------|----------|--------------|-----------|---------|--------|---------|------------|-----|-----|-----|-------|---------|---------|-------|--------------|-----------|-----------|-------|
| 1-Jul | 8% | 7% | 1% | 1% | 6% | 6% | 2% | 7% | 7% | 7% | 7% | 7% | 6% | 10% | 5% | 8% | 8% | 1% | 3% | 3% |
| 8-Jul | 8% | 7% | 1% | 1% | 5% | 5% | 2% | 6% | 6% | 6% | 6% | 6% | 5% | 10% | 4% | 7% | 7% | 1% | 2% | 2% |
| 15-Jul | 8% | 8% | 1% | 1% | 5% | 5% | 2% | 7% | 7% | 7% | 7% | 7% | 5% | 11% | 5% | 8% | 8% | 0% | 2% | 2% |
| 22-Jul | 8% | 9% | 1% | 1% | 5% | 5% | 1% | 6% | 6% | 6% | 6% | 6% | 3% | 11% | 4% | 7% | 7% | 0% | 1% | 1% |
| 29-Jul | 10% | 10% | 2% | 2% | 4% | 4% | 1% | 6% | 6% | 6% | 6% | 6% | 3% | 11% | 4% | 7% | 7% | -1% | 0% | 0% |
| 5-Aug | 11% | 10% | 2% | 2% | 4% | 4% | 1% | 6% | 6% | 6% | 6% | 6% | 3% | 11% | 4% | 7% | 7% | -2% | 0% | 0% |
| 12-Aug | 10% | 9% | 2% | 2% | 4% | 4% | 0% | 6% | 6% | 6% | 6% | 6% | 2% | 10% | 4% | 6% | 5% | -2% | -1% | -1% |
| 19-Aug | 8% | 7% | 2% | 2% | 3% | 3% | 0% | 5% | 5% | 5% | 5% | 5% | 1% | 7% | 2% | 4% | 4% | -2% | -1% | -1% |
| 26-Aug | 7% | 6% | 2% | 2% | 2% | 2% | 0% | 4% | 4% | 4% | 4% | 4% | 0% | 6% | 2% | 3% | 3% | -2% | 0% | 0% |
| 2-Sep | 6% | 5% | 2% | 2% | 2% | 2% | 0% | 4% | 4% | 4% | 4% | 4% | 1% | 6% | 2% | 4% | 3% | -1% | 0% | 0% |
| 9-Sep | 5% | 4% | 2% | 2% | 2% | 2% | 1% | 4% | 4% | 4% | 4% | 4% | 1% | 5% | 3% | 4% | 4% | 0% | 1% | 1% |
| 16-Sep | 6% | 4% | 2% | 2% | 3% | 3% | 1% | 5% | 5% | 5% | 5% | 5% | 2% | 5% | 3% | 4% | 4% | -1% | 1% | 1% |
| 23-Sep | 4% | 3% | 2% | 2% | 3% | 3% | 1% | 4% | 4% | 4% | 4% | 4% | 1% | 3% | 3% | 3% | 3% | -1% | 1% | 1% |
| 30-Sep | 4% | 3% | 2% | 2% | 3% | 3% | 1% | 3% | 3% | 3% | 3% | 3% | 1% | 2% | 2% | 2% | 2% | 0% | 1% | 1% |
| 7-Oct | 2% | 1% | 2% | 2% | 1% | 1% | 0% | 2% | 2% | 2% | 2% | 2% | 0% | 1% | 1% | 1% | 1% | 0% | 1% | 1% |
| 14-Oct | 1% | 0% | 1% | 1% | 2% | 2% | 1% | 2% | 2% | 2% | 2% | 2% | 0% | 1% | 1% | 1% | 1% | 0% | 1% | 1% |
| 21-Oct | 1% | 0% | 1% | 1% | 1% | 1% | 0% | 1% | 1% | 1% | 1% | 1% | 0% | 0% | 1% | 1% | 0% | -1% | 0% | 0% |
| 28-Oct | 0% | -1% | 0% | 0% | 1% | 1% | -1% | 1% | 1% | 1% | 1% | 1% | -1% | 0% | 0% | 0% | -1% | -2% | -1% | -1% |
| 4-Nov | -1% | -1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | -2% | -1% | -1% | -1% | -1% | -4% | -2% | -2% |
| 11-Nov | 0% | -1% | 0% | 0% | 1% | 1% | -2% | 0% | 0% | 0% | 0% | 0% | -3% | 0% | -1% | -1% | -2% | -5% | -3% | -3% |
| 18-Nov | -2% | -2% | -1% | -1% | -1% | -1% | -3% | -2% | -2% | -2% | -2% | -2% | -4% | -2% | -3% | -3% | -4% | -5% | -3% | -3% |
| 25-Nov | -3% | -3% | -1% | -1% | -1% | -1% | -4% | -3% | -3% | -3% | -3% | -3% | -5% | -2% | -3% | -4% | -5% | -5% | -4% | -4% |
| 2-Dec | -4% | -5% | -3% | -3% | 0% | 0% | -4% | -2% | -2% | -2% | -2% | -2% | -5% | -1% | -3% | -3% | -5% | -5% | -4% | -4% |
| 9-Dec | -4% | -5% | -3% | -3% | 0% | 0% | -4% | -3% | -3% | -3% | -3% | -3% | -5% | -2% | -3% | -3% | -5% | -4% | -4% | -4% |
| 16-Dec | -4% | -5% | -2% | -2% | -2% | -2% | -4% | -4% | -4% | -4% | -4% | -4% | -6% | -3% | -4% | -5% | -6% | -3% | -4% | -4% |
| 23-Dec | -3% | -4% | -2% | -2% | -1% | -1% | -4% | -3% | -3% | -3% | -3% | -3% | -5% | -1% | -4% | -4% | -5% | -3% | -4% | -4% |
| 30-Dec | -3% | -4% | -2% | -2% | -1% | -1% | -4% | -3% | -3% | -3% | -3% | -3% | -4% | 0% | -3% | -3% | -4% | -2% | -4% | -4% |
| 6-Jan | -3% | -4% | -1% | -1% | -2% | -2% | -3% | -2% | -2% | -2% | -2% | -2% | -3% | -1% | -3% | -3% | -3% | -1% | -3% | -3% |
| 13-Jan | -3% | -4% | -2% | -2% | -3% | -3% | -4% | -3% | -3% | -3% | -3% | -3% | -3% | -2% | -3% | -3% | -3% | -2% | -3% | -3% |
| 20-Jan | -1% | -2% | -1% | -1% | -1% | -1% | -3% | -2% | -2% | -2% | -2% | -2% | -1% | 1% | -2% | -2% | -2% | -2% | -3% | -3% |
| 27-Jan | 1% | -1% | 0% | 0% | 0% | 0% | -1% | 0% | 0% | 0% | 0% | 0% | 1% | 2% | 0% | 0% | 0% | -1% | -2% | -2% |
| 3-Feb | 2% | 0% | 1% | 1% | 1% | 1% | 0% | 1% | 1% | 1% | 1% | 1% | 2% | 3% | 2% | 1% | 2% | -1% | -2% | -2% |
| 10-Feb | 3% | 1% | 1% | 1% | 2% | 2% | 1% | 3% | 3% | 3% | 3% | 3% | 2% | 4% | 3% | 1% | 3% | -2% | -1% | -1% |
| 17-Feb | 2% | 1% | 0% | 0% | 2% | 2% | 0% | 3% | 3% | 3% | 3% | 3% | 3% | 4% | 3% | 1% | 3% | -3% | -1% | -1% |
| 24-Feb | 2% | 0% | 0% | 0% | 4% | 4% | 2% | 4% | 4% | 4% | 4% | 4% | 2% | 5% | 4% | 2% | 3% | -2% | 0% | 0% |
| 2-Mar | 1% | 0% | 0% | 0% | 2% | 2% | 1% | 2% | 2% | 2% | 2% | 2% | 1% | 2% | 2% | 1% | 1% | -1% | 0% | 0% |
| 9-Mar | 2% | 1% | 1% | 1% | 4% | 4% | 2% | 3% | 3% | 3% | 3% | 3 | | | | | | | | |

6. High emissions scenario hydro inflow modelling – initial results

- Changing water impacts only at this stage
- Wind changes in progress

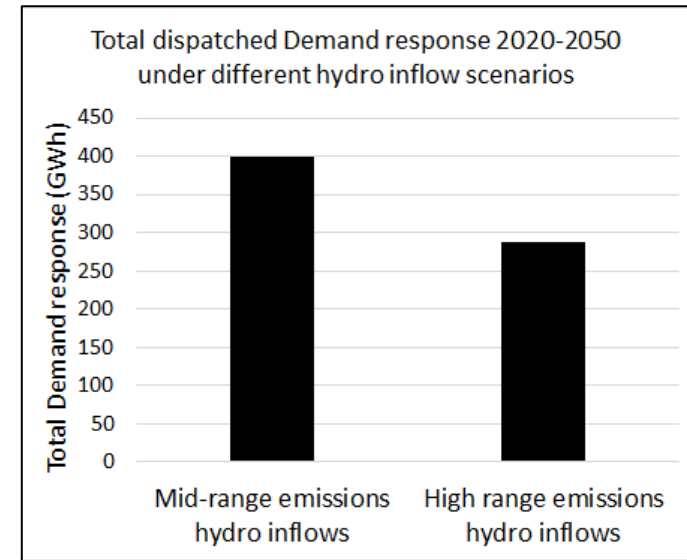
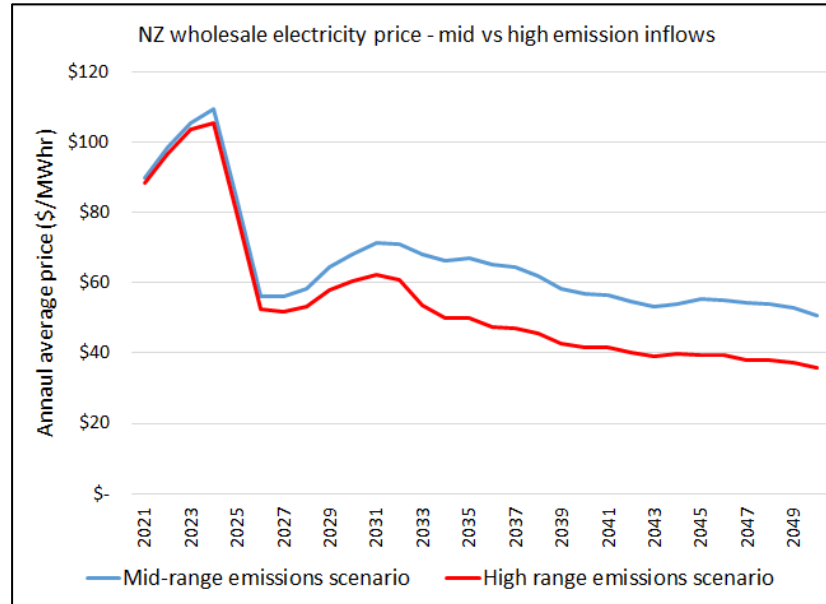
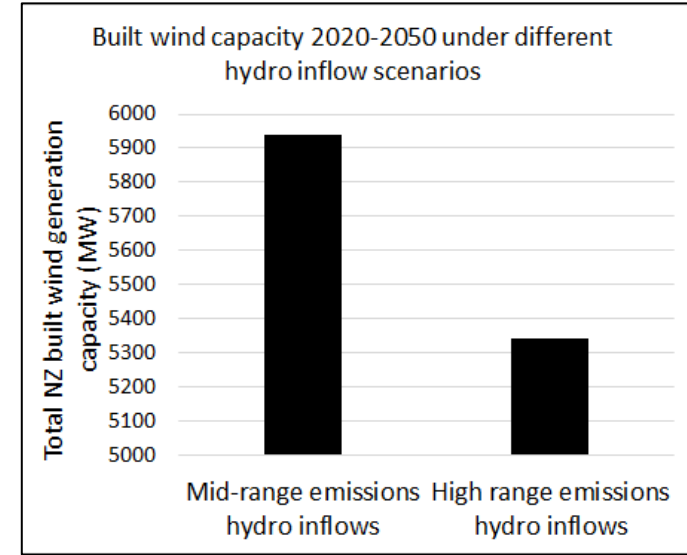
6. High emissions scenario hydro inflow modelling – initial results

- Impacts of increased annual inflows in the South Island, decreased annual inflows in the North Island, and changing seasonality of inflows – high range vs mid-range emissions

| LPCon region | Manapouri | Clutha | Pukaki | Tetapoto | GYM-RoR | ISL-RoR | KIK-RoR | BPE-RoR | Tongariro | Waikaremoana | BOP-RoR | Waikato |
|--------------|-----------|--------|--------|----------|---------|---------|---------|---------|-----------|--------------|---------|---------|
| 1-Jul | 20% | 13% | 23% | 13% | 13% | 10% | 11% | -1% | 6% | -3% | -3% | 2% |
| 8-Jul | 20% | 14% | 23% | 13% | 13% | 10% | 11% | 0% | 6% | -3% | -3% | 2% |
| 15-Jul | 19% | 13% | 23% | 13% | 13% | 10% | 10% | 0% | 7% | -3% | -2% | 3% |
| 22-Jul | 18% | 14% | 23% | 13% | 13% | 9% | 11% | 1% | 7% | -3% | -1% | 3% |
| 29-Jul | 17% | 13% | 22% | 12% | 12% | 9% | 10% | 1% | 6% | -2% | -1% | 3% |
| 5-Aug | 16% | 12% | 21% | 12% | 12% | 7% | 10% | 1% | 5% | -3% | -1% | 2% |
| 12-Aug | 15% | 11% | 21% | 11% | 12% | 6% | 9% | 0% | 5% | -3% | -2% | 1% |
| 19-Aug | 13% | 10% | 19% | 10% | 11% | 5% | 9% | 0% | 4% | -3% | -2% | 1% |
| 26-Aug | 10% | 8% | 17% | 9% | 10% | 4% | 8% | 0% | 3% | -3% | -2% | 0% |
| 2-Sep | 10% | 7% | 16% | 8% | 10% | 3% | 7% | -1% | 2% | -4% | -3% | 0% |
| 9-Sep | 9% | 6% | 15% | 7% | 9% | 2% | 7% | -1% | 1% | -4% | -3% | -1% |
| 16-Sep | 8% | 5% | 13% | 6% | 7% | 1% | 6% | -2% | 0% | -5% | -4% | -2% |
| 23-Sep | 7% | 5% | 11% | 5% | 7% | 0% | 5% | -2% | -1% | -5% | -5% | -3% |
| 30-Sep | 6% | 4% | 9% | 4% | 6% | -1% | 4% | -3% | -2% | -6% | -6% | -4% |
| 7-Oct | 7% | 4% | 8% | 3% | 6% | -1% | 4% | -3% | -3% | -7% | -7% | -5% |
| 14-Oct | 6% | 4% | 6% | 2% | 6% | -1% | 3% | -3% | -3% | -8% | -8% | -6% |
| 21-Oct | 6% | 3% | 5% | 1% | 5% | -1% | 3% | -3% | -4% | -9% | -9% | -6% |
| 28-Oct | 5% | 3% | 3% | 0% | 5% | -1% | 2% | -3% | -4% | -10% | -10% | -7% |
| 4-Nov | 5% | 3% | 2% | -1% | 5% | -1% | 2% | -3% | -4% | -11% | -10% | -8% |
| 11-Nov | 5% | 3% | 1% | -1% | 5% | -2% | 2% | -3% | -4% | -12% | -10% | -8% |
| 18-Nov | 5% | 3% | 0% | -2% | 4% | -2% | 1% | -3% | -5% | -12% | -10% | -9% |
| 25-Nov | 5% | 3% | -1% | -2% | 4% | -2% | 1% | -1% | -5% | -12% | -10% | -9% |
| 2-Dec | 5% | 3% | -1% | -2% | 4% | -2% | 0% | -2% | -6% | -12% | -9% | -9% |
| 9-Dec | 4% | 3% | -2% | -2% | 3% | -2% | -1% | -3% | -7% | -11% | -7% | -9% |
| 16-Dec | 5% | 3% | -1% | -2% | 4% | -3% | -1% | -4% | -7% | -11% | -7% | -10% |
| 23-Dec | 4% | 2% | -2% | -2% | 3% | -2% | -1% | -4% | -7% | -11% | -7% | -9% |
| 30-Dec | 4% | 3% | 0% | 0% | 4% | -2% | -1% | -3% | -8% | -10% | -7% | -9% |
| 6-Jan | 4% | 3% | 0% | 0% | 3% | -2% | -2% | -4% | -8% | -10% | -7% | -8% |
| 13-Jan | 5% | 3% | 0% | 0% | 3% | -3% | -2% | -4% | -9% | -10% | -5% | -8% |
| 20-Jan | 5% | 4% | 1% | 1% | 2% | -3% | -2% | -5% | -10% | -10% | -6% | -9% |
| 27-Jan | 5% | 4% | 2% | 0% | 2% | -3% | -2% | -5% | -10% | -10% | -7% | -9% |
| 3-Feb | 5% | 4% | 2% | 1% | 3% | -3% | -2% | -5% | -10% | -9% | -6% | -8% |
| 10-Feb | 5% | 3% | 3% | 1% | 3% | -2% | -2% | -5% | -9% | -9% | -8% | -9% |
| 17-Feb | 5% | 4% | 3% | 2% | 3% | -2% | -2% | -4% | -9% | -8% | -8% | -8% |
| 24-Feb | 5% | 3% | 5% | 2% | 4% | -1% | 0% | -3% | -8% | -8% | -9% | -8% |
| 2-Mar | 4% | 3% | 5% | 2% | 3% | -1% | 0% | -3% | -6% | -7% | -9% | -6% |
| 9-Mar | 4% | 3% | 6% | 3% | 4% | 0% | 0% | -3% | -6% | -7% | -9% | -6% |
| 16-Mar | 4% | 3% | 5% | 2% | 4% | 0% | 0% | -4% | -5% | -6% | -8% | -5% |
| 23-Mar | 4% | 3% | 6% | 3% | 5% | 0% | 1% | -4% | -5% | -6% | -9% | -6% |
| 30-Mar | 4% | 3% | 6% | 2% | 5% | 1% | 1% | -5% | -4% | -5% | -8% | -5% |
| 6-Apr | 4% | 3% | 6% | 2% | 5% | 2% | 1% | -5% | -4% | -4% | -7% | -4% |
| 13-Apr | 3% | 3% | 6% | 3% | 5% | 2% | 1% | -5% | -3% | -3% | -7% | -4% |
| 20-Apr | 4% | 3% | 8% | 3% | 5% | 2% | 2% | -6% | -3% | -3% | -7% | -3% |
| 27-Apr | 5% | 3% | 8% | 3% | 5% | 2% | 3% | -6% | -2% | -2% | -5% | -2% |
| 4-May | 6% | 4% | 9% | 4% | 5% | 3% | 3% | -6% | -1% | -3% | -5% | -2% |
| 11-May | 9% | 5% | 11% | 6% | 6% | 4% | 4% | -6% | -1% | -4% | -5% | -3% |
| 18-May | 10% | 7% | 13% | 6% | 6% | 5% | 4% | -6% | 0% | -4% | -5% | -2% |
| 25-May | 11% | 7% | 14% | 7% | 6% | 5% | 5% | -6% | 0% | -3% | -5% | -2% |
| 1-Jun | 13% | 9% | 16% | 8% | 7% | 6% | 6% | -5% | 2% | -3% | -4% | -1% |
| 8-Jun | 15% | 10% | 17% | 9% | 9% | 7% | 8% | -4% | 3% | -3% | -4% | 0% |
| 15-Jun | 17% | 11% | 20% | 11% | 10% | 8% | 8% | -3% | 4% | -3% | -4% | 0% |
| 22-Jun | 18% | 12% | 21% | 12% | 11% | 9% | 9% | -2% | 5% | -3% | -4% | 1% |

More water, arriving when it is needed for generation, resulted in:

- 10% less new built capacity (wind) 2020-50
- 28% less demand response dispatched
- 30% lower prices by 2050



Summary

- The timing and quantity of hydro inflows dominate the NZ electricity system, and are going to become increasingly important with growing levels of renewables. Including these in electricity system modelling makes a big difference to outcomes.
- Significant changes to river flows have already been seen over the 100 year record.
- Significant shifts in the seasonality of river flows are expected in coming decades, particularly in snow-fed catchments, with river flows projected to be significantly higher in winter than in the past.
- River flows are expected to become more volatile, particularly in the South Island, with flood peaks increasing, and dry periods getting drier.
- Wind speeds are projected to generally get lower in summer and higher in winter in future.
- When these projected inflow changes are input to an electricity system model, LPCon, hydro lakes in the South Island spent more time at higher levels, and spill doubled by 2050 under even a mid-range emissions scenario.
- The amount of generation capacity needed was significantly affected under high emissions scenario, and prices and other system measures were also impacted by the changes to inflows.
- These changes should be accounted for in some form in future energy system modelling.
- This work is ongoing, and results will be finalised early 2024.

