Climate drivers and seasonal outlook for the Wellington Region

Summer 2022-2023 summary

Autumn 2023 outlook

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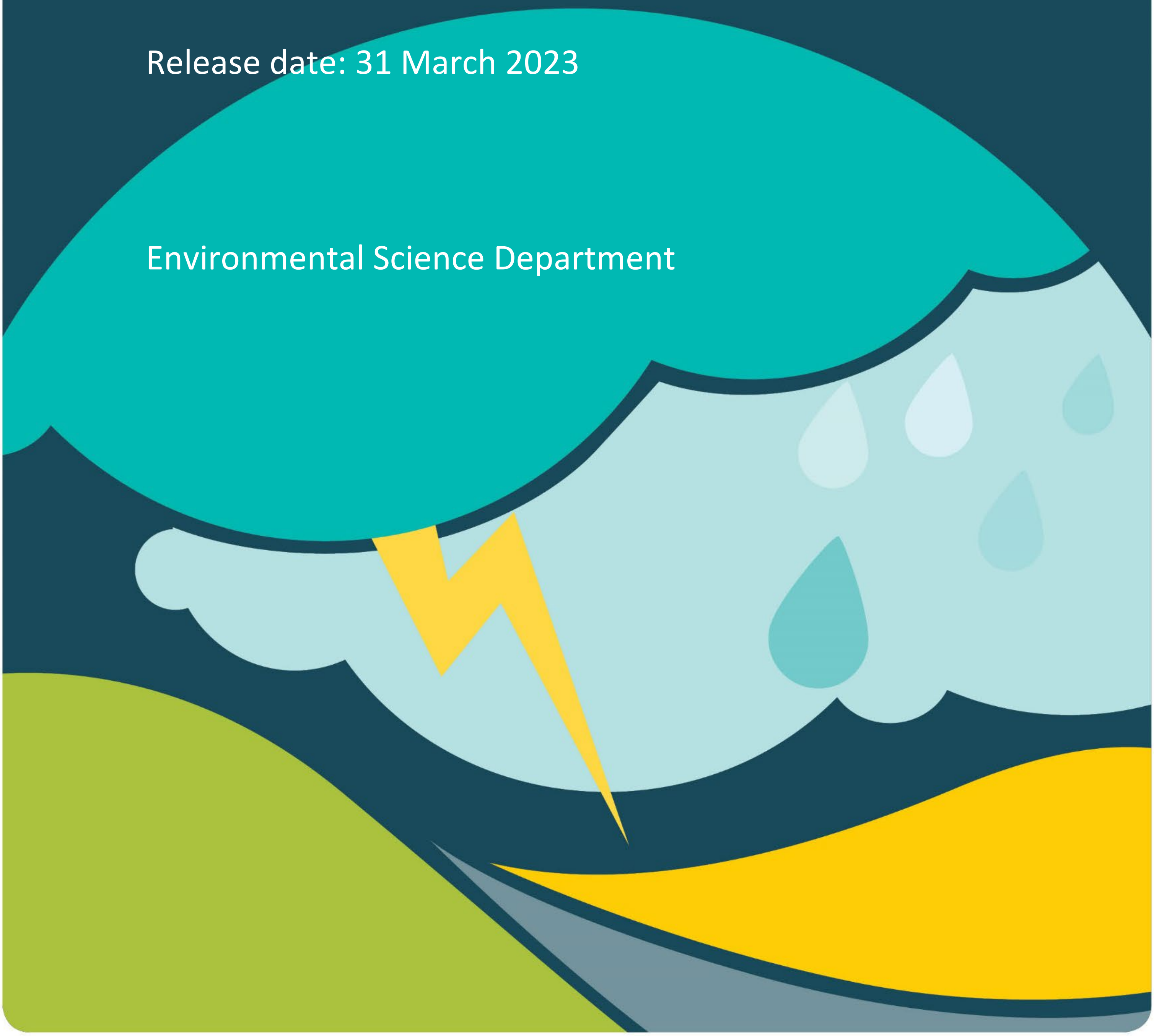
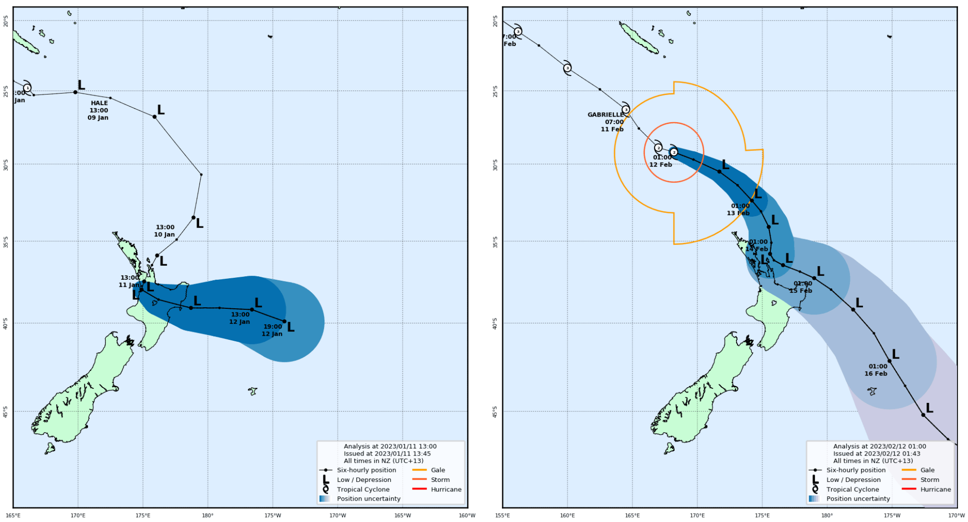
Environmental Science Department





Summer 2022-2023 made history as one of the most remarkable ever recorded in New Zealand, unfortunately for all the wrong reasons. Ex TC Hale in January (left panel) and ex-TC Gabrielle in February (right panel) both affected the northern and eastern North Island with unprecedented amounts of rain and destruction, and sadly with human lives lost. The rain from these systems added to various additional atmospheric river events already affecting the northern part of the country, with Auckland also being significantly hit by a previous storm. While ex-tropical cyclones affecting New Zealand are not caused by climate change, incoming storms are encountering higher background levels of heat and humidity from global warming, making these more conducive for heavy rainfall bursts. Both trajectory panels show the forecasts when these storms were still classed as Tropical Cyclones, courtesy of MetService (TC Hale starting 9 January, TC Gabrielle starting 10 February).

Overview

Summer 2022-2023

Summer 2023 was a remarkable season of record breaking storms, with unprecedented amounts of rainfall and destruction. Two very active ex-tropical cyclones, Hale and Gabrielle, intensified during their approach to the North Island. These storms, combined with additional atmospheric river events, caused a trail of mud, destruction of property and sadly of human life loss. For the eastern hills and east Wairarapa coast, summer rainfall was over three times the normal. Both Castlepoint and Longbush had over 600 mm of rain, leading to the wettest on record season for at least 120 years of measurements. For Wellington, summer 2023 was the least windy on record, since at least 1961. Sunshine hours were also well below average. All in all, the summer season was a remarkable example of both climate variability (through La Niña) and climate change (through background warming and increased humidity). These drivers worked in tandem to create warmth, high humidity, and storms.

Climate drivers

The La Niña phenomenon has now dissipated. For three consecutive years, La Niña has been contributing to marine heatwaves and an unprecedented abundance of atmospheric rivers affecting New Zealand. International climate models are now predicting a somewhat abrupt change towards a possible El Niño developing later in the year. This could cause a return of more normal westerly flows and drier and cooler conditions.

Climate outlook for autumn 2023

With the demise of La Niña, the atmosphere will now progressively re-adjust the circulation back to typical autumn south-westerly flows, with the likely return of sea surface temperatures to closer to normal values. Most international climate models are currently diverging in how quickly this change will play out. As the circulation progressively responds to the departure of La Niña, autumn should see closer to seasonal average temperatures. Rainfall will progressively shift to normal to above normal in the west, and normal to below normal in the east.

Live regional climate maps (updated daily): Daily updated climate maps and tables of regional rainfall, and soil moisture, are provided on GWRC’s environmental data webpage (graphs.gw.govt.nz/#dailyClimateMaps).

Contents

1. Climate drivers

1.1 El Niño – Southern Oscillation (ENSO)

The ensemble projections of the Australian climate model below show that the ENSO phenomenon is predicted to progressively shift from residual La Niña/neutral to El Niño. For the autumn season, this progressive shift indicates a gradual adjustment of the atmosphere back to more average conditions, with a return of westerly-south-westerly flows, cooler conditions and drier in the east.

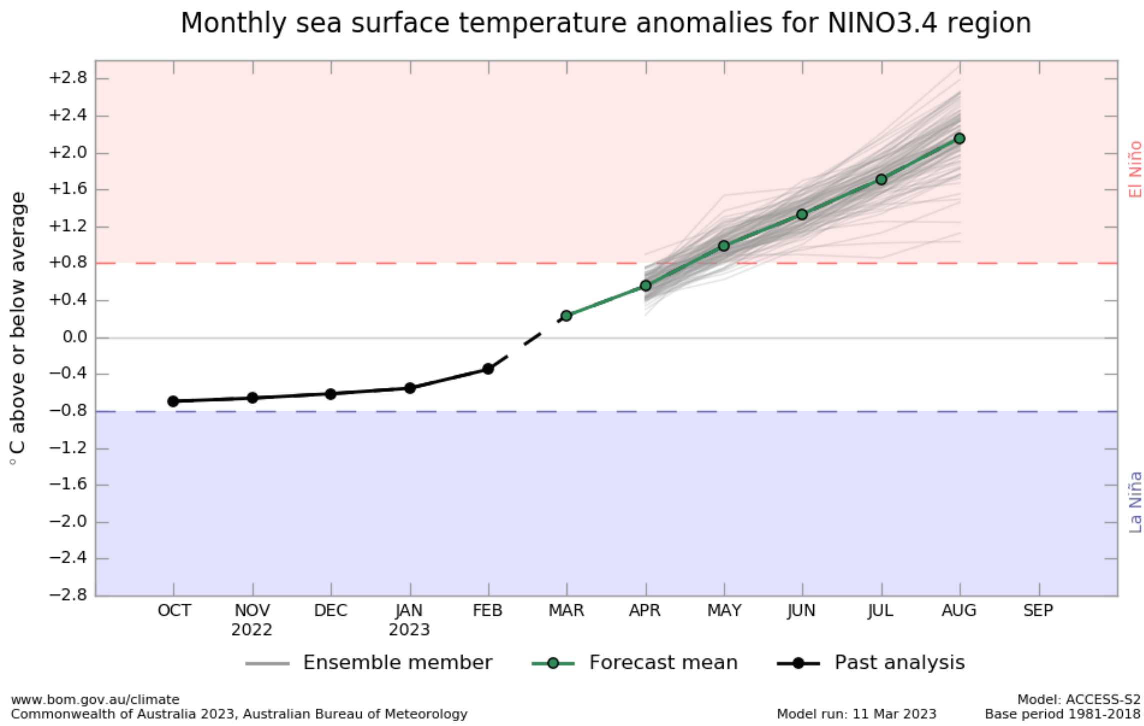


Figure 1.1: Average modelled projections (in green) show that the ENSO phenomenon is expected to progressively shift towards the positive phase by the second half of the year. Source: Australian Bureau of Meteorology.

1.2 Sea Surface Temperature (SST) anomalies

The SST anomalies and the total Sea Ice Extent (SIE, in white) are shown in Figure 1.2, as of 26 March 2023.

The overall pattern shows the residual La Niña in the Equatorial Pacific (cold tongue), and a warm tongue now forming on the Peruvian coast. Meanwhile, the waters remain warmer than average around New Zealand. The SIE (in white) has reached the lowest on record in February, with a nearly 40% reduction of Antarctic sea ice compared to the long-term climatology. This reduction is very significant. As we can see below, there are areas around Antarctica with near total loss of sea ice.

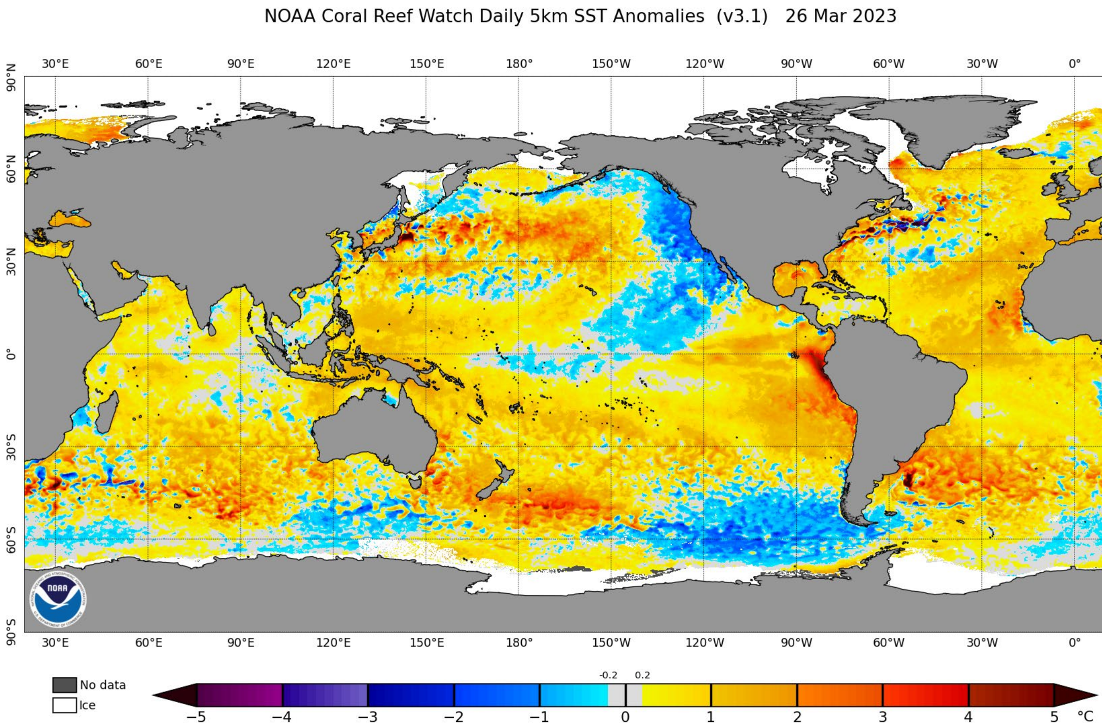


Figure 1.2: Sea Surface Temperature (SST) anomalies as of 26 March 2023. Sea ice coverage is shown in white. Water temperatures south of New Zealand are well above average. The Equatorial Pacific (ENSO) is neutral. The Sea Ice Extent (in white) reached the lowest on record for the end of summer. Source: NOAA.

1.3 Southern Annular Mode (SAM)

The SAM is the natural pressure oscillation between mid-latitudes and the Antarctic region. Normally, positive SAM is associated with high pressures around the North Island keeping the weather stable and dry/cloud-free (especially in summer), whereas the opposite is expected when the SAM is in the negative phase. During La Niña summers, the dryness associated with the positive SAM phase tends to be centred most strongly to the west of the South Island.

The SAM has been predominantly positive, but since the arrival of ex-tropical cyclone Gabrielle it turned more on the negative to neutral side. The combination of a positive SAM and La Niña, with background global warming escalating the likelihood of marine heatwaves around New Zealand, has helped create a very dry and hot summer for the South Island, and very stormy for the North Island. Now that La Niña is over, the atmospheric circulation should progressively return to a more normal autumn pattern, with stronger westerly fronts, cooler temperatures and drier conditions in the east.

Figure 1.3 shows that the summer sea level pressure pattern was characterised by a combination of an anomalous low pressure to the north and a high pressure centre to the south of New Zealand. This pattern largely blocked the normal flow, preventing the westerlies from reaching the country, and instead 'locking' the atmosphere into a moisture-laden, north-easterly flow.

This La Niña-induced pattern created very humid 'corridors' for atmospheric river events and the influence of ex-tropical cyclones. In the eastern Wairarapa this was the wettest summer for at least 120 years of data, with over 600 mm of rain. This impressive amount (over half a metre of water) corresponded to more than three times the normal seasonal average, sitting at 64% of the annual average rainfall.

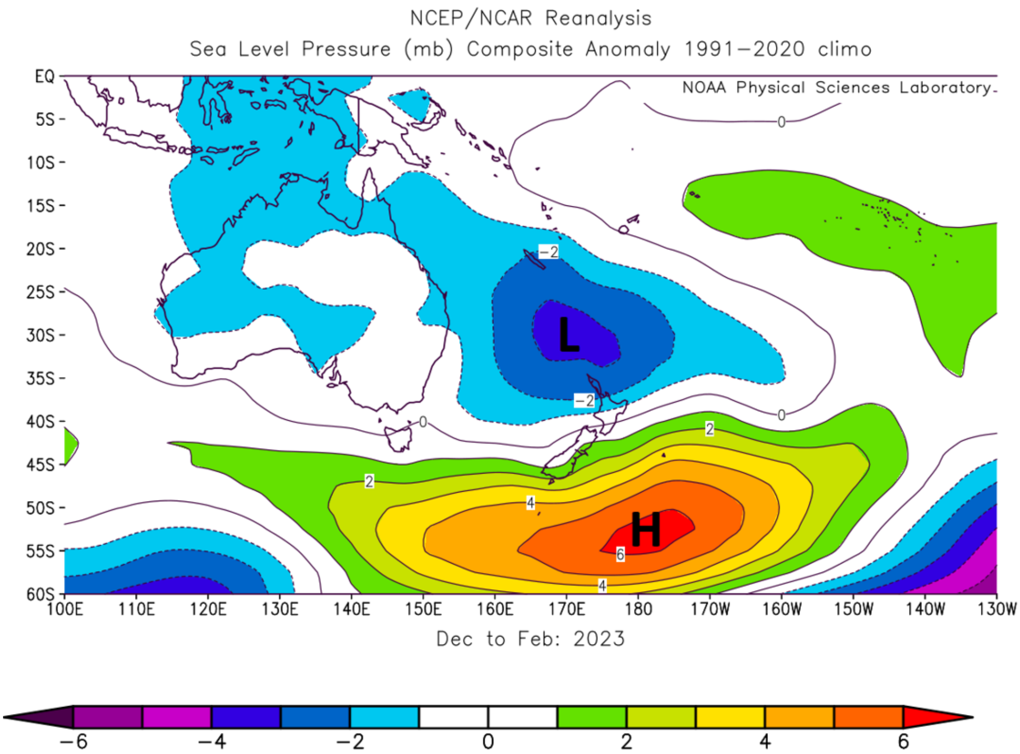


Figure 1.3: Mean sea level pressure anomaly map (hPa) for summer 2022-2023. The 'H' indicates the centre of the anomalous blocking high pressure area to the south, and the 'L' indicates the anomalous unstable low pressure area to the north. This pattern was associated with a La Niña and a positive Southern Annular Mode, and a predominant warm and moist north-easterly flow over New Zealand. Source: NCEP Reanalysis.

2. Seasonal variability and outlook

2.1 Trend analysis

The graphs below (Figure 2.1) show summaries of seasonal climate change and variability for Wellington and the Wairarapa using reference climate stations, chosen based on length of data record and availability.

The key climate variables shown are: mean temperature, total sunshine hours, mean wind, total rainfall and total number of rain days (above 0.1 mm). Temperature measurements go back to the 1910s, allowing for a meaningful analysis of climate change trends. Most other variables also have long periods of measurement greater than 50 years, except sunshine hours and wind for the Wairarapa; these are only available for less than two decades, which is a very short period climatologically and does not allow for an analysis of trends.

The red and blue bars show the extreme years of the entire measurement period. Red indicates seasons that were warmer, drier, sunnier and less windy than average (i.e., extreme hot/dry), and blue indicates seasons that were colder, wetter, cloudier and windier than average (i.e., extreme cold/wet). The reference climatological average (1981-2010) is shown by a horizontal bar where available.

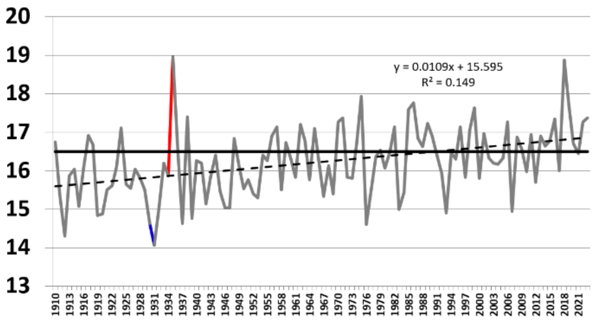
An analysis of linear trends associated with climate change is plotted onto the graph only when the trends are statistically different from zero at the 99% confidence level.

The climate change and variability summary for summer 2022-2023 is as follows:

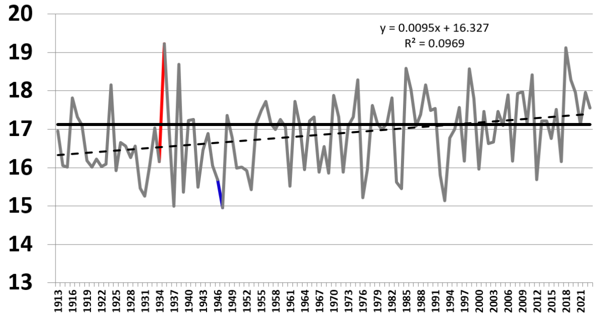
- Statistically significant trends are seen only for temperature and wind, meaning that summer is getting warmer and less windy due to ongoing climate change. The long-term warming trend is about 1.0 and 1.1 degree per century for Masterton and Wellington respectively;
- Summer 2022-2023 temperatures were warmer than normal for both Wellington and the Wairarapa, with greater anomalies for Wellington;
- Sunshine hours were well below average for both Wellington and the Wairarapa;
- Seasonal average wind speed was the lowest on record in Wellington, and below average in the Wairarapa. Importantly, our mapping shows widespread reductions in average wind speeds throughout the entire region this season;
- Seasonal rainfall was well above average in Wellington, and a record high in the Wairarapa. In the eastern Wairarapa coast, it rained over 600 mm which was more than three times the seasonal average, and equivalent to 64% of the annual average;

- Rain days were above average for Wellington, and the highest on record for the eastern Wairarapa, by a far margin.

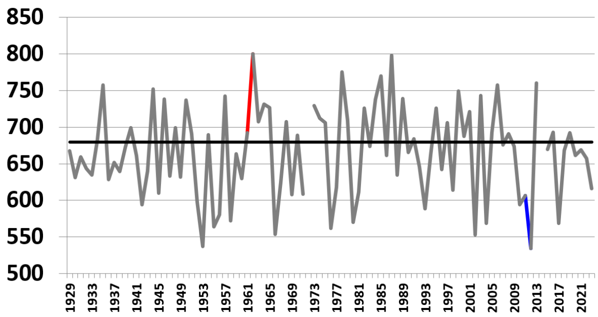
Summer Mean Temperature (deg C) - Kelburn (1910-2023)



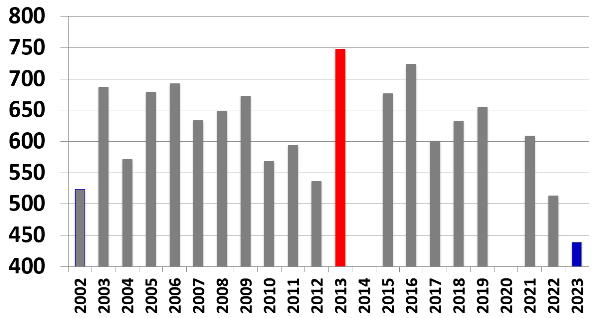
Summer Mean Temperature (deg C) - Masterton (1913-2023)



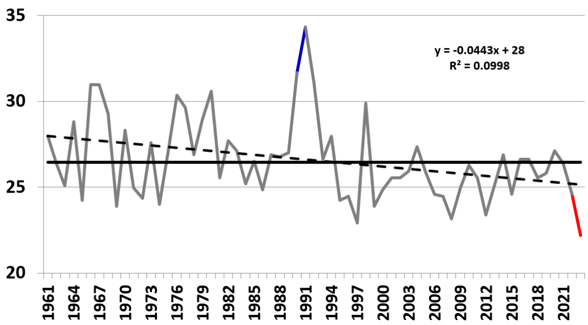
Summer Total Sunshine Hours - Kelburn (1929-2023)



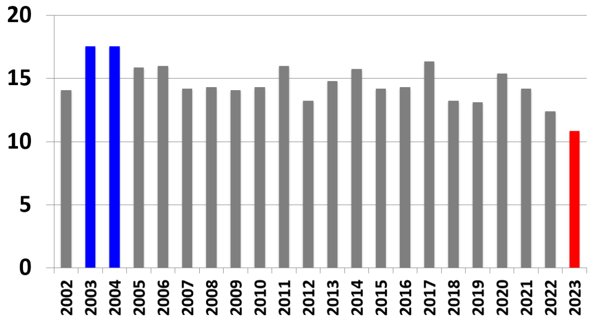
Summer Total Sunshine Hours - Martinborough (2002-2023)



Summer Mean Wind (km/h) - Wellington Airport (1961-2023)



Summer Mean Wind (km/h) - Martinborough (2002-2023)



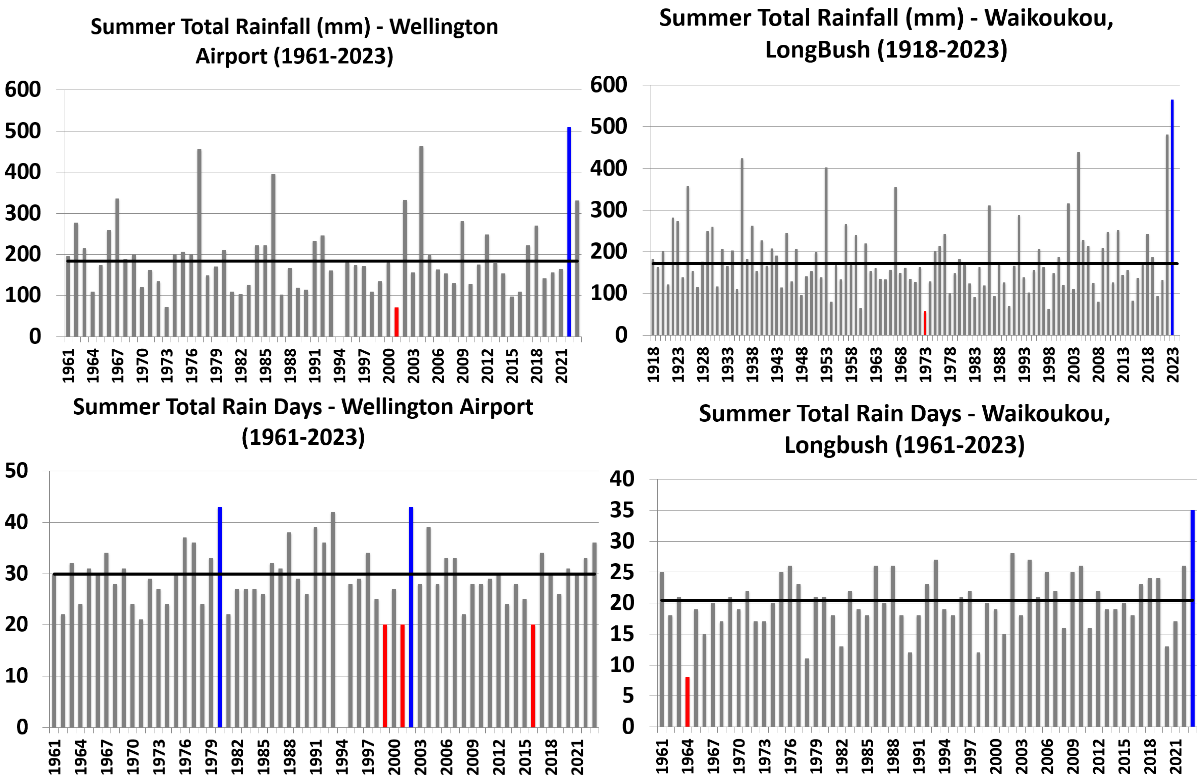


Figure 2.1: Climate change and variability graphs for summer in Wellington and the Wairarapa. The thick horizontal line shows the 1981-2010 average (where available), and the dashed line shows the linear trend. Trends are plotted only when statistically significant at 99% confidence level. For all graphs, the bright red and blue bars show the extreme min and max values for each time series (red for warm, dry, sunny and calm and blue for cool, wet, cloudy and windy). The key variables shown are: mean temperature, total number of sunshine hours, mean wind speed, total rainfall and total number of rain days (>0.1mm). Missing bars means that no reliable mean seasonal data was available for that particular year. The last bar (or data point) of each graph shows the last available data for the currently analysed season, unless there are missing data.

2.2 Seasonal Outlook

- A neutral ENSO pattern, with a progressive return of cooler westerly flows normal for autumn;
- Sea Surface Temperatures remain warmer than average, but will likely start to return to a more normal range;
- Seasonal rainfall above average in the west, normal to below east of the ranges;
- Above average temperatures, but closer to normal.

Whaitua*	Variables	Climate outlook for autumn 2023
Wellington Harbour & Hutt Valley	**Temperature:**	Average to above.
	Rainfall:	Average to above. High chance of extreme rainfall events.
Te Awarua-o-Porirua	**Temperature:**	Average to above.
	Rainfall:	Average to above. High chance of extreme rainfall events.
Kāpiti Coast	**Temperature:**	Average to above.
	Rainfall:	Above average. High chance of extreme rainfall events.
Ruamāhanga	**Temperature:**	Average to above.
	Rainfall:	Average to below. High chance of extreme rainfall events.
Wairarapa Coast	**Temperature:**	Average to above.
	Rainfall:	Average to below. High chance of extreme rainfall events.

*Whaituas are the whole catchment areas (https://www.gw.govt.nz/environment/freshwater/protecting-the-waters-of-your-area/)

Appendix 1 – Seasonal temperature and wind anomalies for selected stations

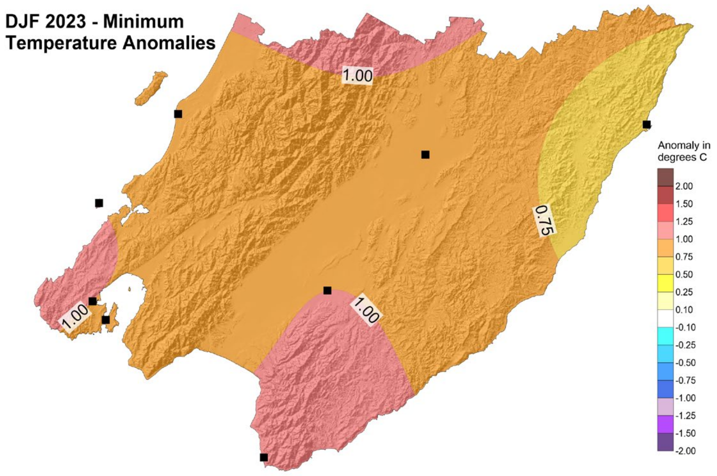
Dec-Jan-Feb 2023	Min T	Max T
Castle Point	0.6	-0.8
Kelburn	1.0	0.8
Masterton	0.9	-1.7
Ngawi	1.1	0.0
Paraparaumu	0.8	1.4
Wellington Airport	0.9	0.2
Martinborough	1.0	-0.1
Mana Island	1.0	1.7

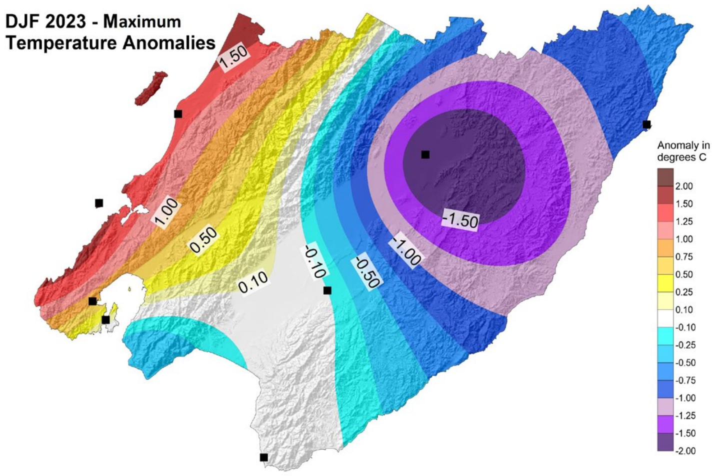
Table 1: Temperature anomalies (°C) for summer (DJF) 2022-2023 relative to the 1981-2010 climatology. Significant positive and negative anomalies (greater than 0.5°C magnitude) are highlighted in red (warmer than average) and blue (colder than average).

Dec-Jan-Feb 2023	Wind %
Castle Point	-14.0
Masterton	-15.1
Ngawi	-17.4
Paraparaumu	-15.3
Wellington Airport	-16.0
Martinborough	-28.6
Baring Head	-14.9

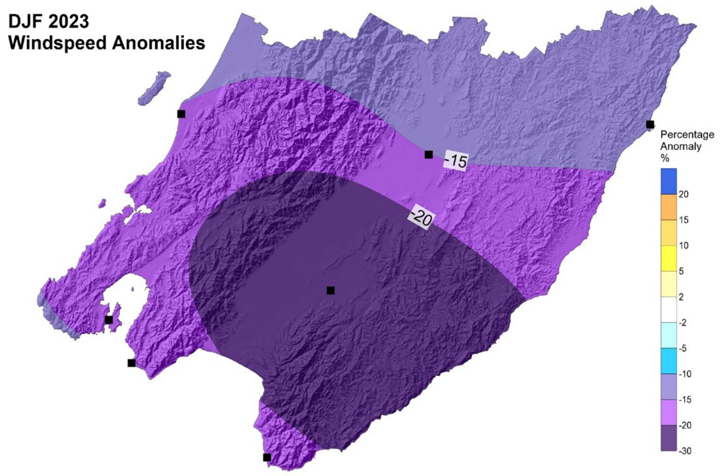
Table 2: Wind anomalies (%) for summer (DJF) 2022-2023 relative to the 1981-2010 climatology. Significant positive and negative anomalies (greater than 5%) are highlighted in red (calmer than average) and blue (windier than average).

Appendix 2 - Seasonal anomaly maps in relation to the (1981-2010) long-term averages

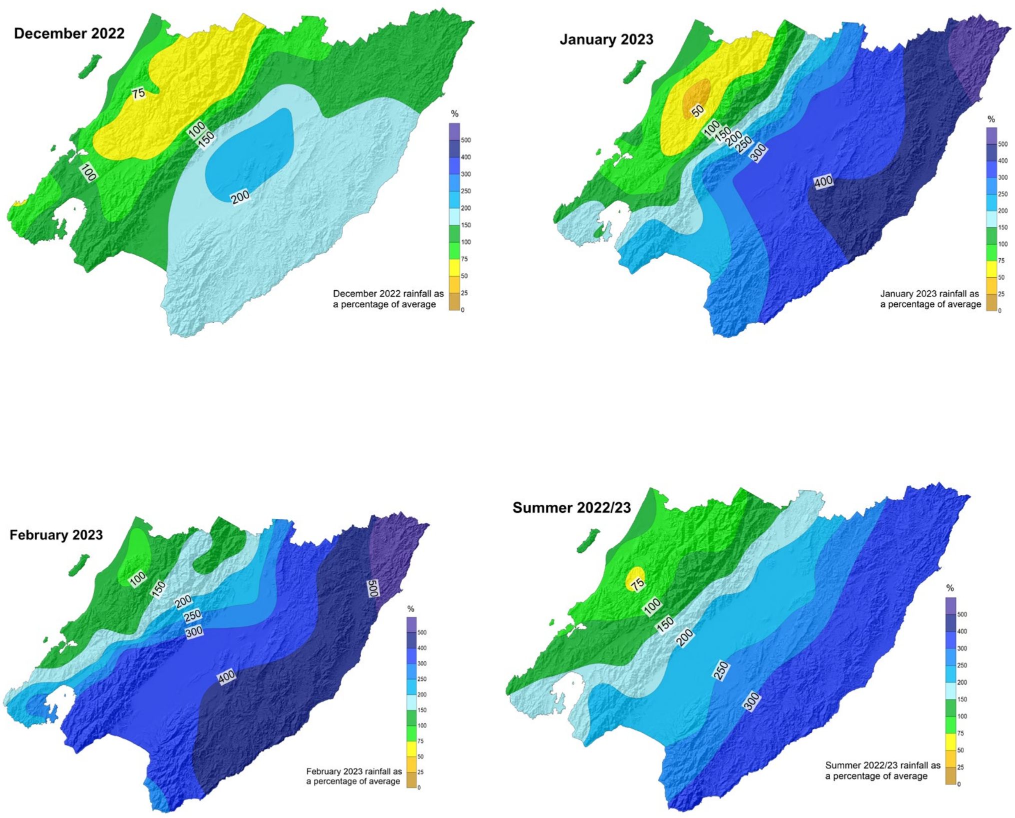




Min and Max Temperature anomalies (°C)



Wind anomalies (%)



Rainfall anomalies (%)

Acknowledgements

We would like to thank NIWA for providing selected VCSN data points for the calculation of the regional soil moisture map and for supplementing the rainfall percentage maps in data sparse areas.

Online resources

GWRC online climate mapping tools:

- **Live regional climate maps and rainfall tables (updated daily):** Climate maps for regional rainfall and soil moisture (updated daily) are provided online at GWRC's environmental data webpage (graphs.gw.govt.nz/#dailyClimateMaps)

  - **Drought check:** https://www.gw.govt.nz/environment/environmental-data-hub/climate-monitoring/drought-check/

- **Interactive climate change and sea level rise maps:** This webpage provides easy to plot climate change mapping that illustrates the predicted future impacts of climate change in the Wellington Region. Maps are available for every season, for mid (2040) and late century (2090). A total of 21 climate variables can be plotted, for every greenhouse gas emission scenario modelled by the IPCC. Dynamical downscaling provided by NIWA: https://mapping1.gw.govt.nz/gw/ClimateChange/

Key Reports:

- **Main climate change report (NIWA 2017)**

https://www.gw.govt.nz/assets/Documents/2017/06/Climate-Change-and-Variability-report-Wlgtn-Regn-High-Res-with-Appendix.pdf

- **Main climate drivers report (Climate Modes) (NIWA 2018)**
  https://www.gw.govt.nz/assets/Documents/2021/10/GWRC-climate-modes-full-report-NIWA-3-Sep-2018-compressed.pdf

- **Climate change extremes report (NIWA 2019)**

https://www.gw.govt.nz/assets/Documents/2021/11/GWRC-NIWA-climate-extremes-FINAL3.pdf

Climate Portals

- **GWRC Climate change impacts webpage**

https://www.gw.govt.nz/environment/climate-change/impacts-on-our-region/

- **GWRC Seasonal climate hub**
  https://www.gw.govt.nz/environment/environmental-data-hub/climate-monitoring/