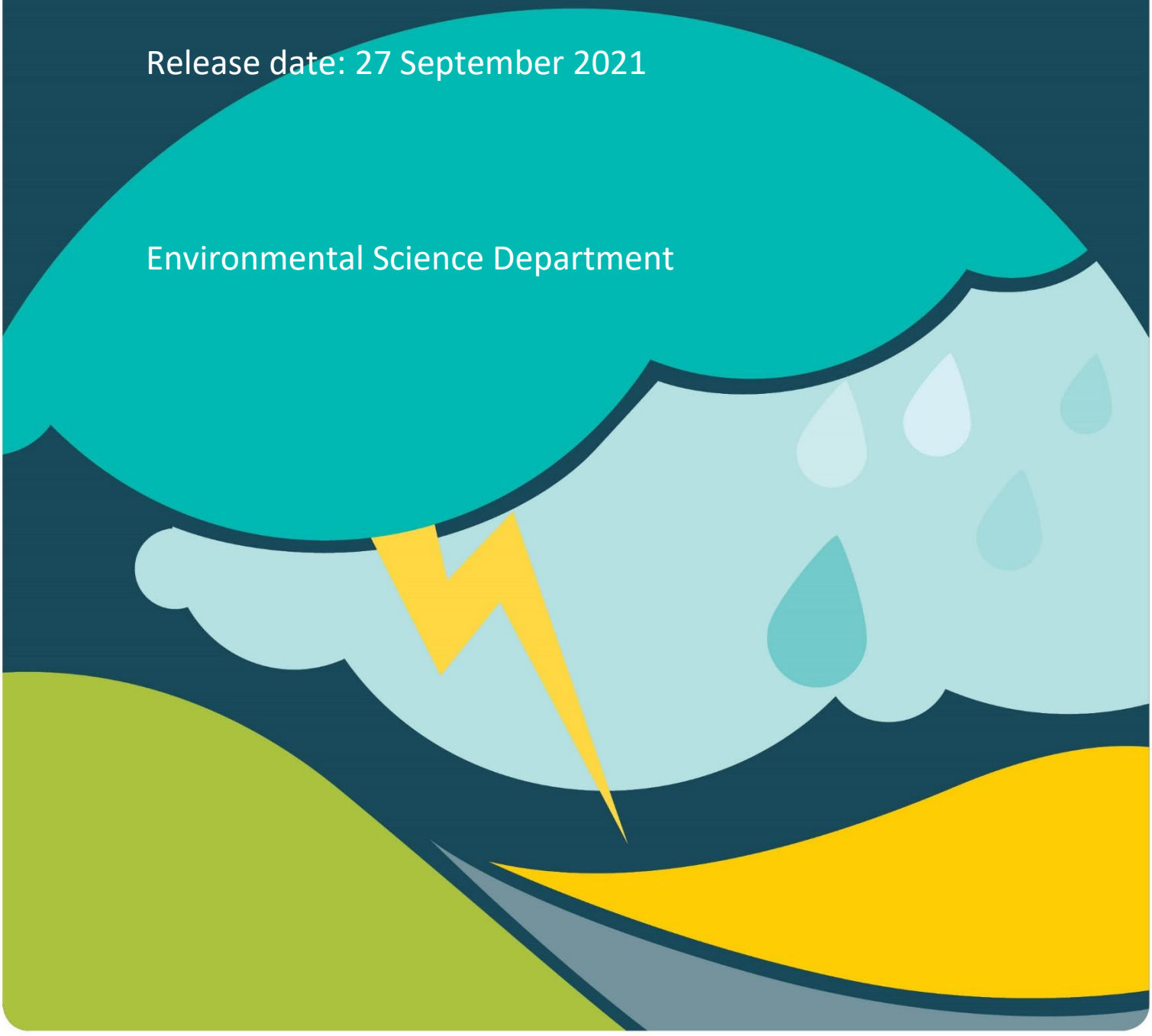
Climate and Water Resources Summary for the Wellington Region

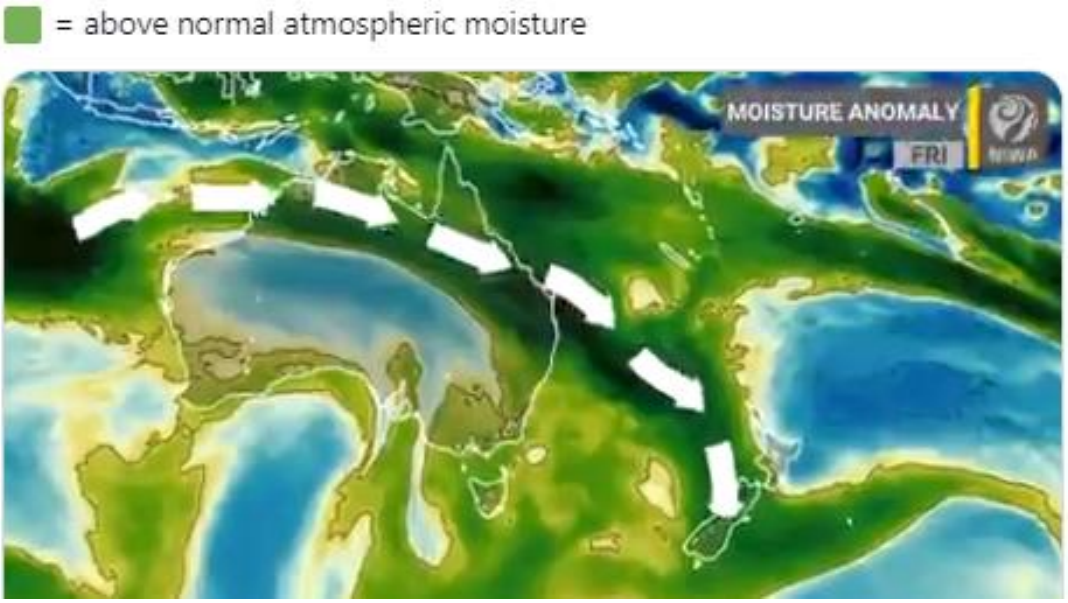
Winter 2021 summary

Spring 2021 outlook

Release date: 27 September 2021

Environmental Science Department





This atmospheric moisture diagram from NIWA shows the plume that came into New Zealand from the Indian Ocean on Friday 15 July. This plume is a clear example of tropical-extratropical interaction in a warmer world. It created the necessary conditions for the exceptional Wellington floods on Sunday 17 July, which followed on the back of the flood damage caused by the system in Westport and Marlborough. Credits to NIWA for the image shown.

Overview

Winter 2021

Winter 2021 continued a pattern of more or less relentless extreme weather systems, manifesting through both westerly and easterly flow. It was the warmest winter on record for the entire region, and also for New Zealand as a whole, superseding last year's winter which also held the title for the warmest on record. Flooding, wind storms, abrupt cold spells with snow and hail, severe frosts, and a background of very mild temperatures were the keynote of a winter which has given us a taste of what climate change potentially looks like. Overall, it was also a wet winter, being the wettest since 2008 for both Wellington and the Wairarapa. Of note, is the irregular distribution of the precipitation, especially reflected in some extreme weather events. The Wellington urban area in particular had really remarkable short duration rainfall totals, with outputs consistent with tropical regions. Our Te Papa rain gauge, for instance, recorded a one-minute rainfall rate of 180mm/h on 17 July, while some spots had longer duration rates hitting the mark of a 1 in 50-year event. The highest wind gust was a remarkable 163km/h at Baring Head on 9 August, the second highest on record since 1969.

Climate drivers

The climate drivers have been overall in the neutral phase, and the Southern Annular Mode (SAM) oscillated between positive and negative. This has allowed for a remarkable pattern of alternating strong westerly flow and blocked easterly flow, inducing extreme weather events on both sides of the ranges. This set up, against a backdrop of above average sea surface temperatures (SST), helped provide energy for several bursts of weather extremes affecting the region during winter.

Climate outlook for spring 2021

Most climate models are predicting that a blocking anticyclone will persist east of New Zealand during spring. This anticyclone or high pressure area, along with a significantly warmer than average SST pattern, is expected to provide a very strong blueprint for a warmer than average spring. The predicted pattern is likely dry in the east, and normal to wetter on the west coast. In concert with this pattern, there is also a chance that slight negative ENSO conditions (i.e., La Niña) may continue to develop. A La Niña in spring would normally be associated with slightly drier conditions in the Wairarapa.

Live regional climate maps (updated daily): Daily updated climate maps 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 (Figure 1.1) show that the ENSO phenomenon is predicted to remain neutral but with a tendency towards borderline La Niña conditions. A high degree of interchange between westerly fronts and easterly, blocked flows, have characterised most of the year so far, since the advent of the original La Niña back in 2020.

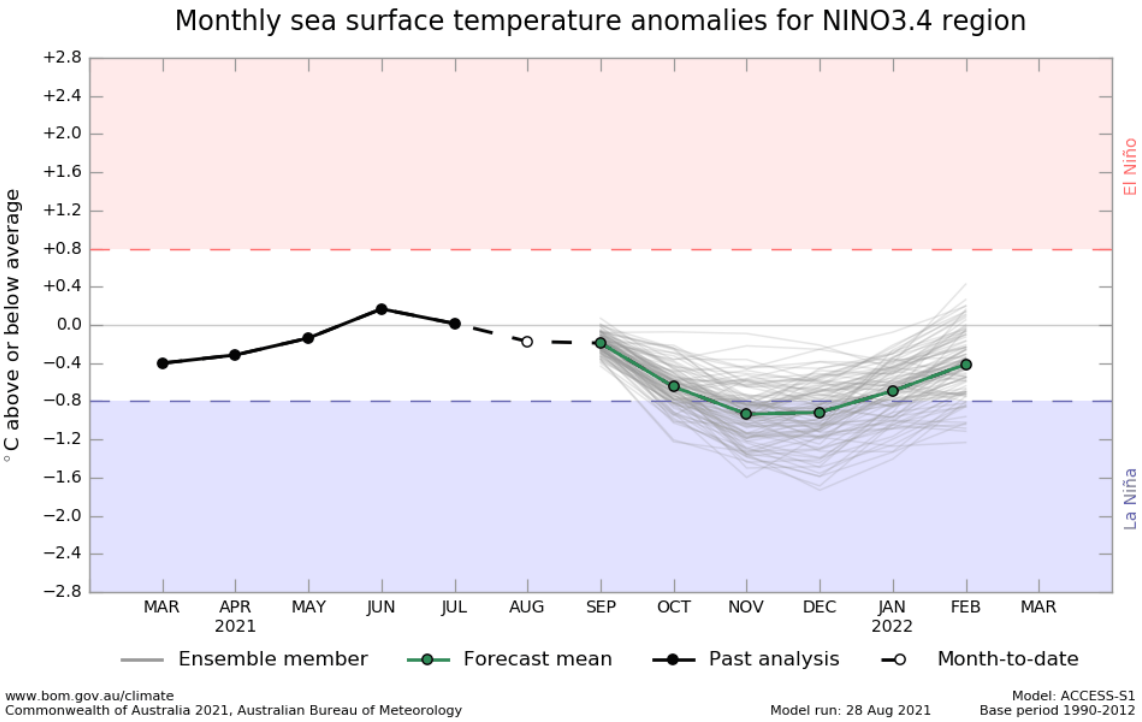


Figure 1.1: Averaged modelled projections (in green) show that ENSO is expected to remain within the neutral range, or slight La Niña conditions, over the next few months.
Source: Australian Bureau of Meteorology.

1.2 Sea Surface Temperature anomalies

The Sea Surface Temperature (SST) anomalies and the total sea ice extent (in white) are shown in Figure 1.2, as of 8 September 2021.

The pattern shows a potential La Niña signature re-emerging in the Equatorial Pacific, even though all ENSO indices are still mostly neutral. Warmer than average SSTs are seen around and north-east of New Zealand. The southern Australian region shows a variable pattern, with several eddies of colder than normal water, implying a more pronounced westerly flow and transient fronts to the west. New Zealand, influenced by warmer waters, will likely continue to experience increased frequency of extreme weather events, and warmer than normal air temperature.

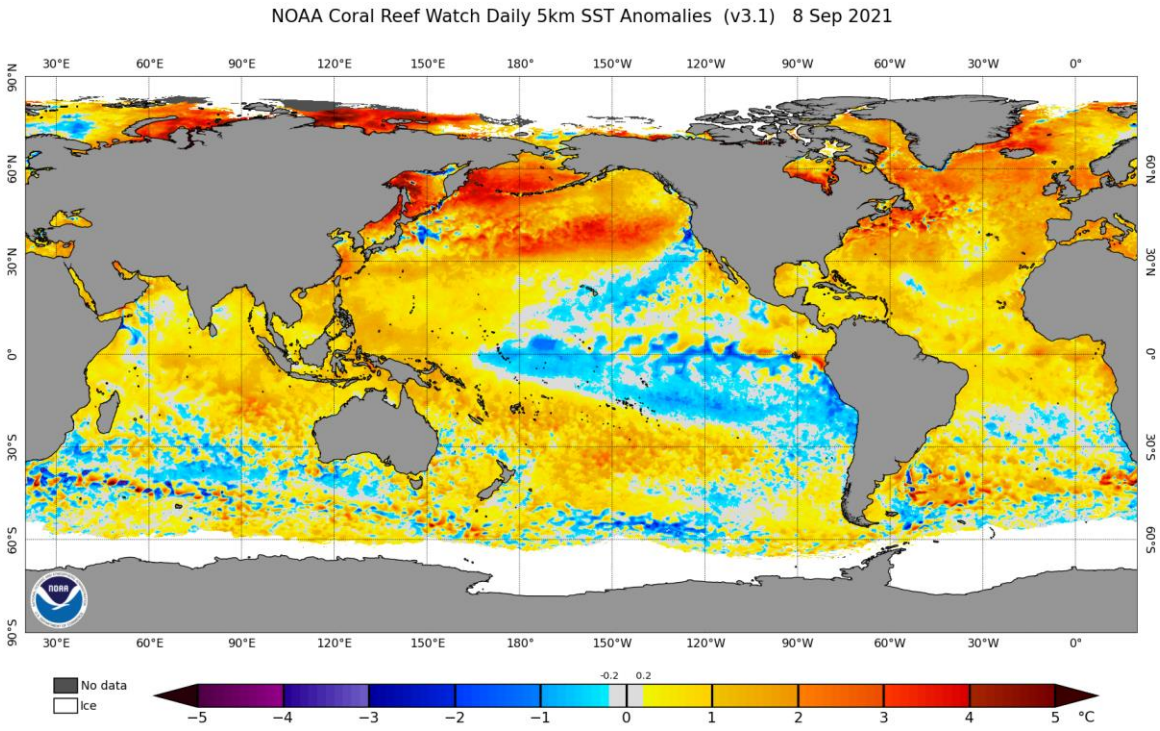


Figure 1.2: Sea Surface Temperature (SST) anomalies as of 8 September 2021. Sea ice coverage is shown in white. Water temperatures around New Zealand, and especially to the east and northeast of the country, are warmer than average. The Equatorial Pacific (ENSO) is evolving towards a potential (weak) La Niña signature, with most indicators still neutral. The sea ice extent (in white) has now stabilised slightly above its long term average (as of 8 September), following a very similar path compared to last year. 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.

The SAM was predominantly oscillating between positive and negative in winter, with warmer than average air temperatures, but significantly above average rainfall overall. Figure 1.3 shows that a blocking high to the east of New Zealand, and a low south of Australia, largely dominated the seasonal flow. This pattern contributed to the development of an anomalous northerly flow. The sustained warmer than normal temperatures led to the warmest winter on record for New Zealand.

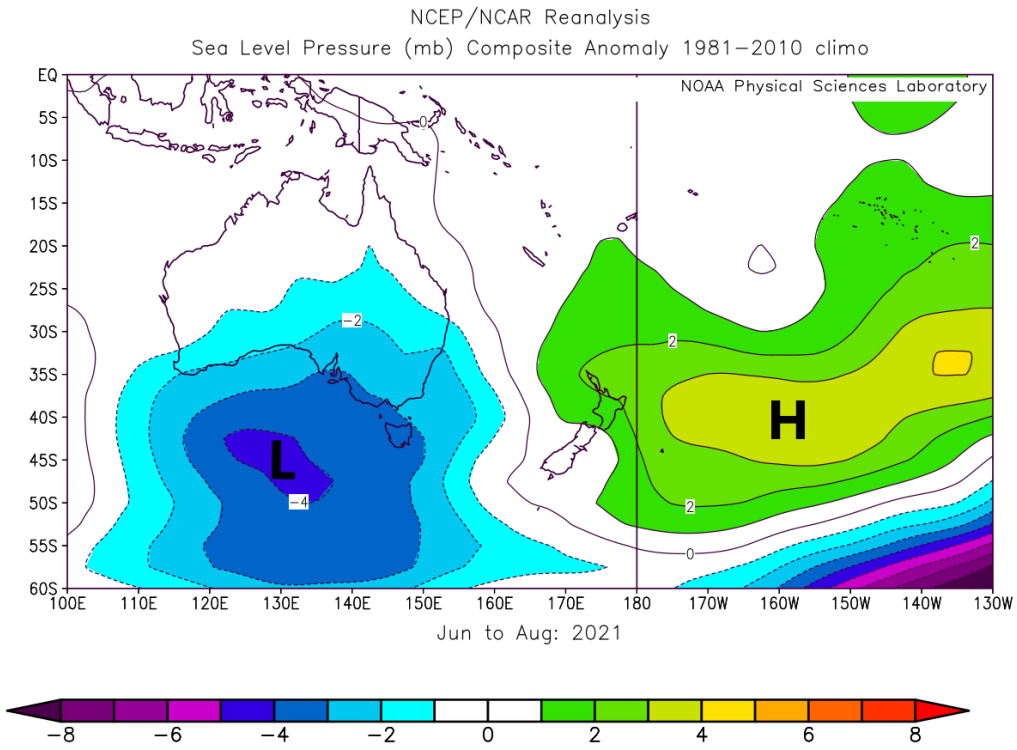


Figure 1.3: Mean sea level pressure anomaly map (hPa) for winter 2021. The 'H' indicates the central position of the anomalous high pressure areas, and 'L' indicates the position of the anomalous low pressure. We can see an interesting pattern with a blocking high to the east of New Zealand. This pattern, together with a deeper anomalous low to the southwest, contributed to an enhanced northerly flow, and the warmest winter on record for New Zealand. Source: NCEP Reanalysis.

2. What is the data showing?

2.1 Regional temperature

Figure 2.1 shows the seasonal minimum and maximum temperature anomalies (against the 1981-2010 reference period) for the region based on all monitoring sites available from GWRC, NIWA and MetService.

In general, we can see a pattern of substantially warmer than average day and night time temperatures across the region. The warming was more pronounced in the south and western part of the region.

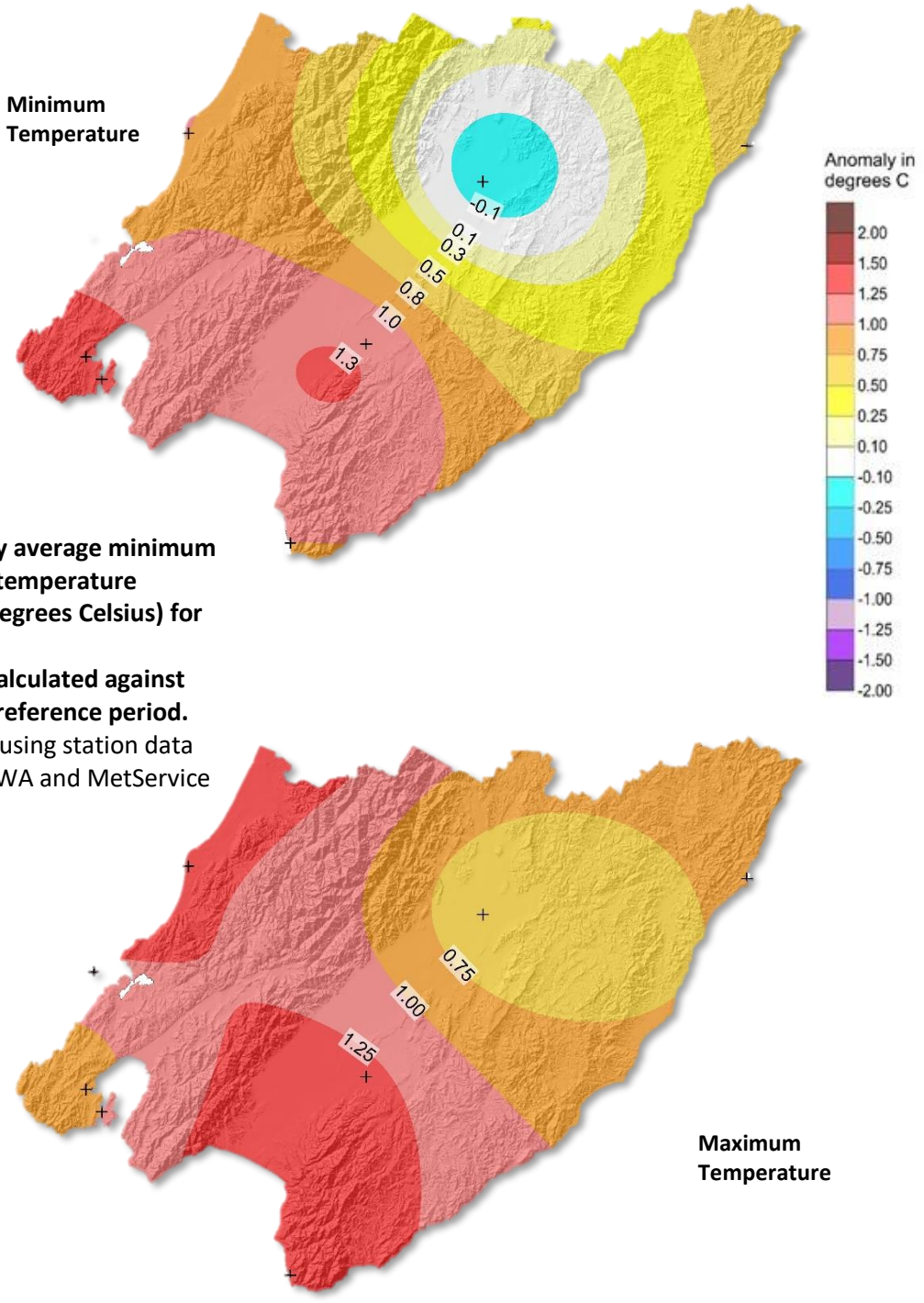


Figure 2.1: Daily average minimum and maximum temperature anomalies (in degrees Celsius) for JJA 2021.
All anomalies calculated against the 1981-2010 reference period.
Source: GWRC, using station data from GWRC, NIWA and MetService networks.

2.2 Regional wind

Figure 2.2 shows the mean seasonal wind anomalies (against the 1981-2010 reference period). Virtually all of the region experienced below average wind speeds, except a small area around Makara and Cape Palliser.

JJA 2021
Wind speed Anomalies

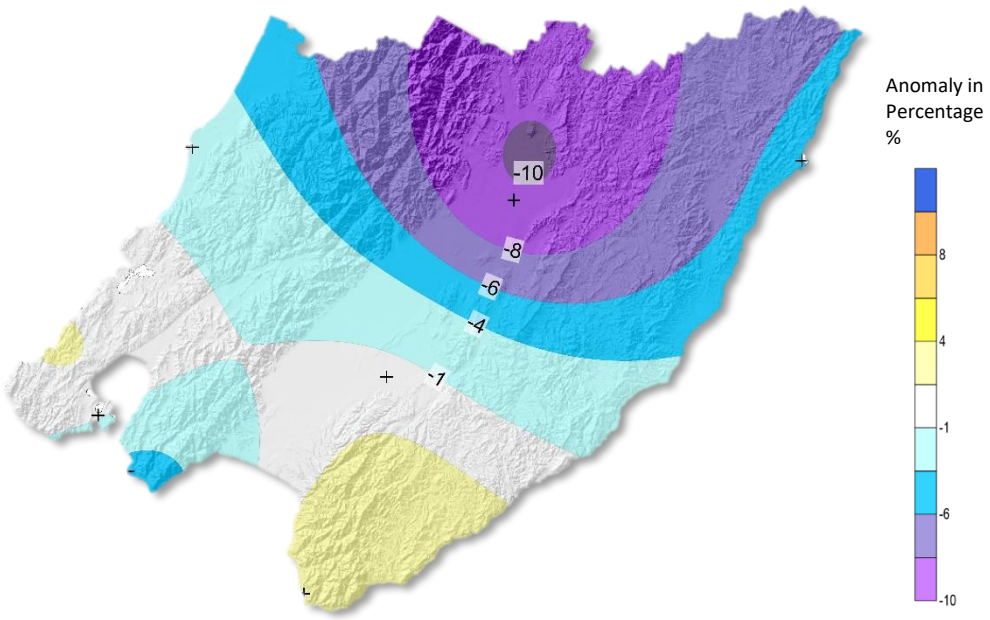


Figure 2.2: Daily mean wind anomalies (as percentage departure from the average) for JJA 2021. All anomalies calculated against the 1981-2010 reference period.
Source: GWRC, using station data from NIWA and MetService

2.3 Regional soil moisture

Figure 2.3 shows that the soil moisture levels were normal for most of the region at the beginning of spring, and slightly above normal for the western coast. The much needed replenishment happened thanks to several extreme rainfall events during winter, both under westerly and easterly flows.

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

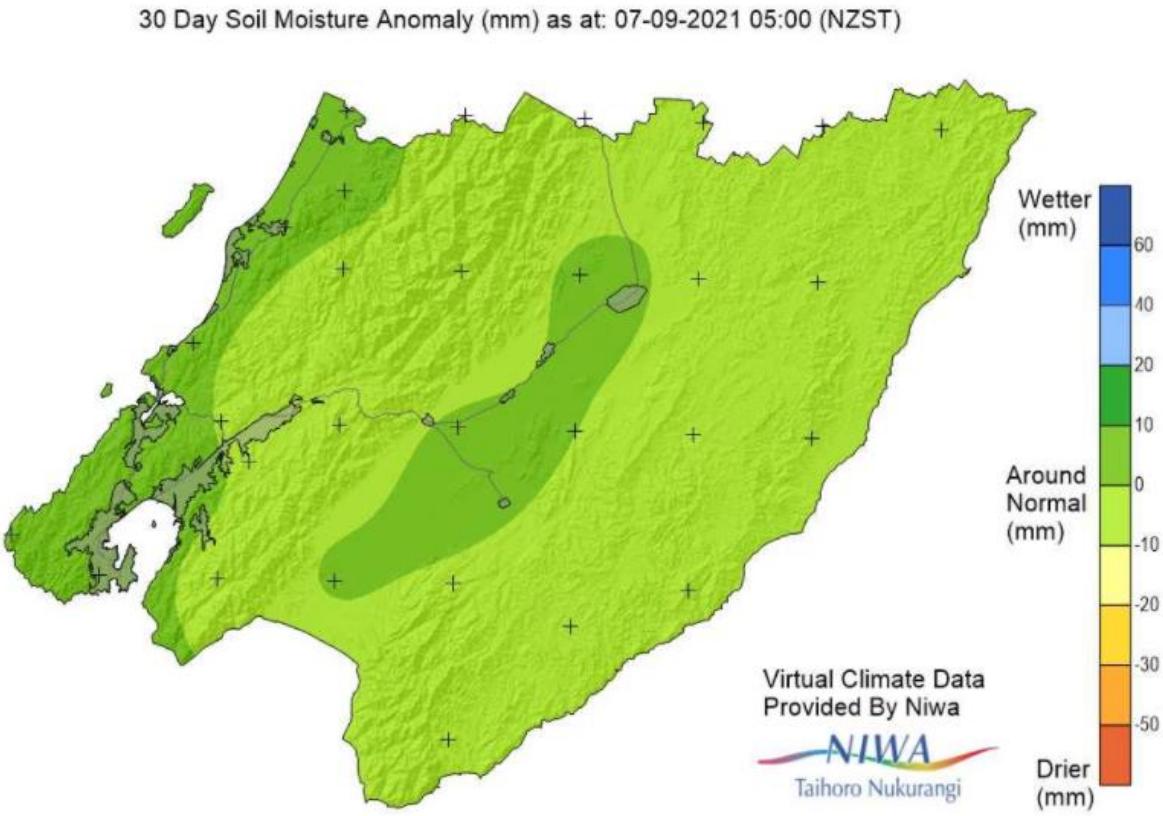


Figure 2.3: 30 Day soil moisture anomaly as at 7 September 2021. Most of the region shows average or slightly above average soil moisture levels. Source: GWRC, using selected Virtual Climate Station Network (VCSN) data kindly provided by NIWA. *Note that this data is indirectly calculated by modelling and interpolation techniques, and does not necessarily reflect the results obtained by direct measurements. This map only provides a general indication of the spatial variability*

2.4 Regional rainfall

Figure 2.4 shows the regional monthly winter rainfall expressed as a percentage of the long-term average. Rainfall during June was up to twice the average in the eastern Wairarapa and in the Tararua Range. July was dry across the eastern Wairarapa and wetter than average in western parts of the region. Some parts of the Wairarapa had only 40-50% of average July rainfall.

The overall seasonal pattern for winter showed higher than average rainfall conditions throughout the region, with up to 150% of average rainfall in Kāpiti and up to 130% across much of the Wairarapa.

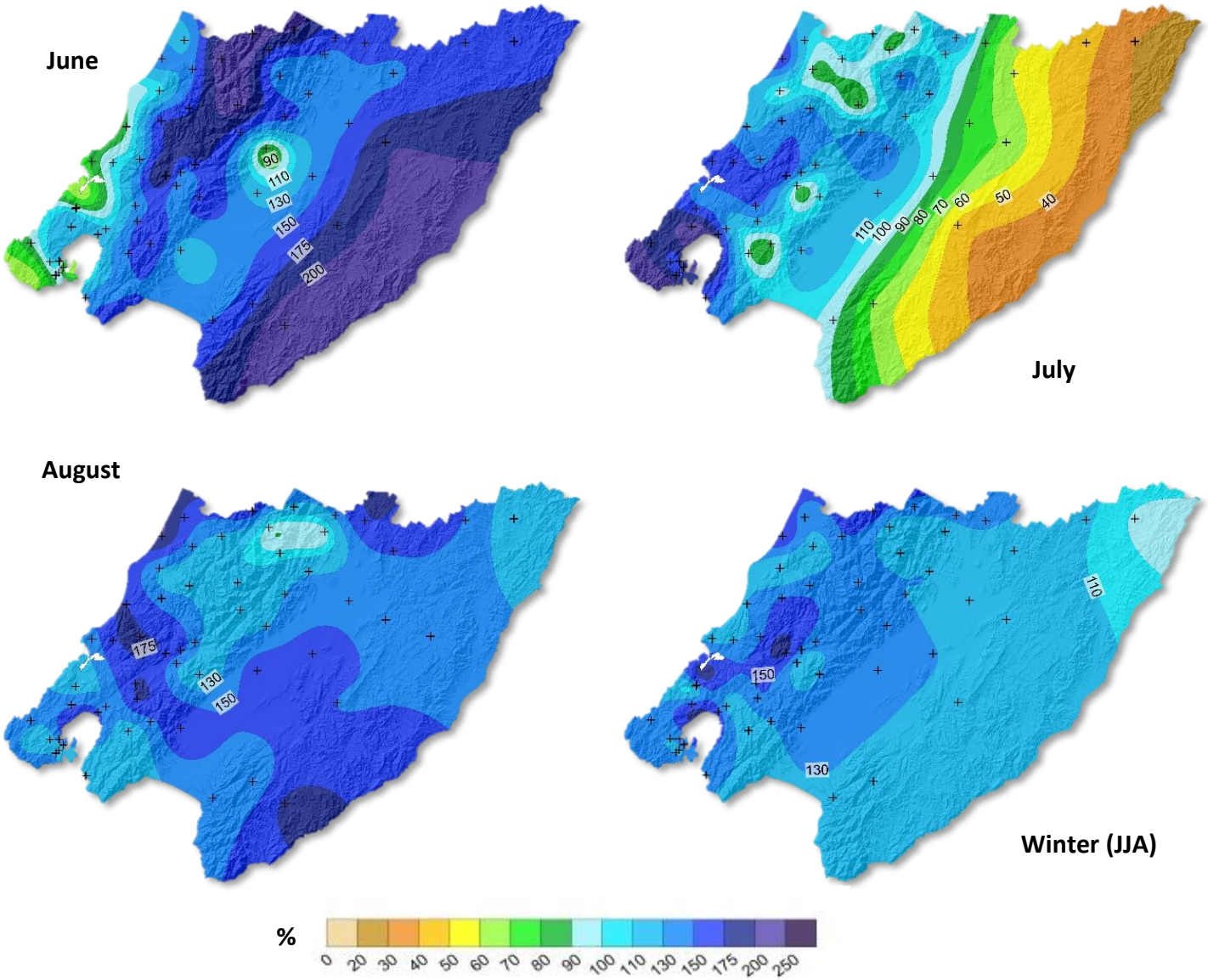


Figure 2.4: Rainfall for June (upper left), July (upper right), August (lower left) and Winter (lower right) 2021 as a percentage of the long-term average. Source: GWRC

2.5 Climate change and variability indicators

The graphs below (Figure 2.5) 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.

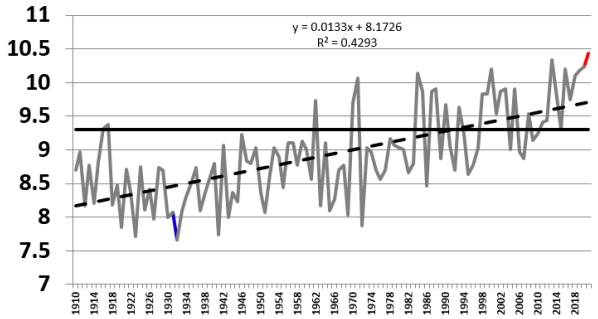
An analysis of linear trends associated with climate change is plotted onto the graph only when the trends are statistically significant from zero at 99% confidence level.

The climate change and variability summary for winter is:

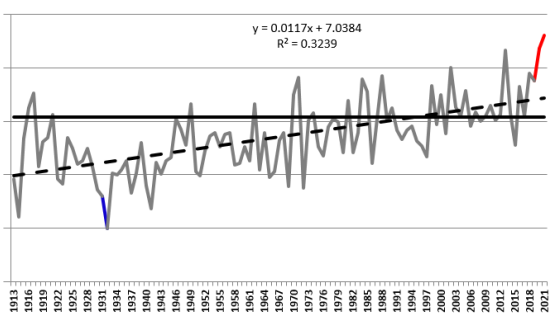
- Statistically significant trends are seen only for temperature, meaning that winter is getting warmer as a result of ongoing climate change, with 1.3 degrees of warming per century for Wellington, and 1.2 degrees per century for Masterton;
- Winter 2021 was the hottest on record for both Wellington and the Wairarapa, superseding winter 2020 which had already been the warmest on record;
- Sunshine hours and seasonal average wind were close to the climatological average;
- Seasonal rainfall and rain days were well above average. Winter 2021 was the wettest since 2008 for both Wellington and the Wairarapa.

What is the data showing?

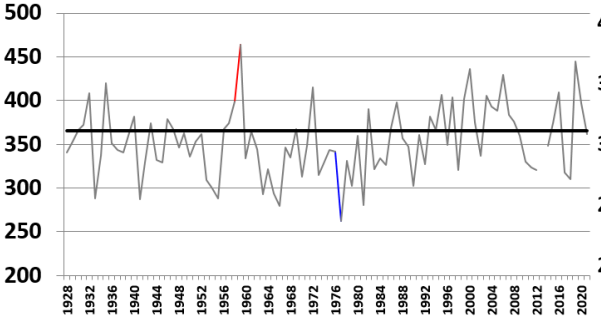
Winter Mean Temperature (deg C) - Kelburn (1910-2021)



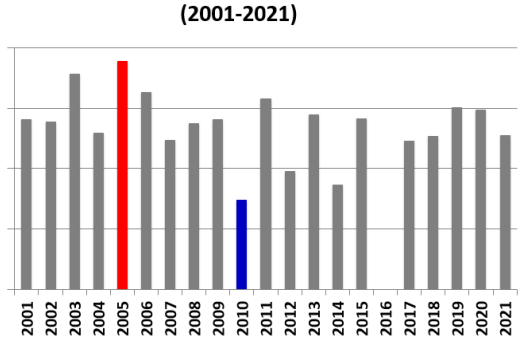
Winter Mean Temperature (deg C) - Masterton (1913-2021)



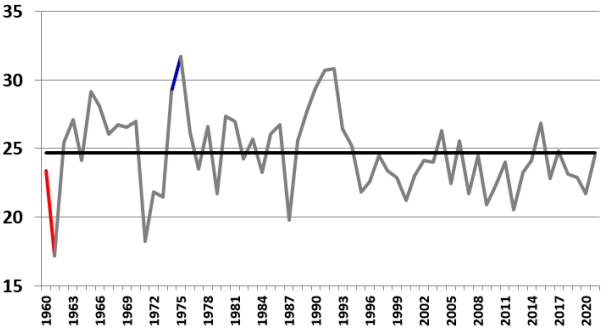
Winter Total Sunshine Hours - Kelburn (1928-2021)



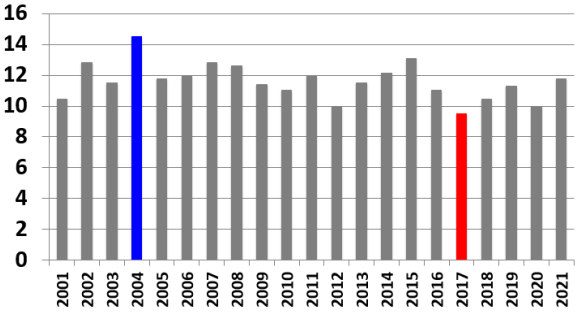
Winter Total Sunshine Hours - Martinborough (2001-2021)



Winter Mean Wind (km/h) - Wellington Airport (1960-2021)



Winter Mean Wind (km/h) - Martinborough (2001-2021)



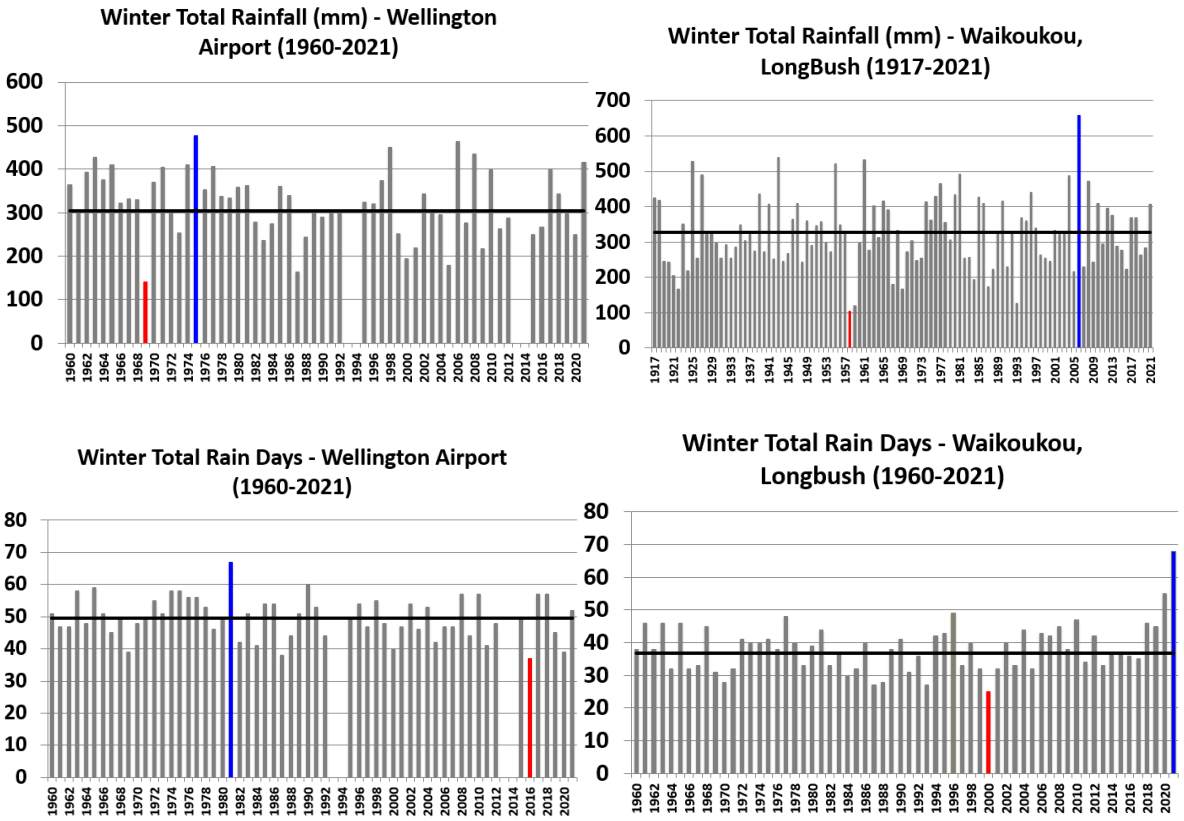


Figure 2.5: Climate change and variability graphs for Wellington and the Wairarapa. The thick horizontal line shows the 1981-2010 average (where available), and the dashed line shows the linear trend. Trends are plotted only when statistically significant at 99% confidence level. For all graphs, the 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 of each graph shows the last available data for the currently analysed season, unless there are missing data.

2.6 Observed rainfall and soil moisture conditions for selected sites

Figure 2.6 shows the location of selected GWRC rainfall and soil moisture monitoring sites. Plots of accumulated rainfall and soil moisture trends are provided in the following pages.

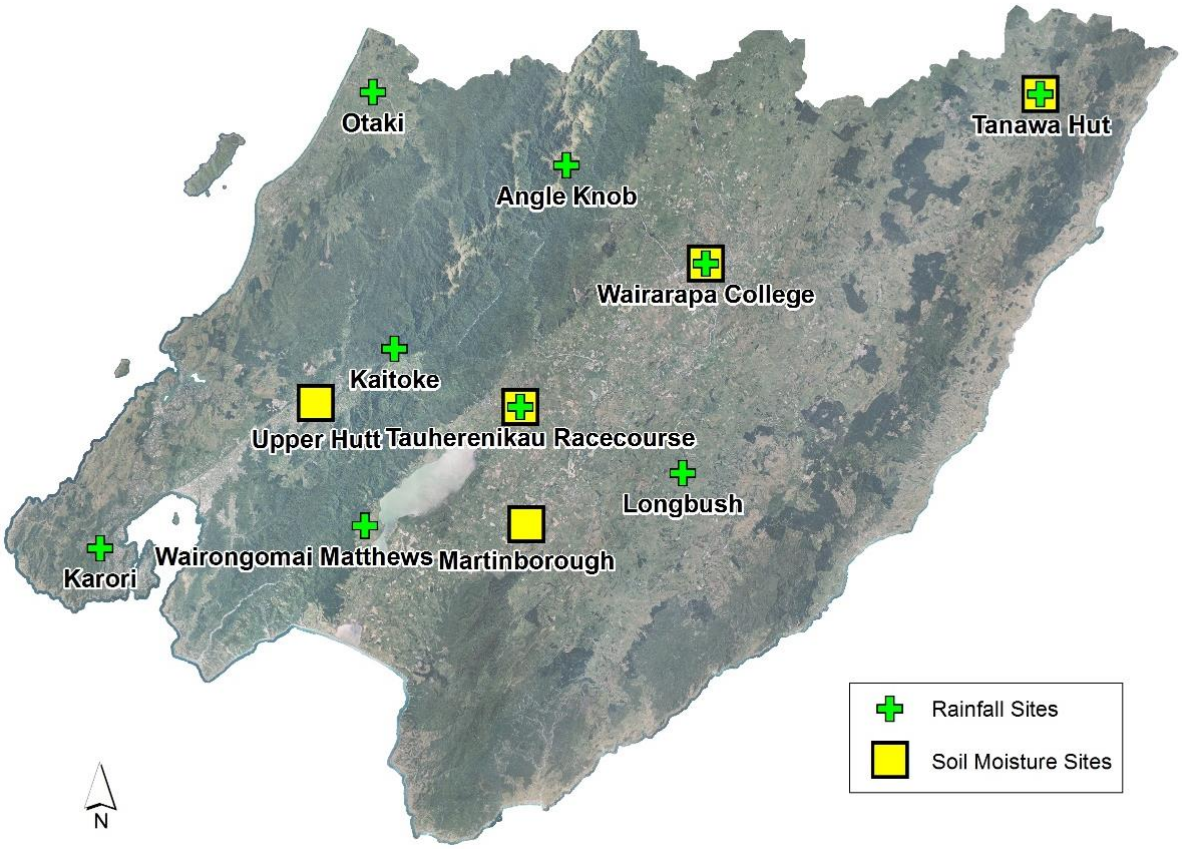


Figure 2.6: Map of GWRC rainfall and soil moisture monitoring locations

2.6.1 Rainfall accumulation for hydrological year (1 June to 31 May)

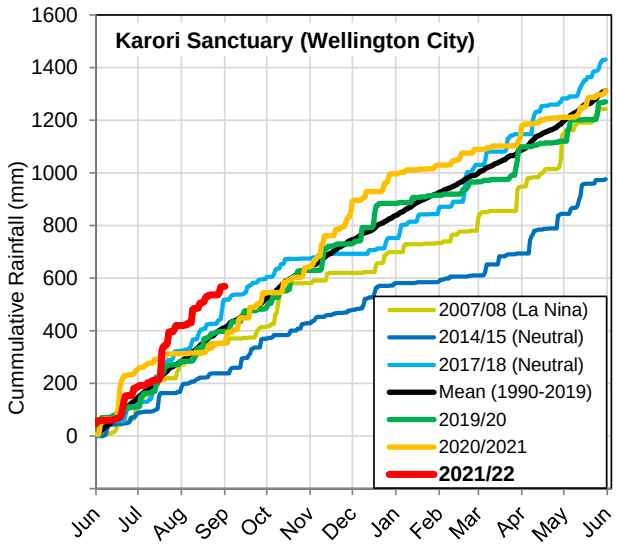
The following rainfall plots show total rainfall accumulation (mm) for the hydrological year at several locations. For comparative purposes, cumulative plots for selected historic years with notably dry years have been included as well as the site average.

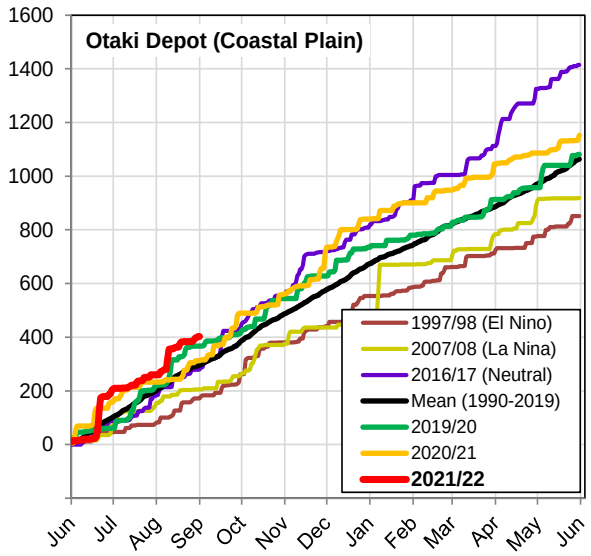
Many of the GWRC telemetered rain gauge sites in the lower lying parts of the Wairarapa have only been operating since the late 1990s so the period of data presented is limited to the last two decades. For each historical record plotted, an indication of ENSO climate state (El Niño, La Niña or neutral) at that time is also given.

GWRC does not operate a rain gauge in the southern-most parts of the Wairarapa Valley that is suitable for presenting data in this report. This means that we cannot be confident that the rainfall patterns seen elsewhere extend to this part of the region other than the VCSN data already presented.

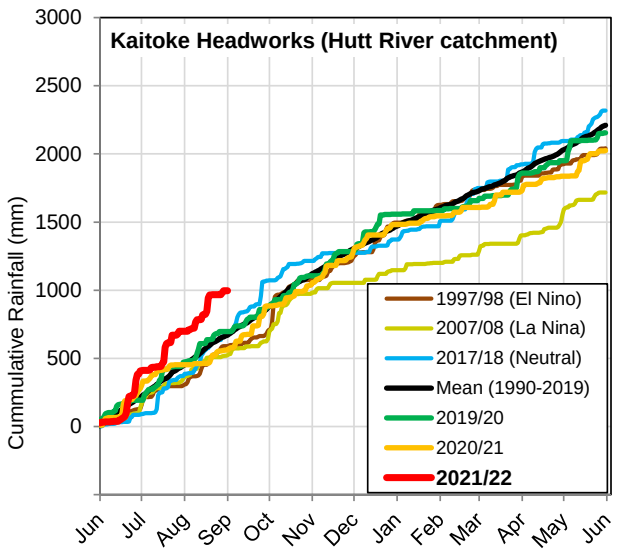
Overall, total rainfall accumulations in all areas have ended the winter season above the average line. The very wet conditions experienced during June are evident as a spike of the graph on the rainfall accumulation graphs.

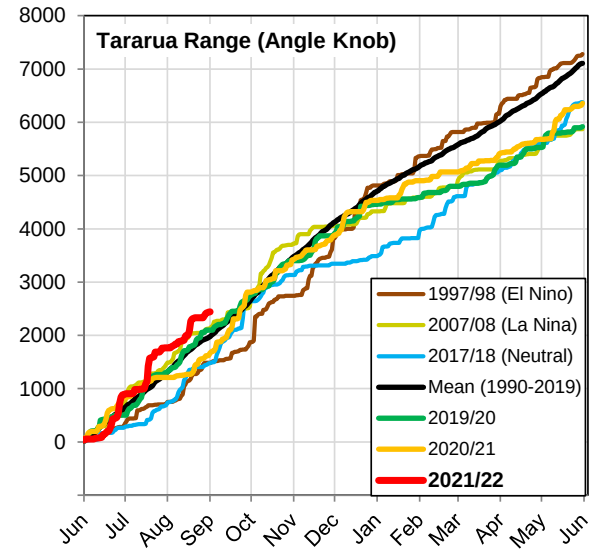
Kāpiti Coast and Southwest (Wellington City)



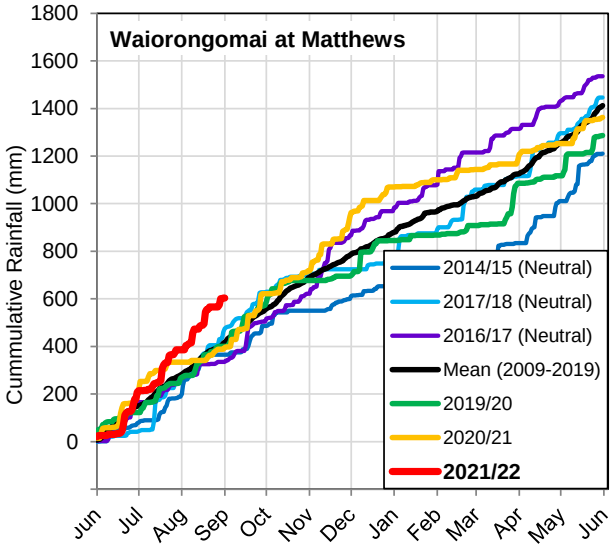


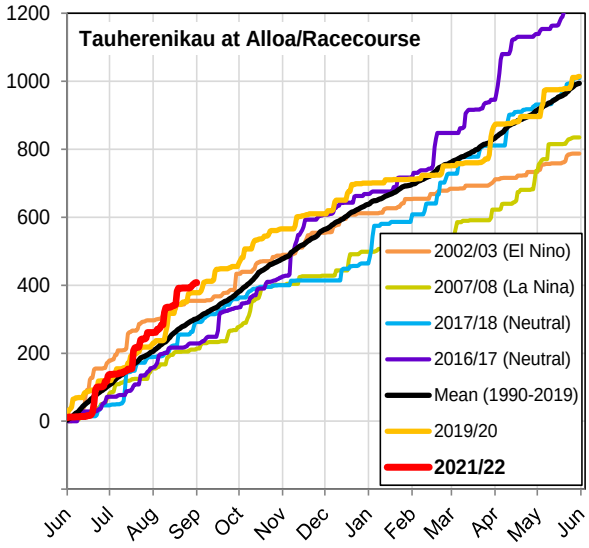
Hutt Valley and the Tararua Range

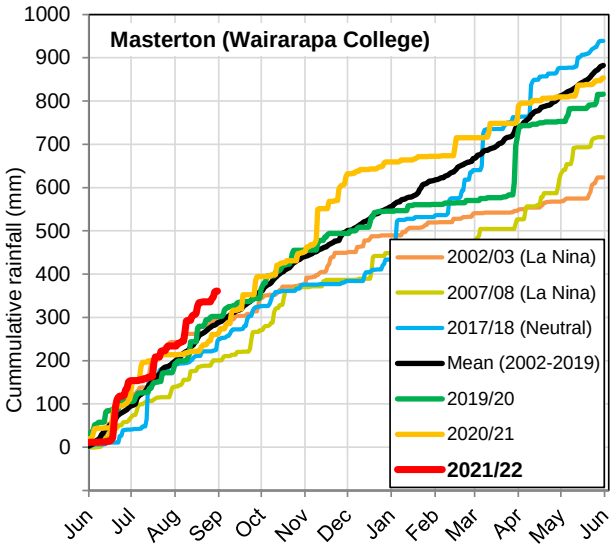


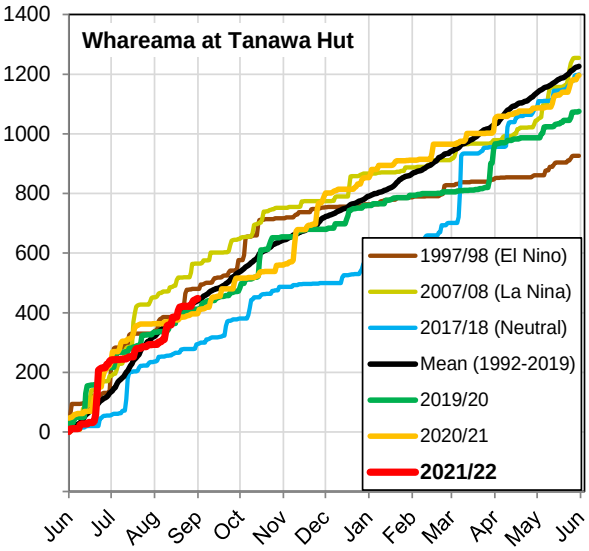


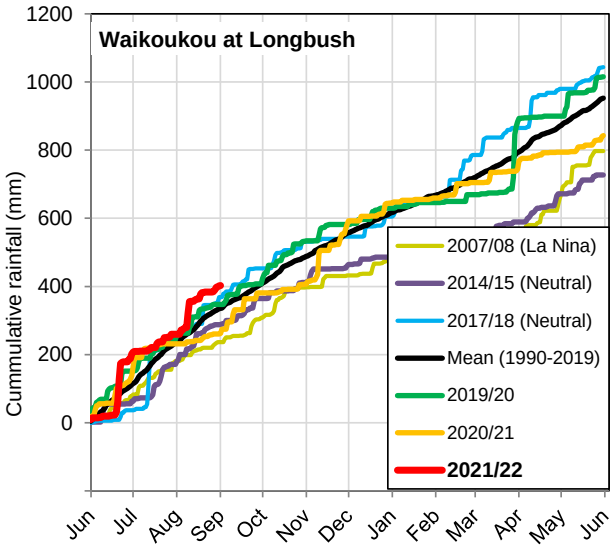
Wairarapa


Waiorongomai at Matthews
Cummulative Rainfall (mm)
1800
1600
1400
1200
1000
800
600
400
200
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
2014/15 (Neutral)
2017/18 (Neutral)
2016/17 (Neutral)
Mean (2009-2019)
2019/20
2020/21
2021/22


Tauherenikau at Alloa/Racecourse
1200
1000
800
600
400
200
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
2002/03 (El Nino)
2007/08 (La Nina)
2017/18 (Neutral)
2016/17 (Neutral)
Mean (1990-2019)
2019/20
2021/22


Masterton (Wairarapa College)
Cummulative rainfall (mm)
1000
900
800
700
600
500
400
300
200
100
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
2002/03 (La Nina)
2007/08 (La Nina)
2017/18 (Neutral)
Mean (2002-2019)
2019/20
2020/21
2021/22


Whareama at Tanawa Hut
1400
1200
1000
800
600
400
200
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
1997/98 (El Nino)
2007/08 (La Nina)
2017/18 (Neutral)
Mean (1992-2019)
2019/20
2020/21
2021/22


Waikoukou at Longbush
Cummulative rainfall (mm)
1200
1000
800
600
400
200
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
2007/08 (La Nina)
2014/15 (Neutral)
2017/18 (Neutral)
Mean (1990-2019)
2019/20
2020/21
2021/22

Live cumulative plots (updated daily): Real-time graphs for cumulative rainfall are available online at GWRC's environmental data webpage (http://graphs.gw.govt.nz/). Select a rainfall monitoring site, then choose *Cumulative Historic* from the *Interval* selector, then optionally change the period from the last 12 months to the hydrological year (July – June) as required

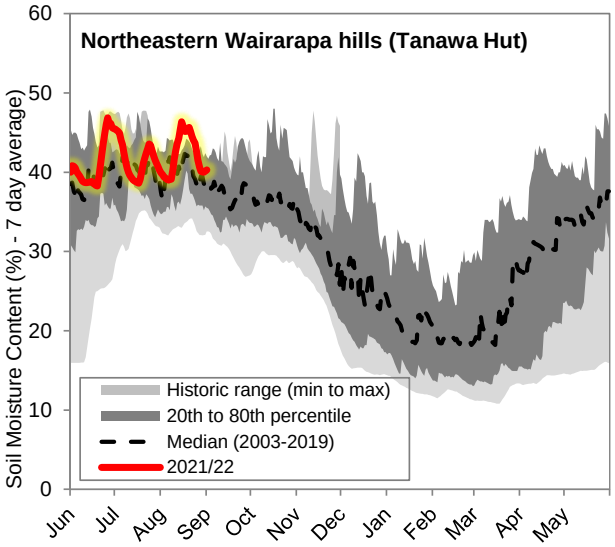
2.6.2 Soil moisture content (since 1 June 2021)

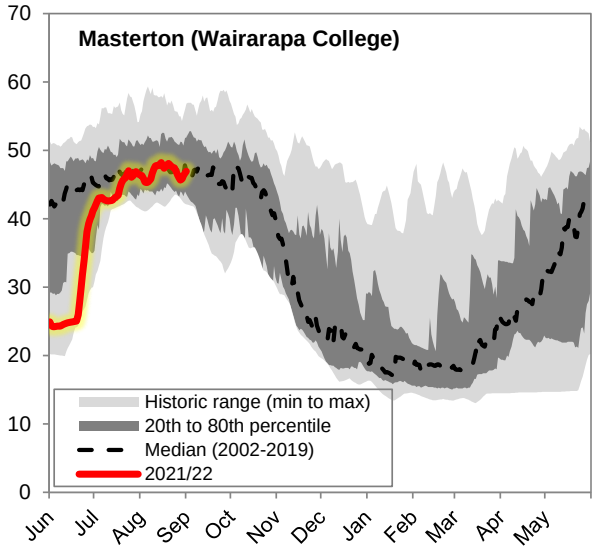
The following soil moisture graphs show the seven day rolling average soil moisture content (%) since 1 June 2021. This is plotted over an envelope of the range of historic recorded data (and the median) at the site to provide an indication of how the current soil moisture compares with that for a similar period in past years.

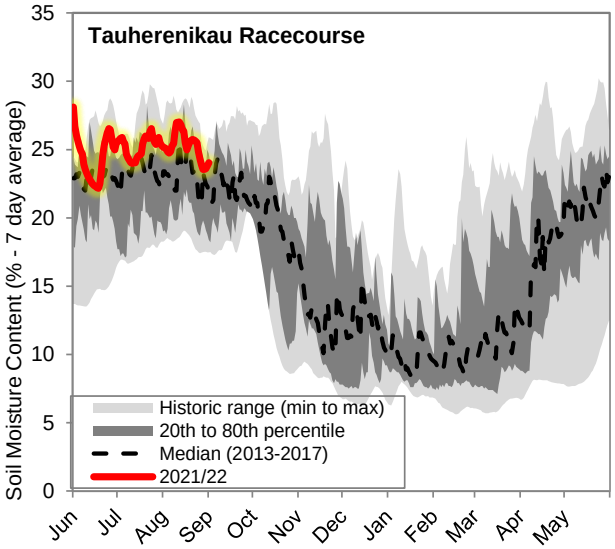
While the soil moisture plots are useful for tracking change within the current season and comparing relative differences between years, the absolute moisture content (%) for any given site and date should not be considered accurate. Many of the GWRC soil moisture sites have not yet been fully calibrated to provide accurate absolute measures of soil moisture.

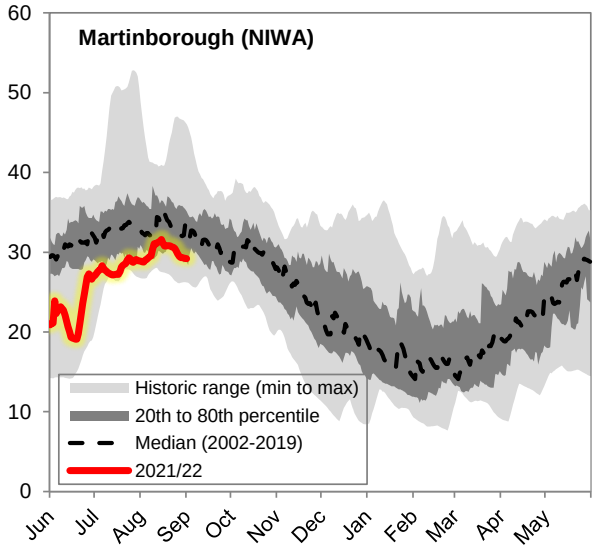
An initially dry June is evident in the soil moisture graphs, particularly for the Upper Hutt and Martinborough monitoring sites. The significant rainfall event is June is then shown with the large spike in the graphs. Overall, soil moisture was above average throughout the region, with the exception of Martinborough which remained below average throughout the season. The relatively dry Martinborough reading might have been influenced by local conditions at the measuring NIWA site, and may not be representative of the larger surroundings.

Wairarapa

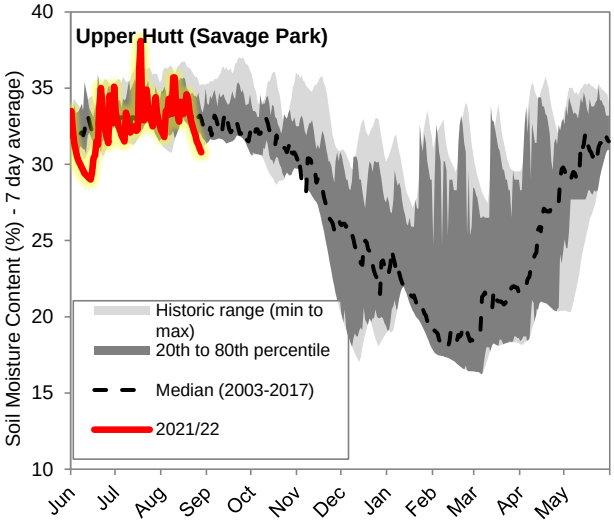

Northeastern Wairarapa hills (Tanawa Hut)
Soil Moisture Content (%) - 7 day average)
Historic range (min to max)
20th to 80th percentile
Median (2003-2019)
2021/22
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May


Masterton (Wairarapa College)
Historic range (min to max)
20th to 80th percentile
Median (2002-2019)
2021/22
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May


Tauherenikau Racecourse
Soil Moisture Content (% - 7 day average)
Historic range (min to max)
20th to 80th percentile
Median (2013-2017)
2021/22
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May


Martinborough (NIWA)
Historic range (min to max)
20th to 80th percentile
Median (2002-2019)
2021/22
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May

Upper Hutt



Live soil moisture plots (updated daily): Real-time "envelope" graphs for soil moisture are available online at GWRC's environmental data webpage (http://graphs.gw.govt.nz/). Select a soil moisture monitoring site, then choose *Envelope Graph* from the *Interval* selector, then change the period from the last 12 months to the hydrological year (July – June) as required.

3. Outlook for spring 2021

- ENSO to remain neutral to negative, with a moderate chance of a weak La Niña developing;
- Sea Surface Temperatures (SSTs) are expected to remain largely above average around and to the north of New Zealand;
- Significantly warmer than normal seasonal air temperatures are expected to continue;
- Strong north-westerly flow, drier than average in the east and wetter than average in the west;
- High chance of heavy rainfall events, with highly irregular distribution likely shaping the seasonal total rainfall.

Whaitua*	Variables	Climate outlook for spring 2021
Wellington Harbour & Hutt Valley	**Temperature:**	Significantly above average.
	Rainfall:	Average to above. High chance of extreme rainfall events.
Te Awarua-o-Porirua	**Temperature:**	Significantly above average.
	Rainfall:	Average to above. High chance of extreme rainfall events.
Kāpiti Coast	**Temperature:**	Significantly above average.
	Rainfall:	Average to above. High chance of extreme rainfall events.
Ruamāhanga	**Temperature:**	Significantly above average.
	Rainfall:	Average to below. High chance of extreme rainfall events.
Wairarapa Coast	**Temperature:**	Significantly above average.
	Rainfall:	Average to below. High chance of extreme rainfall events.

*See http://www.gw.govt.nz/assets/Environment-Management/Whaitua/whaituamap3.JPG for whaitua catchments

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 (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:** http://www.gwrc.govt.nz/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)**
  http://www.gw.govt.nz/assets/Climate-change/Climate-Change-and-Variability-report-Wlgtn-Regn-High-Res-with-Appendix.pdf

- **Main climate drivers report (Climate Modes) (NIWA 2018)**
  http://www.gw.govt.nz/assets/Our-Environment/Environmental-monitoring/Environmental-Reporting/GWRC-climate-modes-full-report-NIWA-3-Sep-2018-compressed.pdf

- **Climate change extremes report (NIWA 2019)**
  https://www.gw.govt.nz/assets/Climate-change/GWRC-NIWA-climate-extremes-FINAL3.pdf

Climate Portals

- **GWRC Climate change webpage**
  http://www.gw.govt.nz/climate-change/

- **GWRC Seasonal climate hub**
  http://www.gw.govt.nz/seasonal-climate-hub/