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State of the Climate 2013

A snapshot of recent climate in New Zealand (2010-2012)

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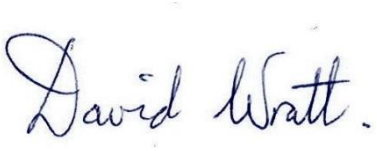

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1 Introduction

This report describes month-to-month and seasonal-scale variability in New Zealand climate over the three years 2010, 2011 and 2012. It is the second in a series of documents published every two to three years which describe recent climate fluctuations in New Zealand, and how they relate to the climate system at the broader scale across the Southern Hemisphere and the Globe. The report is intended to be a supplement to the State of the Climate 2010 (Renwick et al, 2010)[1] which covered the years 2008 and 2009. For information on the context of New Zealand's climate in the global setting and sources of data, please refer to this earlier document.

1.1 Description of material

This report presents the observed fluctuations and extremes in New Zealand surface climate over the years 2010, 2011 and 2012 and is based on the annual climate summaries for these years. These summaries, along with detailed monthly, seasonal and annual statistical summaries of the climate can be found at:

www.niwa.co.nz/our-science/climate/publications/all/cs[2].

Note that the annual summary for 2012 was released on 10 January 2013 and may yet be subject to change when climate data are reviewed in May 2013.

Observed variability is put in the context of regional-scale variations in weather patterns, and into the context of hemispheric- and global-scale variations in climate.

The report follows a similar structure to the State of the Climate 2010. It begins with a description of the large-scale climate patterns, their influence on New Zealand climate, and their recent variations. It then discusses rainfall patterns and drought occurrence, followed by temperature variations and frost occurrence. There is a section on extremes and significant weather events over the past three years, and a discussion of the state of snow and ice storage in the Southern Alps. Finally, there are two appendices which summarise observed climate for 2010-2012.

[1] Available for download from the National Climate Centre (http://www.niwa.co.nz/climate/state-of-the-climate, date of last access 20 February 2013)
[2] Date of last access 20 February 2013. Annual summaries are available back to 2000 while seasonal and monthly summaries are available from December 2001

2 Large-scale climate conditions during 2010-2012

The largest signal in the climate system on seasonal time scales is the changing of the seasons themselves, driven by the changing latitudinal distribution of solar heating as the Earth orbits around the Sun. After that, there are a number of modes of natural variability of the climate that involve exchanges of energy between different locations or different components of the system (e.g., atmosphere and ocean). These features are not driven by external influences such as solar heating changes, but are intrinsic to the climate system itself. The three main modes of natural climate variability that are relevant to New Zealand are the El Niño – Southern Oscillation (ENSO), the Interdecadal Pacific Oscillation (IPO) and the Southern Annular Mode (SAM). These modes were described in SOC 2010, what follows is an overview of their variations over the last three years.

2.1 ENSO

The evolution of ENSO from mid-2009 to the end of 2012 is illustrated using the Southern Oscillation Index (SOI) in Figure 2-1. The SOI measures the difference in mean sea-level pressure between Tahiti (eastern Pacific) and Darwin (western Pacific), and thus indicates the strength of the trade winds. Stronger than normal trade winds are associated with a positive SOI (La Niña) and weaker than normal trades winds are associated with a negative SOI (El Niño).

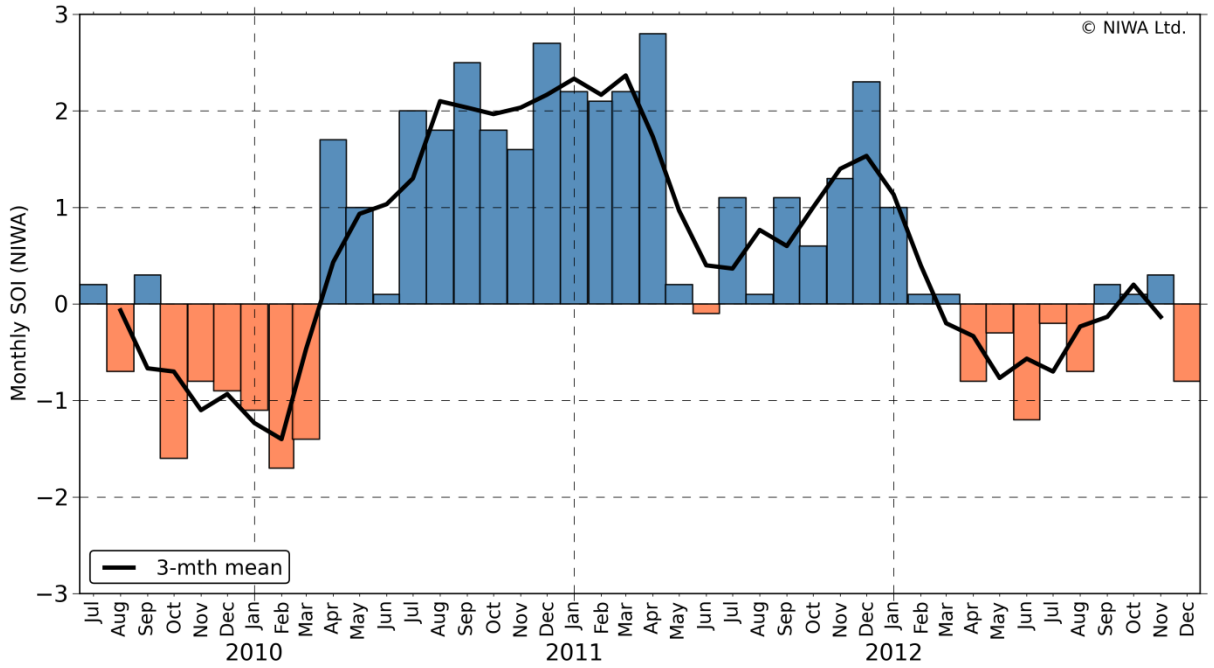

Figure 2-1: The Southern Oscillation Index (SOI) from mid-2009 to the end of 2012. Bars indicate monthly values and the black curve indicates values that have been lightly smoothed with a 3-month running mean. Values of +1 or more indicate the presence of La Niña conditions, while values of –1 or below indicate the presence of El Niño conditions.

The start of 2010 was dominated by a moderate El Niño event in the equatorial Pacific. During autumn, the tropical Pacific climate returned to neutral (neither El Niño nor La Niña), but by July a La Niña event had developed. The La Niña conditions strengthened to moderate to strong intensity by September and prevailed through the end of 2010. In broad

terms, the predominance of La Niña conditions in 2010 contributed to the relative warmth of 2010 over New Zealand

Strong La Niña conditions continued through to May 2011. Neutral conditions prevailed during the autumn 2011, followed by a return to weak La Niña conditions through the end of the year.

La Niña conditions terminated in the summer 2011/2012 and the SOI switched to mostly neutral values from February 2012. Although ocean temperatures in the equatorial Pacific Ocean reached the El Niño threshold by spring, the atmosphere failed to adequately respond, meaning that a fully-developed El Niño pattern did not occur (and neutral conditions continued through the remainder of 2012).

2.2 IPO

The IPO refers to a 20–30 year modulation in the behaviour of the ENSO cycle (Mantua et al. 1997, Power et al 1999, Salinger et al. 2001). The strength and sign of the IPO from 1900 to 2010[3] is illustrated in Figure 2-2, and is based on slowly-varying sea-surface temperature patterns across the Pacific Basin.

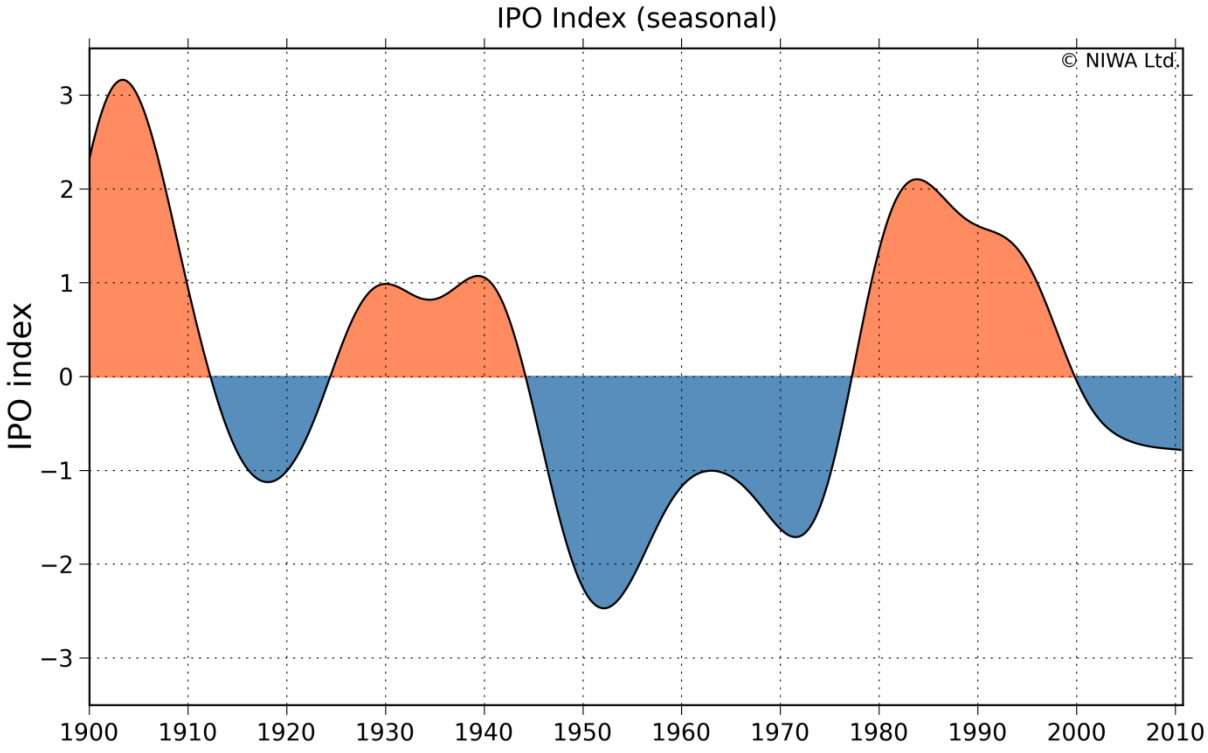

Figure 2-2: Time series for the IPO index from 1900 to 2010. Based on sea surface temperature data from the UK Met Office.

The IPO switched to its negative phase around the year 2000. It is expected that this will continue over the coming two to three decades with a tendency towards more La Niña events, and a relative lack of strong El Niño events.

[3] Data were not available for 2011 and 2012.

2.3 SAM

The SAM is a fluctuation in the westerly wind circulation over the middle and high latitudes of the Southern Hemisphere (Kidson, 1988; Thompson and Wallace, 2000; Kidson et al., 2009) and is one of the most prominent features of southern hemisphere climate on monthly and seasonal time scales. When positive, the SAM (illustrated in Figure 2-3) is usually associated with higher than normal pressures over New Zealand, and relatively settled and often dry conditions. The negative SAM is usually associated with lower than normal pressures over New Zealand, and a tendency for storms to track across the New Zealand region, accompanied by unsettled and often wet conditions in parts of the country.

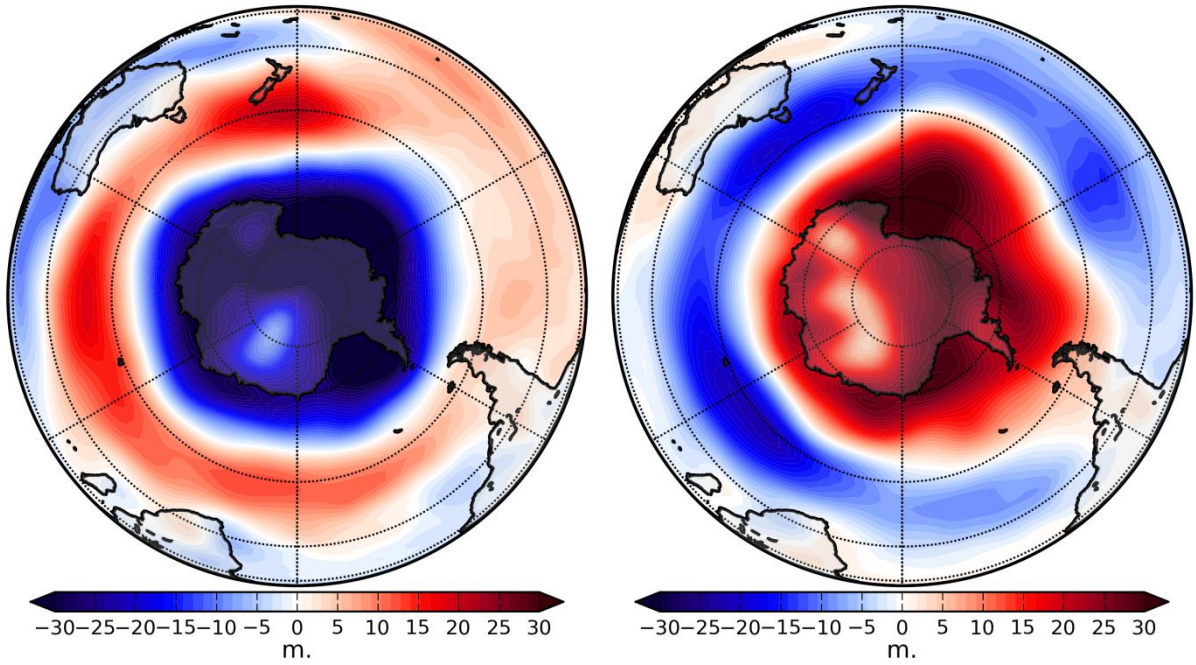

Figure 2-3: The spatial pattern of the Southern Annular Mode (SAM), shown in its positive and negative phases. The figure shows the anomalies of the altitude of the 700 hPa in geopotential metres. Higher than normal pressures are shown in red and lower than normal pressures in blue.

The SAM index from mid-2009 to the end of 2012 are shown in Figure 2-4. The SAM was predominantly in its positive phase during 2010, consistent with the known tendency for the positive SAM during La Niña conditions (e.g. L'Heureux and Thompson 2006), but switched to negative values towards the winter 2011. The summer of 2011/2012 and the winter 2012 were broadly characterized by a weak positive SAM, while in spring 2012 the SAM switched to negative values.

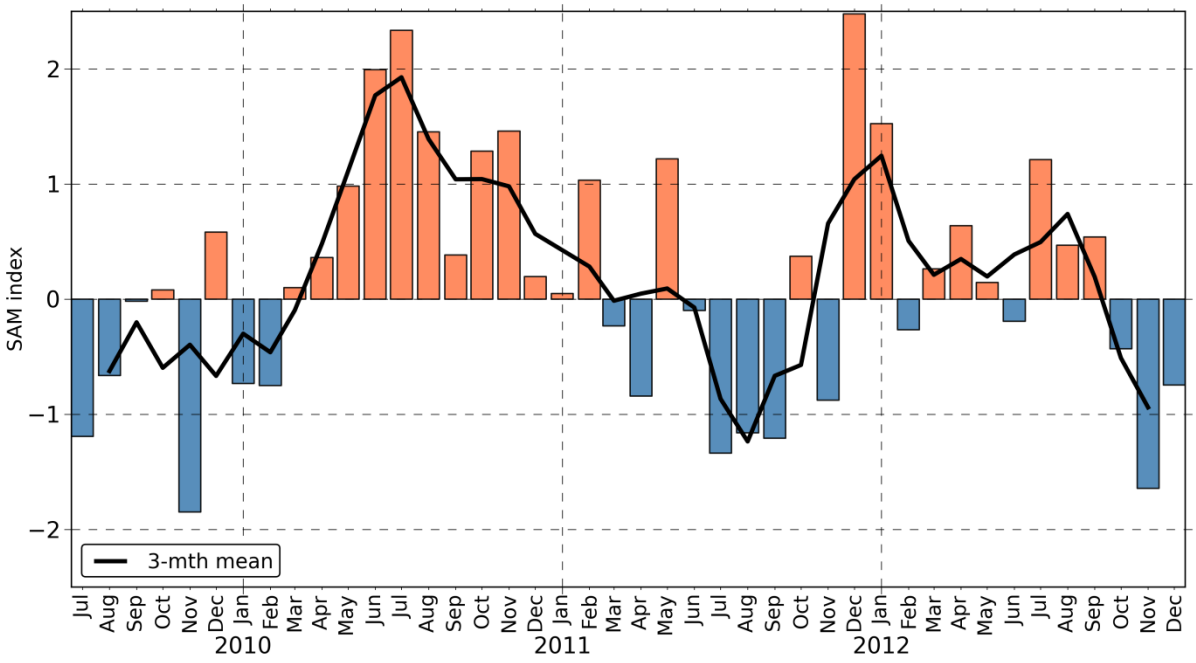

Figure 2-4: The SAM index from mid-2009 to the end of 2012. Bars indicate monthly values and the black curve indicates values that have been lightly smoothed with a 3-month running mean. The index is calculated as the amplitude of the leading pattern of variability in the Southern Hemisphere (south of 20°S) 700hPa height field. Data is from the Climate Prediction Center (CPC, USA)

3 Weather Patterns

The day-to-day weather over New Zealand may be defined in terms of wind and pressure patterns across the country. Twelve 'weather types' were defined by Kidson (2000), and are illustrated in Figure 3-1. For any day, the weather (or mean sea-level pressure) pattern may be categorised as one of the 12 types. Kidson grouped the types into three 'regimes': the *Trough* regime (mostly unsettled weather); the *Zonal* regime (mostly westerly flow over New Zealand); and the *Blocking* regime (mostly slow-moving anticyclones over New Zealand). The monthly frequency of occurrence of the types and the regimes are a way to characterize the type of weather experienced around the country. Over the course of a year, the frequency of occurrence of each regime varies. The frequency of troughs peak in spring, blocking is more frequent in summer and zonal is most frequent in winter.

The occurrence of each weather type varies with El Niño and La Niña (Jiang et al. 2004; Jiang 2011). During an El Niño, there is usually a higher frequency of the trough and Zonal types, such as 'SW' and 'HNW', and lower occurrence of the 'NE' weather type (see figure caption for definition of types). This has implications for both mean rainfall and flood-producing extreme 1-day rainfall totals in New Zealand. Extremely high daily rainfalls in the northeast of the North Island are strongly related to occurrence of the 'NE' weather type (Griffiths, 2006), with a higher frequency of 'NE' weather types equating to larger extreme 1-day rainfall events in this region. Extreme daily rainfall totals in Gisborne and Hawkes Bay are significantly affected by the 'R' weather type, with larger 1-day rainfall totals occurring with a higher frequency of this weather type. Extreme 1-day rainfall in the southeast of the South Island is linked to the frequency of the 'TSW' weather type – more 'TSW' events typically produce more extreme 1-day rainfalls in this region.

The monthly frequency of occurrence of each of the three regimes is shown in Figure 3-2 for the years 2010-2012. In this figure, black lines indicate the long-term mean seasonal cycle of the frequency of occurrence of each regime; blue bars indicate that the frequencies are less than normal and red bars that the frequencies are greater than normal.

The occurrence of Trough regime Kidson types were generally below normal in 2010. The Zonal regime was prevalent at the beginning of the year and the Blocking regime dominated both the winter (May-July) and the summer months from October 2010 to January 2011. The dominance of anticyclones near New Zealand compared to normal produced a relatively settled climate for 2010 overall, with average or above average annual temperatures in all regions, a relatively sunny year in many districts, and drought in place at the start of the year in Northland, and declared at the end of the year in Northland, Waikato and Ruapehu.

While the Blocking regime continued into 2011 and dominated the summer months, autumn and winter were dominated by the *Trough* regime, before an especially unusual frequency of the Blocking regime in October and December. Annual mean sea level pressures were higher than usual to the east of the North Island in 2011, producing more northeasterly winds than usual over northern and central New Zealand, on average for the year. Indeed, the northeasterly winds resulted in above average annual temperatures and well above normal rainfall, for many areas of the North Island, and the north of the South Island. Mean sea level pressures were also slightly above normal across the South Island, producing a somewhat drier than usual year for much of the South Island (with the exceptions of Nelson and central Otago, which were much wetter than usual).

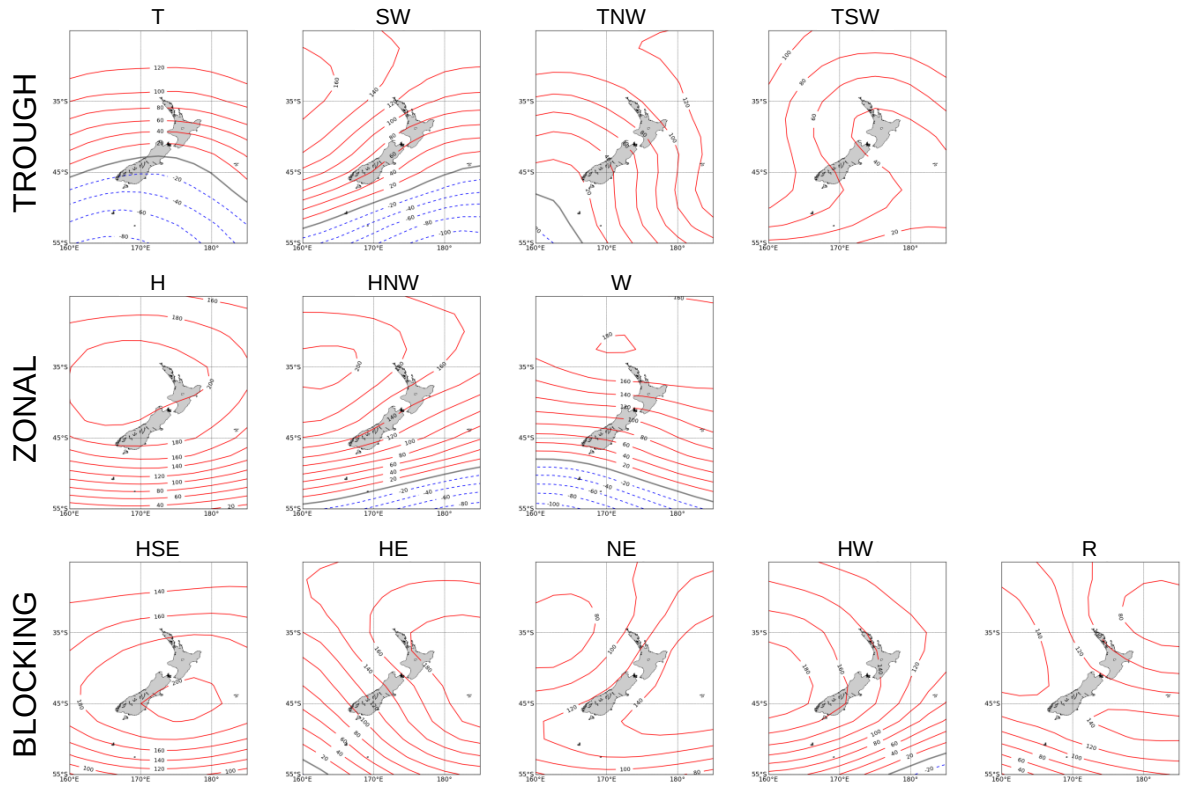

Figure 3-1: The twelve Kidson weather types, shown as average patterns of 1000hPa height (analogous to mean sea-level pressure). Names for the types are indicated in top right of each panel, where 'T' stands for Trough, 'SW' for Southwest, 'TNW' for Trough-Northwesterly, 'TSW' for Trough-Southwesterly, 'H' for High, 'HNW' for High to Northwest, 'W' for Westerly, 'HSE' for High to Southeast, 'HE' for High to East, 'NE' for Northeasterly, 'HW' for High to West, and 'R' for Ridge. The three regimes are indicated at left. See Kidson (2000) for further details.

The year 2012 was quite mixed in terms of frequency of the Kidson regimes, which resulted in relatively weak circulation anomalies for the year overall. The winter of 2012 experienced less troughs than normal (usually 40%, but in July 2012, for example, there were less than 10%), while the Zonal regimes were more frequent than normal from April to July, followed by 3 months (in July to September 2012) characterized by more Blocking regimes than normal. More easterly circulation than normal, affected the country for the first five months of the year, as well as in August. But a change took place in the second half of the year, with more frequent southwesterly airflows than usual in June, September, October and November. July and December were influenced by frequent anticyclones, and more northerly quarter winds, overall.

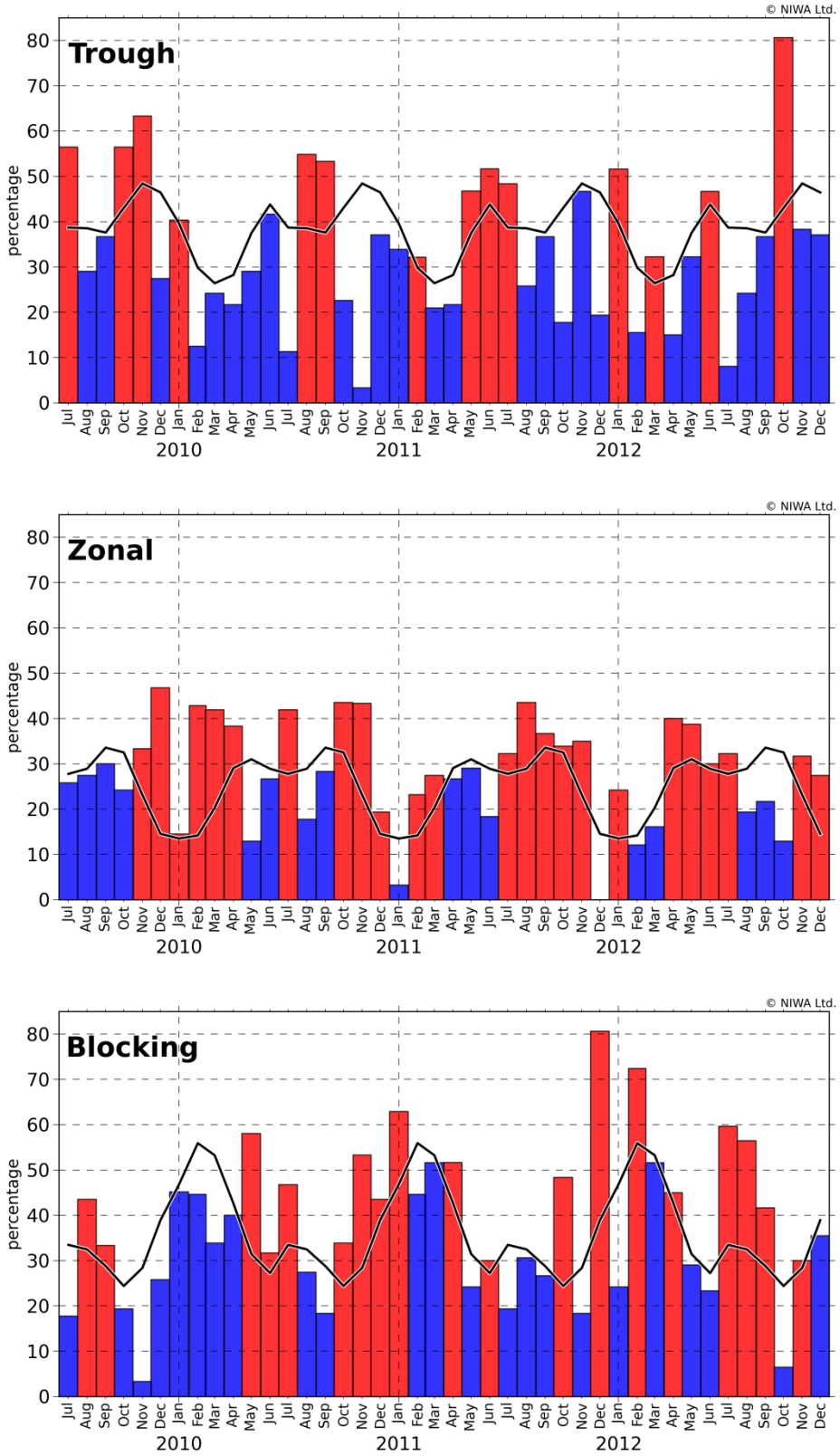

Figure 3-2: Monthly per cent frequency of occurrence of the three Kidson regime types, mid 2009 to the end of 2012. Black lines indicate the long-term mean seasonal cycle of the frequency of occurrence of each regime. Blue bars indicate that the frequencies are less than normal and red bars that the frequencies are greater than normal.

4 Rainfall

This section presents a summary of the annual rainfall for the years 2010-2012. Annual rainfalls are compared to the 1981-2010 30-year annual rainfall normals in Figure 4-1. The mean annual rainfall is also presented for selected stations in Appendix A and monthly rainfall anomalies with respect to the monthly rainfall normals are mapped in Appendix B.

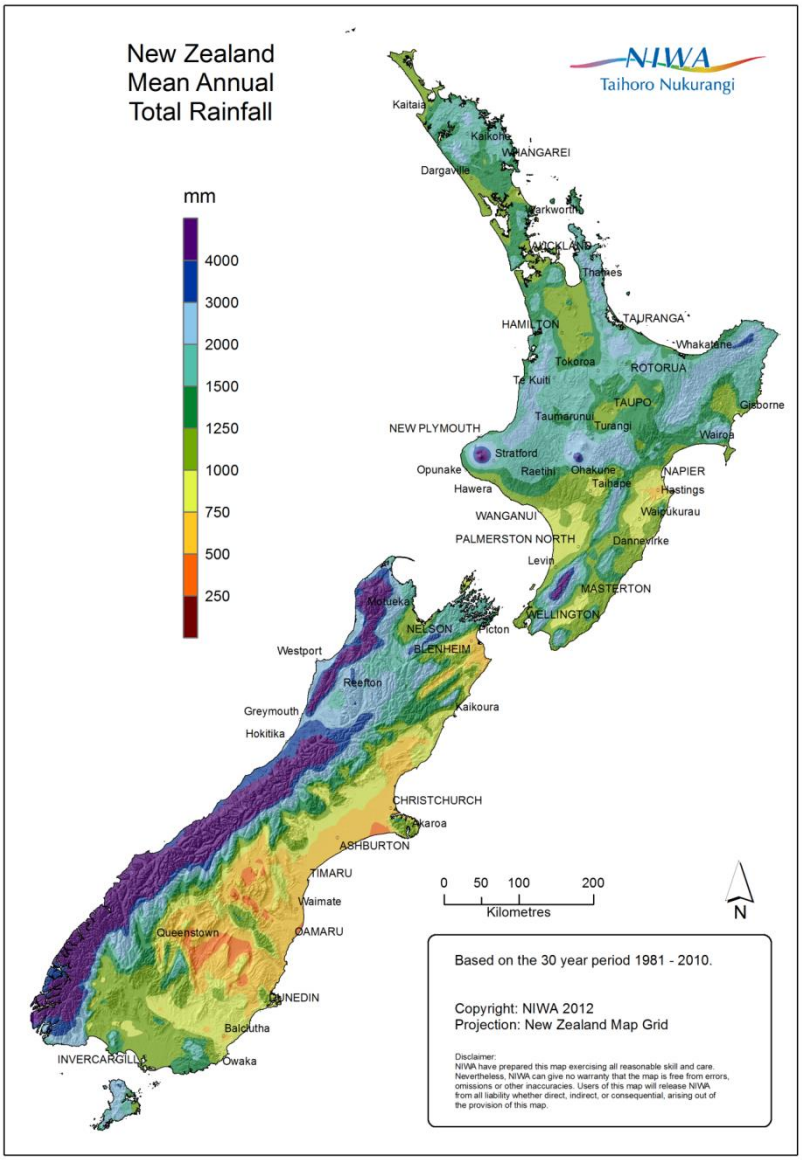

Figure 4-1: New Zealand mean annual total rainfall. 1981-2010 30-year normals.

4.1 Rainfall in 2010,

Annual rainfall anomalies for 2010 compared to the 1981-2010 30-year normals are shown in Figure 4-2.

In general terms, six months of the year were wetter than normal and six were drier than normal. This meant that annual rainfall totals for 2010 as a whole were in the near normal range (85 to 120 per cent of normal) across most of the country. The exceptions were eastern parts of the North Island (specifically Coromandel, parts of the Bay of Plenty,

Gisborne, Hawke's Bay, and Wairarapa), Blenheim, parts of North Canterbury and southwest Fiordland, which experienced above normal annual rainfall (with totals more than 120 per cent of normal). In contrast, areas of Northland, Auckland and Waikato, Otago, the Lakes District and parts of the West Coast and Buller recorded below normal annual rainfall totals (between 50 and 85 per cent of normal).

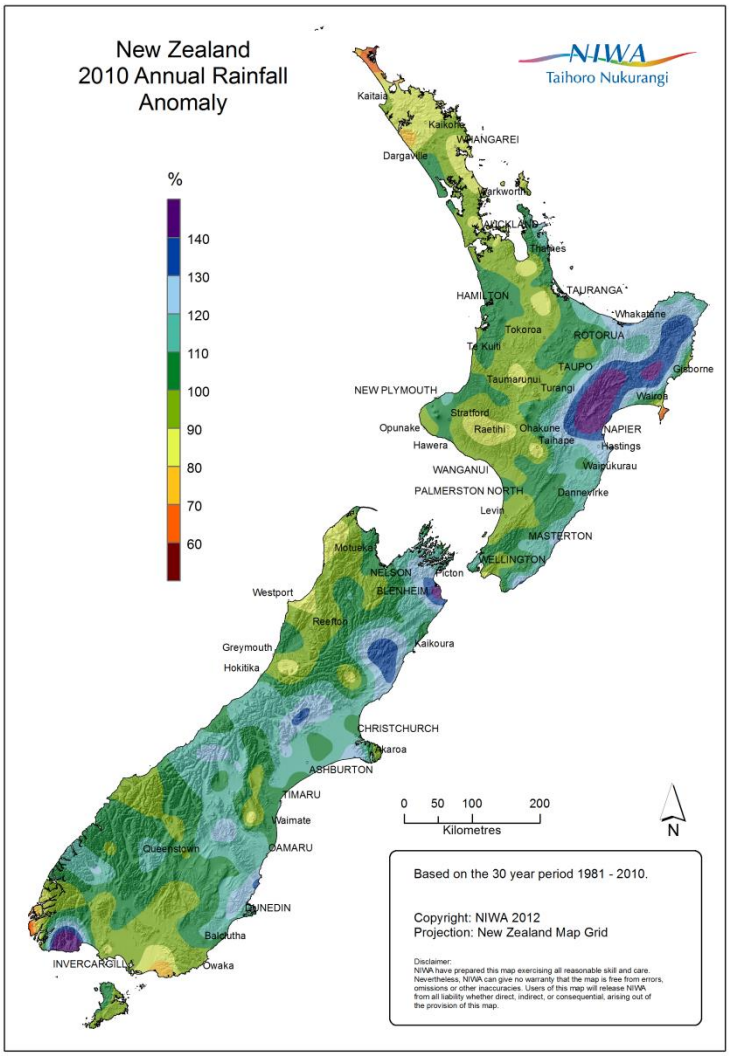

Figure 4-2: 2010 annual rainfall anomaly (percentage of the 1981-2010 normal).

Milford Sound received the top 1-day rainfall in 2010 (314 mm on 25 April, the second highest April daily value there), followed by Mount Cook (313 mm on 27 December) and North Egmont (255 mm on 13 August). A record high annual 1-day rainfall extreme occurred at Whakatane on 1 June, with 170 mm of rainfall recorded there in the 24 hours.

4.2 Rainfall in 2011

Annual rainfall anomalies for 2011 compared to the 1981-2010 30-year normals are shown in Figure 4-3. In broad terms, six months of the year were wetter than normal and two were drier than normal. Four months were mixed, with large geographical differences between very wet regions and areas of extreme dryness.

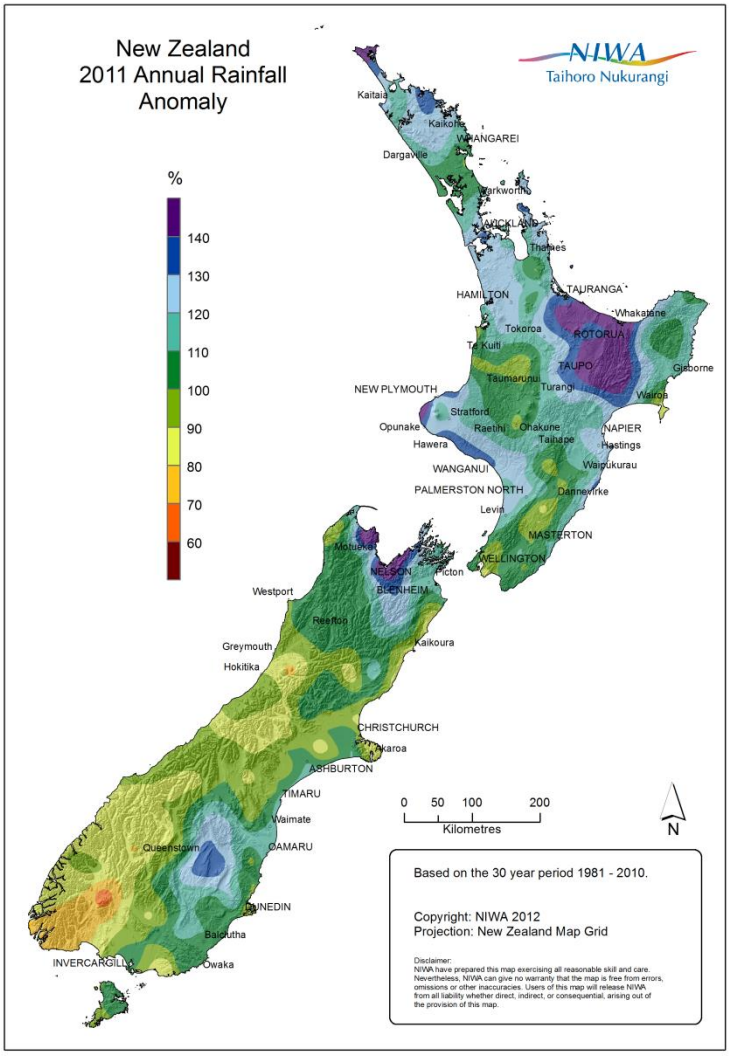

Figure 4-3: 2011 annual rainfall anomaly (percentage of the 1981-2010 normal).

Annual rainfall totals for 2011 as a whole were above normal (more than 120 per cent of annual normal) in parts of: Northland, Auckland, Coromandel, Bay of Plenty, Nelson, and central Otago; as well as around New Plymouth, Napier, Wanganui and Palmerston North. It was the wettest year on record for Wanganui, since records began there in 1987. Of the regularly reporting gauges (based on data available at time of writing), the wettest locations in 2011 were Cropp River (West Coast) with 9493 mm, North Egmont with 8236 mm and Doon (Fiordland) with 6107 mm.

The top 1-day rainfall in 2011 was 392 mm recorded at Takaka on 14 December (a new all-time daily rainfall record there). This rainfall resulted in widespread flooding with a State of Emergency being declared in the Nelson region. The second highest rainfall (331 mm) was recoded at Aramoana[4], on the coast of Hawkes Bay south east of Waipukurau, on 26 April, followed by 301 mm at North Egmont on 25 May. The driest rainfall recording locations

[4] The Aramoana daily rainfall reading was a manual one, and was not available at the time of writing the April 2011 Climate Summary.

were: Clyde with 395 mm of rainfall recorded for the year, followed by Rangiora with 498 mm, and then Middlemarch with 501 mm.

4.3 Rainfall in 2012

Annual rainfall anomalies for 2012 compared to the 1981-2010 30-year normals are shown in Figure 4-4. Annual rainfall totals for 2012 were below normal (less than 80 per cent of annual normal) in western areas of the North Island between Wanganui and the Kapiti Coast, and for Fiordland.

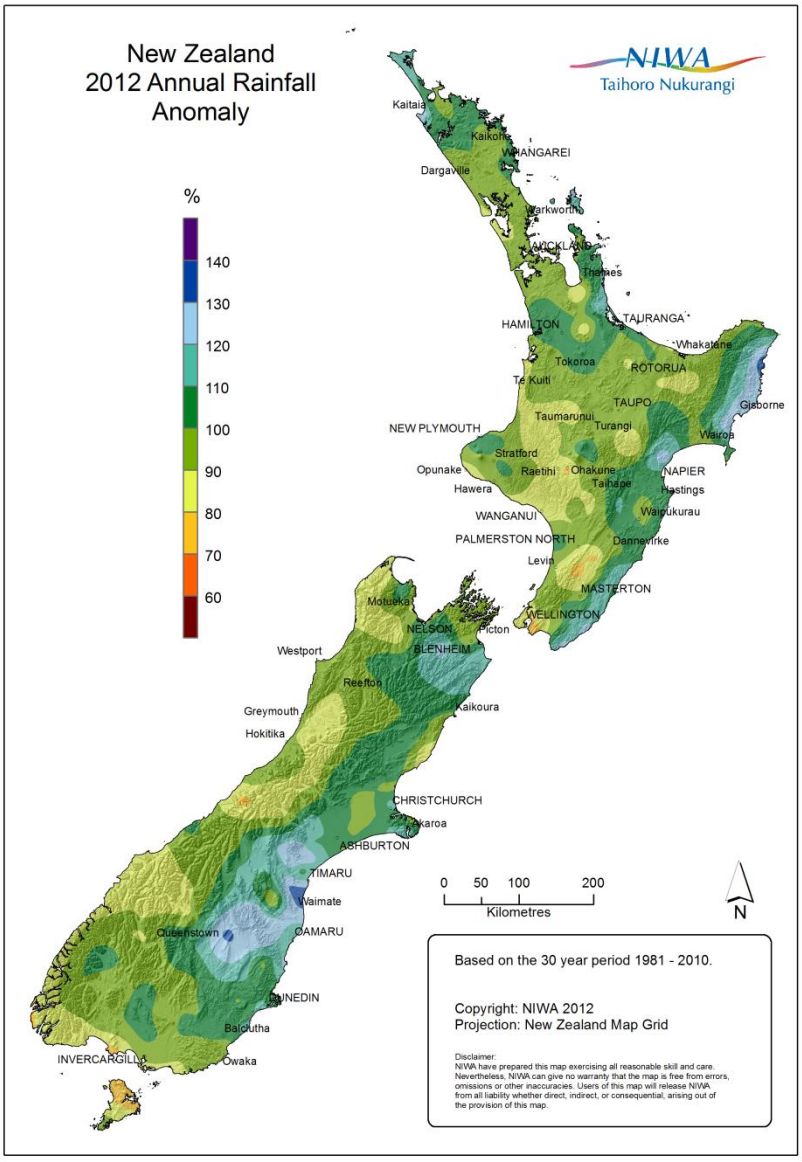

Figure 4-4: 2012 annual rainfall anomaly (percentage of the 1981-2010 normal).

The top three daily rainfall totals from regularly reporting gauges in 2012 were all recorded at North Egmont, being 336 mm observed on 15 July; 275 mm on 22 February, and 256 mm on 14 July. The highest 'lower elevation' rainfalls observed in the year were 204 mm observed at Takaka on 14 July, 198 mm at Akaroa on 12 August, and 168 mm at Kerikeri on 18 March. Of the regularly reporting gauges (based on data available at time of writing), the wettest

locations in 2012 were Cropp River (West Coast) with 9630 mm, Doon River (Fiordland) with 7410 mm, and Tuke River (West Coast) with 7175 mm[5].

It was the driest year on record for Wanganui and Secretary Island. It was also a relatively dry year (with rainfall between 80 and 100 per cent of annual normal) for the south, west, and north of the South Island, and across much of the remainder of the North Island (except for Gisborne). Above normal rainfall (more than 120 per cent of annual normal) was observed in Gisborne, as well as for parts of central Otago, and between Oamaru and Timaru. The driest rainfall recording locations (based on data available at time of writing) were: Alexandra with 378 mm of rainfall recorded for the year, followed by Clyde with 417 mm, and then Cromwell with 455 mm.

[5] Tuke River rainfall only covers the period 01-January to 22-October-2012

5 Drought

Generally speaking, a drought is a rainfall deficit that restricts or prevents a human activity. Extended dry periods are typically experienced somewhere in New Zealand in most years, and because there is no absolute definition of drought, dry periods are often described as 'drought-like'. Recent guidance on managing drought published by the Ministry for Primary Industries (MPI, 2013) contains three definitions for drought:

- Meteorological drought:
  "The state of the climate system that creates abnormally dry weather, prolonged enough for the lack of rainfall to cause serious hydrological imbalances"
- Hydrological drought
  "*A deficit of water in the landscape, either in ground water reserves or in the surface hydrological system such as rivers, streams, lakes, etc."*
- Agronomic/agricultural drought
  "A protracted period of deficient precipitation resulting in extensive damage to crop/pasture growth and production"

While low rainfall is clearly a significant factor in the management of activities such as hydroelectric water storage, and in natural systems such as river and stream ecologies; the focus of this report is on agronomic drought as the impact of low rainfall is often most keenly felt by the agricultural community. MPI (2013) notes that an agronomic drought will generally, but not always, follow a hydrological drought. Whether drought occurs will depend upon the season and management practices such as irrigation, supplementary feed, and stocking rate practices. Useful indicators are grass growth rates, crop yields and livestock condition. In this study, soil moisture deficit is used as an index of agronomic drought. The availability of soil moisture in the pasture root zone varies with season: moisture levels are typically lower in summer when evaporation rates are high and there is generally less rain; while in winter evaporation rates are low.

Maps showing the departure from the estimated long-term average (1998-2013) availability of water to plants in the pasture root zone, at 9am on the first day of each calendar month, are given in Appendix B. These maps introduce the important concept that it is not just the absolute availability of water that is important in defining drought (biological systems 'expect' dry and wet seasons), but it is also the duration and severity of the periods when there is less moisture than average for a season. The maps highlight areas of unusual dryness that were further examined, in the section below, against historical records to determine their likelihood of occurrence.

5.1 Soil moisture deficits 2010

Drought was declared in Northland in January 2010 after a three-month period of extremely low rainfall in the region. Severe soil moisture deficits (more than 130 mm of deficit) continued in Northland during February, and developed in parts of Auckland, Marlborough, Canterbury and Otago during March as the dryness continued. At the end of March, significant soil moisture deficits (more than 110 mm of deficit) had also developed in Waikato, Bay of Plenty, Coromandel, Taupo and parts of Gisborne and Hawke's Bay. Drought was declared for Auckland, Waikato, Bay of Plenty, South Taranaki, South

Canterbury and Otago in April. Even after rainfall at the end of April, significant soil moisture deficits remained in many areas of the North Island (exceptions were Taranaki, Gisborne, and the Kapiti Coast), as well as in Marlborough and Canterbury. The drought finally broke in May.

In the second half of the year, unusually large soil moisture deficits had again developed in much of Northland, coastal Nelson, mid Canterbury, and North Otago by the end of October. After the extremely low rainfall experienced in November, severe soil moisture deficits were in evidence by the end of the month in Northland, Auckland, parts of the Waikato, Nelson, the Lakes District and central Otago, with significant soil moisture deficits (more than 110 mm of deficit) elsewhere in the Waikato, Taupo, parts of the Manawatu and Gisborne, in Hawke's Bay and the Wairarapa, Marlborough, and parts of Canterbury. Drought was again declared in Northland, Waikato and the Ruapehu district in December.

5.2 Soil moisture deficits 2011

Soil moisture deficits in 2011 were generally short-lived. At the beginning of the year, significant soil moisture deficits (more than 110 mm of deficit) affected parts of western Northland, Waikato, Bay of Plenty, Gisborne, Manawatu and Wairarapa, as well as parts of Canterbury and central Otago. However, the extremely wet January in all North Island regions fully recharged soil moisture levels by the end of the month right across the North Island. In contrast, February was very dry for parts of Northland and Auckland, the Central Plateau, parts of southern Hawkes Bay and the Wairarapa, and parts of Marlborough, so that significant soil moisture deficit had redeveloped by the end of February in southern Taranaki, Manawatu, Kapiti coast, Wellington, Wairarapa, Nelson, and Marlborough, and had continued in north Canterbury. March was generally wet in many regions, so that significant soil moisture deficit remained only in the Tasman District, Marlborough and parts of Canterbury. Rainfall in April replenished all remaining dry soils.

August and September were relatively dry, and the combination of low rainfall and enhanced southwesterly winds over the country meant that soil moisture levels are already below normal by the middle of spring in north Canterbury, Mackenzie country and central Otago, as well as parts of the North Island. By the end of November, significant soil moisture deficits were observed in regions north of Taupo, also Hawkes Bay, Gisborne, Marlborough, and central Otago. Above normal rainfall totals in December throughout the North Island improved soil moisture levels there, but deficits had become extreme (deficit of more than 130 mm) in central Otago and parts of Southland by the end of the year.

5.3 Soil moisture deficits 2012

At the start of 2012, soil moisture deficits were evident in eastern areas of both Islands, including central Otago. By the end of January, significant soil moisture deficit (more than 110 mm of deficit) was observed in eastern areas of the South Island, central Otago, and Gisborne, but soil moisture levels were near-normal elsewhere. A relatively wet start to 2012 meant that deficits were alleviated across much of New Zealand by the first week of March.

During the spring westerlies of September, eastern areas of both Islands again started to dry out. An unusually dry October followed for much of the North Island, as well as in north Canterbury and Marlborough, and soils had become much drier than usual in Gisborne, Hawkes Bay and the Wairarapa. November continued dry for much of the North Island, as

well as Nelson, Marlborough, Buller, and the West Coast of the South Island. At the start of summer on 1 December, soils were extremely dry for the time of year across much of the North Island (except for Gisborne and northern Hawkes Bay), as well as in Nelson and Buller. Dry conditions persisted through the first half of December across much of New Zealand, and significant soil moisture deficits were in evidence mid-December across much of the north and east of the South Island, as well as Hawkes Bay, Wairarapa, much of the Manawatu, and parts of: Northland, Auckland, Bay of Plenty, and Gisborne. At year's end, significant soil moisture deficits were present in parts of Auckland, Waikato, Bay of Plenty, Gisborne, Hawkes Bay, Wairarapa, Manawatu, Wellington, Nelson, Marlborough, Kaikoura coast, Canterbury, Otago, and central Southland. The dry period has extended into 2013 with drought declared over the entire North Island and Westland at the time of writing (5 April, 2013).

6 Temperature

This section presents a summary of the annual temperature statistics for the years 2010-2012. The progression of New Zealand temperature departures from normal (1971-2000) is illustrated in Figure 6-1 (annual and decadal mean values from 1910–2009) using NIWA's seven-station temperature series which begins in 1909[6]. Annual temperatures are compared to the 1981-2010 30-year annual temperature normals, which are shown in Figure 6-2. Annual temperature statistics (mean, maximum and minimum temperatures) are presented for selected stations in Appendix A and monthly temperature anomalies with respect to the monthly temperature normals are mapped in Appendix B.

The tendency for either northerly (warmer in most places) or southerly (cooler in most places) wind flows means that New Zealand temperatures often vary in concert across the country. Exceptions occur due to the influence of topography. Eastern regions can be warmed by downslope föhn winds while western regions remain cool. Conversely, in strong easterly wind situations, western regions may be warmed by the same process while eastern regions remain cool.

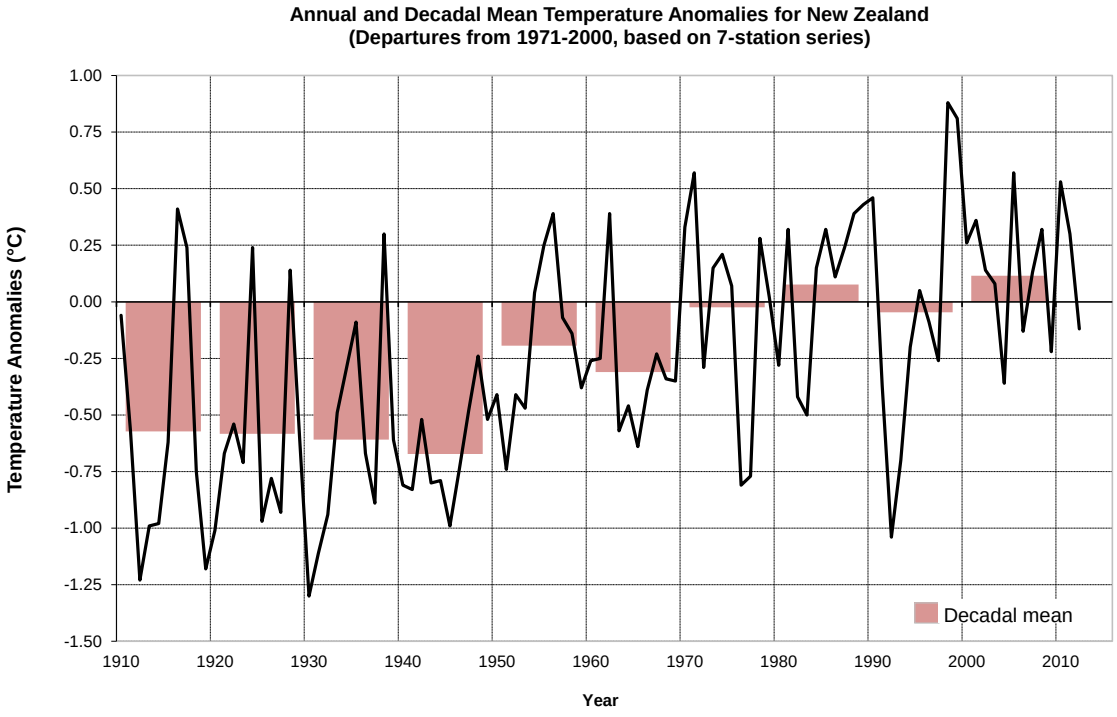

Figure 6-1: Mean annual and decadal mean NZ temperature differences.

[6] Information on the temperature series, and the data themselves, may be obtained from the NIWA web site http://www.niwa.co.nz/our-science/climate/news/all/nz-temp-record (Date of last access, 5 April 2013)

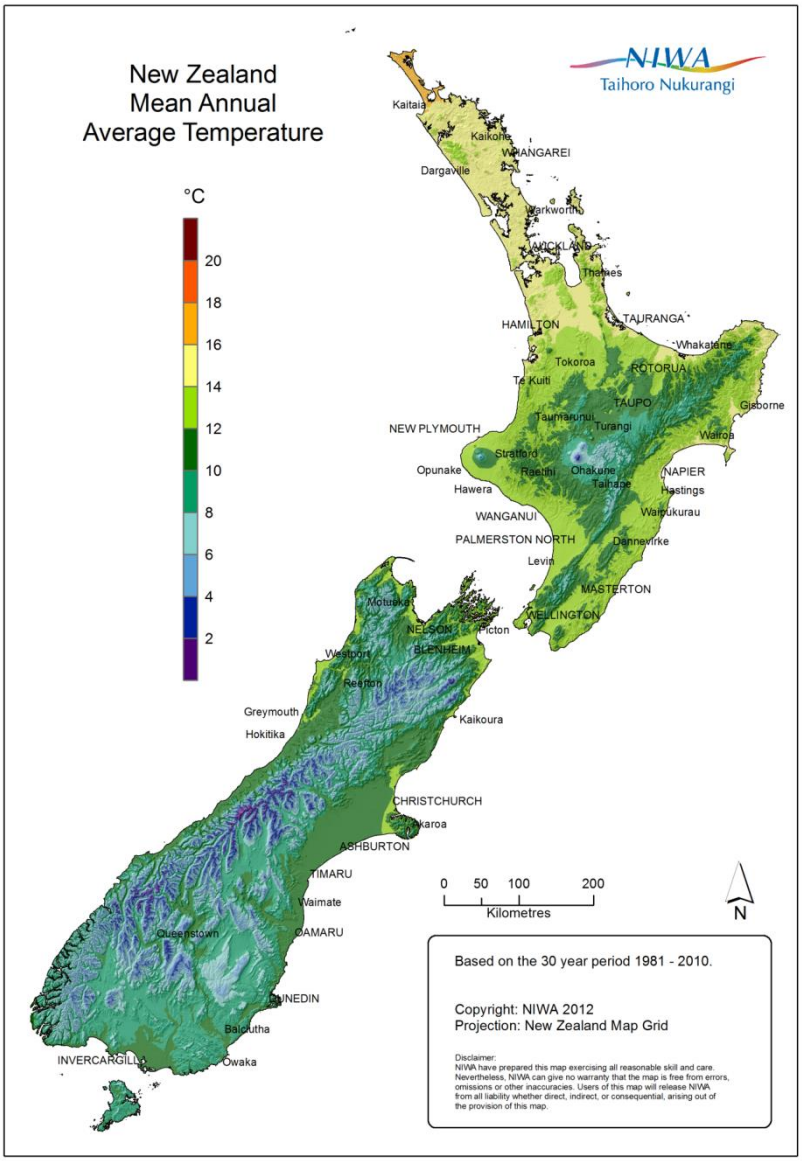

Figure 6-2: New Zealand mean annual mean temperature. 1981-2010 30-year normals.

6.1 Temperature in 2010

Departures from the annual mean temperature 30-year normal (1981-2010) for 2010 are shown in Figure 6-3. The year was notable for seven warmer than normal months (February, April, May, August, September, November and December). The nation-wide average temperature for 2010 was 13.1°C, 0.6°C above the 1971-2000 annual average using NIWA's seven station temperature series which begins in 1909. The year was the 5th warmest year since 1900, based on the seven-station temperature series.

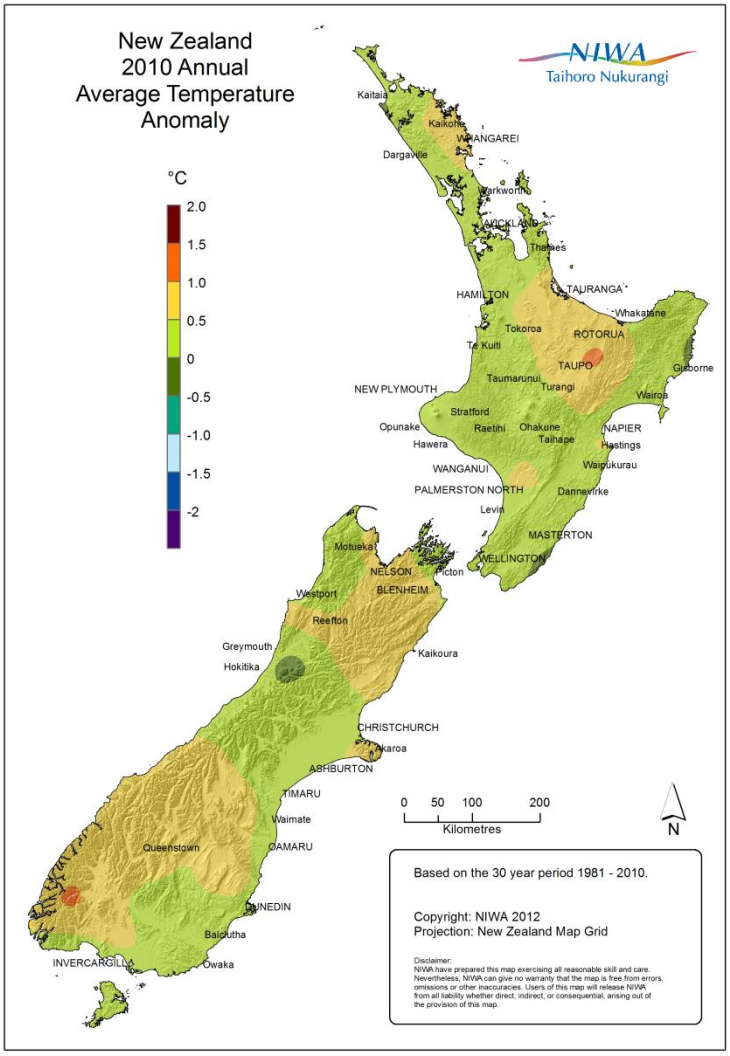

Figure 6-3: 2010 annual temperature anomaly (departure from of the 1981-2010 normal).

Whangaparaoa recorded the highest annual average temperature (16.5°C), the warmest year on record for this location, followed by Whangarei with 16.4°C and Kaitaia with 16.1°C. It was also the warmest year on record at Whenuapai, Te Puke, Reefton, Motueka, Lake Rotoiti, Nelson, Arthurs Pass, Tara Hills, Cromwell and Alexandra. Mean annual temperatures were above average (between 0.5°C and 1.2°C above the long-term average) in the northeast of the North Island, and in Nelson, Marlborough, parts of Canterbury, Fiordland and parts of Westland, the southern Lakes District and central Otago. Mean annual temperatures were near average elsewhere (within 0.5°C of the long-term average).

6.1.1 High temperatures and heat waves

The highest recorded extreme temperature of the year (35.6°C) occurred in Cheviot on 22 February (the second highest February temperature recorded there). The second highest temperature for the year was 34.3°C in Blenheim on 1 January, and the third highest was 32.9°C in Waiau recorded on 29 November (the second highest November temperature recorded there).

Heat waves affected the West Coast of the South Island over the period 29 January–1 February associated with easterly winds and foehn warming in the lee of the Southern Alps, and central Otago sweltered during 8–9 March. Many areas of both islands broke all-time November extreme temperature records between 28 and 30 November, caused by an intense late-spring anticyclone which produced calm, sunny conditions and very warm afternoon temperatures. Similar conditions resulted in record December maximum temperatures being set on 12-15 and 27 December at multiple sites in the North Island. The second and third highest temperatures for the year reported above were associated with these heat waves.

6.1.2 Low temperatures and severe frost

Figure 6-4 shows the number of days in 2010 which recorded a screen frost (i.e., where the minimum ambient air temperature at the screen height, normally 1.4m, dropped below 0°C). January and October were notable cool months in 2010.

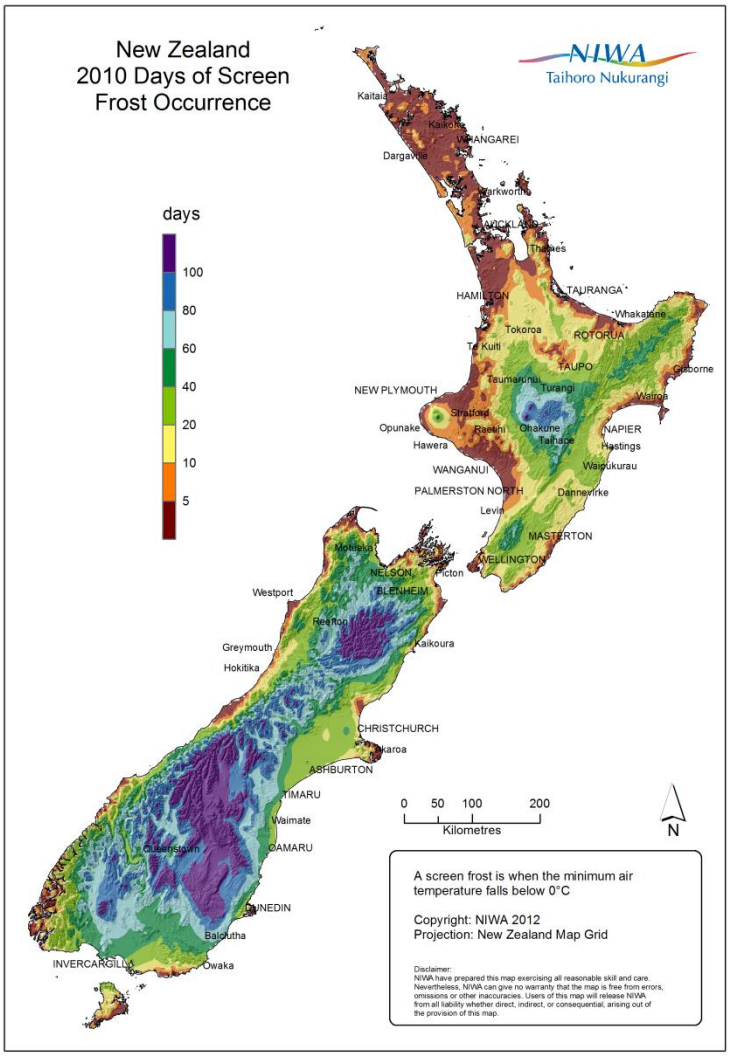

Figure 6-4: Number of days in 2010 which recorded a screen frost.

Many minimum temperature records were broken on 18 March in central and western North Island locations, after a calm, clear night followed a cold southeasterly change. An extremely cold spell affected all of New Zealand between 10 and 13 July, caused by an intense winter anticyclone over the country. The anticyclone produced clear skies, light winds, and widespread severe frosts. Numerous sites experienced record or near-record low July minimum temperatures during this period. On December 9th, record low December minimum temperatures were observed in central Otago, following an unusually cold southerly change and a clear, still night.

The lowest air temperature of the year was -12.6ºC recorded at Lake Tekapo on 10 August (the second lowest August temperature recorded there) followed by -10.7°C on 9 June, also at Lake Tekapo. The third lowest air temperature (-9.6°C at Hanmer Forest on 12 July) occurred during the aforementioned extreme cold spell. An intensely cold southwesterly event during 17–24 September in Southland brought snow to very low levels and record low afternoon temperatures on September 18.

6.2 Temperature in 2011

Departures from the annual mean temperature 30-year normal (1981-2010) for 2011 are shown in Figure 6-5. The nation-wide average temperature for 2011 was 12.8°C, 0.3°C above the 1971–2000 annual average using NIWA's seven-station temperature which begins in 1909. The year was the 17th warmest since 1909, based on this 7-station series.

Mean annual temperatures were above average (between 0.5°C and 1.2°C above the long-term average) in the northeast of the North Island, and over the north of the South Island. Mean annual temperatures were generally near average (within 0.5°C of the long-term average) elsewhere. Whangarei recorded the highest mean annual temperature (16.3°C)[7]. Overall, it was the warmest year on record at Kerikeri and Te Puke. Mean annual temperatures were also record or near-record high in other parts of Northland, as well as in Auckland, Bay of Plenty, the Taranaki and Ruapehu regions, as well as in the north of the South Island.

6.2.1 High temperatures and heat waves

Record-breaking high temperatures (and humidity) were experienced over much of the North Island on 18/19 January 2011, as tropical air was delivered to the country by ex-tropical cyclones Vania and Zelia. The entire country was affected by scorching temperatures between 2 and 7 February, as long-fetch northwest winds became slow-moving over New Zealand. Many sites recorded temperatures in excess of 30.0°C during February 5 and 6. Timaru recorded 41.3°C on 6 February, a new all-time record at the stations since records began in the area in 1885. This was also the highest recorded extreme temperature for the year. The second highest temperature for the year was 40.3°C recorded at Timaru Airport on the same day (a new all-time high record at this site). The third highest was 36.3°C which occurred in Gisborne on 2 February (the second highest February temperature in the area), and the fourth highest temp recorded was 36.0°C observed at Orari on 6 February.

[7] The NCC Climate Summary for 2011 records Leigh as having the highest temperature (16.7 °C), however a subsequent site visit showed that the site had become overgrown. For this reason, Leigh was removed from the temperature record for 2011 in the updated climate statistics **https://www.niwa.co.nz/sites/default/files/updated_2011_annual_stats_final.pdf** (Date of last access, 5 April 2013)

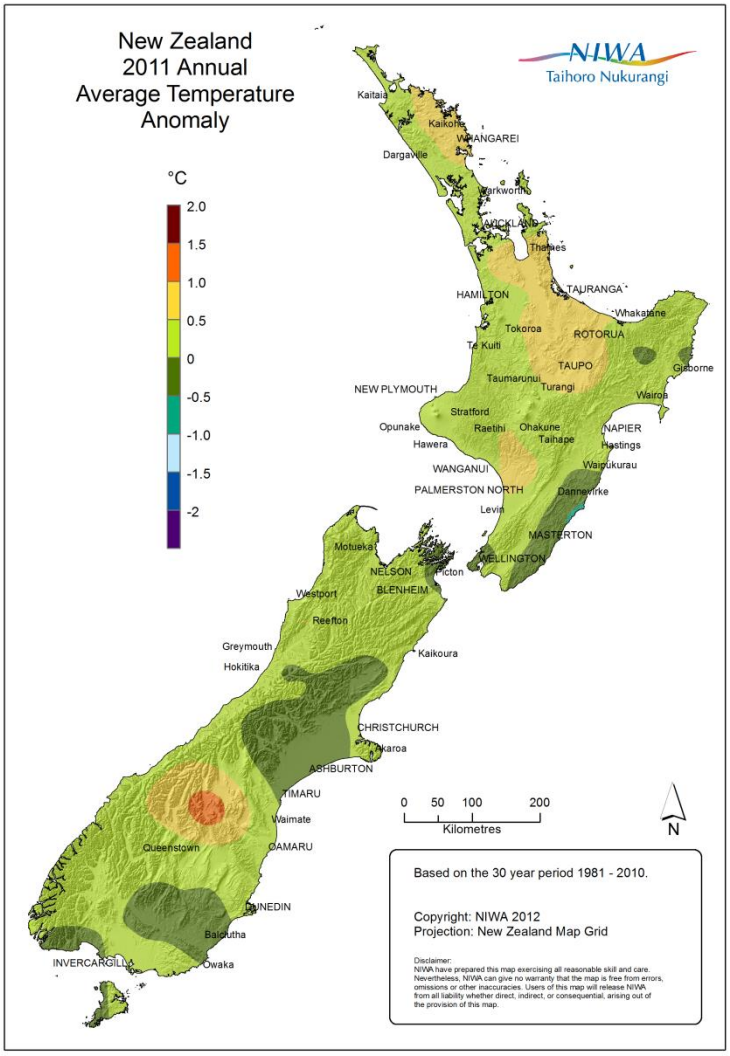

Figure 6-5: 2011 annual temperature anomaly (departure from of the 1981-2010 normal).

Unusually, the heat continued into April and May on occasion, with easterly winds causing temperatures of 28.4°C at Westport on 26 April, and a heat wave on the West Coast of the South Island and in Nelson on 1 May.

6.2.2 Low temperatures and severe frost

Figure 6-6 shows the number of days in 2011 which recorded a screen frost. The year 2011 was notable for three cold months (April, August, and September). Two exceptional snow fall events during 2011 (see Section 10.2.2) were also record-breaking with regards temperatures. The polar blast during 24-26 July delivered a bitterly cold air mass over the country, breaking several all-time low temperature records. An unusually long-lived southerly air-stream brought blast after blast of sub-Antarctic air onto New Zealand between 14-17 August; many August low minimum temperature records were broken across the country. The August event was notable in that afternoon (maximum) temperatures were also exceptionally low. At Auckland Airport, and in Upper Hutt, the Wairarapa, Rotorua, Port Taharoa, the Takapau Plains, as well as the Kaikoura Coast, maximum temperatures on 15

August were the lowest ever observed based on climate records of approximately 30-50 years' duration.

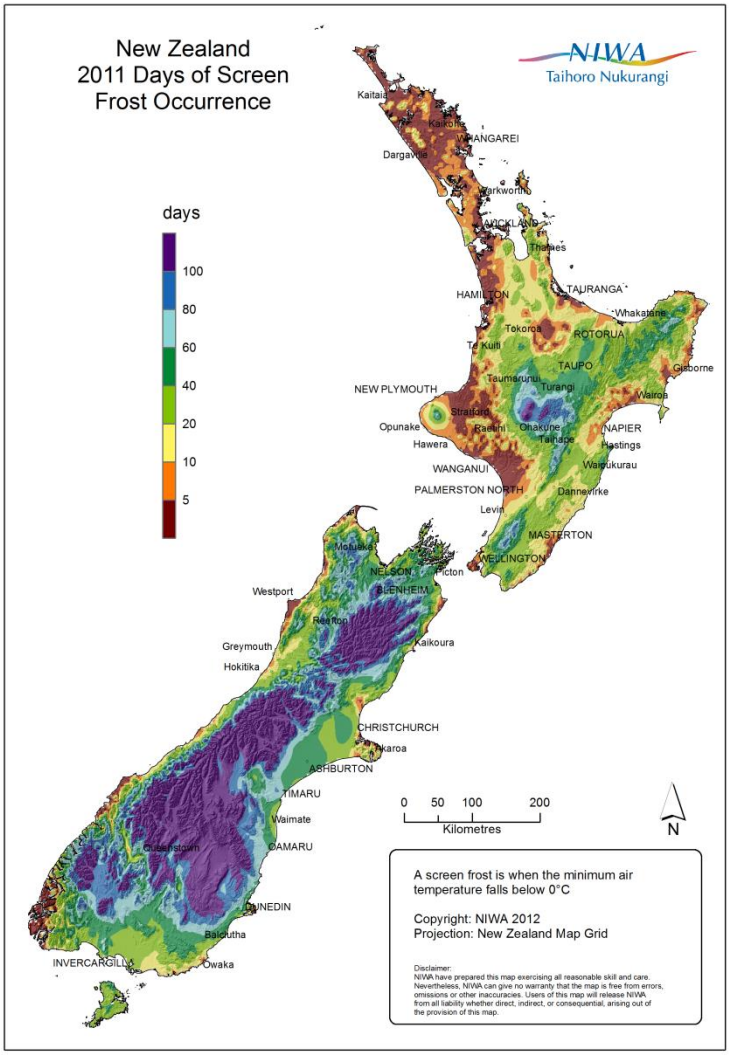

Figure 6-6: Number of days in 2011 which recorded a screen frost.

The lowest air temperature of the year was –10.2 ºC recorded at Manapouri on 26 July (a new all-time low temperature record in the area), followed by –10.1°C at Lake Rotoiti (Nelson Lakes) and -9.5°C at Chateau, Ruapehu, both observed on 16 August and both new August low temperature records at these sites.

6.3 Temperature in 2012

Departures from the annual mean temperature 30-year normal (1981-2010) for 2011 are shown in Figure 6-7. The nation-wide average temperature for 2012 was 12.5°C (0.1°C below the 1971–2000 annual average), using NIWA's seven-station temperature series which begins in 1909. 2012 was the 41st warmest year since 1909, based on this seven-station series.

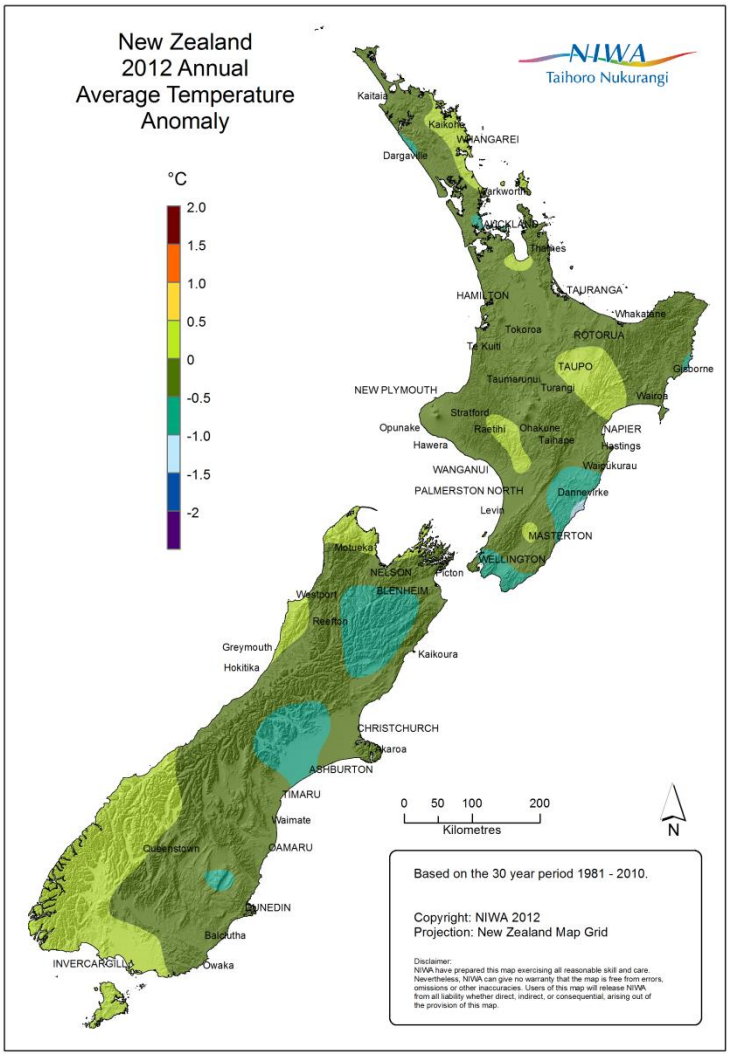

Figure 6-7: 2012 annual temperature anomaly (departure from of the 1981-2010 normal).

As in 2011, Whangarei recorded the highest annual average temperature for 2012 (15.8°C). Kaitaia followed with 15.7°C and Cape Reinga and Whangaparaoa, both recorded annual averages of 15.5°C. Mean annual temperatures were below average (more than 0.5°C below the long-term average) in the northeast of the South Island, as well as for Wellington, Wairarapa, parts of the Manawatu, and between the Tararua District and the Waikato. Mean annual temperatures were generally near or slightly below average (within 0.5°C of the long-term average) elsewhere. Overall, it was the second-coldest year on record at Taumarunui and Martinborough. Mean annual temperatures were also near-record low in parts of the Waikato, central North Island, Tararua District, and the Wairarapa.

6.3.1 High temperatures and heat waves

Heat waves and extreme high temperatures were generally lacking in 2012. January and February were cool due to the cloudy and wet conditions associated with La Niña. In contrast, winter warmth was periodically observed – with northerly winds producing unusual warmth during the second half of July, 25-27 August, the last two days of September, and the last week of October. Ex-Tropical Cyclone Evan slowly approached the northern North Island between 22 and 27 December, dragging very warm and humid subtropical air onto the

country. Humidity levels were very high during this period over the North Island. The northeast air stream also produced extremely high Christmas Day and Boxing Day temperatures in western areas which were in the 'lee', namely Taranaki to Wellington, as well as Nelson. Elsewhere, numerous extreme maximum temperature records occurred during the week around Christmas due to warm windy northwesterly conditions.

The highest recorded extreme temperature of the year (34.5°C) occurred at Gisborne on 19 December, followed by 33.5°C recorded at Middlemarch and Clyde on 25 December, and 33.3°C observed at Christchurch on 17 December.

6.3.2 Low temperatures and severe frost

Figure 6-8 shows number of days in 2012 which recorded a screen frost. The year 2012 will likely be remembered as one of periodic, unusual, cold snaps. Severe frosts were widespread and frequent in the second half of June; and unusually late frosts on 7 and 8 November were problematic for some. The lowest air temperature of the year was –11.8°C recorded at Darfield on 7 June, followed by –11.5°C at Lake Pukaki on the same day, and –11.3°C observed at Ranfurly on 2 July.

An extremely cold event occurred on 6 June. Christchurch Airport reached a maximum temperature of only 0.4°C, the lowest maximum temperature recorded at this site since records began there in 1954, with heavy snow falling throughout the daylight hours (see Section 10.3.2). Records for the lowest maximum temperature recorded were also broken at Hokitika, Cheviot, and Waipara West (with climate records of approximately 50 years, 30 years, and 40 years, respectively). Lincoln, which recorded a maximum temperature of only 0.7°C on 6 June, had second lowest maximum temperature at that site since records began in 1881. Severe frosts followed the snow event on 7 and 8 June as clear skies prevailed, and were subsequently widespread and frequent over the second half of June. Minimum (morning) temperatures in Canterbury were also extremely low on these two mornings.

An unusually cold southerly air stream for the time of year affected New Zealand on 11-12 September, breaking September temperature records at many southeastern sites. Afternoon temperatures on the 12th at Martinborough and Mahia were the coldest on record for September. Record low September morning temperatures were recorded in Kerikeri, Warkworth, Whangaparaoa, Rotorua, and Te Kuiti on the 13th of September.

An unseasonably cold southerly which dragged very cold air from about 60^{0}S up and over the country occurred on 5 and 6 November. This resulted in some extremely low afternoon temperatures in Canterbury on the 5th of November. Ridging (high pressures) then affected New Zealand on 7 and 8 November, meaning that clear skies and light winds produced unusually late frosts. Morning (minimum) temperatures in many regions of the country were record or near-record low on these two days. An unusually cold southeast air stream affected the east coast of the North Island on 13 November, with near-record low daytime (maximum) temperatures observed in Gisborne and Hawkes Bay.

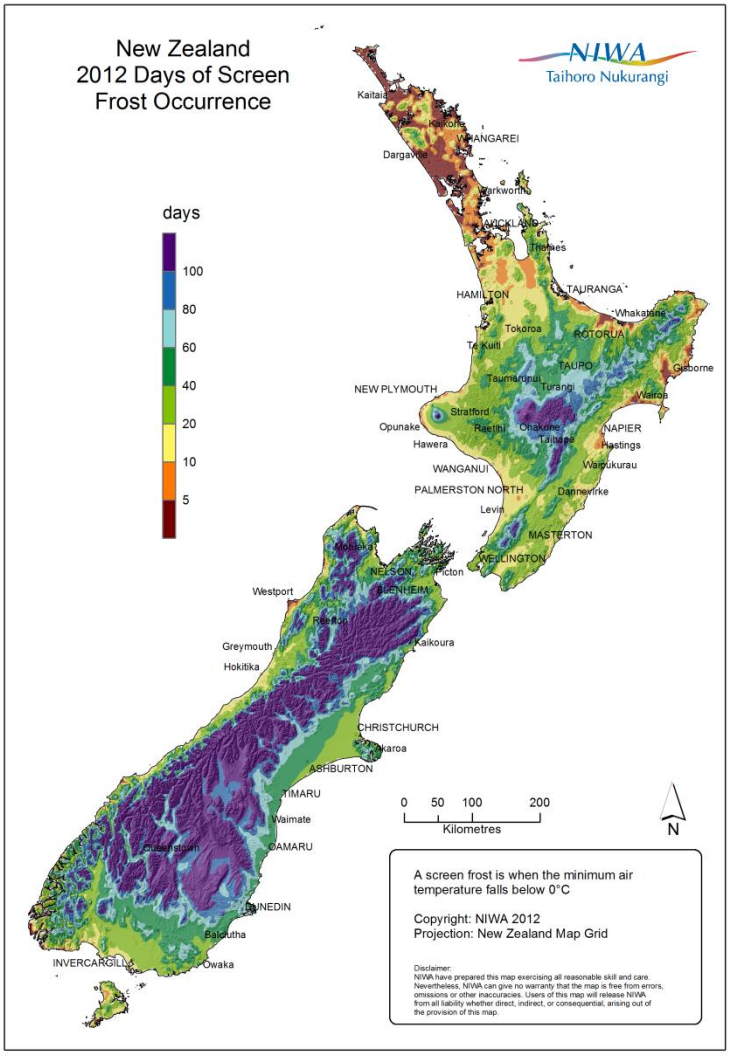

Figure 6-8: Number of days in 2012 which recorded a screen frost.

7 Sunshine hours

Mean annual sunshine hours for the 30-year period 1981-2010 are shown in Figure 7-1. Annual sunshine hours are presented for selected stations in Appendix A.

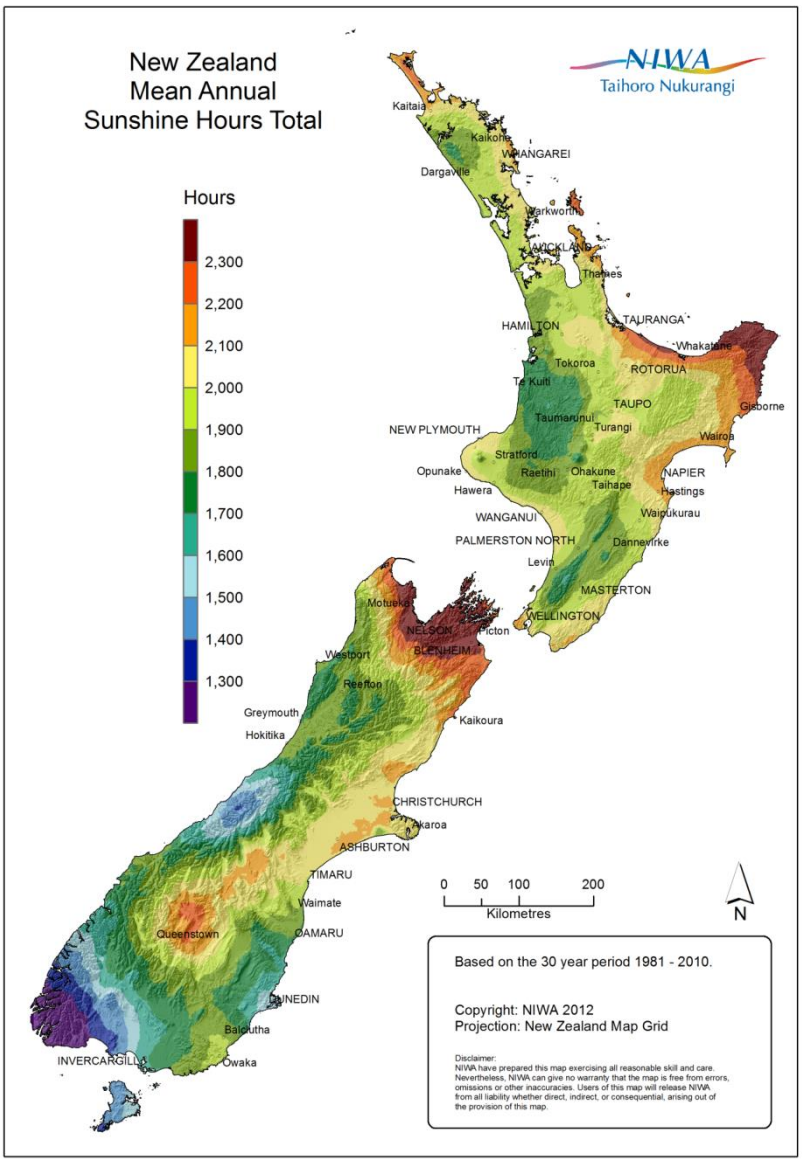

Figure 7-1: New Zealand mean annual sunshine hours. 1981-2010 30-year normals.

Above normal sunshine hours (between 110 and 130 per cent of normal) were observed in 2010 in the north and west of the North Island, and in the west and south of the South Island, with above normal annual sunshine hours observed. Whakatane was the sunniest location in 2010, recording 2561 hours, followed by Nelson (2474 hours) and Blenheim (2415 hours). In Te Kuiti, 2010 was the sunniest year since records began there in 1962. Elsewhere across the country, annual sunshine hours were nearer to normal, ranging between 95 and 105 per cent of normal.

In 2011, above normal sunshine was observed in the centre of the North Island, and for much of western and southern South Island (with annual sunshine totals between 110 and 125 per cent of normal). Parts of Wellington region received below normal (between 75 and

90 per cent of normal) sunshine totals for 2011. Elsewhere, sunshine totals were generally close to the annual normal. Nelson was the sunniest location in 2011, recording 2487 hours, followed by Tekapo (2463 hours) and Whakatane (2380 hours).

The western areas of the North Island from Te Kuiti southwards to the Kapiti Coast and the West Coast of the South Island had higher than normal sunshine hours in 2012. It was the sunniest year on record for Te Kuiti, New Plymouth, Paraparaumu, and Greymouth. This sunshine pattern reflects the enhanced easterly winds that occurred for the first five months of the year, as well as in August. In contrast, below normal annual sunshine totals (below 95 per cent of annual normal) were observed for the Wairarapa, Wellington, Blenheim, central Otago, and Northland. Elsewhere, sunshine totals were generally close to the annual normal. Whakatane was the sunniest location in 2012, recording 2602 hours, followed by Nelson (2584 hours) and Lake Tekapo (2562 hours).

8 Wind

The months of January, March and September 2010 were windy, otherwise the year as a whole was relatively settled, due to the prevalence of anticyclones over New Zealand. Of particular note was the widespread wind damage that occurred over many regions of New Zealand during 17–23 September, associated with a period of very intense south-westerly winds over much of the country. The highest recorded wind gust for the year was 217 km/h at Baring Head, Wellington, on 12 March (a new all-time record there). The second highest wind gust was 204 km/h recorded at Cape Turnagain on 23 September, followed by 178 km/hr at Secretary Island, Fiordland, on 18 February.

2011 was a windy year with seven very windy months (January, February, March, April, May, July and October). A tornado swept through Albany (Auckland) on 3 May resulting in the death of a construction worker working at a shopping mall when he was lifted and thrown into a concrete wall. Of particular note was the month of July, in which westerly winds from Christchurch southwards were the second-strongest for July, since the "westerly wind" index began in 1941. The highest confirmed wind gust for the year (as archived in the NIWA climate database) was189 km/h at Cape Turnagain on 12 July. The next highest wind gusts observed were both 183 km/hr, recorded at Southwest Cape, Stewart Island, on 12 May and 24 October, respectively.

Fourteen tornados or waterspouts were observed around the country during 2012 including a tornado in West Auckland on 6th December which killed three construction workers at a Hobsonville School (see Section 10.3.3). The highest confirmed wind gust for 2012 was 206 km/hr recorded at Cape Turnagain on 2 December. Gusts of 185 km/h were experienced at both the Rock and Pillar range, central Otago, on 31 January, and at Cape Turnagain (on 18 and 25 October).

9 End of summer snowline

The Ministry of Business, Innovation and Employment (MBIE, formerly the Ministry of Science and Innovation, MSI) funds NIWA to report on the state of 50 selected "index" glaciers in New Zealand. The project aims to provide an annual snapshot of the "health" of New Zealand's glaciers. Glaciers respond to the changing climate, and an integral of these changes are recorded by the annual aerial surveys. The surveys measure the altitudes of the snowlines of 50 glaciers at the end of summer as a surrogate for annual glacier mass-balance. The surveys are carried out by hand-held oblique photography taken from a light aircraft. Both the absolute and relative position of the snowlines are recorded and this provides a time series of glacier-climate interaction back to 1977.

The mass balance history over the course of the surveys is depicted in Figure 9-1 which indicates the departure from the Equilibrium Line Altitude; the separation line between the glacial accumulation and ablation zones. The figure shows a downwards departure in the mass balance index indicating loss in ice mass. The last three glacier years have continued an overall trend since the 2004/05 year of ice loss with occasional years such as 2009/10 having very small ice mass gains. Larger index glaciers with well-defined permanent ice areas have lost ice during the course of the 36-year monitoring period. This mass loss has occurred during large negative mass balance years and has not been replaced after a cycle of positive mass balance years.

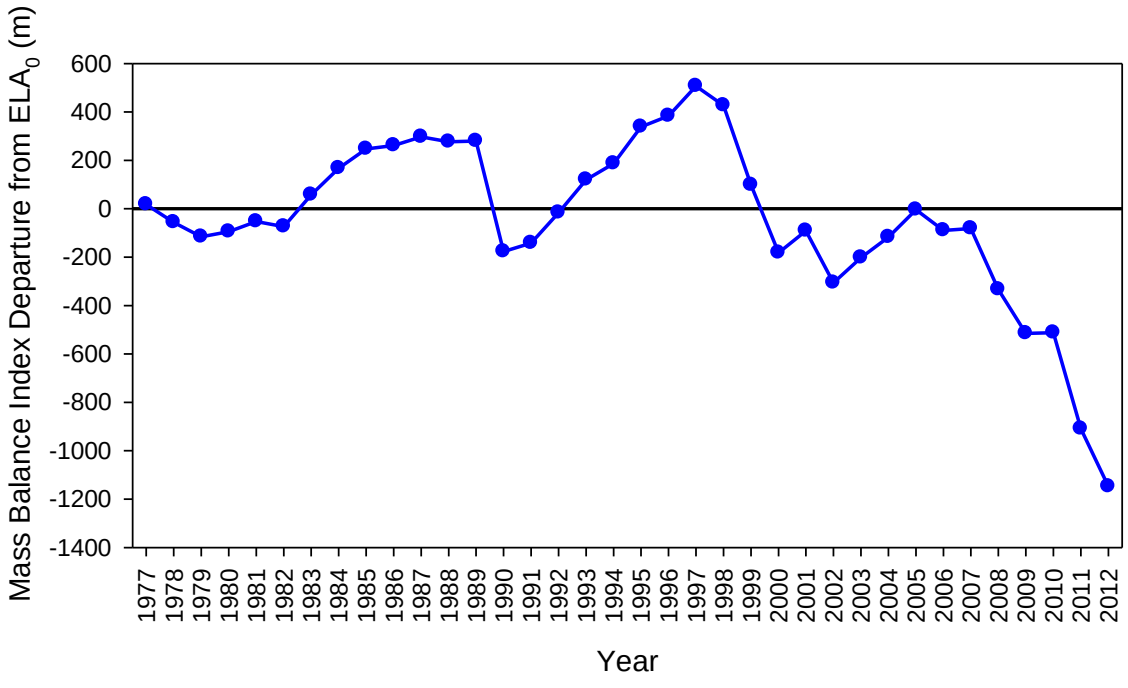

Figure 9-1: New Zealand Index Glacier Scaled Mass Balance: 1977–2012. ELA_0 refers to the Equilibrium Line Altitude.

The following is a synthesis of the 2009/10 (April 2009 – March 2010), 2010/11 (April 2010 – March 2011), and 2011/12 (April 2011 – March 2012) glacier years. Full details can be found in the annual summaries (Willsman et al., 2013, 2012 and 2010).

On average, during the 2009/10 glacier year there were slightly positive mass balance conditions with an inferred slight gain of ice mass over the year. This slight mass balance gain was due to stronger southerly and southwesterly winds during spring and winter, which bought cooler temperatures and significant snowfalls in the mountains.

During the 2010/11 glacier year there was strong negative mass balance conditions with a large loss of ice mass over the year. The average snowline position was 208 m above the average equilibrium elevation which would keep the ice mass constant on the glaciers. This year was the second highest recorded average snowline position over the course of the entire survey. The large loss of ice mass was due to frequent anticyclones, warmer than normal temperatures, and reduced rainfall.

The 2011/12 glacier year continued the trend from the previous year with an average snowline elevation 118m above the equilibrium elevation to keep the ice mass constant. This moderate negative mass balance was due to drier than normal conditions and warmer temperatures with below normal snowfalls.in the mountains.

10 Significant weather events

10.1 Events in 2010

Notable climate features of 2010 included two droughts, several heat waves (see Section 6.1.1) and three significant rainfall events which resulted in flooding.

10.1.1 Heavy snowfall causes Southland Stadium roof collapse

There were numerous heavy snow falls in 2010. The most significant snowfall event of the year occurred during 15–23 September, with heavy snowfalls observed in the southwest of the South Island. On 18 September, conditions were particularly extreme, causing the roof of Stadium Southland in Invercargill to collapse (Figure 10-1). The stadium was later demolished. After a paint shop roof also collapsed, a central Invercargill street was cordoned off because of concerns the building's windows would break on to the street. Several other commercial properties all had sagging roofs and were closed. In Tweed Street, a 1000 m^2 glasshouse was destroyed by the snow.

Figure 10-1:The roof of the Southland Stadium in Invercargill collapses under a blanket of heavy wet snow. 18 September, 2010 (photo used with permission of Fairfax Media).

Following this snowfall, Fonterra was unable to collect milk from more than 400 dairy farmers in Edendale, Winton, and Eastern Southland because of the dangerous roads, and some farmers were asked to dump milk. Thousands of lambs were lost with those born during the weekend storm having little chance of survival. Some farmers reported lambing losses of up to 80 per cent. Invercargill airport was closed by snow all day, and in very poor visibility, an air bridge clipped the wing of an Air New Zealand plane, which had stopped slightly short of its normal position. Snow also closed SH93 between Mataura and Clinton, SH94 from Te Anau to Milford Sound, and the Southern Scenic Route between Owaka and Niagara.

10.1.2 Heavy rainfall and floods

There were a relatively low number of heavy rainfall events during 2010, due to the largely settled nature of the year. The worst flooding events during 2010 included: an exceptionally heavy rainfall event on 31 January, associated with a humid easterly airstream and embedded thunderstorms, which affected the northeast of the North Island, in particular Coromandel, Bay of Plenty, Gisborne and Hawke's Bay. The rainfall caused slips and floods. SH5 between Napier and Taupo, and SH2 north of Gisborne were both closed. Rising floodwaters and debris buckled a bridge on the Waipaoa River, isolating more than 30 people at Waipaoa Station. Mangatuna village residents were moved out in the morning as the Uawa River rose; they were allowed to return several hours later, but were evacuated again in the afternoon. In the Coromandel, Hahei and the Hot Water Beach area were cut off by flooding on Hot Water Beach Road. Tairua was accessible from the north but not from the south, and SH25 at Onemana near Opoutere was blocked by flooding. In the Auckland region, homes were flooded on the Whangaparaoa Peninsula, North Shore, Auckland City, and Howick. A woman was trapped in her car by rising floodwaters underneath a motorway overpass in Ellerslie, and another driver was trapped by flood water in Remuera.

Widespread heavy rainfall and flooding occurred over the southwestern South Island between 25–27 April which resulted in very high (flood threshold) levels of Lake Wakatipu. A sustained period of heavy rainfall occurred between 24 and 30 May across the east of the South Island, which caused numerous floods, slips, river breaches, road and property damage. Heavy rainfall on 27–28 December which led to flooding on the West Coast, Nelson and Marlborough.

10.1.3 Drought declared

Drought was declared in January in Northland, and in Auckland, Waikato, Bay of Plenty, South Taranaki, South Canterbury and Otago in April. The drought broke in May, only to be declared again in December in Northland, Waikato and Ruapehu. See Section 5.1 for information on soil moisture deficits.

10.2 Events in 2011

The year 2011 will be remembered as one of extremes. Sub-tropical lows during January produced record-breaking rainfalls. The country melted under exceptional heat for the first half of February. Winter arrived extremely late – May was the warmest and June the third-warmest on record. In contrast, two significant snowfall events in late July and mid-August affected large areas of the country. Snow also fell across the lower North Island, with flurries in unusual locations further north, such as Auckland and Northland. Torrential rain caused a State of Emergency to be declared in Hawkes Bay in April and again Nelson in December.

10.2.1 An unusually mild start to winter

2011 experienced the warmest May and third warmest June on record using NIWA's seven-station temperature series which begins in 1909. In May, the nation-wide average temperature for May was 12.9°C (2.2°C above the 1971–2000 May average). Monthly mean temperatures for May were at least 2°C above May average between Waikato and Christchurch, as well as in the South Island Lakes District, with many records broken. For the remainder of the country, monthly mean temperatures were also well above average (between 1.2°C and 2°C above May average).

The nation-wide average temperature in June 2011 was 10.0°C (1.5°C above the 1971–2000 June average). Monthly mean temperatures for June were well above average (at least 1.2°C above June average) across the north and west of both Islands. Many June temperature records were broken in the North Island and the northern South Island on 5 June, associated with a very mild, northerly airstream brought down from the sub-tropics.

10.2.2 Heavy snowfalls in July and August

Despite the warmer than normal start to winter, two extremely significant and widespread snowfall events occurred during 2011, the first in July and the second in August.

A polar blast during 24-26 July delivered a bitterly cold air mass over the country. Snowfall was heavy and to very low levels over Canterbury, the Kaikoura Ranges (both Inland and Seaward), the Richmond Ranges, Tararua and Rimutaka Ranges, the Central Plateau, and around Mt Egmont. During the event, snow closed the Desert Road, the Rimutaka Hill Road, the Napier-Taupo and Napier-Taihape Roads. In the South Island, major road closures occurred, including SH1 from Cheviot to Waipara, Oamaru to Dunedin and Dunedin to Gore. Both Lincoln and Canterbury Universities, and Otago and Canterbury Polytechnics were closed. In Dunedin, many banks and retail businesses did not open, and meals-on-wheels deliveries were cancelled by the District Health Board. The Christchurch, Dunedin, Queenstown and Invercargill airports were all closed. Snow on power lines cut power across Canterbury. Elective surgery was cancelled at both Christchurch and Southland Hospitals. Snow was down to sea level at New Brighton and Spencerville beaches. City bus services in Christchurch, Waimakariri and Selwyn districts were cancelled, as were many long distance bus services. Courier and rural post deliveries were cancelled, and in Balclutha and Queenstown, the day's court proceedings were postponed. Snow was also reported from the Kaimai Ranges, Taupo, Hawera, Stratford, Wanganui, Palmerston North, the Kapiti Coast, Wellington, Masterton, Greytown, Martinborough, Greymouth, Hokitika, Nelson, Mapua, Motueka, Takaka Hill, Rai Saddle and Kaikoura. Brief dustings of snow were also reported in the ranges of Motueka and Northland on the 25th.

An unusually long-lived southerly airstream brought blast after blast of sub-Antarctic air onto New Zealand, between 14-17 August. On 14 August, snow fell to very low levels across much of the South Island, as well to central Wellington and the hill suburbs. On 15 August, the southerly winds continued to deliver extremely cold air and snowfalls to the country, and airports and schools remained closed in Christchurch, Queenstown, Invercargill and Dunedin. On the West Coast, snow fell in Rotomanu, Inchbonnie, Reefton, Greymouth, Blackball and Ikamatua. Snow fell again to sea level in Wellington, closing schools and the airport. Both Rotorua and New Plymouth reported snow falling in the central city. Snow reached the Kaimai Ranges and Mount Fitzroy (Great Barrier Island), and Te Mata Peak was covered in snow. Snow fell briefly in the Auckland CBD for the first time since 1939 but did not settle, and was also reported from the Waitakere Ranges, Drury, Waiuku, Clevedon and the Bombay Hills. The snow reached Northland, with hillside properties around Dargaville reporting snow falling. Taupo Airport was also closed as heavy snow fell around the lake. In the Waikato, snow was seen in central Hamilton, Te Kuiti, and briefly in Raglan. Snow settled in Wanganui, reputedly for the first time since 1974. Between 15 and 17 August, many eastern and alpine South Island roads, as well as lower North Island roads, remained affected by snow or ice, and airports, hospitals, mail deliveries, and power lines remained affected in these regions.

10.2.3 Flooding: States of Emergency declared in Hawkes Bay and Nelson

There were five very significant rainfall events in 2011. A low of tropical origin (which formed near New Caledonia) moved towards New Zealand on 22-23 January, producing significant heavy rainfall, flooding, slips and road closures over much of the North Island, north of about Wanganui. Tropical Cyclone Wilma moved rapidly across the northeastern North Island on 28 January, causing widespread deluge rainfalls, severe flooding and slips, in north eastern regions of the North Island. Otago and Southland experienced very heavy rainfall on 6 February during severe northwesterly conditions and an associated frontal passage.

On 25 and 26 April, heavy rain and winds caused flooding and slips across central North Island regions. Hawkes Bay was particularly hard hit with treble the normal rainfall. A deluge hit the coastal settlements around Aramoana on the 26th, causing severe land slips. Most of this rain fell in two days (between 26 and 28 April), and a State of Emergency was declared there on 28 April. Residents were evacuated from Te Awanga, east of Hastings, after the heavy rain, and Aramoana was completely cut off.

More northeast winds than normal affected New Zealand during December 2011, bringing generally warm conditions across the country. Well above normal rainfall for December was experienced in most of the North Island and northern South Island. Record rainfalls were recorded at both Nelson and Takaka. Nelson received more than six times and Takaka received more than eight times their normal December rainfall causing widespread flooding (Figure 10-2).

Figure 10-2:Farm house hit by mudslides and extensive flooding in the Wainui Inlet, Golden Bay. State of Emergency declared region in Nelson region, December 2011. (Photo used with permission of Fairfax Media).

A State of Emergency was declared in the Golden Bay region on 14 December. As well as flooding, the region was hit by landslides leaving some settlements isolated. Slips caused havoc on the roads with sections of road being swept away including on the main Takaka to Collingwood road. Twenty homes in the Pohara Valley, one of the most affected areas, were

evacuated. Other regions to be affected by heavy rainfall in December included Canterbury and Bay of Plenty.

10.3 Events in 2012

Notable events in 2012 included extreme rainfalls across the country, heavy snowfalls in the south and a fatal tornado in Auckland. The year ended with much of the country experiencing extreme soil moisture deficits (see Section 5.3) which have extended into 2013.

10.3.1 Eight extreme rainfall events lead to flooding

On 22-23 February, heavy rain caused flooding and slips in Otago, Nelson, and central North Island. On 22 and 23 February, heavy rain in Otago flooded properties in Alexandra. Dunedin Airport was closed for several hours, and rural roads in South Otago, and SH97 at Lowther in northern Southland, were closed by surface flooding. Tourists were trapped at a camping ground at Trotter's Gorge near Hampden, and some groups in the Otago Goldfield's Heritage Trust Cavalcade Trail became stuck in the Nevis area. In the Nelson area, slips came down on Cable Bay Road. Hospitals in both Rotorua and Taupo were flooded, with some patients having to be moved. A large slip blocked one lane of SH2 inland from Opotiki.

A weather 'bomb' during 3-4 March caused heavy rain and extremely strong winds for the western and southern North Island, and Nelson. A rapidly deepening low (or weather 'bomb') approached New Plymouth from the Tasman Sea on 3 March, migrating eastwards across the lower North Island on the 4th. The low brought heavy rain and extremely strong winds. The Round New Zealand yacht race fleet was between New Plymouth and Nelson at the time, with one boat issuing a Mayday and several yachts seeking shelter in Golden Bay. Patea and Waverley were badly affected with property damage, and downed trees blocked SH3 in more than one place. In Wellington, the Hutt River burst its banks.

On 19 March, Northland was affected by widespread floodwaters due to a deep low stalling east of the Bay of Islands. The hills above Kaeo received approximately twice the normal March rainfall total in 35 hours (283.5 mm). This low moved south over the North Island on 20 March, all but isolating Gisborne by causing slips and tree-falls that blocked numerous roads.

On 5 June, the northwest South Island was affected by record-breaking rain, associated with a rapidly deepening low over the Tasman Sea.

On 16 July, flooding was widespread in many regions over the southern half of the North Island and the northern South Island. Westport was isolated, and numerous State Highways were closed due to slips and floodwaters.

The Western Bay of Plenty and Coromandel were flooded in back-to-back events on 23 and 30 July. Katikati was flooded on 23 July, and both Katikati College and Katikati Primary School closed early. Waihi Beach was isolated after both roads heading into the town were closed.

Several heavy rain events in the period to 1-15 August flooded parts of Marlborough, Canterbury, and north Otago; closing many roads due to slips and surface flooding, and damaging numerous properties.

10.3.2 Heavy snowfalls in June and September

There was an extremely heavy snowfall on 6 June 2012. Snowfall was heavy and to very low levels over Canterbury, Arthur's Pass, Otago, West Coast, and Marlborough. During the event, many major roads were closed, including SH1 between Greta and Waipara, Lewis Pass, SH8 between Fairlie and Twizel, Porter's Pass, Arthur's Pass, and Dansey's Pass. Local roads were also closed. Schools throughout the affected regions closed for the day; pupils were sent home early from schools in Kaikoura and St Arnaud. Christchurch Polytechnic Institute of Technology and the Southern Institute of Technology (Christchurch campus) were closed, and the University of Canterbury closed at midday. Buses in Christchurch did not go into the hill suburbs and early morning bus services to Dunedin's hill suburbs were also affected by ice. In Marlborough, snow blocked road access to Wairau Valley, and brought down trees. Many flights in and out of Christchurch, Dunedin, and other airports were disrupted because of the weather. I n the following days, numerous roads were still closed or required chains due to snow and ice. Power was cut to thousands of homes, mainly because snow-laden trees fell on to power lines. In Hanmer Springs the power cuts closed many businesses, including the hot pools, and schools all over central Canterbury closed for the day. New Zealand Post suspended deliveries in Greymouth and central Canterbury, with delays in Westport, Gore and Balclutha.

Further snow fell on 26 June, causing numerous road closures in Canterbury and Otago, and SH94 between Te Anau and Milford Sound. On 27-28 June, snow closed additional roads, including Lewis Pass, Arthur's Pass, SH1 at the Desert Road, and the Napier-Taihape Road, and chains were required on many other main highways. Snow fell to sea level on the West Coast, and settled further inland, with 15 cm reported at Reefton.

Later in the year, snowfalls between 9-12 September caused road closures in Southland, Canterbury, and Otago. SH 94 from Te Anau to Milford Sound was closed for a number of days, and SH 1 at the Desert Road and SH 2 at the Rimutaka Ranges were closed for a time also. Chains were required on other major roads in the South Island, including SH 73 at Arthurs Pass, SH 7 at Lewis Pass, the Crown Range Road between Arrowtown and Wanaka, and roads around Queenstown and central Otago. Schools were closed or starting times were delayed, and Queenstown airport was closed with about 30 flights diverted.

10.3.3 More tornado fatalities

Fourteen tornados or waterspouts were observed around the country during 2012 including a tornado in West Auckland on 6th December which killed three men at a Hobsonville school construction site. These deaths follow the death of a workman in nearby Albany during a tornado on 3 May 2011. Around midday on 6 December, an active trough line containing thunderstorms passed across Auckland and then moved southeastwards across the Bay of Plenty during the afternoon, and onwards to Mahia Peninsula. It then moved out to sea by evening. In Auckland, one of the thunderstorm cells contained the fatal tornado which touched down near Hobsonville. The three workmen were killed by falling slabs of concrete. Several people were also injured and required hospital treatment. The tornado damaged about 150 houses in the area and forced around 250 residents to evacuate to the nearby Whenuapai air force base. The Fire Service attended about six calls from Hobsonville residents requiring assistance as heavy rain leaked through damaged roofs. Power was cut off to about 1300 customers. The damage to the area around Waimarie and Totara Roads was extensive, with eight power poles and three transformers needing to be replaced.

Auckland Transport suspended several bus services because of the extreme weather. The same trough was reported to have spawned another tornado in Ngongotaha (Lake Rotorua) during the afternoon, which brought down trees and power lines, damaged property, sent calves flying, injured horses and trapped children at a remote riding school.

Figure 10-3:Three were killed during a tornado which ripped through West Auckland on 6 December. The event also caused widespread damage to property. Photo by Dave Allen, NIWA.

10.3.4 High winds stoke fires

On 13-14 October, unusually strong winds were experienced in Northland, Auckland, and the Waikato, as well as parts of Canterbury and the West Coast. Trees were brought down and caused power cuts in many areas. On the Mahia Peninsula, extreme winds were identified as a major factor in spreading two bushfires.

On 17 October, large trees were blown onto SH1 north of Wellington, and fire fighters were forced to abandon a fire in a pine forest because of dangerous conditions caused by the wind.

11 Extreme rainfall and temperature variability

11.1 Extreme rainfalls – 2010-2012 compared to other years

The largest 1-day rainfalls observed at the six main centres during 2010, 2011 and 2012 are shown in

Table 11-1 along with a comparison to the average, and largest recorded, extreme daily rainfall.

The year 2010 was relatively benign with respect to extremely large rainfall events at both Auckland and Hamilton, with relatively low peak 1-day rainfalls observed at these locations. This is consistent with the lower than usual frequency of northeasterly Kidson regimes observed in 2010 (see Table 11-2). In contrast, Tauranga received 120 mm of rainfall on 31 January 2010, during an exceptionally heavy rainfall event associated with humid easterly winds and localised thunderstorms which affected Coromandel and the Bay of Plenty, Gisborne and Hawkes Bay, particularly badly. For Wellington and Christchurch, the magnitude of the peak daily rainfall in 2010 was very close to the long-term average, as was the combined frequency of TNW and TSW weather types (13%) during the year. In Dunedin, the largest 1-day rainfall total in 2010 was 58 mm, occurring on 27 December.

The year 2011 was relatively stormy overall for New Zealand, related to negative SAM conditions (see Section 2.3), and a higher than usual number of northeasterly airstreams affecting the country. The peak annual 1-day rainfall magnitude was above the long-term average for the northeastern centres of Auckland, Hamilton, and Tauranga, consistent with the high number of northeasterly events. The passage of ex-tropical Cyclone Wilma on 28 January was one such example – the tropical low moved rapidly across the northeastern North Island, causing widespread deluge rainfalls, severe flooding and slips in northeastern regions. For both Auckland and Tauranga, this event produced the peak 1-day rainfall of 2011. In comparison, the largest daily rainfall observed in 2011 at Hamilton was recorded on 17 December – with the rainfall total linked to ex-tropical Cyclone Wilma ranked as the third-largest for the year. The peak 24-hour rainfall magnitude observed at Wellington and Dunedin during 2011 was again close to the long-term average (consistent with the combined TSW and TNW frequency being close to the long-term average, again), but was slightly smaller than average at Christchurch (31 mm, experienced on 19 October).

The year 2102 was also relatively benign with respect extreme high daily rainfalls at all of the six main centres, except Christchurch (which was close to the long-term average). Positive SAM conditions prevailed across the start and middle of 2012, and the combined frequency of TNW and TSW patterns was slightly down (10% compared to an average of 13%).

Table 11-1: Annual extreme daily rainfall (mm) - summary information for the six main centres.

Annual extreme 1-day rainfall		Auckland Airport	Hamilton, Ruakura	Tauranga Airport	Wellington, Kelburn	Christchurch Airport	Dunedin, Musselburgh
Year records began		1963	1908	1941	1928	1944	1918
Average		67	61	101	68	46	51
Highest recorded (year)		162 (1985)	148 (1967)	241 (2005)	152 (1939)	110 (1980)	229 (1923)
Highest recorded	2010	39	53	120	69	46	58
	2011	73	88	174	69	31	55
	2012	44	56	98	61	45	42
Difference from average (mm)	2010	-28	-8	19	1	0	7
	2011	6	27	73	1	-15	4
	2012	-23	-5	-3	-7	-1	-9

Table 11-2: Comparison of the frequency (%) of Kidson weather types for the years 2010-2012 compared to the long-term 1981-2010 normal. Frequencies for the three weather types most closely associated with extreme rainfall are given in bold.

Kidson weather type*	Average frequency (1981-2010	2010	2011	2012
T	11.6	6.7	6.7	10.5
SW	11.8	9.5	13.5	14.5
TNW	7.2	**8.4**	**6.9**	**6.5**
TSW	6.0	**4.7**	**6.5**	**3.3**
H	13.8	16.1	11.5	15.8
HNW	7.8	10.0	8.5	4.8
W	5.1	4.8	5.8	4.9
HSE	13.8	17.7	14.2	14.1
HE	7.5	9.0	10.3	9.1
NE	5.3	**4.1**	**8.0**	**6.1**
HW	5.6	3.9	5.7	5.6
R	4.5	5.1	2.6	4.6

*The weather types are defined in Figure 3-1

11.2 Extreme temperatures – 2010-2012 compared to other years

Table 11-3 shows the number of hot days (maximum daily air temperature exceeding 25°C) per year at the six main centres.

The year 2010 was extremely warm overall, and the annual count of hot days was well above the long term average for Auckland, Tauranga, Hamilton, and Christchurch; averaging around 20 more hot days than usual at the latter three centres. The annual hot day count was closer to normal, in comparison, in Wellington and Dunedin (noting that hot days are less common at these two centres).

It was also a warmer than usual year in 2011 – with elevated counts of hot days in Hamilton (16 more days than usual), Tauranga and Christchurch (both 11 days more than usual), and Auckland (5 days above average). Once again, annual hot day count in 2011 was closer to normal at both Wellington and Dunedin.

The annual mean temperature in 2012 was close to the long-term average, overall. But typical summer temperatures were lacking. The summer was notable in that January was extremely cool, and February was record cloudy and unusually cool in many eastern areas. Auckland, Hamilton and Dunedin show a much lower than usual count of hot days in 2012, while Tauranga and Wellington were close to the long-term average. Christchurch was the only one of the six main centres which recorded more hot days that usual, in 2012.

Table 11-3: Annual count of 'hot days' (maximum temperature > 25°C) - summary information for the six main centres.

Number of hot days / year		Auckland Airport	Hamilton, Ruakura	Tauranga Airport	Wellington, Kelburn	Christchurch Airport	Dunedin, Musselburgh
Year records began		1966	1940	1944	1931	1954	1949
Average		21	28	21	3	21	8
Most recorded (year)		49 (1998)	59 (1970)	49 (1970)	13 (1935, 1971)	49 (1998)	20 (1998)
Number recorded / year	2010	36	47	40	1	43	10
	2011	26	44	32	1	32	5
	2012	14	15	20	2	25	4
Difference from normal (days)	2010	15	19	19	-2	22	2
	2011	5	16	11	-2	11	-3
	2012	-7	-13	-1	-1	4	-4

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Appendix A Annual weather summary tables, 2010-2012

All data reported in the following tables have been extracted from the National Climate Database (http://cliflo-niwa.niwa.co.nz/). Date of extraction 25 February – 12 March 2013.

Agent Number refers to the climate station code in the database.

Stations listed here have annual averages reported in the database for all three years as well as an average (normal) value for the 1981-2010 30-year period.

Record or near-record values for each station are highlighted along with the year the station record began. The rankings in the tables are relevant to the climate data from a group of nearby stations, some of which may no longer be operating. The current climate value is compared against all values from any member of the group, without any regard for homogeneity between one station's record and another. This approach is used because of the practical limitations of performing homogeneity checks in real-time.

The annual summary tables are:

Table A-1: Annual rainfall totals for 2010-2012 compared to the 1981-2010 normal for a selection of North Island locations.

Table A-2: Annual rainfall totals for 2010-2012 compared to the 1981-2010 normal for a selection of South Island locations.

Table A-3: Annual average daily mean temperature for 2010-2012 compared to the 1981-2010 normal for a selection of North Island locations.

Table A-4: Annual average daily mean temperature for 2010-2012 compared to the 1981-2010 normal for a selection of South Island and outer island locations.

Table A-5: Annual average and extreme daily maximum temperature for 2010-2012 compared to the 1981-2010 normal for a selection of North Island locations.

Table A-6: Annual average and extreme daily maximum temperature for 2010-2012 compared to the 1981-2010 normal for a selection of South Island and outer island locations.

Table A-7: Annual average and extreme daily minimum temperature for 2010-2012 compared to the 1981-2010 normal for a selection of North Island locations.

Table A-8: Annual average and extreme daily minimum temperature for 2010-2012 compared to the 1981-2010 normal for a selection of South Island and outer island locations.

Table A-9: Annual sunshine hour totals for 2010-2012 compared to the 1981-2010 normal for selected New Zealand stations.

Table A-1: Annual rainfall totals for 2010-2012 compared to the 1981-2010 normal for a selection of North Island locations. Record or near-record totals are highlighted.

Station	Agent number	Average annual rainfall (mm) 1981-2010	2010		2011		2012	
			Total rainfall (mm)	Percentage of normal (%)	Total rainfall (mm)	Percentage of normal (%)	Total rainfall (mm)	Percentage of normal (%)
Auckland Aero	1962	1101	959	87	1390	126	1063	97
Auckland, Ardmore	1965	1249	1112	101	1506	137	1069	97
Auckland, Mangere	22719	1125	1055	96	1540	140	1011	92
Dargaville	25119	1136	1176	107	1260	114	1026	93
Gisborne	2810	987	1180	107	1143	104	1309	119
Hamilton	2112	1202	1236	112	1539[a]	140	1290	117
Hamilton, Ruakura	26117	1118	1087	99	1396	127	1155	105
Kaitaia Aero	18183	1253	995	90	1432	130	1317	120
Kaitaia	17067	1394	1104	100	1455	132	1359	123
Kaitaia Observatory	1041	1367	1107	101	1537	140	1412	128
Kerikeri Aerodrome	37258	1775	1579	143	2413	219	1901	173
Levin	3275	1082	930	84	1224	111	920	84
Napier Aero	2980	823	1039	94	1047	95	741	67
New Plymouth	2283	1409	1559	142	1955	178	1365	124
Palmerston North	3243	900	928	84	1180	107	889	81
Paraparaumu Aero	8567	976	937	85	1018	92	901	82
Stratford	23872	2022	1986	180	2328	211	1928	175
Taupo	1858	960	899	82	1225	111	938	85
Tauranga Aero	1615	1189	1325	120	1698	154	1202	109
Te Puke	12428	1642	1800	163	2388[b]	217	1664	151
Wairoa, North Clyde	3126	1216	1434	130	1591	144	1137	103
Wallaceville	17029	1268	1200	109	1171	106	1188	108
Wanganui, Spriggens Park	3715	921	887	80	1216	110	778	71
Warkworth	17838	1454	1289	117	1614	147	1295	118

Station	Agent number	Average annual rainfall (mm) 1981-2010	2010		2011		2012	
			Total rainfall (mm)	Percentage of normal (%)	Total rainfall (mm)	Percentage of normal (%)	Total rainfall (mm)	Percentage of normal (%)
Wellington Aero	3445	957	1057	96	981	89	798	72
Wellington, Kelburn	25354	1215	1503	136	1380	125	1185	108
Whakatane Aero	1673	1189	1573	143	1837	167	1008	92
Whitianga Aero	1520	1840	2192	199	2290	208	1818	165

a Third highest since 1935

b Second highest since 1973

Table A-2: Annual rainfall totals for 2010-2012 compared to the 1981-2010 normal for a selection of South Island locations. Record or near-record totals are highlighted.

Station	Agent number	Average annual rainfall (mm) 1981-2010	2010		2011		2012	
			Total rainfall (mm)	Percentage of normal (%)	Total rainfall (mm)	Percentage of normal (%)	Total rainfall (mm)	Percentage of normal (%)
Blenheim Aero	4326	711	1016[a]	143	772	109	667	94
Blenheim Research	12430	650	826	127	699	108	580	89
Christchurch Aero	4843	594	660	111	621	105	655	110
Christchurch Gardens	4858	618	668	108	620	100	631	102
Darfield	4836	756	876	116	812	107	695	92
Dunedin, Musselburgh	15752	738	728	99	660	89	745	101
Ettrick No.2	5645	574	531	93	646	113	543	95
Gore	5778	945	915	97	970	103	938	99
Hanmer Forest	11234	1032	1261	122	1013	98	972	94
Hokitika Aero	3909	2901	2909	100	2642	91	2711	93
Invercargill Aero	5814	1149	1102	96	1235	107	1081	94
Kaikoura Plains	4497	833	996	120	801	96	875	105
Lincoln, Broadfield	17603	599	687	115	630	105	582	97
Manapouri Aero	5430	1136	1157	102	854[b]	75	1031	91
Mt Cook	18125	4285	4737	111	3660	85	3679	86
Nelson Aero	4241	959	1008	105	1467	153	922	96
Nugget Point	5893	844	677[c]	80	876	104	790	94
Queenstown Aero	5451	757	844	111	621	82	735	97
Ranfurly	18593	438	434	99	562	128	536	122
Reefton	3925	1943	1807	93	2007	103	1743	90
Tara Hills	5212	506	530	105	575	114	515	102
Timaru Aero	5086	550	617	112	628	114	606	110
Timaru	35703	539	605	112	624[d]	116	693	128
Tiwai Point	5823	1124	987	88	1119	100	978	87

Station	Agent number	Average annual rainfall (mm) 1981-2010	2010		2011		2012	
			Total rainfall (mm)	Percentage of normal (%)	Total rainfall (mm)	Percentage of normal (%)	Total rainfall (mm)	Percentage of normal (%)
Wanaka Aero	7426	594	533	90	525	88	496	84
Westport Aero	7342	2046	1808	88	2078	102	2033	99

a Second highest since1927

b Second lowest since 1961

c Fourth lowest since 1930

d Fourth highest since 1990

Table A-3: Annual average daily mean temperature for 2010-2012 compared to the 1981-2010 normal for a selection of North Island locations. Record or near-record totals are highlighted.

Station	Agent number	Mean air temperature 1981-2010	2010		2011		2012	
			Mean air temperature (°C)	Difference from normal (°C)	Mean air temperature (°C)	Difference from normal (°C)	Mean air temperature (°C)	Difference from normal (°C)
Auckland Aero	1962	15.5	16.0[a]	0.5	15.9	0.4	15.4	-0.1
Auckland, Mangere	22719	15.4	15.4	0.0	15.9	0.5	15.2	-0.2
Dargaville	25119	15.2	15.7	0.5	15.9[b]	0.7	15.1	-0.1
Gisborne	2810	14.5	14.8	0.3	14.8	0.3	14.2	-0.3
Hamilton	2112	13.6	14.2	0.6	14.1	0.5	13.4	-0.2
Hamilton, Ruakura	26117	13.8	14.3	0.5	13.4	-0.4	12.5	-1.3
Hicks Bay	2692	14.9	15.2	0.3	15.5	0.6	14.9	0.0
Kaitaia Aero	18183	15.7	16.1	0.4	16.2	0.5	15.7	0.0
Kerikeri Aero	37258	15.1	15.5	0.4	15.5	0.4	14.9	-0.2
Levin	3275	13.1	13.4	0.3	13.5	0.4	12.9	-0.2
Martinborough	21938	12.8	13.3	0.5	12.9	0.1	12.3[c]	-0.5
Mt Ruapehu, Chateau	18464	7.5	8.0	0.5	7.6	0.1	6.7	-0.8
New Plymouth	2283	13.7	14.3	0.6	14.1	0.4	13.5	-0.2
Palmerston North	21963	13.3	13.6	0.3	13.5	0.2	12.8	-0.5
Paraparaumu Aero	8567	13.0	13.3	0.3	13.3	0.3	12.8	-0.2
Port Taharoa	2136	15.2	15.5	0.3	15.7[d]	0.5	15.3	0.1
Rotorua Aero	1770	12.7	13.1	0.4	13.0	0.3	12.3	-0.4
Takapau Plains	25820	11.9	12.0	0.1	11.8	-0.1	11.1[e]	-0.8
Taupo	1858	11.7	12.3	0.6	12.2	0.5	11.4	-0.3
Tauranga Aero	1615	14.9	15.7[f]	0.8	15.7[g]	0.8	15.1	0.2
Te Kuiti	23899	13.6	13.6	0.0	13.7	0.1	12.9[h]	-0.7
Te Puke	12428	14.0	14.6[i]	0.6	14.7[j]	0.7	14.0	0.0
Wairoa, North Clyde	3126	14.3	14.3	0.0	14.3	0.0	14.3	0.0

Station	Agent number	Mean air temperature 1981-2010	2010		2011		2012	
			Mean air temperature (°C)	Difference from normal (°C)	Mean air temperature (°C)	Difference from normal (°C)	Mean air temperature (°C)	Difference from normal (°C)
Wallaceville	17029	12.5	13.0	0.5	12.4	-0.1	11.7	-0.8
Whanganui	3719	13.8	14.0	0.2	14.2	0.4	13.6	-0.2
Whanganui, Spriggens Park	3715	14.0	14.4	0.4	14.4	0.4	13.5	-0.5
Warkworth	17838	14.5	14.9	0.4	14.8	0.3	14.3	-0.2
Wellington Aero	3445	13.8	13.9	0.1	13.8	0.0	13.4	-0.4

a Second highest since 1959
b Third highest since 1943
c Second lowest since 1986
d Second highest since 1973
e Fourth lowest since 1962
f Second highest since 1913
g Third highest since 1913
h Third lowest since 1959
i Second since 1973 (registered as the highest on record in the 2010 Annual Climate Summary)
j Highest since 1973

Table A-4: Annual average daily mean temperature for 2010-2012 compared to the 1981-2010 normal for a selection of South Island and outer island locations. Record or near-record totals are highlighted.

Station	Agent number	Mean air temperature 1981-2010	2010		2011		2012	
			Mean air temperature (°C)	Difference from normal (°C)	Mean air temperature (°C)	Difference from normal (°C)	Mean air temperature (°C)	Difference from normal (°C)
Alexandra	5576	11.1	11.6[a]	0.4	11.4	0.3	10.8	-0.3
Appleby	21937	12.6	12.6	0.0	12.3	-0.3	12.0	-0.6
Awatere Valley, Dashwood R	18468	12.7	13.3	0.6	12.7	0.0	11.6	-1.1
Blenheim Aero	4326	12.6	13.2	0.6	12.5	-0.1	12.3	-0.3
Blenheim Research	12430	13.1	13.7[b]	0.6	13.1	0.0	12.9	-0.2
Campbell Island	6174	7.1	7.1	0.0	6.9	-0.2	7.3	0.2
Cape Campbell	4424	13.1	13.1	0.0	12.8	-0.3	12.8	-0.3
Christchurch Aero	4843	11.6	12.1	0.5	11.6	0.0	11.3	-0.3
Christchurch Gardens	4858	12.2	12.6	0.4	12.2	0.0	12.0	-0.2
Christchurch, Kyle St	24120	12.1	13.1	1.0	12.3	0.2	12.0	-0.1
Dunedin Aero	7339	10.3	10.6	0.3	10.3	0.0	10.1	-0.2
Dunedin, Musselburgh	15752	11.1	11.7	0.6	11.4	0.3	11.1	0.0
Ettrick No.2	5645	10.4	11.0	0.6	10.5	0.1	10.4	0.0
Franz Josef	24926	11.0	11.4	0.4	11.2	0.2	11.0	0.0
Gore	5778	9.8	10	0.2	10.0	0.2	9.9	0.1
Greymouth Aero	3950	12.2	12.7	0.5	12.8	0.6	12.7	0.5
Hanmer Forest	11234	10.3	10.9	0.6	10.2	-0.1	9.4	-0.9
Hokitika Aero	3909	11.7	12.1	0.4	12.0	0.3	11.8	0.1
Invercargill Aero	11104	9.9	10.4	0.5	10.2	0.3	10.2	0.3
Kaikoura	4506	12.4	12.8	0.4	12.5	0.1	12.2	-0.2
Lake Tekapo	24945	8.8	9.5	0.7	9.3	0.5	8.4	-0.4
Le Bons Bay	4960	11.4	11.9[c]	0.5	11.4	0.0	11.2	-0.2
Lincoln, Broadfield	17603	11.7	12.2	0.5	11.6	-0.1	11.4	-0.3

Station	Agent number	Mean air temperature 1981-2010	2010		2011		2012	
			Mean air temperature (°C)	Difference from normal (°C)	Mean air temperature (°C)	Difference from normal (°C)	Mean air temperature (°C)	Difference from normal (°C)
Manapouri Aero	5430	9.3	9.9	0.6	9.7	0.4	9.5	0.2
Middlemarch	18437	9.9	10.6	0.7	10.1	0.2	9.5	-0.4
Mt Cook	18125	8.8	9.5[d]	0.7	9.1	0.3	8.5	-0.3
Nelson Aero	4241	12.7	13.5	0.8	13.3	0.6	13.0	0.3
Nelson	4271	13.0	13.8[e]	0.8	13.6	0.6	13.2	0.2
Nugget Point	5893	10.2	10.4	0.2	10.1	-0.1	10.1	-0.1
Queenstown Aero	5451	9.7	10.2	0.5	9.9	0.2	9.7	0.0
Ranfurly	18593	8.9	10.2	1.3	9.4	0.5	8.9	0.0
Rangiora	17244	11.5	12.2	0.7	12.0	0.5	11.6	0.1
Takaka	23849	12.6	13.2	0.6	13.1	0.5	13.1	0.5
Timaru Aero	5086	10.6	11.1	0.5	10.6	0.0	10.3	-0.3
Tiwai Point	5823	10.6	10.7	0.1	10.8	0.2	10.5	-0.1
Wanaka Aero	7426	10.5	11.4	0.9	10.9	0.4	10.6	0.1
Westport Aero	7342	12.6	13.2[f]	0.6	13.1	0.5	12.9	0.3

a Highest since 1983
b Second highest since 1941
c Second highest since 1984
d Third highest since 1929
e Highest since 1943
f Fourth highest since 1937

Table A-5: Annual average and extreme daily maximum temperature for 2010-2012 compared to the 1981-2010 normal for a selection of North Island locations. Record or near-record totals are highlighted..

Station	Agent Number	Mean daily maximum temperature 1981-2010 (°C)	2010				2011				2012			
			Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme	Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme	Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme
Auckland Aero	1962	19.0	19.6[a]	0.6	28.3	22-Dec	19.3	0.3	27.8	13-Feb	19.0	0.0	27.2	24-Dec
Auckland, Mangere	22719	18.9	18.9	0.0	27.3	22-Dec	19.5	0.6	27.5	7-Jan	18.8	-0.1	25.8	30-Dec
Dargaville	25119	18.7	19.7	1.0	29.8	13-Dec	19.5	0.8	29.0	18-Jan	18.6	-0.1	26.7	22-Dec
Gisborne	2810	19.5	19.7	0.2	30.2	2-Jan	19.7	0.2	36.3	2-Feb	18.9	-0.6	31.7	19-Dec
Hamilton	2112	19.0	19.5	0.5	30.3	15-Dec	19.3	0.3	30.3	17-Jan	18.7	-0.3	27.0	24-Dec
Hamilton, Ruakura	26117	18.9	19.5	0.6	30.0	15-Dec	18.4	-0.5	29.8	17-Jan	17.7	-1.2	28.1	23-Dec
Kaitaia Aero	18183	19.5	20.1[b]	0.6	28.3	30-Jan	19.9	0.4	28.1	14-Feb	19.4	-0.1	26.9	22-Dec
Kerikeri Aerodrome	37258	19.5	20.0	0.5	29.4	14-Feb	19.7	0.2	30.0	5-Feb	19.0	-0.5	27.0	13-Feb
Martinborough	21938	18.0	18.5	0.5	30.7	29-Nov	18.1	0.1	31.4	18-Jan	17.5	-0.5	31.3	25-Dec
Mt Ruapehu, Chateau	18464	12.0	12.5	0.5	25.2	17-Nov	12.1	0.1	24.5	17-Jan	11.1	-0.9	24.4	24-Dec
New Plymouth	2283	17.4	18.3	0.9	28.7	30-Jan	18.0	0.6	27.2	18-Jan	17.4	0.0	29.9[c]	24-Dec
Palmerston North	3243	17.7	18.3	0.6	28.5	30-Jan	18.0	0.3	32.5	18-Jan	18.0	0.3	30.8[d]	26-Dec
Paraparaumu Aero	8567	16.8	17.0	0.2	25.3	1-Dec	17.0	0.2	28.0	18-Jan	16.9	0.1	29.2[e]	24-Dec
Rotorua Aero	1770	17.3	17.6	0.3	26.3	12-Dec	17.5	0.2	28.2	5-Feb	17.0	-0.3	26.0	24-Dec
Takapau Plains	25820	17.0	16.8	-0.2	28.1	27-Dec	16.5	-0.5	29.7	18-Jan	15.8	-1.2	27.8	21-Dec
Taupo	1858	16.7	17.2	0.5	28.2	15-Dec	16.9	0.2	28.4	4-Jan	16.3	-0.4	28.5	24-Dec
Tauranga Aero	1615	19.1	19.9[f]	0.8	27.6	31-Dec	19.8	0.7	30.7	5-Feb	19.4	0.3	28.1	7-Mar
Te Kuiti	23899	18.8	19.0	0.2	29.1	30-Jan	18.8	0.0	28.2	4-Jan	18.4	-0.4	29.3	24-Dec
Wairoa, North Clyde	3126	19.3	19.3	0.0	31.2	3-Jan	19.4	0.1	34.5	2-Feb	19.3	0.0	30.6	19-Dec
Wallaceville	17029	17.1	18.1[g]	1.0	30.3	29-Jan	17.3	0.2	28.5	18-Jan	16.6	-0.5	29.3	25-Dec

Station	Agent Number	Mean daily maximum temperature 1981-2010 (°C)	2010				2011				2012			
			Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme	Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme	Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme
Wellington Aero	3445	16.7	16.7	0.0	26.9	30-Jan	16.6	-0.1	29.4[h]	18-Jan	16.4	-0.3	29.6[i]	25-Dec

a Third highest since 1959
b Fourth highest since 1985
c Fourth highest since 1944
d Fourth highest since 1991
e Third (equal) highest since 1953
f Third highest since 1913
g Highest since 1939
h Third highest since 1962 (registered as Second highest in the 2011 Annual Summary)
i Second highest since 1962

Table A-6: Annual average and extreme daily maximum temperature for 2010-2012 compared to the 1981-2010 normal for a selection of South Island and outer island locations. Record or near-record totals are highlighted..

Station	Agent Number	Mean daily maximum temperature 1981-2010 (°C)	2010				2011				2012			
			Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme	Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme	Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme
Alexandra	5578	17.8	18.5	0.7	33.9	2-Feb	18.3	0.5	35.7	6-Feb	17.8	0	35.1	25-Dec
Appleby	21937	17.8	18.5[a]	0.7	29.3	31-Jan	17.9	0.1	29.8	2-Feb	17.9	0.1	29.1	24-Dec
Awatere Valley, Dashwood	18468	18.0	18.5	0.5	31.3	1-Jan	18.0	0.0	34.2	6-Feb	16.8	-1.2	30.5	25-Dec
Blenheim Aero	4326	18.4	19.0[b]	0.6	34.3	1-Jan	18.4	0.0	34.1	6-Feb	18.2	-0.2	32.1	25-Dec
Christchurch Aero	4843	16.9	17.6	0.7	32.8	2-Jan	16.8	-0.1	35.9	6-Feb	16.8	-0.1	31.2	17-Dec
Dunedin Aero	7339	16.0	16.4	0.4	31.5	22-Feb	15.7	-0.3	32.4	6-Feb	15.9	-0.1	29.5	16-Dec
Dunedin, Musselburgh	15752	14.7	15.3	0.6	30.7	21-Dec	15.0	0.3	34.4	6-Feb	14.7	0.0	26.7	19-Jan
Ettrick	5645	16.5	17.1	0.6	30.6	2-Feb	16.5	0.0	33.5	6-Feb	16.7	0.2	33.1	25-Dec
Franz Josef	24926	15.6	15.8	0.2	26.5	31-Jan	15.7	0.1	24.8	5-Feb	15.6	0.0	25.7	1-Jan
Gore	5778	14.1	14.4	0.3	26.1	1-Feb	14.3	0.2	28.8	12-Dec	14.4	0.3	29.0	25-Dec
Hanmer Forest	11234	17.0	18.0[c]	1.0	32.0	22-Feb	17.4	0.4	34.4	5-Feb	16.7	-0.3	32.0	25-Dec
Hokitika Aero	3909	15.7	16.0	0.3	27.7[d]	31-Jan	15.9	0.2	26.7	1-May	15.8	0.1	26.1	8-Jan
Invercargill Aero	11104	14.3	14.9	0.6	26.5	17-Dec	14.6	0.3	27.2	12-Dec	14.8	0.5	27.3	9-Jan
Lake Tekapo	24945	14.6	15.4[e]	0.8	29.5	22-Feb	14.9	0.3	32.7	6-Feb	14.3	-0.3	29.2	4-Jan
Manapouri Aero	5430	14.6	14.9	0.3	28.7	1-Feb	15.1	0.5	26.4	9-Jan	14.9	0.3	28.8	9-Jan
Middlemarch	18437	16.1	16.7	0.6	32.3	23-Feb	16.2	0.1	35.2	6-Feb	15.9	-0.2	33.5	25-Dec
Mt Cook	18125	14.0	15.4[f]	1.4	29.5	5-Feb	15.3	1.3	28.6	5-Feb	14.6	0.6	29.0	4-Jan
Nelson	4271	17.5	18.6[g]	1.1	28.3	31-Jan	18.2	0.7	30.2	2-Feb	18.0	0.5	30.3	24-Dec
Nugget Point	5893	13.5	13.6	0.1	28.8[h]	22-Feb	13.3	-0.2	24.0	5-Feb	13.4	-0.1	27.9	31-Jan

Station	Agent Number	Mean daily maximum temperature 1981-2010 (°C)	2010				2011				2012			
			Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme	Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme	Mean daily maximum temperature (°C)	Difference from normal (°C)	Highest daily maximum temperature (°C)	Date of extreme
Takaka	23849	18.2	18.6[i]	0.4	28.8	11-Dec	18.5	0.3	33.0[j]	6-Feb	18.5	0.3	30.5	24-Dec
Timaru Aero	5086	16.3	16.9	0.6	34.1	1-Jan	16.5	0.2	40.3[k]	6-Feb	16.3	0.0	30.5	19-Jan
Wanaka Aero	7426	16.1	16.9[l]	0.8	33.0	4-Feb	16.5	0.4	29.8	6-Feb	16.2	0.1	30.7	25-Dec

a Highest since 1943
b Fourth highest since 1932
c Third highest since 1906
d Fourth highest since 1963
e Second highest since 1927
f Highest since 1929
g Highest since 1943
h Fourth highest since 1970
i Fourth highest since 1978
j Highest since 1978
k Highest since 1990
l Fourth highest since 1955

Table A-7: Annual average and extreme daily minimum temperature for 2010-2012 compared to the 1981-2010 normal for a selection of North Island locations. Record or near-record totals are highlighted.

Station	Agent number	Mean daily minimum temperature 1981-2010 (°C)	2010				2011				2012			
			Mean daily minimum temperature (°C)	Difference from normal (°C)	Lowest daily minimum temperature (°C)	Date of extreme	Mean daily minimum temperature (°C)	Difference from normal (°C)	Lowest daily minimum temperature (°C)	Date of extreme	Mean daily minimum temperature (°C)	Difference from normal (°C)	Lowest daily minimum temperature (°C)	Date of extreme
Auckland Aero	1962	12.0	12.4[a]	0.4	2.4	11-Jul	12.4	0.4	1.5	26-Jul	11.8	-0.2	1.4	17-Jun
Auckland, Mangere	22719	11.8	11.8	0	0.6	11-Jul	12.3	0.5	1.3	16-Aug	11.5	-0.3	-0.1	13-Sep
Dargaville	25119	11.6	11.6	0	0.4	15-Jul	12.3[b]	0.7	1.4	16-Jul	11.6	0	0.3	10-Jul
Gisborne	2810	9.5	9.9	0.4	-0.4	10-Jun	9.9	0.4	-0.6	1-Aug	9.5	0	0.7	18-Jun
Hamilton	2112	8.3	8.9	0.6	-3.3	11-Jul	9	0.7	-3.9	21-Aug	8	-0.3	-3.6	30-Jun
Hamilton, Ruakura	26117	8.7	9.1	0.4	-3.5	10-Jul	8.4	-0.3	-4.3	26-Jul	7.3	-1.4	-4.5	30-Jun
Kaitaia Aero	18183	11.9	12.2	0.3	1.7	15-Jul	12.5	0.6	1.1	20-Oct	12.1	0.2	1.5	13-Sep
Kerikeri Aero	37258	10.7	11	0.3	3.1	15-Jul	11.2	0.5	0	16-Aug	10.7	0	1.9	17-Jun
Martinborough	21938	7.7	8.2	0.5	-3	13-Jul	7.7	0	-2.8	15-Jul	7	-0.7	-3.8	21-May
Mt Ruapehu, Chateau	18464	3	3.5	0.5	-6.4	10-Jul	3.2	0.2	-9.5	16-Aug	2.3	-0.7	-8.1	13-Sep
New Plymouth	2283	10	10.2	0.2	0.5	11-Jul	10.2	0.2	-2.6[c]	26-Jul	9.6	-0.4	-1.3	13-Sep
Palmerston North	3243	8.6	8.9	0.3	-3.3	11-Jul	9.2	0.6	-2.8	16-Aug	8.2	-0.4	-3.9[d]	17-Jun
Paraparaumu Aero	8567	9.3	9.6	0.3	-2.7	14-Jul	9.6	0.3	-1.7	15-Jul	8.7	-0.6	-4.2	2-Jul
Rotorua Aero	1770	8.1	8.5	0.4	-2.1	11-Jul	8.6	0.5	-5.2[e]	16-Aug	7.6	-0.5	-3.6	30-Jun
Taupo	1858	6.8	7.5	0.7	-4.7	11-Jul	7.5	0.7	-5.4	21-Aug	6.5	-0.3	-5.1	17-Jun
Tauranga Aero	1615	10.7	11.5	0.8	2.2	12-Aug	11.6	0.9	-0.3	16-Aug	10.7	0	0.1	13-Jun
Te Kuiti	23899	8.4	8.2	-0.2	-4.3	12-Jul	8.6	0.2	-3.4	16-Aug	7.4	-1	-3.9[f]	2-Jul
Wairoa, North Clyde	3126	9.3	9.2	-0.1	-0.8	12-Aug	9.2	-0.1	-1.7	27-Jul	9.4	0.1	0	20-Jul
Warkworth	17838	10.2	10.7	0.5	-0.7[g]	11-Jul	10.9	0.7	-1	17-Aug	10.2	0	-0.7	17-Jun

a Third highest since 1959
b Third highest since 1943
c Lowest since 1944
d Second lowest since 1991
e Lowest since 1946
f Fourth lowest since 1959
g Third lowest since 1966

Table A-8: Annual average and extreme daily minimum temperature for 2010-2012 compared to the 1981-2010 normal for a selection of South Island and outer island locations. Record or near-record totals are highlighted.

Station	Agent number	Mean daily minimum temperature 1981-2010 (°C)	2010				2011				2012			
			Mean daily minimum temperature (°C)	Difference from normal (°C)	Lowest daily minimum temperature (°C)	Date of extreme	Mean daily minimum temperature (°C)	Difference from normal (°C)	Lowest daily minimum temperature (°C)	Date of extreme	Mean daily minimum temperature (°C)	Difference from normal (°C)	Lowest daily minimum temperature (°C)	Date of extreme
Alexandra	5578	4.4	4.6	0.2	-8.5	12-Jul	4.5	0.1	-7.2	26-Jul	3.9	-0.5	-10	2-Jul
Appleby	21937	7.4	6.8	-0.6	-5.0	11-Jul	6.7	-0.7	-3.9	20-Aug	6.1	-1.3	-5.5	1-Jul
Awatere Valley Dashwood	18468	7.4	8.2	0.8	-3.8	13-Jul	7.5	0.1	-4.7	26-Jul	6.3	-1.1	-4.4	17-Jun
Blenheim Aero	4326	6.8	7.3	0.5	-4.9	13-Jul	6.6	-0.2	-6.2[a]	16-Aug	6.3	-0.5	-5.3	30-Jun
Christchurch Aero	4843	6.3	6.6	0.3	-5.4	11-Jul	6.4	0.1	-6.3	26-Jul	5.7	-0.6	-5.8	7-Jun
Christchurch Gardens	4858	7.3	7.7	0.4	-3.0	11-Jul	7.5	0.2	-5.2	3-Aug	7.1	-0.2	-5.6	27-Jun
Christchurch, Kyle St	24120	7.1	8.1	1	-4.6	11-Jul	7.7	0.6	-5.7	26-Jul	6.9	-0.2	-4.9	7-Jun
Darfield	4836	6.2	6.9	0.7	-3.0	12-Jul	6.2	0	-2.5	22-Jul	6	-0.2	-7.3	7-Jun
Dunedin Aero	7339	4.6	4.7	0.1	-6.7	12-Jul	4.9	0.3	-5.8	31-Jul	4.3	-0.3	-7.8	2-Jul
Dunedin, Musselburgh	15752	7.6	8.0	0.4	-0.7	12-Jul	7.8	0.2	-1.2	26-Jul	7.4	-0.2	-3.2	17-Jun
Ettrick	5645	4.2	5.0	0.8	-5.5	11-Jul	4.4	0.2	-5.8	2-Jul	4.1	-0.1	-7.3	3-Jul
Franz Josef	24926	6.4	7.0	0.6	-1.5	8-Jul	6.8	0.4	-3.7	26-Jul	6.4	0.0	-2.2	30-Jun
Gore	5778	5.5	5.6	0.1	-3.8	12-Jul	5.7	0.2	-3.2	10-Aug	5.4	-0.1	-4.7	2-Jul
Hanmer Forest	11234	3.6	3.8	0.2	-9.6	12-Jul	3.1	-0.5	-9.9	26-Jul	2.1	-1.5	-10.3	2-Jul
Hokitika Aero	3909	7.7	8.2[b]	0.5	-1.4	8-Jul	8.1	0.4	-2.3	16-Aug	7.7	0.0	-2.3	29-Jun
Hokitika	3910	7.7	8.2	0.5	-1.5	8-Jul	8.1	0.4	-2.4	16-Aug	7.7	0.0	-2.4	29-Jun
Invercargill Aero	11104	5.5	6	0.5	-4.5	2-Jun	5.8	0.3	-2.9	28-Apr	5.5	0.0	-6.0	4-Jul
Kaikoura	4506	9.2	9.4	0.2	1.7	22-Sep	9.2	0	-1.0[c]	15-Aug	9.0	-0.2	1.0	7-Jun
Lake Tekapo	24945	3.0	3.6	0.6	-12.6	10-Aug	3.6	0.6	-9.4	20-Aug	2.4	-0.6	-10.2	7-Jun
Lincoln, Broadfield	17603	6.6	7.2	0.6	-4.4	11-Jul	6.9	0.3	-3.7	26-Jul	6.4	-0.2	-6.3	7-Jun

Middlemarch	18437	3.6	4.5	0.9	-7.3	12-Jul	4.0	0.4	-6.5	19-Jul	3.2	-0.4	-10.6	2-Jul
Mt Cook	18125	3.6	3.6	0	-8.2	26-Jun	3.0	-0.6	-7.9	24-Jul	2.4	-1.2	-8.3	25-Jul
Nelson	4271	8.5	9.0[d]	0.5	-2.0	11-Jul	8.9	0.4	-2.8	26-Jul	8.4	-0.1	-2.2	1-Jul
Queenstown Aero	5451	4.3	4.6	0.3	-7.2[e]	12-Jul	4.3	0	-8.9[f]	26-Jul	4.0	-0.3	-7.7	5-Jul
Takaka	23849	7.0	7.7	0.7	-2.7	13-Jul	7.8	0.8	-1.8	3-Sep	7.7	0.7	-1.4	1-Jul
Timaru Aero	5086	5.0	5.3	0.3	-6.1	12-Jul	4.7	-0.3	-7.8[g]	26-Jul	4.4	-0.6	-6.8[h]	24-Jul

a Third lowest since 1932
b Fourth highest since 1963
c Lowest since 1963
d Third highest since 1963
e Second lowest since 1871
f Third lowest since 1871
g Second lowest since 1990
h Fourth lowest since 1990

Table A-9: Annual sunshine hour totals for 2010-2012 compared to the 1981-2010 normal for selected New Zealand stations. Record or near-record totals are highlighted.

Station	Agent number	Mean annual sunshine hours 1981-2010 (hours)	2010		2011		2012	
			Total sunshine hours (hours)	Percentage of normal (%)	Total sunshine hours (hours)	Percentage of normal (%)	Total sunshine hours (hours)	Percentage of normal (%)
North Island								
Auckland, Mangere	22719	2038	2088	102.4	2009	98.6	2026	99.4
Dannevirke	2534	1892	1949	103.1	1898	100.3	1890	99.9
Dargaville	25119	2056	2053[a]	99.8	1935	94.1	1878	91.3
Kaitaia	17067	2171	2279[b]	105.0	2160	99.5	2118	97.6
Martinborough	21938	2093	1972	94.2	1917	91.6	1904	91.0
Napier, Nelson Park	2997	2265	2258	99.7	2238	98.8	2194	96.9
Palmerston North	21963	1750	1732	99.0	1632	93.3	1774	101.4
Paraparaumu Aero	3145	2057	2046	99.5	2052	99.8	2160	105.0
Te Kuiti	23899	1719	1988	115.6	1926[c]	112.0	2023[d]	117.7
Wellington, Kelburn	3385	2110	2013	95.4	1955	92.6	2008	95.1
South Island								
Appleby	21937	2546	2490	97.8	2475	97.2	2530	99.4
Arapito	3846	1789	1902	106.3	1898	106.1	1962	109.7
Blenheim, Research	12430	2459	2415	98.2	2358	95.9	2445	99.4
Christchurch Aero	4843	2141	2041	95.3	2029	94.8	2135	99.7
Dunedin, Musselburgh	15752	1681	1879	111.8	1804	107.3	1831	109.0
Franz Josef	24926	1724	1517	88.0	1598	92.7	1700	98.6
Greymouth Aero	3950	1725	1766	102.4	1713	99.3	1848	107.1
Hokitika Aero	3909	1894	1808	95.5	1826	96.4	1970	104.0
Invercargill Aero	5814	1681	1821	108.3	1753	104.3	1874	111.5
Lake Tekapo	24945	2411	2346	97.3	2463[e]	102.2	2562[f]	106.3
Middlemarch	18437	1844	1826	99.0	1772	96.1	1712	92.8

Station	Agent number	Mean annual sunshine hours 1981-2010 (hours)	2010		2011		2012	
			Total sunshine hours (hours)	Percentage of normal (%)	Total sunshine hours (hours)	Percentage of normal (%)	Total sunshine hours (hours)	Percentage of normal (%)
Mt Cook	18125	1574	1592	101.1	1622	103.0	1647	104.6
Nelson Aero	4241	2472	2475	100.1	2487	100.6	2584	104.5
Palmerston	5323	1740	1777	102.1	1797	103.3	1684	96.8
Rangiora	17244	2093	1924	91.9	2158	103.1	2389	114.1
Takaka	23849	2414	2355	97.6	2312	95.8	2309	95.6

a Fourth highest since 1943
b Second highest since 1986
c Third highest since 1962 (registered as Second highest in the 2011 Annual Summary)
d Highest since 1962
e 5th highest since 1928 (registered as Fourth highest in the 2011 Annual Summary)
f Third highest since 1928

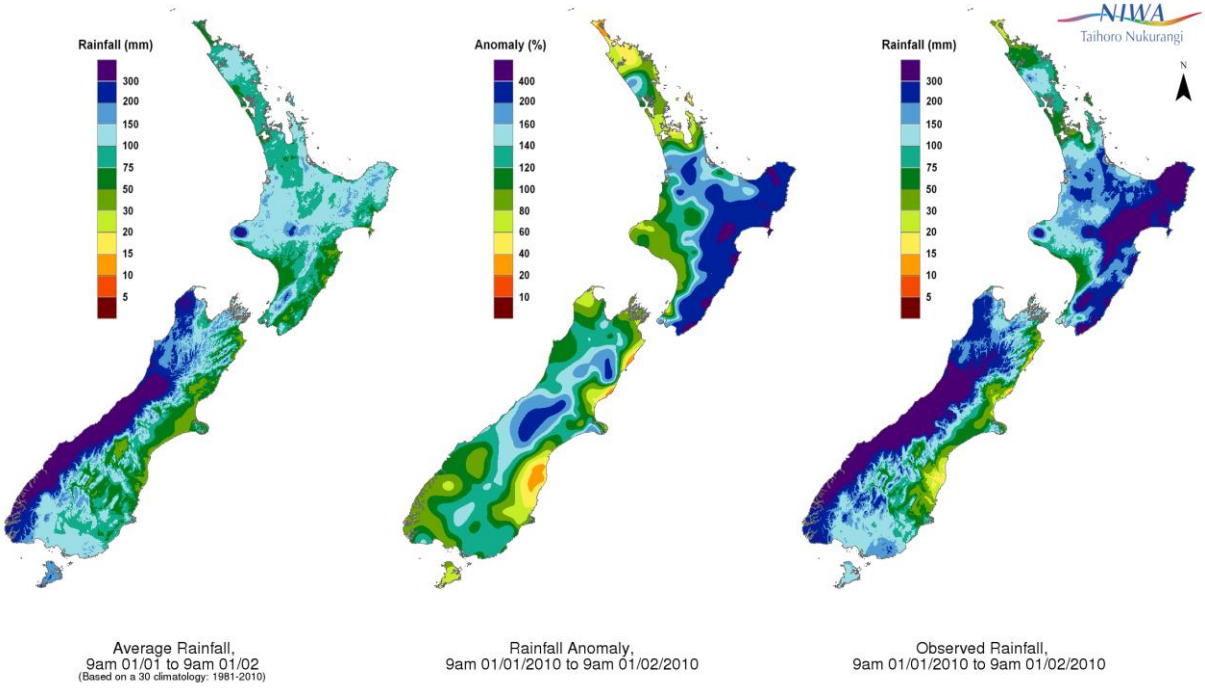
Appendix B Monthly weather summary maps, 2010-12

Monthly temperature, rainfall and soil moisture deficit anomalies for the years 2010-2012 are summarised in the following maps.

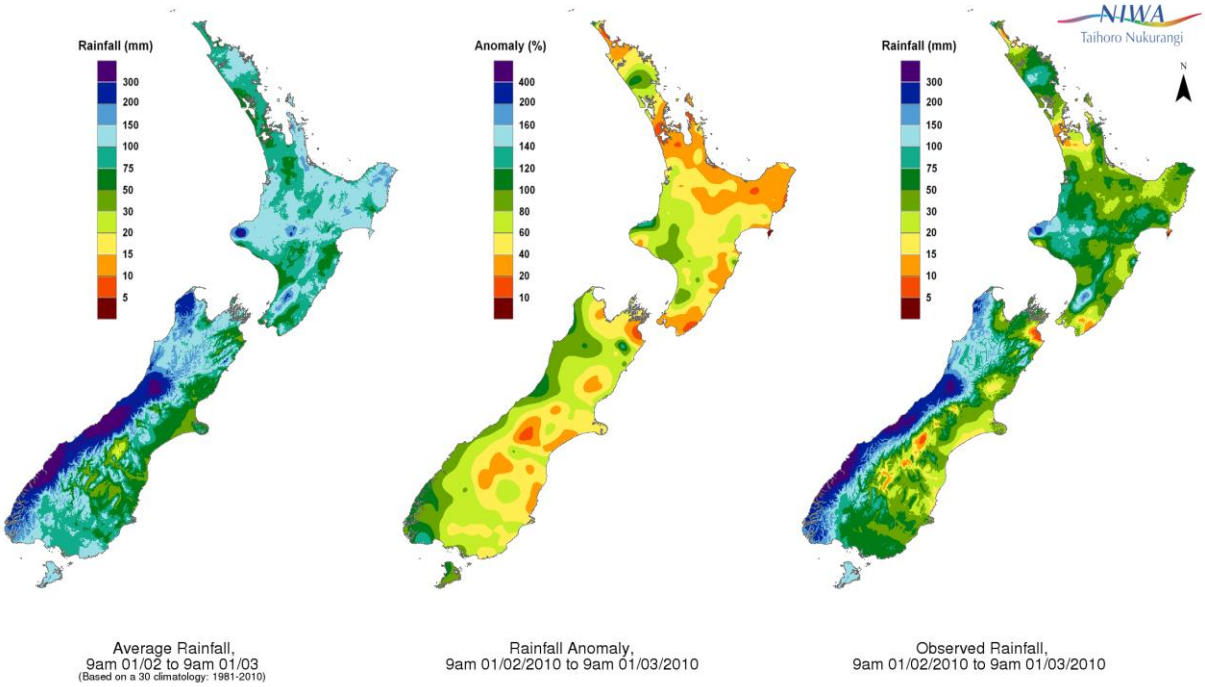
For rainfall and temperature, the maps give the 1981-2010 30-year normal monthly value (left), the observed monthly value (right) and the departure from normal of the observed value (centre).

The soil moisture deficit from the estimated long-term average (1998-2013) availability of water to plants in the pasture root zone, at 9am on the first day of each calendar month (e.g., the January deficit is reported on 1 February).

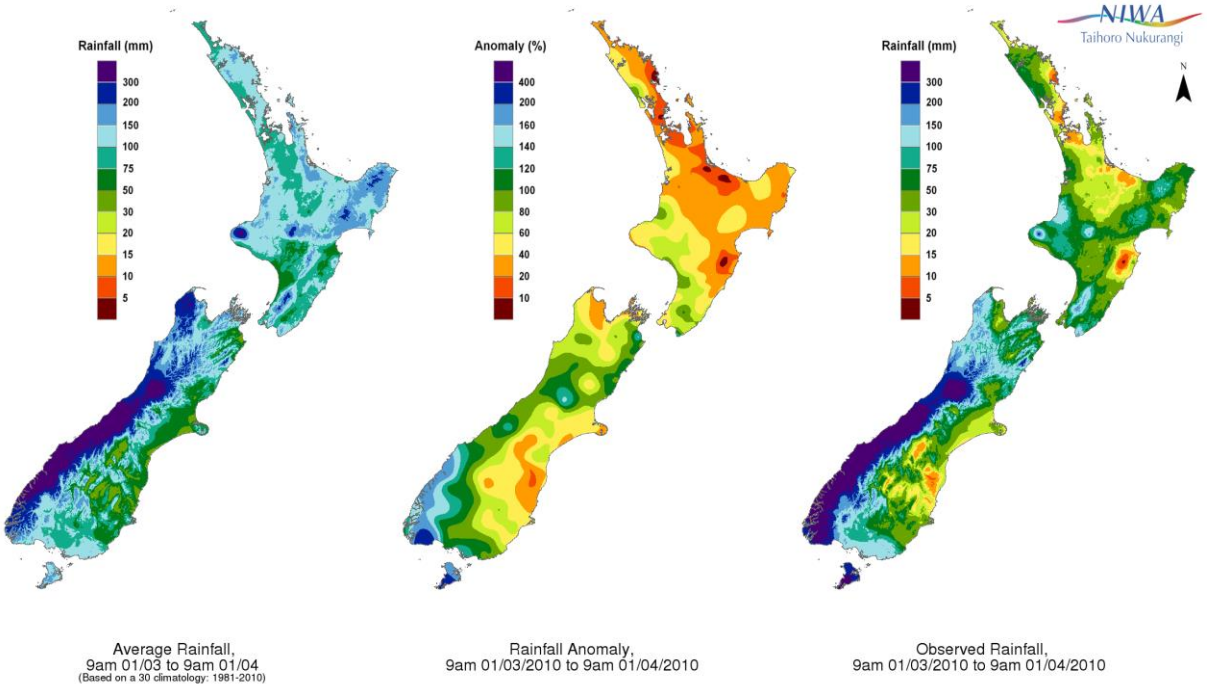
Rainfall
2010



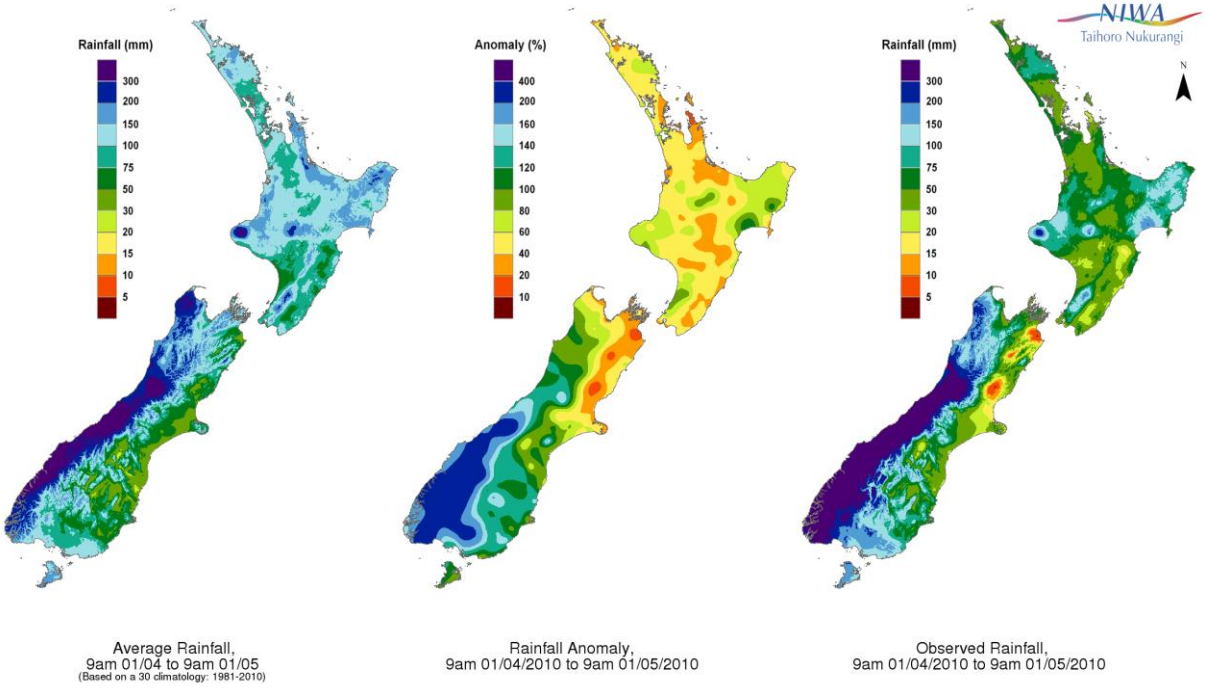
January 2010



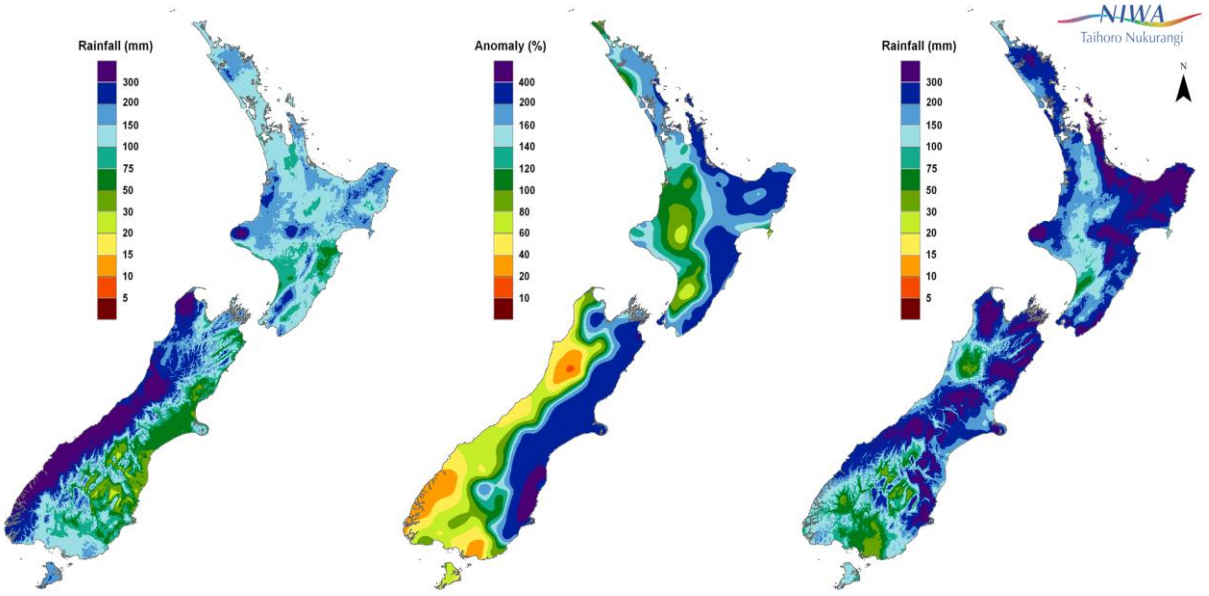
February 2010



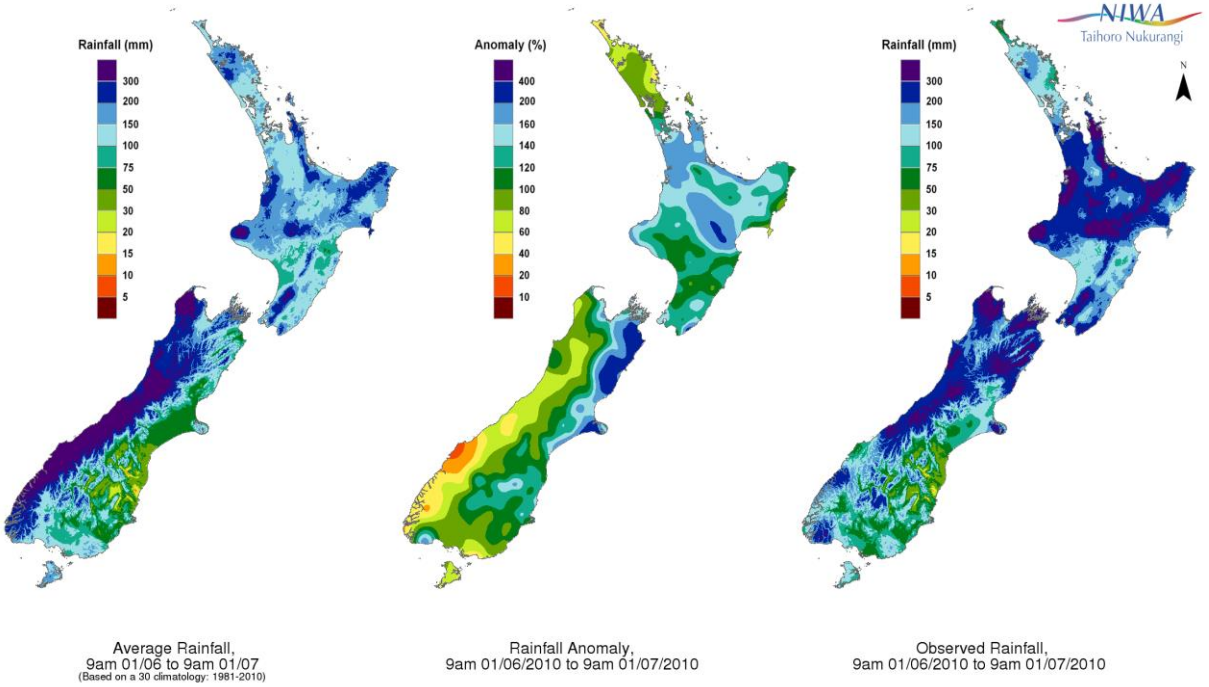
March 2010



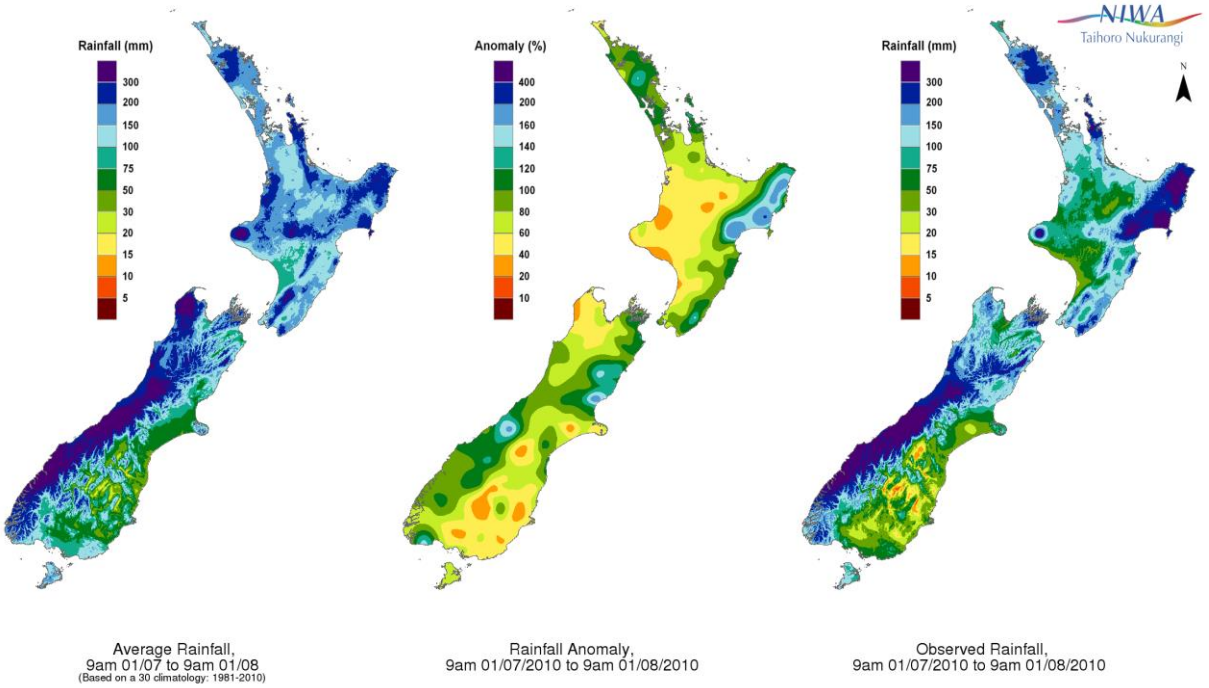
April 2010



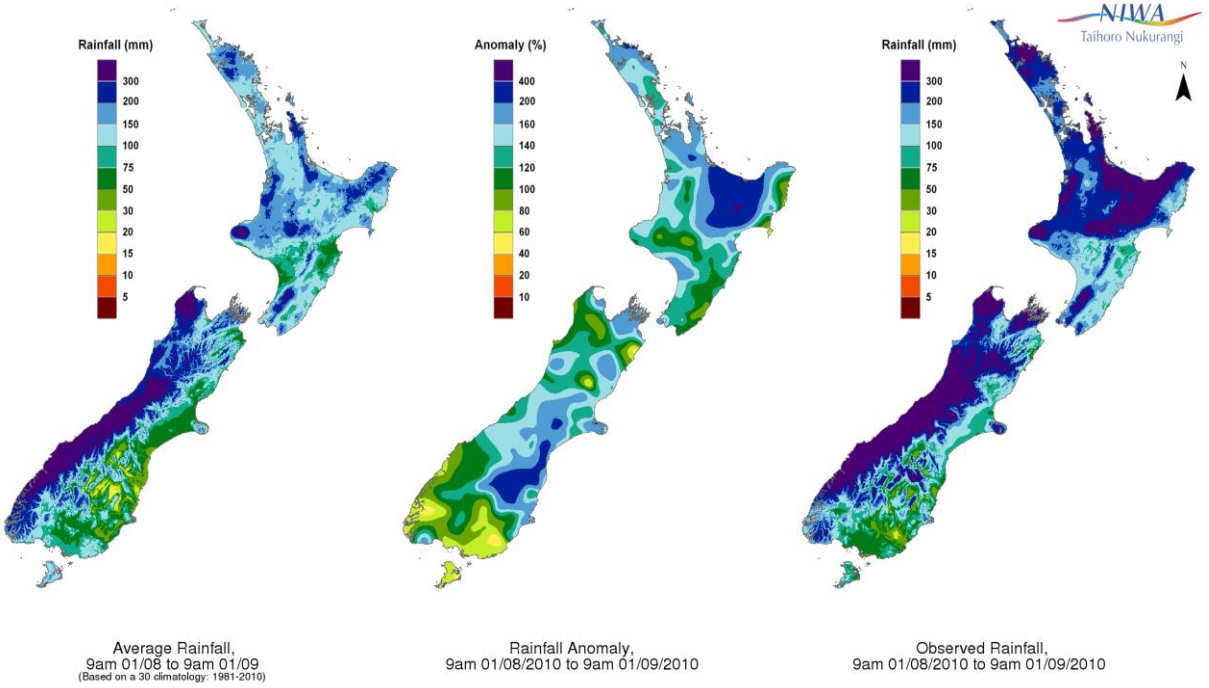
May 2010



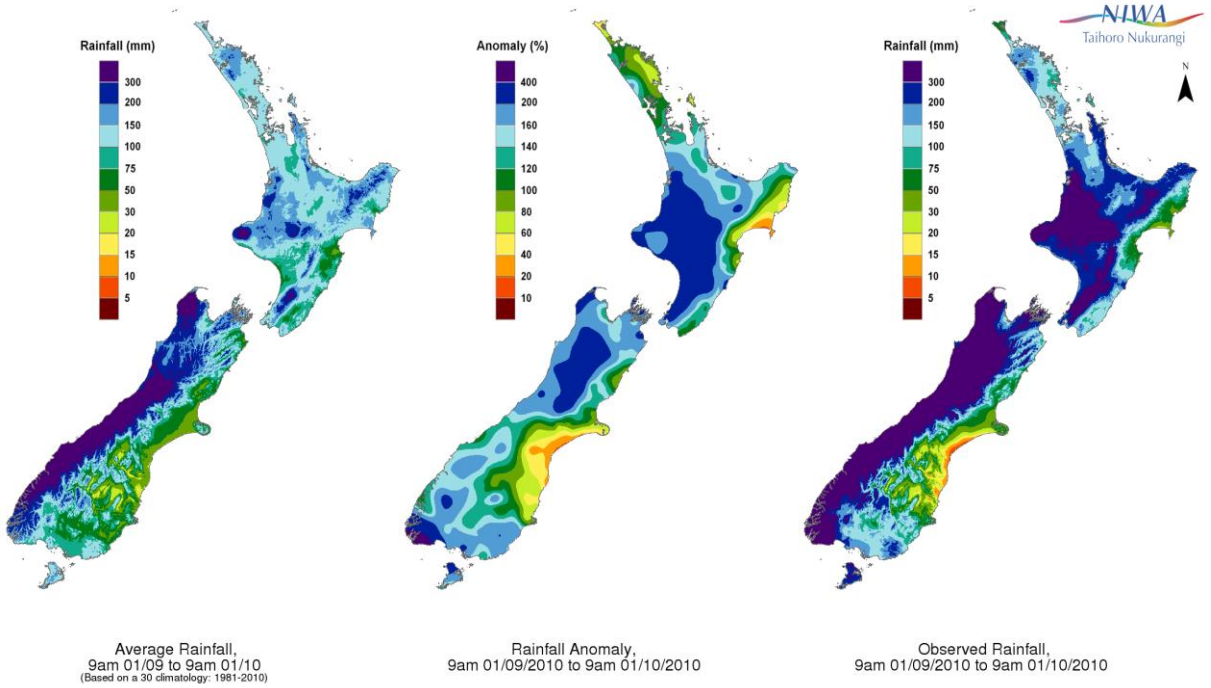
June 2010



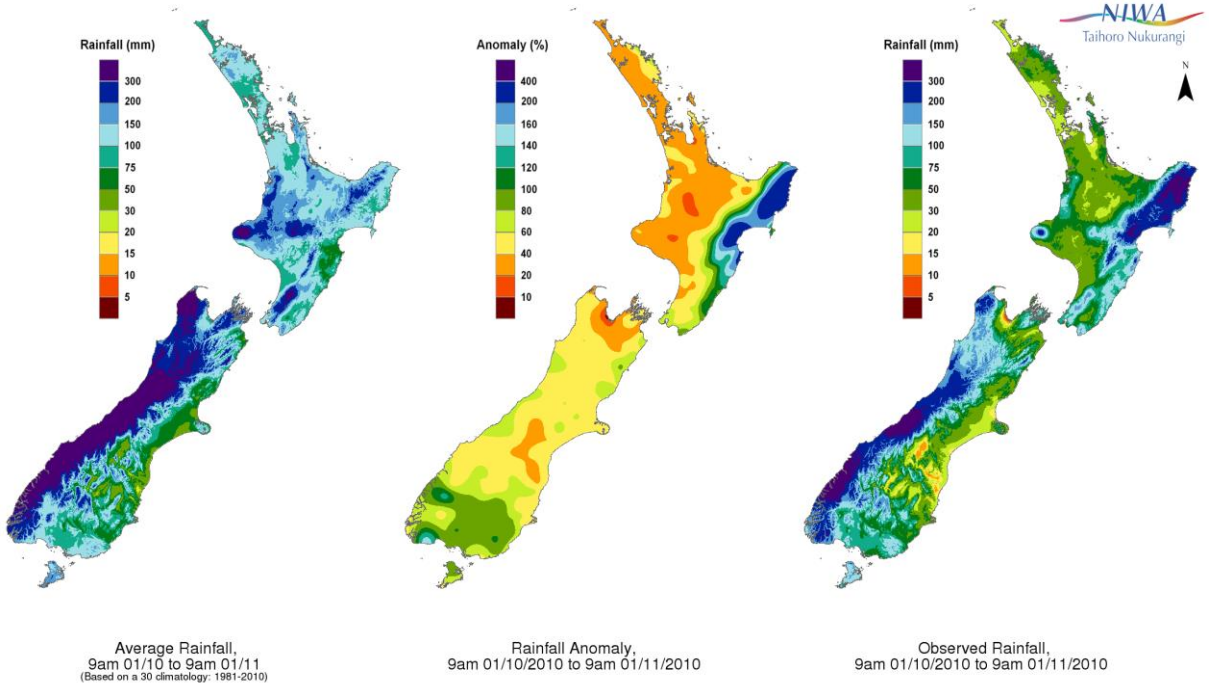
July 2010



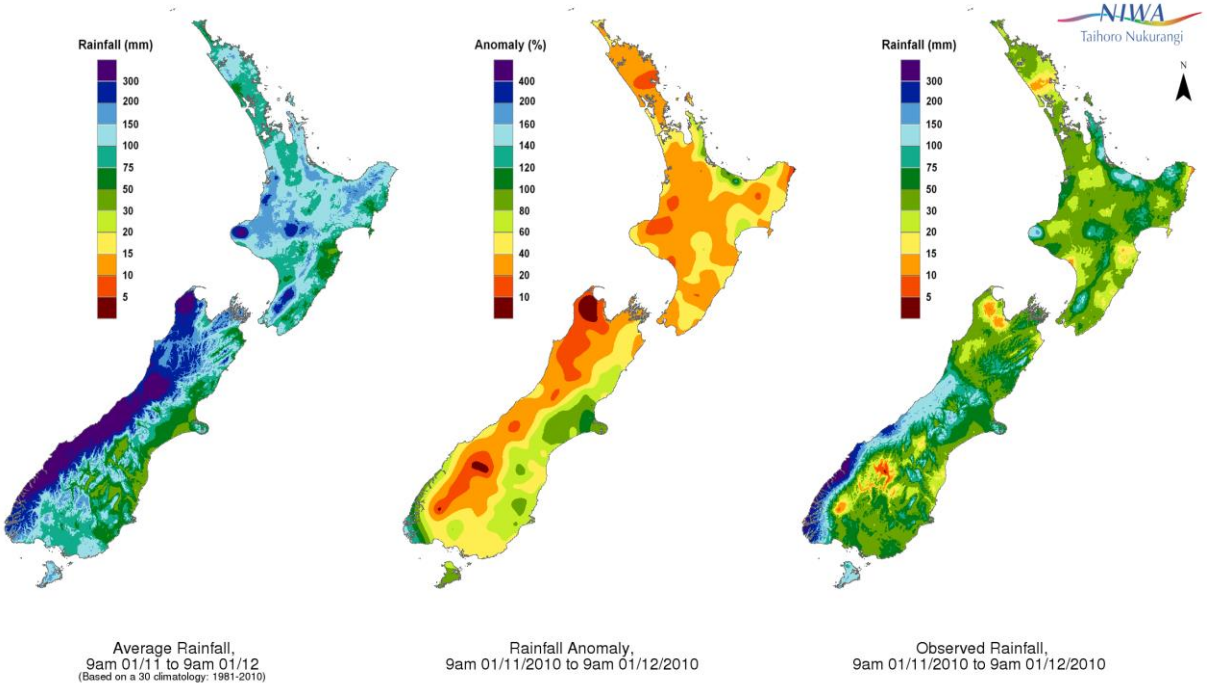
August 2010



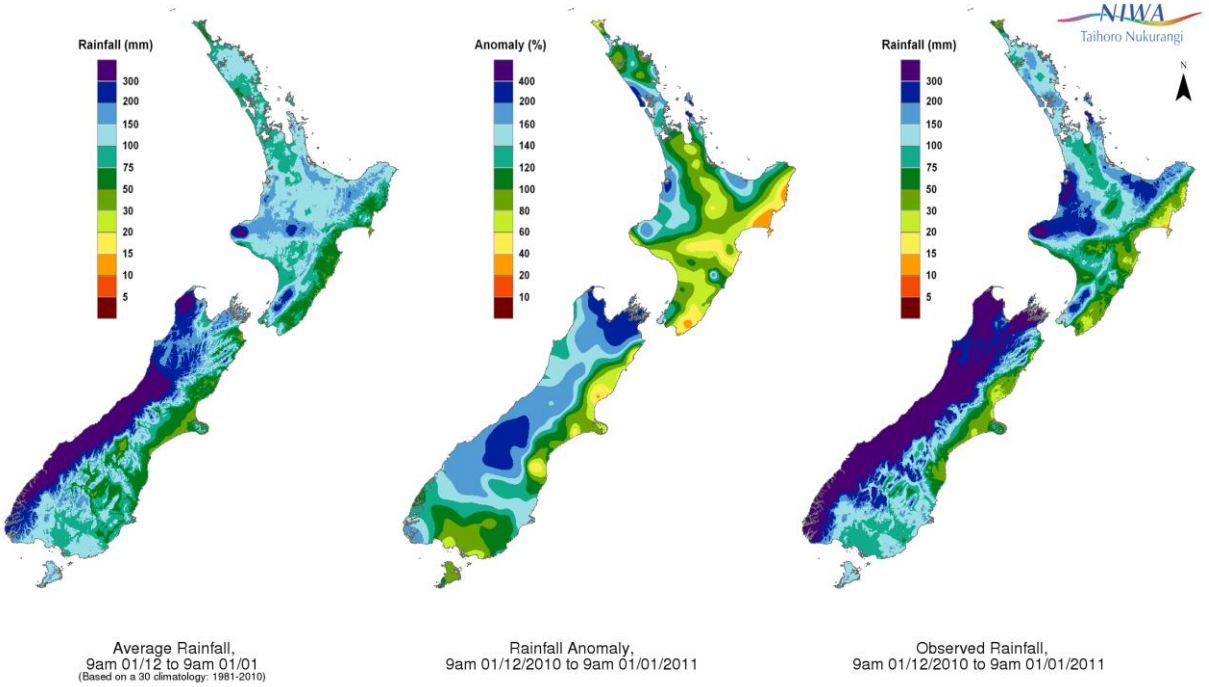
September 2010



October 2010

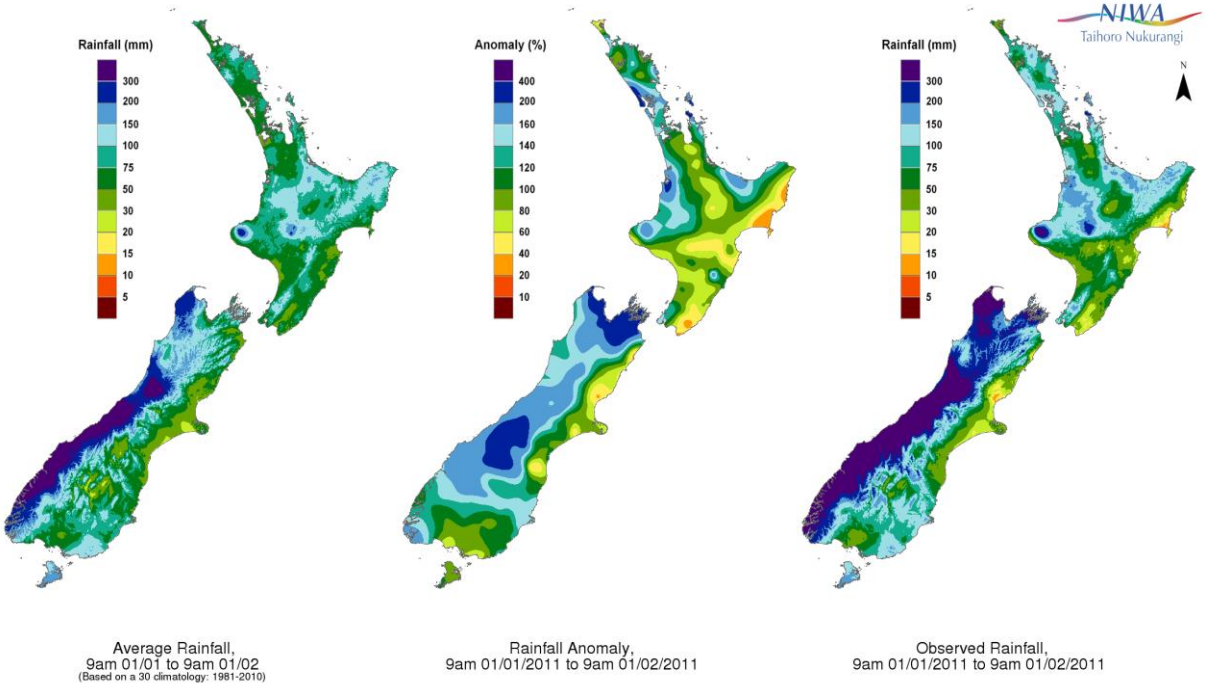


November 2010



December 2010

2011

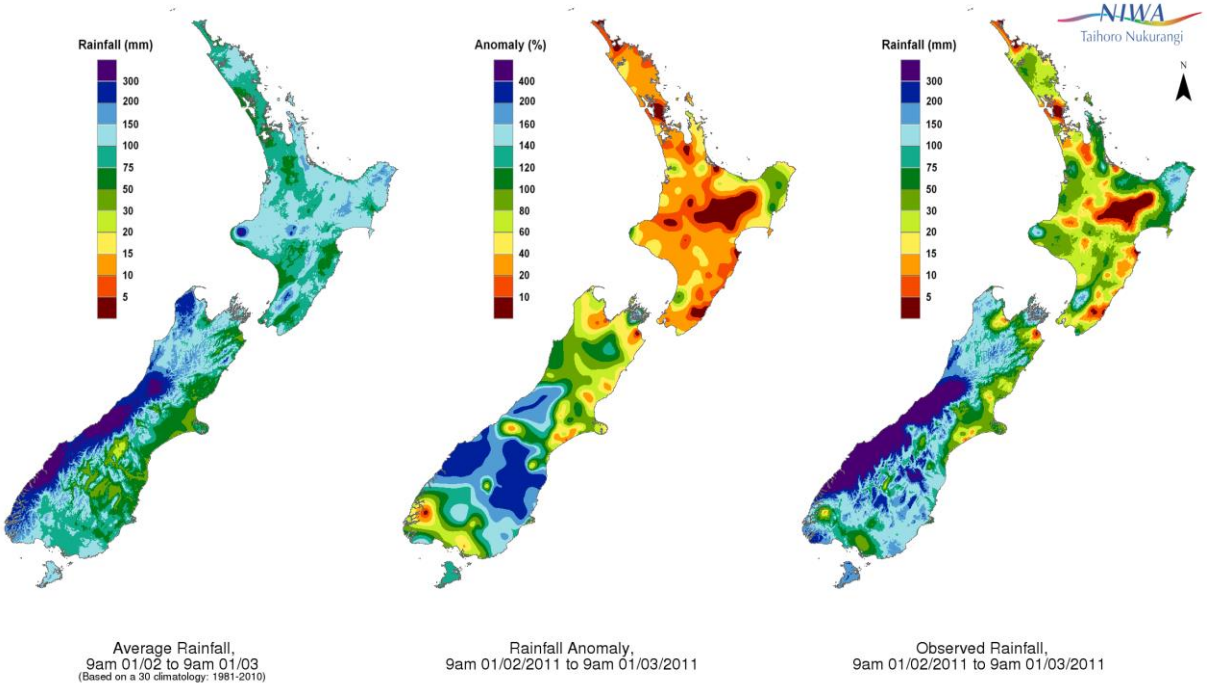


Average Rainfall,
9am 01/01 to 9am 01/02
(Based on a 30 climatology: 1981-2010)

Rainfall Anomaly,
9am 01/01/2011 to 9am 01/02/2011

Observed Rainfall,
9am 01/01/2011 to 9am 01/02/2011

January 2011

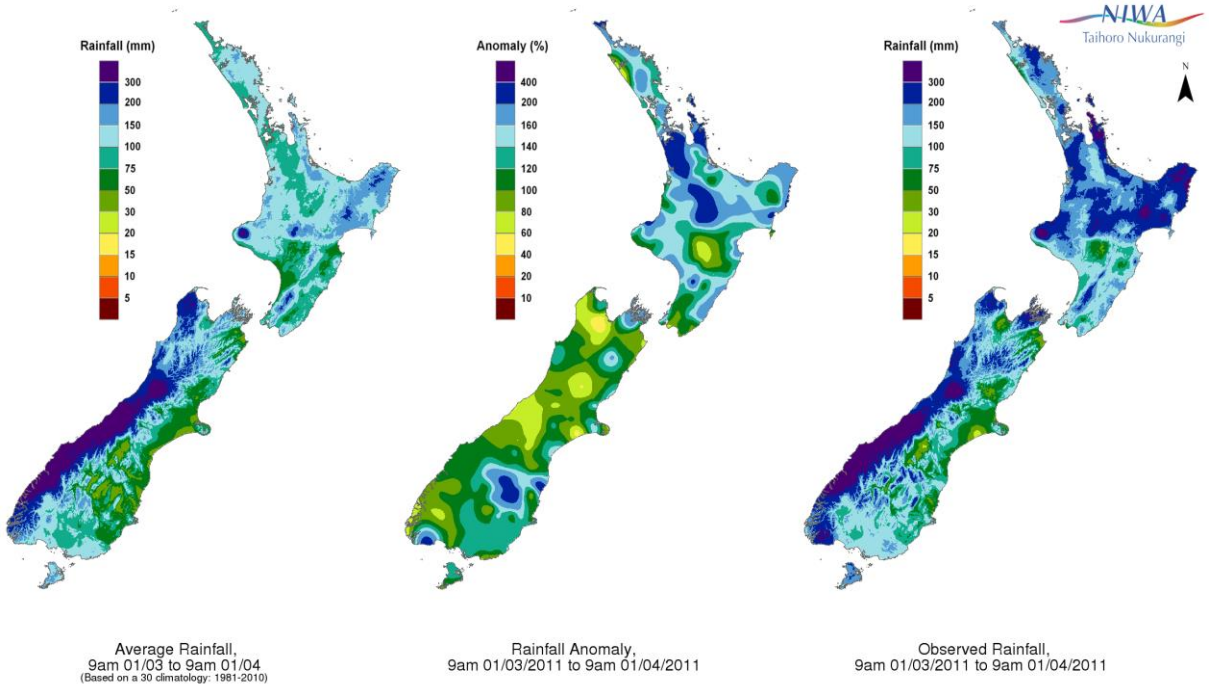


Average Rainfall,
9am 01/02 to 9am 01/03
(Based on a 30 climatology: 1981-2010)

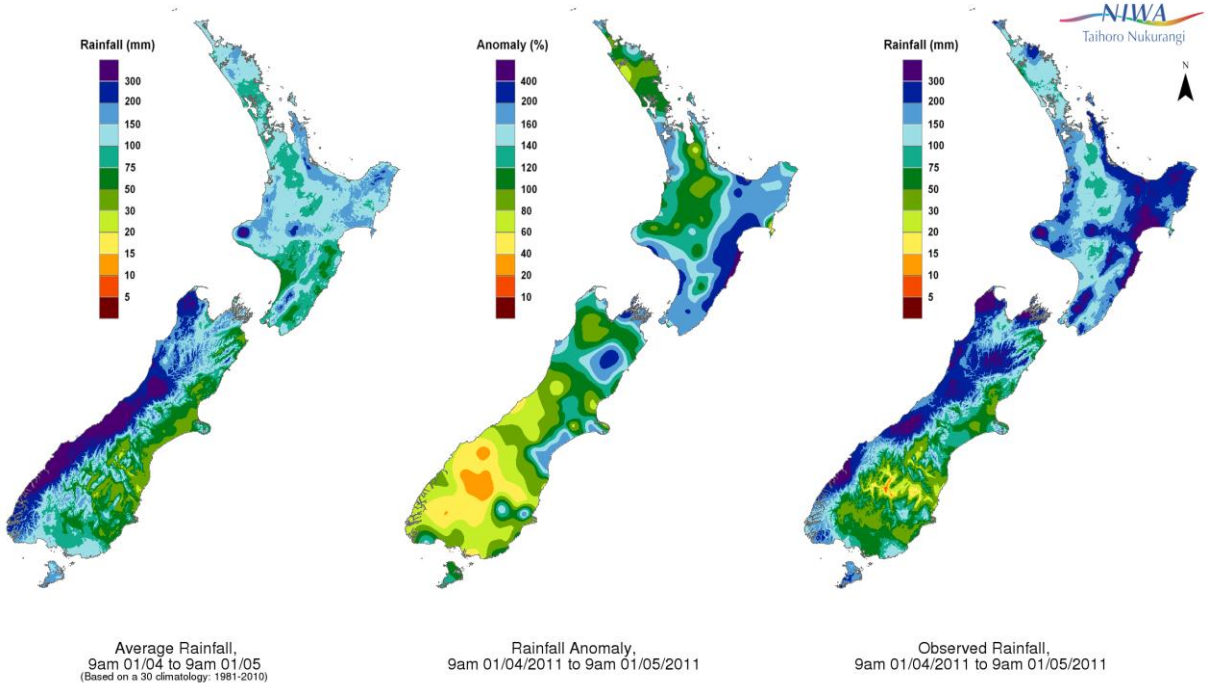
Rainfall Anomaly,
9am 01/02/2011 to 9am 01/03/2011

Observed Rainfall,
9am 01/02/2011 to 9am 01/03/2011

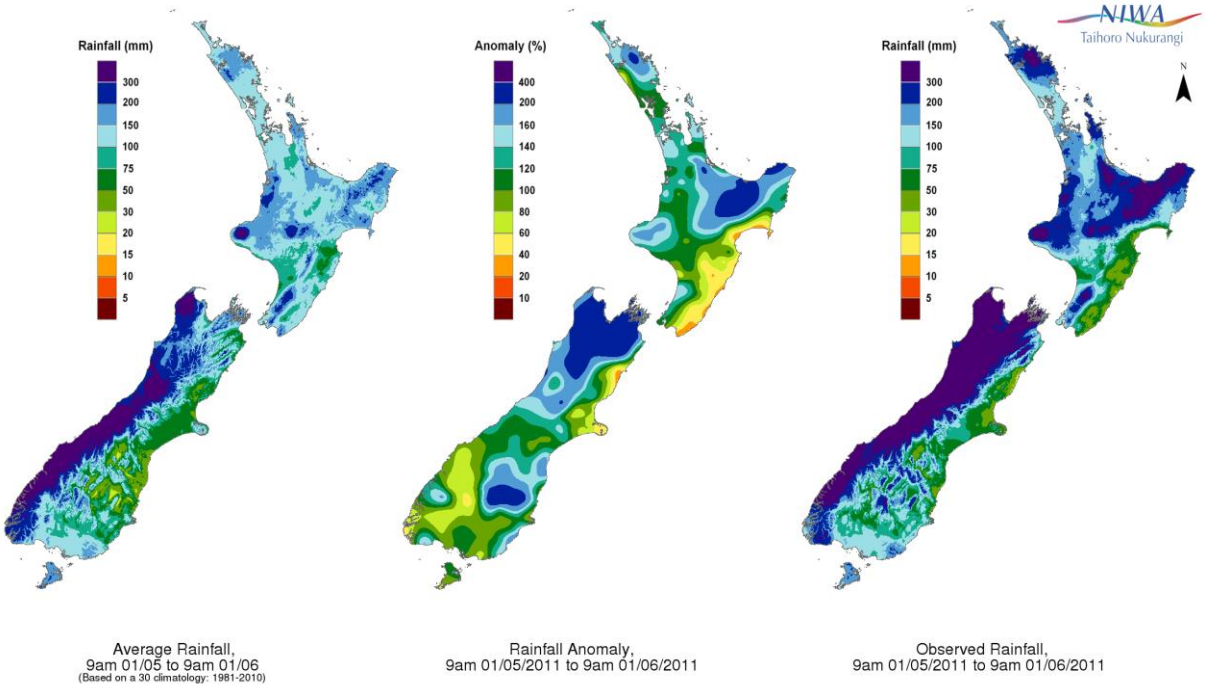
February 2011



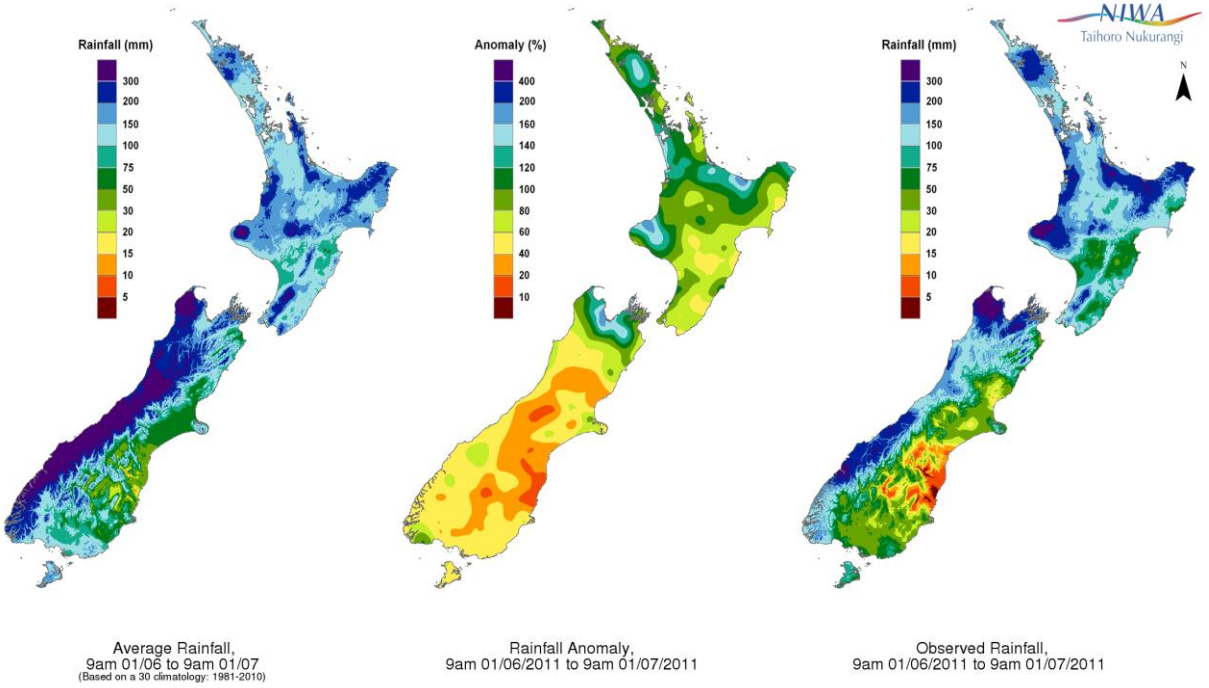
March 2011



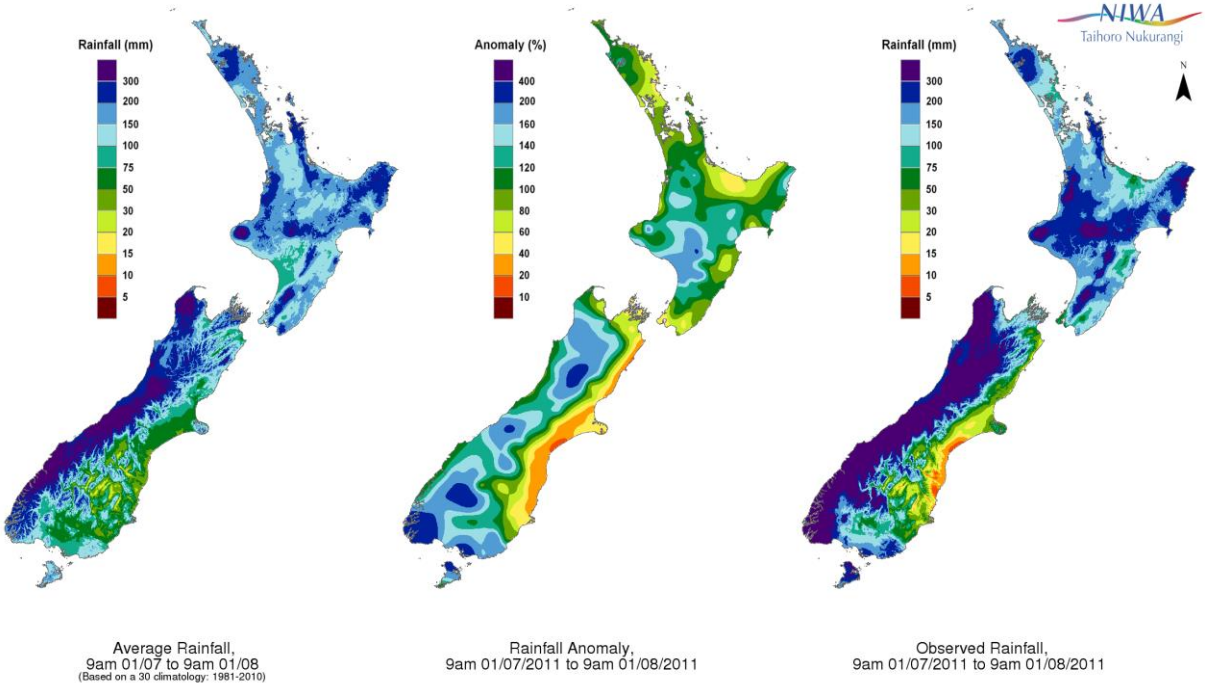
April 2011



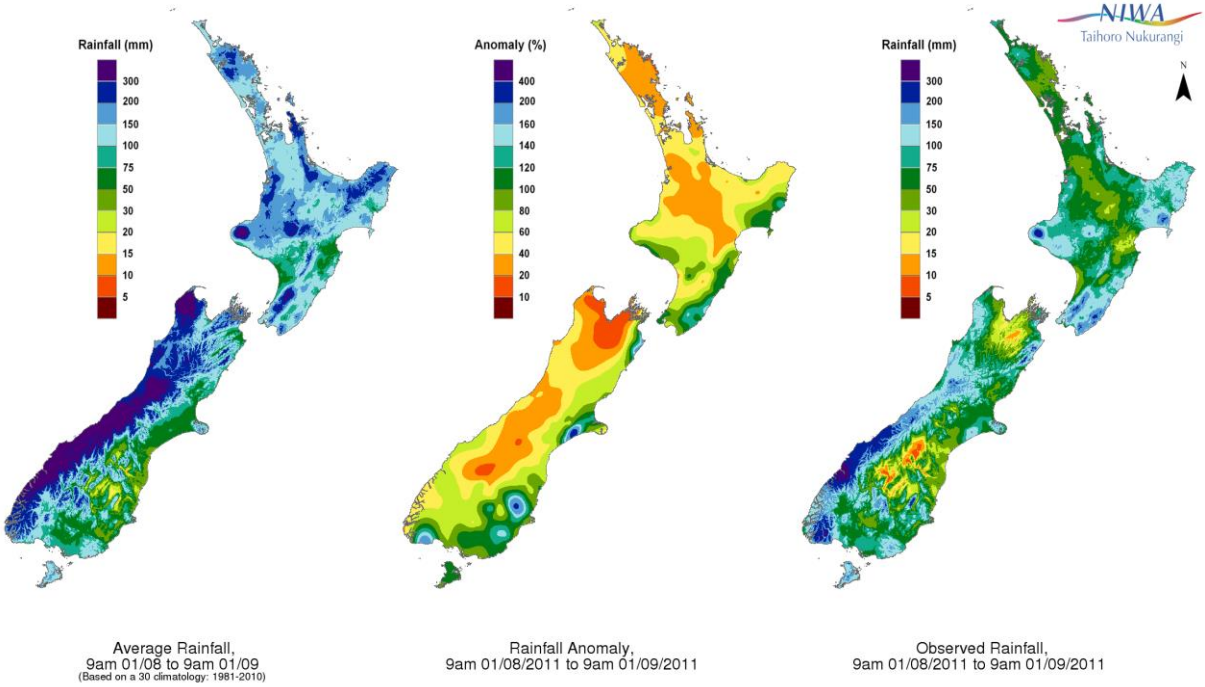
May 2011



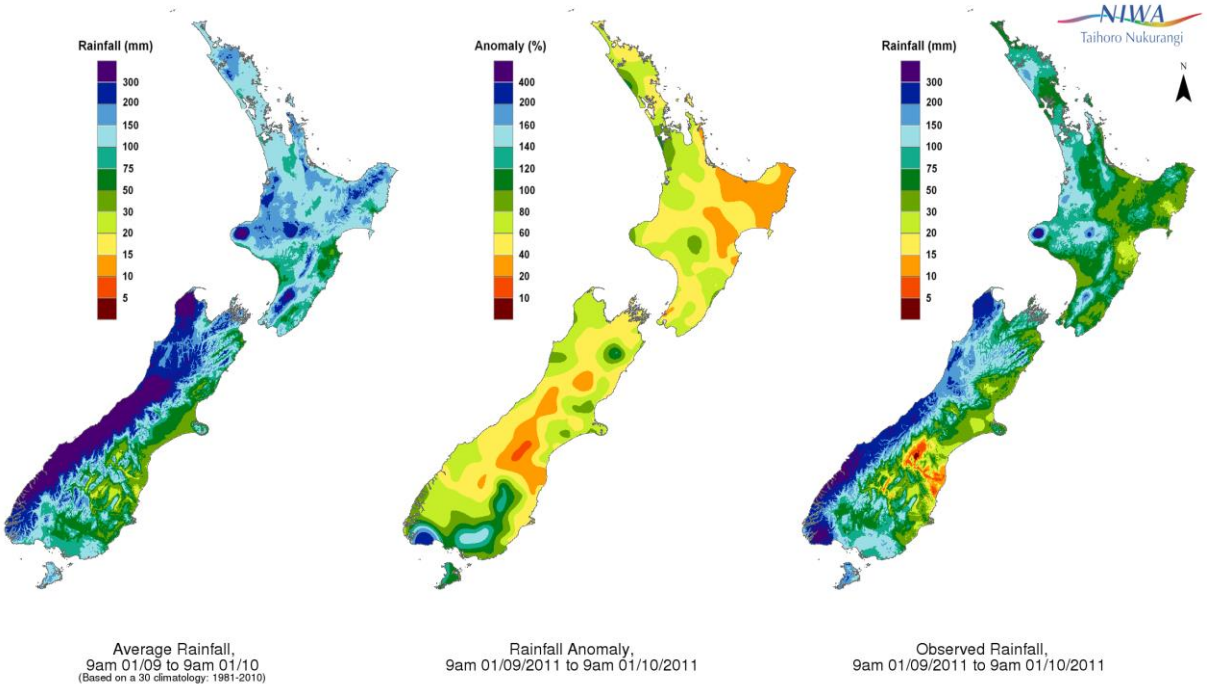
June 2011



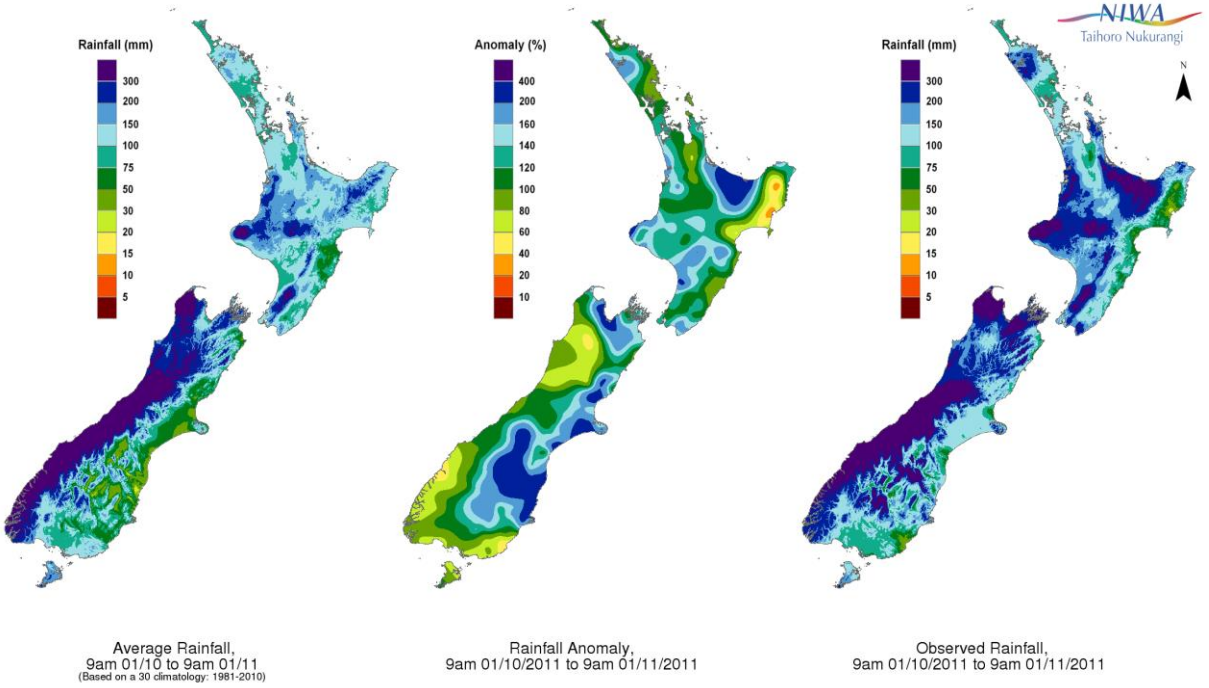
July 2011



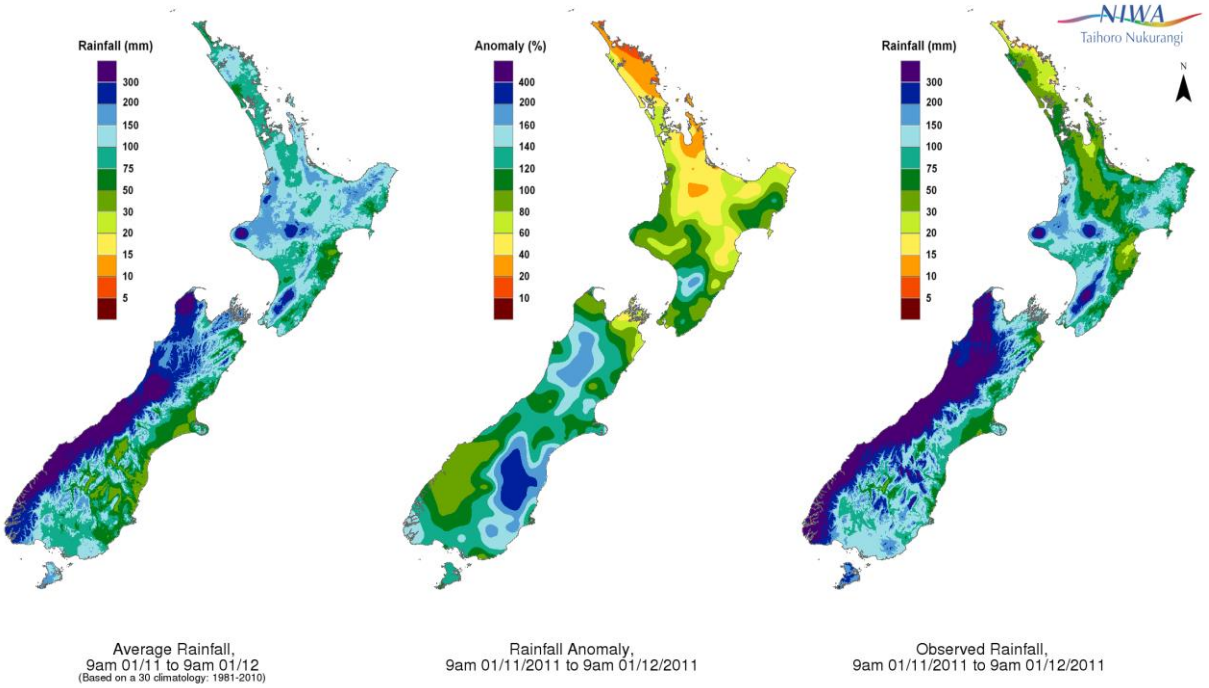
August 2011



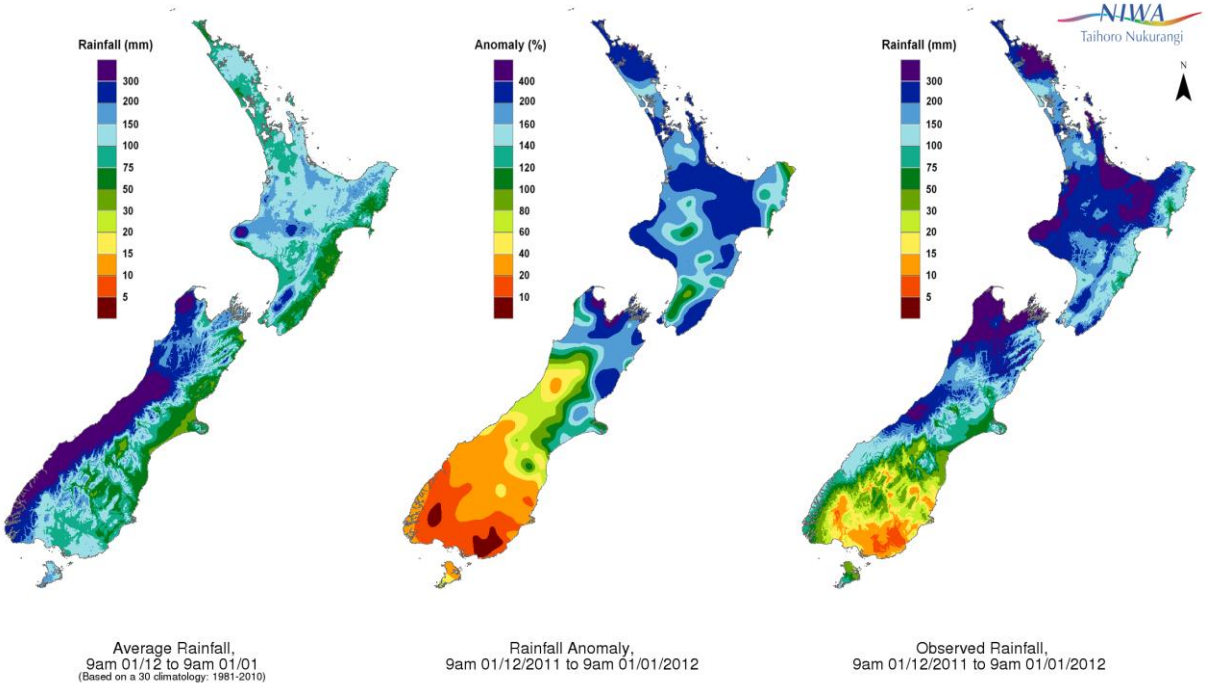
September 2011



October 2011

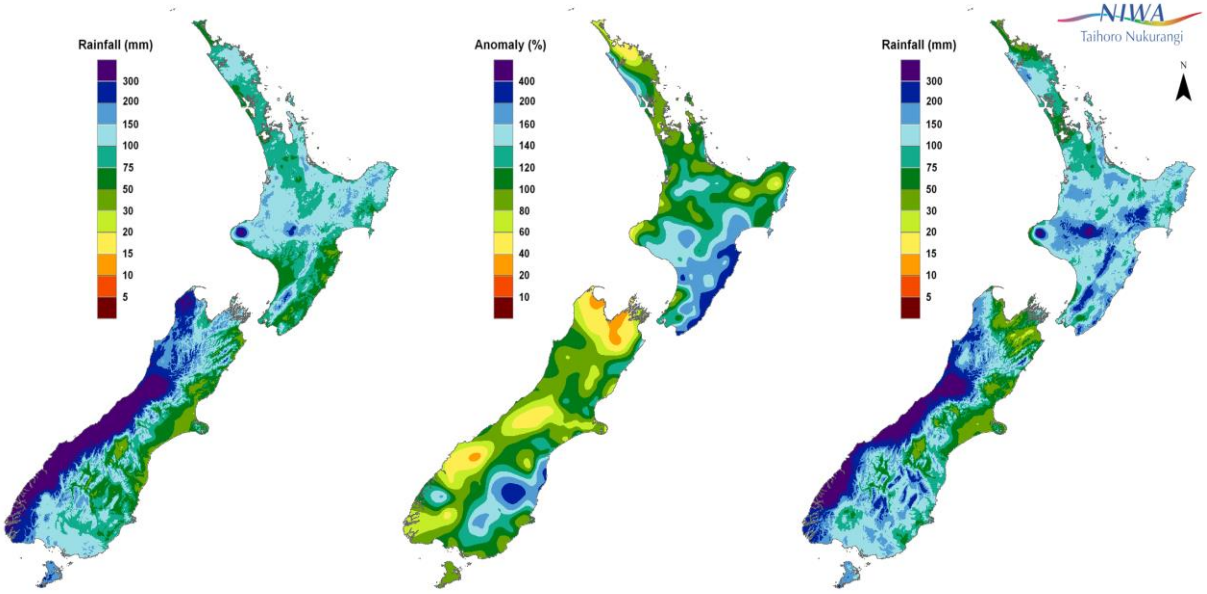


November 2011



December 2011

2012

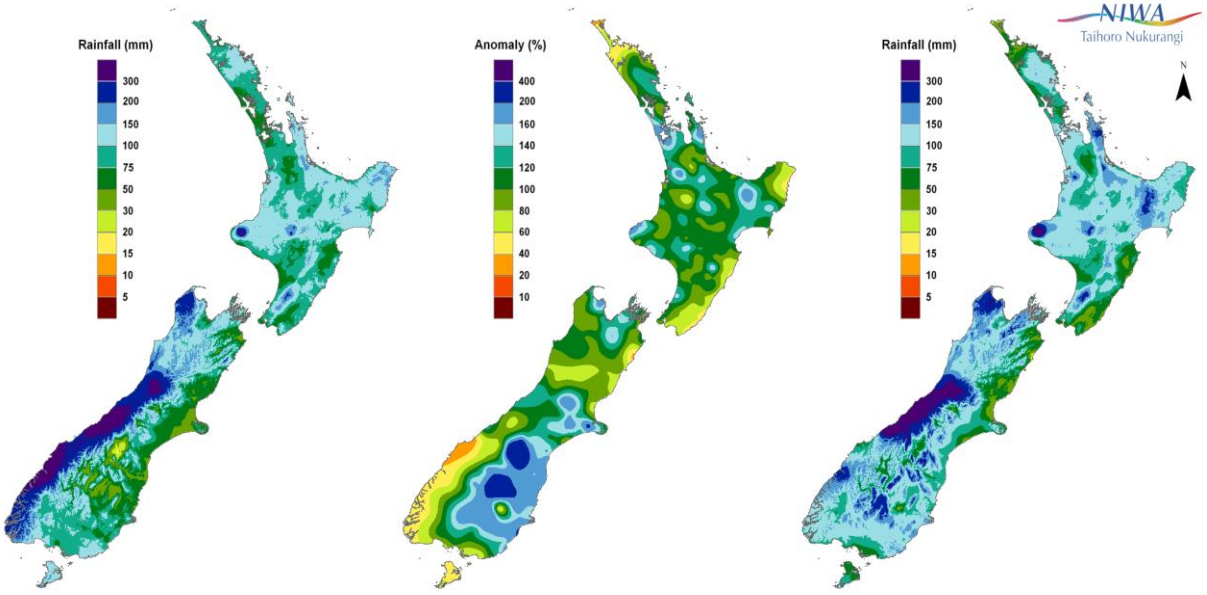


Average Rainfall, 9am 01/01 to 9am 01/02 (Based on a 30 climatology: 1981-2010)

Rainfall Anomaly, 9am 01/01/2012 to 9am 01/02/2012

Observed Rainfall, 9am 01/01/2012 to 9am 01/02/2012

January 2012

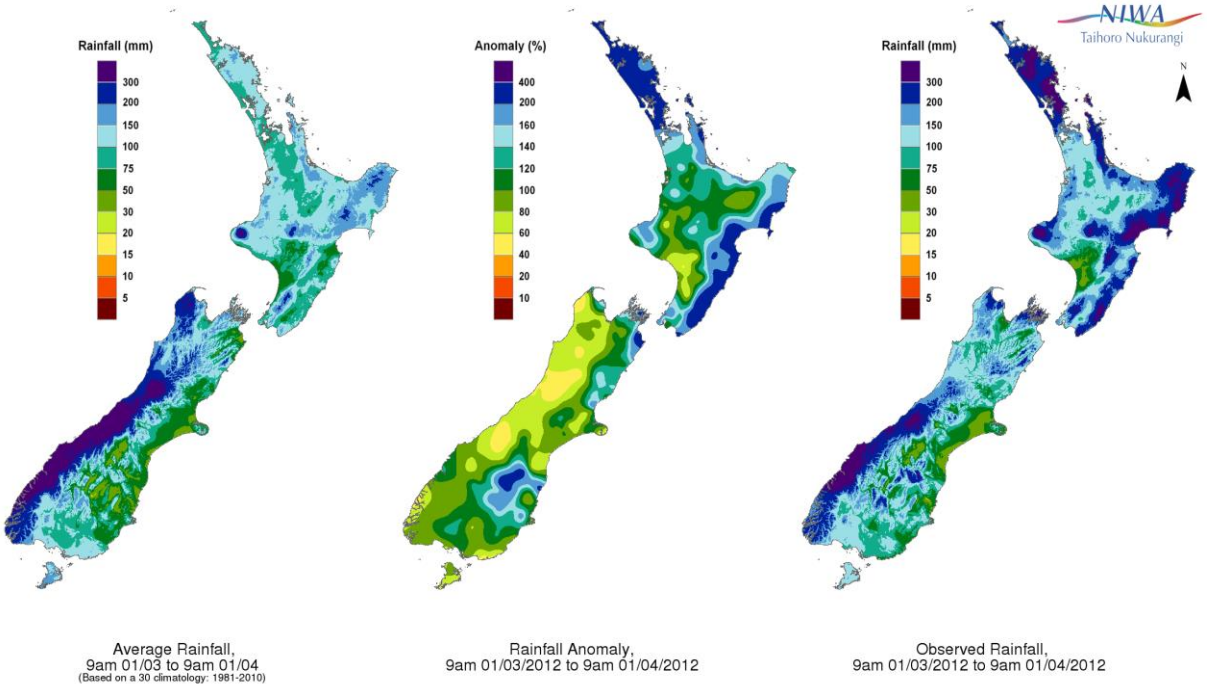


Average Rainfall, 9am 01/02 to 9am 01/03 (Based on a 30 climatology: 1981-2010)

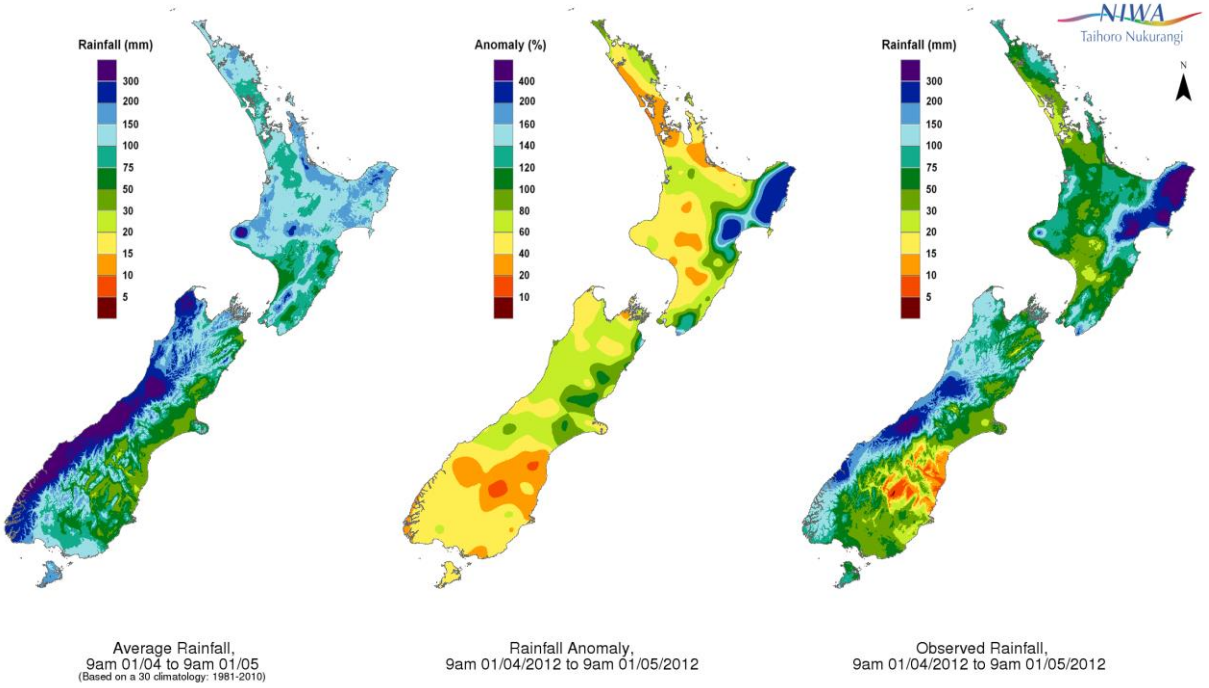
Rainfall Anomaly, 9am 01/02/2012 to 9am 01/03/2012

Observed Rainfall, 9am 01/02/2012 to 9am 01/03/2012

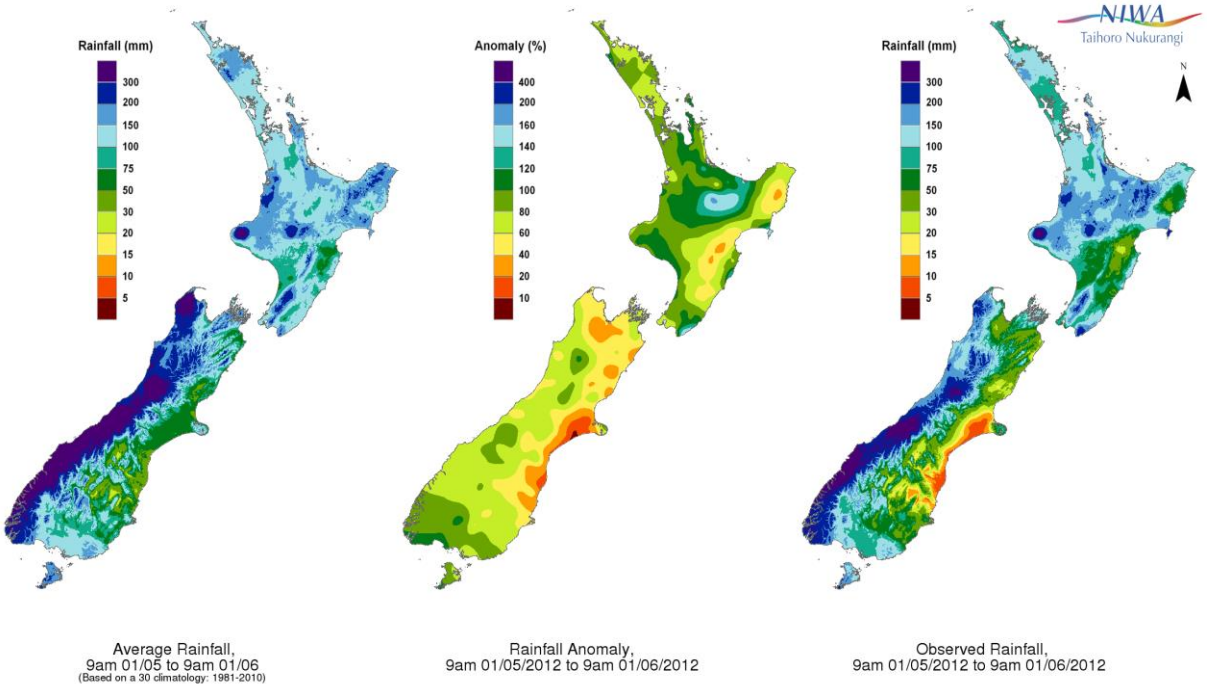
February 2012



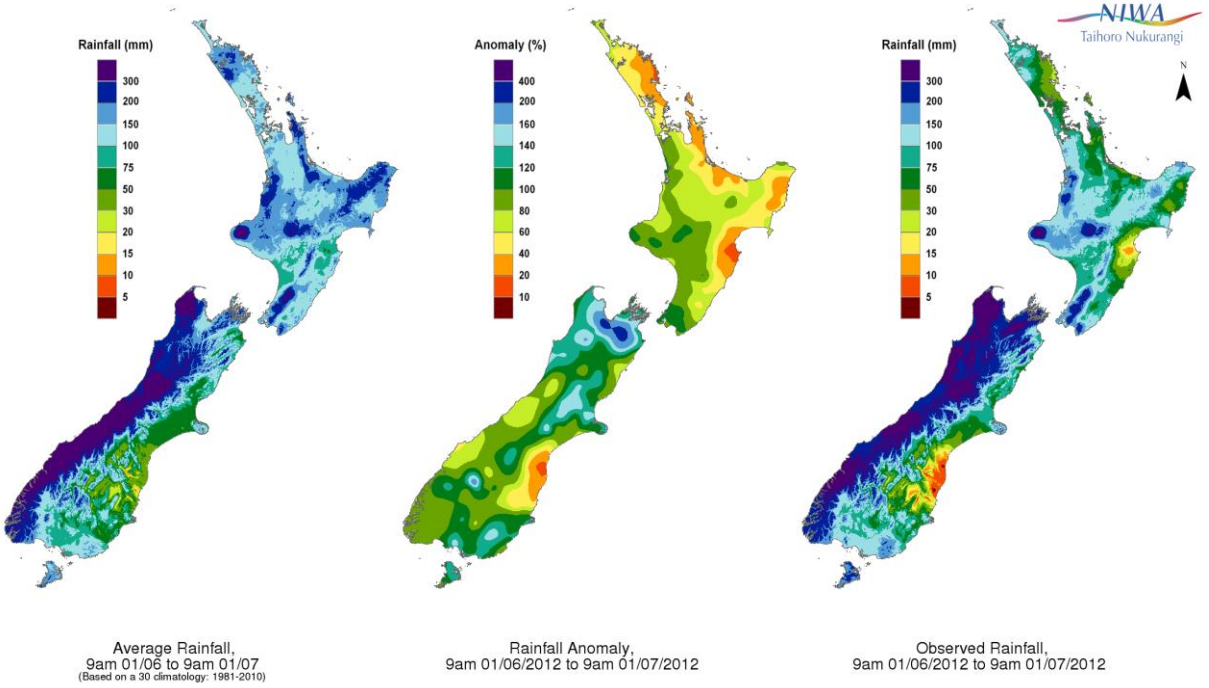
March 2012



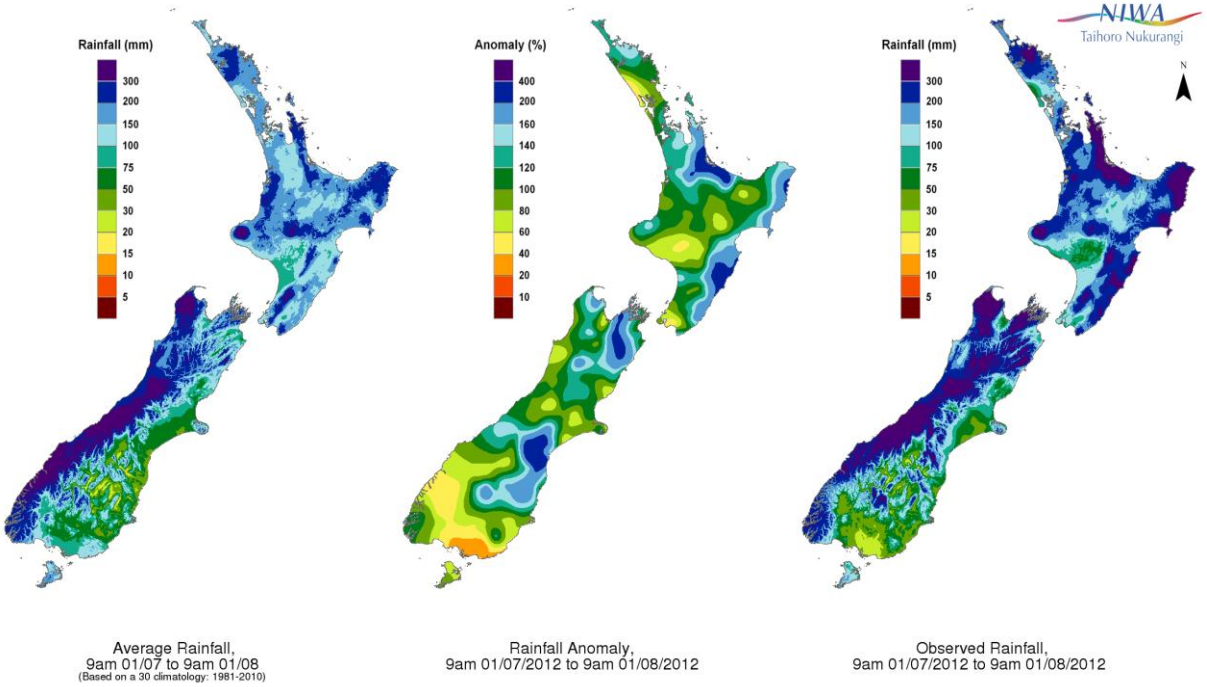
April 2012



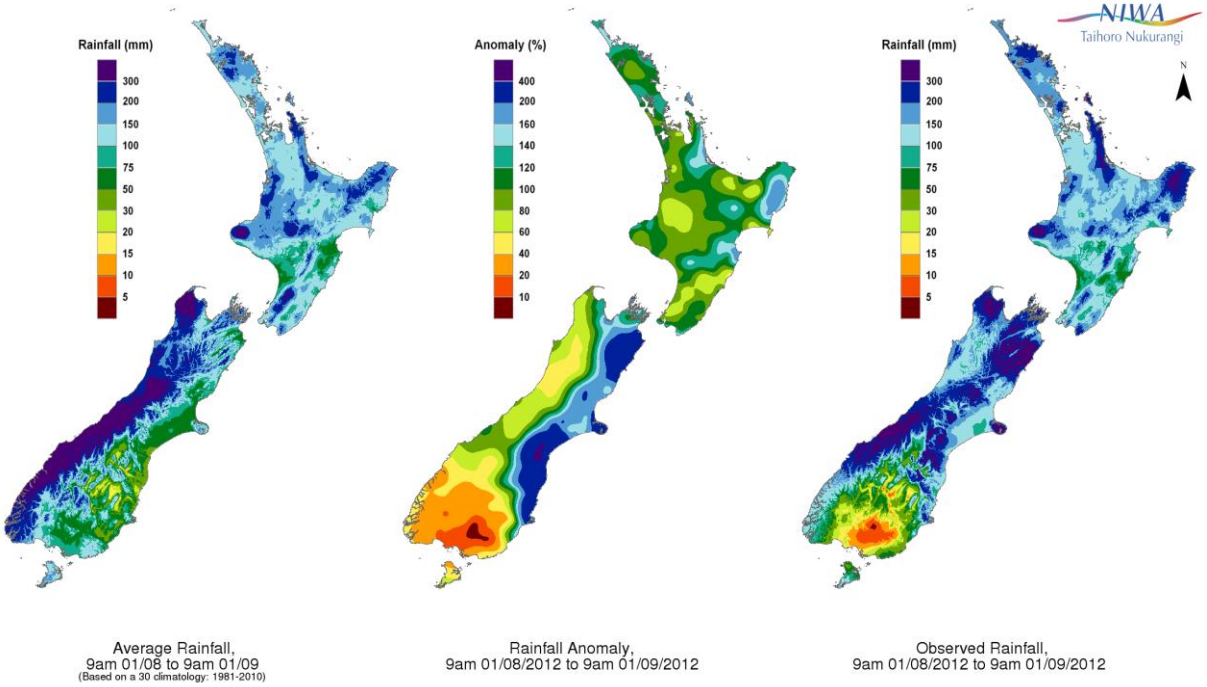
May 2012



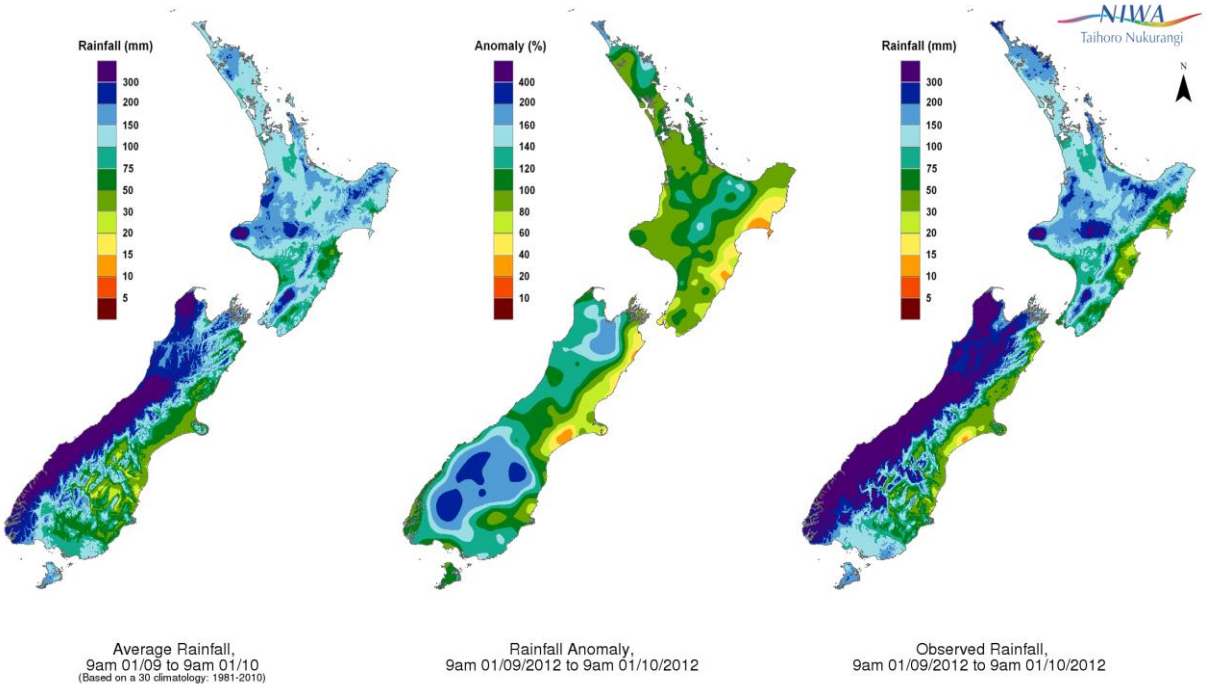
June 2012



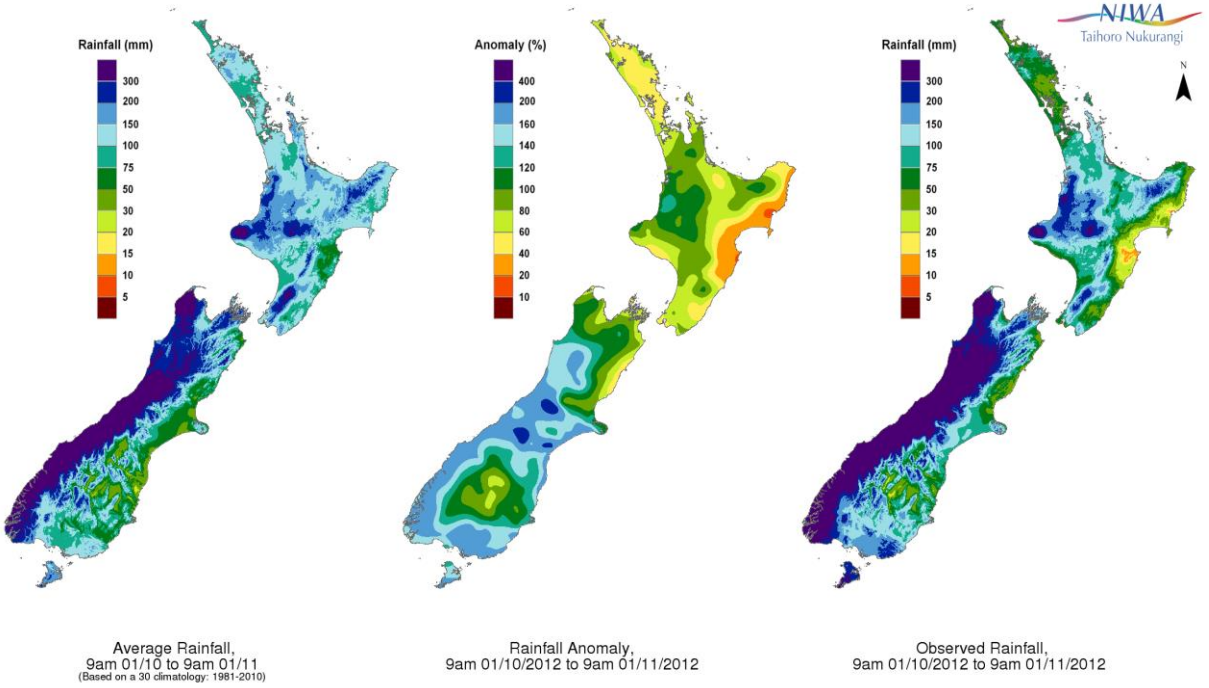
July 2012



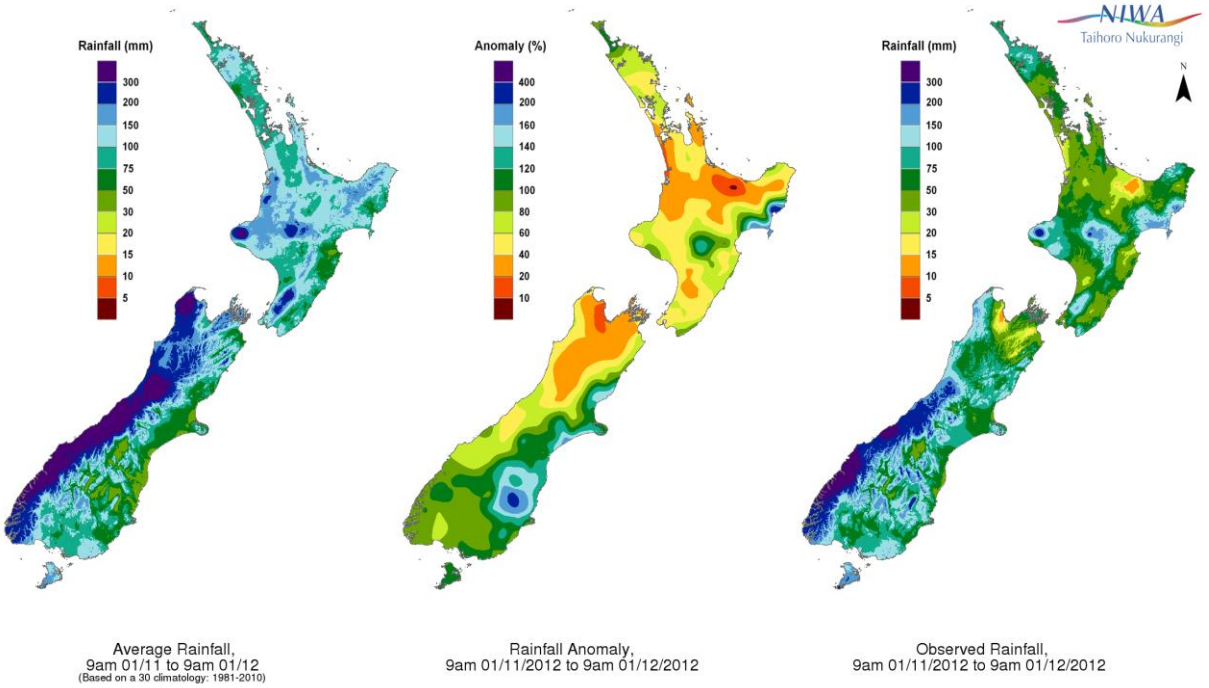
August 2012



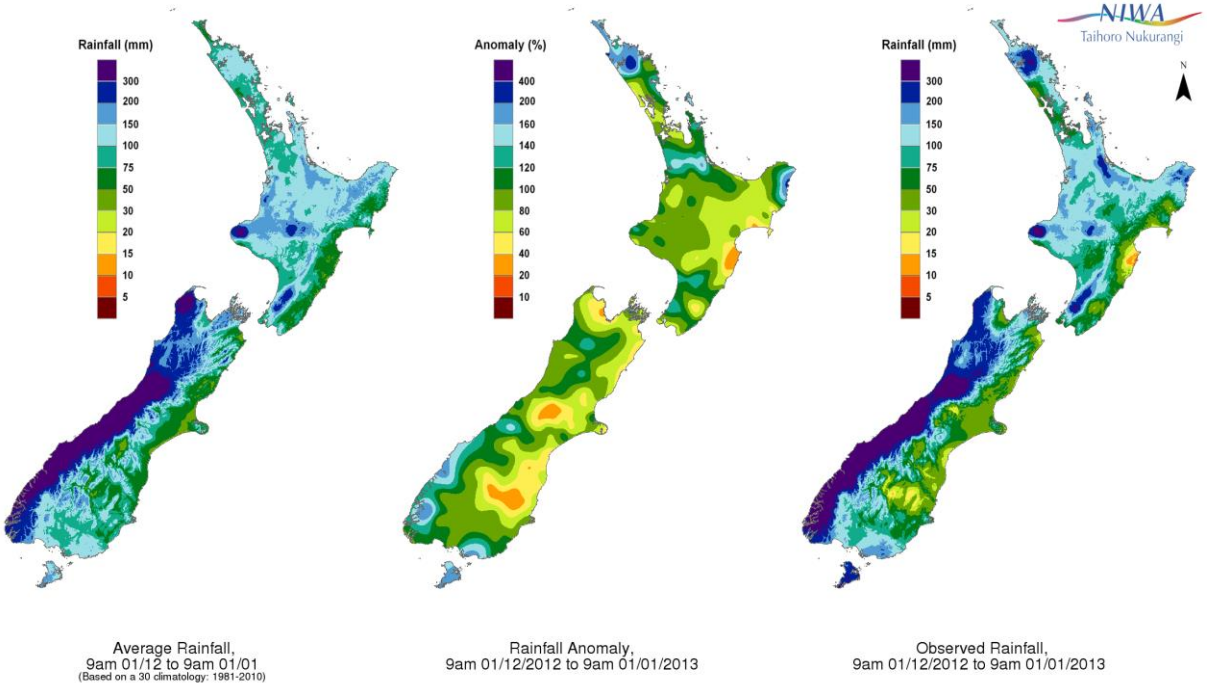
September 2012



October 2012

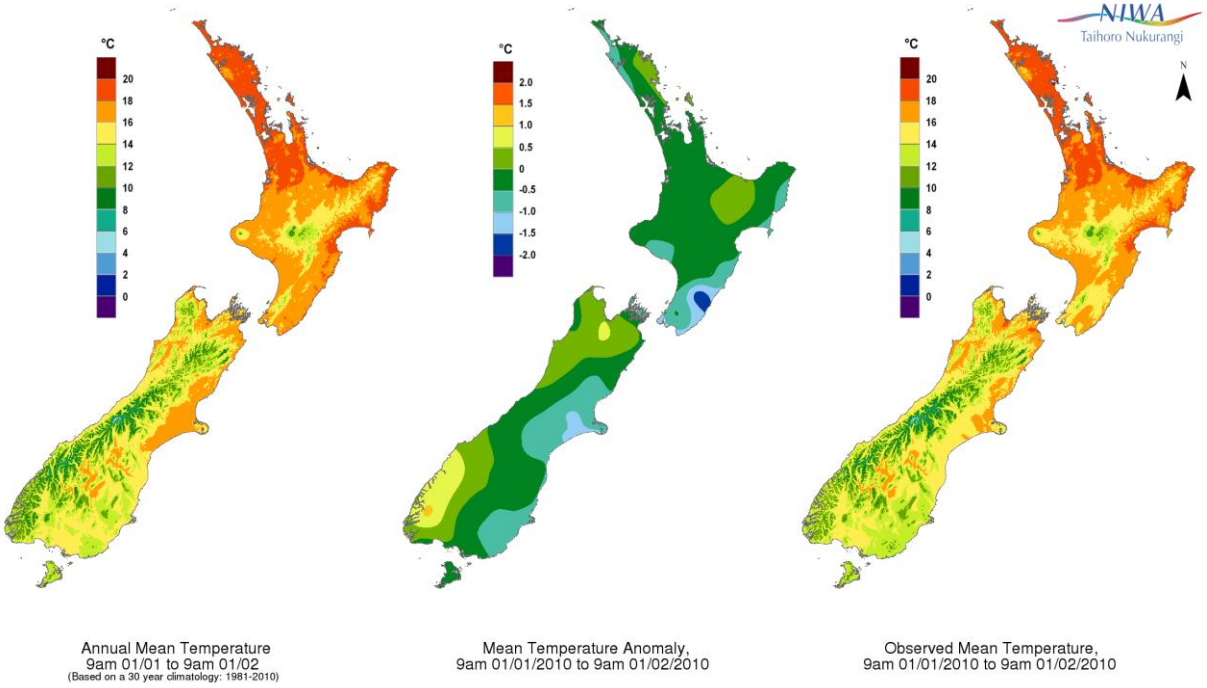


November 2012



December 2012

Temperature
2010

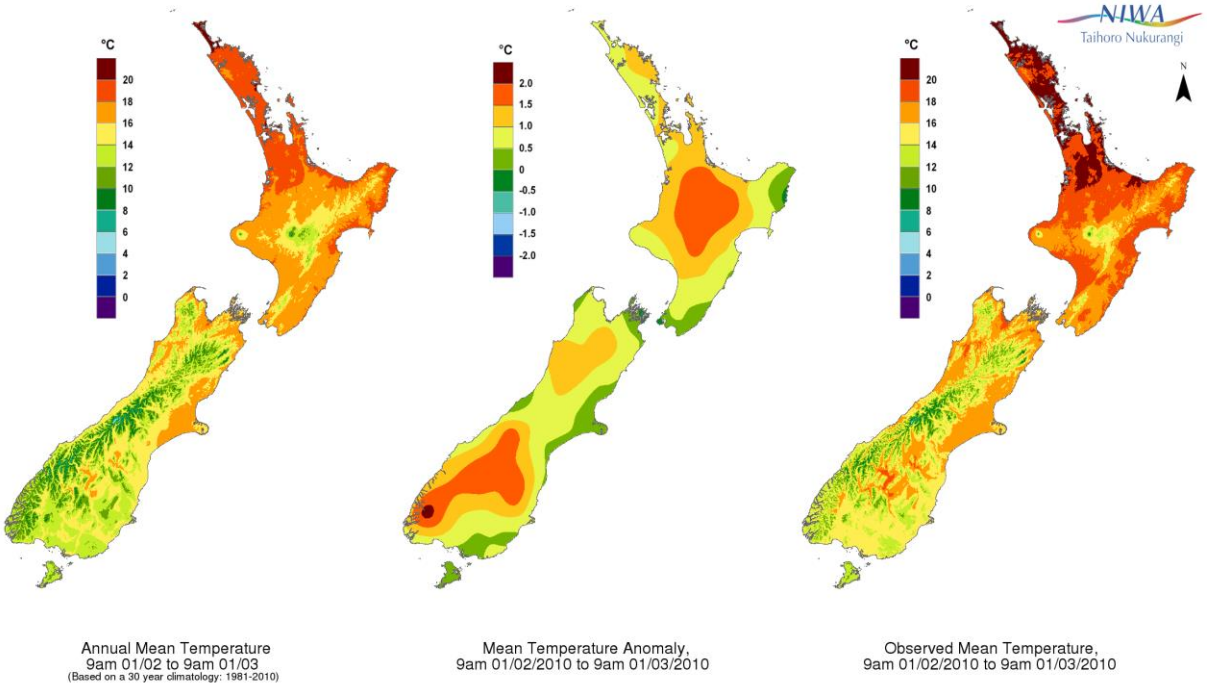


Annual Mean Temperature
9am 01/01 to 9am 01/02
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/01/2010 to 9am 01/02/2010

Observed Mean Temperature,
9am 01/01/2010 to 9am 01/02/2010

January 2010

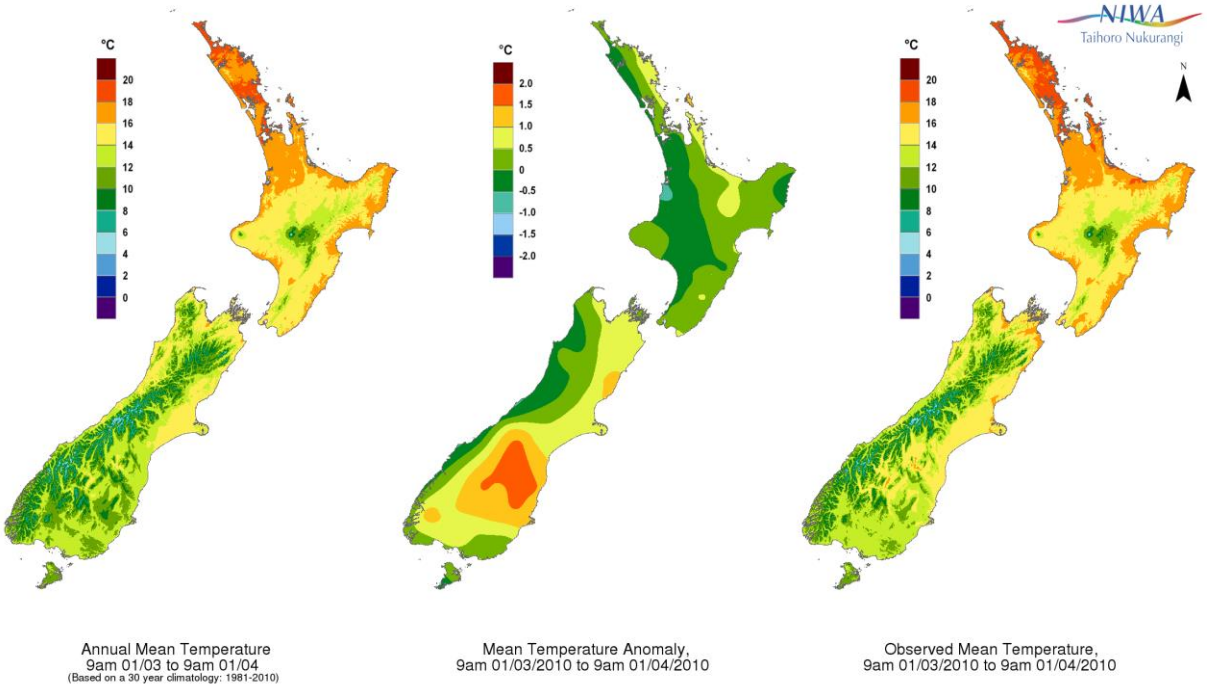


Annual Mean Temperature
9am 01/02 to 9am 01/03
(Based on a 30 year climatology: 1981-2010)

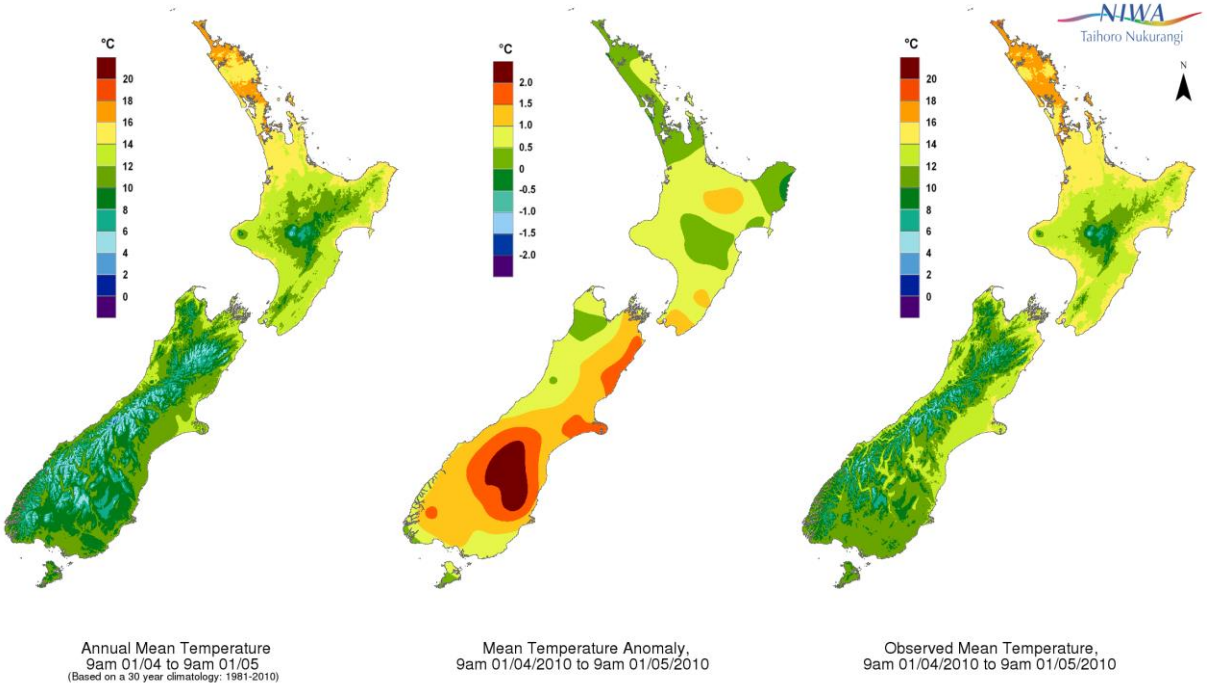
Mean Temperature Anomaly,
9am 01/02/2010 to 9am 01/03/2010

Observed Mean Temperature,
9am 01/02/2010 to 9am 01/03/2010

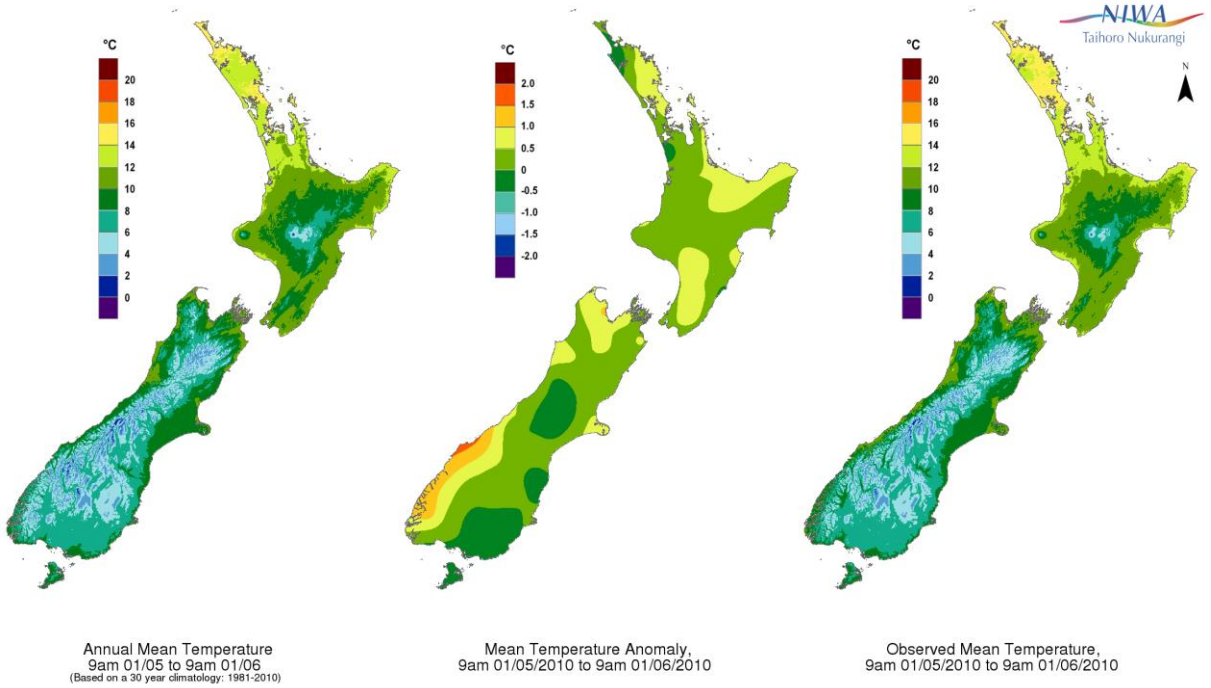
February 2010



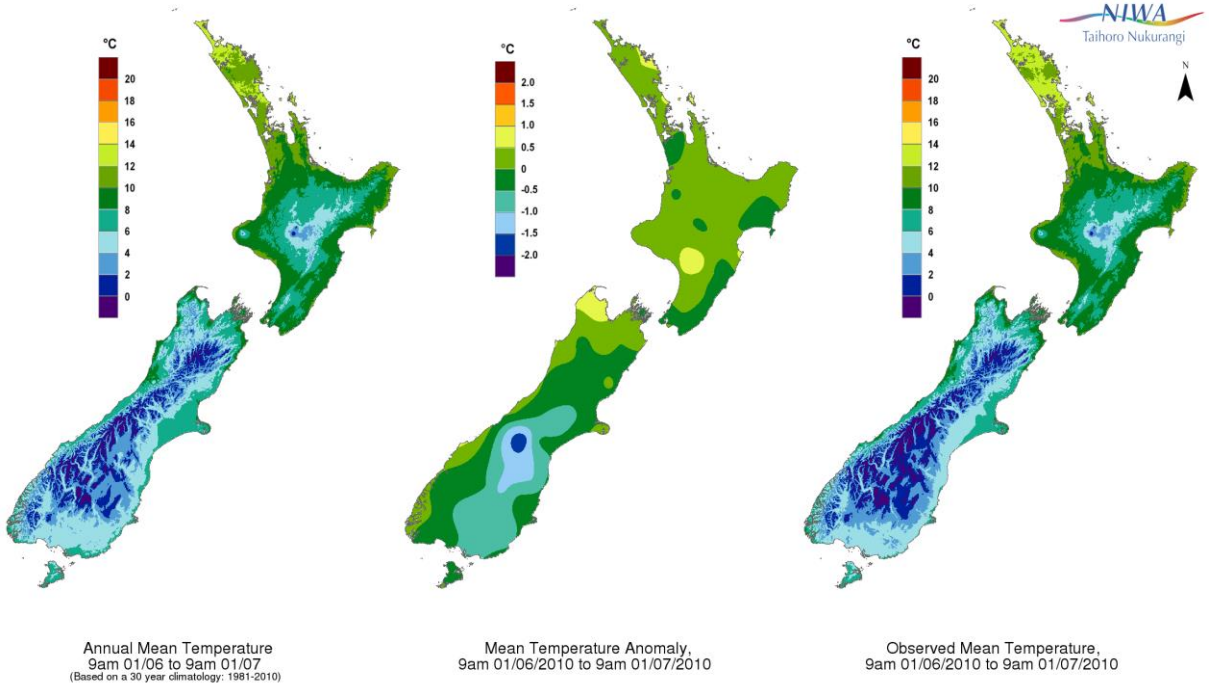
March 2010



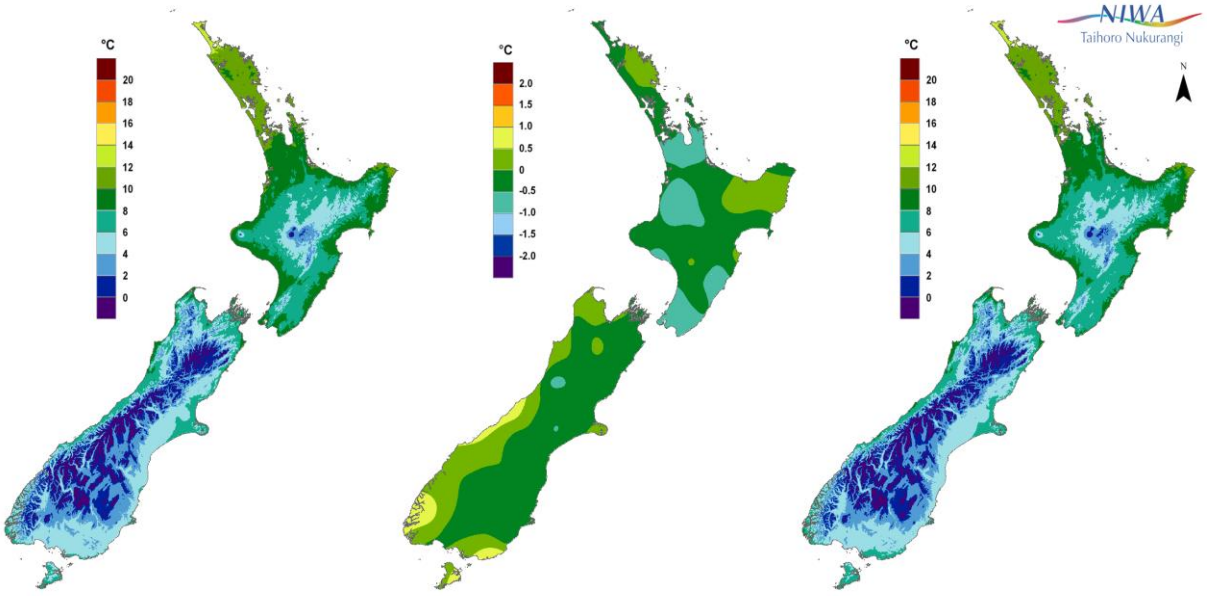
April 2010



May 2010



June 2010

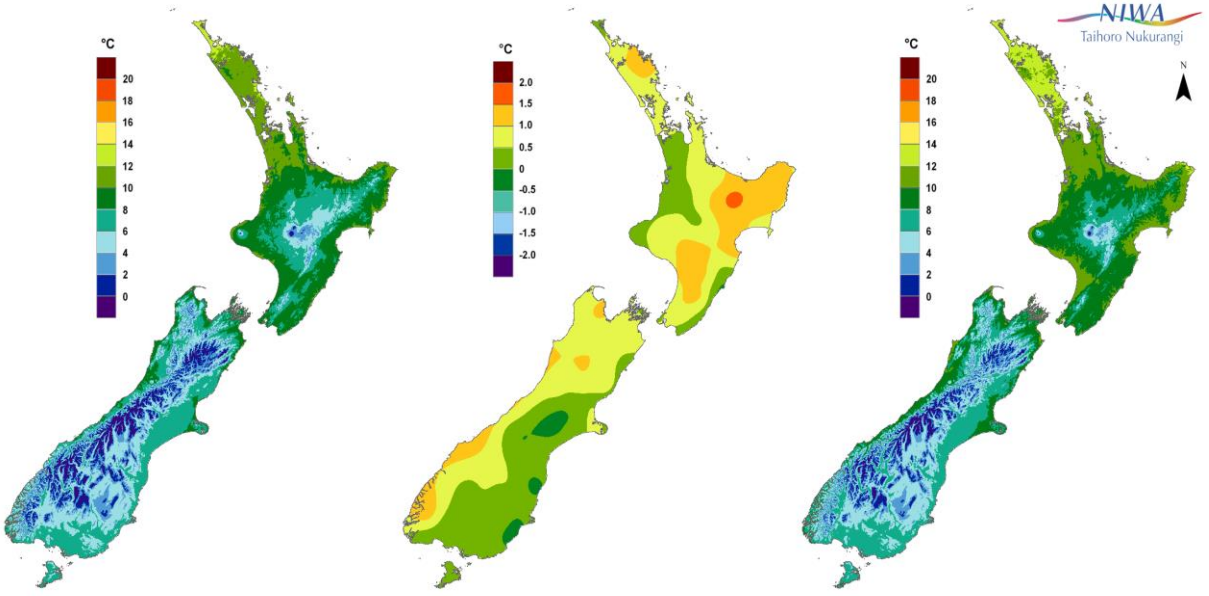


Annual Mean Temperature
9am 01/07 to 9am 01/08
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/07/2010 to 9am 01/08/2010

Observed Mean Temperature,
9am 01/07/2010 to 9am 01/08/2010

July 2010

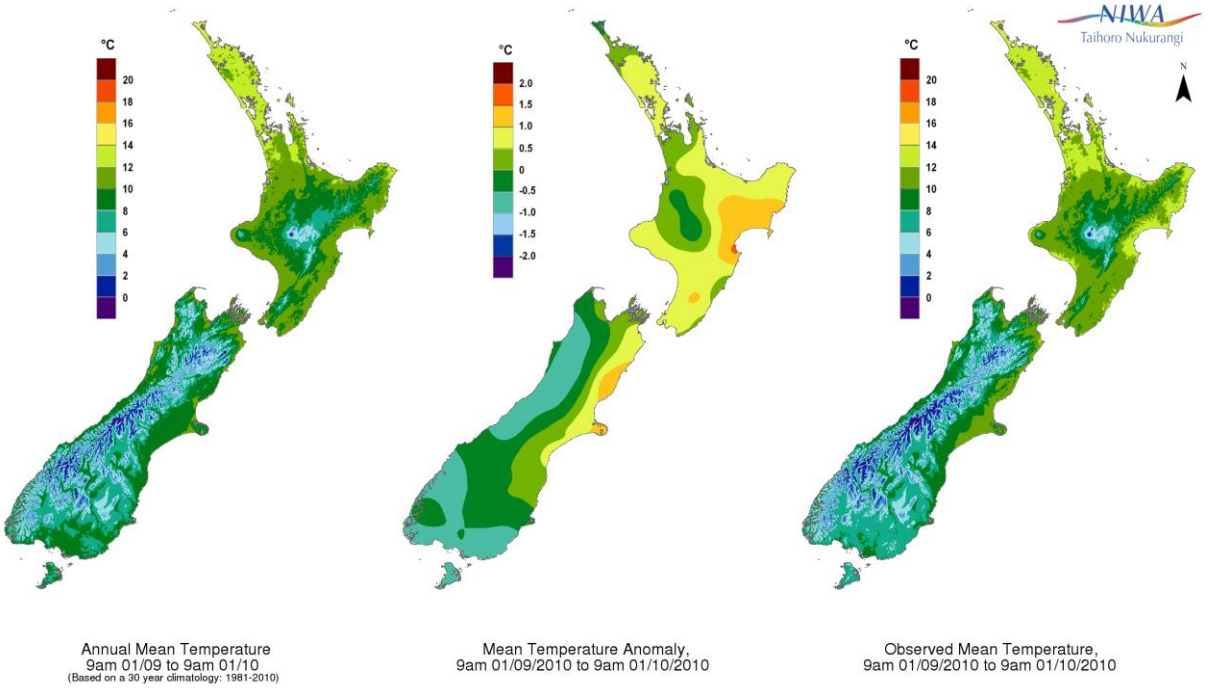


Annual Mean Temperature
9am 01/08 to 9am 01/09
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/08/2010 to 9am 01/09/2010

Observed Mean Temperature,
9am 01/08/2010 to 9am 01/09/2010

August 2010

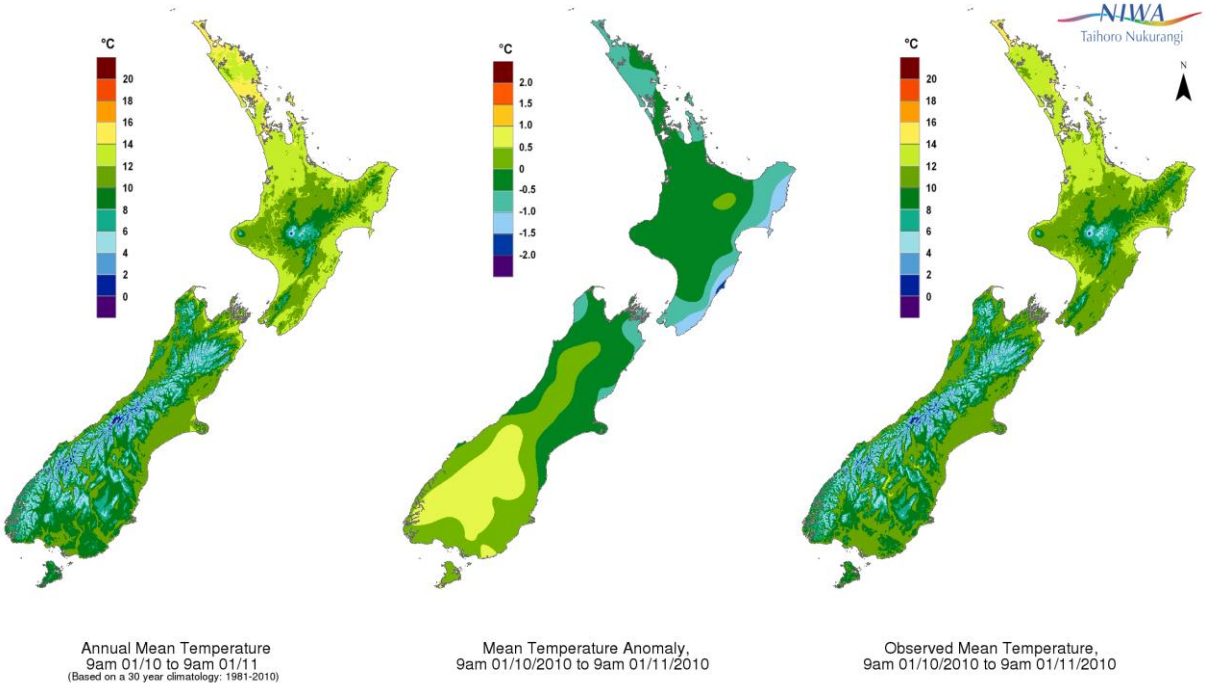


Annual Mean Temperature
9am 01/09 to 9am 01/10
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/09/2010 to 9am 01/10/2010

Observed Mean Temperature,
9am 01/09/2010 to 9am 01/10/2010

September 2010

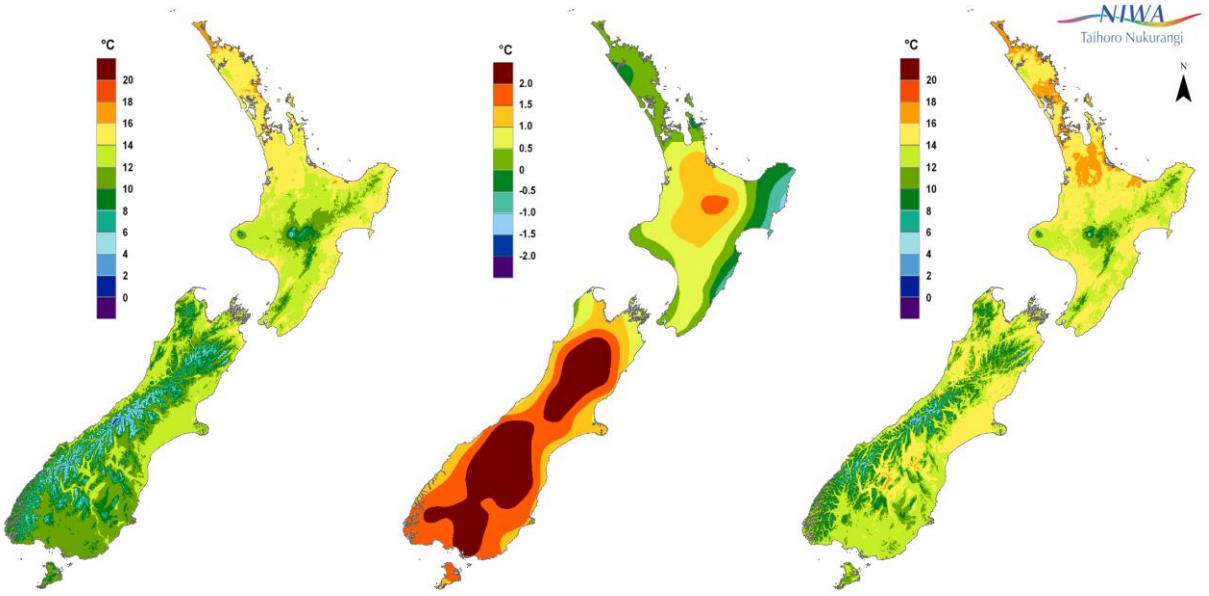


Annual Mean Temperature
9am 01/10 to 9am 01/11
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/10/2010 to 9am 01/11/2010

Observed Mean Temperature,
9am 01/10/2010 to 9am 01/11/2010

October 2010

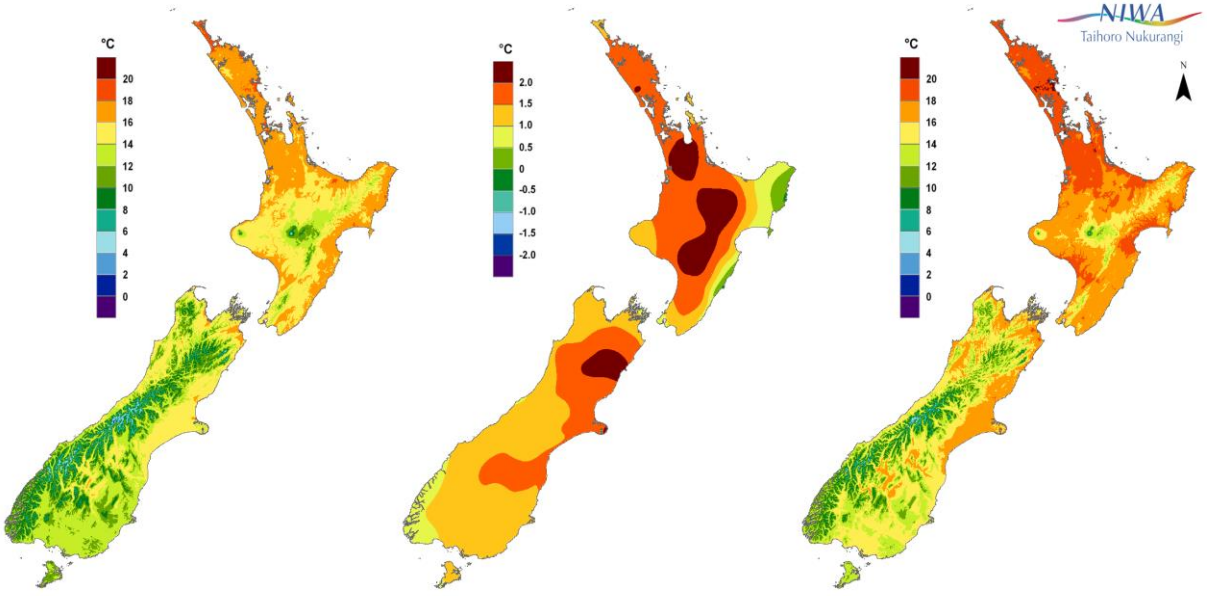


Annual Mean Temperature
9am 01/11 to 9am 01/12
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/11/2010 to 9am 01/12/2010

Observed Mean Temperature,
9am 01/11/2010 to 9am 01/12/2010

November 2010



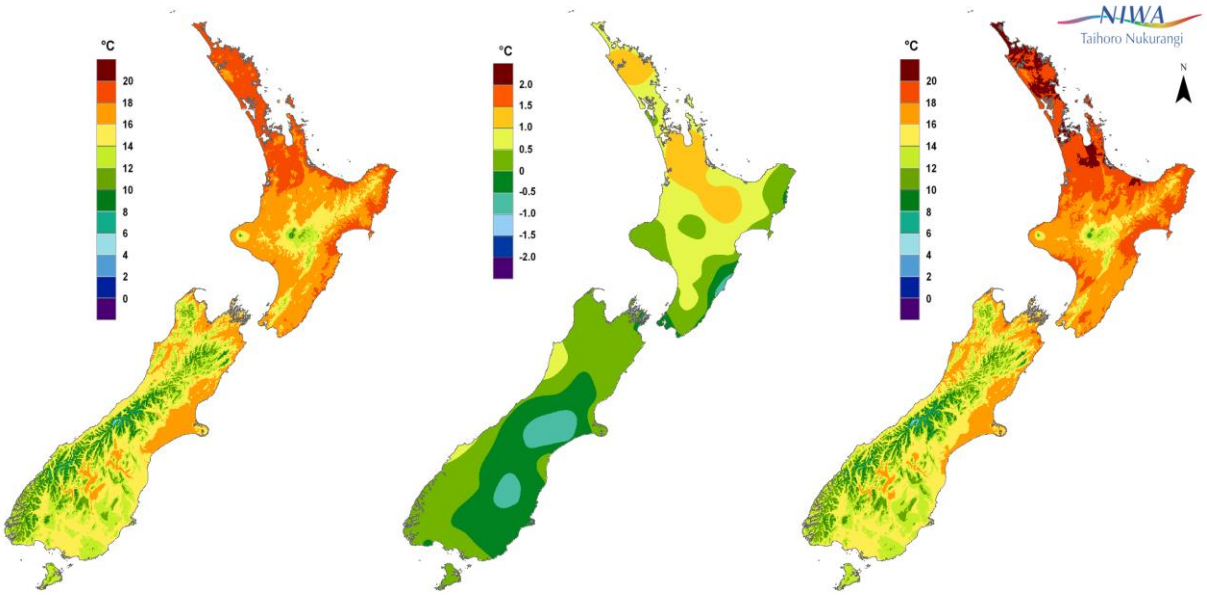
Annual Mean Temperature
9am 01/12 to 9am 01/01
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/12/2010 to 9am 01/01/2011

Observed Mean Temperature,
9am 01/12/2010 to 9am 01/01/2011

December 2010

2011

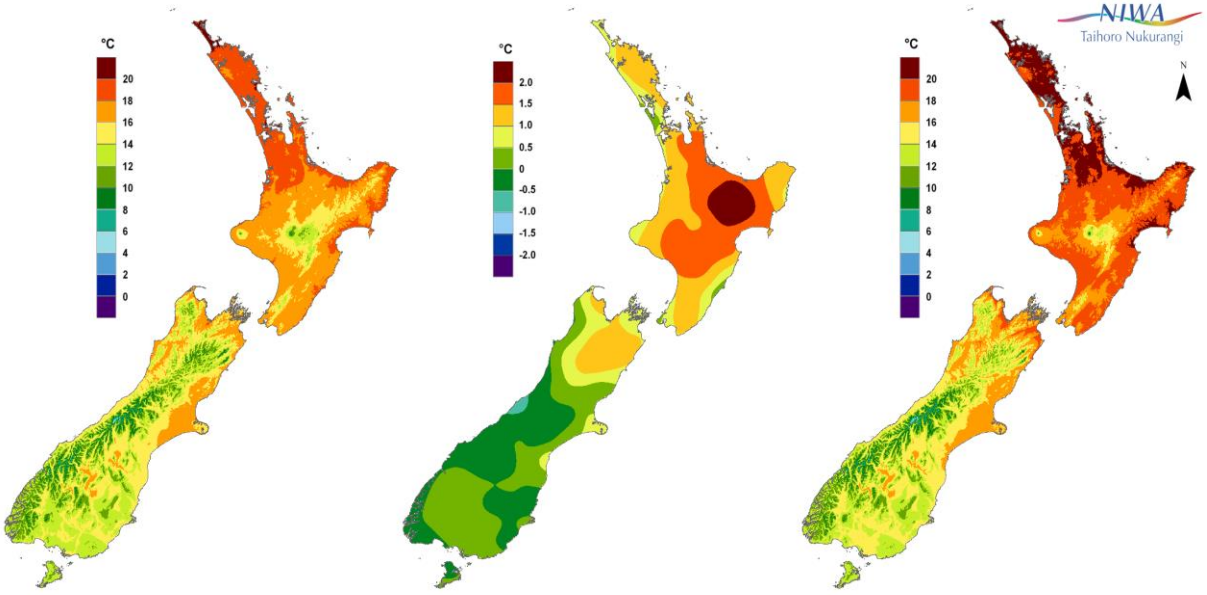


Annual Mean Temperature
9am 01/01 to 9am 01/02
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/01/2011 to 9am 01/02/2011

Observed Mean Temperature,
9am 01/01/2011 to 9am 01/02/2011

January 2011

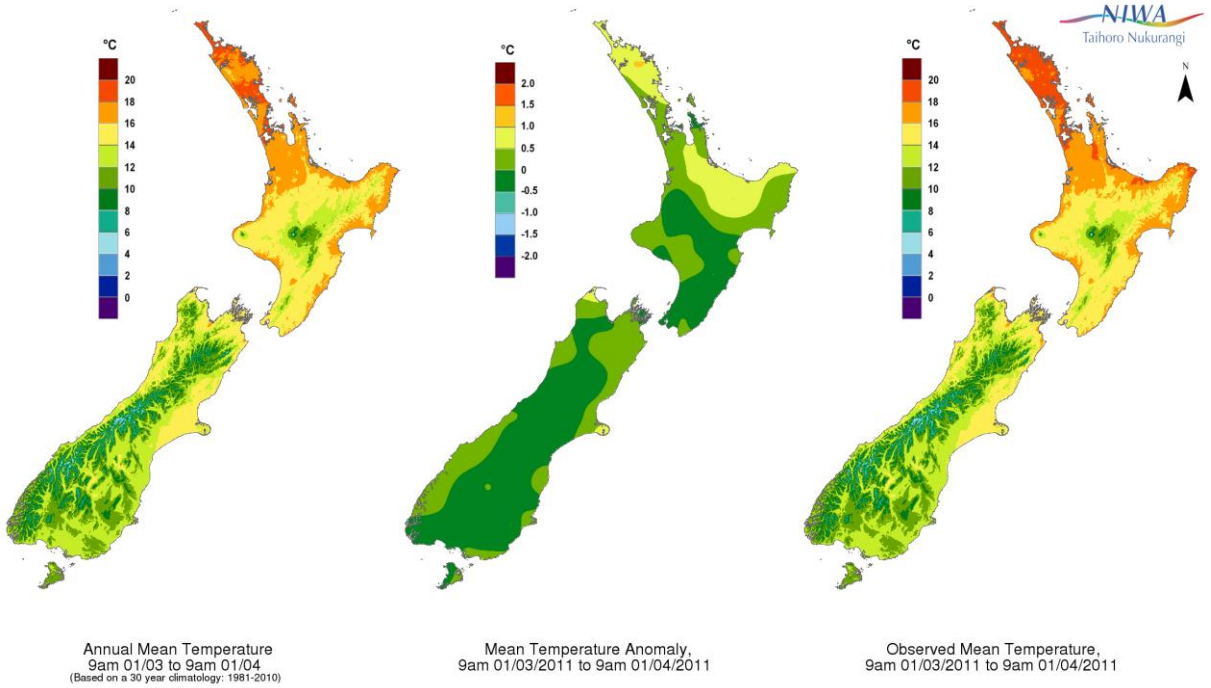


Annual Mean Temperature
9am 01/02 to 9am 01/03
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/02/2011 to 9am 01/03/2011

Observed Mean Temperature,
9am 01/02/2011 to 9am 01/03/2011

February 2011

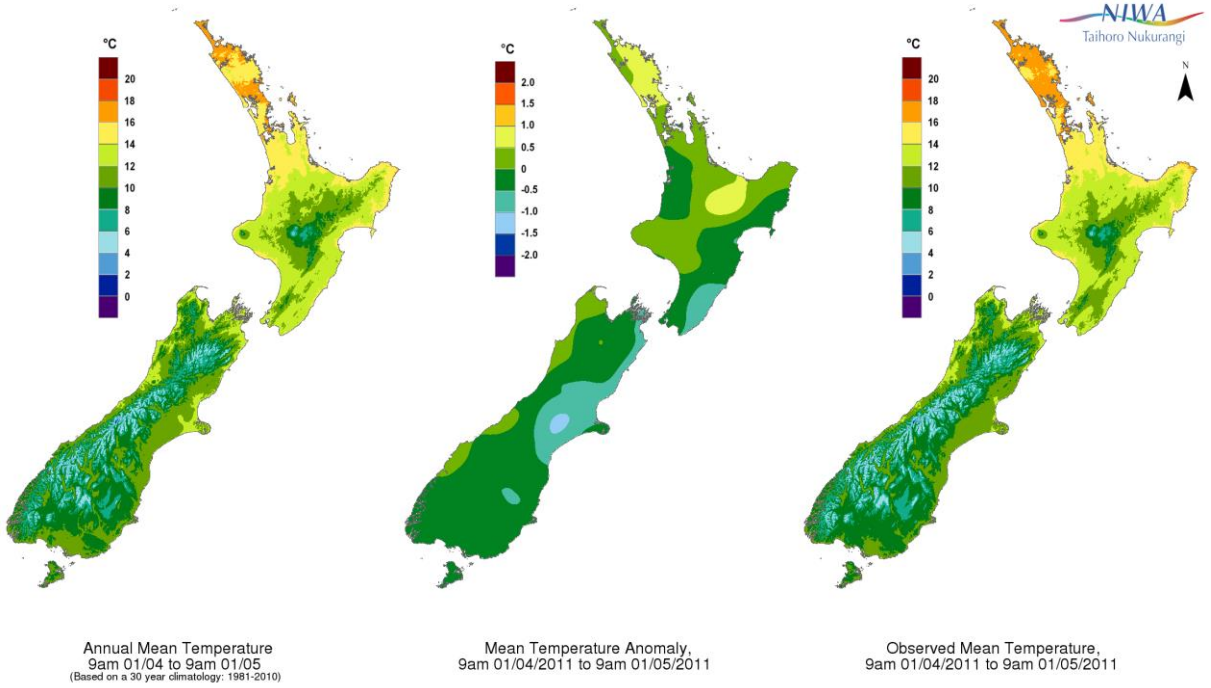


Annual Mean Temperature
9am 01/03 to 9am 01/04
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/03/2011 to 9am 01/04/2011

Observed Mean Temperature,
9am 01/03/2011 to 9am 01/04/2011

March 2011

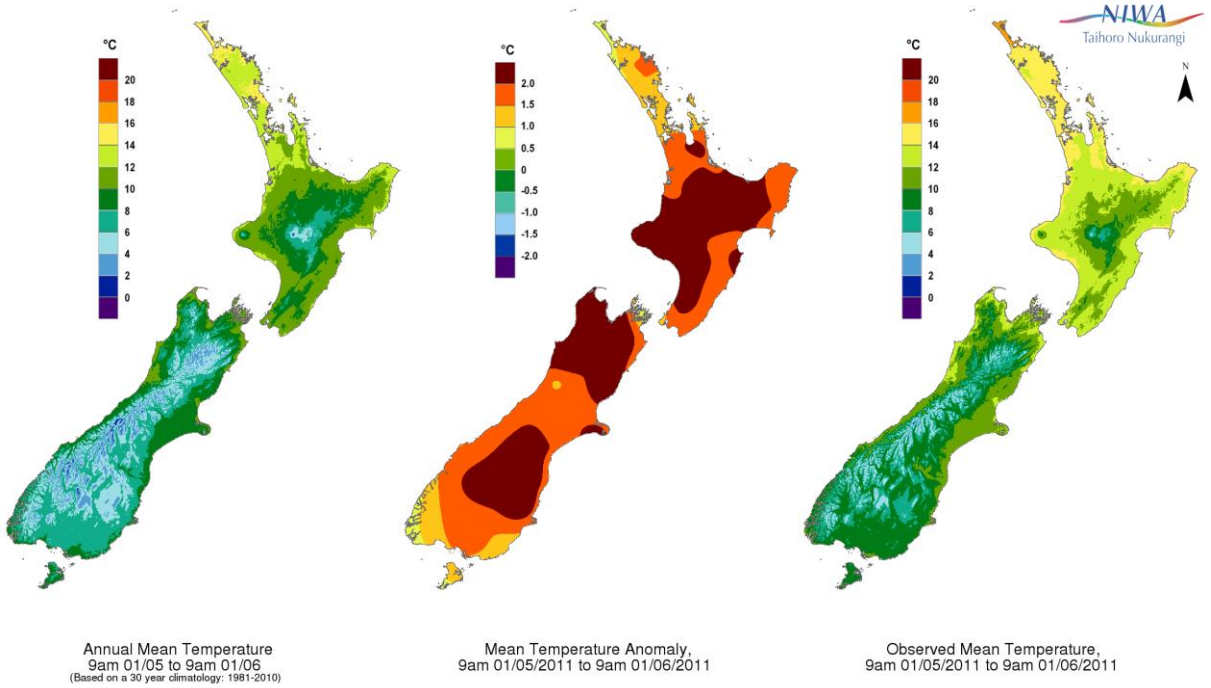


Annual Mean Temperature
9am 01/04 to 9am 01/05
(Based on a 30 year climatology: 1981-2010)

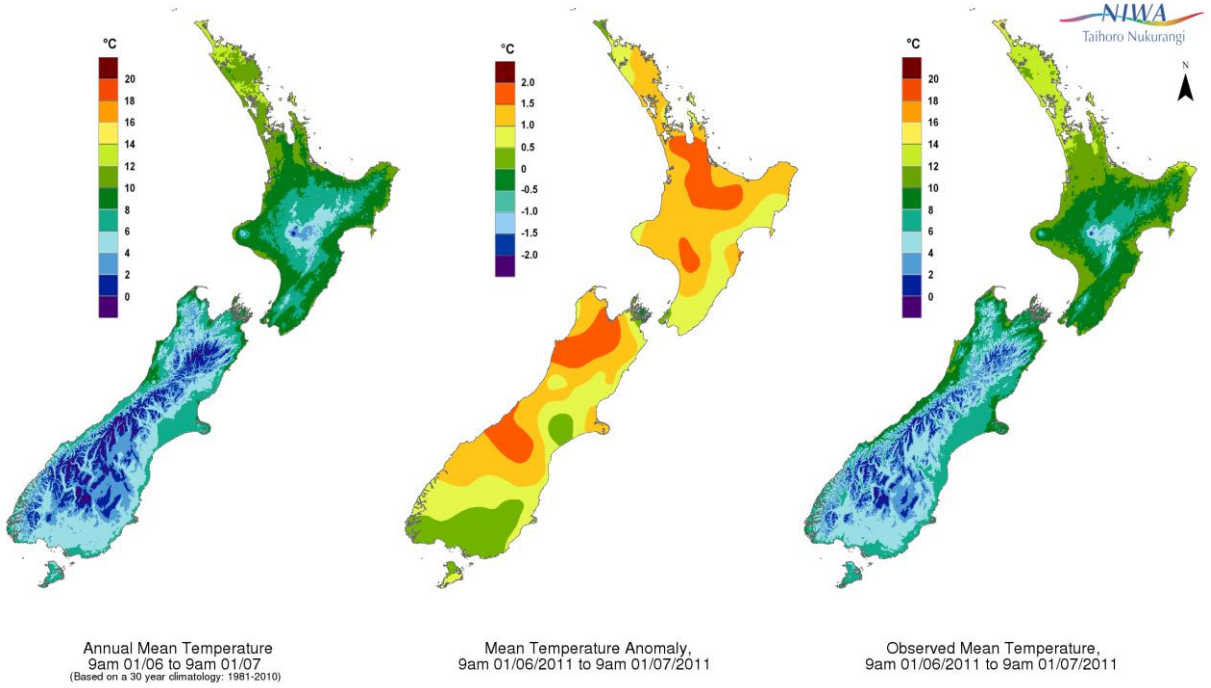
Mean Temperature Anomaly,
9am 01/04/2011 to 9am 01/05/2011

Observed Mean Temperature,
9am 01/04/2011 to 9am 01/05/2011

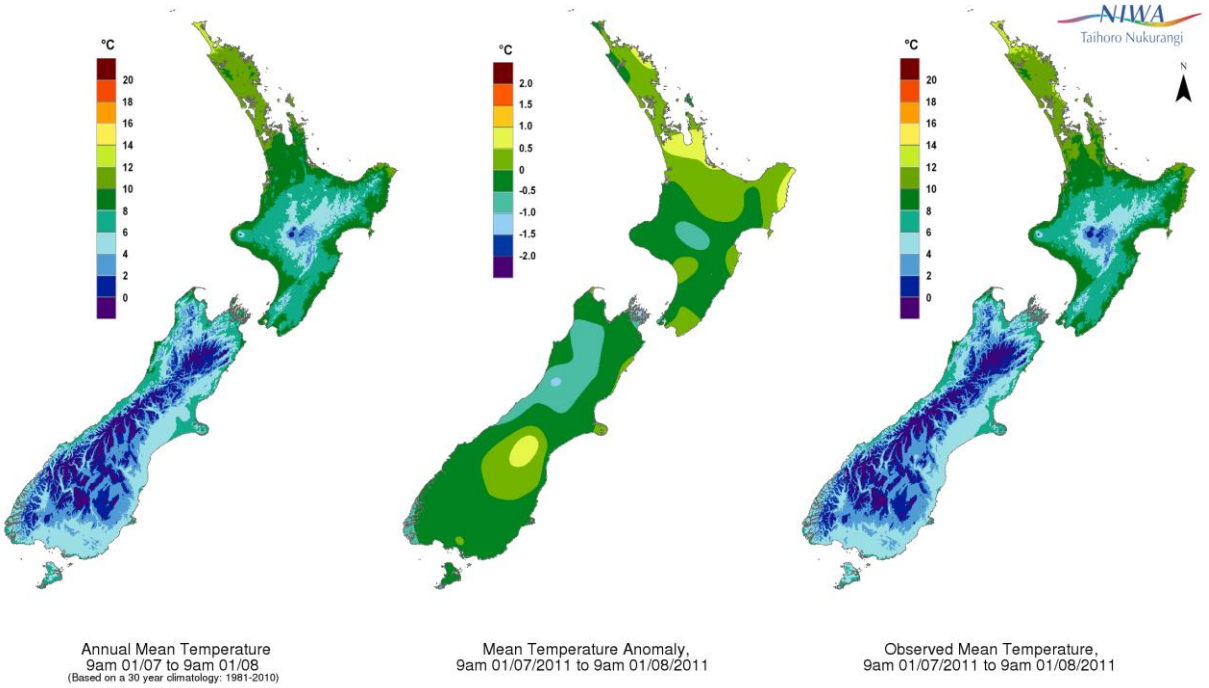
April 2011



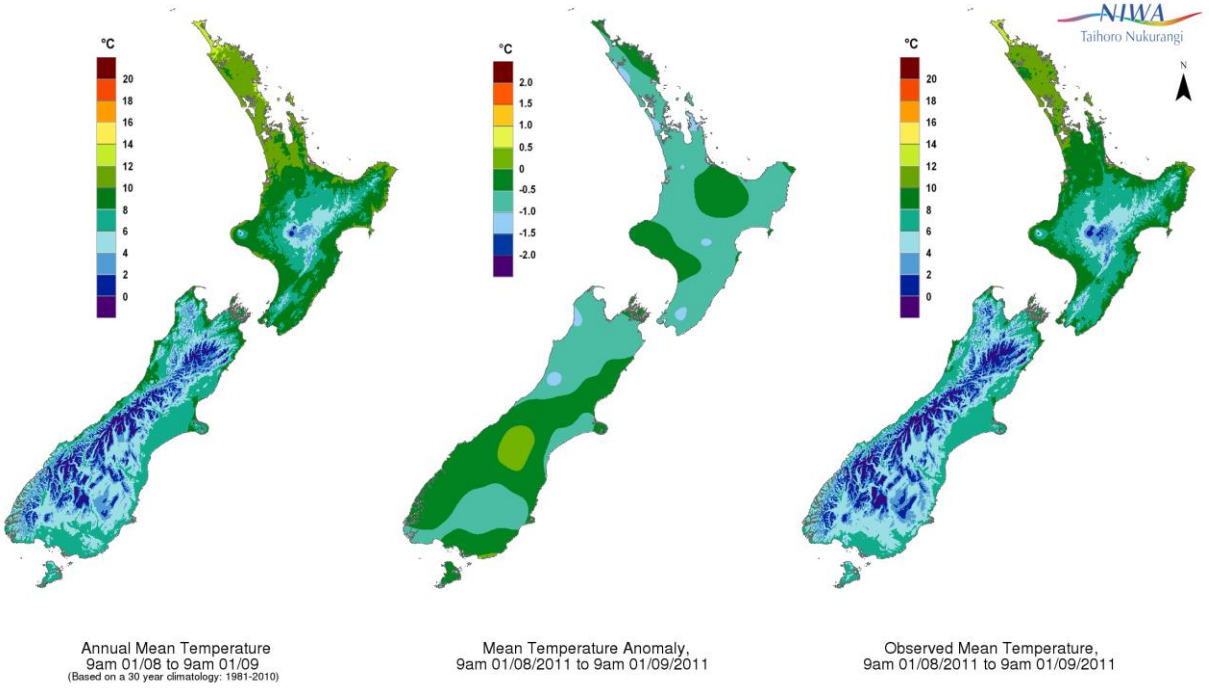
May 2011



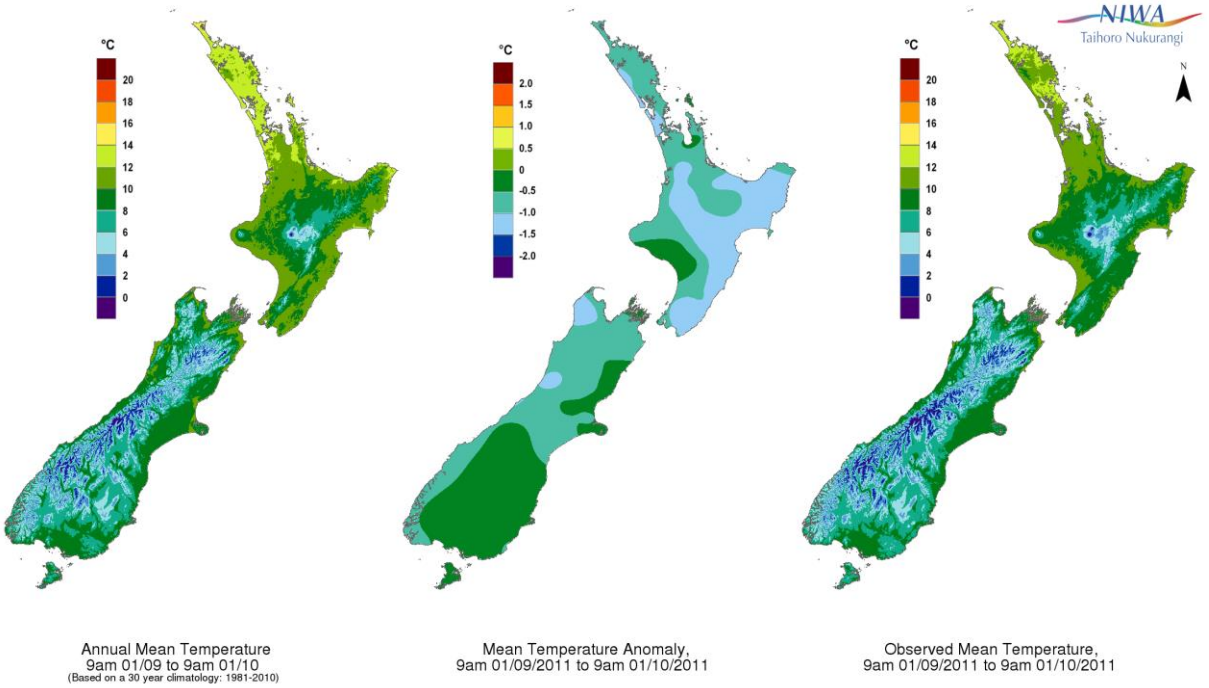
June 2011



July 2011



August 2011

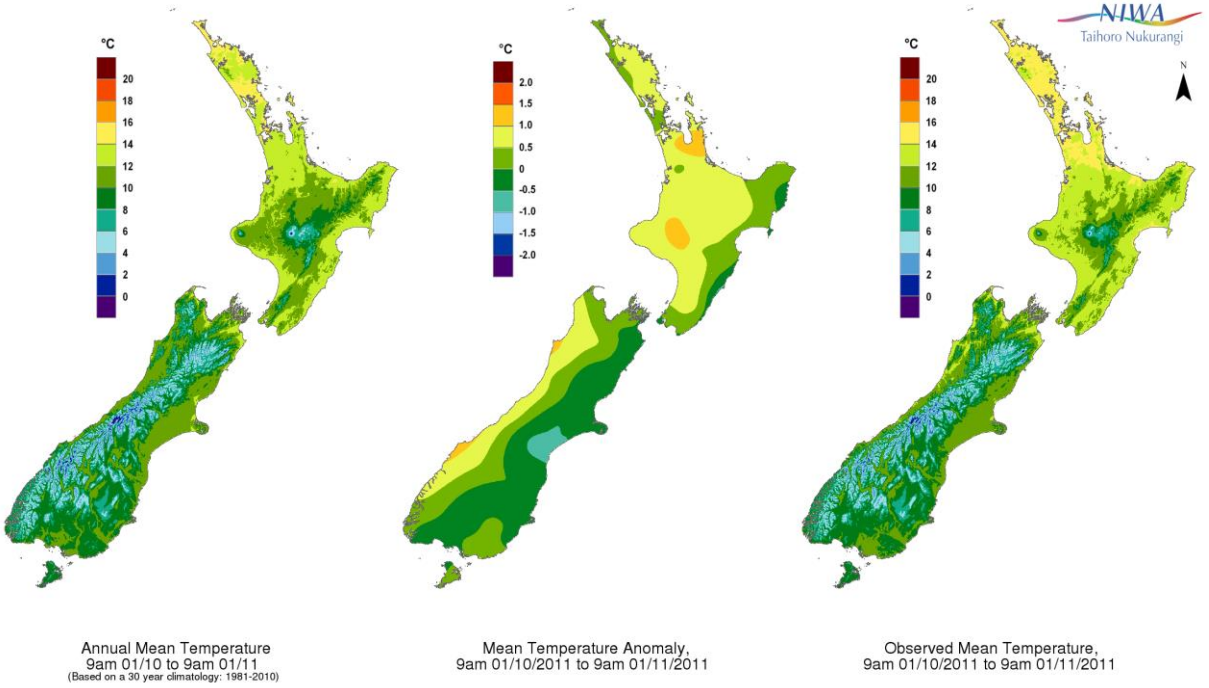


Annual Mean Temperature
9am 01/09 to 9am 01/10
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/09/2011 to 9am 01/10/2011

Observed Mean Temperature,
9am 01/09/2011 to 9am 01/10/2011

September 2011

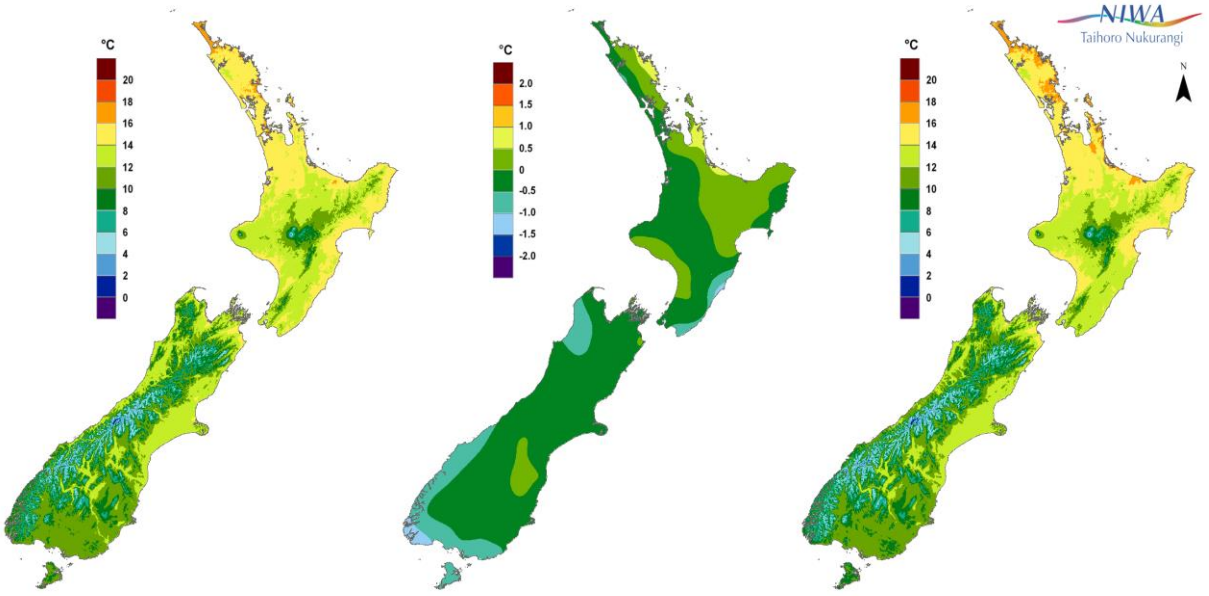


Annual Mean Temperature
9am 01/10 to 9am 01/11
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/10/2011 to 9am 01/11/2011

Observed Mean Temperature,
9am 01/10/2011 to 9am 01/11/2011

October 2011

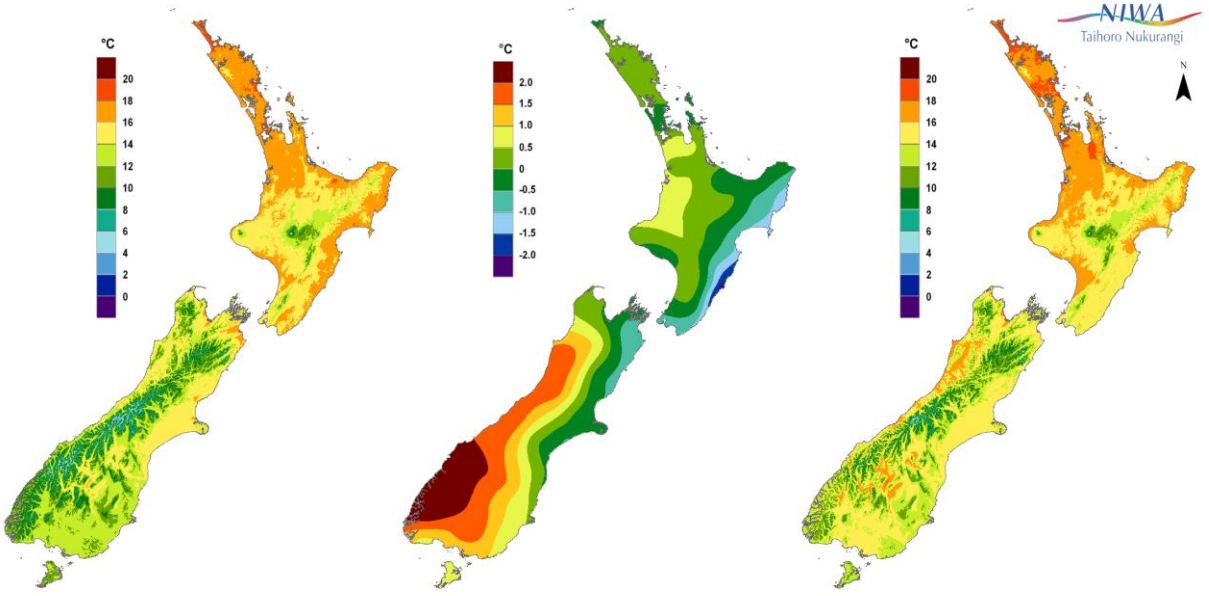


Annual Mean Temperature
9am 01/11 to 9am 01/12
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/11/2011 to 9am 01/12/2011

Observed Mean Temperature,
9am 01/11/2011 to 9am 01/12/2011

November 2011



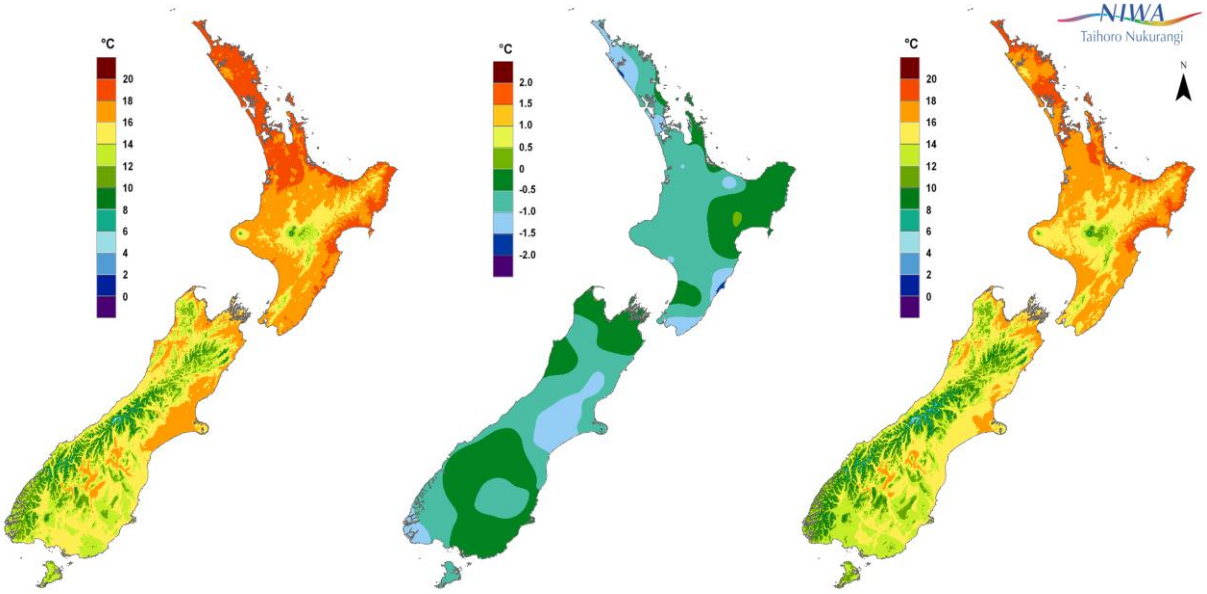
Annual Mean Temperature
9am 01/12 to 9am 01/01
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/12/2011 to 9am 01/01/2012

Observed Mean Temperature,
9am 01/12/2011 to 9am 01/01/2012

December 2011

2012

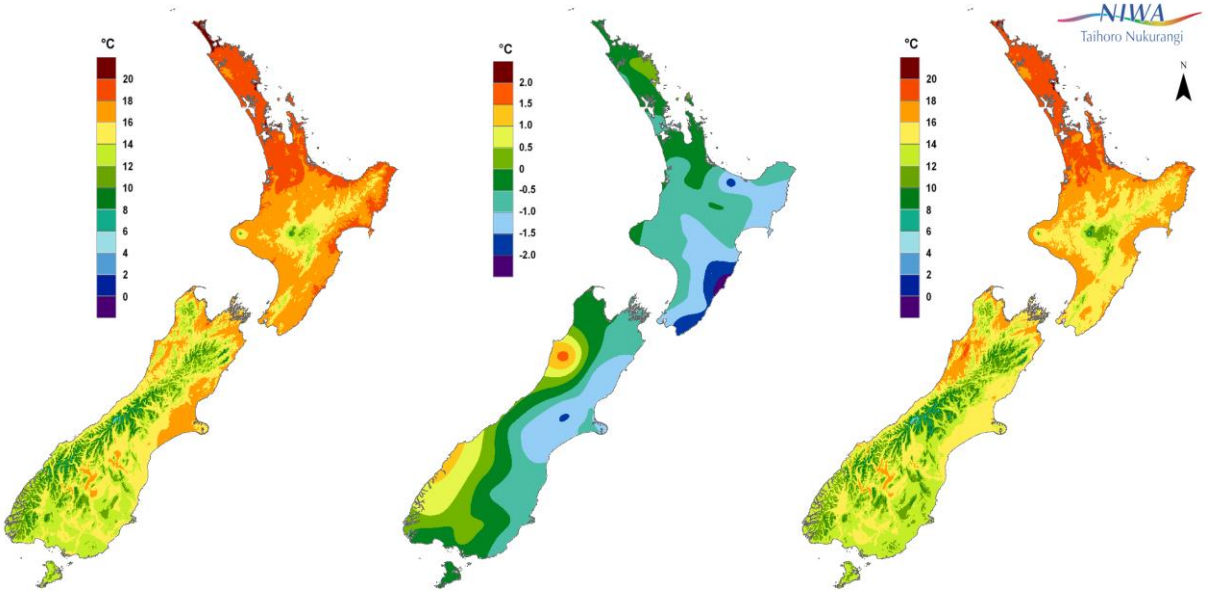


Annual Mean Temperature
9am 01/01 to 9am 01/02
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/01/2012 to 9am 01/02/2012

Observed Mean Temperature,
9am 01/01/2012 to 9am 01/02/2012

January 2012

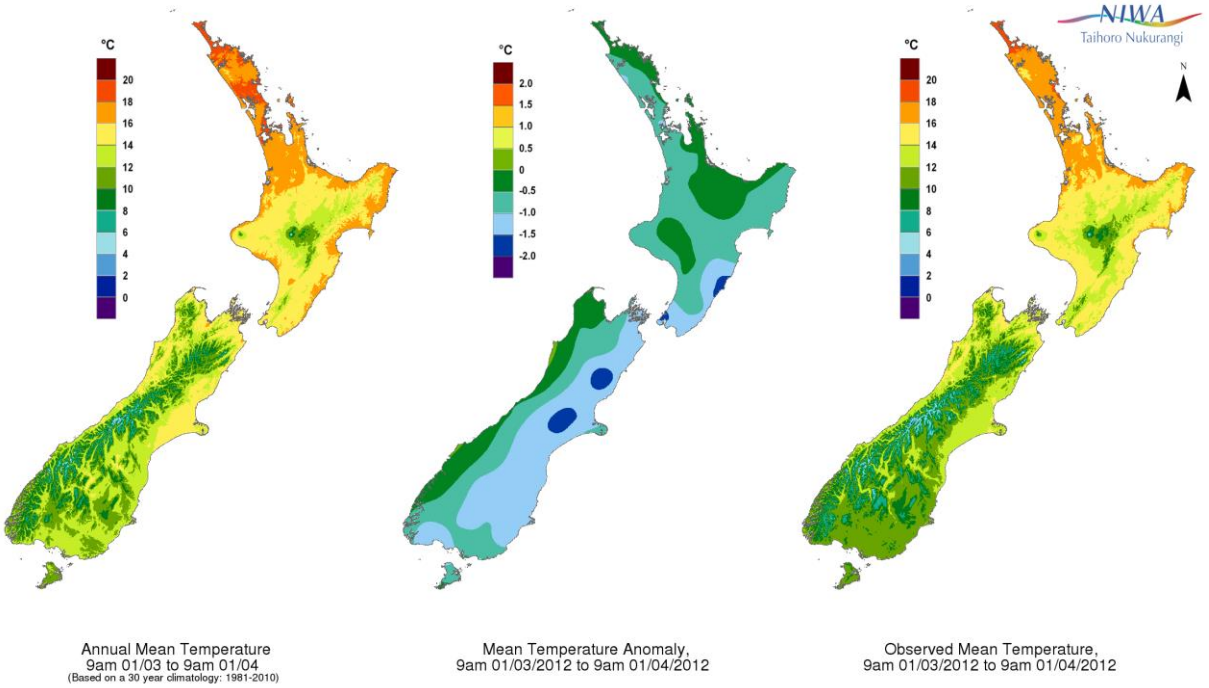


Annual Mean Temperature
9am 01/02 to 9am 01/03
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/02/2012 to 9am 01/03/2012

Observed Mean Temperature,
9am 01/02/2012 to 9am 01/03/2012

February 2012

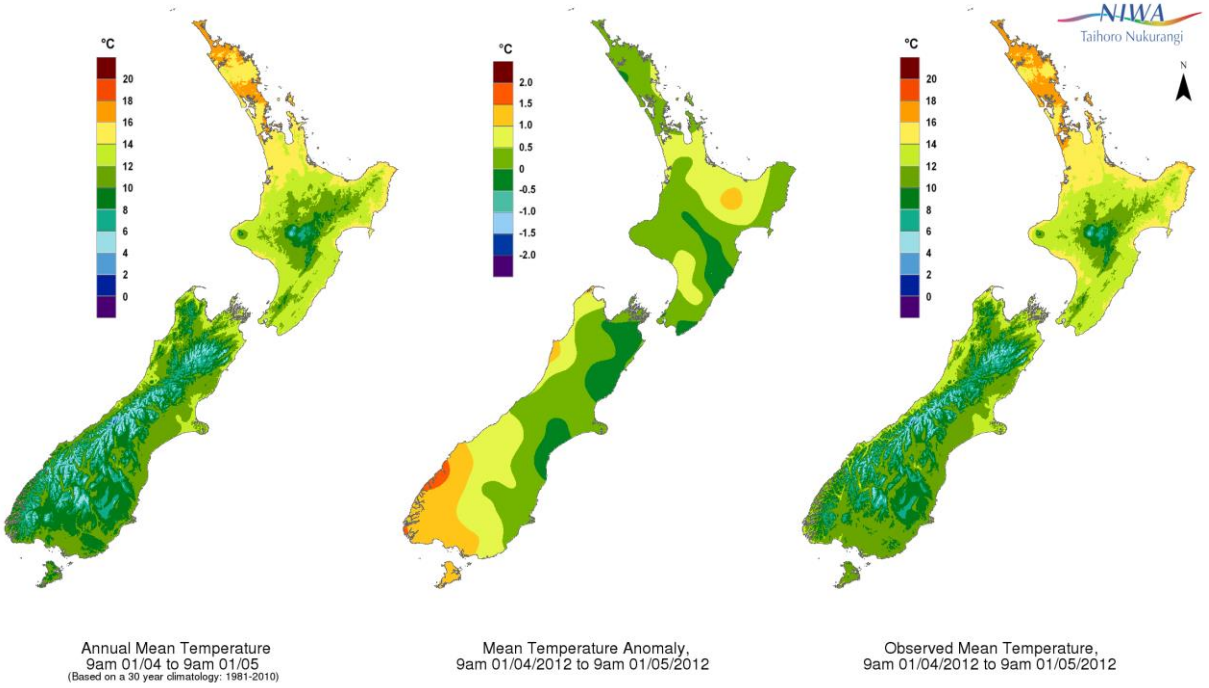


Annual Mean Temperature
9am 01/03 to 9am 01/04
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/03/2012 to 9am 01/04/2012

Observed Mean Temperature,
9am 01/03/2012 to 9am 01/04/2012

March 2012

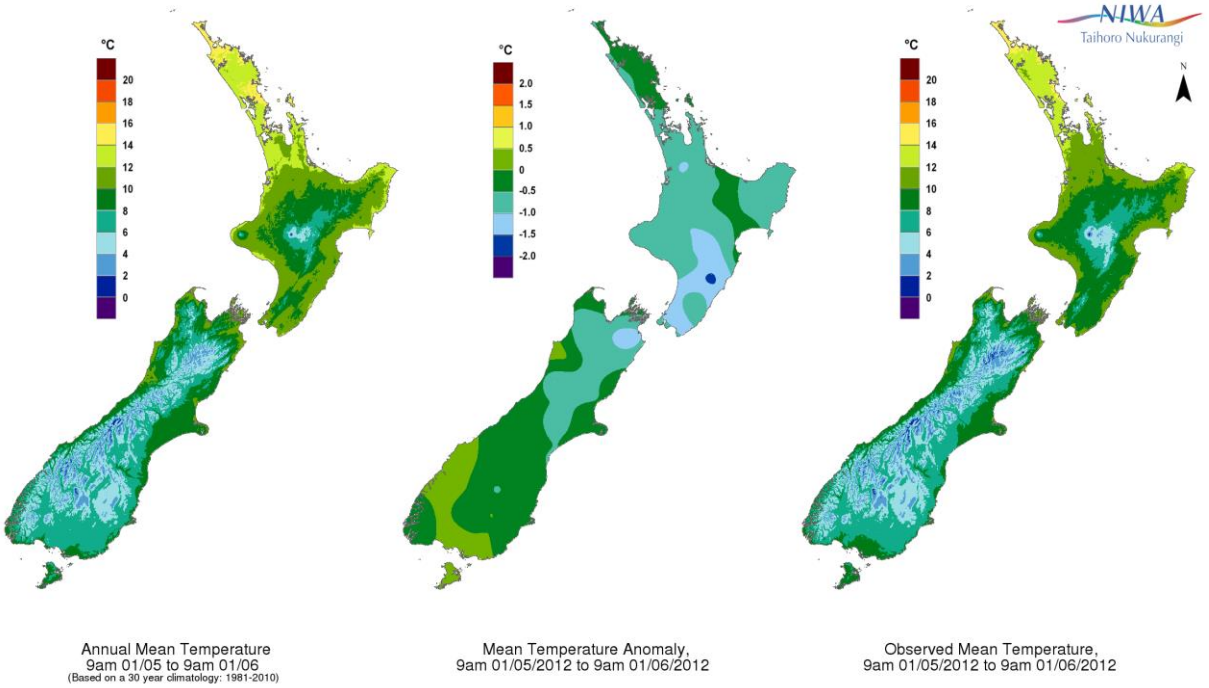


Annual Mean Temperature
9am 01/04 to 9am 01/05
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/04/2012 to 9am 01/05/2012

Observed Mean Temperature,
9am 01/04/2012 to 9am 01/05/2012

April 2012

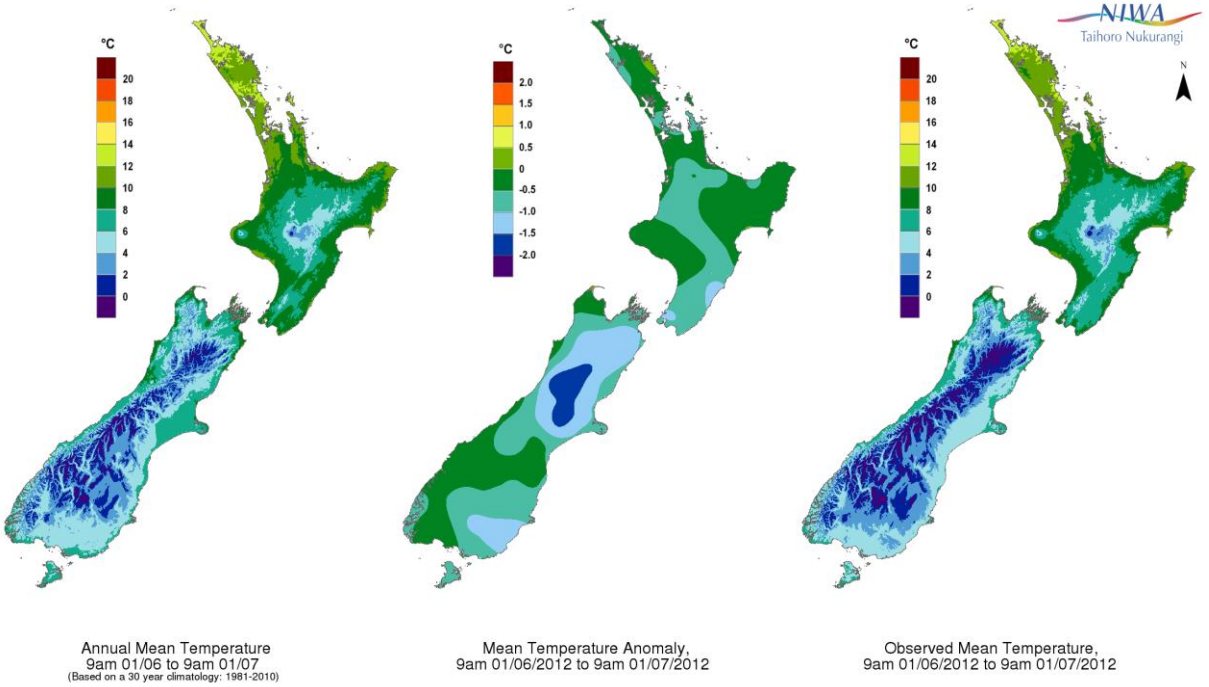


Annual Mean Temperature
9am 01/05 to 9am 01/06
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/05/2012 to 9am 01/06/2012

Observed Mean Temperature,
9am 01/05/2012 to 9am 01/06/2012

May 2012

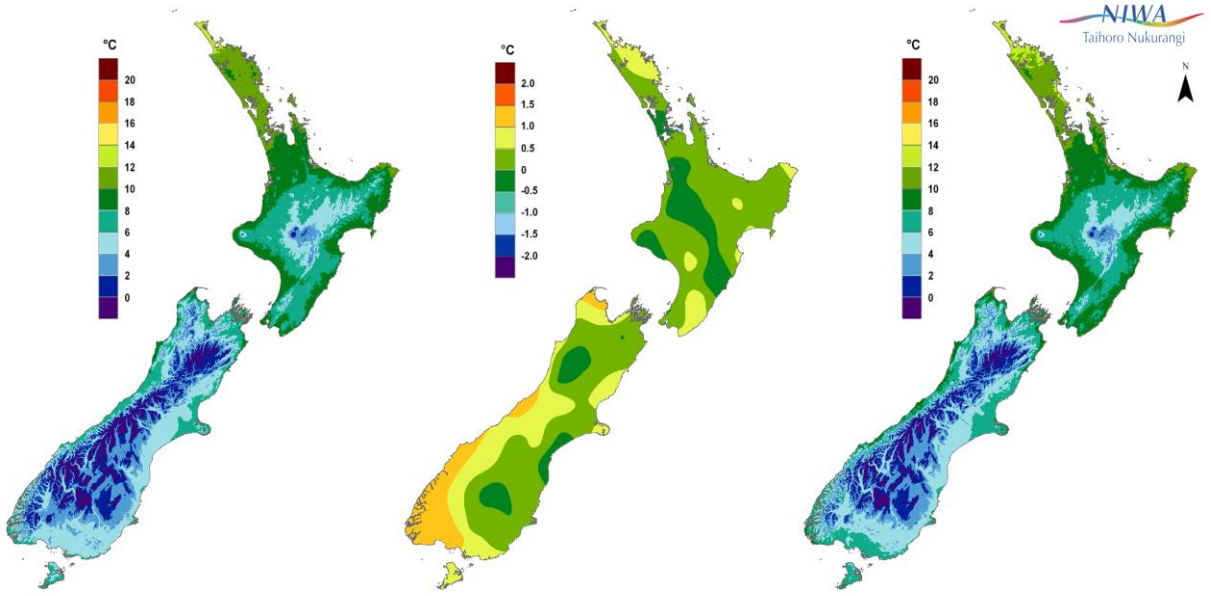


Annual Mean Temperature
9am 01/06 to 9am 01/07
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/06/2012 to 9am 01/07/2012

Observed Mean Temperature,
9am 01/06/2012 to 9am 01/07/2012

June 2012

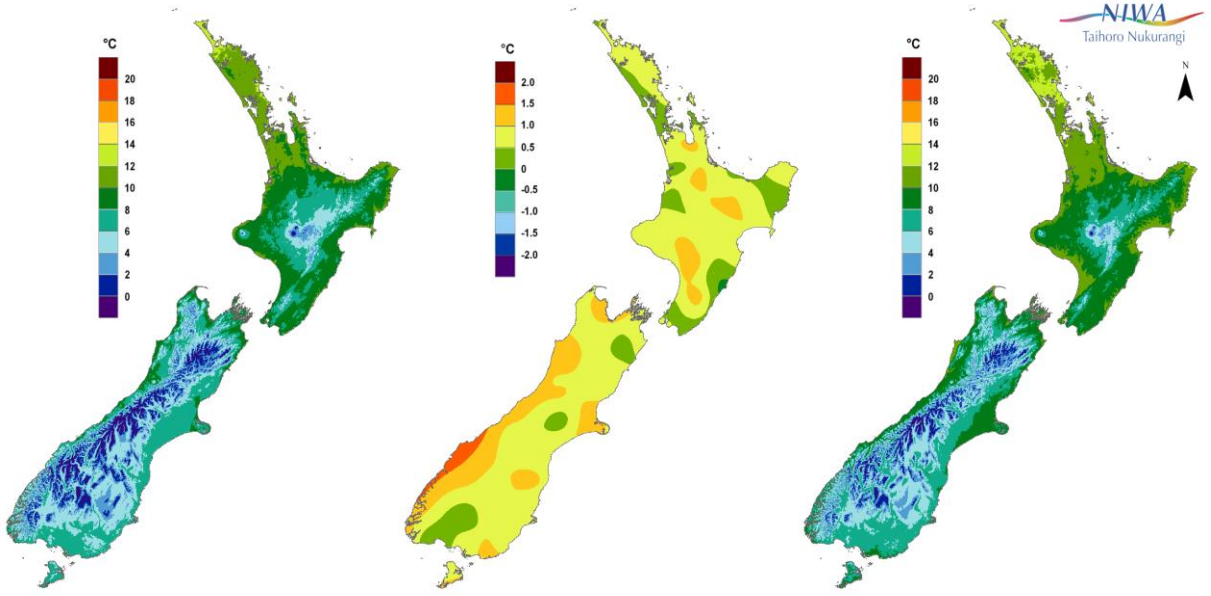


Annual Mean Temperature
9am 01/07 to 9am 01/08
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/07/2012 to 9am 01/08/2012

Observed Mean Temperature,
9am 01/07/2012 to 9am 01/08/2012

July 2012

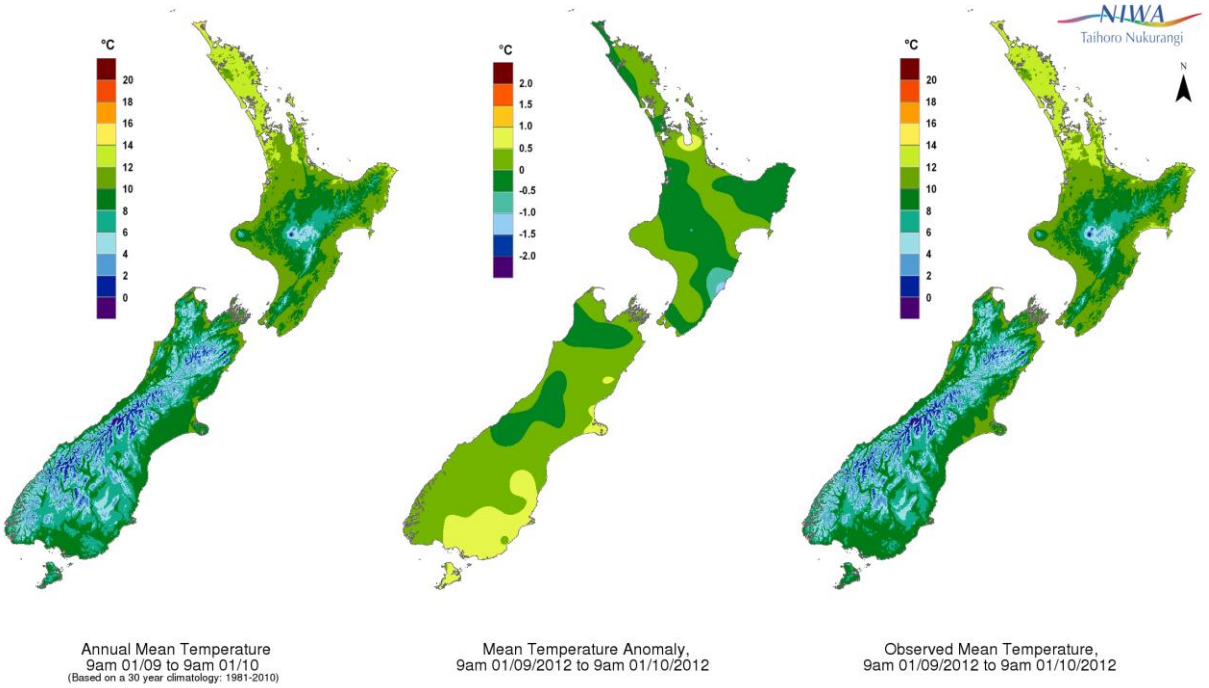


Annual Mean Temperature
9am 01/08 to 9am 01/09
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/08/2012 to 9am 01/09/2012

Observed Mean Temperature,
9am 01/08/2012 to 9am 01/09/2012

August 2012

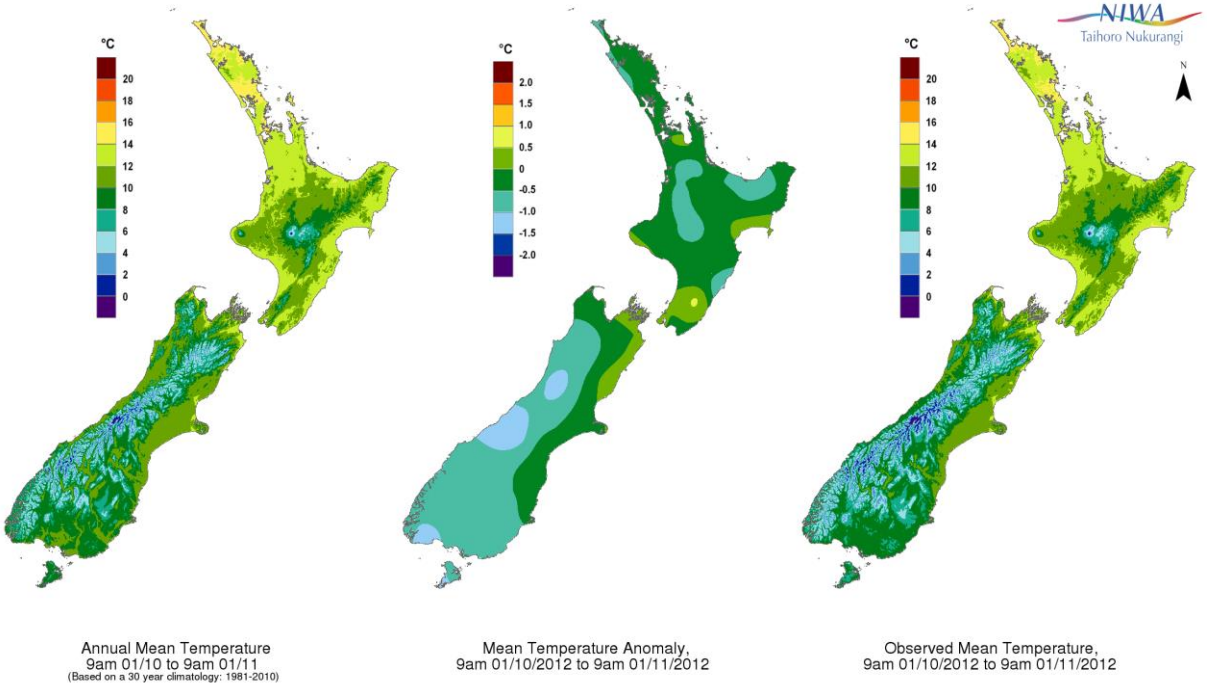


Annual Mean Temperature
9am 01/09 to 9am 01/10
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/09/2012 to 9am 01/10/2012

Observed Mean Temperature,
9am 01/09/2012 to 9am 01/10/2012

September 2012

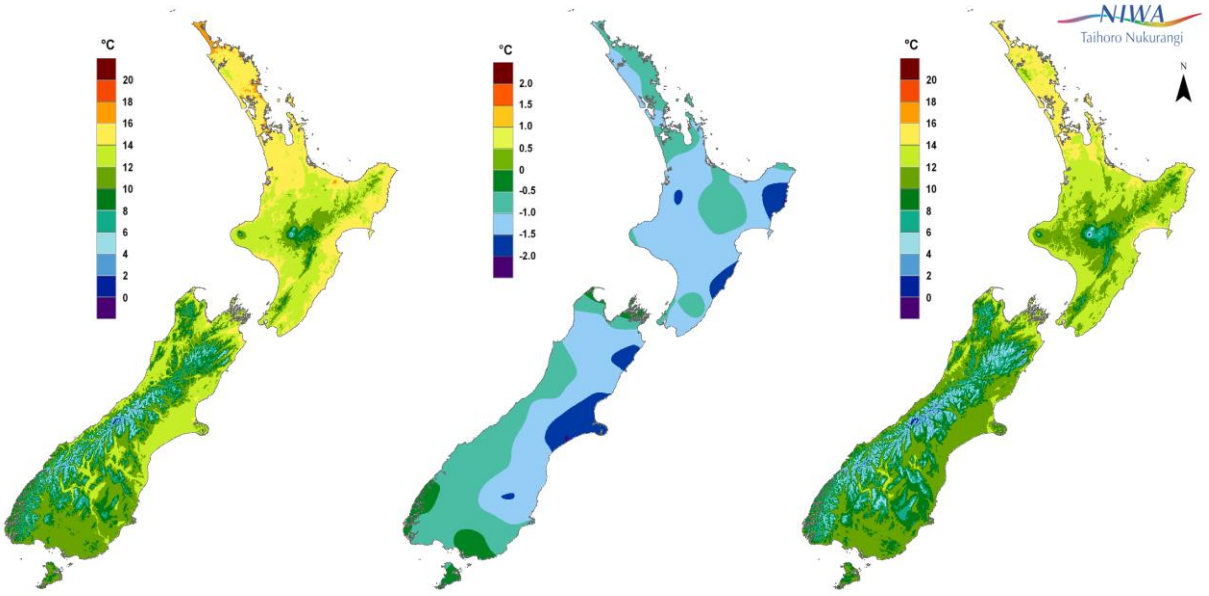


Annual Mean Temperature
9am 01/10 to 9am 01/11
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/10/2012 to 9am 01/11/2012

Observed Mean Temperature,
9am 01/10/2012 to 9am 01/11/2012

October 2012

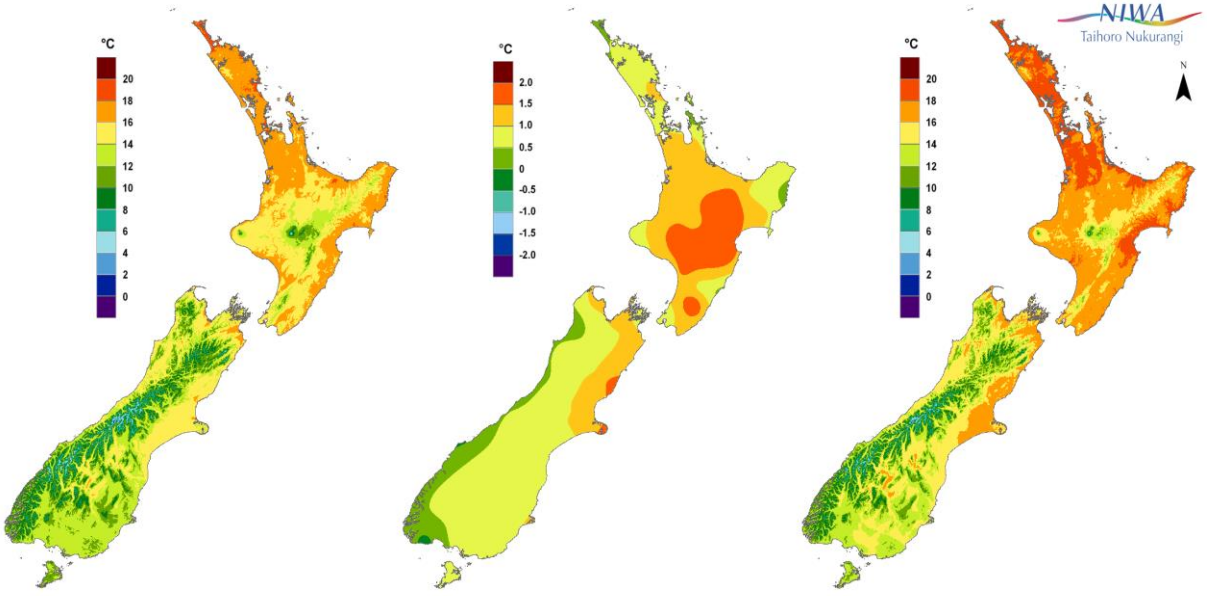


Annual Mean Temperature
9am 01/11 to 9am 01/12
(Based on a 30 year climatology: 1981-2010)

Mean Temperature Anomaly,
9am 01/11/2012 to 9am 01/12/2012

Observed Mean Temperature,
9am 01/11/2012 to 9am 01/12/2012

November 2012



Annual Mean Temperature
9am 01/12 to 9am 01/01
(Based on a 30 year climatology: 1981-2010)

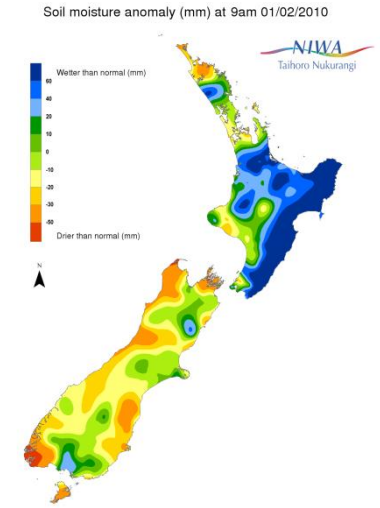
Mean Temperature Anomaly,
9am 01/12/2012 to 9am 01/01/2013

Observed Mean Temperature,
9am 01/12/2012 to 9am 01/01/2013

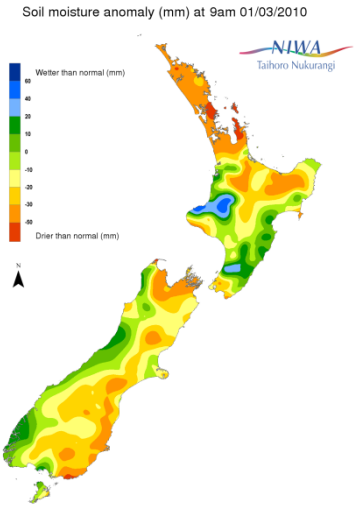
December 2012

Soil moisture deficits

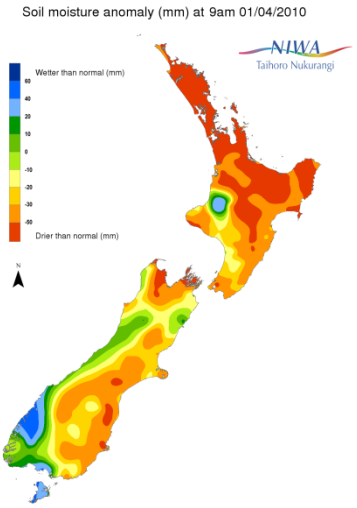
2010



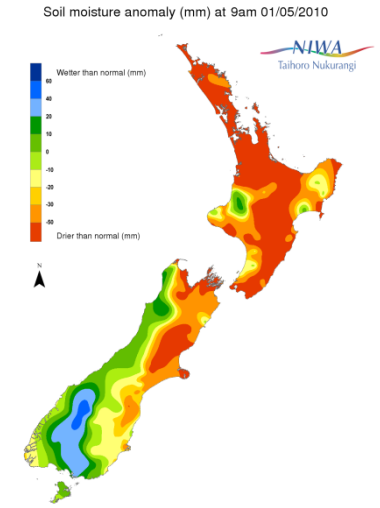
January 2010



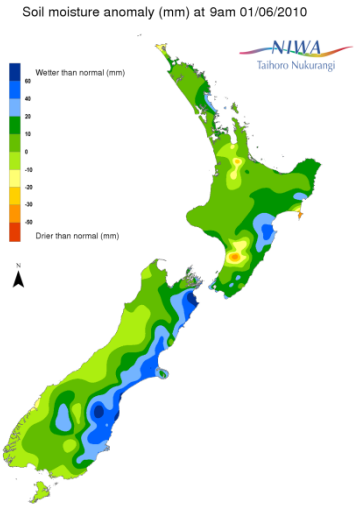
February 2010



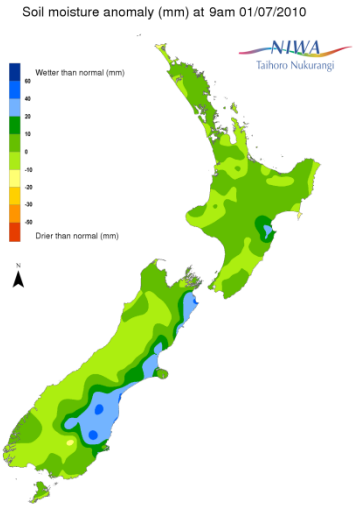
March 2010



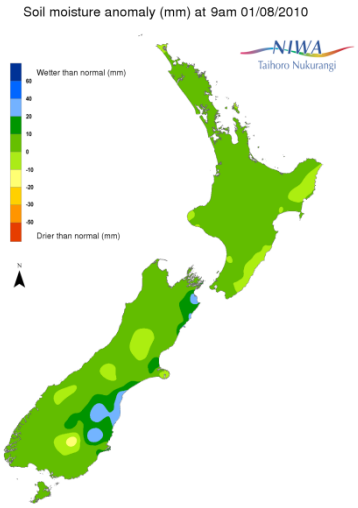
April 2010



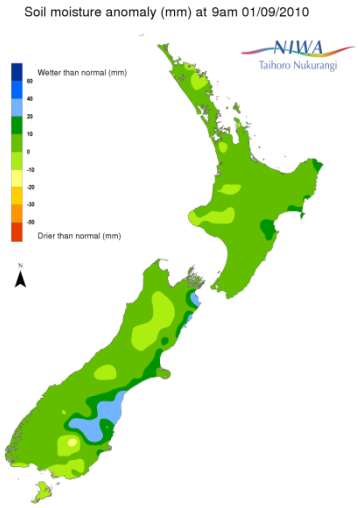
May 2010



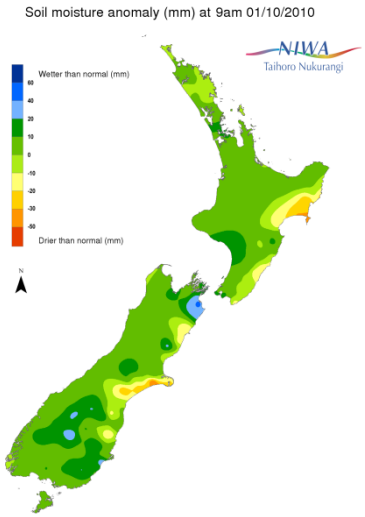
June 2010



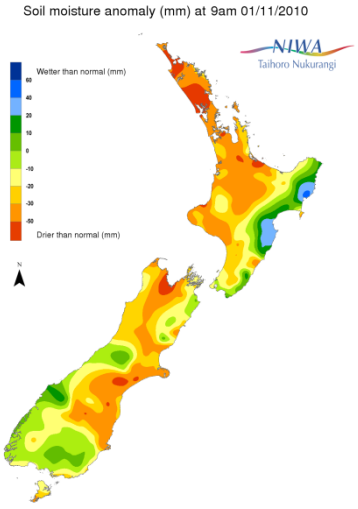
July 2010



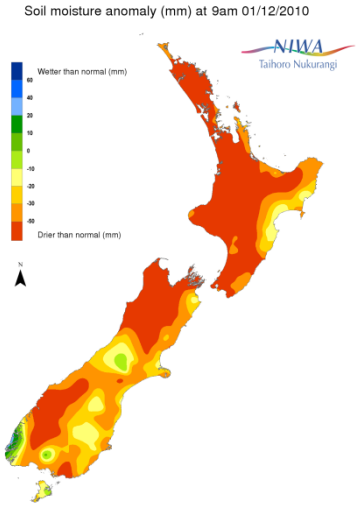
August 2010



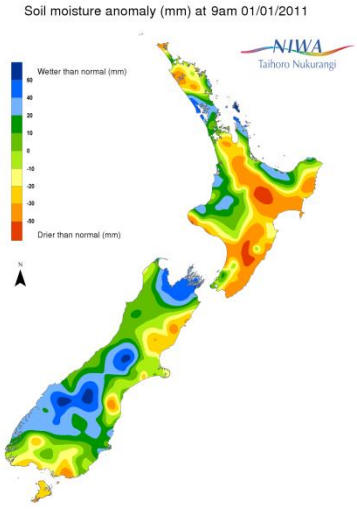
September 2010



October 2010

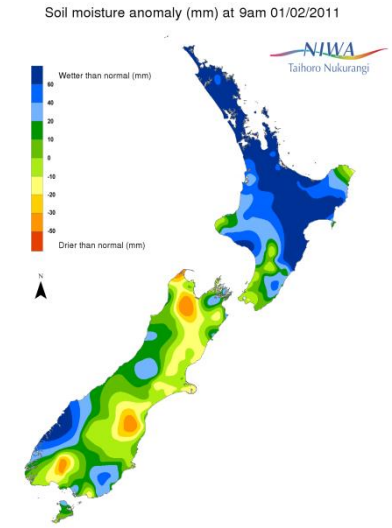


November 2010

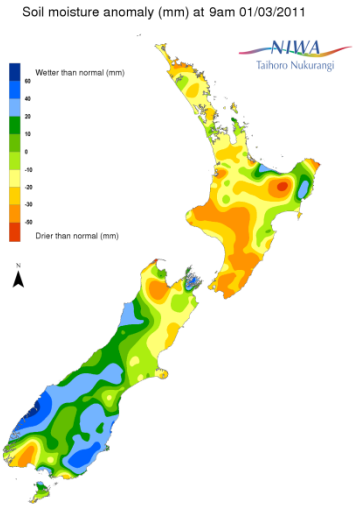


December 2010

2011



January 2011



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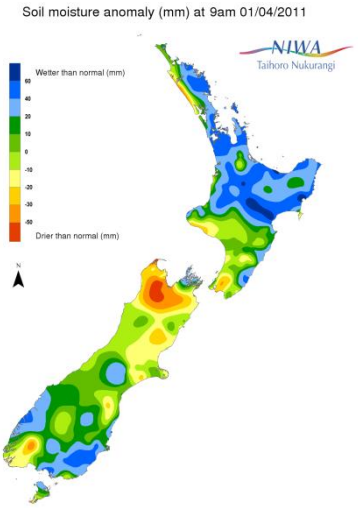

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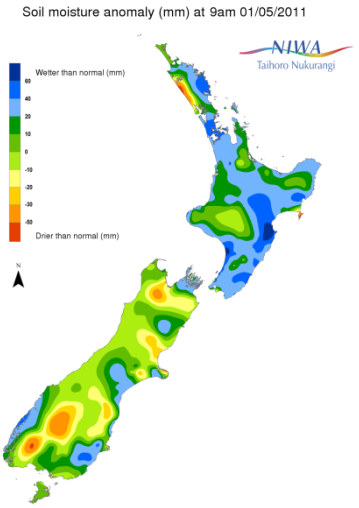

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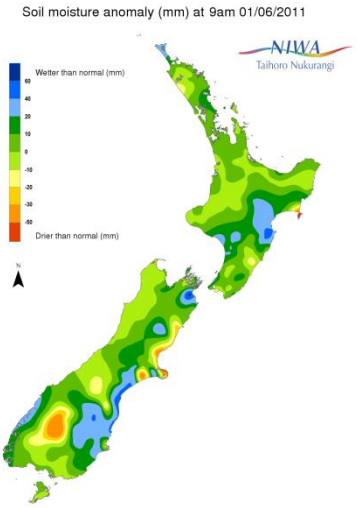

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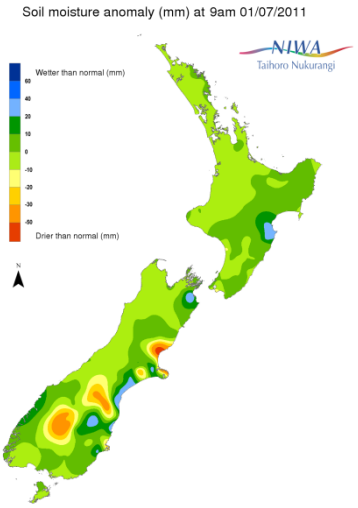

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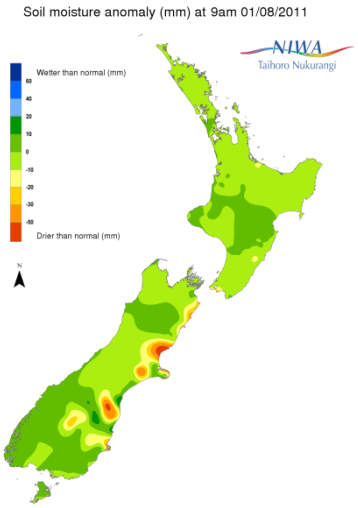

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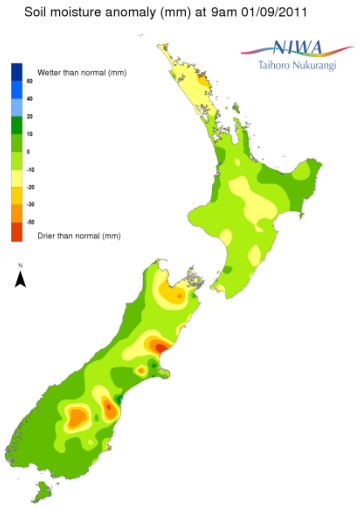

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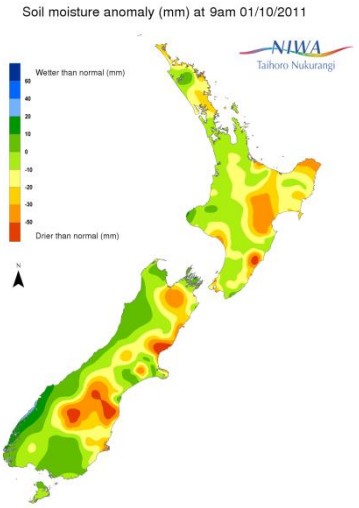

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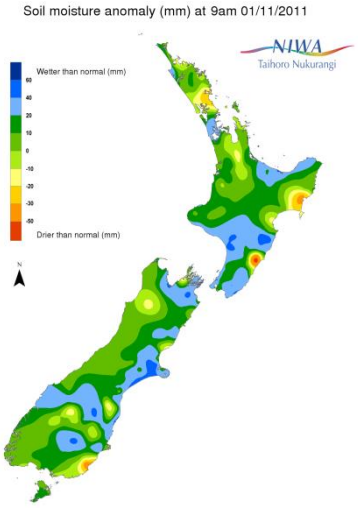

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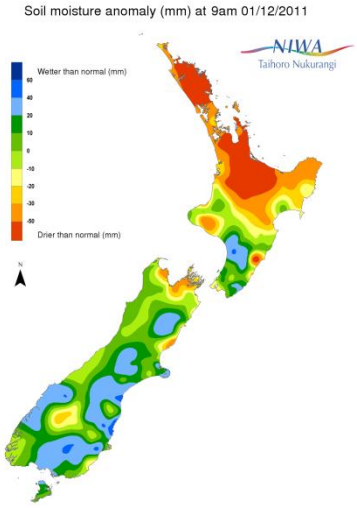

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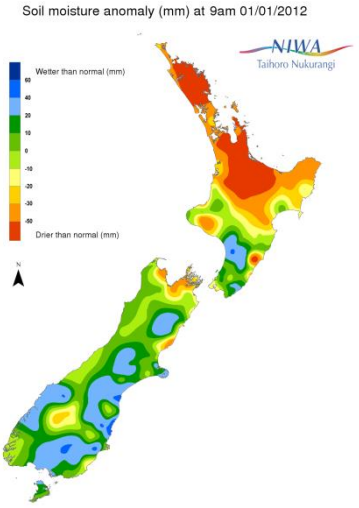
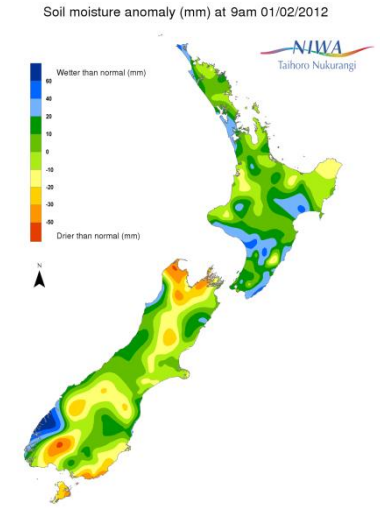


December 2011

2012



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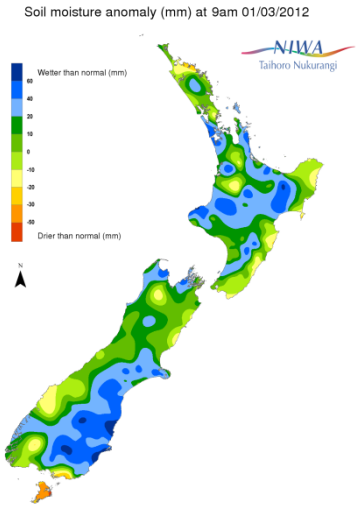

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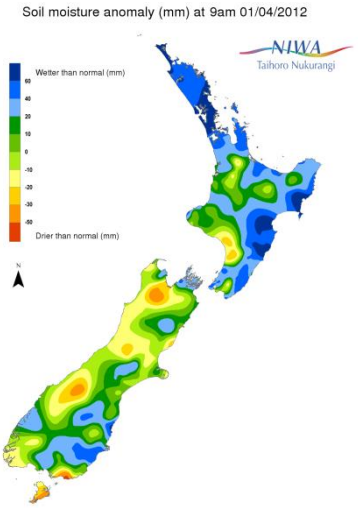

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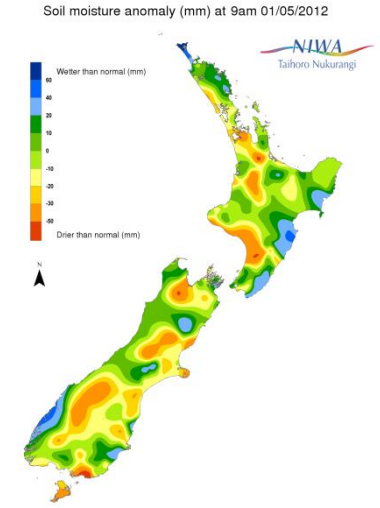

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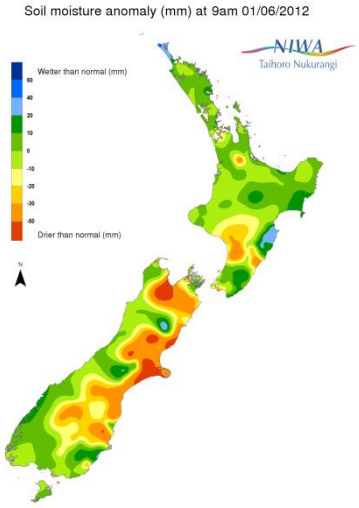

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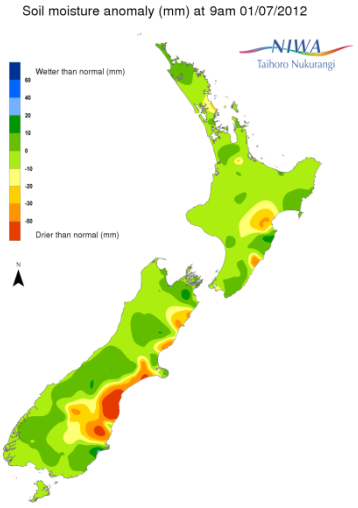

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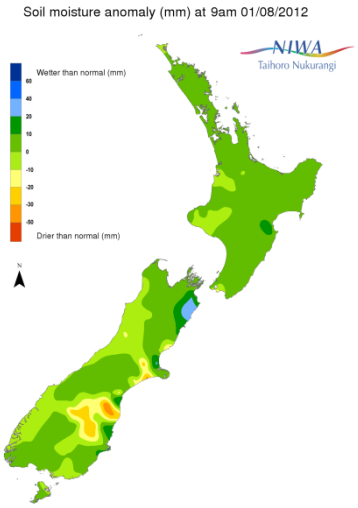

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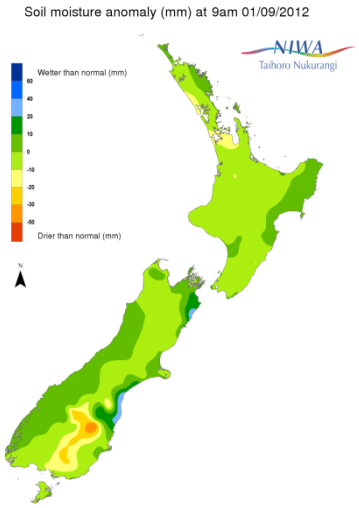

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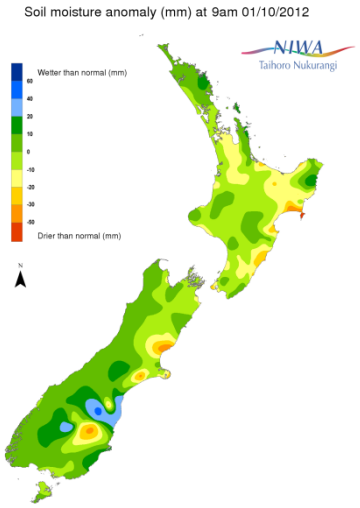

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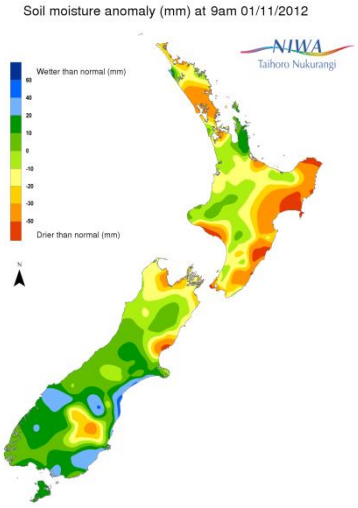

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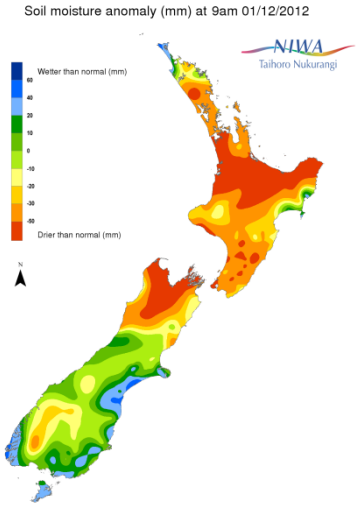

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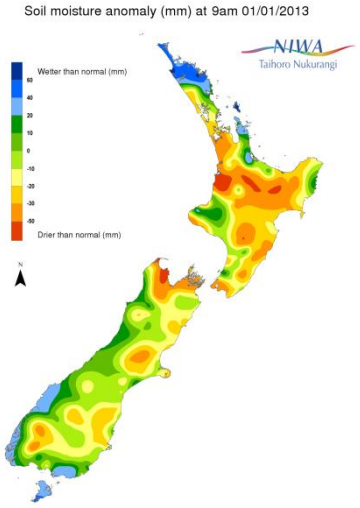

December 2012