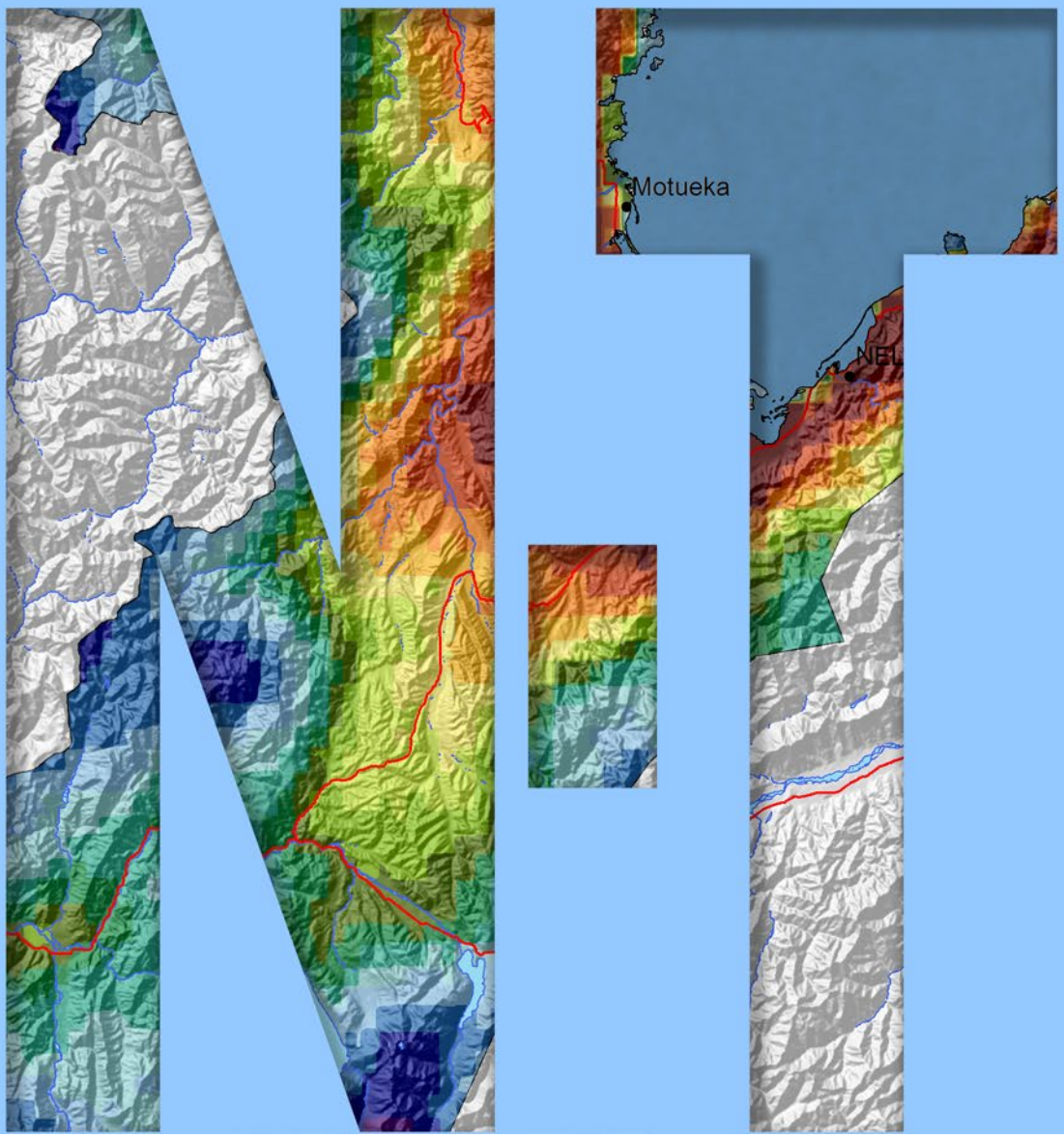
NIWA
Taihoro Nukurangi

THE CLIMATE AND WEATHER OF NELSON AND TASMAN

2nd edition

G. R. Macara



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Note to Second Edition

This publication replaces the first edition of New Zealand Meteorological Service Miscellaneous Publication 115 (3), written in 1965 by J. F. de Lisle and I. S. Kerr. It was considered necessary to update the first edition, incorporating more recent data and updated methods of climatological variable calculation.

THE CLIMATE AND WEATHER OF THE NELSON AND TASMAN DISTRICT

2nd edition

G. R. Macara

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SUMMARY

Nelson City and Tasman District are located in the most north-westerly part of the South Island and generally are the first to be influenced by weather systems moving onto the island from the north. The area is well exposed to these systems, whereas it is sheltered a great deal from systems arriving from the south. The region is situated in the latitudes of prevailing westerlies, and parts around the north-western tip (e.g. Farewell Spit) often experience strong winds, but the winds are lighter elsewhere. Rainfall is fairly evenly distributed across the year, although February and March are typically the driest months of the year whereas the wettest months are observed in winter or spring. Parts of the Tasman Mountains receive in excess of 6000 mm of annual rainfall. Nelson and the Waimea Plain are the driest areas of the region, and are well sheltered from rain-bearing systems arriving from the west and south. Here, annual rainfall totals of approximately 1000 mm are recorded. Dry spells of more than two weeks are quite common, particularly in eastern and inland locations. Temperatures are mild compared with the rest of the country, with the region's close proximity to the sea resulting in a relative lack of extreme high and extreme low temperatures. Temperatures exceeding 30°C are rare in coastal areas. Frosts are quite common in the cooler months, however they occur less frequently than most other South Island locations. Nelson and Tasman are renowned for receiving a great deal of sunshine, particularly in Nelson City itself where average annual sunshine hours (approximately 2,400 hours) are among the highest recorded in New Zealand.

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INTRODUCTION

New Zealand spans latitudes 34 to 47 degrees south, and so lies within the Southern Hemisphere temperate zone. In this zone, westerly winds at all levels of the atmosphere move weather systems, which may also be either decaying or developing, eastwards over New Zealand giving great variability to its weather. These prevailing westerlies sometimes abate, and air from either tropical or polar regions may reach New Zealand with heavy rainfalls or cold showery conditions, respectively. The features of Nelson City and Tasman District's climate which differentiate it from that of other areas in central New Zealand can be accounted for by the topography of the area. The Waimea Plain lies north-east to south-west in orientation, and is open to Tasman Bay. Together with the coastal strip around Golden Bay and the Takaka Valley, they form the only extensive lowland areas in the region. The plains are sheltered both from the prevailing westerly winds and from winds from an easterly and southerly direction. This results in a sunny, mild climate, which is less windy than most other areas in New Zealand but prone to frost in sheltered locations. The rainfall, which is typically adequate for spring pasture growth, is liable to be insufficient in summer and early autumn when extended dry spells and occasionally drought can occur.

The Nelson City and Tasman District area (Figure 1) is comprised of the coastal margins of the north-western South Island, from low elevation locations adjacent to the Tasman Sea, Golden Bay and Tasman Bay, to higher elevations farther south including the Tasman Mountains and Nelson Lakes National Park. The landscapes of the regions are diverse, which combined with the variety of activities available make the regions a popular tourist destination.

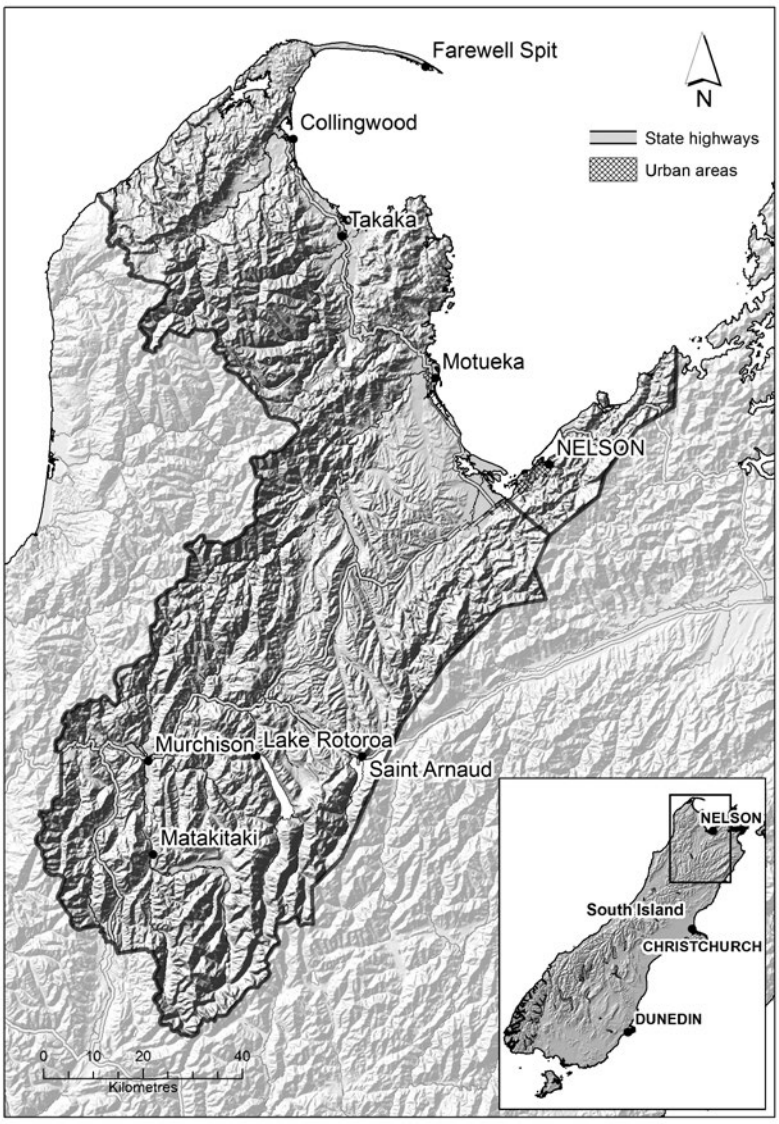

Figure 1. Map of Nelson City and Tasman District, showing the places mentioned in this publication.

Note that all numbers given in the following tables are calculated from the 1981-2010 normal period (a normal is an average or estimated average over a standard 30-year period), unless otherwise stated. Also note that throughout this publication, 'Nelson and Tasman' is used to define the entire region shown in Figure 1, comprising Nelson City and Tasman District.

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TYPICAL WEATHER SITUATIONS IN NELSON AND TASMAN

New Zealand lies in the zone of mid-latitude westerlies where a succession of depressions (lows) and subtropical anticyclones (highs) generally progress eastwards over the country. Often, a trough of low pressure separates two highs, and it usually contains a frontal system, which extends into one or more lows on the southern side of the highs. As the highs move east, New Zealand experiences a regular weather sequence, which has a period of about a week. The path followed by the centre of an anticyclone may be to the north of New Zealand, across the country, or occasionally to the south. The first type of track is more likely in winter and spring and the other types are more likely in summer and autumn. It is unusual for an anticyclone to move from Australia across the Tasman Sea and out to the east without a change in its intensity, speed and direction of movement. These changes are closely related to developments in the low-pressure trough which is an unstable region where vigorous storms sometimes form. The storms are depressions which typically form in the north-west Tasman Sea. From there they tend to move in a south-east direction, growing in intensity as they move, and frequently cross or pass near the North Island. Another less frequent type of storm which may affect New Zealand is the ex-tropical cyclone which forms in the south-west Pacific in the months from November to April. The air in an ex-tropical cyclone is still warm and moist by the time the storm reaches New Zealand due to its long passage over tropical waters, and the resulting rainfall may be especially heavy.

The weather in Nelson and Tasman is dominated by migratory anticyclones and intervening troughs of low pressure. The majority of anticyclones passing over New Zealand are centred to the north of Cook Strait, and the wind flow in the lower atmosphere over Nelson and Tasman is generally from a westerly quarter. However, at the surface the wind direction is modified by topographical influences. For example, a general westerly flow over central New Zealand produces strong north-west winds through the funnel of Cook Strait, but in Tasman Bay the wind direction swings around to the north or north-east. Although many different weather situations are possible in Nelson and Tasman, they tend to fall into only a few characteristic categories: (a) fine weather spells, (b) heavy rain, and (c) showery weather.

Fine weather spells

Prolonged spells of fine weather of five days or more are usually associated with a large anticyclone moving slowly eastwards over New Zealand. If a depression develops to the north or north-east of the North Island a ridge of high pressure may still extend over the upper South Island when the anticyclone is centred far to the east or south-east. This type of situation is shown in Figure 2. Fine, sunny weather and light winds typically prevail over Nelson and Tasman during such periods, although there are some exceptions. For example, fresh sea breezes can occur along coastal areas, especially during summer. Additionally, anticyclones support the development of low cloud or fog in inland parts of Tasman, chiefly during May to September.

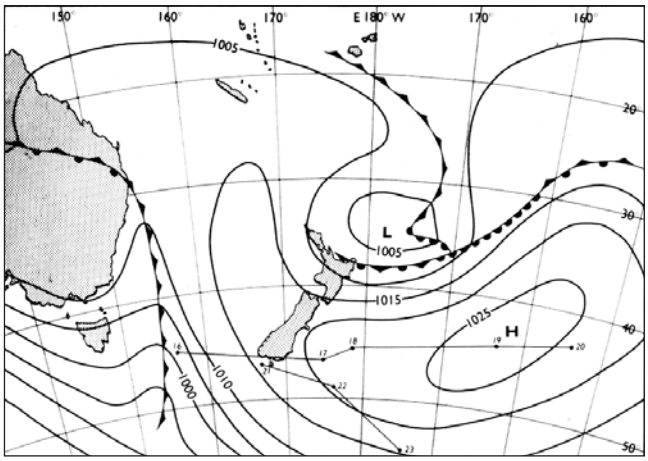

Figure 2. Mean sea level pressure analysis for 1200 hrs NZST on 19 November 1960.

Heavy rain

Prolonged periods of heavy rain occur most commonly when there is a large, slow-moving anticyclone east of New Zealand and a deep depression in the eastern Tasman Sea. This results in a strong northerly flow of air over New Zealand, which may be warm and moist if the air is of tropical origin. The period of 17 to 19 May 1965 (Figure 3) was typical of this type of situation. Rain began to fall in Nelson around midday on 17 May and continued for approximately two days, reaching its greatest intensity on the morning of 18 May. Total rainfall for the period in Nelson was 42.7 mm, and Takaka recorded 60.7 mm. The hills and ranges of the region provided shelter for locations farther south, such that Murchison only recorded 7.1 mm of rain during this time.

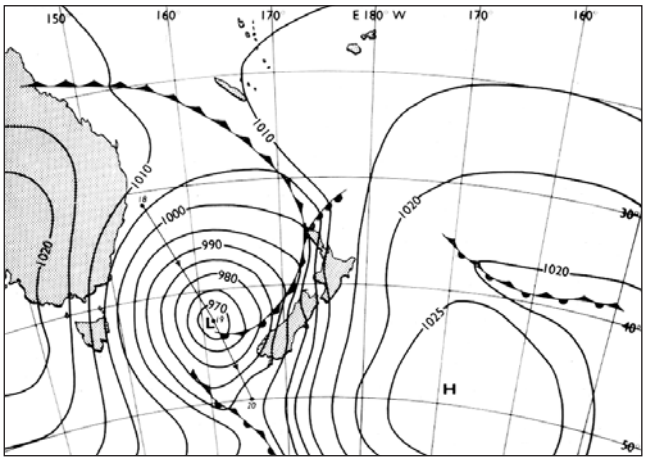

Figure 3. Mean sea level pressure analysis for 0600 hrs NZST on 19 May 1965.

Brief periods of rain

Brief periods of rain in Nelson and Tasman are typically associated with the northward passage of a cold front over New Zealand. In western parts the rain may last for several hours and amount to 10 to 25 mm or more. In eastern parts the duration and amount of rainfall is likely to be much less, and occasionally there may be no rain at all. Such a situation is shown in Figure 4. Here, a cold front lying in the trough of low pressure between two eastward moving anticyclones was situated just north of the South Island at 6 p.m. on 26 April 1965. Nelson remained dry for much of the day on 26 April, until 3.4 mm of rain was recorded between 5 p.m. and 7 p.m. Only 0.4 mm of rain was recorded over the remainder of the night. Farther north-west, Takaka recorded a total of 7.4 mm of rain on 26 April.

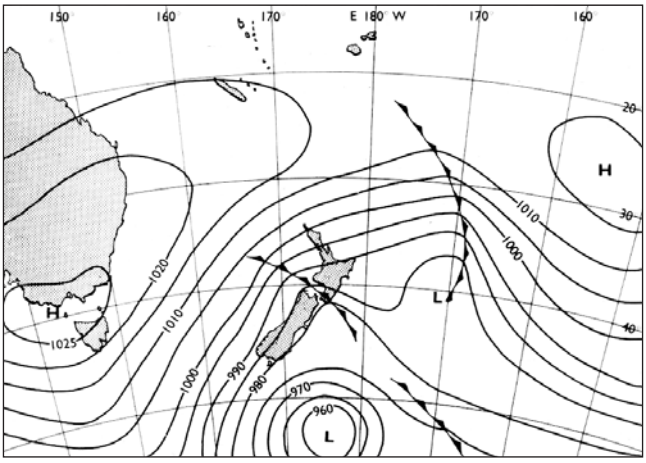

Figure 4. Mean sea level pressure analysis for 1800 hrs NZST on 26 April 1965.

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CLIMATIC ELEMENTS

Wind

Wind direction over New Zealand in the zone directly above the Earth's surface may be interpreted from a mean sea level pressure (MSLP) map, following the general principle that in the Southern Hemisphere air flows in a clockwise direction around a depression (or a 'low'), and in an anticlockwise direction around an anticyclone (or a 'high'). As such, MSLP maps can be used to indicate the general wind direction at the Earth's surface. However, actual wind direction and speed at a particular locality is modified by the influence of friction and topography. Sea breezes develop along coastal parts of Nelson and Tasman when synoptic-scale pressure gradients are weak, and are generated by air temperatures over land becoming higher than air temperatures over the sea. These sea breezes may develop throughout the year, but are most common in summer and least common in winter. Figure 5 shows mean annual wind frequencies of surface wind based on hourly observations from selected Nelson and Tasman locations.

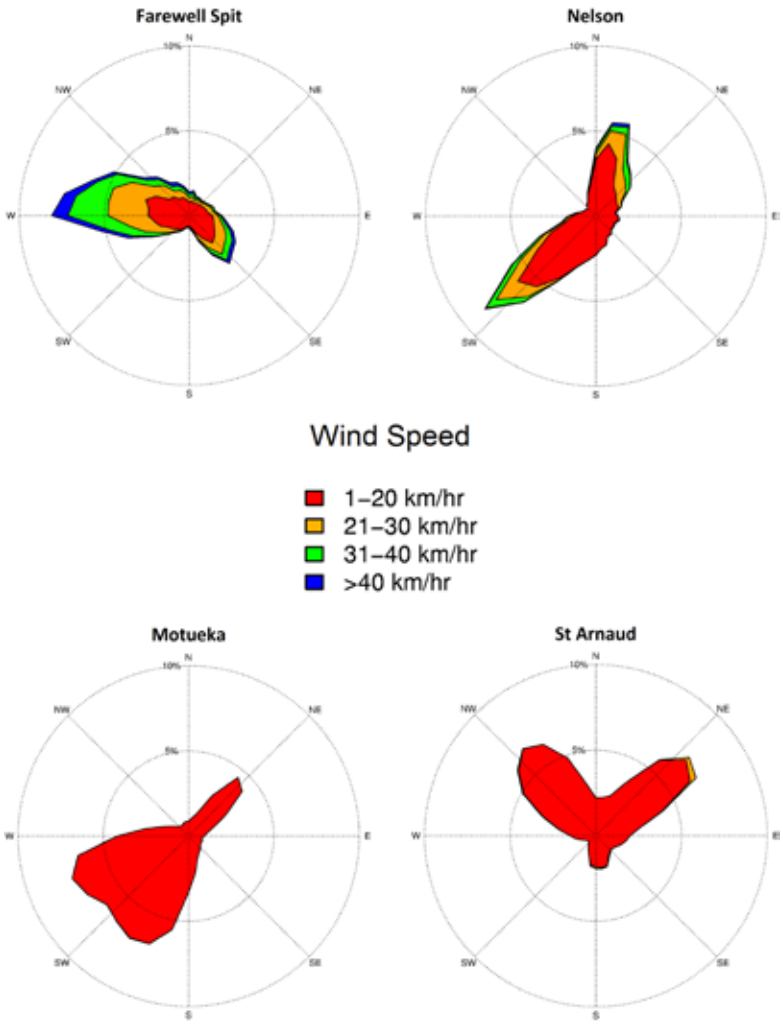

Figure 5. Mean annual wind frequencies (%) of surface wind directions from hourly observations at selected Nelson and Tasman stations. The plot shows the directions from which the wind blows, e.g. the dominant wind direction at Farewell Spit is from the west.

Mean wind speed data (average wind speeds are taken over the 10 minute period preceding each hour) are available for a number of Nelson and Tasman locations, and these illustrate the several different wind regimes of the region (Table 1). Mean wind speeds are highest at exposed coastal locations such as Farewell Spit, and lowest at inland and sheltered locations. There is notable variability in mean monthly wind speeds over the course of a year in Nelson and Tasman, where wind speeds are typically highest from around mid-spring (October) to mid-summer (January), and lowest from mid-autumn to the end of winter (April to August).

Table 1. Mean monthly and annual wind speed (km/hr) for selected Nelson and Tasman locations, from all available data.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Farewell Spit	21.3	19.7	20.0	19.0	19.6	19.9	19.9	19.7	22.3	24.7	25.1	22.6	21.2
Nelson	14.3	12.4	12.3	10.0	9.6	8.8	8.3	9.6	11.7	14.2	14.9	14.8	11.7
St Arnaud	9.1	8.4	8.3	6.8	6.6	6.5	6.9	6.2	6.8	8.7	8.7	8.1	7.6
Murchison	7.9	7.6	6.9	6.0	5.9	6.2	6.0	6.5	7.4	8.4	9.2	8.1	7.2
Motueka	5.6	5.1	4.9	4.1	4.0	4.0	4.2	4.5	5.1	5.9	6.1	5.9	5.0

Table 2 gives the seasonal distribution and frequency of occurrence of strong winds (defined as having a daily mean wind speed of greater than 30 km/hr). For example, of all strong winds recorded at Nelson, 30% (nine strong wind days, on average) occur in summer. As a further example, Farewell Spit and Motueka share the same distribution of strong winds in winter, with 25% of their respective annual strong winds being recorded in that season. However, Farewell Spit has an average of 16 strong wind days in winter, compared to less than one such day in Motueka. This highlights that although a similar seasonal distribution of strong winds may be observed between different locations in Nelson and Tasman, the actual number of strong wind days per season at those locations may be considerably different. St Arnaud and Murchison are well sheltered by the surrounding mountains, and strong wind days at these locations are exceptionally rare. As shown in Tables 1 and 2, spring and summer are typically the windiest seasons throughout the region.

Table 2. Seasonal distribution and frequency (mean number of days) of strong winds (daily mean wind speed > 30 km/hr) recorded at selected Nelson and Tasman locations, from all available data.

Location	Summer		Autumn		Winter		Spring		Annual Frequency
	Distribution	Frequency	Distribution	Frequency	Distribution	Frequency	Distribution	Frequency	
Farewell Spit	23%	15	20%	13	25%	16	32%	21	65
Nelson	30%	9	21%	6	13%	4	36%	11	30
Motueka	26%	0.6	17%	0.4	25%	0.6	31%	0.7	2
St Arnaud	0%	0	0%	0	0.6%	0.6	0%	0	0.6
Murchison	0%	0	0%	0	0%	0	0%	0	0

Diurnal variation in wind speed is well-marked, with highest wind speeds occurring mid-afternoon before decreasing overnight. This is because heating of the land surface is most intense during the day, and stronger winds aloft are brought down to ground level by turbulent mixing. Cooling at night generally restores a lighter wind regime. Table 3 gives average wind speeds at three-hourly intervals for selected locations, whilst Figure 6 visually highlights the typical diurnal variation of wind speed observed throughout Nelson and Tasman.

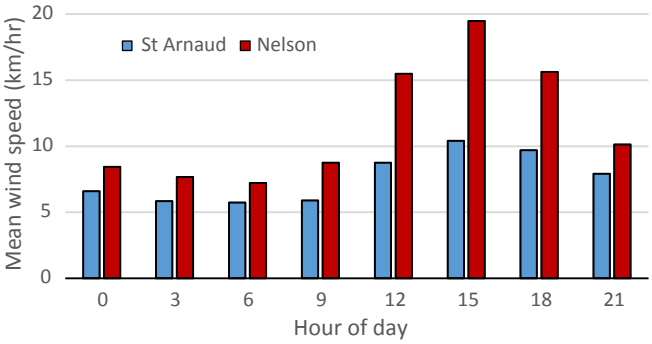

Figure 6. Mean wind speed at selected hours of the day for Nelson and St Arnaud.

Table 3. Mean wind speed (km/hr) at three-hourly intervals of the day.

Location	0000	0300	0600	0900	1200	1500	1800	2100
Farewell Spit	19.7	18.8	18.2	18.5	21.5	24.0	22.8	20.6
Motueka	4.4	4.0	3.9	5.7	7.0	8.3	7.1	5.2
Murchison	5.9	5.5	5.4	5.9	7.5	9.4	9.5	7.9
Nelson	8.4	7.7	7.2	8.8	15.5	19.5	15.6	10.1
St Arnaud	6.6	5.8	5.7	5.9	8.7	10.4	9.7	7.9

Gusty winds are relatively infrequent throughout most lowland Nelson and Tasman locations, occurring more frequently in the mountain ranges and exposed coastal locations. Nelson experiences an average of 38 days per year with wind gusts exceeding 61 km/hr, considerably less than Farewell Spit where on average 106 such days per year are recorded (Table 4). Maximum gusts recorded at Nelson and Farewell Spit are listed in Table 5. The highest gust recorded in Nelson was 139 km/hr on 12 March 1975.

Table 4. Mean number of days per year with gusts exceeding 61 km/hr (33 knots) and 94 km/hr (50 knots) for selected locations.

Location	Gusts >61 km/hr	Gusts >94 km/hr
Farewell Spit	106	4
Nelson	38	0.7
St Arnaud	6	0

Table 5. Highest recorded wind gusts at Farewell Spit and Nelson, from all available data.

Location	Gust (km/hr)	Direction	Date
Farewell Spit	127.8	W	17/05/1977
Nelson	139.0	ESE	12/03/1975

Rainfall

Rainfall distribution

Nelson and Tasman's median annual rainfall is shown in Figure 7, which clearly illustrates how rainfall is affected by topography and exposure to the main rain-bearing airflows from the west. Rainfall is highest in the Tasman Mountains which have both high elevation and western exposure. This is the result of orographic enhancement. Specifically, moisture-laden air masses passing over the Tasman Sea are forced to rise over the western ranges. As these air masses rise, they cool rapidly, causing the stored water vapour to condense, resulting in rainfall. The air masses continue eastwards, but they hold significantly less moisture once beyond the western ranges. As a result, there is a marked decrease eastwards in median annual rainfall. Nelson and the Waimea Plain are the driest areas of the region, as they are well sheltered from rain-bearing systems arriving from the west and south. Here, annual rainfall totals of around or just below 1000 mm are typically recorded.

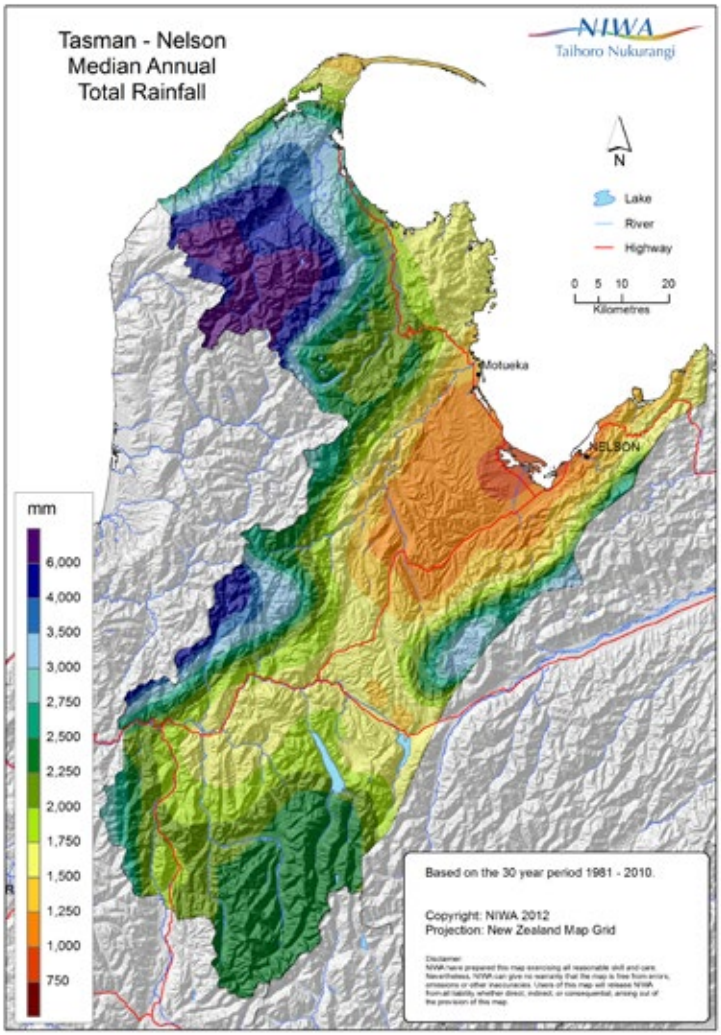

Figure 7. Nelson and Tasman median annual total rainfall, 1981–2010.

Table 6 lists monthly rainfall normals and the percentage of annual total for selected locations. Rainfall is fairly evenly distributed throughout the year at all locations, although February and March are typically the driest months of the year whereas the wettest months are observed in winter or spring. The distribution of monthly rainfall is shown in Figure 8. The 10th percentile, 90th percentile, and mean rainfall values for each month are shown along with maximum and minimum recorded values for several stations.

Table 6. Monthly and annual rainfall normal (a; mm), and monthly distribution of annual rainfall (b; %) at selected Nelson and Tasman locations, for the period 1981 – 2010.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Collingwood	a	258	200	210	239	304	326	246	302	324	399	276	288	3371
	b	8	6	6	7	9	10	7	9	10	12	8	9	
Farewell Spit	a	92	69	77	94	118	148	102	108	138	98	80	89	1212
	b	8	6	6	8	10	12	8	9	11	8	7	7	
Lake Rotoroa	a	138	133	165	107	155	173	169	144	184	207	153	206	1934
	b	7	7	9	6	8	9	9	7	9	11	8	11	
Matakitaki	a	138	108	117	128	142	198	144	169	170	218	166	159	1856
	b	7	6	6	7	8	11	8	9	9	12	9	9	
Motueka	a	82	86	95	106	116	141	131	144	122	117	99	104	1341
	b	6	6	7	8	9	11	10	11	9	9	7	8	
Murchison	a	121	83	94	125	127	171	145	141	156	169	142	147	1620
	b	7	5	6	8	8	11	9	9	10	10	9	9	
Nelson	a	77	64	71	81	82	92	78	82	85	87	78	84	959
	b	8	7	7	8	9	10	8	9	9	9	8	9	
St Arnaud	a	121	105	111	110	121	144	115	124	147	162	124	164	1548
	b	8	7	7	7	8	9	7	8	9	10	8	11	
Takaka	a	131	118	141	156	162	203	196	183	197	198	159	168	2012
	b	7	6	7	8	8	10	10	9	10	10	8	8	

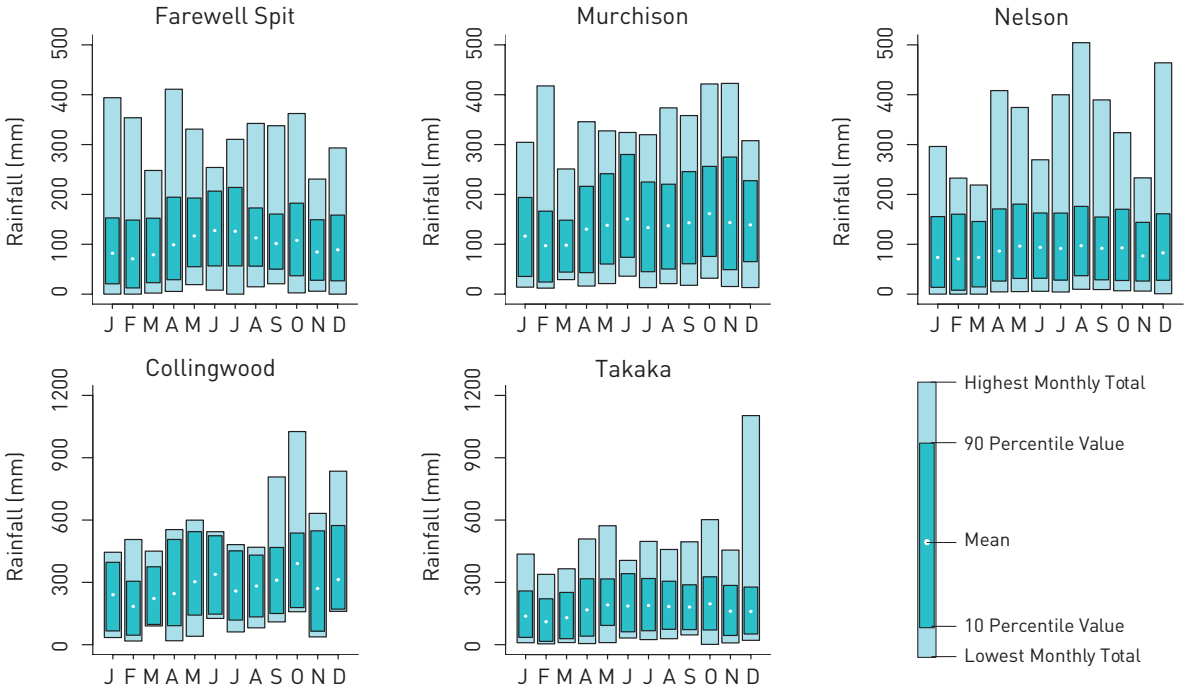

Figure 8. Monthly variation of rainfall for selected Nelson and Tasman locations from all available data.

Rainfall variability is further indicated by rainfall deciles, as given in Tables 7, 8 and 9. The 10th percentile values show the accumulated rainfalls that will normally be exceeded in nine out of ten years, whilst the 90th percentile values indicate the accumulated falls that will normally be exceeded in only one year in ten. The tables include periods from one month to twelve months (annual), with each time period that is longer than one month beginning with the month stated. For example, using the table for Nelson (Table 8), it can be seen that in the three month period beginning in January, 104 mm or more of rainfall can be expected in nine years in ten, while a total of 353 mm or more should occur, on average, in only one year in ten.

Table 7. Rainfall means and deciles at monthly, 3-monthly, 6-monthly, 9-monthly and annual intervals for Murchison from all available data.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Murchison												
1 month												
90th	194	166	148	216	242	280	225	221	246	256	275	228
Mean	116	97	98	130	138	151	134	137	143	162	144	139
10th	35	24	44	43	60	74	45	50	61	76	49	65
3 months												
90th	438	481	512	555	562	557	595	651	597	586	567	497
Mean	313	326	368	418	422	422	414	443	450	444	400	353
10th	192	210	235	282	305	281	236	279	267	281	254	246
6 months												
90th	926	951	967	1031	1073	1096	1112	1054	1041	980	982	922
Mean	732	747	788	832	863	871	859	845	805	756	726	723
10th	559	573	627	662	669	639	627	606	594	561	547	565
9 months												
90th	1422	1442	1510	1532	1496	1472	1426	1427	1431	1429	1424	1395
Mean	1146	1187	1236	1277	1266	1228	1174	1174	1176	1176	1148	1144
10th	920	919	944	1009	1018	912	901	951	955	935	917	955
Annual												
90th	1920											
Mean	1593											
10th	1290											

Table 8. Rainfall means and deciles at monthly, 3-monthly, 6-monthly, 9-monthly and annual intervals for Nelson from all available data.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Nelson												
1 month												
90th	149	142	146	174	170	159	151	161	146	167	145	159
Mean	73	67	74	87	94	92	88	93	88	90	77	82
10th	14	8	18	25	32	32	27	33	29	26	26	28
3 months												
90th	353	362	388	372	408	405	382	415	359	369	370	348
Mean	215	229	255	273	275	274	270	272	256	249	231	221
10th	104	136	138	159	176	166	148	157	148	131	129	114
6 months												
90th	651	682	740	735	728	719	707	680	636	638	644	676
Mean	487	503	530	543	547	529	520	505	477	465	460	475
10th	320	339	354	378	378	336	360	348	300	305	315	307
9 months												
90th	1005	1027	1075	1069	1019	999	960	947	936	934	941	1004
Mean	759	775	785	793	780	751	738	735	733	736	731	746
10th	547	557	523	560	575	512	510	522	519	539	554	544
Annual												
90th	1321											
Mean	1010											
10th	756											

Table 9. Rainfall means and deciles at monthly, 3-monthly, 6-monthly, 9-monthly and annual intervals for Takaka from all available data.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Takaka												
1 month												
90th	259	221	252	317	317	342	319	305	288	327	285	277
Mean	138	111	130	168	192	186	189	183	181	196	161	160
10th	35	16	29	41	93	62	67	74	73	71	44	51
3 months												
90th	615	597	730	810	787	723	750	794	821	822	722	624
Mean	383	408	486	543	562	558	554	562	540	518	462	412
10th	206	213	276	332	371	369	369	361	358	298	243	218
6 months												
90th	1224	1258	1303	1334	1415	1466	1444	1399	1305	1251	1199	1155
Mean	929	976	1044	1092	1126	1103	1083	1032	950	909	881	905
10th	676	672	741	837	803	783	765	739	653	556	592	613
9 months												
90th	1852	1908	1994	2101	1929	1944	1889	1814	1860	1844	1819	1836
Mean	1481	1535	1585	1617	1600	1521	1475	1442	1432	1453	1441	1462
10th	1118	1119	1149	1205	1176	1106	1070	1046	1092	1080	1135	1151
Annual												
90th	2577											
Mean	2006											
10th	1539											

Rainfall frequency and intensity

Table 10 lists the average number of days per month with at least 0.1 mm (a 'rain day') and at least 1 mm (a 'wet day') of rain for selected locations. The number of rain and wet days recorded at a given station tends to be higher towards the south of the region, and lower near the coast of Tasman Bay. The average number of rain days each year varies from 130 days at Nelson to 179 days at Matakitaki. Nelson and Motueka exhibit the lowest number of wet days in the region, with 95 and 101 wet days recorded on average respectively, compared with 143 wet days at Matakitaki. A seasonal variation of rain days and wet days is present in most Nelson and Tasman locations, with a maximum occurring in spring. This may be attributed to the seasonal changes in the general circulation of the Southern Hemisphere. Specifically, westerly air flows over New Zealand may be intensified by development and southward movement of the belt of subtropical anticyclones which in turn are associated with changes in the principal upper-air hemispheric jet stream. The seasonal changes in the general circulation of the Southern Hemisphere result in a maximum frequency of disturbed westerly situations in spring (Reid, 1980).

Heaviest short period rainfalls in Nelson and Tasman are typically recorded at relatively high elevations in river catchments, which often occur when persistent northerly/northwesterly airflows are established as a trough approaches the South Island. For remaining areas of Nelson and Tasman, heavy short period rainfalls occur with the passage of a depression over or close to the region (e.g. Figure 3), or in association with slow moving fronts, especially when the air has originated from tropical regions. In Table 11, maximum short period rainfalls for periods of 10 minutes to 72 hours with calculated return periods are given for Nelson and Takaka. Also listed in this table are the maximum rainfalls expected in 2, 5, 10, 20, and 50 years. Depth-duration frequency tables for Nelson and Tasman locations are available from NIWA's High Intensity Rainfall Design System (HIRDS). HIRDS uses the index-frequency method to calculate rainfall return periods. For more information on methods and to use the tool, see http://hirds.niwa.co.nz/.

Table 10. Average monthly rain days (a; days where at least 0.1 mm rainfall is measured) and wet days (b; days where at least 1 mm rainfall is measured) at selected Nelson and Tasman locations.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Collingwood	a	10	9	10	11	14	14	14	15	16	17	13	14	159
	b	10	9	9	10	13	14	13	14	15	16	11	13	148
Farewell Spit	a	8	7	9	10	12	13	13	13	12	13	11	10	133
	b	7	6	7	9	10	11	11	11	10	11	9	9	112
Matakitaki	a	13	11	12	12	16	16	15	16	18	19	15	17	179
	b	10	8	9	10	12	14	12	12	14	15	12	14	143
Motueka	a	8	7	9	10	12	13	13	13	14	13	11	10	132
	b	6	5	7	8	9	9	10	10	11	10	8	8	101
Murchison	a	12	10	11	13	14	14	14	15	16	17	15	15	167
	b	10	8	9	11	12	11	11	12	13	14	13	13	138
Nelson	a	9	8	9	10	11	11	11	13	12	13	12	11	130
	b	7	6	7	7	8	8	8	9	9	9	8	8	95
Takaka	a	9	8	9	10	12	12	13	13	13	14	12	12	137
	b	7	6	8	9	10	11	11	11	12	11	10	10	117

Table 11. Maximum recorded short period rainfalls and calculated return periods (or average recurrence intervals, ARI) from HIRDS.

Location		10min	20min	30min	1hr	2hrs	6hrs	12hrs	24hrs	48hrs	72hrs
Nelson	a	16.5	22.3	29.5	43.0	62.8	118.9	137.3	143.7	159.5	179.5
	b	Mar 1963	Apr 1990	Feb 1964	Jan 1985	Jan 1985	Jan 1985	Jan 1985	Jan 1985	Aug 1970	Aug 1970
	c	43	28	34	30	50	100+	89	32	27	31
	d	7.5	11.3	14.2	21.3	28.2	43.9	58.1	76.8	88.9	96.9
	e	9.8	14.6	18.5	27.8	36.4	56.1	73.6	96.6	111.9	121.9
	f	11.6	17.4	22.1	33.1	43.2	65.9	86.1	112.5	130.2	141.9
	g	13.8	20.6	26.1	39.1	50.8	77	100.1	130.2	150.7	164.2
	h	17.1	25.6	32.4	48.6	62.8	94.2	121.7	157.2	182	198.3
Takaka	a	29.0	42.0	53.0	69.1	78.4	156.8	260.7	396.5	606.6	618.7
	b	Jul 1990	Jul 1990	Oct 2013	Oct 2013	Oct 2013	Dec 2011	Dec 2011	Dec 2011	Dec 2011	Dec 2011
	c	100+	100+	100+	59	23	40	85	100+	100+	100+
	d	7.7	12.9	17.3	28.9	42.2	77.1	112.7	164.8	190.9	208.1
	e	10.1	16.8	22.6	37.7	54.6	98.3	142.3	206.2	238.9	260.4
	f	12	20	27	45	64.8	115.4	166.1	239.2	277.2	302.1
	g	14.2	23.7	32	53.3	76.3	134.7	192.7	275.8	319.6	348.3
	h	17.7	29.5	39.8	66.4	94.3	164.4	233.5	331.6	384.2	418.8

a: highest fall recorded (mm)
b: month and year of occurrence
c: calculated return period of a (years)
d: max fall calculated with ARI 2 years (mm)
e: max fall calculated with ARI 5 years (mm)
f: max fall calculated with ARI 10 years (mm)
g: max fall calculated with ARI 20 years (mm)
h: max fall calculated with ARI 50 years (mm)

Recent extreme events in Nelson and Tasman

Nelson and Tasman have experienced numerous extreme weather events, with significant damage and disruption caused by heavy rain and flooding. The events listed below are among the most severe rainfall and flooding events to have affected the Nelson and Tasman region in recent times.

April 2013: A complex low pressure system in the Tasman Sea directed a warm and moist airmass over New Zealand. This clashed with a cold southeasterly airmass, which generated considerable instability and resulted in torrential rainfalls across Nelson and Tasman, particularly in Richmond and Stoke. The rainstorm was one of the most intense ever recorded in the region. The maximum 1-hour rainfall total during the storm was 101 mm in the Roding catchment area near Richmond, a rainfall total which has a 500-year return period in this area. The highest 24-hour rainfall total recorded during the event was 216 mm, recorded at the Tasman District Council office in Richmond. Landslides caused a number of road closures throughout the region, and an estimated 90 homes were flooded. The worst affected area was along Orphanage Creek in Stoke, with many shops suffering stock damage and roads left covered in mud and debris. There was also serious damage to the roads and paths within the Saxton Field sports complex, forcing its closure for more than a week.

December 2011: An active front associated with a low pressure system was preceded by a strong and very humid northeasterly flow, which transported air directly from the sub-tropics to New Zealand. The front moved very slowly eastwards across New Zealand, resulting in very heavy rainfall across Nelson and Tasman. Some exceptionally large rainfall totals were recorded across the region. In Takaka, nearly 400 mm was recorded in just 24 hours and 607 mm in 48 hours, greatly exceeding any previous record at this site. The event was also the largest 48-hour accumulation ever recorded in an urban area in New Zealand, with an estimated return period of 500 years. A state of emergency was declared on 14 December, and the National Crisis Management Centre at Parliament was activated. More than 200 landslides occurred across the region, with Collingwood, Cable Bay, Totaranui and Ligar Bay isolated due to landslides cutting off access roads to those areas. In Nelson and Pohara, 160 and 30 houses were evacuated due to flooding or landslides, respectively. Insurance claims from the event totalled $16.8 million. This event was the primary contributor to record-breaking December rainfall totals throughout the region. Nelson received more than six times and Takaka received more than eight times their normal December rainfall (the highest December totals there since records began in 1941 and 1976, respectively).

Periods of low rainfall

Periods of fifteen days or longer with less than 1 mm of rain on any day are referred to as 'dry spells'. Dry spells are quite common in most areas of Nelson and Tasman, however they occur relatively infrequently in the western-most parts of the region. Dry spells throughout Nelson and Tasman typically occur when a persistent (blocking) anticyclone becomes established over the South Island. Table 12 outlines the dry spell frequency and duration for Nelson and Takaka. On average, a dry spell occurs once every four months in Nelson, and once every six months in Takaka. The longest dry spell was 40 days, recorded in Nelson during May and June in 2008. Table 13 shows the seasonal distribution of dry spells at Nelson and Takaka. Dry spells occur most frequently in summer and least frequently in spring at both locations.

Table 12. Average dry spell (at least 15 consecutive days with less than 1 mm rainfall per day) frequency and duration at Nelson and Takaka, from all available data.

Location	Frequency	Mean duration (days)	Max duration (days)	Max duration date
Nelson	One every 4 months	20	40	13/5/2008 to 21/6/2008
Takaka	One every 6 months	19	35	9/2/2014 to 15/3/2014

Table 13. Seasonal distribution (%) of dry spells at Nelson and Takaka, from all available data.

Location	Summer	Autumn	Winter	Spring
Nelson	34%	28%	20%	18%
Takaka	36%	32%	18%	14%

Temperature

Sea surface temperature

Monthly mean sea surface temperatures (SST) off the coast of Nelson are compared with mean air temperature for Nelson and Murchison in Figure 9. There is a lag in the increase of sea surface temperatures when compared to air temperatures from July to September. This may be at least in part attributed to the greater heat capacity of the sea compared to land, which results in the sea surface temperatures taking longer to increase and decrease in response to changing seasons compared to land-based areas. Nelson records higher mean air temperatures in winter compared to the inland location of Murchison. This may be partly attributed to the moderating influence of the sea on overnight minimum temperatures near the coast. Figure 10 shows the mean sea surface temperatures for the New Zealand region for February and August, which are the warmest and coolest months with respect to sea surface temperatures.

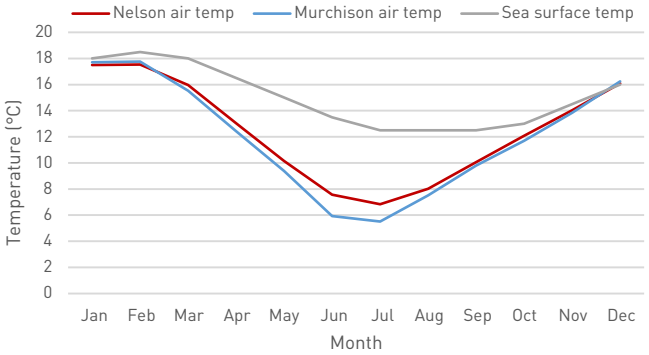

Figure 9. Mean monthly air temperature (Nelson and Murchison) and estimated sea surface temperatures (off the coast of Nelson).

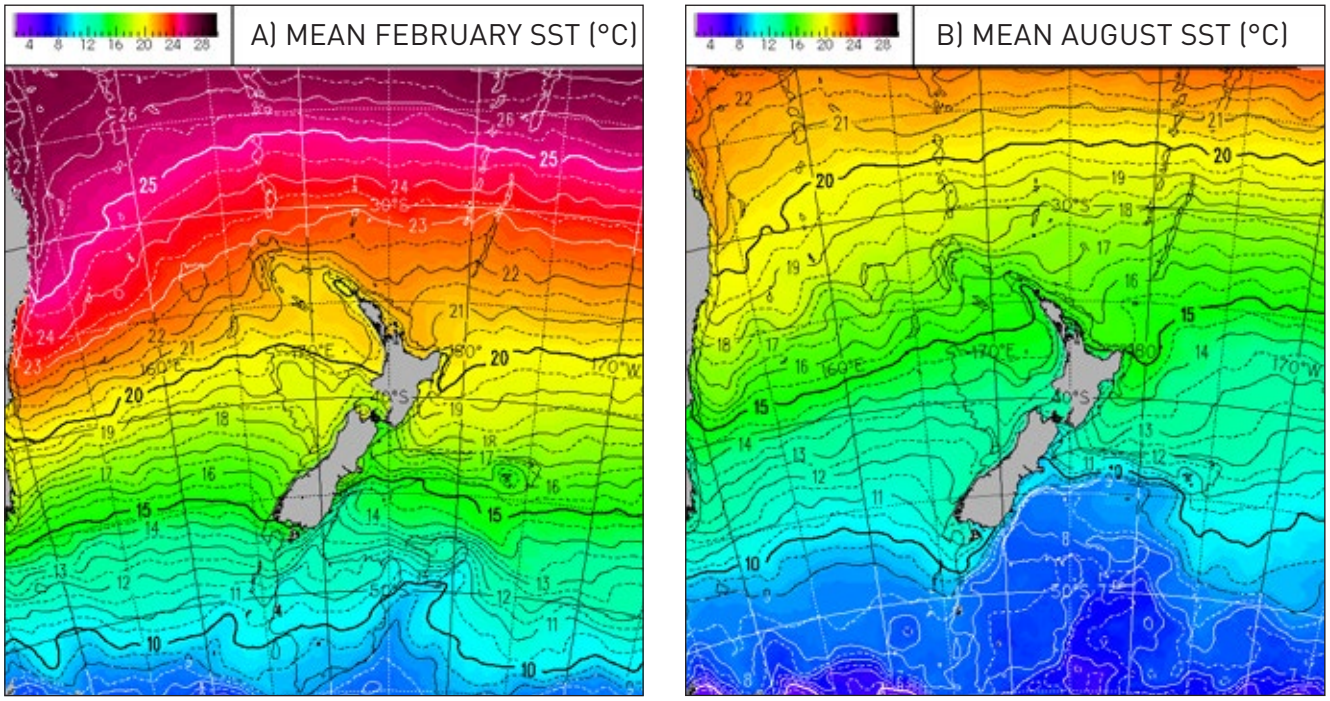

Figure 10. Monthly mean sea surface temperatures (°C) for: a) February; b) August. Source: NIWA SST Archive, Uddstrom and Oien (1999).

Air temperature

Nelson and Tasman typically observe afternoon temperatures reaching between 20°C and 23°C in summer, and overnight temperatures falling to between -1°C and 5°C in winter (Figure 11). Similar daily maximum temperatures are recorded throughout Nelson and Tasman, with the notable exception of high elevation areas where temperatures become increasingly lower as elevation increases. In winter, daily minimum temperatures become lower as distance from the coast and elevation increases. Figure 12 shows the median annual average temperature in Nelson and Tasman, and clearly demonstrates that lower temperatures are recorded at higher elevation locations. Low elevation locations have a median annual temperature of between 11°C and 13°C. Median annual temperatures of below 4°C occur at high elevations along the Ella, Travers and St Arnaud Ranges which are located towards the south of the region. Figure 13 gives the monthly temperature regime (highest recorded, mean monthly maximum, mean daily maximum, mean, mean daily minimum, mean monthly minimum, and lowest recorded) for selected Nelson and Tasman locations.

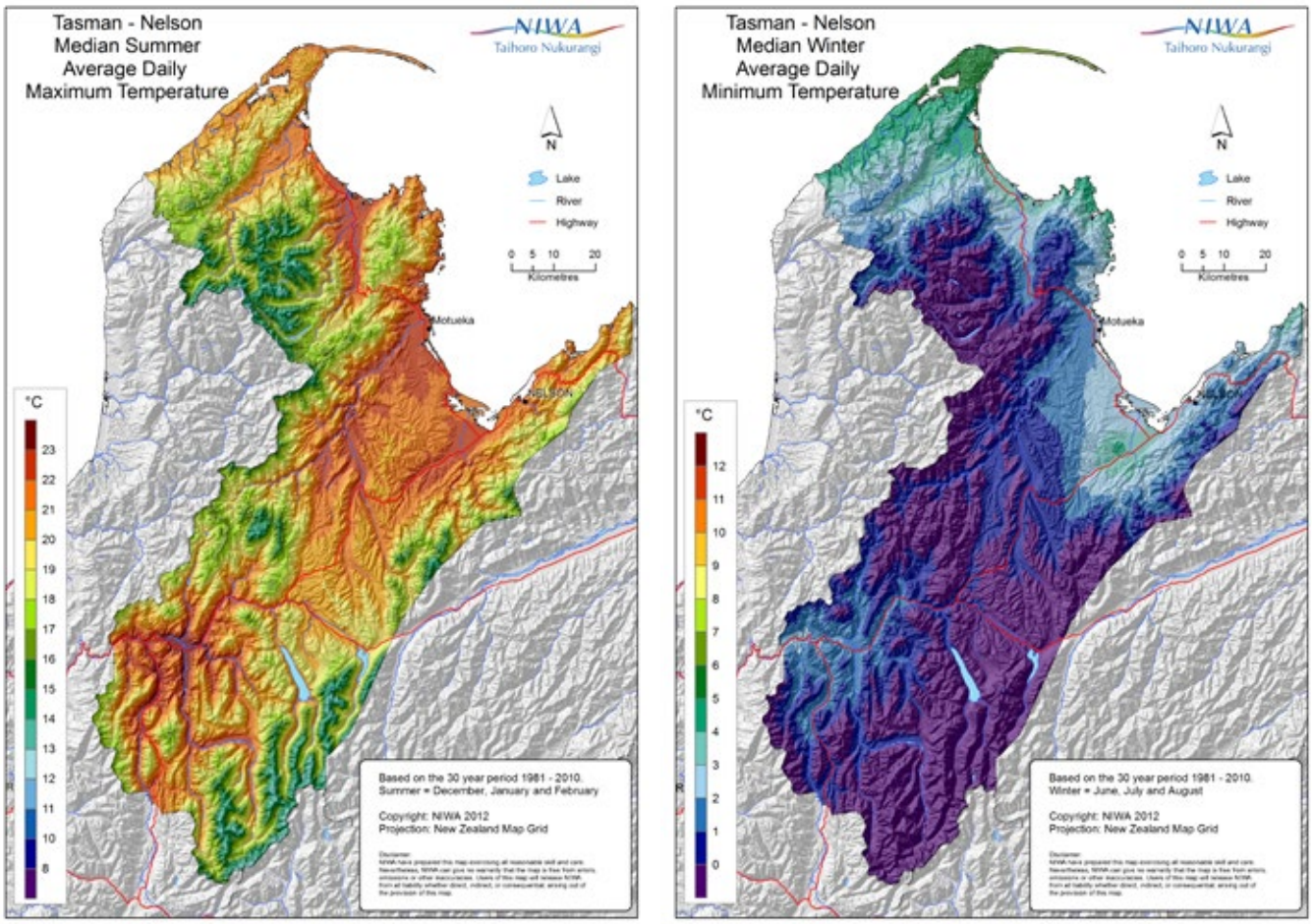

Figure 11. Left: Nelson and Tasman median summer (December, January and February) average daily maximum temperature; Right: Nelson and Tasman median winter (June, July and August) average daily minimum temperature, 1981-2010.

Photo: ©mychillybin.co.nz/Mark Meredith

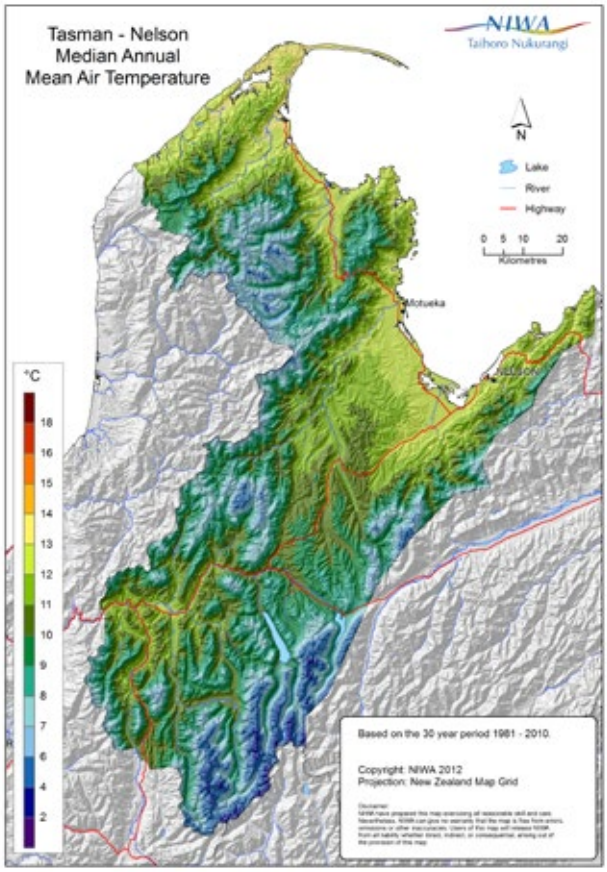

Figure 12. Nelson and Tasman median annual average temperature, 1981–2010.

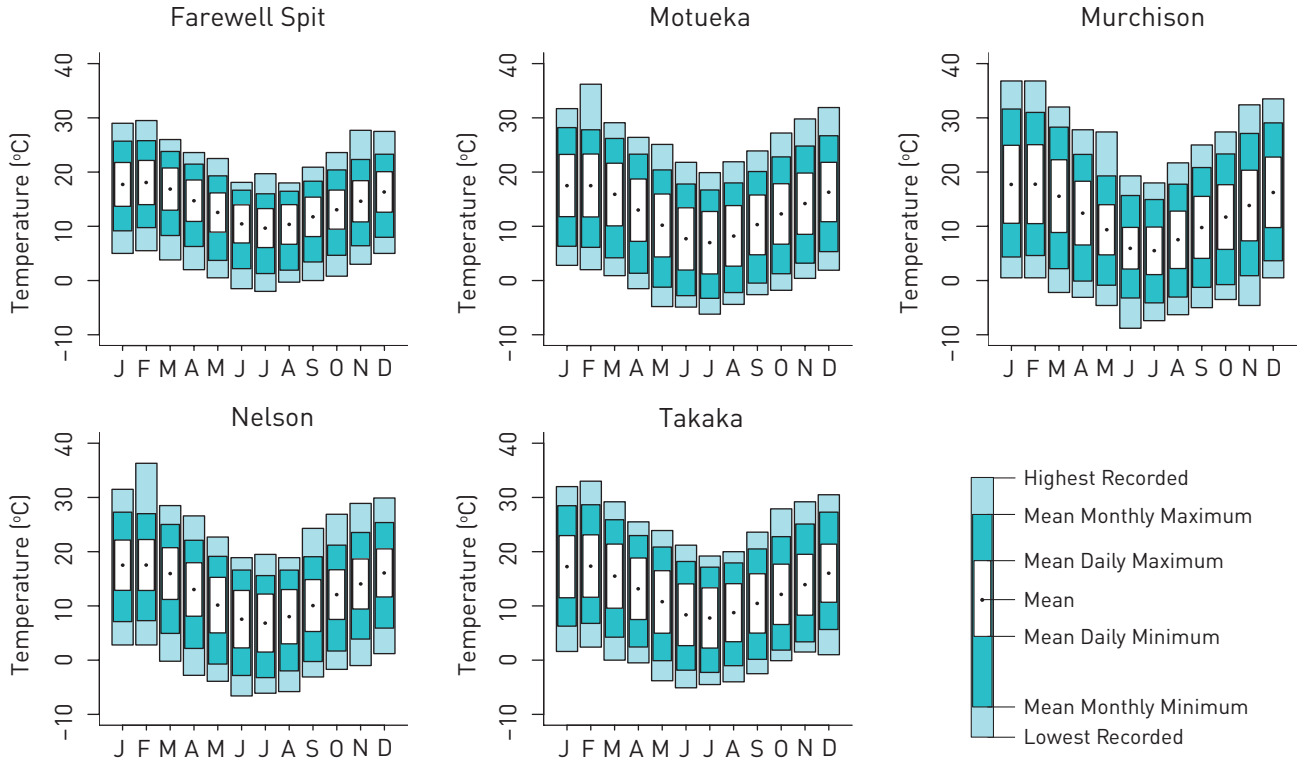

Figure 13. Monthly variation in air temperatures for selected Nelson and Tasman locations from all available data.

Table 14 shows that the average daily temperature range, i.e. the difference between the daily maximum and minimum temperature, varies minimally over the course of the year at locations near the coast. In contrast, the inland location of Murchison observes considerable variation in average daily temperature range over the course of the year: the range is highest in February and lowest in June.

Table 14. Average daily temperature range (Tmax – Tmin, °C) for selected Nelson and Tasman locations.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Farewell Spit	8.1	8.1	7.8	7.6	7.2	7.0	7.2	7.3	7.3	7.2	7.6	7.5	7.5
Motueka	11.5	11.6	11.6	11.5	11.6	11.5	11.5	11.2	11.0	11.1	11.3	10.9	11.4
Murchison	14.4	14.6	13.4	11.7	9.2	7.7	8.8	10.6	11.4	11.9	13.0	13.0	11.6
Nelson	9.3	9.4	9.5	9.9	10.2	10.6	10.7	10.0	9.6	9.2	9.2	8.9	9.7
Takaka	11.5	11.5	11.8	11.3	11.5	11.4	11.1	10.7	10.9	11.1	11.2	10.7	11.2

Figure 14 and Table 15 further highlight the diurnal temperature range, showing the median hourly mean air temperature for January and July at Nelson and Takaka. Overnight air temperatures at Takaka remain lower than Nelson in January and July, which may be attributed to the influence of cold air drainage down the Takaka valley. Note that hourly mean air temperature at a given time is calculated as the mean of many air temperature observations recorded over the previous hour. As such, both the daily maximum and minimum air temperatures calculated from hourly values are damped, resulting in a reduced diurnal temperature range (Table 15) compared to the absolute daily temperature range (Table 14) recorded at Nelson and Takaka.

Table 15. Median hourly mean air temperatures for January and July at Nelson and Takaka.

		00	01	02	03	04	05	06	07	08	09	10	11
Nelson	**January**	17.0	16.5	16.1	15.5	15.1	14.8	14.5	14.2	15.1	16.7	18.1	19.5
	July	6.1	5.8	5.4	5.2	4.8	4.8	4.5	4.5	4.2	4.5	6.2	8.2
		12	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
	January	20.5	21.1	21.4	21.5	21.5	21.5	21.3	20.5	19.8	19.0	18.1	17.5
	July	9.9	11.4	12.0	12.3	12.0	11.0	9.6	8.5	7.8	7.1	6.7	6.5
		00	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**
Takaka	**January**	15.0	14.3	13.7	13.3	12.6	12.3	12.0	12.1	13.3	16.1	18.0	19.5
	July	5.1	4.9	4.8	4.6	4.4	4.2	3.7	3.6	3.6	4.3	6.6	9.1
		12	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
	January	20.5	20.8	21.3	21.7	21.6	21.3	21.3	20.6	20.0	18.7	16.9	15.8
	July	11.3	12.6	12.8	12.5	11.9	11.2	9.0	7.4	6.5	6.0	5.9	5.6

Maximum air temperatures in excess of 25°C occur relatively frequently at low elevation inland locations, particularly in Murchison, where an annual average of 47 such days occur (Table 16). Maximum air temperatures in excess of 30°C rarely occur in Nelson and Tasman, with the exception of Murchison where the maximum temperature exceeds 30°C on an average of six days each year. Minimum temperatures below 0°C occur very frequently at St Arnaud and Lake Rotoroa, but are rare at Farewell Spit. The highest air temperature recorded in Nelson and Tasman to date is 36.8°C at Murchison on 5 February 2005. This temperature occurred in the middle of an extremely hot spell in Murchison between 24 January and 10 February 2005. During these eighteen days, the average daily maximum temperature was 32.9°C, with

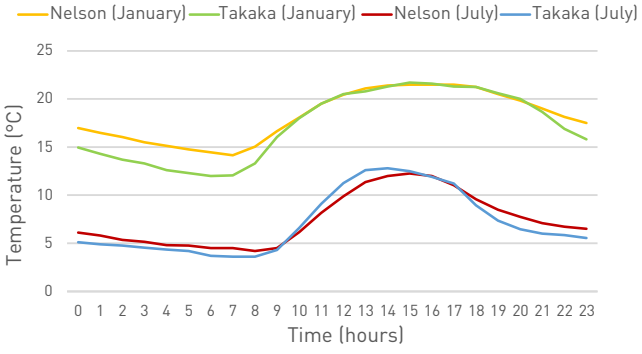

Figure 14. Median hourly mean air temperatures at Nelson and Takaka in January and July.

the temperature reaching at least 30.0°C on each of the eighteen days: an extraordinary occurrence for a New Zealand location. St Arnaud recorded the lowest air temperature in Nelson and Tasman; -10.1°C on 16 August 2011.

Table 16. Highest and lowest recorded air temperatures, average number of days per year where maximum air temperature exceeds 30°C and 25°C, and average number of days per year where the minimum air temperature falls below 0°C, for selected Nelson and Tasman locations from all available data.

Location	Highest recorded (°C)	Annual days max temp > 30°C	Annual days max temp > 25°C	Lowest recorded (°C)	Annual days min temp < 0°C
Farewell Spit	29.5	0	3	-2.0	0.5
Lake Rotoroa	30.1	0.09	12	-7.1	60
Motueka	36.2	0.4	21	-6.2	32
Murchison	36.8	6	47	-8.8	37
Nelson	36.3	0.2	8	-6.6	31
St Arnaud	31.4	0.4	11	-10.1	87
Takaka	33.0	0.6	19	-5.5	19

Earth temperatures

Earth (soil) temperatures are measured once daily at 9 a.m. at several Nelson and Tasman locations. Earth temperatures are measured at varying depths and are important for determining the growth and development of plants. Different plants have different rooting depths and as such, earth temperatures are routinely monitored at 10, 20, 30, and 100 cm depths. Table 17 lists mean monthly earth temperatures for a number of standard depths. At the coastal Nelson location, higher winter earth temperatures are observed when compared to the inland location of St Arnaud.

Figure 15 shows how earth temperatures change throughout the year at Nelson, compared with mean air temperature. The 10 cm earth temperatures are lower than the mean air temperature except during late-spring and summer. The annual earth temperature cycle at 100 cm depth is more damped and lagged than at shallower depths. As a result, earth temperatures at 100 cm remain above mean air temperature at all times of the year. Diurnal variation of earth temperatures (not shown) decreases with increasing depth, such that earth temperatures may show little-to-no diurnal variation at 100 cm depth.

Table 17. Monthly and annual mean 9 a.m. earth temperatures (°C) at varying depths from the ground surface for selected Nelson and Tasman locations.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Motueka													
10 cm	19.5	18.9	16.0	11.9	7.7	4.7	3.8	5.6	8.8	12.3	15.6	18.3	11.9
20 cm	21.1	20.8	17.9	13.7	9.4	6.0	5.0	6.8	10.0	13.4	16.7	19.5	13.4
30 cm	21.8	21.6	18.9	14.8	10.5	7.0	5.8	7.6	10.8	14.1	17.4	20.1	14.2
100 cm	19.2	19.8	18.8	16.5	13.5	10.4	8.4	8.7	10.5	12.8	15.3	17.5	14.3
Nelson													
10 cm	18.3	18.0	15.7	12.1	8.4	5.6	4.5	5.9	8.7	11.9	14.7	17.1	11.7
20 cm	19.2	19.1	17.2	13.8	10.2	7.2	5.9	7.3	9.7	12.7	15.3	17.7	12.9
30 cm	20.0	20.1	18.3	15.1	11.6	8.5	7.0	8.3	10.6	13.4	16.1	18.4	13.9
100cm	18.5	19.2	18.4	16.5	13.8	11.1	9.2	9.4	10.8	12.9	15.0	17.0	14.3
St Arnaud													
10cm	16.0	15.9	13.7	10.3	6.9	3.8	2.5	3.7	6.5	9.3	12.1	14.5	9.6
20cm	16.6	16.7	14.6	11.0	7.7	4.5	3.0	4.2	6.9	10.0	12.5	14.8	10.2
30cm	17.1	17.4	15.4	11.8	8.5	5.2	3.6	4.8	7.4	10.5	13.1	15.4	10.8

Frosts

Frost is a local phenomenon and both its frequency of occurrence and intensity can vary widely over small areas. Frosts occur most frequently in winter during periods of anticyclonic conditions, primarily for two reasons. Firstly, clear skies associated with anticyclones enhance the rate of radiative cooling during the night. Secondly, anticyclones are associated with light winds, which reduces the amount of turbulent mixing of air. Cold air is relatively dense, so when there is a lack of turbulent mixing it tends to sink towards the Earth's surface. Therefore, areas most likely to experience frost are flat areas, where relatively cold air is not able to drain away on calm nights, and in valleys and basins, where relatively cold air pools after descending from higher elevation areas nearby. Under such conditions, temperature inversions (where the air temperature increases with elevation) are common.

There are two types of frost recorded. Air frosts occur when air temperature measured by a thermometer in a screen 1.3 m above the ground falls below 0°C. Ground frosts are recorded when the air temperature 2.5 cm above a closely cut grass surface falls to -1.0°C or lower. Both types of frost are quite common in Nelson and Tasman in the cooler months, but they occur less frequently than most other South Island regions. Table 18 lists for selected locations the mean daily grass minimum and extreme grass minimum temperatures, and the average number of days each month with ground and air frosts. Ground frosts occur more frequently than air frosts, and both types occur most frequently at the inland location of St Arnaud.

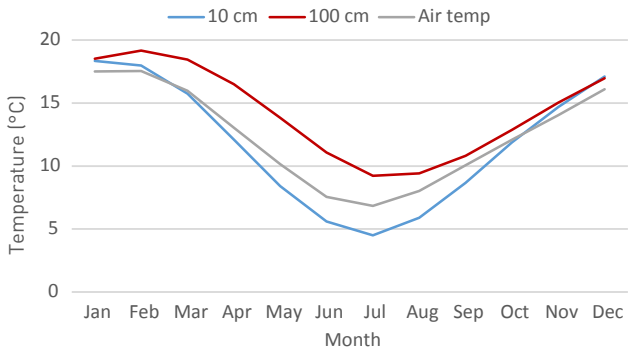

Figure 15. Monthly mean 9 a.m. earth temperature at different depths from the ground surface, and monthly mean air temperature, from all available data at Nelson.

Table 18. Frost occurrence and grass minimum temperatures at selected Nelson and Tasman locations from all available data.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Motueka	a	9.1	9.0	7.2	4.0	1.1	-1.3	-2.0	-0.5	1.7	3.8	5.7	8.3
	b	-1.5	-1.8	-3.1	-6.0	-9.1	-9.4	-10.5	-8.9	-7.2	-5.8	-3.3	-1.6
	c	0.02	0.05	0.5	4	12	18	20	16	9	3	0.7	0.1
	d	0	0	0	0.2	3	10	12	6	1	0.2	0	0
Nelson	a	9.1	9.1	7.4	4.2	1.4	-1.2	-2.0	-0.5	1.5	3.9	5.6	8.0
	b	-1.7	-2.8	-5.0	-10.2	-10.2	-13.0	-9.7	-9.4	-8.1	-6.1	-5.8	-3.2
	c	0.01	0.1	0.7	4	11	18	21	17	10	4	1	0.3
	d	0	0	0.01	0.1	3	9	11	6	1	0.2	0.01	0
St Arnaud	a	6.6	6.4	4.9	1.9	-0.8	-3.4	-4.1	-2.9	-0.6	1.4	3.3	5.7
	b	-5.0	-5.4	-7.9	-8.7	-11.6	-13.9	-14.7	-13.8	-13.9	-9.9	-6.7	-5.4
	c	0.5	0.7	2	9	15	20	23	20	14	10	4	1
	d	0.1	0.1	0.8	4	12	18	21	17	10	5	2	0.4

a: mean daily grass minimum (°C)
b: lowest grass minimum recorded (°C)
c: mean number of ground frosts per month
d: mean number of air frosts per month

Sunshine and solar radiation

Sunshine

Sunshine hours are highest along the coast and slightly inland of Tasman Bay, where annual sunshine totals of around 2,400 hours are typical (Figure 16). Nelson is frequently one of the top-four sunniest locations in New Zealand on an annual basis. Annual sunshine hours tend to decrease towards the south of the region, especially at high elevation mountainous areas where increased cloudiness reduces the annual sunshine totals experienced. Figure 17 shows the monthly mean, maximum, and minimum recorded bright sunshine hours for selected Nelson and Tasman locations. Note that the lower sunshine hours recorded in the winter months tends to reflect the northerly declination of the sun, as opposed to signalling an increase in cloudiness during those times.

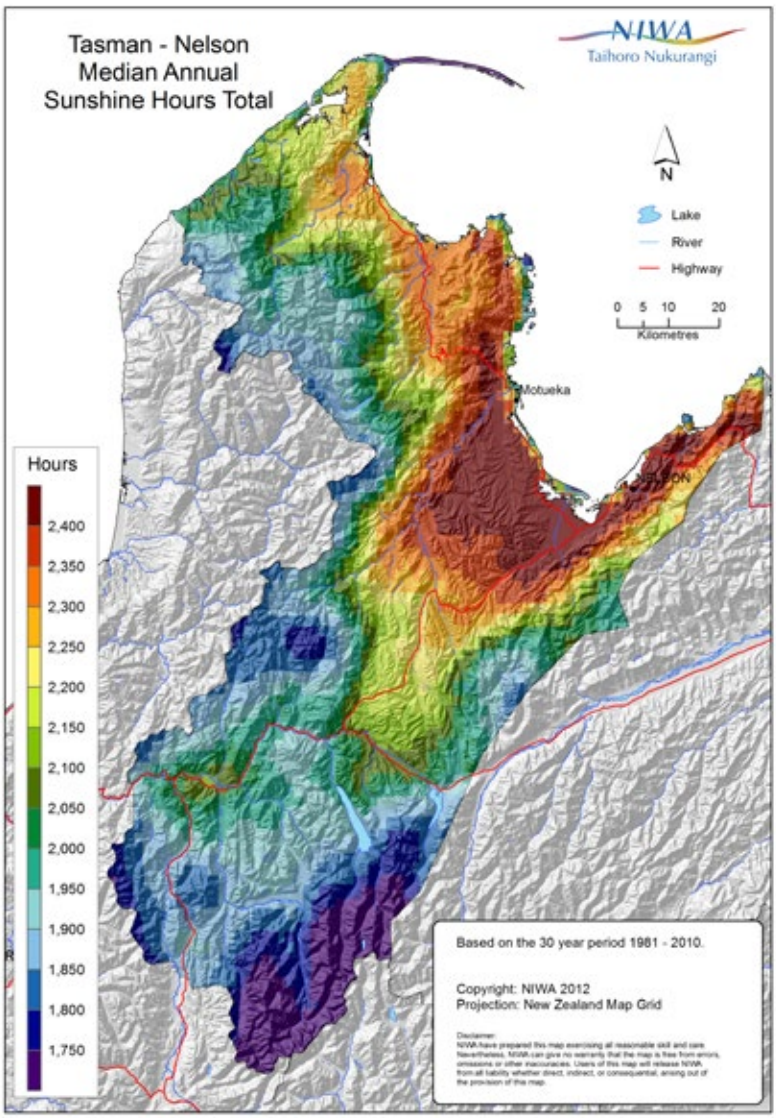

Figure 16. Median annual sunshine hours for Nelson and Tasman, 1981–2010.

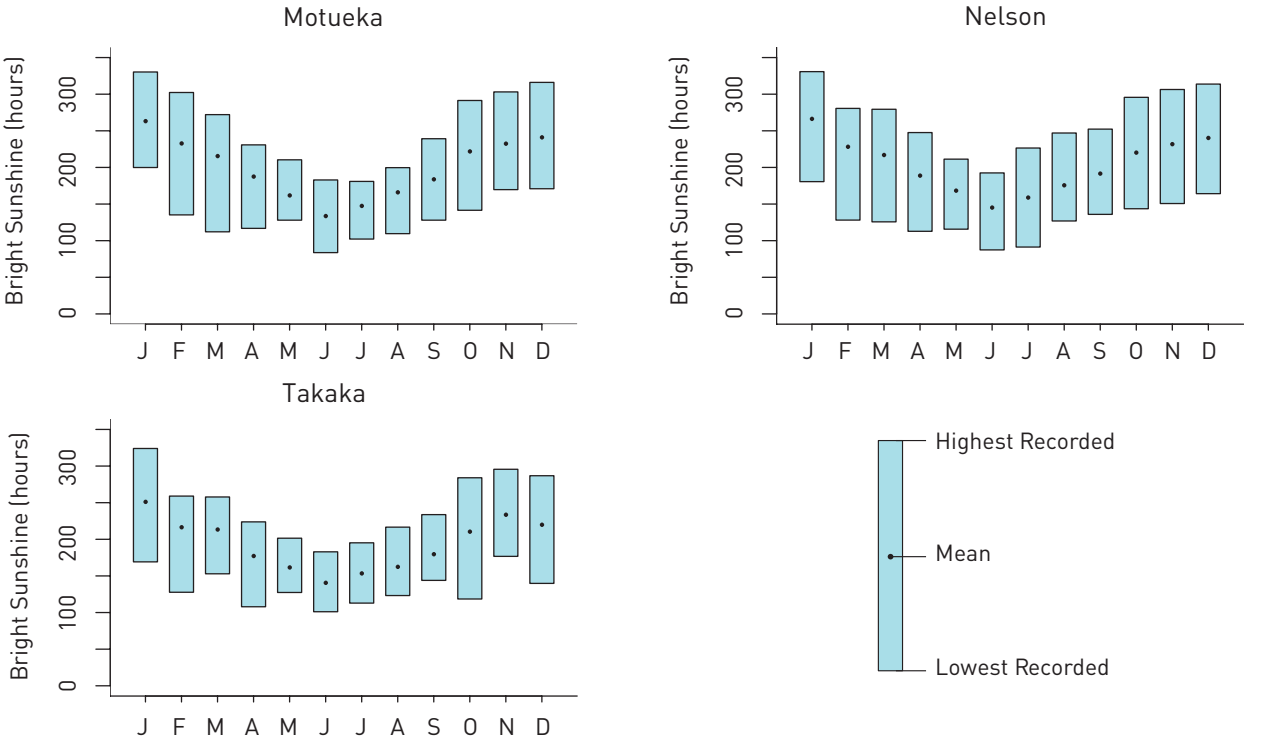

Figure 17. Mean, highest and lowest recorded monthly bright sunshine hours for selected Nelson and Tasman locations from all available data.

Solar radiation

Solar radiation observations of greater than 10 years are available for only a few Nelson and Tasman sites. Table 19 presents the mean daily global (i.e. direct and diffuse) solar radiation for Motueka, Nelson and Takaka. Insolation is highest in January and lowest in June at all locations.

Table 19. Mean daily global solar radiation (MJ/m²/day) for selected Nelson and Tasman locations from all available data.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Motueka	24.2	21.0	17.0	11.1	7.7	6.0	6.8	9.4	13.4	18.1	22.6	23.6	15.1
Nelson	24.4	21.6	17.2	11.5	8.0	6.0	6.7	9.7	13.6	18.2	22.5	23.4	15.2
Takaka	24.8	21.2	16.7	11.2	7.9	6.1	6.8	9.3	13.6	18.3	23.2	23.0	15.2

UV (ultra-violet) radiation

Figure 18 shows an example of a UV forecast for Nelson, indicating the UV levels and times of the day where sun protection is required. UV levels in Nelson are higher than New Zealand's southern-most locations, but lower than those experienced in northern-most areas. All Nelson and Tasman locations observe significantly higher UV levels in summer than in winter.

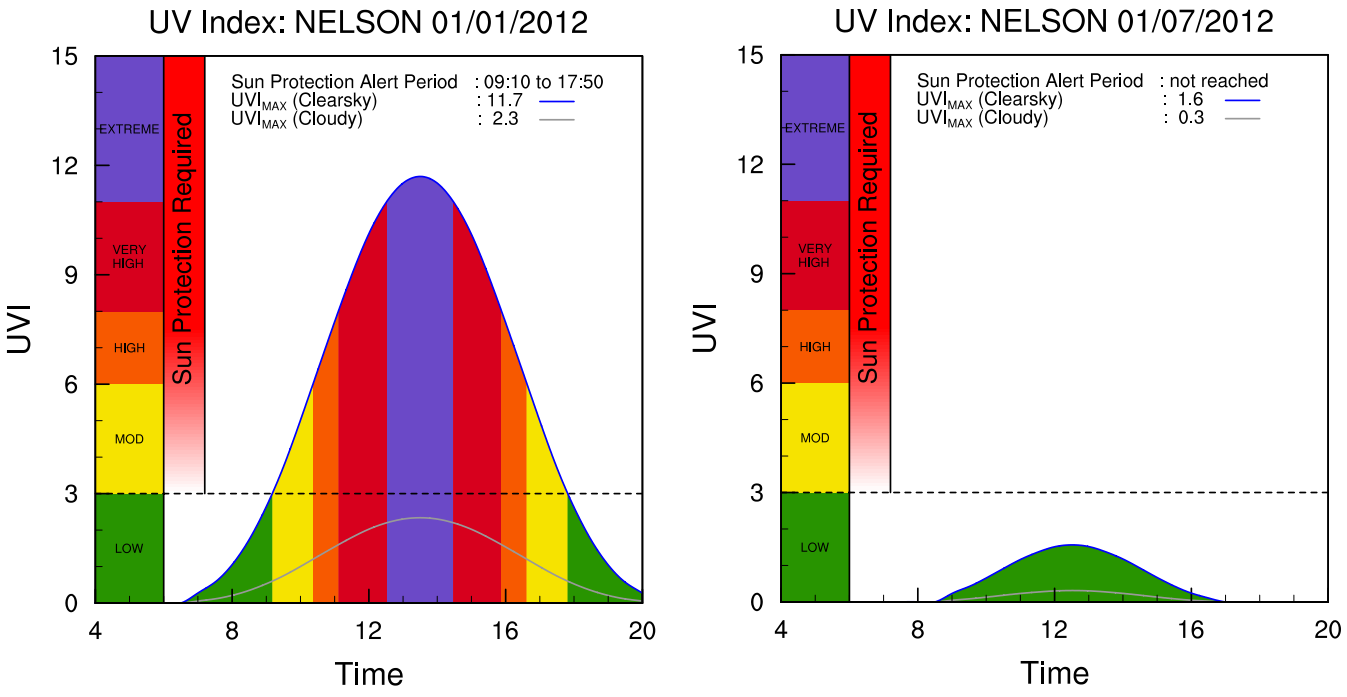

Figure 18. UV Index forecast for Nelson, January and July. Source: https://www.niwa.co.nz/our-services/online-services/uv-ozone

Other elements

Thunderstorms and hail

Thunderstorms are a relatively infrequent occurrence in Nelson and Tasman, with seven and four days of occurrence per year in Nelson and St Arnaud, respectively (Table 20). Hail is also uncommon in Nelson and St Arnaud, with both locations observing an average of just two days of occurrence per year, respectively. Due to the localised nature of thunderstorm and hail occurrence, it is possible that not all severe convection events are detected at each station. Thunderstorms in Nelson and Tasman are associated with bouts of high intensity rainfall, lightning, hail, and wind squalls which sometimes cause considerable localised flooding and damage to vegetation and crops. Severe hailstorms may be classified as those which cause damage and/or have hailstones of at least 0.5 cm in diameter. One such severe hailstorm struck parts of the Tasman District on 4 November 2014, with the worst-affected areas around Lower Moutere, Motueka and Riwaka. The worst of the hailstorm lasted approximately 20 minutes and resulted in significant damage to apple and kiwifruit crops: an estimated 15 to 20 orchards were seriously affected with many crops deemed a complete write-off. In some cases hail nets that were used to protect the orchards collapsed under the weight of hail, with trees subsequently breaking under the weight of the collapse nets. Motueka recorded 5.4 mm of rainfall in the hour between 10 p.m. and 11 p.m.

Fog

The most common type of fog in inland parts of Nelson and Tasman is radiation fog, formed when the air cools to its dew-point on clear nights, allowing the water vapour in the air to condense. Near the coast, advection fog can occur, where sea fog spreads onto the land as evening cooling proceeds. The average number of days per year with fog for Nelson and St Arnaud is listed in Table 20. Although fog can occur at any time of the year in Nelson and Tasman, it is recorded most frequently during late-autumn and winter. For example, of the annual average of 17 days with fog at Nelson Airport, 10 days (60%) are recorded between May and August.

Table 20. Average number of days each year with snow, thunder, hail and fog recorded at Nelson and St Arnaud, from all available data. The elevation of each station above mean sea level is also shown.

	Fog	Thunder	Hail	Snow
Nelson Airport (2 m)	17	7	2	0.1
St Arnaud (634 m)	11	4	2	8

Snow

Snowfalls occur frequently in the mountains and high elevation inland locations of Nelson and Tasman, but are very rare at low elevations. Table 20 shows the average number of days each year that snowfall occurs at Nelson (0.1 days/year equates to 1 day/10 years) and St Arnaud. Snow doesn't usually settle at coastal locations, however settled snow may last longer than a day or two at a time at higher elevation inland locations after particularly heavy snowfall events. Seasonal snowfields typically begin to accumulate in the mountains in late autumn, and persist through to late-spring.

In August 2011, low pressure to the east of the New Zealand and an anticyclone to the south of the Tasman Sea resulted in a very cold southerly airflow across most of New Zealand. Snow fell to low elevations in many areas which very rarely record snowfall, including in Nelson and Tasman. Snow reportedly fell and settled throughout the region, including at Motueka, Kaiteriteri and Appleby in the evening of 24 August. Snow also reportedly settled to 100 metres above sea level in the hills surrounding Golden Bay. Farther inland, St Arnaud was isolated for a time due to the closure of State Highway 63.

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DERIVED CLIMATOLOGICAL PARAMETERS

Apart from elements such as temperature and rainfall which can be measured directly, it has been found that parameters calculated from several elements have some important uses, especially in industry. Parameters which define the overall suitability of the climate for agriculture, horticulture, architectural and structural designs, and contracting, etc., are vapour pressure, relative humidity, evapotranspiration (leading to soil water balance), degree-days (thermal time), and rainfall extremes. Some of these and their uses are discussed in the following paragraphs. Note that short-term high intensity rainfalls have already been addressed in this publication.

Vapour pressure and relative humidity

Vapour pressure and relative humidity are the two parameters most frequently used to indicate moisture levels in the atmosphere. Both are calculated from simultaneous dry and wet bulb thermometer readings, although a hygrograph may be used to obtain continuous humidity readings.

Vapour pressure is the part of the total atmospheric pressure that results from the presence of water vapour in the atmosphere. It varies greatly with air masses from different sources, being greatest in warm air masses that have tropical origins and lowest in cold, polar-derived air masses. Vapour pressure can be important in determining the physiological response of organisms to the environment (very dry air, especially if there is a pre-existing soil moisture deficit, can cause or increase wilting in plants). Mean monthly 9 a.m. vapour pressures for several locations are given in Table 21, which shows that vapour pressures are lowest in the winter months.

Relative humidity relates the amount of water present in the atmosphere to the amount of water necessary to saturate the atmosphere. Unlike vapour pressure, relative humidity is dependent on the air temperature. This is because as air temperature increases, the capacity of the atmosphere to hold water also increases. Therefore, relative humidity often displays large diurnal variation. Table 22 highlights this diurnal variation, showing 9 a.m. relative humidity is higher than that recorded at 3 p.m. at corresponding times of the year. Highest relative humidity is typically experienced in the winter months due to lower air temperatures.

Table 21. Mean monthly and annual 9 a.m. vapour pressure (hPa) at selected Nelson and Tasman locations from all available data.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Farewell Spit	15.4	15.6	15.0	13.5	11.6	10.1	9.5	10.2	11.2	11.9	12.7	14.6	12.6
Motueka	14.8	15.0	14.1	11.9	9.5	8.0	7.6	8.4	9.8	10.9	12.2	13.8	11.3
Murchison	14.0	14.1	12.7	11.2	9.7	7.9	7.3	8.0	9.2	10.3	11.2	12.8	10.6
Nelson	14.6	15.0	14.0	12.2	10.1	8.2	7.8	8.8	9.9	11.1	12.0	13.7	11.4
St Arnaud	12.1	12.2	11.3	9.6	8.0	6.8	6.2	6.7	7.7	8.7	9.6	11.2	9.2
Takaka	14.9	14.9	13.2	11.8	10.1	8.5	7.9	8.9	10.1	11.0	11.9	14.1	11.4

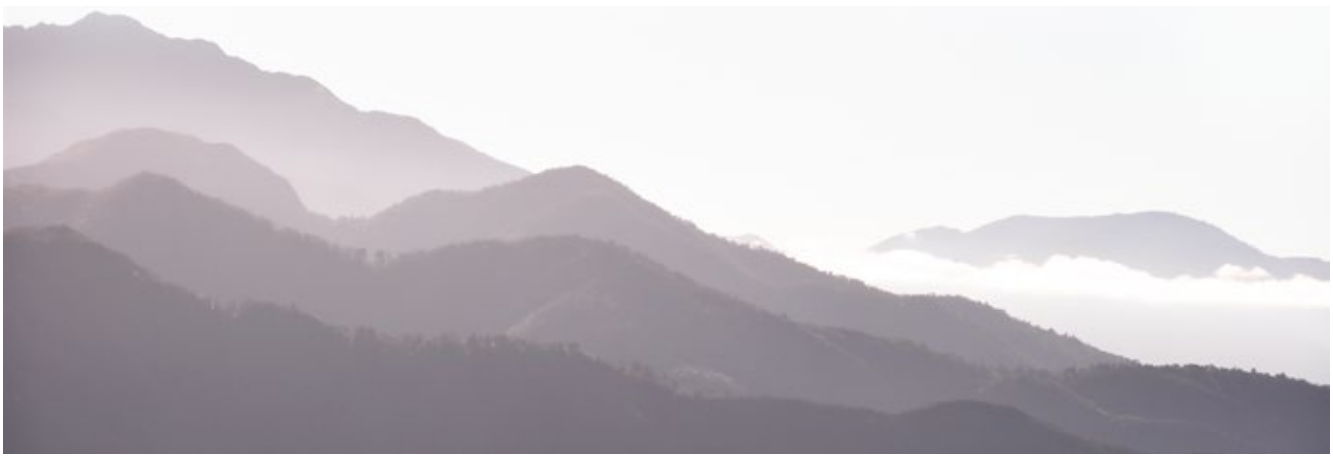

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Table 22. Mean monthly and annual 9 a.m. (a) and 3 p.m. (b) relative humidity (%) at selected Nelson and Tasman locations.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Farewell Spit	a	77	79	79	80	82	84	84	84	80	78	76	78	80
	b	66	66	67	72	75	76	71	74	69	69	65	72	70
Motueka	a	75	81	81	84	88	90	90	87	79	75	75	74	82
	b	61	65	64	69	68	70	66	69	71	65	62	65	66
Murchison	a	84	85	88	92	94	95	95	93	87	83	80	79	88
	b	47	48	51	60	72	80	75	65	59	54	47	50	59
Nelson	a	73	77	80	83	88	90	90	87	80	76	73	73	81
	b	64	64	63	66	67	70	65	70	66	67	63	70	66
St Arnaud	a	80	83	83	84	88	90	88	85	80	79	78	80	83
	b	50	52	55	57	63	68	64	62	57	54	47	54	57
Takaka	a	78	83	82	83	87	90	87	86	80	80	75	77	82
	b	60	61	60	65	65	67	65	65	64	61	58	62	63

Evapotranspiration and soil water balance

Evapotranspiration is the process where water held in the soil is gradually released to the atmosphere through a combination of direct evaporation and transpiration from plants. A water balance can be calculated by using daily rainfalls and by assuming that the soil can hold a fixed amount of water with actual evapotranspiration continuing at the potential rate until total moisture depletion of the soil occurs. The calculation of water balance begins after a long dry spell when it is known that all available soil moisture is depleted or after a period of very heavy rainfall when the soil is at field capacity. Daily calculations are then made of moisture lost through evapotranspiration or replaced through precipitation. If the available soil water becomes insufficient to maintain evapotranspiration then a soil moisture deficit occurs and irrigation becomes necessary to maintain plant growth. Runoff occurs when the rainfall exceeds the field capacity (assumed to be 150 mm for most New Zealand soils).

Mean monthly and annual water balance values for a number of Nelson and Tasman locations are given in Table 23. Soil moisture deficit peaks in summer throughout Nelson and Tasman, with

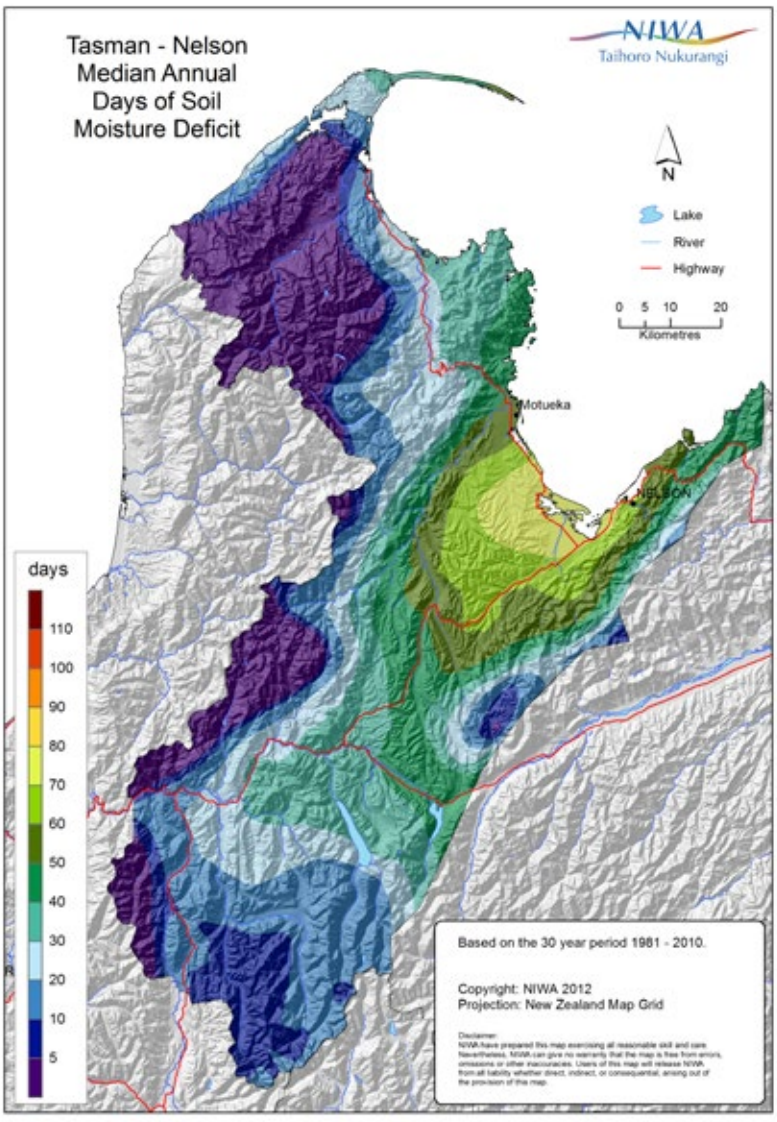

Figure 19. Median annual days of wilting point deficit for Nelson and Tasman, 1981–2010.

highest soil moisture deficit observed in Nelson, whereas runoff peaks in the winter months. Figure 19 shows region-wide variability in days of soil moisture deficit per year, which further illustrates the dryness of Nelson and the Waimea Plain compared to other parts of the region.

Potential evapotranspiration (PET) has been calculated for Motueka and Nelson using the Penman method (Penman, 1948). The monthly mean, minimum, and maximum PET values for these locations are listed in Table 24.

Table 23. Mean monthly and annual water balance summary for a soil moisture capacity of 150 mm at selected Nelson and Tasman locations.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Farewell Spit	DE	68	49	26	8	0	0	0	0	0	0	23	37	212
	ND	14	12	9	5	1	0	0	0	0	0	5	8	54
	RO	1	13	2	27	41	114	82	82	49	35	13	7	467
	NR	0	0	0	2	4	10	9	9	6	3	1	1	45
Matakitaki	DE	9	19	9	0	0	0	0	0	0	0	6	10	53
	ND	2	5	3	0	0	0	0	0	0	0	1	3	15
	RO	33	15	8	53	121	187	121	115	145	156	65	50	1070
	NR	3	1	1	4	10	15	11	11	11	11	4	4	84
Motueka	DE	73	63	26	7	1	0	0	0	0	2	29	50	250
	ND	15	15	9	5	1	0	0	0	0	1	6	11	62
	RO	6	8	11	48	77	117	120	113	68	52	19	12	651
	NR	0	0	1	2	5	8	8	8	6	4	1	1	43
Nelson	DE	90	69	34	10	1	0	0	0	0	6	41	64	317
	ND	18	16	11	6	1	0	0	0	0	2	9	13	77
	RO	3	0	3	14	41	62	61	58	31	20	7	6	306
	NR	0	0	0	1	3	6	6	6	3	2	1	0	28
Takaka	DE	35	42	14	2	0	0	0	0	0	0	11	19	124
	ND	7	10	5	1	0	0	0	0	0	0	3	4	31
	RO	35	17	39	105	144	185	168	171	142	131	84	66	1287
	NR	1	1	2	4	7	10	9	9	8	6	4	2	64

DE: average amount of soil moisture deficit (mm)
ND: average number of days on which a soil moisture deficit occurs
RO: average amount of runoff (mm)
NR: average number of days on which runoff occurs

Table 24. Penman calculated maximum, mean, and minimum monthly potential evapotranspiration (mm), and mean annual total potential evapotranspiration, for Motueka and Nelson.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Motueka	Max	158	121	94	52	31	17	20	34	62	97	125	151	
	Mean	136	104	79	44	23	12	15	29	51	85	109	128	817
	Min	120	87	63	34	19	9	12	25	45	69	89	104	
Nelson	Max	188	138	112	66	35	25	25	39	72	114	147	180	
	Mean	152	115	89	49	25	15	17	30	57	92	120	141	901
	Min	124	86	75	37	19	10	11	25	47	55	99	115	

Degree-day totals

The departure of mean daily temperature above a base temperature which has been found to be critical to the growth or development of a particular plant is a measure of the plant's development on that day. The sum of these departures then relates to the maturity or harvestable state of the crop. Thus, as the plant grows, updated estimates of harvest time can be made. These estimates have been found to be very valuable for a variety of crops with different base temperatures. Degree-day totals indicate the overall effects of temperature for a specified period, and can be applied to agricultural and horticultural production. Growing degree-days express the sum of daily temperatures above a selected base temperature that represent a threshold of plant growth. Table 25 lists the mean monthly growing degree-day totals above base temperatures of 5°C and 10°C for locations in Nelson and Tasman.

Cooling and heating degree days are measurements that reflect the amount of energy that is required to cool or heat buildings to a comfortable base temperature, which in this case is 18°C. Table 26 shows that the number of cooling degree days reaches a peak in mid-late summer in Nelson and Tasman, when energy required to cool building interiors to 18°C is highest. Conversely, heating degree days reach a peak in winter, when the energy required to heat buildings to 18°C is highest. Figure 20 shows region-wide variability in the number of heating degree days per year. The number of heating degree days tends to be lower in low elevation coastal areas, compared with areas further inland and at higher elevations.

Table 25. Average growing degree-day totals above base 5°C and 10°C for selected Nelson and Tasman locations.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Farewell Spit	5°C	394	368	368	291	233	162	143	165	202	250	288	351	3215
	10°C	239	226	213	141	82	33	19	28	57	96	138	196	1478
Motueka	5°C	389	354	336	238	160	82	67	103	160	226	275	351	2740
	10°C	234	213	181	91	32	7	3	8	31	76	126	196	1196
Murchison	5°C	391	369	325	224	141	69	40	93	150	212	262	348	2626
	10°C	236	228	171	81	30	15	2	10	28	68	114	194	1176
Nelson	5°C	388	354	341	241	160	81	64	95	152	220	271	344	2711
	10°C	233	213	186	95	35	8	3	7	28	72	122	189	1190
St Arnaud	5°C	301	275	241	143	63	18	10	22	60	124	181	251	1688
	10°C	147	135	93	25	4	0	0	0	2	16	49	102	574
Takaka	5°C	379	349	327	244	179	102	89	117	164	221	267	342	2779
	10°C	224	208	172	96	41	11	6	10	32	70	118	187	1175

Table 26. Average cooling (CDD) and heating (HDD) degree-day totals with base 18°C for selected Nelson and Tasman locations.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Farewell Spit	CDD	17	20	9	1	0	0	0	0	0	0	0	5	51
	HDD	28	20	44	101	172	229	261	238	188	153	103	58	1594
Motueka	CDD	21	19	7	0	0	0	0	0	0	0	1	11	60
	HDD	35	33	74	153	244	311	341	301	230	177	116	63	2078
Murchison	CDD	30	29	6	0	0	0	0	0	0	0	2	13	81
	HDD	41	28	84	167	265	347	389	316	240	191	130	68	2266
Nelson	CDD	21	19	7	0	0	0	0	0	0	0	1	7	56
	HDD	36	32	70	149	243	313	346	310	238	183	120	67	2108
St Arnaud	CDD	4	3	0	0	0	0	0	0	0	0	0	1	8
	HDD	106	96	162	248	351	419	449	412	337	280	209	153	3224
Takaka	CDD	16	17	5	0	0	0	0	0	0	0	1	7	47
	HDD	40	34	81	147	224	289	316	287	227	182	124	69	2018

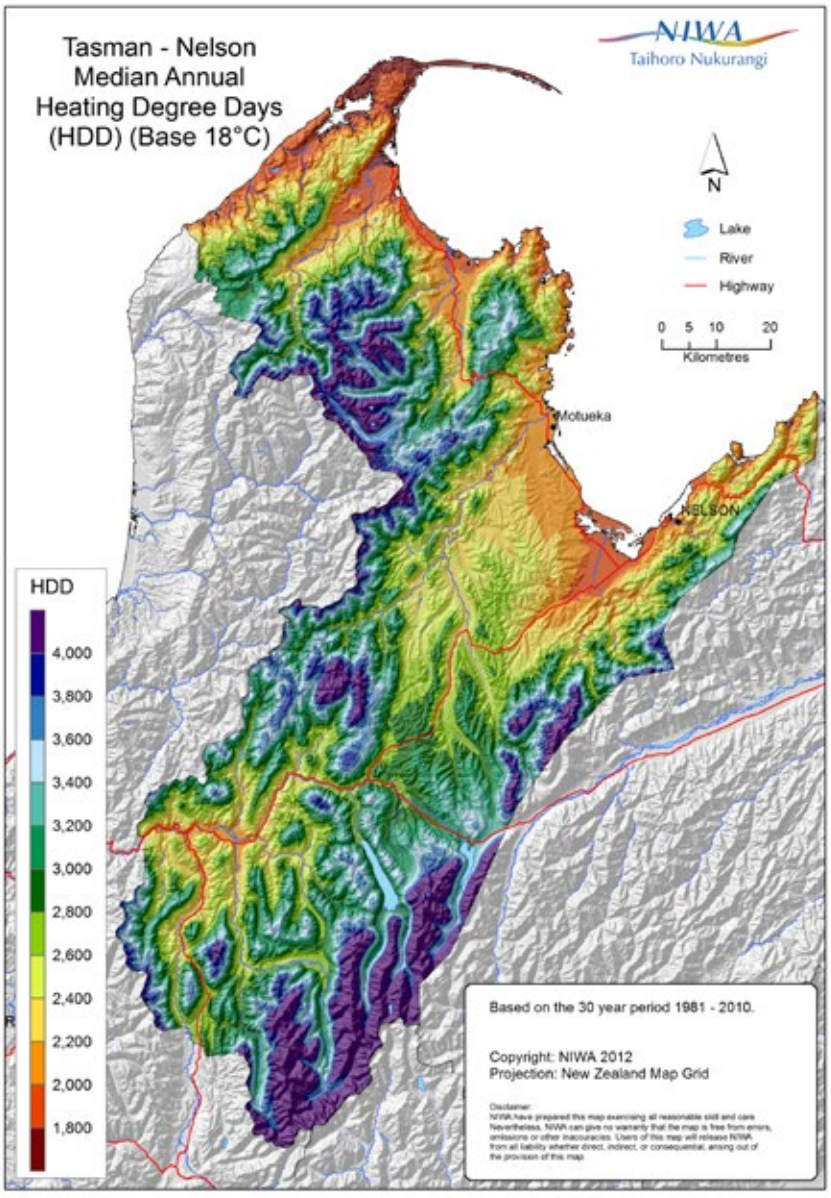

Figure 20. Median annual heating degree days for Nelson and Tasman, 1981–2010.

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