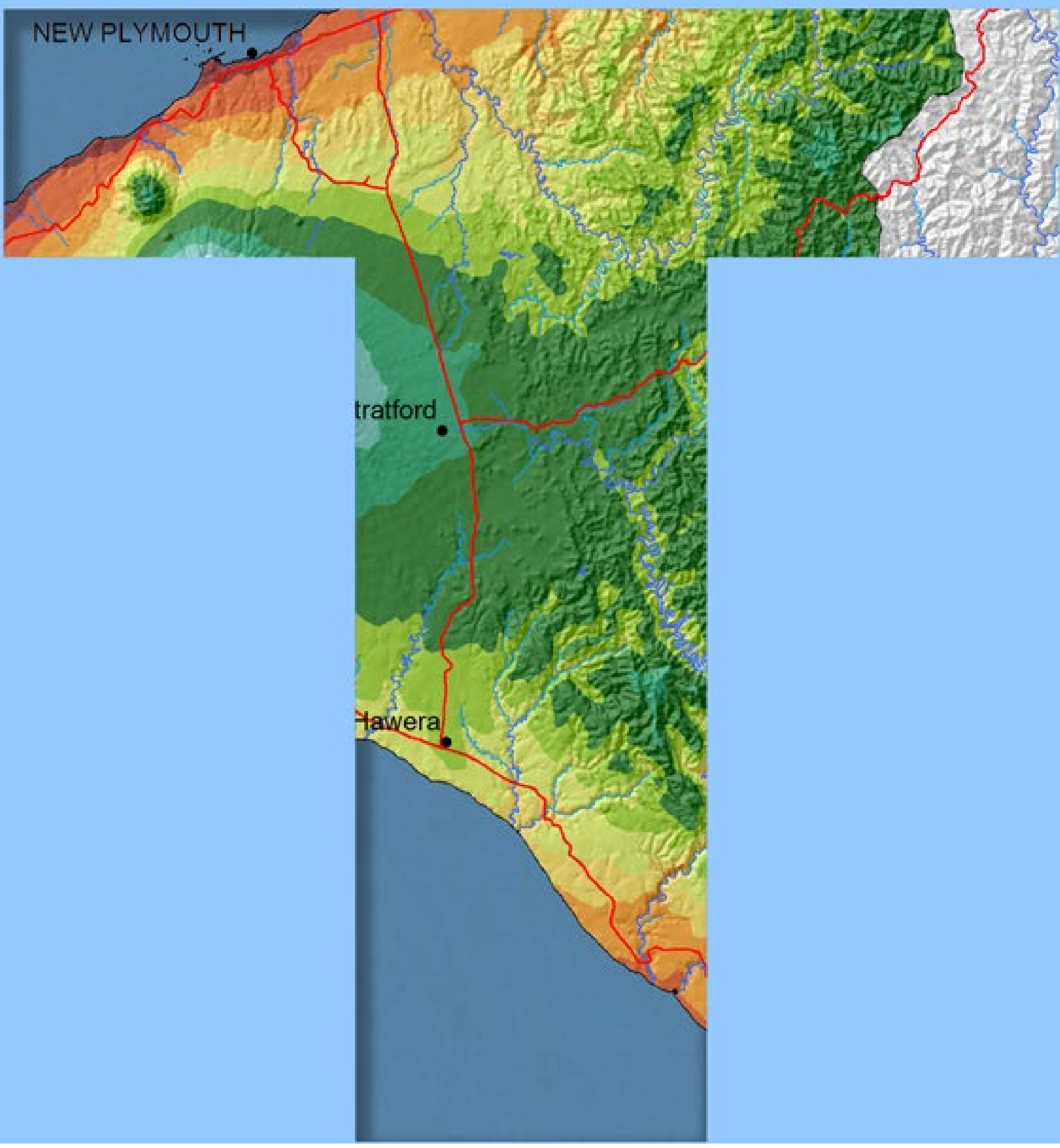
NIWA
Taihoro Nukurangi

THE CLIMATE AND WEATHER OF TARANAKI

2nd edition

P.R. Chappell



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Note to Second Edition

This publication replaces the first edition of the New Zealand Meteorological Service Miscellaneous Publication 115 (9), written in 1981 by C.S. Thompson. It was considered necessary to update the second edition, incorporating more recent data and updated methods of climatological variable calculation.

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CONTENTS

SUMMARY

The climate of Taranaki is determined largely by its position in relation to the large scale weather patterns affecting New Zealand. Situated on the western side of the North Island, Taranaki is exposed to all weather systems migrating over the Tasman Sea. The predominant westerly airstream makes the Taranaki region one of the windiest in New Zealand. Taranaki is therefore generally a sunny, windy region with a good supply of evenly distributed rainfall and moderate temperatures. Except at higher elevations, snow and hail are rare occurrences, and fogs occur most frequently in areas away from the coast. The climate and soils are well suited for the intensive dairy production of the region, although moisture deficiency during most summer months limits pasture production for a time.

INTRODUCTION

New Zealand lies in a vast area of ocean within the mid-latitude westerly wind zone. It is a narrow mountainous country with a major range extending from Puysegur Point in the south to East Cape in the north, broken only by Cook Strait which separates the two main islands. The westerly winds are normally moisture-laden and cause high rainfalls and reduced sunshine west of the ranges, and low rainfalls and higher sunshine duration to the east.

Within the mid-latitude westerlies, eastward moving anticyclones and depressions affect the day-to-day weather of New Zealand, and determine the broad climatic features of the country. Occasionally, New Zealand is affected by airmasses which originate in the tropics or the Antarctic region. These airmasses are modified as they move over the oceans, and when they reach New Zealand, they bring periods of intense showery weather associated with cold air, or heavy rainfalls from a warm humid airmass.

In this publication, the Taranaki region is that administered by Taranaki Regional Council (Figure 1). The focal point of the region is the snow-capped dormant volcano, Mt Taranaki, rising 2518 m above mean sea level. The main peak of Mt Taranaki forms the centre of the 33,500 ha Egmont National Park. Part of Whanganui National Park also overlaps into the region. The major urban area in the region is New Plymouth, situated on the coast to the north of Mt Taranaki. The Taranaki region is bordered by the Manawatu-Wanganui region to the east, and there is a small border with the Waikato region to the north. The region is well-suited to intensive dairy production, which for over 100 years has been a major industry. Besides dairying, some beef and sheep farming is carried out but on a much smaller scale. The soils of volcanic origin are highly fertile and free-draining.

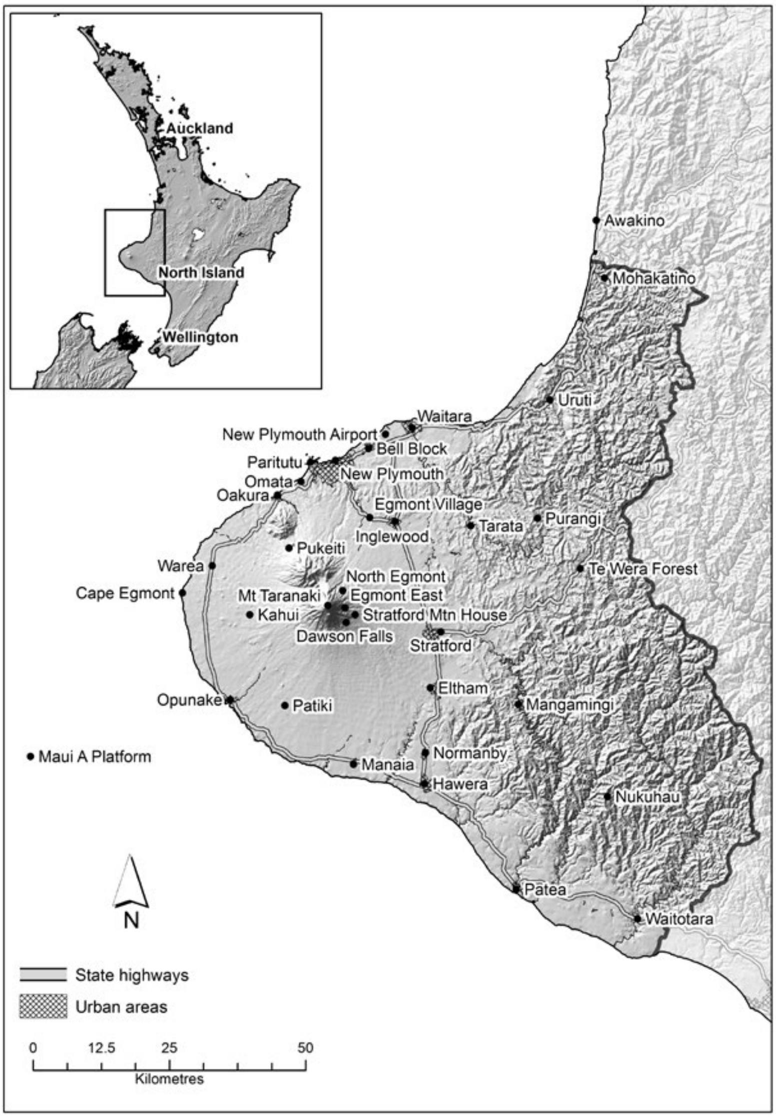

Figure 1. Map of Taranaki region, with locations of places mentioned in the text, tables, and figures.

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.

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TYPICAL WEATHER SITUATIONS IN TARANAKI

Northerly airstreams

A typical northerly airstream occurred on 30 June 1980 (Figure 2). With such an airstream, mild humid air from tropical regions ahead of the cold front can flow over the country, and localised heavy rainfalls are common on Mt Taranaki. In the northerly airflow ahead of a frontal system, high cloud steadily increases with the approach of the front. North Taranaki frequently becomes covered in a sheet of stratocumulus cloud from which scattered showers occur while south Taranaki experiences scattered cloud and mainly dry conditions.

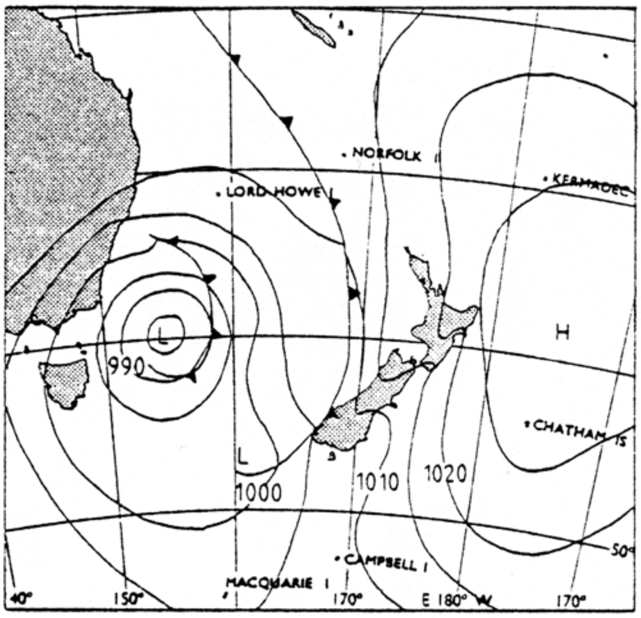


Figure 2. Mean sea level analysis for 0000 NZST 30 June 1980.

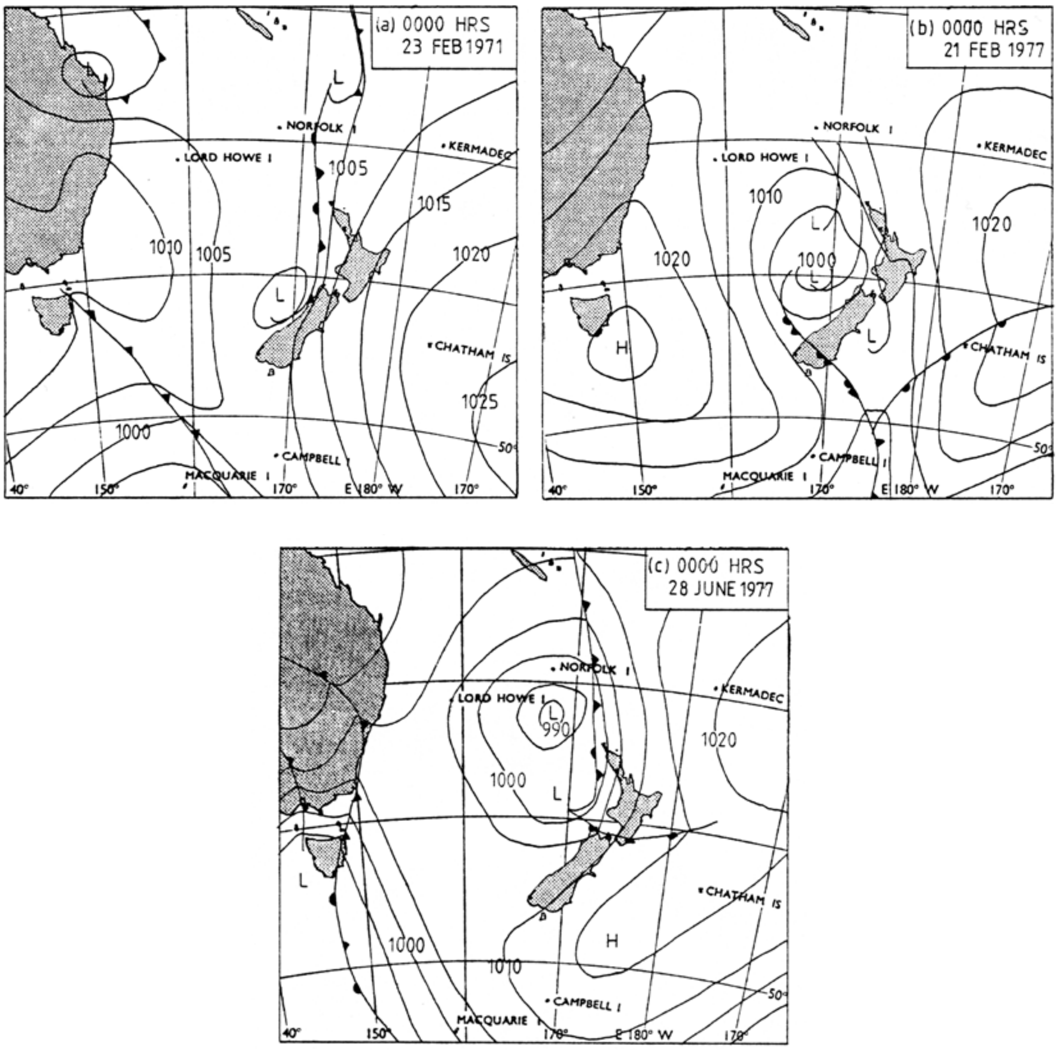


Figure 3. Meteorological situations producing heavy rain over Taranaki.

On 30 June 1980 rain fell all day in Taranaki and there was a period of heavier rain with the passage of the front about midday. The rainfall for this day was: at Uruti (20 mm), New Plymouth airport (12 mm), Stratford Mountain House (165 mm), Normanby (16 mm), Te Wera Forest (32 mm), and Nukuhau (4 mm). Wind strength varied throughout the day at New Plymouth from 35 to 55 km/hr with gusts to 75 km/hr. The track of the depression centre is important in these situations, as further periods of rain are common if the centre passes to the north. On this occasion the depression moved southeast, and consequently the flow turned westerly and the rain eased to scattered showers.

Many periods of high rainfall occur in Taranaki when a slow moving anticyclone lies to the east of New Zealand, allowing warm moist northerly air from the tropics to flow over the country. Heavy rain for periods of up to three days can occur if these conditions are associated with slow moving fronts lying north-south near Taranaki, or when depressions move across the region. Figure 3 illustrates such meteorological situations in which high rainfalls were recorded in Taranaki.

Northeasterly airstreams

When the airflow over New Zealand is mostly northeasterly, rainfall observed in Taranaki tends to be scattered and light until the next frontal zone crosses the region. Taranaki is sheltered in such airflows and surface winds are relatively light. Figure 4 illustrates the situation for 20 July 1980. Although Taranaki skies were covered by middle and high layered cloud, light rain did not break out until late on the following day. Surface winds are generally deflected from the broad-scale northeast flow; therefore southeasterlies prevailed at New Plymouth up to the time when the front passed, and at Stratford and Hawera the winds were from northwest and north, respectively.

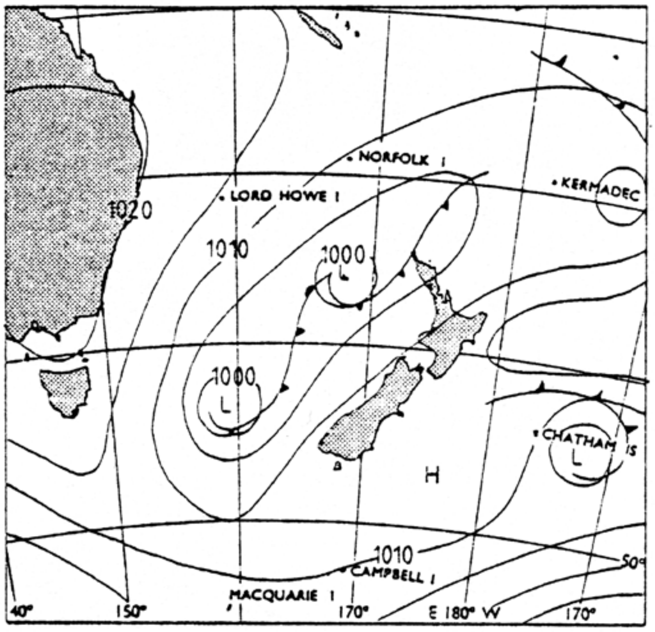


Figure 4. Mean sea level analysis for 0000 NZST 20 July 1980.

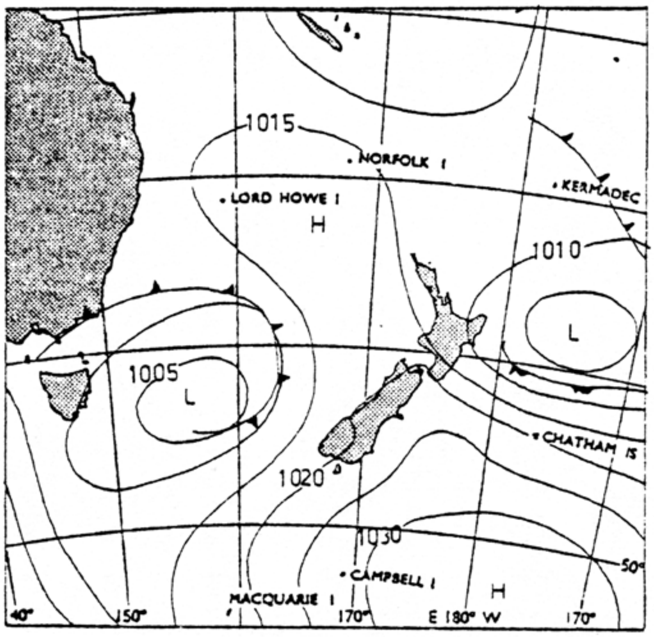


Figure 5. Mean sea level analysis for 0000 NZST 4 March 1980.

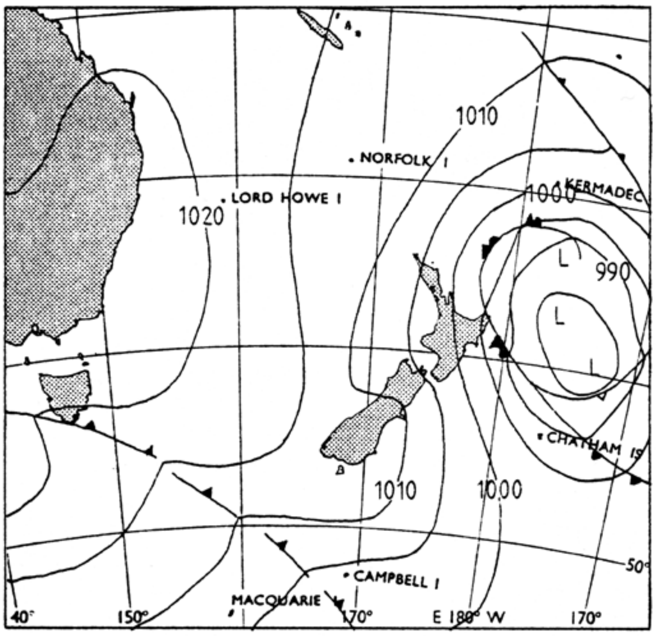


Figure 6. Mean sea level analysis for 0000 NZST 6 September 1977.

Southeasterly airstreams

With a depression to the east of the North Island and an anticyclone southeast of New Zealand, southeasterlies cover the North Island (e.g. Figure 5) bringing mostly fine weather to Taranaki. However, if the airflow is more southerly, southern Taranaki generally has cloudy skies with light showers. At midday on 4 March 1980 the Maui A Platform reported winds of 65 km/hr from the east-southeast, Hawera reported east-southeast 10 km/hr, Stratford reported south-southwest 10 km/hr, New Plymouth reported southeast 27 km/hr and the wind over northern Taranaki was light and variable. Mild conditions prevailed, New Plymouth reporting a temperature of 23°C at 2pm. This was mainly due to foehn heating of the airflow as it crossed the North Island.

Another example of a southeasterly airstream over Taranaki is shown in Figure 6 for 6 September 1977. This illustrates a cold south to southeast flow over New Zealand. There were scattered showers in south Taranaki, snow showers on Mt Taranaki, and dry weather elsewhere. Winds at midday on 6 September 1977 were as follows: New Plymouth reported southerly winds at 46 km/hr, Stratford reported southerly at 37 km/hr, Hawera reported southeast at 55 km/hr, and Awakino reported southerly at 37 km/hr.

Southwesterly airstreams

The distribution of weather over Taranaki is very much dependent on the direction of the isobars in a southwesterly airflow. If the flow of air is more south-southwest, then fine weather will generally be experienced, but if it is west-southwest then scattered showers commonly prevail throughout the region. Small-scale features such as the afternoon development of heat lows over the north of the South Island further affect the weather. These lows, for example, deflect the airflow more westerly over Taranaki;

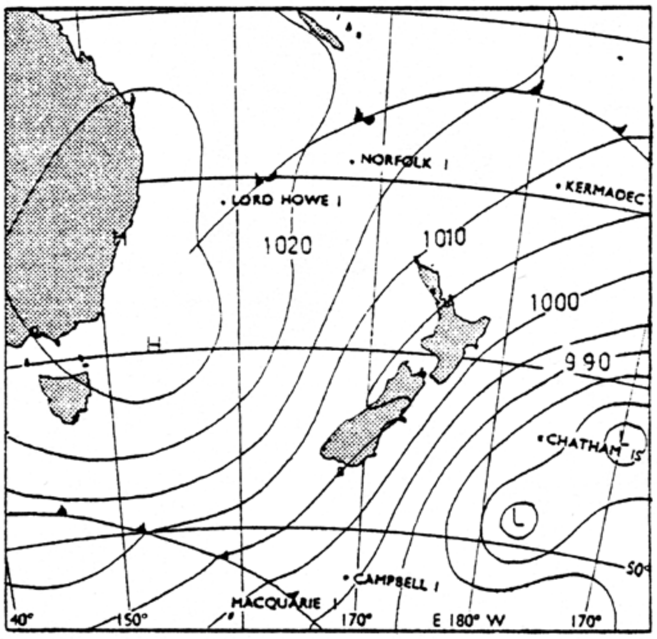


Figure 7. Mean sea level analysis for 0000 NZST 13 July 1980.

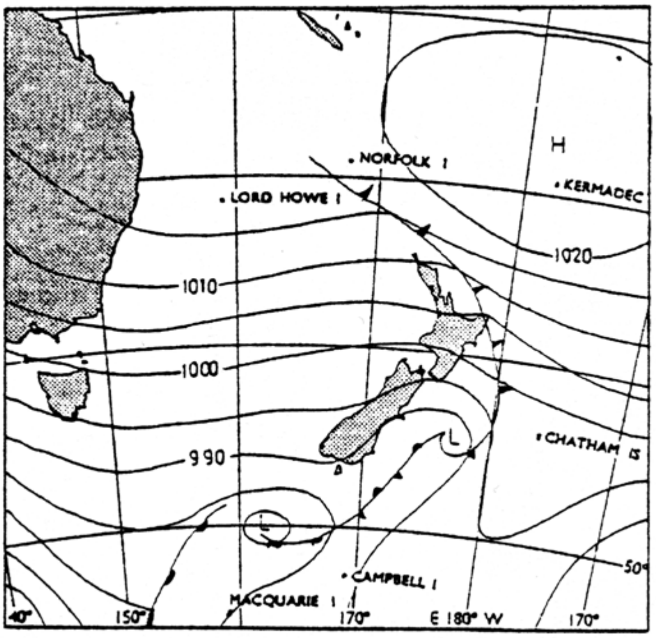


Figure 8. Mean sea level analysis for 0000 NZST 17 September 1980.

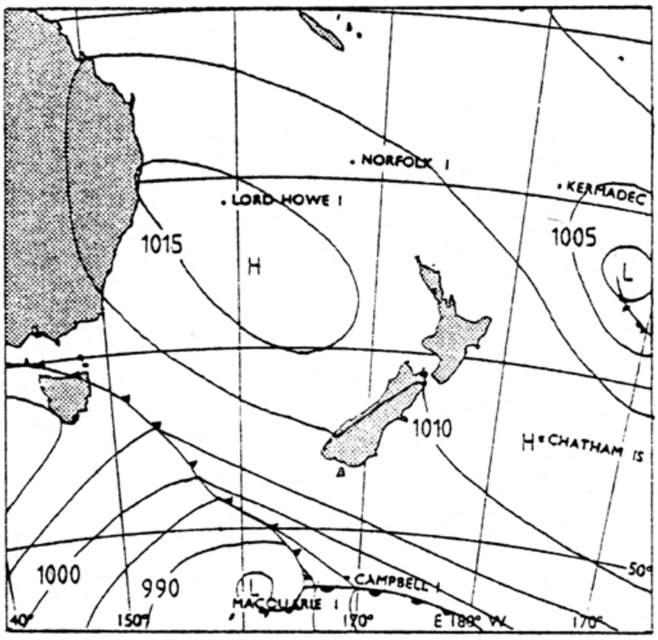


Figure 9. Mean sea level analysis for 0000 NZDT 20 February 1980.

consequently shower activity may become widespread and especially so if the airstream is unstable.

Figure 7 shows a typical meteorological situation for 13 July 1980 where a cool southwesterly airflow covers New Zealand. Winds over Taranaki on 13 July 1980 were mostly southwest. Cape Egmont measured winds between 45 and 55 km/hr, New Plymouth reported winds of 28 to 37 km/hr, and Egmont East recorded 37 to 45 km/hr with very frequent gusts to 75 km/hr. Offshore at the Maui A Platform, west-southwest winds 55 to 65 km/hr were observed.

Westerly airstreams

In Taranaki, westerly airstreams are associated with periods of unsettled showery weather. In these situations, a belt of high pressure lies to the north of the country, while to the south migratory depressions move steadily eastwards. The westerly airstream, which can span a large portion of the hemisphere, frequently contains rapidly moving cold fronts, which bring periods of heavier showers to western regions of New Zealand. Figure 8 shows the situation for 17 September 1980. During the day, surface winds were west-southwest 27 to 37 km/hr, and the Maui A Platform reported 65 km/hr at midday. New Plymouth reported gusts to 83 km/hr in squally showers. Rainfall was recorded in most areas of Taranaki, but the amounts were small.

Sea breeze situations

Sea breezes in Taranaki are not as common as in east coast regions, because of more prevalent on-shore gradient winds. However, they do occur under clear skies in anticyclonic conditions, and typically have a wind speed of 18 to 28 km/hr. The sea breeze circulation is a shallow system, characterised by a low level onshore wind, with offshore winds at a height between

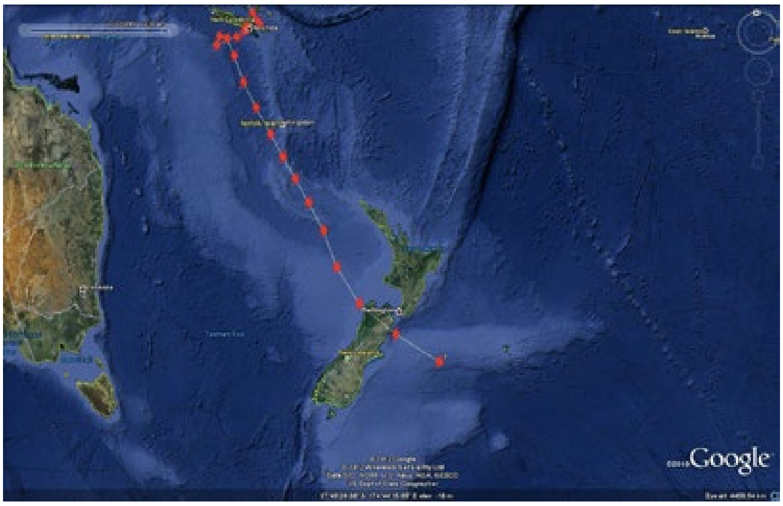


Figure 10a. Tropical cyclones which made landfall in New Zealand during December, 1970-2010. Source: Southwest Pacific Enhanced Archive of Tropical Cyclones (SPEArTC; Diamond et al., 2012).

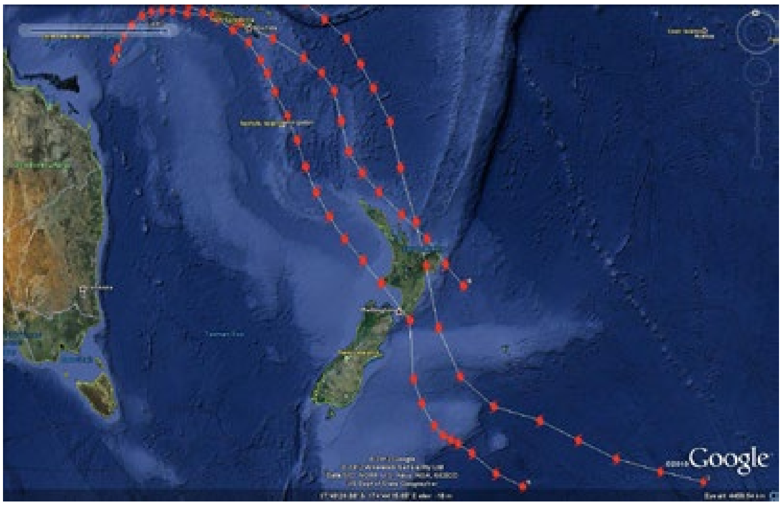


Figure 10b. Tropical cyclones which made landfall in New Zealand during January, 1970-2010. Source: SPEArTC (Diamond et al., 2012).

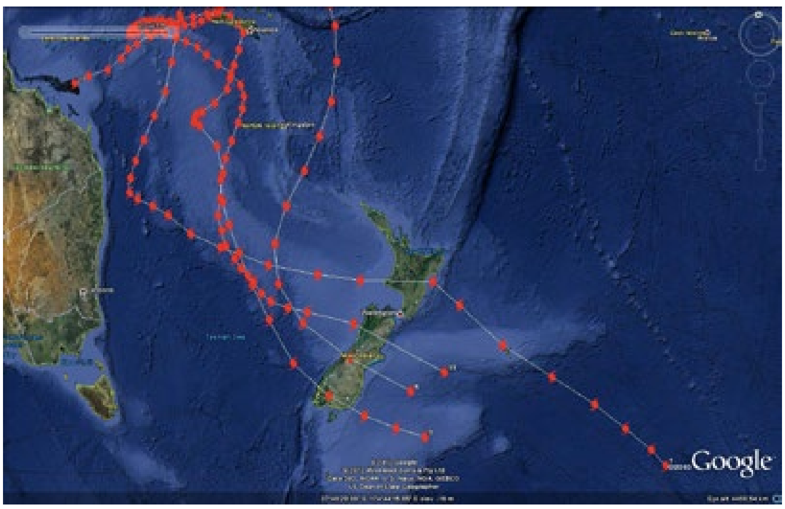


Figure 10c. Tropical cyclones which made landfall in New Zealand during February, 1970-2010. Source: SPEArTC (Diamond et al., 2012).

200 and 1000 m. Figure 9 illustrates a day when sea breezes occurred in Taranaki.

Cyclones of tropical origin

The tropical cyclone season in the southern hemisphere lasts from November to April. Originating in low latitudes within the cloud masses of the South Pacific Convergence Zone, tropical cyclones reaching northern New Zealand and still retaining true cyclonic characteristics, such as a warm core, are extremely rare. They are nevertheless accompanied by heavy rain and strong winds. Ex-tropical cyclones often approach New Zealand from the northwest, and sometimes affect the Taranaki region. Tracks of tropical cyclones which have made landfall in New Zealand between 1970 and 2010 are shown in Figure 10a-e.

Figure 11 shows the meteorological situation for 8 March 1988 as ex-tropical cyclone Bola was positioned east of Cape Reinga. Bola caused gale force winds in the Taranaki region, which damaged 500 houses in the New Plymouth District, felled power lines, and caused extensive property damage. These winds also caused widespread damage to forestry throughout the central North Island. Average wind speeds at the Maui A Platform were 110-130 km/hr for 36 hours from 12pm on 7 March to 12am on 9 March, with a peak gust of 152 km/hr (Burgess et al., 2006). A Civil Defence Emergency was declared in Taranaki due to the damaging winds. Insurance losses due to wind damage alone amounted to $19 million in the Taranaki region alone.

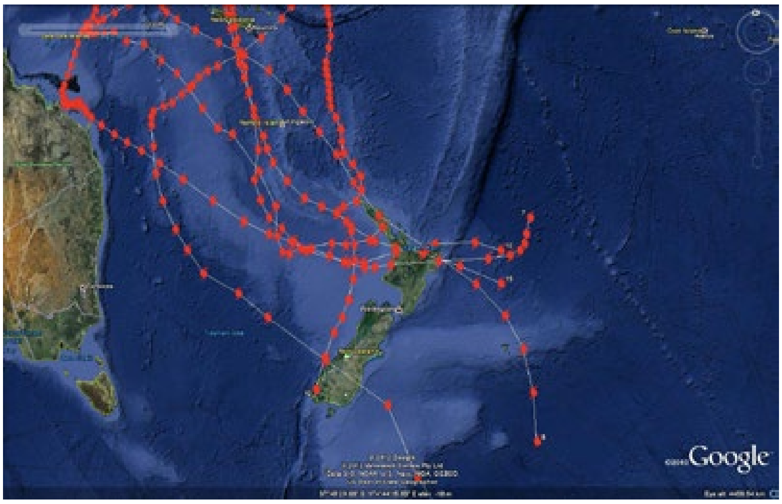


Figure 10d. Tropical cyclones which made landfall in New Zealand during March, 1970-2010. Source: SPEArTC (Diamond et al., 2012).

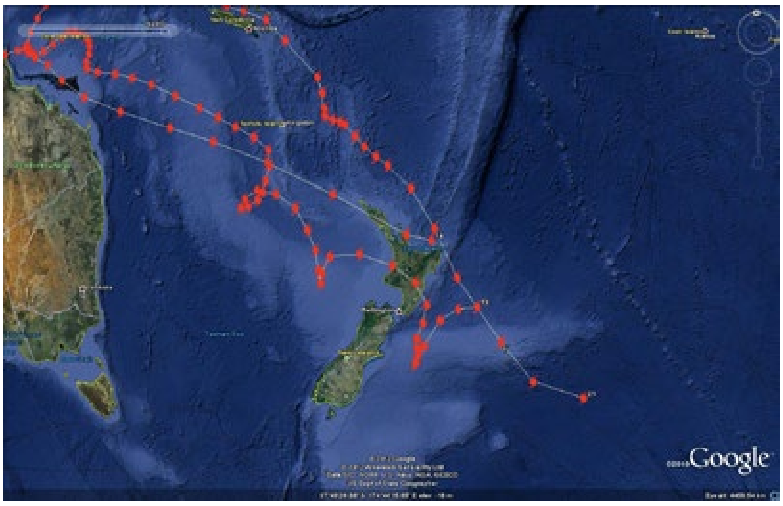


Figure 10e. Tropical cyclones which made landfall in New Zealand during April, 1970-2010. Source: SPEArTC (Diamond et al., 2012).

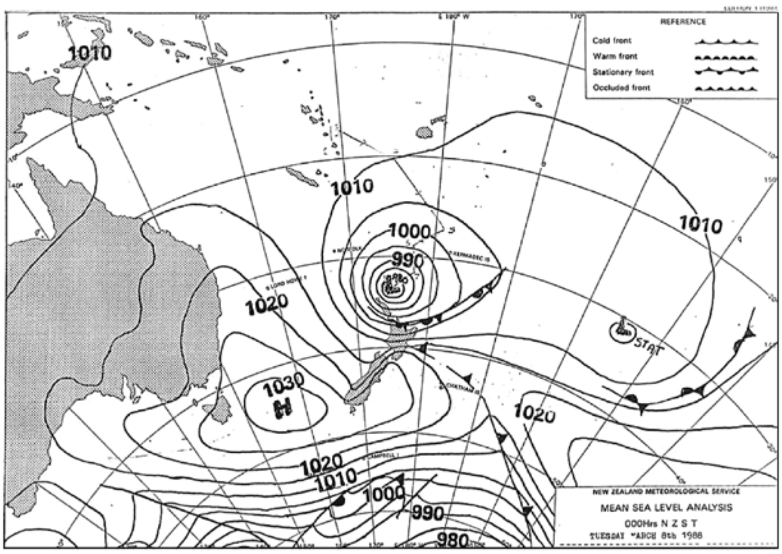


Figure 11. Synoptic map showing ex-tropical cyclone Bola at 0000 NZST 8 March 1988 (near the time of most intense wind). Source: Burgess et al. (2006)

CLIMATIC ELEMENTS

Wind

The prevailing winds over New Zealand in the zone directly above the earth's surface are westerly, and they influence the general precipitation and temperature regimes of Taranaki. At the surface, winds are markedly influenced by local terrain effects, notably the location relative to Mt Taranaki and the central high country and the orientation of the coast. At Maui A Platform, the predominant wind direction is from the west. At New Plymouth airport, southeasterlies predominate. These winds are due to:

a. The deflection by Mt Taranaki of winds from a southerly quarter to a southeasterly direction;
b. A southeasterly drainage of cold air (katabatic wind) from the slopes of Mt Taranaki, and
c. Night-time land breezes.

Northerly flows are dominant at Stratford and Hawera. Figure 12 shows mean annual frequencies of surface wind based on hourly observations from selected stations. Exposed sites such as Maui A Platform have a higher percentage of strong winds than more sheltered sites, such as Stratford.

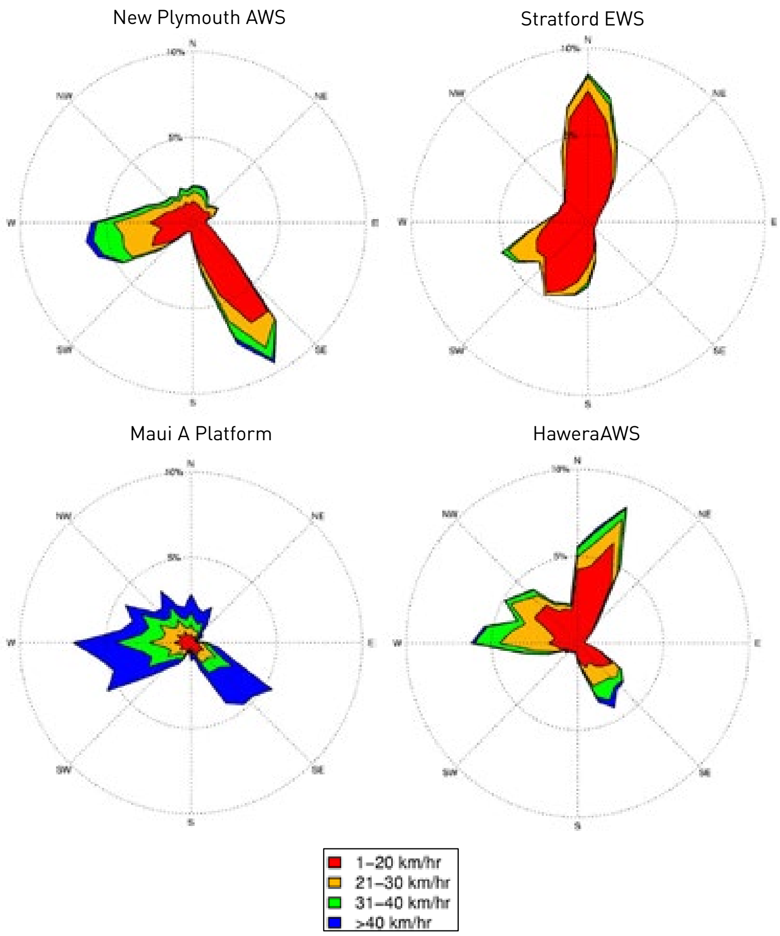


Figure 12. Mean annual wind frequencies (%) of surface wind directions from hourly observations at selected Taranaki stations. The plots show the directions from which the wind blows, e.g. the dominant wind direction at Stratford is from the north.

Table 1. Mean monthly/annual wind speeds (km/hr) for Taranaki sites, from all available data.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Cape Egmont	20.9	20.6	21.2	23.6	24.6	23.4	23.5	23.8	25.8	24.7	23.6	23.3	23.3
Maui A Platform	33.3	34.5	37.4	39.4	39.6	39.5	37.8	37.3	43.3	38.8	35.8	34.1	37.6
New Plymouth Aero	18.0	16.8	17.2	18.4	18.8	18.9	19.3	19.3	20.7	20.8	19.9	18.8	18.9
Normanby EDR	15.3	13.9	14.1	13.0	14.6	15.4	14.4	15.7	16.5	18.1	17.3	15.8	15.3

Table 2. Seasonal percentages of strong and light winds (%) for Taranaki sites, from all available data.

Location		Summer	Autumn	Winter	Spring
Cape Egmont	Strong	20	24	28	28
	Light	27	24	25	24
New Plymouth Aero	Strong	21	23	24	31
	Light	26	26	24	23
Normanby EDR	Strong	19	20	24	36
	Light	24	26	26	24

Mean wind speed data (average wind speeds are taken over the 10 minute period preceding each hour) are available for several sites in Taranaki, and these illustrate the different wind regimes of the region (Table 1). Maui A Platform, which is located 33 km offshore, is much windier throughout the year compared with the other onshore sites. Normanby, which is located inland from Hawera, experiences the lightest winds of the sites considered.

Spring is generally the windiest season throughout the region, whereas the least strong winds are observed in summer. Table 2 gives the seasonal proportion of strong and light winds as a percentage of the annual total. For example, of all strong winds recorded at New Plymouth, 21% occurred in summer, 23% in autumn, 24% in winter and 31% in spring. In compiling this table a strong wind was defined as having a mean wind speed of at least 31 km/hr.

Diurnal variation in wind speed is well-marked, with greatest wind speeds occurring in the middle of the afternoon. This is because at that time of day heating of the land surface is most intense and stronger winds aloft are brought down to ground level by turbulent mixing. Cooling at night generally detaches the upper flow and restores a lighter wind regime. Table 3 gives average wind speeds at three-hourly intervals for selected stations.

Gusts of at least 63 km/hr are recorded at the exposed site at Cape Egmont on an average of 126 days each year, and gusts over 96 km/hr occur on average 12 days each year (Table 4). In comparison, the more sheltered site further inland at Normanby records 46 days per year with gusts over 63 km/hr, and only one day each year with gusts over 96 km/hr.

Table 3. Average wind speed (km/hr) for selected hours, from all available data.

Location	00	03	06	09	12	15	18	21
Cape Egmont	22	22	22	23	26	26	23	22
New Plymouth Aero	18	18	18	19	22	23	20	18
Normanby EDR	13	13	13	16	20	21	16	12

Table 4. Average number of days per year with gusts exceeding 63 km/hr and 96 km/hr for selected stations, from all available data.

Location	Gusts >63 km/hr	Gusts >96 km/hr
Cape Egmont	126	12
New Plymouth Aero	83	6
Normanby EDR	46	1
Omata	60	3

Table 5. Highest recorded gusts at selected Taranaki stations, from all available data.

Location	Gust (km/hr)	Direction (°)	Date
Cape Egmont	139	SSE	14/03/1985
Egmont East	172	NNW	10/09/1980
Hawera AWS	104	NNE	12/06/2006
Maui A Platform	174	SE	21/05/1981
New Plymouth Aero	158	SE	9/04/1982
New Plymouth AWS	118	S	24/01/2011
Normanby EDR	109	-	9/07/1998
Omata	113	SE	27/05/1986
Paritutu	134	-	26/11/1971

Although gale force winds can occur in any month, they are most frequent in winter. The highest gust recorded on land in the region was 172 km/hr at Egmont East on 10 September 1980 (this excludes the maximum gust from the offshore Maui A Platform of 174 km/hr). Maximum gusts recorded at different stations in the region are listed in Table 5.

Rainfall

Rainfall distribution

Taranaki's rainfall patterns are closely related to elevation and exposure to the main rain-bearing northerly to westerly winds. Figure 13 shows the distribution of median annual total rainfall over the region. Rainfalls averaging less than 1500 mm per year occur only in the southern part of the region and on a narrow coastal strip in the north. Most of northern Taranaki experiences rainfall in excess of 2000 mm per year, and Mt Taranaki is particularly wet. The high regular rainfalls on the mountain provide the water for the many swift running rivers which radiate from it.

The variability of seasonal and annual rainfall over Taranaki is similar to that of other western areas of New Zealand and is markedly less than many east coast districts. Table 6 lists monthly rainfall normals and percentage of annual total for selected stations. The proportion of annual rainfall that is recorded in the winter months from June to August is fairly consistent across the Taranaki region at 29% (ranging from 27% to 31%), but the proportion of rainfall recorded in the summer months from December to February ranges from 18% at Kahui and

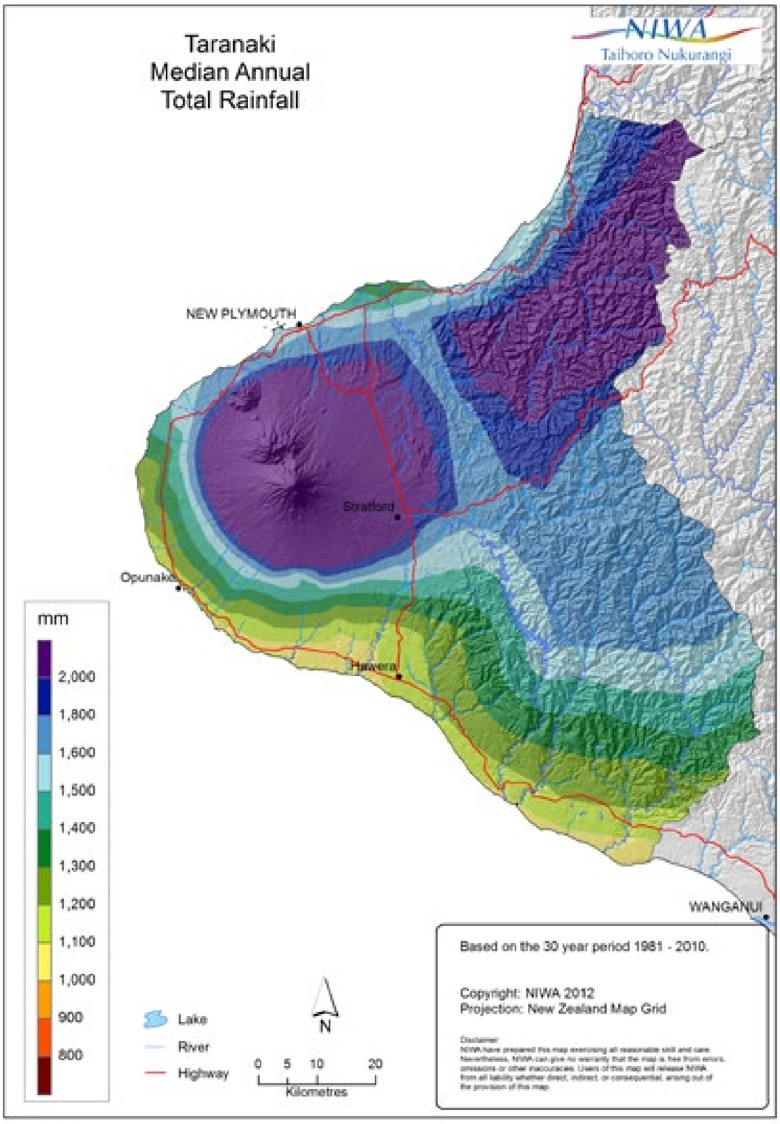


Figure 13. Taranaki median annual total rainfall, 1981-2010.

Table 7. Monthly/annual rainfall normals (a; mm); percentage of annual total for each month (b; %).

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Eltham 2	a	104	106	155	129	117	167	187	155	134	144	130	112	1637
	b	6	6	9	8	7	10	11	9	8	9	8	7	
Hawera AWS	a	76	73	83	83	98	120	119	99	94	110	94	92	1141
	b	7	6	7	7	9	10	10	9	8	10	8	8	
Inglewood	a	230	148	228	163	158	200	225	230	181	240	180	215	2397
	b	10	6	10	7	7	8	9	10	8	10	7	9	
Kahui 2	a	124	106	158	148	158	183	198	177	170	234	173	129	1957
	b	6	5	8	8	8	9	10	9	9	12	9	7	
Manaia Dem Farm	a	87	83	96	60	99	107	113	70	83	104	93	77	1072
	b	8	8	9	6	9	10	10	7	8	10	9	7	
Mangamingi, Aorere Rd	a	94	111	102	116	124	143	140	145	129	157	112	109	1481
	b	6	7	7	8	8	10	9	10	9	11	8	7	
Mohakatino	a	116	122	79	117	182	215	175	174	205	153	140	157	1834
	b	6	7	4	6	10	12	10	9	11	8	8	9	

Table 7 continued.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
New Plymouth AWS	a	93	96	98	116	126	148	136	127	120	125	104	121	1409
	b	7	7	7	8	9	11	10	9	9	9	7	9	
Normanby EDR	a	63	77	82	102	93	116	128	108	104	128	120	74	1195
	b	5	6	7	9	8	10	11	9	9	11	10	6	
North Egmont	a	457	381	432	480	603	654	698	695	676	809	555	589	7029
	b	6	5	6	7	9	9	10	10	10	12	8	8	
Patea Hydro	a	121	91	114	132	148	158	173	149	138	154	163	119	1659
	b	7	6	7	8	9	10	10	9	8	9	10	7	
Patiki	a	89	87	93	101	113	143	139	113	114	132	112	107	1343
	b	7	6	7	8	8	11	10	8	9	10	8	8	
Pukeiti	a	228	213	243	235	297	316	306	295	312	363	264	304	3376
	b	7	6	7	7	9	9	9	9	9	11	8	9	
Purangi	a	145	146	143	160	178	193	205	185	202	230	178	206	2171
	b	7	7	7	7	8	9	9	9	9	11	8	9	
Stratford EWS	a	122	132	140	146	172	196	208	190	181	218	152	165	2022
	b	6	7	7	7	9	10	10	9	9	11	8	8	
Tarata	a	118	116	122	138	155	173	166	155	161	172	137	153	1766
	b	7	7	7	8	9	10	9	9	9	10	8	9	
Warea, Lower Bayly Road	a	82	76	69	95	137	142	132	124	94	120	102	118	1290
	b	6	6	5	7	11	11	10	10	7	9	8	9	

Normanby to 25% at Inglewood. Throughout Taranaki there is a seasonal variation with a winter maximum and a summer or early autumn minimum.

The distribution of monthly rainfall is shown in Figure 14. The 10th percentile, 90th percentile, and mean rainfall values for each month are shown along with maximum and minimum recorded values for several stations.

Rainfall variability over longer periods is indicated by rainfall deciles, as given in Table 7. The 10th percentile values show the accumulated rainfalls that will normally be exceeded in nine out of ten years, while the 90th percentile values indicate the accumulated falls that will normally be exceeded in only one year in ten. The table includes periods from one month to twelve months; each period over one month begins

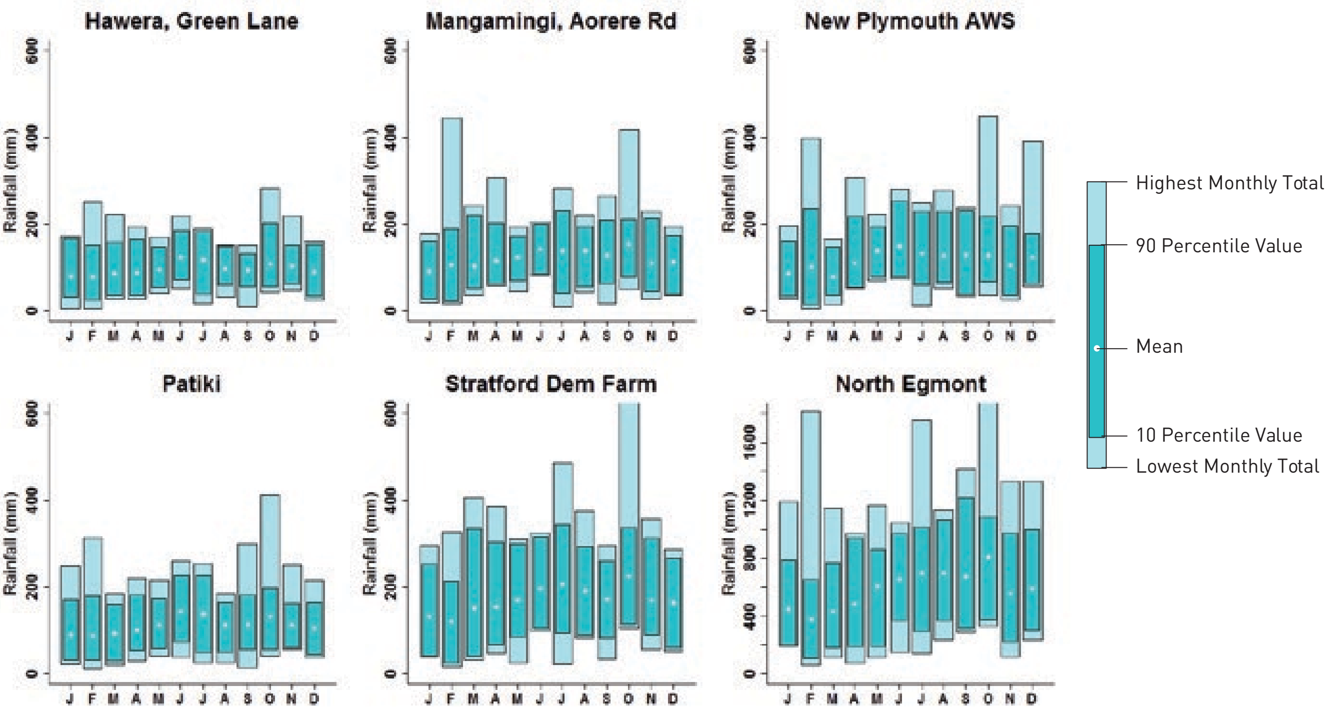


Figure 14. Monthly variation in rainfall for selected Taranaki stations. Note that North Egmont has a different vertical scale.

with the month stated. For example, using the table for New Plymouth, it can be seen that in the three month period beginning in April, 286 mm or more of rainfall can be expected in nine years in ten, while a total of 541 mm or more is expected in only one year in ten.

Table 7. Rainfall deciles for consecutive months for selected Taranaki stations.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hawera, Green Lane												
1 month												
10th	33	25	36	35	54	71	40	59	56	55	61	33
90th	166	152	159	164	148	184	183	150	132	202	152	153
3 months												
10th	152	171	177	202	209	207	209	216	237	186	148	175
90th	367	358	373	418	464	434	399	381	395	431	382	379
6 months												
10th	416	445	483	482	457	459	460	455	432	415	410	406
90th	682	719	766	762	844	830	767	688	747	746	659	649
12 months												
10th	942	981	1010	1001	926	893	892	983	947	934	935	957
90th	1327	1364	1320	1366	1410	1373	1351	1339	1359	1408	1374	1390
New Plymouth AWS												
1 month												
10th	29	15	43	54	72	77	59	64	36	67	35	62
90th	139	235	151	225	198	217	231	236	236	226	197	179
3 months												
10th	152	191	230	286	305	268	219	266	240	242	195	178
90th	437	529	451	541	540	583	610	493	489	627	434	652
6 months												
10th	478	525	557	620	633	578	554	481	466	391	404	467
90th	867	851	982	1046	1022	995	1036	967	1149	988	900	882
12 months												
10th	1135	1116	1076	1086	1150	1097	1138	1168	1126	1099	1116	1093
90th	1669	1755	1844	1830	1841	1781	1726	1730	1724	1742	1734	1736
Stratford Dem Farm												
1 month												
10th	42	23	40	67	85	105	93	89	83	113	89	60
90th	252	213	335	306	299	315	344	293	259	337	312	268
3 months												
10th	193	243	329	317	388	365	373	423	374	360	290	314
90th	609	634	603	651	730	762	739	698	716	795	703	558
6 months												
10th	678	711	863	835	910	859	940	870	777	744	674	786
90th	1146	1180	1246	1277	1394	1461	1402	1272	1292	1291	1260	1133
12 months												
10th	1670	1678	1733	1684	1698	1607	1642	1745	1697	1631	1646	1718
90th	2468	2489	2414	2410	2618	2479	2392	2328	2389	2449	2443	2397

Rainfall frequency and intensity

Rain day frequency increases towards Mt Taranaki. The frequency of rain days is greatest during winter months (around 30% of the annual total) and least in summer (around 20% of the annual total). Rain is frequently heavier and more intense in the high country than elsewhere. The annual number of rain days (where at least 0.1mm falls) over the Taranaki region as a whole is about 180, but varies from 123 days at Tarata to 224 at Pukeiti. The annual number of wet days (where at least 1 mm of rain falls) exhibits the same geographic variability, with an average of 155 days across the region, but a minimum of 118 days at Tarata to a maximum of 193 days at Pukeiti. Table 8 lists the average number of days per month with 0.1 mm and 1 mm of rain for selected stations.

Table 8. Average monthly rain days and wet days for Taranaki stations; a: 0.1 mm rain day, b: 1 mm wet day.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Eltham 2	a	11	9	13	15	19	20	20	18	18	18	14	12	188
	b	10	8	11	13	17	17	18	16	15	16	12	11	164
Hawera,Green Lane	a	13	11	13	15	18	20	19	19	19	17	16	15	195
	b	9	8	9	11	13	15	15	14	13	13	11	11	142
Inglewood	a	14	11	14	13	17	18	18	18	17	19	15	15	188
	b	12	9	11	11	13	15	15	15	15	16	12	13	155
Kahui 2	a	14	12	14	16	19	22	20	21	20	20	16	16	209
	b	10	9	11	12	16	19	17	15	15	16	12	12	164
Mangamingi, Aorere Rd	a	10	9	10	11	13	15	14	15	14	14	11	11	147
	b	10	9	9	11	12	14	14	14	13	14	11	11	142
New Plymouth AWS	a	11	11	12	13	17	19	18	20	18	17	14	16	186
	b	9	8	9	10	13	15	14	15	14	13	11	12	142
Normanby EDR	a	12	11	12	15	18	20	20	20	19	17	15	13	191
	b	8	7	9	11	11	14	15	15	14	13	12	10	139
North Egmont	a	15	12	15	16	18	20	20	21	20	21	18	17	212
	b	13	11	12	14	17	18	19	19	18	19	16	15	192
Patea Hydro	a	14	12	14	15	20	22	21	21	19	19	17	15	209
	b	11	10	11	12	15	18	18	17	15	15	15	13	169
Patiki	a	9	8	9	11	14	16	16	14	13	13	11	12	147
	b	9	8	9	11	13	15	15	14	13	13	11	11	141
Pukeiti	a	15	13	15	17	20	22	21	22	21	22	18	19	224
	b	12	11	12	15	18	20	18	19	18	18	15	16	193
Purangi	a	12	10	12	12	16	16	16	17	16	18	13	15	174
	b	10	9	10	10	12	13	14	15	14	16	11	13	146
Stratford Dem Farm	a	12	10	12	13	15	18	18	18	16	17	14	14	177
	b	10	8	10	11	13	14	15	15	14	15	12	12	147
Tarata	a	8	8	8	8	10	13	10	14	11	12	10	11	123
	b	8	7	8	8	9	12	10	13	10	12	9	11	118

Heavy rainfalls can occur in Taranaki with northerly and westerly flows, when ex-tropical depressions pass near the region, and also with thunderstorms. In Table 9, maximum short period rainfalls for periods of 10 minutes to 72 hours with calculated return periods are given for several stations. Also listed in this table are the maximum rainfalls expected in 2, 5, 10, 20, and 50 years. Depth-duration frequency tables for Taranaki 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 hirds.niwa.co.nz.

Table 9. 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
New Plymouth Aero	a	22	34	37	48	69	125	226	361	393	396
	b	50	55	30	16	28	70	100+	100+	100+	100+
	c	10	15	19	28	36	52	66	84	102	114
	d	13	19	24	37	46	67	85	108	131	147
	e	15	23	29	43	55	79	101	127	155	174
	f	18	27	34	51	65	93	118	149	182	204
	g	22	33	42	63	80	115	145	183	223	250
North Egmont	a	17	24	27	48	90	173	286	378	501	612
	b	10	7	4	5	11	8	10	4	5	7
	c	12	19	24	38	61	127	203	322	410	472
	d	15	23	30	48	75	156	248	393	499	574
	e	17	27	35	55	87	179	283	447	568	654
	f	19	31	40	63	99	204	321	507	644	741
	g	23	36	48	75	118	241	379	596	757	871
Stratford NZED	a	31	46	52	77	83	105	163	258	301	308
	b	90	100+	87	100+	50	20	39	94	68	40
	c	11	15	18	25	35	58	81	112	140	159
	d	14	20	24	33	46	75	103	141	175	200
	e	17	24	29	41	55	89	121	163	204	232
	f	21	29	35	49	66	105	141	189	235	268
	g	26	37	45	63	83	130	172	227	283	323

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

Recent extreme events in Taranaki

Taranaki region has experienced a number of extreme weather events, with significant damage and disruption caused by flooding and high winds. The events listed below are some of the most severe events to have affected the Taranaki region between 1980 and 2013.

7-8 March 1988: Ex-tropical cyclone Bola caused significant damage in the Taranaki region. Almost 500 houses in the New Plymouth District were severely damaged by high winds. More than 50 houses lost their roofs, and a number were uninhabitable. An estimated 10,000 trees were downed, 54 km of fencing was destroyed, and 90 hay barns and 30 dairy sheds were severely damaged or destroyed. All schools in north Taranaki and most shops were closed during the storm, and a number of roads were also closed. Power was cut to isolated areas, and millions of dollars in cash crops were destroyed. A Civil Defence Emergency (CDE) was in effect for some parts of the region during and following the storm.

20-23 April 1995: Very heavy rain associated with a depression caused widespread flooding in and around New Plymouth. The city was cut off from the north and east by flooding, and a number of people were evacuated from their homes. The 21st was one of the wettest days in New Plymouth's history, with a nine-hour period of high intensity rainfall. Insurance payout for the floods was approximately $5 million 2010 dollars.

14-19 February 2004: A deep low moved slowly eastwards over the North Island, causing intense rainfall and strong winds. Parts of the Taranaki region were without power for several days, which closed schools and meant that farmers could not milk their cows. Extensive flooding and landsliding occurred in the region. Slipping blocked access to farms, destroyed fences, and damaged water supply systems. The township of Waitotara was evacuated due to flooding. High winds caused significant damage to buildings, especially hay barns. A CDE was declared in south Taranaki on the 15th, which lasted for 10 days.

29 April – 1 May 2008: A combination of fronts caused heavy rain and flooding in the Taranaki region. Water supplies and kilometres of fencing were destroyed in coastal Taranaki. The storm caused record-high river levels between Opunake and Oakura, and numerous small road bridges were washed away. Bridges and tracks in Egmont National Park were destroyed by flooded streams and slips.

Numerous tornados have also caused damage in the Taranaki region. Information on tornadoes in the region is detailed in the 'Severe convective storms' section.

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'. There is an average of 1.4 such periods each year in the Taranaki region. The average duration of a dry spell is about 19 days. The longest recent dry spell between three key sites in Taranaki (New Plymouth AWS, Stratford Dem Farm/Stratford EWS, and Hawera Green Lane/ Hawera AWS) was 40 days recorded in Stratford, from 6 February to 17 March 2013. During this dry spell, 38 consecutive days were without any rain. The longest recent dry spell in Hawera was 38 days, from 7 February to 16 March 2013 (all days without any rain). In New Plymouth, the longest recent dry spell was 27 days from 4 to 30 March 2008, of which 14 consecutive days were without any rain.

Temperature

Sea surface temperature

Monthly mean sea surface temperatures (SST) off the coast of Taranaki are compared with mean air temperature for New Plymouth in Figure 15. The minima of land and sea temperatures occurs at about the same time of year (July). Throughout the year, mean air temperatures are cooler than mean sea surface temperatures. Figure 16 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.

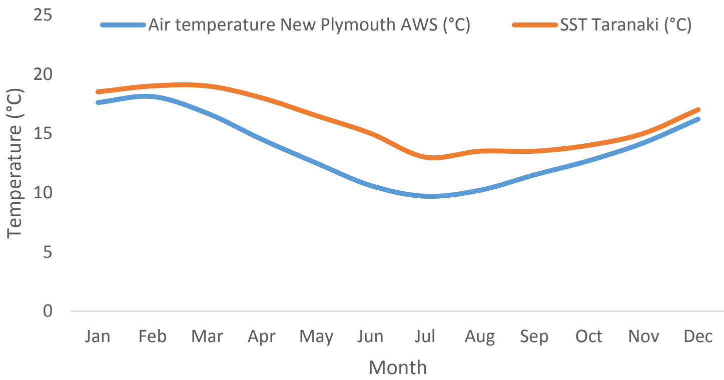


Figure 15. Mean monthly land (New Plymouth AWS) and sea surface temperatures (off the coast of New Plymouth)

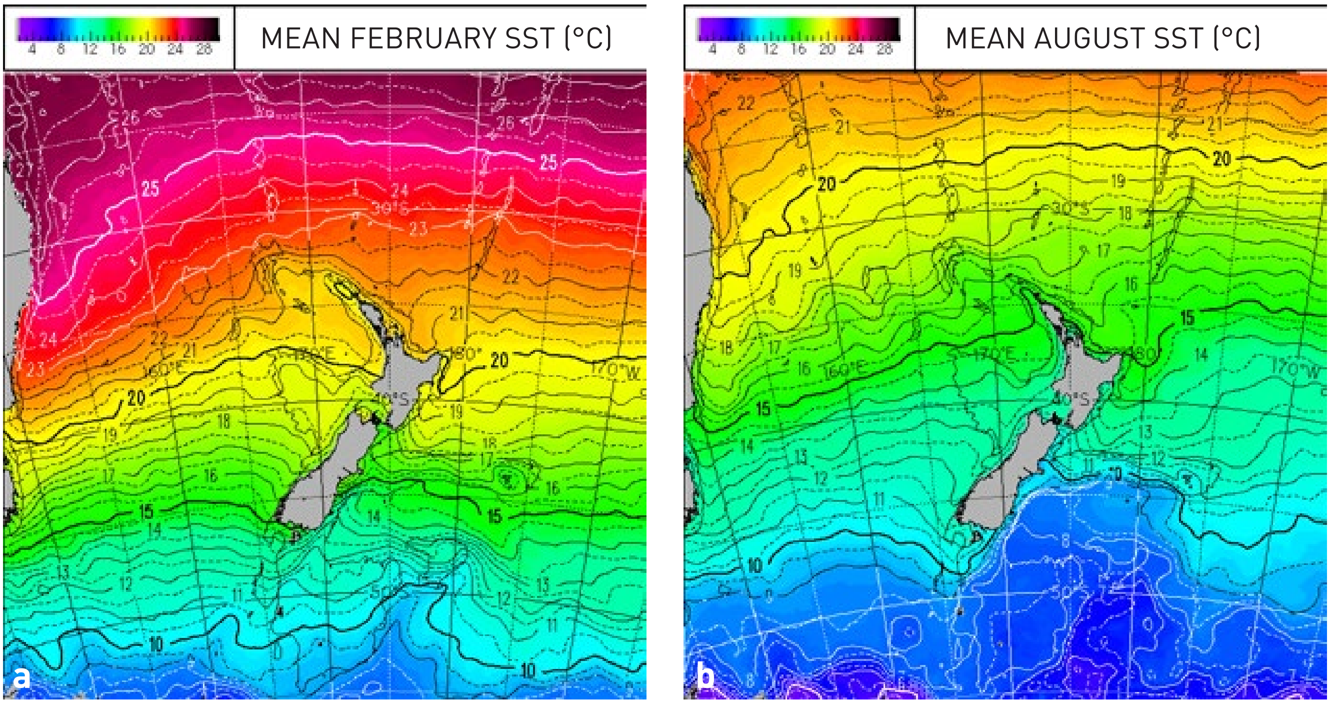


Figure 16. Monthly mean sea surface temperatures (°C) for: a) February; b) August. Source: NIWA SST Archive, Uddstrom and Oien (1999).

Air temperature

In general, most of the Taranaki region experiences warm summer afternoon temperatures of 20-22°C, with temperatures appreciably cooler towards the summit of Mt Taranaki (Figure 17a). During winter nights, temperatures on the coastal strip are milder than further inland and at higher elevations, due to the modifying effect of the sea on air temperature (6-8°C at the coast, 2-3°C further inland, and less than 2°C near the summit of Mt Taranaki, Figure 17b).

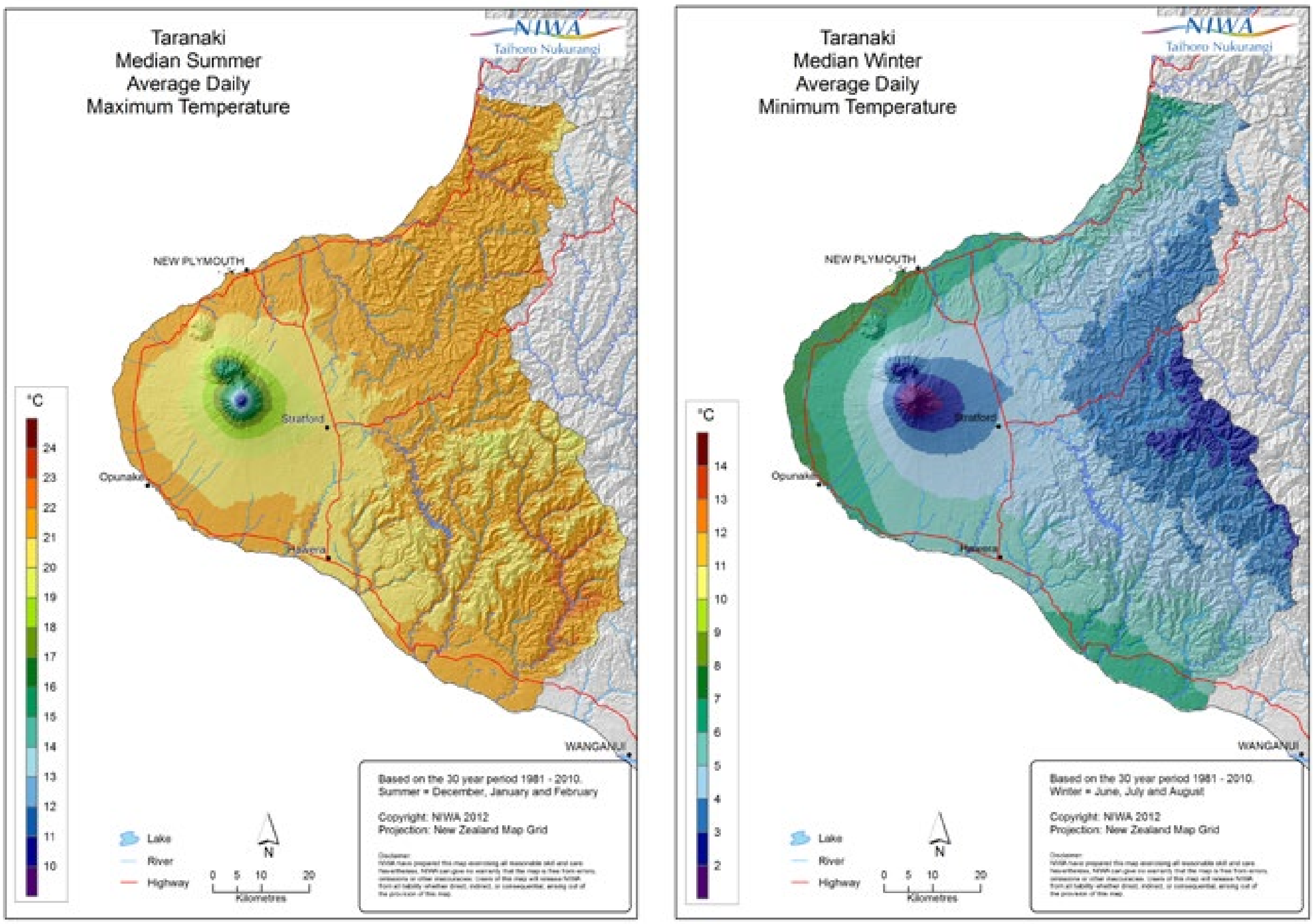


Figure 17. a) Left: Taranaki median summer average daily maximum temperature; b) Right: Taranaki median winter average daily minimum temperature 1981–2010.

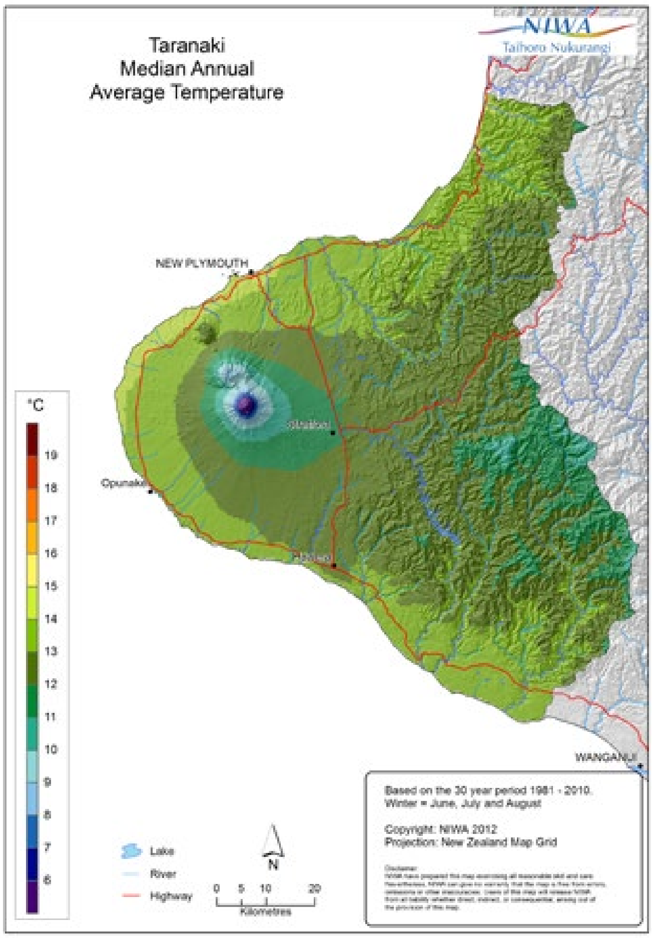


Figure 18. Median annual average air temperature for Taranaki, 1981–2010.

Figure 18 shows that median annual average temperature in the Taranaki region varies with elevation. Low-lying areas around the coast have a mean annual temperature of around 13.5°C, whereas the inland hill country experiences mean annual temperatures of about 10-12°C. Mean annual air temperatures are much lower at the summit of Mt Taranaki (less than 6°C), since air temperature decreases with height above sea level by about 0.6°C for each 100 m increase in elevation. In elevated areas, the cooler conditions mean that temperatures will often fall below freezing, especially during the winter. Further, the daily variation in temperature decreases as the altitude increases. Figure 19 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 sites in Taranaki.

Daily temperature ranges in Taranaki are smaller than those in eastern areas of New Zealand (Table 10). The daily range of temperature, i.e. the difference between the maximum and the minimum, is smaller

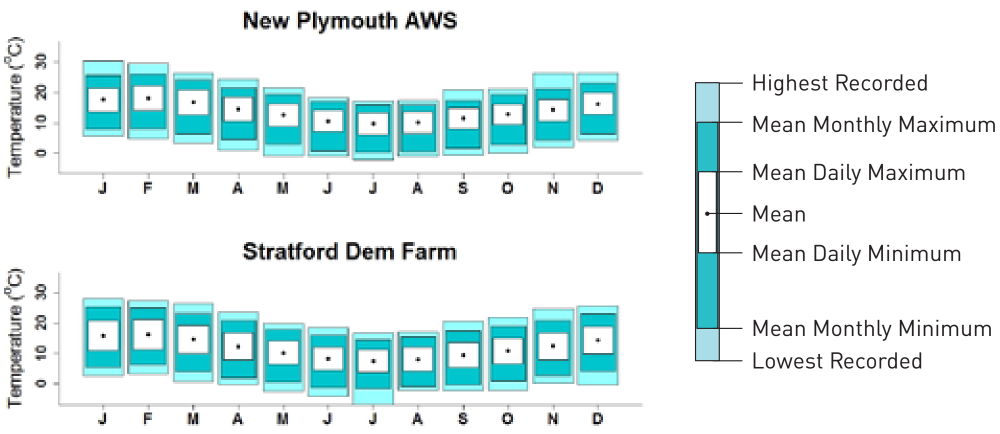


Figure 19. Monthly variation in air temperatures for selected Taranaki stations.

at the coast (e.g. New Plymouth and Patea) than inland areas (e.g. Stratford). However, in the ranges the daily variation is also influenced by cloudiness and elevation; the higher the elevation and cloudier the conditions, the smaller the temperature range (e.g. North Egmont).

The diurnal temperature range for New Plymouth is moderate, and less than that of locations further inland due to the modifying effect of the sea. Table 11 and Figure 20 show mean hourly temperatures for New Plymouth for January and July.

Table 10. Average daily temperature range (Tmax – Tmin, °C) for Taranaki sites (Stratford data from 1971-2000).*

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
New Plymouth AWS	7.8	8.2	8.2	7.9	7.2	7.0	7.2	7.2	6.8	6.6	7.1	7.0	7.4
Patea AWS	7.4	7.3	8.0	7.3	6.7	6.6	7.0	6.9	6.8	6.7	7.5	7.3	7.1
Stratford Dem Farm*	9.9	9.8	9.3	8.7	7.8	7.5	7.7	7.9	8.2	8.5	9.0	9.4	8.6
North Egmont	8.1	7.9	7.5	7.1	6.3	5.6	5.7	6.0	6.4	7.1	7.4	7.5	6.9

Table 11. Mean hourly temperature at New Plymouth Aero in January and July (°C).

hrs	00	01	02	03	04	05	06	07	08	09	10	11
January	15.9	15.6	15.3	15.1	14.9	14.7	15.0	16.3	17.7	18.7	19.3	19.8
July	8.3	8.1	8.0	8.0	7.8	8.1	8.0	7.9	8.0	8.8	10.4	11.4
hrs	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
January	20.2	20.4	20.4	20.5	20.3	20.0	19.5	18.7	17.8	17.1	16.6	16.3
July	12.1	12.4	12.5	12.5	12.1	11.3	10.4	9.8	9.5	9.1	8.7	8.5

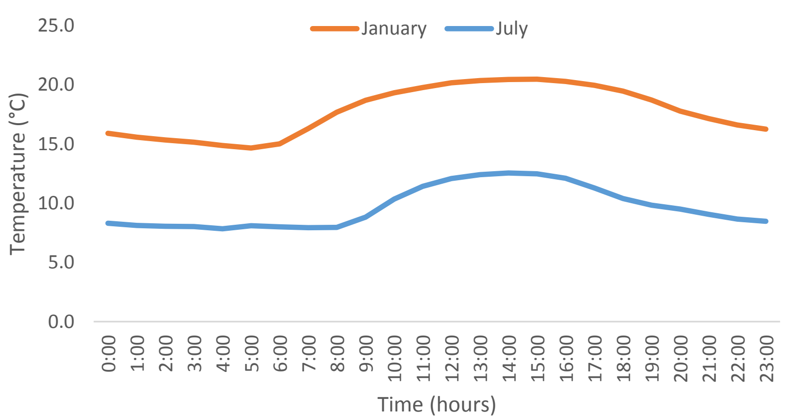


Figure 20. Mean hourly temperatures at New Plymouth Aero for January and July.

New Plymouth has an average of 5 days per year when the maximum temperature exceeds 25°C and has about 1.5 days per year when the temperature falls below 0°C. Manaia also records about 5 days per year when the maximum temperature exceeds 25°C, but has about 8 days per year when temperatures below 0°C are recorded. In contrast, Stratford only records 3 days per year with temperatures above 25°C, and 11 days with temperatures below 0°C.

Extreme maximum temperatures in Taranaki are not as high as have been recorded under foehn conditions in east coast regions of New Zealand. The highest maximum temperature measured in the region to date is 31.3°C, recorded at Te Wera Forest on 5 January 1975. The extreme minimum temperature of -7.5°C was recorded at Stratford Dem Farm on 2 July 2001. These extreme temperatures compare to national extremes of 42.4°C and -25.6°C.

Photo: ©mychillybin.co.nz/Giles Stepney

Earth Temperatures

Earth (soil) temperatures are measured once daily at 9 am at several Taranaki locations. Earth temperatures are measured at varying depths and are important, amongst other things, 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 12 lists mean monthly earth temperatures for a number of standard depths.

In the Taranaki region, earth temperatures, like air temperatures, vary spatially. The sites at higher elevations, such as Stratford DEM Farm, exhibit cooler 9 am earth temperatures than sites at lower elevations, such as New Plymouth. Figure 21 shows how earth temperatures change throughout the year at New Plymouth, compared with air temperature. The temperature cycle for 100 cm depth is more damped and lagged than at shallower depths.

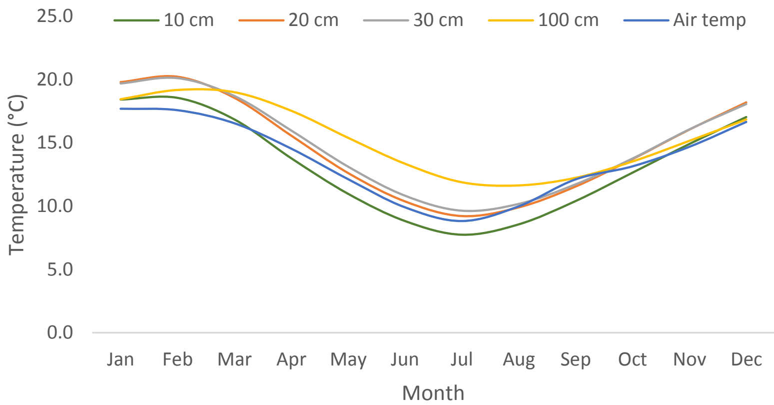


Figure 21. Average monthly 9 am earth temperatures for different depths and mean 9 am air temperature at New Plymouth Aero.

Table 12. Mean 9 am earth temperatures at different Taranaki locations, with station elevations, from all available data.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Manaia Dem Farm (98 m)	10 cm	18.1	17.6	15.8	12.7	10.0	8.1	7.0	7.7	9.7	12.1	14.3	16.6	12.5
	20 cm	19.1	18.9	17.1	14.2	11.4	9.3	8.2	8.8	10.6	12.8	15.1	17.4	13.6
	30 cm	18.9	18.9	17.4	14.8	12.2	10.1	8.9	9.5	11.1	13.2	15.3	17.4	14.0
	100 cm	16.2	16.9	16.7	15.8	14.4	12.8	11.5	11.1	11.4	12.4	13.6	14.9	14.0
New Plymouth Aero (27 m)	10 cm	18.4	18.6	16.9	13.8	11.0	8.8	7.8	8.6	10.4	12.6	14.9	17.0	13.2
	20 cm	19.8	20.2	18.5	15.6	12.6	10.4	9.2	9.9	11.5	13.7	16.0	18.2	14.6
	30 cm	19.7	20.1	18.7	16.0	13.1	10.8	9.6	10.2	11.7	13.8	16.1	18.1	14.8
	100 cm	18.4	19.2	19.0	17.5	15.4	13.3	11.9	11.6	12.2	13.5	15.1	16.8	15.3
Stratford Dem Farm (311 m)	10 cm	16.9	16.8	15.0	12.1	9.5	7.3	6.2	6.9	8.8	11.1	13.4	15.7	11.6
	20 cm	18.2	18.3	16.6	13.8	11.0	8.8	7.5	8.2	9.8	12.1	14.4	16.6	12.9
	30 cm	18.0	18.2	16.7	14.1	11.4	9.3	8.0	8.5	10.0	12.1	14.4	16.5	13.1
	100 cm	15.7	16.4	16.4	15.4	13.8	12.1	10.5	9.9	10.3	11.3	12.8	14.2	13.2

Frosts

Frost is a local phenomenon and its frequency of occurrence can vary widely over very small areas. Areas most likely to be subjected to frost are flat areas, where air is not able to drain away on calm winter nights, and valleys, where cold air is likely to drift from higher areas.

There are two types of frost recorded. Air frosts occur when air temperature measured in a screen by a thermometer 1.3 m above the ground falls below 0°C.

Ground frosts are recorded when the air temperature 2.5 cm above a clipped grass surface falls to -1.0°C or lower. Both types of frost are common in the Taranaki region in the cooler months. Table 13 lists for selected sites the mean daily grass minimum and extreme grass minimum temperatures and the average number of days each month with ground and air frosts. Data on air temperatures (mean daily, monthly minima, and extreme minima) can be obtained from Figure 19.

Table 13. Occurrences of frosts and grass minimum temperatures in Taranaki, from all available data

Location		**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Ann**
Manaia Dem Farm	a	10.2	9.8	9.2	6.9	4.8	3.1	2.1	2.6	4.3	5.9	7.3	8.8	6.3
	b	-1.1	-1.9	-2.5	-3.3	-5.1	-7.5	-7.8	-7.3	-5.4	-4.8	-3.0	-1.0	
	c	0.0	0.1	0.0	0.7	2.9	5.6	8.5	6.4	3.0	1.0	0.4	0.0	28.8
	d	0.0	0.0	0.0	0.0	0.4	1.8	2.9	1.8	0.7	0.0	0.0	0.0	7.6
New Plymouth AWS	a	11.7	12.1	10.5	8.6	7.1	5.2	4.2	4.4	6.1	7.5	8.3	11.0	8.1
	b	0.6	1.5	0.2	-0.8	-2.6	-4.2	-5.9	-5.0	-4.3	-2.7	-1.8	-0.3	
	c	0.0	0.0	0.0	0.0	0.6	1.4	3.2	1.8	0.8	0.6	0.2	0.0	8.5
	d	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.3	0.1	0.0	0.0	0.0	1.3
Stratford Dem Farm	a	7.8	7.9	6.6	4.4	2.5	1.2	0.2	0.6	1.9	3.3	4.8	6.6	4.0
	b	-5.0	-4.6	-7.0	-10.1	-10.6	-11.1	-9.8	-12.9	-12.5	-8.8	-6.7	-3.9	
	c	0.4	0.6	1.4	3.5	7.5	10.3	13.7	12.8	9.0	6.2	2.7	1.1	69.2
	d	0.0	0.0	0.0	0.1	0.7	2.6	4.1	2.5	1.0	0.3	0.0	0.0	11.3
Te Wera Forest	a	7.8	7.6	6.8	4.3	2.0	0.1	-0.8	0.5	1.8	3.7	5.1	6.8	3.8
	b	-3.7	-4.7	-6.6	-7.7	-9.8	-11.2	-11.7	-12.5	-9.7	-7.7	-7.0	-5.5	
	c	0.9	0.7	1.6	4.8	9.8	13.5	15.7	12.1	9.1	6.3	3.3	1.2	78.8
	d	0.0	0.0	0.3	1.9	5.6	9.8	11.5	7.6	3.6	1.3	0.4	0.0	42.0

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

Sunshine and Solar Radiation

Sunshine

Western and coastal areas of Taranaki are generally quite sunny (Figure 22), generally experiencing over 2000 sunshine hours per year. Increased cloudiness in the hill country reduces the amount of sunshine towards the border with Manawatu-Wanganui, where sunshine is less than 1800 hours per year, and the summit of Mt Taranaki receives less than 1750 hours of annual bright sunshine. Figure 23 shows the monthly mean, maximum, and minimum recorded bright sunshine hours for selected sites in Taranaki.

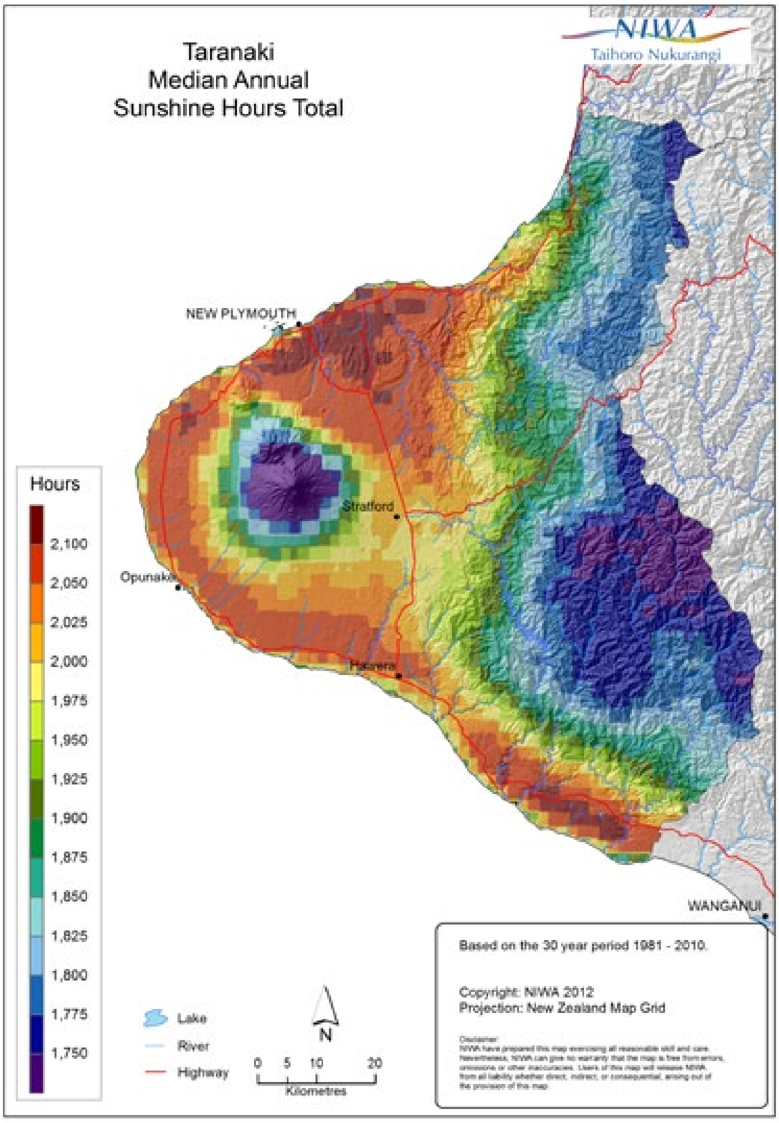


Figure 22. Median annual sunshine hours for Taranaki, 1981-2010.

Figure 23. Mean, highest, and lowest recorded monthly bright sunshine hours for selected sites in Taranaki.

Solar radiation

Solar radiation records are available for a number of sites in Taranaki, but only a few sites have a long record (>10 years). Insolation is at a maximum in December and January and a minimum in June. Table 14 shows mean daily solar radiation (global) for each month for New Plymouth Aero and Normandy.

UV (Ultra-violet radiation)

UV measurements are not available for any stations in the Taranaki region. Figure 24 shows an example of a UV forecast for New Plymouth, and indicates the levels of UV and times of the day where sun protection is required.

Fog

Most fogs reported in Taranaki form at night under anticyclonic conditions with clear skies and very little air movement. Radiational cooling of the land also cools the air above and fogs will normally form if the air is cooled to its dew-point, allowing the water vapour in the air to condense.

The frequency of fog varies widely over the Taranaki region, ranging from an average of 39 days with fog per year at Stratford Mountain House to an average of once every six months at Manaia Dem Farm. Although fog can occur at any time of the year it is recorded most frequently between March and August. The average number of days per year with fog for selected stations in the Taranaki region is listed in Table 15.

Table 15. Average number of days each year with thunder, fog, and hail, from all available data.

Location	Thunder	Fog	Hail
Cape Egmont	4	5	2
Manaia Dem Farm	6	2	4
New Plymouth Aero	15	16	7
Normanby MAF	4	4	4
Stratford Dem Farm	7	15	5
Stratford Mtn House	7	39	13
Te Wera Forest	3	23	1

Table 14. Mean daily global solar radiation (MJ/m²/day) for Taranaki sites.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
New Plymouth AWS	24.0	21.2	16.9	11.6	7.8	6.2	7.0	9.8	13.4	17.3	21.6	22.2	14.9
Normanby EDR	22.4	19.8	15.5	10.6	7.3	5.6	6.7	8.8	12.4	16.2	20.1	21.9	13.9

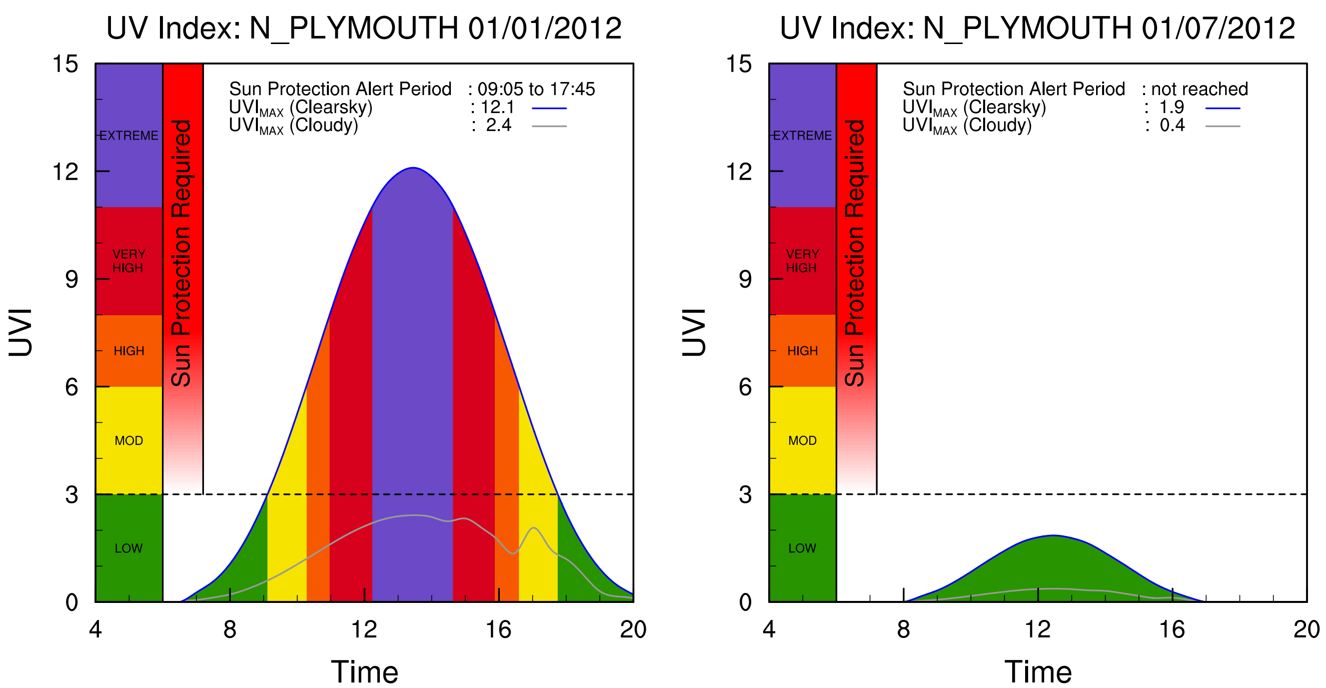


Figure 24. UV Index forecast for New Plymouth, January and July. Source: https://www.niwa.co.nz/our-services/online-services/uv-and-ozone.

Severe convective storms

Thunderstorms

Thunderstorms are fairly evenly distributed throughout the year, but there is a tendency for them to be more frequent during the winter when cold and unstable air masses cross the region. Thunderstorms are usually associated with cold south or southwest airstreams. Average annual frequencies for selected stations are given in Table 15, and range from 15 per year at New Plymouth to three per year at Te Wera Forest. At some of the stations, it is likely that not all thunderstorms are detected. The heavy rain, lightning, hail, wind squalls, and rare tornadoes which can occur with thunderstorms will sometimes cause severe local flooding, disruption of electrical and electronic equipment, and damage to trees, crops, and buildings.

Hail

Table 15 gives the average number of days per year on which hail is reported at selected stations. These range from one day per year at Te Wera Forest up to 13 days per year at Stratford Mountain House. As with thunderstorms, an unknown number of hail falls will escape detection at some of the stations. Hail is most likely over the winter and spring months.

Tornadoes

Tornadoes are rapidly rotating columns of air extending from the base of a cumulonimbus cloud, and have in New Zealand a damage path typically 10-20 m wide and 1-5 km long. The small size (compared to tornadoes in the USA), their short lifetimes, and the sparse population of much of New Zealand must result in an unknown number of tornadoes not being reported.

On average, one tornado occurs in the Taranaki region per year, with the frequency of severe cases about once in four years (Burgess et al., 2007). Most tornadoes that occur in Taranaki have wind speeds between 116 and 180 km/hr, with 10% attaining wind speeds in excess of 180 km/hr. Most tornadoes occur in August, double the frequency of any other month, and the least occur in November (Burgess et al., 2007).

An extreme tornado event occurred in the Taranaki region on the night of 5 July 2007. A swarm of about seven tornadoes hit near Oakura, Egmont Village, Inglewood, Waitara, and Bell Block. Roofs were blown off, trees were uprooted, cars were lifted and spun around and debris was scattered widely. About 50 houses were damaged in Oakura, some sustaining damage of up to 80%, making many uninhabitable. The main state highway south of New Plymouth (SH 45) was blocked by fallen trees and powerlines. Power was cut to about 8000 homes. A CDE was declared in the New Plymouth District which lasted until the 7th. The total insurance cost of the tornadoes was $8.3 million. More information on tornadoes in Taranaki can be found at NIWA's Historical Weather Events Archive (hwe.niwa.co.nz).

Snow

There is a permanent snow field on Mt Taranaki, and during winter the snow line usually descends to about 1000 m. However, snow fall occurs on Mt Taranaki with very few synoptic conditions, and snowfalls are therefore highly variable from year to year. Stratford Mountain House (846 m above sea level) with an average of 18 days of snowfall per year, had 26 days in 1977, and only 7 days in 1973. Snow is very infrequent at sea level. During the period 1972-1991, there were only 2 reported occasions of snowfall at New Plymouth. On 20-22 May 2009, a front brought a southerly airflow to the country. Snow fell in the Taranaki region, with heavy snow in Stratford and Dawson Falls, and on Mt Taranaki. Ice was a major problem for motorists, causing numerous accidents.

Most snowfalls on Mt Taranaki are associated with a trough of low pressure or a depression over or east of the North Island with a strong cold south to southwest airstream over the southern districts of the North Island. Typical meteorological situations associated with falls of snow on Mt Taranaki are given in Figure 25.

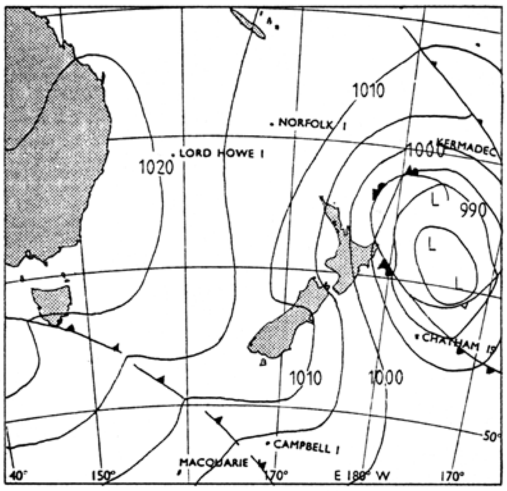
Sea swell and waves

The ocean off Taranaki is exposed to the prevailing west to southwest swells of its latitude zone. Consequently, swells off the west coast of New Zealand are much higher than those off the east coast. At Maui A Platform, prevailing swells come from the southwest quarter (75% of the time). Of all swells observed, the frequency of those from one to two metres is 35%, while for those greater than two metres is 30% (Gorman et al., 2003). Swells greater than four metres account for about 2% of waves.

There is a known relationship between steady wind speed and wave heights over the open sea. The most probable wave heights for a given wind speed over a typical fetch length in New Zealand coastal waters of about 500 km are given in Table 16.

Table 16. Generated wave heights associated with specific wind speeds. Assumes a fetch length of 500 km with unlimited wind duration.

Wind speed (km/hr)	Associated wave height (m)
10	0.5
20	1
30	2
40	3
50	4
75	7
100	11
125	13+



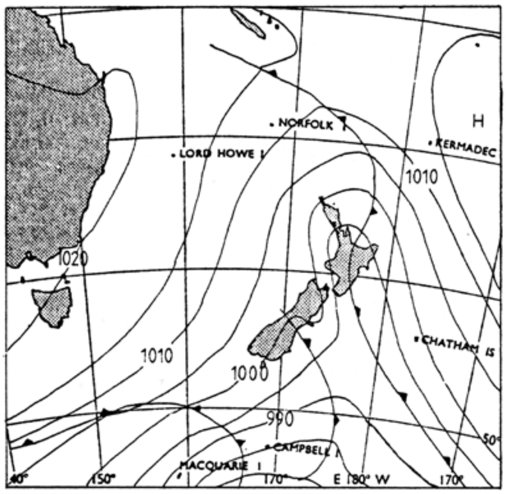


Figure 25. Typical meteorological situations associated with snowfalls on Mt Taranaki; left: 0000 NZST 6 September 1977, right: 0000 NZST 12 June 1980.

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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 computed 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. Short-term high intensity rainfalls have been covered previously.

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 total air 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). Average 9 am vapour pressures for several stations are given in Table 17.

Relative humidity is quite high in all seasons, but there is a peak in winter, as shown in Table 18. The sites inland (Normanby and Stratford) tend to have higher relative humidity than coastal sites (New Plymouth).

Table 17 Mean monthly/annual 9 am vapour pressure (hPa) for selected Taranaki sites.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
New Plymouth Aero	16.5	16.8	15.6	13.7	12.3	10.7	9.9	10.5	11.8	12.7	13.5	15.6	13.3
Normanby EDR	16.0	16.1	14.7	13.2	11.8	10.5	9.5	10.2	11.2	12.2	12.6	14.8	12.7
Stratford Dem Farm	15.7	15.8	14.6	13.0	11.3	9.8	9.2	9.5	10.5	11.6	12.7	14.5	12.4

Table 18. Mean monthly/annual 9 am relative humidity (%) for selected Taranaki sites.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
New Plymouth Aero	80.9	82.5	81.8	82.4	85.4	86.1	85.7	84.4	82.7	82.8	80.1	81.4	83.0
Normanby EDR	82.5	84.3	83.2	85.2	86.6	88.3	89.0	87.5	84.1	83.1	80.3	80.6	84.5
Stratford Dem Farm	86.9	88.6	86.4	87.6	88.3	89.7	89.1	86.8	84.4	84.7	85.9	84.4	86.9

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 maximum 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 completely saturated. 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 soil moisture capacity (assumed to be 150 mm for most New Zealand soils).

Mean monthly and annual water balance values are given in Table 19, for a number of sites in Taranaki. It can be seen from this table that sites at lower elevations have more days of soil moisture deficit, e.g. New Plymouth (43 days of soil moisture deficit between November and April) compared with Stratford (11 days of soil moisture deficit). There is generally adequate moisture available to maintain plant growth between June and October. Higher elevation sites exhibit more runoff than lower elevation sites. Figure 26 shows region-wide variability in days of soil moisture deficit per year.

Potential evapotranspiration (PET) has been calculated for New Plymouth, Normanby, and Stratford using the Penman method (Penman, 1948). The monthly mean, minimum, and maximum PET values are listed in Table 20.

Drought in Taranaki

The Taranaki region is generally not prone to drought, due to exposure to moisture-laden westerly winds. However, a significant drought occurred throughout the entire North Island during summer and early autumn of 2012-2013. Extreme soil moisture deficits (more than 130 mm of deficit) were present in parts of the Taranaki region (Figure 27), meaning that pasture growth had all but ceased. The dry conditions meant that farmers had to dry off cattle early and sell off stock. The stock feed situation remained low in drought-stricken

Table 19. Mean monthly/annual water balance summary for a soil moisture capacity of 150 mm.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Hawera, Green Lane (105m)	NR	0	1	0	1	5	13	14	11	7	4	1	0	58
	RO	1	6	5	10	35	98	96	66	45	41	15	3	421
	ND	11	11	7	3	1	0	0	0	0	0	1	6	40
	DE	48	44	19	5	1	0	0	0	0	0	3	24	145
New Plymouth AWS (30m)	NR	1	1	0	2	6	12	12	11	8	4	2	1	58
	RO	3	14	2	26	64	115	104	86	71	51	20	18	577
	ND	12	12	9	2	1	0	0	0	0	0	3	5	44
	DE	60	51	31	4	2	0	0	0	0	0	11	22	181
Patiki (152m)	NR	1	1	1	2	9	14	14	11	8	6	2	1	69
	RO	10	11	7	18	67	125	116	81	65	62	23	14	599
	ND	8	10	6	2	0	0	0	0	0	0	1	3	30
	DE	34	38	17	3	0	0	0	0	0	0	2	13	107
Stratford Dem Farm (311m)	NR	2	1	4	6	10	14	14	13	10	8	5	4	91
	RO	32	33	61	94	142	182	189	159	127	154	81	64	1318
	ND	3	4	2	1	0	0	0	0	0	0	0	1	11
	DE	11	14	6	1	0	0	0	0	0	0	0	2	34

NR is the average number of days per month on which runoff occurs
RO is the average amount of runoff in mm
ND is the average number of days per month on which a soil moisture deficit occurs
DE is the average amount of soil moisture deficit in mm

areas, and the price of feed significantly increased. Numerous locations in the region experienced low rainfall during the drought, with New Plymouth recording only 30 mm of rain in February 2013, 31% of normal February rainfall. During November 2012 to March 2013, New Plymouth recorded 61% of normal rainfall for these five mouths (312 mm). At the time of writing (July 2013), economic costs due to the 2012-13 drought across the North Island and Westland were estimated at a minimum of $2 billion. Figure 28 shows the soil moisture deficits reached at New Plymouth over the drought period, compared to normal soil moisture deficit conditions for the same time of year (soil moisture deficit from September to May averaged from 1981-2010).

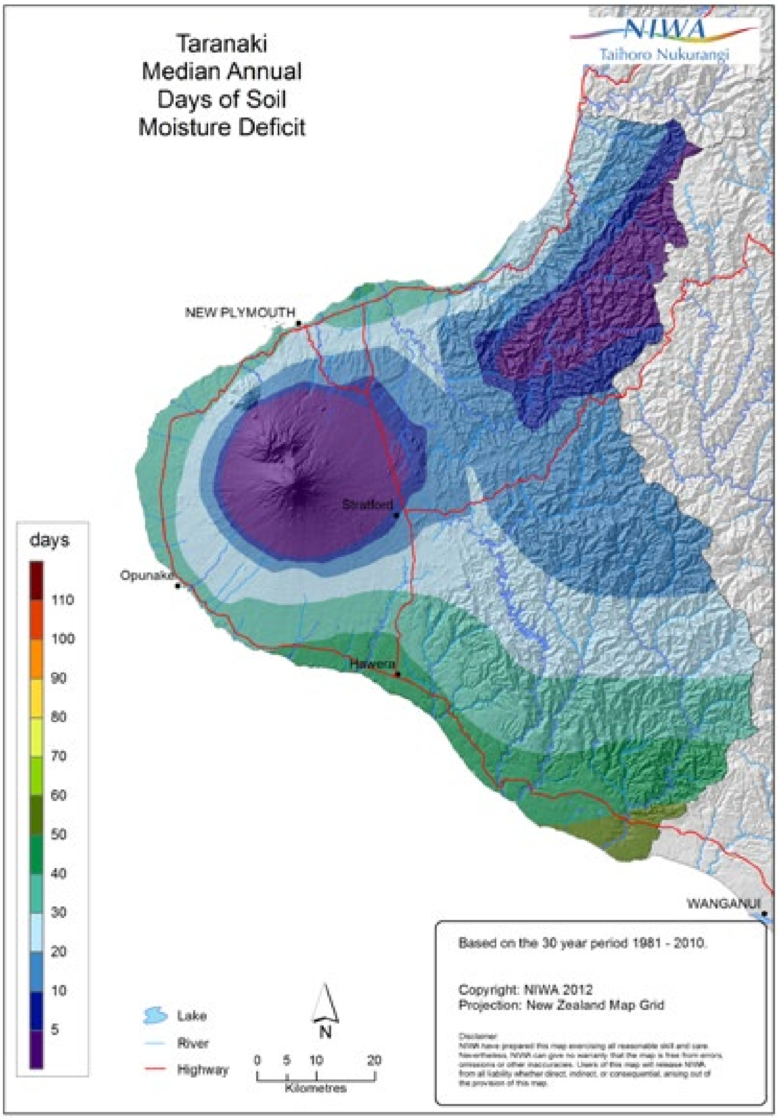

Figure 26. Taranaki median annual days of soil moisture deficit, 1981-2010.

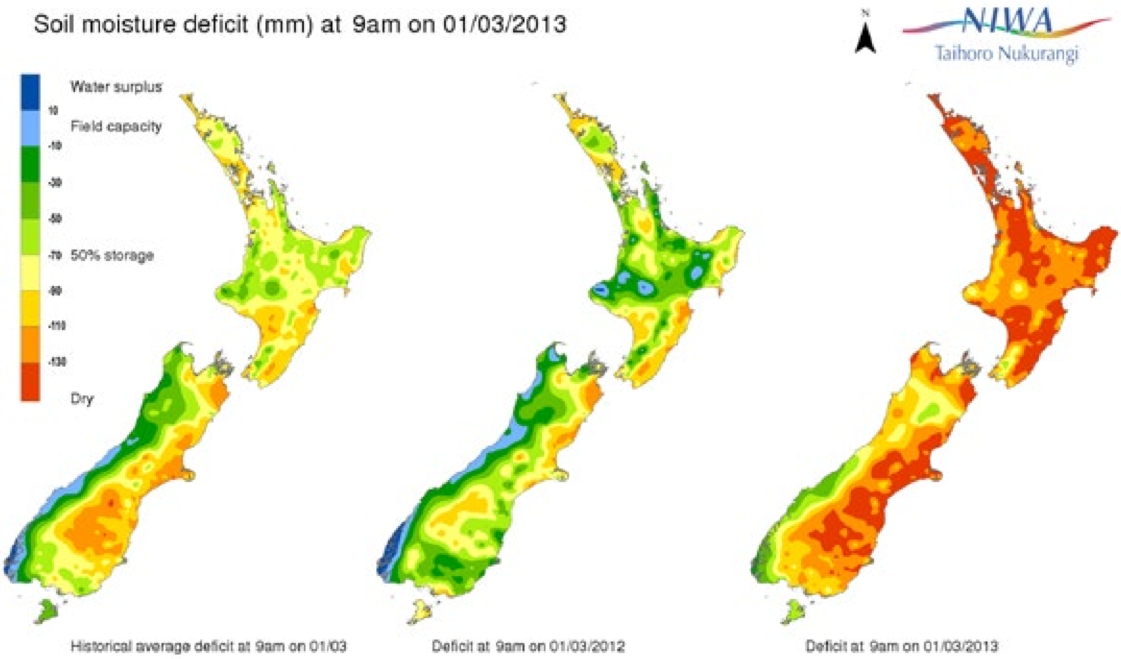

Figure 27. Soil moisture deficit as at 1 March 2013 (right hand map). Areas of extreme soil moisture deficit (more than 130 mm of soil moisture deficit) are shown in red, and areas of significant soil moisture deficit (more than 110 mm of soil moisture deficit) are shown in dark orange. Normal soil moisture deficit conditions for the time of year are given in the left hand figure, and the middle figure shows soil moisture deficit conditions as at 1 March 2012.

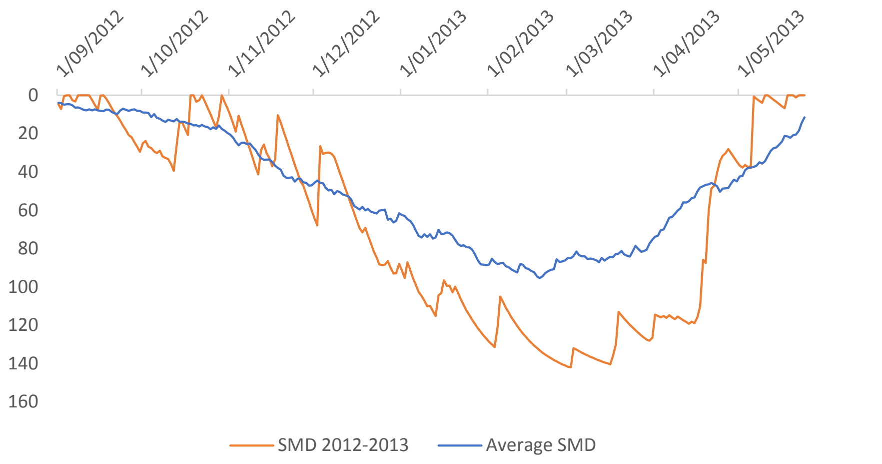

Figure 28. Soil moisture deficit (SMD) at New Plymouth AWS during the summer and early autumn 2012-2013 drought, compared with normal soil moisture deficit conditions for the same time of year at New Plymouth AWS (1981-2010).

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 21 lists the monthly totals of growing degree-day totals above base temperatures of 5°C and 10°C for sites in the Taranaki region.

Cooling and heating degree days are quantities 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 22 shows that the number of cooling degree days reach a peak in summer in

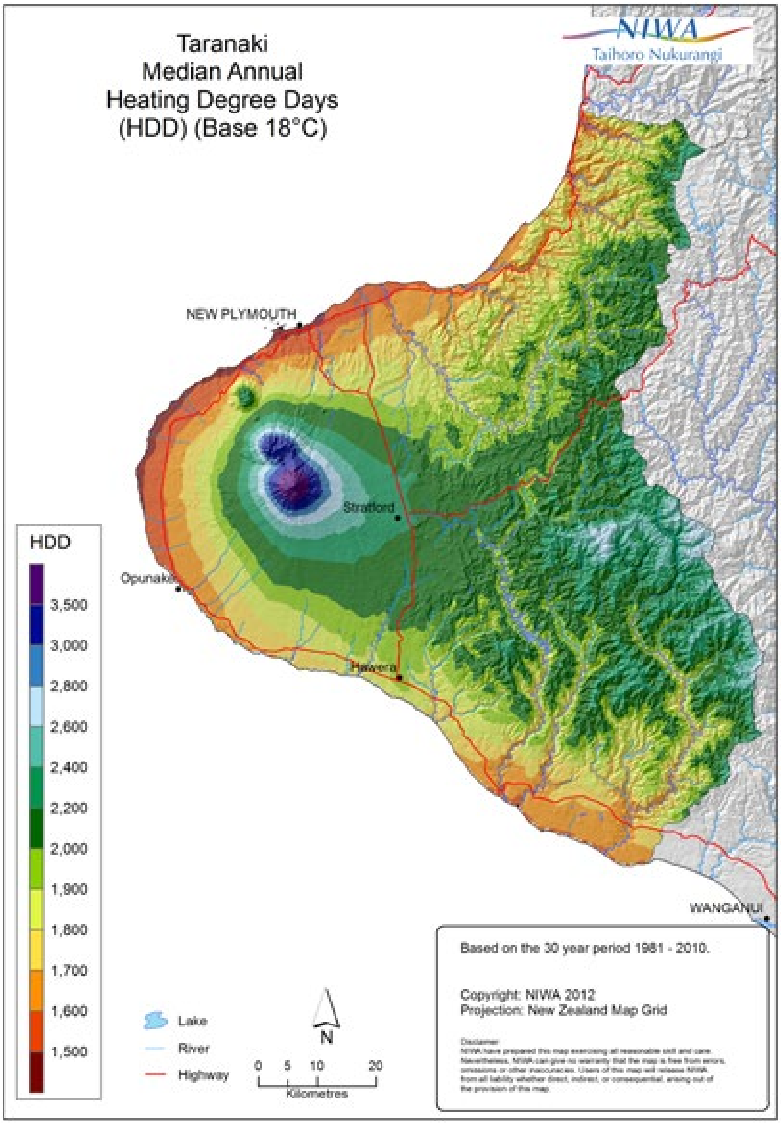

Figure 29. Median annual heating degree days for Taranaki, 1981-2010.

Taranaki, where there is a higher demand for energy to cool building interiors to 18°C. Conversely, heating degree days reach a peak in winter, where the demand for energy to heat buildings to 18°C is highest. Figure 29 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 (e.g. New Plymouth), compared with areas further inland and at higher elevations (e.g. Normandy and Stratford).

Photo: ©mychillybin.co.nz/Giles Stepney

Table 20. Penman calculated maximum, mean, and minimum monthly potential evapotranspiration (mm), as well as total mean annual PET.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
New Plymouth AWS	Max	174	139	114	75	50	34	45	53	68	109	136	144	
	Mean	145	120	100	59	37	27	30	43	60	90	117	130	80
	Min	125	103	85	49	32	19	25	28	48	73	98	118	
Normanby EDR	Max	144	116	92	53	35	25	25	37	60	89	113	143	
	Mean	129	103	81	44	28	18	20	32	52	80	103	124	68
	Min	113	85	60	34	19	13	13	23	46	71	89	95	
Stratford Dem Farm	Max	128	108	85	49	29	19	22	33	54	82	105	133	
	Mean	119	98	74	41	23	13	17	30	47	73	94	111	62
	Min	101	86	58	32	12	6	10	20	38	56	82	99	

Table 21. Average growing degree-day totals above base 5°C and 10°C for selected Taranaki sites.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
New Plymouth AWS	5°C	388	371	360	288	241	172	150	161	196	237	268	344	3176
	10°C	233	230	205	138	89	42	26	28	55	86	118	189	1439
Normanby EDR	5°C	360	341	325	244	201	136	108	127	163	220	238	320	2782
	10°C	205	200	170	98	60	24	11	13	35	72	91	165	1144
Stratford Dem Farm	5°C	340	318	300	220	166	101	85	98	135	185	224	291	2462
	10°C	185	177	145	75	34	10	5	6	19	46	77	136	914

Table 22. Average cooling (CDD) and heating (HDD) degree-day totals with base 18°C for selected Taranaki sites.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
New Plymouth AWS	CDD	21	26	11	2	0	0	0	0	0	0	0	7	67
	HDD	37	22	54	104	162	218	253	242	194	166	123	66	1640
Normanby EDR	CDD	14	16	6	1	0	0	0	0	0	0	1	4	41
	HDD	57	41	84	147	202	254	298	277	227	183	152	87	2011
Stratford Dem Farm	CDD	7	7	2	0	0	0	0	0	0	0	0	1	17
	HDD	70	56	106	170	238	290	321	306	255	218	166	113	2309

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REFERENCES

NIWA databases used:

The National Climate Database cliflo.niwa.co.nz

HIRDS (High Intensity Rainfall Design System)
hirds.niwa.co.nz

New Zealand Historic Weather Events Catalogue
hwe.niwa.co.nz

NIWA Sea Surface Temperature Database

References:

BURGESS, S., SALINGER, J., GRAY, W. & MULLAN, B. 2006. Climate hazards and extremes – New Plymouth District: Cyclones of tropical origin. Wellington: NIWA client report WLG2006-27.

BURGESS, S., SALINGER, J., TURNER, R. & REID, S. 2007. Climate hazards and extremes – Taranaki region: High winds and tornadoes. Wellington: NIWA client report WLG2007-048.

DIAMOND, H. J., LORREY, A. M., KNAPP, K. R. & LEVINSON, D. 2012. Development of an enhanced tropical cyclone track database for the southwest Pacific from 1840-2010. *International Journal of Climatology*, 32, 2240-2250.

GORMAN, R. M., BRYAN, K. R. & LAING, A. K. 2003. Wave hindcast for the New Zealand region: Nearshore validation and coastal wave climate. *New Zealand Journal of Marine and Freshwater Research*, 37, 567-588.

PENMAN, H. L. 1948. Natural evaporation from open water, bare soil, and grass. *Proceedings of the Royal Society of London A*, 193, 120-145.

UDDSTROM, M. J. & OIEN, N. A. 1999. On the use of high resolution satellite data to describe the spatial and temporal variability of sea surface temperatures in the New Zealand Region. *Journal of Geophysical Research (Oceans)*, 104, 20729-20751.