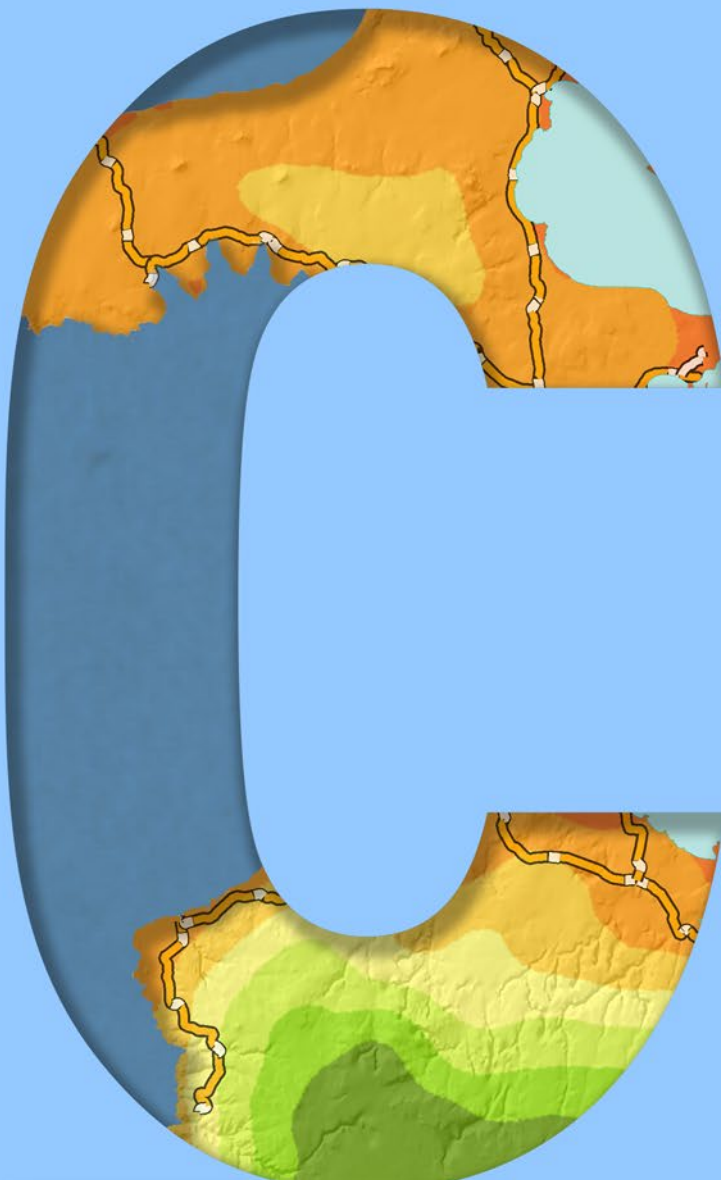


THE CLIMATE AND WEATHER OF THE CHATHAM ISLANDS

2nd edition

P.R. Pearce



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Note to Second Edition

This publication replaces the first edition of the New Zealand Meteorological Service Miscellaneous Publication 115 (13), written in 1983 by C.S. Thompson. It was considered necessary to update the second edition, incorporating more recent data and updated methods of climatological variable calculation.

THE CLIMATE AND WEATHER OF THE CHATHAM ISLANDS

2nd edition

P.R. Pearce

SUMMARY

The weather of the Chatham Islands is marked by rapid changes of conditions, and typically windy cloudy conditions.

Rainfall is moderate and reliable with a winter maximum. Although rain falls on the Chatham Islands on about 200 days a year, amounts are generally small. Most rain falls as showers in southerly airstreams, but occasional heavy rain is associated with warm northerlies.

The Islands are surrounded by the vast South Pacific Ocean. Temperature extremes are rare because of the ever present wind and also due to the influence of the ocean in modifying passing airstreams. Fishing plays a large role in the economic wellbeing of the Islands' community, but rough seas and strong winds can curtail this activity. Gale force winds can blow for several days on end.

The climate of the Chatham Islands has been found suitable for sheep farming, and there are areas where, with suitable shelter, orchards and vegetable gardens are highly productive.



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Photo: Marty Flanagan, NIWA

INTRODUCTION

The Chatham Islands (Figure 1) are situated in the South Pacific Ocean, approximately 750 km east of New Zealand. They are the largest of the outlying groups of islands adjacent to New Zealand. The island group consists of the main island (Rekohu or Chatham Island) and Pitt Island (Rangiauria) as well as several tiny outliers.

Chatham Island has an area of 900 km² and is roughly T-shaped. There is a large lagoon (area 186 km²) which covers much of the central portion of the island. Northern and central areas are mostly low-lying with several volcanic cones rising to 180 m. In contrast, the southern portion is a much dissected remnant of a plateau area, which rises from sea level near the lagoon, to a height of nearly 300 m along the southern coastline.

Pitt Island has an area of 63 km². The island's coastline is bounded in many places by steep cliffs rising 70-100 m to a highly dissected plateau which covers most of the island. The highest part of the island is an outcrop of volcanic rock rising to 241 m.

The first official Chatham Islands weather records were made in 1878 from the Waitangi district by a

local resident, Mr A. Shand. An almost continuous record was kept there until 1994. Since the 1970s and 1980s, a number of climate stations have opened and closed, with most recording data for less than ten years. As at early 2016, two climate stations are in operation: Chatham Island EWS (operated by NIWA) and Chatham Island Aero AWS (operated by the New Zealand MetService) – these two climate stations are in the same location, at the Chatham Island airport. Note that Chatham I Waitangi, Chatham I Po Radio, and Chatham Islands AWS stations were also at the same location, but none are currently operating. Figure 1 shows the locations from which data were gathered for this publication.

Due to limited station data for periods longer than ten years, all available data from NIWA's National Climate Database have been used to calculate monthly and annual averages from the stations mentioned in the tables and text. Raw data can be found on NIWA's National Climate Database, accessed via <http://cliflo.niwa.co.nz>.

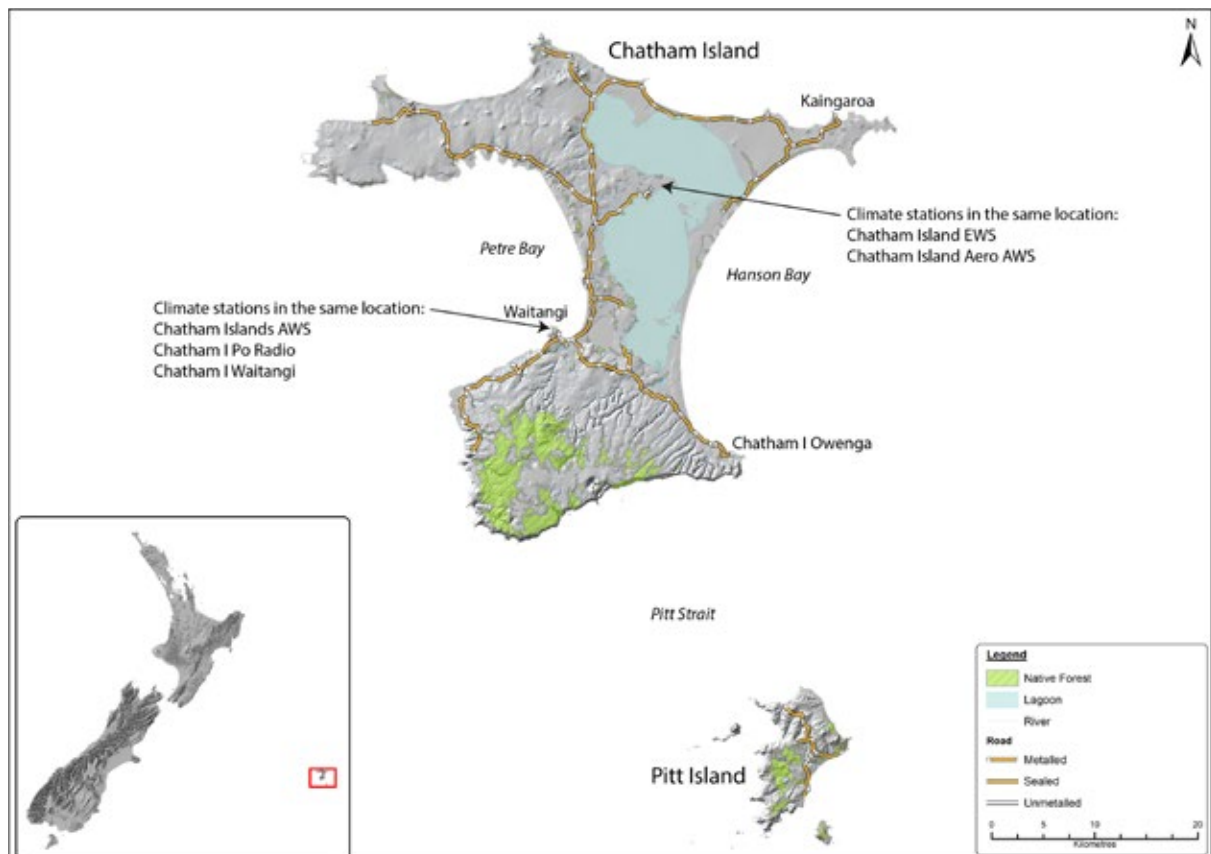


Figure 1. Map of the Chatham Islands, with locations of places mentioned in the text, tables, and figures.



Photo: Marty Flanagan, NIWA

TYPICAL WEATHER SITUATIONS IN THE CHATHAM ISLANDS

A characteristic of the atmospheric circulation in the New Zealand region is the abundance of semi-permanent anticyclones. Daily surface weather maps often show a series of eastward-moving anticyclones over the Tasman Sea/New Zealand area, separated by troughs of low pressure or depressions. These large-scale synoptic features affect the day-to-day weather of the Chatham Islands and also determine the broad climatic features of the region. Examples follow of some common weather patterns and their associated weather.

South to south-west airstreams

South to south-west airstreams are by far the most frequent to cover the Chatham Islands, occurring about 35% of the time. When anticyclones are centred in the Tasman Sea and pressures are low to the east of the Chatham Islands, south-westerlies flow over the Islands (Figure 2). However, when an anticyclone is centred south of New Zealand, the airstream is southerly (Figure 3). In slow-moving situations, conditions such as this may last for up to 7 to 10 days, but 2 to 3 days is more usual.

These situations are associated with cool, showery weather and cloudy skies. Strong to gale south-westerly or southerly winds are not uncommon. Hail sometimes occurs, and precipitation amounts are generally small.

West to north-west airstreams

West or north-west airstreams flow over the Islands about 30% of the time. They are, however, more prevalent during spring and summer than at other times of the year. Westerly airstreams cover the region when a belt of high pressure lies to the north of New Zealand, together with low pressures to the south. Embedded in these airstreams are frequent and rapidly moving cold fronts which bring showers to the Chatham Islands (Figure 4). If, on the other hand, frontal systems are spaced well apart (Figure 5) fine sunny, yet windy conditions are likely, due to the anticyclonic curvature of the isobars between the fronts.

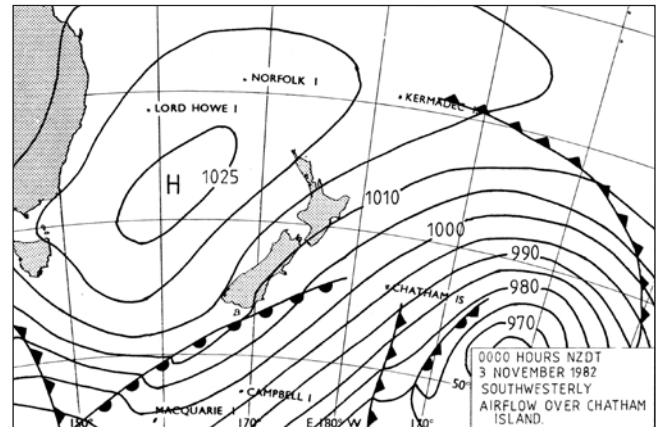


Figure 2. Southwest airstream over the Chatham Islands. MSL analysis for 3 November 1982.

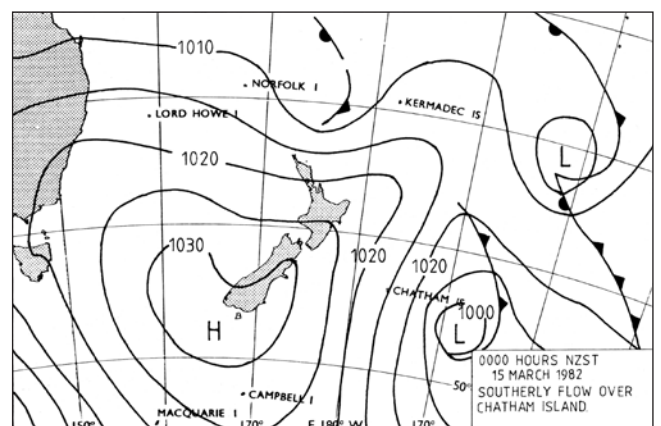


Figure 3. Southerly airstream over the Chatham Islands. MSL analysis for 15 March 1982.

North to north-east airstreams

North or north-east airstreams flow over the Chatham Islands about 15% of the time (Figures 6 and 7). They are characterised by a relatively mild and humid airstream which flows between a large anticyclone to the east of the Chatham Islands and a low pressure area to the west. These situations may be slow-moving when the anticyclone blocks the movement of the depression. Heavy falls of rain are a frequent feature of these situations, both in the flow ahead of the front, and also with the front.

On 15 June 1981 (Figure 7) there were strong north-easterly winds, and rain began to fall over the Chatham Islands from about 7 pm. Rain continued during the following two days, with some heavy falls recorded at Waitangi as the front approached late on 17 June 1981. The front crossed the Chatham Islands during the mid-afternoon of 18 June 1981 and was followed by westerly winds and clearing conditions.

East to south-east airstreams

East to south-east airstreams affect the Chatham Islands about 15% of the time. Figure 8 is an example of an easterly airstream flowing over the Chatham Islands. Although cloudy, drizzly conditions are usual, fine weather normally prevails so long as the centre of the anticyclone is west of the Chatham Islands.

An example of a south-easterly airflow over the Chatham Islands is shown in Figure 9. South-easterly conditions are typically associated with depressions which pass to the north or east. In most cases, these airstreams persist for no more than one or two days at a time but bring strong or gale force winds and periods of rain.

Cyclones of tropical origin

The tropical cyclone season in the Southwest Pacific lasts from November to April. Originating in low latitudes within the cloud masses of the South Pacific Convergence Zone, tropical cyclones reaching the Chatham Islands 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 mostly approach the Chatham Islands from the north-west, and sometimes affect the island group. Tracks of tropical cyclones which have passed within 500 km of the Chatham Islands between 1970 and 2010 are shown in Figures 10-14.

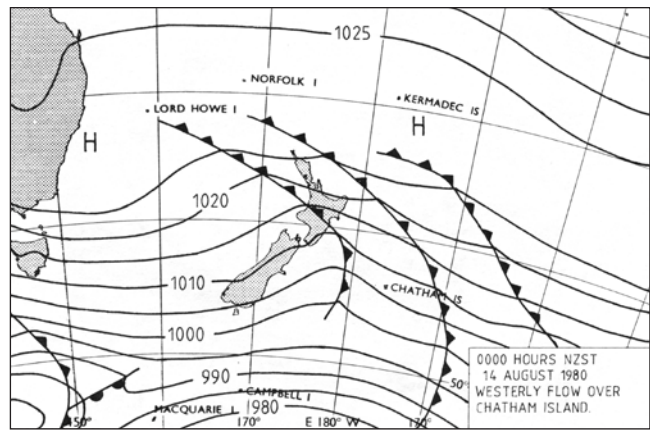


Figure 4. Northwest airstream at the Chatham Islands. MSL analysis for 14 August 1980.

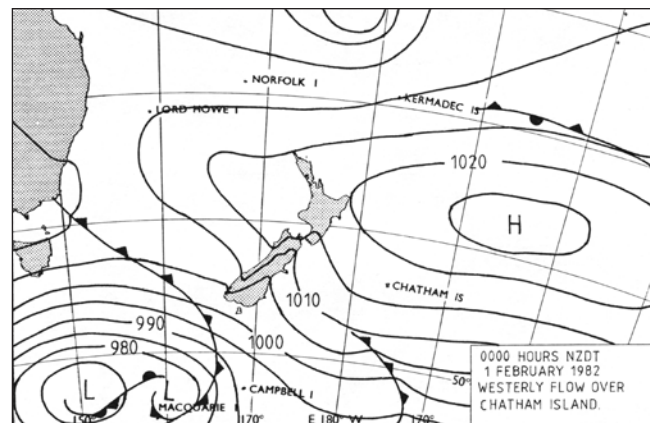


Figure 5. Northerly airstream at the Chatham Islands. MSL analysis for 1 February 1982.

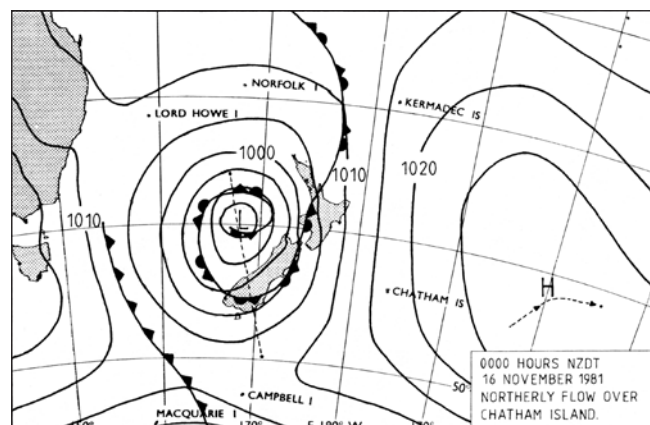


Figure 6. Northerly airstream over the Chatham Islands. MSL analysis from 16 November 1981.

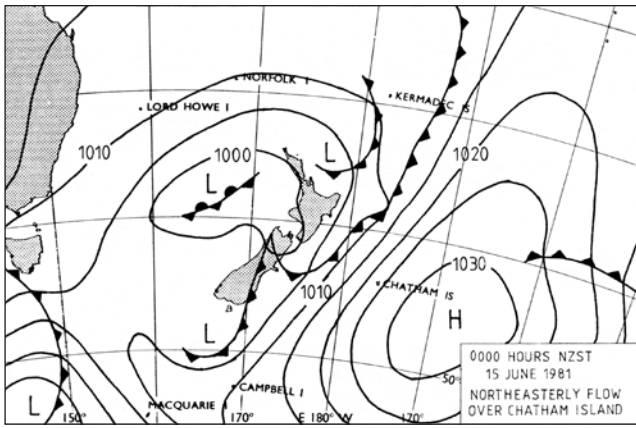


Figure 7. North-easterly airstream over the Chatham Islands. MSL analysis for 15 June 1981.

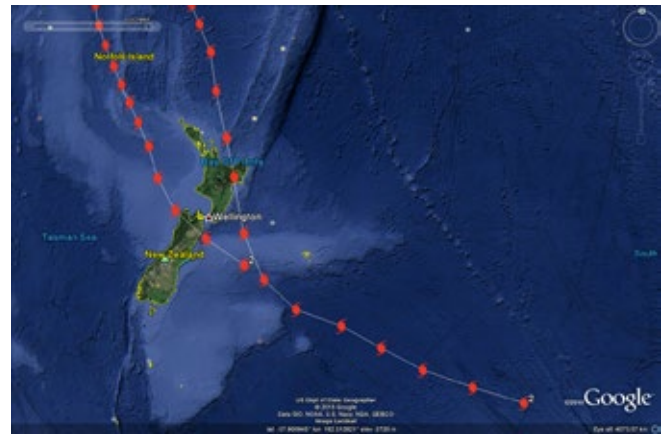


Figure 10. Tropical cyclones which passed within 500 km of the Chatham Islands during December, 1970-2010. The Chatham Islands are the small yellow dot to the east of New Zealand's South Island. Source: Southwest Pacific Enhanced Archive of Tropical Cyclones (SPEARTC; Diamond et al., 2012).

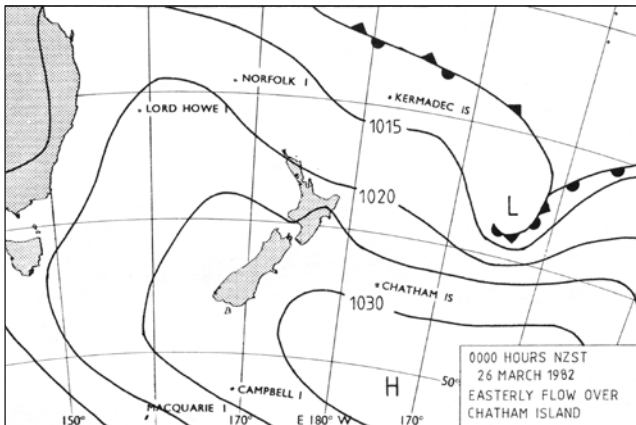


Figure 8. Easterly airstream affecting the Chatham Islands. MSL analysis for 26 March 1982.

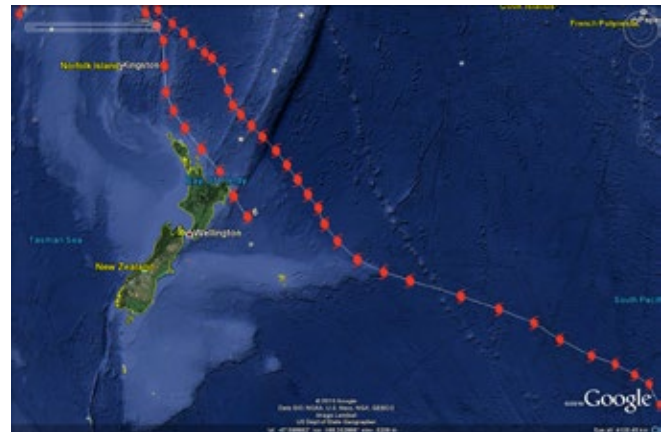


Figure 11. Tropical cyclones which passed within 500 km of the Chatham Islands during January, 1970-2010. Source: Southwest Pacific Enhanced Archive of Tropical Cyclones (SPEARTC; Diamond et al., 2012).

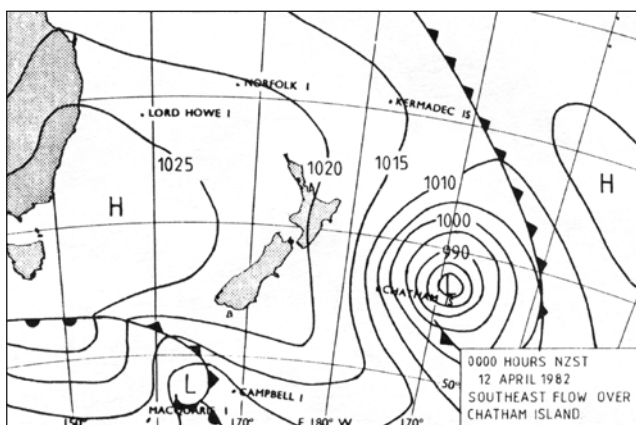


Figure 9. South-easterly airstream over the Chatham Islands. MSL analysis for 12 April 1982.

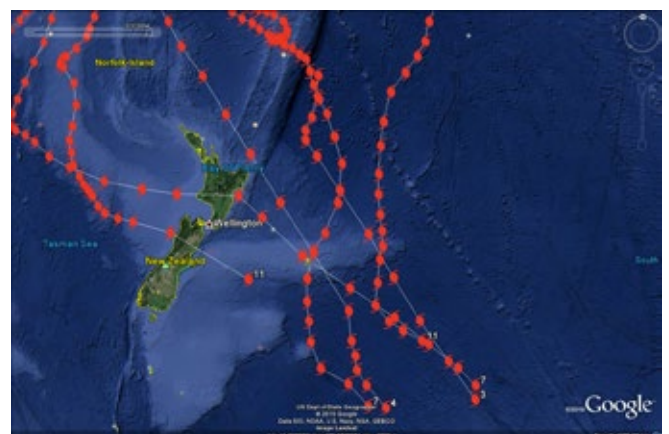


Figure 12. Tropical cyclones which passed within 500 km of the Chatham Islands during February, 1970-2010. Source: Southwest Pacific Enhanced Archive of Tropical Cyclones (SPEARTC; Diamond et al., 2012).



Figure 13. Tropical cyclones which passed within 500 km of the Chatham Islands during March, 1970–2010. Source: Southwest Pacific Enhanced Archive of Tropical Cyclones (SPEARTC; Diamond et al., 2012).



Figure 14. Tropical cyclones which passed within 500 km of the Chatham Islands during April, 1970–2010. Source: Southwest Pacific Enhanced Archive of Tropical Cyclones (SPEARTC; Diamond et al., 2012).



Photo: Marty Flanagan, NIWA

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 ("low"), and in an anticlockwise direction around an anticyclone ("high"). As such, MSLP maps can be used to indicate the general wind direction at the earth's surface. However, actual wind direction at a particular locality is modified by the influence of friction and topography. Wind speeds are also subject to topographical influence. The prevailing wind direction over the southern oceans of the world in the zone above the Earth's boundary layer is westerly.

At the surface, the main wind directions on the Chatham Islands are from the south-westerly quarter (from west to south on the compass), with a secondary maximum from the north-west (Figure 15).

Wind on the islands is a marked feature of the climate; calm conditions are rare. The mean wind speed is about 24 km/hr, and calm periods (wind speed less than 2 km/hr) occur only about 0.2% of the time. Strong winds (over 39 km/hr) blow nearly 10% of the time, and autumn and winter have the highest frequencies of strong winds. Comparing the "windiness" at the Chatham Islands with some South Island, New Zealand sites of similar latitude, the mean wind speeds at Christchurch, Timaru, Dunedin, and Invercargill are 14 km/hr, 9 km/hr, 14 km/hr, and 17 km/hr respectively.

Gale force wind days (beaufort wind scale 8 or more) are encountered on an average of 14 days each year, mostly during the months of May to September. Forty-nine days of gale were reported in 1988, and there were a further five occasions between 1956 and 1993 when over 25 days

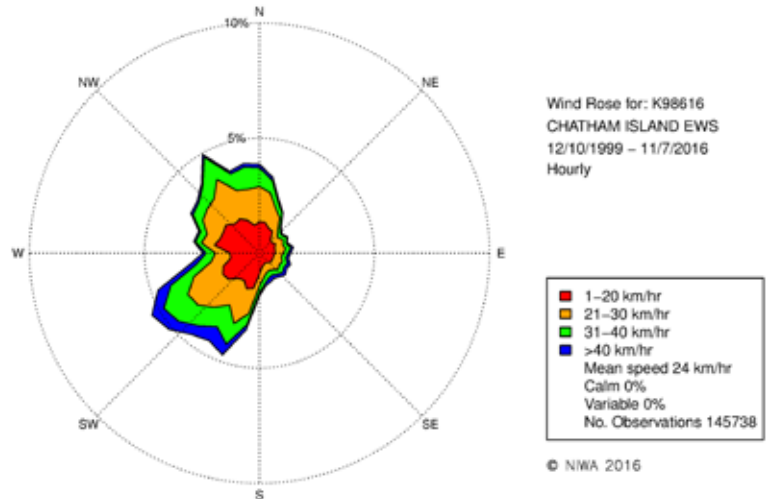


Figure 15. Mean annual wind frequencies (%) of surface wind directions from hourly observations at Chatham Island EWS station. The plot shows the directions from which the wind blows, e.g. the dominant wind directions are from the southwest and northwest.

of gale were observed in a single year ('days of gale' information is available in NIWA's National Climate Database, for Chatham Island Waitangi station, between 1956 and 1993). Gales generally blow from the south-west, and have a tendency to develop when cyclogenesis (i.e. the formation of a low pressure centre) occurs southeast of the Islands. Under these conditions it is not unusual for strong to gale force winds to blow for up to 7 days at a time. Because south-westerly conditions cover a large area of ocean to the south of the Islands, prolonged periods of high winds from the southwest allow a sufficient time for heavy seas and swell to be generated. Petre Bay on the western side of Chatham Island is totally exposed to the sea in such conditions.

The south-western parts of Chatham Island are most affected by cold south-westerly airstreams. Many trees along the southern and western coasts and in other exposed positions on the island are misshapen and lean north-eastwards (see photo page 8). The winds in these areas and in Pitt Strait are at times anecdotally reported as being stronger than those observed in Waitangi.

Mean wind speed data (average wind speeds are taken over the 10 minute period preceding each hour) are available for two sites in the Chatham Islands (Table 1 and Figure 16). Both sites have relatively similar wind patterns throughout the year, with the AWS site being slightly windier in winter and slightly less windy in summer compared with the EWS site. This is likely due to the AWS site position near the west coast, compared to the EWS site which is further inland.

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

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham Island EWS	24.8	23.5	23.0	23.0	22.2	24.2	22.2	23.5	24.9	26.2	25.7	24.5	24.0
Chatham Islands AWS	22.6	21.7	23.2	23.5	22.8	26.9	23.5	24.5	26.0	26.8	25.9	23.4	24.2

Spring is generally the windiest season throughout the region, and the least strong winds are observed in autumn. 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 Chatham Island EWS, 26% occurred in summer, 20% in autumn, 22% in winter and 32% in spring. In compiling this table a strong wind was defined as having an hourly mean wind speed of at least 31 km/hr, and light winds were less than 31 km/hr.

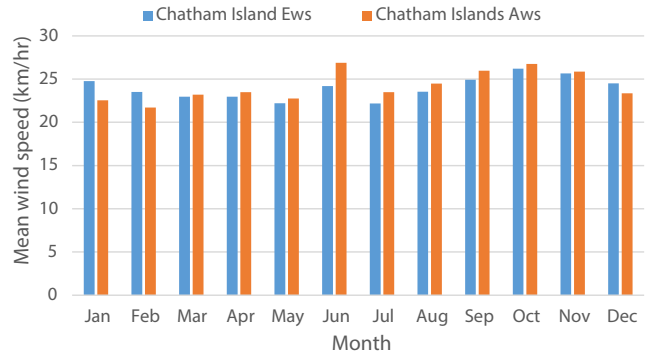


Figure 16. Mean monthly wind speed (km/hr) at Chatham Islands sites, from all available data.

Table 2. Seasonal percentages of strong or light winds (%) for Chatham Islands sites, from all available data.

Location		Summer	Autumn	Winter	Spring
Chatham Island EWS	Strong	26	20	22	32
	Light	25	26	26	23
Chatham Islands AWS	Strong	19	23	27	31
	Light	27	26	24	23

Diurnal variation in wind speed is relatively well-marked, with greatest wind speeds occurring in the middle of the day. 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 restores a lighter wind regime. Table 3 gives average wind speeds at three-hourly intervals for selected stations, whilst Figure 17 visually highlights the typical diurnal variation of wind speed observed in the Chatham Islands.

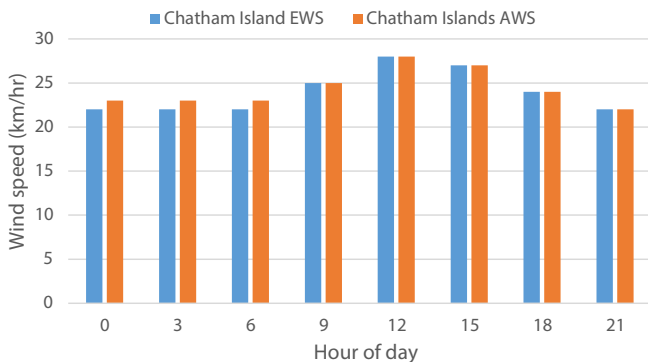


Figure 17. Hourly mean wind speed (km/hr) at Chatham Islands stations, from all available data.

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

Location	0000	0300	0600	0900	1200	1500	1800	2100
Chatham Island EWS	22	22	22	25	28	27	24	22
Chatham Islands AWS	23	23	23	25	28	27	24	22

Gusty winds are quite frequent in the Chatham Islands due to the exposed location. Gusts of at least 63 km/hr are recorded at the exposed site of Chatham Islands AWS (situated on the west coast of Chatham Island) on an average of 117 days each year, and gusts over 96 km/hr occur on average 9 days each year (Table 4). In comparison, the more sheltered site further inland at Chatham Island EWS records 99 days per year with gusts over 63 km/hr, and 5 days each year with gusts over 96 km/hr. The inland site is still very windy, and this reflects the windy nature of the Chatham Islands as a whole.

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

Location	Days with Gusts >63 km/hr	Days with Gusts >96 km/hr
Chatham Island EWS	99	5
Chatham Islands AWS	117	9

Although gale force winds can occur in any month, they are most frequent in winter. The highest gust recorded (according to NIWA's National Climate Database) on land in the Islands was 156 km/hr at Chatham Islands AWS on 29 May 1993. Maximum gusts recorded at different stations on Chatham Island are listed in Table 5.

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

Location	Gust (km/hr)	Direction	Date
Chatham Islands AWS	156	WSW	31/01/1993
Chatham I Waitangi	124	SSW	29/05/1993
Chatham Island EWS	117	SW	14/03/2007
Chatham Island EWS	117	SW	3/06/2005
Chatham Island EWS	117	SW	2/11/2005



Photo: Ville Miettinen from Helsinki, Finland - View from our cottage, CC BY 2.0, <https://commons.wikimedia.org/w/index.php?curid=3214115>

Rainfall

Rainfall distribution

In the Chatham Islands, the mean annual rainfall total varies with elevation. The lowland areas of Chatham Island (north of the southern highlands) experience between 800 and 1000 mm of rainfall per year (Figure 18). In contrast, the southern highlands experience up to double this amount of rainfall in parts, up to 2000 mm. Pitt Island experiences between 800 and 1400 mm of annual rainfall.

In the Chatham Islands, there is a maximum of rainfall in late autumn and early winter, and a summertime minimum (Figure 19). May is usually the wettest month and November or December the driest. Much of the rain that falls over the Chatham Islands is associated with fronts or depressions, or showers in southerly airstreams. Nearly half of the rainfall occurs when the wind is from the south-westerly quadrant although the more intense falls are usually with north-westerly and northerly winds.

The variability of seasonal and annual rainfall over the Chatham Islands is similar to that of western areas of New Zealand and is markedly less than many NZ east coast districts. This is due to exposure of the Chatham Islands to the prevailing westerly and south-westerly winds and the islands geographical location. Table 6 lists monthly rainfall averages (calculated using all available data) 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 Chatham Island at an average of 29% (ranging from 27% to 30%), and the proportion of rainfall recorded in the summer months from December to February ranges from 19% at Waitangi to 23% at the Chatham Island EWS station.

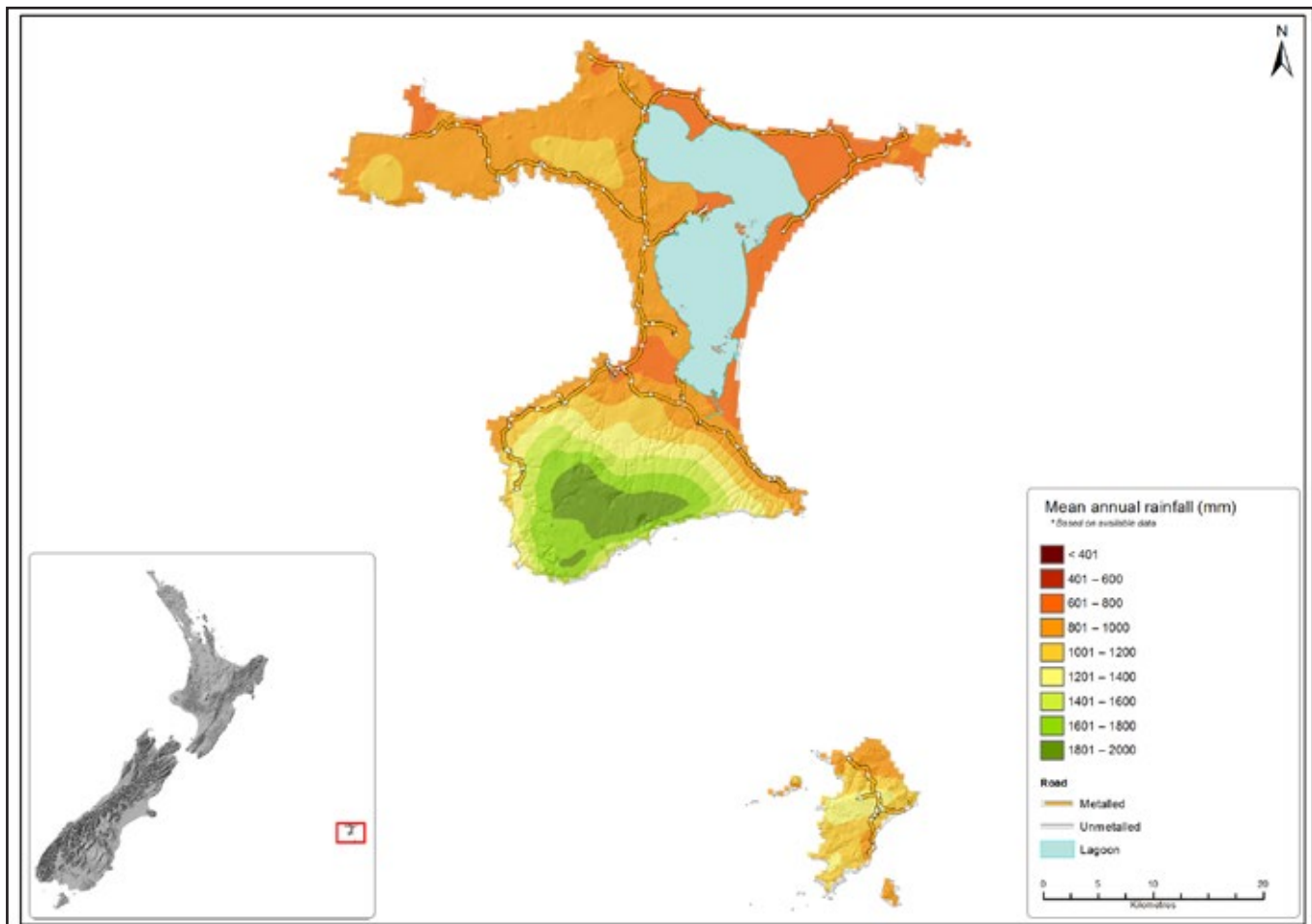


Figure 18. Mean annual rainfall at the Chatham Islands, from all available data.

Table 6. Monthly and annual rainfall normal (a; mm), and monthly distribution of annual rainfall (b; %) at selected Chatham Islands stations from all available data.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham I Owenga	a	54.6	53.4	61.3	69.5	109.5	78.9	90.3	58.7	64.6	58.5	54.0	50.6	804.0
	b	6.8	6.6	7.6	8.6	13.6	9.8	11.2	7.3	8.0	7.3	6.7	6.3	
Chatham I Po Radio	a	69.7	67.3	75.3	78.6	104.4	99.5	91.7	88.3	64.5	55.9	64.0	63.6	922.9
	b	7.6	7.3	8.2	8.5	11.3	10.8	9.9	9.6	7.0	6.1	6.9	6.9	
Chatham I Waitangi	a	53.3	58.1	78.2	78.2	103.2	97.3	87.1	81.7	66.7	59.7	59.6	59.7	883.0
	b	6.0	6.6	8.9	8.9	11.7	11.0	9.9	9.3	7.6	6.8	6.7	6.8	
Chatham Island EWS	a	56.3	68.9	72.1	72.1	87.5	89.9	60.2	71.0	60.3	58.1	48.4	61.7	806.6
	b	7.0	8.5	8.9	8.9	10.8	11.1	7.5	8.8	7.5	7.2	6.0	7.7	
Chatham Islands AWS	a	63.0	66.4	84.4	81.7	95.6	112.9	80.4	85.3	71.3	64.2	66.7	69.7	941.5
	b	6.7	7.1	9.0	8.7	10.2	12.0	8.5	9.1	7.6	6.8	7.1	7.4	

Data years: Chatham I Owenga: 1971–1986; Chatham I Po Radio: 1878–1963; Chatham I Waitangi: 1951–1994; Chatham Island EWS: 1999–2015; Chatham Islands AWS: 1991–2012.

The distribution of monthly rainfall is shown in Figure 19. The 10th percentile, 90th percentile, and mean rainfall values for each month are shown along with maximum and minimum recorded values for several stations.

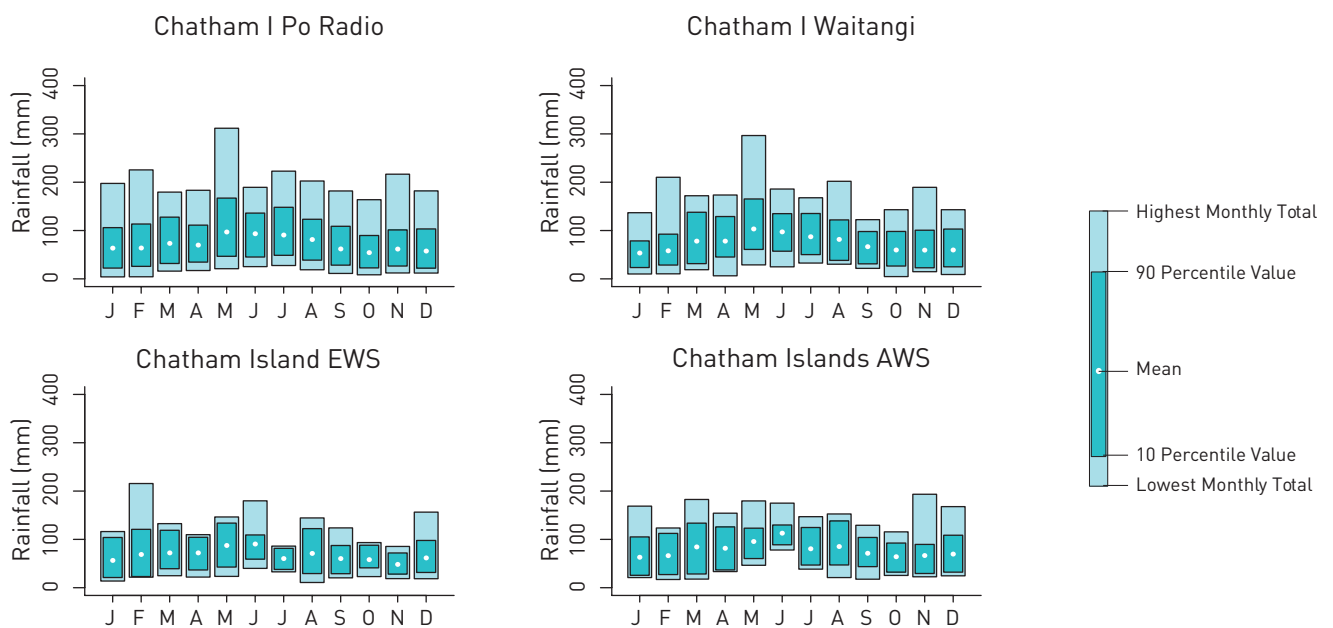


Figure 19. Monthly variation in rainfall for selected Chatham Island stations. Note that these stations have different periods of record: Chatham I Po Radio (1878–1963), Chatham I Waitangi (1951–1994), Chatham Island EWS (1999–2015), and Chatham Islands AWS (1991–2012), so comparisons between stations should be made with caution.

Rainfall variability is often depicted 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 (annual), with each time period that is longer

than one month beginning with the month stated. For example, using the table for Chatham Islands AWS, it can be seen that in the three month period beginning in April, 243 mm or more of rainfall can be expected in nine years in ten, while a total of 363 mm or more will occur in only one year in ten, on average.

Table 7. Rainfall deciles for consecutive months for selected Chatham Islands stations, from all available data.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chatham Islands AWS												
1 month												
10th	25	24	23	36	57	86	42	43	30	29	28	27
90th	113	115	147	129	129	161	126	146	120	93	126	145
3 months												
10th	150	156	180	243	206	187	159	148	123	128	138	133
90th	284	308	345	363	383	360	306	291	283	259	265	294
6 months												
10th	424	416	449	421	392	386	303	344	336	298	339	377
90th	602	655	661	619	605	600	547	582	476	499	550	573
Annual												
10th	762	762	770	747	734	775	807	804	801	798	788	790
90th	1075	1083	1079	1055	1085	1094	1116	1138	1123	1122	1145	1109
Chatham Island EWS												
1 month												
10th	17	23	33	30	37	42	34	22	21	33	23	26
90th	115	164	128	109	138	139	85	132	107	93	76	123
3 months												
10th	127	144	171	185	163	131	128	132	113	113	106	93
90th	293	283	330	325	325	328	259	268	227	250	259	307
6 months												
10th	382	363	319	328	337	296	263	275	223	305	297	340
90th	538	545	541	568	563	529	495	507	497	470	472	502
Annual												
10th	683	670	645	653	654	676	684	662	676	691	712	689
90th	1048	1049	955	965	981	945	978	988	1018	994	1022	1023

Rainfall frequency and intensity

The number of rain days (days with at least 0.1 mm of rain) on the Chatham Islands is considerable when compared with many places in mainland New Zealand. At Waitangi, it rains on average 211 days each year, while at Auckland there are usually 183 days, Wellington 155 days, and Christchurch 128 days of rain. Wet days (days with 1.0 mm or more of rain) occur at Waitangi on 134 days per year on average. Rain falls mostly as light showers or as drizzle, is of short duration and occurs frequently. The number of rain days and wet days each season is given in Table 8. The frequency of rain days in the Chatham Islands is greatest during winter months (about 32% of the annual total) and least in summer (about 18% of the annual total).

The annual number of rain days over the Chatham Islands as a whole is about 200, but varies from 176 days at Chatham Island EWS to 217 at Chatham Islands AWS. The annual number of wet days exhibits

the same geographic variability, with an average of 131 days across all stations, but a minimum of 113 days at Chatham Island EWS to a maximum of 144 days at Chatham Islands AWS and Chatham Island Po Radio.

Rainfall intensities are influenced by the surrounding topography and normally increase with altitude. Higher rainfall intensities may therefore be expected on the southern highlands of Chatham Island and on the high country of Pitt Island. High intensity rainfall, particularly at sub-hourly periods, is typically associated with thunderstorm activity. In Table 9, maximum short period rainfalls for periods of 10 minutes to 72 hours are given for one station in the Chatham Islands (there is only one station with short period rainfall data available) and some mainland New Zealand sites for comparison.

Table 8. Average monthly rain days and wet days for Chatham Islands 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
Chatham I Owenga	a	10	11	12	16	22	21	24	16	15	14	14	11	185
	b	7	7	8	9	16	13	15	10	10	10	9	7	120
Chatham I Po Radio	a	12	11	14	16	20	22	21	20	16	14	14	14	194
	b	10	8	10	12	15	17	16	15	11	10	11	10	144
Chatham I Waitangi	a	13	12	16	17	23	23	23	22	18	16	15	14	211
	b	8	7	10	11	15	15	15	13	12	10	9	8	134
Chatham Island EWS	a	10	11	12	15	18	20	18	18	14	15	12	13	176
	b	6	7	8	9	12	13	11	10	10	10	8	9	113
Chatham Islands AWS	a	13	13	17	18	22	24	23	22	19	17	15	14	217
	b	9	8	11	12	14	17	15	15	12	12	11	10	144

Table 9. Maximum recorded short period rainfalls from Chatham Islands AWS and New Zealand main centres for comparison.

Location	10min	20min	30min	1hr	2hrs	6hrs	12hrs	24hrs	48hrs	72hrs
Chatham Islands AWS	13	18	21	28	33	61	77	96	138	155
Auckland	14	27	38	53	61	127	153	168	181	181
Wellington	12	20	24	25	35	54	98	141	159	172
Christchurch	16	20	22	27	51	81	108	118	121	138

Recent extreme events in the Chatham Islands

The Chatham Islands are regularly affected by storms such as ex-tropical cyclones (see page 10), but damage is often not reported in New Zealand’s mainstream media. As such, only two events where civil defence emergencies were declared are listed here.

17-18 March 1980: Ex-tropical cyclone Sina caused a civil defence emergency to be declared on the Chatham Islands due to high winds. During this storm, 18 people were evacuated from their homes.

15-18 March 2015: Ex-tropical cyclone Pam caused a civil defence emergency to be declared on the Chatham Islands. The storm caused high winds, heavy rain, and large swells (>7 m swells). Impacts included power outages to many residents caused by trees falling on power lines and damage to wharves from heavy seas at Kaingaroa and Pitt Island. Schools were closed as a precaution due to the weather.

recent dry spell between two key sites on the Chatham Islands (Chatham Islands AWS and Chatham Island EWS) was 33 days recorded at Chatham Island EWS, from 16 November to 18 December 2007. During this dry spell, 14 consecutive days were without any rain. The longest recent dry spell at Chatham Islands AWS was 27 days, from 16 August to 11 September 2005 (8 consecutive days without any rain). Most dry spells occur during the months November to March. This corresponds to the time when rainfall variability is greatest and total amounts least, due to a frequent ridge of high pressure over northern New Zealand. Cold fronts passing over the Chatham Islands in this season are subsequently weak as they impinge into the southern limits of the high pressure zone.

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 not particularly common in the Chatham Islands due to its location in the path of moisture-laden winds. There is an average of 1.25 dry spells each year in the Chatham Islands. The average duration of a dry spell is about 19 days. The longest

Temperature

Sea surface temperature

Monthly mean sea surface temperatures near the Chatham Islands are compared with mean air temperature for Chatham Island EWS and Chatham Islands AWS in Figure 20. There is a lag in the increase of sea surface temperatures when compared to air temperatures from July to August/September. This is 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. Throughout most of the year, mean air temperatures are cooler than mean sea surface temperatures, although air temperature at Chatham Island EWS rises slightly above the sea surface temperature during the summer months. Figure 21 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.

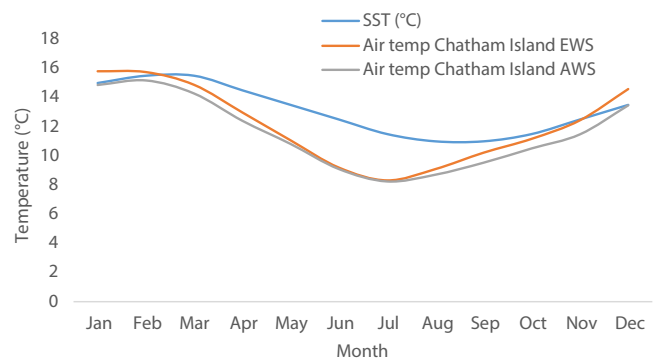


Figure 20. Mean monthly land (Chatham Islands AWS and Chatham Island EWS) and sea surface temperatures (surrounding the Chatham Islands).

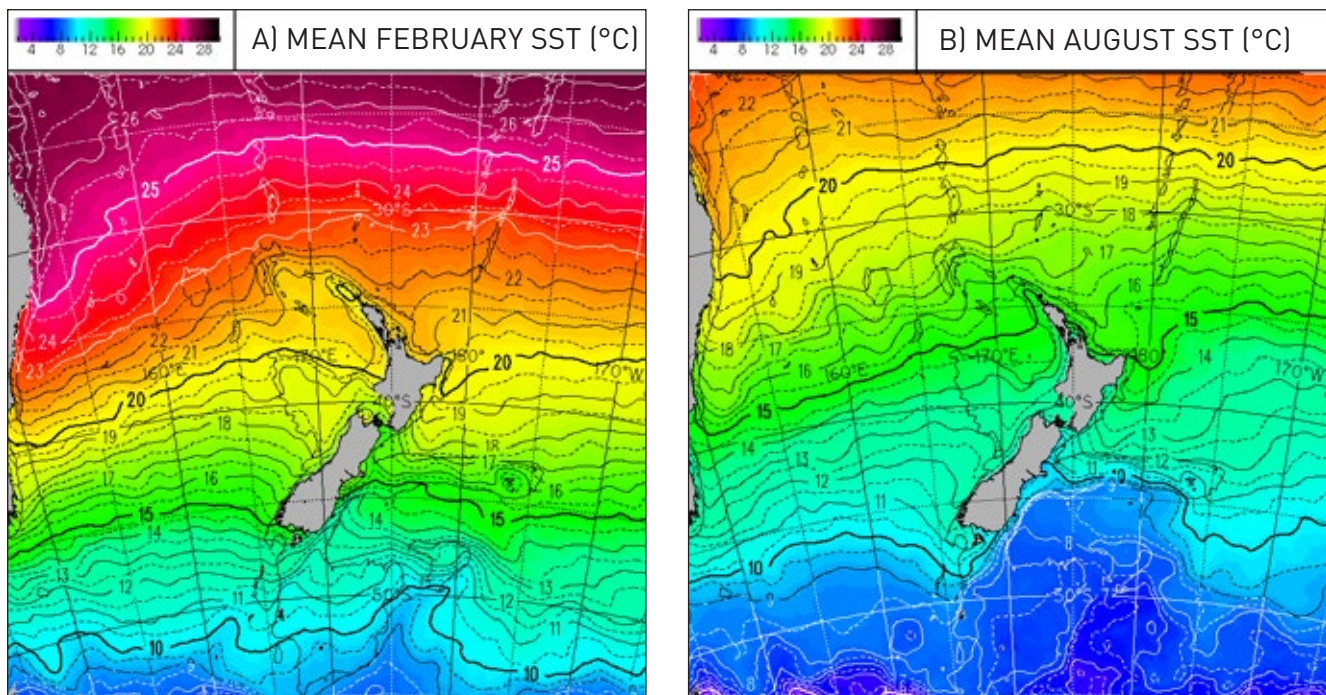


Figure 21. Monthly mean sea surface temperatures [°C] for: a) February; b) August. Source: NIWA SST Archive, Uddstrom and Oien (1999).

Icebergs have been sighted only once near the Chatham Islands, in October 1892. One stranded on Chatham Island and others were seen in Pitt Strait, Petre and Hanson Bays (Shand, 1892). Other independent observations of icebergs were reported between the islands and New Zealand. At that time no living person on Chatham Island had heard of such an occurrence previously.

Air temperature

The temperature regimes of small islands are strongly influenced by the prevailing wind flows with their associated air mass characteristics, and hence by the surrounding sea surface temperatures. Since the Chatham Islands are situated in a zone of strong and rather persistent westerlies, the daily and annual temperature variations are small.

Mean annual temperatures for most of the land area on the Chatham Islands is between 11 and 12°C, with the southern highlands on Chatham Island slightly cooler with a mean annual temperature of between 10 and 11°C (Figure 22). Table 10 shows the mean monthly and annual temperature for various stations in the Chatham Islands, and Table 11 shows mean maximum (afternoon) and mean minimum (morning) temperatures for these stations.

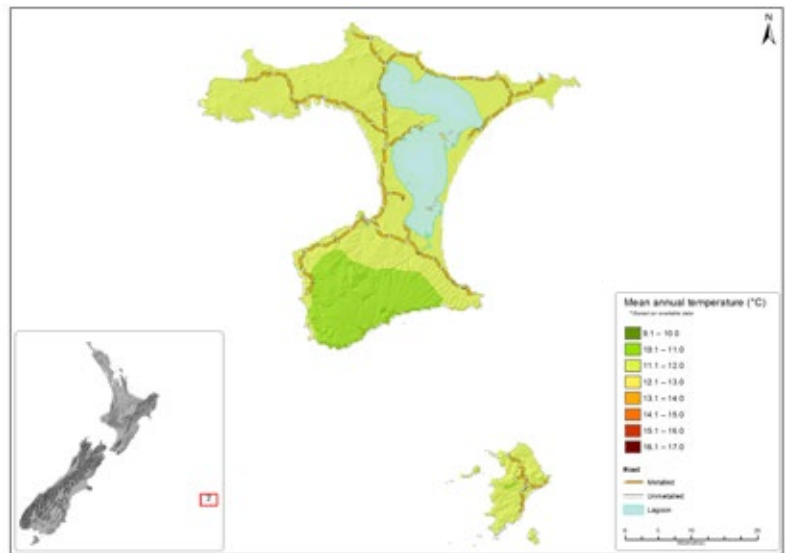


Figure 22. Mean annual temperature at the Chatham Islands, based on all available data.

Table 10. Mean monthly and annual temperatures for selected Chatham Islands stations, from all available data.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham I Po Radio	14.2	14.4	13.6	12.0	10.2	8.2	7.5	7.8	9.0	10.3	11.5	13.1	11.0
Chatham I Waitangi	14.7	15.1	14.3	12.4	10.3	8.7	7.9	8.4	9.2	10.4	11.7	13.6	11.4
Chatham Island EWS	15.8	15.8	14.9	13.0	11.1	9.2	8.3	9.1	10.2	11.2	12.4	14.6	12.1
Chatham Islands AWS	14.9	15.2	14.3	12.4	10.8	9.1	8.2	8.7	9.5	10.5	11.5	13.5	11.6

Table 11. Mean maximum and mean minimum temperatures for selected Chatham Islands stations, from all available data.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham I Po Radio	Max	17.4	17.6	16.6	14.8	12.8	10.7	10.1	10.5	11.8	13.1	14.5	16.3	13.8
	Min	10.9	11.3	10.7	9.1	7.6	5.7	4.9	5.2	6.2	7.4	8.4	10.0	8.1
Chatham I Waitangi	Max	17.8	18.0	17.1	15.0	12.8	11.1	10.3	10.8	11.7	13.0	14.5	16.5	14.0
	Min	11.6	12.1	11.4	9.8	7.8	6.4	5.5	6.0	6.7	7.8	8.9	10.8	8.7
Chatham Island Ews	Max	19.4	19.2	18.0	15.9	14.0	11.9	11.2	12.0	13.5	14.7	16.1	18.1	15.3
	Min	12.3	12.3	11.7	10.0	8.2	6.5	5.5	6.2	6.9	7.6	8.8	11.1	8.9
Chatham Islands Aws	Max	17.8	18.1	17.0	14.9	13.2	11.3	10.6	11.1	12.0	13.1	14.2	16.3	14.1
	Min	11.9	12.2	11.6	10.0	8.4	6.9	5.9	6.3	7.1	7.9	8.7	10.6	9.0

Figure 23 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 the Chatham Islands.

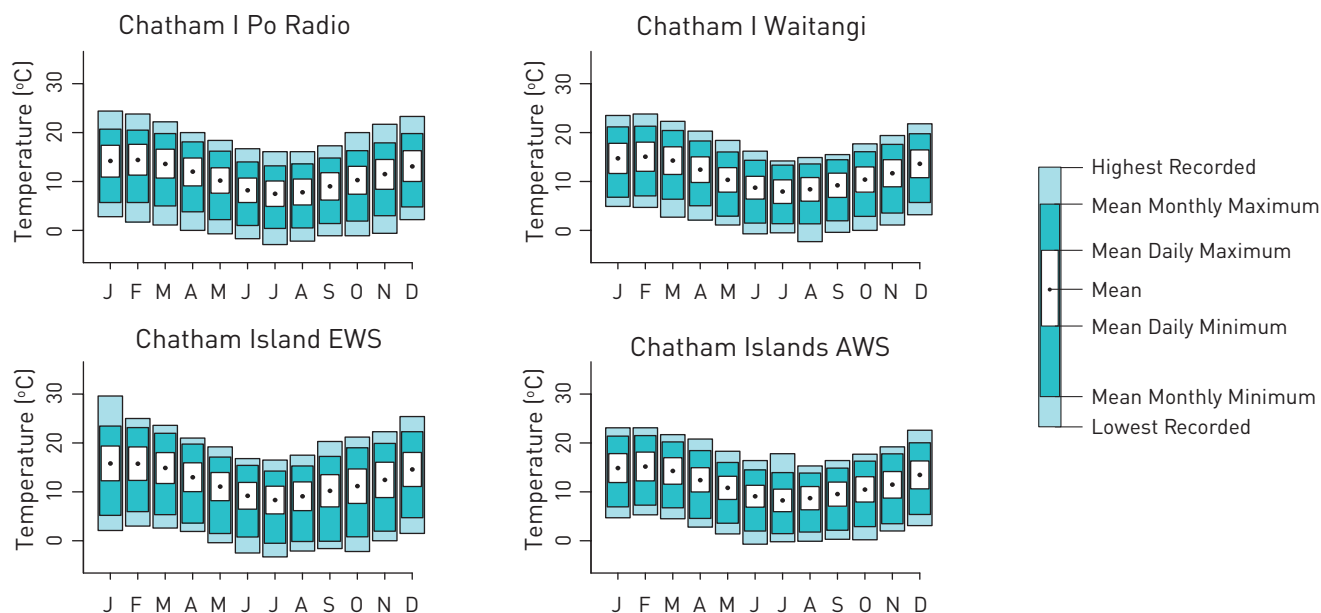


Figure 23. Monthly variation in air temperatures for selected Chatham Islands stations, from all available data.

Daily temperature ranges in the Chatham Islands are smaller than those in mainland New Zealand, due to the small land mass of the islands and the moderating influence of winds and the sea. Table 12 shows the average daily temperature range at different Chatham Islands sites. Table 13 shows the mean hourly temperatures at Chatham Island EWS, and Figure 24 shows these data in a graph, to illustrate how temperature changes over the course of an average day in January and July.

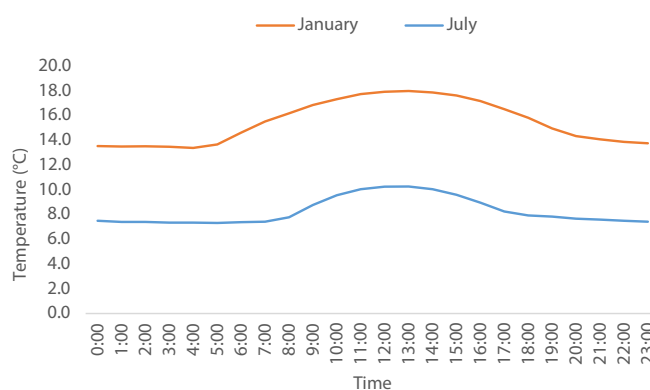


Figure 24. Mean hourly temperatures at Chatham Island EWS for January and July.

Table 12. Average daily temperature range ($T_{max} - T_{min}$, °C) for Chatham Islands sites.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham I Po Radio	6.5	6.2	5.9	5.7	5.2	5.0	5.2	5.3	5.5	5.8	6.1	6.3	5.7
Chatham I Waitangi	6.2	6.0	5.7	5.2	5.0	4.7	4.8	4.8	5.0	5.2	5.5	5.7	5.3
Chatham Island EWS	7.1	6.9	6.3	5.9	5.8	5.5	5.7	5.9	6.6	7.0	7.2	7.0	6.4
Chatham Islands AWS	5.9	5.9	5.4	5.0	4.7	4.5	4.6	4.8	4.9	5.2	5.4	5.7	5.2

Table 13. Mean hourly mean air temperatures at Chatham Island EWS for January and July.

	00	01	02	03	04	05	06	07	08	09	10	11
January	13.5	13.5	13.5	13.5	13.4	13.7	14.6	15.5	16.2	16.9	17.3	17.7
July	7.5	7.4	7.4	7.4	7.3	7.3	7.4	7.4	7.8	8.8	9.6	10.0
	12	13	14	15	16	17	18	19	20	21	22	23
January	17.9	18.0	17.9	17.6	17.2	16.5	15.8	15.0	14.3	14.1	13.9	13.8
July	10.2	10.3	10.0	9.6	9.0	8.2	7.9	7.8	7.7	7.6	7.5	7.4

The Chatham Islands do not experience extreme temperatures to the same extent as most mainland New Zealand region. The Chatham Islands have about 4 days per year when the temperature falls below 0°C, and the temperature very seldom reaches above 25°C (only three occurrences between 2000 and 2016 were recorded at Chatham Island EWS). In summer, maximum temperatures exceeding 20°C can be expected on about 14 days each year. The highest maximum temperature measured on the islands in NIWA's National Climate Database is 29.6°C, recorded at Chatham Island EWS on 30 January 2013. The extreme minimum temperature of -3.3°C was also recorded at Chatham Island EWS on 21 July 2007. These extreme temperatures compare to New Zealand national extremes of 42.4°C and -25.6°C.

Earth temperatures

Recent measurements of earth (soil) temperatures from the Chatham Islands are not recorded in NIWA's National Climate Database. From 1956 to 1993, however, earth temperatures were measured once daily at 9 am at the Waitangi site and these data are presented here.

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 14 lists mean monthly earth temperatures for a number of standard depths.

Figure 25 shows how earth temperatures change throughout the year at Waitangi, compared with air temperature. The temperature cycle for 100 cm depth is more damped and lagged than at shallower depths.

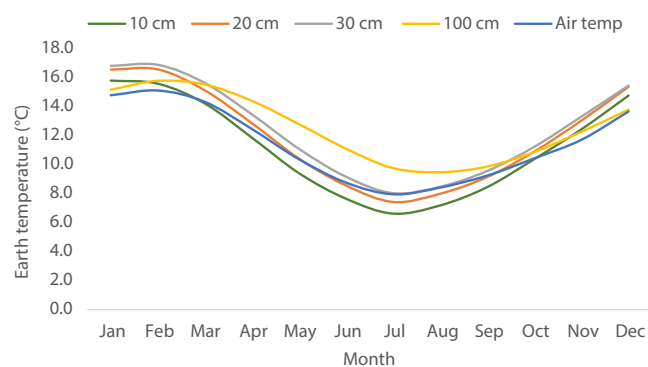


Figure 25. Average monthly 9 am earth temperatures for different depths from the ground surface and mean 9 am air temperature at Chatham Island Waitangi.

Table 14. Monthly and annual mean 9 am earth temperatures (°C) at varying depths from the ground surface at Chatham I Waitangi site (height above sea level: 44 m).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
10 cm	15.7	15.5	14.2	11.8	9.4	7.6	6.6	7.2	8.4	10.4	12.4	14.7	11.2
20 cm	16.5	16.5	15.1	12.8	10.4	8.5	7.4	8.0	9.1	10.9	13.0	15.3	12.0
50 cm	16.7	16.8	15.6	13.4	11.0	9.1	8.0	8.4	9.5	11.2	13.3	15.4	12.4
100 cm	15.1	15.7	15.5	14.3	12.7	11.1	9.7	9.4	9.8	10.8	12.2	13.7	12.5

Frosts

Frost is a local phenomenon and its frequency of occurrence can vary widely over very 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 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, 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 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 closely cut grass surface falls to -1.0°C or lower. Both types of frost are relatively uncommon in the Chatham Islands, with ground frosts being recorded 4 times a year in Waitangi and 10 times a year at Chatham Island EWS, and air frosts only recorded about once in two years at Waitangi and about four times a year at Chatham Island EWS. Table 15 lists for these two 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 23.

Table 15. Occurrences of frosts and grass minimum temperatures in the Chatham Islands, from all available data.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham I Waitangi	a	10.0	10.6	9.8	8.1	6.1	4.8	3.7	4.3	5.1	6.3	7.3	9.1	7.1
	b	0.4	-0.5	0.1	0.2	-2.2	-2.7	-3.0	-3.0	-2.9	-2.1	-2.1	-2.5	
	c	0.0	0.0	0.0	0.0	0.1	0.7	1.3	0.9	0.8	0.3	0.1	0.1	4.2
	d	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.1	0.0	0.0	0.0	0.4
Chatham Island EWS	a	11.5	11.5	10.9	9.1	7.1	5.3	4.3	5.0	6.0	6.8	8.0	10.3	8.0
	b	0.4	1.9	-0.4	-0.8	-2.5	-5.1	-5.5	-4.4	-3.8	-3.8	-2.9	-1.1	
	c	0.0	0.0	0.0	0.0	0.7	1.3	3.6	1.9	1.5	0.7	0.4	0.1	10.1
	d	0.0	0.0	0.0	0.0	0.1	0.3	1.4	0.7	0.7	0.3	0.0	0.0	3.5

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

The Chatham Islands are frequently cloud-covered, and as such, receive only about 1400 hours of bright sunshine per year (compared to over 2000 hours observed in Auckland, Wellington, and Christchurch). Table 16 shows the monthly and annual averages for Waitangi and for other New Zealand sites. There are about 50 days each year when no bright sunshine is recorded. Waitangi has an average of 10 days with no bright sunshine in summer, 17 days in winter, 11 days in spring and 13 in autumn. Figure 26 shows the monthly mean, maximum, and minimum recorded bright sunshine hours for the Waitangi site in the Chatham Islands.

Table 16. Average monthly and annual bright sunshine hours for Chatham Island Waitangi station, from all available data. Other sites from New Zealand are provided as a comparison.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham I Waitangi	186	143	124	100	82	63	77	96	109	137	155	161	1433
Auckland	243	204	184	160	141	111	134	145	151	186	200	235	2093
Wellington	247	211	205	161	133	99	119	147	163	193	209	223	2110
Christchurch	238	195	191	163	140	117	127	154	170	204	224	220	2141

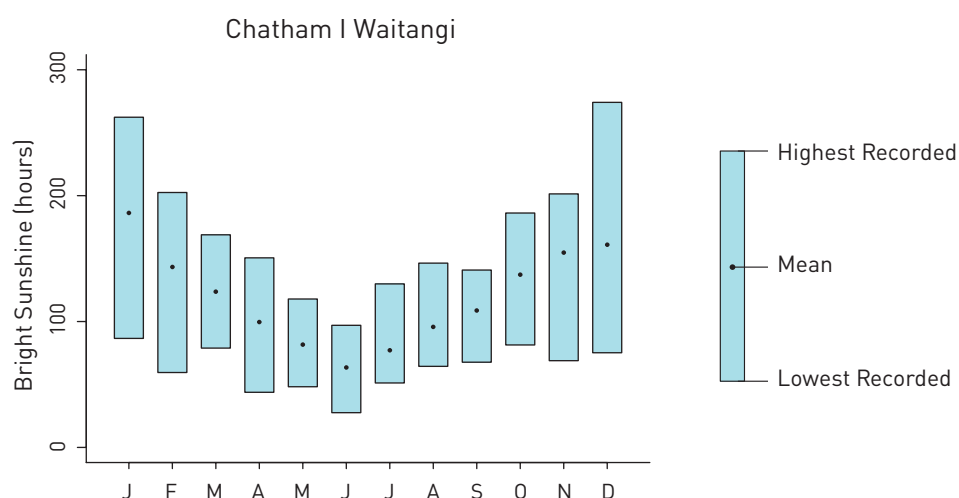


Figure 26. Mean, highest, and lowest recorded monthly bright sunshine hours for Chatham Island Waitangi.

Solar radiation

Solar radiation data is available for two sites on the Chatham Islands. Insolation is at a maximum in December and January and a minimum in June. Table 17 shows mean daily solar radiation (global) for each month for these two sites.

Table 17. Mean daily global solar radiation ($MJ/m^2/day$) for Chatham Islands sites, from all available data.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham Island EWS	21.5	18.1	13.3	8.8	5.6	4.4	5.1	7.8	11.8	16.1	20.6	21.4	12.9
Chatham Islands AWS	20.2	17.2	13.0	8.5	5.3	4.1	4.8	7.4	11.2	15.3	19.3	20.5	12.2

Other elements

Fog

Fog on the Chatham Islands is reported on about 19 days each year (Table 18). It is mostly advection (or sea) fog and very occasionally frontal fog. Both types can occur at any time of the day and are fairly evenly distributed throughout the year. Sea fog will form when a warm humid northerly air mass is cooled to below its dew point by a colder sea. Sea fog over the islands can be persistent but will normally lift to low stratus during daylight hours.

On occasions in moist north-westerly or northerly airstreams, fog or stratus cloud may be present on the north-eastern side of the Chatham Island and on the southern highlands when there is no indication of this at Waitangi. A meteorological situation when fog was reported most of the day at Waitangi is shown in Figure 27, during a northerly flow system. The fog band lay within the warm sector of the frontal system.

Thunderstorms

On average there are five days of thunder each year at the Chatham Islands (Table 18), and 10 days of thunder in a year are likely once every 50 years. Although fairly evenly distributed throughout the year, there is a tendency for thunderstorms to occur more frequently from April to June and especially during the night. Meteorological situations associated with thunderstorms usually occur with cold unstable showery south-westerlies, or cold fronts crossing the islands. Due to the localised nature of thunderstorm occurrence, it is possible that not all thunderstorms are detected.

The heavy rain, lightning, hail, and wind squalls which can occur with thunderstorms will sometimes cause severe local flooding, disruption of electrical and electronic equipment, and damage vegetation and buildings.

Hail

Hailstorms are reported on about 17 days each year (Table 18). There is a pronounced maximum of occurrence from May to August in which nearly 60% of all hail falls. Cold unstable south to southwest airstreams as displayed in Figure 28 often bring hail to the islands. On 13 July 1980 (Figure 28), both hail and snow fell on the Chatham Islands. As with thunderstorms, an unknown number of hail falls will escape detection.

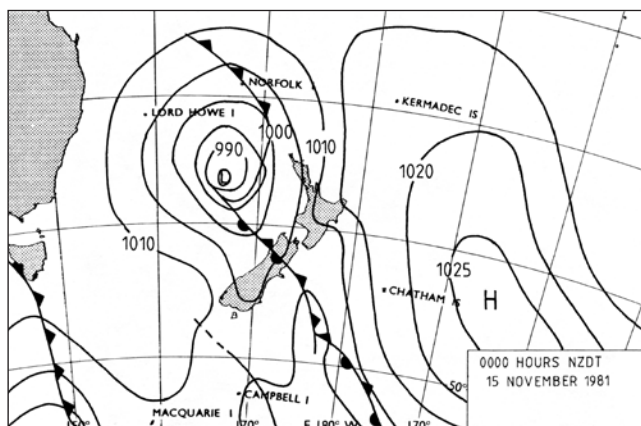


Figure 27. A situation when fog was observed at the Chatham Islands. MSL analysis for 15 November 1981.

Table 18. Average number of days each year with thunder, fog, and hail, at Chatham Island Waitangi station, from all available data.

Phenomenon	Days of occurrence
Thunder	5
Fog	19
Hail	17
Lightning	6

Snow

Snowfall is uncommon at the Chatham Islands especially on the lower levels of the Islands. It is reported one or two times per year and is confined to the colder months.

Snowfall occurs in cold south to southwest airstreams which flow around deep depressions situated east of the islands. An intense anticyclone normally lies over the Tasman Sea or New Zealand. A meteorological situation when snow and hail fell over the islands is given in Figure 28.

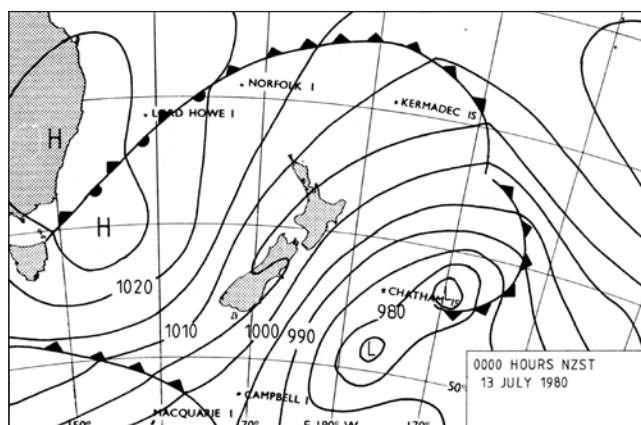


Figure 28. A meteorological situation when snow and hail fell at the Chatham Islands. MSL analysis for 13 July 1980.

Sea swell and waves

Exploration of the ocean's resources frequently requires sea conditions which are not too rough. Since the wind is ever present at and around the Chatham Islands, so too are there locally-generated sea waves, and swell which originates from outside the area. Predominant wave directions are from the south or south-west and also from the north. Most swells arriving in the Chatham Islands area originate in the strong westerly wind zone to the south and south-west of New Zealand, as well as in south-westerly airstreams which frequently blow between New Zealand and the Islands.

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/Chatham Islands coastal waters of about 500 km are given in Table 19.

Table 19. 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+



Photo: Vlk2cz - Own work, CC BY 3.0, <https://commons.wikimedia.org/w/index.php?curid=4051609>



Photo: Richard O Driscoll, NIWA

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 hygograph 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 in the Chatham Islands are given in Table 20, 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. Due to the marine environment of the Chatham Islands, relative humidity remains high all year round (Table 21). The daily variation is small when compared with other locations in New Zealand. At Chatham Island EWS, there is a mean diurnal variation of 15% in January and 9% in July. In comparison, Auckland has a mean diurnal variation of 22% in January and 16% in July, and Christchurch has values of 28% in January and 24% in July.

Table 20. Mean monthly/annual 9 am vapour pressure (hPa) for selected Chatham Island sites, from all available data.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham I Waitangi	14.2	14.6	14.1	12.7	11.4	10.0	9.5	9.9	10.3	11.0	11.8	13.4	11.9
Chatham Island EWS	15.6	15.7	15.2	13.5	12.3	10.8	10.2	10.6	11.0	11.4	12.3	14.5	12.7
Chatham Islands AWS	14.0	14.5	13.8	12.5	11.6	10.1	9.5	9.9	10.4	11.0	11.3	13.0	11.8

Table 21. Mean monthly/annual 9 am relative humidity [%] for selected Chatham Islands sites.

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham I Waitangi	81.6	82.8	83.1	84.0	86.0	86.1	86.7	86.3	84.0	83.5	82.2	82.6	84.1
Chatham Island EWS	83.5	85.5	87.2	85.3	87.6	88.2	89.0	86.8	81.8	81.7	80.6	83.3	85.0
Chatham Islands AWS	80.4	82.2	82.1	81.9	85.5	84.6	84.9	84.4	82.5	83.4	80.5	81.0	82.8

Evapotranspiration

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). No soil moisture calculations for the Chatham Islands are held in NIWA's National Climate Database.

Potential evapotranspiration (PET) has been calculated for two Chatham Island sites using the Penman method (Penman, 1948). The monthly mean, minimum, and maximum PET values are listed in Table 22.

Degree-day totals

The Chatham Islands are suitable for certain types of agricultural and horticultural activities. With suitable protection from the wind (such as shelter belts which set up their own microclimate) many fruits and vegetables are grown. The suitability of the climate for a particular crop to grow successfully can be assessed from the concept of "degree-days".

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 23 lists the monthly totals of growing degree-day totals above base temperatures of 5°C and 10°C for sites in the Chatham Islands. For example for a successful harvest of peas, between 650 and 800 growing degree-days are required above a threshold of 5°C during the August to February period. Peas can be grown quite successfully on the Chatham Islands as there are over 1400 growing degree-days between August and February. The difference in growing degree days is likely due to the difference in exposure between the two sites (Chatham Islands AWS is on the coast, whereas Chatham Island EWS is further inland).

Table 22. Penman calculated maximum, mean, and minimum monthly potential evapotranspiration (mm), as well as total mean annual PET (mm) for selected Chatham Islands sites, from all available data.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham Island EWS	Max	156	109	83	53	30	20	26	39	69	105	137	151	
	Mean	128	96	72	40	18	11	12	27	54	85	109	123	775
	Min	112	78	58	29	7	3	3	15	37	62	87	101	
Chatham Islands AWS	Max	145	109	93	58	44	32	32	44	66	91	120	147	
	Mean	123	95	77	45	25	20	21	32	53	79	104	119	795
	Min	105	77	70	36	14	10	10	24	44	65	84	95	

Table 23. Average growing degree-day totals above base 5°C and 10°C for selected Chatham Islands sites, from all available data.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham Island EWS	5°C	335	304	306	240	188	126	104	127	157	191	223	297	2598
	10°C	180	162	151	92	48	17	7	13	30	47	78	143	969
Chatham Islands AWS	5°C	306	288	288	222	178	123	101	115	136	171	194	262	2385
	10°C	151	146	133	77	39	15	7	9	19	33	52	109	789

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 24 shows that the number of cooling degree days reach a peak in summer in the Chatham Islands, where there is a higher demand for energy to cool building interiors to 18°C. However, due to the Chathams' relatively cool climate, there is only a small number of cooling degree days in any year. Conversely, heating degree days reach a peak in winter, where the demand for energy to heat buildings to 18°C is highest. As with growing degree days, the difference between the two sites is likely due to exposure differences.

Table 24. Average cooling (CDD) and heating (HDD) degree-day totals with base 18°C for selected Chatham Islands sites, from all available data.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chatham Island EWS	CDD	5	4	2	0	0	0	0	0	0	0	0	2	13
	HDD	73	68	99	151	215	264	300	276	234	212	167	108	2165
Chatham Islands AWS	CDD	2	2	1	0	0	0	0	0	0	0	0	0	5
	HDD	99	82	116	168	225	267	302	288	254	232	196	141	2370



Photo: Marty Flanagan, NIWA





Photo: T. Shand

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