THE CLIMATE AND WEATHER

OF

NIUE

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Note to 188 series

This publication is the first in a series on the climate and weather of selected South Pacific island groups.

This series replaces an earlier Meteorological Service series entitled: 'Climatological Notes - South Pacific Region' (N.Z.M.O. Series C), published in 1943.

The following titles have been published, or are in preparation:

188(1) Climate and Weather of Niue (published)

188(2) Climate and Weather of Southern Cooks

188(3) Climate and Weather of Northern Cooks

188(4) Climate and Weather of Tokelau

188(5) Climate and Weather of Tonga

188(6) Climate and Weather of Tuvalu

188(7) Climate and Weather of Western Kiribati

188(8) Climate and Weather of Western Samoa

Cover - an outrigger canoe with asymmetrically cross-sectioned hull from the Caroline Islands (after a drawing by Louis Choris in 1815).

THE CLIMATE AND WEATHER OF NIUE

Summary

The climate of Niue is dominated by the trade wind regime in which it lies and by its proximity to the south pacific convergence zone. Tropical cyclones also exert a major influence on the climate, and may cause considerable damage on occasions.

Niue is a low lying island with a relatively small range in temperature. Rainfall can be very variable, with very wet or dry months possible at any time.

1. INTRODUCTION

Niue is an isolated island in the South-West Pacific, lying midway between Fiji and the Southern Cook Islands. The island has an area of approximately 259 km^2 and consists of upheaved coral, on top of a submerged volcano. Encircling the island is a low broad ridge, ranging in height from 50-60 m above mean sea level. The entire coastline is cliffed. The interior plateau is mostly flat or slightly undulating and is well wooded.

An important feature of the atmospheric flow pattern in the South Pacific is the south pacific convergence zone (SPCZ), which lies in a north-west to south-east orientation and marks the boundary between the south-east trade winds of the Southern Hemisphere and the divergent easterlies of the south-east Pacific. The SPCZ generally lies to the north of Niue, thus south-east trade winds prevail over the island. The zone is sometimes active and sometimes weak, particularly in winter when it may be difficult to locate. It is an area of cloudiness and precipitation, with many thunderstorm clouds present when active.

Surface winds in the trade wind regime are usually moderate to fresh but may locally be 35-50 km/h for a few days at a time.

Tropical cyclones, of which there are on average 8-9 per year in the South-West Pacific, sometimes pass close to or over Niue. These storms can on occasion be particularly destructive.

Alofi, on the western side of the island, is the site from which weather and climatological observations have been made since 1905. There was a brief period (1971-1976) when observations were made at an alternative site, 2.4 km inland at Kaimiti. However, as Alofi is the only site from which long-term records are available, most of the statistics presented here will refer to this site only.

Niue's position in relation to other islands in the South-West Pacific, and the places referred to in the text are shown in Fig. 1.

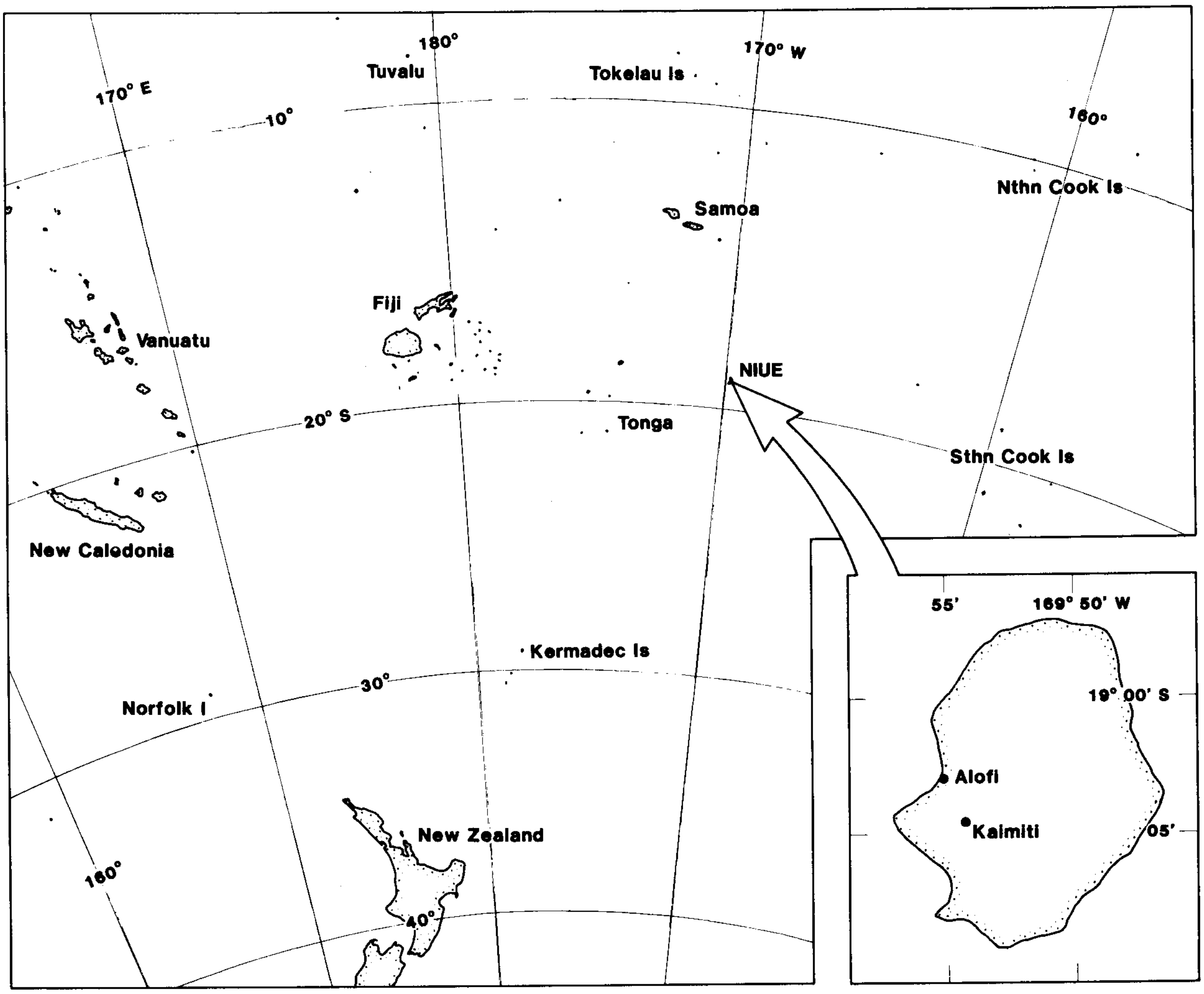

Fig. 1. Location map

2. WEATHER SYSTEMS AFFECTING NIUE

<u>South-east trades</u>

The south-east trade winds are the prevailing winds over Niue. The traditional concept of trade wind weather is of fresh south-east winds with scattered fair weather cumulus clouds beneath a strong trade wind inversion in windward regions, and completely clear skies in leeward regions. As Niue is a small, low lying, island little appreciable difference in weather conditions occurs between the windward and leeward sides.

Evaporation from the sea and vertical mixing give rise to cumuliform clouds, which often appear to be in lanes aligned with the wind direction with clear bands in between. Surface visibility is generally good, although it may be reduced by haze particularly in strong wind conditions. Upper-level westerlies usually predominate above the trade wind belt and there is commonly an inversion at the level where the wind changes direction. The air in the westerlies is usually descending and drier; thus cumulus clouds rarely penetrate far above the inversion. Consequently, showers are infrequent in this situation over islands such as Niue since there is no orographic lifting to provide greater vertical extent.

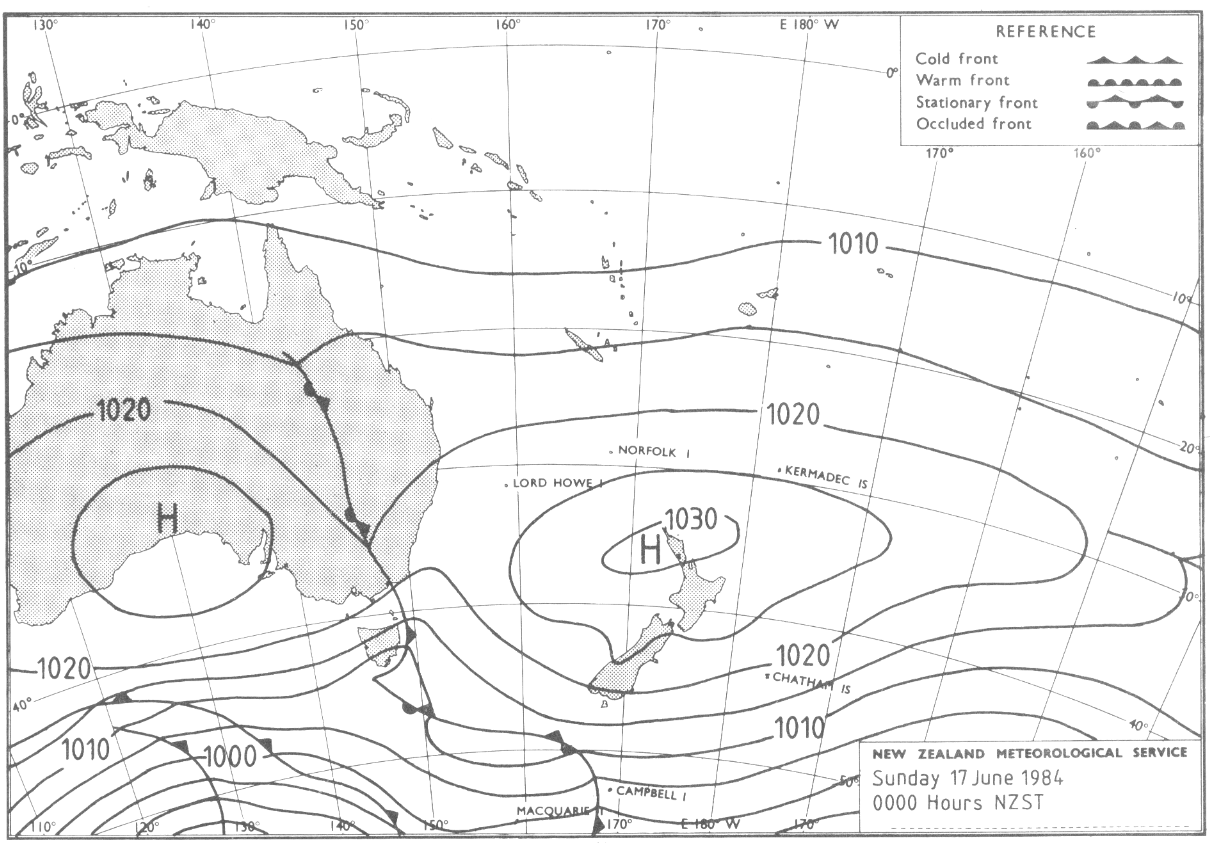

Fig. 2. M.s.l. analysis for 0000 NZST 17 June 1984 showing the situation of a broad easterly air-stream over Niue

Convergence zone weather

As a result of convergence of the northeast flow around the western flank of the semi-permanent south-east Pacific anticyclone and the southerly flow ahead of the migratory anticyclones of the south-west Pacific, a semi-permanent trough is to be found (fluctuating about an average position) on mean sea level charts of the south-west Pacific. Associated with this trough, and lying to the north and east of it, is a cloud band known as the south pacific convergence zone (SPCZ).

The day-to-day movement of the SPCZ is irregular; it may be apparent in a certain geographical position for a number of days, and then weaken, followed by subsequent reappearance in another geographical position. On some occasions two distinct convergence zones may be present. The width of the SPCZ is a general indication of the amount of activity within it; localised pressure falls within the zone may lead to the development of closed-isobar depressions.

The weather associated with the zone varies according to its activity. When weak, the SPCZ comprises scattered cumulus and stratiform clouds, and isolated cumulonimbus (possibly with anvil tops). When active the zone consists of a dense stratiform cloud sheet with embedded cumulus and cumulonimbus. Isolated cumulonimbus may be very large and extend high into the troposphere, and have accompanying severe thunderstorms.

In general the SPCZ is more active and further south in summer than it is in winter. It occasionally lies over Niue, especially in the summer months and, as a result, unsettled weather can be expected.

The SPCZ is shown in Fig. 3b by a belt of cloud extending in a northwest southeast direction from a point near 10°S, 170°E. Cumulonimbus clouds are indicated by some dense bright spots within the cloud belt. The mean sea level (m.s.l.) analysis for this situation is shown in Fig. 3a.

Wet season weather

In the region of the South Pacific in which Niue lies, the year may be divided into two seasons, November-April (wet) and May-October (dry).

From November to April, the SPCZ is further south; thus winds from between north and west occur for a greater percentage of the time than they do from May to October. They transport moist air into the Niue region from more northern latitudes. As a consequence of the SPCZ lying further to the north and east of Niue in the months June-August, drier south to south-east winds are more predominant. Figures 3a and 3b may also be thought of as illustrating a typical wet season weather situation.

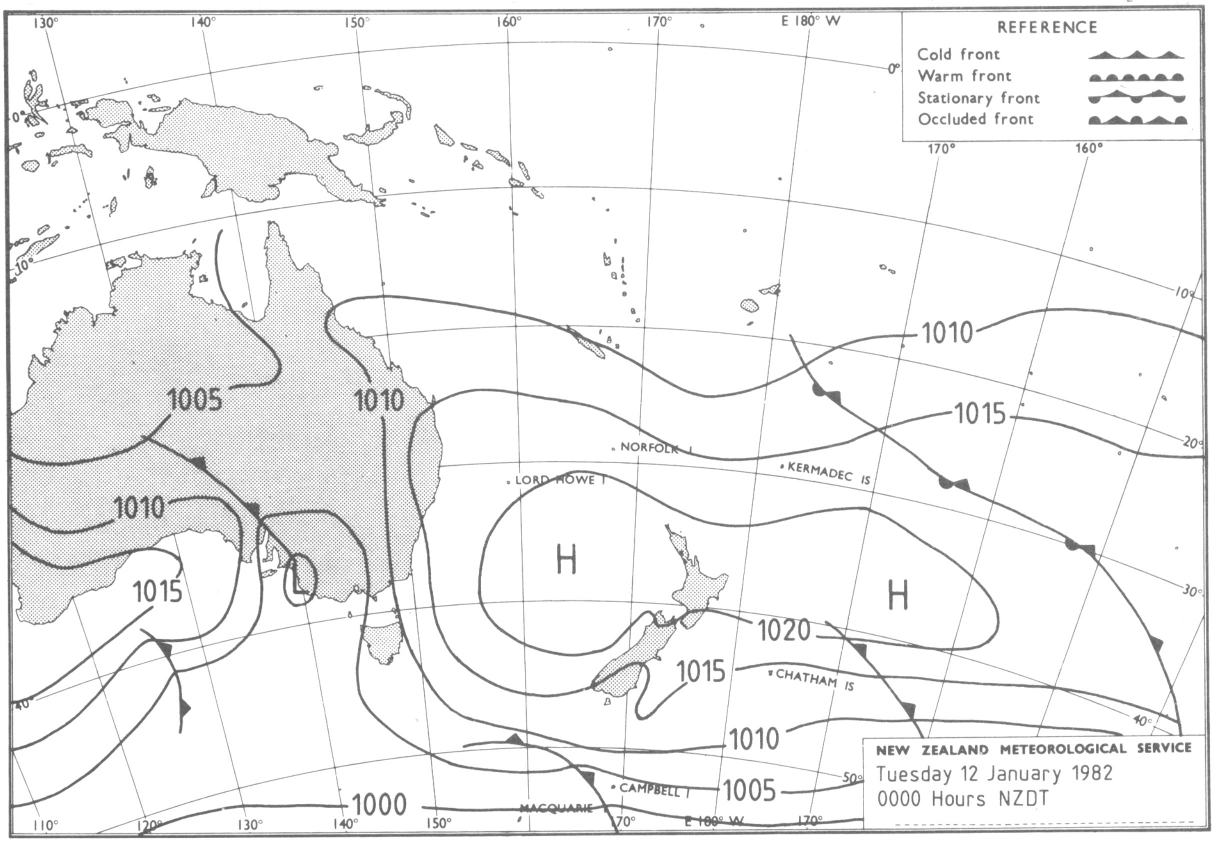

Fig. 3a. M.s.l. analysis for 0000 NZDT 12 January 1982

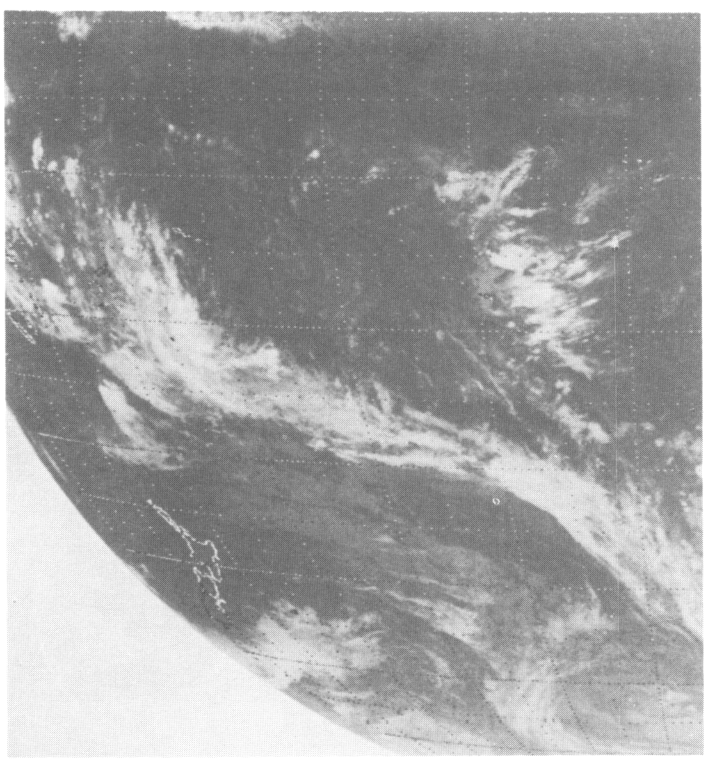

Fig. 3b. Satellite view of SPCZ lying close to Niue

Tropical rainfall appears to conform to the pattern of a maximum frequency of showers in the afternoon over land and in the night and early morning over the sea. These features result from strong heating over the land by day producing convective cloud and strong radiative heat loss from cloud tops at night, the sea acting as a heat source to prevent radiative cooling at the base of the cloud. This is generally true for Niue, where the rainfall is usually of a convective nature. However, when synoptic systems are present, precipitation may occur at any time of the day or night.

The passage of tropical storms close to Niue during the months November to April also contributes greatly to the total wet season rainfall.

Cold fronts

The winter weather between 15°S - 20°S is complex because successive cold fronts moving from the south-west often become stationary in this zone, producing periods of persistently unsettled weather. On most occasions the outbreaks of cold air behind the cold fronts are sufficiently vigorous to move them only a few degrees latitude north of Niue.

These cold fronts are usually associated with upper-air troughs ahead of which large-scale dynamic lifting produces broad altostratus cloud sheets which may be 900-1000 km wide. The rain from the altostratus cloud may be widespread, persistent and heavy when the upper westerlies are strong. The intensities and movements of the cold fronts are irregular and there is sometimes only slight temperature change across them at the surface.

Often the most important change noticeable at sea level after a cold frontal passage is a change in dew-point, signifying the presence of an air mass advecting from a higher latitude. Such changes mean more comfortable conditions and are eagerly awaited in the hotter months.

Figs. 4a and 4b show the m.s.l analysis and satellite view of a cold front lying over Niue.

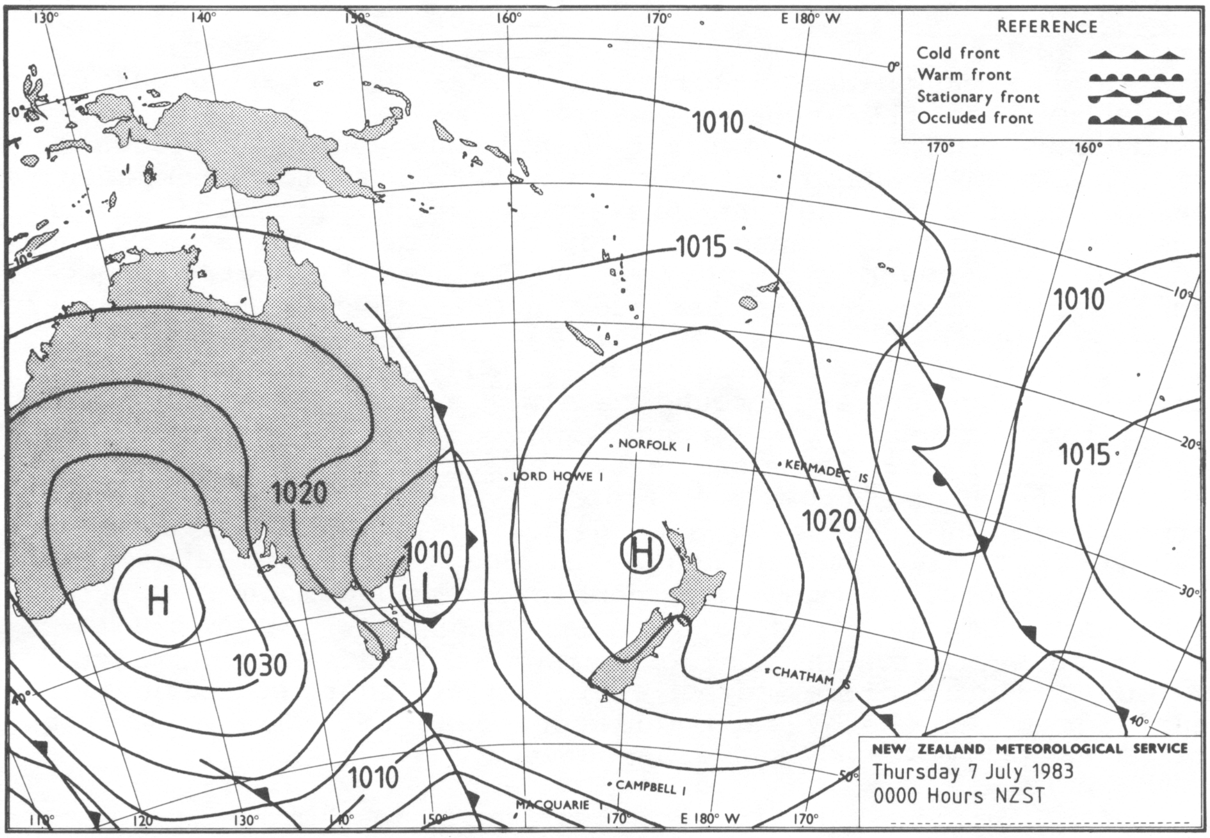

Fig. 4a. M.s.l. analysis for 0000 NZST 7 July 1983

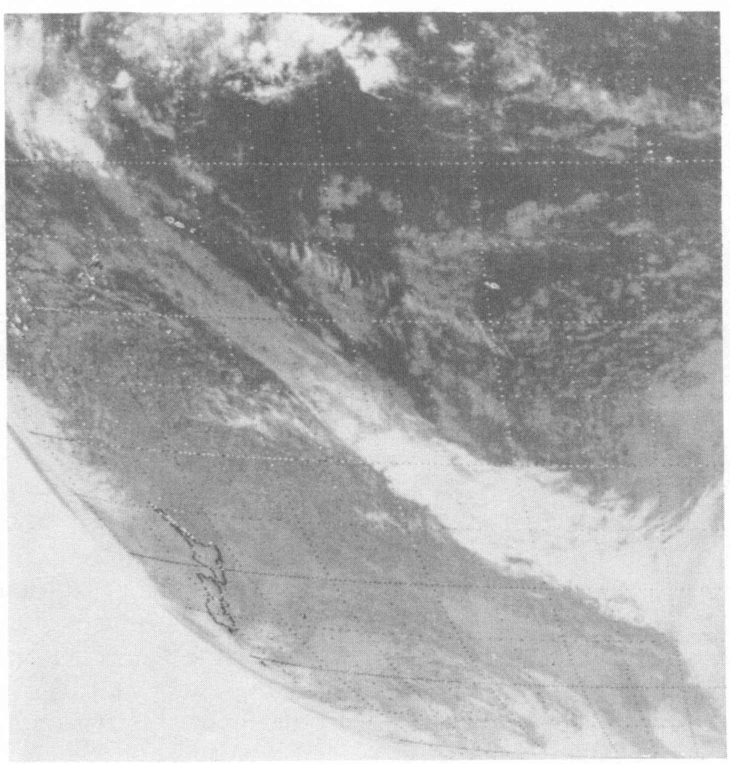

Fig. 4b. Satellite view of cold front lying northwest-southeast over Niue

Tropical cyclones

In the South-West Pacific tropical cyclones occur most frequently in the months November to April. An initial disturbance given favourable environmental conditions - principally an extensive ocean area with a surface temperature greater than 27°C and the presence of an anticyclone in the upper troposphere - may develop into a tropical cyclone. Tropical cyclones may be only a few hundred kilometres across, much smaller than middle latitude depressions. In the mature stage, there is a central eye some 15-60 km in diameter which is a region of light winds and usually clear skies. Dense convection clouds surround this eye, producing heavy precipitation and very strong winds. Hurricane force winds (greater than 118 km/h are usually confined to a small area between 30-100 km from the centre. The central pressure is normally 50-100 hPa below average. The strong winds and very high seas, and a rise in sea level due to reduced atmospheric pressure (a storm surge), may combine to cause much damage over land, particularly along coastlines.

Once the cyclone moves over cooler seas or land it is deprived of its energy supply (latent heat of condensation) and will eventually weaken and dissipate.

Of 17 tropical cyclones affecting Niue during the period 1905 to 1979, two occurred in November, three in December, seven in January, four in February, and one in March.

Probably the worst tropical cyclone on record occurred in February 1959. It passed directly over Niue between 2 p.m. and 5 p.m. on Thursday 26 February local time (see Fig. 8). A sustained wind force of more than 185 km/h was recorded in the afternoon of the 26th before the anemometer blew down. Another 12 hours of winds above gale force (63 km/h), with heavy rain, followed this.

Of the island's 770 houses only 290 were left intact. Severe damage was done to the island's banana, pawpaw and coconut crops, and road transport was disrupted for a week. The Alofi church which had withstood every storm for more than 100 years was all but destroyed, and the total cost of damage and loss of exports to Niue was put at $1,500,000.

Before the island had had time to recover, another tropical cyclone hit in January 1960. Although the damage was not as severe as in February 1959, 4000 people were left homeless and cash export crops were set back again some 12 to 18 months. The cyclone passed over Niue on the morning of 18 January. Between 2 a.m. and 3 a.m. (local time) the wind blew at hurricane force from the northeast; after a lull of about one hour the wind blew again from the south. During the passage of the storm's centre the pressure dropped below 950 hPa. The rainfall in the 7 hours from midnight was 175 mm.

Export crops were again seriously affected by a cyclone which passed over Niue during February 1968. The storm was first detected south of Samoa on 7 February (local date). The intensifying storm moved slowly southeastwards, reaching hurricane force in the early hours of 10 February, over Niue. Hurricane force winds blew over Niue from near midnight until about 7 a.m. The maximum sustained winds reached 148 km/h.

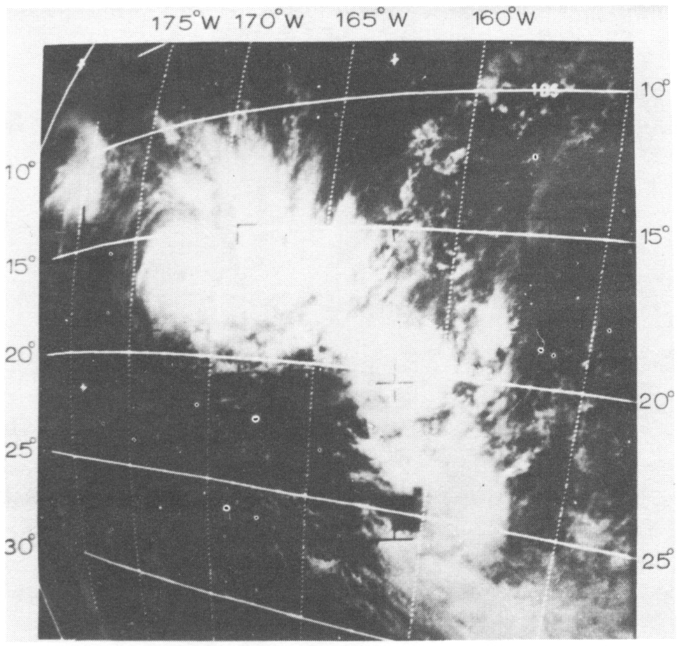

Fig. 5. A satellite photograph of the storm showing a dense cirrus shield above the well organized area of deep convective clouds

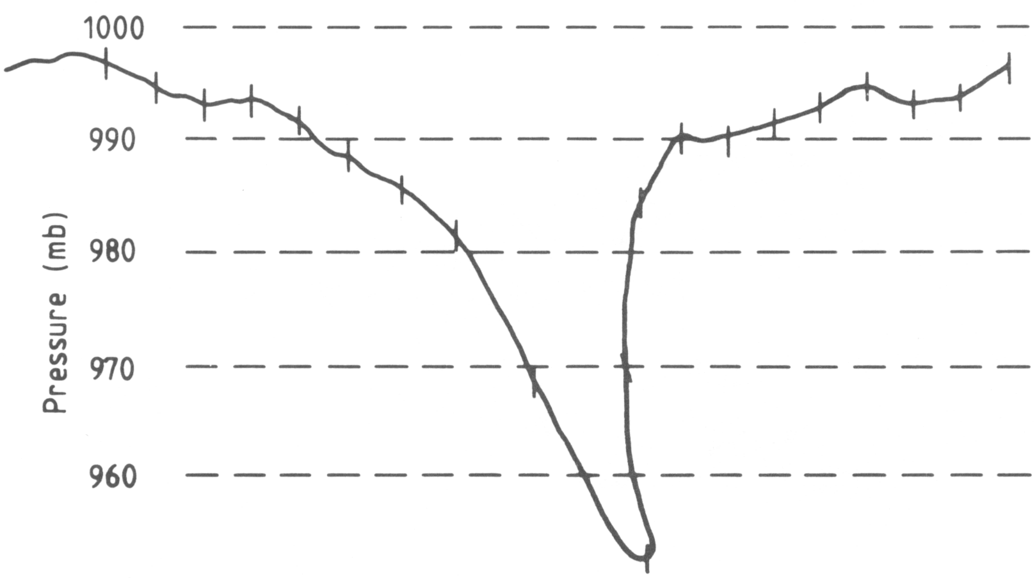

Fig. 6. Record of pressure at Alofi as the hurricane moved southwards. Vertical strokes indicate 3-hour time intervals

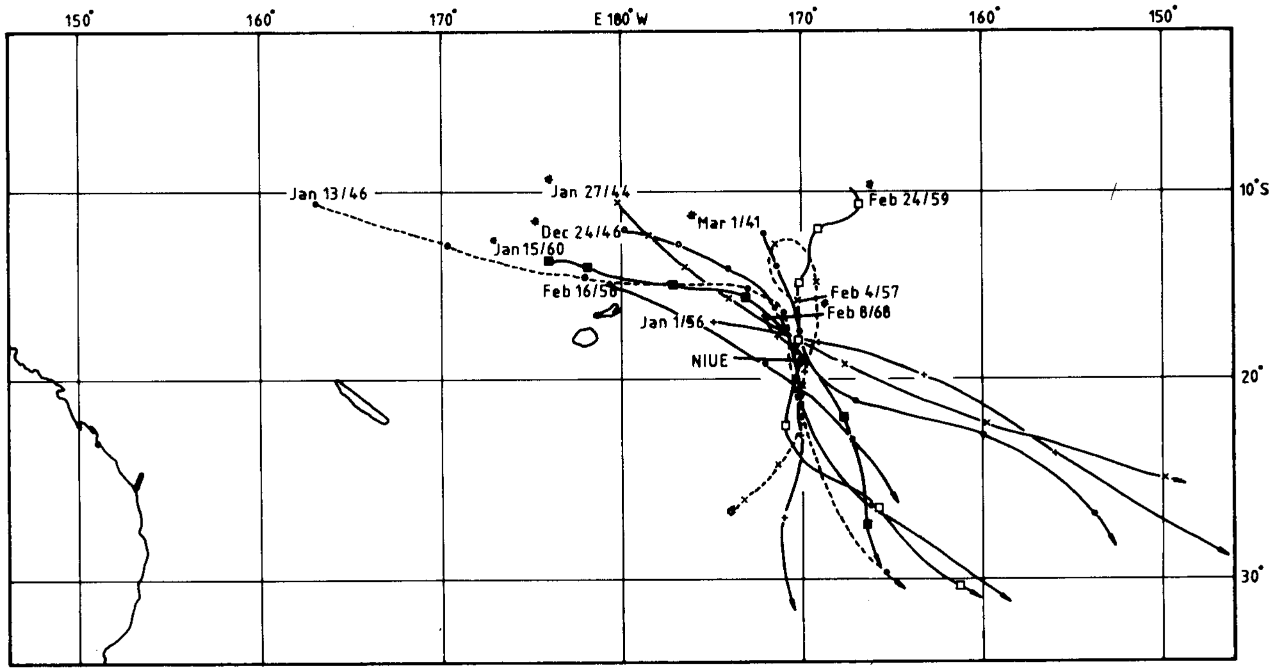

Fig. 7. Tropical storms and hurricanes passing near Niue in the period November 1939 to April 1969. Positions of the low pressure centres are shown for midday NZ time. (An asterisk implies a storm with a moderate to severe effect on Niue.)

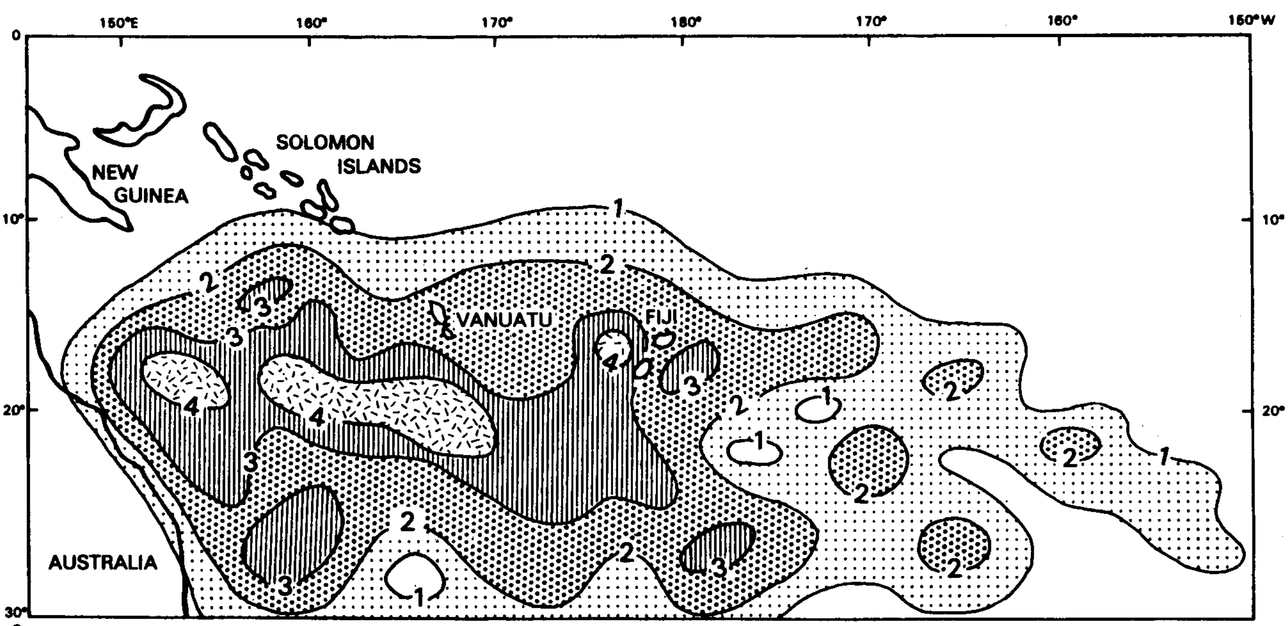

Fig. 8. Average frequency per decade of tropical cyclone centres passing within 40 miles (after Gabites 1976)

Fig. 9. Satellite photograph taken 18 June 1970. The 200 hPa analysis is superimposed. A dense cloud sheet associated with a jet stream may be seen covering a broad area of the south west pacific including Niue

Jet stream weather

A jet stream is a narrow current of air flowing at high speed. The jet has one end as an entrance and the other as an exit and may be thousands of kilometres long with winds blowing along the length. The strongest jet stream winds commonly exceed 150 knots and are usually found just below the tropopause.

In the months June - November a continuous jet stream may extend across the south-west Pacific from western Australia to beyond 150°W. Upward motion tends to occur upwind of the jet maximum on the equatorial side of the jet and downwind of the jet maximum on the polar side, and if there is sufficient moisture in these areas cloud will form. The amount of upward motion is increased where the jet is blowing from the north-west. It is common to find very wide cloud sheets originating in the region of north-westerlies and dissipating many kilometres downstream where the flow turns south-westerly. Such a situation is illustrated in Fig. 9.

Thus moist tropical air may be carried aloft and south-east by the jet stream circulation giving rise to very extensive, dense cloud sheets which may be the source of considerable precipitation to islands in the south-west Pacific such as Niue.

3. CLIMATIC ELEMENTS

Wind

Observations of wind speed and direction have been made at Alofi and Kaimiti, and analysed for the periods 1978-83 and 1971-76 respectively. When discussing the wind regime at Alofi it is worth noting that the Alofi site is somewhat sheltered and winds within the sector northeast to east and south to southwest, particularly, will be much lighter than those experienced in more exposed positions such as Kaimiti. The winds at Kaimiti are probably more representative of the island as a whole.

South-east trade winds prevail over Niue, due to the location of the SPCZ. This is evident from the wind roses constructed for Kaimiti and Alofi (Fig. 11). The next most common wind direction is easterly. Table 1 gives the seasonal distribution of wind directions (for all wind speeds) and shows the predominance of east and southeast winds in both seasons. The highest average wind speeds tend to occur in the months Sep - Nov at Kaimiti and Oct - Jan at Alofi. Average wind speeds in all months generally increase during the day, varying from about 7 km/h in the early morning to 13 km/h mid-afternoon at Alofi, and from 9 km/h early morning to 19 km/h early afternoon at Kaimiti.

Table 1. (a) Seasonal wind direction summary as percent of 3-hourly observations

	Direction	Wet Season (Nov - Apr)	Dry Season (May - Oct)
Alofi (1978-83)	N	4.0	3.3
	NE	8.1	6.7
	E	20.5	17.9
	SE	42.6	44.7
	S	7.0	8.8
	SW	2.8	2.8
	W	1.8	1.6
	NW	5.2	3.6
	Calm	8.1	10.5
Kaimiti (1971-76)	N	7.3	3.6
	NE	18.7	14.3
	E	26.4	30.1
	SE	24.2	34.9
	S	2.8	4.5
	SW	3.3	4.1
	W	3.3	1.4
	NW	10.3	3.8
	Calm	3.7	3.2

Table 1. (b) Mean monthly/annual wind speeds (km/h)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Alofi 1978-83	10.7	10.2	9.1	10.2	9.1	8.5	9.6	9.4	9.4	10.5	11.4	10.4	9.8
Kaimiti 1971-76	13.0	10.7	11.3	11.1	13.9	13.1	14.1	14.1	15.7	15.0	15.7	13.9	13.3

Table 1. (c) Diurnal variation of mean wind speed (km/h)

	Hour (NZST*)						
	00	06	09	12	15	18	21
Alofi 1978-83	6.8	7.2	11.1	13.5	13.3	9.1	8.3
Kaimiti 1971-76	9.2	9.6	17.0	19.2	17.4	10.5	9.6

* Niue is 23 hours behind New Zealand Standard Time

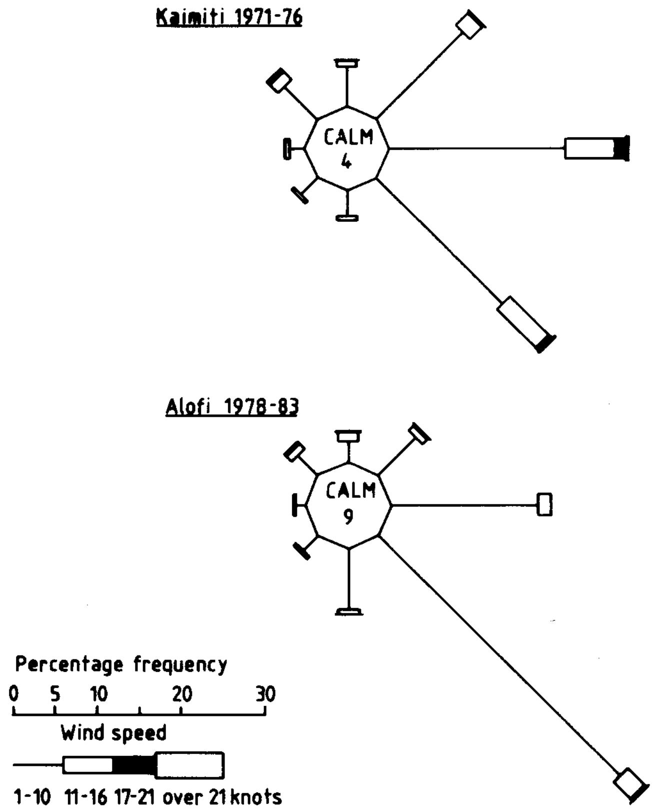

Fig. 10. Mean annual wind frequencies (percentage) of surface wind directions frequencies found from 3-hourly observations

The strongest winds usually come from the northwest-northeast sector, particularly during the first four months of the year, coincident with the passage of tropical storms in the sea area to the north of Niue. Gales occur on average about once a year, most frequently from the northwest, but they may also occur from the southeast and west. The wind may reach gale force with the passage of squall lines or tropical storms as mentioned, though rarely do they persist for more than a few hours.

Rainfall

As the exposure of the rain-gauge at Alofi during the period 1978-82 was unsatisfactory, rainfall satistics for Alofi for the period 1905-1977 are presented here. The rainfall in Niue is generally of a convective nature, tending to occur frequently during the afternoon or evening when temperatures are highest.

Rainfall statistics. The average annual rainfall is 2009 mm, with the driest year on record being 1931 when only 1066 mm was recorded, and the wettest year 1924 with 3184 mm. There are no running streams on Niue; thus the island is sensitive to dry conditions. The shortage of rain in 1931 was reported as having a disastrous effect on practically all crops.

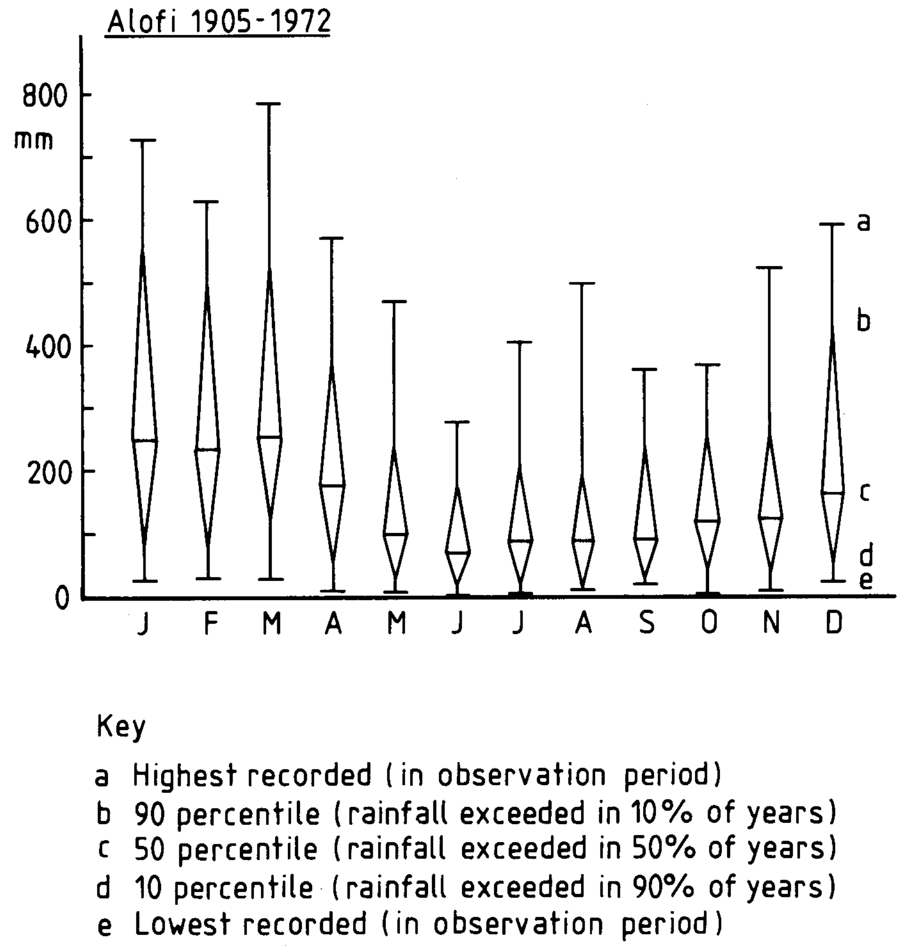

Fig. 11. Mean monthly rainfall for Alofi

An indication of the distribution of monthly rainfall is given in Fig. 11. As can be seen, Jan, Feb, Mar are the wettest months, accounting for about 41 percentage of the average yearly rainfall. The year can be divided into two seasons, wet (November - April) and dry (May - October). As the figures in the following table show, approximately twice as much rainfall is received in the wet season as the dry season.

Table 2. Seasonal/annual distribution of rainfall (mm)

	Wet season	Dry season	Year
Alofi 1905-77	1368(68*)	641(32*)	2009

* percentage of annual total

However, the rainfall pattern can generally be described as erratic with very dry or wet months possible at any time. Rainfall is more variable in the dry season as Table 3 shows.

Table 3. Variability* of seasonal and annual rainfall

	Wet season	Dry season	Year
Alofi 1905-77	25	31	23

* rainfall variability (coefficient of variation) is defined as the ratio of the seasonal or annual standard deviation to its mean value.

The mean monthly and annual distributions of raindays are shown in Table 4 together with the maximum one-, two-, and three-day rainfalls. The rainday distribution ties in well with the seasonal distribution of rainfall.

Very heavy rainfalls are common. The highest one-day rainfall ever recorded was on 25 December 1930, when the passage of a cyclone in the vicinity of Niue brought 388 mm of rain.

Table 4. Mean monthly/annual raindays and maximum one-day, two-day and three-day rainfalls (mm), Alofi (1905-77)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Raindays 1.0mm or more												
15	15	17	13	10	8	9	9	9	9	10	12	136
Maximum one-day rainfall												
346	236	204	190	223	126	131	172	262	254	263	388	388
Maximum two-day rainfall												
422	301	356	245	254	131	199	186	325	265	267	422	422
Maximum three-day rainfall												
428	341	453	274	276	137	233	195	336	273	283	426	453

Depth-duration-frequency data have been calculated by Coulter and Hessell (1980) using the theory of extreme values. The 24-hour to 72-hour estimates of rainfall which may be expected to recur or be exceeded at two-, ten-, twenty- and fifty-year intervals are given in Table 5.

Table 5. 24-, 48-, 72-hour rainfalls (mm) with return periods of 2, 10, 20, 50 years, Alofi (1905-1980)

Years	2	10	20	50
24-hour	158	269	312	367
48-hour	194	317	364	425
72-hour	212	337	385	446

Drought. There are no surface water supplies on Niue, the freshwater supplies coming from a groundwater system, the only source of water for which is rainfall. Thus the island is very sensitive to dry conditions.

Dry spells, which may be defined as (a) periods of 15 days or more during which no rain falls or (b) periods of 15 days or more with less than 1 mm rain/day, are not unusual, as the following table shows:

Table 6. Frequencies of dry spells, Alofi (1905-1977)

Number of occasions	Longest period (days)	Average number per Year
(a) 57	29 (26 Aug-23 Sep 1919)	0.8
(b) 89	38 (19 Apr-26 May 1932)	1.2

Notes: (a) no rain for at least 15 days.
(b) not more than 1 mm/day for at least 15 days.

Very dry periods (i.e. no rain) commonly last for 15-17 days and there may be more than one such period a year. An extreme case occurred in 1969 when there were four very dry periods in the months from May - August. There was a total of 70 days with no rain during this time.

Water balance. A simple water balance may be calculated by assuming a fixed soil moisture capacity which is added to by rainfall and reduced by evaporation from the soil surface and transpiration by plants (collectively known as evapotranspiration). The model used makes several assumptions (Coulter, 1973):

1. Rainfall is added to the soil until field capacity is reached, after which the surplus becomes runoff.

2. The actual evapotranspiration is assumed to continue at the maximum rate so long as soil moisture is available.

3. If the available soil moisture is insufficient to meet the evaporative demand then the amount by which it falls short (i.e. the deficit) may be taken as a measure of the irrigation requirement.

The water balance may be commenced after either a very dry spell when the soil moisture store is empty or a wet spell when the soil is at field capacity.

A daily water balance summary for Alofi is given in Table 7. Penman potential evapotranspiration estimates for Alofi are based on sunshine hours estimated from the best information available.

It is interesting to note that deficits can occur in any month of the year, with September and October having the greatest frequency. The greatest annual (July - June) deficit for the period was 913 mm spread over 229 days during 1925/1926. Reports by the meteorological observer at the time stated that by February 1926 the dry period was beginning to show its effect on the island and by May rain was very badly required. The rain which fell in October 1926 was very welcome as the water supply was by then very low. In fact the monthly rainfall total for November 1926 was 522 mm, the highest November total on record to date.

Rainfall totals and deciles for consecutive months. The table following is derived from an analysis of rainfall totals for a consecutive number of months, and also identifies low rainfall periods:

Table 7. Daily water balance summary Alofi (1905-1977)
(Soil moisture capacity = 75 mm)

Averages	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
PE (mm)	162	147	146	119	106	90	99	116	130	146	154	162	1577
RR (mm)	269	258	306	194	124	82	103	104	103	133	143	202	2021
Years	67	67	67	66	65	65	63	63	64	64	65	67	
DE (mm)	19	17	7	5	13	20	25	35	46	47	42	40	316
ND (days)	5	4	2	2	5	8	9	11	13	11	10	9	89
RO (mm)	121	122	161	92	44	18	27	27	22	28	31	74	767
NR (days)	5	4	7	4	2	1	1	1	1	1	1	3	31

Frequency (percent) of months/years with water deficit (DE greater than zero)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	52	43	21	26	43	66	65	71	83	81	72	69	100

Frequency (percent) of months/years with water surplus (RO greater than zero)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	78	73	91	77	57	29	44	35	36	45	51	60	100

Frequency distribution of annual (July-June) totals of days with deficit (ND)

ND greater/equal than:	10	20	30	40	50	60	80	100
Frequency (percent)	100	98	86	81	74	69	47	34

Frequency distribution of annual (July-June) totals of days with evapotranspiration deficit (DE)

DE (mm) greater/equal than:	0.1	25	50	100	150	200	250	300
Frequency (percent)	100	100	100	86	78	72	57	47

where: PE = average potential evapotranspiration
RR = rainfall
DE = evapotranspiration deficit
RO = water surplus
ND = number of days with deficit
NR = number of days with surplus

Table 9. Rainfall deciles for consecutive months (mm) Alofi (1905-1977)

Number of months: 3

Month	Min	1	2	3	4	5	6	7	8	9	Max	Mean
Jan	311	459	568	612	725	781	906	988	1117	1262	1549	833
Feb	270	417	514	631	689	739	793	907	1004	1124	1228	758
Mar	277	382	412	468	531	582	663	775	824	931	1237	625
Apr	42	182	251	321	348	388	435	482	523	631	940	401
May	65	177	204	211	253	270	305	387	442	505	797	311
Jun	44	119	155	181	224	274	307	353	408	543	774	289
Jul	64	144	170	195	241	283	322	372	435	529	898	309
Aug	81	149	200	255	305	328	376	390	467	517	834	340
Sep	59	193	272	320	349	364	408	473	501	562	654	378
Oct	66	195	261	363	412	464	529	577	673	774	870	470
Nov	106	323	446	475	514	590	654	730	846	971	1301	617
Dec	132	387	500	537	610	681	808	889	971	1164	1325	731

Number of months: 6

Month	Min	1	2	3	4	5	6	7	8	9	Max	Mean
Jan	425	776	921	980	1126	1259	1322	1390	1559	1774	2065	1239
Feb	340	682	805	918	964	1074	1178	1257	1351	1461	1711	1074
Mar	322	561	660	746	807	870	933	1057	1177	1337	1596	917
Apr	134	447	499	566	620	668	744	843	915	1048	1399	718
May	245	403	475	514	556	595	692	768	871	996	1182	657
Jun	160	418	495	573	595	660	724	771	828	948	1361	673
Jul	168	467	568	673	734	814	846	912	974	1086	1469	789
Aug	264	607	728	822	898	986	1070	1156	1211	1308	1505	970
Sep	230	662	812	904	1030	1173	1254	1306	1446	1523	1947	1119
Oct	427	766	996	1119	1210	1326	1424	1481	1651	1818	2226	1316
Nov	441	891	1063	1149	1258	1333	1449	1594	1636	1995	2294	1381
Dec	430	865	1021	1134	1260	1329	1447	1548	1685	1934	2202	1365

Number of months: 12

Month	Min	1	2	3	4	5	6	7	8	9	Max	Mean
Jan	1066	1366	1645	1808	1855	1990	2127	2233	2488	2615	3185	2025
Feb	1133	1492	1776	1848	1974	2053	2113	2235	2397	2524	3073	2051
Mar	1100	1395	1675	1812	1986	2089	2163	2277	2489	2641	2951	2058
Apr	961	1522	1626	1857	1969	2136	2238	2327	2468	2600	2911	2062
May	890	1450	1642	1879	2014	2128	2190	2280	2457	2578	2968	2069
Jun	833	1496	1585	1853	2030	2122	2243	2333	2417	2577	3005	2069
Jul	830	1467	1519	1846	1987	2113	2178	2288	2436	2583	2945	2056
Aug	917	1453	1583	1823	2008	2077	2184	2295	2448	2665	2854	2056
Sep	805	1482	1604	1860	1947	2049	2157	2322	2395	2698	3079	2051
Oct	806	1483	1623	1765	1892	2018	2147	2284	2393	2739	3215	2039
Nov	851	1450	1636	1752	1836	1926	2105	2276	2488	2763	3252	2037
Dec	1133	1442	1555	1742	1932	1984	2085	2263	2410	2708	3387	2033

Table 8. Periods of lowest rainfall for consecutive months at Alofi (1905-1977)

No. of months	Lowest rainfall (mm)	Date from
1	2	June 1915
2	18	July 1976
3	42	April 1915
6	134	April 1915
12	805	Sept. 1925

The 12-month period from September 1925 to August 1926 is thus the driest 12-month period so far recorded at Alofi. This was also evident from the water balance calculations.

Rainfall deciles for consecutive months are a useful indication of the range of rainfall totals which may be expected. Those for three, six and twelve months are given in Table 9.

Frequency percent of n-days rainfall. The likelihood of specified amounts of rain falling in a given number of days has been calculated using daily rainfall records for Alofi. Table 10 gives the seasonal likelihood (frequency percentage) of number of days of rain occurring for various periods of days.

Table 10. Frequency percent of nil rainfall in n-days, Alofi (1905-1977)

n	Wet Season	Dry Season
1	53	67
2	36	51
3	26	39
5	13	23
7	7	14
10	3	7
14	1	3
30	0	0

Effect of the 1983 southern oscillation. The southern oscillation index (SOI) is a measure of the atmospheric pressure fluctuations occurring over the tropical Pacific and Indian Ocean regions. When pressures over the mid-Pacific are high, pressures are low over the Indian Ocean region and vice-versa. The pressure anomalies, which are also linked to ocean temperatures west of South America, are related to anomalies in rainfall in Peru and Chile.

A simple analysis was made of Alofi's rainfall and the SOI. Correlations were first determined for moving 5-monthly blocks of rainfall and SOI values. This did not reveal any significant trends.

A chi-square test was then performed by classifying the rainfall and SOI values into one of three categories; i.e. lowest third, middle third and top third of observations in each series. There was a definite non-randomness in the tables, only some of which being consistent with the idea that there is a direct association between rainfall and SOI. For although there was a strong tendency for below average SOI to be associated with below average rain, there was also a strong tendency for above average SOI to be associated with below average rain.

A more complex model may have revealed a stronger association.

The SOI during early 1983 was the lowest it had been for a 100 years, i.e. pressures were much lower than normal in the mid-Pacific. In this situation the southeast trade winds and equatorial easterlies weakened allowing the SPCZ to move to the northeast of its normal position.

The resulting effect on Niue's rainfall was very marked. The rainfall at Alofi for the months Jan-Apr 1983 was 180 mm, only 20 percent of what is expected for these months. In fact, the total rainfall for 1983 of 839 mm was much lower than the previous lowest yearly rainfall of 1066 mm recorded in 1931.

Temperature

The mean air temperature at Alofi varies from 26.6°C in February, to 22.9°C in July and August. Figure 12 shows the temperature regime for Alofi. It can be seen from the figure that the average daily range (mean of daily differences in maxima and minima) is almost constant at 7.3°C for all months. This is typical of the modifying influence of the sea on a small low lying island.

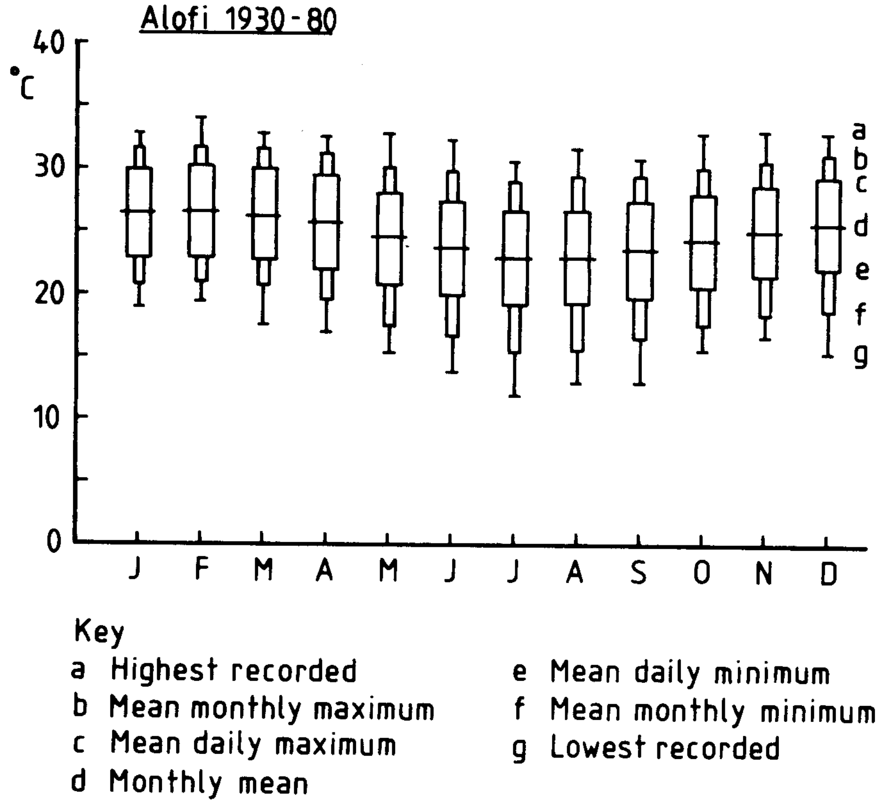

Fig. 12. Mean monthly temperature for Alofi

Sea surface temperatures

The mean monthly surface temperature of the sea in the vicinity of Niue ranges from approximately 24°C in the cooler months to 28°C in the warmer months (estimated by B.F. Taylor, C.S. Thompson, 1980). The annual cycle of sea surface temperature is consistent with the mean air temperatures as measured at Alofi, with the sea surface temperatures being generally 1-2°C warmer in all months.

Special phenomena

Thunder and hail. Thunder occurs most frequently during the months Dec - Apr and is reported on average eleven days a year. Lightning is occasionally severe, striking and damaging trees, while distant lightning may in some months be seen almost daily. Hail is extremely rare.

Relative humidity. The relative humidity provides a measure of the moisture content of the atmosphere.

The average monthly relative humidity at 7.20 a.m. varies from 85 percent to 90 percent throughout the year. The variation is greater during the day with the relative humidity being some 10 percent lower in the early afternoon compared with the morning.

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APPENDIX

Climate summary at Alofi, Niue Island

Rainfall (mm)

Period	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Year
					Highest Monthly/Annual Total								
1905-77	728	629	785	571	469	277	405	494	361	367	522	590	3184
					90 Percentile Value								
1905-77	546	499	522	375	235	174	210	199	238	247	255	445	2615
					Mean 10 Percentile Value								
1905-77	269	258	306	194	124	83	100	101	103	129	140	201	2009
1905-77	75	73	136	59	31	19	15	15	28	42	42	55	1403
					Lowest Monthly/Annual Total								
1905-77	23	30	25	9	8	2	5	10	15	5	4	22	1066
					Average Rain Days 1.0mm or more								
1905-77	15	15	17	13	10	8	9	9	9	9	10	12	136
					Maximum 1-Day Rainfall								
	346	236	204	190	223	126	131	172	262	254	263	388	388
					Maximum 2-Day Rainfall								
	422	301	356	245	254	131	199	186	325	265	267	422	422

Air Temperature (°C)

Period	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Year
					Highest Recorded								
1946-80	32.8	34.0	32.8	32.5	32.8	32.3	30.6	31.6	30.8	32.8	33.0	32.8	34.0
					Average Monthly/Annual Maximum								
1946-80	31.6	31.7	31.6	31.2	30.1	29.8	29.0	29.3	29.3	29.9	30.6	31.1	32.3
					Average Daily Maximum								
1930-80	29.9	30.2	30.0	29.4	28.1	27.3	26.6	26.7	27.3	27.9	28.5	29.2	28.4
					Mean Average Daily Range								
1930-80	26.4	26.6	26.3	25.7	24.5	23.7	22.9	22.9	23.5	24.2	24.9	25.6	24.8
1930-80	7.1	7.2	7.2	7.4	7.3	7.3	7.4	7.5	7.6	7.3	7.2	7.2	7.3
					Average Daily Minimum								
1930-80	22.8	23.0	22.8	22.0	20.8	20.0	19.2	19.2	19.7	20.6	21.3	22.0	21.1
					Average Monthly/Annual Minimum								
1946-80	20.8	21.0	20.8	19.6	17.5	16.8	15.3	15.8	16.5	17.5	18.3	18.8	14.7
					Lowest Recorded								
1946-80	19.0	19.4	17.5	17.0	15.3	13.9	12.0	12.9	13.1	15.5	16.6	15.2	12.0

				Average Relative Humidity (percent) Average at 7.20 a.m.									
1928-70	88	89	90	90	88	88	87	88	87	85	85	86	88
					Special Phenomena								
					Average Days of Gale								
1905-42	0.3	0.2	0.2	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	1.0
					Fog								
1905-42	2	0	2	1	1	2	0	1	2	2	1	1	15
					Thunder								
1907-70	1.5	1.5	1.7	1.1	0.8	0.3	0.3	0.5	0.4	0.7	0.9	1.2	10.9

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