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NEW ZEALAND METEOROLOGICAL SERVICE

TECHNICAL NOTE 194

SOME SYNOPTIC ASPECTS OF DROUGHT IN NEW ZEALAND IN THE SUMMER 1969-70

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Issued for limited distribution by:

The Director
New Zealand Meteorological Service
P.O. Box 722
WELLINGTON.

30 April, 1971

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SOME SYNOPTIC ASPECTS OF DROUGHT IN NEW ZEALAND IN THE SUMMER 1969-70

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Abstract

The summer 1969-70 in New Zealand was very dry for quite long periods over large parts of the country and drought became of economic significance. The synoptic aspects of two of the long dry periods affecting much of the country are examined. One was a very persistent anticyclonic spell in November 1969. The other was an equally significant dry period, over much of the North Island and the east of the South Island in a westerly regime with the disturbances separating migratory anticyclone cells being predominantly frontolytic. It gave little significant rain except in some western South Island areas and lasted much of January 1970. Vertical sections of the dew-point depression over the North Island are presented in both cases showing in general that little precipitable moisture was available and that the probability of any alleviation of the drought by artificial inducement of rain was low.

Introduction

The summer of 1969-70 was generally dry over much of New Zealand. In some areas the situation was aggravated by below normal rainfalls in some preceding months. Quite long dry spells arise from time to time in New Zealand because of large, slow moving, deep warm-type anticyclones stagnating over New Zealand and the adjacent seas. Typical blocking highs in which there is either a near concentric anticyclonic circulation in great depth or in which the upper tropospheric flow bifurcates widely about the extremities of the sea-level system leaving slack gradients aloft are not uncommon. They permit four-day forecasts of dry weather for harvesting to be made with fairly high confidence. Long persistence of this type of regime results in drought over large areas. The period in November 1969 was of this type.

Another typical weather regime between 35°S and 45°S is the disturbed westerly pattern. In this case depressions move approximately west to east in the latitudes south of New Zealand and the associated frontal systems pass

eastwards across the country. They are separated by moving anticyclone cells which do not have the same vertical extent as the stagnating and usually larger warm-type anticyclones. In view of the orography of New Zealand, with its mountain barriers lying SW - NE through both islands, even fairly active systems may, because of the orographic sheltering, produce little rain in eastern areas except in the far south of the South Island. The exception to this arises when the associated pressure trough has enough amplitude for the wind to be sufficiently southerly to blow onshore on the NE - SW oriented eastern coasts. It is, however, evident that there are often occasions in the summer months when that part of a front passing over New Zealand is far removed from its associated depression, the latter being well to the south of the country. Under these circumstances the air ascending in the frontal zone may often have had a very recent history of subsidence in the adjacent anticyclone. It would be so dry that the vertical motion could not produce any significant rain even in areas west of the ranges. The dry spell of January 1970 was due to this type of situation.

Times used throughout this paper are N.Z.S.T.

The November 1969 dry spell

The first three weeks of November 1969 were dry over much of New Zealand. The very persistent anticyclonic regime occurring is clearly demonstrated in Fig. 1, showing the position of the 1020mb isobar on the sea-level maps for midday each day from 1 to 20 November. Much of New Zealand was within the 1020mb isobar for the whole period. The persistence of the location of the northern, western and southern perimeter of the anticyclone is also clearly indicated by the similarity of the daily positions of this isobar. To the east of New Zealand there was a much greater variability in the position of the isobar representing the occasional extension eastward of a lobe of the anticyclone. It is evident from this diagram that the day to day sea-level maps through the period were all very similar to the mean pressure field.

The flow pattern in mid troposphere for the period 1 to 20 November is shown in Fig. 2 where the 5700m contours in the 500mb surface for midday each day have been drawn on the one map. It will be seen that with little exception there was throughout the period an upper level ridge over the eastern Tasman Sea - New Zealand area while troughs persisted over eastern Australia and to the east of New Zealand. The trough-ridge-trough system was almost stationary through the whole period and the ridge aloft was accompanied by the persistent anticyclone over the New Zealand area at sea

level. A typical daily map with the 500mb field superimposed on the sea level pressure field is shown in Fig. 3 for 8 November 1969. Subsequently the sea-level depression near Tasmania moved SSE into the area far southwest of New Zealand with the regime over the country remaining anticyclonic. As will be evident from the persistence of the sea-level anticyclone and associated upper-level ridge shown by Figs 1 and 2 other individual daily maps had similar characteristics during this November dry spell.

The vertical distribution of moisture

Upper air soundings were available from Auckland, Christchurch and Invercargill at 0000 N.Z.S.T. and 1200 N.Z.S.T. During this dry November period there was little rain in the North Island or in the South Island except in the southwest and far south. The Auckland station has been chosen to represent the humidity state in the anticyclonic regime rather than Christchurch since for most of the time the anticyclone centre was north of Christchurch with a northwesterly airstream about its southern edge flowing onto the South Island. Under these conditions significant fohn effects would be present in air arriving over Christchurch. In the case of the Auckland soundings no such orographic modification was to be expected and they should therefore be representative of the air over the country.

From the soundings a time section of the dew-point depression, i.e., dry bulb temperature minus dew-point, was constructed for the whole dry period 1 to 22 November 1969. Part of this, which is very similar to the whole, is shown in Fig. 4. It will be seen that for most of the time except in a fairly shallow layer about 1.5 km deep near the ground, the dew-point depression was more than 15°C in a deep layer up to at least the 500mb level (about 5.5km). This was the upper limit of the humidity data on most occasions.

The time section also contains the upper wind observations up to the 200mb level (about 12km) for Ohakea. (During the period under review the radar wind measurements from the Auckland station were unfortunately irregular owing to equipment failures.) These winds with their predominantly southerly component demonstrate the presence of an upper-level ridge to the west of the country.

Under the time section are shown the rainfalls for three North Island stations, Auckland, New Plymouth and Rotorua. The amounts are for the six hour period ending at the time for which they are plotted and were quite negligible at all stations.

On most occasions the rapid decrease in the available moisture above the lowest 1.5 km coincided fairly closely with increasing thermal stability of the sounding which would have restricted convective development. Any cloud developing would have rapidly dissipated by evaporation into the very dry environment.

The freezing level over Auckland is also shown on the time section. It will be seen that it lay well within the dry air after the first 12 hours. The probability of having cloud development above the freezing level was therefore generally very small.

The prospects of artificial cloud modification to initiate precipitation would be very poor. There would not only be a general absence of clouds tall enough and cold enough to be worth seeding, but any isolated cloud pillar, if made to grow would also rapidly dissipate by evaporation into the surrounding air. Under such deep, persistent anticyclonic conditions with very dry well-subsided air, the probability of even local enhancement of rainfall would seem to be quite negligible. The moisture was not there to be precipitated.

The dry spell 11 to 31 January 1970

Unlike the November dry period, this spell which was a part of a still longer dry period in many areas, was not characterised by a persistent anticyclonic regime in which the maps at sea level or aloft were essentially similar from day to day. In this January period the anticyclone cells were migratory. Fig. 5 clearly demonstrates no pattern in the position of the chosen isobar (1015mb) unlike the configuration in Fig. 1. The dissimilarity in the mid-tropospheric patterns is also shown in a comparison of Figs 6 and 2. Fig. 6 which gives the daily positions of the 5700m contour in the 500mb surface for 11 - 31 January 1970 presents a picture of migratory trough-ridge systems. If in Fig. 6, two of the contours over and east of New Zealand are disregarded, the envelope of the remaining contours shows a predominantly WNW - ESE trend. The troughs either have less amplitude or do not extend into such low latitudes as they pass from southeast Australia to the New Zealand area. This trend was associated with a southeastward movement of the accompanying sea-level systems and with loss of activity as they passed into the New Zealand area.

The disturbance of 14 - 15 January 1970

A typical transitory and minor break in the January dry spell occurred 14 - 15 January and is shown in Figs 7(a), (b) and (c) in which the 500mb contours are

superimposed on the sea-level pressure field. On 14 January the sea-level frontal trough was moving eastwards over the North Island with the associated trough in the 500mb constant pressure surface lying NW - SE over the Tasman Sea. By 15 January the sea-level system had moved eastwards off the country and the 500mb trough had crossed much of New Zealand having apparently appreciably decreased in amplitude. This disturbance produced less than 12mm of rain at New Plymouth, a windward coast normally giving orographic enhancement of the rain, and at Auckland about 6mm and only half of this amount at Rotorua. By the following day 16 January, (Fig. 7c) another anticyclone on the western side of the trough had moved onto the eastern Tasman Sea and was spreading onto New Zealand accompanied by another long rainless period in most places. Under these conditions the trivial amount of rain which did accompany the trough passage would have little if any agricultural significance most of it being quickly lost again in evaporation.

Vertical distribution of moisture during the January dry spell

A vertical section of the dew-point depression over Auckland for the period 11 to 22 January 1970 is shown in Fig. 8, which also contains the upper winds for Auckland at 12-hour intervals and the Auckland freezing level. Below the section are shown the six-hourly rainfalls for three North Island stations, Auckland, New Plymouth and Rotorua, in mm.

There was a large moisture deficit through a deep layer of the troposphere and for much of the period the dew-point depression was up to 20°C above 1 to 2 km. A brief break in this extreme dryness occurred on 14 January when the dew-point depression fell below 5°C up to about the 600mb level, (4km) during the passage of a trough. This is seen in the shift of the winds from nearly westerly to southerly through a deep layer between 0000NZST and 1200NZST 15 January. It was very soon followed by the very dry regime of the succeeding anticyclone.

Another similar disturbance is to be seen on 19 January when another trough, apparently of fairly small amplitude judging by the size of the wind shift over Auckland, gave some brief rain. This, however, amounted to about only 17.0mm at New Plymouth and 2.5mm at Auckland with no rain at Rotorua. Another period with a very large moisture deficit through most of the troposphere immediately followed.

Throughout the January dry spell the freezing level over Auckland was mainly near the 600mb level (approaching 4km) and, as in the dry November spell lay well within the

very dry, deep layer. Thus when there was no rain from natural causes, i.e., with the weak trough passages between succeeding anticyclone cells the prospect of artificially initiating any rain must have been quite negligible.

Discussion

Significant long dry spells making up a dry summer arise from more than one sort of circulation pattern in a middle latitude region such as New Zealand. The persistent blocking-type anticyclonic regime is commonly associated with such spells and although New Zealand lies in a vast oceanic area, the large scale field of vertical motion is such that, except for a shallow layer near the ground, the air can be very dry in great depth. The amount of moisture available for precipitation is very small. Under these circumstances rain from natural causes is near negligible and there is no sound reason to believe that there is any possibility of inducing rainfall artificially.

In many circumstances in the summer, even when there is no persistent anticyclonic regime but a mobile westerly type, continuing dry weather often prevails except where the orographic effects are very marked on the windward slopes of the higher mountains in the South Island. In these cases the depression centres move east or southeast, far to the south of the country and the accompanying troughs passing over New Zealand move into an area in which the flow is predominantly anticyclonic and there is descending air motion.

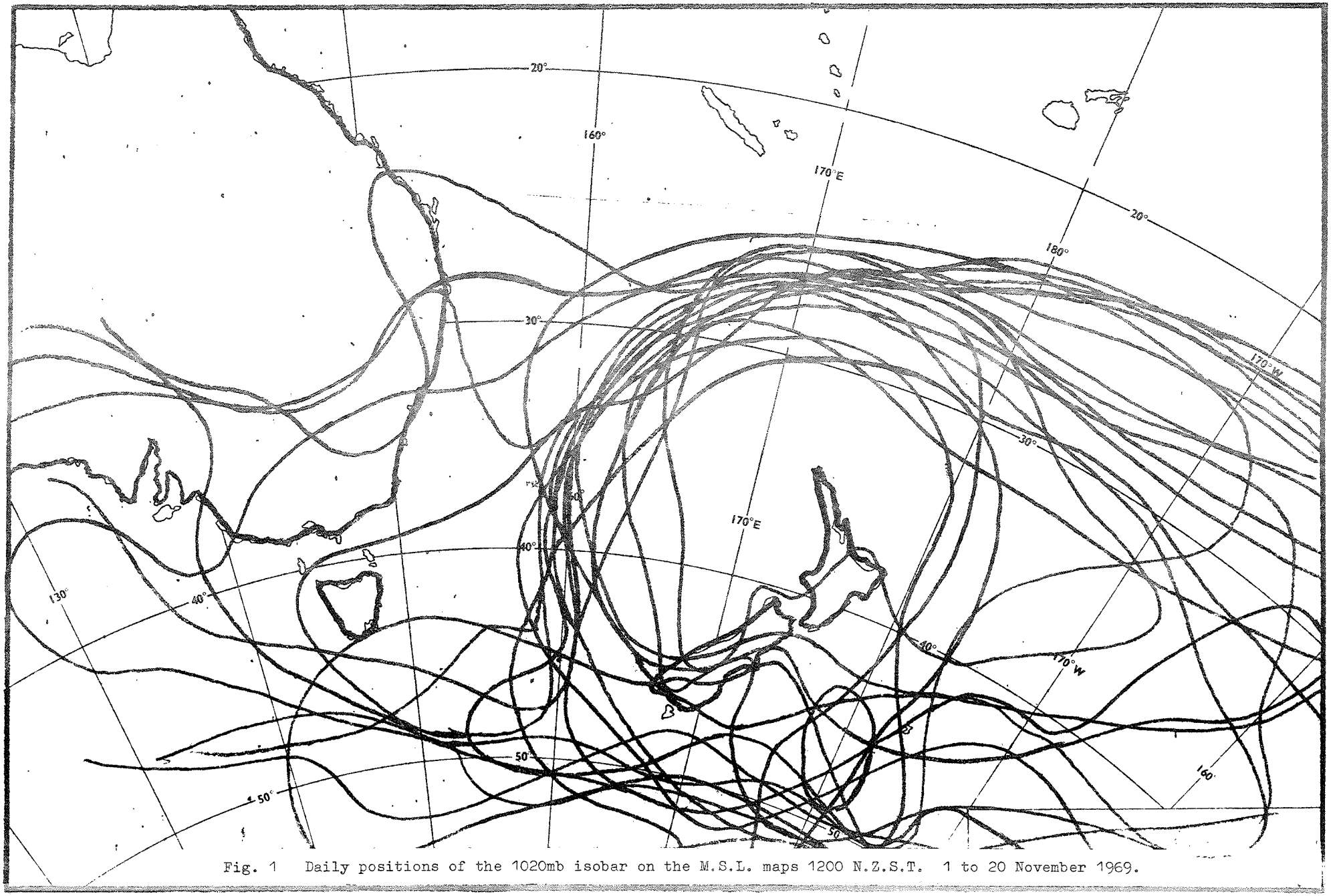


Fig. 1 Daily positions of the 1020mb isobar on the M.S.L. maps 1200 N.Z.S.T. 1 to 20 November 1969.

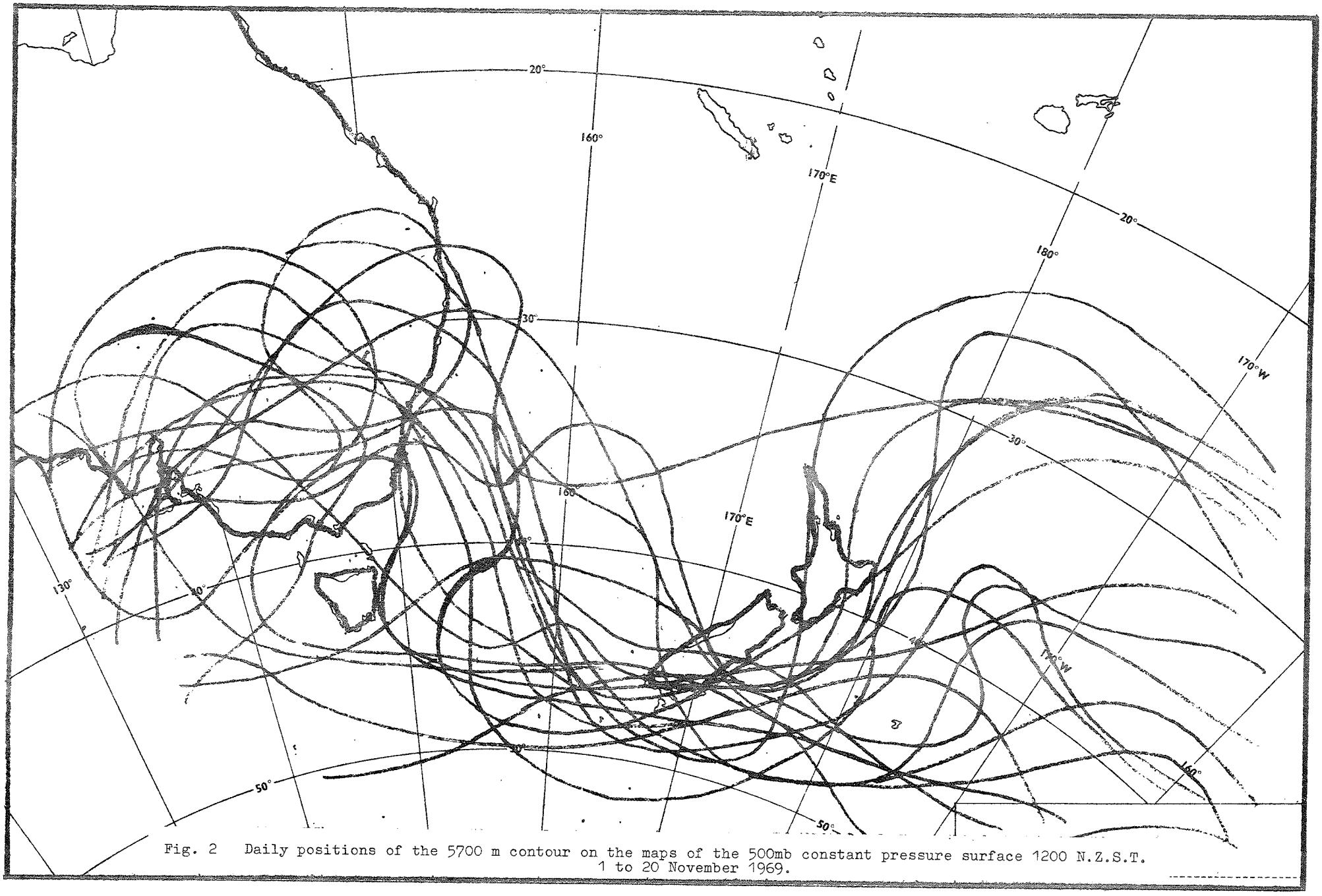


Fig. 2 Daily positions of the 5700 m contour on the maps of the 500mb constant pressure surface 1200 N.Z.S.T. 1 to 20 November 1969.

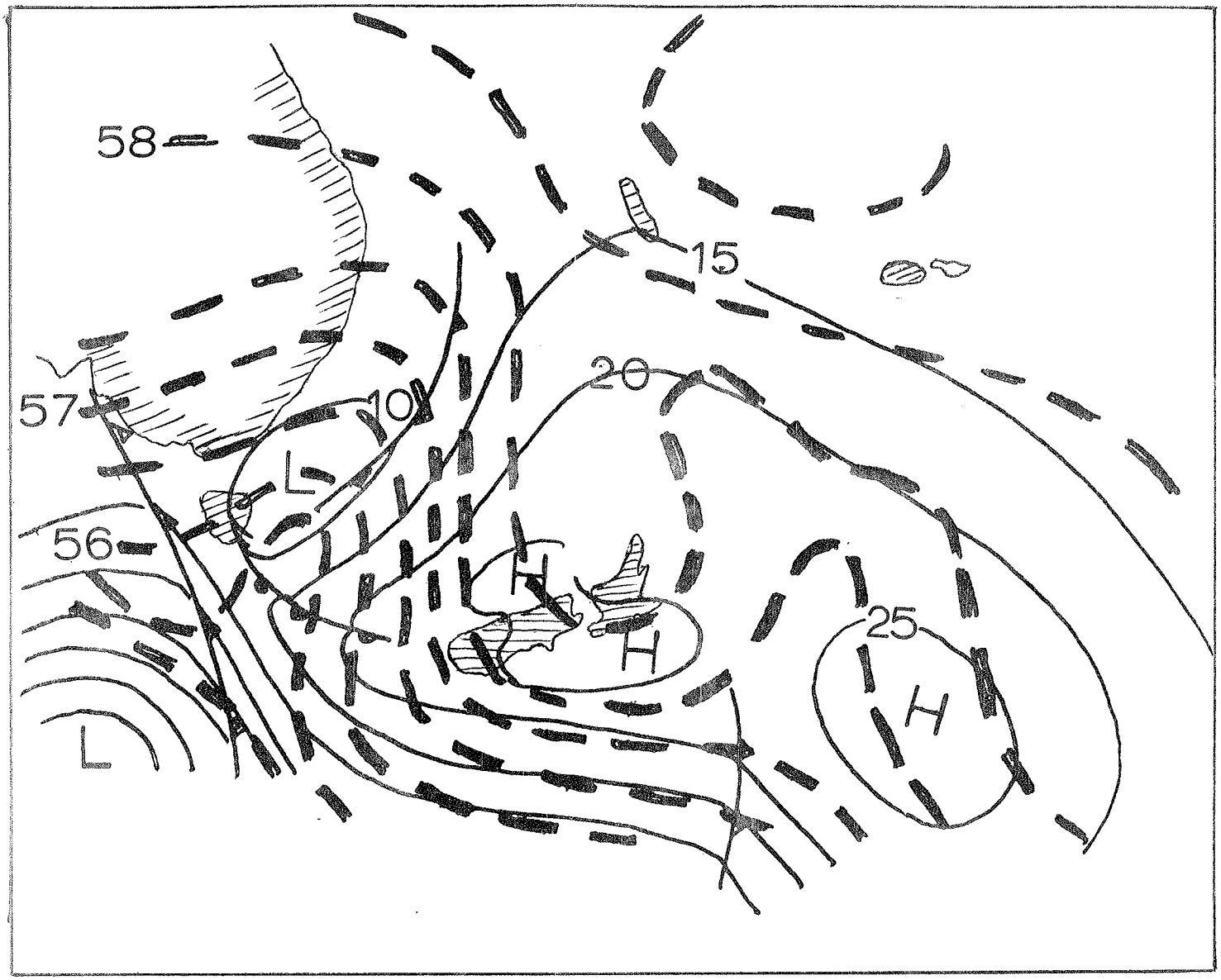
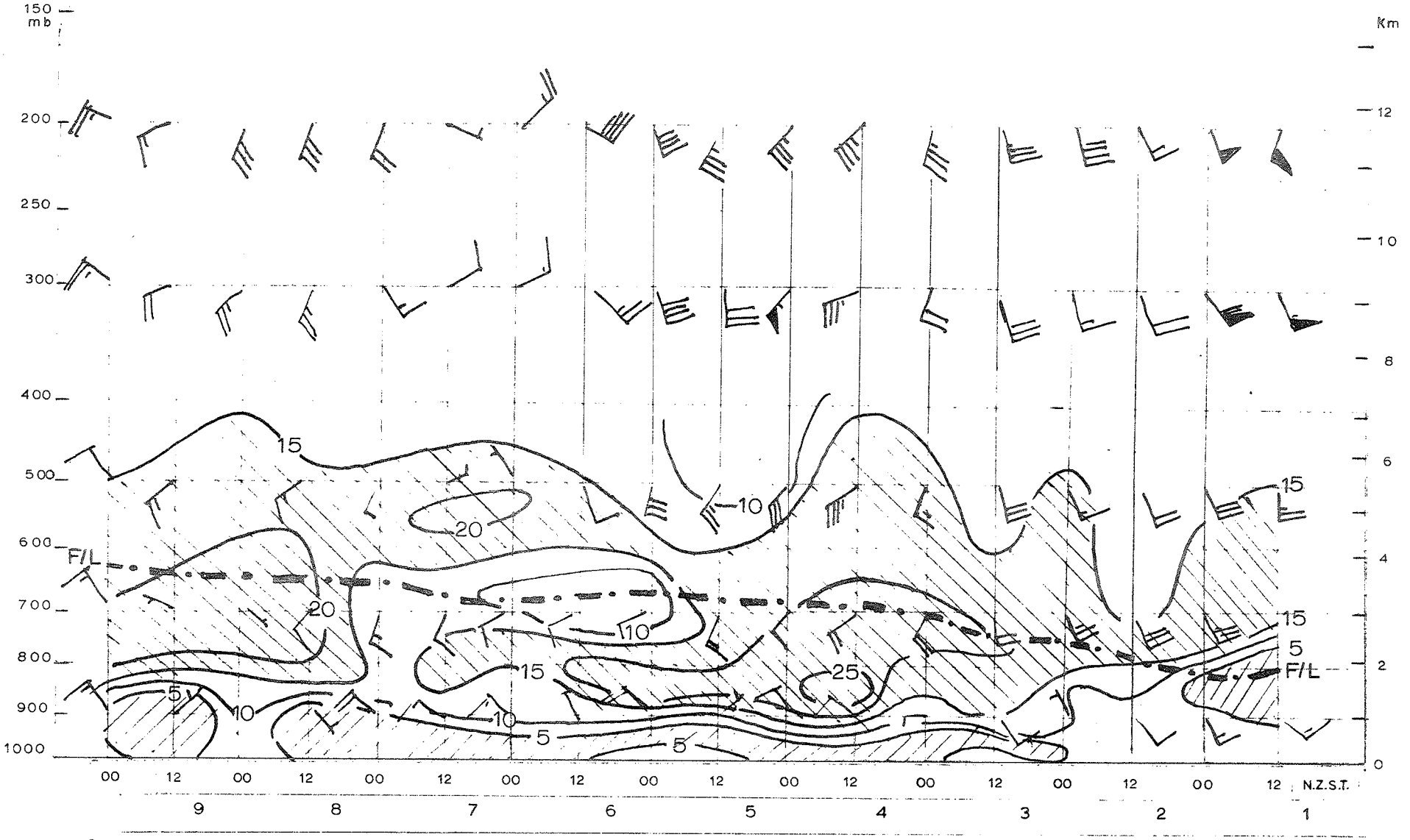


Fig. 3 The 1200 N.Z.S.T. M.S.L. chart with 500mb field superimposed for 1200 N.Z.S.T. 8 November 1969.

Legend:
M.S.L. Isobars - solid lines
500mb contours - dashed lines



6 HOURLY RAINFALL (mm)

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	AUCKLAND
0	0	0	0	0	0	0	0	0	T	0	0	0	0·5	T	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N.PLYMOUTH
0	0	0·5	0	0	0	0	0	0	0	0	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	ROTORUA

Fig. 4 Time section of depression of dew-point (°C) over Auckland during part of November 1969.
(Upper winds used for this period are Ohakea observations)

Legend:
Isopleths of dew-point depression:
Region with depression in excess of 15°C:
Relatively moist regions:
Freezing level:

Winds for given levels shown by convention:
arrows pointing downwards-Northerly, pointing from right to left Easterly and so on. Single barb = 10 kt, Triangle = 50 kt

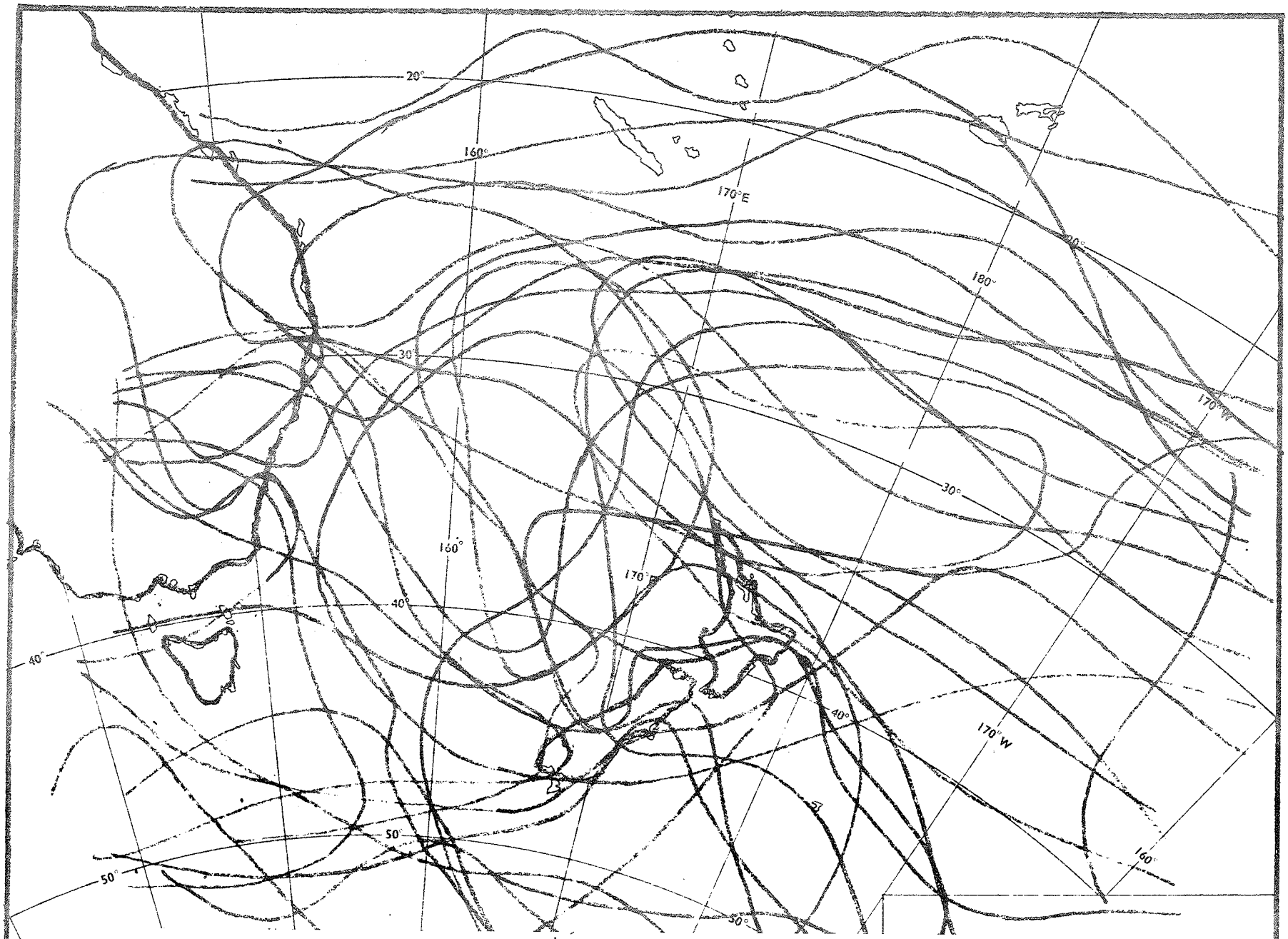


Fig. 5 Daily positions of 1015mb isobar on the 1200 N.Z.S.T. M.S.L. maps 11 to 31 January 1970.

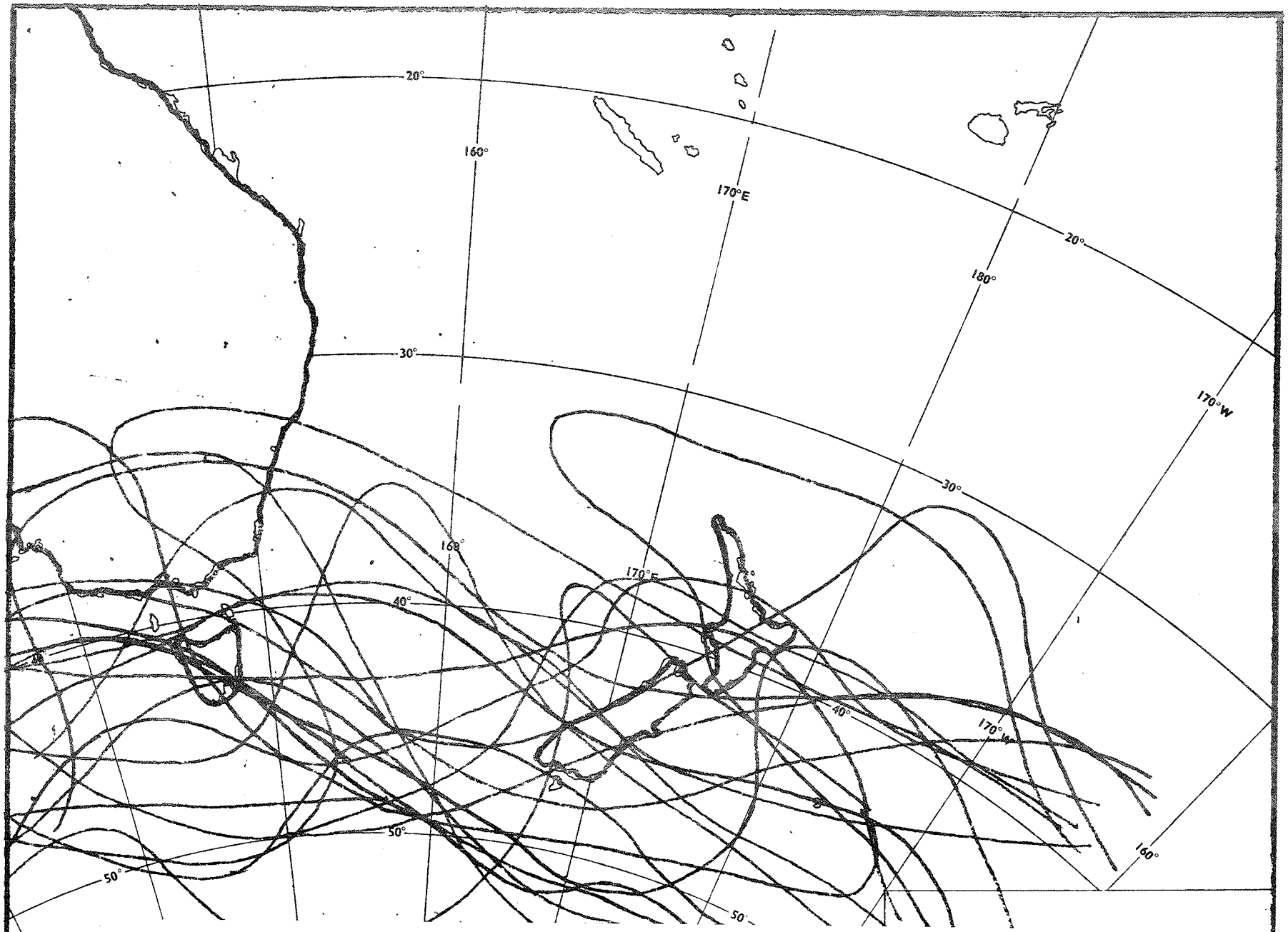
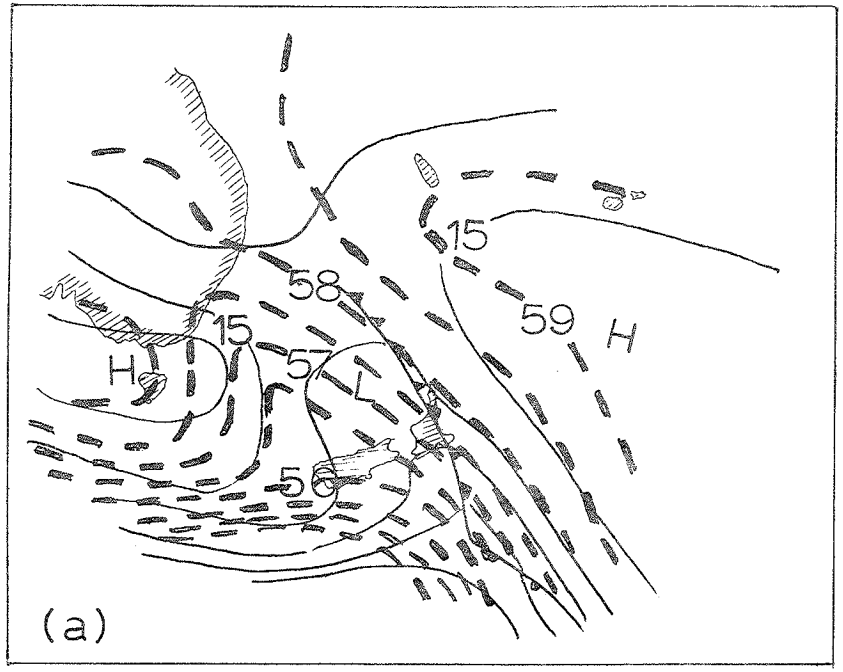
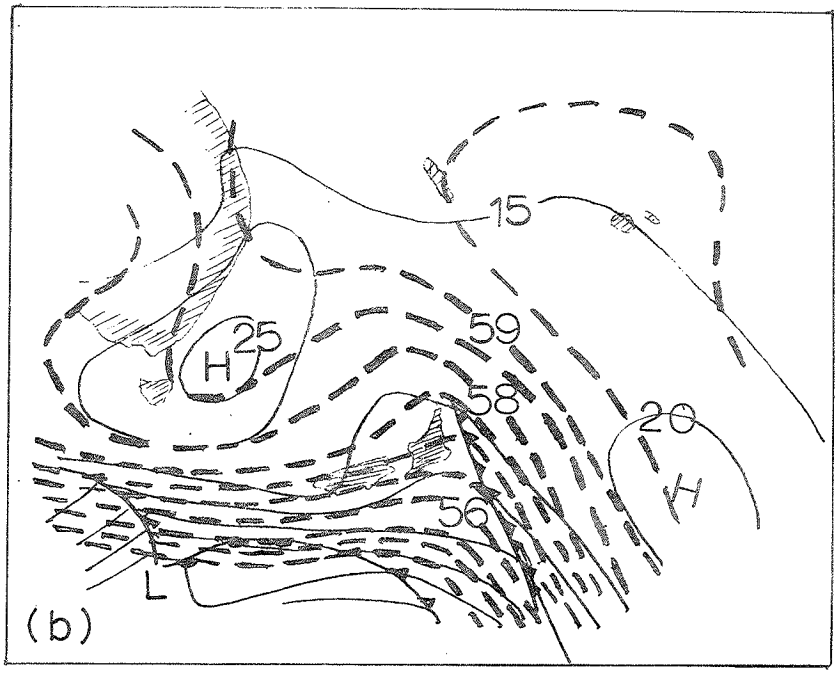


Fig. 6 Daily positions of the 5700 m contour on maps of the 500mb constant pressure surface 1200 N.Z.S.T. 11 to 31 January 1970.





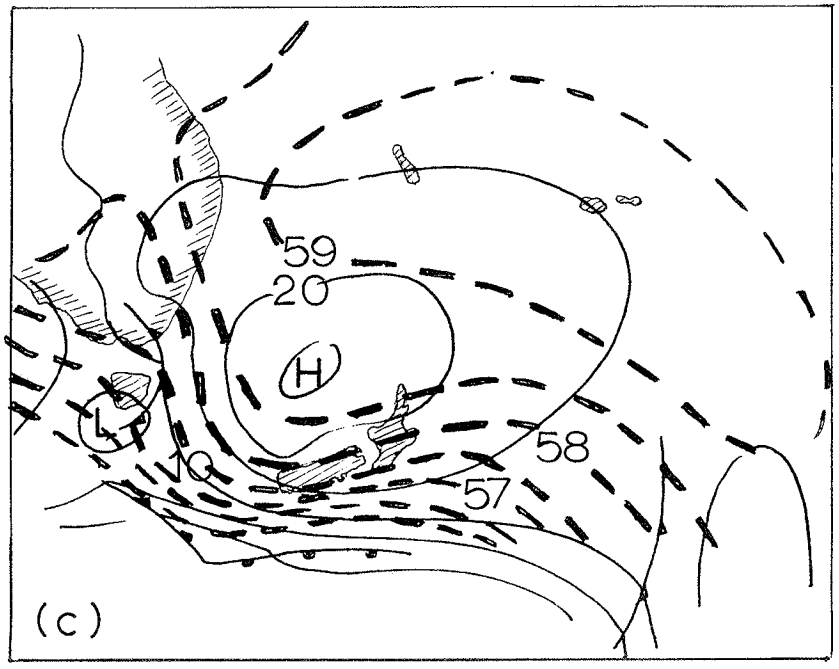


Fig. 7 (a) M.S.L. chart with 500mb field superimposed for 1200 N.Z.S.T. 14 January 1970.

(b) M.S.L. chart with 500mb field superimposed for 15 January 1970.

(c) M.S.L. chart with 500mb field superimposed for 16 January 1970. Legend in each case as in Fig. 3.

Fig. 8 Time section of depression of dew-point (°C) over Auckland 11 to 22 January 1970.
Legend as in Fig. 4. (Auckland Upper Winds used.)