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A case study of meso-scale rainfall variations in northern New Zealand

C.G. Revell

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Abstract

The distribution of rainfall associated with some summertime weak disturbances in northern New Zealand was found to have a sub-synoptic scale of organization. This organization is due to diurnal and topographic effects similar to those encountered in tropical regions.

Introduction

Very few studies have been made in New Zealand of the meso-scale variations of rainfall with time and distance, though such variations are of importance in local forecasting. Observation indicates that certain recurrent diurnal and spatial patterns are associated with typical weather situations.

The space and time distributions of rainfall in the North Island, north of a line from Opotiki in the east to the ranges south of Taupo to Ohura in the west were studied for the 36 hours from 0900 NZST 28 December 1966 to 2100 NZST 29 December 1966. During this time a weak circulation centre passed over the North Island moving eastnortheast.

Data

The data were extracted from returns from climatological stations, routine synoptic reports, charts from all automatic raingauges in the region and analysed sea-level maps (3-hourly). In addition a record was kept of visual observations made at Pukekohe from where large cumulonimbus cloud can be seen at distances exceeding 100 miles in most directions.

Analysis Procedure

The 36 hour period was divided into 3-hour intervals for which the occurrence or non-occurrence of rain was mapped for each raingauge site and for each locality from which a reliable report was available. The main stations are shown in Fig. 1.

For each interval the region was then divided into areas having the same distinctive weather character. These are shown chronologically in Figs 2(1) - 2(12) in which explanatory notes on the rainfall distribution and tendency have been added.

The low level wind flow at the beginning of each 3-hour period is given as is also the 500 mb wind flow at 0000 NZST and 1200 NZST. The flow at 500 mb is also given separately in Fig. 3. Well defined trough lines at the surface are marked in the figures. The location of the vorticity centre at 1200 NZST 29 December was confirmed by a satellite photograph of a spiral cloud pattern over the North Island.

Total rainfall in the 36 hour period ranged from less than 0.1 in. in most parts of Northland to as much as 1-2 in. in the King Country-Taupo-Rotorua area.

Discussion

On 28 December a weak cold front crossed the region giving scattered drizzle in western areas before 0900 NZST. The area later affected by showers lay under the cyclonic shear zone of the 500 mb flow (Fig. 3a). This area expanded during the afternoon while windward-facing coasts remained free of precipitation (Figs 2(1), 2(2)). Towards evening, showers spread from the west (Figs 2(3), 2(4)) with cumulonimbus present over the sea.

During the night a shallow trough separating winds from easterly and westerly quarters reached the centre of the North Island with an accompanying area of heavy rain (Figs 2(5), 2(6)). Early on 29 December thundery showers appeared in association with this trough and also with a minor wind shift in the westerly flow (Figs 2(6) - 2(9)). This wind shift subsequently became unidentifiable as a weak cyclonic circulation developed over the region (Figs 2(10), 2(11)). Eastward progress of the thundery trough also could not be followed synoptically by simple extrapolation nor was the propagation of thunderstorms compatible with that of the 500mb low (Fig. 3b).

In the early afternoon (Fig. 2 (10) showers died out in most parts of the region but later a widespread outbreak of thundery rain covered the Bay of Plenty and parts of Waikato and Taupo districts. The areas to the north and west again remained completely free of rain (Fig. 2(11)), irrespective of their position relative to the wind flow. Finally the circulation system moved eastward in the evening while light showers again developed in the windward coastal areas (Fig. 2(12)).

Notable features of the rainfall distribution on both days were:

(1) The growth of shower areas over the eastern Waikato and Bay of Plenty districts in the afternoon hours with apparent retardation of the trough-precipitation system.

(2) Afternoon suppression of showers to the north and west where night and morning maxima occurred.

This can be seen from a comparison of Fig. 2 (2) with Figs 2(4) and 2(5) and also of Fig. 2(8) with Figs 2(10) - 2(12).

These effects were superimposed on the basic rainfall pattern of maximum intensity in the immediate vicinity of troughs. The horizontal curvature and shear of the wind flow in the middle and upper troposphere (Figs 3a,b,c) also exerted a modifying influence, shower intensity being enhanced in regions of greater cyclonic relative vorticity.

Similar variations are often observed when a showery airstream flows over land even in the absence of a synoptic disturbance, although the pattern may vary from the above according to differences in terrain.

While the field of vertical motion in the atmosphere is basically controlled by large-scale systems there is much evidence, as exemplified by this case study, that land-induced circulations arising in part from friction and heating have an important modifying effect. Since this investigation was carried out, results presented by Ryan (1968) of a radar data study confirm the existence of this effect.

Conclusions

The above case study illustrates the following general principles.

1. Organised synoptic systems are modified by diurnal and terrain effects in such a way that inland areas tend to experience a precipitation maximum in the afternoon hours with a corresponding suppression in surrounding coastal areas.

2. The modifications are most apparent with the weaker synoptic systems.

3. Windward coasts have a maximum shower frequency in the night and morning hours whether or not disturbances are present.

In the above ways rainfall variations in northern New Zealand are comparable with those long known to prevail in tropical oceanic regions.

Reference

Ryan, A.P., 1968: A three-year radar climatology for Ohakea. Unpublished, Presented at N.Z. Met. S. Annual Conference.

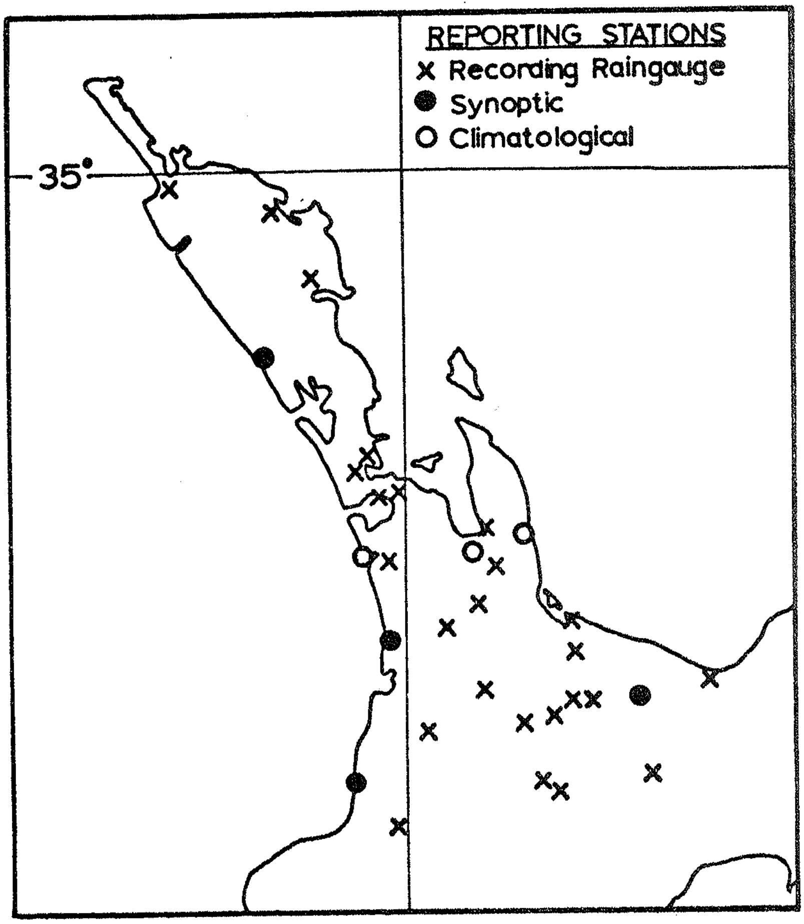
REPORTING STATIONS
x Recording Raingauge
● Synoptic
O Climatological
35°

FIG. 1

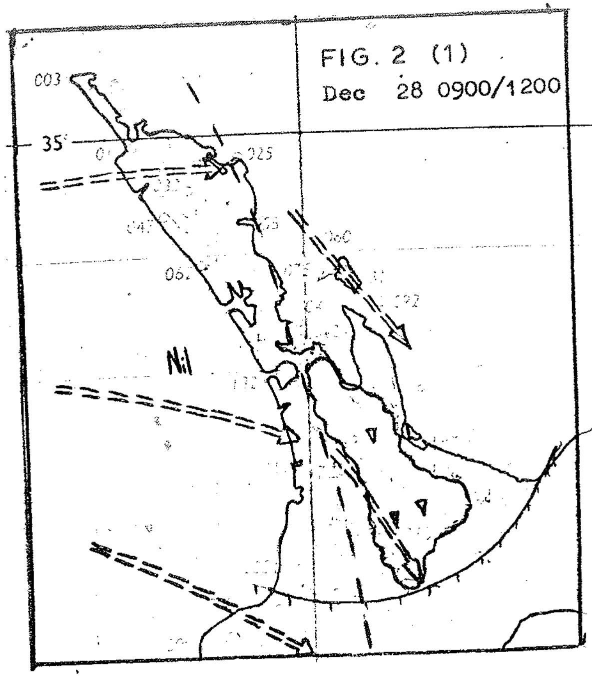
FIG. 2 (1)
Dec 28 0900/1200
Nil

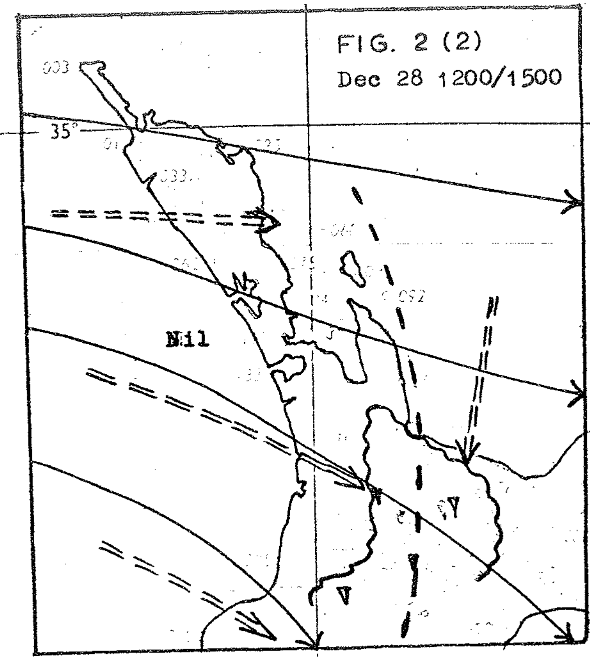
FIG. 2 (2)
Dec 28 1200/1500
Nil

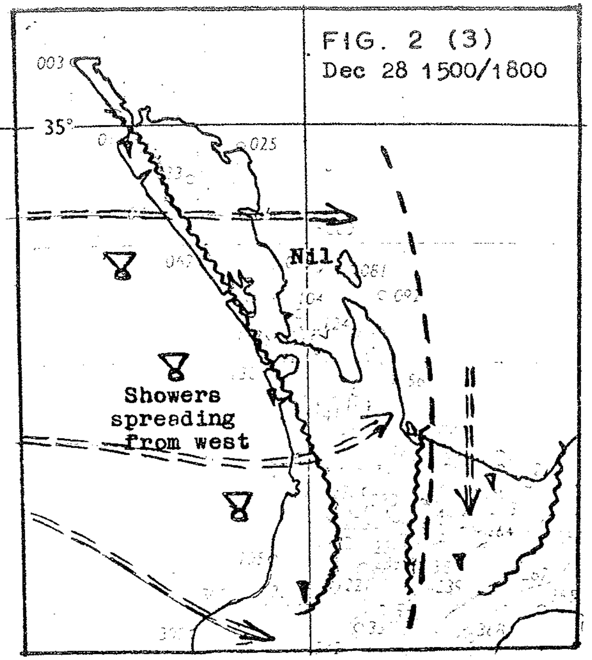
FIG. 2 (3)
Dec 28 1500/1800
Nil
Showers
spreading
from west

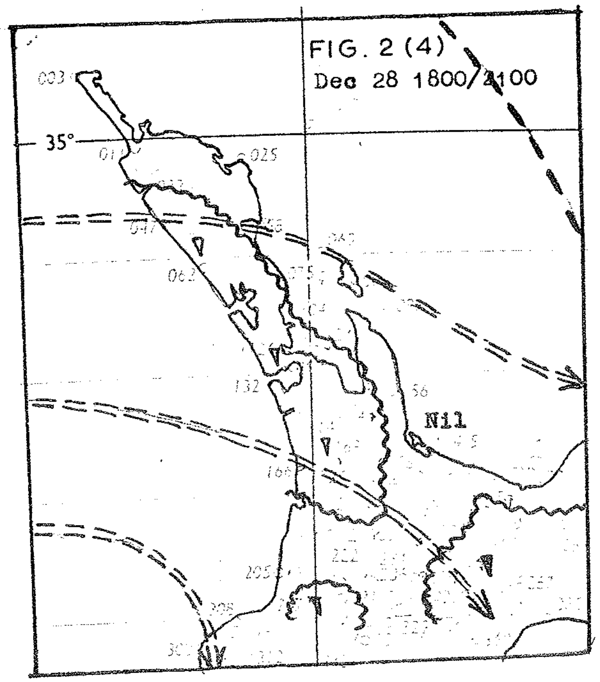
FIG. 2 (4)
Dec 28 1800/2100
Nil

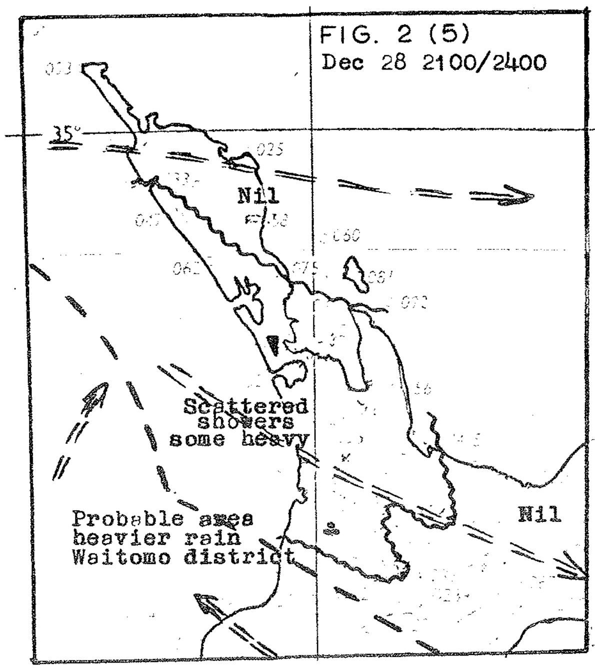
FIG. 2 (5)
Dec 28 2100/2400
Nil
Scattered
showers
some heavy
Probable area
heavier rain
Waitomo district
Nil

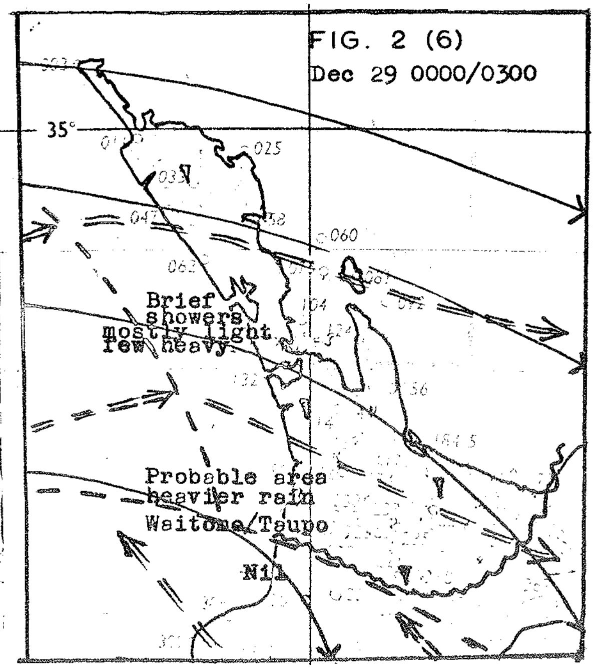
FIG. 2 (6)
Dec 29 0000/0300
Brief
showers
mostly light
few heavy
Probable area
heavier rain
Waitomo/Taupo
Nil

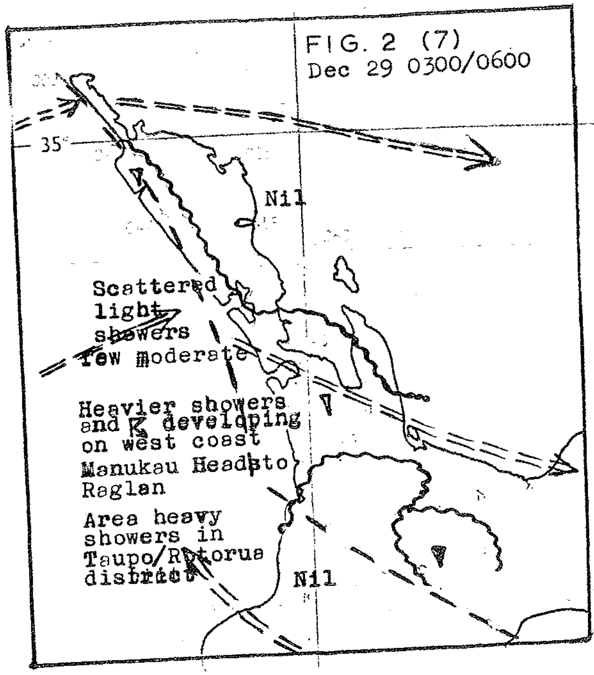

FIG. 2 (7)
Dec 29 0300/0600

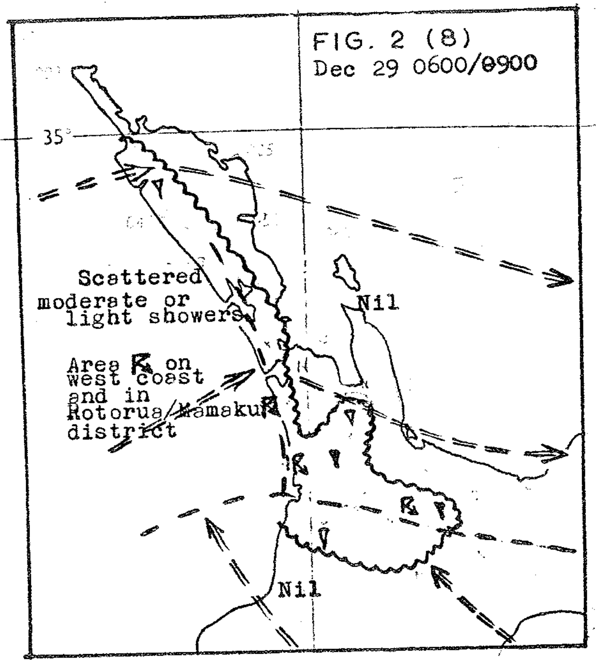

FIG. 2 (8)
Dec 29 0600/0900

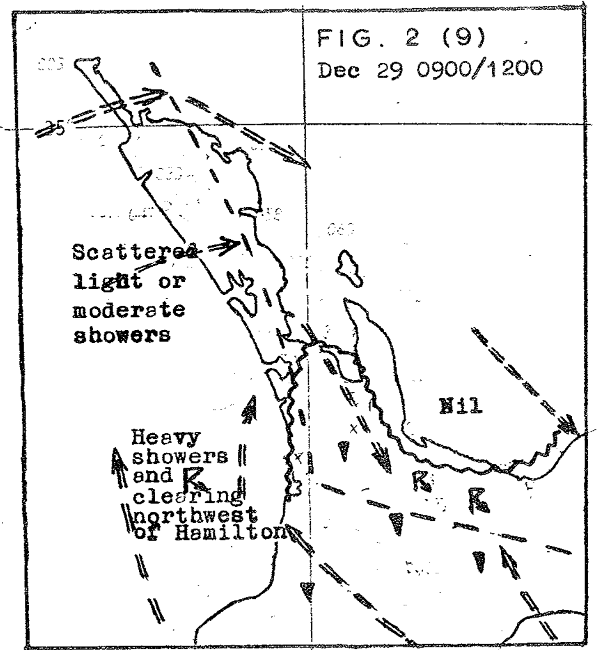

FIG. 2 (9)
Dec 29 0900/1200

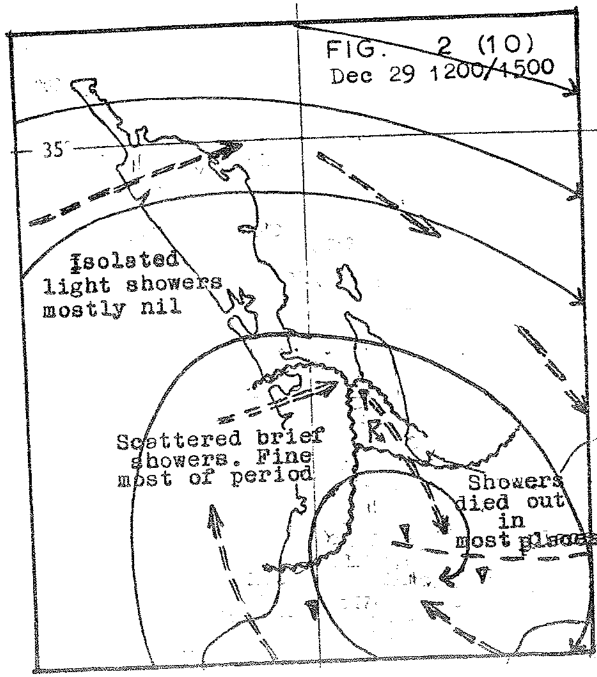

FIG. 2 (10)
Dec 29 1200/1500

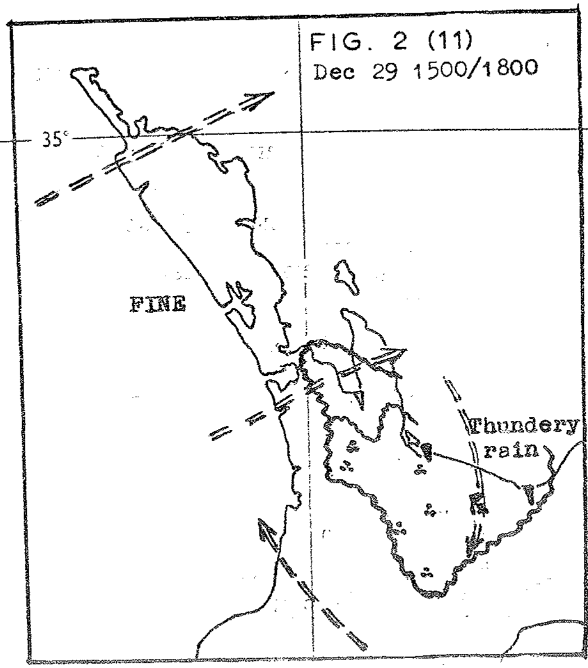

FIG. 2 (11)
Dec 29 1500/1800

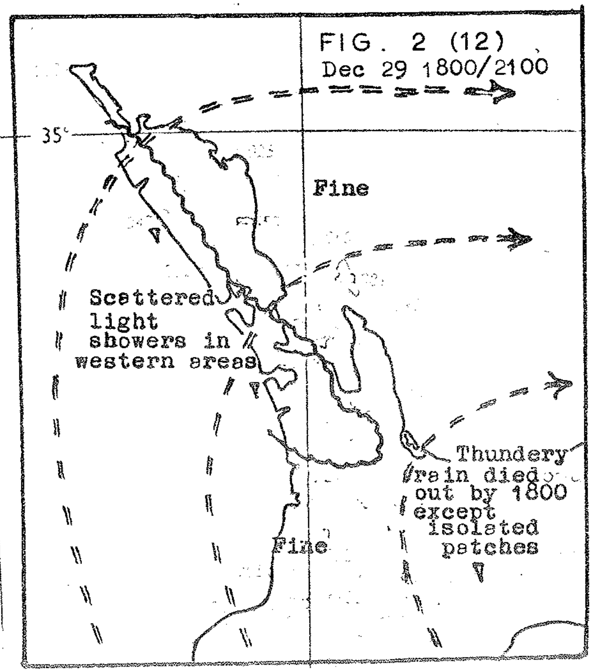

FIG. 2 (12)
Dec 29 1800/2100

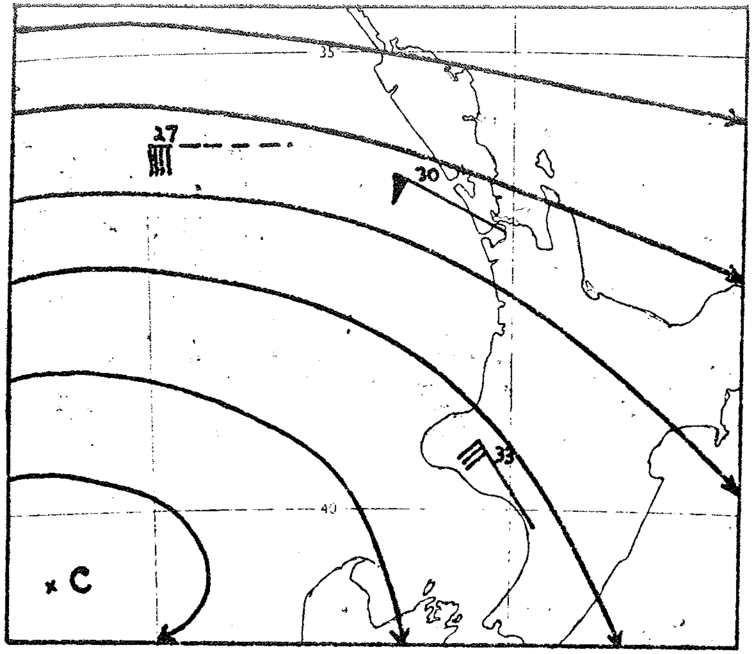

FIG. 3(a) 1200 NZST 28 DECEMBER.

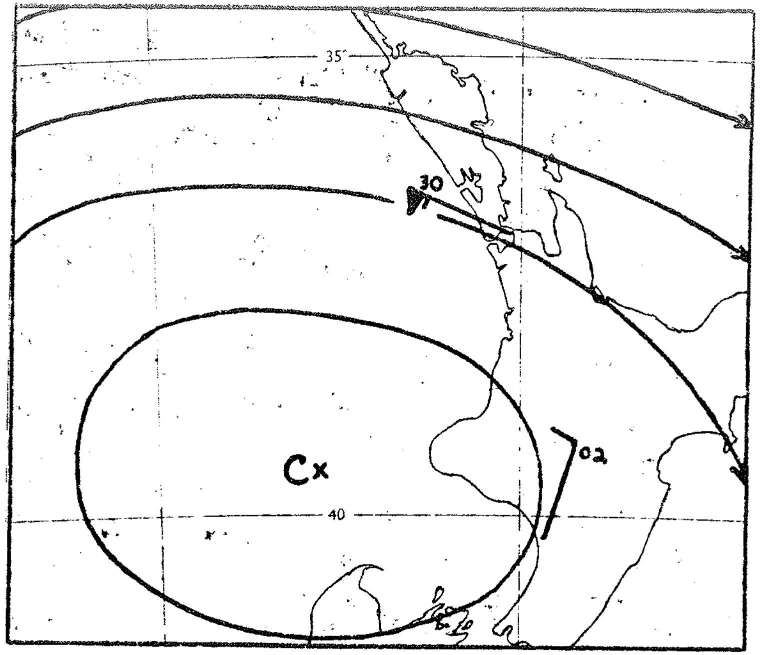

FIG. 3(b) 0000 NZST 29 DECEMBER.

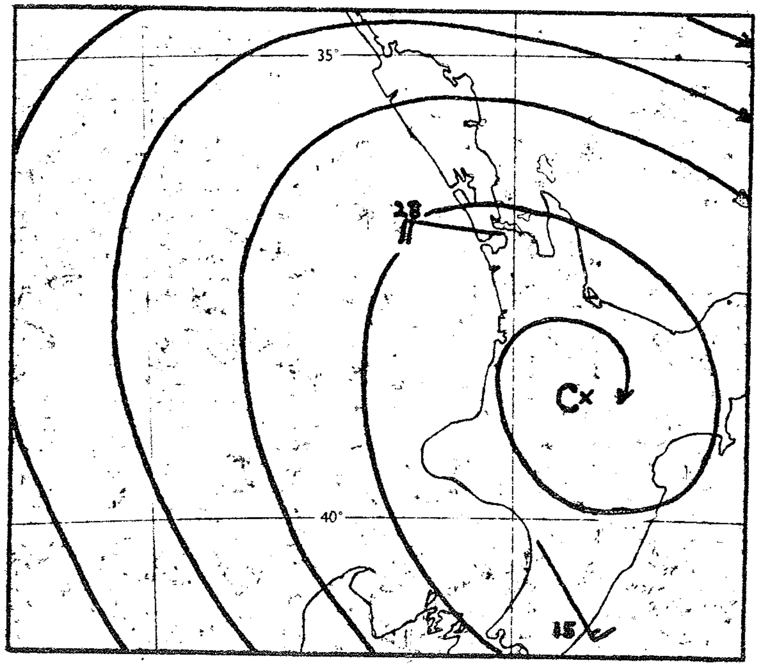

FIG. 3(c) 1200 NZST 29 DECEMBER.