

3. MSL CYCLONES AND ANTICYCLONES IN NOVEMBER 1969 AND JUNE 1970

A.B. Neal

(a) Introduction

MSL pressure analyses for November 1969 and June 1970 were prepared twice daily for the GARP Basic Data Set Project (Phillipot *et al*, 1971; Lamond *et al*, 1972). The frequency distribution of cyclone and anticyclone centres for each month was obtained by plotting the analysed position of centres over a grid of 5 degrees latitude \times 10 degrees longitude for cyclones, and 10 degrees latitude \times 10 degrees longitude for anticyclones. (The larger grid for anticyclones provided a more convenient grouping because of their lower frequency of occurrence.) Grid frequencies were then normalised to a "unit block" centred on 45°S by multiplying by the factor $\cos 45^\circ / \cos \phi$, where ϕ is the middle latitude of each block.

Cyclogenesis was defined in the same manner as Taljaard (1967), namely as the first appearance of a closed low or pronounced cyclonic distortion of the isobars subsequently leading to a closed centre. The appearance of a heat low was not considered as cyclogenesis unless it developed into a migratory system.

(b) Cyclone Centres

November 1969

The normalised frequency distribution of cyclone centres for November 1969 is shown in Fig 3.1. The dominant feature was a zone of high frequency extending around the hemisphere between Antarctica and about 55°S. The axis of this zone was mostly located about 5 degrees of latitude north of the Antarctic continent except in the South Pacific Ocean sector (from 180° to 75°W) where it was of the order of 10 degrees north of the continent.

In mid-latitudes a high frequency finger extended from the southern coast of Brazil into a pronounced high frequency belt (separated from the circumpolar belt) lying across the South Atlantic Ocean mainly between 45°S and 55°S. In the Pacific Ocean another high frequency belt extended between about 35°S and 45°S from New Zealand almost to South America. There were no mid-latitude high frequency zones in the Indian Ocean Sector.

A pronounced frequency maximum occurred off the southeastern tip of Australia. This region was a favoured area for cyclogenesis. In lower latitudes persistent heat lows were evident over northwest Australia, South Africa and the Gran Chaco region of South America.

June 1970

The normalised frequency distribution of cyclone centres for June 1970 is shown in Fig 3.2. There were essentially two high frequency zones encircling the hemisphere; one within about 5 degrees of latitude of the Antarctic continent and the other in middle latitudes.

The circumpolar high frequency band was best defined from the Antarctic Peninsula eastwards to the Ross Sea where it turned towards the pole into a pronounced north-south zone. From the Ross Sea eastwards to the Antarctic Peninsula, the high frequency band was broader and more disjointed.

The middle latitude high frequency band encircled most of the hemisphere at about 45°S to 50°S but extended northwards to 40°S in the Australian and South Pacific sectors. The band turned southeast approaching South America and merged with the circumpolar band near 60°S to the west of the Antarctic Peninsula. However two distinct bands, that in the mid-latitude having an ENE orientation, were observed.



Fig. 3.1 The normalised frequency distribution of cyclone centres in November 1969. Solid lines indicate major high frequency axes and dashed lines indicate minor high frequency axes.

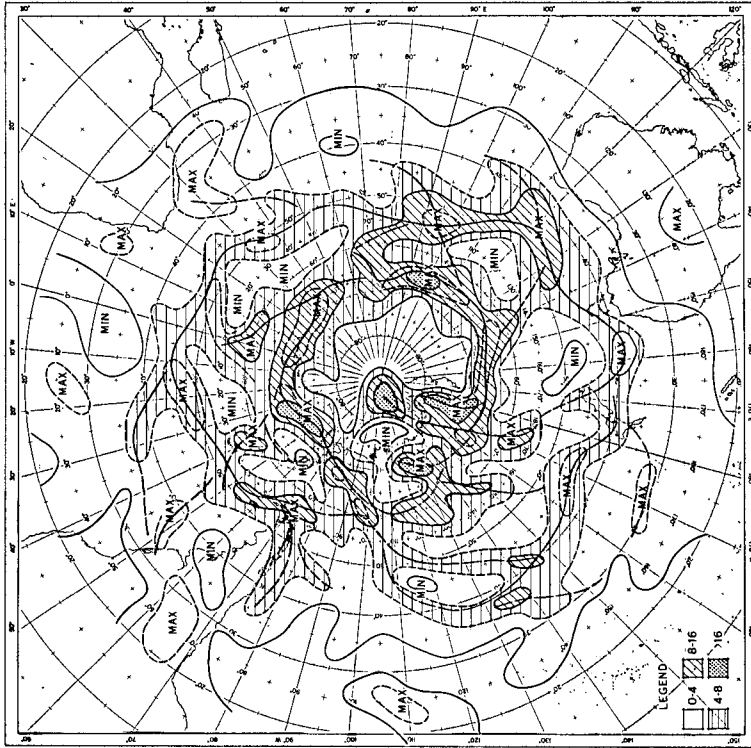


Fig. 3.2 The normalised frequency distribution of cyclone centres in June 1970. Solid lines are major high frequency axes. Dashed lines are minor high frequency axes.

High frequency fingers extended southeastwards from South Africa, and central South America towards the mid-latitude band while a north-south orientated maximum was located off the south Chilean coast.

A well defined cyclone frequency maximum was observed near the pole. This is in complete contrast to November 1969 when the only significant cyclone occurrence over Antarctica was in the region extending southeast from Halley Bay. Another noticeable difference between the patterns in the two months was the considerably better definition of the mid-latitude high frequency zone in June 1970.

(c) Anticyclone Centres

November 1969

The normalised frequency distribution of anticyclone centres for November 1969 is shown in Fig 3.3. A well defined zone of maximum frequency encircled the hemisphere between latitudes 25°S and 40°S with the dominant high frequency area centred off the west coast of South America. Breaks within the high frequency belt occurred along and to the south of the west coasts of Australia and South America and also in the central South Pacific Ocean (125°W - 135°W). No pronounced break was observed in the vicinity of South Africa.

Anticyclones were rare over the high latitude oceans, especially in the South Pacific and South Indian Oceans. By contrast however there was a very high anticyclone frequency over the Antarctic continent with two favoured areas; one in East Antarctica near Vostok and the other in West Antarctica over Ellsworth Land. MSL pressure patterns over the interior of Antarctica are of course fictitious, due to the predominantly elevated topography of the region.

June 1970

The normalised frequency distribution of anticyclone centres for June 1970 is shown in Fig 3.4. The hemispheric high frequency belt covered about the same latitudes as November 1969 with frequency maxima in roughly the same relative locations. The general east-west elongation of the belt is probably representative of migration of systems from one preferred region to another.

Over higher latitudes anticyclone centres were much more frequent than in November 1969 with minor high frequency areas in the South Pacific and evidence of anticyclone occurrence in other sectors polewards to nearly 60°S . A pronounced maximum occurred near the Antarctic Peninsula, a region devoid of anticyclones in November 1969. However although anticyclone centres were more common over the higher latitude oceans than in November 1969, they were still few in number especially in the South Indian and far southeast Pacific Oceans.

On the Antarctic continent a very high frequency maximum was located over East Antarctica (there was an anticyclone centre in this region on every chart) with a lesser maximum over West Antarctica.

(d) Cyclogenesis

The distribution of the areas of cyclogenesis is shown in Fig 3.5 (November 1969) and Fig 3.6 (June 1970), with the respective high frequency axes of cyclone centres superimposed. Within the circumpolar trough zone, lows rarely developed to any great degree following cyclogenesis. The exception to this was the Weddell Sea where significant cyclones sometimes developed in the lee of the Antarctic Peninsula.

In both months cyclogenesis occurred most frequently in the mid-latitudes between about 35°S and 55°S . There were several instances of cyclogenesis in subtropical latitudes (20°S to 30°S) of the southwest Pacific (west of about 110°W) and southwest Atlantic (west of about 15°W) but it is notable that there was an almost complete absence of cyclogenesis in both months in subtropical latitudes of the eastern Pacific, eastern Atlantic and the entire Indian Ocean.

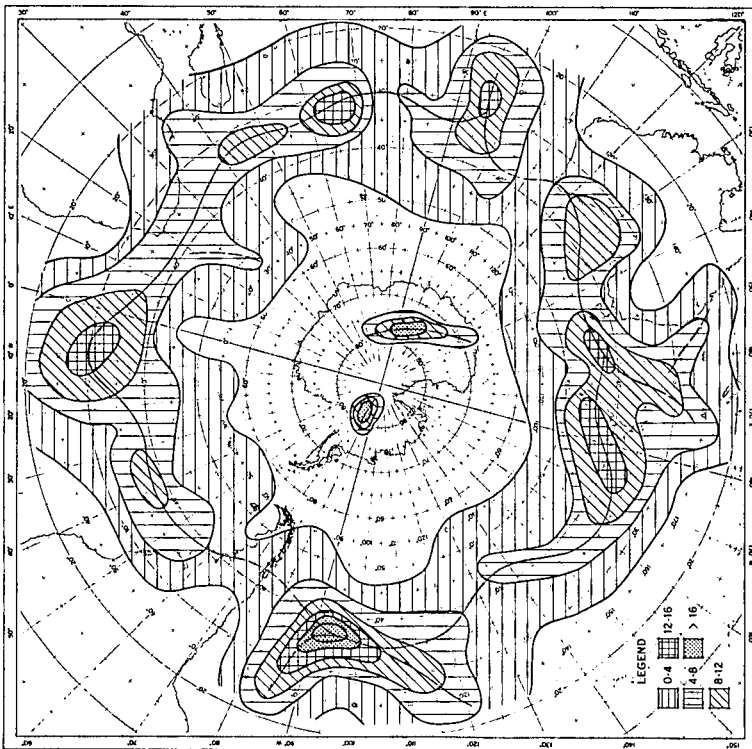


Fig 3.3 The normalised frequency distribution of anticyclone centres in November 1969. Solid lines represent major high frequency axes. Dashed lines are minor high frequency axes.



Fig 3.4 The normalised frequency distribution of anticyclone centres in June 1970. Solid lines represent major high frequency axes. Dashed lines are minor high frequency axes.

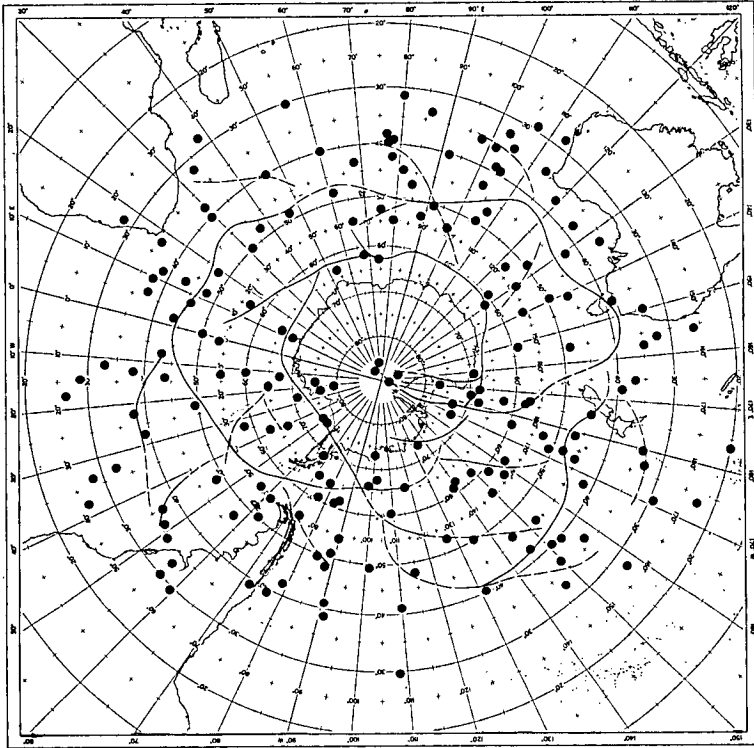


Fig 3.6 The distribution of location of cyclogenesis in June 1970.
Corresponding high frequency cyclone axes are also shown.

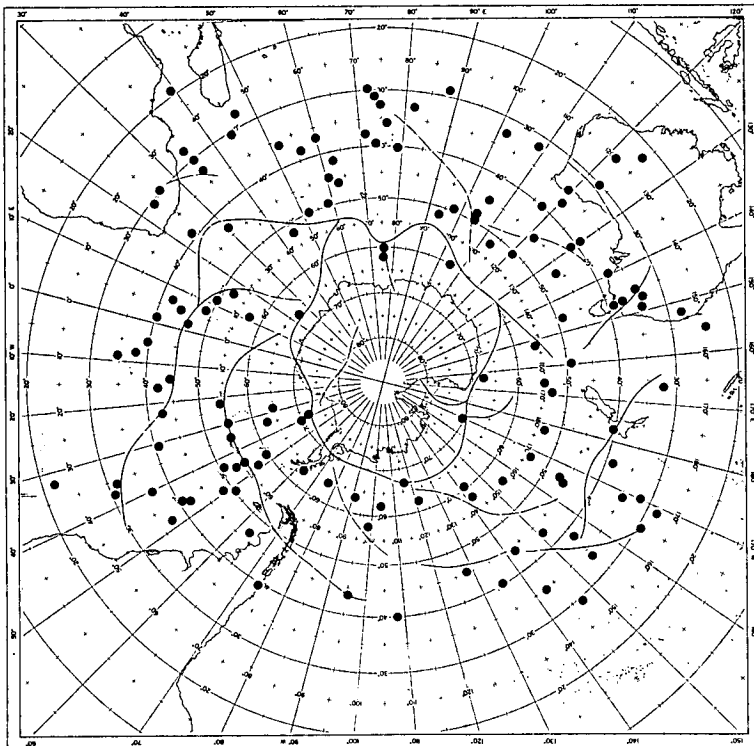


Fig 3.5 The distribution of location of cyclogenesis in November 1969.
Corresponding high frequency cyclone axes are also shown.

Locations of cyclogenesis seem to be randomly scattered with respect to frequency maxima of cyclone centres (Fig 3.5) although in both months cyclogenesis makes a strong contribution to the high cyclone frequency arm extending southeast from subtropical South America.

The frequency of cyclogenesis off southeastern Australia was very pronounced in November 1969 and contributed significantly to the maximum cyclone frequency noted from Fig 3.1. The distribution of cyclogenesis in this area was much more random in June 1970.

(e) Movement

Cyclones

In both months tracks were of varying lengths (the greatest being 7000 km) and the lifetime of individual systems ranged from 12 hours to as many as 10 days. Cyclone tracks between 20°S and 55°S in November 1969 and June 1970 are shown in Fig 3.7 and 3.8. Higher latitude tracks have been described by Lamond (1972) and will not be repeated here.

(i) November 1969

The predominant direction of movement was east-southeast except in the southwest Atlantic (60°W - 25°W) where tracks were more often easterly. During the first half of the month (Fig 3.7a), over all but the Atlantic sector, movement became more southeasterly as the cyclones moved towards higher latitudes. During this period also few cyclones penetrated the New Zealand sector (160°E - 170°W), no doubt a reflection of the intensity and persistence of anticyclonic activity in this region.

During the second half of the month (Fig 3.7b) poleward curving tracks were considerably less frequent and movement in all latitudes was more generally east-southeast. Northeast or northward movement was mostly confined to the early parts of the tracks, although there were several instances in the Pacific between 110°W and 80°W, of northeast movement towards the end of the track.

(ii) June 1970

Again the predominant direction of movement was east-southeast although a greater number of cyclones showed a definite southeast movement than in November 1969. In the far southeast Pacific (140°W - 80°W), tracks curved strongly southeast towards the Bellingshausen Sea.

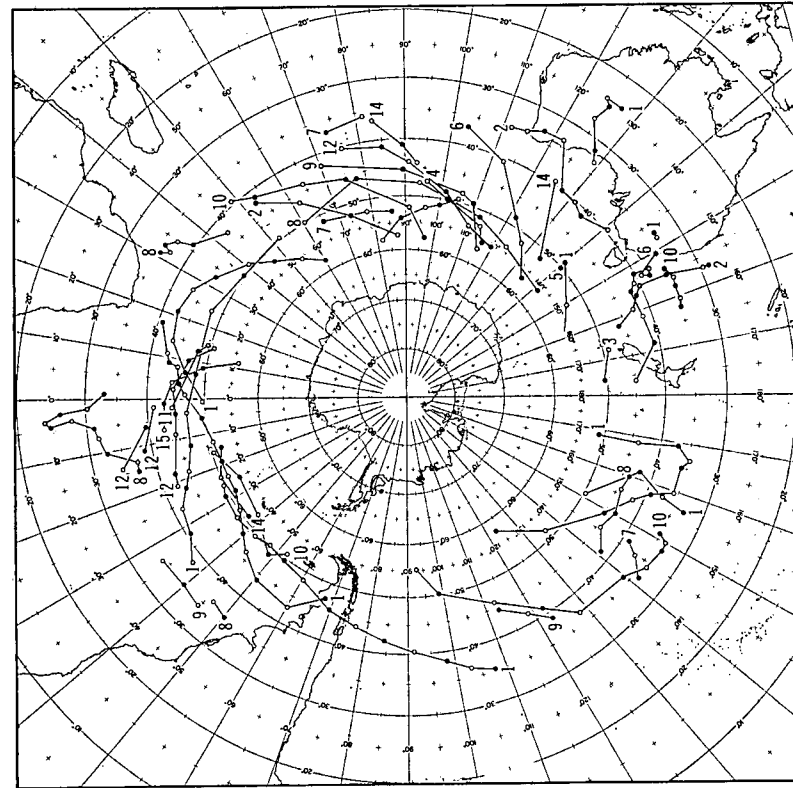
During the first 10 days (Fig 3.8a) a number of tracks extended east-southeast from subtropical South America and another group (though less clearly defined) in the central Pacific. Several cyclones exhibited prolonged southward movement in the Australasian region (130°E-170°E) and one in particular maintained a south-southwest movement for two days.

The middle part of the month (Fig 3.8b) was characterised by the total absence of tracks in the Australian sector between 140°E and 160°E. Most tracks in the Indian Ocean sector during this period were highly zonal, but as cyclones advanced beyond about 100°E they curved southeast or east-southeast and filled before reaching 140°E. This is no doubt a reflection of intense blocking in the Tasman Sea during this period.

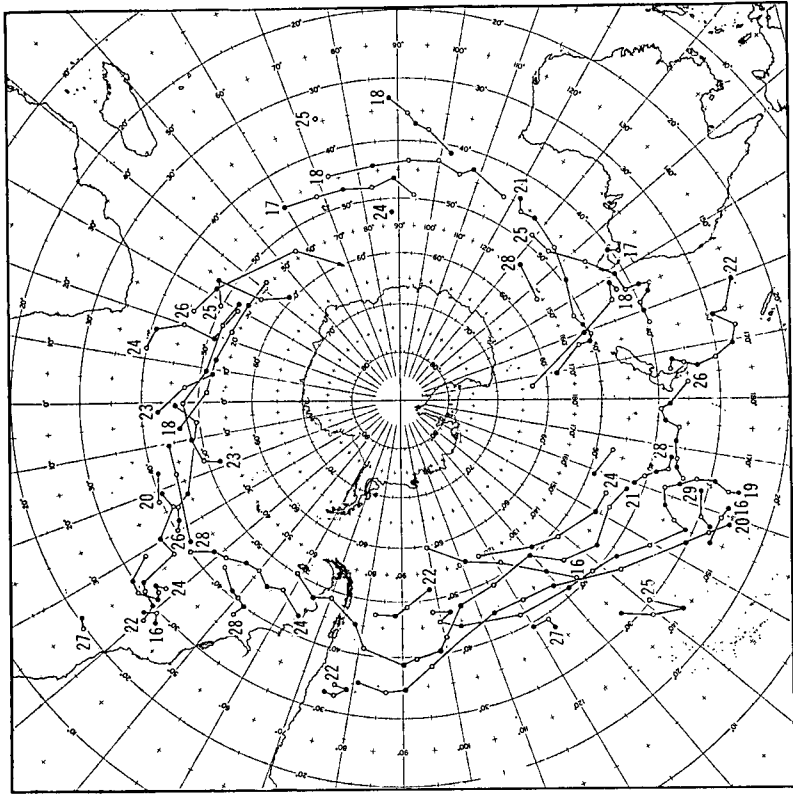
There was no apparent inhibition of movement in the Australian region in the last part of the month (Fig 3.8c).

Anticyclones

It was difficult to track anticyclones from day to day because of the tendency for new centres to form within a general area of high pressure. However in both months some systems could be tracked over distances of up to 4500 km and periods of 5 days or more. Over the higher latitudes tracks were usually quite short and no system could be identified for more than 4 days. A selection of tracks for November 1969 and June 1970 is shown in Fig 3.9 and 3.10.



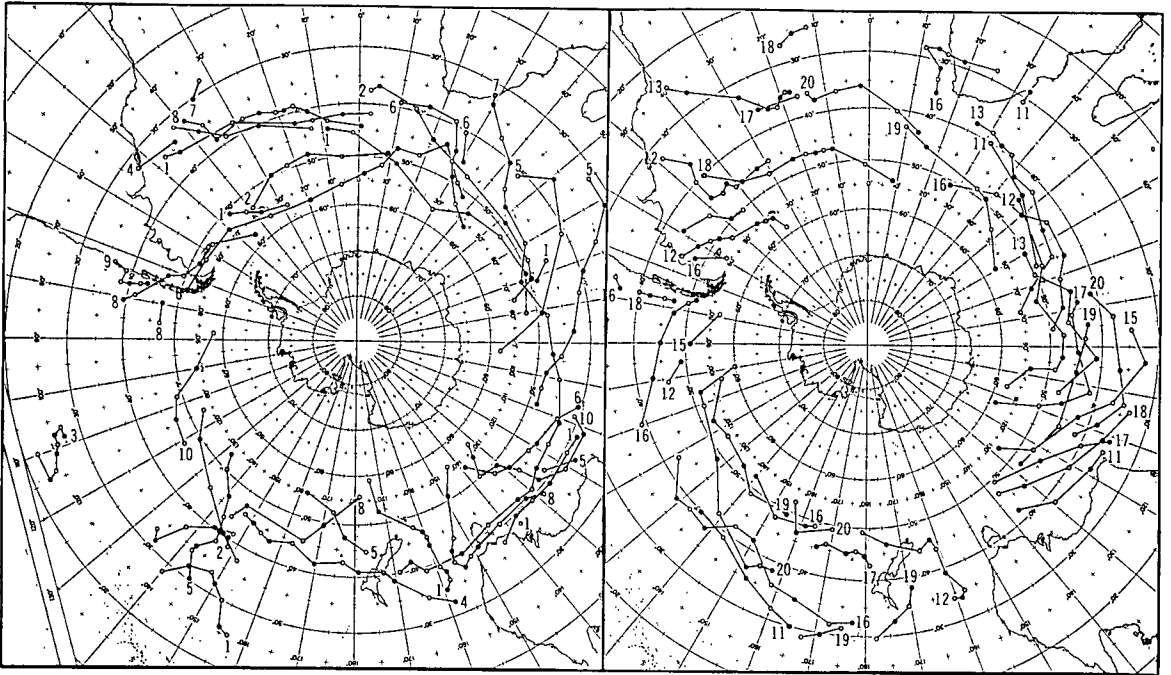
(A) 1-15 NOVEMBER



(B) 16-30 NOVEMBER

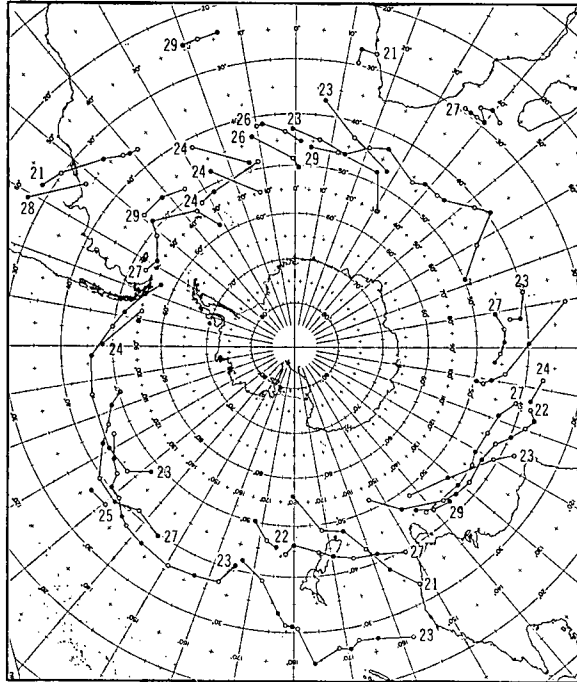
LEGEND
 00 GMT
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Fig. 3.7 Cyclone tracks from (20°S to 55°S) during November 1969.



(A) 1-10 JUNE

(B) 11-20 JUNE



(C) 21-30 JUNE

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Fig. 3.8 Cyclone tracks from 20°S to 55°S during June 1970.

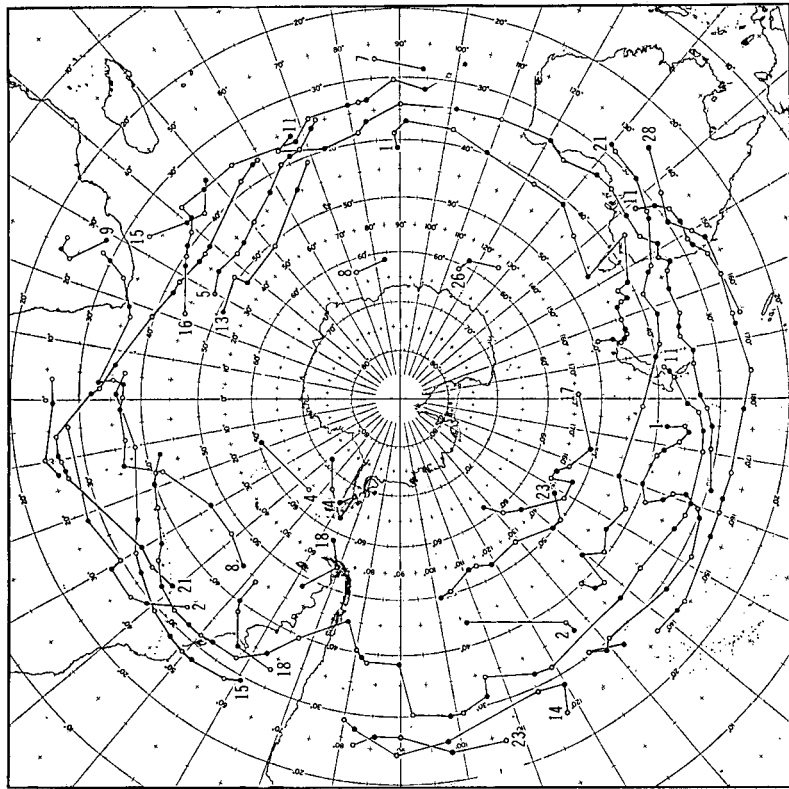


Fig 3.10 JUNE 1970

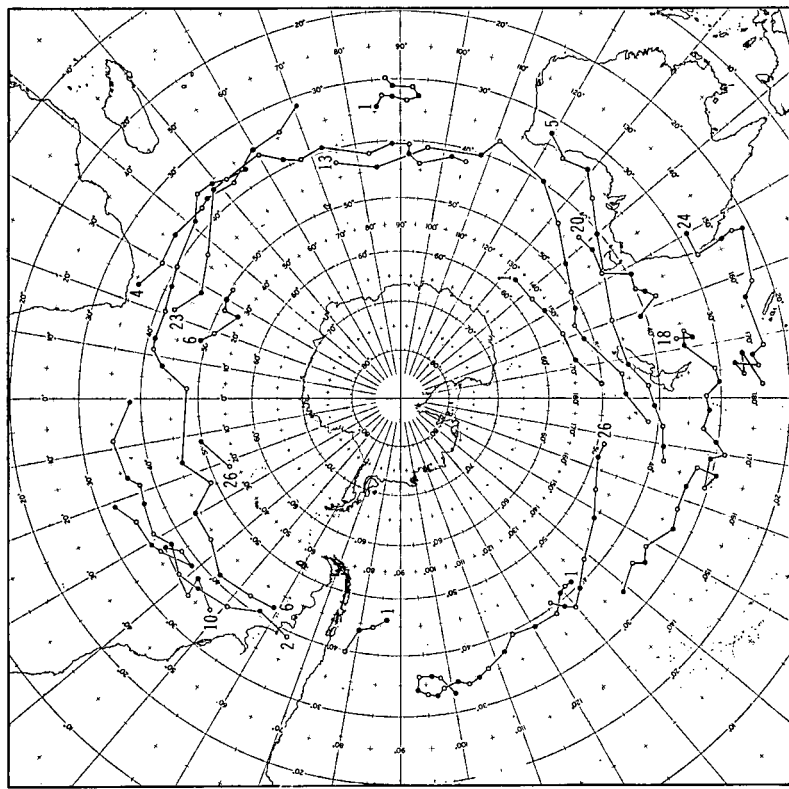


Fig 3.9 NOVEMBER 1969

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A selection of anticyclone tracks (20°S to 55°S)

(i) November 1969

There was a dominant eastward movement of systems around the hemisphere. However southeast or east-southeast movement was fairly frequent in the regions to the southwest of Australia and Africa with east-northeast movement common in the regions just east of South America and Africa.

(ii) June 1970

Again eastward movement predominated but there was much less variation in direction of motion than in November 1969. Fairly frequent east-northeast movement occurred in the region east of South Africa.

(f) Comparison with Other Years

Gibbs (1953), using data for July 1949 and January 1950, studied *inter alia* the distribution of cyclone and anticyclone centres in the Southern Hemisphere. He found a major maximum frequency of cyclone occurrence in winter at about 57°S with a minor maximum near 38°S . These are both well north of the major (about 66°S) and minor (about 45°S) high cyclone frequency axes in June 1970. Gibbs' winter anticyclone frequency maximum (27°S) is also north of the mean position of the June 1970 high frequency frequency axis (about 32°S).

However this and other early studies of the behaviour of surface pressure systems were hampered by lack of observations over the oceans and as a result conclusions have been necessarily of a general nature and often speculative. Not until the IGY period (July 1957 to December 1958) was the observing network sufficient to obtain a reasonable picture of the distribution and movement of systems, but even then data gaps remained.

Taljaard (1967) carefully studied the behaviour of surface systems during the IGY period. His results for "winter" (June to September) are compared here with those of June 1970, and the "intermediate: season (October/November and April/May) with November 1969. There were many similarities between the respective IGY distributions and those of the two Basic Data Set (BDS) periods, (Tables 3.1 and 3.2), whilst major differences are shown in Table 3.3. Despite some variation between the IGY and BDS location of individual frequency maxima within the circumpolar high frequency zone, there was general agreement in six locations.

- | | | |
|---|---|---|
| (1) $60^{\circ}\text{-}70^{\circ}\text{S}$, $20^{\circ}\text{-}35^{\circ}\text{E}$ | (2) $60^{\circ}\text{-}65^{\circ}\text{S}$, $65^{\circ}\text{-}90^{\circ}\text{E}$ | (3) $60^{\circ}\text{-}65^{\circ}\text{S}$, $105^{\circ}\text{-}125^{\circ}\text{E}$ |
| (4) $65^{\circ}\text{-}80^{\circ}\text{S}$, $170^{\circ}\text{E}\text{-}150^{\circ}\text{W}$ | (5) $65^{\circ}\text{-}70^{\circ}\text{S}$, $85^{\circ}\text{-}70^{\circ}\text{W}$ | (6) $65^{\circ}\text{-}75^{\circ}\text{S}$, $60^{\circ}\text{-}30^{\circ}\text{W}$ |

Most of which coincide with embayments in the Antarctic coastline. This further supports Taljaard's (1967) inference of the association between cyclone occurrence near Antarctica and coastal topography.

Surface circulation features of the IGY period were also studied by van Loon (1965) and he presented percentage occurrences of cyclones, anticyclones and cyclogenesis for the winter and spring of 1957. His conclusions are similar to those of Taljaard but he shows evidence of a mid latitude high frequency of cyclones at about 50°S . This was a feature of the cyclone distribution in June 1970.

Streten and Troup (1972), Troup and Streten (1972) and Streten (1968a, b; 1970) used global satellite pictures to study various aspects of the behaviour of Southern Hemisphere cyclones. These investigations were limited south of 65°S by both the effect of the polar ice cap and the construction of the digital mosaics used. No studies of winter periods were possible because of the effect of the polar darkness on cloud photographs.

It is difficult to compare the IGY and the BDS November 1969 distributions directly with Streten and Troup's intermediate season because they subdivided cyclones into various types according to cloud characteristic and stage of development. However

Table 3.1 Features of substantial agreement in the distribution of cyclogenesis in the IGY period and the BDS periods

| Description of Feature | Comment |
|---|--|
| 1 Circumpolar high frequency belt at about 60°S containing numerous frequency maxima which tend to occur in about six "preferree" locations | BDS location of high frequency axis about 2 to 3 degrees of latitude poleward of IGY location in each season |
| 2 Two spiral arms of high frequency; one from sub-tropical South America extending southeast to high latitudes; the other from the sub-tropical South Pacific (180°-130°W) southeast to the Drake Passage | South Pacific spiral arm noticeable in the BDS period but not as clearly defined as in the IGY |
| 3 Favoured areas of heat lows over the sub-tropical continents in the intermediate season | - |
| 4 A fairly frequent area of cyclones near the Chilean coast between about 30°S and 40°S | - |
| 5 Predominant east-southeast movement of systems | - |
| 6 Cyclogenesis most frequently occurs in the zone between 35°S and 55°S | Insufficient occasions of cyclogenesis in BDS periods to warrant more detailed comparison |

Table 3.2 Features of substantial agreement in the distribution of anticyclones in the IGY period and the BDS periods

| | Description of Feature | Comment |
|----|--|---|
| 1. | Pronounced high frequency belt encircling the hemisphere between about 25°S and 40°S containing several frequency maxima | Frequency maxima in similar geographic locations |
| 2 | Distinct breaks in this belt on the western | Better agreement in winter |
| 3 | Few anticyclone centres over the high latitude oceans | - |
| 4 | Pronounced maximum frequency area over West Antarctica | - |
| 5 | Pronounced high frequency in the Weddell Sea area in winter | - |
| 6 | Anticyclone centres over East Antarctica every day | By inference only. The extremely elevated topography in this area makes MSL analysis fictitious |
| 7 | Dominant eastward movement | - |

Table 3.3 Main features of disagreement between IGY and BDS distributions

| Description of Feature | Comment |
|--|--|
| 1 Different distribution of frequency maxima of both cyclones and anticyclones in the Australian-New Zealand region and the adjacent SW Pacific | Associated with blocking patterns (especially in November 1969) and probably reflects significant differences in circulation patterns between the IGY and BDS patterns |
| 2 Complete absence of anticyclone centres in the Weddell Sea in November 1969 | There was a minor frequency maximum in this region in the IGY intermediate period |
| 3 High cyclone frequency near the pole in June 1970 | This was not a feature in November 1969 nor in any of the IGY seasons |
| 4 Southward components of movement of anticyclones tend to occur in three preferred regions (<i>viz.</i> , off the southwest coasts of South Africa and Australia, and off the coast of southern Chile) | Not a feature in June 1970 but was noticeable in November 1969 off southwest South Africa and Australia |
| 5 "Compensating" northward component of movement of anticyclones to the east and southeast of the continents | Not a feature east of Australia in either BDS months, but did occur South Africa in both months and east of South America in November 1969 |

their results do show the existence of the circumpolar high frequency zone and the "spiral arms" in the western South Atlantic and South Pacific, all of which were evident in the IGY and BDS distributions.

Karelsky (1961) studied patterns of "cyclonicity" and "anticyclonicity" (defined as the time in hours during which centres occupied 5 degree latitude squares over a relatively small area embracing the Australian and New Zealand region for all months in the period 1946 to 1960. Karelsky's winter patterns are very similar to the respective cyclone and anticyclone frequency patterns are similar to the anticyclone distribution found in November 1969. However the November 1969 BDS cyclone distribution is markedly different from Karelsky's cyclonicity patterns, except for the heat low over northwest Australia. The BDS high frequency belt is displaced some 5 degrees further north than Karelsky's in the New Zealand region and a much more pronounced maximum exists in the western Tasman Sea. The IGY "intermediate" season distributions are more closely related to Karelsky's for November.

(g) Concluding Remarks

Atmospheric circulation and paths of systems can show marked differences in corresponding periods of different years, as illustrated by Taljaard (1967). Thus no sweeping conclusions can be made from the cyclone and anticyclone patterns in the two GARP Basic Data Set months. Nevertheless, combined with the results obtained by Streten and Troup (1972) and Troup and Streten (1972), they do add credence to the basic findings of van Loon (1965) and Taljaard (1967) concerning Southern Hemisphere circulation patterns. Some uncertainty must remain however because of the short period of data.

Acknowledgment

The considerable assistance of Mr I. Butterworth in compiling data is gratefully acknowledged.