GEOGRAPHICAL DISTRIBUTION OF PRESSURE IN THE CENTRES
OF SURFACE LOWS AND HIGHS IN THE AUSTRALIAN REGION
IN JANUARY AND JULY, 1952 - 1963

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(Manuscript received September 1963)

Abstract: Averages of pressure in the centres of
cyclones and anticyclones in $5^\circ$ lat. / long. squares
in the Australian Region in January and July have
been computed for the twelve year period 1952-1963.
The extreme minimum pressure in cyclonic centres
and extreme maximum pressure in anticyclonic
centres in each $5^\circ$ square, in which a sufficient
number of centres occurred, has also been charted.
Results are represented by isopleths of the
pressure averages, extreme minimum and extreme
maximum pressure of centres. Although the
relation between the changes in intensity of systems
and their direction of motion has not been investi-
gated specifically, it is felt that the charts might
indicate areas where systems tend to intensify or
to weaken. The charts should be considered as a
first approximation to the climatologically reliable
distribution.

It is intended to prepare similar charts for
all months of the year.

1. ORIGINAL DATA AND THE METHOD

Positions and tracks of all anticyclonic and cyclonic centres for all consecutive
natural periods of three to eight days (Karelsky 1953) have been plotted from 1946 to date,
from 9 a.m. and 9 p.m. daily mean sea level synoptic charts of the Central Analysis Office.
Records of pressure at centres at 9 a.m. and 9 p.m. have been made as routine since 1952.

All values of pressure at the centres in January and in July have been collected from
these charts of positions and tracks, and grouped in all $5^\circ$ squares whose positions of centres
were located at 9 a.m. and 9 p.m. and in all squares which were crossed by tracks of centres
between 9 a.m. and 9 p.m. If a centre has been stationary in a $5^\circ$ square for several
consecutive 9 a.m. and 9 p.m. charts and several pressure values are shown for the same
centre in the same $5^\circ$ square, only one pressure value has been taken into account for this
centre: the maximum value for an anticyclonic centre and the minimum value for a cyclonic
centre. If the track of the same centre crossed several $5^\circ$ squares during a 12 hour (9 a.m. to
9 p.m. or 9 p.m. to 9 a.m.) period, the pressure value in squares between two consecutive
9 a.m. - 9 p.m. positions of this centre has been evaluated by simple interpolation between
pressures for 9 a.m. and 9 p.m. positions. As a result the number of pressure values at
centres plotted in each $5^\circ$ square is equal to the number of different centres which passed this
square during January or during July of all years 1952-1963.

Pressure values have been plotted on two separate synoptic charts, one for anti-
cyclonic centres and another for cyclonic centres.

The number of different centres and tracks which crossed any $5^\circ$ square has been
counted and the average pressure per one centre in each $5^\circ$ square has been computed. Recorded
maximum and minimum pressure in each 5° square has also been processed.

These charts show:-

(i) Average value of pressure for anticyclonic and cyclonic centres in January (Figs. 1 and 3) and in July (Figs. 5 and 7). The average values are plotted in the centre of 5° squares, the number of different centres recorded in these squares is in the upper right hand corner, the maximum value in the upper left hand corner and the minimum in the lower left corner.

(ii) Maximum recorded values of pressure in anticyclonic centres in January (Fig. 2) and in July (Fig. 6); maximum value is plotted in centres of squares and the number of different centres in the upper right hand corner.

(iii) Minimum recorded values of pressure in cyclonic centres in January (Fig. 4) and in July (Fig. 8). Minimum value of pressure is plotted in the centres of squares and the number of different centres in the upper right hand corner.

Isopleths on the above charts are drawn at 5mb intervals of pressure values which are plotted omitting first 10 or 9, i.e., 27 means 1027 mb and 95 means 995 mb.

2. ACCURACY OF DATA AND OF RESULTS

Pressure in centres over areas without direct observations depends, of course, on the subjective extrapolation of the pressure field by analysts. Not only the pressure but also the positions and tracks of centres over these areas can differ on charts of the same data drawn independently by two different analysts. Analysis over areas without observations is not always "continuous" and some centres can appear or disappear in 5° squares within periods of less than 12 hours.

Therefore values of pressure in centres and number of centres in 5° squares are rather unreliable over areas:

(i) West of longitude 110°E in all latitudes.
(ii) West of longitude 140°E and south of latitude 40°S.
(iii) Over areas more than 5° south of Tasmania, over the Central Tasman Sea, southeast to New Zealand and over some areas of the South Pacific.

The average and extreme values of pressure are disregarded in all squares with number of centres less than 3 over above quoted areas, but they are quoted in squares containing even 1 or 2 centres over areas with or close to an adequate network such as the Australian continent or New Zealand.

It is believed, however, that average pressure values (per centre) in all 5° squares without direct observations can be considered as "reasonable" provided that the number of centres in these squares is 10 or more. In this case the average values can be considered sufficiently accurate to draw isopleths at 5mb intervals. Some inaccuracies will have been introduced by inability to locate exactly the position of "centres" and other subjectivity in the analyses particularly over ocean areas.

The average and also minimum and maximum values may, of course, be statistically unrepresentative in all 5° squares, even with a dense network, where the number of recorded centres is small, for example less than 5.

Statistical comparison of the accuracy of the values in different 5° squares with different number of centres has not been attempted in this first study. Ideally, frequency distribution should be presented, but for statistically reliable distributions a period much longer than 12 years would be necessary. Nevertheless, analysis of the data obtained show that the fields of the average pressures in centres and even the maximum and minimum values were
continuous and reasonably smooth. It is believed that even a 12 year period gives information which could be useful for practical analysis and prognosis.

3. DISCUSSION

Average monthly anticyclonicities and cyclonicities in January and July for 15 years period 1946-1960 (Karelsky 1961) are relevant to the following discussion.

(a) January Anticyclonic Centres (Figs. 1 and 2)

Weak maxima of average pressure in anticyclonic centres appear over the latitudinal belt between 40°S and 50°S. Low frequency of occurrence of centres in squares south of latitude 45°S, except the south Tasman Sea and the area south and southeast of New Zealand, and the absence of observations prevents a reliable discussion of results there. But the number of centres between latitudes 40°S and 45°S is large enough to conclude that on the average anticyclones between these latitudes have higher central pressure than those in the area of average maximum anticyclonicity, which in January is between latitudes 35°S and 40°S. The few anticyclonic centres which moved over the southern area of the Australian continent and over the northern Tasman Sea between latitudes 30°S and 35°S in January were on the average weaker than the centres moving south of 35°S. The number of anticyclonic centres over Victoria, Tasmania and New Zealand between latitudes 35°S and 45°S is definitely less than the number of centres in the 5° squares over the sea surface just west and east of these land masses. This means that even the relatively narrow land masses like Tasmania or New Zealand are not favourable for "closed" anticyclonic circulation on the surface in summer. However, Tasmania and New Zealand do not markedly influence pressure in those anticyclonic centres which occasionally pass over these land masses. Anticyclonic centres over Victoria are on the average weaker than those over the adjacent sea surfaces.

The patterns of the average and maximum pressures in centres are quite similar to distribution of the average pressure.

Although this aspect has not been specifically studied, the patterns suggest that north of 45°S, in January, anticyclonic centres which have a southward component in their motion tend to increase in intensity more frequently than to decrease; centres moving with a northward component tend to weaken more frequently than to intensify.

(b) January Cyclonic Centres (Figs. 3 and 4)

The average pressure in cyclonic centres in January is quite uniform over the Australian continent, varying from 1001 to 1004 mb and being slightly higher over the eastern part than over the western part of the continent. The frequency of centres is low in squares between longitude 125°E and 135°E but is very high in the "heat" low and monsoon low areas. Average pressure is higher over the areas between latitudes 30°S and 40°S over and south of Western Australia, over eastern South Australia and over Victoria, over the eastern Tasman Sea and also between longitudes 150°E and 160°E and latitudes 30°S and 35°S over and off the eastern New South Wales coast. This belt is close to the belt of maximum anticyclonicity in January and could be considered as unfavourable for intensification of cyclonic centres passing over these areas. Tropical cyclones which have the lowest average pressure in centres southeast and southwest of New Caledonia apparently become weaker on the average when they move to areas south of latitude 30°S and especially to the eastern coast of New South Wales or to the eastern Tasman Sea. The pattern of minimum pressure over this area is similar to the pattern of averages. Low average pressure and minimum pressure off the northwest of Western Australia and on the extreme north of Queensland is of course due to tropical lows which occasionally develop there in January.

The average and minimum pressures in cyclonic centres decrease markedly with increasing latitude south of 45°S over areas south of Tasmania, south of the Tasman Sea and south of New Zealand.

The features of Fig. 3 also suggest a hypothetical rule: cyclonic centres over areas south of the Australian continent tend to intensify when moving from the area south of Western
Fig. 1 Average pressure in centres of Anticyclones in January for 12 years 1952 - 1963.

Fig. 2 Maximum pressure in centres of anticyclones in January for 12 years 1952 - 1963.
Fig. 3 Average pressure in centres of Cyclones in January for 12 years 1952 - 1963.

Fig. 4 Minimum pressure in centres of cyclones in January for 12 years 1952 - 1963.
Australia to the Bight area and tend to weaken when moving from the eastern Bight eastwards.

It should be noted that the pattern of minima of pressure is much more irregular than the pattern of average pressure in cyclonic centres. However, a period of 12 years is too short to indicate the probable absolute minimum in each 5° square.

(c) July Anticyclonic Centres (Figs. 5 and 6)

The average pressure in anticyclonic centres in July appears to be higher in latitudes between 35°S and 40°S west of longitude 135°E, and between latitudes 40°S and 45°S east of this longitude. In other words the belt of highest average pressure in centres is about 5° to 10° south of the belt of maximum anticyclonicity (see Karelsky 1961) in the area of the Australian continent and approximately coincides with maximum anticyclonicity over the Tasman Sea and over New Zealand. The July patterns suggest that north of about 40°S the anticyclonic centres intensify more frequently than they weaken when moving with a southward component and weaken more frequently than they intensify when moving with a northward component.

It should be noted that no more than four anticyclonic centres were charted to the south of latitude 40°S and to the west of longitude 135°E in July in 12 years but quite a large number were charted in January over these areas. It seems that the almost complete absence of centres over this area in July cannot be attributed to the absence of direct observations of pressure, but is a real feature of the general circulation in July when only cyclonic centres or ridges of highs move in this latitudinal belt.

The maximum value of pressure in anticyclonic centres exceeding 1035 mb covers approximately the same area as covered by average pressure exceeding 1025 mb. In the 12-year period the highest pressures (between 1040 and 1043 mb) are shown over Tasmania, just southeast of Tasmania and over and east of New Zealand. As indicated in Section 2 these values should be considered as approximate.

(d) July Cyclonic Centres (Figs. 7 and 8)

The average pressure in cyclonic centres is highest over the Australian continent and the lowest pressure is in the southern latitudes as might be expected. A relatively cold and large land surface in winter is of course not favourable for cyclonic circulation on the surface and its damping influence extends to the Bight area. Some irregularities over the continent are due to the small number of cyclonic centres there and to the consequent unreliability of the pressure averages in centres. Isopleths of average pressure south of the Australian continent are in general orientated WNW to ESE, i.e. cyclonic centres over areas west of 145°E are, on the average, weaker than over the area south of Western Australia, which is opposite to the January distribution. This might suggest a tendency for cyclonic centres to weaken when they are moving eastwards or with a northward component over these areas, and a tendency to preserve their intensity or to deepen when they are moving with a southward component. The patterns of Fig. 7 might also suggest that, east of 145°E, centres moving from the west tend to deepen more frequently than weaken.

Irregularities in the average and minimum pressure in cyclonic centres in the vicinity of Macquarie and Campbell Islands cannot be considered as climatologically significant, for the number of centres there is too small. In the 12-year period the absolute minimum pressure in a cyclonic centre was charted as 955 mb in the 5° square just south of Macquarie Island, the number of centres there being 20.

The second lowest minimum is 965 mb in the 5° square between latitudes 40°S and 45°S and longitudes 160°E and 165°E where the number of centres was 21. The accuracy of these minima is, of course, not high due to the absence of direct measurements of pressure over these areas and to the too short period.

The relative minimum of averages and of the minimum values of pressure at centres of lows over the Tasman Sea as compared with the pressure over eastern Australia is partly explained by the tendency for surface cyclogenesis in cold airmasses moving from the west, southwest and south to the much warmer surface of the Tasman Sea when southern troughs move to this region.
Fig. 5 Average pressure in centres of anticyclones in July for 12 years 1952 - 1963.

Fig. 6 Maximum recorded pressure in centres of anticyclones in July for 12 years 1952 - 1963.
Fig. 7 Average pressure in centres of cyclones in July for 12 years 1952 - 1963.

Fig. 8 Minimum pressure in centres of cyclones in July for 12 years 1952 - 1963.
4. CONCLUSIONS

(i) Twelve years is not sufficient to compute a climatologically reliable average and to determine maximum and minimum values of pressure in anticyclonic and cyclonic centres over areas without a network of observations or with a very small number of charted centres. Figs. 1-8 for these areas should be considered as a rough approximation to the climatologically reliable distribution for much longer periods.

(ii) The distribution of pressure in centres over areas with an adequate network and/or with a large number of centres can be considered as a climatologically significant basis for discussions and practical applications.

(iii) Figs. 1-8 might assist in the preparation of daily prognostic charts by indicating areas favourable for intensification or weakening of anticyclonic and cyclonic centres, provided that the accuracy and reliability of data are taken into account. However, further investigations into the relation between changes in intensity of systems and their direction of motion are desirable.

(iv) The patterns depicted pose a series of problems such as the influence on the intensity of systems of surface sources and sinks of heat and of the orography, etc. A complete investigation of these problems would involve not only surface charts but all other data describing the three dimensional structure of the atmosphere.

This study is a preliminary step in attacking these problems. It is intended to prepare similar charts for all months of the year.

ACKNOWLEDGEMENTS

The author is indebted to Mr. J. N. McRae who suggested this project and the lines of the investigation, to Mr. K. T. Spillane who read the text and discussed the problems involved, and to Messrs. I. Sullivan and R. Weinert who undertook the painstaking work of data collection and computation.

REFERENCES