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Mean pressure field over the south-west Atlantic from March to December 1979*)

ABSTRACT: On the basis of surface pressure analyses covering the area of south-west Atlantic, maps of monthly mean pressure fields for the period from March to December 1979 were drawn. In order to accentuate the dynamics of pressure processes, maps of standard deviation as well as of the skewness coefficient of the values forming the pressure field were also prepared. Apart from this, the variation of pressure in the particular points of the field in the months considered, was discussed. Attention was drawn to the distinct quasi-periodicity, dependent on location of the given point.

Key words: Antarctic, meteorology

1. Introduction

Duties of the meteorological group of winterers at the Arctowski Station, 1979, included, beside standard meteorological observations, meteorological services for the expedition's activities and of the adjacent subantarctic fishing grounds. The products of the services — daily issued forecasts and warnings — were broadcasted to their users and herewith their rôle ended. However the data the forecasts were based on, could be used for further scientific investigations. Thus the presented work was prepared by using synoptic facsimile surface analyses. It deals with the mean surface pressure field over the area enclosing the Antarctic Peninsula, Drake Passage, Scotia and Weddell Seas, i.e. the southernmost part of the south-west Atlantic.

The aim of this paper is to illustrate the general characteristics of the pressure field there, and to point out some features of its high dynamics, the latter being of great significance to other measurements performed, giving their meteorological background.

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2. Data set and procedure

As already mentioned, daily surface pressure maps were used as source material. They were usually the facsimile maps, broadcasted by RMC Buenos Aires, received routinely in the expedition's weather bureau at the Arctowski Station. Pressure values were taken once a day, from the 12 hrs GMT maps. The accuracy of reading was 1 hPa, due to the quality and the scale of the maps.

The area over which the computations were performed was limited by meridians 80°W and 40°W and by parallels of latitude 50° and 70°S. Thus, the Arctowski Station was approximately in the centre of the area, the fishing grounds extending towards north and northeast.

The pressure values were read in 25 points of the area: every 5 degrees of latitude and every 10 degrees of longitude. The data set gained was processed by means of simple statistical analysis. Monthly means were calculated for each grid point, and so was the standard deviation and skewness coefficient. For each month maps showing distribution of these characteristics were drawn.

Since the day-to-day changes of pressure are significant in that area, it is difficult to present the generalized variation of this element without any smoothing. Thus, the course of pressure during the ten months of 1979 was determined by calculating 11-day overlapping means in four extreme points of the area considered. Some missing values for a few days were interpolated as means from the neighbouring days, prior to averaging. The same method was applied to present the pressure variation at the Arctowski Station, but instead of pressures from one definite hour — daily means were used for overlapping averaging.

3. Mean pressure field

Investigations of the mean distribution of pressure in the circumpolar Antarctic belt (Pogosjan 1959, Tauber 1959, Taljaard et.al. 1969, van Loon et al. 1972) reveal a stationary depression extending between 60° and 70° of latitude. The pressure values along its latitudinal axis approximate 985 hPa. This depression is split into separate centres by weak ridges of higher pressure or, more precisely, by col areas, one of which appears quite frequently in the region of Antarctic Peninsula (Fig. 1A, B). Northward of the depression belt, to approximately 45° of latitude, the zone of highest pressure or, more precisely, by col areas, one of which appears quiet Antarctic part of the south-west Atlantic did not differ much from this picture. From March through December the mean monthly pressures ($\bar{P}$) over the area ranged from 1010 hPa in the north-west (March, Aprill) and 1005 hPa in the north-east (March and July) to 984 hPa in the south-west (July and August) and 978 hPa in the south east (April). Such a distribution of extreme values determined to some degree the field pattern: isobars ran mainly from south west to north east, crossing the parallels at a small angle. During March, April and May the lowest

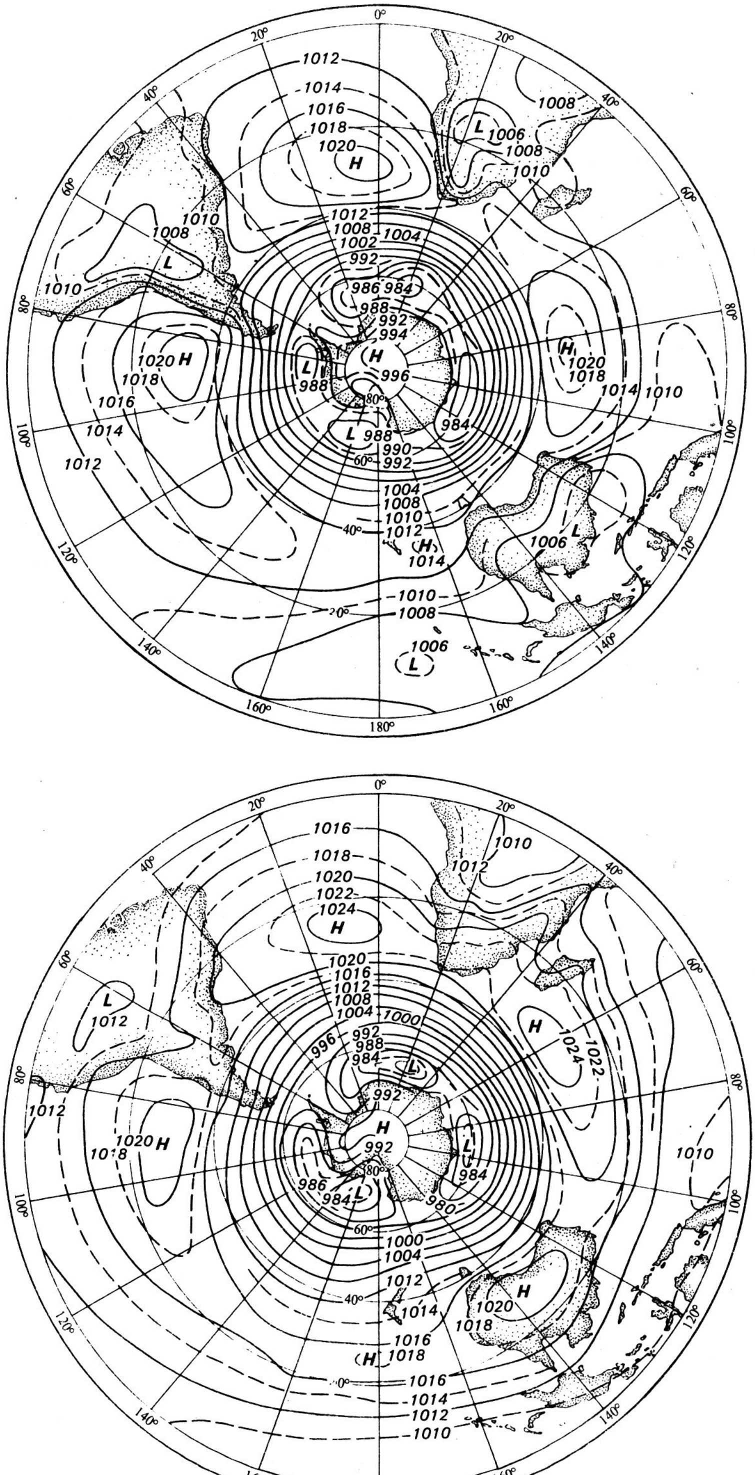

Fig. 1. Mean surface pressure field over the Southern Hemisphere (after Meteorology of the Southern Hemisphere, Taljaard et al. 1972). L — low, H — high, pressure in hPa
A — in January, B — in July

pressures marked by frequently cyclonally curved isobars, persisted in the south east, over the Weddell Sea. In June the centre of the lowest pressure was split into two, lying symetrically on both sides of the Peninsula. In July, August and September it moved to the west, over the Bellingshausen Sea, to return late in spring over the areas to the east of the Antarctic Peninsula. In December it appeared over the Bellingshausen Sea again. Thus in the transition periods — autumn and spring — the Antarctic Peninsula was influenced by the north-western edge of the Atlantic centre of stationary circumpolar depression, whereas in winter — by the north eastern edge of its Pacific part, or was in the col between them. (Fig. 1A, B). Thus, oscillations of these great stationary depressions may cover quite long periods, connected probably with the season of the year and they may be irregular in time. The stationary col separating these two centres persists over the Antarctic Peninsula usually in July (Fig. 1B). In 1979 it distinctly occurred in June, and the July isobars showed only a weak anticyclonal curvature (Fig. 2).

The main feature of the pressure field in 1979 was its high zonality and, consequently, high horizontal pressure gradients. Of special interest was here April (Fig. 2), when between the parallels 55° and 60°W the mean horizontal pressure gradient exceeded 2 hPa per 100 km.

4. Distribution of standard deviation

Since the maps of mean pressure ($\bar{P}$) present only a static picture of the distribution of this element, the maps of standard deviation σ (P) were drawn (Fig. 3) to accentuate the dynamic properties of the pressure field more clearly. By means of them those fragments of the area could be pointed out, where the most vigorous changes of pressure occurred.

The smallest variability of pressure prevailed over the Scotia Sea, where the departures of the mean value oscillated on the average between 7 and 10hPa. Another area with relatively smaller oscillations was the Bellingshausen Sea, where the standard deviation varied between 8 and 10 hPa.

Other parts of the area cannot be determined unanimously as regards the dynamics of pressure changes expressed by means of standard deviation. In March values exceeding 10 hPa were recorded over the Drake Passage and the northern part of the Bellingshausen Sea. In April the whole area except the Scotia Sea underwent standard deviations of 11 to 13 hPa. In May and June maximum standard deviations, exceeding 12 hPa, concentrated to the NW of the Antarctic Peninsula. In July the area of maximal standard deviations shifted toward South Georgia, and in August — east of South Orkney Islands. The greatest pressure ascillations were noted in September and October. Standard deviations in these months exceeded 15 hPa: in September south-east of Tierra del Fuego, and in October — east of that coast. November brought some decrease of the dynamics of pressure changes and December was even more calm. In December, from South Georgia to the south-west there was extending a zone of standard deviations

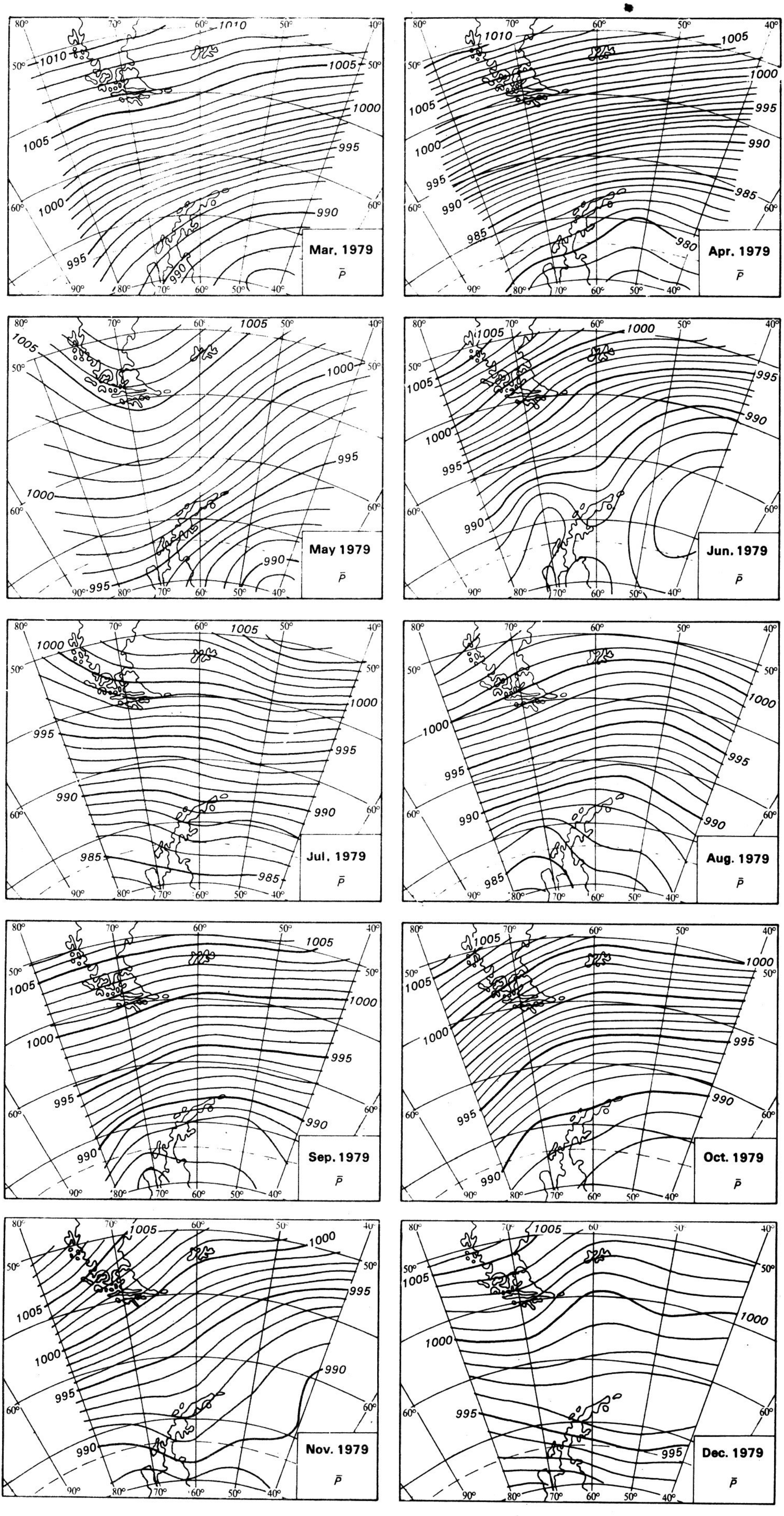

Fig. 2. Mean monthly pressure ($\bar{P}$) fields over the Antarctic part of south-west Atlantic. March through December 1979. Pressure in hPa.

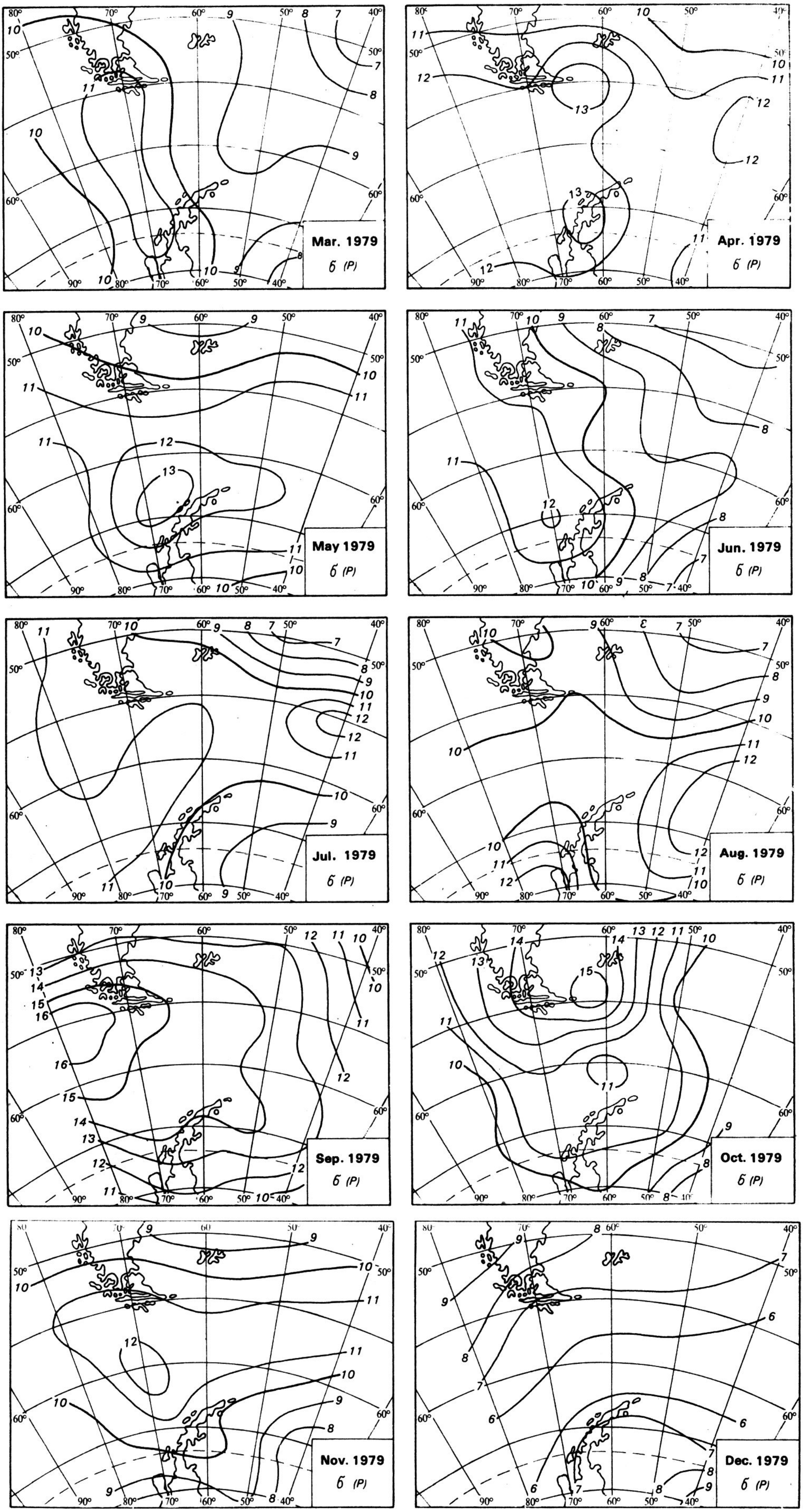

Fig. 3. Distribution of standard deviation of pressure σ (P) hPa, at 12 GMT, March through December 1979 over the Antarctic part of south-west Atlantic

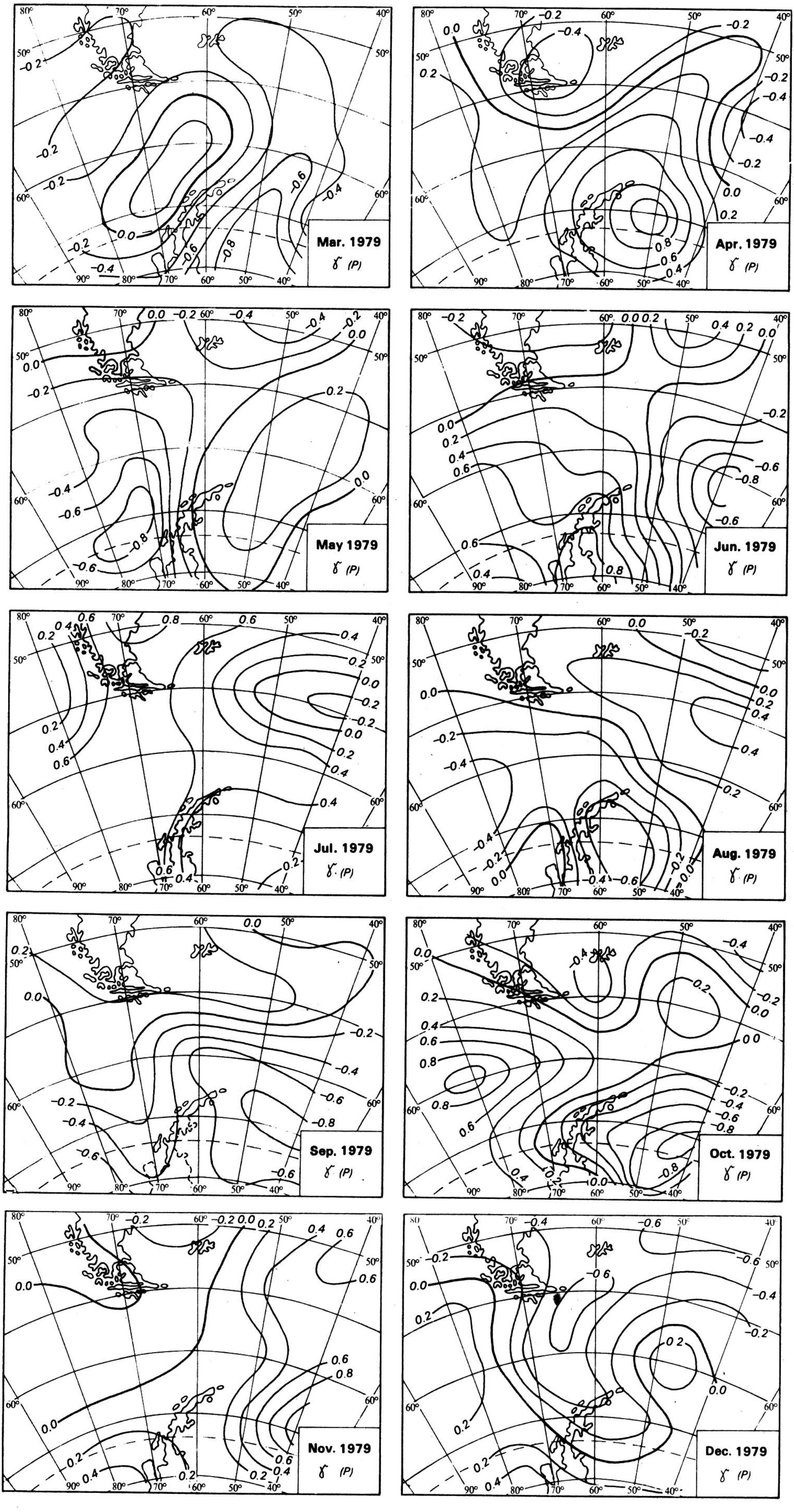

Fig. 4. Distribution of skewness coefficient γ (P) at 12 GMT, March through December 1979 over the Antarctic part of south-west Atlantic

not higher than 6 hPa. Such a distribution was consistent with the zone of the smallest mean pressure gradient in that month (Fig. 2). These features are assumed to be characteristic for the summer season.

5. Distribution of skewness coefficient

Skewness coefficient γ was used to indicate the sign of prevailing departures of the individual pressure values from the mean value (Fig. 4). Where there was $\gamma > 0$, the mean monthly values in the area exceeded the modal value. This indicated, that lower pressures prevailed and the relatively high mean value was achieved due to less frequent cases of comparatively higher pressure. In areas of $\gamma < 0$ the opposing relations existed. Generally, in the field of γ positive values prevailed, but there were months, as for instance March, September and December, when the greater part of the area was covered by negative γ values.

More detailed consideration should be paid to the pressure distribution and the field of skewness coefficient of April. In that month the lowest values of $\bar{P}$ spread over the Weddell Sea. Skewness coefficients over that area were positive and exceeded 1.0. This gives evidence that the majority of pressures encountered there was markedly lower than the mean value and a vigorous cyclonal activity could be assumed to have predominated over that region. As the area of high pressure in the norht-west, over Patagonia and Falkland Islands, was within negative skewness coefficients, greater frequency of higher pressure systems prevailing there should be concluded.

By means of the computed characteristics it was possible to estimate the extreme values of the field considered. If, for example, from the lowest $\bar{P} = 976$ hPa from over the southern part of the Weddell Sea in April (Fig. 3) we subtract the relevant standard deviation $\sigma = 12$ hPa (Fig. 4), the resulting 964 hPa will give an idea of the lowest pressures encountered in that month. If subsequently we add the value $\sigma = 11$ hPa to the highest pressures of the same April field, $\bar{P} = 1010$ hPa over Patagonia (Fig. 3 and 4), the addition will yield 1021 hPa, i.e. the value of the highest pressures encountered in that month. Thus, the difference between both the extremes reaches nearly 60 hPa. With the skewness coefficients γ positive in the lowest pressure area and negative in the highest pressure area, the individual extreme values might have been even more contrasted.

Similar considerations on the pressure conditions may be easily carried out for the remaining months as well.

6. Variation of pressure with time

Apart from the static picture of the mean pressure field the variation of this element with the time has been considered. For each of the four extreme points of the area and for its centre a variation curve has been drawn, smoothed, as already explained, by overlapping averaging over 11 consecutive days. The resulting variation curves revealed — apart from longer periods — also shorter oscillations, proving high dynamics of atmospheric processes. The longest periods on the outskirts of the field lasted for 30—40 days, whereas in the central part of the area, at the Arctowski Station, they lasted as long as 20—30 days, on average. Both the higher pressure spells and the spells of pressure depression were marked by shorter periods, of only 2—5 days duration. These shorter oscillations were connected with individual lows moving through the region investigated. The variation curves are shown in Fig. 5. Lines A and B refer to the northern (50°S and 80°W) and southern (70°S and 80°W) points of the western outskirts of the field, respectively. The course of pressure at the Arctowski Station is illustrated by curve C, whereas D and E refer to the eastern outskirts of the area: to its northern (50°S and 40°W) and southern (70°S and 40°W) points.

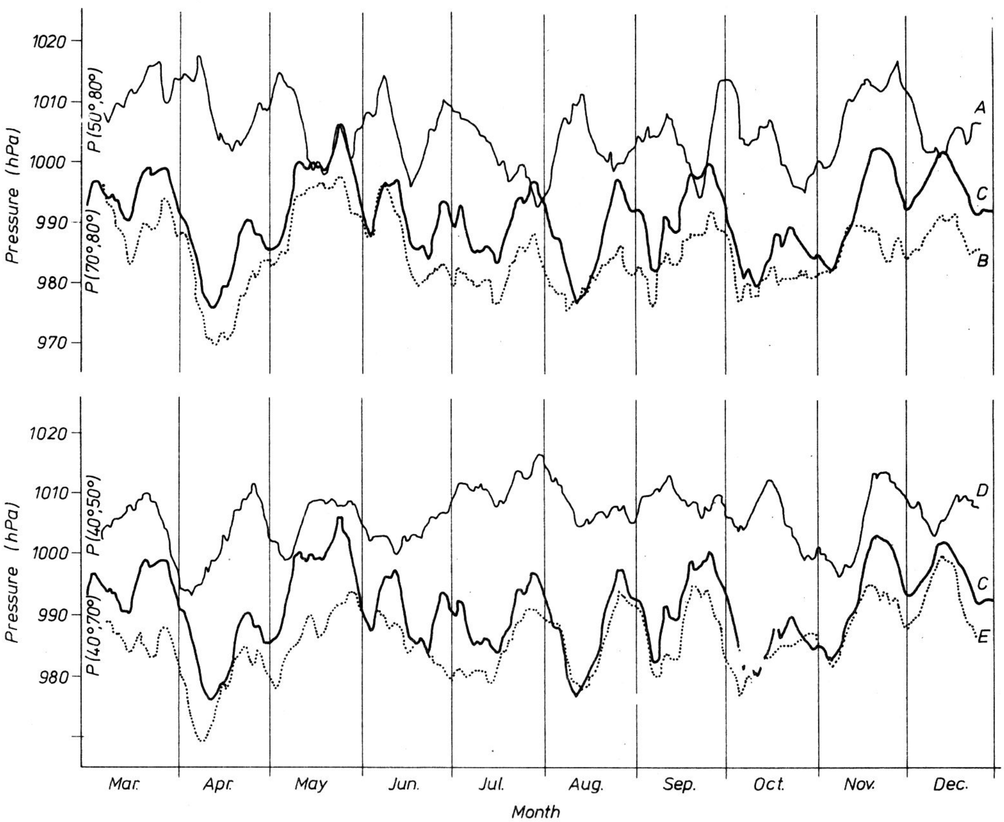

Fig. 5. Course of surface pressure in different points of the Antarctic part of south-west Atlantic, March through December 1979:
A — in the north-western edge of the area (50°S, 80°W) B — in the south-western edge of the area (70°S, 80°W) C — at the Arctowski Station, in the approximately central point of the area (62°S, 58°W) D — in the north-eastern edge of the area (50°S, 40°W) E — in the south-eastern edge of the area (70°S, 40°W)

Let us first consider the northern edge of the area. In its north-western point (Fig. 5A) the long term pressure oscillations were comparatively regular, with eight maxima and periods of 28—40 days. The amplitudes varied between 15 and 20 hPa. Likewise oscillations of shorter periods, between 15 and 20 days, were to be found, apart from the 2—5 day ones already mentioned. If we consider the ten months as a whole, we will be able to distinguish a weak minimum in the winter months.

In the north-eastern point of the area, over the Atlantic, the regularity of pressure variations was less pronounced (Fig. 5D). Regular variations during the autumn months, of periods similar to those on the western edge, must be admitted. The 30—40 days periodicity, however, for June — September was not so obvious. In October, November and December the pressure showed again regular oscillations with periods of over 30 days. The amplitudes were more differentiated than in the north-east and varied between 25 and 10 hPa. For the ten months as a whole one could speak of a slight maximum in winter.

The course of pressure in both the extreme points of the southern edge of the area, along 70° of latitude, showed a greater similarity (Fig. 5B, E), than the relevant points in the north. One of the reasons is that the distance between the southern extreme points is twice as small as between the northern ones. (Fig. 2, 3 and 4). In the south, during autumn and at the beginning of winter the periods of oscillations were almost twice as long as in the north. In both the southern extreme points the maximum at the turn of March and the next minimum were in phase. The fragment of the pressure curve between May and mid-July, although deformed by small oscillations, maintained similar tendencies in both the points. Beginning from mid-July distinct long period oscillations appeared again, the average period being 30 days. No phase shift was observed and the amplitudes were similar in both the areas.

Special interest was paid to the pressure course at the Arctowski Station (Fig. 5C). An interesting feature of its variation was the great regularity of the long term oscillations and its response to the changes occurring in the edge points, described before.

Some fragments of the pressure curve, for example between mid-March and mid-May, were almost quite consistent with the changes in the southern outskirts of the area (Fig. 5B, E). From mid-May to the end of June a great resemblance could be found with the variations in the western edge of the area, especially in the north-western part of it; for example the pressure maximum on the Arctowski Station in the second half of May is reflected as a somewhat weaker maximum in the north-western part of the area and only as a slight rise of pressure in the south-west. Nevertheless, the rise was distinct and remained in phase with both the maximum at the Station and in the north-western part of the area. Another maximum on the beginning of June was equally distinct in all the three points considered. The next increase of pressure that followed at the turn of June could be observed as a pretty shaped maximum in the north-west, whereas the pressure line for the Arctowski Station showed a somewhat deformed, smaller peak, and in the south-west only a very flat maximum could be distinguished.

But other details, compared with the ones recorded at the Arctowski Station, were maintained. For instance, a drop of pressure at the turn of June is clearly seen in the top part of the Station maximum as well as in the pressure line for the south-western point. Later in July and August the pressure course at the Station was influenced by the same pressure processes as the considered neighbouring areas, but the extreme north-west. Afterwards, from mid-August till the end of the year the variations at the Station were strikingly consistent with the pressure at the southeastern edge of the area.

7. Conclusions

The analysis of the mean pressure field has been based on material from the cold period of 1979, extending over December that year, as a month of the warm season, for the purpose of comparison. The following features of distribution and course of pressure became especially evident:

1. Confirmed was — published previously by a number of authors — frequent occurrence of a col or ridge of high pressure over the Antarctic Peninsula (Taljaard et al. 1969, van Loon et al. 1972).

2. Similarly, confirmation was gained on the increased zonal circulation in the transitional months, between winter and summer (Schwerdtfeger 1970, Gusev 1959); in 1979 it was especially high in April.

3. Both stationary depressions — the west Atlantic and east Pacific centres of action of circumpolar Antarctic low pressure belt showed an approximately half-yearly oscillation near the Antarctic Peninsula.

4. Standard deviation used as a measure of the pressure field dynamics was within ± 16 hPa; the lowest fluctuations of this statistical parameter occurred over the Atlantic, in the north-eastern part of the region discussed, and the highest ones — over Patagonia and the Drake Passage; these values were consistent with those given by van Loon (1969) for these latitudes.

5. The variation of pressure in practically all parts of the field considered showed quasi-regular fluctuations, which could be identified with the oscillations of the west wind belt in those latitudes. The most pronounced periods were 30—40 days long.

6. From the shape of the variation curves for the north — western and north-eastern edges of the area (Fig. 5A, D) it might be concluded that the phase lag of the pressure wave between those points varied from about 30 to 10 days. Sometimes, however, no shift at all could be found.

8. Summary

On the basis of daily synoptic weather maps broadcasted by RMC Buenos Aires maps of average monthly pressure over the southwestern part of Atlantic were drawn for the period from March through December 1979.

The main feature of the pressure field was its heigh zonality and, despite the monthly averaging, high values of the horizontal gradient (Fig. 2), which in April exceeded 2 hPa per 100 km in the belt between 55° and 60° of latitude. The average monthly pressure in the whole period was within 1010 hPa to the north-west (March and April) and 1005 hPa to the north-east (March and July), 984 hPa to the south-west (July and August) and 978 on the south-western edges (April).

The area of the lowest pressure persisted over the Weddell Sea between March and May. In June it lied symmetrically on both sides of the Antarctic Peninsula; in July, August and September it moved to the west, over the Bellingshausen Sea, to return again in late spring over the areas to the east of the Peninsula.

An analysis of the variability of the pressure field using standard deviation and skewness coefficient revealed the smallest deviations over the Bellingshausen and Scotia Sea, where they were limited to 7—10 hPa. The greatest deviations occurred in the vicinity of Tierra del Fuego, where they exceeded 15 hPa (Fig. 3). The highest skewness coefficients were encountered over the southern outskirts of the area, especially over the Weddell Sea (Fig. 4).

In December, the summer month differing from the cold season by the character of circulation a comparatively weak pressure gradient was observed. In close relation to this were the lowest standard deviations and the lowest (as to the absolute value) skewness coefficients of all the months considered (Fig. 2, 3 and 4).

The course of overlapping 11-day means of pressure in several points of the area: in its four corners and on the centrally situated Arctowski Station — showed a considerable periodicity. The lenght of the most pronounced periods ranged from 30 to 40 days approximately (Fig. 5).

9. Резюме

В основании на ежедневных синоптических картах трансмиттованных по радио из Буэнос Аирес составлены карты средних давлений из периода от марта до декабря 1979 года, охватывающие антарктическую часть южно-западной Атлантики.

Основной чертой поля давления в этой области была сильная зональность а также сильные — несмотря на подсчитывания за весь месяц — величины горизонтального градиэнта давления (рис. 2). Рекордным в этом отноиении был апрель, когда между 55° и 60° параллель средний градиэнт перешёл 2 hPa на 100 км. Средние месячные давления во всём периоде выступали в пределах от около 1010 hPa на северо-западе (в марте и впреле) и 1005 hPa на северо-востоке (в марте и июле) до 984 hPa наюго-западе (в июле и августе) и 978 hPa на юго-восточных границах (в апреле). Район минимальных давлений оставался от марта до мая над морем Ведделя. В июне он растягивался симетрически по обеим сторонам Антарктического Полуострова, в июле, августе и сентябре передвинулся на запад на море Беллингсгаузена, чтобы поздней весной возвратиться на восток от Полуострова.

Анализ изменчивости барического поля проведен на основании величины стандартного отклонения определил малейшие колебания давления над морем Скотия и морем Беллингсгаузена, где они ограничивались до 7—10 hPa. Самые большие колебания выступили в близи Огненной Земли, где перешли 15 hPa (рис. 3). Самыми большими по абсолютной величине коэфициентами ассимметрии характеризовались южные границы анализированного района, особенно моря Ведделла (рис. 4).

Декабрь уже летний месяц, отличающийся от рассмотренных месяцев холодного периода характером циркуляции имел малейший градиэнт давления как и малейшие стандартные отклонения и коэфициенты ассимметрии всего анализированного поля (рис. 2, 3 и 4).

Ход средних консекутивных 11-дневных величин давления, в нескольких пунктах района: в его четырёх углах и в расположенной в его середине Станции Арцтовского указывает значительную периодичность. Продолжательность более чётких периодов колеблется в приближении от 30 до 40 дней (рис. 5).

10. Streszczenie

W oparciu o codzienne mapy synoptyczne transmitowane przez radio z RMC Buenos Aires wykonano mapy średnich ciśnień z okresu od marca do grudnia 1979 roku obejmujące antarktyczną część południowo-zachodniego Atlantyku.

Zasadniczą cechą pola ciśnienia na tym obszarze była bardzo silna strefowość oraz bardzo duże — mimo uśredniania za cały miesiąc — wartości poziomego gradientu ciśnienia (rys. 2). Rekordowym pod tym względem był kwiecień, kiedy to pomiędzy równoleżnikami 55° i 60° średni gradient przekroczył 2 hPa na 100 km. Wartości średnich ciśnień miesięcznych w całym okresie zamykały się w granicach od około 1010 hPa na północnym zachodzie (w marcu i kwietniu) i 1005 hPa na północnym wschodzie (w marcu i lipcu) do 984 hPa na południowym zachodzie (w lipcu i sierpniu) i 978 hPa na krańcach południowo-wschodnich (w kwietniu). Obszar najniższych ciśnień pozostawał od marca do maja nad Morzem Weddella. W czerwcu leżał symetrycznie po obu stronach Półwyspu Antarktycznego; w lipcu, sierpniu i wrześniu przemieścił się na zachód, nad Morze Bellingshausena, by późną wiosną wrócić znowu nad obszary na wschód od Półwyspu.

Analiza zmienności pola barycznego wykonana na podstawie wielkości odchylenia standardowego wykazała najmniejsze wahania ciśnienia nad Morzem Scotia i Morzem Bellingshausena, gdzie ograniczały się one do 7—10 hPa, największe zaś wystąpiły w sąsiedztwie Ziemi Ognistej, gdzie przekraczały 15 hPa (rys. 3). Największymi co do wartości bezwzględnej wyspółczynnikami skośności charakteryzowały się południowe krańce rozważanego obszaru, zwłaszcza Morza Weddella (rys. 4).

Grudzień, miesiąc już letni, różniący się od rozpatrzonych miesięcy okresu chłodnego charakterem cyrkulacji, miał zarówno najmniejszy gradient ciśnienia jak i najmniejsze odchylenia standardowe i współczynnik skośności całego analizowanego pola (rys. 2, 3 i 4).

Przebieg średnich konsekutywnych 11-dniowych wartości ciśnienia w kilku punktach obszaru: w czterech jego narożach i na leżącej w punkcie środkowym Stacji Arctowski wykazuje znaczną okresowość. Długości najwyraźniejszych okresów wahają się w przybliżeniu od 30 do 40 dni (rys. 5).

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