# *The Isoporic Charts of the Antarctic for the Period of 1959-1964*

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As a result of the efforts of a number of the countries during the recent 5–10 years along the Antarctic seashore was organized a net of magnetic observatories nearly as dense as the nets in the other continents. But, beyond the Antarctic Continent, over the vast areas of the Southern oceans the information on SV might be obtained only at the island and continental observatories, which are situated irregularly and at a great distance from one another. The sharp and not monotonous variations of the annual mean values $X$, $Y$ and $Z$ at the magnetic observatories of the Southern Hemisphere may be hardly attributed to the secular variation of the geomagnetic field only. To some degree they are influenced by the geomagnetic disturbances, insufficient accuracy of the basic values, and perhaps by some other causes. Therefore, even the values of SV averaged at 5 years intervals may be erroneous from the viewpoint of the inner secular variation. These two arguments, shortage of data and their poor accuracy for the Antarctic, render it both necessary and instructive to utilize the results of spherical harmonic analysis of the world-spread data in the compilation of SV charts for the Antarctic. But the coefficients of this analysis must be chosen so as to represent the distribution of SV in the Antarctic with the highest reliability; of course such analysis will not be representative on the world-wide scale.

In 1966, up to the time of the Antarctic charts compilation, the mean annual values, mostly up to 1964, at the world magnetic observatories were collected. The values of $\delta X$, $\delta Y$, $\delta Z$ at 138 points, 127 of which are at the magnetic observatories, were analyzed. To estimate the truncation of the spherical harmonic series and to choose the number of the coefficients the following considerations were used:

1. The external part of the SV field, when the average values of five years are used, may safely be neglected[1]. Therefore, separation of the SV into inner and external parts is not reasonable, especially when the accuracy of the data is taken into account.

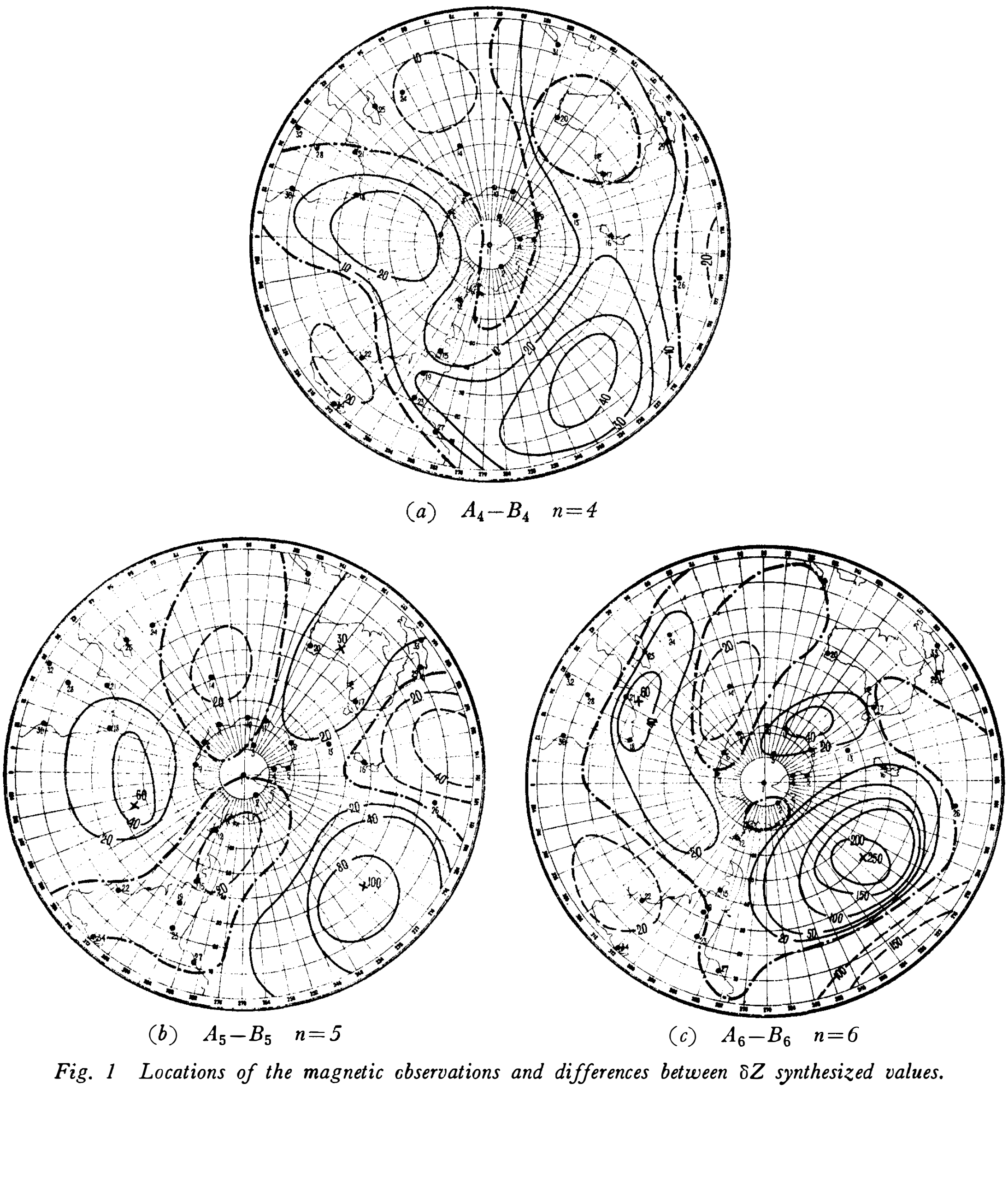
2. On the earth's surface three rectangular components of the SV field may be expressed as:

$$\delta X = n\sum_{n=1}^{k}\sum_{m=0}^{n}(\delta g_n^m \cos m\lambda + \delta h_n^m \sin m\lambda)\, X_n^m \qquad (1)$$

$$\delta Y = n \sum_{n=1}^{k} \sum_{m=0}^{n} (\delta g_n^m \sin m\lambda - \delta h_n^m \cos m\lambda)\, Y_n^m \qquad (2)$$

$$\delta Z = -(n+1) \sum_{n=1}^{k} \sum_{m=0}^{n} (\delta g_n^m \cos m\lambda + \delta h_n^m \sin m\lambda) P_n^m \qquad (3)$$

Where $X_n^m$, $Y_n^m$, $P_n^m$ are LEGENDRE's polynoms, depending on $\theta$, $m$, $n$ in the SCHMIDT quasi-normalized form, $\theta$, $\lambda$ are the coordinates of the input data, $\delta g_n^m$ and $\delta h_n^m$ are the coefficients, depending on the intensity and distribution of the SV field. The coefficients $\delta g_n^m$ and $\delta h_n^m$ in the equations 1, 2 and 3, taking into account the potentiality of SV field and external part being zero, may be con-



(a) $A_4 - B_4$ $n=4$

(b) $A_5 - B_5$ $n=5$

(c) $A_6 - B_6$ $n=6$

*Fig. 1 Locations of the magnetic observations and differences between $\delta Z$ synthesized values.*

sidered equal, within the accuracy of input data. Then the differences between the values of one of the SV components, synthesized from the coefficients, deduced from the analyses of the other components may be used as a guide in fixing the order of the spherical harmonic series and in estimating the reliability of the analytical representation of SV.

On the basis of 138 values, distributed over the earth's surface, three subsequent analyses were performed up to $n=m=4$, $n=m=5$ and $n=6$, $m=6$, $m=5$ when $m=6$ excluded (44 coefficients). Separate solution for each component was used, and after the coefficients were computed from $\delta X$ and $\delta Y$ coupled:

$$\delta g_n^m(\delta X, \delta Y)=\frac{\delta g_n^m(\delta X)+\delta g_n^m(\delta Y)}{2}$$

$$\delta h_n^m(\delta X, \delta Y)=\frac{\delta h_n^m(\delta X)+\delta h_n^m(\delta Y)}{2}$$

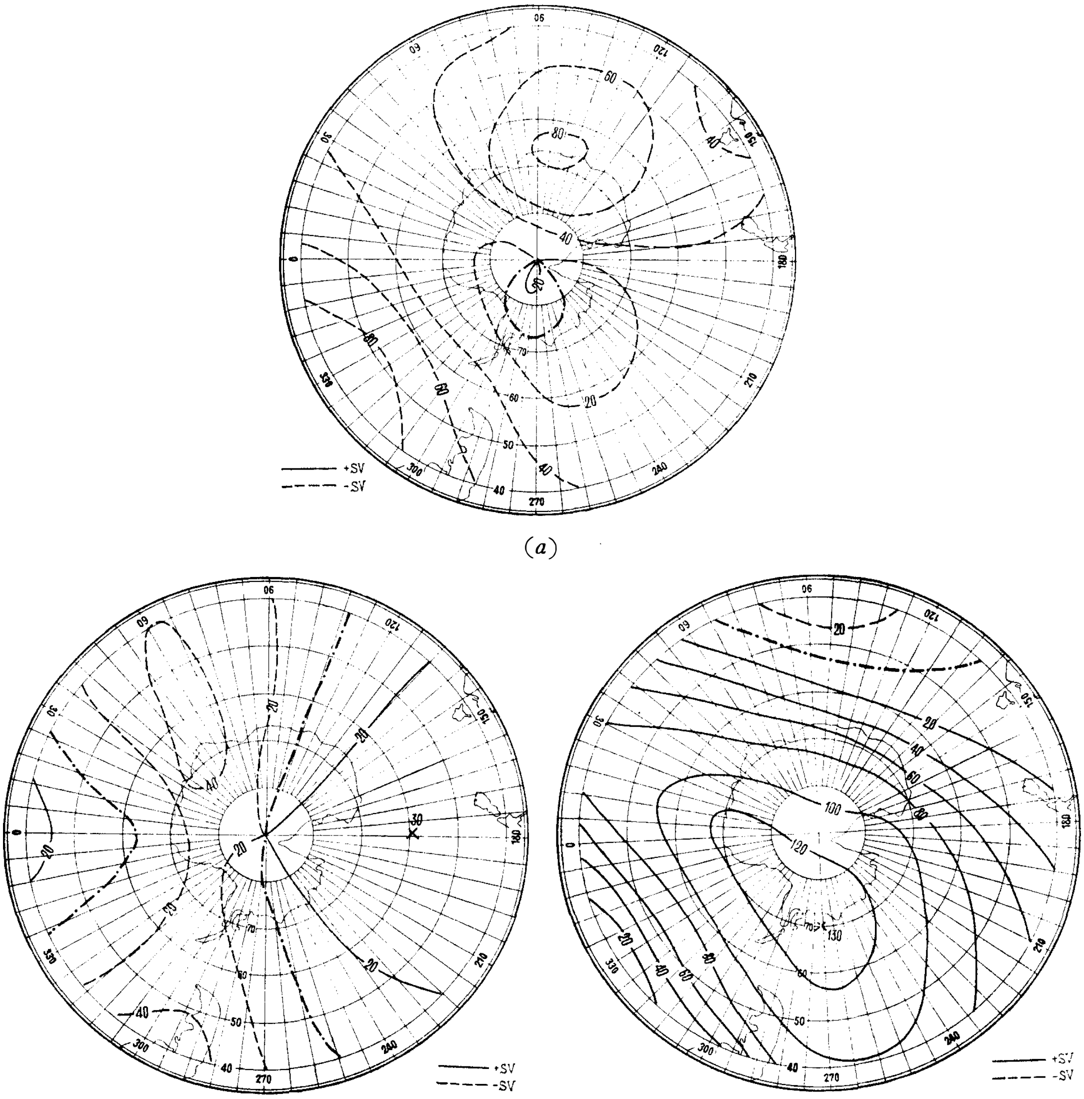
So, for each analysis two sets of coefficients were obtained and, using them, the corresponding syntheses of $\delta Z$ were performed. For simplification we marked $A_n$ to those based on $\delta Z$ and $B_n$ to $\delta X$, $\delta Y$. The vertical component of SV field was preferred because of its more complicate configuration and bigger errors of the input data; owing to more difficulties in the representation of $\delta Z$ than $\delta X$ and $\delta Y$. The differences between $\delta Z$ synthesized values are given in Figs. 1 (a)-(c). Within the Antarctic Continent these differences do not exceed $20\gamma$ in the analyses to the 4th and 5th orders and increase insignificantly to the 6th order. Off from the Antarctic Coast the differences increase for all $n$, especially for $n=6$ and on the Pacific Ocean they reach the striking value of $\sim 250\gamma$. If Figs. 1 (a),(b) and (c) are compared with the locations of the magnetic observatories, it will be easily recognized that the largest differences occur in the

*Table 1. Mean and maximum values of* $\delta Z_{obs}-A_n$ *and* $\delta Z_{obs}-B_n$.

| | $n$ | $\sum\pm(\delta Z_{obs}-A_n)$ | $\delta Z_{obs}-A_n$ | $\delta Z_{obs}-B_n$ | $\sum\pm(\delta Z_{obs}-B_n)$ |
|---|---|---|---|---|---|
| SE | 6 | +157 mean | 15 | 23 | +440 |
| | | −221 max. | 37 | 30 | −151 |
| SW | 6 | + 69 mean | 12 | 13 | + 41 |
| | | − 63 max. | 28 | 33 | −108 |
| SE | 5 | +197 mean | 16 | 22 | +374 |
| | | −219 max. | 40 | 66 | −191 |
| SW | 5 | + 30 mean | 9 | 16 | + 1 |
| | | − 54 max. | 29 | 35 | −130 |
| SE | 4 | +242 mean | 19 | 21 | +363 |
| | | −218 max. | 42 | 42 | −185 |
| SW | 4 | + 41 mean | 9 | 10 | + 35 |
| | | − 60 max. | 20 | 31 | − 72 |

areas farthest from the observatories.

For the Antarctic Continent a good agreement of $A_n$ and $B_n$ is reached when 5 terms of the spherical harmonic series are summed, but in this case the $A_n-B_n$ differences to the north are two times greater than when only 4 terms are summed. In order to minimize errors over the oceanic area, which is the basis of compilation of Antarctic SV charts, the results of synthesis $\delta X$, $\delta Y$, $\delta Z$ up to $n=4$, are used but with some correction in the position of SV lines near the magnetic observatories. Then values of $A_n$ and $B_n$ were compared with the observed $\delta Z$ values for the observatories of the Southern Hemisphere. The divergences $\delta Z_{obs}-A_n$ appeared naturally less than $\delta Z_{obs}-B_n$, as observed values of $\delta Z$




(a) (b) (c)

*Fig. 2 Isoporic charts of the Antarctic ($\delta X$1959–1964).*

were initial for $A_n$. Taking into account the low density of southern observatories, $\delta Z_{obs}-A_n$ may be regarded as the least error, or the error in the vicinity of the magnetic observatories. The divergences $\delta Z_{obs}-B_n$ do not depend on input $\delta Z$ values, so they may be considered mean errors, peculiar to the Southern Hemisphere in the whole. The mean and maximum values of $\delta Z_{obs}-A_n$ and $\delta Z_{obs}-B_n$ are given in Table 1.

The mean value of $\delta Z-A_n$ and $\delta Z-B_n$ are in a good agreement when four terms of the spherical harmonic series are summed. The maximum values differ insignificantly, and their distribution according to plus and minus is rather uniform. The errors of the synthesis in this case, and consequently the errors of the charts based on it, are about 10–15$\gamma$, which increase up to 30–40$\gamma$ over separate areas and, to all appearance over the world oceans in the first. The isoporic charts (Fig. 2) of the Antarctic for the period of 1959–64, proposed here, differ from those compiled for the period of 1956–59[2]. In $\delta X$ and $\delta Y$ these variations are not significant, 10–15$\gamma$ on average and only between longitudes 220°–240° and 20°–40° they increase for $\delta Y$ up to 30–40$\gamma$. The variations of such magnitude may be ascribed to real SV-changes, as well as to some changes in the sets of initial data used for both periods. No data were available at Little America ($\varphi=78°$, $\lambda=196°$) for the last period, and very important Japan observatory Syowa ($\varphi=69°$, $\lambda=40°$) was closed in 1962. The changes between $\delta Z$ charts for these two periods are large, and it would not be reasonable to ascribe them completely to the real change in $\delta Z$ during such a short time interval. It is more appropriate to ascribe these large differences to the errors of both sets of charts, resulting from the poor distribution and uneven quality of the initial data.

Most of the Antarctic observatories were organized quite recently, and have no long-time series of observations, so that the annual mean values are sometimes low in accuracy.

## References

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