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Mishin, V.M., Bazarzhapov, A.D., Nemtsova, I.E., Sholpo, M.E. "Mgnovennie" kartini Sq-tokov po dannim cezona ravnodenstviia MGG" Akademiya Nauk SSSR. Sibirskoe Otdelenie. Sibirskogo Instituta Zemnogo Magnetizma, Ionosferi i Rasprostraneniia Radiovoln, Izvestiya. No. 1, 49-61 (1966)

"INSTANTANEOUS" ASPECTS OF SQ-CURRENTS ACCORDING TO DATA ON THE EQUINOX SEASON DURING THE IGY

N69-32715

Introduction

The modern ideas on quiet sun-daily geomagnetic variations are in general, expressed as follows. It is assumed that the main cause for the existence of Sq-variations is the system of currents in the lower ionosphere. This currents system is composed, in the median and low altitudes* of two vortices (turbulences), one vortex in the northern and one in the southern hemispheres, with centers close to the noon meridian, at 30 40° latitudes.

The current intensity (1 plus 3.10^5 amp) increases from winter toward summer and depends upon the phase of the 11-year sun cycle. Near the magnetic equator there exists a zone of maximum current density which is the equatorial electric flux. The external (ionospheric) system of currents is created by the dynamo-effect. Currents in the ionosphere induce an analogous current system in the conductive Earth layers.

* While deducting Sq-variations from the night level of the geomagnetic field during quiet days.

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These concepts refer to mean daily (static) systems of Sq-currents and are based, mainly, on works of Shuster (1), Chapman (2) and Bartels (3). The calculation method of current systems used in these computations was suggested by Shuster (1). The method pre-supposes the independence of Sq-currents upon the universal time of the day in the system of reading which is immobile in relation to the Sun.

The second state of investigations of Sq-variations was begun in a series of articles by Hasegawa (4) devoted to the dynamics (changeability) of Sq-currents. Hasegawa has established that from one day to another and during a 24 hour period, Sq-currents experience significant changes in the magnitude of the full current as well as in the configuration of current lines.

His deductions were complemented in the articles of N.P. Ben'kova (5) and Price and Wilkins (6); all these authors, including Hasegawa made attempts to build "instantaneous" systems of Sq-currents and confirmed the existence of a significant changeability in the basic parameters of current systems.

Articles (4 - 6) were completed on the basis of data obtained during the IGY from materials relating to geomagnetic observations.

The present study is a continuation of the investigation of the dynamics of the Sq-field based on materials of the world network of IGY stations utilizing the modern fast-acting computer technique. The main aims of the article are the following: to work out a method of computation of the "instantaneous" current systems responsible for Sq-variations and learning about the regular changes in the Sq-field as affected by the universal time of day.

Method of analytical presentation of an "instantaneous" Sq-field

The most widely-used method of analytical description of geomagnetic fields is based on the possibility of a precise determining of the field potential as an infinite series of spherical functions. When possessing data from a finite number of magnetic stations we can determine with their help the finite number of coefficients of the approximating series, in other words, we can find the approximate analytical concept of a geomagnetic field. Thus, for instance, the vertical component of the Sq-field may be presented by the series

$$Z(\theta,\lambda)=\sum_{n=0}^{K}\sum_{m=0}^{n}\left(j_n^m\cos m\lambda+k_n^m\sin m\lambda\right)P_n^m(\cos\theta), \qquad (1)$$

where $P_n^m(\theta)$ are the added Legendre polynoms. The coefficients j_n^m and k_n^m may be found by solving the system of linear equations of the (1) type each of which contains in the left part the value Z_i measured at the station by means of coordinates θ_i, λ_i.

The number of such equations is equal to the number of magnetic stations (N). It is evident that the number of the j_n^m, k_n^m coefficients in (1) (let us designate this number as R) cannot exceed N. However, a certain considerable indefiniteness still persists. First of all, the R value may be of any magnitude from 1 to N. Secondly, at a given R, there exists an infinite number of combinations of spherical functions which may enter the approximating series (1).

It is important to note that precision in the computation of the coefficients of series (1) depends very strongly upon the selection of the R value and the actual spectrum of approximating functions. As can be seen from Fig. (1) (taken from (7)) a doubling of the R value may change the values calculated for coefficients j_n^m, k_n^m an entire order and even more.

It follows, that the practical important question is in the manner of selection in (1) the number of members $R < N$ and the spectrum of approximating spherical functions in order to ensure the most precise determination of the j_n^m, and k_n^m coefficients.

The approximation method of selecting the optimal spectrum of spherical functions which would approximate the Sq-field as given for a non-homogeneous network of magnetic stations is only individual feature in our method of analytical presentation of "instantaneous" Sq-fields as compared with well-known methods of spherical harmonic analysis.

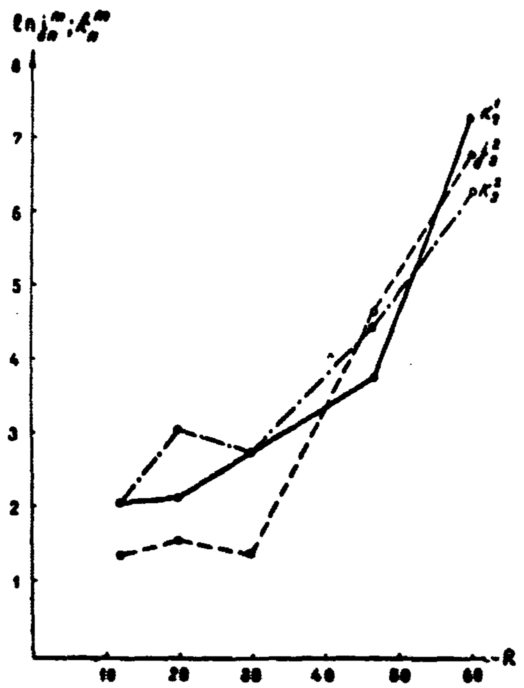

Fig. 1. Dependence of coefficients of spherical analysis upon the length of the approximating series.

This method has been described in (7). The main ideas are as follows:

a) let us write (1) as:

$$Z(x_i)=\sum_{K=1}^{R} d_K^* G_K(x_i), \quad i=1,2\ldots N;\ R \leq N . \qquad (2)$$

Here x_i is the marking of a point with the coordinates θ_i, λ_i; $G_k(x)$; G_k (x) is one of the polynoms $\left.\begin{matrix}\sin m\lambda\\ \cos m\lambda\end{matrix}\right\} P^m_n(\cos\theta)$.
The presentation of Z(x) according to (2) is approximate inasmuch as the precise presentation is spelled out as

$$Z(x_i)=\sum_{K=1}^{R} d_K G_K(x_i)+\sum_{K=R+1}^{\infty} d_K G_K(x_i)+\Delta_i \quad , \qquad (3)$$

where d_k are the Fourrier **series**, Δ_i **are** errors in measurements In order to find the errors $\Delta d_k^* = d_k^*$ it is expedient - as suggested by Fougere (8) to change from the system of N functions of $G_k(x)$ to the system of N functions of $\Phi_k(x)$ which possess orthogonality in the network of magnetic stations.

If the system of the $G_k(x)$ functions is given and their consecutivity is determined, the change-over from the $G_k(x)$ functions to the $\Phi_k(x)$ functions is performed simply following the Gram-Schmidt formulae: $\Phi_1(x)=G_1(x)$,

$$\Phi_2(x)=\alpha_{21}\Phi_1(x)+G_2(x),$$

....

.... ,

$$\Phi_K(x)=\sum_{p=1}^{K-1}\alpha_{Kp}\Phi_p(x)+G_K(x) , \qquad (4)$$

$$\alpha_{Kp}=-\frac{(G_K,\Phi_p)}{(\Phi_p,\Phi_p)} .$$

* (See footnote pag.11)

Then from the system of conventional equations

$$Z(x_i)=\sum_{K=1}^{R} d_K^* G_K(x_i)=\sum_{K=1}^{R} a_K' \Phi_K(x_i) \qquad (5)$$

we find the coefficients

$$a_K'=\frac{(Z,\Phi_K)}{(\Phi_K,\Phi_K)} \qquad (6)$$

and the coefficients

$$d_K^*=\sum_{l=K}^{R} \beta_{lK}\cdot a_K' \quad , \qquad (7)$$

which satisfy the condition of a minimum of the mean square error of the approximation. The formulae (6) are obtained by the scalar multiplication method (5) by $\Phi_k(x)$; the formulae (7) - by substituting (4) into (5) and by adjusting the coefficients of $G_k(x)$ in both the right and the left part of the equation:

$$\sum_{K=1}^{R} d_K^* G_K(x_i)=\sum_{K=1}^{R} a_K' \Phi_K(x_i) .$$

We may obtain (8) in the same manner:

$$\beta_{kk}=1, \quad \beta_{Kp}=\sum_{m=p}^{K-1}\alpha_{Km}\beta_{mp} \quad , K=1,2\dots,R;\ p=1,2\dots,K .$$

From the above, as well as from (4) we see that the values β_{lk} do not depend upon the selection of R; they are constant for a given stations network, when the consecutivity of N functions of $G_k(x)$ has been pre-established. Similarly, (under the same conditions) the selection of R does not effect the values of coefficients a'_k. Therefore, the values d_k^* and their errors depend upon the selection of R.

It is easy to establish (7) that

$$\Delta d_K^* = \sum_{i=K}^{R} \beta_{iK} \Delta a'_i - \sum_{i=R+1}^{N} \beta_{iK} a_i \; , \qquad (8)$$

where

$$\Delta a'_K = \frac{(\delta Z, \Phi_K)}{(\Phi_K, \Phi_K)} \approx \frac{0{,}8\,\overline{|\delta Z|}}{\sqrt{(\Phi_K, \Phi_K)}} , \qquad (9)$$

$$\delta Z_i = \sum_{n=R+1}^{\infty} d_n G_n(x_i) + \Delta_i \quad . \qquad (10)$$

Here $\Delta a' = a' - a$; the coefficient a coincides with a' at $\delta Z = 0$. The method of evaluating the magnitude δZ is described in (7).

Formula (8) may serve as a basis for an optimal selection of $G_k(x)$ functions which participate in the approximation (2). As a matter of fact the components of both sums in the right part (8) may be considered as a sum of random sign-changing values not

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* Fougere (8) is the author of the first type of objective selection of the spherical functions spectrum which approximate the "instantaneous" geomagnetic field. This method is briefly described in (7).

correlated between themselves. For this type of values y_1 the co-relation justified reads as follows:

$$\sum_{i=1}^{N} y_i \approx \sqrt{N}\,|y|. \qquad \text{Therefore}$$

$$(\Delta a_K^*)^2 \approx \sum_{i=K}^{R}(\beta_{iK}\Delta a_i')^2 + \sum_{i=R+1}^{N}(\beta_{iK}a_i)^2 - 2\sqrt{(R-K)(N-R-1)}\left|\beta_{ik}a_i'\beta_{jp}a_j'\right| .$$

It is apparent from the above that modulus Δd_k^* changes - when the R increases per unit - due to the fact that, in the right part, the component $(\beta_{R+1,K}\,a_{R+1})^2$ is replaced by the component $(\beta_{R+1,K}\,\Delta a'_{R+1})^2$. It is evident that the next step in the R increase will diminish modulus Δd_k^* under the condition that:

$$\left|\frac{\Delta a'_{R+1}}{a_{R+1}}\right| < 1 .$$

Therefore, the optimal spectrum of the approximating series contains functions $\Phi_k(x)$ for which

$$\left|\frac{\Delta a'_K}{a_K}\right| < 1 . \qquad (11)$$

b) it is impossible to directly utilize condition (11) inasmuch as the values a_k are not known. Therfore, it is possible, in principle, to achieve only a certain approximation to the optimal spectrum.

As calculations of Sq-fields have demonstrated, the values

$\Delta a'_k$ increase rapidly with the figure k. At that, the relative error of the a'_k coefficients after a certain $k = k_0$ remains, roughly speaking, on a constant level. These data make possible the assumption that, as the k values increase, the a_k values diminish. Under such conditions the selection of a spectrum of approximating functions longer than that of the optimal spectrum presents a greater danger than the selection of a spectrum shorter than the optimal one.

From (11) we may obtain the condition which insures the selection of a series of approximating functions, with a content not exceeding the optimal- with a given probability. As a matter of fact, assuming that $a'_k = a_k + \Delta a_k$ it is easy to establish that under the condition

$$\left|\frac{\Delta a'_K}{a_K}\right| < 0,5 \qquad (12)$$

the disparity (11) may be achieved with as much probability as $|\Delta a'_k| > |a'_k| - |a_k|$. Thus, condition (12) is an approximate equivalent of (11). A further approximation to the optimal spectrum is possible by the empirical method using additional physics considerations. These reserve possibilities have not as yet been experimented with.

The method described above was applied in a spherical harmonic analysis of Sq-fields based on data from the world network of magnetic stations of the IGY. Each analysis used mean hourly values $\delta X, \delta Y, \delta Z$* as obtained by adjusting to the international quiet days at one of the universal time hours. The Sq-fields calculated in this manner were called "instantaneous" in order to differentiate from the mean daily ones, calculated with the use of 24 consecutive hourly values of $\delta X, \delta Y, \delta Z$ instead of only one hourly value.

Regular variations of ionospheric Sq-currents with the universal time

"Equivalent" systems of currents were built according to the coefficients of the spherical harmonic analysis and pre-established altitudes ($h_e = 115$ and $h_i = -300$ km) using the usual method (3,5); these current systems create Sq-variations for eight consecutive moments (Figs. 2 - 9). The main parameters of such "instantaneous" systems built for the equinox season in 1958 and based on data obtained from stations in an amplitude of geomagnetic latitudes reaching from 10 to 60° are presented in table 1.

The list of the stations used in the analysis and their geographic coordinates are presented in table 2.

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* The $\delta X, \delta Y, \delta Z$ determine deflections of X.Y,Z from the level of the night time hours.

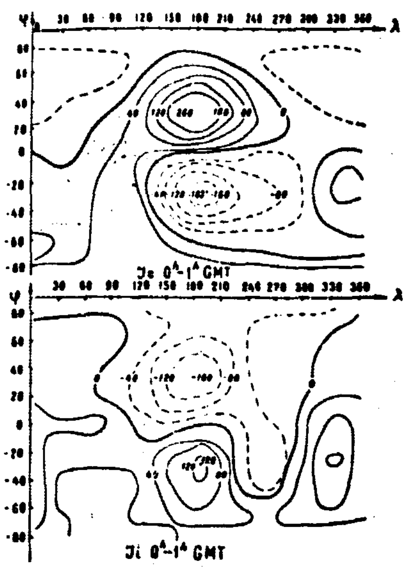

Рис. 2.

Fig. 2

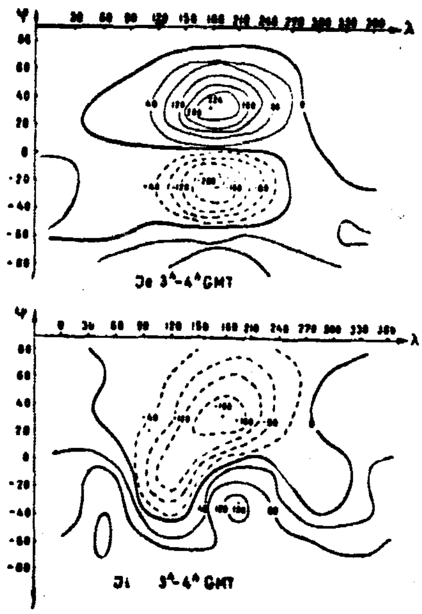

Рис. 3.

Fig. 3

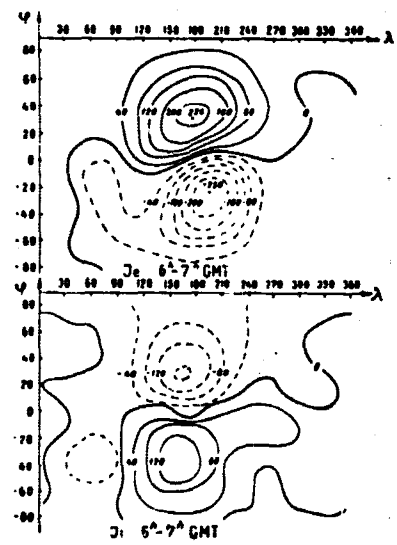

Fig. 4

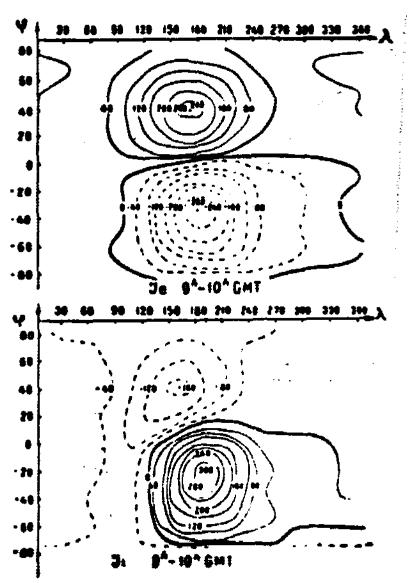

Fig. 5

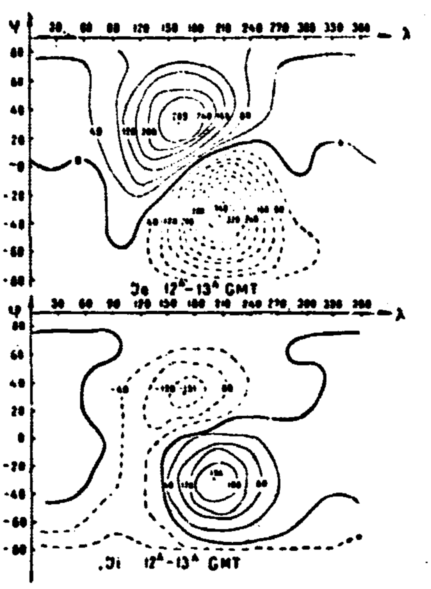

Рис. 6.

Fig. 6

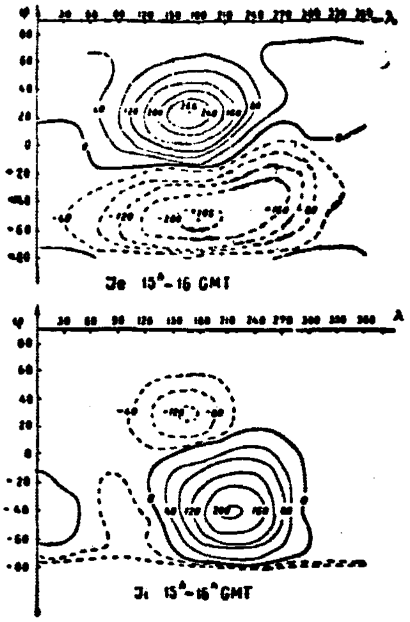

Рис. 7.

Fig. 7

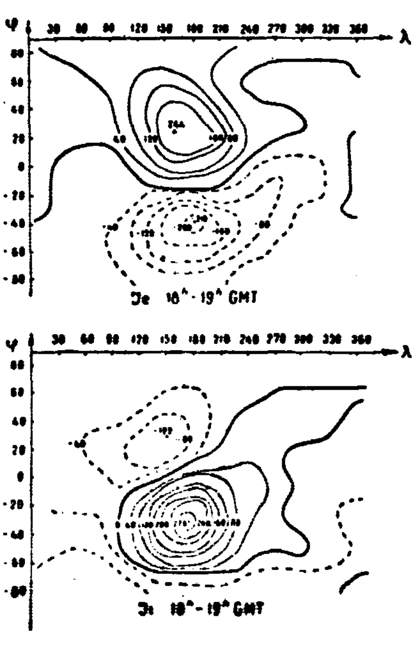

Fig. 8

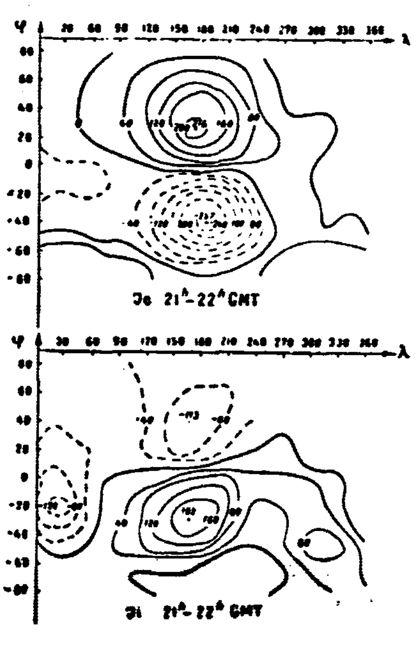

Fig. 9

The evaluation of **errors** ΔI **have** been obtained from a comparison of results of each month of the equinox season. Table 1 and Figures 10 and 11 reveal regular and considerable changes in Sq-currents with the unviersal time of day. The main characteristics of UT-variations in the external current systems are as follows:

1. Focuses of the northern and southern hemispheres are displaced with the motion of the unviersal time, along closed trajectories (Fig. 10). This rotation of focuses occurs basically in the counter clockwise direction in the northern hemisphere, and in the clockwise direction in the southern hemisphere. The amplitude of the 24 hour (daily) changes in the focus' coordinates exceeds 20° along the latitude, as well as longitudinally; at that, this amplitude is greater in the southern hemisphere than in the north. Minimal values of latitudes of two focuses take place at a moment close to noon, at the corresponding geomagnetic pole. It is not difficult to see a connection between these motions of the focuses and the 24 hour rotation of the northern and southern geomagnetic poles.

2. The intensities of the northern and southern vortices - the I_n and I_s magnitudes - experience regular changes with the UT (Fig. 11); the amplitude of these variations reach, within 24 hours 50% of the average daily level; at that this amplitude is greater in the southern hemisphere than in the northern one.

Table 1

The IT changes of the basic characteristics of Sq-currents

ИТ	0^h—1^h	3^h—4^h	6^h—7^h	9^h—10^h	12^h—13^h	15^h—16^h	18^h—19^h	21^h—22^h
I_N в 1000 a	206	225	224	245	289	266	244	216
θ_N	60°	57°	54°	54°	57°	66°	69°	63°
λ_N	175°	180°	175°	170°	160°	170°	165°	170°
I_s в 1000 a	—183	—209	—250	—263	—348	—205	—218	—257
θ_s	117°	114°	114°	123°	126°	141°	135°	129°
λ_s	180°	180°	195°	180°	200°	175°	175°	180°
Δ I в 1000 a	17	14	12	21	21	12	~ 12	—

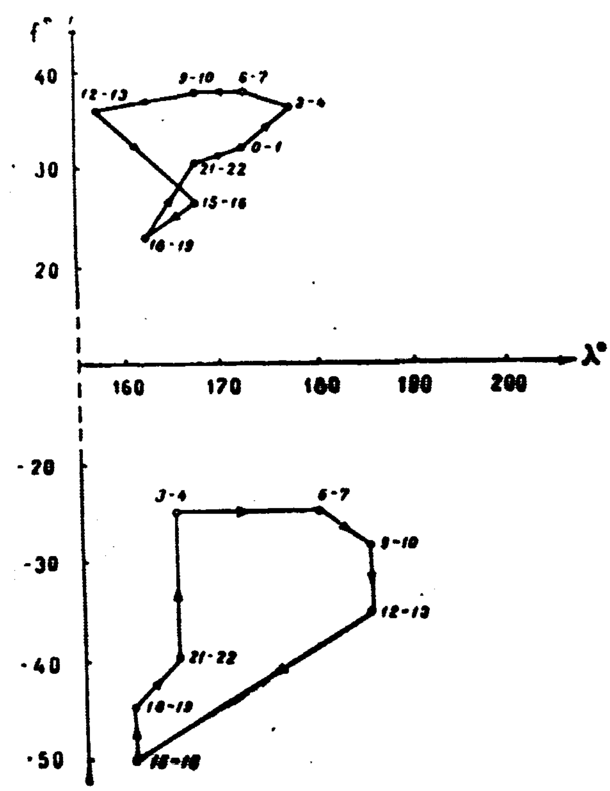

Fig. 10. Motion of the focuses of ionospheric Sq-currents systems during 24 hr UT

Ut-changes in I_n and I_s occur almost cophasally; the maximum of these magnitudes is reached at about 12 o'clock UT.

The cophasality of UT-variations in I_n and I_s is confirmed by the spherical harmonic analysis of Sq-variations according to data on the V - VIII season of IGY. These data are presented in Fig. 11 (dotted lines).

Two facts - the cophasality of UT-variations of I_n and Is and the appearance of the maximum of these magnitudes at about 12 o'clock UT would be difficult to understand from the point of view of the dynamo-theory of Sq-variations. As a matter of fact, the main region of Sq-current generation is found in the proximity of the noon meridian. These currents - if they originate due to the dynamo-action should become stronger when the Earth zones with larger values of the vertical component of the geomagnetic field "approach" the noon meridian. It is well known that the modulus Z is subjected to considerable changes when affected by the geographic longitude (λ). A harmonic analysis of function $|Z(\lambda)|$ performed using data (9) shows that the first (basic) harmonic of the function $|Z(\lambda)|$ has phases differing almost 180° in the northern and southern hemispheres.

Therefore, the UT changes in I_n and I_s expected according to the dynamo-theory should occur in the opposite phase; the main maxima of I_n and I_s should occur at about 16 o'clock UT in the northern hemisphere and at about 4 UT in the southern hemisphere.

Table 2

№	Название станции (Name of station)	φ	λ	№	Название станции (Name of station)	φ	λ
1	Якутск	62° 01′	129° 40′	37	Тбилиси	42° 05′	44° 42
2	Нурмиярви	60 30	24 39	38	Ташкент	41 25	69 12
3	Ленинград	59 57	30 42	39	Толедо	39 53	355 57
4	Лово	59 21	17 50	40	Прайс	39 36	249 10
5	Ситка	57 04	224 40	41	Белойт	39 29	261 53
6	Свердловск	56 44	61 04	42	Карролтон	39 22	266 38
7	Томск	56 28	84 56	43	Фредериксбург	38 12	282 38
8	Руде Сков	55 51	12 27	44	Альмерия	36 51	358 46
9	Казань	55 50	48 51	45	Какиока	36 14	140 11
10	Москва	55 28	37 19	46	Эспанола	35 49	253 56
11	Эскадалемюир	55 19	356 48	47	Симосато	33 35	135 56
12	Хэл	54 36	18 48	48	Туксон	32 15	249 10
13	Вингст	53 45	09 04	49	Асо	32 53	131 01
14	Иркутск	52 28	04 02	50	Каноя	31 25	130 53
15	Свидер	52 07	21 15	51	Хельван	29 52	31 20
16	Нимег	52 04	12 40	52	Таманрассет	22 48	05 30
17	Валенсия	51 56	349 45	53	Ча-па	22 21	103 50
18	Хартланд	51 00	355 31	54	Гонолулу	21 18	201 54
19	Киев	50 43	30 18	55	Теолоюкан	18 45	260 49
20	Дурбас	50 06	4 36	56	Алибаг	18 38	72 52
21	Пругоница	49 59	14 33	57	Сан-Хуан	18 23	29 53
22	Львов	49 54	23 45	58	М'Бур	14 24	343 03
23	Виктория	48 24	236 35	59	Парамарибо	5 50	304 58
24	Фурстен-Фельдбрюк	48 10	11 17	60	Фукене	5 28	286 16
25	Шамбон-ла Форе	48 01	2 16	61	Кейпер	−6 02	106 44
26	Гурбаново	47 54	18 12	62	Порт Моресби	−9 24	147 09
27	Ю. Сахалинск	46 57	142 43	63	Апиа	−13 48	188 14
28	Тихани	46 54	17 54	64	Моти Тахити	−17 33	210 23
29	Одесса	46 47	30 54	65	Уотеру	−30 19	115 53
30	Сурлари	44 41	26 15	66	Гнангара	−31 47	115 57
31	Гроска	44 39	20 46	67	Германус	−34 26	19 14
32	Мемамбетцу	43 55	144 12	68	Туланги	−37 32	145 28
33	Владивосток	43 41	132 10	69	Амберли	−43 09	172 43
34	Аженкорт	43 47	280 44	70	Треле	−43 15	294 41
35	Панагюрище	42 31	24 11	71	Кергулен	−49 21	70 15
36	Логроньо	42 27	357 30	72	Аргентина	−65 95	295 44

1. Yakutsk
2. Nurmiyarvi
3. Leningrad
4. Lowo
5. Sitka
6. Sverdlovsk
7. Tomsk
8. Rude Skov
9. Kazan'
10. Moscow
11. Escadalemuir
12. Hall
13. Wingst
14. Irkutsk
15. Svider
16. Nimeg
17. Valencia
18. Hartland
19. Kiev
20. Durbas
21. Pruhonice
22. Lvov
23. Victoria
24. Fursten-Feldbruck
25. Chambon-la Foret
26. Hurbanovo
27. So. Sakhalinsk
28. Tihanyi
29. Odessa
30. Surlari
31. Groska
32. Memambetsu
33. Vladivostok
34. Agincourt
35. Panagyurishche
36. Logronyo
37. Tbilisi
38. Tashkent
39. Toledo
40. Price
41. Beloitte
42. Carrolton
43. Fredricksburg
44. Almeria
45. Cacnoca
46. Espanola
47. Simosato
48. Tucson
49. Aso
50. Canoya
51. Helvan
52. Tamanrasset
53. Cha=pu
54. Honolulu
55. Teoloyukan
56. Alibag
57. San Juan
58. M'Boor
59. Paramaribo
60. Foukene
61. Caper
62. Port Moresby

63. Apia 64. Moti Tahiti 65. Waterloo 66. Hiangara 67. Hermanus
68. Tulangi 69. Amberlee 70. Trele 71. Kergoulen 72. Argentina

These results of the dynamo-theory do not coincide with data in Table 1. Therefore, it seems more expedient to try to find the explanation for the UT variations of Sq-currents outside the frame of the dynamo-theory. A. Akopyan (11) was, apparently, the first author who tried to account for the part played by the electric induction field in the formation of Sq-currents ;this field originates in the system of coordinates connected with the Sun during the daily (24 hour) rotation of a non-homogeneous (longitude-wide) field. However, in his calculations the part of the induction field was not sufficiently considred, just as in (11) the non-dipole part of the geomagnetic field has not been sufficiently clarified.

Let us compare the evaluations of a dynamo-field $\vec{E}_g = \frac{1}{c}[\vec{v}\vec{Z}]$ and an induction field $\vec{E}_u$, determined by the Maxwell equation $\partial\vec{H}/\partial T = -c \operatorname{rot} \vec{E}_u$.

By accepting $Z \approx 0{,}5$ oersted, $V \approx 5 \cdot 10^3$ cm/sec we find the value of $E_g \approx 1 \cdot 10^{-7}$ CGSE. This field originates in the coordinates system immobile in relation to the Earth. In a system of coordinates connected with the Sun there originate the fields $\vec{E}_u$ & $\vec{E}_g' = \frac{1}{c}[\vec{\omega}\vec{R}] Z \cos\varphi$, where $\vec{\omega}$ is the angular velocity of the Earth rotation, φ the latitude and R is the earth radius. However, the effect of the $\vec{E}'_g$ field upon the charge moving together with the ionosphere is compensated by the field of the Lorentz forces and, therfore, is not importnt. Yet the field $\vec{E}_u$ is closed by means of a "gliding ontact" - the rotating ionosphere - and creates currents (for the

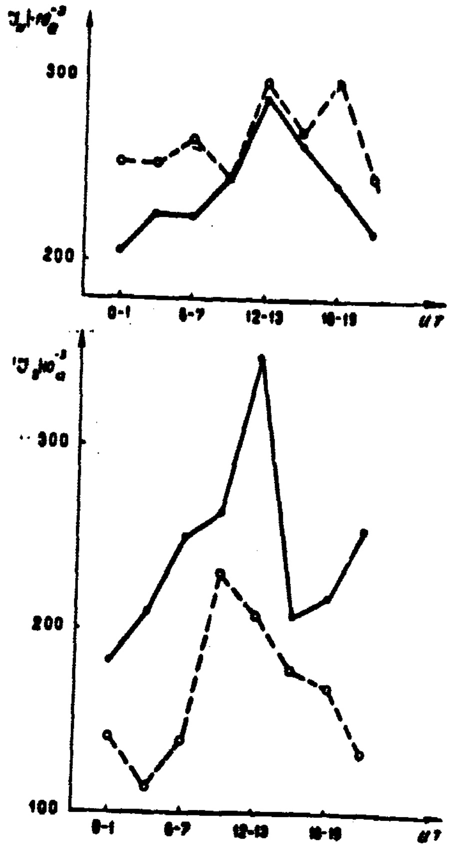

Fig. 11. Changes in the intensity of ionospheric Sq-current vortices during a universal time day (24 hr)

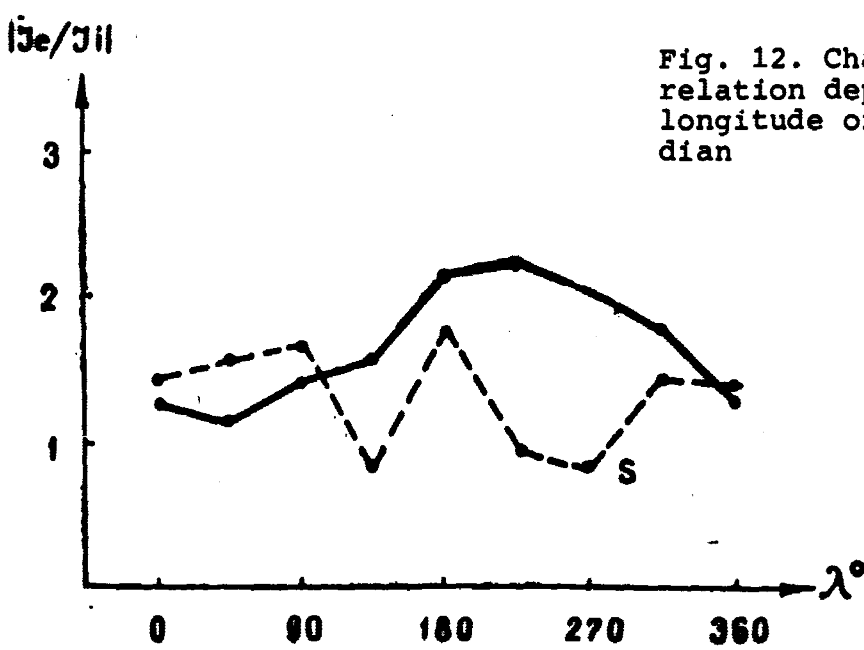

Fig. 12. Change in the $\frac{I_e'}{I_i}$ relation relation depending on the longitude of the noon meridian

major part on the day side). An evaluation of E_u we can first find in the dipole approximation of the geomagnetic field. In such case [10]

$$Z = 2\left[g_1^0 \sin\varphi + \sqrt{(g_1^1)^2 + (h_1^1)^2} \cdot \cos\varphi \cdot \cos(t - T - \lambda_0)\right],$$

where $g_1' \approx 2 \cdot 10^{-3}$ CGSM, $h_1' \approx 6 \cdot 10^{-3}$ CGSM. Wherefrom $\partial Z/\partial T = \approx 2 \cdot 0{,}6 \cdot 7 \cdot 10^{-3} \cdot \cos\varphi : 2 \cdot 10^4$ сек. $\approx 4 \cdot 10^{-7} \cdot \cos\varphi \frac{CGSM}{сек.}$ and evaluation $E_u \approx 4 \cdot 10^{-7} \cdot \cos\varphi \cdot c^{-1} \cdot L$ CGSM. At the equator, at $L = 3 \cdot 10^8$ centimeters (the dimension of an average - latitude Sq-vortex) $E_u \approx 0{,}4 \cdot 10^{-8}$ CGSM. In an actual geomagnetic field with altitudes in the lower ionosphere, the Z-changes with the longitude have an amplitude considerably greater than in a dipole field.

At the equator, the amplitude of the first harmonic of the $Z(\lambda)$ function is close to 10000 gammas, which would correlate with the evaluation $E_u \approx 4 \cdot 10^{-8}$ CGSM. This magnitude is about half of the evaluation given to E_g. Based on this fact it is possible to assume that the induction field E_u is a substantial factor in causing Sq-currents and UT-changes in I_n and I_s shown in Fig. 10 and table 1.

UT-variations in the position of focuses of Sq-vortices shown in Fig. 10 may be dependent, mainly, on the dynamo-effect.

This deduction was obtained qualitatively by one of the present authors and later on confirmed by calculations in (11).

The calculations of Sq-currents, taking into account both the dynamo-field as well as the E_u fieled, are being computed and the results will be published later.

A series of other mechanisms, not considered in the present article but which originate UT-variations of Sq-currents are duscussed in (12), (13).

UT-variations of internal Sq-currents

Fig. 11 shows the UT-changes of the values $|I_e/I_i|$, where I_e is the intensity of external Sq-currents, while I_i is that of the internal ones. The relation $|I_e/I_i|$ characterizes the distribution of electric conductivity in the region of the Earth in which the internal Sq-currents are induced.

At different moments of the universal time this region corresponds with various longitudinal sections, for instance, at 16 to 18 UT it corresponds with the American longitudinal sector, at 9 to 10 UT to the European-African sector, etc. Therefore, the character of changes $|I_e/I_i|$ with the universal time proves, apparently, that the distribution of electric conductivity in a region filled with internal Sq-currents is subjected to regular changes depending on the longitude. At that, it should be pointed out that there is a marked tendency toward the opposite phase in UT-changes of the relation $|I_e/I_i|$ in the northern and southern hemisphere and the fact that the extreme values of $|L_e/L_i|$ are close to the noon moments at geomagnetic poles (4 and 16 o'clock) of the universal time. This type of movement of the curves $|L_e/L_i|$ corresponds to the axisymmetric (with an axis of the symmetry close to the geomagnetic axis) distribution of electric conductivity in the upper mantle which, when extrapolated into the earth core may be responsible for the incline of the geomagnetic axis toward the geographic axis. However, this statement needs, evidently, careful investigation and comparison with other data.

The low and median values of $|L_e/L_i|_S$ when compared with $|L_e/L_i|_N$ according to [14] - may be in connection with a greater conductivity of the oceans; the predominance of oceans in the southern hemisphere over the continents is considerably larger than it is in the northern hemisphere.

The authors continue their work on investigations of UT-variations in Sq-fields according to the winter and summer seasons of 1958; the results will be published at a later date.

LITERATURE REFERENCES

1. A. Shuster. Phil. Trans. A. 180,467, 1889
2. S. Chapman. Phil. Trans.A, 218,1,1919
3. S. Chapman, a,J. Bartels, Geomagnetism. Oxford,1950
4. M. Hasegawa.Proc.Imp.Acod.Japan.12,221,225,277,1936

5. N. P. Ben'kova. NII GUMS, works, ser. VI, issue 1, 1941.

6. A.T. Price, G.A. Wilkins, Phil. Trans. A, 256, 31, 1963.

7. V.M. Mishin, A.D. Bazarzhapov. Coll. Geomagnitnye issledovaniya (Geomagnetical Research), N°. 8, ser. Results MGG., M., 1966,

8. Paul F. Fougere, J. Geoph. Res., 68, 1131, 1963.

8a. Paul F. Fougere, J. Geoph. Res. 70, 2171, 1965.

9. N.V. Adam, N. P. Ben'kova, V.P. Orlov, N.I. Osipov, L. Tiurmina. Geomagnitnoye pole na vysotakh ot 0 do 15000 km dlia epokhi 1955g. (Geomagnetic Field at altitudes from 0 to 15000km for 1955). IZMIRAN SSSR, M., 1964.

10. B.M. Yanovskii. Zemnoi magnetizm (Earth Magnetism) Izd-vo LGU, 1964.

11. A. Akopyan. The present collection

12. V.M. Mishin. Geomagnetizm i aeronomiya, 1966 (at printer's)

13. V.M. Mishin, E.I. Nemtsova, The present collection

14. Price, Radio Science. Journal of Research, NBS USNC. URSI, Vol. 69D, No.8, August 1965.

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