P. V. Sumaruk and Ya. I. Fel'dshteĭn. Interplanetary Magnetic Fields and Geomagnetic Variations in the Subpolar Region. It is generally recognized that the sun is a source of magnetic disturbances in near-earth space. The kinetic energy density of the solar wind at the earth's orbit is more than an order higher than the energy density of the magnetic field frozen into the plasma. However, the first measurements of the density, velocity and temperature of the solar plasma failed to detect any substantial changes that might be regarded as responsible for the generation of strong magnetic disturbances and auroras. Research done during the last several years has brought out the importance of the north-south component (across the plane of the ecliptic) of the interplanetary magnetic field (IMF) in the development of the strong polar magnetic disturbances that are a component part of magnetospheric substorms covering the entire planet. The same IMF component has been found to be related to high-frequency magnetic-field variations of type DP2, which are governed by large-scale convection of plasma in the tail of the magnetosphere.

At the same time, it was known from magnetic-activity studies that strong magnetic disturbances with no relation to magnetospheric substorms occur over the subpolar regions during the daytime hours in summer. Attention was drawn in[1,2] to the existence of two characteristic types of variations in the subpolar region, variations that cover the northern and southern polar caps simultaneously and are closely related to the sectoral structure of the IMF (toward the sun or away from the sun in the plane of the ecliptic). Disturbances of a certain type usually exist for several days in a row, forming a group. The groups show a tendency to recur at 27–29-day intervals, indicating a solar origin of the disturbance source. During certain time intervals, sometimes as long as a whole day, however, significant disagreement has been observed between the field variation expected in the subpolar regions on the basis of the sign of the IMF sector and the variations actually observed. It was shown in[3,4] that this disagreement is eliminated if it is assumed that the nature of the magnetic variations in the subpolar region is controlled not by the direction of the IMF sectoral structure, but by the direction and magnitude of the azimuthal (Y_{SE}) east-west component of the IMF. We shall denote this variation by DPC(Y_{SE}). On magnetograms from the subpolar observatories, the DPC(Y_{SE}) are superimposed on the field variations due to other parameters of the interplanetary medium, the magnetosphere, and the ionosphere and (or) their variations. Separation of DPC(Y_{SE}) in pure form is a rather complex problem, and there is much disagreement in the literature in regard to definition of the zero reference level describing field variations other than DPC(Y_{SE}) (see[5]). The paper[5] proposed a method of separating DPC(Y_{SE}) in the three components of the field variation in the subpolar region on the basis of correlations between the intensity of the variations and the Y_{SE} intensity. The contribution of the magnetospheric-substorm field was eliminated by choosing one-hour intervals with AE < 150 γ. Table I gives the correlation coefficients (r) and their standard deviations (σ_r) for each three-hour Universal Time interval as obtained during the summer of 1966 at Northern Hemisphere high-latitude magnetic observatories for the north (horizontal) component. At $80° \leq \Phi' \leq 84°$, a rather close correlation exists for practically the entire day, but outside of this latitude belt the variability of the field due to other sources makes it impossible to discern the correlation except in the daytime hours. Table II gives equations of linear regression of X (H) on Y_{SE} and the possible errors of the respective terms. The absolute term and its variations throughout the day, season, and solar-activity cycle describe the field variations that are unrelated to the Y_{SE} component of the IMF. The slope coefficient of Y_{SE}, the susceptibility of X (H) to the azimuthal component, varies significantly in the course of the day, reaching its maximum values during the midday hours. Similar relationships were also obtained for the vertical (Z) and east (Y) components of the geomagnetic field at all high-latitude observatories. In practically all cases, if there is a correlation between X, Z, Y

TABLE I. Coefficients of correlation between values of azimuthal interplanetary magnetic field components (Y_{SE}) and north (horizontal) component of geomagnetic field at subpolar observatories durung July-August 1966

Observatory	0–3	3–6	6–9	9–12
Alert (X)	0,47±0.12	—	—	−0.45±0.12
Thule (H)	0.5±0,11	—	—	—
Resolute Bay (X)	0.67±0,08	0,52±0.11	0,54±0.1	0.56±0.09
Mould Bay (X)	0.66±0.08	0.68±0.07	0.55±0.1	0.4±0.1
Godhavn (X)	0,65±0,08	0.5±0,1	0.61±0.08	0.7±0.07
Baker Lake (X)	—	—	0.4±0.13	0.4±0.11
Churchil (X)	—	—	—	—
Observatory	**12–15**	**15–18**	**18–21**	**21–24**
Alert (X)	−0.68±0,06	—	—	—
Thule (H)	0.6±0.07	0.7±0.05	0.7±0.07	0.69±0.07
Resolute Bay (X)	—	0.48±0.09	0.8±0.05	0.8±0.05
Mould Bay (X)	—	0.67±0,06	0.85±0.04	0.91±0.02
Godhavn (X)	—	0.46±0,09	0.58±0.1	0.65±0.08
Baker Lake (X)	0.58±0.8	—	—	—
Churchil (X)	—	0.4±0.1	—	—

TABLE II. Equations of linear regression between values of north (horizontal) component of magnetic field at subpolar observatories and IMF Y_{SE} during July-August 1966.

Observatory	Alert (X) (500 γ+)	Thule (H) (3800 γ+)	Resolute Bay (X)
0–3 UT	$3.2\pm0.8Y_{SE}+240\pm1$	$3.0\pm0.7Y_{SE}+234\pm1$	$6.3\pm0.7Y_{SE}+146\pm1$
3–6	—	—	$3.3\pm0.7Y_{SE}+178\pm1$
6–9	—	—	$4.1\pm0.8Y_{SE}+196\pm2$
9–12	$-8.7\pm2.4Y_{SE}+202\pm9$	—	$5.6\pm0.9Y_{SE}+197\pm2$
12–15	$-6\ 0\pm0\ 9Y_{SE}+204\pm2$	$10.0\pm1.1Y_{SE}+150\pm4$	—
15–18	—	$17.0\pm1.0Y_{SE}+169\pm4$	$10.5\pm1.9Y_{SE}+136\pm5$
18–21	—	$11.1\pm1.1Y_{SE}+195\pm3$	$20.6\pm1.2Y_{SE}+111\pm4$
21–24	—	$5.7\pm1.4Y_{SE}+236\pm1$	$14.6\pm0.9Y_{SE}+129\pm1$

Observatory	Mould Bay (X) (900 γ+)	Godhavn (H) (8000 γ+)
0–3 UT	$12.0\pm1.3Y_{SE}+139\pm3$	$3,0\pm0.4Y_{SE}+308\pm0$
3–6	$4.9\pm0.5Y_{SE}+163\pm1$	$4.0\pm0.8Y_{SE}+297\pm2$
6–9	$3.3\pm0.6Y_{SE}+182\pm1$	$4.0\pm0.5Y_{SE}+272\pm1$
9–12	$3.4\pm0.8Y_{SE}+194\pm2$	$7.8\pm1.3Y_{SE}+229\pm3$
12–15	—	—
15–18	$12.8\pm1.2Y_{SE}+182\pm3$	$6.4\pm1.3Y_{SE}+310\pm3$
18–21	$26.2\pm1.2Y_{SE}\pm143\pm3$	$8,9\pm1.5Y_{SE}+304\pm4$
21–24	$28.0\pm1.2Y_{SE}+158\pm3$	$6.0\pm0.8Y_{SE}+295\pm1$

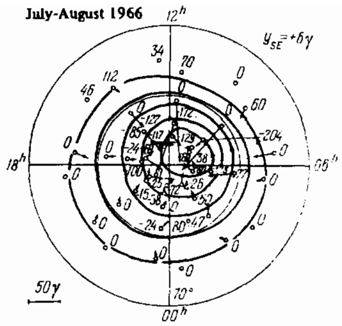

FIG. 1

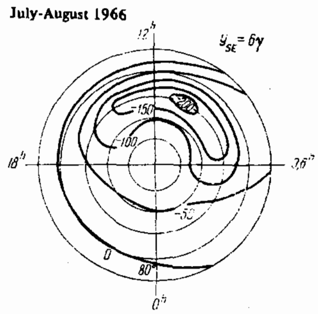

FIG. 2

and the strength of the IMF component Y_{SE} after elimination of magnetically disturbed intervals, it is nearly linear. The relationship obtained can be used to calculate the field variations at the earth's surface for fixed values of Y_{SE} It was assumed that $z \le 0.4$ signifies no correlation and that the corresponding variation at the earth's surface equals zero. Figure 1 shows, in polar coordinates, the corrected geomagnetic latitude and local geomagnetic time and the distributions of the magnetic variation vectors in the horizontal and vertical planes (arrows and numericals, respectively) for $Y_{SE} = +6\gamma$. The solid lines represent the equivalent current system in the ionosphere. There are 6×10^4 amperes between current lines. The crowding of the current lines in the daytime sector at $\Phi' \approx 81°$ can be interpreted as a subpolar electrojet in which the direction of the current is determined by the sign of Y_{SE}.

Model conceptions as to the generation of DPC(Y_{SE}) were developed in[6-8]. It was shown in[7] that the field of the three-dimensional current system covering the magnetosphere and ionosphere is very similar at the earth's surface to the field shown in Fig. 1. Observational results made it possible to calculate certain parameters of the model: the position of the central line and the high- and low-latitude boundaries of the current jet (~78° and ~84°), and to estimate quantitatively the efficiency of penetration of the electric field from the solar wind into the polar ionosphere (~ 10%). According to[7], the intensity of DPC(Y_{SE}) is determined by the integral conductivity of the ionosphere (Σ) at the latitudes of the daytime cusp. The variations of Σ at daytime-cusp latitudes were determined in[9] for cusp locations at $\Phi' = 78°$ and $\Phi' = 81°$: diurnal as a function of Universal Time, seasonal, and cyclic. These calculations showed that the observed one-order-of-magnitude seasonal intensity variations of DPC(Y_{SE}) from the Summer Solstice to the Winter Solstice are governed by ionospheric-conductivity variations. In summer, the diurnal (UT) variations amount to ~20%, and the cyclic variations to ~60%, from the very strong 1957 maximum to the 1964 minimum. The calculated results, which make it possible to obtain values of Σ for any time, can be used for diagnosis of the hourly average values of Y_{SE} on the basis of ground observations of the magnetic field variations in the subpolar region. Figure 2 shows isolines of ΔZ (the deviation of Z from Z_0 at $Y_{SE} = 6\gamma$), reduced to the value $n_e = 10.5 \times 10^4$ cm^{-3} ($\Sigma_n \approx \Sigma_r = 8.2$ mΩ), with the corrected geomagnetic latitude and the local time as coordinates. Using these data, we can determine the magnitude and direction of Y_{SE} from the ΔZ observed at the earth's surface in the subpolar region.

The current system proposed in Fig. 1, with electrojets along Φ' ~81° on the daytime side and variation of the current direction with the sign of Y_{SE}, is quite consistent with electric-field measurements made at the daytime cusp on satellites of the Kosmos and Injun types[10, 11]. When the quasistationary convection from the daytime side of the magnetosphere to the night side is taken into account by changing the field reference level, the resulting current systems are in excellent agreement with the results of Northern Hemisphere electric field measurements made during the summer by the OGO-6 satellite in the plane of the morning-evening meridians[12].

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