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# Certain Regularities of Geomagnetic and Baric Fields at High Latitudes

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The value of the north component $X'$ of geomagnetic field at the stations that get under cusps on the sunlit side of the magnetosphere depends on the polarity of interplanetary magnetic field sectors. Under otherwise identical conditions, in the northern hemisphere $X'$ is greater when Earth is in the positive sector while in the southern hemisphere $X'$ is greater when Earth is in the negative sector (north-south asymmetry). The difference $\Delta X'$ resulting from the change of sector polarities is greater in both hemispheres in spring than in autumn (spring-autumn asymmetry).

Similar regularities are revealed in the distributions of atmospheric pressure $P$ in the near-Earth layer at the conjugate stations Mould Bay and Dumont d'Urville in 1964.

Resemblance of regularities in the distribution of $X'$ and $P$ is conditioned apparently by a common cause: a zonal magnetospheric convection and related circumpolar ionosphere current vortices that appear first in the southern and then in the northern hemisphere depending on the sector polarity.

During some phases of the solar activity cycle, the sectors of one polarity are predominant for a long time. This may cause an accumulation of weak impulses of the same sign, conditioned by solar wind, that sometimes get in resonance with oscillation processes in the atmosphere and in the ocean, thus changing the course of the processes that determine the weather and climate.

The existence of a relation between the variations of magnetic field at Earth's surface in near pole regions and the sector structure of the interplanetary magnetic field (IMF) is generally accepted and is considered as the evidence of influence of the solar wind with its magnetic field on the processes proceeding in the magnetosphere.

The characteristics and physical essence of this relation, the idea about the so-called geomagnetic effect of IMF sector structure, are given in the work by Wilcox (1972). This work, however, does not show the following two peculiarities of the relation between geomagnetic and interplanetary fields: north-south and spring-autumn asymmetry. Both peculiarities are important for understanding the mechanism of solar/plasma magnetosphere interaction, and, hence, for the study of solar/terrestrial relations. The essence of these peculiarities consists in the following:

At the stations that are under the magnetospheric cusps during daytime, at the geomagnetic latitude $\Phi_c = \pm(78° \text{ to } 80°)$, the dependence of Earth's surface magnetic field on the polarity of IMF sectors (under otherwise identical conditions) is expressed by the following inequalities:

$$\left.\begin{array}{ll}\text{Northern hemisphere:} & M\left(X_N^{1+}\right) > M\left(X_N^{1-}\right)\\ \text{Southern hemisphere:} & M\left(X_S^{1+}\right) < M\left(X_S^{1-}\right)\end{array}\right\} \quad (1)$$

where $M\left(X_N^1\right)$ and $M\left(X_S^1\right)$ are the time values averaged for a certain interval of the north $X^1$

component of the geomagnetic field in Hakura's system of coordinates (Hakura, 1965) in the southern $S$ and northern $N$ hemispheres, calculated separately for days with IMF directed away from the Sun (+) and toward the Sun (−). Thus, the geomagnetic effect of IMF sector structure is displayed in the fact that under otherwise identical conditions $X'$ is greater in the northern hemisphere when Earth is within the positive sector of IMF and in the southern hemisphere when Earth is within the negative sector of IMF.

Inequalities $I$ have the greatest values if the sample $X'$ is made by near midday hours of local magnetic time in summer. In the behavior of $M(X')$ calculated from the data of all hours of the day, the following has been revealed: magnitudes $M\left(X_N^{1-}\right)$ and $M\left(X_S^{1+}\right)$ obtained as a result of a successive averaging of the data for 2-month periods keep their levels nearly unchanged during a year, while the magnitudes $M\left(X_N^{1+}\right)$ and $M\left(X_S^{1-}\right)$ obtained in the same way are changing regularly and forming an annual wave with the maximum in local summer. As in the behavior of magnitudes $M(X')$ in the northern and southern hemispheres, similar characteristics are observed at different IMF directions; the peculiarity of the relation between geomagnetic field and IMF is called "the north-south asymmetry." It is the evidence of an essentially different (depending on the sign of IMF sector) response of northern and southern parts of the magnetosphere to the solar wind.

In both hemispheres, the following inequalities are observed for the samples selected during equinoctial periods:

$$\left.\begin{aligned} \left[M\left(X_N^{1+}\right) - M\left(X_N^{1-}\right)\right]_{\text{III–IV}} &> \left[M\left(X_N^{1+}\right) - M\left(X_N^{1-}\right)\right]_{\text{IX–X}} \\ \left[M\left(X_S^{1-}\right) - M\left(X_S^{1+}\right)\right]_{\text{III–IV}} &< \left[M\left(X_S^{1-}\right) - M\left(X_S^{1+}\right)\right]_{\text{IX–X}} \end{aligned}\right\} \quad (2)$$

Inequalities (2) show that the difference $\Delta X'$ appearing with the change of sector polarity (in other words, the magnitude of geomagnetic effect of IMF sector structure) in both hemispheres is greater in local spring than in autumn ("spring-autumn asymmetry").

Figure 1 represents the histograms of the mean magnitudes of the geomagnetic field north component $X'$ in gammas for March-April and September-October 1964 for the stations Dumont d'Urville and Mould Bay during two 3-hr groups (morning and afternoon) for the IMF directed away and toward the Sun. Calculations of $X'$ from observations of $X$ and $Y$ (projections of the horizontal component on geographical meridian and parallel) made at the stations are made by

$$X' = 0.87X + 0.49Y$$

for Dumont d'Urville and by

$$X' = 0.69X + 0.72Y$$

for Mould Bay.

Both peculiarities of the relationship of geomagnetic and interplanetary fields are represented in the histograms. The average values $M(X')$ given in table 1 satisfy inequalities (1) and (2).

Control of the significance of the results of analysis by the method of mathematical statistics showed that the distribution of magnitudes $X'$ at positive and negative directions of IMF in 1964 was different with a probability of 99 percent or greater (according to Kholmogorov's and Wilcox's criteria) both for March-April and September-October periods at the Mould Bay station. At the Dumont d'Urville station the distribution of $X'$ was different with the same probability (99 percent or more) only for the period of local spring (September-October). For the period of local autumn (March-April) it was different with the probability of at least 90 percent, according to Kholmogorov's criterion, and at least 94 percent, according to Wilcox's and Pirson's criteria. Thus, one may consider with much confidence that the distributions of $X'$ vary at different directions of IMF. The application of $t$ criteria to estimate the reliability of the difference between the average values $X'$ for these two samples showed that the average values $X'$ in

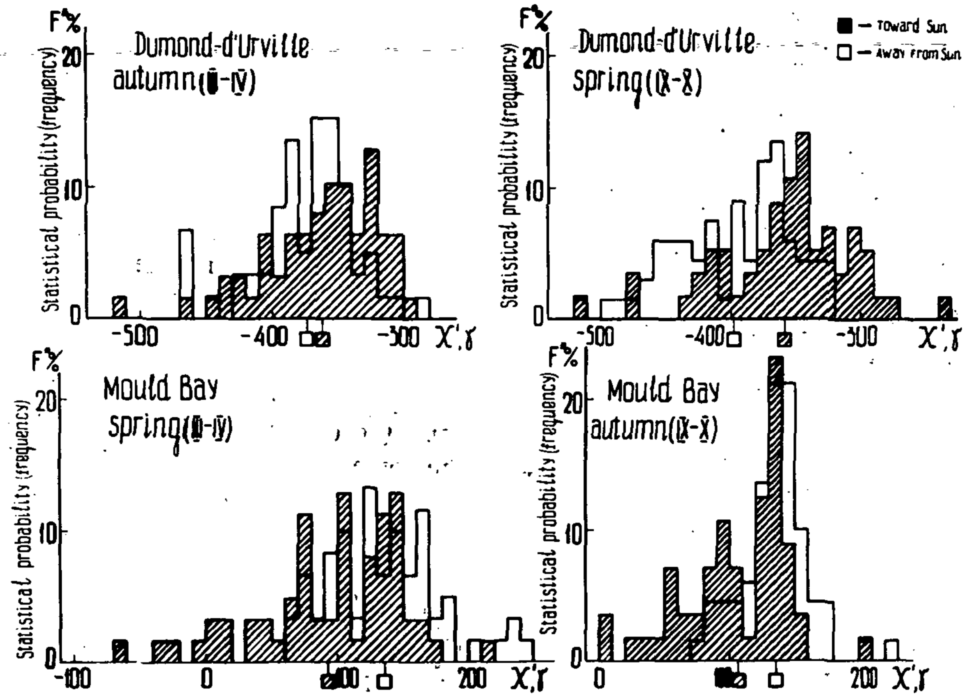


FIGURE 1.—Histograms of the mean magnitudes of the geomagnetic field north component $X'$ in gammas.

local spring at both stations and in local autumn at the Mould Bay station differed with a probability of 99.9 percent. This difference in local autumn at the Dumont d'Urville station is less probable (its probability is about 80 to 90 percent).

In the works by Smirnov (1972), Mansurov et al. (1972), and Wilcox et al. (1973), there are indications of a noticeable influence of IMF sector structure upon near-Earth atmospherical layers and upon the stratosphere. Therefore, the result of analysis of the atmosphere pressure data $P$ in near-Earth layer at the magnetically conjugate Dumont d'Urville and Mould Bay stations (which can be expressed by inequalities (3) and (4) analogous to inequalities (1) and (2)), does not seem occasional. This dependence is of the form:

$$\left.\begin{aligned} &\text{Northern hemisphere:} \quad M\left(P_N^+\right) < M\left(P_N^-\right) \\ &\text{Southern hemisphere:} \quad M\left(P_S^+\right) > M\left(P_S^-\right) \end{aligned}\right\} \tag{3}$$

$$\left.\begin{aligned} \left[M\left(P_N^-\right) - M\left(P_N^+\right)\right]_{\text{III–IV}} &> \left[M\left(P_N^-\right) - M\left(P_N^+\right)\right]_{\text{IX–X}} \\ \left[M\left(P_S^+\right) - M\left(P_S^-\right)\right]_{\text{III–IV}} &< \left[M\left(P_S^+\right) - M\left(P_S^-\right)\right]_{\text{IX–X}} \end{aligned}\right\} \tag{4}$$

where the $M(P)$ values are the average values of atmospheric pressure for the southern S and northern N hemisphere stations calculated on eight synoptic terms per day separately for the days with positive (+) and with negative (−) polarity of sectors for the sample sizes for each pair of equinoctial months.

Figure 2 represents the histograms of the dis-

TABLE 1.—*Values of* M(X′) *and* M(P)

| Station | III–IV | IX–X |
|---|---|---|
| Dumont d'Urville: | Autumn | Spring |
| $M(X_S^{1-})$ | −362 (62) | −359 (56) |
| $M(X_S^{1+})$ | −374 (59) | −398 (66) |
| $\Delta X'$ | 12 | 39 |
| $M(P_S^-)$ | 975.6 (248) | 969.9 (224) |
| $M(P_S^+)$ | 979.7 (240) | 984.1 (264) |
| $\Delta P$ | 4.1 | 14.2 |
| Mould Bay: | Spring | Autumn |
| $M(X_N^{1+})$ | 136 (60) | 136 (66) |
| $M(X_N^{1-})$ | 95 (62) | 107 (56) |
| $\Delta X'$ | 41 | 29 |
| $M(P_N^+)$ | 1013.5 (240) | 1015.8 (264) |
| $M(P_N^-)$ | 1017.3 (248) | 1016.9 (224) |
| $\Delta P$ | 3.8 | 1.1 |

*Note:* Numbers in parentheses indicate sample size.

tribution of atmosphere pressure $P$ values in millibars for March-April and September-October 1964 at the two stations for eight synoptical terms per day with IMF directed toward and away from the Sun. It is seen that both the peculiarities of pressure value distributions depending on IMF structure (north-south and spring-autumn asymmetry) as well as the case of $X'$ distribution (fig. 1) are clearly revealed. The average values of $M(P)$ given in table 1 satisfy the inequalities (3) and (4).

The control of reliability of the obtained results showed that the distributions of $P$ are different during the equinoctial period at both stations with a probability no less than 99 percent (according to Kholmogorov's and Wilcoxon's criteria) when the IMF sector polarity is different.

The estimation of difference between the average values of pressure for different IMF directions by means of $t$ criteria showed that average pressure values are different with the probability 99.9 percent in spring and in autumn at the Dumont d'Urville station and in spring (March-April) at the Mould Bay station. In autumn the average values $P$ are different with the probability equal to 95 percent at the Mould Bay station.

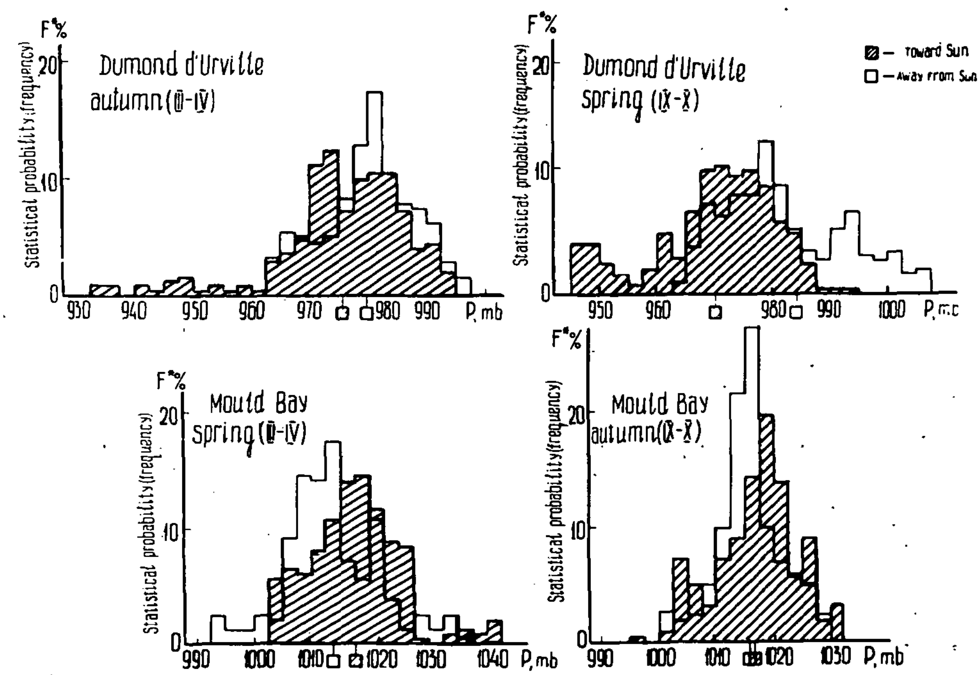


FIGURE 2.—Histograms of the distribution of atmospheric pressure $P$ values in millibars.

The resemblance of the distribution regularity of $X'$ and $P$ depending on the sign of the IMF sector at magnetically conjugate high-latitudinal stations may be the result of the influence of solar wind and its magnetic and electric fields upon the ionosphere and the influence of ionosphere upon the neutral atmosphere. Apparently, there exist many mechanisms of such influence. The complex of geophysical phenomena that display relations with IMF sector structure (among which one may mention the absorption in auroral zones studied in detail by Hargreaves, 1969) implies that in these mechanisms an important role is played by bremsstrahlung radiation. Such an assumption was first made by Roberts and Olsen (1973) while they were explaining the revealed relation between the baric field and geomagnetic disturbances. According to Yoshida et al. (1971), there is a north-south asymmetry in cosmic ray intensity that depends on IMF sector sign. Our results are in agreement with the conception of Sazonov (1972) concerning the cosmic rays effects upon the atmosphere lower layers.

Smirnov (1972) indicated that the relation between the thermobaric field of lower atmosphere and large-scale inhomogeneities of interplanetary medium tends to be revealed more distinctly at coast regions where the so-called "coast effects"

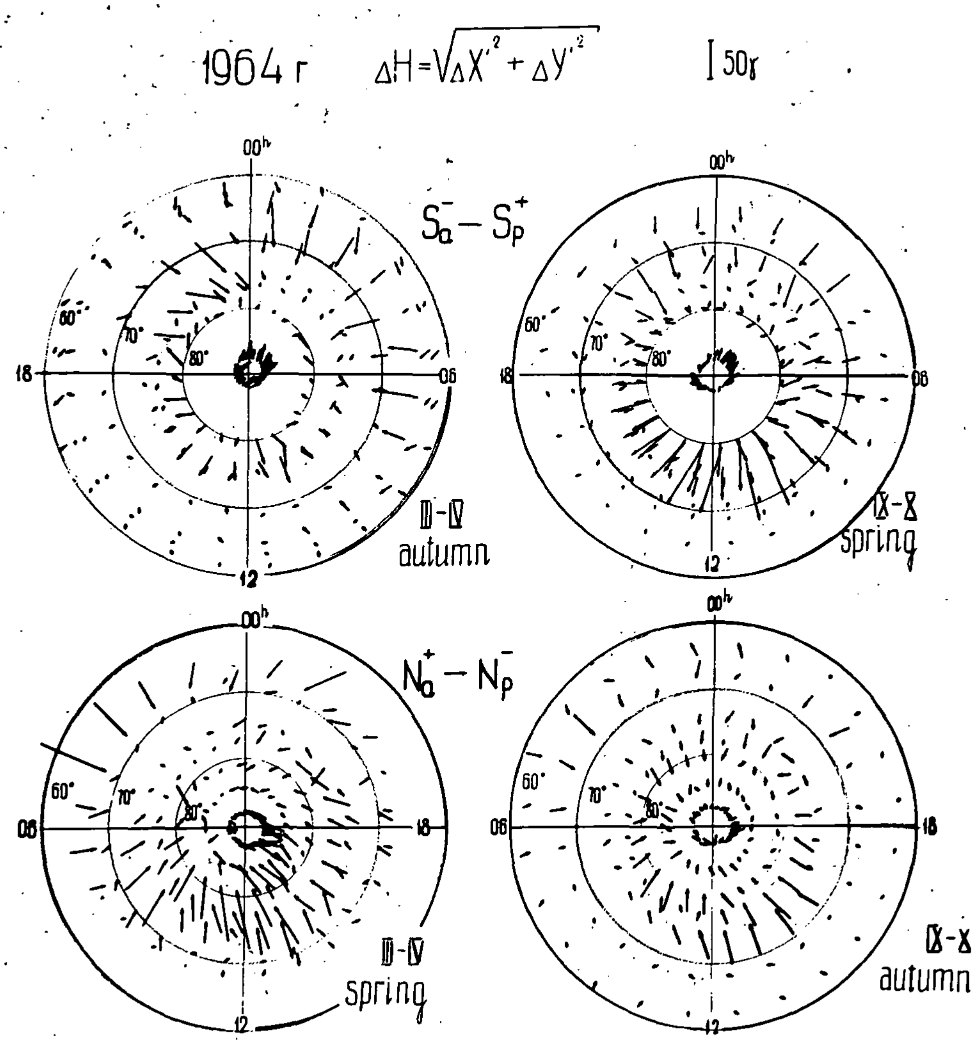


FIGURE 3.—Geomagnetic effect of the sector structure of IMF in horizontal component. The top graphs are of Dumont D'Urville and the bottom graphs are of Mould Bay.

are observed by Sen'ko (1959) and by Mansurov (1958). It means that in the mechanism of relation between upper and lower parts of the atmosphere, together with wave oscillation, which may occur as a result of the upper atmosphere heat and then may pass to the lower atmosphere, as assumed by Reshetov (1972), an essential role is played by electromagnetic induction. Therefore one may expect that during some phases of the solar activity cycle when the sectors of IMF of the same polarity are predominant for a long time (Svalgaard, 1972), weak impulses of one sign that appear by induction may be accumulated and, getting in resonance with oscillation processes in the atmosphere and in the ocean, may cause a change in the direction of air and oceanic flows that determine the weather and the climate. Such possibility ensues from the fact that zonal magnetospheric convection appears now in one hemisphere, then in another, depending on the sign of IMF sector. The notion on zonal convection is given in figure 3.

Figure 3 shows the distribution of vectors of $\Delta H$ difference $S_a^- - S_p^+$ for the southern hemisphere and $N_a^+ - N_p^-$ for the northern hemisphere between the mean hour values of the horizontal component of the geomagnetic field, calculated separately for samples at positive ($S_p^+$ and $N_a^+$) and negative ($S_a^-$ and $N_n^-$) directions of IMF for two equinoctial periods of 1964 of 2-month duration.

In figure 3, which shows the geomagnetic effect of the sector structure of IMF in horizontal component, the spring-autumn asymmetry of the effect is well seen, which is displayed in the baric field.

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