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GEOMAGNETIC ACTIVITY OF MAGNETIC CLOUDS CONSIDERING SEASON OF YEAR

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1. Introduction

As a result, long-term observation of the geomagnetic activity the existence of its semi-annual variations, manifested in the spring and autumn in the form of peaks in the long-term average values of the various indices of geomagnetic activity was established [*Cortie, 1912*]. For explain this characteristic geomagnetic activity behavior during the year two sets of hypotheses is designed: the axial hypothesis and hypothesis equinox. Axial hypothesis to the change Earth's gelioprojection on the solar disk during the year is related [*Cortie, 1912; Chapman and Bartels, 1940*]. In spring and autumn, due to changes in rotation axis inclination of the Sun to the Sun-Earth line at ~ 7 °, the angular distance from the projection of the Earth to the Sun's equator are maximized, and the Earth is more closely associated with zones of active regions (sunspot groups). They are grouped in the "royal" zones from 10 to 30 degrees north and south heliographic latitudes (see Fig. 1). Thus, in equinoxes times, with a maximum of latitude Earth's gelioprojection, are most likely to encounter the Earth with solar flux of active regions are recognized.

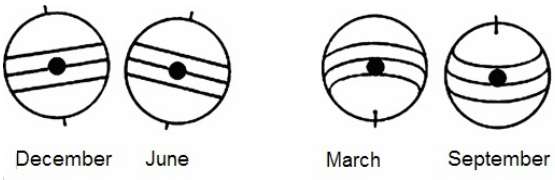

Figure 1. Change latitude Earth's gelioprojection on the solar disk with the season depending

According to the second group of hypotheses, geomagnetic activity increases when the angle between the Earth's dipole and Solar wind flow about 90^0 is observed. Here two models is recognized – the Kelvin-Helmholtz instability (Boller-Stolov model) and Russell- McPherron effect [*Boller and Stolov, 1970; Russell and McPherron, 1973*]. In [*Boller and Stolov, 1970*] Kelvin-Helmholtz instability occurs on the magnetosphere flanks, and its intensity depends on the daily and annual changes in the angle between Earth's dipole and Solar wind was shown. The maximum wave instability during the equinox (when the Earth's dipole is perpendicular to Solar wind flow), and the minimum – for solstice periods occurs. It is assumed that the observed at the magnetopause Kelvin-Helmholtz instability generates geomagnetic disturbances, which as semi-annual changes in geomagnetic activity are defined.

Seasonal variation of geomagnetic activity within the Russell-McPherron effect is to increase the value of the interplanetary magnetic field (IMF) southward component in connection with its change in Solar-magnetospheric coordinate system with respect to the Solar-equatorial [*Russell and McPherron, 1973*] is explanation. According to him, the IMF in the Solar-equatorial coordinate system is formed, and the interaction of the IMF southern component with the magnetosphere in Solar-magnetospheric system occurs. These coordinate systems have a common axis X, which points to the Sun, and the Y-axis and Z are different rotation around of axis X. Thus, Bx component of the IMF will be the same in each system, and the values the components By and Bz during the transition from one coordinate system in another will change. This hypothesis does not exclude the axis model, since the Solar-equatorial system depends on the Earth's heliographic latitude [*Russell and McPherron, 1973*].

All the hypotheses of seasonal variation of geomagnetic activity only the mutual orientation of the Sun, or the Solar wind and the Earth's dipole, without affecting the internal structure of the flows and their characteristics take into account. However, the structure of the plasma flow by the type of its Solar source is determined, and its effect on the Earth's magnetosphere on the relative position of the Solar source and the Earth also depends. Such geoeffective structures as magnetic clouds, in contrast to other plasma flows have pronounced orientation in space defined by the magnetic field lines of a sunspot group, which in turn are the most preferred location along the Solar latitude. That is why they sources of varying intensity magnetic storms during periods of equinoxes and solstices can become.

The hypothesis seasonal dependence of geomagnetic activity for the most geoeffective Solar flow of magnetic clouds of the Solar wind proposed. They by the relative orientation of the axial magnetic field of magnetic clouds and the Earth's magnetic dipole is registered. In times of equinoxes and solstices the projection of an axial magnetic field clouds on the Earth's dipole are different. This should be reflected in the seasonal dependence of geomagnetic

activity. Furthermore, since the Solar sources of magnetic clouds are spot groups, located mainly in the areas of "royal" latitude, then due to changes Earth's gelioprojection on the Solar disk, the frequency of occurrence of ejection in the vicinity of the Earth should increase during the equinox. Verification of this hypothesis seasonal dependence of geomagnetic activity performed on the data on the orientation of 52 magnetic clouds, registered in the near-Earth from 1980 to 2004 according to the system OMNI.

2. Axial hypothesis for magnetic clouds of Solar wind

Investigation of the effect of the Sun rotation axis inclination to the Sun-Earth line for seasonal variation of geomagnetic activity within the proposed hypothesis based on the directory of solar flares, coronal mass ejections (*http://www.ngdc.noaa.gov/stp/SOLAR/ftpsolarflares; html; daw.gsfc.nasa.gov/CME_list/index.html*) and data on the global geomagnetic activity (Dst-index) was conducted for the period from 1980 to 2004. On the basis of these directories Solar sources and their coordinates for the 52 considered magnetic clouds were installed. Checking the axial hypothesis for magnetic clouds in the framework of the statistical analysis of the latitude Solar sources distribution in times of equinoxes and solstices was carried out (Fig. 2). The analysis carried out the presence of a "shift" for latitude Solar sources in the areas of active regions («royal» latitudes) during equinox and symmetrical distribution during periods solstice are showed. The resulting latitude distribution an increase in geomagnetic activity due to higher probability of meeting the Earth's magnetosphere with plasma flows during periods of equinox was shows.

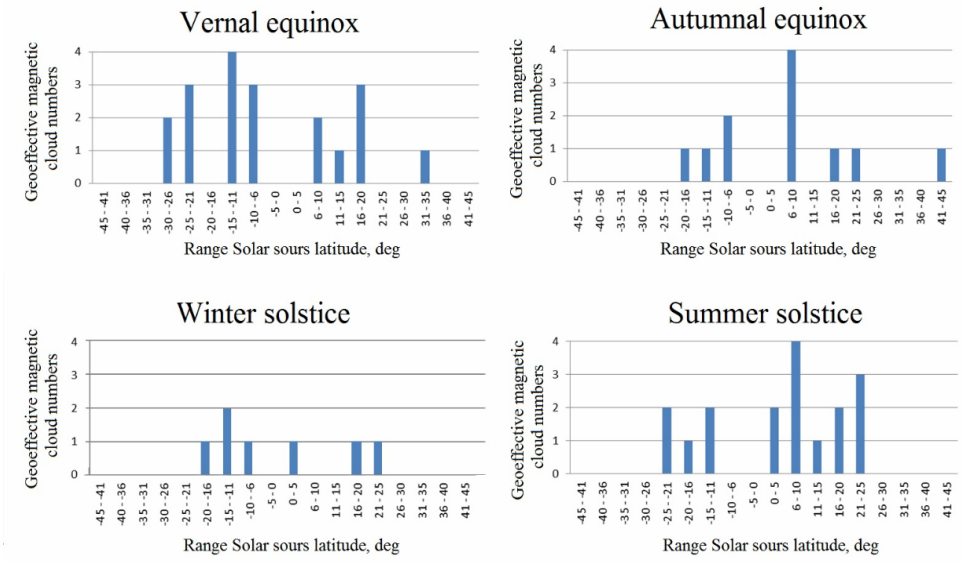

Figure 2. Latitude distribution of magnetic clouds sources by seasonal

3. Seasonal dependence of geomagnetic activity on the magnetic cloud structures

Investigation of the effect of the magnetic cloud orientation on the seasonal variation of geomagnetic activity on the basis of analysis of the ratio (percentage) of geoeffective and not geoeffective clouds of different orientations around the equinoxes and solstices carried out (Fig. 3, gray bars - geoeffective, black bars - not geoeffective clouds). All viewed magnetic clouds into three groups according to the angle ε: from 0 to 30^0, from 30 to 60^0 and 60 to 90^0 were divided. In Fig.3 each range values of ε corresponds to 100%.

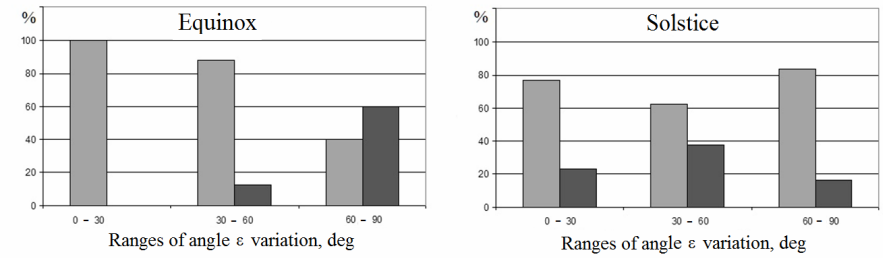

Figure 3. The ratio of geoeffective (gray bars) and not geoeffective (black bars) magnetic clouds of the Solar wind for intervals of the angle ε from 0^0 to 30^0, from 30^0 to 600, from 60^0 to 90^0 in percent

The resulting distribution the contribution in geoeffectiveness of each of the ranges values of the angle ε allows us to estimate. Since magnetic clouds with large (60 - 90^0) axis angles to ecliptic plane geomagnetic disturbances in 85% of cases in the solstice periods and 40% of the equinoxes are caused. Magnetic clouds with small angles for

sources of geomagnetic storms in 80% of cases in the period's solstice and 100% of the equinoxes was become. The study that the geomagnetic activity during the equinoxes increases due to the different orientation of the clouds and clouds especially with small values of axis cloud inclination to ecliptic plane are shows. These clouds most often near the Earth due to the particular conditions of their Solar sources (input and output (tail) spots), mostly parallel to the equator of the Solar disk is recorded [*Bothmer and Schwenn, 1998; Vitinsky, 1983*].

4. Testing the hypothesis by comparing geomagnetic effectiveness of magnetic clouds similar orientation

According to the proposed hypothesis of magnetic clouds with a similar orientation and magnetic field magnitude must be different geomagnetic effectiveness in different seasons are recognized. To verify this assertion a pair of magnetic clouds similar orientation and with similar values interplanetary magnetic field Bz component, recorded in different seasons of the year (Table 1), were considered. As a measure of the intensity of the geomagnetic activity Dst- index examined.

Table 1

	01.07.96	17.02.97	*30.09.01*	*01.11.01*	**14.01.07**	**29.10.09**
Angle ε,^{0}	-8	-7	8	8	-4	-1
Bz, nT	-7,8	-7,7	-10	-10	-6	-5
Dst, nT	-20	-54	-148	-106	-18	-40

A comparison of Dst-index corresponding to the considered pairs of magnetic clouds with small values of the axis inclination angle to the ecliptic plane with a similar orientation and similar values geoeffectiveness Bz component of the interplanetary magnetic field has shown that in equinox times its value to 1.4-2.7 times higher . Consequently, the magnetic clouds with small values of the axis inclination angle to the ecliptic plane are more geoeffective structures around the equinoxes.

5. Conclusions

Seasonal variation of geomagnetic activity, depending on the magnetic cloud orientation of Solar wind have investigated. It is shown that changes in the level of geomagnetic activity during the year the presence of a magnetic cloud particular orientation in space, unlike other plasma flows is manifested. In solstice periods magnetic clouds with small angles to the axis of ecliptic plane to the geomagnetic activity due to reduced projections of their axial magnetic field on the Earth's magnetic dipole does not contribute. In equinox periods contribution to geomagnetic activity magnetic clouds give any orientation.

Analysis of the latitude solar sources distribution of geoeffective magnetic clouds, registered in the vicinity of the Earth, the presence of a shift in the zone of active regions (royal latitudes) during equinox and symmetrical distribution during solstice periods was revealed. The resulting latitude distribution an increase in geomagnetic activity during the equinoxes as a result increases the probability of Earth's magnetosphere meeting with magnetic clouds are manifested. Comparison of geomagnetic activity pairs of magnetic clouds with small values of the axis inclination angle to the ecliptic plane with similar orientations and close values of geoeffectiveness Bz component of IMF are shows that in equinox times intensity of the generated magnetic storms above.

Thus, studies that in equinox periods geomagnetic activity increases due to magnetic clouds with axial magnetic fields oriented along the ecliptic plane was show. Clouds with such an orientation in the near-Earth due to the particular conditions of their Solar sources in the form as master and slave systems of sunspots most often recorded. In solstice periods such clouds are not geoeffective due to decrease the value of the projection of the axis magnetic field of clouds on the Earth's magnetic dipole in these intervals. This in the reduction of geomagnetic activity in the summer and winter is reflected.

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