GEOMAGNETIC DIPOLE INTENSITY DECREASE DURING LAST DECADE

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ABSTRACT

In the last decade, according to the International Geomagnetic Reference Field 2000 (IGRF-2000) and IGRF-2005 models, geomagnetic field weakens with the rate 11-15 nT/year. In this paper we assume that the external source, namely the ionospheric current system controlled by solar activity, contributes to the model. If so, we show - this source provides more than a half to the observed weakening. As the quantitative indicators of solar activity we use the index *F10.7*, solar wind speed *V* and the *Z*-component of interplanetary magnetic field (*Bz*). Basic data for the model are taken from the CHAMP satellite for May 2001 - December 2005 period. In the analysis, we exclude the trend associated with solar activity from the three main coefficients of the spherical harmonic expansion of the magnetic field and show - the remained weakening is 4-8 nT/year only.

1. INTRODUCTION

The geomagnetic activity created by magnetosphere and magnetosphere-ionosphere current systems, is supervised, first of all, by solar corpuscular and wave radiations. Wave radiation defines conductivity of an ionosphere; the corpuscular radiation – energy of current systems. Time dynamics of intensity of these radiations consist of regular and random components. Regular component is a time change of sunlight, known as an 11-years solar cycle activity. The strongest geomagnetic disturbances (magnetic storms) concern to random component of activity. Due to accident distribution of number of magnetic storms on months of year and the general number of storms year by year can vary in the random manner. It is reflected as in time dynamics of secular variation of the geomagnetic field, recorded by magnetic observatories, as in time dynamics of secular variation of indexes of geomagnetic activity. Therefore, for correct definition of change of the main geomagnetic field on observable data the account of influence of the geomagnetic activity created by magnetosphere-ionosphere current systems is required. The regular component of geomagnetic activity connected with regular influence of solar activity on conductivity and an electric field of a terrestrial ionosphere. Both are controlled by solar cycles. This time variation of a variable part of a geomagnetic field is not considered by a modern method of model construction. This fact leads to the overestimation of geomagnetic dipole speed of change. Roles of solar activity at the analysis of secular variations of a geomagnetic field have been spoken since first third part of 19 century, but its quantitative estimation it is not presented till now. Attempt to make such estimation is undertaken in this work.

2. DATA PROCESSING AND RESULTS

Construction of models of the main magnetic field of the Earth is based on a method Spherical Harmonic Analysis (SHA) that allows dividing the measured values of a magnetic field into fields of internal and external sources. Modern magnetic surveys are carried

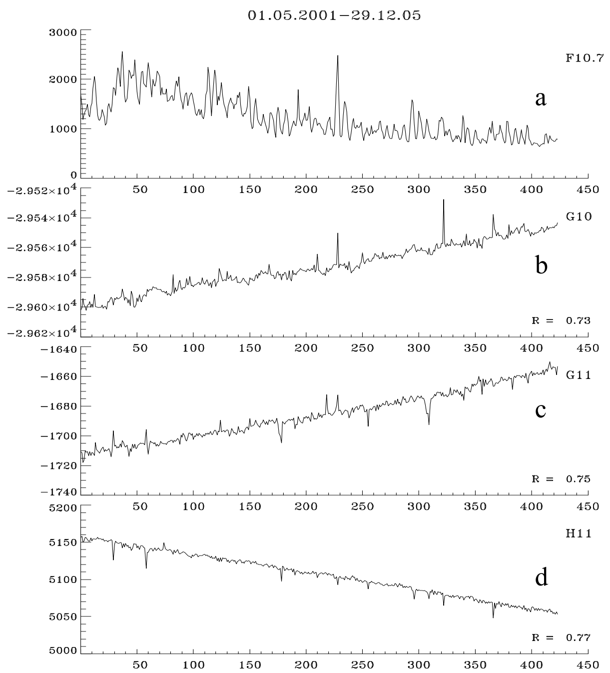

Figure 1. Time scale: interval – 01.05.2001- 29.12.2005, step - 4 days, all data points – 424. a - *F10.7, the index of solar activity - stream of a Sun's radio emission on a wave of 10.7 cm, daily average amplitude;* b, c, d - *coefficients $g_1^0(t)$, $g_1^1(t)$, $h_1^1(t)$ of author's SHA models of main geomagnetic field (G10, G11, H11). R – correlation factors between coefficients $g_1^0(t)$, $g_1^1(t)$, $h_1^1(t)$ and parameter F10.7.*

out at the orbits that pass above the current layer of an ionosphere (E-layer), so they fix a magnetic field of the

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magnetosphere-ionosphere current systems. Thus, SHA models, applying for representation field only of

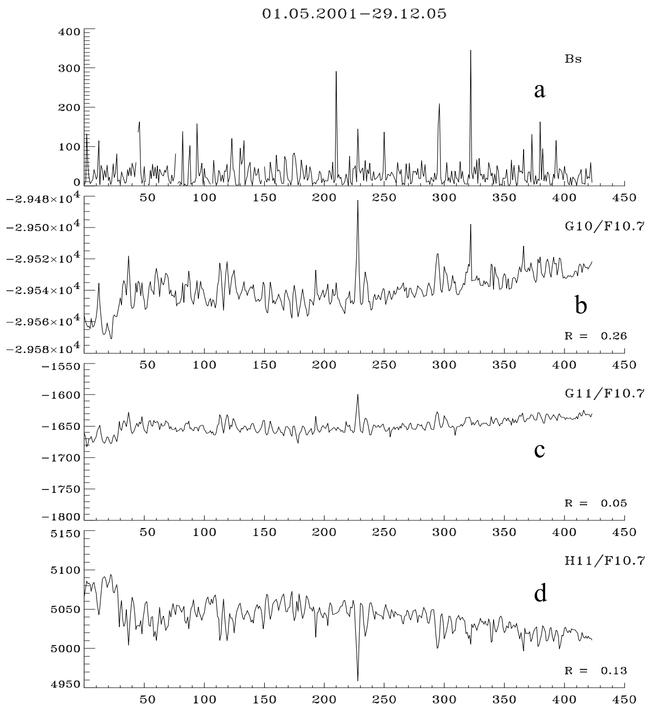

Figure 2. a - *curve Bs of value ΣV*Bs - corpuscular nature of Sun activity parameter (daily average sum of V*Bs; V - hourly average speed of a solar wind; Bs = 0 at Bz> 0 and Bs = -Bz at Bz <0, where Bz - vertical component of IMF vector;* b *(G10/ F10.7),* c *(G11/ F10.7),* d *(H11/ F10.7) –* $g_1^0(t)$, $g_1^1(t)$, $h_1^1(t)$ *coefficients of Fig.1 (*b, c, d*), but free of F10.7 connection; R- correlation factors between curve ΣV*Bs and curve G10/ F10.7, G11/ F10.7, H11/ F10.7.*

internal sources, contain fields of the ionosphere ring current sources. Below proofs of the come out assumption are presented. To estimate the changes of a main geomagnetic field the CHAMP satellite data of period May 2001 - December 2005 were used. We took the daily vector satellite data with one-second step. They were used for construction of daily SHA models up to n=m=10 with for every 4-th days (all are 424 daily average models). In Fig. 1b, 1c, 1d coefficients $g_1^0(t)$, $g_1^1(t)$, $h_1^1(t)$ of these models are shown. As the first parameter of solar activity, the index of solar activity *F10.7* (a stream of a radio emission of the Sun on a wave of 10.7 cm, daily average amplitude) is chosen. This index reflects the wave natures of activity of the Sun. Their values are shown in Fig. 1a for the same period. The daily sum of *V*Bs* (*ΣV*Bs*) is chosen as the second parameter of solar activity. Here, *V* - hourly average speed of a solar wind; *Bs* = 0 at *Bz*> 0 and *Bs* = -*Bz* at *Bz <0*, where *Bz* - vertical component of interplanetary magnetic field (IMF) vector.

This parameter reflects the corpuscular nature of activity of the Sun. Both parameters characterize variability of magnetosphere-ionosphere current systems day by day because supervise changing of ionosphere conductivity and electric fields. Coefficients $g_n^m(t)$, $h_n^m(t)$ of daily models and value of parameters *F10.7* and *ΣV*Bs* were exposed to the linear correlation analysis. In Fig. 1 factors of correlation (*R*) between coefficients $g_1^0(t)$, $g_1^1(t)$, $h_1^1(t)$ and parameter *F10.7* are resulted. Using the correlation equations, we have cleared coefficients $g_1^0(t)$, $g_1^1(t)$ *and* $h_1^1(t)$of *F10.7*'s connection. On Fig. 2 (b, c, d) these cleared coefficients - G10/ F10.7, G11/ F10.7 and H11/ F10.7 are shown. According to models IGRF-2000 and IGRF-2005, speed of change of $g_1^0(t)$, defining the main part of Earth's magnetic dipole amplitude, is equal ~12 nT/year. Taking to account a role of parameters of solar activity, this speed seems much less in Fig. 2, apparently. On Fig. 2a curve "Bs" of parameter *ΣV*Bs* during the same interval of time is resulted. Repeating procedure of the correlation analysis, we find the link of parameter *ΣV*Bs* with other curves of Fig. 2. Values of correlation factors (R) for curves G10/ F10.7, G11/ F10.7, H11/ F10.7 and parameter *ΣV*Bs* are resulted there. In a similar way we have cleared the curves of Fig. 2 (G10/F10.7, G11/F10.7 and H11/F10.7) from influence of parameter *ΣV*Bs*. The received curves (G10/ F10.7/Bs, G11/F10.7/Bs, H11/ F10.7 /Bs) are shown in Fig. 3. The course of coefficients $g_1^0(t)$, $g_1^1(t)$, $h_1^1(t)$ constructed by IGRF-2000 and IGRF-2005 - curves G10 (IGRF), G11 (IGRF) and H11 (IGRF) – are

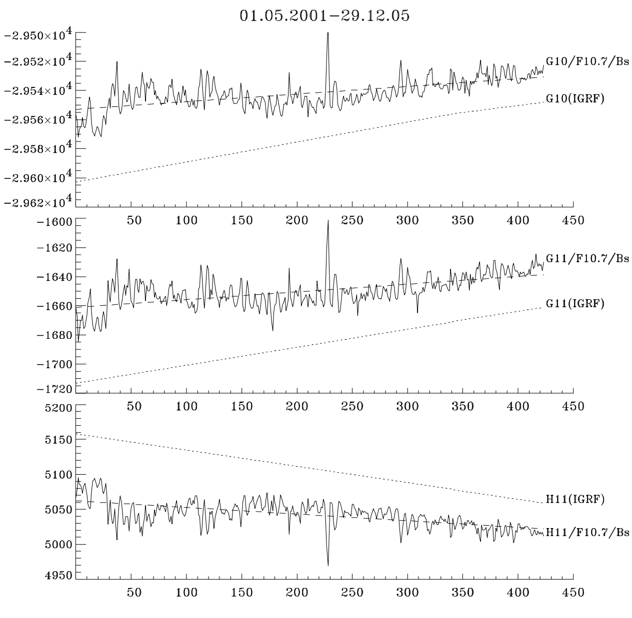

Figure 3. Coefficients $g_1^0(t)$, $g_1^1(t)$, $h_1^1(t$ *of author's model (G10/* $F_{10.7}$*/Bs, G11/* $F_{10.7}$*/Bs, H11/* $F_{10.7}$*/Bs - solid lines) free of F10.7 and ΣV*Bs links. Dashed lines – one's RMS-approximation. Point lines - coefficients* $g_1^0(t)$, $g_1^1(t)$, $h_1^1(t)$ *of IGRF (2000-2005).*

presented in Fig.3, too. Using Fig. 3, it is possible to compare speed of decreasing of the basic coefficients of IGRF models and the coefficients received in given work. Such comparison is resulted in the Tab. 1.

TABLE 1. Rate of changing of coefficients (nT /year).

Coefficients	IGRF (2000-2005)	Reported model
$g_1^0(t)$	11,59	4,70
$g_1^1(t)$	11,04	4,75
$h_1^1(t)$	20,97	8,50

3. CONCLUSIONS

The method of construction of IGRF models does not allow clearing them of influence of external sources completely. The contribution of an external source into the models is really small in comparison with a field from internal sources. However, it plays a significant role in an estimation of time dynamics (speed of change or the first derivative) coefficients of IGRF models that is connected with change of ionosphere conductivity and eclectic fields during solar cycles. Our estimations show, that a magnetic field of the magnetosphere-ionosphere ring currents varying in a cycle of solar activity due to change of conductivity of an ionosphere under influence of wave radiation (parameter F10.7). This is the main reason of overestimation of speed of change of the geomagnetic dipole, which is calculated by the IGRF models (2000-2005). So, decreasing of magnetic dipole field occurs to be in ~ 2,5 times smaller, than it turns out by IGRF-2000, 2005 models. This result agree with conclusions of the researchers, who indicate on a regular presence the near periodic variations with characteristic time ~11, 22 years (characteristic time of solar activity) in longtime series of the observatory's data. Thus, the accounting of the contribution of external sources of a geomagnetic field in circular variations can considerably reduce the estimation of speed of the changing of the main geomagnetic field, accepted today.

4. ACKNOWLEDGEMENTS

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