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INVESTIGATIONS OF THE STRUCTURE OF THE DIURNAL VARIATIONS OF GEOMAGNETIC FIELD

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A b s t r a c t: Changes in solar activity mechanisms generate changes in geomagnetic activity. The structure of geomagnetic activity can be illustrated by classes of the periodic and non-periodic variations of geomagnetic field. This study shows the results of the analysis of the periodic and non-periodic diurnal variations in the geomagnetic field (variations S_q, S_d,) and disturbances of geomagnetic activity (variations of indices R_i, K_p). The analysis was carried out during the months in which extreme solar and geomagnetic storms were recorded, October 2003 and November 2004. An analysis the structure and morphology of diurnal variations was made on the basis of the recorded geomagnetic data (the mean hourly values of geomagnetic field, three-hour indices of geomagnetic activity), at the Geomagnetic Observatory Grocka (GCK) (Serbia)..

Key words: solar activity; geomagnetic activity; diurnal variations; geomagnetic disturbances

INTRODUCTION

On the basis of observatory geomagnetic measurements the main or primary values of the geomagnetic field may be illustrated as an average annual values for a certain period of observation, for example during a hundred years or several sun cycles. On the basis of statistical analysis the variations of geomagnetic field, which arise from external sources (solar activity changes, solar magnetic field changes, solar winds), may be selected from the registered deviations in the average values of the geomagnetic field which have been recorded at observatories or stations.

The Earth's magnetic field, which originates in the liquid core of the Earth, changes in three essentially different ways. One is the slow secular variation and this also comes for the core. Its changes have a magnitude, over long periods of time, comparable with that of the field itself. They are of order ten thousand nano Teslas (nT). In the course of geological ages the field may even be reversed in direction, perhaps many time.

The other two types of geomagnetic variations are called transient because their typical course involves much shorter intervals of time, less than one or few days. One of these two types of transient changes, its periodic in a solar or lunar day. The range of the daily variations is much less than that of the secular changes thought the rate of the change is greater. The amplitude of the daily changes is at most of order 100 nT (nano Teslas). They are produced above the Earth, at relatively low levels in ionosphere. The cause is dynamo action by daily varying flow of ionized air across the geomagnetic field.

The second type of transient change is the irregular or non-periodic variations and it has source outside (above) the Earth. Its general name is geomagnetic disturbance or geomagnetic activity. Its more intense forms are called geomagnetic/magnetic storms. Like the regular daily variations magnetic disturbances and storms can be regarded as manifesting the superposition, on the main field extending outwards from the core, of an additional geomagnetic field. This geomagnetic field is called the *D* field (D for disturbance). The main field may likewise be called the *M* field (Chapman S., 1972).

Though these transient fields originate above the Earth, they induce electric currents within the

Earth, whose magnetic fields contribute to the recorded magnetic changes at the Earth's surface.

The variation amplitudes of the external geomagnetic field are much lower than is the intensity of the mean geomagnetic field. The external geomagnetic field's changes are shorter in comparison with the longer period changes in the mean geomagnetic field values (the secular changes).

The morphology and structure of the external part of geomagnetic field can be illustrated using the different classes of variations. The regular diurnal variations may be defined by the changes of geomagnetic field recorded during magnetically quiet days. If we observed the geomagnetic field's changes during magnetically disturbed days – for periods of a month, a season or a year – then we may give an account of daily variations in the magnetically disturbed days.

Through many years of the systematic observation of changes in solar activity, it was ascertained that the number of sunspots increases and decreases periodically at eleven-year intervals. Therefore it is possible to say that solar activities have a common eleven-year cycle. The time interval between two successive minimums of the sunspots number is called Sun cycle or Solar cycle.

Periodic changes in solar activity include three components: a quite regular component with an approximately eleven year period which represents the solar activity cycle; a component with an approximately yearly quasi-period; and the irregular fluctuations with monthly periods (Fig. 1). The common characteristic for each solar activity cycle is a rapid increase in the sunspots (index R_j) from the minimum to the maximum during the period of growth and a considerably slower decrease in the number of sunspots (R_i) to the minimum in the period after the maximum in the downward slope of the cycle diagram.

Surveys showed that there is a connection between the changes in solar activities and the changes in geomagnetic activities. Figure 2 shows the yearly changes in the total number of magnetic storms (*N*) which were recorded at the Geomagnetic Observatory Grocka (GCK), over the period 1958–2006. From the diagram it is clear that the years of maximum solar activities coincide with the years of maximum geomagnetic activity changes, where the changes are demonstrated by the total number of the recorded magnetic storms. Such a maximum occurred over the interval 1968–1970 (the 20 Solar Cycle), when the maximum number of magnetic storms was recorded and also over the interval 1989 – 1991, in the phase of the 23 Solar Cycle maximum, when the number of appearances and the frequency of magnetic storms also was at a maximum (Fig. 2).

Geomagnetic activity comprises the basic long-term change whose period is approximately 11 years (Fig. 2). The surveys of the phase-shift during the solar cycles showed that the maximum changes in geomagnetic activity shifted in phase. Therefore they have a 15–18 months' delay in appearance after the solar activity changes occur.

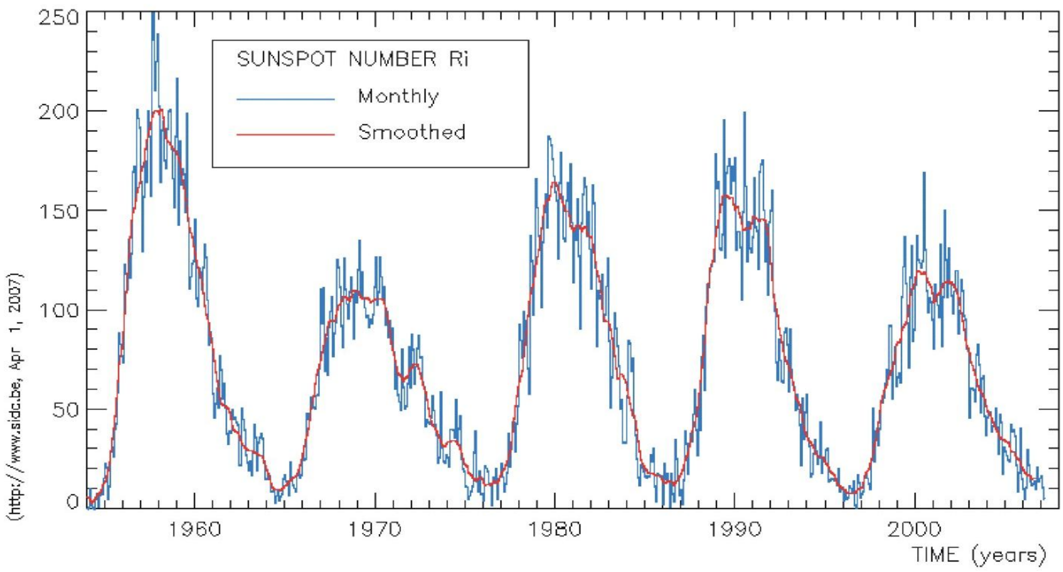


Fig. 1. Solar activity changes represented by the R_i relative sunspotsnumber over the period 1955 – 2006 (according to www.sidc.be)

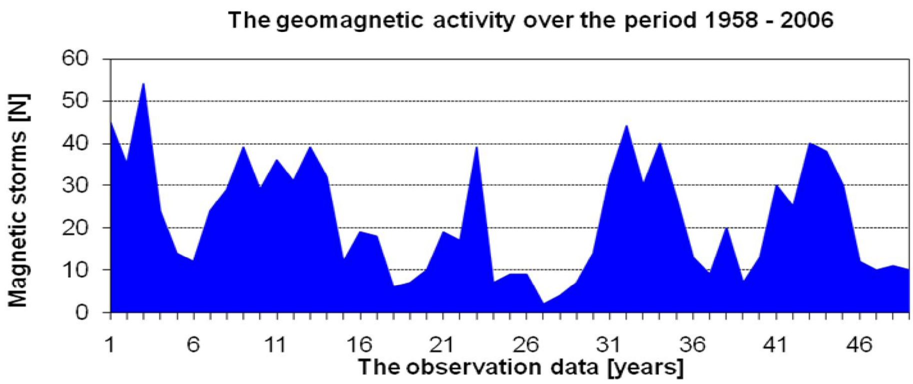


Fig. 2. Geomagnetic activity changes demonstrated by the $N_{m.s.}$ total number of magnetic storms which were recorded at the Geomagnetic Observatory Grocka – GMO (GCK) over the period 1958 – 2006

DIURNAL VARIATIONS OF GEOMAGNETIC FIELD

During the 1960s, in the area of solar geophysical research important studies were made. They showed the characteristics of the daily variations of geomagnetic field and the characteristics of geomagnetic disturbances and they also introduced a classification of geomagnetic field variations according to the sources and processes which generate these variations (S-I. Akasofu, Chapman S., 1961, 1972; Sugiura M., 1961).

The regular variations of the geomagnetic field are related to rotation and/or orbital movements of the Earth, Sun and Moon. The most prominent is the diurnal variation or solar daily variation having, an amplitude of the order of 10–100 nT.

The idealized definition of the S_q variation is: the daily magnetic variations characteristic of days when the ionosphere is everywhere ionized only by solar radiation. Solar radiation ionizes the upper atmosphere during the daylight hours, and the gravitational forces of the Sun and the Moon force the ionosphere layers in a tidal motion. So the ionized gas in the ionosphere moves in the geomagnetic field, creating electric currents which are seen as daily variations in magnetic recordings.

This variation is in fact called S_q from "solar quiet", where "solar" indicates that the variation acts following the local solar time and "quit" indicates that is typical of an unperturbed situation. The variation known as diurnal variation, acts following the local time. Each geomagnetic field element / component shows a time behavior, that can be interpreted as a superimposition of waves with periods 24 and 12 hours, and their harmonics with an amplitude of the order of some tens of nT. The variations are restricted to the daylight hours, and during the night it is negligible. For disturbed days, the variation that is fixed to the local time is called S_d variation, "S" for solar and "d" for disturbed.

A spherical harmonic study has shown that 2/3 of the daily variation is of external origin to the Earth and can be attributed to electrical currents circulating in the ionosphere and partly in the magnetosphere. In the ionosphere on the daytime side of the Earth these currents are constituted by a couple of fixed vortices one in each hemisphere whose position is fixed with respects to the Sun and thus follows its apparent rotation. The remaining 1/3 of the variation is of internal origin and is due to electrical currents produced by electromagnetic induction in the Earth's interior probably extending down to the depth of about 800 km, by the varying external magnetic field.

The S_q amplitude changes during the seasons with a summer maximum and a winter minimum at high and mid latitudes, and with a maximum at the equinoxes in the inter-tropical zone for H and Z component. Moreover S_q amplitude depends on the phase of the sunspot cycle with the quietest levels occurring around minimum sunspot numbers years. The ratio between maximum and minimum amplitudes can reach 2 to 2.5.

The basic characteristics of the regular daily variations are their regular and periodic occurrence and also the continual presence of the variation source. The regular daily variations defined in this way may be selected by observation of the geomagnetic field at the observatories during different time periods: from one month to a season to a year or more of solar cycles. Therefore it may be concluded that they are the basic morphological forms which define geomagnetic activity.

The survey methodology for the geomagnetic field's daily variation was applied to the geomagnetic storms which were recorded in February 1986 and in March 1989 (February 06, 1986 and March 13, 1989). For the analysis of these two geomagnetic storms the recorded data from the geomagnetic mid-latitude European observatories were used. The morphology of the regular daily variations was analyzed for the magnetically quiet days and the magnetically disturbed days (Mihajlović et all, 1998).

The survey methodology for the daily variations in the geomagnetic field and geomagnetic disturbances was applied again to two extreme geomagnetic disturbances during 23rd Solar Cycle, an geomagnetic storm October29, 2003 and geomagnetic storm November 7, 2004 (Mihajlović et all, 2005).

SOLAR AND GEOMAGNETIC ACTIVITY IN OCTOBER 2003

In October 2003 solar geomagnetic activity moved from a low level in the first half of the month to an extremely high level of activity during the last ten days (Solar Influences Data Analysis, Sunspot Bulletin 2003, no.10; Monthly Summary of Solar and Geomagnetic Activity). In October 2003 a few large groups of sunspots were observed on the solar disc, and they were designated as the Catania 70 sunspot group. In this sunspot group activity, different classes of solar flares were observed.

The distributions of daily values indices solar and geomagnetic activities Figure 3 shows the diagram indices solar and gepomagnetic activityes in October 2003. Solar activity is represented by the R_i – relative sunspots number, and geomagnetic activity is represented with the K_p – planetary indices geomagnetic activity.

In second decade on October 2003, solar activity was reduced and the conditions were defined as quiet (October 10–17, 2003). The solar activity centres with these sunspot groups covered 0.14 % of the total surface of the solar disc. All these events heralded the extreme solar activity and the interplanetary conditions over the last 10 days of October 2003.

The big Catania 70 sunspot group appeared on the eastern section of the solar disc on October 23, 2003. The spatial parameters of the Catania 70 sunspot group were impressive: it occupied more than 0.25% of the solar disc surface. This was one of the largest sunspot groups recorded during Solar Cycle 23 and its magnetic activity was represented by several types of extremely strong solar flares (Solar Influences Data Analysis, Sunspot Bulletin 2003, N°10; Monthly Summary of Solar and Geomagnetic Activity). Many flares emerged in the area of the solar meridian and they sent very fast radiation streaming (called Coronal Mass Ejection – CME) towards Earth. The phenomenon of CME streaming defines the conditions for the emergence of very intensive geomagnetic disturbances and other phenomena in interplanetary space.

On October 26, 2003 (about 18 00 UT) a solar storm, which was defined by the appearance of proton fluxes, was observed within the solar activity. On the diagram of the solar activity changes this event is shown as a period with extreme values in the index $R_i > 100$ (Fig. 3). The activity of X1.2-class flares is defined by proton flux with energy E > 10 MeV. During the activity of the Catania 70 sunspots, a X17.2-class flare emerged on October 28, 2003. Particle radiation, which defines geomagnetic storms, was dominant.

From October 29, 2003 an energy value of E > 10 MeV was present in the proton fluxes. The activity of the Catania sunspot group and the flares' classes maintained the energy level of the proton fluxes and this prolonged the duration of the proton storm till the end of October, 2003. On the diagram of the solar activity this event is shown with days which have extremely high daily values in the solar activity index $R_i > 150$ (Fig. 3).

Figure 4 shows the distribution of the three-hourly geomagnetic activity planetary indices in October 2003 (the K_{GCK} indices were compared with the three-hourly geomagnetic activity planetary indices, where K_{GCK} is the geomagnetic activity index recorded at the Geomagnetic Observatory Grocka GMO (GCK)). During the first ten days of October 2003 geomagnetic activity was quiet. During this period the recorded three-hourly geomagnetic activity indices were $K_P = 0$, $K_P = 1$, and $K_P = 2$, and they define the geomagnetic activities under quiet conditions.

The daily values of the geomagnetic activity planetary index were $\Sigma Kp < 25$ (ISGI Publications; Office Monthly Bulletin; N° 3-10 October 2003). The speed of the solar wind was about 400 km/s. During the period from October 5 to 9, 2003 an increase of 700 km/s (approximately) was recorded in the solar wind speed. During this period the changes in the Interplanetary Magnetic Field (IMF) – which were generated by the solar-wind speed increase – oscillated from positive to negative values.

The combination of the increase in the solar wind speed and the changes in the IMF's intensity and dynamics influenced the geomagnetic field conditions in such a way that a geomagnetic disturbance emerged. Figure 3 shows the distribution of the ΣKp – daily values of geomagnetic activity planetary indices.

In the diagram of geomagnetic activity index changes, on October 14 to 21, 2003 the values were recorded respectively $\Sigma K_P = 41$ and $\Sigma K_P = 40$. On these two days the conditions of geomagnetic activity were specified by magnetic storms of moderate intensity, which had a maximum three-hourly geomagnetic activity index of $K_P = 6$ (Fig. 4).

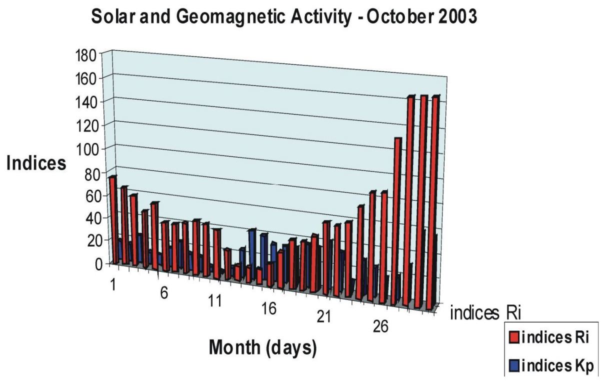


Fig. 3. Changes on the daily values of the R_i solar activity index and the ΣK_p geomagnetic activity planetary index at October 2003

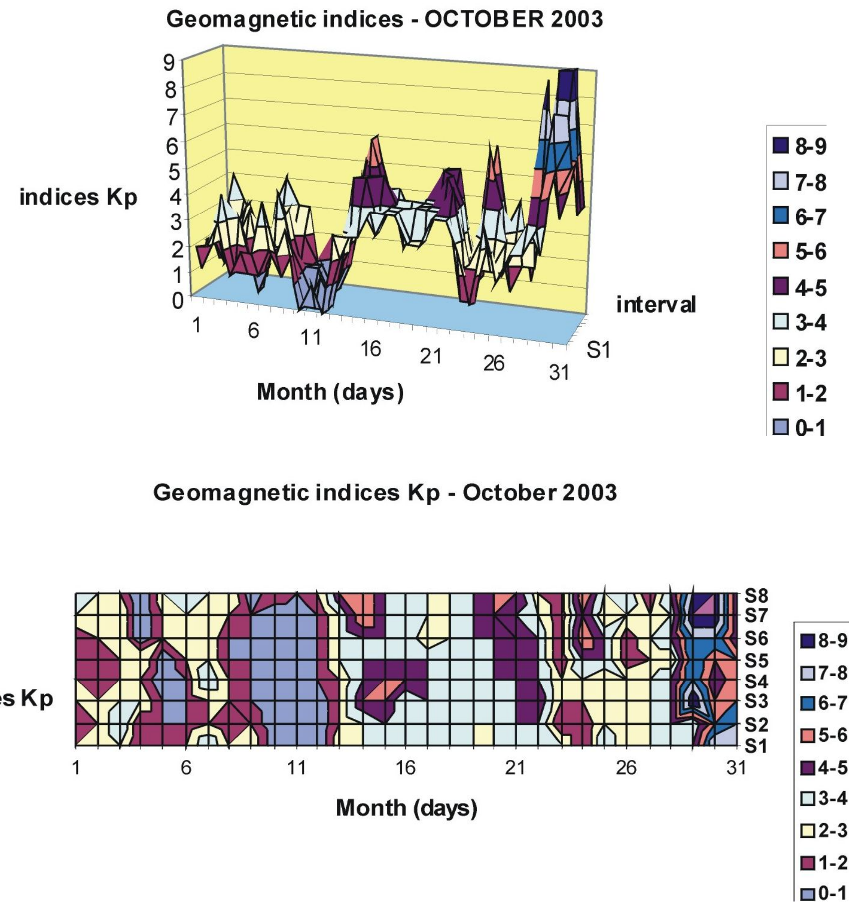


Fig. 4. The three-hour range geomagnetic activity indices K_p in October 2003

In the second and third decade of October 2003, the conditions in g.m.a. were determinated as disturbed and there are registered the groups of intensive (geo)magnetic storms. The changes of daily values of g.m.a. indices (ΣK_p and ΣK_{GCK}) were enhanced (Fig. 3 and Fig. 4.).

In relation to the aforementioned moderate geomagnetic storms the following events were recorded: explosive and intense CMEs, flare groups from the Catania 65 sunspot groups and an increase in solar wind speed by 1100 km/s. Geomagnetic activity conditions were defined as disturbed and moderate and minor magnetic storms were recorded. From the diagram of the daily value changes in the geomagnetic activity index (K_p) on October 24, 2003 we can see $\Sigma K_P = 29$ (Fig. 3) and for the three-hourly values on the geomagnetic activity index we can see $K_P = 5$, $K_P = 6$ (Fig. 4).

During the period from October 28 to 31, 2003 intensive and strong CME radiation was recorded. Solar wind speed was extremely high. On October 28, 2003 the speed was about 2125 km/s, while on October 29, 2003 it was about 1950 km/s. The B_z component of the interplanetary magnetic field (IMF) reached about 50 nT (Solar Influences Data Analysis, Sunspot Bulletin 2003, no. 10; Monthly Summary of Solar and Geomagnetic Activity).

This energy surge "attacked" the Earth's magnetic field at about 06 00 UT, on October 29, 2003. At 06 12 UT, on October 29, 2003 the SSC impulse (SSC – Sudden Storm Commencement) marked the start of one of the strongest magnetic storms recorded during the last ten solar cycles.

During the geomagnetic storm the geomagnetic activity planetary index was extremely high; e.g. on October 29 the geomagnetic index was $\Sigma K_p = 58$; on October 30 it was $\Sigma K_p = 56$ (Fig. 3). Maximum values for the geomagnetic index were also recorded during the three-hourly intervals $K_p = 7$, $K_p = 8$ and $K_p = 9$ (Fig. 4.). The geomagnetic storm lasted till November 1, 2003.Analysis of the hourly changes in the *Dst* index values indicates that in October 2003 geomagnetic activity passed through three periods with different activity levels. The *Dst*-index values show the hourly changes in the geomagnetic field horizontal component (H), during one month. Over October 01–13, 2003 the geomagnetic activity expressed by the hourly values of the *Dst*-index was quiet; while over the period October 14–27, recorded geomagnetic activity was on average disturbed. In the latter period the maximum change of the *Dst*-index values was $Dst < -100$ nT. In the period, from October 28 to November 2, 2003 geomagnetic activity was extremely intense, and the observatories recorded intensive geomagnetic disturbances. Three magnetic storms were recorded. At 23 00 UT, on October 30, 2003, the maximum indices were exceeded, and the *Dst*-index amplitude was $Dst = -401$ nT (according WDC-C2 Geomagnetism, Kyoto University; Monthly Bulletin No. 03–10 October 2003; Hourly Equatorial *Dst* Values (Provisional) – October 2003).

The Structure of the Diurnal Variations of Geomagnetic Activity in October 2003

An analysis of the daily variations structure was made on the basis of the recorded data for the horizontal component of geomagnetic field (average or mean hours values), at the mid-latitude geomagnetic Observatories, in October 2003. In this caption will be shown the results of analyze of class daily variations, which are registered on Geomagnetic observatory Grocka (GCK). The daily trend of the mean values horizontal component of geomagnetic field (H component) was presented: the S_R – regular daily variation for all day of the month; the S_q – regular daily variation for five magnetically quiet days (q – quiet days); and S_d – disturbed daily variation for five magnetically disturbed days (d – disturbed days).

Figure 5 shows the morphology of the S_q – daily variation for the magnetically quiet days, and Figure 6 shows the morphology of the S_d – daily variation for the magnetically disturbed days both of which were recorded in October 2003 at the Observatory GMO (GCK).

Hourly mean values of horizontal component of geomagnetic field, registered on GMO (GCK), in October 2003, are shown in Geomagnetic Yearbook 2003, N^o 43(09). That is standard tables of hourly mean values for all days in month. On diagrams, on which are shown classes of daily variations, are used table values of horizontal component of geomagnetic field.

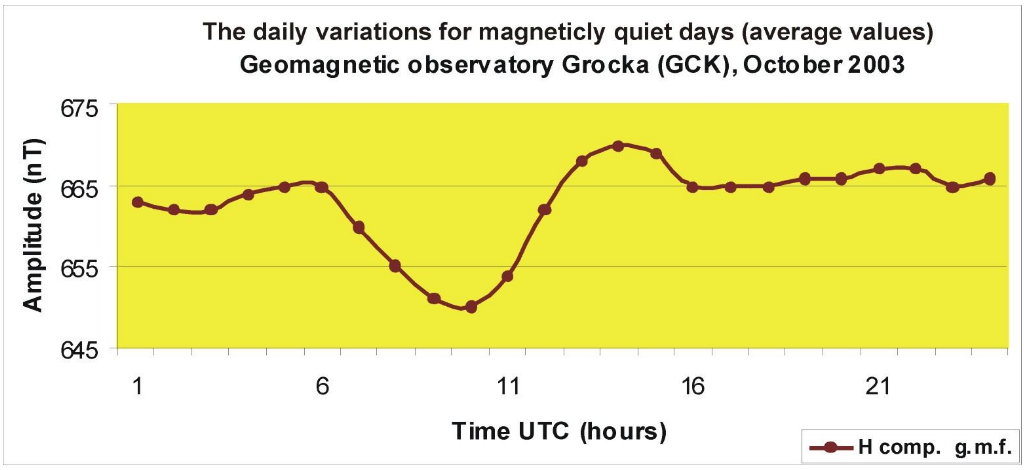
The regular daily variation S_q can be shown by distribution hourly mean values of horizontal component of geomagnetic field, for five magnetically quiet days $q_{(1-5)}$. Distribution of hourly mean values of horizontal component of geomagnetic field, for five magnetically quiet days, in October 2003, on Geomagnetic Observatory Grocka (GCK), is shown on diagrams 5a, 5b.

On the S_q variations, in October 2003, of the $q_{(2)}$ magnetically day, at 14 UT, is registered maximum value $H = 22\,674$ nT, and of the $q_{(3)}$ magnetically day, at interval of 09 UT, is registered minimum value of horizontal component $H = 22\,642$ nT. The daily mean value, for five magnetically quiet days was $S_{q(\text{mean})} = 22\,663$ nT. The deviation maximum hourly value of $S_{q(\text{mean})}$ value was $\Delta H_{\max(q)} = 11$ nT, and deviation of minimum hourly value was registered $\Delta H_{\min(q)} = -21$ nT.

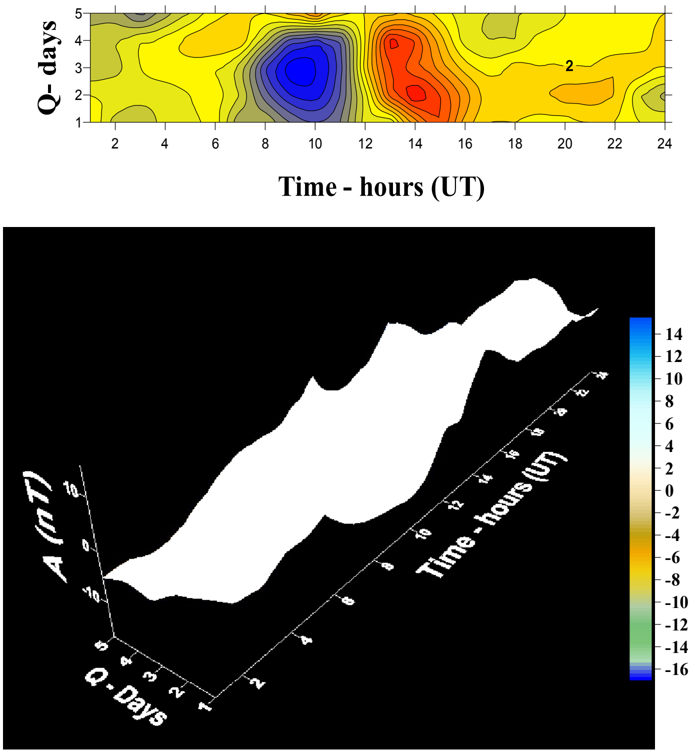
Maximum change of the hourly mean values of H – horizontal component geomagnetic field, for magnetically quiet days, is shown by extreme values (minimum/maximum values), in statistic analyses of geomagnetic data, it is shown as the S_q-rang daily variation.

The S_q-rang of daily variation in October 2003, on Geomagnetic Observatory (GCK), was about ΔH = 32 nT. Regular daily variation S_q for five magnetically quiet days, in October 2003, is regular signal of sinusoidal form (Fig. 5a).

The structure and the development of changes in solar-geomagnetic activity, on the S_d disturbed daily variation, in October 2003, was determined by registration of intensive magnetic storm, which began in October 29, 2003. This variation is determined for five magnetically disturbed days, and that were days with registrations of intensive magnetic storm. On Figure 6, on appropriate diagrams, is shown distribution of the hourly mean values of H-horizontal component of geomagnetic field, for five magnetically disturbed days $d_{(1\text{-}5)}$, in October 2003, on Geomagnetic Observatory Grocka (GCK).



(a)

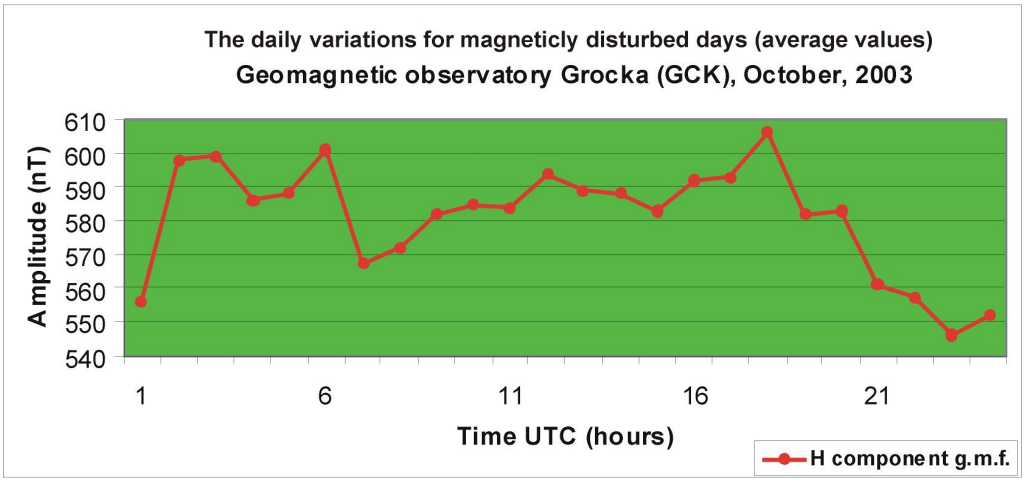


(b)

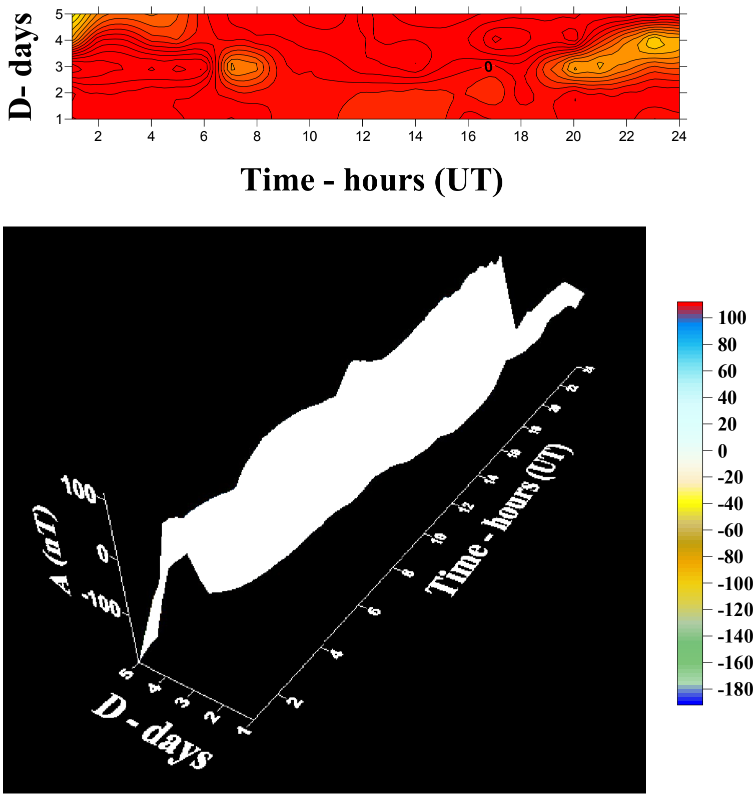
Fig. 5. The structure of the S_q daily variation for magnetically quiet days which were recorde in October 2003, at the Geomagnetic Observatory Grocka (GCK)

On the S_d disturbed daily variation, in overnight intervals from 01 UT and from 22 UT to 24 UT were registered minimum hourly mean values, and in intervals 06 UT and 18 UT were registered maximum values. Into the S_d daily variation are registered maximum values of the H = 22 675 nT, to minimum hourly mean values of horizontal component of geomagnetic field H = 22 345 nT. For five magnetically disturbed days, is computed daily mean value of variation $S_{d(\text{mean})}$ = 22 581 nT. Deviation maximum hourly mean values from the $S_{d(\text{mean})}$ value, were $\Delta H_{\max(d)}$ = +94 nT, and deviation minimum hourly mean value is registered $\Delta H_{\min(d)}$ = –236 nT (Figs. 6a; 6b).

Distribution of the hourly mean values of the H – horizontal component of geomagnetic field, for five magnetically disturbed days $d_{1\text{-}5}$, is shown on diagrams 6b. Rang, apropos registered maximum amplitude of the S_d daily variation, in October 2003, on Observatory GMO (GCK) was ΔH = 330 nT (Fig. 6b).



(a)



(b)

Fig. 6. The structure of the S_d daily variation for magnetically disturbed days which were recorded in October 2003, at the Geomagnetic Observatory Grocka (GCK)

SOLAR AND GEOMAGNETIC ACTIVITY IN NOVEMBER 2004

During the first ten days of November 2004 a sudden jump in the solar activity index was recorded. In the second half of November 2004 solar activity was reduced to quiet conditions, or in other words, during this period low solar activity indices were recorded. Figure 7 shows the changes in the R_i solar activity index in November 2004 (R_i – sunspot number).

Over November 3rd – 10th 2004, the Catania 61 sunspot group dominated solar activity. During this period, it produced M-flares (on November 7th) with the largest flare, an X2.5 (on November 10th). Most of these flares were accompanied by full or partial halo CMEs. The changes in the speed of the solar winds indicated conditions in the solar activity. The solar wind speed calculated on the basis of the recorded data was on 4 November 600 km/s, 7 November 1770 km/s, 9 November 1700 km/s and 10 November 1560 km/s. After November 10th a very quiet period continued till November 15th, 2004.

A series of interplanetary shocks was observed by satellites (ACE and SOHO/CELIAS) on November 7th 2004. The cold ICME matter arrived late on November 7th. This was probably a compound disturbance produced by the interaction of halo CMEs that erupted over November 3rd – 10th. The compound ICME contained a strong southward interplanetary magnetic field (up to –50 nT), resulting in a severe geomagnetic storm on November 7th – 8th. Geomagnetic conditions returned to major storm levels later on November 8th. The activity rose further to severe storm levels on November 9th–10th, in response to a new double shock (Solar Influences Data Analysis, Sunspot Bulletin 2004, No.11; Monthly Summary of Solar and Geomagnetic Activity).

After a quiet start, geomagnetic conditions reached severe storm levels over the period November 7th – 10th due to the impact of several coronal mass ejections (CMEs). The estimated K_p index reached a maximum value of 9 several times during this period. After November 10th things became much calmer and the rest of the month was mostly quiet with occasional active conditions.

At 2:57 UT on November 7th, an SSC impulse was registered, and it indicated the beginning of an intensive magnetic storm. The geomagnetic storm continued till November 13th 2004. During observation of the magnetic storm (over the period November 6th – 10th 2004) extremely high values in the solar activity indices and the planetary geomagnetic activity indices were recorded.

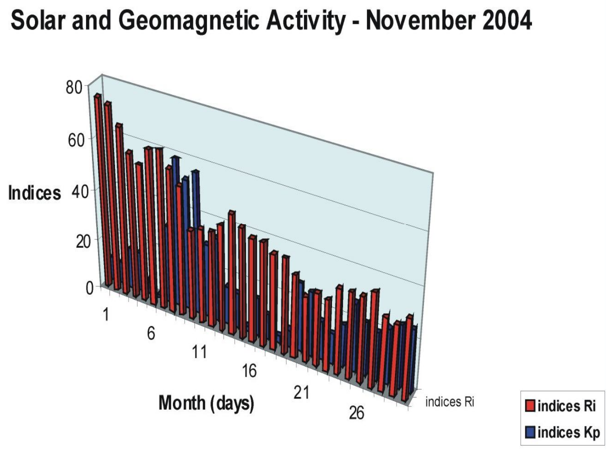
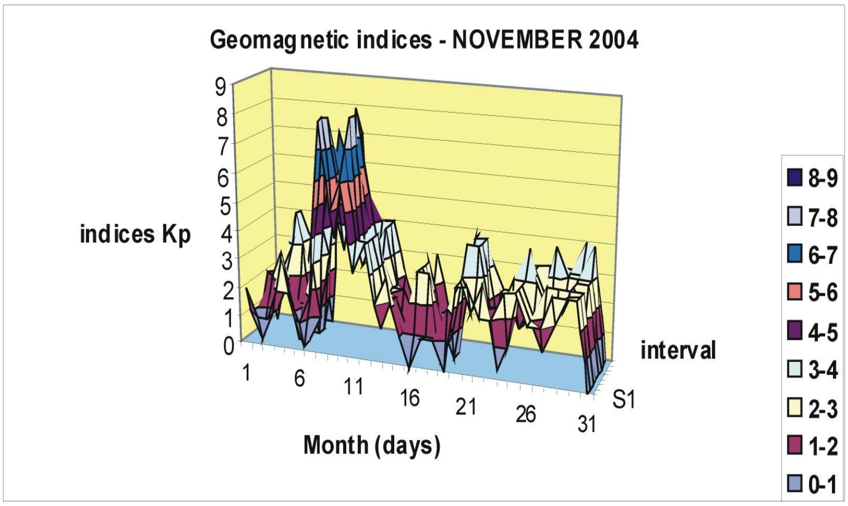


Fig. 7. Changes on the daily values of the R_i solar activity index and the ΣK_p geomagnetic activity planetary index at November 2004

Daily average and sum values were on 6 November $R_i = 62$, $\Sigma K_p = 1$; 7 November $R_i = 63$, $\Sigma K_p = 31$; 8 November $R_i = 57$, $\Sigma K_p = 50$; 9 November $R_i = 52$, $\Sigma K_p = 52$; 10 November $R_i = 36$, $\Sigma K_p = 56$; 11 November $R_i = 38$, $\Sigma K_p = 29$; 12 November $R_i = 38$, $\Sigma K_p = 33$ and 13 November $R_i = 42$, $\Sigma K_p = 15$.

The geomagnetic activity conditions in the first half of the month were disturbed. During the magnetic storm the daily sum values of the geomagnetic activity planetary index reached an extremely high level: $\Sigma K_p \geq 50$ (Fig. 7). During several three-hourly intervals maximum values for the geomagnetic activity index $K_p = 6$, $K_p = 7$ and $K_p = 8$ (Fig. 8) were recorded. The changes in the hourly D_{st}-values indicated that in November 2004, there were two periods with different geomagnetic activity levels. Over the period from 1st to 13th November, geomagnetic activity expressed by the hourly values of the *Dst* index was disturbed, while the period from 14th to 30th November 2004 was determined as a period of quiet geomagnetic activity. The level of the hourly *Dst* values recorded at 7:00 UT on November 8th 2004 was $Dst = -373$ nT (according *WDC-C2* Geomagnetism, Kyoto University; Monthly Bulletin, No. 03–10 October 2003; Hourly Equatorial *Dst* Values (Provisional) – November 2004).



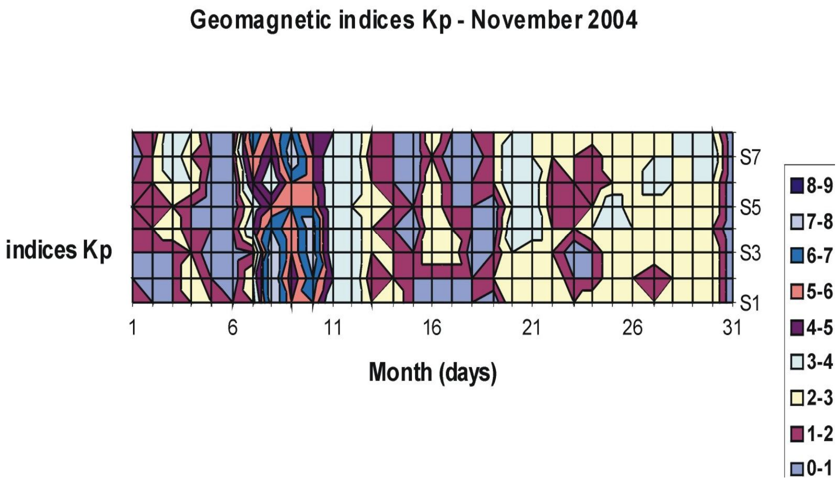


Fig. 8. The three-hour range geomagnetic activity indices K_p in November 2004

The Structure of the Diurnal Variations of Geomagnetic Activity in November 2004

On November 2004, the S_q daily variation is shown by distribution hourly mean values of horizontal component of geomagnetic field, for five magnetic quite days. On Figure 9 is shown morphology of the S_q daily variation for magnetic quite days in November 2003 that is registered on Geomagnetic Observatory Grocka (GCK).

On the S_q daily variation of quite days, in November 2004, of the $q_{(4)}$ magnetic day was registered minimum value of the component H = 22 641 nT, in interval 01 UT, and maximum value of the H – horizontal component of geomagnetic field, H = 22 682 nT is registered of the $q_{(2)}$ geomagnetic day, in interval 01 UT (Fig. 9a,b). We can show daily mean value for five magnetic quite days $S_{q(\text{mean})}$ = 22 663 nT. The deviation maximum hourly value of $S_{q(\text{mean})}$ value was $\Delta H_{\max(q)}$ = 19 nT, and deviation of minimum hourly value was registered $\Delta H_{\min(q)}$ = –22 nT. The S_q-rang of daily variation in November 2004 is registered ΔH_q = 41 nT (Fig. 9a,b).

The S_d disturbed daily variation has complex structure. This variation is in relation with five magnetic disturbed days, ant those are days when is registered intensive magnetic storm, which began November 07, 2004. Registration of intensive magnetic storm is determined morphology of S_d disturbed daily variation in November 2004. On Figure 10, is shown structure of the S_d daily variation for magnetic disturbed days, in November 2004, on the GMO (GCK).

Distribution of the hourly mean values of the H – horizontal component of geomagnetic field, for five magnetically disturbed days $d_{(1–5)}$, is shown on diagrams 10a,b. We can defined the hourly mean value for five magnetically disturbed days $S_{d(\text{mean})}$ = 22 588 nT.