VARIATIONS IN GEOMAGNETIC CUTOFF RIGIDITY OF COSMIC RAYS IN AUGUST 2005

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Variations in geomagnetic cutoff rigidity (August 2005) are calculated using data from ground-based observations of cosmic ray intensity at the worldwide network of stations. The calculated variations in geomagnetic cutoff rigidity are presented together with Dst-variations of the geomagnetic field. Paper also presents survey of variations in geomagnetic cutoff rigidity for different levels of disturbance of the geomagnetic field at different instants of the period under consideration.

INTRODUCTION

Geomagnetic disturbances during magnetic storms may cause significant variations in trajectories of charged particles in the magnetosphere - allowed trajectories can thus become forbidden and vice versa. This has two major consequences for ground-based observations: 1) variations in effective cut-off thresholds; 2) variations in effective asymptotic directions of arrival of particles and consequently in receiving coefficients for different stations.

The magnetospheric effect associated with cutoff rigidity variations may be sufficiently dramatic to change the time dependence of cosmic ray (CR) intensity variations observed at mid- and low-latitude stations, unlike the time dependence of CR intensity variations at high-latitude stations where this effect is absent.

Firstly, magnetospheric variations of the CR intensity are of interest from physical standpoint (i.e., from the standpoint of formation, development and disintegration of magnetospheric current systems). Besides, variations in the threshold geomagnetic cutoff rigidity (GCR) obtained from investigation into CR geomagnetic effects may be additional source of information for checking one or another model of the Earth's magnetosphere. Secondly, magnetospheric effects are of importance from methodological standpoint, since they hinder studying extraterrestrial CR variations and should be left out of experimental data whenever possible. We studied variations in the threshold GCR in August 2005. The period under consideration is characterized by the following features: presence of some high-speed streams with solar wind (SW) velocities up to ~700 km/s in interplanetary space; increase in modulus of the interplanetary magnetic field (IMF) up to ~45 nT; large amplitudes of CR modulations (5-9 % at polar and mid-latitude stations) involving geomagnetic disturbances with Dst up to ~ -230 nT.

DATA AND METHOD

Ground-based measurements averaged over one-hour intervals from the worldwide network of neutron monitors (44 stations) were used for analysis. Modulation amplitudes were reckoned from the quiet level of 2 April 2005.

The SGS method [1] was used to obtain information about variations of primary-CR angular and energy distribution beyond the Earth's magnetosphere and about changes in the GCR planetary system for each observation hour.

The following system of nonlinear algebraic equations was solved:

$$\frac{\delta I_c^i}{I_c^i}(h_\ell) = -\Delta R_c W_c^i(R_c, h_\ell) \times \left(1 + \frac{\delta J}{J}(R_c)\right) + \int_{R_c}^{\infty} \frac{\delta J}{J}(R) W_c^i(R, h_\ell) dR,$$

where $\frac{\Delta I_c^i}{I_c^i}(h_l)$ are the amplitudes of variations of the type-*i* secondary particle flux (relative to some background level I_c^i) observed at the geographical point *c*, at the level h_ℓ in the Earth's atmosphere;

R_c is the effective GCR; $W_c^i(R, h_\ell)$ is the coupling function between primary and secondary CR variations; $\frac{\delta J}{J}(R)$ are the amplitudes of primary spectrum variations. The formal mathematical approximation $\frac{\delta J}{J}(R)$ is used in the SGS method. The threshold GCR dependence ΔR_c on the threshold rigidity is approximated by the expression $\Delta R_c(R_c) = \left(b_1 R_c + b_2 R_c^2\right) e^{-\sqrt{R_c}}$. As CR stations are non-uniformly distributed all over the world, we did not take account of the longitude effect in planetary changes of cosmic-ray GCR when performing calculations.

RESULTS, DISCUSSION AND CONCLUSIONS

Figure 1 shows the IMF modulus, B_z -component of IMF, SW velocity (V), intensity of particles with rigidity of 0.108 and 5 GV, Dst-index [2], GCR variations (ΔRc) at the stations "Irkutsk" (Rc=3.66 GV, red line) and "ESOI" (Rc=10.8 GV, blue line) obtained by the SGS method. Figure 2 presents GCR variations (ΔRc) dependent on threshold rigidities Rc at certain instants of time in August 2005.

According to Fig. 1, there were 2 magnetic storms with different intensities in August 2005: on 24-25 August (Dst ~ -216 nT, |B| ~ 45 nT, Bz ~ -40 nT) and 31 August (Dst ~ -130 nT, ,|B| ~ 17.5 nT, Bz ~ -17 nT). Time dependence of GCR variations for the station with Rc=3.66 GV within the period of 24-31 August correlates well with the Dst-index. The correlation coefficient between ΔRc and Dst is 0.83. The correlation coefficient between ΔRc and Dst for the point with Rc=10.8 GV is low (~ 0.5) within this period. Maximum values of the GCR decrease at Irkutsk station synchronize with geomagnetic field maximum decrease (on 24 August at 12:00 – 13:00 UT, ΔRc= -1.25-1.30 GV, Dst~ -200 nT; on 31 August at 18:00 UT, ΔRc= -0.7 GV, Dst ~ -130 nT), whereas they lag at the station "ESOI" (on 25 August at 04:00 UT, ΔRc=-0.66 GV, Dst ~ -83 nT; on 31 August at 22:00 UT, ΔRc=-0.48 GV, Dst ~ -109 nT).

Fig. 2 presents dependence of threshold GCR variations (ΔRc) on threshold rigidities Rc at certain instants of time in August 2005. Red solid lines indicate calculation results obtained by the SGS method with data from the worldwide network of CR stations. Blue dashed lines indicate calculation results of the effect of the westward current flowing with the strength proportional to the latitude cosine along parallels on the sphere for different radii of the current ring in the dipole field [3,4]. The current ring radii on 24 August at 10:00, 11:00 and 12:00 UT were about 3, 5 and 9 Earth radii, respectively. These radii at 18:00 and 21:00 UT were about 5 Earth radii. By the end of 31 August, GCR variations at low-latitude CR stations were larger compared to high- and mid-latitudes (see three lower panels in Fig. 2). The current ring radius within this period decreased from ~5 down to ~3 Earth radii.

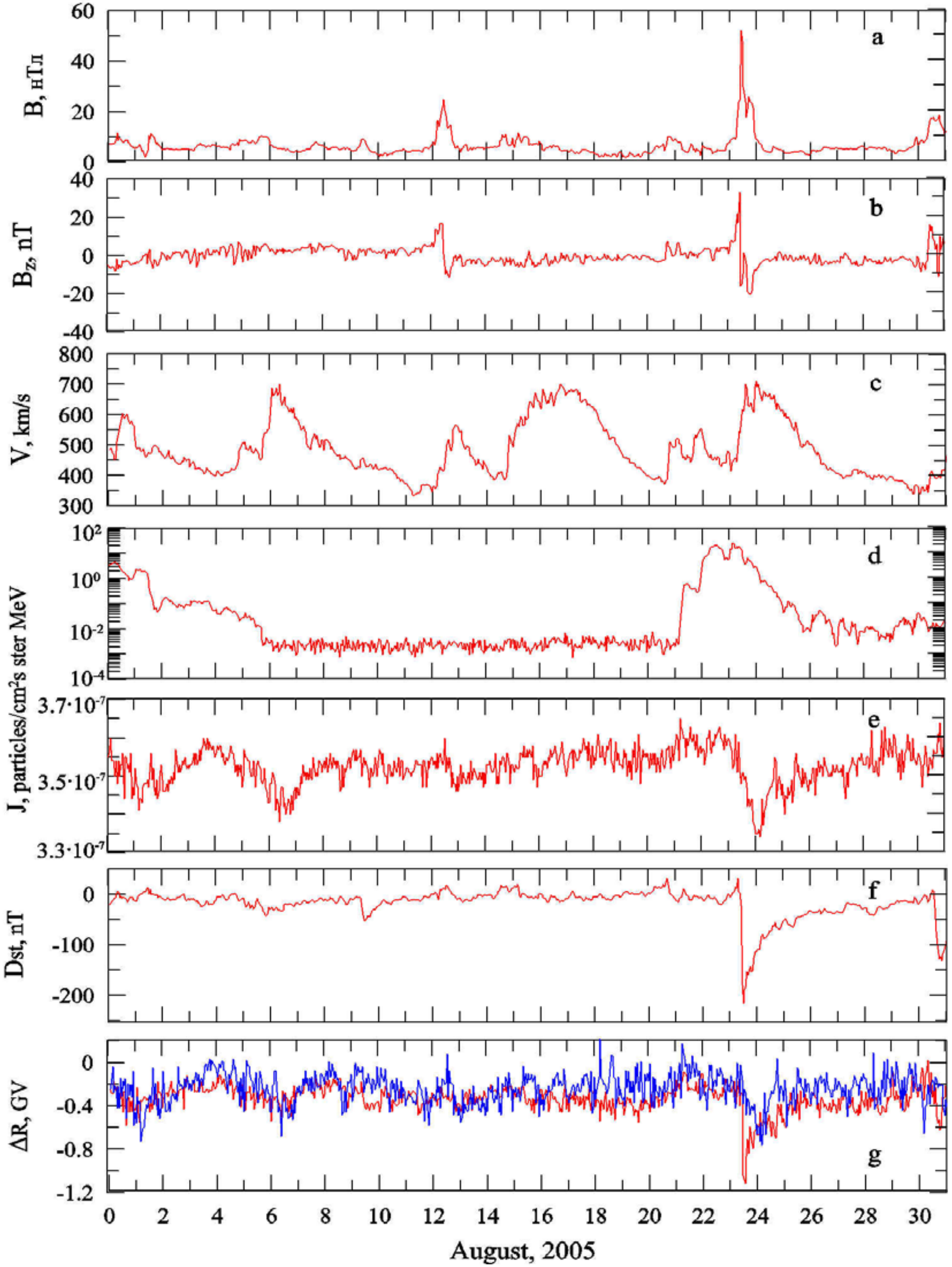

Fig. 1. *The IMF modulus (a), Bz -component of IMF (b), SW velocity (V), intensity of particles with rigidity of 0.108 (d) and 5 GV (e), Dst-index (f), GCR variations (Rc) at Irkutsk stations (Rc=3.66 GV) and “ESOI” (Rc=10.8 GV) (g), red and blue lines, respectively.*

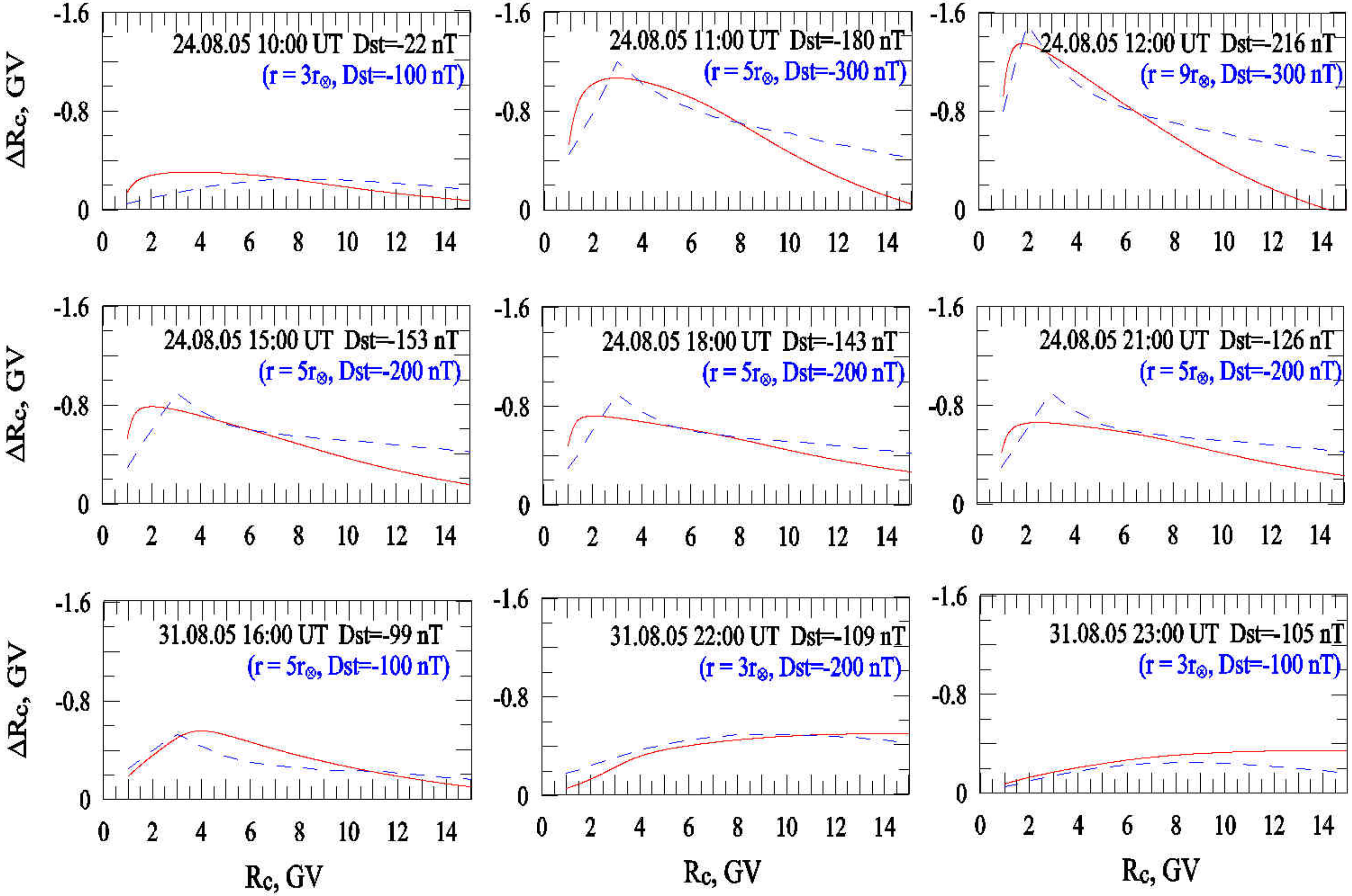

Fig. 2. *Dependence of GCR variations (ΔRc) on threshold rigidities Rc at certain instants during geomagnetic disturbances in August 2005 (red line); the dependence was calculated using data from the worldwide network of CR stations. Dependence of GCR variations (ΔRc) on threshold rigidities Rc, based on calculations of the effect of the westward current flowing with the strength proportional to the latitude cosine along parallels on the sphere for different radii of the current ring in the dipole field.*

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