July 2000 Forbush-effect from world network of cosmic rays stations

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Abstract. We studied variations in the galactic cosmic ray (CR) rigidity spectrum and anisotropy during the July 2000 strong magnetic storm from the ground-based observations of cosmic rays within the world network of neutron monitor stations through spectrographic global survey. We show the time history for amplitude variations in the rigidity spectrum of cosmic rays, their anisotropy and planetary system of the geomagnetic cutoff rigidity during the Forbush-effect evolution over that period.

1. Introduction
Staring with 10 July 2000, several decreases in intensity of cosmic rays (CR) were recorded. Those events are associated with active region 9077 on the Sun. On 14 Jul 2000, ground-based CR stations recorded a significant increase in the CR intensity against the Forbush decrease that had started on 13 July 2000. That increase is linked to a 3B/X5.7 solar flare that occurred at 10:30 UT in active region 9077 with the heliographic coordinates being N22°, W07°. On 15 July 2000, a strong magnetic storm started on the Earth as well as a recurrent decrease in the CR intensity that is associated [1] with a coronal mass ejection (CME) attending a solar flare. At that time, the solar wind (SW) magnetic field velocity and modulus reached ~1100 km/s and ~60 nT, respectively, and the D_s-index at the magnetic storm main phase reached ~ –300 nT on the Earth, the CR intensity decrease observed at high-latitude neutron monitors reached ~ –15 %, while at mid-latitude ones it was ~ –10 %.

2. Data and method
We used the hour-averaged data from ground-based measurements within the world network of neutron monitors (35 stations).

By using the method of spectrographic global survey (SGS method) [2, 3], we obtained the information on variations in angular and energy distribution of primary CR outside the Earth magnetosphere, and on variations in planetary system of geomagnetic cutoff rigidities for each observational hour. Modulation amplitudes were counted off against the 6 July 2000 background level.

3. Results and conclusions
Figure 1 shows the rigidity spectra for the amplitudes of variations in primary CR in the Earth orbit at some instants of the Forbush-effect evolution on 15 July and 16 July 2000. One can see a phase of a sharp decay in intensity on 15 July 2000 at 20:00–23:00 UT, the decay maximum phase on 16 July 2000 at 01:00 UT, and a recovery phase 09:00 through 12:00 UT. It is obvious that the variation rigidity spectrum is not an exponential function of particle rigidity at all the instants. The particle
modulation is maximal over the ~ 3 to ~ 8 GV rigidity range, and the extremum shifts as the effect evolves first towards lower rigidities, and then towards higher rigidities at the recovery phase.

At 20:00 UT on 15 July 2000, one observed an increase in the CR pitch-angular distribution first spherical harmonic amplitude for the 4 GV particles up to ~30%. At the next instant, an increase in the amplitude of bidirectional anisotropy for the 4 GV particles up to ~8% was observed. On 16 July 2000 at 08:00 and 09:00 UT, the first spherical harmonic amplitude for the 4 GV particles was ~25 % and 60 %, respectively, while the bidirectional anisotropy amplitude for the 4 GV particles was ~10 % over that period and during the next 3 hours.

![Figure 1. Primary CR variation spectra.](image)

Figure 2 presents the CR intensity relative changes for the 4 GV and 10 GV particles (relative to 6 July 2000) in the solar-ecliptic geocentric coordinate system at various instants of the Forbush-effect evolution. The abscissa axis exhibits the longitudinal angle values, while the ordinate axis shows the latitude angle values.

One can see that the arrival of various energy particles at the Earth during the period under consideration occurs approximately from identical directions except for the 08:00 UT 16 July 2000 instant when one observes bidirectional anisotropy for the 4 GV particles which is not the case for the 10 GV particles.

The increased values of amplitudes for the first spherical harmonic and CR bidirectional anisotropy testify to that the Earth got to an area with an intensified IMF strength produced by the CME passage with the corresponding loop like IMF pattern which caused the Forbush-effect and strong geomagnetic disturbance.

Over that period, there were essential changes in planetary system of the geomagnetic cutoff rigidity. Thus, the geomagnetic cutoff threshold rigidity decreased by ~ –0.8 – –1.0 GV at the magnetic storm main phase for the Irkutsk CR station. In Figure 3, the solid line presents the dependences of changes in the geomagnetic cutoff threshold rigidity on the threshold rigidity at some instants close to the magnetic storm main phase. The dashed line shows results of computations for the effect of the current flowing westward along parallels on the sphere with a strength proportional to the latitude cosine for various radii of the current ring in the dipole field [4]. For all the given instants, the calculated radius of the ring current (in units of the Earth radius) is equal to 5, and the variations in the geomagnetic field horizontal component at 01:00, 03:00 and 12:00 UT on 16 July 2000 were –300, –200 and –200 nT, respectively. I.e. one may assume that over that period the ring current distance from the Earth did not vary, but it was its strength that varied. The correlation coefficient between the computed changes
in the geomagnetic cutoff threshold rigidity ($R_c=3.66$ GV) and $D_s$-index 15 July through 18 July 2000 is 0.85 in Irkutsk.

Figure 2. CR intensity relative changes for the 4 GV and 10 GV particles in the solar-ecliptic geocentric coordinate system.

Figure 3. Dependence of variations in the geomagnetic cutoff threshold rigidity $\Delta R_c$ on threshold rigidities $R_c$ at individual instants of the July 2000 geomagnetic disturbances.

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