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Changes in cosmic ray intensity observed on CORONAS-I satellite during magnetic storms in April 1994

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Abstract. The energetic charged particles (E_p > 70 MeV and E_e> 55 MeV) were measured by SONG instrument on board low altitude polar-orbiting CORONAS-I satellite. The interplanetary shock arrivals on 3-4 April 1994 (D_{st}=-111 nT) and 17 April 1994 (D_{st}=-201 nT) caused significant variations of fluxes of the energetic charged particles detectable on altitude of CORONAS-I satellite. The latitudinal dependence of these effects has been investigated separately for south and north of the minimum *L* equator on 500 km. The comparison with changes in the cutoff rigidities calculated by Smart et al. (1999a) is done.

1 Introduction

The aim of the present work is to discuss the dependence of cosmic ray (CR) variations on latitude during magnetic storms with help of the data measured by SONG device aboard of low altitude CORONAS-I satellite. Decrease of local geomagnetic cutoff due to the effect ring currents leads to the enhancement of galactic cosmic radiation accompanied by Forbush-decreases (FD's) of CR intensity, which is associated with propagating solar wind disturbances. However, recently the phenomenon of Forbush-increase has been discussing as a one of the possible aspect of Forbush-effect in the heliosphere (Belov et al., 1999).

2 Instrumentation and method

Low altitude satellite CORONAS-I has been devoted to the study of various aspects of solar activity. The SONG device is a part of the complex measuring high energy electromagnetic and corpuscular emissions from the Sun. The instrument consisted of a CsI(Tl) crystal (20 cm diameter x 10 cm length) and was intended for detection of gamma-rays and neutrons. The threshold energy loss for charged particles in the scintillator was set at 50 MeV and can release protons with energy E_p> 70 MeV and electrons with energy E_e>55 MeV (Kuznetsov et al., 1995). The temporal resolution of count rates was 2.5 sec.

The CORONAS-I satellite was launched on March 2, 1994 into a nearly circular orbit with an altitude of 500 km and inclination 83°. The SONG device was placed on the platform for scientific instruments about 1 m from the upper end of the satellite body. The nominal orientation during its first working period (until July 5, 1994) was with its longitudinal axis directed toward the Sun. This was true for both day as well as night passes (SONG was oriented towards the Earth on night side of orbit).

In the present paper the intensity variations are discussed during FD's on April 3-4, 1994 (designated as Event 1, the peak K_p=7+, D_{st}=-111 nT) and on April 17, 1994 (Event 2, the peak K_p=8+, D_{st}=-201 nT). Both events were recorded by SONG instrument (fluxes of protons E_p> 70 MeV and electrons E_e>55 MeV) on board CORONAS-I satellite and carefully analyzed in the previous papers (e.g. Myagkova et al, 1999). The data measured over the period from April 6 to April 16, 1994, we use as a background level of CR intensity (the average K_p value was 4+). The all three data sets (measurements on April 4, April 17, and April 6-16, 1994) have been divided into the 14 groups in *L*: 1-1.03-1.1-1.2-1.3-1.4-1.6-1.8-2-2.4-3-4-5-7-12, and distinguished into the southern and northern hemispheres according to the minimum *L* equator on altitude 500 km. The McIlwain's *L* parameter was calculated using the IGRF-91 magnetic field model. In order to exclude trapped radiation (protons in South Atlantic Anomaly), the minimal altitude of mirror points was chosen to be H_{min}< 100 km.

3 Results and discussion

The intensity variations of CR's (protons E_p> 70 MeV and electrons E_e>55 MeV) on *L* for both events at northern and southern hemispheres are shown in Fig. 1. The profile of

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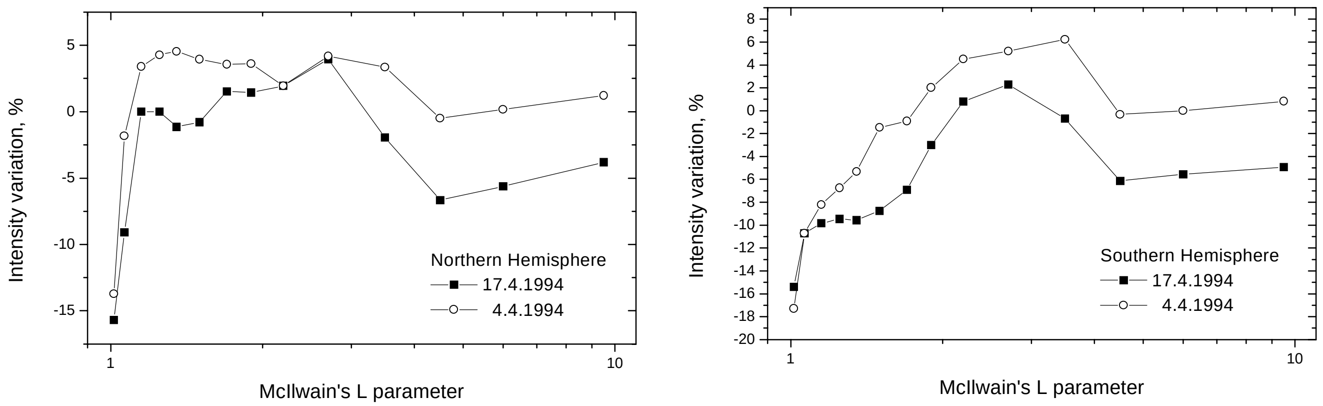

Fig.1. The intensity variations of CR's (protons E_p> 70 MeV and electrons E_e>55 MeV) on L for both events at northern (left panel) and southern hemispheres (right panel).

this dependence should be assumed to reflect at least the influence of two strong effects, namely (a) – the FD variation, and (b) – cutoff rigidity changes. A slow variation in the CR intensity at L >4.5 can be attributed the slow changes in cutoff rigidity and constant FD. We propose the uniform FD due to well-known high-latitude cutoff in galactic CR. Note, there is observed plateau in latitude dependence of the energetic charged particles (E_p> 70 MeV and E_e>55 MeV) above L =4. Since FD is the most pronounced at high latitudes we can estimate the maximum value of this decrease, which achieve at least 5.5 % in case of Event 2. The largest increase in CR intensity at L ~2-3 can be probably related to the maximum decrease in geomagnetic cutoff. Similar results about cutoff rigidity variations (the weak change at high latitudes and near equator, and maximum variations at the middle latitudes) is possible to obtain from Smart et al. (1999b, 1999c) calculations for altitude of 450 km.

As seen in Fig. 1, the near equatorial region is area of the maximum CR depression instead of expected FD attenuation. We propose speculation there is variation in charged albedo fluxes (atmospheric – splash or re-entrant

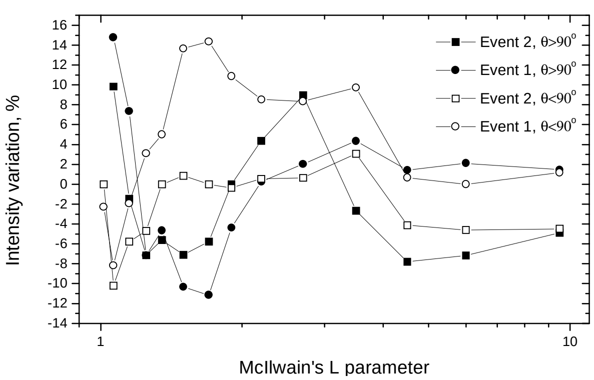

Fig. 2. The intensity variations of upward (zenith angle θ >90°) and downward (θ <90°) CR's (protons E_p> 70 MeV and electrons E_e>55 MeV) on L for both events at southern hemisphere.

and instrument albedo) at the lowest values of L. Energetic albedo particles have rigidities below local geomagnetic cutoff, and therefore could be strongly affected by fluctuations in interplanetary magnetic field. It should be noted, in the equatorial region, the galactic CR intensity achieves only 20-25 % of the total measured flux unlike polar caps where attains > 90 % (Kuznetsov et al., 1997). Moreover, below L=2 the strong longitude (Kuznetsov et al., 1997) and zenith angle variations of particle fluxes have been found. The illustration of the zenith angle dependence of the charged particle fluxes at southern hemisphere is given in Fig. 2. Figure 2 shows separation of the observed fluxes with energy release > 50 MeV according to the zenith angle. The anisotropy in intensity variation from L=1.03 to 2 is apparent. We note that the average value of the relative difference between upward (zenith angle θ >90°) and downward (θ <90°) moving particle fluxes reaches ~ 22% at L<2. We suppose that upward flux contains splash (or direct) component and downward flux re-entrant component of the atmospheric albedo. Furthermore, it was assumed that the spectrum of the re-entrant protons (or electrons) in the energy range 37-334 MeV (10-1100 MeV for electrons) at the top of the atmosphere and that of the splash albedo protons (or electrons) are the same (Israel, 1969; Verma, 1967). These measurements were performed below the 4.5 GV geomagnetic cutoff. Therefore, if we consider possible similar behaviour also for other rigidities, one of the reasons for different intensity variation below L=2 might result from enhanced local emission (i.e. instrument albedo) in upward fluxes. Further work is needed to clarify the ratio of the various components of charged albedo flux.

Comparing the zones of the weakest level of the intensity variation (above L=4.5, see Fig. 1) with those where the peak of particle enhancement was observed (L ~ 2-3), one can infer that change in cutoff rigidity is increasing function of magnetic activity. This conclusion is in agreement with Smart et al., 1999a calculations.

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References

Belov, A. V., Eroshenko, E. A., and Yanke, V. G., Cosmic Ray Effects Caused by Great Disturbances of the Interplanetary Medium in 1990-1996, *Proc. 26th ICRC*, 6, 431, 1999.

Israel, M. H., Cosmic ray electrons between 12 MeV and 1 GeV in 1967, *J. Geophys. Res.*, 74, 4701, 1969.

Kuznetsov, S. N., Bogomolov A. V., Gordeev, Yu. P., Gotselyuk, Yu. V., Denisov, Yu. I. et al., *Izvestyia RAN, Ser. Fiz.*, 59, 2, 1995.

Kuznetsov, S. N., Bogomolov, A. V., Dmitriev, A. V., Kudela, K., Myagkova, I. N., and Ryumin, S. P., *Izvestyia RAN, Ser. Fiz.*, 61, 1104, 1997.

Myagkova, I. N., Kuznetsov, S. N., Kudela, K., Ryumin, S. P., and Mavromichalaki, H., Forbush-effect April 17, 1994 on Data of the Flying Detector on a Board of CORONAS-I satellite, *Proc. 26th ICRC*, 6, 427, 1999.

Smart, D. F., Shea, M. A., Flückiger, E. O., Tylka, A. J., and Boberg, P. R., Changes in Calculated Vertical Cutoff Rigidities at the Altitude of the International Space Station as a Function of Geomagnetic Activity, *Proc. 26th ICRC*, 7, 337, 1999a.

Smart, D. F., Shea, M. A., Flückiger, E. O., Tylka, A. J., and Boberg, P. R., Calculated Vertical Cutoff Rigidities for the International Space Station During Magnetically Active Times, *Proc. 26th ICRC*, 7, 398, 1999b.

Smart, D.F., Shea, M. A., and Flückiger, E. O., Calculated Vertical Cutoff Rigidities for the International Space Station During Magnetically Quiet Times, *Proc. 26th ICRC*, 7, 394, 1999c.

Verma, S. D., Measurement of the Charged Splash and Re-Entrant Albedo of the Cosmic Radiation, *J. Geophys. Res.*, 72, 915, 1967.