SH 2.1.04

Forbush-effect April 17, 1994 on Data of the Flying Detector on a Board of CORONAS-I Satellite

I.N. Myagkova[1], S.N. Kuznetsov[1], K. Kudela[2], S.P. Ryumin[1] and H. Mavromichalaki[3]

[1]*Scobeltsyn Institute of Nuclear Physics, Moscow State University, 119899 Moscow, Russia*

[2]*Institute of Experimental Physics, SAS, 043 53 Kosice, Slovakia*

[3]*Physics Department, Athens University, 15771 Athens, Greece*

Abstract

A Forbush-effect was observed by SONG instrument on board of "CORONAS-I" satellite during April 17, 1994. We analyzed latitude dependence of this effect from local time 11 to 23 h. and compared with data from ground-based neutron monitor stations at different latitudes.

1 Introduction:

Short-term cosmic ray decreases are investigated by ground neutron monitors (NM) and by detectors on board near-Earth satellites detecting primary GCR (e.g., Lockwood, Webber & Debrunner, 1991; Cane, Richardson, von Rosenvige & Wibberenz, 1994; Cane, Richardson & von Rosenvige, 1995;). Since every monitor has its own receiving cone and in every determined time moment it detects the particles coming from the definite direction, to investigate Forbush decreases spectra we need the system of monitors, situated on different longitudes and latitudes. Data obtained on board of such satellites as IMP-8, ICE does not permit to study Forbush decreases in a broad interval of energies. The detector with large geometric factor for cosmic ray detection on board of a low-altitude satellite used as moving monitor of cosmic rays permits to observe Forbush decreases at different latitudes and to study Forbush decreases value dependence on cut-off rigidity. Advantages of such moving monitor in comparison with the ground neutron monitor were discussed in our earlier paper (Bogomolov et al., 1995). In this paper Forbush decrease 1994, April 17 the measurements in different latitudes by SONG instrument on board of CORONAS-I satellite and comparing with neutron monitor data are presented. Earlier Forbush decreases measurements on board of low-altitude satellite (by charged counters on board OGO-6 satellite with a perigee of 400 km and apogee of 1100 km) were reported in Ifedili (1996).

2 Experiment:

The "CORONAS-I" satellite was launched on March 4, 1994 into a circular orbit with altitude 500 km and 83 degree inclination. It was oriented towards the Sun and was equipped with a set of instruments for studies of solar flares and corresponding SCR phenomena (Kuznetsov et al., 1995). GCR variations were studied with the help of data obtained due to the SONG-instrument. It based on CsI(Tl) crystal (∅ 20 cm and h 10 cm) and was used in the experiment on board "CORONAS-I" satellite as gamma-ray and neutron detector. Energetic particle fluxes (with energy releases E>50 MeV) were detected. Such energy releases can be caused by protons (E_p>70 MeV) and by electrons (E_e>55 MeV). The SONG instrument was oriented in Sunward direction. Preliminary results of GCR variation measurements with the help of the SONG-instrument during the time period of March-April 1994 were reported in Bogomolov et al. (1995).

During the time period of April 16-l 17, 1994 a Forbush decrease was observed. For the study of this effect we used SONG-instrument data from 5 to 18 April of 1994 (days from 5 to 14 April were used for the background condition estimation). All data were presented as four groups obtained in the northern hemisphere during local day, in the northern hemisphere during local night, in the southern hemisphere during local day

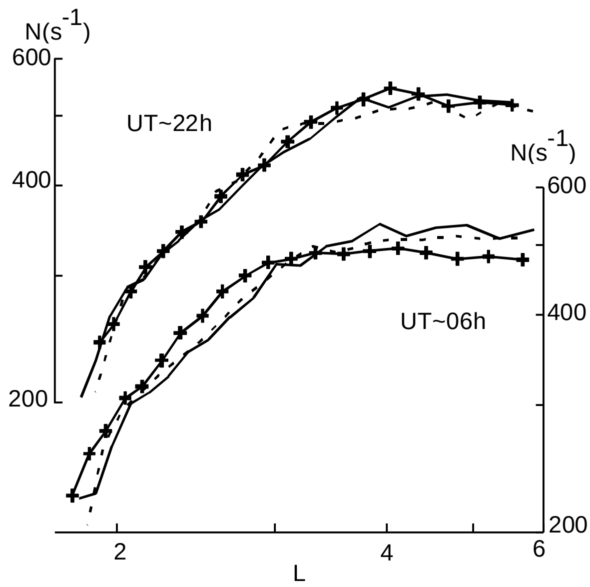

Figure 1: The latitude dependencies of protons (E_p>70 MeV) and electrons (E_e>55 MeV). fluxes in northern hemisphere during local day.

and in the southern hemisphere during local day, respectively. As an example the latitude dependence of energetic particles fluxes for L-shells from 1.8 to 6 in the northern hemisphere during local day are shown in Fig.1. These latitude dependencies were obtained before and during Forbush decrease - 1994, April, 15, 16,17 in UT=22 h and 1994, April, 16, 17, 18 in UT=06 h (consequently, solid line, solid line with crosses and dashed line for both UT intervals.) Mean data for 20 seconds time intervals were used for each orbit, so statistic error of each point varied from 2% (at the equator) to 1% (at high latitudes). All three longitude dependencies in UT=22 h were obtained at -170^O longitude and UT=06 h - at 70^O longitude. We can see that three curves in top part of Fig.1 are practically equal, since April, 16 in 22 h Forbush decrease had not started yet, but in bottom part of Fig.1 the latitude dependence obtained already during Forbush decrease April 17 (solid line with crosses) is different. In UT=06 h of April 17 at high latitudes (L more than 4.5) count rate of SONG instrument was significantly lower than before and after Forbush decrease (April 16 and 18), but. In the middle latitudes (2<L<3) SONG instrument's count rate was lower than before and after Forbush decrease.

To study the phenomena more carefully we analyzed mean count rate of SONG instrument in polar caps and in the middle latitudes (L=2.1-2.9, mean L≈2.5), since in this interval of L latitude dependence of count rate is linear) for each orbit. To take into account longitude dependence we normalized our data obtained in the middle longitudes during considered time interval (April 15-18) using mean data at different longitudes obtained during 10 days before (April 4-l4). It was done for each of four middle latitude data groups and after that we found that normalized data obtained both in the northern and in the southern hemispheres are similar, but ones obtained during local day and local night are different. So we used mean values of count rate in the northern and in the southern hemispheres separately for local day and local night.

3 Results:

Time dependencies of SONG instrument 's count rate and different ground neutron monitors (hourly data) obtained during Forbush decrease 1994, April 17 are presented in Fig.2. To compare our data with ground NM ones we normalized both SONG and NM data to mean background count rate obtained for 10 days before April 15. We compared SONG date obtained in the middle latitudes during local night (closed diamonds) with Climax NM data (cut-off rigidity P=2.99 GV), ones for local day (open diamonds)- with Moscow NM ones (P=2.43 GV), ones for the southern polar cap (crosses) - with south polar McMurdo NM (P=0 GV) and ones for the northern polar cap (crosses) - with north Thule NM (P=0 GV). On the bottom of Fig. 2 time dependence of D_{st} index (in nT) for this Forbush decrease time interval is shown. Unfortunately we have no data of SONG instrument in April 17 from 07 h 30 min. to 22 h and so we can not analyze data of the SONG instrument during the total time interval of the Forbush decrease.

It's clear seen that data obtained both by SONG instrument and by neutron monitors at the middle and at the high latitudes are different, but the difference between middle and high latitudes for SONG instrument's data is stronger than for neutron monitors ones. The range of Thule and McMurdo data variations 4% and 5% correspond to ≈8% range of variations in CORONAS-I data. It is connected with differences in minimal energy of particles detected by NM Thule and McMurdo (~500 MeV) and CORONAS-I (~70 MeV). SONG data obtained in the high latitudes in southern cap correlates with McMurdo and Thule data (r=56% for McMurdo and r=85% for Thule) and with D_{st} index (r=77 %), but ones obtained in northern cap correlate only with NM Thule data (r=74 %) and with D_{st} index (r=68 %). We can see that both SONG instrument and neutron monitors detected the beginning of Forbush decrease at the North earlier than at the South and in the South the decrease was more graduated.

At the middle latitudes SONG instrument and NM data obtained during Forbush decrease of April 17 are very different. Middle-latitude neutron monitors show weaker Forbush decrease than polar NM - the range NM data decrease measured in Climax and Moscow are equal to 4% and 3.5%, correspondingly, but this maximal value were detected only during very short time. Data obtained with the help of SONG instrument at L from 2.1 to 2.9 show a significant enhancement - 9% during local day and 10% during local night. So there was no correlation SONG instrument's data with NM ones at the middle latitudes. It is connected with the different nature of second particles detected by SONG instrument and neutron monitors and variations of cut-off rigidity during geomagnetic storm. For example, Fluckiger, Smart & Shea (1980) showed that during initial phase of geomagnetic storm (D_{st} =-100 nT) cut-off rigidity value variations (P= 2-3 GV) reached 15%. The similar results about cut-off rigidity variations were reported in Lockwood & Webber (1991). Such

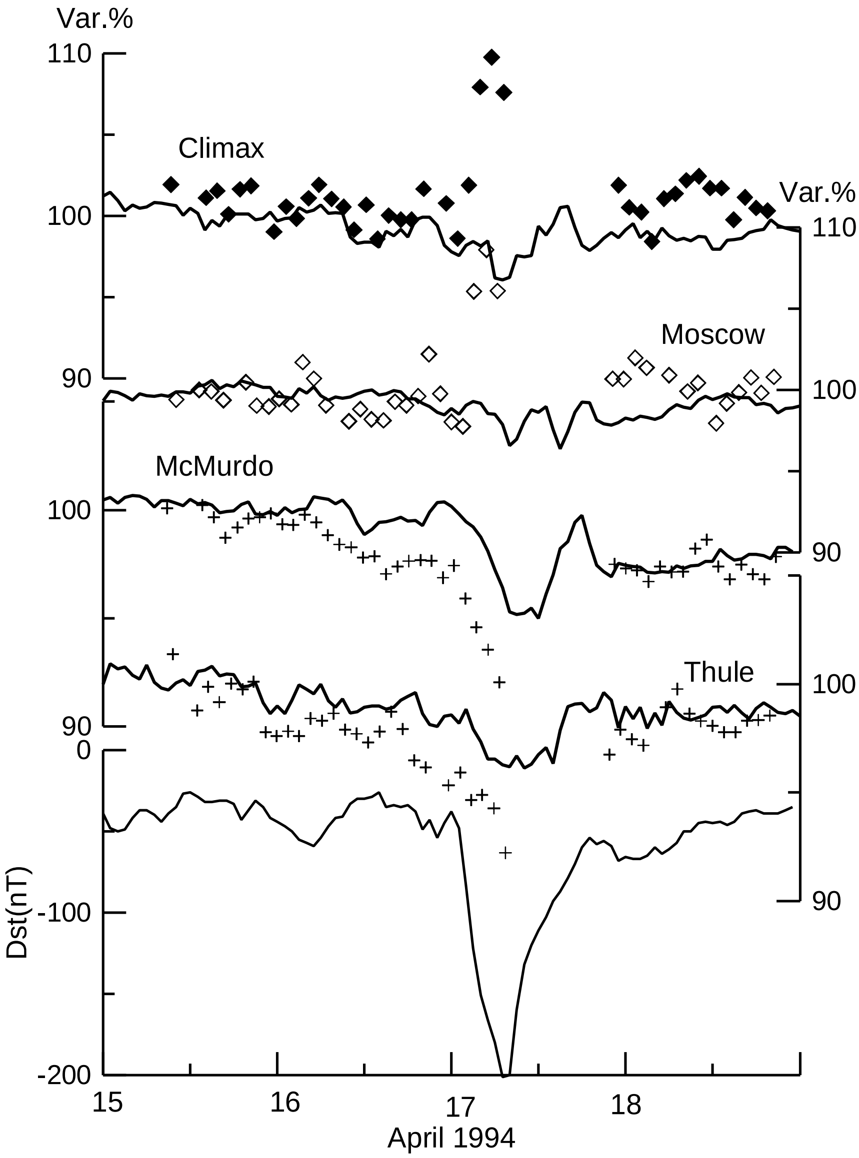

Figure 2: Time dependencies of SONG instrument and different ground neutron monitors count rates (hourly data) and D_{st} index obtained during Forbush decrease April 17, 1994.

variations of cut-off rigidity caused by ring current development led to the enhancement of cosmic ray flux detected by SONG instrument.

4 Conclusions:

Complex analyze of data obtained during Forbush decrease 1994, April 17 with the help of SONG instrument on board low-altitude satellite ‘CORONAS-I‘ and different ground neutron monitors ones shown, that variations of protons (E_p>70 MeV) and electrons (E_e>55 MeV) fluxes measured by the SONG instrument in polar caps were in a good agreement with the polar neutron monitor data variations. At the middle latitudes during D_{st} index decreasing, cut-off rigidity variations are so strong that instead of Forbush decrease (it was rather weak in middle latitude neutron monitor stations) the SONG instrument detected a significant enhancement of protons with energies >70 MeV and electrons with energies >55 MeV.

References

Bogomolov, A.V., Dmitriev, A.V., Kuznetsov, S.N., et al. 1995, Proc. 24th ICRC (Roma, 1995) 4, 836

Cane, E.V., Richardson, I.G., von Rosenvige, T.T., & Wibberenz, G. 1994, JGR 99, 21,441

Cane, E.V., Richardson, I.G., & von Rosenvige, T.T. 1995, Proc. 24th ICRC (Roma, 1995) 4, 872

Fluckiger, E.O., Smart, D. F., & Shea, M.A. 1980, Proc. 20th ICRC (Moscow, 1980) 4, 216

Ifedili, S.O. 1996, Solar Phys. 168, 195

Lockwood, J.I., & Webber, W.R. 1991, JGR 96, 11,587

Lockwood, J.I., Webber, W.R., & Debrunner, H. 1991, JGR 96, 5447

Kuznetsov, S.N., Bogomolov, A.V., Gordeev, Yu.P. et al. 1995, Izvestiya RAN. Ser.Fiz. 59, 2