Cosmic Ray Intensity and Anisotropy under the Influence of High-Speed Streams from Coronal Holes

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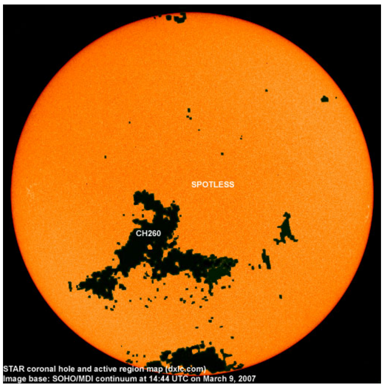

INTRODUCTION

It is reasonable to divide the Forbush-effects (FEs) into the groups by their solar sources: sporadic and recurrent, where the first group is being connected with disturbances of the interplanetary medium caused by ejection of the solar coronal mass (ICMEs), while the events in latter group are usually caused by streams of high-speed solar wind from the low-latitude coronal holes (CHs). The goal of present investigation is studying of influence of the high-speed solar wind streams (HSSs) from low-latitude CHs on the cosmic rays (CRs).

DATA AND METHODS

In our study we use the database of FEs which has been created in IZMIRAN. Using the global survey method (GSM) for calculation of the CR density variations and anisotropy vectors we operated the whole bulk of experimental material through the 2007 year. One of advantages of the 2007 year for our study is a possibility to observe the high-speed streams from CHs without CME.

ANALYSIS OF THE EVENTS

As an example of the disturbance caused by HSS from the low-latitude CH the event on 11-15 March, 2007 is presented in figure 1. In this event, we see that the direction of the vector of the equatorial component of CR anisotropy (A_{xy}) changes before Forbush decrease. The mean characteristics averaged by all the events in 2007 caused by coronal holes, are shown in figure 2. The prolonged CR decrease with a late minimum is rather characteristic for the events in 2007. The maximum speed of HSS from CH, averaged for 48 events, was 567km/s, and the maximum IMF intensity was 11.6±0.5 nT, Kp-index of geomagnetic activity was 4.08±0.13, equatorial component A_{xy} of the vector CR anisotropy varies very slightly.

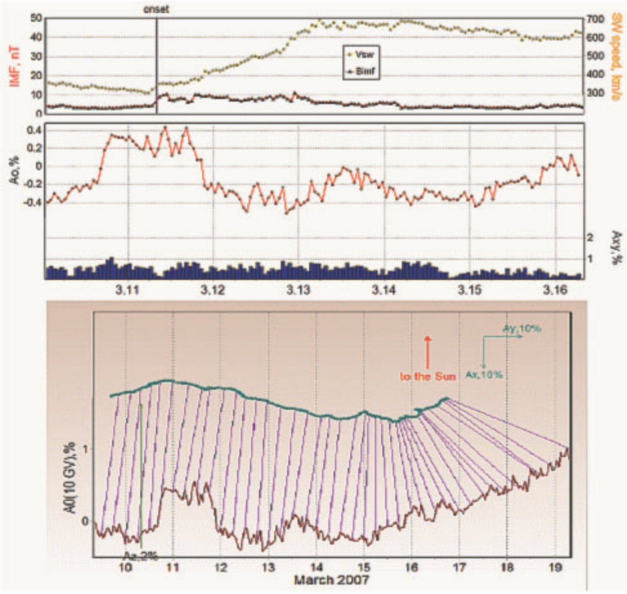

Fig.1. Behavior of the solar wind parameters: IMF intensity and solar wind velocity (upper panel); 10 GV CR density (A_0) and equatorial component of the first harmonic of CR anisotropy (A_{xy}) (middle panel); vector diagram of A_{xy} component of CR anisotropy together with CR density variations (lower panel) during the March 9-19, 2007.

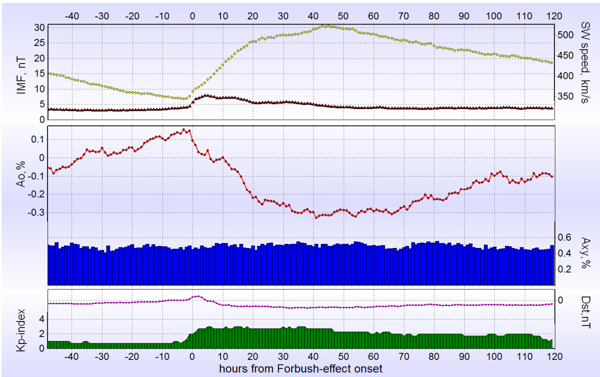

Fig.2. Behavior of the mean characteristics by all the FDs in 2007 caused by coronal holes: IMF intensity and solar wind velocity (upper panel); 10 GV cosmic ray density (A_0) and equatorial component of the CR anisotropy (middle panel); Kp and Dst-indexes of geomagnetic activity (lower panel). All parameters are averaged by epoch method, where zero day is the day of the FD onset.

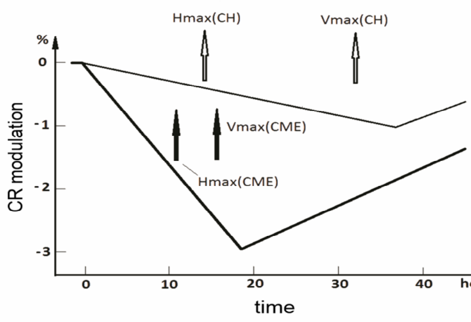

Fig.3. Average characteristics of FEs in 2007 caused by coronal holes (48 events), and events for all years, created by CME (349 events). X axis - time from FE onset, Y axis - magnitude of CR modulation.

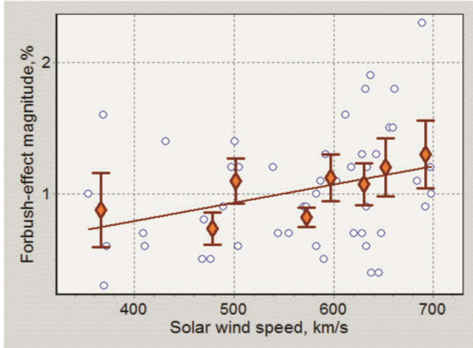

Fig.4. Dependence of FE magnitude on the maximum solar wind speed in 2007.

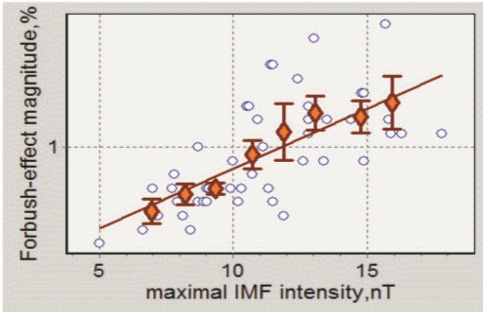

Fig.5. Dependence of the FE magnitude on the maximum IMF intensity in 2007.

DEPENDENCE OF THE FE MAGNITUDE ON THE SOLAR WIND CHARACTERISTICS

We tried to find correlation for the CH events. Figures 4 and 5 show dependence of the FE magnitude on the maximum speed of solar wind and on maximum IMF intensity.

The maximum speed in considered CH events varied between 354 and 698 km/s, i.e. the FE in cosmic ray intensity during the 2007 occurred even at a very low wind velocity.

It follows from these plots and other calculations (not presented here) that the connection of the FE magnitude for cosmic ray rigidity R = 10GV with the solar wind velocity (correlation coefficient c = 0.38, see figure 4) is much weaker than that with the maximum IMF intensity (c = 0.74). One can suppose that the solar wind velocity itself has not a decisive influence upon modulation of CR.

CONCLUSION

Forbush effects caused by coronal hole streams in 2007 were small but prolonged.

The highest correlation of the FE magnitude was found with the magnetic parameters (IMF intensity and critical CR rigidity), but not with solar wind speed. It is possible to assume that properties of recurrent FEs in 2007 are typical for effects from coronal holes, but this statement needs a confirmation.