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Aurora

Response of morning auroras and cosmic noise absorption to the negative solar wind pressure pulse: A case study

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ABSTRACT:

A case study of response of particle precipitation to negative impulse of solar wind dynamic pressure is presented. The study was performed using the data of PGI all-sky camera at Barentsburg observatory (arch. Spitsbergen) and imaging riometer IRIS located in Northern Finland. Two stages of the response were found. At first, the reduction of cosmic noise absorption (CNA) in the center of the auroral zone and the decay of the auroras near the pole boundary of the auroral oval were observed. The second stage was started in 10 minutes and characterized by the appearance of new bright forms near the pole boundary of the auroral oval. No significant changes in the CNA were observed at this time. We connect such reaction of the auroras and CNA during the first stage with propagation of the front of MHD disturbance through the source of precipitating particles in the magnetosphere. We explain the changes in the aurora dynamics at the second stage by the large-scale reconfiguration of the magnetosphere which was manifested in the ionosphere as a change of position of dawn vortex of ionosphere convection in the region of the optical observations.

Keywords: Solar Wind, Magnetosphere, Ionosphere, Sudden Impulse (SI), Aurora, Cosmic Noise Absorption (CNA).

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1. Introduction

Sudden increase of the solar wind dynamic pressure (sudden impulse, SI+) is accompanied by the aurora brightening and by the enhancement of the cosmic noise absorption (CNA) [1,2]. Both effects may be explained in the frame of one model – scattering of the electrons to the loss cone due to growth of the electron-cyclotron instability [3]. The response of the precipitations to sudden decrease of the solar wind dynamic pressure (SI-) is less investigated question. In the paper [4] with using all-sky TV camera data it was shown that the brightness of the discrete arcs increases and aurora begin to move poleward. Otherwise, in the paper [5] it was inferred from the POLAR images the decrease of the aurora intensity after SI. In present work the response of the aurora and CNA to the negative SI is examined.

2. Instrumentation

The IMAGE, INTERMAGNET magnetometer networks data with 1-min resolution were used in this study for the observation of the geomagnetic field variations. For the observation of the aurora the all-sky camera data of Polar Geophysical Institute at Barentsburg (Spitsbergen) were used. Imaging multi-beam riometer IRIS (Kilpisjarvi) were used for the control of energetic particle precipitation. LANL geostationary spacecrafts data were used for the measurements of particle fluxes in the magnetosphere. SuperDARN radar in Hanksalmi used to determine ionosphere convection and spectral width of the reflected signal. The ACE, WIND and GEOTAIL spacecrafts measured the parameters of the solar wind and interplanetary magnetic field (IMF).

3. Results

Figure 1 (upper panel) shows the parameters of interplanetary medium and variation of H-component of the magnetic field at low latitude station KAK. The decrease of solar wind dynamic pressure was detected by WIND satellite at 03.10 UT. Using the data of three satellites (ACE, WIND and GEOTAIL) we inferred that the irregularity impacts the magnetopause from the evening side. Sketch in Fig.1 (bottom panel) shows that front of magnetospheric disturbance passed the presumable location of the sources of precipitating particles in KIL and BAB (i.e. equatorial parts of KIL and BAB magnetic flux tubes) almost at the same time. This assumption was further used for timing the moment of optical response to SI- in Barentsburg.

On Fig. 2. CNA on IRIS riometer at KIL and H-component of the magnetic field at TRO station are shown. The TRO station located in the field of view of IRIS riometer. At 03.21 UT the decrease of the CNA at IRIS was observed. The negative SI do not clearly seen in geomagnetic field variations at TRO station and other stations of IMAGE profile located in the auroral zone.

Images in Fig. 3. (upper panel) demonstrate auroral activity before and after T_0=03.20 UT. The intensity of two arcs located southern to the zenith decreased. We associate this with of the reduction of particle precipitation to the ionosphere. 10 minutes late, new aurora arcs appeared (Fig. 3, lower panel). The arcs came from the lower latitudes. Arc shift may be connected with the expansion of the dayside magnitosphere in sun direction caused by the decrease of the solar wind dynamic pressure. Connection of aurora dynamics with the large-scale reconfiguration of the magnetosphere may be confirmed by behavior of the ionosphere convection in Fig. 4 (left panel) showing the expansion of morning vortex move toward the noon. Right panel shows the poleward displacement of the reflection boundary after 03.30 UT that also confirms our assumption concerning the magnetosphere expansion.

4. Discussion

We pick out two stages of the aurora and CNA response to the abrupt decrease of the solar wind dynamic pressure. During the first stage the decrease of the CNA in the center of auroral zone was observed and auroral arcs near the polar cap boundary disappeared. During the second stage the aurora activity increased there due to drift of the aurora from the lower latitudes.

We suppose that the decrease of the precipitation is caused by the propagation of “decompression” wave through the source of particle precipitation which located in the equatorial part of field line. In accordance with [1], the compression wave generated during positive SI leads to the increase of plasma anisotropy, development of the electron-cyclotron instability and scattering of the particles to the lose cone. During the negative SI the reverse scheme may be realized. The “decompression” wave leads to the decrease of the plasma anisotropy coefficient, “breaking” of the electron-cyclotron instability and stopping of the particle scattering.

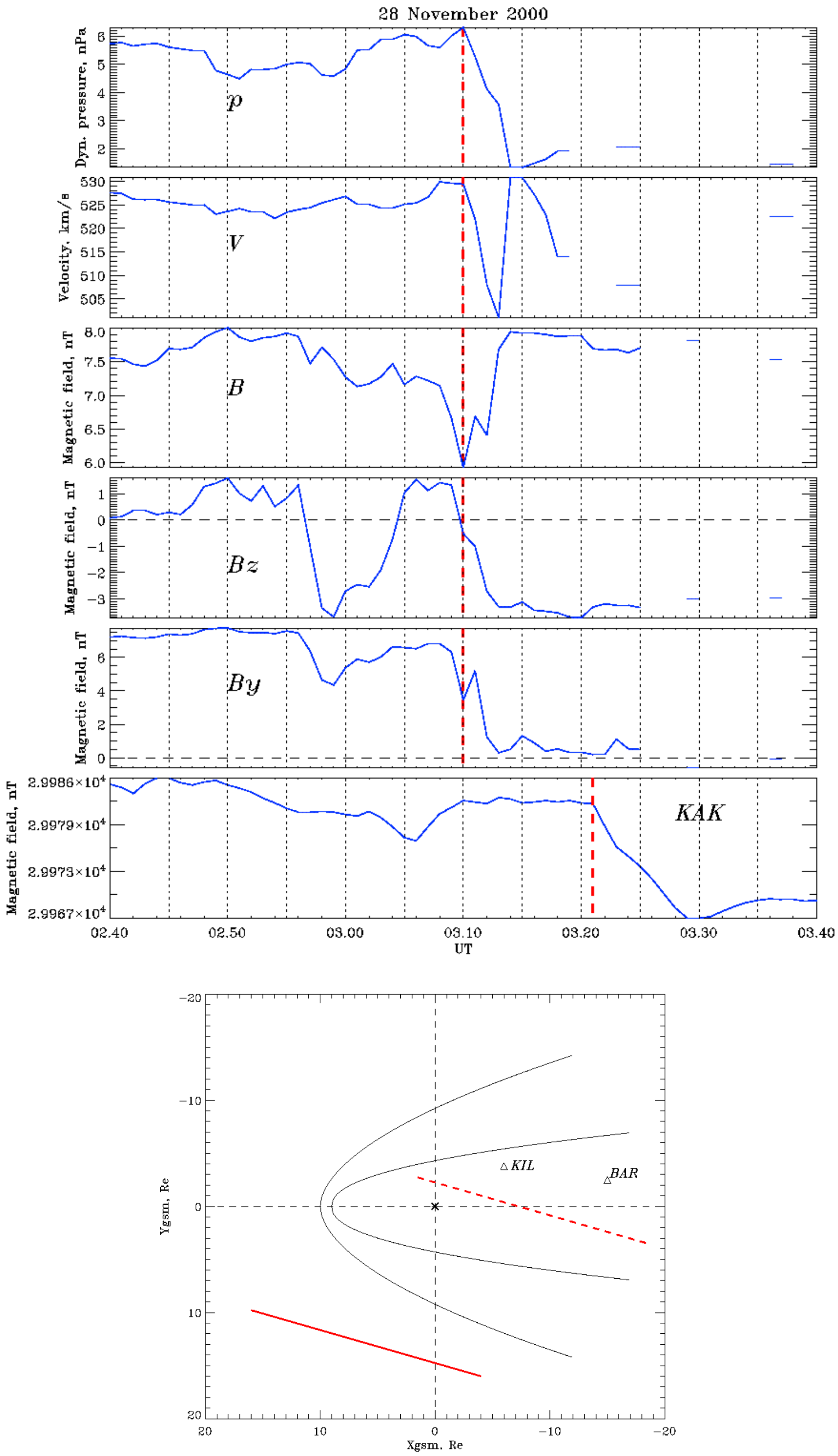

Fig. 1: Parameters of interplanetary medium (solar wind dynamic pressure, velocity, module of IMF, Bz, By-components of IMF) from the WIND spacecraft data, H-component of geomagnetic field at low-latitude station KAK (up). Orientation of the front disturbance in XY plane in GSE coordinate system (down).

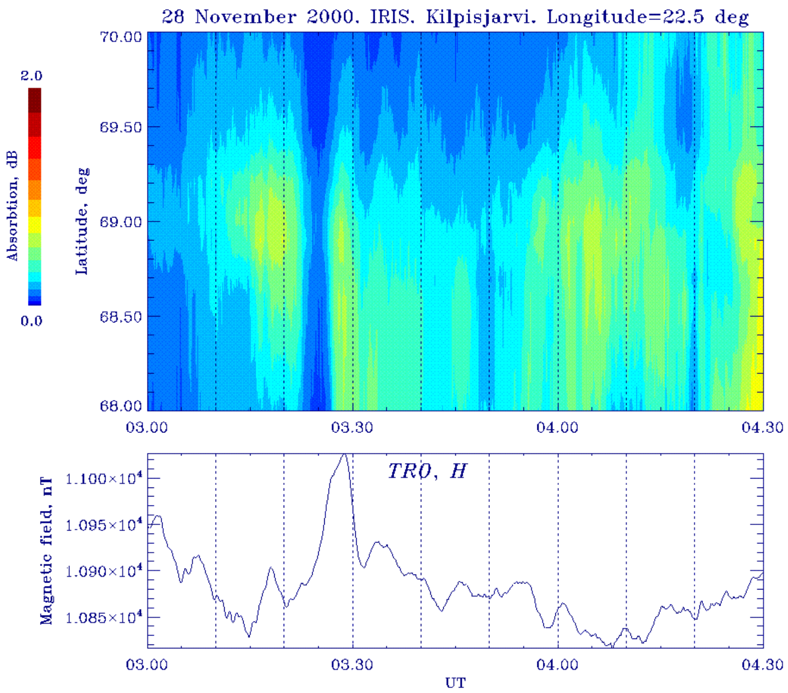

Fig. 2: Cosmic noise absorption on riometer IRIS in KIL (upper panel), magnetic field at TRO station (lower panel).

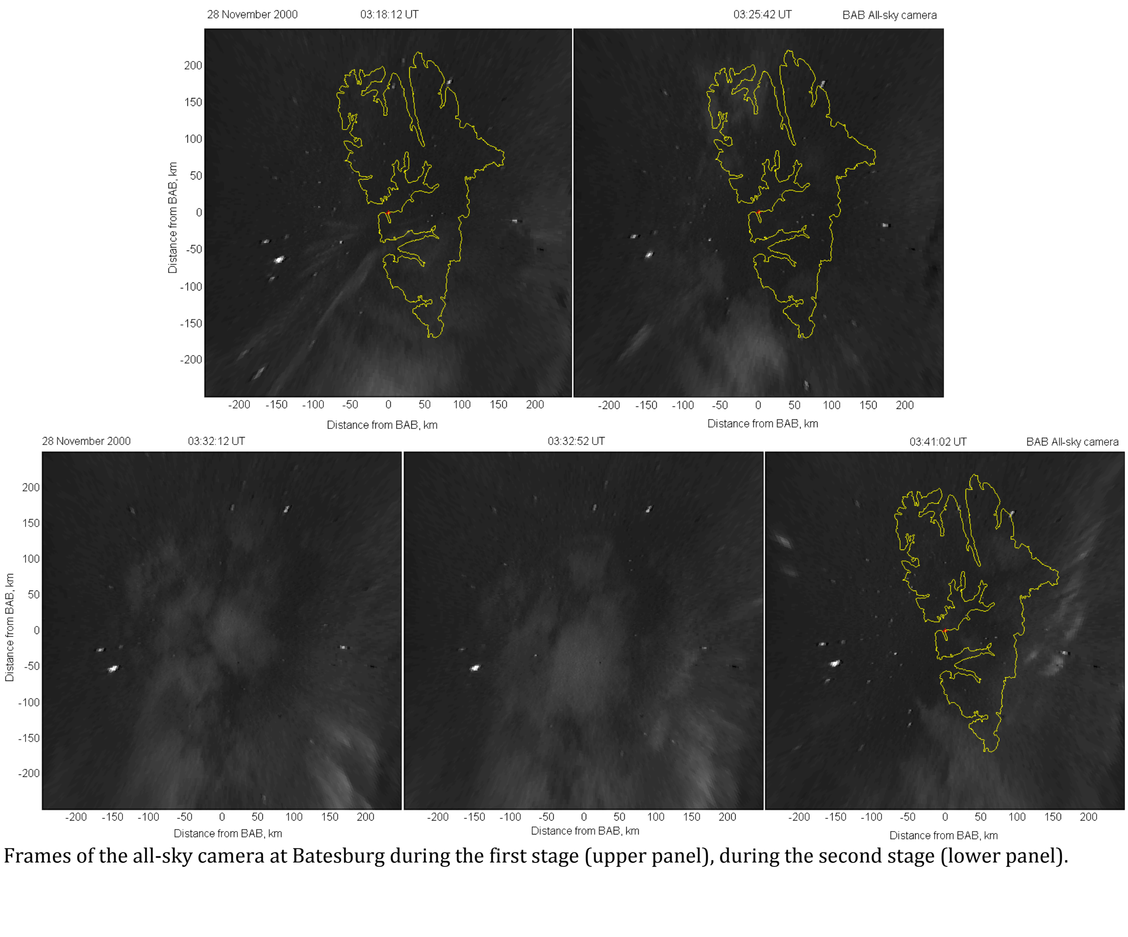

Fig. 3: Frames of the all-sky camera at Batesburg during the first stage (upper panel), during the second stage (lower panel).

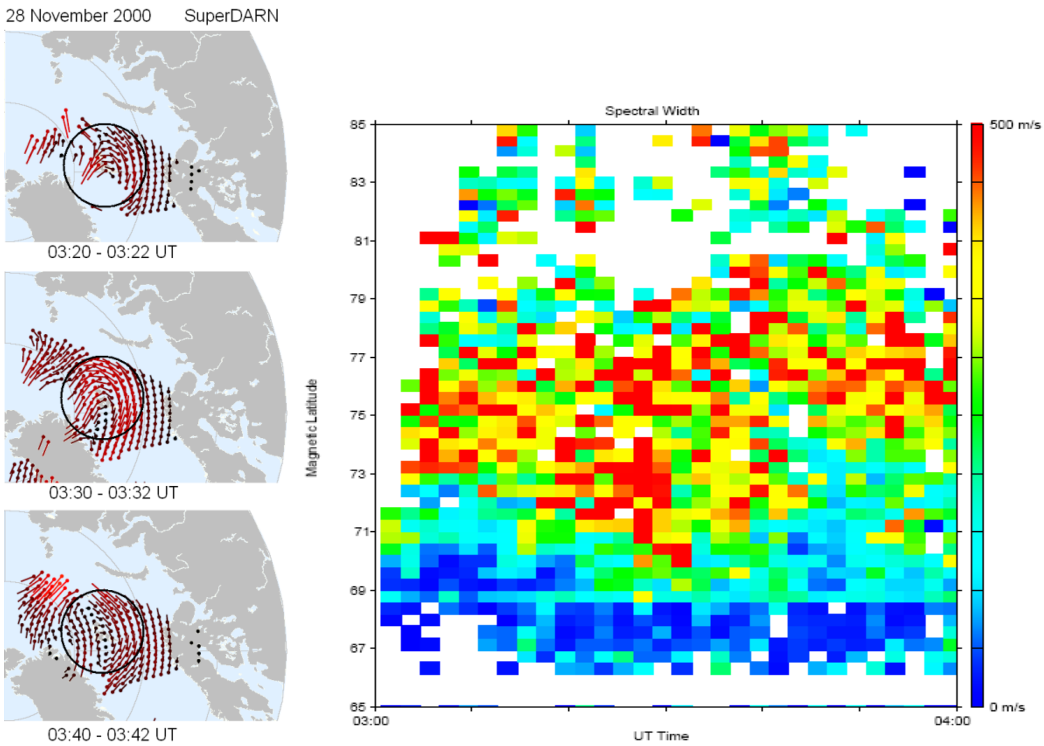

Fig. 4: Ionosphere convection from the SuperDARN radar data (left), spectral width of the reflected signal from the SuperDARN radar data (right).

5. Conclusions

In this work were shown that the response of the aurora to the negative impulse of the solar wind dynamic pressure may have two studies. During the first stage the decrease of the intensity of the aurora and CNA were observed. During the second stage (ten minutes after first stage) the increase of the intensity of aurora were observed due large-scale reconfiguration of the dayside magnetosphere. Earlier two stage response of the aurora to the positive SI was reported in the papers [6,7].

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