Ground-based experimental complex for Space Weather study in Kazakhstan: science and data product

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Almaty High Mountain Cosmic Ray Station (cosmic ray station Alma-Ata B) is situated near Almaty city on a distance of 28 kilometers at the altitude of 3340 m above sea level and 50 km from the Institute of the Ionosphere. It has been operated since 1973. The neutron monitor data are presented in the graphic and text form with a minutely updating in real time (Fig. 1) (cosray.ionos.kz/CosRay/index.htm).

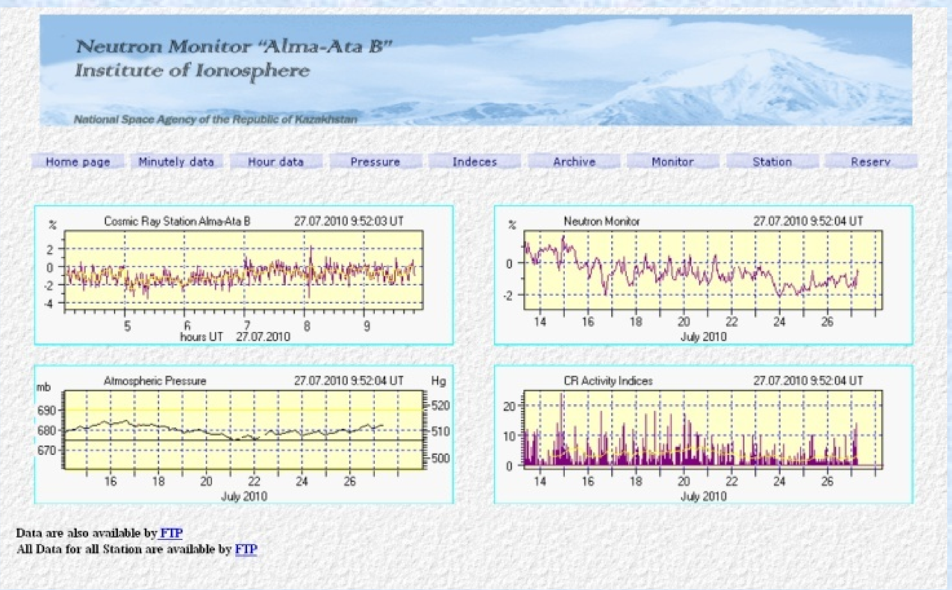


Figure 1. Website with neutron monitor data in real time with 1-min update

The interface with cosmic ray intensity data in real time obtained by means of high-altitude neutron monitor has been realized on Institute of the Ionosphere web-site. Control panel allows to select a time interval, type of the data and the form of data presentation (Fig. 2).

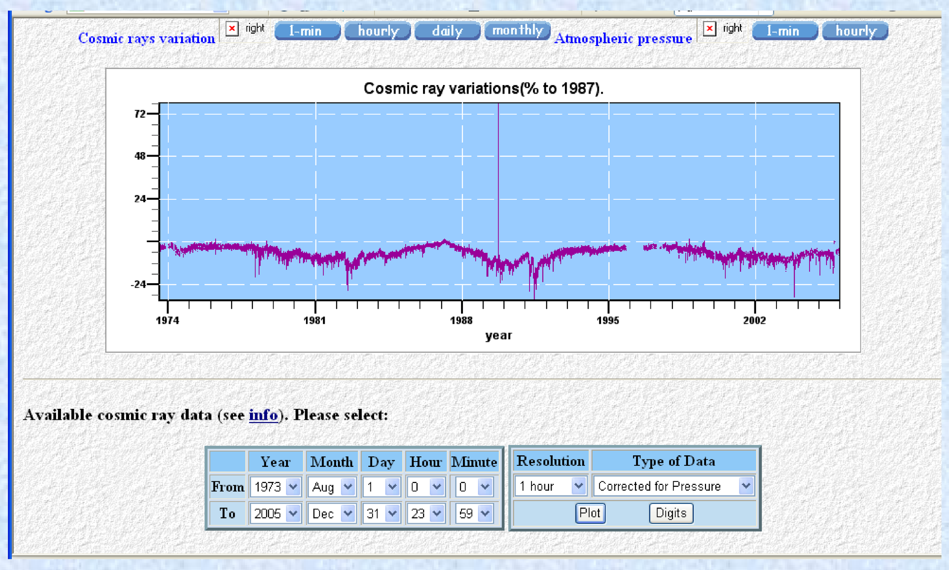


Figure 2. The interface with Almaty neutron monitor data

Almaty Cosmic Ray station is included in the worldwide neutron monitor network and European database NMDB (www.nmdb.eu) for the real-time monitoring of primary cosmic rays in the (0.5-20) GeV energy range.

SATI instrument

The Spectral Airglow Temperature Imager (SATI) instrument measures the column emission rate and vertically averaged rotational temperature of the OH (6–2) and of the O2 (0–1) atmospheric band and hence monitors the atmospheric temperature at about 87 and 95 km, where the peaks of the OH and O2 emission layers are located, respectively. Measurements of the temperature structure of the upper atmosphere with the SATI instrument are carried at the highmountain research station near Almaty, Kazakhstan from 2007. SATI is a spatial and spectral imaging Fabry–Perot spectrometer in which the etalon is a narrow band interference filter and the detector is a CCD camera. It is based on the property of a narrow-band Fabry–Perot interference filter that transmits light from spectral lines of decreasing wavelength at increasing incidence angles.

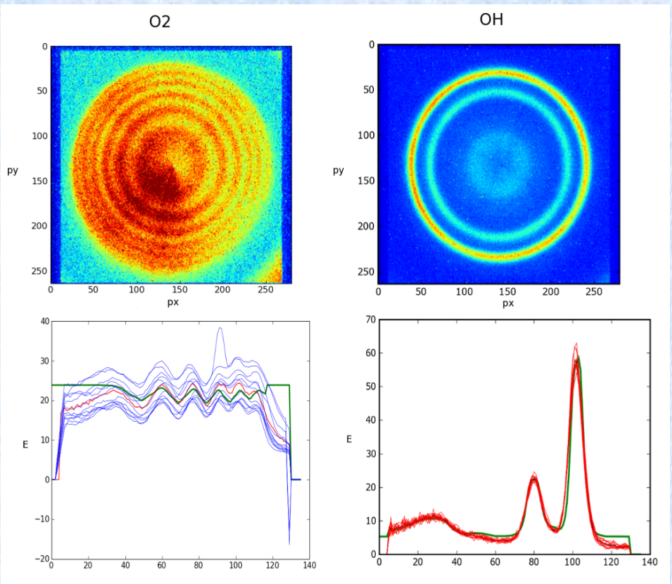


Figure 3. An example of wave structures in the hydroxyl emission from observation on the SATI

Recent scientific results

Possible Ground Level Enhancement on January 27, 2012 (Proceeding of 24th European Cosmic Ray Symposium, Germany, Kiel, 2014)

The first large proton event in 2012 started on January 23, after the flare of M8.7 class from the region AR11402 (N27W71), On the 27 January of 2012 a large proton increase for particles >100 MeV (11.9 pfu) began, and flux of particles with the energy of >10 MeV reached of 800 pfu. For particles of >100 MeV, the event was close to finish on the next day 28 January 2012. Below, in figure 4 data from NMs South Pole B (SOPB), South Pole (SOPO) and Mirny (MRNY) with 30 minute resolution intervals are plotted together with 5-minute data on the protons of >10 MeV, >50 MeV, >100 MeV from GOES 13. Apparently, the increase of CR intensity recorded at these stations started at the same time as increase recorded by satellite GOES 13.

Small increase of intensity was also observed at other high latitudinal NMs: Thule (THUL), Inuvik (INVK), McMurdo (MCMU), Terre Adelie (TERA), Fort Smith (FSMT) (in figure 5 they are partly plotted).

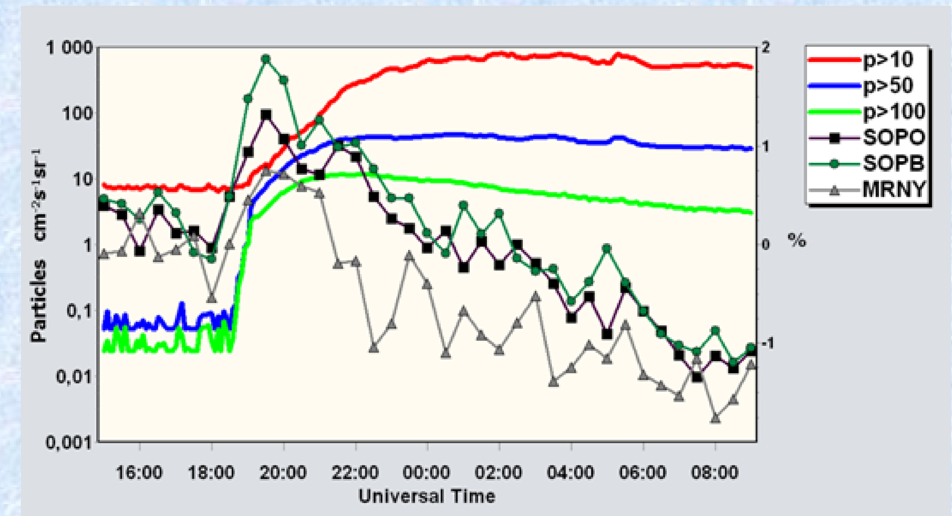


Figure 4. CR variations recorded at NMs South Pole B, South Pole and Mirny with 30-minute resolution and 5-minute data of proton fluxes recorded at GOES 13 on 27-28 January 2012

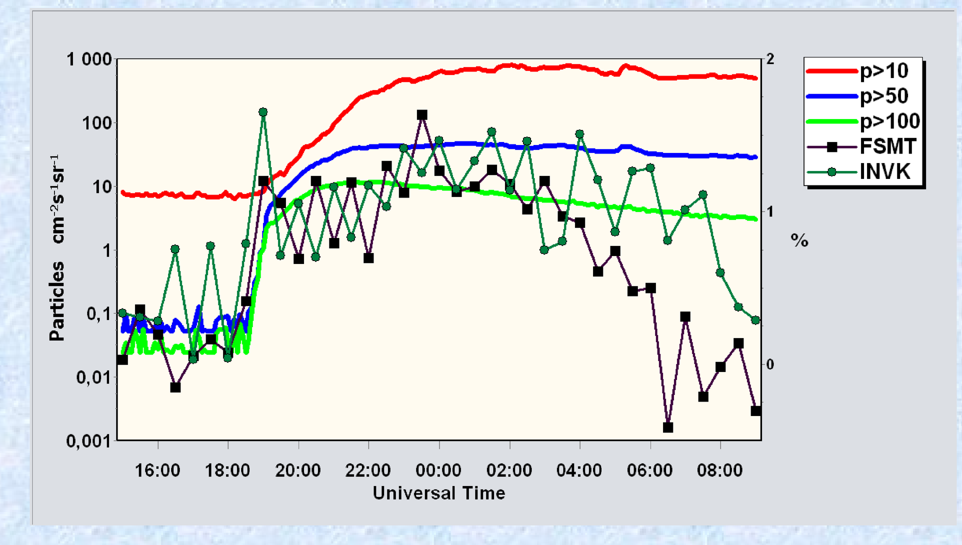


Figure 5. CR variations recorded at NMs Fort Smith and Inuvik with 30-minute resolution and 5-minute data of protons by the data of GOES 13 on 27-28 January 2012

In figure 6 data from HEPAD for particles of energies >375, >485 and >605 MeV are presented together with data from some NMs with 10 minute resolution. A coincidence in the onset of enhancements in both groups of data is evident, that allows us to consider the event on 27.01.2012 as ground level enhancement (GLE). However, it is worthy further studying and modeling.

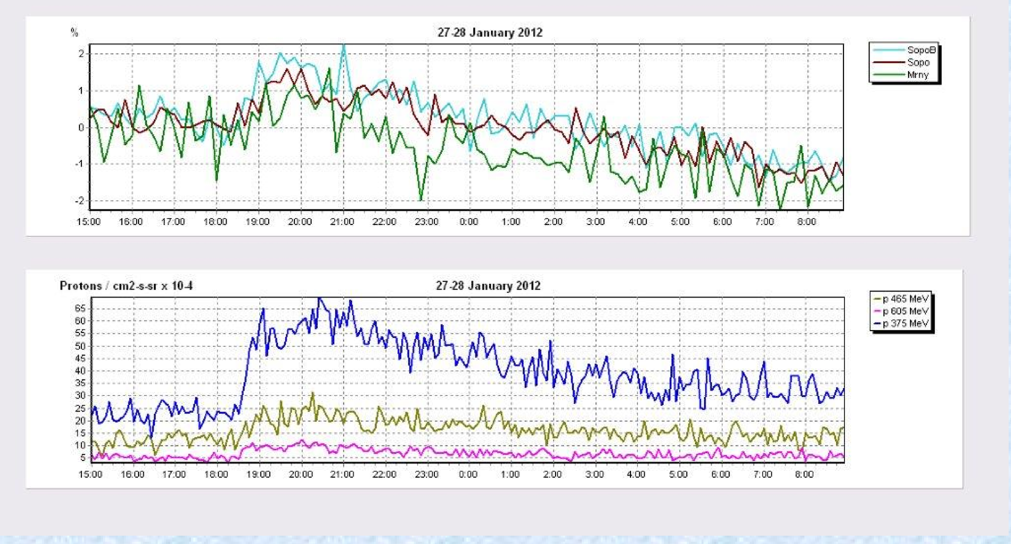


Figure 6. CR intensity recorded at NMs South Pole B, South Pole and Mirny with 10 min resolution (upper panel) and proton fluxes recorded by different energy channels on GOES/HEPAD on 27-28 January 2012

All data are represented on the web-site of the Institute of Ionosphere (www.ionos.kz) in real time. Now we have complex database with hourly data of cosmic ray intensity, geomagnetic field intensity and solar flux density at 10.7cm and 27.8 cm wavelengths.

The measurements by means of Kazakhstan experimental complex are presented in Fig.7.

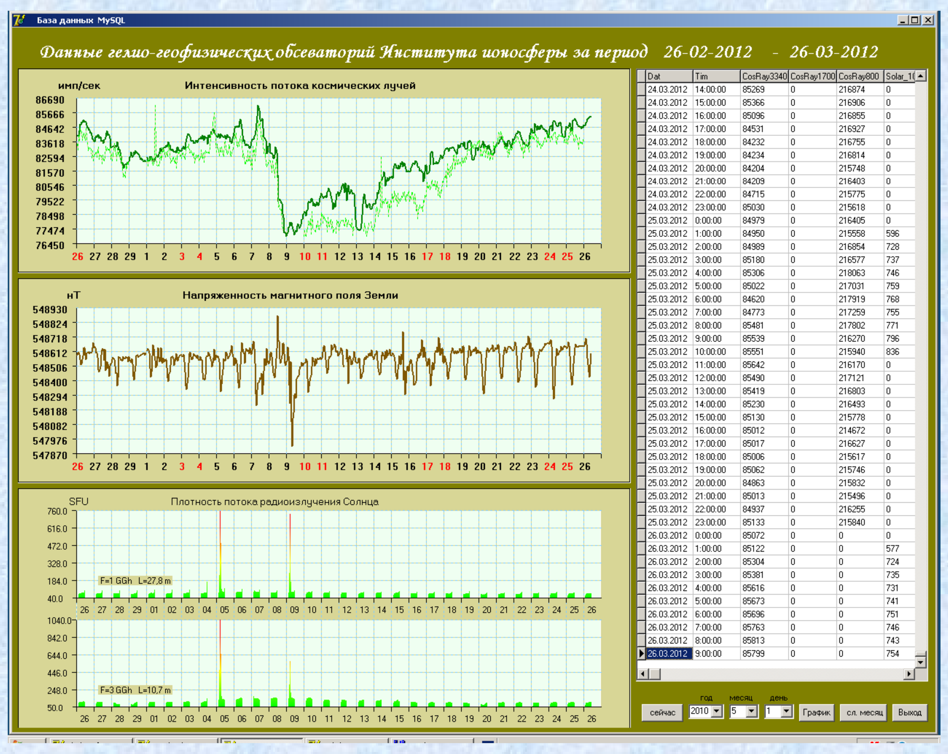


Figure 7. The measurements by means of Kazakhstan experimental complex in real time

Geomagnetic Observatory "Alma-Ata" has operated since 1963. It is located at the altitude of 1300 m above sea level at the Institute of the Ionosphere, geographical coordinates of the observatory are 43.18 N, 76.95 E. Type of equipments are: a magnetometer LEMI-008 and Lemi-018, a portable single-component magnetometer LEMI-203, and a overhauser effect proton precession magnetometer QM Laboratory type POS-1. In late 2005, Geomagnetic Observatory "Alma-Ata" was certified as an international organization of INTERMAGNET (www.intermagnet.bgs.ac.uk). All experimental data and local K-indices are presented on website (geomag.ionos.kz) in real time (Fig. 8).

Since 2010 Geomagnetic Observatory "Alma-Ata" is a part of international network for the normalization of Dst-index. Geomagnetic data are sent to Dcx-index Server (University of Oulu, Finland, http://dcx.oulu.fi) in real-time.

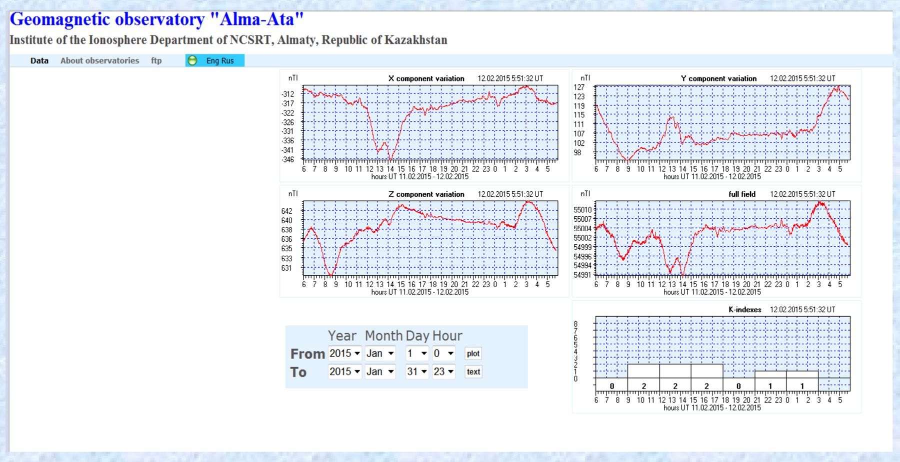


Figure 8. Website with geomagnetic data in real time. (ionos.kz/?q=en/node/22)

We realized a method for measuring the speed of coronal mass ejections (CMEs), based on spectrographic observations of type II solar radio bursts (fundamental frequency slowly drifts towards lower frequencies) generated by the shock wave originated from the CME. A burst recorded in the 24-th cycle of solar activity on the radio spectrograph Callisto installed in Almaty is analyzed. An estimation of coronal mass ejection speed using the standard model of the altitude dependence of the coronal plasma density is carried out.

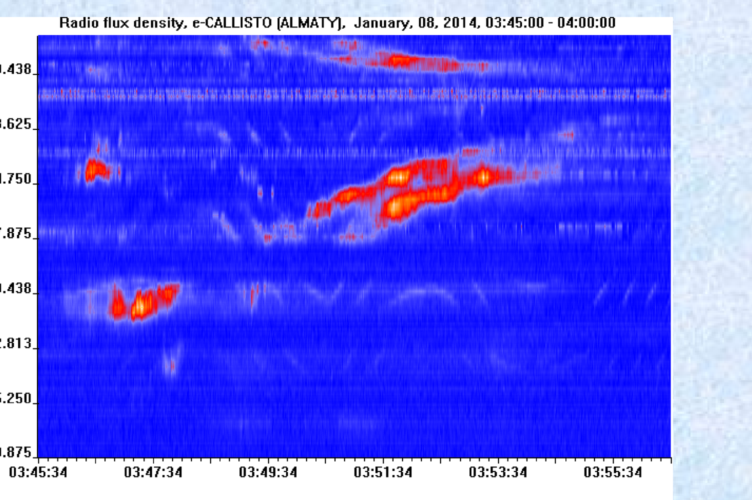


Figure 9. The dynamic spectrum of the type II burst, recorded January 8, 2014

Figure 9 shows the dynamic range of a type II burst observed by January 8, 2014. There was a splitting of the fundamental frequency, which began in 03:47 UT at frequency f ≈ 230 MHz and ended at 03:52 UT at a frequency of ≈ 110 MHz. Time derivative of the fundamental frequency was df / dt ≈ 0.40 MHz / s and a scale height calculated from the expression for the plasma frequency of 170 MHz, corresponding to h ≈ 1.17 Rs according the hybrid model was H = 88,000 km. The calculated average speed has been estimated as v ≈ 415 km/s.

The solar flux density at 10.7cm and 27.8 cm wavelengths is measured using fully automated radio telescope. A 12-meter parabolic antenna and radiometers RM-10 and RM-30 are used for measurements. The two radiometers record solar flux density at 10.7cm and 27.8 cm wavelengths each day for as long as the Sun is above the local horizon. Real time and archival data of solar flux on 1 GHz and 2.8 GHz (10.7 cm) are presented on web-site (www.ionos.kz/?q=orbita) as shown in Figure 10.

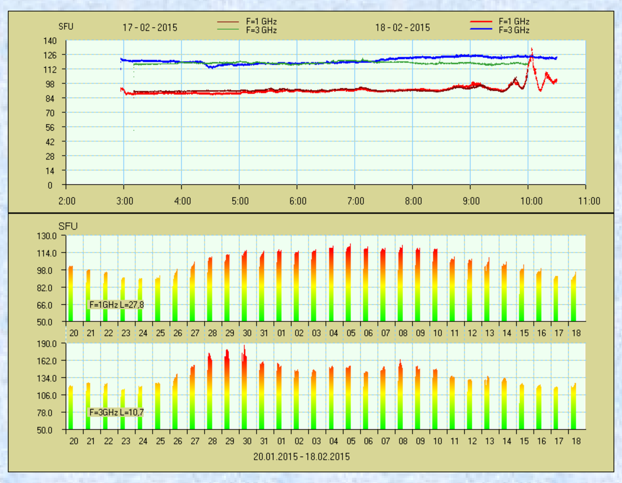
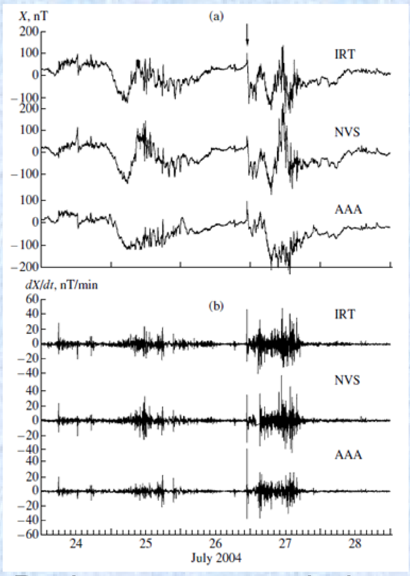


Figure 10. The solar flux density at 10.7cm and 27.8 cm wavelengths for the last 30 days

Appearance of geomagnetically induced currents (GIC) in conductive ground-based systems (power lines, pipelines) is one of the negative effects of the Space Weather on technological systems. The aim of the present work is to study the possibility of appearance of considerable GICs in this region based on the variations in the geomagnetic field horizontal component measured at Alma-Ata, Novosibirsk, and Irkutsk magnetic observatories, the geomagnetic latitudes of which are close to those of the Kazakhstan southern and northern borders.

The method we used in our studies is based on the linear dependence between GIC and time derivative of the magnetic field horizontal component (dH/dt), following from the Faraday law. Initial data for this study were the minute values of the variations in the magnetic field X and Y components (AAA, NVS) and the values of the field horizontal component H and declination D (IRT).



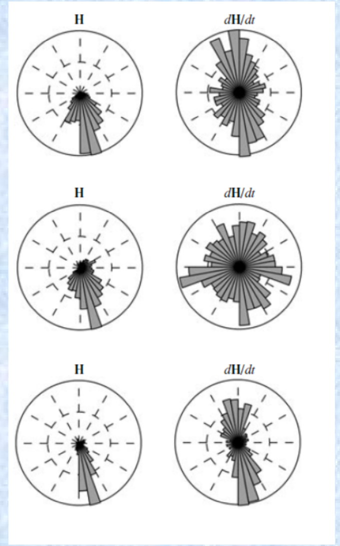


Figure 11. Variations (a) in the northern component and (b) its derivative for three observatories during the magnetically active period July 24–28, 2004

Figure 12. Distributions of H and dH/dt directions for Irkutsk (top panels), Novosibirsk (middle panel) and Alma-Ata (lower panel) in the magnetically active period July 24–28, 2004.

During seven periods of high magnetic activity in 2003–2005, we determined the duration of the periods of large field derivative values exceeding the threshold (30 nT/min), when GIC could cause unwanted consequences in the Kazakhstan power grids. We indicated that, during strong storms (especially during the storm of October 30–31, 2003) the Kazakhstan power systems were affected by considerable GICs for a rather long time. We demonstrated that large H values, responsible for significant GIC values, were observed at a sudden commencement of strong storms, which has the character of a pulsed disturbance of the geomagnetic field, and during large-amplitude pulsations of the geomagnetic field. We constructed the distributions of the dH/dt and dH/dt directions, the most interesting properties of which were narrow, extended along the magnetic meridian, H and dH/dt distributions for Alma-Ata and wider angular distributions for Novosibirsk and Irkutsk.