

Space Weather activities in Kazakhstan in 2023

**Institute of Ionosphere,
Almaty, Kazakhstan**

Vienna, February, 2024

Kazakhstan multi-level complex for key space weather parameters measurements



Neutron Monitor 18 NM-64 at high mountain cosmic ray station (**3340 m a.s.l.**) (www.nmdb.eu)

Geomagnetic observatory "Alma-Ata" (**1300 m a.s.l.**)

Measurements of the solar radio spectra of the Sun in the range of 40 - 800 MHz from the CALLISTO spectrometer at Almaty and the solar radio emission flux density at frequencies of 1.08 GHz and 2.8 GHz (**2700 m a.s.l.**)

All measurements are included in a common information system that displays real-time measurements with high resolution

Development of a prototype system for generating an alert signal about the beginning of a large proton enhancement in solar cosmic rays on Earth to warn about radiation hazards in spacecraft orbits

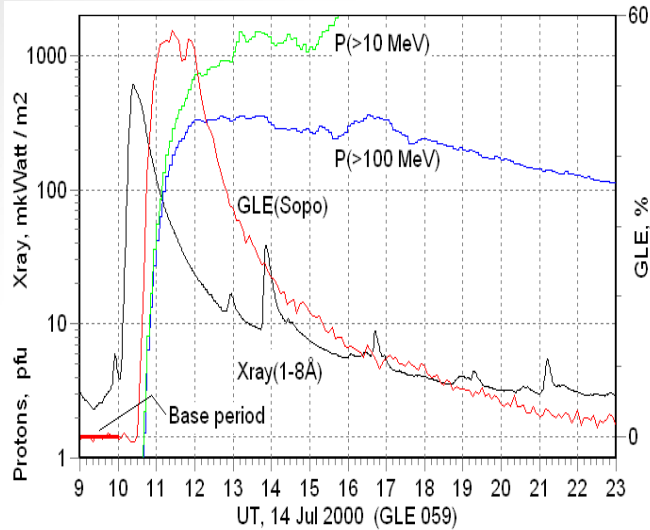
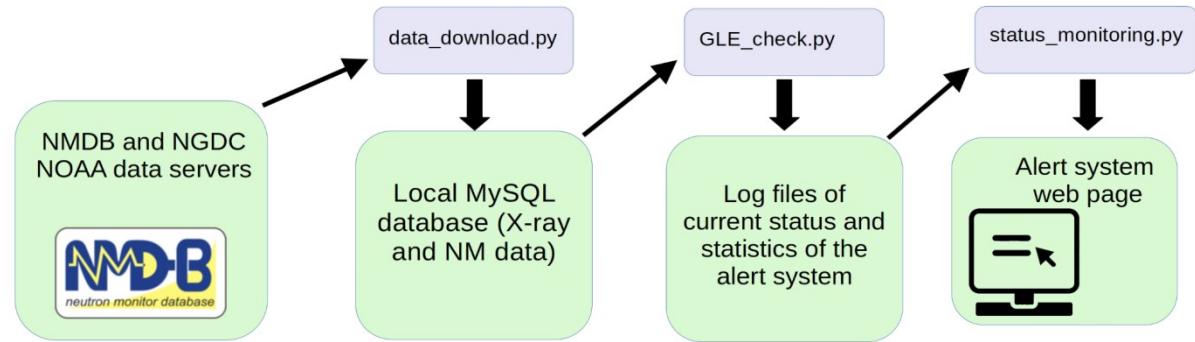


Illustration of time delays relative to flare onset for X-ray (1-8Å), ground-based and proton (>100 MeV and >10 MeV) enhancements using the July 14, 2000 event as an example.



Schematic diagram of the operation of the prototype alert system

A prototype system for generating an alert signal about the beginning of a large proton enhancement in solar cosmic rays on the Earth was developed to warn about radiation hazards in spacecraft orbits. The system is a set of Python 3 programs and configuration files. The main functionality of the system is implemented by three programs - *data_download.py*, *GLE_check.py* and *status_monitoring.py*. The program *data_download.py* is designed to download data from neutron monitors and solar X-rays. The *GLE_check.py* program is designed to analyze data from neutron monitors and X-ray radiation, and determine ground-based enhancement events. The *status_monitoring.py* program is designed to monitor the results of the *GLE_check* program, display current information about the status of the alert system on a web page, and launch alerts when a ground enhancement is detected.

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The page contains information about the current level of the alert signal: *GLE Warning* - an enhancement was detected simultaneously at 2 neutron monitor stations, *GLE Alert* - an enhancement was detected simultaneously at 3 or more neutron monitor stations. The *GLE Alert* level means that a large proton enhancement is expected in the coming minutes. In addition, the page contains graphs of the neutron flux enhancement coefficient for all available stations, a graph of the delay time of the arrival of neutron monitor data for the last day, information about the presence of the Forbush effect and about the last detected ground-based enhancement event.

Web page of a prototype system for generating an alert signal about the beginning of a large proton enhancement

Development of the disturbance index for the state of near-Earth space

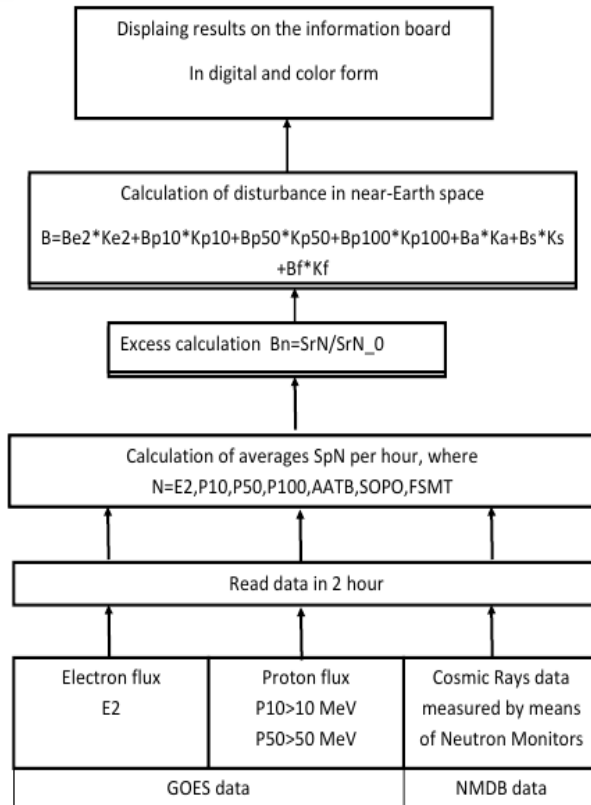
The results of the disturbance calculation using the example of July 4, 2004 are presented on the information board, and the results of intermediate calculations are also visible there. The program provides the ability to determine NES disturbance over a 20-year period. The information board contains a calendar for selecting dates and a "Calendar Start" button to initiate calculations based on the calendar date.

➤ Proton flux with energy:

- > 10 MeV
- > 50 MeV
- > 100 MeV

➤ Electron flux with energy:

- >2 MeV

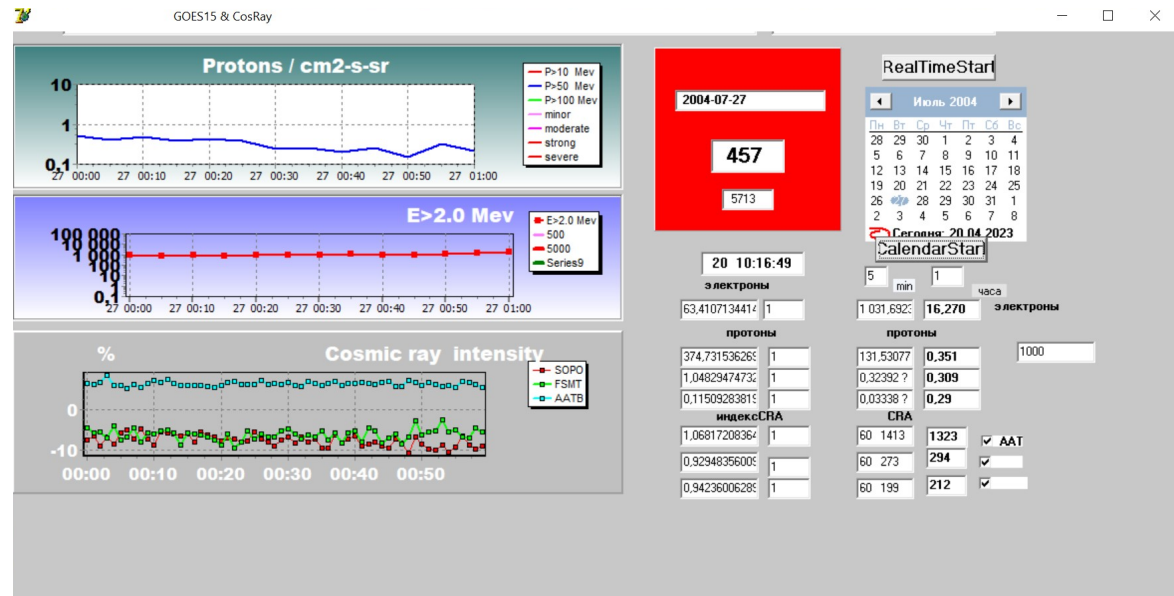


Algorithm for calculating NES disturbance

➤ To calculate changes in the intensity of galactic cosmic rays, measurements are used:

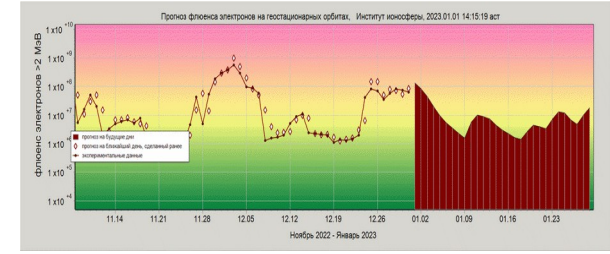
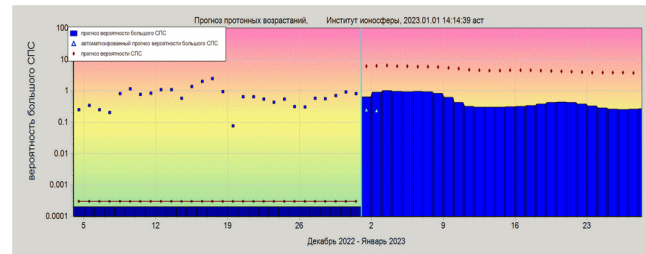
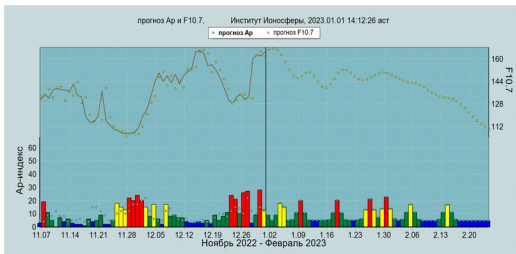
- High-altitude neutron supermonitor 18NM-64 (AATB station, Almaty, RK)
- South Pole Station (SOPO, Antarctica, USA)
- Fort Smith Station (FSMT, North America, USA)

The disturbance index can be calculated in real time.



Information window of the NES disturbance calculation program

KAZAKHSTAN SPACE WEATHER PREDICTION CENTER



Kazakhstan Space Weather Prediction Center works daily. We issue the short-term and long-term forecasts of the magnetic activities (Ap-indexes) and solar activity (F10.7) for 55 days, the forecast of probability of a large proton enhancement for 28 days and the forecast of fluence of magnetospheric electrons with energy > 2 MeV at geostationary orbit for 28 days. We provide this information to all interested organizations in Kazakhstan.

Thank you for attention!