

# Space Weather Research in Kazakhstan

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**Almaty, Kazakhstan**

*Workshop on the International Space Weather Initiative  
8-12 October 2012, Quito, Ecuador*

**In Kazakhstan there is an experimental complex for space weather study and forecasting. This complex is situated near Almaty (Kazakhstan). It includes an experimental setup for records of cosmic ray intensity (neutron monitor) at the altitude of 3340 m above sea level, the magnetic observatory «Alma-Ata», an optical interferometer SATI for recording the emission of night sky, an ionospheric sounder and solar radio telescope. Nowadays the measurements of the solar radio flux at frequencies of 1.078 GHz and 2.8 GHz (10.7 cm) are carried out on the regular basis with 1 second time resolution. Type II solar radio bursts are currently one of the main observable precursors of CMEs that will arrive at Earth within a few days after bursts. In view of future upgrade of the «Orbita» ground regarding new radio astronomical instruments, a measurement campaign was planned and organized between Institute of ionosphere, «NCSRT» and ETH Zurich, supported by SSAA. A new Callisto radio spectrometer (eC37) was installed and configured while the «Orbita» ground station. Results of space environment monitoring in real time are accessible via Internet.**





***Almaty High Mountain Cosmic Ray Station***  
*(cosmic ray station Alma-Ata B) is situated near Almaty city on distance of 28 kilometers at the mountain and 50 km from the Institute of Ionosphere. It has been operated since 1973. Location of Cosmic Ray Station Alma-Ata B:*  
Latitude 43.25 N  
Longitude 76.92 E  
Altitude 3340 m above sea level

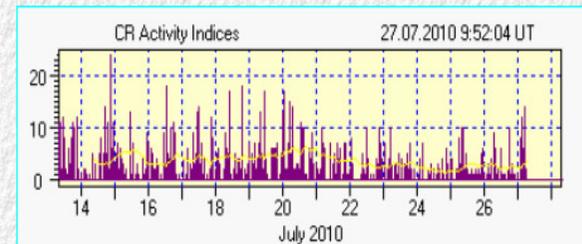
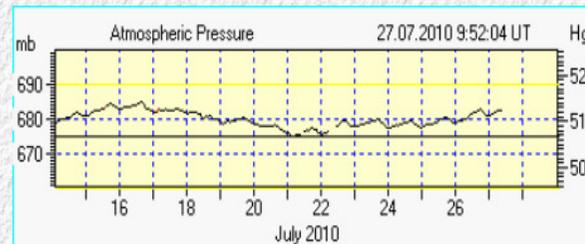
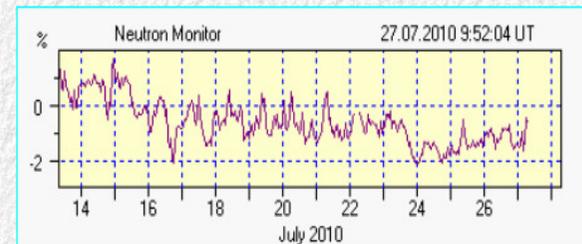
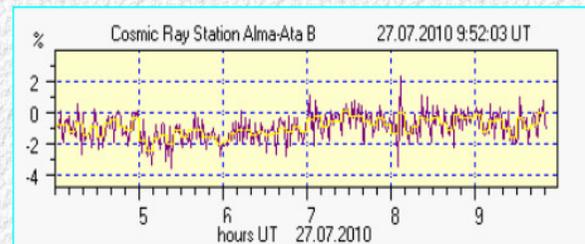


Present high mountain Alma-Ata neutron supermonitor (Alma-Ata B, 43.1 N latitude, 76.6 E longitude, geomagnetic rigidity cutoff 6.69 GV) consists of the 18 SNM15 type neutron counters, which are divided between three standard 6-counter units. The sum rate of the monitor count is  $\sim 4.5-5.0 \cdot 10^6$  pulse per hour (depending on the solar activity phase).

## Neutron Monitor "Alma-Ata B" Institute of Ionosphere

National Space Agency of the Republic of Kazakhstan

Home page Minutely data Hour data Pressure Indeces Archive Monitor Station Reserv



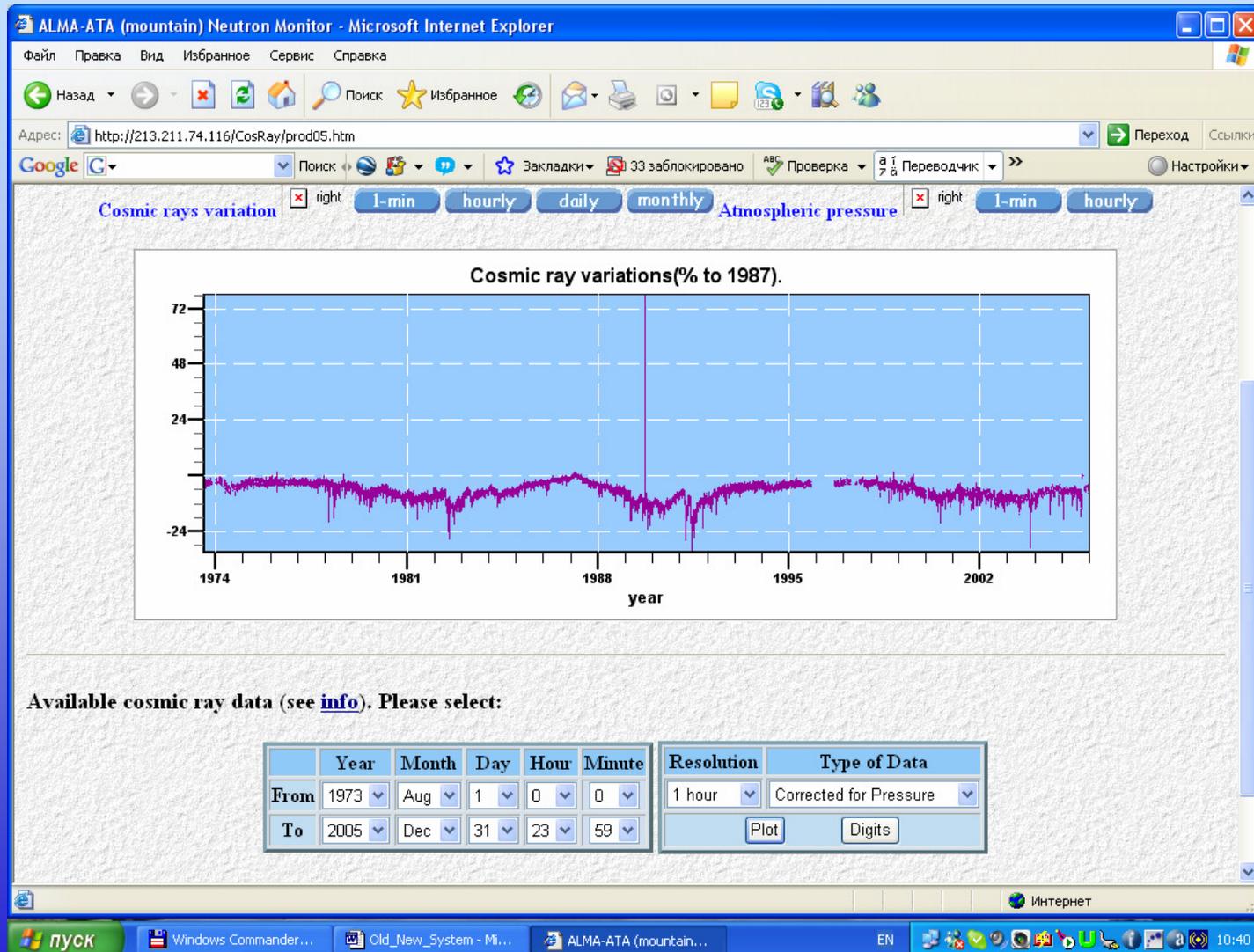
Data are also available by [FTP](#)  
All Data for all Station are available by [FTP](#)

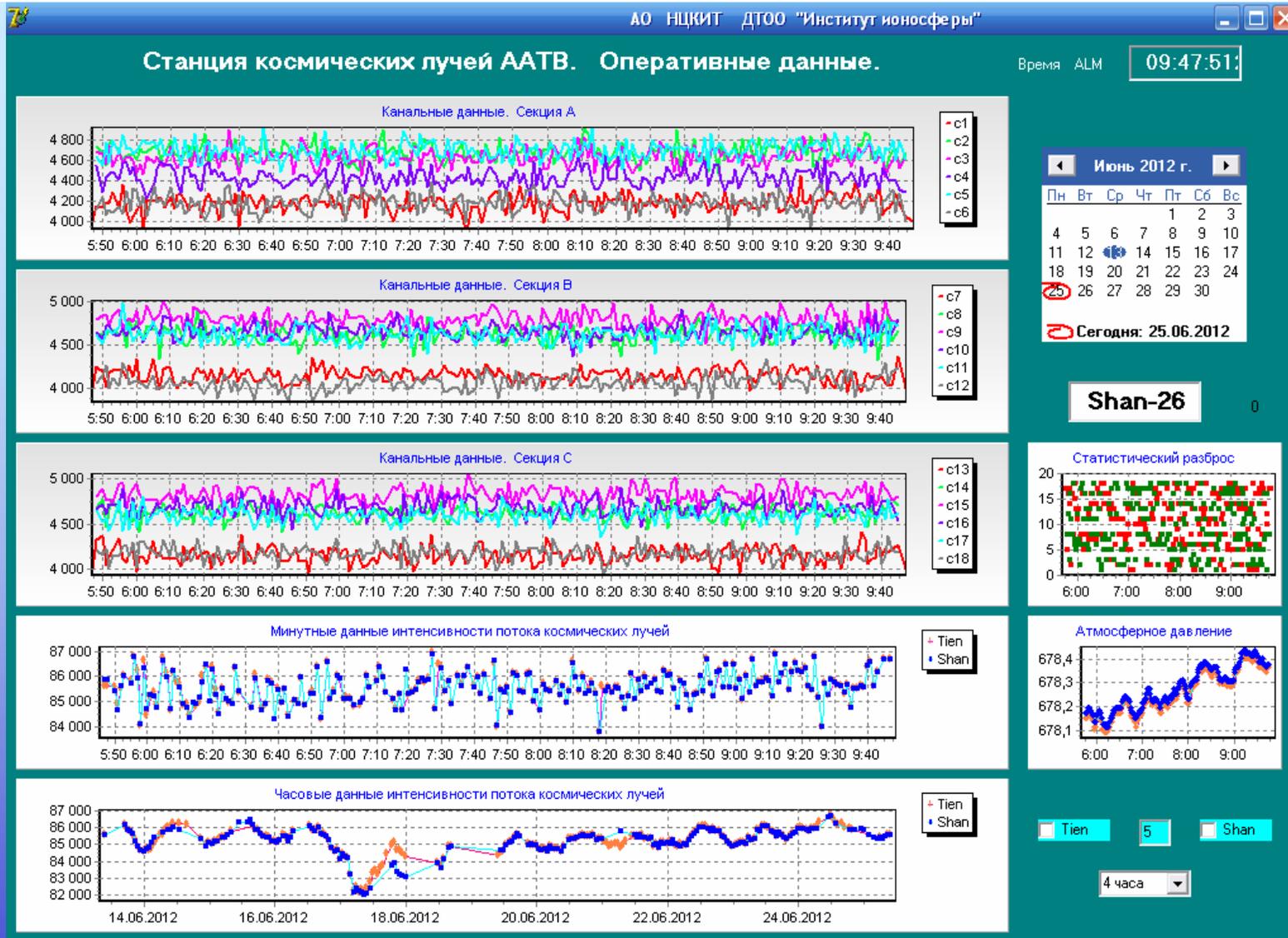
The neutron monitor data are presented in the graphic and text form with a minutely updating in a real time.

<http://cosray.ionos.kz/CosRay/index.htm>

The interface with cosmic ray intensity data in real time obtained by means of high-altitude neutron monitor has been realized on Institute of Ionosphere web-site.

*Control panel allows to select a time interval, type of the data and the form of data presentation.*





**New online system with 1-minute update for visual control of Neutron Monitor data quality and MySQL database were created. This database was set up at the institute where we can see 1-min canal data of intensity and atmospheric pressure. Now the intensities of neutron pulses are recorded with a 1-minute temporal resolution separately for the each neutron counter.**

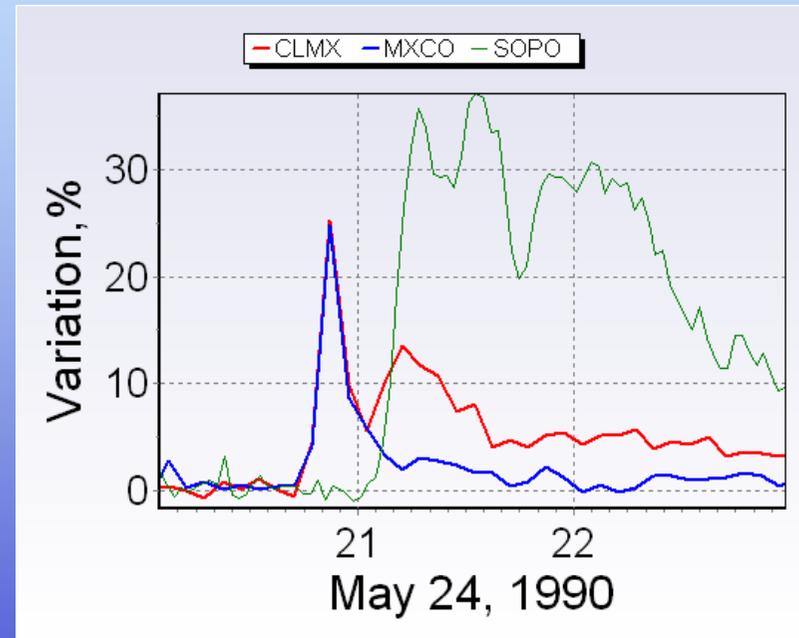
## Monitoring of solar neutrons by the observations with ground level neutron monitors.

The observation at the Earth of solar protons and neutrons, generated during powerful solar flares (in combination with X-ray and gamma-ray data) allows us to obtain unique information on the Sun's flare process and particle acceleration mechanisms.

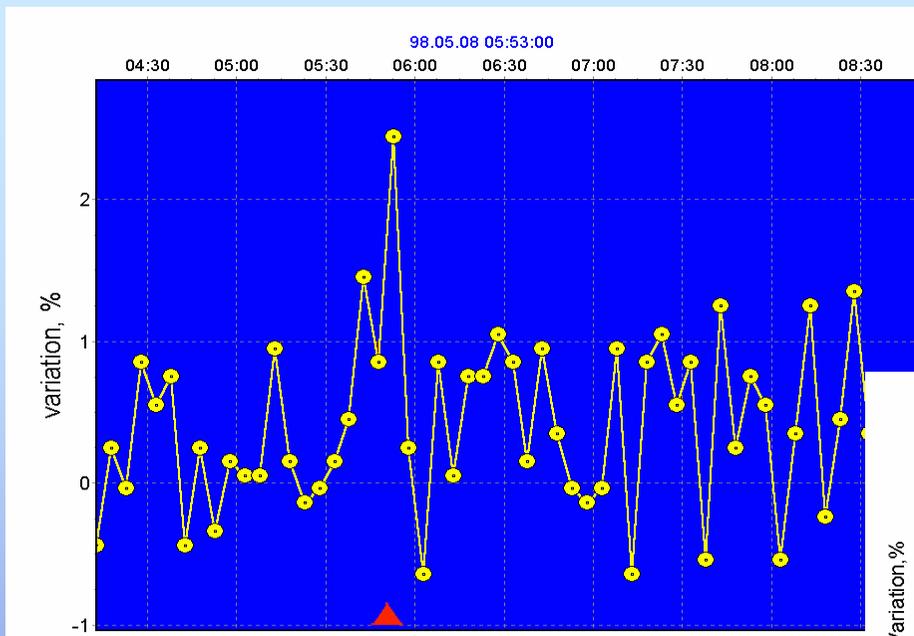
The detection of solar neutrons is mostly probable near local noon at mid- and low-latitude mountain neutron monitors. There are only a few such cosmic ray stations in the world network (about 10), and high mountain (3340 m) neutron monitor at Alma-Ata (Institute of Ionosphere) is among them. The combination of its geomagnetic cutoff rigidity (6.7 GV), altitude (3340 m) and high statistical accuracy makes this station enable to record solar neutrons of the energy order of 300 MeV.

Belov A. et al. A real-time search for solar neutron events in the data of high-altitude neutron monitors. Proc. 31 ICRC, 2009, 1107.

Two types of the ground-level enhancements of the solar cosmic ray: neutron and proton enhancements, but neutron enhancement can be registered before neutron enhancement.

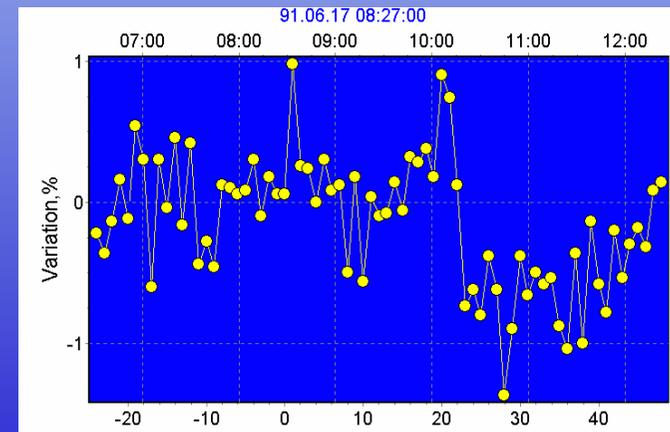
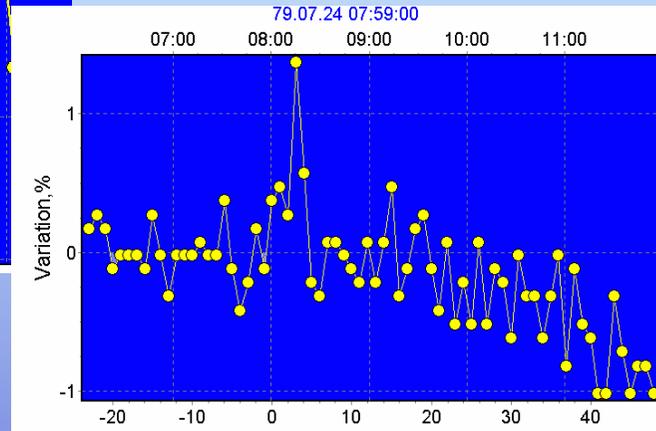


The count rate variations at the neutron monitors Mexico (MXCO), Climax (CLMX), and South Pole (SOPO) during the GLE on May 24, 1990.



*flare onset*

*Variations of the Alma-Ata NM 1-min  
count rate 8 May 1998.*



*SEARCH FOR SOLAR NEUTRON  
EVENTS  
IN ALMA-ATA NEUTRON MONITOR  
DATA*

*Proceeding of ICRC, 1999, SH 1.3.05*

# AATB + OULU neutron monitors 1-min data in real time (MySQL database at the Institute of Ionosphere)

**AATB** 17.05.2012 4:33:16 OULU

dt	act	press
21.05.2012 9:58:00	1426,699	681,5
21.05.2012 9:57:00	1422,5	681,5
21.05.2012 9:55:00	1426,300	681,5
21.05.2012 9:54:00	1423,300	681,5
21.05.2012 9:53:00	1438,199	681,5
21.05.2012 9:52:00	1409,699	681,5

dt	act	press
21.05.2012 8:00:00	1427,5	681,4400
21.05.2012 7:00:00	1433,699	681,5300
21.05.2012 6:00:00	1432,900	681,5399
21.05.2012 5:00:00	1431,099	681,5999
21.05.2012 4:00:00	1427,900	681,4500
21.05.2012 3:00:00	1418,599	681,4000

2012-05-16 22:33:16

2012-05-16 22:33:06 UT

AATB  
2012-05-21 09:59:00 1427 681.5  
2012-05-21 09:58:00 1426.7 681.5  
2012-05-21 09:57:00 1422.5 681.5

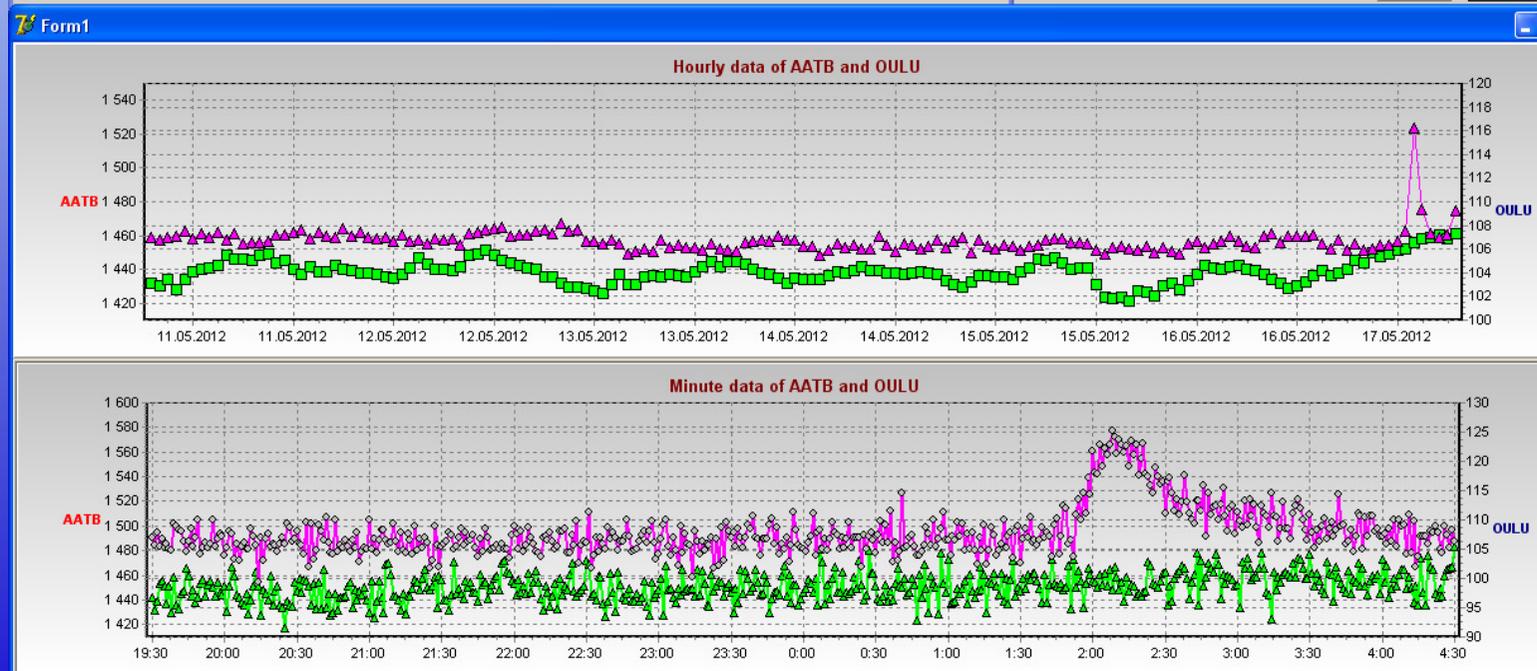
OULU  
2012-05-21 09:58:00 105,294 1018,08  
2012-05-21 09:57:00 106,156 1018,06  
2012-05-21 09:56:00 102,519 1018,02

2012-05-21 09:05:31 UT

AATB  
2012-05-21 08:00:00 1427.5 681.44  
2012-05-21 07:00:00 1433.7 681.53  
2012-05-21 06:00:00 1432.9 681.54

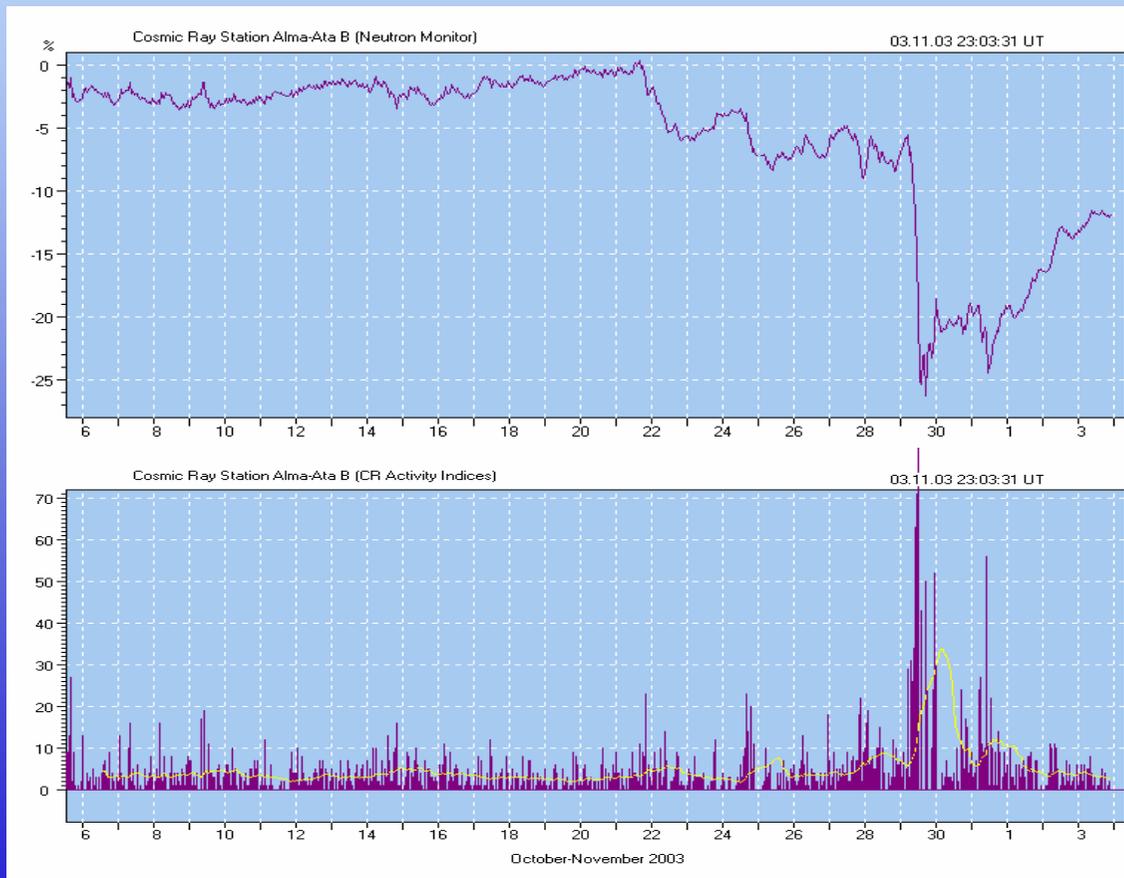
OULU  
2012-05-21 08:00:00 106,483 1017,64  
2012-05-21 07:00:00 106,233 1017,28  
2012-05-21 06:00:00 106,033 1016,92





In the frame of cooperation between the Institute of Ionosphere (Almaty), the Lebedev Physical Institute of Russian Academy of Sciences (Moscow), the Institute for Physics and Technology (IPT, Almaty) and the Physics Department of the Kazakh National University (KNU) three experimental setups for registration of cosmic ray intensity (neutron monitors) at altitude of 3340, 1750 and 850 m above sea level were integrated in common experimental complex, the ATHLET collaboration (Amurina et al., 2005) (<http://www.tien-shan.org/she/yardbaccess/index.html>) *ATHLET (Almaty THree Level Experimental Technique)*

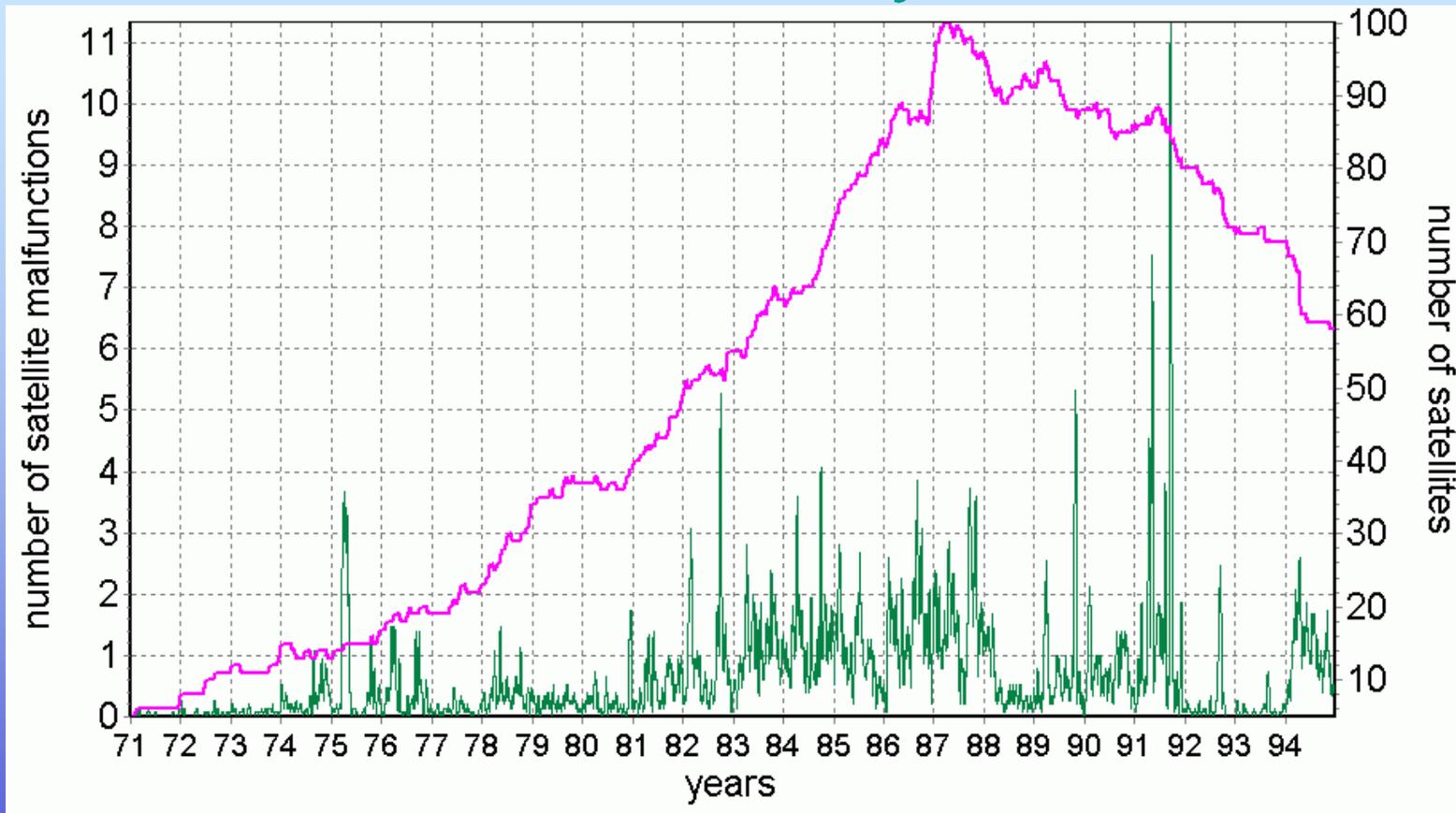
**We propose to input cosmic ray activity indices for investigation of space weather disturbances in real time**



Variations of cosmic ray intensity.

Cosmic ray activity indices.

# Satellite and Anomaly Number



~300 satellites

~6000 satellite malfunctions

INTAS-00-0810 "Improvement of the control and prognosis methods of the periods of dangerous influence of the space weather on satellite electronics".

# Satellite malfunction data

The main contribution was from NGDC satellite anomaly database, created by Daniel Wilkinson.

+

“Kosmos” data (circular orbit at 800 km altitude and 74° inclination)

+

1994 year anomalies - Walter Thomas report (Thomas, 1995).

+  $\epsilon$

The satellites characteristics - from different Internet sources:

<http://spacescience.nasa.gov/missions/index.htm>

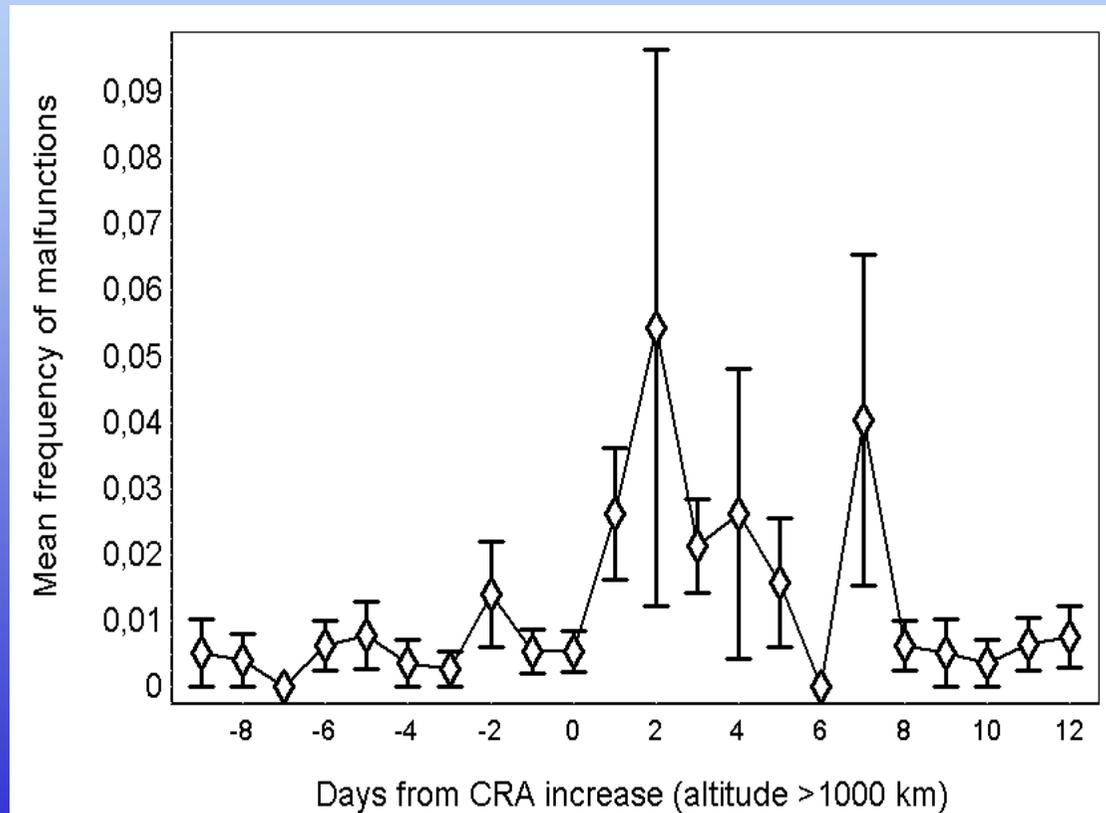
<http://www.skyrocket.de/space/index2.htm>

<http://hea-www.harvard.edu/QEDT/jcm/space/jsr/jsr.html>

<http://www.astronautix.com/index.htm>

INTAS project 00810, Belov A., Dorman L., Iucci N., Kryakunova O., Ptitsyna N. The relation of high- and low-orbit satellite anomalies to different geophysical parameters.// in "Effects of Space Weather on Technology Infrastructure" edited by I.A. Daglis, Kluwer Academic Publishers, Dordrecht, The Netherlands, NATO Science Series II, 2004, Vol.176, pp. 147-163.

The relation of satellite malfunctions to the behavior of cosmic ray activity indices for Alma-Ata station. We applied the epoch method to our data, choosing day with each of satellite anomalies as zero-day. This figure demonstrates that at the high altitude, just after CRA-index increase, a significant rise of the satellite malfunctions frequency is observed.



*Belov A.V., Eroshenko E.A., Yanke V.G., Kryakunova O.N., Nikolaevskiy N.F. International Journal of Modern Physics A.-2005.*



# Real Time Neutron Monitor Data-Base (NMD-B)

<http://www.nmdb.eu>

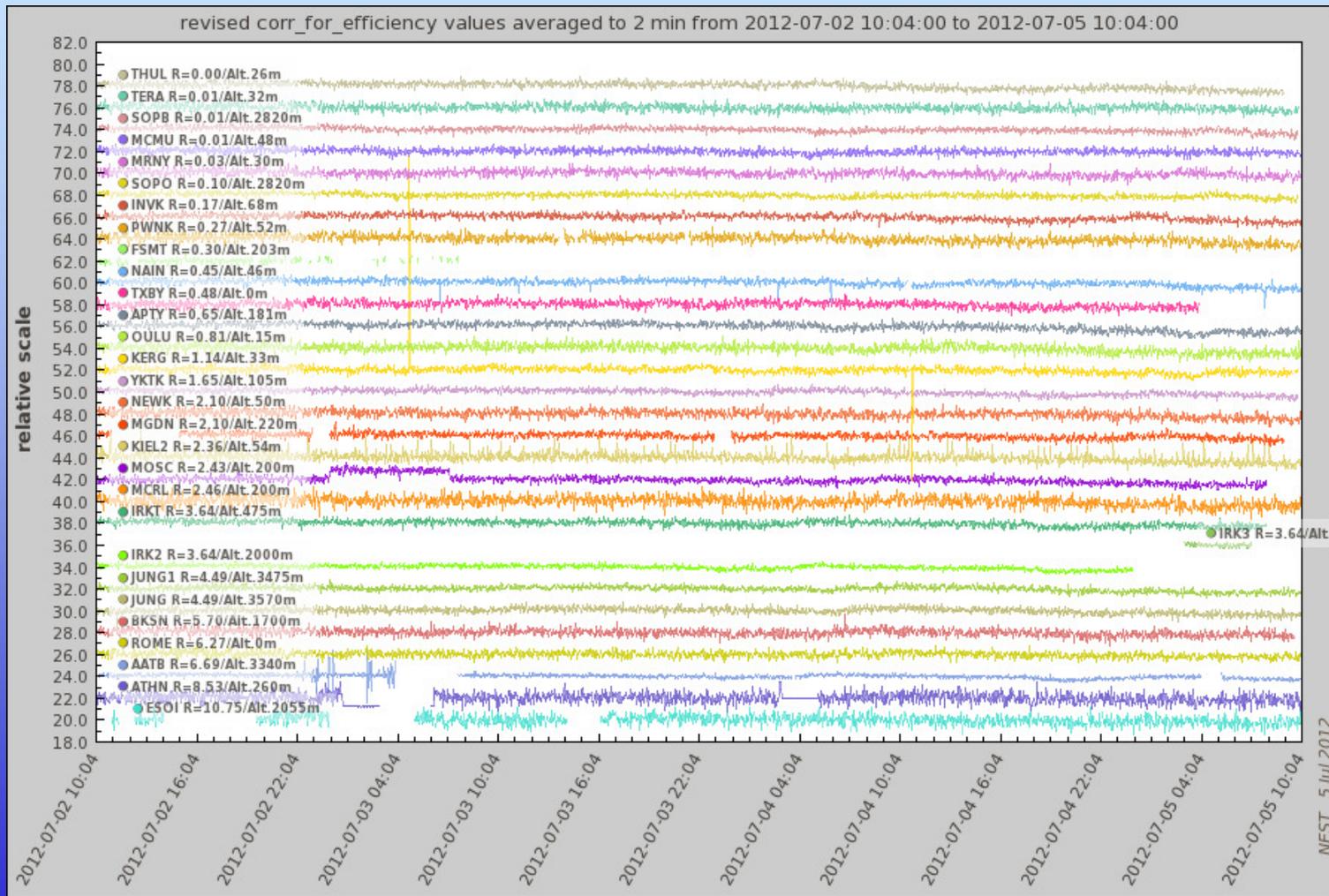


- 12 partners
- 28 NM stations in real-time

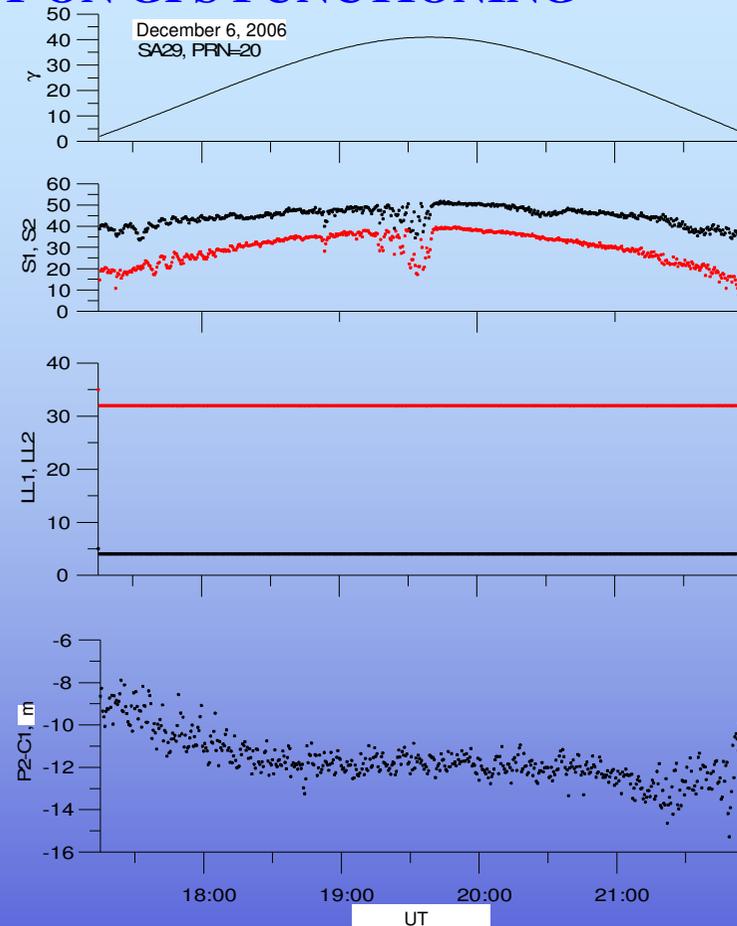
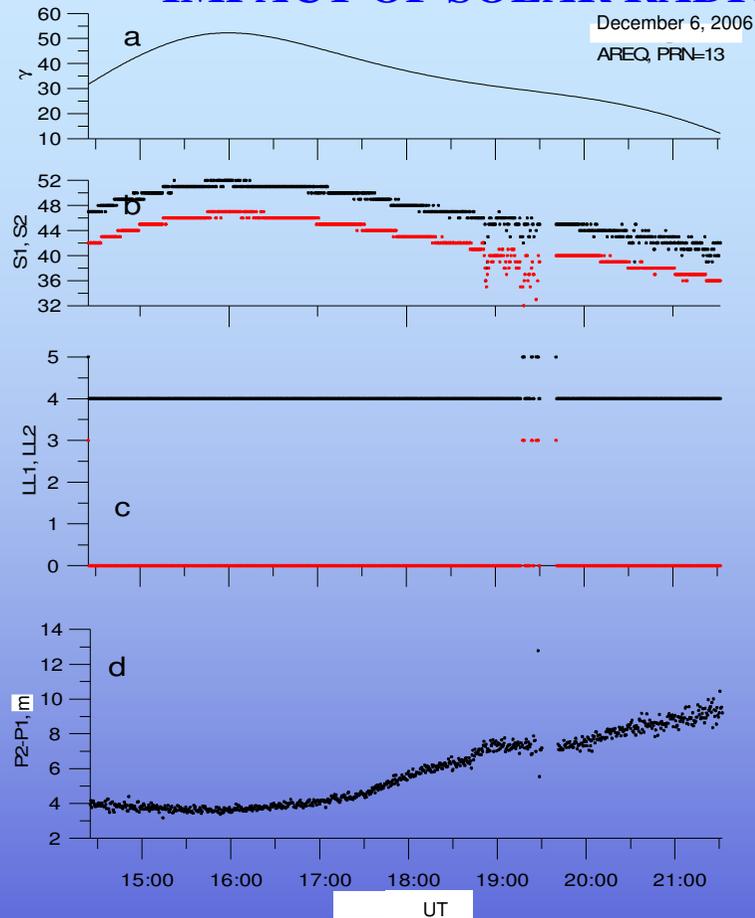


Almaty Cosmic Ray station is included in the world-wide neutron monitor network for the real-time monitoring of the space weather conditions and European database NMDB

<http://www.nmdb.eu>

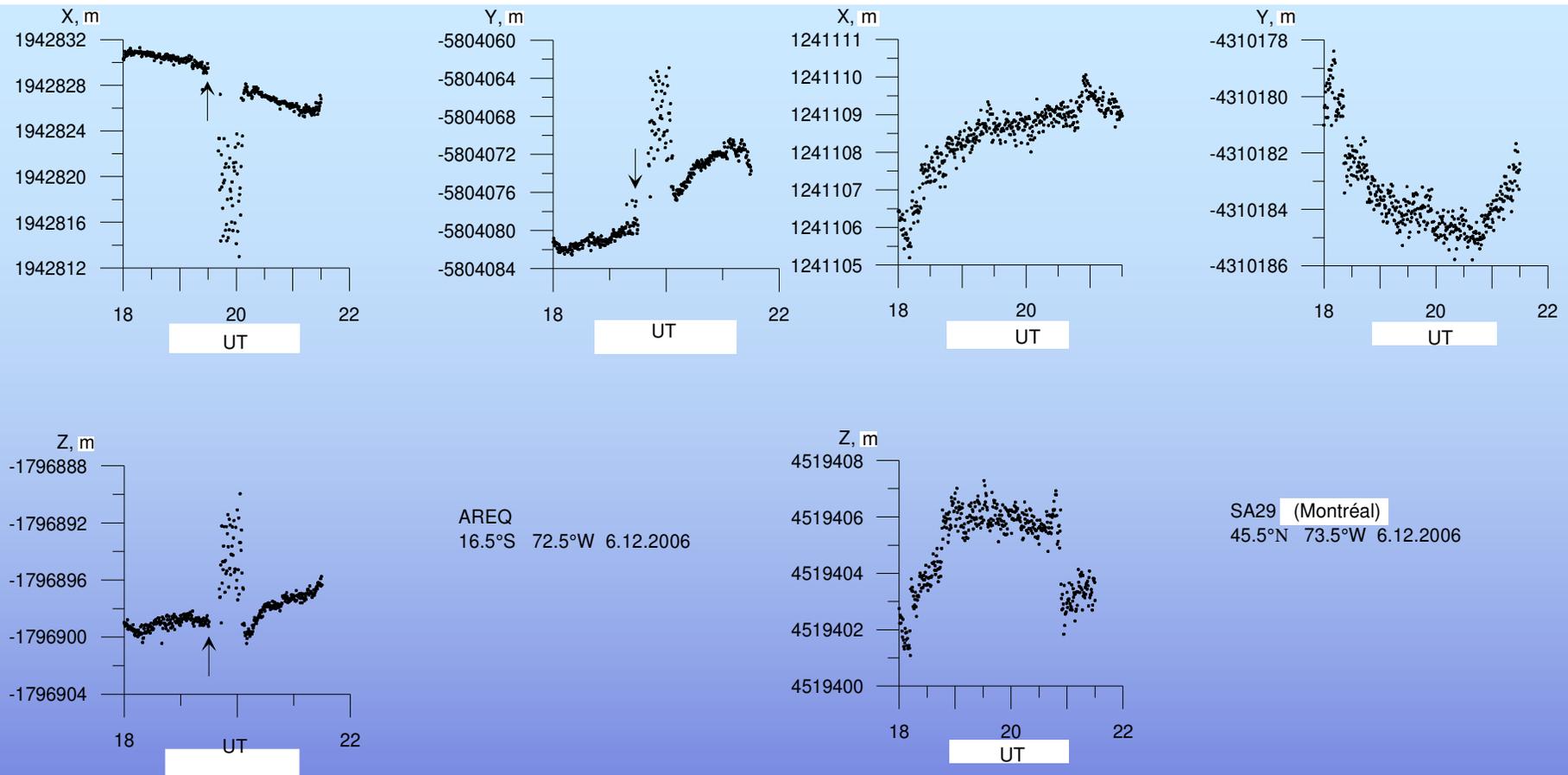


# IMPACT OF SOLAR RADIO BURST ON GPS FUNCTIONING



Temporal dependence of the satellites elevation (a), signal strength  $S_1$  and  $S_2$  for frequencies  $L_1$  (black) and  $L_2$  (red) (b), Cycle Slips ( $LL_1$  and  $LL_2$  for frequencies  $L_1$  and  $L_2$ , respectively) (c), and difference of the pseudoranges ( $P_2 - P_1$ ) (d) for Arequipa (Peru) (left panels) and Montreal (Canada) (right panel).

*A. Yakovets, C. Monstein et al. Solar radio burst on December 06, 2006 and GPS functioning. Izvestia of Academy of Science, Kazakhstan, Physics and mathematics, 2012, in print.*



**Calculated current coordinates of receivers in the geocentric Cartesian coordinate system for Arequipa (left panels) and Montreal (right panel). Arrows show the beginning of a position outage at 19:30 UT for Arequipa. There is a significant difference in functioning GPS receivers located at sites with the same longitudes but different latitudes during solar radio bursts. A magnitude of the solar radio flux is modulated by the gain of a GPS antenna used. The gain of the antenna for a low elevation of the Sun may be on 9 DB lower compared with the Sun located at zenith. Therefore, the depth of C/No fading during solar radio bursts has to depend on solar zenith angle. For the solar radio burst considered solar zenith angles were 83° and 22° for Arequipa and Montreal respectively. Therefore, a significant difference in functioning GPS receivers located at these sites can be explained on the basis of this reason.**



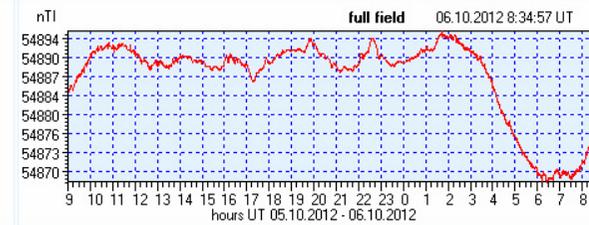
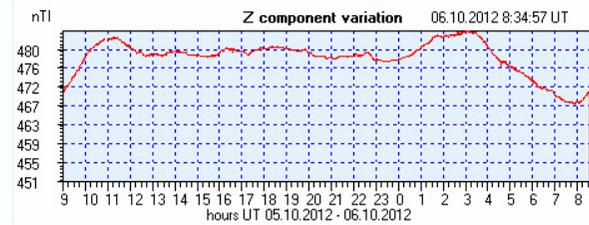
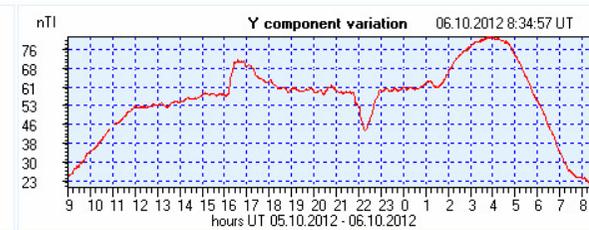
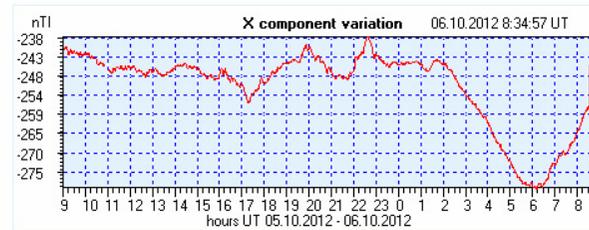
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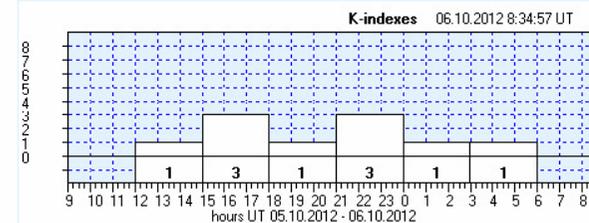
NAVIGATE:

- Geomagnetic Observatory ✓
- Prediction of geophysical conditions
- The solar flux
- cosmic rays

### Geomagnetic Observatory



From Year: 2012, Month: Jan, Day: 1, Hour: 0 [plot]  
To Year: 2012, Month: Jan, Day: 31, Hour: 23 [text]



**Geomagnetic observatory «Alma-Ata» is included in INTERMAGNET**

**“Orbita” station is situated on the 2700 m altitude in Zailiyskiy Alatau mountings about 40 km from Almaty city at the altitude of 2700 m a.s.l.**

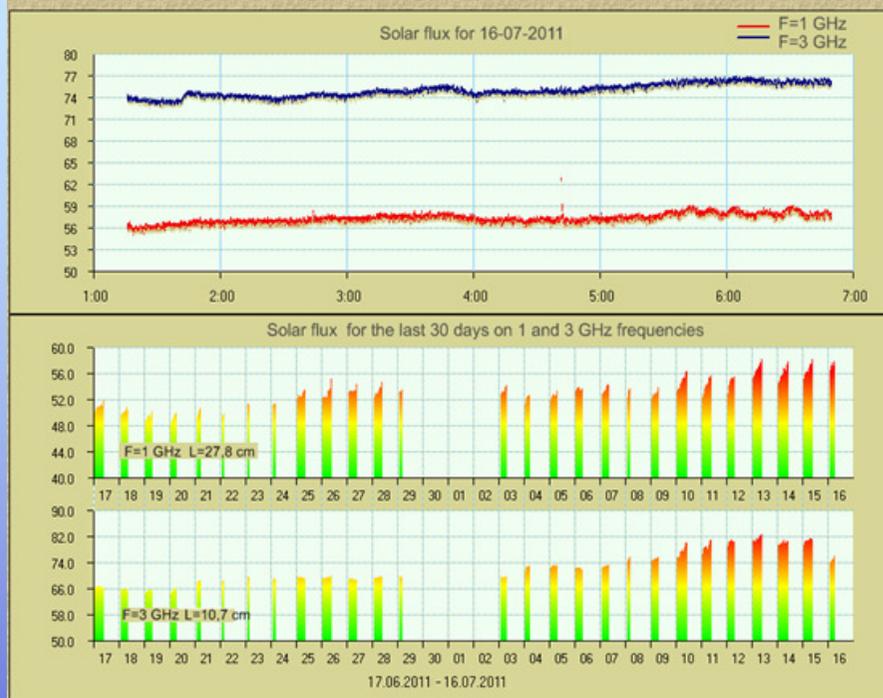


Mahonin V. Rudakov I.





Republic of Kazakhstan, Almaty city,  
DLTD "Institute of ionosphere"  
"Orbita" station,  $43^{\circ}03'29''\text{N}$ ,  $76^{\circ}58'24''\text{E}$   
Solar flux at wavelength 27.8 and 10.7 cm



"Orbita" station placed on the 2700 m altitude in Zailiyskiy Alatau mountings about 40 km from Almaty city. For the registration of the solar flux 12 m parabola antenna TNA-57M an radiometers RM-30 and RM10 are used.

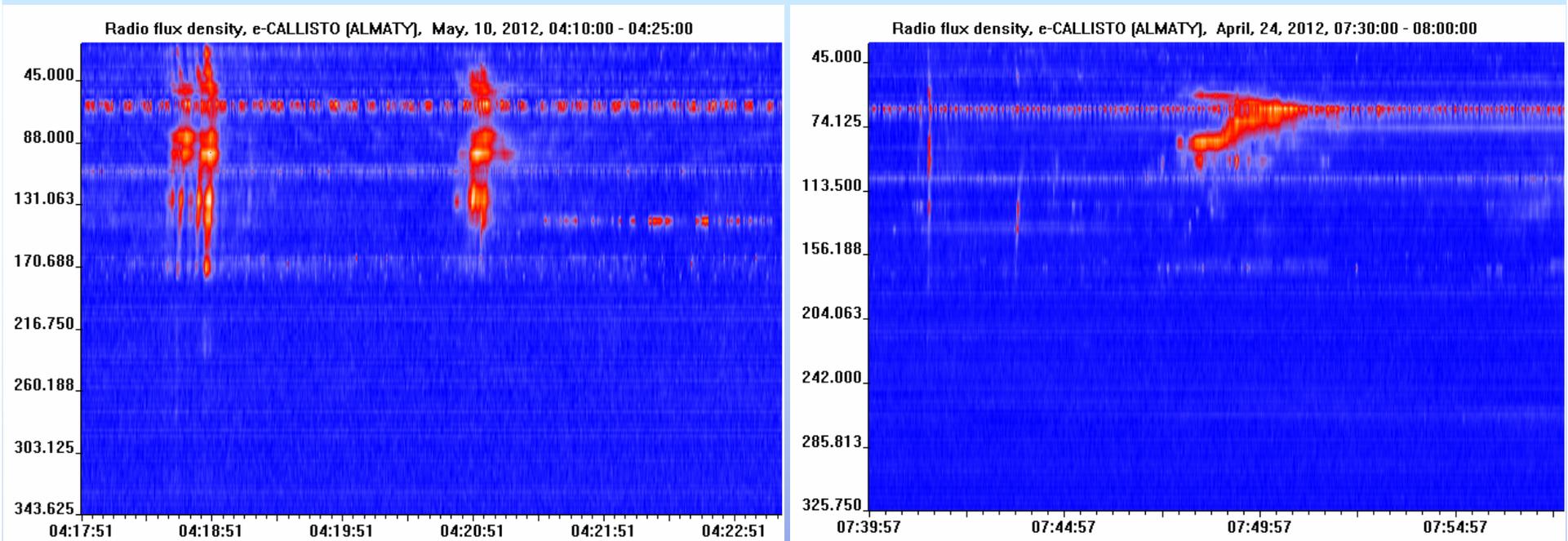
Solar flux observed regular from October 2009. At graphics are shown digital data for the last 30 days.

Determine the time interval for data output.

2011 Jul 16 output

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 3 GHz are presented on web-site (<http://www.ionos.kz/?q=orbita>).



**Radio burst of type III recorded on the 10 of May, 2012.**

**Radio burst of type II recorded on the 24 of April, 2012.**

**In view of upgrade of the «Orbita» ground regarding new radio astronomical instruments, a measurement campaign was planned and organized between Institute of Ionosphere and ETH Zurich, supported by SSAA. A new Callisto radio spectrometer (eC37) was installed and configured while the «Orbita» ground station.**

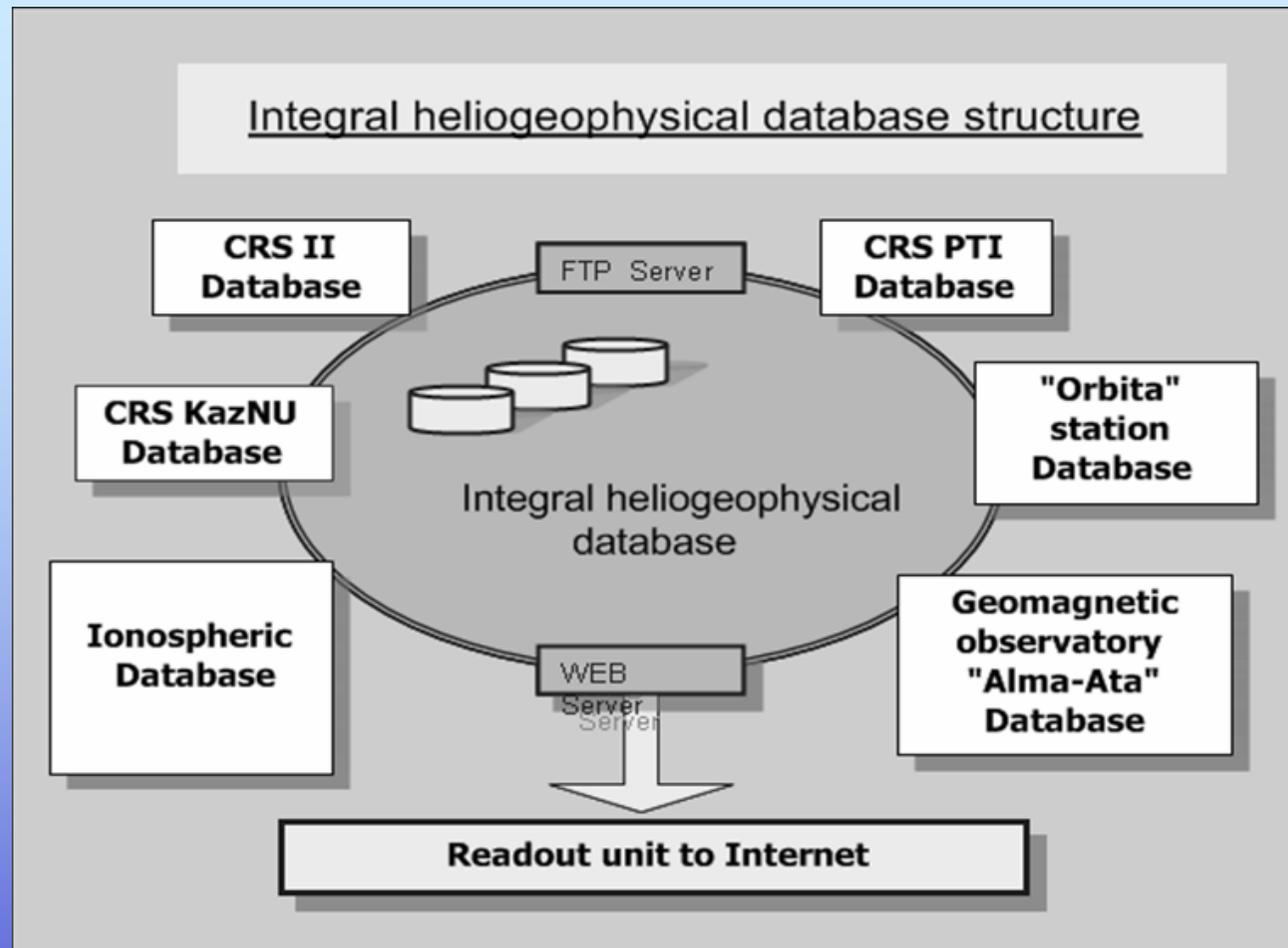


All data are represented on the web-site of the Institute of Ionosphere ([www.ionos.kz](http://www.ionos.kz)) in real time.

March, 2012.  
The measurements by means of Kazakhstan experimental complex.



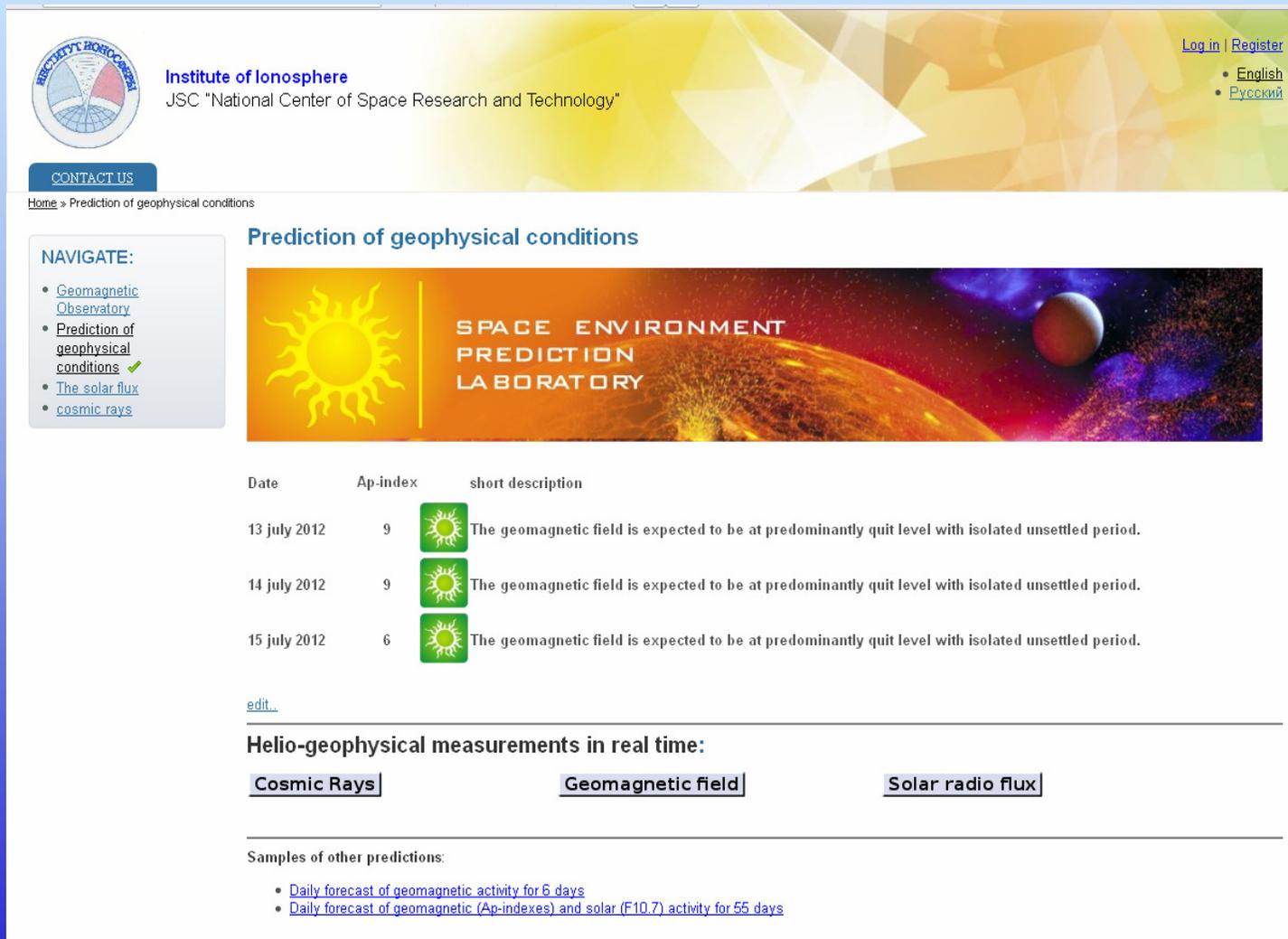
The fine structure of solar flare on 9 of March, 2012 (5-second data)



**The integral database joins the databases of six heliogeophysical stations. All distributed information system works continuously in an automatic mode.**

**In the database the information from following installations: the high-mountainous neutron supermonitor 18NM64, (3340 m above sea level); the neutron monitor located in KNU (800 m above sea level); the neutron monitor located in IPT (1700 m above sea level); a geomagnetic observatory "Alma-Ata" located in 10 km from city Almaty; the "Orbita" station located in mountains at height of 2700 m is collected.**

Since July, 2006 the space environment prediction laboratory represents the forecast of geomagnetic activity every day on the site ([www.ionos.kz/?q=en/node/21](http://www.ionos.kz/?q=en/node/21)).



The screenshot shows the website of the Institute of Ionosphere, JSC "National Center of Space Research and Technology". The page is titled "Prediction of geophysical conditions". It features a navigation menu with links to "Geomagnetic Observatory", "Prediction of geophysical conditions" (which is highlighted with a green checkmark), "The solar flux", and "cosmic rays". The main content area displays a table of geomagnetic activity predictions for July 13, 14, and 15, 2012. Each row includes the date, the Ap-index, a green sun icon, and a description of the geomagnetic field. Below the table, there are buttons for "Cosmic Rays", "Geomagnetic field", and "Solar radio flux". At the bottom, there are links to "Daily forecast of geomagnetic activity for 6 days" and "Daily forecast of geomagnetic (Ap-indexes) and solar (F10.7) activity for 55 days".

**Institute of Ionosphere**  
JSC "National Center of Space Research and Technology"

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**Prediction of geophysical conditions**

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- [Prediction of geophysical conditions](#) ✓
- [The solar flux](#)
- [cosmic rays](#)

**SPACE ENVIRONMENT PREDICTION LABORATORY**

Date	Ap-index	short description
13 July 2012	9	 The geomagnetic field is expected to be at predominantly quiet level with isolated unsettled period.
14 July 2012	9	 The geomagnetic field is expected to be at predominantly quiet level with isolated unsettled period.
15 July 2012	6	 The geomagnetic field is expected to be at predominantly quiet level with isolated unsettled period.

[edit...](#)

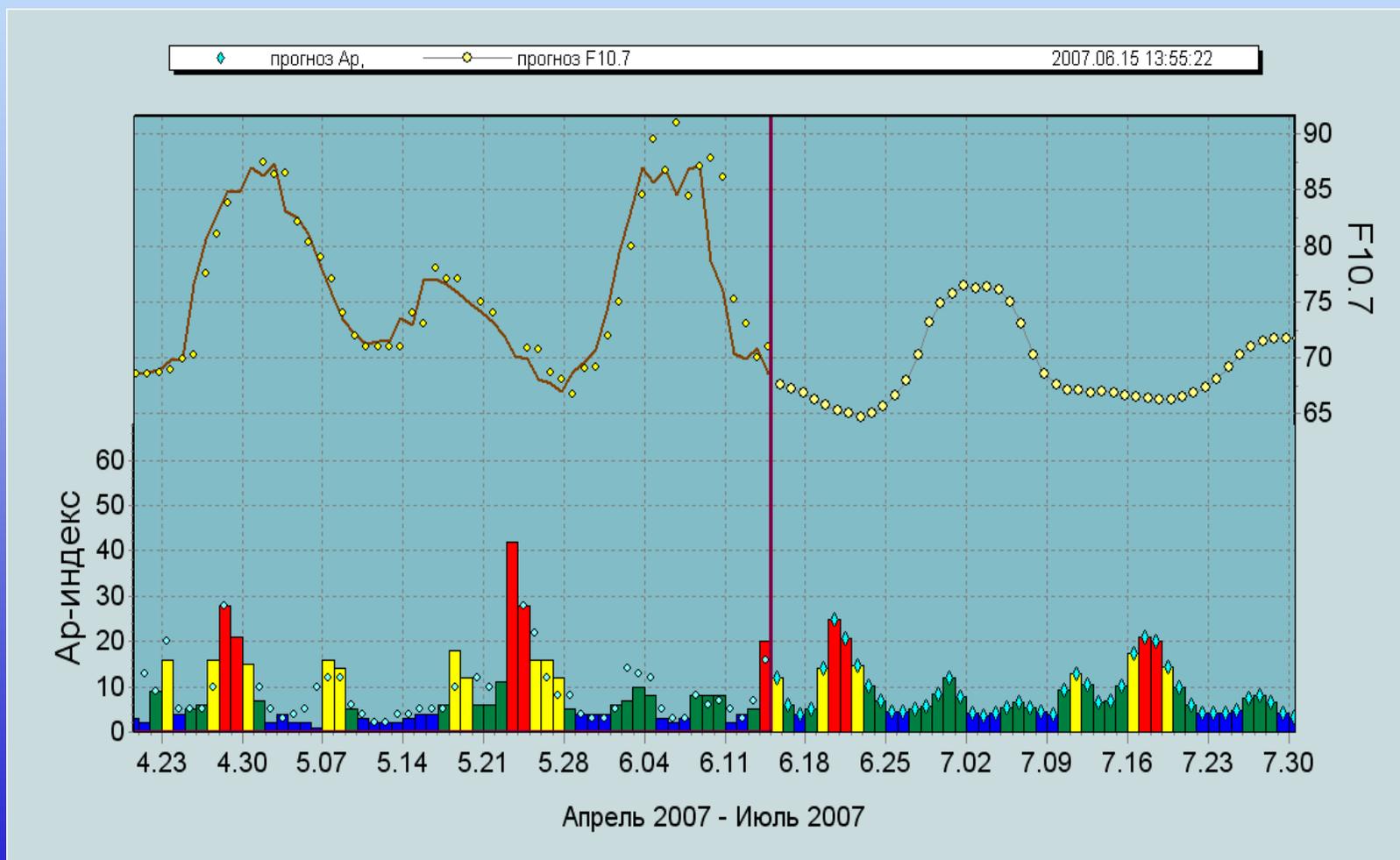
**Helio-geophysical measurements in real time:**

[Cosmic Rays](#)      [Geomagnetic field](#)      [Solar radio flux](#)

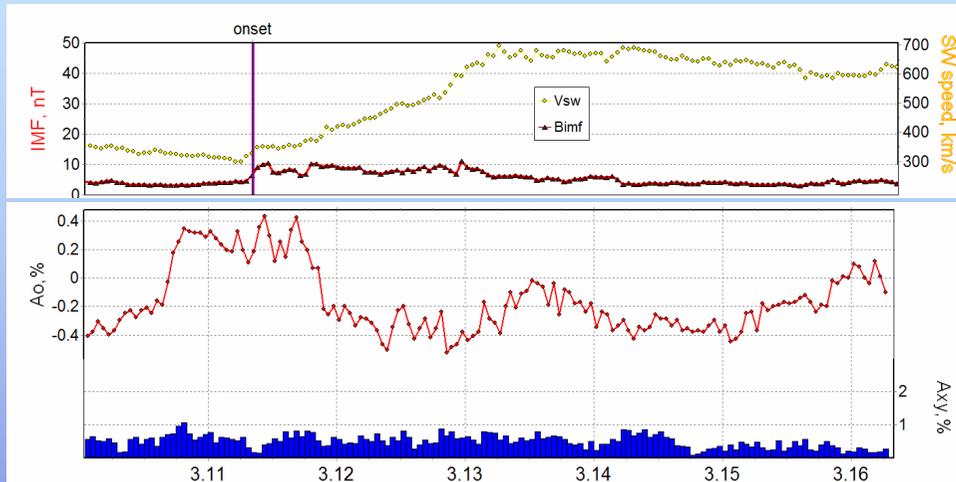
Samples of other predictions:

- [Daily forecast of geomagnetic activity for 6 days](#)
- [Daily forecast of geomagnetic \(Ap-indexes\) and solar \(F10.7\) activity for 55 days](#)

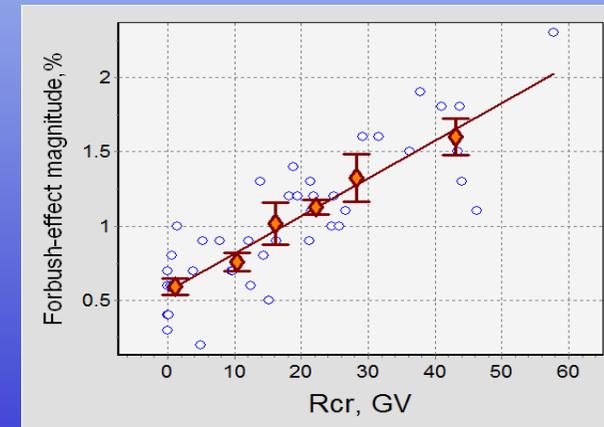
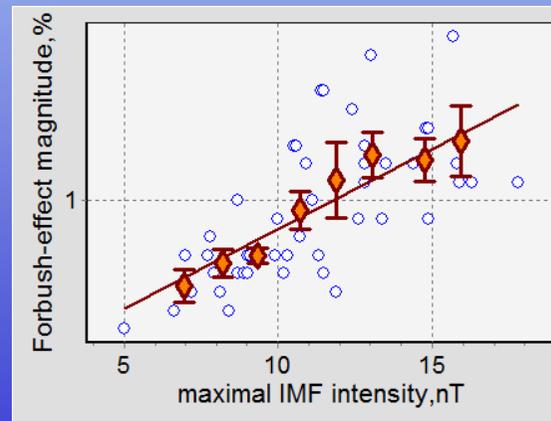
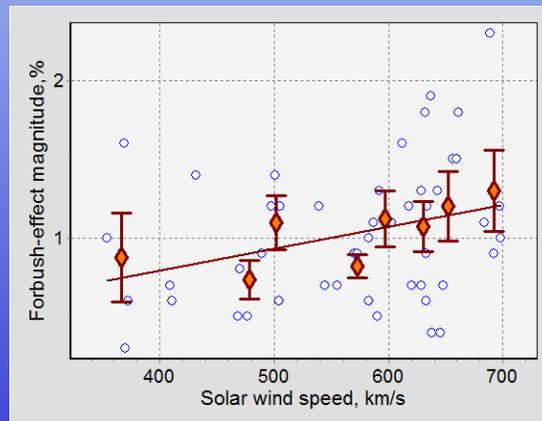
**Since July, 2006 the space environment prediction laboratory represents the every day forecast of geomagnetic activity and the solar flux density at 10.7 cm for 55 days.**



# Influence of high-speed streams from coronal holes on cosmic ray intensity



**Behavior of 10 GV cosmic ray density ( $A_0$ ) and equatorial component  $A_{xy}$  of the vector CR anisotropy, and relevant parameters of the interplanetary magnetic field: (IMF) intensity and solar wind velocity, during the March 10-16, 2007.**



**Dependence of FE magnitude on the maximum solar wind speed, maximum IMF intensity and CR critical rigidity in 2007.**

*See poster presentation!*

*Thank you for your attention!*



Mahonin V. Rudakov I.

*The Big Almaty lake nearby Cosmic Ray Station  
and “Orbita” station*