Cosmic Rays and Neutron Monitors – a training course in science and applications

neutron monitor database

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NMDB Training Course
Laboratory Exercises

NMDB laboratory exercises:

NMDB Lab Exercise 1

CR particle transport from heliosphere via magnetosphere. Diurnal variation of CR.

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SUMMARY: Examples of running code(s) of charged particle trajectory by back-tracing method are illustrated. By setting initial conditions, the numerical integration of equation of motion in IGRF is done. Allowed trajectories with asymptotic directions are computed and structure of penumbra is obtained. Particle trajectory from magnetospheric boundary to the given point above the Earth's detector is plotted in 2D plots.
Diurnal CR variation fit is obtained by online tool from given neutron monitor and given day when 1-min data is available.

1. CR trajectory tracing in geomagnetic field

Cosmic ray trajectory tracing is done, similarly to earlier papers cited e.g. in [1,2] by numerical solution of equation of motion of particles in the geomagnetic field model IGRF. Starting from the point of interaction (above the detector), reversing the charge sign and velocity vector, tracing is done by linearization of short time interval motion of particle. The time step is given as T/n, where T is gyroperiod in given field. The step is controlled by comparison of two subsequent short linear lines approximating the particle trajectory. It is shortened if the curve of trajectory is not sufficiently smoothed. Maximum number of steps gives the constraint for unresolved trajectories (quasitrapped). These are assumed as forbidden along with those „finishing“ on the Earth's surface. Here only vertical directions are assumed.

<u>**Lab exercise (step 1),**</u> single particle trajectory (code in Fortran, ase):

Input (example, file ase1b.txt)

 3.000 -1.   3.000   start rigidity (f9.4), sign of charge (f4.0), end rigidity(f9.4)
 20.00 49.2 20.22   starting elevation (km, f10.3), geog. lat., long. (f6.2),
 1995 1 1   1 12 00 00 year(i5),month, day(i3), day of year(i4), hour, min, sec(i3).
 1000   6   1 1   50000   10000 0.01 nk1,iopt,ist,jgrf,nkonc,nkma,tu0
-1.00 mark for end of computation

nk1 – starting step (division of gyroperiod)
iopt, ist, jgrf – fixed parameters in this case (IGRF only)
nkonc,nkma - maximum number of steps, maximum division of gyroperiod

tu0 – allowed angle between two subsequent short straight lines of trajectory (in radians)

instruction: put into the input file the geographical coordinates of your University/laboratory and subsequently try three different rigidities, e.g. 0.5; 3.0 and 15.0 GV for trajectory computation. For each trajectory use the identical start and end rigidity.

Output: rigidity, coordinates on trajectory (GEO) □□r (in Earth radii)

instruction: after starting **ase.exe**, put the name of input file (e.g. **ase1b.txt**), after “file name missing…” put the name of output file (e.g. **ase1bo.txt**). The output file is created by computations and put into the same directory as the input file.

<u>Lab exercise (step 2)</u>, particle trajectories and structure of penumbra (code Fortran, asg).

instruction: instead of identical start and end rigidity, compute the Stormer cutoff rigidity (RS) for vertical access at your position. Put in input file (e.g. **asg1.txt**) starting rigidity RS – 2 (in GV, if RS>2) and end rigidity RS+4. Plot by any available plotting tool (preferrably Origin for Windows) the trajectory (latitude, longitude vs r) and obtain the structure of transmissivity function with dR=0.1 GV.

Input (asg1.txt). The same structure as ase, the start and end rigidity can be put as different values.

Output:rigidity, asymptotic directions $\square_{as}\square_{as}$, coordinates of the point of intersection with magnetopause or 25 Re (GEO) □□ asymptotic directions $\square_{as}\square_{as}$, $\tilde{r}$

instruction: after starting **asg.exe**, put the name of input file (e.g. **asg1.txt**), after“ file name missing…” put the name of output file (e.g. **asg1o.txt**).

2. CR short term variability: diurnal variation.

For the study of short time CR fluctuations, the diurnal variation of CR which is a stable and dominant one in the power spectra constructed from long time series (Fig.1.) has to be identified.
The simple procedure using least square method of fitting that is online available at http://cosmicrays.oulu.fi/~igor/variation/. The solar diurnal anisotropy resulting from co-rotational streaming of particles past the Earth

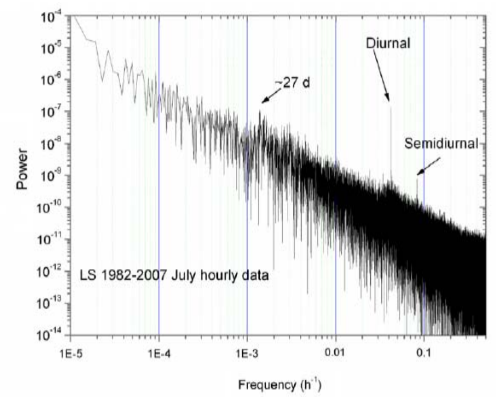

Fig.1. (from [4]). The power spectrum density of neutron monitor counting rate (hourly data) at Lomnicky stit being one of the NMDB stations.

Short description: Input is 1440 1min data from a single day and single station. Short gaps (length < 20) are not taken into account for the smoothing. By selecting smoothing n, the data are smoothed as

Xsm(t) = 1/(2n+1)*sum [Xmeas(t+i)];
i = -n, -n+1,...,0,...n-1,n; t=1,2,..., 1440.

Xmeas(t) is count rate/s from NMDB and the station in time t (there are taken into account also data from previous and next day for smoothing).
The fit is:
Xfit(t) = P1+P2*cos((2*π*t/1440)+P3)
by least square method fitting P1, P2, P3 (in the UT of maximum)
Results returned: P1, P2, P3, r , var (daily mean, amplitude, phase of diurnal wave fitted; linear correlation coefficient between the fit and measurements; (measure of quality of fit, or declination from the fit), smoothing parameter n.

Var = 1/(P1*1440)*sqrt(sum [(Xsm(t)-Xfit(t)]^2}, t=1,..., 1440.

Additionally, the number of missing data (gap) is there two.

Lab exercise (step3) Smoothing CR 1 min data and obtaining the diurnal variation amplitude, phase, and the quality of the fit.

On-line at http://cosmicrays.oulu.fi/~igor/variation/.

a. use only a single station with the available data for past 10 days. Put smoothing n=240 (6 hours) and summarize the values of the fit, plotting phase, amplitude, amplitude/mean and variation/amplitude of the diurnal variation.

b. from the 10 days select that one with lowest var (variation, the best fit). Change the smoothing as 1, 5, 60, 300 and evaluate the fitted parameters.

c. for the day selected compare the fits of diurnal variation for more stations and summarize the number of stations where the fit is possible.

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Useful links for the tasks:

Systems of coordinates:
http://www.spenvis.oma.be/spenvis/help/background/coortran/coortran.html
http://www.iki.rssi.ru/vprokhor/coords.htm

Single point Corrected Geomagnetic Coordinates and IGRF/DGRF Model Parameters
http://omniweb.gsfc.nasa.gov/vitmo/cgm_vitmo.html

Model field at a point by IGRF
http://wdc.kugi.kyoto-u.ac.jp/igrf/point/index.html

Transformation of Coordinate
(Geographic <-> Geomagnetic)
http://wdc.kugi.kyoto-u.ac.jp/igrf/gggm/index.html

Geographic - Geomagnetic Coordinate Conversion Tool
http://www.ukssdc.ac.uk/cgi-bin/wdcc1/coordcnv.pl

vertical geomagnetic cutoff estimates
http://www.cosmicrays.org/muon-cutoff-rigidity.php

Plasma calculator
http://www2.warwick.ac.uk/fac/sci/physics/research/cfsa/people/erwin/teaching/px384l/calculator/

Larmor radius and gyrofrequency calculator
http://pps.coe.kumamoto-u.ac.jp/streaming/PulsedPower/formulary/cal-lr.html

For cosmic ray transport in heliosphere e.g.
http://www.atnf.csiro.au/pasa/18_1/duldig/paper/node5.html#SECTION00053000000000000000

NMDB LAB Exercise 2

From cosmic ray spectra to the estimation of radiation hazards to aircraft crew

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SUMMARY: An estimate of the radiation dose caused by cosmic rays (galactic and solar) during commercial flights will be made in this lab exercise. The determination is based on the published effective radiation dose rates on the NMDB webpage. The obtained results will be compared with the results of other models. Finally, the results of the investigations will be summarized in a short report.

Detailed information about this lab course is available under:
http://cosray.unibe.ch/FP7/LC_Radiation/

1 Introduction

The exposure to cosmic radiation onboard aircraft has become an issue of increasing interest in recent years. In 1996, aircraft crews in the European Union (EU) were recognized as occupationally radiation exposed workers. Consequently, assessment of the radiation exposure of air crews is required by European law.
For the NMDB application _Effective radiation dose rate at flight altitude_ the galactic cosmic ray (GCR) flux and the solar cosmic ray (SCR) flux near Earth (but outside the geomagnetosphere) based on real-time neutron monitor data from NMDB as well as the CR particle trajectories through the geomagnetosphere are calculated in a _rst step. In a next step the CR flux at the top of the Earth's atmosphere is determined based on the information calculated in the first step. Then the interactions of the GCR and the SCR with the Earth's atmosphere are simulated, i.e. the flux of the different secondary particle species in the Earth's atmosphere are determined. The computer code PLANETOCOSMICS based on GEANT4 Monte Carlo simulations is used for this task. Finally, the effective dose rates at a selected atmospheric depth are calculated from the secondary particle flux in the atmosphere at this altitude by using published flux to dose conversion factors.

2 Exercises

1. Determine the flight paths
2. Determine the radiation dose for selected flights
3. Compare the obtained results with other models
4. Write a short report about your investigations

2.1 Determination of flight path

Tasks:

Determine the path of your flight to Athens and/or of other selected flights (e.g. transatlantic flight between Europe and North America, _ight on polar route).

2.2 Determination of the radiation dose with the NMDB application Effective radiation dose rate at flight altitude for selected flights

The effective radiation dose rate caused by cosmic rays at an atmospheric depth of 250g/cm2 (altitude of 10.5 km) will be available in the future from the NMDB webpage. For the moment these data are available under http://kspc22.unibe.ch

Tasks:

- Determine the dose rates along flight paths during times with SCR (GLE on 20 January 2005, maximum around 0700 UT), i.e. GCR+SCR, and without SCR, i.e. only GCR.
- Plot the effective radiation dose rates along the flight path as a function of the geographic or geomagnetic latitude.
- Summation of radiation dose rates along the flight path to obtain total exposure during flight.

2.3 Compare the obtained results with other models

There are different computer codes to determine the radiation exposure at aircraft altitudes due to the galactic cosmic radiation, e.g.:

CARI http://jag.cami.jccbi.gov/cariprofile.asp and
http://www.faa.gov/data_research/research/med_humanfacs/aeromedical/radiobiology/cari6/
EPCARD www.helmholtz-muenchen.de/epcard2/index_en.phtml
SIEVERT www.sievert-system.org

Tasks:

- Compute the radiation doses for the same flight paths and times as you did under section 2.2.
- Compare the results obtained with the different methods and comment.

NMDB LAB Exercise 3

Part I

GLE alert and the prediction of SEP events using NM data

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SUMMARY: Configuration of the parameters of the real time GLE Alert System using historical data for the period 1/1/2001-31/12/2006. Examples of running the system in lower and higher sensitivity settings. Alert and Onset time estimation, comparison with GOES alarms.

1. Introduction

Real-time GLE Alert production

GLEs are defined as transient enhancements of the solar cosmic ray intensity observable at the Earth. These are extreme events that give a straightforward evidence of a space environment anomaly. Thus they are keys for understanding both space and high altitude environment that react accordingly. The tracing and understanding of solar energetic particles (SEP/GLEs) and the ionization that these events generate in the atmosphere have been an open scientific issue for many years [4]; [5]). One of the most important goals of the NMDB project is the creation of a system for high-resolution registration and evaluation of this type of events in real time.

Several groups (NKUA, IZMIRAN, TAU, ALMATY) participating in the NMDB project run various GLE Alert functions – some of which are of use for real-time applications [6], [1], [7], [8], [9], [10], [11]. Within the cooperation of NMDB, these groups work together to provide the best possible Alert system.

The Alert software is based on the idea that the early detection of an Earth-directed cosmic ray event by NMs gives a good chance of preventive monitoring SEP-flux rise, providing an alert with a very low probability of false alarm [7], [11]). The cosmic ray-flux in the energy range above 500 MeV/nucleon cannot be recorded by satellites with enough accuracy because of their small detecting area. However, it can be measured by ground-based NMs with high statistical accuracy.
One minute Data from NM stations on Earth are processed in order to search for the start of the GLE. The initiation of a GLE is identified as the simultaneous detection of the enhancement in at least three NM stations.

In order to establish the Alert system, a two-step procedure is followed. We produce a Base Station GLE Alert for every station that registers the enhancement event and a General Alert.

When a Base Station GLE Alert is produced?

Firstly for every station and every minute a threshold value is defined M +N * Sigma (1< N <3) by the running mean M.

- When the last measurement exceeds this moving threshold the system marks a pre-alert point for this minute. The threshold multiplier N has been defined for every station as the value, for which for the past 10 years GLE alerts, we see the maximum number of true alerts with the minimum number of false.
- If we have P pre-alert points in succession we define a Station Alert
- If the last measurement exceeds the moving threshold, the program writes down a pre-alert point

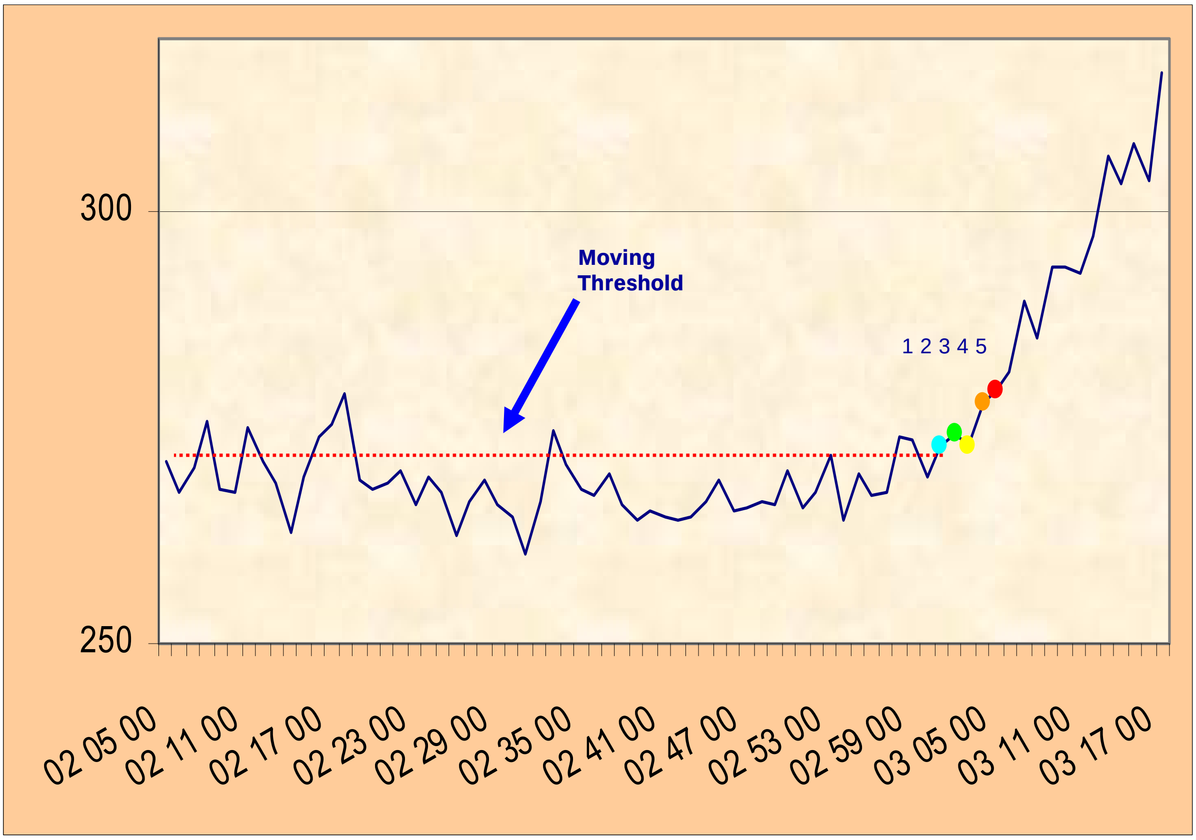


Figure 1.- Evolution of a base station alert

When a General GLE Alert is produced?

- A Supervision program checks every minute the status of every station.

- If this program detects at least S stations in “station alert mode” in a time window T then produces a General GLE Alert Signal

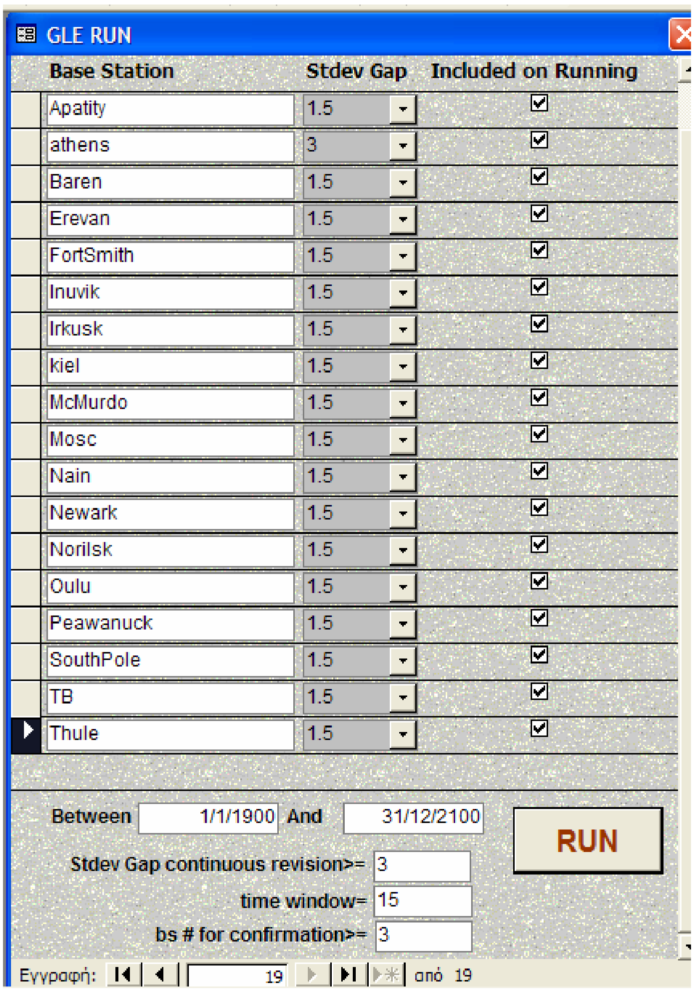
2. LAB Exercise
GLE Alert production using Historical Data

For this lab Exercise we have developed a software that can produce the base station alerts and the general GLE alerts from the historic one-minute data of several stations. The software is based on Microsoft Access database.

Using the form GLE_RUN (Fig. 2),
One can determine:

- The stations that are participating to the run.
- The time period for the event searching.
- The threshold multiplier N (marked as stdev Gap)
- The number of pre alert points that confirm the base station alarm (marked as stdev Gap continuous revisions)
- The time period in witch we are waiting for the number of stations to confirm an event (marked as Time Window).
- The number of stations that confirm the general alarm (marked as bs # for confirmation)

On pressing the run button the system produces the general alerts for the above settings and stores them in a database


GLE RUN

Base Station	Stdev Gap	Included on Running
Apatity	1.5	☑
athens	3	☑
Baren	1.5	☑
Erevan	1.5	☑
FortSmith	1.5	☑
Inuvik	1.5	☑
Irkusk	1.5	☑
kiel	1.5	☑
McMurdo	1.5	☑
Mosc	1.5	☑
Nain	1.5	☑
Newark	1.5	☑
Norilsk	1.5	☑
Oulu	1.5	☑
Peawanuck	1.5	☑
SouthPole	1.5	☑
TB	1.5	☑
Thule	1.5	☑

Between 1/1/1900 And 31/12/2100

RUN

Stdev Gap continuous revision>= 3

time window= 15

bs # for confirmation>= 3

Εγγραφή: 19 από 19

Using the GLE_RUNs form (see Fig. 3), someone can retrieve the results and mark the date and the time that the general GLE alarm was occurred (DT_Defined) :

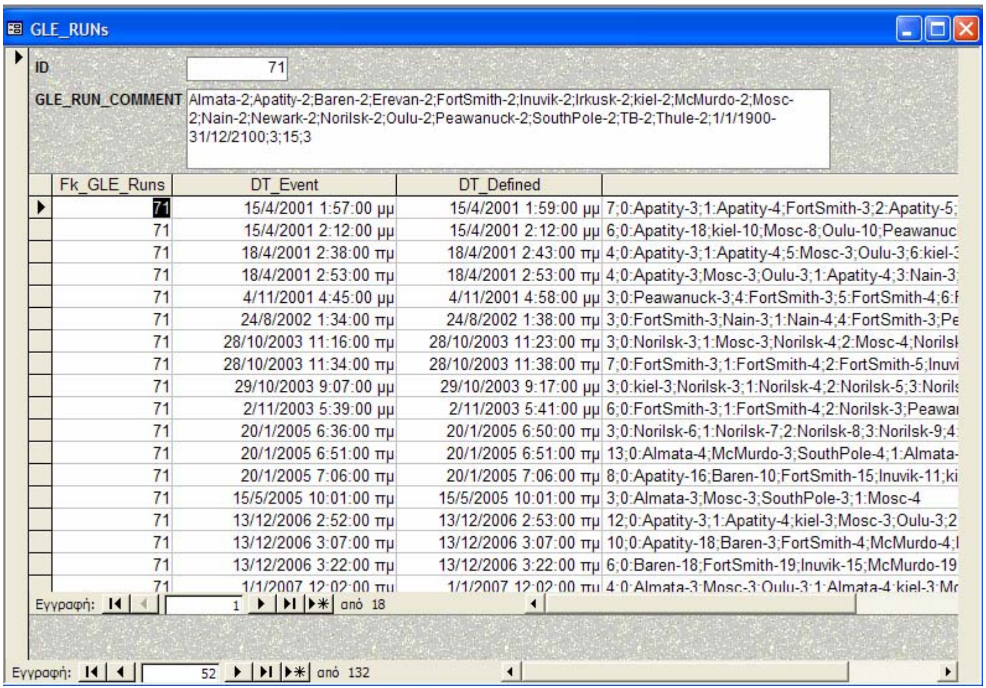


Figure 3.- Results of the GLE Alert system

Step 1: The system runs with the following two configurations

1st run

Period	1/1/2001-31/12/2006
Time Window (min)	15
Number of pre alert points	3
Number of stations in bs alert	3
The threshold multiplier (N)σ	2
Stations	Almata, Apatity, Baren, Erevan, Fort Smith, Inuvik, Irkusk,kiel, McMurdo, Mosc, Nain, Newark, Norilsk, Oulu, Peawanuck, South Pole, TB, Thule

2nd run

Period	1/1/2001-31/12/2006
Time Window (min)	15
Number of pre alert points	4
Number of stations in bs alert	2
The threshold multiplier (N)σ	1,5
Stations	Apatity, Baren, Fort Smith, Inuvik, Kiel, McMurdo, Mosc, Nain, Norilsk, Oulu, Peawanuck,

Step 2: Filling the Tables I and II results obtained from the true events and the onset given by GOES satellites are compared .

Step 3: Everyone writes an estimation of the parameters and makes his own third run

3rd run

Period	1/1/2001-31/12/2006
Time Window (min)	
Number of pre alert points	
Number of stations in bs alert	
The threshold multiplier (N)σ	
Stations	

Step 4: You can fill the Tables with the new results and discuss them.

Table I

GLE		Flare Onset, given by GOES	100MeV Integral Flux exceeded 1pfu GOES (1st alert)	ATHENS GLE ALERT RUN					
				First run		Second run		Third Run	
				Alert time	Diff (min)	Alert time	Diff (min)	Alert time	Diff (min)
60	15/4/2001 13:59	13:19	14:21						
61	18/4/2001 2:43	2:11	3:11						
62	4/11/2001 16:58	16:03	17:07						
63	26/12/2001 6:07	4:32	6:14						
64	24/8/2002 1:38	0:49	1:48						
65	28/10/2003 11:23	9:51	11:51						
66	29/10/2003 21:17	20:37	no						
67	2/11/2003 17:41	17:03	17:56						
68	17/1/2005		no						
69	20/1/2005 6:50	6:36	7:04						
70	13/12/2006 2:53	2:48	3:12						

Table II

					Γεγονότα GLE											
					60	61	62	63	64	65	66	67	68	69	70	
RUN	Time Window (min)	number of pre alert points	number of stations in bs alert	The threshold multiplier (N)σ	15/4/2001	18/4/2001	4/11/2001	26/12/2001	24/8/2002	28/10/2003	29/10/2003	2/11/2003	17/1/2005	20/1/2005	13/12/2006	False alarms
First run	15	3	3	2												
Second run	15	4	2	1,5												
Third run																

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Dorman, L.I. Monitoring and forecasting of great radiation hazards for spacecraft and aircrafts by online cosmic ray data. Annales Geophys., 23, No. 9, 3019-3026, 2005a.

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NMDB Lab Exercise 3: PART II

A. GLE alert and express estimation of the SEP spectrum by the neutron monitor data in Real Time.
B. Search for neutron enhancements by the neutron monitor data in Real Time.

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A. GLE alert and express estimation of the SEP spectrum by the neutron monitor data in Real Time.

SUMMARY: This Part of Lab Exercise is a continuation of Part I conducted by Athens group. It devoted to teaching and training of work on the basis of Internet project "GLE alert and SEP spectrum estimation by the neutron monitor data in real time": http://cr0.izmiran.ru/GLE-AlertAndProfilesPrognosing/index.htm. The following questions will be considered in Part II, A:

1. Short Introduction;
2. Criterion of the GLE ALERT signal formation at each station and in common;
3. Data from which stations are used for producing GLE ALERT in Real Time?
4. Auto testing of the GLE ALERT system;
5. LAB Exercise: GLE ALERT by the data from neutron monitor network in real time.

1. Introduction

2. Criteria of the GLE ALERT signal creation for each station and common signal.

Choose of the base period.

The first full hourly interval preceded GLE is chosen as the base period. This period is moving with the current time, but if it is found that enhancement started this time interval remains fixed up to the end of recorded enhancement.

Choice of threshold level and criteria of an alert signal formation.

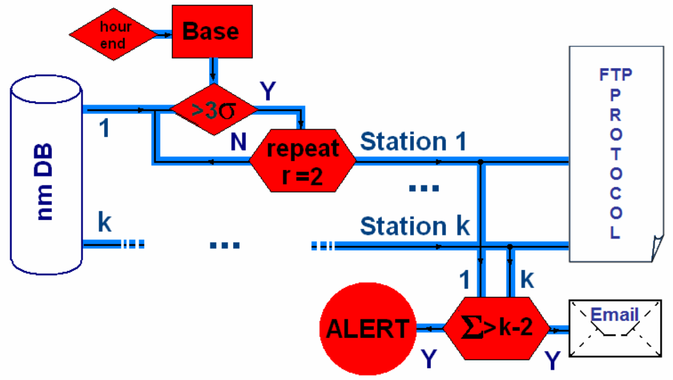
The choice of a level of selection of events at formation of alert signal is very important and critical. The aspiration to lower selection level (for example, 2.5 σ) creates the problems with false events. The choice of high level of selection

(for example, 5 σ) leads to the admission of small GLE. Really, statistical accuracy of the minute data of the neutron monitor 18NM64, which are in the majority, nearby 1 %. We choose level of selection of 3 %.
Choice of the time-resolution of data used.
Having developed an alert signal at each station, at a following stage it is necessary to unite this information and to develop the general signal. Can happen that at small and enough anisotropic GLEs, for parts of stations it will not be feasible to get an alert signal. Therefore at development of general ALERT signal it is necessary to use soft enough conditions to consider a possible situation of possible anisotropic GLE. The analysis of retrospective events has shown that at generation of general signal ALERT it is enough to have alert signal on 60 % considered stations. It has proved to be true on 12 events investigated by us without formation of a false signal.

3. Data from which stations are used for producing GLE ALERT in Real Time?
For formation an alert signal it is enough to use the data of several (4-6) high-latitude stations in regular intervals located on a longitude. For reliable definition of spectrum GLE it is necessary to include in addition middle-latitude and even equatorial stations. Depending on used model it can be from 10 to all possible number of stations, publishing data in a real time mode.
4. Auto testing of the ALERT system
Considered events are very rare, so, continuous testing of software and hardware therefore is necessary to provide. With this aim two copies of the program have to start. The first one analyzes the real data, and the second is used for system testing. In current date a year was replaced by the year in which the real GLE was observed in analogous month. As a result within a year the second program will monthly generate test alert signal as shown in table1, where the number of GLE in each month is taken from the former years.

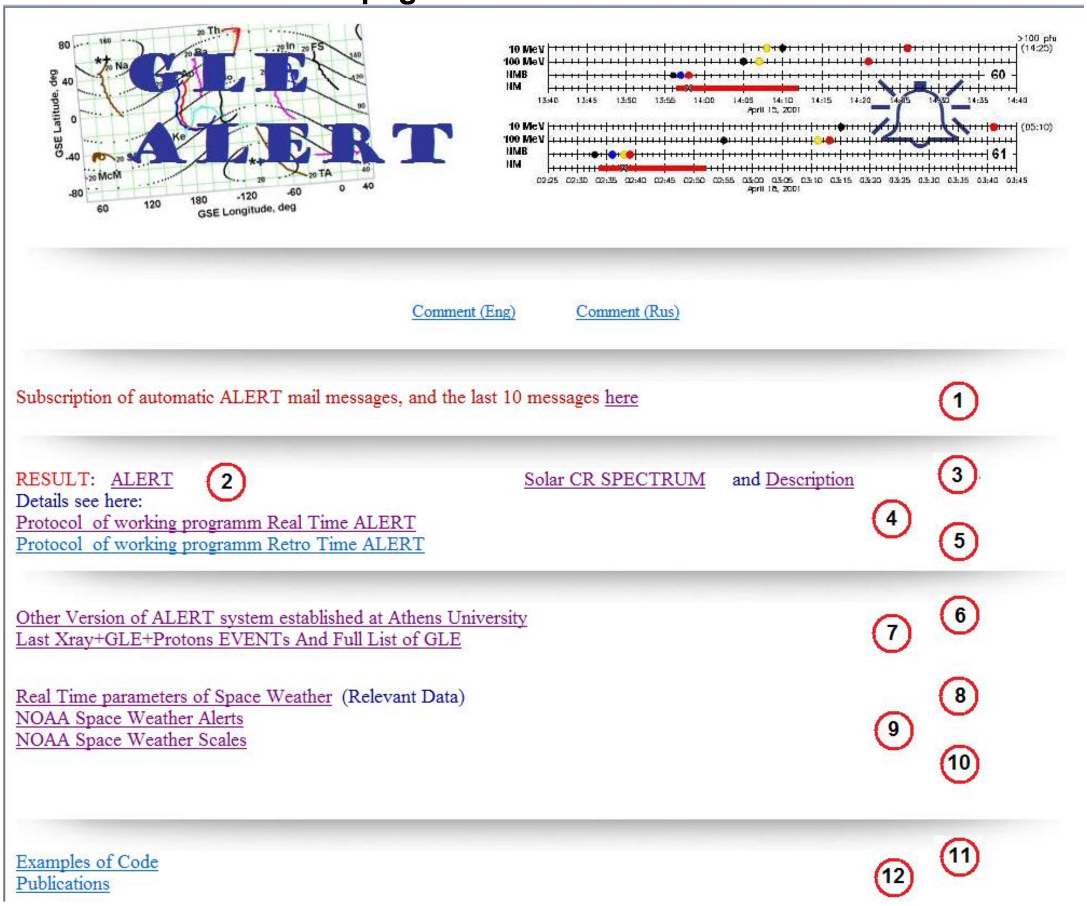
Table 1.

1	2	3	4	5	6	7	8	9	10	11	12
069	059	060	061	057	51-53	059	064	042	065	067	070
2005-01/20	2000 07/14	2001 12/26	2001-04/18	1998-05/06	1991 06/11; 1991 06/15; 1992-06/25	2000-07/14	2002-08/24	1989-09/29	2003-10/28	2003-11/02	2006-12/13



Block-scheme of a system for elaboration of ALERT signal of GLE

5. LAB Exercise: GLE ALERT by the data from neutron monitor network in real time.
Enter GLE ALERT Web page from the NMDB site.



	STEP	RESULT
1	The general acquaintance with a resource http://cr0.izmiran.ru/GLE-AlertAndProfilesPrognosing/index.htm	Main web page of the site
2	Look the result of current ALERT analysis 2	RESULT of the GLE Alert for the last 12 minutes.
3	Look the result of GLE spectrum calculation 3	Results obtained for the GLE by retrospective data
4	Subscribing on automatic ALERT mail messages 1	Dialogue window of a subscription and management.
5	Program protocol (real time) 4	List for learning
6	Program protocol (retro) 5	List for learning
7	Other Version of ALERT system established at Athens University 6	Version of Athens University.
8	Last Xray+GLE+Protons EVENTs And Full List of GLE 7	List of GLE и Xray, Protons EVENTs.
9	Real Time parameters of Space Weather 8	acquaintance with a resource
10	NOAA Space Weather Alerts 9	acquaintance with a resource
11	NOAA Space Weather Scales 10	acquaintance with a resource.
12	Examples of a code in Perl for searching of solar protons 11	acquaintance with a resource.
13	References 12	Acquaintance with a list

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[11] Archive GLE Data, available from ftp://cr0.izmiran.ru/COSRAY!/FTP_GLE

[12] Real Time X ray (1-8 A°), available from http://www.sec.noaa.gov/ftpdir/lists/xray

[13] Real Time Proton Data (>10 MeV and >100 MeV), available from http://www.sec.noaa.gov/ftpdir/lists/particle .

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B. Search for solar neutron enhancements by the neutron monitor data in real time.

This Part II of Lab course is devoted to teaching and training of work on the basis of Internet project "**Search for solar neutron enhancements by the neutron monitor data in real time**": http://cr0.izmiran.ru/SolarNeutronMonitoring/index.htm . It consists of:

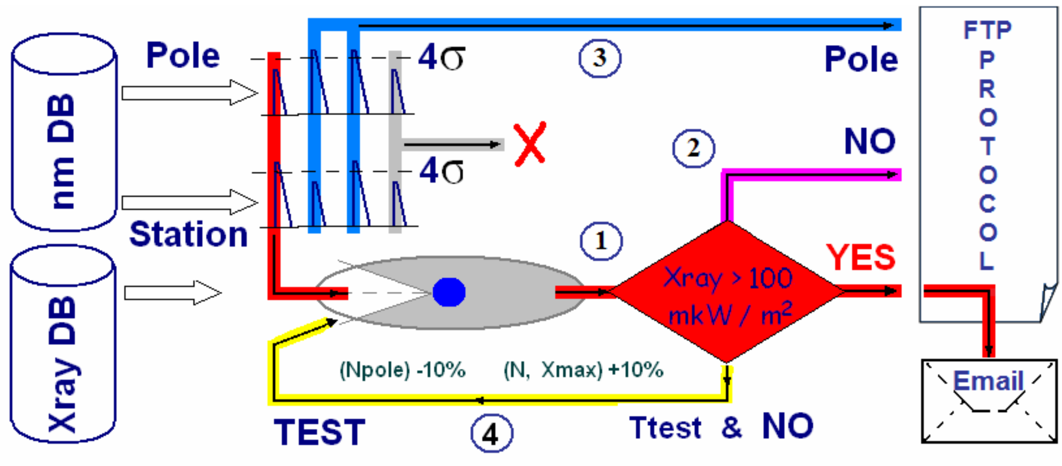
1. Short introduction

2. Criterion of the solar neutron enhancement selection;

3. Data from which stations are used for searching of neutron enhancements in Real Time?

4. How the system is tested?

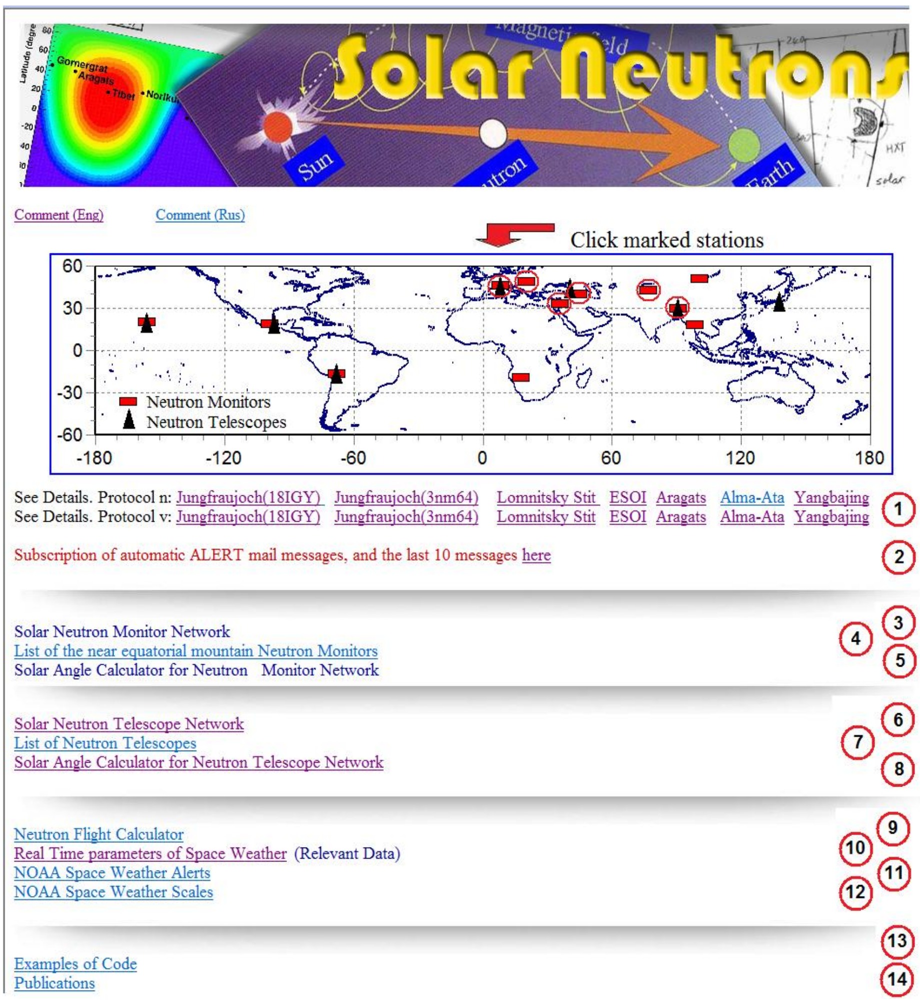
5. LAB Exercise: “Search for solar neutron enhancements by the neutron monitor data in real time”



Block-scheme of the system for elaboration of the neutron enhancement signal

Illustration of the real signal generation and testing of the system.

5. LAB Exercise: Work with the Internet site.



	STEP	RESULT
1	The general acquaintance with a resource http://cr0.izmiran.ru/SolarNeutronMonitoring/index.htm	Main page of the site
2	Click on the marked stations	List of contenders for neutron enhancement for each station (7 stations. ESOI and ARGATS are not in real time yet).
3	Data from each station: click lines on the site **1**	Protocol for each station: counting rate and variations
4	Subscription on the automatic mailing of the event onset **2**	Dialogue window of subscription and management.
5	List of neutron monitors available for solar neutron searching	List for learning
6	Map of neutron telescope network **6**	Learning of the site
7	List of neutron telescopes **7**	List for learning
8	Network calculator (Japan) for the neutron flux distribution **8**	Graphic map of the neutron flux distribution
9	Net calculator (Japan) of the time of propagation for the neutron of certain energy **9**	Dialogue window and result.
10	Real Time parameters of Space Weather **10**	Learning of site.
11	NOAA Space Weather Alerts **11**	Learning of site.
12	NOAA Space Weather Scales **12**	Learning of resource.
13	Examples of Perl code for the task of searching for solar neutron enhancement **13**	Learning of resource.
14	Review of references **14**	Learning of resource.

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[http://www.sec.noaa.gov/ftpdir/lists/particle .

NMDB LAB Exercise 4

Asymptotic longitudinal distribution of cosmic ray variations in real time as the method of interplanetary space diagnostic.

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SUMMARY: This Lab Exercise is devoted to learning and training on the basis of retrospective data (from CDs) and real time by the Internet project http://cr0.izmiran.ru/PrecursorMonitoring/index.htm of the construction and analysis of asymptotic distribution of cosmic ray variations for the interplanetary space diagnostics.
This Lab Exercise contents:

1. Introduction.
2. Description of the CR asymptotic distribution and precursors.
3. Which data and method are used for plotting the asymptotic CR distribution?
4. Examples of precursors of the large interplanetary disturbances and geomagnetic storms.
5. LAB Exercise: Asymptotic distribution of cosmic ray variations in real time.

Short description.

The galactic cosmic rays (GCR) interact with transients moving in the space toward the Earth. Due to their high speed they might provide the information about coming disturbed region well in advance it arriving to Earth. Precursor effect consists of combination of two kinds of galactic CR variations: pre-decrease and pre-increase, on a miscellaneous distributed by various CR stations at the same time before the shock arrival. Precursory decreases apparently result from a “loss-cone” effect, in which a neutron monitor station is magnetically connected to the cosmic ray-depleted region downstream the shock [2, 9 and references there] as it shown in Fig.1. Pre-increase is usually caused by particles reflecting from the approaching shock. The many of predictors have a peculiar longitude (or, pitch-angle) dependence of CR intensity with the abrupt transfer from minimum to maximum of CR variations which cannot be fitted by the sum of only the first two harmonics. The NMN is a good tool for detecting such anomalies in the pitch-angle or asymptotic longitudinal distribution. At present, when data of many stations are accessible in real time, it would be desirable to search such anomalies in real time mode and use this information in the short time forecasting of geomagnetic activity.
For searching and study of precursory effects hourly data from NM network are usually used in the Ring Station (RS) method. It is preferable to use stations with cutoff rigidity Rc<4 GV and homogeneously distributed by the ring around the globe. This method provides obtaining of different than harmonic longitudinal distribution of CR intensity at each hour.

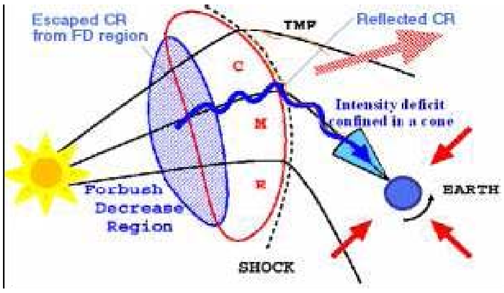
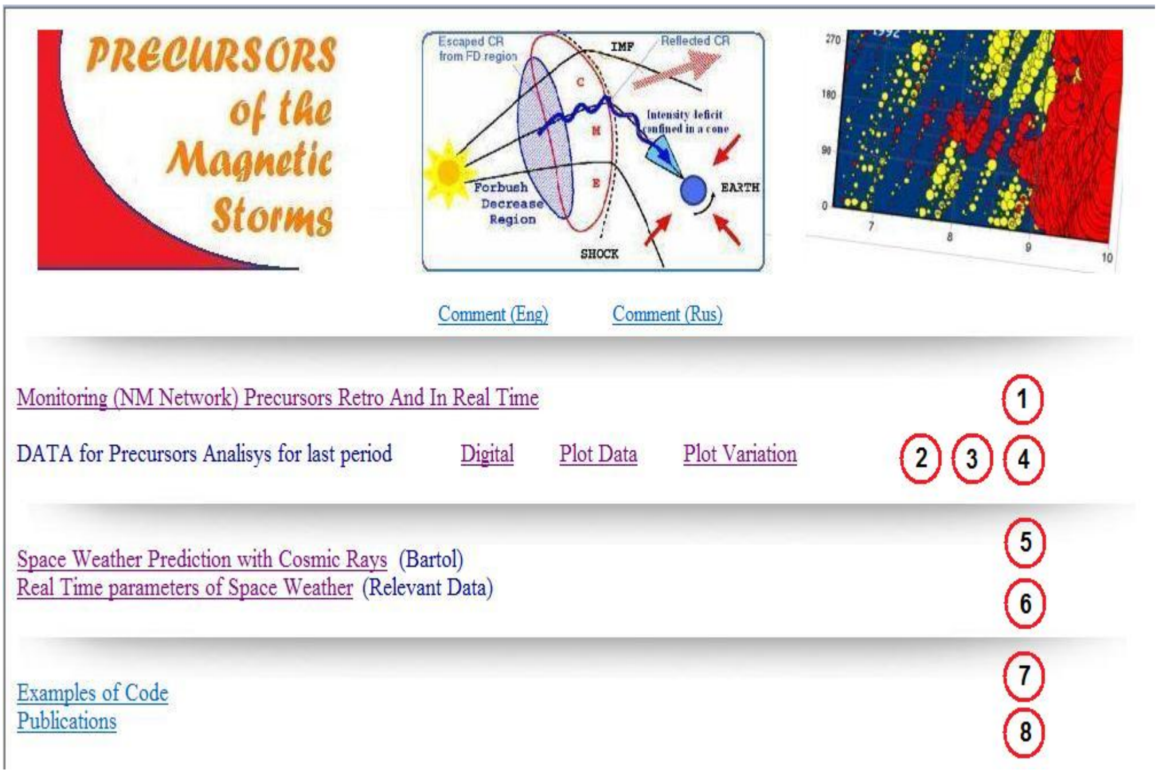


Figure 1. Illustration of “loss cone” effect in cosmic ray variations observable at Earth.

5. LAB Exercise: Asymptotic distribution of cosmic ray variations in real time.

WEB PAGE with the Internet project



	STEPS	RESULT
1.	Introduction. General familiarizing with asymptotic CR distribution and precursors	Participants will have an imagination about precursor’s picture
2.	Work with CD. Some examples of precursors by retrospective data (List of 5-6 events).	Participants will deal with a program choosing time intervals and picturing CR distribution
3.	General familiarizing with the Internet project http://cr0.izmiran.ru/PrecursorMonitoring/index.htm	Main Web page of the site
4.	Viewing of the asymptotic CR distribution by retrospective and current data in real time. **1**	RESULT of the A-Distribution analysis.
5.	Viewing of data for the distribution construction used (digit and graphical) **2, 3**	Participants study which stations and data are used for analysis.
6.	Other Version of Precursor analysis. **5**	Version of Bartol University.
7.	Real Time parameters of Space Weather **6**	Learning of the site.
8.	Examples of the code (in Perl) for the asymptotic distribution construction. **7**	Learning of the resource.

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