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# НА ПУТИ СОЗДАНИЯ АВТОМАТИЧЕСКОЙ СИСТЕМЫ ПРЕДСКАЗАНИЯ УРОВНЯ РАДИАЦИОННОЙ ОПАСНОСТИ ОТ КОСМИЧЕСКИХ ЛУЧЕЙ ДЛЯ ОБЪЕКТОВ В МЕЖПЛАНЕТНОМ ПРОСТРАНСТВЕ, МАГНЕТОСФЕРЕ, И В ЗЕМНОЙ АТМОСФЕРЕ

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# The matter of the Problem

- In the last years became possible thanks to the Project NMDB (Neutron Monitor Data Base) to have on-line through Internet one-minute cosmic ray (CR) data from many neutron monitors (in high energy region) as well as from several spacecrafts (in very low energy region). To avoid damage of electronics and negative effects for people health is necessary in time forecast expected fluency of energetic particles and radiation hazards. It was shown by myself and colleagues that this possible to do by using the first 20-30 minutes of CR data on the basis of coupling functions, spectrographic method, and by solving inverse problem, and then calculate expected results on radiation hazards for many hours of Solar Energetic Particle (SEP) event. Really now all these calculations take time few months and cannot practically used for real forecasting. All these procedures must be made automatically, including the formation of corresponding alerts on the expected level of radiation hazard for different objects. We describe obtained algorithms for several automatically working stages.

- The **first's stage** works continue, collecting from Internet all available one minute data on CR variations (corrected on meteorological and geomagnetic effects). The **seconds stage** also works continue according to automatically working program "SEP-Start" - supposed, developed and checked in the Israel Cosmic Ray and Space Weather Centre. Using of this program on many CR stations and on satellites allowed to determine automatically the beginning of SEP event (it can be different at different stations caused to anisotropy at beginning of SEP). If the **seconds** stage gives positive result, starts to work automatically the **thirds stage** according to program "SEP-Coupling" – using method of coupling functions and spectrographic method for transformation obtained at different altitudes and cutoff rigidities data on CR intensity variations to the space and calculation CR energy spectrum and angle distribution out of the Earth's atmosphere and magnetosphere, directly in the interplanetary space near the Earth.

- After obtaining results by **thirds stage** starts to work automatically the **fourths stage** according to program "SEP-Inverse Problem", and it is determined source function, time of ejection SEP into interplanetary space, and diffusion coefficient of propagation in dependence of SEP energy and distance from the Sun. After obtaining results by **fourths stage** starts to work automatically the **fifths stage** according to program "SEP-Direct Problem", and it is determined by found at **fourths stage** parameters the time variations of primary SEP in dependence of particles energy in interplanetary space near the Earth for many hours ahead, up to few days (on the basis of only 20-30 minutes of SEP beginning).

- On the basis of information, obtained in the **fifths stage**, it is easy to calculate by known coupling functions and cutoff rigidities expected time variations of SEP intensity in atmosphere and in magnetosphere at different altitudes, and compare the beginning part with available observations and estimate the quality of forecasting (**sixths stage**, program “SEP-Forecasting”). If the forecasted radiation hazard is expected dangerous for different objects, will be immediately send corresponding Alerts (**sevenths stage**, program “SEP-Alerts”). By obtaining new data, forecasting Alerts became more and more exactly.

# What we need to prepare before start the automatically forecasting procedure?

- **1. Data what we need to use for automatically on-line forecasting procedure.** We will use one-minute CR data, available from Internet (first of all – NMDB data): high-latitude stations with $R_C < 1$ GV (Oulu, Apatite, South Pole, and some other), middle-latitude stations with $R_C = 2$–$4$ GV (Moscow, Kiel, Novosibirsk, Yakutsk, Lomnitsky Stit, Yungfraujokh, and others), stations with $R_C = 6$–$7$ GV (Rome, Athens, Tjan Shan, and others), and low-latitude stations with $R_C = 10$–$16$ GV (Mt. Hermon, Mt. Norikura, Mexico, Haleacala, and others). For very small energy solar CR we will use satellite one-minute data, also available from Internet (e.g., GOES data).

- **2. For each used CR stations we need to know exactly values of cutoff rigidities and how they change with secular variations of the main geomagnetic field and with magnetic activity**. Now in IZMIRAN are calculated planetary distribution of during the period 1950 – 2050 in dependence of the level of magnetic activity (Dorman et al., 2017).
- **3. For each used CR stations we need to know exact values of atmospheric pressure *h*** (in units 1000 g/cm$^2$ ) at the point of CR detector.
- **4. For each used CR stations we need to calculate coupling functions** according to following formulas. For the polar normalized coupling function for any secondary component of type *i* ( for total neutron component, for neutron multiplicities , for hard muons, for soft muons, for electron-photon component, and so on) can be approximated by the special function

# Algorithms for the first stage: automatically determining the start of SEP event

$$D_{AZ} = \left[ \ln(I_{AZ}) - \sum_{k=Z-1560}^{k=Z-120} \ln(I_{Ak})/1440 \right] \Big/ \sigma$$

$$D_{BZ} = \left[ \ln(I_{BZ}) - \sum_{k=Z-1560}^{k=Z-120} \ln(I_{Bk})/1440 \right] \Big/ \sigma$$

$$W_{oi}(R,h) = a_i(h)k_i(h)R^{-(k_i(h)+1)}\exp\left(-a_i(h)R^{-k_i(h)}\right)$$

$$W_i(R_c, R, h) = \begin{cases} 0 & \text{if} \quad R < R_c \\ a_i(h)k_i(h)R^{-(k_i(h)+1)}\left(1 - a_i(h)R_c^{-k_i(h)}\right)^{-1}\exp\left(-a_i(h)R^{-k_i(h)}\right) & \text{if} \quad R \geq R_c \,. \end{cases}$$

$$a_n = \left(-2.915h^2 - 2.237h - 8.654\right)\ln(N_{\mathrm{Cl}}) + \left(24.584h^2 + 19.460h + 81.230\right)$$

$$k_n = \left(0.180h^2 - 0.849h + 0.750\right)\ln(N_{\mathrm{Cl}}) + \left(-1.440h^2 + 6.403h - 3.698\right)$$

$$a_m = \left[\left(-2.915h^2 - 2.237h - 8.638\right)\ln(N_{\mathrm{Cl}}) + \left(24.584h^2 + 19.46h + 81.23\right)\right] \times \left(0.987m^2 + 0.225m + 6.913\right)/9.781,$$

$$k_m = \left[\left(0.180h^2 - 0.849h + 0.750\right)\ln(N_{\mathrm{Cl}}) + \left(-1.440h^2 + 6.403h - 3.698\right)\right] \times \left(0.081m + 1.819\right)/1.940$$

$$\ln(N_{\mathrm{Cl}}) = (2.048 \pm 0.005) \times \ln(N_{\mathrm{Roma}}) - (1.965 \pm 0.024); \; CC = 0.9819 \pm 0.0004.$$

$$\ln(N_{\mathrm{Cl}}) = (1.178 \pm 0.003) \times \ln(N_{\mathrm{Apat}}) - (2.256 \pm 0.016); \; CC = 0.9922 \pm 0.0002.$$

$$\ln(N_{\mathrm{Cl}}) = (1.194 \pm 0.003) \times \ln(N_{\mathrm{Mosc}}) + (1.853 \pm 0.017); \; CC = 0.9845 \pm 0.0003.$$

$$a_n = \left(-2.915h^2 - 2.237h - 8.654\right)\ln\left(N_{\mathrm{Cl}}\right) + \left(24.584h^2 + 19.460h + 81.230\right)$$

$$k_n = \left(0.180h^2 - 0.849h + 0.750\right)\ln\left(N_{\mathrm{Cl}}\right) + \left(-1.440h^2 + 6.403h - 3.698\right)$$

$$\ln\left(N_{\mathrm{Cl}}\right) = (2.048 \pm 0.005) \times \ln\left(N_{\mathrm{Roma}}\right) - (1.965 \pm 0.024);\ CC = 0.9819 \pm 0.0004.$$

$$\ln\left(N_{\mathrm{Cl}}\right) = (1.194 \pm 0.003) \times \ln\left(N_{\mathrm{Mosc}}\right) + (1.853 \pm 0.017);\ CC = 0.9845 \pm 0.0003.$$

$$\delta a_n = \left(\partial a_n / \partial h\right)\delta h + \left(\partial a_n / \partial \ln\left(N_{\mathrm{Cl}}\right)\right)\delta \ln\left(N_{\mathrm{Cl}}\right) = \left[(-5.830h - 2.237) \times \ln\left(N_{\mathrm{Cl}}\right) + (49.168h + 19.460)\right]\delta h + \\ + \left(-2.915h^2 - 2.237h - 8.654\right)\delta \ln\left(N_{\mathrm{Cl}}\right). \quad (3.16)$$

$$\delta k_n = \left(\partial k_n / \partial h\right)\delta h + \left(\partial k_n / \partial \ln\left(N_{\mathrm{Cl}}\right)\right)\delta \ln\left(N_{\mathrm{Cl}}\right) = \left[(0.360h - 0.849) \times \ln\left(N_{\mathrm{Cl}}\right) + (-2.880h + 6.403)\right]\delta h + \\ + \left(0.180h^2 - 0.849h + 0.750\right)\delta \ln\left(N_{\mathrm{Cl}}\right). \quad (3.17)$$

# Tabulating special functions for each used CR station and each component

$$\Delta D(R,t)/D_o(R) = b(t)R^{-\gamma(t)}$$

$$F_i(R_c,\gamma) = a_i k_i \left(1-\exp\left(-a_i R_c^{-k_i}\right)\right)^{-1} \int_{R_c}^{\infty} R^{-(k_i+1+\gamma)} \exp\left(-a_i R^{-k_i}\right) dR$$

$$\int_{R_c}^{\infty} R^{-(k_i+1+\gamma)} \exp\left(-a_i R^{-k_i}\right) dR = \frac{a_i^{-\gamma/k_i}}{a_i k_i} \cdot \int_0^{a_i R_c^{-k_i}} y^{\gamma/k_i} \exp(-y) dy = \frac{a_i^{-\gamma/k_i}}{a_i k_i} \cdot \gamma\left(\frac{\gamma}{k_i+1}; a_i R_c^{-k_i}\right),$$

$$F_i(R_c,\gamma) = a_i^{-\gamma/k_i} \gamma\left(\frac{\gamma}{k_i+1}; a_i R_c^{-k_i}\right)\left(1-\exp\left(-a_i R_c^{-k_i}\right)\right)^{-1}$$

# Determination of exponent $\gamma(t)$

$$\delta N_k(R_{c1},t)/\delta N_l(R_{c2},t) = \Psi_{kl}(R_{c1},R_{c2},\gamma)$$

$$\begin{aligned}\Psi_{kl}(R_{c1},R_{c2},\gamma) &= F_k(R_{c1},\gamma)/F_l(R_{c2},\gamma)\\ &= a_k^{-\gamma/k_k}\gamma\left(\frac{\gamma}{k_k+1};a_k R_{c1}^{-k_k}\right)\left(1-\exp\left(-a_k R_{c1}^{-k_k}\right)\right)^{-1} \Big/ a_l^{-\gamma/k_l}\gamma\left(\frac{\gamma}{k_l+1};a_l R_{c2}^{-k_l}\right)\left(1-\exp\left(-a_l R_{c2}^{-k_l}\right)\right)^{-1}.\end{aligned}$$

$$\gamma(t) = \Omega_{kl}\left(\delta N_k(R_{c1},t)/\delta N_l(R_{c2},t)\right)$$

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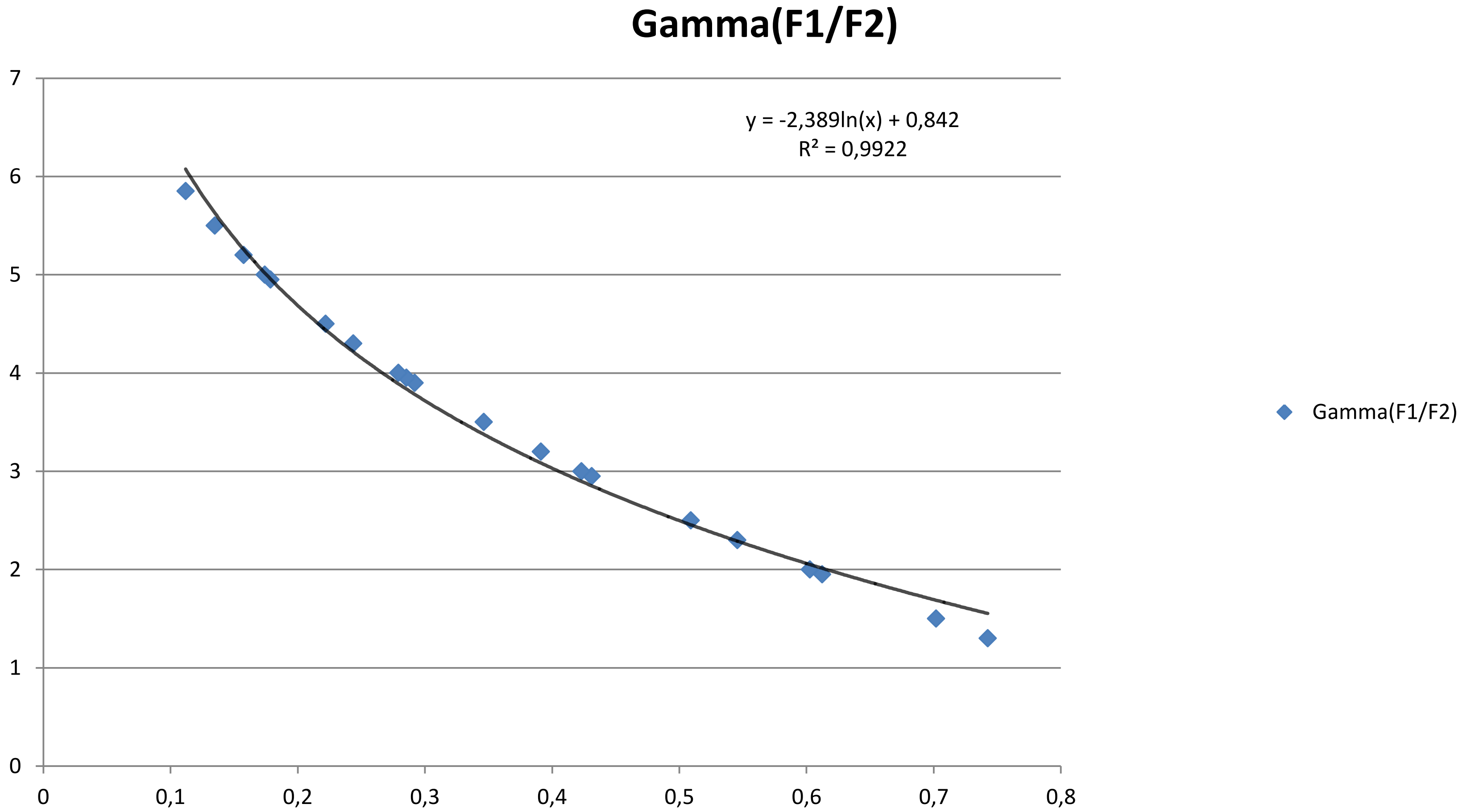


$$\delta N_k(R_{c1};t)/\delta N_l(R_{c2};t)=\Psi_{kl}(R_{c1};R_{c2};\gamma)$$

$$\Psi_{kl}(R_{c1},R_{c2},\gamma)=F_k(R_{c1},\gamma)/F_l(R_{c2},\gamma)$$
$$=a_k^{-\gamma/k_k}\gamma\left(\frac{\gamma}{k_k+1};a_kR_{c1}^{-k_k}\right)\left(1-\exp\left(-a_kR_{c1}^{-k_k}\right)\right)^{-1}\Big/a_l^{-\gamma/k_l}\gamma\left(\frac{\gamma}{k_l+1};a_lR_{c2}^{-k_l}\right)\left(1-\exp\left(-a_lR_{c2}^{-k_l}\right)\right)^{-1}.$$

$$\gamma(t)=\Omega_{kl}\left(\delta N_k(R_{c1},t)/\delta N_l(R_{c2},t)\right)$$

$$b(t)=\delta N_m(R_{c1},t)/F_m(R_{c1},\gamma(t))=\delta N_n(R_{c2},t)/F_n(R_{c2},\gamma(t))$$

$$Q(R,r,t)=N_o(R)\delta(r)\delta(t)$$

$$N(R,r,t)=N_o(R)\times\left[2\pi^{1/2}(\kappa(R)t)^{3/2}\right]^{-1}\times\exp\left(-\frac{r^2}{4\kappa(R)t}\right)$$

$$t_1 = T_1 - T_e = x, \quad t_2 = T_2 - T_e = T_2 - T_1 + x, \quad t_3 = T_3 - T_e = T_3 - T_1 + x$$

$$\frac{T_2 - T_1}{x(T_2 - T_1 + x)} = -\frac{4\kappa(R)}{r_1^2} \times \ln\left\{ \frac{N_1(R)}{N_2(R)} \left( x/(T_2 - T_1 + x) \right)^{3/2} \right\}$$

$$\frac{T_3 - T_1}{x(T_3 - T_1 + x)} = -\frac{4\kappa(R)}{r_1^2} \times \ln\left\{ \frac{N_1(R)}{N_3(R)} \left( x/(T_3 - T_1 + x) \right)^{3/2} \right\}$$

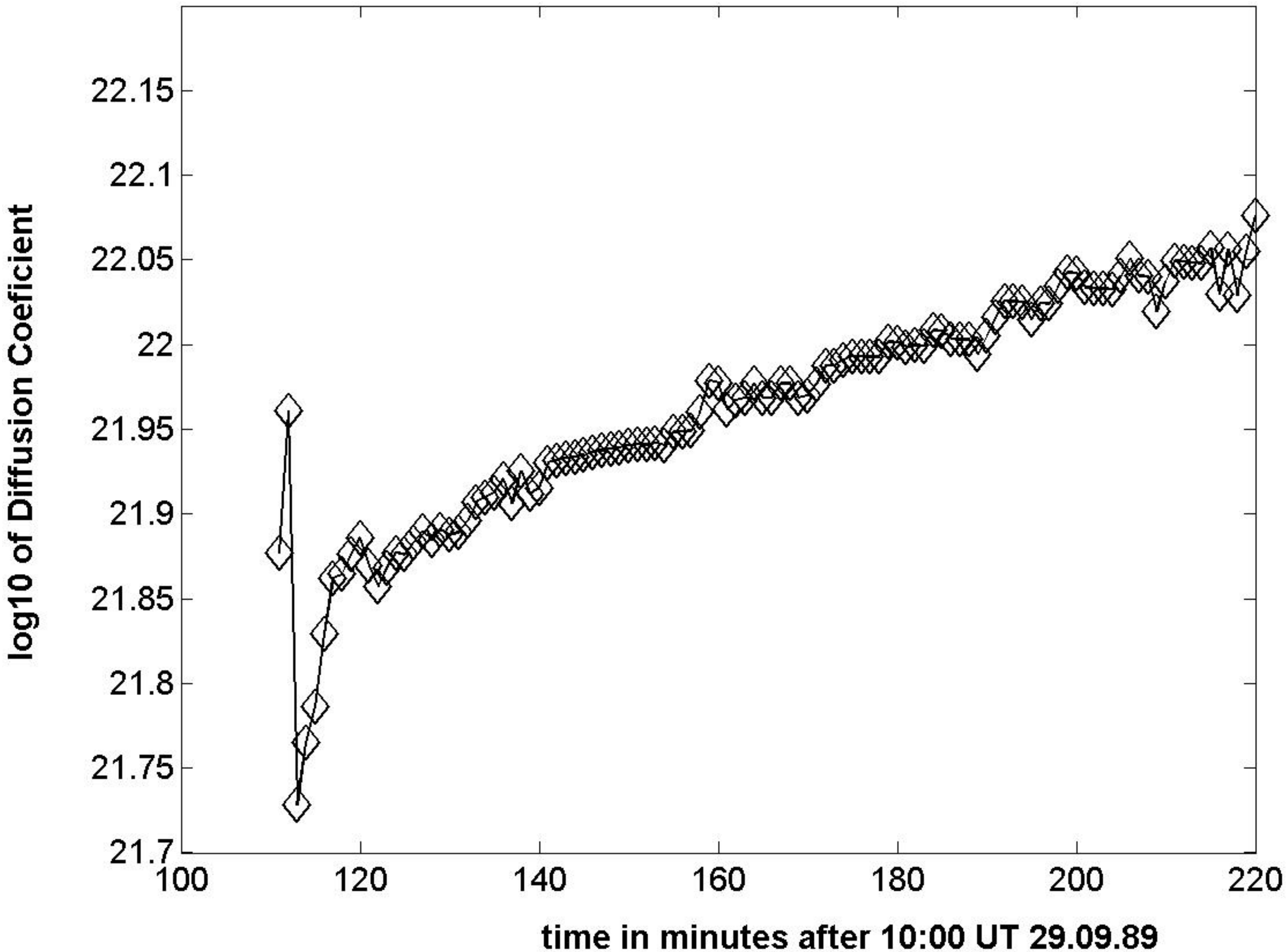
$$x = \left[ (T_2 - T_1)\Psi(x) - (T_3 - T_1) \right] / \left( 1 - \Psi(x) \right)$$

$$\Psi(x) = \left[ (T_3 - T_1)/(T_2 - T_1) \right] \times \frac{\ln\left[ N_1(R)\left( x/(T_2 - T_1 + x) \right)^{3/2} / N_2(R) \right]}{\ln\left[ N_1(R)\left( x/(T_3 - T_1 + x) \right)^{3/2} / N_3(R) \right]}$$

$$K(R) = -\frac{r_1^2 (T_2 - T_1) / 4x(T_2 - T_1 + x)}{\ln\left\{\frac{b(T_1)}{b(T_2)} \left(x/(T_2 - T_1 + x)\right)^{3/2} R^{\gamma(T_2) - \gamma(T_1)}\right\}} = -\frac{r_1^2 (T_3 - T_1) / 4x(T_3 - T_1 + x)}{\ln\left\{\frac{b(T_1)}{b(T_3)} \left(x/(T_3 - T_1 + x)\right)^{3/2} R^{\gamma(T_3) - \gamma(T_1)}\right\}}$$

$$N_o(R) = 2\pi^{1/2} b(t_1) R^{-\gamma(t_1)} D_o(R) \times \left(K(R)t_1\right)^{3/2} \exp\left(r_1^2 / (4K(R)t_1)\right) = 2\pi^{1/2} b(t_2) R^{-\gamma(t_2)} D_o(R) \times$$
$$\times \left(K(R)t_2\right)^{3/2} \exp\left(r_1^2 / (4K(R)t_2)\right) = 2\pi^{1/2} b(t_3) R^{-\gamma(t_3)} D_o(R) \times \left(K(R)t_3\right)^{3/2} \exp\left(r_1^2 / (4K(R)t_3)\right)$$

$$n(R, r, T) = N_o(R) \times \left[2\pi^{1/2} \left(K(R)(T - T_e)\right)^{3/2}\right]^{-1} \times \exp\left(-\frac{r^2}{4K(R)(T - T_e)}\right)$$




The behavior of $K(R)$ for R ~ 10 GV with time

$$K(R,r)=K_1(R)\times(r/r_1)^{\beta} \qquad n_1, n_2, n_3 \qquad t_1, t_2, t_3$$

$$n(R,r,t)=\frac{N_o(R)\times r_1^{3\beta/(2-\beta)}(K_1(R)t)^{-3/(2-\beta)}}{(2-\beta)^{(4+\beta)/(2-\beta)}\Gamma(3/(2-\beta))}\times\exp\left(-\frac{r_1^{\beta}r^{2-\beta}}{(2-\beta)^2K_1(R)t}\right)$$

$$\beta=2-3\left[(\ln(t_2/t_1))-\frac{t_3(t_2-t_1)}{t_2(t_3-t_1)}\ln(t_3/t_1)\right]\times\left[(\ln(n_1/n_2))-\frac{t_3(t_2-t_1)}{t_2(t_3-t_1)}\ln(n_1/n_3)\right]^{-1}$$

$$K_1(R)=\frac{r_1^2\left(t_1^{-1}-t_2^{-1}\right)}{3(2-\beta)\ln(t_2/t_1)-(2-\beta)^2\ln(n_1/n_2)}=\frac{r_1^2\left(t_1^{-1}-t_3^{-1}\right)}{3(2-\beta)\ln(t_3/t_1)-(2-\beta)^2\ln(n_1/n_3)}$$

$$N_o(R)=n_1(2-\beta)^{(4+\beta)/(2-\beta)}\Gamma(3/(2-\beta))r_1^{-3\beta/(2-\beta)}(K_1(R)t_k)^{3/(2-\beta)}\times\exp\left(\frac{r_1^2}{(2-\beta)^2K_1(R)t_k}\right)$$

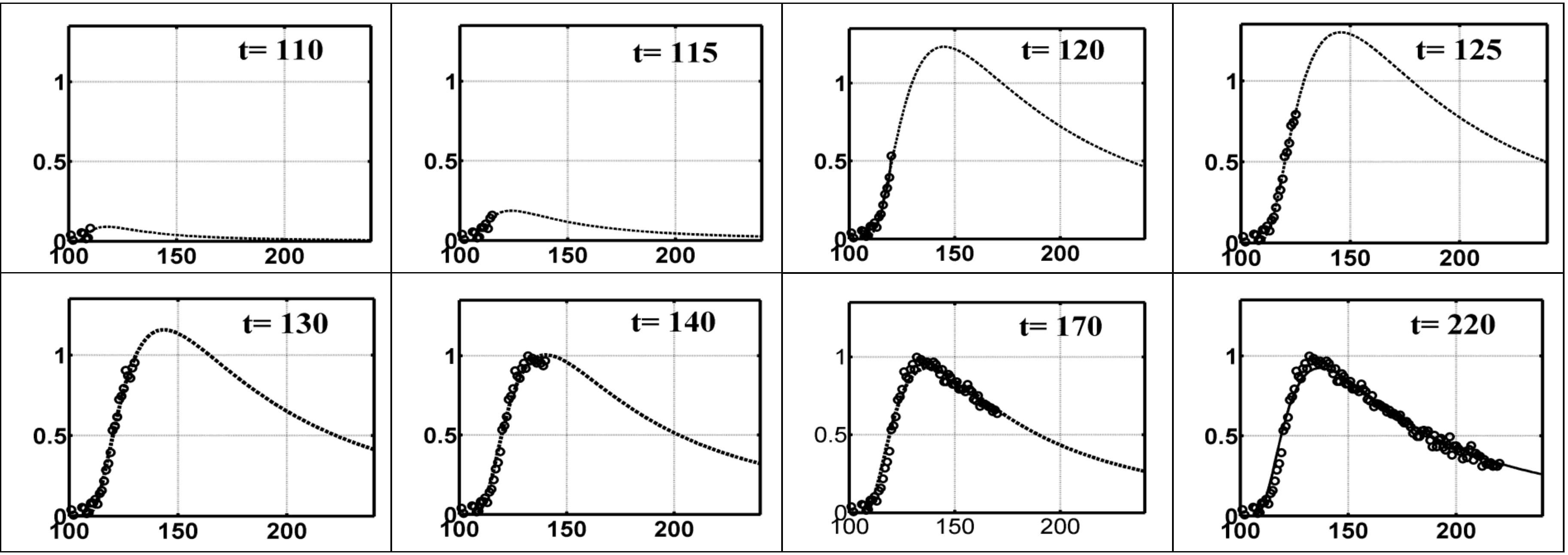



**Fig. 2** . Calculation on line parameters $\beta$ , $K_1(R)$ , $N_o(R)$ and forecasting of total neutron intensity (time $t$ is in minutes after 10.00 UT of September 29, 1989; curves – forecasting, circles – observed total neutron intensity) .

## COMBINED FORECASING ON THE BASIS OF NM DATA AND BEGINNING OF SATELLITE DATA

$$N_o(R,T) = N_o(R)\delta(T - T_e) \times R^{-(\gamma_o + a\ln(E_k/E_{k\max}))}$$

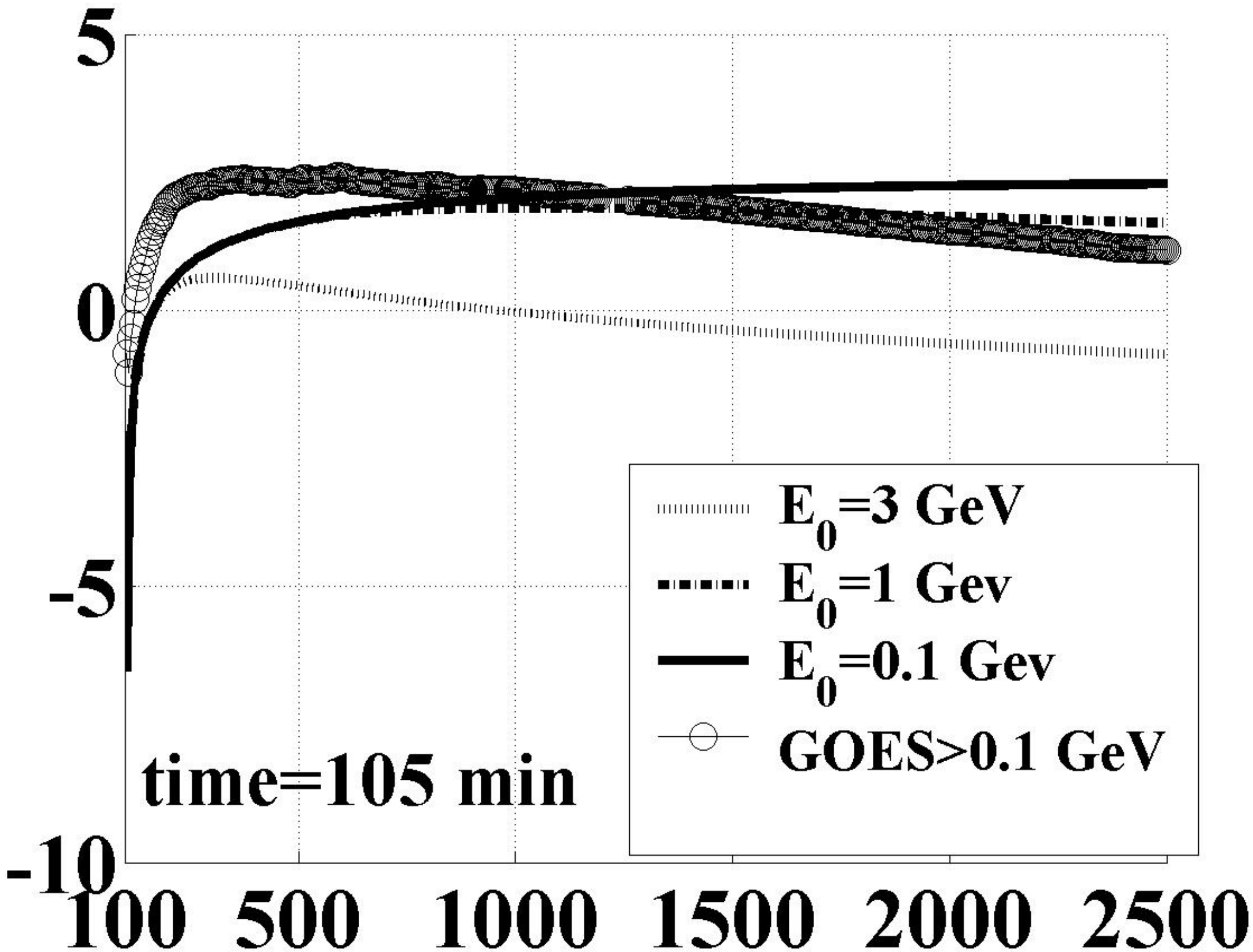
$$K(R,r) = K_1(R) \times (r/r_1)^{\beta}$$

$$K_1(R) = K_1 \times (v/c) \times (R/R_1)^{\delta}$$

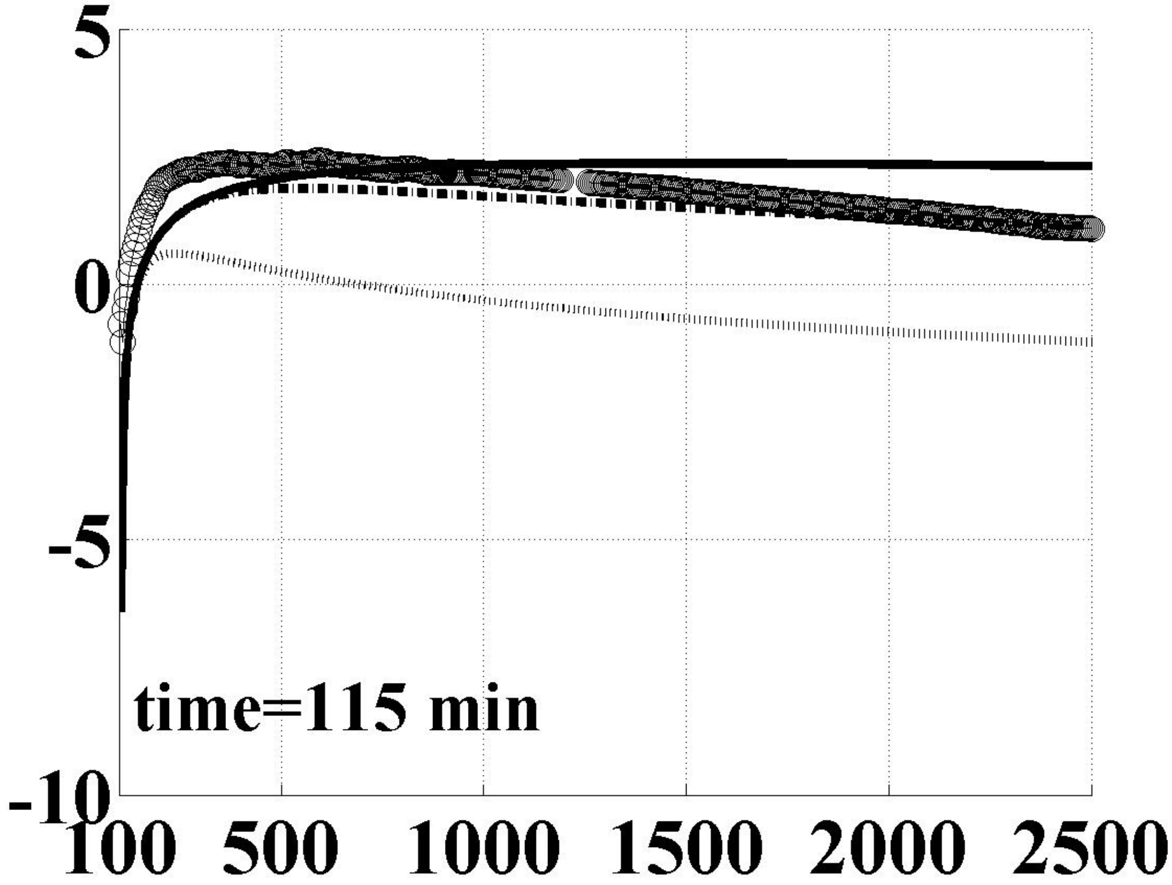
$$n(R,r,T) = \frac{N_o(R) \times r_1^{3\beta/(2-\beta)}((T - T_e)K_1(R))^{-3/(2-\beta)}}{(2-\beta)^{(4+\beta)/(2-\beta)}\Gamma(3/(2-\beta))} \times \exp\left(-\frac{r_1^{\beta} r^{2-\beta}}{(2-\beta)^2 (T - T_e)K_1(R)}\right)$$

$$F_s(R_c(T)) = \int_{T_e}^{\infty} dT \int_{R_c(T)}^{\infty} N_o(R) \times \frac{r_1^{3\beta/(2-\beta)}((T-T_e)K_1(R))^{-3/(2-\beta)}}{(2-\beta)^{(4+\beta)/(2-\beta)}\Gamma(3/(2-\beta))} \times \exp\left(-\frac{(2-\beta)^{-2} r_1^2}{(T-T_e)K_1(R)}\right) dR\, dR$$

# 5. COMBINED FORECASTING ON THE BASIS OF NM DATA AND BEGINNING OF SATELLITE DATA



# 5. COMBINED FORECASTING ON THE BASIS OF NM DATA AND BEGINNING OF SATELLITE DATA



# Forecasting of expected radiation hazards for space-crafts in the interplanetary space

$$F_1(r) = \int_0^\infty dt \int_{R_{\min}}^\infty N_o(R) \times \left[2\pi^{1/2}\left(\kappa(R)t\right)^{3/2}\right]^{-1} \times \exp\left(-\frac{r^2}{4\kappa(R)t}\right) dR$$

$$F_2(r) = \int_0^\infty dt \int_{R_{\min}}^\infty \frac{N_o(R) \times r^{3\beta/(2-\beta)}\left(\kappa_1(R)t\right)^{-3/(2-\beta)}}{(2-\beta)^{(4+\beta)/(2-\beta)}\Gamma\left(3/(2-\beta)\right)} \times \exp\left(-\frac{r^2(2-\beta)^{-2}}{\kappa_1(R)t}\right) dR$$

# Forecasting of expected radiation hazards for space-crafts in the Geomagnetosphere

$$F_1(r_1) = \int_0^\infty dt \int_{R_{\min}(t)}^\infty N_o(R) \times \left[2\pi^{1/2}\left(\kappa(R)t\right)^{3/2}\right]^{-1} \times \exp\left(-\frac{r_1{}^2}{4\kappa(R)t}\right) dR$$

$$F_2(r_1) = \int_0^\infty dt \int_{R_{\min}(t)}^\infty N_o(R) \times \frac{r_1^{3\beta/(2-\beta)}\left(\kappa_1(R)t\right)^{-3/(2-\beta)}}{(2-\beta)^{(4+\beta)/(2-\beta)}\Gamma\left(3/(2-\beta)\right)} \times \exp\left(-\frac{r_1^2(2-\beta)^{-2}}{\kappa_1(R)t}\right) dR$$

# Forecasting of expected radiation hazards for air-crafts and long-lived balloons in stratosphere and troposphere

$R_{\min} = \max\,(R_c\,,\,R_s\,).$

$$F_1(h,r_1)=\int_0^{\infty}dt\int_{R_{\min}(t)}^{\infty}m(R,h)N_o(R)\times\left[2\pi^{1/2}\left(\kappa(R)\,t\right)^{3/2}\right]^{-1}\times\exp\left(-\frac{r_1^{\;2}}{4\kappa(R)\,t}\right)dR$$

$$F_2(h,r_1)=\int_0^{\infty}dt\int_{R_{\min}(t)}^{\infty}m(R,h)N_o(R)\times\frac{r_1^{3\beta/(2-\beta)}\left(\kappa_1(R)t\right)^{-3/(2-\beta)}}{(2-\beta)^{(4+\beta)/(2-\beta)}\Gamma\left(3/(2-\beta)\right)}\times\exp\left(-\frac{r_1^{2}(2-\beta)^{-2}}{\kappa_1(R)\,t}\right)dR$$

# The inverse problem for SEP propagation and generation in the frame of anisotropic diffusion and in kinetic approach

- It is well known that energy spectrum of solar energetic particles (SEP), observed by ground based neutron monitors and muon telescopes (in high energy region; the transfer to the space from the ground observations is made by the method of coupling functions, see in Chapter 3 of Dorman, 2004), and by detectors on satellites and space-probes (in small energy region) changed with time very much (usually from very hard at the beginning of event to very soft at the end of event). The observed spectrum of SEP and its change with time are determined by three main parameters: energy spectrum in source, time of ejection, and propagation mode. In the past we considered the first step for forecasting of radiation hazard: the simple isotropic mode of SEP propagation in the interplanetary space (see Chapter 2 in Dorman, 2006). It was shown that on the basis of observation data at several moments of time could be solved the inverse problem and determined energy spectrum in source, time of ejection, and diffusion coefficient in dependence of energy and distance from the Sun. Here we consider the inverse problem for the complicated case: mode of anisotropic diffusion and kinetic approach. We show that in this case also the inverse problem can be solved, but it needs NM data at least at several locations on the Earth. We show that in this case the solution of inverse problem starts to work well sufficiently earlier than solution for isotropic diffusion, but after 20-25 minutes both solutions give about the same results. It is important that obtained results and reality of used model can be controlled by independent data on SEP energy spectrum in other moments of time (does not used at solving of inverse problem). On the basis of obtained results can be estimate the total release energy in the SEP event and radiation environment in the inner Heliosphere, in the magnetosphere, and atmosphere of the Earth during SEP event.

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# THE STEPS OF FORECASTING 1-3

- For realization of the **first step** of forecasting we need one minute real-time data from about all NM of the world network. On the each NM must work automatically the program for the search of the start SEP events as it was described in Sections 1-3. This search will help to determine which NM from about 50 of total number operated in the world network show the narrow peak of the anisotropic stream of the first arrived solar CR (NM of the 1-st type) and which show a diffusive tail with a wide maximum at a later time (NM of the 2-nd type). In the **second step** we determine rigidity spectrum of arrived solar CR by using separately NM of the 1-st type and 2-nd type by using method of coupling functions as it was described above in Section 4 (in more detail see Chapter 3 in Dorman, 2004). In the **third step** we need to determine for different NM the mean Rc, $\lambda$ and $\Delta\lambda$ characterized for this event.

# THE STEPS OF FORECASTING 4-6

- By using these parameters and experimental data on NM time profiles in the beginning time we cane determine parameters of solar CR non-scattering and diffusive propagation, described in Section 12 (the **fourth step**). On the basis of determined parameters of solar CR non-scattering and diffusive propagation we then determine expected CR fluxes and pitch-angle distribution for total event in interplanetary space in dependence of time after ejection (the **fifth step**). In the **sixth step** by using again method of coupling functions we can determine expected radiation doze which will be obtain during this event inside space probes in interplanetary space, satellites in the magnetosphere, aircrafts at different altitudes and cutoff rigidities, for people and technologies on the ground.

# SEP AUTOMATICALLY FORECASTING: CONCLUSION

**BY ONE-MINUTE NEUTRON MONITOR DATA AND ONE-MINUTE AVAILABLE FROM INTERNET COSMIC RAY SATELLITE DATA FOR 20-30 MIN DATA IT IS POSSIBLE AUTOMATICALLY TO DETERMINE PRIMARY CR VARIATIONS, AND THEN THE TIME OF EJECTION, SOURCE FUNCTION, AND DIFFUSION COEFFICIENT IN DEPENDENCE FROM ENERGY AND DISTANCE FROM THE SUN.**

**THEN IT IS POSSIBLE AUTOMATICALLY TO FORECAST OF SEP FLUXES AND FLUENCY IN HIGH AND LOW ENERGY RANGES UP TO ABOUT TWO DAYS FOR DIFFERENT OBJECTS IN INTERPLANETARY SPACE, IN GEOMAGNETOSPHERE, AND IN THE ATMOSPHERE.**