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**User's Guide for Program  
FUNC**

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## I. COMMON NOTATIONS

The program is used for calculation of functions on earthquake flow. Initial data for calculation of functions - catalogs of earthquakes. The program works in an interactive mode. The necessary input data are requested by using window interface. The values of parameters for calculation of functions are written in a special binary format file - **PROFILE**. The calculated values of functions are written in the same file. The extension of the name of this file should be **.PAT**. The program may create a file on a disk with results of dialog for printout. The name of this ASCII format text file is **PRO.PRI**. The ASCII format text file with the name **FUN.PRI**, which contains the values of the functions for printout, may also be created.

### *To users.*

The program is modified from time to time according to the experience of its applications. Any suggestions or information on results obtained will be kindly appreciated. Please send both to Dr.A.A.Soloviev,  
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### 1.1 Catalogs

The program operates on catalogs of main shocks stored as non-text files (standard "**20 bytes binary format**"). These catalogs have to be prepared by using program **AFT** or selected from such catalog by using program **CATAL**. Records in a catalog should be ordered in increasing time.

The records in a file with a catalog are specified as follows.

The first 4 bytes of the first record contain an integer, which is the total number of records in the file (the number of earthquakes plus 1).

For all other records:

Positions in a record	Contents	Type
1-4	time of the earthquake in minutes A.D.	integer *4
5-6	latitude, degrees multiplied by 100	integer *2
7-8	longitude, degrees multiplied by 100	integer *2
9-10	depth, km	integer *2
11-12	magnitude <i>mb</i> multiplied by 100	integer *2
13-14	magnitude <i>ms</i> multiplied by 100	integer *2
15-16	magnitude <i>ml</i> multiplied by 100	integer *2
17-18	magnitude <i>mp</i> multiplied by 100	integer *2
19-20	macroseismic intensity (not used usually in these programs)	integer *2

## 1.2 Functions

Values of functions may be calculated for objects (moments of time) in one or several regions.

Before calculation of the functions three magnitude thresholds  $m_1 \leq m_2 \leq m_3$  have to be calculated or specified. The low threshold  $M_0$  for magnitudes of strong shocks has also to be specified. In the function definitions listed below there are parameters  $\underline{M}$  (magnitude) and  $s$  (time). The values of these parameters have to be specified for functions separately. Parameter  $\underline{M}$  may take values  $m_1, m_2$  or  $m_3$ . Parameter  $s$  is an integer number of years. In the function definitions  $t$  means the time of the object.

The program calculates the following functions:

1. N1 - the number of main shocks with magnitude  $M \geq \underline{M}$  calculated for the time period from  $t - s$  to  $t$ .
2. N2 - the same as N1 but with other values of  $\underline{M}$  and  $s$ .
3. K - the difference  $K_1 - K_2$  between the numbers  $K_1$  and  $K_2$  of main shocks with magnitude  $M \geq \underline{M}$ . Here  $K_1$  is calculated for the time period from  $t - s$  to  $t$  and  $K_2$  - for the time period from  $t - 2s$  to  $t - s$ .
4. G - the difference  $1 - L_2/L_1$ . Here  $L_1$  is the number of main shocks with magnitude  $M \geq \underline{M}$  calculated for the time period from  $t - s$  to  $t$  and  $L_2$  is the number of main shocks with magnitude  $M \geq \underline{M}$  calculated for the same time period. Value of parameter  $\underline{M}'$  is defined by the following way: if  $\underline{M} = m_1$  or  $\underline{M} = m_2$  then  $\underline{M}' = m_1$ ; if  $\underline{M} = m_3$  then  $\underline{M}' = m_2$ .
5. SIGMA - the sum  $\sum C10^{D(M_i-F)}$  for main shocks with magnitudes  $\underline{M} \leq M_i \leq \overline{M}$  and the origin time from  $t - s$  to  $t$ .
6. Smax -  $\max_j S_j/K_j$ . Here  $S_j$  is the sum  $\sum C10^{D(M_i-F)}$  for main shocks with magnitudes  $\underline{M} \leq M_i \leq \overline{M}$  and the origin time from  $t - j$  years to  $t - (j-1)$  years;  $K_j$  is the number of such main shocks;  $j = 1, 2, \dots, s$ .
7. S1max -  $\max_j S_j/K_j^2$ . Here  $S_j$  and  $K_j$  have the same sense as in the definition of the function Smax;  $j = 1, 2, \dots, s$ . Values of coefficients  $C, D$  and  $F$  and magnitude threshold  $\overline{M}$  are the same for functions Smax and S1max.
8. Zmax -  $\max_j S_j/K_j^{2/3}$ . Here  $S_j$  and  $K_j$  have the same sense as in the definition of function Smax;  $j = 1, 2, \dots, s$ . Values of coefficients  $C, D$  and  $F$  and magnitude threshold  $\overline{M}$  may differ from their values for functions Smax and S1max.
9. N3 - the number of main shocks with magnitude  $M \geq \underline{M}$  calculated for the time period from  $t - 3s - 1$  year to  $t - 2s - 1$  year.
10. L - the difference between  $L_1$  and ratio  $\frac{L_2(t - T_0)}{t - T_0 - s}$  rounded to the nearest integer. Here  $T_0$  is the time of the beginning of the catalog;  $L_1$  is the number of main shocks with magnitude  $M \geq \underline{M}$  calculated for the time period from  $T_0$  to  $t$ ;  $L_2$  is the same number calculated for the time period from  $T_0$  to  $t - s$ .

11.  $q$  - the sum  $\sum_{j=1}^s \max\{0, \text{ENTIRE}(A-K_j)\}$ . Here  $A = sa_{\underline{M}}$ , where  $a_{\underline{M}}$  is the average annual number of main shocks with magnitude  $M \geq \underline{M}$  in the catalog;  $K_j$  is the number of main shocks with magnitude  $M \geq \underline{M}$  calculated for the time period from  $t - s' - s - j$  years to  $t - s' - j$  years, where  $s' = \text{ENTIRE}((s-1)/2)$ .
12.  $M_l$  - the maximal magnitude multiplied by 100 of the long-range aftershocks in the region under consideration within the time period from  $t - s$  to  $t$ . Long-range aftershock is a main shock with magnitude  $M \geq \underline{M}$ , which follows a strong (with magnitude  $M \geq M_1$ ) main shock in the region or in its neighbourhood within 1 year.
13.  $B_{\max}$  - the maximal number of aftershocks of main shocks with the origin time from  $t - s$  to  $t$ . The number of aftershocks has to be in 13-14 positions of records of the catalog.
14.  $Q$  - the sum  $\sum_{j=2}^{j^*} |K_j - K_{j-1}|$ . Here  $K_j$  is the number of main shocks with magnitude  $M \geq \underline{M}$  calculated for the time period from  $t - js$  to  $t - (j - 1)s$ ;  $j^*$  is the first number  $j$ , for which  $K_j > K_{j-1}$  and  $K_j > K_{j+1}$  (if there are no such  $j$  for  $j = 2, 3, \dots, \text{ENTIRE}(15/s)$  then  $j = \text{ENTIRE}(15/s)$ ).
15.  $V$  - the sum  $\sum_{j=2}^{s+1} |K_j - K_{j-1}|$ . Here  $K_j$  is the number of main shocks with magnitude  $M \geq \underline{M}$  calculated for the time period from  $t - j$  years to  $t - (j - 1)$  years.
16.  $NF_1$  - the number of main shocks with magnitude  $M \geq M_0 - \delta$ , which occurred during the time period from  $t - s$  to  $t$  in all regions, which are indicated as the regions on the same fault for the region under consideration. Here  $M_0$  is a low magnitude threshold for strong earthquakes.
17.  $NF_2$  - the same as  $NF_1$  but with other values of  $\delta$  and  $s$ .
18.  $NR_1$  - the number of main shocks with magnitude  $M \geq M_0 - \delta$ , which occurred during the time period from  $t - s$  to  $t$  in all regions, which are indicated as the regions in the whole area for the region under consideration. Here  $M_0$  is a low magnitude threshold for strong earthquakes.
19.  $NR_2$  - the same as  $NR_1$  but with other values of  $\delta$  and  $s$ .
20.  $Taq$  -  $\min_k T_k$ . Here  $T_k$  is the integer number of years, which passed before  $t$  after the end of the last time period with duration  $s$ , during which the numbers of main shocks with magnitude  $M \geq \underline{M}$  in the region under consideration and in the  $k$ -th region from its neighbourhood differ essentially. The time periods from  $t - s - j$  years to  $t - j$  years ( $j = 0, 1, \dots, 15-s$ ) are considered. Numbers of main shocks differ essentially if one of them belongs to 1/3 quantile (number is small) and another belongs to 2/3 quantile (number is large). Quantiles are calculated for the regions by using whole catalogs. If numbers differ non essentially for all considered intervals then by definition  $T_k = 17 - s$ .
21.  $SIGTH$  - the sum  $\sum C 10^{D(M_i - F)}$  for main shocks with magnitudes  $M_i \geq \underline{M}$  and the origin time from  $t - s$  to  $t$ . Values of parameters  $\underline{M}$  and  $s$  and coefficients  $C$ ,  $D$  and  $F$  are the same for functions  $SIGMA$  and  $SIGTH$ .

### 1.3 Set of functions for CN algorithm

If CN algorithm (Keilis-Borok and Rotwain, 1990) is applied the following set of functions is used:

- N2 with  $s = 3$  and  $\underline{M} = m_3$ ;
- K with  $s = 2$  and  $\underline{M} = m_2$ ;
- G with  $s = 3$  and  $\underline{M} = m_2$ ;
- SIGMA with  $s = 3$ ,  $\underline{M} = m_1$ ,  $C = 1$ ,  $D = 1$ ,  $F = 4.5$ , and  $\overline{M} = M_0 - 0.1$ ;
- Smax with  $s = 3$ ,  $\underline{M} = m_1$ ,  $C = 1$ ,  $D = 1$ ,  $F = 4.5$ , and  $\overline{M} = M_0 - 0.1$ ;
- Zmax with  $s = 3$ ,  $\underline{M} = m_1$ ,  $C = 1$ ,  $D = 0.5$ ,  $F = 4.5$ , and  $\overline{M} = M_0 - 0.1$ ;
- N3 with  $s = 3$  and  $\underline{M} = m_2$ ;
- q with  $s = 6$  and  $\underline{M} = m_2$ ;
- Bmax with  $s = 3$ ;
- SIGTH with  $s = 3$ ,  $\underline{M} = m_1$ ,  $C = 1$ ,  $D = 1$  and,  $F = 4.5$ ;

This set of functions with the indicated values of parameters is called "**Standard CN**".

## II. DIALOG IN PROGRAM FUNC

To input data the program uses the interface organized as a set of menus with accessible windows.

### 2.1 First menu

*The first* menu contains the window where the name of the input **PROFILE** has to be indicated. The name has to have the extension **.PAT**. Blank means that input **PROFILE** will not be used.

By pressing **F10** it is possible to stop the program.

### 2.2 Second menu

*The second* menu contains the following windows.

#	Window Name	Function and Comments
1	List of regions	To specify <i>the indexes of regions</i> , for which values of functions will be calculated. These indexes may be from 1 to 25. The total number of regions has to be less than 26.
2	Region catalogs from	To specify <i>the common name of files with subcatalogs</i> , which contain main shocks of regions. The name of the file for the specific region will be formed by inserting the index of the region in the common name before extension. The name has to have extension <b>.DAT</b> . Function key <b>F9</b> may be used to search the file in the current directory.
3	Time from	To specify <i>the beginning (year, month, day, hour and minute) of the catalogs</i> .
4	Time to	To specify <i>the end (year, month, day, hour and minute) of the catalogs</i> .

5	Skipping to	To specify <i>the beginning (year, month, day and hour) of the time interval for moments, for which the values of the functions may be calculated.</i>
6	Learning to	To specify <i>the end (year, month, day and hour) of time interval, which is used for determination of magnitude thresholds <math>m_1</math>, <math>m_2</math> and <math>m_3</math>.</i>
7	M0	To specify <i>a value of the low threshold <math>M_0</math> for magnitudes of strong shocks.</i>
8	<Definition of dates>	To specify <i>the dates of objects.</i> <b>By list</b> - A list of dates will be specified. <b>By step</b> - Dates will be with a constant step. The window can be opened by pressing <b>F2</b> to get into <i>the third menu</i> to specify the list of dates or the first and the last dates and the step.
9	<Functions>	To specify <i>the list of functions</i> , which will be calculated and values of their parameters. <b>Standard CN</b> - Standard CN set of function will be calculated. <b>Not standard</b> - The window can be opened by pressing <b>F2</b> to get into <i>the fourth menu</i> to specify the the list of functions and values of their parameters.
10	<Thresholds>	To specify <i>values of magnitude thresholds <math>m_1</math>, <math>m_2</math>, and <math>m_3</math></i> <b>Magnitudes</b> - The window can be opened by pressing <b>F2</b> to specify the values of $m_1$ , $m_2$ , and $m_3$ for each region. <b>Nos of events</b> - The values of $m_1$ , $m_2$ , and $m_3$ will be calculated for each region to obtain the average annual number $a_1$ of main shocks with $M \geq m_1$ , the average annual number $a_2$ of main shocks with $M \geq m_2$ and the average annual number $a_3$ of main shocks with $M \geq m_3$ . Values of $a_1$ , $a_2$ and $a_3$ are the same for all regions and have to be specified. The segments of catalogs from " <b>Time from</b> " to " <b>Learning to</b> " are used for determination of $m_1$ , $m_2$ and $m_3$ .
11	Annual events	To specify <i>values of <math>a_1</math>, <math>a_2</math> and <math>a_3</math> (<math>a_1 \geq a_2 \geq a_3 &gt; 0</math>).</i> This window is used only if $m_1$ , $m_2$ , and $m_3$ are calculated to obtain $a_1$ , $a_2$ , and $a_3$ as average annual numbers of events (" <b>Nos of events</b> " is in window 10).
12	Type	To set <i>will values of functions be typed or not.</i> <b>ON</b> - Values of functions will be typed. <b>OFF</b> - Values of functions will not be typed.
13	Line to type	To specify <i>the value of <math>k</math>.</i> Values of functions will be typed for objects with sequential numbers $ki + 1$ ( $i = 0, 1, \dots$ ). This window is used only if values of functions will be typed. (" <b>ON</b> " is in window 12).
14	Print	To set <i>will printout be created or not.</i> <b>ON</b> - Files <b>PRO.PRI</b> with the results of dialog and <b>FUN.PRI</b> with values of functions will be created for printout. <b>OFF</b> - File <b>FUN.PRI</b> will not be created.

15	Protocol	To set <i>will printout with the results of dialog be created or not</i> . <b>ON</b> - Files <b>PRO.PRI</b> with the results of dialog for printout will be created. <b>OFF</b> - File <b>PRO.PRI</b> will not be created. This window is used only if file <b>PAR.PRI</b> with values of functions for printout will not be created (" <b>OFF</b> " is in window 14).
16	Title for printout	To specify <i>a title of printout</i> (a string with not more than 30 symbols, which will be written in file <b>FUN.PRI</b> as a title). This window is used only if file <b>FUN.PRI</b> will be created (" <b>ON</b> " is in window 14).
17	Output profile	To specify <i>the name of the output PROFILE</i> , which will contain the results of the dialog and the values of the functions. The name has to have extension <b>.PAT</b> . <b>Blank</b> means that output <b>PROFILE</b> will not be created.
18	Control	To show <i>consistency of input data</i> already indicated. <b>OK</b> - data are consistent. If the cursor will be moved to this window then after pressing <b>ENTER</b> the values of thresholds $m_1$ , $m_2$ , and $m_3$ or numbers $n_1$ , $n_2$ , and $n_3$ will be calculated for each region. Here $n_1$ is the total number of main shocks with magnitude $M \geq m_1$ in the region during time period from " <b>Time from</b> " to " <b>Learning to</b> ", $n_2$ is the same for $M \geq m_2$ , $n_3$ - for $M \geq m_3$ . After calculation of $m_1$ , $m_2$ , and $m_3$ or $n_1$ , $n_2$ , and $n_3$ it is necessary to answer the question " <b>THRESHOLDS O.K.?</b> ". If the answer is " <b>Y</b> " the program begins to calculate the values of the functions. If the answer is " <b>N</b> " it returns to <i>the second menu</i> . <b>???</b> - data are not consistent. By pressing <b>ENTER</b> the cursor is moved to the window with inconsistent data.

By pressing **ESC** it is possible to return to *the first menu*.

By pressing **F10** it is possible to stop the program.

### 2.3 Third menu

If the dates of objects are specified "**by list**" *the third menu* contains the following windows.

#	Window Name	Function and Comments
1	<List>	To indicate <i>how the list of dates of objects will be formed</i> . <b>Current</b> - After entering into window 2 a current list of dates remains. <b>From strong shocks dates</b> - After entering into window 2 a new list of dates will be formed accordingly to the dates of strong shocks in the regions, for which values of functions are calculated.

2	Dates of objects	To input or to change <i>the dates of objects</i> . The maximal number of dates is 100. The first date has to be after the date "Skipping to" (see window 5 of <i>the second menu</i> ). <b>WARNING.</b> If "From strong shock dates" is in window 1 then after entering into window 2 the list of dates will be changed by the following way. The list will contain the dates of strong shocks of all regions, for which values of functions are calculated minus an hour, the dates of strong shocks minus a year and an hour and minus two years and an hour, which are not before the previous strong shock and all dates 1 h of January 1, which are not less than two years before the dates of strong shocks. All these dates will be selected for time interval from "Skipping to" to "Time to" (see windows 4 and 5 of <i>the second menu</i> ). If the total number of such dates is more than 100 it will be reduced to 100.
3	Mag.	To specify <i>the low threshold for magnitudes of strong shocks</i> , which will be used to form the list of dates. This window is used only if "From strong shock dates" is in window 1.

If the dates of objects are specified "by step" the *third menu* contains the following windows.

#	Window Name	Function and Comments
1	Dates from	To specify <i>the first date (year, month, day and hour)</i> .
2	Dates to	To specify <i>the upper boundary (year, month, day and hour) of dates</i> .
3	Step	To specify <i>the step (years, months and days) between dates</i> .

By pressing **ESC** it is possible to return to *the second menu*.

By pressing **F10** it is possible to stop the program.

The names of the objects are formed by the following way. The name consists of 5 symbols: the first two symbols are the number of the region, the next two symbols are the last two digits of the year of the object date and the last symbol ('1', '2', '3', '4', '5', '6', '7', '8', '9', 'o', 'n' or 'd') indicates the month of the object date.

## **2.4 Fourth menu**

The *fourth* menu contains the following windows.

#	Window Name	Function and Comments
1	Time Magnitude Delta	To specify <i>the functions, which will be calculated, and values of their parameters: s</i> (Time), <i>M</i> (Magnitude) and $\delta$ (Delta). Function SIGTH is always calculated with values of parameters of function SIGMA besides the case when all functions N1, N2, K, SIGMA, N3, L, q, MI, Bmax, Q, V, NF1, NF2, NR1, NR2, Taq are calculated.



2	for SIGMA and SIGTH	To specify <i>values of coefficients C, D, and F for functions SIGMA and SIGTH and a value of the threshold magnitude <math>\bar{M}</math> for function SIGMA.</i>
3	for Smax and S1max	To specify <i>values of coefficients C, D, and F and a value of the threshold magnitude <math>\bar{M}</math> for functions Smax and S1max.</i> This window is used only if functions Smax or/and S1max are calculated.
4	for Zmax	To specify <i>values of coefficients C, D, and F and a value of the threshold magnitude <math>\bar{M}</math> for function Zmax.</i> This window is used only if function Zmax is calculated.
5	Catalog of main shocks for Ml	To specify <i>the name of the file with the catalog, from which strong main shocks will be selected for calculation of function Ml.</i> This name has to have extension <b>.DAT</b> . This window is used only if function Ml is calculated. Function key <b>F9</b> can be used to search the file in the current directory.
6	M0 for Ml	To specify <i>a value of magnitude threshold <math>M_1</math> for calculation of function Ml.</i> This window is used only if function Ml is calculated.
7	List of regions	To specify <i>lists of regions for calculation of functions NF1, NF2, NR1, NR2 and Taq.</i> <b>on same fault</b> (for NF1 and NF2) - by pressing <b>F2</b> the window can be opened to input the lists of regions ( $\leq 10$ ) on the same fault with the regions, for which values of functions are calculated. <b>in whole area</b> (for NR1 and NR2) - by pressing <b>F2</b> the window can be opened to input the lists of regions ( $\leq 6$ ) in the whole area with the regions, for which values of functions are calculated. <b>in neighbourhood</b> (for Taq) - by pressing <b>F2</b> the window can be opened to input the lists of regions ( $\leq 10$ ) in the neighbourhoods of the regions, for which values of functions are calculated. Indexes of regions have to be from 1 to 25. The names of the files with the subcatalogs of main shocks for the regions are formed from the common name by the same way as in the case of regions, for which values of the functions are calculated (see window 2 of <i>the second menu</i> ). This window is not used if functions NR1, NR2, NF1, NF2 and Taq are not calculated.

By pressing **ESC** it is possible to return to *the second menu*.

By pressing **F10** it is possible to stop the program.

### REFERENCE

Keilis-Borok, V.I., and I.M., Rotwain, 1990. Diagnosis of Time of Increased Probability of strong earthquakes in different regions of the world: algorithm CN. *Phys. Earth Planet. Inter.*, **61**: 57-72.