Advanced School on Understanding and Prediction of Earthquakes and other Extreme Events in Complex Systems

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User's Guide for Program AFT

and FUNC

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I. COMMON NOTATIONS

Program **AFT** is intended to be used for

- identification of main shocks and aftershocks in a catalog;
- creation of a catalog of main shocks.

The program is written in Turbo Pascal and C for PC compatible computers.

Program **FUNC** is used for calculation of functions on earthquake flow. It is written inC for PC compatible computers.

Initial data for the both programs are catalogs of earthquakes. The programs work 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 file – **PROFILE**.

The programming skill is not required from users. Some experience with computers would be helpful.

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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Format of Catalogs

The programs operate on catalogs of earthquakes stored as non-text, binary files, (standard **20 bytes binary format** that is described below).

Each earthquake in the catalog is described by a vector (*T*, *LA*, *LO*, *DEP*, *mb*, *ms*, *ml*, *mp*) where *T* is the origin time; *LA* and *LO* are latitude and longitude of the epicenter in degrees and decimals (Western longitude and Southern latitude are negative); *DEP* is the focal depth in kilometers; *mb*, *ms*, *ml*, *mp* are four magnitudes (0 usually corresponds to unknown value of magnitude).

The records in a file with the 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	Notation
1-4	time of the earthquake in minutes A.D.	integer *4	*T*
5-6	latitude, degrees multiplied by 100	integer *2	*LA*
7-8	longitude, degrees multiplied by 100	integer *2	*LO*
9-10	depth, km	integer *2	*DEP*
11-12	magnitude *mb* multiplied by 100	integer *2	*mb*
13-14	magnitude *ms* multiplied by 100	integer *2	*ms*
15-16	magnitude *ml* multiplied by 100	integer *2	*ml*
17-18	magnitude *mp* multiplied by 100	integer *2	*mp*
19-20	macroseismic intensity (not used usually in these programs)	integer *2	

II. PROGRAM AFT

Input catalog should have standard **20 bytes binary format.** Records in the input catalog should be ordered by ascending time. Catalogs in this format could be prepared from data reported in other formats by using **CompiCat**(http://www.mitp.ru/soft/ecp/doc/mainindex.html).

2.1 Menu

The program has the user interface based on the window menus.

We call a menu a set of windows on a screen. Each window is a box with a header and with one or several values inside. A value may be numerical, logical or text variable. User can move around the menu and select any window he needs. The current window is highlighted. It can be entered to change values. Some windows can be opened to enter the next level menu. The headers of such windows are enclosed in brackets, e.g. <**Magnitude**>.

- To move cursor around the screen or inside the windows, use **arrows**, **Home**, **End**, **PgUp**, and **PgDn** keys.
- To enter current window, press **Enter**.
- To accept value(s) in the window and to leave the window, press **Enter**. If cursor remains in the window it means that selected value is of wrong type or out of range.
- If you do not need some parameter of the string type, replace it by ' ' (i.e. press **SpaceBar** in that window).
- To open the window and to enter the menu of the next level, use function key **F2**. To select files, use **F9**. To abort the program, use **F10**. The keys which can be currently used are shown in the bottom line of the screen.
- To accept all the values in current menu and leave it, returning to the previous level, press **Esc**. When it is possible, the hint '**Esc - Exit**' appears at the bottom of the screen.
- In some windows values can be toggled by pressing + or -. In this case, '+/-' will appear in the bottom line of the screen.

2.2 Files

The set of selected values of parameters can be stored in a separate file, called **PROFILE**.
The parameters are rather numerous, since the program is flexible and offers a wide variety of possibilities. At the same time, some computations may differ only in few parameters, while the rest remain the same.
PROFILE is created in order to avoid the repetition in choosing the values of the parameters. Default values of parameters will be suggested if you do not use any **PROFILE**. Several **PROFILEs** may exist under different names. However, the extension of a **PROFILE** should be **.AFT**.
As mentioned above the input of the program is a catalog of earthquakes in the standard **20 bytes** format. Output is a catalog of main shocks. It is stored on a disk in the same format. In the catalogs of main shocks created by the program **AFT** *mb* is magnitude, *ms* is the number of aftershocks divided by 100, *ml* = *mp* = 0. The names of the catalogs should have the extension **.DAT**. Optional printout file has the name **AFT**.**PRI**.

2.3 Definition of aftershocks

The program separates earthquakes into main shocks and aftershocks. Everywhere in these notes M is the magnitude of the main shock. An earthquake is identified as an aftershock of a preceding main shock if the following conditions are satisfied:

- its magnitude does not exceed M;
- the distance between their epicenters does not exceed $R(M)$;
- time difference does not exceed $T(M)$;
- modulus of difference in depth does not exceed $H(M)$.

Here $T(M)$, $R(M)$, and $H(M)$ are empirical functions.

If the conditions are satisfied for several preceding main shocks the earthquake is assigned to the latest among the strongest main shocks.

Details of this definition of aftershocks are given by *Keilis-Borok et al.* (1980).

For each main shock the following statistics are given in the printout:

- The number of aftershocks $b(e(i))$ during the time interval $e(i)$ after the main shock; here $e(1) < e(2) < ... < e(j) < T(M)$, $j < 5$.
- The weighted sum **Sigma** (**sg**) counted for these aftershocks.

The value of $b(e(1))$ divided by 100 is recorded in *ms* position of the output catalog.

After a strong earthquake (i.e. main shock with $M \geq M_0$) the count of $b(e(i))$ and **sg** is terminated for all preceding main shocks. However, the identification of aftershocks is carried on.

2.4 Parameters for definition of aftershocks

Limitations on magnitude of the aftershock M_a may be of the following types:

Abs - $Ma1 \leq M_a \leq Ma2$,
Rel - $M - dM1 \leq M_a \leq M - dM2$,
No - no limitation.

Here M is the magnitude of the main shock, and the constants Ma1, Ma2, dM1, dM2 are specified by a user.

Limitations on depth of the aftershock H_a may be of the same types:

- **Abs** - $Ha1 \leq H_a \leq Ha2$,
- **Rel** - $H - dH1 \leq H_a \leq H - dH2$,
- **No** - no limitation.

Here H is the depth of the main shock, and the constants Ha1, Ha2, dH1, dH2 are specified by a user.

Limitations on the distance R_a between epicenters may be of the types **Abs** and **No** only:

- **Abs** - $R_a \leq Ra1$,
- **No** - no limitation.

Here the constant Ra1 is specified by a user.

Limitations on time T_a between the main shock and its aftershock may be of the type **Abs**:

Abs - $T_a \leq Ta1$.

Here the constant Ta1 is specified by a user.

2.5 Limitations as function of M

We consider main shocks in magnitude range $M_1 \le M \le M_2$. This interval can be subdivided into intervals by k points c_i:

$$M_1 < c_1 < ... < c_k < M_2.$$

Limitations of type **Abs** on magnitude, depth, distance, and time, namely Ma1, Ma2, Ha1, Ha2, Ra1, and Ta1, may be common (notation-'**Mono**') for all M or be different (notation '**Poly**') for different intervals.

For example, consider the following limitations on M_a:

for $M_1 = c_0 \le M < c_1$ - $\text{Ma1}(1) \le M_a \le \text{Ma2}(1)$;
for $c_1 \le M < c_2$ - $\text{Ma1}(2) \le M_a \le \text{Ma2}(2)$;
.....
for $c_k \le M < c_{k+1} = M_2$ - $\text{Ma1}(k+1) \le M_a \le \text{Ma2}(k+1)$.

Here $[c_i, c_{i+1})$ are magnitude intervals with different limitations and Ma1(i), Ma2(i) are corresponding limits. The number k of points of division should be less than 10.

2.6 Menu

[Control] window.
'**???**' in this window means some inconsistence in the selected values of the parameters. If there is '**OK**' in the window, one may finish parameter selection. Enter the '**Control**' window to get explanations in the first case or to start execution in the second.

[Type] window. In this window one may select, whether full amount of information will be displayed during the program execution [**Type-ON**], or just the necessary minimum [**Type-OFF**].

[Print] and **[Protocol]** windows. If in the **[Print]** window you select value **ON**, then the file for printout will contain complete output. If you select **OFF** in the **[Print]** window, then you have an option to create a smaller printout with information about the set of the selected parameters. To do this, choose the value **ON** in the window **[Protocol]**.

The program selects from the input catalog a subcatalog, for which the separation of earthquakes into main shocks and aftershocks is carried out. This selection is determined by the time, magnitude, and depth intervals and the area.

The time interval is determined by windows [Time from] and [Time to]
Format for Time - YY DD HH.

Definition of the input magnitude is made by window [<Magnitude>]
The following options can be selected in this window

mb (**ms**, **ml**, **mp**) - the magnitude *mb* (*ms*, *ml*, *mp*) will be chosen only from input catalog without any transformation. Limitation for the selection has to be specified for this magnitude only by entering (using function key **F2**) the menu of the next level.

common - common magnitude M is calculated in one of the following ways:

a) $M = \max\{f(mb), f(ms), f(ml), f(mp)\}$;
b) $M = \min\{f(mb), f(ms), f(ml), f(mp)\}$;

c) according to priority in sense of specified preferences. For example, suppose the priority is *mb*, *mp*, *ml*, *ms*. Then $M=f(mb)$, if *mb* is not 0, $M=f(mp)$ if $mb=0$ and *mp* is not 0, $M=f(ml)$ if $mb=mp=0$ and *ml* is not 0, $M=f(ms)$ if $mb=mp=ml=0$ and *ms* is not 0. Another example: if priority *mb*, *mb*, *mb*, *mb* is indicated then the program deals with input magnitude *mb* only.
Here $f(m) = A \cdot m + B$, values of the coefficients in $f(mb)$, $f(ms)$, $f(ml)$, and $f(mp)$ may be different.
Method (**Max**, **Min**, **Priority**) of calculation of the common magnitude has to be specified in window [Select] by entering (using function key **F2**) the menu of the next level. The coefficients *A* and *B* for recalculation of magnitudes and limitations ([Magn from], [Magn to] for the common magnitude are specified in the same window.

The depth interval is determined by windows [Depth from] and [Depth to]

Area for selection of earthquakes [<Area>]

The program selects the earthquakes with epicenters from an area specified in geographic coordinates. The boundaries are included. This area can be:

Rectangle [<Area>-Rectangle]
Rectangle is specified by the intervals of latitude and longitude.
It may cross longitude 180^o. [<Area>-Polygon Over]

Polygon [<Area>-Polygon]
Polygon is specified by coordinates of its vertices (their total number should not exceed 20) and should not contain a pole.
It may cross longitude 180^o. [<Area>-Rectangle Over]

If a rectangle or a polygon crosses longitude 180^o then it should not cross longitude 0^o. Coordinates of an area have to be entered in the next level menu. Open window <**Area**> to view and change them. In the Polygon option program allows to view it by pressing **F8**.

The value of Sigma for each main shock may be displayed during execution of the program. [Type Sigma-ON]
One may limit the displaying of the main shock to those with the number of aftershocks exceeding some threshold. [Min Number]

To set all the parameters for aftershock selection and identification, described above, move the cursor to the window <**Functions**> and press Enter or **F2**.

Specified value(s)	Window
Number of magnitude intervals, $k + 1$	[Number of Lines]
$M_1, c_1, c_2, \ldots, c_k, M_2$ (boundaries of magnitude intervals)	[Interval]
c, *d*, and *f* for calculation of **Sigma** = $\Sigma c 10^{dM-f}$	[c] [d] [f]
M_0	[Strong]
For each magnitude interval:	
Ma1, Ma2, dM1, dM2	[Magnitude]
Ha1, Ha2, dH1, dH2	[Depth]
Ra1	[Distance]
Ta1	[Time]
$e(1), \ldots, e(5)$ (time interval boundaries)	[Time1], ... , [Time5]

III. PROGRAM FUNC

3.1 Files

The values of parameters for calculation of functions are written in a file called **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.
The programe operates on the catalogs of main shocks stored in standard **20 bytes binary format.** These catalogs have to be prepared by using program **AFT** or selected from such catalog by using **CompiCat** (http://www.mitp.ru/soft/ecp/doc/mainindex.html).
Records in the input catalog should be ordered by ascending time. Note that in the catalog of main shocks *mb* is the magnitude, *ms* is the number of aftershocks divided by100, *ml*=*mp*=0.

3.2 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 $m_1 \le m_2 \le m_3$ 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 $M \ge \underline{M}$ 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 $M \ge \underline{M}$. 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 $M \ge \underline{M}'$ calculated for the time period from $t - s$ to t and L_2 is the number of main shocks with magnitude $M \ge \underline{M}$ 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 $\Sigma C10^{D(Mi-F)}$ for main shocks with magnitudes $\underline{M} \le M_i \le \overline{M}$ and the origin time from $t - s$ to t.

6. Smax - $\max_j S_j/K_j$. Here S_j is the sum $\Sigma C10^{D(Mi-F)}$ for main shocks with magnitudes $\underline{M} \le M_i \le \overline{M}$ and the origin time from $t - j$ years to $t - (j-1)$ years; K_j is the number of such main shocks; $j = 1, 2, ..., s$.

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; $j = 1, 2, ..., s$. 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; $j = 1, 2, ..., s$. 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 $\sum_{j-1}^{s} \max\{0, \text{ENTIRE}(A\text{-}K_j)\}$. 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 $s' = \text{ENTIRE}((s\text{-}1)/2)$.

12. Ml - 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. Bmax - 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 $\sum_{j=2}^{j^*} \left| K_j - K_{j-1} \right|$. 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 $j = 2, 3, ...,$ ENTIRE(15/s) then $j = \text{ENTIRE}(15/s)$).

15. V - the sum $\sum_{j=2}^{s+1} \left| K_j - K_{j-1} \right|$. 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. NF1 - 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. NF2 - the same as NF1 but with other values of δ and s.

18. NR1 - 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. NR2 - the same as NR1 but with other values of δ 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, ..., 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 $\Sigma\ C10^{D(Mi-F)}$ 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.

3.3 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**".

3.3 Dialog in program FUNC

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

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.

Second menu

The second menu contains the following windows.

#	Window Name	Function and Comments
1	List of regions	To specify ***the indexes of regions***, 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 ***the common name of files with subcatalogs***, 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 **.DAT**. Function key **F9** may be used to search the file in the current directory.
3	Time from	To specify ***the beginning (year, month, day, hour and minute) of the catalogs***.
4	Time to	To specify ***the end (year, month, day, hour and minute) of the catalogs***.
5	Skipping to	To specify ***the beginning (year, month, day and hour) of the time interval for moments, for which the values of the functions may be calculated***.
6	Learning to	To specify ***the end (year, month, day and hour) of time interval, which is used for determination of magnitude thresholds*** m_1, m_2 and m_3.
7	M0	To specify ***a value of the low threshold M_0 for magnitudes of strong shocks***.
8	<Definition of dates>	To specify ***the dates of objects***. **By list** - A list of dates will be specified. **By step** - Dates will be with a constant step. The window can be opened by pressing **F2** to get into ***the third menu*** to specify the list of dates or the first and the last dates and the step.
9	<Functions>	To specify ***the list of functions***, which will be calculated and values of their parameters. **Standard CN** - Standard CN set of function will be calculated. **Not standard** - The window can be opened by pressing **F2** to get into ***the fourth menu*** to specify the the list of functions and values of their parameters.
10	<Thresholds>	To specify ***values of magnitude thresholds m_1, m_2, and m_3*** **Magnitudes** - The window can be opened by pressing **F2** to specify the values of m_1, m_2, and m_3 for each region. **Nos of events** - 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 "**Time from**" to "**Learning to**" are used for determination of m_1, m_2 and m_3.
11	Annual events	To specify ***values of a_1, a_2 and a_3*** ($a_1 \geq a_2 \geq a_3 > 0$). 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 ("**Nos of events**" is in window 10).

#	Window Name	Function and Comments
12	Type	To set ***will values of functions be typed or not***. **ON** - Values of functions will be typed. **OFF** - Values of functions will not be typed.
13	Line to type	To specify ***the value of k***. Values of functions will be typed for objects with sequential numbers $ki + 1$ ($i = 0, 1, ...$). This window is used only if values of functions will be typed. ("**ON**" is in window 12).
14	Print	To set ***will printout be created or not***. **ON** - Files **PRO.PRI** with the results of dialog and **FUN.PRI** with values of functions will be created for printout. **OFF** - File **FUN.PRI** will not be created.
15	Protocol	To set ***will printout with the results of dialog be created or not***. **ON** - Files **PRO.PRI** with the results of dialog for printout will be created. **OFF** - File **PRO.PRI** will not be created. This window is used only if file **PAR.PRI** with values of functions for printout will not be created ("**OFF**" is in window 14).
16	Title for printout	To specify ***a title of printout*** (a string with not more than 30 symbols, which will be written in file **FUN.PRI** as a title). This window is used only if file **FUN.PRI** will be created ("**ON**" is in window 14).
17	Output profile	To specify ***the name of the output PROFILE***, which will contain the results of the dialog and the values of the functions. The name has to have extension **.PAT**. **Blank** means that output **PROFILE** will not be created.
18	Control	To show ***consistency of input data*** already indicated. **OK** - data are consistent. If the cursor will be moved to this window then after pressing **ENTER** 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 "**Time from**" to "**Learning to**", 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 "**THRESHOLDS O.K.?**". If the answer is "**Y**" the program begins to calculate the values of the functions. If the answer is "**N**" it returns to ***the second menu***. **???** - data are not consistent. By pressing **ENTER** 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.

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 ***how the list of dates of objects will be formed***. **Current** - After entering into window 2 a current list of dates remains. **From strong shocks dates** - 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 ***the dates of objects***. The maximal number of dates is 100. The first date has to be after the date "**Skipping to**" (see window 5 of ***the second menu***). **WARNING.** 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 ***the second menu***). If the total number of such dates is more than 100 it will be reduced to 100.
3	Mag.	To specify ***the low threshold for magnitudes of strong shocks***, 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 ***the first date (year, month, day and hour)***.
2	Dates to	To specify ***the upper boundary (year, month, day and hour) of dates***.
3	Step	To specify ***the step (years, months and days) between dates***.

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.

Fourth menu

The ***fourth*** menu contains the following windows.

#	Window Name	Function and Comments
1	Time Magnitude Delta	To specify ***the functions, which will be calculated, and values of their parameters***: *s* (Time), $\underline{M}$ (Magnitude) and δ (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, Ml, Bmax, Q, V, NF1, NF2, NR1, NR2, Taq are calculated.
2	for SIGMA and SIGTH	To specify ***values of coefficients C, D, and F for functions SIGMA and SIGTH and a value of the threshold magnitude*** $\overline{M}$ ***for function SIGMA***.
3	for Smax and S1max	To specify ***values of coefficients C, D, and F and a value of the threshold magnitude*** $\overline{M}$ ***for functions Smax and S1max***. This window is used only if functions Smax or/and S1max are calculated.
4	for Zmax	To specify ***values of coefficients C, D, and F and a value of the threshold magnitude*** $\overline{M}$ ***for function Zmax***. This window is used only if function Zmax is calculated.
5	Catalog of main shocks for Ml	To specify ***the name of the file with the catalog, from which strong main shocks will be selected for calculation of function Ml***. This name has to have extension **.DAT** . This window is used only if function Ml is calculated. Function key **F9** can be used to search the file in the current directory.
6	M0 for Ml	To specify ***a value of magnitude threshold*** M_1 ***for calculation of function Ml***. This window is used only if function Ml is calculated.
7	List of regions	To specify ***lists of regions for calculation of functions NF1, NF2, NR1, NR2 and Taq***. **on same fault** (for NF1 and NF2) - by pressing **F**2 the window can be opened to input the lists of regions (≤ 10) on the same fault with the regions, for which values of functions are calculated. **in whole area** (for NR1 and NR2) - by pressing **F2** the window can be opened to input the lists of regions (≤ 6) in the whole area with the regions, for which values of functions are calculated. **in neighbourhood** (for Taq) - by pressing **F2** the window can be opened to input the lists of regions (≤ 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 ***the second menu***). 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.

REFERENCES

Keilis-Borok,V.I., Knopoff ., and I.M.,Rotwain, 1980. Bursts of aftershocks, long-term precursors of strong earthquakes. *Nature,* **283:** 259-263.

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