THE COMPLEX ANALYTICAL AND MONITORING METHOD OF THE LONG-TERM AND SHORT-TERM FORECASTING OF STRONG EARTHQUAKES

(ON THE EXAMPLE OF THE EARTHQUAKE IN TURKEY IN THE REGION OF THE CITY OF IZMIR IN 1999)

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Keywords

Interdisciplinary approaches, analytical method, forecasting

Abstract

The earthquakes forecasting is based on statistics of seismic events have occurred, monitoring of the current lithosphere condition and probability to an estimation of time of earthquakes' occurrence. Expected time of earthquake is defined in a range from a month to about one year and more. The problem of the probabilistic approach of forecasting is uncertainty of distribution law of seismic processes and events. Now the huge volume of the statistical information is saved up, however mathematical methods of statistical processing of databases on earthquakes still do not allow to reveal law of earthquakes' occurrence. Scientific and prognostic value of this information is obvious and great, but new technologies are necessary for such analysis.

From analysis of conditions of occurrence of strong earthquakes follows, that they have taken place on extremums of transients change of solar activity, fluctuations and shift of terrestrial axis and at characteristic phases of the Moon. Basis of the new complex analytical and monitoring method of the long-term and short-term forecasting of time and a place of earthquakes makes:

the account of transients change of helio-geophysical factors or any other parameters describing any influence or change of a lithosphere energy condition;

definition of global and local statistical spectral-temporal laws of earthquakes activization after extreme values of transients change of helio-geophysical parameters;

monitoring of "sensitivity" - the response of a controllable local or regional geographical zone to extreme changes of transients and the coordination of changing local geophysical parameters or "harbingers" with an calculated time of earthquakes activization.

Opportunities of practical use of this method are shown by the example of the analysis of conditions of occurrence of earthquake in Turkey (area Izmir) in 1999.

Sections

The earthquakes forecasting is based on statistics of seismic events which have occurred, to monitor the current lithosphere condition and the probability of an estimation of earthquakes'

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occurrence time. The expected time of an earthquake is in the range of a month to about one year or more. The problem of the probabilistic approach of forecasting is the uncertainty of the distribution law of seismic processes and events.

In the last centuries of seismological supervisions, the huge volume of statistical information has been saved up. However, mathematical methods of statistical processing of databases on earthquakes have not yet allowed to reveal the laws of earthquake occurrence.

Scientific and prognostic value of this information is obvious, but new principles and methods are necessary for such analysis (Bayda C., 2007).

Recently, two directions in perfection of the long-term and short-term forecast of strong earthquakes were defined; this takes account of a solar-terrestrial relationship (Chizhevskiy A., 1995; Djadkov P., 2002; Sytinskiy A., 1987 and 1998) and monitoring of the meteorological (Molchanov O. et al., 2004; Zakharenkova I. et al., 2006; Ananjin I. et al., 2002; Tronin A., 2002) and bio- harbingers (Zimina S., 2002). Experience of the use of these methods for earthquake forecasts has shown, that high solar activity not always accompanies strong earthquakes. Presence of harbingers or their attributes doesn't always indicate the preparation of an earthquake and can be connected to other natural processes.

For an increase in reliability of earthquake prediction, it is necessary to know the conditions, the direct initial reasons and the laws causing their initiation and which are characterized by disconnected or loosely connected processes. The presence of a connection between such processes is explained by the "Lorentz butterfly" effect the logical meaning of which is, that the butterfly flapping its wings in Iowa, can cause a heavy rain in Indonesia.

New approaches and methods of earthquake forecast are necessary for the solving the problem taking into account of the maximal and unlimited number of parameters of the various physical nature and describing any changes in the environment.

The method offered here is based not on probabilistic, but on analytical decisions stemming from concepts of chaos theory, catastrophe theory and nonlinear dynamic systems. It essentially distinguishes it from traditional geophysical approaches, but does not contradict them, instead supplementing them with new analytical tools.

The conceptual basis for research of spatio-temporal laws of occurrence of strong earthquakes is the unity of space and terrestrial energy processes and, in particular, transient processes of heliogeophysical factors. Transient processes of change in the properties and characteristics of external spatial influences and the environment, including the lithosphere, atmosphere and hydrosphere, reflect the energy of the process of these transformations. The physical essence of the influence of transient processes in changing the heliogeophysical conditions and parameters will be, that these transient processes will show a load which will result in a change of these conditions or parameters in the physical structure or system of the Earth.

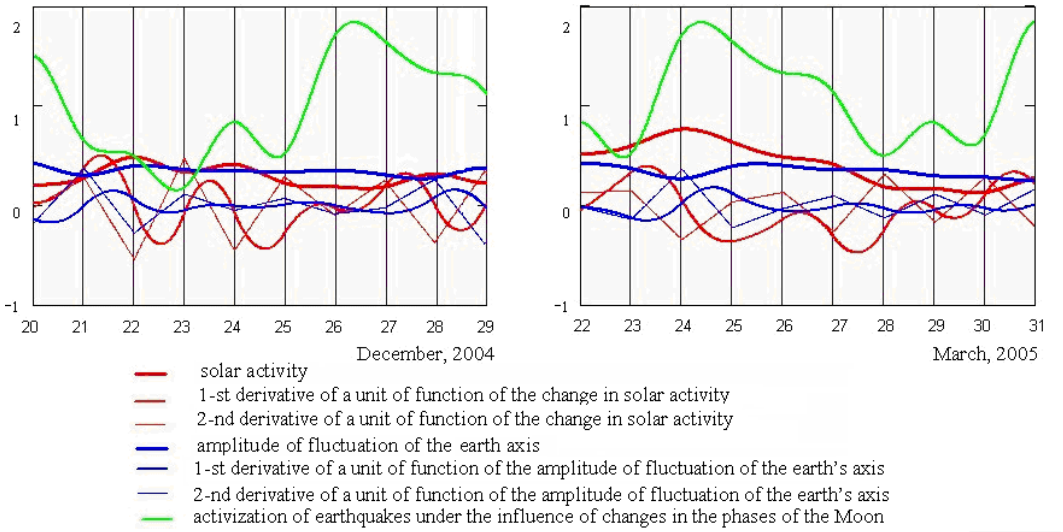
From the catastrophe theory follows: each change of the external factor, is accompanied by a respective internal reorganization of that structure which it influences. Accordingly, the first derivative of the factor change will show the speed of reorganization of this structure, and the second derivative – the acceleration of structure reorganization. If the physical structure, after the discontinuance of external influence can restore the former equilibrium position or create a new condition of balance, then it keeps its integrity. If is not present, it corresponds to irreversible structural changes which are shown as a destruction or catastrophe of the system.

The earthquake as a catastrophe in the lithosphere system, arises owing to an infringement of stable equilibrium of physical structures at the extreme of the transient process, under the influence of which, the structure or system at a bifurcation point either accumulates potential energy, or collapses, dropping to a lower potential level.

At precisely the bifurcation point, that of the choice of the direction of reorganization, the system is most sensitive to the minimal external influences and here the effect of "Lorentz butterfly" is shown.

Thus, the transient processes initiate the start of processes which could end in a strong earthquake. The time and place of earthquakes is subordinate to laws which can be revealed by the mathematical analysis of space and heliogeophysical transient processes (Bayda S., 2006).

FIGURE 1. THE SCHEDULE OF CHANGE IN HELIOGEOPHYSICAL CONDITIONS, CORRESPONDING TO STRONG EARTHQUAKES, IN RELATIVE VALUES ON DECEMBER 26, 2004 (THE EARTHQUAKE 9M AND TSUNAMI IN INDIAN OCEAN) AND ON MARCH 28, 2005 (THE EARTHQUAKE 8.7M IN NORTHERN SUMATRA, INDONESIA)



The analysis of transient processes of changing the heliogeophysical factors and time of occurrence of strong earthquakes, has revealed the following laws of their occurrence:

1. At extreme values of changing the absolute size of heliogeophysical parameters occurs in 22-57 % of earthquakes, at extreme values of the first derivative of the researched factor - 15-55 % and at extreme values of the second derivative of the researched factor - 15-53 %. With the combination of analysis results the connection between transient processes and earthquake occurrence of 90-95 % is revealed (Fig. 1) (Bayda S. et al., 2005).

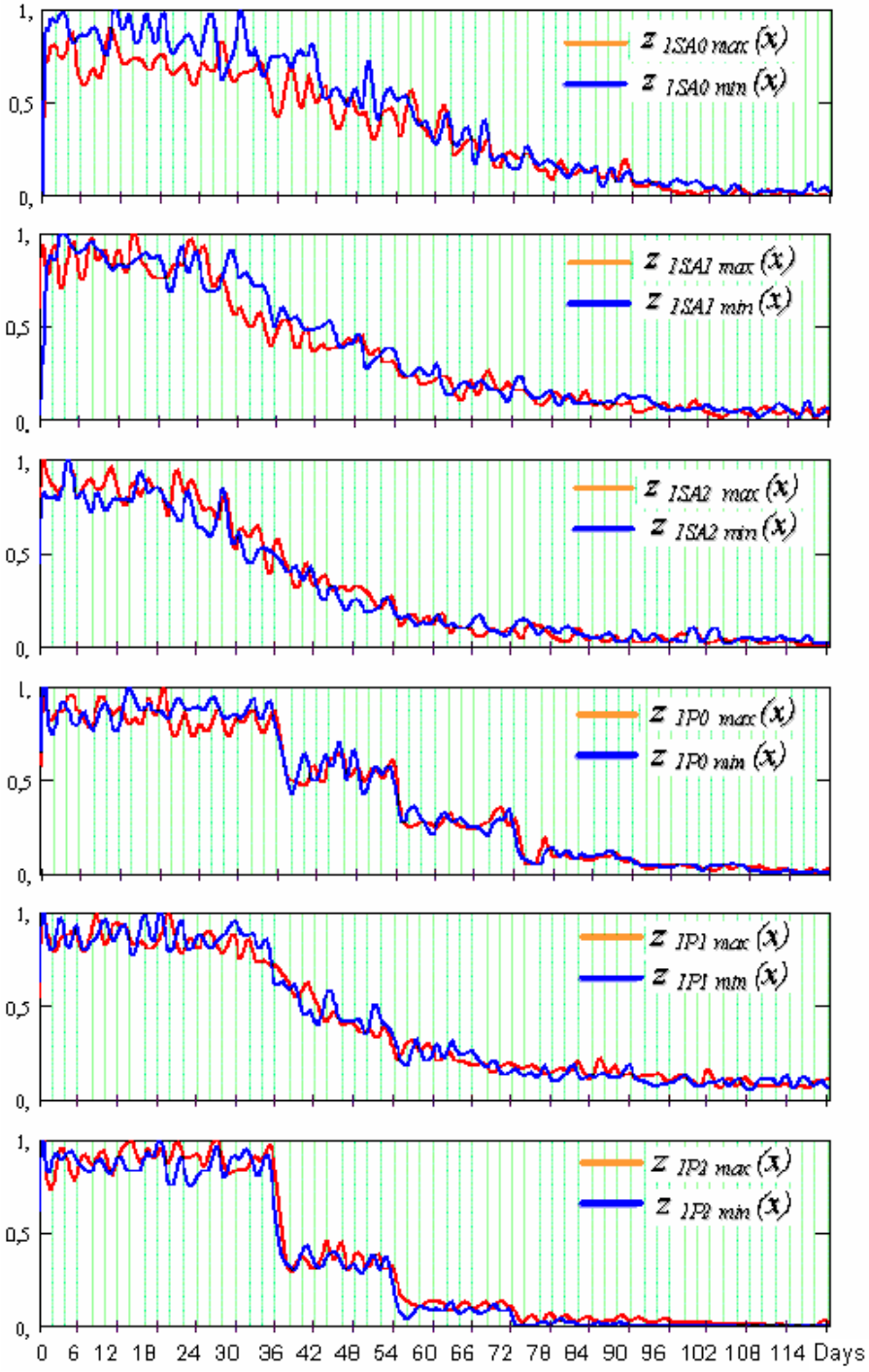
2. In 50-70 % of cases, earthquakes don't arise at once, but a while after extreme changes in the parameter of transient processes. The time of earthquake "delay" after extreme change in the value of the influencing factor follows a statistical and mathematical law, it can be calculated and expressed as a spline-function of the time-and-frequency spectrum of earthquake activization. The spline-functions of the time-and-frequency spectra calculated on the basis of the processing of statistical data of occurred earthquakes, depends on the filtration of this data by energy or scale and geographical location, have a global and local predictability. Time-and-frequency spectra of earthquake activization by its physical nature have a similarity with the display of the FPU effect – the return of oscillatory activity of mechanical oscillators system, investigated by Fermi, Pasta and Ulam (Bayda S., 2007).

3. According to parameters of changing the position of the cosmic system of the Sun-Earth-Moon, cyclic spectral-time functions of earthquake activization are calculated: synodical month – 29.53 days; Saroc cycle – 6585.333 days; recurrences in the conformity of the Moon's phases and days of the year – 6794 days.

4. Each new extreme change of heliogeophysical conditions, like an external physical influence, causes the start of new internal cycles of activization of dangerous processes in the lithosphere, hydrosphere, atmosphere and biosphere and occurs with a background of the old dying cycles caused by the previous extreme changes and, being combined with them, is amplifies. According to the submitted approach, of the occurrence of an earthquake, this is an

irreversible reaction of structure to changes in external influences and the interaction of internal cyclic processes of the lithosphere and environment, having arisen as a reaction to previous external influences.

FIGURE 2. THE SPLINE-FUNCTIONS OF TIME-AND-FREQUENCY SPECTRA OF EARTHQUAKE ACTIVIZATION AFTER EXTREME VALUES OF TRANSIENT PROCESSES OF THE CHANGE IN SOLAR ACTIVITY AND THE CHANGE IN THE POSITION OF THE TERRESTRIAL AXIS. WITH THE DETERMINATION OF EXTREMES, THE FACTOR OF SMOOTHING THE SPLINE-FUNCTIONS OF TRANSIENT PROCESSES CORRESPONDED TO AN AVERAGE VALUE OF 29.7 DAYS



The basis of the analytical method of the long-term and short-term forecast of time and place of earthquakes consists of:

- the account of transient processes of change in the heliogeophysical factors or any other parameters describing any influence or change in the lithosphere energy condition;

- the determination of time-and-frequency spectra of earthquake activization after extreme values of change in the transient processes of heliogeophysical parameters on the basis of the statistical analysis of occurred earthquakes at a global and regional scale;

- monitoring of "sensitivity" - the response of the controllable local seismic hazardous zone to extreme changes of transient processes and the coordination of changes in the local geophysical parameters with the time of earthquake activization, calculated with the help of prognostic functions (Bayda S., 2006).

Calculation of the time of earthquake activization is carried out with the use of the system of six prognostic functions. We must consider, that the moment of any extreme change in the influencing factor is the start of processes of earthquake activization. Therefore for the creation of prognostic functions of one time scale 12 time-and-frequency spectra of heliogeophysical factors z1A(t) (Fig. 2) and also 3 spectra of the space factors are used, influencing the activization of earthquakes (Fig. 3). The basis of prognostic functions is the sum of all splines-functions of time-and-frequency spectra of earthquake activization, the beginning of which is the start of the cycle or the time of extreme change in the influencing factor.

The potential function of earthquake activization - is the sum of all individual spline-functions of time-and-frequency spectra of earthquake activization started at time tA , tB , tC … according to extreme changes in transient processes of heliogeophysical parameters A, B, C … and shows relative and conditional general inflow of energy from the environment "feeding" earthquakes (1).

$$Z_{pot}(t) = \sum z_{1A}(t - t_A) + \sum z_{1B}(t - t_B) + \sum z_{1C}(t - t_C) + ... \quad (1)$$

The cyclical function of earthquake activization is the sum of cyclical spline-functions of time-and-frequency spectra of earthquake activization connected with periodical processes stable to time, the change of the Moon's phases and space planetary cycles (2).

$$Z_{cikl}(t) = z_{1L}(t - t_L) + z_{1LD}(t - t_{\mathrm{LD}}) + z_{1SGL}(t - t_{SGL}) \quad (2)$$

The active function of earthquakes is the sum of all spline-functions of time-and-frequency spectra of earthquake activization started after extreme changes in transient processes of heliogeophysical parameters, corresponding to time tZ of earthquake occurrence. It shows a level of conditional energy activization of the lithosphere (3).

$$Z_{act}(t) = \sum z_{1A}(t - t_Z) + \sum z_{1B}(t - t_Z) + \sum z_{1C}(t - t_Z) + ... \quad (3)$$

The disbalance function of potential and active function of the earthquakes - is the difference between potential and active function and shows the accumulation of energy for the occurrence of earthquakes (4).

$$Z_{db}(t) = Z_{pot}(t) - Z_{act}(t) \quad (4)$$

The function of earthquake realization shows the conditional energy equivalent of the occurred earthquakes and serves for the control of calculation of earthquake activization according to the potential function, active function, disbalance function and cyclical function. It is calculated as the sum of all earthquakes of magnitude greater than 5M on a daily or monthly scale, occurred in the period of time that had passed (5).

$$z_{real}(t) = N_{\Sigma}(t) \quad (5)$$

The function of changing the indicating parameters of earthquakes - as this function it is possible to choose any of the monitoring data pi or their combination which show the current changes of environmental parameters (6). Monitoring of atmospheric processes, geophysical measurements (Adam A., et al., 1986) (Ouzounov D., et al., 2008) or bio-harbingers can be used here. This function is the basis for the determination of local zones of strong earthquake preparation.

$$P_{A\Omega}(t) = \sum p_i(t) \qquad (6)$$

The given method is the analytical tool for the definition of time and local zone where external and internal corresponding conditions occur and where there can be a strong earthquake. Earthquakes never occur unexpectedly. There is always a period of time of preparation, which can be found out as a response to any external influence according to the concurrence of extreme rises (peaks) of these functions.

FIGURE. 3. THE SINGULAR SPLINE-FUNCTIONS OF TIME-AND-FREQUENCY SPECTRA OF EARTHQUAKE ACTIVIZATION CALCULATED ACCORDING TO CYCLICAL TRANSIENT PROCESSES CONNECTED TO THE MOON'S PHASES AND ITS POSITION IN RELATION TO THE SUN AND THE EARTH

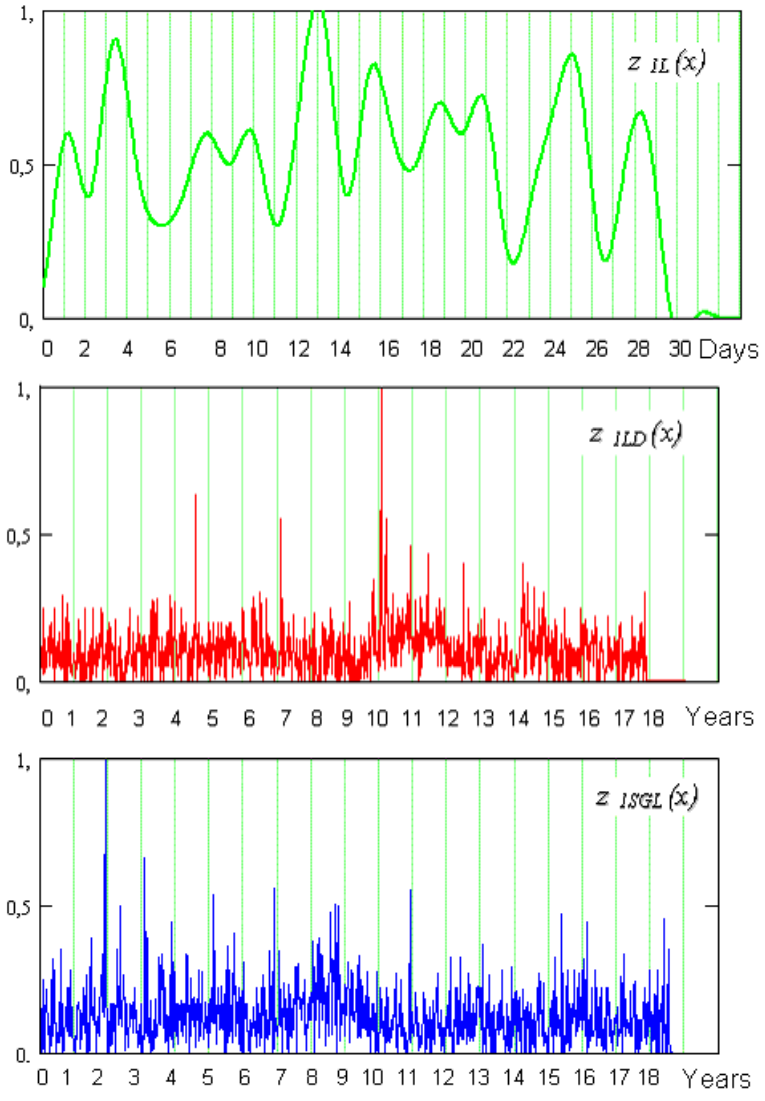


FIGURE 4. SYSTEM OF THE FIVE BASIC PROGNOSTIC FUNCTIONS USED FOR THE CALCULATION OF THE TIME OF EARTHQUAKE ACTIVIZATION. CALCULATION IS MADE ACCORDING TO THE DATA FOR MAY 1, 2007: THE POTENTIAL FUNCTION OF EARTHQUAKE ACTIVIZATION $Z_{pot}(t)$; THE CYCLICAL FUNCTION OF EARTHQUAKE ACTIVIZATION $Z_{cikl}(t)$; THE ACTIVE FUNCTION OF EARTHQUAKES $ZACT(T)$; THE DISBALANCE FUNCTION OF POTENTIAL AND ACTIVE FUNCTION OF THE EARTHQUAKES $Z_{db}(t)$; THE FUNCTION OF EARTHQUAKE REALIZATION $Z_{real}(t)$.

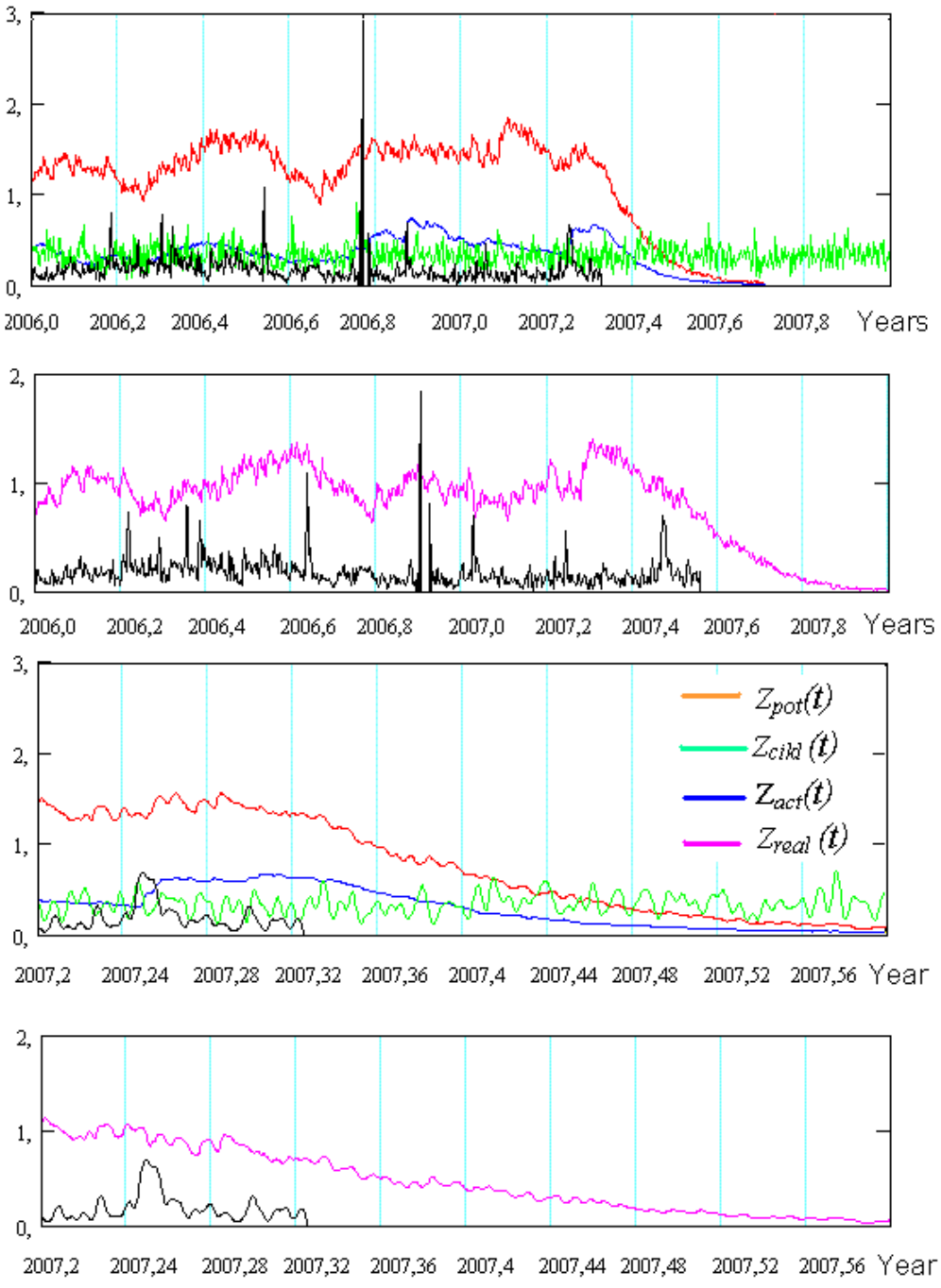
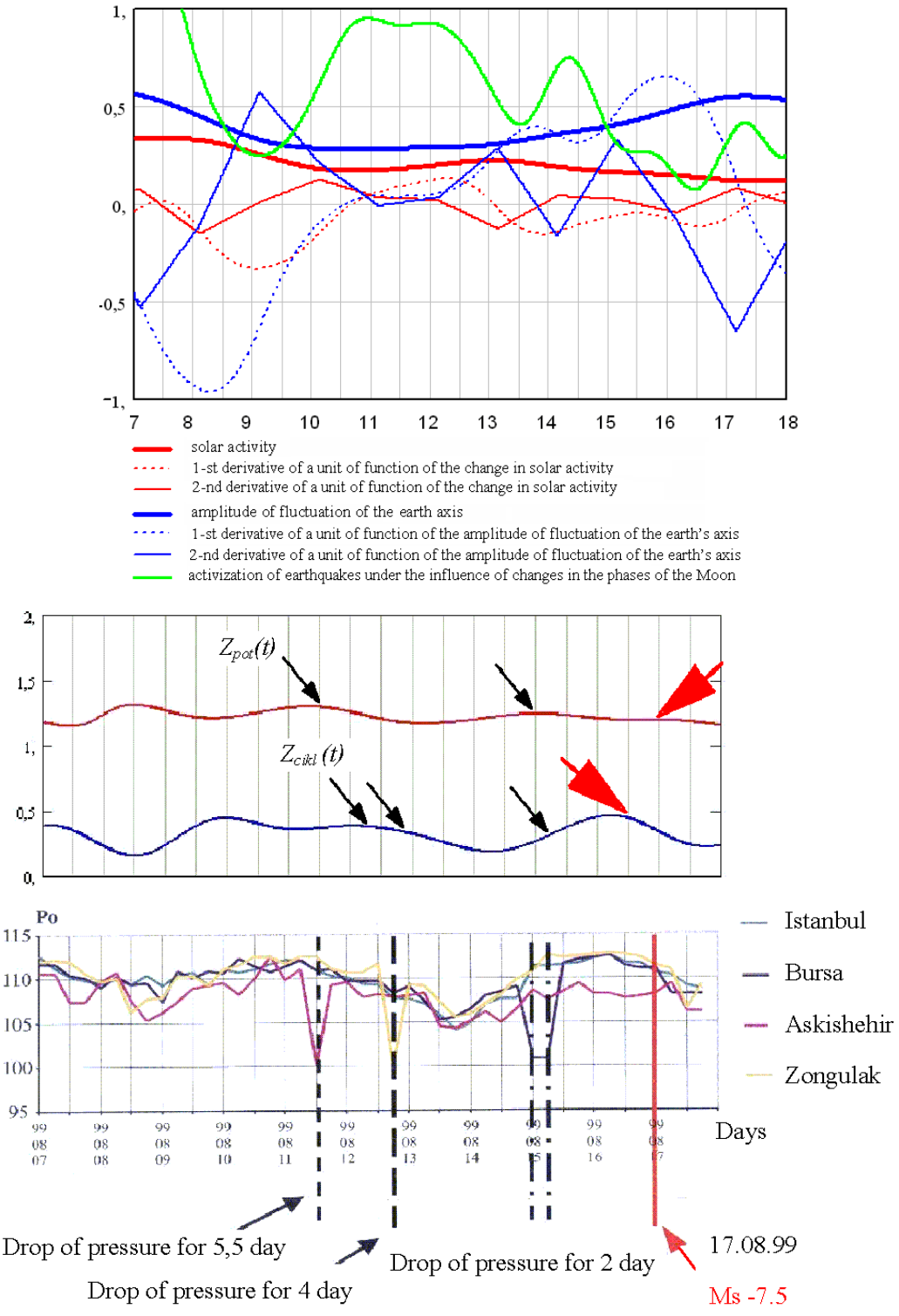


FIGURE. 5. THE GRAPH OF TRANSIENT PROCESSES OF CHANGES IN THE HELIOGEOPHYSICAL CONDITIONS, CORRESPONDING TO STRONG EARTHQUAKES, IN RELATIVE VALUES ON AUGUST 17, 1999. CONNECTION OF CHANGING THE LOCAL ATMOSPHERIC PRESSURE AND THE CALCULATED PROGNOSTIC FUNCTIONS OF EARTHQUAKE ACTIVIZATION BEFORE AN EARTHQUAKE OF MAGNITUDE 7.5M IN THE REGION OF THE CITY OF IZMIR IN TURKEY ON AUGUST 17, 1999 (THE BAROMETRIC DATA ARE TAKEN FROM NIGMETOV G. ET AL., 2001)



In Figure 5 is shown the schedule of changing the atmospheric pressure before an earthquake on 17-th August 1999 with magnitude 7.5M in Turkey in the region of the city of Izmir and the calculating function of daily activization of earthquakes are shown. Abnormal falling of atmospheric pressure 5, 4 and 3 days prior to the earthquake, coinciding with the peaks of the function of the daily activization of earthquakes, show a "preparation" of conditions for the realization of an earthquake with a big magnitude.

The feature of the complex analytical and monitoring method is that it allows to reveal the process of preparation of a strong earthquake and to take into account the joint influence of factors, diverse in physical nature and dimension in any combination. The submitted method can become the basis for the creation of a global system and technologies of forecast and prevention of strong earthquakes.

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