OLAP Methods for EQ Alarm Systems Design

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Abstract

In our paper we present a set of OLAP and Data Mining opportunities to solve well known problem of the seismic shocks forecasting. As known, the three of parameters such as time, magnitude, location are integrated in this problem and if any of them can not be forecasted well, the total forecast can not play the role of the warning. Our goal is to discuss the points concerning the development of the EQs early alarm reliable systems on the basis of modern IT opportunities spectrum we have briefly mentioned in [1-7].

Any creative techniques to solve the problem have both advantages and weaknesses plus some limitations to be applied. The most effective way to increase the reliability of the EQ alarm systems is a strong collaboration between long-, medium- and short-term techniques of forecasting and, as well, the interdisciplinarity of the research methods. We present a set of such tools for EQ events forecasting developed on the basis of the ultra-long data series (up to 60 GB) collected at the Russian Far East IRIS stations of Kamchatka.

As widely known, it is extremely difficult to guess the location of coming EQ with precursors recorded at only one seismic station. However, we noticed a high degree of correlation exists at the Efficiency and the Entropy precursor curves corresponding to EQs occurring in the same location but at different times, even if the magnitudes of the events were different [1-3].

We present and discuss both some general practical (Fig.1, 2) and theoretical (Fig.3, 4) results obtained with analytical processing of huge data arrays mentioned above we usually deal with in geophysics. It was noticed, verified and proved, the existence of asymptotically stable limit value for the Efficiency connected with both the Maxwell-Boltzmann and Shannon entropies (Fig.4, 5). We present the thermodynamical way to get the explicit value of the parameter and discuss the wide spectrum of geophysical applications of the phenomenon. Some Entropy methods developed recently by us to study the crisis events [4-7] can be fruitfully applied to solve the short-term EQs forecasting problem (Fig.6-9).

We present a creative spectral distance method for ultra-long data series processing to explain EQ short-term forecasting algorithms (Fig.4, 7, 9).

Finally, we discuss some opportunities to solve the seismic shock/fore-shock identification problem on the basis of the USGS NEIC series processed for the 30-Y period (Fig.10).

Wide spectrum of the IT ideas for reliable EQ alarm systems is presented.

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FIGURES

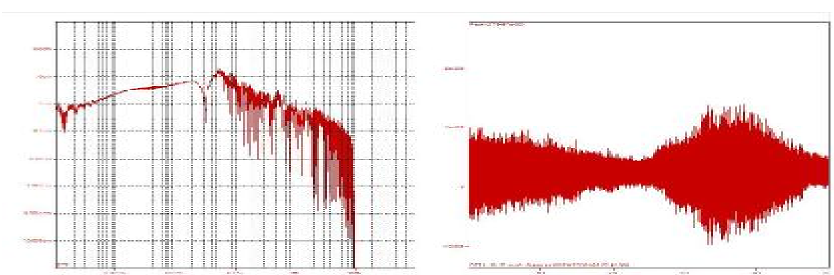


Fig.1. FFT for 1997 Kronotskoe EQ (5-days spectrum before the event).

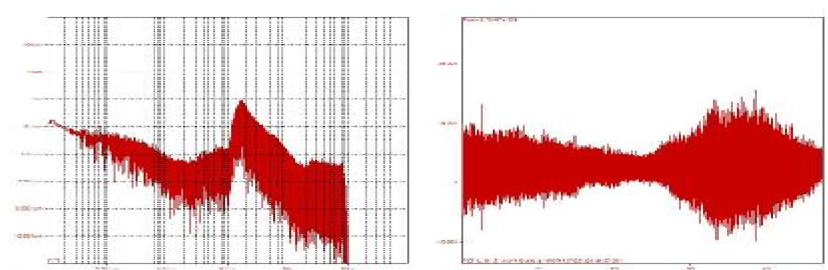


Fig.2. FFT for 1997 Kronotskoe EQ (4.5-days spectrum before the event).

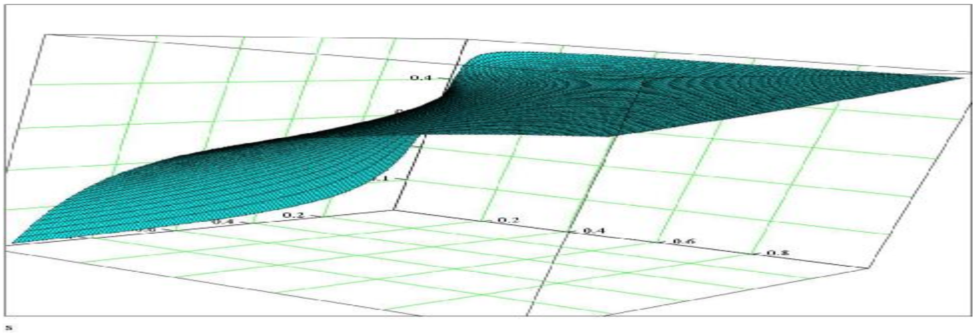
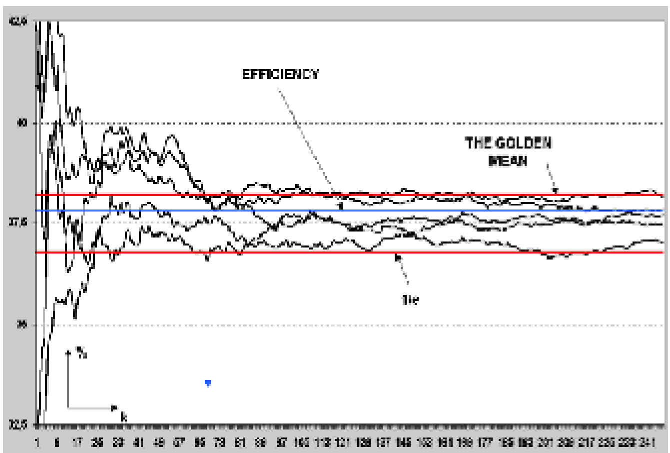


Fig.3. Efficiency surface for making-decisions (normalized over the unit cube).



$$E = \frac{1+e^2\varphi}{e(e+1)} \approx 0.37817755$$

$$\frac{E-1/e}{\varphi - E} = e$$

$$\varphi = 1 - \Phi,\ \Phi = \frac{\sqrt{5}-1}{2}$$

Fig.4. Relationships with fundamental physical constants for making-decisions.

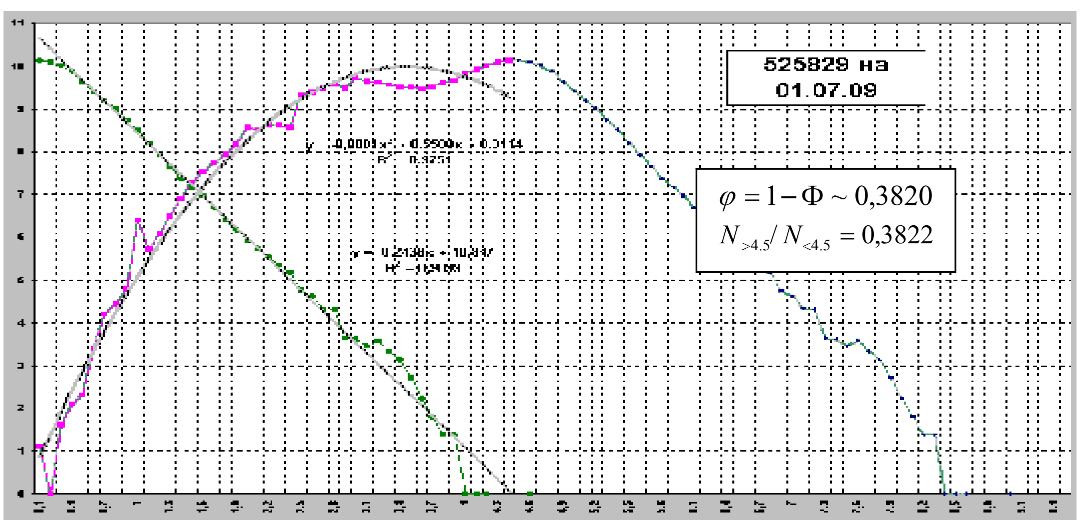


Fig.5. Global EQs distributions since 1971 by the moment and Fibonacci numbers.

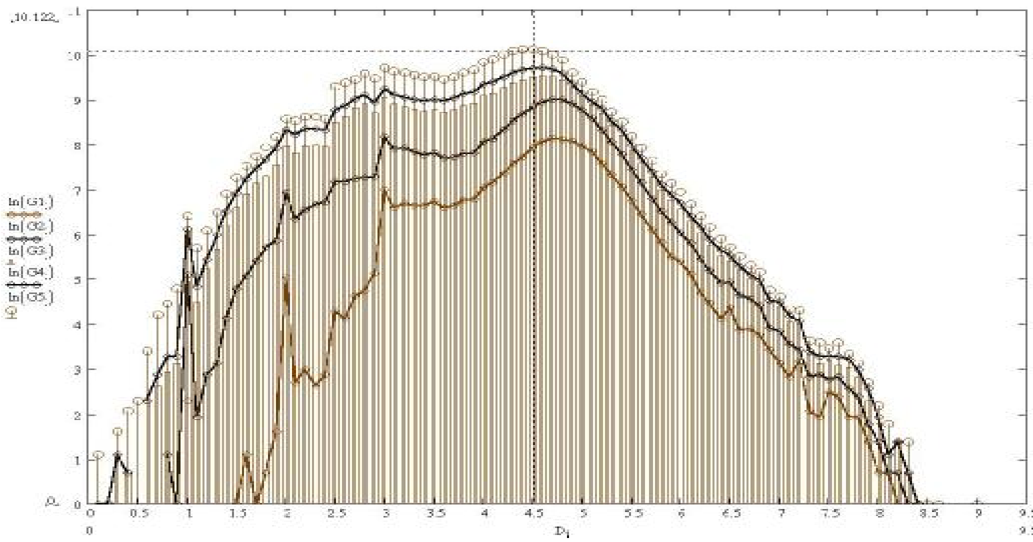


Fig.6. Global EQs distributions since 1971 step-by-step.

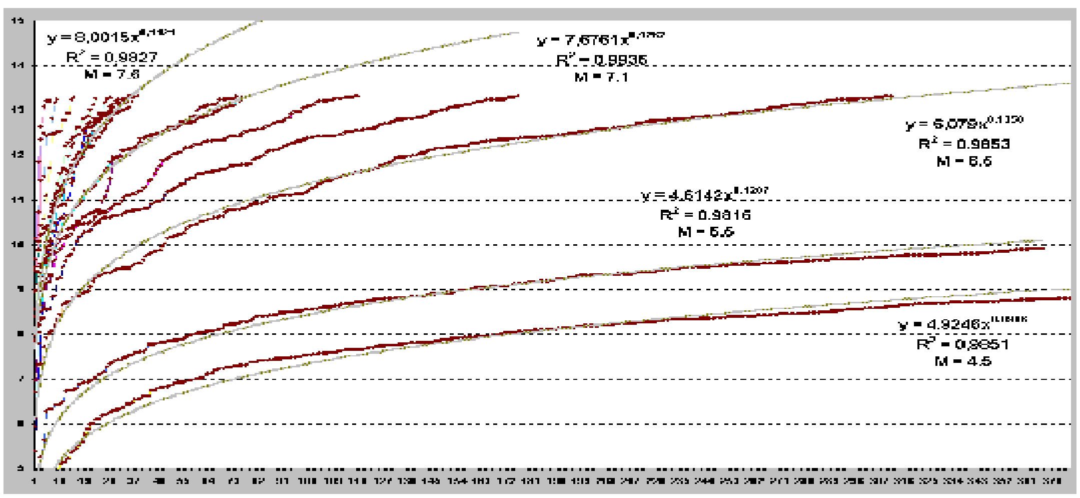


Fig.7. Semi-log scale for Magnitude-EQs (USGS NEIC) equations (with R^2~1).

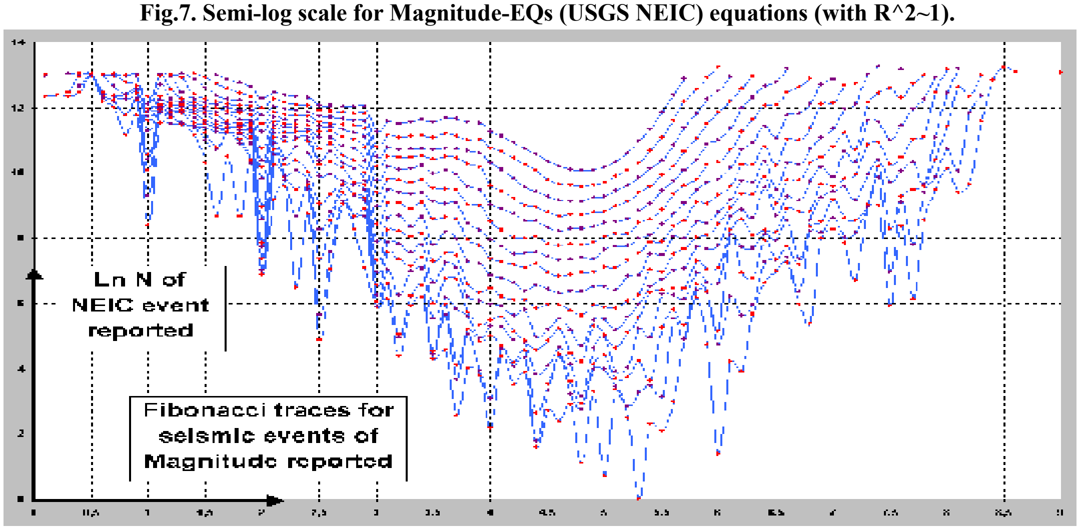


Fig.8. Semi-log chart for Magnitude-EQs (USGS NEIC) Fibonacci events forecasting.

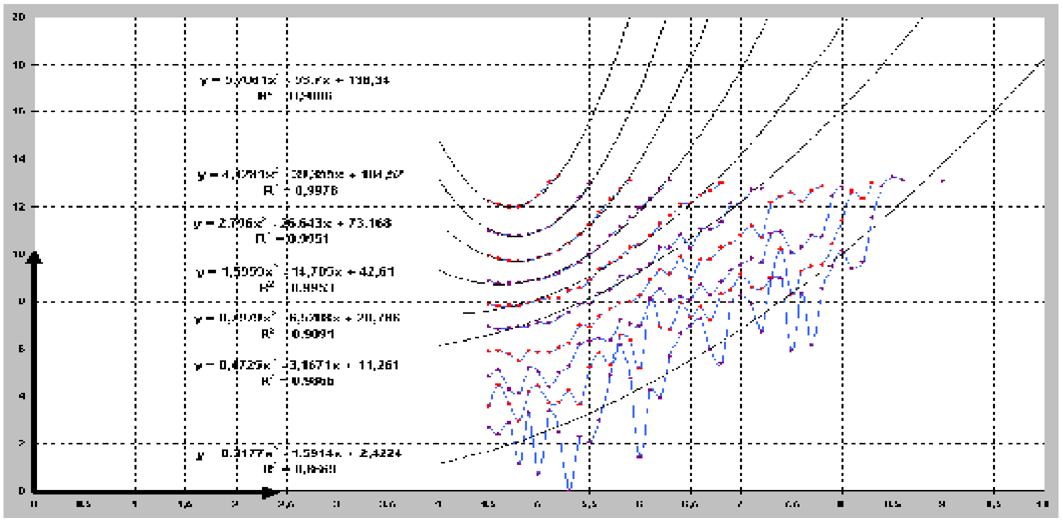
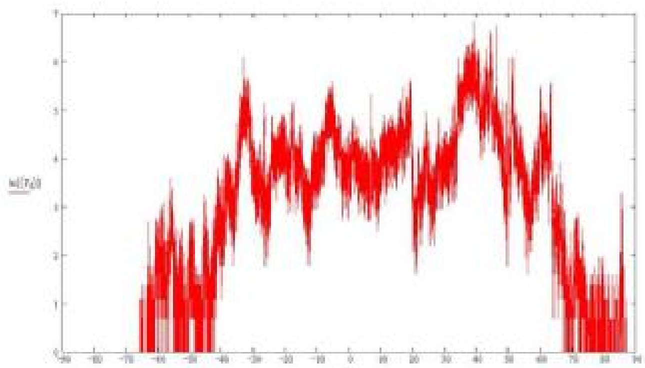


Fig.9. Right-hand side of Fig.8. for Fibonacci events forecasting (with R^2~1).



$$\phi = \Phi\sqrt{2}/2 \sim 0{,}4370$$

$$\alpha_k = \arcsin(k/n)\,,$$

$$k = 1 \ldots n,\ n \to \infty$$

$$\rho = 0{,}4375$$

Fig.10. Global EQs distributions over the latitudes and Fibonacci law of the 2-nd order.