THE EARHTQUAKE PRECURSORS IN WAVELET TRANSFORM OF THE DATA FROM THE NEUTRON MONITOR AT TIEN-SHAN HIGH ELEVATION RESEARCH STATION

N.M. Duisekeyeva, A.S. Kussainov, V.V. Oskomov
Al-Farabi Kazakh National University, Almaty, Republic of Kazakhstan

We stipulate the possibility for the short-term earthquake prediction assuming the one may be preceded by specific variation in the wavelet frequency spectrum of the neutron monitor data. The wavelet transform of the neutron counting rate at Tien-Shan high elevation research facility was referenced with the seismic events database. Particular variations corresponding to our expectations are located. We have observed the correlation of the frequency variation with an earthquake.

Introduction

In publications covering the seismically active regions of the former Soviet Union countries, the question of earthquakes prediction justifiably takes the central role. The problem of short and long term prediction of earthquakes is addressed and partially solved by different methods. In this paper we have further tested the earlier suggested method [1] exploiting the search for the specific sequence of events in the signal of neutron monitor. This sequence of events or variations presumably bares an imprint of the fractal structure of earthquake build up.

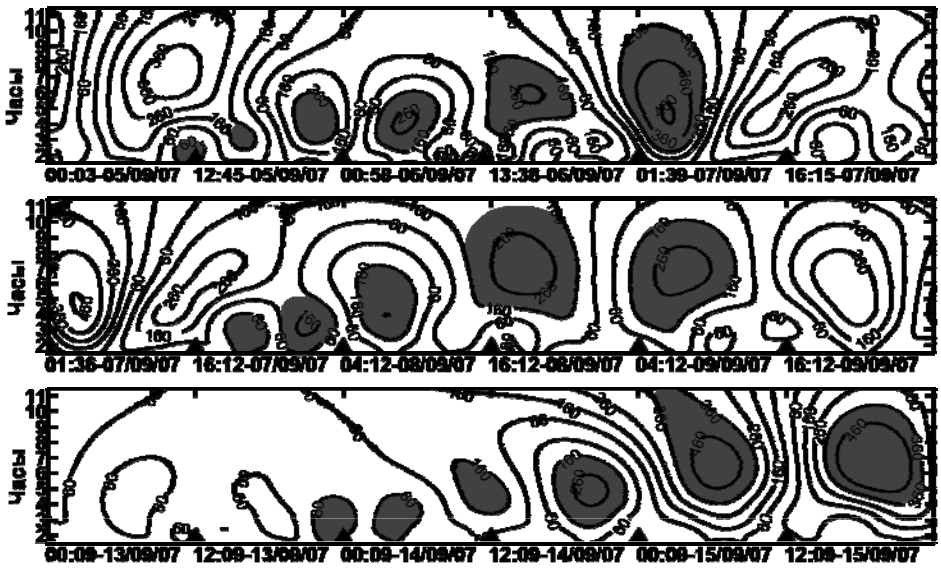

Fig.1. Selected parts of the signal wavelet transform from September 2007 data set. The time of the beginning and the end of variations could be seen from the X axis, scales are plotted on the Y axis. Earthquake precursor sequences are shaded in gray.

Depending on the particular experimental setup and the primary source of the registered neutrons, different authors are drawing connections between the neutron counting rate with the recurring earthquakes. M.A. Despotashvili et al. [2] and V. F. Ostapenko et al. [3] had studied the counting rate associated with the hard component of the cosmic rays and its standard deviation, while B. M. Kuzhevskij et al. [4] and N.N. Volodichev et al. [5] studied the neutrons produced in interaction between the alpha-particles released in the radioactive gases decay and different nuclei of the Earth's crust and atmosphere. Certain statistics of positive correlation has been presented in each work.

Modern theory of the fractal nature of the earthquakes development and building-up process is actively used for the earthquakes statistics, properties and mechanism analysis, as well as for its prediction of periodicity of seismic events. Besides the well-known and time-proven Guttenberg-Richter's and Omori's laws, other complex earthquake theories and models have found their practical applications [6].

Wavelet transform [7] applications are abundant and mainly include seismograms analysis [8] and their fractal nature [9], as well as neutron counting rates analysis performed in different locations [10]. However, to the authors' best knowledge, the persuasive analysis of correlations

between the frequency spectrum of neutron counting rate and the isolated earthquakes by means of wavelet analysis have not been published yet [1].

Experimental results

In this work we have studied a particular sequence of variations (see Fig. 1) in wavelet transform of the neutron monitor signal which could be qualified as a precursor of the forthcoming earthquakes. The program was written in Matlab to analyze the neutron counting rate provided by the 18 channel experimental setup that included preliminary noise filtration, signal averaging, atmospheric pressure correction and the following wavelet transform plotted as a contour plot for the analysis. Detailed description of the experimental setup (type NM64 neutron monitor at the Tien-Shan high elevation research station) could be found in publications and other materials [11].

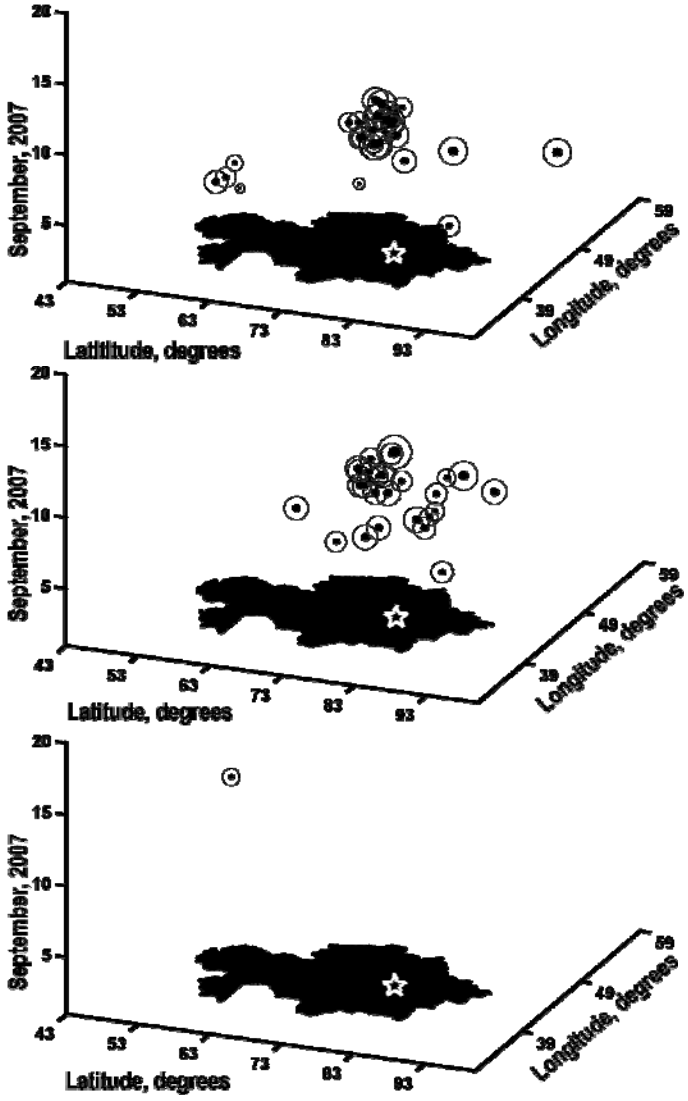

Fig.2. 3D maps of events preceding and following, within the 5 hour time period, the end of the signal variations plotted on Fig.1.

Figure 1 shows three occurrences where the sequence of increase in amplitude and duration of variations (scales from 2 to 7 hours) is observed. Each one is about two days long. The timeline is plotted on the X axis. We suggest that it is possible to see the signal bearing the imprint of the fractal nature of the earthquake preparation.

Figure 2 shows three-dimensional maps of these events. From top to bottom, each of the plots corresponds to its counterpart plot from the Fig.1. Latitude and longitude of the events are plotted on the X and Y axis correspondingly, Z axis represents the timeline of the earthquake, and the magnitude (from 2 up to 6) it is represented by black circumpuncts. The number of events plotted is determined by the 5 hours time period before and after the end of the variation. The range of the events taken into consideration is determined by a network of the monitoring facilities, MKAR, ABKAR, KKAR, BVAR and KURK (IRIS), available to the NNC KR [12]. White star represents the location of Almaty city.

Discussion

The first two pictures on Fig.1 are followed by the noticeable earthquakes of magnitude 3.85 (10.09 pm, September 07, 2007, local time) and 4.11 (03.31 am, September 09, 2007, local time). The third set of the data (00.09 am, Sep 16, 2007) is followed by the relatively quite period with no major earthquake registered within 5 hours range in both directions. We have chosen the end of the diurnal variation cycle as the sequence termination point.

Despite the fact that this particular experimental set-up is sensitive to all type of neutrons, hard and soft component of its flow at the detectors level, we can speculate the positive correlation between the presence of these variations and the forthcoming earthquake. The absence of such correlations in other studies may be attributed to the complexity of the events and low signal-to-noise ratio.

Conclusions and future studies

We have analyzed the available database for the specific variation from the beginning of the year 2007 till the present time. The main objective was to find the most effective mechanism of correlation between the single chosen event in the earthquake database of particular magnitude, depth and other properties with the continues data feed from the neutron monitor.

We suggest the possibility of the pattern analysis of the events clustered around the moment corresponding to the end of the variation (see Fig. 2).

In addition, we have developed interactive map of seismic events to analyze the events with similar properties in terms of neutron counting rate, as well as to search for possible connections and variations between the more distant events.

Acknowledgments

Authors would like to say thanks to the A.L. Shepetov (The Lebedev Physical Institute of the Russian Academy of Sciences, Moscow, Russia) for the data provided for the analysis. Also we would like to thank V.F. Ostapenko (Seismology Institute, Almaty, Kazakhstan) for helpful discussions.

References

1. A.H. Argynova, A.A. Loctionov, V.V. Oskomov, T.H. Sadykov, “Search for the short time variations in wavelet spectrum of neutron counting rate correlating with the processes of upcoming earthquakes build up”, “Contemporary space technologies”, Almaty, October 7-9, 2008, pp. 108-110.

2. M.A.Despotashvili, N.G.Khazaradze, N.A.Nachkebia, L.Kh.Shatashvili, D.I.Sikharulidze. Anomalous solar-diurnal variation of Cosmic Ray Neutron and Hard components intensity, cosmic phenomena and the problem of Earthquakes. Proceedings of the 26th International Cosmic Ray Conference. August 17-25, 1999. Salt Lake City, Utah, USA,Vol.7, pp.440-443.

3. V. F. Ostapenko, V. A. Krasnoperov. Analysis of natural neutron flux in a seismically active zone, Natural Hazards and Earth System Sciences, 2003, Vol:3, Issue:6, p. 777-780.

4. B. M. Kuzhevskij, O. Yu. Nechaev, E. A. Sigaeva, V. A. Zakharov. Neutron flux variations near the Earth's crust. A possible tectonic activity detection. Natural Hazards and Earth System Science, 2003, Volume 3, Issue 6, pp.637-645.

5. N.N. Volodichev, O.Y. Nechayev, Y.A. Sigayeva, V.P. Antonova, S,V. Kryukova, A.P. Chubenko, A.L. Shepetov. Registration of the thermal neutron flow from the secondary cosmic rays near the Earth surface during gravitational or seismic waves propagation. 31-st Conference on Cosmic Rays, Moscow, MSU, 2010, GEO_18, pp. 1-4.

6. P. Bak, K. Christensen, L. Danon, T. Scanlon. Unified Scaling Law for Earthquakes. Physical Review Letters, 2002, 88, pp. 178501-178505.

7. N M Astafieva, "Wavelet analysis: basic theory and some applications", PHYS-USP, 1996, 39 (11), pp. 1085–1108.

8. E. Bogdan; I. Kiyoshi; S. Zbigniew, Wavelet-based multiscale resolution analysis of real and simulated time-series of earthquakes. Geophysical Journal International, Vol.164, Issue 6, pp. 63-74.

9. Daizhi Liu, Ke Zhao, Hongxing Zou, Juan Su, Fractal analysis with applications to seismological pattern recognition of underground nuclear explosions, Signal Processing, Volume 80, Issue 9, September 2000, pp. 1849-1861.

10. N. Zarrouk, R. Bennaceur. A wavelet based analysis of cosmic rays modulation. Acta Astronautica, 2009,Vol. 65, Issues 1-2, pp. 262-272.

11. Antonova V.P., Chubenko A.P., Kokobaev M.M. et al. Phenomen of the anomalous delay of hadronic and electronic components of EAS // Nuclear Physics B (Proc.Suppl.), 1999, 75A, pp .333-335.

12. N.N. Mikhailova, I.L. Aristova. Reference events database for the needs of seismology. Vestnik NNC RK, 2005, 2 (22), pp. 62 - 72.

ЖЕР СІЛКІНУДІҢ АЛДЫНА АЛА БІЛДІРУШІ БИІК ТАУ АИМАҒЫНДАҒЫ ТЯНЬ-ШАНЬ ҒЫЛЫМИ СТАНЦИЯСЫНДА НЕЙТРОН МОНИТОРЫНЫҢ СИГНАЛЫН ВЕЙЛВЕТ ТҮРЛЕНДІРУІМЕН АНЫҚТАУ.

Н.М. Дуйсекеева, А.С. Құсайынов, В.В. Оскомов

Бұл жұмыста аз уақытық прогноз жер сілкіну мүмкіндігі Тянь-шань биік тау аймағындағы нейтрон мониторының сигналының вейлвет түрлендіруіне байланысты мінездемесінің өзгерісі қарастырылған. Тянь-шандағы биік тау аймағындағы стансиясының нейтрон мониторының санау жылдамдығының вейлвет түрлендіруі белгілі жер сілкіну мөлшерімен индекстелген. Біз күткен өзгерістер анықталған. Біз жиілік спектірінің өзгерістерінде болашақ жер сілкіну мумкіншілігі байланыс екенін байқадық.

ПРЕДВЕСТНИКИ ЗЕМЛЕТРЯСЕНИЙ В ВЕЙВЛЕТ ПРЕОБРАЗОВАНИИ СИГНАЛА НЕЙТРОННОГО МОНИТОРА НА ТЯНЬ-ШАНЬСКОЙ ВЫСОКОГОРНОЙ НАУЧНОЙ СТАНЦИИ

Н.М. Дуйсекеева, А.С. Кусаинов, В.В. Оскомов

Рассматривается возможность краткосрочного прогноза землетрясений, исходя из предположения о том, что оно должно следовать за характеристическими вариациями в вейвлет преобразовании сигнала нейтронного монитора. Вейвлет преобразование скорости счета нейтронного монитора на Тянь-шаньской высокогорной научной станции было проиндексировано с базой данных землетрясений. Были обнаружены вариации, отвечающие нашим ожиданиям. Мы наблюдаем определенную взаимосвязь между вариациями в частоте спектра с последующими землетрясениями.