Detecting earthquake precursors by mathematical modelling of ionospheric time series

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ABSTRACT

Aiming at earthquake precursors apportionment the earthquake preparation display of Nakhitchevan (Azerbaijan, 02.09.2008, M=5.1), Ararat (Armenia, 11.06.2008, M=2.6) earthquakes in time-series have been studied using the ionospheric tools. The anomaly in the ionospheric plasma is investigated by a radio-astronomical method forecast the earthquake.

Keywords

Earthquake, ionospheric, radio – astronomical method, time - series

1. INTRODUCTION

It is known, that the geophysical environment, including seismically active zones, is made up of solid, liquid and gaseous phases. It is known as well that in the zone of two phases separation a Zone of Separated Changes (ZSC) is formed, or as they are called in physical chemistry, double ionic (electric) layers. Depending on their structure, each of the ZSC of geophysical environment is characterized by capacity, inductive and resistance (see [1]). The results obtained earlier allow to make out the difference between activity of ionosphere, by the method of vertical reconnaissance of ionosphere.

Radio astronomical monitoring method makes possible, along with immediate detection of electromagnetic emission from the Earth's depth in the selected frequency band, to observe other types of lithosphere impact on the atmosphere, such as aerosol, electrostatic, acoustical/gravitational, etc. This configuration allows reception of signals from point cosmic radio sources Swan and Cassiopeia-A, with nearly the same amplitudes of interference lobes.

2. THE METHOD and TECHNIQUE of RESEARCH

A new Methodology has been elaborated that provides possibility to estimate the current Seismic hazard (its intensity, location and time) with a sufficiently big probability. The elaborated methodology was used for analysis of data received in the process of perpendicular ionosphere from "Swan- A" and "Cassiopeia - A" point radio sources by radio astronomy methods. With the purpose of earthquakes forecasting the anomaly formations in the ionospheric plasma are investigated by a radio-astronomical method. There have been used the time – series for Shooshi and Saravand ionosphere stations.

On (figure.1) values of power at discrete point radio sources before the Nakhitchevan earthquake are depicted. It can be seen from (figure.1) that electromagnetic radiation waves from discrete point radio sources had been absorbed,in result of which the estimates of radiation drastically changed. In (01.09.08, Saravand station) a change of election of concentration occurred which is a precursor of predicted earthquake. Similar anomalies were observed at Shooshi station (07.06.08, 11.06.08, figure3).

The detected anomalies are seismogenic, since all factors that can cause changes in concentrations of electrons in ionospheric layers were not observed that time it is evident from pictures that an absorbtion process took place which is a precursor of anticipated earthquake. The process on (figure2) reflects that before Nakhitchevan and Ararat earthquakes the power daily indications from discrete point radio sources had changed, which means that an absorbtion process took place.

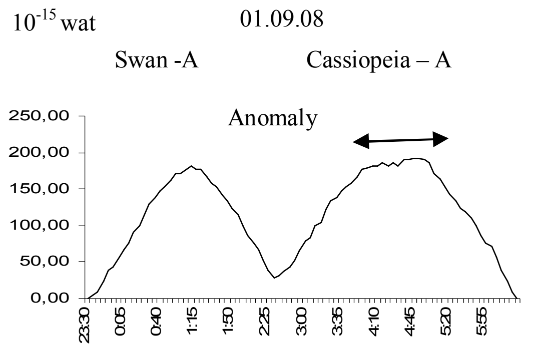

Figure1. The time – series of the ionosphere field (Saravand station) obtained by Radio astronomic method for the Nakhitchevan (Azerbaijan, 02.09.2008, M=5.1) earthquake preparation.

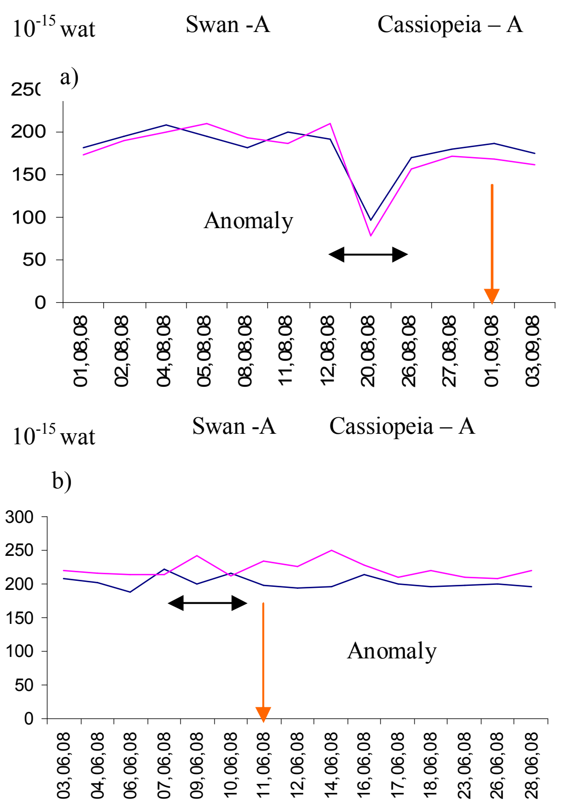

Figure 2 a)The time – series of the ionosphere field (Saravand station) obtained by Radio astronomic method for the Nakhitchevan (Azerbaijan, 02.09.2008, M=5.1) earthquake preparation.b) The time – series of the ionosphere field (Saravand station) obtained by Radio astronomical method for the Ararat (Armenia, 11.06.2008, M=2.6) earthquake preparation.

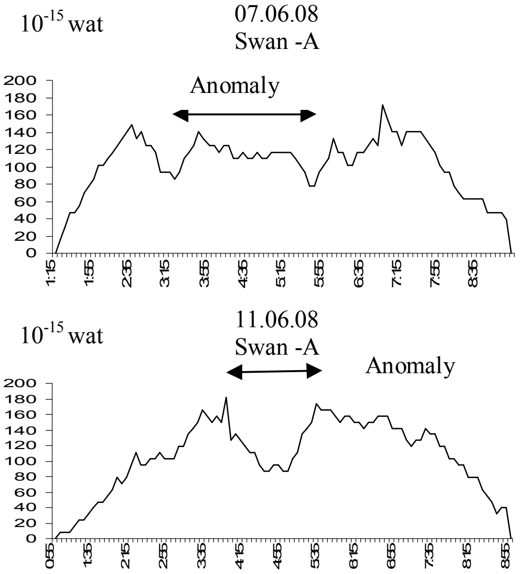

Figure3. The time – series of the ionosphere field (Shooshi station) obtained by Radio astronomical method for the Ararat (Armenia, 11.06.2008, M=2.6) earthquake preparation.

Ionosphere excitation possibility:
The theoretical substantiation

Taking it into consideration that a strong earthquake of M=7.0 is matched on average with a 35 km long rock rupture, a conclusion can be drawn that the linear dimension of a uniformly oriented ZSC area should fall on average within the limits of $l \cong$ 35 km.

Here, the radiation wavelength in the area of uniformly oriented ZSC is ($\lambda \cong$ 70 km).

In this way a low frequency radiator that emits electromagnetic radiation most effectively propagating in the atmosphere is formed under the action of elastic strains due to the effect of uniformly oriented ZSC during strong earthquake preparation in a seismically active zone.

The efficiency of very low frequency wave propagation ($\lambda \cong$ 70 km) with a quasi-square wave –front in the atmosphere is determined by the maximum quality of Earth-ionosphere spherical resonator and weak influence of such factors as diffraction and dissipation over the atmospheric in homogeneities.

Reasoning from the above, setting a task on the character of very long electromagnetic wave propagation from the seismogenic source in the atmosphere is apparently required. The equation describing propagation of electromagnetic waves for the quasi – static case and for the case of wave front perpendicular to the Earth surface is as follows ([2]):

$$\frac{d^2E(z)}{dz^2} = i\frac{4\pi\mu\sigma(z)\varpi}{c^2}E(z) \qquad (1)$$

where:

E is the electric field intensity:

$\mu \cong 1$ is the magnetic permeability of the atmosphere;

$\sigma(z) = \sigma_0 \exp\left(z/h\right)$ is the atmosphere conductivity in the direction perpendicular to the earth surface(z);

$\varpi = 2\mu f_0$ is the field angular frequency;

C Is the light speed;

H is the scope of atmosphere electric conductivity inhomogeneity.

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The general solution of equation (1) given by the exponential law of σ(z) changes with height ([3]). It is expressed in the following way ([4]):

$$E(z) = C_1 J_0\left((1+i)\frac{2h}{\delta}e^{z/2h}\right) + C_2 Y_0\left((1+i)\frac{2h}{\delta}e^{z/2h}\right) \quad (2)$$

Where $\delta = c/\sqrt{2\pi\mu\sigma\varpi}$ J (z) and Y(z) are Bessel`s functions of zero order , first and second kind correspondingly, C1,2 are constant coefficients, defined by boundary conditions (one of them is, $E(z) \to 0,$ given $z \to \infty$).

Far from the Earth surface the arguments of Bessel,s function are much greater than 1, so it can be easily supposed that asymptotic expression could be implemented.

$$J_0(z) \cong \sqrt{\frac{2}{\pi t}}\cos\left(z - \frac{\pi}{4}\right) \quad Y_0(z) \cong \sqrt{\frac{2}{\pi t}}\sin\left(z - \frac{\pi}{4}\right) \quad (3)$$

Substituting the value of argument z from (3), E (z) takes a form:

$$\mathrm{E}(z) \cong a_1 e^{-z/4h}\cos\left[(1+i)\frac{2h}{\delta}e^{z/2h}\right] + a_2 e^{-z/4h}\sin\left[(1+i)\frac{2h}{\delta}e^{z/2h}\right] \quad (4)$$

where a_1 and a_2 are (4) new constants.

Defining sin and cos, calculating the electric field modules square (intensity) we obtain that an exponential term $e^{-z/2h}$ is multiplied by the sum of two terms. One of them oscillates according to the $\sin\left(\frac{2h}{\delta}e^{z/2h}\right)$ and $\cos\left(\frac{2h}{\delta}e^{z/2h}\right)$ law, while the second grows rapidly obeying the $ch\left(\frac{2h}{\delta}e^{z/2h}\right)$ and $sh\left(\frac{2h}{\delta}e^{z/2h}\right)$ law.

As far as the second term grows faster than $e^{-z/2h}$ it has physical meaning. What this means is that the coefficient preceding the second term shall be equal to 0.If this is the case then

$$|E(z)|^2 \cong Ae^{-z/2h}\cos^2\left(\varphi + \frac{2h}{\delta}e^{z/2h}\right) \qquad (5)$$

where A and φ are constants.

Expression (5) indicates that on average the electric field attenuates according to the exponential law.

More interesting, however, are in our opinion, the results that the field value $E(z)$ rapidly oscillates as z height increases due to $\cos^2\left(\varphi + \frac{2h}{\delta}e^{z/2h}\right)$ term.

Therefore expression (5) proves that low frequency electric field $E(z)$ radiated by the seismogenic nature source (the are of uniformly oriented ZSC) experiences strong oscillations in higher atmosphere layers during earthquake preparation.

Taking into account that in high atmospheric layers, at the level of a highly conductive ionosphere, the electric field intensity constitutes rather small values, it is not difficult to suppose that strong (5) oscillations of low frequency electromagnetic wave reaching the ionosphere, from the seismogenic source, may cause significant ionosphere disturbances.

3. RESULTS

The results of the retrospective analysis of ionosphere observation data before Nakhitchevan (Azerbaijan, 02.09.2008, M=5.1), Ararat (Armenia, 11.06.2008, M=2.6) revealed the following basic types of anomaly (Figure. 1-3):

1. Blinking of ionosphere active radio-source Swan – A on the frequency of 74 MHz.
2. Anomaly of above – mentioned precursors is coming out up to 10 days before earthquake.

4. CONCLUSION

The results of analysis by used methods show that the anomalies generally appear on 1- 10 days before the earthquake.

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