ENGINEERING SCIENCES

COMPUTER FORECASTING OF EARTHQUAKES BASED ON THE STUDY OF CHANGES IN THE WATER LEVEL IN THE CONTROL WELLE

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DOI: https://doi.org/10.30525/978-9934-588-84-6-18

The natural disasters forecasting, such as earthquakes, remains very relevant for humanity, but, as shown by Kanamori H. [1, p. 1429], has still not been resolved. One of the ways to solve it is associated with the search for precursors sensitive to impending disasters, for example, water fluctuations in deep wells.

So, as shown by Wang C. Y. [2, p. 56], the seismic wave’s generation is accompanied by various violations of the ground hydrodynamic regime and surface waters in the form of changes in pressure and water level in a measuring well. During severe earthquakes of magnitude 8–9, the seismic wave’s effect as shown by Roeloffs E. A. [3, p. 880], recorded at distances up to tens of thousands of kilometers from the epicenter. This reflects, as shown by Brodsky E. E. [4, p. 2392], the planetary scale of the impact of such earthquakes on the Earth's hydrosphere.

A similar effect is carried out, as shown by Cooper H. H. [5, p. 3920], through seismic waves reaching a well. An important frequency component of these waves, as shown by Bower D. [6, p. 335], is the lunar-tidal harmonic.

The article considers the earthquake forecasting methodology, based on on the behavior analysis of the water fluctuations in deep wells in the period preceding the earthquake, which, as shown by Nahornyi V. V. [7, p. 163], allows a reliable forecast of the time of the forecasted earthquake.

The considered earthquake forecasting methodology consists in regular monitoring of prognostic sign (precursor) value of the natural disaster. The nature of the water level fluctuations in the measuring well is considered as a similar feature in the article.

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Level measurements are made in 6 min increments throughout the entire monitoring period. The amplitude H_w of the water level obtained during each of the measurements complements the array of previously obtained data and creates a time series (trend) with them. This series serves as initial data for forecasting a future earthquake in a region that is under the control of a measuring well under consideration.

Mathematically, the forecasting procedure is to minimize the functional (1):

$$U = \sum_{i=1}^{n} \left(H_w - H_w^m \right)^2 \tag{1}$$

where H_w^m – amplitude value calculated using the forecast model; n – number of time series values.

The analytical expression for the forecast model is as follows:

$$H_w^m = H_w(t_0) \cdot \left[1 + A \cdot \left(\frac{t - t_0}{T_{for} - t} \right)^{\alpha} - B \cdot \left(\frac{t - t_0}{T_{for} - t} \right)^{\beta} \right], \tag{2}$$

where T_{for} – earthquake forecast; t_0, t – registration time of the controlled parameter, respectively, at the time of initial and current measurements; $H_w(t_0)$ – amplitude value recorded in the first measurement; A, B, α, β – experimental parameters determined together with time T_{for} in the initial (field) data approximation by the forecast model.

Time T_{for} is the most probable (mathematical expectation) of the forecast, which with a confidence probability $P_{con} = 0.95$ is covered by its confidence boundaries T_{for}^{up} and T_{for}^{low}. These boundaries are recorded in the «Earthquake Forecast Protocol».

The initial data for forecasting were obtained as a result of the water level measurements in a well located in the south of Ukraine from November 23, 2018 to March 3, 2019 as shown in Figure 1.

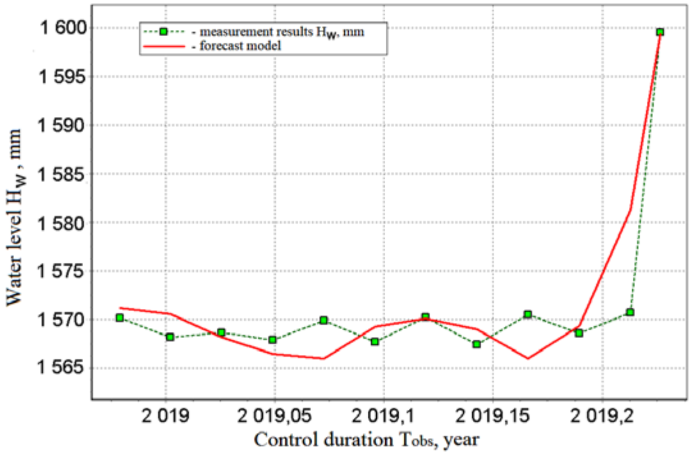

Figure 1. Records of changes in water level during the observed period

The time series composed of amplitude value recorded in the measurement is shown in Figure 1.

Character of the forecast change T_{for} determined regularly every 10 days during the observation period is shown in Figure 2. The forecast confidence limits (P_{con}=0.95) are also indicated there. Forecasting lead was 100 years.

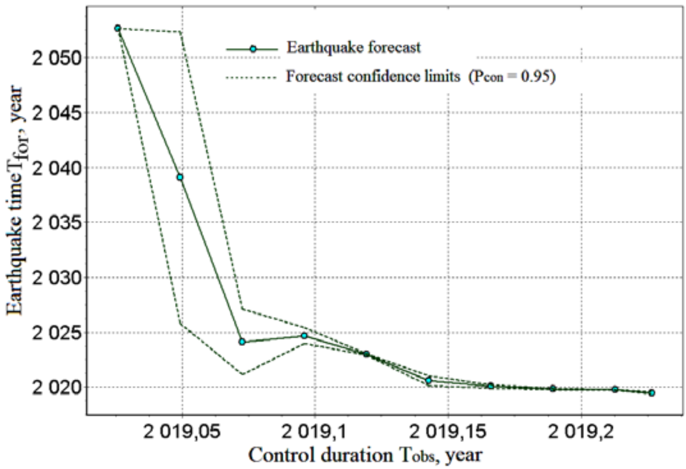

Figure 2. Earthquake Forecast

The figure clearly shows that as the number of trend points approximated by the model increases, the forecast confidence limits narrow, and the forecast itself over the last 4 points remains almost unchanged.

The last control of water fluctuations is reflected in the «Forecasting Protocol...».

PROTOCOL

earthquake forecast

(for 2.22.2019)

- most likely earthquake date:

6.17.2019

- with confidence $P_{conf} = 0.95$ varies within the following limits:

from 5.19.2019 to 7.16.2019

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