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Information precursors of the Sakurajima volcanic eruption of November 14, 2018

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Abstract. The morphodynamics of a local thesaurus of communications within the Internet community responded to the manifestation of both seismic and volcanic activities during the Sakurajima volcanic eruption of November 14, 2018, on Japan's southern island of Kyushu and the preceding strong earthquake of November 4, 2018, in the vicinity of the Island of Hokkaido. An ontological model of seismic hazard precursors and estimates (obtained using Internet search engines) of the frequency of semantic characteristics of a seismic hazard were used for form a local thesaurus. The prospects for using information precursors and Internet resources in monitoring both seismic and volcanic risks are discussed.

Keywords. Volcano, eruption, seismic hazard, precursors, thesaurus, search engines, Internet, society.

1. Introduction

Socium, as an element of the anthropogenic impact on the natural environment, is a bioindicator of changes in its state [1-3]. However, not all bioindicators identically feel and respond to changes in the environment. But such changes may manifest themselves in large sociums.

The second signaling system unites any socium. Changes in the activity of socium representatives even in the face of latent natural or imposed hazards inevitably manifest themselves in the morphology of their thesaurus. This phenomenon may be recorded using technical means of communication. With advances in social networks, Internet, and artificial intelligence technologies there is a unique opportunity to diagnose the social behavior of different sociums for specific regions on a time scale that is close to the real one.

The conceptual scheme of the socium response to geophysical field disturbances during volcanic or seismic risks is given in Figure 1.
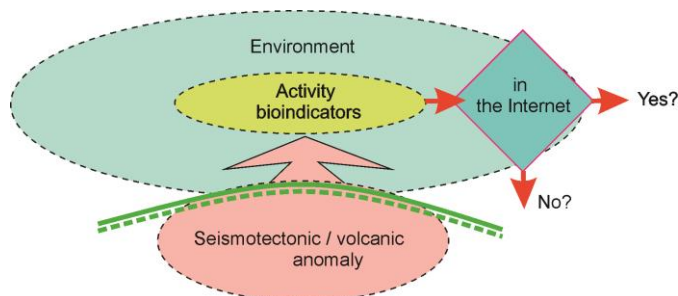

Figure 1. Interaction of geophysical field disturbances during volcanic or seismic risks with the behavior of bioindicators

In Figure 1, it is assumed that the effect of geophysical fields is detected by socium bioindicators and manifests itself in the intensity of communications, search for answers to arising questions and associations, and in the thesaurus morphology. Internet search engines, which are a tool for diagnosing the activity of the Internet community, are actively used to amplify signals and search for information [4-6]. To this end, programs have been created for text processing, linguistic searching, and information analysis. Local thesauruses---sets of query words associated with the ontology of potential processes or phenomena---are used in this search.

According to the reaction of the Internet community, it is necessary to diagnose the ontological model of a process or phenomenon that is represented by a knowledge base and briefly characterized by a list of the most important words that affect the consciousness and speech of people. This list is a local thesaurus that may be used to diagnose the risk of the ontological model of a dangerous process or phenomenon in the communication environment.

The list of the names of earthquake precursors is usually used to form a local seismic hazard thesaurus. According to these names (queries), one can estimate their citation using the technical capabilities of the Internet counters of search engines. The larger the citation is, the larger number of participants involved in the discussion of the problem is. In this case, one can study the structure of the participants in the socium, obtain estimates of the time spent on the site that is also characterized by a set of query keywords, the number of pages viewed on the site, the geography of visitors, gender characteristics, the frequency of returns to the site, the type of access to the site (mobile or stationary), and other metrics. This may be used in estimating the mental features of the behavior of the Internet socium in specific regions, including religious grounds.

2. An interaction process model

The representatives of the second signaling system are affected by those of the first signaling system, who respond to changes in the state of geophysical fields. The seismic activity is associated with the mental state of people in the corresponding regions, the formation of the corresponding "…value system and culture in general (behavioral and socio-political), which ensure the survival of the human community under given conditions…", and with a complex of geophysical fields and their disturbances [7, 8]. The effect of the seismogenic disturbances of geophysical fields on the mental state of socium manifests itself also in other seismically active regions [3].

What causes this effect? The lack of oxygen in the middle mountains (as well as weather and climate) affects thought processes and behavior. The potential mechanisms of the effect of a complex of geophysical fields on biosystems due to variations in the properties of water molecules, including those in the human body, which is reflected in both physical and mental states of people, are discussed in [9].

Ionospheric disturbances are recorded over seismically hazardous regions before strong earthquakes [10, 11], which, due to Schumann resonances and Rydberg radiations, affect the properties of blood, fluids, and behavior---the activity of the representatives of both first and second signaling systems. The activity is directed toward satisfying needs (drives, motives, intentions, etc.) and searching (including on the Internet) for answers to safeguarding questions. This factor is also used in social activity modification technologies. The behavior and responses to hazards and risks are the visible observable part of mental activity.

A number of technologies have been developed to obtain online estimates of the Internet community's moods and activities [12]. It is quite natural to adapt these technologies for monitoring hydrometeorological, seismic, and volcanic risks. The preliminary stage in implementing this plan is to measure the social activity in seismically hazardous regions using modern search engines and to assume that the primary converters of geophysical field disturbances during the preparation of an earthquake are the Internet users. Their behavior should show a search for the confirmation of their observations and feelings, descriptions, and discussions through electronic messages and texts on the Internet. Such an activity in the form of psychomotor acts (actions) on the Internet is directed toward communicating and searching for satisfaction of needs (drives, motives, intentions, etc.).

The Internet community enhances the occurrence of weak signals-feelings from individual users by increasing their number and the frequency of the words under discussion, for example, semantically related to earthquake preparation processes. Changes in the flow of query words (rhombus in Figure 1) may be represented in the form of the simplest simulation model of a box with both input and output information, control actions according to the state standard R ISO/IEC 12207-99 (Figure 2).
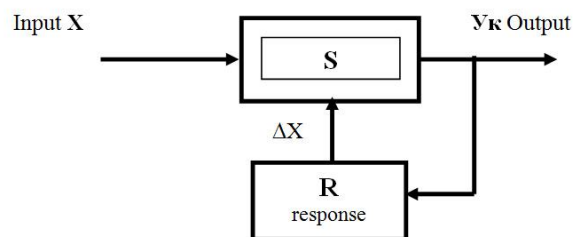

Figure 2. Scheme of the response of the Internet community: **X** is the input information flow, **Y** is the output result, **S** is the transfer function, **R** is the feedback function

The response function is associated with the activity of bioindicators for the output information flow. In the simplest case, coefficient R is usually within the interval $]0…1]$; S may represent the functional of security or response of the Internet community to incoming information that characterizes the state of the environment. For the response to a seismic risk, $0 < S < 1$, which is characteristic of a weak sensitivity of bioindicators.

At prompt feedback $\Delta X = RY$, $Y_к = S(X+\Delta X) = S(X+RY) = XS/(1–RS)$. Coefficient $S/(1–RS)$ determines the capacity of regulation. The value of Y may increase due to feedback. Estimating the hypothesis $Y_к > Y$ (**?**) makes it possible to estimate the existence of informative earthquake precursors.

For the technical implementation of the screening of the Internet community's activity, there are operators-suppliers of search engines in the field of electronic information (Yandex™, Google™, Bing™ and others), which provide the place for its location, content aggregators (for example, Digg™, Reddit™), content recommendation systems (for example, StumbleUpon™, Pinterest™), etc. They often combine several functions, including the possibility to process texts and complex queries in the Internet search engines, linguistic search programs, and information analysis.

The results obtained by [1, 2, 5, 13, 14] formed the basis for ontological models describing notions of earthquake preparation processes.

Simplified (colloquial) terms were used to form a working local thesaurus for the experiment, because, at a latent seismic risk, for example, "hydrogeological precursors" are unlikely to be discussed among most members of the Internet community. Most likely they will manifest themselves in using the key term "water". "Gravitational precursors" may manifest themselves through the term "sleep" etc. A set of such simplified terms formed the working

local thesaurus, which was thinned out based on the analysis of the frequency of query words for more than three dozen strong earthquakes in different regions of the world. The working set of query words included: avariya, zdorovye, voda, vozdukh, radioaktivnost' and their English analogues: crash, health, water, air, radioactivity. The bilingualism was due to the fact that, on the Russian-language Internet, the portion of the Google search engines used is comparable to that of the Yandex search engines [4]. The set of the indicated terms forms a semantic subset to diagnose seismic risks.

3. Experiment results

The results of estimating volcanic hazards became a side effect in diagnosing seismic risks according to a set of query words on the Internet using search engines. No special set of terms to diagnose volcanic hazards was formed. The Sakurajima volcano on Japan's southern island of Kyushu threw out a column of ash and smoke up to 4 km high on November 14, 2018. The volcano height is 1117 m above the sea level. The eruption hazard was associated with the fact that the Sendai nuclear power station is located at a distance of 50 km from the volcano, one of the power-generating units of which restarted in late 2017, and it has been producing electricity in industrial volumes since 2017 [15, 16].

The dynamics of the set of the indicated query words was studied using search engines, in the algorithms of which each query word is searched for in all possible forms (plural, case, etc.). The results found by the search engines were tabulated with the sampling result (in the xml format, in the Internet Explorer). The queries received in the format---*query word*+*georeference*+*date*--- did not necessarily reflect themes or relation to a country/ locality, because messages could only mention the indicated geographical region. Moreover, the query words are rather abstract. Errors in georeferencing were also possible. The typed arrays of messages were strictly filtered with respect to advertising messages.

Figure 3 gives the results of message filtering in the form of changes in the sum of minimax normalized frequency of the words - «crash», «water», «air», «health» and «avariya», «voda», «vozdukh», «zdorovye» - before and after the volcanic eruption of November 14, 2018.
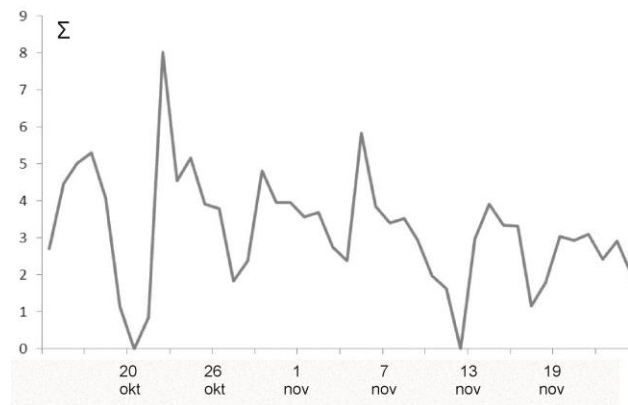

Figure 3. Changes in the sum of minimax normalized frequency of the words «crash», «water», «air», «health»   and «avariya», «voda», «vozdukh», «zdorovye» on the Internet for Japan in October-November 2018

On November 13, 2018, the day before the eruption, the activity of the Internet community (mass media) rapidly decreased (see Figure 3). A decade before, on November 4, 2018, 19:26:3.7 UT, a strong earthquake (epicenter coordinates 44.50 N, 145.65 E, H=24 km) with a magnitude of 6.2 (5.8 according to other estimates) occurred near Hokkaido. A little earlier, at 18:54:23.3, an earthquake (M=5.0, 23.48 N, 143.33 E, H= 10 км) was recorded (Volcano Islands, Japan).

Weak signals are well pronounced aganst the background of natural noise according to spectral analysis results. The normalized amplitude diagram of the time series in Figure 3for a sliding window 16 days wide is given in Figure 4.
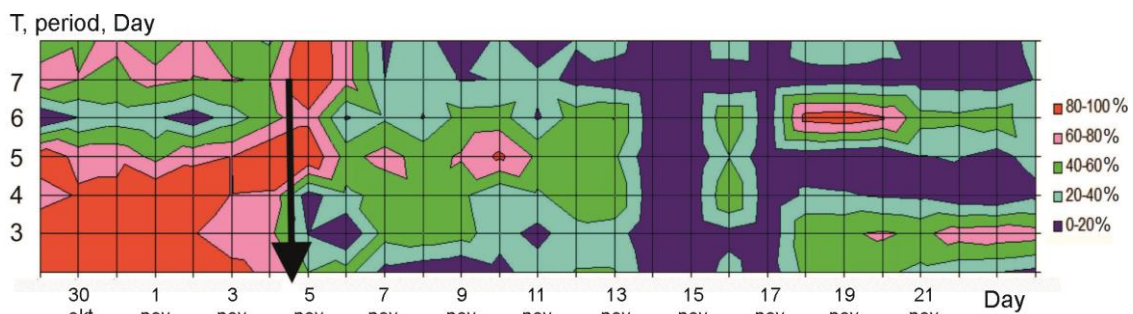

Figure 4. Normalized amplitude diagram of the time series in Figure 3 for a sliding window 16 days wide

The black vertical arrow corresponds to a day with the earthquake.

The spectra were calculated using the fast Fourier transform and were assigned to the right border of the window. The calculated estimates of the amplitude for each period in the spectra were normalized according to the minimax of the period under analysis, which was determined over the entire set of spectra in the observation period under consideration.

Three fragments may be distinguished in the morphology of the amplitude diagram of the frequency of the query words-before, after the earthquake before its eruption, and after its eruption. During its eruption, the Internet community rapidly reduced the use of the query words under analysis. The signs of the eruption preparation (according to the semantic criteria of seismic hazards in amplitude T=5 days) were masked by the effects of the strong previous earthquake that occurred 4 days before the event.

Before the earthquake, the amplitudes of the 3-, 4-, and 7-day periods increased with respect to average (with going beyond the boundaries of the 95% confidence interval according to the Student criterion), and the amplitude of the 6-day period decreased with respect to average. On the whole, the earthquake occurred at an increased level of the amplitude of all periods before November 5, 2018. Then, the amplitude diagram is recovered to both background and lower (with respect to the background) values until the time of the eruption of November 14, 2018, marked by minima (with going beyond the boundaries of the 95% confidence interval according to the student criterion) for all periods under analysis.

It is quite possible that the results could be better in analyzing the activity of regional social networks. This applies to both Russian- and English-language publications.

The magnetic activity was low in summer 2018 and it started to slightly increase in fall. This is a known seasonal effect. Within the time period under analysis, the magnetic activity was low. Only the next day after the earthquake, on November 5, 2018, the daily mean planetary Kp-index reached 4. However, there was no surge in the frequency of the query words. The new moon was observed on November 7, 2018.

Figure 5 shows the change in the difference between the sums of the minimax normalized frequency of the words -«crash», «water», «air», «health» and «avariya», «voda», «vozdukh», «zdorovye» - for the time period under analysis.
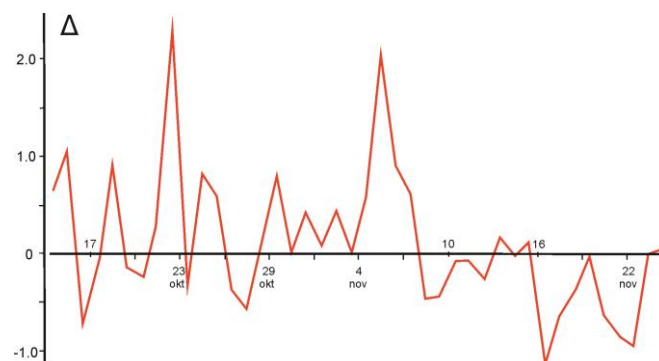

Figure 5. Change in the difference between the sums of the minimax normalized frequency of the words «crash», «water», «air», «health» and «avariya», «voda», «vozdukh», «zdorovye»

The mean value of the analyzed parameter in Figure 5 0.107, RMS=0.703, before the earthquake from October 14, 2018 to November 4, 2018 (including the day with the earthquake) the mean value is 0.301, RMS=0.671, after the earthquake from November 5, 2018 to November 24, 2018 the mean value is -0.106, RMS=0.710.

It is sufficiently evident that, before November 6, 2018, the difference in the sums of the English words («crash», «water», «air», «health») exceeded that of their Russian equvalents. The peak between November 4 and 7 is due to the Russian public holidays. After November 7, the reverse trend was observed. This does not imply that the representatives of the Russian-speaking Internet community responded to the strong earthquake with a delay. In their messages, they responded to the catastrophe that occurred in the other country expressing their condolences in accordance with the homeostatic principle of human mental functioning. This principle is directed toward leveling the balance disturbed by any external or internal effect with the help of activities and subsequent calming. This is what happens after an earthquake. Before an earthquake and during a seismic calm, the hedonistic principle of activity motivation works most likely, which is accompanied by the feeling of satisfaction due to a decrease in the stress level; however, under weak precursor perturbations of geophysical fields, unmet needs may appear. At any motivation of the behavior, the principle of energy conservation also works.

4. Conclusions

Monitoring the morphodynamics of the Internet community' thesaurus proved promising in estimating the infromation precursors of both seismic and volcanic risks.

The morphodynamics of the flow of semantic characteristics of seismic risks supported the response of the Internet community to the volcanic eruption and the preceding strong earthquake in the region. Before the earthquake, the hyperactivity of the Internet community was noted according to the set of the query words used for search engines. There are surges that imply precursor signals.

During the eruption of the Sakurajima volcano on Japan's southern Island of Kyushu (November 14, 2018), the regional Internet community significantly decreased its activity in using the working local thesaurus used in diagnosing seismic risks; this activity recovered within, at least, two weeks.

It is necessary to form a local thesaurus of semantic characteristics for monitoring volcanic hazards.

Conflict of interest statement

There is no conflict of interest.

Authors Contribution

Alexandr V. Tertyshnikov - author, idea, calculations, text, decoration.
Sergei N. Kulichkov - consultations, translation

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