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NATURAL HAZARDS AND EARLY WARNING SYSTEMS

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ABSTRACT. Several classifications about the different natural hazards and their possible influence are constructed. The possible early warning systems are considered. Both topics are under investigations due to the many factors influencing these issues. The natural hazards are classified on the basis of their area coverage, power (intensities and/or magnitudes), destructive potential and other physical properties like time duration, medium where they occurred, etc. The reliability, effectiveness and the possibilities of the data collection, transfer and warning issues are considered about the recent early warning systems. Critical analysis is made concerning the physical properties, modeling abilities, transfer velocity, etc. The critical points of the warning systems are outlined. It is shown that many factors are influencing these activities and the reliable early warnings for the different hazards are still under development.

ПРИРОДНИ БЕДСТВИЯ И СИСТЕМИ ЗА РАННО ПРЕДУПРЕЖДЕНИЕ

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РЕЗЮМЕ. Предложени са няколко класификации на различни природни опасности, както и за системи за ранно предупреждение от тях. Изследванията са продиктувани от многофакторния, комплексен характер на проблемите свързани с тях. Природните бедствия са класифицирани според тяхната сила, разрушителен потенциал, физически свойства и средата в която се случват, както и по време на продължителност. Отчетени са надеждността, ефективността, възможностите за събиране и обработка на данните, моделирането на развитието на процесите и други важни параметри на възможните предупредителни системи, като скорост на предаване на данни и решения, начини за достигане на информацията до населението и управляващите институции и др. Отбелязани са критичните моменти в различните възможни ситуации. Показано е, че поради сложността на тези дейности, изграждането на надеждни системи за ранно предупреждение все още се намира в стадии на изследване и развитие.

Introduction

The recent development of the technology and the fast information transfer is the main basis of the development and implementation of the early warning systems (EWS) about different natural hazards. Since several decades the early warning systems considering different hazardous phenomena have been developed in different countries on global, regional and local scale. They are based on the physical properties, destructive potential and better organization oo the information dissemination to the decision makers, specialized institutions and population. During the last years, sophisticated satellites are following the forest fires and floods development, desertification, droughts spreading, etc. All these distant methods have been developed in close cooperation with the surface observations and monitoring. During the last years (especially after the destructive Sumatra tsunami in the Indian ocean, 2004) large actions and funding have been targeted to the GEOS (Global Earth Observing System). They are focusing on multipurpose targets – continuous monitoring, fast data exchange, easy accessibility of the end users. New experiments of establishing regional and local early warning systems targeting to the increased reliability to relatively fast processes and phenomena – tsunamis, earthquakes, flash floods, volcanic gas and lava eruptions, etc. are under development. Staring with the Pacific tsunami early warning system (PTEWS) (established in the early 60-ties with headquarters located at Hawaii), the first experiences have been collected. The observations, modeling (travel time calculations, the locations of the strong, powerful tsunamigenic earthquakes) and the fast and reliable warnings dissemination have been launched among the priorities of that system. After that, the positioned stationary satellites have been launched on orbits and the meteorological phenomena get in focus of the everyday practice of the meteorological forecast. Then branching systems about the typhoons and hurricanes prediction and their development and modeling, going trough the tornadoes generation and consequences and the expected storms (hails, snow or rain), etc., have been established und used by the institutions. In this way the meteorological prediction systems are the most successful and wildly used in the practice during the last years. During the last times satellites and land based recent systems started operation to the volcanic continuous observations. With some successful eruption predicted these technologies are used as well as about the different mass movements observations, modeling and forecast – landslides, avalanches, slope processes and mining activities and consequences, etc. The recent technology transfer and fast development of the communication technologies put new challenges to all existing, new established and newly developing early warning systems. The main aims of this paper are to investigate and formulate the possible effectiveness, reliability and possible fast transfer to the end users. The both sides of this phenomenon are considered: The early warning system as the physical basis of the used parameters for higher reliability from one side and the compromise between fast alerts and reliability on the other. Some classification are developed investigating the possibilities of the recent technologies to cover the need for fast and reliable early warnings in the different fields of the natural hazards and risks to the population. This is really important due to the possibilities to safe people's life and properties.

Classifications of the natural hazards

In general several natural hazards have been under consideration:
Solid Earths' events like: Forest fires (FF), Earthquakes (E), Volcanic eruptions (V), Subsidence and collapse (S+C),
Landslides (including most of the slope processes, like mud flows, rock slides, etc.) – (L), Avalanches (A);
Hydrosphere events like: Floods (including flash floods) – (F), Tsunamis (T);
Atmospheric (meteorology) events like: Storms (including rain, snow and hail) – (S), Frost and Icing (F+I), Strong Winds (SW) – (including tornadoes, typhoons, hurricanes).

Table 1
Classifications of the natural hazards according the possible time duration (TD), possible time of early warnings, level of sudden appearance and the reliability of the early warnings

Hazards/ Parameters	E	L	V	S+C	F	T	S	I+F	SW	FF	A
Possible time EW(min.)	$0\text{-}10^{1}$ (aft.)	10^{0}-10^{3}	10^{2}-10^{5}	$0\text{-}10^{1}$	10^{2}-10^{3}	10^{1}-10^{2}	10^{2}-10^{3-4}	10^{2}-10^{3}	10^{2}-10^{4}	10^{2}-10^{3}	$0\text{-}10^{3}$
TD(min.)	10^{-1}-10^{1}	10^{1}-10^{4}	10^{2}-10^{5-6}	10^{0}-10^{2}	10^{2}-10^{4}	10^{1}-10^{3}	10^{2}-10^{4}	10^{2}-10^{4}	10^{1}-10^{3}	10^{2}-10^{4}	10^{-1}-10^{1}
Level of sudden appearance	H	H-M	M	H	M-L	M	M-L	L	H-M	L	H
Reliability EW	L	L-M	L-M	L	M-H	M-H	H	H	H	L-M	L

Time dependency is another aspect of the reliability and classifications – the velocity of the process and the data (information) and warning transfer trough the channels of communication is essential. The duration of the single or multiple hazardous events is also a specific characteristic of the different natural dangers and a new and useful classification is proposed. It includes – the time duration, the level of sudden appearance of the natural hazards (like a measure of the predictability), the possible time and the reliability of the early warning in minutes. – Table.1. (Ranguelov, 2006). All data in the Table 1 are in minutes. Level of sudden appearance and the reliability of the early warnings are presented qualitatively. L – means low, M – middle and H – high. The different diapasons are also acceptable. For example the time prediction of the earthquakes are not possible, but for the aftershocks (the strongest one) is rather common. For some phenomena (especially in the solid earth) level of sudden appearance is high, for others – the predictability based on the process development is very high (for example in atmosphere and hydrosphere).

Potential reliability of the EWS

The reliability is assessed on the recent knowledge of the physics of the process and possible measurements and assessment of its future development. Most of the systems are looking for some direct expressions as precursors of the generated natural hazard (for example clouds configuration and air velocity for the hurricanes). Some are considering non direct relationships (for example underwater strong earthquakes as generators of tsunamis). Most of the existing systems are modeling the possible dynamics of the expected or developing hazardous events. So the reliability is a complex multiparametric function of many factors acting in different directions. The most important are:

The physical properties the hazardous event – power, magnitude, intensity, space position, etc. These are measurable parameters thus suggesting that's why the accuracy of the measurements is essential. The transfer of data and information is another essential element, because the velocity of this process influences a lot the effectiveness. The models used and the parameters included in them are influencing direct or not direct spreading and distribution of the dangerous elements and parameters of the hazardous event. Frequently different approximations are used to decrease the computing time.

The transfer of the information of any kind – from the measurements sensors to the data collecting centers from one side is essential. Then to obtain reliable information about the development of the phenomena and to predict its development in time and space is not an easier task using primary information or through the models. The transfer to the decision makers and the warning information dissemination to the public and end users is the most important (and one of the most difficult) task on the other side.

The information transfer considerations

The data and information transfer may use some recent facilities: satellites, radio links, cell networks, telephone lines.
The data used by the early warning systems usually are signals generated by the sensors in the frequency diapason

0.001–100 Hz. The high dynamic range is around 120 dB. These signals could be transferred by analog or digital channel.

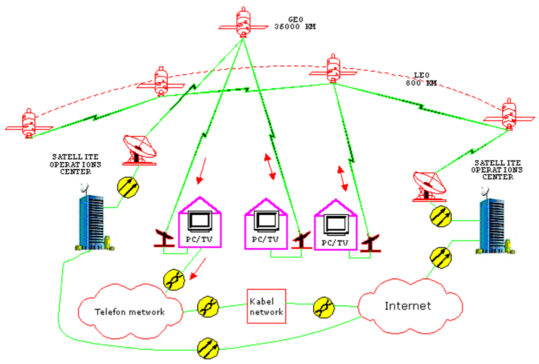

Fig. 1. The transfer of the data and information for the early warning system is an essential element

Usually the analog signal has low amplitude and needs some measures and devices to provide its reliable transfer like magnifiers, filters and compensators, etc. There are cable networks in use to transfer the data into the information centers for data processing. The disadvantages of such networks are the high price of the transfer and the larger losses of the useful part of the signals. There are as well the transfer networks using the telephone cables. They need a modular frequency (500 to 2500 Hz) to modulate the signal.

These networks have also some disadvantages – high noise ratio, vulnerability to the different construction works, high price cables, etc. All analogue channels have the biggest advantage – they allow the real time analog signals transfer. The digital networks (even the most sophisticated) work in the near real time mode. The digital technology goes fast in all recent systems. The advantages of this technology are much more – the digital signals are reliable to the noise protection, the data transfer and processing are much easier using the recent computer technologies, the data storage is much more effective. The low prices and the wide use of the digital technologies make them leaders in the recent early warning systems. In many cases the analogue channels are eliminated by the high density information channels compressed even in a single cable doublet. The telephone companies introduce the digital technology and increase the security and reliability levels of their transferred signals. The recent cellular networks are also suitable for the signal and information transfer. Such type transfer networks are related to the radio links. The price is lower, but the special regime of use needs more administration and formalities, like retranslations, heavy problems connected with the sharp relief, etc. A variant of the radio links is the satellite connection. After the big numbers of geostationary satellites have been launched to orbit they build up a network which is largely used about the telemetry of the geophysical and meteorological data. The satellites on Low Earth Orbit (700-1400 km) are called LEO, on the medium (10000-15000 km) – MEO and on the Geostationary (36000 km) – GEO. All these satellite systems created the global communication ring, which is under operation for different purposes. To use it as an element of the early warning systems is the main challenge of the recent times.

Existing and near future early warning systems

The differences between the recent and near future early warning systems are the two heavy and slower blocks presented on the scheme – Fig. 2. – the processed information - transfer and the end users and decision maker's solutions. They could be eliminated by the simplest, but most powerful software and hardware able to decrease the false alarms using the triggering mechanism and intelligent sensors, which may provide more reliable information and take decisions about the early warning dissemination automatically. The philosophy about the recent and the near future systems shows that it could be possible to eliminate the slower and less effective blocks concerning the transfer of the processed information and the end users and decision maker's solutions – to be or not to be issued the early warning. This task could be reach by the more sophisticated software, supperfast computing abilities and the "smart" location of the sensors.

Near real time early warning systems in use are about: Meteorological events (for hurricanes, tornadoes, other meteorological events), Tsunamis (PTEWS), Volcanoes (for example Hawaii, Vesuvius, Reunion, Azores networks, etc.) and show relatively reliable exploitation.

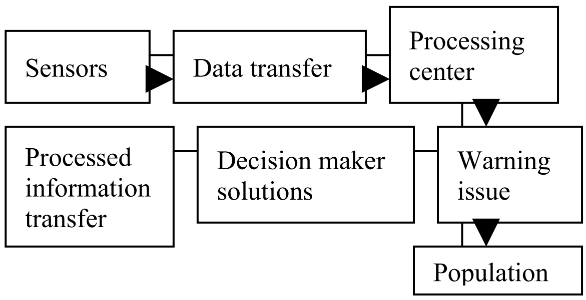

Fig. 2. A comparative scheme of the present day and the near future early warning systems (arrows way)

The use of the "smart" sensors, which are able to "take and perform " the decision, the sophisticated software, which is able to prove the reliability of the warning issue and the fastest recent digital technologies are the main elements which could provide the highest reliability of the near future early warning systems. The main problem in this competition is to save time. The fastest communications can win against the velocity of the natural hazards. This could be reach by recent technologies and better software.

Conclusions

The methodology concerning some natural hazards and the possible early warning systems application is developed in general terms. The selection of the natural hazards under recent observation and future development of the early warning systems is made on the principal physical and geophysical considerations. The most perspective are to the: tsunamis, floods, strong winds, volcanic eruptions, etc. The effectiveness of the early warnings is taken into consideration. The main parameters defining the effectiveness are the velocity of the process, the velocity of the data and information transfer, the organization of the early warning issue and the transfer of the reliable information to the public. Two ways are described. The established EWS existing up to now and the recent new established and near future EWS. The use of the recent technologies in all aspects of the information collection, processing transfer and dissemination appears essential. The main issue is considered the possibilities to save time due to the fast recent technologies for the information collection, data transfer and warning issues.

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References

Рангелов, Б. 2006. Оценка на последиците от природни бедствия. – *Минно дело и геология*, 2, 29-32.

http://www.msnbc.msn.com/