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Computerization of Seismological Activity in Cuba

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Abstract: A set of applications and utilities accessible from the CENAIS website is presented, which allow decision-makers and the general public to be informed about seismic activity in Cuba and the world. Here, we can access to different didactic materials related to the seismological issue that allow people to deal with earthquakes of great intensity. Application for mobiles, like the APK SismoCuba, displays the location of recent seismic activity on the map, with the possibility to make perceptibility reports in an automated way. It also presents utilities for the monitoring and detection of seismic and magnetic anomalies, as well as the occurrence of tsunamis with the real-time visualization of different tide gauges in the Caribbean.

Key words: seismicity; earthquakes; APK; website

1. Introduction

The shelter and access to the information generated by any institution or entity is of vital importance for the computerization of society. The efficiency in state functions depends largely on having access to information and interacting with the use of computer technology and communications with all the processes involving the functioning of a society. Denais has two fundamental objectives related to constant monitoring of seismic activity in Cuba and surrounding areas, as well as the development of fundamental and applied research for the reduction of seismic risk in the national territory. In the fulfillment of its objectives, a large volume of information of great importance for government authorities and general public is generated. Therefore, it is necessary that all the information be accessible from a website to be able to make adequate valuations in decision making that include response plans against a great intensity earthquake and urban planning. The fundamental objective of this result is to provide Cuba and the international community with all relevant information on monitoring seismic activity in our country, as well as the scientific results of the institution. We also provide websites that are compatible with computer devices such as mobile phones and tablets, as well as interactive, simple, and intuitive user interfaces for the public. There is also a mobile or APK application that complements important functionalities within the seismological activity in Cuba.

2. Materials and Methods

Selected support and development systems (software) are on a general public license, better known by their English name (General Public License, GNU), widely used in the world of free program and open source, in correspondence with the policies of the Ministry of Computer Science and Communication (MIC), guaranteeing the end users the freedom to use, study and share the software.

For the development of the website, WordPress (https://es.wordpress.org/) was used, which is open source software with high performance and high security. This utility has personalized designs and more than 55 thousand functions (plugins) with a powerful media management. The architecture of this platform is customer-server (Harooon-Sulyman, 2014), so the development of the site is carried out with a web interface. Web applications inserted on the site are also designed with a customer-server architecture. It is based on HTML-Java Scripts codes for the client side and PHP services on the server side (Nixon, 2018 and Icode Academy, 2017). The information is stored in a SQL database, based on a relational model (Molinaro, 2005), allowing quick and easy maintenance access. The SQL database inserted in a geospatial data infrastructure (of Man, 2007, González and Torres, 2011, Ureña-Cámara et. Al., 2018 and Gutierrez and Rocha, 2021) fulfills the three basic characteristics that the data must have according to Brewer (2000): consistency, availability and tolerance to partitioning (Seth & Lynch, 2002). The IDE is supported by a map server with all the characteristics defined by the OGC (Open Geospatial Consortium). This allows sovereignty in the operation of the system by not having to access maps servers located in other countries. To establish the communication between the SQL database and the user's requests, it was necessary to develop PHP applications that are executed on the server side. These can be used by other web applications, knowing the URL address and input parameters.

3. Results

The website (https://www.cenais.gob.cu) is designed blog type in which two articles related to the theme of seismic and seismic ephemeris culture are published monthly. It has a menu at the top with the starting options, seismological service, research and products. The starting option contains information about the function of the entity and the scientific work or CV of the staff. The seismological service option (2) includes everything related to seismological stations, earthquake catalog and some applications for the development of epicenters maps, focal mechanism maps and discharge of continuous traces or earthquake records.

The research option contains information on the scientific and technical services provided by the entity and the lines of research being developed. The products option contains: (a) Monthly informative brochures in which the main activities of the entity are disclosed; (b) Annual seismicity bulletins, in which the seismic activity of each year is summarized; (c) Didactic materials, in which community interest and audiovisual materials produced with the collaboration of international projects are accessed and contain a link to our YouTube channel; (d) Theses, which provides access to all doctoral and master's theses obtained by the institution; (e) Publications, which lists all publications involving CENAIS researchers; (f) Project output, which lists all available reports; and (g) Scientific and technical services. The last 3 options have the possibility to download the PDF documents from the intranet.

In addition to the functions related above, the site frames several options on the left side containing: (a) Perceptible earthquake note; (b) Chronology of notes, which has all the notes of perceptible earthquakes from 2002 to the present; (c) Materials of community interest and seismic culture, which highlights the APK SismoCuba (Figure 1) for the visualization of recent seismic activity and the report by the population of perceptible earthquakes. Within this sector, the link already existing in the options menu is duplicated as (d) Earthquake navigator (Figure 2) where the user can interact with the earthquakes located on a map, select the perceptible events and make saves of the data.

You can also access significant earthquakes that relate seismic events of greater historical significance in our country from 1528 to the present. This last option has detailed information on most earthquakes related to scientific articles, perceptibility report, damage report, historical photos, maps, press news, among others. Within the seismological service option, you can access the real-time monitoring of the data from tide gauges and magnetic stations located in the Caribbean.

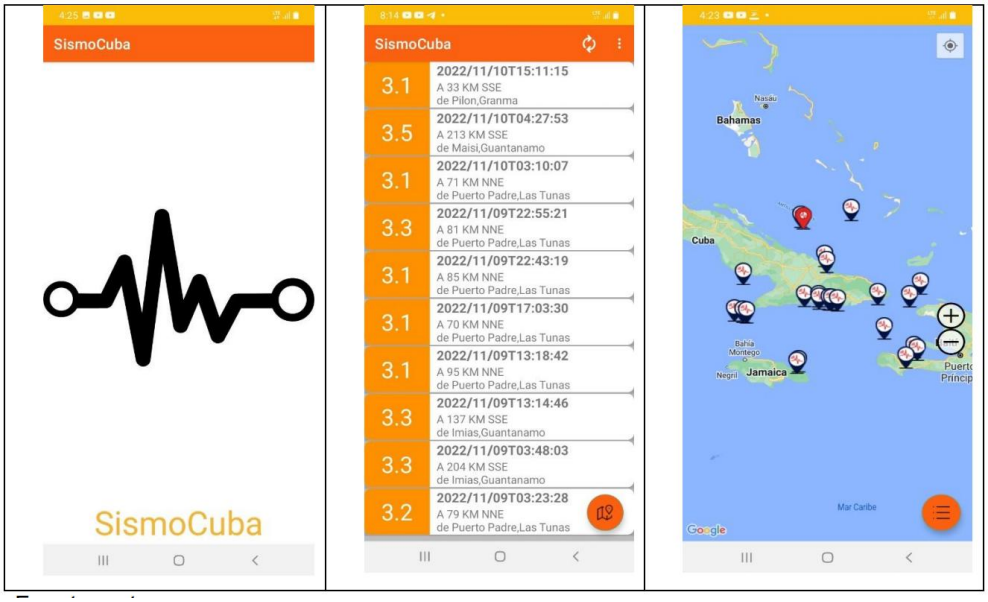

Figure 1. SismoCuba apk. Author.

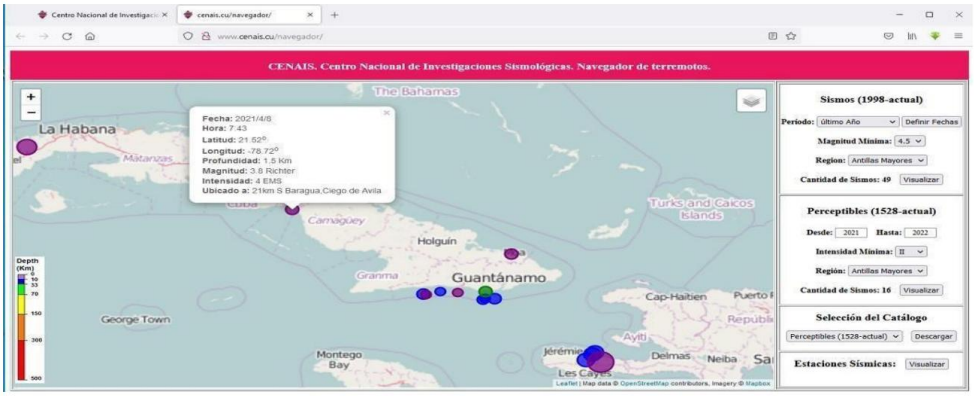

Figure 2. Earthquake browser. Author.

There are also 4 icons that represent the most use utilities. The first bond (f) perceptible earthquake shows the map of the earthquake epicenter with all calculated parameters (length, latitude, depth, magnitude, etc.). Then it follows (g) earthquakes last 7 days, which shows the map of epicenters of the earthquakes recorded in the last week. The epicenters are represented in different colors indicating the elapsed time (24 hours, 48 hours, 3 days and 7 days). The third option (h) records 12 hours and shows the seismic signal of the last 12 hours for each of the seismological stations. The fourth option (i) seismic statistics (Figure 3) allows the monitoring of the seismic activity, which we describe below.

3.1 Monitoring and detection of seismic anomalies

The forecast or prediction of earthquake is established in probabilistic terms and is based on the study of certain natural factors known as earthquake precursors. These precursors are evidenced when the preparation of the strong earthquake is in its final stage. For example: the increase in the number of seismic events in a short period of time or seismic swarms are considered anomalies that could indicate the proximity of a strong earthquake. Based on these concepts, a web application was implemented to detect anomalies through visual inspection of different temporal graphics (Figure 3) that group variables such as the number of events recorded with the associated released energy and the maximum magnitude recorded.

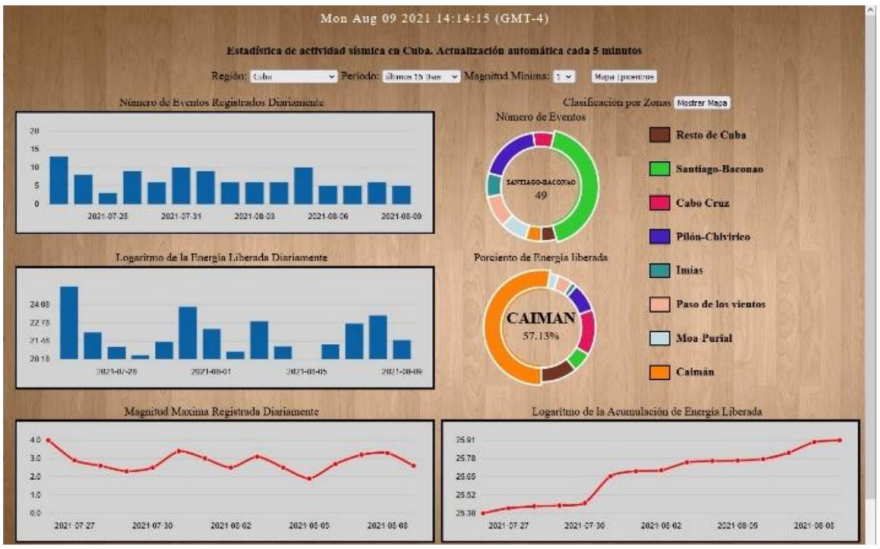

Figure 3. Monitoring of seismic anomalies. Author.

3.2 Sea level monitoring

Tsunamis have caused numerous human and material losses throughout history. In the Caribbean region, although these phenomena are few frequent, there are historical records of tsunamis generated by strong earthquakes. For example, the earthquake of August 4, 1946 with magnitude 7.8 that occurred on the northeastern coast of the Dominican Republic, where broad damage and a tsunami were reported in Haiti and the Dominican Republic. That is why there is an international effort for the implementation of tsunamis alert systems that include seismological stations, tide gauges and Dart buoys for the detection and monitoring of tsunamis.

When a strong earthquake occurs with epicenter in the sea and with a focus of superficial depth, a tsunami alert is immediately emitted, which after a few minutes is confirmed or discarded by the tide gauges closest to the epicenter. That is why it is required to have real time access to record data from international networking sectors, mainly in the Caribbean area. In this sense, a web application was developed that allows to visualize this information in real time and thus be able to confirm anomalies at sea level (Figure 4).

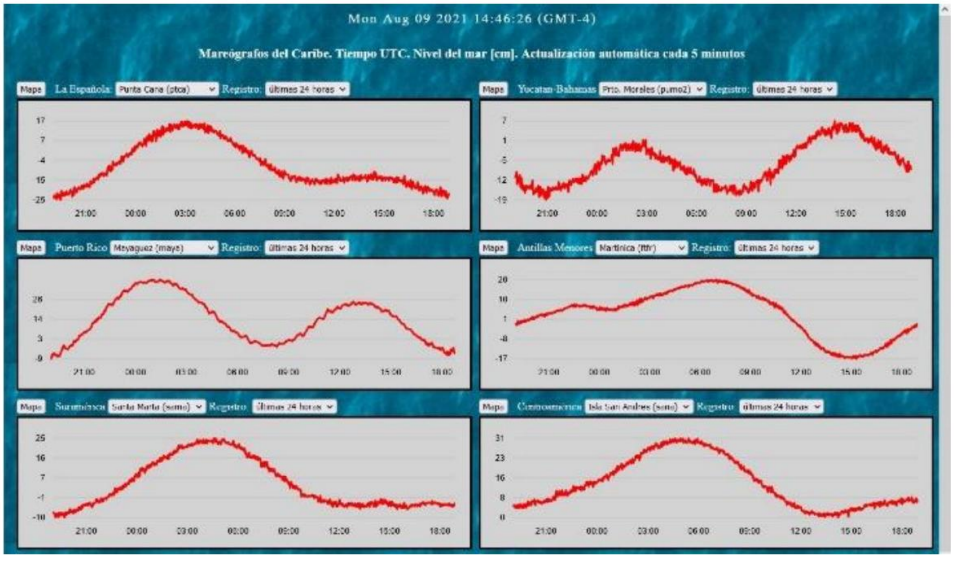

Figure 4. Sea level monitoring in the Caribbean. Author.

3.3 Other utilitarians developed

Among other utilities implemented is the computerization of several of the institution's internal processes. With the improvement of the intranet, client-server applications were implemented for the control of energy carriers and the preparation and control of individual work plans and at the vice-directorate and work group levels, which contribute to the center's general plan. All servers were also virtualized, allowing for the automated saving of all information.

One of the important results is the implementation of a mobile application (Macrosismic APK) that allows to collect damage information (Muson et al., 2009) to a set of buildings previously stored in a database called "engineering polygon for strong earthquakes". This polygon characterizes the existing constructive typology in the city of Santiago de Cuba with more than 250 buildings classified by the type of use, technical state, year of construction, number of floors, among others. With this utility, real-time effective damage assessment of earthquakes and taxes can be conducted on centralized databases.

4. Discussion

The development in information and communications technologies (ICT) has allowed the decision-making process to be much more efficient and timely. Today it is extreme importance to have tools for access to information in quasi-real time. In this sense, the response to many extreme natural phenomena, for example an earthquake of great intensity, allows to save human lives, since the search and rescue process is addressed to the areas of greater damage when knowing the acceleration data of the land in different parts of a city.

Also the preparation of the population increases by accessing different didactic materials, which leads to raising the perception of the risk to which they are exposed. In addition, the massive access to cell phone devices has allowed the information to reach a large percentage of the population and that a feedback is achieved with the data management centers for the process of continuous improvement and quality in the information.

5. Conclusions

Most of the information generated by the entity is available to the public and provides a high degree of interaction with the user. The website is designed with a simple user interface, intuitive operation and portable for cell phones and tablets. With the implementation of web applications, it is allowed to access the earthquake catalog, which includes data on the source, seismological stations, perceptible earthquakes, among others. Other applications includes anomalous seismic activity monitoring through daily statistics and energy graphics. The monitoring of the magnetic field and the sea level is also allowed through real time access of magnetic stations and tide gauges located in the Caribbean.

The detection of seismological and geophysical anomalies allows the authorities of a possible occurrence of strong earthquakes, as well as to confirm the existence of tsunamis. The development and implementation of the SismoCuba and Macrosismic APK is very useful to have a database with the effects caused by earthquakes that are reported by the population. The collected information makes it possible to improve seismic norms or earthquake-resistant codes in our country, as well as implement effective strategies for urban planning.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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