EXPERT TSUNAMI DATABASE FOR THE PACIFIC REGION

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Abstract

The objective of the proposed project is the development of the Expert Tsunami Database (ETDB) on regional and Pacific-wide basis for further application in tsunami warning, risk assessment and mitigation. The ETDB is intended to be a comprehensive source of observational data on historical tsunamis in this region along with some basic additional and reference information related to the tsunami problem and to provide an enhanced environment for IBM PCs and compatibles for retrieval, visualization and processing of data.

1. Introduction

The compilation of historical data on tsunami occurrence and coastal manifestation is an important part of investigation of tsunami problem for any tsunamigenic region of the Pacific and elsewhere. Traditionally, historical data have been compiled and published in the form of tsunami catalogs as for the whole Pacific as for its particular regions. However, the data in the paper catalogs become obsolete rather quickly. Besides, they have the fixed predetermined format that makes their retrieval and handling rather complicated and time consuming process. The modern information technology demands the organization of data in the form of databases, where data are in the active form and their handling can be interactively made in the fast and efficient manner.

Recent achievements in the development of PC-based DBMS software along with declining prices of personal computers provide an excellent opportunity to bring all observational tsunami data to a desk of the researcher who wish to have all available information at his hands. It is highly desirable to make all regional and Pacific-wide tsunami catalogs available to individual researches and provide them with a specialized PC-based software which can be easily used to manipulate with this type of data. Direct access to historical tsunami databases in a standardized format along with basic mathematical models of tsunami behaviour and efficient processing tools will open new possibilities for investigations related to many aspects of the tsunami problem.

Database technology has been significantly developed over last two decades for all kinds of computers including mainframe, mini and personal computers. However, this development was mainly in response to commercial data processing needs, which are characterized by large, record-oriented, fairly homogeneous data sets mostly retrieved by relatively simple (point, interval and range) queries.

But today, database research and practice are increasingly concerned with other application, such as management of spacial data that stretch the conventional DB technology to its limit and beyond. One of the main feature of these data is that are embedded in space and are typically accessed through their position in space.

In response of these needs, the new class of the supporting software - Geographical Information Systems (GISs) has been developed and since the beginning of 80's became an important area for software development.

In the past, the GISs have concentrated mostly on retrieval and display problems, but now they are beginning to develop the analytical and modeling tools. Today some of GISs can provide a very sophisticated and enhanced environment for spacial data handling and processing. The ability of GISs to handle and analyse spatially referenced data may be seen as a major characteristic which distinguishes GIS from information systems

developed to serve the needs of business data processing as well as from CAD or map production systems.

However, as many of standardized multipurpose systems, GISs are turned out to be not very flexible and cost effective for a number of specific, particular applications like geophysical data compilation, storage and processing. Their price and computer requirements are usually much higher than the standard DBMS software. Besides, in the most of existing GISs, the compiled data are related to socio-economic phenomena and are often organized in an administrative hierarchy, so that all further data queries should strictly follow this hierarchy.

That is why the development of the inexpensive PC-based software for the handling of geophysical and, in particular, earthquake and tsunami data is still the matter of interest.

2. ETDB concept

As a result of a feasibility study, a concept of the Expert Tsunami Data Base (ETDB) was developed at the Tsunami Research Group of the Novosibirsk Computing Center, Russian Academy of Sciences. The ETDB contains in the digital form all available earthquake and tsunami information for a particular region (source parameters, observed heights, original historical descriptions, etc.) as well as basic reference information on regional seismic and mareograph networks, regional geography, geology and tectonics. Additionally, it includes some blocks for tsunami modeling (e.g. calculation of travel time charts) and some standardized built-in tools for data processing and plotting. The specially developed graphic shell provides the possibility to manipulate maps, models and data in the convenient and efficient manner.

In elaborating the ETDB we are to meet the following basic requirements:

(1) system should have a module structure allowing flexibility and adjustment to particular application as well as to be an open system providing the potential of growth to keep abreast of research advancement;

(2) it should have built-in computer mapping subsystem providing the ability to display the data on actual geographical bases;

(3) system should have built-in tools for some standardized data processing and analysis;

(4) system should have a friendly user's interface based on menu -driven approach.

We proposed to build the ETDB on the basis of Hypertext conception which allows the integration within one software system of all kinds of data: numerals, text, graphics, source codes (e.g. mathematical models), even audio and video information. The ultimate goal of the ETDB Project is to develop the comprehensive database on tsunami and related geophysical phenomena, which contains the complete set of original, uninterpreted information available to anyone who wishes to revise estimates, to make his own interpretation, to raise questions or to propose improvements. The final product could be used not only as a comprehensive tsunami database, but also as a convenient electronic textbook and reference book on the tsunami topic as well as a computer-aided device for investigation of different aspects of the tsunami problem.

According to our conception the Expert Tsunami Database should exist in two forms which can be called conventionally as the parents' form and the user's form. The database in its parents' form should exist at a regional warning center or specialized data center on some dedicated hardware and be provided with continuing qualified maintenance, that is, to have the database administrator who is authorized and responsible for routine updating, editing and refinement of data.

In its user's form, the ETDB exists as an automated tsunami catalog embedded inside a specialized graphic shell that is a user's interface and provides possibilities for fast and convenient retrieval, visualization and handling of data. In this relation the user's database represents an electronic analog of conventional tsunami catalogs, however considerably surpasses them in its efficiency and convenience. The user's database is also provided with some tools for data editing and further data compiling that makes possible to use it as a basement for development of the personal database containing all the meaningful information related to the needs of the individual researcher.

The potential application of the ETDB can be threefold:

(1) facilitating the decision-making process at the regional Tsunami Warning Centers;

(2) in-depth education and orientation of officials, public demonstrations and pre-event emergency planning;

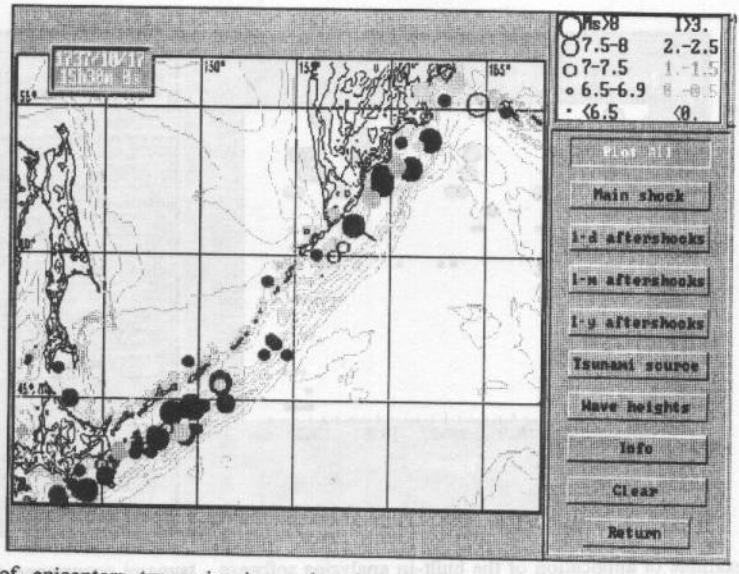

Fig.1. Map of epicenters tsunamigenic earthquakes occurred during 1737-1990 within the Kuril-Kamchatka region. The size of circles represents the event magnitude, the density of black tone - tsunami intensity.

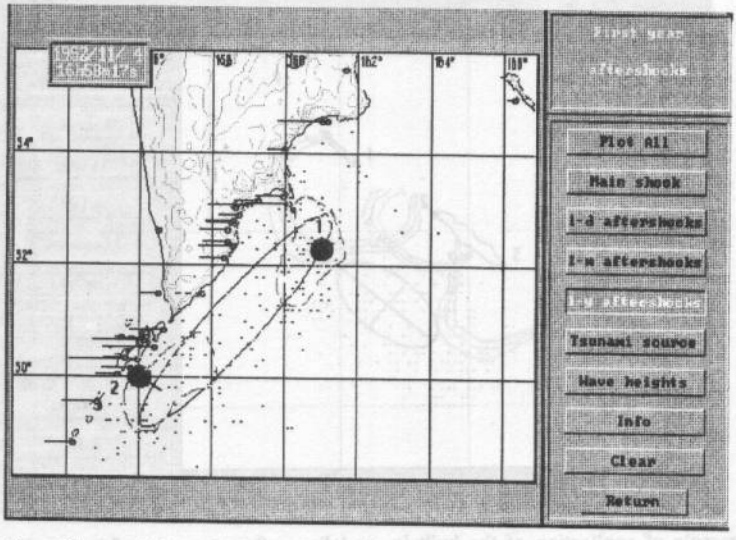

Fig.2. Visualization of tsunami data for the selected event of November 4, 1952. The solid ellipse shows the estimated position of the tsunami source. Black points represent the first year aftershocks. Sections of black lines show the run-up heights observed during this tsunami.

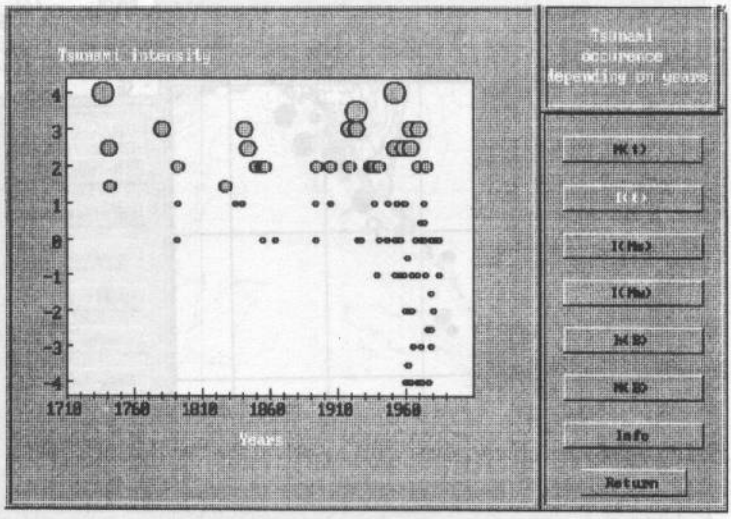

Fig.3. An example of application of the built-in analyzing software - tsunami occurrence depending on a year. The size of circles is proportional to the tsunami intensity.

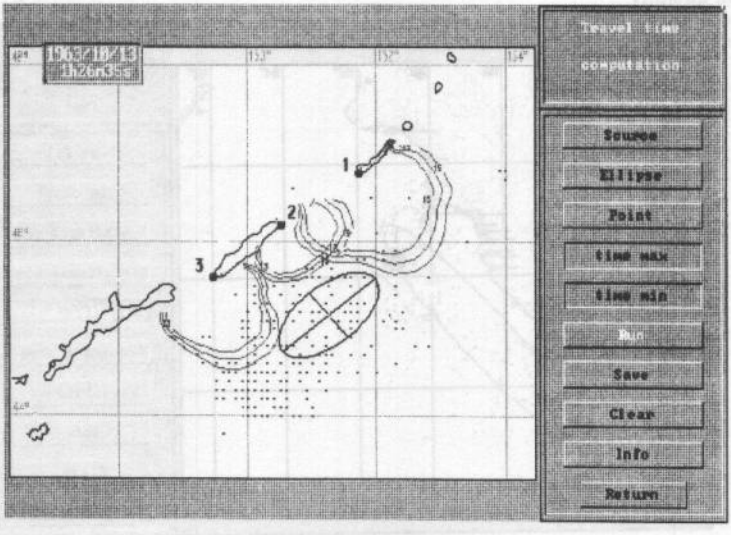

Fig.4. An example of application of the built-in modeling software - map of inverse isochrons for the event of October 13, 1963, calculated and plotted for three coastal points where observed travel times of this tsunami are available. Solid ellipse shows the estimated posituion of the tsunami source.

(3) it can be used as the basement for development of personal database for cientists involved in tsunami research and investigation.

The software developed under ETDB Project is the Data Base Management System (DBMS), menu-driven graphic shell for data retrieval and handling and the supporting mapping software. It runs on 286 or 386 PC under MS-DOS.

4. EDTB prototype

The demonstration version of the ETDB has been developed at the Tsunami Research Group of Novosibirsk Computing Center on the basis of historical tsunami database for the Kuril-Kamchatka region. It covers the area within 41.30' to 64.00' N and 130.00' to 168.00' E and consists of four main parts: earthquake database, tsunami database, geographical mapping and data processing subsystems. Two additional databases contain some basic reference information of the existing regional seismic and mareograph networks.

Currently, the earthquake database contains the source data of almost 42 000 events occurring within the region from 1737 to 1990. Source information includes date, time, coordinates of epicenter, depth, magnitude (basically Ms), and seismic intensity followed by indexing to data sources. All data can be cross-correlated and retrieved by geographical area, date, depth and magnitude.

The tsunami database covers the same period and contains 129 events with 115 of them having regional and 14 distant sources. Among 115 regional tsunamis, 105 have tectonic, 6 volcanic and 4 unknown sources. The tsunami data set consists of four main blocks: detailed source data of tsunamigenic events, coastal observations of tsunami wave heights, original descriptions of tsunamis and bibliographical references. Source data of tsunamigenic effects are cross referenced to the earthquake database but contain the extended set of magnitudes including moment-magnitude Mw, tsunami -magnitude Mt, seismic moment, moment-tensor and source mechanism (where available), tsunami intensity, maximum run-up height, position of tsunami source, validity of event, warning status and some other complementary information. The tsunami data can be retrieved by area, date, source magnitude and tsunami intensity. The information can be output in summary (condensed) or detailed (expanded) form. The latter includes all available observations of tsunami heights, periods, direction of the first motion, observed and calculated arrival time (where available).

The third part of tsunami database, which is still in process of compilation, contains comments, bibliographic data and the primary tsunami descriptions collected from original publications. Its main destination is to bring to the researcher the full initial descriptions of old events, some of them can be re-interpreted from a contemporary point of view.

6. Conclusion

Despite the ETDB is developed first for Kuril-Kamchatka region, it could be applicable and easily adapted to any other tsunamigenic region of the Pacific like Alaska, Hawaii, Philippines, Indonesia, South Pacific region, Chile, Peru, Ecuador, Mexico. At minimum cost it may be customized to the particular region of the Pacific and elsewhere (mainly, by extension of geographical database) after that the actual data compiling from the existing regional tsunami catalogs and other sources of data can be made in a relatively short term. A wealth of such data already exists but they are not properly organized, are not uniformly collected and are not readily available. Therefore, standards must be established for the collection of data and tsunami databases must be organized on a regional scale initially and shared on the Pacific-wide scale in later time. After the integration of all this knowledge into the expert database it will be widely used for real time operations in event mode and for tsunami risk assessment and mitigation in pre- and post-event mode.

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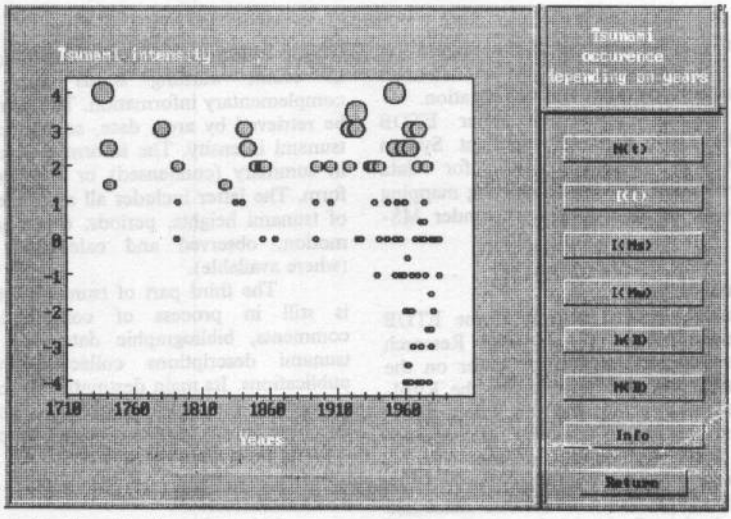

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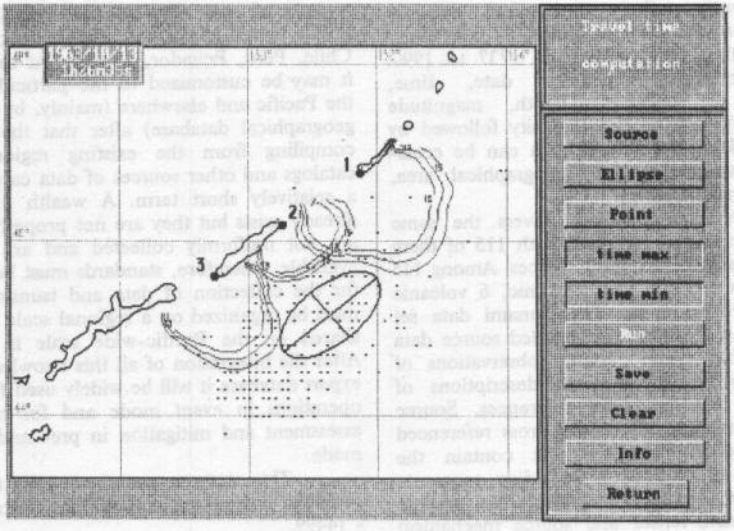

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