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Web version of the historical tsunami database for the Pacific region*

V.K. Gusiakov, I.V. Marinin

The paper describes the results of the application of the "client–server" technology for the development of the Web version of the Historical Tsunami Database for the Pacific. The database consists of two main parts: the catalog of tsunamigenic events in the Pacific with their basis source parameters and the catalog of the observed or measured run-up heights at the coast. As a supplement part, the database contains the textual descriptions of tsunami manifestations, a set of digitized tsunami photos and some supporting information related to the tsunami problem (active tectonic faults, catalog of active volcanoes, list of mareograph stations, etc.). Currently, the event catalog contains 1447 tsunamigenic events occurred in the Pacific from 47 B.C. to the present time. The run-up catalog contains nearly 8000 coastal run-up observations and tide-gauge measurements provided with the geographical coordinates of sites. The Web version of the database is located on the server of the Tsunami Laboratory of the ICMMG SD RAS (http://tsbun.sscc.ru/htdbpac) in the Microsoft SQL Server 7.0 format that works under Windows NT Server 4.0 Service Pack 4, IIS 4.0. The client interface is written on Microsoft Visual InterDev 6.0 (ASP). The system is the platform independent (from the "client" part) and provides a remote user, who has the standard browser (Netscape 4.5 or Internet Explorer 4.0) and the network or modem connection to the Internet, with a certain set of function for the interaction with the database. Special screen forms were developed to provide a remote user with the possibility for data search by complex criteria, for data listing, sorting and for several types of data processing.

1. Background

Historical data on tsunami occurrence and coastal manifestation are essential tools for evaluating the tsunami potential of coastal areas and determination of the degree of tsunami hazard and risk. They are also of a critical value for studies of tsunami generation mechanism, propagation and run-up features, damaging and destruction effects. The better access to the large volume of historical data already accumulated within the tsunami community will facilitate many aspects of tsunami research and mitigation. Recent achievements in the development of the World Wide Web (WWW) and declining prices for the long-distance communication provide an excellent

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opportunity to readily bring all accumulated historical and observational tsunami data to any researcher in any country who is seeking for available information.

The primary goal of the WebHTDB/PAC (Web version of the Historical Tsunami Database for the Pacific) project is to test the "client–server" methodology for construction of the interacting Web sites and to present historical tsunami data and information to anyone who has a high-bandwidth Internet connection and a World Wide Web (WWW) browser to access this information. An additional important advantage is that the user interface is established and standardized by inexpensive and widely available commercial WWW browsers such as Netscape Navigator or Microsoft Explorer; digital images and videos are either directly or indirectly supported; and the development of a specific problem oriented Web site is straightforward.

Although not currently available to the tsunami community in all Pacific countries, the Internet computer network will continue to grow and become more accessible to those who are not yet connected. Furthermore, it is already clear that the Internet is the most versatile, convenient and efficient communication medium for quick and wide distribution of tsunami observation data and related information.

Historically, observational data on tsunamis have been compiled and published in the form of tsunami catalogs for the whole Pacific and for its particular regions [1–10]. Collection and refinement of the primary data scattered in numerous sources is a great deal of efforts and the importance of the published catalogs for the tsunami research and mitigation cannot be overestimated. However, some of these catalogs are more than 10 years old, and a lot of new information is now available for many areas. Besides, all historical catalogs have been compiled and published in the form of a descriptive plain text of different styles, formats and approaches used. The quantitative data in these catalogs are usually scattered over the text and they are not easy to be retrieved and handled that limits to some extent their further application in the tsunami research. The present-day information technology demands organization of data in the form of computerized databases, where data can be kept in a constantly updated and active form and easily accessible. The information from the database can be retrieved in many different ways and formats, and can be easily transferred to other relational databases and data processing and visualization programs.

The initial work on the development of the computerized tsunami database was started at the International Tsunami Information Center (ITIC) in Honolulu, Hawaii (USA) in the mid-seventies. In response to the recommendation of the ITSU-XI (Beijing, 1987), the standardized formats have been developed, and the initial tsunami database was compiled from many available sources and distributed through the ITSU National Contacts [7]. Unfortunately, at that time these efforts were not sufficiently supported both

financially and conceptually. Also, a little of tsunami data was available in the computer readable form. Therefore, the progress in the further data collection was slow, and the proposed formats did not become mandatory for the further data compilers and database developers.

In the middle 80s, a lot of efforts were made at the National Geophysical Data Center in Boulder, Colorado (USA) for compiling the quantitative tsunami data from all the available catalogs and many special studies of tsunamis [4]. Unfortunately, the initially compiled data sets have never been carefully refined as well as provided with a convenient problem oriented graphic shell for easy data retrieval and visualization. However, for many years the NGDC Worl wide Tsunami Database remained the only source of tsunami information available in the computer readable form and it have been used for the creation of the tsunami databases in several research institutions and operational centers.

The next stage in the tsunami database development is connected with efforts of the Tsunami Laboratory of the Institute of Computational Mathematics and Mathematical Geophysics (the former Computing Center) of the Siberian Division of Russian Academy of Sciences (ICMMG SD RAS) made under the Expert Tsunami Database (ETDB) project [11]. The concept of the project is based on integration of observational data, some numerical models, analytical and processing tools with the visualization and mapping software. Therefore, from the very beginning a lot of attention was being paid to the development of the geographical mapping subsystem for easy data retrieval and visualization. Another important feature of this project is that the ETDB is intended to be a multi-entry database, that means that for a single tsunamigenic event we are trying to collect the full set of original data and information as provided by different sources leaving to a future researcher the right to make his/her own interpretation and judgement.

2. Database content

The Historical Tsunami Database for the Pacific (HTDB/PAC) was established and is being maintained by the Novosibirsk Tsunami Laboratory (NTL) of the Institute of Computational Mathematics and Mathematical Geophysics ICMMG, Siberian Division of Russian Academy of Sciences since 1991. The initial data collection from the existing tsunami catalogs and primary publications was made under the ETDB (Expert Tsunami Database) Project supported by the Russian Foundation for Basic Research (grants 93-05-14499 and 95-07-19335) and the Intergovernmental Oceanographic Commission of UNESCO (contracts SC/RP 207.518.4 and SC/RP 207.566.6). At that stage, the dBASE IV was used as the database management system. Additionally, a special DOS based graphic shell for easy

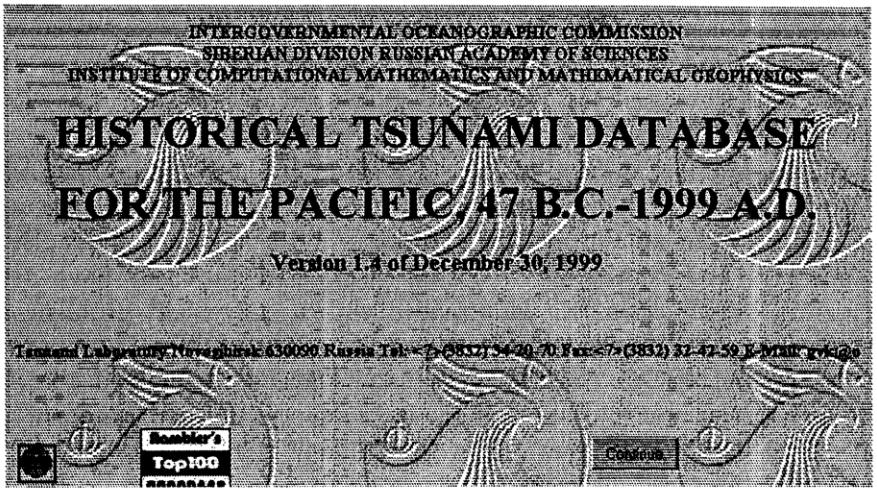

Figure 1. Start-up page of the Web-version of the Historical Tsunami Database for the Pacific Region (HTDB/PAC)

data retrieval and display has been developed [12]. This shell acts as geographic mapping subsystem and provides fast and convenient options for search, retrieval, display and processing of tsunami data.

The database consists of the two main sets of observational data – tsunami event catalog and tsunami run-up catalog. The first set contains the source parameters and some integrated characteristics for 1447 historical tsunamigenic events occurred in the Pacific basin (within the area between 65 S to 65 N and 80 to 50 W) from 47 B.C. up to end of 2000. A set of parameters includes the full date (Year, Mo, Da) and time (Hr, Mn, Sec) of an event, position of its source (Lat, Long), the source depth Dep, the basic set of source magnitudes (mb, Ms, Mw, Mt), tsunami intensity I (on the Soloviev–Imamura scale), tsunami magnitude m (on the Imamira–Iida scale), the maximum observed run-up value Hmax, the total number of available run-up and tide-gauge measurements N, damage code D, the number of reported fatalities due to an event F, a cause of the tsunami C, validity of an event V, warning status WS (where available), tsunamigenic region code TRC, the basic reference BR and a brief description of the tsunami source region.

The second set contains nearly 8000 coastal run-up observations and tide-gauge measurements of wave heights. This part of the database was initially imported from the NGDC Worldwide Tsunami Database and in its considerable part it is still fully identical to the NGDC run-up data file. Major improvements and corrections were made for the Kuril–Kamchatka region and for the US Pacific coast including Alaska and Hawaii. Also, a lot of measurements of wave heights for the recent Pacific tsunamis of 1992–1999 obtained in the post-event field surveys have been added. For

each wave run-up or tide record, a set of displayed parameters includes the 3-level name of the site (Region name, Area name and Site name), its geographical coordinates (Lat, Long), the type of measurement T (R – run-up, T – tide-gauge) and the observed run-up height or the double amplitude H (in meters). A more detailed explanation of the data format can be obtained upon clicking the "Legend" button on the "Run-up data" screen form. Each run-up data set for a particular event is preceded by the line containing the basic source parameters of the event in the format accepted for the event data.

The third part of the database contains the world-wide catalog of significant (with magnitude Ms > 6.0) earthquakes (nearly 6300 events) occurred from 2100 B.C. till present. It contains the following set of parameters: full date (Year, Mo, Da) and time (Hr, Mn, Sec) of an event, source coordinates (Lat, Long), the source depth Dep, and source magnitude (basically Ms).

3. Implementation

The Web version of the database is located on the Web server of the Tsunami Laboratory of the ICMMG SD RAS at the following URL: http://tsun.sscc.ru/htdbpac. It is maintained on the Microsoft SQL Server 7.0, that works under Windows NT Server 4.0, Service Pack 4, IIS 4.0. The client interface is written on Microsoft Visual InterDev 6.0 (ASP). The system is the platform independent (from the "client" part) and provides a remote user, who has the standard browser (Netscape 4.5 or Internet Explorer 4.0) and the network or modem connection to the Internet, with a certain set of function for the interaction with the database. This set of functions includes the formation of users requests to the database, listing of the results of the data retrieval, their sorting and some built-in functions for statistical processing of the data with presentation of results in the form of graphs and diagrams.

The HTDB/PAC Web site has been formed on the basis of the dynamic HTML technology. The main reason for the selection of this technology was our intention to provide the reliable processing of the client's requests with an acceptable response time in the conditions of the low transmitting rate that are typical for the Internet channels. The following principal scheme is used. A client, willing to retrieve the historical tsunami data from our Web server, connects with the SQL server by means of the IIS through ODBC. A client forms the customer's request by filling in the HTML screen forms or by using some interactive graphic procedures (for instance, for the indication of a geographical area for the data search). As a result, the IIS receives a string of the SQL request, which is then transmitted to the SQL server. Upon receiving the server's response, the IIS forms the HTML page

and forwards it to a client as a result of his request. The HTDB/PAC site has just a few static pages, the rest of them are formed dynamically. The application of the Java script for the development of the visual creator for the indication of geographical boundaries for the data search, instead of the development of a Java applet, is also stipulated mainly by low transmitting rate of the available Internet channels. We use the MS SQL server as a DBMS, keeping in mind the application of its replication mechanism for the construction of the distributed database in the future. From our point of view, the MS SQL server is a reliable and easily adjusted system for the data storage, search, processing and for the data transfer. In operations with the MS SQL server, one can use not only simple requests, but also stored procedures for the creation of graphical images, for example, as well as the extended procedures for plotting of the selected geographical areas in the visual creator.

Special screen forms have been developed to provide a user with a possibility to present user's requests for data search, listing, sorting, visualization on the map and for several types of data processing (the latter is currently available for the event data only). By default, the data search by each parameter is made for the maximum range of its possible values, including records with the "NULL" (undefined) value of this parameter. The example of these screen forms are shown in Figures 2–4. Figures 5 and 6 represent data processing examples – the histogram of tsunami occurrence (Figure 5) and the diagram of tsunami intensity versus source magnitude (Figure 6).

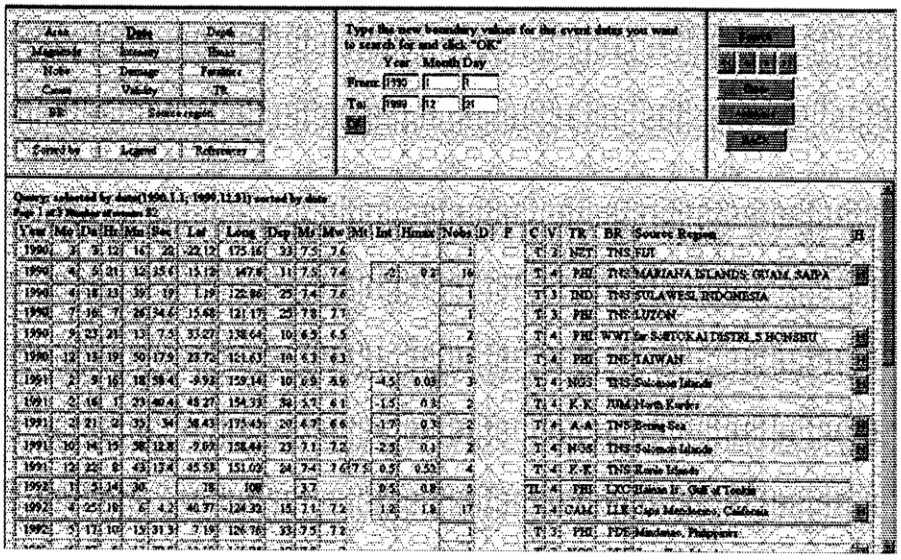

Figure 2. An example of implementation of user's request on the obtaining of the list of tsunamigenic events occurred in the Pacific from 1990 to 1999

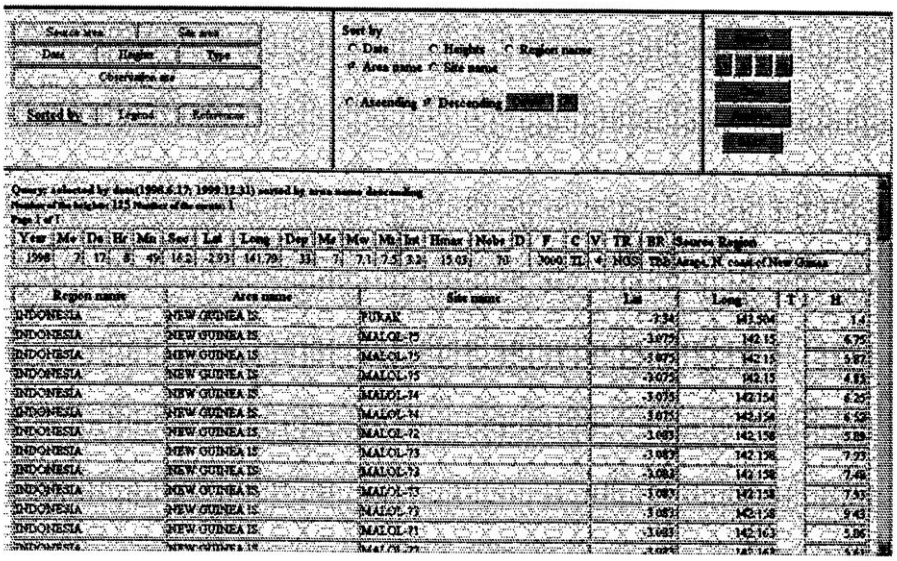

Figure 3. An example of implementation of user's request on the obtaining of the list of observed run-up heights of the Papua New Guinea Tsunami of July 17, 1998

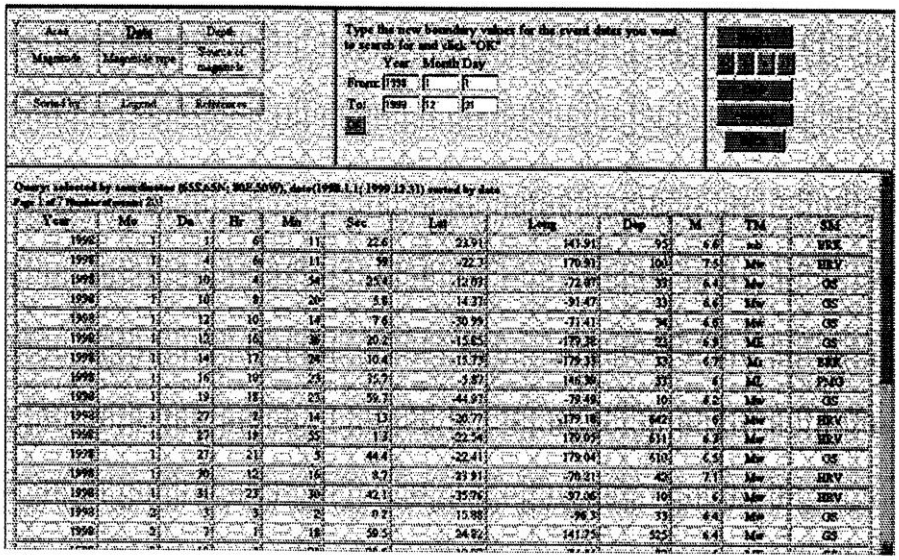

Figure 4. An example of implementation of user's request on the obtaining of the list of earthquakes occurred in the Pacific from 1980 to 1999

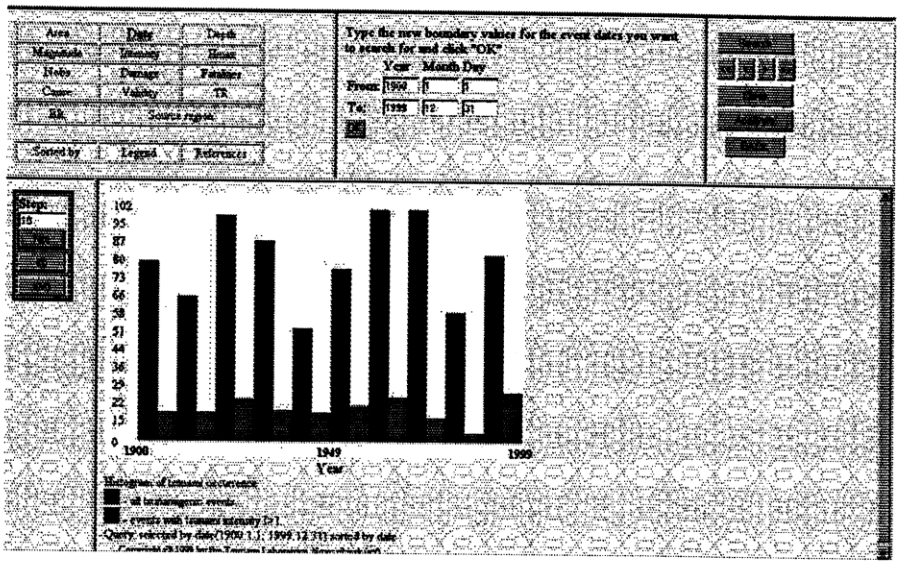

Figure 5. An example of implementation of user's request on the data processing – the histogram of tsunami occurrence (in 10-year intervals) for the period from 1900 to 1999. Gray tone represents all events, black tone – the events with intensity $I > 1$

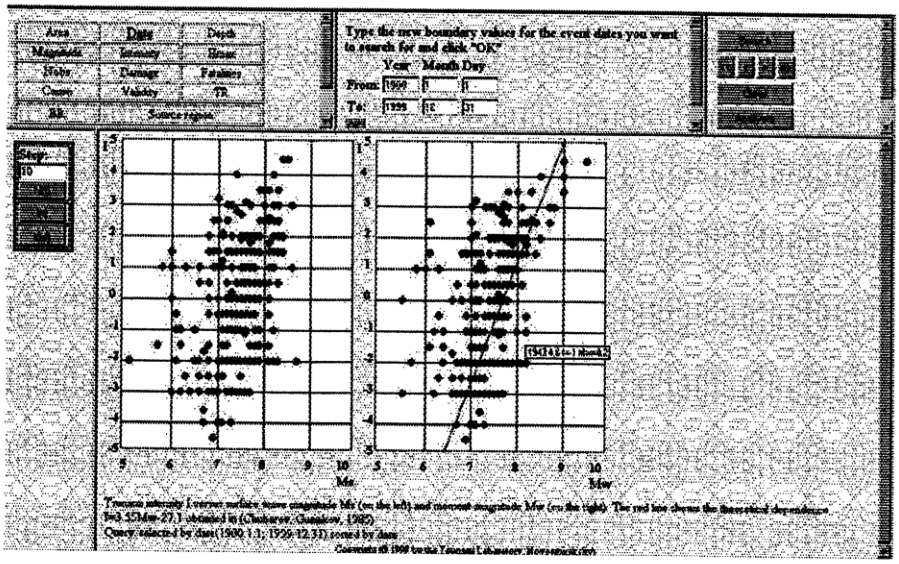

Figure 6. An example of implementation of user's request on the data processing – the diagram of tsunami intensity I (on Soloviev–Imamura scale) versus source magnitude Ms (on the left) and Mw (on the right) for the tsunamigenic events occurred in the Pacific from 1900 to 1999

4. Conclusion

The Web version of the Historical Tsunami Database (HTDB) for the Pacific has been developed and is being maintained at the Tsunami Laboratory of the ICMMG SD RAS for the easy access of remote users to a large set of historical tsunami data. The HTDB summarized the long term efforts of several research groups and individuals in collecting, refining and digitizing the tsunami related data. In its present form, it represents the most complete set of tsunami related data otherwise unavailable in digital domain. The direct access to the large set of historical and observational data can facilitate many aspects of tsunami research and hazard mitigation.

The future development of the WebHTDB/PAC project is seen as the establishment of the network of the dedicated Web sites exploiting existing WWW based communication to create a virtual network that will provide a remote access to the large volume tsunami related data and analyzing software. At the first stage, such a network could consists of three interacting Web sites supported by the Tsunami Laboratory in Novosibirsk (Russia), the International Tsunami Information Center in Honolulu (USA), Hawaii and the Pacific Marine Environmental Laboratory in Seattle (USA). This three node system can be seen as a prototype of the future Integrated Tsunami Information Network [13] for exchanging tsunami data and information between scientists, emergency officials and operational centers on both a routine basis and during tsunami warning operations.

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