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3 – 7 October 2005

Summary Report on the Global Tsunami Data Base Project implementation

1. Introduction

In 2003, the ITIC (Honolulu), the WDC/NOAA (Boulder) and the NTL/ICMMG (Novosibirsk) have developed a plan to compile a unified and comprehensive Global Tsunami Database (GTDB) by merging two existing tsunami databases maintained separately by the WDC/NGDC and the NTL/ICMMG. The benefits of having such a single, unified product are straightforward. First, this product will reduce confusion for end users looking for a reliable source of information on historical tsunamis. Second, in the process of preparation of the joint product, many discrepancies and uncertainties in parameters of historical tsunamigenic events still existing in both the HTDB and WWTD databases will be resolved. The first draft of the proposal was developed in June of 2003 and was discussed at the first working meeting on the GTDB Project that was held on July 8, 2003 in Sapporo, Japan, before the IUGG Tsunami Symposium. A general plan of action was discussed at this meeting, including the need for a new database format and the close cooperation with the HTDB regional coordinators. The detailed proposal on the GTDB Project was presented to the ITSU-XIX (Wellington, New Zealand, October of 2003), was positively met by the Member States and resulted in a special recommendation (ITSU-XIX.3 Recommendation).

This recommendation encourages the project participants (ITIC, WDC/NGDC, and NTL/ICMMG) to implement the GTDB Project in 2004-2005 with the financial support provided jointly by the NWS/PR and the IOC. It was recommended that the official copy of the database would be housed and maintained at the WDC/NGDC in the Oracle RDBMS from where the data can be accessed via Web-based HTML forms and ArcIMS interactive maps as well as exported in different formats specified by the ITIC for the use of the tsunami warning centers and other potential users. The offline, standalone application (WinITDB graphic shell) will continue to be supported and updated by adding a new software calculation of Tsunami Travel Times (TTT). This will take into account that some users may not have easy access to the Internet, and it will respond to the needs of requiring access to the historical data in an “offline” mode.

The present report mainly reflects the progress achieved in the NTL/ICMMG in 2004-2005 in the GTDB Project implementation.

2. The current status of the GTDB Project implementation

In the NTL/ICMMG the work on the GTDB Project implementation in 2004-2005 was going on in four main directions:

(1) Adding a new software for calculation of the Tsunami Travel Time (TTT) charts, thus converting WinHTDB graphic shell into the WinITDB (Integrated Tsunami Data Base) graphic shell;
(2) Further development of the WinITDB graphic shell and its extension to cover all main tsunamigenic regions of the World Ocean;

(3) Development of a new PDM shell (PDM – Parametric Data Manager) for compiling, editing and storage of the parametric and descriptive tsunami data and related graphic images;
(4) Development of a new, full 3D graphic shell (Global ITDB) with the global coverage for visualization and handling of all types of tsunami data;
(5) Further updating and verification of historical tsunami data (EVENT and RUN-UP catalogs) for the main tsunamigenic regions of the World Ocean (Pacific, Atlantic, Indian Oceans and the Mediterranean Sea) and converting them into the Global Tsunami Catalog.

2.1. Incorporation the TTT software into the WinHTDB graphic shell

The TTT software for fast calculation of tsunami travel time charts was initially developed in 1997 for the Caribbean region under the contract with the University of Puerto Rico. This software used the WinHTDB graphic options for selection of geographical area, specifying a tsunami source and parameters of calculation and for visualization of resulted TTT maps. Later similar software has been developed for the South America region (under the agreement between the NTL and SHOA). However, these versions of the TTT package did not contain the built-in historical database and did not allowed the TTT calculation for particular historical tsunamigenic events.

In response of recommendation of the ITSU-XIX, the software block for TTT calculation was incorporated in the full-scale WinHTDB graphic shell containing the comprehensive earthquake and tsunami catalogs and full set of options for their visualization. In the process of this integration, several major improvements of the TTT algorithm have been made. These improvements include:

- New algorithm for plotting isochrones (that eliminates breaks in lines);
- New option for plotting travel time values at the isochrone lines (in several formats – secs, min:secs, hours);
- New heuristic method to prevent isochrones from jumping over the narrow land strips (like the Panama isthmus);
- New dialog window for display settings for plotting point and elliptic sources (allows selection of different colors and width).

These new TTT options were incorporated into the WinHTDB graphic shell as a built-in subroutine, having special options in the main menu, thus forming a new shell – WinITDB (Integrated Tsunami Database), the latest version of which (5.15 of July 31, 2005) will be presented at the ITSU-XX. An example of the TTT calculation (for the case of the 2004 Sumatra tsunami) is presented in Fig.1.

The version 5.15 of the WinITDB shell can be considered as a prototype of the next generation product – WinITRIS (Integrated Tsunami Research and Information System), that is now under development in the Novosibirsk Tsunami Laboratory. It is supposed that in addition to the TTT software, the system will include the subroutine for dynamic tsunami modeling allowing quick calculation of tsunami generation and propagation from realistic earthquake source within any area of the World Ocean provided with detailed digital bathymetry data.

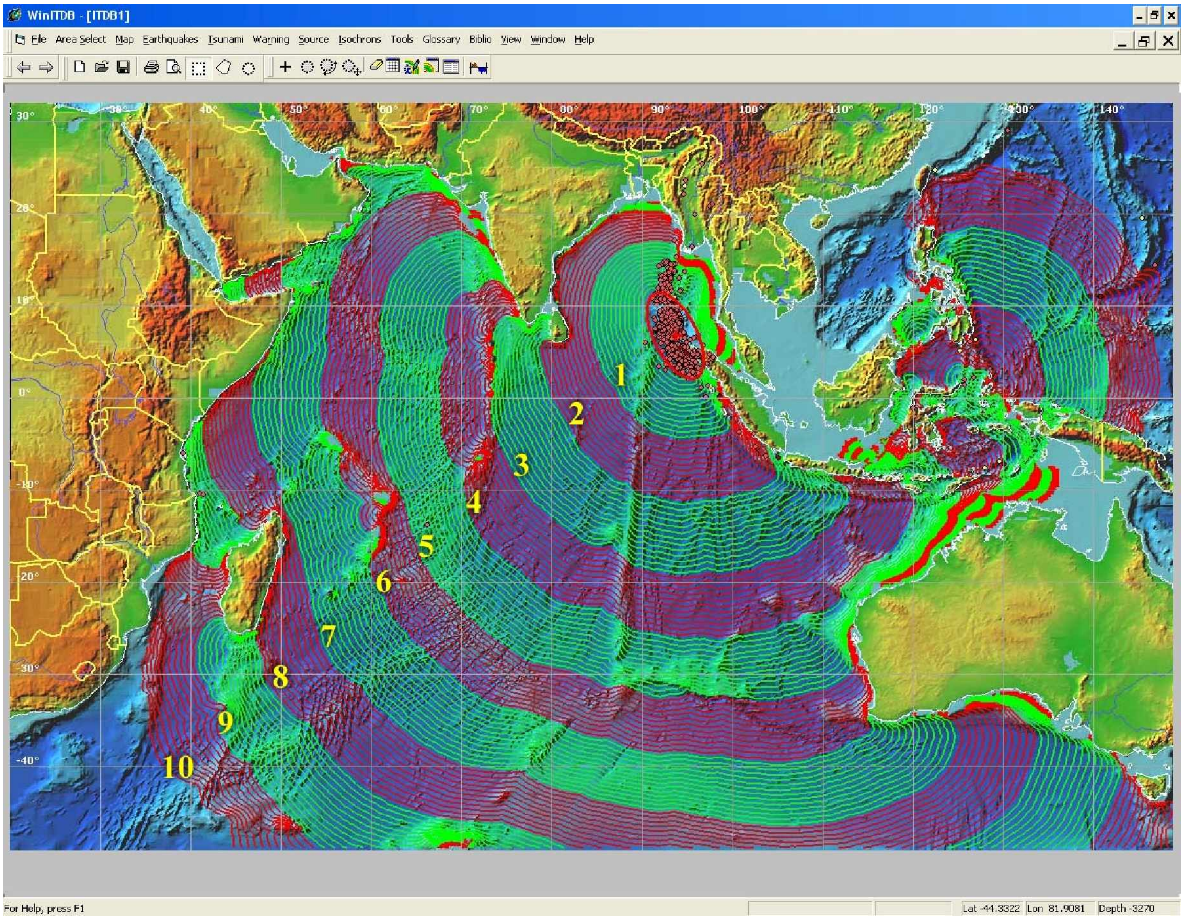


Fig.1. Example of the screen output provided by the WinITDB graphic shell (version 5.15) – calculation of the tsunami travel time chart for the Dec.26, 2004 Sumatra tsunami.

2.2. Extension of the WinITDB graphic shell to the global coverage

The WinITDB graphic shell that initially has been developed for the Pacific, was extended to cover other tsunamigenic areas of the World Ocean. Extension was made by changing the start-up map from the Pacific region (within 65ºS-65ºN and 80ºE – 60ºW) to the world-wide map (within 80ºS-80ºN and 25ºE – 25ºE). For user's convenience, four additional regional maps (for the Pacific, Atlantic and Indian Oceans and for the Mediterranean Sea) were added as new options in the "Area Select" menu. Example of output provided by this updated version of the WinITDB graphic shell are shown in Fig.2. as the maps of tsunami sources for the main tsunamigenic regions of the World Ocean).

Other major improvements of the WinITDB graphic shell, as compared to the WinHTDB graphic shell, include the following new features:

- New vector layer "Isolines of Relief" (added to the "Map" sub-menu) that can be overlaid over the shaded relief or used instead of it;
- New dialog window ("Isolines") in the "Map Settings" pop-up window to set the parameters for isolines display;
- The layer "Regions" was made active and allows to make the selection of the events related to a particular region upon right mouse click while it is highlighted on the Pacific-wide map. The listing of these events is displayed upon double left-mouse click;
- New option "Bibliography" (added to the main menu) that provides listing of tsunami bibliography grouped into five sub-options (Historical Catalogs, General Books, Conference Proceedings, Selected Papers, Tsunami web-sites);

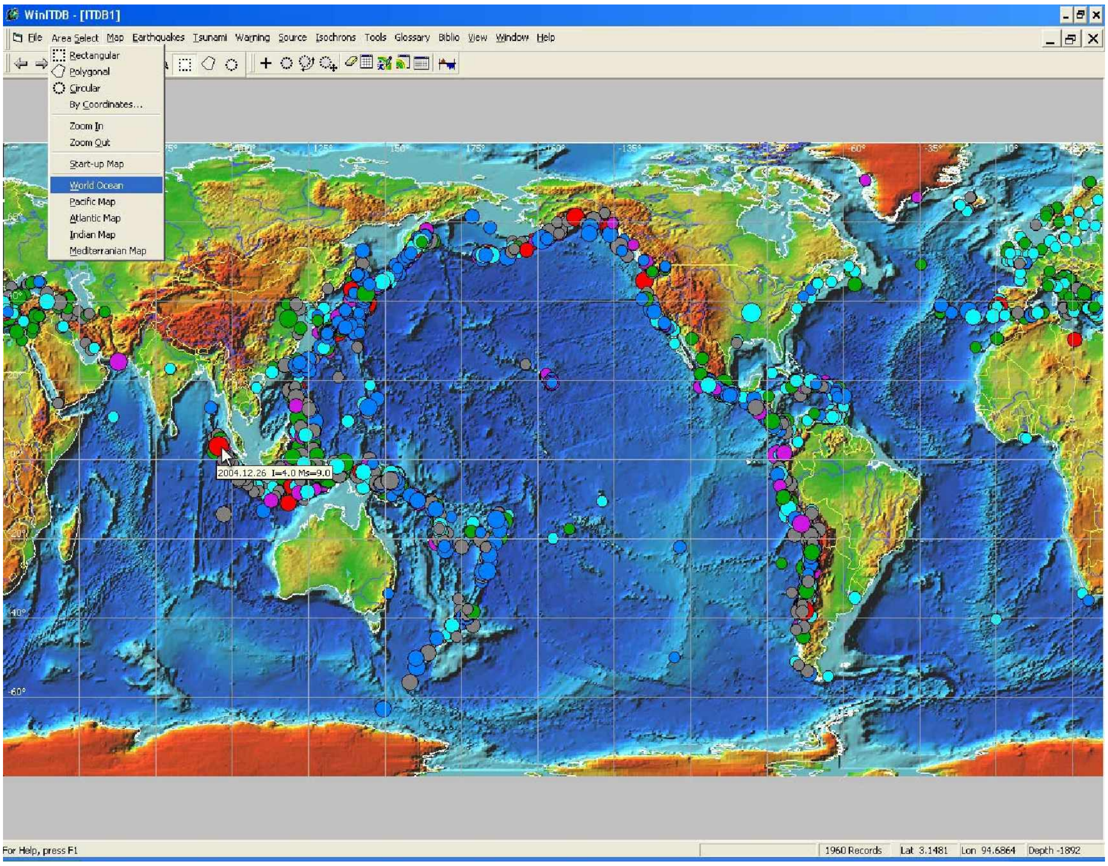


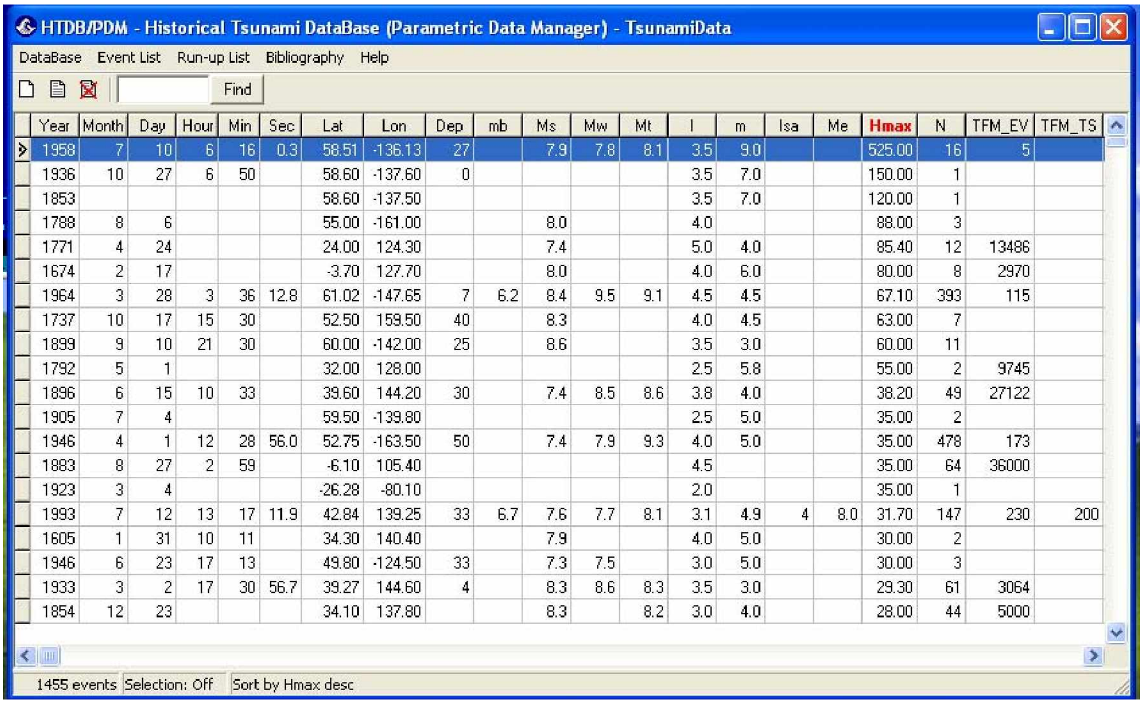
Fig.2. Example of the screen output provided by the WinITDB graphic shell (version 5.15) – start-up map with the global coverage and the global tsunami catalog overlaid. The "Area Select" pull-down menu shows the list of available regional maps.

- The geographical coverage of the WinITDB graphic shell has been extended to cover the main tsunamigenic areas of the World Ocean (Pacific, Atlantic, Indian Oceans and the Mediterranean Sea).

2.2. Development of the PDM graphic shell

Within the third direction, a new Windows-based graphic shell **(PDM – Parametric Data Manager)** has been developed. The PDM is an interactive graphic shell (screen form) intended for easy manipulation of parametric (source data, run-up observations) and descriptive (structured text, bibliographical references) data related to historical tsunamigenic events. Its main function is to assist the HTDB administrator in collection, editing and listing of parametric data related to historical tsunamigenic events. It is supposed that the PDM shell will be used by regional coordinators as a major instrumental tools in their work on further improvement of the quality and completeness of historical tsunami data for the World Ocean.

The PDM consists of the **Quick Look Table (QLT)** that lists the condensed set of parametric data related to tsunamigenic events (Fig.3) and the **Tsunami Event Card (TEC)** that gives the full set of parametric and reference data related to a particular event (Fig.4). In the QLT each event is representing by a single line of parameters representing the basic set of data on a particular historical event. Except the listing of tsunamigenic events, the QLT allows to make any event retrieval by multiple criteria, sorting and report printing.



HTDB/PDM - Historical Tsunami DataBase (Parametric Data Manager) - TsunamiData

Year	Month	Day	Hour	Min	Sec	Lat	Lon	Dep	mb	Ms	Mw	Mt	I	m	Isa	Me	Hmax	N	TFM_EV	TFM_TS
1958	7	10	6	16	0.3	58.51	-136.13	27		7.9	7.8	8.1	3.5	9.0			525.00	16	5	
1936	10	27	6	50		58.60	-137.60	0					3.5	7.0			150.00	1		
1853						58.60	-137.50						3.5	7.0			120.00	1		
1788	8	6				55.00	-161.00			8.0			4.0				88.00	3		
1771	4	24				24.00	124.30			7.4			5.0	4.0			85.40	12	13486	
1674	2	17				-3.70	127.70			8.0			4.0	6.0			80.00	8	2970	
1964	3	28	3	36	12.8	61.02	-147.65	7	6.2	8.4	9.5	9.1	4.5	4.5			67.10	393	115	
1737	10	17	15	30		52.50	159.50	40		8.3			4.0	4.5			63.00	7		
1899	9	10	21	30		60.00	-142.00	25		8.6			3.5	3.0			60.00	11		
1792	5	1				32.00	128.00						2.5	5.8			55.00	2	9745	
1896	6	15	10	33		39.60	144.20	30		7.4	8.5	8.6	3.8	4.0			38.20	49	27122	
1905	7	4				59.50	-139.80						2.5	5.0			35.00	2		
1946	4	1	12	28	56.0	52.75	-163.50	50		7.4	7.9	9.3	4.0	5.0			35.00	478	173	
1883	8	27	2	59		-6.10	105.40						4.5				35.00	64	36000	
1923	3	4				-26.28	-80.10						2.0				35.00	1		
1993	7	12	13	17	11.9	42.84	139.25	33	6.7	7.6	7.7	8.1	3.1	4.9	4	8.0	31.70	147	230	200
1605	1	31	10	11		34.30	140.40			7.9			4.0	5.0			30.00	2		
1946	6	23	17	13		49.80	-124.50	33		7.3	7.5		3.0	5.0			30.00	3		
1933	3	2	17	30	56.7	39.27	144.60	4		8.3	8.6	8.3	3.5	3.0			29.30	61	3064	
1854	12	23				34.10	137.80			8.3		8.2	3.0	4.0			28.00	44	5000	

1455 events | Selection: Off | Sort by Hmax desc

Fig.3. Example of the screen output provided by the PDM graphic shell (version 3.1) – the **Quick Look Table** that lists the condensed set of parametric data related to tsunamigenic events. In this listing, the events are sorted by the value of their maximum run-up heights.

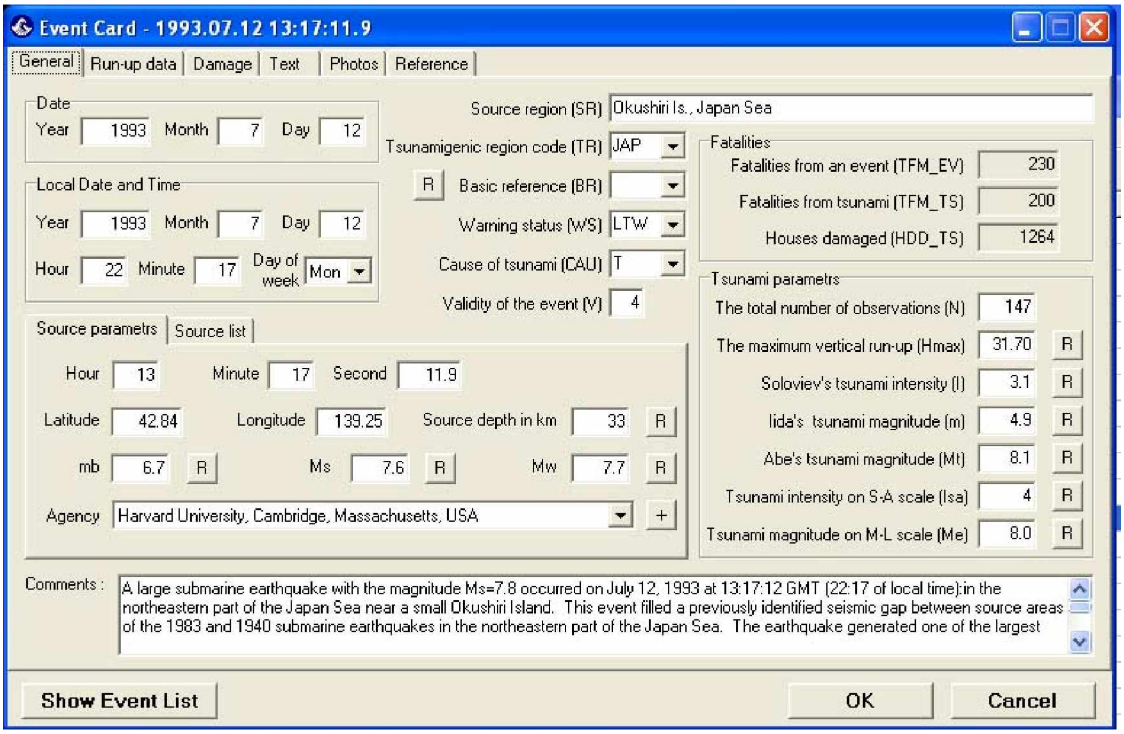


Fig.4. Example of the screen output provided by the PDM graphic shell (version 3.1) – the **Tsunami Event Card** with the detailed data for the 1994 Shikotan tsunami.

The TEC provides an access to the full set of data related to a particular event. It consists of several tags each representing a particular type of information (source event data, data on damage, run-up heights, textual description of an event, digitized photos, bibliographical references). The important feature of the

TEC is the ability to manipulate with the adequately referenced multi-string data related to a single event (source coordinates, magnitudes, estimates of damage) as provided by different sources.

2.4. Development of the full 3D global graphic shell

Within the third direction, the prototype of a new, full 3D graphic shell with the global coverage (GlobalITDB) has been developed (Fig.5). The shell is written in C#, a new powerful programming language, using the .NET Framework infrastructure and a new specialized graphic library (GeoGL) specially developed by the NTL programmers for visualization of geophysical data in the full 3D mode.

The basic features of the new shell include

(1) support of several basic coordinate systems and map projections used in mapping of geophysical data;
(2) support of several database formats used for historical data compilation and storage;
(3) procedures for the full 3D visualization of the land surface and ocean bottom relief;
(4) procedures for calculation and display of isoline charts;
(5) options for interactive rotation of resulted images;
(6) procedures for overlay of additional information (captions, annotations) on the resulted maps;
(7) options for saving the resulted user-made maps in different graphic formats.

It is supposed that the Global ITDB shell will support manipulations with the built-in subroutines for TTT calculation and numerical modeling of tsunami propagation as well as procedures of calculation of the long-term tsunami risk for particular coastal areas.

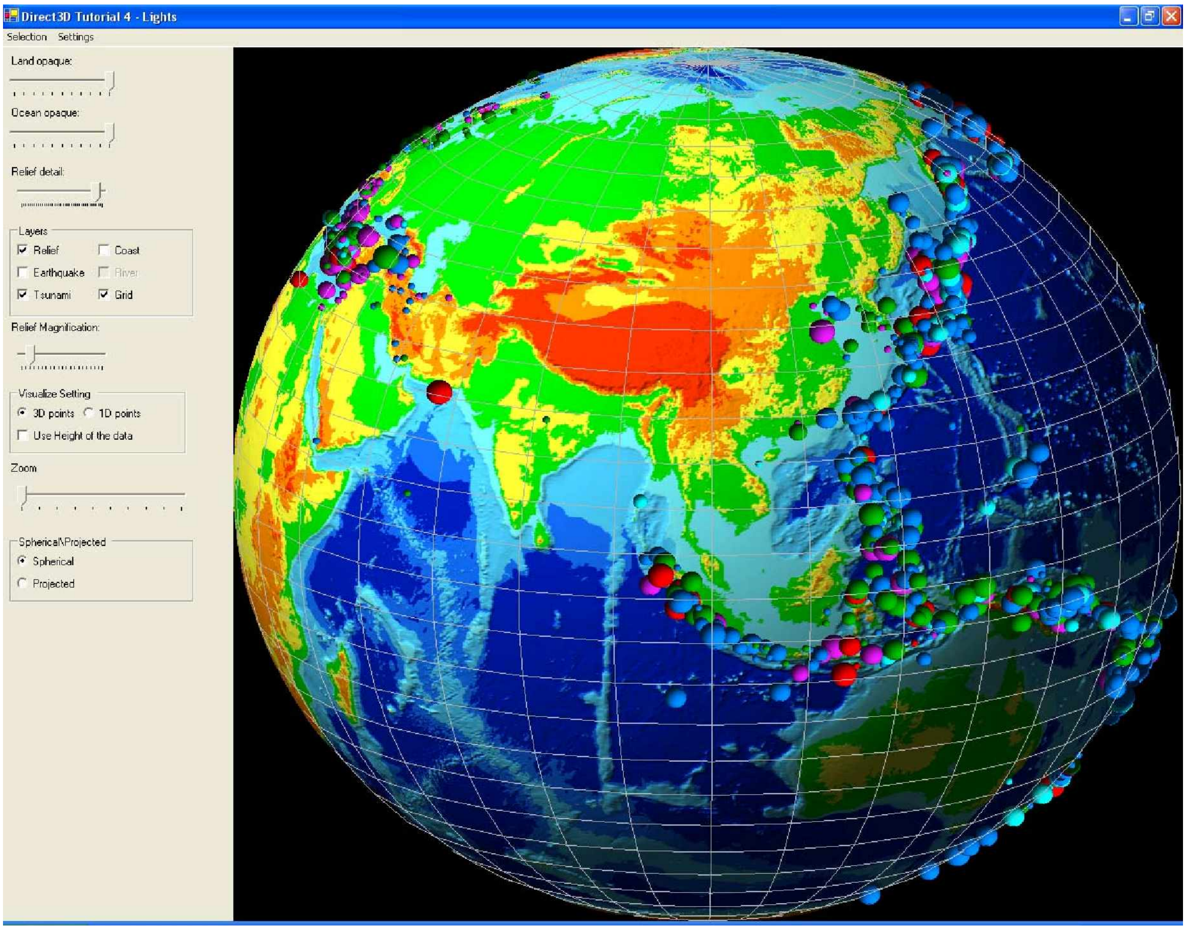


Fig.5. Example of the screen output provided by the beta-version (1.0) of the full3D graphic shell (Global ITDB) – visualization of the global tsunami catalog.

2.5. Further updating the regional tsunami catalogs and converting them into the Global Tsunami Catalog

The work made by the NTL/ICMMG in 2004-2005 in this direction includes:

- Development of the new format for GTDB data set (jointly with the NGDC/NOAA and the ITIC). Comparatively to the present HTDB format (that is used in the WinHTDB graphic shell) it includes two new fields in the EVENT catalog (the total number of fatalities from an event, and the total number of destroyed and damaged houses due to a tsunami) and two new fields in the RUN-UP catalog (the number of fatalities at a particular location, and bibliographical reference for run-up value).
- Standardization of the Region and Area names in the RUN-UP catalogs. Region names for all observation sites were standardized in accordance with the names of the main tsunamigenic regions in the Pacific and other areas.
- Checking and correction of the "Type of measurement" field in the RUN-UP catalog, based on information on existing tide networks in the different areas of the World Ocean.
- Extension and correction of historical data set for the Tonga-Fiji-Vanuatu region based on the data in the regional catalog (Everingham, 1987) provided by Dr.B.Pelletin (New Caledonia).
- Forming the Indian Ocean tsunami catalog as a separate catalog (earlier the data for the eastern Indian Ocean were included in the Pacific tsunami catalog) and its extension on the basis of available publications (Berninghausen, 1964, 1966, 1969).
- Compiling the detailed data on the coastal run-up measurements for the December 26, 2004 Sumatra tsunami (more than 450 measurements are currently available).

According to the plan discussed at the ITSU-XIX It was foreseen that Dr.Gusiakov would come to Honolulu and Boulder in February-March of 2004 for the joint work with ITIC and NGDC/NOAA for further data compilation, verification and their merging with the NGDC data to form a new GTDB data set. However, due to a problem with getting US visa, this visit could not be implemented. It was decided that during the rest of 2004 and in 2005 both groups (NTL/ICMMG and NGDC/NOAA) will work independently based on their sources of historical tsunami data and will seek other possibilities for the work for data merging and conversion into the GTDB format..

3. The GTDB current content

In the summer of 2005, using the PDM software as a supporting instrumental tool, the NTL made a conversion of the four existing regional tsunami catalogs (for the Pacific, Atlantic and Indian Oceans and for the Mediterranean Sea) into a single global database (in the *.mdb format) containing historical events and run-up data for the World Ocean. Currently this database contains 2258 records covering the period from 1628 B.C. to present with 2106 of them having the validity index equal or more than 1. Thus, the database has 152 records with validity 0 that are considered to be false entries. These records are kept in the database to prevent their further re-entry because information on them exists in the literature. Some of these records have their analogs in the main part of the database just with different dates or locations.

Distribution of events over the validity index is as follows (Fig.6):

Validity 4 (definite event)	761
Validity 3 (probable event)	400
Validity 2 (doubtful event)	611
Validity 1 (very doubtful event)	334
Validity 0 (false entry)	152

In all further analysis only the events with validity equal or greater than 1 are taken into account.

Among 2106 historical tsunamis only 1967 have currently their assigned source coordinates. The rest of 139 events still need for determination of their origin (information of these events is based on description of their manifestation at the coast). Distribution of 2106 tsunamigenic events over the main tsunamigenic regions is as follows (Fig.7):

Pacific Ocean	1265 (60%)
Mediterranean Sea (including the Black Sea)	517 (25%)
Atlantic Ocean (including the Northern and the Baltic Seas)	247 (12%)
Indian Ocean	77 (4%)

However, this distribution does not quite reflect the actual tsunami activity of the main tsunamigenic regions, because the total length of historical catalogs for them is quite different and varies from almost 3500 years for the Mediterranean to slightly longer than 400 years for the Indian ocean.
If we consider the same distribution for the XXth century where all catalogs can be considered as most complete, it will look like (Fig.8)

Pacific Ocean	723 (78%)
Atlantic Ocean (including the Northern and the Baltic Seas)	89 (10%)
Mediterranean Sea (including the Black Sea)	81 (9%)
Indian Ocean	33 (4%)

Thus, more than ¾ of all tsunamigenic events of the World Ocean occur in the Pacific.

Distribution of all tsunamigenic events over the type of origin is as follows (Fig.9):

Tectonic	1646	(72%)
Landslide	229	(10%)
Volcanic	104	(5%)
Meteorological	42	(2%)
Unknown	246	(11%)

(In this distribution, some events exist in two or more groups due to complexity of their source, for instance, tectonic + landslide, volcanic + landslide, etc.).

The variation of the global tsunami catalog completeness over time can be seen from the number of entries within different historical periods (Fig.10):

XX century	926
XIX century	600
XVII century	210
XVII century	122
XVI century	50
1001-1500 AD	78
501-100AD	40
0-500	29
BC	25

Less than half (45%) of all tsunamigenic events are provided with quantitative estimates of maximum run-up heights. For many old events historical descriptions mention only the degree of damage resulted from tsunami, quite often expressed in very general terms (“many boats in a harbor sink”). Distribution of tsunamigenic events having quantitative data on their maximum run-up heights (Hmax) is as follows (Fig.11):

Hmax ≥ 1m	494
Hmax ≥ 5m	200
Hmax ≥ 10m	116
Hmax ≥ 15m	63
Hmax ≥ 20m	38
Hmax ≥ 30m	24
Hmax ≥ 50m	11
Hmax ≥ 100m	3 (all in the Lituya Bay, Alaska)

Only 573 (27%) of all historical tsunamis have reported fatalities. Their distribution over the number of fatalities (FAT) is (Fig.12):

FAT ≥ 1	225
FAT ≥ 10	172

FAT ≥ 100	109
FAT ≥ 1000	53
FAT ≥ 10000	13
FAT ≥ 100000	1 (Sumatra 2004)

And, finally, of all 2106 historical events only 7 tsunamis can be considered as really “trans-oceanic” events that produced considerable damage and fatalities well outside (at a distance more then 5000 km) of their area of origin. They are the Lisbon 1755 tsunami in the Atlantic, the 1946 and 1957 Aleutians, 1952 Kamchatka, 1960 Chile and 1964 Alaska tsunamis in the Pacific and the 2004 Sumatra tsunami in the Indian Ocean.

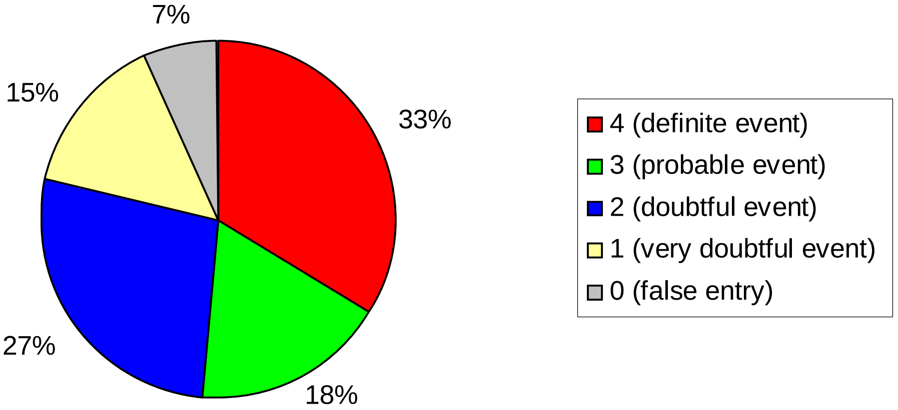
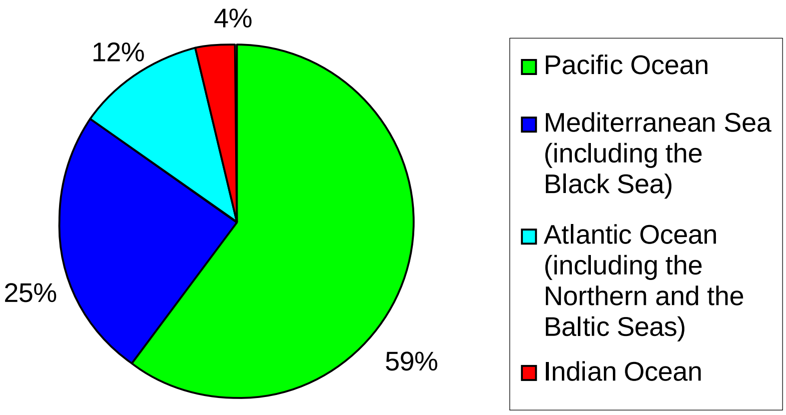


Fig.6. Distribution of global tsunamigenic events over the validity index



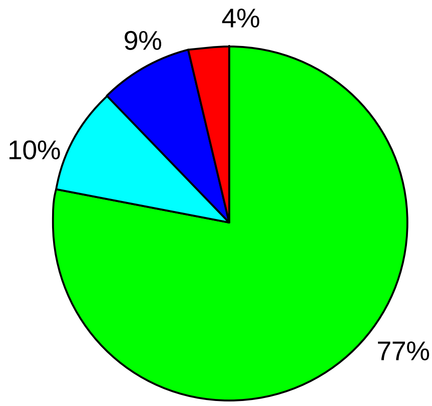


Fig.7. Distribution of the events over the main tsunamigenic regions (for the whole period)

Fig.8. Distribution of the events over the main tsunamigenic regions (for XX century)

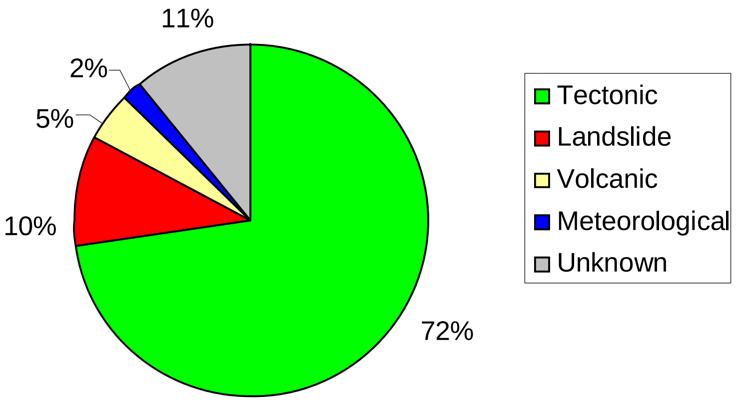


Fig.9. Distribution of the tsunamigenic events over the type of source

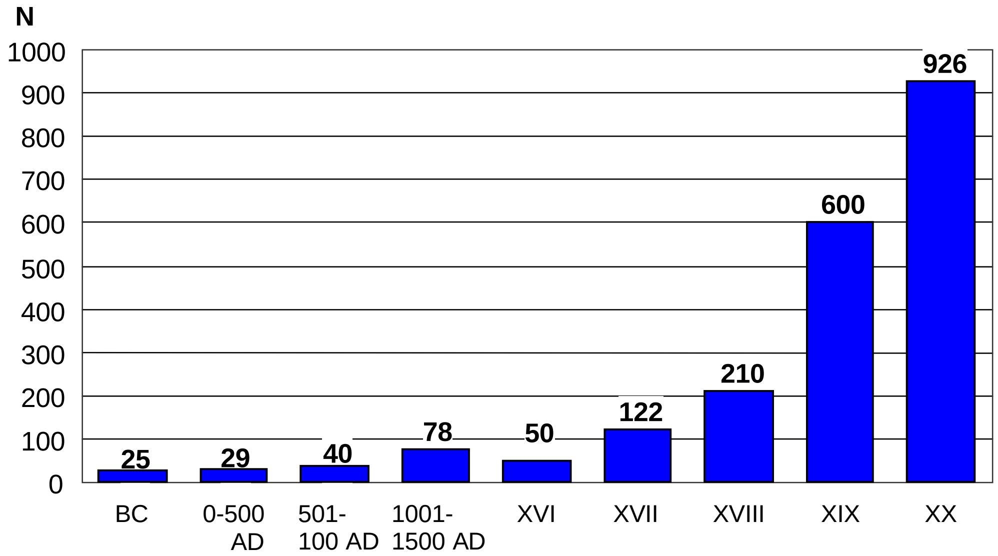


Fig.10. Histogram of the global tsunami occurrence within 100-year intervals

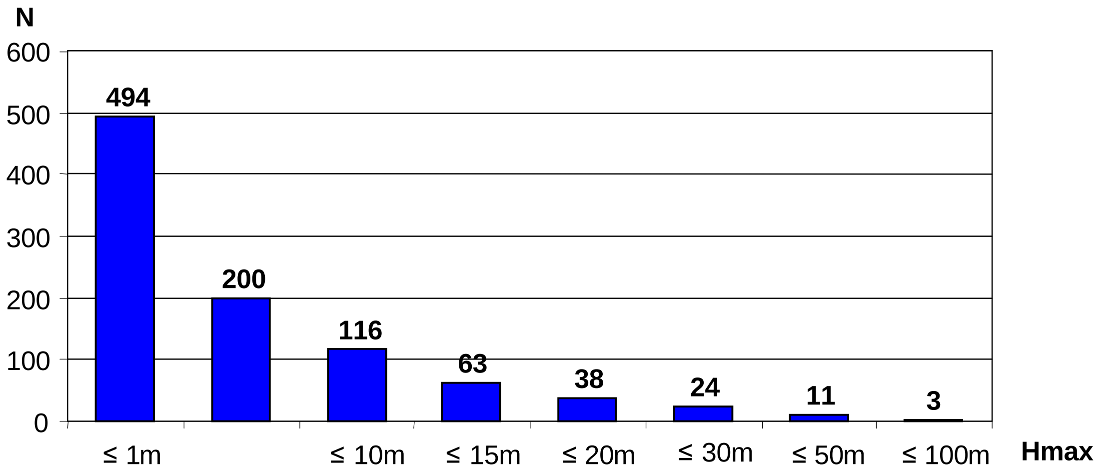


Fig.11. Number of tsunamigenic events depending on their maximum run-up heights

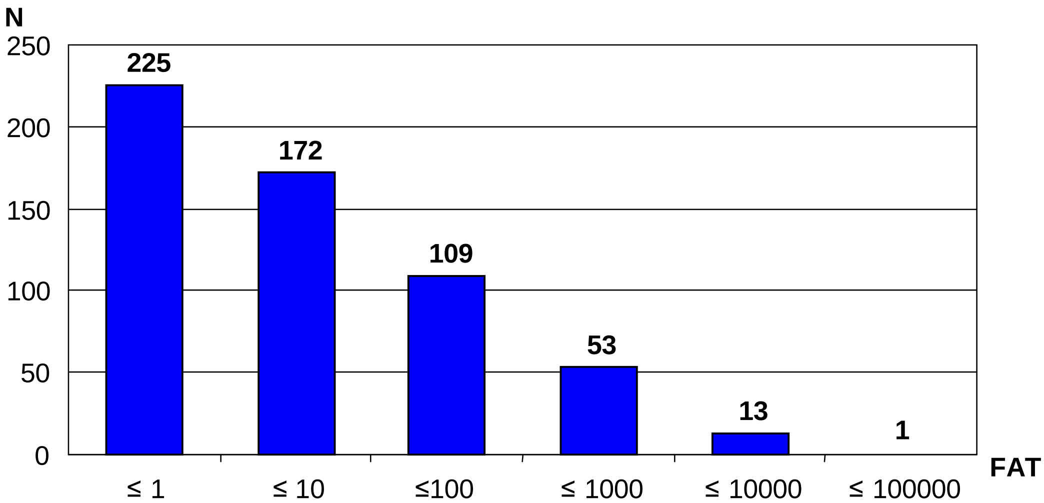


Fig.12. Number of tsunamigenic events depending on the number of resulted fatalities