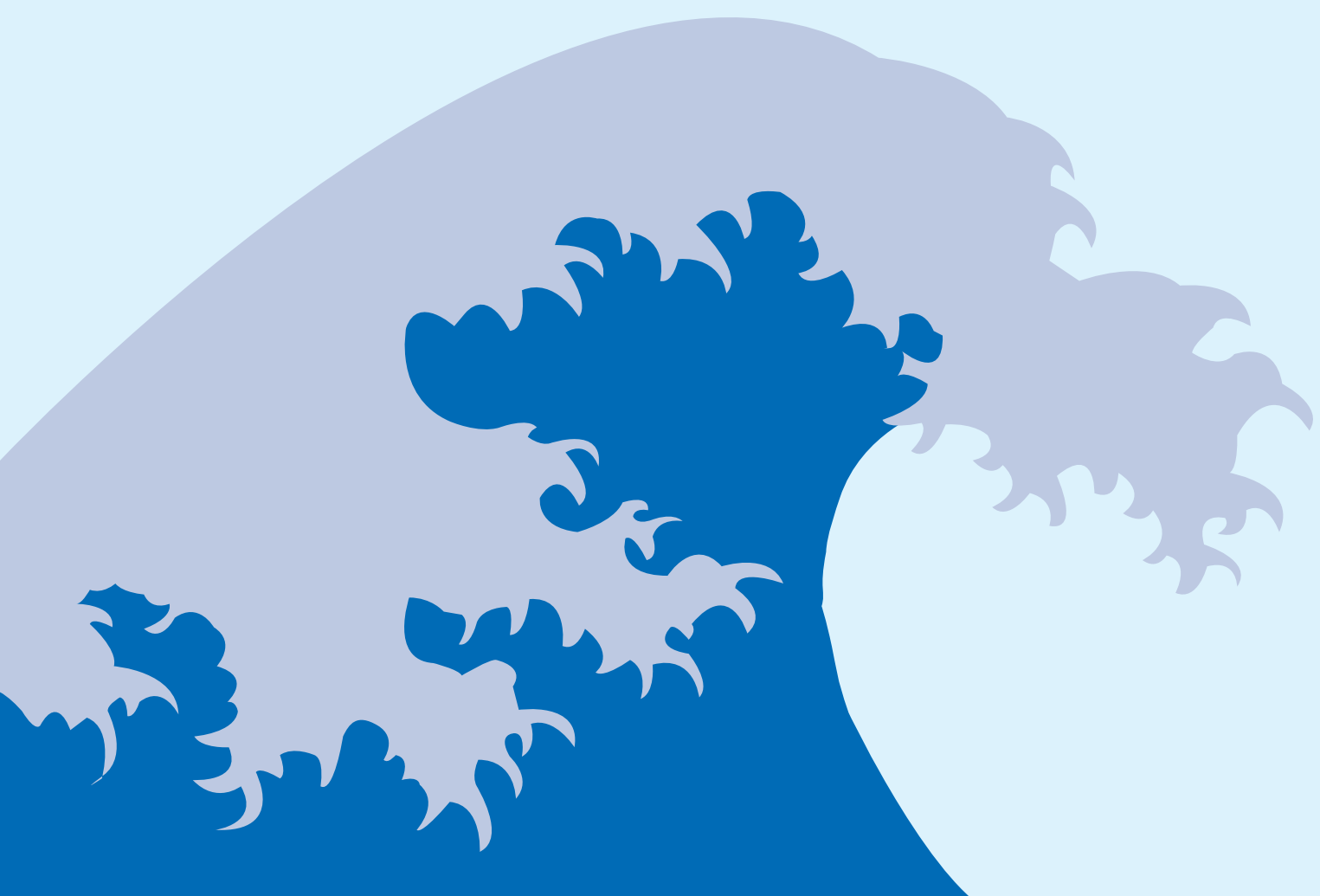


Strengthening Tsunami Warning and Emergency Responses:

Training Workshop on the development of End-to-End Tsunami Standard Operating Procedures



Course Manual 2008 - 2023

Tsunami Warning Decision Support Tools



United Nations
Educational, Scientific and
Cultural Organization



Intergovernmental
Oceanographic
Commission



National Oceanic
and Atmospheric
Administration



The International
Tsunami Information
Center

Organized by the UNESCO IOC - NOAA
International Tsunami Information Center
for Member States of the
Pacific Tsunami Warning and Mitigation System
and
Tsunami and Other Coastal Hazards Warning
System for the Caribbean and Adjacent Regions



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TSUNAMI WARNING DECISION SUPPORT TOOLS

*Compiled and distributed by International Tsunami Information Center (ITIC)
January 2023*

These following are useful decision support tools available free-of-charge to governments and other designated authorities involved in tsunami warning and mitigation. For more information, contact the ITIC (itic.tsunami@noaa.gov) or its Director (Laura Kong, laura.kong@noaa.gov). Additional information is available at the ITIC web site, <http://www.tsunamiwave.org/>

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- 1. Real Time Earthquake Display (RTED) Tool** - developed by US Geological Survey and the California Office of Emergency Services (California Integrated Seismic Network, CISN) with support from the US National Tsunami Hazard Mitigation Program. *This GIS display provides real-time earthquake information as broadcast by the US Geological Survey National Earthquake Information Center (USGS NEIC) and includes tsunami information from the PTWC and US National Tsunami Warning Center (US NTWC, formerly WC/ATWC). The USGS NEIC serves as the World Data Center for Seismology. Available since 2005.*
- 2. Tsunami Warning Operations: Sea Level Monitoring – Tide Tool and IOC Sea Level Monitoring Facility**
Tide Tool is an operations tool developed and supported by the Pacific Tsunami Warning Center for the decode, display, and manipulation of sea level data (coastal and DART deep-ocean stations) transmitted over the WMO Global Telecommunications System (GTS). The tool continuously decodes sea level in real-time and displays the time series on a computer screen, along with station status and metadata. Map clients enable easy viewing. Tsunami travel time and expected arrival time information available from 2014. Non-operational versions exist for data transmissions through the internet and for archived data. Available since 2005.

The IOC Sea Level Monitoring Facility, developed originally under the IOC IODE Project for the ODINAFRICA sea level network in 2006, is a web-based real-time monitoring tool for sea level stations globally. The URL is <http://www.ioc-sealevelmonitoring.org/map.php>. The tool provides sea-level data, station status and metadata, data plots, and other database services. This tool should be used with caution for operational purposes since timely web access cannot be guaranteed all over the globe during emergencies. Available since 2008.
- 3. Tsunami Bulletin Board (TBB)**
The TBB is an email list serve that provides immediate sharing of tsunami information by and among tsunami professionals (scientists, researchers, emergency officials, and other officials). PTWC and US NTWC bulletins are immediately posted to TBB. Its purpose is to provide an open, objective scientific forum for the posting and discussion of tsunami news, information, and research. It is not open to the media or the general public, and is not intended for advertising or activities of a commercial nature. The TBB began in 1995.

4. Tsunami Travel Time Software

The World Data Service for Geophysics (WDS-Geophysics), co-located at the NOAA National Centers for Environmental Information (NCEI, formerly National Geophysical Data Center NGDC), serves as the world's recognized tsunami database and archiving centre. *The WDS-Geophysics and the ITIC are providing free-of-charge, tsunami travel time calculation and display software to government organizations involved in providing tsunami warning and mitigation services. Other interested organizations and individuals are requested to obtain the software directly from the developer, Geoware.* The Tsunami Travel Time (TTT) software is used by the PTWC for its operations calculations, such as in Tide Tool. Map graphics are made using the open-source Generic Mapping Tools (GMT). Available since 2007.

5. Tsunami Coastal Assessment Tool (TsuCAT)

TsuCAT is an offline tool that can assist a country in its tsunami hazard assessment, tsunami exercise and response planning, and warning decision-making. The tool provides access to a pre-computed database of Pacific, Caribbean, and Indian Ocean tsunami scenarios (M6.8 to M9.5) calculated using the NOAA MOST and RIFT numerical models. Version 4 (2019) introduces an exercise tool that produces the PTWC public text and enhanced graphical products. Simulations for historical tsunami sources from the NCEI and the USGS earthquake archives, and from IOC Tsunami Sources expert meetings, are also included. Developed by NOAA's National Center for Tsunami Research (NCTR) and ITIC. Available to countries since March 2017.

6. Tsunami Historical Databases

The WDS-Geophysics NCEI provides extensive online, web-based and offline tools and other hazards information and digital bathymetry services. In 2009, the NCEI and ITIC developed an enhanced offline tool (*TsuDig GIS tool*) that accesses the WDS tsunami database and includes features of specific use and interest to tsunami warning and emergency response decision-makers; TTT calculations and displays are included in *TsuDig*. *Since the 1990s with the last features update in 2005, the Novosibirsk Tsunami Laboratory (NTL) has provided the WinITDB as an offline, standalone tool working on Windows platform.*

7. Google Earth Database Files

The Google Earth visualization tool can be used to display a number of earthquake and tsunami-related information and databases. KMZ or KML files include USGS-located earthquakes (in near real-time), the WDS/NCEI Global Historical Tsunami, Significant Earthquakes and Volcanic Eruptions databases, and the IRIS Global Seismic Network, as well as the PTWC Enhanced Product forecasts for events.

8. TsunamiTeacher Tsunami Resource Toolkit

TsunamiTeacher brings together authoritative and reliable materials of interest to a range of stakeholders involved in tsunami warning and mitigation. Sections cover the roles of the media, educational systems, and the public (government) and private sectors. The tool is available as an electronic resource as an offline DVD from ITIC. The version will work on older PCs and current Macintosh systems. Available since 2006. TsunamiTeacher has been translated into several languages to date. In 2011, the ITIC produced a 6-min Tsunami Basics video for US TsunamiTeacher.

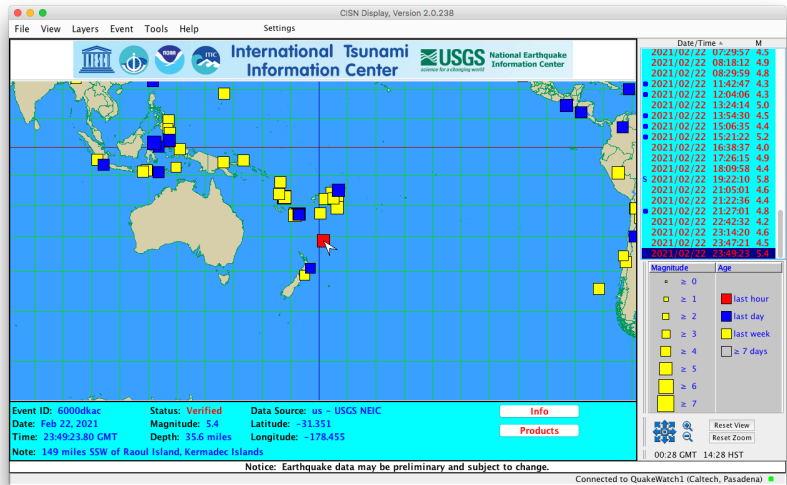
Real Time Earthquake Display (RTED) California Integrated Seismic Network (CISN) tool Version 3.4.264, November 2022

Summary:

The RTED (or originally CISN) Display provides reliable delivery of real-time earthquake information, including rapid notification and ShakeMap to critical end users. Users are able to customize the tool according to their own local needs, including the setting of thresholds for display and alarming and import of additional graphics data layers. The tool was developed by the US Geological Survey in collaboration with the California Office of Emergency Services, and further supported by the US National

Tsunami Hazard Mitigation Program.

Recent program improvements included: Web Services middleware that allows data to get through firewalls; improved layers, including more detailed coastlines; integrated e-mail capability; new event sorting options; a "T" for events for which a tsunami warning has been generated and "I" for Internal messages in the event list (emergency version only). The CISN has 4 servers online to provide reliable access to earthquake information.



Eligibility:

Freely available to everyone. ITIC is a CISN-registered organization serving as a focal point for institutions interested in using CISN for tsunami warning and mitigation in their country.

Minimum System requirements for operating CISN Display:

- Java Runtime Environment 1.8.X or higher (available from Sun at <http://java.com/en/download/manual.jsp>)
- Pentium-III, 1GHz CPU speed or comparable hardware 384 Mb RAM or more
- IP Address (private or public)
- Access to port 443 (HTTPS) and connection to the following:
 - <https://cgs1-quakewatch-fdsn.azureedge.net>
 - <https://cgs1fnpublic.azurewebsites.net>
 - <https://cgs2-quakewatch-fdsn.azureedge.net>
 - <https://cgs2fnpublic.azurewebsites.net>
 - <https://earthquake.usgs.gov>

Instructions for obtaining RTED/CISN:

1. Install the software, copy the folder from the TWTTools disk or download from <https://quakewatch.isti.com/qwclient/download/download.html>
2. Installation options:
 - Windows XP, Vista, Windows 7, Windows 10, Mac OS X, UNIX/Linux
 - Manual (not recommended)

*US Geological Survey, California Emergency Mgmt Agency, FEMA, US Natl Tsunami Hazard Mit Program
update November 2022*

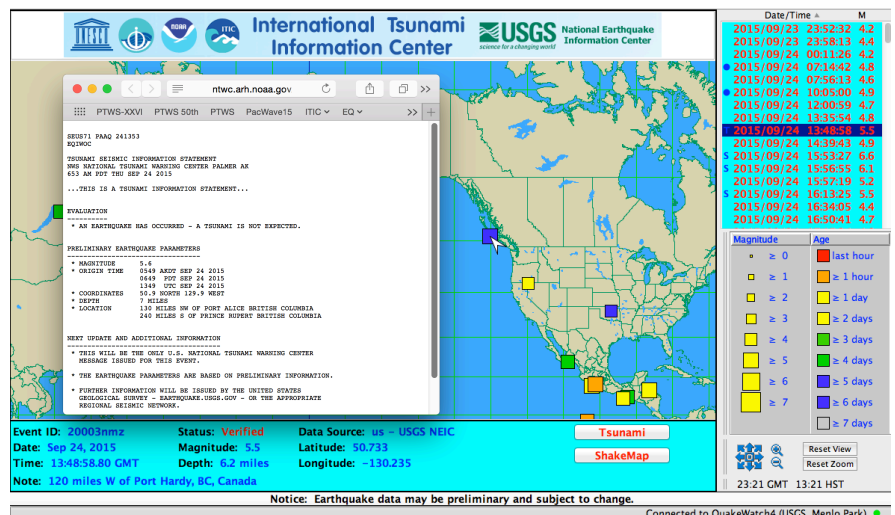
3. Check to make sure you have Java Runtime Environment (JRE) 1.8.X or higher installed. To get Java (it's free), visit <http://java.com/en/download/index.jsp>. Note: installation of new software sometimes requires administrative privileges on the host machine. If any part of the installation fails, contact your local systems administrator for assistance.

Installation of the software. Follow the instructions as outlined in the installation shield. Once complete, launch the application, enter your user-account username/password and check the lower-right corner for a green status light that indicates a good connection to a QuakeWatch Server. There should be no need to specify a server address; the client comes preconfigured with one. A shortcut icon should be created on your desktop to use to access the software.

4. Refer to the CISN Display User's Guide to learn more about customizing your user-interface settings... every organization should do this! Documentation available includes:
 - Revision History
 - User's Guide (v1.2, 2005)
 - Display Settings Manual
 - Event Viewer Manual

For example, you may wish to have your organizations' logo displayed instead of the default CISN logo. To do this, create a .gif file and place it in the "banners" directory of the "CISN_Display" folder. The banner is then selected from the Settings/Display menu once the program is started.

The ITIC Display Configuration is an example of a useful default display for tsunami warning centers.



Tsunami messages, when issued by the US NTWC or PTWC, are also available by clicking on the "Tsunami" button. This opens another window where the message is shown. The example below is from a M4.7 earthquake in Barbados on 30 March 2007. To display the "Tsunami" button on the screen, choose it as a Product button from the Settings/Config tab.

Acknowledgements:

Developed as a cooperative project of the CISN. Funding provided by the OES, USGS, FEMA/OES Hazards Mitigation and Emergency Management Performance Grant Program, and the US National Tsunami Hazard Mitigation Program. Additional financial support was provided by Instrumental Software Technologies, Inc. (ISTI). This software was developed in partnership with ISTI.

OTHER ALERTS:

Receiving email/SMS alerts through RTED/CISN:

The CISN tool allows the configuring of parameter thresholds for sending email and SMS text messages to customers. Systems administrator privileges may be required; you will need to know the name of your SMTP server. Because your own mail servers are used, SMS dissemination and its timeliness will be dependent on your servers and configuration. To receive alerts as earthquakes occur, the CISN must always be running (7x24 basis). While issuance may only take only a few seconds, message receipt may be much longer. Regular tests should be performed to monitor performance.

USGS Earthquake Notification Service (ENS) - Alternative to RTED/CISN alerts:

An easy-to-configure and maintain tool for receiving email information is provided by the USGS. Visit <https://earthquake.usgs.gov/ens/help> to sign up and configure the thresholds for notification. ENS is functional in English and Spanish.

IMPORTANT NOTES:

- *The above services have NOT been tested as operational tsunami warning tools. Users will need to assess the timeliness of information delivery to their own country and operations centers.*
- *For highest reliability, enable all the services to ensure redundancy, and monitor to see if one service is more timely than the other. It is wise practice for any important message to always be received through at least two different communications methods.*

Quickinfo RTED / CISON Installation

Update Nov 2022, L. Kong, laura.kong@noaa.gov, T. Fukuji, tammy.fukuji@noaa.gov

Use:

CISON is a real-time earthquake monitor that automatically receives and immediately plots earthquake epicenters on a GIS display as they are posted by the US Geological Survey. As additional data are received and incorporated, the CISON will update the earthquake information. Agencies that are currently submitting their information include the Pacific Tsunami Warning Center (PTWC) and US National Tsunami Warning Center (US NTWC); a “Tsunami” product button can be displayed, and when activated immediately indicates that the tsunami warning centers (TWC) have issued a tsunami message.

The CISON will receive and post PTWC and US NTWC earthquake observatory messages; these messages, which are preliminary, unofficial products, are the earliest notification that a sizeable earthquake has occurred and will be issued a few minutes before an official TWC message. The TWC earthquake observatory message is also the only TWC product that will be issued when a small earthquake occurs that is below the tsunami reporting threshold.

NOTE: The CISON earthquake information that is displayed is that of the US Geological Survey, which serves as the authoritative agency for earthquakes in the US. The USGS hypocenter and magnitude will likely differ (by a small amount) from those published by the PTWC and US NTWC. During a tsunami event, the PTWC and US NTWC work together, but independently from the USGS, to calculate the hypocenter and magnitude, and they use these in their tsunami products.

ITIC and PTWC recommend the use of CISON as a means for displaying real-time earthquake information, and for alerting duty staff that PTWC has issued a tsunami message.

Start:

The program is started by double-clicking the desktop icon, or other method. Required internet bandwidth is minimal, so can be minimized and run in the ‘background’ on any desktop.

Instructions for installation:

The following are quick instructions for installing and using CISON. For details, consult RTED_Info_nov2022.pdf, CISON User Guide, and other manuals (in Manual_info folder of installation disk).

This distribution includes CISON version 3.4.264.

1. Install software:
 - a. Copy folder from TWTtools DVD to your desktop or download from <https://quakewatch.isti.com/qwclient/download/download.html>
 - b. Open install folder, find your installation and double-click on “Setup” to run.
2. Agencies with firewalls will need to ensure that CISON ports (and/or server domains) for information dissemination to the CISON software are allowed.
3. Customize your CISON display to your needs.
 - i. Load ITIC default configuration to set all display parameters (CISON_Display_ITIC.xml)
 - ii. Further customize as need. Some options are (access from tabs in Settings file menu).
 - a. Set earthquake display threshold (M4 or M5, in Filters tab)
 - b. Time zone display, if other than GMT (in Display tab)
 - c. Magnitude threshold for Alarm (M4 or M5, in Alarm tab)
 - d. Include “Tsunami” product button in display (in Config tab)
 - e. Center “default view” to your region; for Pacific, try 20, 180, scale 125000000)
 - f. Specify colors to use for symbols (for example if you would like to color code by single day, in Event Colors tab)

- g. Specify Banner for display; you can use the ITIC one (ITIC_USGS_banner.gif, move from your installation disk in 'OtherBanners' folder to Banners folder on your computer), or create your own (needs .gif file) (in Display tab)

**TSUNAMI WARNING OPERATIONS: SEA LEVEL MONITORING
TIDE TOOL: DISPLAY AND DECODE OF SEA LEVEL DATA TRANSMITTED OVER
THE WMO GLOBAL TELECOMMUNICATIONS SYSTEM
(vers 10.7, Jan 2023)**

Pacific Tsunami Warning Center (NOAA)
International Tsunami Information Center (NOAA-UNESCO/IOC)

Tide Tool is a software application that provides end users with the ability to decode, display, and manipulate sea level data broadcast over the Global Telecommunications System (GTS) of the World Meteorological Organization (WMO). Data download through the internet is also available, but is not recommended because timely, complete delivery of all data packets cannot be guaranteed. Tide Tool is enabled by the Tide.tcl script and region-specific map clients that provide simple-to-use graphical user interfaces to the continuously-incoming sea level data streams; the tool uses the Tcl/Tk software package and its BLT extension. Tsunami travel times can be calculated and a contour map overlaid onto the map client; estimated tsunami arrival times (ETA) at mouse-selected locations are provided. Tcl/Tk is an open source, platform-independent software package offering a powerful shell programming language and graphical toolkit. getTide, also included with Tide Tool, is a BLT script that can be used to read and analyze archived sea-level data log files.

The software application was developed and is supported by the US NOAA NWS Pacific Tsunami Warning Center (PTWC) as an operational tool for the real-time continuous tsunami monitoring in the Caribbean, Indian and Pacific Oceans. The travel time calculation software was developed by Geoware, and its algorithm is used by PTWC. The primary users of Tide Tool and its accompanying tools are National Tsunami Warning Centres, such as the National Meteorological and Hydrological Service (NMHS), or other agencies acting in this capacity, and with a downlink from the GTS or to a data file containing those data formatted in a similar manner. It has been tested under Unix/Linux, Windows 2000/XP/Vista/Windows 7/10 (32- and 64-bit) environments since 2005, and implemented using a non-GTS 'ftp' data transmission protocol in Linux and Windows systems for tsunami centers without GTS links. The 'ftp' method should be considered non-operational if commercial internet service is utilized since connection reliability and timeliness, especially during tsunami emergencies, cannot be guaranteed. A Tide Tool Manual is available providing information on its installation and use.

The primary use of this software is as an operational programme run by tsunami warning centres, or other operational centres, which need to continuously monitor sea levels for tsunamis. Features of the tool include time series display, wave arrival time, height and amplitude measurement, tide prediction removal, de-spiking, and station state-of-health and metadata. Accompanying software calculates predicted tsunami travel times. Users are able to select which stations to receive and display through edits to input files or by mouse-selection from a station map. Mouse-clickable functions include the expansion of the time series to enable easy measurement and logging of the arrival time, wave height and wave period from the incoming signal. Station and data transmission information, raw data packets, and station health reports can be viewed from within Tide Tool. Calculated travel time contours can be overlain.

Requirements:

In order to decode and display the data, the following are required:

- Computer running Tcl/Tk software with BLT extension, or WIZE software package
- Sea level data that are continuously archived into a data file
- Tide.tcl and associated map client software.

Computer and Tcl/Tk software with BLT extension

The software requires the installation of the Tcl/Tk software package and the BLT extension, both of which are freely available for download and easy to install. The software is able to run under Unix/Linux, Windows 2000/XP/Vista/Windows 7/10, and Macintosh OSX (under BSD Unix) operating systems; the preferred platform is Unix or Linux because of its stability. For Windows 7/10, it is recommended to install the WIZE software package, which includes the newer Tcl/Tk v8.5.9. Use on other platforms is possible as it only depends on Tcl/Tk and BLT softwares being available. The software does not require substantial computing power, and can thus run easily on a

Pentium III or higher PC system.

Sea level data

The input is assumed to be a continuously-appended, ascii text file containing transmissions of data from different sea level stations. Each station and its data transmission is described by a unique set of parameters, including a Satellite Product Headers, Station Platform ID, method of transmission and transmission time, and file formats (Figure 1).

Figure 1. Sample of transmissions from field station Data Collection Platform (DCP) in formats used by the University of Hawaii Sea Level Center, Australia National Tidal Centre, and US National Ocean Service, respectively.

```
SWIO40 RJTD 250015
:ENB 1 #1 M 3908 3908 3910 3909 3911 3909 3912 3910 3913 3913 3917 3917
3917 3917 3915 3918 3914 3917 3912 3913 3913 3913 3912 3913 3911 3908 3908
3905 3909 :ENC 1 #2 3409 3410 3411 3411 3413 3419 3419 3420 3419 3415 3414
3418 3411 3408 3410 3409 3409 3408 3409 3414 3413 3409 3414 3414 3410
3412 3409 3410 3413 :BATTLOAD 0 12.83 :NAME=

91642 46/// /1205 10296 40080 22200 00287
555 77744 A0102 516`3 60029 6315B 03024 83030 00A07 02548 02901 29631 6B090
24520 2400A 13025 90036 00297 317B1 50240 60310 0A190 26230 38002 96317
B2102 37103 100A2 50266 50330 02973 18B27 02331 02800 A3102 70103 10029
8318B 33022 92026 00A37 02736 03401 29831 8B390 22570 2801A 43027 66028
00299 319B4 50222 50230 0A490 27960 34002 98319 B5102 19202 901A5 50282
20380 02983 19B57 02163 03200 BV289 134S1 41249 C0501 22080 00070 23677 44777=

^^33487552
206011307M94168411DZpQ^(@rI)0uW@1[Am@~@BsBYB\AG@BrBYBzAM@BqBZCUAB@BoBZCmA@@BmBZDMAI@BlBZDrAG@BlBZD?A
D@BkBZETAL@BjBZEwAGABhBZ"@qv@oL3@[DvAI4B[5Ad6a`=OE0uVW>ZAnA|BYBkCRCqCsDWDnER"@us@so0uVV>YCqC?DBctDSD
[DnDxEgEa"@wh@wB
_OLAoP 50+1NN 116W
```

In general, sea level data is digitized and sampled at the field station. Ideally, the data transmitted for tsunami monitoring will be 1-minute (or better) averaged data values that are transmitted at least every 15 minutes, or more frequently for stations in tsunami source zones; currently, stations transmit every 3-60 minutes and data averages are at 1-15 minute sampling intervals. The data are transmitted over a number of different satellites to regional telecommunications hubs of the WMO, and onwards to customers such as the Pacific Tsunami Warning Center, the Japan Meteorological Agency (JMA), and to any requesting National Meteorological and Hydrological Service (Figure 2).

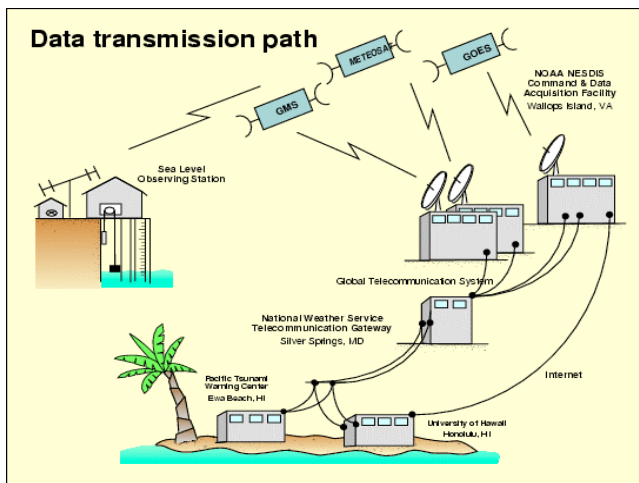


Figure 2. Transmission from the Data Collection Platform at the field station to the warning centres.

In the Indian Ocean, the primary satellites used for transmission from the field station are the Japanese MTSAT for the eastern Indian Ocean and the EUMETSAT operational satellite system for the central and western Indian Ocean. In the Pacific, the US GOES and Japan MTSAT satellite systems are used. The PTWC receives its data through the USA GOES satellite system and the US National Weather Service Telecommunications Gateway (NWSTG) and other dedicated communications links. The satellites are part of the GTS. The GTS is a semi-private, reliable communications system supported by the 187-member WMO for the transmission of environmental data, and information messages and / warnings. The GTS is the primary means by the PTWC and JMA receive sea level data and issue tsunami advisories and warnings.

Tide.tcl

The program is started by typing `wize Tide.tcl`. The program decodes the received sea level data that are found in a single data logging file, creates individual station files containing the decoded data, and starts a graphical user interface display that allows each station to be displayed as a plot (Figures 3-5). Map clients for the Atlantic, Caribbean, Indian, and Pacific Oceans and South China Sea display a map from which the user may select several stations to show their time series. A strip chart window displaying multiple stations simultaneously is an option. V10.0 enables overlay of calculated travel time contours to graphically show wave propagation from the source. When the mouse is moved over the map, the Estimated Tsunami Arrival time (ETA) is displayed in the lower right (in Zulu time).

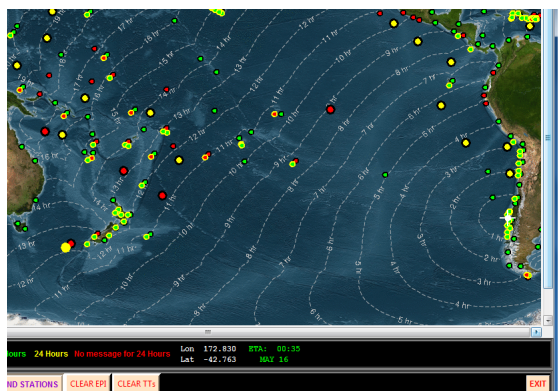
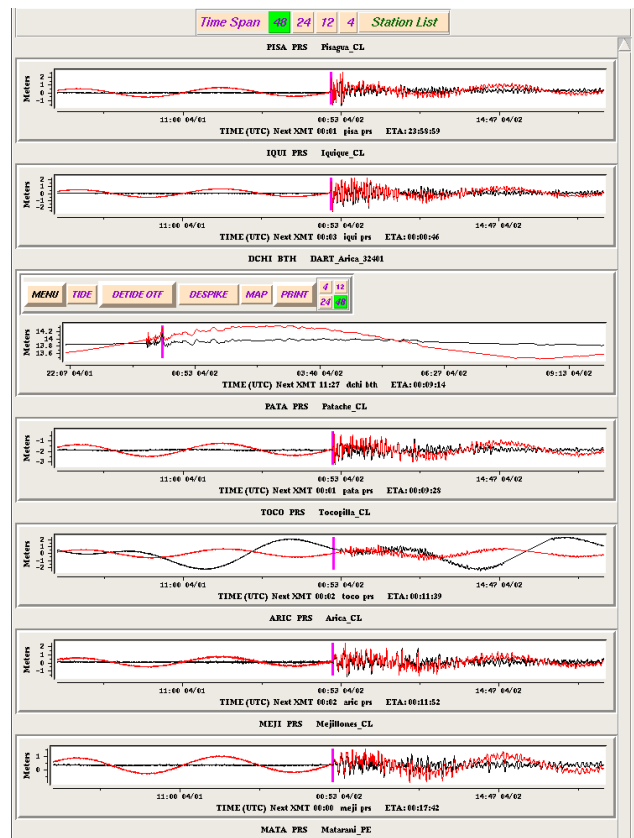
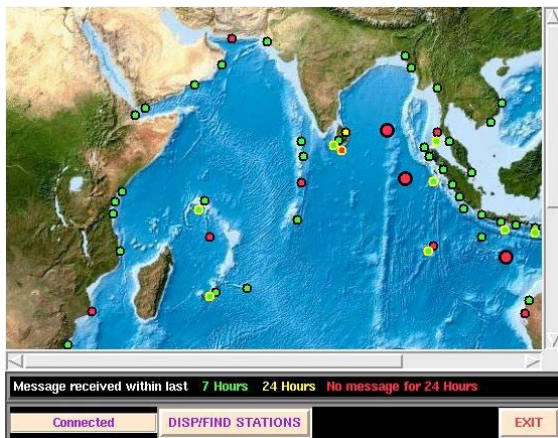
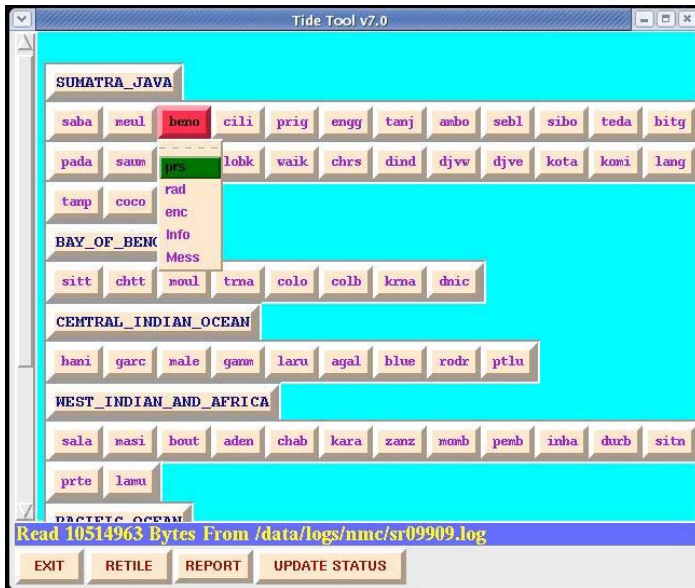


Figure 3a. Caribbean, Indian, and Pacific Map clients showing the coastal and DART stations, with color indicating when data last received (green = data received within last 7 hrs). Travel time contours overlayed on Pacific Map, with ETA shown in lower right. Sea level records can be plotted by mouse-selecting the station and choosing the sensor to plot, or by enabling a

'zoom' client to choose and automatically plot several close-by stations. Station names can be displayed on the map if desired.

Figure 3b. Tide.tcl GUI showing all stations that were decoded, arranged by region. Station sensor types, station metadata, and the raw data packet can also be viewed.



Each time series can be displayed with or without the tidal signal removed, can be manipulated using a mouse in order to zoom/enlarge the time series and to pick an amplitude or wave period (Figure 4a), and can be 'despiked' to remove spurious 'bad' points (Figure 4b). A postscript plot of the time series window can be made and printed.

Figure 4a. Sea level time series showing observed and tide-removed time series. A mouse is used to select the part that should be enlarged to pick the arrival time.

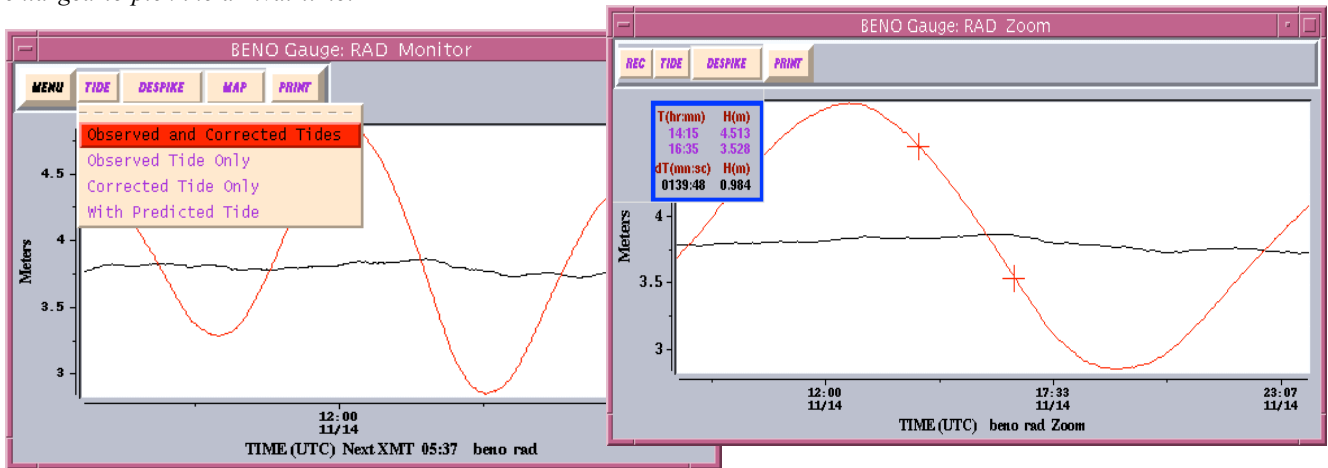
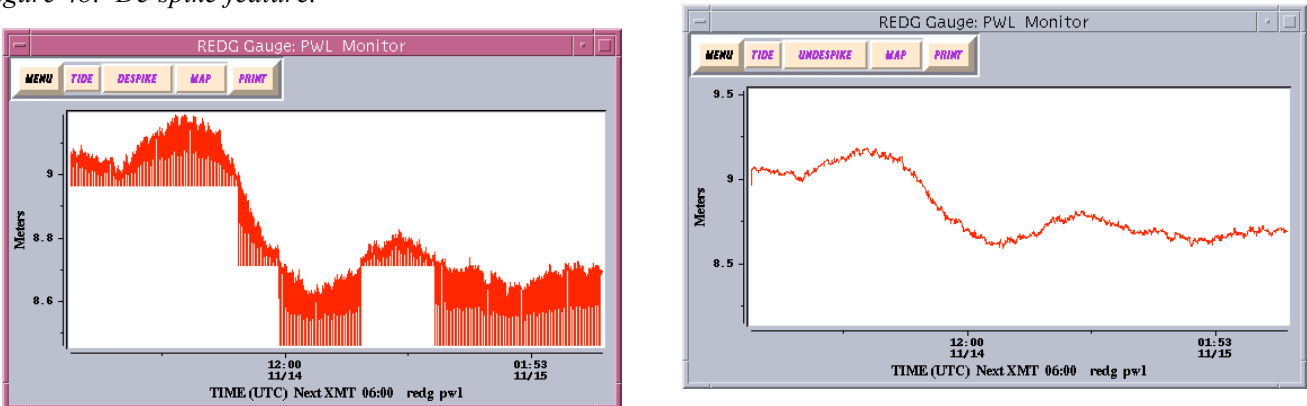


Figure 4b. De-spike feature.



BENO Station Data

Station Data For BENO

Location: Bena
WMO Header: SXXX32
Platform ID: 22856700
Transmission Interval: 15mins
SENSORS:
Sensor Type: prs Sample Rate: 1mins Unit: .001M
Sensor Type: rad Sample Rate: 3mins Unit: .001M
Sensor Type: enc Sample Rate: 15mins Unit: .001M
Lat: -8.7666 Long: 115.2166

EXIT

Messages For Station YAPI

EXIT **Print**

```

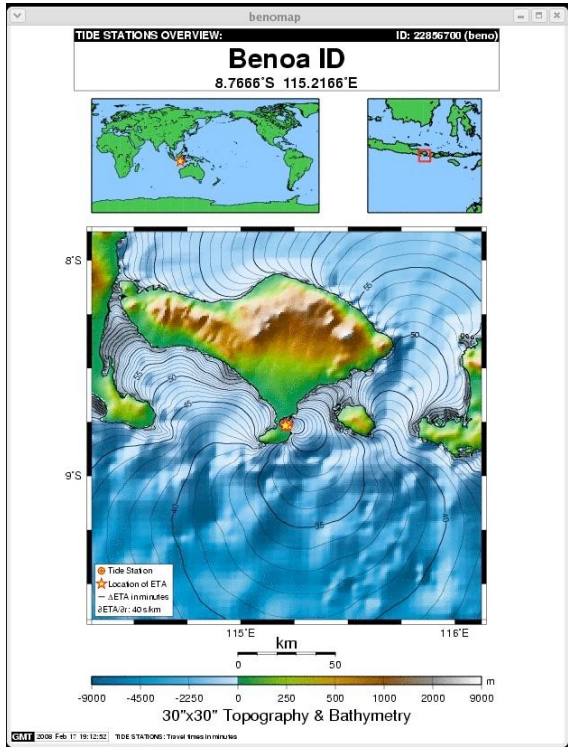
SWPA41 RJTD 160005 0647 0647 0647 0647 0647 0647 0647 0646 0646 0647 0647 0647
0647 0647 0646 0646 0647 0647 0647 0647 0647 0646 0646 1134 1134 1134
1134 1134 1133 1133 1133 1134 1134 1134 1134 1133 1133 1133 1134 1134
1134 1134 1134 1133 1133 0666 0667 60 60 00 00 13.23 13.40 13.19
13.07=

SWPA41 RJTD 160017 0647 0647 0646 0646 0647 0647 0647 0647 0647 0646 0646
0646 0646 0645 0645 0645 0645 0644 0644 0644 0644 1134 1133 1133
1133 1134 1134 1134 1134 1134 1134 1133 1133 1133 1133 1132 1132 1131
1131 1131 1131 1131 1131 1130 0667 0664 60 60 00 00 13.40 13.39 13.07
13.27=

SWPA41 RJTD 160029 0646 0646 0646 0645 0645 0645 0644 0644 0644 0644 0644
0644 0643 0644 0644 0643 0643 0643 0642 0642 0643 0644 1133 1133 1132
1132 1132 1131 1131 1131 1131 1131 1131 1130 1129 1130 1130 1130 1130
1129 1129 1129 1128 1129 1130 0664 0662 60 60 00 00 13.39 13.60 13.27
13.25=

SWPA41 RJTD 160041 0644 0643 0644 0644 0644 0643 0643 0643 0642 0642 0643 0644
0644 0643 0642 0642 0643 0644 0644 0643 0643 0643 1130 1129 1130
1130 1130 1130 1129 1129 1129 1128 1128 1130 1130 1129 1129 1128 1128 1130
1130 1130 1130 1129 1129 0664 0662 60 60 00 00 13.27 13.25

```



Transmission Report For Last 12 Hours

EXIT **Print**

Station	Received	Expected	%Rec
saba	048	048	100%
neul	048	048	100%
beno	048	048	100%
cili	047	048	097%
prig	047	048	097%
eng	044	048	091%
tanj	048	048	100%
ambo	048	048	100%
sebl	044	048	091%
sibo	047	048	097%
teda	047	048	097%
bitg	048	048	100%
pada	048	048	100%
saum	048	048	100%
sade	047	048	097%
lobk	047	048	097%
waik	048	048	100%
chrs	238	240	099%
dind	000	002	000%
djvw	000	002	000%
djve	004	002	200%
kota	033	048	068%
komi	000	048	000%
lang	048	048	100%
tanp	038	040	095%
coco	011	012	091%
cocb	231	240	096%
sitt	047	048	097%

0643 0644 0644
130 1129 1128
28 1129 1129
1.67 13.30

0640 0641 0641
130 1129 1128
24 1124 1124
1.65 13.11

0634 0634 0633
127 1125 1124

Figure 5. Station metadata, as well as recent raw data transmissions of the sea level messages and a station transmission report, are available. A location map and tsunami travel times near the station are also provided for reference.

Tide.tcl operates continuously once started. It will check every 20 seconds to see if any new data has arrived, and if so, it will decode and update the station time series that is plotted. When Tide.tcl is started it will read data from the current day data log. Tide.tcl will keep up to 24 hours of data. As more data arrives beyond what Tide.tcl is supposed to hold, it will discard the older data to make room for the new. For each station, multiple sensors are often available and decoded. The sensor code is given by three letters, where prs stands for pressure sensor, bub indicates bubbler, rad indicates radar.

Tide Tool can also be used to viewing older or archived data log files.

To obtain the software, and for further information and questions, please contact Stuart Weinstein, Asst Director, NOAA Pacific Tsunami Warning Center (stuart.weinstein@noaa.gov), or Laura Kong, Director, UNESCO/IOC-NOAA International Tsunami Information Center (laura.kong@noaa.gov).

TIDE TOOL – QUICK INFO

For more information, refer to Tide Tool Manual.

OVERVIEW:

The Tide Tool system downloads global sea level data from the NWS Telecommunication Gateway (NWSTG, USA), and the IODE Sea Level Monitoring Facility (Belgium) decodes the data, and displays it. Calculated tsunami travel time contours can also be overlain on the map client to graphically show the propagation of the tsunami from the earthquake epicenter, as well as ETAs on the marigrams. All stations that PTWC receives are available through Tide Tool. The system consists of 3 scripts (*get_data.tcl*, *Tide.tcl*, *Client.tcl*) that run simultaneously on 1 PC. *Tide.tcl* and *Client.tcl* (*PACIFIC client*) are softwares that PTWC uses in their operations.

For other oceans, please replace *PACIFIC* with *INDIAN* (IO), *CARIBBEAN* (CAR), *ATLANTIC* (ATL) or South China Sea (SCS) in the Quick Info text. Instructions refer to the generic names of scripts without a version number (*Tide.tcl*, *Client.tcl*, etc).

In order to calculate and display tsunami travel times, the ITIC Tsunami Travel Time (TTT) software package must also be installed.

CISN may be run on the same PC to monitor seismicity and alert Duty Staff when large earthquakes occur and when Tsunami messages are sent by PTWC or US NTWC.

USE:

1. Monitor stations for tsunami confirmation after a large earthquake has occurred.
To display sea level records (marigrams), use *Tide.tcl* or *Client.tcl* map
To determine the estimated arrival time, you may:
 - Use *TTT* button in *Tide.tcl* to calculate tsunami travel times using actual earthquake epicenter (this will enable overlay onto *Client.tcl* map)
 - Use PTWC bulletins which give estimated tsunami arrival time at different locations
 - Use *ttt_calcXX.exe* (double click *ttt_calc* icon on desktop) or *TsuDig* to calculate tsunami travel time map (use either ‘bullseye map with your location (e.g., Pago Pago / Apia) as center’ or event map using actual earthquake epicenter)
2. Monitor state-of-health of your stations. Report if out of order.

STARTUP AND TTT CALCULATION / OVERLAY:

1. Start *get_data.tcl*. **Double click *GET_DATA* icon on desktop.** This script downloads data every 200 seconds from the NWSTG. Data are accumulated in a file (in *TideTool_data* (desktop icon) / *SR_LOG* folder, file *srxxxyr.log*, where *xxx* is Julian day and *yr* equals year. The *GET_DATA* console window that opens should be regularly checked to ensure that data are still being collected.
2. Start *Tide.tcl*. **Double click *TIDE* icon on desktop.** This script looks to see if there is new downloaded data in *srxxxxyy.log* and if yes, decodes the new data and updates the sea level station data file/display.
3. Start *Client.tcl* (*PACIFIC OCEAN*). **Double click *PACIFIC* icon on desktop.** Wait until *Tide.tcl* (Tide Tool) completes the decode of the initial file (may take up to 20-30 min if at the end of the Julian Day). To start *Client.tcl* for other regions do the same, double click on icon(s) (*ATLANTIC*, *CARIBBEAN*, *INDIAN*, *SCS*) on desktop.

When an event occurs, calculate tsunami travel times. **Click *TTT* button in *Tide.tcl***. Run *ttt_tidetool.bat* via *TTT* button to calculate Tsunami Estimated Times of Arrival (ETA) and create a map to overlay on *Client.tcl* map (*GET ETAs* and *TTT* in *Tide.tcl*, *PLOT TTs* in *Client.tcl* to overlay).

IMPORTANT CHECKS DONE BY EACH DUTY SHIFT:

1. PC on GMT time. This is needed for correct time decoding.
2. *get_data.tcl* is running. Check *GET_DATA* console window to see if the last download is current (e.g., 5 minutes ago). If not, then data are not being collected. Restart programs.
 - a. Close the inactive *WIZE* and start the *get_data.tcl* again. Refer to 1. in STARTUP
 - b. Check to see if you also need to restart *Tide* and *Client*. If the softwares do not update or are frozen, then close and restart. Exit *Tide* and *Client* window(s) (e.g., PACIFIC OCEAN). Start each program again (refer to 2. and 3. in STARTUP)

Notes:

1. Stations transmit data by satellite (generally GOES, MTSAT, EUMETSAT) at different intervals (every 3-60 min) and different times (in a given hour). Therefore, before deciding on the tsunami threat, sometimes you may have to wait until the next transmission if only part of the tsunami wave has arrived.
2. Stations have sensors that ‘damp’ the signal (see IOC Manual on Sea Level Measurement and Interpretation (2006) appendix for sensor types). Therefore, what you measure will probably underestimate the wave height reported by eyewitnesses. Coastal signals also depend on the gauge location and local features, e.g., some stations always amplify signals.
3. DART stations are located in the deep ocean (not on land). Therefore, signals measured will be much smaller (few cm / 10s of cm, or inches to 1-3 feet) than signals on coastal (land) gauges. When DART waves hit shallow water (the coast), tsunami wave physics says that wave height increases – therefore, a small DART wave in the deep ocean could end up as a large wave when it hits land. Tsunami modeling must be used to forecast what is expected at the coast.

TIPS FOR EFFICIENT USE:

1. View individual sea level stations using *Tide* window (choose station using 4-letter station code, left mouse click, or use Sea Level Station map hard copy), or *Client* window (choose dot on map, left mouse double click). Choices are
 - Sensor type (pressure gauge, encoder, aquatrak, bubbler, radar)
 - *Info* (station and transmission information)
 - *Mess* (actual data download, undecoded)
 - *MAP* showing station location with travel time contours using station location as source
2. Marigram ZOOM widget:
 - a. Measure wave height and wave period from an individual station by mouse-selecting (right) time window to expand time series (ZOOM widget), then mouse-select (left) points you want to measure – a time and height difference is automatically calculated if you select 2 points.
 - b. You can record the picks made using the *REC* tab; picks are recorded to the file *Tide_Tool_LOG* in in the *TideTool_data* folder.

- c. Choosing *MIN MAX* in *REC* auto-picks the minimum and maximum height in the selected window; to then record the picks, click on the *Peak to Peak REC* menu item.
 - d. Marigram data can be written to a file by clicking *WRITE* tab (data are time, height including tide, height with tide removed); file is located in the in the *TideTool_data/PLOTS* directory.
3. Fast viewing of stations in a region is done using the *Client* – mouse-outline (right click & drag) a box of interested stations, and then Show *Tile or Strip* to display all stations. The *Strip* feature allows many stations to be displayed simultaneously, similar to a seismic record section. If *ttt_tidetoolxx.bat* has been run, then the order of the marigrams will be from the closest (1st-arriving tsunami wave) to farthest station from the source. The *Tile* feature shows each station as an individual window.
 4. Station locations and 4-letter station names are found using the hard-copy maps (*PTWC_AtlanticMediterranean_SL_Stations_20220216.pdf*, *PTWC_Caribbean_SL_Stations_20220216.pdf*, *PTWC_IndianOcean_SL_Stations_20220216.pdf*, *PTWC_Pacific_SL_Stations_20220216.pdf*, in *TideTool_data* folder), or by *Disp/Find* button in *Client*
 5. Estimated Tsunami Travel Times from the earthquake epicenter can be overlain on the map after running *ttt_tidetool.bat*. TTT button in *Tide.tcl* is used to run *ttt_tidetool.bat*. It will open a Tsunami Travel Times window to be used to input data to calculate travel times and create map overlay. Latitude and longitude are given at the location of mouse cursor. Origin time (OT) of the earthquake source is also shown.
 6. To retain a picture of the screen, options are:
 - Use *Print Plot File Only* option in time series window (postscript plot files found in *TideTool_data/PLOTS* directory, and viewed with Adobe Acrobat).
 - Use *Ctrl+Alt+Print Screen* (individual window) or *Print Screen* (entire display), and then paste in MS Word file

VIEWING ARCHIVED DATA:

Tide Tool can be run in ‘archive’ mode to view past data (files in folder *SR_LOG*).

1. Use the correct station metadata file to view archived data. This should be the *COMP_META* file that was in use when the data was collected; it may not be the most current one. (Replace the current *COMP_META* file with this file, but be sure to save the current *COMP_META* file to another filename so you will have it for the real-time version)
2. Run *Tide.tcl*. To run: double click *wize.exe* in the *TideTool_bin* folder on the desktop.
3. Type “wize Tide.tcl H”
4. Enter JD, YR (2 digit), SPAN (1 or 2 corresponding to number of days of *SRLOG* files)
5. *Tide.tcl* will decode and then display the *SRLOG* files specified
6. *Client.tcl* (for all regions) can be run. Note that in this mode, all station dots will be red since there is not live data.
7. Once the *SR_LOG* file(s) have been decoded, station files by JD and sensor are created (in *TideTool_data/Decoded_Data/JD/station.sensor.JD* These time series files are then usable for later station plotting.

Tide Tool Update Widget

To facilitate the easy update of Tide Tool, a Widget is available.

The Update folder must be placed in the directory C:\Tcl\TideTool\

Steps:

1. Open the Update folder and create a shortcut to the Update_Tide_Tool.vbs file and move it to the Desktop.
2. Before performing an Update, stop Tide Tool and any of the Map Clients that are running. The get_data.tcl process does not need to be stopped unless it is being updated.
3. After the Tide Tool processes have been killed, you can start updating
Click the shortcut to start the Update widget:

4. To update the software, click the button with the name of the file that is to be updated. It will turn green.

Tide.tcl – script that decodes binary data

Client.tcl – script that enables maps

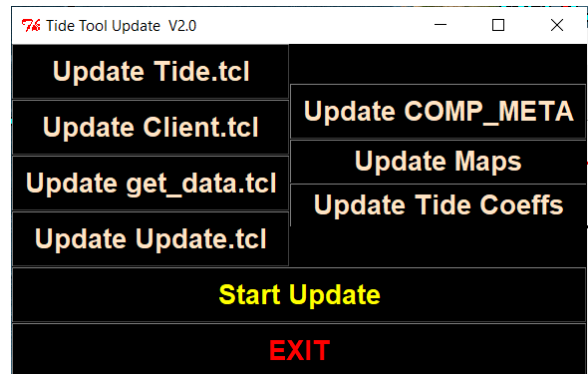
get_data.tcl – script that retrieves binary data

Update.tcl – script retrieves latest Update widget

COMP_META – sea level station data

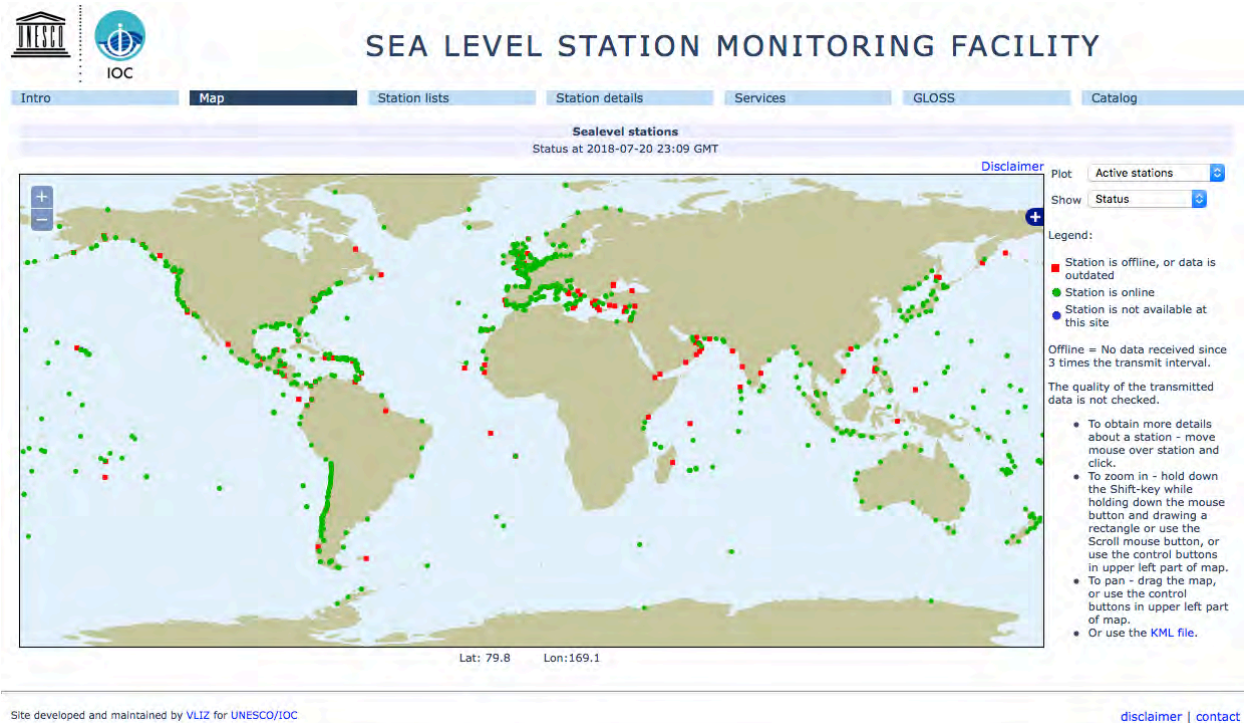
Maps – sea level station travel time maps

Tide Coeffs – tide coefficients for detiding sea level stations



5. Click the "Start Update" button and the update will commence. The "Start Update" will change to "Update Starting." When it is finished, that will change to "Update Finished." At this point, the Update(s) is complete. Click the "EXIT" button to quit the Update widget and then restart Tide Tool.

UNESCO Intergovernmental Oceanographic Commission (IOC)
SEA LEVEL STATION MONITORING FACILITY
URL: <http://www.ioc-sealevelmonitoring.org/map.php>



The UNESCO IOC Sea Level Monitoring Facility is a web-accessible tool for viewing sea level data received in real time from different network operators. The IOC's service is freely available to all. Please note that the data has not undergone any quality control and is provided as received. IOC, VLIZ and data suppliers accept no liability for errors and/or delays in data or for tsunami warning or other public safety decisions carried out on the basis of data viewed using this tool. The sampling frequency and data transmission frequency varies for the stations. This service should not be viewed as operationally robust since its access utilizes commercial Internet services that could become clogged during a large tsunami event.

This service provides (i) information about the operational status of global and regional networks of real time sea level station, and (ii) a display service for quick inspection of the raw data stream from individual stations. The site initially focused on operational monitoring of sea level measuring stations in Africa and was developed from collaboration between Flanders Marine Institute ([VLIZ](#)) and the [ODINAFRICA](#) project of [IODE](#). It has been expanded to a global station monitoring service for real time sea level measuring stations that are part of IOC programmes i.e. (i) the Global Sea Level Observing System Core Network; and (ii) the networks under the regional tsunami warning systems in the Indian Ocean (IOTWS), North East Atlantic & Mediterranean (NEAMTWS), Pacific (PTWS) and the Caribbean (CARIBE-EWS). As of July 2018, 159 organizations were contributing data.

The data and products available are made available in accordance with the [IOC Oceanographic Data Exchange Policy as adopted by the 22nd session of IOC Assembly in Resolution 6](#). Data and products available on this web-site may not be used for any commercial purposes. Commercial users should contact the relevant data originators.

This IOC Sea Level Station Monitoring Facility web site provides the following capabilities:

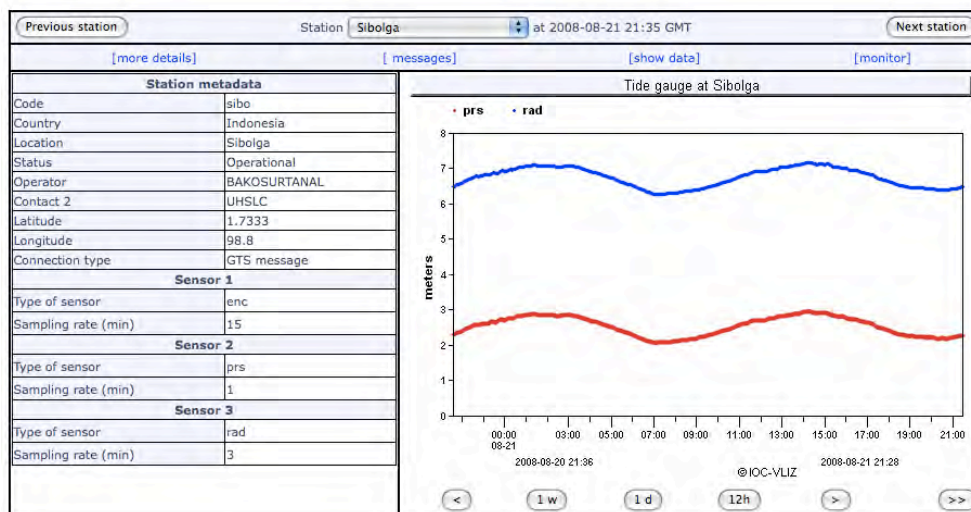
- Global sea level network map, showing color-coded operational status (working/not working)
- Station listing, showing metadata (4-letter code, GLOSS ID number, Location, Collection method, Last Data Transmission date/time, Delay, and Transmit Interval)
- Plotting and download of data received

It does not provide low frequency and high frequency research quality sea level data, which is available from GLOSS designated data centers at the Permanent Service for Mean Sea Level (PSMSL), the British Oceanographic Data Center (BODC), the University of Hawaii Sea Level Center (UHSLC) or the data originators. A 'QC data' link on the station details page gives information on retrieving research quality data.

Station Listing screen, from which users may select stations to view:

Status at 2008-08-21 21:37 GMT : 338 stations listed								
Show <input type="radio"/> only active <input type="radio"/> only GLOSS <input type="radio"/> only GTS <input type="radio"/> only FTP <input type="radio"/> only Webservice <input type="radio"/> only Email <input checked="" type="radio"/> all known stations								
Code	GLOSS ID	Country	Location	Connection	Latest data yyyy-mm-dd GMT	Delay	Transmit Interval	View
acaj	182	El Salvador	Acajutla	SEMS40	2008-08-21 21:15	23'	60'	[open]
acap	267	Mexico	Acapulco	SEPA40	2008-08-21 21:30	8'	5'	[open]
acnj	220	USA	Atlantic City	web	2008-08-21 21:18	20'	6'	[open]
adak	302	USA	Adak	web	2008-08-21 21:18	20'	6'	[open]
aden	3	Yemen	Aden	SXXX33	2008-08-21 21:12	26'	15'	[open]
alak		USA	Alitak	web	2008-07-09 10:42	43d	6'	[open]
alam		USA	Alameda	SXXX03	2008-07-22 13:18	30d	6'	[open]
alme		Spain	Almeria	ftp	2008-08-14 11:59	7d	10'	[open]
amal		USA	Charlotte-Amalie	web	2008-08-21 21:18	20'	6'	[open]
anch		USA	Anchorage	web	2008-08-21 21:18	20'	6'	[open]

Station Data plotting. User-selectable time windows are also available.



Partners: This project was made possible by the joint effort of:

- IOC Intergovernmental Oceanographic Commission of UNESCO
- GLOSS Global Sea Level Observing System
- IODE International Oceanographic Data and Information Exchange
- ODINAFRICA Ocean Data and Information Network for Africa
- CARIBE-EWS Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions
- IOTWS Indian Ocean Tsunami Warning and Mitigation System
- NEAMTWS North-Eastern Atlantic, the Mediterranean and Connected Seas Tsunami Warning and Mitigation System
- PTWS Pacific Tsunami Warning and Mitigation System
- GFZ German Research Centre for Geosciences
- POL Proudman Oceanographic Laboratory
- UHSLC University of Hawaii Sea Level Center
- VLIZ Flanders Marine Institute
- WMO World Meteorological Organization
- JMA Japan Meteorological Agency
- KMI Royal Belgian Meteorological Institute
- Meteo-France
- Many operators of the WMO GTS network

TSUNAMI BULLETIN BOARD

International Tsunami Information Center

The ITIC has hosted the Tsunami Bulletin Board (TBB) since 1995. The service is an email list serve providing tsunami information to ~479 international members (as of Feb 2022) in the tsunami field. Pacific Tsunami Warning Center (PTWC) and US National Tsunami Warning Center (US NTWC) bulletins are posted immediately to the TBB. Membership is open to any tsunami professional. To subscribe, please contact the ITIC (itic.tsunami@noaa.gov). The TBB uses Mailman and is maintained by the USA NOAA National Weather Service. The service is not guaranteed for timely delivery, and should not be used as a critical communication component by national tsunami warning centres.

The purpose of the list serve is to provide an open, objective scientific forum for the posting and discussion of news and information relating to tsunamis and tsunami research. It is not open to the media or the general public. The ITIC provides this list serve to tsunami researchers and other technical professionals for the purpose of facilitating the widespread dissemination of information on tsunami events, current research investigations, and announcements for upcoming meetings, publications, and other tsunami-related materials. All members of the TBB are welcome to contribute. Messages are immediately broadcast to all members without modification.

The TBB is available as a mailing list only. Users may send emails using the email address that was used to subscribe to the TBB.

- To post information, send email to tsunami_bb@list.woc.noaa.gov
- The maximum total size of file attachments is 10 MB.
- By default, replies to TBB posts are routed to the all TBB members, so please take care to change the email address when sending a personal reply.

The TBB expects that members will carry out scientific discussions in an objective and respectful manner. Certain behaviors will not be tolerated, and by using the Tsunami Bulletin Board, you are agreeing to the following simple guidelines:

1. The TBB is intended for discussion, announcements and to assist those seeking information not readily available elsewhere. It is not intended for advertising or activities of a commercial nature. Please refrain from any form of commercial solicitation.
2. Please do not include any information in your message that you do not want to make available to all TBB members. If you wish to discuss personal/specific issues with an individual, please contact the individual personally and do not use the TBB.
3. No libelous remarks, hate propaganda or mongering, or profanity will be tolerated. Material which is untrue or which knowingly defames, personally attacks, abuses, harasses or threatens others will be removed.
4. Statements and/or images that are bigoted, hateful, mean-spirited, vulgar, obscene, pornographic, or indecent are not permitted. Any derogatory content or content deemed racist, sexist, or in any other way inappropriate will be removed.
5. Material that advocates illegal activity or discusses illegal activities with the intent to commit them is not permitted.
6. Unauthorized copyrighted material, including, but not limited to, text, sound or graphic files, shall not be posted.

The ITIC reserves the right to delete, w/o prior notice, any content judged inappropriate or offensive from the bulletin board. The ITIC reserves the right to moderate users who repeatedly use inappropriate language, and may remove them permanently from the Tsunami Bulletin Board.

Disclaimer:

The contributions to the Tsunami Bulletin Board are the sole opinions of the individuals providing them. The ideas are not the opinion of the ITIC, nor are they presented to be facts. The ITIC posts the information as is, without any warranty of any kind, express or implied, and is not liable for its accuracy, for mistakes, errors, or omissions of any kind, nor for any loss or damage caused by a user's reliance on information obtained from these postings.

If there are any concerns / suggestions regarding the Tsunami Bulletin Board, please contact the TBB administrator at itic.tsunami@noaa.gov. The ITIC is also interested in receiving any comments on the usefulness of this tool.

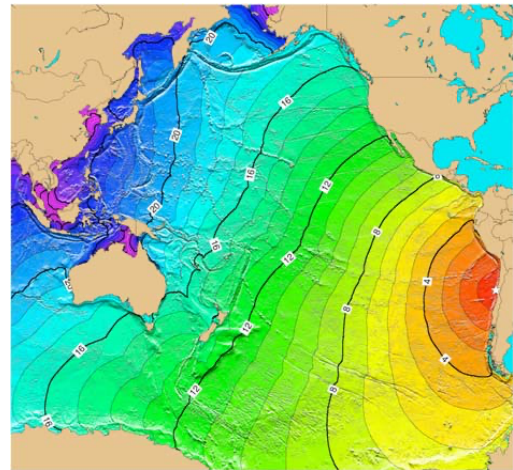


Tsunami Travel Time (TTT) Software Package Version TTT SDK 4.0.1, Jan 2023

TTT_README.DOC

NOAA's National Centers for Environmental Research (NCEI, formerly National Geophysical Data Center), as the World Data Service for Geophysics (WDS-Geophysics), and the International Tsunami Information Center (ITIC), a NOAA-UNESCO/IOC Partnership, are collaborating to provide, free of charge, tsunami travel time calculation and display software to government organizations involved in providing tsunami warning and mitigation services. Other interested organizations and individuals are requested to obtain the software directly from the developer Geoware.

The Tsunami Travel Time software (TTT SDK v 4.0.1) was developed by Dr. Paul Wessel (Geoware, <http://www.geoware-online.com>), and is used by the NOAA Pacific Tsunami Warning Center. ITIC has purchased the TTT license to permit widespread free distribution. The public domain mapping software Generic Mapping Tools (GMT) was developed by Drs. Paul Wessel and Walter Smith (<https://www.generic-mapping-tools.org/>). For this PC-environment distribution, the ITIC and NCEI are also providing easy-to-use, sample scripts for running the software and producing maps such as shown to the right.



The software included in this distribution is for systems using a Microsoft Windows XP, Vista and 7/10 operating system. The software code available is not platform-specific, so ITIC/NCEI is able to provide other distributions, such as for Linux, Unix or Mac OSX, upon request.

Components included on this CD

1. TTT (Tsunami Travel Time) software, TTT SDK version 4.0.1. Copyright Paul Wessel, Geoware, 2018. <http://www.geoware-online.com>. Licensed to NOAA/ITIC for redistribution.
2. Global bathymetry grids derived from NCEI's ETOPO1 at varying resolutions (60, 30, 20, 15, 10, 5, 2 and 1 arc-minute, and 30 arc-sec grids) for the Pacific, Atlantic, and Indian Oceans.
3. Easy-to-use scripts for automatically calculating and making travel time maps.
4. Historical Earthquake and sea level station data sets. Historical Tsunamis TTT maps.
5. Hands-on exercises to illustrate how to make Indian Ocean, South China Sea, Pacific, and Caribbean region tsunami travel times maps.
6. GMT (Generic Mapping Tools), version 4.3.1. Released under the GNU General Public License (GPL). <https://www.generic-mapping-tools.org/>
7. Ghostscript, version 9.52. Released under the Aladdin Free Public License (AFPL). <http://www.cs.wisc.edu/~ghost/>
8. ImageMagick, version 7.1.0. Distributed under the Apache 2.0 license. <http://www.imagemagick.org/script/license.php>

For questions, please email Laura Kong (Laura.Kong@noaa.gov) at ITIC or Nicolas Arcos (nicolas.arcos@noaa.gov) at NCEI.

Technical Background

Background information on the calculation of tsunami travel times is provided in *TTTSDK4.0.1_Docs.pdf* (in C:\TTT Package\Software\TTT\doc), *Annex V: Methods for Tsunami Travel Time Calculation used by PTWC, WC/ATWC, and JMA* of the PTWS Operational Users Guide (draft, December 2007, and *Analysis of Observed and Predicted Tsunami Travel Times for the Pacific and Indian Oceans* (Wessel, 2009) in C:\TTT Package\TTT_GMT_otherdocs). Accuracy is most dependent on the accuracy of the bathymetry file used for the calculations, e.g., the finer grid size of the bathymetric file, the more accurate the estimate - at the same time, however, computation time increases significantly as finer grid size bathymetric files are used (e.g., calculation using 2-min (distance, ~2 mile grid interval) bathymetry grid takes 10 minutes (time) or more to complete). Inadequate characterization of the tsunami source (epicenter point source vs. finite fault rupture length) can also result in significant differences between the predicted and observed times. Together, these errors can cause large delays (up to hours).

TTTSDK4.0.1 upgrades from TTTSDK4.0 by updating all 9 bathymetry grids using latest global grid sources.

Installation Instructions

If you have an older version of the TTT Software package, please uninstall first. This can be done through the Control Panel ->Add/Remove Programs.

It may be required to run the installer as a user with administrative privileges. Run `Setup_TTT_vx.x_xxbit_YYYYMMDD.exe` to install the TTT software, examples, GMT, Ghostscript and ImageMagick. All required software, except Ghostscript and ImageMagick, will be installed in the directory specified (i.e. 'C:\TTT Package'). If you already have Ghostscript or ImageMagick installed, you may choose not to install these packages at this time. The installer will ask if you would like to install Ghostscript, and will then launch a separate installer for Ghostscript (loaded in C:\Program Files\gs). Then it will ask to install ImageMagick, and will then launch a separate installer for ImageMagick (loaded in C:\Program Files\ImageMagick-versionNumber).

Computer Requirements

The software included in this distribution is for systems using a Microsoft Windows XP, Vista, 7 & 10 operating system. The software code available is not platform-specific, so NGDC/ ITIC is able to provide other distributions, such as for Linux, Unix or Mac OSX, upon request.

The recommended computer specifications/requirements are:

- PC running Windows (XP/Vista/7/10)
- At least 256 MB of RAM
- At least 900 MB of hard disk space
- No CPU speed requirements, but the software will run faster on faster CPUs.

Directory Structure for Software Usage

Files to be used for TTT calculation and plotting can be found in the following directories.

Directory: C:\TTT Package\Software\TTT\bin

TTT calculation: `ttt_clientXX.exe`

TTT mapmaking (using GMT):

Fixed region: `ttt_fancy_atl/ind/pac/world.bat`

User-specified: `ttt_fancy.bat`

Examples using above scripts:

C:\TTT Package\Examples\EXAMPLE_CARIBBEAN or IO_SCS/MAKRAN/PACIFIC

Main Scripts for ttt_calcXX

ttt_autoXX.bat
ttt_fancy_atl/ind/pac_auto.bat

Output files from running ttt_calcXX.exe will be placed in sub-directory:
C:\TTT Package\Examples\TTT_AUTO_XXXXXX,
where XXXXXX equals computer clock HRMNSC

Data files:

Historical earthquakes (USGS Centennial List):

GMT-plot format: centennial6_ed.txt

Reference files: centennial6.txt, centennial.xyzm

Sea level stations (as received by PTWC):

Data files: stations.txt, stations_tidetool.txt (Feb 2022)

Maps: PTWC_AtlanticMediterranean/Caribbean/IndianOcean/Pacific
_SL_Stations_YYYYMMDD.pdf (Feb 2022)

Color pallets (as read by scripts): CPT\ttt1-30.cpt, centennial.cpt

Software Usage Instructions

The software included is to be run from the Windows command line, or by double-clicking on a .bat script in order to open a Window command window for running the software. Easy-to-use software (executable and scripts) for calculating travel times and making travel time maps are included in this distribution, and described in this section and the next (Easy TTT calculation and plotting). The executable ttt_client.exe and the plotting scripts are located in C:\TTT Package\Software\TTT\bin.

Examples and hands-on exercises which utilize ttt_client.exe (calculation) and ttt_fancy (plotting) can be found in the Examples section of this document and in C:\TTT Package\Examples (for Caribbean, Indian Ocean, Pacific, South China Sea).

Producing TTT plots is a 2-stage process. First, the TTT program is executed to calculate the tsunami travel times over the specified map boundaries (e.g., create a grid file of tsunami travel times).

Second, the GMT software is used to make a postscript plot of the travel times, and to create raster images (such as in jpg or png formats). The GMT software is a general plotting software that can be customized to produce many types of plots. Further information and documentation on GMT can be found in C:\TTT Package\TTT_GMT_otherdocs\GMT_Manuals

1. The TTT program (ttt_client.exe) is executed to calculate the tsunami travel time to each point on a grid. This calculation is made using input files giving 1) the earthquake epicenter (or a series of point locations representing a long fault rupture) 2) the water depth, which is extracted from the bathymetric file. TTT is run with the following command (text in square brackets, i.e. [], should be replaced with the appropriate file name):

```
ttt_client [bathymetry grid filename] -e[epicenter filename] -T[travel-time grid filename]  
-VL
```

The travel-time grid is the output file. The bathymetric grid name is given without the .i2 extension, all other filenames should be given with the file extensions.

Information on ttt_client.exe

ttt_client is a command-line program that generates tsunami travel time grids (in GMT grdf file or GeoTIFF format) given an input bathymetry grid and a source location. It can also be used to report the travel times to a list of stations given an existing travel-time grid as input.

Usage:

```
ttt_client <input_bathymetry_file> [-A<stations_file>] [-R(w/e/s/n)]  
[-E<lon/lat> or -e<file>] [-I] [-N<nodes>] [-O|o<yyyy/mm/dd/hh/mi/ss>]  
[S[<radius>][/<depth>]] [-T<output_ttt_file>] [-G<output_geotiff_file>] [-V[L]] [-U]
```

ttt_client attempts to decode <input_bathymetry_file> using the following order:

1. If filename ends in ".b" it is read as bathymetry data [GMT binary float format].
2. If \$TTTT_DIR/<input_bathymetry_file>.i2 exists it will be used as bathymetry data [GMT binary short format].

OPTIONS:

- A Gives filename with multiple stations to which we will estimate the Estimated Tsunami Arrival time (ETA) if option -O is given ("tsunami origin time"). If -O is not given, ETA will output the tsunami travel time.
 - b Do NOT normalize the travel times to avoid bias [Default will correct for bias]
 - E Sets the location of the epicenter using the format <lon/lat>
 - e Gives filename with multiple "epicenters" to mimic a non-point source.
 - I Store travel times as 2 byte integers with units of 10 sec [Default is 4-byte float in hours]
 - N Number of Huygens nodes to use (8, 16, 32, 48, 64) [64]
 - O Sets "tsunami origin time" (UTC), which is assumed to be the earthquake origin time in the simplest case. Use lower case -o if local time is used
Note: this calculation will only work correctly for the years 1970 to 2038.
 - R Specify a sub-region of the grid [Use entire grid].
 - S Substitute nearest ocean node if epicenter is on land. Optionally, append search radius in degrees [5]. Furthermore, you may append the shallowest depth you want to place epicenter [0].
 - T Names the output grdf file with travel times in hrs [ttt.b or ttt.i2 (see -I)].
 - U Use UTC time when reporting ETAs (requires -A).
 - V Run in verbose mode. Append L to get progress messages from within the tttAPI library.
2. The output is then plotted using GMT (Generic Mapping Tools), which is a general command line controlled graphics tool. To simplify the plotting stage, basic batch script files are provided. These are four hardwired scripts for plotting the individual and world oceans (ttt_fancy_atl.bat, ttt_fancy_ind.bat, ttt_fancy_pac.bat), and one interactive script (ttt_fancy.bat) to plot any desired region and to specify contour plotting interval and other simple customization. However, plots are entirely customizable if GMT is learned.

All the scripts have a similar run command format, e.g.,

```
ttt_fancy [travel-time grid filename] [bathymetry grid filename] [epicenter filename] [ps filename]
```

```
ttt_fancy_atl/ind/pac [travel-time grid filename] [bathymetry grid filename] [epicenter filename] [ps filename]
```

GMT batch script files:

```
ttt_fancy_atl.bat, ttt_fancy_ind.bat, ttt_fancy_pac.bat, ttt_fancy_world.bat, ttt_fancy.bat
```

Each of these batch files, run from the Windows command line, runs a series of GMT commands to generate colored contour maps (with shaded-relief bathymetry) of tsunami travel time grids generated by `ttt_client.exe`. Each batch file is customized for each ocean (Pacific, Indian, Atlantic/Caribbean), or can be interactively specified (`ttt_fancy.bat`).

`ttt_fancy_atl/ind/pac.bat` creates output files under the current directory.

`ttt_fancy` creates output files under a subdirectory (`TTT_FANCY_timestamp`) under `C:\TTT Package\Examples`, where `timestamp` is the current computer clock time (hr min sec).

With knowledge of GMT commands (documentation at <https://www.generic-mapping-tools.org/>, and also in `C:\TTT Package\TTT_GMT_otherdocs`), these files can be modified to create other desired output. By default, a Postscript document and PNG image files are created, but other formats (.jpg, tif, etc) are available.

Usage:

```
ttt_fancy_atl <input_tttgrid> <input_bathygrid> <input_epicenter_file> <output_psfile>
ttt_fancy_ind <input_tttgrid> <input_bathygrid> <input_epicenter_file> <output_psfile>
ttt_fancy_pac <input_tttgrid> <input_bathygrid> <input_epicenter_file> <output_psfile>
ttt_fancy <input_tttgrid> <input_bathygrid> <input_epicenter_file> <output_psfile>
```

Easy TTT calculation and plotting

To provide for easier calculation and map-making, a user-friendly GUI named `ttt_calc32.exe` and `ttt_calc64.exe` (referred to as `ttt_calcXX.exe`) is provided which simplifies and automates the process. `ttt_calcXX.exe` uses the `ttt_autoXX.bat` scripts (Windows). `ttt_calcXX.exe` and its associated scripts creates a travel time data file and two maps (ocean-wide and zoomed-in) using user-input information on the tsunami source location (latitude and longitude), magnitude (assumed to be from an earthquake), bathymetry file grid size, source origin time, and map region. To run quickly, 15-arc min bathymetry is recommended; for greater accuracy, a finer resolution bathymetric grid should be used.

`ttt_calcXX.exe` runs specific regional `ttt_fancy` scripts (`ttt_fancy_atl/ind/pac_auto.bat`) to make the maps, Output files are created under `C:\TTT Package\Examples\TTT_AUTO_xxxxxx`, where `xxxxxx` is the computer clock time (hr, min, sec) at the time the script is run.

Instructions for using `ttt_calcXX.exe` and information on parameters that can be changed to customize plots are included in the file `C:\TTT Package\TTT_calc_ttt_auto_README_feb22.pdf`

Troubleshooting: Required environment variables

If the software does not work correctly, please check that these environment variables are properly set:

`TTT_DIR` should be set to the TTT data directory

(i.e. `C:\TTT Package\Software\TTT\share\data`)

`GMTHOME` should be set to the GMT home directory

(i.e. `C:\TTT Package\Software\GMT`)

`GMT_SHAREDIRE` should be set to the GMT share directory

(i.e. `C:\TTT Package\Software\GMT\share`)

The system PATH should contain:

- the TTT bin directory (i.e. C:\TTT Package\Software\TTT\bin)
- the GMT bin directory (i.e. C:\TTT Package\Software\GMT\bin)
- the Ghostscript bin directory (i.e. C:\Program Files\gs\gs9.52\bin)

These variables can be modified by opening the Control Panel, clicking on System and Security, clicking on System, clicking on Advanced system settings, then clicking on Environment Variables, and editing the PATH.

Examples

Software Usage Examples (provided by NCEI)

The software is to be run from the Windows command line, or by double-clicking on a .bat script in order to open a Window command window for running the script containing the software.

You can run these examples from the “bin” directory (i.e. C:\TTT Package\Software\TTT\bin). Or, if using another directory, please copy the files ‘epicenter_1960.txt’, ‘epicenters_2004.txt’, and ‘epicenter_1964.txt’, and ‘stations_pacific_ocean.txt’ in “bin” to this new directory and run the scripts from there. In C:\TTT Package\TTT_Maps, you can also find some example TTT maps for historical events.

- Generate a new global travel-time grid with the 1960 Chile earthquake as the source, using 5' bathymetry, and report the travel times to multiple stations listed in ‘stations_pacific_ocean.txt’:

```
ttt_client ttt_topo_5m -eepicenter_1960.txt -Ttt_chile_1960_5m.b -Astations_pacific_ocean.txt -VL
```

- Generate a colored contour map for the Pacific Ocean using the 'ttt_chile_1960_5m.b' global travel-time grid (this will create a Postscript file and a .PNG image as output):

```
ttt_fancy_pac ttt_chile_1960_5m.b ttt_topo_5m epicenter_1960.txt ttt_chile_1960_5m.ps
```

- Generate a new global travel-time grid in GMT grid format ('ttt_2004_1226.b') for the 2004 Indian Ocean tsunami, approximating the earthquake rupture with a list of multiple epicenters, then generate a global contour map (Postscript and .PNG image format) of the travel times:

```
ttt_client ttt_topo_5m -eepicenters_2004.txt -Ttt_2004_1226.b -VL  
ttt_fancy_world ttt_2004_1226.b ttt_topo_5m epicenters_2004.txt ttt_2004_1226.ps
```

- Generate a new travel-time grid ('ttt_alaska_1964.b') for the 1964 Alaska earthquake, automatically moving the epicenter to the nearest water node of at least 100 meters depth, then generate a colored contour map for the Pacific (Postscript and .PNG image format) of the travel times:

```
ttt_client ttt_topo_5m -eepicenter_1964.txt -Ttt_alaska_1964.b -S5/-100 -VL  
ttt_fancy_pac ttt_alaska_1964.b ttt_topo_5m epicenter_1964.txt ttt_alaska_1964.ps
```

Converting Tsunami Travel Time grid output to GeoTIFF (for importing into GIS software)

This series of commands will convert a tsunami travel time grid in GMT binary grid format ('example_ttt.b') into a GeoTIFF that can be imported into most GIS software (i.e. ArcGIS). The free software package GDAL/FWTools is required for this conversion (available at <http://fwtools.maptools.org/>)

```
gdcreformat example_ttt.b=bf example_ttt.grd=cs
gdal_translate -a_ullr -180 90 180 -90 -a_srs epsg:4326 example_ttt.grd example_ttt.tif
```

Software Usage Examples (provided by ITIC)

Plots for Tsunami Warning Operations

These files, located in C:\TTT Package\Software\TTT\bin and in C:\TTT Package\Examples, create commonly-used images to support tsunami warning operations. The “Hands-on exercise” examples have been used in trainings by the ITIC and so are accompanied by instructions for installing and running the scripts.

EASY TTT CALCULATION AND PLOTTING (PRE-SET OPTIONS) – see previous section:

ttt_calcXX.exe: easy and quick creation of travel time contour maps using user-specified arc-min bathymetry files

ttt_calcXX.exe quickly outputs a map, one or two zoomed-in maps and a file of tsunami travel or arrival times to user-selected locations. Inputs are the earthquake epicenter, magnitude, region for the contour maps, and a location file where travel times (or arrival times if the origin time is specified) are tabulated. Output files are placed in a directory that is automatically created under the “Examples” subdirectory using the computer clock time for each run.

ttt_calcXX.exe calls **ttt_autoXX.bat**, **ttt_client.exe** and **ttt_fancy_atl/ind/pac_auto.bat**, and automatically creates pre-named output files. To run quickly, 15-arc min topography is recommended; for greater accuracy, especially for near-shore maps, a finer resolution bathymetric grid should be used but the travel time computation will take longer.

ttt_calcXX.exe can be run from any directory, but all data files that are plotted should reside in C:\TTT Package\Software\TTT\bin. In other words, if epicenters, stations, and/or historical earthquakes will be plotted, these files should exist in C:\TTT Package\Software\TTT\bin. Alternatively, **ttt_autoXX.bat** can be edited to include the full path of the data files.

For more detailed instructions for its usage, see *TTT_calc_ttt_auto_README_feb22.pdf*

GENERAL PLOTTING

ttt_fancy.bat: Allows user-specified boundaries and several customization options, including option to color shade only some ttt contour intervals.

ttt_fancy.bat requires 30 files (ttt1.cpt to ttt30.cpt) that are in the sub-directory “CPT” The .cpt files are color palettes that differ by the number of hours contoured in colors versus non-colored (white). If this script is run in another directory, the “CPT” directory and **ttt_fancy.bat** should be copied to that new directory, and the .bat file should be edited to designate the correct directory to use for the scripts and other input files.

HANDS-ON TUTORIALS

These handouts are hands-on exercises providing step-by-step instructions for creating travel time contour maps using the TTT and GMT softwares.

Scenarios are from the Caribbean, Pacific Ocean, Indian Ocean, and South China Sea (C:\TTT Package\Examples\EXAMPLE_CARIBBEAN or IO_SCS / MAKRAN / PACIFIC)

QUICK INFO: TSUNAMI TRAVEL TIME CALCULATION

For more info, see *TTT_README_feb2022.pdf* or
TTT_calc_ttt_auto_README_feb22.pdf in *TTT Package folder*

PLOT INSTRUCTIONS

1. Open *ttt_calc32.exe* or *ttt_calc64.exe*, double click the *TTT_CALC32* or *TTT_CALC64* icon on desktop
2. Follow directions in screen shot to the right, e.g., input
 - map title < 50 characters
 - latitude, longitude
 - location of plots to be made (Pacific)
 - output travel times (or arrival times)
 - bathy file to use (10-min grid for fast plot; 2 min-grid for most accurate (takes longer))
 - plot sea level stations, plot historical seismicity
3. The script will
 - create a binary grid file of tsunami travel times (or arrival times)
 - output file of tsunami arrival or travel times at user-input locations
 - create up to 3 tsunami travel time plots (in .png format and .ps format). Plots are Pacific, regional, local map boundaries
4. Plot files are found in *TTT_examples* under folder *TTT_AUTO_XXXXXXX*, where *XXXXXX* corresponds to plot time (hrmsec)
5. Example is source at NWS Pago Pago office. 20-min bathymetry is used and plots are made for the entire Pacific Ocean, near the source, and the SW Pacific region. 3 tsunami travel time maps automatically produced (.png format)

TTT CALC 09/2020

Tsunami Travel Time Calculator

INTERNATIONAL TSUNAMI INFORMATION CENTER
WWW.TSUNAMIWAVE.ORG

Input information stored in TTT_Input.txt
Output stored in C:\TTT Package\Examples

Please Enter Title You Would Like For Map:

Source Latitude (decimal degrees, N(+), S(-)):

Source Longitude (decimal degrees, E(+), W(-)):

Please Select Region the Ocean Event is Occurring in:

Pacific Ocean Selected,
Please Select Zoomed PO Region to Plot:

Please Note: Output times at locations
arrival times are calculated correctly only for events years 1970-2038)

Select What You Would Like Outputted

Select bathymetry grid file to use,
15min recommended for fast run.

Options are (arc min): 60, 30, 20, 15, 10, 5, 2, 1:

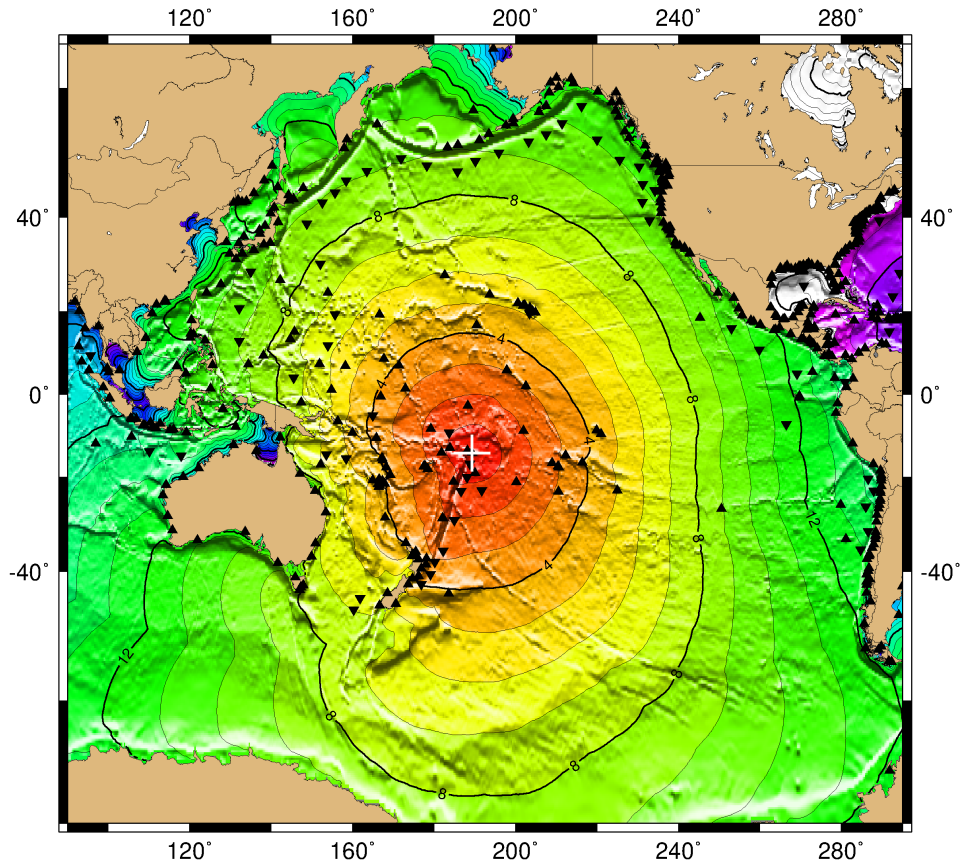
Plot Sea Level Stations?

Plot Historical Earthquakes? (Centennial List)

Notes:

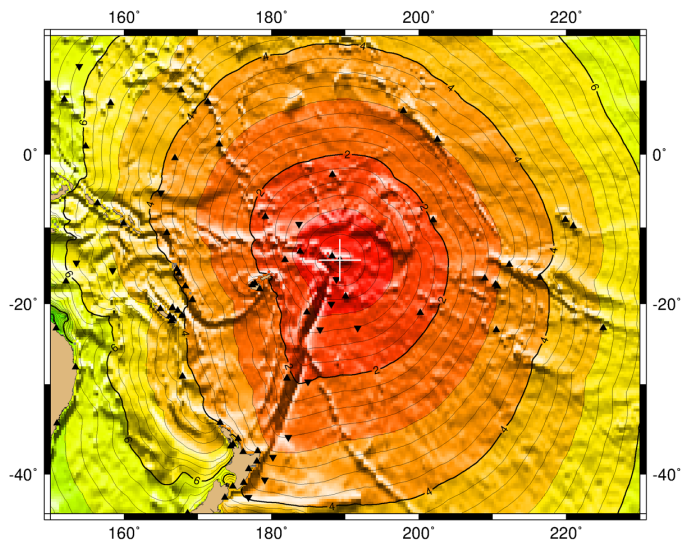
- Tsunami travel times are calculated from sea floor bathymetry. Therefore, they are estimates predicting the arrival time. The actual time may differ by 10s of minutes
- For local tsunamis, because the source is near, calculated tsunami travel times using the actual epicenter may over- or under-estimate because of uncertainties in the near-source bathymetry and nature of the earthquake rupture.

Pago Pago



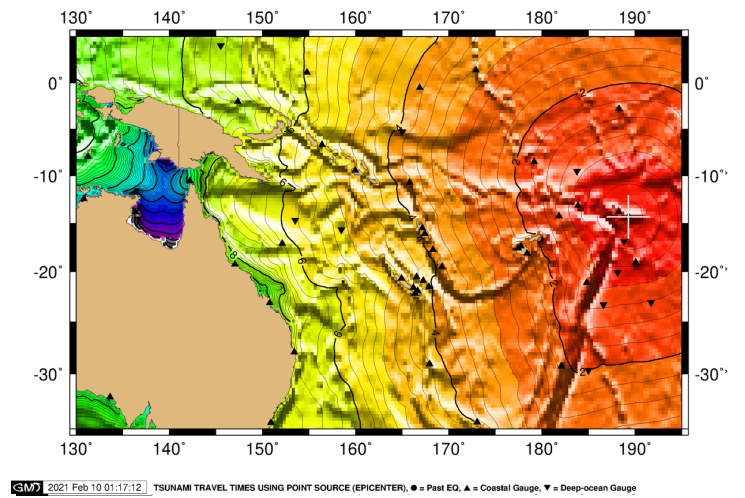
GM7 2021 Feb 10 01:17:11 TSUNAMI TRAVEL TIMES USING POINT SOURCE (EPICENTER), ● = Past EQ, ▲ = Coastal Gauge, ▼ = Deep-ocean Gauge

Pago Pago



GM7 2021 Feb 10 01:17:11 TSUNAMI TRAVEL TIMES USING POINT SOURCE (EPICENTER), ● = Past EQ, ▲ = Coastal Gauge, ▼ = Deep-ocean Gauge

Southwest Pacific



GM7 2021 Feb 10 01:17:12 TSUNAMI TRAVEL TIMES USING POINT SOURCE (EPICENTER), ● = Past EQ, ▲ = Coastal Gauge, ▼ = Deep-ocean Gauge

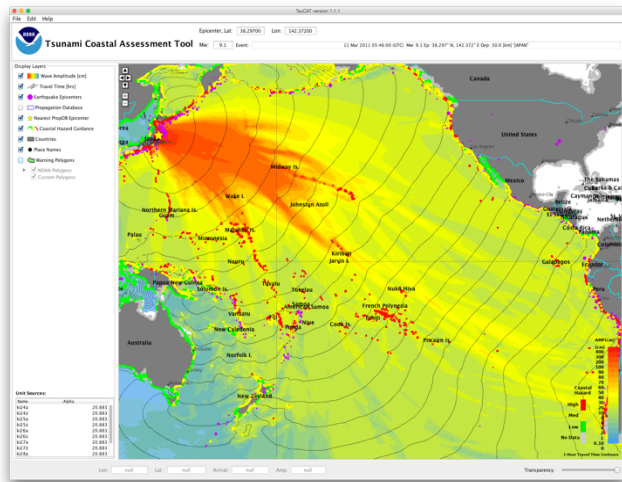


Tsunami Coastal Assessment Tool (TsuCAT)

TsuCAT provides access to a Pacific, Caribbean, and Indian Ocean database of tsunami modeling results from NOAA’s pre-computed catalog of sources and for the Pacific and Caribbean, the RIFT model, to assist a country in its tsunami hazard assessment, tsunami exercise and response planning, and warning decision-making. Simulations for historical tsunami sources from NOAA’s National Centers for Environmental Information (NCEI) and the U.S. Geological Survey earthquake archive, as well as IOC expert meeting worst case regional seismic tsunami scenarios are included.

A new tool allows countries to choose their own scenario and to generate the PTWC’s enhanced text and graphical products to use in their exercises.

During an event, national tsunami warning centers must be able to assess their threat, and decide when to issue warnings based on their alert level criteria. For earliest decision-making, especially for local tsunamis, countries may want to use a pre-computed, look-up database containing plausible warning scenarios and thresholds. TsuCAT may be help by providing

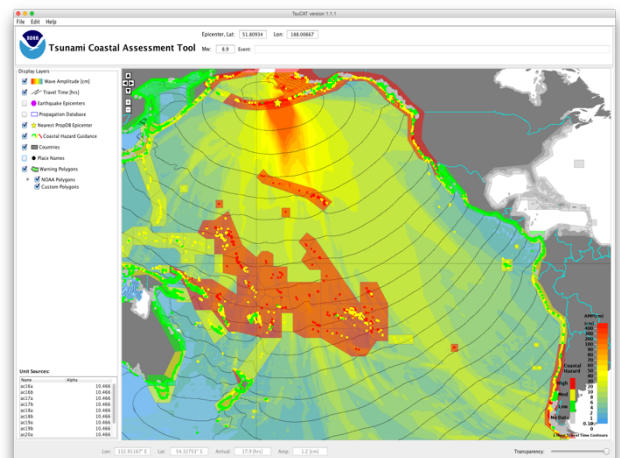


TsuCAT graphical user interface. Maximum wave amplitude and wave arrival time contours for the 11 March 2011 Japan Tsunami is shown when TsuCAT is launched.

a quick and easy way to obtain scenario-based coastal impact guidance before official event-specific PTWC information is available.

TsuCAT is platform independent and ‘stand-alone’ in that it runs on the Windows, Apple, and Linux computing platforms, and does not require Internet connectivity. All libraries, databases, and documentation are installed in their entirety on the host machine. The only requirement is a Java v1.8 or higher free installation.

TsuCAT features include: Pan and zoom map; Editable epicenter and Mw; Base-layer map image tile, place names and labeling; Map display layer control; Results export; Easily-queried maximum wave amplitude and arrival times; tsunami observations. The Coastal Hazard Guidance is represented as the deep-ocean wave amplitude extrapolated to the coastline accounting for shoaling using the Green’s Law approximation. The Coastal Hazard Polygon layer is identical to the PTWC’s Coastal Tsunami Amplitude Forecast Polygon map, and customizable. PTWC text and enhanced product messages are created using user’s source location, magnitude, origin time.



Warning polygons for a Mw 8.9 scenario in Aleutian Islands

TsuCAT v1 was introduced at ICG/PTWS-XXVII (2017), and subsequent versions released at meetings and trainings to authoritative tsunami officials globally. TsuCAT v4.0 was issued in April 2019, v4.1 in September 2019, and v4.2 in October 2020.

Feedback or questions about TsuCAT, its use, or to report bugs should be directed to NCTR and/or ITIC: Christopher.Moore@noaa.gov; Laura.Kong@noaa.gov http://itic.ioc-unesco.org/index.php?option=com_content&view=category&layout=blog&id=2239&Itemid=2763

Ref: Gica, E., M.C. Spillane, V.V. Titov, C.D. Chamberlin, and J.C. Newman (2008): Development of the forecast propagation database for NOAA’s Short-term Inundation Forecast for Tsunamis (SIFT), NOAA Tech. Memo OAR PMEL139, NOAA/PMEL, Seattle, WA, 89 pp.

Ref: Users Guide for the Pacific Tsunami Warning Center Enhanced Products for the Pacific Tsunami Warning System. IOC Technical Series No 105, Revised edition. UNESCO/IOC 2014 (English; Spanish)



Tsunami Coastal Assessment Tool (TsuCAT): A Tool for Rapid Initial Tsunami Assessment

Christopher Moore², Laura Kong¹, Marie Eble², Edison Gica², Diego Arcas²

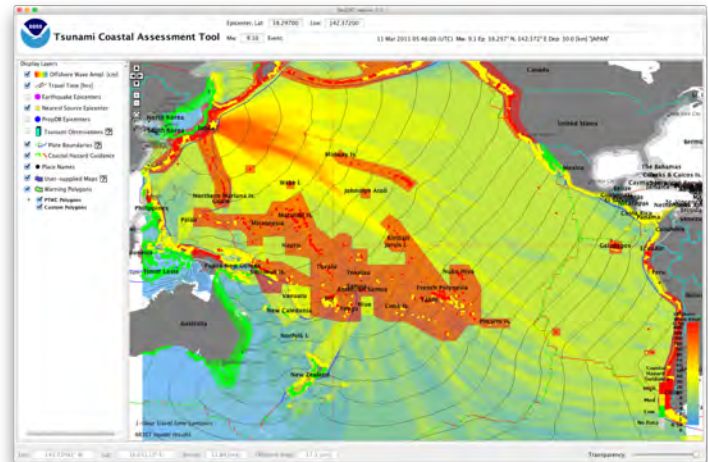
¹NOAA Center for Tsunami Research (NCTR), Pacific Marine Environmental Laboratory
²UNESCO/IOC – NOAA International Tsunami Information Center (ITIC)



TsuCAT: a stand-alone early assessment tool

The Tsunami Coastal Assessment Tool (TsuCAT) is a simple and quick, yet powerful tool for exploring the impact from many different tsunamis. It was developed by the NOAA Center for Tsunami Research (NCTR) to support the International Tsunami Information Center's (ITIC) effort to provide countries with tsunami decision support tools.

TsuCAT provides access to a database of tsunami modeling results from NOAA's pre-computed catalog of sources (Propagation Database) to assist a country in its tsunami hazard assessment, tsunami exercise and response planning, and warning decision-making. The pre-run models have been combined to represent earthquakes of larger magnitudes, and the wave amplitude for any magnitude can be shown to the user to allow assessment of wave amplitude at any given location in the ocean basin. The standard 100km-by-50km fault plane works well for forecasting larger magnitudes using MOST, but for magnitudes below 8.0 TsuCAT uses RIFT model results with fault lengths decreasing appropriately with magnitude. This allows accurate results over a range from Mw 6.5 up to the theoretical maximum of 9.6 (spaced every 0.3).



TsuCAT displaying maximum offshore wave amplitude, coastal amplitude, arrival times, and warning polygons colored by maximum wave within the region.

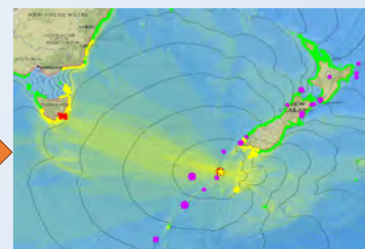
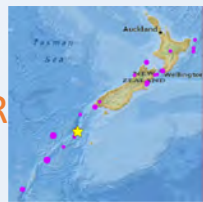
TsuCAT Workflow

TsuCAT gives offshore wave amplitude, arrival time, and extrapolated values along the coastline for any epicenter in the global subduction zones, and at any magnitude. To use TsuCAT the user must choose an epicenter and magnitude: this is done by dragging the yellow epicenter "star" and editing Mw. TsuCAT then chooses the closest epicenter from its database of 5400 runs, and scales it up or down to match the requested magnitude.

TsuCAT also comes with a catalog of historical events. Users can choose earthquake epicenters and magnitudes from a list:

Date	Mw	Latitude	Longitude	Country
2017-11-01 02:23	6.6	21.648° S	168.858° E	NEW CALEDONIA
2017-11-19 09:25	6.3	21.638° S	168.673° E	NEW CALEDONIA
2017-11-01 08:09	6.1	21.728° S	168.914° E	NEW CALEDONIA
2003-12-27 04:55	6.1	22.107° S	169.350° E	NEW CALEDONIA
2017-11-20 08:09	6.0	21.485° S	168.809° E	NEW CALEDONIA
2004-12-23 14:59	6.1	49.312° S	161.345° E	NEW ZEALAND
1855-01-23 09:00	8.0	41.250° S	175.000° E	NEW ZEALAND
2016-11-13 11:02	7.8	42.757° S	179.077° E	NEW ZEALAND
2009-07-15 09:22	7.8	45.762° S	166.562° E	NEW ZEALAND
1884-10-18 12:15	7.6	40.200° S	173.900° E	NEW ZEALAND
2007-09-30 05:23	7.4	49.418° S	161.954° E	NEW ZEALAND
2003-08-21 12:12	7.2	45.164° S	167.144° E	NEW ZEALAND
2016-09-01 16:37	7.1	37.493° S	179.055° E	NEW ZEALAND
2004-11-22 20:26	7.1	46.676° S	164.721° E	NEW ZEALAND

OR

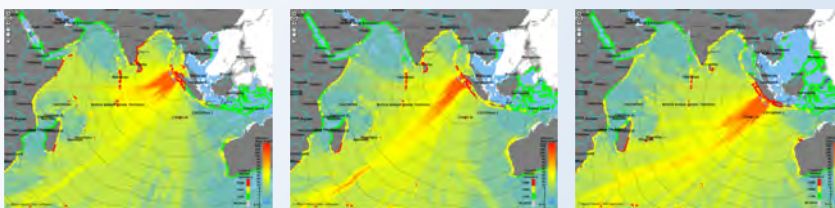


See focused impact of 1981 Peysegur event on Tasmania

Example: Assessing Directionality

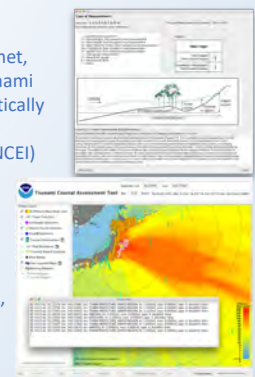
TsuCAT can be used to quickly get a visual impact of increasing magnitude, and this is useful to fully appreciate the logarithmic nature of moment magnitude, but since tsunami dynamics depend so heavily on bathymetry, exploring directionality can also be very useful.

Here we see the effect of keeping magnitude constant, but moving the epicenter just a few hundred kilometers: not only does the maximum amplitude change, but TsuCAT shows the drastic effect on coastal values regionally.



More Use Cases

When connected to the internet, TsuCAT's earthquake and tsunami database will update automatically from the NOAA Center for Environmental Information (NCEI) Global Historical Tsunami Database and the US Geological Survey (USGS) earthquake catalog. The NCEI tsunami observation database includes tide gauge, DART buoy, and post-event survey data for a given event.



Contact and Info

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<http://itic.ioc-unesco.org>
NCTR: Marie.C.Eble@noaa.gov
Christopher.Moore@noaa.gov
<http://nctr.pmel.noaa.gov/TsuCAT>



WORLD DATA SERVICE FOR GEOPHYSICS



NOAA's National Centers for Environmental Information (NCEI, formerly National Geophysical Data Center) hosts the World Data Service for Geophysics (replaces former World Data Centers for Geophysics and Marine Geology and Solar-Terrestrial Physics). The solar data are not described.

Maintained by: U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). The WDS for Geophysics, Boulder, is operated by, and collocated with, the NCEI.

Summary of Data Held: WDS for Geophysics, Boulder manages geophysical data as well as marine geological data. This includes global gravity and magnetism, global relief (bathymetry and topography), data from the ocean floor, and global natural hazards. Data include descriptions, analyses, and images of sea floor samples, deep drilling data, underway, downhole and airborne geophysical measurements, natural hazards data, and derived gridded data sets.

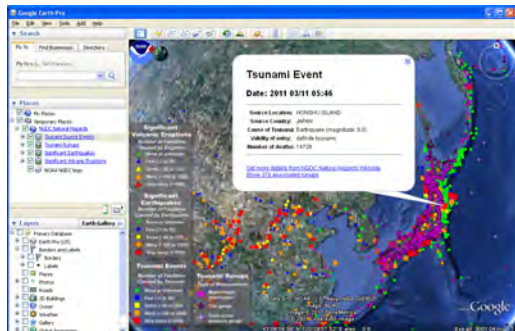
The WDS for Geophysics Global Natural Hazards data include global tsunami event and runup data, significant earthquake and volcanic eruption data, tsunami deposits and proxies, and sea level (coastal tide gauge and deep-ocean tsunameter) data. Historical tsunami data include the location, date, and description of the event generating a tsunami as well as location, date, description, maximum wave height, deaths, damage, and photographic evidence of coastal impacts. Significant earthquakes and significant volcanic eruptions data include descriptions of events that caused death, \$1 Million in damage, or generated a tsunami. The global tsunami deposits and proxies data include descriptions of tsunami deposits for locations all over the world, extracted from published sources. The WDS-Geophysics also stewards the U.S. coastal and deep-ocean sea level data as well as over 5000 images of damage from past hazard events.

Data are contributed by sources from around the world and were originally collected for a variety of purposes, including academic research, international and interdisciplinary scientific projects, commercial mineral resource evaluations, defense, and government environmental baseline studies.

Data Access: The WDS for Geophysics natural hazards data or inventories are all stored and integrated in a relational database management system (RDBMS). The data are available on-line and can be searched by attribute (e.g. event, runup, location, date, deaths). The search results link to additional information, sources, imagery, plots and download screens for the Deep-ocean Assessment and Reporting of Tsunamis (DART™) buoys (if triggered), and tide-gauge data (where available).

All of the natural hazards data are accessible via Open Geospatial Consortium (OGC) Web Map Services which allows any OGC-enabled client to incorporate a map image of the data. The Web maps operate off the same RDBMS. They provide limited GIS capability and are linked to photos, additional event information, and references.



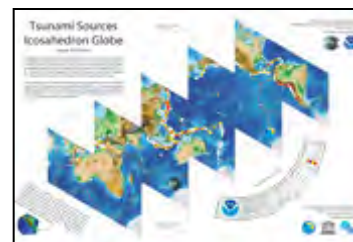


The NCEI/WDS website provides a Keyhole Markup Language (KML) file containing tsunami sources and runups, significant earthquakes, and volcanic eruptions. Many applications display KML, including *Google Earth*, *Google Maps*, *NASA WorldWind*, and *ESRI ArcGIS Explorer*. The KML file provides basic information on each event (date, magnitude, death, damage), updated nightly, and links to the NGDC database for the full content.

User Services: The WDS for Geophysics is located in the David Skaggs Building at 325 Broadway, Boulder, Colorado. Visitors are welcome during normal working hours; advance notice is required. A visiting scientist program exists. Data processing, copying, and analysis facilities are available. Data are available on most media including DVD, via Internet, and other media on request. On-line access via Worldwide Web (URL <http://www.ngdc.noaa.gov/>) WDS for Geophysics inventories are fully searchable via the WWW and much of the data is available for download.

Publications: WDS for Geophysics includes the publication series for the WDC-SEG and WDS for Geophysics. This includes color images, data reports, and scientific reports of interest to the GMG community.

Posters and Icosahedrons: WDS for Geophysics in collaboration with the UNESCO/IOC – NOAA International Tsunami Information Center produced a global map showing tsunami sources and a global cut-out and fold-up model of the Earth displaying global relief in full color overlaid with tsunami sources.



Special Projects: WDS for Geophysics participates in the Intergovernmental Oceanographic Commission (IOC) technical committee on International Oceanographic Data and Information Exchange (IODE), Intergovernmental Coordination Groups for Tsunamis (ICG Pacific and CARIB), the General Bathymetric Chart of the Oceans (GEBCO), regional IOC international mapping projects, and cooperates extensively with the International Ocean Drilling Program (ODP), for which it operates a parallel data archive. The WDS for Geophysics is also active in the International Association of Geomagnetism and Aeronomy (IAGA) Division V and the World Digital Magnetic Anomaly Map Project. Special emphasis is given to data supporting IUGG, IOC, and UNEP programs.

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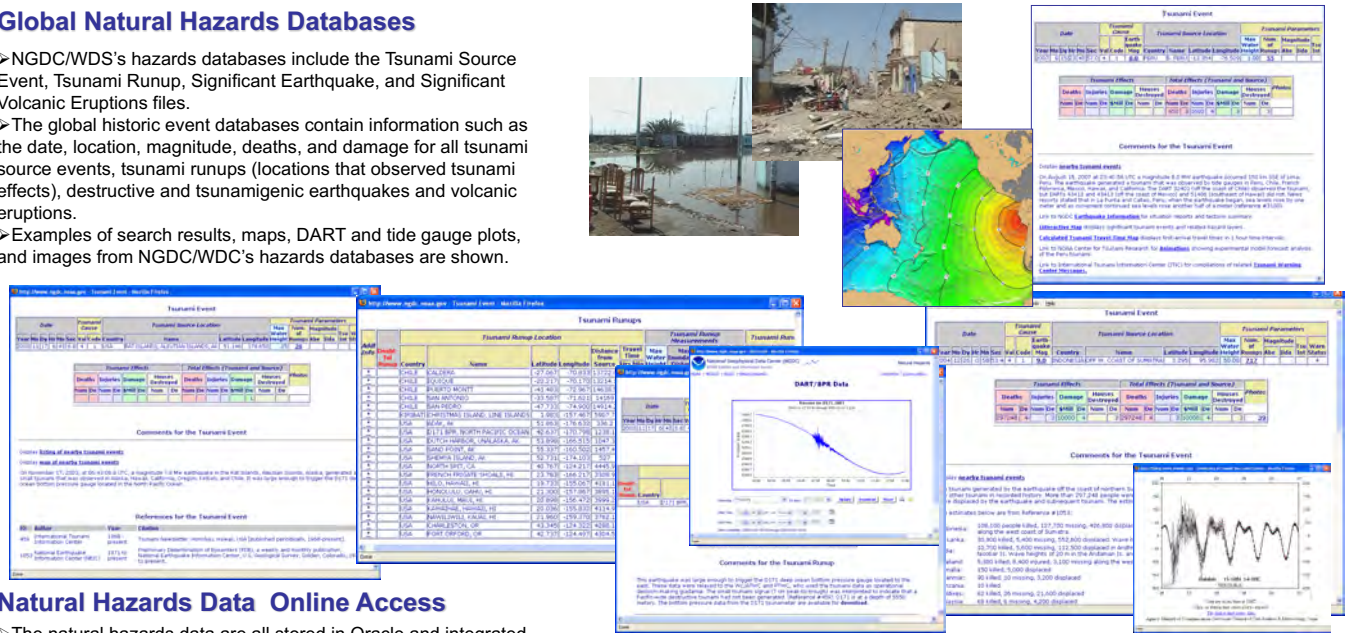
Online Access to Tsunami and Related Data

<http://www.ngdc.noaa.gov/hazard/hazards.shtml>

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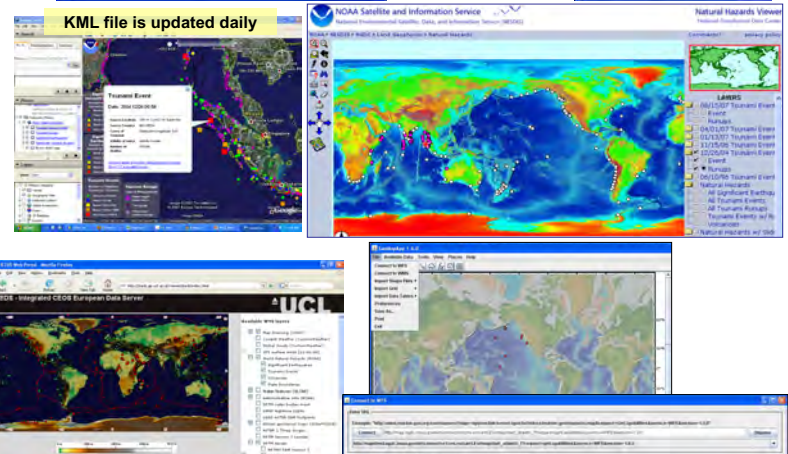
Global Natural Hazards Databases

- NGDC/WDS's hazards databases include the Tsunami Source Event, Tsunami Runup, Significant Earthquake, and Significant Volcanic Eruptions files.
- The global historic event databases contain information such as the date, location, magnitude, deaths, and damage for all tsunami source events, tsunami runups (locations that observed tsunami effects), destructive and tsunamigenic earthquakes and volcanic eruptions.
- Examples of search results, maps, DART and tide gauge plots, and images from NGDC/WDC's hazards databases are shown.



Natural Hazards Data Online Access

- The natural hazards data are all stored in Oracle and integrated. The data are available on-line (<http://www.ngdc.noaa.gov/hazard>) and can be searched by attribute (e.g. event, runup, location, date, deaths, etc). The search results link to additional information, sources, imagery, plots and download screens of the Deep-ocean Assessment and Reporting of Tsunamis (DART) buoys (if triggered), and plots of tide-gauge data (where available).
- All of the natural hazards data are accessible via Open Geospatial (OGC) Web Map Services which allows any OGC-enabled client to incorporate a map image of the data. The Web maps operate off the same oracle databases as the traditional forms. They provide limited GIS capability and are linked to photos, additional event information, and references.
- The DART Metadata are available via OGC Web Feature Service (Allows any OGC-enabled client to access DART metadata, links to NGDC to download high-resolution data)
- The hazards data are also available via Google Earth (the NGDC/WDC Web site serves a KML file containing tsunami sources and runups, significant earthquakes and volcanic eruptions. The Google Earth view provides basic information on each event (death, damage, magnitude, date) and links to the to the NGDC/WDC database for the full content.



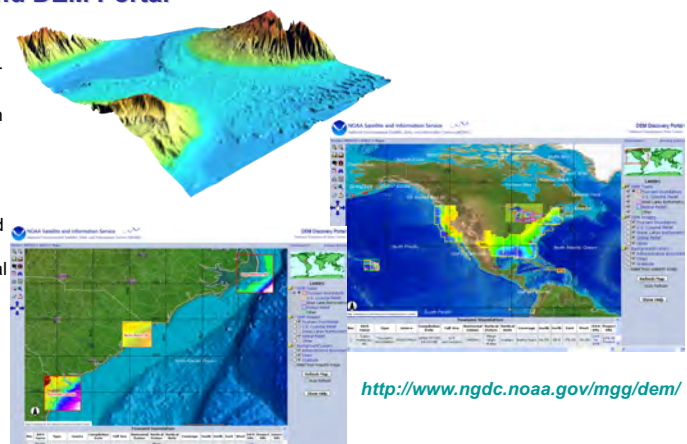
Tsunami Deposits Database

- NGDC/WDC has developed a tsunami deposits database to extend the tsunami database backwards in time. For example, the "Only a Matter of Time" image is a paleoseismic and paleotsunami record at Willapa Bay, Washington. A stack of layers dating from 1700 A.D. back to 900 B.C. is very distinctive. Each layer represents the downdropping of the marsh during a Cascadia subduction zone earthquake and subsequent depositing of locally generated tsunami sands. This database is available online and is linked with the historical tsunami event database.

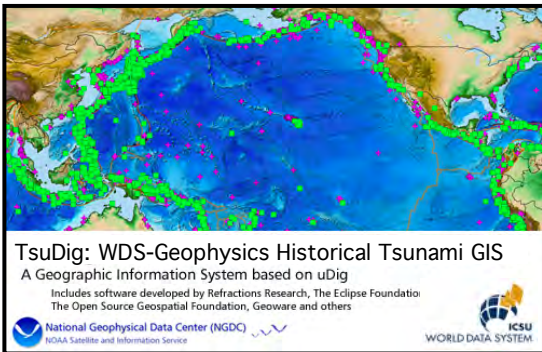


Tsunami Inundation Digital Elevation Models (DEM) and DEM Portal

- NGDC/WDC is building high-resolution digital elevation models (DEMs) for select U.S. coastal regions. These combined bathymetric-topographic DEMs are used to support tsunami forecasting and modeling efforts at the NOAA Center for Tsunami Research, Pacific Marine Environmental Laboratory (PMEL).
- The DEMs are part of the tsunami forecast system SIFT (Short-term Inundation Forecasting for Tsunamis) currently being developed by PMEL for the NOAA Tsunami Warning Centers, and are used in the MOST (Method of Splitting Tsunami) model developed by PMEL to simulate tsunami generation, propagation, and inundation.
- The project website allows for search, viewing and download of DEMs, detailed DEM development reports, and metadata.
- NGDC/WDC has created a web-based interactive map portal for locating Digital Elevation Models (DEMs), or gridded representations of terrain data collected from above and below water. The "DEM Discovery Portal" makes it easier for researchers to locate, preview and download DEMs from organizations within and external to NOAA. In North Carolina, for instance, a high-resolution tsunami inundation DEM for Cape Hatteras is being used as a template for building a state-wide coastal DEM for hurricane storm-surge modeling. Once completed, the new DEM will be included in the portal. Within NOAA, scientists in just about every line office use DEMs, from ecologists mapping fish habitat to hurricane modelers estimating coastal inundation.



<http://www.ngdc.noaa.gov/mgg/dem/>

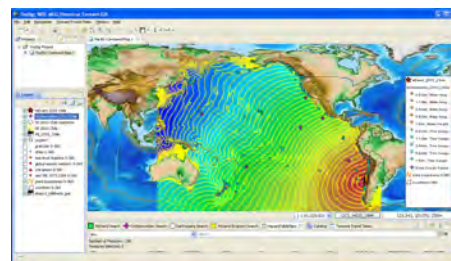
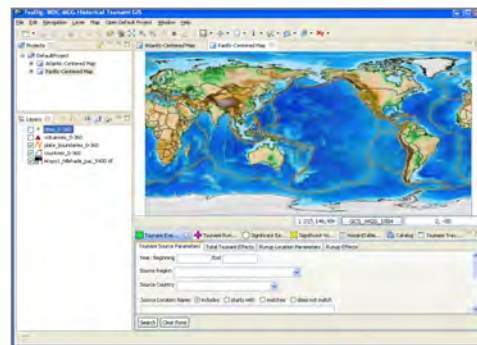


TsuDig WDS-Geophysics Historical Tsunami GIS version 1.1, August 2013

The World Data System for Geophysics (WDS-Geophysics), co-located at the NOAA National Geophysical Data Center (NGDC), maintains a historical hazard database of tsunamis, significant earthquakes, and volcanic eruptions from ancient times (2000 B.C.) to the present. The database includes >1,800 Tsunami Events (validity >0), >13,000 Tsunami Runups associated with Tsunami Events (validity >0), >5,000 Significant Earthquakes, and >500 Significant Volcanic Eruptions. In order to meet the needs of local authorities and tsunami warning centers from countries around the world, WDS-Geophysics and the UNESCO/IOC-NOAA International Tsunami Information Center (ITIC) developed a standalone GIS application to interact with a local copy of the historical hazards database. The software is based on uDig (User-friendly Desktop Internet GIS), an open-source GIS framework written in Java, which is built upon the well-established Eclipse Rich Client Platform (RCP). We have customized the behavior of uDig by developing plugins that allow the user to query the database using many different search parameters, and to display information about events on a map and in table format.

Features available within TsuDig include:

- Pacific-Centered, and Atlantic-centered maps with the following data Layers:
 - ETOPO1 topography/bathymetry
 - Major cities
 - Country boundaries
 - Volcano locations
 - Plate boundaries
 - Sea Level Network
 - Global Seismic Network
 - Historical earthquakes (magnitude 5+ from 1973-2009) from the USGS NEIC
- Customized searches of Tsunami Events and Observations, Earthquakes, and Volcanic Eruptions the WDS-Geophysics NGDC Historical Hazard database; the database is easily updated
- Tsunami Travel Times (TTT) calculation and display
- Customization of legend, symbols, and other display and plot styles
- Map export to PDF, PNG, JPG, or other formats
- Import of GIS layers



If you have questions about the database, please contact Paula Dunbar (paula.dunbar@noaa.gov) at NGDC. For general questions or software/CD copies, please contact Laura Kong (laura.kong@noaa.gov) at ITIC.

GLOBAL TSUNAMI DATABASE FOR THE WORLD

Dr. V. Gusiakov, Head, Novosibirsk Tsunami Lab
(gvk@sscc.ru)

ICMMG SAD RAS, Novosibirsk, Russia
Version 6.52, Oct 2008 (database update 2013)

The GTDB (formerly HTDB) is a joint IUGG/TC and ICG/PTWS Project under the IOC of UNESCO, with formerly additional funding assistance from the US NOAA National Weather Service, directed at the improvement of the catalogue of historical tsunamis in the world. The database consists of three main parts: the catalog of tsunamigenic events with their basic source parameters, the catalog of the observed run-up heights and a global catalog of historical earthquakes from pre-historic times to the present. The current version of the database covers the period from 2000 B.C. to 13 January 2007 (Kurils earthquake and small tsunami), and contains 2120 entries in the event catalog and more than 7000 run-up heights provided with the exact geographical coordinates of the observational sites. Additionally, the software includes a tsunami travel time calculator, making it a useful tool for tsunami warning centers and for emergency managers wishing to develop scenario events. The software calculates expected tsunami travel times to locations in and around the different oceans and marginal seas, and displays the information graphically at user-selectable map scales.

The tsunami and earthquake catalogs, collected within the GTDB Project, are embedded inside a specially-developed GIS-type graphic shell (WinITDB) for easy data retrieval, visualization and processing. The WinITDB shell operates on Windows PC platforms with no additional co-located software required. The WinITDB graphic shell has been designed with an "easy-to-learn" and "easy-to-use" graphic interface, that encourages a "try and see" approach to its learning. So, the most effective way is simply to run the system and to explore its possibilities. However, the graphic shell has many specific features for constructing and saving background maps as well as several different data retrieval modes (some of them can be not quite clearly understood from the beginning), that is why we recommend to familiarize yourself with the WinITDB user's manual before running the software.

The full version of the database, including the textual descriptions of tsunami manifestation and some additional reference information related to the tsunami problem, is distributed on the CD-ROM. The Web-version of the database is maintained by the NTL/ICMMG on the following Web-site:
<http://tsun.sscc.ru/htdbpac>.

The GTDB data set contains almost all historical data published in the earlier tsunami catalogs and can be considered as a complete and reliable historical tsunami data set available in digital domain; these contain both verified tsunamis and reported observations of unexpected wave interactions which may not be tsunamis. Please note that the process of the data compilation and editing is still far from completion, and a wealth of additional and more accurate data still exists in regional and local sources. These data are scattered in numerous publications (reports of regional conferences, magazines, newspapers, original reports, etc.) and most of them are unavailable outside the region of origin, and quite often published in languages other than English. The further improvement of the database's quality and completeness requires the help of regional or national coordinators who are working in the regions and have an access to local sources of information. The GTDB project welcomes the cooperation and collaboration of everyone interested in contributing new and corrected data to the tsunami database.

Please contact ITIC (itic.tsunami@noaa.gov or laura.kong@noaa.gov) if you have questions or need further information or copies.

GOOGLE EARTH DATABASE FILES FOR TSUNAMI WARNING

2007-2015, July 2018

Google Earth is a popular graphical tool that can display a number of data layers simultaneously. Several organizations are now providing data files (.kml and/or .kmz) that can be imported into this user-friendly visualization. Tsunami-related database files include those for the USGS-located earthquakes (in near real-time), WDS/NCEI Global Historical Tsunami, Significant Earthquakes and Volcanic Eruptions databases, and the IRIS Global Seismic Network, as well as the PTWC Enhanced Product tsunami forecasts during events.

If you have other .kml or .kmz files that are useful, please let ITIC (itic.tsunami@noaa.gov) know so we may add them to our list of available information.

Google Earth Software:

<https://www.google.com/earth/>

USGS Earthquakes (including real-time) and Tectonics

<https://earthquake.usgs.gov/learn/kml.php>

IRIS Global Seismic Network:

http://ds.iris.edu/gmap/#network=_GSN&planet=earth

Station KML available for download from web site (lower left)

WDS/NCEI Natural Hazards, including tsunamis, earthquakes, volcanoes

World Data Service / National Centers for Environmental Information

<https://www.ngdc.noaa.gov/hazard/>

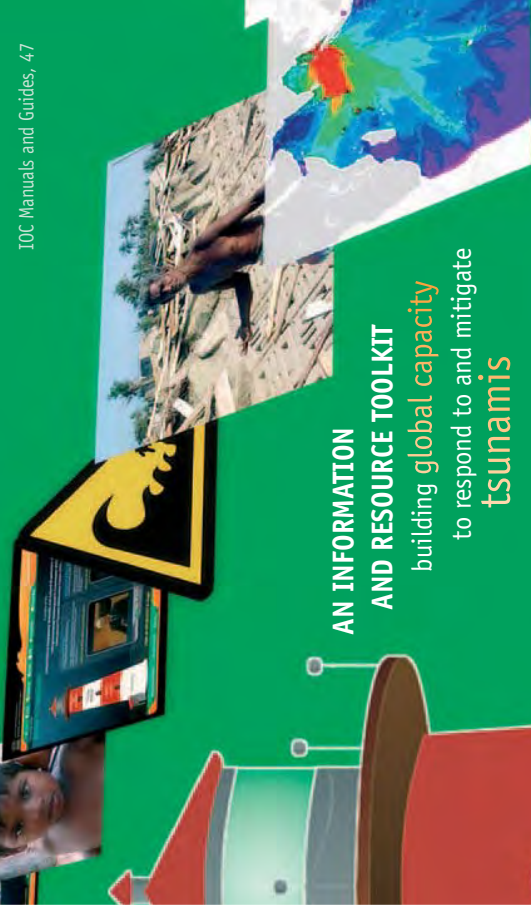
Natural Hazards KMZ available for download from web site

Sea Level Network

IOC IODE Sea Level Monitoring Facility – Sea Level stations

KML file available for download from web site

<http://www.ioc-sealevelmonitoring.org/map.php>



**AN INFORMATION
AND RESOURCE TOOLKIT**
building global capacity
to respond to and mitigate
tsunamis

Tsunami Teacher



TsunamiTeacher is supported both as a dynamic, electronic, on-line resource that will be **continually reviewed, updated, and complemented by experts on a dedicated website: www.tsunamiteacher.org** and as an off-line set of DVDs which will run on PC and Macintosh platforms. The base language is English, with translations presently planned into Bahasa Indonesia, Bangladesh Bangla, French, Spanish, and Thai.

TsunamiTeacher is produced and distributed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and its **Intergovernmental Oceanographic Commission**. It was prepared under the supervision of the IOC's **International Tsunami Information Centre** in Hawaii, USA.



Intergovernmental Oceanographic Commission (IOC)

United Nations Educational, Scientific
and Cultural Organization

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Fax: +33 1 45 68 58 12

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TsunamiTeacher content

The content of *TsunamiTeacher* is divided into four main sections. It is recommended that all users read carefully through "1- Getting Started" before proceeding to Training Modules.

The "1- Getting started", "3- Workshops and Evaluation" and "4- Resource Collection" sections are common to all users and can be accessed at any point by clicking on the appropriate link button. Training modules for different *TsunamiTeacher* audiences are in "2- Training Modules".

There are a further three sections, always readily accessible as buttons on the screen – "Resources collection", "Glossary" and "Links and Contacts".

This product is not intended for sale.

how to run this computer-based training (CBT)

No installation required.

On a Windows platform

Insert the DVD and it will 'Autorun'. Else, go to Windows Explorer and double click on the DVD icon and then double click on Tsunami.exe to enter the CBT.

On a Macintosh,

Insert the DVD, double click on the DVD icon and then double click on Tsunami to launch the course.

This course is designed for MAC 10.3 or above versions. In the lower versions, the course will run properly but the PDFs will not be launched and will have to be opened manually from their respective folder. Path: (data\Resource).PDF)

TsunamiTeacher can be run directly from your computer hard disk. For this, copy all files on the DVD to the hard disk.

Recommended System Requirements

Processor: 1GHz or higher;

Memory: 256 MB RAM or higher

CD ROM: 8x or higher

Display: 800 x 600, 16 bit High Color

Operating System: Windows2000 or XP or higher; MAC OS X3 or higher

Additional Software Required

Adobe's Acrobat Reader 6.0 or higher. If you don't have one, the installers are packed with the TsunamiTeacher DVD for different platforms.



The Indian Ocean tsunami of 26 December 2004 claimed the lives of more than 230,000 people, the highest toll in recorded history.

cade 1994 to 2003 – according to the World Disasters Report 2005 of the International Federation of Red Cross and Red Crescent Societies.

In just a few hours, stunning the world with its destructive power, the tsunami struck every country in the Indian Ocean, wreaking massive damage along coasts and causing deaths in 11 countries. Indonesia, Sri Lanka, and southeast India were the worst hit.

The tsunami was largely to blame for a surge in the death toll from natural disasters in 2004, to 250,000 globally – three times higher than in 2003, 10 times more than in 2002 and three times the annual average for the de-

A tsunami is an unstoppable natural hazard, but the 2004 event made it tragically clear that countries were poorly prepared for the phenomenon. The goals now are to raise the ability of people **to recognize and react in a timely manner** to an approaching tsunami, to grow the capacity of nations to respond rapidly and effectively to tsunami warnings when they are issued, and to mitigate the impacts when tsunamis occur.

“Tsunami disasters pose a major threat to the coastal populations of the Pacific and other world oceans and seas. They have been responsible for the loss of thousands of lives and great damage to property.

“Although understanding of the tsunami phenomenon has increased in the past four decades and early warning systems have been established, these advances have been partially offset by population growth and extensive development of coastal zones.

“Therefore the tsunami risk and vulnerability of people living in coastal areas will continue to increase in the future.”

Intergovernmental Oceanographic Commission, UNESCO

In the aftermath of the 2004 tsunami, national authorities across the Indian Ocean region were charged, among other things, with developing tsunami information, awareness, education and resource materials for the media, schools, decision-makers and the public.

TsunamiTeacher pulls together a wealth of information on tsunamis that already exists, gathered down the decades on individual events and responses to them, and enriched by research and scientific advances. Many organizations and countries have also produced, or are developing, locally and regionally relevant materials on tsunamis.

TsunamiTeacher is the first single, reliable and verified resource that pulls this material together at the global level and makes them widely accessible to people, groups and governments around the world.

TsunamiTeacher contributes to build awareness and capacity to respond and mitigate the impact of tsunamis through the sharing of knowledge, research, and best practices.

Training Modules target the Media, Schools, and the Public and Private Sectors, including governments, non-government organizations, businesses, and community groups. Within the government sector, a large amount of training material has been assembled on earthquake and tsunami science and research, tsunami events, and the building of tsunami warning and mitigation systems. These topics include hazard and risk assessment, operational warning and dissemination systems, tsunami emergency response, alerting, and preparedness, environmental, engineering mitigation and policy, and education and outreach. Resource materials are provided as examples and guidance for decision-makers.



The IOC encourages the duplication and wide distribution of this product, free of charge to the users