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TSUNAMI WARNING DECISION SUPPORT TOOLS

Compiled and distributed by International Tsunami Information Center (ITIC)
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These following are useful decision support tools available free-of-charge to governments and other recognized authorities involved in tsunami warning hazard mitigation. For more information, contact the ITIC (itic.tsunami@noaa.gov) or its Director (Laura Kong, laura.kong@noaa.gov)

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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 times and estimated arrival time features implemented in May 2014. Non-operational versions also 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. **PTWC Tsunami Messages: RANET Alert Watcher SMS text message**
   The PTWC, through the RANET project, provides an SMS Heads-up alert to government authoritative tsunami warning and response agencies. The messages are brief in order to alert the recipient that official message (which is longer) has been sent. Available since 2005.

4. **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 WC/ATWC 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.

5. **Tsunami Travel Time Software**
   The World Data Center for Marine Geology and Geophysics (WDC-MGG), co-located at the NOAA National Geophysical Data Center, serves as the world's recognized tsunami database and archiving centre. *The WDC-MGG 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.* The Tsunami Travel Time (TTT) software is used by the NOAA Pacific Tsunami Warning Center for its operations calculations. Map graphics are made using the open-source Generic Mapping Tools (GMT). TTT is included in TsuDig. Available since 2007.

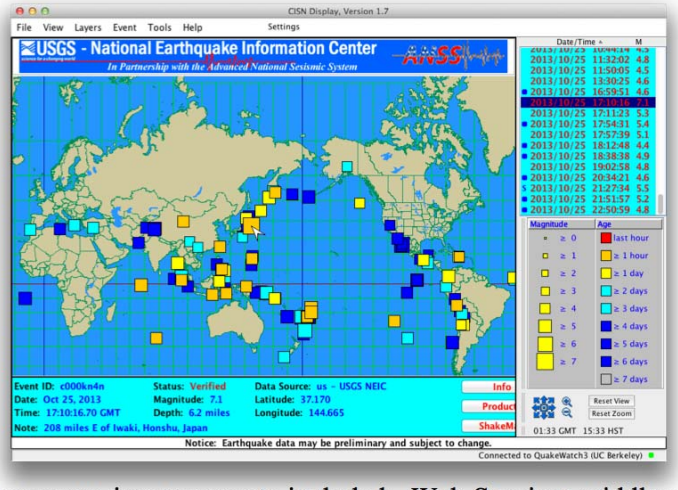
6. **Tsunami Historical Databases**
   The WDC-MGG provides extensive online, web-based and offline tools and other hazards information and digital bathymetry services. In 2009, the WDC-MGG and ITIC began distributing an enhanced offline tool (TsuDig GIS tool) that accesses the WDC database and includes 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 tsunami-related databases. These include files for USGS-located earthquakes (in near real-time), WDC/NGDC Historical Tsunami Database as well as Significant Earthquakes and Volcanic Eruptions, and the IRIS Global Seismic Network.

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 or IOC. 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 1.7, August 2013

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; and a "T" for events for which a tsunami warning has been generated. 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 1.5.X or higher
  (available from Sun at http://java.com/en/download/manual.jsp)
- Pentium-III, 1GHz CPU speed or comparable hardware384 Mb RAM or more
- IP Address (private or public)
- Access to Internet on ports 39977/39988

Instructions for obtaining RTED/CISN:

1. Send request for account to ITIC Director (laura.kong@noaa.gov). ITIC is the administrator for those wishing to register as tsunami institutions. Alternatively, you may register as your own institution directly with CISN.

2. ITIC will approve and send you a Registration Code (*regcode*). For the present, the Registration Code to use is KI1NZ1 or QCEA or JIQY1.

3. Create a User account by visiting http://www.cisn.org/software/login/index.php and clicking "Create a New User" and typing in *regcode* and personal information. Users must create their own CISN Display (CD) accounts in order to be registered in the CISN server database to receive information from the QuakeWatch server. After creating a user, you will receive an email asking you to confirm your contact information – please follow the directions given to validate.

4. ITIC will then approve the User, and send an email providing instructions on how to download and install the software. Your username is your email address and your password will be 6 characters.

5. Download and install the software, or copy the folder from the TWTools disk.
   http://www.cisn.org/software/QWClient/index.html
   Installation options:
   - Windows XP, Vista, Windows 7, Mac OS X, Linux, Solaris, UNIX
   - Cross-platform installer (Java .jar file)
   - Manual (not recommended)

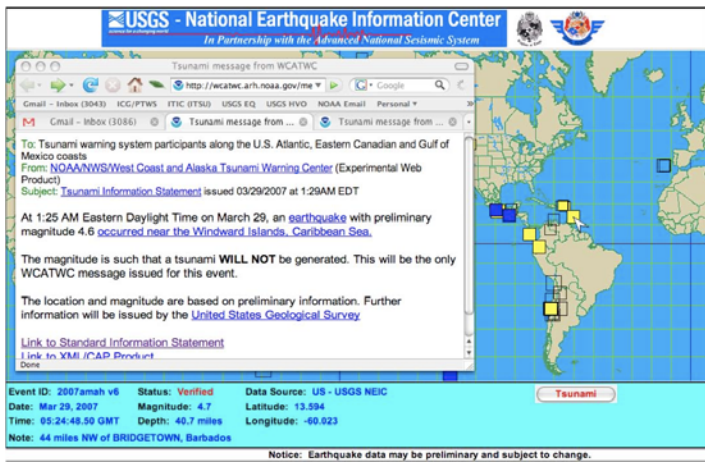
6. Check to make sure you have a Java Runtime Environment (JRE) 1.5.X or higher installed. To get Java (it's free), visit http://java.com/en/download/index.jsp. Note: installation of new software sometimes requires administrative privileges on the host machine. If any part of the installation fails, contact your local systems administrator for assistance.

   Download 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.

7. 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. This example is for Tonga.

Tsunami messages, when issued by the WC/ATWC 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 Server (ENS) - Alternative to RTED/CISN alerts:
An easier-to-configure and maintain tool for receiving information is provided by the USGS. Visit https://sslearthquake.usgs.gov/ens/ to sign up and configure the thresholds for notification. ENS now supports messages from the WC/ATWC and PTWC (check these boxes when setting up an alert profile). This should work both in the USA and internationally, but has not been tested for SMS alerts nor for timeliness of receipt of messages/email. In 2009, the USA had 140,000+ registered users for its notification system, but the majority were in the US.

RANET Alert Watcher (RAW, SMS Heads-Up Alert)
A SMS tsunami message alert service (RAW) is available for PTWC messages through the RANET international project. This service provides a short summary text message to mobile phones whenever the PTWC issues a message. This service is provided as a courtesy only to national authorities and is not intended to replace any official and timely operational communications methods. The service has proven reliable for receipt internationally since its start in 2005; estimated time for receiving a SMS alert is within 5 minutes after message issuance. For sign-up contact ITIC (laura.kong@noaa.gov) or Kelly Sponberg (raw@ranetproject.net)

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 CISN Installation

November 2013, L. Kong, laura.kong@noaa.gov, T. Fukuji, tammy.fukuji@noaa.gov

Use:

CISN 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. Agencies that are currently submitting their information include the Pacific Tsunami Warning Center and West Coast / Alaska Tsunami Warning Center; a "Tsunami" product button can be displayed, and when activated immediately indicates that the tsunami warning centers (TWC) have issued a tsunami message. *The CISN will receive and post TWC 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.*

ITIC and PTWC recommend the use of CISN are 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 CISN. For details, consult the RTED_Info_wRegCode_nov2013.pdf, CISN User Guide, and other manuals (in Manual_info folder of installation disk).

1. Go to http://www.cisn.org/software/login/index.php
2. "Create a New User", use registration code KI1NZ1 or QCEA or JIQY1. (see TWTools detailed instructions)
3. Check your email, and validate your username information (email address)
4. Check your email after ITIC approves. It will contain your 6-character password
5. Install software:
    a. Copy folder from TWTools DVD to your desktop
    b. Open install folder, find your installation and double-click on "Setup" to run.
6. Start CISN and input your username (email addr) and password (6 characters). Agencies with firewalls will need to ensure that CISN ports (and/or server domains) for information dissemination to the CISN software are allowed.
7. Customize as your CISN display to your needs. These might include the following options (access from tabs in Settings file menu). An example ITIC settings is found in CISN_Settings_ITIC; the configuration file (CISN_Display_ITIC.xml) can be loaded to set all display parameters).
    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 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 10.2, May 2014)

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 overlayed 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 is 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 (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, and Macintosh OSX (under BSD Unix) operating systems; the preferred platform is Unix or Linux because of its stability. For Windows 7, 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 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).

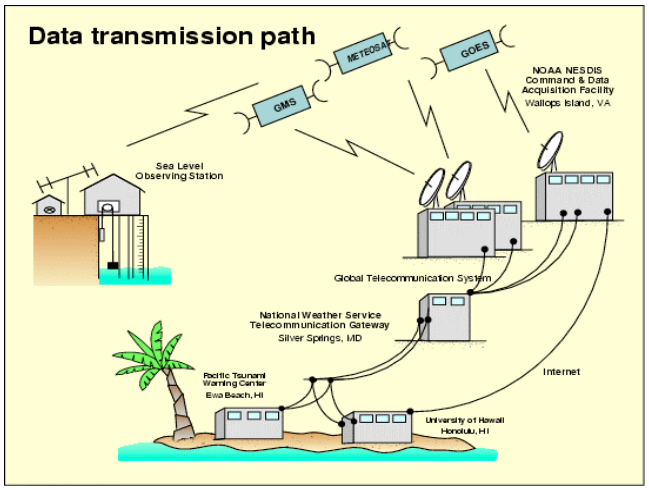


Figure 2.
Transmission from the Data Collection Platform at the field station to the warning centres.

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 bltwish 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 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 beta 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).

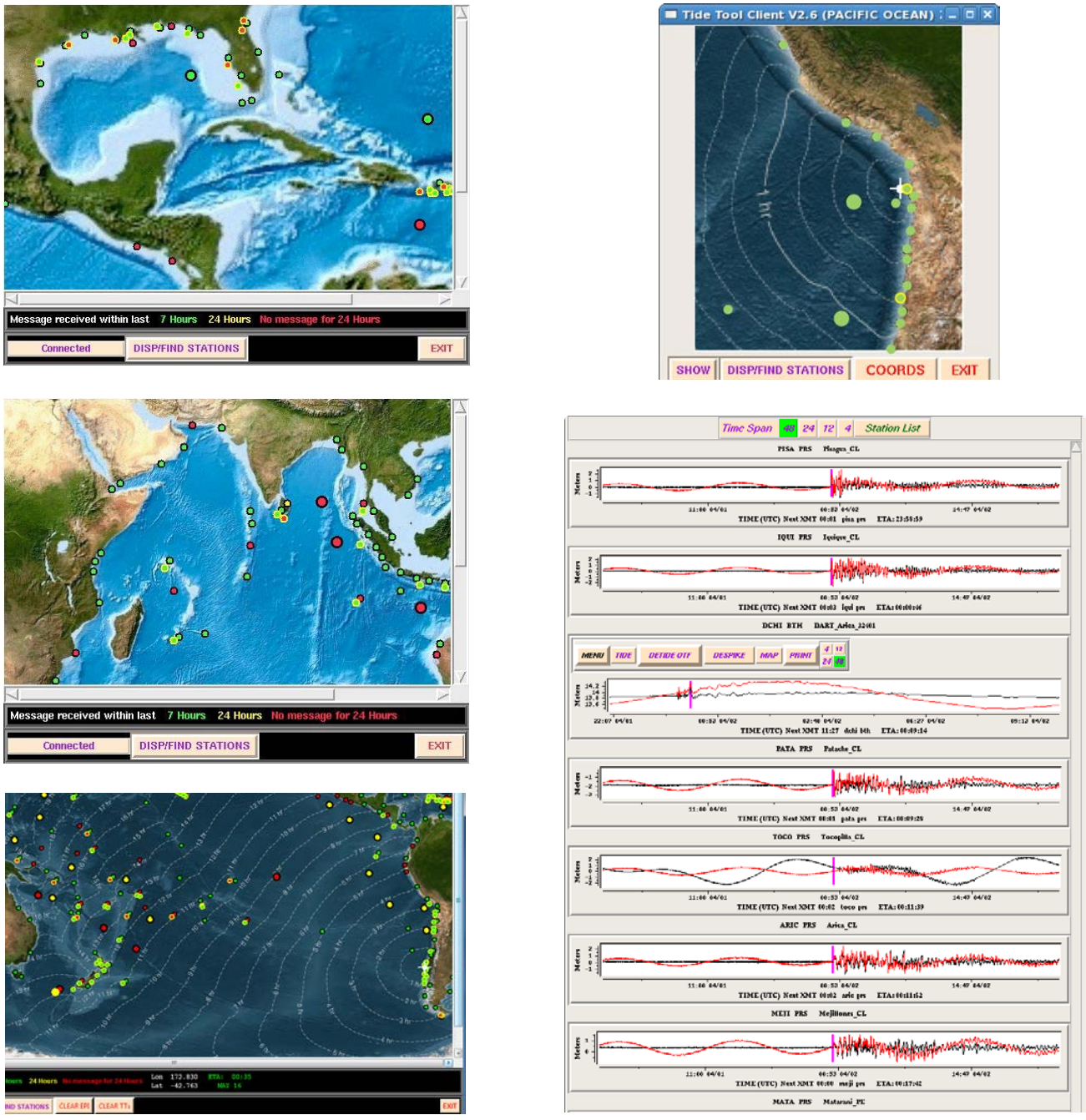
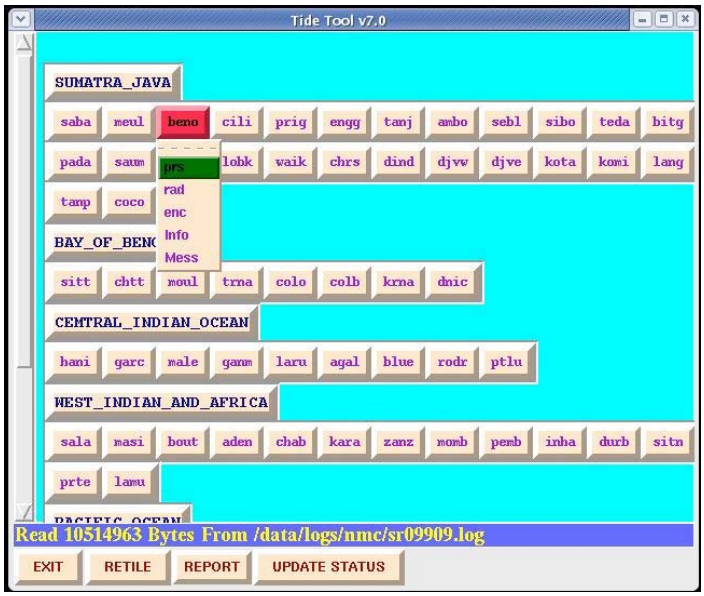


Figure 3a. Caribbean, Indian, and Pacific Map clients showing the coastal and DART stations, with color indicating when data last received (green = data received within last 7 hrs). Travel time contours overlayed on Pacific Map, with ETA shown in lower right. Sea level records can be plotted by mouse-selecting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

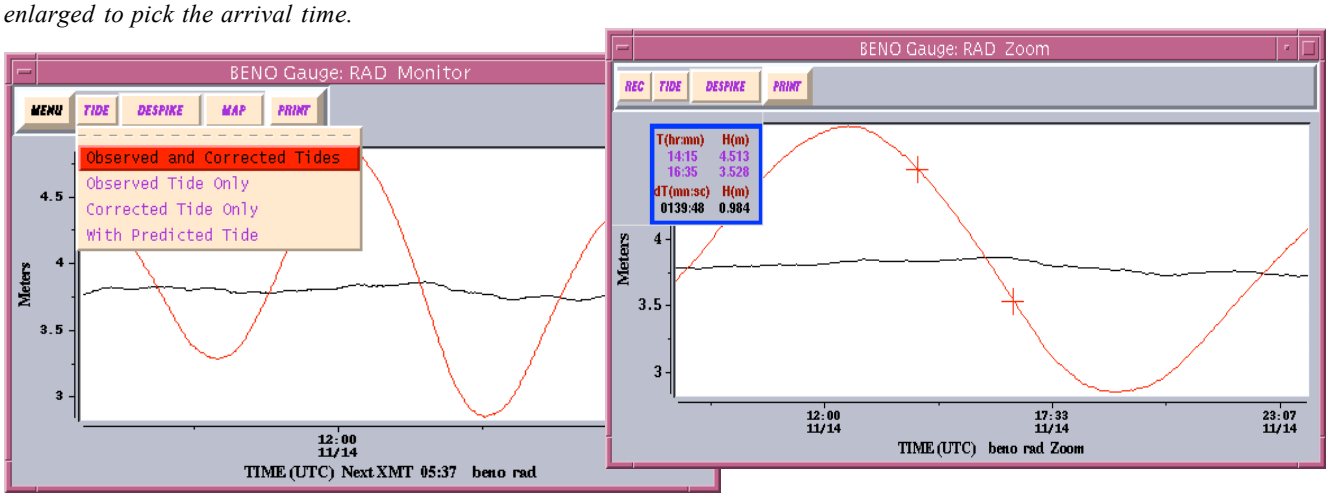
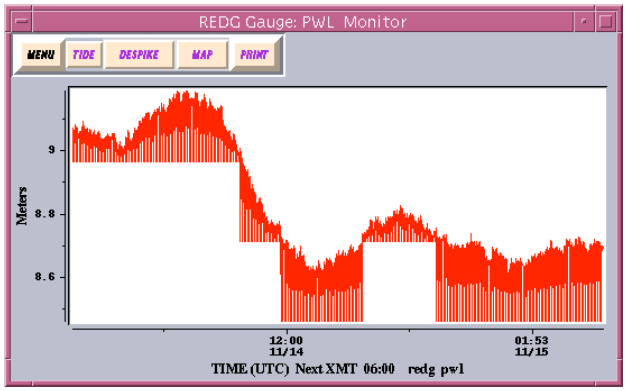
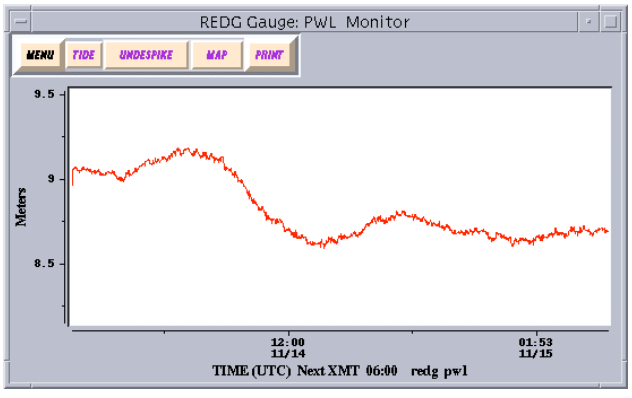


Figure 4b. De-spike feature.





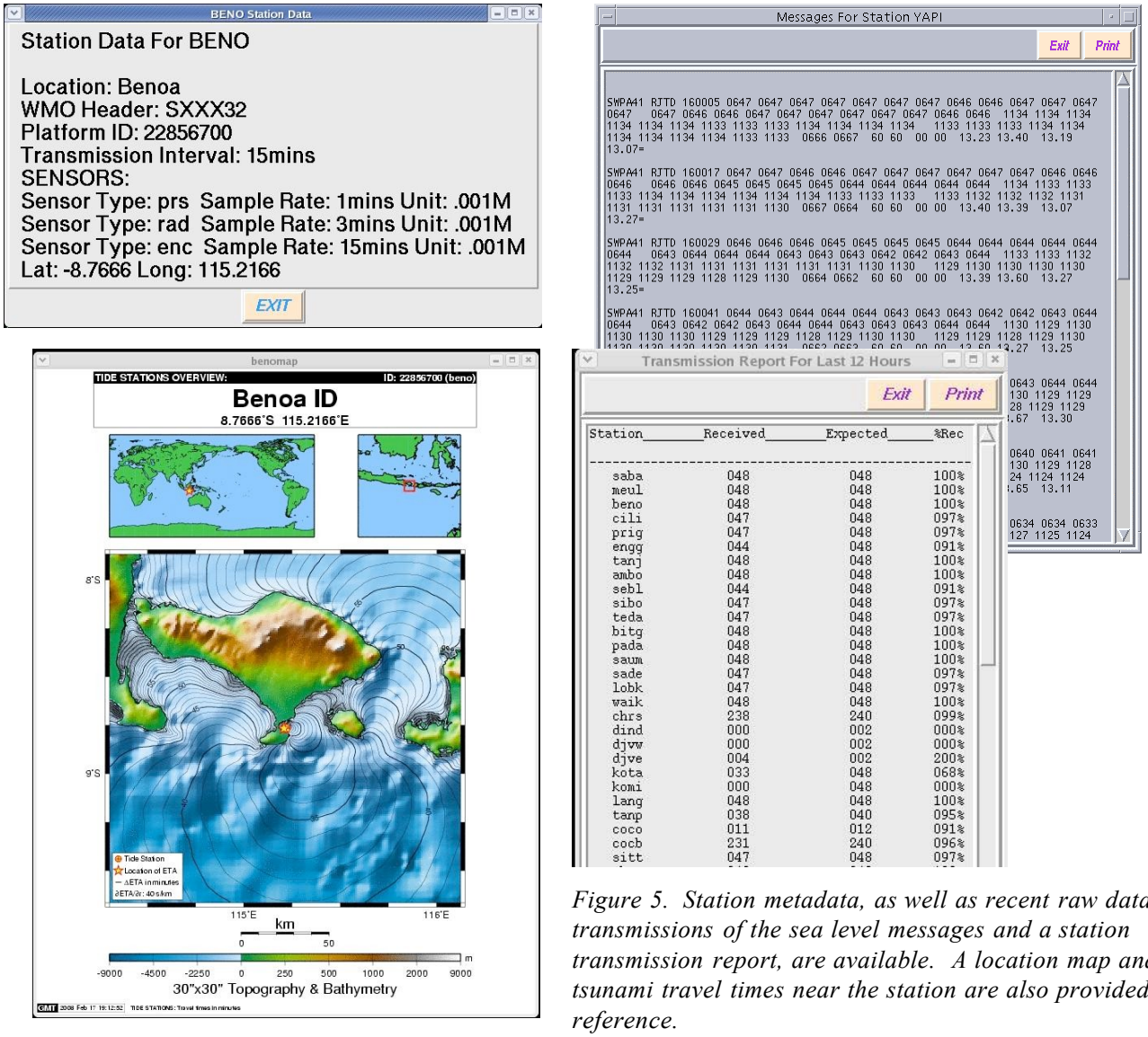


Figure 5. Station metadata, as well as recent raw data transmissions of the sea level messages and a station transmission report, are available. A location map and tsunami travel times near the station are also provided for reference.

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 Pacific sea level data from the NWS Telecommunication Gateway (NWSTG), 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. 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)* are softwares that PTWC uses in their operations.

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

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 (WC/ATWC).

USE:

1. Monitor stations for tsunami confirmation after a large earthquake has occurred. To determine the estimated arrival time, you may:
    - Use *ttt_tidetool.bat* 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_auto.bat* 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 (e.g., Pago Pago/Apia/Upolu), or other gauges). Report if out of order.

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, 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) 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.

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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 *WIZE* window to see if the last download is current. If not, then data are not being collected. Restart all programs.
   a. Close the inactive *WIZE* and start the *get_data.tcl* again. Refer to 1. STARTUP
   b. Exit *Tide* and *Client* window(s) (e.g., PACIFIC OCEAN). Start each program again (refer to 2. and 3. in STARTUP)

TIPS FOR EFFICIENT USE:

1. View individual sea level stations using *Tide* window (choose station using 4-letter station code, left mouse click), or *Client* window (choose the dot on the 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. Measure wave height and wave period from an individual station by mouse-selecting (right) time window to expand time series, then mouse-select (left) points you want to measure – a time and height difference is automatically calculated if you select 2 points.
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*, and all stations are displayed. The *Strip* feature allows many stations to be displayed simultaneously, similar to a seismic record section. 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 (*CaribbeanAtlantic_SL_Stations_nov2013.pdf, Indian_SL_Stations_2012.pdf, Pacific_SL_Stations_nov2013.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_tidetoolxx.bat*. 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

STARTUP:

1. Start *get_data.tcl.* 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. To start: drop *get_data.tcl* in *TideTool_bin* folder (desktop icon) onto *WIZE* icon on desktop.
2. Start *Tide.tcl*. This script looks to see if there is new downloaded data in srxxxyy.log and if yes, decodes the new data and updates the sea level station data file/display. To start: double click *TIDE* icon on desktop.
3. 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). Then start *Client.tcl (PACIFIC OCEAN)*. To start: double click

PACIFIC icon on desktop. To start Client.tcl for other regions do the same, double click on corresponding icon(s) (ATLANTIC, CARIBBEAN, INDIAN) on desktop.

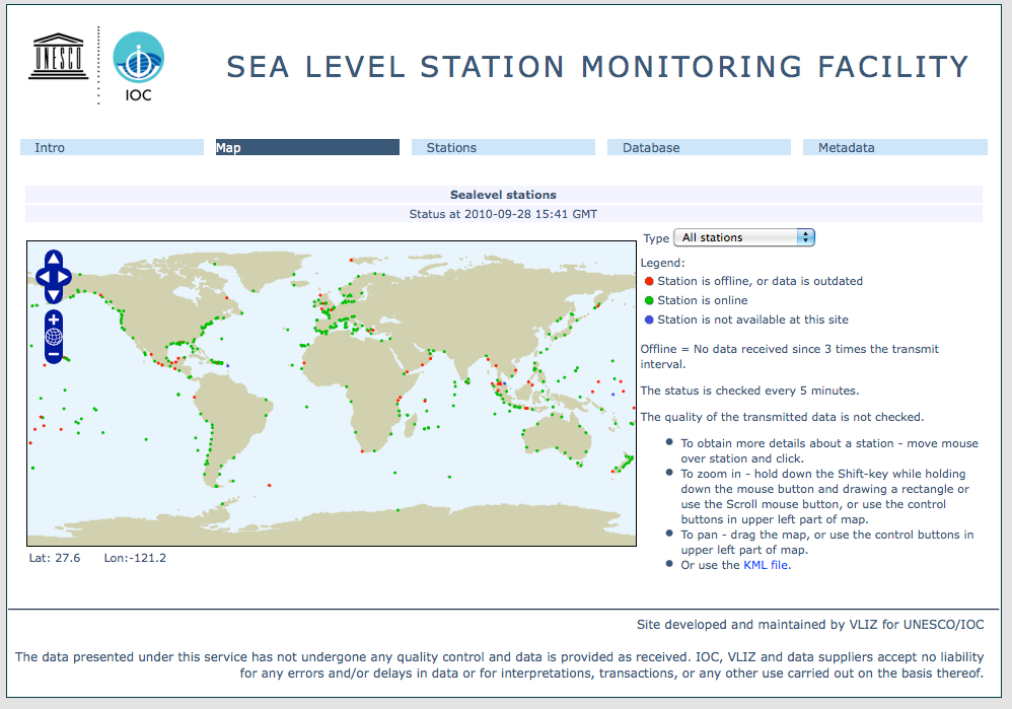
4. When an event occurs, run *ttt_tidetool.bat* to calculate a Tsunami Travel Time map and overlay on Client.tcl map (GET ETAs in *Tide.tcl*, PLOT TTs and EPI in *Client.tcl* to overlay). To start: double click *TTT_TIDETOOL32 or TTT_TIDETOOL64* icon on desktop. If you do not have the icon on your desktop you need to install the latest version of TTT on your computer.

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

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 September 2010, 89 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 the GLOSS-designated data centers at the Permanent Service for Mean Sea Level (PSMSL), the British Oceanographic Data Center (BODC) and the University of Hawaii Sea Level Center (UHSLC).

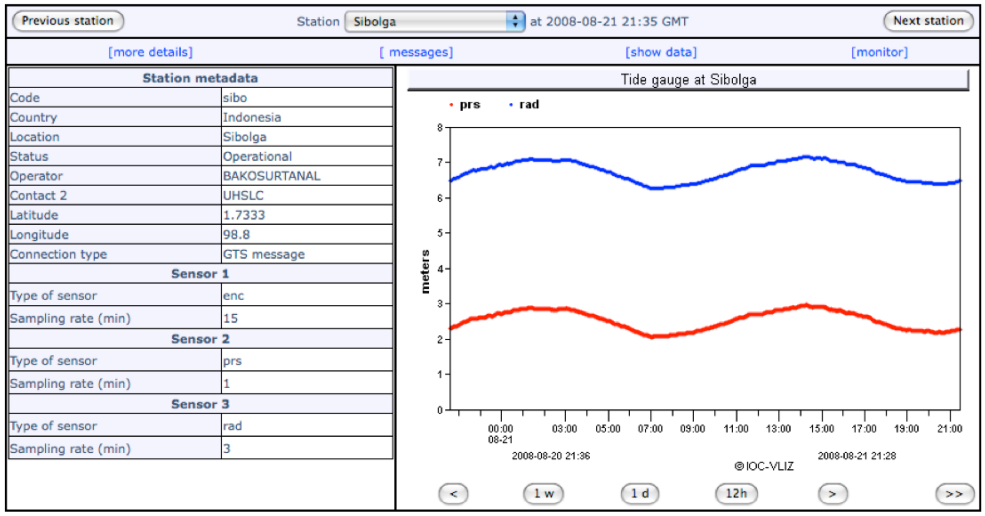
Station Listing screen, from which users may select stations to view:

Status at 2008-08-21 21:37 GMT : 338 stations listed

Show ○ only active ○ only GLOSS ○ only GTS ○ only FTP ○ only Webservice ○ only Email ◉ 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]
almе		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:

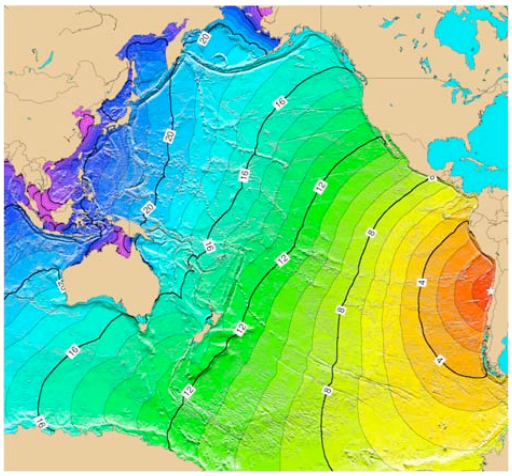
IOC	Intergovernmental Oceanographic Commission of UNESCO
GLOSS	Global Sea Level Observing System
IODE	International Oceanographic Data and Information Exchange
ODINAFRICA	Ocean Data and Information Network for Africa
CARIBE-EWS	Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent 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 Travel Time (TTT) Software Package
Version 3.2, May 2014

TTT_README.DOC

NOAA's 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 3.3.2r1) was developed by Dr. Paul Wessel (Geoware, http://www.geoware-online.com), and is used by the NOAA Pacific Tsunami Warning Center. The ITIC and NGDC have 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 (http://gmt.soest.hawaii.edu/). For this PC-environment distribution, the NGDC and ITIC 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 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.

Components included on this CD

1. TTT (Tsunami Travel Time) software, TTT SDK version 3.3.2r1. Copyright Paul Wessel, Geoware, 2008. http://www.geoware-online.com. Licensed to NOAA/ITIC for redistribution**.**
2. Global bathymetry grids derived from NGDC's ETOPO1 at varying resolutions (60, 30, 20, 15, 10, 5, 2 and 1 arc-minute, and 1 arc-minute grids for the Pacific, Atlantic, and Indian Oceans.
3. Easy-to-use scripts for automatically calculating and making a 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). http://gmt.soest.hawaii.edu/
7. Ghostscript, version 8.63. Released under the Aladdin Free Public License (AFPL). http://www.cs.wisc.edu/~ghost/

For technical questions, please email Paula Dunbar (Paula.Dunbar@noaa.gov) or Jesse Varner (Jesse.Varner@noaa.gov) at NGDC. For general questions or copies, please email Laura Kong (Laura.Kong@noaa.gov) at ITIC.

Funding: NOAA Pacific Region Integrated Data Enterprise Program ITIC: FY05 Project "Analysis of Extreme Events and Trends in Pacific Ocean Water Level Data and its Application to Risk and Vulnerability Assessment (M. Merrifield, L. Kong, J. Marra)." NGDC: FY06 Project "Integrated Pacific Region Tsunami-related Data and Information Products (P. Dunbar)" and FY07 NGDC tsunami project money

QUICK INFO: TSUNAMI TRAVEL TIME CALCULATION

For more info, see *TTT_README_may2014.doc* or
ttt_auto_README_MAY14.doc in *TTT Package folder*

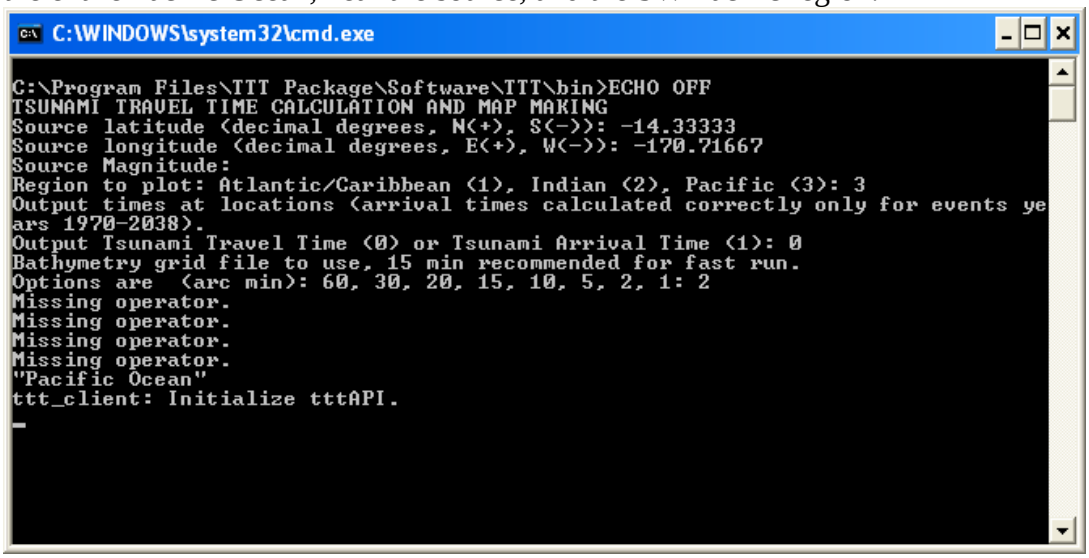
PLOT INSTRUCTIONS

1. Start *ttt_auto32.bat or ttt_auto64.bat (select based on 32 or 64 bit OS), double click the TTT_AUTO32 or TTT_AUTO64 icon* on desktop, or click on the file in the folder TTT_bin folder on the desktop
2. Follow directions in screen shot below, e.g., input
   - latitude, longitude, earthquake magnitude (if known)
   - 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))
   - if desired, plot sea level stations, plot historical seismicity
3. The script will
   - create a binary grid file of tsunami travel times (or arrival times)
   - if desired, 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_xxxxxx, such as 190806, where 190806 corresponds to plot time (hrmnsec)
   These are .png files. Options exist to plot Sea Level stations or historical seismicity.

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.

Example is source at NWS Pago Pago office. 2-min bathymetry is used and plots are made for the entire Pacific Ocean, near the source, and the SW Pacific region.



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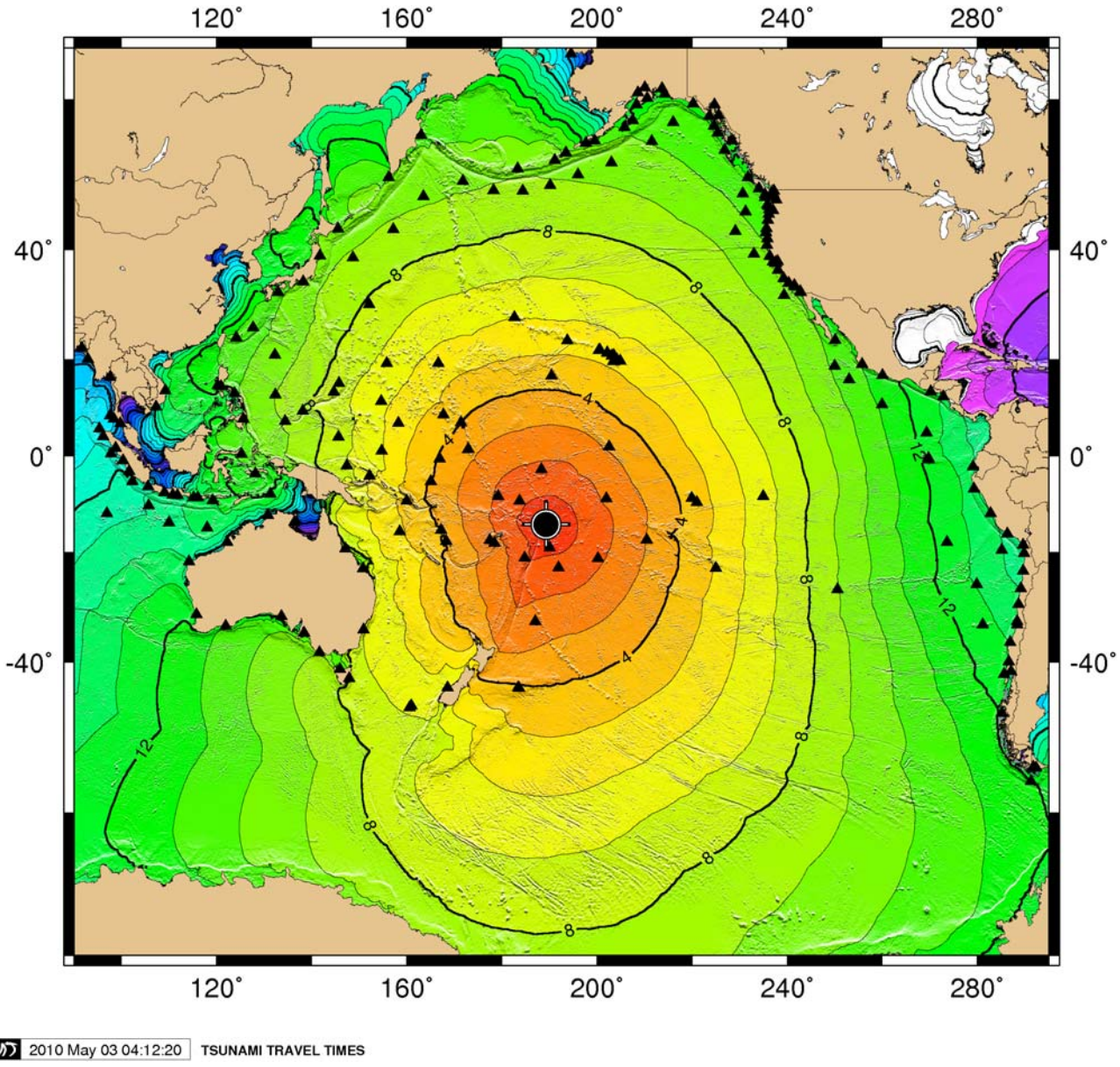
3 tsunami travel time maps automatically produced (.png format)



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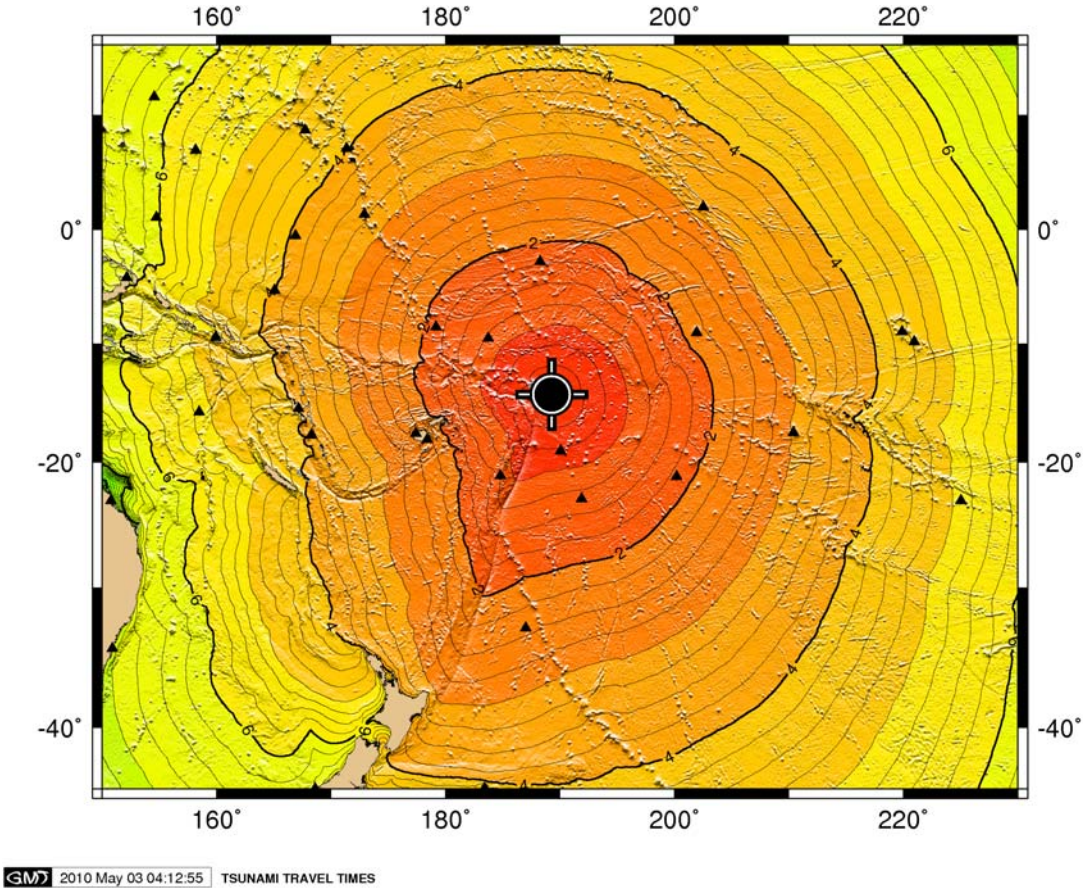

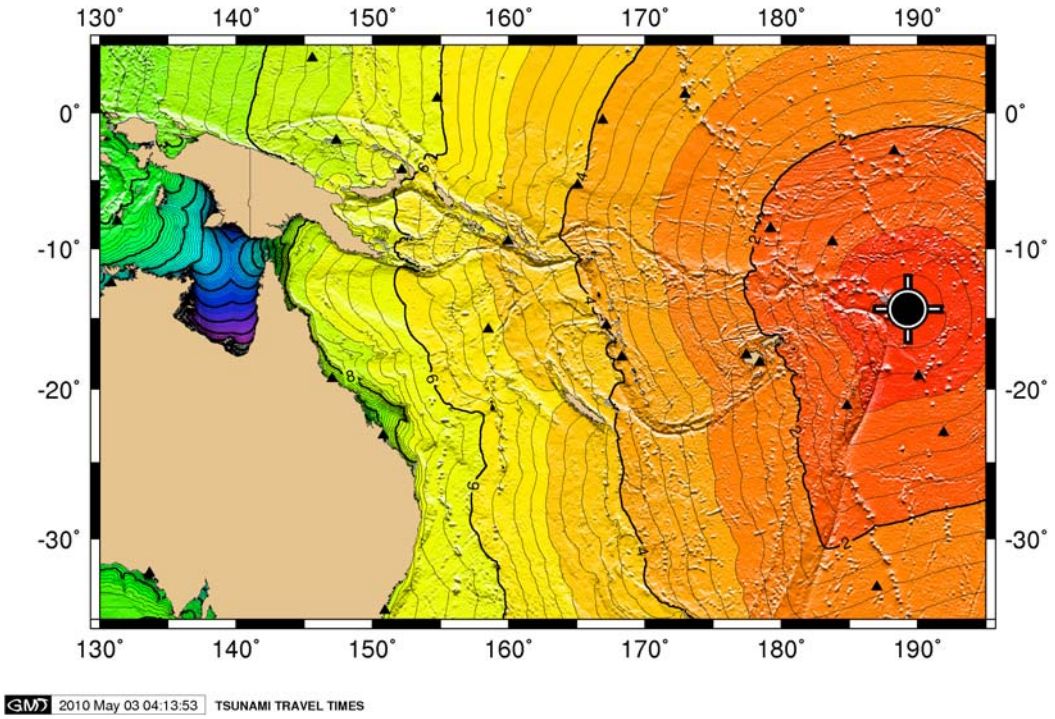

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