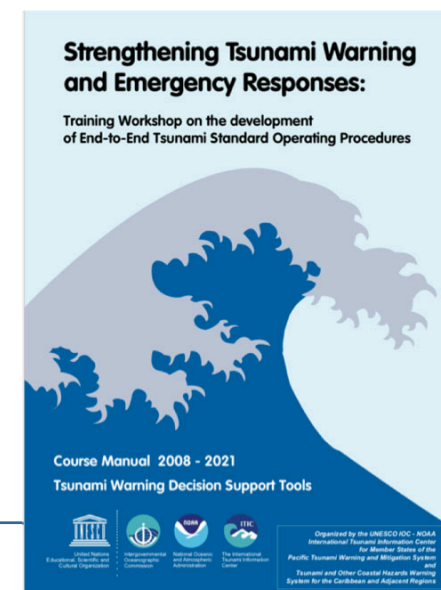




UNESCO/IOC – NOAA/ITIC
Tsunami Early Warning and Mitigation Systems
November 2021

Keeping Authorities Informed: Available TW Decision Support Tools Earthquakes, Sea Level, Historical Events, Travel Times, Hazard Assessment



Laura Kong

UNESCO/IOC – NOAA International Tsunami Information Center

ITIC, IOC, USGS, PTWC, NCEI, WDS-Geophysics, RANET,
PMEL/NCTR

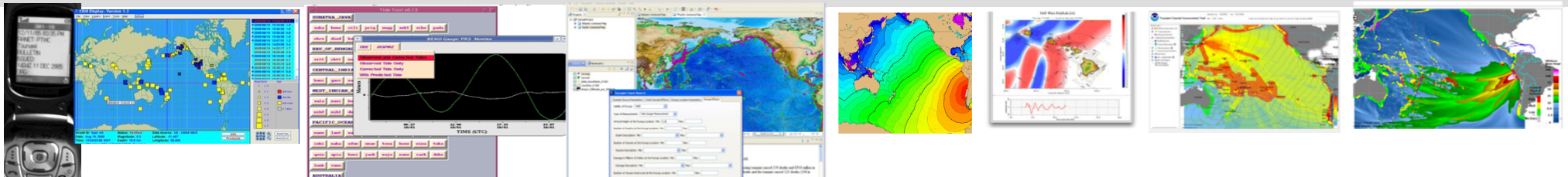


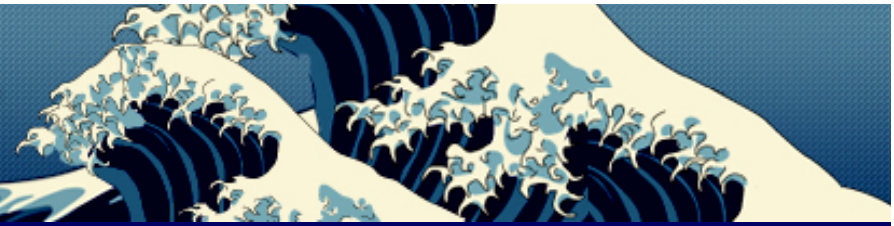
Tsunami Warning Decision Support Tools

ITIC distributed, supported



- ~~☐ Heads-up SMS TW Alert Bull Board (NOAA USAID RANET, ITIC, PTWC, 2005-2014)~~
- ☐ Tsunami Bull Board (ITIC, 1995) ~500 science/tsu/govt – email to itic.tsunami@noaa.gov
- ☐ Real time EQ Display (v1.72, EQ Observatory msg (CISN, USGSNTHMP, 2005), ~350
- ☐ Real-time Sea Level monitoring
 - Tide Tool v10.68 – TWC operations monitoring (PTWC, 2005)
 - IOC Sea Level Monitoring web site (IOC, 2008)
- ☐ Tsunami Travel Time Software SDK 4.0.1 (ITIC, NCEI, 2007)
- ☐ Tsunami Historical Database Online (WDS-NCEI), Offline (TsuDig, NCEI, ITIC, 2009)
- ☐ Tsunami Hazard Assessment Tools (2017)
 - ComMIT/MOST inundation modeling (PMEL, 2000, support evac maps 2015)
OTGA TEMPP planned as hybrid 2022-2023
 - Tsunami Coastal Assessment Tool v4.2 Oct 2020 (TsuCAT, PMEL, ITIC)





Tsunami Bulletin Board

Email List-serve, Currently, ~500 (March 2021)

**Membership: Scientists, Tsunami prof, govt,
NO MEDIA - NO PUBLIC**

Features

- 1. Immediate delivery**
- 2. No censureship**
- 3. Forum for sharing science and early results -
NOT peer-reviewed**
- 4. PTWC, US NTWC tsunami messages**

Contact: itic.tsunami@noaa.gov

Real-Time Earthquake Display and Alert System (CISN)

- Internet
- Passive (automatic receive)
- Multi-platform
- EQ broadcast
- Alert system (SMS, email)
- GIS layers
- Tsunami Warning msgs

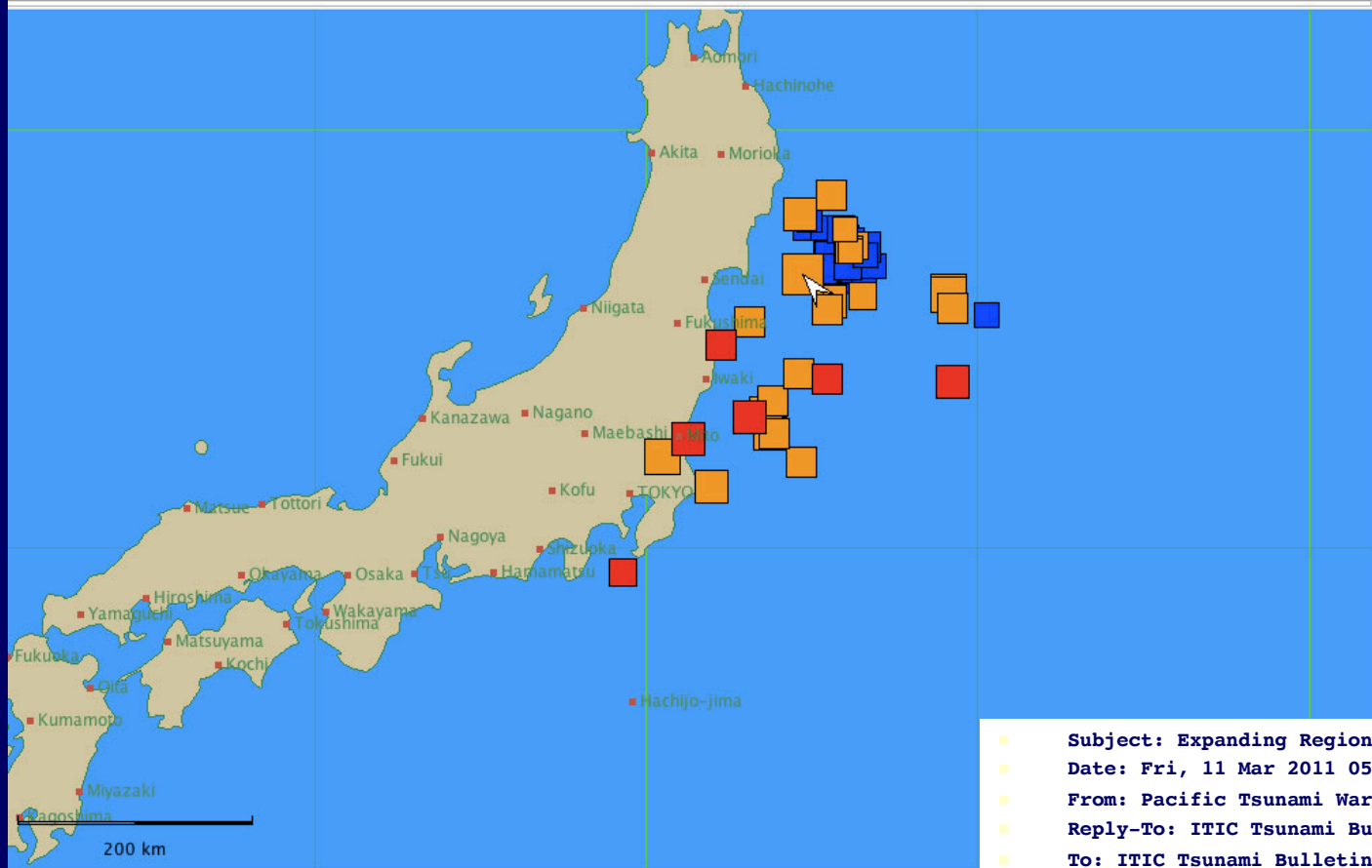
Event ID: 2009czb9 v6 **Status:** Verified **Data Source:** US - USGS NEIC
Date: Feb 12, 2009 **Magnitude:** 6.1 **Latitude:** -31.315
Time: 18:54:29.90 GMT **Depth:** 21.7 miles **Longitude:** -178.184
Note: 144 miles S of Raoul Island, Kermadec Islands

Notice: Earthquake data may be preliminary and subject to change.

Legend:
 Magnitude: ■ ≥ 0, ■ ≥ 1, ■ ≥ 2, ■ ≥ 3
 Age: ■ last hour, ■ ≥ 1 hour, ■ ≥ 1 day, ■ ≥ 2 days



Sign-up - Contact: itic.tsunami@noaa.gov



Date/Time	M
2011/03/11 05:46:23	7.9
2011/03/11 05:46:23	8.9
2011/03/11 06:06:11	6.4
2011/03/11 06:07:21	6.4
2011/03/11 06:15:45	6.8
2011/03/11 06:25:50	7.1
2011/03/11 06:25:51	7.1
2011/03/11 06:48:47	6.3
2011/03/11 06:57:14	6.3
2011/03/11 07:10:59	5.8
2011/03/11 07:13:47	5.9
2011/03/11 07:14:59	6.3
2011/03/11 07:25:33	6.1
2011/03/11 07:28:12	6.1
2011/03/11 07:38:26	5.9
2011/03/11 07:42:55	5.8
2011/03/11 07:54:44	5.7
2011/03/11 07:56:15	5.6
2011/03/11 08:01:58	5.9
2011/03/11 08:10:47	5.4
2011/03/11 08:12:04	6.2
2011/03/11 08:15:40	6.2

Magnitude	Age
■ ≥ 0	■ last hour
■ ≥ 1	■ ≥ 1 hour
■ ≥ 2	■ ≥ 1 day
■ ≥ 3	■ ≥ 2 days

Event ID: c0001xgp vA Status: Unverified Data Source: US - USGS NEIC
 Date: Mar 11, 2011 Magnitude: 8.9 Latitude: 38.322
 Time: 05:46:23.70 GMT Depth: 24.4 km Longitude: 142.369
 Note: 130 km E of Sendai, Honshu, Japan

Notice: Earthquake data may be preliminary ar

Subject: Expanding Regional Warning - Initial
 Date: Fri, 11 Mar 2011 05:56:02 +0000 (GMT)
 From: Pacific Tsunami Warning Center <ptwc@ptwc.noaa.gov>
 Reply-To: ITIC Tsunami Bulletin Board <tsunami_bb@infolist.nws.noaa.gov>
 To: ITIC Tsunami Bulletin Board <tsunami_bb@infolist.nws.noaa.gov>

ITIC Tsunami Bulletin Board
 TSUNAMI BULLETIN NUMBER 001
 PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
 ISSUED AT 0555Z 11 MAR 2011

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA... WASHINGTON...OREGON AND CALIFORNIA.

... A TSUNAMI WARNING AND WATCH ARE IN EFFECT ...

A TSUNAMI WARNING IS IN EFFECT FOR

JAPAN / RUSSIA / MARCUS IS. / N. MARIANAS

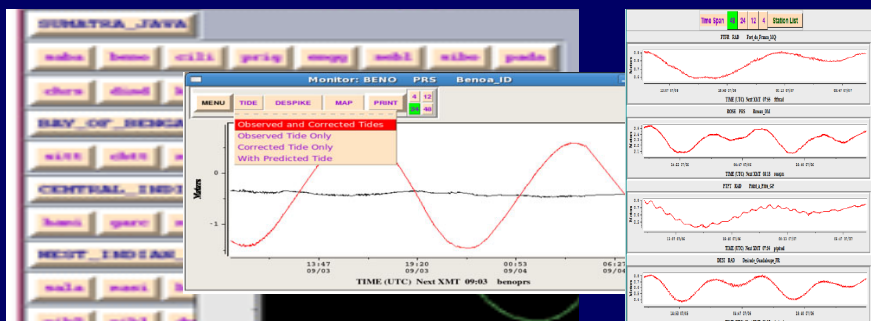
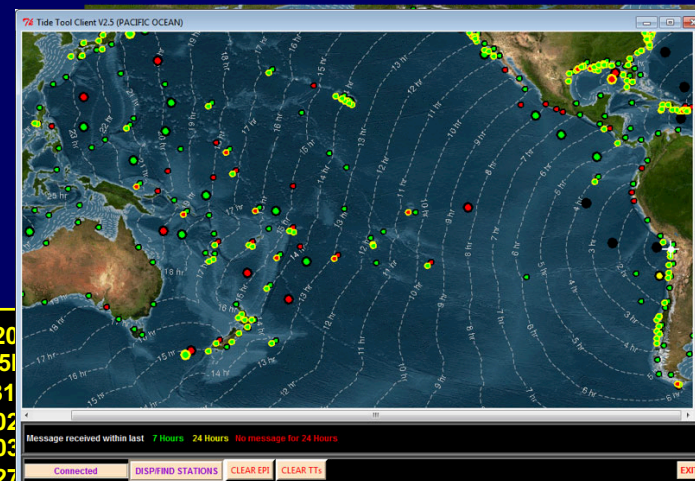
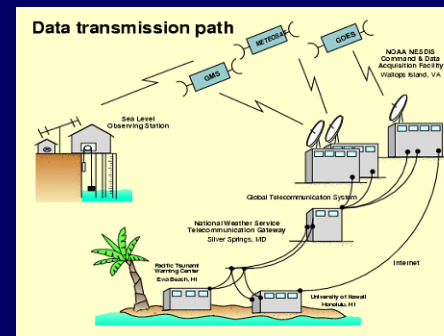
CISN: 11 March 2011

TideTool - Interactive Sea Level Monitoring

(OPERATIONAL Tool for Tsunami Warning Centres)

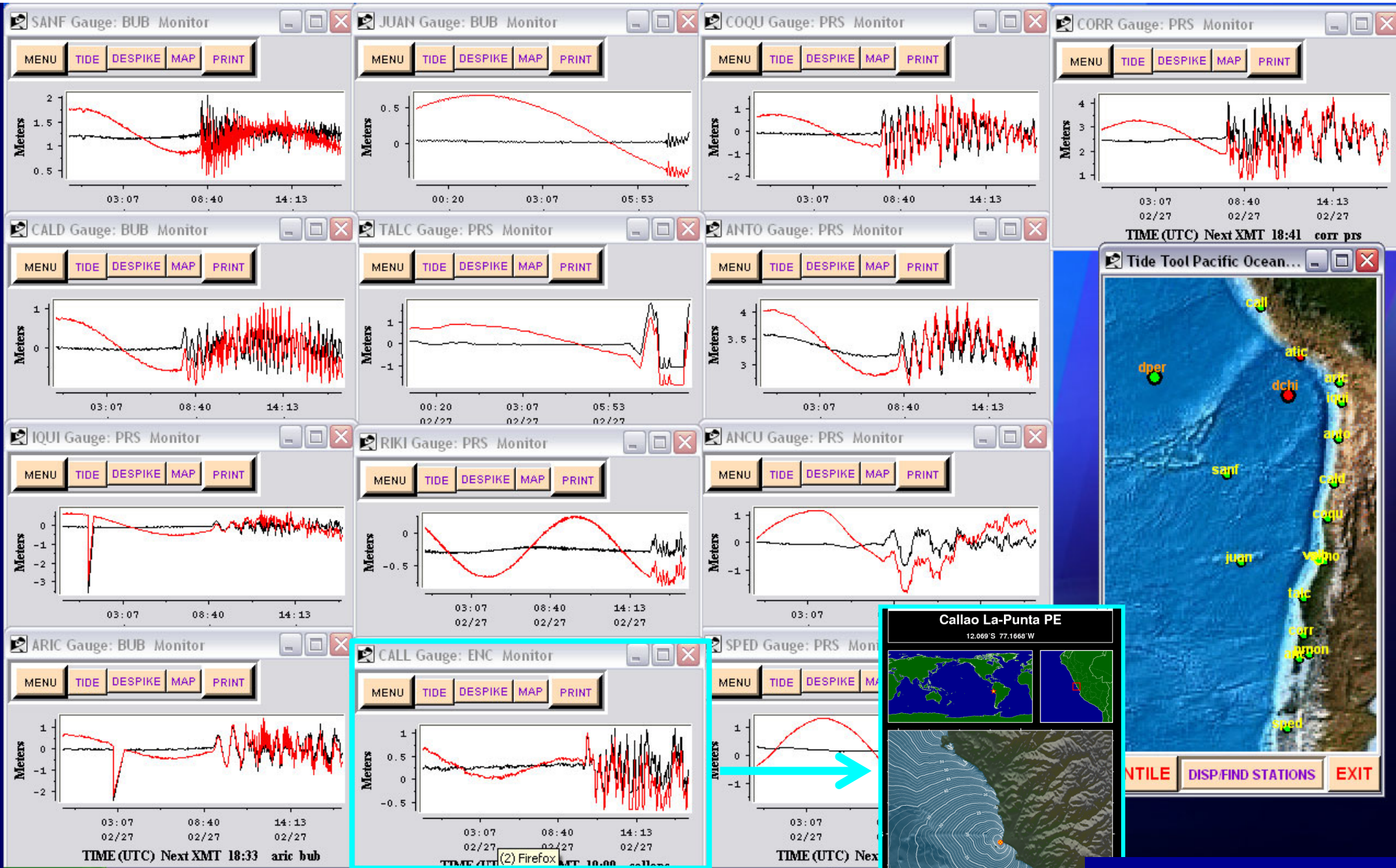


- **PTWC-received sea level stations (GLOSS, non-GLOSS)**
- **Decode, Display, Manipulate** (expand, measure period/amplitude) satellite-transmitted sea level data
- **Open-source** shell programming, graphics (Tcl/Tk, BLT extension), PC, Linux, Unix
- **Continuously decodes:** expand time series, remove tide, pick amplitude, metadata, msg Downloads data from GTS (Met Svc) Also by ftp from NOAA NWS gateway
- **Runs locally (data, software)**
- **Dynamic, interactive, customize**



91642 46/// /1205 10296 40080 2220
 555 77744 A0102 516'3 60029 6315
 24520 2400A 13025 90036 00297 31
 B2102 37103 100A2 50266 50330 02
 8318B 33022 92026 00A37 02736 03
 00299 319B4 50222 50230 0A490 27
 20380 02983 19B57 02163 03200 BV289 134S1 41249 C0501 22080 00070 23677 44777=

Contact: stuart.weinstein@noaa.gov, laura.kong@noaa.gov



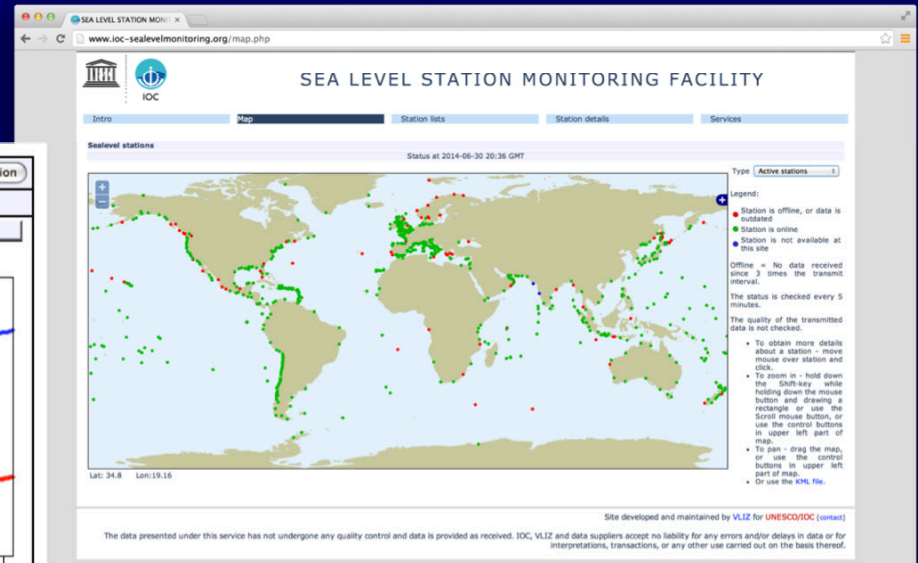
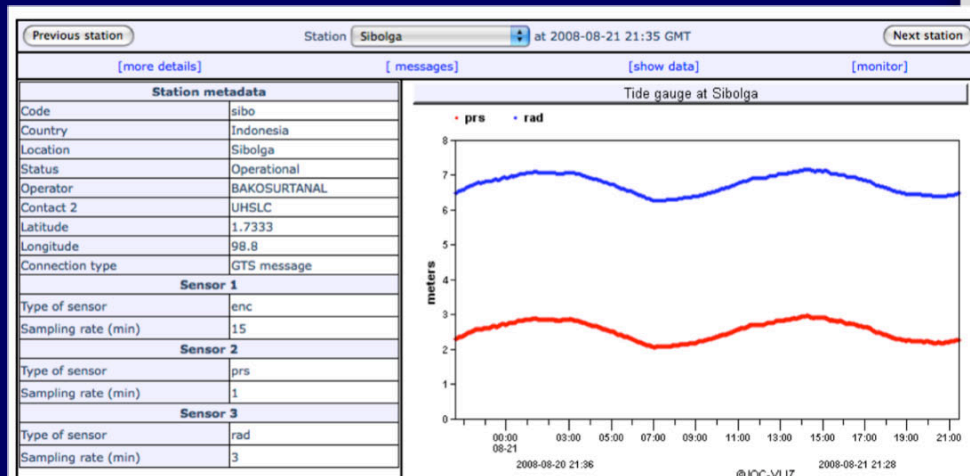
Tide Tool: 27 February 2010



IOC Sea Level Monitoring Facility

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

- **Global Monitoring** of satellite-transmitted data (Station health)
- **Easy-to-use Web tool** (runs in Belgium, not locally)
Uses Internet (could become clogged during real event)
- **Continuously downloads to site:** from GTS and other sites
- **Continuously decodes:** displays / expand time series, station metadata, messages
- **Data download manually**



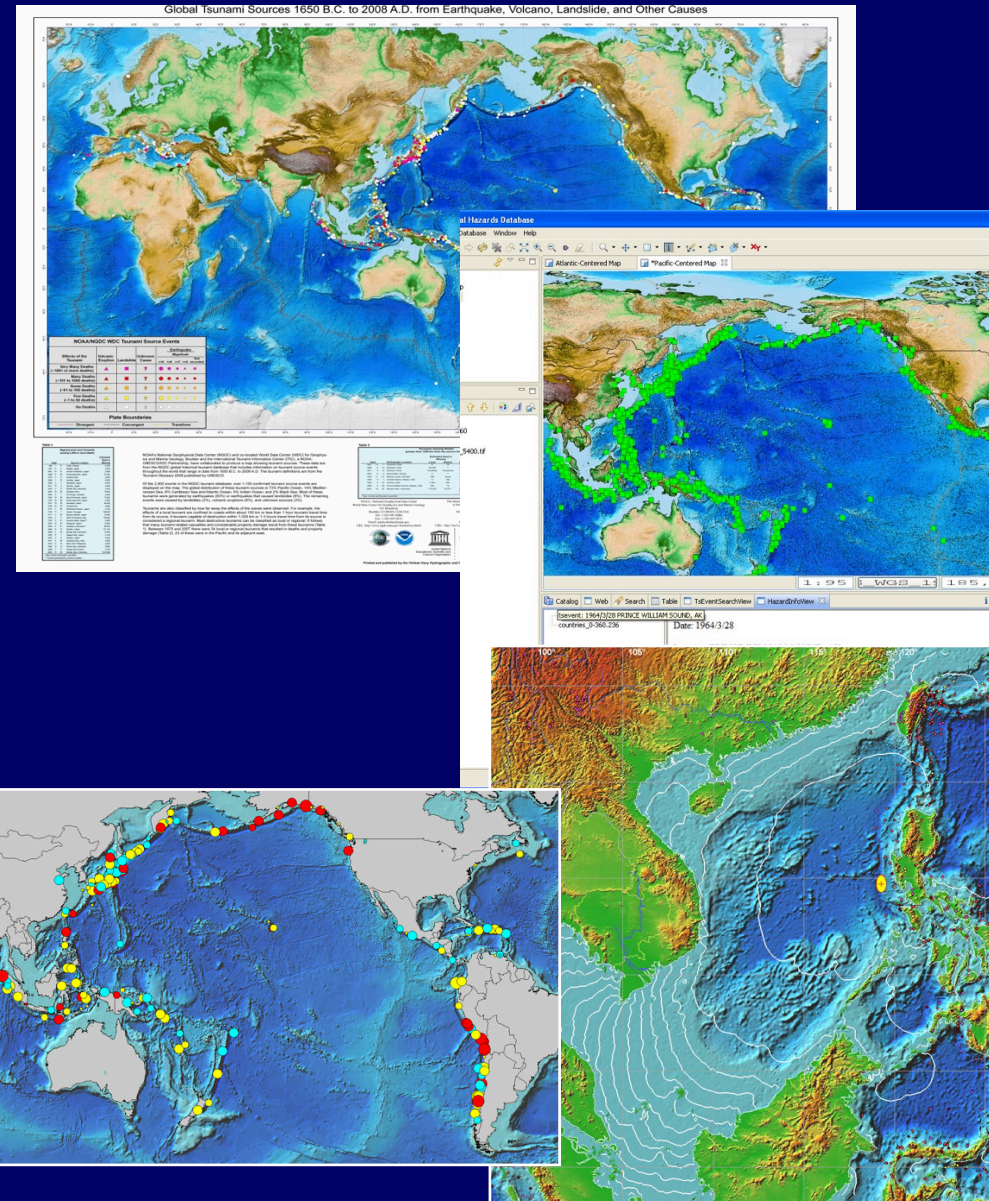
Global Historical Databases

- **WDS-Geophysics/NCEI**
online - Web online
offline – TsuDig (2009)
- **ITDB** – Russia
offline (1990s)

Features:

- GIS display
- EQ, Tsunamis, Run-ups
- Seismic, Sea Level networks
- Event sorting
- Travel Times

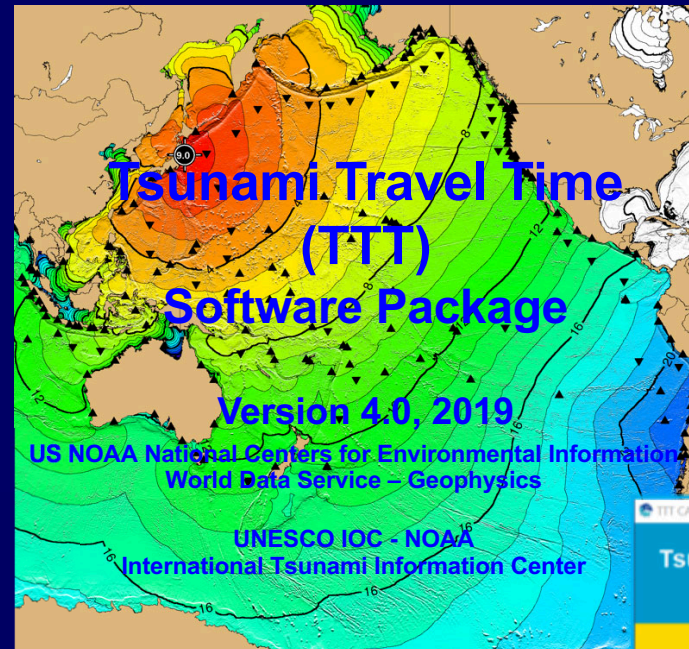
Contact: itic.tsunami@noaa.gov



Tsunami Travel Time Calculation and Map Display



- PC-Windows, Linux, Unix, Mac OSX
- Calculation
- Map display (GMT)
- Used by PTWC
- Examples, Simple scripts
- Accuracy on bathymetry Etopo1 (1-min) and coarser grids
- Available to TWFP / govt agencies
- TTT GUI for easy use (2021)

A screenshot of the 'Tsunami Travel Time Calculator' web application. The interface includes a title bar 'TTT CALC 09/2020', a header with the ITIC logo, and a yellow banner with instructions: 'Input information stored in TTT_input.txt Output stored in C:\TTT Package\Examples'. The form contains several input fields and dropdown menus: 'Please Enter Title You Would Like For Map:' (text box with 'Pago Pago'), 'Source Latitude (decimal degrees, N(+), S(-)):' (text box with '-14.33333'), 'Source Longitude (decimal degrees, E(+), W(-)):' (text box with '-170.71667'), 'Please Select Region the Ocean Event is Occurring in:' (dropdown menu with 'Pacific' selected), 'Please Select Zoomed PO Region to Plot:' (dropdown menu with 'SW Pacific' selected), 'Please Note: Output times at locations arrival times are calculated correctly only for events years 1970-2030!', 'Select What You Would Like Outputted' (dropdown menu with 'Tsunami Travel Time' selected), 'Select bathymetry grid file to use, 15min recommended for fast run.' (text box), 'Options are (arc min): 60, 30, 20, 15, 10, 5, 2, 1:' (dropdown menu with '20' selected), 'Plot Sea Level Stations?' (checkbox checked), and 'Plot Historical Earthquakes? (Centennial List)' (checkbox unchecked). At the bottom, there are 'Reset Inputs' and 'Generate Image' buttons.

Contact: paula.dunbar@noaa.gov, laura.kong@noaa.gov



UNESCO IOC – NOAA International Tsunami Information Center (ITIC)

NOAA Pacific Environmental Laboratory,
NOAA Center for Tsunami Research (PMEL/NCTR)

Pacific Tsunami Warning Center (PTWC)

Tsunami Coastal Assessment Tool

TsuCAT

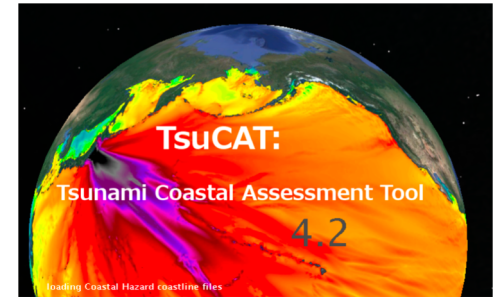
Christopher Moore, Dr. Diego Arcas, Marie Eble
NOAA Center for Tsunami Research (NCTR)

Dr. Laura Kong
ITIC

Dr. Charles McCreery
PTWC

TsuCAT: Tsunami Coastal Assessment Tool (NCTR, ITIC)

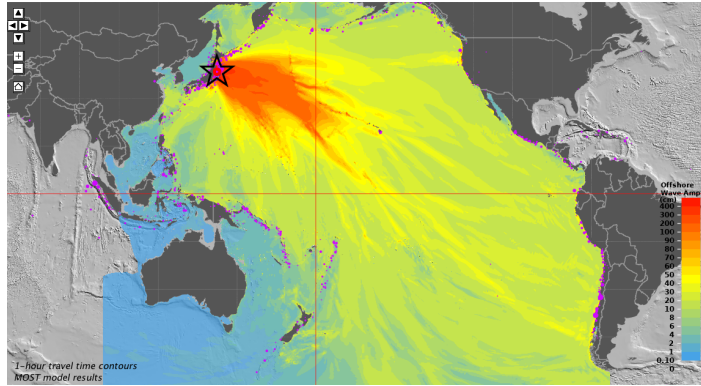
- ❑ **Why / What:** Request by Pacific Islands for warning DSS
Gives country capacity to assess tsunami hazard
- ❑ **Who:** Country agencies with Tsunami Hazard Assessment, Warning and Emergency Response responsibilities
- ❑ **Tool use:**
 - Planning tool - assess threat before – ‘energy beams’
 - Decision system support tool – Customize country sub-regions (polygons), Quick, early assessment through DB lookup
 - Exercise tool – develop scenarios to use (from v4.0, 2019)
- ❑ **Features:**
 - Database: ~5400 earthquake scenarios from along active subduction zones, Pacific, Caribbean, Indian Ocean (M6.5-9.5)
 - Scenarios from Expert Meetings (Caribbean, Pacific)
 - Results from NOAA models (MOST/SIFT (M8+), RIFT (M6.5-7.9))
 - Offshore max amplitude / coastal wave amplitude (Green’s Law)
 - PTWC or User custom forecast polygons



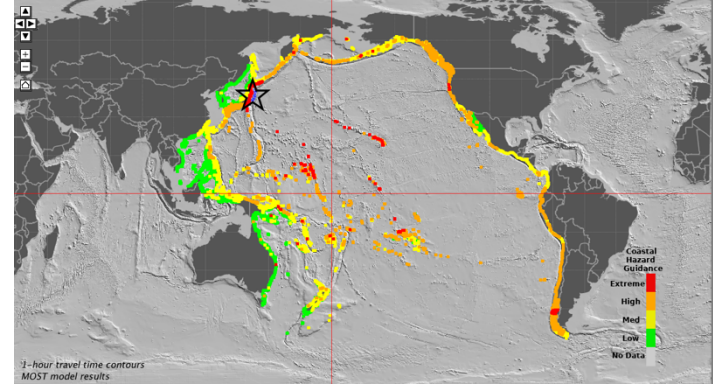
TsuCAT: Coastal Impact DB Tool



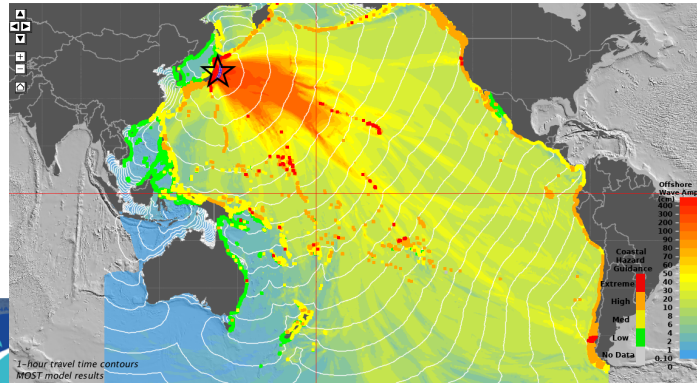
Deep-Ocean Offshore Max Ampl – Historical seismicity



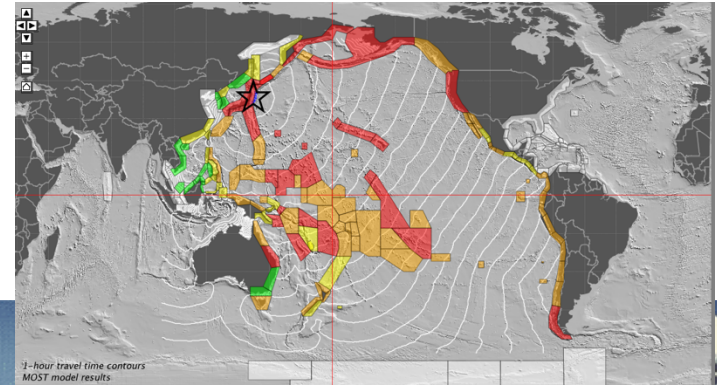
Coastal Hazard Guidance Ampl (CHG)



Offshore – CHG – Tsunami Travel Times (TTT)



PTWC Coastal Polygons – TTT



TsuCAT – Generate Exercise messages



- ❑ **PTWC Public Text and Enhanced Products for events in TsuCAT pre-computed database**

- ❑ **Select Menu - “Export Exercise Messages”**
 - Set Event (historical database or by mouse, origin time, magnitude)
 - Choose Generate (PTWC Text Messages, Enhanced Products (graphical, polygon table, kmz file))
 - Output folder, e.g., message/2019-04-02_0000_M9.0_Russia_PTWCproducts

- ❑ **Varying issue time and magnitude update**



GUI – Export Exercise Messages – 1957 Kamchatka M9.0



Export Exercise Messages

Mag: 9.0 Epicenter: 52.688° N, 160.549° E

Adjust for date of Exercise: 10/16/2020 02:38

Generate 00:06 Message 1

00:33 Coastal Forecast Polygons

00:23 Coastal Forecast Amplitude

00:23 Deep Ocean Forecast Amplitude

00:23 Coastal Forecast Polygons

00:23 Regional West Central Pacific

00:23 Regional South Central Pacific

00:23 Regional South China Sea

00:23 Regional Northwest Pacific

Text Messages Graphical Products

TEST...TSUNAMI MESSAGE NUMBER 1...TEST
NWS PACIFIC TSUNAMI WARNING CENTER EKA BEACH HI
0244 UTC FRI OCT 16 2020
...THIS MESSAGE IS FOR TEST PURPOSES ONLY...
...TEST PTWC TSUNAMI THREAT MESSAGE TEST...

**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE ****
THIS MESSAGE IS ISSUED FOR INFORMATION ONLY IN SUPPORT OF THE
UNESCO/IOC PACIFIC TSUNAMI WARNING AND MITIGATION SYSTEM AND IS
MEANT FOR NATIONAL AUTHORITIES IN EACH COUNTRY OF THAT SYSTEM.
NATIONAL AUTHORITIES WILL DETERMINE THE APPROPRIATE LEVEL OF
ALERT FOR EACH COUNTRY AND MAY ISSUE ADDITIONAL OR MORE REFINED
INFORMATION.
**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE ****

TEST... PRELIMINARY EARTHQUAKE PARAMETERS ...TEST

- * MAGNITUDE 8.8
- * ORIGIN TIME 0238 UTC FRI OCT 16 2020
- * COORDINATES 52.7 NORTH 160.5 EAST
- * DEPTH 22 / 14 MILES
- * LOCATION OFF THE EAST COAST OF THE KAMCHATKA PENINSULA, RUSSIA

TEST... EVALUATION ...TEST

- * AN EARTHQUAKE WITH A PRELIMINARY MAGNITUDE OF 8.8 OCCURRED
OFF THE EAST COAST OF THE KAMCHATKA PENINSULA, RUSSIA AT 0238 UTC FRIDAY
OCTOBER 16 2020
- * THIS IS A TEST MESSAGE.
- * BASED ON THE PRELIMINARY EARTHQUAKE PARAMETERS... WIDESPREAD
HAZARDOUS TSUNAMI WAVES ARE POSSIBLE.

TEST... TSUNAMI THREAT FORECAST ...TEST

- * HAZARDOUS TSUNAMI WAVES FROM THIS EARTHQUAKE ARE POSSIBLE
WITHIN THE NEXT THREE HOURS ALONG SOME COASTS OF
RUSSIA... ALASKA AND JAPAN.

TEST... RECOMMENDED ACTIONS ...TEST

completed.

Export Exercise Messages

Mag: 9.0 Epicenter: 52.688° N, 160.549° E

Adjust for date of Exercise: 10/16/2020 02:38

Generate 00:33 Message 4

00:33 Coastal Forecast Amplitude

Text Messages Graphical Products

PTWC Coastal Tsunami Amplitude Forecast

Actual amplitudes at the coast may vary from forecast amplitudes due to uncertainties in the forecast and local features. In particular, maximum tsunami amplitudes on atolls and at locations with fringing or barrier reefs will likely be much smaller than the forecast indicates.

This message is issued for information only in support of the UNESCO/IOC Pacific Tsunami Warning and Mitigation System and is meant for national authorities in each country of that system. National authorities will determine the appropriate level of alert for each country and may issue additional or more refined information.

NOAA
Pacific Tsunami Warning Center

Earthquake:
16 Oct 2020
02:38:44 Z
Lat: 52.69° N
Lon: 160.55° E
Depth: 22 km
Mw: 9.00

Determined Earthquake Mechanism:

Maximum Amplitude (m)
4.80
3.00

2020-10-16_0238_M9.0_Russia_PTWCproducts

View Arrange Action Share Edit Tags

Name

- PTWC_msg16_2020_10_16_0238.rtf
- PTWC_msg17_2020_10_16_0238.rtf
- PTWC_msg18_2020_10_16_0238.rtf
- PTWC_msg19_2020_10_16_0238.rtf
- PTWC_msg20_2020_10_16_0238.rtf
- PTWC_msg21_2020_10_16_0238.rtf
- PTWC_msg22_2020_10_16_0238.rtf
- PTWC_msg23_2020_10_16_0238.rtf
- PTWC_msg24_2020_10_16_0238.rtf
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- PTWC_msg27_2020_10_16_0238.rtf
- PTWC_msg28_2020_10_16_0238.rtf
- PTWC_msg29_2020_10_16_0238.rtf
- PTWC_msg30_2020_10_16_0238.rtf
- PTWC_msg31_2020_10_16_0238.rtf
- PTWC_msg32_2020_10_16_0238.rtf
- ThreatGraphical_msg3_regional
 - ptwcregionalmaps1of2
 - Coastal_Forecast_Northwest_Pacific.png
 - Coastal_Forecast_South_America.png
 - Coastal_Forecast_South_Central_Pacific.png
 - Coastal_Forecast_South_China_Sea.png
 - Coastal_Forecast_Southwest_Pacific.png
 - Coastal_Forecast_West_Central_Pacific.png
 - ptwcregionalmaps2of2
 - ptwctsunamithreatmaps
 - coastal_amp.kmz
 - Coastal_Forecast_Regional.png
 - Deep_Ocean_Forecast_Regional.png
 - polygons_table.txt
 - PTWS_Forecast_Polygons_Regional.png
 - ThreatGraphical_msg4_BasinWide
 - ptwcregionalmaps1of2
 - ptwcregionalmaps2of2



A NATIONAL TWC SOP

1. RECEIVE EQ INFO

- **RTED / CISN, Tsunami Bull Board** - Tsunami Service Providers (PTWC, JMA, IOTWMS TSP, others)
- *National alarm (seismic network), Feel shaking, Phone call*

2. IF LARGE EQ, THEN QUICKLY ISSUE TSUNAMI MESSAGE

3. DETERMINE WHEN TSUNAMI WILL ARRIVE (automate)

- **TTT (sea level stations, towns), PTWC message, TsuCAT, TsuDig**
- *National Tsunami DB (gives arrival times)*

4. DETERMINE HISTORICAL TSU HAZARD – QUERY DB

- **Tsunami Historical Database (online, offline), TsuCAT**
- *National Tsunami TB*
- *Pre-computed National Inundation Scenarios, Real-time forecast*

5. MONITOR SEA LEVEL STATIONS TO CONFIRM TSUNAMI

- **Tide Tool, IOC Sea Level Monitoring Facility**
- *National Sea Level network*

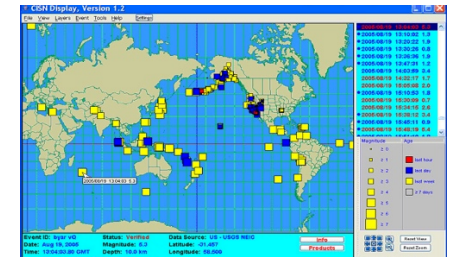
6. RECEIVE / ISSUE MORE INFO (update EQ/forecast, observ), INFORM MEDIA

7. CANCEL WHEN NO DAMAGING TSUNAMI WAVES

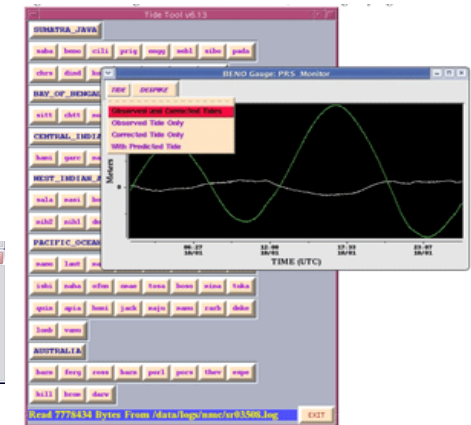
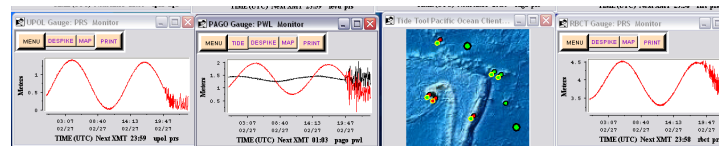
ITIC – Tsunami Warning Tools – In Office



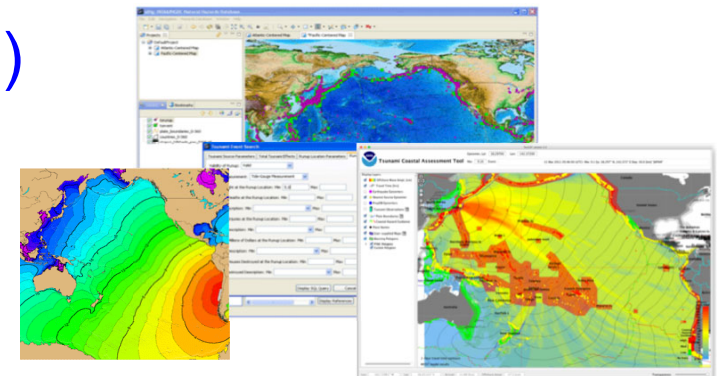
- Real time Earthquake Display / California Integrated Seismic Display (USGS) (real-time)



- Sea Level monitoring (real-time)
 - **Tide Tool – TWC sea level monitor (PTWC)**



- Tsunami Historical Database (NCEI, ITIC)
 - Online – NCEI
 - Offline – TTT, TsuDig
 - TsuCAT scenario database





UNESCO/IOC – NOAA/ITIC
Tsunami Early Warning and Mitigation Systems
November 2021

Thank You

Laura Kong

UNESCO/IOC – NOAA International Tsunami Information Center

ITIC, IOC, USGS, PTWC, NCEI, WDS-Geophysics, RANET, PMEL