UNESCO/IOC – NOAA ITIC Training Program in Hawaii (ITP-TEWS Chile)
TSUNAMI EARLY WARNING SYSTEMS
AND THE PACIFIC TSUNAMI WARNING CENTER (PTWC) ENHANCED PRODUCTS
TSUNAMI EVACUATION PLANNING AND UNESCO IOC TSUNAMI READY PROGRAMME
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TIDE TOOL: SOFTWARE TO ANALYZE GTS SEA-LEVEL DATA

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USAID FROM THE AMERICAN PEOPLE

SMART CABLES Earth's Pulse

GTS – Global Telecommunications Service:

Maintained by the WMO and is comprised of a network of surface and satellite based telecommunications links and centers. It is a system for the global exchange of meteorological, climatic, seismic and other data to support multipurpose early warning and forecast systems*.

The TWCs (Tsunami Warning Centers) rely heavily on the GTS to supply sea-level data in near real time from ~700 sea-level stations world wide and to transmit Tsunami Bulletins.

*Source: http://www.wmo.ch/pages/prog/drr/events/humanitarian/Documents/HumanitarianBackground%20document.pdf

GOESW

CHANNEL 32

Downloaded at Wallops Island VA/USA and forwarded to the US TWCs and Met. Offices.

Primary Functions of the Global Sea-Level Network

1. Confirm the existence or non-existence of destructive tsunami waves. Measure period and amplitude of tsunami waves.
2. Validate/Revise forecasts. Sea-level observations can be used to scale forecasts and/or adjust the source model.
3. Hazard Monitoring (storm surges)
4. Climate Change (sea-level rise)
5. Coastal management

Basic Types of Sea-Level Stations

- Coastal Sea-Level Stations
  (Shallow Water)
- Bottom Pressure Sensors (DARTs)
  (Deep Water)
- Cabled sensors
  (Intermediate Depths –Deep Water)

GTS Sea-Level Data is structured in a rich variety of formats. There are approximately 12 or so basic formats, with a number of variations.

UHSLC format (Manzanillo, MX) Readable ASCII (XMT 5min)

SEPA40 KWAL 050000 (WMO HEADER Origin Mdhhmm)

^^3541502E (Platform ID#) 186000003 :PRS 0 #1 9140 9139 ……

9139 9068 8284 8446 (Readings in mm):RAD 1 #1 6494 6483 6483 …..

:BAT 4 #5 13.3 :NAME 3541502E 38+0NN 216W (GOESW Chan 216)

NOS "Tsunami Expert" Station (Nawiliwili, Hawaii USA)

SXXX03 KWAL 050000 Base 64 Encoding (XMT 6min)

^^336015FC 186000041"P16114001@|]~[@@v0KwW1@il@WADWDM

@ij5DY<U`2@Rs@T@"@Rt kTWyJBQBeBcB^BqBo 41+0NN 148W

(ONE MINUTE DATA)

SOMX10 KWAL 061135 OTT Format (Zihuatanejo, Mexico)

0102D23E 310113501 OTA@lca{[D@@K@`@@J@`B@h@@J@`B@h

@@J@`B@h@@J@`A@pB@DcCCyp@Nl`CRxPGN|cCvx@CN`^CUx

GTS Sea-Level Data is structured in a rich variety of formats. There are approximately 12 or so basic formats, with a number of variations.

SEHA10 KWAL 051738 **Port Au Prince**
49A00782 309173801 OT12 ID:HT-PTPR-01 DT:2014 11 05 17 36
:RD 1973 1971 1972 1970 1972 1967 1967 1965 1964 1956
:PR 2012 2006 1995 2010 2010 2003 1989 2003 1987 1979
:B 13.6V **Data in chronological order, first 5 samples redundant**

SWPA41 RJTD 051928 **Yap**
:PRS 1 #1 1854 1848 1844 1841 1837 1832 1827 1823 1819 1815 1811 1807
:RAD 1 #1 6666 6661 6657 6653 6649 6644 6639 6635 6631 6627 6622 6619
:ENC 1 #6 5106 5080 5056 5027 :SW1 28 #60 59 :SW2 58 #60 30 :BAT 5 #6
12.4 :NAME 065012F8 **Data in reverse chronological order, last 5 samples redundant**

Redundant data good to have!

As you can see, GTS Sea-Level Data does not come gift wrapped and easy to use.

For a TWC to use GTS Sea-Level Data, the TWC needs (at minimum):

1. Access to GTS Data!
   (Easier said than done in many cases)
2. A Decoder to translate Sea-Level messages into sea-level data.
3. A MetaData Database (used by the decoder).

Tide Tool

Tide Tool continuously decodes sea-level messages in real-time and displays the time series using the open source, platform independent, graphical scripting language Tcl/Tk.

Tide Tool consists of three main parts:

1. **Data retriever called get_data that acquires data from NOAA and the IOC webservice.**
2. **Decoder which reads log files of GTS sea-level messages and a sea-level station metadata base.**
3. **Dynamic map based clients that allow the user to select a single station or a group of stations to display and analyze.**

Tide Tool Requirements

In order to decode GTS messages, run the dynamic map clients and display the time series, the following are required*:

- Computer running Tcl/Tk software with BLT extension.
- GTS Sea level messages that are continuously archived into a log file.
- Tide.tcl , get_data.tcl, client Tcl/Tk scripts. (contains decoder and creates marigram displays)
- Sea-level Station metadata.
- A link to GTS data via the country's Met Service if possible.

Tide Tool

COMP_META metadata database*

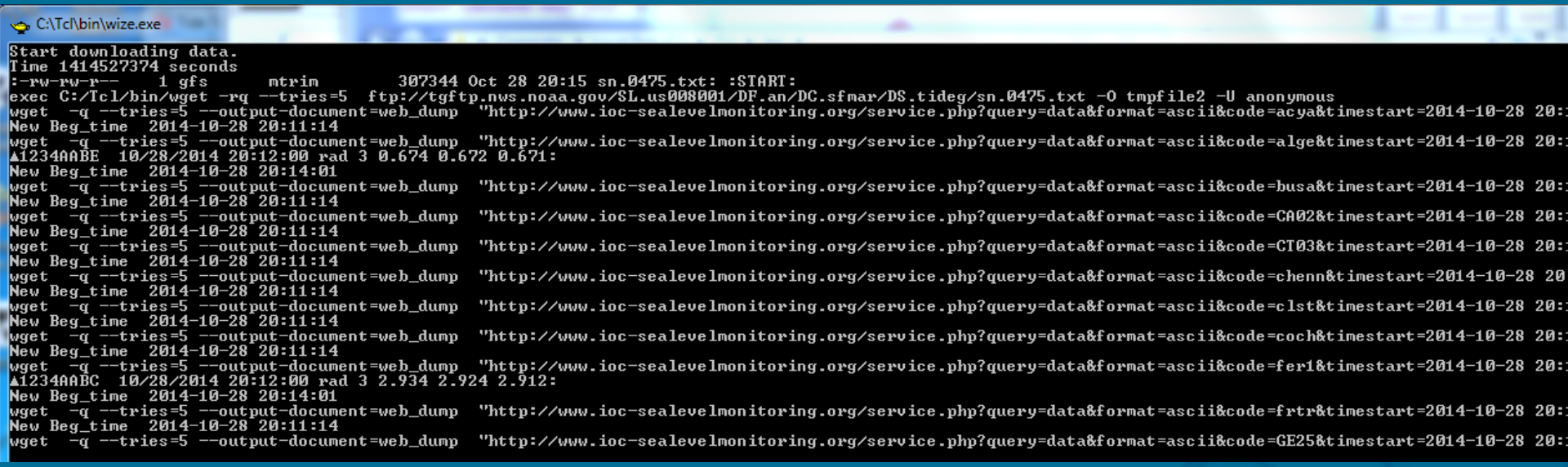
PTWC actively maintains a database (COMP_META) of all sea-level stations that transmit sea-level messages via the GTS. Tide Tool reads a *dump* of this database to understand how sea-level messages are structured for the various sea-level stations.

```
manz          Manzanillo_MX     3541502E  SEPA40  prs  1  10  M  3 -1  1.0000
  005 0000   19.0558  -104.3176     1      UHSLC  163  PARSE_GLOSS
manz          Manzanillo_MX     3541502E  SEPA40  rad  1  10  M  3 -1  1.0000
  005 0000   19.0558  -104.3176     1      UHSLC  163  PARSE_GLOSS
```

The COMP_META database has ~2000 entries

get_data.tcl Script

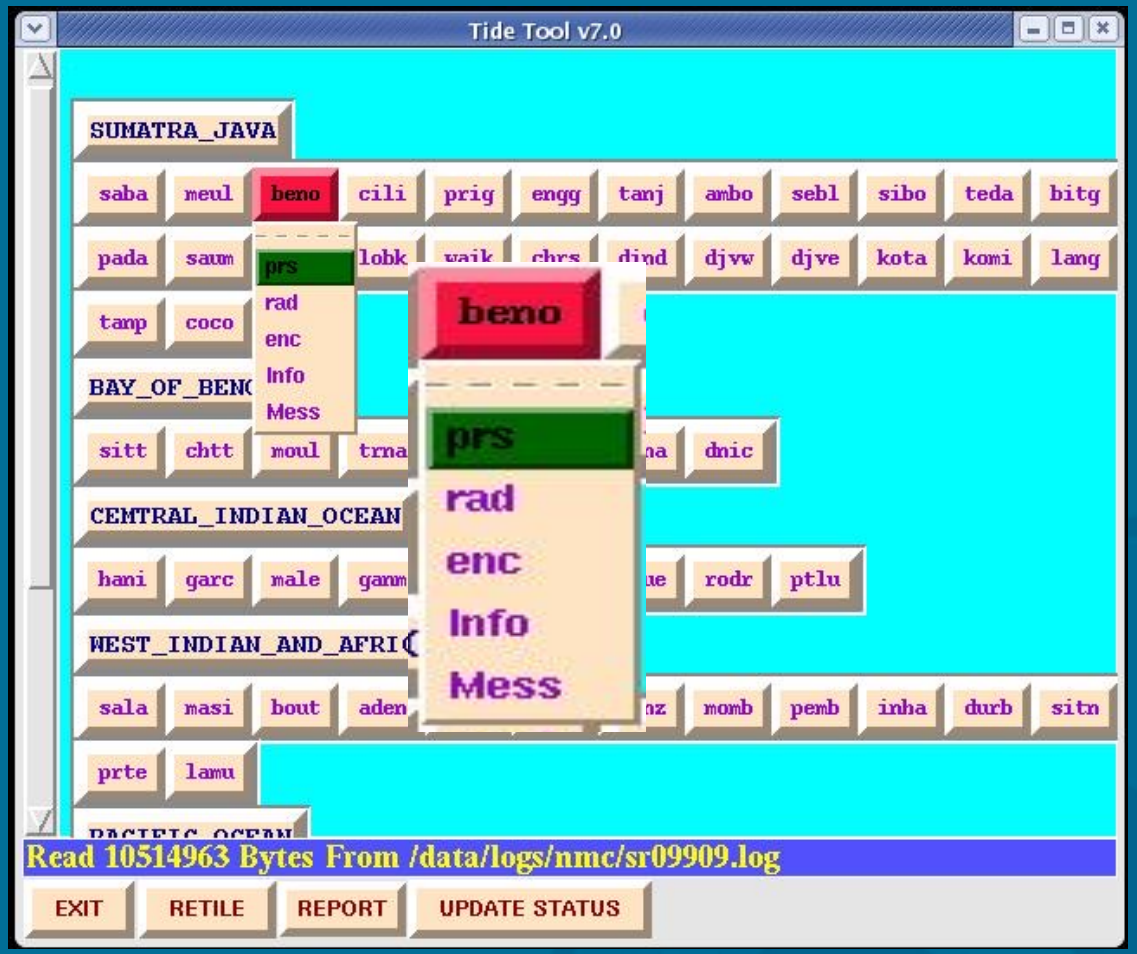
The get_data.tcl script retrieves sea-level data from the IOC using the IOC webservice and sea-level data in the form of GTS messages via ftp from a NOAA website.



get_data will start the data retrieval process every 200s. Once started, it will run continuously, and will not be affected by network outages..

Tide Tool Decoder
(Tide.tcl script)

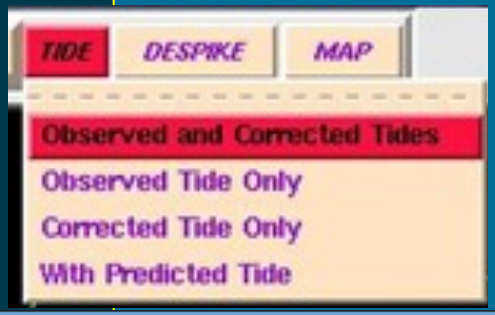
- Reads and decodes GTS sea-level messages from the logfile.
- Constructs the main GUI which responds to mouse clicks.
- Sends and services Instructions to and from clients respectively.
- Supports multiple clients via sockets.
- Creates transmission report and determines status of stations.
- Scrollable.



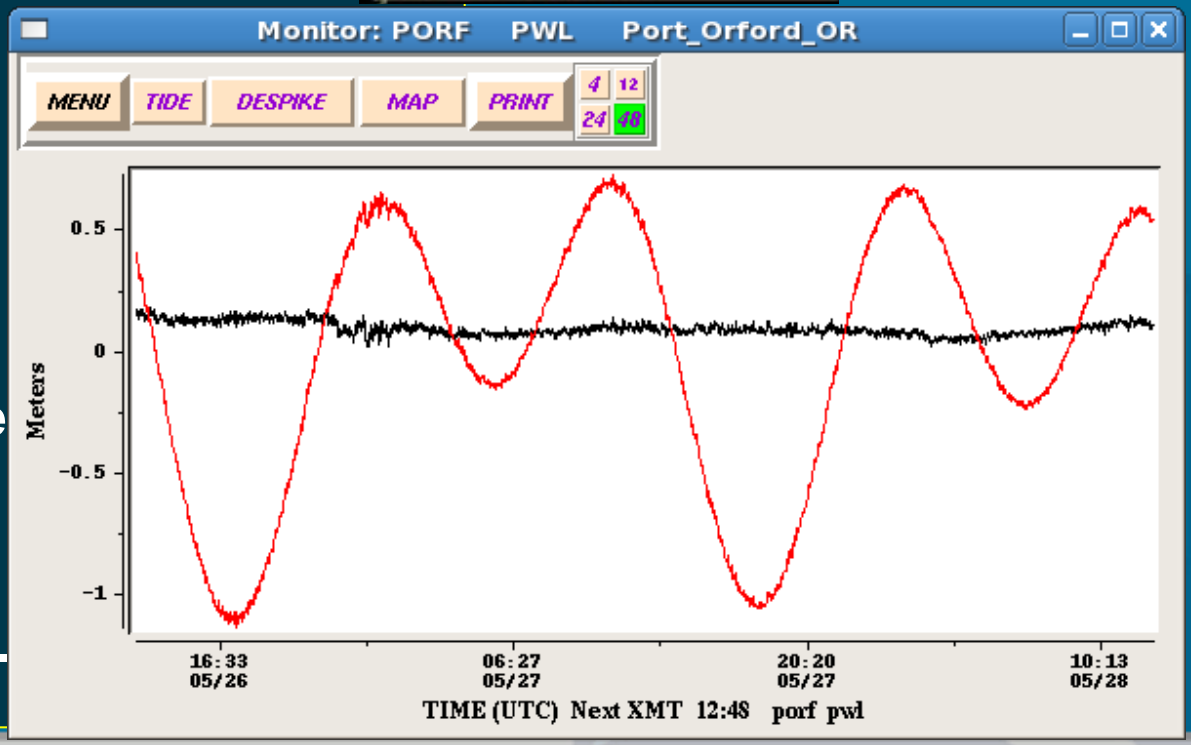
Tide Tool Monitor Widget

- Can display up to three different time series:

  Red – Actual time series
  Black – De-tided time series
  Blue – Predicted time series



- Two de-tiding options: permanent or on-the-fly coefficients.
- Automatically Updates
- Despike option based on three point median.
- Station location map option showing reverse travel-time contours.
- Rubber banding zoom option to expand time series.



Tide Tool Zoom Widget

- Used to measure tsunami wave arrival time, amplitude, and period with mouse clicks and record measurements in a file. Can zoom recursively.

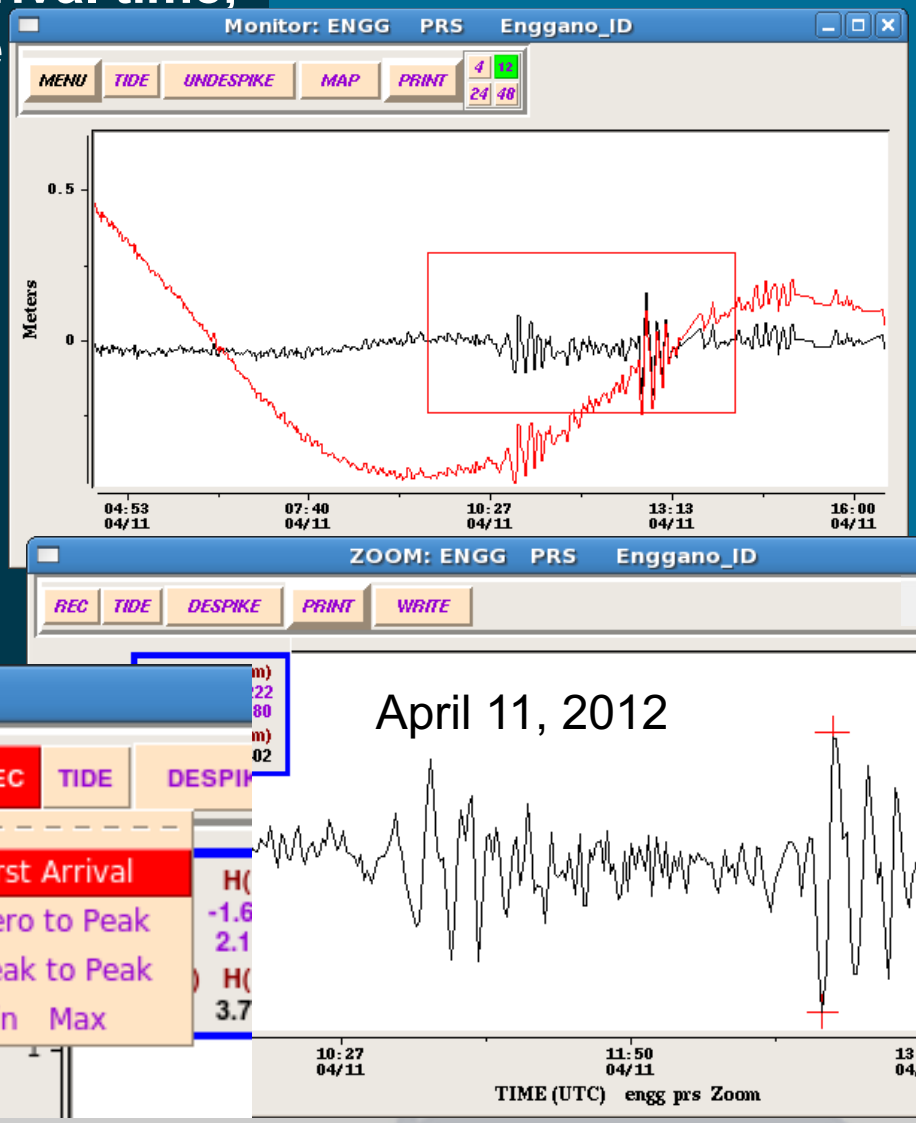
- Can display up to three different time series:

  Red – Actual time series
  Black – De-tided time series
  Blue – Predicted time series

- Two de-tiding options: permanent or on-the-fly coefficients.

- De-spike option based on three point median.

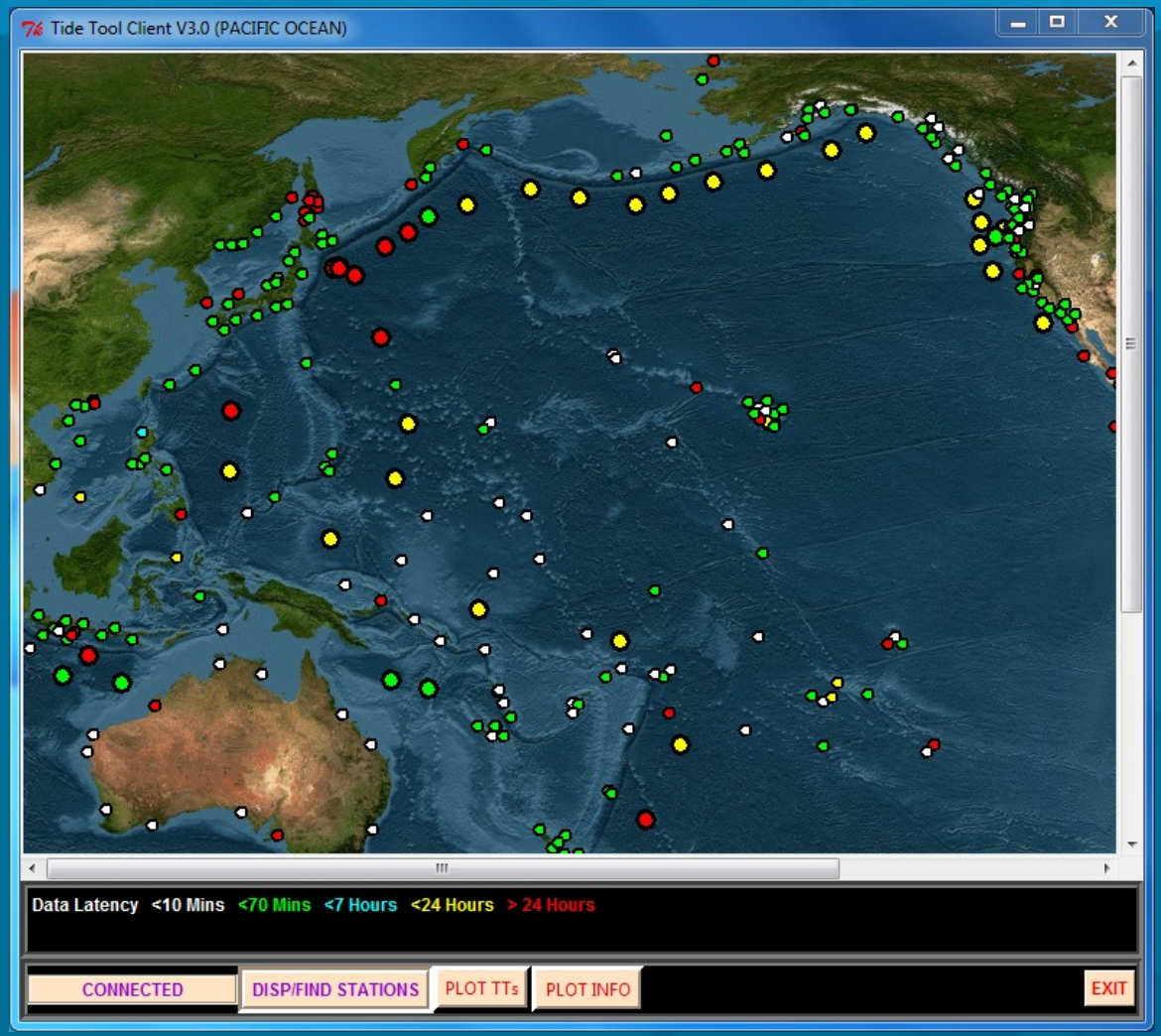
- Zoom History




Tide Tool Clients
Tide Tool Client V3.0 (PACIFIC OCEAN)
Pacific Client
Tide Tool Client V3.0 (CARIBBEAN)
Caribbean Client
Data Latency <10 Mins <70 Mins <7 Hours <24 Hours > 24 Hours
CONNECTED
DISP/FIND STATIONS
PLOT TTs
PLOT INFO
EXIT
Tide Tool Client V3.0 (INDIAN OCEAN)
Indian Client
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

Pacific Client

- Send instructions to Decoder to display time series or other information.
- Responds to mouse operations to display a single station or zoom in on a region and display multiple stations.
- Scrollable.
- Indicates station status (color).



Tide Tool Clients

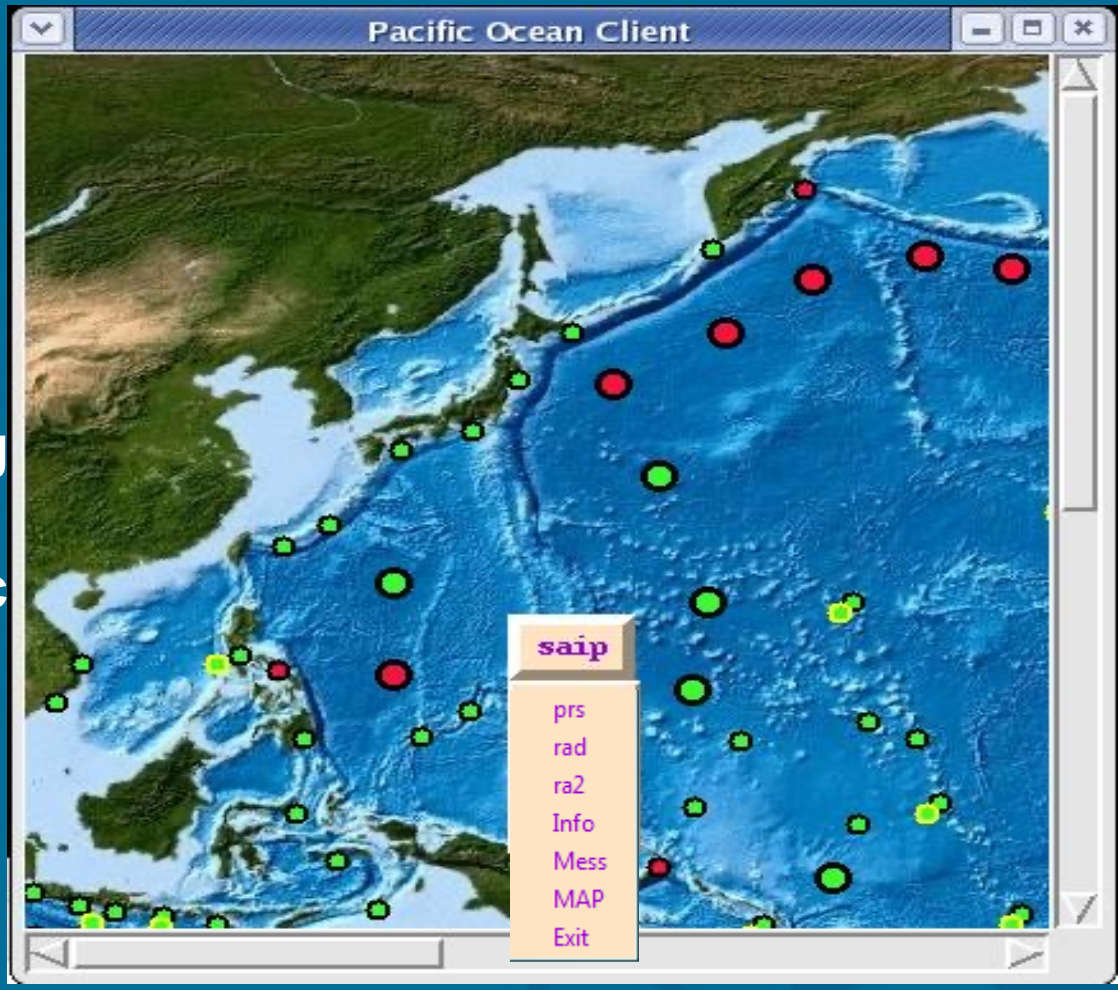
- You can choose to hide DARTs/BPRs or hide coastal Stations.

- Locates stations by code or NDBC number (DARTS).

Tide Tool Clients

- Double click on a station Creates a button with a drop-down menu.
- Menu has selections to display time series for each sensor and widgets showing station info, recent GTS messages, and a geographic map of the nearby area with tsunami travel-times.

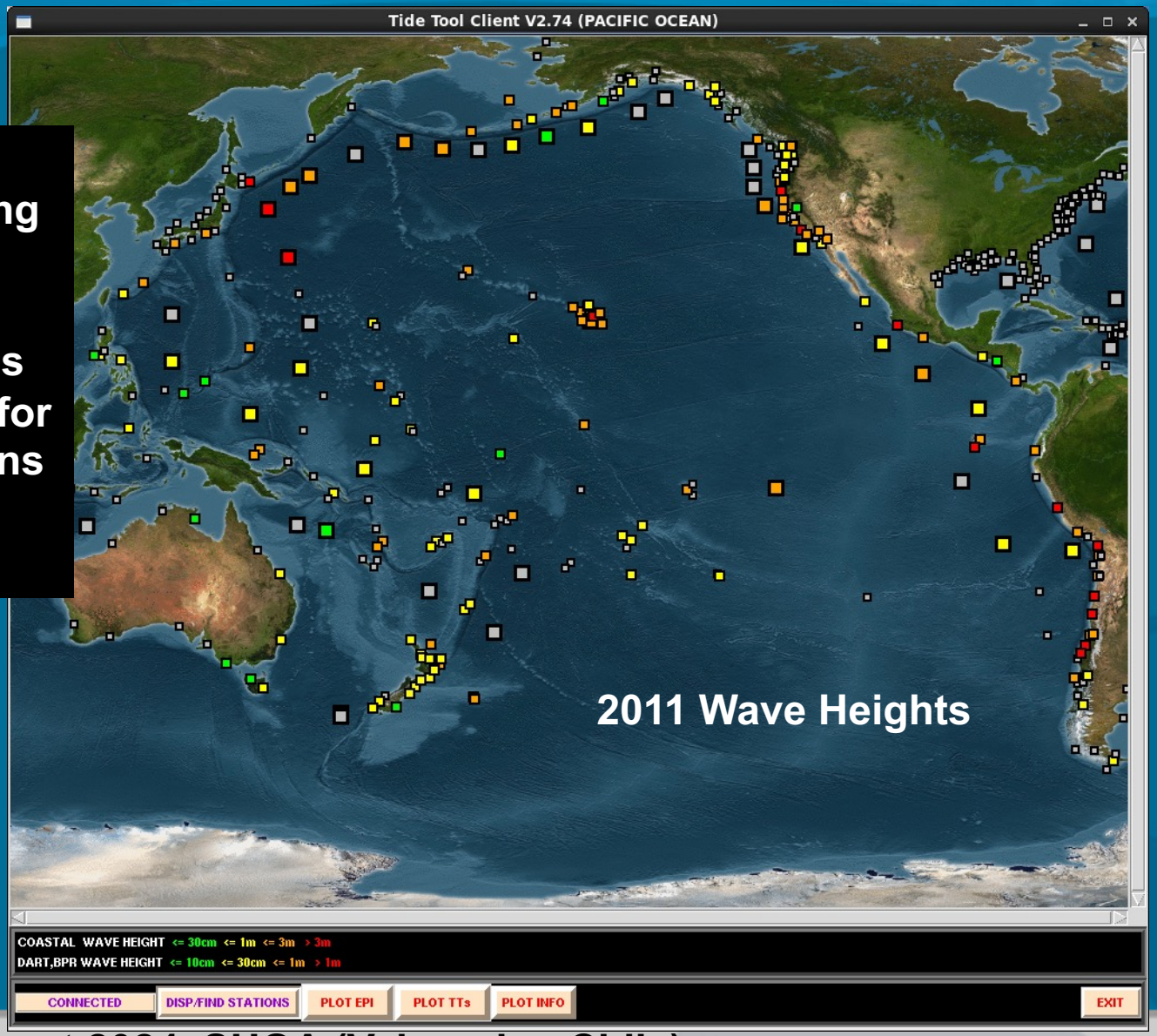
(Settlement Pt., Bahamas in this example.)



Tide Tool Clients

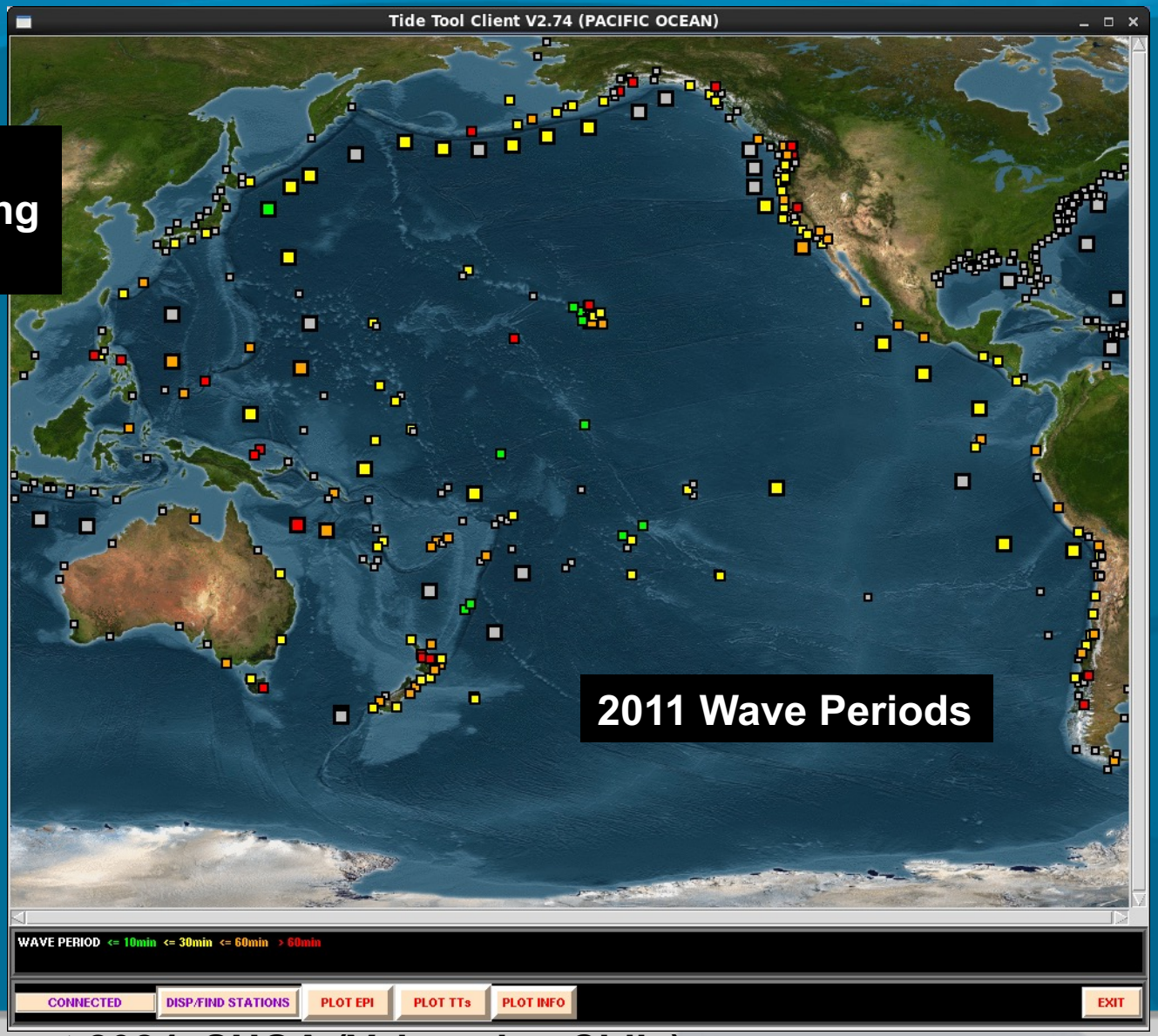
Tide Tool clients now have layers for showing Observations

Wave Height/Amp uses different color scales for BPRs & coastal stations



Tide Tool Clients

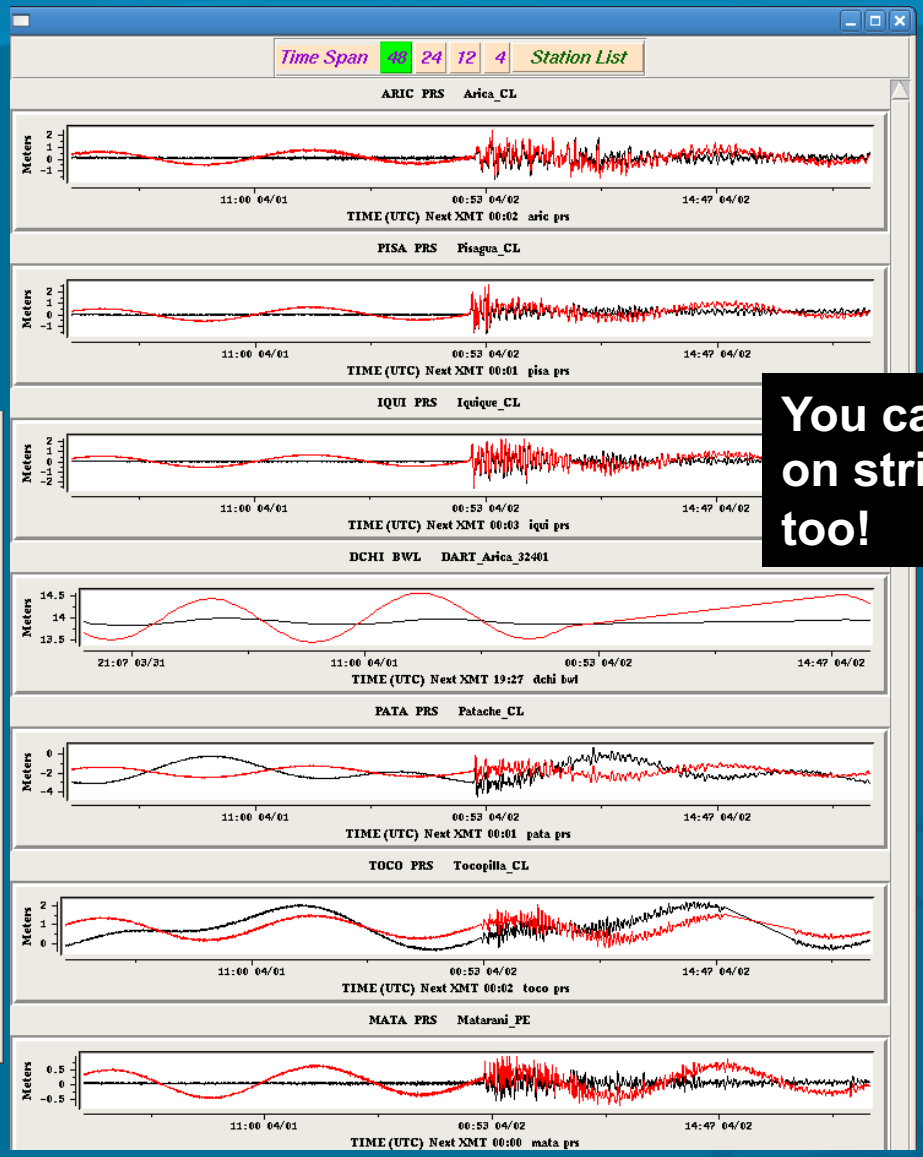
Tide Tool clients now have layers for showing Observations



Tide Tool Clients

…. make a
“Strip Chart Widget”

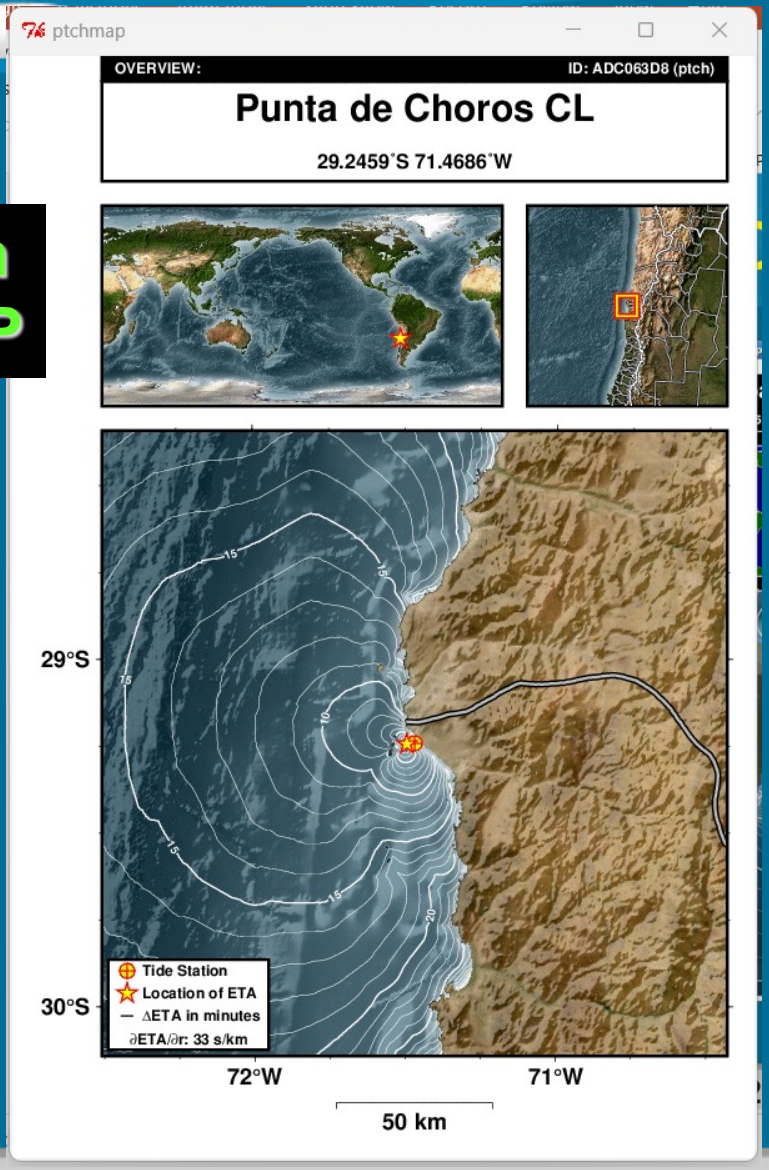
ancu	Ancud_CL
bmsa	Bahia_Mansa_CL
buca	Bucalemu_CL
cons	Constitucion_CL
coqu	Coquimbo_CL
corr	Corral_CL
crnl	Coronel_CL
cstr	Castro_CL
juan	Juan_Fernandez
lebu	Lebu_CL
pcha	Puerto_Chacabuco_CL
pich	Pichidangui_CL
pmel	Puerto_Melinka_CL
pmon	Puerto_Montt_CL
qtro	Quintero_CL
quel	Queule_CL
quir	Quiriquina_CL
sano	San_Antonio_CL
talc	Talcahuano_CL
valp	Valparaiso_CL



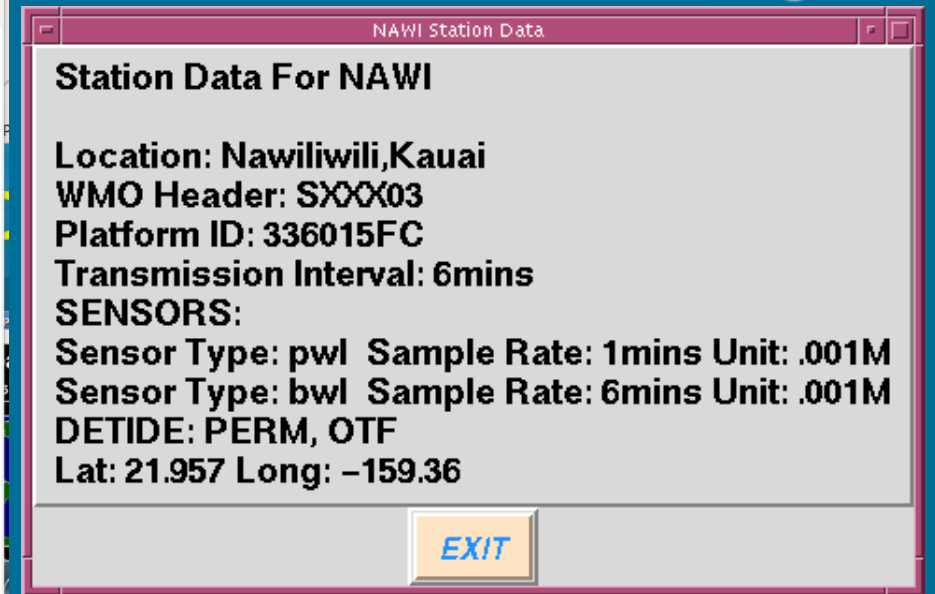
You can zoom on stripchart widget too!

Other Features

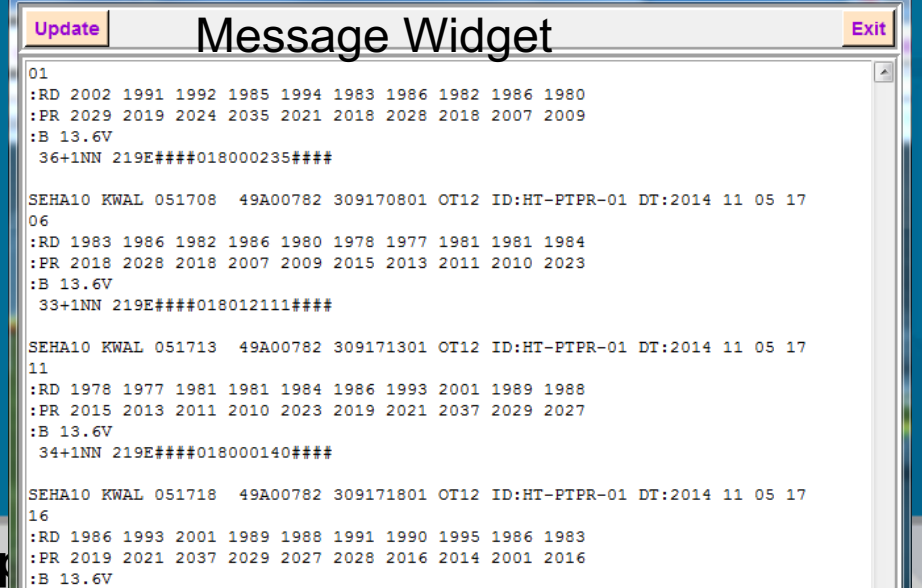
Station MAP



Station Information Widget



Message Widget



Other Features

Tide Tool will decode historical GTS logfiles provided the correct Metadata is available.

Tide Tool will write files containing decoded data in a simple two column format:

102.48542 0001.300
102.48611 0001.324
102.48681 0001.333
102.48750 0001.290

Tide Tool records wave measurements:

engg prs Peak to Peak 102/12 12:45 H -0.222 102/12 12:48 H 00.180 Per 00:03 Amp 00.402 2012149 15:13

Tide Tool De-Tiding

For the purpose of accurate tsunami measurement it is important to remove the tide signal. Tsunamis have long enough periods that variations in sea-level can significantly affect the measurement of Tsunamis from marigrams. On the marigram, the tsunami will "ride the tide" affecting the precision of measurement.

Tide Tool uses two methods for de-tiding. One method is based on *permanent* coefficients* (long term prediction) determined (Foreman's method) from long time series (years). The other method, "on-the-fly" (short term prediction), uses non-static coefficients determined using recent (previous few days) data (Wang, 2009).

*PTWC maintains a set of permanent coefficients and these are available for distribution with Tide Tool

Tide Tool De-Tiding

Both de-tiding methods have strengths and weaknesses:

Short Term Prediction

Strengths: Does not require long time series and can therefore be used for new stations.

Will eliminate non-gravitational effects.

Weakness: Will not work well if data contains gaps or other defects.

Coefficients need to be computed every two hours.

Tide Tool De-Tiding

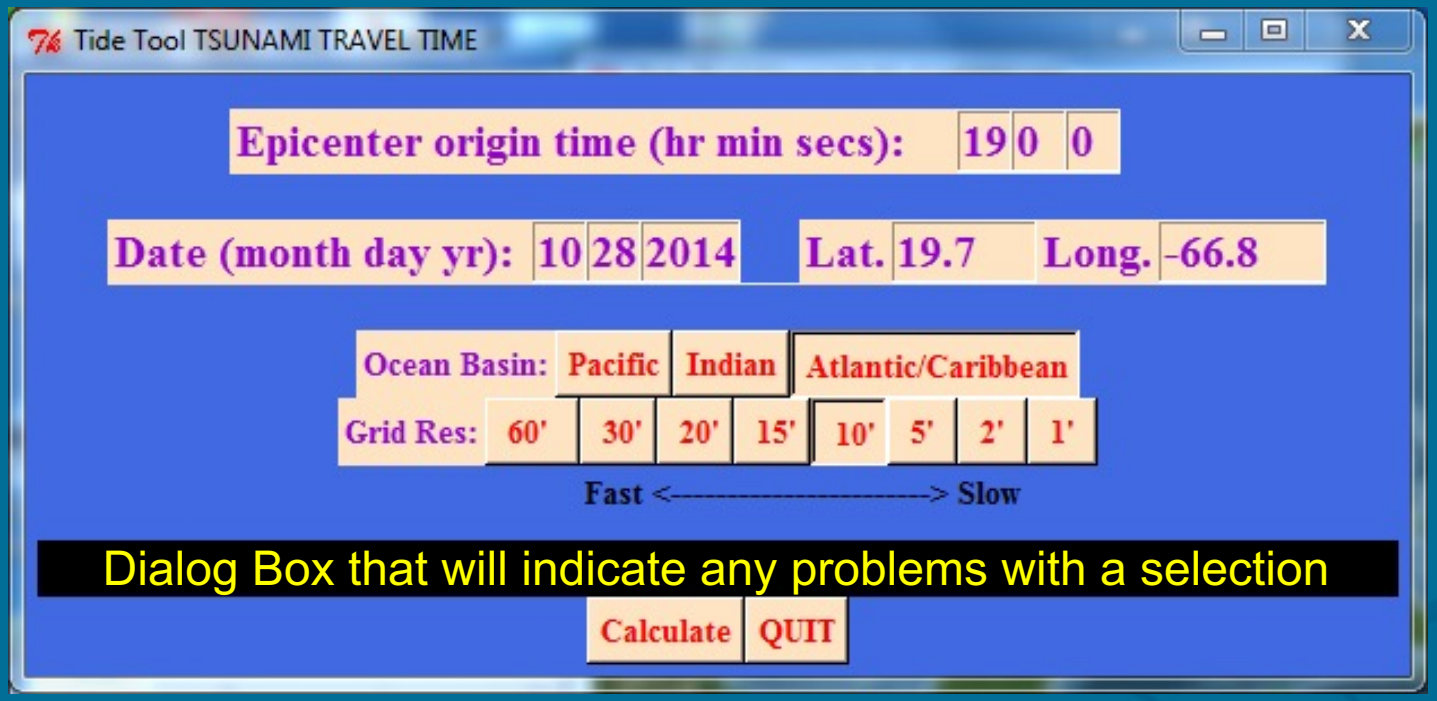
Both de-tiding methods have strengths and weaknesses:

Long Term Prediction

Strengths: De-tiding not affected by spikes or other defects in the data.

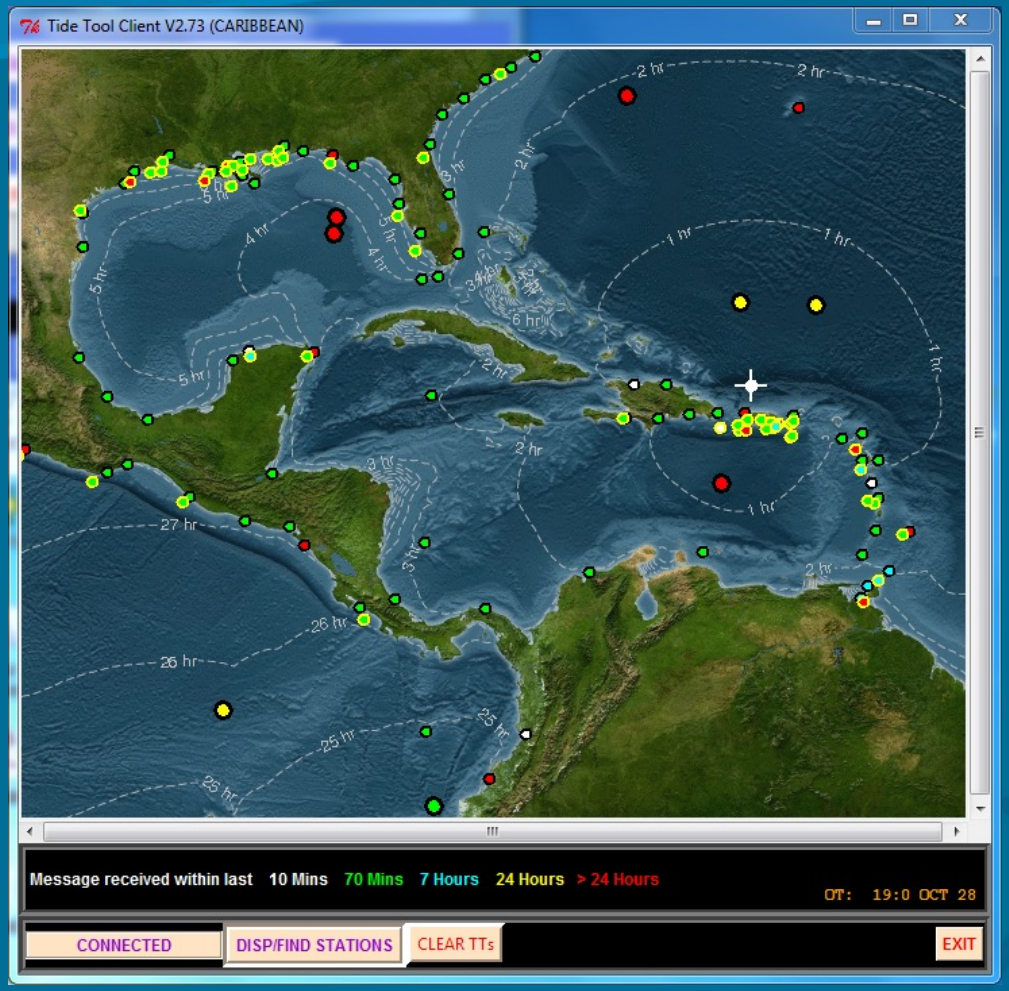
Weaknesses: Requires one or more years worth of data to compute coefficients that give correct phase well into the future.
=> Can't be used for new stations

Tide Tool and Tsunami Travel Times



Simple to use GUI that can be invoked by hitting the TTT button on the Main GUI. A WINx cmdtool is created and the ttt_client program is executed. When it is done…

Tide Tool and Tsunami Travel Times

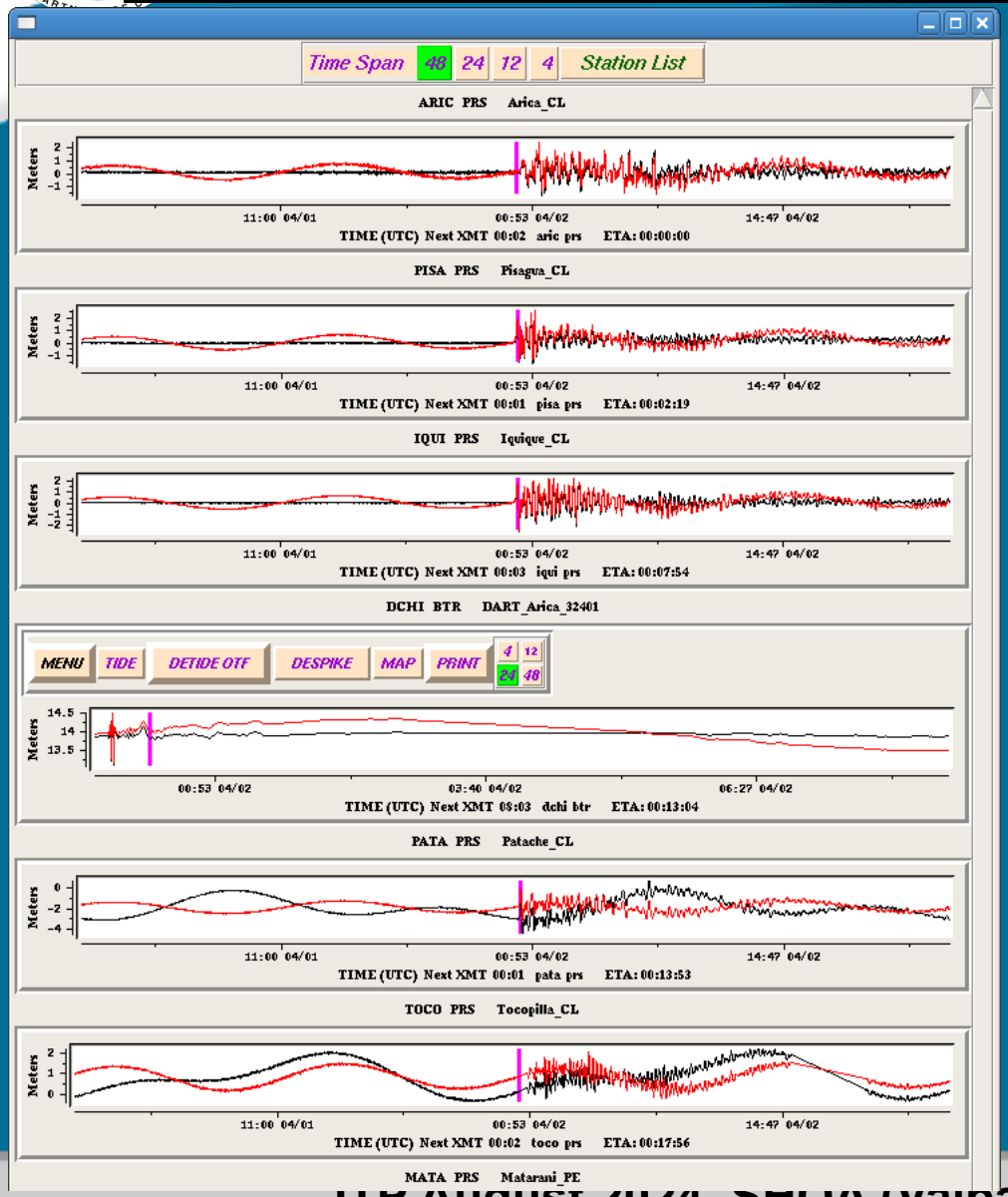


Click the “TTT” button on the base of the Client and the travel-time contours are superimposed. Moving the mouse over the Client will reveal the ETA.

Tide Tool and Tsunami Travel Times

Note that the zoom widgets are larger when travel time contours are displayed. On the Client zoom widgets, the contour interval is 15 minutes. Moving the mouse over the Client zoom widget will reveal the ETA and coordinates under the cursor.

Tide Tool and Tsunami Travel Times



Click the “Get ETAs” button on the main GUI which loads the ETAs into Tide Tool’s data structures.

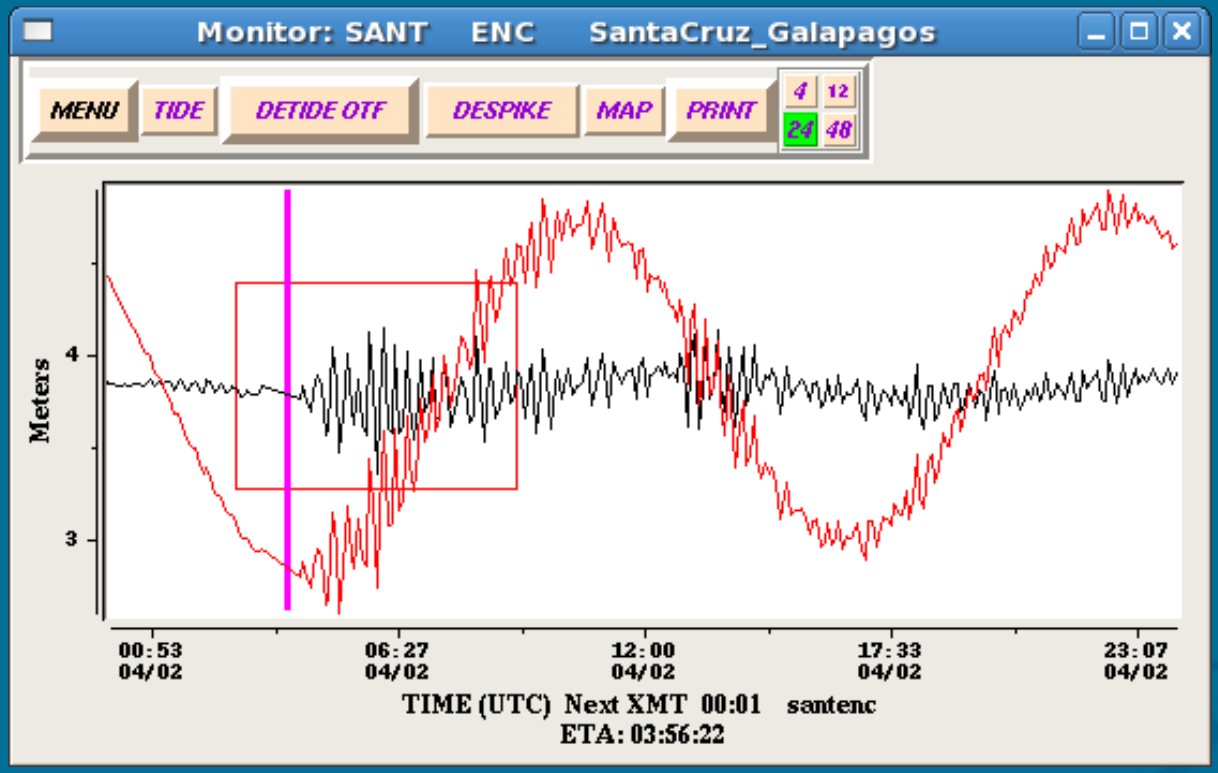
Select the “Strip” option under the “SHOW” button and create the stripchart. Stations are arranged in ETA order.

The magenta line indicates the expected arrival time.

The marigrams in the stripcharts have exactly the same time scale and every 60s the time scale updates.

48 hour time scale

Tide Tool and Tsunami Travel Times



ETA also indicated on the monitor widgets….

Future Directions

1. “On The Fly” Tide Modeling distributed with Tide Tool
2. Update Widget
3. Incorporate Atmospheric Tsunami Travel Times and Tsunami Measurements
4. Hi-Low detection
5. Tsunami Detector

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Thank You

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