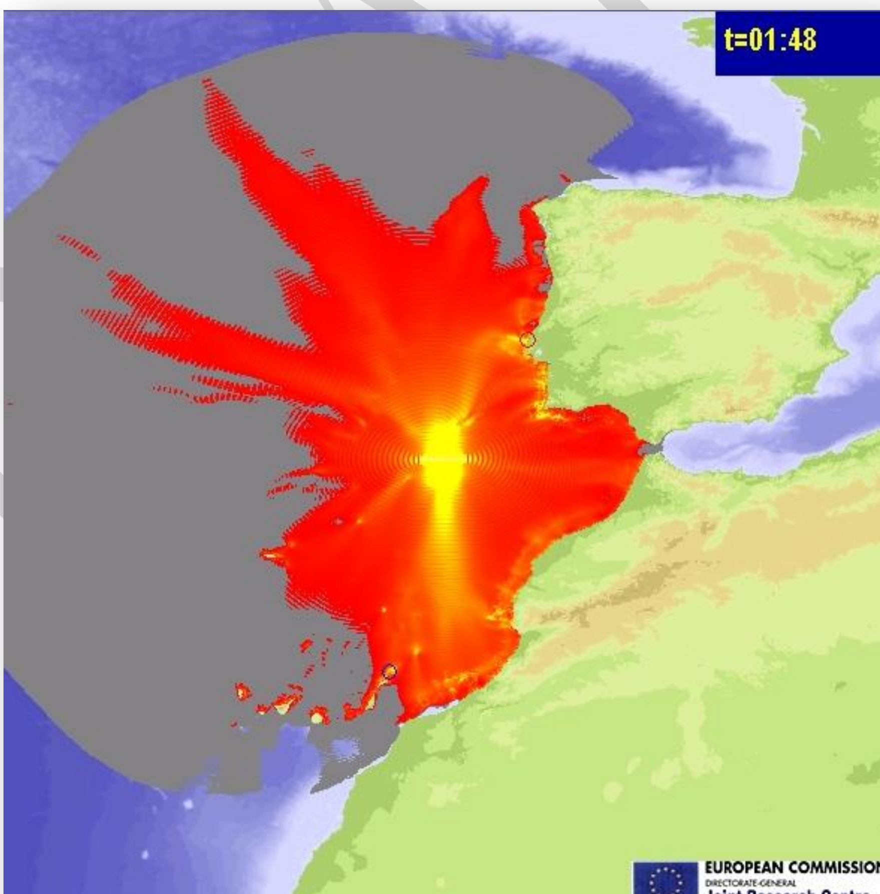
JOINT RESEARCH CENTRE

Tsunami Analysis Tool User Guide

A. Annunziato



JOINT RESEARCH CENTRE

European Crisis Management Lab

CRITECH JRC

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Chapter 1

Introduction

The analysis of an ongoing Tsunami requires a dedicated Decision Support Tool that allows understanding the phenomena

The Joint Research Centre of the European Commission is operating the Global Disasters Alerts and Coordination System (GDACS, http://www.gdacs.org) since 2003. This System, jointly developed by the European Commission and the United Nations, combines existing web-based disaster information management systems with the aim to alert the international community in case of major sudden-onset disasters and to facilitate the coordination of international response during the relief phase of the disaster. When new natural disasters events occur automatic analysis reports are created and sent to the users by mail, fax or SMS (Short Message System).

As a consequence of the 26th December Tsunami JRC included Tsunami modeling in the GDACS system in order to improve and complete the automatic reporting system. At the beginning of 2005 a travel time wave propagation model was included (Annunziato 2005). This model calculates the wave arrival time independently on the initial tsunami wave height. In 2006 a new analytical tool has been developed in order to be able to provide also the height and identify the locations with higher risk of tsunami damage. The calculation tool which was organized at JRC Ispra using this model allows performing automatic on-line calculations of Tsunami as soon as any new event is detected on the international seismological networks. During the on-line calculation (which takes about 30-40 min) to be completed, a web site page in the GDACS portal, is constantly updated with the new information coming from the model. Therefore a user connecting with that page after an event can follow the progression of the calculation
[1].

In order to understand what is really occurring during a real event, however, the sole web page is not enough because it shows the estimated sea level but does not show *real* sea level and therefore it is difficult to take actions using values estimated on the basis of Magnitude and Location only. The possible actions deriving from the analysis depend on the user analyzing the event: in the case of an official in charge of protecting the people on the coasts it could be the decision on a possible evacuation; in the case of on duty staff of an international organization it could mean to inform top level management of possible need for support in the potential consequences of a Tsunami. In all the cases the objective is the understanding of the real situation which is the objective of the **Tsunami Analysis Tool (TAT)**.

The Tsunami Analysis Tool is a software developed by the Joint Research Centre to support the analysis of the Tsunami events. The report describes all the options of the software and should be able to enable users to benefit from all the features of the programme. It can be used with any Tsunami software results, provided that the format of the files that the programme expects is preserved. One of the appendices at the end of the document explains the format of the data required by TAT.

Chapter

2

How to quickly analyze an ongoing event

This chapter describes which option to activate in order to quickly analyze an event and compare with analytical results.

Let's suppose that we want to analyze one of the calculations that have been done for the 11 March 2011 Tsunami in Japan and that we know its address as http://tsunami.jrc.it/model/swan/Reports/2371/

After starting the TAT programme, you should click on *Windows* menu and select *New Window*. A new analysis window will open and you need to specify the above address in the box labeled as "Select your case" and press Return or press the button "***Show***". You need to be connected in Internet or order to correctly analyse the case.

The *location* of an event may be an internet address or a location on the local disk which contains the files needed by TAT to perform the analysis. This folder could also contain the results of a scenario calculation.

The programme will load a number of information describing the conditions for which the calculation has been done such as Epicenter location, depth, Initial Height, Fault characteristics etc., FIGURE 1.

By selecting the various tabs it is possible to visualize additional information. The main window is the one indicated as "*Max Height*" that shows the maximum value of the height in the calculation space, FIGURE 2. This visualization allows seeing which are the available sea level devices that can be compared with the estimated calculated values. Also on the same window a number of locations are shown with the estimated height on the coast. By passing the mouse over the various circles (sea level) or squares (locations) it is possible to understand which is the device or the location (with its maximum height).

We want now to know how much the calculation is accurate respect to the real event. If our calculation is accurate on several measured values, it means that the estimation of the heights at the various locations is reliable. Very often there are not enough sea level devices to show the height in every coast thus the only possibility is to compare them where available and use the calculated value to derive all the rest.

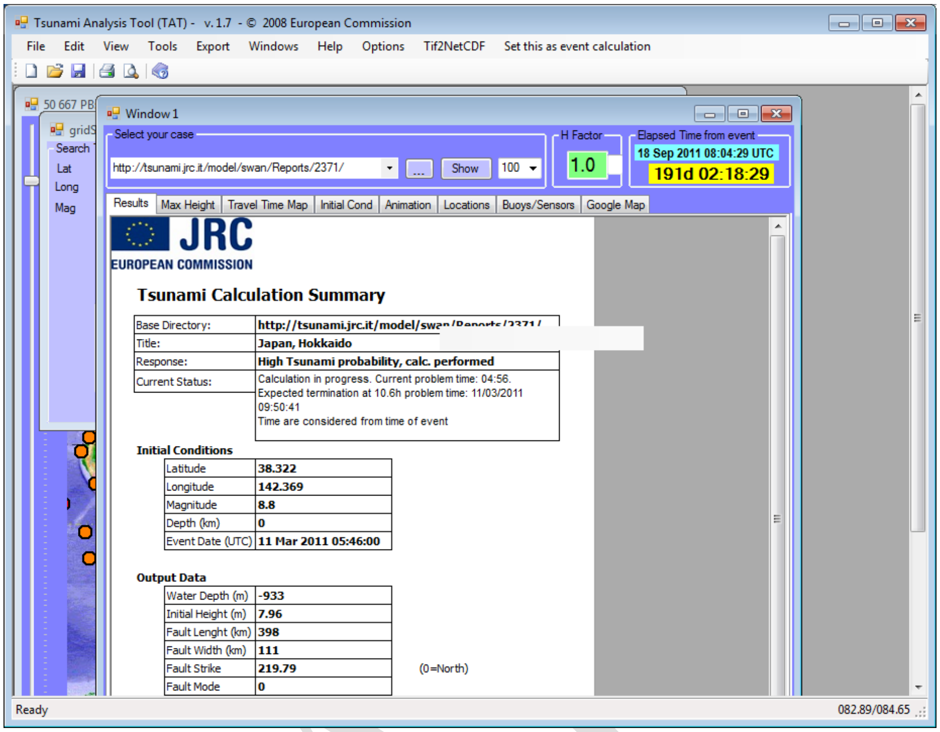


FIGURE 1 – Initial screen showing the characteristics of the calculation

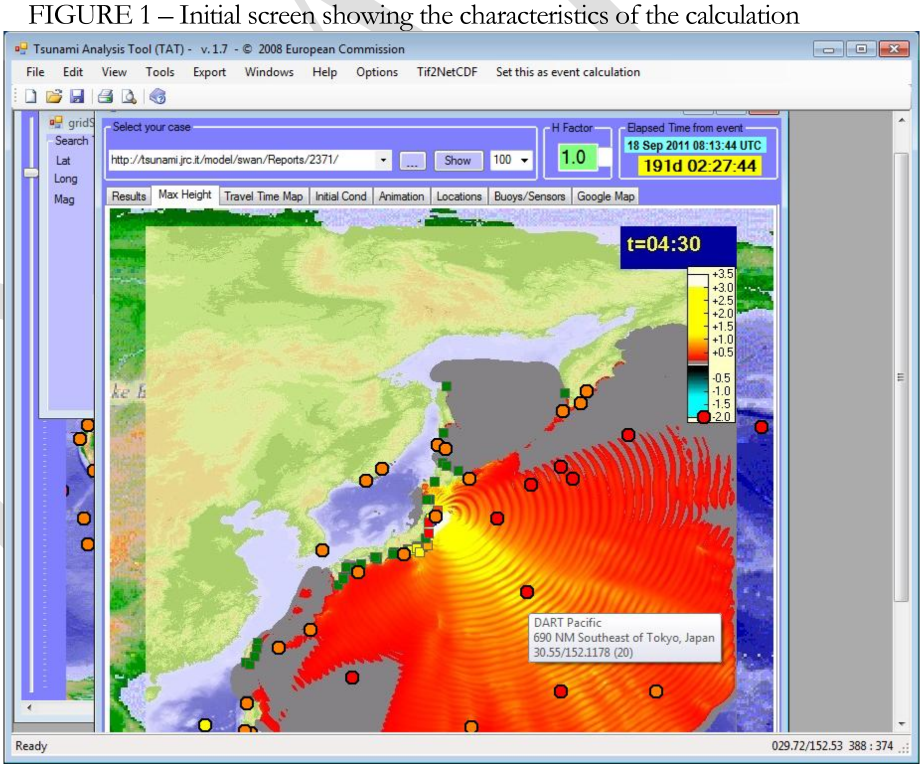


FIGURE 2 – Maximum height with indication of available sea level measurements (circle) and estimated heights on the coasts (rectangles)

The comparison is performed by creating a "sensor" (see the box on the right) by left clicking with the mouse on any point of the calculation space. A green square is created indicating the point.

☞ **A sensor** is a "probe" of the calculation that allows retrieving the calculated value at that particular location. The programme establishes the required cell and from that cell extract the quantity needed (height or water velocity).

In order to establish a sensor exactly on the point where the measurements are located, right click on the sensor and select the option "*Add a sensor at buoy*" in the popup menu that will appear. A green square is created below the buoy location and the form of the buoy becomes a triangle.

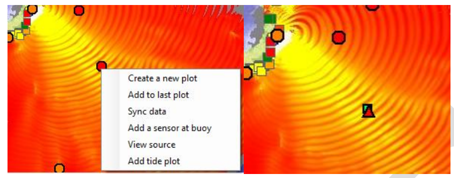


FIGURE 3 - Creation of a sensor at the buoy location

☞ **It is better** to include first the calculation result and then the sea level measurement because the first one is exactly on the time window needed for analyzing the event. Requesting first the measured quantity the system will show all the recorded data and it is more difficult to search the exact time window of the event .

In order to visualize the sea level at the sensor position you may click with the left mouse button on the sensor square in order to retrieve the sea level at that point. A first plot of the calculated sea level is shown on the screen; then right click on the buoy symbol (the triangle) and select the option "*Add to Last Plot*". Now there are two possibilities: a) it is the first time this plot is performed or b) you already executed this operation. In the first case the programme will look in the local database to check if the data of this particular buoy for the requested time window. In case there is no data available the programme asks if you want to retrieve data from the GLOSS database of UNESCO (See http://www.ioc-sealevelmonitoring.org/) or from the DART database of NOAA (http://www.ndbc.noaa.gov/dart.shtml) or whichever is the required source of the data. If the answer is yes the programme will connect with the source of the data and will request the synchronization of the current local database with the data available online. If the data exist on the source they are downloaded, stored in the local database and shown as overlay plot with the previous calculated trend obtained by the sensor.

To resume, the following actions:

- Open a new window
- Type the folder http://tsunami.jrc.it/model/swan/Reports/2371
- Press the "Show" button
- Go to the Max Height window and create a sensor a one buoy location
- Click on the sensor green rectangle and create the basic plot
- Right click on the buoy triangle and add the measurement to the calculated value

will create a plot like this:

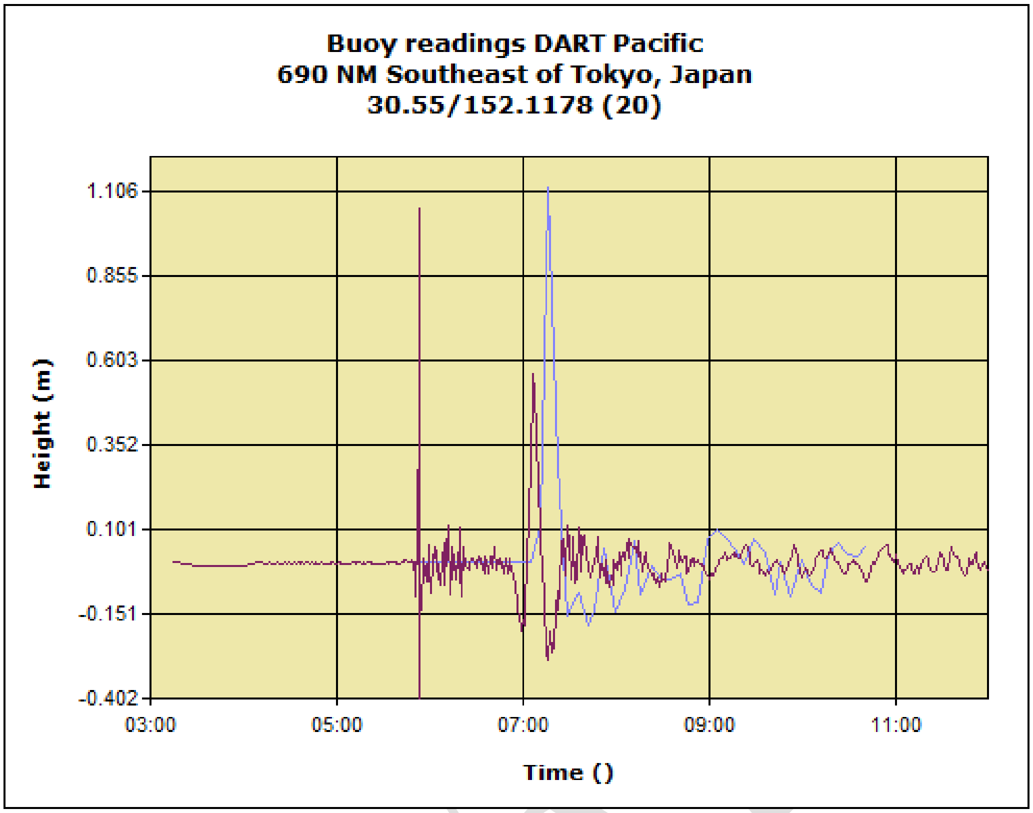


FIGURE 4 – Basic comparison plot of a calculated and measured quantity

The plot above, FIGURE 4, shows the comparison of the sea level measured on the DART located 690 NM (Nautical Miles) South East of Tokyo with the same quantity estimated by the calculation. The Blue curve is the calculated quantity and shows an increase of the sea level delayed respect to the measurement.

It is possible to double click on the top axis, FIGURE 5, to create a time mark (green square in the figure below) and moving the square by dragging and dropping the mouse it is possible to read the absolute time (7:12 AM), relative time (1h 26 min from the earthquake) and the values of the quantities in the plot at that particular time (1.11 m and 0.01 m).

By right clicking in a white space around the plot, it is possible to visualize the characteristics of the plot, FIGURE 6 and thus change the time limits, the plot min/max, the size of each curve, to include a multiplication factor for the values or for the time, an x or y offset and other important factors that will be described in the Filtering Data section, later in the Manual.

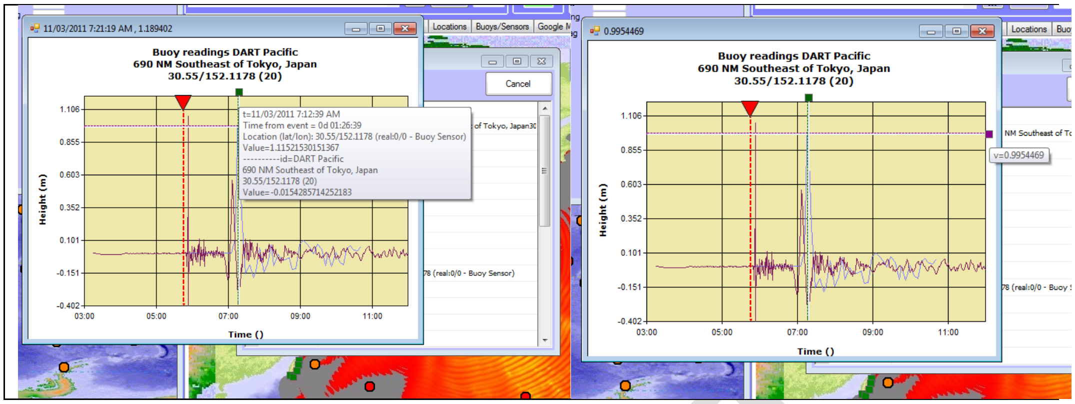


FIGURE 5 - Identification of relevant times and values

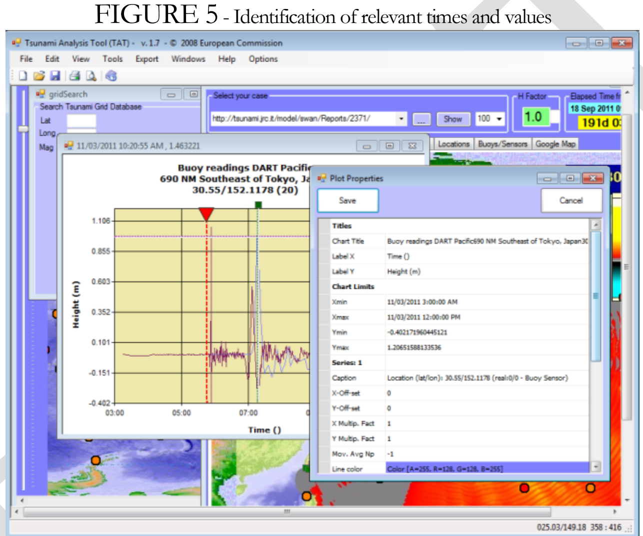


FIGURE 6 – Plot characteristics

When the plot characteristics window is shown, in the main menu an additional "Options" label appears where it is possible to select, among other, a different type of time units, such as minutes or hours and the plot changes accordingly when saving the new characteristics, FIGURE 7.

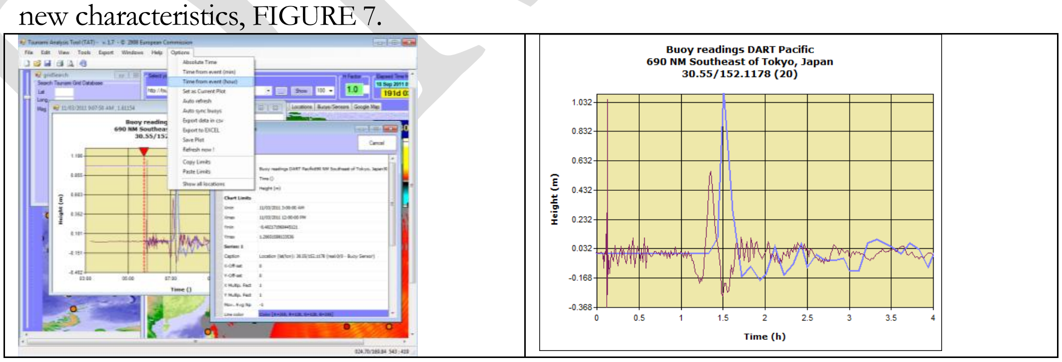


FIGURE 7 – Changing the Time Unit in Hours from the event

Chapter 3

DATA FILTERING

It is important to apply the right filtering to the data in order to get the right Tsunami behavior from the measured quantities

The signal of a Tsunami event has to be deduced by an overall sea level which contains a low frequency component corresponding to the tidal wave plus other higher frequencies due to other local or regional phenomena. The tidal component could be estimated using several methods such as ephemerid components which however are not known apriori in all locations in the world. There are some programs that calculate the tide, such as xtide32 but they need to be initialized with the local conditions which often are not identical to the ones that is needed at the location of the tide gauge. In addition, very often the forecast points never coincide with open sea where also is necessary to estimate the tide.

TAT uses various methods, more or less complicated, to remove the tide component and get the right value for the Tsunami signal. In particular the following methods are used:

- Moving average
- 3 points filtering
- FFT
- Xtide32 tide removal

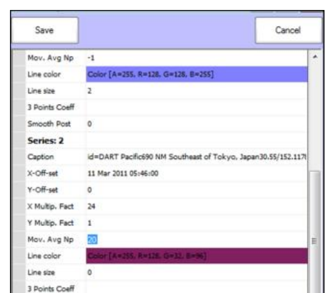


Figure 8 – The moving average is activated by selecting the number of points in the average

Moving Average method

This method consists in recalculating each point as the difference between the signal and the average between a number of points before and a number of points after the current one:

$$V_i = V_i - \text{Average}(V_i, i-N, i+N)$$

The number of points depends on the acquisition frequency. Typical values are 60-80 for DART measurements and 20-30 for tidal gauges.

The number of points can be changed by the user (Figure 8) that can change the default value, stored in the local database. By specifying a value of -1 the "real" signal is shown, without any tidal correction; a large negative number (e.g. -60) will show the real signal averaged with N points before and after the current one:

$$V_i = \text{Average}(V_i, i-N, i+N)$$

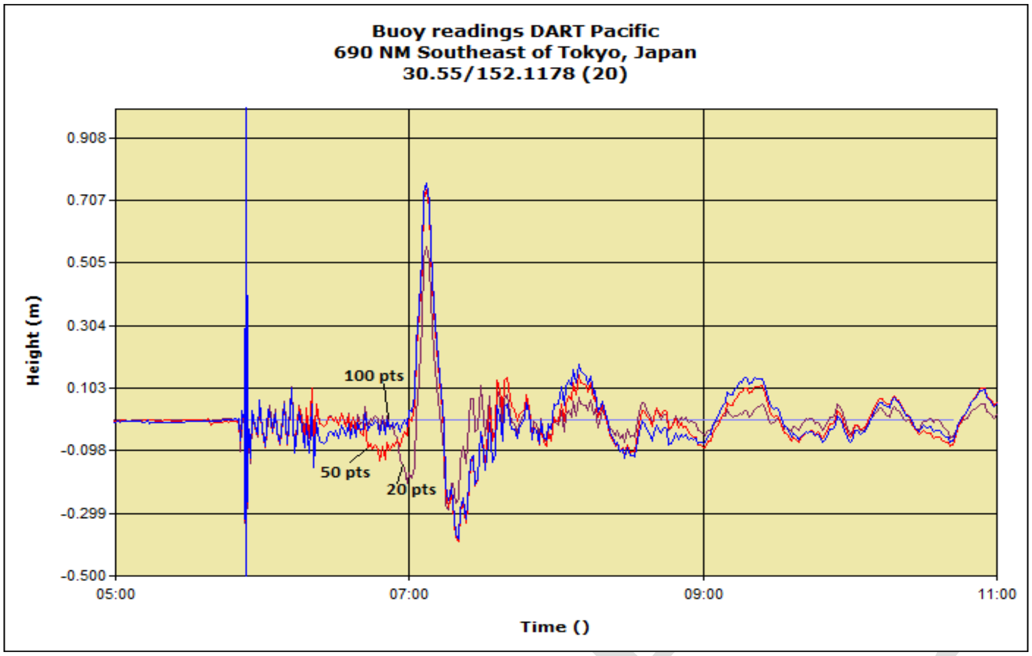


FIGURE 9 – The same quantity of previous figures with different number of points for the average

The above figure shows the effect of increasing the moving average number. From the curves it is possible to note that with 20 points there is a large initial decrease before the large excursion while with 20 or 100 the maximum value is almost the same . A further increase of the number of points does not change substantially the curve but it is better not to increase too much this number or the curve can become totally flat.

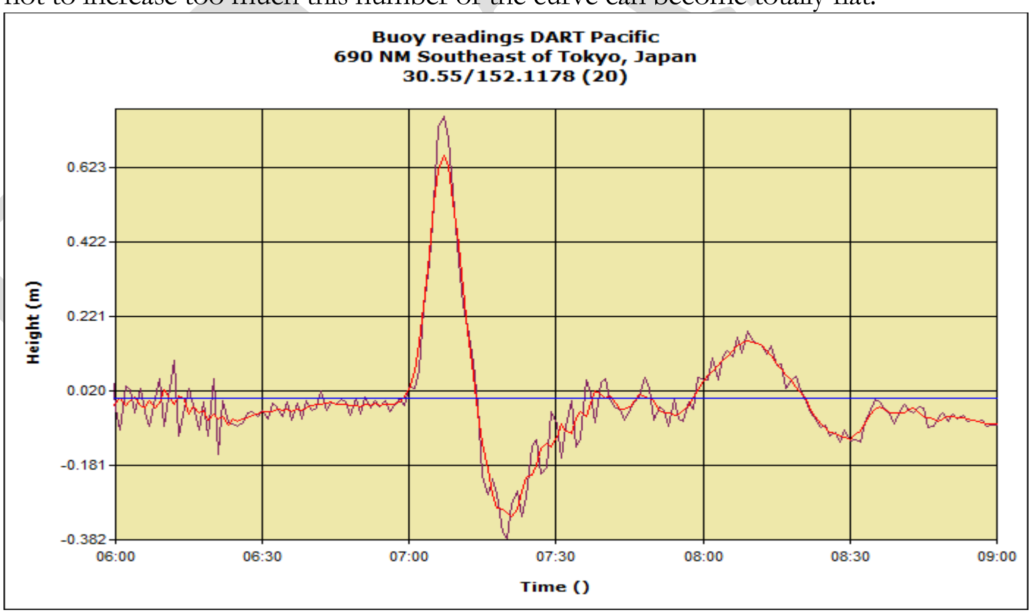


FIGURE 10 – Use of post average averaging procedure (brown curve is with 100 points of Moving average while the in the red curve the residual has been further averaged with 10 points.

3 POINTS Filtering

The Moving average method is very fast for a quick evaluation but it requires testing the number of points for the average to avoid to cut too much the real signal.

The 3 points method has been established from the consideration that looking at the "real" signal (with -1 as moving average), it is relatively easy to identify the long tidal wave behavior and therefore establishing a second order polynomial curve that represents the tidal gauge is easy and can be removed from the real signal to obtain the Tsunami signal.

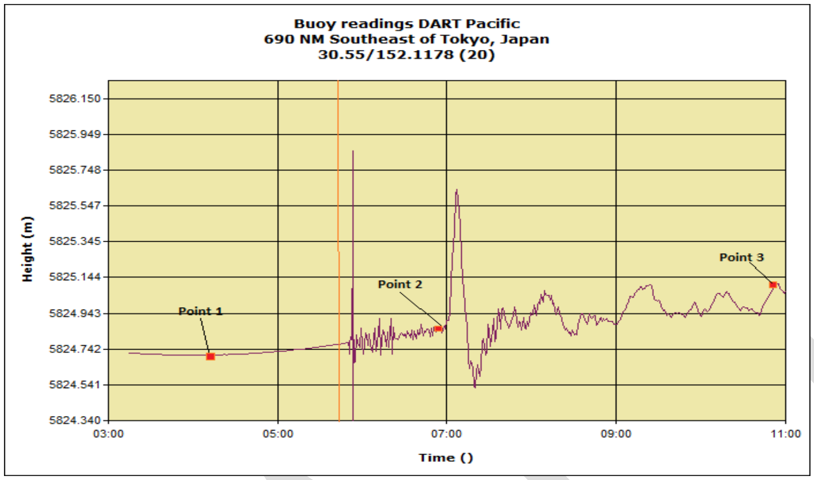


FIGURE 11 – The real curve with the indication of the 3 points that will be selected for the polynomial curve

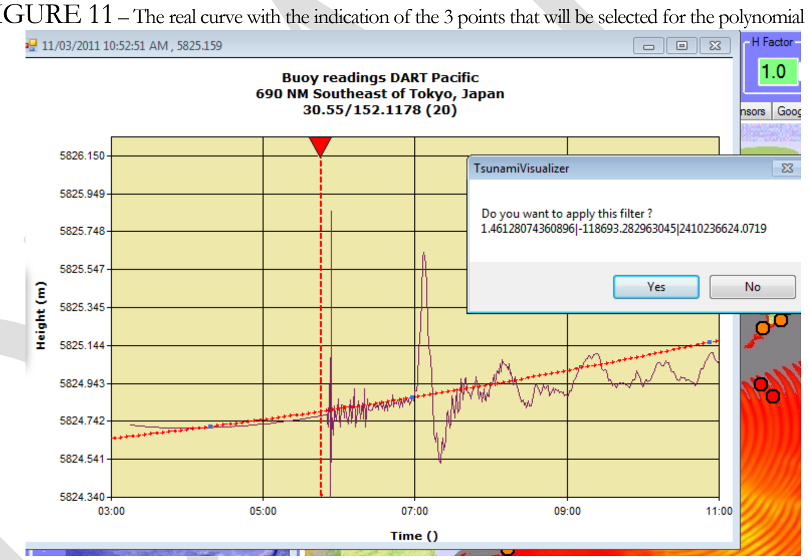


FIGURE 12 – The red curve obtained from the 3 points selected

As an example in the same example previously indicated the real signal is the one in FIGURE 11, where 3 points are selected: before the event, close to the main peak and at the end of the period. The red dotted curve in FIGURE 12 is the resulting polynomial curve that is removed to the real value to obtain the true Tsunami signal.

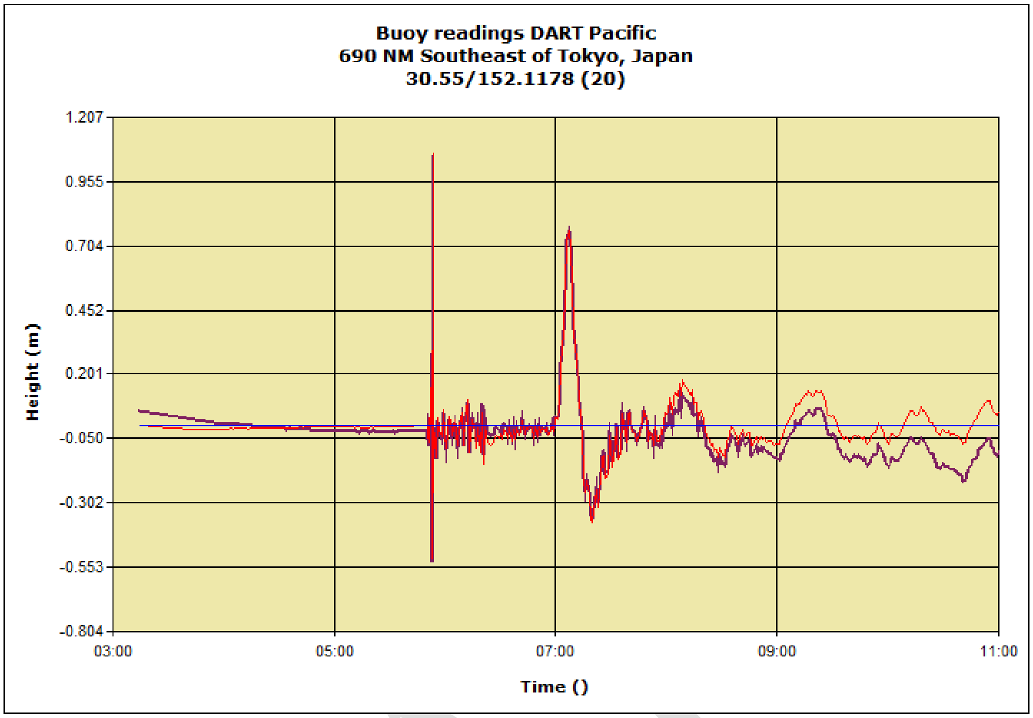


FIGURE 13 – The brown thick curve is the one obtained with 3 points filter, the red one is obtained with 100 points Moving average

☞ **The 3 points filtering** method is better respect to the one with the moving average because it does not cut frequencies to the signal. However it is a bit more time consuming (change visualization mode, selecting the points, redraw). Therefore it is generally used in order to validate the Moving Average method and check the correct number of points to perform the average.

As it can be seen by the FIGURE 13 the trend is comparable with the 100 points moving average. The only exception is at the borders where there is a deviation which was also visible in the dotted curve of FIGURE 12.

This method is particularly useful with tidal gauges which in general have a much lower acquisition frequency and therefore sometimes the moving average is unable to work properly.

FFT Method

This method aims at establishing a low pass and high pass cut filters on the Fast Fourier Transformation (FFT) on the curve and reconstruct it using the remaining part of the components in the frequency domain. The FFT is a method to find the coefficient of the Fourier series approximating a curve. The coefficients represent the weight of each cosinus or sinus series component of increasing frequency that, once rebuilt, allows to approximate the curve. Every point in time can be expressed as

$$Y(t)=a0+\Sigma_i(a_i*\cos(2\pi*i*t/\Delta T) + b_i*\sin(2\pi*i*t/\Delta T)) + \varepsilon$$

Where ΔT is the time interval min max in which interpolation is obtained. Considering that the tidal component is a long period component in the order of at least 4 h while the level change due to the Tsunami has a shorter period of about 10-15 min, it is possible to apply at the same time a high pass filter to remove the tidal component and a low pass filter to remove the noise on the signal. The filtering is performed considering only the components of the series whose frequency is within the required filter band.

FIGURE 14 shows the power spectrum of the curve of the examples above. By selecting a high pass filter period at 1h (f=0.00027 Hz) and low pass filter period at 6 min (f=0.0027 Hz), the resulting curve is compared with the moving average at 100 points in FIGURE 15. It is possible to see that the filter is able to remove almost completely the initial peak due to the earthquake and shows a considerably smooth trend in the rest of the curve. However the maximum peak is slightly reduced.

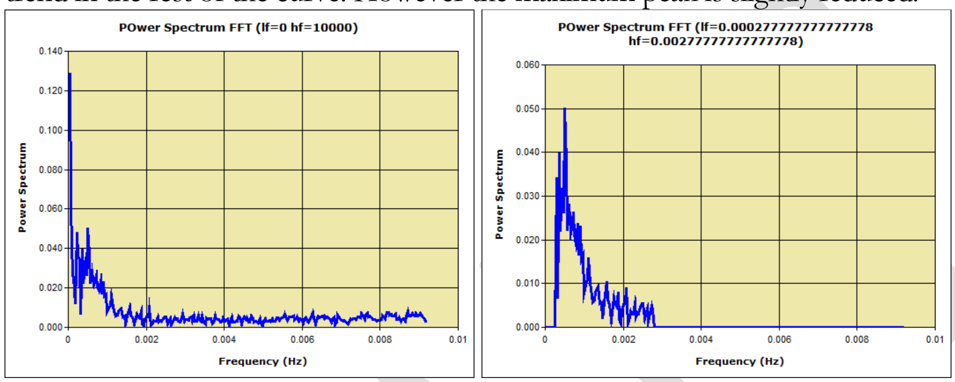


FIGURE 14 – Power spectrof the curve: left without filtering, right filtering high pass filter at 1h (0.00027 Hz) and 6 min (0.0027 Hz) as low pass filtering

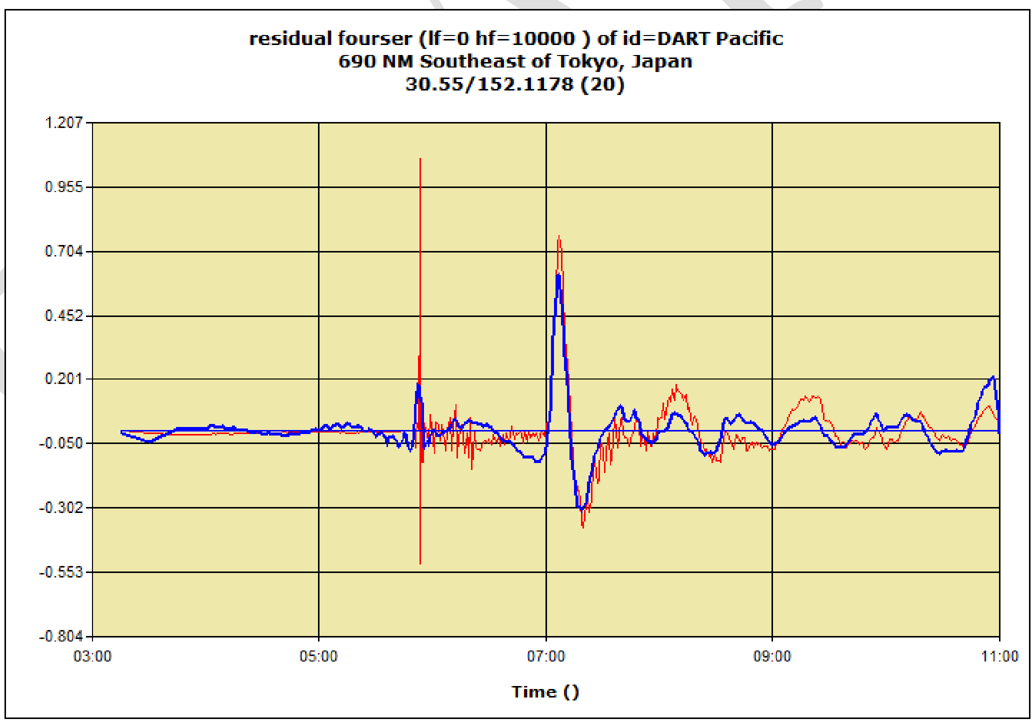


FIGURE 15 – Resulting curve after application of FFT filtering (blue curve) compared with the Moving average with 100 points

Xtide32 tide removal

This method aims at calculating the real tidal component using an external programme (xtide32, http://www.wxtide32.com/). The algorithm that XTide uses to predict tides is the one used by the National Ocean Service in the U.S. XTide reads these data from *harmonics files*. These harmonics files are not available everywhere and therefore the method is correctly and successful only in some locations of the world. Where a location does not exists a procedure allows to try to estimate and adapt the tide evaluation to the measured trend.

The tide removal method is particularly useful when the Tsunami phenomenon extends over one or two periods (ex. Analysis of Tropical Cyclones data) because in this case the previous methods (moving average or 3 points filter) do not work properly. In addition this method is useful to estimate values at the coast because most of the locations present in xtide database are ports at the coast; as a consequence this method should not be used for DART buoys which are offshore.

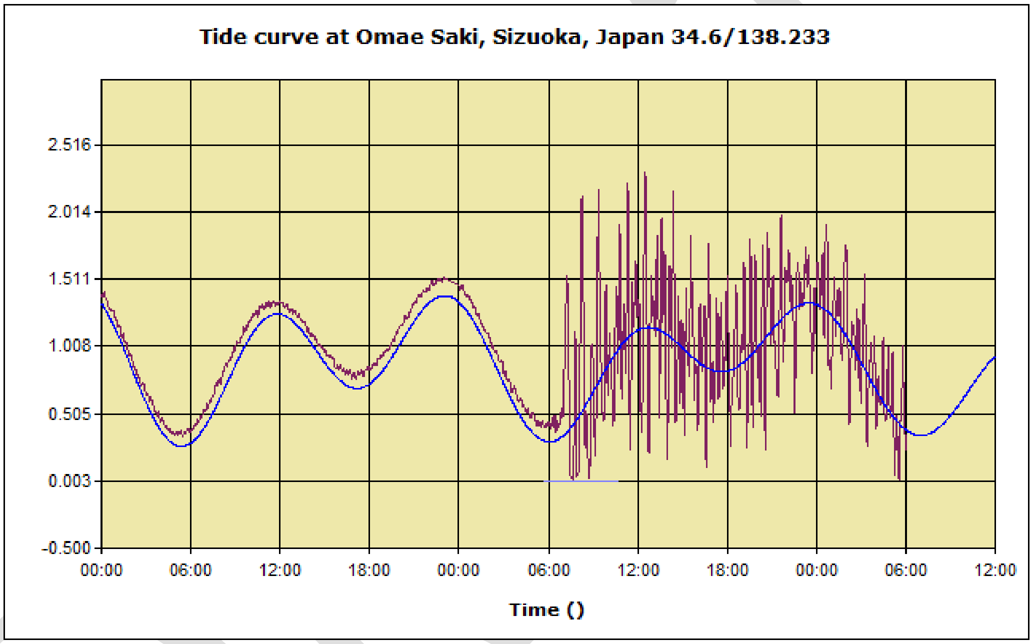


FIGURE 16 – The brown curve is the real signal and the blue curve is the calculated tide

The example of the above figure is related to a location, Omaezaki (or Omae Saki), located at lat/lon 34.6/138.23 for which there is a prediction location in the xtide database, which is not always the case however. As it can be seen the prediction is fine but there is a slightly offset in the curve which would lead to a positive component of the signal even before the event. Therefore a procedure has been included which consists in selecting one minimum and one maximum of the measured signal; the programme will then use the times to include a time offset and an offset and a multiplication factor to take into account the different amplitude (e.g. the curve is forced to pass through the 2 minimum and maximum points). The result is that it is so possible to have a better residual curve (see FIGURE 17).

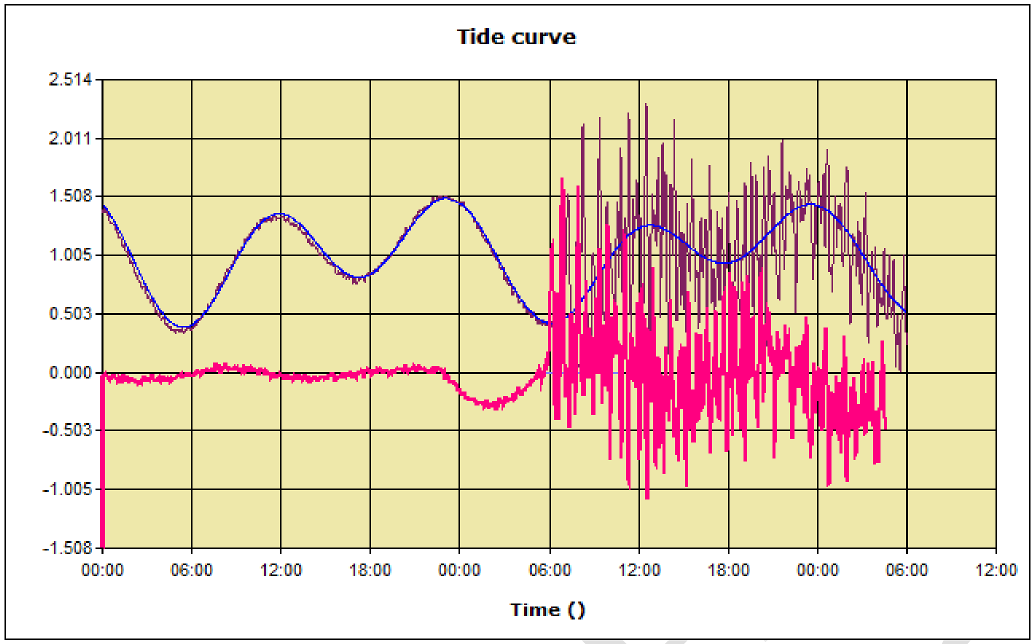


FIGURE 17 – The brown curve is the real signal and the blue curve is the calculated tide corrected with the 2 points procedure while the pink curve is the residual, the difference among the two curves.

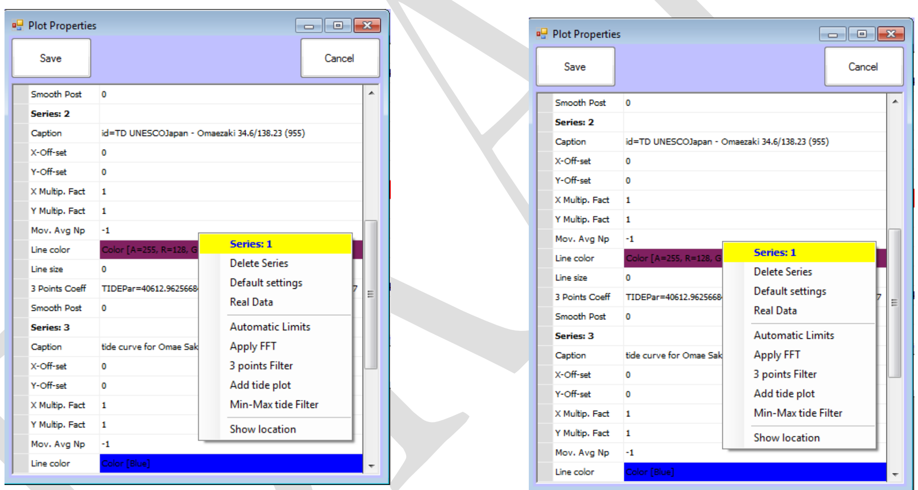


FIGURE 18 – Possible options included in the menu for each quantity

FIGURE 18 shows the various possible options that can be selected, as described in the previous paragraphs.

Chapter 4

Sea Level Database and Synchronizing strategies

This section describes how to keep updated the sea level database and how to synchronize their data

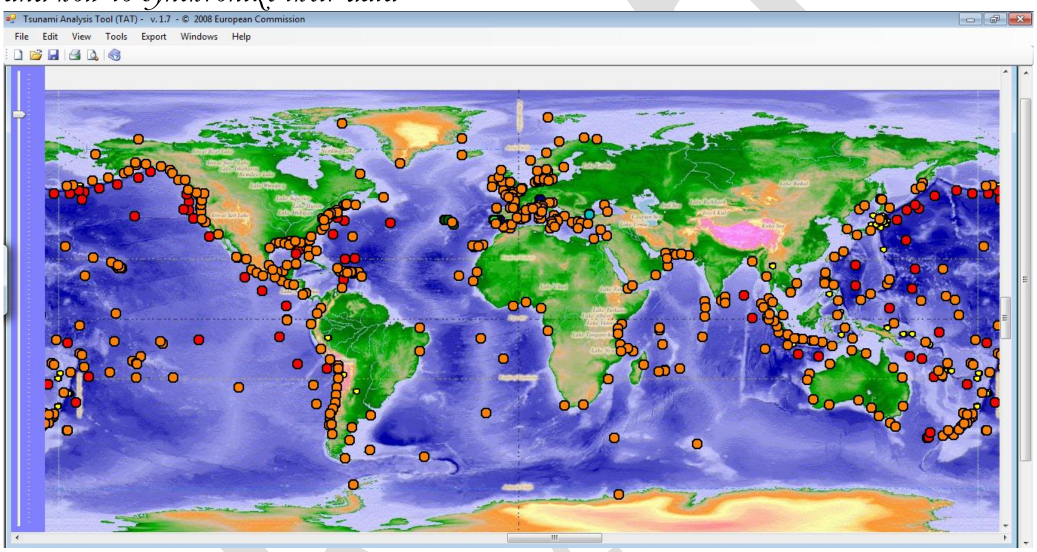


FIGURE 19 – Current distribution of sea level network that can be used to understand the sea level behavior during a Tsunami

An important component in the Tsunami analysis is the on line availability of sea level measurements. The two most important sources of information for these quantities are: the network of DARTs (Deep-Ocean Analysis and Reporting on Tsunamis, http://nctr.pmel.noaa.gov/Dart/) from NOAA and the Sea Level Monitoring Facility (http://www.ioc-sealevelmonitoring.org/), in the frame of the GLOSS programme from UNESCO.

The DART network is a series of deep Ocean pressure sensors located offshore in strategic positions to catch the initial Tsunami waves and be able to give indication on the sea level in open sea. These are particularly important because they allow an easy comparison with the calculated quantities from codes and thus allow to judge about the correct definition of the fault parameters. NOAA uses the DART network in order to identify the "real" deformation and thus *forecast* the prediction to the coasts using a novel technique[1].

[1] When a tsunami event occurs, the first information available about the source of the tsunami is based only on the available seismic information for the earthquake event. As the tsunami wave propagates across the

The GLOSS network is aimed at collect and disseminate data related to real time sea level tidal gauges. Initially it was 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. The system 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).

FIGURE 20 – The first operational DART® buoy system design is shown in the photograph on the left (NOAA web site)

Other sources of information may be included in the list of possible real time data. At the moment of writing we included also

- Sea level measurements from Portugal
- Sea level measurements from Turkey
- Sea level measurements from Italy (ongoing)

Some of these sea level measurements are already included in the GLOSS system but due to bilateral agreement with JRC it is possible to access higher frequency data or get a more frequent update, and thus reducing the time delay.

FIGURE 19 shows the current distribution of sea level sensors that can be used during a Tsunami event. The list is contained in the local database and in the server database (see later) and can be automatically or manually updated as there are new devices available.

ocean and successively reaches the DART® systems, these systems report sea level information measurements back to the Tsunami Warning Centers, where the information is processed to produce a new and more refined estimate of the tsunami source. The result is an increasingly accurate forecast of the tsunami that can be used to issue watches, warnings or evacuations

Data Storage location and working modes

TAT has two methods for storing and accessing the data of the sea level: on the local computer or on a server accessible via internet.

Local Database

The TAT uses an Access Database named *tsvis.mdb* and located in the subdirectory /DB in the installation directory. This database contains several tables that are needed for the working ***BuoyData*** and as it can be guessed contain: the location and the characteristics of each sensor and the data points that are read online from the various providers.

Online Mode

In this mode the database is located in Ispra and a procedure automatically reads the sea levels from the related sources and store the level data on a SQL server database. The access from TAT is performed via a web service which provides the data within a specified interval for any particular sea level gauge

> ☞ ***Local*** **or** ***Online*** **mode ?** The **Local** method has the advantage that the database is always available even if there is no internet connection. This method is particular useful for off-line checking of events. However in this case it is necessary to synchronize The Online mode means that all the gauges are synchronized by a dedicated procedure and there the data can immediately be used. As the network is not available the comparison is no longer possible.

Data Syncronization

The synchronization of the tide gauges, in the case on Local database is performed by activating the sync procedure. This can be activated for all the sea level gauges or only for the sea level gauges in the window that is being analysed or only for a special gauge. The sync can be manual or automatic at an interval of 5 min.

SYNC ALL THE GAUGES

The automatic sync of all the tidal gauges is performed by selecting the option *Tools>Buoys>Sync*. A window open where a command "*Sync now*" is present. The pressing of this command performs only one sync of all the tidal gagues. A check box, identified by the label "Activate timer" allows to perform a periodic sync at an interval indicated on the same window; the interval can be modified by the user.

> ☞ ***Auto sync in a parallel instance***
> If you prefer to adopt the local database to store and retrieve the sea level data, it may be a good practice not to use the current TAT programme for a continuous sea levels sync because it may interfere (slow down) the programme itself. Its better instead to launch another instance of the programme that keep updating the database so that the data are already updated when needed.

SYNC BUOYS IN THE ANALYSIS WINDOW

When an analysis in performed and a window is open, as described in the chapter 2, in which only a limited number of tidal gauges is shown, the option that is activated with the menu "*Options>Sync buoys in window*" allows to sync only the gauges in the window and no other gauges that may be not interesting.

SYNC ONLY ONE BUOY OF INTEREST

This can be done in two ways: by clicking the right button of the mouse over one buoy and selecting the menu item *Sync buoy* or, when plotting a sea level, by selecting in the plot options window, the item labeled as "Auto sync buoys". With this option all the buoys that have been plotted are periodically synchronized. Therefore using this option in connection with "Auto refresh" option in the same menu item, it is possible to continuously update a plot with always new data.

Update of List of Buoys

The list of available buoys change from time to time and sometimes some of the buoys become obsolete and useless when analyzing an event. Therefore periodically (once a month) it is a good practice to check if there are new sensors being published by NOAA or by GLOSS.

This is performed by selecting the item *Tools>Buoys>Update List*. The programme connects with the relevant sites and presents a list of new sensors. In the resulting window a button allows to update the list automatically.

It is also possible to manually update the list of sensors by adding a new row to the table **BuoysLocations** in the **tsvis.mdb** database.

This is an example of record in this table

buoysLocations																			
ID	lat	Lon	latDegMin	lonDegMin	name	status	groupID	fileType	sensor	filename	Notes	Online	X Multiplication Factor	Y Multiplication Factor	X-offset	Y-offset	MovAvgNp	Label
65	-5.3633	165.0467	5° 21' 48" S	165° 2' 48" E	Station 52406 - 450 NM Northeast of the Guadalcanal	active	2	DART		http://www.ndbc.noaa.gov/data/realtime2/52406.dart			1	1	0	0	20	

This is the explanation of the various fields

- ID: *don't fill, is an automatic number. All the acquired data contains this as BuoyID*
- Lat: *latitude in decimal degrees*
- Lon: *longitude in decimal degrees*
- latDegMin: *If you do not know Lat in decimal degrees, you can insert here the latitude in the following form: D° mm' ss" S/N, example 5° 21' 48" S*
- lonDegMin: *same as above with the exception to write E or W for east or west*
- name: *description of the sensor*
- status: *active or inactive*
- groupID: *this is a number that has a correspondence in the Groups table, see later*
- fileType: *indicates the form of the data see after*
- sensor: *ignore, future use*
- filename: *this can be a filename or an internet address containing the data in the form specified by fileType*
- Notes: *free text*
- Online: *yes or no*
- X Multiplication Factor: *the time data read are multiplied by this factor (default 1)*
- Y Multiplication Factor: *the value data read are multiplied by this factor (default 1)*
- X-offset: *the time data are moved by this factor (default 0)*
- Y-offset *the value data are moved by this factor (default 0)*
- MovAvgNp: *this is the default vale for the Moving Average filtering procedure (see previous chapter). The normal for tidal gauges is 20, for DART is 60. Indicate -1 if you want to see the real data, without filtering*
- Label: *this is a label appearing as Y label. If null it is Level (m)*

The possible formats of the data are the following:

AZO TD: Azores University data

BOM: Bureau of Meteorology Data, Australia

DART: NOAA DARTs

GITEWS: used for a specific sensor in Indonesia

GLOSSxml: common method by GLOSS, XML format

PT TD: format for Portugal sea levels

SET: format for Setubal buoy

TAD_P: format for Tsunami Alerting Device, pressure curve

TAD_T: format for Tsunami Alerting Device, temperature curve
TR: Turkey sea level sensors

It is always possible to add new buoys manually but one of the above formats has to be specified. If the format is another one, you need to contact JRC for an update of the software after specifying the required format.

Chapter 5

Seismic Events Collection

This section explains how to collect automatically data seismological data from various sources

TAT contains a section that allows to monitor ongoing seismic events that may be the ones that are then analysed for a potential Tsunami. By selecting the option *Tools>Seismic Events* the window below will appear reporting the timeline of the seismic events.

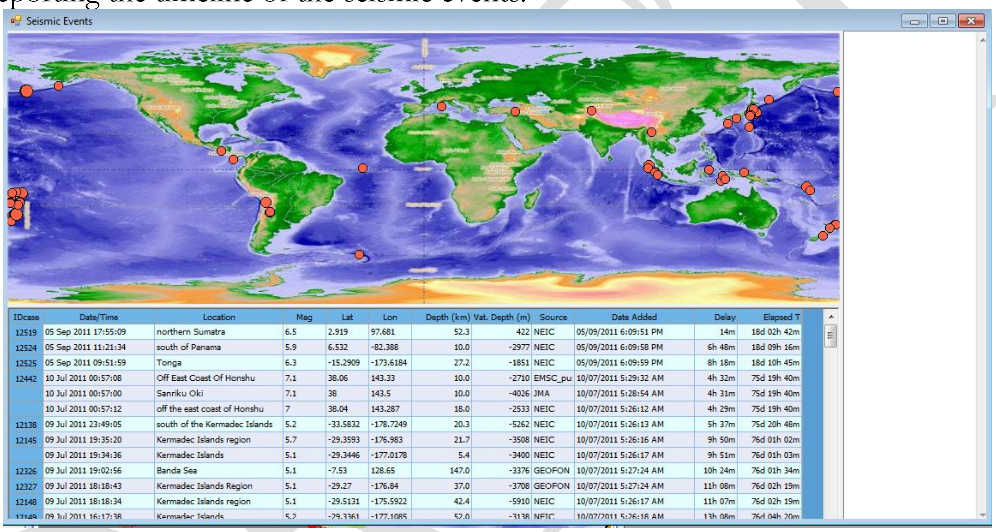


FIGURE 21 – The seismic events window in TAT

In order to update the list of events, it is necessary to activate the item *Scraping>Enable Scraping* and the system will start collecting the events by connecting with the sources that are defined in the **tsVis.mdb** database, table **Seismic Feeds.** From this moment every 5 min a new check is performed or it is possible to use the option *Scraping>Scrape Now!* If you want to execute immediately the scraping of the events.

It is possible to add new seismic feeds but the format has to be agreed with JRC that has to provide the right interface to read the data. At the moment we are using the following sources of information:

Seismic Feeds	
name	**URL**
NEIC	http://earthquake.usgs.gov/eqcenter/catalogs/eqs7day-M2.5.xml
EMSC	http://www.emsc-csem.org/index.php?page=current&sub=list
INGV	http://cnt.rm.ingv.it/~earthquake/index_web_cnt.php

Seismic Feeds	
name	**URL**
BMG	http://www.bmg.go.id/dataxml/gempaterkini.xml
GEOFON	http://geofon.gfz-potsdam.de/db/eqinfo.php
JMA	http://www.jma.go.jp/en/quake/quake_local_index.html
IRIS	http://www.iris.edu/seismon/last30.html
IM_push	http://www.gdacs.org/earthquakes/push.asp?mode=rss&source=IM
EMSC_push	http://www.gdacs.org/earthquakes/push.asp?mode=rss&source=EMSC

In some cases the scraping page is an XML file while in other cases (ex. JMA) it is a web page and it is necessary then to navigate in further links to get all the required information.

Double clicking on one of the events the following window opens which has a number of tabs and this represents the starting point when analyzing a totally new event.
The left window contains the event characteristics and shows if there is an event in the scenario database that can represent it. If you want to check this event you should click on "Open" and the results of the scenario database are shown.

By selecting the tab labeled "Seismic Matrix" the evaluation of the event using IOC type of matrix is presented. For the event below, for example (M7.1, Off East Coast Of Honshu of 10 July 2011 00:57:08) the seismic matrix foresees a Tsunami Watch /Warning.

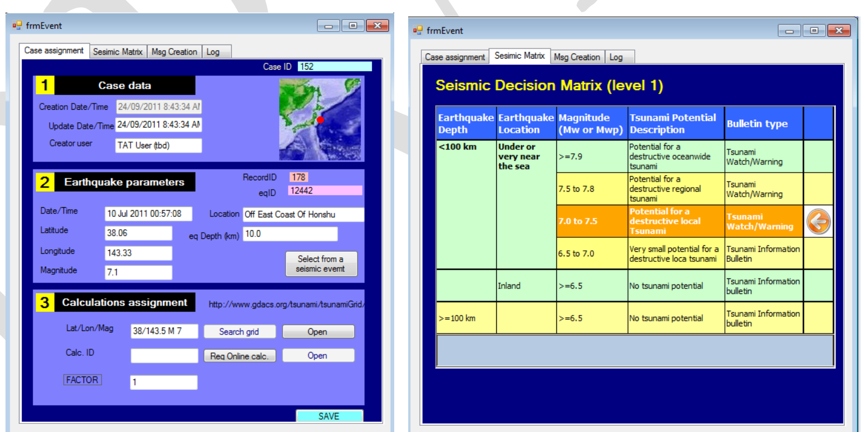


FIGURE 22 – The seismic events analysis

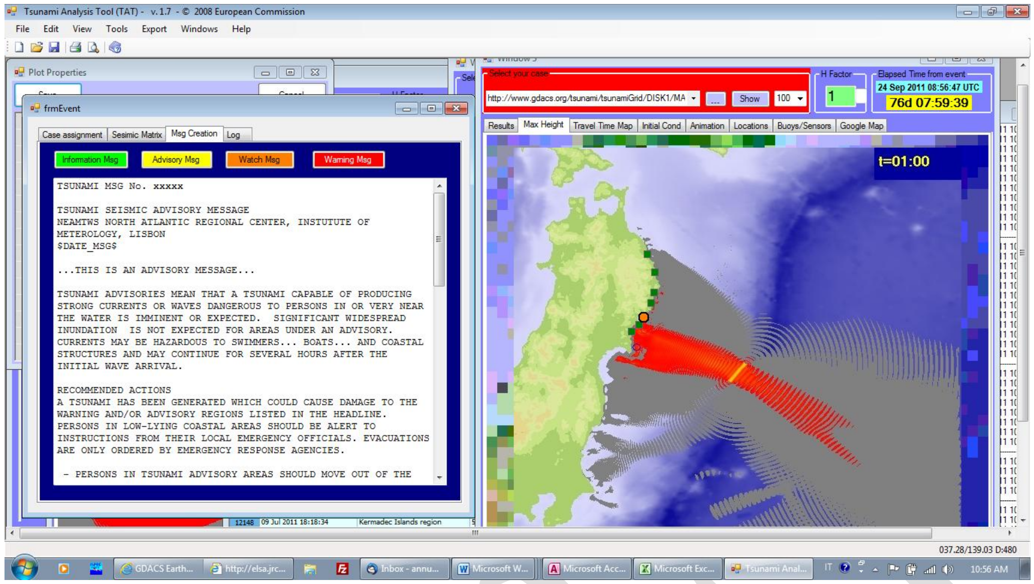


FIGURE 23 – The bulletin creation

By selecting the tab labeled "Msg Creation" a bulletin is created depending on the type of requested information (Information or Advisory, etc). The parameters to compose the message are obtained by the event window and by the forecasted points window. The text of the message is configurable and is contained in the **tsVis.mdb** database, table **Options**, keywords InfoMsg and AdvisoryMsg.

In the InfoMsg and AdvisoryMsg there are keywords that represent information for the message

$TIME_MSG$: current date of the message
$LIST_CALC$: list of locations and forecasted height
$MAGNITUDE$: magintude of earthquake
$TIME_EVENT$: time of the event
LAT_LON : latititude and longitude
$LOCATION$: textual information on the location
$DEPTH$: earthquake depth

A sample message composed with the information above for the previous event, takes the form below. From the window it can be cut and pasted in real bulletin, adjusted in the text and sent out via email or other alerting messaging system. It is a quick way to facilitate the preparation of the bulletin.

TSUNAMI MSG No. xxxxx

TSUNAMI SEISMIC ADVISORY MESSAGE
NEAMTWS NORTH ATLANTIC REGIONAL CENTER, INSTUTUTE OF METEROLOGY, LISBON
$DATE_MSG$

...THIS IS AN ADVISORY MESSAGE...

TSUNAMI ADVISORIES MEAN THAT A TSUNAMI CAPABLE OF PRODUCING STRONG CURRENTS OR WAVES DANGEROUS TO PERSONS IN OR VERY NEAR THE WATER IS IMMINENT OR EXPECTED. SIGNIFICANT WIDESPREAD INUNDATION IS NOT EXPECTED FOR AREAS UNDER AN ADVISORY. CURRENTS MAY BE HAZARDOUS TO SWIMMERS... BOATS... AND COASTAL STRUCTURES AND MAY CONTINUE FOR SEVERAL HOURS AFTER THE INITIAL WAVE ARRIVAL.

RECOMMENDED ACTIONS
A TSUNAMI HAS BEEN GENERATED WHICH COULD CAUSE DAMAGE TO THE WARNING AND/OR ADVISORY REGIONS LISTED IN THE HEADLINE. PERSONS IN LOW-LYING COASTAL AREAS SHOULD BE ALERT TO INSTRUCTIONS FROM THEIR LOCAL EMERGENCY OFFICIALS. EVACUATIONS ARE ONLY ORDERED BY EMERGENCY RESPONSE AGENCIES.

- PERSONS IN TSUNAMI ADVISORY AREAS SHOULD MOVE OUT OF THE WATER… OFF THE BEACH AND OUT OF HARBORS AND MARINAS.

THIS MESSAGE IS BASED ON EARTHQUAKE DATA… OBSERVED TSUNAMI AMPLITUDES… HISTORICAL INFORMATION AND FORECAST MODELS.

A TSUNAMI HAS BEEN OBSERVED AT THE FOLLOWING SITES
… or … if based on calculations
A TSUNAMI IS FORESEEN AT THE FOLLOWING SITES

LOCATION	LAT	LON	TIME	AMPL
KAMAISHI - JAPAN	39.2N	141.8E	12:57 UTC	0.2M/0.6F
OMOTO - JAPAN	39.8N	141.9E	12:57 UTC	0.2M/0.6F
YAMADA - JAPAN	39.4N	141.9E	12:57 UTC	0.1M/0.3F
KESENNUMA - JAPAN	38.8N	141.6E	12:57 UTC	0.2M/0.6F
KUJI - JAPAN	40.1N	141.8E	12:57 UTC	0.1M/0.3F
MINATO - JAPAN	38.7N	141.5E	12:57 UTC	0.2M/0.6F

TIME - TIME OF MEASUREMENT OR CALCULATION
AMPL - TSUNAMI AMPLITUDES ARE MEASURED RELATIVE TO NORMAL SEA LEVEL. IT IS …NOT… CREST-TO-TROUGH WAVE HEIGHT.
VALUES ARE GIVEN IN BOTH METERS(M) AND FEET(FT).

PRELIMINARY EARTHQUAKE PARAMETERS
MAGNITUDE - 7.1
TIME - 0057 UTC SUN JUL 10 2011
LOCATION - 38.06 NORTH 143.33 EAST
OFF EAST COAST OF HONSHU
DEPTH - 10.0 KM

Chapter 6

Current Calculations by JRC and NOAA

This section explains how to access and analyse online events

When a new event occurs the GDACS system or other online systems can activate a calculation in the JRC online system. It is therefore possible to analyse these events while the calculations are still ongoing. Similarly NOAA publishes a list of "solutions" from their database that can represent the ongoing event based on seismic parameters; in some cases they also publish the "real" solution based on the analysis based on the inversion technique, see later.

JRC Online calculations

The calculations are triggered by the GDACS system or by a web server in which several data providers (USGS, EMSC, Portuguese IM, Turkey Kandilly) write their data and can trigger a new calculation.

The list of available calculations is obtained by selecting *Tools>Current Calculations.* All the requested calculations are listed in order of request; which means that for one event there may be 5-10 calculations depending on the evaluation and the estimate made by the various organizations.

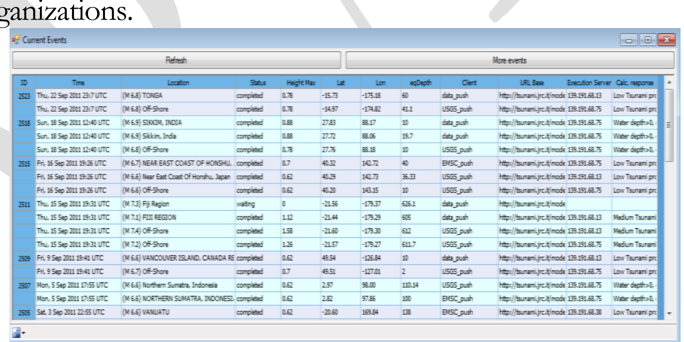


FIGURE 24 – The list of performed calculations

In order to select one calculation you need to double click on the line representing it. A window of analysis is open and you can use all the features explained in Chapter 2 to analyse the event.

Once an analysis window is open and you want to use this window (and not for example the one coming from the scenario database) as basis for the issuing of the alerting bulletins, you should press the menu item "*Set this as event calculation*".

The online calculations are performed automatically with the conditions estimated by the seismological organizations. It is always necessary to compare them with the real online measurements available in order to judge how the initial conditions in the calculations are representative of the real conditions.

NOAA unit source scenario results

During the analysis you can compare the calculated quantities with the sea level. Also you can compare the calculations for the same point with an equivalent value estimated with the NOAA unit sources analyses. This is a method developed by V. Titov from PMEL/NOAA that consists in the approximation of the real deformation source as a series of "unit source" each one being 100km x 50 km of unitary height. Each of this corresponds to an earthquake of about 7.5 magnitude. Composing various sources and identifying the multiplication factors per each source, it is possible to simulate greater events or smaller events (e.g. one source with multiplication factor lower than 1).

In the logic of the Tsunami forecasting (http://nctr.pmel.noaa.gov/propagation-database.html), it is then possible to "invert" the solutions by comparing them with the measured DART sea levels and obtain the "true" solution which consists in the list of factors that needs to be multiplied the selected unit sources to have the better agreement with the measured quantities. For example in the case of Tohoku earthquake of 11 March 2011 the "seismic" solution was represented by the following expression

15.70*kiszz26+15.70*kisza26+15.70*kiszz27+15.70*kisza27+15.70*kiszy26+15.70*kiszy27+15.70*kiszb26+15.70*kiszb27

which indicates that the sea level is obtained, for each point by the linear combination of the results of 8 unit sources, each multiplied by the factor 15.70 (m). The various unit sources are identified by the keywords kiszz, kisza, etc.

After comparing this with the sea level measurements the resulting solution is the following

4.66*kiszb24+12.23*kiszb25+26.31*kisza26+21.27*kiszb26+22.75*kisza27+4.98*kiszb27

which shows a different list of sources and different factors for each of them.

The list of solutions from NOAA is shown by selecting *Tools>NOAA events*.

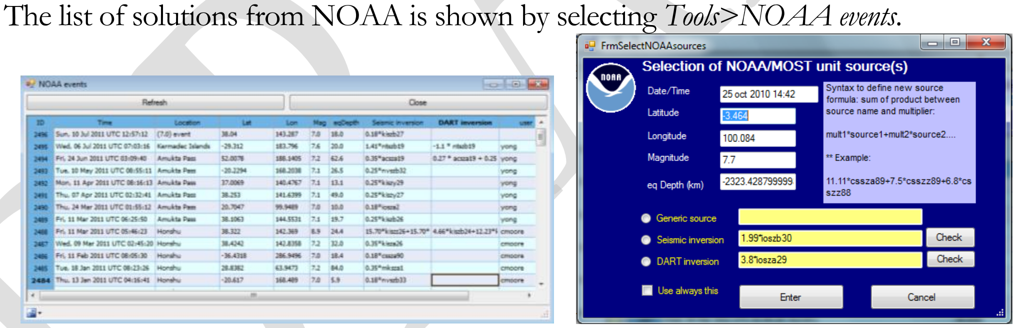


FIGURE 25 – The list of events in the NOAA site (left) and window to enter the specific source combination to analyse

It is possible verify the result of the solutions by selecting one of the DART sensors, create a sensor at the buoy position and right click on the sensor specifying Add NOAA result; in the following window you should select one of the proposed solutions or write your solution yourself. In the figure below the DART value (brown curve) is compared with the NOAA seismic solution (red curve) with the solution coming from the inversion process (green curve). The NOAA unit sources solution should only be used off-shore because they have been obtained with a 4 min bathymetry which is not suitable close to the coast.

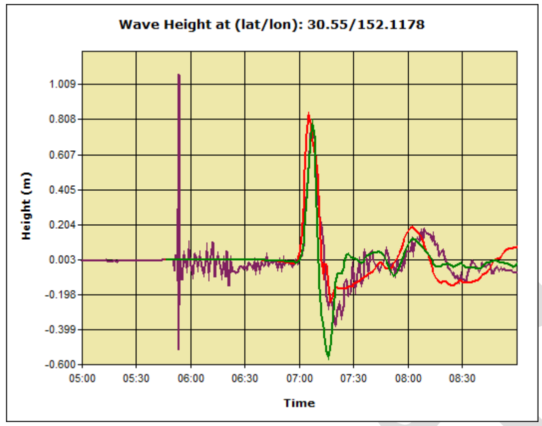


FIGURE 26 – Example of NOAA solution for the Tohoku earthquake at the DART named Pacific 690 NM Southeast of Tokyo

Chapter

7

Simulation mode

For Training purposes TAT allows to play an existing event to check the response of operators.

FIGURE 27 – Situation room during a Tsunami Analysis
(European Crisis management Lab, JRC Ispra)

If a Tsunami is a very unlikely event it is also true that is not very often. This means that the operators of an emergency center do not have many possibilities to put in practice their skills in the use of this programme. It is therefore important to organize simulation training sessions on a periodical basis. TAT foresees the use of a procedure that uses stored values for the measurements and the calculations that are slowly made available in order to simulate an ongoing event.

The simulation mode is initialized by opening a new Analysis window and calling one event (scenario or online calculation, on the disk or online) and then selecting the item *Options>Start Simulation Mode*. The window represented below is open which allows to control the simulation.
With reference to the FIGURE 28:

Zero Time: is the time of the initiating event, cannot be changed

Accel Factor: is the factor accelerating the time. Any value can be used but a real event should have factor 1. To save time you can increase the factor to 5 or 10 times the real time.

Start Time: In a real event the operators will start looking at the event after the identification of the earthquake, i.e. 10-15 min. This time is the time from which the simulation will start. The format is hh:mm.

Refresh interval: It is the time in s for the refresh of all the curves (15 s or 30 s is fine)

Calc/real time ratio: When comparing with a calculation this controls how fast the calculation is. In general during a real event the online calculations are executed with a calculation speed higher than real time. If this ratio is 2 it means that after 1h the calculation is already at 2 h simulation time. Using 1 or lower the calculation is equal or slower than real time (no forecasting).

During the simulation mode, the use can perform any analysis operation that is possible in a real event, such as creating sensors, comparing with buoys sensors, zooming in the plots etc. The curves representing the buoys, however, are shown "as if" the time is advancing from the starting time, as indicated in the analysis window while the calculated quantities advance according to the current time eventually accelerated by the calc/real time ratio.

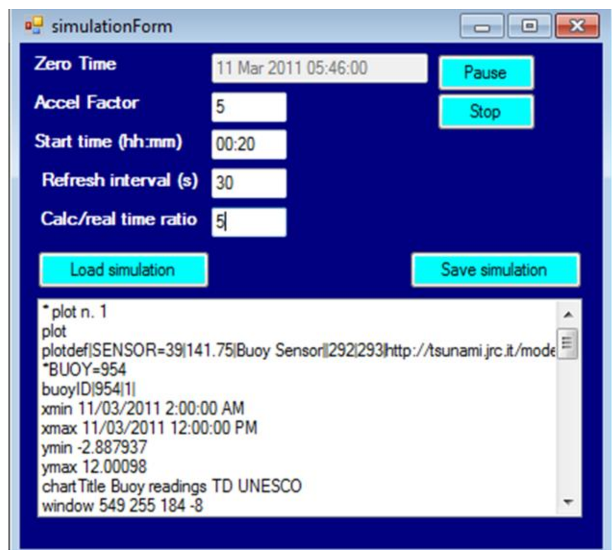


FIGURE 28 – Simulation form

FIGURE 29 – When the simulation starts the time shown in the analysis window shows the current simulated time and the simulated time from the event

When a situation of windows, limits and curves established is established, it is possible to save the simulation for further analyses by pressing the button *Save simulation* and reload it at a later stage with *Load simulation.*

As it can be seen in FIGURE 30, the curves are updated only until the current simulated time (see

> ☞ ***Proper selection of simulation cases***
>
> In order to perform a simulation session, it is better to use a case which is stored on the disk (i.e. scenario case or a dedicated analysis) instead of using an online calculation because the access time to the server can limit the simulation speed and makes the application less responsive.

also FIGURE 29). It should be noted that the plots are not automatically refreshed, as it should be in a real case. In order to auto refresh you have to activate the option in the plots property page.

One possible way of using the Simulation mode is that a trainer could establish a new case and the trainee should select the corresponding scenario and try to estimate the evolution of the event.

Simulations or replay of past events are essential to be ready during the next event.

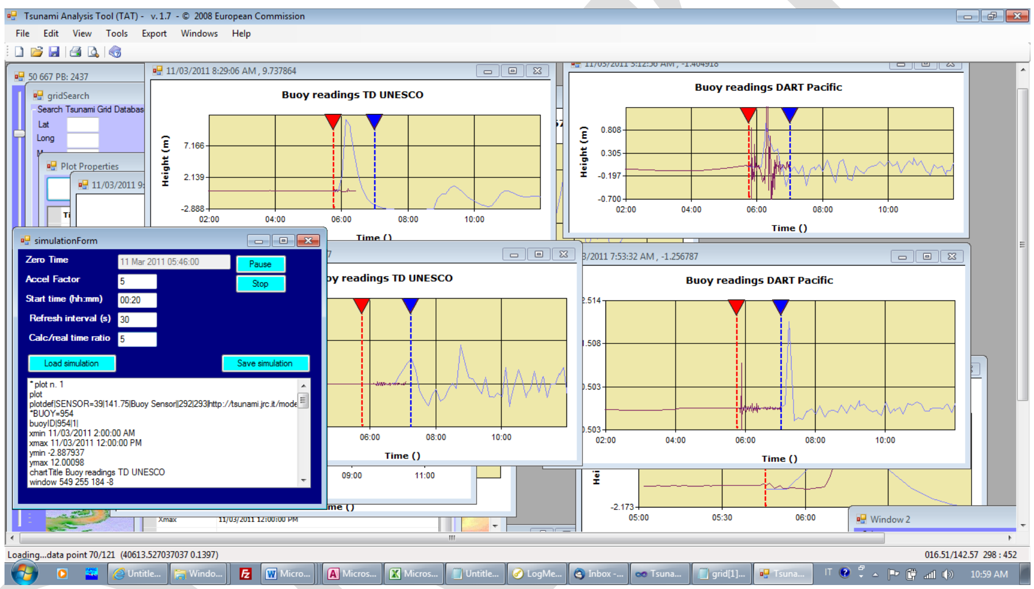


FIGURE 30 – Simulation mode with some windows open

Chapter

8

Request an online calculation

It is possible to request an online calculation to the JRC system by specifying the initial conditions of the event

Calculation of specific events may be requested online. In order to do so use the option: *Tools>Request a calculation*. An authentication form will be shown. User and password to access the calculation mode have to be requested to JRC.

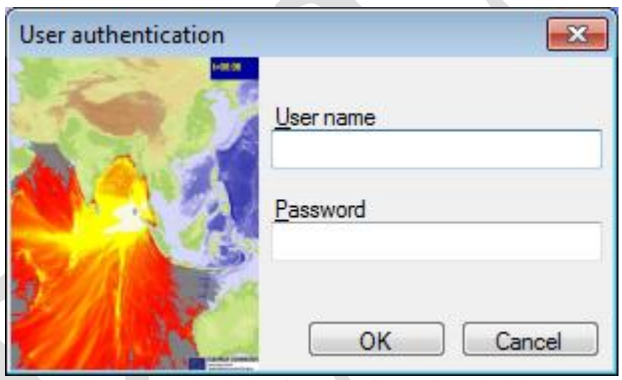


Figure 31 - Authentication form to perform online calculations

The form below will open in order to collect the necessary data to perform the calculation. It is possible to specify a very limited number of information (lat/lon/mag/depth) and the system will automatically initialize the calculation with these data. In alternative it is possible to define the fault parameters (strike, dip, rake, width/length,slip) and the system will define the rest of the needed quantities (width of the calculation space, time step etc).

The objective of this form is not to allow to perform a detailed calculation analysis but rather to give the analyst a simple tool to analyze a potential event. Therefore it is not possible to specify the width of the calculation or perform a nested approach. For this other tools should be available whose result may then be analysed with TAT if the output is conform to it.

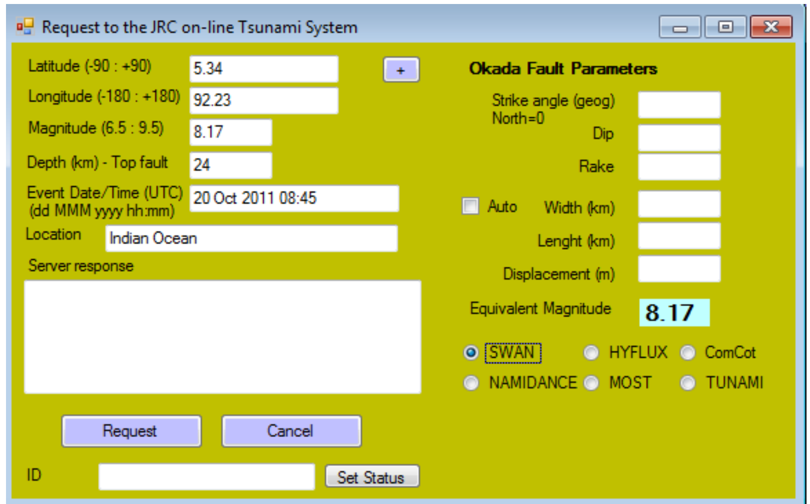


Figure 32 – Data input form for the online calculation

In principle it is also possible to select the code to perform the calculation; by default this is SWAN but other codes will be possible (option not yet available).

The result of the calculation will be stored online and therefore it may be accessible by all users having TAT.

This section is being developed. Therefore there are not so many details. It may change in the next future in terms of input and masks and the manual will be updated accordingly.

Chapter 9

Scenario databases

TAT relies on pre-calculated scenarios in order to have a quick estimate of the event

Scenario databases are a series of pre-calculated events that can be called and analysed as well as compared with real data. At the moment JRC relies on a number of scenario databases built with different initial condition logic. During a real event, if the online calculations are not yet available, it is possible to search and use the scenario databases results as a first approximation of the real events.

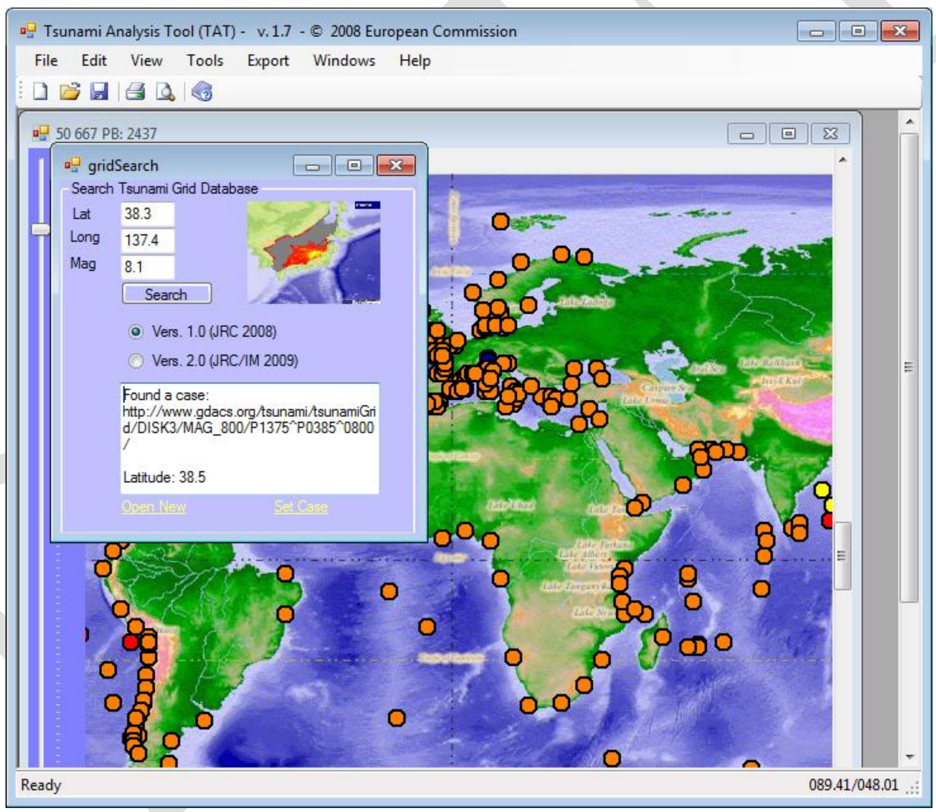


FIGURE 33 – Search window

When opening TAT by default the search window is open. If closed during the operations, it is possible to reopen it by selecting *Tools>Grid>Search grid*. The window allows to specify Latitude, Longitude and Magnitude of the event. At the moment there are two possible choices for the scenario, the JRC 1.0 or the JRC/IM 2.0. Other scenarios will be added in the next months. The JRC scenario has a worldwide coverage and has been composed using simple cosinusoidal deformation, with a maximum height established using a simple logarithmic formula, as indicated in Annunziato 2007. The JRC/IM scenario has been defined by JRC and Institute of Meterology (Portugal) and contain scenarios in the North Atlantic Region.

Pressing the search button TAT search in the location specified in Options>Grid>Grid Location the closest event. For example, specifying 38.3/137.4 as Lat / Lon and magnitude 8.1 and searching in www.gdacs.org, the system will answer with the following text:

```
Found a case:
http://www.gdacs.org/tsunami/tsunamiGrid/DISK3/MAG_800/P1375^P0385^0800/

Latitude: 38.5
Longitude: 137.5
Magnitude: 8
```

which indicates that one case close to the requested point has been found that can represent the requested case. By clicking on "*Open new*" the Analysis window below is open and it is possible to analyze the case as previously indicated for other analyses windows. It should be noted that the date assumed for the event is the current date which may be not representative of the case to be analysed; it can be changed by double clicking on the date and entering the right one.

It is a current practice, when analyzing an ongoing event to open at the same time of an online calculation, also the corresponding scenario result because while the online calculation is going on, the scenario result is immediately available and can already give a first identification of the possible effects of the event.

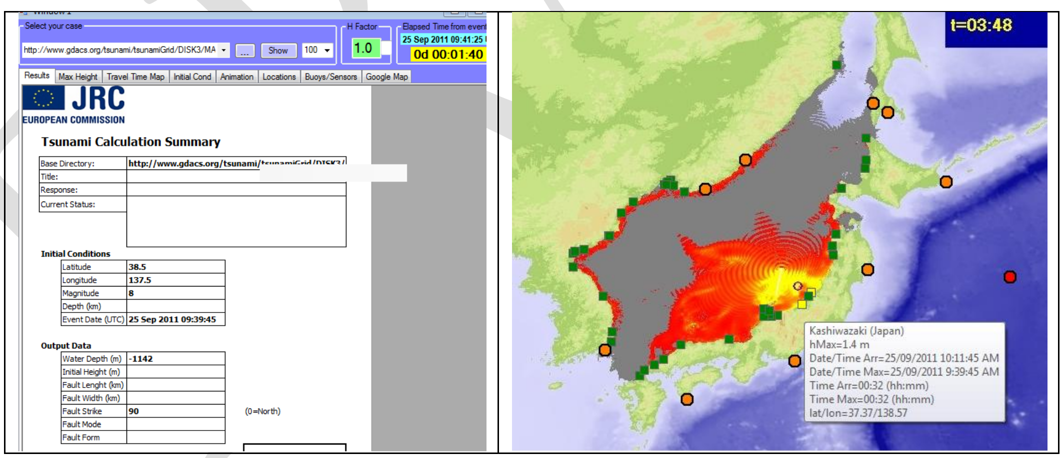
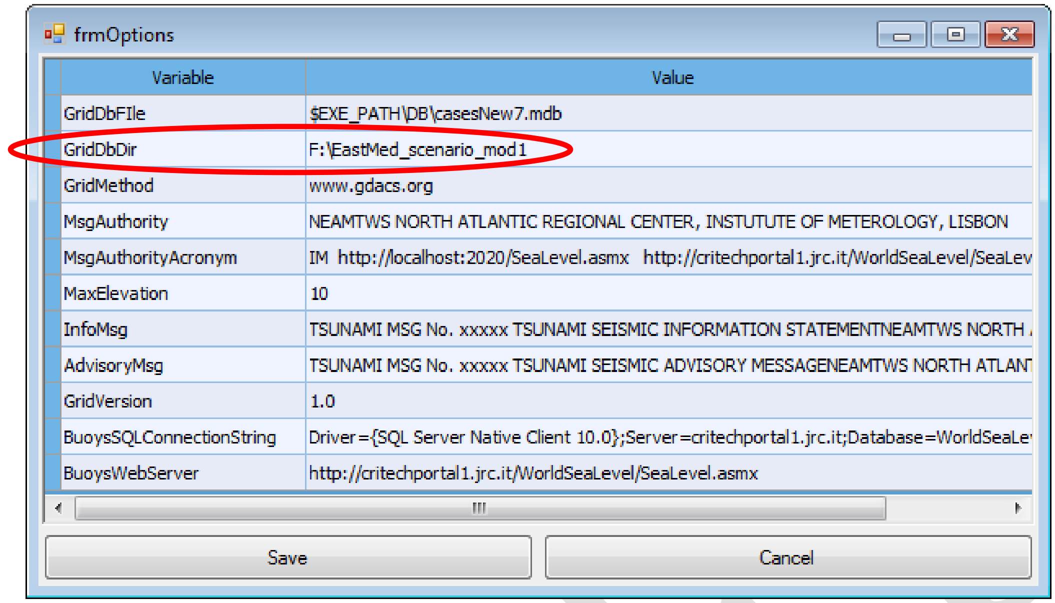


FIGURE 34 – Scenario analysis

The location of the scenario database is specified by indicating the parameter GridDbDir in the Options table of the tsVis.mdb database.


frmOptions
Variable
Value
GridDbFIle
$EXE_PATH\DB\casesNew7.mdb
GridDbDir
F:\EastMed_scenario_mod1
GridMethod
www.gdacs.org
MsgAuthority
NEAMTWS NORTH ATLANTIC REGIONAL CENTER, INSTUTUTE OF METEROLOGY, LISBON
MsgAuthorityAcronym
IM http://localhost:2020/SeaLevel.asmx http://critechportal1.jrc.it/WorldSeaLevel/SeaLev
MaxElevation
10
InfoMsg
TSUNAMI MSG No. xxxxx TSUNAMI SEISMIC INFORMATION STATEMENTNEAMTWS NORTH
AdvisoryMsg
TSUNAMI MSG No. xxxxx TSUNAMI SEISMIC ADVISORY MESSAGENEAMTWS NORTH ATLANT
GridVersion
1.0
BuoysSQLConnectionString
Driver={SQL Server Native Client 10.0};Server=critechportal1.jrc.it;Database=WorldSeaLe
BuoysWebServer
http://critechportal1.jrc.it/WorldSeaLevel/SeaLevel.asmx
Save
Cancel

Chapter 10

Other features

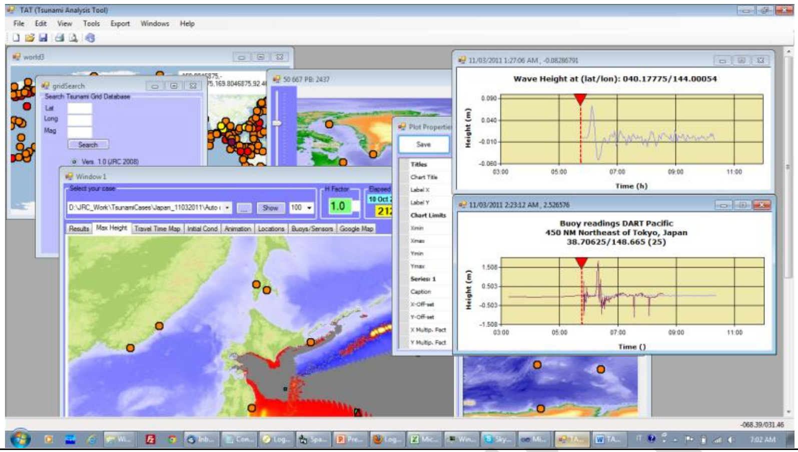
Other options and features are available in TAT. A brief description of the main ones follow

TAT contains a section that allows to monitor ongoing seismic events that may be the ones that

- `Views`
- `Views into Word`
- `Export Locations`
- `Travel times`
- `Google Maps`
- `Support for Hurricanes analysis`
- `City Class filtering`

Views, Views into Word

Once you have prepared your plots to follow an event, you may want to save this configuration in order to be able to recall it at a later stage. You may do this by using the command File>Save View or File>Save View As to save the current arrangement to the same file used earlier or to change the file where to save.
The views are saved in a text file that can also be modified. An example of this file is give below. It is possible to see that every curve. FIGURE 35 shows two plots that have been created by the procedure indicated below.
It should be noted that the procedure stores also the absolute file paths of the calculations and if these are moved or deleted they are not found any more.
In order to open a view you should use the command File>Open View. The command File>Open >Word will open a view and then export all the screenshots in a Word document. You may also create very long procedures to recreate or send to a Word document several plots with just one command.




```
* plot n. 1
plot

plotdef|SENSOR=040.17775|144.00054|Sensor||403|310|D:\JRC_Work\TsunamiCases\Japan_11032011\
Auto calculations\104706\coarse\|11 Mar 2011 5:46:23|1.0|1||1|
  xmin 11/03/2011 3:00:00 AM
  xmax 11/03/2011 12:00:00 PM
  ymin -0.0603257940667681
  ymax 0.10054299011128
  chartTitle Wave Height at (lat/lon): 040.17775/144.00054
  window 560 250 771 6
endplot
* plot n. 2
plot
  plotdef|SENSOR=38.70625|148.665|Buoy
Sensor||527|349|D:\JRC_Work\TsunamiCases\Japan_11032011\Auto calculations\104706\coarse\|11
Mar 2011 5:46:23|1.0|1||1|
   *BUOY=25
   buoyID|25||
  xmin 11/03/2011 3:00:00 AM
  xmax 11/03/2011 12:00:00 PM
  ymin -1.5081448516692
  ymax 2.01085980222561
  chartTitle Buoy readings DART Pacific 450 NM Northeast of Tokyo, Japan 38.70625/148.665
(25)
  window 561 278 772 256
endplot
```

FIGURE 35 - The procedure that will recreate the configuration of plots illustrated in the figure at the top

Export Locations, Filtering

When you have an analysis window open and you are analyzing the Locations (pressing the Locations tab), you may want to export the list of the locations in a CSV (Comma Separated Values) text file that can be then open in EXCEL for further analysis or filtering.

Looking at the Locations list it is possible to click on the color of the **alert** in order to show only locations in which the alert level is at least that one (ex. All RED alert locations). You may obtain the filtering by clicking once on the alert color, double click to remove filtering.

By clicking once on the **country** you will filter on that value. By clicking on the city **class** (1=large city… 6) you can visualize only locations with class value lower than that.

Travel times

An important simple feature is the evaluation of the travel time between 2 points.

During an analysis by right clicking on 2 points on the map, you will get the distance in km and the expected travel time between the 2 points. If there is an island in between the calculation of the time is not performed. The calculation is performed using the ray tracing method.

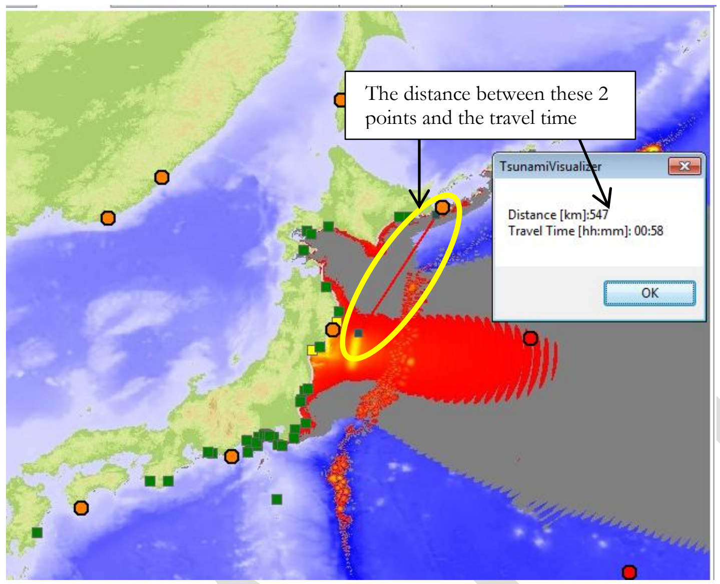


FIGURE 36 – Travel time between 2 points

Once the two points of the travel time are drawn on the picture, it is possible to right click the green squares and you can plot the height distribution of the bathymetry or of the sea level.

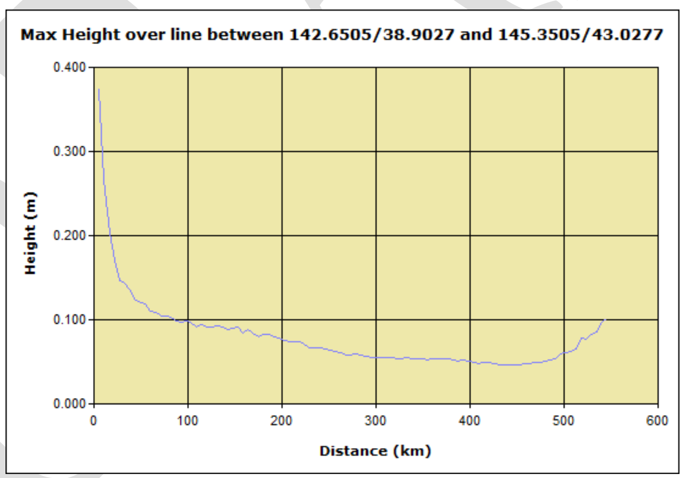
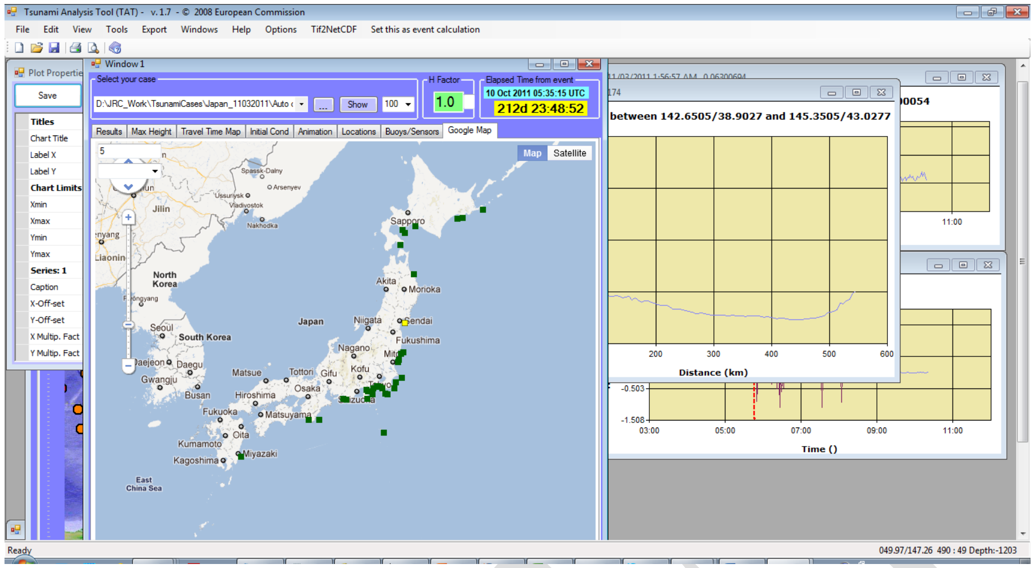


FIGURE 37 – Sealevel height between the 2 points indicated in the previous figure

Google Maps

A recent inclusion is the possibility to see the list of buoys and the locations through a Google Map which allows to zoom up to very small values, use satellite images as background etc, but this is still in progress and will be better described at a later stage.



Support for Hurricanes analysis

Also this is a new option that is aimed at analyzing the results of Hurricane calculations. Recently at JRC we are using a Tsunami code (HYFLUX) to analyse the storm surge caused by Tropical Storms, Hurricanes or Typhoons. The output of the code is similar to the one of a Tsunami and therefore we use the same analysis tool. In order to support this activity few options have been implemented just for that.

In particular in the analysis window, by activating Options>Hurricanes>Load Track the file hollandData.txt is searched that contains the track points with wind gust and min. pressure and is visualized on top of the maximum sea level.

In general the comparison of sea level for an hurricane needs absolutely the use of the tidal removal option because in contrast with the Tsunami, the hurricane lasts for several days and therefore any other filtering method does not work.

Chapter 11

Conclusions

This manual is in continue evolution but it represents the updated information in order to allow the users to perform the basic operation of the Tsunami Analysis. In the future it will be updated in order to reflect the new options that will be included in the software.

REFERENCES

[1] Annunziato, A., 2007. The Tsunami Assessment Modelling System by the Joint Research Centre, Science of Tsunami Hazards, 26(2), pp 70-92

APPENDIX A – Minimum Required Files for TAT

This section describes which files are necessary for creating output that are compatible with TAT.

1	Locations.xml	Compulsory
2	Base.jpg	Compulsory
3	P1_MAXHEIGHT_END.jpg	Compulsory
4	Outres1.gif	Optional
5a	Timeline files in netcdf • NETCDF_H.nc • NETCDF_U.nc • NETCDF_V.nc	 • Compulsory • Optional • Optional
5b	Timeline files in geoTif • Listfiles.txt • TIF_H_nnnnnnnn.tif • TIF_U_nnnnnnnn.tif • TIF_V_nnnnnnnn.tif	 • Compulsory • Compulsory • Optional • Optional
6	Bathymetry.tif	Optional
7	WPFiles.tar WTFiles.tar	Optional

1. **Locations.xml**

This is an xml file in a RSS extended format containing information on the epicenter and calculation details and a list of locations reached by the wave with their information.

The basic form of the file is
<rss>
<channel>
<item> <!—the first item is the epicenter and fault info →
…
</item>

<item> <!-- all the items after the first one are the locations reached->
..
</item>
…. Several items

</channel>
</rss>

An example of file with 2 items is presented here

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<rss version="0.91"
xmlns:geo="http://www.w3.org/2003/01/geo/wgs84_pos#">
<channel>
<item>
<title><![CDATA[]]></title>
<description>
Longitude=142.4&lt;BR&gt;
Latitude = 38.3&lt;BR&gt;
Magnitude =9.00&lt;BR&gt;
Water Depth    =   0&lt;BR&gt;
</description>
<image>/P1_MAXHEIGHT_END.jpg</image>
<location></location>
<geo:lat> 38.3</geo:lat>
<geo:long>142.4</geo:long><depth></depth>
<dc:subject
xmlns:dc="dc">EPICENTER</dc:subject>
<pubDate>11 Mar 2011 5:46</pubDate>
<link></link>
<initialConditions>
    <Fault><Lenght> 501</Lenght>
           <Width> 140</Width>
       <Height>12.65</Height>
       <Form>8</Form>
       <Magnitude>9.000000</Magnitude>
       <Mode>0</Mode>
       <Angle type="trig angle:
north=90, south=-90">263.0</Angle>
       <okadaPar>
          <strike type="geogr angle:
north=0, south=180">187.0</strike>
          <dip>14.0</dip>
          <rake>68.0</rake>
          <depth>32.0</depth>
          </okadaPar>
   </Fault>
   <Bathym>7.250000</Bathym>
   <window>
       <lonmin>98.768997</lonmin>
       <lonmax>185.768997</lonmax>
       <latmin>-5.178001</latmin>
       <latmax>70.000000</latmax>
   </window>
   <dtMax>7.250000</dtMax>
</initialConditions>
</item>


--: follows in the next column
```

```
<item>
<title><![CDATA[Japan: Inuwaka (2.04
m)]]></title>
<description><![CDATA[Country: Japan
Location: Inuwaka
Time (hh:mm): 00:00
Maximum Height: 2.044883 m
Time Max (hh:mm): 02:42
]]></description>
<pubDate>11 Apr 2011 06:46:00</pubDate>
<cityName>Inuwaka</cityName>
<country>Japan</country>
<maxHeight>2.044883</maxHeight>
<timeMaxH>02:42</timeMaxH>
<timeArrival>00:00</timeArrival>
<cityClass>5</cityClass>
<popEst>-1</popEst>
<geo:long>140.858505</geo:long>
<geo:lat>35.697960</geo:lat>
<dc:subject
xmlns:dc="dc">2</dc:subject>
<cputime>9</cputime>
</item>
<item>
<title><![CDATA[Japan: Tokawacho (2.04
m)]]></title>
<description><![CDATA[Country: Japan
Location: Tokawacho
Time (hh:mm): 00:00
Maximum Height: 2.044883 m
Time Max (hh:mm): 02:42
]]></description>
<pubDate>11 Apr 2011 06:46:00</pubDate>
<cityName>Tokawacho</cityName>
<country>Japan</country>
<maxHeight>2.044883</maxHeight>
<timeMaxH>02:42</timeMaxH>
<timeArrival>00:00</timeArrival>
<cityClass>6</cityClass>
<popEst>-1</popEst>
<geo:long>140.856186</geo:long>
<geo:lat>35.698036</geo:lat>
<dc:subject
xmlns:dc="dc">2</dc:subject>
<cputime>9</cputime>
</item>
</channel>
</rss>
```


2,3 -Base.jpg, P1_MAXHEIGHT_END.jpg

Base.jpg is a jpeg image representing the calculation space before the tsunami arrival. It is an image with the number of horizontal pixels equal to the number of horizontal calculation cells and the vertical pixels as the number of vertical cells. In general the bathymetry and topography are shown.

P1_MAXHEIGHT_END.jpg represents the maximum height at the end of the calculation and represents the basis for the locations and sea level measurements that are overlaid in the analysis window. The size is the same as base.jpg.

4- outres1.gif

This is a gif animation showing the evolution of the tsunami wave. It is optional.

5. Timeline data

These are very important data because represent the result of the calculation vs time at each calculation point. Two types of files are possible: netcdf and geotiff. The first one are much quicker to be loaded while the second one allow to have snapshot at the various times that can be used in a GIS environment; the loading time is longer and for very long calculations is not a very convenient method.

5a. Netcdf files

NetCDF (network Common Data Form) is a set of interfaces for array-oriented data access and a freely-distributed collection of data access libraries for C, Fortran, C++, Java, and other languages. The netCDF libraries support a machine-independent format for representing scientific data. Together, the interfaces, libraries, and format support the creation, access, and sharing of scientific data (http://www.unidata.ucar.edu/).

In the TAT environment every variable (bathymetry data, height or velocity data) has its own NETCDF file which contains all the values of the calculation space at each time step. The following variables are used:

LON for longitude
LAT for latitude
TIME for the elapsed time

The dependent variables may be
HA for the height (m)
U for the horizontal velocity (m/s)
V for the vertical velocity (m/s)

The result of the command for one sample file for height

```
ncdump -h netcdf_h.nc
```

is the following

```
netcdf  netcdf_h {
dimensions:
        LON = 720 ;
        LAT = 622 ;
        TIME = UNLIMITED ; // (213 currently)
variables:
        double LON(LON) ;
                LON:units = "degrees_east" ;
                LON:point_spacing = "even" ;
        double LAT(LAT) ;
                LAT:units = "degrees_north" ;
                LAT:point_spacing = "even" ;
        double TIME(TIME) ;
                TIME:units = "seconds" ;
        float HA(TIME, LAT, LON) ;
                HA:units = "m" ;

// global attributes:
                :hystory = "SWAN 1.0 - JRC Ispra European Commission" ;
}
```

5b. geoTiff files

GeoTIFF is a public domain metadata standard which allows georeferencing information to be embedded within a TIFF file. The potential additional information includes map projection, coordinate systems, ellipsoids, datums, and everything else necessary to establish the exact spatial reference for the file. The GeoTIFF format is fully compliant with TIFF 6.0, so software incapable of reading and interpreting the specialized metadata will still be able to open a GeoTIFF format file.

Several libraries are available to read or write geoTiff files, such as gdal libraries. An overview is present at http://trac.osgeo.org/geotiff/ .

The TAT implementation relies on a series of geoTIFF files, one for each time. Therefore if geoTIFF format is specified there will be n files for any of the n data point and the system will open and read all the n files to create the timeline plots. In order to know which files are used we use a listfiles.txt file, an ASCII space separated file which contain the list of the files assigned to the right time in seconds.

This is the initial part of a listfiles.txt file:

```
*time             HA          U           V
*list of files for current case ./listfiles.txt
0.000000 TIF_H_00000000.tif TIF_U_00000000.tif TIF_V_00000000.tif
123.250000 TIF_H_00000123.tif TIF_U_00000123.tif TIF_V_00000123.tif
246.500000 TIF_H_00000246.tif TIF_U_00000246.tif TIF_V_00000246.tif
369.750000 TIF_H_00000369.tif TIF_U_00000369.tif TIF_V_00000369.tif
493.000000 TIF_H_00000493.tif TIF_U_00000493.tif TIF_V_00000493.tif
616.250000 TIF_H_00000616.tif TIF_U_00000616.tif TIF_V_00000616.tif
739.500000 TIF_H_00000739.tif TIF_U_00000739.tif TIF_V_00000739.tif
862.750000 TIF_H_00000862.tif TIF_U_00000862.tif TIF_V_00000862.tif
...
```

The first line identifies the time and the quantities (HA for height, U and V for velocities), the second line is a comment and then the other lines report the time in first column and the names of the geoTif files that will be found in the directory where the listfiles.txt is present.

6. Bathymetry.tif

This is a geoTIFF file representing the bathymetry data used for the calculation

7. WPFiles.tar or WTFiles.tar

These are compressed files containing one file per each location and containing the time trend for that particular location. It is a way to reduce the loading time of the quantities.

The content of each file inside these compressed file, named with the name of the location, is something like

```
* Location: Abe lat=33.787910 - lon=134.637207
14280.000000,0.064485,0.064485
14400.000000,0.044906,0.064485
14520.000000,0.044906,0.064485
14640.000000,0.044906,0.064485
14760.000000,0.045670,0.064485
14880.000000,0.044906,0.064485
15000.000000,0.044906,0.064485
15120.000000,0.044906,0.064485
```

Showing the time in seconds and the height. The values starts when the location is reached by the wave.