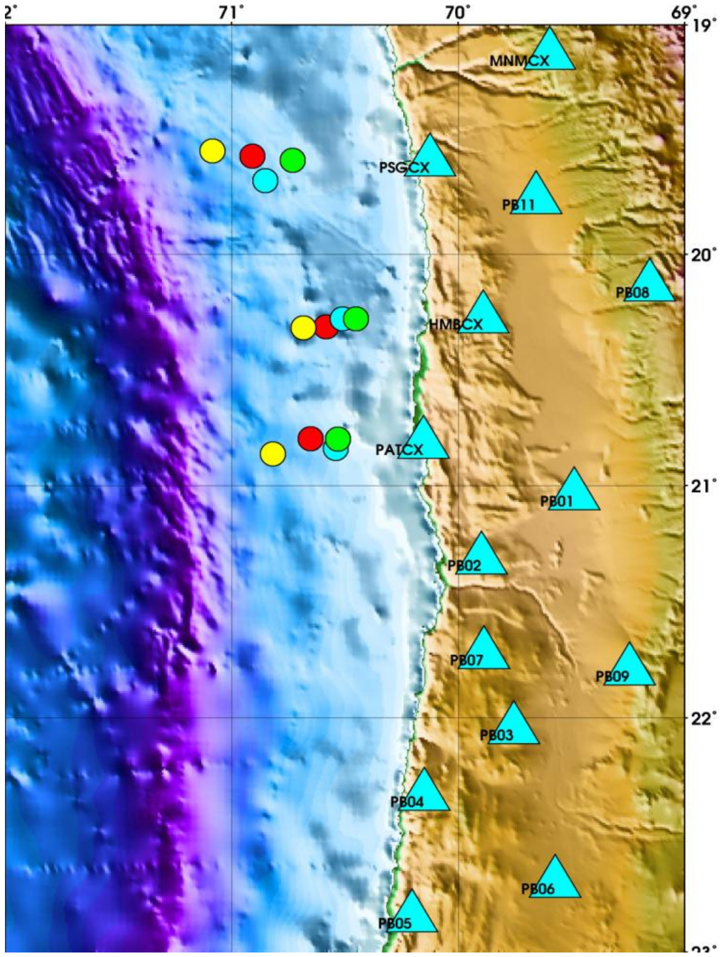
RTQUAKE

A Real-Time Earthquake Detection System Integrated with SEISAN

Version 1.5



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Cover

The map shows 3 events recorded by the example configuration described in this manual. The yellow marker is the automatic location done by RTQUAKE. The red, green and cyan markers are locations done by other institutions.

The events are:
2014/04/01 23:46 M 8.2
2014/04/03 01:58 M 6.3
2014/04/03 05:26 M 6.3

Questions and suggestions

Any questions or suggestions concerning the software can be sent to the email addresses on the front page or to rtquake@gmail.com

1 INTRODUCTION

RTQUAKE is a system for monitoring, triggering and recording of data coming from one or several SeedLink servers or digitizing units providing data according to the SeedLink protocol. The system is intended for routine operation of local and regional networks. RTQUAKE is written in C and uses OpenGL and GD (Boutell) for graphics.
The system functionality is similar to both Earthworm and SeisComp3 in the sense that it detects events and records them. It does not have the many utilities and advanced features for automatic processing of these systems, but has the advantage of recording events and S-files (event parameter files) directly into the SEISAN database (Havskov and Ottemöller (1999)) ready for processing without further steps.
The installation and configuration however, is simple and the manual processing through SEISAN of recorded events and continuous data in the Seiscomp3 ring buffer system is very easy.
The SEISAN system is mainly working with event data, so for each event there is one ASCII file (so called S-file) containing all parameter data for the event as well as a link to the corresponding waveform file(s) or position in the SeisComp3 archive. The S-files are organized in a data base like structure which can be accessed through a main processing program. The main task for a real time system is then to create this S-file and the corresponding waveform files and put them into the correct location in the data base.
RTQUAKE has several independent modules of which the trigger-recording module RTDET is the core module. The user can chose to run several other modules depending on the degree of monitoring that is desired. Common for most modules is that they read incoming streams from a SeedLink server (SeedLink clients).
RTQUAKE has an option for doing automatic location of events that works reasonably well when the phase-picker is able to find well defined phases on a sufficient number of stations. In general the automatic location option works better for events with a magnitude from 2.0 and above. The calculated locations should be used as indicators and by no means as a final determination of an event location.
The automatic magnitude that is calculated is based on the events coda, in this case from the event onset until the de-trigger of the event.
RTQUAKE has also an option for "close-to-real-time" automatic location of events. Data-buffers entering the system from the seismic network can be examined immediately for p phases. When a sufficient number of phases have been detected (specified in the parameter file), the system will try to compute a preliminary location and a magnitude if the specific parameters are set in the parameter file. As more phases are detected from other stations, new locations are computed. A parameter set the length of the time window in which phases have to be detected. Depending on the length of the time window, s phases are also included in the location process if the event is local.
The success of automatic location on both complete recorded events and “close-to-real-time” data will depend on several factors. Noisy data, gaps and spikes in the data, long distance between stations, low magnitude (signal to noise ratio) are all factors that will make an automatic location very complicated. Spikes and noise may produce false phase readings and result in wrong locations or no locations at all. P and S phases (and noise) may be wrong interpreted and give wrong results.
It is recommended that the user creates a simple start configuration to get an idea of how the detection works, adjust the trigger levels, look at recordings in SEISAN, check for data quality, remove noisy stations from the trigger configuration etc.
RTQUAKE has an option for computing local magnitude (Ml and Mw from spectra) automatically (using a SEISAN module) provided that the response-files for the stations are

present. For the test configuration the response files for the stations are supplied in the distribution and should be copied into the SEISAN CAL catalogue.
RTQUAKE can be configured to run single-network, subnets and to read data from different SeedLink servers. The SeedLink servers can be digitizers that support the SeedLink protocol, local or remote SeedLink servers that provide data from a single seismic network or from international SeedLink servers that provide data from a lot of international seismic stations. It is important to note that the user must ensure the SeedLink servers used in the configuration allow the RTQUAKE system both to read data buffers and to extract wave data from the archives. In some cases it can be practical to install a local SeedLink server to receive the data from the different stations and let RTQUAKE retrieve data from this local SeedLink server.

In the case where the seismic stations are spread over a geographically big area it would make sense to configure subnets from for example the northern part, the southern part, the eastern and western part. Events would then be recorded from the specified regions. The subnets can overlap in the sense that several stations from one region also are defined in another region.

Several subnets can be defined within one instance of RTQUAKE.

In chapter 3 several different configurations are discussed in detail.

The figure below explains some possible configurations:

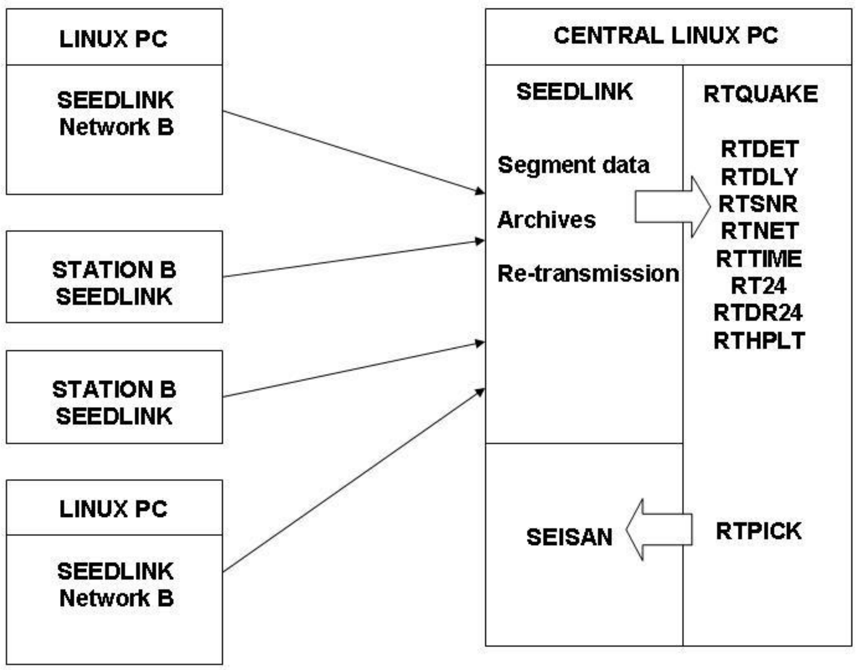


Figure 1.1 A typical RTQUAKE configuration using input-data from one or more SeedLink servers. The data enters a local SeedLink server before being processed by RTQUAKE in

order to have direct access from SEISAN to the archive with continuous data. See chapter 13-20 for documentation on the different modules.

- In this configuration RTQUAKE runs on the same computer as the local SeedLink server receiving data and SEISAN.
- Data from different SeedLink servers and stations are fed into the local SeedLink server and RTQUAKE connects to the local SeedLink server as a client, selecting the components that will be used for detection.
- Detections are recorded directly in the SEISAN database with the corresponding S-file.
- The events can be processed manually immediately.
- The software includes an automatic phase picking option to include phases in the S-file. Optionally automatic location and magnitude can be done based on these readings.
- The software includes an automatic phase picking option that works in "close-to-real-time" that can give very fast preliminary location and magnitude.
- SEISAN has direct access to the SeedLink server archive.

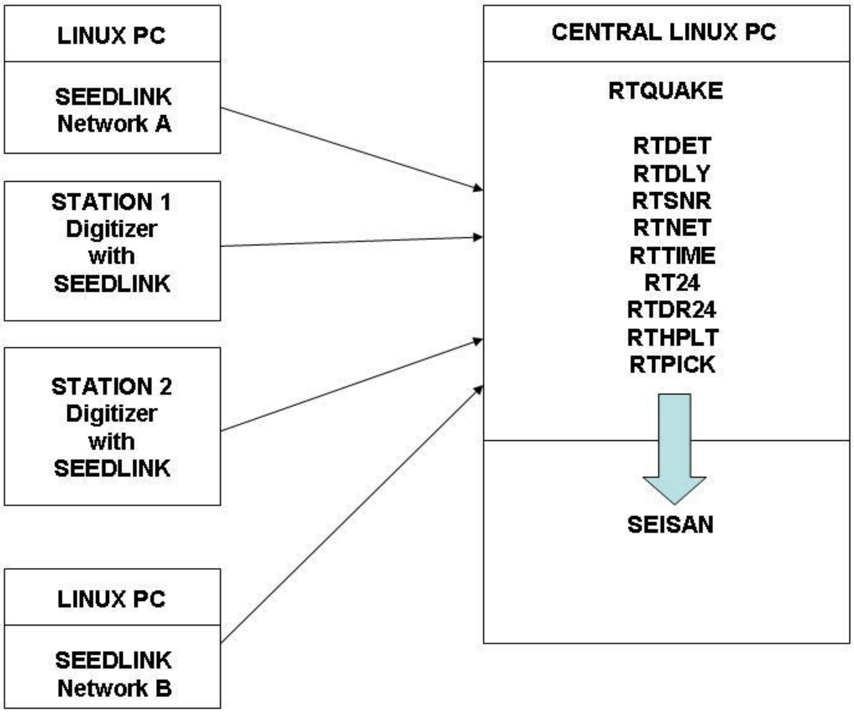


Figure 1.2. An alternative configuration is that RTQUAKE is configured to read directly from external SeedLink servers or digitizers that support the SeedLink protocol. You then do not need a local SeedLink server installed locally, but you will lose the direct access to the SeedLink archive from SEISAN.

The distribution comes with a test setup so immediately after installation, the system can be tested with real data.

2 INSTALLATION

Pre-requisites:

Before installing RTQUAKE, some third party free software must be installed.

2.1 SeedLink

RTQUAKE routines will only work when there is access to a SeedLink server locally or remotely. If a local SeedLink server will be used, it must be installed. The SeedLink server is part of SeisComp 2.5 or SeisComp3. Version 2.5 is public software and is included with RTQUAKE in the SeedLink catalogue in the distribution together with the user manual. SeisComp3 can be found at: http://www.seiscomp3.org . A local SeedLink server is not needed if you only want to run the test example.

2.2 Graphics libraries

All graphics modules use OpenGL and/or the GD library by Thomas Boutell.
The following libraries must be installed:

GD library (In Ubuntu: search for gd with the Synaptic Package Manager or with the Ubuntu Software Centre and look for: Generate graphs using the GD library). Select "**libgdchart-gd2-xpm-dev**" Generate graphs using the GD library (development version). When you select this package, other needed packages will automatically be installed.

OpenGL (In Ubuntu: search for glut or freeglut with the Synaptic Package Manager or Ubuntu Software centre and look for: glut. Select "**freeglut3-dev**" OpenGL Toolkit development files. When you select this package, other needed packages will be automatically installed.

Python. (In Ubuntu: search for **python** and **python-tk** and install both)

GD library (In Centos: yum search gd)
OpenGL (In Centos: yum search glut)

2.3 SEISAN

SEISAN for data analysis must be installed before using RTQUAKE as recorded events are stored in the SEISAN database and SEISAN programs are used for the manual and automatic processing. SEISAN is found at www.seisan.info

2.4 STEP-BY-STEP installation of RTQUAKE

RTQUAKE can be installed on a standard installation of Linux. It has been developed and tested under Linux Centos, Ubuntu and Fedora.

STEP 1:

It is assumed there exist a user account in which to install RTQUAKE. If not or you want to use a separate account, then first create a user account with a username and directory name. An account **seismo** will be used throughout this manual, but any account name will work.

Username: **seismo**
Password: selected by the user.

This will create a home directory: /home/seismo.

Log into this account to start the installation.

STEP 2:

Make a directory for the RTQUAKE installation. Can be any legal directory name.

mkdir mydir
cd mydir

STEP 3:

RTQUAKE is distributed as rtquakeddmmmyy.tar or rtquakeddmmmyy.tar.gz file, where dd is day, mmm is month and yy is year, for example: rtquake06feb12.tar. The distribution can be found at:

ftp://ftp.geo.uib.no/pub/seismo/SOFTWARE/RTQUAKE

Download the distribution file to the directory you just created and uncompress the file and unpack the distribution:

gunzip rtquakeddmmmyy.tar.gz
tar –xvf rtquakeddmmmyy.tar

A directory structure has now been installed with programs, parameter files, data files, temporary files etc. For details see chapter 7 and 8. The most important for the user operation are:

/home/seismo/mydir/par	Parameter files for the different modules. Each setup of parameters is in a named subdirectory which contains several parameter files for the particular setup. An example is the DEMO1 directory with the parameter files for the test run.
/home/seismo/mydir/par/DEMO1	Test configuration (Test run example)

/home/seismo/mydir/wrk	Work catalogue for testing of software
/home/seismo/mydir/map	File containing locations, station file, html file showing last location.
/home/seismo/mydir/loc	Links to static Google map showing locations.

STEP 4

Set environment for where RTQUAKE is installed:

In the /home/seismo/mydir/com directory there is a setup file that must be sourced. This can be done from the command line or from the .cshrc or .bashrc file depending on the shell used in your account. Check what shell is used with the command:

env | grep SHELL

Edit the setup_rt.csh or setup_rt.bash file in the /home/seismo/mydir/com catalogue before sourcing it so that it corresponds to your environment !!
Modify the line that define the RTQUAKE_TOP to fit your RTQUAKE catalogue.
RTQUAKE expects to find SEISAN installed on the system and the environment variable SEISAN_TOP defined, see SEISAN manual.

for csh:
Include the following line at the end of your /home/seismo/.cshrc file:
source /home/seismo/mydir/com/setup_rt.csh

for bash:
Include the following line at the end of your /home/seismo/.bashrc file:
source /home/seismo/mydir/com/setup_rt.bash

When you now open a new terminal window the correct environment will be active.
Continue with STEP 5 to compile the software.

STEP 5:

Installation and compilation of complete RTQUAKE package:

cd /home/seismo/mydir
make clean
make rtquake
make install

Change to the RTQUAKE work directory or to a working directory in your home directory. This is to avoid temporary output files to be mixed with the RTQUAKE software:

rtwrk

RTQUAKE is now ready for operation.

3 TEST RUN INCLUDING MONITORING

3.1 Aliases, scripts and parameter files to start the test run

A set of parameter files has been prepared to test the installation of the RTQUAKE package. The SeedLink server at GFZ Potsdam, Germany is used. The server has both public and restricted data.
To demonstrate the use of the software, the non-restricted data from the Plate Boundary Project (IPOC), GFZ Potsdam, Germany in northern Chile are used.
As this is a very active seismic area, new events will normally be detected and recorded within a few minutes. In some cases several stations may have data "fall-outs", i.e. no data are transmitted. This can cause that events are not detected as the trigger criteria are not met.
To test the software, the setup files and parameter files have been prepared. The user can use these as recipes for setting up a configuration for an actual network. For details of the test configuration see chapter 4.

3.2 Update the SEISAN0.HYP file

In SEISAN version 10.1 and later, the IPOC stations are included in the STATION0.HYP file. If you are using a different STATION0.HYP file, the IPOC stations must be added if you want to locate events recorded during the test run. The file IPOC.TST file (in SEISAN format) in /home/seismo/mydir/par must then be included in your STATION0.HYP file.

3.3 Start and Stop test run

Two aliases have been prepared to start and stop the RTQUAKE test run:
rtstart arg where *arg* is the catalog under mydir/par where the parameter files are stored. The *rtstop* will stop all processes running under RTQUAKE.

To start the test, type:

rtstart DEMO1

This command will start RTQUAKE

rtstop

This command will stop the data acquisition and the graphic monitoring.

Output from test run:

After executing the start command, you will after some seconds see a plot showing the signals in real time (Figure 3.1) and a plot showing indication of the trigger times and duration of triggers (Figure 3.2).

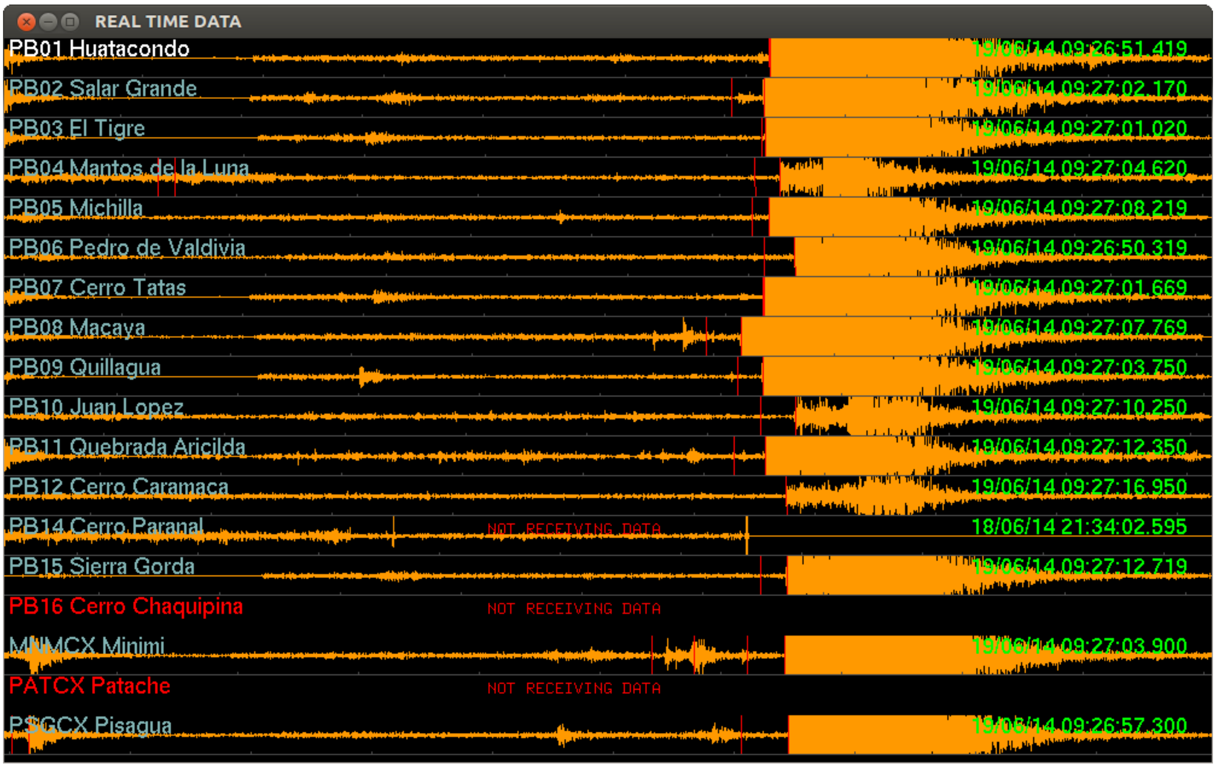
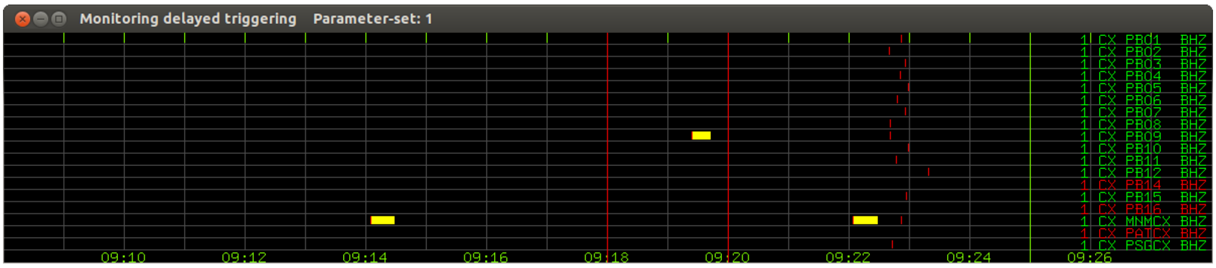
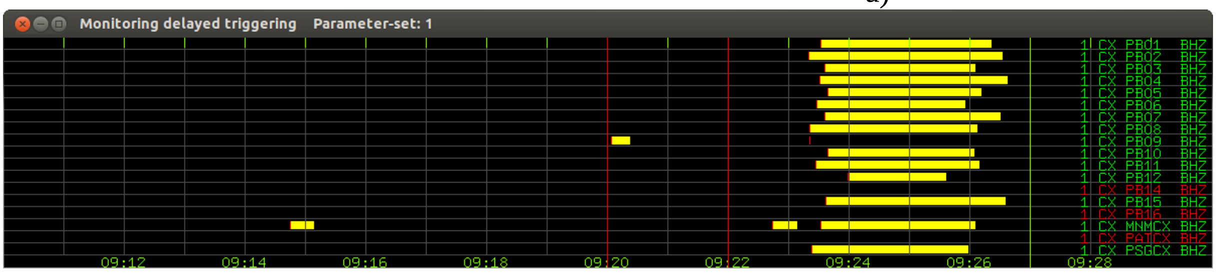


Figure 3.1 RTNET shows the signal from selected channels in "near-real-time". It also indicates when channels are not transmitting data as for station PB14, PB16 and PATCX in this case. The red vertical lines indicate possible triggers, and are inserted when the traces are filtered. These triggers are not the RTQUAKE triggers computed by the RTDET module. Several instances of the program can be executed to show different stations, to apply different band pass filters, different color schemes, different window sizes and different positioning on the screen.



a)



b)

Figure 3.2 RTDLY shows the onset and duration of triggers (yellow lines) for individual channels. When a trigger starts on a particular channel, this is indicated with a small red vertical lines at the trigger time. When the trigger is turned off, the duration of the trigger is indicated with a yellow line. The green vertical line to the right indicates the current time. The two vertical red lines indicate the array-propagation-window (APW) within which the network detection is performed. The text on the right, for example 1 CX PB01 BHZ, displays the subnet number, network id, station name and component respectively. Figure 3.2 top shows the onsets of triggers at a) while the bottom figure shows the situation a minute later at b). Most triggers are now turned off and the duration of the triggers are marked in yellow. The triggers will finally reach the Array-Propagation-Window (between the two vertical red lines) and a network trigger will be declared if sufficient triggers are flagged. Station names marked with red color indicates that the station is not receiving data.

3.4 Optional web pages and graphics

If the default test run records some events and manage to do a location, several maps are generated automatically that can be shown in a standard browser. The different maps have different information, but at least the automatically calculated location of the event.
The graphics can be used on for example monitor screens to continuously show the current seismic activity.

3.5 Reverse Geocoding

In the parameter file there is an option to turn on what is called "Reverse Geocoding". The automatically calculated latitude and longitude for an event can be used in a request to a public server (Mapquest) to get the geographical name of the location returned to RTQUAKE. The name is returned in UTF-8 coding and will be in the local language for the location. The option is shown in some of the examples that follows.

3.6 Examples of optional graphics

/home/seismo/mydir/map/LAST_TRIG.html will show Figure 3.3 or Figure 3.4 on the screen with the stations and the suggested location marked. Clicking on the station markers will show the signal for that station if generated. This link will only show the last located event. A parameterfile /home/seismo/mydir/map/map.par control the zoom-level, latitude/longitude grid, maptype id, number of previous event location to plot and if the red marker should be blinking or not.

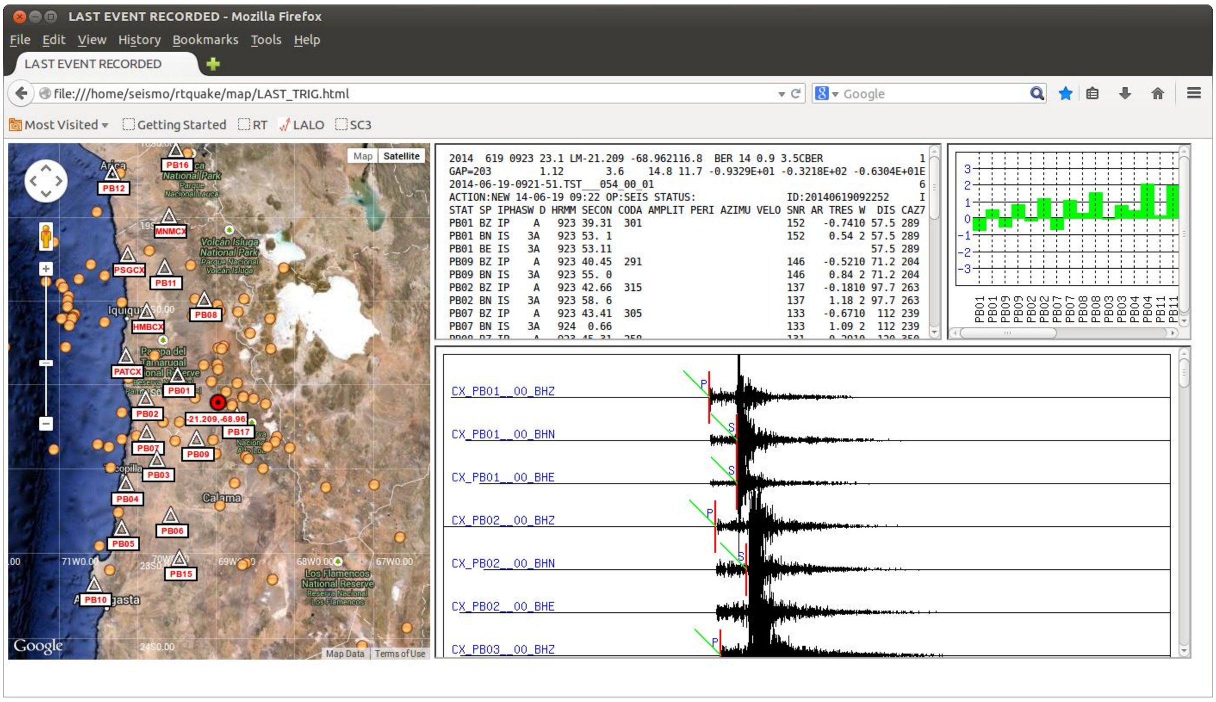


Figure 3.3 Web page showing location of last located event. Maptype set to HYBRID.

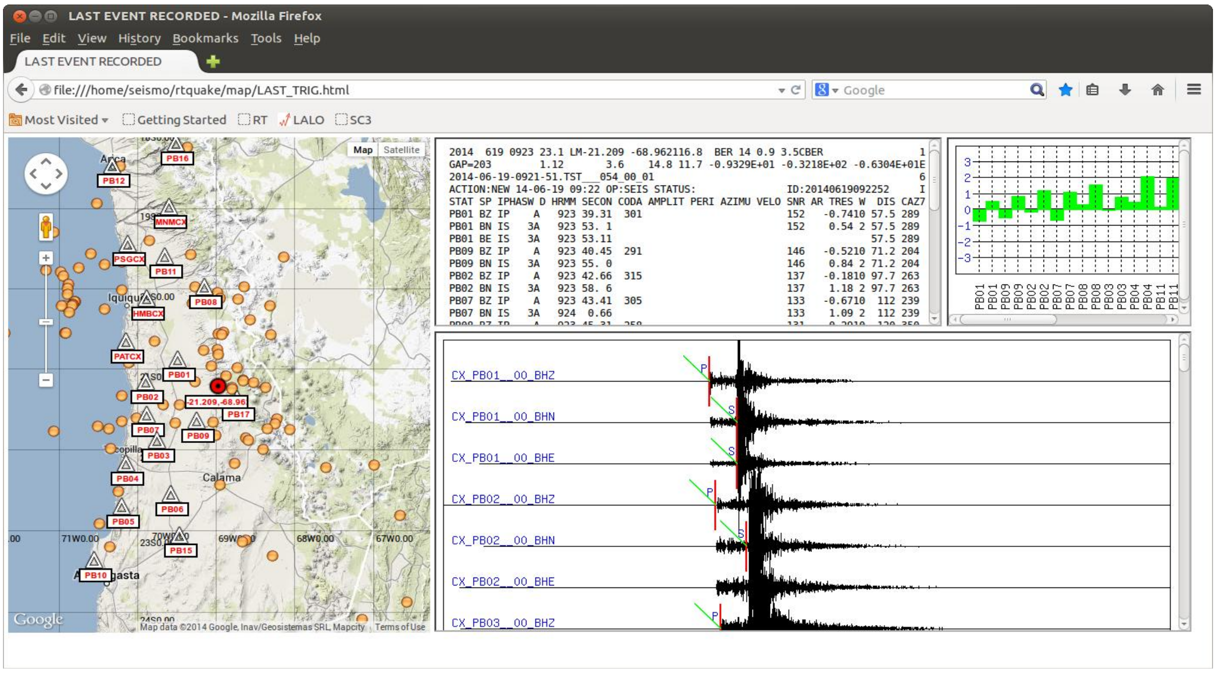


Figure 3.4 Web page showing location of last located event. Maptype set to TERRAIN.

The left window in the browser shows the map with the stations show as triangles and name. The calculated location is marked in the center of the map with the red circle and the coordinates below.

Initially the window right-below shows the recorded signals with phases marked. Clicking on one of the stations on the map will show the signals from that station only if existing, with the suggested phases.

The window center-top shows a listing of the s-file for this event.

The window right-top shows a plot with the residuals for each component with a phase reading.

/home/seismo/mydir/map/rt_screen1.html will show the webpage in Figure 3.5. This page shows only the google map with the red marker (blinking or not) with the last located event and the 'x' number of the last events if specified in the map.par.

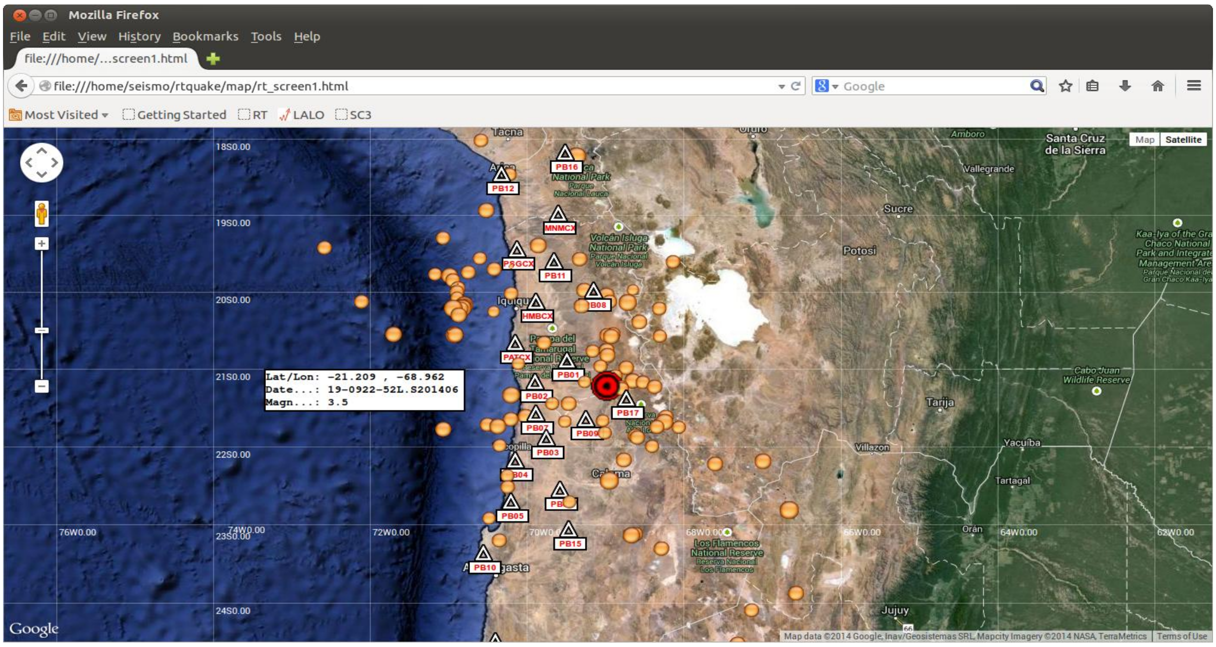


Figure 3.5 Web page showing location of last located event. Maptype set to SATELITE.

/home/seismo/mydir/map/AUTLOC_MON.html shows the webpage in Figure 3.6. The page shows the last automatically located event with an information label that gives a geographical name of the event location, the UTC time, location and the magnitudes mw and ml if available.

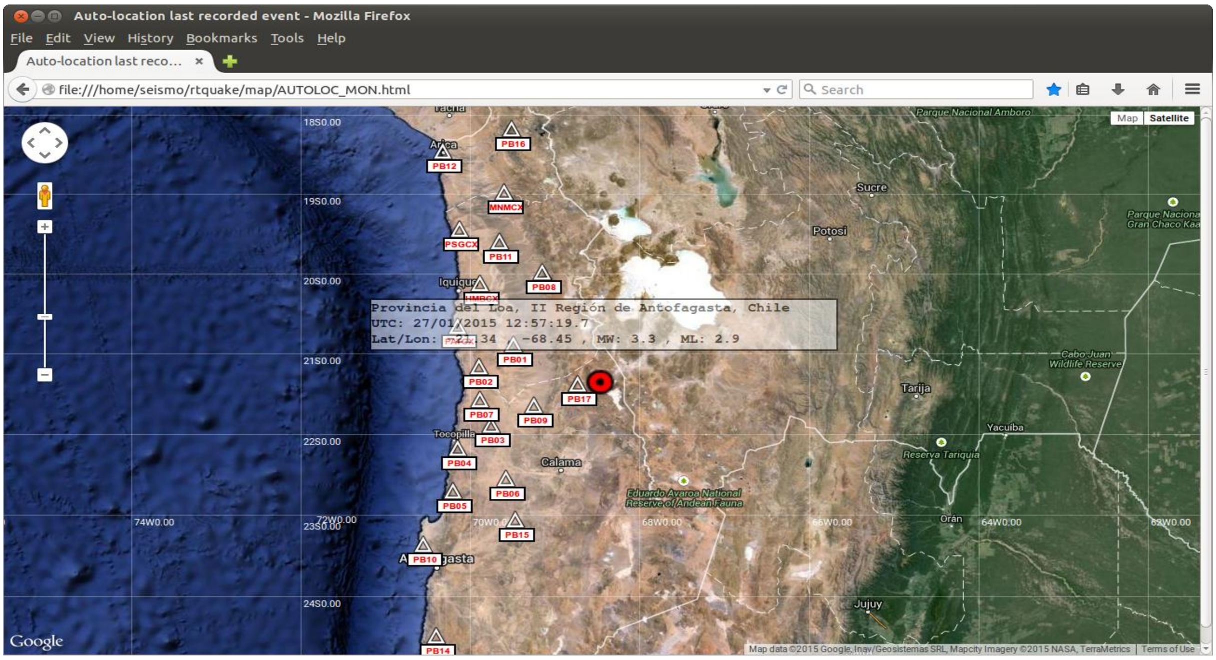


Figure 3.6 Web page showing geographical name, UTC time, locations and mw and ml.

/home/seismo/mydir/map/AUTOLOC_RT.html shows the page in Figure 3.7. This page is generated by the "close-to-real-time" location process and contains the current preliminary location, the geographical name (reverse geocoding), UTC time, location and mw if available. On the right the last generated SEISAN s-file. The page is dynamically updated when new locations are available. The user can click on the menu to the left of the header and select a time to have a look at recent locations.

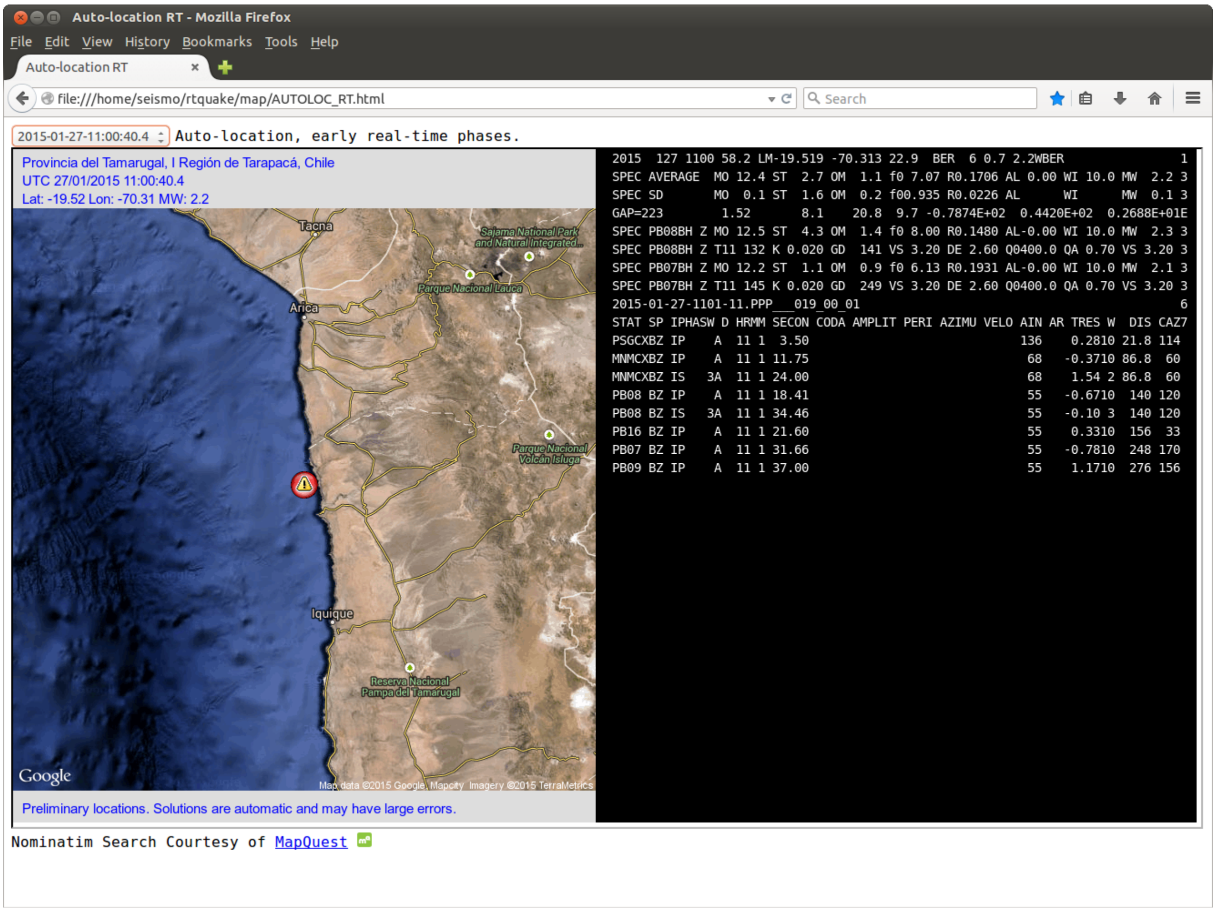


Figure 3.7 Web page showing dynamically updated maps for "close-to-real-time" locations.

/home/seismo/mydir/map/AUTOLOC.html shows the page in Figure 3.8. The page shows the same information as for Figure 3.7, but it is generated after the complete waveform file for the event has been stored and processed by the autolocation process.

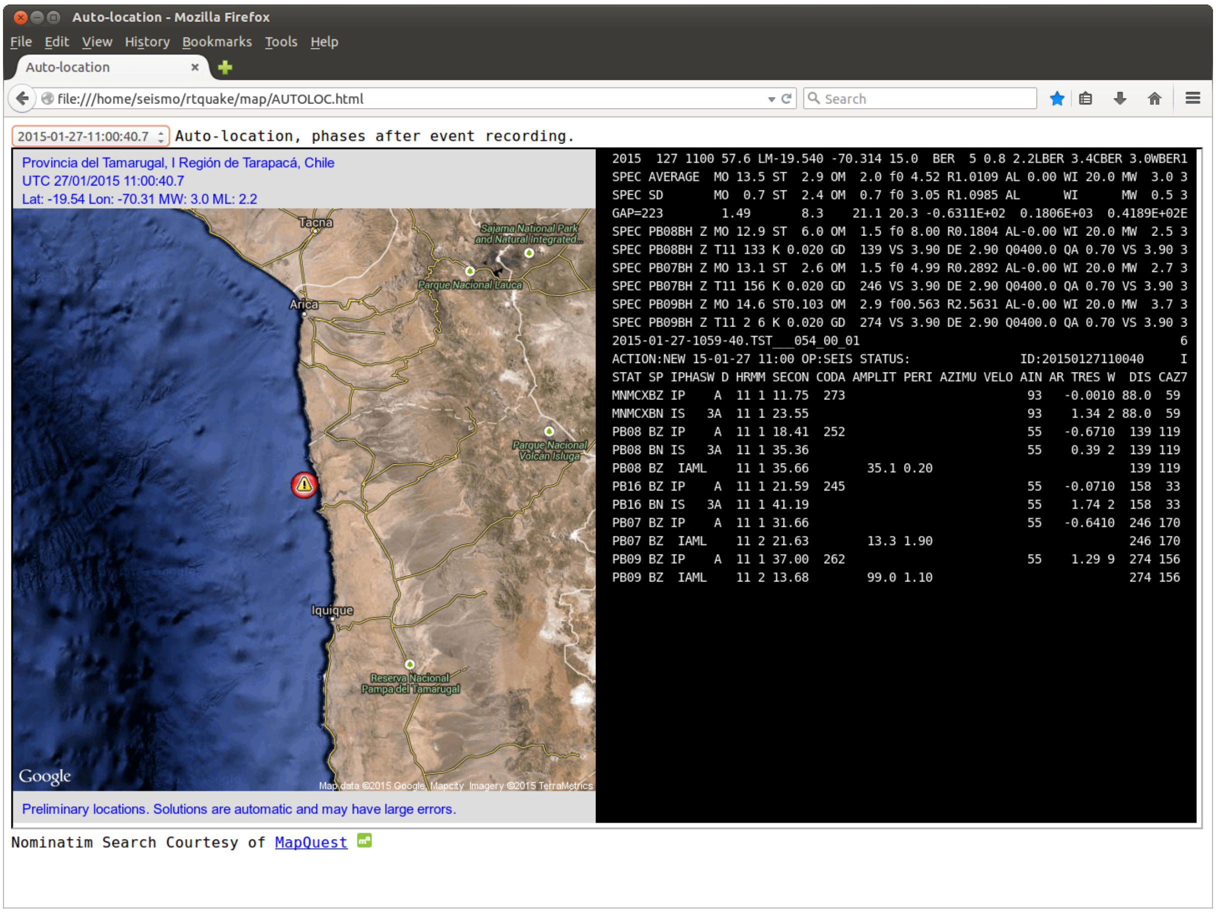


Figure 3.8 Web page showing the autolocation based on processing the complete waveform.

The python script **rtloc** shows a dynamically update of a map with last automatic location from "close-to-real-time" phase picks or from a complete recorded event. The header information is also updated dynamically. Just after an update, the header background color is set to red to indicate a recent new location. After a while the color turns back to gray.

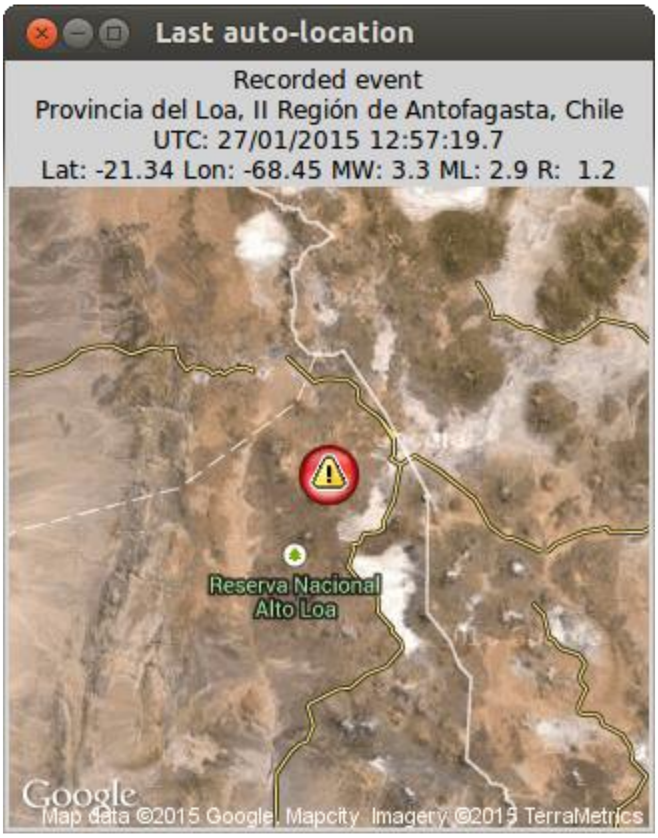


Figure 3.9 Dynamic map created by the python script **rtloc**.

The parameter file for the web pages is described in detail in 4.7

In the catalog /home/seismo/mydir/loc you can find links to recent locations up to the current time. Entering a link in your browser will show a static map as in the Figure 3.10 below with the suggested automatic location.

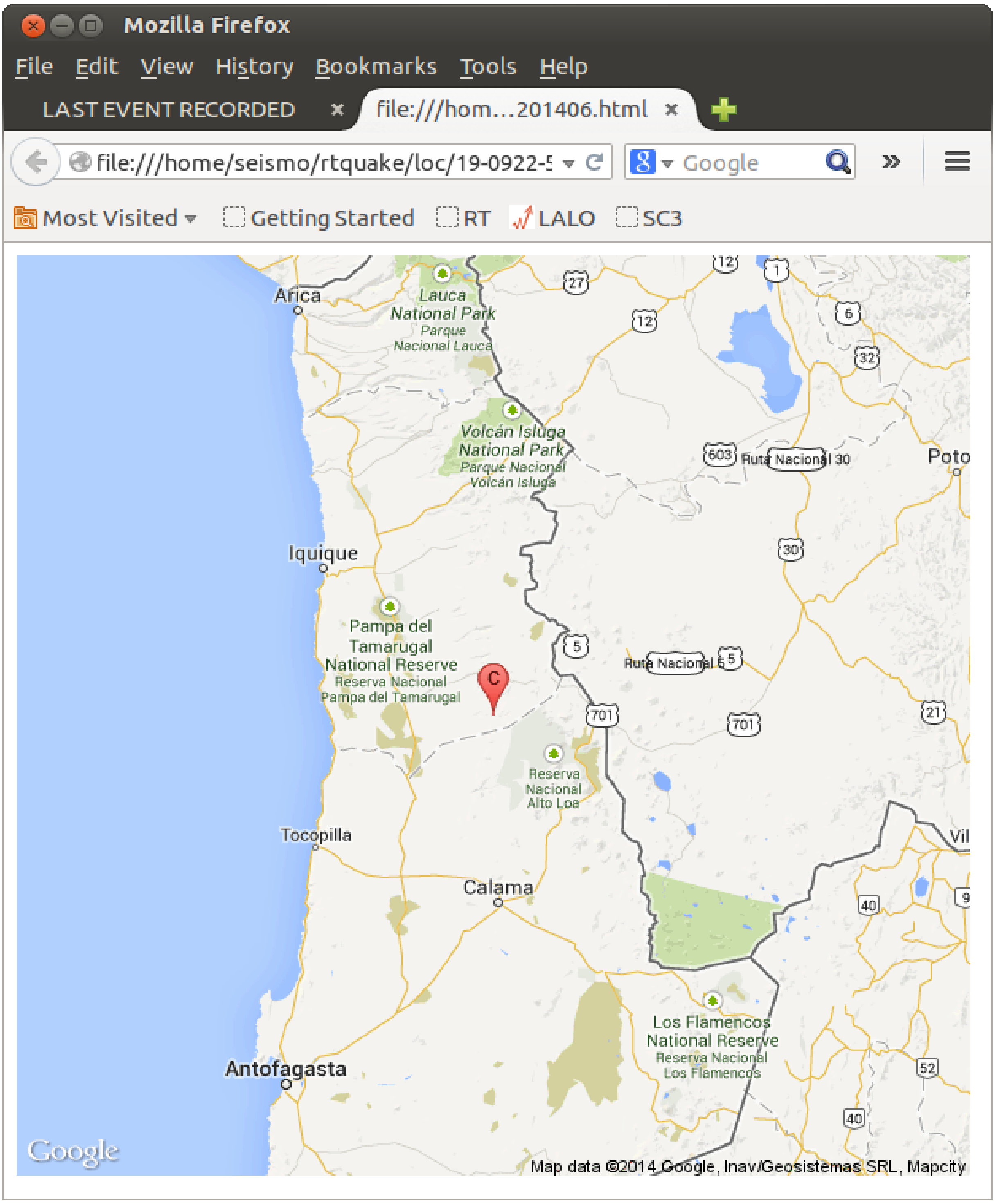


Figure 3.10 Static Google map generated by RTQUAKE.

In the DEMO1 test run, the detected events are stored in the SEISAN data base TST. In order to check the events, use SEISAN command eev 201406 TST (for events in June 2014), find the event and write "po" to e.g. plot the event (Figure 3.11). For more details see SEISAN manual.

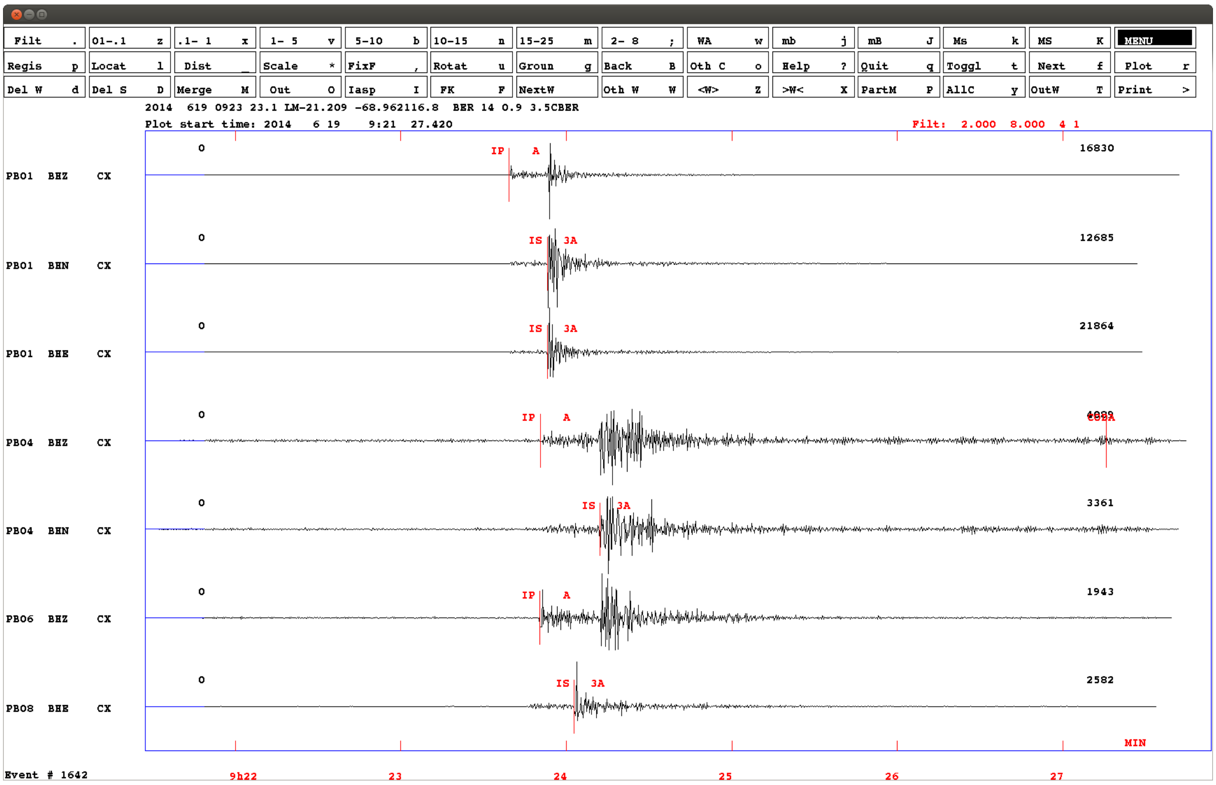


Figure 3.11 Recorded event plotted by SEISAN

The recorded event can now be plotted and processed by SEISAN. The test run is configured to pick phases and they are shown on the plot as in Figure 3.11.

In the test-run, the events waveform files are stored in the SEISAN WAV catalog structure (e.g. /home/seismo/WAV/TST__/2014/06/xxx and the database is called TST__ as set up in the test parameters (see chapter 4).
For the test run, the IPOC.TST file in /home/seismo/mydir/par must be included in the STATION0.HYP file to facilitate location of events. The IPOC.TST file contains the coordinates for the IPOC stations used in the test. If SEISAN10.1 or later is used, the stations are already installed.

To process an event change to the WOR catalog (wo) (or any other catalog you want to work in) and run eev for the actual date, for example: eev 20130110 TST

The test setup can also generate helicorder plots (see the examples at in chapter 20) and send out mail (see chapter 12).

4 PARAMETER FILES, SCRIPTS and ALIASES

4.1 Overview of configuration and parameter files, scripts and aliases

The following is a description of the different configuration and parameter files in RTQUAKE that the user has to adjust to the actual environment and network.

In /home/seismo/mydir/com:

rtquake.par
Configuration file where the user can adjust some RTQUAKE system parameters such as where to write event files, if the system should do auto-location or not, if the system should calculate Ml and Mw or not, if the system should send a mail when detections occur etc. The file is described in 4.2

In /home/seismo/mydir/par/user_created_subdirectory:

Parameters for one particular setup is in a directory called user_created_subdirectory (name decided by user, an example was TEST1)

rt_config: This file defines the channels and SeedLink servers for one of several subnets using the same SeedLink servers, trigger parameters etc. See 4.3

streams_plot: streams to input from SeedLink server for continuous plot (RTNET module). See 4.5

stations_plot: selected components of streams, station description for continuous plot (RTNET module). See 4.5

rtslpl_config: selected components of streams and SeedLink servers for continuous plot (RTSLPL module). See 4.6

streams_heli: streams to input from SeedLink server for heliplots. See 4.7

stations_heli: stations to plot, factor to amplify signals, filters. See 4.7

Aliases defined in the /home/seismo/mydir/com/setup_rt.bash and setup_rt.csh:

`alias rtstart='$RTQUAKE_TOP/com/rtquake_start'`
Start the rtquake_start script See 4.8 **`$RTQUAKE_TOP is set in rt_config.`**

`alias rtstop='$RTQUAKE_TOP/com/rtquake_stop'`
Start the rtquake_stop script. See 4.8

alias rtloc='$RTQUAKE_TOP/com/rtloc.py
Shows last autolocation on small map with geocoding. See Figure 3.9.

alias rtheli1='$RTQUAKE_TOP/com/rtquake_heli_tst1'
Start the rtquake_heli_tst1 script. See 4.9

alias rtheli2='$RTQUAKE_TOP/com/rtquake_heli_tst2'
Start the rtquake_heli_tst2 script. See 4.9

alias rthom='cd $RTQUAKE_TOP'
Change directory to /home/seismo/mydir

alias rtcom='cd $RTQUAKE_TOP/com'
Change directory to /home/seismo/mydir/com

alias rtrtdet='cd $RTQUAKE_TOP/rtdet'
Change directory to /home/seismo/mydir/rtdet

alias rtpar='cd $RTQUAKE_TOP/par'
Change directory to /home/seismo/mydir/par

alias rtut1='cd $RTQUAKE_TOP/utils1'
Change directory to /home/seismo/mydir/utils1

alias rtut2='cd $RTQUAKE_TOP/utils2'
Change directory to /home/seismo/mydir/utils2

alias rtwrk='cd $RTQUAKE_TOP/wrk'
Change directory to /home/seismo/mydir/wrk

4.2 RTQUAKE system parameters: rtquake.par

In this file you specify if you want s-files created and how. You can also specify if you want auto-location, some parameters for the Filterpicker and how the delayed trigger should work. An example file is included below where the parameters are explained in some more detail.
The FilterPicker routine process each component of recorded data trying to identify p and s phases and their onset time.
The parameters marked 'FilterPicker' are default parameters for the FilterPicker module and should not be altered. The parameters are described in Lomax et al. (2012).
For the automatic location option to work, the coordinates of the stations must be included in the SEISAN STATION0.HYP file. For the test configuration, the coordinates can be found in /home/seismo/mydir/par/IPOC.TST file. If SEISAN10.1 or later is used, the stations are already included.
For the automatic computation of local magnitude, the response files for the configured stations must be present in the SEISAN CAL catalogue. For the test configuration the response files are stored in the /home/seismo/mydir/cal catalogue and should be copied into SEISAN CAL directory.

For some parameters, see the respective programs

Example of file:

The following is an overview of /home/seismo/mydir/com/rtquake.par:

```
This file is parameter file for rtquake.
Only the lines with recognized keyword under KEYWORD will be read.
The comments have no importance.
Columns Par 1-Par 2 start in columns 41,51.

keep   locate        Action
----------------------------
  -1      0/1        A new s-file is created with no phase-picks.
                     No location. This option is used for RTQUAKE: detection + no picks + no
location

   0      0/1        A new s-file is created with the detection phase-picks only. No
location.

   1       0         A new s-file is created with all phase-picks from FilterPicker.
                     No location. This option is used for RTQUAKE: detection + NO location

   1       1         A new s-file is created with all phase-picks from FilterPicker.
                     Automatic location. Phases causing high residuals will be removed
automatically
                     until MAX RESIDUAL (see below) and or MINSTALOc (see below) is reached.
                     The s-file will contain the location and the phase-picks that are left.
                     This option is used for RTQUAKE: detection + autoloc

All keywords in capital letters.

KEYWORD...........Comments............Par 1.....Par 2
----------------------------------------how to record s-files----------------------------
KEEP              1:sfile,-1:no sfile  1
----------------------------------------automatic location or not------------------------
LOCATION          1:Locate,0:No Locate 1
----------------------------------------geographical name of location or not-------------
GEOLOCATION       1:yes, 0:no          1
----------------------------------------detail level of geographical name of location-----
GEODETAIL         6-10                 7
----------------------------------------automatic local magnitude or not------------------
AUTOMAG           1 compute Ml,Mw      0
----------------------------------------name of SEISAN database---------------------------
DBASENAME         For SEISAN           TST__
----------------------------------------SEISAN catalogue for waveforms--------------------
WAVEDIR           For SEISAN           WAV
----------------------------------------store waveforms in database or not----------------
WAVE_DB_ACTIVE    For SEISAN           1
----------------------------------------max number of iterations discarding phases--------
ITERATION         Number of iterations 100.0
----------------------------------------maximum acceptable avg. residual to do location---
MAX_RESIDUAL      Maximum residual     2.0
----------------------------------------min. no of stations with phase reading to do location-
MINSTALOC         Min stat to locate   5
----------------------------------------separate sub networks or all as one---------------
ALLSUBNETS        0-sep.net >0 one net 0
----------------------------------------p-phases and s-phases or p-phases only------------
PHASES            0-p, 1-p+s           1
----------------------------------------mail or not---------------------------------------
MAIL1             0-no mail,1-mail     0         terjeu@hotmail.com
MAIL2             0-no mail,1-mail     0         abcd@online.no
MAIL3             0-no mail,1-mail     0         whatever@mail.com
MAIL4             0-no mail,1-mail     0         any@mail.com
MAIL5             0-no mail,1 mail     0         to_you@yahoo.com
----------------------------------------total delay buffer trigger------------------------
DELAY_BUFFER      Minutes delaybuffer  20.0
----------------------------------------where to set current time in delay buffer---------
MINUT_NOW         Minut current data   17.0
```

```
----------------------------------------delay for trigger window--------------------------
DET_DELAY          Detection delay     7.0
----------------------------------------array-propagation-window--------------------------
APW                Array prop. window  120.0
----------------------------------------seconds to shufle buffer don't change-------------
SECONDS2SHUFLE     Seconds to shift    4.0
----------------------------------------pre-event in seconds------------------------------
PRE_EVENT          Pre-event (seconds) 60.0
----------------------------------------post-event in seconds-----------------------------
POST_EVENT         Post-event (seconds) 60.0
----------------------------------------no of days to save heliplots----------------------
HELI_DAYS          No of days to save  5.0
----------------------------------------filterpicker don't change-------------------------
FILTERWINDOW       FilterPicker        300.0
LTWINDOW           FilterPicker        500.0
THRESHOLD1         FilterPicker        10.0
THRESHOLD2         FilterPicker        10.0
TUPEVENT           FilterPicker        20.0
----------------------------------------sound on or off when trigger----------------------
SOUND              1-sound, 0-nosound  1.0
----------------------------------------printing or not-----------------------------------
PRINTING           Debug printing      0
******************************************************************************************
* Parameters for preliminary autolocation based on "close-to-real-time" phase picks      *
******************************************************************************************
----------------------------------------auto location based on p-phase picking in real-time
REALTIME_PICK      0-no, 1-yes         1
----------------------------------------max. residual to do loc. based on real-time phases
MAX_RES_PPH        Max residual rt     2.0
----------------------------------------min. stations with phase reading for realtime loc.
MINSTALOCPPH       min. no. stations   6
----------------------------------------accept p-phases in time-window: current time - seconds
TIMEWINDOW         seconds back in time 70
----------------------------------------p-phases and s-phases or p-phases only real-time picks
RTPHASES           0-p, 1-p+s          1
```

KEEP	How to record s-files. -1: Record the s-file in the database, but with no phases. 1 : Record the s-file with phases 0 : Record the s-file with detection phases only
LOCATION	Try to do automatic location. 1: do automatic location. If KEEP=-1, location will not be executed. 0: no location.
GEOLOCATION	0: no geolocation 1: geolocation to indicate geographical name of location after an auto-location. Used in maps and web-pages.
GEODETAIL	Level of detail in the geolocation.
AUTOMAG	Calculate Ml and Mw 1: calculate Ml and Mw 0: no magnitude calculated
DBASENAME	SEISAN database name (up to 5 letters)
WAVEDIR	SEISAN waveform directory
WAVE_DB_ACTIVE	SEISAN. Store waveform data in the specified directory in WAVEDIR or in a database structure under WAVEDIR.
ITERATION	Number of times to run hyp, remove components with bad residuals and run hyp again.
MAX RESIDUAL	Maximum residual to accept running location
MINSTALOC	Minimum number of stations with phase to accept running location.

ALLSUBNETS	All subnets as one network or separate subnetworks. If set to zero the individual subnets specified in rtquake.par will trigger individually based on the minimum number of triggers in the line NETWORK name n, for example: NETWORK Chile 6, where 6 specify the minimum number of triggers to record an event for this subnet. If set to a positive number, all subnets will be treated as on network and the minimum number of triggers to record an event will be the number specified here.
PHASES	0: record p-phases only 1: record p-phases and s-phases
MAILn	Send mail to address.
DELAY_BUFFER	Maximum number of minutes in delay buffer.
MINUTE_NOW	Minute in delay buffer defined as current time.
DET_DELAY	Number of minutes delay before network detection.
APW	Array Propagation Window. Network detection takes place. inside this time window just after the DET_DELAY minutes.
SECONDS2SHUFLE	Number of seconds the delay buffer is shifted.
PRE_EVENT	Number of seconds to record before the trigger.
POST_EVENT	Number of seconds to record after the event has de-triggered.
HELI_DAYS	Number of days to keep helicorder plots to keep at all time.
FILTERWINDOW	FilterPicker, do not change
LTWINDOW	FilterPicker, do not change
THRESHOLD1	FilterPicker, do not change
THRESHOLD2	FilterPicker, do not change
TUPEVENT	FilterPicker, do not change
SOUND	Play sound when trigger
PRINTING	Print debug information, do not change

The following parameters in the rtquake.par file decides if close-to-real-time location should be active. Location is based on very early p-phase readings. Waveforms containing the phases with corresponding s-files are stored in the SEISAN data base WAV/PPHAS and REA/PPHAS. If the AUTOMAG is set, a preliminary ml is calculated. Results can be seen in maps and web pages described below.

REALTIME_PICK	0: no automatic location based on p-phases not active 1: automatic location based on p-phases active
MAX_RES_PPH	Maximum rms residual accepted to do location
MINSTALOCPPH	Minimum number with phase reading to do location with real-time p-phases
TIMEWINDOW	Accept p-phases in a time-window: current time - n seconds
RTPHASES	0: use only p-phases 1: use p-phases and early s-phases that fall into the timewindow defined above.

4.3 RTQUAKE Station and Network configuration: rt_config

Before starting RTQUAKE a configuration file must be present in a sub directory of /home/seismo/mydir/par. The user must create this sub directory. The name of the sub directory can be any legal name, but it is recommended to use a name reflecting for example

the name of your network, geographical area or purpose of the configuration: NNSN, GEO1, EXAMPLE etc. This name will later be used when starting RTQUAKE.
In this sub directory the user has to create a file called rt_config (or modify an example file). The file must follow the following format described below. The lines marked with bold types are keyword lines and must be present.

rt_config parameter file:

Below is shown part of an example configuration file and after that the explanation. The lines are numbered to help the explanation, the numbers are not part of the file.

```
 1. SERVERS
 2. S01 139.17.3.177
 3. S02 rtserve.iris.washington.edu
 4. -------------------------------------
 5. ALLSUBNETS
 6. -------------------------------------
 7. NETWORK IPOC 7
 8. NW STAT  LOC CMP FL    FH     STA   LTA     T-ON  T-OFF SERVER
 9. CX PB01  ..  BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
10. --------------------------------------------------------
11. RECORD IPOC
12. NW STAT  LOC CMP SERVER
13. CX PB01  ..  BHZ S01
14. # This is a comment
15. CX PB01  ..  BHN S01
16. CX PB01  ..  BHE S01
17. IU LVC   00  BHZ S02
18. ----------------------------------------------------------
```

Line 1. Keyword line: must contain the word SERVERS only

Line 2. User line that contains 2 text strings:
The first string is a fixed form word naming and numbering the servers. The first letter must
be ‘S’ and the next 2 is the numbering 01,02……99.
The second string is the actual SeedLink address.

Line 3. User line that contains 2 text strings:
The first string is a fixed form word naming and numbering the servers. The first letter must
be ‘S’ and the next 2 is the numbering 01,02……99.
The second string is the actual SeedLink address.

Line 4. Keyline. Obligatory after the server definition.

Line 5. Keyword. Must be present.

Line 6. Keyline. Obligatory.

Line 7. First word is a keyword. Must be present. The second string can be used to give the network or subnet a name (not used but something must be there) Third string is the minimum number of triggers to
record an event based on the stations defined in this section (a subnet).

Line 8. This line is a key line. Must be present. This is a header line to explain the input for the lines in this section.
NW : network code
STAT : station code

	LOC	: location code (no location code must be marked with '..', two dots)
	CMP	: component code
	FL	: low-pass filter for detection, floating point number
	FH	: high-pass filter for detection, floating point number
	STA	: length of STA in seconds, floating point number
	LTA	: length of LTA in seconds, floating point number
	T-ON	: STA/LTA level to trigger
	T_OFF	: STA/LTA level to de-trigger
	SERVER	: name of server from where to get the data (S01, S02….)
Line 9.	Channel definitions for the network	
Line10.	Keyline. Obligatory.	
Line11.	First word is a keyword. Must be present. The second string any name to identify network.	
Line12.	This line is a key line. Must be present. This is a header line to explain the input for the lines in this section.	
	NW	: network code
	STAT	: station name
	LOC	: location code (no location must be marked with '..', two dots)
	CMP	: component code
	SERVER	: name of server from where to get the data (S01, S02….)
Line13.	Station definitions for components to be recorded.	
Line14.	A '#' in column one means that this line is a comment. It can hold whatever information. One use can be to exclude a component from triggering or recording due to noisy data.	
Line15.	Station definitions for components to be recorded.	
Line16.	Station definitions for components to be recorded.	
Line17.	Station definitions for components to be recorded.	
Line18.	Keyline. Obligatory.	

Below some examples of different configurations with some comments:

DEMO1/rt_config

The example below is the configuration file for the test run.
Here we define one SeedLink server from where we can read all data from all stations defined. As only one network (one subnet) is defined we will treat the defined network as one network.
The trigger algorithm will use the components defined under the key line
NETWORK IPOC 7 as input, and the specified filters, STAs etc. will be used. Data will be read from S01 as specified under SERVER.
When we have 7 or more single-channel triggers on the components specified, the components specified under the keyword RECORD be retrieved and stored.

```
SERVERS
S01 139.17.3.177
--------------------------------------
ALLSUBNETS
--------------------------------------
NETWORK IPOC 7
NW STAT  LOC CMP FL    FH     STA   LTA     T-ON  T-OFF SERVER
```

```
CX PB01  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB02  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB03  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB04  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB05  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB06  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB07  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB08  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB09  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB10  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB11  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB12  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB14  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB15  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB16  .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX MNMCX .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PATCX .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PSGCX .. BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
---------------------------------------------------------
RECORD IPOC
NW STAT  LOC CMP SERVER
CX PB01  .. BHZ S01
CX PB01  .. BHN S01
CX PB01  .. BHE S01
CX PB02  .. BHZ S01
CX PB02  .. BHN S01
CX PB02  .. BHE S01
CX PB03  .. BHZ S01
CX PB03  .. BHN S01
CX PB03  .. BHE S01
CX PB04  .. BHZ S01
CX PB04  .. BHN S01
CX PB04  .. BHE S01
CX PB05  .. BHZ S01
CX PB05  .. BHN S01
CX PB05  .. BHE S01
CX PB06  .. BHZ S01
CX PB06  .. BHN S01
CX PB06  .. BHE S01
CX PB07  .. BHZ S01
CX PB07  .. BHN S01
CX PB07  .. BHE S01
CX PB08  .. BHZ S01
CX PB08  .. BHN S01
CX PB08  .. BHE S01
CX PB09  .. BHZ S01
CX PB09  .. BHN S01
CX PB09  .. BHE S01
CX PB10  .. BHZ S01
CX PB10  .. BHN S01
CX PB10  .. BHE S01
CX PB11  .. BHZ S01
CX PB11  .. BHN S01
CX PB11  .. BHE S01
CX PB12  .. BHZ S01
CX PB12  .. BHN S01
CX PB12  .. BHE S01
CX PB14  .. BHZ S01
CX PB14  .. BHN S01
CX PB14  .. BHE S01
CX PB15  .. BHZ S01
CX PB15  .. BHN S01
CX PB15  .. BHE S01
CX PB16  .. BHZ S01
CX PB16  .. BHN S01
CX PB16  .. BHE S01
CX MNMCX .. BHZ S01
CX MNMCX .. BHN S01
```

```
CX MNMCX ..  BHE S01
CX PATCX ..  BHZ S01
CX PATCX ..  BHN S01
CX PATCX ..  BHE S01
CX PSGCX ..  BHZ S01
CX PSGCX ..  BHN S01
CX PSGCX ..  BHE S01
```

DEMO2/rt_config

In the example configuration below we define 2 different SeedLink servers from where we want to read data.
Recorded events will also include data from both SeedLink servers.
The use of comments is included.
For the LVC stations different filters and trigger criteria has been included to show the use of individual parameters for each component of data.

```
SERVERS
S01 139.17.3.177
S02 rtserve.iris.washington.edu
--------------------------------------
ALLSUBNETS
--------------------------------------
NETWORK CHILE1 6
NW STAT  LOC CMP FL    FH     STA   LTA     T-ON  T-OFF SERVER
CX PB01  ..  BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB02  ..  BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB03  ..  BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB04  ..  BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB05  ..  BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB06  ..  BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB07  ..  BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
# Next component commented out to show use of comments in file
#CX PB08  ..  BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB09  ..  BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
CX PB10  ..  BHZ 2.0   8.0    2.0   100.0   3.5   1.5   S01
# The following 3 components have different filters and triggers
IU LVC   00  BHZ 2.1   8.1    2.0   100.0   2.5   1.5   S02
IU LVC   00  BH1 2.2   8.2    2.0   100.0   3.5   1.5   S02
IU LVC   00  BH2 2.3   8.3    2.0   100.0   4.5   1.5   S02
---------------------------------------------------------
RECORD CHILE1
NW STAT  LOC CMP SERVER
CX PB01  ..  BHZ S01
CX PB01  ..  BHN S01
CX PB01  ..  BHE S01
CX PB02  ..  BHZ S01
CX PB02  ..  BHN S01
CX PB02  ..  BHE S01
CX PB03  ..  BHZ S01
CX PB03  ..  BHN S01
CX PB03  ..  BHE S01
CX PB04  ..  BHZ S01
CX PB04  ..  BHN S01
CX PB04  ..  BHE S01
CX PB05  ..  BHZ S01
CX PB05  ..  BHN S01
CX PB05  ..  BHE S01
CX PB06  ..  BHZ S01
CX PB06  ..  BHN S01
CX PB06  ..  BHE S01
CX PB07  ..  BHZ S01
CX PB07  ..  BHN S01
CX PB07  ..  BHE S01
CX PB08  ..  BHZ S01
```

```
CX PB08  ..  BHN S01
CX PB08  ..  BHE S01
CX PB09  ..  BHZ S01
CX PB09  ..  BHN S01
CX PB09  ..  BHE S01
CX PB10  ..  BHZ S01
CX PB10  ..  BHN S01
CX PB10  ..  BHE S01
IU LVC   00  BHZ S02
IU LVC   00  BH1 S02
IU LVC   00  BH2 S02
-----------------------------------------------------------
```

DEMO3/rt_config

In the example configuration below we define 2 different SeedLink servers from where we want to read data.
We define 2 different networks that overlaps and that will trigger and record individually.
To have the configuration to treat the two networks as one, the ALLSUBNETS 0 in rtquake.par should be changed to for example ALLSUBNETS 6 where 6 is the minimum number of triggers for the whole network. The minimum number of triggers defined for each network is overridden by this parameter.

```
SERVERS
S01 rtserve.iris.washington.edu
S02 139.17.3.177:18000
-------------------------------------
ALLSUBNETS
-------------------------------------
NETWORK CHILE1 4
NW STAT  LOC CMP FL   FH     STA   LTA     T-ON  T-OFF SERVER
IU LVC   00  BHZ 2.0  8.0    2.0   100.0   3.5   1.5   S01
IU LVC   00  BH1 2.0  8.0    2.0   100.0   3.5   1.5   S01
IU LVC   00  BH2 2.0  8.0    2.0   100.0   3.5   1.5   S01
CX PB01  ..  BHZ 2.0  8.0    2.0   100.0   3.5   1.5   S02
CX PB02  ..  BHZ 2.0  8.0    2.0   100.0   3.5   1.5   S02
CX PB03  ..  BHZ 2.0  8.0    2.0   100.0   3.5   1.5   S02
---------------------------------------------------------
RECORD CHILE1
NW STAT  LOC CMP SERVER
IU LVC   00  BHZ S01
IU LVC   00  BH1 S01
IU LVC   00  BH2 S01
-------------------------------------------------------------
NETWORK CHILE2 4
NW STAT  LOC CMP FL   FH     STA   LTA     T-ON  T-OFF SERVER
CX PB01  ..  BHZ 2.0  8.0    2.0   100.0   3.5   1.5   S02
CX PB02  ..  BHZ 2.0  8.0    2.0   100.0   3.5   1.5   S02
CX PB03  ..  BHZ 2.0  8.0    2.0   100.0   3.5   1.5   S02
CX PB04  ..  BHZ 2.0  8.0    2.0   100.0   3.5   1.5   S02
CX PB05  ..  BHZ 2.0  8.0    2.0   100.0   3.5   1.5   S02
CX PB06  ..  BHZ 2.0  8.0    2.0   100.0   3.5   1.5   S02
---------------------------------------------------------
RECORD CHILE2
NW STAT  LOC CMP SERVER
CX PB01  ..  BHZ S02
CX PB01  ..  BHN S02
CX PB01  ..  BHE S02
CX PB02  ..  BHZ S02
CX PB02  ..  BHN S02
CX PB02  ..  BHE S02
CX PB03  ..  BHZ S02
CX PB03  ..  BHN S02
CX PB03  ..  BHE S02
```

```
CX PB04  ..  BHZ S02
CX PB04  ..  BHN S02
CX PB04  ..  BHE S02
CX PB05  ..  BHZ S02
CX PB05  ..  BHN S02
CX PB05  ..  BHE S02
CX PB06  ..  BHZ S02
CX PB06  ..  BHN S02
CX PB06  ..  BHE S02
IU LVC   00  BHZ S01
IU LVC   00  BH1 S01
IU LVC   00  BH2 S01
------------------------------------------------------------
```

4.4 Extracting data from SeedLink servers

In the rt_config file the user can specify input from several SeedLink servers like in the example above. Before starting RTQUAKE, the user must ensure that the specified SeedLink servers allow both reading real-time data and also allow extracting data from the SeedLink archives. Some SeedLink servers are behind firewalls or the configuration is set to reading data "not allowed" and extraction of data is "not allowed". If the SeedLink server only allow for reading real-time data, one solution to extract data is to install a local SeedLink server to read data from the external SeedLink servers and then configure your local SeedLink server to allow to read and extract data. This is also more practical solution if you are reading from several SeedLink servers. The user does not have to install the complete Seiscomp3 system. The older and more simple to configure Seiscomp 2.5 includes a SeedLink server that can do this job. This SeedLink server is identical or very similar to the one in Seiscomp3.
If you have access to a Seiscomp3 with all the stations you want to use in a parallel RTQUAKE system, RTQUAKE can be configured to read and extract data from this system.

4.5 Configuration files for continuous plot

The RTNET module plots selected components from seismic stations in near-real time.
RTNET needs 2 parameter files, one for defining the input streams of data and another to define the actual components to plot. The names for these files are streams_plot and stations_plot respectively and are stored in /home/seismo/mydir/DEMO1. The two files includes the same streams and stations that were configured in the /home/seismo/mydir/DEMO1/rt_config file.

streams_plot
Each line is in standard SeedLink format, but each station component and location must be included.

```
First 13 characters must be formatted as follows:
NN     Network name
-      Space
SSSSS Station name 5 characters
LL    Location 2 characters
CCC   Component 3 characters

NN-SSSSSLLCCC
CX PB01   BHZ
CX PB02   BHZ
CX PB03   BHZ
```

```
CX PB04   BHZ
CX PB05   BHZ
CX PB06   BHZ
CX PB07   BHZ
CX PB08   BHZ
CX PB09   BHZ
CX PB10   BHZ
CX PB11   BHZ
CX PB12   BHZ
CX PB14   BHZ
CX PB15   BHZ
CX PB16   BHZ
CX MNMCX  BHZ
CX PATCX  BHZ
CX PSGCX  BHZ
```

stations_plot

```
First 10 characters must be formatted as follows:
SSSSS Station name 5 characters
LL    Location 2 characters
CCC   Component 3 characters

SSSSSLLCCC

PB01   BHZ PB01 Huatacondo
PB02   BHZ PB02 Salar Grande
PB03   BHZ PB03 El Tigre
PB04   BHZ PB04 Mantos de la Luna
PB05   BHZ PB05 Michilla
PB06   BHZ PB06 Pedro de Valdivia
PB07   BHZ PB07 Cerro Tatas
PB08   BHZ PB08 Macaya
PB09   BHZ PB09 Quillagua
PB10   BHZ PB10 Juan Lopez
PB11   BHZ PB11 Quebrada Aricilda
PB12   BHZ PB12 Cerro Caramaca
PB14   BHZ PB14 Cerro Paranal
PB15   BHZ PB15 Sierra Gorda
PB16   BHZ PB16 Cerro Chaquipina
MNMCX  BHZ MNMCX Minimi
PATCX  BHZ PATCX Patache
PSGCX  BHZ PSGCX Pisagua
```

4.6 Configuration file for continuous plot from multiple SeedLink servers

The RTSLPL module plots selected components from seismic stations in near-real time.
The module is basically the same as the RTNET, but have much less options. The main advantage is that it can read input data from multiple SeedLink servers.
See parameter file example below:

```
SERVERS
S01 139.17.3.177
S02 rtserve.iris.washington.edu
--------------------------------------
NW STAT  LOC CMP SERVER
CX PB01  ..  BHZ S01
CX PB02  ..  BHZ S01
CX PB03  ..  BHZ S01
CX PB04  ..  BHZ S01
CX PB05  ..  BHZ S01
CX PB06  ..  BHZ S01
CX PB10  ..  BHZ S01
IU LVC   00  BHZ S02
IU LVC   00  BH1 S02
IU LVC   00  BH2 S02
---------------------------------------
```

The parameter file must follow the format shown above. The keyword SERVERS must be present and also the two dashed lines. The line NW STAT LOC CMP SERVER must also be present. It is used as a format indicator for:

NW	Network name
STAT	Station name
LOC	Location
CMP	Component name
SERVER	Server id (S01, S02 etc)

In the example above stations from 2 SeedLink servers are plotted.

4.7 Configuration files helicorder plots

The three modules RT24, RTDR24 and RTDRUM are used to create helicorder plots of unfiltered and filtered data from streams from a SeedLink server. Two parameter files are used as input, one to define the different streams to read and another to select the actual components to plot. See Chapter 20.

streams_heli This file is in standard SeedLink format and lists the stations and components that will be read from the SeedLink server for plotting. Stored in /mydir/par/DEMO1.

```
CX PB01 BHZ
CX PB02 BHZ
CX PB03 BHZ
CX PB04 BHZ
CX PB05 BHZ
CX PB06 BHZ
CX PB07 BHZ
CX PB08 BHZ
CX PB09 BHZ
CX PB10 BHZ
CX PB11 BHZ
CX PB12 BHZ
```

stations_heli

This file specifies the components that will be generated as helicorder plots. The content is station, location, component, amplification factor unfiltered data, amplification factor filtered data, low-pass frequency, high-pass frequency and the name to appear on the helicorder plot. The amplification factors can be modified dynamically when the system is running. This way the helicorder plot can be checked for reasonable amplitudes on the plot.

```
First 10 characters must be formatted as follows:
SSSSS Station name 5 characters
LL    Location 2 characters
CCC   Component 3 characters
AMP1  Amplification factor raw data
AMP2  Amplification factor filtered data
FL    Low pass filter
FH    High pass filter

SSSSSLLCCC   AMP1   AMP2   FL  FH  NAME
PB01   BHZ 0.0100 0.0300 2.0 8.0 Huatacondo
PB02   BHZ 0.0100 0.0300 2.0 8.0 Salar Grande
PB03   BHZ 0.0100 0.0300 2.0 8.0 El Tigre
PB04   BHZ 0.0100 0.0300 2.0 8.0 Mantos de la Luna
PB05   BHZ 0.0100 0.0300 2.0 8.0 Michilla
PB06   BHZ 0.0100 0.0300 2.0 8.0 Pedro de Valdivia
PB07   BHZ 0.0100 0.0300 2.0 8.0 Cerro Tatas
PB08   BHZ 0.0100 0.0300 2.0 8.0 Macaya
PB09   BHZ 0.0100 0.0300 2.0 8.0 Quillagua
PB10   BHZ 0.0100 0.0300 2.0 8.0 Juan Lopez
PB11   BHZ 0.0100 0.0300 2.0 8.0 Quebrada Aricilda
PB12   BHZ 0.0100 0.0300 2.0 8.0 Cerro-Caramaca
```

4.8 Parameterfile web-pages

Two web pages are available to monitor the events recorded and located by RTQUAKE. Both html files, LAST_TRIG.html and rt_screen1.html, are stored in /home/seismo/mydir/map and use the same parameter file that are also located in /home/seismo/mydir/map. The parameter file is called: map.par

```
NUMBER OF EVENTS           # Number of events back in time to plot
100
ZOOM FACTOR                # Google maps zoom factor
7
LATITUDE-LONGITUDE-GRID    # Add latitude/longitude grid or not
1
MAPTYPE 0-SAT,1-TER        # Maptype id Google maps: 0-SATELITE, 1-TERRAIN
0
BLINK                      # Blinking red marker, 0-blinking, 1-no blinking
0
```

4.9 Aliases and Scripts

alias rtstart='$RTQUAKE_TOP/com/rtquake_start'

The command rtstart starts the script rtquake_start. This is the start script to start RTQUAKE and the file actually installed is set up for the test run and can be used as a recipe for the user to set up the actual network. As you see in the example below, the DEMO1 subdirectory is used.

```
killall rtdet
killall rtdly
killall rtnet
$RTQUAKE_TOP/bin/rtdet -par 0 -cfg DEMO1 &
sleep 2
$RTQUAKE_TOP/bin/rtdly &
sleep 2
$RTQUAKE_TOP/bin/rtnet -x 650 -y 750 -xo 150 -yo 150 -d -m 10 -n 20 -fl 2.0
-fh 8.0 -l DEMO1/streams_plot -f DEMO1/stations_plot 139.17.3.177:18000 &
```

First any active RTQUAKE modules are stopped, then the rtdet module is started with the configuration given in DEMO1, then the rtdly module is started and finally the rtnet module is started. See module descriptions for more details on the parameters for each module.
Important: The ip number in the start command for the rtnet module must be changed to fit your configuration. Other rtnet arguments may also be modified to fit number of channels, filters etc.

alias rtstop='$RTQUAKE_TOP/com/rtquake_stop'
Activate the rtquake_stop script.

The command rtstop stops all running RTQUAKE modules.

```
killall rtdet
killall rtsnr
killall rtmon
killall rtnet
killall rtdly
killall rt24
killall rtdrum
killall rtdr24
```

alias rtheli1='$RTQUAKE_TOP/com/rtquake_heli_tst1'
The command rtheli1 starts the generation of the helicorder plots, one plot per day.

rt24 –heli 1 –logol logo_left_def.gif –logor logo_right_def.jpg –col 5 –to_wi 1200 –fr_hg 600 –mt 15 –l DEMO1/streams_heli –f DEMO1/stations_heli 139.17.3.177

See module descriptions for more details on the parameters for each module.

alias rtheli2='$RTQUAKE_TOP/com/rtquake_heli_tst2'

The command rtheli2 starts the generation of helicorder plots always showing the last 24 hours.

rt24 –heli 0 –logol logo_left_def.gif –logor logo_right_def.jpg –col 0 –to_wi 1200 –fr_hg 600 –mt 15 –l DEMO1/streams_heli –f DEMO1/stations_heli 139.17.3.177

See module descriptions for more details on the parameters for each module.

5 START SCRIPT TEST RUN

When starting the main modules in RTQUAKE with the start script, several parameters are given in the script. Below is the example script rtquake_start with explanation of the parameters used.

```
killall rtdet
killall rtdly
killall rtnet
echo Start profile: $1
$RTQUAKE_TOP/bin/rtdet –cfg $1 &
sleep 5
$RQUAKE_TOP/bin/rtnet -x 650 –y 700 –xo 50 –yo 300 -d -m 10 –n 20 -fl 2.0 -fh 8.0 -l
$1/streams_plot -f $1/stations_plot  139.17.3.177:18000 &
sleep 5
$RTQUAKE_TOP/bin/rtdly &
```

Explanation of the parameters used in the rtquake_start:

rtdet is the acquisition and detection module. The different parameters have the following meaning:

-cfg argument	Name of profile catalog under: /home/mydir/rtquake/par that contains the configuration files (DEMO1).

rtdly is graphically monitoring the components that are defined in the configuration file for triggers and the durations of the triggers. The module takes the following parameters:

rtnet plots continuous data of specified components. The module takes the following parameters:

-x 650	x size of plot frame in pixels
-y 700	y size of plot frame in pixels
-xo 50	x position of upper left corner of plot frame.
-yo 300	y position of upper left corner of plot frame.
-d	Plot geographical name instead of station name as specified in the stations_plot file, see 4.5.
-m 10	Number of minutes on screen
-fl 2.0	Specifies lower frequency in band pass filter
-fh 8.0	Specifies higher frequency in band pass filter
-l DEMO1/streams_plot	Streams or components to read from SeedLink server
-f DEMO1/stations_plot	Stations to plot
-n 20	Number of stations to plot
139.17.3.177:18000	IP address and port number for the SeedLink server.

Be aware that the IP number in the example is ONLY valid for the example configuration.

6 CONFIGURATION OF A NEW NETWORK

To configure your own network, first create a new sub-catalogue under the /mydir/par catalogue that identify your network. You can use the parameter files used in the test example as a recipe. Make a copy the files rt_config, streams_plot and stations_plot in the par/DEMO1. Edit the files to fit your stations, components etc. Check the rtquake.par file. As a start most default values can be used. Remember to include your station coordinates (if auto locations are to be made) in the SEISAN STATION0.HYP file if not already there in your SEISAN installation. Remember to include the response files in the SEISAN CAL catalogue if local magnitude is to be calculated. The start script should also be modified to fit your configuration.

Automatic start of RTQUAKE with a cron job

RTQUAKE can be set up to start automatically when the computer starts up. Modules may also stop due to different reasons and should then be restarted. A cron job can do this by checking that a specific module is active at regular time intervals.

```
cron_restart.csh

#!/bin/csh
#
set PROCESS='rtdet'

set val = `ps -e | grep rtdet | sed -e "s/.*\(rtdet[^ ]*\).*/\1/"`

if($val != "") then
  echo "RTDET running, EXIT"
  exit

else
  echo "$PROCESS is not running"
  echo "start the process"
  echo "Start $PROCESS !"
#echo "put in the start command here"
/home/seismo/mydir/par/start_rtdet.csh > /dev/null &
echo "$PROCESS started"
endif
```

A crontab job to restart the rtdet module can be created by starting the script above for example every 5 minutes:

```
*/5 * * * * /home/seismo/rtquake/par/cron_restart.csh
```

Both scripts cron_restart.csh and start_rtdet must be changed to “executable” to function.
A typical start_rtdet.csh would look like:

```
#!/bin/csh
source /home/seismo/rtquake/com/setup_rt.csh
source /home/seismo/COM/.SEISAN
cd /home/seismo/rtquake/wrk
/home/seismo/rtquake/bin/rtdet -cfg DEMO1&
```

NOTE: Be aware that the name of the cron script can NOT contain the name of the module you want to restart. cron_restart.csh is ok, restart_rtdet.csh is NOT ok if you want to restart the module rtdet.

For the bash shell the cron script will look like this:

```
cron_restart.bash

#!/bin/bash
#
PROCESS='rtdet'
if ps ax | grep -v grep | grep $PROCESS > /dev/null
then
exit
else
#echo "$PROCESS is not running"
#start the process
#echo "Start $PROCESS !"
#echo "put in the start command here"
#/home/seismo/rtquake/par/STARTUP-SCRIPT-FOR-RTDET > /dev/null &
/home/seismo/mydir/par/start_rtdet > /dev/null &
fi
```

```
*/5 * * * * /home/seismo/mydir/par/cron_restart.bash
```

```
#!/bin/bash
source /home/seismo/mydir/com/setup_rt.bash
source /home/seismo/seismo/COM/SEISAN.bash
/home/seismo/mydir/bin/rtdet –par 0 –cfg DEMO1&
```

7 DIRECTORY STRUCTURE

If we assume a top directory: /home/seismo, the following directory structure will be created:

/home/seismo/mydir	Main directory containing all subdirectories, include files, makefile
/home/seismo/mydir/bin	Executables
/home/seismo/mydir/com	Environment scripts and test scripts
/home/seismo/mydir/doc	All documentation in word or pdf format.
/home/seismo/mydir/heli	Example configuration, scripts etc for helicorder plots
/home/seismo/mydir/inc	Include files for RTQUAKE
/home/seismo/mydir/libslink	Libraries and include files for SeedLink library.
/home/seismo/mydir/loc	Static Google map links for plotting automatic locations
/home/seismo/mydir/map	Temporary hypocenter files for generating maps, station files
/home/seismo/mydir/par	Parameter files for the different modules
/home/seismo/mydir/par/DEMO1	Test configuration (Test run example)
/home/seismo/mydir/par/DEMO2	Demo configuration (Example)
/home/seismo/mydir/par/DEMO3	Demo configuration (Example)
/home/seismo/mydir/picker	Source files Filter-picker, include files and make file
/home/seismo/mydir/req	Request files. One file for each triggered event. The files are executable and can be run to extract the event file if it for some reason was not recorded at trigger time, for example: delayed data. Depending on the size of the segment buffer in the SeedLink server, this can be done several days after the time of the trigger.
/home/seismo/mydir/rt/cod	Catalog for automatically generated png and html files used by web page: /home/seismo/mydir/map/AUTOLOC.html.
/home/seismo/mydir/rt/latency	Catalog for latency of arriving SeedLink data from RTTIME module.
/home/seismo/mydir/rt/png	Catalog for unfiltered helicorder plots
/home/seismo/mydir/rt/png_filt	Catalog for filtered helicorder plots
/home/seismo/mydir/rt/pph	Catalog for automatically generated png and html files used by web page: /home/seismo/mydir/map/AUTOLOC_RT.html
/home/seismo/mydir/rt/tmp	Catalog for unfiltered datafiles to make helicorder plots
/home/seismo/mydir//rt/tmp_filt	Catalog for filtered datafiles to make helicorder plots
/home/seismo/mydir/rt/tmp0-10	Catalogs for execution of 10 parallell rtpick programs for 10 different subnets.
/home/seismo/mydir/rtdet	Source files and make file for main module
/home/seismo/mydir/seedlink	Distribution and user manual SeedLink
/home/seismo/mydir/tmp	Temporary files. Removed after x days specified in the /home/seismo/mydir/com/rtquake.par file.
/home/seismo/mydir/utils1	Source files main monitoring utilities, makefile,
/home/seismo/mydir/utils2	Source files monitoring utilities, makefile.
/home/seismo/mydir/wrk	Work catalogue for testing of software

8 GENERAL DESCRIPTION AND MODULE OVERVIEW

In general the modules are dependent on data recorded by a SeedLink server. The server can be located locally or remotely as long as you as the user have access to the server through internet. Some modules are written as clients to the SeedLink server to extract data in near real time while others are used to monitor this activity. Another group of modules monitor the activity on the SeedLink server.
The modules can be categorized into 3 different groups

- **Detection, Recording and Monitoring**

RTDET Detection and recording of events. Reads data from local or remote SeedLink server.

RTPICK Automatic phase-picking and auto-location. Both in close to real time and after a complete events has been recorded.

RTSNR Graphical monitoring of R=STA/LTA of each station, each parameter set in RTPICK.

RTDLY Monitor onsets of triggers and duration of triggers for the individual components specified in the detection parameter file.

- **Monitoring of SeedLink**

RTNET Plots selected components in “near-real-time”. Reads data from a local or remote SeedLink server.

RTTIME Graphic monitoring of latency of stations transmitting to a SeedLink server.

- **Helicorder plots**

RT24 Generates temporary data files of specified station components. Files are input for RTDR24 that generates helicorder plots. Data are read from local or remote SeedLink server.

RTDRUM Creates helicorder plots of specified station components. One-day.

RTDR24 Creates helicorder plots of specified station components. Last 24 hour.

RTHPLT Creates a menu to plot individual helicorder plots. Two individual html files are generated for raw and filtered data respectively. The routine also removes files older than x days where x is given as a parameter for the routine.

9 DETECTION AND RECORDING OF EVENTS

RTDET – Detection based on input data from a SeedLink server.

RTDET is written as a SeedLink client, and executes under Linux. The program can be run on the same machine as the SeedLink server or remotely.
A SeedLink server will normally hold data from a network covering a larger geographical area. By using different parameter sets, it is possible to divide the network into several sub-nets for detection of more local events.

Each parameter set can have different parameters such as:

different and/or overlapping stations with other parameter sets
different filters
different trigger-ratio
different de-trigger-ratio
different sta & lta length
different parameter sets can record different components.

All parameters for the rtdet module are defined in the mydir/com/rtquake.par file and in the parameter file where stations and networks are defined, mydir/par/yournetwork/rt_config.

Description of the trigger algorithm.

Data buffers from stations specified in the parameter files are read from the SeedLink server. Data from each component are stored in a two-dimensional array, (component, sample). New data are stored in the bottom of the array, while old data are shifted out from the top. Each component is continuously checked for triggers with a standard STA/LTA computation.
A 3-dimensional array (parameter set, channel-number, length in seconds) can hold trigger-times for up to one hour. Trigger times for individual components are stored in this array in the correct place with reference to current UTC time. The array is shifted at regular intervals so that the array always keeps new data at the current UTC time. Network detection is then computed at a later time, controlled by a parameters in the rtquake.par file, see 4.2. Figure 3.2 illustrates this in more detail.
Triggers will exist as valid until they are shifted out of the array-propagation-window, also explained in Figure 3.2.
When subnets are defined, each subnet will have its own trigger-thread independent of the others.
The trigger algorithm allows triggers to be detected with a delay in time. This means that for example data from one or more stations arrives with a variable delay due to for example communication problems can be used to correctly trigger an event.

10 AUTOMATIC LOCATION

10.1 Automatic location on complete recorded events.

To activate the automatic location in RTQUAKE, several parameters have to be set to correct values in the rtquake.par file, see 4.2. The parameters KEEP and LOCATION must both be set to 1 as explained in 4.2. This will ensure that a s-file will be created with phase-picks from the rtpick module. LOCATION=1 means that location of the event will be initiated. ITERATION, MAX_RESIDUAL and MINSTALOC are used in the iteration process to reduce the number of phases in the s-file that have high residuals. ITERATION=200 means that the program will try with up to 200 iterations to reduce the average residual to MAX_RESIDUAL=2.5. MINSTALOC=5 means that the program will need minimum 5 stations left to do location when the MAX_RESIDUAL=2.5 has been reached. See 4.2 rtquake.par.
For SEISAN the parameter "RMS residual low limit for bisquare weighting for local events" (RESET TEST(36)) should be set to e.g. 6 s in the SEISAN0.HYP file. This means that when the RMS of travel time residuals is less than 6 s, residual weighting will start to be used and large outliers will have little or no influence in the location.

The automatic location procedure in RTQUAKE is outlined in the flowchart below:

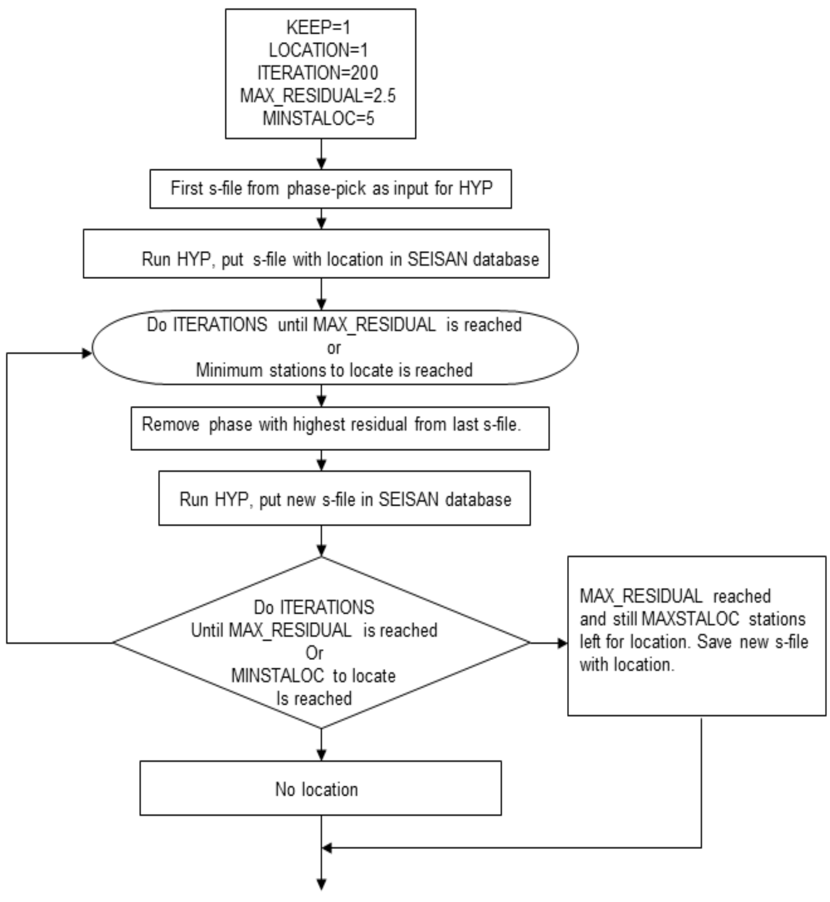


Figure 10.1 Automatic location process

Below is an example output from the iteration process. In the example the MAX_RESIDUAL is set to 2.5 and the MAXSTALOC to 5 stations. In bold one can see that the average residual is decreasing for each iteration until the 2.5 limit has been reached and there are still 25 stations left for location.

```
MAX_RESIDUAL 2.5

RTPICK: Path+s-filename.............: /home/seismo/snew/REA/TST__/2014/05/05-0805-20L.S201405
RTPICK: S_REC: fullpath.............: /home/seismo/snew/REA/TST__/2014/05/05-0805-20L.S201405
RTPICK: S_REC.......................: Write new s-file header to s-file.
RTPICK: S_REC: Create s-file........: /home/seismo/snew/REA/TST__/2014/05/05-0805-20L.S201405
S_REC: Write new phases to s-file.
 PB01 BZ IP    A   8 5 57.36  270
 PB02 BZ IP    A   8 5 57.31  277
 PB04 BZ IP    A   8 6  8.36  223
 PB05 BZ IP    A   8 6 14.86  263
 PB06 BZ IP    A   8 6 15.86  240
 PB07 BZ IP    A   8 6  2.46  274
 PB08 BZ IP    A   8 5 53.86  275
 PB09 BZ IP    A   8 6  8.50  269
 PB10 BZ IP    A   8 6 22.54  233
 PB11 BZ IP    A   8 5 44.85  309
 PB12 BZ IP    A   8 5 38.55  254
 PB15 BZ IP    A   8 6 22.86  129
 PB16 BZ IP    A   8 5 50.94  293
 MNMCXBZ IP    A   8 5 45.20  318
 PATCXBZ IP    A   8 5 49.60  211
 PSGCXBZ IP    A   8 5 37.20  322
 PB01 BN IS   3A   8 6 24.31
 PB08 BN IS   3A   8 6 21.46
 PB08 BE IS   3A   8 5 54.81
 PB09 BN IS   3A   8 6  9.30
 PB11 BN IS   3A   8 6  3. 0
 PB11 BE IS   3A   8 6  3. 5
 PB12 BN IS   3A   8 5 50.89
 PB12 BE IS   3A   8 5 51. 9
 PB16 BN IS   3A   8 6 13. 9
 PB16 BE IS   3A   8 6 13.79
 MNMCXBN IS   3A   8 6  5.25
 MNMCXBE IS   3A   8 6  4. 0
 PATCXBN IS   3A   8 5 50.30
 PSGCXBN IS   3A   8 5 51. 0
 PSGCXBE IS   3A   8 5 50.80
RTPICK: Create_Sfile..: Locate + new s-file.
RTPICK: comm0.....: rm hyptemp.txt
RTPICK: com10.....: cp /home/seismo/snew/REA/TST__/2014/05/05-0805-20L.S201405 s_org.out
RTPICK: comm1.....: hyp /home/seismo/snew/REA/TST__/2014/05/05-0805-20L.S201405 >> hyptemp.txt
RTPICK: comm2.....: cp hyp.out /home/seismo/snew/REA/TST__/2014/05/05-0805-20L.S201405
RTPICK: comm8..........: cp hyp.out hyp_all.out
RTPICK: Found..........: hyp.out
RTPICK: readings left..: 31 Avg.res:    34.00  phases left: 30 Avg.residual in HYP_NEW:  27.53
RTPICK: readings left..: 30 Avg.res:    27.40  phases left: 29 Avg.residual in HYP_NEW:  21.34
RTPICK: readings left..: 29 Avg.res:    21.34  phases left: 28 Avg.residual in HYP_NEW:  16.28
RTPICK: readings left..: 28 Avg.res:    16.28  phases left: 27 Avg.residual in HYP_NEW:  10.85
RTPICK: readings left..: 27 Avg.res:    10.85  phases left: 26 Avg.residual in HYP_NEW:   6.85
RTPICK: readings left..: 26 Avg.res:     6.85  phases left: 25 Avg.residual in HYP_NEW:   2.68
RTPICK: readings left..: 25 Avg.res:     2.68  phases left: 24 Avg.residual in HYP_NEW:   1.41
RTPICK: STOP iterations. Residual below..: 2.50
RTPICK: Average residual................: 2.679000
RTPICK: No more iterations..............: Number of stations: 25 Avg: res.:    2.679
RTPICK: comm6...........................: cp hyp.out hyp.tmp
RTPICK: com11...........................: cp hyp.out /home/seismo/rtquake/map
RTPICK: comm2............: cp hyp.out /home/seismo/snew/REA/TST__/2014/05/05-0805-20L.S201405
RTPICK: SEISAN_TOP......................: /home/seismo/snew
RTPICK: RTQUAKE_TOP.....................: /home/seismo/rtquake
RTPICK: RSS.............................: 2679
RTPICK:.................................: Update map
RTPICK: MAG.............................: 3.4
RTPICK: mail1...........................: 0
rtn>
```

Below is the final s-file after the iteration and location process:

```
rtn>eev 201405050805
 2014  5 Reading events from base TST__   732
#  731   5 May 2014 08:05 19  LM-19.318 -71.135  0.3  N 0.6 3.4CBER   16  ? t

 File name: /home/seismo/snew/REA/TST__/2014/05/05-0805-20L.S201405
2014  5 5 0805 19.7 LM-19.318 -71.135  0.3  BER 16 0.6 3.4CBER                 1
GAP=235        1.10        5.4      9.2  8.6 -0.2931E+02  0.1503E+02  0.1272E+02E
2014-05-05-0804-20.TST___054_00                                                6
ACTION:NEW 14-05-05 08:05 OP:SEIS STATUS:              ID:20140505080519     I
STAT SP IPHASW D HRMM SECON CODA AMPLIT PERI AZIMU VELO SNR AR TRES W  DIS CAZ7
PSGCXBZ IP    A   8 5 37.20  322                       91   -0.3210  111 106
PSGCXBE IS   3A   8 5 50.80                            91    0.08 2  111 106
PB12 BZ IP    A   8 5 38.55  254                       91    0.2810  115  48
PB12 BN IS   3A   8 5 50.89                            91   -1.15 2  115  48
MNMCXBE IS   3A   8 6  4. 0                            50   -0.78 2  163  83
PB11 BZ IP    A   8 5 44.85  309                       50   -0.5910  163 108
PB11 BN IS   3A   8 6  3. 0                            50   -1.51 2  163 108
MNMCXBZ IP    A   8 5 45.20  318                       50   -0.3910  163  83
PATCXBZ IP    A   8 5 49.60  211                       50    0.1410  195 148
PATCXBN IS   3A   8 5 50.30                            50   -21.2 0  195 148
PB16 BZ IP    A   8 5 50.94  293                       50    0.1610  203  58
PB16 BE IS   3A   8 6 13.79                            50   -0.01 3  203  58
PB08 BZ IP    A   8 5 53.86  275                       50    0.2910  227 114
PB08 BN IS   3A   8 6 21.46                            50    2.80 2  227 114
PB02 BZ IP    A   8 5 57.31  277                       50    0.2510  257 150
  Return to continue, q to return to EEV

PB01 BZ IP    A   8 5 57.36  270                       50    0.2410  257 138
PB01 BN IS   3A   8 6 24.31                            50   -0.52 2  257 138
PB07 BZ IP    A   8 6  2.46  274                       50    0.3510  297 154
PB09 BZ IP    A   8 6  8.50  269                       50    1.27 9  338 145
PB09 BN IS   3A   8 6  9.30                            50   -33.1 0  338 145
PB04 BZ IP    A   8 6  8.36  223                       50   -0.2710  349 163
PB05 BZ IP    A   8 6 14.86  263                       50   -0.4310  403 166
PB06 BZ IP    A   8 6 15.86  240                       50   -0.1510  409 157
PB15 BZ IP    A   8 6 22.86  129                       49    0.0410  464 158
PB10 BZ IP    A   8 6 22.54  233                       49   -0.6410  468 173
```

The web page below (see Chapter 3) shows the map with the location, the s-file, a plot of the residuals each component and a plot of the waveform of the event.

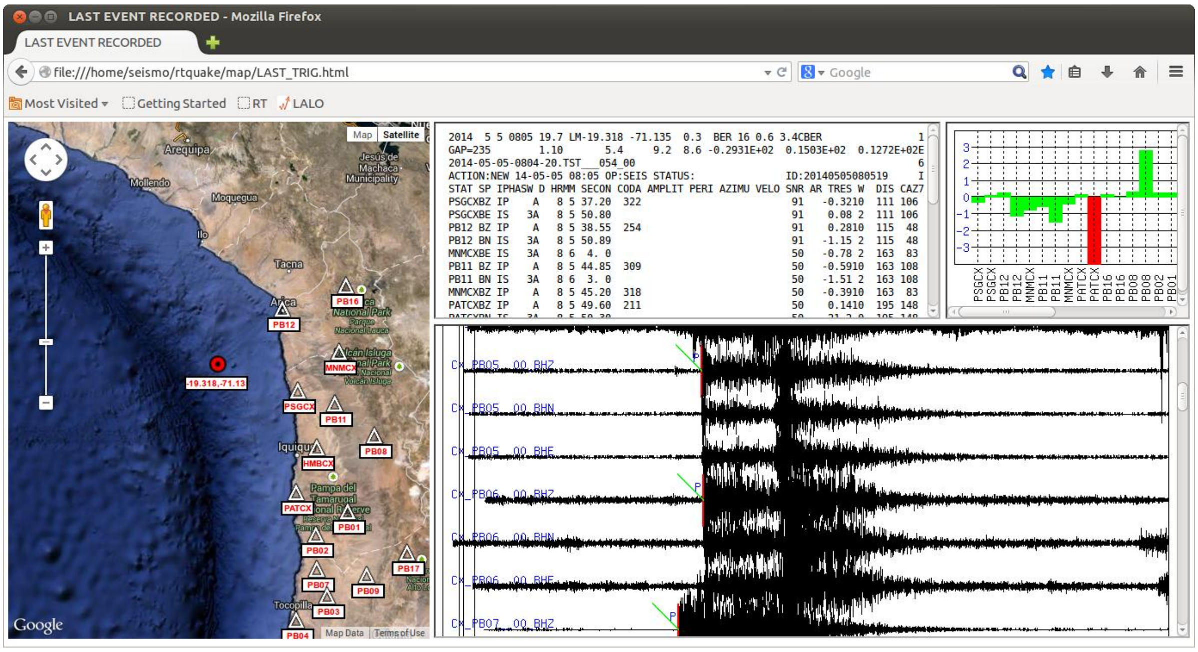


Figure 10.2 Web page showing location of last located event.

10.2 Automatic location in "close-to-real-time".

Close to real time location can be performed by the RTDET program if the parameter REALTIME_PICK is set to 1 in the rtquake.par parameter file. With this option active the system will try to do an automatic location based on phase-picks done in a small time window close to real time. This time-window works as an array-propagation window, but the time window is immediately after the data enter the system from the SeedLink server. When a sufficient minimum number of phases are available, the system will try to do a location. The location may be rejected due to high rms residual or due to few phases. As more data enters the time-window, the location may succeed, and can also be improved as more data enter with new phases.

Short waveforms with corresponding s-files are stored in the SEISAN data base under /WAV/PPHAS and /REA/PPHAS.

The ml and mw can also be computed if the response files for the actual stations are installed in SEISAN.

Locations and magnitudes can be monitored on the web-page mydir/map/AUTOLOC_MON.html, mydir/map/AUTOLOC_RT.html and the program rtloc as described in Figures 3.6,3.7 and 3.9.

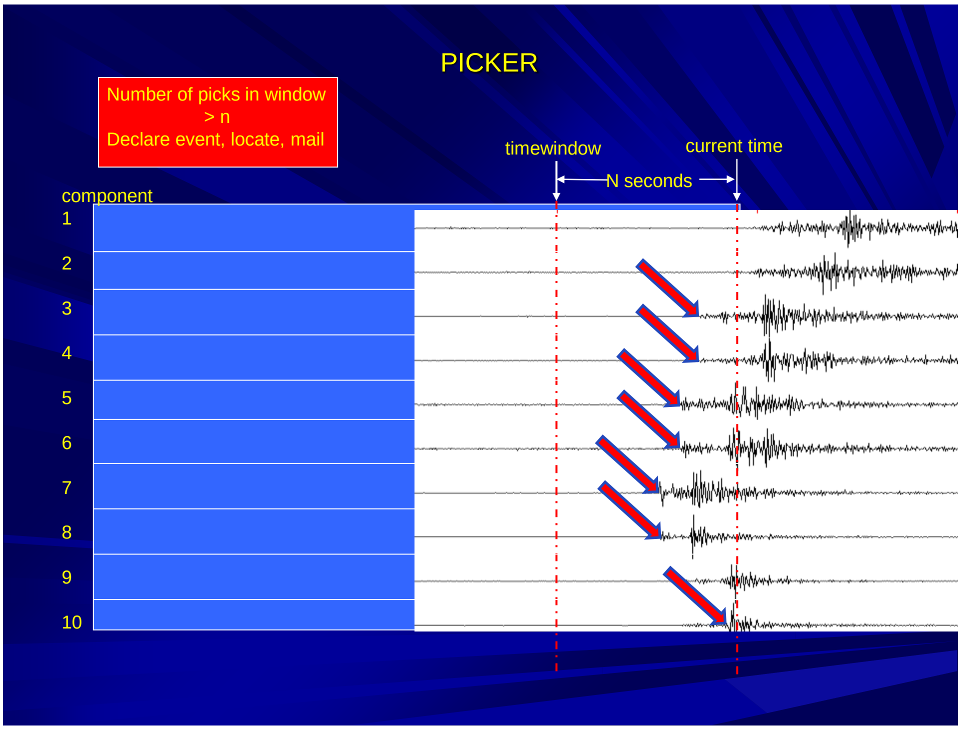


Figure 10.3 Automatic location based on "close-to-real-time" phases.

11 PROCESSING DETECTIONS WITH SEISAN

SEISAN is intended to be used as the main data-inspection and processing system since the triggered events are written directly out in a SEISAN data base and, if SEISAN is mounted on the same computer as the SeisComp system, SEISAN can also read the SeisComp ring buffer system.

SEISAN trigger files

For each trigger, an S-file is created in the SEISAN data base with P-arrival times, signal duration as well as a reference to the trigger waveform file, see example below. The S-files can be used for SEISAN processing like earthquake location and plotting.

Checking triggered events
Events that have triggered the system can be found by using the command eev. E.g the command 'eev 200905' is used to inspect data for May 2009. This command can be given from any directory.

Plotting triggered events
From eev, give command po and the MULPLT program is started with the current event. The user can now do housekeeping by inspecting events, delete false triggers, and do final registration of the event into the SEISAN-database.

Plotting data with a SeisComp ringbuffer database (the archive)

In SEISAN, 'mulplt' is able to plot from the SeisComp ringbufferes (archive), so that any time-window, from any number of channels, can be seen at the same time. The ringbuffer consists of a flat file system with one channel files one day long (see SeisComp manual).
The channels to be plotted and the location of the archive must have been defined in the SEISAN.DEF file in DAT (see SEISAN manual). The procedure is then:

Start 'mulplt'.
Give option 'arc'
Select start time and interval, the plot will then come up in the usual way with all selected channels. It is now possible to move forwards and backwards in the ring buffer.

It is possible to plot and extract out data from the ringbuffer a couple of minutes after real time.

Extracting data from the archive using 'mulplt':

Use 'Out' function to extract data selected on the screen or use 'Regis' function to extract a waveform file to the WAV directory and create a corresponding new event (S-file) in the data base. This option can be used to recover data if RTDET did not trigger or trigger interval was not correct

The S-file

An example of a name is:

12-1145-22L.199911

The name consists of ‘day of month’ and time. The L indicates that the event is a local event by default (see SEISAN). On the left hand side is year and month. The S-files are written in ASCII and the format follows the SEISAN-definition. An example for an S-file is shown below:

```
1999  623  7 5 30.0 L                       BER                              1
1999-06-23-0705-30S.BERG__003                                                6
ACTION:NEW 99-06-23 07:05 OP:SEIS STATUS:               ID:19990623070530     I
STAT SP IPHASW D HRMM SECON CODA AMPLIT PERI AZIMU VELO SNR AR TRES W  DIS CAZ7
BER  SZ IP    A  0705 30.10   10
ASK  SZ IP    A  0705 30.10   10
EGD  SZ IP       0705 30.10   10
```

A full description of the format is found in the SEISAN-manual, so only the important points will be given here. The first line is a header line giving start-time of the recording. The L stands for local event (by default). BER is the station-identifier-code. Line 2 gives the name of the corresponding waveform-file, which normally is located in the directory for event waveform-files. Line 3 is a help line for lines following, which gives the trigger-time for each channel participating in the detection. The duration of the trigger for each channel is given under ‘CODA’. These times can be used by SEISAN for locating the event if more than 3 stations are present, and the magnitude is calculated from the coda.

12 MAIL

12.1 Optional : Mail

RTQUAKE has the ability to send mail when an event has been recorded and a preliminary automatic location has been calculated. This means that automatic location must be activated (see 4.2 rtquake.par) and that the location is written in the S-file. Some events may not be located due to unreliable readings and no mail is sent. This option can be activated in the rtquake.par file (see 4.2 rtquake.par). Be aware that this can cause a lot of mails to be sent if the threshold for triggering is low or if noisy signals result in false triggers. A network in a very seismic area will also cause lot of mails. For RTQUAKE to support this option the user has to install the following packages: **ssmtp** and **mutt** (text-based mail client).
SSMTP is a program to deliver an email from a local computer to a configured mailhost (mailhub). It is not a mail server and does not receive mail, expand aliases or manage a queue. One of its primary uses is for forwarding automated email (like system alerts) from your machine and to an external email address.
For the setup below the user must have access to a gmail account for this purpose. It is recommended to create a separate account for these mails. We assume an account: myaccount@gmail.com with a password: mypassword for the example configuration below.
Never use this account and password in the example above for security reasons!!!!!!
As root the user must edit the two ssmpt configuration files to contain the same information as shown below. In the rtquake.par file the user specify the real email address that will receive the mail. The gmail account will just forward the mail.

Edit **/etc/ssmpt/ssmpt.conf**:

```
#
# Config file for sSMTP sendmail
#
# The person who gets all mail for userids < 1000
# Make this empty to disable rewriting.
root=myaccount@gmail.com

# The place where the mail goes. The actual machine name is required no
# MX records are consulted. Commonly mailhosts are named mail.domain.com
mailhub=smtp.gmail.com:587

# Where will the mail seem to come from?
#rewriteDomain=

# The full hostname
hostname=smtp.gmail.com:587
UseSTARTTLS=YES
UseTLS=YES
AuthUser=myaccount
AuthPass=mypassword
AuthMethod=LOGIN

# Are users allowed to set their own From: address?
# YES - Allow the user to specify their own From: address
```

# NO - Use the system generated From: address
FromLineOverride=NO

Edit **/etc/ssmpt/revaliases:**

```
# sSMTP aliases
#
# Format:       local_account:outgoing_address:mailhub
#
# Example: root:your_login@your.domain:mailhub.your.domain[:port]
# where [:port] is an optional port number that defaults to 25.
root:myaccount@gmail.com:smtp.gmail.com:587
mainuser:myaccount@gmail.com:smtp.gmail.com:587
rtquake:myaccount@gmail.com:smtp.gmail.com:587
```

If mail has been configured and is activated in rtquake.par the email will look like this and contain the following information:

subject: COD UTC: 28/05/2015 09:55:10.1 Lat: -20.13 Lon: -70.21 MC: 3.9 Provincia de Iquique, I Región de Tarapacá, Chile

To: the-address specified in rtquake.par
2 attachments:
ALL.png
hyp.txt

http://maps.googleapis.com/maps/api/staticmap?center=-20.128000,-70.207001&zoom=7&size=900x1000&maptype=hybrid&markers=icon:http://maps.google.com/mapfiles/kml/pal3/icon33.png%7C-20.128000,-70.207001&sensor=false

Clicking on the link will produce a static google map as shown in Figure 12.1. The text "center=-20.128000,-70.207001" is the computed location for the event. The attachment ALL.png contains the plot shown in Figure 12.2 and hyp.txt (s-file) in Figure 12.3

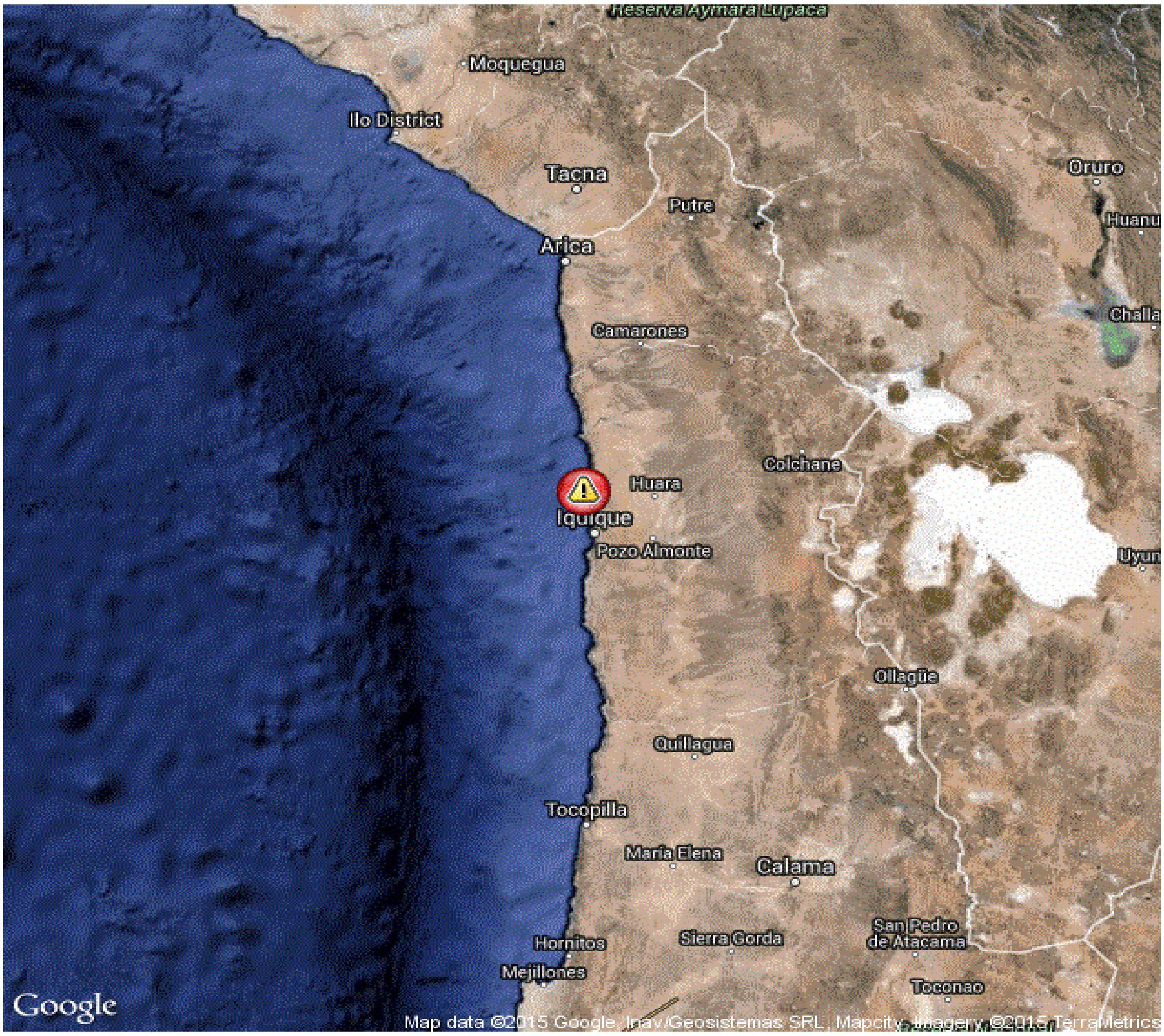


Figure 12.1 Static google map with suggested location marked with the red symbol.

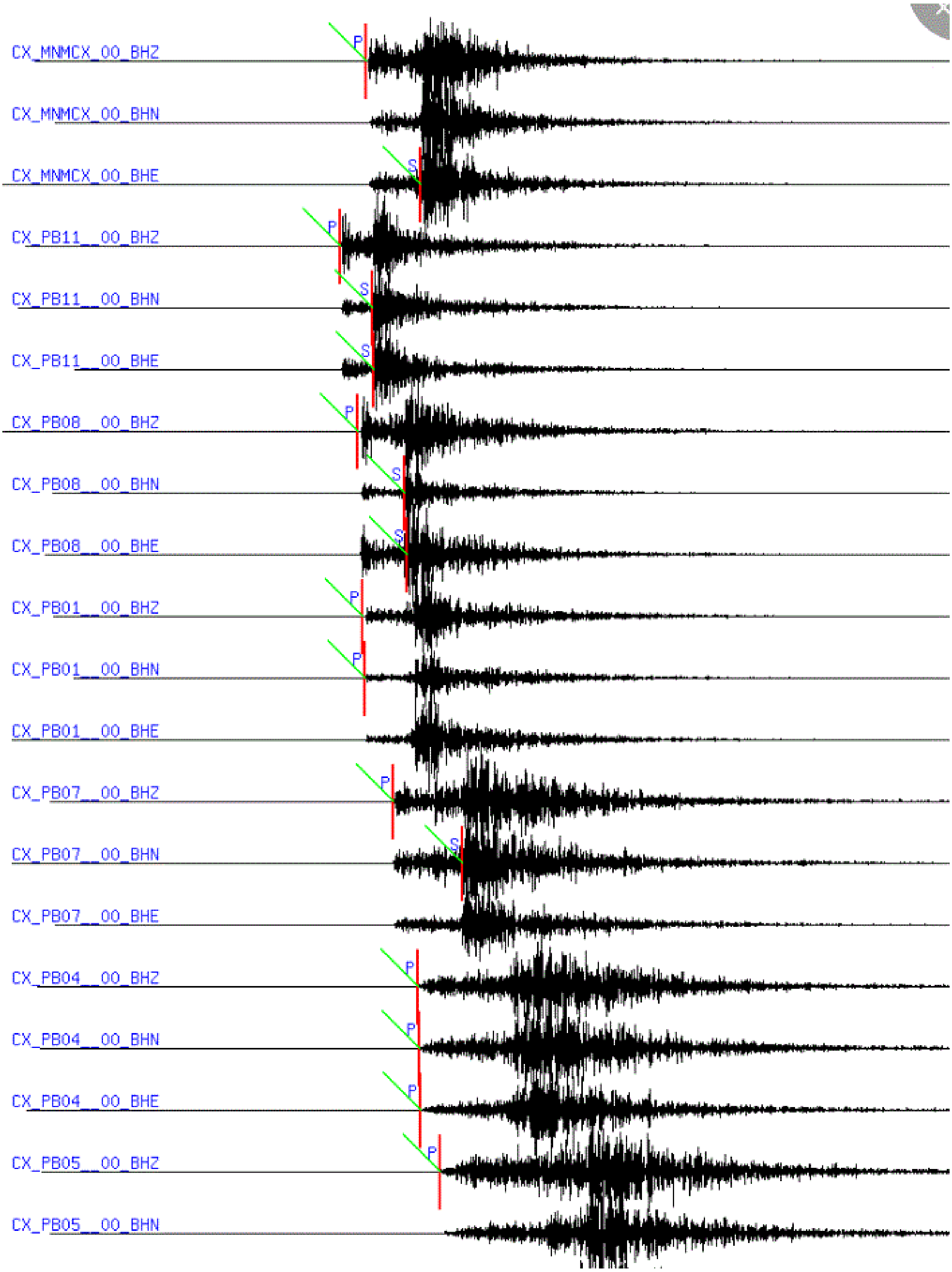


Figure 12.2 ALL.png attachment showing a plot of recorded stations with phases marked.

```
2015  528 0955 13.1 LM-20.128 -70.207 15.0  BER  8 0.7 3.9CBER                1
GAP=205        1.36       6.8    16.9 19.1 -0.5680E+02  0.2369E+03 -0.6277E+01E
2015-05-28-0954-10.TST___054_00_01                                             6
ACTION:NEW 15-05-28 09:55 OP:SEIS STATUS:              ID:20150528095510     I
STAT SP IPHASW D HRMM SECON CODA AMPLIT PERI AZIMU VELO AIN AR TRES W  DIS CAZ7
PB11 BZ IP    A  955 25.20  342                         95    0.6910 70.5  55
PB11 BN IS   3A  955 34.50                              95    1.52 2 70.5  55
PB11 BE IS   3A  955 34.80                                          70.5  55
PB08 BZ IP    A  955 30.31  384                         92   -0.2810  110  91
PB08 BN IS   3A  955 43.86                              92    0.29 2  110  91
PB08 BE IS   3A  955 44.41                                            110  91
PB01 BZ IP    A  955 31.76  388                         55   -1.0010  126 144
PB01 BN IP    A  955 32.41  405                                       126 144
MNMCXBZ IP    A  955 32.60  409                         55   -0.4910  128  30
MNMCXBE IS   3A  955 48.39                              55    0.47 2  128  30
PB07 BZ IP    A  955 40.56  409                         55    1.0210  180 169
PB07 BN IS   3A  956  0.56                              55    1.42 2  180 169
PB04 BZ IP    A  955 47.71  338                         55    0.2010  244 179
PB04 BN IP    A  955 47.86  340                                       244 179
PB04 BE IP    A  955 48.21  346                                       244 179
PB05 BZ IP    A  955 54. 6  365                         55   -0.0110  302 180
PB10 BN IP    A  956  3.20  330                                       377 185
PB10 BZ IP    A  956  3. 5  308                         55   -0.3210  377 185
PB10 BE IP    A  956  3.50  318                                       377 185
```

Figure 12.3 The hyp.txt attachment. S-file for the recorded event.

13 RTPICK

RTPICK is started by RTDET if the parameter –aut is set to 1 as described in the test run chapter. RTPICK will try to find p and s phases when possible and will update the s-file for the corresponding event in the SEISAN database. The phase picking algorithm is based on the FilterPicker algorithm (FilterPicker, Lomax et.al.,2011). RTPICK then uses the s-file as input for the hypocenter program in an iterative process to reduce the residuals to a minimum as explained Chapter 10. Typical automatic readings are shown in Figure 13.1 and Figure 13.2 below.

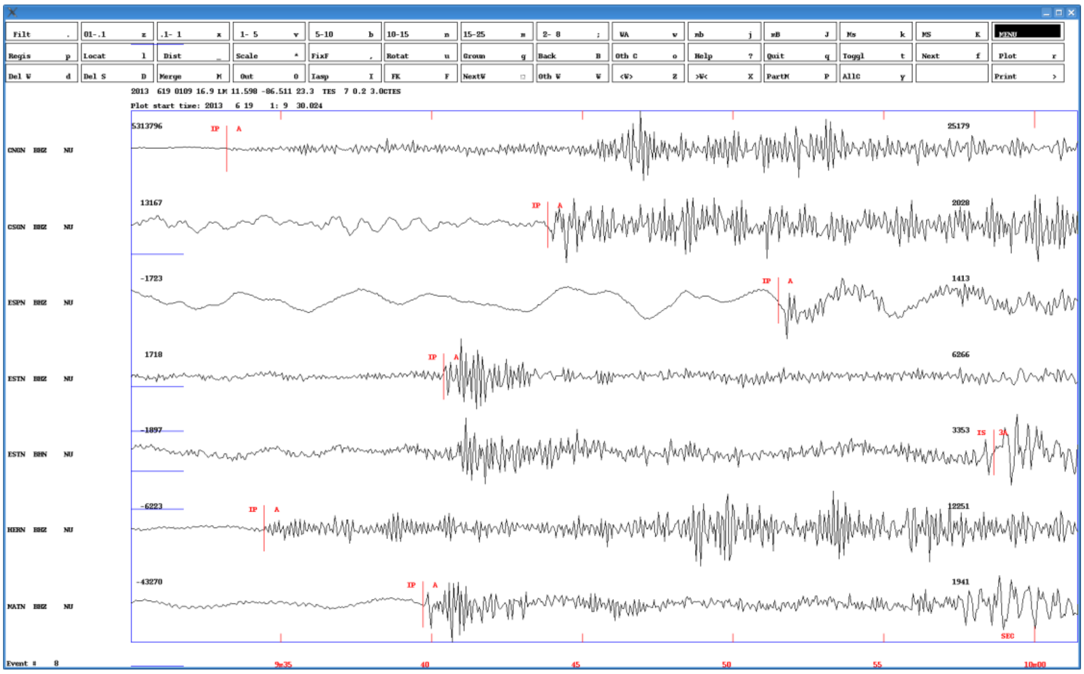


Figure 13.1 Automatic readings by RTPICK.

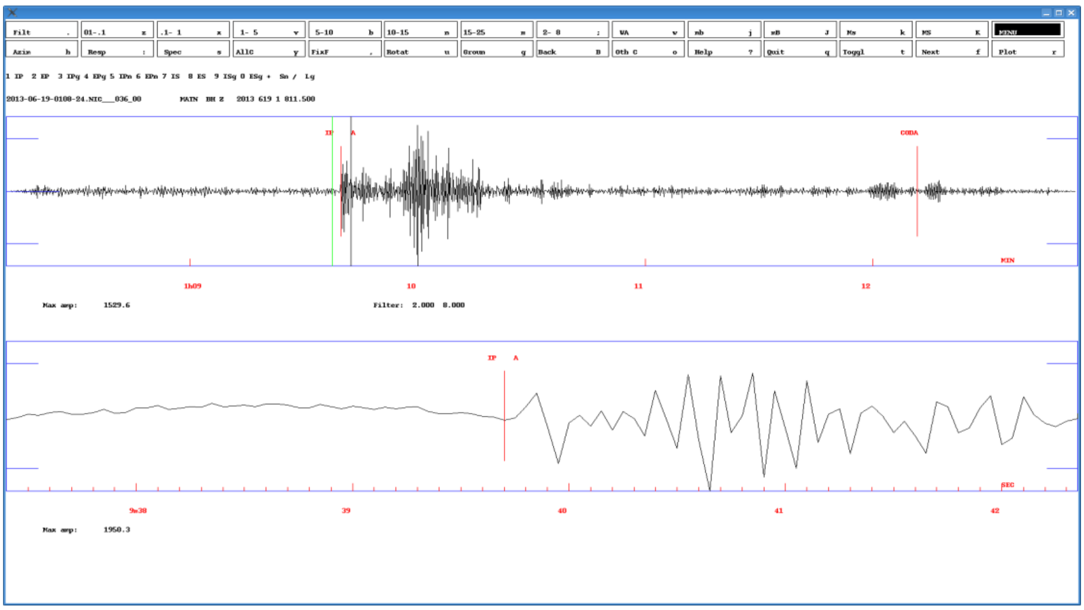


Figure 13.2 Automatic readings by RTPICK.

If RTPICK can produce a location for the event, two different html files are generated that will show the location on maps as shown in Figure 13.3 and Figure 13.4. A coda magnitude is computed based on the coda found by RTQUAKE. The coda is computed as the length of the event from the first pick until the signal produces a long-term-average below the de-trigger level. The coda length is thus often smaller than the coda length that would have been picked manually.
The map in Figure 13.3 can be shown as a normal web page by entering the following link in the browser: /home/seismo/mydir/map/LAST_TRIG.html, where /home/seismo/mydir is where RTQUAKE is installed. The page is refreshed every 5 minutes (can be changed) so new auto located events will appear when detected by RTQUAKE. A file called STATIONS must be located in the directory mydir/map. The STATIONS file must have the following format with " | " (space, vertical, space) between items:

stationname latitude longitude height areaname text1 text2

for example:

```
PB01 | -21.04 | -69.48 |  900 | Huatacondo  |  abc | def
PB02 | -21.31 | -69.89 | 1015 | SalarGrande |  aaa | bbb
```

Stations are marked on the map as triangles. Move the mouse over a triangle and press, and a plot of the signal with readings will appear in the window low-right if the signals are available.
In the window on top to the right of the map the S-file for the event is shown.

Be aware that the autolocation is far from perfect and may give completely wrong locations when the phases are picked wrong!!!! This will of course depend a lot of the quality of the data.

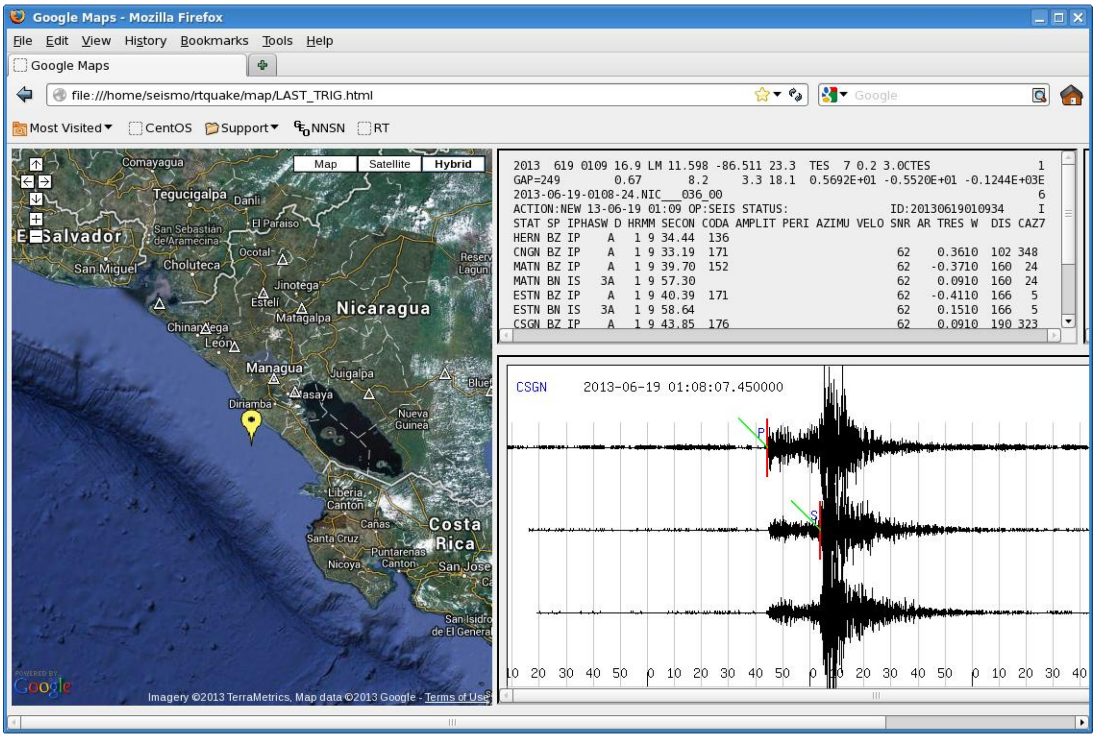


Figure 13.3 Web page generated by the RTPICK routine.

RTQUAKE will also generate the html code for generating a static map as in Figure 13.4. The html files for all automatically located events will be stored under the /home/seismo/mydir/loc catalog. The file names will have the format as for an S-file, plus the extension of html: 01-0854-34L.S201308.html

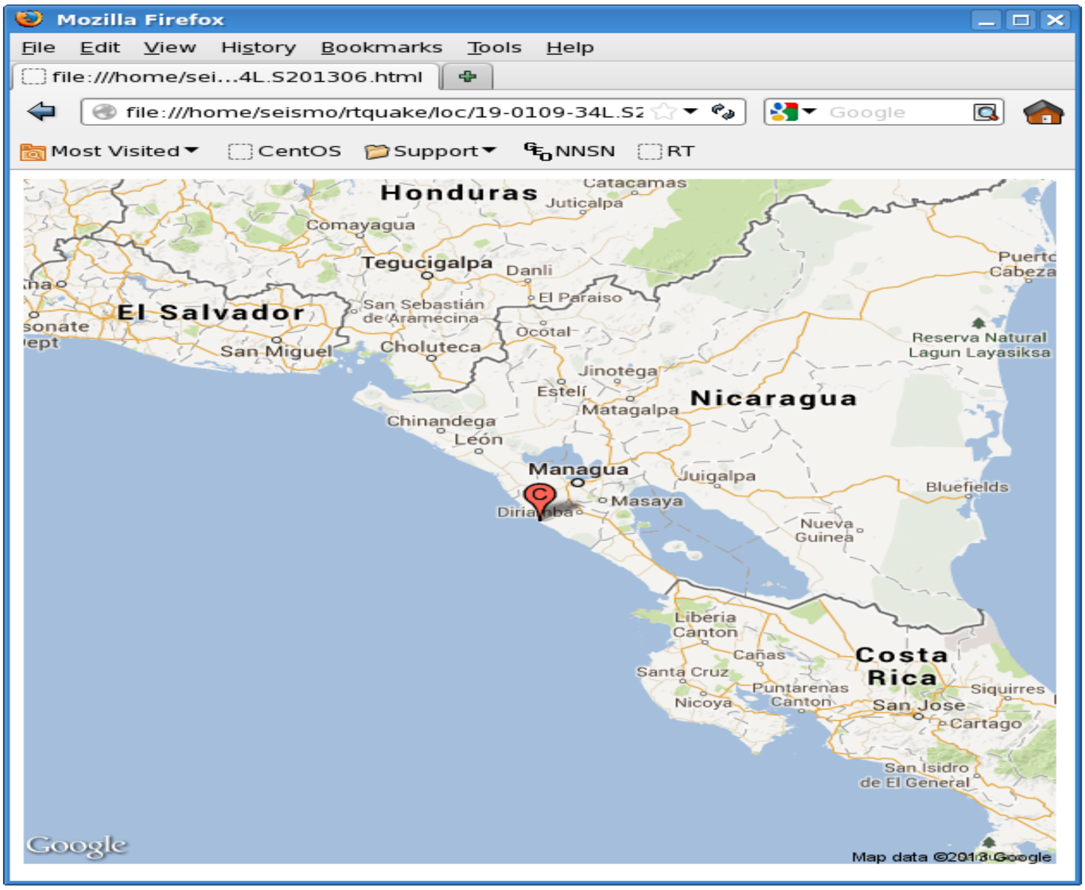


Figure 13.4 Web page generated by the RTPICK routine.

A location file called ALL_EPI0.txt is also generated in /home/seismo/mydir/map. New locations are added as new autolocations are computed. This can be monitored dynamically with Google Earth. See Figure 13.5 below.
Every time a new event is located, the yellow marker is moved to the new location and previous locations are still visible. The Google Earth map is programmed to move in what is called "fly mode", which gives a smooth movement of the map to the new location.
How to set up:
Google Earth must be installed.
A program rtgeepi that is part of the RTQUAKE distribution must run in the background. This program continuously monitor the ALL_EPI0.txt file to check for the last location. A temporary file temp.epi.kml is generated and then copied to tu1_epi.kml. When Google Earth is started the file /home/seismo/mydir/map/rtge_refresh.kml should be opened from Google Earth. This file will read the tu1_epi.kml file every 10 seconds and update the map. When a new location is added, the centre of the map will move to this location. Old locations in ALL_EPI0.txt will also be plotted on the map. The rtgeepi must run at all the time to keep the

last location up to date. The ALL_EPI0.txt will after some time contain a lot of triggers and the map may look a bit unclear. It is recommended to clean up the file by removing the oldest triggers.

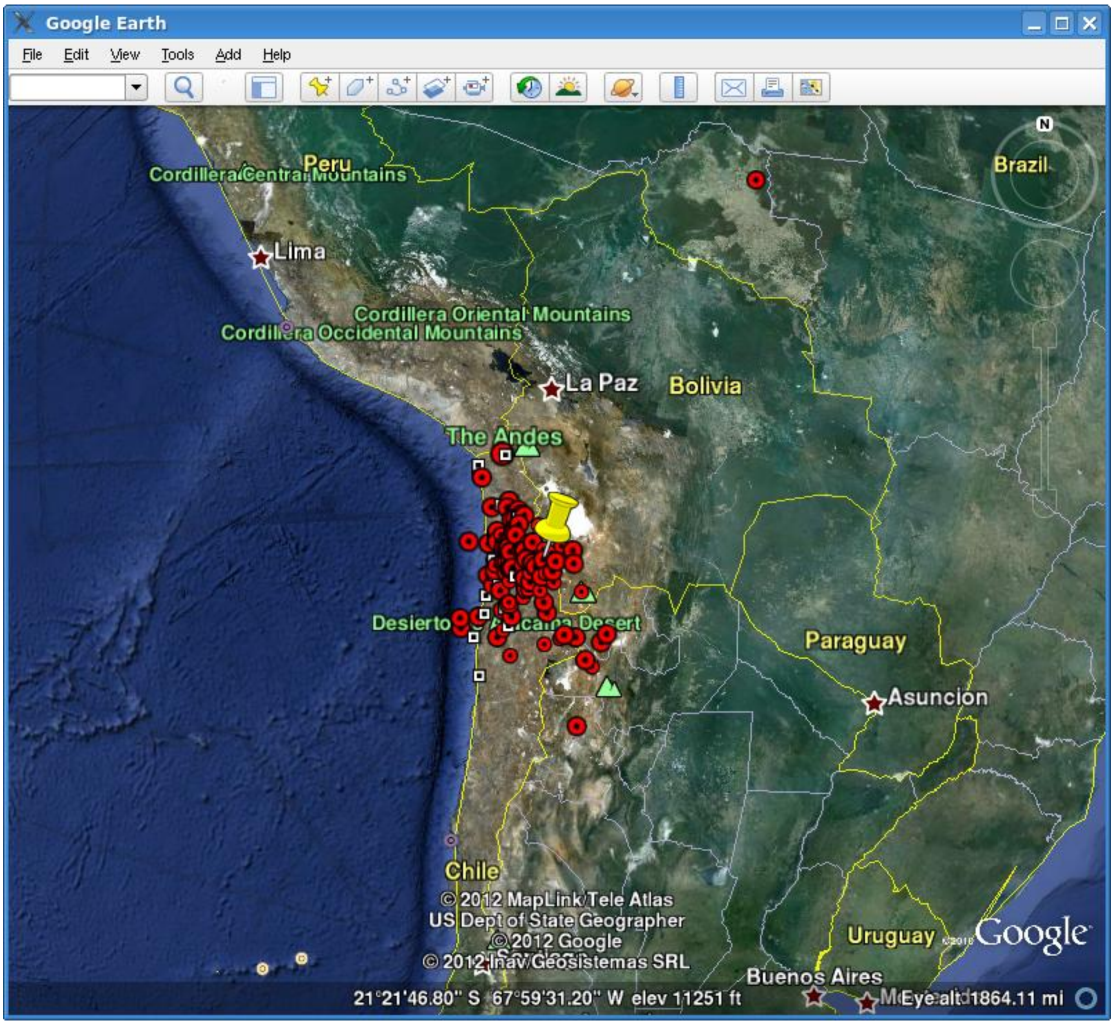


Figure 13.5 Auto location map using Google Earth, refresh every 10 seconds.

14 RTSNR

RTSNR monitors graphically how the current STA/LTA ratio is behaving for individual channels. Each instance of RTSNR can monitor one parameter set used by the RTDET module. Figure 14.1 below shows a typical output. The output shows how the ratio suddenly increase when an event occur. The different colours is just to distinguish between different channels. After a while, when the event finish, the ratio will drop back to the normal level as before the event. Before the event some sporadic noise that raises the ratio to above the trigger level, but as it occurs on one station only it is not considered a seismic event. The program can be useful to discover single channels or stations with sporadic or regular noise that causes unwanted triggers.

```
$ rtsnr -h

Command: rtsnr [options]

Options:
 -h               show this usage message

Options:
 -par    n        instance  parameter set. (default: 0)
 -xo     pixels   position of window x-direction (default: 0)
 -yo     pixels   position of window y-direction (default: 0)
```

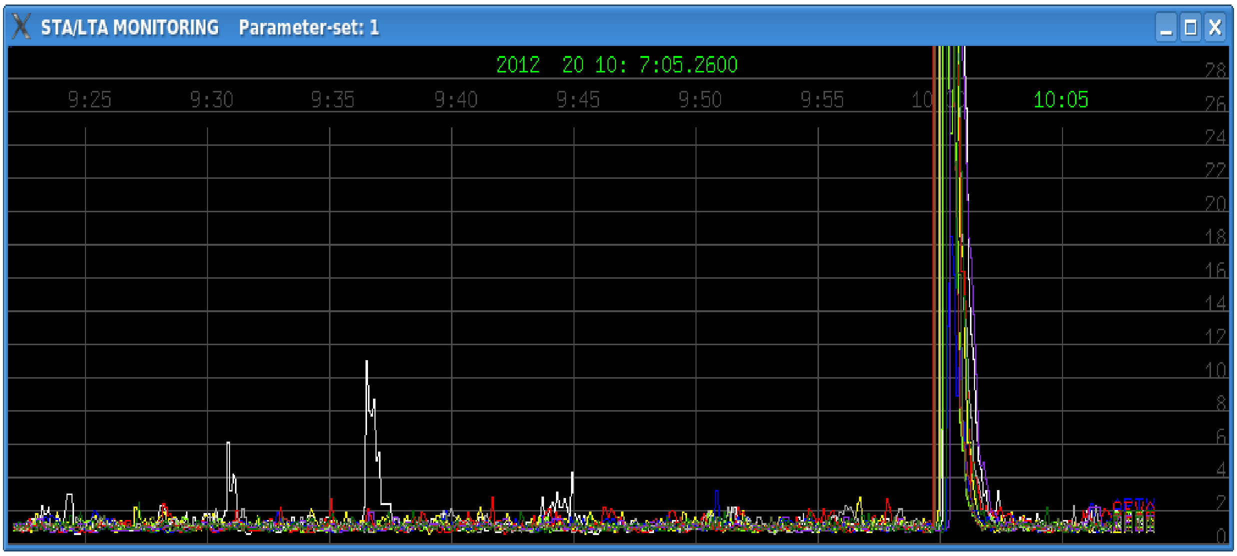


Figure 14.1 RTSNR

15 RTDLY

$ rtdly -h

Command: rtdly [options]

Options:

-h		show this usage message
-par	n	instance parameter set. (default: 0)
-xo	pixels	position of window x-direction (default: 0)
-yo	pixels	position of window y-direction (default: 0)

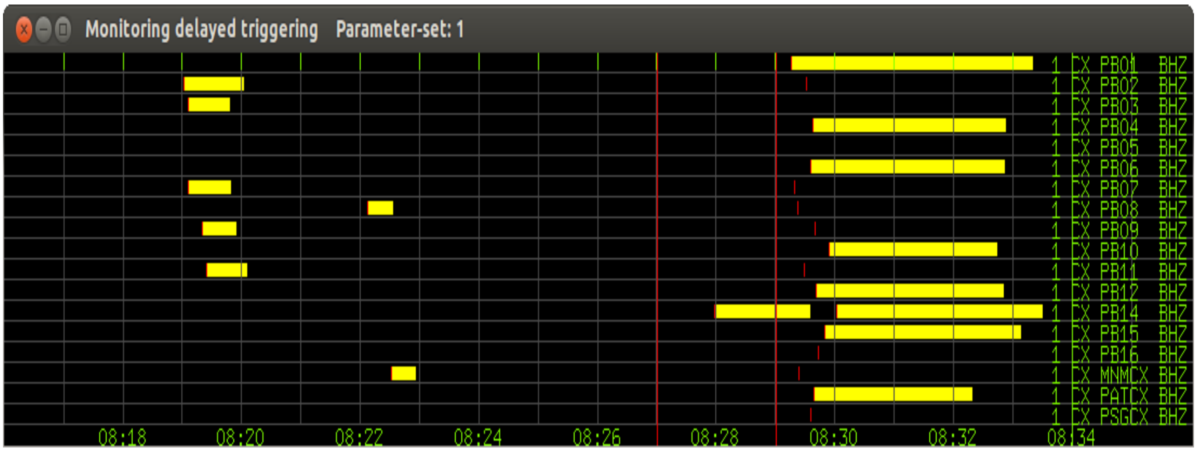


Figure 15.1 RTDLY shows the onset and duration of triggers (yellow lines) for individual channels and the duration of the trigger. The green vertical line to the right indicates the current time. The two vertical red lines indicate the array-propagation-window within which the detection of the event is performed. RTQUAKE can be set up to wait up to 30 minutes before checking for triggers in order to also include delayed channels. Delayed triggers will show up at correct time in the display, and the network trigger will take place within the array propagation window, in this case two minutes wide and seven minutes delayed (left red line). The red and the yellow markers seen closer to the current time-line are individual triggers for a new event. The display can be useful to optimize the delay and array propagation window parameters.
The graphics is dynamic in the sense that the user will see the onsets and duration of the triggers slowly moving to the left towards the array-propagation-window where network triggering takes place. The timelines for the APW and current time are positioned statically while the time scale at the bottom changes according to current UTC time.

Normally the trigger onsets are marked close to real time near the green line marking the current time. In cases where for example data transmission is slow, signals may be received with a significant latency. The triggers will however be marked on the plot at the correct time of occurrence when data is available. In Figure 15.1 we allowed for a latency of 7 minutes which is the total time from the current time to the end of the APW to the left. The APW has been set to 2 minutes. As the trigger onsets move towards and into the APW, the network trigger algorithm will decide if there are sufficient triggers to define a network trigger

This approach secures that trigger onsets arriving up to 7 minutes delayed still are contributing for the network trigger inside the APW. The allowed latency and APW are set by parameters. The display can be useful to optimize the delay and array propagation window parameters. Components that cause frequent false onsets can easily be observed on the display.

16 RTNET

The module plots selected components from seismic stations in near-real time. The module can read data from one SeedLink server only, but several instances of the module can run at the same time reading from different SeedLink servers.

```
$ rtnet -h

Command: rtnet [options] [host][:port]

 Options:
 -V              report program version
 -h              show this usage message
 -top   text     top directory (default: /home/seismo)
 -c              print stations.conf file
 -p              print details of data packets
 -d              print full station name on each seismogram
 -sc             auto-scaling each new data buffer


 ## Graphics options ##

 -x     pixels   width window in pixels (default: 1000)
 -y     pixels   height window in pixels (default: 600)
 -buf   n        0-double 1-single buffering (default: 0)
 -xo    pixels   position of window x-direction (default: 0)
 -yo    pixels   position of window y-direction (default: 0)
 -m     minutesminutes over screen: 1,2,3,4,5,10,15,30,60 (default: 15)

 ## Filter options ##

 -fl    low      lowpass frequency
 -fh    high     highpass frequency

 ## Data stream  selection and station file##

 -l     str      The routine will look for the filename you specify under the
                 /home/seismo/mydir/par/user_created_subdirectory
                 catalog. To specify a file stored in the user subdirectory, you specify the subdirectory
                 name and the filename.

                 Example:
                 A stream file stored in /home/seismo/mydir/par/DEMO1  -l DEMO1/streams_plot
-f      stat     The routine will look for the filename you specify under the
                 /home/seismo/mydir/par/user_created subdirectory
                 catalog. To specify a file stored in the user subdirectory you specify the subdirectory
                 name and the filename.

                 Example:
                 A station file stored in /home/seismo/mydir/par/DEMO1: -f DEMO1/stations_plot

 -n     no       number of stations to plot
 -a     no       which station to plot (0,1,2,3.......)

 [host][:port]   Address of the SeedLink server in host:port format
             f.ex.: 129.177.xx.yy:18000
             f.ex.: localhost:18000
```

The different seismograms are scrolled to the left on the screen when plotting reaches the right end of the defined window for the plot. Each seismogram is plotted individually in its own window. This means that each seismogram have its individual timing.
RTNET needs 2 parameter files, one for defining the input streams of data and another to define the actual components to plot. The names for these files are streams_plot and stations_plot respectively and are stored in /home/seismo/mydir/DEMO1. The two files are initially set equal to the plot files for the test run and the example plots below can be run from the command line after the installation.
The module has several input parameters. Some can also be modified interactively during execution of the program.
An option to filter the incoming data can be activated while running. This option will also start a simple detection algorithm and mark probable events on the plot.
The program will mark stations that have not received data for the last 60 seconds. Another indicator can be a red square in the upper right corner of each seismogram window that indicates that GPS timing is out of synchronization.
The different options can be controlled partly during the start command and partly while running via keyboard or menu.
All options will be described in more detail below. Some examples on how to use it will be given at the end of this documentation.
Two parameter files define the data that are available for the RTNET client:
streams_plot and stations_plot.
streams_plot contains information of which data the SeedLink server should send to the RTNET client. The format follows the standard in SeedLink for defining data streams:

```
CX PB01 BHZ    network: CX    station: PB01  component: BHZ
CX PB02 BHZ
CX PB03 BHZ
CX PB04 BHZ
CX PB05 BHZ
CX PB06 BHZ
CX PB07 BHZ
CX PB08 BHZ
CX PB09 BHZ
CX PB10 BHZ
CX PB11 BHZ
CX PB12 BHZ
```

stations_plot contains information of which data the RTNET client may use. For example a setup to only plot vertical components. The location parameter must be included. The full name of the station is used when the –d (as in the test configuration) is selected. This option is included to make the text more informative for the public.

```
PB01 BHZ PB01 Huatacondo station: PB01 component: BHZ title: PB01 Huatacondo
PB02 BHZ PB02 Salar Grande
PB03 BHZ PB03 El Tigre
PB04 BHZ PB04 Mantos de la Luna
PB05 BHZ PB05 Michilla
PB06 BHZ PB06 Pedro de Valdivia
PB07 BHZ PB07 Cerro Tatas
PB08 BHZ PB08 Macaya
PB09 BHZ PB09 Quillagua
PB10 BHZ PB10 Juan Lopez
PB11 BHZ PB11 Quebrada Aricilda
PB12 BHZ PB12 Cerro Caramaca
```

When you have generated the two parameter files streams_plot and stations_plot you can start RTNET first time like below to get all the options available:

rtnet –h

```
Usage: rtnet [options] [host][:port]

## General program options ##
-V             report program version
-h             show this usage message
-c             print stations.conf file
-p             print details of data packets
-d             print full station name on each seismogram
-sc            auto-scaling each new data buffer

## Graphics options ##
-x pixels      width window in pixels (default: 1000)
-y pixels      height window in pixels (default: 600)
-m minutes     minutes over screen:1,2,3,4,5,10,15,30,60 (default: 15)

## Filter options ##
-fl lowpass    lowpass frequency
-fh highpass   highpass frequency

## Data stream selection and station file##
-l listfile    read a stream list from this file
-f stationfile read a station list from this file
-n no_to_plot  number of stations to plot
-a station no  which station to plot (0,1,2,3.......)

[host][:port]  Address of the SeedLink server in host:port format
```

The different options are self explanatory, but a few may need some more explanation.

General program options:

-d This option can be used when the monitor is installed to give a clearer view of the station names, for example: Kongsberg instead of KONO 10BHZ, and the timing is shown as complete dates rather than day of year. Both text strings are also in bigger fonts.
The text, full station name can be added in the stations.conf file after the standard name as for example: KONO 10BHZ Kongsberg

The graphics options:

The upper left corner of the active drawing window is always placed in the upper left corner of the screen.

-x pixels This parameter sets the width of the active drawing window and must never be bigger than the total width of the screen. Default is 1000 pixels.

-y pixels This parameter sets the height of the active drawing window and must never be bigger than the total height of the screen. Default is 600 pixels.

-m minutes This parameter sets the total number of minutes across the active drawing area selected above. Options are: 1,2,3,4,5,10,15,30 and 60 minutes. Default is 15 minutes.

Filter options:
When starting the program without –fl and –fh set to any values, the data plotted on the screen are unfiltered. However, via the keyboard or the menu, a pre-set filter (2.0-8.0 Hz) can be activated. This filter can be turned on and off while running. Turning on the filter will also activate a simple detection algorithm that will mark probable events in the seismograms.

The options –fl and –fh are to be used from the command line when starting the program and can be set to the values you decide.

Data stream selection and station file options:

-l listfile	read stream list from this file
-f stationfile	read station list from this file
-n no_to_plot	number of components to plot. This parameter can be any number up to the number of components specified in the stations_plot file.
-a station	which station to plot. (0,1,2…..number of stations in the station.conf file). This option can be used to check one particular component. The default time window is 2 minutes, so that more details are visible in the seismogram.

The sequence of lines (stations and components) in both files are free. However, the sequence of the lines in the stations.conf file will decide the sequence of stations plotted. This can give a more logical sequence of stations for example from north-south, east-west etc.
The SeedLink server host:port should always be included on the command line when starting the program.

Options that can be used interactively while program is running.
They can be activated from keyboard or from a menu (right-click on mouse). To see the different options, press 'h' on the keyboard or right-click on the mouse. The different options are:

```
List of key-press functions:
----------------------------
h  : list this on screen
esc: exit
u  : increase amplitude on all channels
d  : decrease amplitude on all channels
S  : freeze graphics
s  : resume graphics
n  : next channel
+  : increase amplitude on current channel
-  : decrease amplitude on current channel
F  : turn on pre-set filter
f  : turn off filtering
1  : Set color scheme to default
2  : Color scheme 2
3  : Color scheme 3
4  : Color scheme 4
```

Note the 'S' and 's' options: The plotting can be halted with the 'S' when something interesting happens. You may take a screenshot and then resume plotting with 's'.
When the program is running, a plot of a selected channel can be plotted in a separate window to see more details in the signal. Point on the channel with the mouse (around zero-level) and left-click on the mouse.

Examples of running RTNET.

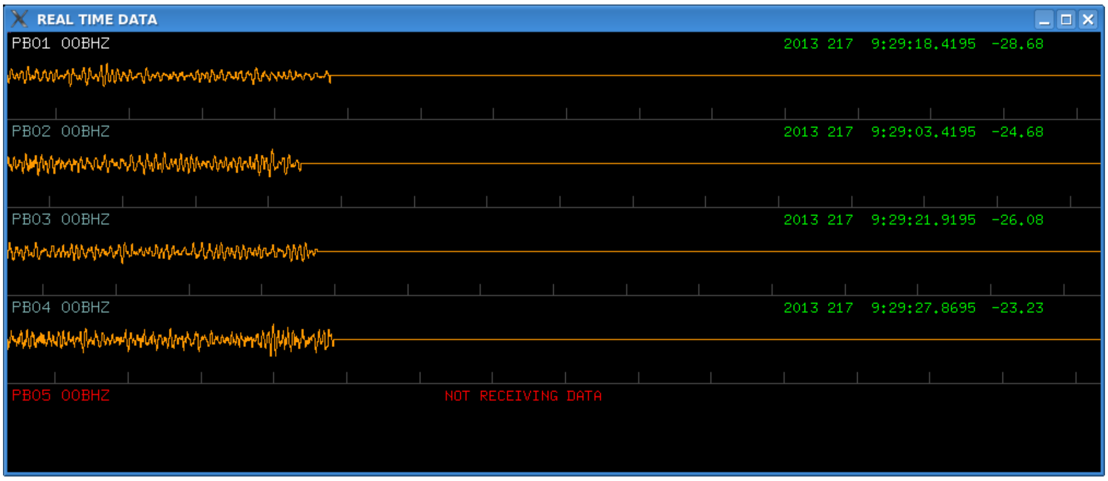


Figure 16.1 From command line: rtnet –n 5 –l DEMO1/streams_plot –f DEMO1/stations_plot 139.17.3.177:18000

Plot the 5 first channels in the stations_plot file. For station PB05 we see the message 'NOT RECEIVING DATA'. This means that the RTNET program has not received data from this station for at least the last 60 seconds. It may be a reason for further checking of this station.

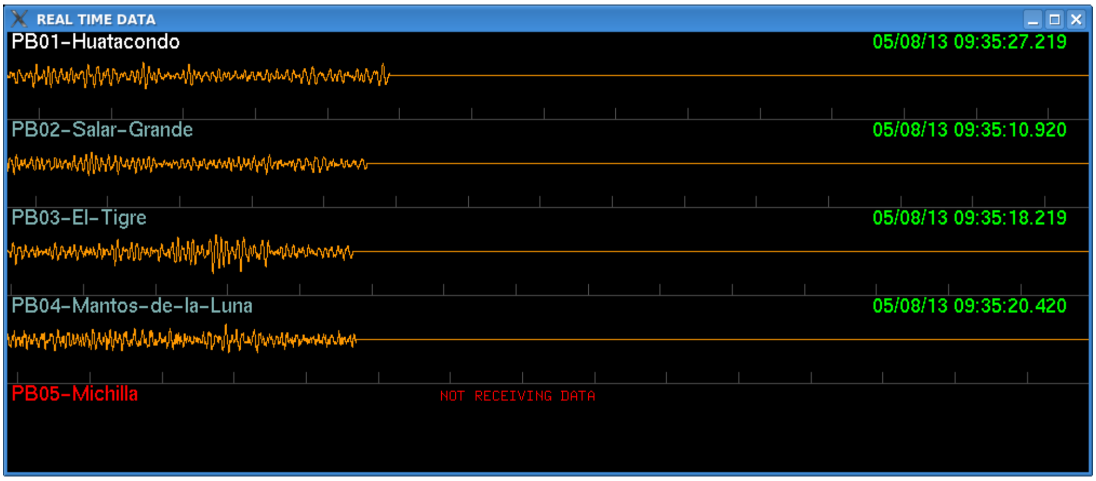


Figure 16.2 From command line: rtnet –n 5 –d –l DEMO1/streams_plot –f DEMO1/stations_plot 139.17.3.177:18000

Plot the 5 first channels in stations_plot file with the option –d. This will plot the text field in the stations_plot file, normally a geographical name.

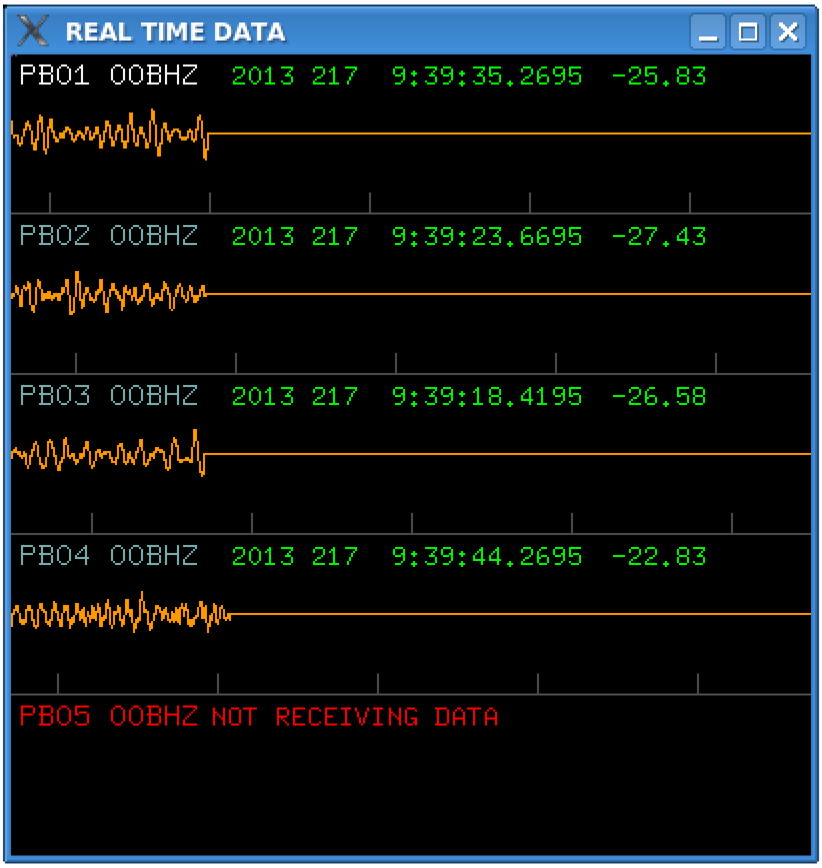


Figure 16.3 From command line: rtnet –n 5 –d –m 5 –x 400 –l DEMO1/streams_plot –f DEMO1/stations_plot 139.17.3.177:18000

Plot the first 5 channels in stations_plot file, textfield, 5 minutes x-axis and x-axis 400 pixels long.

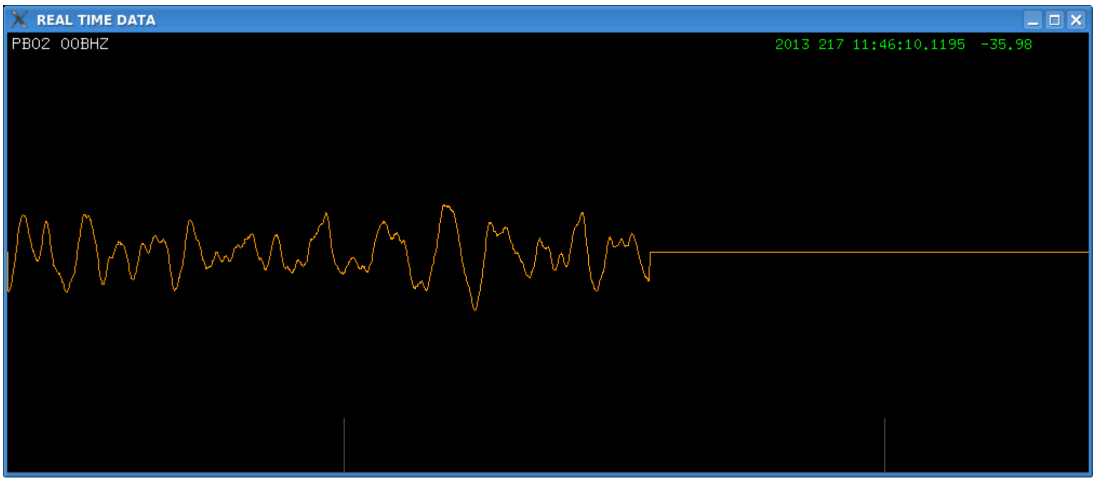


Figure 16.4 From command line: rtnet –a 1 –l DEMO1/streams_plot –f DEMO1/stations_plot 139.17.3.177:18000

Plot the second (1) channel in stations_plot file with default values.

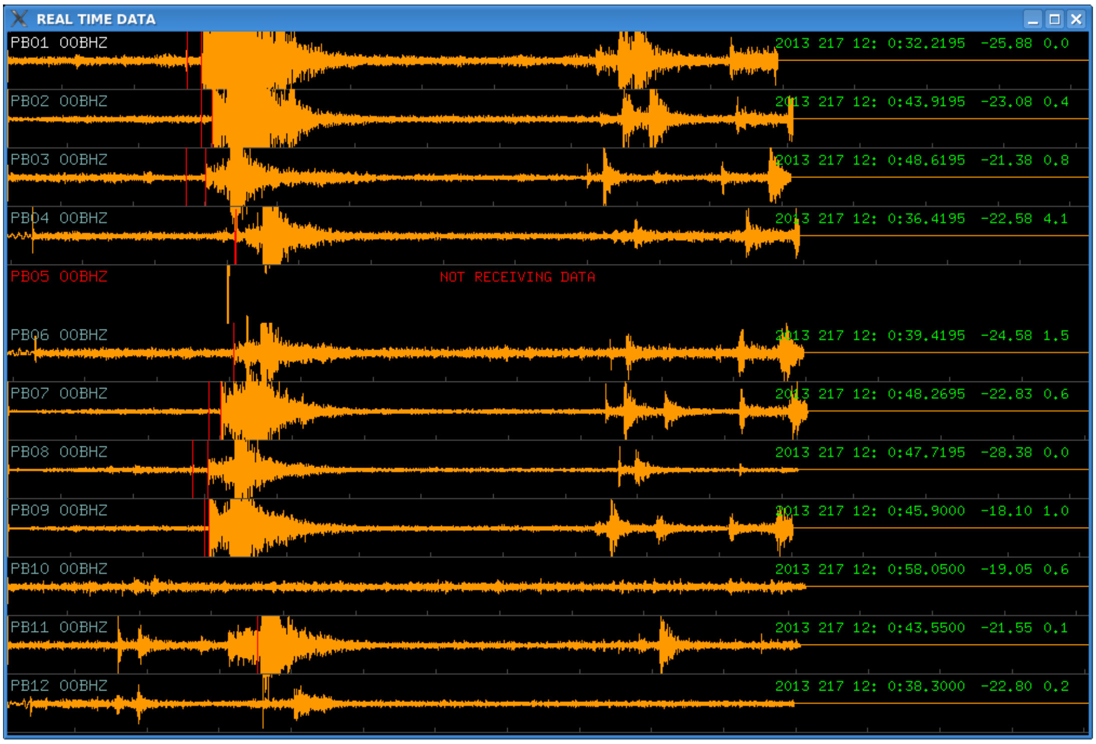


Figure 16.5 From command line: rtnet –n 12 –y 650 –l DEMO1/streams_plot –f DEMO1/stations_plot 139.17.3.177:18000

Plot the first 12 channels in the stations_plot file, make the drawing window 650 pixels high. Filter was turned on from keyboard 'F', and there is a detection indicated on several channels.

Several instances of RTNET can be executed at the same time reading data from the same or different SeedLink servers. Execution can also be started from script-files. This way RTNET can be started automatically at reboot of the PC.

The user can make different script-files that start RTNET with different options. In this way it is possible to for example monitor both unfiltered and filtered signals in two different windows, see Figure 16.6 and Figure 16.7.

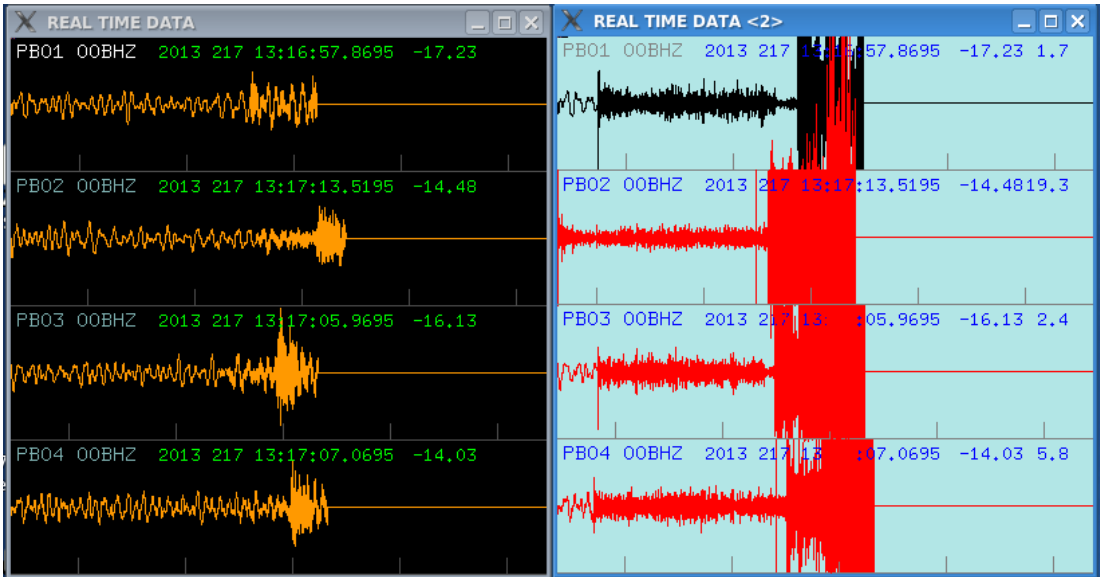


Figure 16.6 From command line: rtnet –n 4 –m 5 –x 400 –l DEMO1/streams_plot –f DEMO1/stations_plot 139.17.3.177:18000

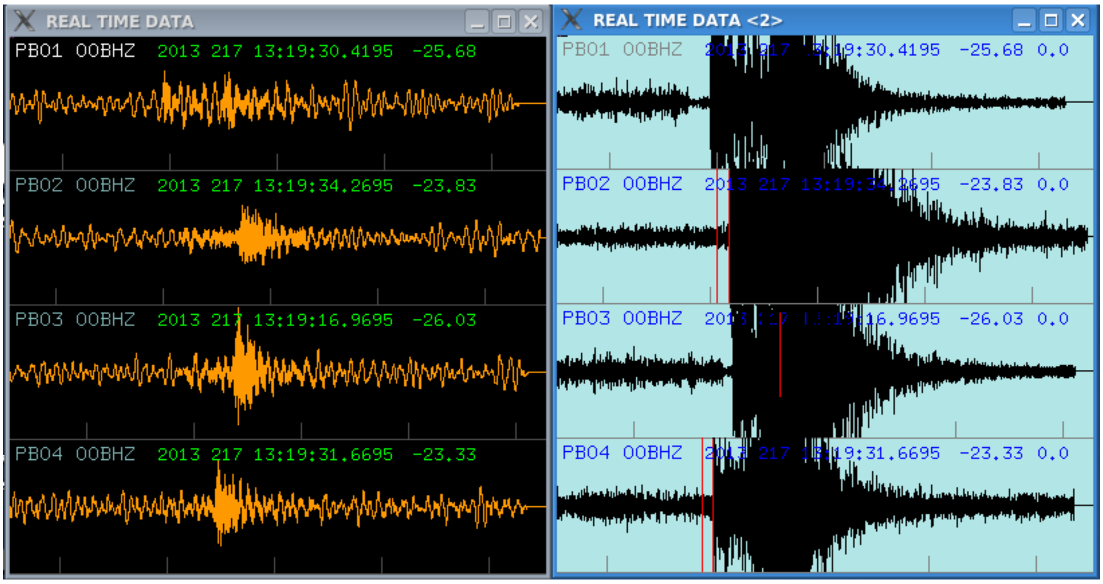


Figure 16.7 From command line: rtnet –n 4 –m 5 –x 400 –l DEMO1/streams_plot –f DEMO1/stations_plot 139.17.3.177:18000

In the example above, two instances of RTNET is running side by side with the same initial command line. The colour scheme on the window on the right has been changed interactively via the right-click menu. The window on the right show filtered data (2-8 Hz). The filter was activated with the right-click menu. We also see that the detection algorithm has detected and marked a probable event. The seismogram is plotted in red as long as the detection algorithm is in trigger-mode.

17 RTSLPL

This module is very similar to the RTNET in the previous chapter. It has less options, but the main advantage is that it can read data from several SeedLink servers in one session. The module has a simple parameter file (mydir/par/DEMO1/rtsl_config) as described in chapter 4.6.

rtsl_config

```
SERVERS
S01 139.17.3.177
S02 rtserve.iris.washington.edu
--------------------------------------
NW STAT  LOC CMP SERVER
CX PB01  ..  BHZ S01
CX PB02  ..  BHZ S01
CX PB03  ..  BHZ S01
CX PB04  ..  BHZ S01
CX PB05  ..  BHZ S01
CX PB06  ..  BHZ S01
CX PB10  ..  BHZ S01
IU LVC   00  BHZ S02
IU LVC   00  BH1 S02
IU LVC   00  BH2 S02
---------------------------------------
```

In the example above stations from 2 SeedLink servers are plotted.

```
rtslpl -h
RTSLPL: RTQUAKE_TOP:             /home/seismo/rtquake
 Valid program options:
 -h              show this usage message
 -d              print full station name on each seismogram

 -x   pixels     width window in pixels (default: 1000)
 -y   pixels     height window in pixels (default: 600)
 -buf n          0-double 1-single buffering (default: 0)
 -xo  pixels     position of window x-direction (default: 0)
 -yo  pixels     position of window y-direction (default: 0)
 -m   minutes    minutes over screen: 1,2,3,4,5,10,15,30,60 (default: 15)
 -col n          color option: 0 (default),1,2,3,4

 -fl  lowpass    lowpass frequency
 -fh  highpass   highpass frequency

 -cfg parameter  Specify catalog under /par where parameter file is stored
```

Figure 17.1 is produced with the command below using the parameter file above, and shows data from stations in Chile, from two different SeedLink servers, in close to real-time.

rtslpl –fl 2.0 –fh 8.0 –cfg DEMO1

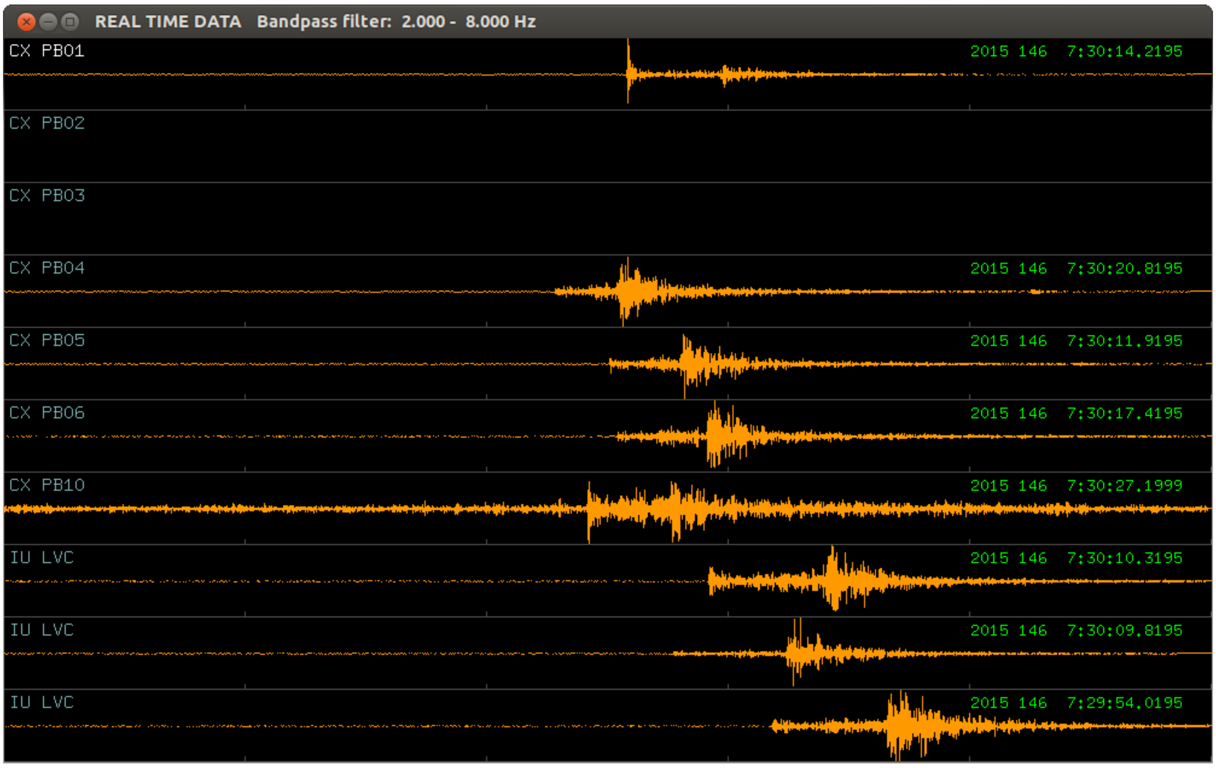


Figure 17.1 Plot showing real-time data from two different SeedLink servers.

The data from the CX network are read from the geofon.gfz-potsdam.de (139.17.3.177) server and the data from the IU network are read from the IRIS server (rtserve.itis.washington.edu).

You exit the program by pressing 'ESC', 'Q' or 'q' in the active window.

18 RTCHK

This module is based on the RTSLPL module in the previous chapter. It can be used to check data from a specific station by connecting to a SeedLink server that holds data from the actual station. Normally three components will be shown, but in the case of signals with different sampling-rates or different sensors, all components will be shown.
Two plots are shown: one with the original data and one with filtered data (default: 2.0-8.0 Hz).

Type **rtchk –h** on the command line to see the different options:

```
rtchk -h
RTCHK: RTQUAKE_TOP:       /home/seismo/rtquake
Valid program options:
-h                show this help info
-sl text          Seedlink address
-st text          Station name to check, f.ex. BER
-cm text          Component(s), f.ex. BH or HH or HHZ
-fl real          Lowpass filter (default: 2.0)
-fh real          Highpass filter (default: 8.0)
-m  minutes       Minutes to plot,1,2,3,4,5,10,15,30,60 (default: 5)
-x  pixels        Width of window in pixels (default: 1200)
-y  pixels        Height of window in pixels (default: 300)
```

-sl Here you must specify the seedlink server from where you want to read the data.
-st Here you must specify the name of the station you want plot.

The other parameters have default values.

Some seedlink servers record many components from the same station. The user normally wants to look at a 3-component selection like the HHZ,HHN,HHE or BHZ,BHN,BHE. The parameter –cm can be used to sort out the components the user wants.

As the KONO station has a lot of components recorded on the IRIS seedlink server, the command:

rtchk -sl rtserve.iris.washington.edu -st KONO

will try to create a plot with the following components found on the SeedLink server. The program rtchk has a limit of 6 components, so the program will exit.

```
IU KONO  00 BH1
IU KONO  00 BH2
IU KONO  00 BHZ
IU KONO  00 LH1
IU KONO  00 LH2
IU KONO  00 LHZ
IU KONO  00 VH1
IU KONO  00 VH2
IU KONO  00 VHZ
IU KONO  00 VM1
IU KONO  00 VM2
IU KONO  00 VMZ
IU KONO  10 BH1
IU KONO  10 BH2
IU KONO  10 BHZ
IU KONO  10 LH1
IU KONO  10 LH2
```

```
IU KONO  10 LHZ
IU KONO  10 VH1
IU KONO  10 VH2
IU KONO  10 VHZ
IU KONO  10 VM1
IU KONO  10 VM2
IU KONO  10 VMZ
IU KONO  20 LN1
IU KONO  20 LN2
IU KONO  20 LNZ
More than 6 available components, use -cm to specify
```

Below two examples that show how the –cm argument can be used to specify the components the user wants to plot.

rtchk -sl rtserve.iris.washington.edu -st KONO -cm B

```
IU KONO  00 BH1
IU KONO  00 BH2
IU KONO  00 BHZ
IU KONO  10 BH1
IU KONO  10 BH2
IU KONO  10 BHZ
```

The command **rtchk -sl rtserve.iris.washington.edu -st KONO -cm "00 B"** show the plot below in Figure 18.1.

```
IU KONO  00 BH1
IU KONO  00 BH2
IU KONO  00 BHZ
```

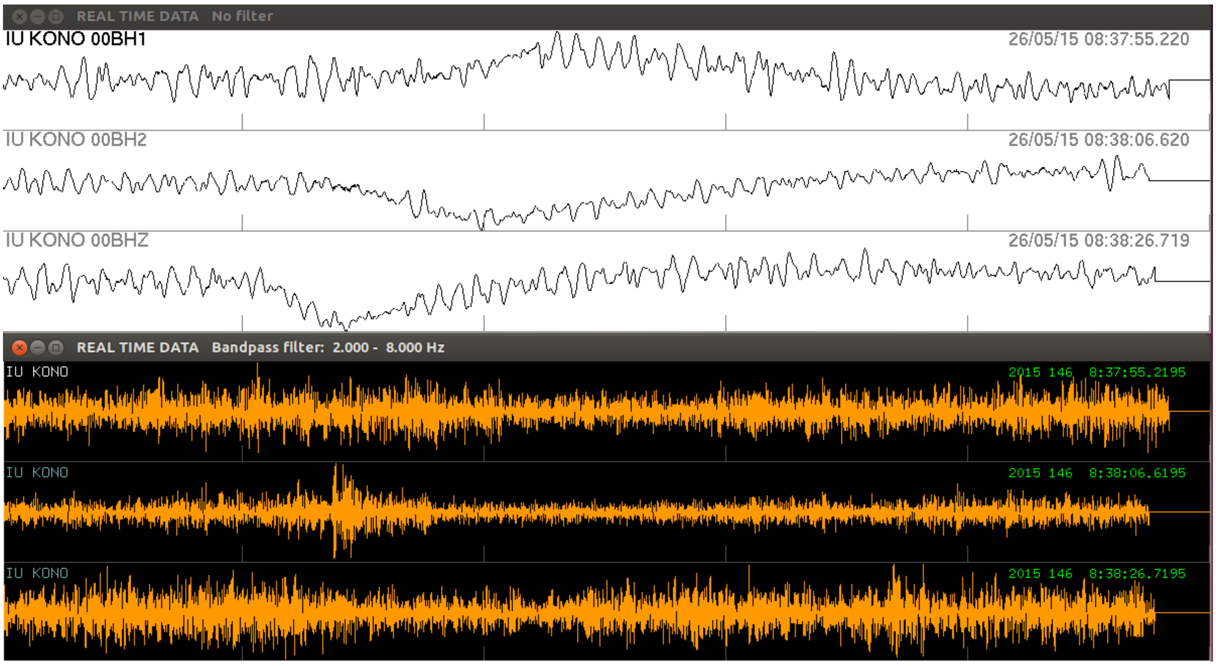


Figure 18.1 Original and filtered data from station KONO

The command **rtchk -sl 139.17.3.177 –st PB01 -cm BH** show the plot below in Figure 18.2

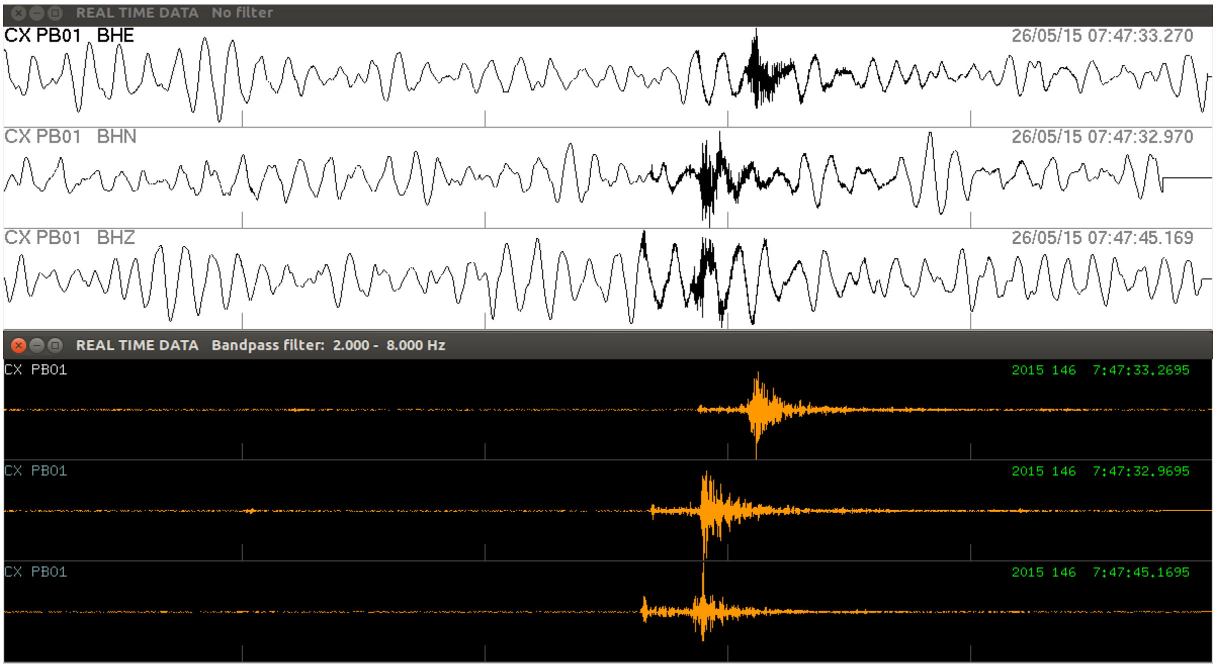


Figure 18.2 Original and filtered data from station PB01

You exit the program by pressing 'ESC', 'Q' or 'q' in the active window.

19 RTTIME

This module can be used to monitor the status of the stations configured in a SeedLink server, see Figure 19.1. It can be used for monitoring a number of stations that can actually fit your display. By pressing the mouse over a station that is marked green, the RTNET program will be started to give a more detailed plot of the signal from that particular station. See Figure 19.2.

The module can read data from one SeedLink server only, but several instances of the module can run at the same time reading from different SeedLink servers.

$ rttime -h

Command: rtgraph [options] [host][:port]

Options:

-h	show this usage message
-top	top directory (default: /home/seismo)
-sizx pixels	length of window in pixels (default:1200)
-sizy pixels	height of window in pixels (default: 500)
-buf n	0-double 1-single buffering (default: 0)
-xo pixels	position of window x-direction (default: 0)
-yo pixels	position of window y-direction (default: 0)
[host][:port]	address of the SeedLink server in host:port format f.ex.: 129.177.xx.xx:18000 f.ex.: localhost:18000

Figure 19.1 RTTIME window**.**

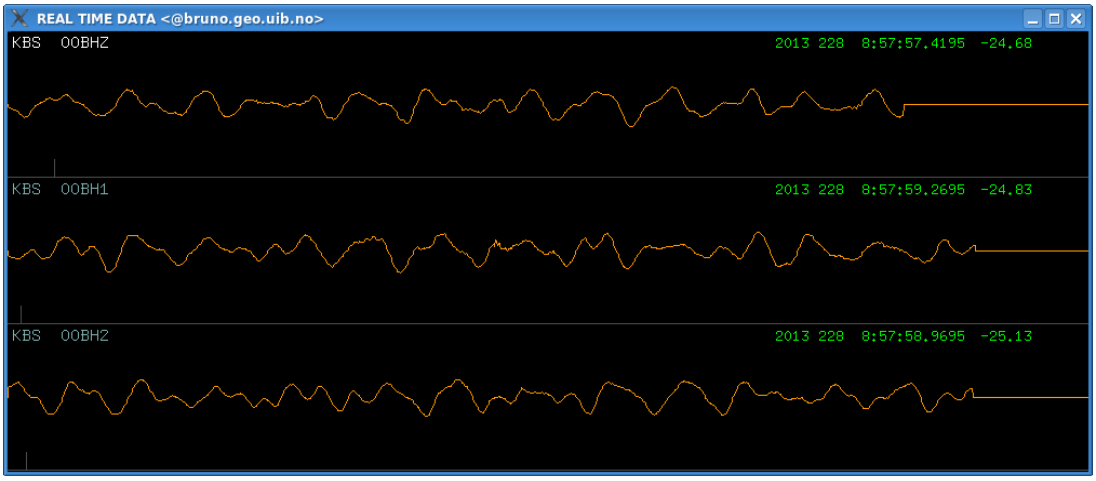


Figure 19.2 RTNET started from the RTTIME window**.**

20 RT24 + RTDR24 + RTDRUM + RTHPLT

These three modules are used to create helicorder plots of unfiltered and filtered data from streams from a SeedLink server. Two parameter files are used as input, one to define the different streams to read and another to select the actual components to plot.
RT24 generates temporary files for each component specified. Each file will contain 24 hours of data. If a filter is specified, filtered data files will be generated in addition.
The SeedLink server to use must be specified in the format ipnumber:port.
RT24 calls RTDR24 at regular intervals to make the helicorder plots based on the continuous files generated by RT24.
RTHPLT should be run to generate an index.html file in the mydir/rt/png and mydir/rt/png_filt catalogues. Loading the index.html files from a browser will give you the menu shown in Figure 20.1. The index.html menu file that is generated is practically the same as you find in the Earthworm system, while the helicorder plots are slightly different.

As part of the installation a directory structure is created under the RTQUAKE top directory:

/home/seismo/mydir/rt/tmp	unfiltered data
/home/seismo/mydir/rt/tmp_filt	filtered data
/home/seismo/mydir/rt/png	plot unfiltered data
/home/seismo/mydir/rt/png_filt	plot filtered data

RT24 writes 24-hour files into /home/seismo/mydir/rt/tmp and /home/seismo/mydir/rt/tmp_filt. These files are input for module RTDR24 that creates plots of the data that are in the files at the current time.
The parameter files for streams and stations must be stored under /home/seismo/mydir/rtquake/par/user_created_subdirectory.

streams_heli
The streams_heli.TST file is standard SeedLink input format where CX is the network name, PB0n is the station name and BHZ the component.

```
CX PB01 BHZ
CX PB02 BHZ
CX PB03 BHZ
CX PB04 BHZ
CX PB05 BHZ
CX PB06 BHZ
CX PB07 BHZ
CX PB08 BHZ
CX PB09 BHZ
CX PB10 BHZ
CX PB11 BHZ
CX PB12 BHZ
```

stations_heli

The format of this file:

PB01	station name
00	location

0.0100	gain for the unfiltered data, can be modified dynamically
0.0300	gain for the filtered data, can be modified dynamically
2.0	low-pass frequency
8.0	high-pass frequency
Huatacondo	name of station, geographical name

```
PB01_00BHZ 0.0100 0.0300 2.0 8.0 Huatacondo
PB02_00BHZ 0.0100 0.0300 2.0 8.0 Salar Grande
PB03_00BHZ 0.0100 0.0300 2.0 8.0 El Tigre
PB04_00BHZ 0.0100 0.0300 2.0 8.0 Mantos de la Luna
PB05_00BHZ 0.0100 0.0300 2.0 8.0 Michilla
PB06_00BHZ 0.0100 0.0300 2.0 8.0 Pedro de Valdivia
PB07_00BHZ 0.0100 0.0300 2.0 8.0 Cerro Tatas
PB08_00BHZ 0.0100 0.0300 2.0 8.0 Macaya
PB09_00BHZ 0.0100 0.0300 2.0 8.0 Quillagua
PB10_00BHZ 0.0100 0.0300 2.0 8.0 Juan Lopez
PB11_00BHZ 0.0100 0.0300 2.0 8.0 Quebrada Aricilda
PB12_00BHZ 0.0100 0.0300 2.0 8.0 Cerro Caramaca
```

RTDR24 reads the component files specified by -comp every -upd second and generates a helicorder plot in directory specified by -www and also in directory -www_filt if the -flt option is specified.

A script in /home/seismo/mydir/com, rtquake_heli will start an example run of the program.

rtquake_heli

```
rt24 -to_wi 1200 -fr_hg 600 -mt 15 -l streams_heli -f stations_heli
139.17.3.177
```

$ rt24 -h

Usage: rt24 [options] [host][:port]

General program options

-V		report program version
-h		show this usage message
-top	text	top directory (default: /home/seismo)
-www	text	directory helicorder plots, unfiltered (/home/seismo/mydir/rt/png)
-www_filt	text	directory helicorder plots, filtered (/home/seismo/mydir/png_filt)
-to_wi	pixels	total width in pixels
-fr_hg	pixels	total frame height in pixels
-mt	min	minutes across frame
-col	n	color scheme

Data stream selection and station file##

-l listfile   read a stream list from this file (streams_heli)
-f stationfile read a station list from this file (stations_heli)

[host][:port]   Address of the SeedLink server in host:port format
f.ex.: 129.177.xx.yy:18000
f.ex.: localhost:18000

```
$ rtdr24 -h

Usage: rtdrum [options]

General program options:
 -h            show this usage message
 -top          top directory (default: /home/seismo)
 -www          directory helicorder plots (/home/seismo/mydir/rt/png)
 -www_filt     directory helicorder plots, filtered (/home/seismo/mydir/rt/png_filt)
 -logo1  txt   name of left side logo (gif file)
 -logo2  txt   name of right-side logo (jpg file)
 -gain         gain factor signals. For example: 0.003
 -flt          will generate filtered helicorder plots
 -comp         filename component to plot, 10 char.(ex: ASK__00EHZ)
 -upd n        update plot every n seconds (default: 120)
```

rtheli1

Helicorder plot. This command will generate one-per-day helicorder plots for as many days you decide using the configuration files found in /home/seismo/mydir/par/DEMO1 and /home/seismo/mydir/com/rtquake.par. The user can use these files as recipes for different configurations.
Helicorder plots are generated in /home/seismo/mydir/rt/png and /home/seismo/mydir/rt/png_filt for unfiltered and filtered data respectively. The helicorder plots are updated with some minutes delay.
Plots can be shown with a standard browser. To generate a menu of all plots the command rthplt is run automatically to create index.html files.

rthplt

Creates the html files the user can use to look at the helicorder plots from the different stations. Enter the address /home/seismo/mydir/rt/png/index.html or /home/seismo/mydir/rt/png_filt/index_filt.html and click on the station you want to check.
Another function of this routine is that files older than n days (specified in /home/seismo/mydir/com/rtquake.par) are removed.

rtheli2

Helicorder plot. This command will generate one helicorder plot per station, but only one per station for the last 24 hours. The plots can be shown as a “slide-show”, switching station automatically every 10-15 seconds. Enter the following address in your browser: /mydir/heli/slide_tst.html

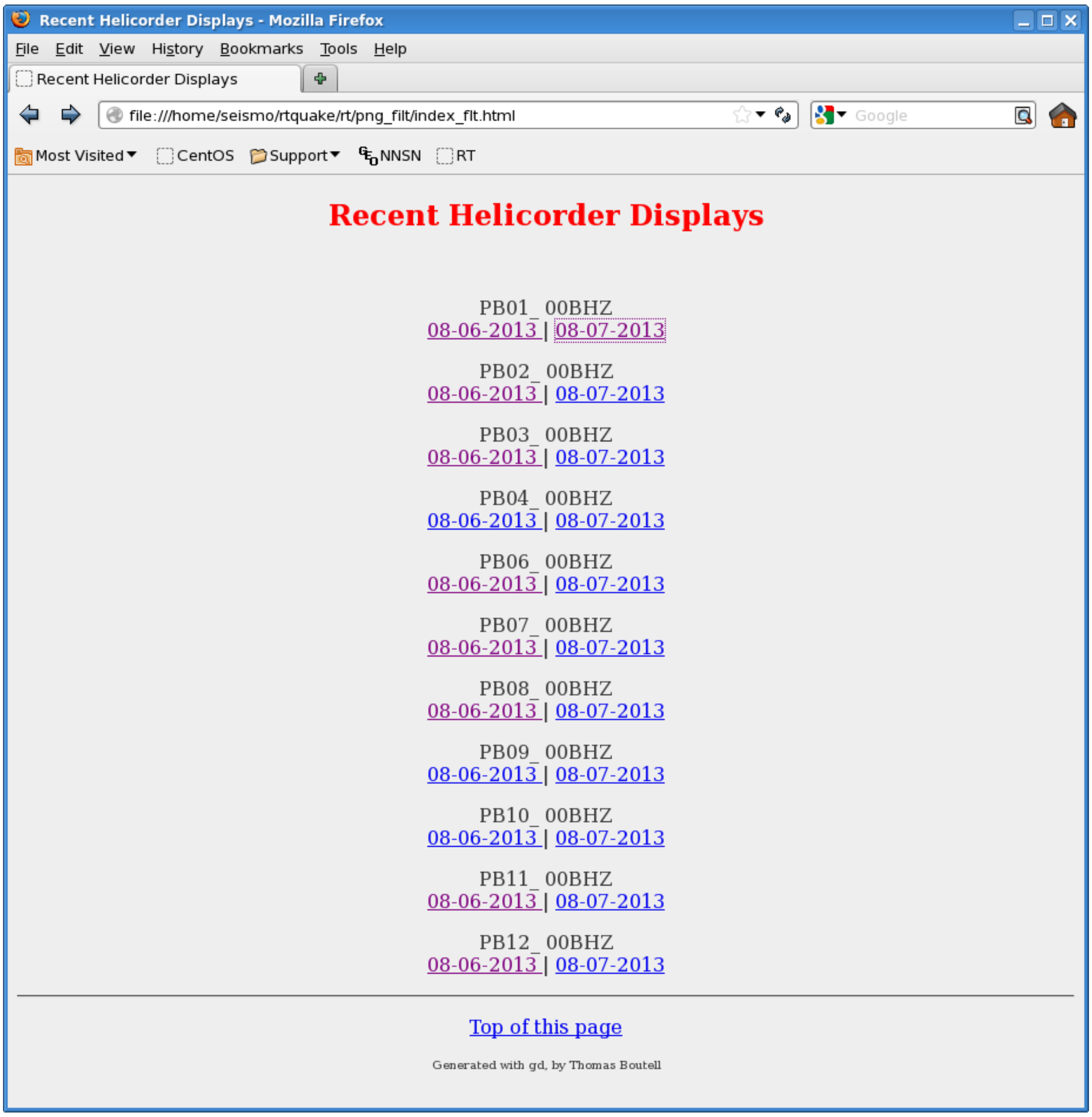


Figure 20.1 Menu helicorder plots

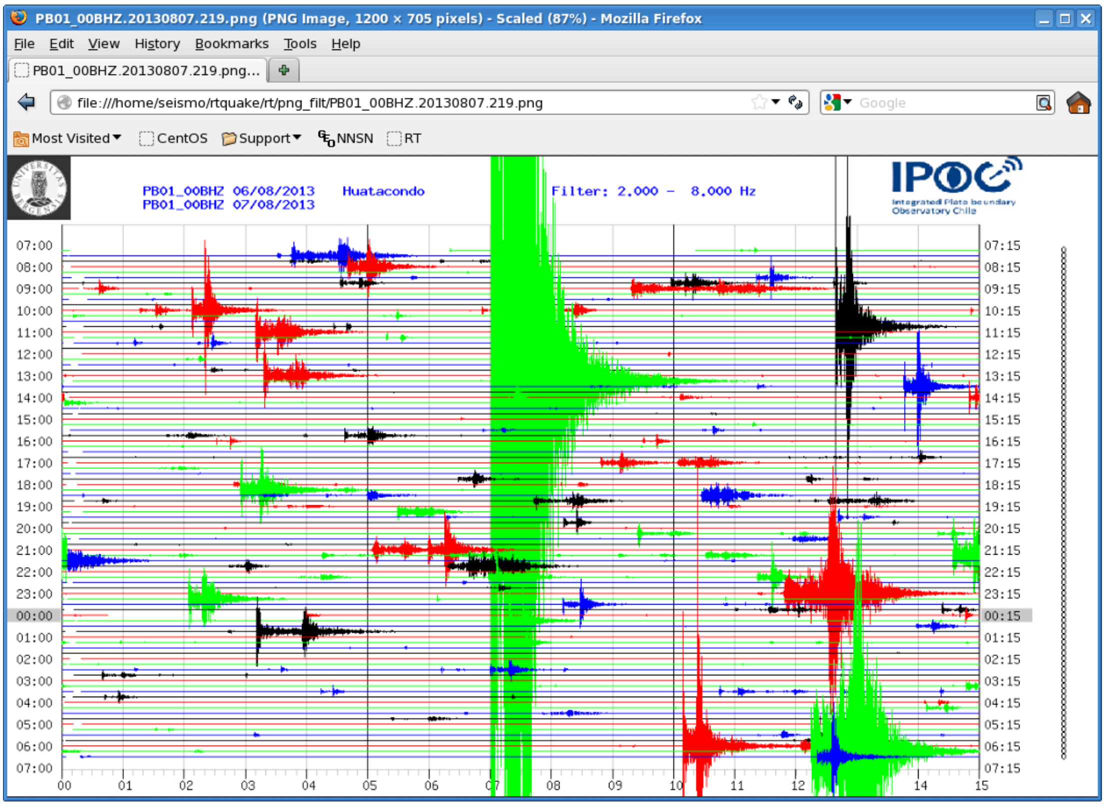


Figure 20.2 Helicorder plot

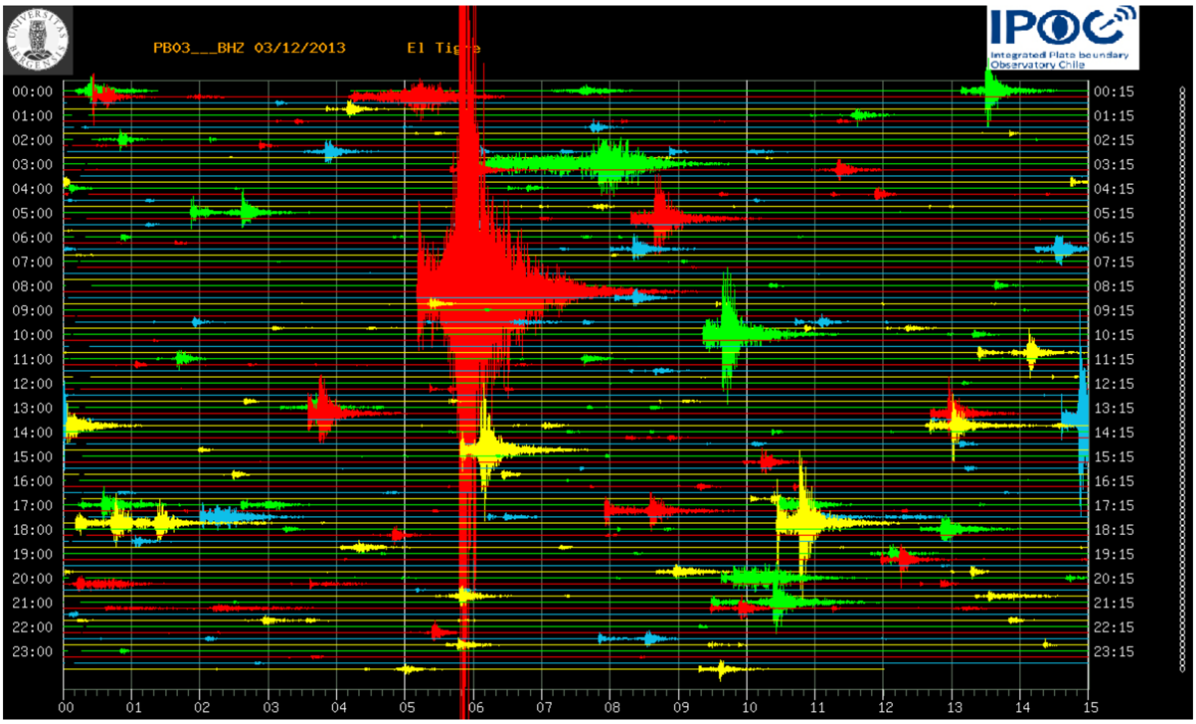


Figure 20.3 Helicorder plot

21 TYPICAL SEQUENCE DURING AN EVENT DETECTION

Below is a typical sequence of what happens during an event detection and location. Some console output is also included to give a better understanding of how RTQUAKE works.

RTQUAKE is started as normal with the DEMO1 parameters and the rtquake.par parameter file as shown below:

```
This file is parameter file for rtquake.
Only the lines with recognized keyword under KEYWORD will be read.
The comments have no importance.
Columns Par 1-Par 2 start in columns 41,51.

keep   locate        Action
-----------------------------
  -1      0/1        A new s-file is created with no phase-picks.
                     No location. This option is used for RTQUAKE: detection + no picks + no
location

   0      0/1        A new s-file is created with the detection phase-picks only. No
location.

   1       0         A new s-file is created with all phase-picks from FilterPicker.
                     No location. This option is used for RTQUAKE: detection + NO location

   1       1         A new s-file is created with all phase-picks from FilterPicker.
                     Automatic location. Phases causing high residuals will be removed
automatically
                     until MAX RESIDUAL (see below) and or MINSTALOc (see below) is reached.
                     The s-file will contain the location and the phase-picks that are left.
                     This option is used for RTQUAKE: detection + autoloc

All keywords in capital letters.

KEYWORD...........Comments............Par 1.....Par 2
----------------------------------------how to record s-files-----------------------------
KEEP              1:sfile,-1:no sfile  1
----------------------------------------automatic location or not-------------------------
LOCATION          1:Locate,0:No Locate 1
----------------------------------------geographical name of location or not--------------
GEOLOCATION       1:yes, 0:no          1
----------------------------------------detail level of geographical name of location-----
GEODETAIL         6-10                 7
----------------------------------------automatic local magnitude or not------------------
AUTOMAG           1 compute Ml,Mw      1
----------------------------------------name of SEISAN database---------------------------
DBASENAME         For SEISAN           TST__
----------------------------------------SEISAN catalogue for waveforms--------------------
WAVEDIR           For SEISAN           WAV
----------------------------------------store waveforms in database or not----------------
WAVE_DB_ACTIVE    For SEISAN           1
----------------------------------------max number of iterations discarding phases--------
ITERATION         Number of iterations 100.0
----------------------------------------maximum acceptable residual to do location--------
MAX_RESIDUAL      Maximum residual     2.0
----------------------------------------min. no of stations with phase reading to do location-
MINSTALOC         Min stat to locate   5
----------------------------------------separate sub networks or all as one---------------
ALLSUBNETS        0-sep.net >0 one net 0
----------------------------------------p-phases and s-phases or p-phases only------------
PHASES            0-p, 1-p+s           1
----------------------------------------mail or not---------------------------------------
MAIL1             0-no mail,1-mail     0         terjeu@hotmail.com
MAIL2             0-no mail,1-mail     0         abcd@online.no
MAIL3             0-no mail,1-mail     0         whatever@mail.com
MAIL4             0-no mail,1-mail     0         any@mail.com
MAIL5             0-no mail,1 mail     0         to_you@yahoo.com
----------------------------------------total delay buffer trigger------------------------
DELAY_BUFFER      Minutes delaybuffer  20.0
----------------------------------------where to set current time in delay buffer---------
```

```
MINUT_NOW           Minut current data   17.0
----------------------------------------delay for trigger window--------------------------
DET_DELAY           Detection delay      7.0
----------------------------------------array-propagation-window--------------------------
APW                 Array prop. window   120.0
----------------------------------------seconds to shufle buffer don't change-------------
SECONDS2SHUFLE      Seconds to shift     4.0
----------------------------------------pre-event in seconds------------------------------
PRE_EVENT           Pre-event (seconds)  60.0
----------------------------------------post-event in seconds-----------------------------
POST_EVENT          Post-event (seconds) 60.0
----------------------------------------no of days to save heliplots----------------------
HELI_DAYS           No of days to save   5.0
----------------------------------------filterpicker don't change-------------------------
FILTERWINDOW        FilterPicker         300.0
LTWINDOW            FilterPicker         500.0
THRESHOLD1          FilterPicker         10.0
THRESHOLD2          FilterPicker         10.0
TUPEVENT            FilterPicker         20.0
----------------------------------------sound on or off when trigger----------------------
SOUND               1-sound, 0-nosound   1.0
----------------------------------------printing or not-----------------------------------
PRINTING            Debug printing       0
*****************************************************************************************
* Parameters for preliminary autolocation based on "close-to-real-time" phase picks      *
*****************************************************************************************
----------------------------------------auto location based on p-phase picking in real-time
REALTIME_PICK       0-no, 1-yes          1
----------------------------------------max. residual to do loc. based on real-time phases
MAX_RES_PPH         Max residual rt      2.0
----------------------------------------min. stations with phase reading for realtime loc.
MINSTALOCPPH        min. no. stations    6

----------------------------------------accept p-phases in time-window: current time - seconds
TIMEWINDOW          seconds back in time 70
----------------------------------------p-phases and s-phases or p-phases only real-time picks
RTPHASES            0-p, 1-p+s           1
```

Note that the parameters LOCATION, GEOLOCATION, AUTOMAG and REALTIME_PICK are all set to 1 (active). It means that when an event occurs, the system will try to make an automatic location and magnitude based on real-time phases picked on data just after arrival from the SeedLink system. In the case of a successful location the system will also try to give a approximate geographical name of the epicenter. This process is normally finished within 1 minute after the first phases are found.

When the event has been recorded in the SEISAN database with the corresponding s-file the system will read the event, look for p and s phases and try to do a new location. If successful the magnitude will be computed. Also in this case the system will try to give a approximate geographical name of the the epicenter. Depending on the post-event that has been specified, this process will finish several minutes after the detection takes place.

Below some graphics and printouts that are produced during this process with some comments attached.

RTQUAKE started and the RTDLY shows the graphic below:

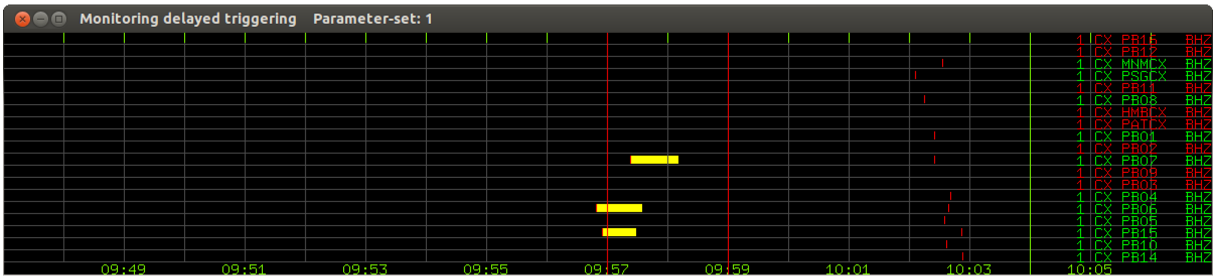


Figure 21.1 RTDLY plot

As can be seen at around time 10:02 several triggers are indicated by the red vertical lines. The system are continuously searching for phases on new data received from the seedlink server. Around the triggers indicated in the figure, several phases are found and the system will try to locate.

The program **rtloc** was also started initially and when there are new locations, the map is updated dynamically. So when new phases are added, new locations will be computed and one can see the epicenter is moving slightly after each new computation. As can be seen on the graphics the text says that this is "Real-time" and there is a UTC time and a preliminary latitude, longitude and MW.

Figure 21.2 RTLOC plot

Different graphics are produced during this stage of the detection. Figure 21.3 below shows the preliminary location and a listing of the s-file. As can be seen in the header of the map the geographical name of the location is included. Both maps are updated dynamically when new real time locations are produced.

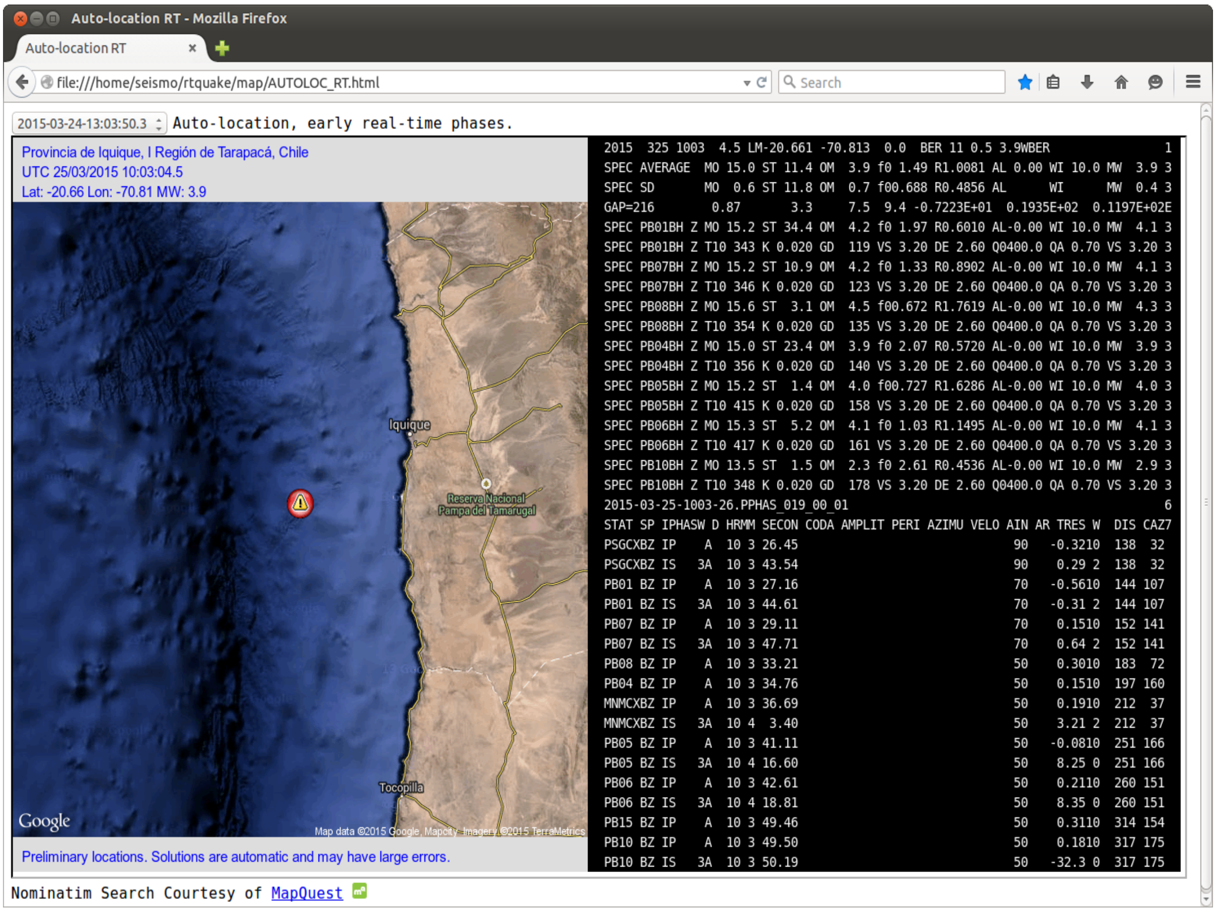


Figure 21.3 AUTOLOC_RT.html

After some minutes when the triggers enter the array propagation, (see Figure 21.1) a network trigger is declared and the complete waveform can be extracted from the SeedLink server. The waveform is stored in the SEISAN database. As we have the auto-location activated, RTQUAKE will process the recorded waveform for new phases and try to compute a new location an magnitude. This process is explained in Chapter 10. Now maps and graphics are updated again, but will now contain results from automatic processing of the complete waveform.

The routine rtloc will update the location and magnitudes based on the processing of the complete waveform. In the header of the map made by rtloc the title is now "Recorded event". The UTC time is the same as before, but the location and magnitude are slightly adjusted compared to the real-time solution. In addition a ML has been computed.

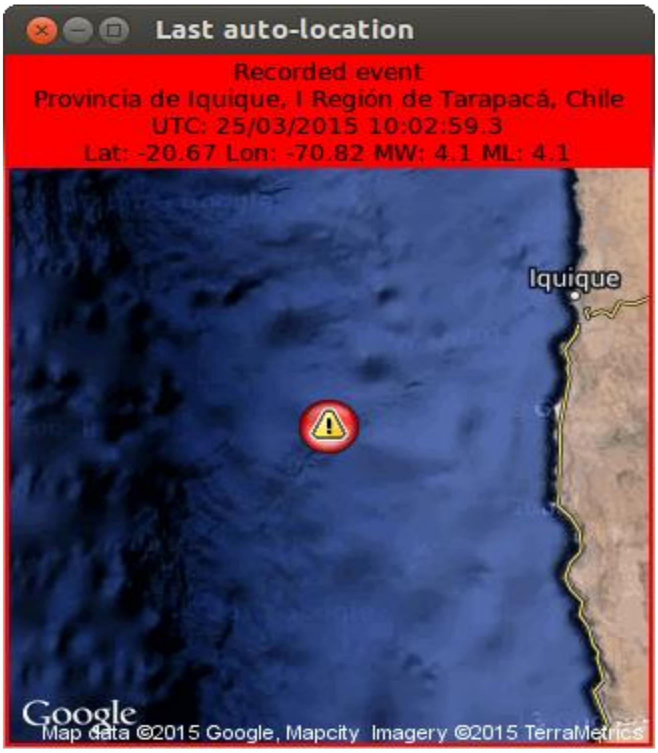


Figure 21.4 RTLOC

The figure below shows the results of the automatic post-processing of the event with the same information as above.

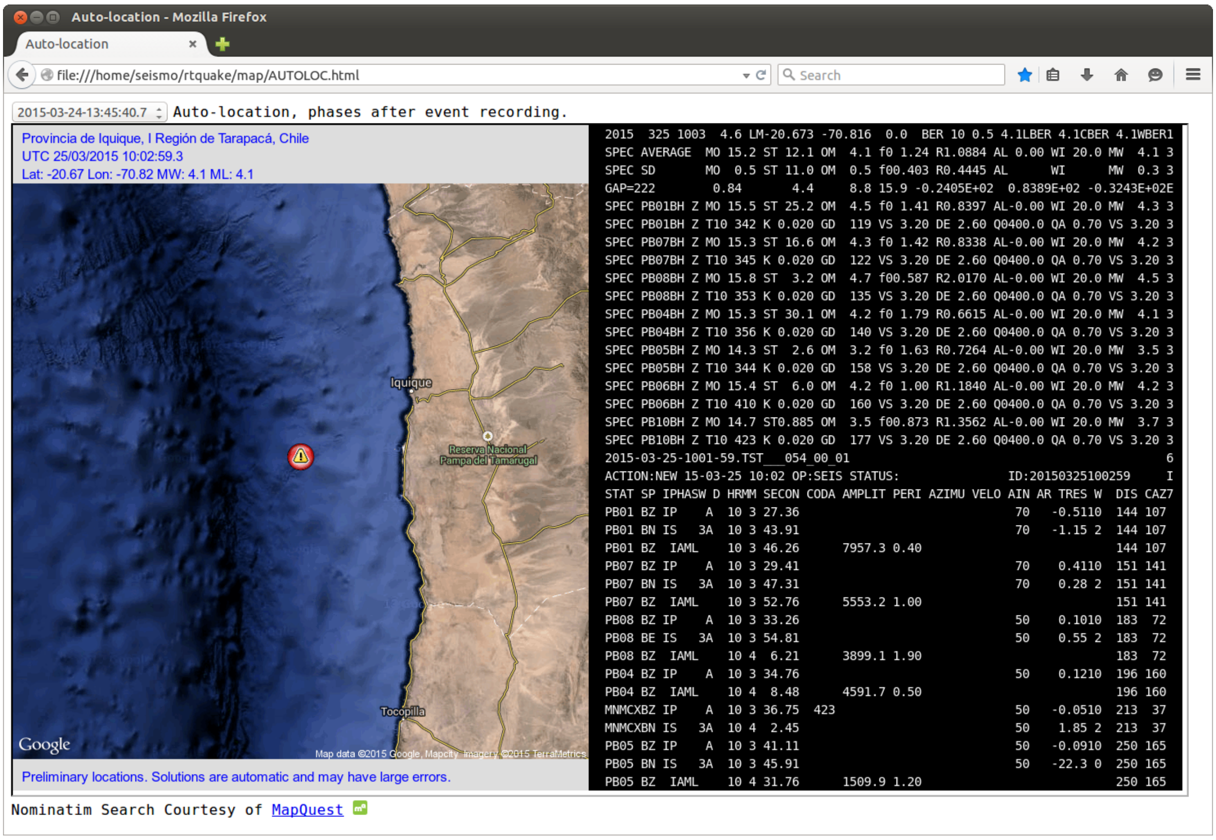


Figure 21.5 AUTOLOC.html

Another map that can be used to show the results of the automatic processing is shown below. The information is more or less the same, but the stations in the network are marked on the map.

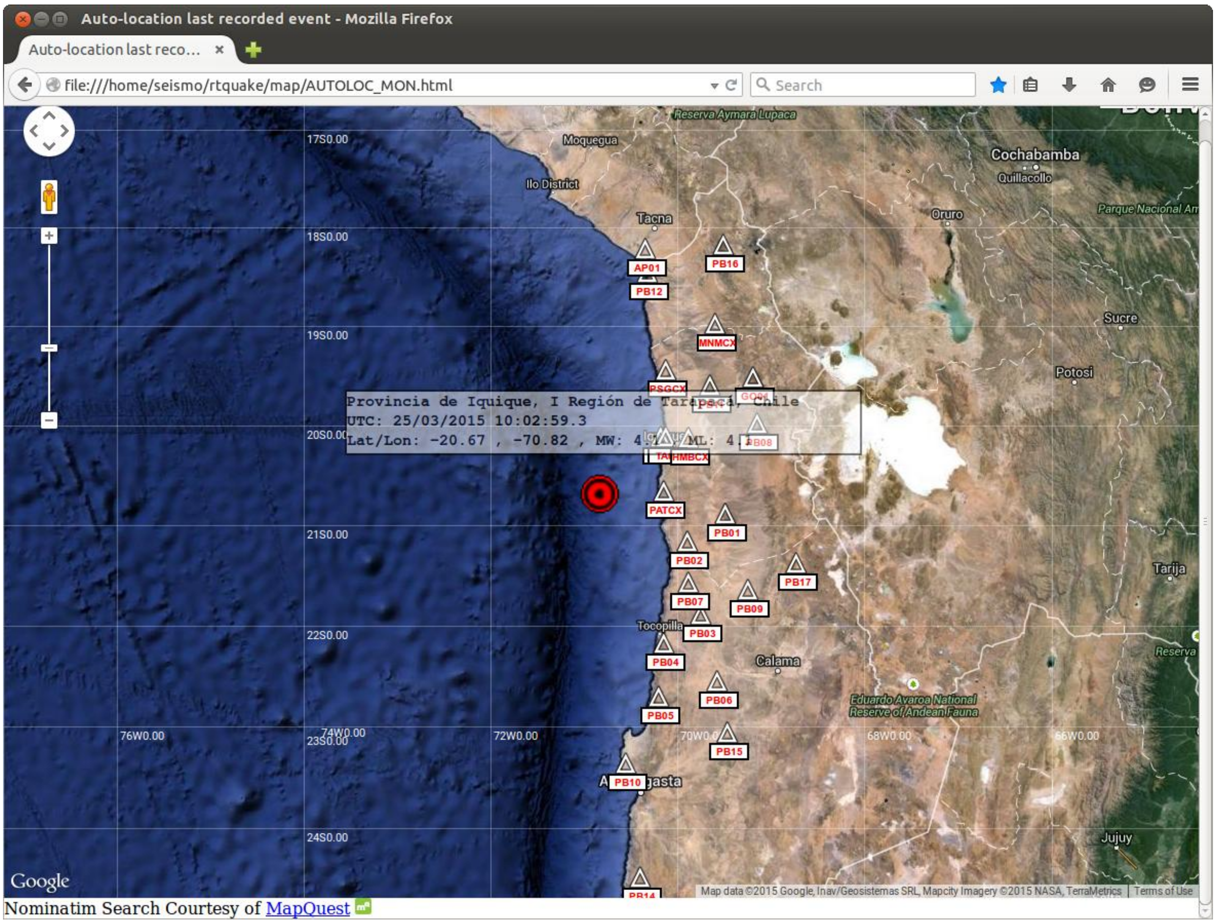


Figure 21.6 AUTOLOC_MON.html

The webpage below shows the automatic location of the event, the s-file and the residuals of the phase readings. A simple plot of the signals with the phases are also shown.

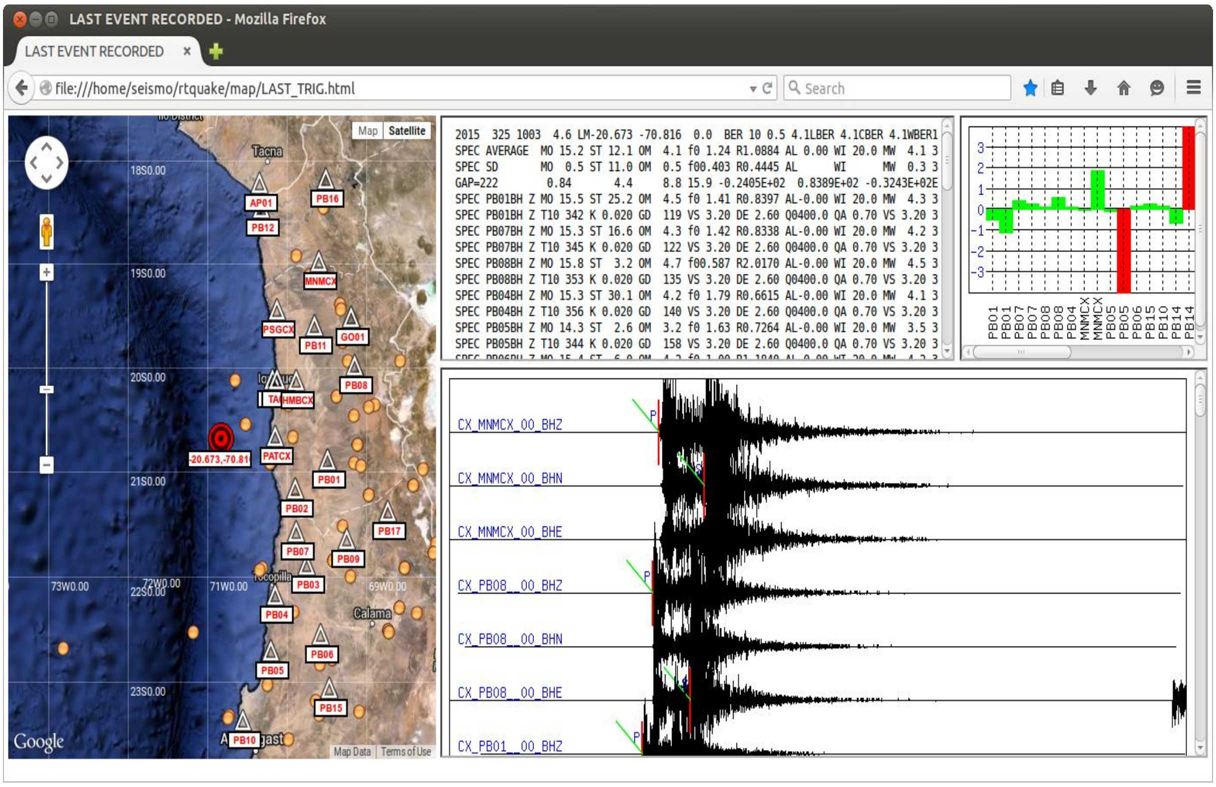


Figure 21.7 LAST_TRIG.html

The real time picks and location are based on a small time window of the signals entering RTQUAKE in real time. When the number of picks comply with the parameters in rtquake.par, the current data in the time window is recorded in the SEISAN database WAV/PPHAS with the corresponding s-file in REA/PPHAS. The data can be treated with eev and mulplt as normal detections, but the length of the signal will be very short. The plot below shows the real time recording with picks from the event in the example.and the other the preliminary location and a listing of the s-file. The total time is around 120 seconds.

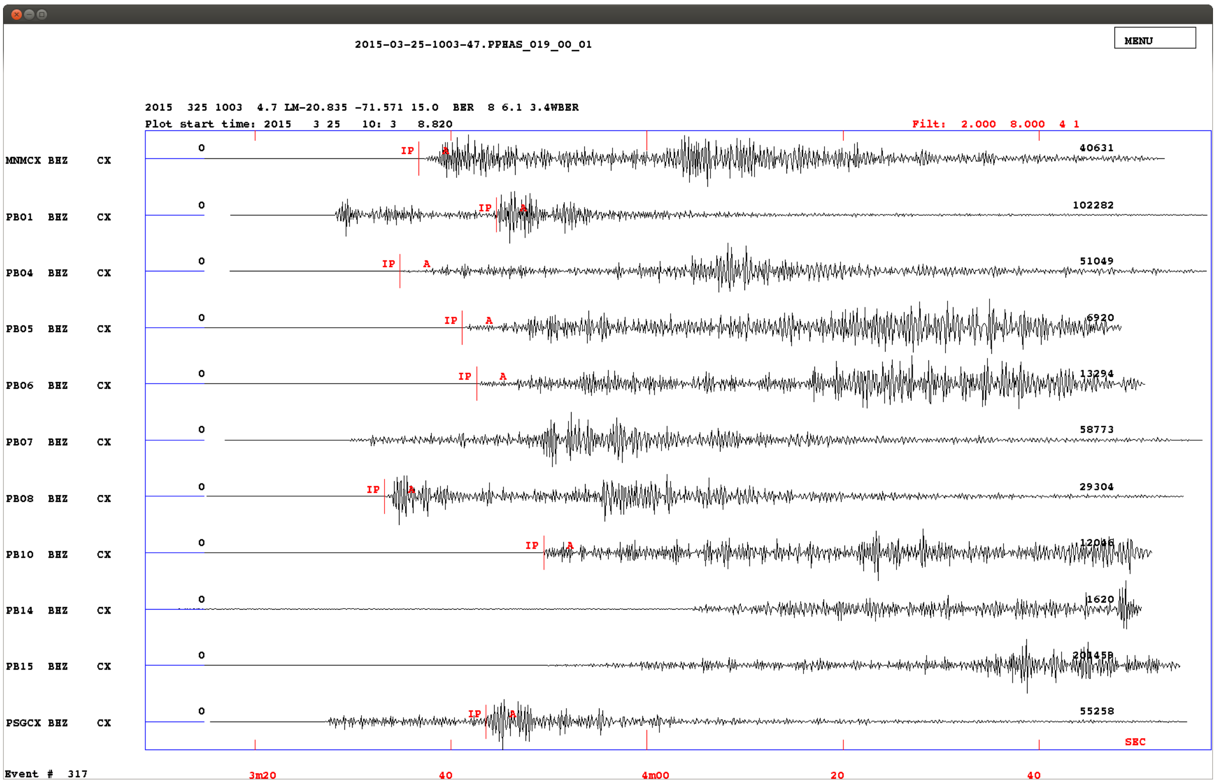


Figure 21.9 MULPLT

After the event has been recorded with the complete post-event and processed automatically it can be plotted and analysed as a normal event by the operator. Automatic readings can be removed and manual readings inserted. The plot below shows the recorded event in the example automatically processed. The time window now is 7-8 minutes.

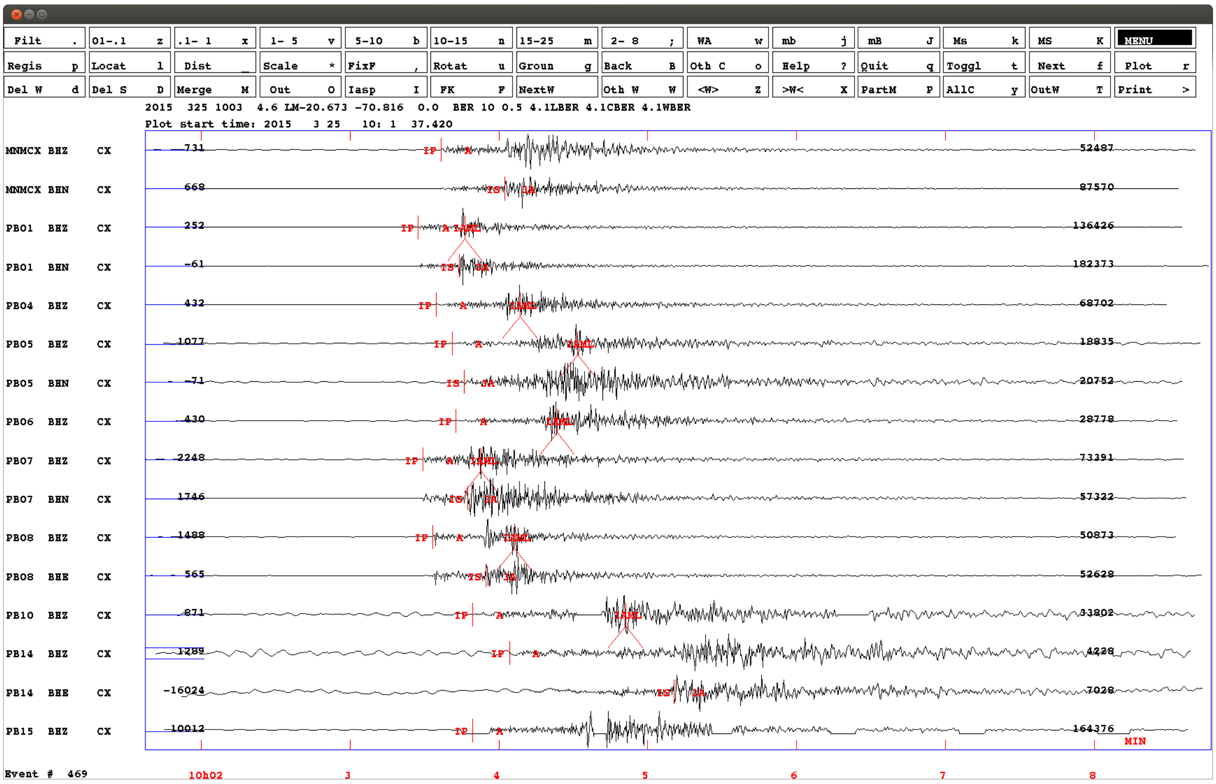


Figure 21.10 MULPLT

Below follows part of the printout on the console during the detection of the event in the example. Some explanation has been added in **bold letters**.

Looking at the RDLY plot on top in this example sequence we can see that som triggers have been detected. Several phases are determined. In this more phases than specified in the parameter file (11) and a real time detection is declared:

```
FPICKS: Phasepics subnet  1: 11
FPICK: AN EVENT IS DETECTED !!
FPICKS:  0 3636353083.1    55.4
FPICKS:  1 3636353087.8    60.1
FPICKS: 10 3636353029.0     1.3
FPICKS: 11 3636353027.7     0.0
FPICKS: 12 3636353029.5     1.8
FPICKS: 13 3636353030.2     2.5
FPICKS: 14 3636353043.4    15.7
FPICKS: 15 3636353044.3    16.6
FPICKS: 16 3636353056.1    28.3
FPICKS: 17 3636353058.8    31.1
FPICKS: 18 3636353075.3    47.6
FPICK: pidx: 11
```

Find the minimum time of the phase readings, create the waveform filename and the corresponding s-file name

```
FPICK: MINPPHASE: 25/03/15 10:03:47.719  mintid: 3636353027.7
TRIGGER_TIME_FPICK: ......wave_file_name: 2015-03-25-1003-47.PPHAS_019_00_01
CREATE_Sfile_P: Time to make Sfile..: 25/03/15 10:03:47.719
Create_Sfile_P: S-filename.........: 25-1003-47L.S201503
Create_Sfile_P DUMMY...............: /home/seismo/snew/REA/PPHAS/2015/03
Create_Sfile_P FULLPATH............: /home/seismo/snew/REA/PPHAS/2015/03//25-1003-47L.S201503
RTDET: S_REC_P.....................: 2015  325 10 3 47.7
In S_REC_P: FILENAME: 2015-03-25-1003-47.PPHAS_019_00_01
 1 CX PB10   BHZ   3636353083.1  25/03/15 10:04:43.100  1
```

```
 1 CX PB14   BHZ   3636353087.8  25/03/15 10:04:47.845  0
 1 CX PB08   BHZ           -1.0  25/03/15 10:03:33.219  0
 1 CX PSGCX  BHZ           -1.0  25/03/15 10:03:26.450  1
 1 CX MNMCX  BHZ           -1.0  25/03/15 10:03:36.699  0
 1 CX PB04   BHZ           -1.0  25/03/15 10:03:34.769  0
 1 CX PB01   BHZ           -1.0  25/03/15 10:03:44.619  0
 1 CX PSGCX  BHZ           -1.0  25/03/15 10:03:43.549  0
 1 CX PB05   BHZ           -1.0  25/03/15 10:03:41.119  0
 1 CX PB06   BHZ           -1.0  25/03/15 10:03:42.619  0
 1 CX PB10   BHZ   3636353029.0  25/03/15 10:03:49.050  0
```

Create the s-file and write the waveform file from the short timewindow (around 120 seconds)

```
Create_Sfile_P........................: cp /home/seismo/snew/REA/PPHAS/2015/03//25-1003-
47L.S201503 hyp_save.out
WRITE_RTPHASE started!
wait.......
wait.......
********************************************************************
                       WRITE DATA BUFFER
      S_FILE:   /home/seismo/snew/REA/PPHAS/2015/03//25-1003-44L.S201503
      W_FILE:   2015-03-25-1003-44.PPHAS_019_00_01
      SUBNET:    1 CHANNEL:  0 to 19
********************************************************************
wait.......
wait.......
  End of s-file
RTPPH:................................: MINTRGTID: 25/03/2015010:03:08.5
RTPPH:................................: TRG_TID:   2015-03-25-10:03:08.5
```

Start the iteration process explained in chapter 10 to get the rms residual below the value set in the parameter file and still have enough components with phase readings left for location. In the example, this is repeated 3 times in the example as new phases from the event are entering the defined time window. The average residual changes and also the location.

```
RTPPH: readings left...................: 25 Avg.res: 2013003904.00  phases left: 24
Avg.residual in HYP_NEW:   4.07
RTPPH: readings left...................: 24 Avg.res:     4.07  phases left: 23 Avg.residual
in HYP_NEW:   3.14
RTPPH: readings left...................: 23 Avg.res:     3.09  phases left: 22 Avg.residual
in HYP_NEW:   2.20
RTPPH: readings left...................: 22 Avg.res:     2.05  phases left: 21 Avg.residual
in HYP_NEW:   1.49
RTPPH: STOP iterations. Residual below..: 2.00
RTPPH: Average residual................: 2.050182
RTPPH: No more iterations..............: Number of stations: 22 Avg: res.:    2.050
wait.......
wait.......
wait.......
RTPPH: UTC: 25/03/2015 10:03:08.5 Lat: -20.85 Lon: -71.07 I Region de Tarapaca, Chile
wait.......
wait.......
wait.......
********************************************************************
                       WRITE DATA BUFFER
      S_FILE:   /home/seismo/snew/REA/PPHAS/2015/03//25-1003-47L.S201503
      W_FILE:   2015-03-25-1003-47.PPHAS_019_00_01
      SUBNET:    1 CHANNEL:  0 to 19
********************************************************************
wait.......
wait.......
  End of s-file
RTPPH:................................: MINTRGTID: 25/03/2015010:03:17.1
RTPPH:................................: TRG_TID:   2015-03-25-10:03:17.1
RTPPH: readings left...................: 25 Avg.res: 2013003904.00  phases left: 24
Avg.residual in HYP_NEW:   5.81
RTPPH: readings left...................: 24 Avg.res:     5.81  phases left: 23 Avg.residual
in HYP_NEW:   4.69
RTPPH: readings left...................: 23 Avg.res:     4.09  phases left: 22 Avg.residual
in HYP_NEW:   3.21
RTPPH: readings left...................: 22 Avg.res:     3.09  phases left: 21 Avg.residual
in HYP_NEW:   2.25
```

```
RTPPH: readings left...................: 21 Avg.res:     2.19  phases left: 20 Avg.residual
in HYP_NEW:   1.83
RTPPH: STOP iterations. Residual below..: 2.00
RTPPH: Average residual................: 2.193238
RTPPH: No more iterations..............: Number of stations: 21 Avg: res.:    2.193
wait.......
RTPPH: UTC: 25/03/2015 10:03:17.1 Lat: -20.83 Lon: -71.57 I Region de Tarapaca, Chile
*********************************************************************
                       WRITE DATA BUFFER
      S_FILE:   /home/seismo/snew/REA/PPHAS/2015/03//25-1003-26L.S201503
      W_FILE:   2015-03-25-1003-26.PPHAS_019_00_01
      SUBNET:    1 CHANNEL:  0 to 19
*********************************************************************
  End of s-file
RTPPH:................................: MINTRGTID: 25/03/2015010:03:04.5
RTPPH:................................: TRG_TID:   2015-03-25-10:03:04.5
RTPPH: readings left...................: 33 Avg.res:     1.89  phases left: 32 Avg.residual
in HYP_NEW:   0.94
RTPPH: STOP iterations. Residual below..: 2.00
RTPPH: Average residual................: 1.893364
RTPPH: No more iterations..............: Number of stations: 33 Avg: res.:    1.893
RTPPH: UTC: 25/03/2015 10:03:04.5 Lat: -20.66 Lon: -70.81 Provincia de Iquique, I Region de
Tarapaca, Chile
Channel  3 more than 300 secs. duration.
Channel  5 more than 300 secs. duration.
Channel 10 more than 300 secs. duration.
Channel  8 more than 300 secs. duration.
Channel  2 more than 300 secs. duration.
READ_PACKETS...:klon: 0 PB14   BHZ turned off. Dur: 261
```

After around 7-8 minutes, the triggers seen in the RDLY figure on top enters the array propagation window and a network trigger is declared. The time for the first trigger is calculated

```
********************************************
*          TRIGGER on thread  1 !          *
********************************************
Playing WAVE '/home/seismo/rtquake/map/glasses.wav' : Signed 16 bit Little Endian, Rate 11025
Hz, Mono
kan:   2  1 CX MNMCX  BHZ time: 3636353006.25 index:   685 dur:   0
kan:   3  1 CX PSGCX  BHZ time: 3636352979.35 index:   658 dur:   0
kan:   5  1 CX PB08   BHZ time: 3636352988.32 index:   667 dur:   0
kan:   8  1 CX PB01   BHZ time: 3636352998.27 index:   677 dur:   0
kan:  10  1 CX PB07   BHZ time: 3636352998.97 index:   677 dur:   0
kan:  13  1 CX PB04   BHZ time: 3636353014.07 index:   693 dur:   0
kan:  14  1 CX PB06   BHZ time: 3636353012.67 index:   691 dur:   0
kan:  15  1 CX PB05   BHZ time: 3636353008.97 index:   687 dur:   0
kan:  16  1 CX PB15   BHZ time: 3636353025.02 index:   704 dur:   0
kan:  17  1 CX PB10   BHZ time: 3636353010.55 index:   689 dur:   0
kan:  18  1 CX PB14   BHZ time: 3636353026.79 index:   705 dur: 269
RTDET: TRG_MUL......................: mintid   :   3636352979.35  maxdur: 269
RTDET: TRG_MUL......................: MINTRGTID: 2015/ 3/25 10: 2:59.3
RTDET: TRG_MUL......................: MINTRGTID: 25/03/2015 10:02:59.3
RTDET: CAT_MUL thread:  1 started. channels:  0 from:  0 to: 54
```

A thread to extract the waveform data from the seedlink server, the waveform file name is generated and the corresponding s-file name

```
********************************************************************************
RTDET:                       CAT_MUL started
********************************************************************************
RTDET: CAT_MUL......................: maxdur: 269
RTDET: CAT_MUL......................: FILNAVN: 2015-03-25-1001-59.TST___054_00_01
RTDET: CAT_MUL......................: PATHANDFIL: /home/seismo/snew/WAV/TST__/2015/03/2015-
03-25-1001-59.TST___054_00_01
RTDET: CAT_MUL......................: CRTDIR: /home/seismo/snew/WAV/TST__/2015/03
RTDET: CAT_MUL......................: 2015/ 3/25 10: 8:28.3
```

Extraction of waveform data

```
********************************************************************************
RTDET: CAT_MUL Extracting data from SeedLink server..........
********************************************************************************
 -S "CX_PB16:BHZ" -tw 2015,3,25,10,1,59:2015,3,25,10,8,28 -nt 5 -nd 5 -o
/home/seismo/snew/WAV/TST__/2015/03/2015-03-25-1001-59.TST___054_00_01 139.17.3.177
```

```
TUMOD network timeout (5s), reconnecting in 5s
 -S "CX_PB16:BHN" -tw 2015,3,25,10,1,59:2015,3,25,10,8,28 -nt 5 -nd 5 -o
/home/seismo/snew/WAV/TST__/2015/03/2015-03-25-1001-59.TST___054_00_01 139.17.3.177
TUMOD network timeout (5s), reconnecting in 5s
 -S "CX_PB16:BHE" -tw 2015,3,25,10,1,59:2015,3,25,10,8,28 -nt 5 -nd 5 -o
/home/seismo/snew/WAV/TST__/2015/03/2015-03-25-1001-59.TST___054_00_01 139.17.3.177
READ_PACKETS...:klon: 0 PB10   BHZ turned off. Dur: 318
TUMOD network timeout (5s), reconnecting in 5s
```

```
 -S "CX_PB12:BHZ" -tw 2015,3,25,10,1,59:2015,3,25,10,8,28 -nt 5 -nd 5 -o
/home/seismo/snew/WAV/TST__/2015/03/2015-03-25-1001-59.TST___054_00_01 139.17.3.177
 -S "CX_PB10:BHE" -tw 2015,3,25,10,1,59:2015,3,25,10,8,28 -nt 5 -nd 5 -o
/home/seismo/snew/WAV/TST__/2015/03/2015-03-25-1001-59.TST___054_00_01 139.17.3.177
 -S "CX_PB14:BHZ" -tw 2015,3,25,10,1,59:2015,3,25,10,8,28 -nt 5 -nd 5 -o
/home/seismo/snew/WAV/TST__/2015/03/2015-03-25-1001-59.TST___054_00_01 139.17.3.177
 -S "CX_PB14:BHN" -tw 2015,3,25,10,1,59:2015,3,25,10,8,28 -nt 5 -nd 5 -o
/home/seismo/snew/WAV/TST__/2015/03/2015-03-25-1001-59.TST___054_00_01 139.17.3.177
 -S "CX_PB14:BHE" -tw 2015,3,25,10,1,59:2015,3,25,10,8,28 -nt 5 -nd 5 -o
/home/seismo/snew/WAV/TST__/2015/03/2015-03-25-1001-59.TST___054_00_01 139.17.3.177
RTDET: CAT_MUL..........................: call Create_Sfile
RTDET: Create_Sfile S-filename..........: 25-1002-59L.S201503
RTDET: Create_Sfile DUMMY...............: /home/seismo/snew/REA/TST__/2015/03
RTDET: Create_Sfile FULLPATH............: /home/seismo/snew/REA/TST__/2015/03//25-1002-
59L.S201503
RTDET: S_REC............................: 2015  325 10 2 59.3
nchannels: 54
RTDET: Create_Sfile.....................: cp /home/seismo/snew/REA/TST__/2015/03//25-1002-
59L.S201503 hyp_save.out
RTDET: CAT_MUL.................SFILEPATH: /home/seismo/snew/REA
RTDET: CAT_MUL.................DBNAME   : TST__
RTPICK is NOT running.
```

Run the phase picker on the extracted data

```
RTDET: CAT_MUL (cd /home/seismo/rtquake/rt/tmp1 && exec /home/seismo/rtquake/bin/rtpick -prt 0
-sfile /home/seismo/snew/REA/TST__/2015/03//25-1002-59L.S201503 -wavefile
/home/seismo/snew/WAV/TST__/2015/03/2015-03-25-1001-59.TST___054_00_01)
RTPICK: SEISAN_TOP......................: /home/seismo/snew
RTPICK: RTQUAKE_TOP.....................: /home/seismo/rtquake
RTPICK: rtquake.par does not exist in current directory.
RTPICK: Look in /home/seismo/rtquake/com/rtquake.par
RTPICK: read rtquake.par
RTPICK:.................................: MINTRGTID: 25/03/2015 10:02:59.3
RTPICK:.................................: TRG_TID:   2015-03-25-10:02:59.3
Extract waveform filename from original s-file
rtpick........................: 2015-03-25-1001-59.TST___054_00_01
SUBNET: 1
wfilename: /home/seismo/snew/WAV/TST__/2015/03/2015-03-25-1001-59.TST___054_00_01
```

Phases found by the picker

```
Components found reading miniseed file. COMP_CNT: 30
 0  0 CX_MNMCX_00_BHZ PICKLINES: STAT   DIG  CMP  ? P0_    ? 20150325 1003   36.7500 GAU
1.500e-01 0.000e+00 2.510e+01 5.000e-02
 1  1 CX_MNMCX_00_BHZ PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1004    3.4000 GAU
2.000e-01 0.000e+00 1.752e+01 4.000e-01
 2  0 CX_MNMCX_00_BHN PICKLINES: STAT   DIG  CMP  ? P0_    + 20150325 1003   36.9000 GAU
1.500e-01 0.000e+00 2.211e+01 2.000e-01
 3  1 CX_MNMCX_00_BHN PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1003   40.9000 GAU
2.500e-01 0.000e+00 1.231e+01 3.200e+00
 4  2 CX_MNMCX_00_BHN PICKLINES: STAT   DIG  CMP  ? P2_    + 20150325 1004    2.4500 GAU
2.500e-01 0.000e+00 1.067e+01 3.200e+00
 5  0 CX_MNMCX_00_BHE PICKLINES: STAT   DIG  CMP  ? P0_    + 20150325 1003   36.8500 GAU
1.500e-01 0.000e+00 1.400e+01 4.000e-01
 6  1 CX_MNMCX_00_BHE PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1003   42.8500 GAU
5.000e-02 0.000e+00 1.054e+01 2.000e-01
 7  0 CX_PB08__00_BHZ PICKLINES: STAT   DIG  CMP  ? P0_    - 20150325 1003   33.2690 GAU
1.500e-01 0.000e+00 1.787e+01 5.000e-02
 8  1 CX_PB08__00_BHZ PICKLINES: STAT   DIG  CMP  ? P1_    - 20150325 1003   54.1190 GAU
6.000e-01 0.000e+00 1.006e+01 2.560e+01
 9  0 CX_PB08__00_BHN PICKLINES: STAT   DIG  CMP  ? P0_    - 20150325 1003   33.3190 GAU
1.500e-01 0.000e+00 1.963e+02 5.000e-02
```

```
10  0 CX_PB08__00_BHE PICKLINES: STAT   DIG  CMP  ? P0_   ? 20150325 1003   33.1690 GAU
5.000e-02 0.000e+00 2.226e+01 5.000e-02
11  1 CX_PB08__00_BHE PICKLINES: STAT   DIG  CMP  ? P1_   + 20150325 1003   54.8190 GAU
1.500e-01 0.000e+00 1.119e+01 6.400e+00
12  0 CX_PB01__00_BHZ PICKLINES: STAT   DIG  CMP  ? P0_   ? 20150325 1003   27.3690 GAU
1.000e-01 0.000e+00 1.345e+01 5.000e-02
13  1 CX_PB01__00_BHZ PICKLINES: STAT   DIG  CMP  ? P1_   - 20150325 1003   44.6190 GAU
6.000e-01 0.000e+00 1.239e+01 2.560e+01
14  0 CX_PB01__00_BHN PICKLINES: STAT   DIG  CMP  ? P0_   ? 20150325 1003   27.6190 GAU
5.000e-02 0.000e+00 2.216e+01 5.000e-02
15  1 CX_PB01__00_BHN PICKLINES: STAT   DIG  CMP  ? P1_   - 20150325 1003   43.9190 GAU
1.000e-01 0.000e+00 1.900e+01 1.600e+00
16  0 CX_PB01__00_BHE PICKLINES: STAT   DIG  CMP  ? P0_   ? 20150325 1003   27.1690 GAU
2.500e-01 0.000e+00 2.182e+01 5.000e-02
17  0 CX_PB07__00_BHZ PICKLINES: STAT   DIG  CMP  ? P0_   + 20150325 1003   29.4190 GAU
1.000e-01 0.000e+00 1.030e+02 5.000e-02
18  1 CX_PB07__00_BHZ PICKLINES: STAT   DIG  CMP  ? P1_   - 20150325 1003   47.7190 GAU
3.000e-01 0.000e+00 1.355e+01 1.280e+01
19  2 CX_PB07__00_BHZ PICKLINES: STAT   DIG  CMP  ? P2_   ? 20150325 1003   51.9690 GAU
1.000e-01 0.000e+00 1.550e+01 8.000e-01
20  0 CX_PB07__00_BHN PICKLINES: STAT   DIG  CMP  ? P0_   ? 20150325 1003   29.2690 GAU
5.000e-02 0.000e+00 1.322e+01 5.000e-02
21  1 CX_PB07__00_BHN PICKLINES: STAT   DIG  CMP  ? P1_   - 20150325 1003   47.3190 GAU
6.000e-01 0.000e+00 1.313e+01 3.200e+00
22  0 CX_PB07__00_BHE PICKLINES: STAT   DIG  CMP  ? P0_   ? 20150325 1003   28.9690 GAU
1.500e-01 0.000e+00 1.069e+01 5.000e-02
23  1 CX_PB07__00_BHE PICKLINES: STAT   DIG  CMP  ? P1_   + 20150325 1003   46.5190 GAU
2.500e-01 0.000e+00 1.298e+01 6.400e+00
24  2 CX_PB07__00_BHE PICKLINES: STAT   DIG  CMP  ? P2_   - 20150325 1003   48.6190 GAU
3.000e-01 0.000e+00 1.456e+01 1.280e+01
25  0 CX_PB04__00_BHZ PICKLINES: STAT   DIG  CMP  ? P0_   ? 20150325 1003   34.7690 GAU
1.500e-01 0.000e+00 1.082e+01 5.000e-02
26  1 CX_PB04__00_BHZ PICKLINES: STAT   DIG  CMP  ? P1_   ? 20150325 1003   37.2190 GAU
1.000e-01 0.000e+00 1.801e+01 5.000e-02
27  2 CX_PB04__00_BHZ PICKLINES: STAT   DIG  CMP  ? P2_   ? 20150325 1003   39.3690 GAU
5.000e-02 0.000e+00 1.232e+01 4.000e-01
28  3 CX_PB04__00_BHZ PICKLINES: STAT   DIG  CMP  ? P3_   + 20150325 1004    2.7690 GAU
1.500e-01 0.000e+00 1.047e+01 6.400e+00
29  0 CX_PB04__00_BHN PICKLINES: STAT   DIG  CMP  ? P0_   - 20150325 1003   35.0190 GAU
5.000e-02 0.000e+00 1.491e+02 5.000e-02
30  1 CX_PB04__00_BHN PICKLINES: STAT   DIG  CMP  ? P1_   ? 20150325 1003   37.0690 GAU
5.000e-02 0.000e+00 2.217e+01 5.000e-02
31  2 CX_PB04__00_BHN PICKLINES: STAT   DIG  CMP  ? P2_   ? 20150325 1003   38.9190 GAU
5.000e-02 0.000e+00 1.703e+01 4.000e-01
32  3 CX_PB04__00_BHN PICKLINES: STAT   DIG  CMP  ? P3_   ? 20150325 1004    6.4690 GAU
3.000e-01 0.000e+00 1.231e+01 1.280e+01
33  0 CX_PB04__00_BHE PICKLINES: STAT   DIG  CMP  ? P0_   ? 20150325 1003   35.0190 GAU
1.000e-01 0.000e+00 2.112e+01 5.000e-02
34  1 CX_PB04__00_BHE PICKLINES: STAT   DIG  CMP  ? P1_   ? 20150325 1003   36.9690 GAU
1.000e-01 0.000e+00 1.176e+01 8.000e-01
35  2 CX_PB04__00_BHE PICKLINES: STAT   DIG  CMP  ? P2_   ? 20150325 1003   38.3190 GAU
1.500e-01 0.000e+00 1.575e+01 1.600e+00
36  3 CX_PB04__00_BHE PICKLINES: STAT   DIG  CMP  ? P3_   + 20150325 1003   56.1190 GAU
1.000e-01 0.000e+00 1.131e+01 1.600e+00
37  4 CX_PB04__00_BHE PICKLINES: STAT   DIG  CMP  ? P4_   - 20150325 1004    2.7190 GAU
1.000e-01 0.000e+00 1.039e+01 3.200e+00
38  0 CX_PB06__00_BHZ PICKLINES: STAT   DIG  CMP  ? P0_   ? 20150325 1003   42.6190 GAU
1.500e-01 0.000e+00 2.285e+01 5.000e-02
39  1 CX_PB06__00_BHZ PICKLINES: STAT   DIG  CMP  ? P1_   ? 20150325 1004   18.8190 GAU
1.000e-01 0.000e+00 1.232e+01 8.000e-01
40  2 CX_PB06__00_BHZ PICKLINES: STAT   DIG  CMP  ? P2_   + 20150325 1004   20.3690 GAU
4.500e-01 0.000e+00 1.158e+01 6.400e+00
41  0 CX_PB06__00_BHN PICKLINES: STAT   DIG  CMP  ? P0_   - 20150325 1003   42.7690 GAU
5.000e-02 0.000e+00 2.329e+01 5.000e-02
42  1 CX_PB06__00_BHN PICKLINES: STAT   DIG  CMP  ? P1_   - 20150325 1003   48.4190 GAU
5.000e-02 0.000e+00 1.197e+01 8.000e-01
43  2 CX_PB06__00_BHN PICKLINES: STAT   DIG  CMP  ? P2_   ? 20150325 1003   50.7190 GAU
5.000e-02 0.000e+00 2.157e+01 5.000e-02
44  3 CX_PB06__00_BHN PICKLINES: STAT   DIG  CMP  ? P3_   - 20150325 1004   20.0190 GAU
6.000e-01 0.000e+00 1.078e+01 2.560e+01
45  0 CX_PB06__00_BHE PICKLINES: STAT   DIG  CMP  ? P0_   + 20150325 1003   42.6190 GAU
2.500e-01 0.000e+00 1.464e+02 5.000e-02
46  1 CX_PB06__00_BHE PICKLINES: STAT   DIG  CMP  ? P1_   - 20150325 1003   43.2190 GAU
2.500e-01 0.000e+00 1.442e+01 8.000e-01
47  2 CX_PB06__00_BHE PICKLINES: STAT   DIG  CMP  ? P2_   ? 20150325 1003   44.4690 GAU
5.000e-02 0.000e+00 2.046e+01 5.000e-02
```

```
48  3 CX_PB06__00_BHE PICKLINES: STAT   DIG  CMP  ? P3_    ? 20150325 1003   48.1690 GAU
1.000e-01 0.000e+00 1.195e+01 4.000e-01
49  4 CX_PB06__00_BHE PICKLINES: STAT   DIG  CMP  ? P4_    - 20150325 1004   15.5690 GAU
6.000e-01 0.000e+00 1.086e+01 2.560e+01
50  0 CX_PB05__00_BHZ PICKLINES: STAT   DIG  CMP  ? P0_    + 20150325 1003   41.1190 GAU
1.000e-01 0.000e+00 1.907e+02 5.000e-02
51  1 CX_PB05__00_BHZ PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1003   42.2690 GAU
2.500e-01 0.000e+00 1.692e+01 5.000e-02
52  2 CX_PB05__00_BHZ PICKLINES: STAT   DIG  CMP  ? P2_    - 20150325 1003   46.7690 GAU
3.000e-01 0.000e+00 1.051e+01 3.200e+00
53  3 CX_PB05__00_BHZ PICKLINES: STAT   DIG  CMP  ? P3_    - 20150325 1004   16.0690 GAU
3.000e-01 0.000e+00 1.287e+01 3.200e+00
54  0 CX_PB05__00_BHN PICKLINES: STAT   DIG  CMP  ? P0_    - 20150325 1003   41.1190 GAU
1.000e-01 0.000e+00 1.122e+02 5.000e-02
55  1 CX_PB05__00_BHN PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1003   45.9190 GAU
4.000e-01 0.000e+00 1.442e+01 3.200e+00
56  0 CX_PB05__00_BHE PICKLINES: STAT   DIG  CMP  ? P0_    ? 20150325 1003   41.3190 GAU
5.000e-02 0.000e+00 2.896e+01 5.000e-02
57  1 CX_PB05__00_BHE PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1003   45.8190 GAU
1.000e-01 0.000e+00 1.091e+01 8.000e-01
58  2 CX_PB05__00_BHE PICKLINES: STAT   DIG  CMP  ? P2_    ? 20150325 1003   51.1690 GAU
2.000e-01 0.000e+00 1.582e+01 5.000e-02
59  3 CX_PB05__00_BHE PICKLINES: STAT   DIG  CMP  ? P3_    + 20150325 1004    6.8690 GAU
3.000e-01 0.000e+00 1.723e+01 3.200e+00
60  4 CX_PB05__00_BHE PICKLINES: STAT   DIG  CMP  ? P4_    + 20150325 1004   20.2690 GAU
2.500e-01 0.000e+00 1.213e+01 3.200e+00
61  0 CX_PB15__00_BHZ PICKLINES: STAT   DIG  CMP  ? P0_    ? 20150325 1003   49.4690 GAU
1.000e-01 0.000e+00 1.535e+02 5.000e-02
62  1 CX_PB15__00_BHZ PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1003   53.9190 GAU
2.000e-01 0.000e+00 1.833e+01 3.200e+00
63  2 CX_PB15__00_BHZ PICKLINES: STAT   DIG  CMP  ? P2_    ? 20150325 1003   55.7190 GAU
1.000e-01 0.000e+00 1.816e+01 2.000e-01
64  3 CX_PB15__00_BHZ PICKLINES: STAT   DIG  CMP  ? P3_    ? 20150325 1004   35.3190 GAU
5.000e-02 0.000e+00 1.023e+01 8.000e-01
65  0 CX_PB15__00_BHN PICKLINES: STAT   DIG  CMP  ? P0_    ? 20150325 1003   49.5190 GAU
1.000e-01 0.000e+00 4.517e+01 5.000e-02
66  1 CX_PB15__00_BHN PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1003   52.2190 GAU
5.000e-02 0.000e+00 1.059e+01 8.000e-01
67  2 CX_PB15__00_BHN PICKLINES: STAT   DIG  CMP  ? P2_    ? 20150325 1003   56.1690 GAU
5.000e-02 0.000e+00 1.062e+01 2.000e-01
68  3 CX_PB15__00_BHN PICKLINES: STAT   DIG  CMP  ? P3_    + 20150325 1004   38.4690 GAU
1.500e-01 0.000e+00 1.023e+01 6.400e+00
69  0 CX_PB15__00_BHE PICKLINES: STAT   DIG  CMP  ? P0_    + 20150325 1003   49.5690 GAU
1.500e-01 0.000e+00 1.045e+01 8.000e-01
70  1 CX_PB15__00_BHE PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1003   51.3690 GAU
5.000e-02 0.000e+00 1.383e+01 5.000e-02
71  2 CX_PB15__00_BHE PICKLINES: STAT   DIG  CMP  ? P2_    - 20150325 1003   55.5190 GAU
1.000e-01 0.000e+00 1.421e+01 1.600e+00
72  3 CX_PB15__00_BHE PICKLINES: STAT   DIG  CMP  ? P3_    + 20150325 1004    0.4690 GAU
3.000e-01 0.000e+00 1.118e+01 1.280e+01
73  4 CX_PB15__00_BHE PICKLINES: STAT   DIG  CMP  ? P4_    + 20150325 1004   37.5190 GAU
1.000e-01 0.000e+00 1.246e+01 3.200e+00
74  0 CX_PB10__00_BHZ PICKLINES: STAT   DIG  CMP  ? P0_    ? 20150325 1003   49.0500 GAU
1.000e-01 0.000e+00 3.221e+01 5.000e-02
75  1 CX_PB10__00_BHZ PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1003   50.0500 GAU
2.000e-01 0.000e+00 1.502e+01 5.000e-02
76  2 CX_PB10__00_BHZ PICKLINES: STAT   DIG  CMP  ? P2_    + 20150325 1004   43.1000 GAU
4.000e-01 0.000e+00 1.174e+01 1.600e+00
77  0 CX_PB10__00_BHN PICKLINES: STAT   DIG  CMP  ? P0_    ? 20150325 1003   48.9500 GAU
2.000e-01 0.000e+00 1.210e+01 5.000e-02
78  1 CX_PB10__00_BHN PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1003   50.5000 GAU
5.000e-02 0.000e+00 1.157e+01 5.000e-02
79  0 CX_PB10__00_BHE PICKLINES: STAT   DIG  CMP  ? P0_    ? 20150325 1003   49.0500 GAU
1.000e-01 0.000e+00 1.389e+01 2.000e-01
80  1 CX_PB10__00_BHE PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1004   22.1000 GAU
1.000e-01 0.000e+00 1.964e+01 2.000e-01
81  0 CX_PB14__00_BHZ PICKLINES: STAT   DIG  CMP  ? P0_    ? 20150325 1004    4.2950 GAU
1.000e-01 0.000e+00 1.048e+01 5.000e-02
82  1 CX_PB14__00_BHZ PICKLINES: STAT   DIG  CMP  ? P1_    ? 20150325 1004    9.0950 GAU
1.000e-01 0.000e+00 1.980e+01 4.000e-01
83  2 CX_PB14__00_BHZ PICKLINES: STAT   DIG  CMP  ? P2_    + 20150325 1004   47.8450 GAU
1.500e-01 0.000e+00 1.016e+01 1.600e+00
84  0 CX_PB14__00_BHE PICKLINES: STAT   DIG  CMP  ? P0_    ? 20150325 1004   47.2450 GAU
5.000e-02 0.000e+00 1.419e+01 5.000e-02
85  1 CX_PB14__00_BHE PICKLINES: STAT   DIG  CMP  ? P1_    - 20150325 1005   10.6950 GAU
3.000e-01 0.000e+00 1.305e+01 3.200e+00
```

```
pix: 16 mintid: 3636353007.17  0 CX_PB01__00_BHE STAT   DIG  CMP  ? P0_    ? 20150325 1003
27.1690 GAU 2.500e-01 0.000e+00 2.182e+01 5.000e-02
pix: 85 maxtid: 3636353110.69  1 CX_PB14__00_BHE STAT   DIG  CMP  ? P1_    - 20150325 1005
10.6950 GAU 3.000e-01 0.000e+00 1.305e+01 3.200e+00
MIN-MAX PICKS:       103.53 seconds. SEKUNDER: 104
PMINTID: 3636353007.17 PMAXTID: 3636353127.17
SEKUNDER: 104
Max picks 86 in window 3636353007.17 - 3636353127.17
w1: 3636353007.17   w2: 3636353127.17
TID: 25/03/15 10:03:36.750 OK
TID: 25/03/15 10:04:02.450 OK
TID: 25/03/15 10:03:42.850 OK
TID: 25/03/15 10:03:33.269 OK
TID: 25/03/15 10:03:54.819 OK
TID: 25/03/15 10:03:27.369 OK
TID: 25/03/15 10:03:43.919 OK
TID: 25/03/15 10:03:29.419 OK
TID: 25/03/15 10:03:47.319 OK
TID: 25/03/15 10:03:48.619 OK
TID: 25/03/15 10:03:34.769 OK
TID:  25/03/15 10:04:06.46 OK
TID:  25/03/15 10:04:02.71 OK
TID: 25/03/15 10:03:42.619 OK
TID:  25/03/15 10:04:20.01 OK
TID:  25/03/15 10:04:15.56 OK
TID: 25/03/15 10:03:41.119 OK
TID: 25/03/15 10:03:45.919 OK
TID:  25/03/15 10:04:20.26 OK
TID: 25/03/15 10:03:49.469 OK
TID:  25/03/15 10:04:38.46 OK
TID:  25/03/15 10:04:37.51 OK
TID: 25/03/15 10:03:49.050 OK
TID: 25/03/15 10:03:50.500 OK
TID: 25/03/15 10:04:22.100 OK
TID: 25/03/15 10:04:04.295 OK
TID: 25/03/15 10:05:10.695 OK
```

Add phases and write new s-file

```
RTPICK: Path+s-filename.................: /home/seismo/snew/REA/TST__/2015/03//25-1002-
59L.S201503
RTPICK: S_REC: fullpath.................: /home/seismo/snew/REA/TST__/2015/03//25-1002-
59L.S201503
RTPICK: S_REC...........................: Write new s-file header to s-file.
RTPICK: S_REC: Create s-file............: /home/seismo/snew/REA/TST__/2015/03//25-1002-
59L.S201503
S_REC: Write new phases to s-file.
 MNMCXBZ IP    A  10 3 36.75  423
 PB08 BZ IP    A  10 3 33.26    0
 PB01 BZ IP    A  10 3 27.36    0
 PB07 BZ IP    A  10 3 29.41    0
 PB04 BZ IP    A  10 3 34.76    0
 PB06 BZ IP    A  10 3 42.61    0
 PB05 BZ IP    A  10 3 41.11    0
 PB15 BZ IP    A  10 3 49.46  413
 PB10 BZ IP    A  10 3 49. 5    0
 PB14 BZ IP    A  10 4  4.29  384
SFIX: 31
 2015  325 10 2 59.3 LM                      TST                              1
 2015-03-25-1001-59.TST___054_00_01                                           6
 ACTION:NEW 15-03-25 10:02 OP:SEIS STATUS:               ID:20150325100259     I
 STAT SP IPHASW D HRMM SECON CODA AMPLIT PERI AZIMU VELO AIN AR TRES W  DIS CAZ7
 MNMCXBZ IP    A  10 3 36.75  423
 PB08 BZ IP    A  10 3 33.26    0
 PB01 BZ IP    A  10 3 27.36    0
 PB07 BZ IP    A  10 3 29.41    0
 PB04 BZ IP    A  10 3 34.76    0
 PB06 BZ IP    A  10 3 42.61    0
 PB05 BZ IP    A  10 3 41.11    0
 PB15 BZ IP    A  10 3 49.46  413
 PB10 BZ IP    A  10 3 49. 5    0
 PB14 BZ IP    A  10 4  4.29  384
 MNMCXBN IS   3A  10 4  2.45
 MNMCXBE IS   3A  10 3 42.85
 PB08 BE IS   3A  10 3 54.81
```

```
 PB01 BN IS   3A  10 3 43.91
 PB07 BN IS   3A  10 3 47.31
 PB07 BE IS   3A  10 3 48.61
 PB04 BN IS   3A  10 0  0. 0
 PB04 BE IS   3A  10 0  0. 0
 PB06 BN IS   3A  10 0  0. 0
 PB06 BE IS   3A  10 0  0. 0
 PB05 BN IS   3A  10 3 45.91
 PB05 BE IS   3A  10 0  0. 0
 PB15 BN IS   3A  10 0  0. 0
 PB15 BE IS   3A  10 0  0. 0
 PB10 BN IS   3A  10 3 50.50
 PB10 BE IS   3A  10 4 22.10
 PB14 BE IS   3A  10 5 10.69
```

Run iteration process as explained in chapter 10

```
RTPICK: Found..........................: hyp.out
RTPICK: readings left...................: 27 Avg.res:    58.12  phases left: 26 Avg.residual
in HYP_NEW:  49.16
RTPICK: readings left...................: 26 Avg.res:    44.13  phases left: 25 Avg.residual
in HYP_NEW:  38.01
RTPICK: readings left...................: 25 Avg.res:    38.01  phases left: 24 Avg.residual
in HYP_NEW:  33.68
RTPICK: readings left...................: 24 Avg.res:    33.68  phases left: 23 Avg.residual
in HYP_NEW:  30.80
RTPICK: readings left...................: 23 Avg.res:    32.25  phases left: 22 Avg.residual
in HYP_NEW:  29.17
RTPICK: readings left...................: 22 Avg.res:    30.04  phases left: 21 Avg.residual
in HYP_NEW:  26.42
RTPICK: readings left...................: 21 Avg.res:    26.42  phases left: 20 Avg.residual
in HYP_NEW:  22.75
RTPICK: readings left...................: 20 Avg.res:    20.00  phases left: 19 Avg.residual
in HYP_NEW:  15.80
RTPICK: readings left...................: 19 Avg.res:    18.95  phases left: 18 Avg.residual
in HYP_NEW:  13.72
RTPICK: readings left...................: 18 Avg.res:    13.72  phases left: 17 Avg.residual
in HYP_NEW:   8.65
RTPICK: readings left...................: 17 Avg.res:     5.13  phases left: 16 Avg.residual
in HYP_NEW:   3.63
RTPICK: readings left...................: 16 Avg.res:     3.11  phases left: 15 Avg.residual
in HYP_NEW:   1.83
RTPICK: STOP iterations. Residual below..: 2.00
RTPICK: Average residual................: 3.113750
RTPICK: No more iterations..............: Number of stations: 16 Avg: res.:    3.114
RTPICK: RSS.............................: 3113
READ_PACKETS...:Trigger CH:  2-> 2 ant:  442 MxAmp:    128.6 nlev:     83.7 sta:  16.3 lta:
3.6 rat:   4.6 3636353503.0 MNMCX  BHZ
  End of s-file
```

Run automag

```
RTPICK: AM:com15........................: cp automag.out
/home/seismo/snew/REA/TST__/2015/03//25-1002-59L.S201503
RTPICK: AM:com14........................: hyp automag.out >> hyptemp.txt
SFILEPATH: /home/seismo/snew/REA/TST__/2015/03//25-1002-59L.S201503
SFILENAME: /home/seismo/snew/REA/TST__/2015/03//25-1002-59L.S201503
```

Update map

```
RTPICK:.................................: Update map
```

New latitude, longitude and magnitudes

```
MAGNITUDES: L C W
LAT: -20.673 LON: -70.816 ML: 4.1 MC: 4.1 MW: 4.1
RTPICK: MAG.............................: 4.1
```

Use latitude, longitude in reverse geocoding to find geographical name of location

```
wget -T 3 -O geo2.xml "open.mapquestapi.com/nominatim/v1/reverse.php?format=xml&lat=-
20.673000&lon=-70.816002&zoom=7" 2>xml2.log
RTPICK: UTC: 25/03/2015 10:02:59.3 | Lat: | -20.67 | Lon: | -70.82 | Provincia de Iquique, I
Region de Tarapaca, Chile | MW: 4.1 | ML: 4.1
```

```
RTPICK: for mail: UTC: 25/03/2015 10:02:59.3 Lat: -20.67 Lon: -70.82 MW: 4.1 ML: 4.1 Provincia
de Iquique, I Region de Tarapaca, Chile
RTPICK: mail1...........................: 0
-20.673 -70.816 4.1
RTPICK: SFCODALOC:       /home/seismo/snew/REA/TST__/2015/03//25-1002-59L.S201503
RTPICK: HTML:  /home/seismo/rtquake/rt/cod/2015-03-25-10:02:59.3.html
RTPICK: SEISAN_TOP......................: /home/seismo/snew
RTPICK: RTQUAKE_TOP.....................: /home/seismo/rtquake
RTPICK: RTQUAKE_TOP.....................: /home/seismo/rtquake
```

Clean up some directories

```
/home/seismo/rtquake/com/purge_dir /home/seismo/rtquake/rt/cod 42
2 file(s) deleted.
/home/seismo/rtquake/com/purge_dir /home/seismo/rtquake/rt/pph 42
10 file(s) deleted.
/home/seismo/rtquake/com/purge_dir /home/seismo/rtquake/loc 40
1 file(s) deleted.
/home/seismo/rtquake/com/purge_dir /home/seismo/rtquake/req 50
1 file(s) deleted.
```

Below the example event is processed by the standard SEISAN eev.
Location and magnitudes can be seen in the line in bold.
Also all the automatic phase picks are shown.

```
rtn>eev 20150325 TST

 2015  3 Reading events from base TST__  469
#  465 25 Mar 2015  8:40 26  LM                     N         TST       ?
#  466 25 Mar 2015 08:47  6  LM-22.351 -68.370 14.3  N 0.9 2.0LBER    5  ?
#  467 25 Mar 2015 09:08  1  LM-23.158 -67.856 17.0  N 0.8 1.6LBER    4  ?
#  468 25 Mar 2015 09:29 53  LM-20.893 -69.919  0.0  N 0.1 3.3CBER    4  ?
#  469 25 Mar 2015 10:03  4  LM-20.673 -70.816  0.0  N 0.5 4.1LBER   10  ?

#    1  1 Mar 2015 11:45 44  LM                     N         TST       ? 469
#  469 25 Mar 2015 10:03  4  LM-20.673 -70.816  0.0  N 0.5 4.1LBER   10  ? po
 Read headers from files:
 /home/seismo/snew/WAV/TST__/2015/03/2015-03-25-1001-59.TST___054_00_01
#  469 25 Mar 2015 10:03  4  LM-20.673 -70.816  0.0  N 0.5 4.1LBER   10  ? t

 File name: /home/seismo/snew/REA/TST__/2015/03/25-1002-59L.S201503
2015  325 1003  4.6 LM-20.673 -70.816  0.0  BER 10 0.5 4.1LBER 4.1CBER 4.1WBER1
SPEC AVERAGE  MO 15.2 ST 12.1 OM  4.1 f0 1.24 R1.0884 AL 0.00 WI 20.0 MW  4.1 3
SPEC SD       MO  0.5 ST 11.0 OM  0.5 f00.403 R0.4445 AL      WI      MW  0.3 3
GAP=222        0.84        4.4      8.8 15.9 -0.2405E+02  0.8389E+02 -0.3243E+02E
SPEC PB01BH Z MO 15.5 ST 25.2 OM  4.5 f0 1.41 R0.8397 AL-0.00 WI 20.0 MW  4.3 3
SPEC PB01BH Z T10 342 K 0.020 GD  119 VS 3.20 DE 2.60 Q0400.0 QA 0.70 VS 3.20 3
SPEC PB07BH Z MO 15.3 ST 16.6 OM  4.3 f0 1.42 R0.8338 AL-0.00 WI 20.0 MW  4.2 3
SPEC PB07BH Z T10 345 K 0.020 GD  122 VS 3.20 DE 2.60 Q0400.0 QA 0.70 VS 3.20 3
SPEC PB08BH Z MO 15.8 ST  3.2 OM  4.7 f00.587 R2.0170 AL-0.00 WI 20.0 MW  4.5 3
SPEC PB08BH Z T10 353 K 0.020 GD  135 VS 3.20 DE 2.60 Q0400.0 QA 0.70 VS 3.20 3
SPEC PB04BH Z MO 15.3 ST 30.1 OM  4.2 f0 1.79 R0.6615 AL-0.00 WI 20.0 MW  4.1 3
SPEC PB04BH Z T10 356 K 0.020 GD  140 VS 3.20 DE 2.60 Q0400.0 QA 0.70 VS 3.20 3
SPEC PB05BH Z MO 14.3 ST  2.6 OM  3.2 f0 1.63 R0.7264 AL-0.00 WI 20.0 MW  3.5 3
SPEC PB05BH Z T10 344 K 0.020 GD  158 VS 3.20 DE 2.60 Q0400.0 QA 0.70 VS 3.20 3
SPEC PB06BH Z MO 15.4 ST  6.0 OM  4.2 f0 1.00 R1.1840 AL-0.00 WI 20.0 MW  4.2 3
SPEC PB06BH Z T10 410 K 0.020 GD  160 VS 3.20 DE 2.60 Q0400.0 QA 0.70 VS 3.20 3
SPEC PB10BH Z MO 14.7 ST0.885 OM  3.5 f00.873 R1.3562 AL-0.00 WI 20.0 MW  3.7 3
SPEC PB10BH Z T10 423 K 0.020 GD  177 VS 3.20 DE 2.60 Q0400.0 QA 0.70 VS 3.20 3
2015-03-25-1001-59.TST___054_00_01                                            6
ACTION:NEW 15-03-25 10:02 OP:SEIS STATUS:           ID:20150325100259     I
  Return to continue, q to return to EEV

STAT SP IPHASW D HRMM SECON CODA AMPLIT PERI AZIMU VELO AIN AR TRES W  DIS CAZ7
PB01 BZ IP    A  10 3 27.36                          70   -0.5110  144 107
PB01 BN IS   3A  10 3 43.91                          70   -1.15 2  144 107
PB01 BZ  IAML    10 3 46.26      7957.3 0.40                       144 107
PB07 BZ IP    A  10 3 29.41                          70    0.4110  151 141
PB07 BN IS   3A  10 3 47.31                          70    0.28 2  151 141
PB07 BZ  IAML    10 3 52.76      5553.2 1.00                       151 141
PB08 BZ IP    A  10 3 33.26                          50    0.1010  183  72
PB08 BE IS   3A  10 3 54.81                          50    0.55 2  183  72
PB08 BZ  IAML    10 4  6.21      3899.1 1.90                       183  72
PB04 BZ IP    A  10 3 34.76                          50    0.1210  196 160
PB04 BZ  IAML    10 4  8.48      4591.7 0.50                       196 160
```

```
MNMCXBZ IP    A  10 3 36.75  423                           50   -0.0510  213  37
MNMCXBN IS   3A  10 4  2.45                                50    1.85 2  213  37
PB05 BZ IP    A  10 3 41.11                                50   -0.0910  250 165
PB05 BN IS   3A  10 3 45.91                                50   -22.3 0  250 165
PB05 BZ  IAML    10 4 31.76      1509.9 1.20                             250 165
PB06 BZ IP    A  10 3 42.61                                50    0.1710  259 150
PB06 BZ  IAML    10 4 23.46      2731.1 1.00                             259 150
PB15 BZ IP    A  10 3 49.46  413                           50    0.2810  313 154
  Return to continue, q to return to EEV

PB10 BZ IP    A  10 3 49.50                                50    0.1710  316 175
PB10 BZ  IAML    10 4 51.02       628.3 2.40                             316 175
PB14 BZ IP    A  10 4  4.29  384                           49   -0.6810  440 175
PB14 BE IS   3A  10 5 10.69                                49   21.08 0  440 175


#  469 25 Mar 2015 10:03  4  LM-20.673 -70.816  0.0  N 0.5 4.1LBER   10  ?
```

As we can see from the graphics and the s-files, RTQUAKE computed the following results:

Automatic real-time: location: -20.66,-70.81 MW: 3.9

Automatic recorded event: location: -20.67,-70.82 MW: 4.1 ML: 4.1

Manually processed by other institutes:

EMSC (Potsdam): location: -20.68,-70.74 MW: 4.6

CSN,Chile: location: -20.64,-70.72 ML: 4.2

COMMENTS: !!!!! BE AWARE THAT THIS IS A GOOD EXAMPLE !!!!!

22 DIRECTORY OVERVIEW AFTER INSTALLATION

mydir
- Makefile

mydir/com
- rtquake.par
- rtquake_start
- rtquake_stop
- rtloc.py
- purge_dir
- setup_rt.bash
- setup_rt.csh
- rtquake_heli_tst1
- rtquake_heli_tst2
- STATION0.HYP

mydir/doc

mydir/inc
- libslink.h
- sh_mem_rt.h
- slplatform.p

mydir/libslink
- the SeedLink client library, Chad Trabant

mydir/loc
- empty

mydir/map
- ALL_EPI0.txt
- emns_epi.kml
- emns_refresh.kml
- glasses.wav
- icon49.png
- icon56.png
- LAST_LOC.txt
- LAST_TRIG.html
- rtge_refresh.kml
- STATIONS
- triangle.png
- tu1_refresh.kml
- yellow-dot.png

mydir/par
- brygge2.jpg
- brygge2.jpg.ok
- brygge2.white.jpg
- detect.TST
- IPOC.TST
- Logo70X70.gif
- record.TST
- stations.conf
- stations_heli.TST
- stations_plot.TST
- streams.conf

streams_heli.TST
streams_plot.TST
streams.TST

mydir/picker
- miniseed library, Chad Trabant
- modified FilterPicker, A.Lomax

mydir/req
- empty

mydir/rt
- empty catalog structure for helicorder plots

mydir/rtdet
- getwindow
- Makefile
- msi
- rtdet.c
- slinktool

mydir/seedlink
- seedlink-2.5 distro

mydir/tmp
- empty

mydir/utils1
- Makefile
- rtdly.c
- rtmon.c
- rtnet.c
- rtsnr.c

mydir/utils2
- Makefile
- rt24.c
- rtdr24.c
- rthplt.c
- rttime.c

mydir/wrk
- rt_IPCH
- rtquake_heli
- rtquake_start
- rtquake_stop
- rt_STOP
- STATION0.HYP

23 REFERENCES

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