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scisola

automatic moment tensor solution for SeisComP3

Nikolaos Triantafyllis [1], Efthimios Sokos [2], Aristidis Ilias [1] & Jiří Zahradník [3]

[1] University of Patras, Department of Computer Engineering and Informatics, Patras, Greece
[2] University of Patras, Department of Geology, Seismological Laboratory, Patras, Greece
[3] Charles University in Prague, Faculty of Mathematics and Physics, Prague, Czech Republic

overview

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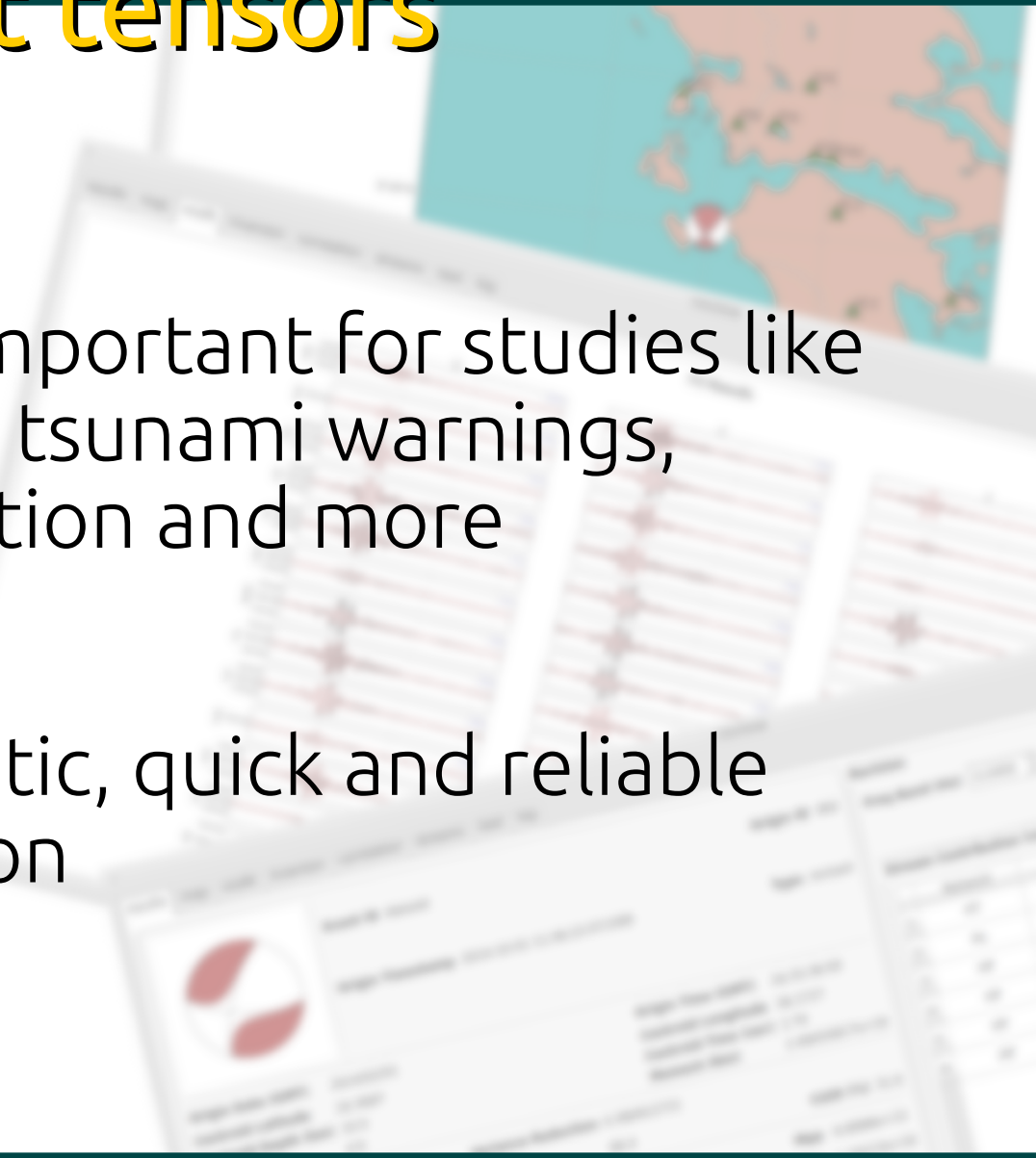
(2) software tools used
(3) architecture
(4) flowchart
(5) case study
(6) screenshots
(7) manual example
(8) future improvements
(9) installation
(10) links & more

moment tensors



- moment tensors are important for studies like shakemap generation, tsunami warnings, ground motion evaluation and more

- importance of automatic, quick and reliable moment tensor solution

scisola

- open-source python based software
- user friendly GUI

supports:

- ✔ automatic Moment Tensor calculation of events provided by SeisComP3 in real-time
- ✔ easy solution overview
- ✔ quick solution revision
- ✔ extensive configuration

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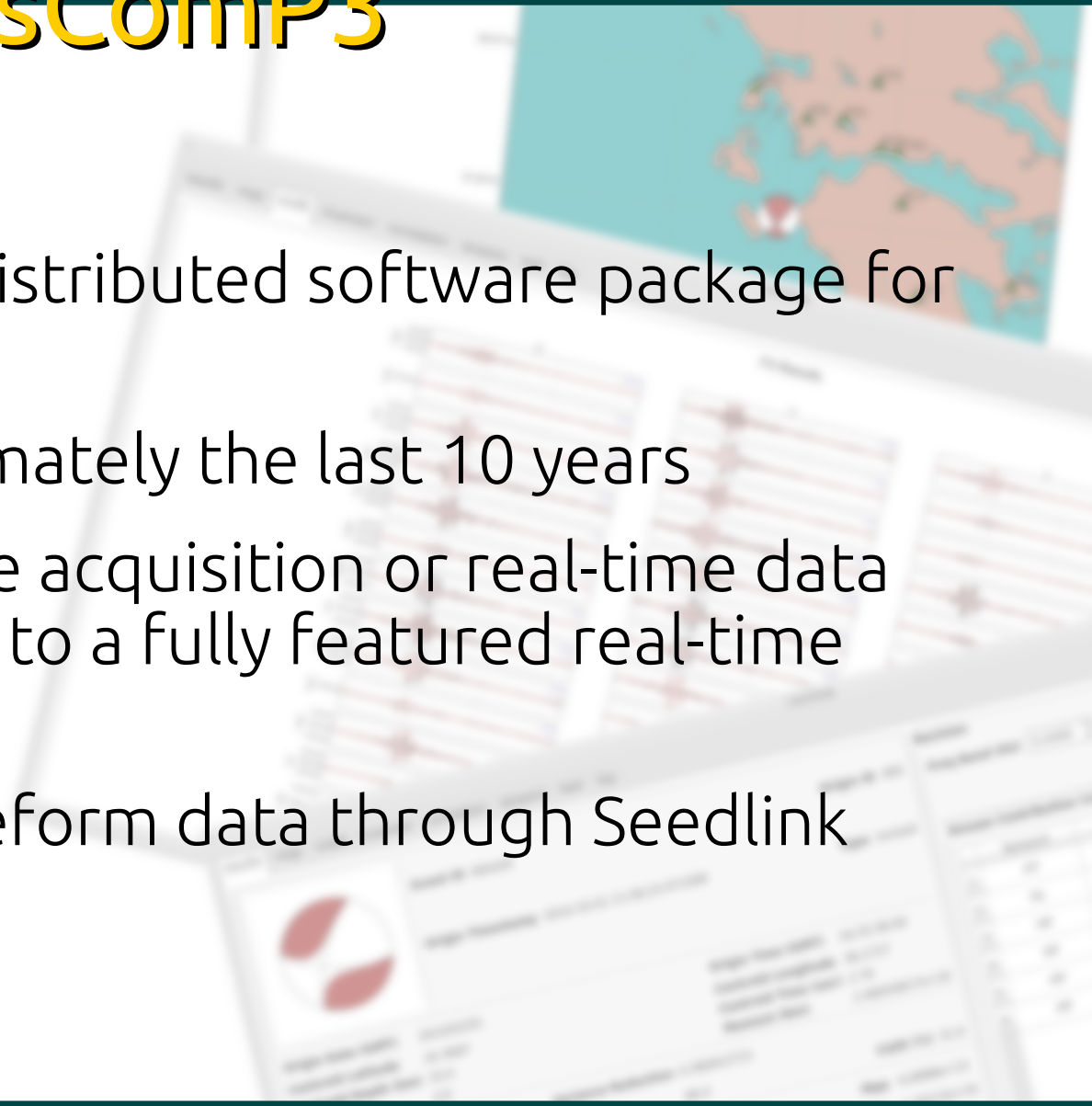
SeisComP3



- likely the most widely distributed software package for seismological purposes
- evolved within approximately the last 10 years
- its use ranges from pure acquisition or real-time data exchange over Internet to a fully featured real-time earthquake monitoring
- provides real-time waveform data through Seedlink protocol

ISOLA

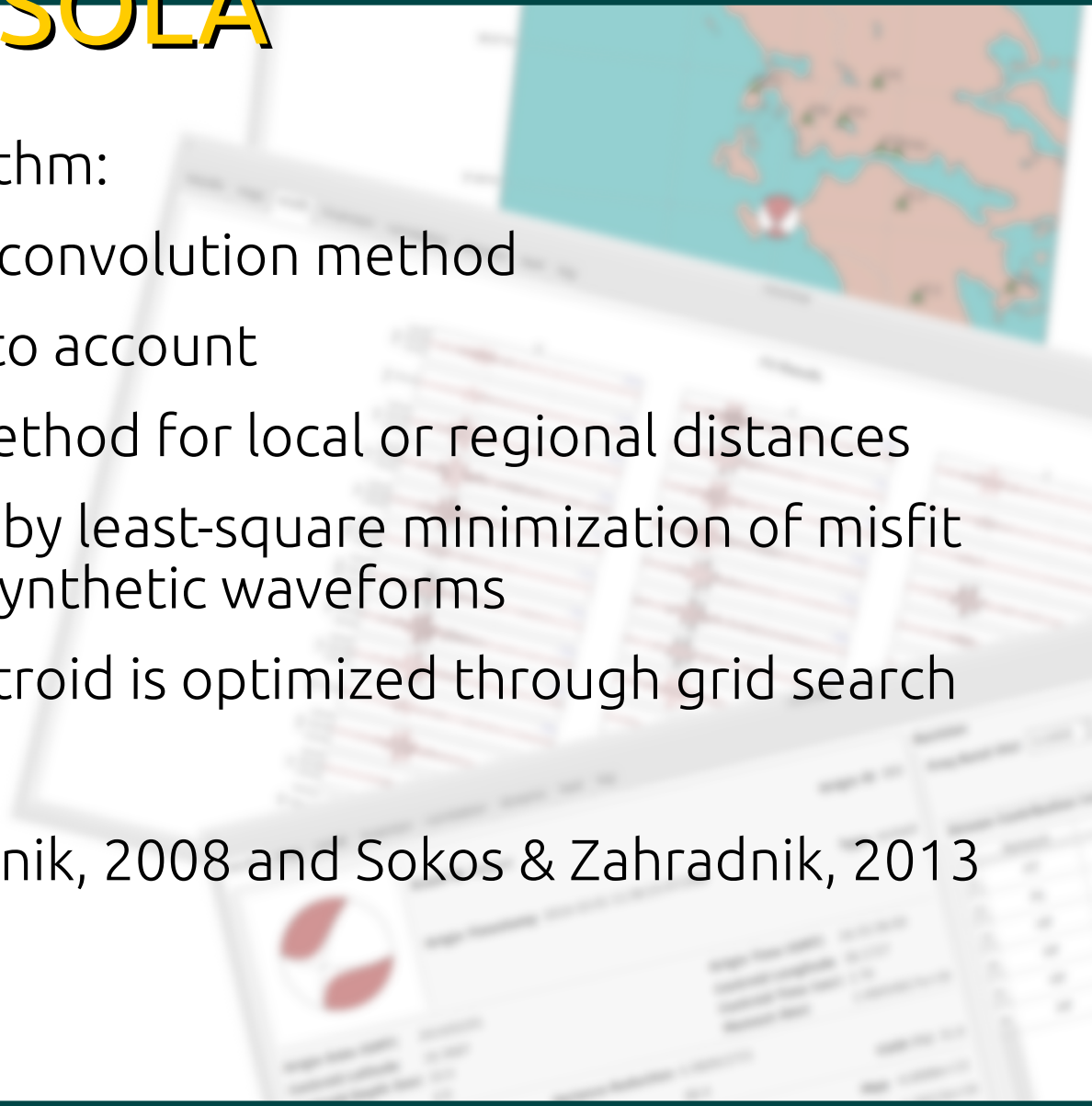
- ISOLA is a package of Fortran and Matlab code (by J. Zahradnik and E. Sokos)
- Matlab code is used for preparing input data and plotting results while FORTRAN for basic calculations. GMT is also used for preparing plots and displaying the results
- first version was released in 2004
- has been used as a routine MT analysis software in various labs, e.g. Univ. Patras, NOA –GI, Greece (reporting to EMSC)
- currently ~ 150 registered users
- seminars on ISOLA use: Costa Rica 2012, Colombia 2014, Brazilia 2014

ISOLA

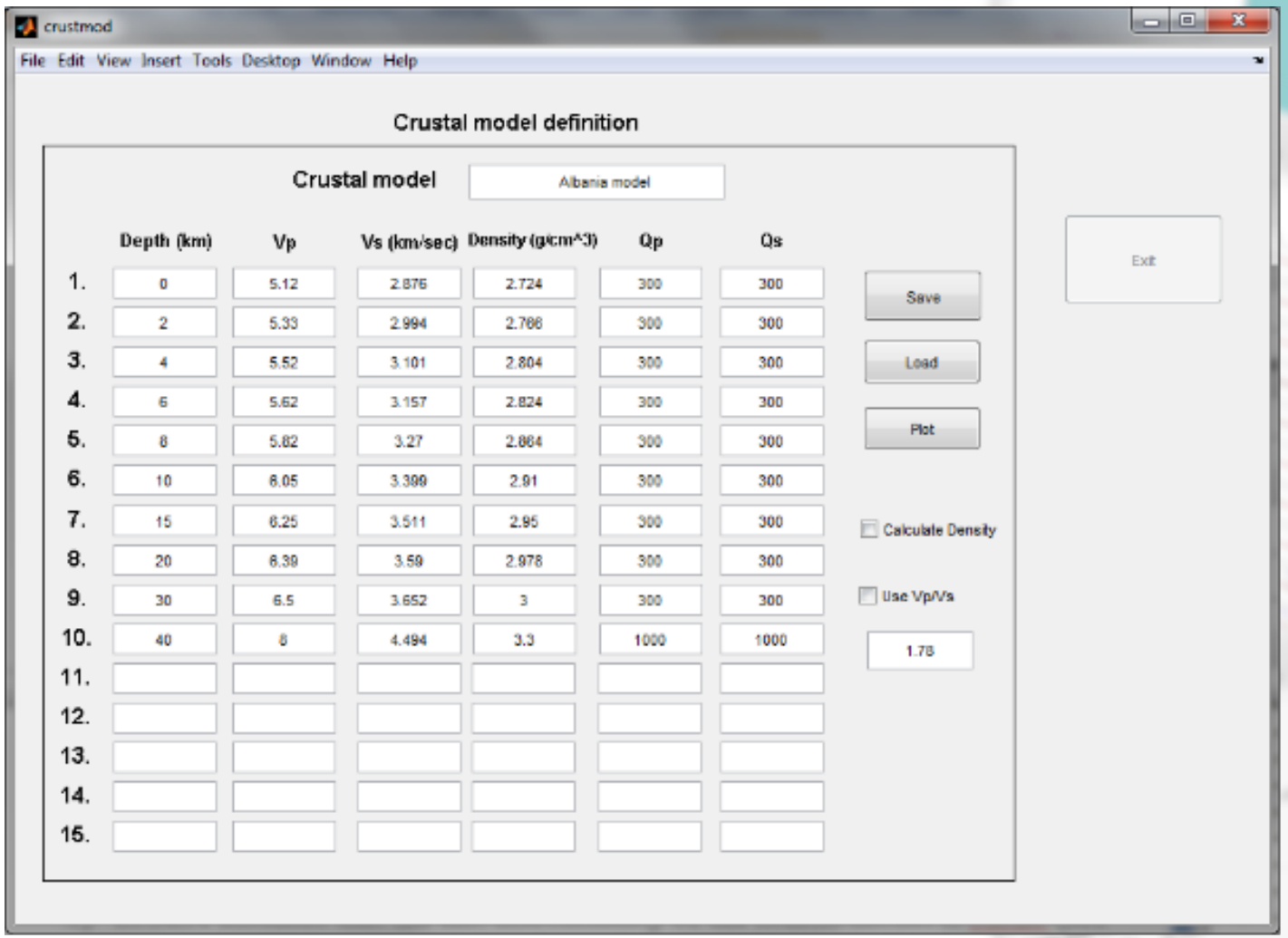
ISOLA moment tensor algorithm:

- point source iterative deconvolution method
- full wavefield is taken into account
- discrete wavenumber method for local or regional distances
- moment tensor is found by least-square minimization of misfit between observed and synthetic waveforms
- position and time of centroid is optimized through grid search

more info in Sokos & Zahradnik, 2008 and Sokos & Zahradnik, 2013



ISOLA



GUI example:
ISOLA tool
for creating
crustal model

ObsPy

- ObsPy is an open-source Python framework for processing seismological data
- provides parsers for common file formats, clients to access data centers and seismological signal processing routines which allow the manipulation of seismological time series
- provides reading and writing data SEED/MiniSEED and Dataless SEED, XML-SEED, GSE2 and SAC, filtering, instrument simulation, triggering, and plotting
- supports retrieving data from ArcLink or a SeisHub database
- can access to the actual time series directly, allowing the use of powerful numerical array-programming modules like NumPy or SciPy
- results can be visualized using modules such as matplotlib or MayaVi (3D)

matplotlib

- matplotlib is a python 2D plotting library
- produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms
- can be used in python scripts, the python and ipython shell (like MATLAB or Mathematica), web application servers and six graphical user interface toolkits
- generates plots, histograms, power spectra, bar charts, errorcharts, scatterplots, etc, with just a few lines of code

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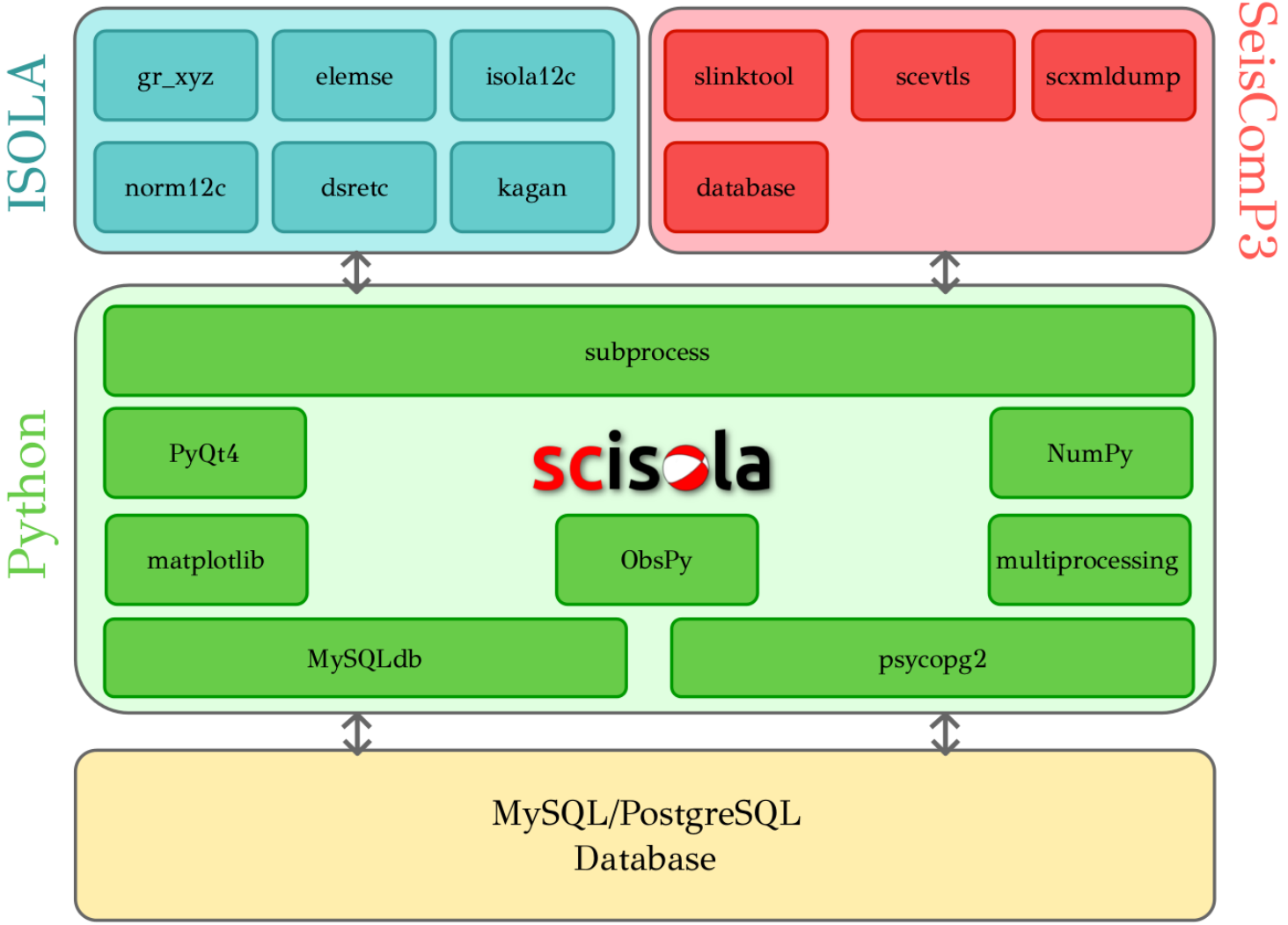
libraries

ObsPy	used for seismological calculations e.g. signal filtering
matplotib	used mostly for plots
Numpy	used for math calculations
PyQt4	used for GUI
subprocess	used for wrapping SeisComP3 and ISOLA
multiprocessing	used for parallelizing calculations
MySQLdb/psycopg2	used for MySQL/PostgreSQL database manipulation

schema


ISOLA
gr_xyz
elemse
isola12c
norm12c
dsretc
kagan
SeisComP3
slinktool
scevtls
scxmldump
database
Python
subprocess
PyQt4
scisola
NumPy
matplotlib
ObsPy
multiprocessing
MySQLdb
psycopg2
MySQL/PostgreSQL
Database

structure

scisola consists of three packages in two layers:

- **lib** (2nd layer -blue box-)

includes all necessary files to implement all the needed functions and algorithms, -logic- of scisola

- **gui** (2nd layer -yellow box-)

includes all necessary files of GUI

- **scisola** (1st layer -red box-)

an abstract layer/package that connects the lib and gui packages

SeisComP3 connectivity

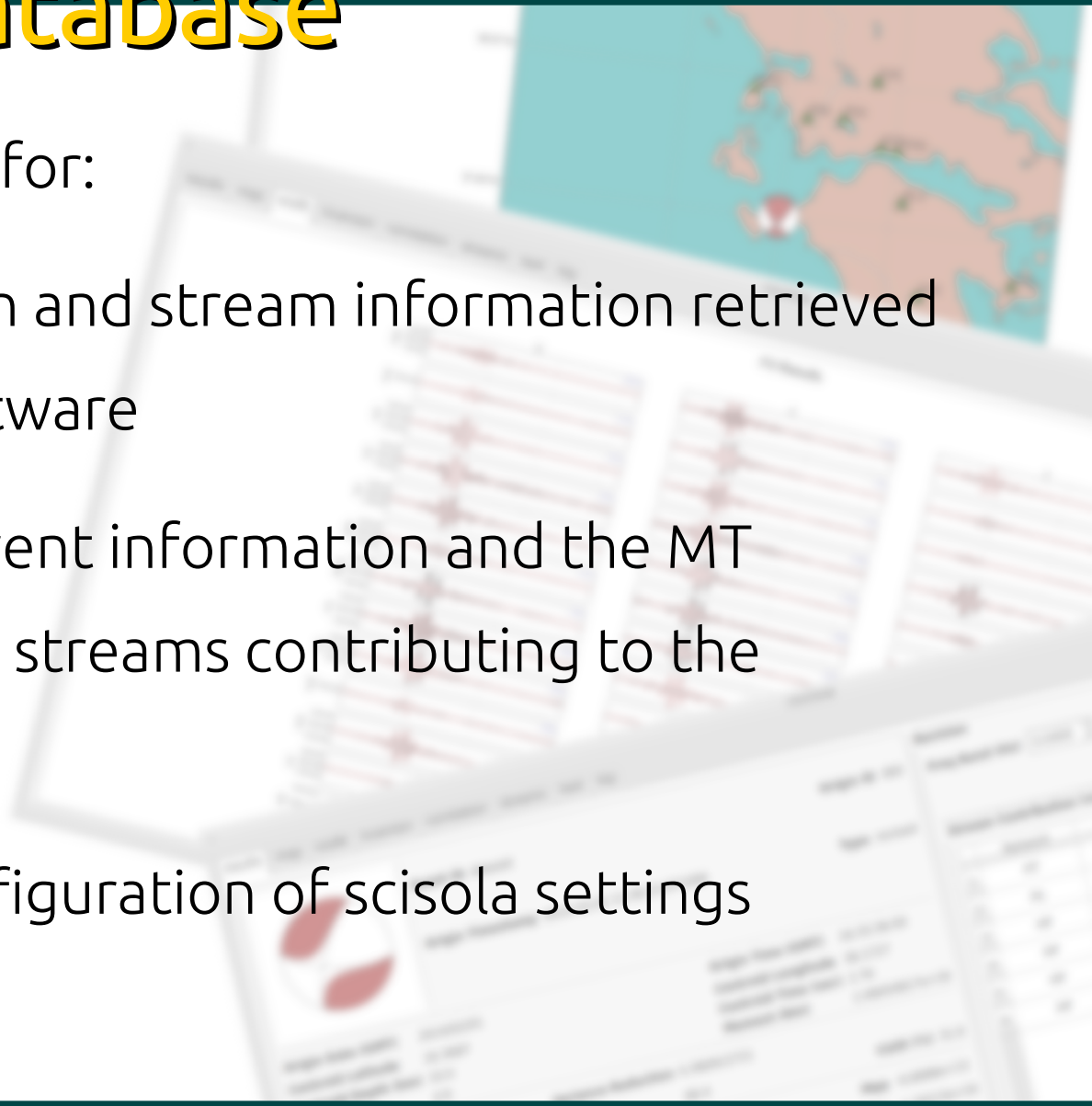
SeisComP3 connectivity

lib/database.py	handles the Stations and Streams information provided by SeisComP3
lib/seedlink.py	use of slinktool in order to retrieve the corresponding waveforms
lib/watcher.py	use of scevtls and scxmldump in order to watch SeisComP3 for new events in real-time and for retrieving the corresponding event and origin information respectively

database

the scisola database is used for:

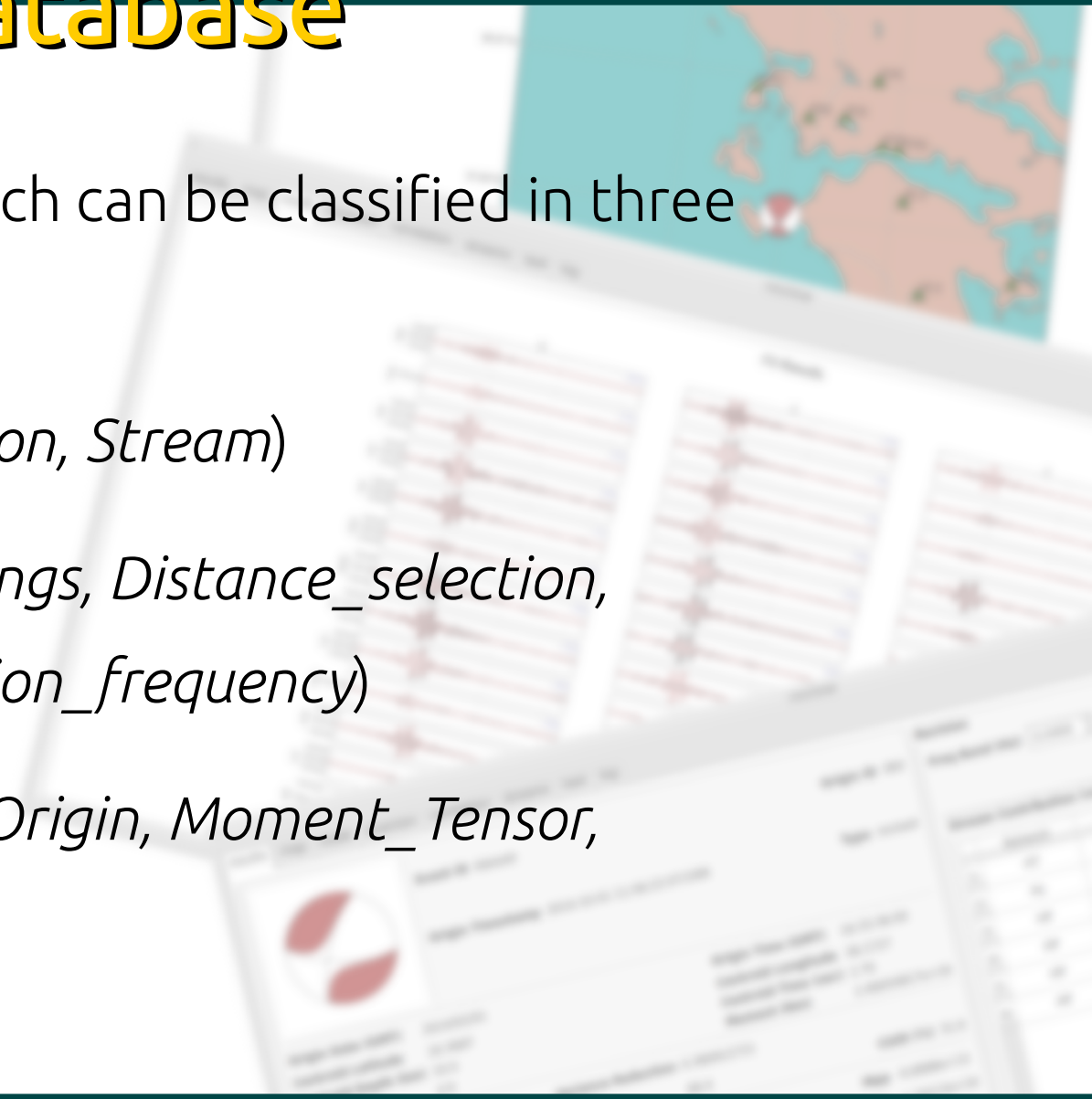
- saving and editing station and stream information retrieved from the SeisComP3 software
- saving the earthquake event information and the MT calculation including the streams contributing to the inversion
- saving the extensive configuration of scisola settings



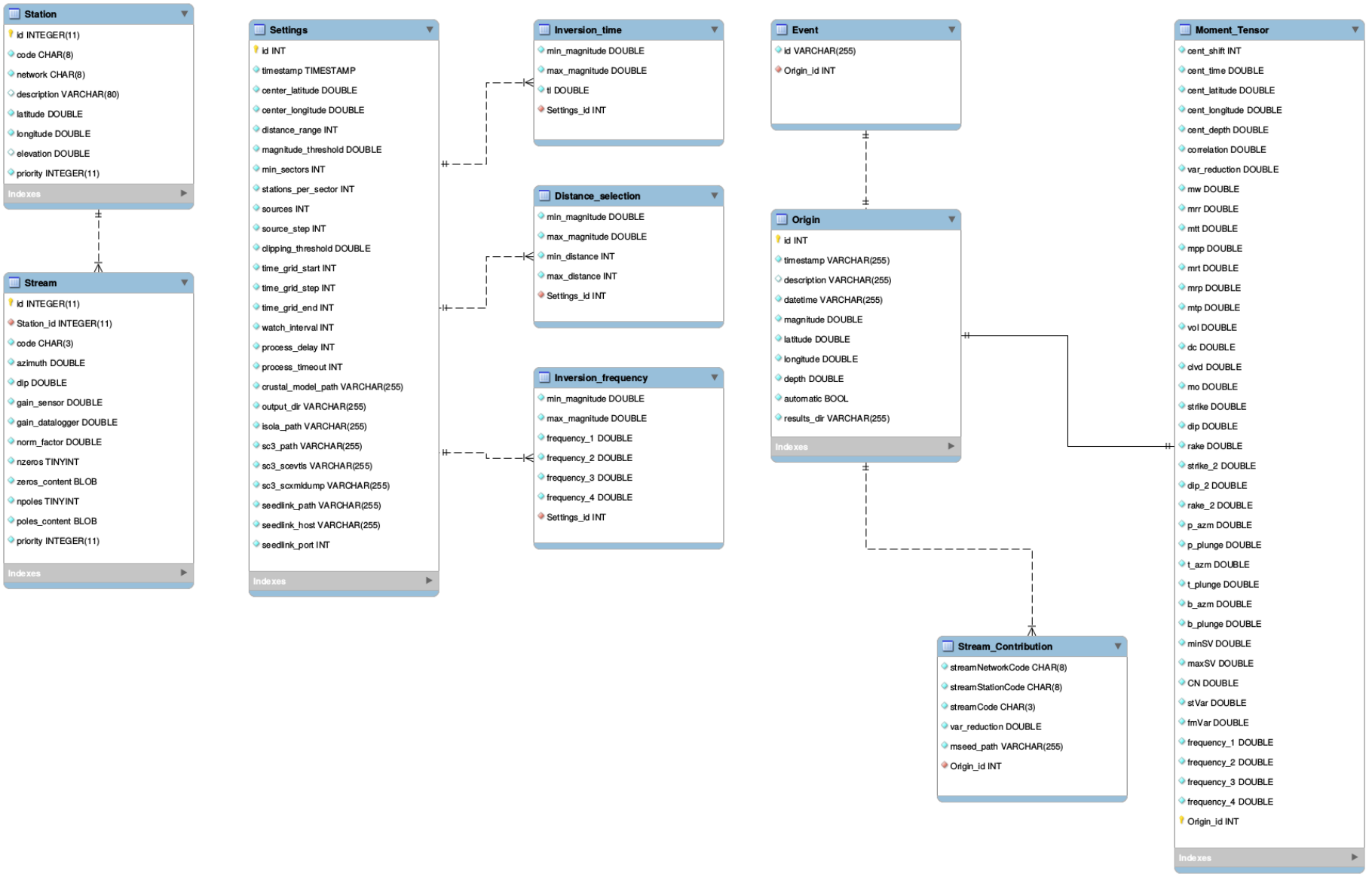
database

it consists of ten tables, which can be classified in three categories:

- Stations (tables: *Station, Stream*)
- Settings (tables: *Settings, Distance_selection, Inversion_time, Inversion_frequency*)
- Event (tables: *Event, Origin, Moment_Tensor, Stream_Contribution*)



database


Station
id INTEGER(11)
code CHAR(8)
network CHAR(8)
description VARCHAR(80)
latitude DOUBLE
longitude DOUBLE
elevation DOUBLE
priority INTEGER(11)
Indexes
Stream
id INTEGER(11)
Station_id INTEGER(11)
code CHAR(3)
azimuth DOUBLE
dip DOUBLE
gain_sensor DOUBLE
gain_datalogger DOUBLE
norm_factor DOUBLE
nzeros TINYINT
zeros_content BLOB
npoles TINYINT
poles_content BLOB
priority INTEGER(11)
Indexes
Settings
id INT
timestamp TIMESTAMP
center_latitude DOUBLE
center_longitude DOUBLE
distance_range INT
magnitude_threshold DOUBLE
min_sectors INT
stations_per_sector INT
sources INT
source_step INT
clipping_threshold DOUBLE
time_grid_start INT
time_grid_step INT
time_grid_end INT
watch_interval INT
process_delay INT
process_timeout INT
crustal_model_path VARCHAR(255)
output_dir VARCHAR(255)
isola_path VARCHAR(255)
sc3_path VARCHAR(255)
sc3_scevtls VARCHAR(255)
sc3_scxmldump VARCHAR(255)
seedlink_path VARCHAR(255)
seedlink_host VARCHAR(255)
seedlink_port INT
Indexes
Inversion_time
min_magnitude DOUBLE
max_magnitude DOUBLE
tl DOUBLE
Settings_id INT
Distance_selection
min_magnitude DOUBLE
max_magnitude DOUBLE
min_distance INT
max_distance INT
Settings_id INT
Inversion_frequency
min_magnitude DOUBLE
max_magnitude DOUBLE
frequency_1 DOUBLE
frequency_2 DOUBLE
frequency_3 DOUBLE
frequency_4 DOUBLE
Settings_id INT
Event
id VARCHAR(255)
Origin_id INT
Origin
id INT
timestamp VARCHAR(255)
description VARCHAR(255)
datetime VARCHAR(255)
magnitude DOUBLE
latitude DOUBLE
longitude DOUBLE
depth DOUBLE
automatic BOOL
results_dir VARCHAR(255)
Indexes
Stream_Contribution
streamNetworkCode CHAR(8)
streamStationCode CHAR(8)
streamCode CHAR(3)
var_reduction DOUBLE
mseed_path VARCHAR(255)
Origin_id INT
Moment_Tensor
cent_shift INT
cent_time DOUBLE
cent_latitude DOUBLE
cent_longitude DOUBLE
cent_depth DOUBLE
correlation DOUBLE
var_reduction DOUBLE
mw DOUBLE
mrr DOUBLE
mtt DOUBLE
mpp DOUBLE
mrt DOUBLE
mrp DOUBLE
mtp DOUBLE
vol DOUBLE
dc DOUBLE
clvd DOUBLE
mo DOUBLE
strike DOUBLE
dip DOUBLE
rake DOUBLE
strike_2 DOUBLE
dip_2 DOUBLE
rake_2 DOUBLE
p_azm DOUBLE
p_plunge DOUBLE
t_azm DOUBLE
t_plunge DOUBLE
b_azm DOUBLE
b_plunge DOUBLE
minSV DOUBLE
maxSV DOUBLE
CN DOUBLE
stVar DOUBLE
fmVar DOUBLE
frequency_1 DOUBLE
frequency_2 DOUBLE
frequency_3 DOUBLE
frequency_4 DOUBLE
Origin_id INT
Indexes

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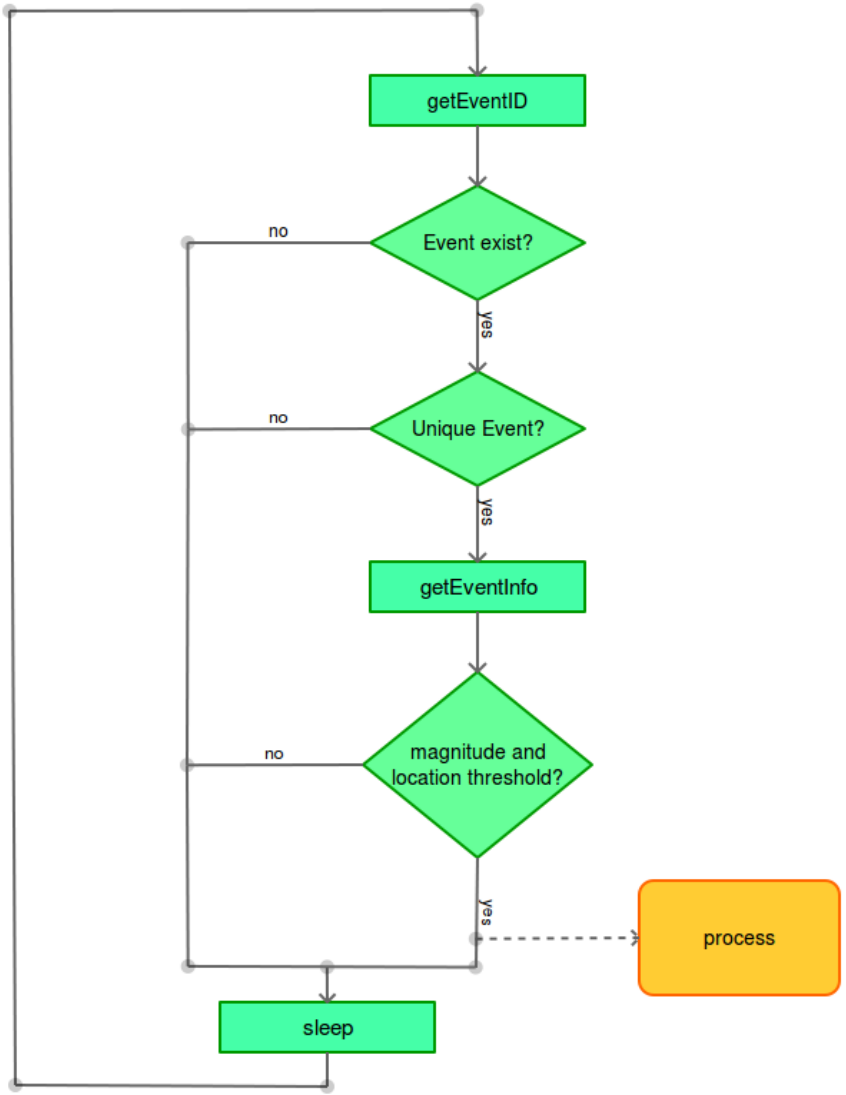
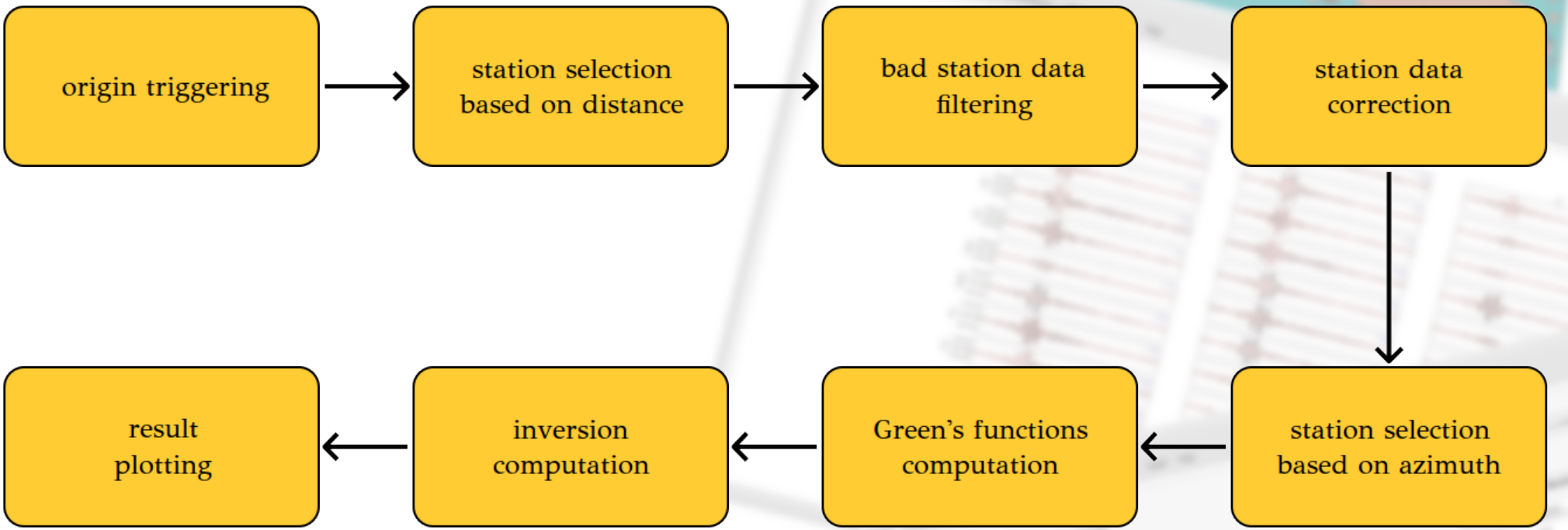
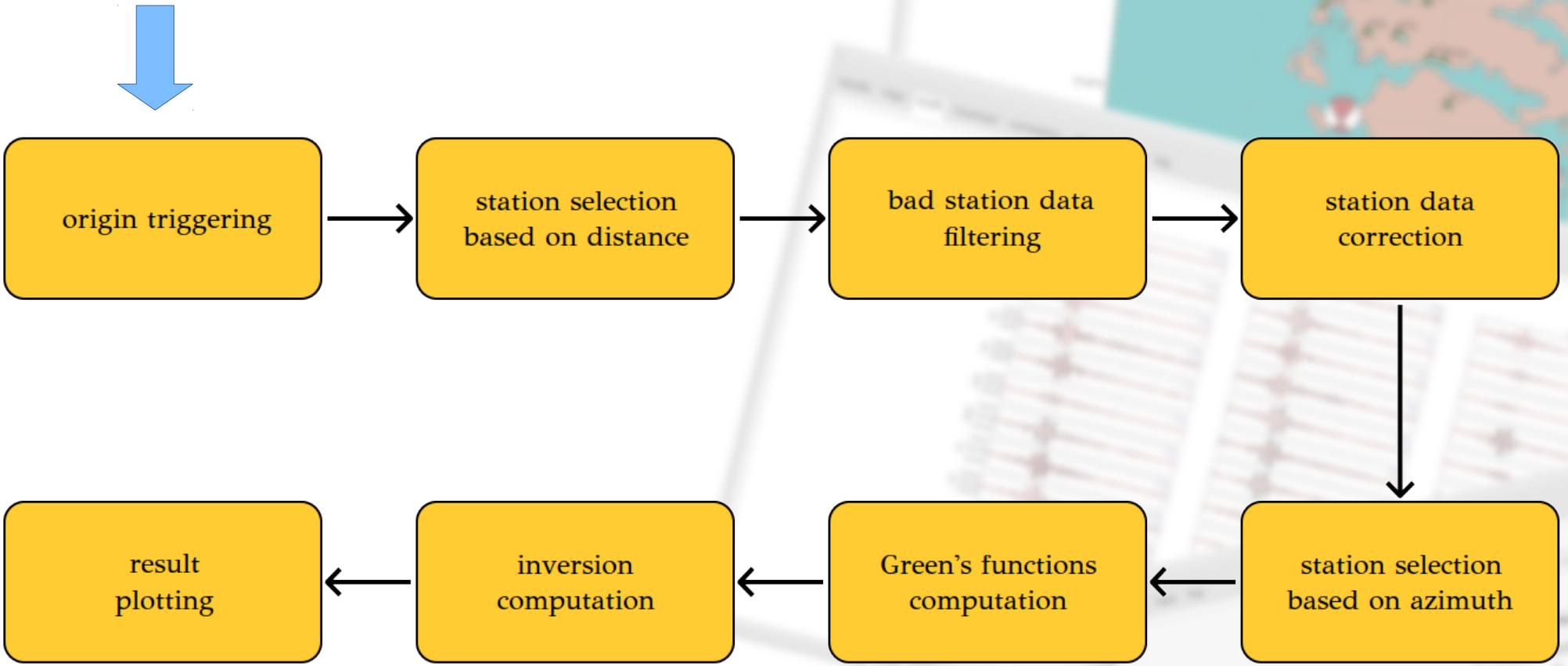
watcher


getEventID
Event exist?
no
yes
Unique Event?
no
yes
getEventInfo
magnitude and location threshold?
no
yes
process
sleep

automatic procedure



automatic procedure



origin triggering

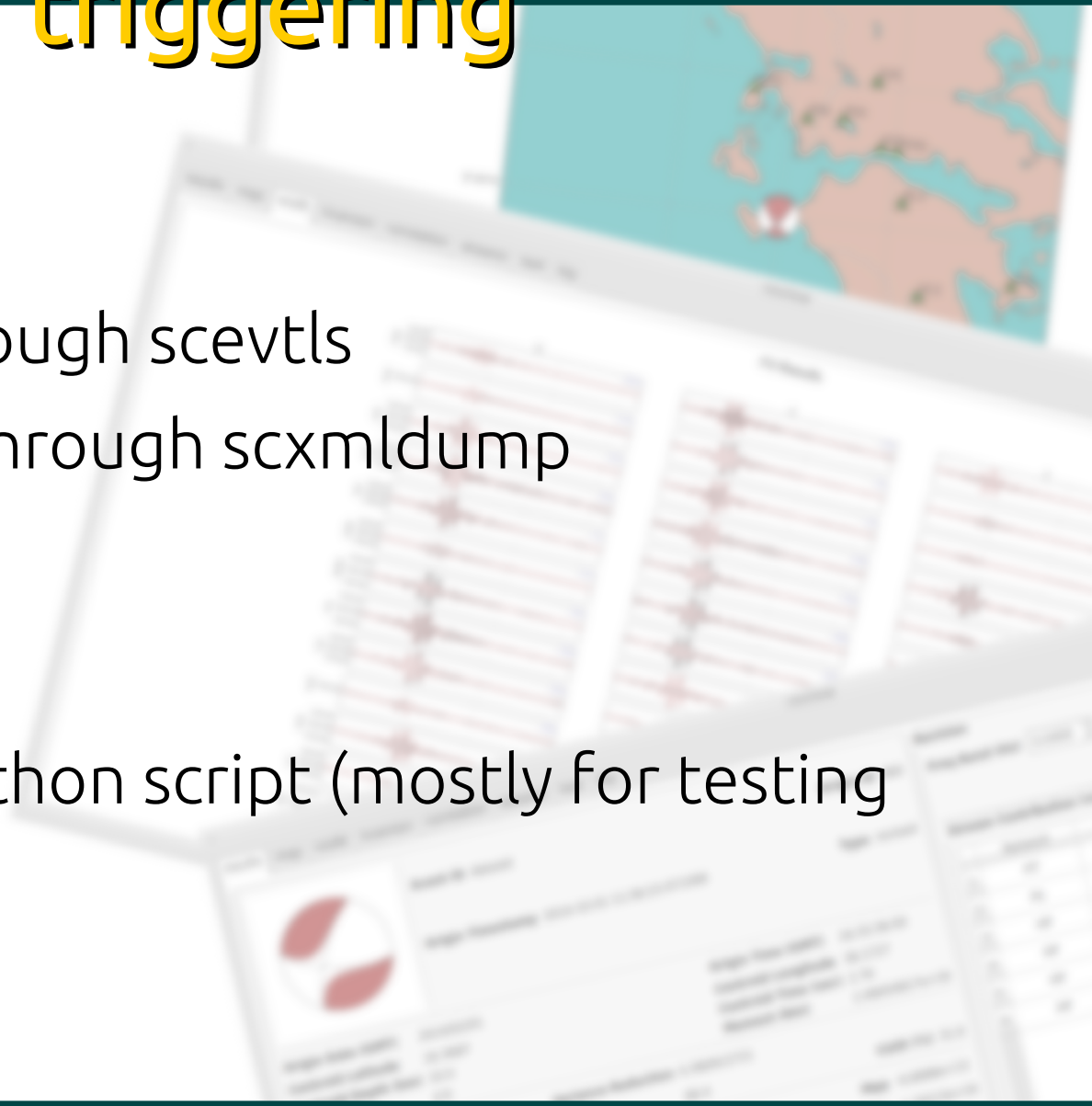
- automatic mode

  watch SeisComP3 through scevtls

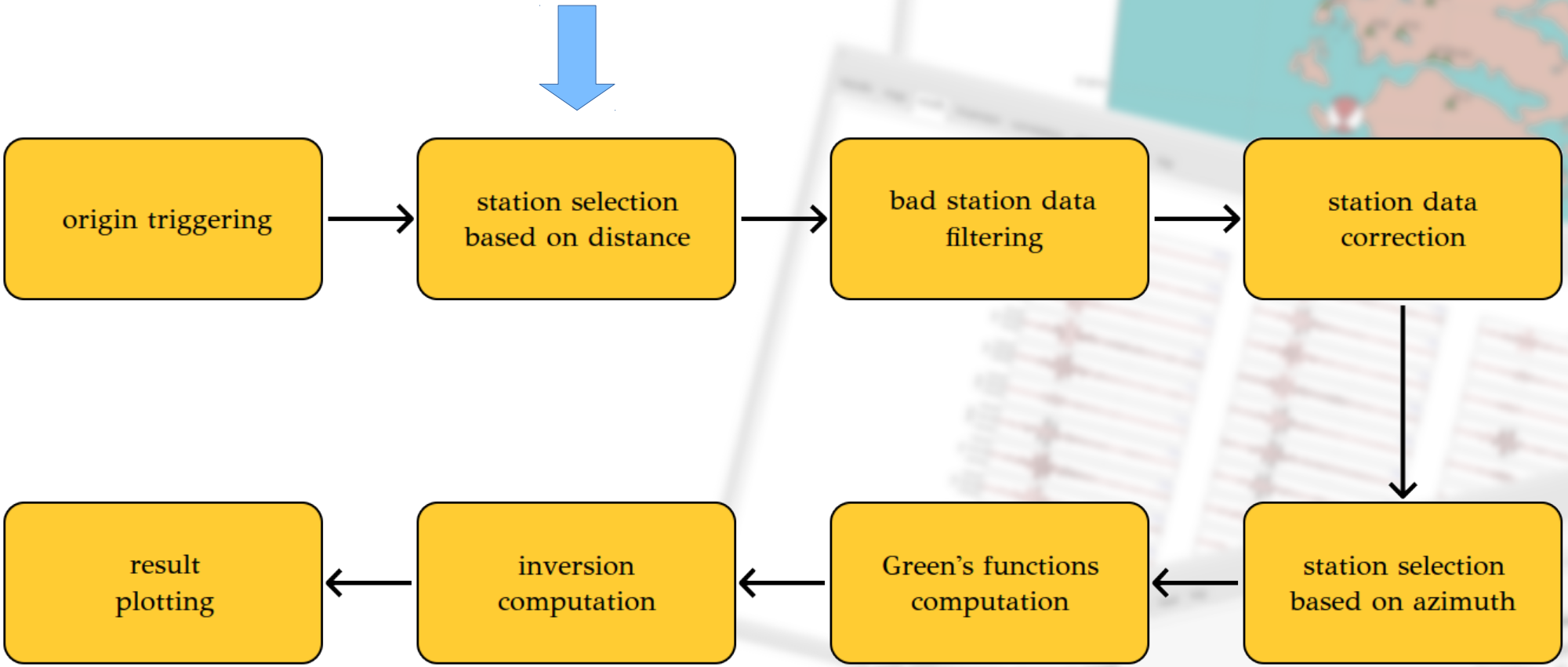
  retrieve origin's info through scxmldump

- manual mode

  execution through python script (mostly for testing purposes)



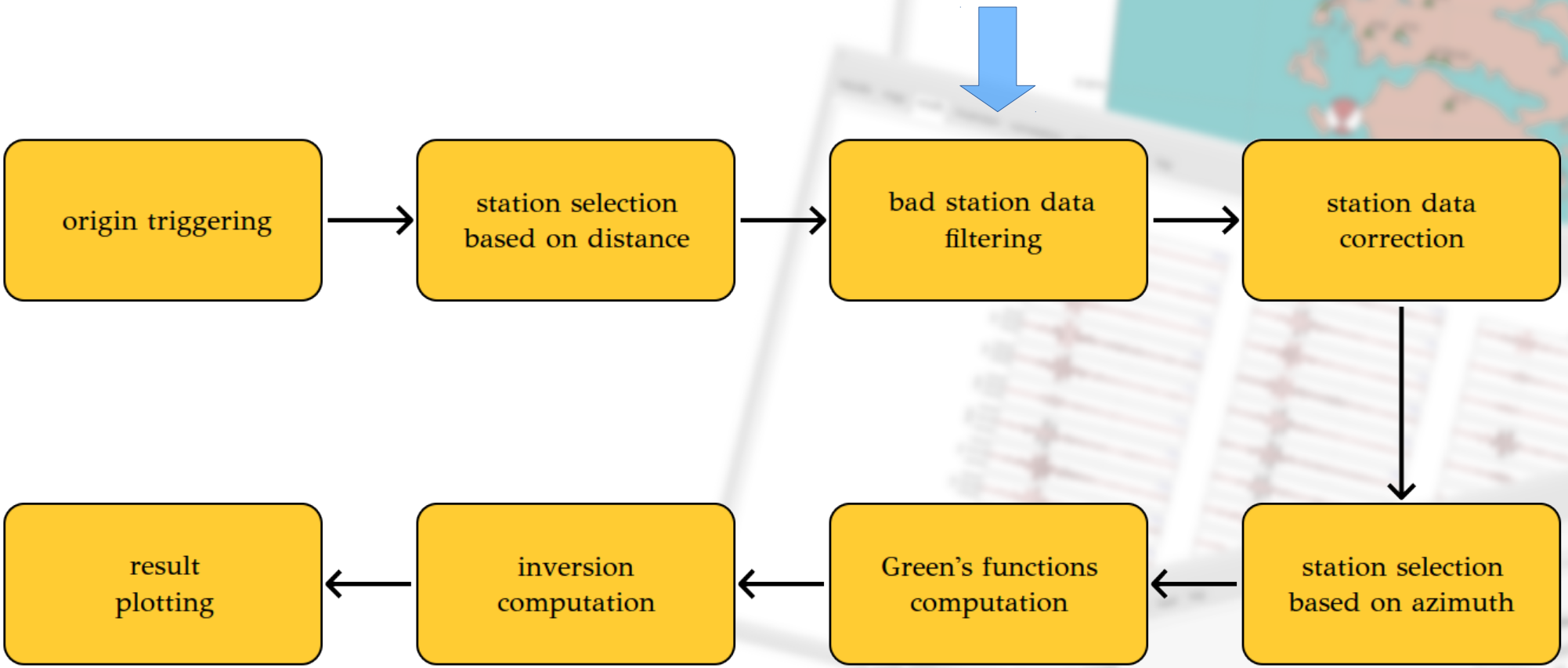
automatic procedure



station selection based on distance

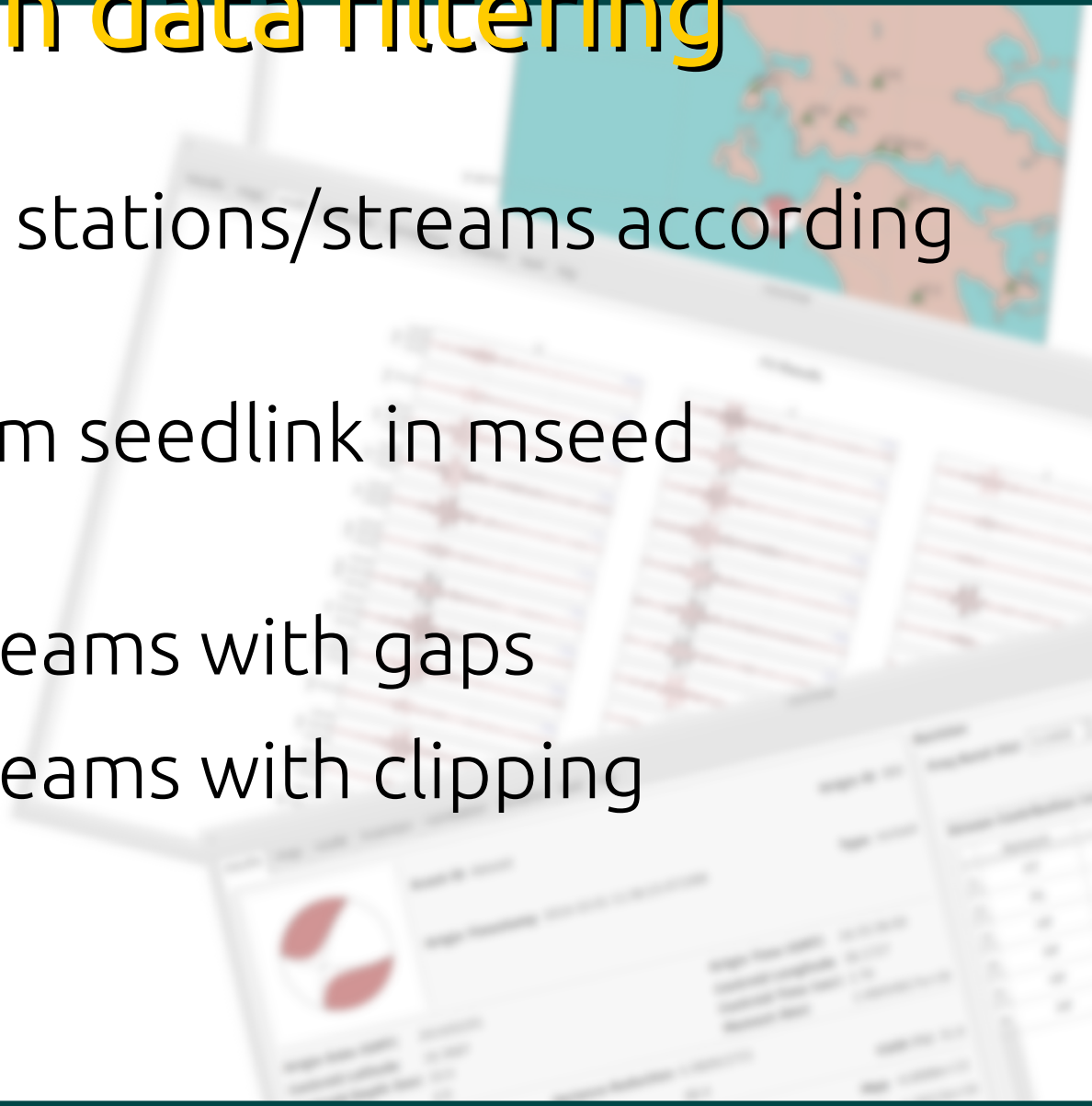
- ✔ retrieves Stations/Streams Info from scisola database
- ✔ filters Stations/Streams by certain type
  (e.g. HHN, HNE)
- ✔ removes Blacklisted Stations/Streams defined by the user
- ✔ calculates distance and azimuth of stations according to epicenter
- ✔ selects Stations/Streams according to “distance rule”, defined by the user
  (e.g. $3.5 \leq mw \leq 4.5 \rightarrow 20 \leq distance \leq 100$ km)

automatic procedure

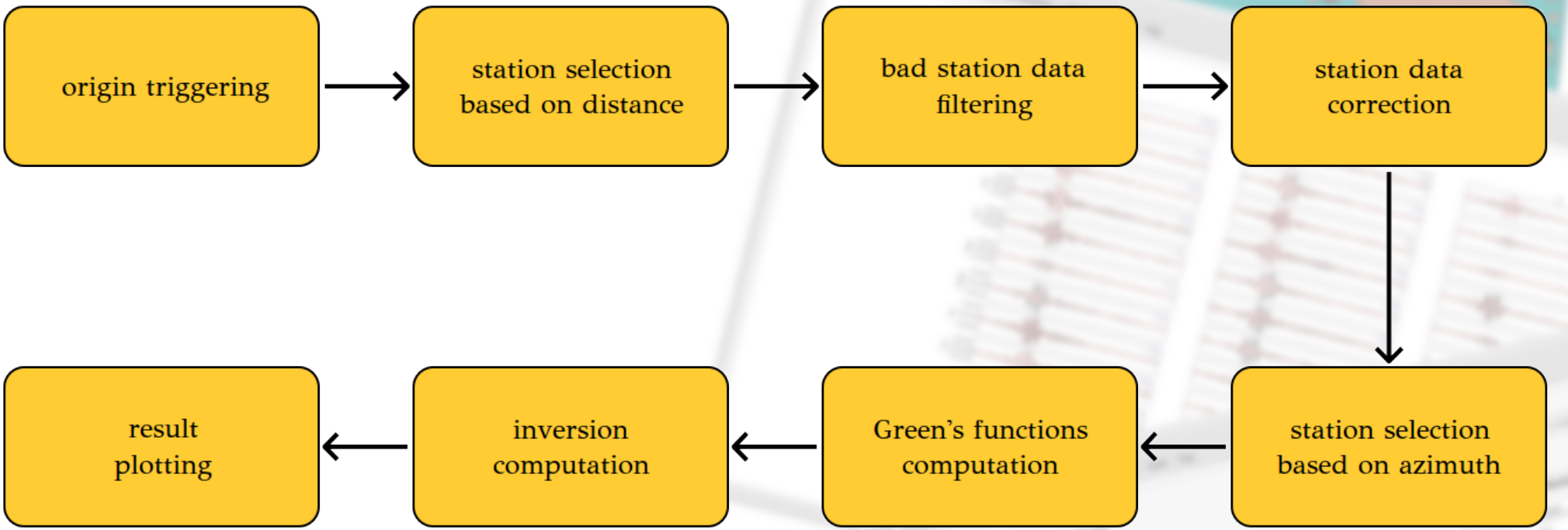


bad station data filtering

- removes unavailable stations/streams according to seedlink
- retrieves records from seedlink in mseed format
- removes stations/streams with gaps
- removes stations/streams with clipping

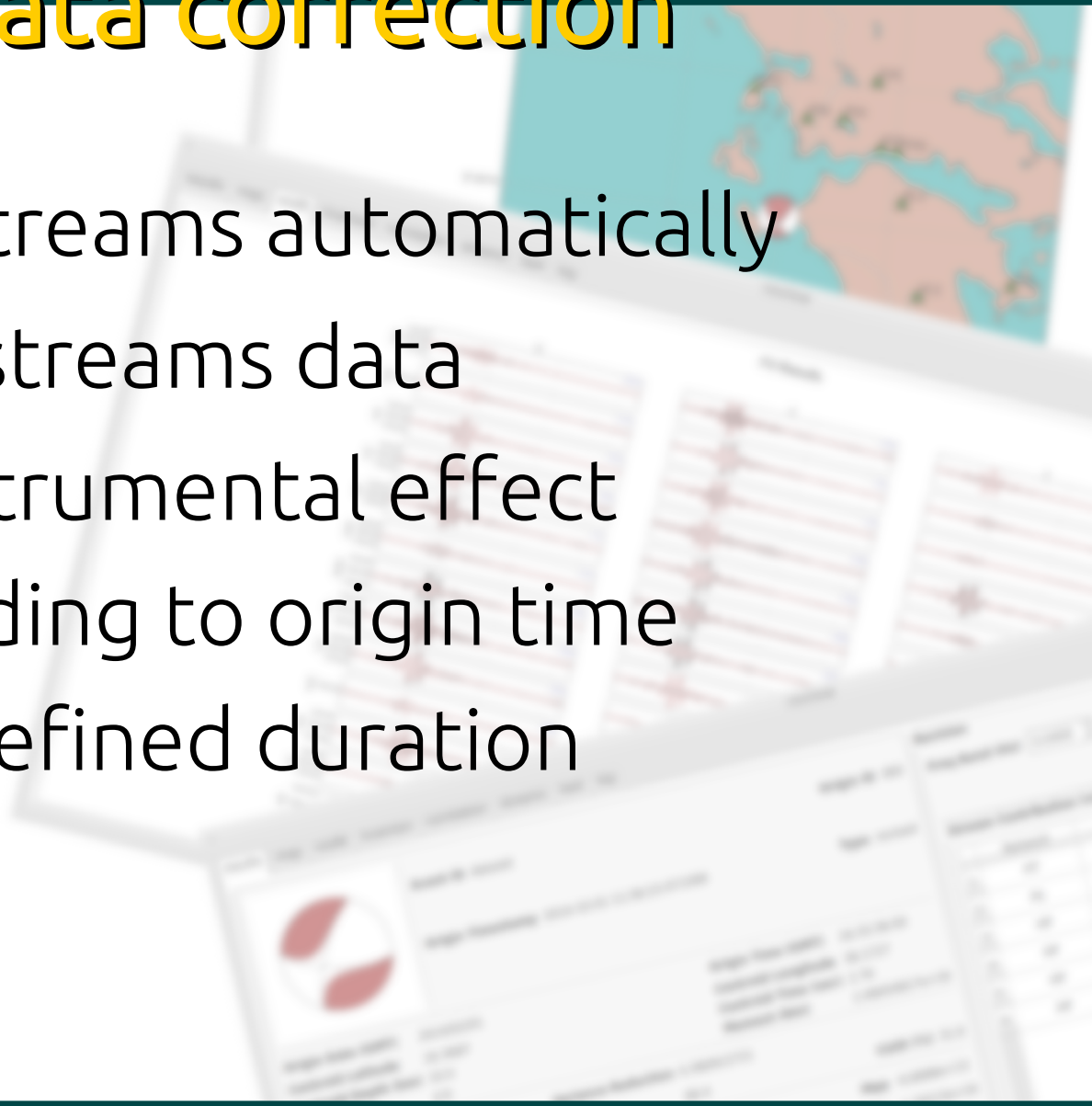


automatic procedure

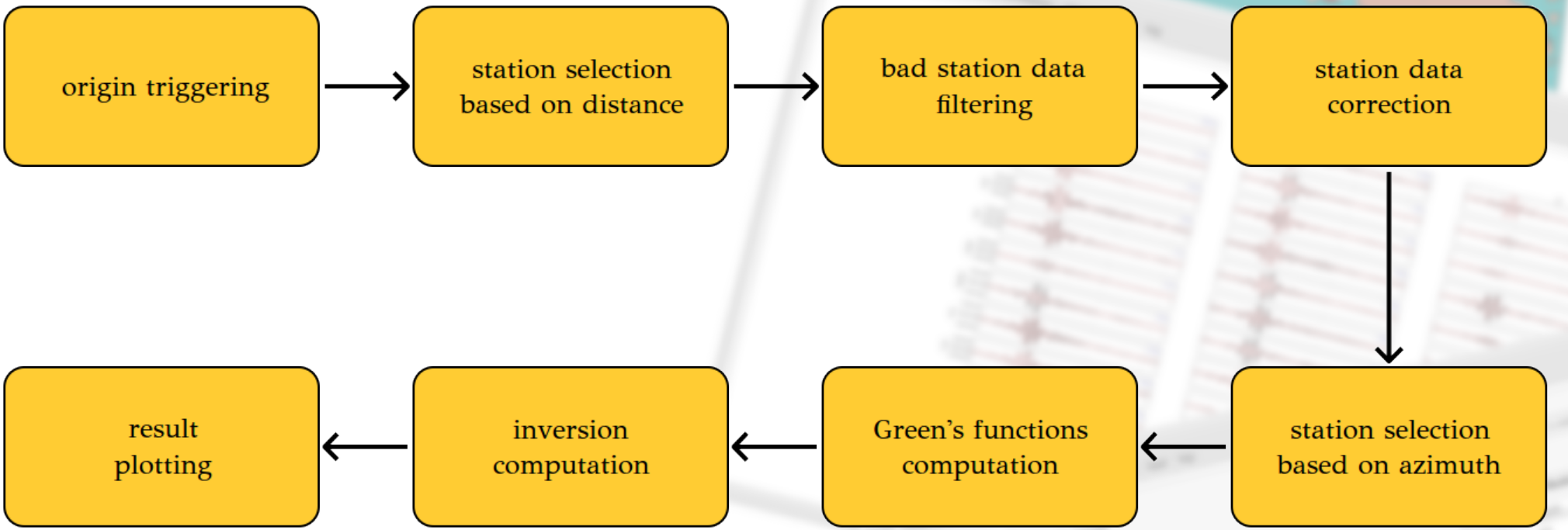


station data correction

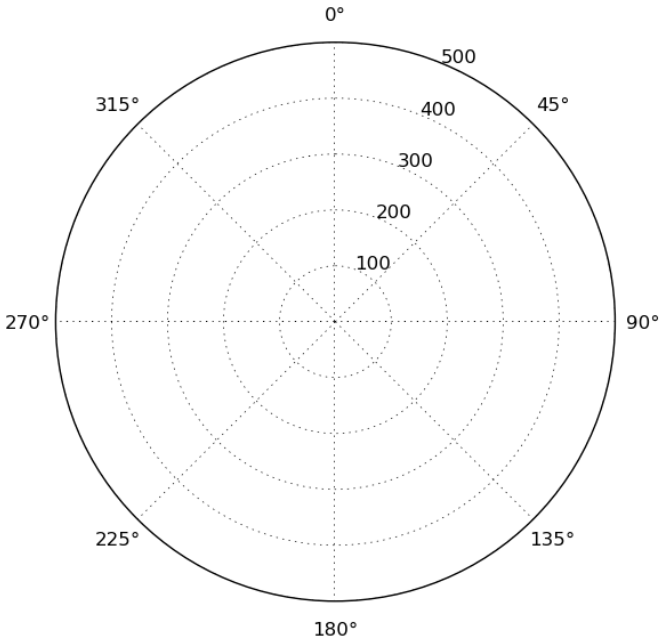
- rotates stations/streams automatically
- corrects stations/streams data
  - removes instrumental effect
  - aligns according to origin time
  - cuts to predefined duration
  - resamples



automatic procedure



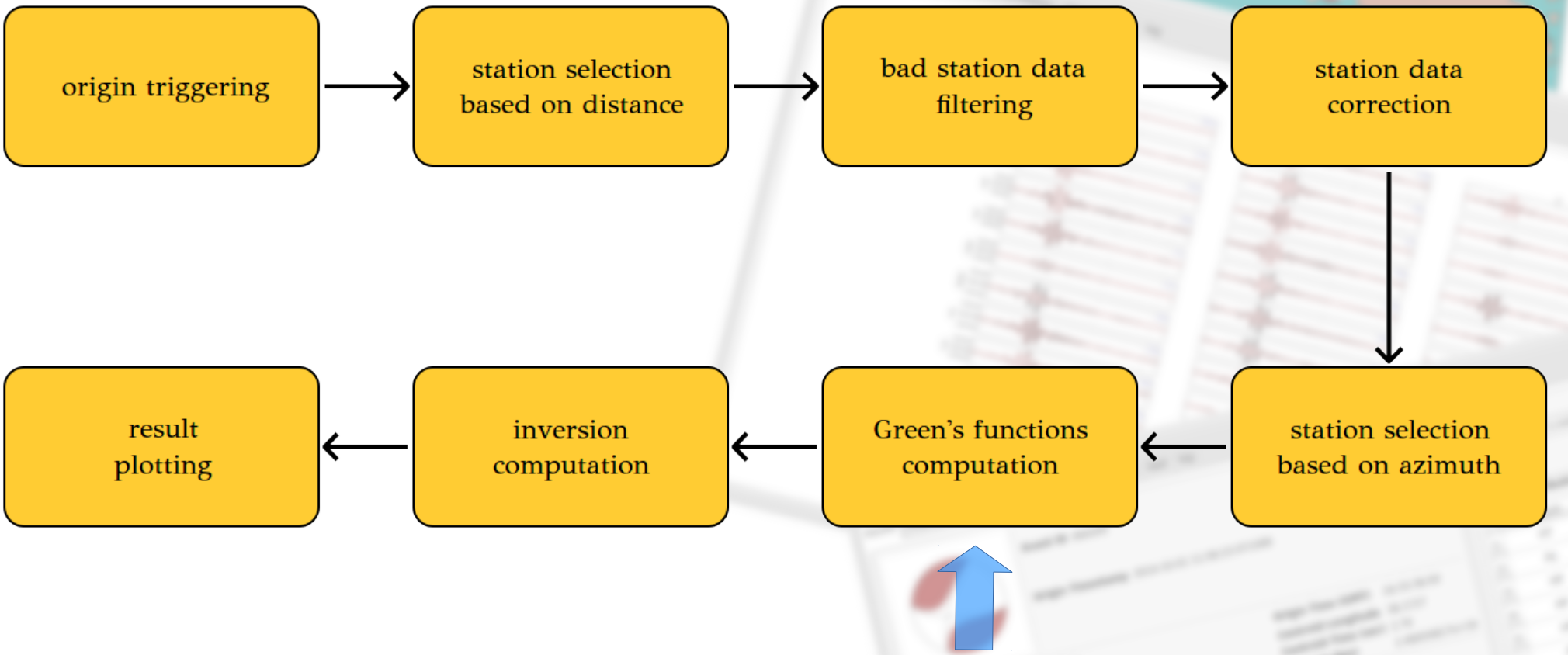
station selection based on azimuth



- station distribution according to epicenter location

  8 sectors, each of 45°
- minimum number of sectors defined by the user
- maximum stations per sector defined by the user
- stations' order based on priority and minimum distance from epicenter

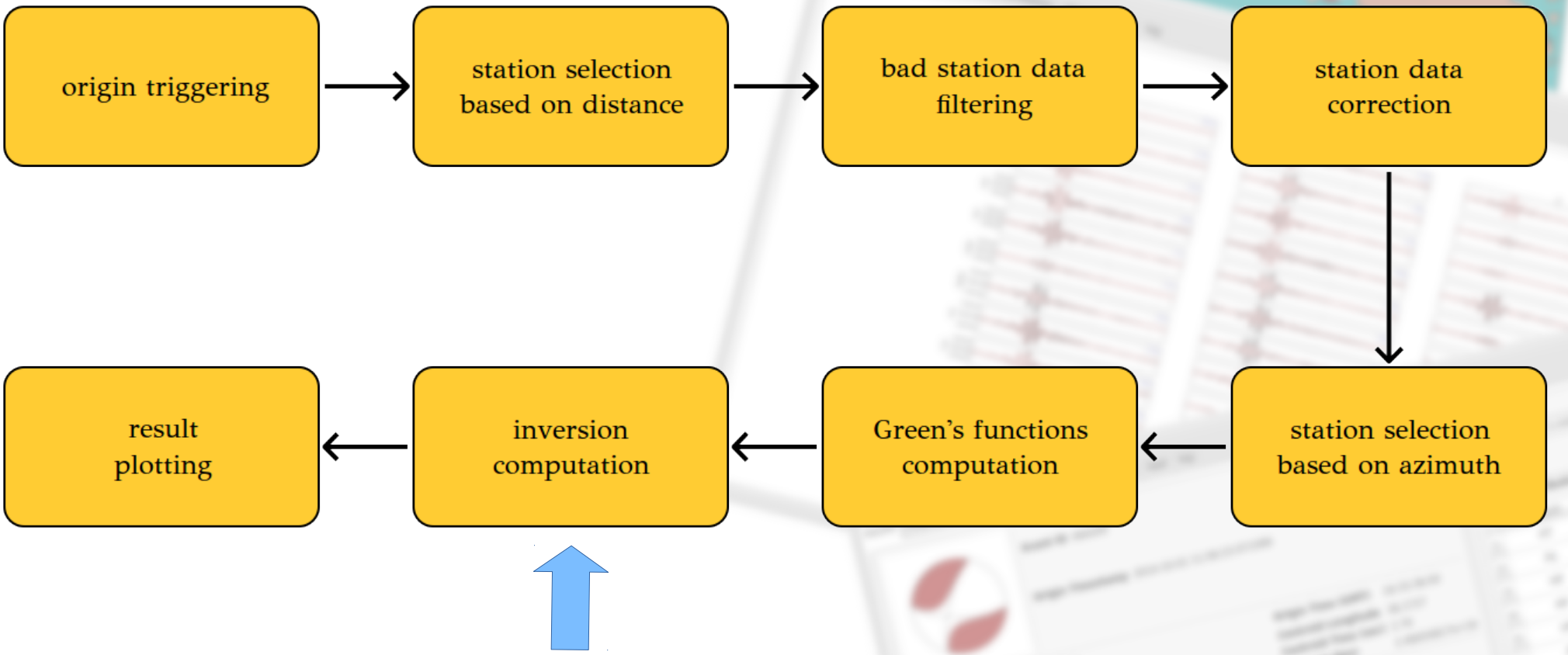
automatic procedure



Green's functions computation

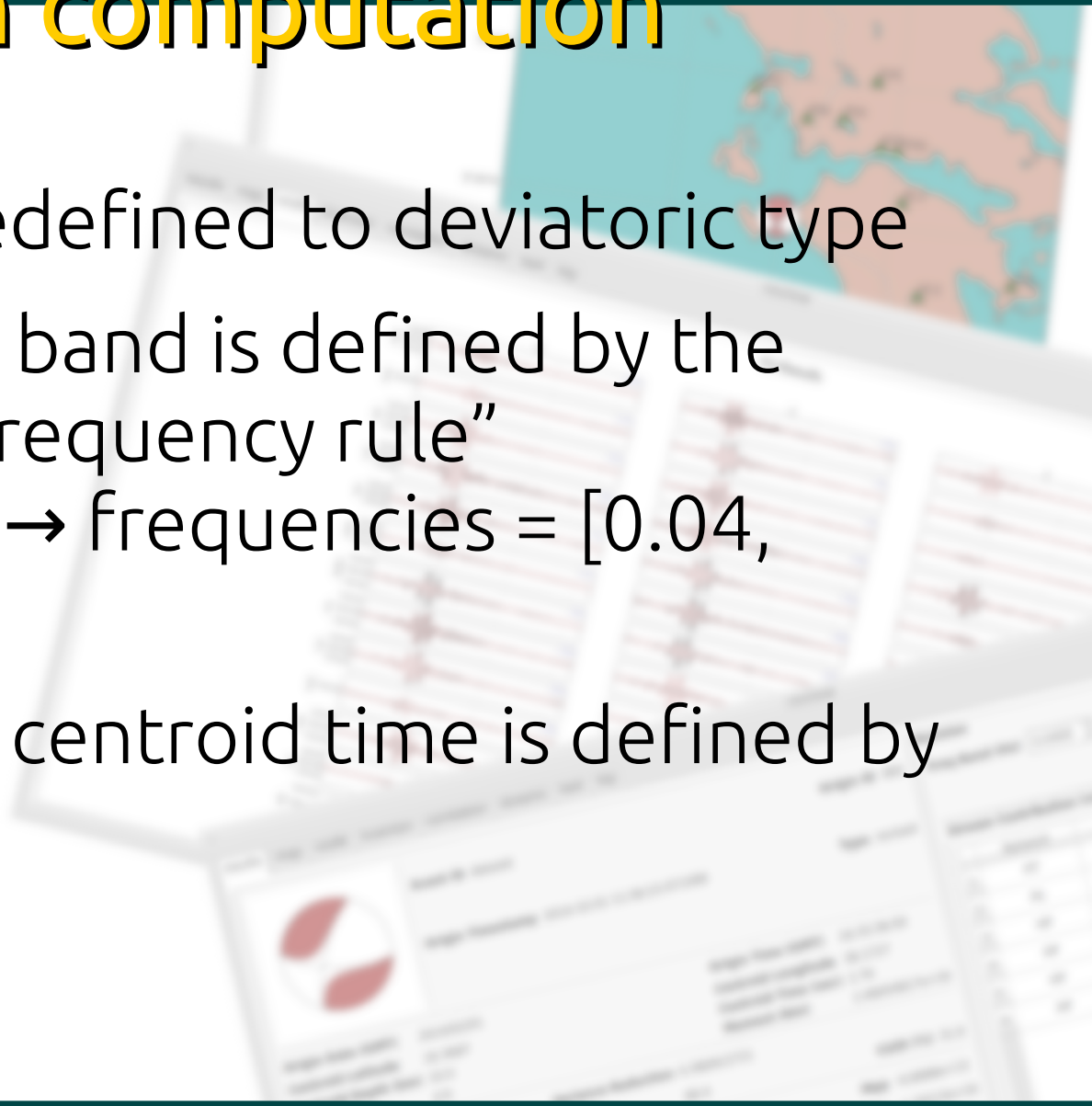
- single 1D crustal model defined by the user
- computation of elementary seismograms (delta time function)
- time window length of inversion procedure (tl) is defined by the user according to “tl rule”
  (e.g. $3.5 \leq mw \leq 4.5 \rightarrow tl = 327.68$ sec)
- centroid horizontal position fixed at epicenter location while centroid depth is grid searched
- the number of trial sources above and below automatic depth estimation is defined by the user

automatic procedure

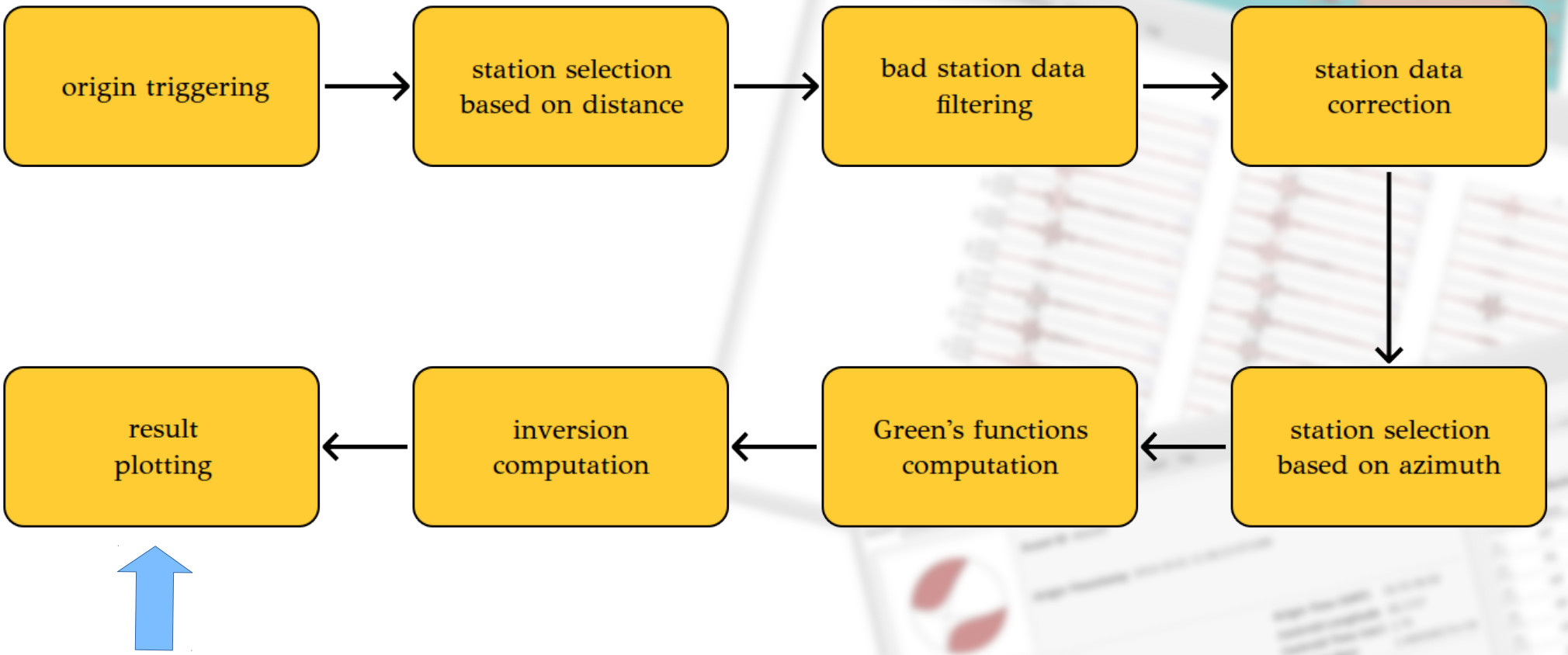


inversion computation

- source inversion predefined to deviatoric type
- inversion frequency band is defined by the user according to “frequency rule” (e.g. $3.5 \leq mw \leq 4.5 \rightarrow$ frequencies = [0.04, 0.05, 0.08, 0.09] Hz)
- time grid search for centroid time is defined by the user

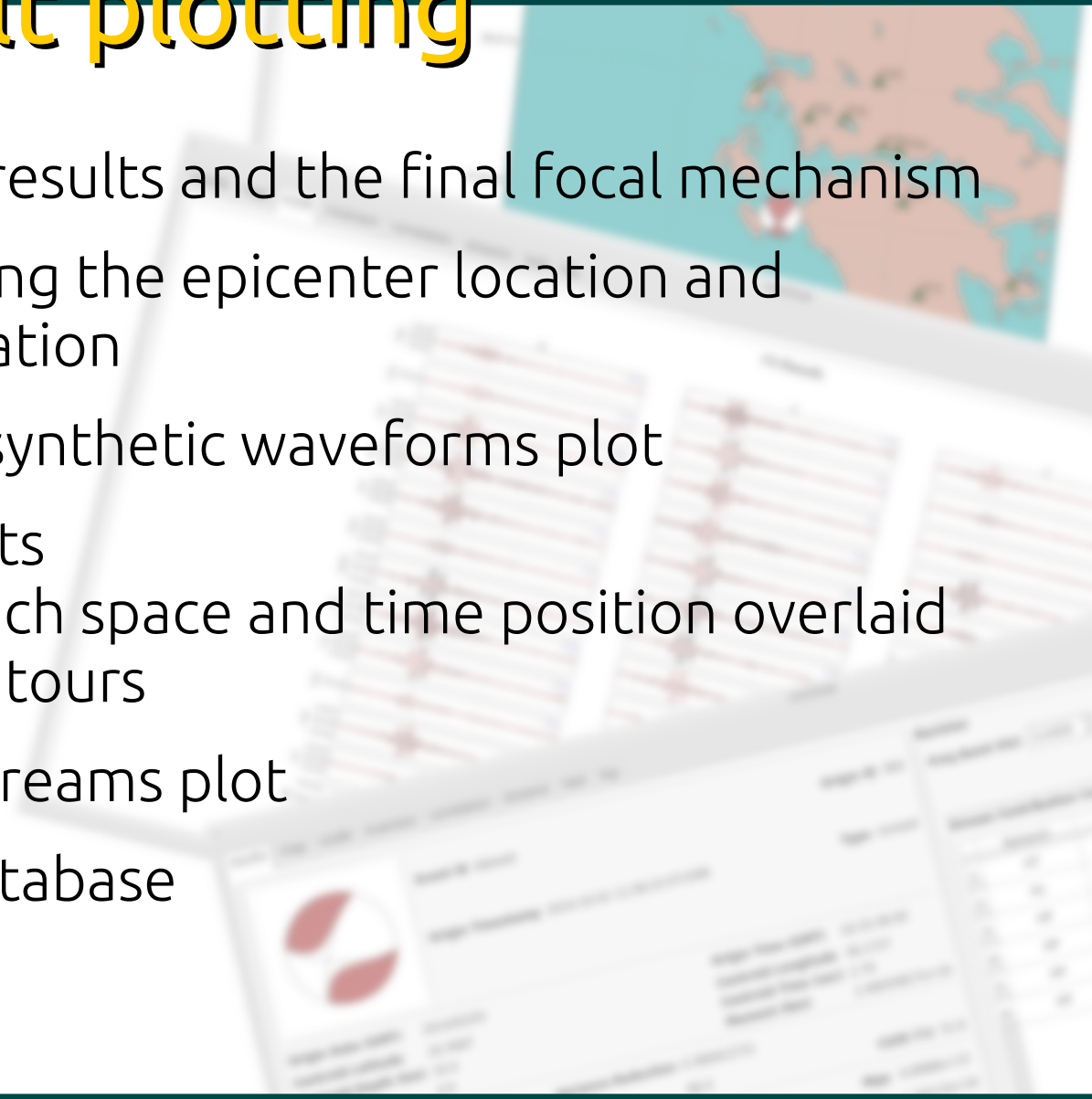


automatic procedure

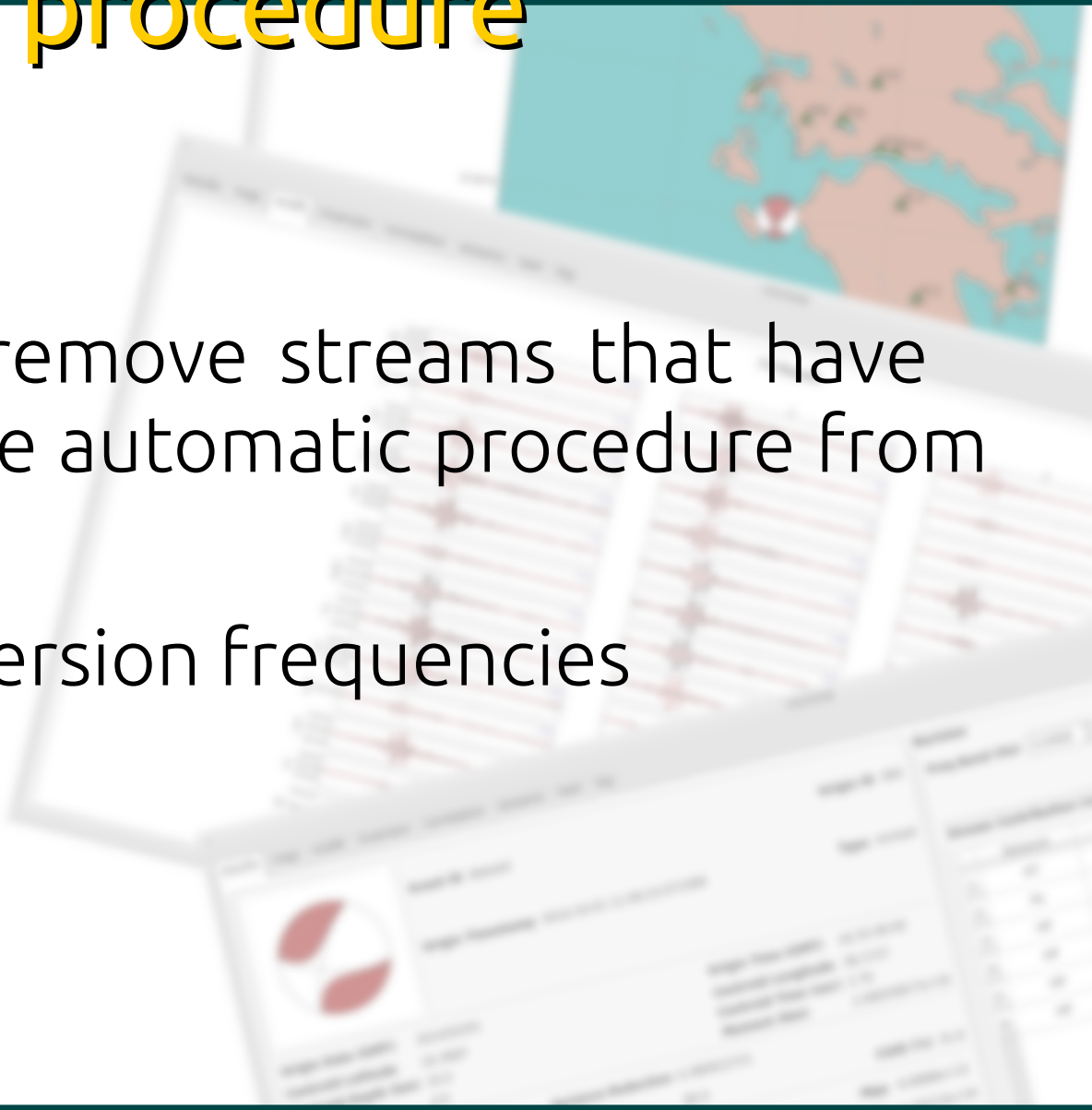


result plotting

- generates text files with results and the final focal mechanism
- generates a map containing the epicenter location and contributing stations' location
- generates observed and synthetic waveforms plot
- generates correlation plots
  i.e. focal mechanism at each space and time position overlaid above the correlation contours
- generates contributing streams plot
- saves results to scisola database



revise procedure



- user can manually remove streams that have been selected by the automatic procedure from the inversion
- user can change inversion frequencies

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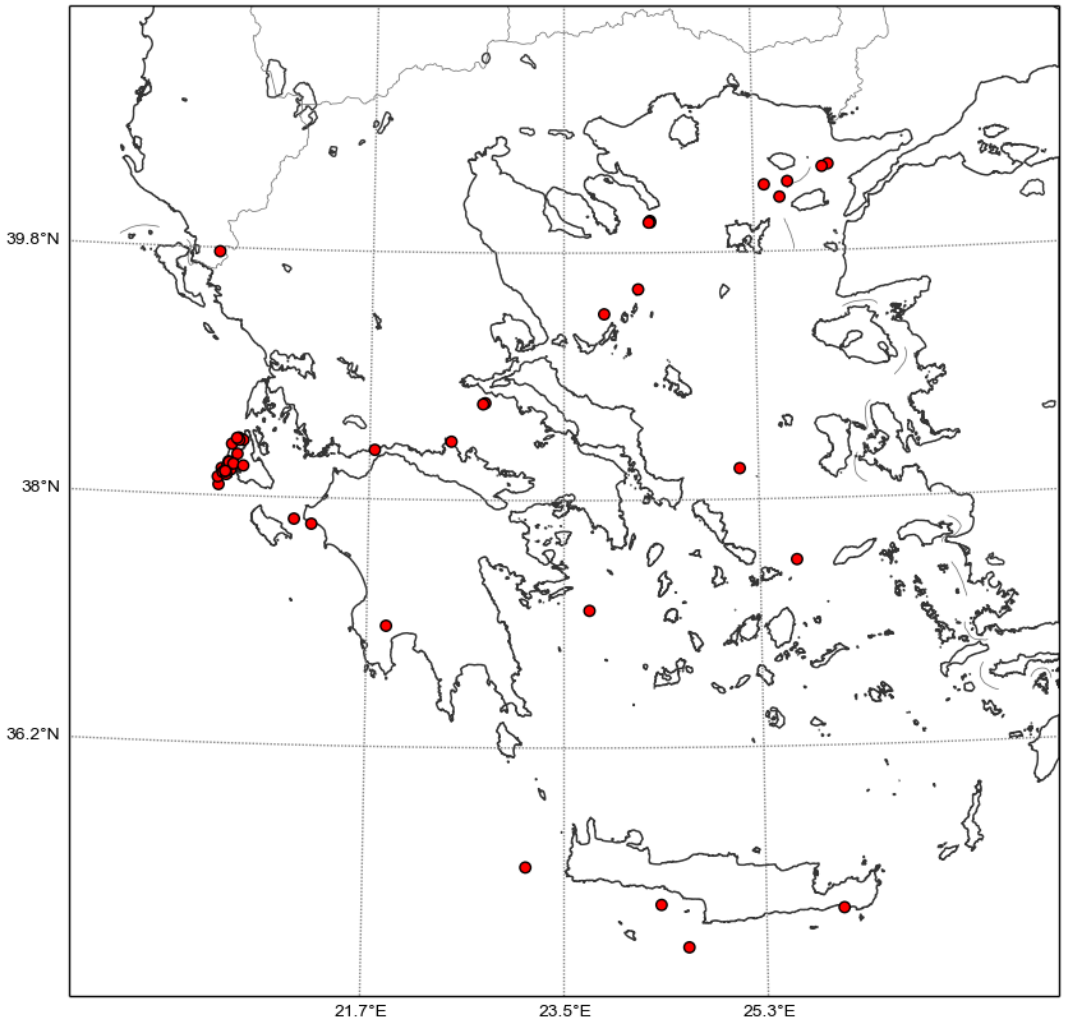
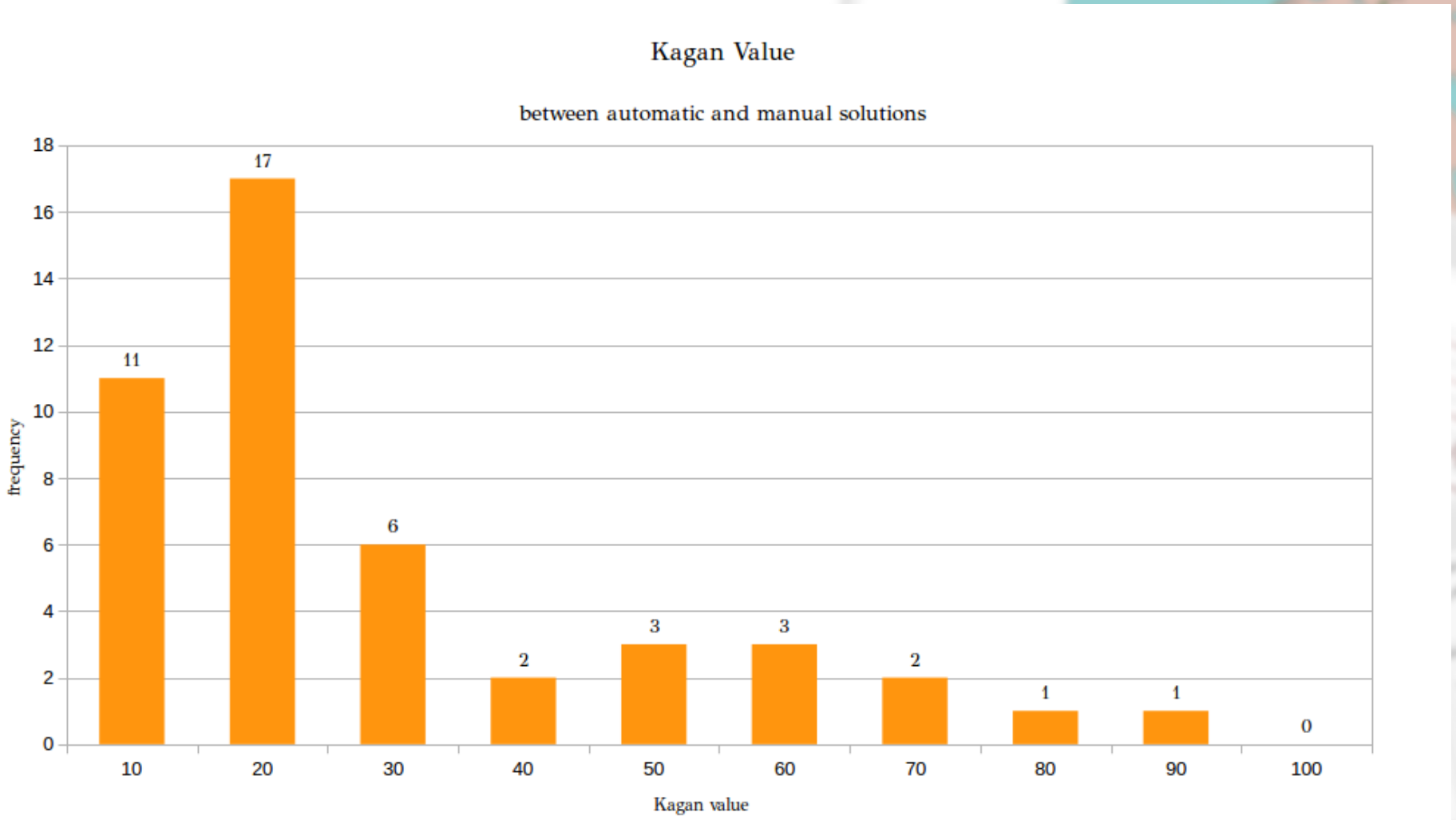
automatic Vs manual

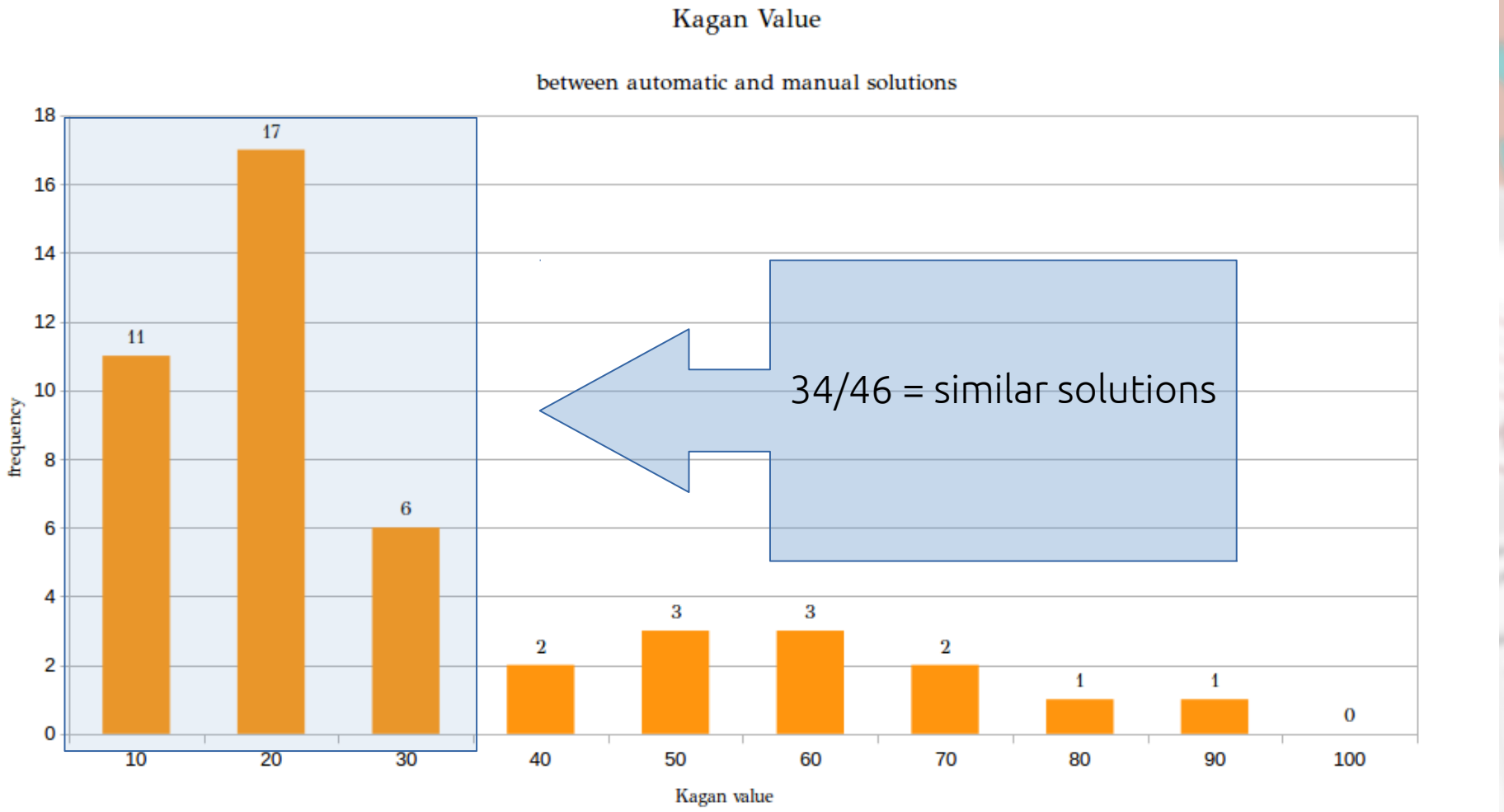


- comparison of 46 manual MT solutions by GI-NOA, with 46 automatic by scisola
- comparison using the Kagan angle metric
- locations → red dots

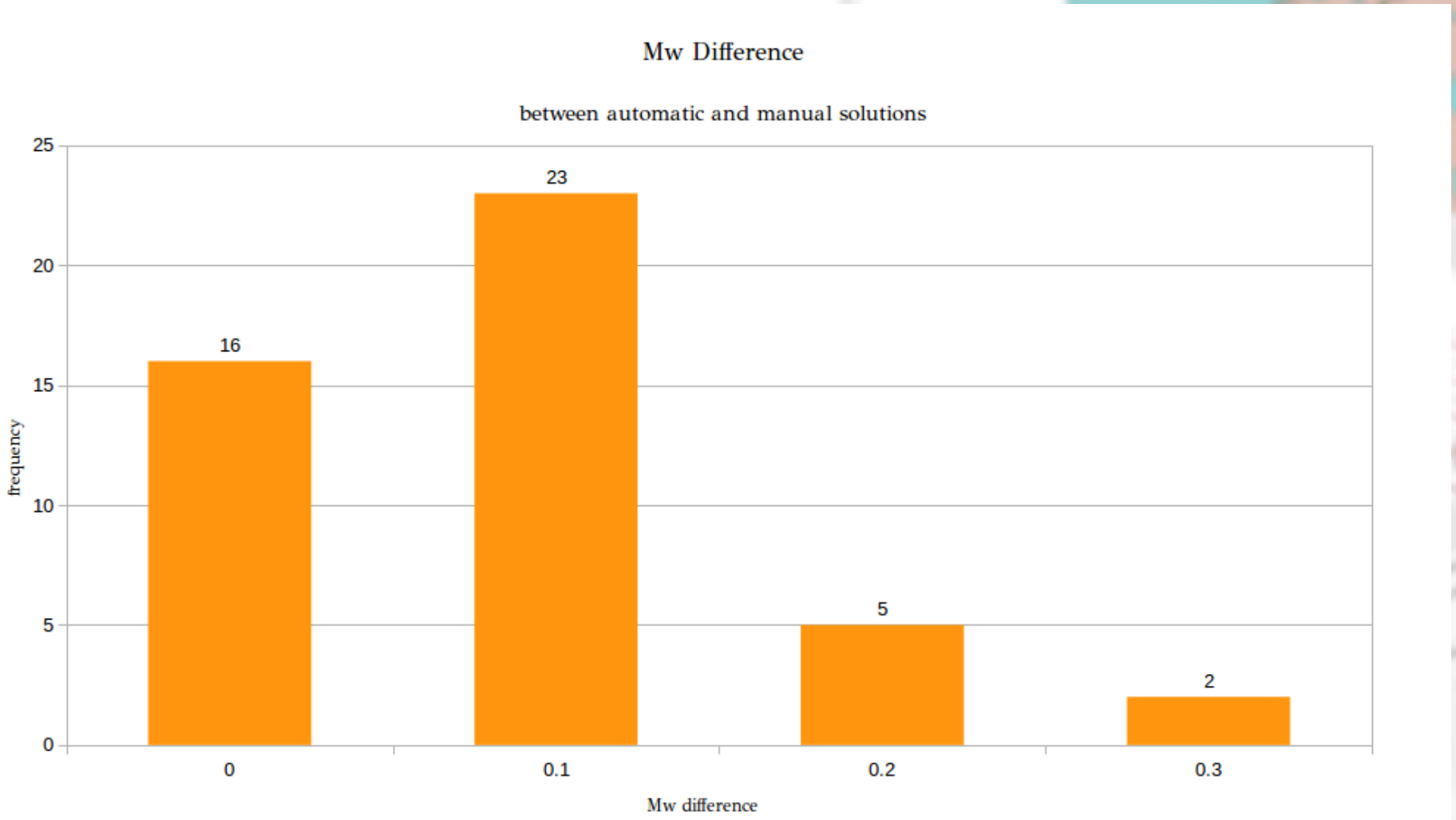
automatic Vs manual



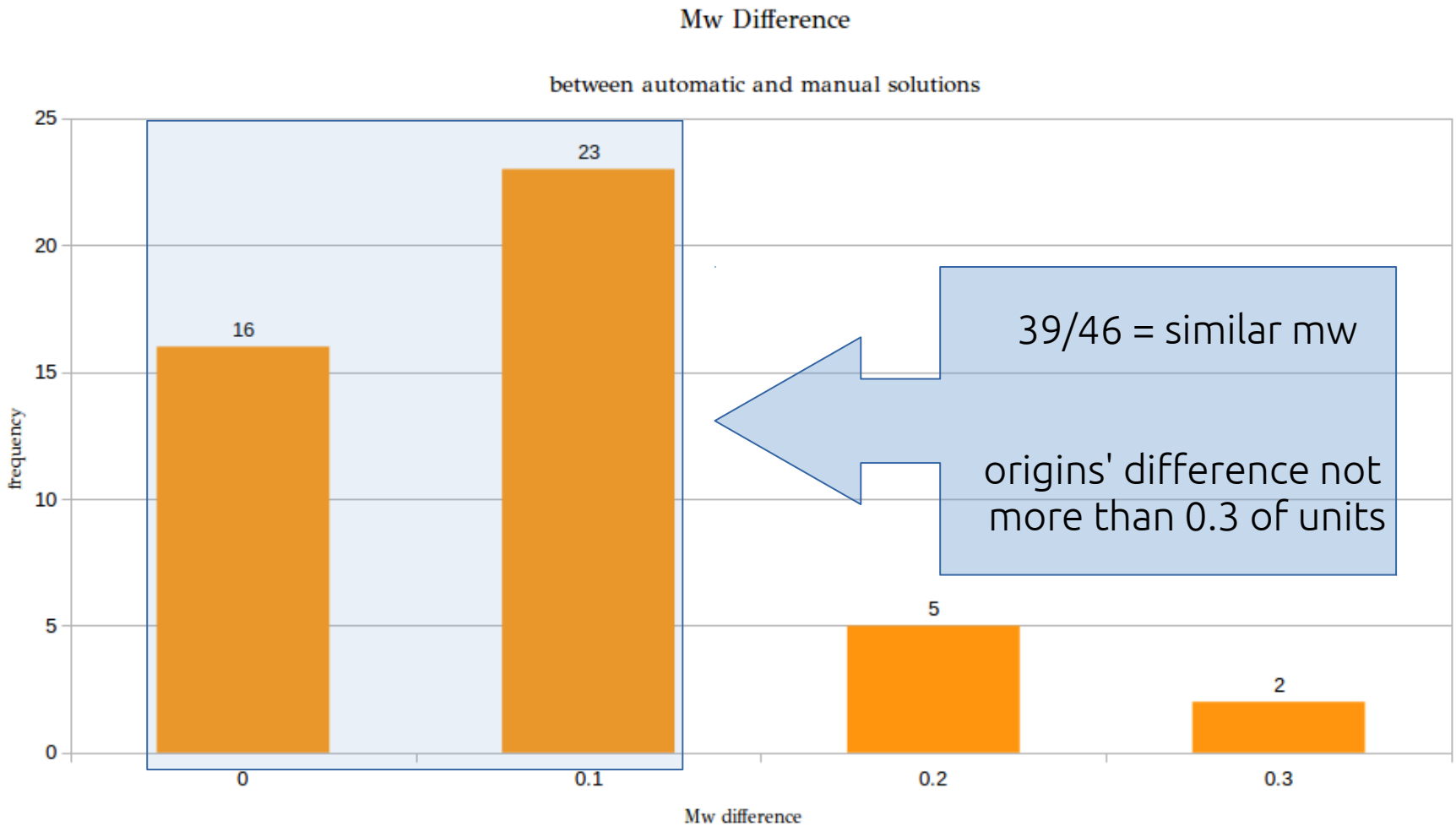
automatic Vs manual



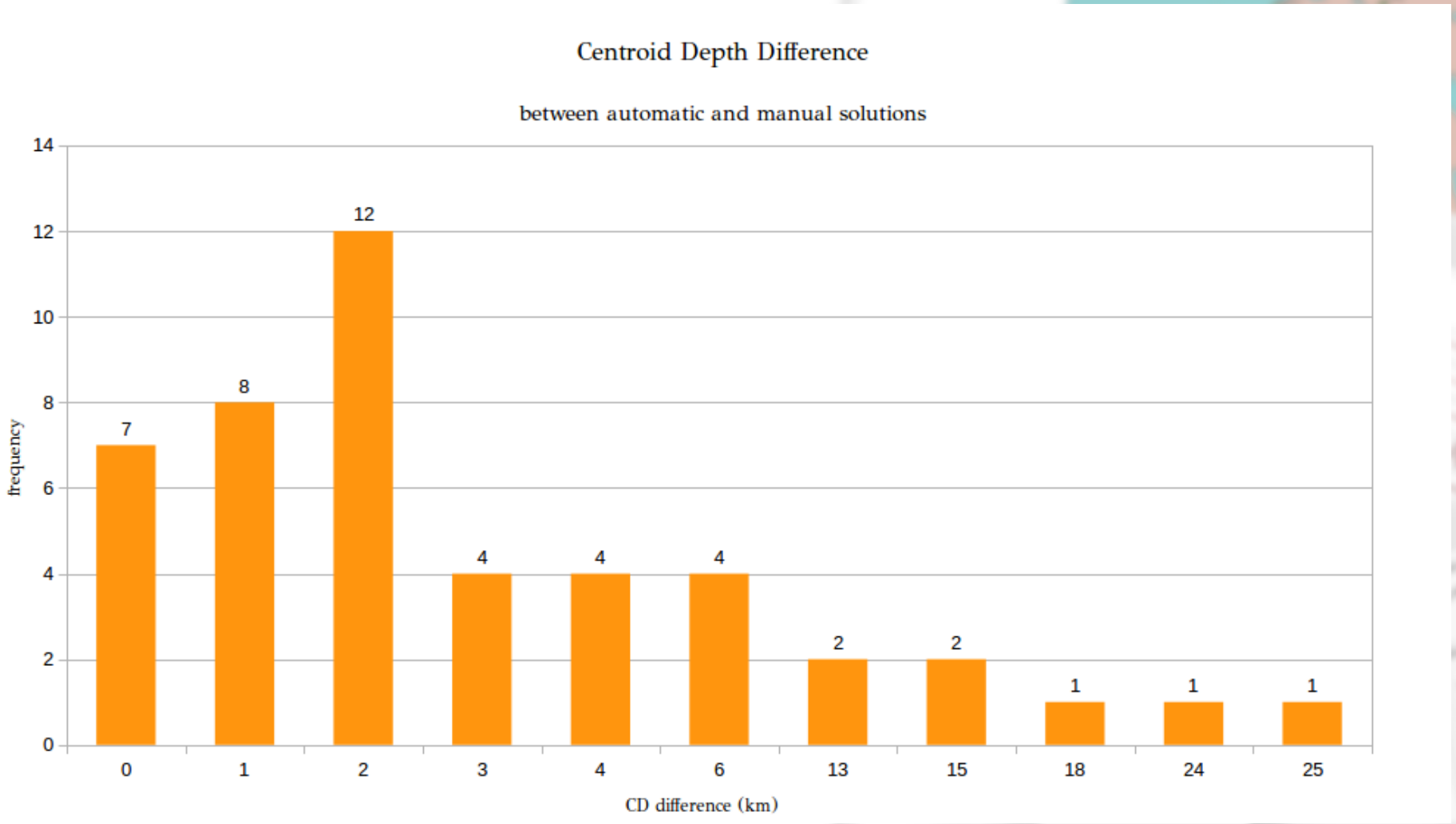
automatic Vs manual



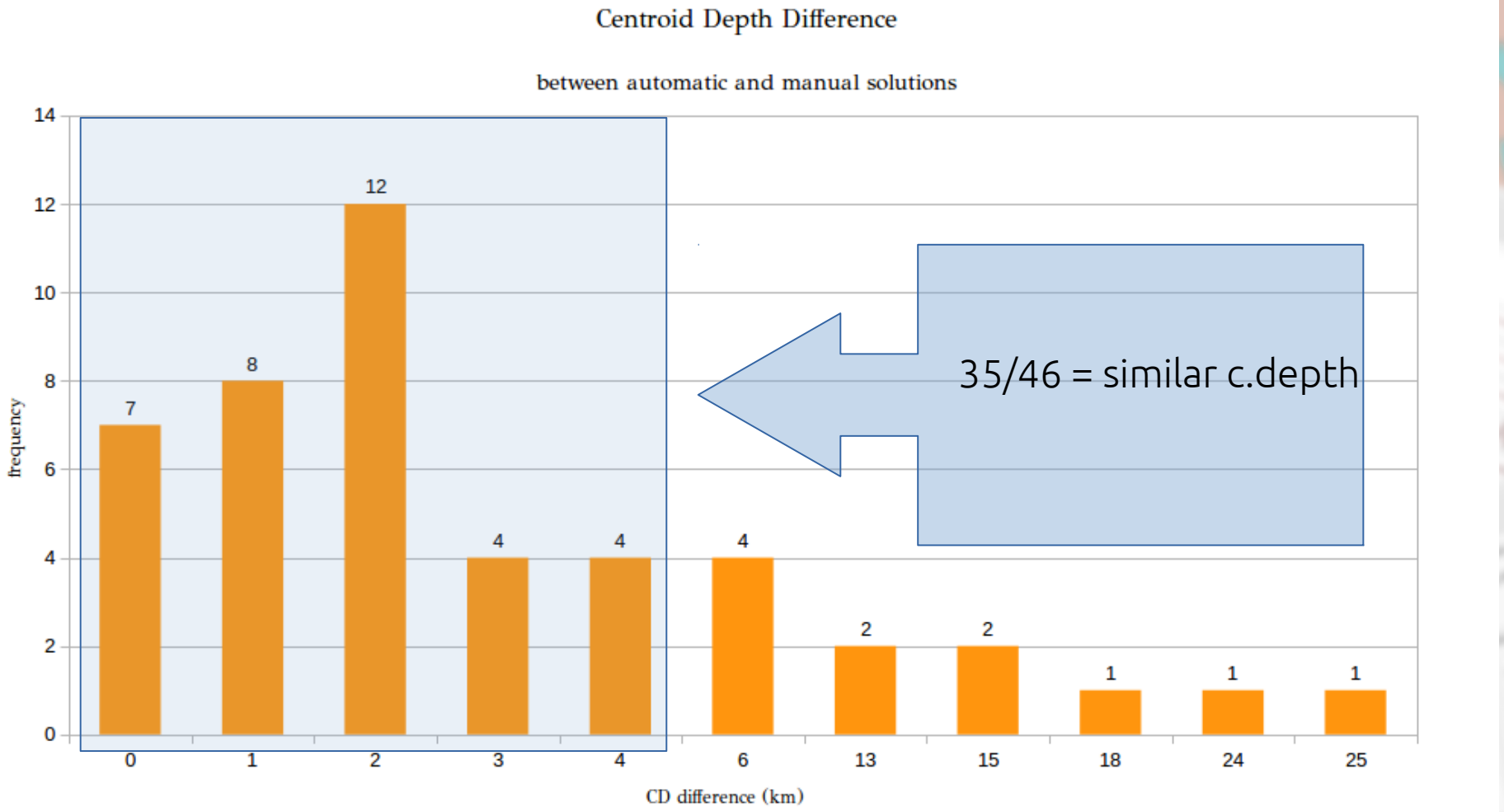
automatic Vs manual



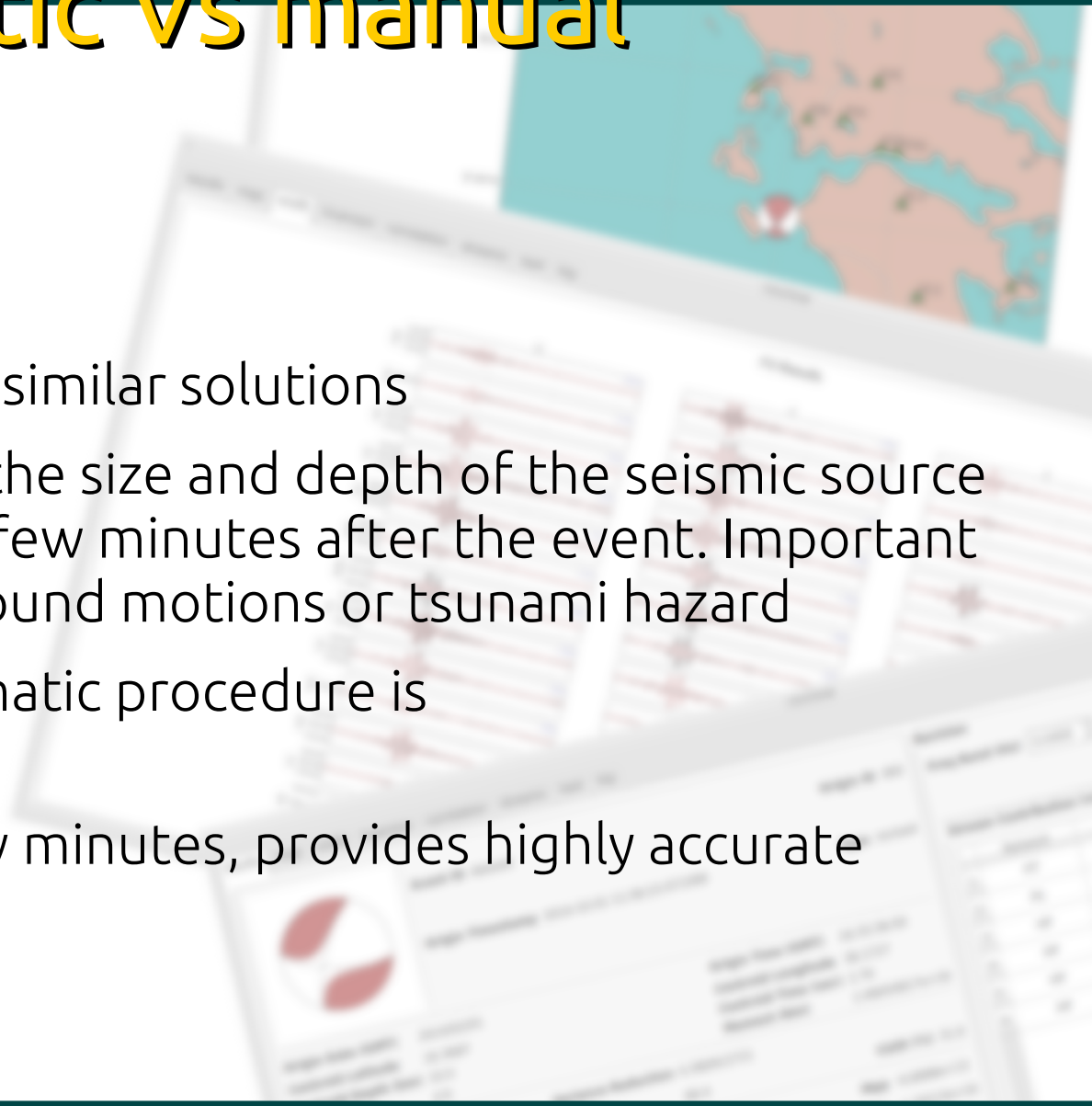
automatic Vs manual



automatic Vs manual



automatic Vs manual



results:

- automatic Vs manual 74% similar solutions
- automatic MTs recognize the size and depth of the seismic source with adequate accuracy a few minutes after the event. Important for quick estimation of ground motions or tsunami hazard
- average time of the automatic procedure is ≈ 5 minutes
- quick revision, in just a few minutes, provides highly accurate solutions

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login screen

- scisola DB (MySQL)
- SeisComP3 DB (MySQL/PostgreSQL)

login screen

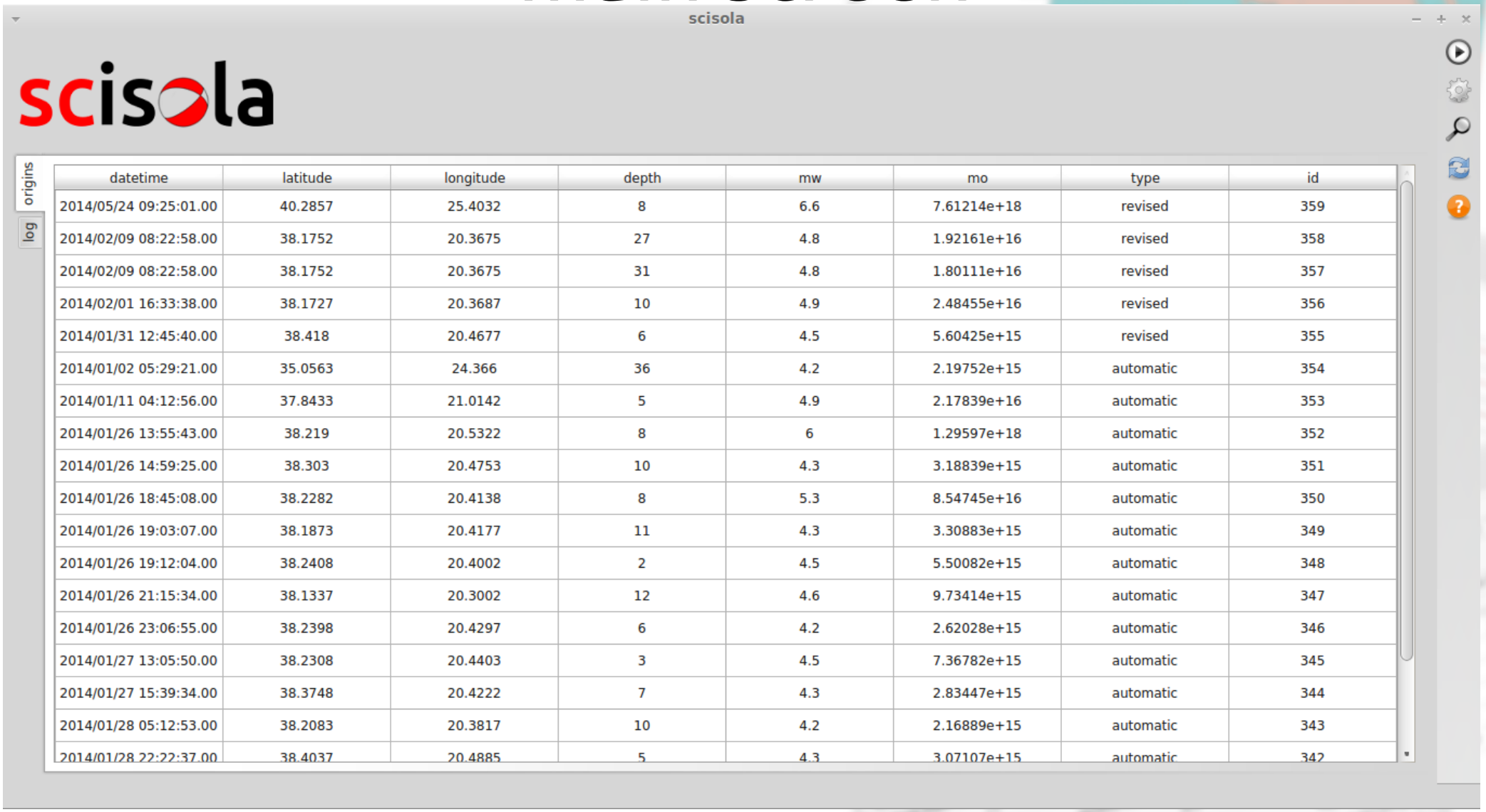
databases

- scisola DB (MySQL)
- SeisComP3 DB (MySQL/PostgreSQL)

login screen

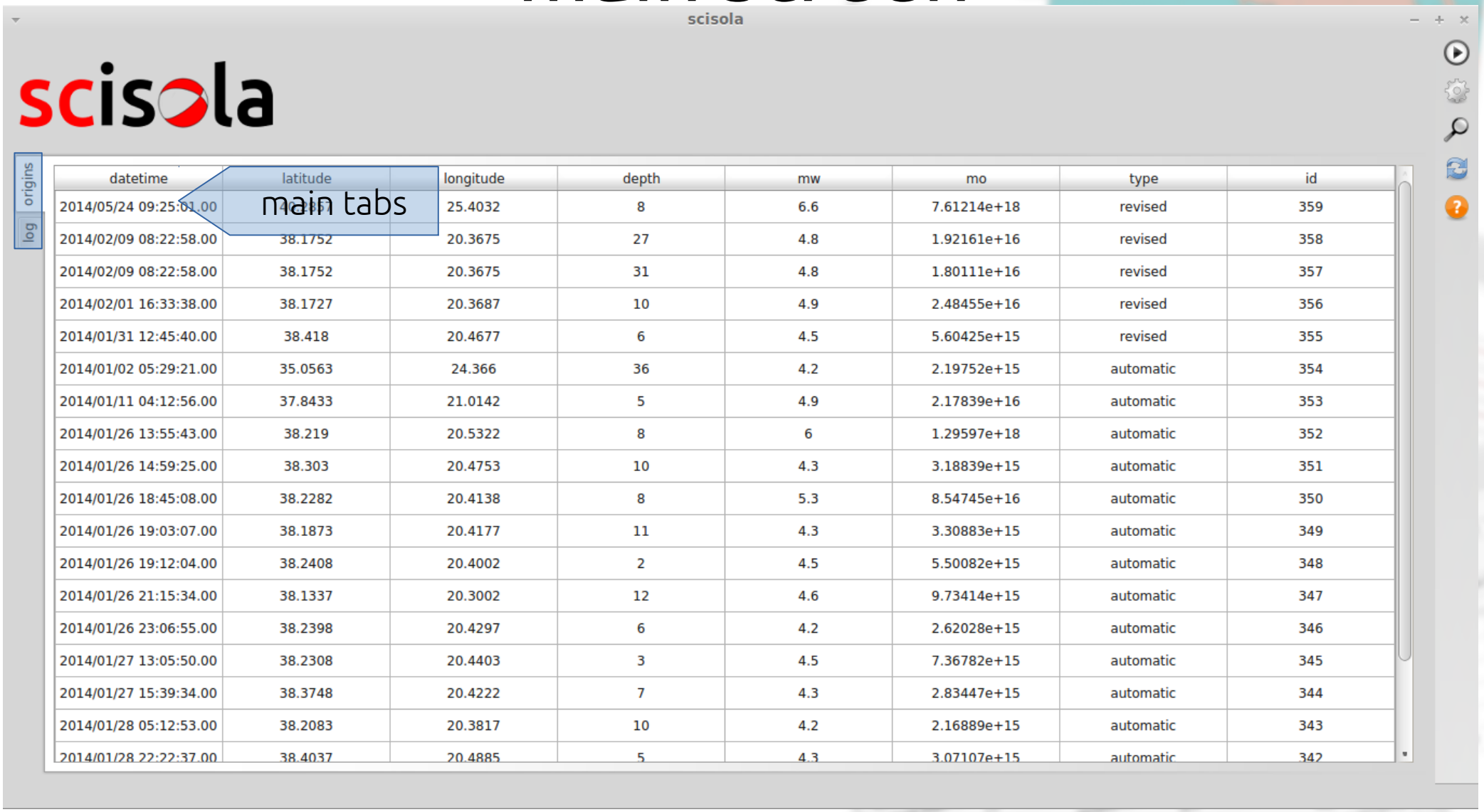
remote login eg. 192.168.1.2

main screen

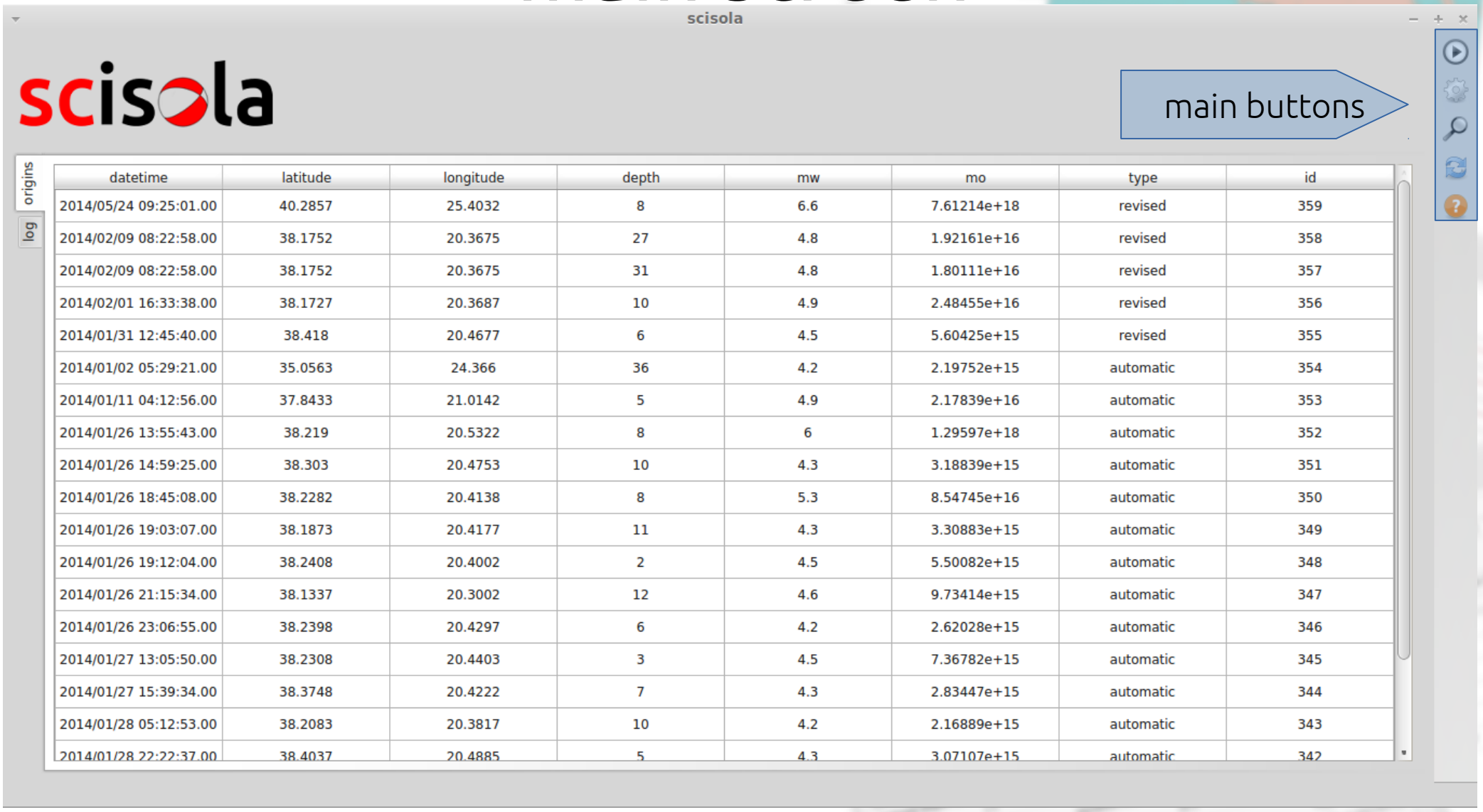


datetime	latitude	longitude	depth	mw	mo	type	id
2014/05/24 09:25:01.00	40.2857	25.4032	8	6.6	7.61214e+18	revised	359
2014/02/09 08:22:58.00	38.1752	20.3675	27	4.8	1.92161e+16	revised	358
2014/02/09 08:22:58.00	38.1752	20.3675	31	4.8	1.80111e+16	revised	357
2014/02/01 16:33:38.00	38.1727	20.3687	10	4.9	2.48455e+16	revised	356
2014/01/31 12:45:40.00	38.418	20.4677	6	4.5	5.60425e+15	revised	355
2014/01/02 05:29:21.00	35.0563	24.366	36	4.2	2.19752e+15	automatic	354
2014/01/11 04:12:56.00	37.8433	21.0142	5	4.9	2.17839e+16	automatic	353
2014/01/26 13:55:43.00	38.219	20.5322	8	6	1.29597e+18	automatic	352
2014/01/26 14:59:25.00	38.303	20.4753	10	4.3	3.18839e+15	automatic	351
2014/01/26 18:45:08.00	38.2282	20.4138	8	5.3	8.54745e+16	automatic	350
2014/01/26 19:03:07.00	38.1873	20.4177	11	4.3	3.30883e+15	automatic	349
2014/01/26 19:12:04.00	38.2408	20.4002	2	4.5	5.50082e+15	automatic	348
2014/01/26 21:15:34.00	38.1337	20.3002	12	4.6	9.73414e+15	automatic	347
2014/01/26 23:06:55.00	38.2398	20.4297	6	4.2	2.62028e+15	automatic	346
2014/01/27 13:05:50.00	38.2308	20.4403	3	4.5	7.36782e+15	automatic	345
2014/01/27 15:39:34.00	38.3748	20.4222	7	4.3	2.83447e+15	automatic	344
2014/01/28 05:12:53.00	38.2083	20.3817	10	4.2	2.16889e+15	automatic	343
2014/01/28 22:22:37.00	38.4037	20.4885	5	4.3	3.07107e+15	automatic	342

main screen


scisola
scisola
origins
log
main tabs
datetime
latitude
longitude
depth
mw
mo
type
id
2014/05/24 09:25:01.00 38.4361 25.4032 8 6.6 7.61214e+18 revised 359
2014/02/09 08:22:58.00 38.1752 20.3675 27 4.8 1.92161e+16 revised 358
2014/02/09 08:22:58.00 38.1752 20.3675 31 4.8 1.80111e+16 revised 357
2014/02/01 16:33:38.00 38.1727 20.3687 10 4.9 2.48455e+16 revised 356
2014/01/31 12:45:40.00 38.418 20.4677 6 4.5 5.60425e+15 revised 355
2014/01/02 05:29:21.00 35.0563 24.366 36 4.2 2.19752e+15 automatic 354
2014/01/11 04:12:56.00 37.8433 21.0142 5 4.9 2.17839e+16 automatic 353
2014/01/26 13:55:43.00 38.219 20.5322 8 6 1.29597e+18 automatic 352
2014/01/26 14:59:25.00 38.303 20.4753 10 4.3 3.18839e+15 automatic 351
2014/01/26 18:45:08.00 38.2282 20.4138 8 5.3 8.54745e+16 automatic 350
2014/01/26 19:03:07.00 38.1873 20.4177 11 4.3 3.30883e+15 automatic 349
2014/01/26 19:12:04.00 38.2408 20.4002 2 4.5 5.50082e+15 automatic 348
2014/01/26 21:15:34.00 38.1337 20.3002 12 4.6 9.73414e+15 automatic 347
2014/01/26 23:06:55.00 38.2398 20.4297 6 4.2 2.62028e+15 automatic 346
2014/01/27 13:05:50.00 38.2308 20.4403 3 4.5 7.36782e+15 automatic 345
2014/01/27 15:39:34.00 38.3748 20.4222 7 4.3 2.83447e+15 automatic 344
2014/01/28 05:12:53.00 38.2083 20.3817 10 4.2 2.16889e+15 automatic 343
2014/01/28 22:22:37.00 38.4037 20.4885 5 4.3 3.07107e+15 automatic 342

main screen



datetime	latitude	longitude	depth	mw	mo	type	id
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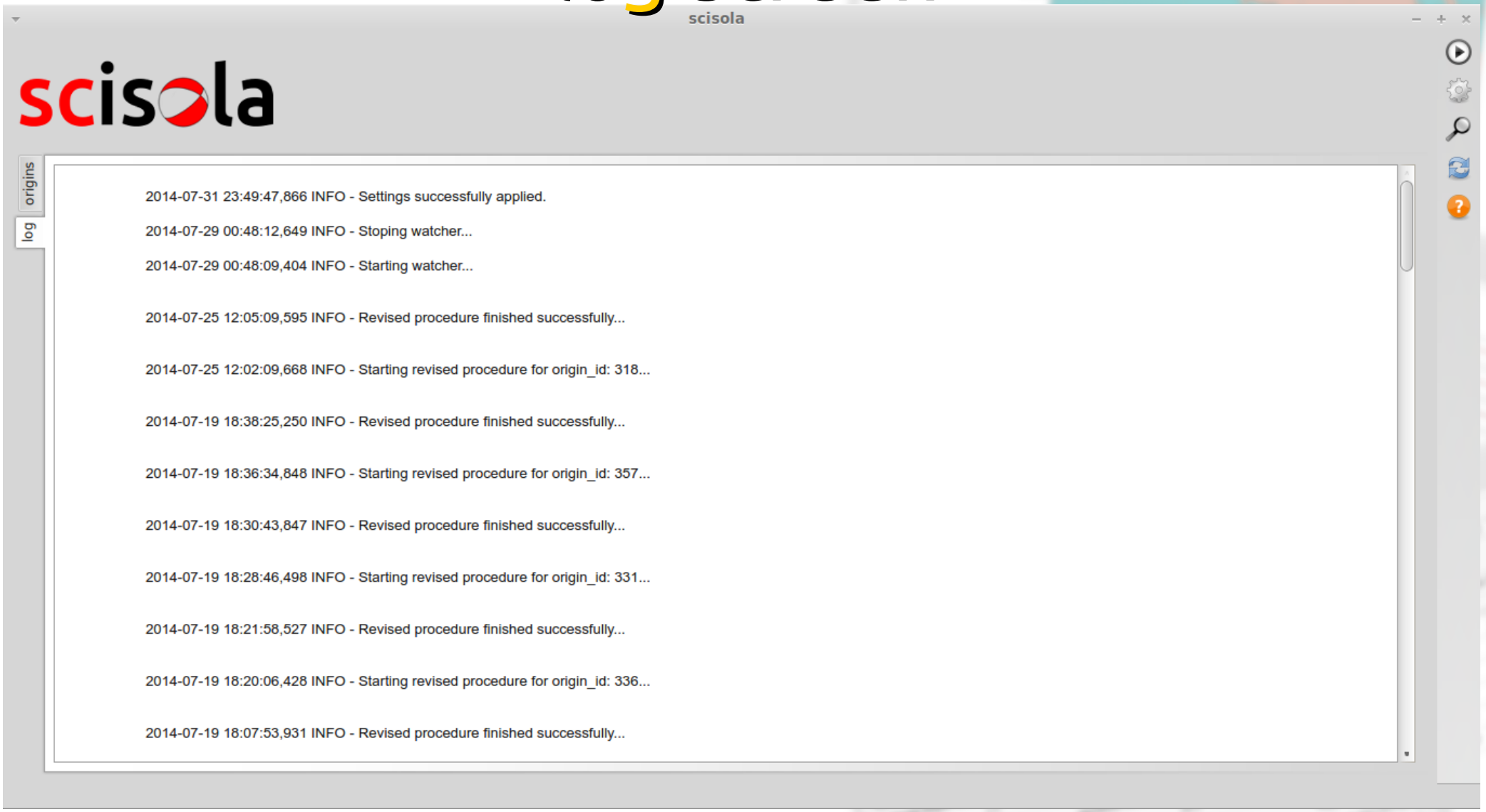
2014/02/09 08:22:58.00	38.1752	20.3675	27	4.8	1.92161e+16	revised	358
2014/02/09 08:22:58.00	38.1752	20.3675	31	4.8	1.80111e+16	revised	357
2014/02/01 16:33:38.00	38.1727	20.3687	10	4.9	2.48455e+16	revised	356
2014/01/31 12:45:40.00	38.418	20.4677	6	4.5	5.60425e+15	revised	355
2014/01/02 05:29:21.00	35.0563	24.366	36	4.2	2.19752e+15	automatic	354
2014/01/11 04:12:56.00	37.8433	21.0142	5	4.9	2.17839e+16	automatic	353
2014/01/26 13:55:43.00	38.219	20.5322	8	6	1.29597e+18	automatic	352
2014/01/26 14:59:25.00	38.303	20.4753	10	4.3	3.18839e+15	automatic	351
2014/01/26 18:45:08.00	38.2282	20.4138	8	5.3	8.54745e+16	automatic	350
2014/01/26 19:03:07.00	38.1873	20.4177	11	4.3	3.30883e+15	automatic	349
2014/01/26 19:12:04.00	38.2408	20.4002	2	4.5	5.50082e+15	automatic	348
2014/01/26 21:15:34.00	38.1337	20.3002	12	4.6	9.73414e+15	automatic	347
2014/01/26 23:06:55.00	38.2398	20.4297	6	4.2	2.62028e+15	automatic	346
2014/01/27 13:05:50.00	38.2308	20.4403	3	4.5	7.36782e+15	automatic	345
2014/01/27 15:39:34.00	38.3748	20.4222	7	4.3	2.83447e+15	automatic	344
2014/01/28 05:12:53.00	38.2083	20.3817	10	4.2	2.16889e+15	automatic	343
2014/01/28 22:22:37.00	38.4037	20.4885	5	4.3	3.07107e+15	automatic	342

main screen

datetime	latitude	longitude	depth	mw	mo	type	id
2014/05/24 09:25:01.00	40.2857	25.4032	8	6.6	7.61214e+18	revised	359
2014/02/09 08:22:58.00	38.1752	20.3675	27	4.8	1.92161e+16	revised	358
2014/02/09 08:22:58.00	38.1752	20.3675	31	4.8	1.80111e+16	revised	357
2014/02/01 16:33:38.00	38.1727	20.3687	10	4.9	2.48455e+16	revised	356
2014/01/31 12:45:40.00	38.418	20.4677	6	4.5	5.60425e+15	revised	355
2014/01/02 05:29:21.00	35.0563	24.366	36	4.2	2.19752e+15	automatic	354
2014/01/11 04:12:56.00	37.8433	21.0142	5	4.9	2.17839e+16	automatic	353
2014/01/26 13:55:43.00	38.219	20.5322	8	6	1.29597e+18	automatic	352
2014/01/26 14:59:25.00	38.303	20.4753	10	4.3	3.18839e+15	automatic	351
2014/01/26 18:45:08.00	38.2282	20.4138	8	5.3	8.54745e+16	automatic	350
2014/01/26 19:03:07.00	38.1873	20.4177	11	4.3	3.30883e+15	automatic	349
2014/01/26 19:12:04.00	38.2408	20.4002	2	4.5	5.50082e+15	automatic	348
2014/01/26 21:15:34.00	38.1337	20.3002	12	4.6	9.73414e+15	automatic	347
2014/01/26 23:06:55.00	38.2398	20.4297	6	4.2	2.62028e+15	automatic	346
2014/01/27 13:05:50.00	38.2308	20.4403	3	4.5	7.36782e+15	automatic	345
2014/01/27 15:39:34.00	38.3748	20.4222	7	4.3	2.83447e+15	automatic	344
2014/01/28 05:12:53.00	38.2083	20.3817	10	4.2	2.16889e+15	automatic	343
2014/01/28 22:22:37.00	38.4037	20.4885	5	4.3	3.07107e+15	automatic	342

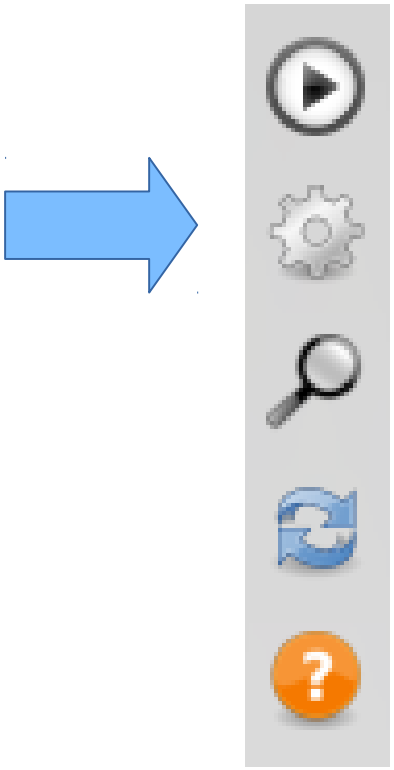
log screen


scisola
scisola
origins
log
2014-07-31 23:49:47,866 INFO - Settings successfully applied.
2014-07-29 00:48:12,649 INFO - Stoping watcher...
2014-07-29 00:48:09,404 INFO - Starting watcher...
2014-07-25 12:05:09,595 INFO - Revised procedure finished successfully...
2014-07-25 12:02:09,668 INFO - Starting revised procedure for origin_id: 318...
2014-07-19 18:38:25,250 INFO - Revised procedure finished successfully...
2014-07-19 18:36:34,848 INFO - Starting revised procedure for origin_id: 357...
2014-07-19 18:30:43,847 INFO - Revised procedure finished successfully...
2014-07-19 18:28:46,498 INFO - Starting revised procedure for origin_id: 331...
2014-07-19 18:21:58,527 INFO - Revised procedure finished successfully...
2014-07-19 18:20:06,428 INFO - Starting revised procedure for origin_id: 336...
2014-07-19 18:07:53,931 INFO - Revised procedure finished successfully...

main buttons

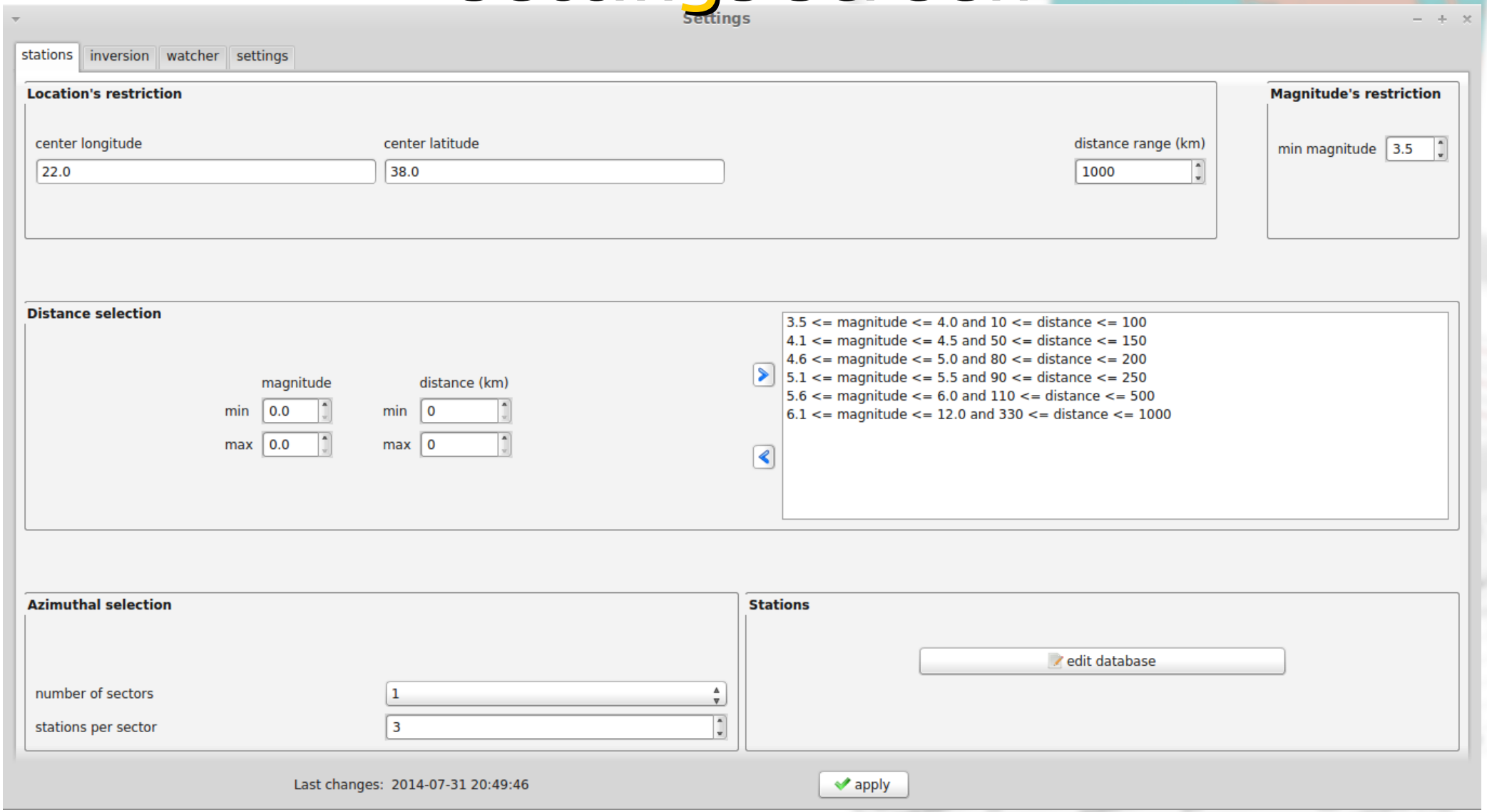
- start/stop watcher
- settings screen
- search screen
- update latest 20 origins
- about screen

main buttons

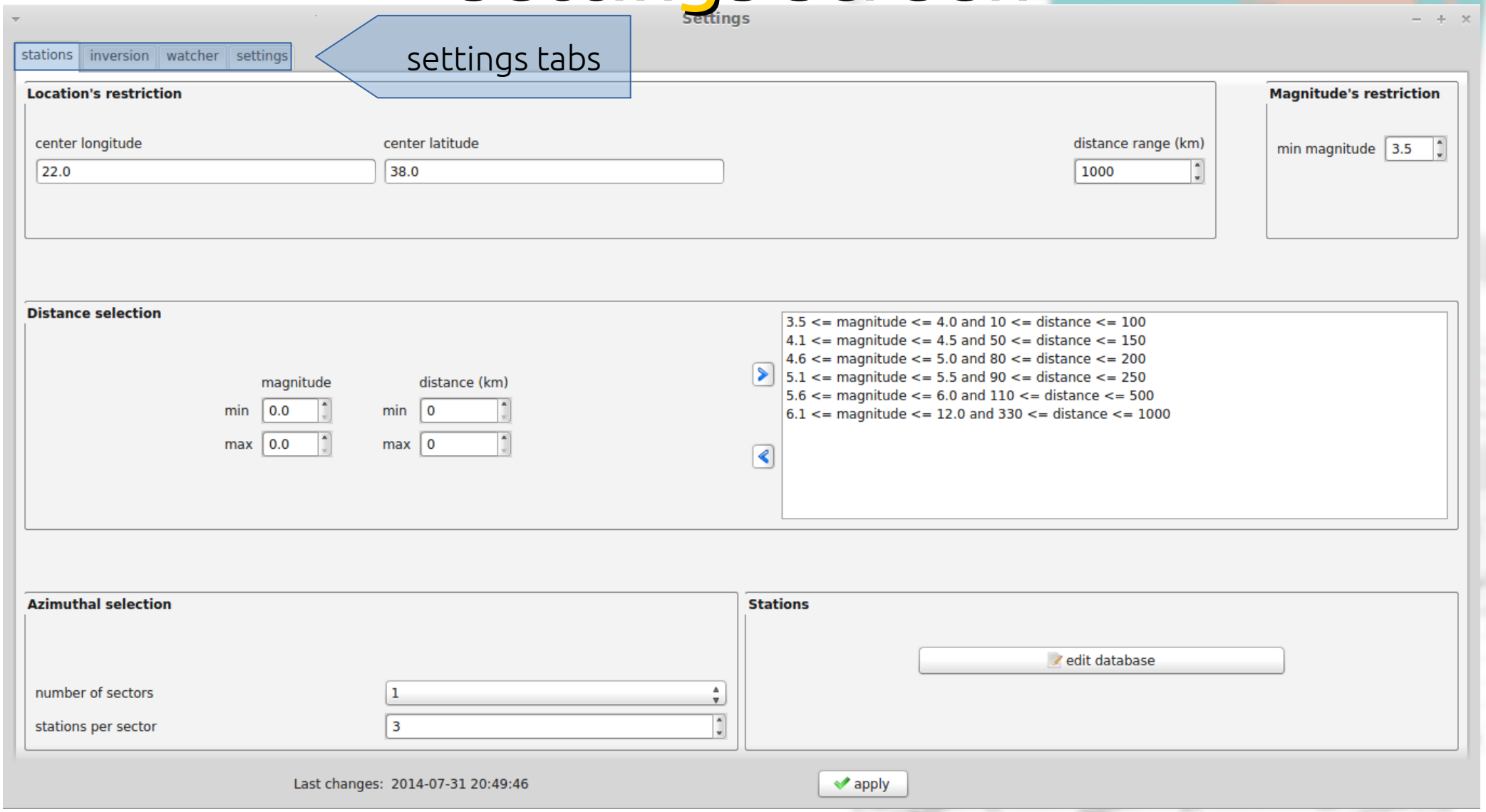


- start/stop watcher
- settings screen
- search screen
- update latest 20 origins
- about screen

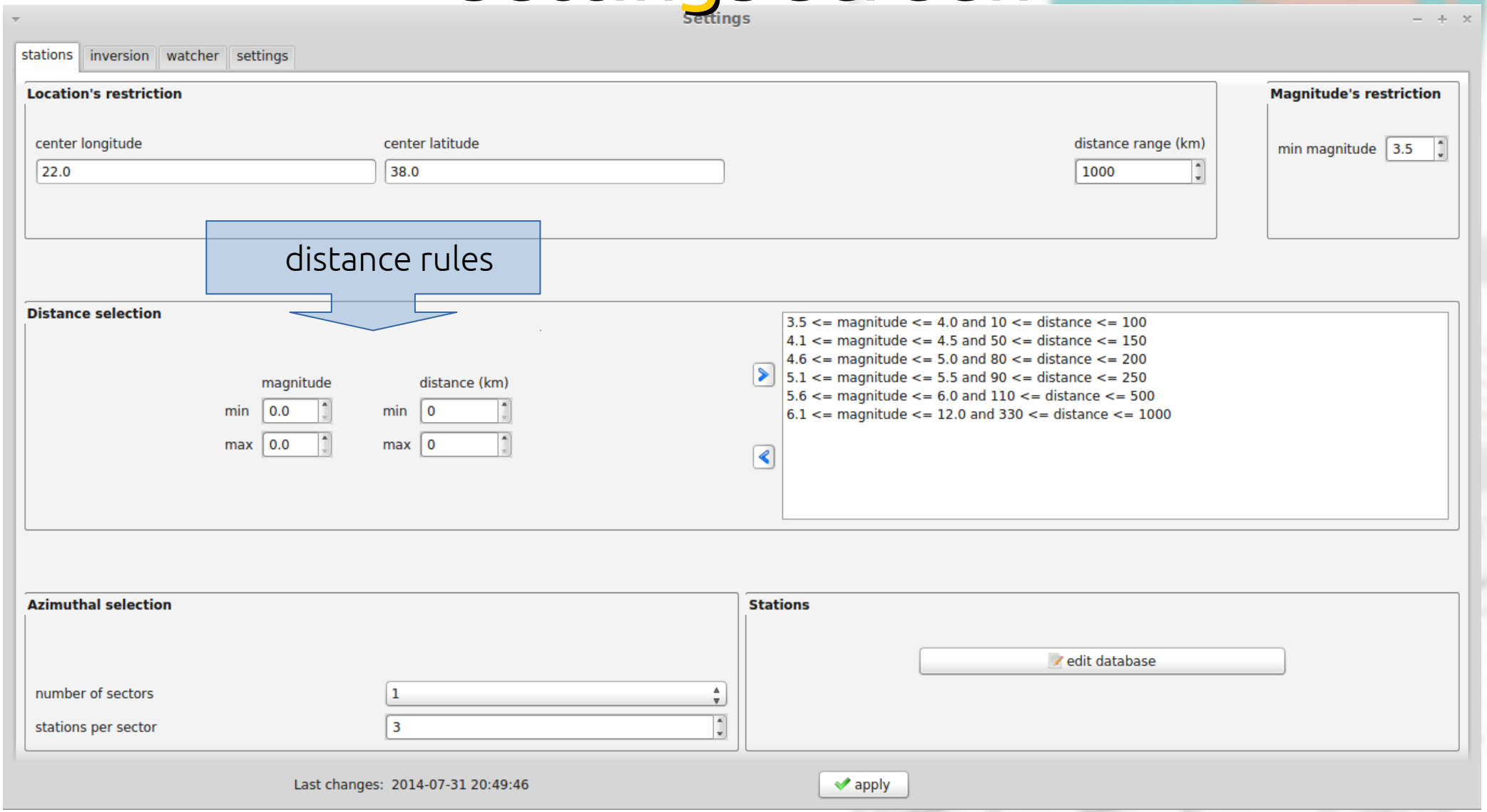
settings screen



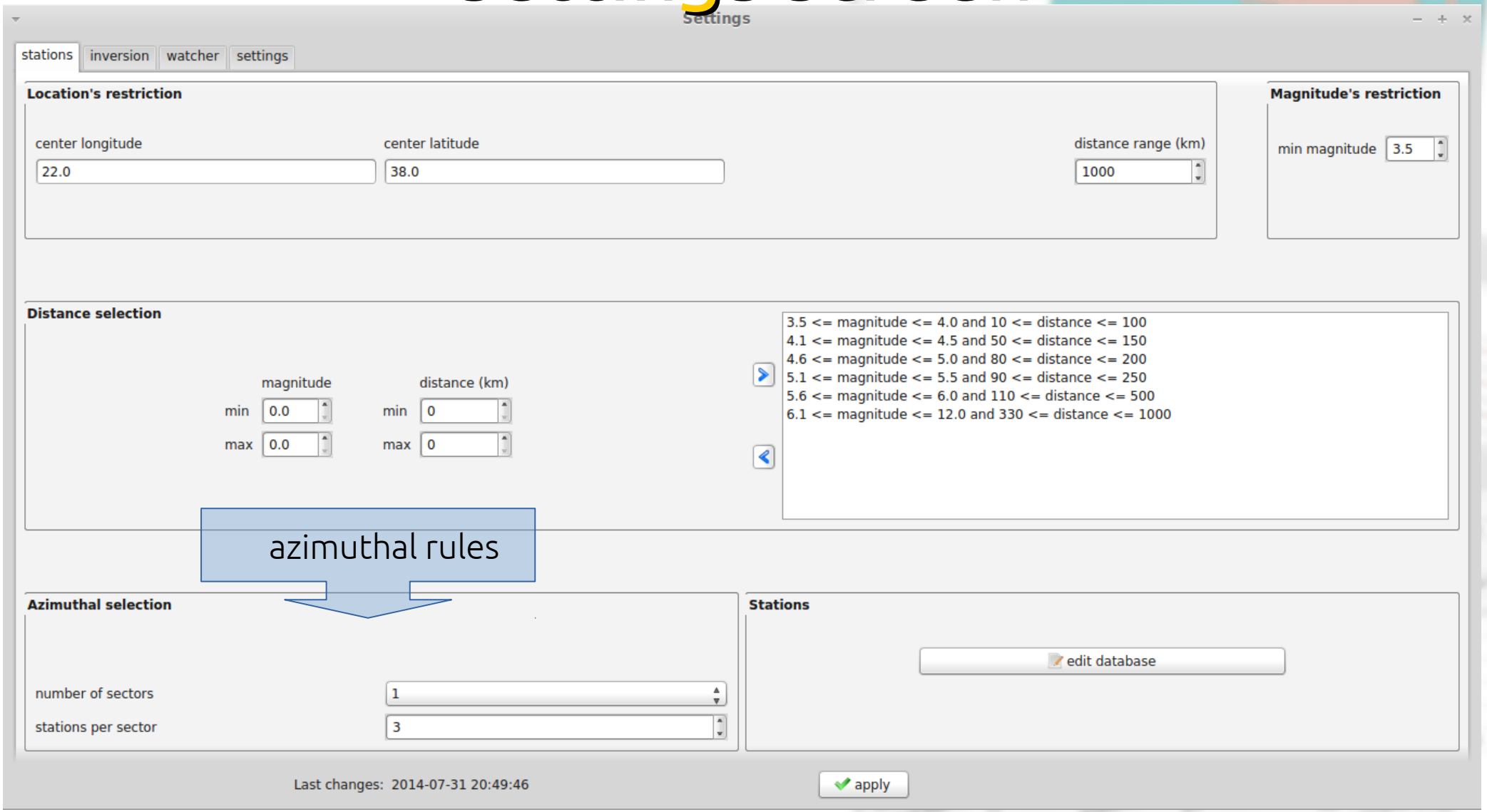
settings screen



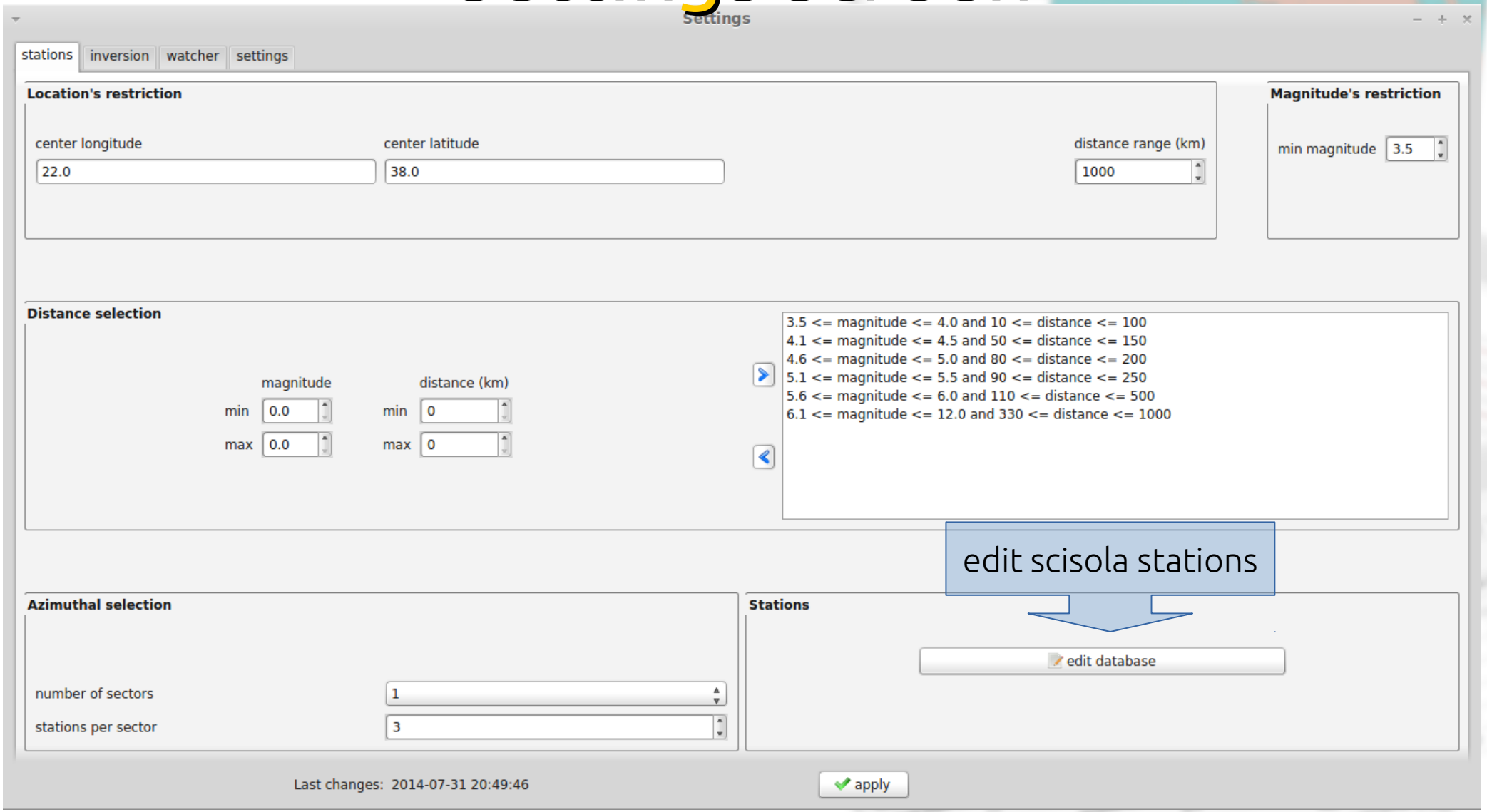
settings screen



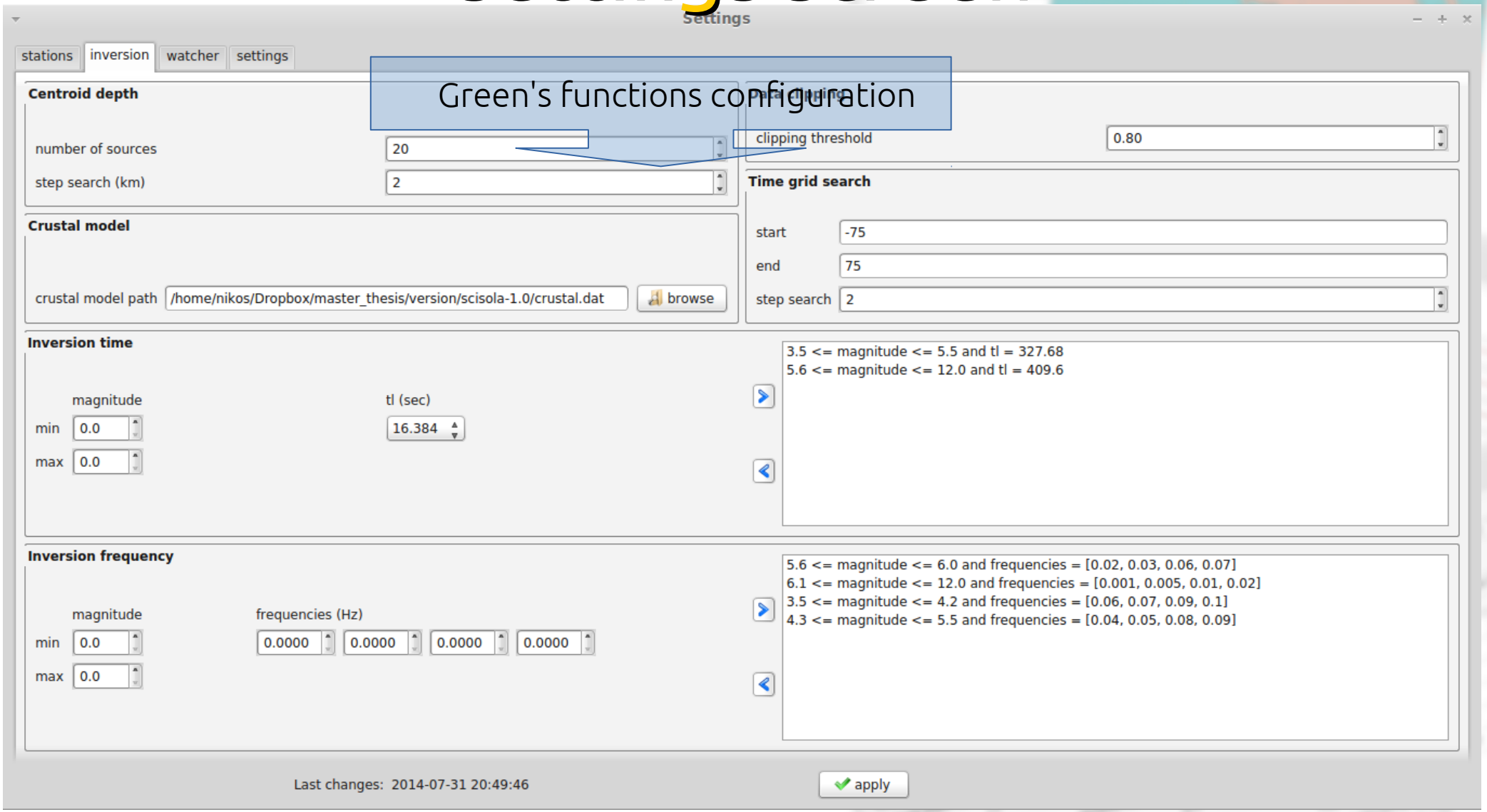
settings screen



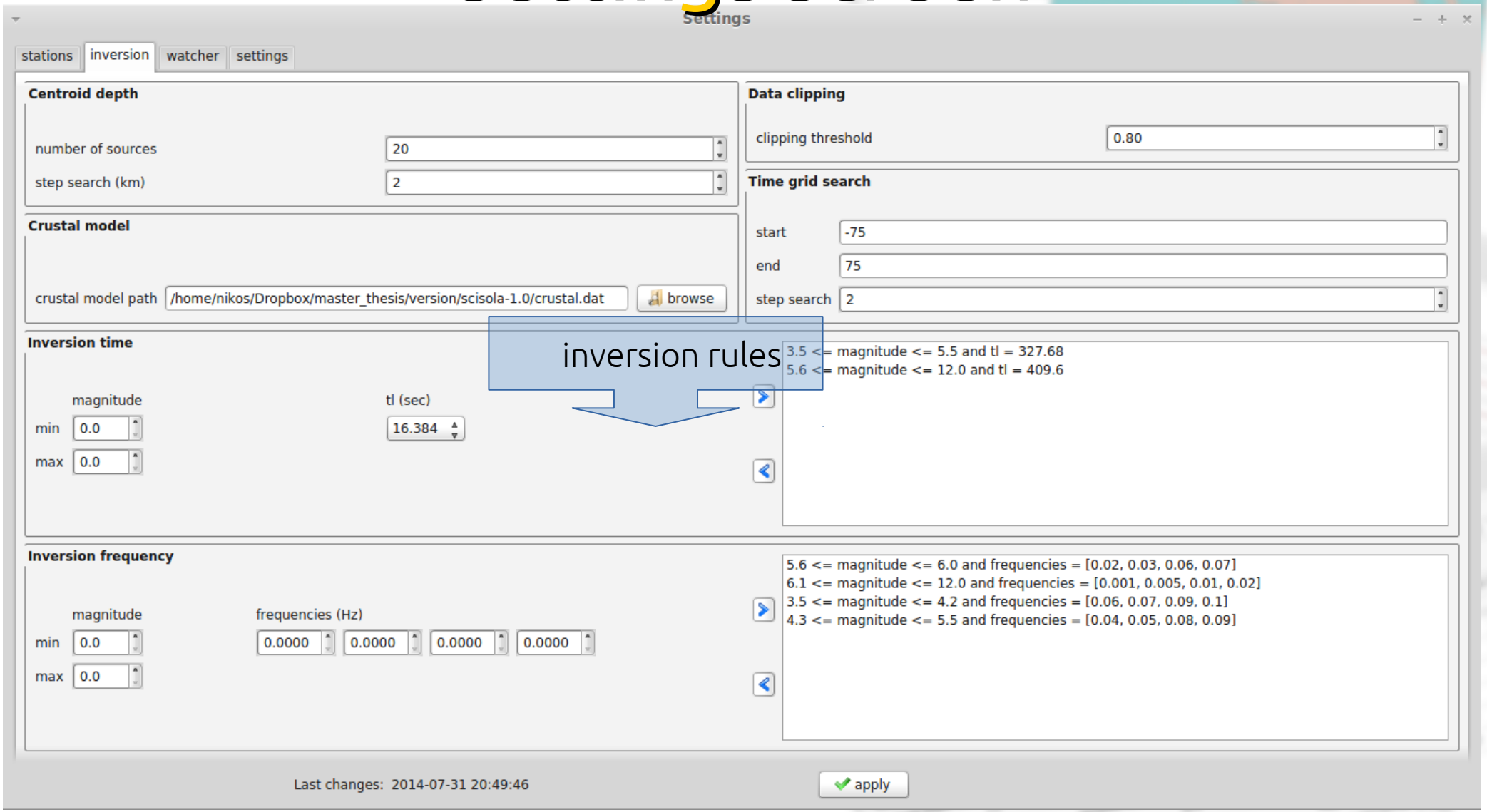
settings screen



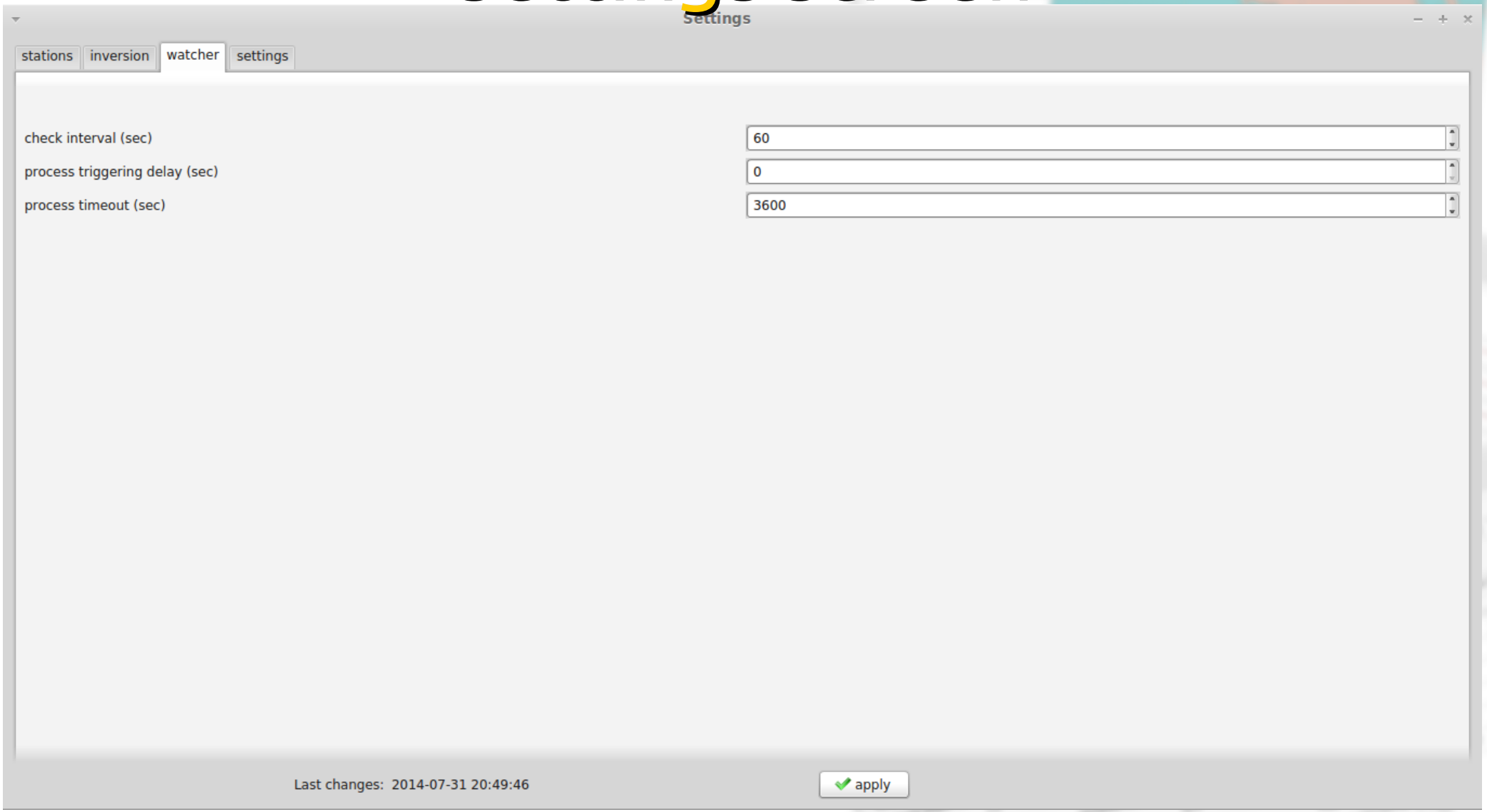
settings screen



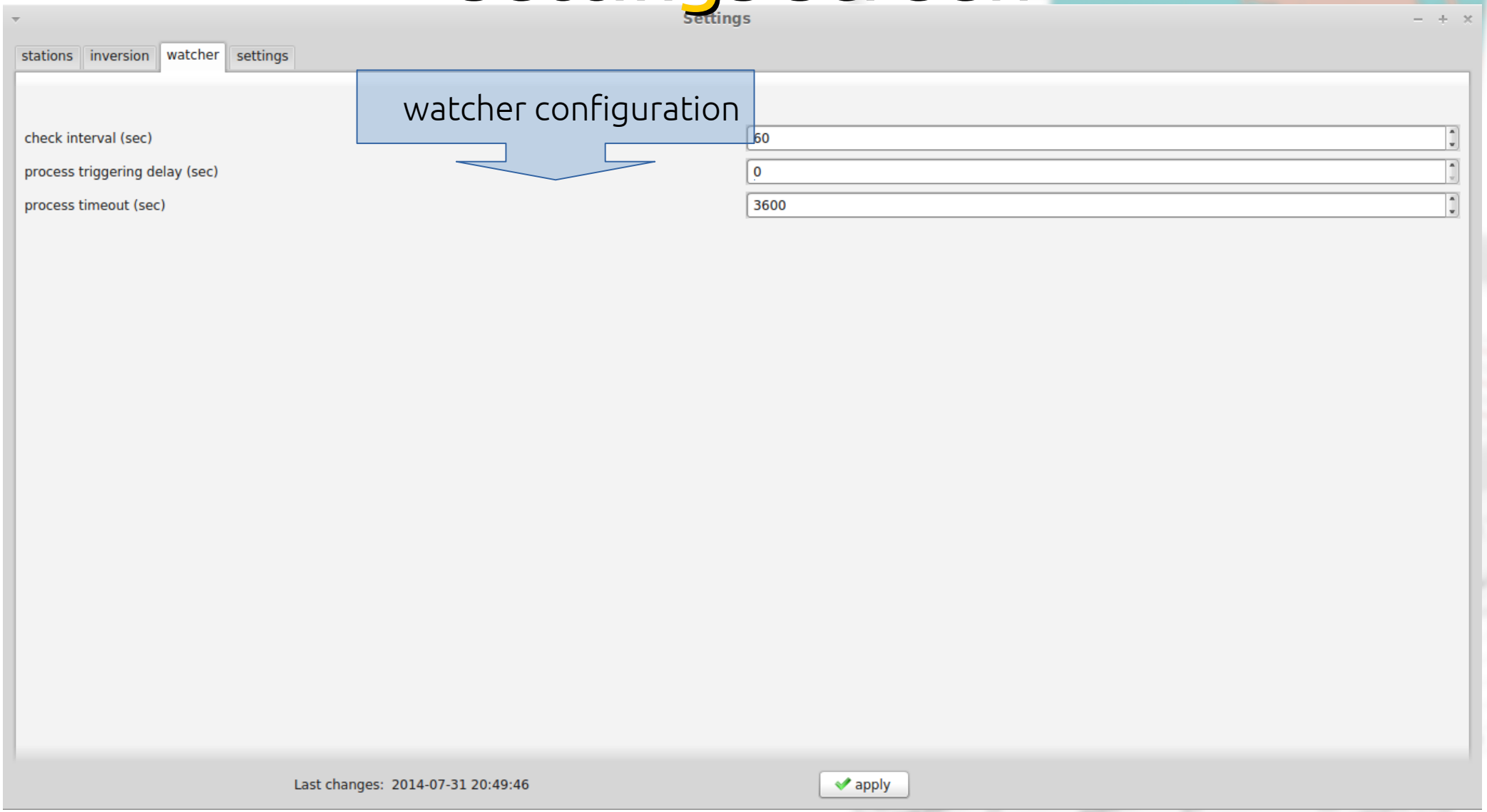
settings screen



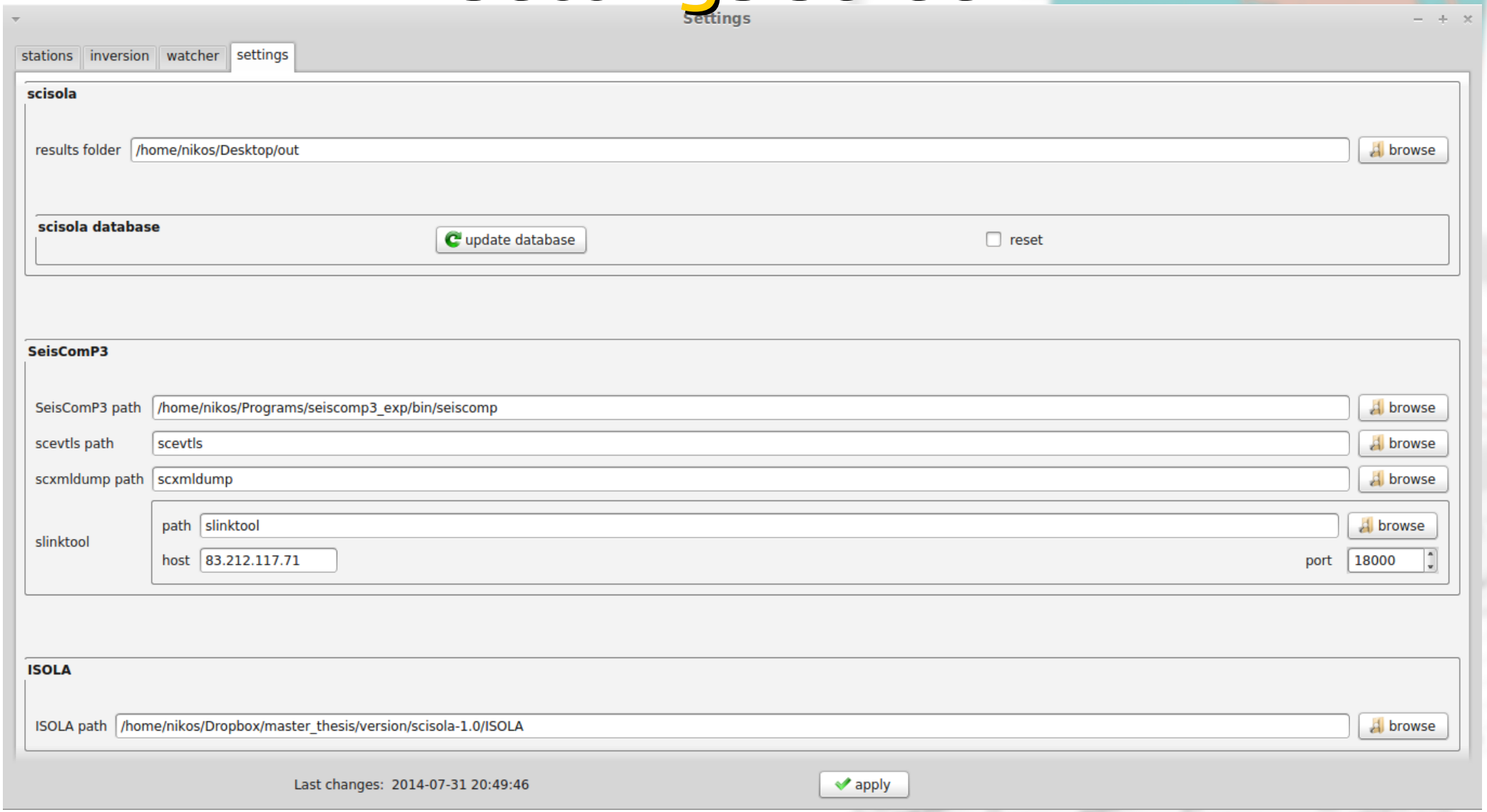
settings screen



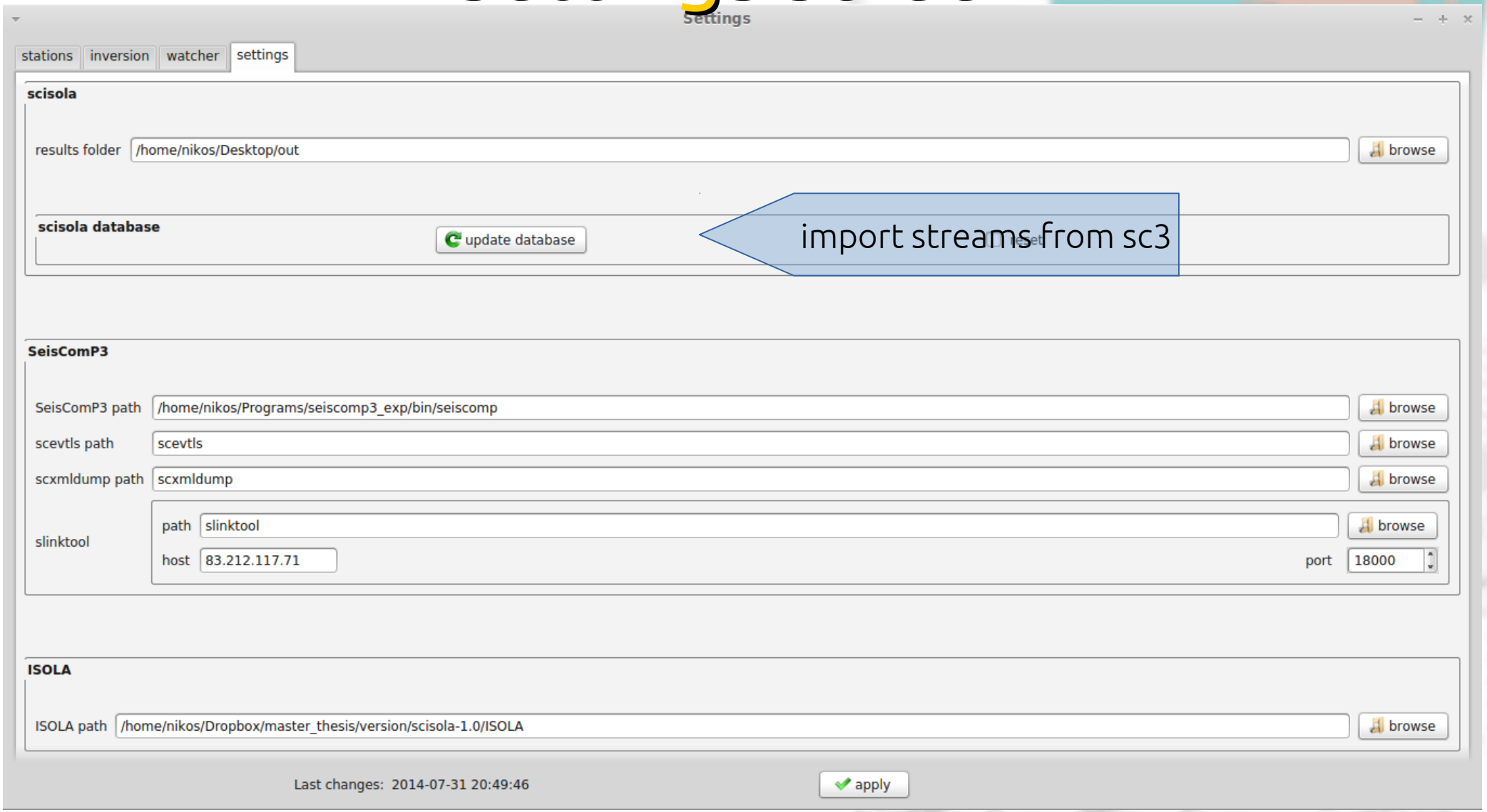
settings screen



settings screen



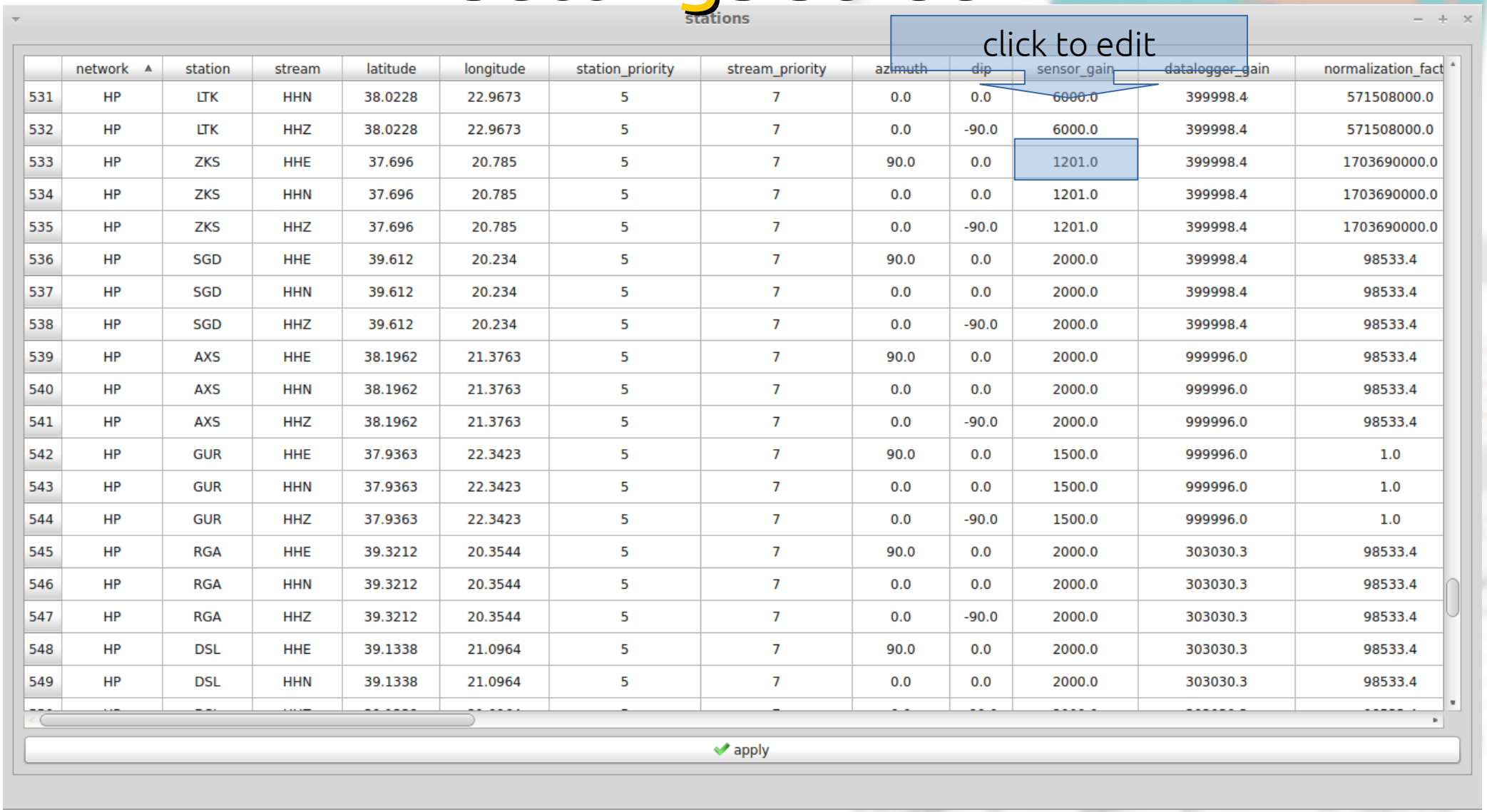
settings screen



settings screen

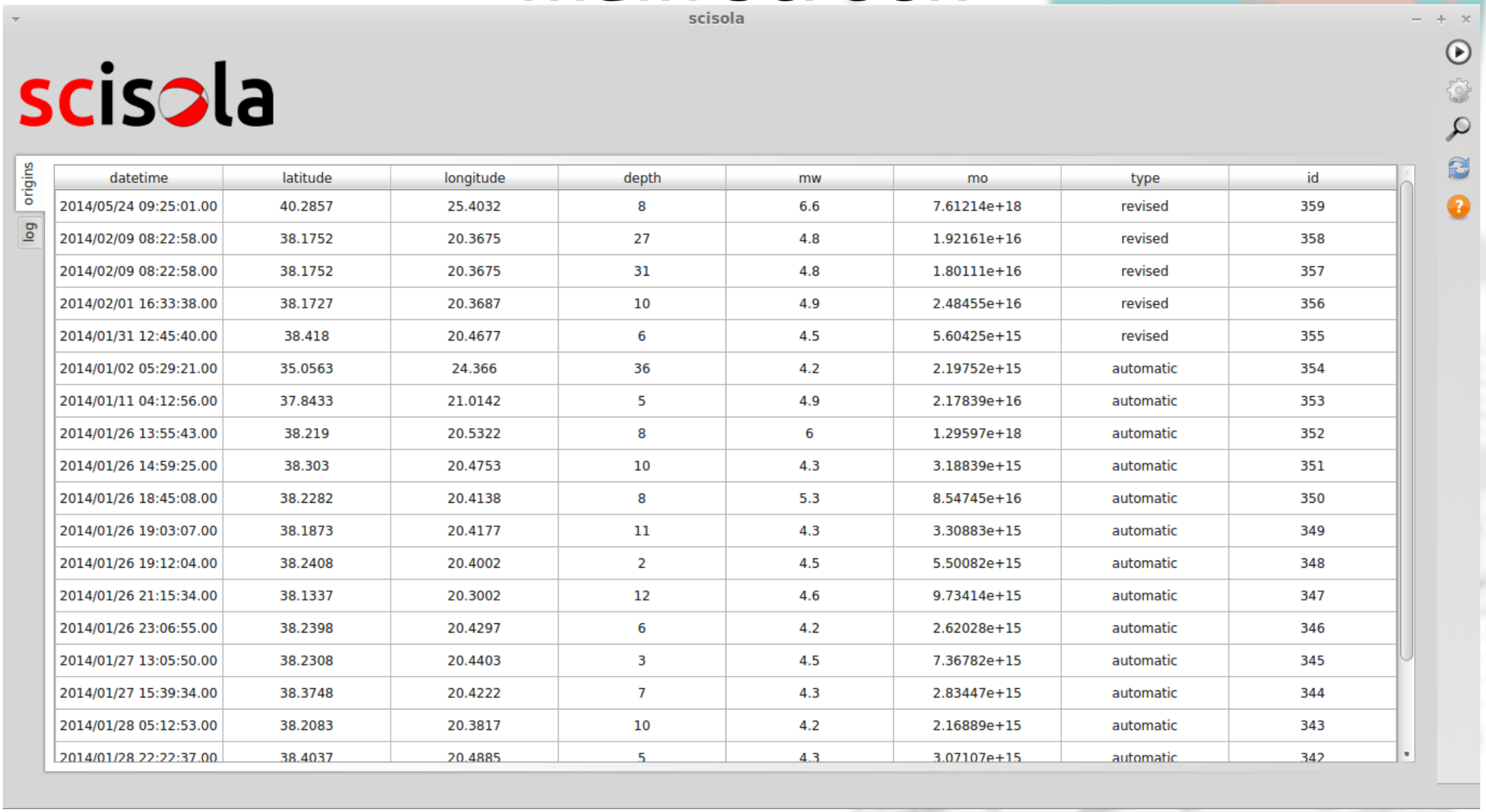
	network	station	stream	latitude	longitude	station_priority	stream_priority	azimuth	dip	sensor_gain	datalogger_gain	normalization_fact
531	HP	LTK	HHN	38.0228	22.9673	5	7	0.0	0.0	6000.0	399998.4	571508000.0
532	HP	LTK	HHZ	38.0228	22.9673	5	7	0.0	-90.0	6000.0	399998.4	571508000.0
533	HP	ZKS	HHE	37.696	20.785	5	7	90.0	0.0	1201.0	399998.4	1703690000.0
534	HP	ZKS	HHN	37.696	20.785	5	7	0.0	0.0	1201.0	399998.4	1703690000.0
535	HP	ZKS	HHZ	37.696	20.785	5	7	0.0	-90.0	1201.0	399998.4	1703690000.0
536	HP	SGD	HHE	39.612	20.234	5	7	90.0	0.0	2000.0	399998.4	98533.4
537	HP	SGD	HHN	39.612	20.234	5	7	0.0	0.0	2000.0	399998.4	98533.4
538	HP	SGD	HHZ	39.612	20.234	5	7	0.0	-90.0	2000.0	399998.4	98533.4
539	HP	AXS	HHE	38.1962	21.3763	5	7	90.0	0.0	2000.0	999996.0	98533.4
540	HP	AXS	HHN	38.1962	21.3763	5	7	0.0	0.0	2000.0	999996.0	98533.4
541	HP	AXS	HHZ	38.1962	21.3763	5	7	0.0	-90.0	2000.0	999996.0	98533.4
542	HP	GUR	HHE	37.9363	22.3423	5	7	90.0	0.0	1500.0	999996.0	1.0
543	HP	GUR	HHN	37.9363	22.3423	5	7	0.0	0.0	1500.0	999996.0	1.0
544	HP	GUR	HHZ	37.9363	22.3423	5	7	0.0	-90.0	1500.0	999996.0	1.0
545	HP	RGA	HHE	39.3212	20.3544	5	7	90.0	0.0	2000.0	303030.3	98533.4
546	HP	RGA	HHN	39.3212	20.3544	5	7	0.0	0.0	2000.0	303030.3	98533.4
547	HP	RGA	HHZ	39.3212	20.3544	5	7	0.0	-90.0	2000.0	303030.3	98533.4
548	HP	DSL	HHE	39.1338	21.0964	5	7	90.0	0.0	2000.0	303030.3	98533.4
549	HP	DSL	HHN	39.1338	21.0964	5	7	0.0	0.0	2000.0	303030.3	98533.4

settings screen



	network	station	stream	latitude	longitude	station_priority	stream_priority	azimuth	dip	sensor_gain	datalogger_gain	normalization_fact
531	HP	LTK	HHN	38.0228	22.9673	5	7	0.0	0.0	6000.0	399998.4	571508000.0
532	HP	LTK	HHZ	38.0228	22.9673	5	7	0.0	-90.0	6000.0	399998.4	571508000.0
533	HP	ZKS	HHE	37.696	20.785	5	7	90.0	0.0	1201.0	399998.4	1703690000.0
534	HP	ZKS	HHN	37.696	20.785	5	7	0.0	0.0	1201.0	399998.4	1703690000.0
535	HP	ZKS	HHZ	37.696	20.785	5	7	0.0	-90.0	1201.0	399998.4	1703690000.0
536	HP	SGD	HHE	39.612	20.234	5	7	90.0	0.0	2000.0	399998.4	98533.4
537	HP	SGD	HHN	39.612	20.234	5	7	0.0	0.0	2000.0	399998.4	98533.4
538	HP	SGD	HHZ	39.612	20.234	5	7	0.0	-90.0	2000.0	399998.4	98533.4
539	HP	AXS	HHE	38.1962	21.3763	5	7	90.0	0.0	2000.0	999996.0	98533.4
540	HP	AXS	HHN	38.1962	21.3763	5	7	0.0	0.0	2000.0	999996.0	98533.4
541	HP	AXS	HHZ	38.1962	21.3763	5	7	0.0	-90.0	2000.0	999996.0	98533.4
542	HP	GUR	HHE	37.9363	22.3423	5	7	90.0	0.0	1500.0	999996.0	1.0
543	HP	GUR	HHN	37.9363	22.3423	5	7	0.0	0.0	1500.0	999996.0	1.0
544	HP	GUR	HHZ	37.9363	22.3423	5	7	0.0	-90.0	1500.0	999996.0	1.0
545	HP	RGA	HHE	39.3212	20.3544	5	7	90.0	0.0	2000.0	303030.3	98533.4
546	HP	RGA	HHN	39.3212	20.3544	5	7	0.0	0.0	2000.0	303030.3	98533.4
547	HP	RGA	HHZ	39.3212	20.3544	5	7	0.0	-90.0	2000.0	303030.3	98533.4
548	HP	DSL	HHE	39.1338	21.0964	5	7	90.0	0.0	2000.0	303030.3	98533.4
549	HP	DSL	HHN	39.1338	21.0964	5	7	0.0	0.0	2000.0	303030.3	98533.4

main screen



datetime	latitude	longitude	depth	mw	mo	type	id
2014/05/24 09:25:01.00	40.2857	25.4032	8	6.6	7.61214e+18	revised	359
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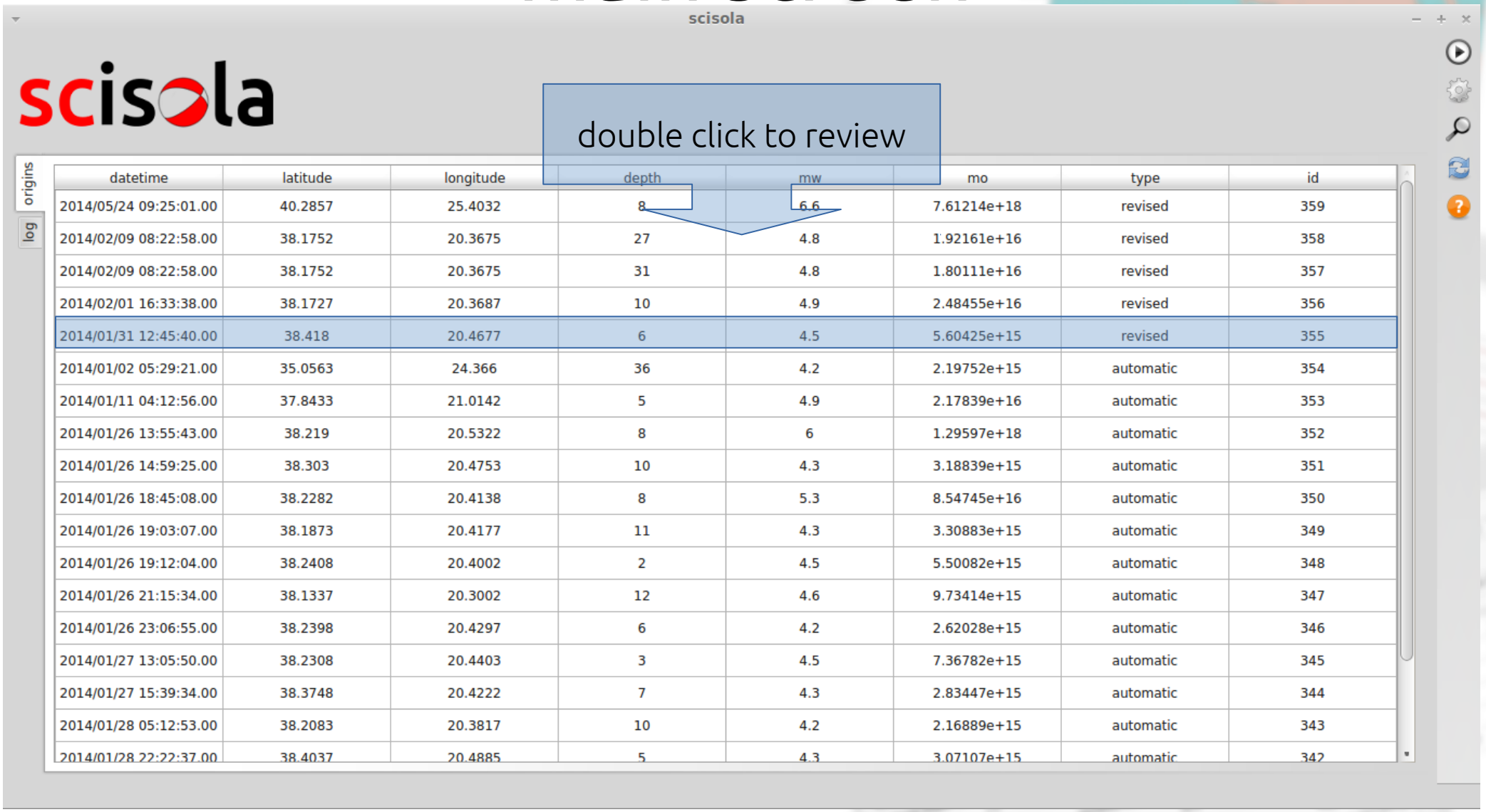
2014/02/09 08:22:58.00	38.1752	20.3675	31	4.8	1.80111e+16	revised	357
2014/02/01 16:33:38.00	38.1727	20.3687	10	4.9	2.48455e+16	revised	356
2014/01/31 12:45:40.00	38.418	20.4677	6	4.5	5.60425e+15	revised	355
2014/01/02 05:29:21.00	35.0563	24.366	36	4.2	2.19752e+15	automatic	354
2014/01/11 04:12:56.00	37.8433	21.0142	5	4.9	2.17839e+16	automatic	353
2014/01/26 13:55:43.00	38.219	20.5322	8	6	1.29597e+18	automatic	352
2014/01/26 14:59:25.00	38.303	20.4753	10	4.3	3.18839e+15	automatic	351
2014/01/26 18:45:08.00	38.2282	20.4138	8	5.3	8.54745e+16	automatic	350
2014/01/26 19:03:07.00	38.1873	20.4177	11	4.3	3.30883e+15	automatic	349
2014/01/26 19:12:04.00	38.2408	20.4002	2	4.5	5.50082e+15	automatic	348
2014/01/26 21:15:34.00	38.1337	20.3002	12	4.6	9.73414e+15	automatic	347
2014/01/26 23:06:55.00	38.2398	20.4297	6	4.2	2.62028e+15	automatic	346
2014/01/27 13:05:50.00	38.2308	20.4403	3	4.5	7.36782e+15	automatic	345
2014/01/27 15:39:34.00	38.3748	20.4222	7	4.3	2.83447e+15	automatic	344
2014/01/28 05:12:53.00	38.2083	20.3817	10	4.2	2.16889e+15	automatic	343
2014/01/28 22:22:37.00	38.4037	20.4885	5	4.3	3.07107e+15	automatic	342

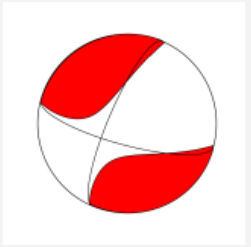
main screen


scisola
scisola
double click to review
origins
log
datetime latitude longitude depth mw mo type id
2014/05/24 09:25:01.00 40.2857 25.4032 8 6.6 7.61214e+18 revised 359
2014/02/09 08:22:58.00 38.1752 20.3675 27 4.8 1.92161e+16 revised 358
2014/02/09 08:22:58.00 38.1752 20.3675 31 4.8 1.80111e+16 revised 357
2014/02/01 16:33:38.00 38.1727 20.3687 10 4.9 2.48455e+16 revised 356
2014/01/31 12:45:40.00 38.418 20.4677 6 4.5 5.60425e+15 revised 355
2014/01/02 05:29:21.00 35.0563 24.366 36 4.2 2.19752e+15 automatic 354
2014/01/11 04:12:56.00 37.8433 21.0142 5 4.9 2.17839e+16 automatic 353
2014/01/26 13:55:43.00 38.219 20.5322 8 6 1.29597e+18 automatic 352
2014/01/26 14:59:25.00 38.303 20.4753 10 4.3 3.18839e+15 automatic 351
2014/01/26 18:45:08.00 38.2282 20.4138 8 5.3 8.54745e+16 automatic 350
2014/01/26 19:03:07.00 38.1873 20.4177 11 4.3 3.30883e+15 automatic 349
2014/01/26 19:12:04.00 38.2408 20.4002 2 4.5 5.50082e+15 automatic 348
2014/01/26 21:15:34.00 38.1337 20.3002 12 4.6 9.73414e+15 automatic 347
2014/01/26 23:06:55.00 38.2398 20.4297 6 4.2 2.62028e+15 automatic 346
2014/01/27 13:05:50.00 38.2308 20.4403 3 4.5 7.36782e+15 automatic 345
2014/01/27 15:39:34.00 38.3748 20.4222 7 4.3 2.83447e+15 automatic 344
2014/01/28 05:12:53.00 38.2083 20.3817 10 4.2 2.16889e+15 automatic 343
2014/01/28 22:22:37.00 38.4037 20.4885 5 4.3 3.07107e+15 automatic 342

review screen

review

results | map | misfit | inversion | correlation | streams | text | log



Event ID dataset **Origin ID** 360

Origin Timestamp 2014-10-01 11:58:23.071589 **Type** revised

Origin Date (GMT)	2014/02/01	**Origin Time (GMT)**	16:33:38.00
Centroid Longitude	20.3687	**Centroid Latitude**	38.1727
Centroid Depth (km)	10.0	**Centroid Time (sec)**	2.76
Mw	4.9	**Moment (Nm)**	2.48454817e+16

Correlation 0.773009 **Variance Reduction** 0.380912721

VOL (%) -0.0 **DC (%)** 68.4 **CLVD (%)** 31.6

Mrr -8.4149e+15 **Mtt** 1.83137e+16 **Mpp** -9.8988e+15

Mrt -2.0432e+15 **Mrp** 7.5847e+15 **Mtp** 1.74213e+16

	NP1	NP2
Strike	203.0	105.0
Dip	71.0	68.0
Rake	-157.0	-19.0

	Azimuth	Plunge
P-axis	65.0	28.0
T-axis	334.0	2.0
B-axis	239.0	61.0

Min Singular Value 6.64989791e-16 **Max Singular Value** 1.22019617e-15 **Condition Number** 1.83490968

STVAR 0.2 **FMVAR** 11.9491111111

Revision

Freq Band (Hz) 0.0400 - 0.0500 **and** 0.0800 - 0.0900

tapered **tapered**

Stream Contribution (variance reduction per component)

	Network	Station	N	E	Z
1	HT	LKD2	0.67	0.91	-0.45
2	HL	RLS	0.82	0.29	-0.57
3	HP	PVO	0.47	0.13	0.65
4	HP	DRO	0.81	-0.62	-3.93
5	HP	AMT	-1.2	0.46	0.3
6	HP	ANX	-1.02	0.49	0.95

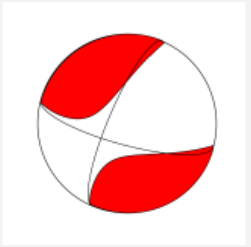
all delete revise

review screen

review tabs

review

results | map | misfit | inversion | correlation | streams | text | log



Event ID dataset

Origin ID 360

Origin Timestamp 2014-10-01 11:58:23.071589

Type revised

Origin Date (GMT)	2014/02/01	**Origin Time (GMT)**	16:33:38.00
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B-axis	239.0	61.0

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STVAR 0.2 **FMVAR** 11.9491111111

Revision

Freq Band (Hz) 0.0400 - 0.0500 **and** 0.0800 - 0.0900

tapered tapered

Stream Contribution (variance reduction per component)

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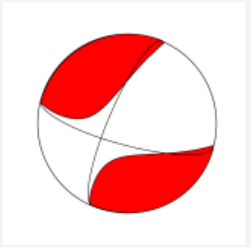
all delete revise

review screen

revision

review

results | map | misfit | inversion | correlation | streams | text | log



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Revision

Freq Band (Hz) 0.0400 - 0.0500 **tapered** and 0.0800 - 0.0900 **tapered**

Stream Contribution (variance reduction per component)

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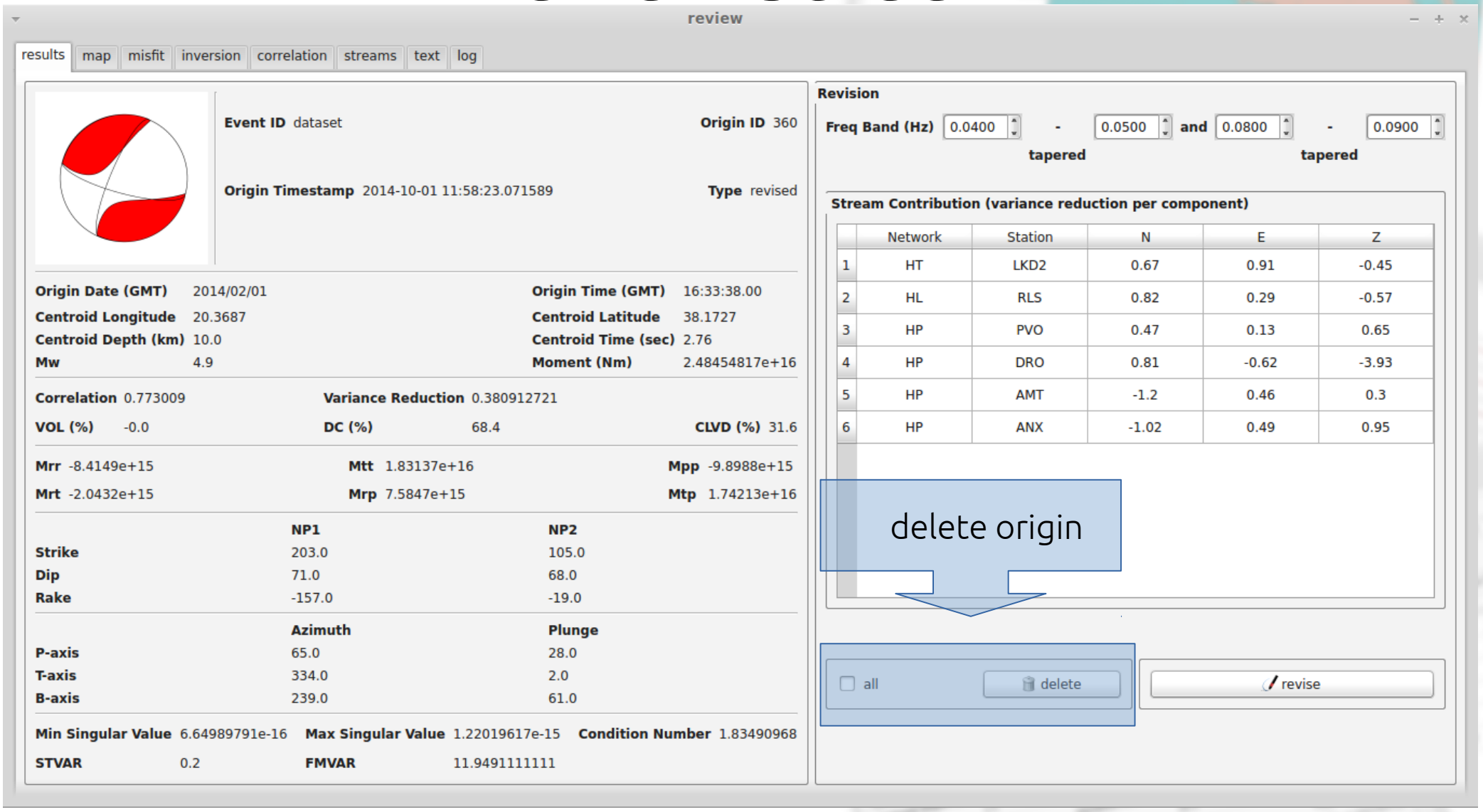
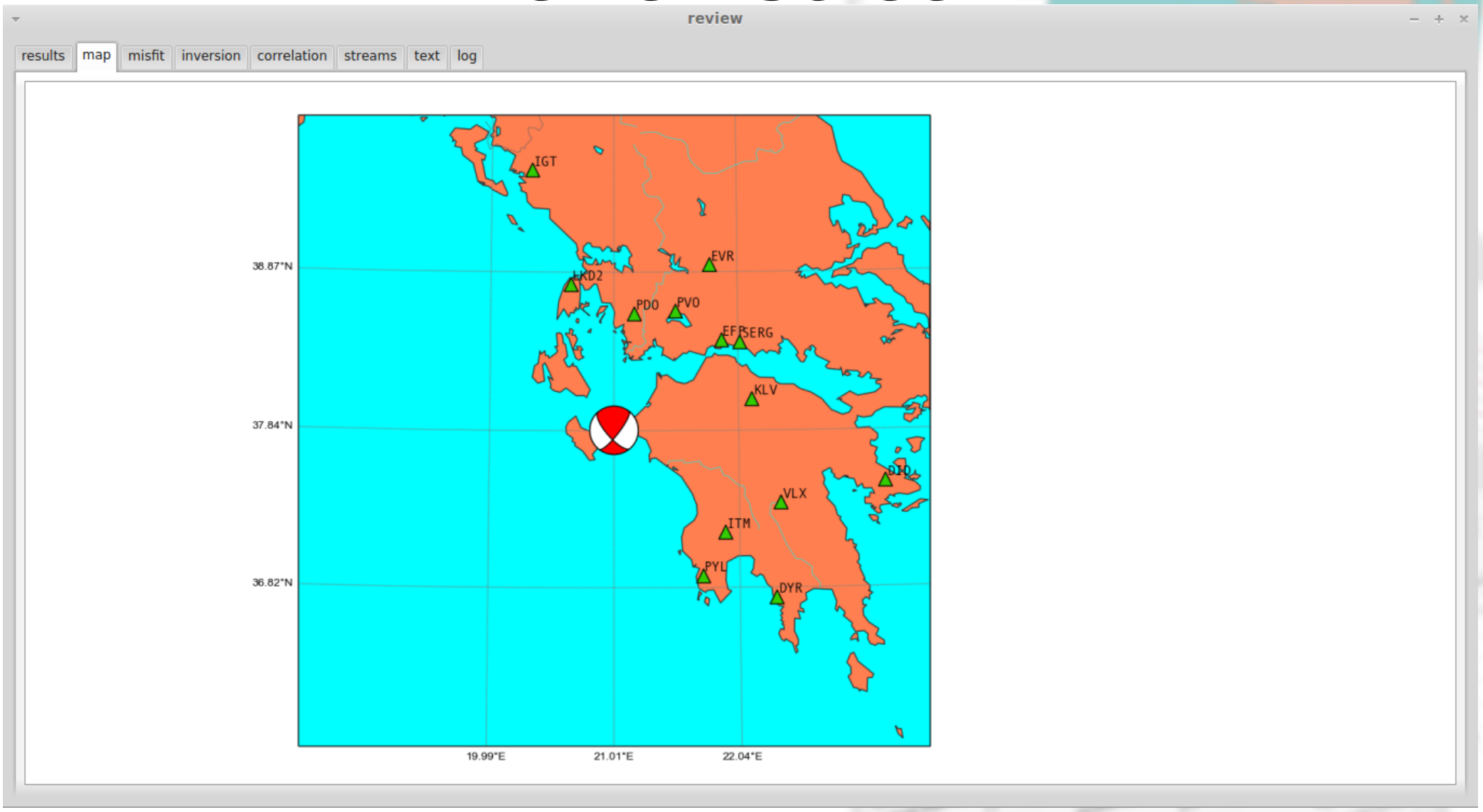
all delete revise

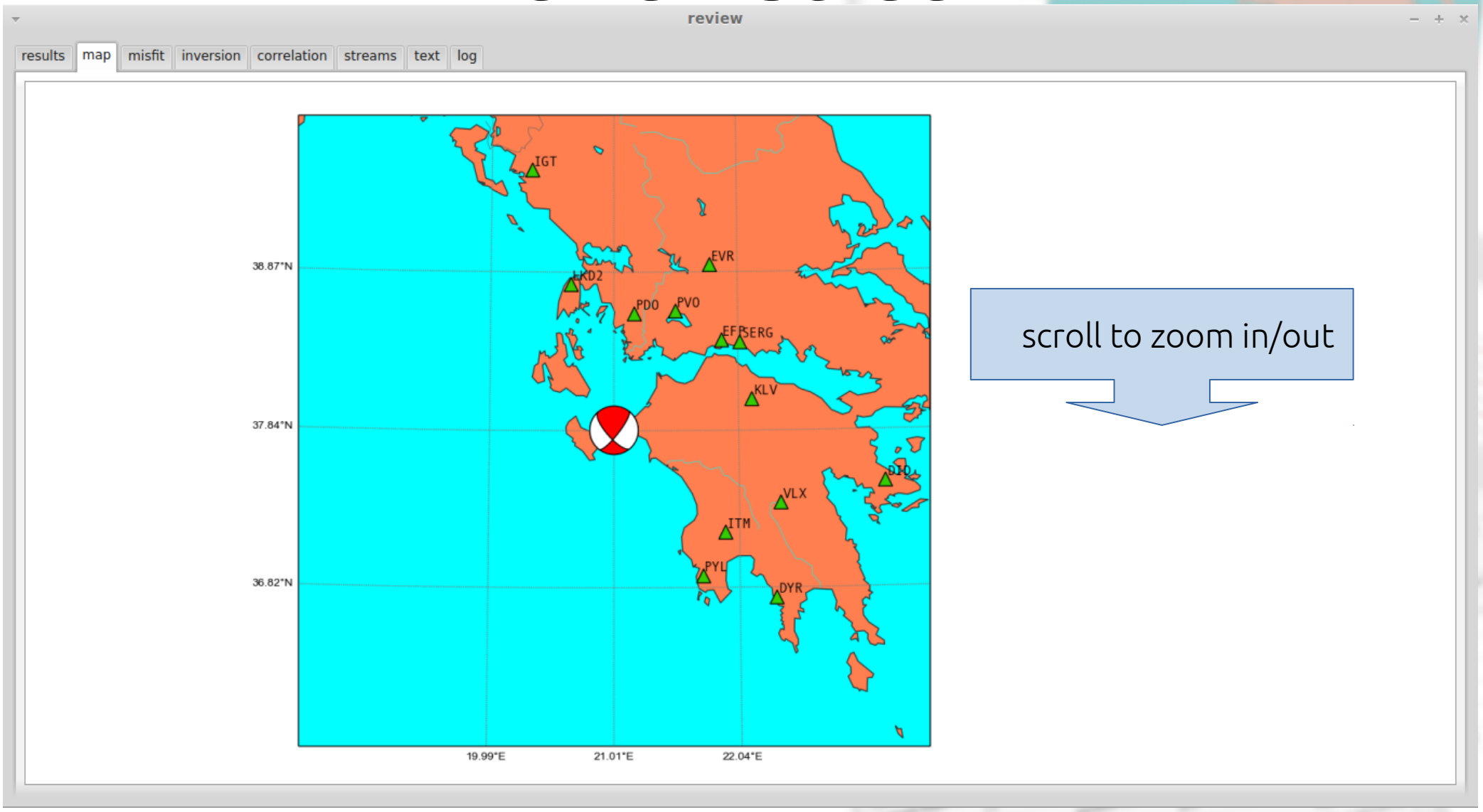
review screen



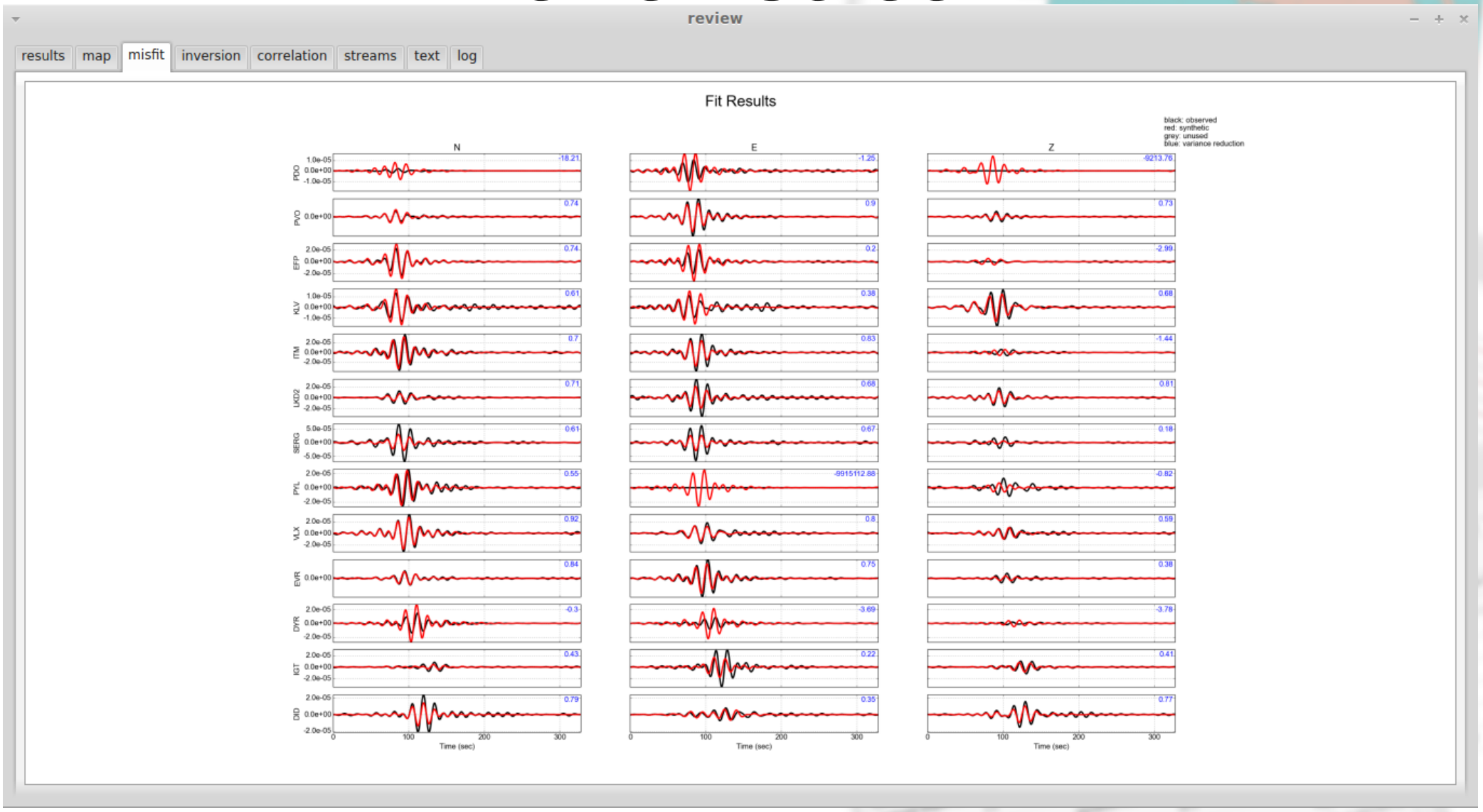
review screen



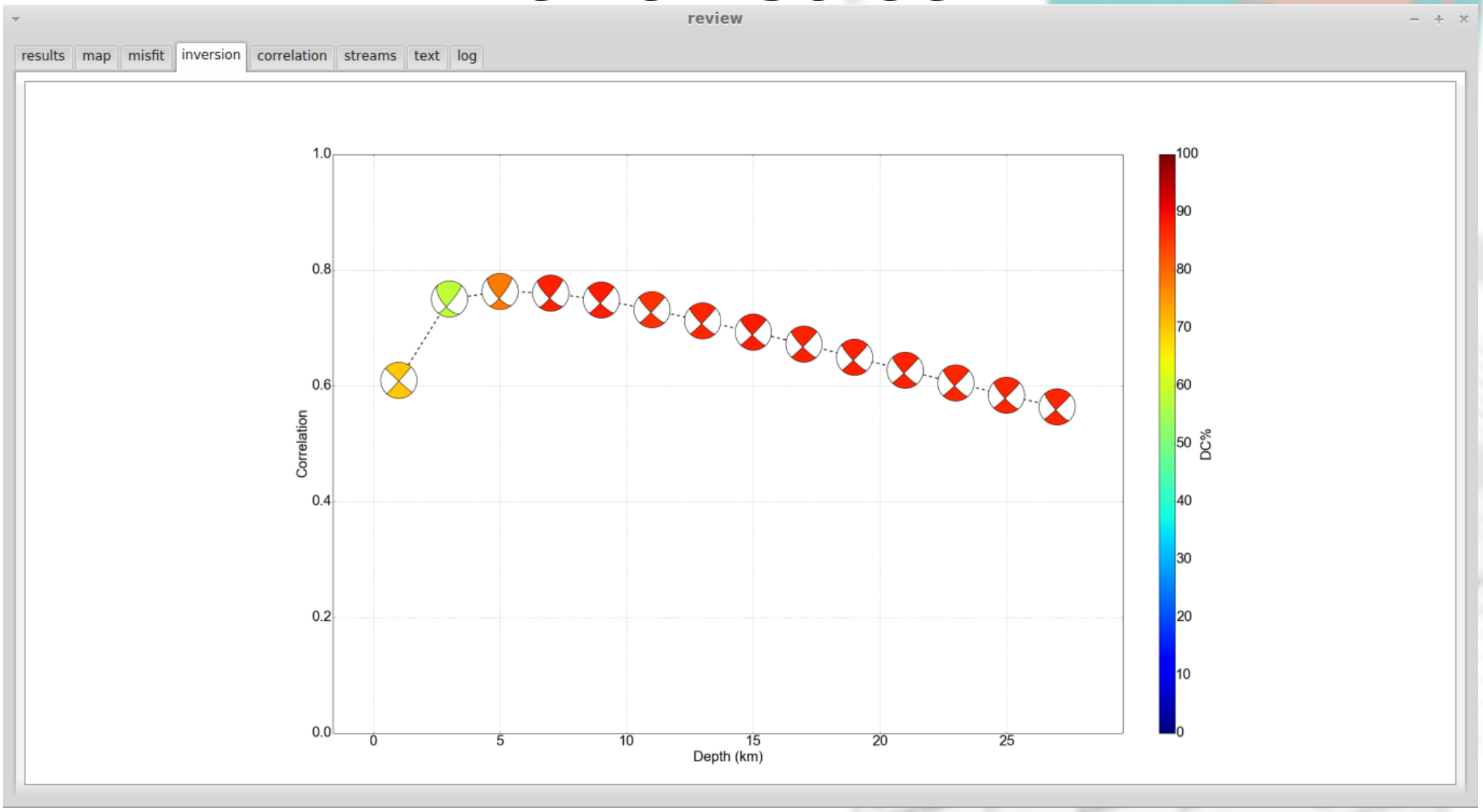
review screen



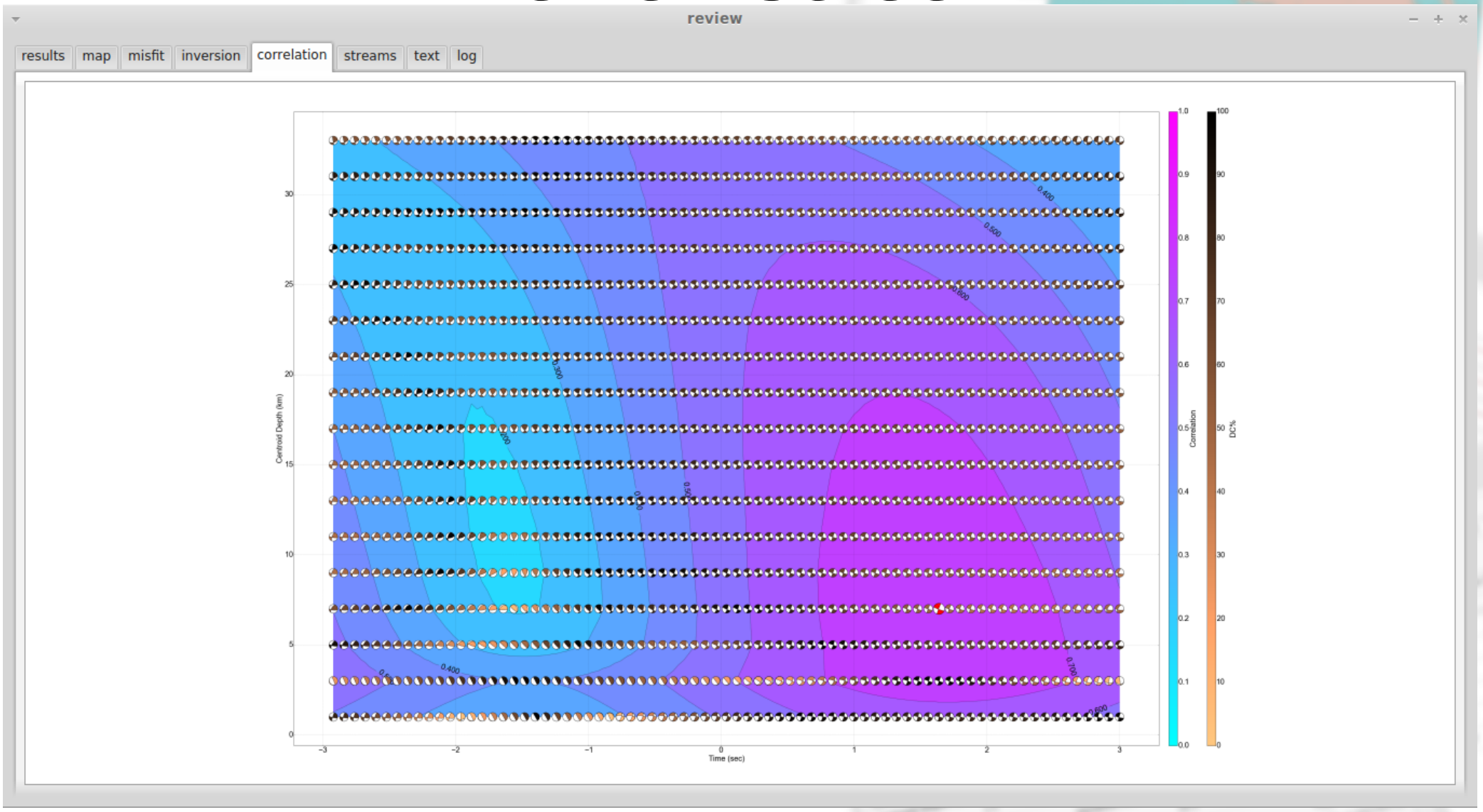
review screen



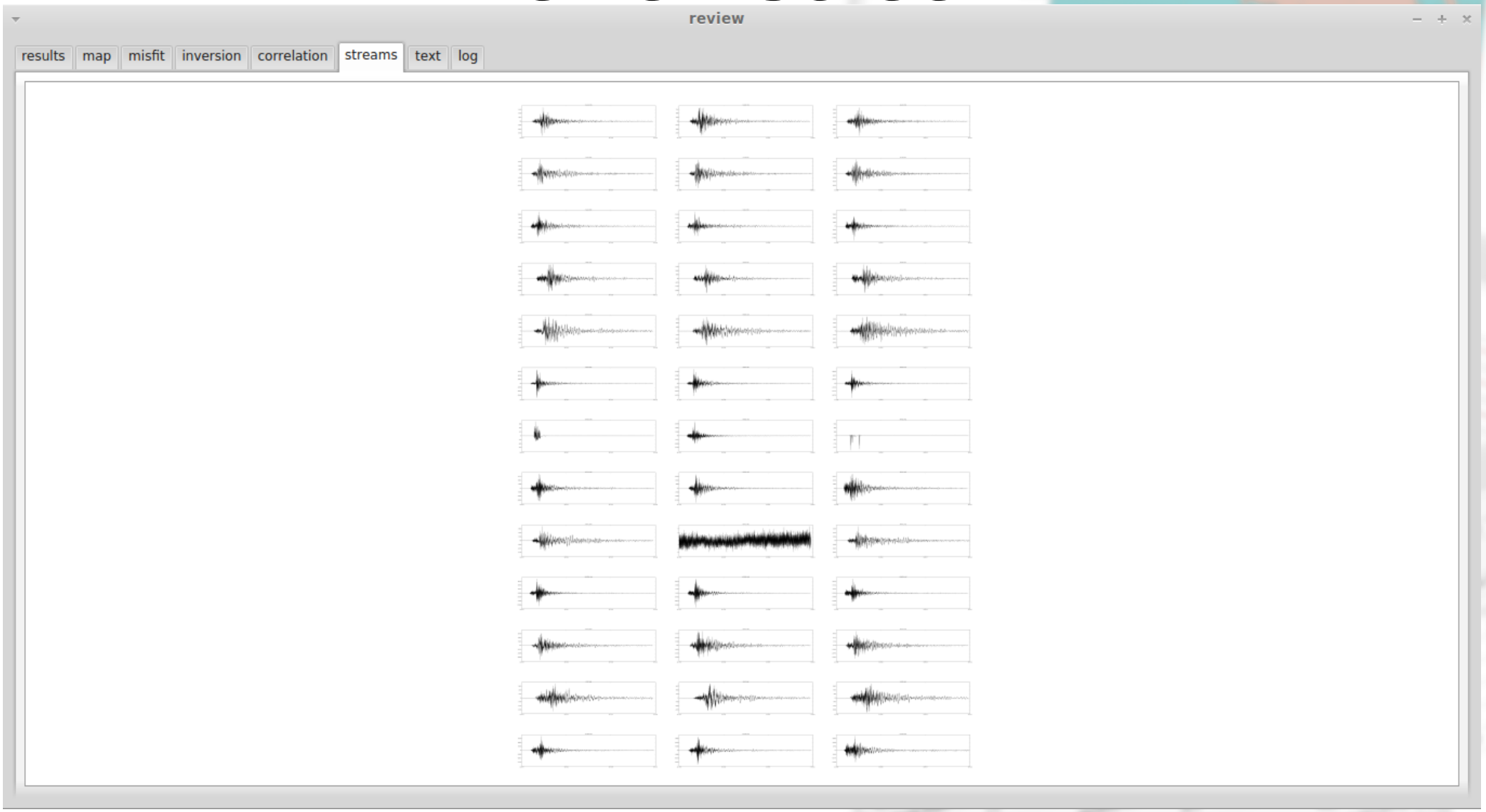
review screen



review screen



review screen



review screen

review

results | map | misfit | inversion | correlation | streams | text | log

```
=====================================================
==================== Automatic ======================
============== Moment Tensor Solution ===============
=====================================================

Origin Time: 20140111 04:12:56.000000
Latitude: 37.8433 Longitude: 21.0142
Depth (km): 7
Mw: 4.9

=====================================================
Centroid Solution
Centroid Time: 3.0 (sec) relative to origin time
Centroid Latitude: 37.8433 Longitude: 21.0142
Centroid Depth (km): 5

=====================================================
No of Stations: 13
Stations N        E         Z
HP.PDO            -18.21    -1.25     -9213.76
HP.PVO            0.74      0.9       0.73
HP.EFP            0.74      0.2       -2.99
HL.KLV            0.61      0.38      0.68
HL.ITM            0.7       0.83      -1.44
HT.LKD2           0.71      0.68      0.81
HP.SERG           0.61      0.67      0.18
HP.PYL            0.55      -9915112.88        -0.82
HP.VLX            0.92      0.8       0.59
HL.EVR            0.84      0.75      0.38
HP.DYR            -0.3      -3.69     -3.78
HT.IGT            0.43      0.22      0.41
HP.DID            0.79      0.35      0.77

Freq band (Hz)
0.05-0.08 tapered 0.04-0.05 and 0.08-0.09
Variance Reduction (%): 0.581956744
```

review screen

review

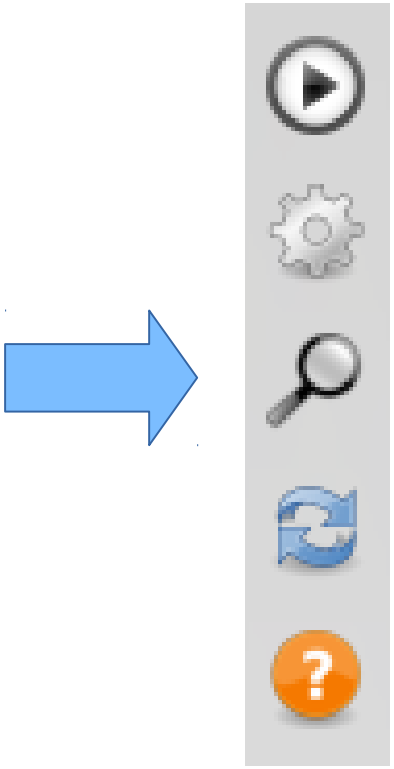
results | map | misfit | inversion | correlation | streams | text | log

2014-07-17 18:32:01,339 INFO - Working directory is set to: /home/nikos/Desktop/out/20140111_041256000000/20140717_153201332480

2014-07-17 18:32:01,340 INFO - Origin's parameters:
datetime: 2014/01/11 04:12:56.00
latitude: 37.8433
longitude: 21.0142
magnitude: 4.7
depth: 7
timestamp: 2014-07-17 15:32:01.332480
event_id: dataset

2014-07-17 18:32:01,340 INFO - Settings's parameters:
time_grid_step: 2
distance_range: 1000
time_grid_end: 75
stations_per_sector: 3
sources: 20
clipping_threshold: 0.8
seedlink_host: 83.212.117.71
sc3_path: /home/nikos/Programs/seiscomp3_exp/bin/seiscomp
source_step: 2
sc3_scxmldump: scxmldump
process_timeout: 3600
inversion_time: [[3.5, 5.5, 327.68], [5.6, 12.0, 409.6]]
id: 1
crustal_model_path: /home/nikos/Dropbox/master_thesis/version/scisola-1.0/crustal.dat
output_dir: /home/nikos/Desktop/out
center_latitude: 38.0
time_grid_start: -75
min_sectors: 1
timestamp: 2014-07-17 09:57:09
process_delay: 0
seedlink_port: 18000
distance_selection: [[3.5, 4.0, 10, 100], [4.1, 4.5, 50, 150], [4.6, 5.0, 80, 200], [5.1, 5.5, 90, 250], [5.6, 6.0, 110, 500], [6.1, 12.0, 330, 1000]]
sc3_scevtls: scevtls
watch_interval: 60
isola_path: /home/nikos/Dropbox/master_thesis/version/scisola-1.0/ISOLA
magnitude_threshold: 3.5
center_longitude: 22.0

main buttons



- start/stop watcher
- settings screen
- search screen
- update latest 20 origins
- about screen

search screen

shows origins defined by datetime (GMT) range

main screen

datetime	latitude	longitude	depth	mw	mo	type	id
2014/05/24 09:25:01.00	40.2857	25.4032	8	6.6	7.61214e+18	revised	359
2014/02/09 08:22:58.00	38.1752	20.3675	27	4.8	1.92161e+16	revised	358
2014/02/09 08:22:58.00	38.1752	20.3675	31	4.8	1.80111e+16	revised	357
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2014/01/11 04:12:56.00	37.8433	21.0142	5	4.9	2.17839e+16	automatic	353
2014/01/26 13:55:43.00	38.219	20.5322	8	6	1.29597e+18	automatic	352
2014/01/26 14:59:25.00	38.303	20.4753	10	4.3	3.18839e+15	automatic	351
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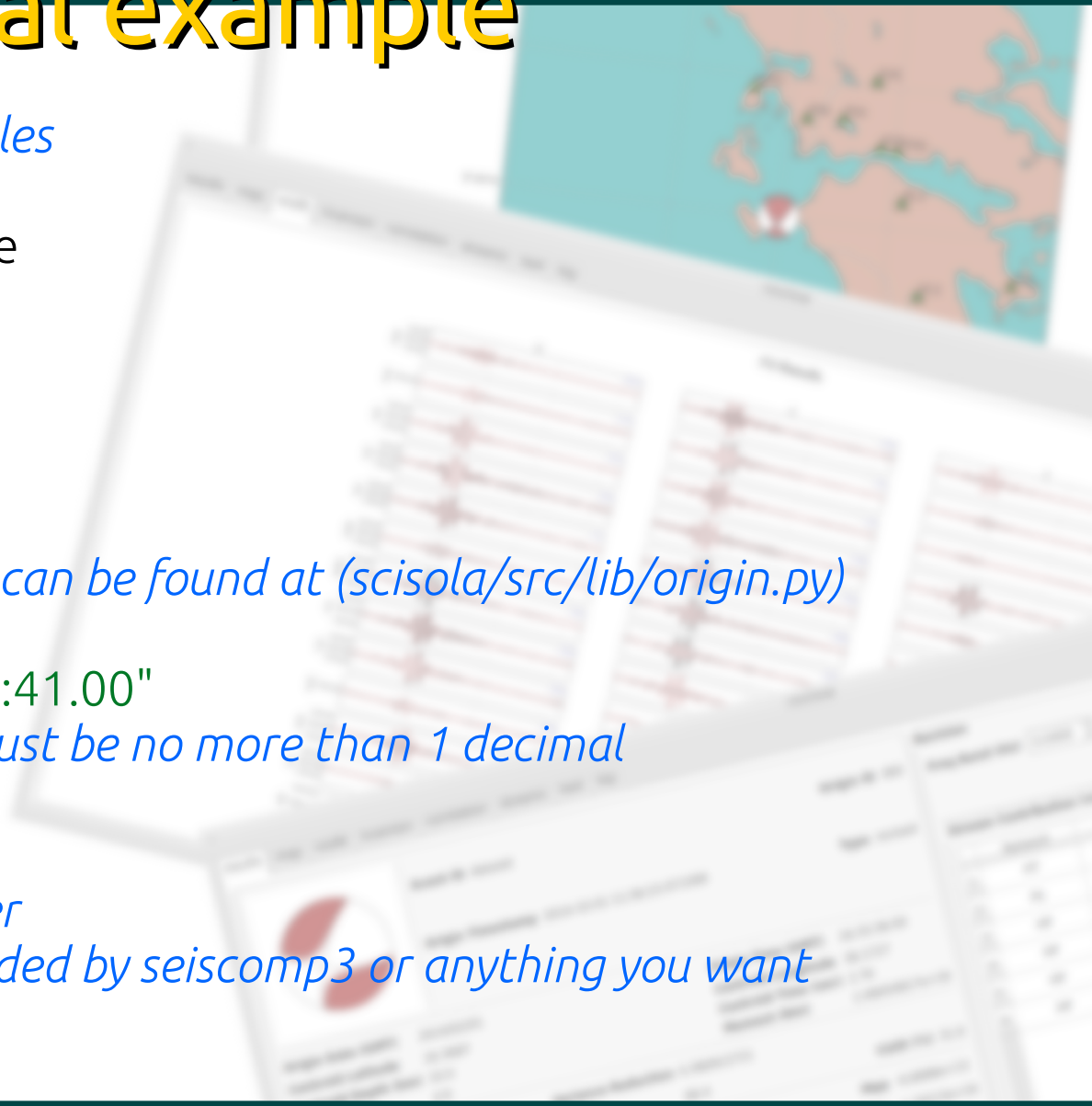
2014/01/26 19:03:07.00	38.1873	20.4177	11	4.3	3.30883e+15	automatic	349
2014/01/26 19:12:04.00	38.2408	20.4002	2	4.5	5.50082e+15	automatic	348
2014/01/26 21:15:34.00	38.1337	20.3002	12	4.6	9.73414e+15	automatic	347
2014/01/26 23:06:55.00	38.2398	20.4297	6	4.2	2.62028e+15	automatic	346
2014/01/27 13:05:50.00	38.2308	20.4403	3	4.5	7.36782e+15	automatic	345
2014/01/27 15:39:34.00	38.3748	20.4222	7	4.3	2.83447e+15	automatic	344
2014/01/28 05:12:53.00	38.2083	20.3817	10	4.2	2.16889e+15	automatic	343
2014/01/28 22:22:37.00	38.4037	20.4885	5	4.3	3.07107e+15	automatic	342

overview

(1) introduction
(2) software tools used
(3) architecture
(4) flowchart
(5) case study
(6) screenshots
(7) manual example
(8) future improvements
(9) installation
(10) links & more

manual example

```
# import the necessary scisola modules
import  src.lib.origin as origin
import  src.lib.database as database
import  src.lib.settings as settings
import  src.lib.process as process

# creates an Origin object
# fill with the desired values
# the attributes of the Origin object can be found at (scisola/src/lib/origin.py)
orig = origin.Origin()
orig.datetime = "2015/11/08 09:21:41.00"
orig.magnitude = round(3.9,1) # must be no more than 1 decimal
orig.longitude = 21.747
orig.latitude = 38.3568
orig.depth = int(7) # must be integer
orig.event_id = "test" # the id provided by seiscomp3 or anything you want
```

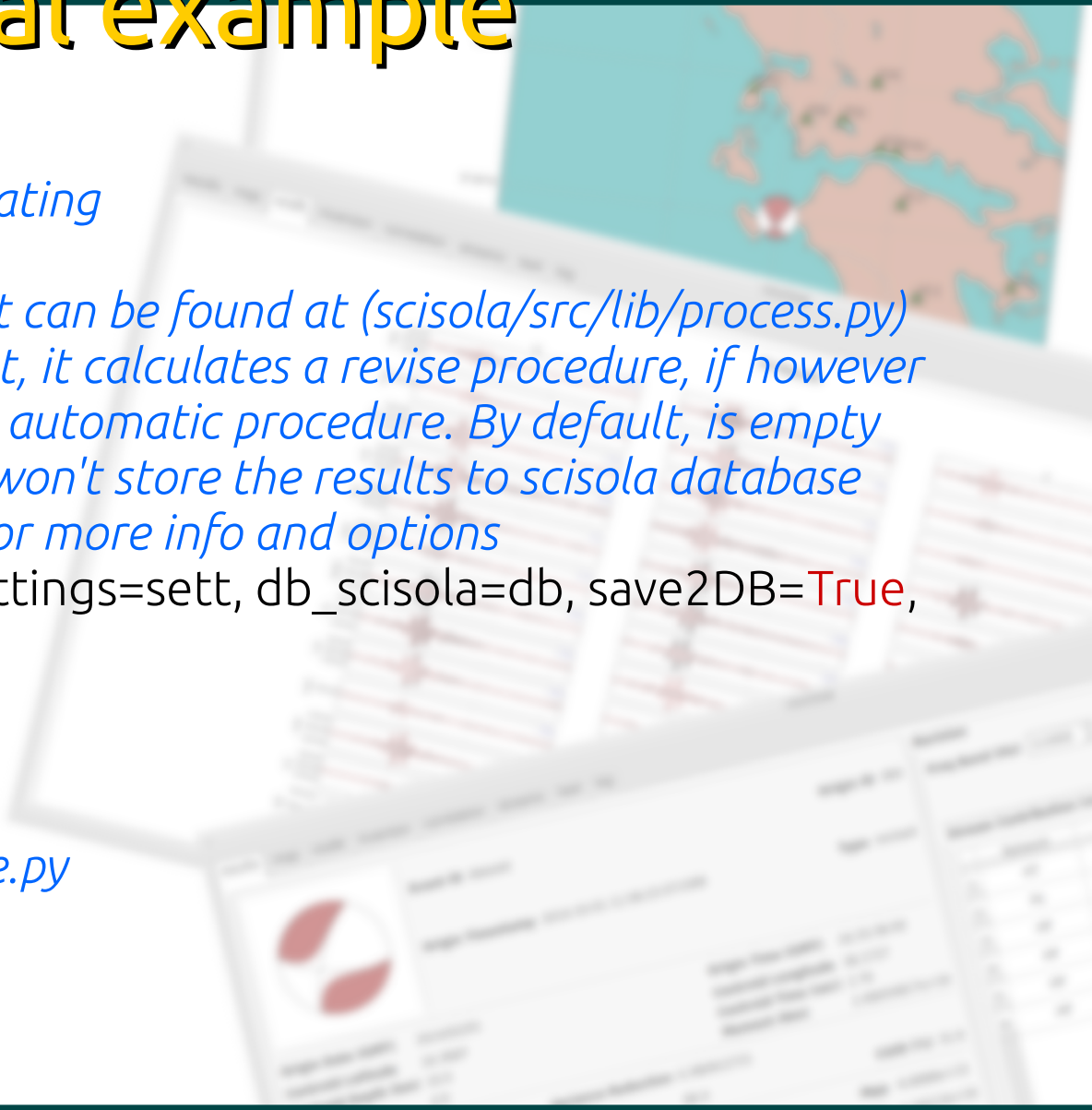


manual example

```
# creates a Database object
# fill with the desired values
# the attributes of the Database object can be found at (scisola/src/lib/database.py)
db = database.Database()
db.password = "password"

# creates a Settings object
sett = settings.Settings()
# retrieves configuration from database
sett = db.loadSettings(sett)

# by-passing database values by filling desired variables
# the attributes of the Settings object can be found at (scisola/src/lib/settings.py)
# e.g.
# setting different results folder than the one provided by the database
sett.output_dir = '/home/user/myoutput' # (example)
```

manual example

```
# creates a Process Object for calculating
# fill with the desired values
# the attributes of the Process object can be found at (scisola/src/lib/process.py)
# if for example provide a station_list, it calculates a revise procedure, if however
station_list is empty, it calculates an automatic procedure. By default, is empty
# if for example save2DB is False, it won't store the results to scisola database
# check (scisola/src/lib/process.py) for more info and options
p = process.Process(origin=orig, settings=sett, db_scisola=db, save2DB=True,
delay=0)
# starting MT calculation
p.start()

# run from terminal: python example.py
```



overview

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future improvements

- advanced methods and artificial intelligence techniques for stations/streams selection
- advanced signal processing methods to be applied to seismic waveforms (to avoid various problems e.g. disturbances, noise and data transmission problems)
  e.g.: Vackář, J. et al, (2014) "Automated detection of disturbances in seismic records; MouseTrap code"
- multiple or 3D crustal models based on earthquake's location
- search of centroid in 3D grid surrounding hypocenter
- pre-calculated Green's functions (for faster performance)
- optimization of inversion, by re-calculating inversion according to streams' correlation
- improved GUI interaction with user
- upgraded configuration and overview info according to user's needs
- save results to SeisComP3

future improvements

- remote/online control via smartphone or tablet
- implementation into the cloud

overview

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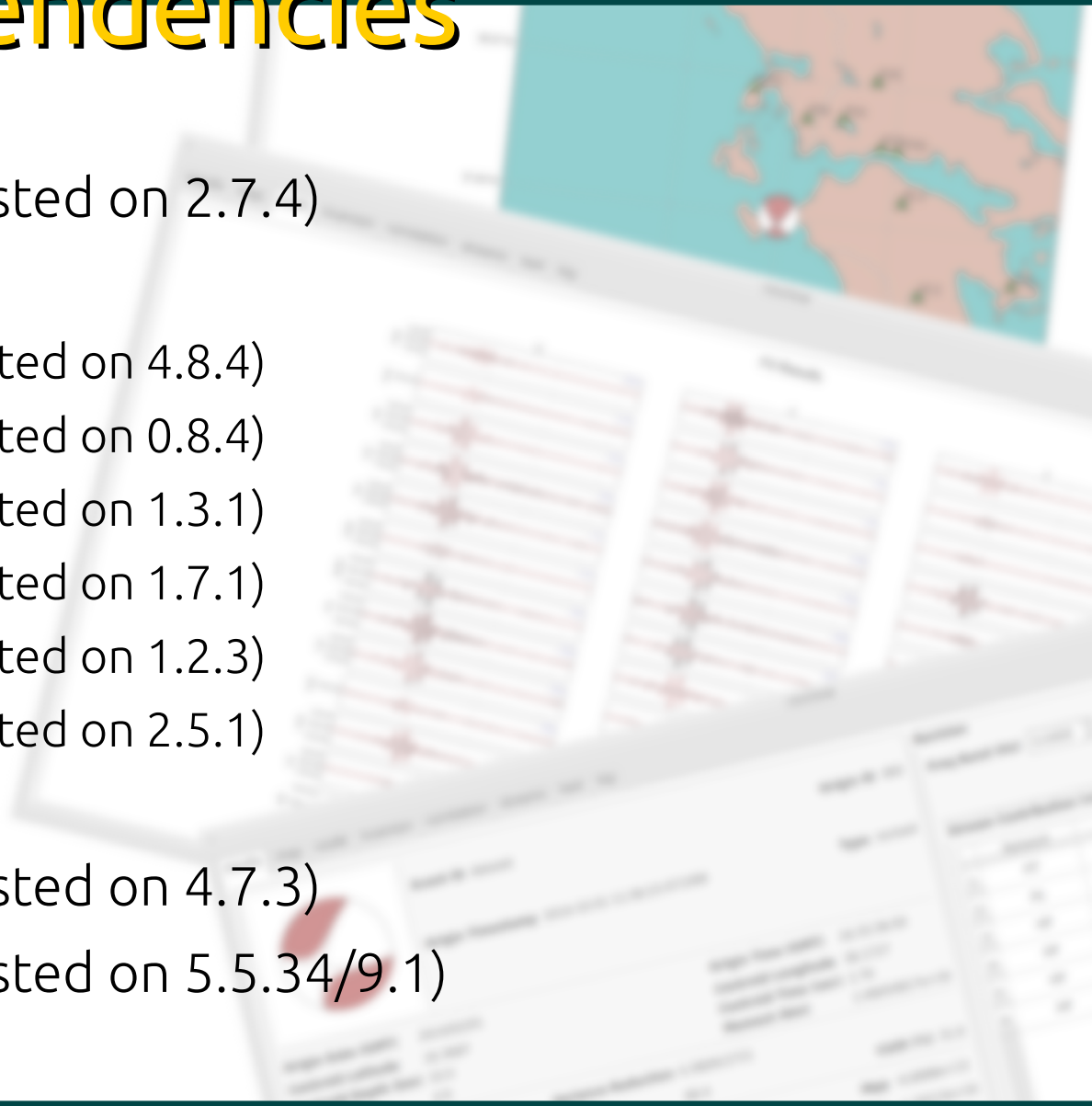
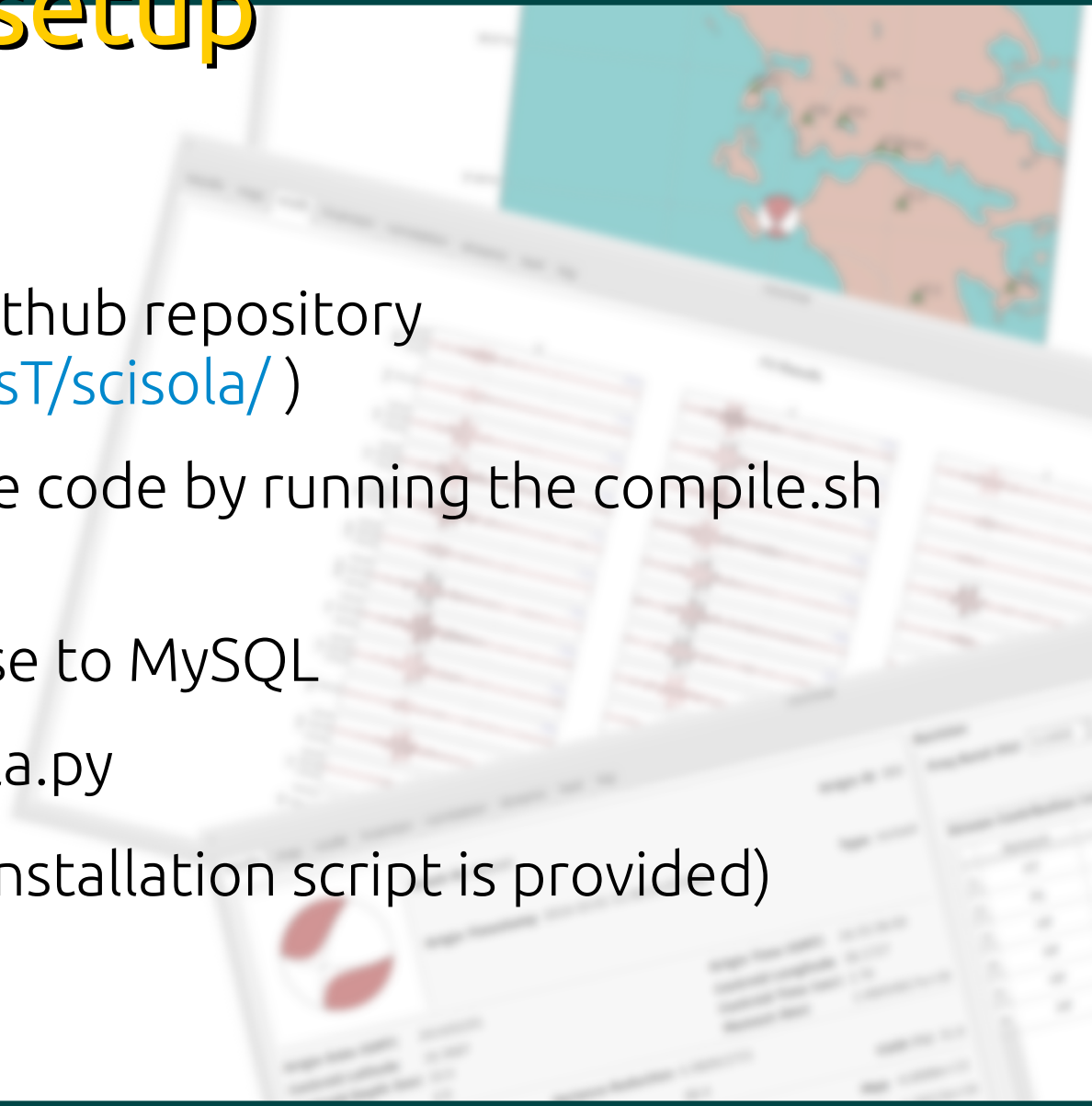
dependencies

- Python (tested on 2.7.4)
- Python libraries:
  - PyQt4 (tested on 4.8.4)
  - ObsPy (tested on 0.8.4)
  - matplotlib (tested on 1.3.1)
  - numpy (tested on 1.7.1)
  - MySQLdb (tested on 1.2.3)
  - psycopg2 (tested on 2.5.1)
  - mpl_toolkits
- gfortran (tested on 4.7.3)
- MySQL/PostgreSQL (tested on 5.5.34/9.1)



setup



i. download scisola from github repository (https://github.com/nikosT/scisola/)

ii. compile the ISOLA source code by running the compile.sh script *(using gfortran)*

iii. insert the scisola database to MySQL

iv. run in shell: python scisola.py

(a simple Ubuntu based installation script is provided)

overview

(1) introduction
(2) software tools used
(3) architecture
(4) flowchart
(5) case study
(6) screenshots
(7) manual example
(8) future improvements
(9) installation
(10) links & more

links

- ✔ scisola website *(Nikolaos Triantafyllis)*
  http://students.ceid.upatras.gr/~triantafyl/scisola/
- ✔ source code
  https://github.com/nikosT/scisola/
- ✔ extensive description & user guide
  http://students.ceid.upatras.gr/~triantafyl/scisola/master_thesis.pdf
- ✔ mailing list
  to subscribe send a blank e-mail to: scisola+subscribe@googlegroups.com
- ✔ ISOLA code *(Jiri Zahradnik and Efthimios Sokos)*
  http://seismo.geology.upatras.gr/isola/index.html

more

- publications:
- 2015 Triantafyllis, N., Sokos, E., Ilias, A., & Zahradník, J. (2015). Scisola: Automatic Moment Tensor Solution for SeisComP3.

  submitted for publication at Seismological Research Letters (Electronic Seismologist)

- 2014 Triantafyllis, N., Sokos, E., & Ilias, A. (2014). Scisola: Automatic Moment Tensor Solution for SeisComP3.

  presented at 34th General Assembly of the European Seismological Commission (24-29 August 2014)

- e-mail me at: triantafyl /AT/ ceid /DOT/ upatras /DOT/ gr