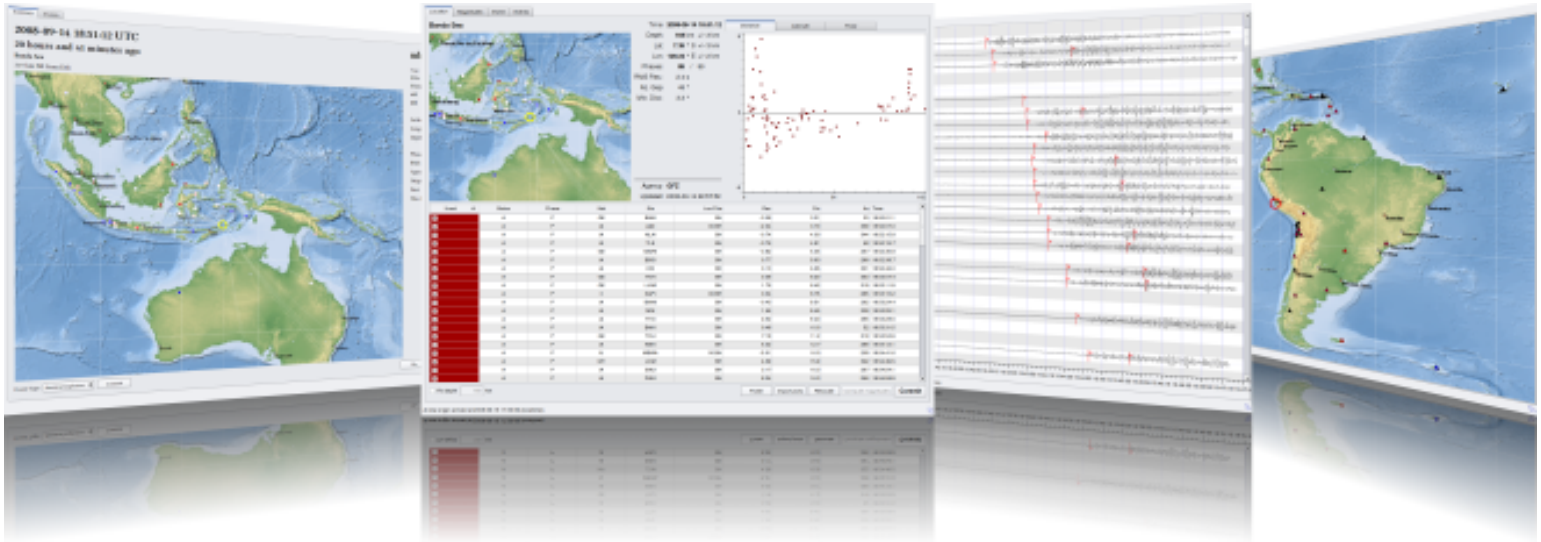
gempa

Real-time Earthquake Monitoring with SeisComP3



Dr. Dirk Rößler, Dr. Bernd Weber, Jan Becker and the gempa team

gempa GmbH, Potsdam, Germany

contact: info@gempa.de

October 12, 2015

Outline

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gempa - short introduction

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- Commercial spin-off of GFZ Potsdam in 2008
- 9 employees (2 seismologists, 4 software engineers, 2 system administrators, 1 web developer)
- Offering solutions for:
  - tsunami early warning
  - monitoring of natural global, regional and local earthquake on Earth and planets (NASA's INSIGHT mission to Mars in 2016)
  - monitoring of induced seismicity in geothermal fields, oil and gas production etc.

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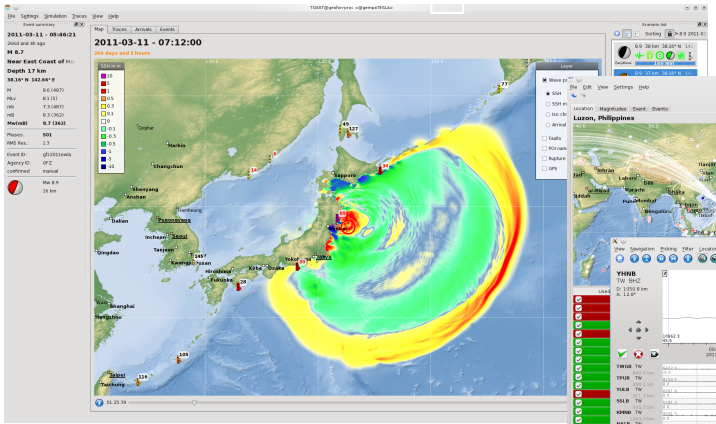

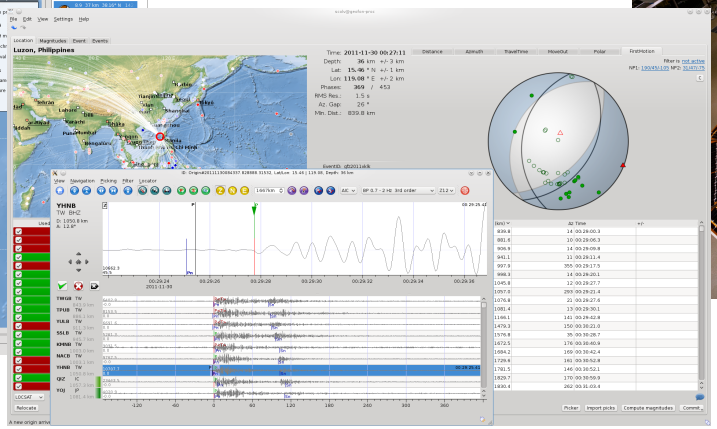

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  - tsunami early warning
  - monitoring of natural global, regional and local earthquake on Earth and planets (NASA's INSIGHT mission to Mars in 2016)
  - monitoring of induced seismicity in geothermal fields, oil and gas production etc.
- Customers worldwide:
  - tsunami warning centers
  - earthquake services
  - energy industry

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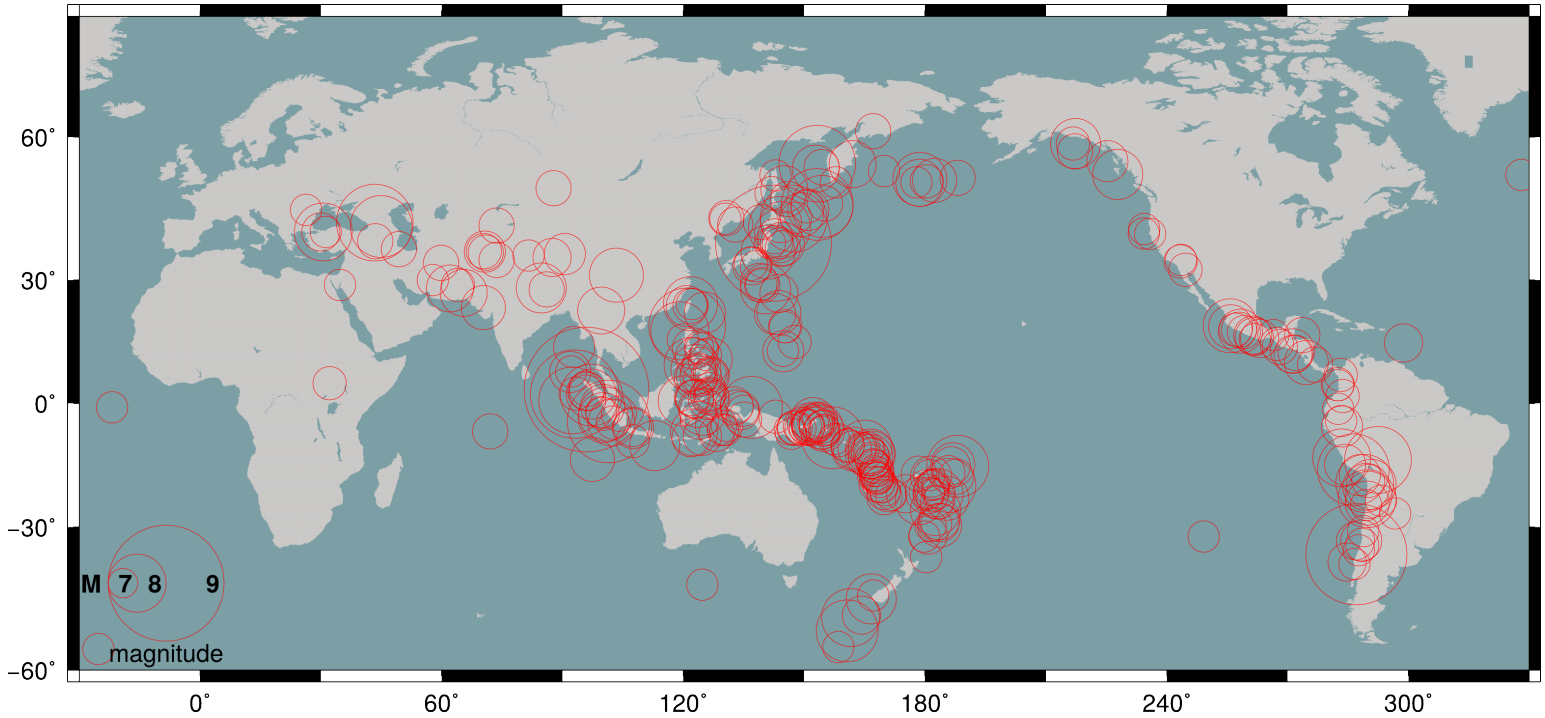
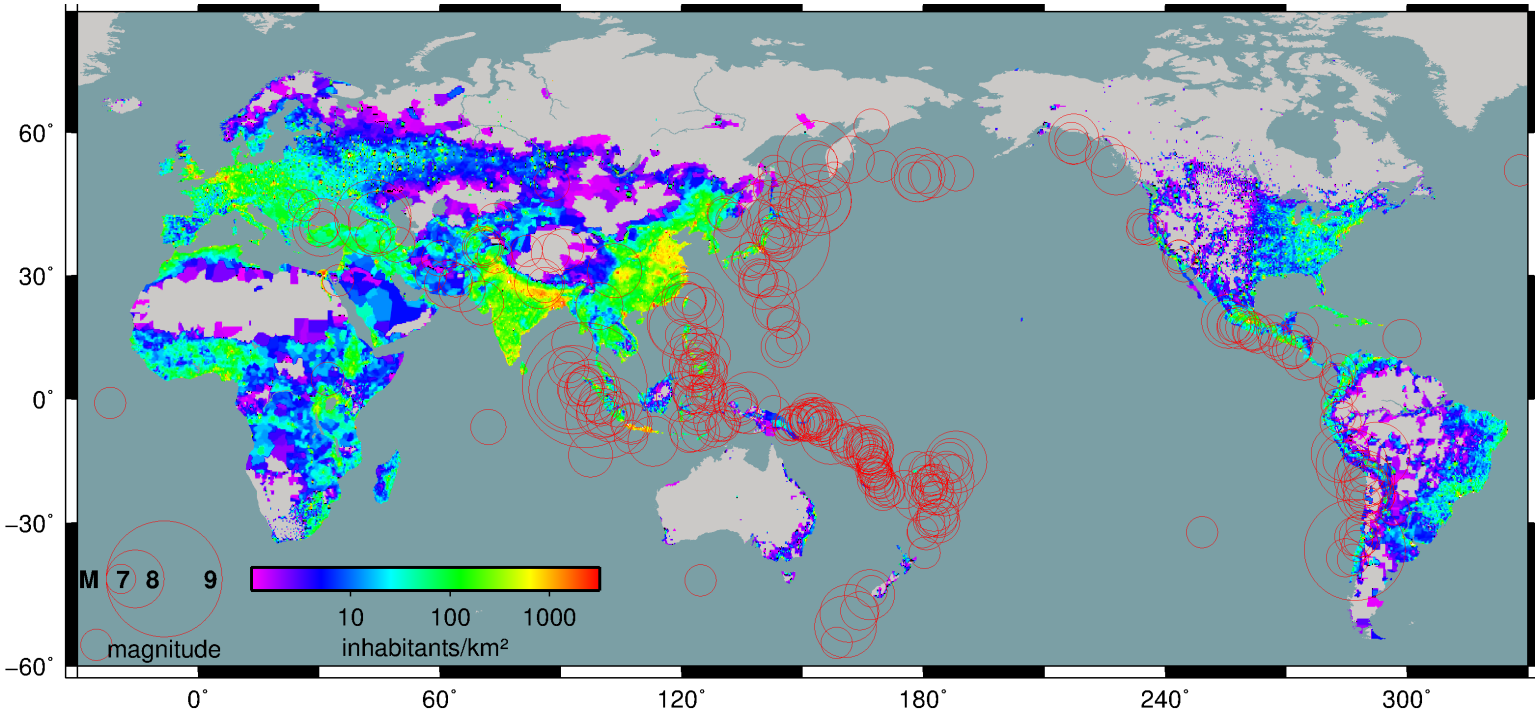
Strong earthquakes with magnitude M≥7 worldwide since 1975



Strong earthquakes often occur at plate boundaries,
e.g. around the Pacific Ocean: ”Ring of Fire”.

Strong earthquakes and population density (from NASA)



Strong earthquakes often occur close to densely populated areas.

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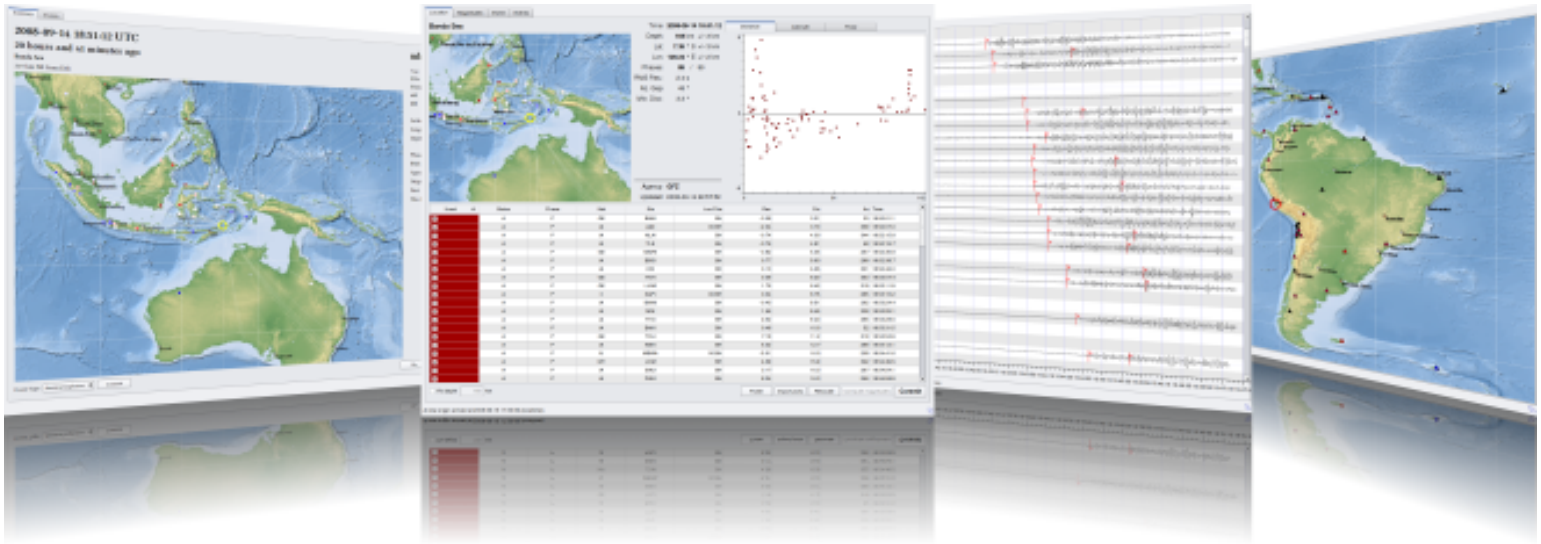
Strong earthquakes: large death tolls and significant economic loss

year	death toll	economic loss ($)	country
2011	16,000	300,000,000	Japan
2011	158	40,000,000	New Zealand
2010	160,000		Haiti
2008	87,587	148,000,000	China
2005	100,000		Pakistan
2004	280,000	15,000,000	Indonesia
1995	6,000	102,500,000	Japan
1994	57	20,000,000	USA
1990	50,000		Iran
1976	700,000		China
1970	100,000		Peru
1948	110,000		Soviet Union
1935	60,000		India
1927	40,900		China
1923	142,807		Japan
1923	273,400		China
1908	123,000		Italy

(numbers selected from https://www.wikipedia.org/)

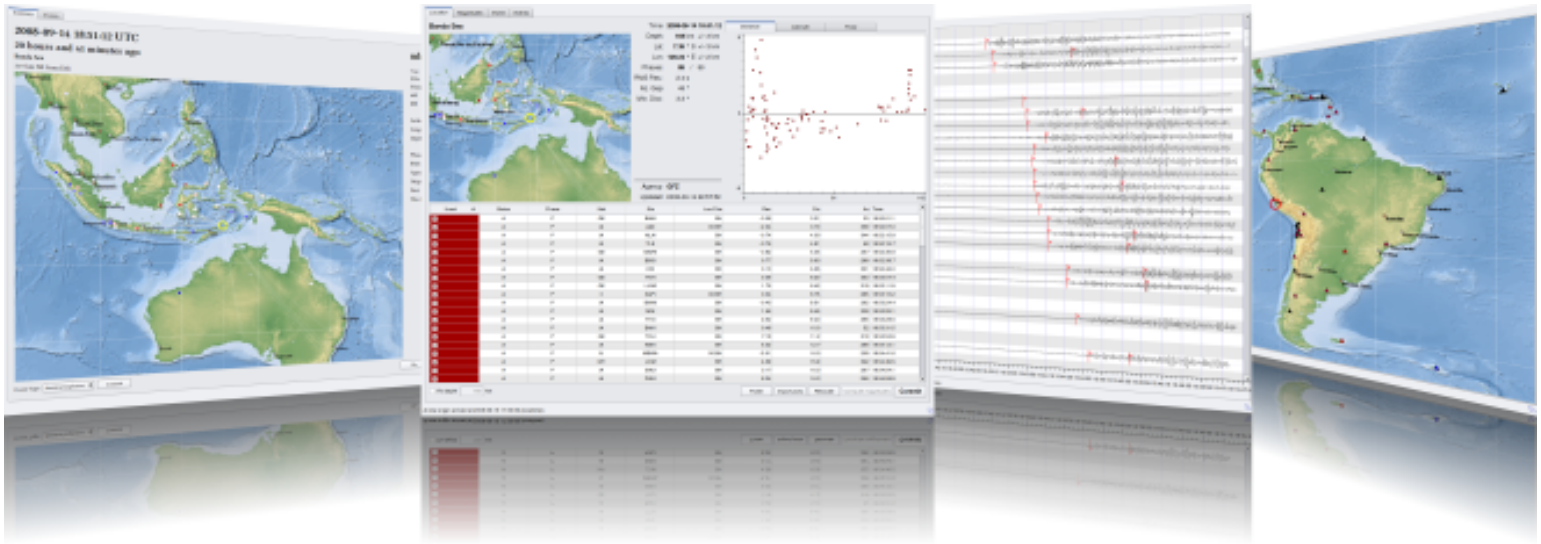
Conclusions:

- Earthquakes state a significant natural hazard to our societies.
- Earthquake monitoring may help to reduce the losses.



SeisComP3 : **earthquake monitoring**

- advanced technology
- automatic, interactive
- real time
- initially developed at GFZ
- now: serviced and enhanced by gempa
- community contributions



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gempa

- Software package, handling seismological data:
  - acquisition
  - archiving data and products
  - processing
  - analysis
  - quality control
- Graphical user interfaces for
  - visualization of waveforms and station status
  - earthquake source visualization
  - state-of-health monitoring for sensors
  - interactive and manual waveform analysis
- Emphasis on simplicity and speed
- Developed and applied in the context of tsunami warning and earthquake monitoring

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- Initially designed as acquisition and archiving software for GEOFON[a] at GFZ Potsdam
- **2001** SeedLink as core acquisition protocol and software becomes a de-facto standard in Europe
- **2003** Development of simple automatic analysis tools (after Boumerdes/Algeria earthquake)
- **2005**
  - global associator/locator
  - interactive analysis using Seismic Handler (SeisComP2)
  - ArcLink server as distributed waveform and meta-data server

[a] http://geofon.gfz-potsdam.de

- **2006** Development of the 3rd generation of SeisComP within GITEWS project
- **2007** Installation at BMKG, Jakarta/Indonesia in May 2007
- **2008** Major release SeisComP3 *Barcelona* (first public release)
- **2009** Major release SeisComP3 *Erice*
- **2010** Major release SeisComP3 *Potsdam*
- **2011** Major release SeisComP3 *Zurich*
- **2012** Major release SeisComP3 *Seattle*
- **2014** Major release SeisComP3 *Jakarta* - Completely open source and free of charge!

Get SeisComP3 from GFZ Potsdam on
http://www.seiscomp3.org

SeisComP world-wide Distribution

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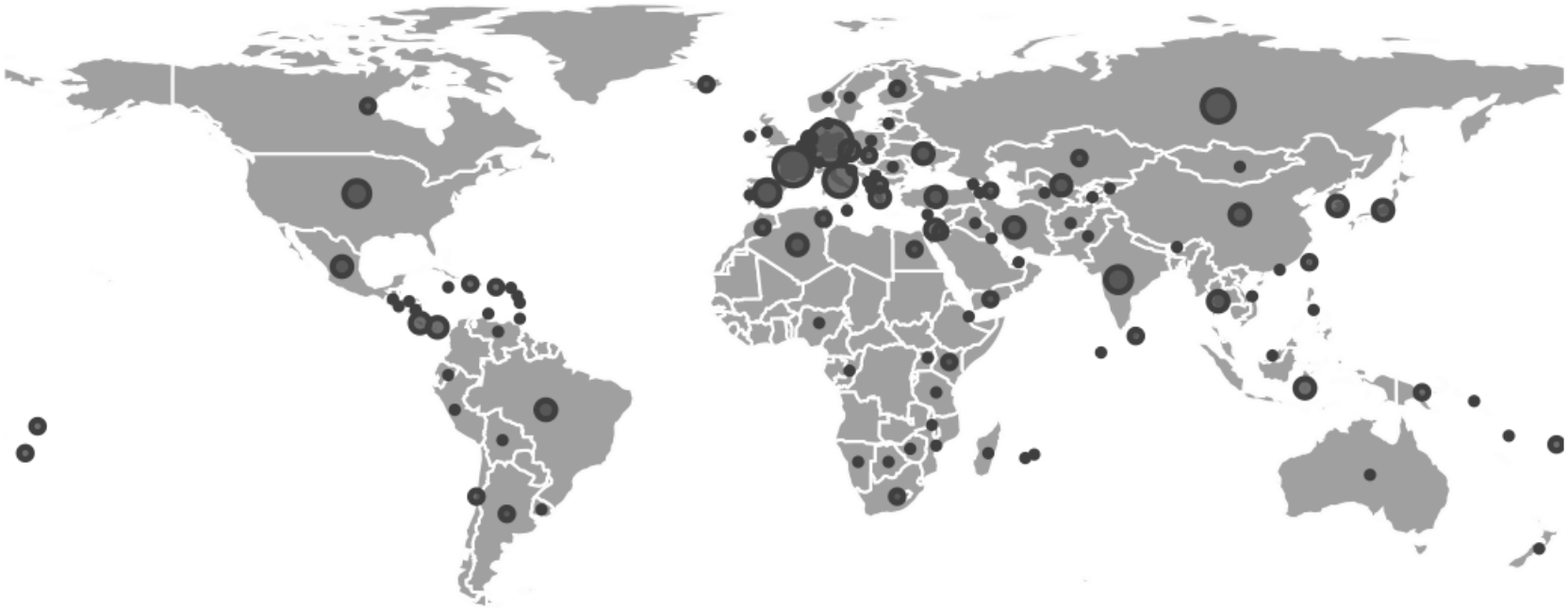


World-wide SeisComP installations (last updated March, 2014)

30 tsunami warning centers

60 universities

10 commercial companies

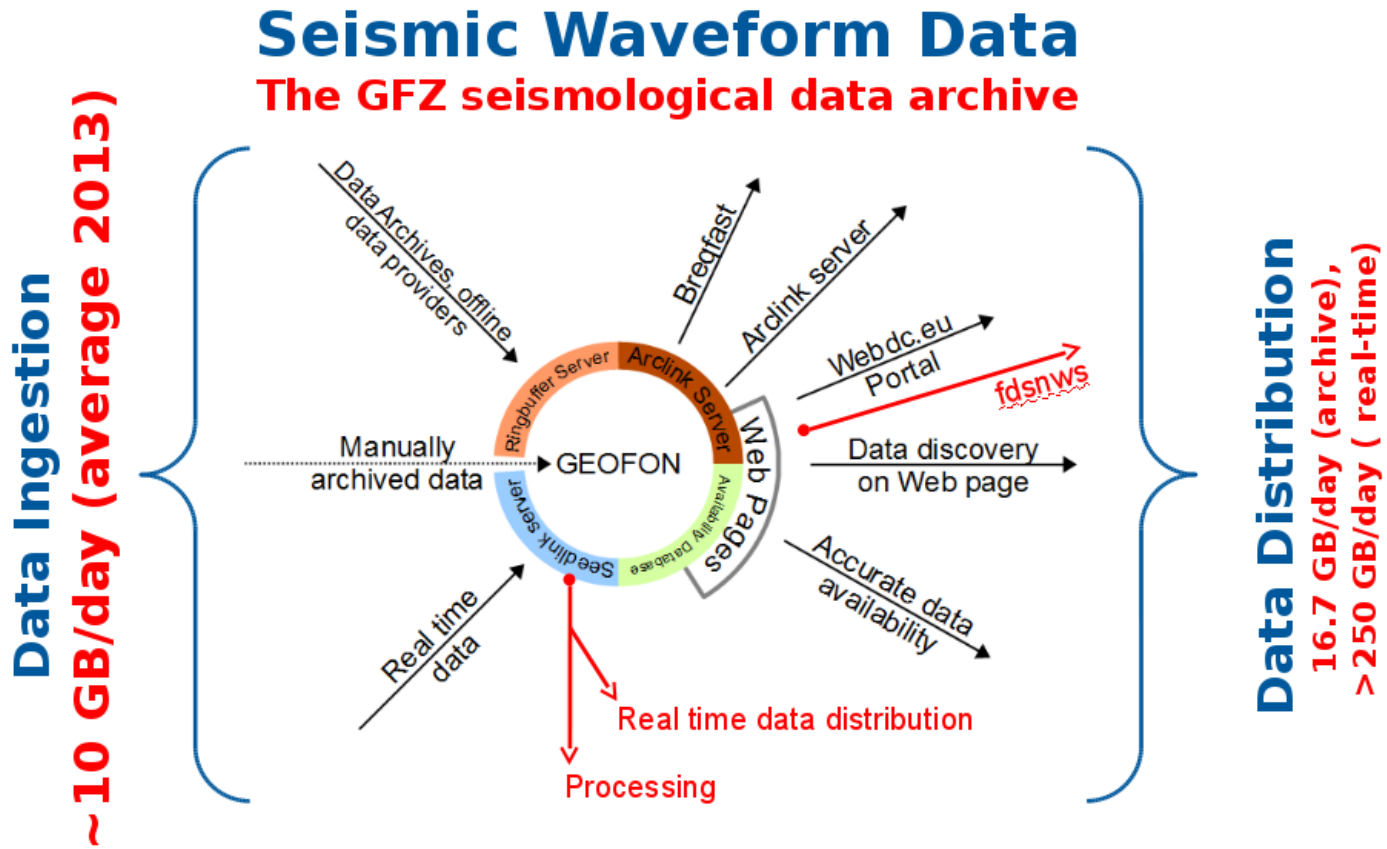
50 earthquake monitoring centers

50 research centers

25 CTBTO NDC using it in daily operation

GEOFON:

- A hub for seismological data from world-wide stations
- Data processing from earthquakes using SeisComP3 and result publishing in real time



Operator's desk with a 4 monitor system and a wall screen connected to the processing server (new warning room)

SeisComP3 for Tsunami Early Warning within GITEWS:

GFZ, DLR, AWI, IFM-GEOMAR, HZG, KDM, GIZ, BGR, UNU (GER)
RISTEK, BMKG, BAKOSURTANAL, BPPT, LAPAN, LIPI, DEPKOM-INFO, BAPPENAS, ITB (Indonesia)

Timeline of Bengkulu earthquake

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Region: Indian Ocean, Sumatra, Indonesia

Source time: 12. September 2007, 11:10:26 UTC, final magnitude: M_w=8.5

OT	State
+2:28 min	First automatic location and magnitude mb 7.3, depth 11 km
~4:00 min	Stabilized location and magnitudes Mw(mB) 7.9, Mwp 8.3
+4:41 min	BMG tsunami warning M 7.9
+6:13 min	Automatic GFZ email alert M 7.9, depth 10 km
+14 min	PTWC tsunami watch M 7.9
+3:14 hrs	GlobalCMT solution M 8.4

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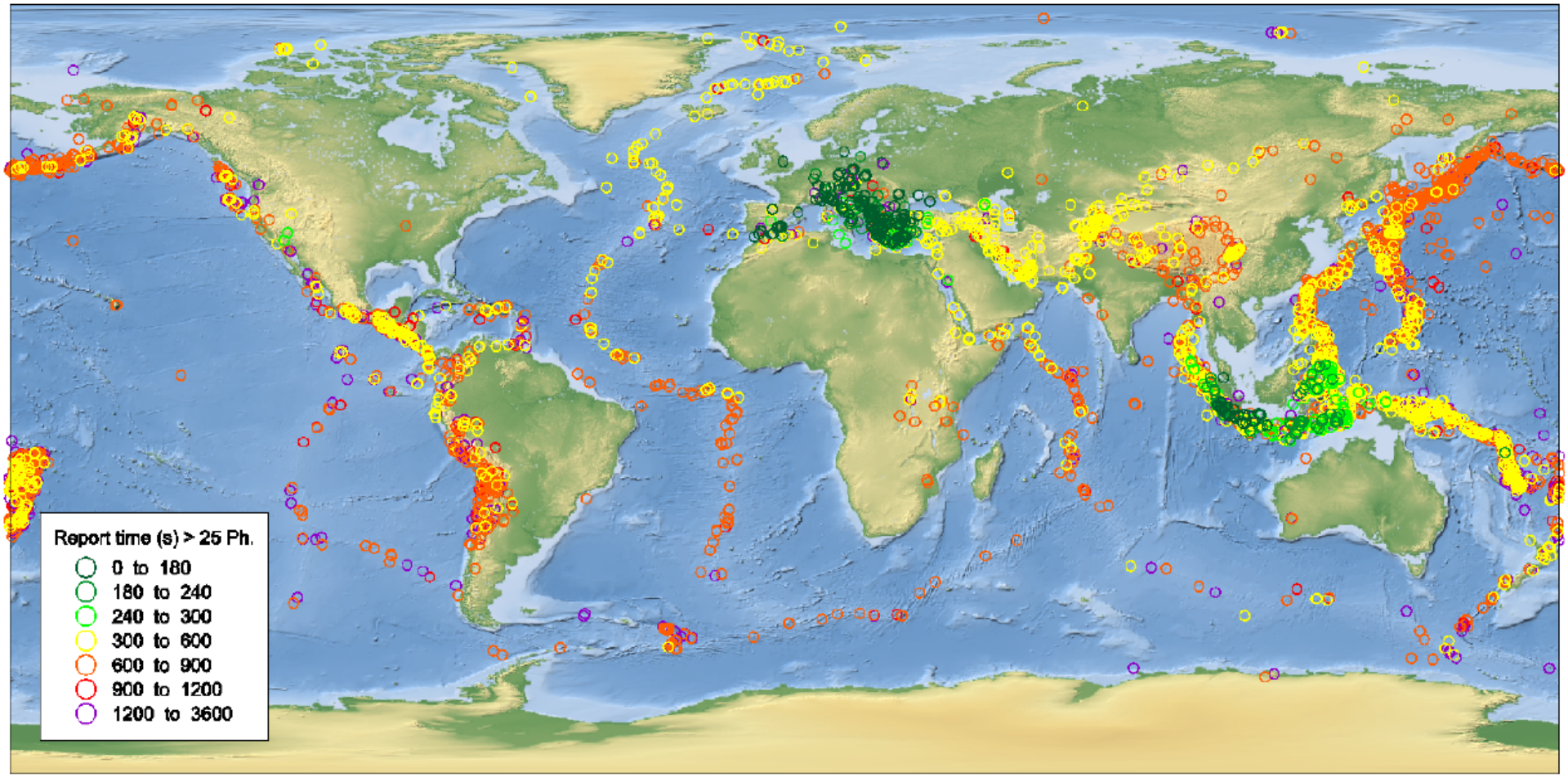
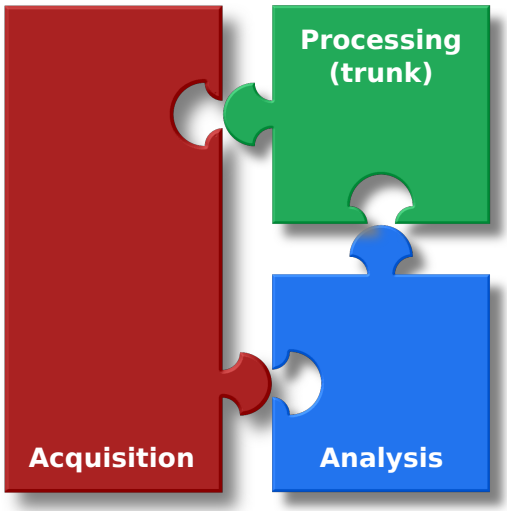


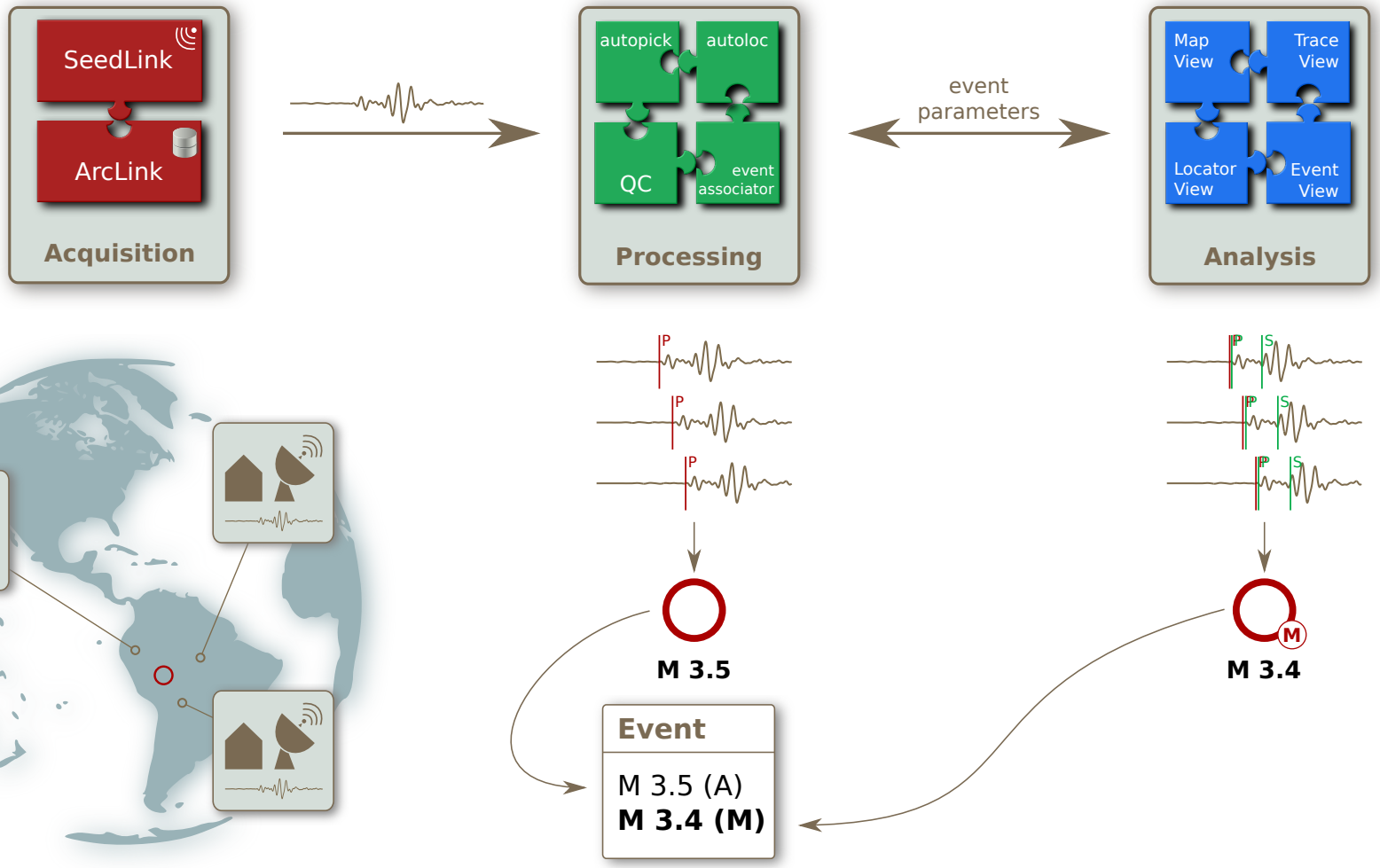
Publishing delay for events processed at GFZ

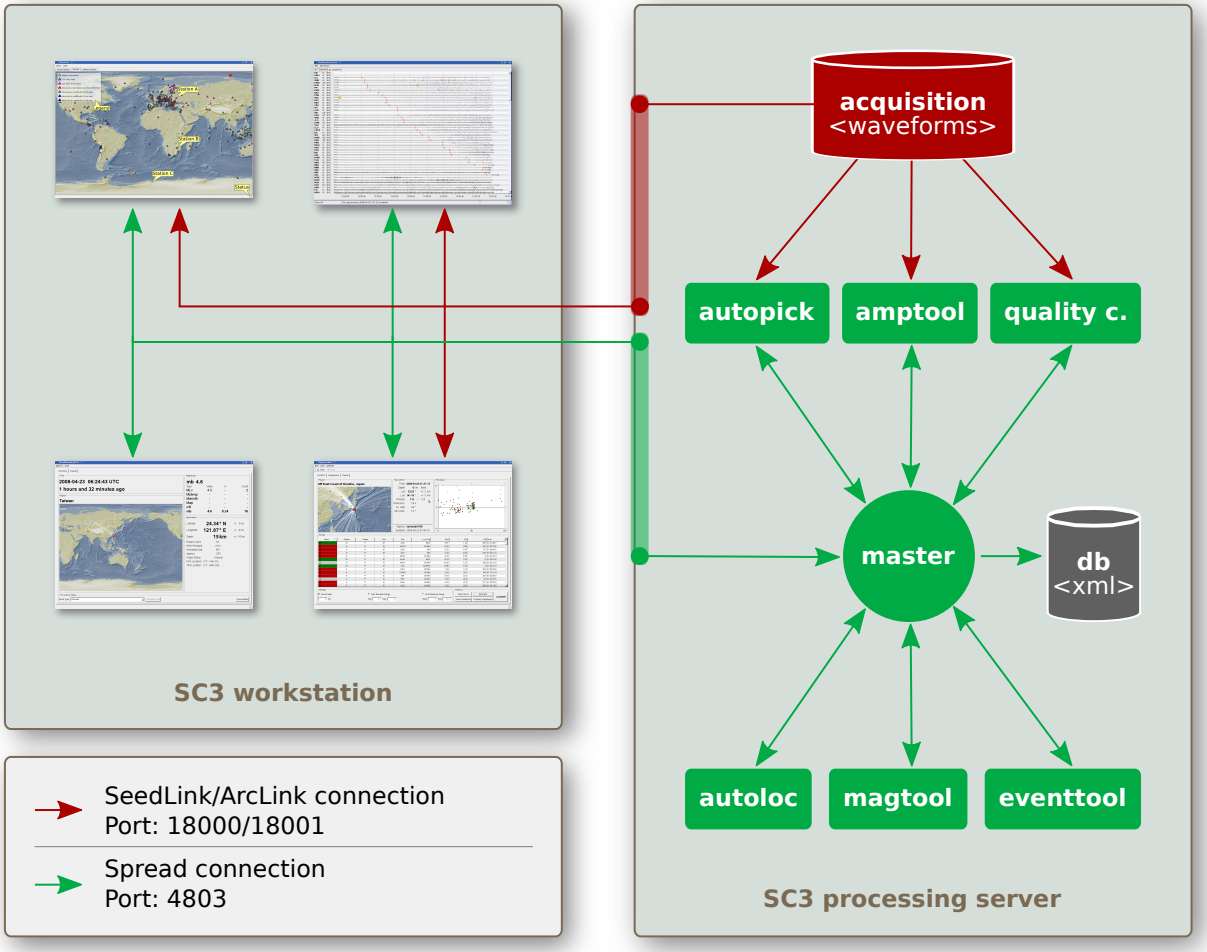


Retrieves waveform data from remote stations, archives it and delivers it to clients on request;
Modules: **SeedLink**, **slarchive** and **ArcLink**

Processes waveform data automatically and emits derived parameters such as picks, amplitudes, magnitudes, hypocenters and events;
Modules: **scmaster**, **scautoloc**, **scautopick**, **scamp**, **scmag** and **scevent**

Provides graphical user interfaces to analyse and verify results and waveforms interactively either in realtime or as post event analysis;
Modules: **scrttv**, **scmv**, **scolv** and **scesv**


SeedLink
ArcLink
Acquisition
autopick
autoloc
QC
event associator
Processing
event parameters
Map View
Trace View
Locator View
Event View
Analysis
P
S
M 3.5
M 3.4
Event
M 3.5 (A)
M 3.4 (M)



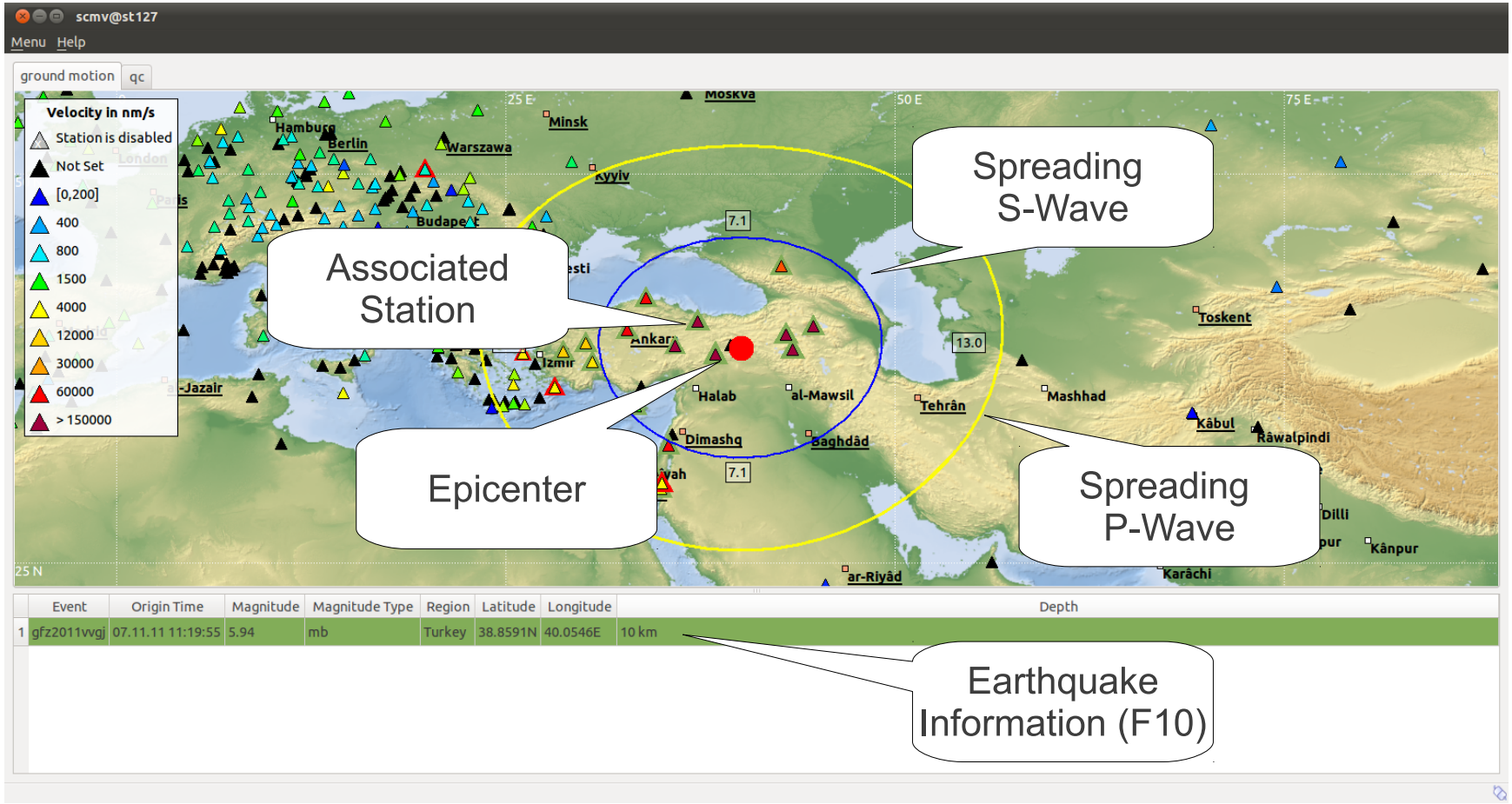
Automatic and interactive systems run on dedicated computers. Both are connected to the same messaging and waveform server.

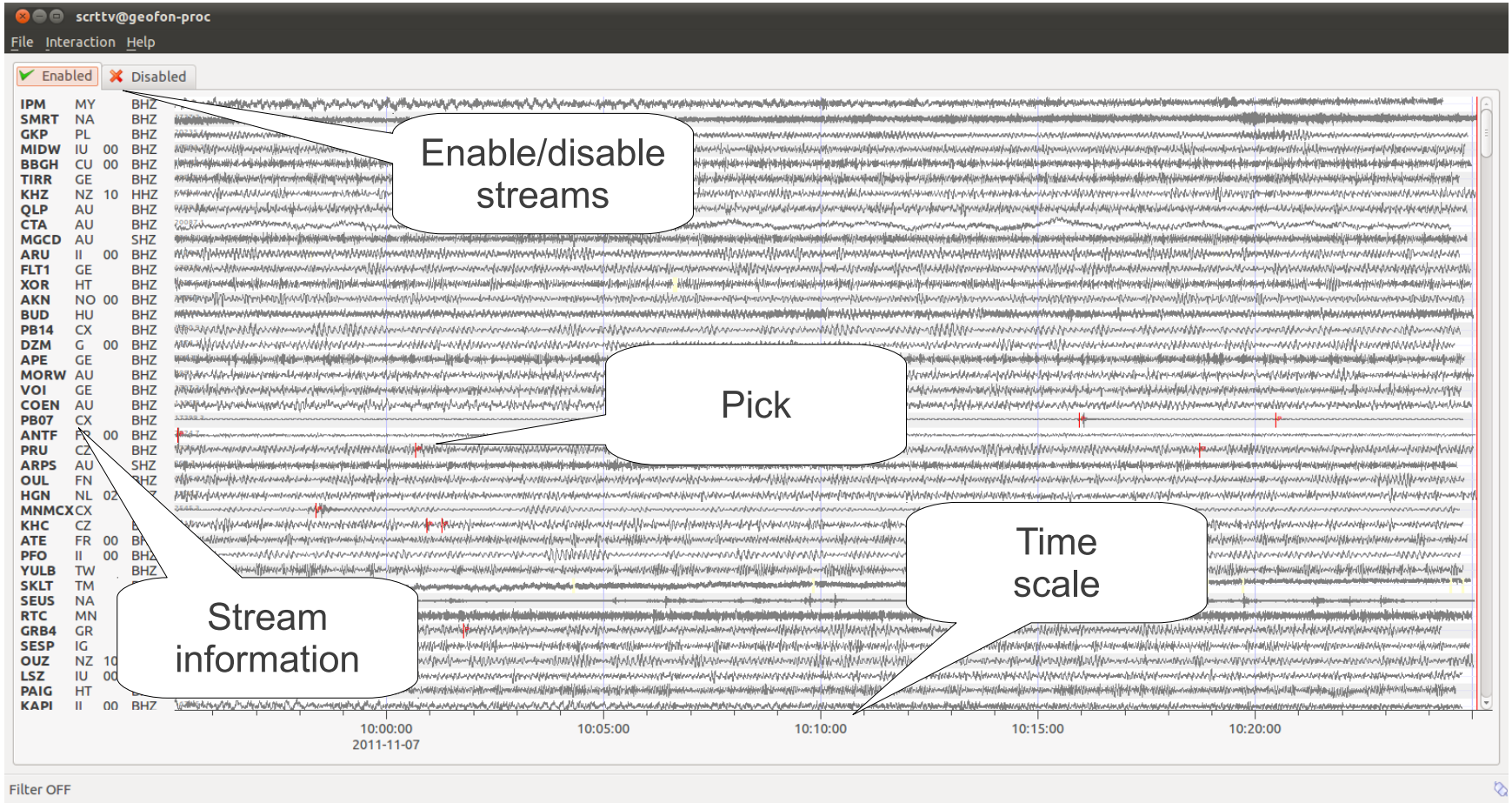
- Lots of background tools for automatic data acquisition, processing and product handling
- GUIs (Graphical User Interfaces) provide tools for manual interaction of operators

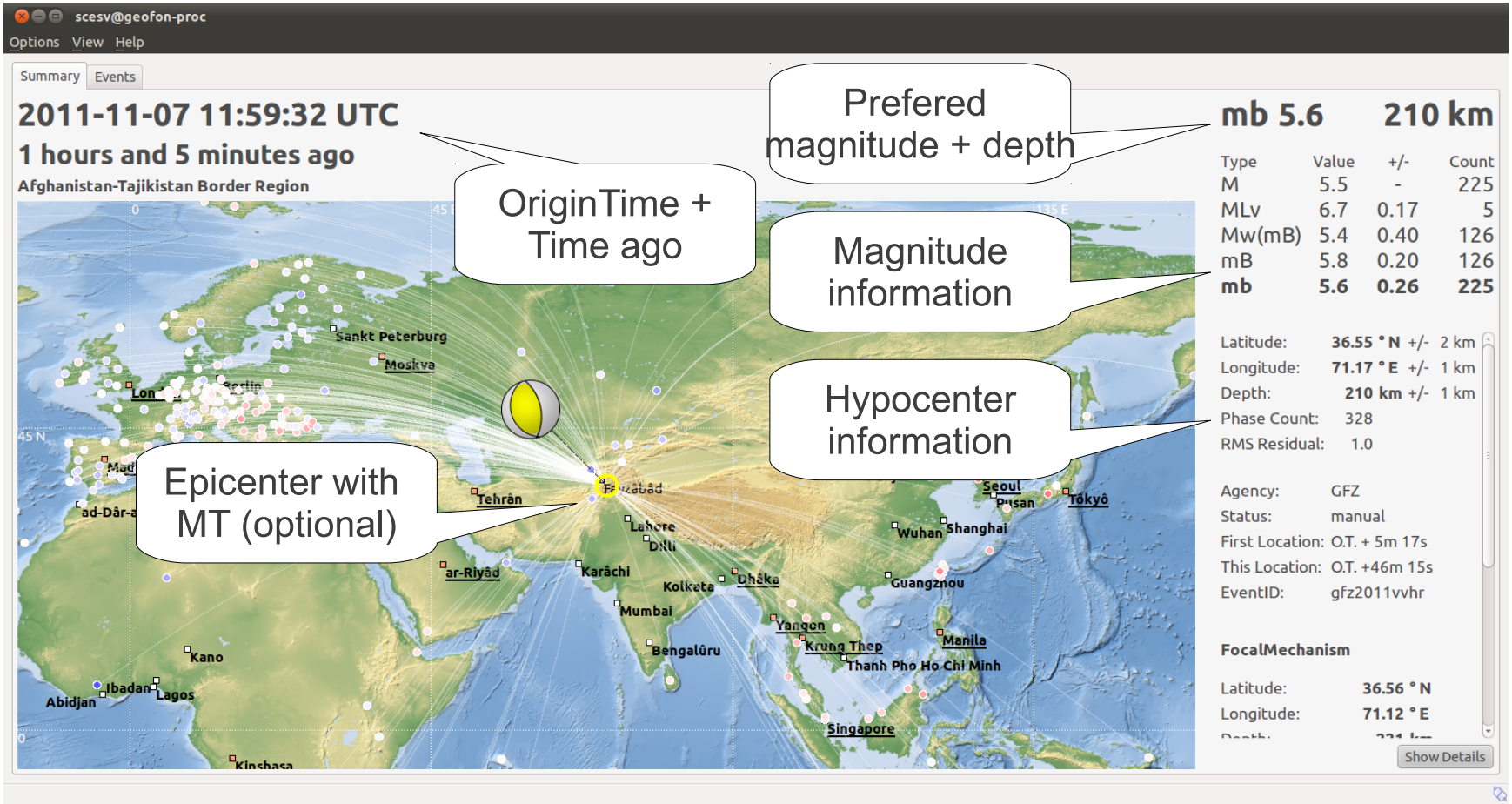
Name	Description
scmv	Map view showing the overall situation
scrttv	Real time seismogram view
scesv	Earthquake summary view
scolv	Interactive revision of earthquake location, magnitude and mechanisms, manually commit results

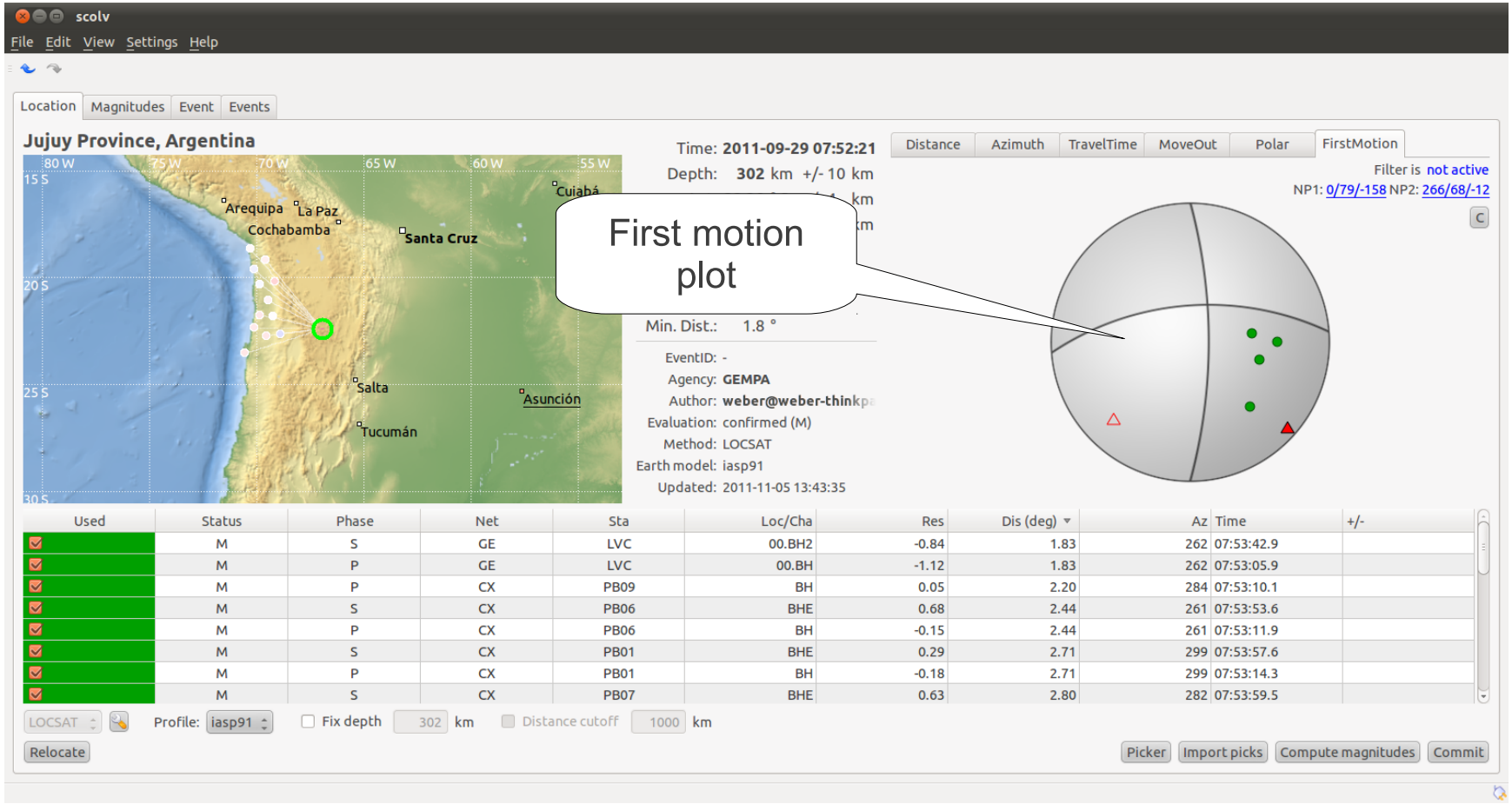
... and even more!


scmv@st127
Menu Help
ground motion
qc
Velocity in nm/s
Station is disabled
Not Set
[0,200]
400
800
1500
4000
12000
30000
60000
> 150000
Ground motion legend
Triggering station
Station showing the recent ground motion
Minsk
Warszawa
Kyyiv
Kharkiv
Praha
Wien
Budapest
Bursa
Ankara
Izmir
Adana
Halab
Tbilisi
Yerevan
Tabriz
al-Mawsil
Tehrân
Mashhad
Toskent
Kâbul
Bayrût
Dimashq
Baghdâd
Esfahân
Tarâbulus
Ammân
al-Iskandariyah
al-Jizah
al-Qahira
ar-Riyâd
Karâchi
Multân


scmv@st127
Menu Help
ground motion
qc
Velocity in nm/s
Station is disabled
Not Set
[0,200]
400
800
1500
4000
12000
30000
60000
> 150000
Associated Station
Epicenter
Spreading S-Wave
Spreading P-Wave
Earthquake Information (F10)
Event
Origin Time
Magnitude
Magnitude Type
Region
Latitude
Longitude
Depth
1
gfz2011vvgj
07.11.11 11:19:55
5.94
mb
Turkey
38.8591N
40.0546E
10 km


scrttv@geofon-proc
File Interaction Help
Enabled
Disabled
Enable/disable streams
Pick
Stream information
Time scale
10:00:00
2011-11-07
10:05:00
10:10:00
10:15:00
10:20:00
Filter OFF


scesv@geofon-proc
Options View Help
Summary Events
2011-11-07 11:59:32 UTC
1 hours and 5 minutes ago
Afghanistan-Tajikistan Border Region
Prefered magnitude + depth
OriginTime + Time ago
Magnitude information
Hypocenter information
Epicenter with MT (optional)
mb 5.6 210 km
Type Value +/- Count
M 5.5 - 225
MLv 6.7 0.17 5
Mw(mB) 5.4 0.40 126
mB 5.8 0.20 126
mb 5.6 0.26 225
Latitude: 36.55 °N +/- 2 km
Longitude: 71.17 °E +/- 1 km
Depth: 210 km +/- 1 km
Phase Count: 328
RMS Residual: 1.0
Agency: GFZ
Status: manual
First Location: O.T. + 5m 17s
This Location: O.T. +46m 15s
EventID: gfz2011vvhr
FocalMechanism
Latitude: 36.56 °N
Longitude: 71.12 °E
Show Details
Sankt Peterburg
Moskva
Tehrân
Lahore
Delhi
Karâchi
ar-Riyâd
Kolkata
Dhâka
Mumbai
Bengalûru
Wuhan
Shanghai
Guangznou
Seoul
Pusan
Tôkyô
Yangon
Krung Thep
Thanh Pho Ho Chi Minh
Manila
Singapore
Kano
Ibadan
Lagos
Abidjan
Kinshasa


scolv
File Edit View Settings Help
Location Magnitudes Event Events
Jujuy Province, Argentina
80 W 75 W 70 W 65 W 60 W 55 W
15 S
20 S
25 S
30 S
Arequipa
La Paz
Cochabamba
Santa Cruz
Cuiabá
Salta
Asunción
Tucumán
Time: 2011-09-29 07:52:21
Depth: 302 km +/- 10 km
Min. Dist.: 1.8 °
EventID: -
Agency: GEMPA
Author: weber@weber-thinkp
Evaluation: confirmed (M)
Method: LOCSAT
Earth model: iasp91
Updated: 2011-11-05 13:43:35
First motion plot
Distance Azimuth TravelTime MoveOut Polar FirstMotion
Filter is not active
NP1: 0/79/-158 NP2: 266/68/-12
C
Used Status Phase Net Sta Loc/Cha Res Dis (deg) Az Time +/-
M S GE LVC 00.BH2 -0.84 1.83 262 07:53:42.9
M P GE LVC 00.BH -1.12 1.83 262 07:53:05.9
M P CX PB09 BH 0.05 2.20 284 07:53:10.1
M S CX PB06 BHE 0.68 2.44 261 07:53:53.6
M P CX PB06 BH -0.15 2.44 261 07:53:11.9
M S CX PB01 BHE 0.29 2.71 299 07:53:57.6
M P CX PB01 BH -0.18 2.71 299 07:53:14.3
M S CX PB07 BHE 0.63 2.80 282 07:53:59.5
LOCSAT Profile: iasp91 Fix depth 302 km Distance cutoff 1000 km
Relocate
Picker Import picks Compute magnitudes Commit

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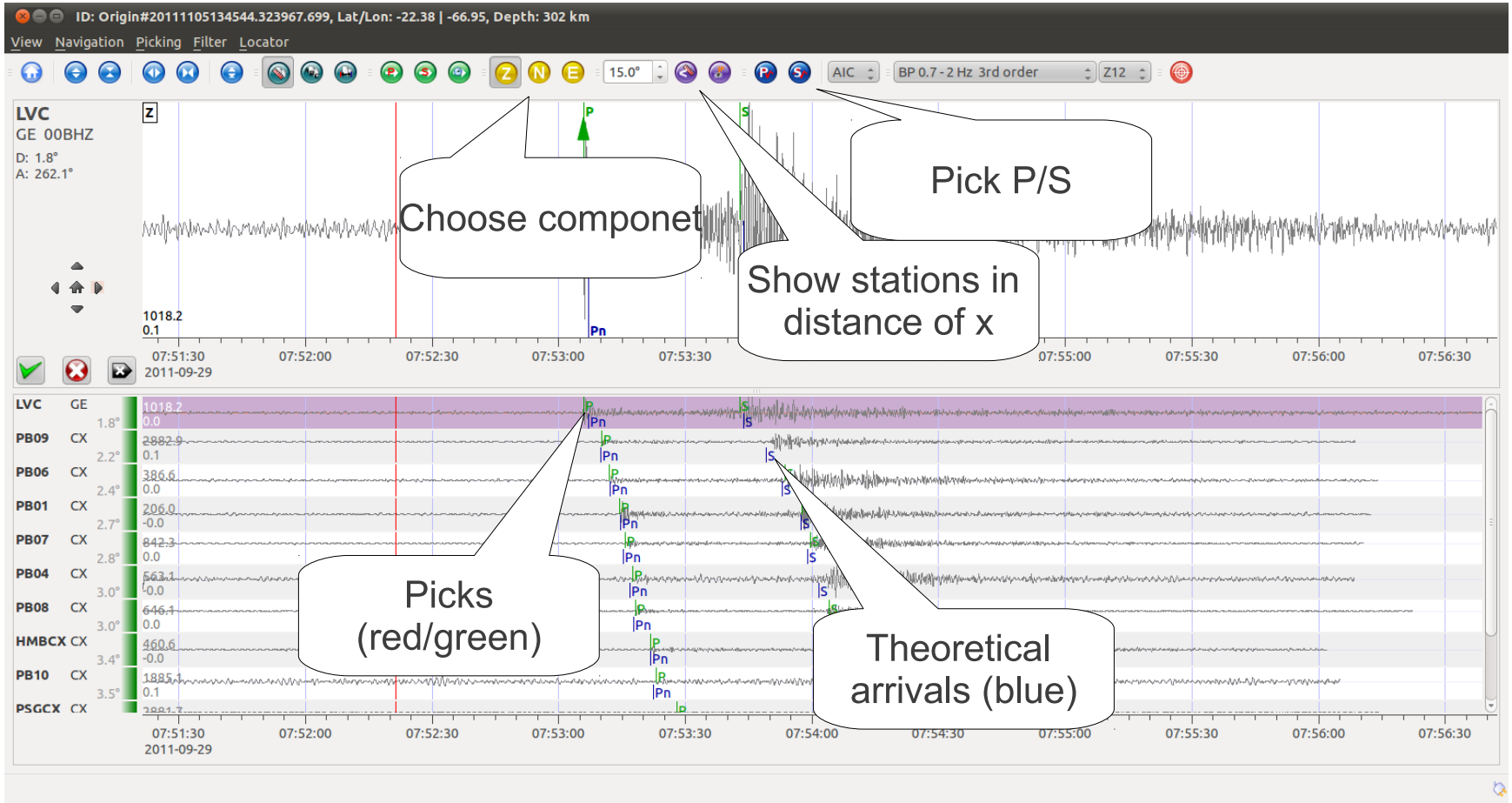
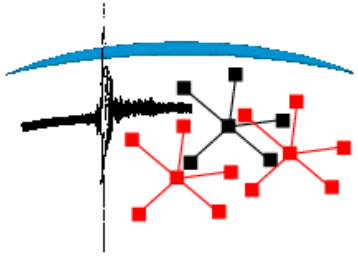

ID: Origin#20111105134544.323967.699, Lat/Lon: -22.38 | -66.95, Depth: 302 km
View Navigation Picking Filter Locator
LVC
GE 00BHZ
D: 1.8°
A: 262.1°
Choose componet
Pick P/S
Show stations in distance of x
Picks (red/green)
Theoretical arrivals (blue)
07:51:30
07:52:00
07:52:30
07:53:00
07:53:30
07:54:00
07:54:30
07:55:00
07:55:30
07:56:00
07:56:30
2011-09-29



SeisComP3

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Support for SeisComP 3

SeisComP 3 can be used free of any charges if the user accepts and respects the licences for SeisComP 3. Support by GFZ Potsdam, however, is limited to coordinating and contributing to the ongoing software development. Specifically, GFZ cannot provide support for installation, upgrading and maintenance issues.

ort and do

Download: http://www.seiscomp3 .org

Subscribe to the mailing list / send requests to seiscomp3-l-on@gfz-potsdam.de

will
ounts that

The SeisComP 3 mailing list `seiscomp3-l` is the right forum for discussing all SeisComP 3 issues. Here users help other users free of charge and this is a very good way of getting help. Before consulting the mailing list, however, make sure your questions are not covered by the wiki already (e.g. in the community section). Naturally, there is no guarantee of help.

To subscribe to the mailing list, send a request to `seiscomp3-l-on @ gfz-potsdam.de`

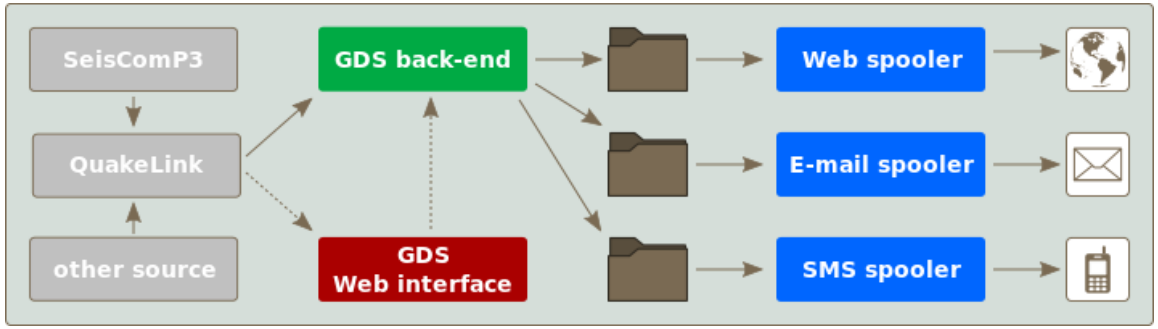
Commercial support

gempa addons for SeisComP3 (see our posters) gempa

Name	Description
CAPS	Multi format acquisition server
GDS with GIS	Dissemination server with image generator
QuakeLink	Real-time event information streaming
scanloc	Advanced earthquake detection and locator
ccloc	Crosscorrelation earthquake detector
sceval	Earthquake evaluator
VORTEX	Volcano monitoring - multi-sensor
automt/SCMTV	Automatic/interactive moment tensor inversion
WEBGUIs	Browser based earthquake monitoring
SMP	Station metadata portal
SMGUI	Strong motion GUI
WebConfig	Browser based version of scconfig

GDS: gempa dissemination server

- Collect earthquake data
- **Distribute information to stakeholders** via web, TV, radio, email, sms, social media
- Automatic and interactive



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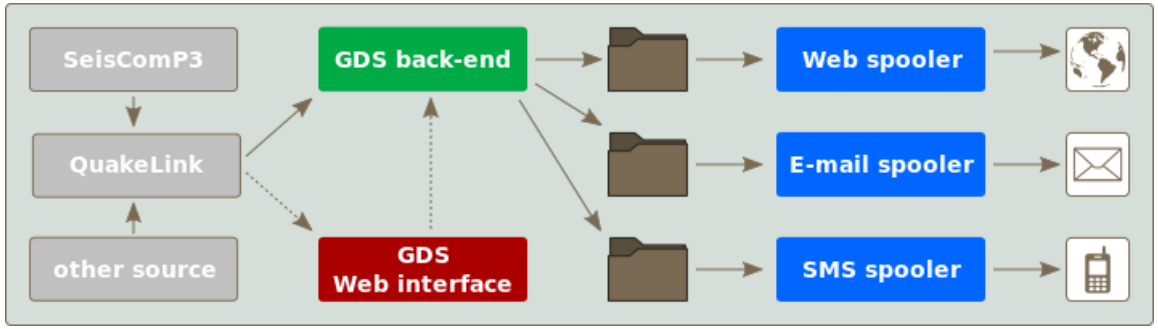
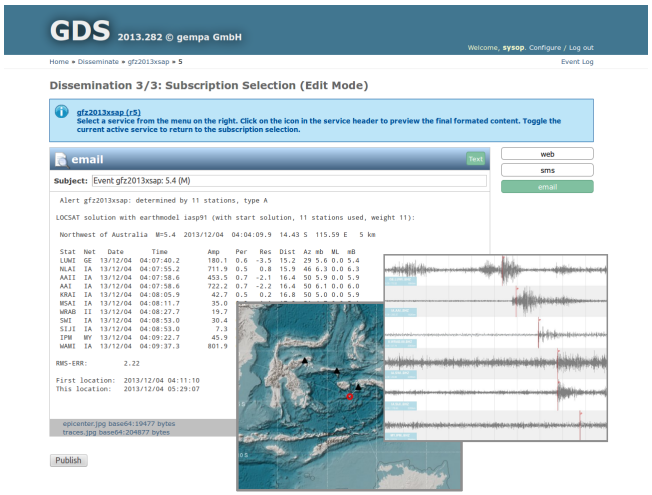


interactive web-based tool



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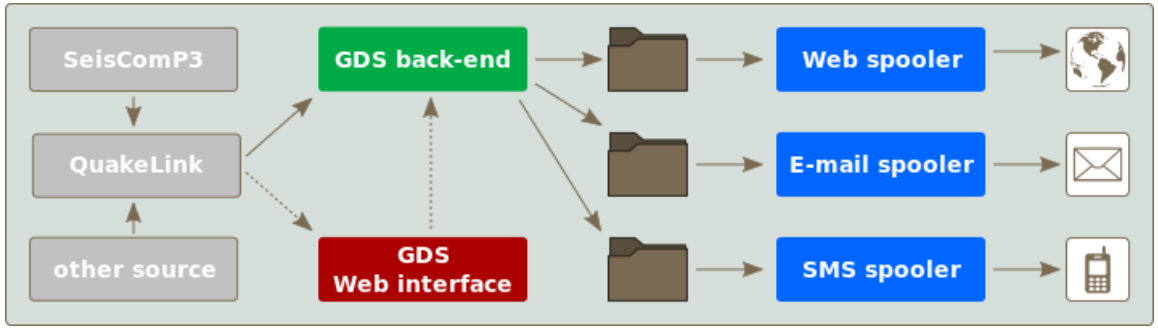
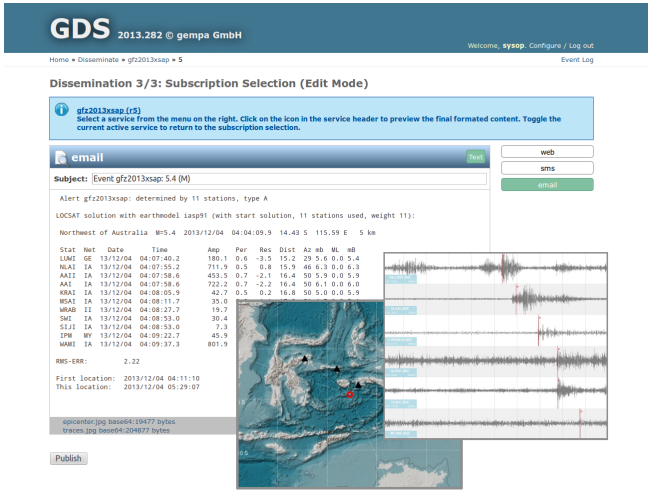
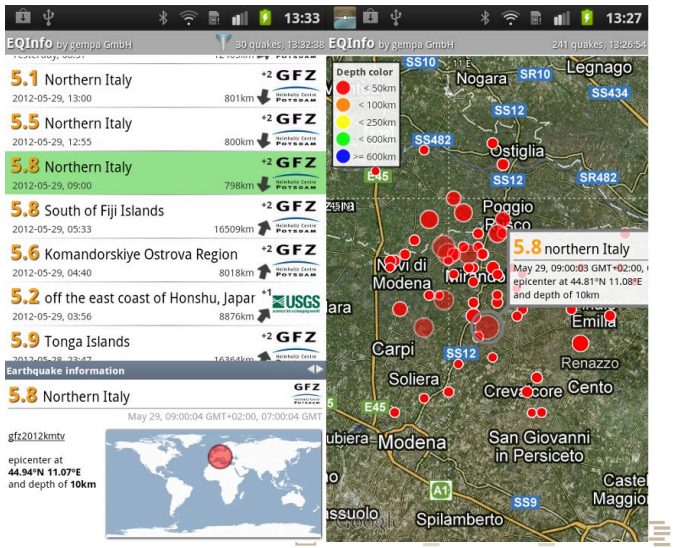


interactive web-based tool



free app for mobile clients



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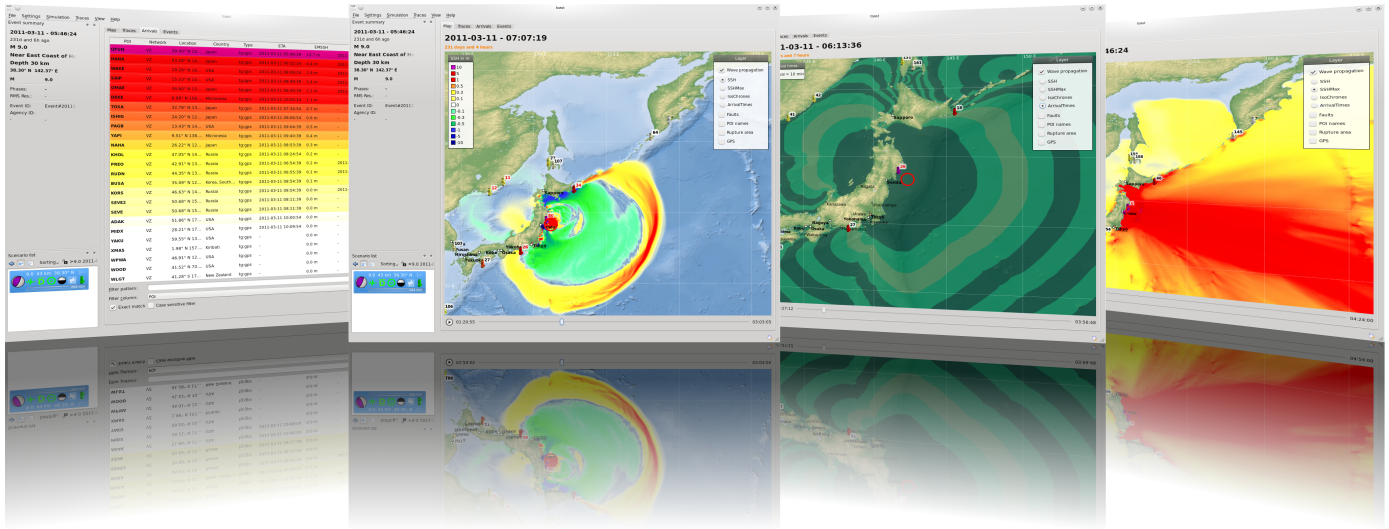
TOAST: Tsunami Observation And Simulation Terminal



- Receive earthquake data
- Integrate other sensors: buoys, tide gauge, radar, cGPS
- **On-the-fly simulation of tsunami propagation and wave heights**
- Detect tsunami arrivals
- Generate video output and customized bulletins for stakeholders

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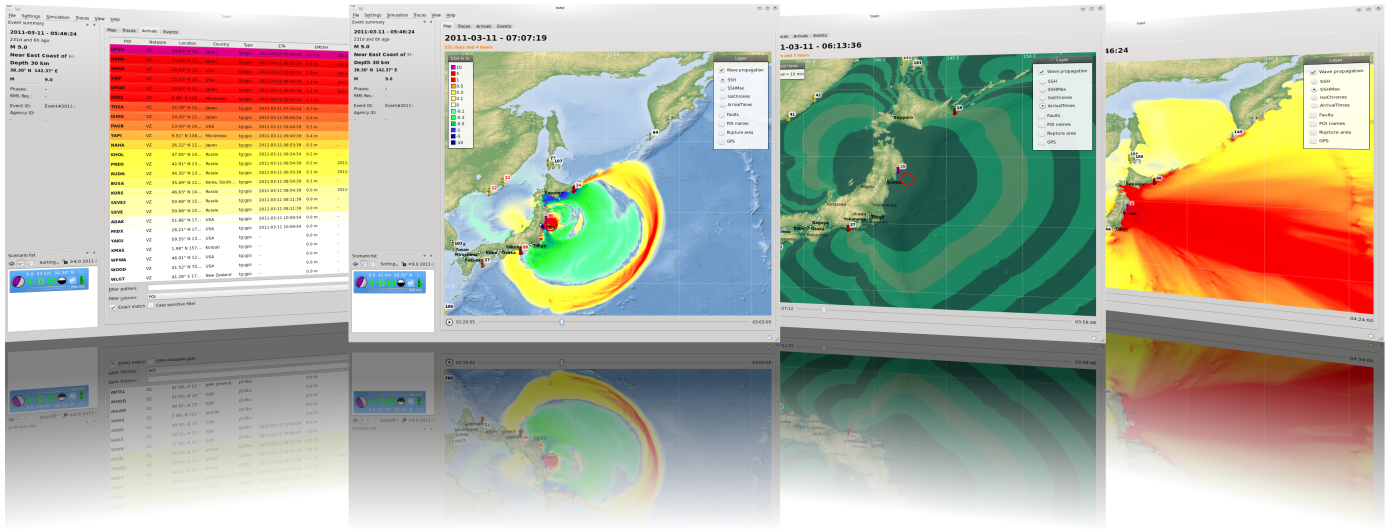
TOAST: Tsunami Observation And Simulation Terminal



- Receive earthquake data
- Integrate other sensors: buoys, tide gauge, radar, cGPS
- On-the-fly simulation of tsunami propagation and wave heights
- Detect tsunami arrivals
- Generate video output and customized bulletins for stakeholders

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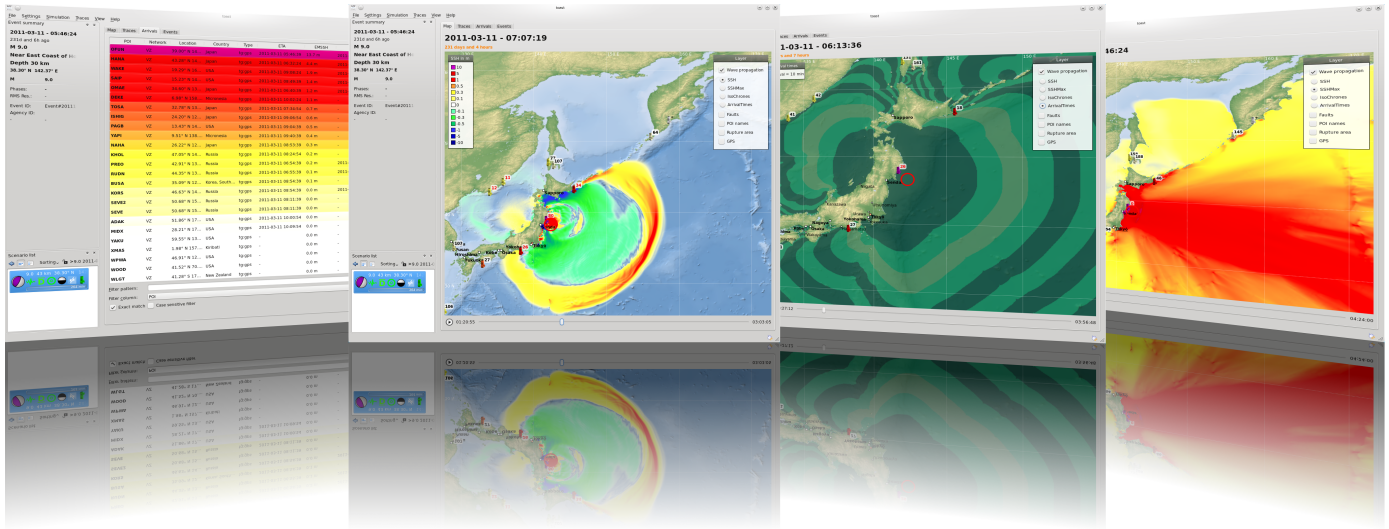

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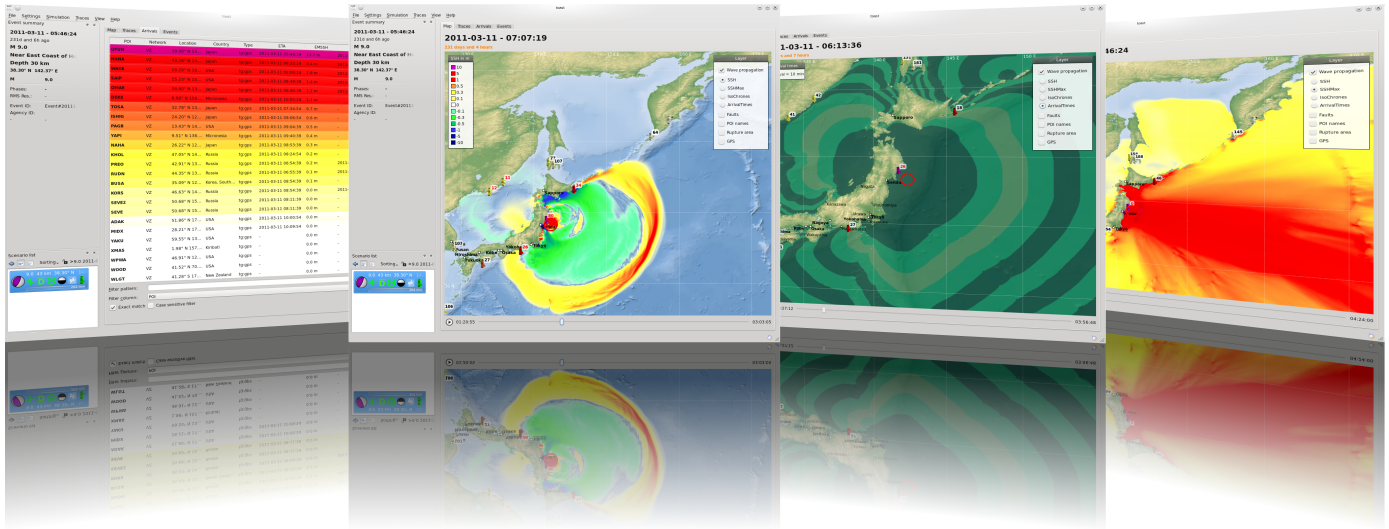

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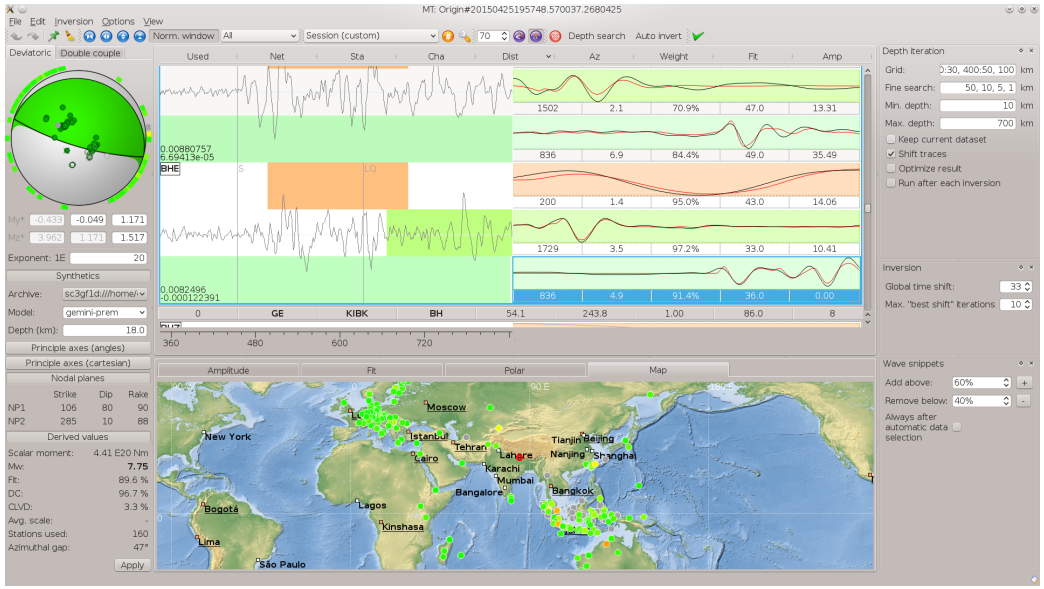
SCMTV: automatic and interactive earthquake source inversion



- Receive earthquake data: waveforms, hypocentres, wave polarities
- Determine earthquake geometry (moment tensor) and centroid
- Generate customized bulletins
- Automatic and interactive

[1] jointly with GFZ German Research Centre for Geosciences

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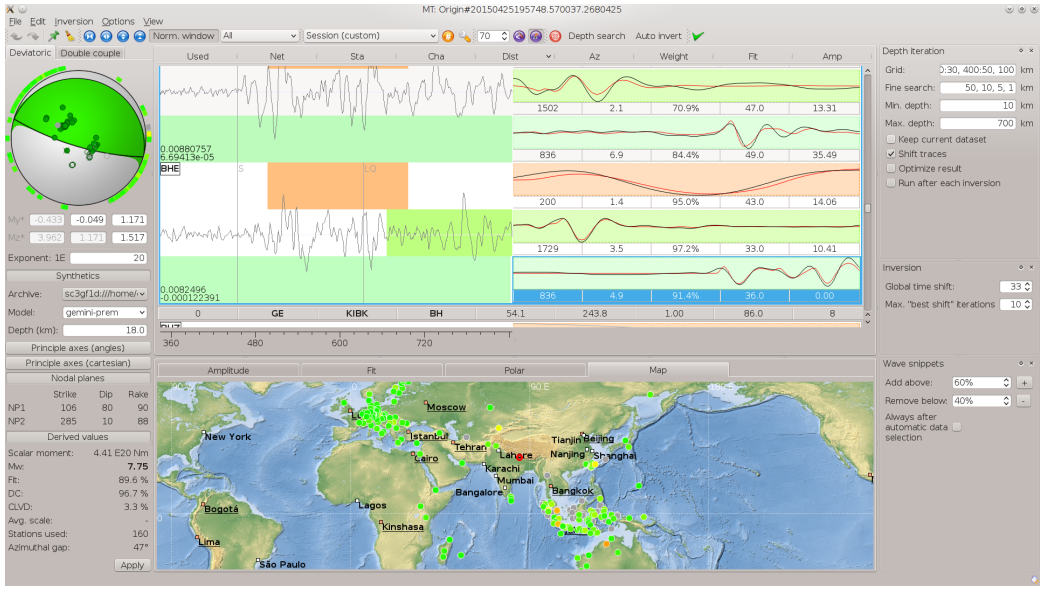

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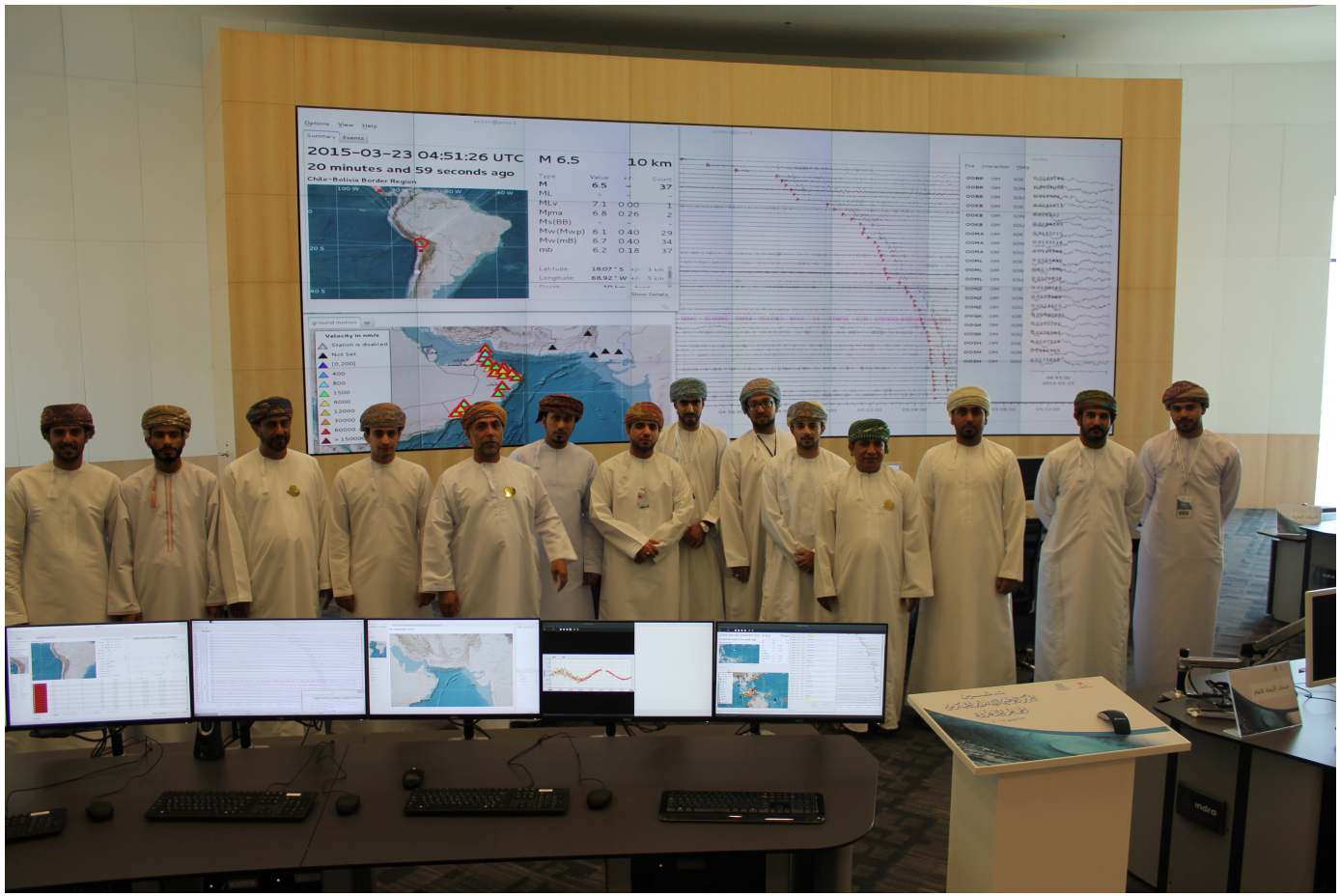
gempa 's recent contribution to Tsunami Early Warning:

DGMAN, Muscat/Oman in 2015



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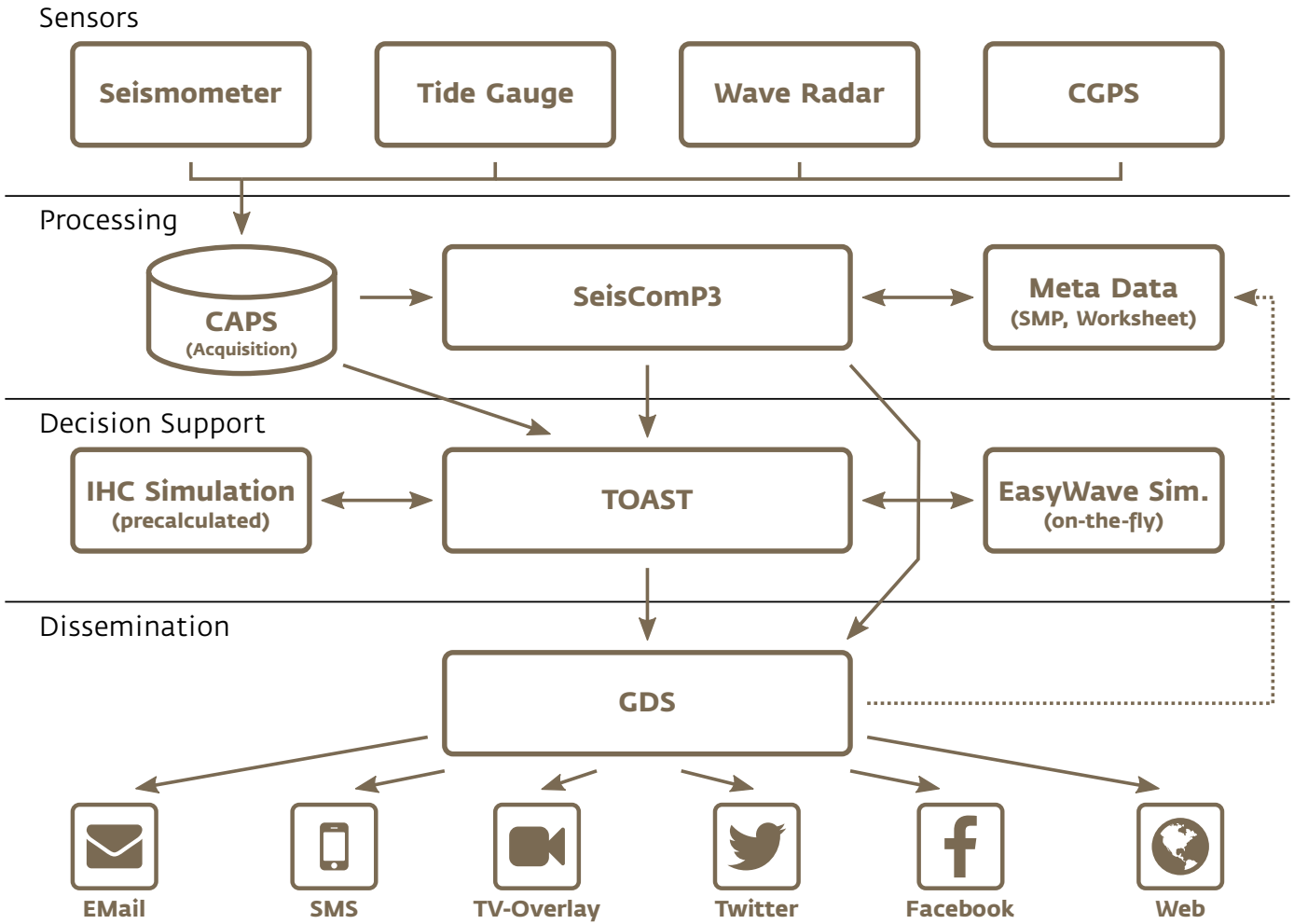

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Thank you for your attention and see you again at our posters!

http://www.seiscomp3.org

http://www.gempa.de

Many thanks for input: J. Lauterjung, A. Strollo.
With figures from gempa , GFZ Potsdam and NASA.