

From ground shaking to timely earthquake information and seismological research - challenges for data handling in seismology

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GEOFON Program*

Deutsches GeoForschungsZentrum GFZ

LSDMA Spring Meeting, March 11-13, 2013
DESY, Hamburg

Seismological infrastructure

- research target: planet earth, too large to be taken into a lab
- measuring instrument: aggregation of seismic networks
- seismological equipment: various manufacturers, proprietary formats, protocols and software
- funding policy: national, mostly for seismic monitoring
- data policy: mixed, research data mostly open, monitoring data differs
- strategy: urgent need for cooperation and standardization
- international organizations: FDSN (global), ORFEUS (Europe)
- major global programs: IRIS, GEOFON
- GEOFON community developments: SeedLink, ArcLink, SeisComP
- European infrastructure projects (ORFEUS coordinated): MEREDIAN (FP5), NERIES (FP6), NERA (FP7), EPOS (ESFRI)
- major achievements: VEBSN (Virtual European Broadband Seismograph Network), EIDA (European Integrated Data Archive)

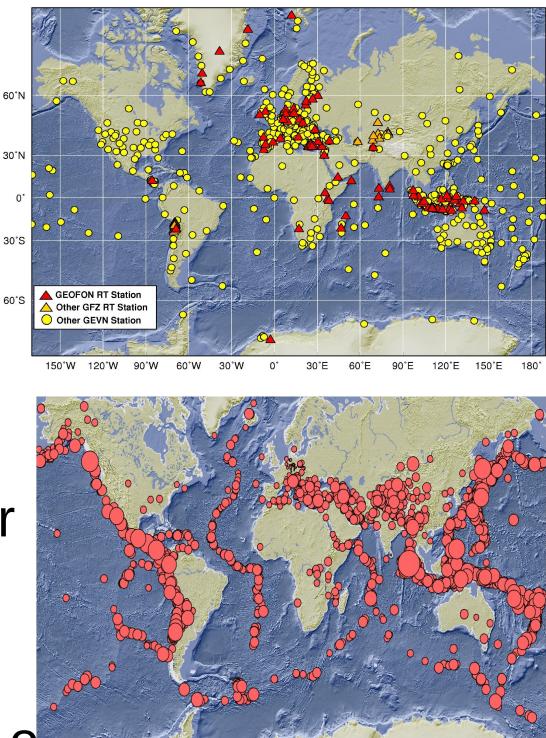
GEOFON is a major global player in seismological infrastructure

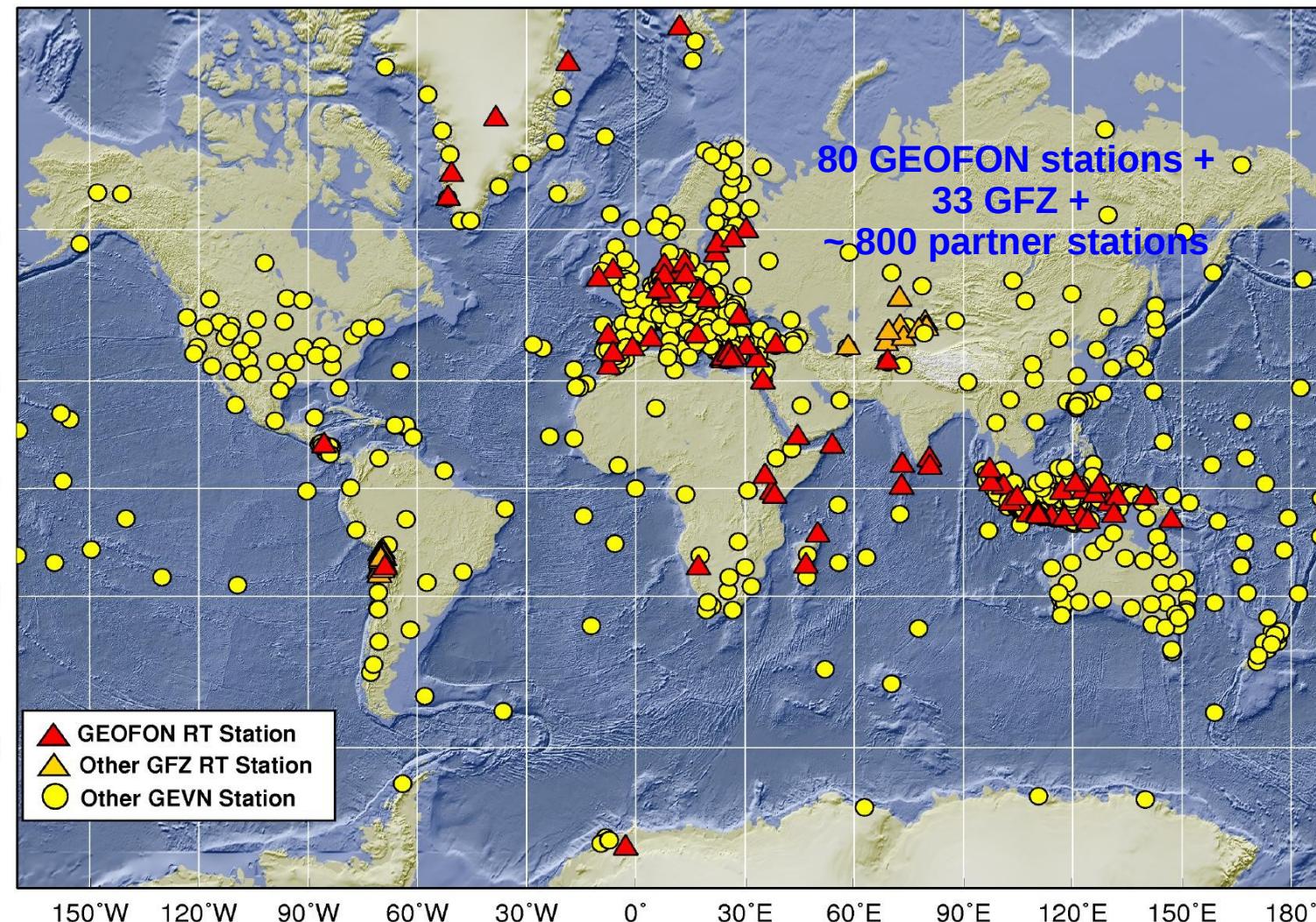
It operates

- the largest collection and distribution point for real-time seismic data streams in Europe
- the largest seismological data archive in Europe
- the central European facility for rapid global earthquake monitoring within EMSC
- a major real-time data and earthquake parameter provider for tsunami warning centers and earthquake services

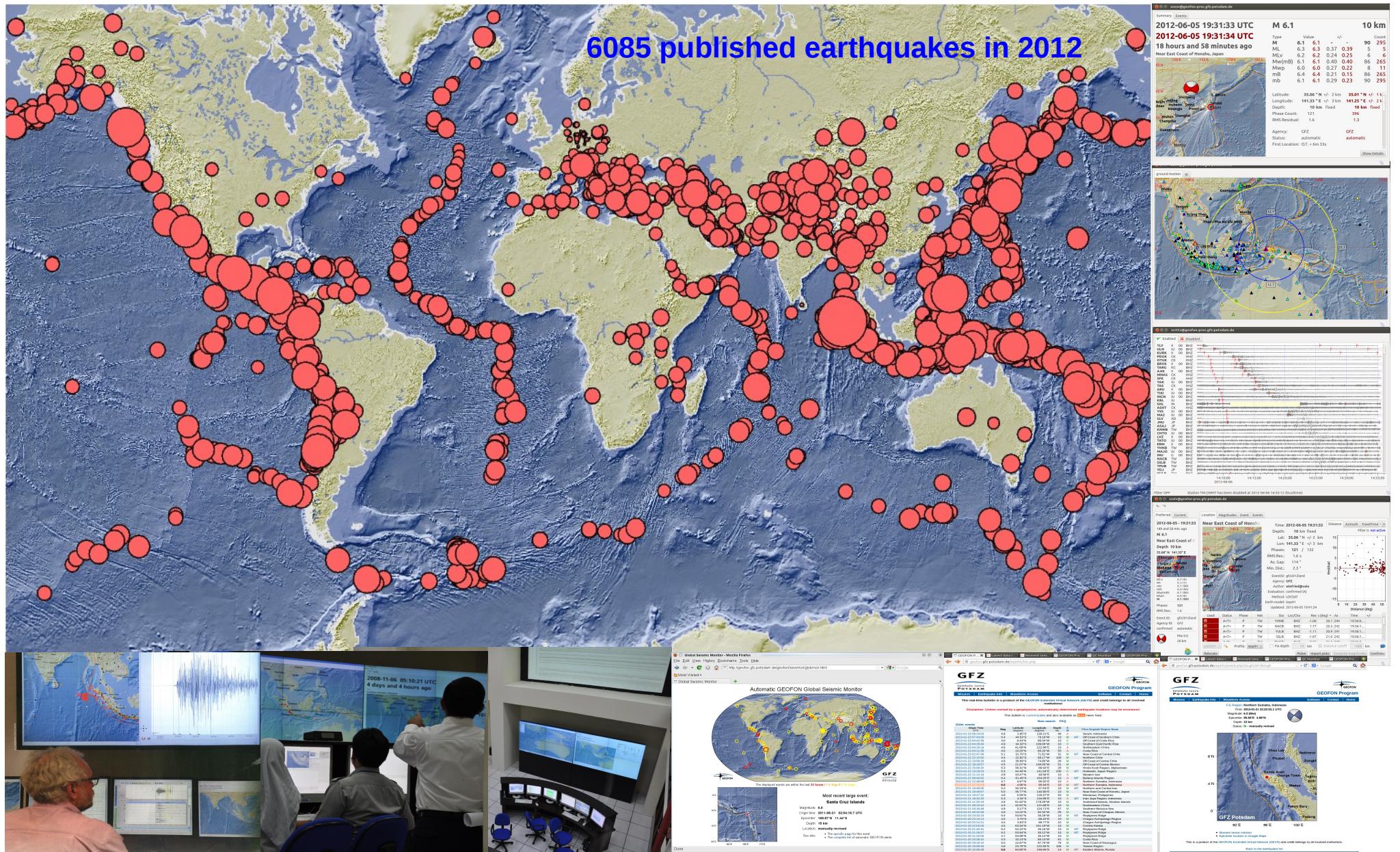
It is

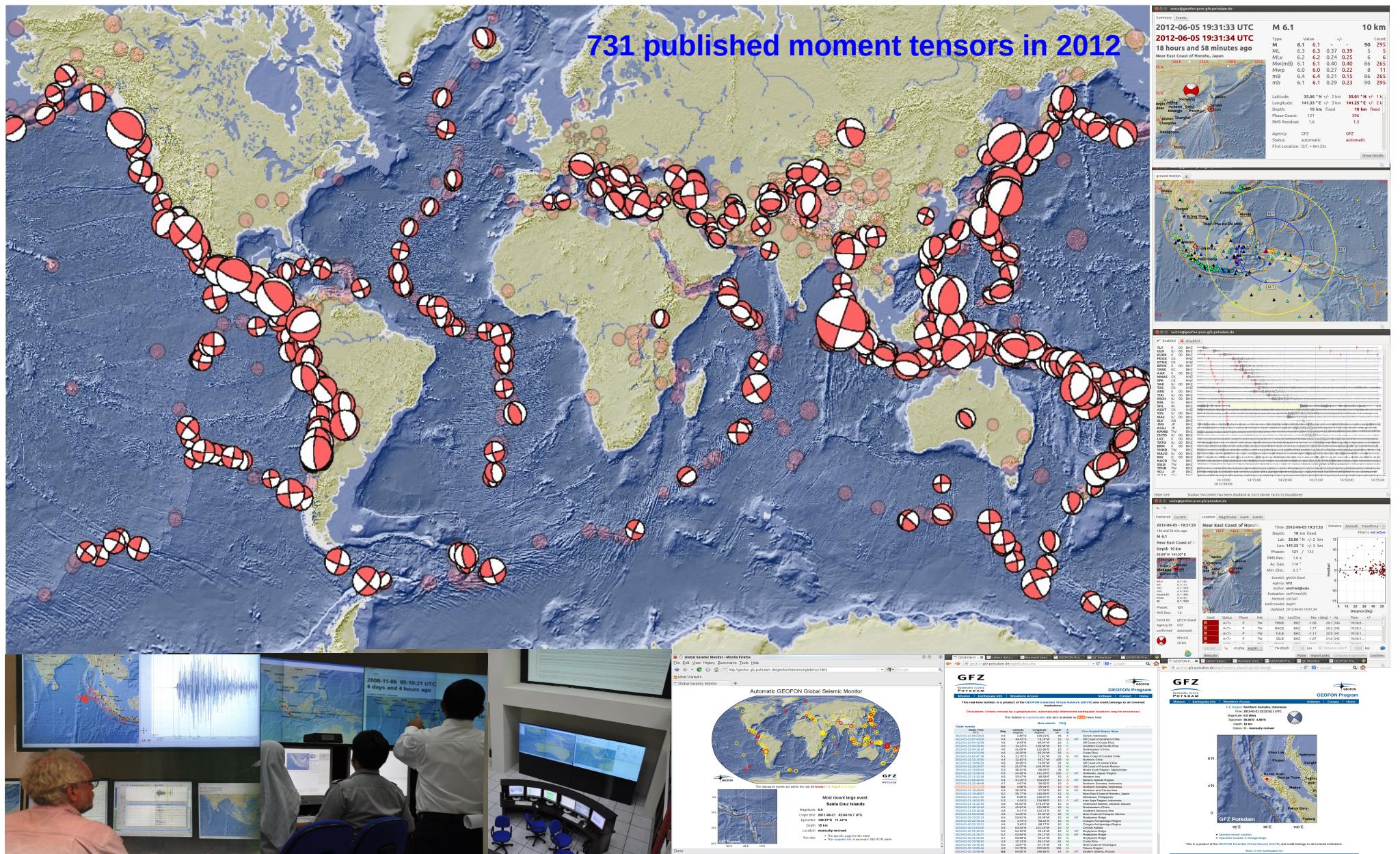
- setting standards and developing software for networking of seismological infrastructures (SeisComP)
- coordinating the establishment of a unified European distributed seismological data center (EIDA) structure within ORFEUS
- the major player in the setup of the seismological component of the Indian Ocean Tsunami Warning System (GITEWS)





GEOFON Earthquake Information Service





GEOFON Earthquake Information Service

GFZ Potsdam - Earthquake Bulletin - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://geofon.gfz-potsdam.de/

Most Visited

GFZ Potsdam - Earthquake ...

GFZ Potsdam >> GEOFON >> Global Seismic Monitor

GFZ Potsdam - Earthquake Bulletin

This real-time bulletin is a product of the **GEOFON Extended Virtual Network (GEVN)** and credit belongs to all involved institutions!

Disclaimer: Unless revised by a geophysicist, automatically determined earthquake locations may be erroneous!

This bulletin is customizable and also available as [RSS news feed](#).

Origin Time	Mag	Latitude	Longitude	Depth	A	M	Flinn-Engdahl Region Name
UTC		degrees	degrees	km			
2011-06-21 08:49:39	5.2	35.66°N	141.50°E	5	A		Near East Coast of Honshu, Japan
2011-06-21 06:12:35	4.7	7.60°S	130.54°E	44	M		Tanimbar Islands Reg., Indonesia
2011-06-21 02:04:18	4.5	35.22°N	75.50°E	43	A		Eastern Kashmir
2011-06-21 02:04:16	6.0	11.44°S	165.57°E	15	M		Santa Cruz Islands
2011-06-20 23:31:04	4.2	73.74°N	8.50°E	10	A		Greenland Sea
2011-06-20 22:05:53	4.9	4.40°S	135.57°E	10	A		Irian Jaya Region, Indonesia
2011-06-20 21:19:58	5.0	53.73°N	35.39°W	10	M		Reykjanes Ridge
2011-06-20 21:16:50	4.9	53.36°N	35.38°W	10	M		Reykjanes Ridge
2011-06-20 21:01:27	4.4	53.65°N	35.27°W	10	M		Reykjanes Ridge
2011-06-20 19:51:59	4.4	7.33°S	67.57°E	10	M		Mid Indian Ridge
2011-06-20 19:37:08	4.7	46.21°N	149.90°E	165	A		Kuril Islands
2011-06-20 18:20:34	4.3	38.07°N	21.97°E	10	A		Greece
2011-06-20 18:12:23	5.3	13.31°S	167.16°E				
2011-06-20 16:35:59	6.5	21.84°S	68.42°W				
2011-06-20 11:25:54	4.6	4.77°N	82.57°W				
2011-06-20 10:16:56	5.2	25.17°N	98.72°E				
2011-06-20 06:27:19	4.9	30.58°N	79.36°E				
2011-06-20 04:25:22	4.7	50.08°S	114.51°W				
2011-06-20 03:27:21	4.7	14.95°S	173.17°W				
2011-06-20 01:46:35	4.9	35.41°N	140.93°E				
2011-06-19 21:26:45	5.3	15.18°S	177.75°W				
2011-06-19 18:58:34	4.7	36.92°N	141.53°E				
2011-06-19 18:13:06	4.6	36.86°N	141.13°E				
2011-06-19 16:53:15	4.9	22.20°N	143.45°E				
2011-06-19 16:13:41	5.0	7.32°N	82.21°W				
2011-06-19 14:35:38	4.1	44.23°N	10.74°E				
2011-06-19 13:44:38	4.9	3.39°S	99.63°E				
2011-06-19 11:05:28	5.4	55.01°S	128.83°W				
2011-06-19 08:37:47	5.1	56.10°S	27.56°W				
2011-06-19 08:29:10	4.9	6.84°N	127.02°E				
2011-06-19 06:52:46	4.8	35.57°N	141.01°E				
2011-06-19 06:03:48	5.0	19.83°S	177.76°W				
2011-06-19 04:15:58	5.3	3.27°S	101.29°E				
2011-06-19 02:28:24	4.5	47.52°N	147.56°E				
2011-06-19 00:20:06	5.4	5.83°S	81.01°W				
2011-06-18 22:54:51	4.9	17.15°N	99.61°W				
2011-06-18 22:50:49	4.8	2.48°S	101.70°E				
2011-06-18 22:11:29	5.0	5.60°S	80.64°W				
2011-06-18 20:04:19	5.3	19.31°S	175.84°W				
2011-06-18 17:30:26	4.9	14.11°N	91.60°W				

Earliest

Helmholtz-Zentrum Potsdam Deutsches GeoForschungsZentrum

No 24/7 service!

Automatic seismogram processing

manuel revision on demand

publishing within 3 - 10 min

(most) rapid global earthquake information!

This is a product of the GEOFON Extended Virtual Network (GEVN) and credit belongs to all involved institutions. This page is also suitable for display on handheld devices.

Done

Global Seismic Monitor - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://geofon.gfz-potsdam.de/

Most Visited

Global Seismic Monitor

Automatic GEOFON Global Seismic Monitor

The displayed events are within the last **24 hours / 1.4 days / 14 days**.

Most recent large event:
Santa Cruz Islands
Magnitude: 6.0

On **GEOFON BIG alert: M 6.4, Chile-Bolivia Border Region - events - GFZ Extern - Mozilla Thunderbird**

File Edit View Go Message Tools Help

Get Mail Write Address Book Tag

events - GFZ Extern **GEOFON BIG alert: M 6...**

from GFZ Earthquake Bulletin <eqinfo-big@gfz-potsdam.de>
 subject: **GEOFON BIG alert: M 6.4, Chile-Bolivia Border Region**
 to: eqinfo-big@gfz-potsdam.de

06/20 other

== Preliminary Earthquake Report ==

Chile-Bolivia Border Region
 2011-06-20 16:35:58 UTC
 6.4
 21.87 S 68.31 W
 96 km
 gzf2011lzwj

Automatically generated report, i.e. this event has not been reviewed by a seismologist. Automatically determined locations may be erroneous.

for this event is sent only once. To examine later estimates for the same event, please look at gfz-potsdam.de/db/equake.php?id=gzf2011lzwj&from=email

recent GEOFON alerts at <http://geofon.gfz-potsdam.de/db/eqinfo.php>

is a joint effort of all GEVN ("GEOFON Extended Virtual Network") partners (http://www.gfz-potsdam.de/geofon/new/netabs/eq_info_nets.html). Proper credit!

 s sent to you because you are subscribed to list eqinfo-big@gfz-potsdam.de.
 , E-mail to: eqinfo-big-off@gfz-potsdam.de
 in DIGEST mode, E-mail to eqinfo-big-dig@gfz-potsdam.de
 in INDEX mode, E-mail to eqinfo-big-index@gfz-potsdam.de
 active queries to eqinfo-big-request@gfz-potsdam.de

R - Google Maps - Mozilla Firefox

Filemarks Tools Help

http://maps.google.com/maps?f=q&q=21.84S+68.42W

Get Mail Write Address Book Tag

21.84S, 68.42W (epicenter)

Drucken Senden Link

Anmelden

Maps-Suche

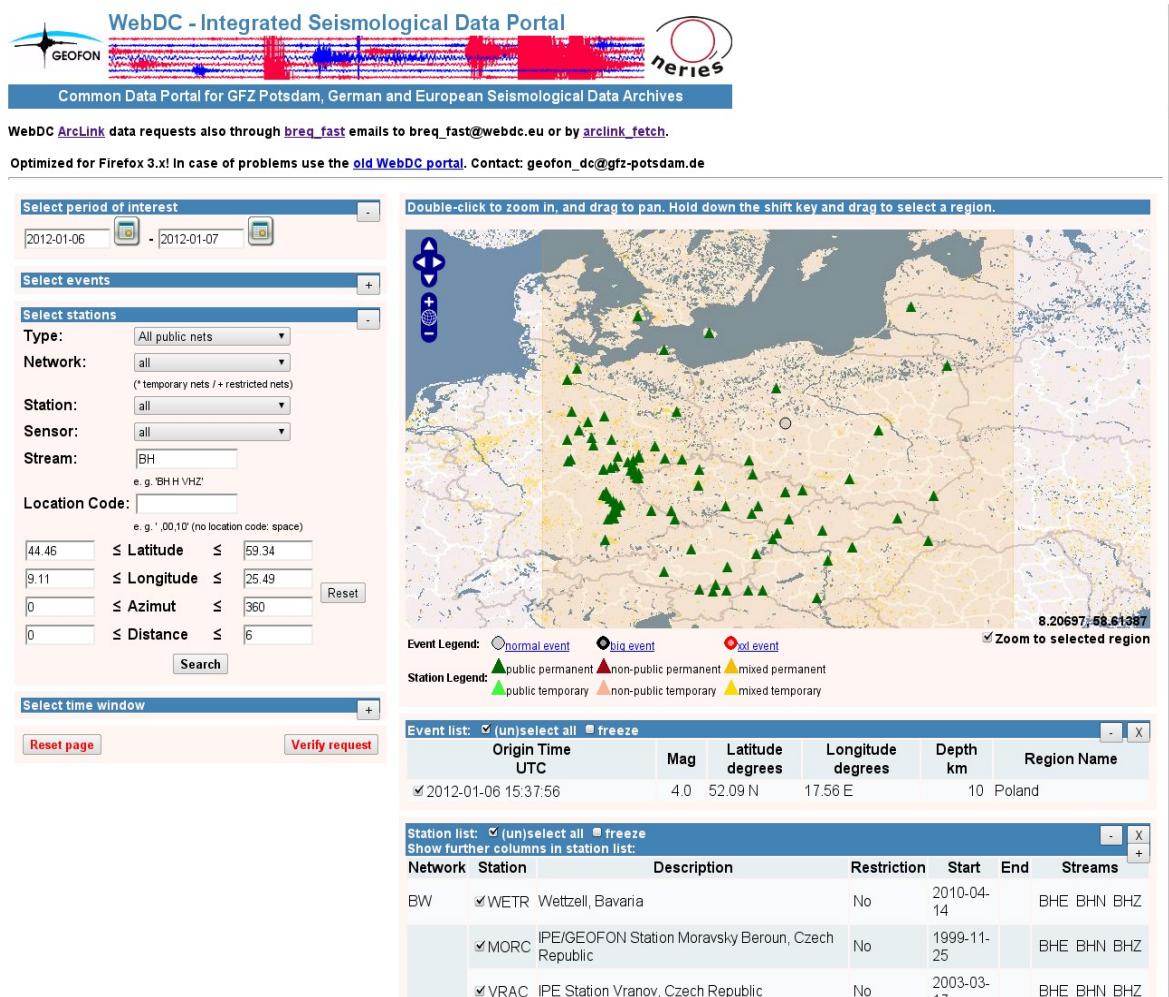
Satellit Fotos

21.84S, 68.42W (epicenter)

Cerro La Aniquilla, Ollague, Volcan Ollague, Callejon Canapa, San Pedro de Atacama

Done

GEOFON/GFZ/EIDA Data Portal: eida.gfz-potsdam.de



WebDC - Integrated Seismological Data Portal
Common Data Portal for GFZ Potsdam, German and European Seismological Data Archives

WebDC ArcLink data requests also through breq_fast@webdc.eu or by [arclink_fetch](#).

Optimized for Firefox 3.x! In case of problems use the [old WebDC portal](#). Contact: gEOFON_dc@gfz-potsdam.de

Select period of interest: 2012-01-06 - 2012-01-07

Select events

Select stations

Type: All public nets

Network: all

Station: all

Sensor: all

Stream: BH

Location Code: e.g. 'BH VHZ'

Latitude: ≤ 59.34

Longitude: ≤ 25.49

Azimuth: ≤ 360

Distance: ≤ 6

Search

Select time window

Reset page Verify request

Event list: (un)select all freeze

Origin Time UTC	Mag	Latitude degrees	Longitude degrees	Depth km	Region Name
2012-01-06 15:37:56	4.0	52.09 N	17.56 E	10	Poland

Station list: (un)select all freeze

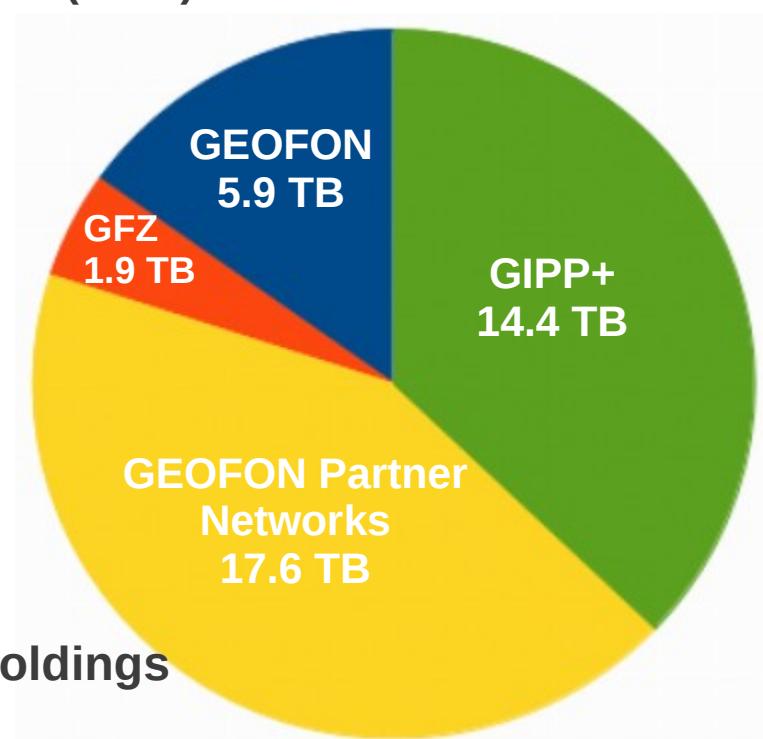
Show further columns in station list:

Network	Station	Description	Restriction	Start	End	Streams
BW	WETR	Wettzell, Bavaria	No	2010-04-14		BHE BHN BHZ
	MORC	IPE/GEOFON Station Moravsky Beroun, Czech Republic	No	1999-11-25		BHE BHN BHZ
	VRAC	IPE Station Vranov, Czech Republic	No	2003-03-17		BHE BHN BHZ

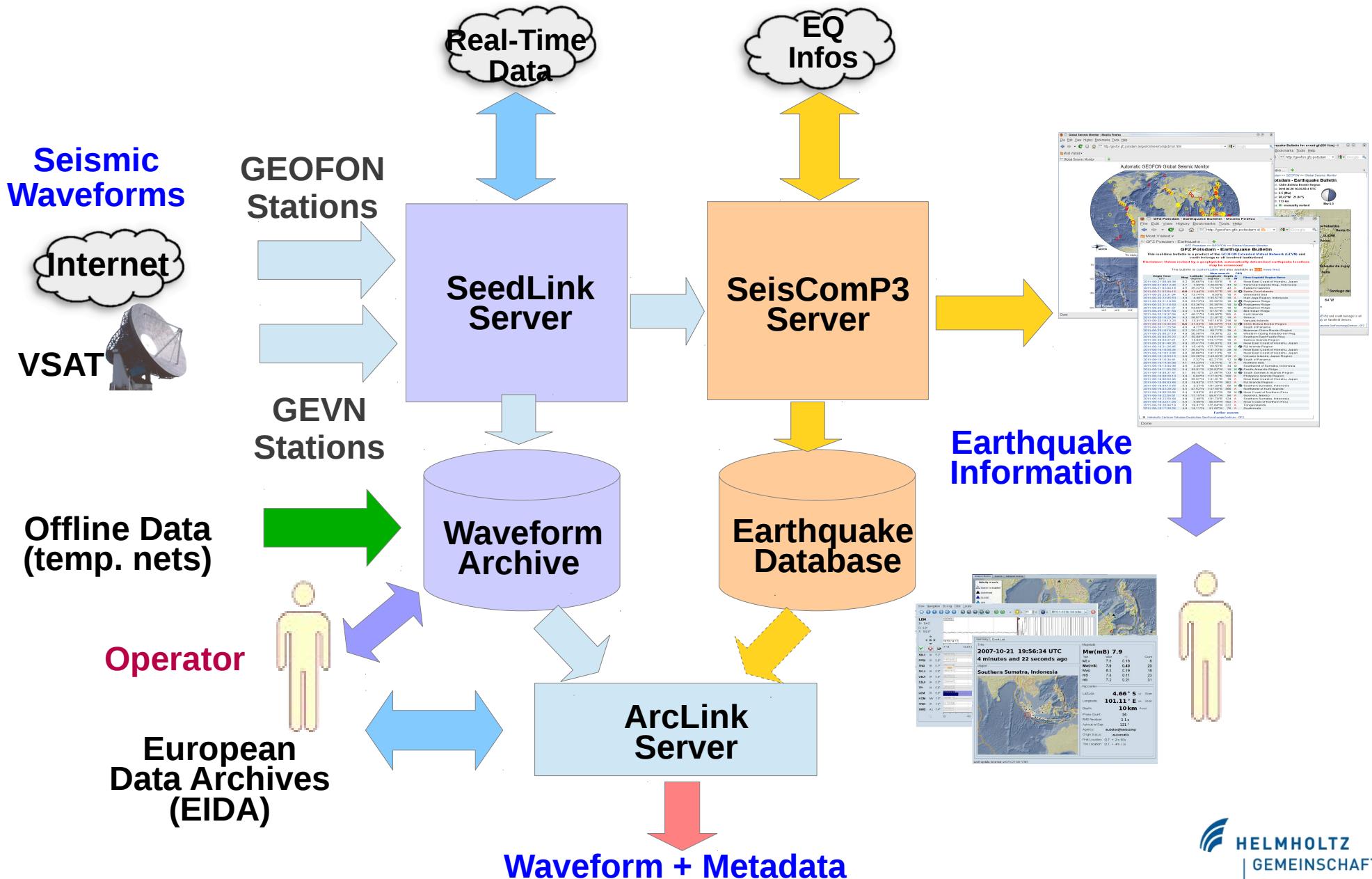
EIDA European Integrated Data Archives

GEOFON data holdings

- Largest seismological data archive in Europe
- Largest distributor of real-time data worldwide (~ 56 TB per year)
- Total archived volume: 40 TB
- Growth: ~ 6 TB per year
- Individual user requests: 1.4 million per year, (8.8 million shipped time windows = 5.9 TB data volume)
- Central node in the distributed European Integrated Data Archive (EIDA) within ORFEUS



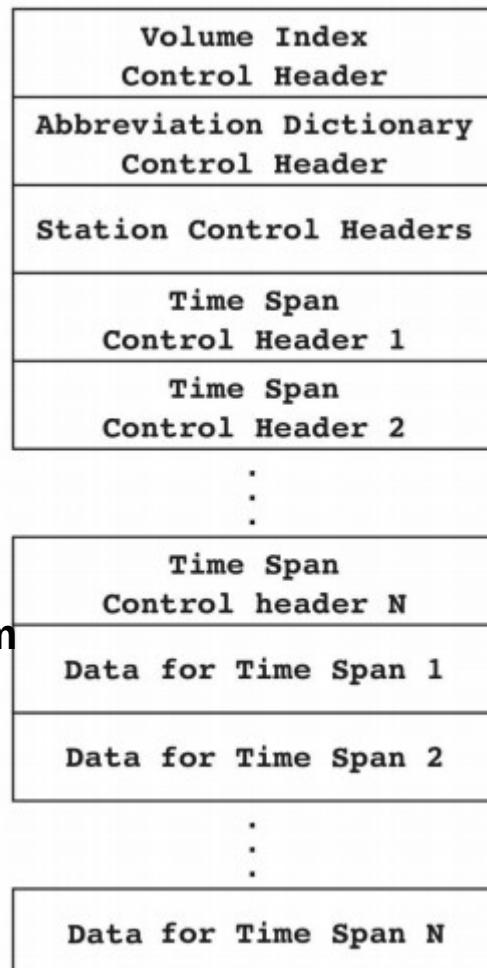
Based on SeisComP3 software



**Challenge 1:
Standard Waveform Data Format
=> merging of different data sets**

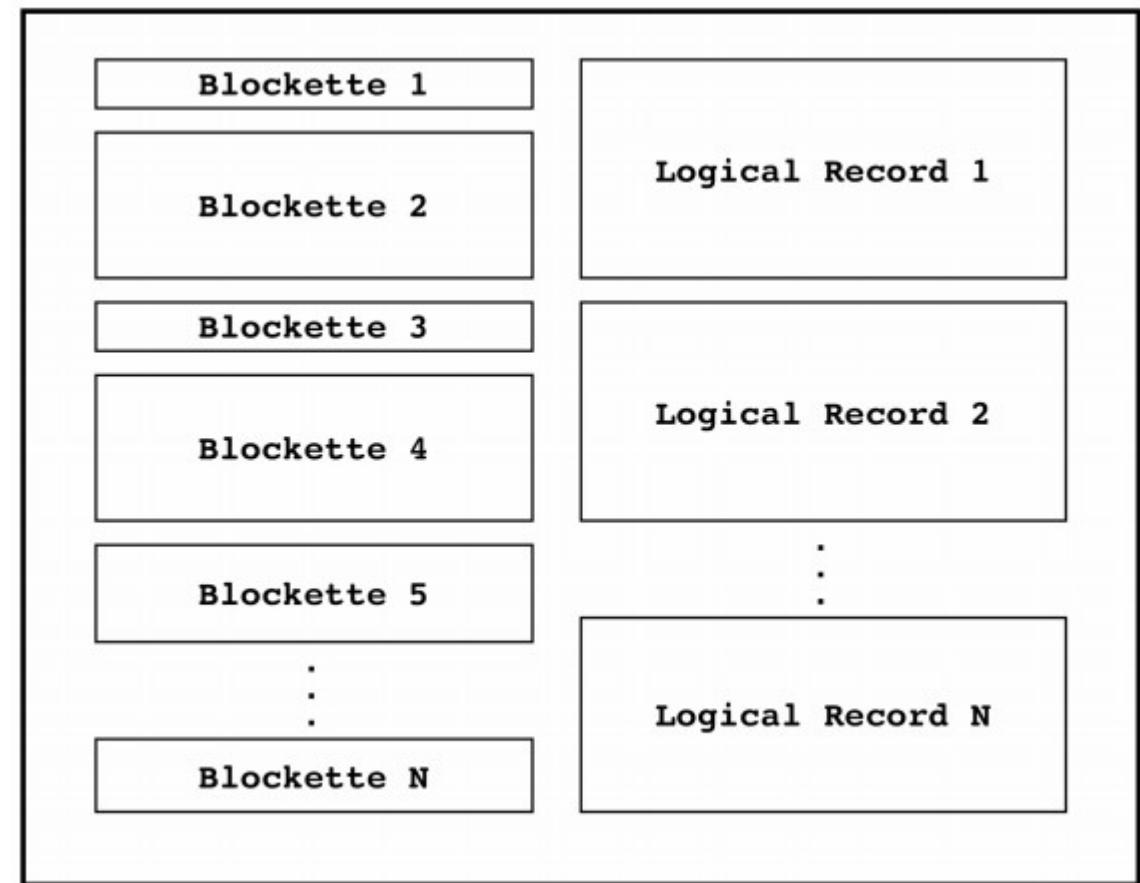
SEED - Standard for the Exchange of Earthquake Data (FDSN)

Meta
data



Waveform
data

Structure of a “Full SEED”
volume



Structure of a SEED header or “dataless SEED volume”
- presently being replaced by a new XML standard

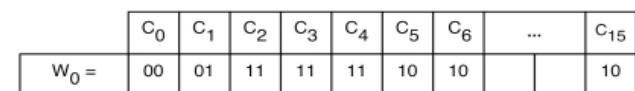
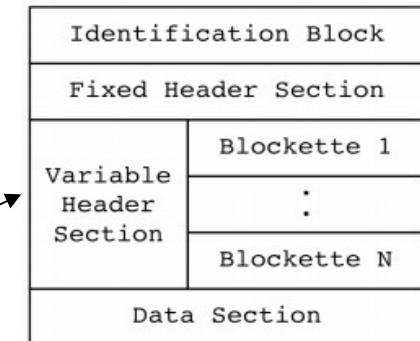
```
/iso_arc/2006/IA/
AAI.IA.2006.iso
BAKI.IA.2006.iso
BJI.IA.2006.iso
BSI.IA.2006.iso
CBIJ.IA.2006.iso
DNP.IA.2006.iso
JAY.IA.2006.iso
JCJI.IA.2006.iso
KDI.IA.2006.iso
KLI.IA.2006.iso
KMMI.IA.2006.iso
KRK.IA.2006.iso
KSI.IA.2006.iso
LEM.IA.2006.iso
MMPI.IA.2006.iso
MNI.IA.2006.iso
NBBI.IA.2006.iso
PCI.IA.2006.iso
PPI.IA.2006.iso
SBJI.IA.2006.iso
SWI.IA.2006.iso
TARA.IA.2006.iso
TLE.IA.2006.iso
TNG.IA.2006.iso
TPI.IA.2006.iso
TSI.IA.2006.iso
WSI.IA.2006.iso
```

isomount /iso_arc/2006/IA/KRK.IA.2006.iso

```
KRK.IA.2006.iso
...
BHZ.D
...
IA.KRK..BHZ.D.2006.146
IA.KRK..BHZ.D.2006.147
IA.KRK..BHZ.D.2006.148
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IA.KRK..BHZ.D.2006.151
IA.KRK..BHZ.D.2006.152
IA.KRK..BHZ.D.2006.153
IA.KRK..BHZ.D.2006.154
...
BHN.D
...
```

Steim2 compressed channel-day files

Compressed station-year ISO files



W₀ = 00 01 11 11 11 10 10 ... 10

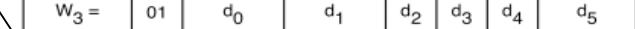
dnib four 8-bit differences



dnib seven 4-bit differences



dnib six 5-bit differences



dnib five 6-bit differences



dnib three 10-bit differences



dnib two 15-bit differences



dnib one 30-bit difference

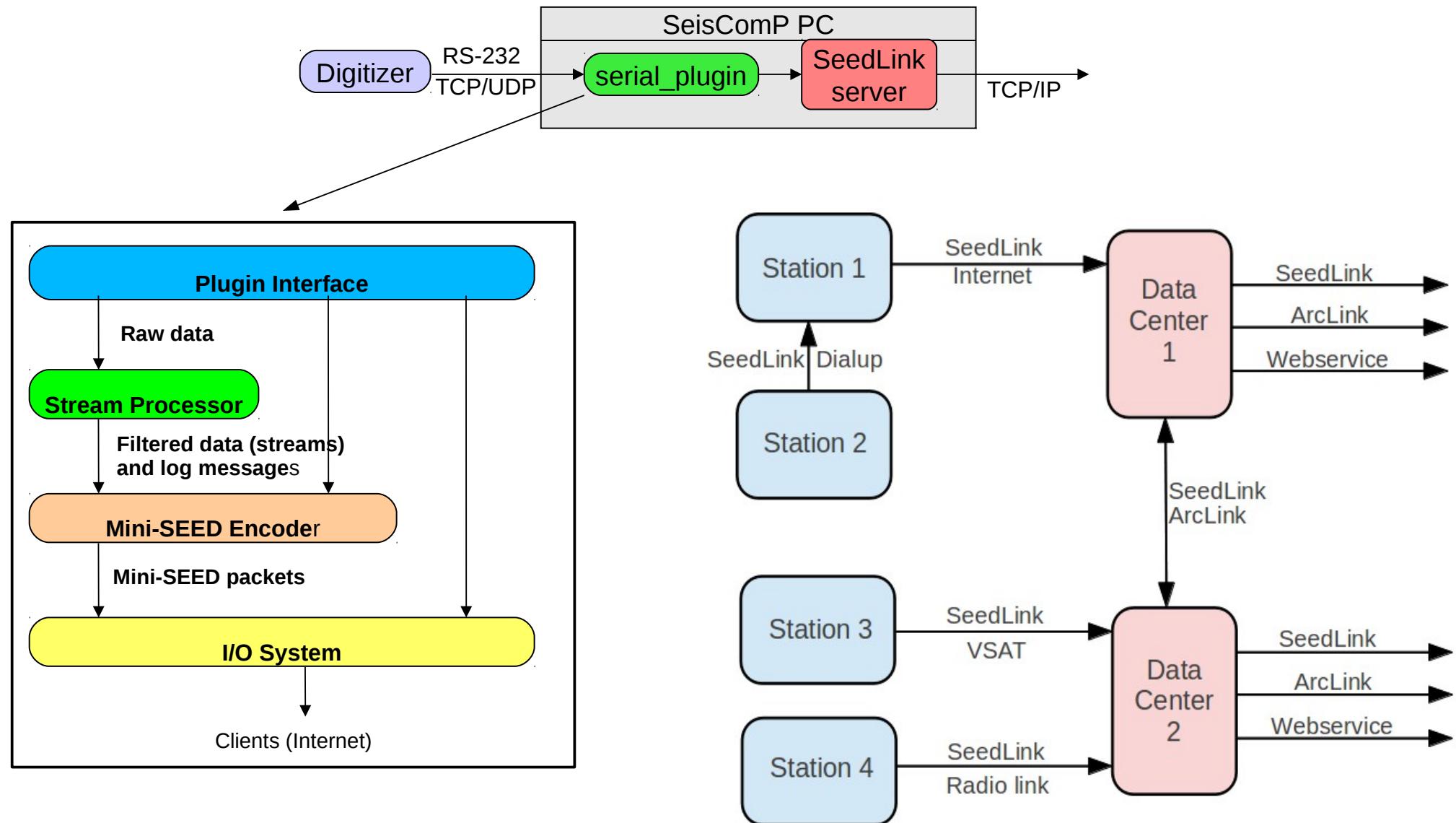


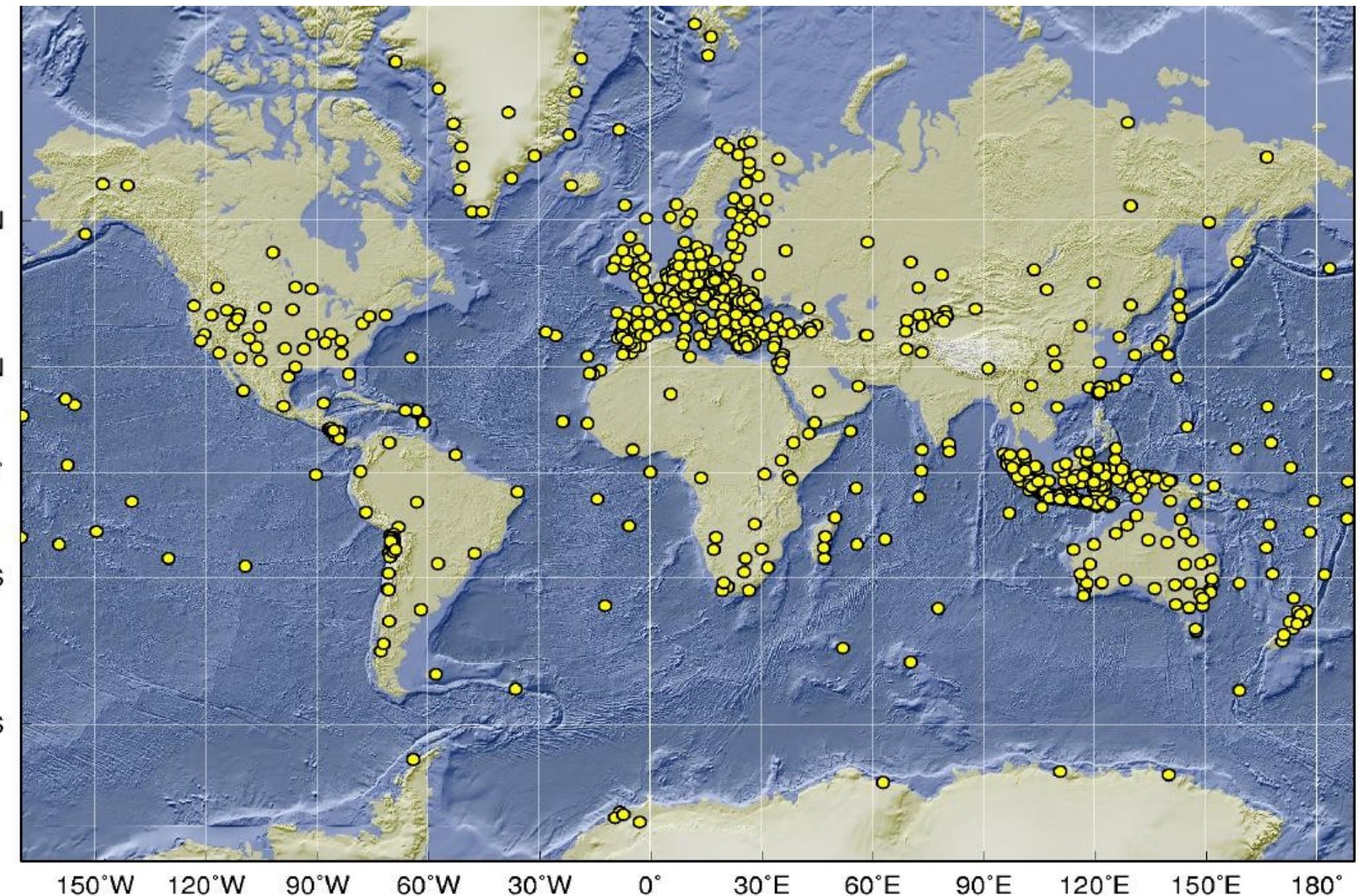
dnib

W₁₅ = 01 d₀

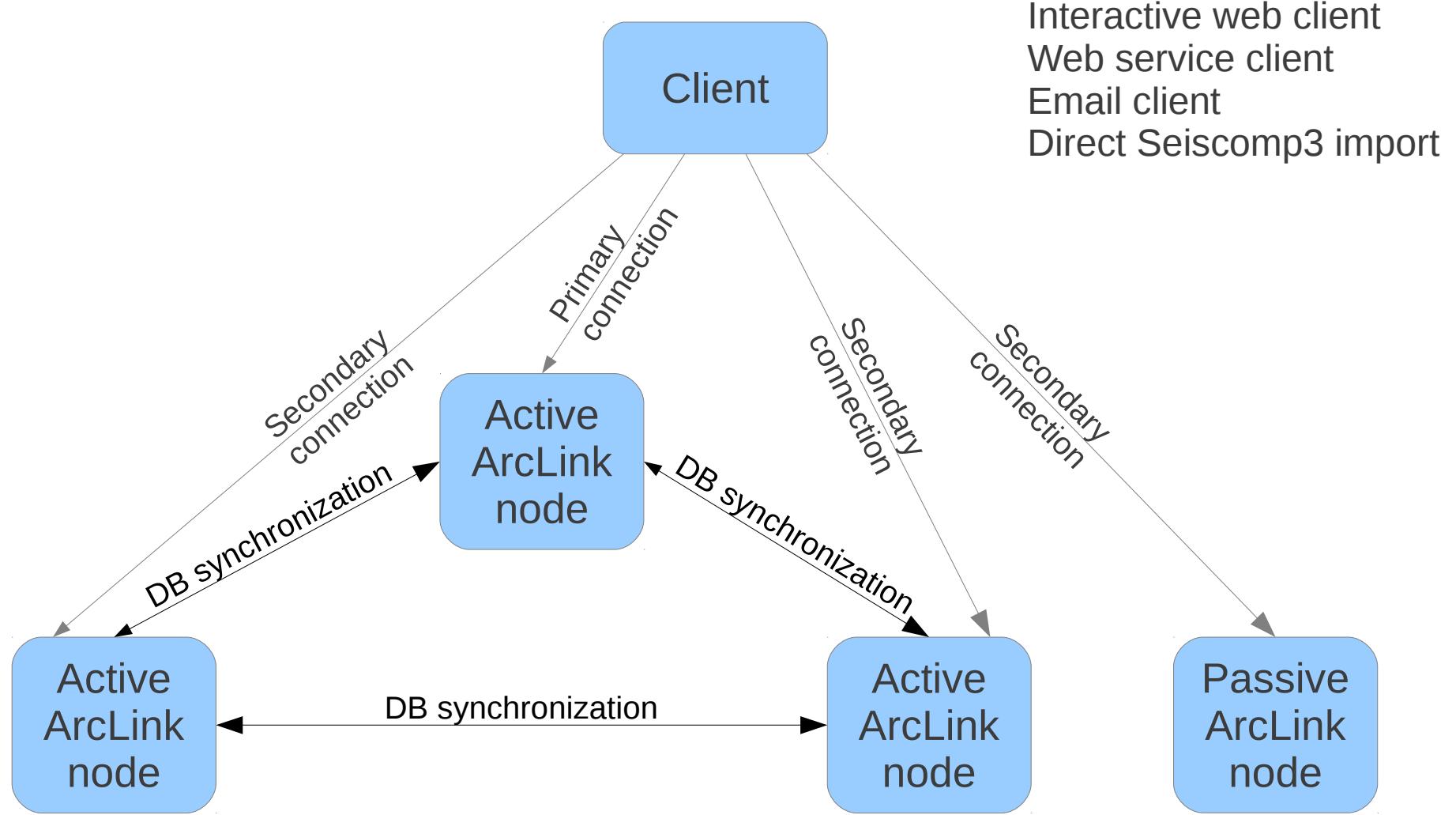
MiniSEED data records  **HELMHOLTZ**
 | GEMEINSCHAFT

Challenge 2:
Standard (Real-Time) Data Exchange Protocol
=> Virtualization of Seismological Networks

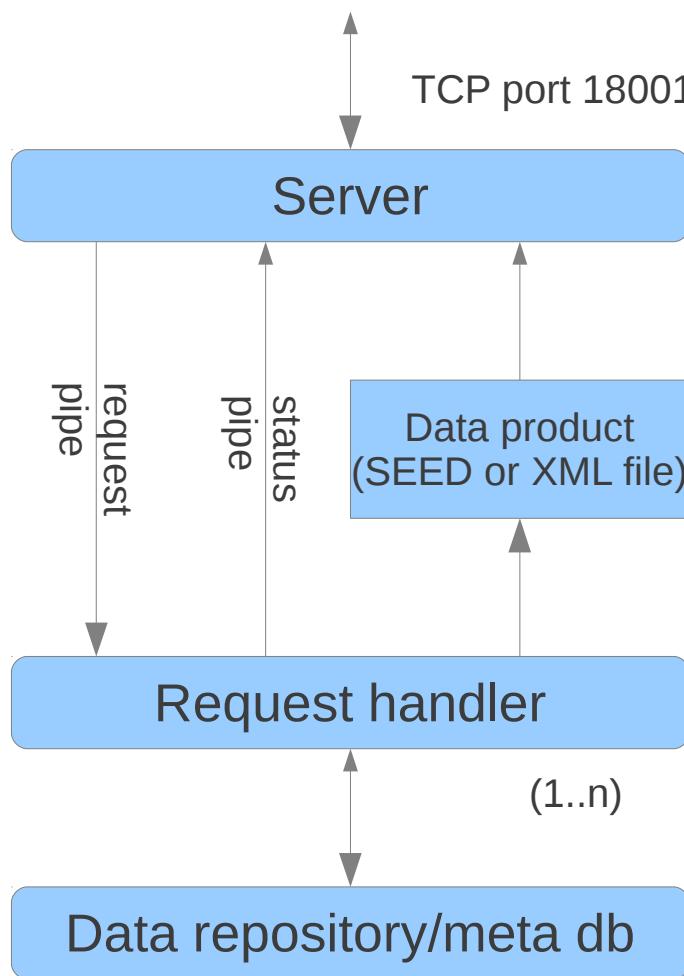




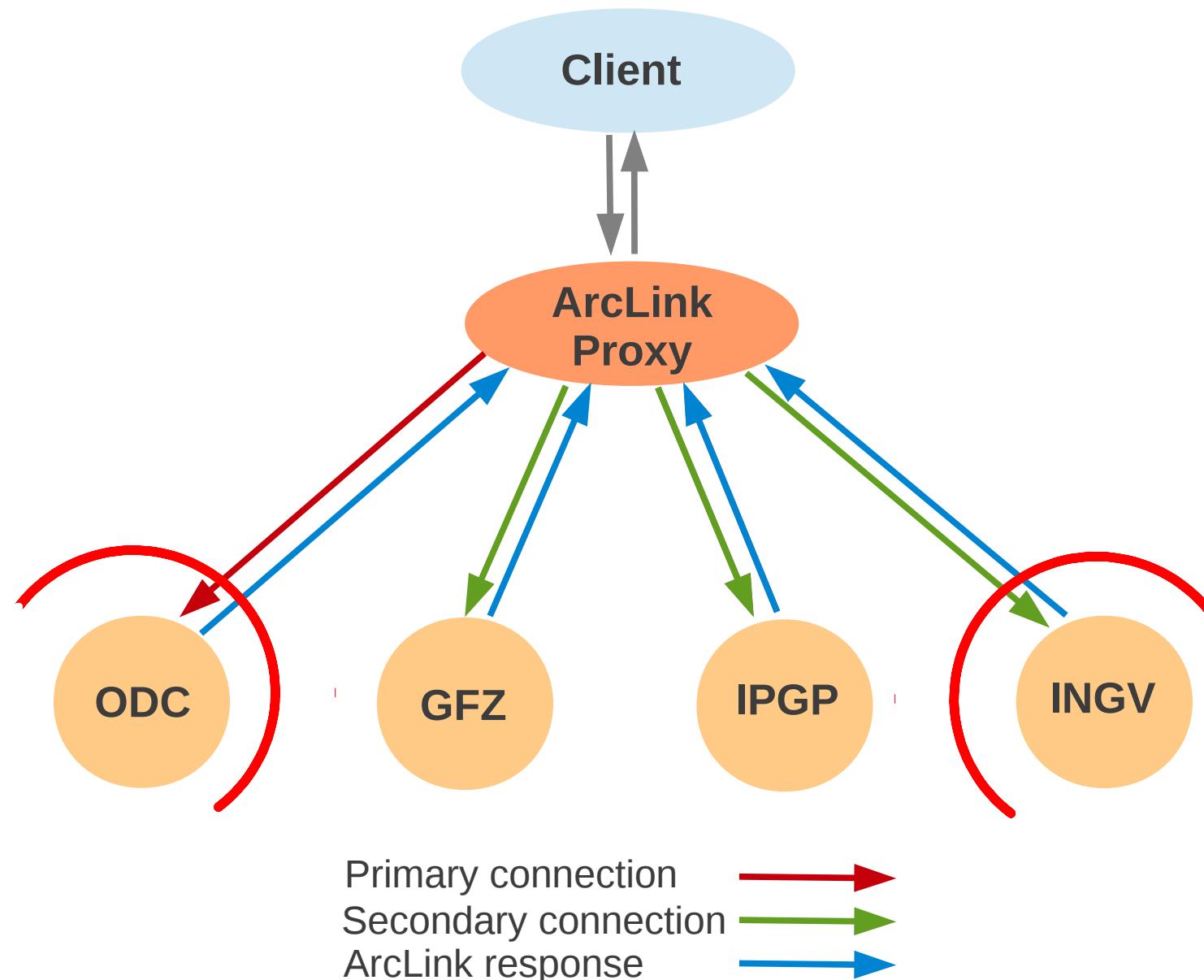
**Challenge 3:
Standard Data Archive Access Protocol
=> Virtualization of Seismological Data Archives**

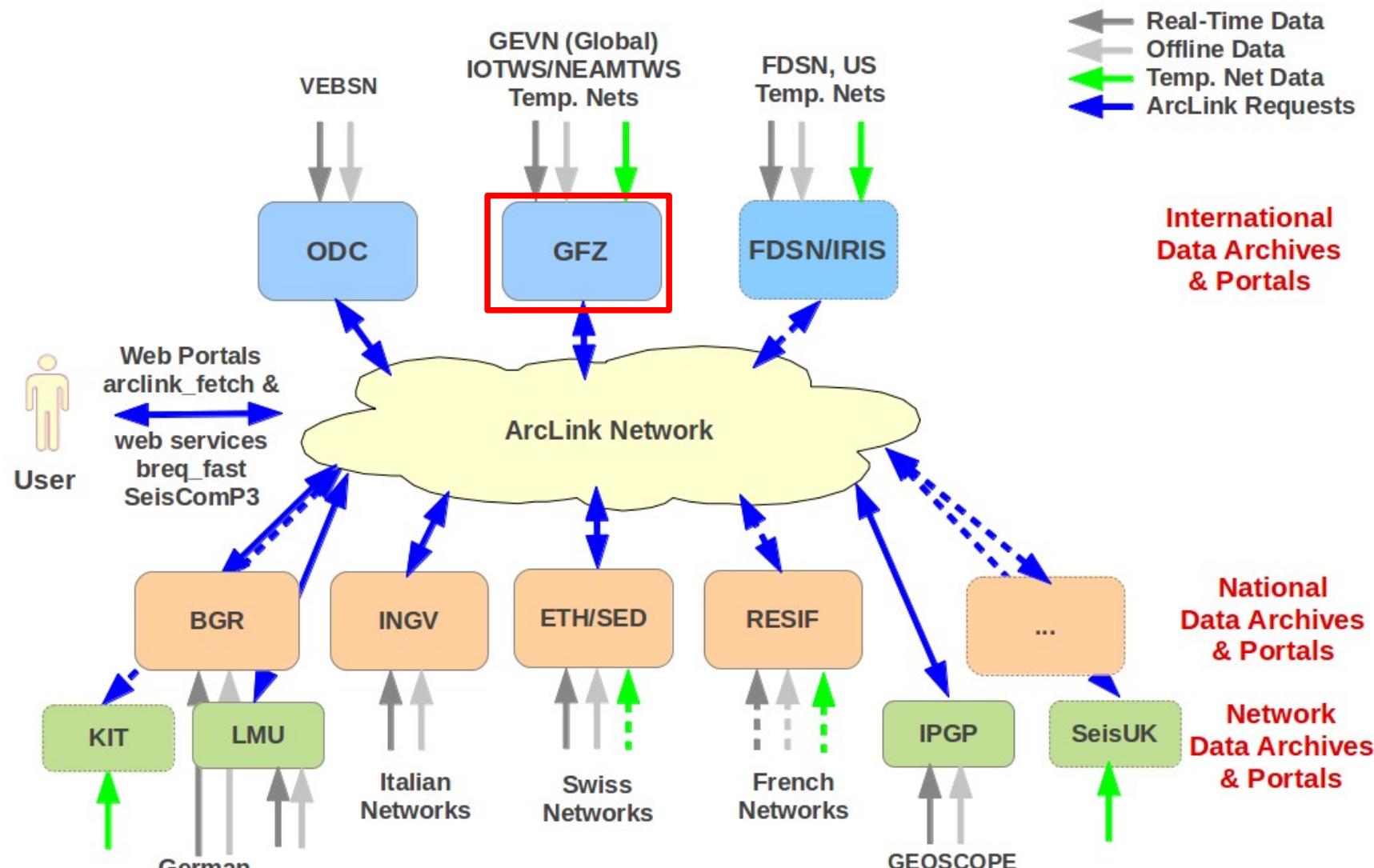


Restricted data sets are delivered encrypted!



<i>Request Type</i>	<i>Attributes</i>	<i>Product Format</i>
INVENTORY	instruments=true false compression=bzip2 none modified_after=date	XML
ROUTING	compression=bzip2 none modified_after=date	XML
RESPONSE	format=SEED compression=bzip2 none	Dataless SEED
WAVEFORM	format=MSEED FSEED compression=bzip2 none	Mini-SEED Full SEED
QC	outages=true false logs=true false	XML

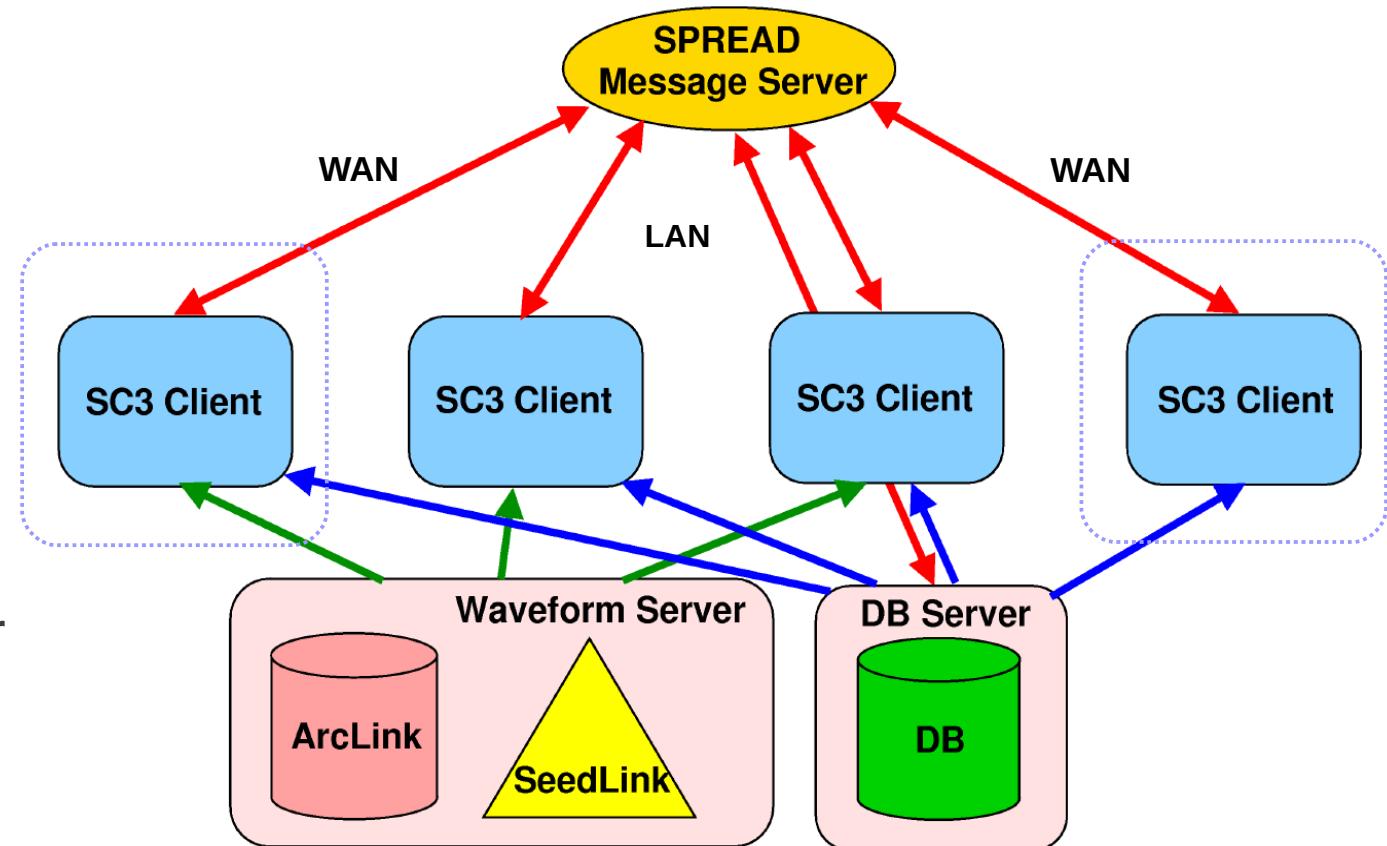




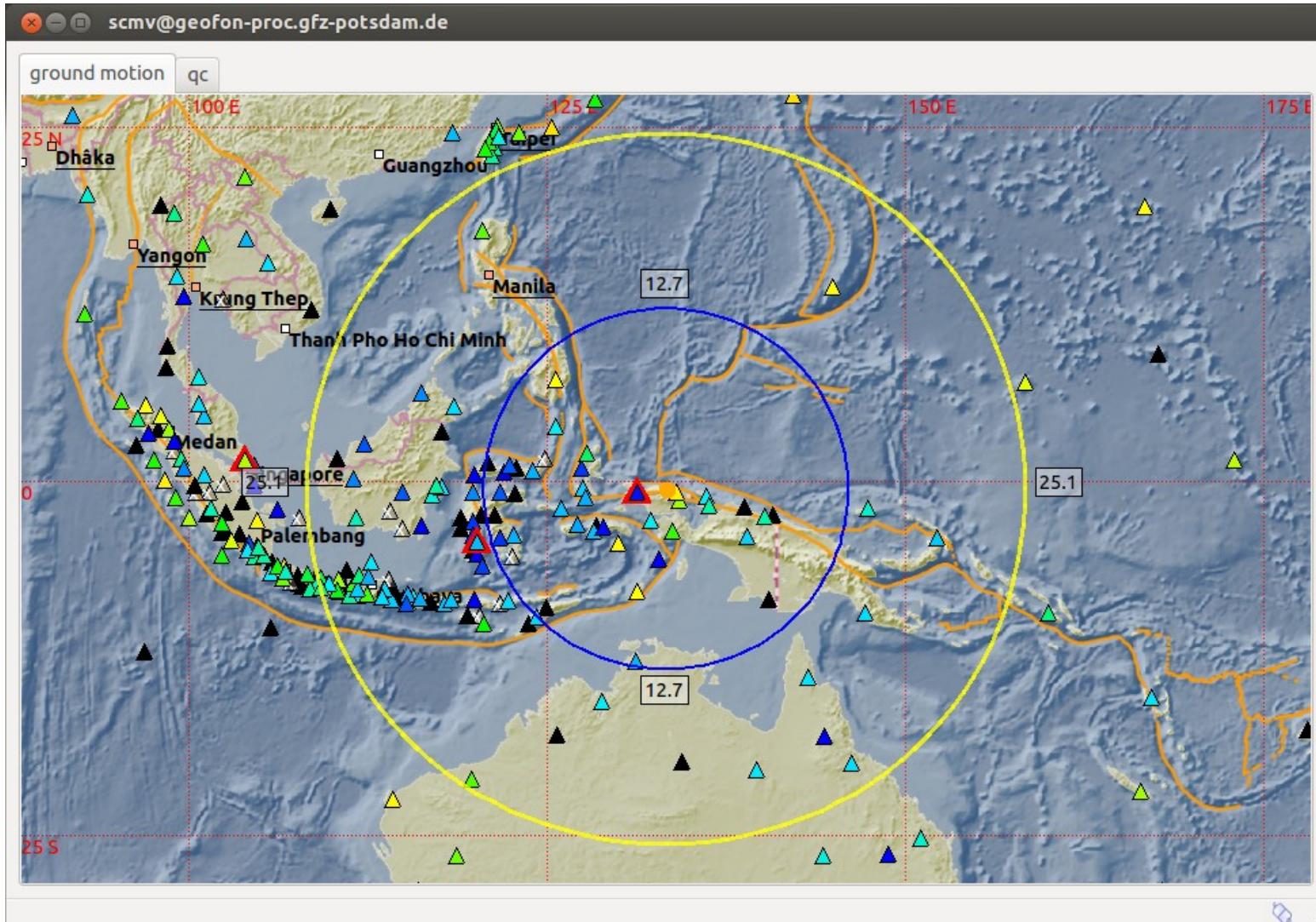
EIDA European Integrated Data Archives

More challenges (GITEWS):
Reliable automatic data processing & analysis
Visualization of automatic results and manual interaction
Standardization of seismic parameter exchange
=> Distributed earthquake & tsunami centers

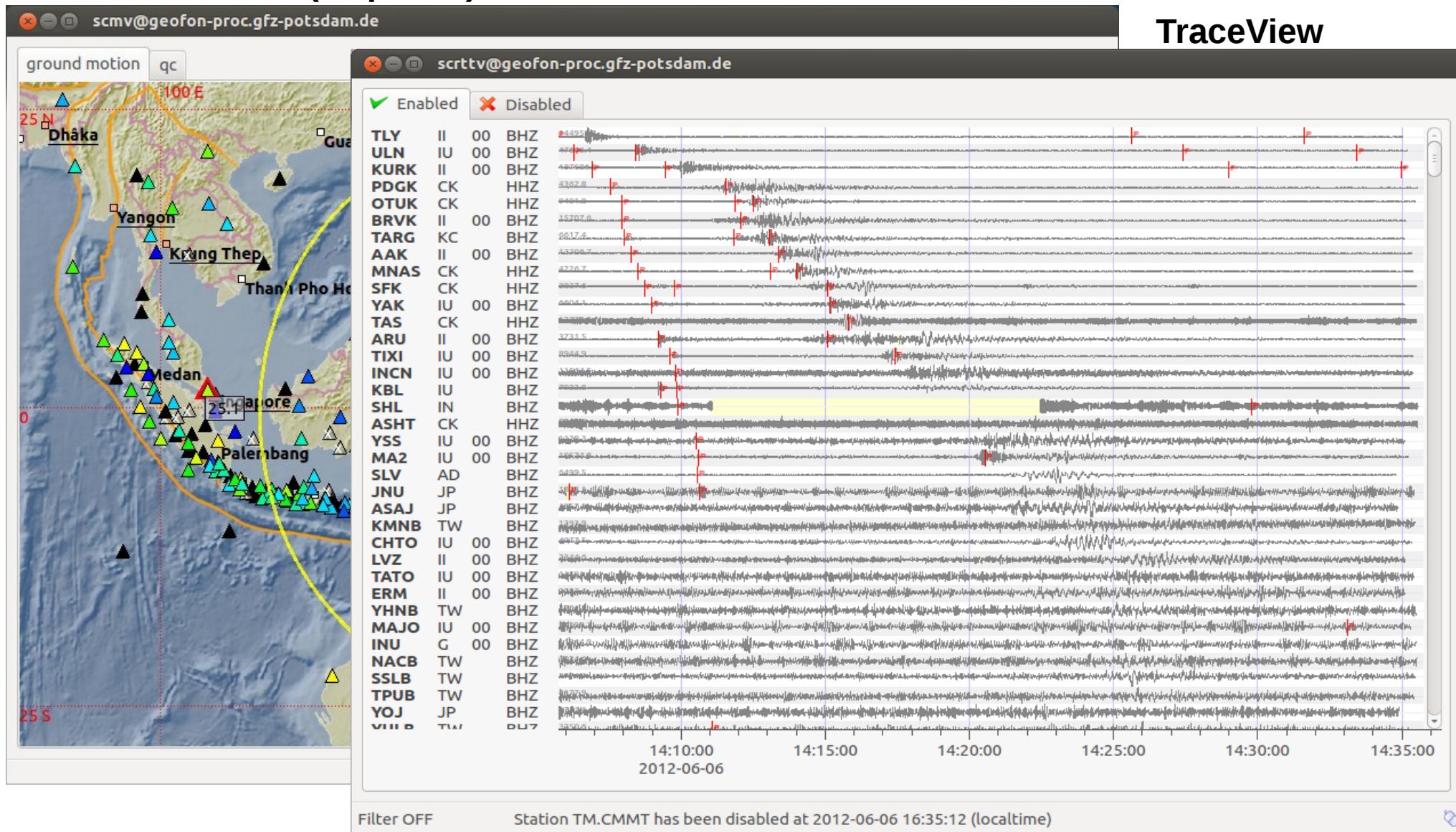
- Fully Automated data processing
- User interactions only for reviewing
- Sophisticated situation displays and manual interaction GUIs
- Widely prevention of operating errors
- Modular design
- Modules communicate over messaging (TCP/IP)
- Distributed computing
- Redundancy
- Unified professional software design and implementation (C++ / Qt)



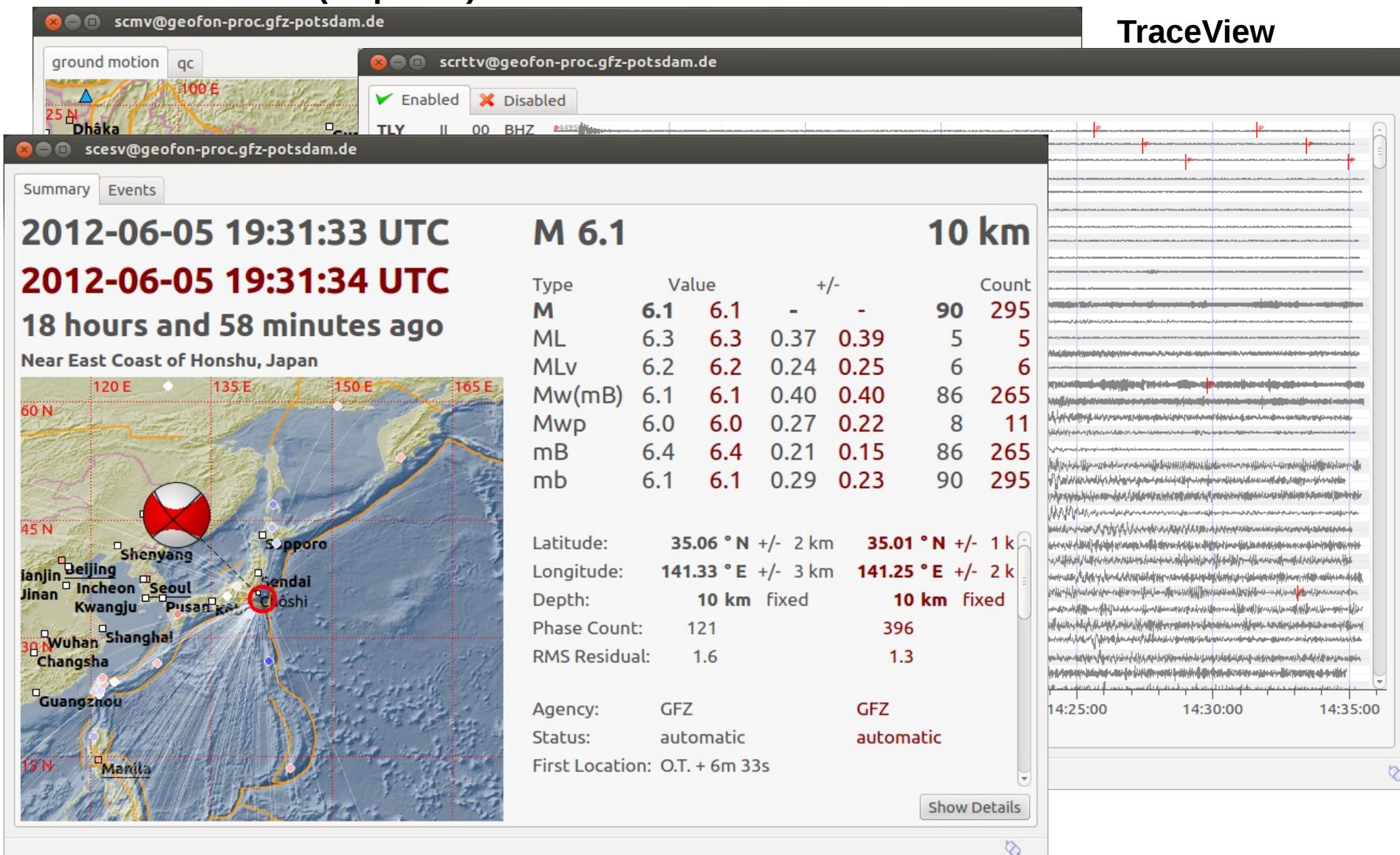
SituationView (MapView)



SituationView (MapView)

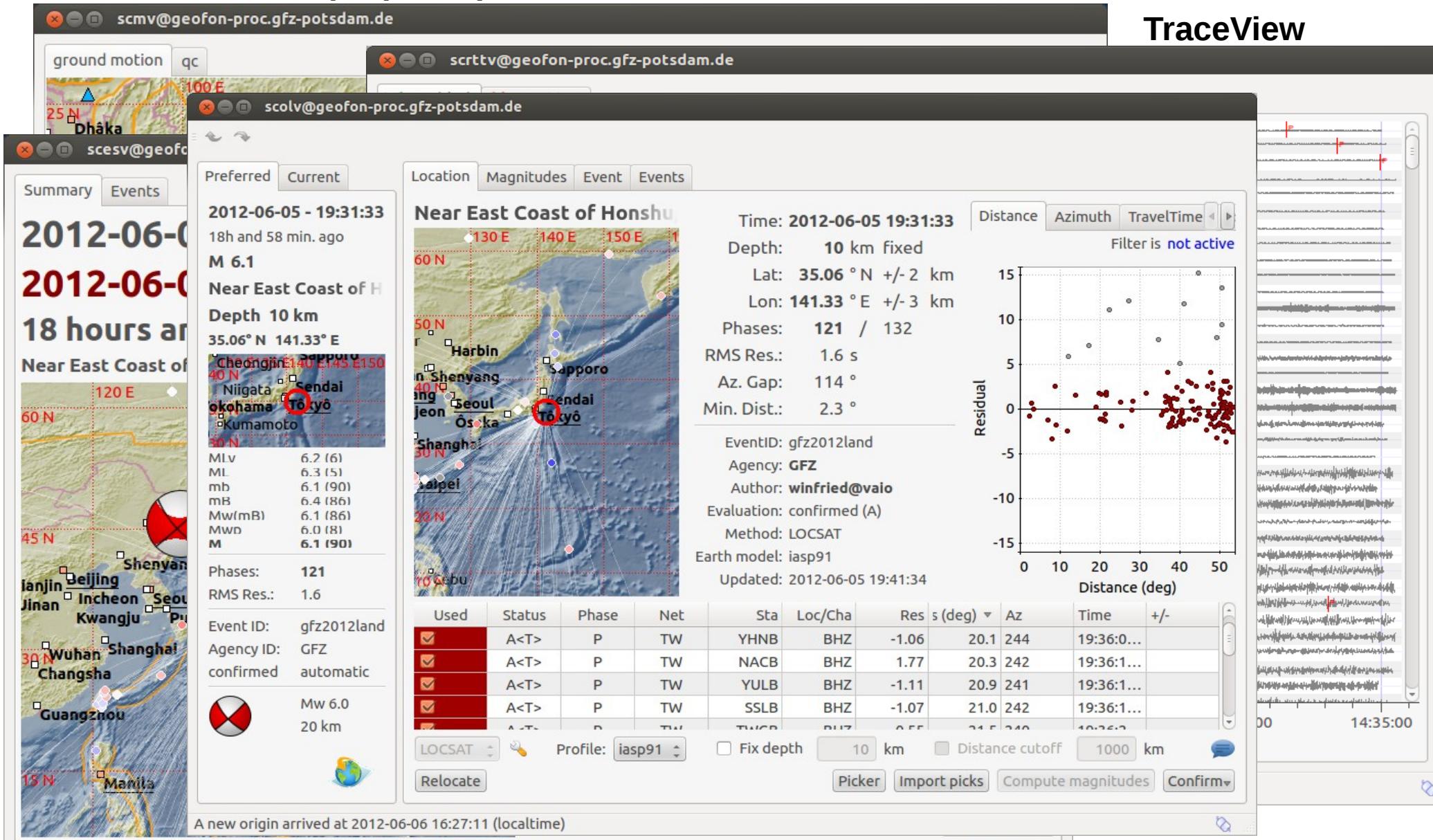


SituationView (MapView)



EventSummaryView

SituationView (MapView)



EventSummaryView

AnalystView
(OriginLocatorView)

SituationView (MapView)

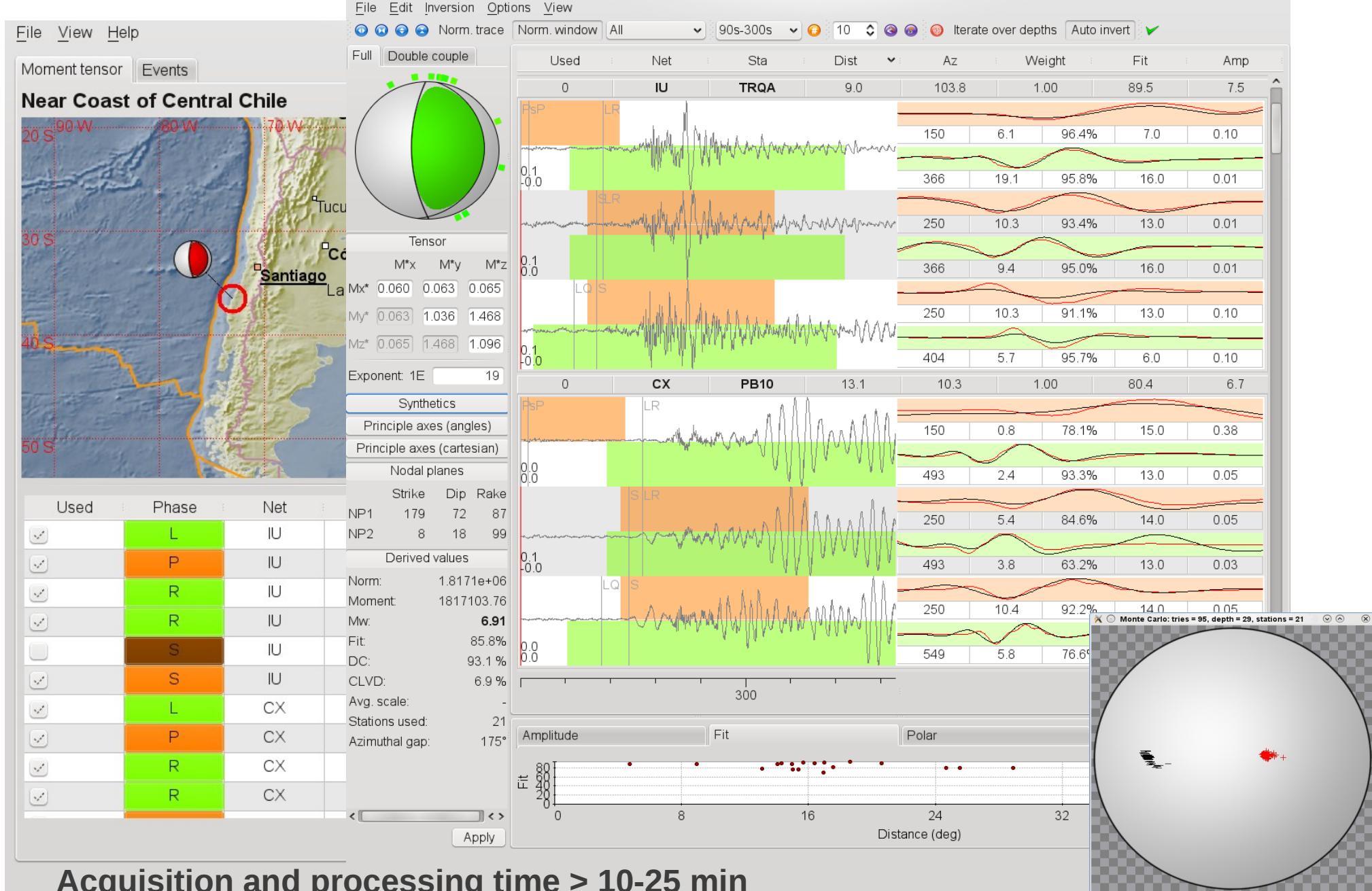


EventSummaryView

ManualPicker

AnalystView
(OriginLocatorView)

MTView



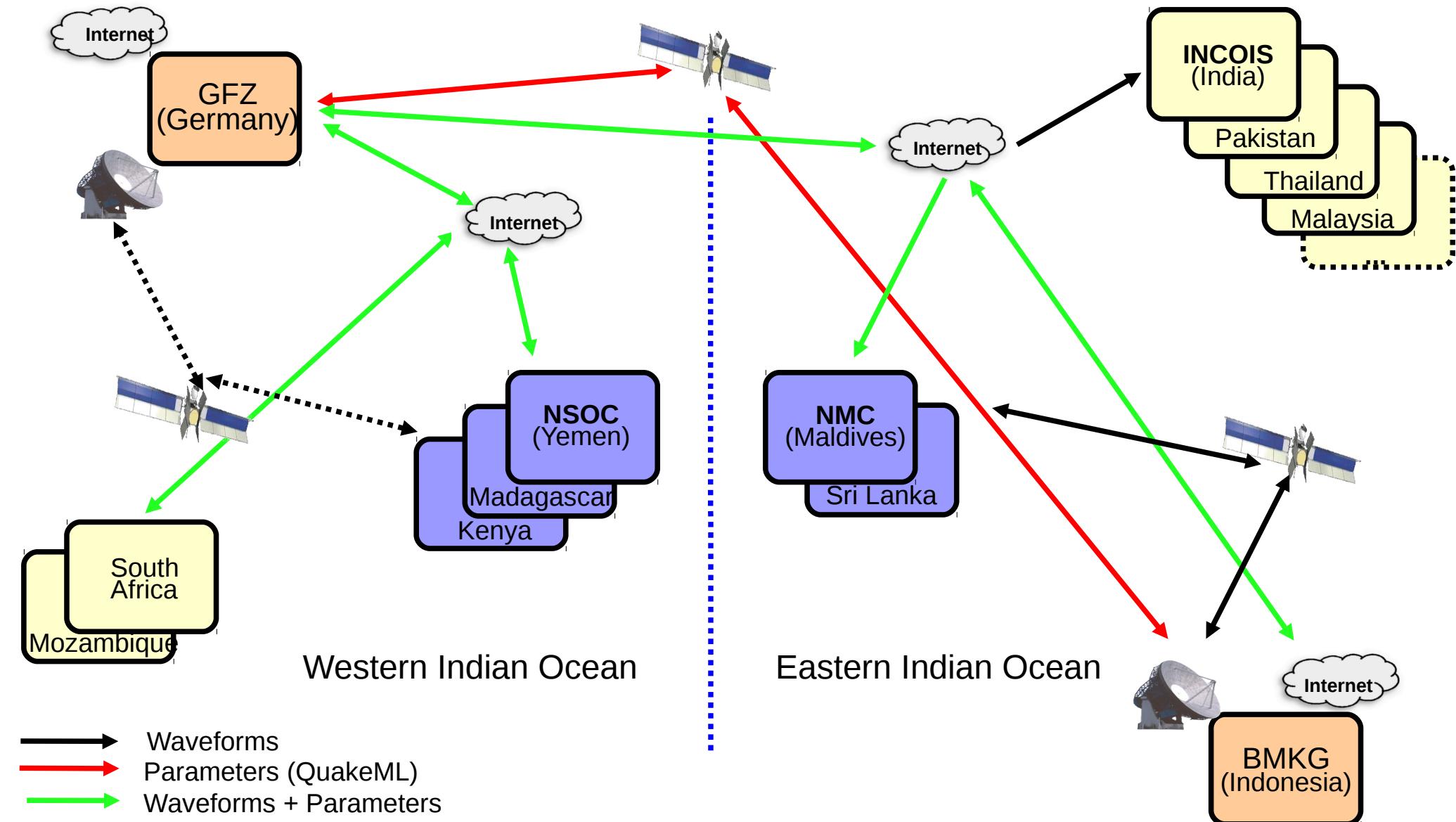
InaTEWS Inauguration: November 11, 2008



GITEWS hand-over: March 31, 2011

Visit Chancelor Merkel: July 11, 2012

Distributed SeisComP3 Systems throughout the Indian Ocean – GFZ Background Support



- Cooperation and standardization in seismology is well established
- but progress is slow, many players still do not fully contribute,
- IT solutions presently mostly community specific,
- joint projects with IT community just starting.

More challenges to be tackled

- Setting standards for data mining products
- Referencing of data provider contributions
- Secure data archive integrity
- Synchronization of distributed data sets
- Handling of synthetic data and earth models
- Combining data and HPC services
- Integration of seismological community services into EPOS integrated services
-
-
- to be completed

Thank you!