LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Seismological Software Developments at LMU Munich

Robert Barsch

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SeisHub

Native, document-centric XML database

- RESTful Web service (HTTP, HTTPS),
- Standard relational database as back-end
- Both worlds: SQL for querying and manipulating data and any standard connected to XML, e.g. XSLT or XSD
- Not restricted to seismology at all

Extended to a “classical” seismic database

- Index of local, file-based waveform archive (MiniSEED, GSE2, SAC, ...)
  - Meta Data: Gaps, overlaps, quality and timing information
  - Waveform previews (30s)
- XML resource types for handling inventory data (XML-SEED) and events (QuakeML based)
- Remote waveforms access (ArcLink)

SeisHub: Technical Details

- Python-based, standalone web service
- Platform independent, open source (GPL)
- Implementation of various web protocols, like HTTP, SSH, SFTP
- Plug-in architecture: Dynamic discovering and loading of modules and support for Python .egg files
- Development remarks:
  - Test-driven development proven software, so far → ca. 250 test cases
  - Well-documented source code
  - Subversion
  - Trac: ticket system and project wiki

SeisHub: Database Design

- Indexing
  - Generated using a XPath expression, type and additional options
  - Simple creation + reindexing via web interface
  - Various build-in types (datetime, bool, numeric, double, float, etc..)
  - ProcessorIndex: custom processing
- Searching
  - XPath-like query on XML catalog object (restricted to indexes)
  - SQL on database object
- Mapper: predefined queries & output format bound to an fixed URL
- FileSystemResource: integrates a file system directory (read only)

SeisHub: Database Design

Data storage

- Primary data → file system
  - Continuous waveform archive (MiniSEED, GSE2, SAC ...)
  - Other data via (GeoTIFF, GPS time series, etc.) file system
- Meta Data → Web service on top of a XML/relational database hybrid
  - Data is packed into a XML document → Data structure is within the document, no need for a predefined database schema
  - XML resources are archived into a BLOB field
  - Only searchable values are indexed
  - Pointers to primary data

SeisHub: Database Design

Data access

- HTTP/HTTPS: REST web service
  - XML documents have a fixed resource identifier (URL's)
  - Data transformation via XML Style Sheets on request (?output=...)
  - Data validation via Schema (XML Schema, RelaxNG, Schematron) on resource upload
  - Document properties like related meta data or indexes
- SFTP: XML documents mapped into a virtual file system

SeisHub: Advantages

Technical:

- Sharing data over the network, but no firewall problems (HTTP / HTTPS)
- License free, open source, internet standards
- Platform independent, most basic client is a standard browser
- XML:
  - Data validation on upload (XML schemas)
  - Data transformation on request (XML stylesheets)
- Querying: SQL or XPath

Scientist:

- May modify there data provided as XML document at any time without corrupting the underlying database
- May dynamically add or delete search indexes, schemas and stylesheets

SeisHub: Disadvantages

Technical:

- Slower than “common” solutions
  - XML parsing during validation and indexing
  - Data overhead (XML verbosity)
- Infrastructure

Scientist:

- Seismologist != IT nerds

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ObsPy

- Python toolbox for seismologists
- Modular architecture
  - Waveform data: GSE2, MiniSEED, SAC, WAV, Q/ASCII
  - Inventory data: Dataless SEED, XML-SEED, RESP
  - Data request clients: ArcLink/WebDC, DHI/Fissures, SeisHub
  - Various pickers, filters and plot routines
  - Waveform indexer
  - [ToDo] Orfeus Web service client (Events, Waveforms)

ObsPy

- Open source (LGPL or GPL)
- 6 core developers
- Platform independent (Win, Mac, Linux) and tested
- Test-driven development (TDD), currently 308 unit tests (http://tests.obspy.org)
- Reliance of well-known third-party libraries (numpy, scipy, matplotlib)
- Reusing well established code, e.g. libmseed, GSE UTI
- Automatic generated API documentation
- Binary distributions: Python Package Index (PyPI), Windows Installer & Debian packages
- Source code & community webpage containing tutorials, installation instructions, ticket system

http://www.obspy.org

SeisHub & ObsPy: Demonstration

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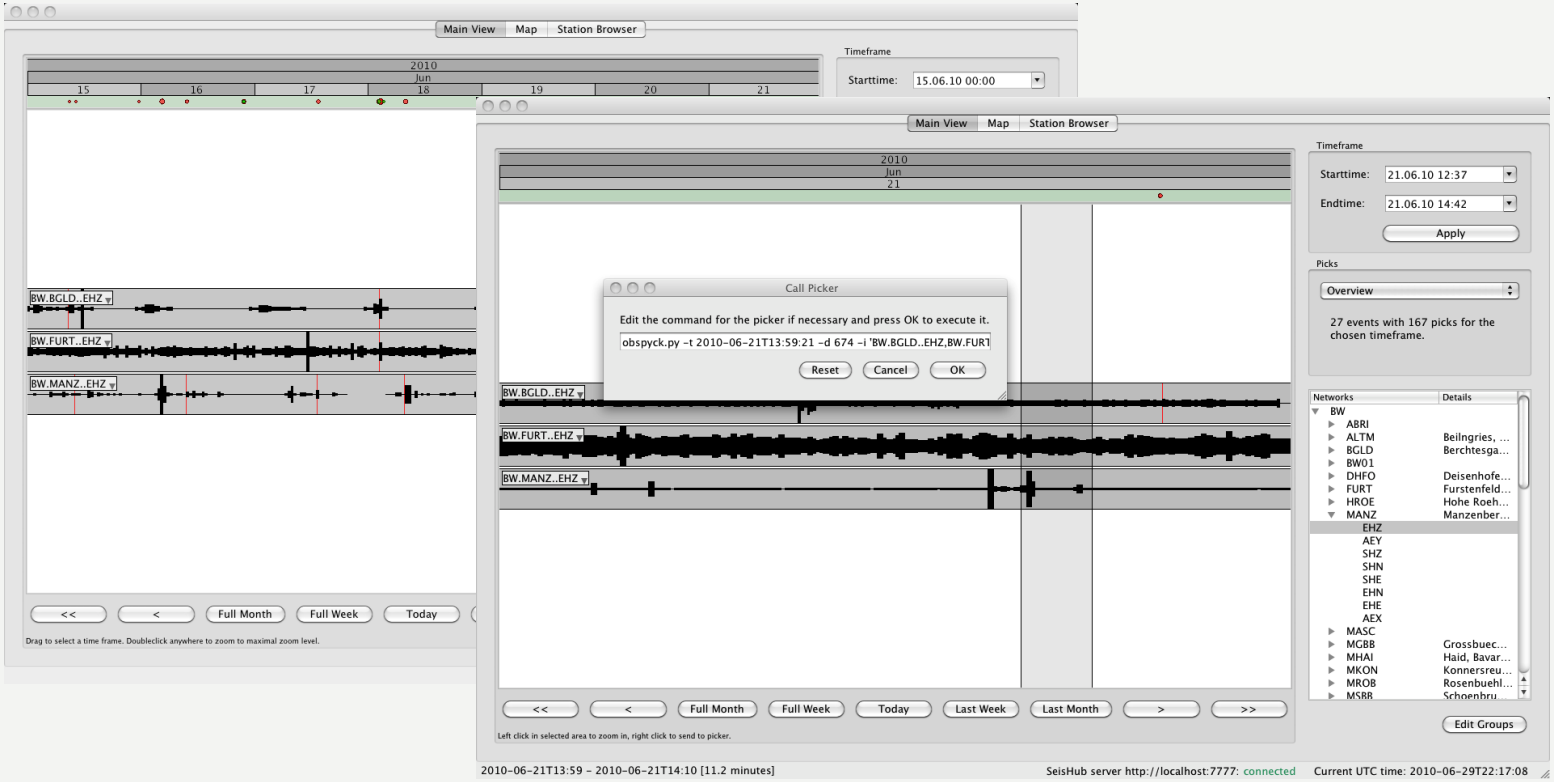
BayernNetz

- Seismological network of the Bavarian Seismological Service (Erdbebendienst Bayern)
- Designed for monitoring local seismic activity in Bavaria and bordering regions for events of $M_L >= 2.0$
- Data is collected, archived and analyzed at the Geophysical Observatory in Fürstenfeldbruck
- Currently 23 SP + 3 BB + 2 BB (GRSN) stations
- Waveform data received from BB stations are transmitted in real time to ORFEUS, GEOFON and BGR
- Neighboring networks may also access data directly

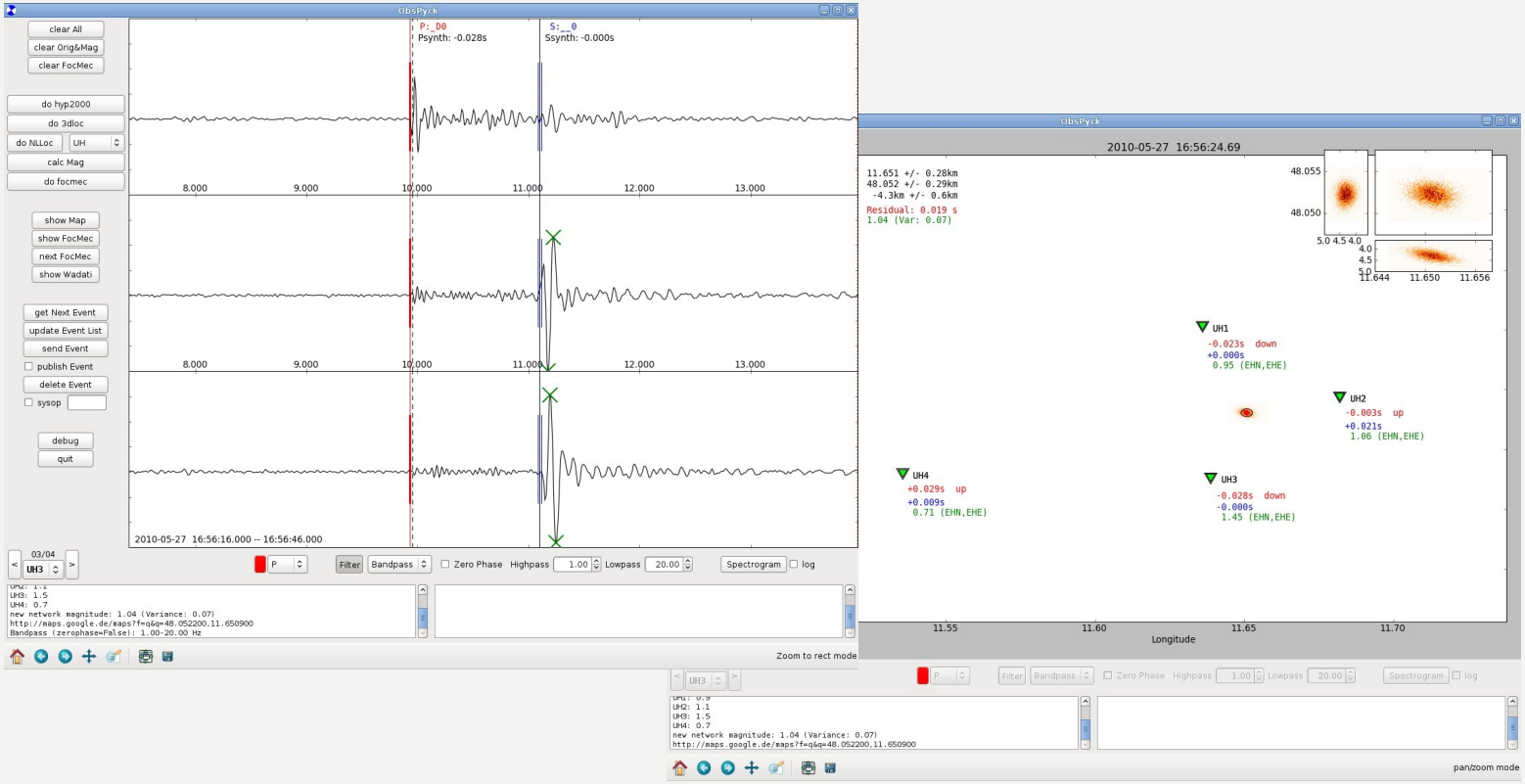
BayernNetz: SeisHub & ObsPy

- SeisHub (experimental)
  - parallel to the GIANT database since spring 2009
  - Events retrieved from Earthworm (real time system) and Pitsa (manually) are automatically stored into SeisHub in QuakeML based format
  - Automated indexing of the MiniSEED waveform archive
  - Stations available in XML-SEED
- ObsPy: seismological Python library and SeisHub client
- Current Tasks
  - Adaption of existing programs and scripts
  - Development of a suitable graphical applications using SeisHub as a data back-end

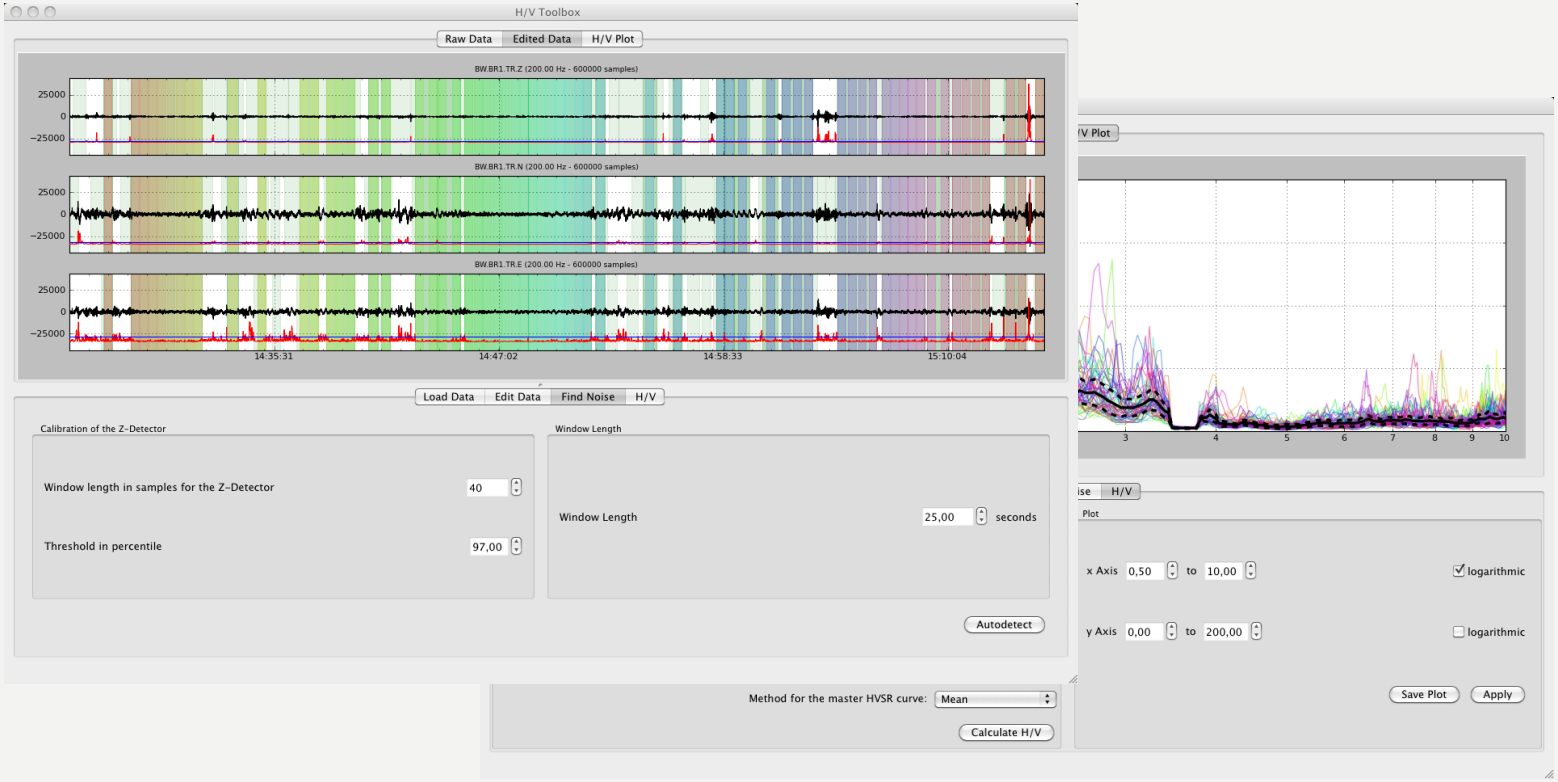
SeisHub Viewer



ObsPyck


ObsPyck
clear All
clear Orig&Mag
clear FocMec
do hyp2000
do 3dloc
do NLLoc
UH
calc Mag
do focmec
show Map
show FocMec
next FocMec
show Wadati
get Next Event
update Event List
send Event
publish Event
delete Event
sysop
debug
quit
P: D0
Psynth: -0.028s
S: 0
Ssynth: -0.000s
2010-05-27 16:56:16.000 -- 16:56:46.000
Zero Phase
Highpass
Lowpass
Spectrogram
log
Zoom to rect mode
2010-05-27 16:56:24.69
11.651 +/- 0.28km
48.052 +/- 0.29km
-4.3km +/- 0.6km
Residual: 0.019 s
1.04 (Var: 0.07)
UH1
-0.023s down
+0.000s
0.95 (EHN,EHE)
UH2
-0.003s up
+0.021s
1.06 (EHN,EHE)
UH3
-0.028s down
-0.000s
1.45 (EHN,EHE)
UH4
+0.029s up
+0.009s
0.71 (EHN,EHE)
Longitude
pan/zoom mode

H / V Toolbox


H/V Toolbox
Raw Data
Edited Data
H/V Plot
BW.BR1.TR.Z (200.00 Hz - 600000 samples)
BW.BR1.TR.N (200.00 Hz - 600000 samples)
BW.BR1.TR.E (200.00 Hz - 600000 samples)
25000
0
−25000
14:35:31
14:47:02
14:58:33
15:10:04
Load Data
Edit Data
Find Noise
H/V
Calibration of the Z-Detector
Window length in samples for the Z-Detector
40
Threshold in percentile
97,00
Window Length
Window Length
25,00
seconds
Autodetect
Method for the master HVSR curve:
Mean
Calculate H/V
V Plot
3
4
5
6
7
8
9
10
ise
H/V
Plot
x Axis
0,50
to
10,00
logarithmic
y Axis
0,00
to
200,00
logarithmic
Save Plot
Apply

Exupéry VFRS

- Volcano Fast Response System (VFRS): mobile monitoring system in case of a volcanic crisis or volcanic unrest
- funded by the German Ministry for Education and Research (BMBF) within the "Geotechnologien" project
- Involves nine different research institutions allover Germany
- Primary goals
  - stable communication basis for stations in the field
  - expert system allowing scientists and local authorities to assess the data through a web-based GIS interface on top of a single centralized database
- Perfect demonstrator for the flexibility of SeisHub as geophysical database:
  - event-based and continuous data,
  - ground-based measurements and satellite data
  - time series (1D), images (2D), and models (3D)

Exupéry VFRS: Database Test Setups

- Prototype at BGR / Hannover since spring 2009
  - Satellite data automatically fetched from the respective data providers and included into the database
  - Ground-based data only tested with sample data
- Second Exupéry prototype setup tested under field conditions at the Azores from 04/2009 – 09/2009
  - over 20 seismic stations (only 4 triggered events)
  - ground measurements of deformation and gas flux
  - only ground-based data collected due to limited Internet bandwidth
  - data synchronized at daily base with the BGR setup

Exupéry VFRS: Demonstration

Thank You!