Seismic Data QC in Support of Earthquake Source Parameter Determination

Poster S21B-2062

R. B. Herrmann, Saint Louis University, rbh@eas.slu.edu and, H. Benz, USGS, benz@usgs.gov, J. L. Bonner, Weston Geophysical, jes_bonner@yahoo.com

Objective

The ANSS (Advanced National Seismic System) requires network operators to deliver quality digital data streams and metadata to the regional data centers, NEIC and IRIS.

This poster presents three components of monitoring compliance with performance standards:

- Examination of contents of the dataless SEED
- Routine noise analysis
- Waveform comparison of noise and earthquakes

Examination of Dataless SEED

Since dataless SEED is manually created, errors occur and a routine way to review the contents is required. Even for one station, the possibility of error is great, since different data streams, e.g., LHZ, BHZ and HHZ, can have different FIR filters for each stage. This is further complicated since the dataless SEED for a network can contain the entire response history of all of the stations and channels of the network for all time, thus requiring the verification of significant amounts of information.

Our approach is to use a SLU modified version of rdseed5.0 which provides additional stderr output that is used with a shell script to create a web page describing the response history for a station. rdseed is invoked within the shell scripts as

rdseed -f SLM.dataless.seed -R -p 2>&1 > rdseed.out

This command line creates the RESP (-R) and Sac pole-zero (-p) files in addition to the augmented stderr output. The processing scripts use evalresp and the Computer Programs in Seismology (CPS) gsac together with CPS graphics to create the entire web page

http://www.eas.slu.edu/Earthquake_Center/NM/SLM/SLM.R/SLMindex.html

Text Output

Summary of Response History

```
NM  SLM     BHZ 1997,037,14:00:00.0000    1999,160,20:40:00.0000    Peak Sensitivity 8.5711e+08 Counts/METER/S at 5.34 Hz
NM  SLM     BHZ 1999,160,20:40:00.0000    99999,9999,00:00:00.0000  Peak Sensitivity 6.3864e+08 Counts/METER/S at 5.34 Hz
```

Station Information from CPS annotated rdseed

```
NET  STA  LC CHP       ON_DATE                  OFF_DATE              LAT         LON         ELV   DIP   AZ       RATE  RESPONSE_FILE
          POLE_ZERO_FILE
 NM   SLM  ** BHZ     1999,160,20:40:00.0000  99999,9999,00:00:00.0000  38.636100  -90.236400   186.0   0.0  90.0          20 RESP.NM.SLM..BHZ
SAC_PZs_NM_SLM_BHZ__1999.160.20.40.00.0000_99999.9999.24.60.60.99999
 NM   SLM  ** BHZ     1997,037,14:00:00.0000  1999,160,20:40:00.0000  38.636100  -90.236400   186.0   0.0  90.0          20 RESP.NM.SLM..BHZ
SAC_PZs_NM_SLM_BHZ__1997.037.14.00.00.0000_1999.160.20.40.60.99999
```

The detailed information permits a quick review of response history, station coordinates and component orientations. The ON and OFF dates are used to select the time window for use with evalresp which can then be associated with the corresponding Sac pole-zero file.

Free Open Documented Software

Computer Programs in Seismology (137 programs):

http://www.eas.slu.edu/People/RBHerrmann/CPS330.html

Tutorials, Documentation, Q&A

Response Plots

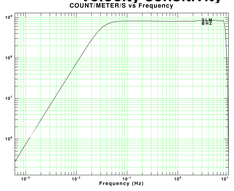
Sensitivity plots permit a quick review of instrument response shape and levels. An associated impulse response permits a check of the sense of first motion, which is a function of the phase response.

Using a command line flag, evalresp is used to provide the velocity sensitivity for broadband sensors and acceleration sensitivity for acceleration channels. The pole-zero response is plotted as displacement sensitivity. For each channel epoch 4 plots are created:

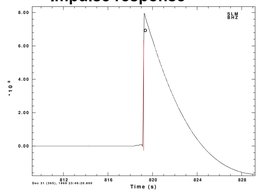
Example: SLM BHZ 1997,037 – 1999,160

Examination of RESP file

Velocity sensitivity

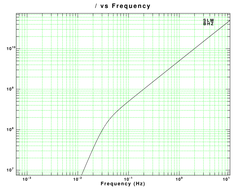


Impulse response

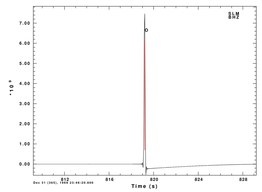


Examination of pole-zero file

Displacement sensitivity



Impulse response



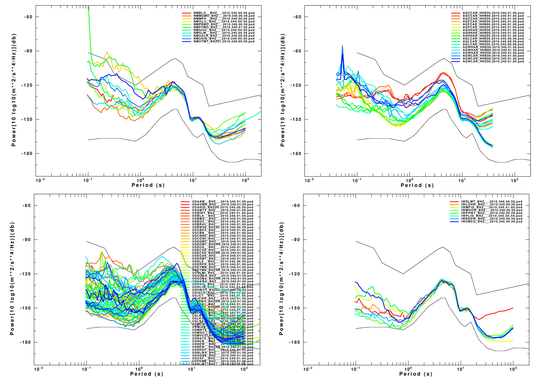
At T=6.28 sec, the responses are the same numerically. The reason for this comparison is that it is possible for the RESP and pole-zero files to be different if the normalization frequency is in the band where the FIR's influence the response since the pole-zero representation cannot use the FIR response. SLU made this mistake once.

Noise Plots

Noise PSD plots can be used to track the performance of a data channel with time. It is also useful for comparing similar components within a network. The assumption is that ground noise, especially in the microseism band is the same everywhere. Deviations from the general trend can be ascribed to sensor malfunction, incorrect metadata or special site conditions.

We focus here on the broadband Z component the NM, AG, US and IW networks. We acquired waveform data from the NEIC Continuous Wave Buffer using CWBQuery and the RESP files using mdget. Thus we check actual deliverables to NEIC. We use the RESP file since the CWBQuery pole-zero file is derived from the RESP file and since the RESP file normally includes the FIR filter stages. We should also test the pole-zero files.

The PSD's are computed using the CPS program sacpsd and some shell scripts.



Detailed examination is possible using a combination of awk and grep to determine the specific station/channel with an anomalous response at a particular period.

For the SLU stations of the NM network, the MPH BHZ is slightly noisy at a period of 20 sec and PVMO is horrible at a period of 0.1 sec. Upon examining the RESP files, we determined that the RESP files in the metadata server were not current, since the waveforms had a 40 Hz sample rate and the RESP file had the response for the older 20 Hz sample rate. From the rdseed procedure the response summary shows that

```
NM  PVMO BHZ 2002,291,16:00:00.0000   2007,075,20:15:00.0000    Peak Sensitivity 8.4425e+08 Counts/METER/S at 5.34 Hz
NM  PVMO BHZ 2007,075,20:15:00.0000   2010,293,18:00:00.0000    Peak Sensitivity 8.5633e+08 Counts/METER/S at 5.34 Hz
NM  PVMO BHZ 2010,293,18:00:00.0000   99999,9999,00:00:00.0000  Peak Sensitivity 8.3635e+08 Counts/METER/S  7.30 Hz
```

Fortunately the gains are similar so that the pole-zero files are not affected much, but the public metadata server is not updating properly.

The AG network groups together better than the NM network. This is because many NM stations are in noisy environments (city for SLM, building air-handling for SIUC, railroad at PVMO).

The IW stations are quieter at short periods, but the station DLMT BHZ has a noisy response at long periods which may be a sensor problem.

The US network covers the continental US and samples different noise environments across the country.

This display differs from the typical USGS/IRIS presentations which focus on the stability of the response of a single channel.

Our comparison of the same component of ground motion is a tool for highlighting station problems in the context of the entire network.

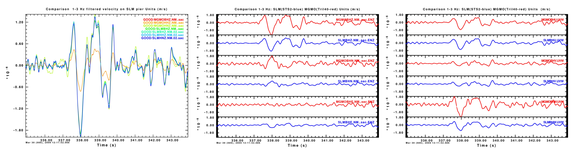
Waveform Comparison

The third element entails waveform comparisons for the purpose of verifying the metadata and for monitoring sensor performance. There are several approaches:

- Comparing the same component of ground motion for all recorded channels at a site by deconvolving the instrument response and filtering all signals in a band with adequate signal. The ideal case is that all traces overlap
- Comparing a teleseismic ground motion at adjacent stations within a network using some part of the signal that should be identical within the dimensions of the network, e.g., P-wave or surface wave.

Side-by-side Comparison

Background: Comparison of ground motions from accelerometer and broadband at MGMO indicated a lack of agreement. The MGMO system was returned to SLU and compared other systems on the same SLM pier. The vote was STS-2, Trillium-120, 2 Episensors against the MGMO Trillium-40.



The ZNE comparison for a teleseism showed no correspondence in ZNE motion . gsac was modified to permit a

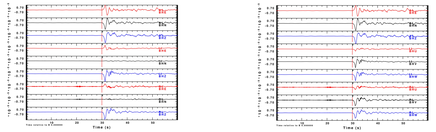
GSAC> rotate3 to UVWTRIL

To synthesize UVW for STS-2 to compare with internal UVW of Trillium.
Conclusion: Repair Trillium since W-axis sensor malfunctioned.

Intra-network Comparison

Problem: When comparing ZNE at AL to RL of the local network and II of IRIS for the same teleseism east of the network, AL is odd. Next apply

GSAC> rot3 to UVWTRIL



Resolution: Sensor interrogation indicated it was in UVW mode and not ZNE. However the synthesized UVW at RL and II do not agree with the presumed AL UVW. Check the AL sensor orientation or repair.

What's Next?

Implement a local SLUQuery
Establish procedures for routine performance evaluation

Conclusion

Seismic network QC requires a complementary set of performance measuring tools to ensure correct metadata and maintenance of data acquisition systems. Being able to develop new tools (e.g., for use within gsac) is necessary.