



OBSIP Data Quality Investigation Report

Cascadia Local Event Clipping 2012-2013

Table of Contents

1. Overview	3
1.1. Analysis Criteria.....	4
2. Procedure.....	4
3. Results.....	5
3.1. Clipping Event 1: Ml 3.1 12/05/2012 19:00:30.00.....	5
3.2. Clipping Event 2: Mw 3.5 12/12/2012 15:49:56.5	9
3.3. Clipping Event 3: Mb 3.5 2013-02-05 22:03:50	13
4. Conclusions.....	14

Document Change History

Version	Description	Date
1	Report prepared by J. Lodewyk	11/20/2013

1. Overview

At the Ocean Bottom Seismograph Instrument Pool Workshop on October 22-23, 2013 and the Oversight Committee Meeting on October 24, 2013, the issue was raised that some Cascadia stations were clipping on local events.

While seismometer clipping is 'expected' for events larger than ~M4.5, waveform clipping was also evident on smaller events on the order of M3+.

On the Management Council Meeting on 11/8/13, the question was raised whether the instruments or the digitizers were causing the clipping.

There are five instrument packages that are deployed during a given year of the Cascadia Initiative (summarized in Table 1). There are three Institutional Instrument Contributors (IICs) that deploy instruments for Cascadia: Lamont Doherty Earth Observatory (LDEO), Scripps Institution of Oceanography (SIO), and Woods Hole Oceanographic Institution (WHOI). The Cascadia Initiative funded the construction of a total of 60 Ocean Bottom Seismometers (OBSs) by the three IICs. All 60 of the ARRA funded OBSs will be equipped with Nanometrics Trillium Compact seismometers. The remaining 10 instruments are the WHOI-Keck instruments that are equipped with the Guralp CMG3T seismometers.

Table 1. Cascadia instrument packages

IIC	Name of Package	Sensor	Digitizer	Packaging
LDEO	LDEO-TRM	Nanometrics Trillium Compact	LDEO digitizer	Trawl Resistant Mount
LDEO	LDEO-OBS	Nanometrics Trillium Compact	LDEO digitizer	Standard
SIO	SIO- Abalone	Nanometrics Trillium Compact	SIO digitizer	Abalone 4x4 Trawl resistant mount
WHOI	WHOI-ARRA	Nanometrics Trillium Compact	Quanterra Q330	Standard
WHOI	WHOI-Keck	Guralp CMG3T_120sec	Quanterra Q330	Standard

In order to determine whether the instruments were clipping or the digitizer was clipping, OMO analyzed three local earthquakes.

1.1. Analysis Criteria

In the OMO analysis the following criteria were used to determine if the digitizer or the instrument was clipping.

1. If the digitizers were causing the clipping, an expected digitizer maximum value of (2^{23}) would be present during the clipping event.
2. If the seismometer were causing the clipping and railing, we would expect to see a waveform that had a square characteristic at the top of the peak and frequency content that was lower than expected.

2. Procedure

1. Jeff McGuire from WHOI provided OMO with a list of events that had at least one clipped station in the 2012-2013 Cascadia dataset. The events are listed below.
 - 2012:347:15:49:56.5 M3.5
 - 2012:297:07:45:50.00 M3.7
 - 2012:340:19:00:30.00 M3.1
 - 2013:062:17:46:59.00 M4.2
 - 2013:138:15:54:00.00 M3.8
 - 2013:138:13:46:00.00 M4.3
 - 2013:140:13:12:50.00 M4.3
 - 2013:140:13:20:55.00 M4.3
 - 2013:140:13:23:50.00 M4.2
 - 2013:140:13:56:30.00 M4.2
 - 2013:140:14:08:00.00 M 4.4
 - 2013:140:14:15:48.00 M?
2. Jeff identified clipping as being most obvious on the 2012:340:19:00:30.00 M3.1 event, where the LDEO compacts are clipping when a nearby SIO instrument did not.
3. OMO determined three events to be used in the clipping analysis, listed below. Two of the events were from the list that Jeff McGuire provided, the third event was chosen because it was a similar magnitude and location to the second event.
 - a. Ml 3.1 12/05/2012 19:00:30.00 Near Coast of Northern California (40.3, -124.5, 19.1 km depth)
 - b. Mw 3.5 12/12/2012 15:49:56.50 Near Coast of Northern California (40.295, -124.498, 10 km depth)
 - c. Mb 3.5 2013-02-05 22:03:50 UTC Off Coast of Northern California (40.423, -125.319, 2 km depth)
4. Data was requested in SAC format for each of the three events using WILBUR 3
5. Data was received in SAC format and plotted using the SAC software package.

6. For each station, Jessica Lodewyk determined whether the event clipped and the largest value of the peak if the event did clip.

3. Results

For each of the events, a table was generated specifying the stations, the instrument at that station, the channels that clipped, and the max value of the clipped signal (if applicable).

For the event a map was also made of the clipped stations.

Table 2. Event Information

Event	Magnitude	Origin Time	Latitude	Longitude	Depth
1	Ml 3.1	12/05/2012 19:00:30.00	40.3 N	124.5 W	19.1 km
2	Mw 3.5	12/12/2012 15:49:56.50	40.295	124.498 W	10 km
3	Mb 3.5	2/05/2013 22:03:50	40.423	125.319 W	2 km

3.1. Clipping Event 1: Ml 3.1 12/05/2012 19:00:30.00

Table 3. Event 1- Clipped Stations

Clipped Stations	Instrument	Channels	Notes
FS05B	WHOI- Keck		No clipping, poor detection
FS06B	WHOI- Keck		No clipping
FS09B	WHOI- Keck		No clipping
G03B	WHOI- Keck		No clipping
G04B	WHOI-ARRA		No clipping, poor detection
G05B	WHOI-ARRA		No clipping, poor detection
G11B	WHOI-ARRA		No clipping
G13B	WHOI-ARRA		No clipping, poor detection
G19B	WHOI-ARRA		No clipping
G20B	WHOI-ARRA		No clipping
G21B	WHOI-ARRA		No clipping, poor detection
G22B	WHOI-ARRA		No clipping, poor detection
G29B	WHOI-ARRA		No clipping, poor detection
G30B	WHOI- Keck		No clipping, poor detection
G35B	WHOI-ARRA		No clipping, poor detection
G36B2	WHOI-ARRA		No clipping, poor detection
J06B	WHOI- Keck		No clipping, poor detection
J19B	WHOI-ARRA		No clipping, poor detection

J23B	WHOI- Keck		No clipping, poor detection
J27B	WHOI-ARRA		No clipping, poor detection
J28B	WHOI- Keck		No clipping, poor detection
J48B	WHOI- Keck		No clipping, poor detection
J63B	WHOI- Keck		No clipping, poor detection
J11B	WHOI-ARRA		No clipping, poor detection
FS02B	LDEO- OBS		No clipping
FS03B	LDEO-TRM	HH2, HHZ	Clips on HH2, HHZ, max digital count value HH2: 4.178867e+06 HHZ: 3.760599e+06
FS04B	TRM-P		No clipping
FS07B	LDEO- OBS	HH1, HH2, HHZ	Clips on all channels, max digital count value HH1: 4.192452e+06 HH2: 4.191358e+06 HHZ: 4.194303e+06
FS08B	TRM-P		No clipping, poor detection
FS10B	LDEO- OBS		No clipping
FS11B	TRM-P		No clipping
FS12B	TRM-P		No clipping
FS13B	LDEO- OBS	HH1, HH2, HHZ	Clips on all channels, max digital count value HH1: 4.194303e+06 HH2: 4.194303e+06 HHZ: 4.190617e+06
FS15B	TRM-P		No clipping
FS16B	LDEO- OBS	HH1, HH2, HHZ	Clips on all channels, max digital count value HH1: 4.194303e+06 HH2: 4.194303e+06 HHZ: 4.194072e+06
FS17B	TRM-P		No clipping
FS18B	TRM-P	HH1, HH2, HHZ	Clips on all channels, max digital count value HH1: 2.408956e+06 HH2: 2.516882e+06 HHZ: 2.155345e+06
FS19B	TRM-P		No clipping
FS20B	LDEO- OBS		No clipping
G09B	LDEO-TRM		No clipping, poor detection
G17B	TRM-P		No clipping
G18B	LDEO- OBS		No clipping
G25B	LDEO-TRM		No clipping, poor detection, calibrating during time window
G26B	LDEO- OBS		No clipping, poor detection, noisy
G33B	LDEO-TRM		Only data on HHZ, no clipping
G34B	LDEO- OBS		No clipping, poor detection
J17B	LDEO-TRM		No data

J25B	LDEO-TRM		No clipping, bad data
J33B	LDEO-TRM		No clipping, poor detection
M09B	LDEO-TRM		No clipping, poor detection
M10B	LDEO-TRM		Only data on HH2, No clipping, poor detection, noisy
M13B	LDEO-TRM		No data
M18B	LDEO-TRM		Only data on HH2, No clipping, poor detection, noisy
FS01B	SIO-Abalone		No clipping
FS14B	SIO-Abalone		No clipping
G02B	SIO-Abalone		No clipping
G10B	SIO-Abalone		No clipping
G12B	SIO-Abalone		Station not recording
G27B	SIO-Abalone		No clipping
G28B	SIO-Abalone		No clipping, poor detection
G37B	SIO-Abalone		No clipping, no detection
J09B	SIO-Abalone		No clipping, no detection
J10B	SIO-Abalone		No BH? data available
J18B	SIO-Abalone		No BH? data available
J20B	SIO-Abalone		No BH? data available
M11B	SIO-Abalone		No clipping, no detection
M12B	SIO-Abalone		No clipping, poor detection
M14B	SIO-Abalone		No clipping

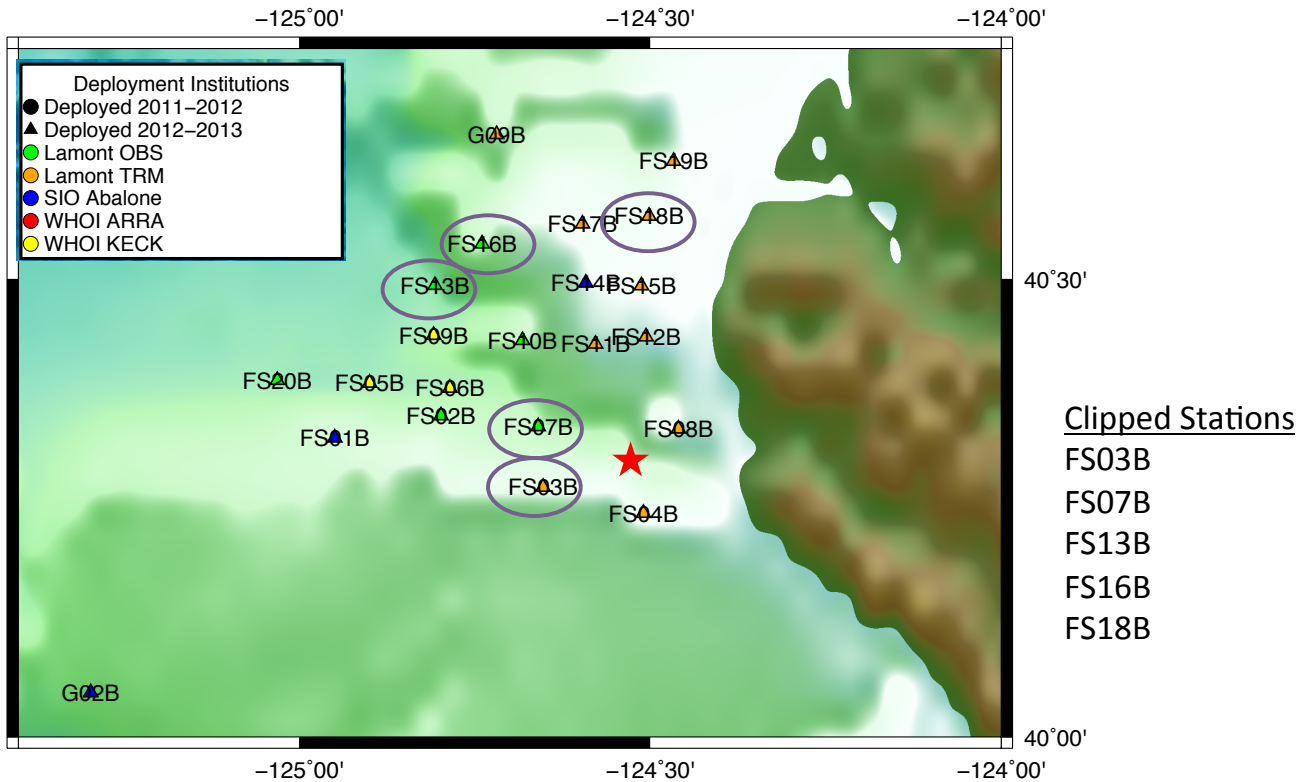


Figure 1. Map showing clipped stations (circled stations) for event 1. The red star is the earthquake location. Instrument package is indicated by color

For the first event, 5 LDEO stations clipped: FS03B, FS07B, FS13B, FS16B, and FS18B.

FS03B and FS07B are fairly close to the event hypocenter, although two LDEO stations that are similar distance from the event (FS04B and FS08B) did not clip.

The other three stations (FS13B, FS16B, and FS18B) are interesting because there are LDEO stations between the event and those stations that did not clip.

The waveforms of the clipped events look consistent with that of the instrument clipping. The waveform ‘squares off’ at the top of the peak and there is lower frequency content than expected. (See Figure 3).

The maximum digital count value for each of the clipped stations varies between stations and is not large enough to be the expected digitizer clip value.

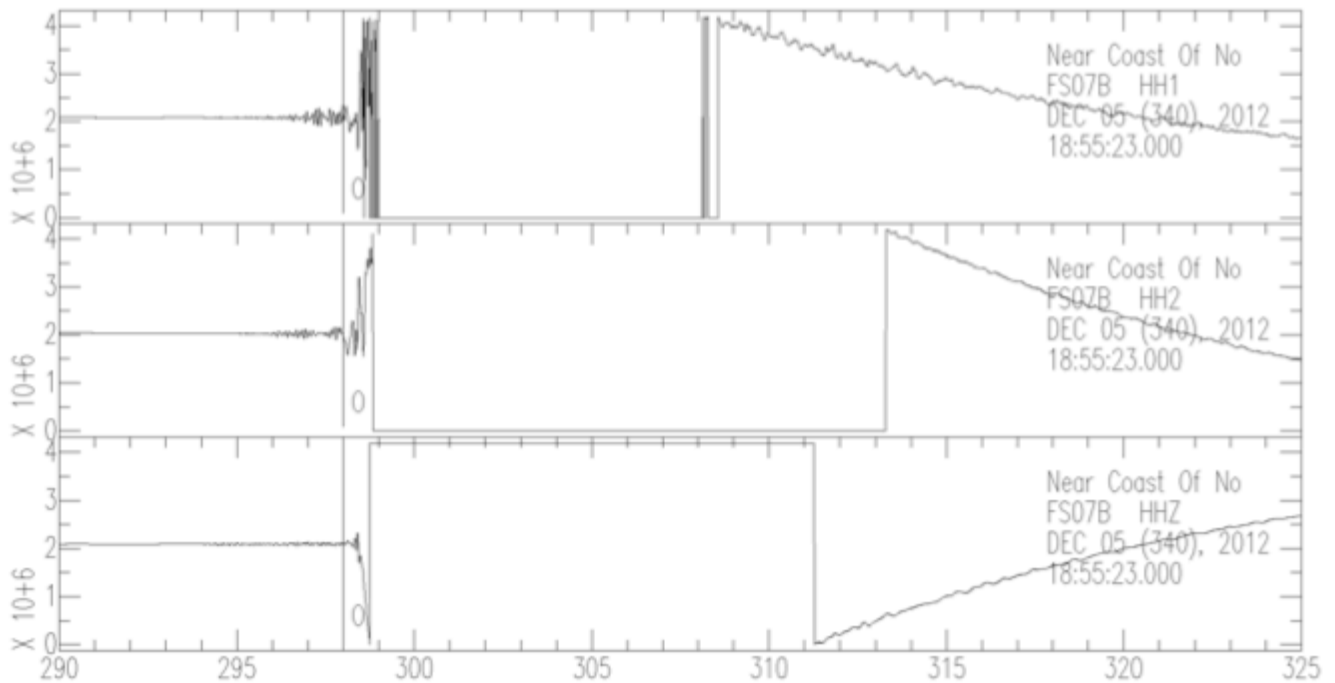


Figure 2. Clipped waveforms for station FS07B for event 1.

3.2. Clipping Event 2: Mw 3.5 12/12/2012 15:49:56.5

Table 4. Event 2- Clipped Stations

Clipped Stations	Instrument	Channels	Notes
FS05B	WHOI- Keck		No clipping
FS06B	WHOI- Keck		No clipping
FS09B	WHOI- Keck		No clipping
G03B	WHOI- Keck		No clipping
G04B	WHOI-ARRA		No clipping
G05B	WHOI-ARRA		No clipping
G11B	WHOI-ARRA		No clipping
G13B	WHOI-ARRA		No clipping, poor detection
G19B	WHOI-ARRA		No clipping
G20B	WHOI-ARRA		No clipping
G21B	WHOI-ARRA		No clipping, poor detection
G22B	WHOI-ARRA		No clipping, poor detection
G29B	WHOI-ARRA		No clipping, poor detection
G30B	WHOI- Keck		No clipping

G35B	WHOI-ARRA		No clipping, poor detection
G36B2	WHOI-ARRA		No clipping, poor detection
J06B	WHOI- Keck		No clipping, poor detection
J19B	WHOI-ARRA		No clipping, poor detection
J23B	WHOI- Keck		No clipping, poor detection
J27B	WHOI-ARRA		No clipping
J28B	WHOI- Keck		No clipping, poor detection
J48B	WHOI- Keck		No clipping, poor detection
J63B	WHOI- Keck		No clipping, poor detection
J11B	WHOI-ARRA		No clipping, poor detection
FS02B	LDEO- OBS		No clipping
FS03B	LDEO-TRM		No clipping, poor quality data
FS04B	TRM-P	HH2	Clip on HH2, Max digital count value HH2: 4.019315e+06
FS07B	LDEO- OBS		No clipping
FS08B	TRM-P		No clipping, poor quality data
FS10B	LDEO- OBS		No clipping
FS11B	TRM-P		No clipping
FS12B	TRM-P		No clipping
FS13B	LDEO- OBS	HH1, HH2	Clips on HH1,HH2 Max digital count value HH1: 4.194303e+06 HH2: 4.194303e+06
FS15B	TRM-P		No data available????
FS16B	LDEO- OBS	HH1, HH2, HHZ	Clips on all channels Max digital count value HH1: 4.194303e+06 HH2: 4.194303e+06 HHZ: 4.191255e+06
FS17B	TRM-P		No clipping
FS18B	TRM-P		No clipping
FS19B	TRM-P		No clipping
FS20B	LDEO- OBS		No clipping
G09B	LDEO-TRM		No clipping
G17B	TRM-P		No clipping
G18B	LDEO- OBS		No clipping
G25B	LDEO-TRM		No clipping
G26B	LDEO- OBS		No clipping, poor quality data
G33B	LDEO-TRM		No clipping, no horizontal data
G34B	LDEO- OBS		No clipping, poor detection
J17B	LDEO-TRM		No data
J25B	LDEO-TRM		No clipping, bad data
J33B	LDEO-TRM		No clipping
M09B	LDEO-TRM		No clipping, poor detection

M10B	LDEO-TRM		No clipping, only HH2 data
M13B	LDEO-TRM		No data
M18B	LDEO-TRM		No clipping, only HH2 data
FS01B	SIO-Abalone		No clipping
FS14B	SIO-Abalone		Station not recording
G02B	SIO-Abalone		No clipping
G10B	SIO-Abalone		No clipping
G12B	SIO-Abalone		Station not recording
G27B	SIO-Abalone		No clipping
G28B	SIO-Abalone		No clipping
G37B	SIO-Abalone		No clipping
J09B	SIO-Abalone		No clipping
J10B	SIO-Abalone		No BH? data available
J18B	SIO-Abalone		No BH? data available
J20B	SIO-Abalone		No BH? data available
M11B	SIO-Abalone		No clipping
M12B	SIO-Abalone		No clipping
M14B	SIO-Abalone		No clipping

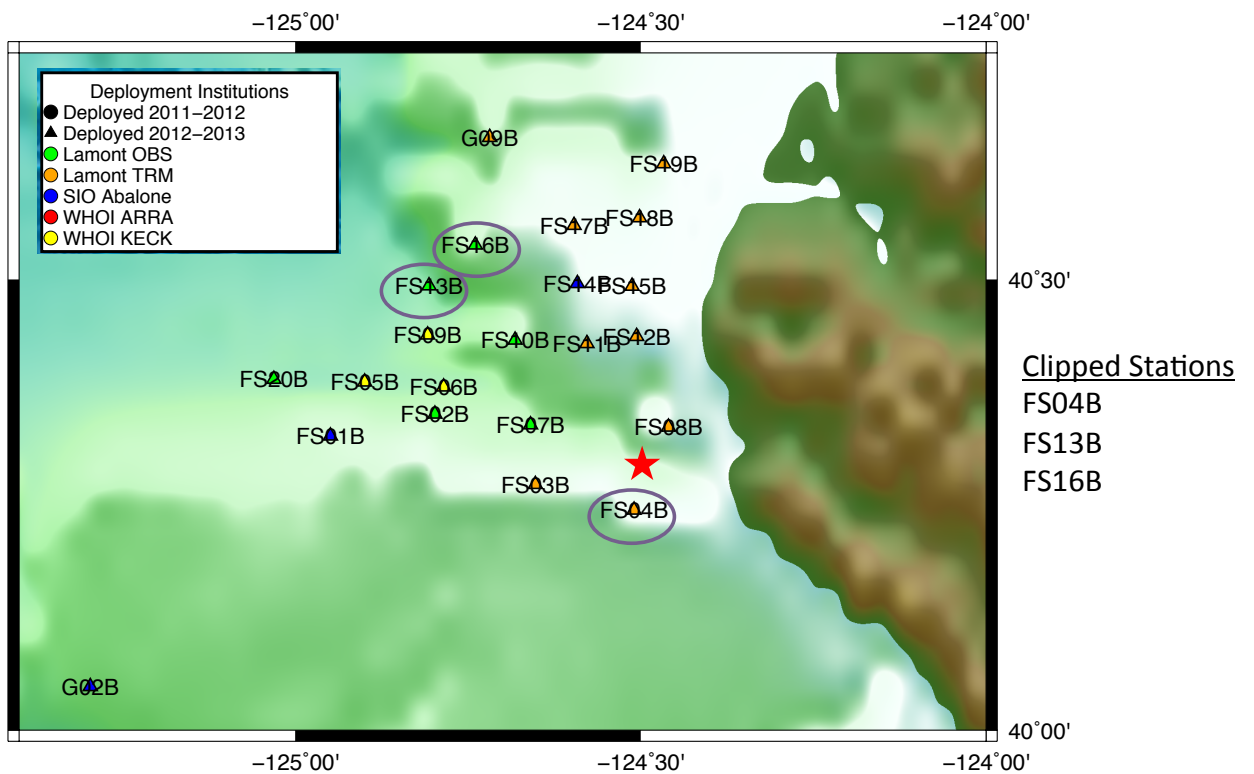


Figure 3. Map showing clipped stations (circled stations) for event 2. The red star is the earthquake location. Instrument package is indicated by color

For the second event, 3 LDEO stations clipped: FS04B, FS13B, and FS16B.

FS04B is close to the event hypocenter. It did not clip on the first event.

FS13B and FS16B also clipped on the first event. There are multiple LDEO stations closer to the event hypocenter that did not clip. The maximum digital count value for event 2 is the same as for event 1.

The waveforms of the clipped events look consistent with that of the instrument clipping. The waveform 'squares off' at the top of the peak and there is lower frequency content than expected. (See Figure 4).

The maximum digital count value for each of the clipped stations varies between stations and is not large enough to be the expected digitizer clip value.

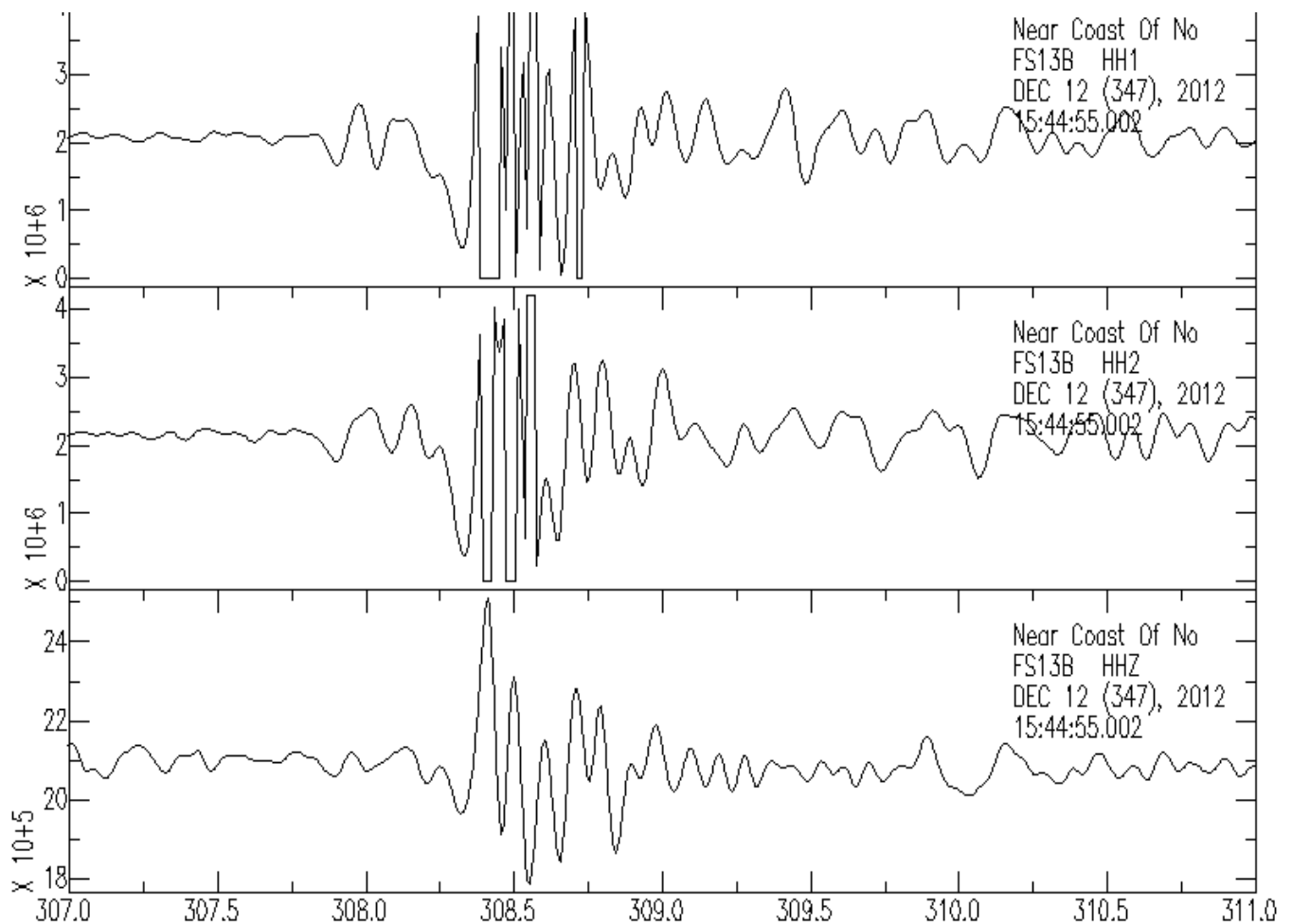


Figure 4. Clipped waveforms for FS13B for event 2.

3.3. Clipping Event 3: Mb 3.5 2013-02-05 22:03:50

Table 5. Event 3- Clipped Stations

Clipped Stations	Instrument	Channels	Notes
FS05B	WHOI- Keck		No clipping
FS06B	WHOI- Keck		No clipping
FS09B	WHOI- Keck		No clipping
G03B	WHOI- Keck		No clipping
G04B	WHOI-ARRA		No clipping
G05B	WHOI-ARRA		No clipping
G11B	WHOI-ARRA		No clipping
G13B	WHOI-ARRA		No clipping
G19B	WHOI-ARRA		No clipping
G20B	WHOI-ARRA		No clipping
G21B	WHOI-ARRA		No clipping
G22B	WHOI-ARRA		No clipping, poor detection
G29B	WHOI-ARRA		No clipping
G30B	WHOI- Keck		No clipping, poor detection
G35B	WHOI-ARRA		No clipping
G36B2	WHOI-ARRA		No clipping
J06B	WHOI- Keck		No clipping
J19B	WHOI-ARRA		No clipping
J23B	WHOI- Keck		No clipping, poor detection
J27B	WHOI-ARRA		No clipping
J28B	WHOI- Keck		No clipping, poor detection
J48B	WHOI- Keck		No clipping
J63B	WHOI- Keck		No clipping, poor detection
J11B	WHOI-ARRA		No clipping
FS02B	LDEO- OBS		No clipping
FS03B	LDEO-TRM		No clipping, poor data quality
FS04B	TRM-P		No clipping
FS07B	LDEO- OBS		No clipping
FS08B	TRM-P		No clipping, poor detection
FS10B	LDEO- OBS		No clipping
FS11B	TRM-P		No clipping
FS12B	TRM-P		No clipping
FS13B	LDEO- OBS		No clipping
FS15B	TRM-P		No data available????
FS16B	LDEO- OBS		No clipping
FS17B	TRM-P		No clipping
FS18B	TRM-P		No clipping
FS19B	TRM-P		No clipping
FS20B	LDEO- OBS		No clipping
G09B	LDEO-TRM		No clipping
G17B	TRM-P		No clipping

G18B	LDEO- OBS		No clipping
G25B	LDEO-TRM		No clipping
G26B	LDEO- OBS		No clipping, poor quality data
G33B	LDEO-TRM		Only HHZ data no clipping
G34B	LDEO- OBS		No clipping
J17B	LDEO-TRM		Bad data
J25B	LDEO-TRM		Bad data
J33B	LDEO-TRM		No clipping, poor detection
M09B	LDEO-TRM		No clipping, poor detection
M10B	LDEO-TRM		Only HH2 data, no clipping
M13B	LDEO-TRM		No data
M18B	LDEO-TRM		Only HH2 data, no clipping
FS01B	SIO-Abalone		No clipping
FS14B	SIO-Abalone		Station not recording
G02B	SIO-Abalone		No clipping
G10B	SIO-Abalone		No clipping
G12B	SIO-Abalone		Station not recording
G27B	SIO-Abalone		No clipping
G28B	SIO-Abalone		No clipping
G37B	SIO-Abalone		No clipping, poor detection
J09B	SIO-Abalone		No clipping, poor detection
J10B	SIO-Abalone		No BH? data available
J18B	SIO-Abalone		No BH? data available
J20B	SIO-Abalone		No BH? data available
M11B	SIO-Abalone		No clipping, poor detection
M12B	SIO-Abalone		No clipping
M14B	SIO-Abalone		No clipping

No stations clipped on this event, so no map was produced.

4. Conclusions

The LDEO instruments appear to be clipping rather than the digitizers. This conclusion is supported by the maximum digital value of the counts when the instrument clips. The max digital values appear to be consistent with the instrument clipping and not the digitizer. Although only the LDEO instruments are clipping the stations it seems that it may be due to two reasons.

- 1) Close proximity to an event hypocenter
- 2) Site effects for certain stations