Observations of the OSOP Sixaola, March 1-3, 2016, at the Albuquerque Seismological Laboratory

There were two representatives (Angel Rodriquez and David Nelson) from OSOP at ASL March 1-3, 2016, and they brought 3 of the Sixaola's for testing. This was not part of a procurement or any formal testing. The Sixaolas tested had six components total: 3 geophone and 3 accelerometer. We found the units to be easy to set up and configure, and in a short time they were streaming data via seedlink. During the visit we recorded data suitable to determine sensor noise levels, performed a shake table test, and we were lucky enough to record the March 2, 2016 M7.8 Indonesian earthquake and a M3.9 Oklahoma earthquake while they were here so we had some earthquakes to look at in addition to noise levels. The snapshots below show examples of data recorded and the corresponding power spectral density (PSD) plots.

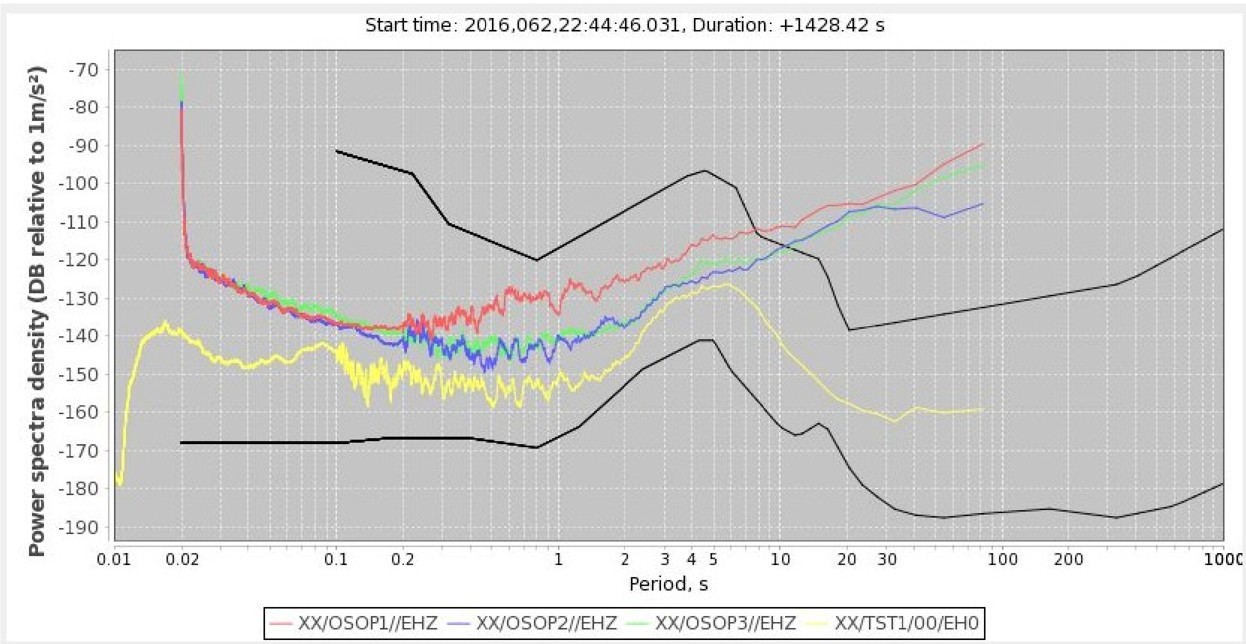

Figure 1. PSD plots for a quiet overnight period. The three Vertical components of the Sixaola geophone are shown along with a reference STS-2 which is installed in the ASL cross tunnel approximately 10 meters away from the Sixaola units. The vertical component of unit 1 (shown in red) had some noise (spiking) issues as can be seen in the elevated noise levels at 5Hz and lower. Since the ambient noise of the ASL vault (shown by the STS-2 PSD) was lower than the geophone noise floor, the PSD's are essentially showing the instrument self-noise level.

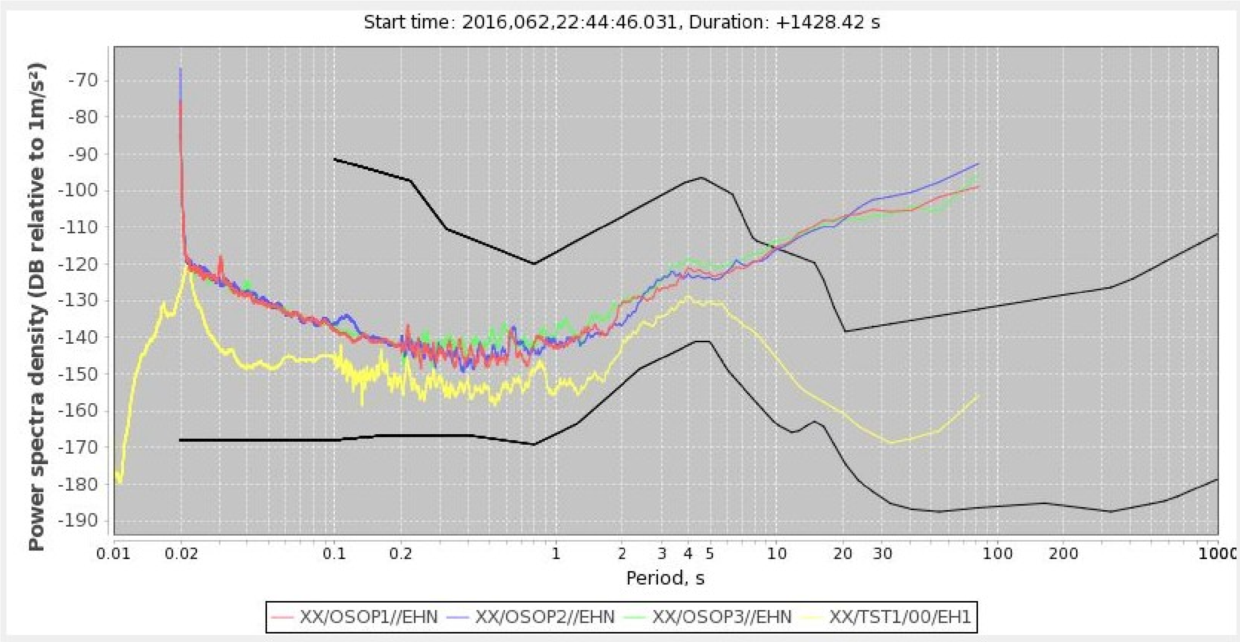

Figure 2. PSD plots for a quiet overnight period. The three North components of the Sixaola geophone are shown along with a reference STS-2 which is installed in the ASL cross tunnel approximately 10 meters away from the Sixaola units. Since the ambient noise of the ASL vault (shown by the STS-2 PSD) was lower than the geophone noise floor, the PSD's are essentially showing the instrument self-noise level.

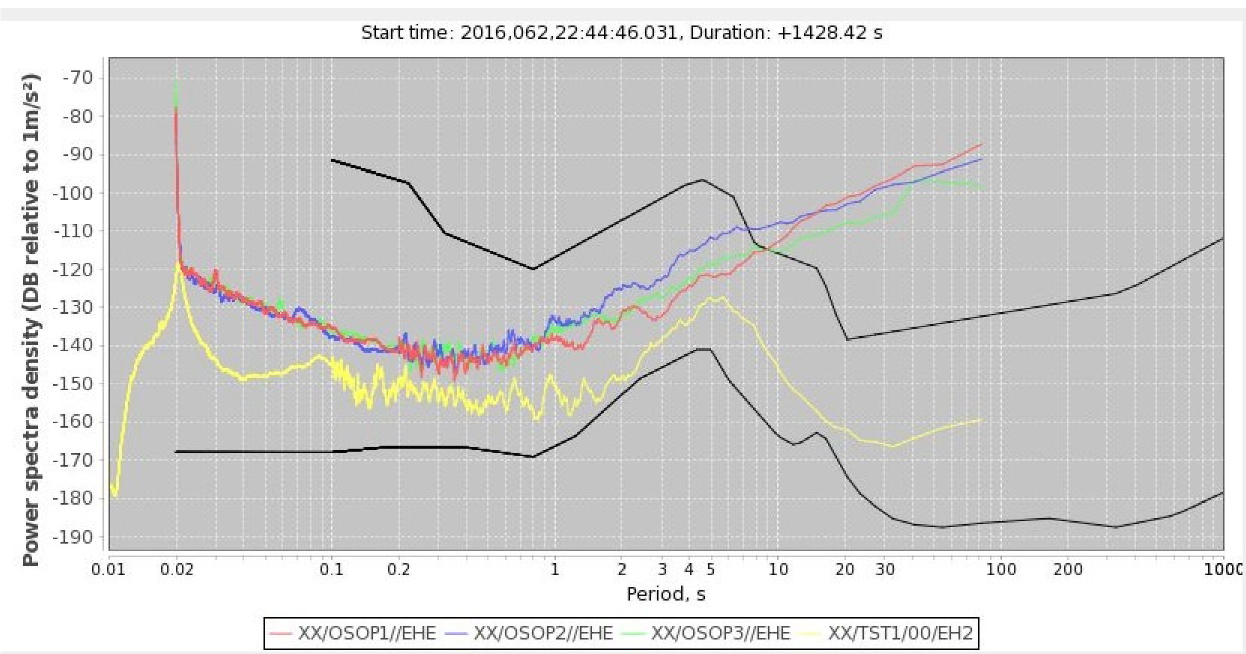

Figure 3. PSD plots for a quiet overnight period. The three East components of the Sixaola geophone are shown along with a reference STS-2 which is installed in the ASL cross tunnel approximately 10 meters away from the Sixaola units. Since the

ambient noise of the ASL vault (shown by the STS-2 PSD) was lower than the geophone noise floor, the PSD’s are essentially showing the instrument self-noise level.

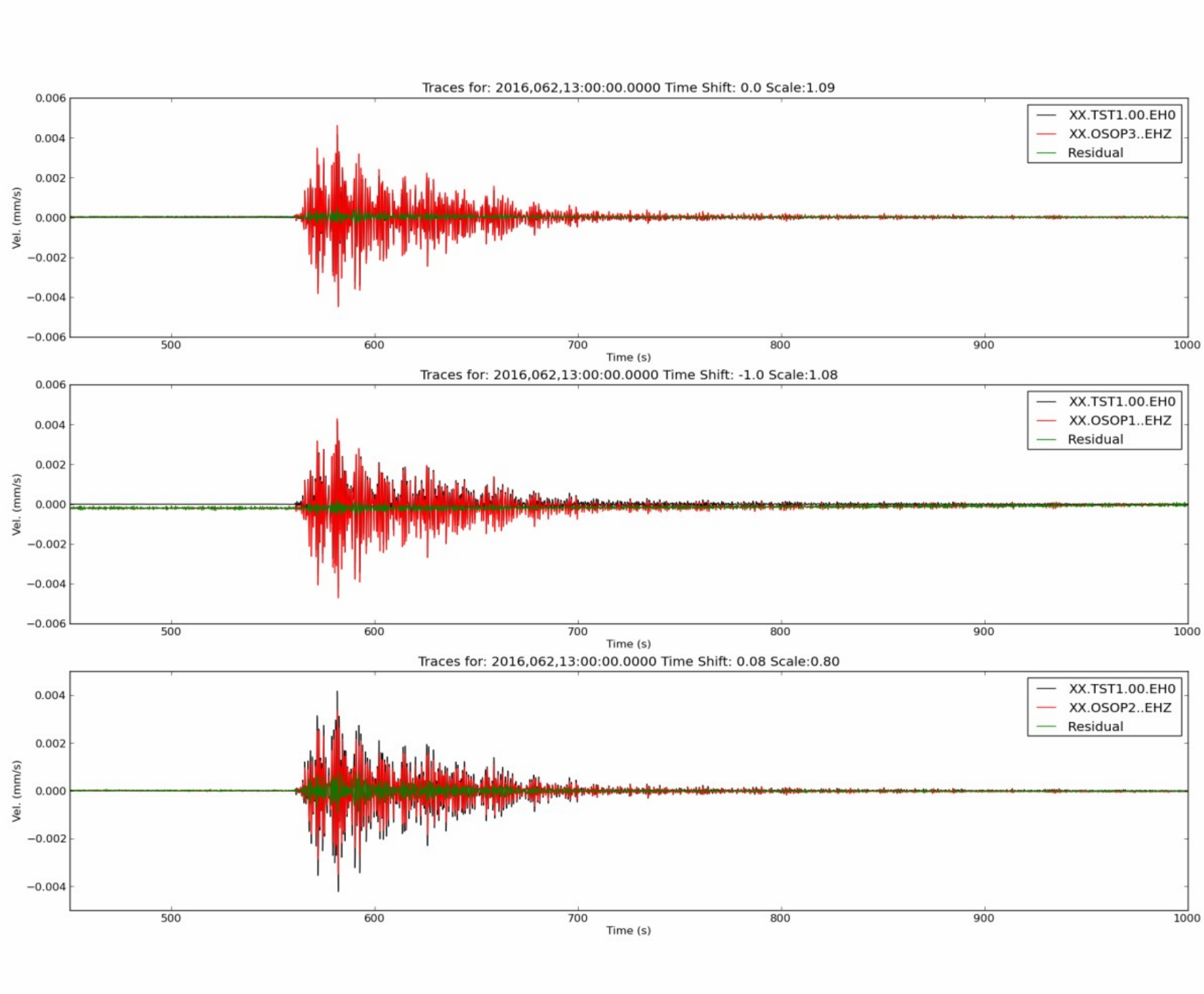

Figure 4. Waveforms from the m7.8, Southwest of Sumatra, Indonesia earthquake (2016-03-02 12:49:48 UTC). The three Vertical components of the Sixaola geophones are shown in red along with the reference STS-2 vertical which is shown in black. The OSOP2 sensor appears to have a scale factor that 20% off of the STS-2 reference. The residuals (after cross-correlation time shift) is shown in green. All traces were deconvolved to a common velocity.

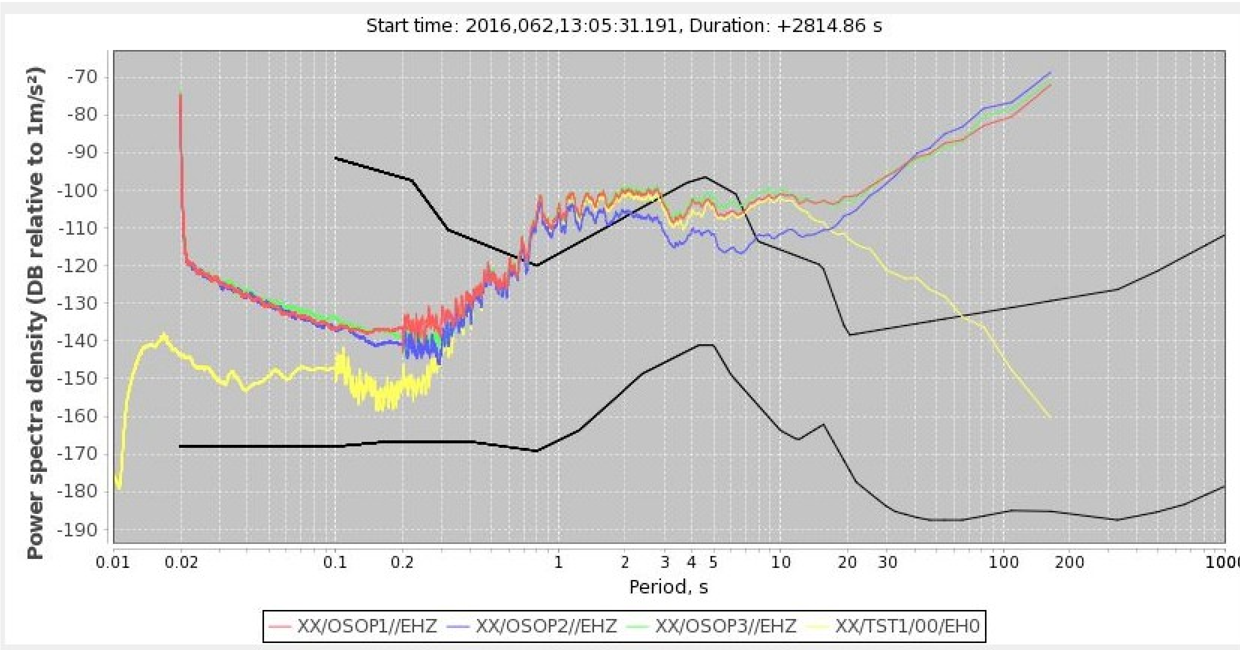

Figure 5. PSD of waveforms from the m7.8, Southwest of Sumatra, Indonesia earthquake (2016-03-02 12:49:48 UTC). The three Vertical components of the Sixaola geophone are shown along with the reference STS-2 (yellow). The vertical component from the Sixaola unit #2 appears to have a response problem at 2-20s periods as shown by the lower amplitudes in this range. At greater than 20s periods, the noise level of the sensors exceeds the earthquake signal amplitude.

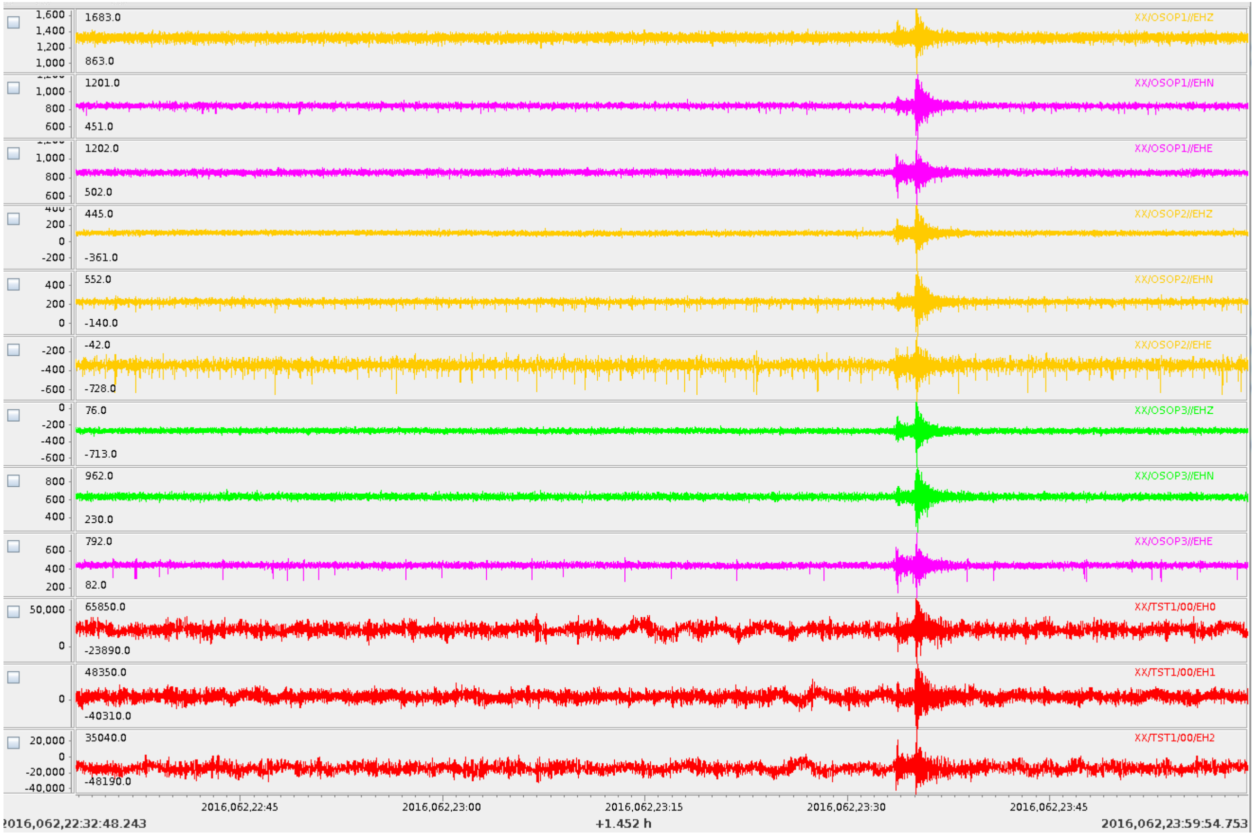

Figure 6. Waveforms from the m3.9, 33km NW of Fairview, Oklahoma earthquake (2016-03-02 23:31:48 UTC). All components of the Sixaola geophones are shown along with the reference STS-2 (bottom 3 traces).

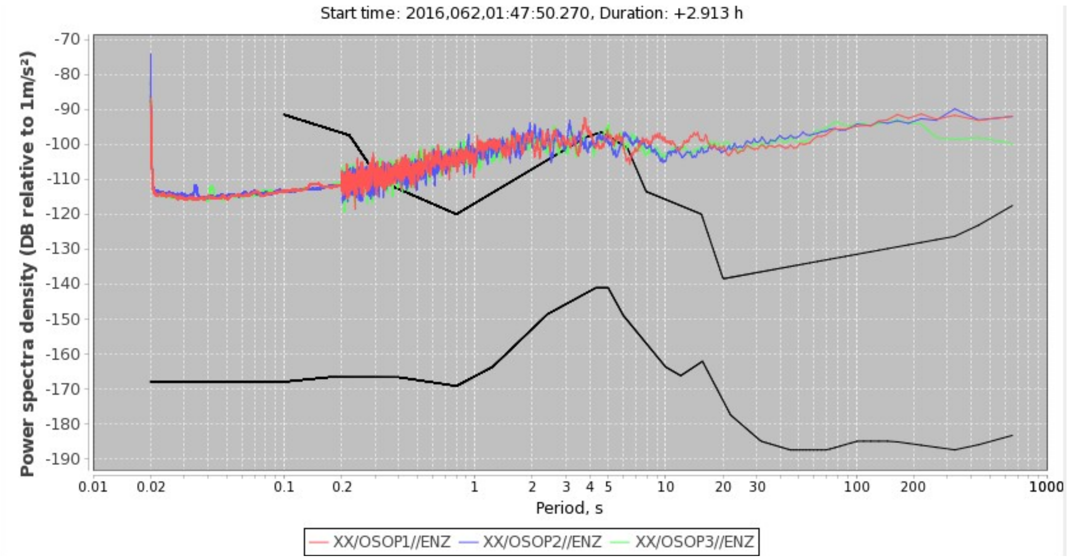

Figure 7. PSD plots for a quiet overnight period. The three vertical components of the Sixaola accelerometer are shown.

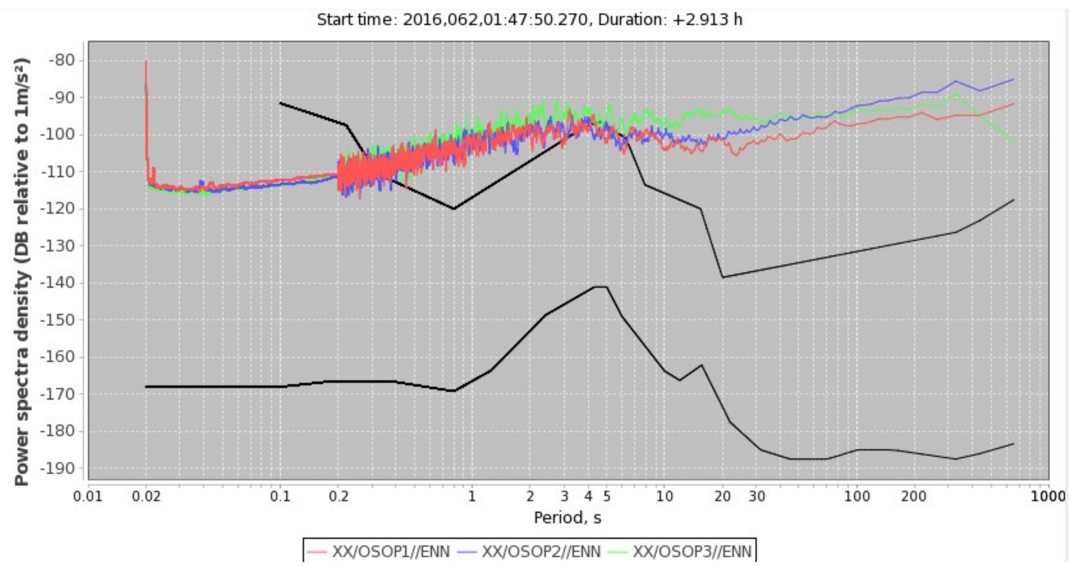

Figure 8. PSD plots for a quiet overnight period. The three North components of the Sixaola accelerometer are shown.

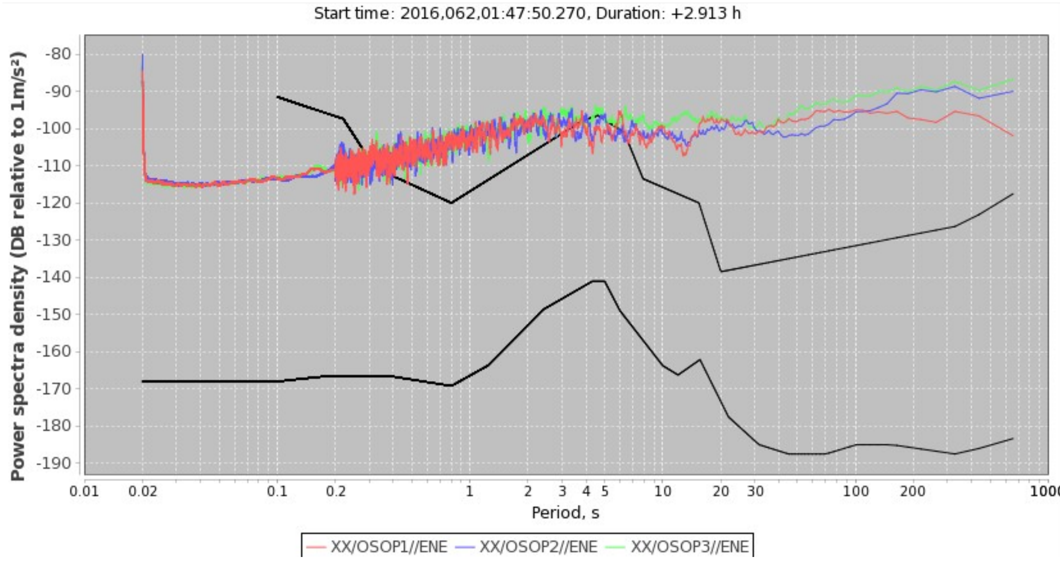

Figure 9. PSD plots for a quiet overnight period. The three East components of the Sixaola accelerometer are shown.

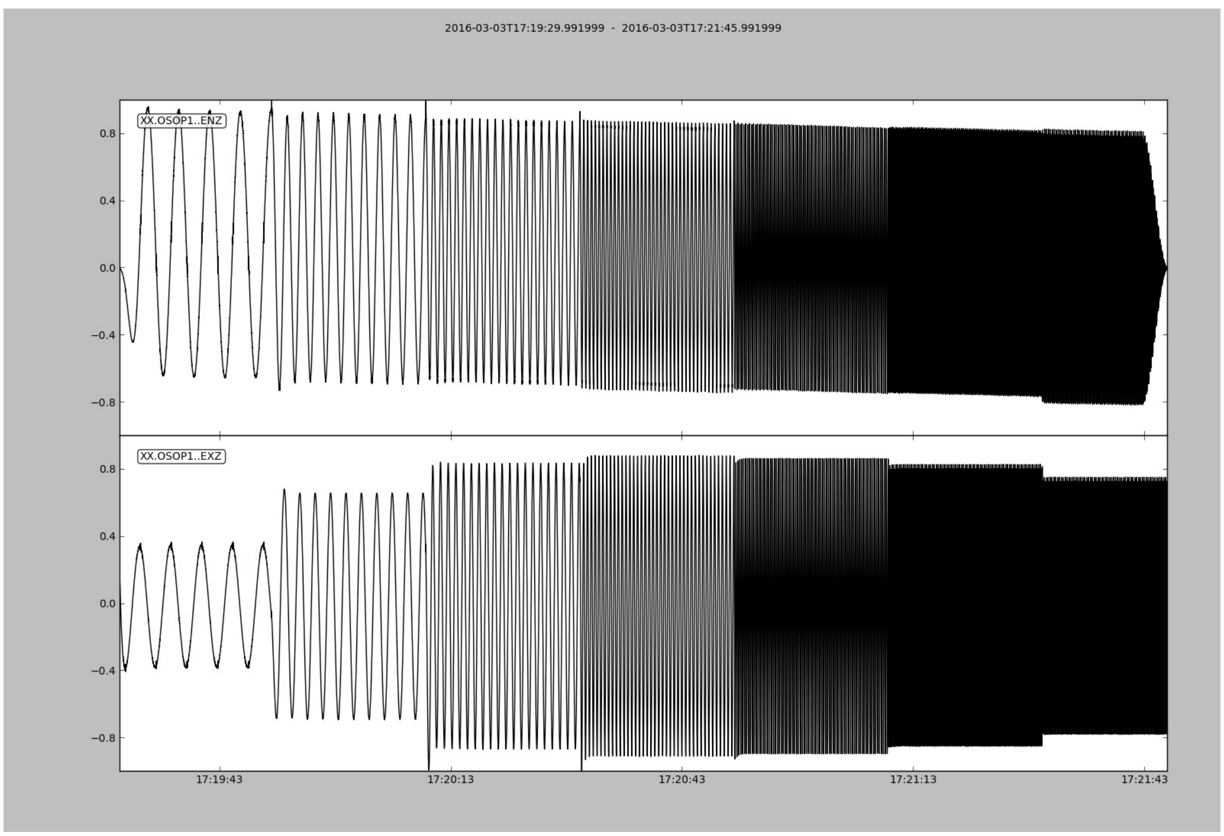

Figure 10. Waveforms from a shake table test performed in the East-West direction. The test consist of constant acceleration input at a range of frequencies. The

frequency bands shown in this plot are .25, .5, 1, 2, 4, 8, and 16Hz. This figure shows the shake table data with the response deconvolved (top) as well as the data not deconvolved (bottom). The deconvolution involves applying a taper and removing a trend so there is a bit of a slope in the top trace which is an artifact of the processing. Everything is normalized to a unity scale. Over the range of frequencies tested the shape of the response curve appears to be well characterized.

Summary

- The Sixaola's are easy to set up and configure
- The geophone is relatively quiet at .2 Hz and higher frequencies, suitable for local and regional earthquake monitoring.
- The noise floor for the accelerometer is near the high noise model at the microseismic peak, consistent with a ~18 bit, class B accelerometer.
- Shake table tests indicate that the accelerometer response may not be flat to acceleration as was originally described in the metadata. The OSOP team recomputed the response after their visit and now the response curve appears to be well characterized.