Testing the Performance of the Metrozet STS1 Very Broadband Sensor Clone

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Introduction

The STS-1 (*Wielandt and Streckeisen*, 1982; *Wielandt and Steim*, 1986), widely viewed as the finest very broadband (VBB) sensor in the world, is currently the principal broadband seismometer used by the Incorporated research Institutions for Seismology (IRIS) Global Seismographic Network (GSN), GEOSCOPE, and several other global or regional seismic networks operated by members of the Federation of Digital Broad-Band Seismograph Networks (FDSN). The installed base (approximately 750 sensor axes) represents a very significant international investment for low frequency seismology. The Berkeley Digital Seismic Network (BDSN) includes 10 STS-1's. Unfortunately, many of the STS-1 seismometers, which were manufactured and installed 10-20 years ago, are encountering both operational failures and age-related degradation (e. g. *Ekström and Nettles*, 2005). This problem is exacerbated by the fact that sensors are no longer being produced or supported by the original manufacturer, G. Streckeisen AG (Pfungen, Switzerland). In response to this growing issue, Metrozet LLC is working with the Berkeley Seismological Laboratory to redesign and test a replacement physical sensor follow successful completion of a replacement electronic controlling package.

Method

The Byerly vault in Berkeley is home to a long running STS1-VBB sensor (BKS) and three newly installed prototype Metrozet vertical sensors. The prototype sensors are independently analyzed and compared with BKS in terms of power spectrum and coherence.

Peterson (1993) computed the standard model for power spectral density (PSD) when he defined the New Low Noise Model (NLNM) against which all PSD's are compared. This method has been used extensively in noise floor calculations and by McNamara and Buland (2004) for assessing noise levels throughout the USArray and accumulating that information in a probability density function (PDF). We propose to follow similar methods for calculations, but use 24 one and a half hour long segments overlapping 66% for each day instead of 13 approximately fifteen minute segments overlapping by 75% over each hour of each day. This variation was chosen to simplify data management on a small-scale test and increase resolution at longer periods (> 100 seconds). We compute PSD's for each hour of 44 days since the installation and stacked the PSD's into a PDF to assess noise variability.

Having multiple co-located sensors allows computation of spectral coherence between the various channels. A PDF of coherence can be used in a similar method as the PDF of the PSD's to measure the variability in the measurements; however coherence can also illuminate variation between sensors.

Preliminary Results

Initial PSD measurements of the BKS reference sensor and the Metrozet prototype sensors (see figure 1) show clear variations in both short and long periods. While BKS is flat at higher frequencies, the Metrozet prototypes are quieter at longer periods. Because the sensor is designed to measure very small, very long period signals, this is a favorable response. However, it is evident from the PDF (figure 2) that the variance at all periods is larger in the new sensors. This may be due to instrument self settling resulting in transient signals.

The coherence analysis (figure 3) shows the new sensors are self-coherent, but only coherent with BKS at the period band of 1-10 seconds. Figure 4 shows the PDF, which highlights this trend and the variation seen in the PSD's. Finally, the coherence between prototype sensor 1 and prototype sensor 2 is by far the best which begs the question why sensor 3 is different. Changing the physical installation of the sensors may reveal some reasons for the similarity within the Metrozet sensors. Longer testing may shrink the variability as the sensors get accustomed to the installation.

Proposal

These preliminary results show very promising results for the Metrozet vertical component sensor. Continued testing over multiple seasons will help to analyze the variability of these sensors in response a seasonally variant noise floor. Upon completion of a horizontal sensor, similar testing will be used to assess the possibility of a replacement sensor with equal or better response compared with the current STS-1 VBB.

While this early study has assessed spectral energy relative to standard measurements, other methods can be utilized assess sensor self-noise (Sleeman et al. 2005) which will help illuminate the reliability of measurements without assuming some proxy for known ground motion.

References

Ekström, G. and M. Nettles, http://www.seismology.harvard.edu/~ekstrom/Projects/WQC.html, 2005.

McNamara, D. and R. Buland, Ambient Noise Levels in the Continental United States *Bull. Seism. Soc. Am.*, 94, 4, 2004.

Wielandt, E. and G. Streckeisen, The leaf spring seismometer: design and performance, *Bull. Seis. Soc. Am., 72*, 2349-2367, 1982.

Wielandt, E. and Steim, J. M., A digital very broad band seismograph, *Annales Geophysicae*, 4 B(3), 227-232, 1986.

Perterson, Observation and modeling of seismic background noise*, U.S. Geol. Surv. Tech. Rept.*, 93-322, 1-95, 1993.

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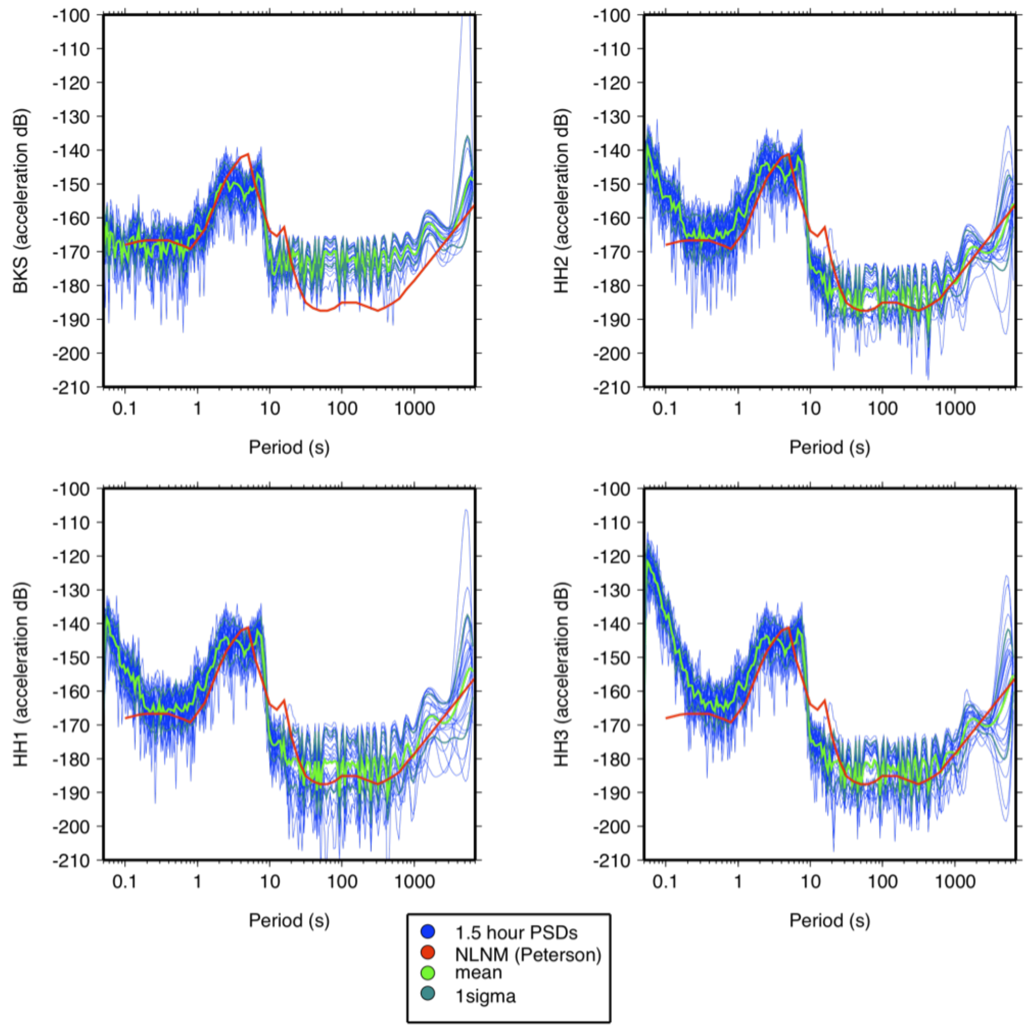

Figure 1: Power spectral densities computed on day 45 of 2009. Reference station BKS is the upper left and the three other boxes are the three prototype sensors.

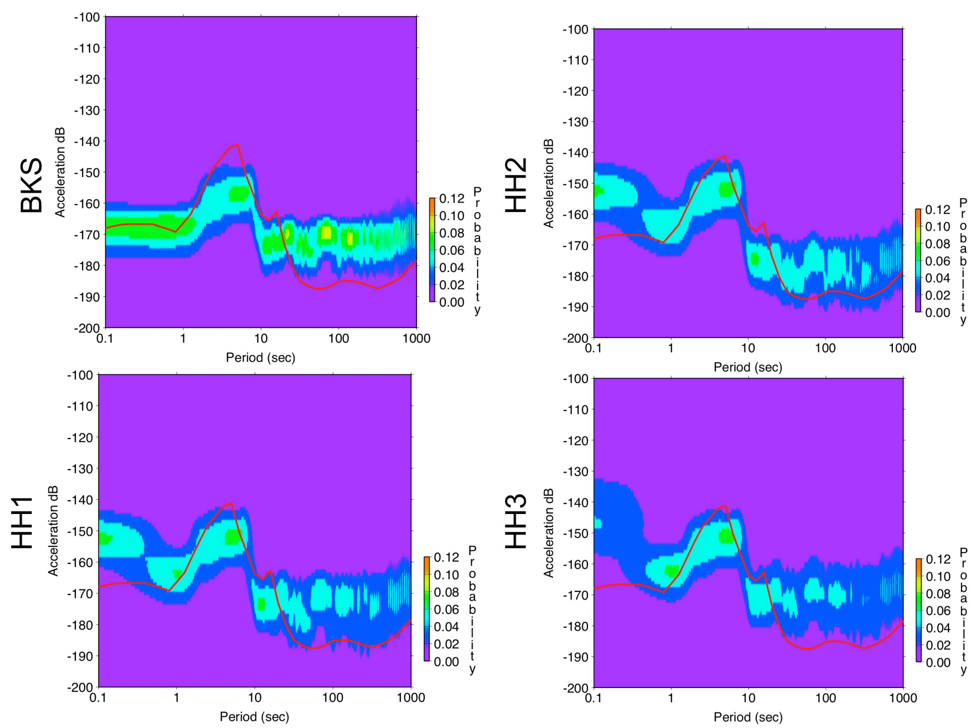

Figure 2; PDF of power spectra for day 2 of 2009 through day 45 of 2009 with red curve showing the NLNM. Again, BKS is in the upper left and the others are the prototype sensors. Dark blue shows background (0 probability), light blue shows mild probability, white medium probability, and red is high probability.

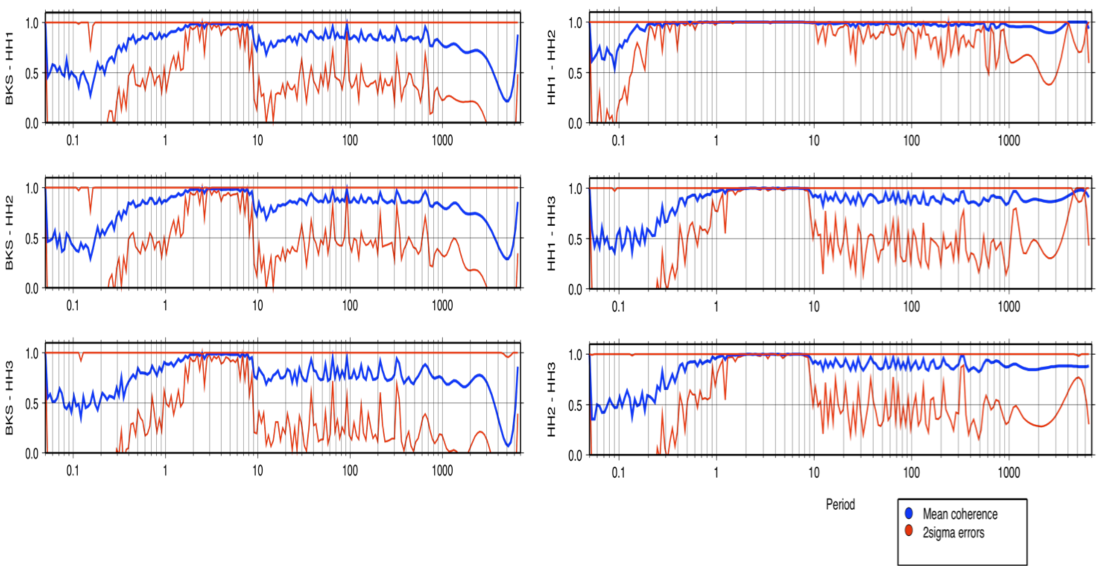

Figure 3: Coherence of various combinations of BKS and the prototype sensors (left) and internally with the prototype sensors (right). This plot shows day 45 of 2009 with +/- 2 standard deviations

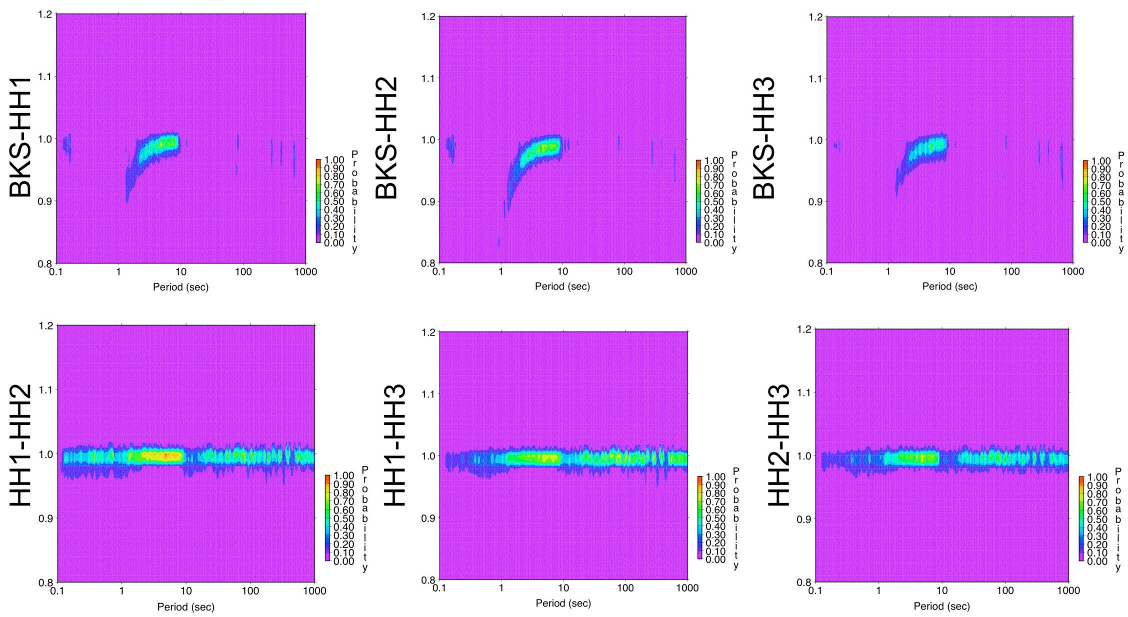

Figure 4: PDF of coherence. BKS and prototype sensor in top row. Inter-prototype sensors in the bottom row. Bright spots show the greatest probability.