Re: Note on filter used at USGS/NEIC for short-period signals to determine m_b
From: Won-Young Kim, Lamont-Doherty Earth Observatory of Columbia University
To: Members of the IASPEI Working Group on Magnitude
Date: April 15, 2002

Recently, Jim [Dewey] sent an E-mail message concerning instrument responses to members of the IASPEI Working Group on Magnitude (mag WG) (April 10, 2002).

The response of the [USGS/]NEIC SP filter (for measuring m_b) has steep slopes at highest and lowest frequencies. The slopes are steeper than for the response of the traditional WWSSN SP. [Ray] Buland says he used the steep high-frequency cut-offs to make easier the automatic detection of P-waves at noisy stations. I suspect that similar modifications to SP response, made to address issues that have nothing to do with magnitude measurements, will be typical of other networks of digital seismographs. The question is whether these changes significantly affect the magnitude measurements.

I guess, **WWSSN SP** response in the above paragraph is the the displacement amplitude response and that the NEIC SP response is represented by 4 zeroes and 8 poles given by Buland. WWSSN SP displacement amplitude response and NEIC SP response are plotted in Figure 1 for comparison. Note that the NEIC SP response is actually the combination of the two bandpass filters. The first one is the Butterworth, second order bandpass filter with cutoffs at 1.05 and 2.65 Hz (two zeroes and four poles). The second one is also the Butterworth, second order bandpass filter with cutoffs at 0.5 and 6.5 Hz (two zeroes and four poles).

However, I believe that the NEIC SP filter is applied directly to signals from the broadband seismographs. The NEIC broadband data are from the USNSN (U.S. National Seismographic Network) station. A typical station of the USNSN consists of a broadband sensor (type CMG-3T with T_0= 100 sec) and datalogger with 24 bit A/D converter. The digital seismogram data are sampled with 40 samples/sec after anti-alias filters and the system provides data with frequency band up to 16 Hz (= 80% of the Nyquist frequency 20 Hz). Hence, the USNSN broadband seismograph has flat response to the input ground velocity in the frequency band 0.01 – 16 Hz.

It appears that NEIC SP filter is applied to the digital data from the broadband seismograph which is *velocity* signal in the frequency band 0.01 – 16 Hz. I think that it is not the same as synthesizing seismic singals corresponding to the WWSSN SP seismogram. To synthesize WWSSN SP seismogram, the USNSN broadband signals (*velocity*) must be multiplied with the WWSSN SP *velocity* response given by 2 zeroes and 5 poles (WWSSN SP filter in Jim's message). Hence, the signal processing at NEIC for m_b measurement, should be compared with NEIC SP filter with WWSSN SP velocity response (see Figure 2).

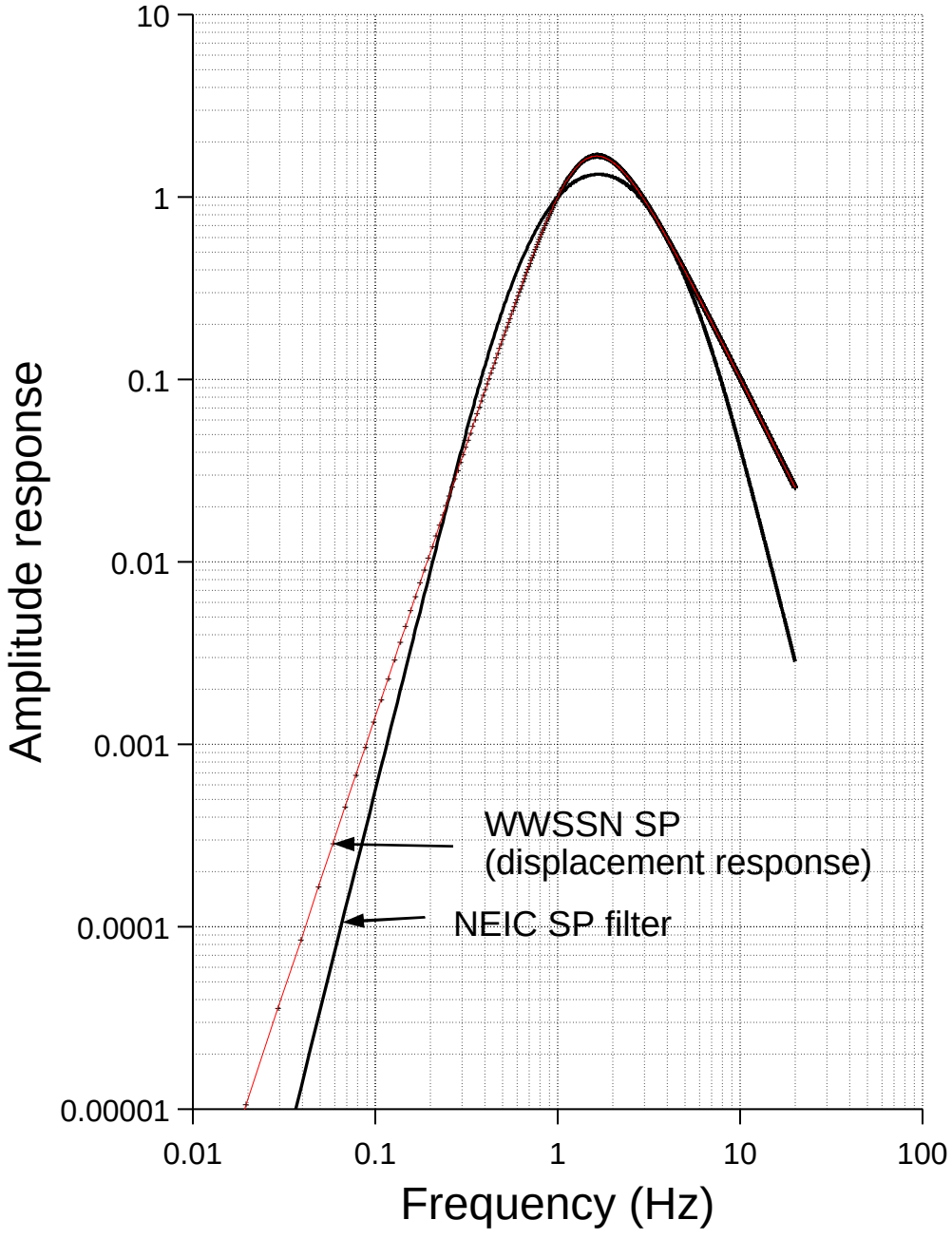

Figure 1: Comparison between the filter used at NEIC for m_b measurement and WWSSN short-period **displacement** amplitude response. NEIC SP response is actually two Butterworth, second order bandpass filters.

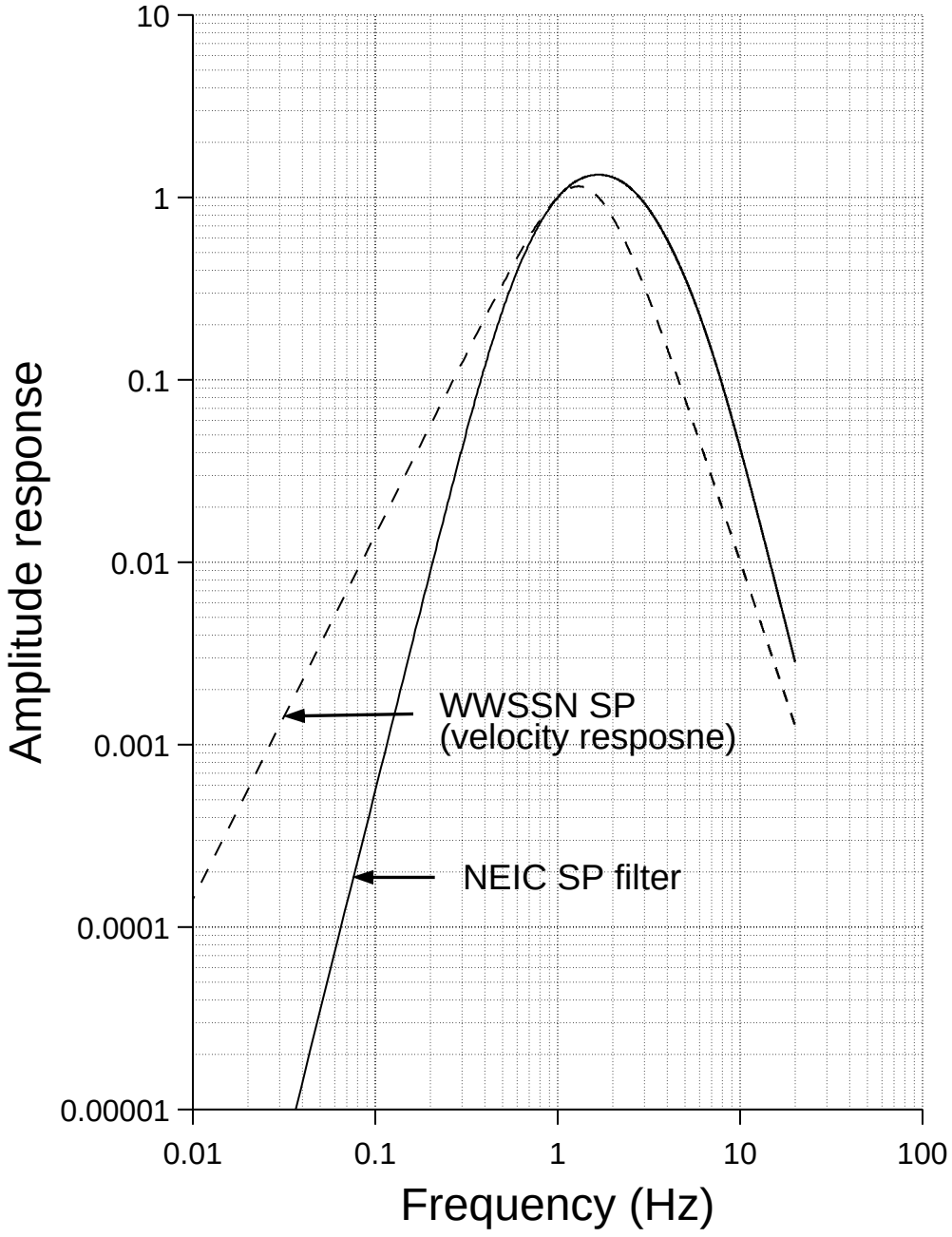

Figure 2: Comparison of the filter used at NEIC for m_b measurement and WWSSN short-period **velocity** amplitude response.