Response spectra for signals having the same FAS but different durations

Notes to myself (David M. Boore)

I've read some papers in which it seems that the authors think that the response spectra at short distances will be smaller at long periods than the spectra from motions at greater distances, because the latter will have more obvious long-duration waves (e.g., "basin waves"). It is important to keep in mind what is being compared with what, but as I stated it, I think the statement is incorrect. To demonstrate this, I computed Fourier spectra (FAS) and response spectra for the simulated motions shown in the middle two panels of Figure 11 in Boore (2003). The FAS for these motions should be the same, on average. The only difference is that in one record the low frequency motions have been delayed relative to the other record. The figures below show what I expect: if the FAS is the same, the response spectrum will be smaller if the energy in the record is spread out over a longer time. For the statement above to be true, the Fourier spectral amplitude for the closer motion would have to be smaller than for the motion at greater distance. Perhaps this could happen for waves trapped in a basin — I should ask basin modelers (e.g., Steve Day). But note that if what is being compared are response spectra at the same distance, one in a basin and one on rock, then the basin record will almost certainly have enhanced long period motion because of the waveguide effect.

References

Boore, D. M. (2003). Some notes on phase derivatives and simulating strong ground motions, *Bull. Seism. Soc. Am.* **93**, 1132–1143.
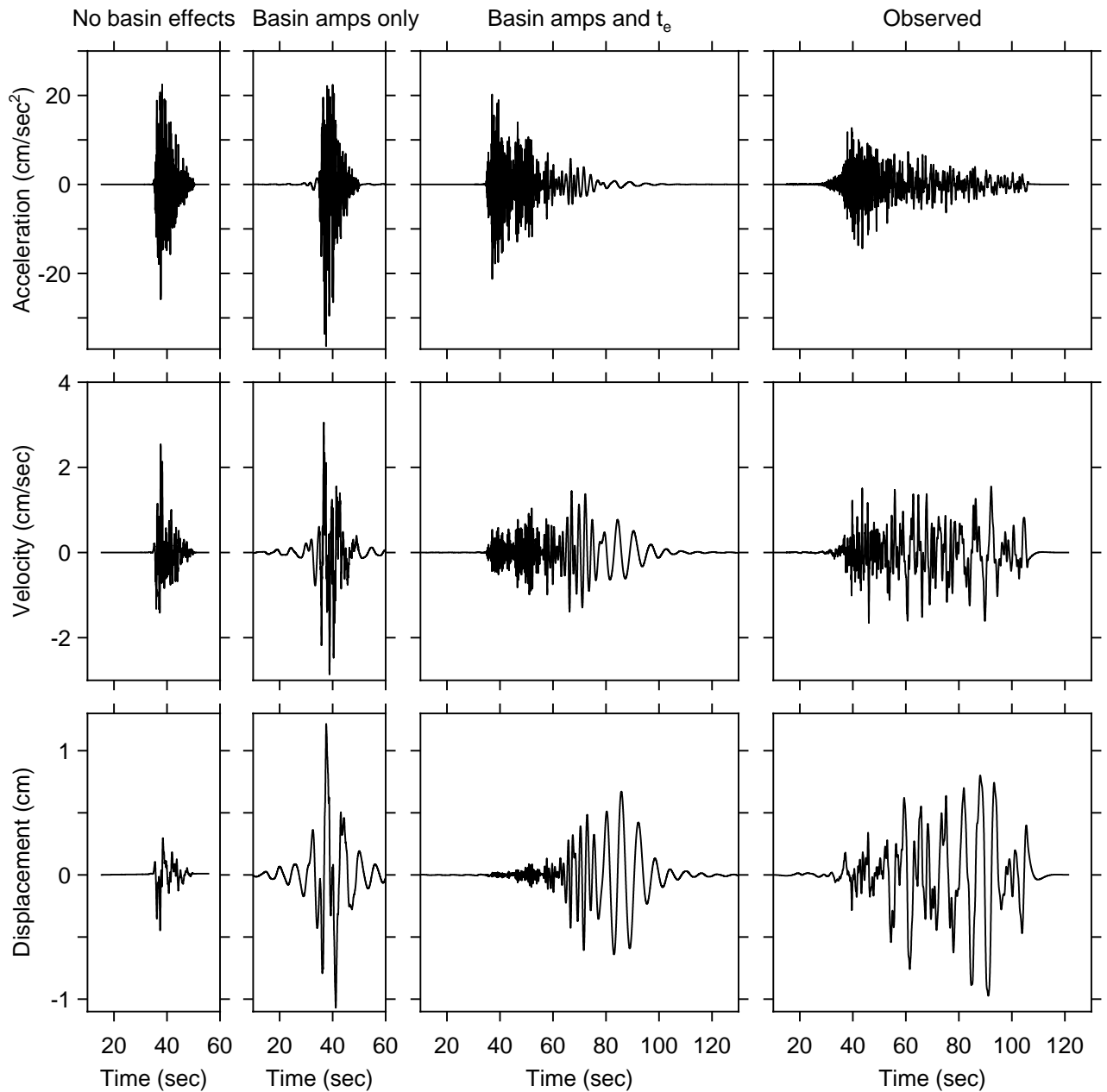
Figure 1. Simulation using frequency-dependent correction to phase given by envelope delay of the 1990 Upland, California, earthquake recorded at station S3E, as well as the relative site response as discussed in the text. Shown are the acceleration, velocity, and displacement of the simulations (with and without basin amplification and envelope delay), and the observed motions at S3E from the 1990 Upland earthquake (74 km epicentral distance and $\mathbf{M}$ 5.6). (see Figure 11 and associated text in Boore, 2003, for details).
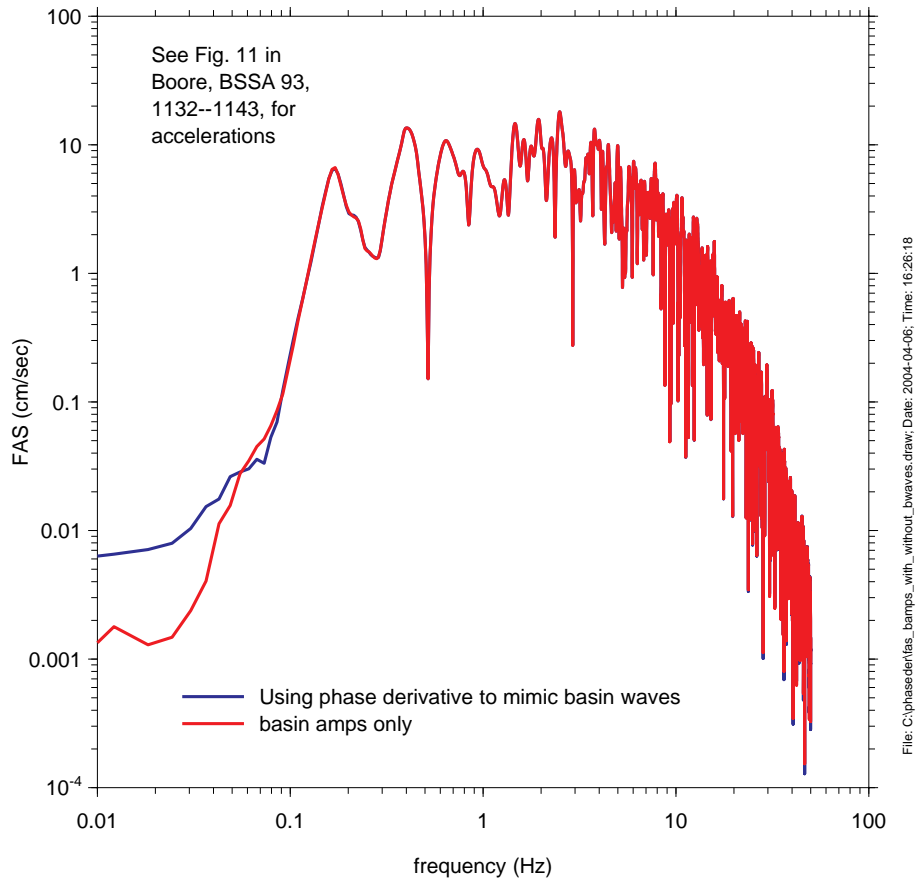
Figure 2. Fourier spectra of the accelerations shown in the middle two panels of the previous figure; the spectra are equal except for the longest periods (lowest frequencies). If averaged over many simulations, they would be identical.
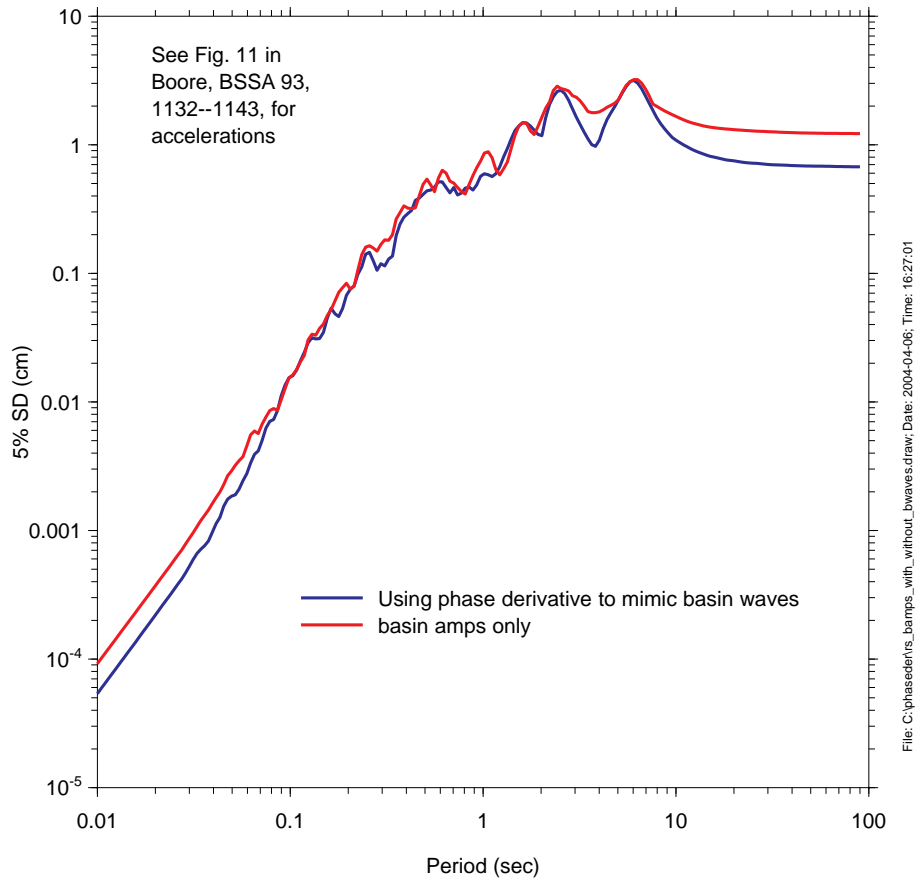
Figure 3.   Response spectra of the accelerations shown in the middle two panels of the previous figure; the longer duration acceleration has a consistently lower response spectrum.