c:\metu_03\lab_proc\comments_pga_filtering_spectral_shape.tex

17 November 2003

Some Comments on PGA, Filtering, and Spectral Shape: Examples from the Cape Mendocino Recording of the 1992 CM Mainshock and the TCU129 Recording of the 1999 Chi-Chi Mainshock

by David M. Boore

Shown here are a few interesting examples of the consequences of high-cut filtering on peak accelerations (PGA) and the corresponding change to spectral shape, defined in two ways: 1) as the pseudo-spectral acceleration (PSA) divided by the peak acceleration, and 2) as the pseudo-spectral acceleration divided by the pseudo-spectral acceleration at $T = 0.2$ sec. The examples show that in cases where PGA is controlled by high-frequency motions, using PGA as the reference in computing spectral shape can lead to spurious spectral shapes. I conclude that it makes more sense to normalize PSA by values of PSA near the periods of interest in design rather than PGA. I also show that the 1.5g peak acceleration recorded at the Cape Mendocino station during the 1992 Cape Mendocino mainshock is not due to high-frequency motions, contrary to what I thought before now. The peak of 1.0g on the other horizontal component is more strongly controlled by frequencies above 10 Hz than is the 1.5g peak.

TC129 Recording of the 1999 Chi-Chi Earthquake

The EW component has a PGA of 1.0g. Wen *et al.* (2001) think that the peak acceleration is controlled by the response of the concrete pedestal on which the sensor is mounted. In separate comments, I conclude that this was only part of the reason for the large acceleration. I showed that high-cut filtering at 10 Hz reduces the 1.0g peak acceleration to 0.70g (and the peak acceleration on the filtered record — 0.82g — is now from a different part of the time series). The accelerations, Fourier spectra, and response spectra for the unfiltered and filtered motions are shown in Figure 1. The portions of the acceleration time series contributing the peak acceleration before and after filtering are shown in the right and left parts of the upper panel, respectively. Note that the earlier peak of 862 cm/sec^2 at 27.3 sec is carried by a pulse with a longer duration than the pulse associated with the largest peak of 983 cm/sec^2 at 34.7 sec, and therefore the amplitude of the earlier pulse is less sensitive to the high-cut filtering. It is for this reason that the peak acceleration for the filtered record is given by the earlier pulse. Normalizing the PSA by the PGA in the normal way leads to apparently different spectral shapes (Figure 2, left), which is clearly a misrepresentation of the spectra at periods greater than about 0.1 sec. Better is to normalize by the PSA at a longer period (e.g., 0.2 sec, as in Figure 2, right).

Cape Mendocino Recording of the 1992 Cape Mendocino Earthquake

I did the same studies for both horizontal components as I did for the EW component of the TCU129 recording. The Cape Mendocino recording is quite interesting, for reasons that I did not suspect. The component 3 record has a peak acceleration of 1.5g, and I always thought that this was associated with very high frequencies and therefore would have little or no effect on response spectra. I was wrong. Careful inspection of the accelerations (Figure 3) shows that it is component 1 that seems to be most affected by high frequencies— note the sharp peaks and the richer high-frequency content relative to motions less than about 8 Hz, and note that the PGA for the filtered record is actually slightly higher than the unfiltered record for the component 3 record! The spectral shapes computed using PGA as the reference seem to be quite different for the component 1 record, but not so different for the component 3 record (Figure 4, top panel). As before, the apparent difference in shape is strongly controlled by the presence or lack of high-frequencies in the motion— a case of the tail wagging the dog. Much better results are obtained by normalizing by PSA at a period longer than 0.1 sec (0.2 sec in the examples shown in Figure 4, bottom panel).

References

Wen, K.-L., H.-Y. Peng, Y.-B. Tsai, and K.-C. Chen (2001). Why $1G$ was recorded at TCU129 site during the 1999 Chi-Chi, Taiwan earthquake, *Bull. Seism. Soc. Am.* **91**, 1255–1266.

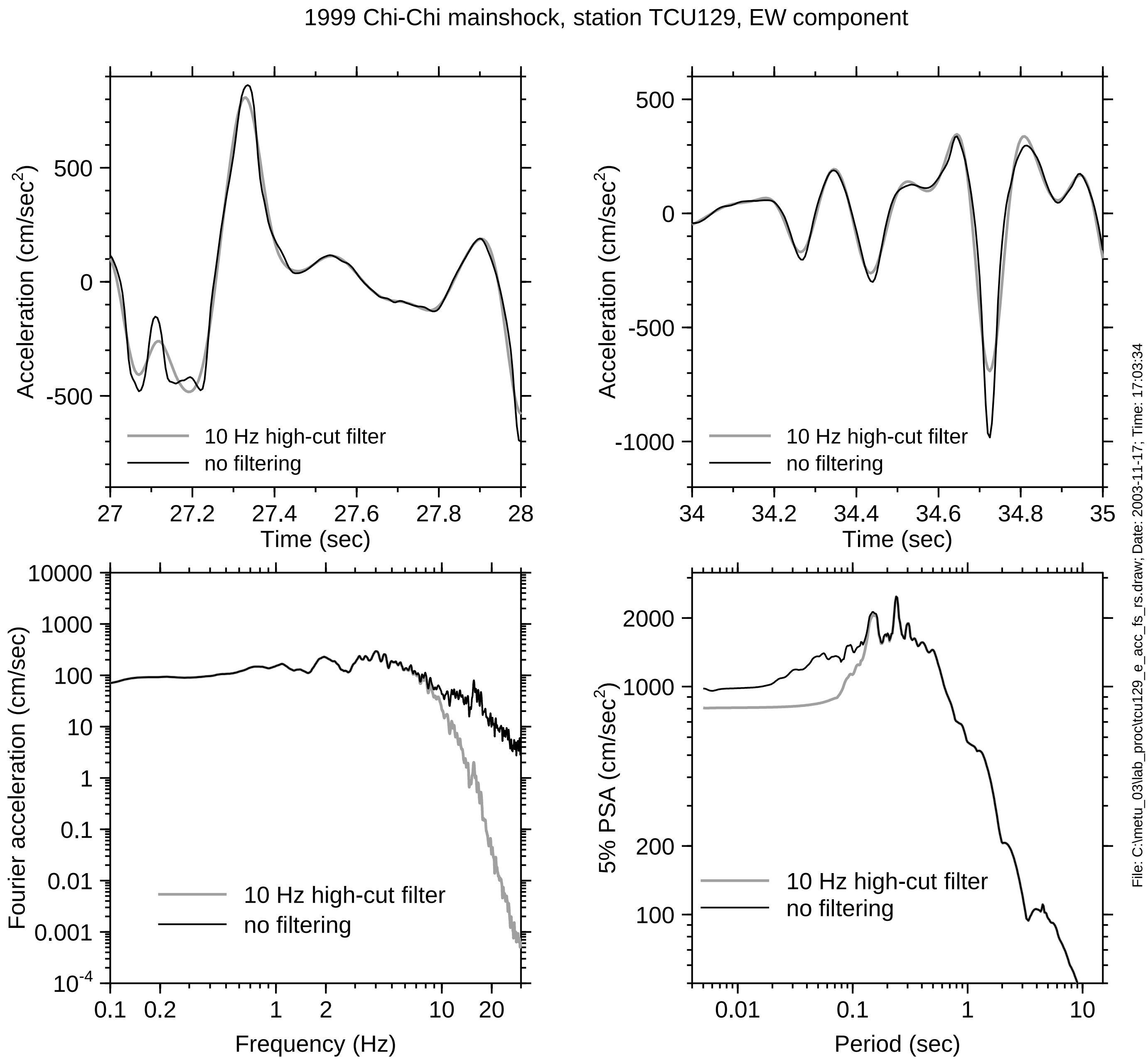

Figure 1. The acceleration, Fourier spectrum, and 5%-damped pseudo-acceleration response spectrum for the EW component recorded at TCU129 from the 1999 Chi-Chi, Taiwan, mainshock. Results are shown with and without acausal 10-Hz high-cut filtering.

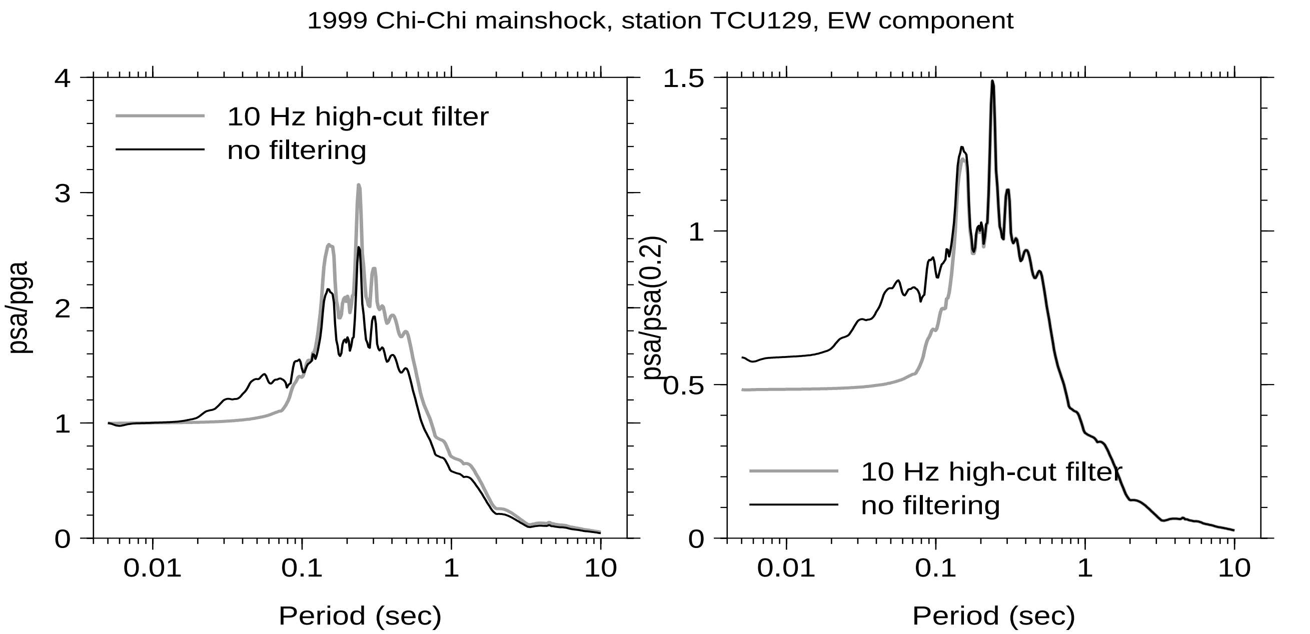

Figure 2. The normalized 5%-damped pseudo-acceleration response spectrum for the EW component recorded at TCU129 from the 1999 Chi-Chi, Taiwan, mainshock. Results are shown with and without acausal 10-Hz high-cut filtering, using peak acceleration and PSA at 0.2 sec as normalizing factors.

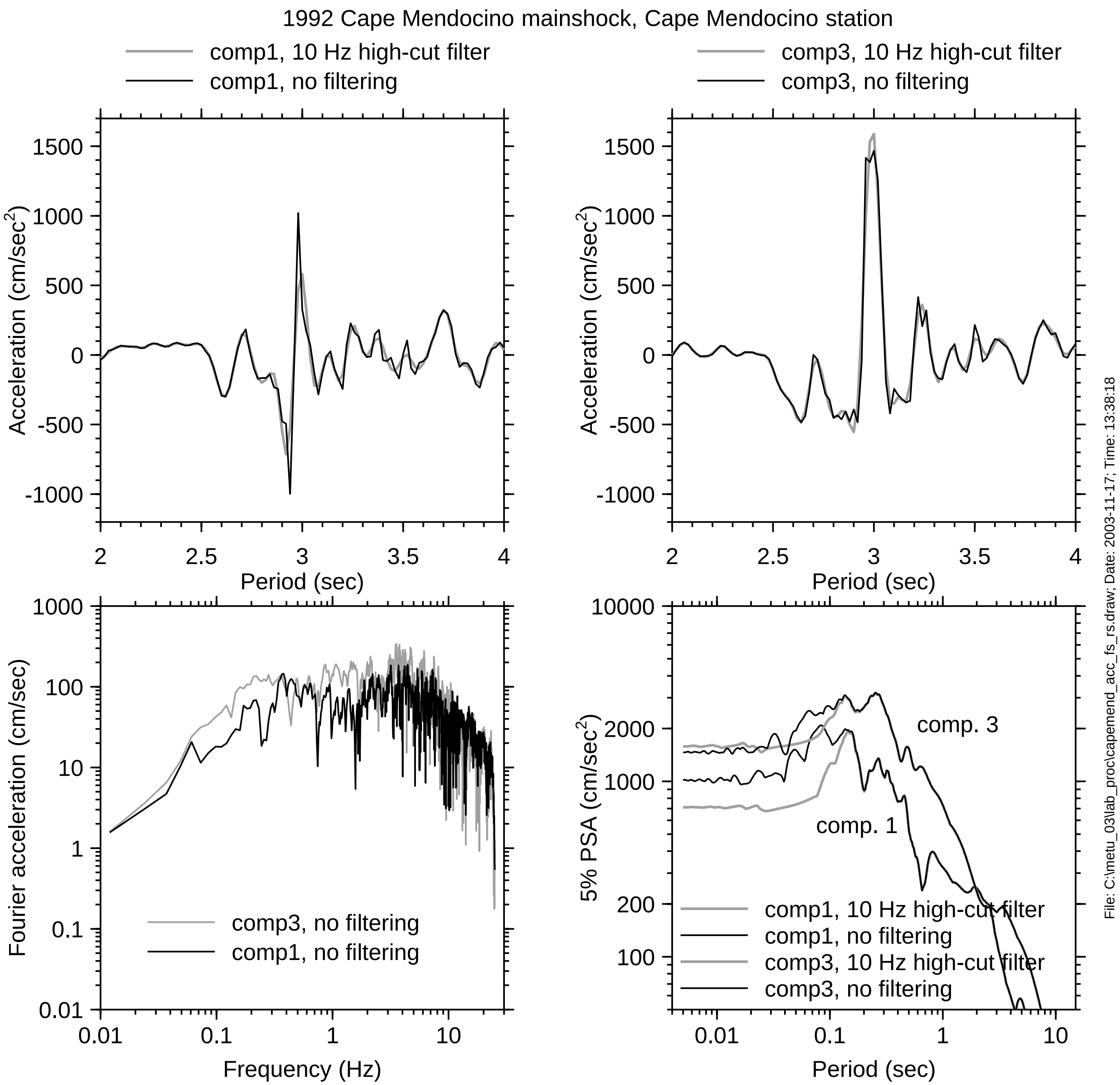

Figure 3. The acceleration, Fourier spectrum, and 5%-damped pseudo-acceleration response spectrum for the two horizontal components recorded at the Cape Mendocino station from the 1992 Cape Mendocino, California, mainshock. Results are shown with and without acausal 10-Hz high-cut filtering.

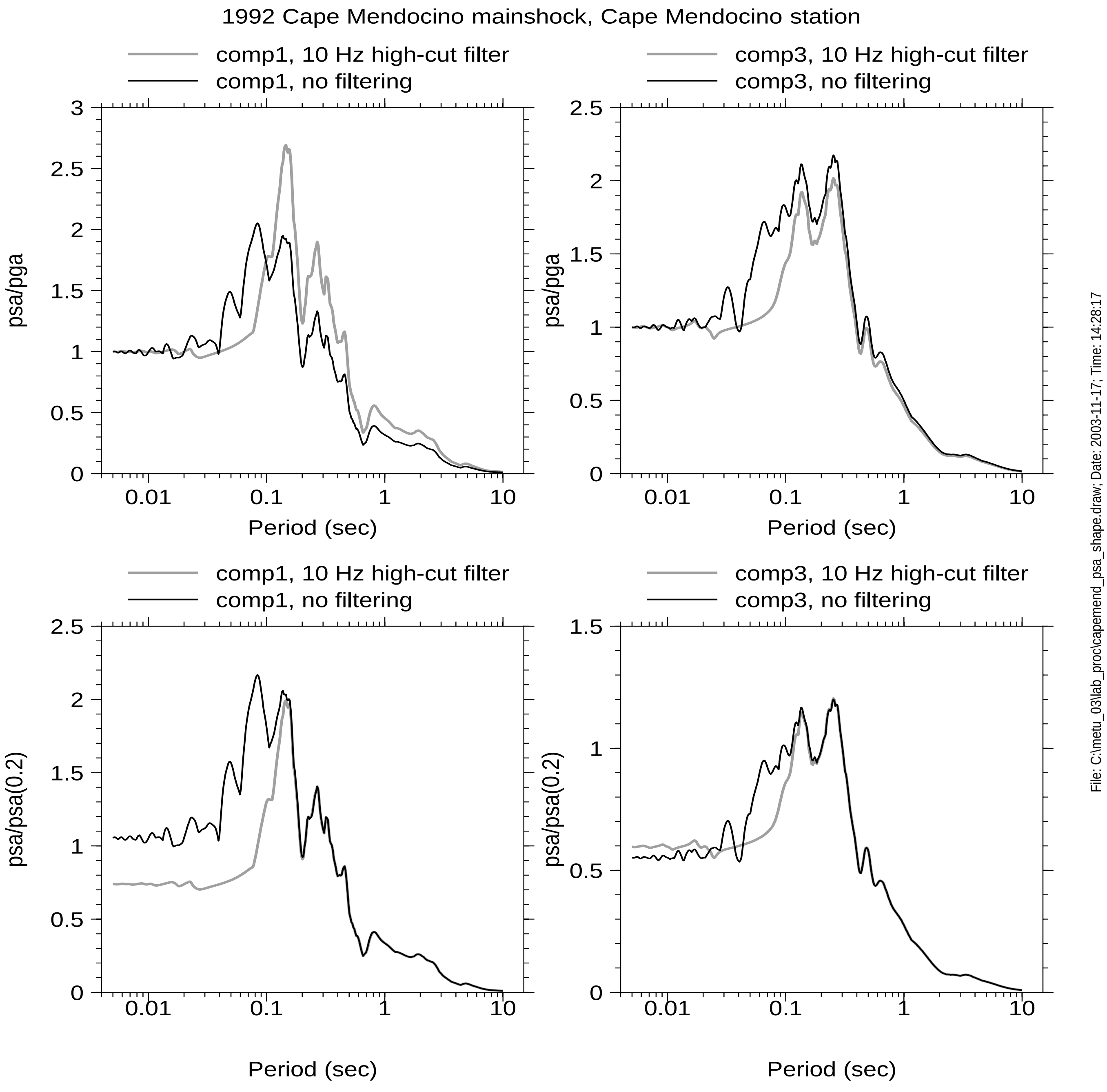

Figure 4. The normalized 5%-damped pseudo-acceleration response spectrum for the two horizontal components recorded at the Cape Mendocino station from the 1992 Cape Mendocino, California, mainshock. Results are shown with and without acausal 10-Hz high-cut filtering, using peak acceleration and PSA at 0.2 sec as normalizing factors.