Notes to myself (D.M. Boore)

Originally in ImpColl folder, with name "roundoff". Now named "response_spectra_need_for_double_precision".

March 15, 2001

Roundoff errors in response spectral programs
and baseline correction programs

Response Spectra

John Douglas of Imperial College made the comment in a draft chapter of his thesis that the Nigam and Jennings algorithm for computing response spectra gives incorrect spectral displacement values at long periods. Because the method uses an analytical solution, there should be nothing fundamentally wrong with the method. I suspected roundoff errors, and therefore I made a double precision version of the subroutine (very easy to do using the implicit real*8 (a-h,o-z) statement). The first figure shows the results of several ways of computing the response spectra for one horizontal component of the SCE Devers recording of the 1986 North Palm Springs earthquake (record 001051x, as provided by John). Clearly, double precision fixed the problem. I had noticed evidence of numerical instability at long periods in my processing of Chi-Chi and Hector Mine, but the problem did not dominate the spectra, and I therefore ignored the problem (more accurately, I was too lazy to figure out what was wrong).

Subsequent figures show more spectra computed using a single precision routine (CMPMAX in BAP) and my double precision routine. I also have redone my figures for my Chi-Chi and Hector baseline processing papers submitted to BSSA. In all cases the double precision routine eliminated the numerical instabilities (and note that both Chi-Chi and Hector Mine records were much longer than the North Palm Springs record).

Note that I originally made a separate double precision version (e.g., rdrvaadp.for rather than rdrvaa.for), but once I determined that the double precision routines worked well, I renamed them to the original names (rd_calc.for, rdrvaa.for, etc.)

Baseline Correction

John Douglas used double precision in fitting polynomials to the velocity trace, whereas my routine (bl_fltr.for) used single precision. Results for a 6th order polynomial fit to the 001051y record were different. I converted my program to double precision and found agreement with his results. Again I originally made a separate program (blfltrdp.for) but then renamed it to the original program name. No tables or figures are included here to illustrate the problem.

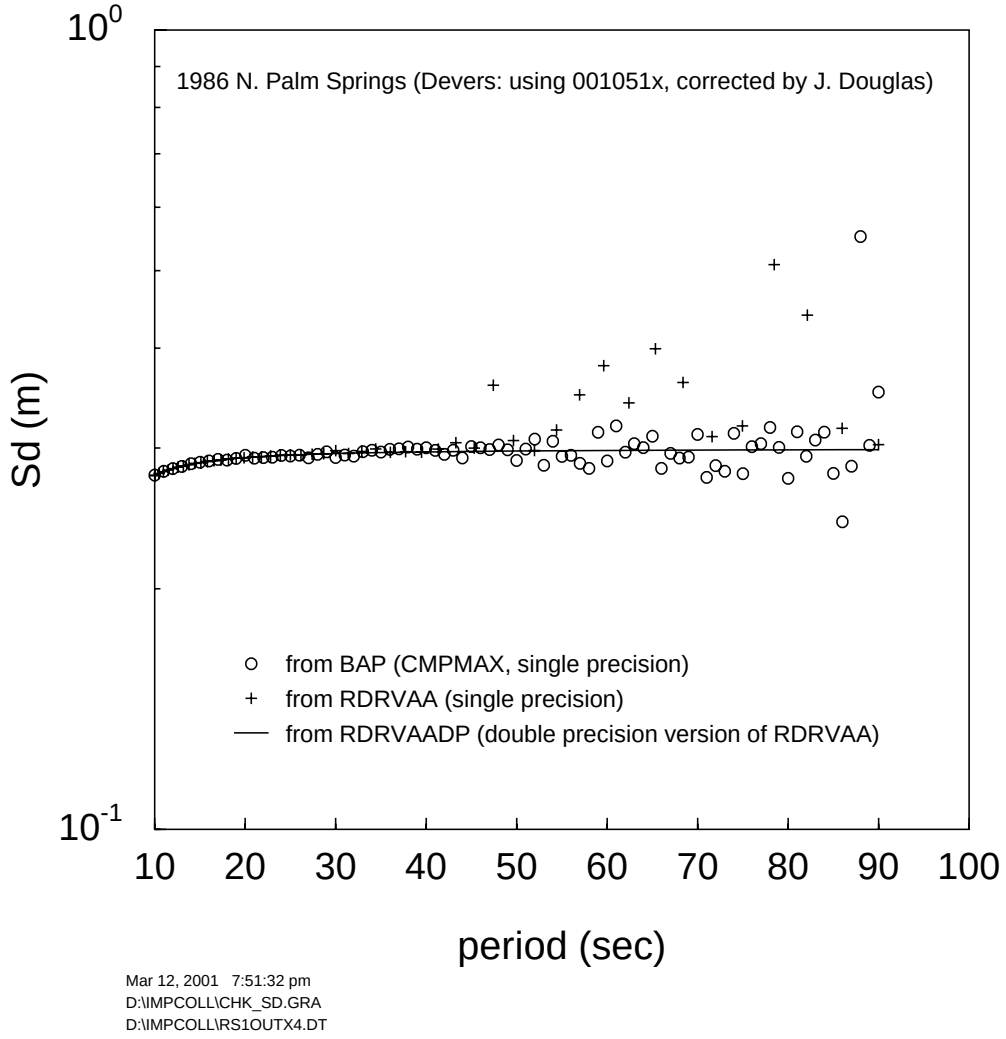

Figure 1. A portion of the S_d response spectrum computed using two single and one double precision routines.

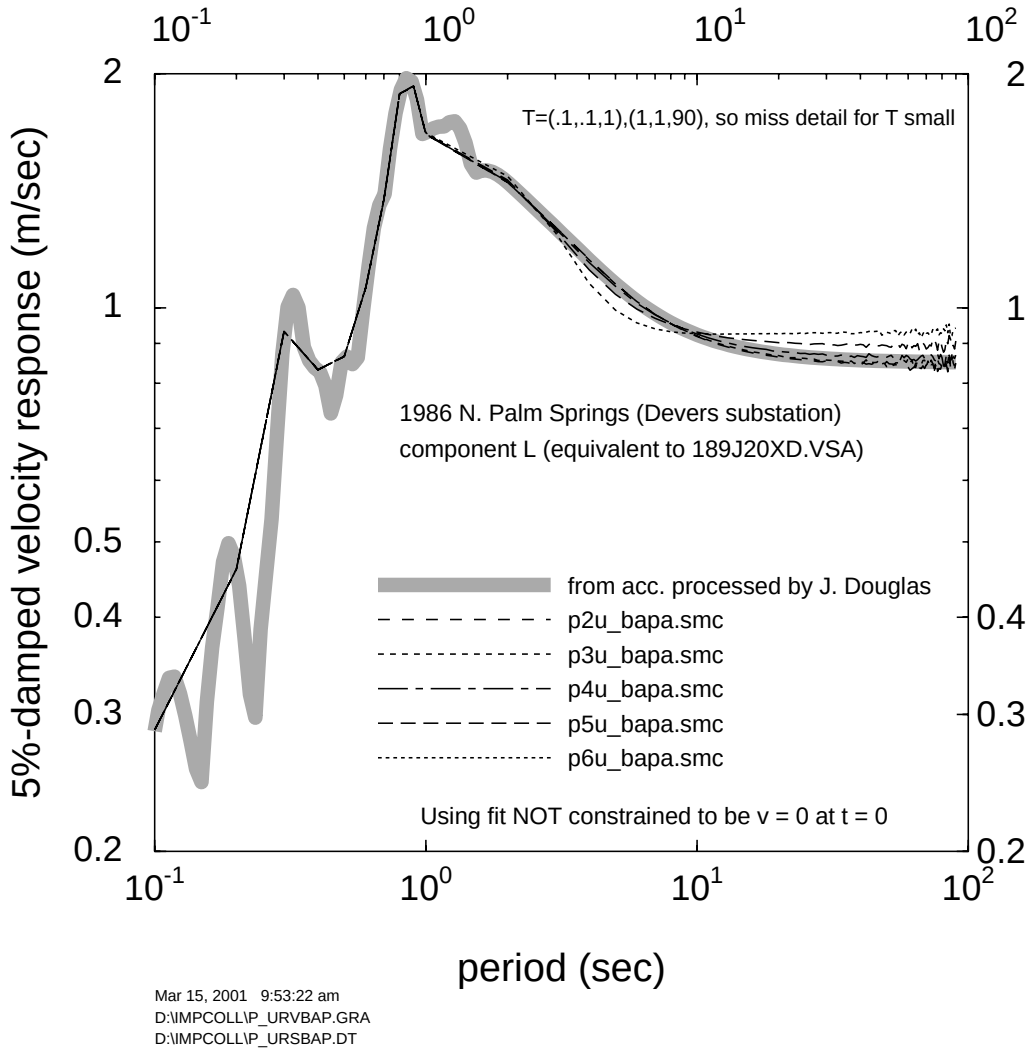

Figure 2. Relative velocity response spectrum for accelerograms processed using various polynomials fit to the velocity trace, showing evidence of roundoff error. The spectra were computed using a single-precision subroutine.

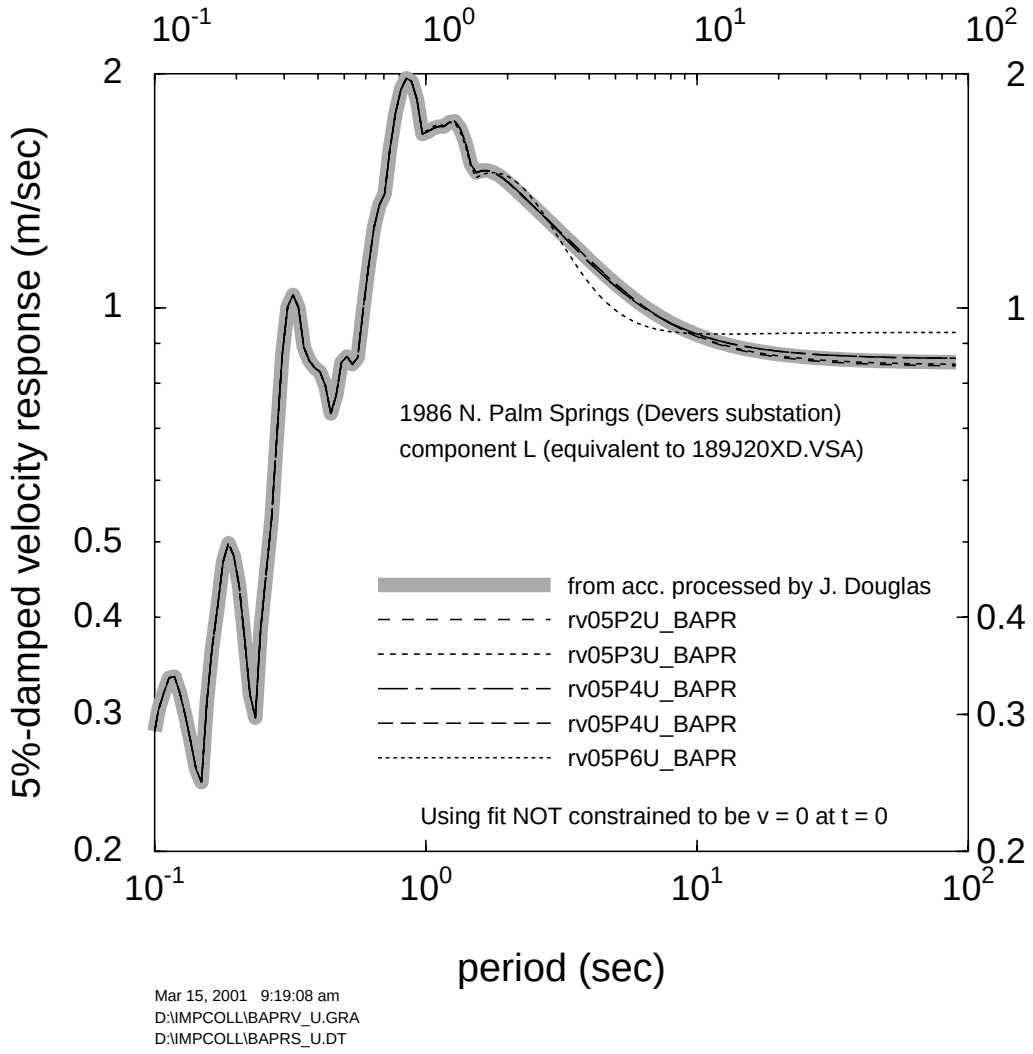

Figure 3. Relative velocity response spectrum for accelerograms processed using various polynomials fit to the velocity trace. The spectra were computed using a double-precision subroutine.

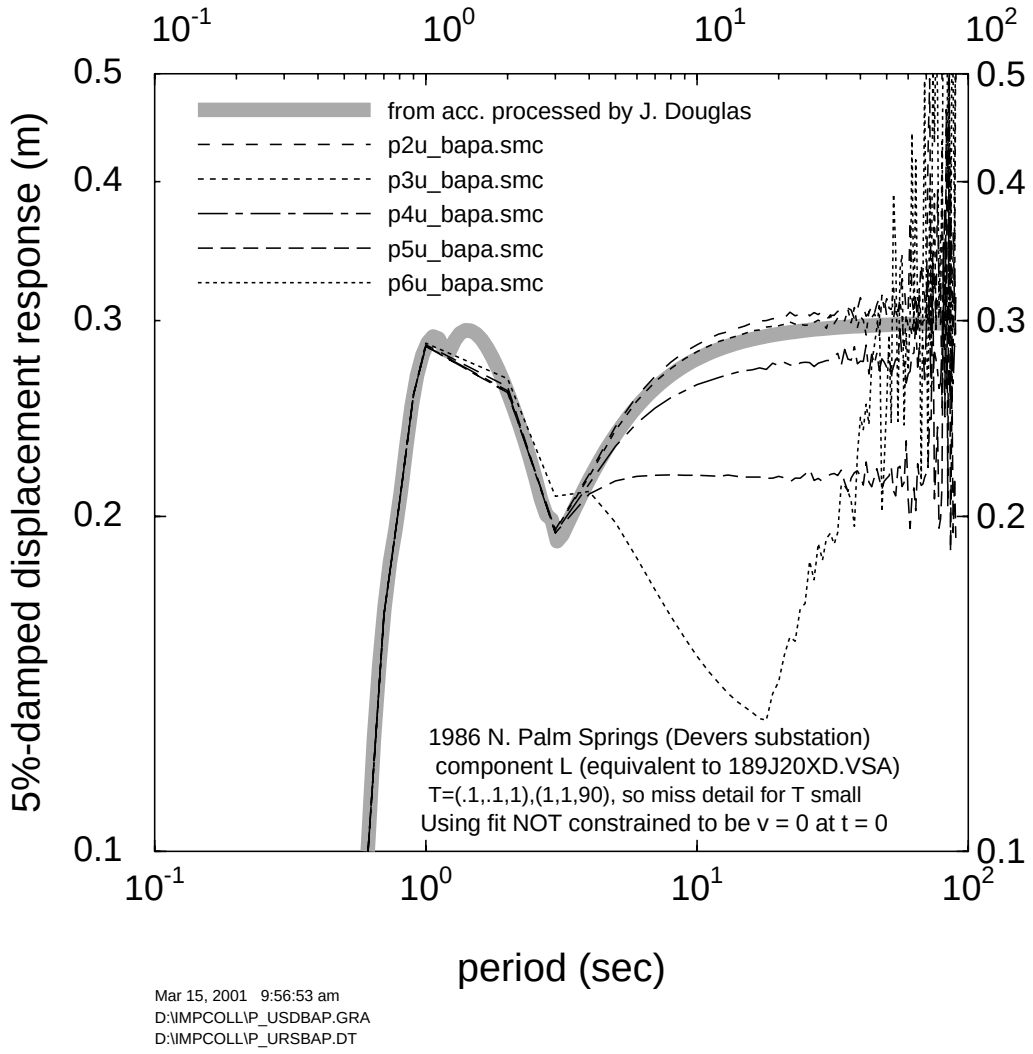

Figure 4. Relative displacement response spectrum for accelerograms processed using various polynomials fit to the velocity trace, showing evidence of roundoff error. The spectra were computed using a single-precision subroutine.

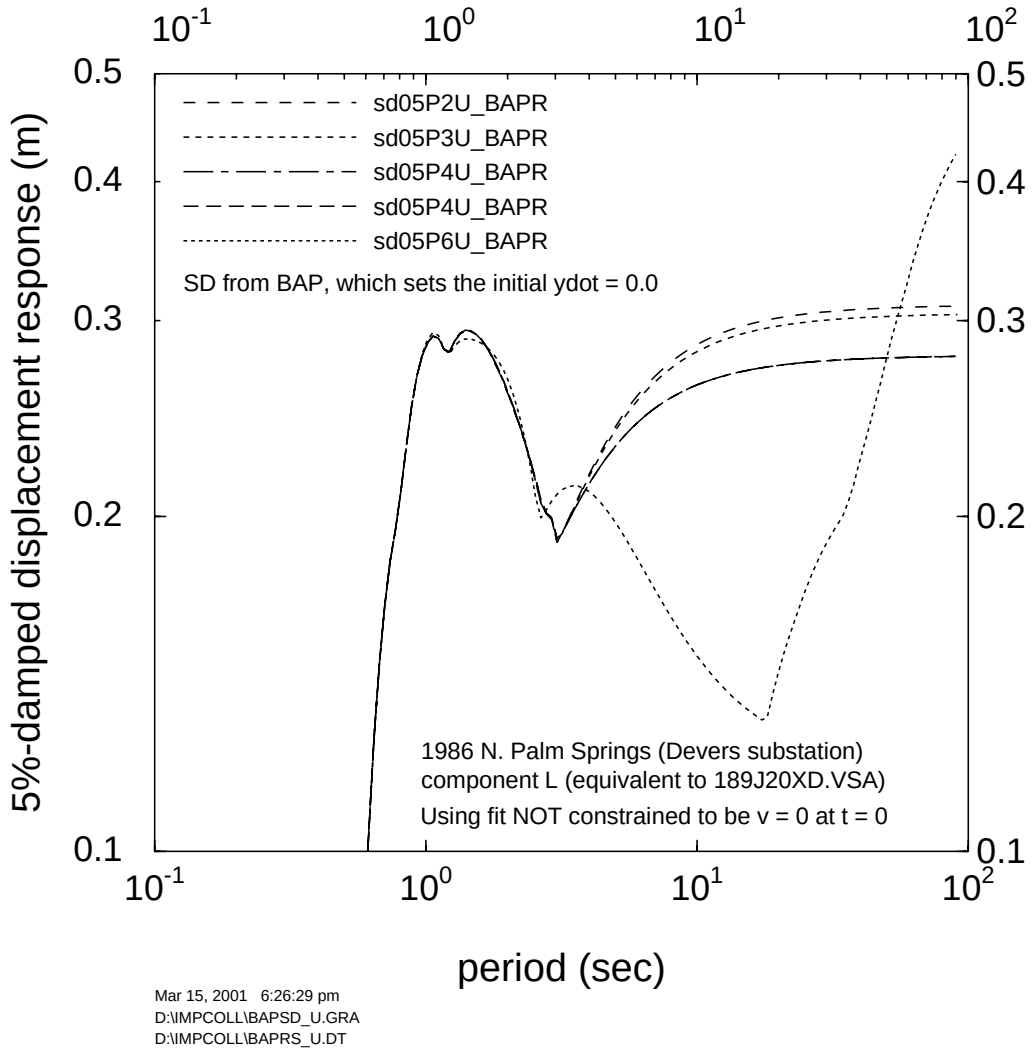

Figure 5. Relative displacement response spectrum for accelerograms processed using various polynomials fit to the velocity trace. The spectra were computed using a double-precision subroutine.