

# Appendix 2A                      SMSIM Parameter File for BS11 Attenuation Model

Here is a SMSIM parameter file for the BS11 attenuation model, Boore and Thompson [2015] finite-fault factor, and crustal amplifications for a site with  $V_{S30} = 3.0$  km/sec (some of the comment lines have been wrapped; each comment line starts with “!”). The parameter file for each of the attenuation models is given in a zip file under the entry for this report on the online publications page of [www.daveboore.com](http://www.daveboore.com).

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!Revision of program involving a change in the parameter file on this date:
  12/18/14
!Title:
  Boatwright and Seekins (2011) attenuation model)
!rho, beta, prttn, radpat, fs:
  2.8 3.7 0.707 0.55 2.0
!spectral shape: source number, pf_a, pd_a, pf_b, pd_b
! where source number means:
! 1 = 1-corner (S = 1/(1+(f/fc)**pf_a)**pd_a)
! 2 = Joyner (BSSA 74, 1167--1188)
! 3 = Atkinson (BSSA 83, 1778--1798; see also Atkinson & Boore, BSSA 85,
!   17--30)
! 4 = Atkinson & Silva (BSSA 87, 97--113)
! 5 = Haddon 1996 (approximate spectra in Fig. 10 of
!   Haddon's paper in BSSA 86, 1300--1313;
!   see also Atkinson & Boore, BSSA 88, 917--934)
! 6 = AB98-California (Atkinson & Boore BSSA 88, 917--934)
! 7 = Boatwright & Choy (this is the functional form used by
!   Boore & Atkinson, BSSA 79, 1736--1761, p. 1761)
! 8 = Joyner (his ENA two-corner model, done for the SSHAC elicitation
!   workshop)
! 9 = Atkinson & Silva (BSSA 90, 255--274)
! 10 = Atkinson (2005 model),
! 11 = Generalized multiplicative two-corner model
!   (S = [1/(1+(f/fa)**pf_a)**pd_a]*[1/(1+(f/fb)**pf_b)**pd_b])
! 12 = Generalized additive two-corner model
!   (S = (1-eps)/(1+(f/fa)**pf_a)**pd_a) + eps/(1+(f/fb)**pf_b)**pd_b)
! NOTE: if M<M for eps = 1.0, the program uses eps = 1, and the source spectrum
only depends
!   on fb, which is equal to the corner frequency of the single-corner source model.
!   One warning: the source duration is given by a weighted average of 1/fa and
1/fb, as
!   specified below. For eps = 1.0 fa will be set equal to fc (the corner frequency
for the
!   single-corner frequency with the specified stress parameter). This will
probably result in a
!   a discontinuity in fa for eps = 1.0 and for eps slightly larger than 1.0. This
may affect the
!   computation of duration. Note that if the weights of 0.5 and 0.0 for 1/fa and
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1/fb used by Atkinson and Boore (1995)
! and Atkinson and Silva (2000) are specified, then the source duration for M
smaller than the M for eps = 1.0
! will be 0.5/fa, whereas it more logically should be 1/fc = 1/fa. This is a
general problem with
! the source duration of the two-corner model if the AB95 and AS00 weights are
used. Because
! M for eps =1.0 is usually small, the inconsistency will probably only arise for
small magnitudes,
! for which the source duration will be small compared to the path duration. But
the
! way to avoid an inconsistency in the source duration is to use weights of 0.5
and 0.5 for 1/fa and 1/fb, respectively.
! For large M, fb will usually be much larger than fa, and the
! source duration will be dominated by 0.5/fa. For this reason, I am revising my
recommendations
! for the source duration weights below.
! pf_a, pd_a, pf_b, pd_b are used for source numbers 1, 11, and 12, usually
! subject to these constraints for an omega-squared spectrum:
! source 1: pf_a*pd_a = 2
! source 11: pf_a*pd_a + pf_b*pd_b = 2
! source 12: pf_a*pd_a = pf_b*pd_b = 2
! The usual single-corner frequency model uses
! pf_a=2.0,pd_a=1.0; the Butterworth filter shape is given by
! pf_a=4.0,pd_a=0.5. pf_b and pd_b are only used by sources 11 and 12, but dummy
! values must be included for all sources.
  1 2.0 1.0 0.0 0.0
!spectral scaling:
! stressc, dlsdm, fbdfa, amagc, c1_fa, c2_fa, amagc4fa, c1_eps, c2_eps, amagc4eps
! stress=stressc*10.0**(dlsdm*(amag-amagc))
! fbdfa, amagc for Joyner model, usually 4.0, 7.0)
! c1_fa, c2_fa, amagc4fa: the coefficients relating log fa to M in
! sources 11 and 12, as given by the equation log fa = c1_fa + c2_fa*(M-amagc4fa).
! c1_eps, c2_eps, amagc4eps: the coefficients relating log eps to M in
! source 12, as given by the equation log eps = c1_eps + c2_eps*(M-amagc4eps).
! fb for sources 11 and 12 are given such that the high-frequency spectral level
! equals that for a single corner frequency model with a stress parameter
! given by stress=stressc*10.0**(dlsdm*(amag-amagc)).
! See Tables 2 and 3 in Boore (2003) for various source descriptions
! (Note: the parameters in the line below are not used for most of the
! sources, for which the spectrum is determined by fixed relations between
! corner frequency and seismic moment, but placeholders are still needed)
! For convenience for those using source 12, here are some of the coefficients for
! fa and eps from Table 3 in Boore (2003):
!
! Model      c1_fa c2_fa amagc4fa c1_eps c2_eps amagc4eps
! Atkinson and Boore (1995) M>=4.0 2.410 -0.533  0.0  2.520 -0.637  0.0
!           M< 4.0 2.678 -0.500  0.0  0.000 0.000  0.0
! Atkinson and Silva (2000) M>=2.4 2.181 -0.496  0.0  0.605 -0.255  0.0
!           M< 2.4 1.431 -0.500  -2.4  0.000 0.000  0.0
! 185.0 0.0 4.0 6.5 0.0 0.0 0.0 0.0 0.0 0.0
!
!finite_fault factor specification:
! iflag_f_ff, nlines, c1, c2, c3, c4, DeltaM (0 0 0 0 0 0 0 if a finite-fault factor
is not to be used)
!
! Distance for point-source calculation
! If iflag_f_ff = 1: rps = sqrt(r^2 + f_ff^2))
! If iflag_f_ff = 2: rps = r + f_ff
! Use rps in the calculations (this variable is called rmod in the code; it should be
changed to rps to
! reflect my current preferred terminology. I do not have time to do this now).
! Specification of the finite-fault factor h:
! If nlines = 1

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! log10(f_ff) = c1 + c2*amag
! If nlines = 2
! log10(f_ff) = c1 + c2*amag for amag<Mh
! log10(f_ff) = c3 + c4*amag for amag>=Mh
! where Mh is determined by the intersection of the two lines
! (this is computed in the program)
! If nlines = 3
! log10(f_ff) = c1 + c2*amag for amag<Mh-DeltaM/2
! log10(f_ff) = c3 + c4*amag for amag>=Mh+DeltaM/2
! log10(f_ff) given by a cubic in amag between the two lines (this
! produces a smooth transition over the magnitude range DeltaM
! *** NOTE: placeholders are needed for c3, c4, and DeltaM, even if not used.
!
! Published finite-fault factors
! Author applicable_region meaning_of_r iflag_f_ff nlines c1 c2 c3
c4
! Atkinson and Silva (2000) ACR r_rup 1 1 -0.0500 0.1500 0.0 0.0
! Toro (2002) SCR r_rup 2 1 -1.0506 0.2606 0.0 0.0
! Atkinson and Boore (2003) subduction r_rup 1 1 -2.1403 0.5070 0.0
0.0
! Yenier and Atkinson (2014) ACR r_rup 1 1 -1.7200 0.4300 0.0 0.0
! Yenier and Atkinson (2015) ACR r_rup 1 1 -0.4050 0.2350 0.0 0.0
! Yenier and Atkinson (2015), SCR r_rup 1 1 -0.5690 0.2350 0.0 0.0
! Boore (2014) ACR r_rup 1 2 -1.7200 0.4300 -0.405 0.2350
!
! Suggested modification for stable continental regions
! Assuming that all of the above the above relations except Toro (2002) and Atkinson
and Boore (2003)
! are for active crustal regions, and that h is proportional to fault radius, then -
0.1644 should be
! added to c1 (and c3 for Boore (2014) to adjust for the smaller fault size expected
for stable continental region
! earthquakes (this adjustment factor uses radius ~ stress^-1/3, and a stress of 88
bars for ACR (from
! my determination of what stress matches the Atkinson and Silva (2000) high-
frequency spectral level--
! see What_SCF_stress_param_is_consistent_with_the_AS00_source_model.pdf in the daves
notes page of
! www.daveboore.com) and 185 bars for SCR, from my inversion of 0.1 s and 0.2 s PSA
values for 8 ENA
! earthquakes, using the Boatwright and Seekins (2011) attenuation model and crustal
amps for a site with
! Vs30=2 km/s. This determination is part of ongoing work for the NGA-East project,
and will appear in a PEER report in 2015.
!
! 1 1 -0.0500 0.1500 0.0 0.0 0.0 ! ACR: AS00
! 1 2 -1.7200 0.4300 -0.405 0.2350 0.0 ! ACR: YA14&YA15, no smoothing
! 1 3 -1.7200 0.4300 -0.405 0.2350 2.0 ! ACR: BT15 (=YA14&YA15, smooth over 2
magnitude units)
! 1 1 -1.7200 0.4300 0.0 0.0 0.0 ! ACR: YA14
! 1 1 -0.4050 0.2350 0.0 0.0 0.0 ! ACR: YA15
!
! 1 1 -0.1576 0.1500 0.0 0.0 0.0 ! SCR: AS00
! 1 1 -1.8276 0.4300 0.0 0.0 0.0 ! SCR: YA14
! 1 1 -0.5126 0.2350 0.0 0.0 0.0 ! SCR: YA15
! 1 2 -1.8276 0.4300 -0.5126 0.2350 0.0 ! SCR: YA14&YA15, no smoothing
! 1 3 -1.8276 0.4300 -0.5126 0.2350 2.0 ! SCR: BT15 (=YA14&YA15, smooth over 2
magnitude units)
! 0 0 0.0 0.0 0.0 0.0 0.0 ! No f_ff
!
!Geometrical spreading option:
! 0 = use standard hinged line segments
! >0 = frequency-dependent spreading (numbers 1 through 3 were for development

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purposes;
! they were not intended for general use):
! 1 = Gail Atkinson's November 2011 proposed spreading for eastern North America
(ENA),
! with  $Q=500f^{0.5}$ , which must be specified below).
! 2 = Dave Boore's trial spreading #1 for ENA).
! 3 = Gail Atkinson's Sept, 2012 report "nga-e-r12_AttenShape.pdf". For this
! model,  $Q = 680f^{0.33}$ , and this must be specified below.
! 4 = Atkinson, G.M. and D.M. Boore (2014). The attenuation of Fourier amplitudes for
rock sites in eastern North America,
! Bull. Seismol. Soc. Am. 104, 513--528. For this
! model,  $Q = 525f^{0.45}$ , and this must be specified below.
0
!Parameters for the frequency dependent gsprd:
! option 2:
! r1_dmb_gsprd, pgsprd_r_le_r1_lf, pgsprd_r_le_r1_hf, pgsprd_r_gt_r1,
! ft1_dmb_gsprd, ft2_dmb_gsprd
! option 4:
! h4gsprad (a nominal value of focal depth; in a later version I will put this into
the control files for the SMSIN driver programs):
! (Placeholders are needed, but not used, even if the geometrical spreading option is
not 2 or 4)
! 60.0 -1.1 -1.3 -0.5 1.0 3.2 ! for option 2 this corresponds to  $1/r^{1.1}$  for  $f \leq 1$  Hz
and  $1/r^{1.3}$  for  $f > 3.2$  Hz,
! ! for  $r < 60$  km and  $1/r^{0.5}$  for all  $f$  beyond 60 km.
10.0 0.0 0.0 0.0 0.0 0.0
!gsprd: r_ref, nsegs, (r1ow(i), a_s, b_s, m_s(i)) (Usually set
! r_ref = 1.0 km)
! *** NOTE: these lines are needed even if option 1 or greater is chosen above---and
! there must be nsegs lines following the "nseg" specification, even if the
! geometrical spreading is not used because option 1 has been chosen.
1.0
2
1.0 -1.0 0.0 6.5
50.0 -0.5 0.0 6.5
!q: fr1, Qr1, s1, ft1, ft2, fr2, qr2, s2, c_q
1.0 410 0.50 1.0 1.0 1.0 410 0.50 3.5
!source duration: weights of 1/fa, 1/fb
! Previous to 03/25/13, I recommended that the weights for source 1 be 1.0 0.0, and
! for the Atkinson and colleagues 2-corner sources be 0.5 0.0. But since dursource is
always computed as  $w_{fa}/fa + w_{fb}/fb$ , and because
! fb is set equal to fa for source 1, even though fb is not used in spect_shape, using
weights of 0.5 and 0.5
! for source 1 will give the same answer as the previously recommended 1.0 0.0
weights. The advantage
! to using weights of 0.5 0.5 is that they are the same as I am now recommending for
the Atkinson and colleagues (and perhaps
! all) 2-corner models, for reasons discussed in the spectral shape, source 12
! section above. This is not what is used by Atkinson and colleagues; they use 0.5 0.0
for the weights
! (Atkinson and Boore (1995, p. 20) and Atkinson and Silva (2000, p. 259)).
0.5 0.5
!path duration: nknots, (rdur(i), dur(i), slope of last segment)
!! Used in AB06:
! 4
! 0.0 0.0
! 10.0 0.0
! 70.0 9.6
! 130.0 7.8
! 0.04
! BT14E (11jul14):
8
0.0 0.0

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15.0 2.6
35.0 17.5
50.0 25.1
125.0 25.1
200.0 28.5
392.0 46.0
600.0 69.1
0.111
!crustal amplification, from the source to the site (note that this can include
! local site amplification): namps, (famp(i), amp(i))
!! AB06:
! 5
! 0.5 1.0
! 1.0 1.13
! 2.0 1.22
! 5.0 1.36
! 10.0 1.41
! B14, BJ97, aoi=00
14
1.00E-03 1.000
7.83E-03 1.003
2.33E-02 1.010
4.00E-02 1.017
6.14E-02 1.026
1.08E-01 1.047
2.34E-01 1.069
3.45E-01 1.084
5.08E-01 1.101
1.09E+00 1.135
1.37E+00 1.143
1.69E+00 1.148
1.97E+00 1.150
2.42E+00 1.151
!site diminution parameters: fmax, kappa, dkappadmag, amagkref
! (NOTE: fmax=0.0 or kappa=0.0 => fmax or kappa are not used. I included this
! to prevent the inadvertent use of both fmax and kappa to control the diminution
! of high-frequency motion (it would be very unusual to use both parameters
! together. Also note that if do not want to use kappa, dkappadmag must also
! be set to 0.0).
0.0 0.006 0.0 6.0
!low-cut filter parameters: fcut, nslope (=4, 8, 12, etc)
0.0 8
!rv params: zup, eps_int (integration accuracy), amp_cutoff (for fup), osc_crrctn(0=no
correction;
! 1=BJ84;2=LP99; 3=BT Drms/Dex, file 1; 4=BT Drms/Dex, file 2; 5=average of BT file 1
& file 2)
10.0 0.00001 0.001 4
!Names of pars files for Boore-Thompson Drms/Dex oscillator adjustment for RV
simulations.
! Note that these adjustments are for a particular rms-to-peak factor. Most recently
we use the
! Der Kiureghian (1980) (DK) factor, but the RV program tmrs_loop_rv_drvr writes out
the results using
! both the DK factor and the earlier default factor from Cartwright and Longuet-
Higgins. The pars files
! are definitely dependent on which rms-to-peak factor was used. I could specify
which peak factor
! to use in the RV programs, but for now, I prefer to write out the results using
both.
!
!NOTE: If no folder is specified, the program will look for the files in
! the folder from which the driver is called).
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!File names are required as placeholders, even if they are not used (e.g., for TD
simulations
! or for RV simulations for which osc_crrctn < 3).
!
!Name of pars file 1:
! The file below used the Raoof et al. (BSSA 1999, 888-902) attenuation model for WNA:
! If this file is used for random-vibration simulations, use the output based on the
! Der Kiureghian (1980) rms-to-peak factor (e.g., output columns from tmrs_loop-
rv_drvr
! with "dk80" as part of the column name). See Boore and Thompson (2015, BSSA, in
press) for details.
    \smsim\bt15_wna_acr_trms4osc.dk_rms2pk.pars
!Name of pars file 2:
! The file below used the Boatwright and Seekins (BSSA 2011, 1769-1782; BS11)
attenuation model for ENA:
! If this file is used for random-vibration simulations, use the output based on the
! Der Kiureghian (1980) rms-to-peak factor (e.g., output columns from tmrs_loop-
rv_drvr
! with "dk80" as part of the column name). See Boore and Thompson (2015, BSSA, in
press) for details.
    \smsim\bt15_ena_scr_trms4osc.dk_rms2pk.pars
!window params: idxwnd(0=box,1=exp), tapr(<1), eps_w, eta_w, f_tb2te, f_te_xtnd
    1 0.05 0.2 0.05 2.12 1.0
!timing stuff: dur_fctr, dt, tshift, seed, nsims, iran_type (0=normal;1=uniform)
    1.3 0.001 50.0 123.0 800 0

```