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Title: "A Proposal in Support of the St. Louis Area Earthquake Hazards Mapping Project: Suite of CEUS-Specific Hard-Rock Time-Histories and Seismic Hazard Model Updates"

Chris H. Cramer

Center for Earthquake Research and Information

University of Memphis

3890 Central Ave

Memphis, TN 38152-3050

901-678-4992

FAX: 901-678-4734

cramer@ceri.memphis.edu

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Summary

The St. Louis Area Earthquake Hazards Mapping Project (SLAEHMP) is a multi-year, multi-contributor project to develop seismic hazard maps for the greater St. Louis area that include the effects of local geology. As part of this effort, both a suite of central and eastern US (CEUS) specific hard-rock time-histories (seismograms) and an updated seismic hazard model based on the 2008 update to the national seismic hazard model are needed for the successful completion of these state-of-the-art regional hazard maps. The development of this suite of time-histories for the St. Louis area and the updating of computer codes used in the St. Louis project was accomplished under this grant. The updated computer codes were used to rerun the three pilot quadrangles of SLAEHMP and comparisons were made with the 2007 versions created using the 2002 national seismic hazard model. Generally, because the ground motion attenuation relations used in the 2008 national model lowered the 2%-in-50-year hazard ground motions by 10-20% relative to the 2002 national model, the new SLAEHMP pilot quadrangle 2%-in-50-year ground motions were also lowered over the older model results. For peak ground acceleration (PGA), overall ground motion levels are reduced by 15-20% using the new 2008 hazard model. For 0.2 s spectral acceleration (Sa), the loess/till covered uplands and the alluvial river bottom ground motions are reduced only by 10% or less compared to the 2007 maps due to less nonlinear deamplification from the reduced input ground motions. For 1.0 s Sa there is little change in ground motion levels between the old and new versions of the national maps and the urban hazard maps. Appropriate suites of time-histories for M5, M6, and M7 earthquakes from within eastern North America (ENA), outside ENA, ENA synthetics, and spectrally matched time-histories have been developed for use by SLAEHMP. Comparisons were made using site amplification distributions calculated for different groups of time-histories using common St. Louis reference soil profiles (alluvium and loess/till) including dynamic soil properties. Because soil response is not particularly sensitive to phase arrivals, site response distributions are less sensitive to the group of time-histories used at the 95% confidence level. There is some shape difference in the M7 site response distributions from the M5 and M6 site response distributions at the 95% confidence level, particularly at lower levels of input ground motion. This suggests the resulting urban seismic hazard maps may show some sensitivity to whether the hazard analysis uses magnitude specific site amplification distributions for M5, M6, and M7 earthquakes or just one M7 site amplification distribution for all earthquakes as is currently done.

Seismic Hazard Model Update

In 2008, the U.S. Geological Survey (USGS) released an update to its National Seismic Hazard Model (Petersen et al., 2008). Changes affecting the St. Louis area included changes to the New Madrid seismic zone model (increased number of alternative faults and a characteristic earthquake clustering model) and updates to the ground motion attenuation relations used in the hazard calculations. Generally, the 2008 model reduced ground motions by 10-20% from the 2002 model, mainly due to the attenuation relation updates.

The USGS provided the updated national seismic hazard computer codes via its website (http://earthquake.usgs.gov/research/hazmaps/products_data/2008/software/). These computer codes were downloaded and implemented on the CERI computer system. They formed the basis for updating the Memphis urban seismic hazard mapping project computer programs (Cramer et al., 2004, 2006) used in generating the SLAEHMP urban seismic hazard maps. These urban hazard mapping codes were modified to access the new 2008 computer codes instead of the older 2002 USGS computer codes. The urban seismic hazard computer codes use the approach of Cramer (2003, 2005) to incorporate the effects of local geology and soils in a completely probabilistic manner. As a quality assurance measure, test runs were made with the unmodified and modified codes using hard rock conditions and with the modified code including a site amplification distribution. The results of the test runs were checked to confirm the proper functioning of the modifications.

Three applications of the modified urban hazard mapping computer codes have been accomplished. First, the computer codes were shared with Jennifer Haase of Purdue University and were used in finalizing the urban hazard maps for Evansville, IN (Jennifer Haase, February 2009, written communication). Second, at the request of the USGS and CUSEC (Mark Petersen, May 2008, telephone call; Bob Bauer, June 2008, telephone call), I generated New Madrid seismic zone M7.7 scenarios with updated geology from CUSEC (Bob Bauer, June 2008, written communication) for the FEMA Catastrophic Planning project at the Mid-America Earthquake Center (phase 2). PGA, PGV, and 0.2 s, 0.3 s, and 1.0 s Sa files of grid-values were provided in June 2008 and are available via Chris Cramer (ccramer@memphis.edu, 901-678-4992).

The third application of the modified urban hazard mapping computer codes was to update the SLAEHMP pilot probabilistic urban hazard maps originally generated using the 2002 USGS seismic hazard model. Karadeniz (2007) generated the original probabilistic maps for the three pilot quadrangles covering parts of St. Louis and East St. Louis in Missouri and Illinois across the Mississippi River. Deniz Karadeniz (November, 2008, written communication) provided the input grid-files of site amplification distributions used to generate the 2007 hazard maps. These files were input to the updated urban hazard mapping codes to generate probabilistic urban hazard maps using the 2008 USGS national seismic hazard model. For quality assurance purposes, the input files were rerun using the 2002 model and compared to the results in Karadeniz (2007).

Comparison of Pilot Quad Results

In this section I present a comparison of 2007 and 2008 SLAEHMP pilot quadrangle results using the 2002 and 2008 USGS national seismic hazard models, respectively. The comparison is made for PGA, 0.2 s Sa, and 1.0 s Sa. As part of this comparison the three pilot quadrangles are shown within their respective 2002 or 2008 national seismic hazard maps (Frankel et al., 2002; Petersen et al., 2008) for B/C boundary (760 m/s Vs30) soil conditions. The national seismic hazard maps generally show a 10-20% reduction in ground motions between 2002 and 2008.

Figures 1 and 2 show the 2007 and 2008 SLAEHMP PGA 2%-in-50-year hazard maps embedded in their respective national seismic hazard map. Some contours have been labeled for ease of making comparisons. The location of the center of the Mississippi and Missouri Rivers are shown in the figures. In Figure 1, the regions of higher ground motion west of the Mississippi and along the east edge of the lower two quadrangles are from the loess/till uplands with thin soil cover. The remaining parts of the study area are the alluvial lowland flood plains of the Mississippi and Missouri Rivers. The reduction in PGA estimates from the 2007 to 2008 pilot maps (2002 to 2008 USGS hazard model) is 15-25% with the uplands showing similar reductions as the softer soils of the lowlands.

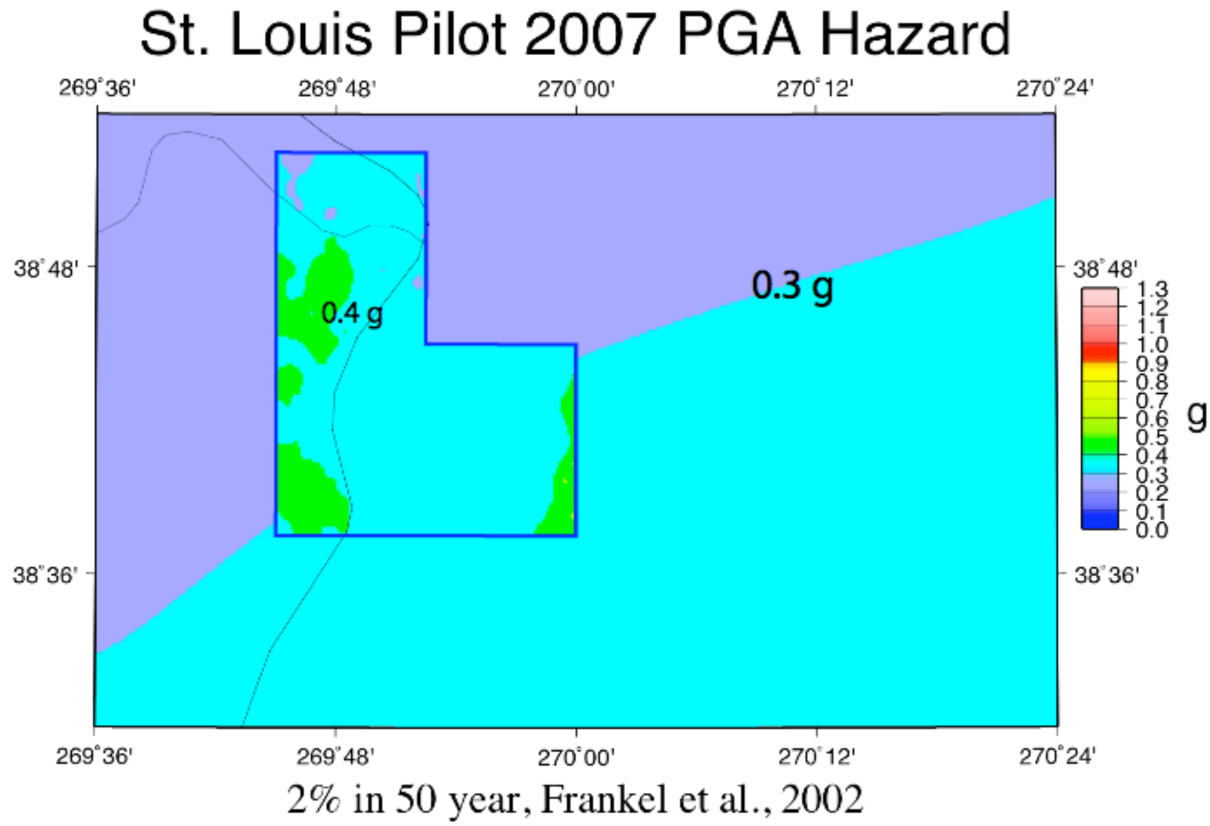


Figure 1: 2007 SLAEHMP and 2002 national seismic hazard maps for 2%-in-50-year PGA hazard.

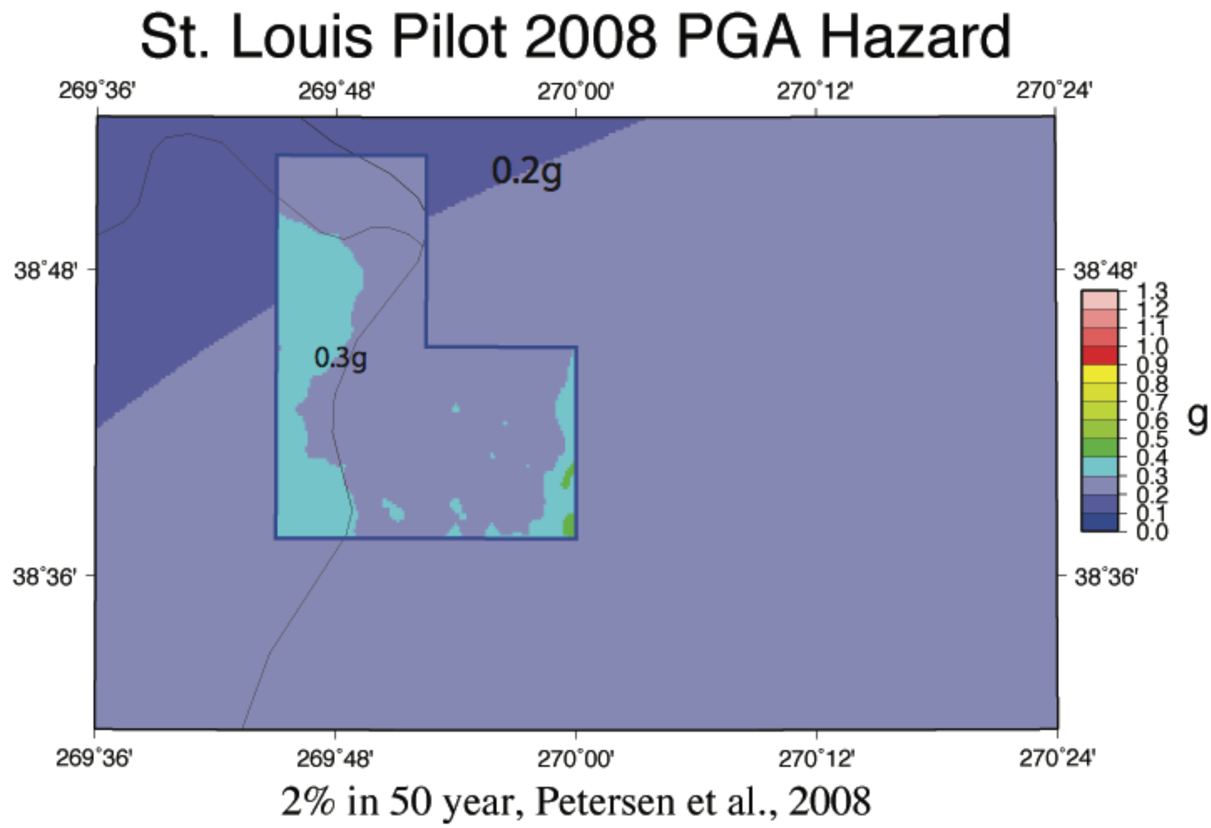


Figure 2: 2008 SLAEHMP and national seismic hazard maps for 2%-in-50-year PGA hazard.

Figures 3 and 4 show the 0.2 s Sa versions of Figures 1 and 2. The reduction in ground motion for 0.2 s Sa from the 2007 to 2008 urban hazard maps is 10% or less, compared to the PGA ground motion reductions of 15-20%. The reduction in input hard rock ground motions by the changes from the 2002 to 2008 national model reduce the nonlinear soil response of the alluvium allowing more relative amplification of the 0.2 s Sa ground motions and a reduced nonlinear effect. Thus the 0.2 s Sa lowlands hazard is not reduced as much by the 2008 national model changes and remains high.

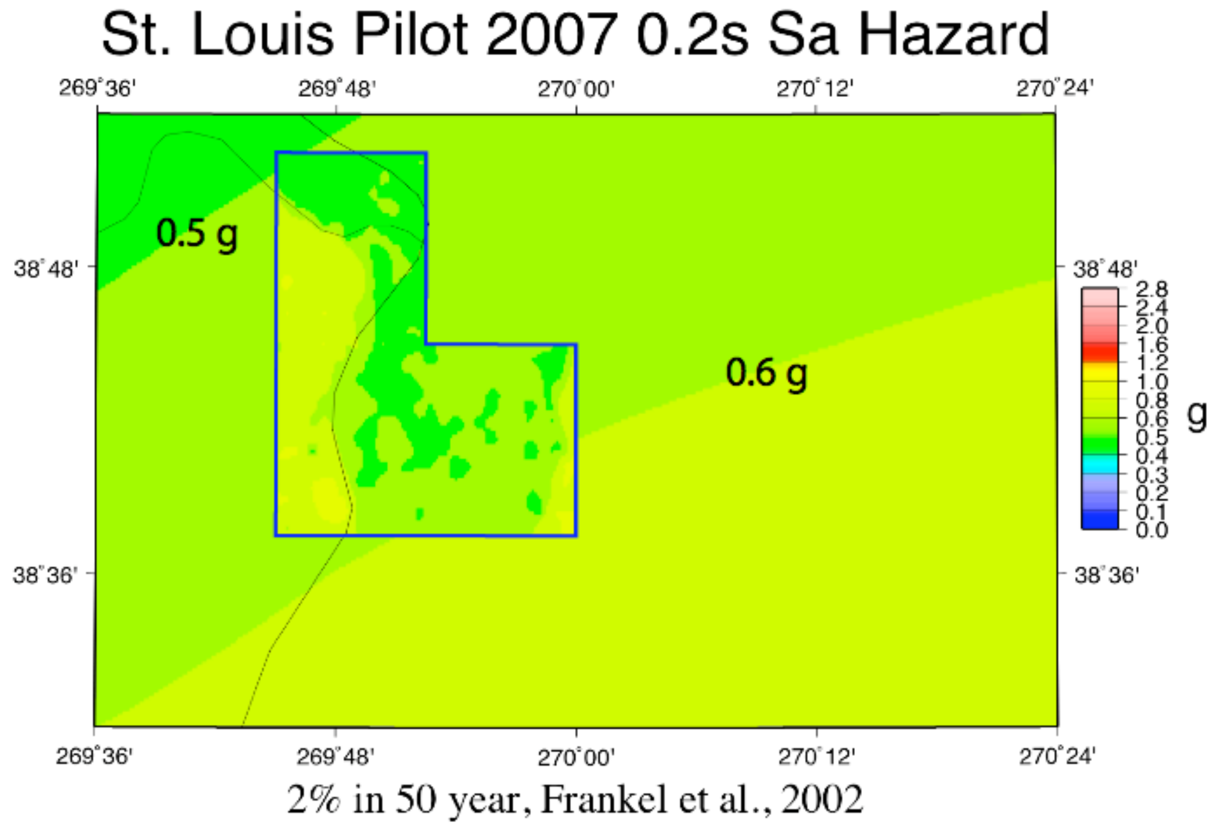


Figure 3: 2007 SLAEHMP and 2002 national seismic hazard maps for 2%-in-50-year 0.2 s hazard.

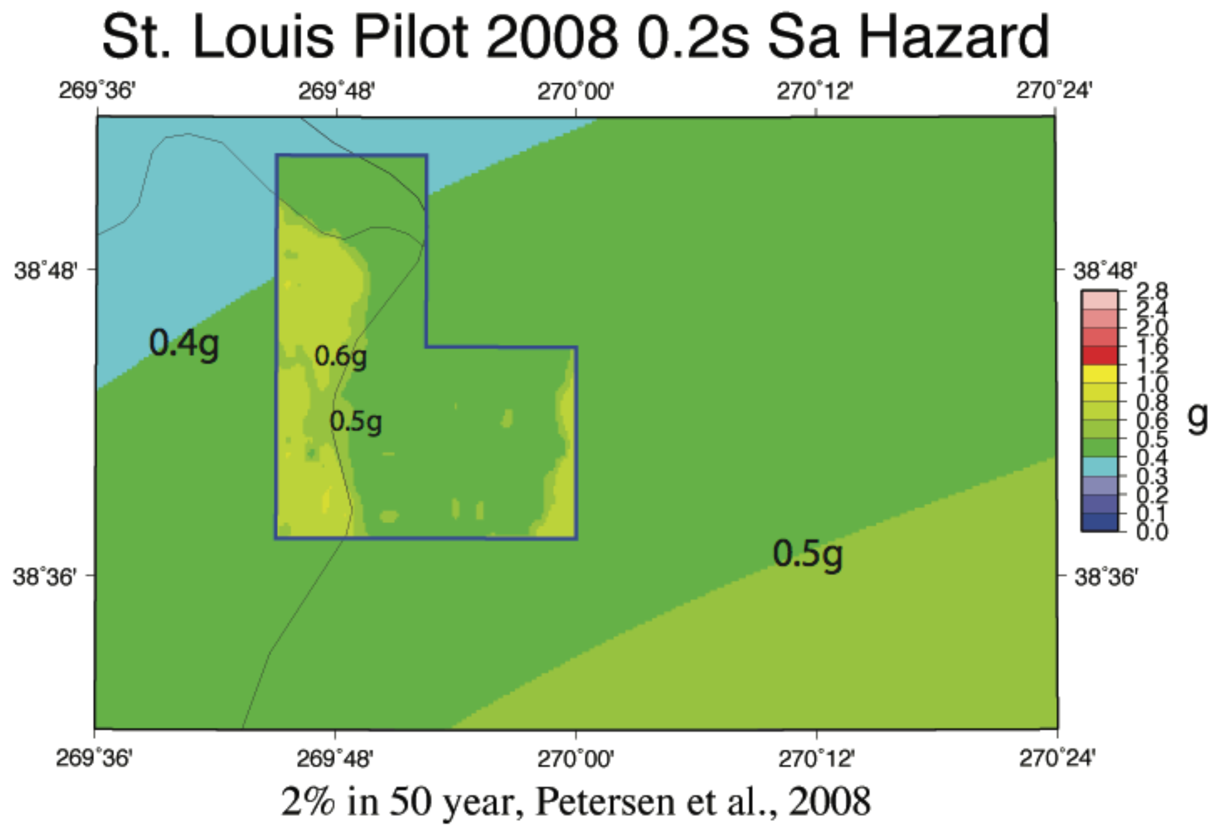


Figure 4: 2008 SLAEHMP and national seismic hazard maps for 2%-in-50-year 0.2 s hazard.

Figures 5 and 6 show the 1.0 s Sa versions of Figures 1 and 2. There is only a slight reduction in the 1.0 s Sa hazard from the 2007 to 2008 urban hazard maps.

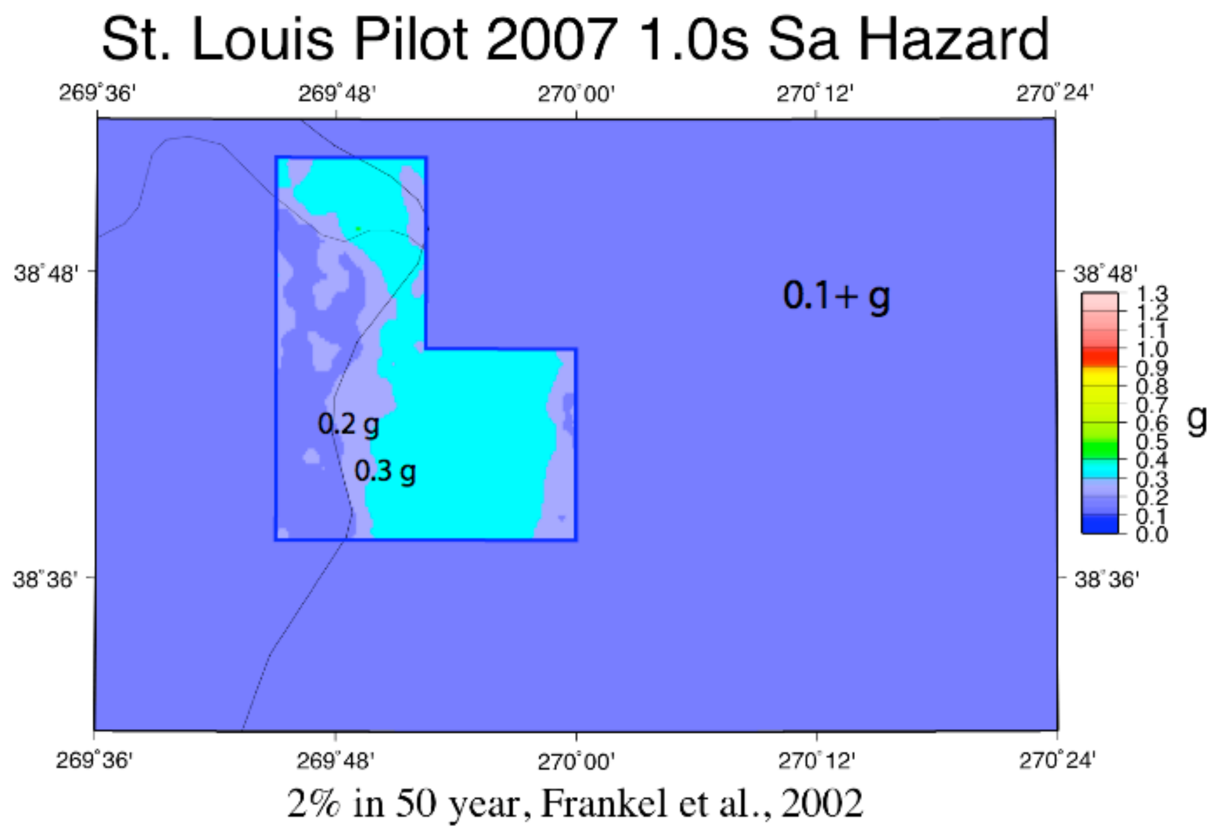


Figure 5: 2007 SLAEHMP and 2002 national seismic hazard maps for 2%-in-50-year 1.0 s hazard.

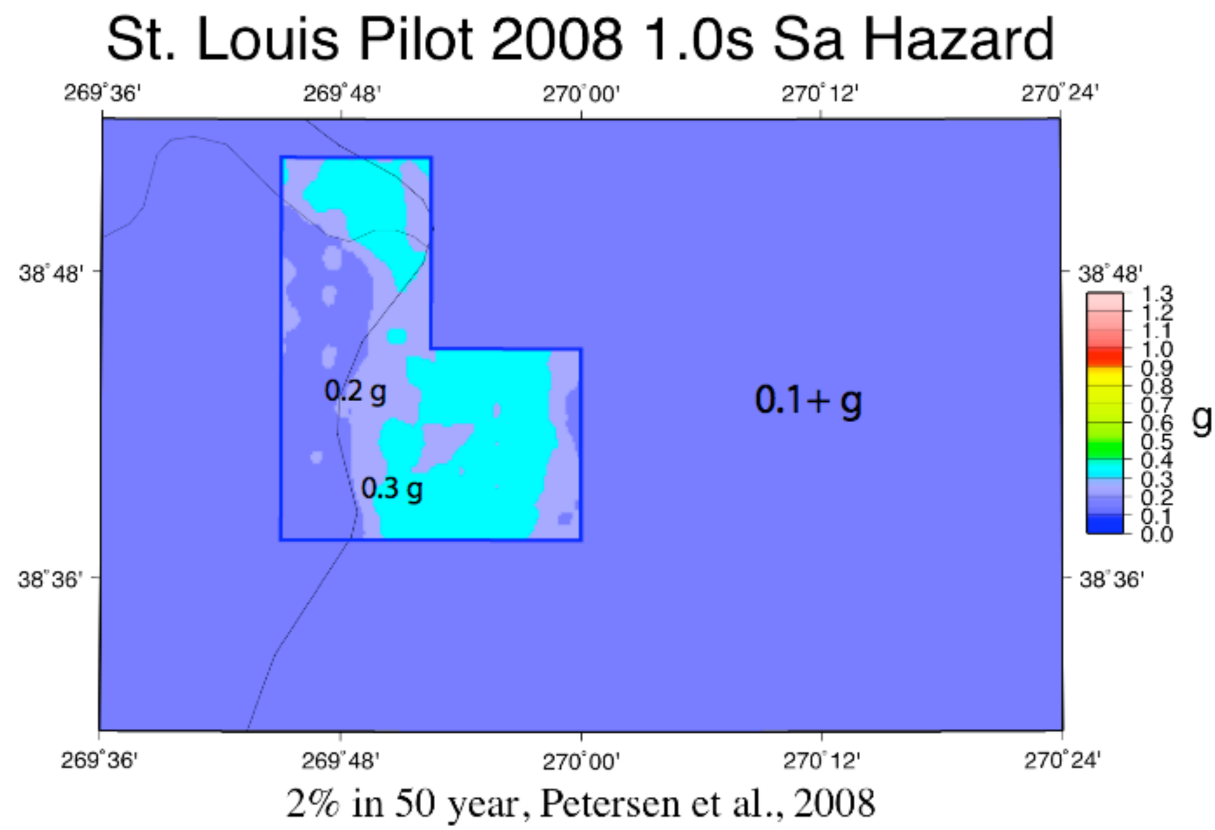
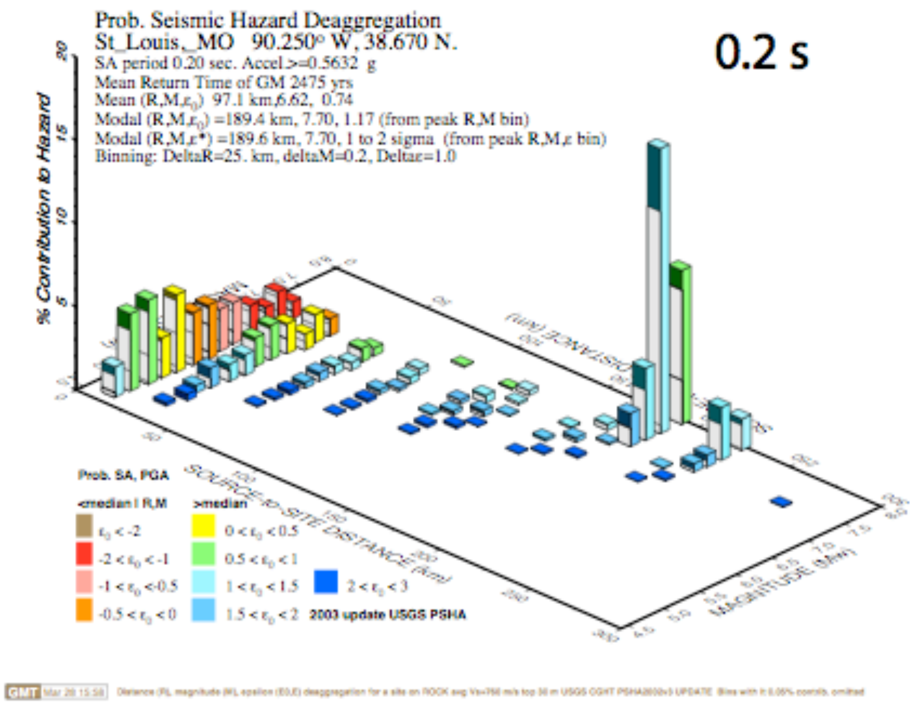


Figure 6: 2008 SLAEHMP and national seismic hazard maps for 2%-in-50-year 1.0 s hazard.

St. Louis Time-History Database

The selection of time-histories for use in a project at a specific location depends on an understanding of the distribution of magnitudes with distance that are important to seismic hazard at a site. Deaggregation of ground motion hazard (Stepp et al., 1993; Chapman, 1995; Boissonnade et al., 1995; McGuire, 1995) provides the best means of identifying the magnitudes and distances of importance to seismic hazard. Figure 7 shows the deaggregation for St. Louis at the 2%-in-50-year hazard level from the 2002 USGS national seismic hazard maps. The deaggregations from the 2008 USGS seismic hazard model are similar, but were not yet available in 2007 when this project was started. We see from the deaggregation plots in Figure 7 that M7 events at a distance of about 200 km (New Madrid seismic zone) are a major contributor. M5 and M6 earthquakes at distances less than 50 km are the other important contributor to seismic hazard in St. Louis, particularly at shorter periods. Consequently, the focus for a St. Louis area time-history database are M5 and M6 records at distances less than 50 km and M7 records at distances around 200 km.



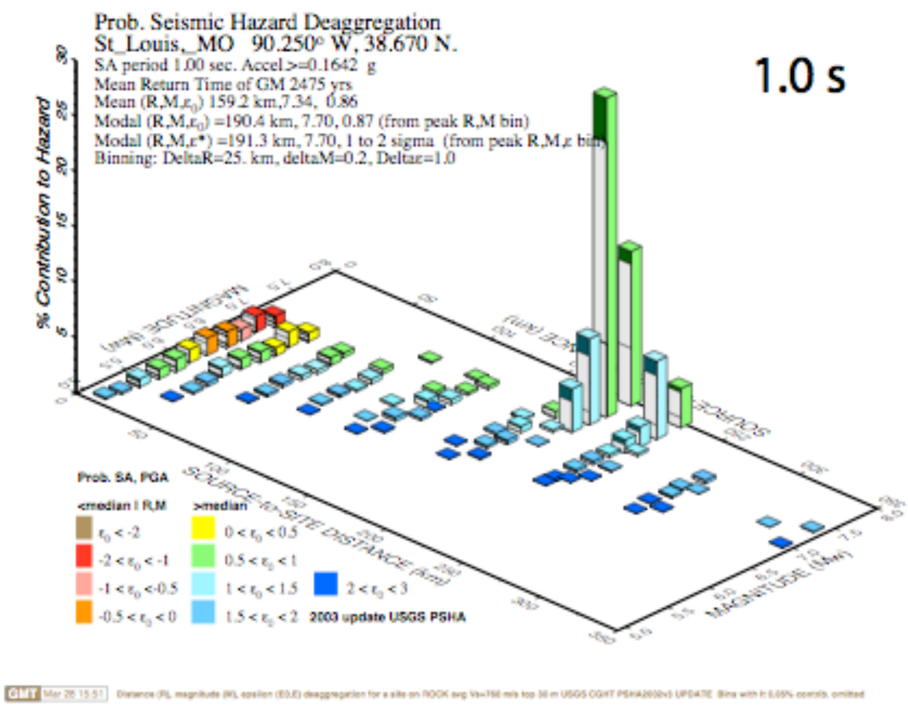


Figure 7: St. Louis, MO deaggregtions from USGS website at 0.2 and 1.0 s (5 and 1 Hz) for 2% in 50 year hazard.

Ideally, time histories from actual earthquakes in the region should be used in soil response analyses provided there are sufficient numbers of records in each magnitude and distance range to yield the input record variability representative of the region. This ideal currently cannot be achieved in eastern North America (ENA) as there are few records, particularly for distances less than 100 km, and there are no records from earthquakes with magnitudes greater than 6. So time histories from within ENA have to be supplemented by time histories from outside ENA, ENA synthetic time histories, and spectrally matched time histories appropriate for ENA.

Time histories were collected from all four groups of time history data sources. Three ENA earthquakes provided time histories for the St. Louis database: the 1988 M5.8 Saguenay, the 2005 M5.0 Riviere du Loup, and the M5.2 (NEIC M5.4) Mt. Carmel earthquakes. The Saguenay time histories came from the NCEER Strong Motion database (http://www.ldeo.columbia.edu/res/data/nceer/strongmo) and were carefully selected to avoid known source effects (radiation pattern and directivity) associated with some time histories for that event. The Riviere du Loup and Mt. Carmel time histories came from a new NGA East database (Cramer, 2007) being assembled from original time history sources (IRIS Data Center, Canadian National Data Center, CERI, and St. Louis University).

The use of time histories from outside a study region is common practice, but in the case of St. Louis involves the selection of active tectonic region records for use in a stable continental tectonic environment. Selected records were taken from the Pacific Earthquake Engineering Research (PEER) Center's Strong Motion Database (http://peer.berkeley.edu/smcat/search.html) and NGA Database (http://peer.berkeley.edu/nga/). Regional differences in attenuation might effect results, particularly at larger distances from the event.

Synthetic time histories generated for a specific region are also commonly used in practice. For this study, synthetic ENA time histories were generated using SMSIM (Boore, 1996, 2000) and supplemented with FINSIM (Beresnev and Atkinson, 1998) time histories for St. Louis from New Madrid M7.5 and M8.0 events (Atkinson and Beresnev, 2002). The SMSIM time histories that were generated used the ENA ground motion model of Atkinson and Boore (1995) and are for M 5.2, 5.5, 5.8, 6.2, 6.5, and 6.8 events at distances from 10 to 50 km at 10 km increments plus M7.2, 7.5, and 7.8 events at distances from 150 to 200 km at 10 km increments.

For this study, I added spectrally modified time histories as an additional source for time histories. The target spectra were SMSIM spectra using the Atkinson and Boore (1995) model for the original record's magnitude and distance. The spectral modifications were accomplished using Norm Abrahamson's spectral matching computer code RSPMATCH (2005, written communication). Many spectrally matched time histories use appropriate non-ENA records, but a few use ENA records from non-hard-rock soil conditions and convert them to hard-rock time histories.

For ENA where high-frequency content is important, care must be taken to select time histories with good high-frequency signal-to-noise ratios. Generally, a minimum high-frequency cutoff of 25 Hz is needed. For spectral matching, this is an important criterion for avoiding the amplification and introduction of high-frequency random noise to the final time history.

Table 1 lists the time histories in the database. The database is divided into four types of time histories: ENA, non-ENA, synthetic, and spectrally matched. Under many of the types several distance ranges are provided for applicability throughout ENA. Information provided includes event, magnitude, station and component, distance, filter cutoffs, samples per second, and some geology or NEHRP site class and additional information. Unless otherwise specified, original time histories are from rock sites with NEHRP site class A or B. Synthetic and spectrally matched time histories are for hard rock site conditions. Copies of the time histories (PEER ascii and SAC format) in the database are available by contacting Chris Cramer (ccramer@memphis.edu, 901-678-4992).

Table 1: Table of Time History Events

Event	M	Stn.cmp	Dist.	Filter (Hz)		Comment	
			(km)	Low	High	sps	geol
ENA Earthquakes:							
0-50 km:							
MtCarmel	5.2	NM.OLIL.HLE	36	.06	32	100	C
MtCarmel	5.2	NM.OLIL.HLN	36	.06	39	100	C
RiviereDuLoup	5.0	CN.A16.HHE	37	.17	46	100	A
RiviereDuLoup	5.0	CN.A16.HHN	37	.11	46	100	A
Saguenay	5.8	C016124	43	.7	70	200	A
Saguenay	5.8	C016214	43	.7	70	200	A
50-100 km:							
MtCarmel	5.2	NM.USIN.HHE	57	.10	44	100	C
MtCarmel	5.2	NM.USIN.HHN	57	.10	43	100	C
RiviereDuLoup	5.0	CN.A11.HHE	66	.11	45	100	A?
RiviereDuLoup	5.0	CN.A11.HHN	66	.11	45	100	A?
RiviereDuLoup	5.0	CN.A54.HHE	60	.12	45	100	A?
RiviereDuLoup	5.0	CN.A54.HHN	60	.11	46	100	A?
Saguenay	5.8	C017000	64	.7	70	200	A
Saguenay	5.8	C017270	64	.7	70	200	A
100-150 km:							
MtCarmel	5.2	NM.BLO.HHE	143	.10	28	80	Rock
MtCarmel	5.2	NM.BLO.HHN	143	.10	30	80	Rock
Saguenay	5.8	C001000	114	.5	70	200	A
Saguenay	5.8	C001270	114	.5	70	200	A
150-200 km:							
MtCarmel	5.2	NM.EDIL.HNE	184	.19	23	50	
MtCarmel	5.2	NM.EDIL.HNN	184	.14	22	50	
Saguenay	5.8	DCKY000	195	.015	50	200	A antinodal
Saguenay	5.8	DCKY090	195	.015	50	200	A antinodal

200-250 km:

MtCarmel	5.2	NM.HICK.HHE	243	.05	45	100
MtCarmel	5.2	NM.HICK.HHN	243	.081	44	100
MtCarmel	5.2	NM.SLM.HHE	206	.05	33	80
MtCarmel	5.2	NM.SLM.HHN	206	.05	32	80

250-300 km:

MtCarmel	5.2	NM.LNXT.HHE	297	.10	22	100
MtCarmel	5.2	NM.LNXT.HHN	297	.16	22	100
MtCarmel	5.2	NM.PARM.HHE	258	.05	45	100
MtCarmel	5.2	NM.PARM.HHN	258	.05	45	100
MtCarmel	5.2	NM.PBMO.HHE	291	.05	33	80
MtCarmel	5.2	NM.PBMO.HHN	291	.05	33	80
MtCarmel	5.2	NM.PENM.HHE	270	.05	45	100
MtCarmel	5.2	NM.PENM.HHN	270	.05	45	100

Non-ENA Earthquakes:

0-50 km:

CapeMendocino	7.1	CPM000	10	.07	23	50	Rock
CapeMendocino	7.1	CPM090	10	.07	23	50	Rock
ChiChi	7.6	HWA056n	41	.03	50	200	
ChiChi	7.6	HWA056w	41	.03	50	200	
ChiChi	7.6	TCU000	17	.06	30	200	
ChiChi	7.6	TCU270	17	.03	30	200	
ChiChiAfter	5.9	TCU071e	21	.4	50	200	
ChiChiAfter	5.9	TCU071n	21	.4	50	200	
CoyoteLake	5.7	G01230a	11	.3	40	200	
CoyoteLake	5.7	G01320a	11	.25	40	200	
Denali	7.9	5595e	51	.04	30	100	B
Denali	7.9	5595n	51	.04	30	100	B
Denali	7.9	5596e	48	.05	40	100	B
Denali	7.9	5596n	48	.05	40	100	B
Duzce	7.1	1060-E	26	.06	50	100	B
Duzce	7.1	1060-N	26	.06	50	100	B
FrioliAfter	5.9	B-SRO000	15	.1	32	200	B
FrioliAfter	5.9	B-SRO270	15	.1	32	200	B
HectorMine	7.1	22161090	42	.07	46?	50	A
HectorMine	7.1	22161360	42	.07	46?	50	A
HectorMine	7.1	HEC000	12	.02	53	100	B
HectorMine	7.1	HEC090	12	.02	53	100	B
Kobe	6.9	KAK000	23	.1	50	100	D
Kobe	6.9	KAK090	23	.1	50	100	D
Kobe	6.9	KJM000	1	.05	25	50	B
Kobe	6.9	KJM090	1	.05	25	50	B

Kobe	6.9	NIS000	7	.1	23	100	C
Kobe	6.9	NIS090	7	.1	23	100	C
Kobe	6.9	OSA000	21	.05	25	50	D
Kobe	6.9	OSA090	21	.05	25	50	D
Kobe	6.9	SHI000	19	.1	23	100	D
Kobe	6.9	SHI090	19	.08	23	100	D
Kobe	6.9	TAK000	1	.05	50	100	D
Kobe	6.9	TAK090	1	.05	50	100	D
Kobe	6.9	TAZ000	0	.05	40	100	D
Kobe	6.9	TAZ090	0	.13	33	100	D
Kocaeli	7.4	GBZ000	11	.03	25	200	
Kocaeli	7.4	GBZ270	11	.08	30	200	
Kocaeli	7.4	IZT090	7	.1	30	200	
Kocaeli	7.4	IZT180	7	.1	30	200	
LomaPrieta	6.9	G01000	10	.2	50	200	
LomaPrieta	6.9	G01090	10	.2	50	200	
LomaPrieta	6.9	SGI270	30	.1	32	200	
LomaPrieta	6.9	SGI360	30	.1	31	200	
MammothLkAftr	5.7	J-LUL000	17	.5	40	200	
MammothLkAftr	5.7	J-LUL090	17	.5	30	200	
MorganHill	6.2	G01230	15	.1	29	200	
MorganHill	6.2	G01320	15	.1	40	200	
Landers	7.3	JOS000	11	.07	23	50	
Landers	7.3	JOS090	11	.07	23	50	
Landers	7.3	LCN000	2	.08	60	200	
Landers	7.3	LCN275	2	.08	50	200	
LittleSkullMtn	5.7	LSM2000	25	.1	33	200	B
LittleSkullMtn	5.7	LSM2270	25	.1	33	200	B
NPalmSprings	6.1	WWT180	6	.1	40	200	
NPalmSprings	6.1	WWT270	6	.5	45	200	
Northridge	6.7	L09000	25	.08	25	50	
Northridge	6.7	L09090	25	.08	25	50	
Northridge	6.7	LIT090	47	.2	46	100	
Northridge	6.7	LIT180	47	.2	46	100	
Northridge	6.7	MTW000	36	.08	25	50	
Northridge	6.7	MTW090	36	.08	25	50	
Northridge	6.7	SAN090	42	.12	46	100	
Northridge	6.7	SAN180	42	.12	46	100	
SierraMadre	5.6	mtwin000	10	.5	23	50	B
SierraMadre	5.6	mtwin090	10	.5	23	50	B
WhittierNarrows	6.0	A-GRN180	15	.35	25	50	
WhittierNarrows	6.0	A-GRN270	15	.35	25	50	

50-100 km:

ChiChi	7.6	HWA026n	52	.03	50	200
ChiChi	7.6	HWA026w	52	.02	50	200

ChiChi	7.6	ILA063n	61	.02	50	250	
ChiChi	7.6	ILA063w	61	.02	50	250	
ChiChi	7.6	TCU025n	53	.05	50	200	
ChiChi	7.6	TCU025w	53	.03	50	200	
Kobe	6.9	MZH000	70	.05	25	50	B
Kobe	6.9	MZH090	70	.05	25	50	B
Kobe	6.9	OKA000	87	.05	25	50	B
Kobe	6.9	OKA090	87	.05	25	50	B
Kocaeli	7.4	MSK000	55	.09	50	200	
Kocaeli	7.4	MSK090	55	.03	50	200	
Landers	7.3	ABY000	69	.1	23	50	
Landers	7.3	ABY090	69	.1	23	50	
Landers	7.3	SIL000	51	.12	23	50	
Landers	7.3	SIL090	51	.12	23	50	
LomaPrieta	6.9	RIN000	74	.2	41	200	
LomaPrieta	6.9	RIN090	74	.2	40	200	
Northridge	6.7	BAL090	71	.3	46	100	
Northridge	6.7	BAL180	71	.3	46	100	
Northridge	6.7	CUC090	80	.3	46	100	
Northridge	6.7	CUC180	80	.3	46	100	
Northridge	6.7	WWJ090	67	.24	46	100	
Northridge	6.7	WWJ180	67	.24	46	100	
NPalmSprings	6.1	H01000	55	.5	40	200	
NPalmSprings	6.1	H01090	55	.5	40	200	
NPalmSprings	6.1	H02000	49	.5	42	200	
NPalmSprings	6.1	H02090	49	.5	50	200	

100-150 km:

ChiChi	7.6	KAU078n	128	.02	50	200	
ChiChi	7.6	KAU078w	128	.02	50	200	
Kobe	6.9	TOT000	120	.05	25	50	B
Kobe	6.9	TOT090	120	.05	25	50	B
Landers	7.3	GRN180	142	.07	25	50	
Landers	7.3	GRN270	142	.13	25	50	

150-200 km:

ChiChi	7.6	KAU000	185	.03	15	200	
ChiChi	7.6	KAU270	185	.3	12	200	
Kobe	6.9	FUK000	159	.05	25	50	D
Kobe	6.9	FUK090	159	.05	25	50	D

Synthetic Time Histories (note that in the filename mxpx and mxx is MX.X and dyyy is distance YYY km):

0-50 km:

AtkBer2002/m7p5a.acc
AtkBer2002/m7p5b.acc
AtkBer2002/m7p5c.acc
AtkBer2002/m7p5d.acc
AtkBer2002/m7p5e.acc
AtkBer2002/m7p5f.acc
AtkBer2002/m8p0a.acc
AtkBer2002/m8p0b.acc
AtkBer2002/m8p0c.acc
AtkBer2002/m8p0d.acc
AtkBer2002/m8p0e.acc
AtkBer2002/m8p0f.acc
Smsim5/m52d010a.at2
Smsim5/m52d020a.at2
Smsim5/m52d030a.at2
Smsim5/m52d040a.at2
Smsim5/m52d050a.at2
Smsim5/m55d010a.at2
Smsim5/m55d020a.at2
Smsim5/m55d030a.at2
Smsim5/m55d040a.at2
Smsim5/m55d050a.at2
Smsim5/m58d010a.at2
Smsim5/m58d020a.at2
Smsim5/m58d030a.at2
Smsim5/m58d040a.at2
Smsim5/m58d050a.at2
Smsim6/m62d010a.at2
Smsim6/m62d020a.at2
Smsim6/m62d030a.at2
Smsim6/m62d040a.at2
Smsim6/m62d050a.at2
Smsim6/m65d010a.at2
Smsim6/m65d020a.at2
Smsim6/m65d030a.at2
Smsim6/m65d040a.at2
Smsim6/m65d050a.at2
Smsim6/m68d010a.at2
Smsim6/m68d020a.at2
Smsim6/m68d030a.at2
Smsim6/m68d040a.at2
Smsim6/m68d050a.at2

~200 km:

AtkBer2002/stlm7p5a.acc
AtkBer2002/stlm7p5b.acc
AtkBer2002/stlm7p5c.acc
AtkBer2002/stlm7p5d.acc
AtkBer2002/stlm7p5e.acc
AtkBer2002/stlm7p5f.acc
AtkBer2002/stlm8p0a.acc
AtkBer2002/stlm8p0b.acc
AtkBer2002/stlm8p0c.acc
AtkBer2002/stlm8p0d.acc
AtkBer2002/stlm8p0e.acc
AtkBer2002/stlm8p0f.acc
Smsim7/D150/m72d160a.at2
Smsim7/D150/m72d170a.at2
Smsim7/D150/m72d180a.at2
Smsim7/D150/m72d190a.at2
Smsim7/D150/m72d200a.at2
Smsim7/D150/m75d160a.at2
Smsim7/D150/m75d170a.at2
Smsim7/D150/m75d180a.at2
Smsim7/D150/m75d190a.at2
Smsim7/D150/m75d200a.at2
Smsim7/D150/m78d160a.at2
Smsim7/D150/m78d170a.at2
Smsim7/D150/m78d180a.at2
Smsim7/D150/m78d190a.at2
Smsim7/D150/m78d200a.at2

Spectrally Matched Time Histories (note that in the filename mxx is MX.X and dyyy is distance YYY km which is followed by the original time-history station name and component):

0-50 km:

Specmatch5/m52d036.olil.e.at2.scl
Specmatch5/m52d036.olil.n.at2.scl
Specmatch5/m59d021.tcu071.e.at2.scl
Specmatch5/m59d021.tcu071.n.at2.scl
Specmatch6/m67d042.san.e.at2.scl
Specmatch6/m67d042.san.s.at2.scl
Specmatch6/m67d047.lit.e.at2.scl
Specmatch6/m67d047.lit.s.at2.scl

50-100 km:

Specmatch5/D50/m52d057.usin.e.at2.scl
Specmatch5/D50/m52d057.usin.n.at2.scl
Specmatch5/D50/m58d064.c017000.n.at2.scl

Specmatch5/D50/m58d064.c017270.w.at2.scl
Specmatch6/D50/m60d064.c017000.n.at2.scl
Specmatch6/D50/m60d064.c017270.w.at2.scl
Specmatch6/D50/m61d049.h02.e.at2.scl
Specmatch6/D50/m61d049.h02.n.at2.scl
Specmatch6/D50/m61d055.h01.e.at2.scl
Specmatch6/D50/m61d055.h01.n.at2.scl
Specmatch6/D50/m65d064.c017000.n.at2.scl
Specmatch6/D50/m65d064.c017270.w.at2.scl
Specmatch7/D50/m70d064.c017000.n.at2.scl
Specmatch7/D50/m70d064.c017270.w.at2.scl

100-150 km:

Specmatch5/D100/m52d143.blo.e.at2.scl
Specmatch5/D100/m52d143.blo.n.at2.scl
Specmatch5/D100/m58d114.c001000.n.at2.scl
Specmatch5/D100/m58d114.c001270.w.at2.scl
Specmatch6/D100/m60d114.c001000.n.at2.scl
Specmatch6/D100/m60d114.c001270.w.at2.scl
Specmatch6/D100/m65d114.c001000.n.at2.scl
Specmatch6/D100/m65d114.c001270.w.at2.scl
Specmatch7/D100/m70d114.c001000.n.at2.scl
Specmatch7/D100/m70d114.c001270.w.at2.scl

150-200 km:

Specmatch5/D150/m52d184.edil.e.at2.scl
Specmatch5/D150/m52d184.edil.n.at2.scl
Specmatch5/D150/m58d195.dcky000.n.at2.scl
Specmatch5/D150/m58d195.dcky090.e.at2.scl
Specmatch6/D150/m60d195.dcky000.n.at2.scl
Specmatch6/D150/m60d195.dcky090.e.at2.scl
Specmatch6/D150/m65d195.dcky000.n.at2.scl
Specmatch6/D150/m65d195.dcky090.e.at2.scl
Specmatch6/D150/m69d159.fuk.e.at2.scl
Specmatch6/D150/m69d159.fuk.n.at2.scl
Specmatch7/D150/m70d195.dcky000.n.at2.scl
Specmatch7/D150/m70d195.dcky090.e.at2.scl

200-250 km:

Specmatch5/D200/m52d206.slm.e.at2.scl
Specmatch5/D200/m52d206.slm.n.at2.scl
Specmatch5/D200/m52d243.hick.e.at2.scl
Specmatch5/D200/m52d243.hick.n.at2.scl

250-300 km:

Specmatch5/D250/m52d258.parm.e.at2.scl
Specmatch5/D250/m52d258.parm.n.at2.scl

Specmatch5/D250/m52d270.penm.e.at2.scl
Specmatch5/D250/m52d270.penm.n.at2.scl
Specmatch5/D250/m52d291.pbmo.e.at2.scl
Specmatch5/D250/m52d291.pbmo.n.at2.scl

Comparisons of Site Amplification Distributions

Representative site amplification distributions were computed to examine the effects of the type of time histories used and the choice of magnitude binning. For this purpose, two reference profiles (Figure 8) from Karadeniz (2007) were used: Alluvium (lowlands) and Loess/Till (uplands). Variability for St. Louis in Vs and layer thickness from Karadeniz (2007) was introduced and remained constant in all site amplification distribution calculations. Dynamic soil property variability was also held fix (0.35 natural logarithmic standard deviation as proscribed by ERPI, 1993). The only source of variability among the site amplification distributions calculated was the variability among time-histories selected as input to the calculation. Thus the full variability expected from the Vs profile, dynamic soil properties, and input time histories is represented in each distribution, but only the time history variability changed from calculation to calculation.

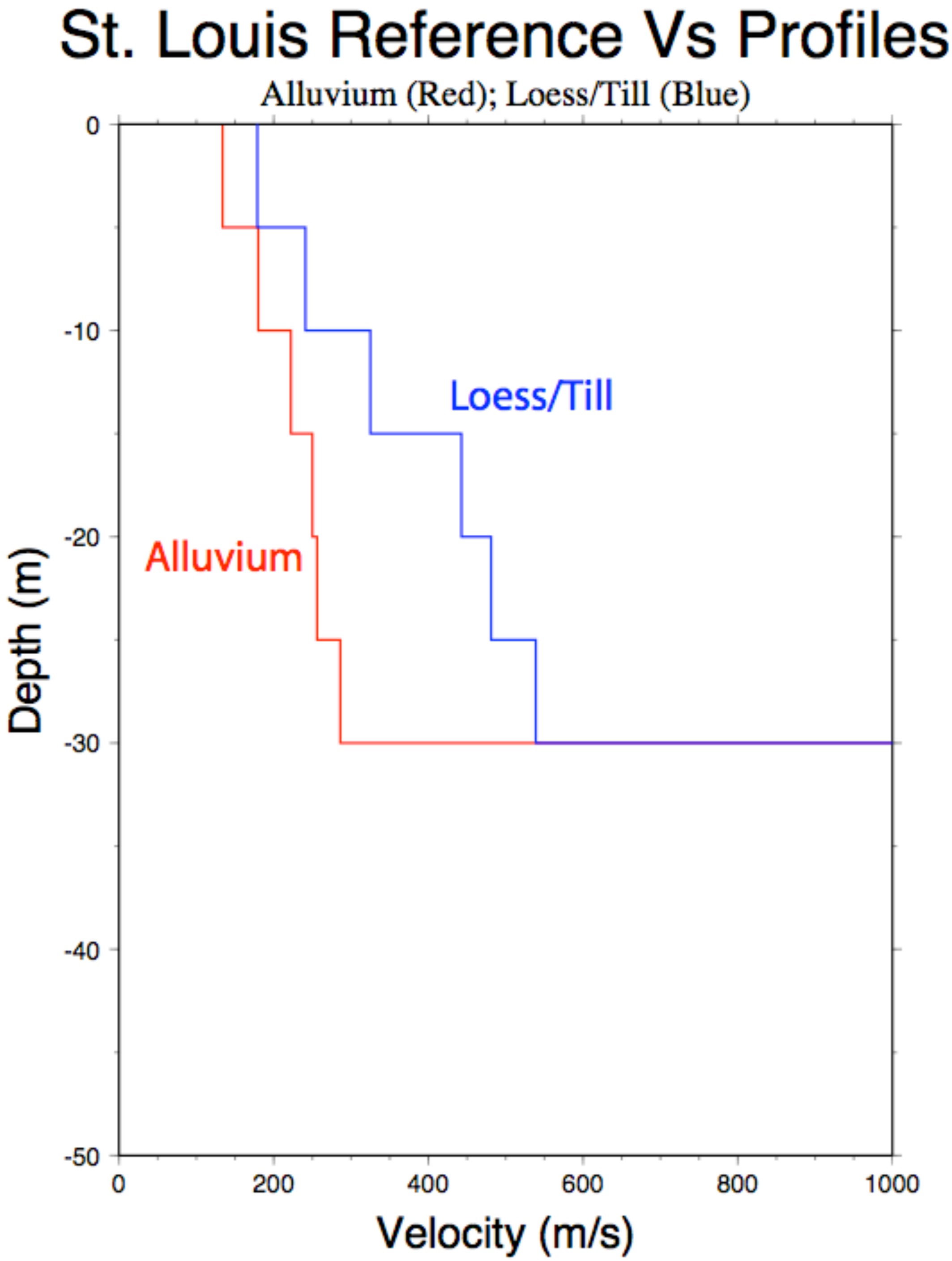


Figure 8: St. Louis Alluvial (lowlands) and Loess/Till (uplands) Vs reference profiles.

Figure 9 presents M5 site amplification distributions for PGA for the alluvial (lowlands) reference profile for ENA, non-ENA, synthetic, and matched time-history types at a distance of less than 50 km. Median and one standard deviation (sd) are shown for each type. One sd approximates the 95% confidence limits on the estimate of the median. Clearly the differences due to type in median site amplification are not significant at a 95% confidence level, given the overall uncertainty involved. The results are similar for 0.2 s Sa and for the Loess/Till (uplands) reference profile (not shown). Because soil response is not particularly sensitive to phase arrivals, site response distributions are less sensitive to the type of time histories used.

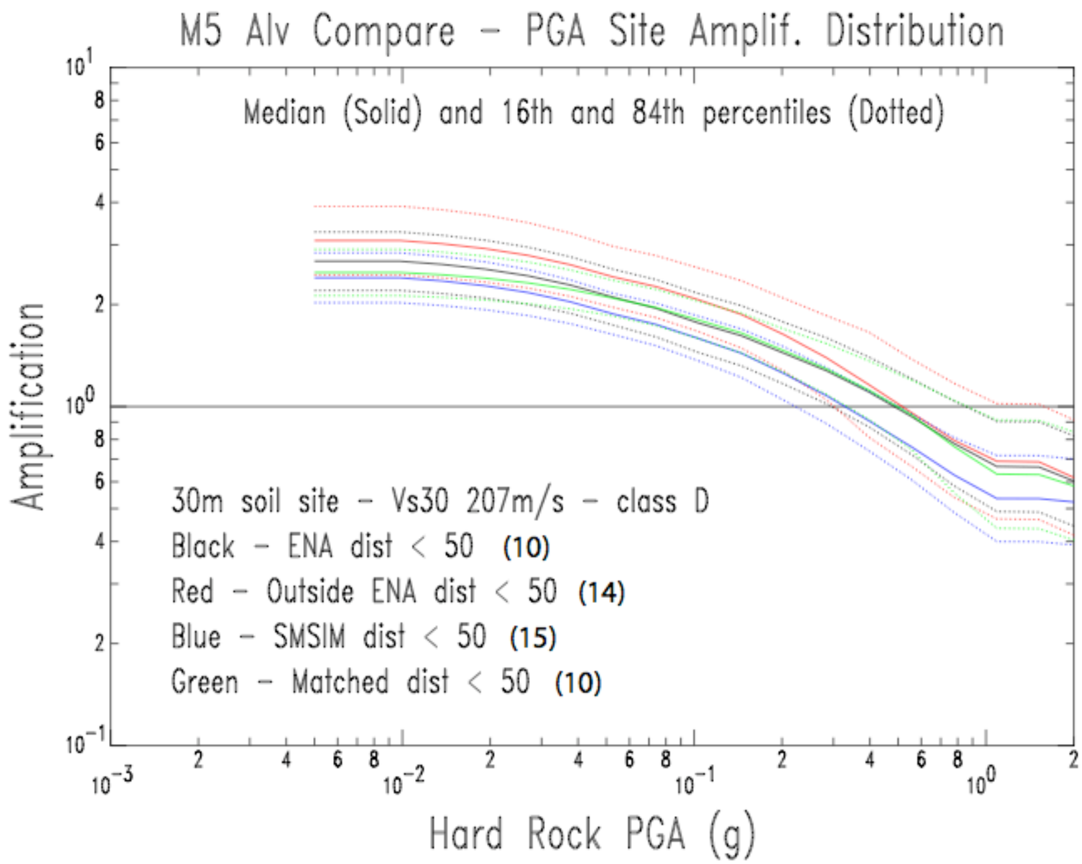


Figure 9: M5 site amplification distribution comparison for ENA, non-ENA, synthetic, and spectrally matched time histories. Value in parentheses indicates the number of time histories used in each group.

Figure 10 presents a comparison of site amplification distributions for PGA again for the alluvial (lowlands) reference profile, this time for synthetic time-histories at M5, M6, and M7. The M5 and M6 time histories are for distances less than 50 km and the M7 time histories are for a distance range of 150-200 km. This is representative of the deaggregation results and the distances that each magnitude contributes to the seismic hazard in St. Louis. The shape of the M7 site amplification distribution seems significantly different from that of the M5 and M6 site amplification distributions at the 95% confidence level, particularly at lower input ground motion levels (< 0.05 g). The results are the same for the Loess/Till (uplands) reference profile (not shown). Thus, particularly at short periods, the use of magnitude dependent (M5, M6, and M7) site amplification distributions in the urban hazard maps calculations may give different results from the current practice of using just the M7 site amplification distribution. This needs further examination.

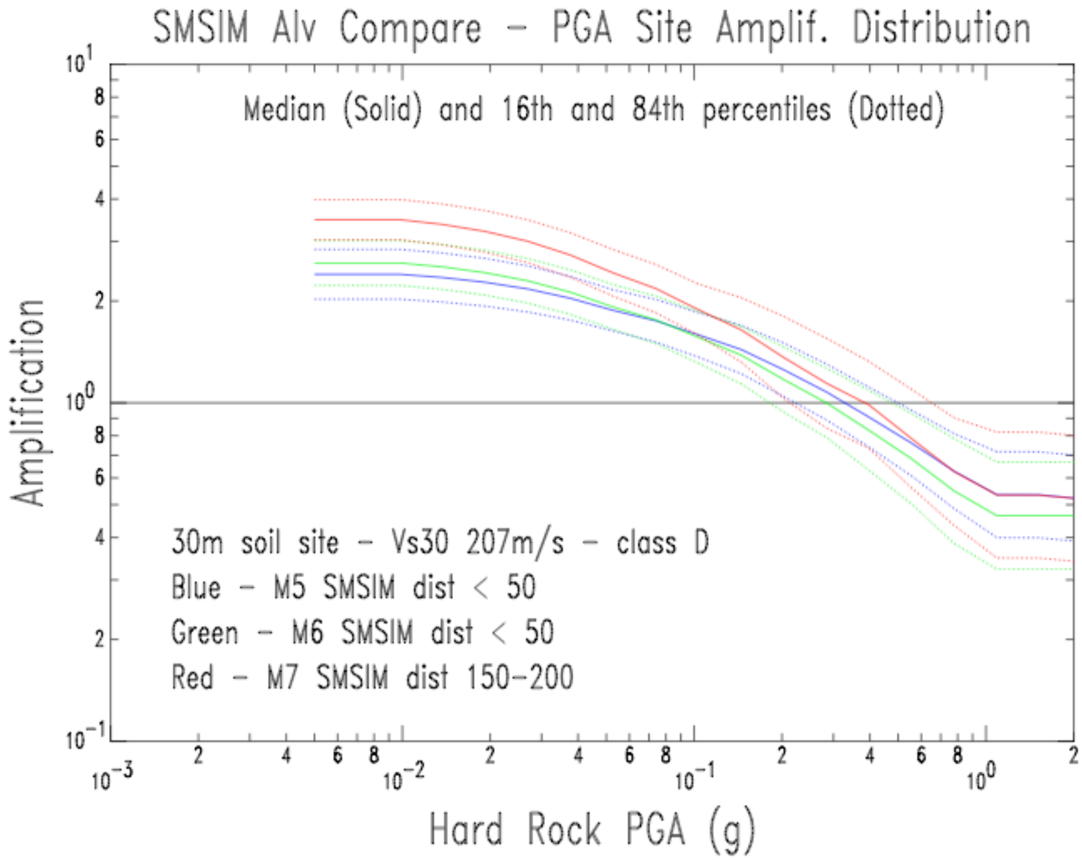


Figure 10: Site amplification distribution comparison for M5, M6, and M7 synthetic time histories. The number of time histories used in each group is 16, 15, and 14 for M5, M6, and M7, respectively.

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Publications from this Research

No publications have resulted from this research as of this date. Future papers based on this work will be provided, as required, when publication occurs.