Seismic Hazard Study for a Site in the Eastern Tennessee Seismic Zone

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Purpose

Evaluate effect on seismic hazard of larger maximum earthquakes in the Eastern Tennessee Seismic Zone (ETSZ)

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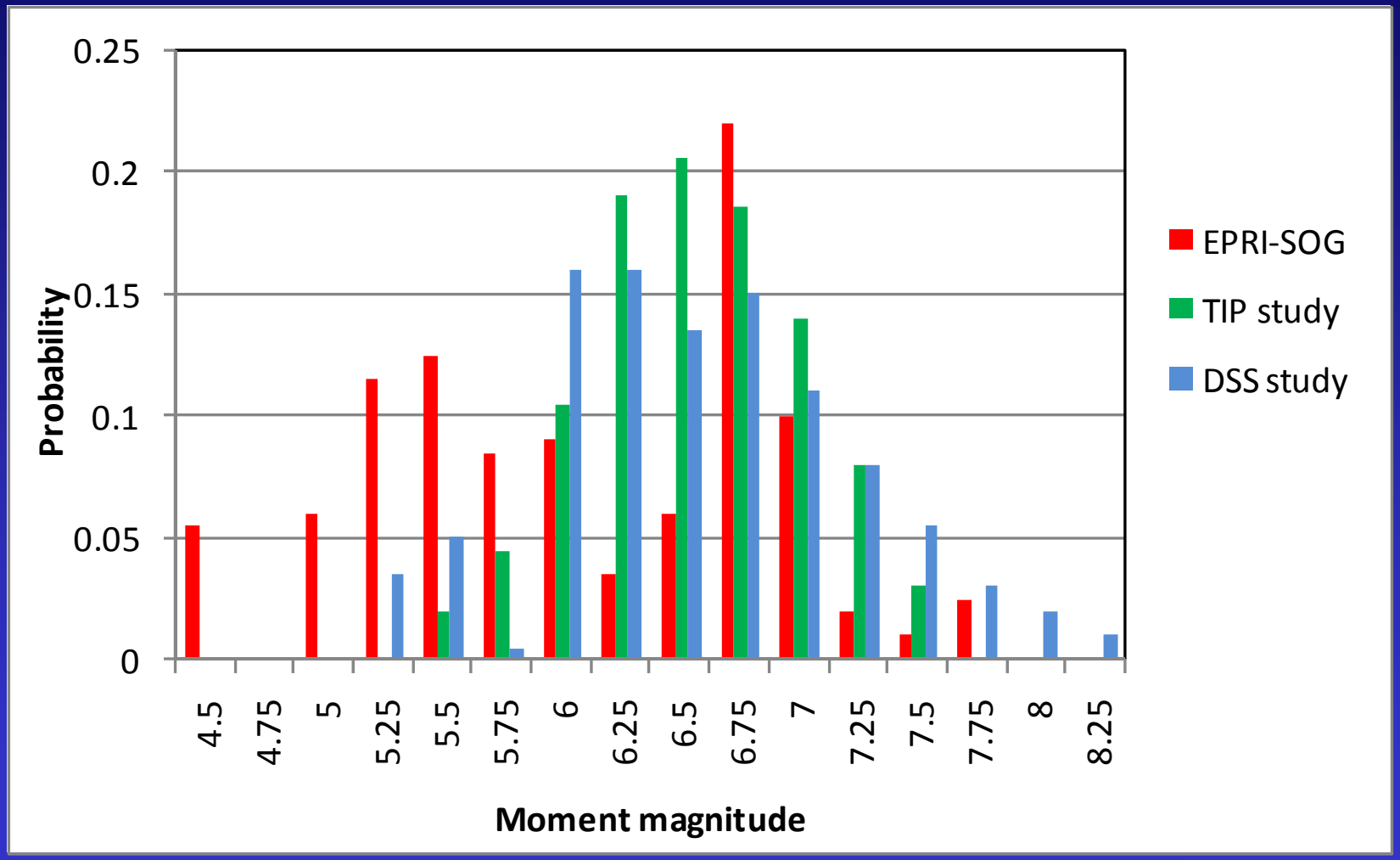
Maximum magnitude (M_{max}) distributions from EPRI-SOG, TIP, and DSS studies (**M** scale)



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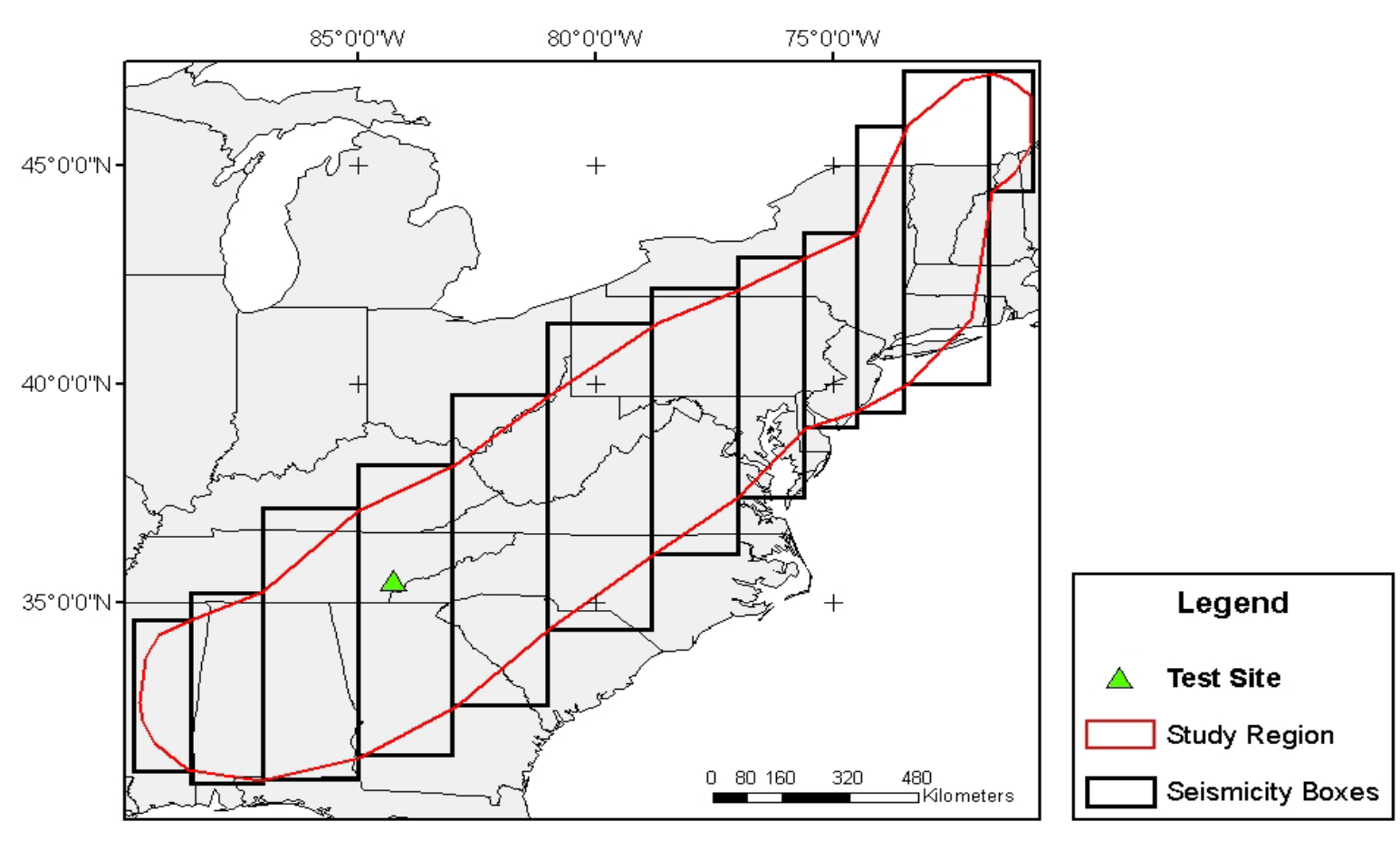
Study region for updated earthquake catalog



Study region for updated earthquake catalog (shown in red), and longitude-latitude boxes used to collect earthquakes for analysis.

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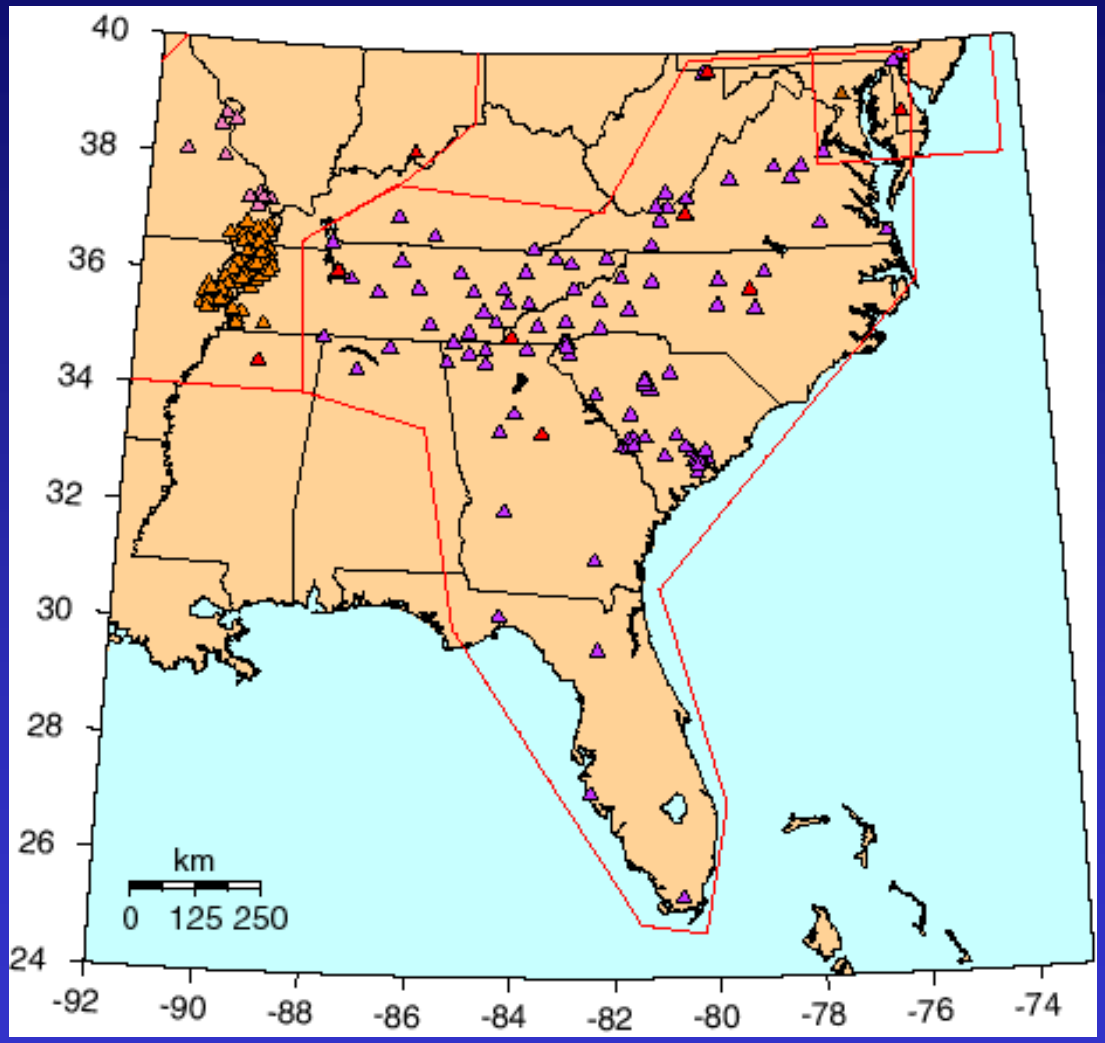
Region used for Southeast US Seismic Network



Region where SEUSSN is considered authoritative by ANSS (from ANSS website). Triangles are seismic stations.

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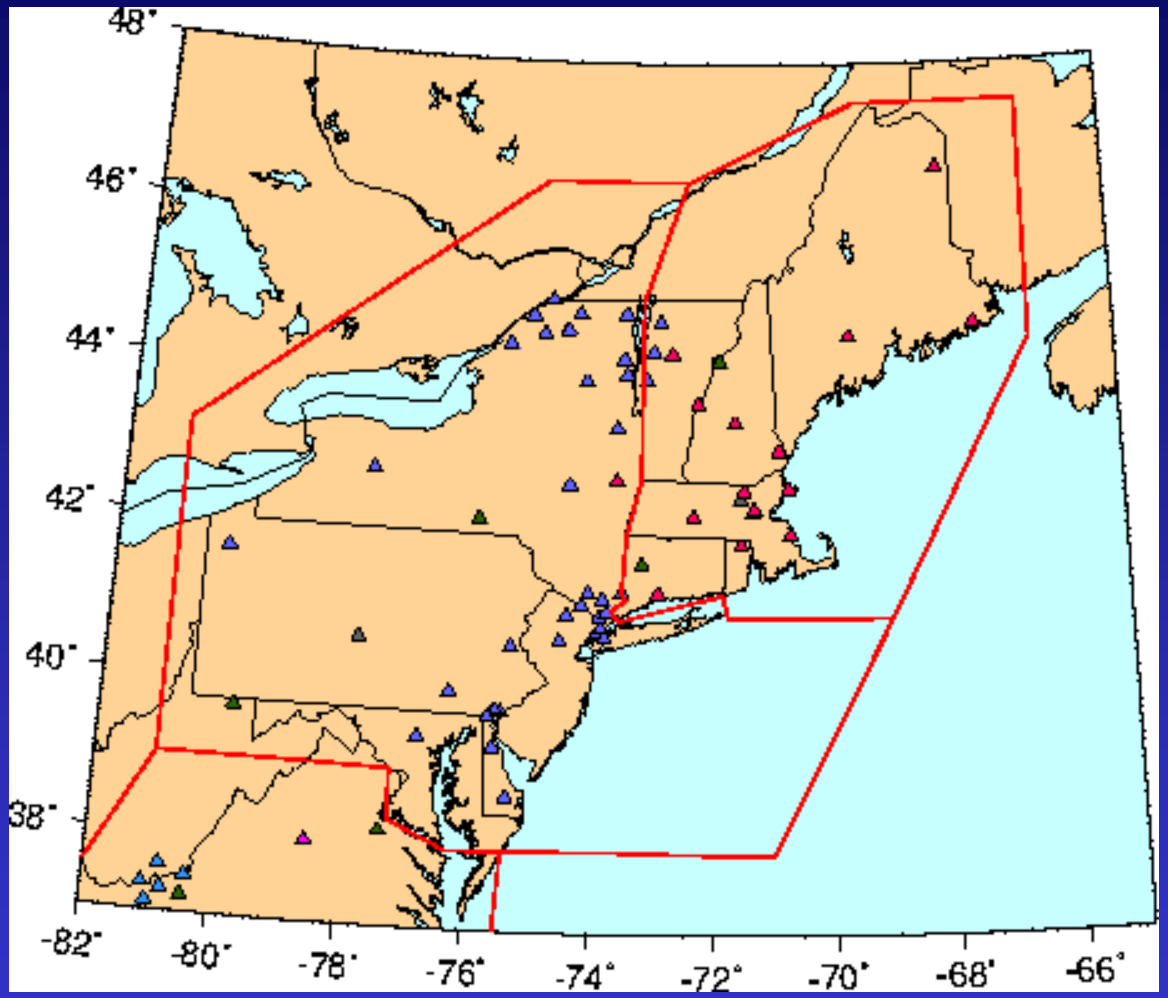
Regions used for Lamont and New England Seismic Networks



Regions for which LCSN (in New York, Pennsylvania, and adjacent states) and NESN (in New England) are considered authoritative by ANSS (from ANSS website). Triangles are seismic stations.

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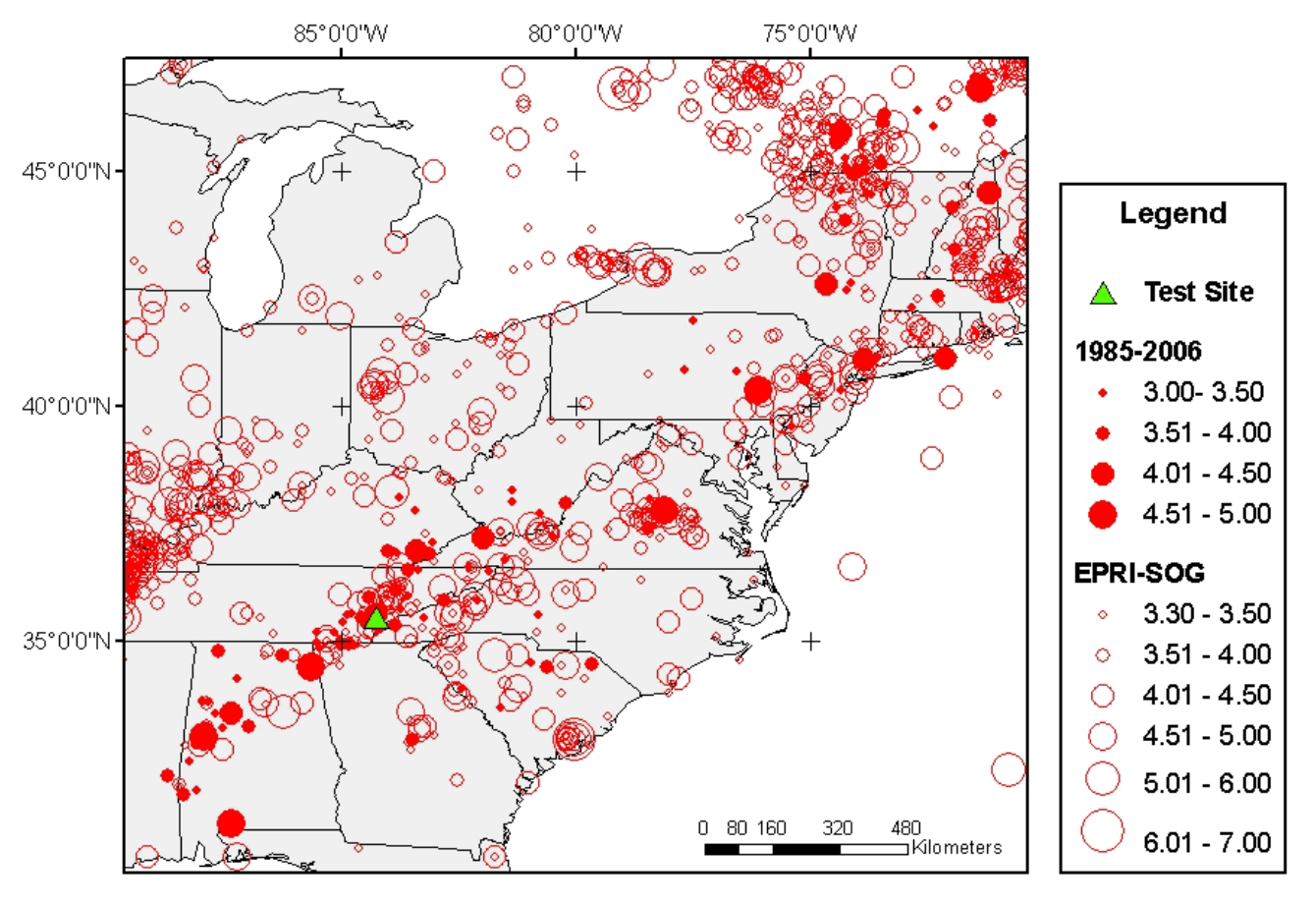
Original EPRI-SOG earthquakes, and earthquakes in extended catalog



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EPRI-SOG team sources representing the ETSZ and related background zones

Team	Source	Name	P_a	Comment
Bechtel	BEC-24	Bristol trends	0.25	ETSZ source
	BEC-25	NY-AL lineament	0.30	ETSZ source
	BEC-25A	Altern. for 25	0.45	ETSZ source
Dames & Moore	DAM-04	Appalachian fold belt	0.35	ETSZ source
	DAM-4A	Kink in fold belt	0.65	ETSZ source
Law Engineering	LAW-17	Eastern basement	0.62	ETSZ source
	LAW-217	Background for 17	0.38	Background
Rondout	RND-13	So. NY-AL lineament	1.0*	Adjacent source
	RND-25	So. Appalachians	0.99*	ETSZ source
	RND-27	TN-VA border zone	0.99*	Adjacent source
Woodward-Clyde	WCC-31	Blue Ridge comb.	0.024	ETSZ source
	WCC-31A	Blue Ridge comb.—Altern.	0.211	ETSZ source
	WCC-BG	Background	0.765	Background
Weston	WGC-24	NY-AL Clingman	0.90	ETSZ source
	WGC-103	So. Appal. background	0.10	Background

***--Three Rondout sources are close to the ETSZ, Pa was taken as 1.0 for all three.**

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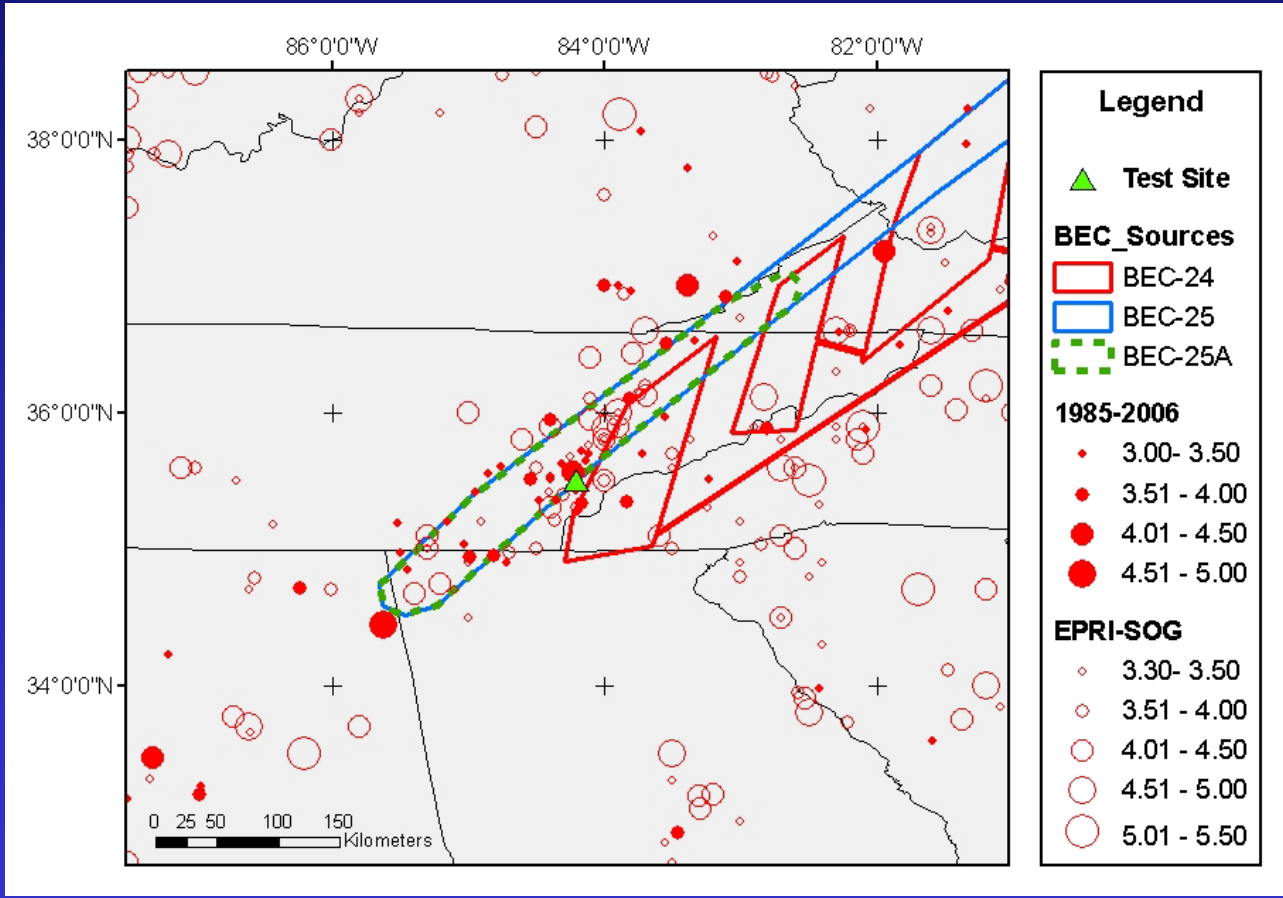
Map of Bechtel team seismic sources and historical seismicity



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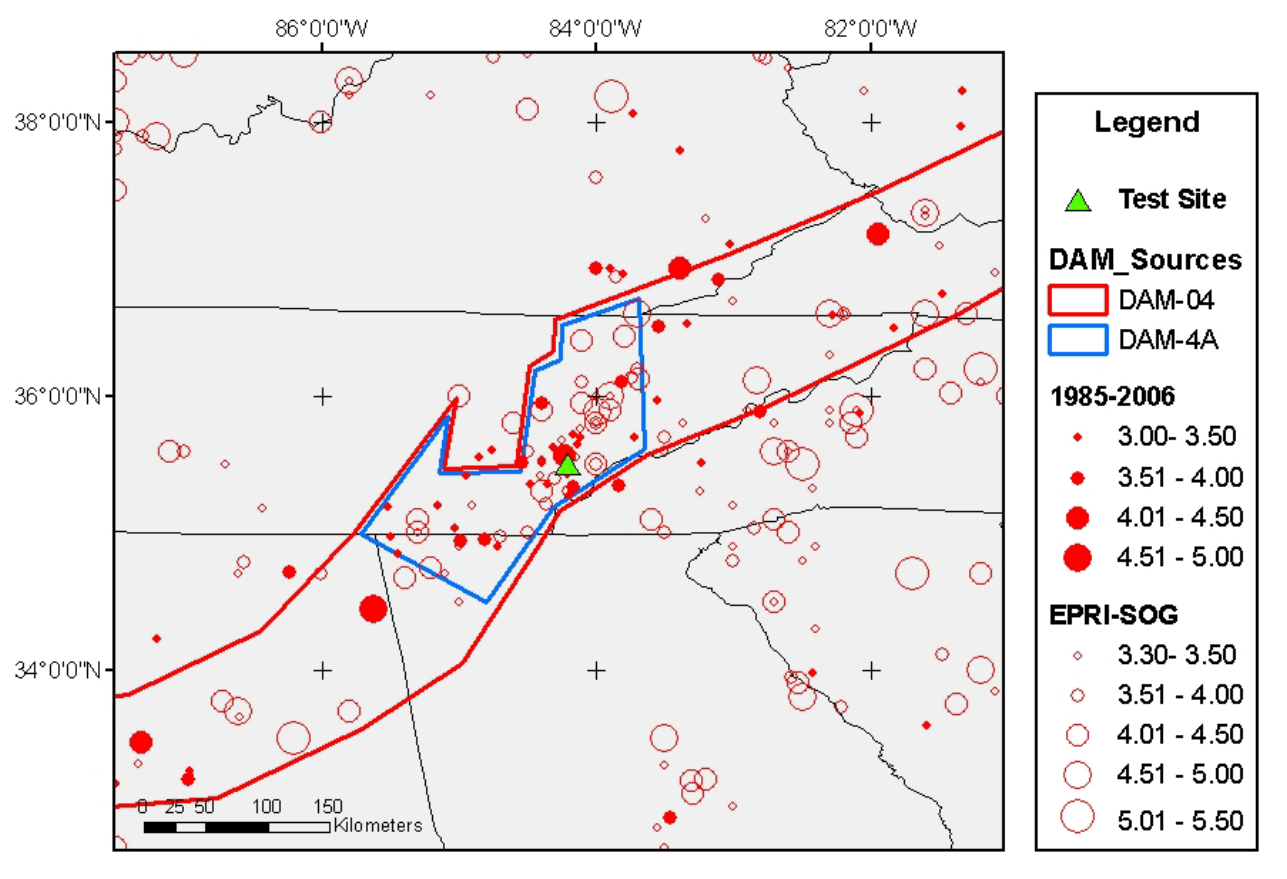
Map of Dames & Moore team seismic sources and historical seismicity



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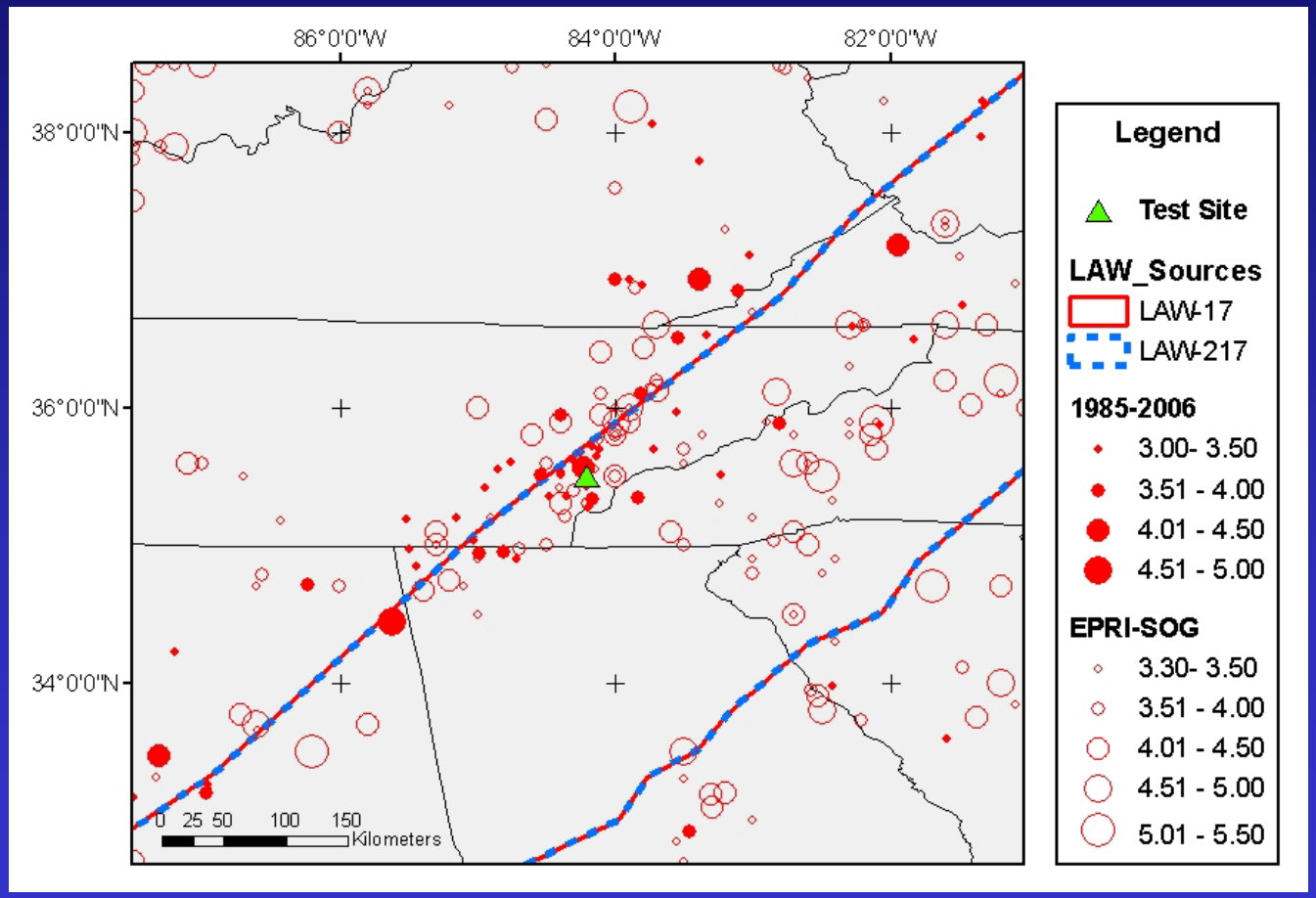
Map of Law team seismic sources and historical seismicity



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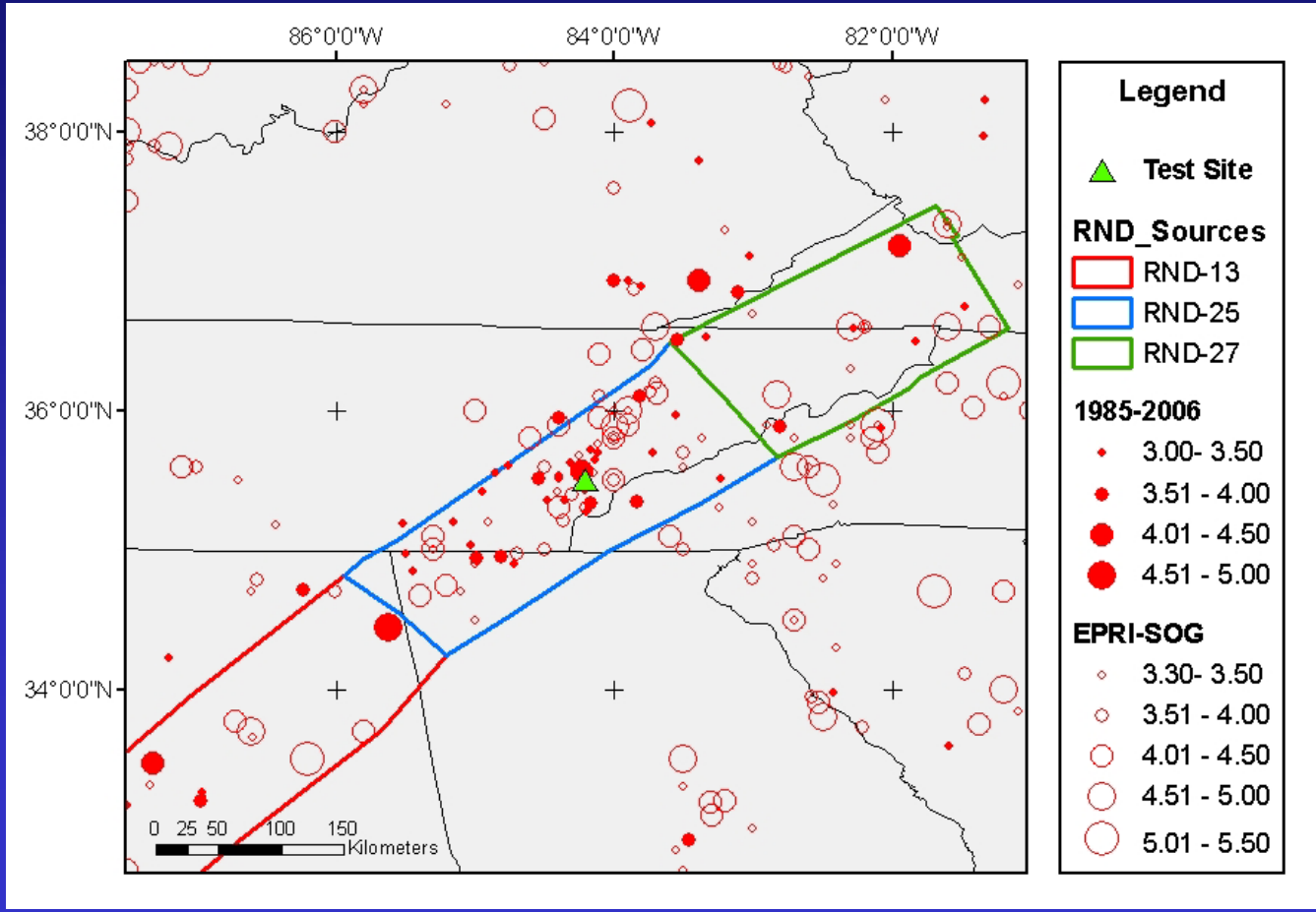
Map of Rondout team seismic sources and historical seismicity



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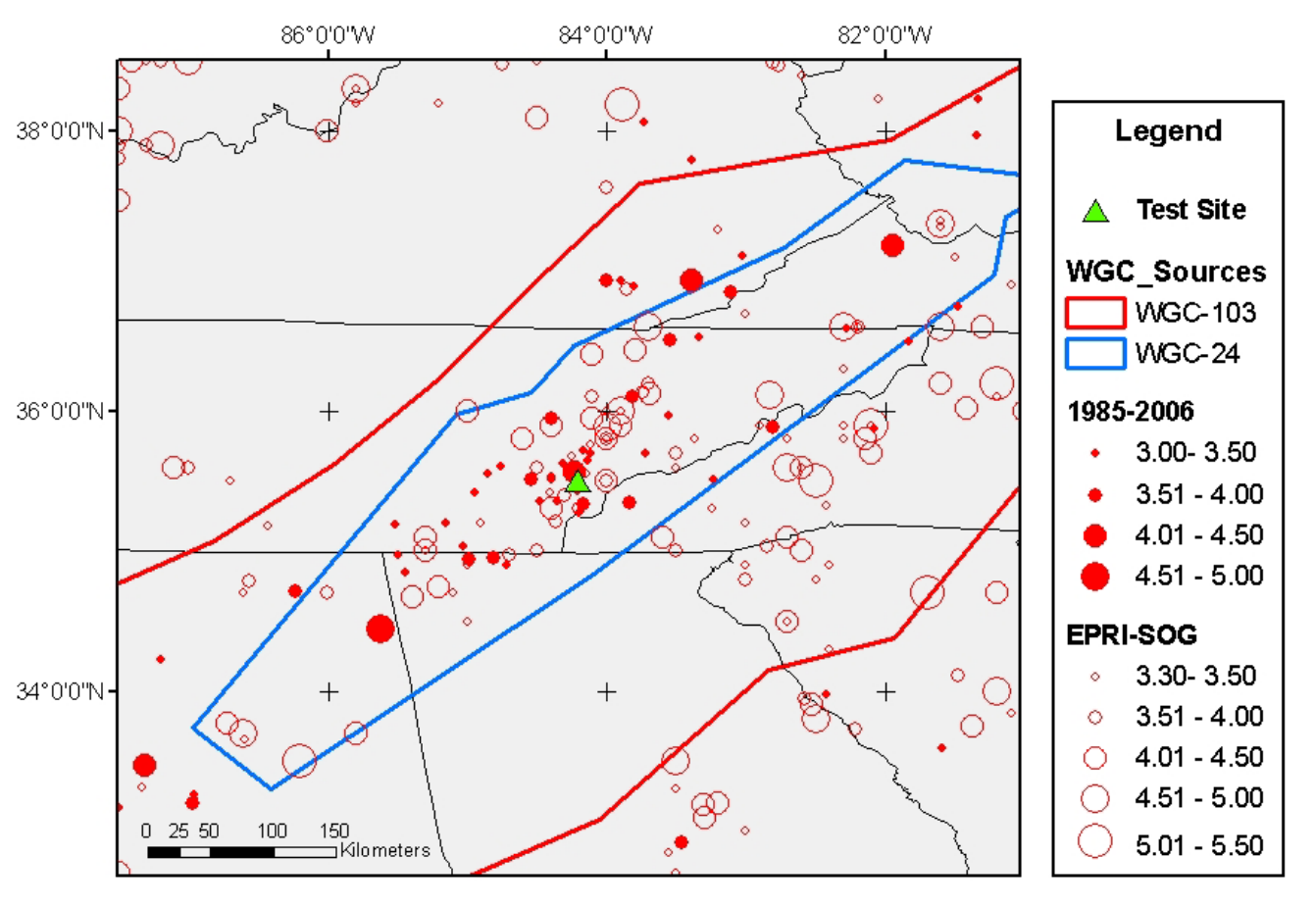
Map of Weston team seismic sources and historical seismicity



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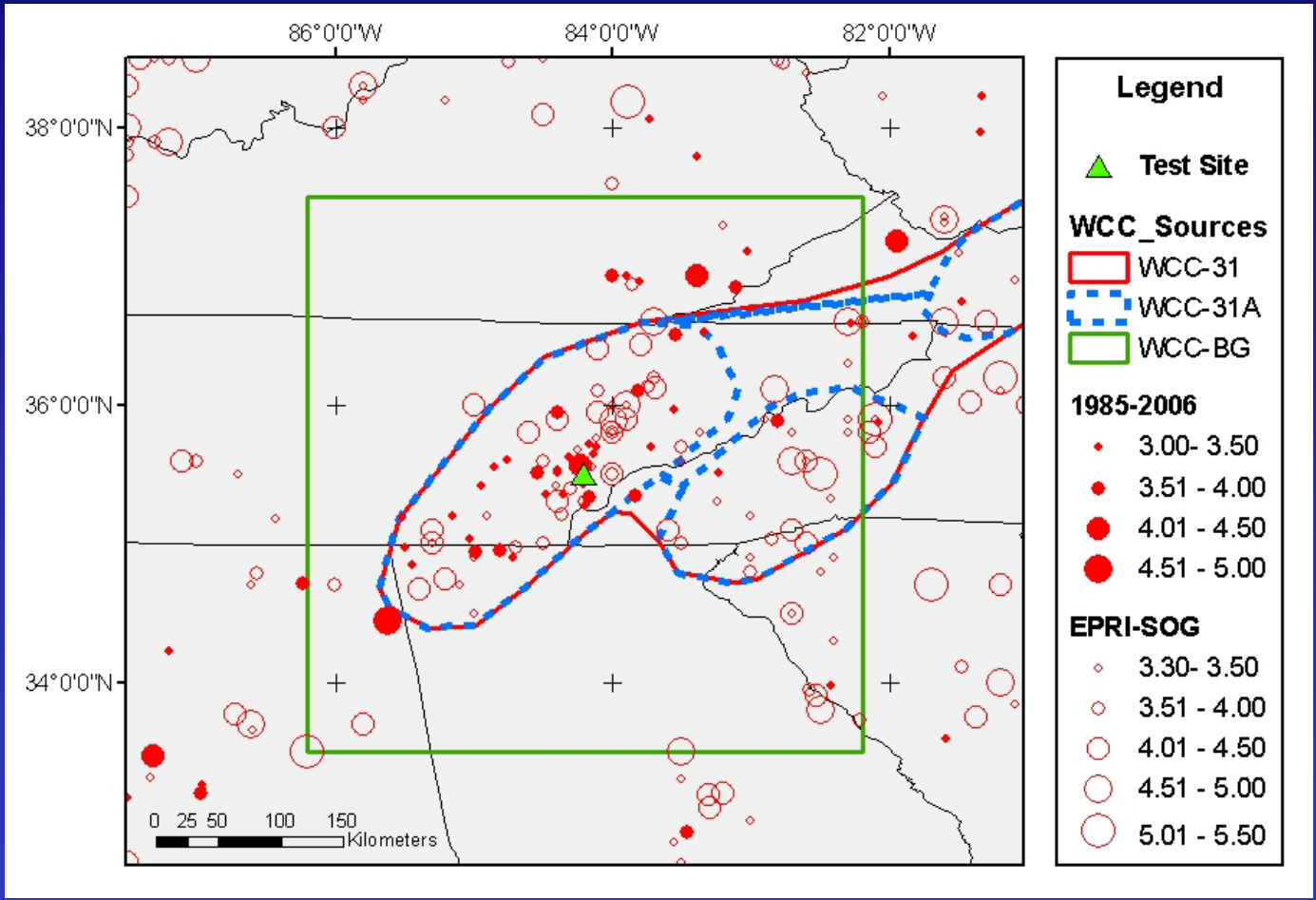
Map of Woodward-Clyde team seismic sources and historical seismicity



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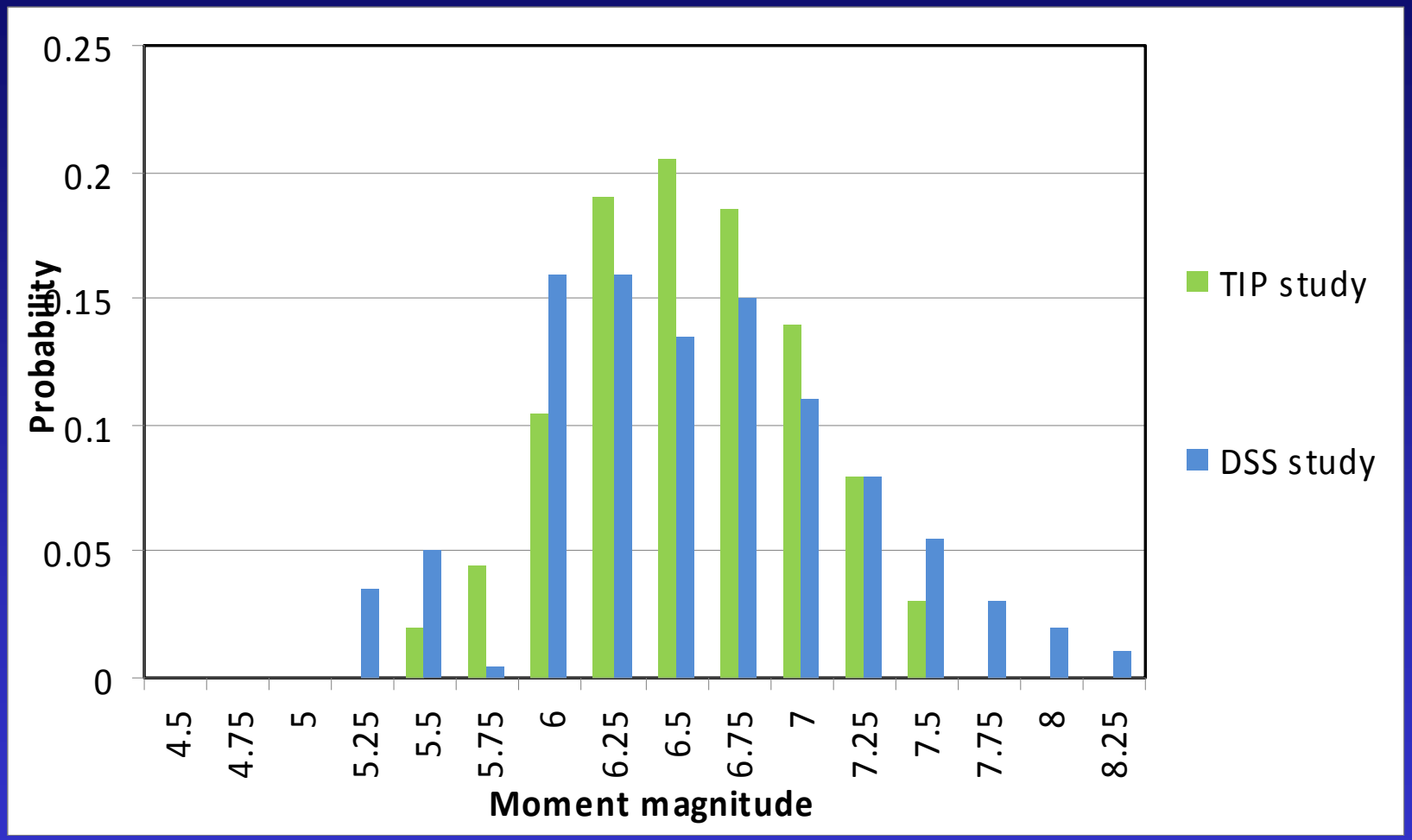
TIP and DSS study M_{max} distributions



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Relationships used to convert M to m_b

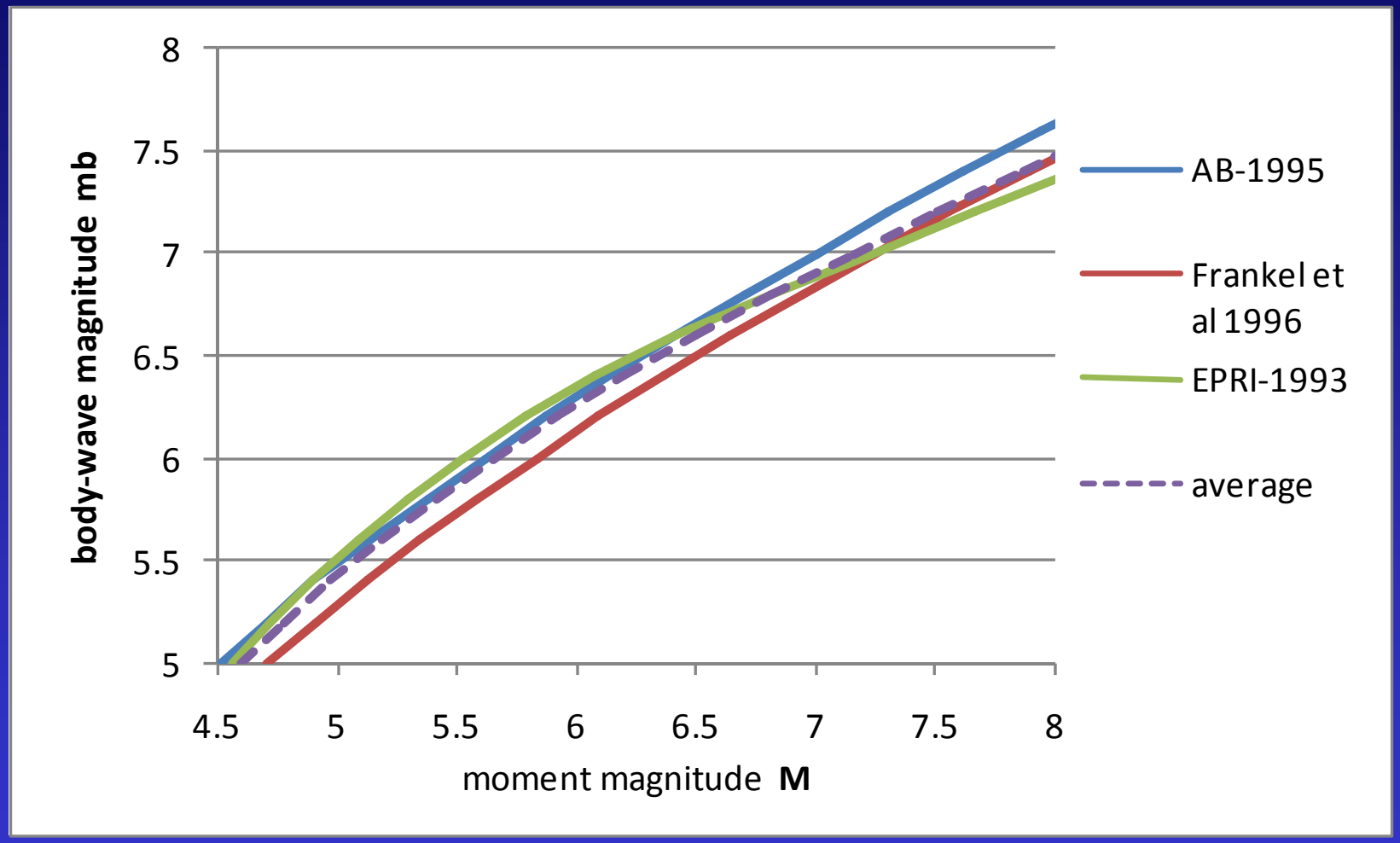

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Table 2. Magnitude distributions for TIP study, TVA study, and composite distribution.

Distribution		Lower (wt=0.28)	Central (wt=0.44)	Upper (wt=0.28)	mean	σ
TIP	**M** value	6.27	6.55	6.83	6.55*	0.21*
	equiv. m_b value	6.45	6.64	6.80	6.63	0.13
	chosen m_b value	6.4	6.6	6.8	6.6	0.15
DSS	**M** value	6.01	6.58	7.15	6.58*	0.43*
	equiv. m_b value	6.26	6.67	7.00	6.64	0.28
	chosen m_b value	6.2	6.6	7.0	6.6	0.30
Composite	**M** value	6.13	6.56	6.99	6.56*	0.32*
	equiv. m_b value	6.35	6.64	6.91	6.63	0.21
	chosen m_b value	6.3	6.6	6.9	6.60	0.22

***--values consistent with distribution from Figure 12.**

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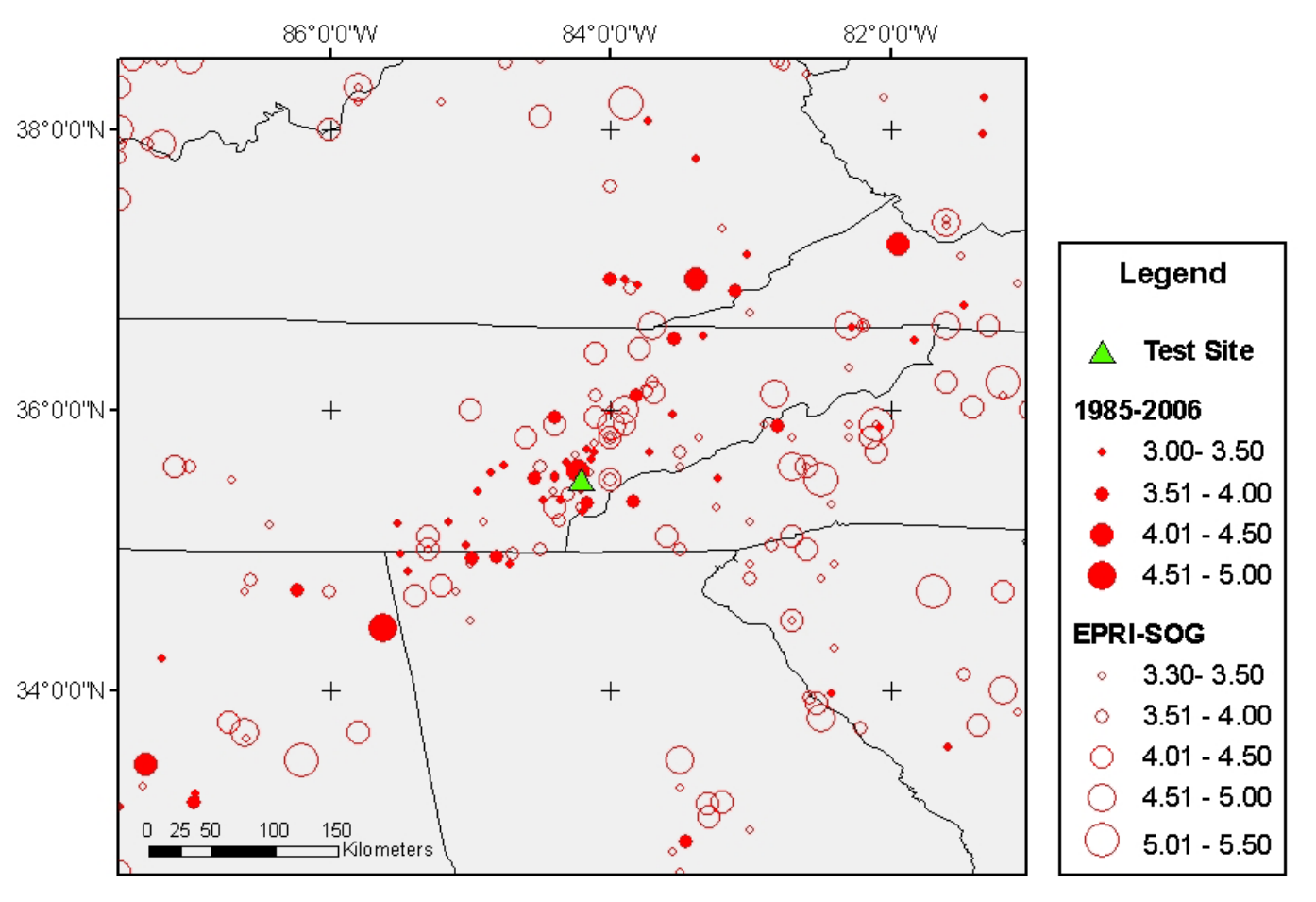
Seismicity in ETSZ region from EPRI-SOG catalog and from extended catalog (1985—2006), showing location of test site



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Example hazard curves

- 10 Hz and 1 Hz
- Rondout team
- Effect of updated seismicity and alternative M_{max} values

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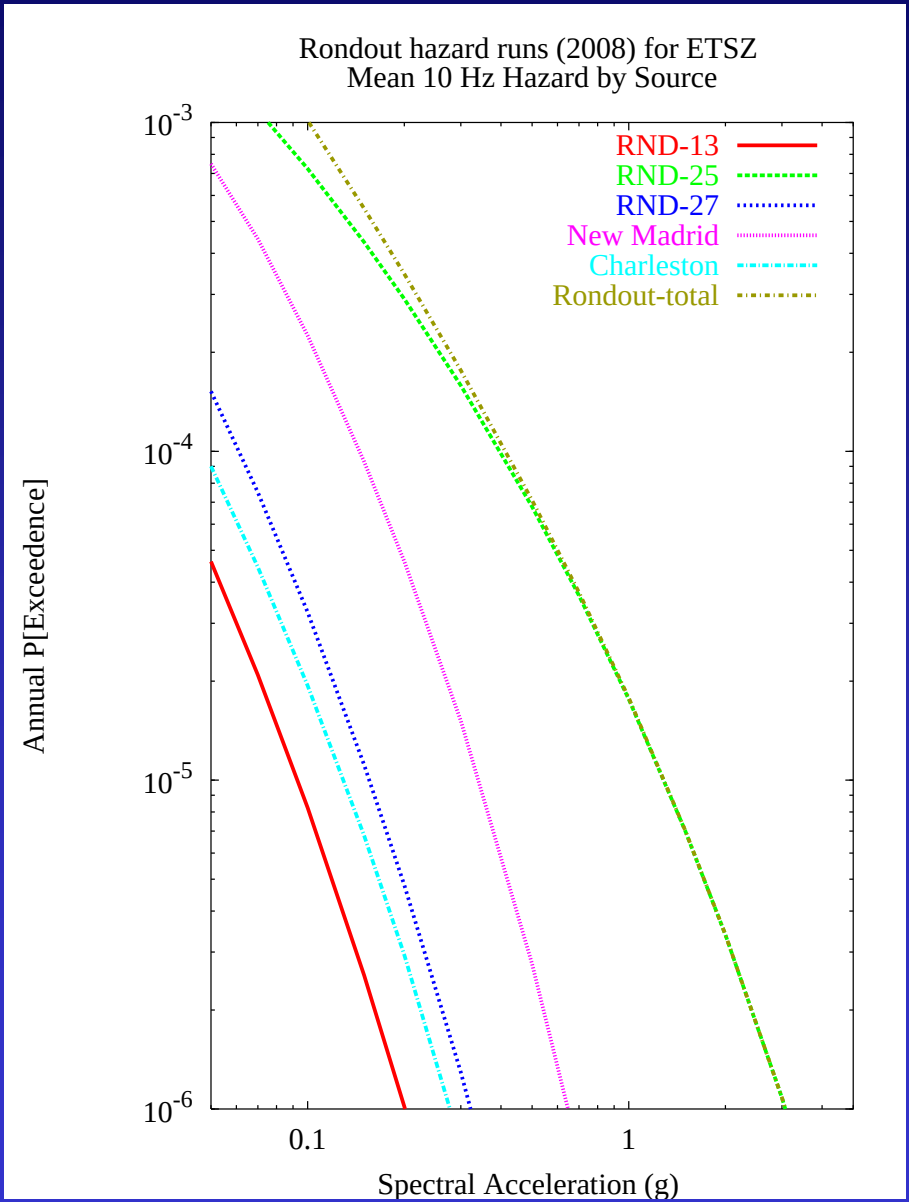
Rondout 10 Hz hazard, no CAV



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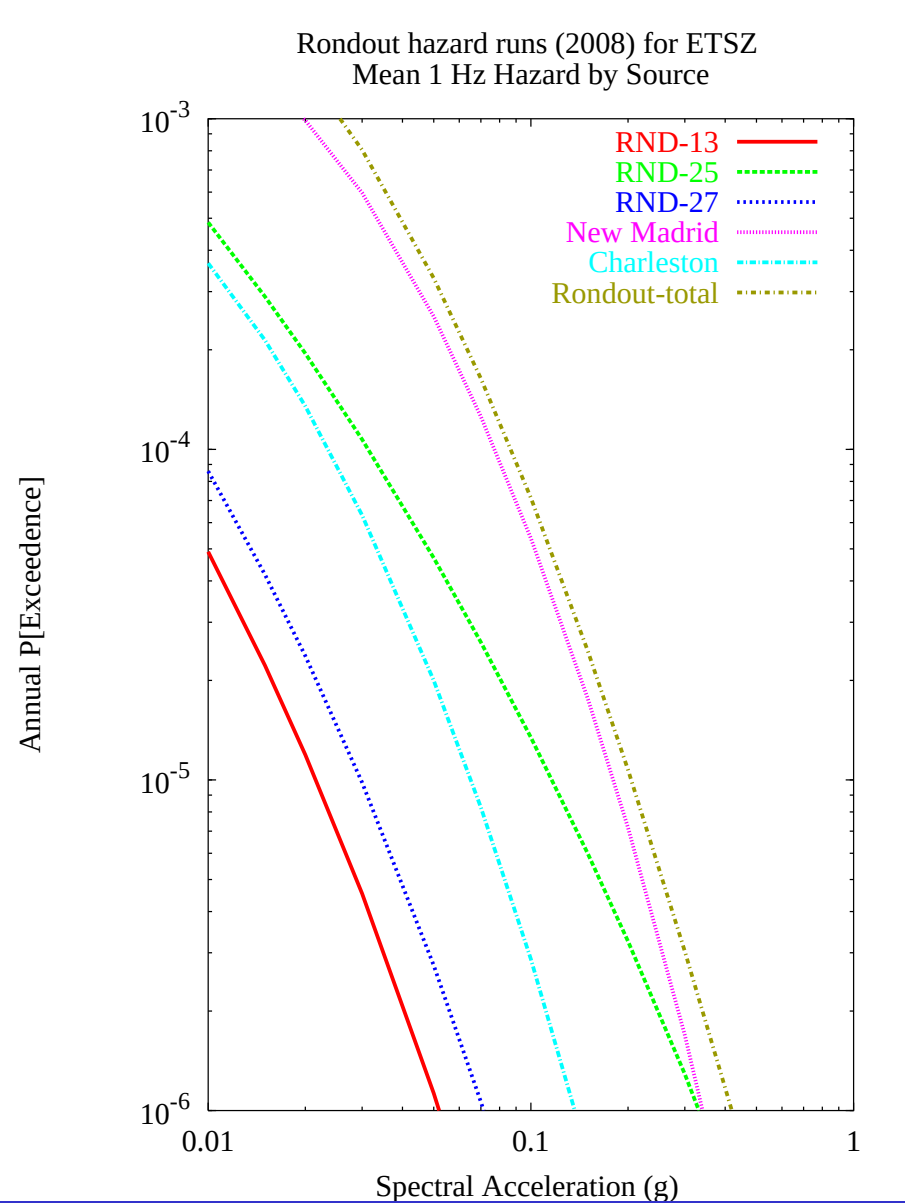
Rondout 1 Hz hazard, no CAV



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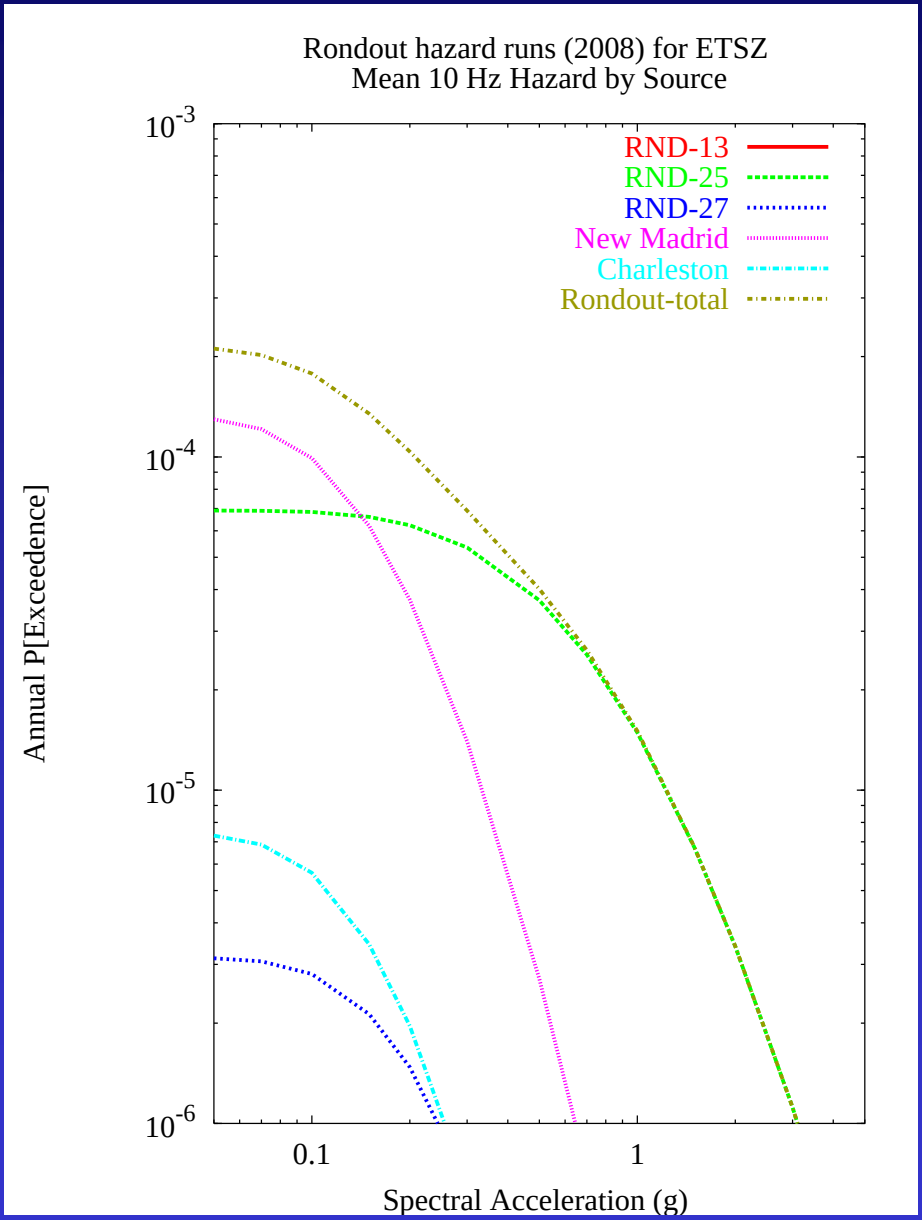
Rondout 10 Hz hazard, CAV



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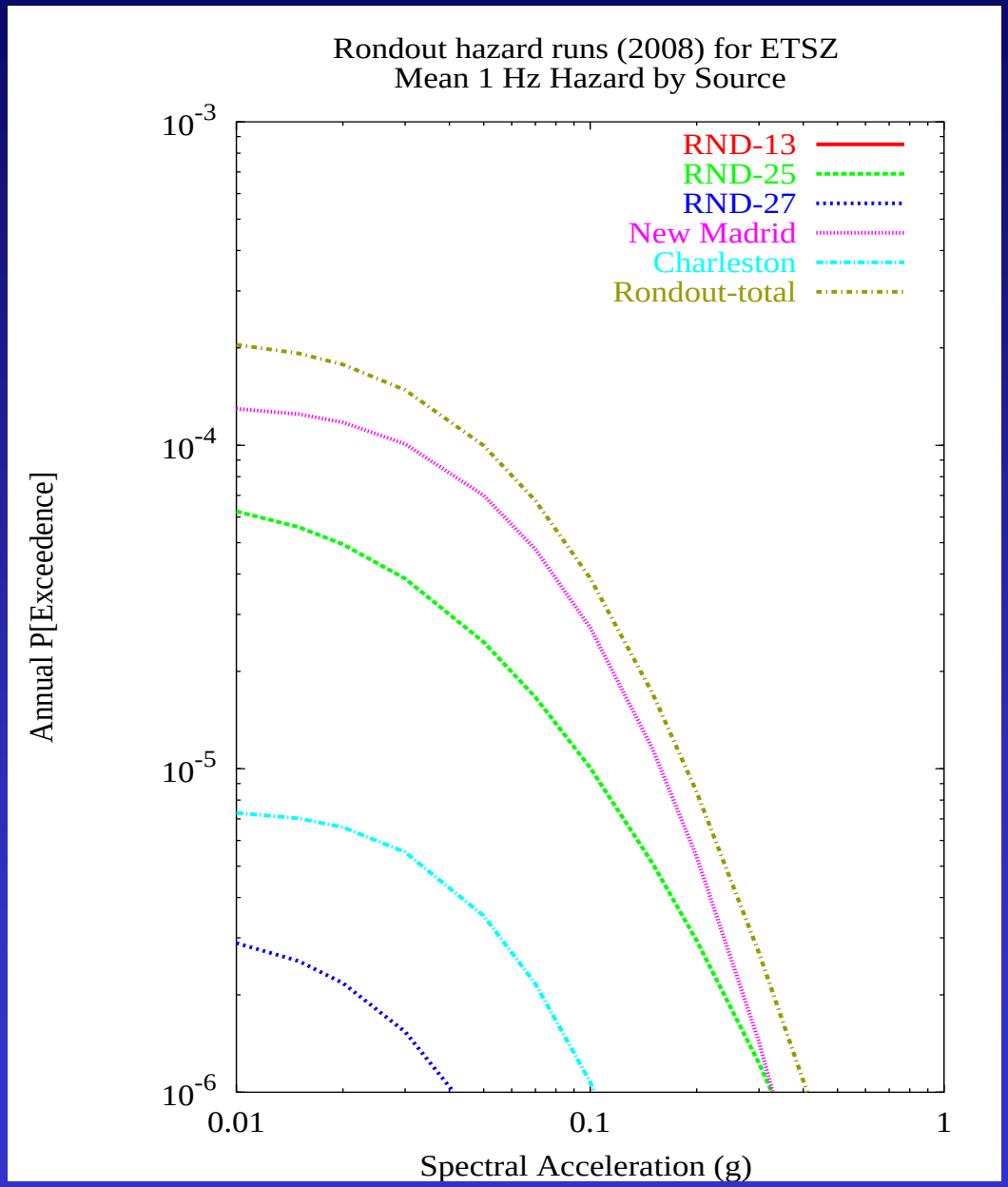
Rondout 1 Hz hazard, CAV



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Comparison #1

- Use alternative M_{max} values with 100% weight
- This is "worst-case" adoption of alternative M_{max} values

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Effect on GMRS at test site between original EPRI-SOG parameters and alternative parameters (no CAV)

Freq. (Hz)	Orig 1E-4 (g)	Orig 1E-5 (g)	GMRS (g)	Alt. 1E-4 (g)	Alt. 1E-5 (g)	GMRS (g)	% DIFF
100	0.264	0.875	0.413	0.280	0.915	0.433	4.9%
25	0.725	2.45	1.15	0.765	2.56	1.21	4.8%
10	0.480	1.48	0.709	0.508	1.548	0.743	4.9%
5	0.306	0.896	0.434	0.322	0.942	0.456	5.2%
2.5	0.173	0.454	0.225	0.180	0.475	0.235	4.6%
1	0.0894	0.217	0.109	0.0911	0.220	0.111	1.4%
0.5	0.0615	0.165	0.0814	0.0620	0.165	0.0814	0.0%

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Effect on GMRS at test site between original EPRI-SOG parameters and alternative parameters (CAV)

Freq. (Hz)	Orig 1E-4 (g)	Orig 1E-5 (g)	GMRS (g)	Alt. 1E-4 (g)	Alt. 1E-5 (g)	GMRS (g)	% DIFF
100	0.135	0.885	0.398	0.157	0.929	0.418	5.0%
25	0.351	2.43	1.09	0.410	2.56	1.15	5.4%
10	0.257	1.43	0.644	0.295	1.51	0.681	5.8%
5	0.191	0.842	0.379	0.210	0.893	0.402	6.1%
2.5	0.114	0.422	0.195	0.122	0.445	0.206	5.8%
1	0.0545	0.202	0.0933	0.0572	0.205	0.0954	2.2%
0.5	0.0302	0.149	0.0672	0.0314	0.149	0.0671	-0.2%

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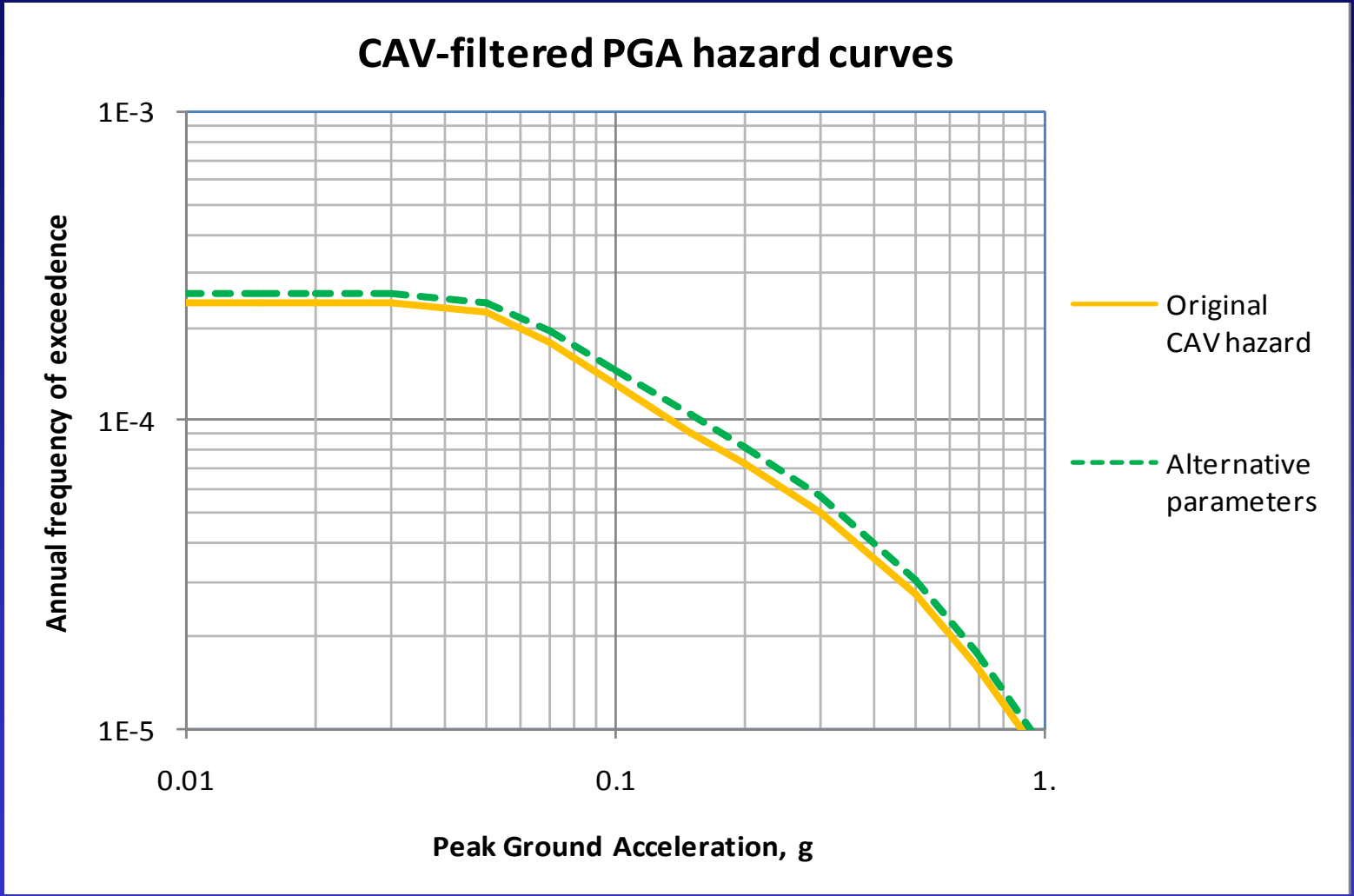
Effect on PGA hazard curve of using alternative parameters



PGA hazard curves using CAV filter for original analysis and for alternative parameters.

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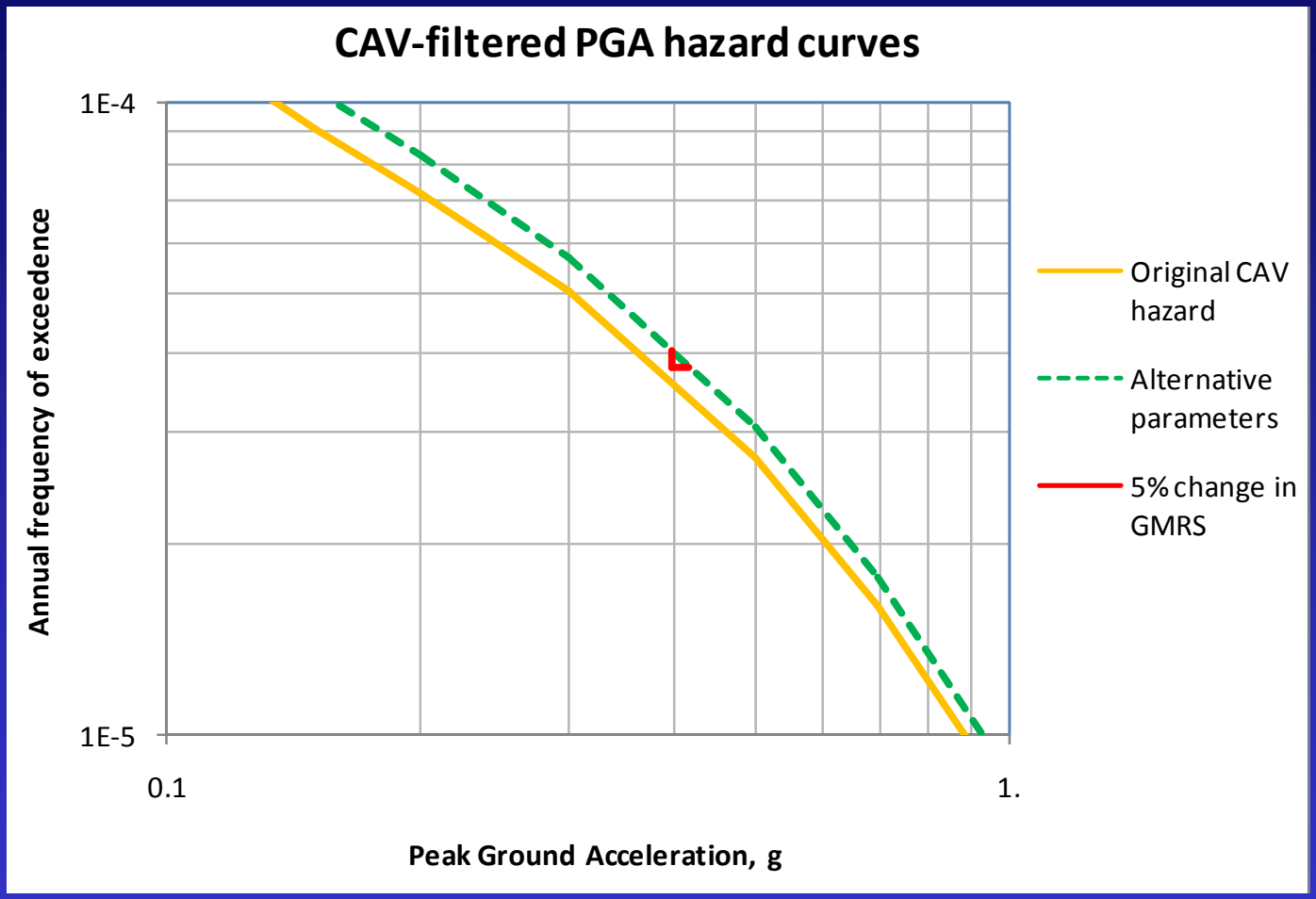
Effect on PGA hazard curve of using alternative parameters (same as previous figure, with expanded X and Y axes)



PGA hazard curves from previous figure expanded to show only one order of magnitude on amplitude and frequency axes. The red triangle shows the change in amplitude and annual frequency when using the GMRS calculated from the original analysis compared to the alternative parameters.

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Comparison #2

- Use alternative M_{max} values to represent two additional team interpretations
- Integrate alternative parameters as follows:

--updated seismicity + original M_{max} values (wt. 0.75)

--updated seismicity + alternative M_{max} values (wt. 0.25)

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Effect on GMRS at test site between original EPRI-SOG parameters and integrated analysis (no CAV)

Freq. (Hz)	Orig 1E-4 (g)	Orig 1E-5 (g)	GMRS (g)	Int. 1E-4 (g)	Int. 1E-5 (g)	GMRS (g)	% DIFF
100	0.264	0.875	0.413	0.266	0.881	0.416	0.7%
25	0.725	2.45	1.15	0.730	2.46	1.16	0.7%
10	0.480	1.48	0.709	0.483	1.49	0.713	0.6%
5	0.306	0.896	0.434	0.307	0.899	0.435	0.4%
2.5	0.173	0.454	0.225	0.174	0.453	0.225	0.0%
1	0.0894	0.217	0.109	0.0894	0.216	0.109	-0.4%
0.5	0.0615	0.165	0.0814	0.0614	0.165	0.0811	-0.4%

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Effect on GMRS at test site between original EPRI-SOG parameters and integrated analysis (CAV)

Freq. (Hz)	Orig 1E-4 (g)	Orig 1E-5 (g)	GMRS (g)	Int. 1E-4 (g)	Int. 1E-5 (g)	GMRS (g)	% DIFF
100	0.135	0.885	0.398	0.136	0.893	0.402	0.9%
25	0.351	2.43	1.09	0.355	2.45	1.10	1.0%
10	0.257	1.43	0.644	0.259	1.44	0.648	0.7%
5	0.191	0.842	0.379	0.192	0.845	0.380	0.4%
2.5	0.114	0.422	0.195	0.114	0.421	0.195	-0.1%
1	0.0545	0.202	0.0933	0.0544	0.201	0.0929	-0.5%
0.5	0.0302	0.149	0.0672	0.0301	0.148	0.0668	-0.6%

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Conclusions

- Integration of alternative M_{max} distribution for ETSZ into EPRI-SOG interpretations as additional interpretations lead to changes in GMRS at a site within the ETSZ of 1% or less, which is insignificant.
- Even worst-case adoption of the alternative M_{max} values would lead to increases in GMRS of only about 5-6%, which is still insignificant.
- These results justify the continued use of EPRI-SOG M_{max} values for seismic hazard characterization.

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