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Prospective test of WGCEP 1995

Summary of 1995 WGCEP Forecast

- 30 year window, 65 zones, 14 fault segments, magnitude 6+
- Three zone types:
  - A: around fault segment with paleo history
  - B: around fault segment with no history
  - C: no dominant fault
- Two separate models:
  - “Preferred” = TD (time dependent)
  - “Alternate” = TI (time independent)
  - I added a third: SoSo (same-old-same-old) based on past seismicity only, Poisson.
- Epicenter rates and 30 year probabilities for all zones
- “Cascade” model estimates rates for 52 contiguous combinations of 14 fault segments
- Total rate: Cascade events, + single segment “characteristic” events in B zones, + distributed events in all zones.

Cascade Earthquake Rates

Preferred, Time Dependent **Alternate, Time Independent**

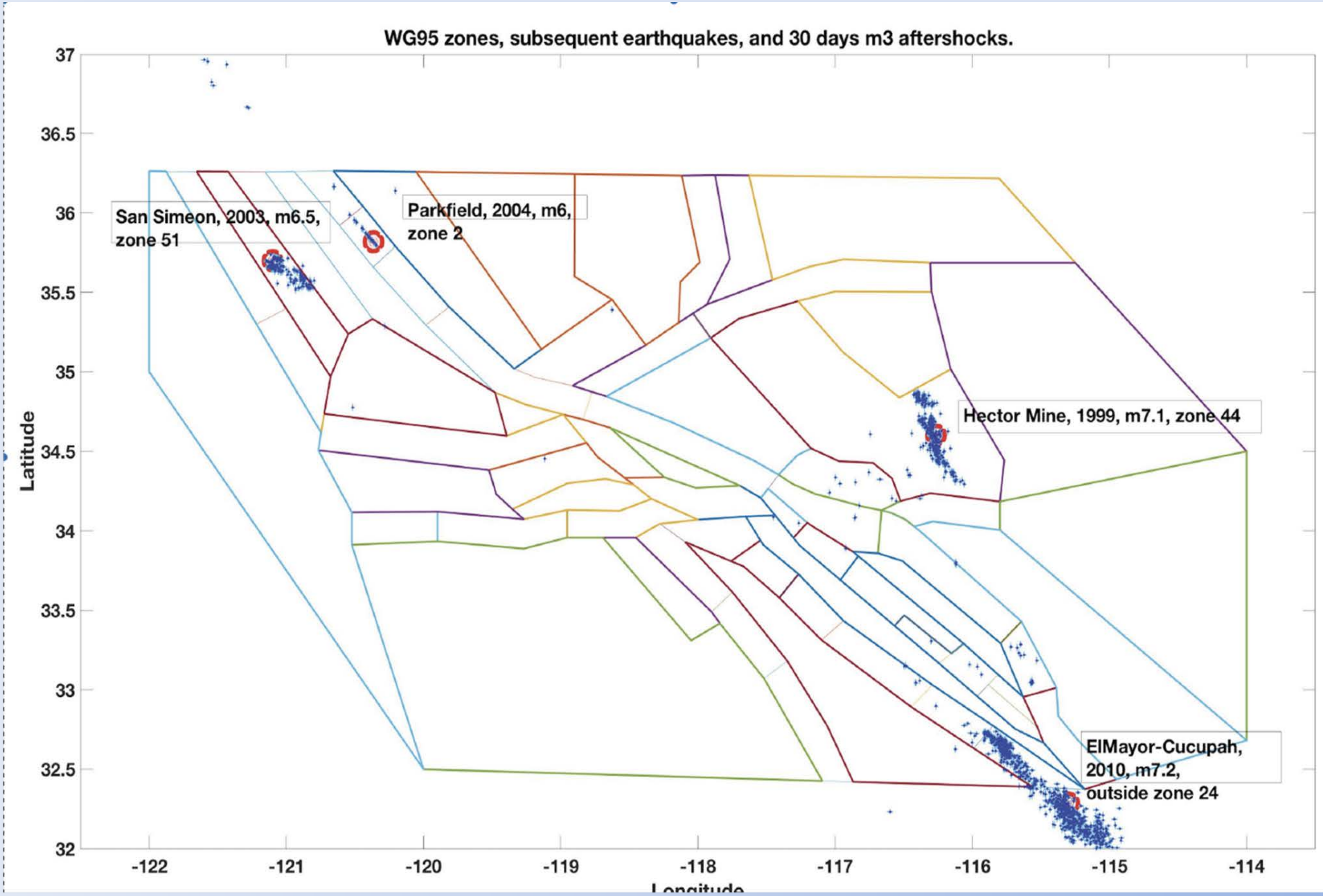
Fault	Zones	Length (km)	Disp. (m)	mw	Lognormal			Poissonian		
					Rupt. Rate	Rate Floor	Rate Est.	Rupt. Rate	Rate Floor	Rate Est.
San Andreas	04-05-06-07	446	4.9	7.90		0.25	1.80		0.25	0.68
	04-05-06	332	5.2	7.84		0.00	0.00		0.00	0.00
	04-05	254	5.7	7.79		1.50	1.50		1.50	1.65
	05-06-07	325	4.1	7.76		0.00	0.49		0.00	0.00
	05-06	211	4.1	7.64		1.00	1.16		1.00	1.00
	04	121	7.0	7.63	6.61	3.31	3.31	4.86	2.43	2.52
	06-07	192	3.8	7.59		1.75	1.75		1.75	1.75
	05	133	4.5	7.53	9.90	4.95	4.95	6.67	3.34	3.34
	07	114	4.0	7.45	8.08	4.04	4.04	6.25	3.13	3.82
	06	78	3.5	7.30	11.15	5.58	5.95	6.86	3.43	3.43
Total San Andreas					35.74	22.37	24.95	24.63	16.82	18.20

Similar tables for San Jacinto and Whittier faults

Magnitude 6+ quakes after 1995

Date	Lat	Lon	Depth	Mw	Zone	Zone Type
1999-10-16	34.603	-116.265	13.7	7.10	44	C
2003-12-22	35.701	-121.101	8.4	6.50	51	C
2004-09-28	35.818	-120.366	8.1	5.97	2	B
Just Outside Zone						
2010-04-04	32.286	-115.295	10.0	7.20	24	B

Map of Source Zones, with m6+ quakes after 1995



Preferred Seismic Source Model

Number	Name	Type	Area Km^2	V	Length Km	M_x Mod.	Rate Full 10^{-3}/yr	Rate Part 10^{-3}/yr	$\dot{M}_g$ 10^{15} Nm/yr	$\dot{M}_f$ 10^{15} Nm/yr	$\dot{M}_s$ 10^{15} Nm/yr	$\dot{M}_d$ 10^{15} Nm/yr	$\dot{M}_c$ 10^{15} Nm/yr	$\dot{M}_m$ 10^{15} Nm/yr	f_d 10^{-3}/yr	f_c 10^{-3}/yr	a Dist.
01	SACreepi	B	718	0	200	6.01	2.33	1.18	0	0	56	2	0	2	2.33	0.00	3.367
02	SAParkfi	B	881	34	30	6.79	3.05	1.32	347	337	70	11	331	342	3.05	21.79	3.484
03	SACholam	B	1045	34	50	7.05	3.54	0.81	515	561	84	18	520	538	3.54	13.74	3.549
04	SACarriz	A	2265	34	121	7.51	8.19	3.05	1094	1358	193	29	1358	1387	3.05	casc	3.484
05	SAMojave	A	2847	30	133	7.56	8.67	3.27	1036	1317	200	34	1317	1350	3.27	casc	3.515
06	SASanBer	A	1799	24	78	7.28	4.78	2.35	585	618	112	17	618	634	2.35	casc	3.371
07	SACoachell	A	2793	25	114	7.48	5.62	3.85	860	941	134	36	941	976	3.85	casc	3.585
08	SJSanBer	A	409	12	35	6.87	1.19	0.47	109	139	28	2	139	140	0.47	casc	2.672
09	SJSanJac	A	820	12	42	6.96	2.41	1.19	129	166	57	5	166	172	1.19	casc	3.076
10	SJAnza	A	1482	12	90	7.36	3.65	2.12	281	356	87	17	356	373	2.12	casc	3.326
63	ColoCorr	C	19376	0.5	40	6.94	13.31	10.84	115	7	319	87	0	87	19.76	0.00	4.296
64	SECorner	C	12564	1	40	6.94	18.95	16.18	83	13	454	83	0	83	18.94	0.00	4.277
65	TranRanW	C	5588	5	70	7.23	10.43	4.84	144	116	245	106	0	106	16.14	0.00	4.208
	All A		19514				50.77	26.58	4738	5377	1193	183	5377	5560	26.58	70.64	
	All B		41380				82.66	51.55	2700	2919	2172	451	2365	2816	82.66	78.79	
	All C		208242				241.68	158.85	1936	982	5670	1484	0	1484	346.51	0.00	
	Total		269136				375.11	236.98	9374	9277	9036	2118	7742	9860	455.75	149.43	

- Pref

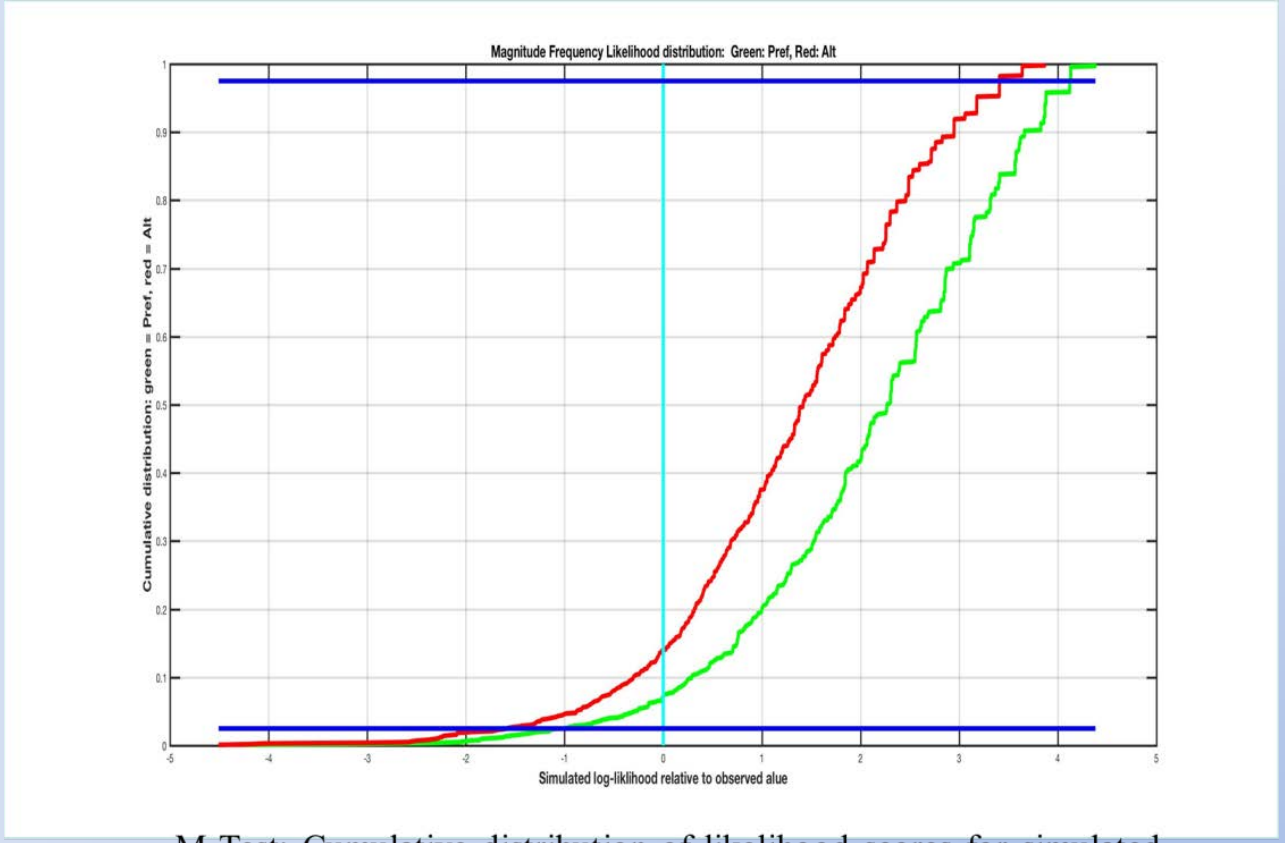
Preferred (Time Dependent) Source Model

N-Test

Model	Mag Thresh	Dist rate	Char rate	Total rate	T, years	lamda	Events, N	Prob (0 - N)	Prob (N or more)
TD A	6	0.027	0.071	0.097	22.5	2.19	0	0.112	1.000
TD B	6	0.083	0.079	0.161	22.5	3.63	1	0.123	0.974
TD C	6	0.347	0.000	0.347	22.5	7.80	2	**0.016**	0.996
TD Total	6	0.456	0.149	0.605	22.5	13.62	3	**0.001**	1.000
TD Char	Char	0.000	0.149	0.149	22.5	3.36	0	**0.035**	1.000
TD Total	7			0.067	22.5	1.51	1	0.555	0.779
TI A	6	0.027	0.054	0.081	22.5	1.82	0	0.162	1.000
TI B	6	0.083	0.010	0.093	22.5	2.09	1	0.382	0.877
TI C	6	0.232	0.000	0.232	22.5	5.21	2	0.108	0.966
TI Total	6	0.341	0.065	0.406	22.5	9.12	3	**0.019**	0.994
TI Char	Char	0.000	0.065	0.065	22.5	1.45	0	0.234	1.000
TI Total	7			0.064	22.5	1.44	1	0.578	0.763
SoSo Total	6			0.350	22.5	7.88	3	**0.046**	0.985
SoSo Total	7			0.035	22.5	0.79	1	0.813	0.545

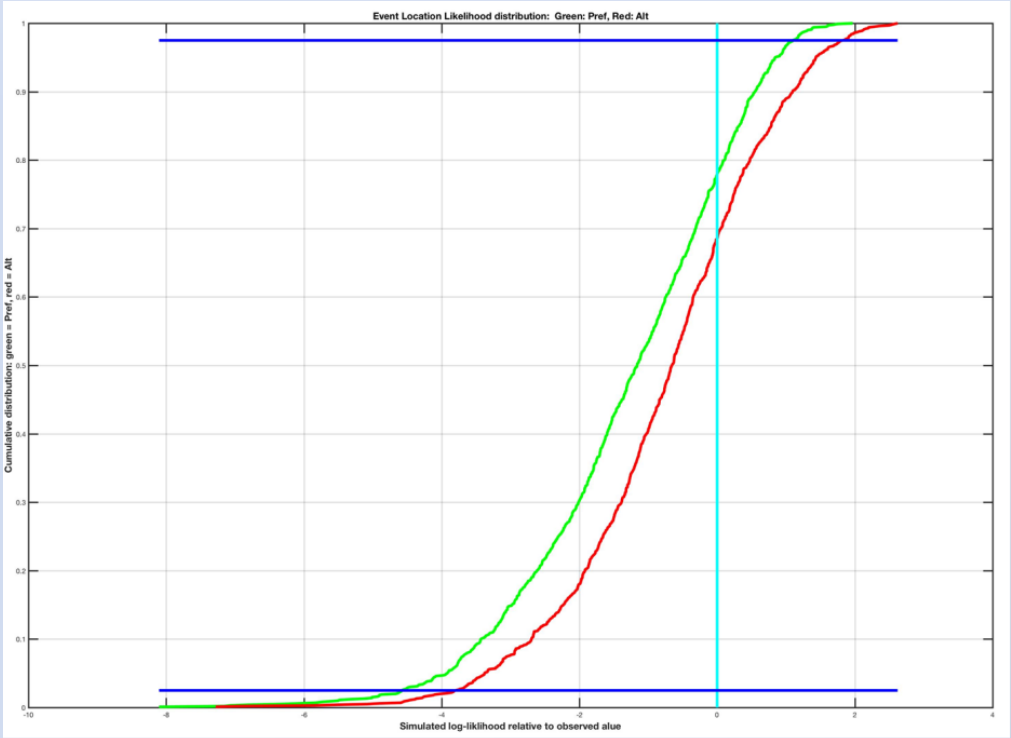
N-Test (Number of events) for Preferred model (TD, time dependent) and Alternate (TI, time independent), as well as various subsets. Red highlights indicate discrepancies expected at less than 5% probability. Lamda is the expected number of events in 22.5 years since 1995; N is the observed. Both the TD and TI models overpredict the expected number of events by a lot; the TD model performs worse. Model SoSo epresents the historical average earthquake rate; it was mentioned in the 1995 report, but was not considered a forecast model.

M-test, Magnitude distribution



M-Test: Cumulative distribution of likelihood scores for simulated 3-event catalogs following the theoreticl magnitude – frequency distribution for the Pref (Time dependent) and Alt (Time independent) models, relative to likelihood of obseved catalog. Vertical cyan line indicated likelihood of observed catalog; horizontal blue lines bound the central 95% conficence interval. Assuming Pref model, observed likelihood exceeds 8% of simulations; for Alt model, 13%. Thus both models pass, and Alt

S-test, Area distribution



S-Test: Cumulative distribution of likelihood scores for simulated 3-event catalogs following the theoretical zone probabilities for the Pref (Time dependent) and Alt (Time independent) models, relative to likelihood of observed catalog. Vertical cyan line indicated likelihood of observed catalog; horizontal blue lines bound the central 95% conficence interval. Assuming Pref model, observed likelihood exceeds 79% of simulations; for Alt model, 68%. Thus both models pass easily, and Pref model fits slightly better.

Conclusions

- Both TI and TD models over-predicted the regional total M6+ events: TD can be rejected at 95% confidence on the N-Test
- M3+ aftershocks mark rupture pretty well.
- The magnitudes of the observed earthquakes, and the zones in which they occurred, are consistent with both the TD and TI forecasts.
- In spite of generous zone widths, it's tempting (but formally not allowed) to adjust the zones. Same for characteristic magnitudes.
- Only one earthquake (Parkfield) occurred on a fault recognized in 1995.
- None of the ruptures fit the definition of a characteristic earthquake or terminated at a presumed segment boundary.
- Lessons for constructing and testing UCERF models:
  - Use broad but specific definitions of expected fault ruptures
  - Calibrate fault activity with historic seismicity