A more realistic model for the probability of large earthquakes

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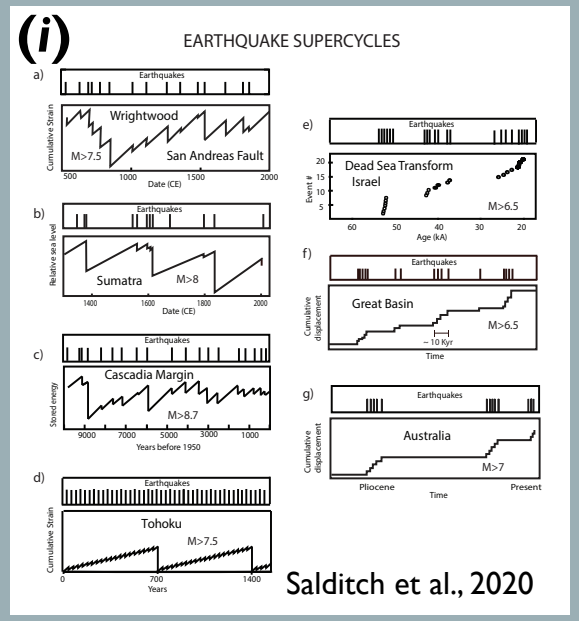
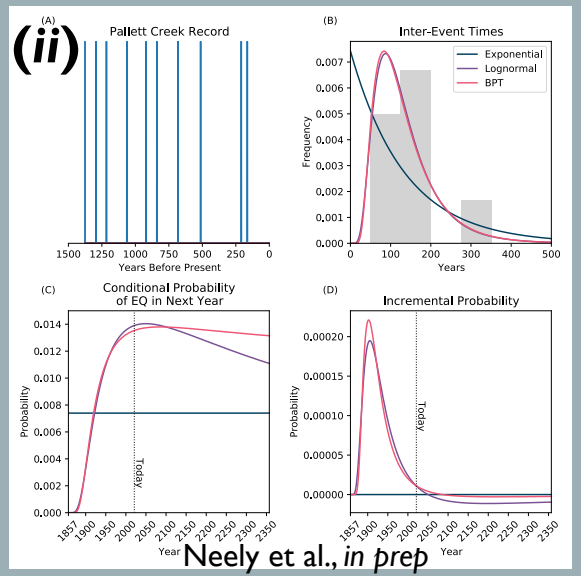
(i) Paleoseismic records contain earthquake clusters indicating supercycles of strain/energy accumulation/release in which strain **does not** drop to zero after an earthquake**.**



Salditch et al., 2020

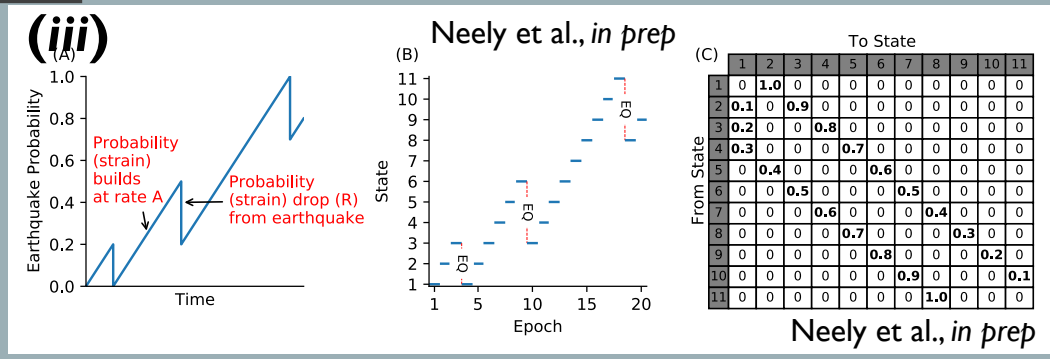
(ii) With the Pallett Creek paleoseismic record (A), we show that the current probability models do not incorporate key aspects of the strain process.

1) Current models assume all strain is released in each large earthquake so probability resets to zero after each earthquake, making inter-event times independent (B).
2) In lognormal and BPT models, earthquake probability eventually decreases with time even as additional strain accumulates (C, D).



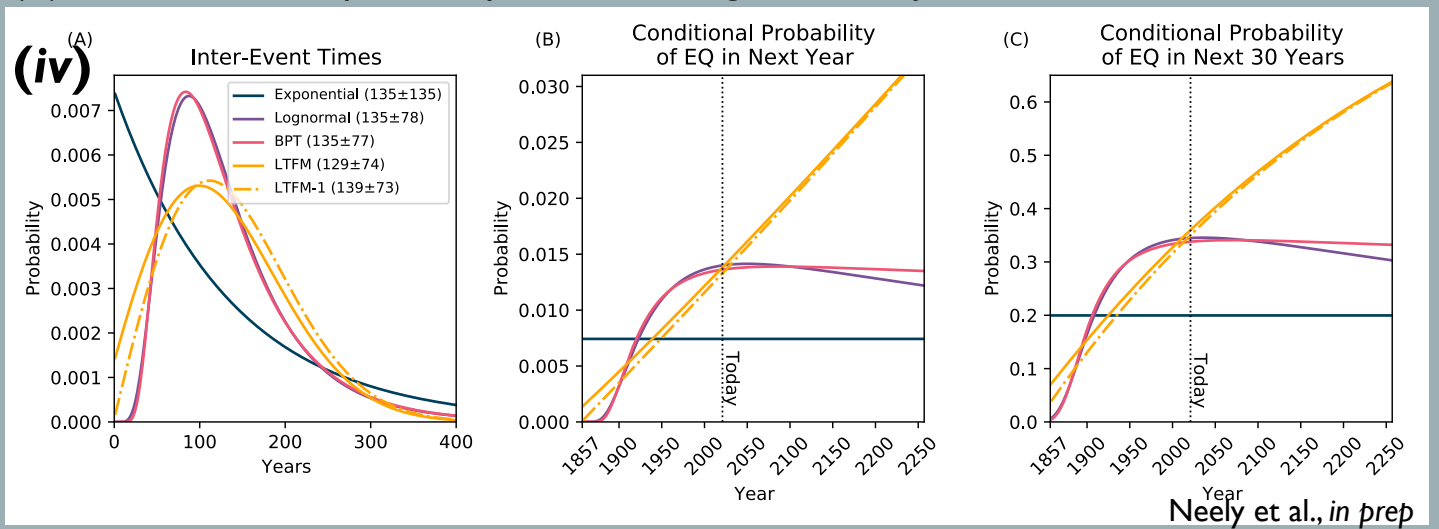
Neely et al., *in prep*

(iii) The Long-Term Fault Memory (LTFM) model (Salditch) does not suffer from these limitations (A). Earthquake probability builds at constant rate *A* and an earthquake produces partial probability drop *R*. We reformulate LTFM as a hidden Markov process (B) by discretizing earthquake probability into states and constructing a transition probability matrix (C) that indicates the probability of transitioning from state *j* to state *k*.



From State \ To State	1	2	3	4	5	6	7	8	9	10	11
1	0	**1.0**	0	0	0	0	0	0	0	0	0
2	**0.1**	0	**0.9**	0	0	0	0	0	0	0	0
3	**0.2**	0	0	**0.8**	0	0	0	0	0	0	0
4	**0.3**	0	0	0	**0.7**	0	0	0	0	0	0
5	0	**0.4**	0	0	0	**0.6**	0	0	0	0	0
6	0	0	**0.5**	0	0	0	**0.5**	0	0	0	0
7	0	0	0	**0.6**	0	0	0	**0.4**	0	0	0
8	0	0	0	0	**0.7**	0	0	0	**0.3**	0	0
9	0	0	0	0	0	**0.8**	0	0	0	**0.2**	0
10	0	0	0	0	0	0	**0.9**	0	0	0	**0.1**
11	0	0	0	0	0	0	0	**1.0**	0	0	0

Neely et al., *in prep*



Neely et al., *in prep*

(iv) We can condition LTFM on prior inter-event times (LTFM-1) instead of just when the most recent earthquake occurred (LTFM) (A). Today, the probability of an earthquake in the next 1 (B) or 30 (C) years is similar for various models (except exponential). Moving forward, the lognormal and BPT models predict probability decreases with time, but the LTFM probability increases with time. By 2100, the LTFM forecasts a 38% higher probability of an earthquake in the next 30 years.

References: Salditch et al., Earthquake supercycles and long-term fault memory, *Tectonophysics* 774 (2020); Neely et al., A more realistic model for the probability of large earthquakes, *in prep.*