Smoothing Background Seismicity

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Basic Principle: When all else fails, earthquakes tend to occur near other earthquakes

- *Kafka and Levin* (2000) found that drawing circles around 3 years of M≥3 California earthquakes such that 30% of the map was covered encompassed 60% of M≥5.0 earthquakes over the next 10 years.

Two problems:

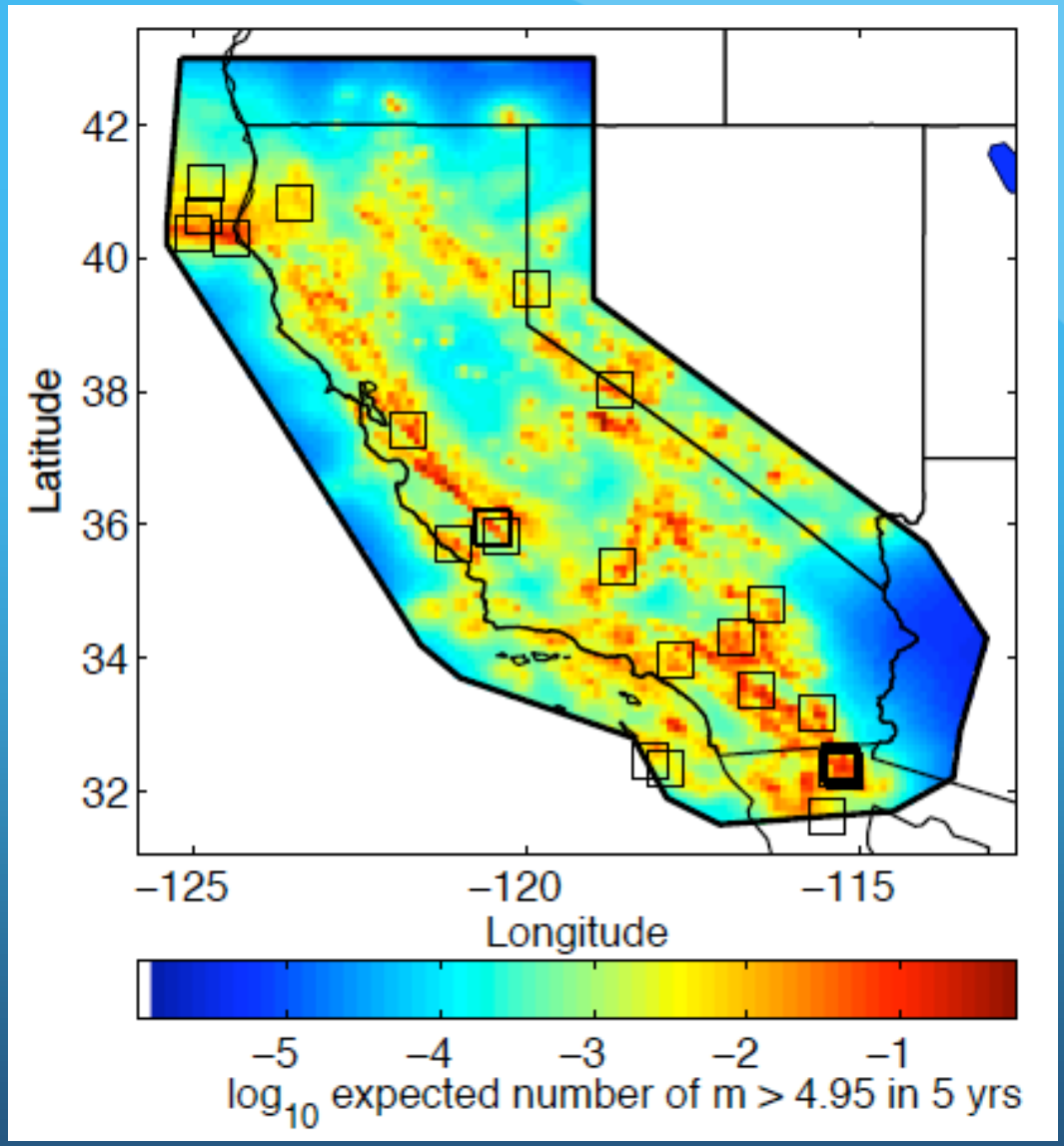
- Earthquakes occur at points or along planes; these need to be generalized into graded areas of expected earthquakes => **smoothing**
- Aftershock sequences decay quickly => over-represent where future earthquakes will occur. Thus **declustering** is required before smoothing.

Declustering methods

- National Hazard Maps (*Frankel*, 1995) uses *Gardner and Knopoff* (1975). Empirical, simple windowing technique. Removes ~60% of seismicity.
- *Werner et al*. (2009) (RELM) uses *Reasenberg (1985)*. More sophisticated, but variable parameters. Parameters chosen remove ~43% of seismicity, probably too little.
- The declustering method has significant impact on results, but the best methods/parameters have yet to be studied and optimized.

Smoothing Methods

- National Hazard Maps (*Frankel*, 1995) uses a Gaussian kernel.
- *Werner et al*. (2009) (RELM) uses Gaussian and Power law kernels.
- With parameter optimization, the two kernels produce very similar results at close/intermediate distances. *Werner et al*. (2009) finds both kernels have similar data fit.



Werner et al. (2009) forecast

Outstanding problems

- Declustering technique needs to be optimized; very difficult problem.
- Where and how many aftershocks will occur not adequately forecast – stay tuned!
- Is there any way to better forecast where the “surprises” will occur?