Applicability of ETAS

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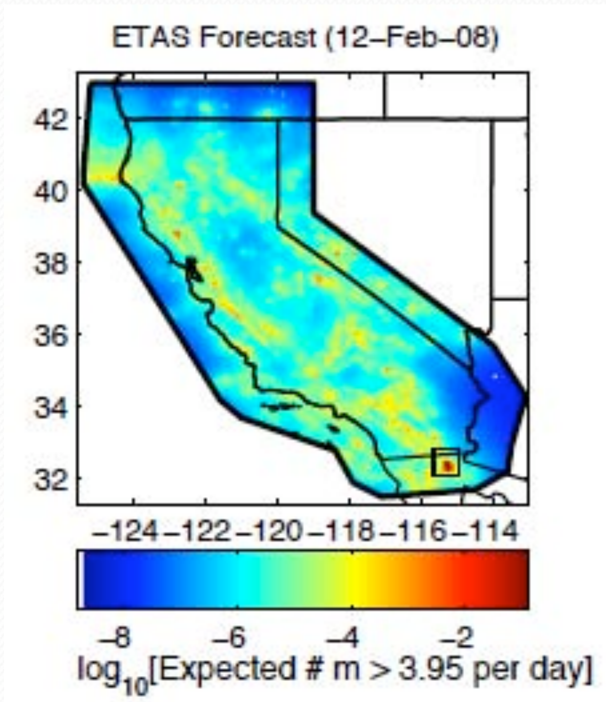
What is ETAS?

- A stochastic simulator of background + aftershock seismicity based on empirical laws. Different authors generally use different “flavors” of the model, and different parameters.
- ETAS generally assumes independence between mainshock and aftershock magnitude.
- Multiple ETAS simulations generate an empirical CDF of expected seismicity rates – different from STEP, which only generates an average.

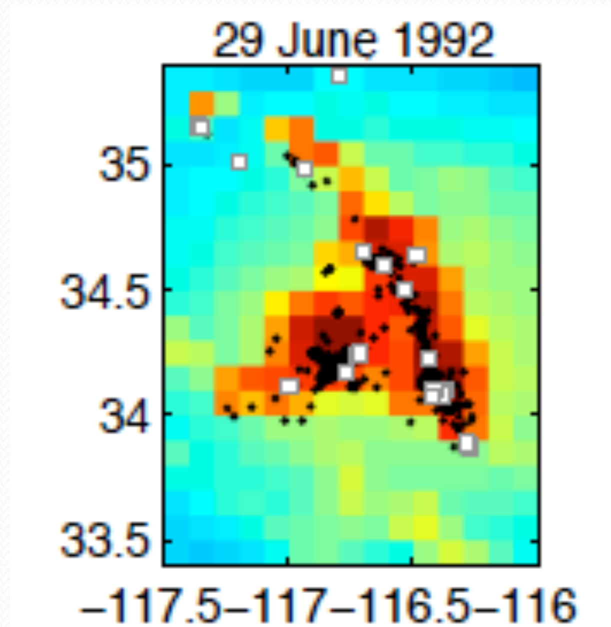
Why use ETAS?

- Good results without physical models and parameters.
- *Werner et al*. (2009) find an average gain of 6 of the ETAS model, updated every 24 hours, vs. a smoothed seismicity Poissonian model. Updating immediately after large events should substantially improve the gain.
- Outside of geothermal areas, aftershock triggering is the only definite time-dependent component of seismicity
- >60% of earthquakes, of all magnitudes, are aftershocks.

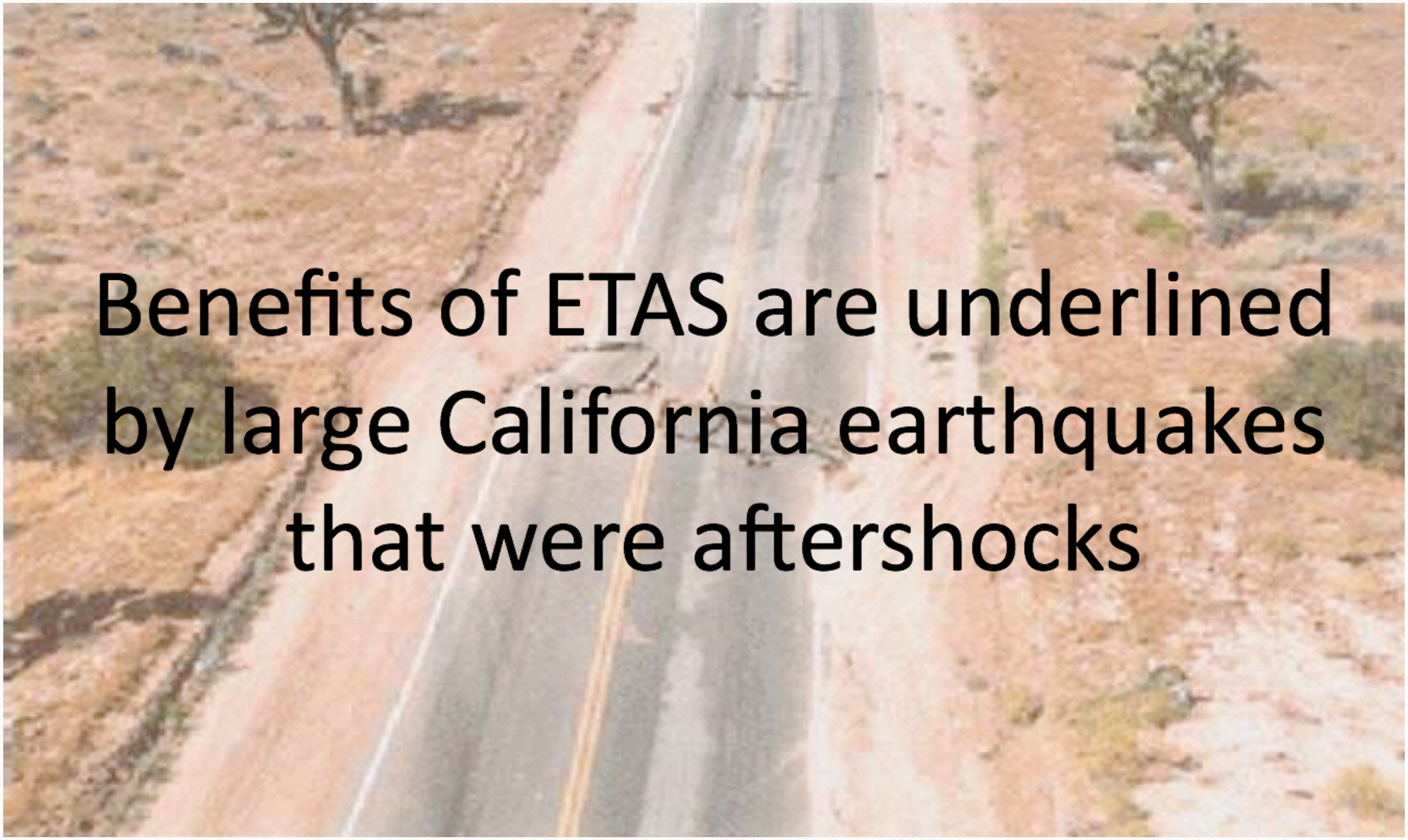
Examples of ETAS forecasts



Feb. 12, 2008 forecast by *Werner et al*. (2009). Black squares where $M \geq 3.95$ occurred.

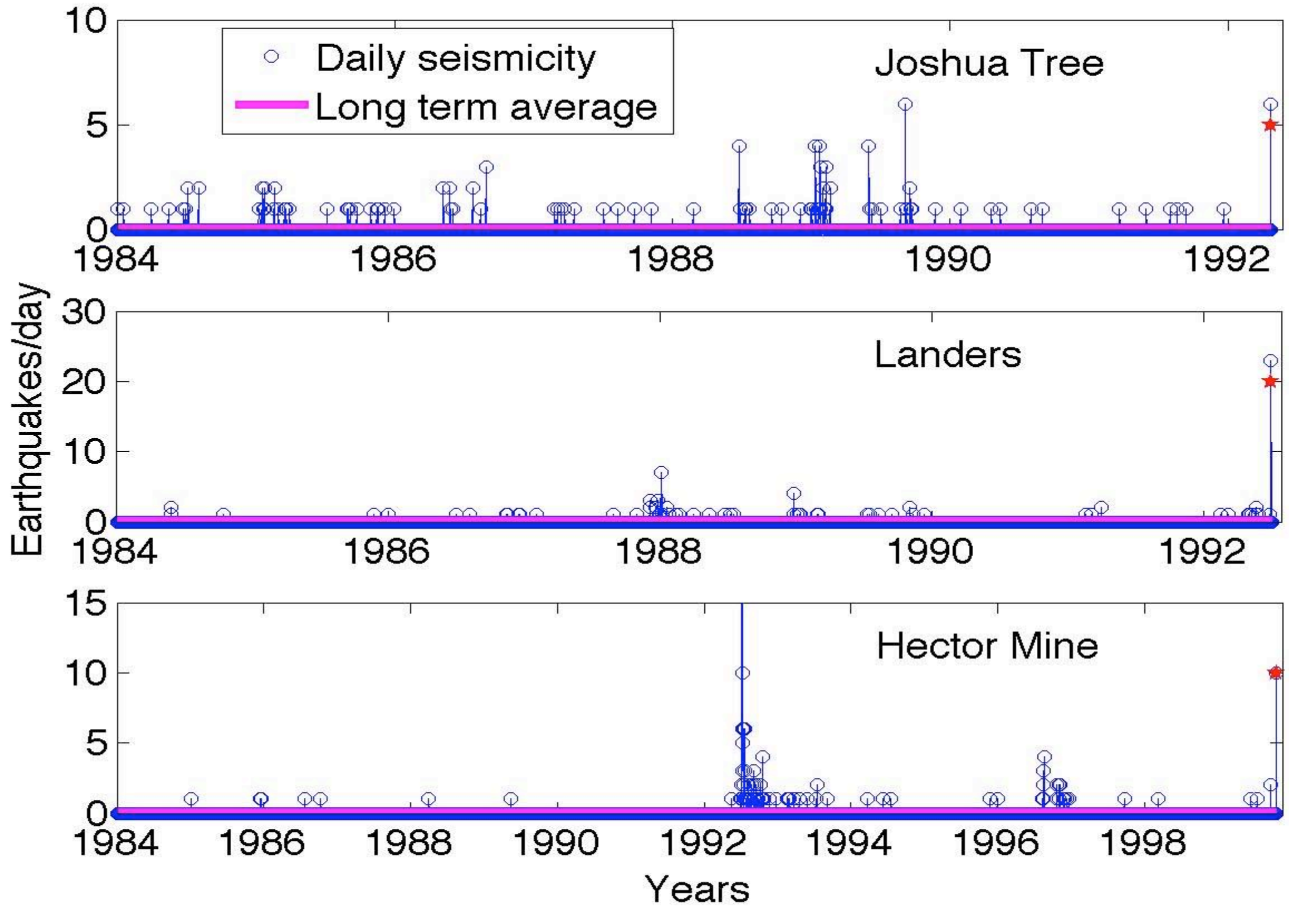


ETAS forecast for Landers aftershocks, made with 24 hours of post-mainshock data by *Werner et al.* (2009)

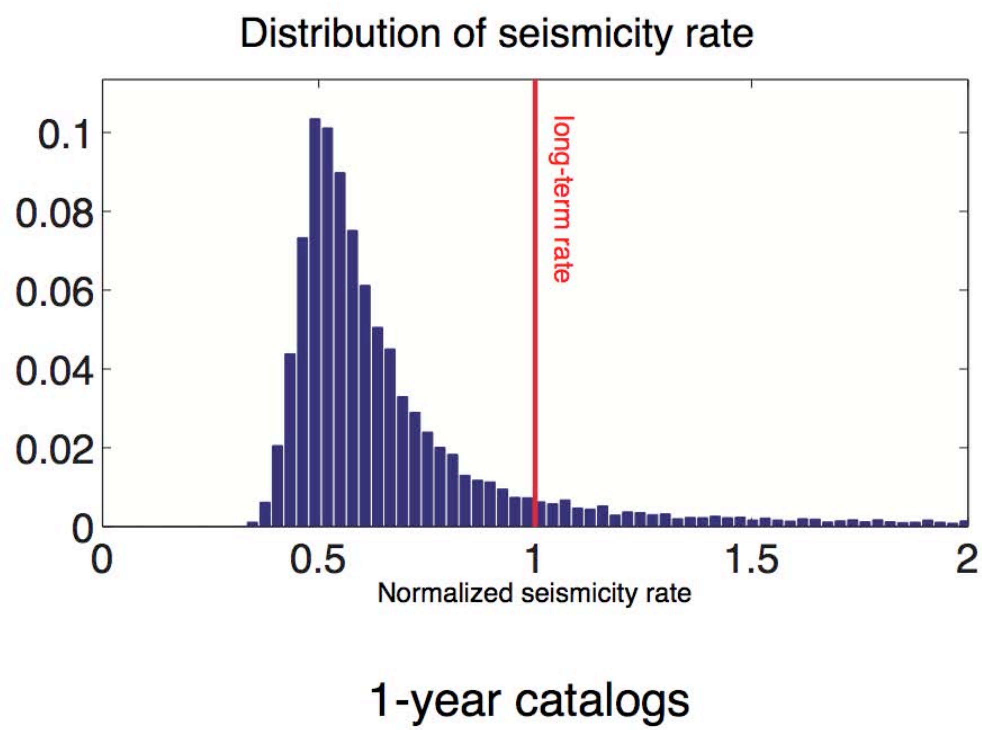


1992 M 7.3 Landers earthquake, SCEC photo

Landers earthquake series is prime example: Forecasting gains of real time ETAS vs. Poissonian probably ~6—20 times



ETAS simulations also have the advantage of illustrating the full range of possible behaviors, rather than just the expected average rate



ETAS simulations of 1 year catalogs around the Southern San Andreas, courtesy of Morgan Page

ETAS problems and challenges

- ETAS parameter determination is extremely difficult. I am not aware of an existing automatic method that produces accurate results.
- ETAS codes are generally run with minimum magnitudes > true Mmin for tractability, but this requires approximations.
- Running many ETAS simulations, especially down to low Mmin or over long periods of time, can be heavy on computing resources.
- A good ETAS simulation requires accurate background rates.

Conclusions

- ETAS is a stochastic numerical simulator that uses empirical laws to model background earthquakes + aftershocks. With frequent updating forecasting gains of at least ~6 can be realized over constant rate forecasts.
- ETAS is clearly useful in the forecast of both large and small earthquakes.
- Practical challenges in ETAS application include parameter determination and computer time.