Non-ETAS Rate Changes

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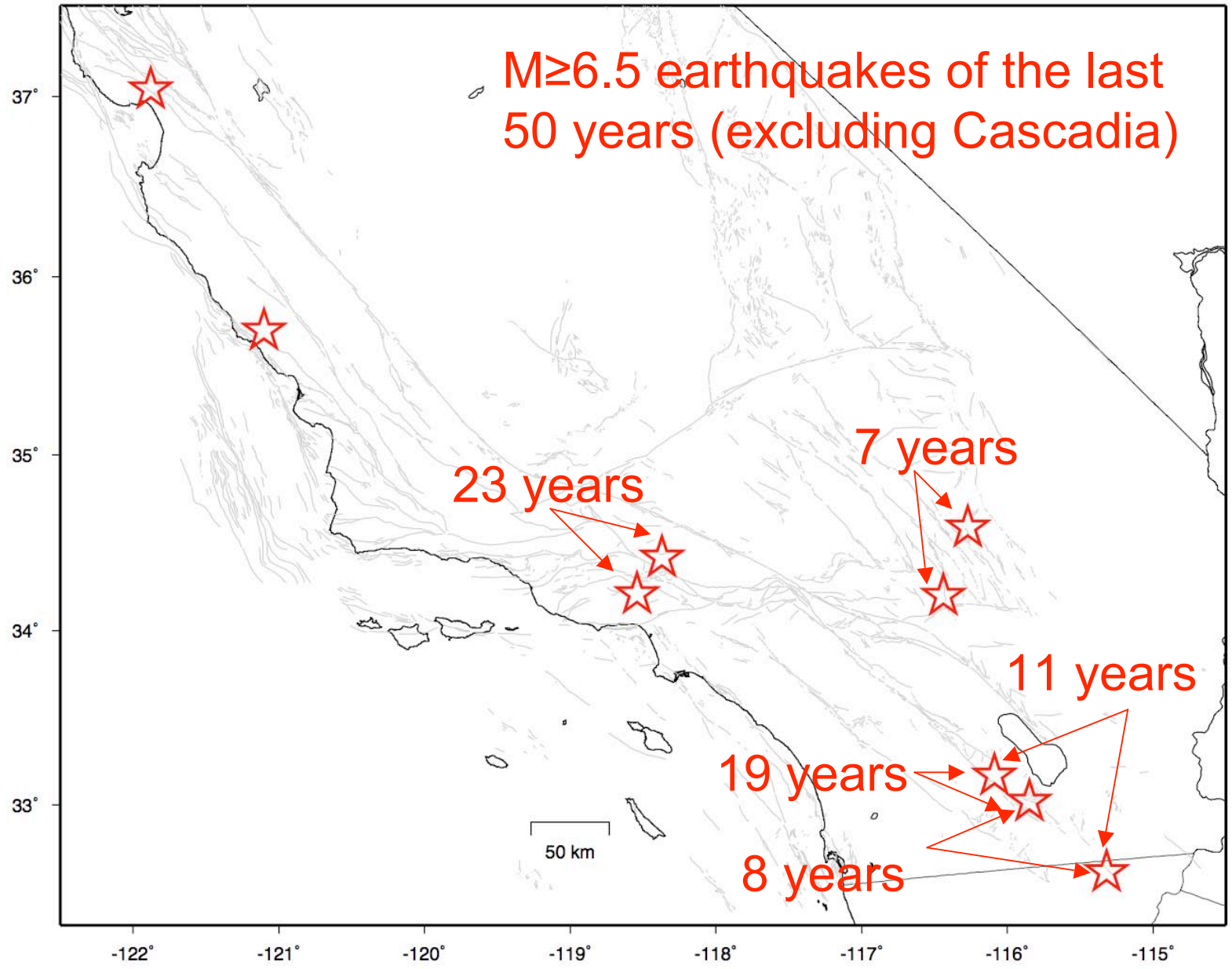
Decade-scale clustering of large earthquakes: the double-branching model


M≥6.5 earthquakes of the last
50 years (excluding Cascadia)
23 years
7 years
11 years
19 years
8 years
50 km
37°
36°
35°
34°
33°
-122°
-121°
-120°
-119°
-118°
-117°
-116°
-115°

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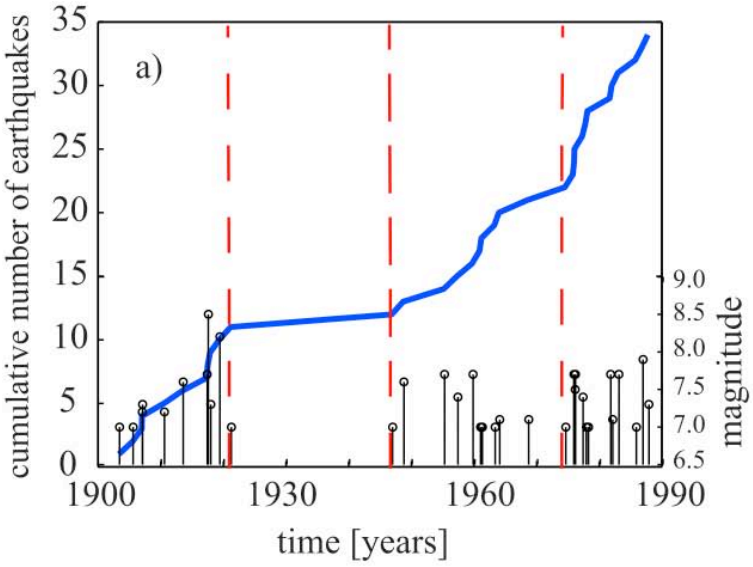
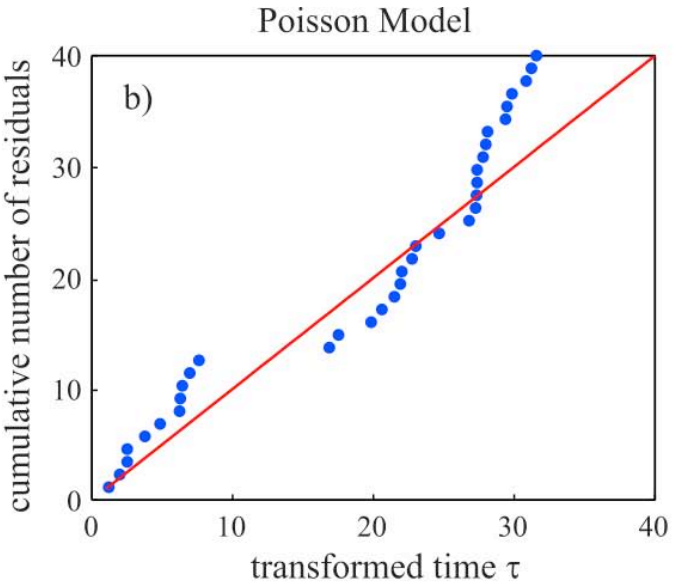
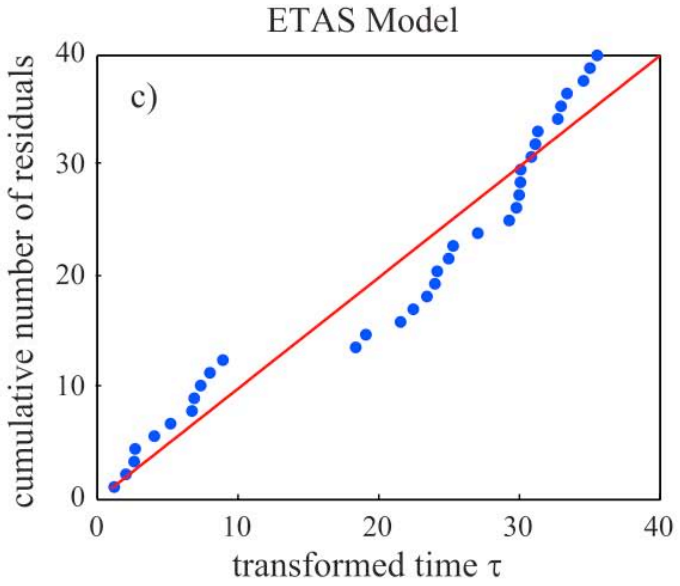
Tonga-Kermadec

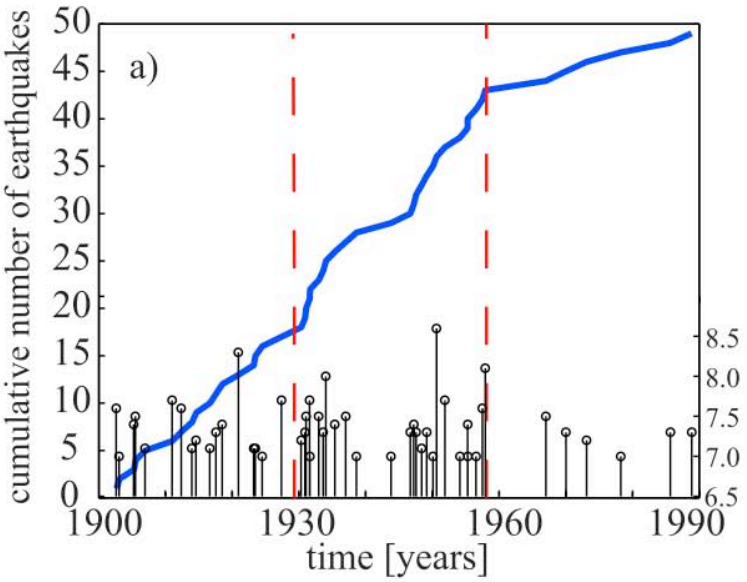


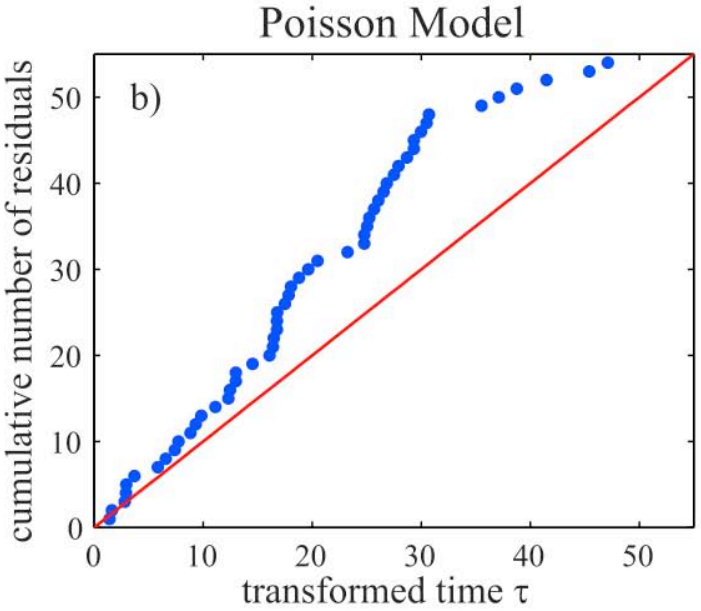


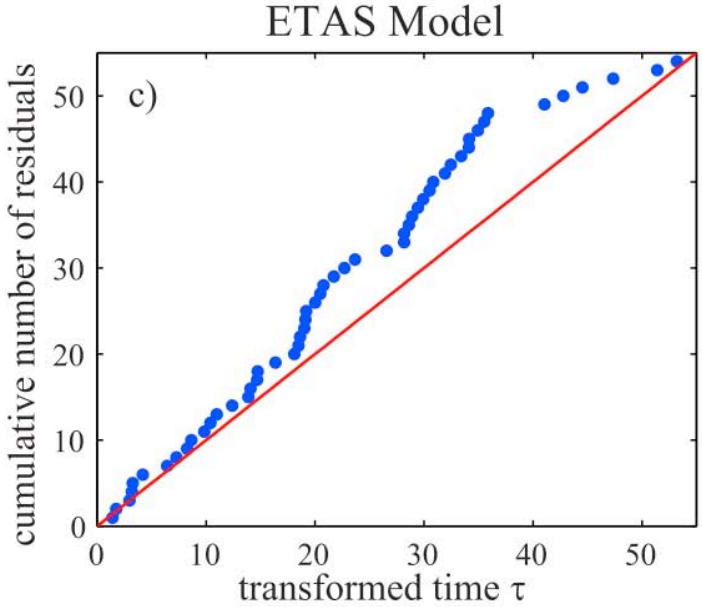


Lombardi & Marzocchi, 2007

India - Central Asia







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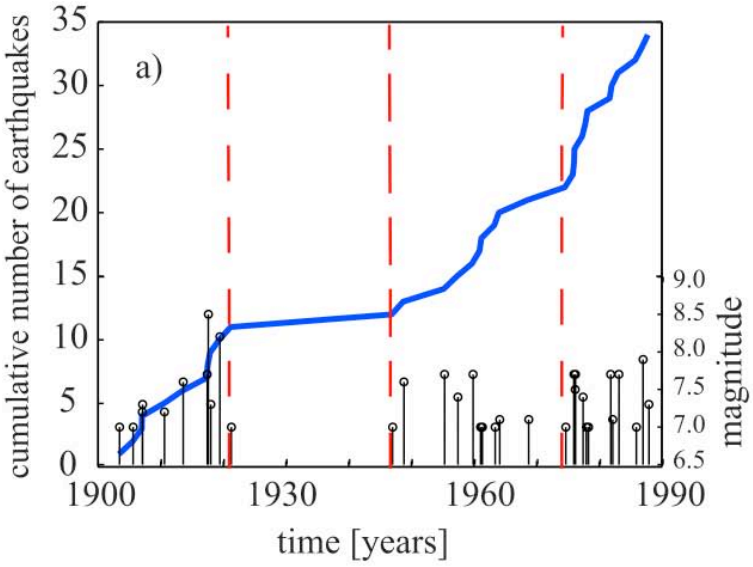
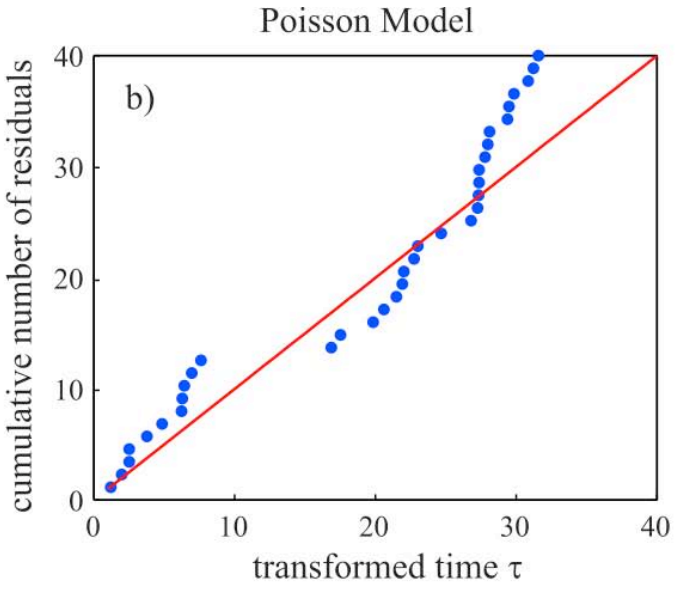
How should the decade-scale non-ETAS time dependence be represented?

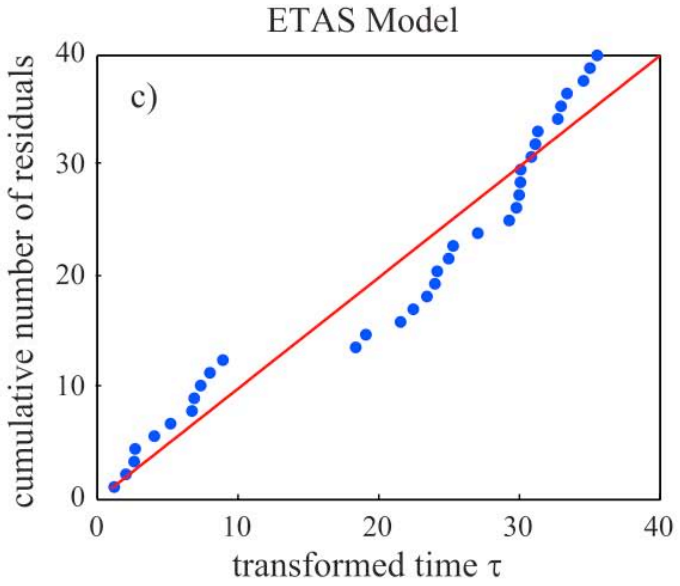
- Time-varying background rate.

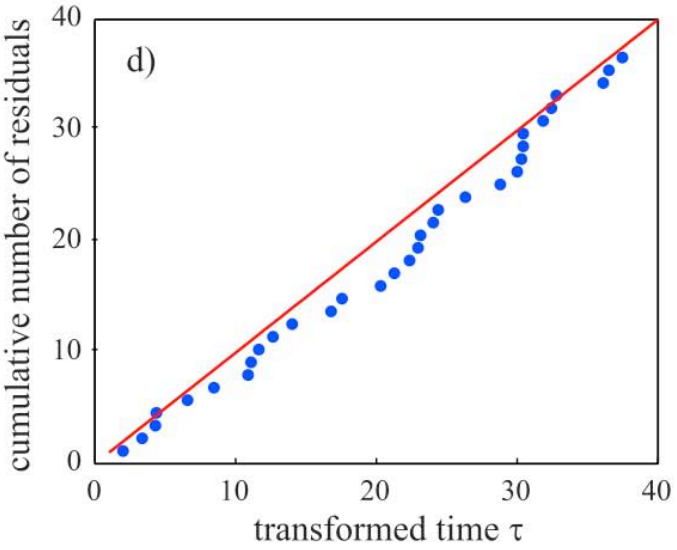
Tonga-Kermadec





Varying background rate ETAS model





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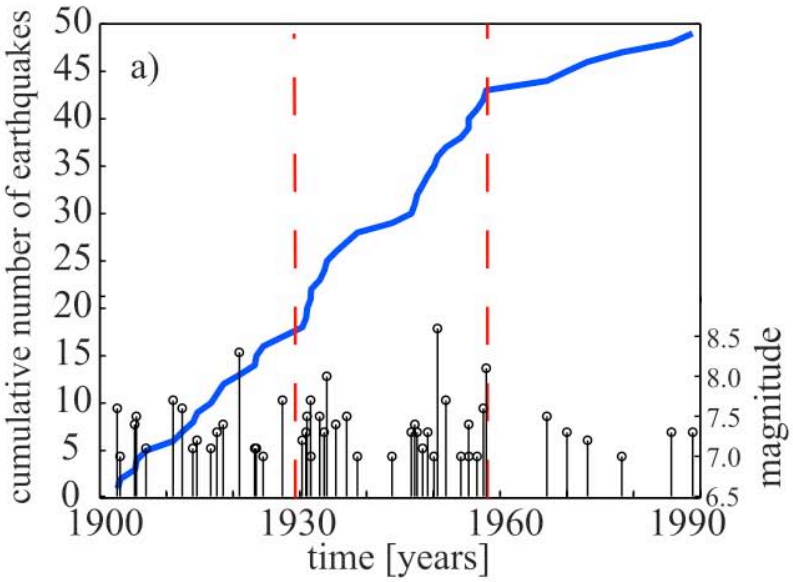

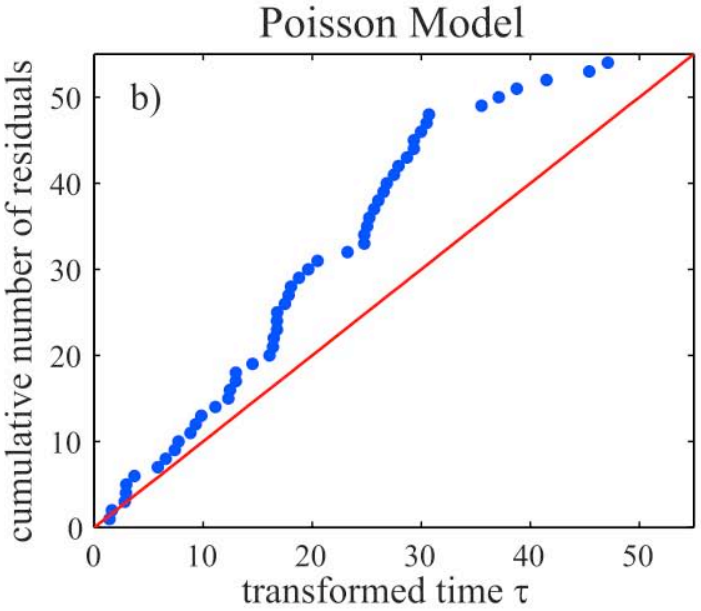

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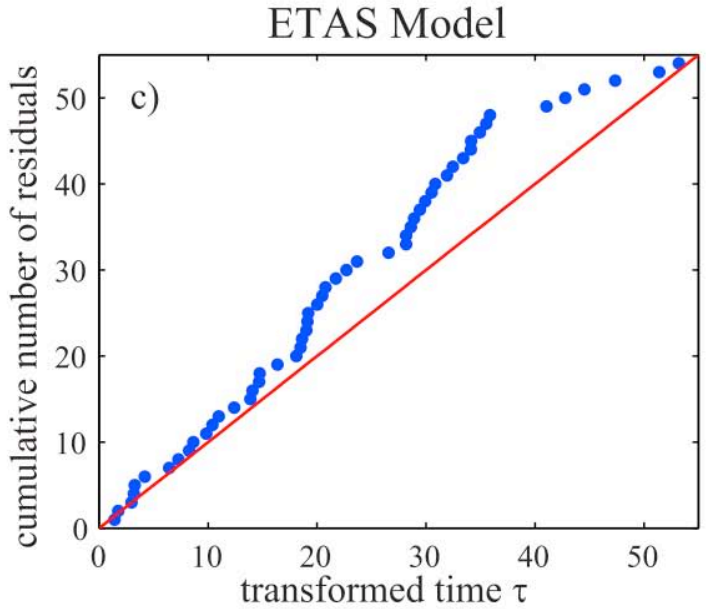

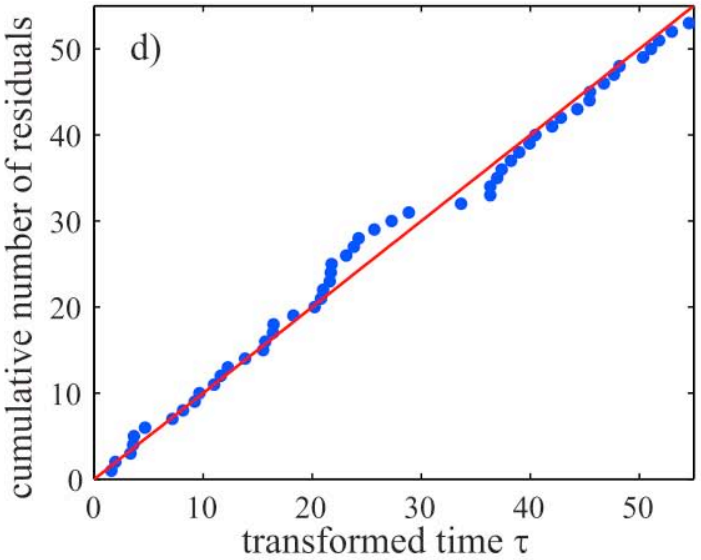

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- Double-branching model (*Marzocchi & Lombardi*, 2008)

    - Second layer of branching in addition to ETAS.

    - Can be used in forecasting, updated with new events, like ETAS.

Double-branching model (*Marzocchi & Lombardi*, 2008).

First Branching:

- Fit power-law decay (ETAS) to full dataset:

$$\lambda(t,x,y) = \lambda_0(x,y) + \sum_{t_i<t} \frac{K}{(t-t_i+c)^p} \times F(M_i) \times F(space)$$

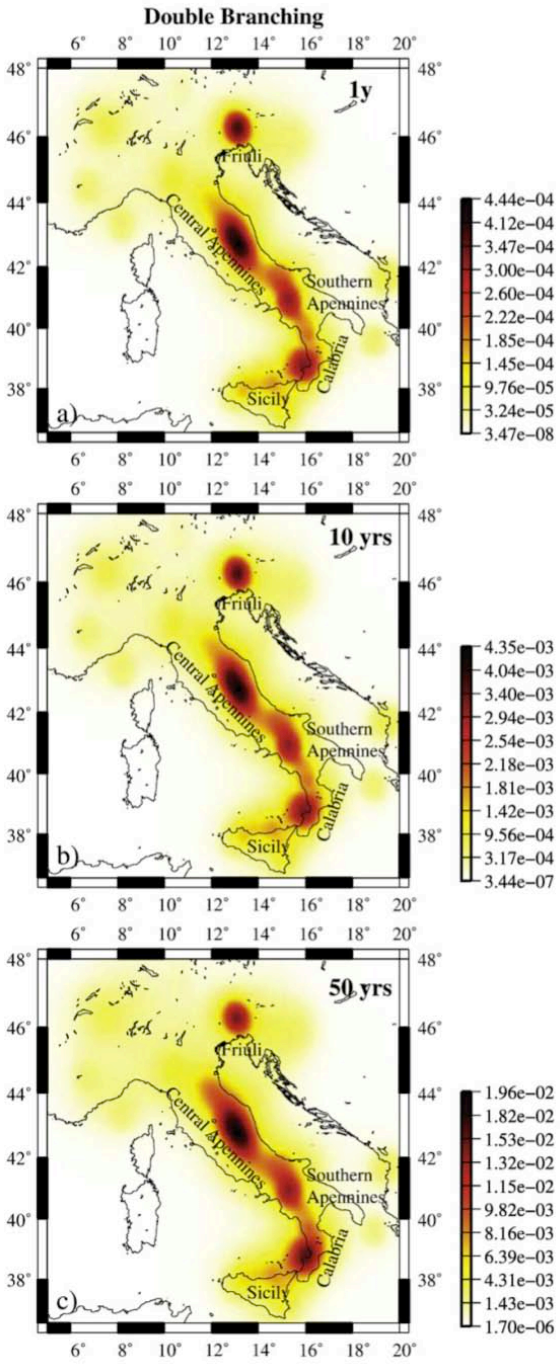
- Decluster: remove earthquake with high ETAS probability of being triggered events.

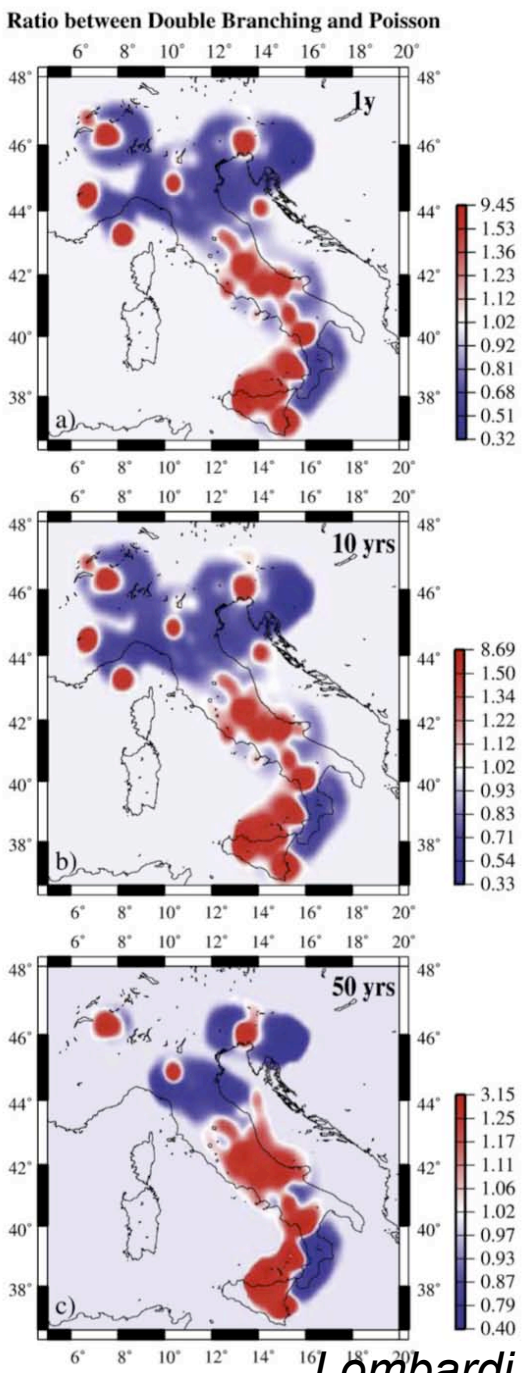
Second Branching:

- Fit exponential decay to ETAS-declustered dataset:

$$\lambda(t,x,y) = \lambda_0(x,y) + \sum_{t_i<t} K \exp\left(-\frac{t-t_i}{\tau}\right) \times F(M_i) \times F(space)$$

- Characteristic time-scale, perhaps related to postseismic relaxation. Found to be ~30 years for both global M≥7 catalog and Italian M≥5.5 catalog.





Lombardi & Marzocchi, 2009

Apply a double-branching-type model to California?

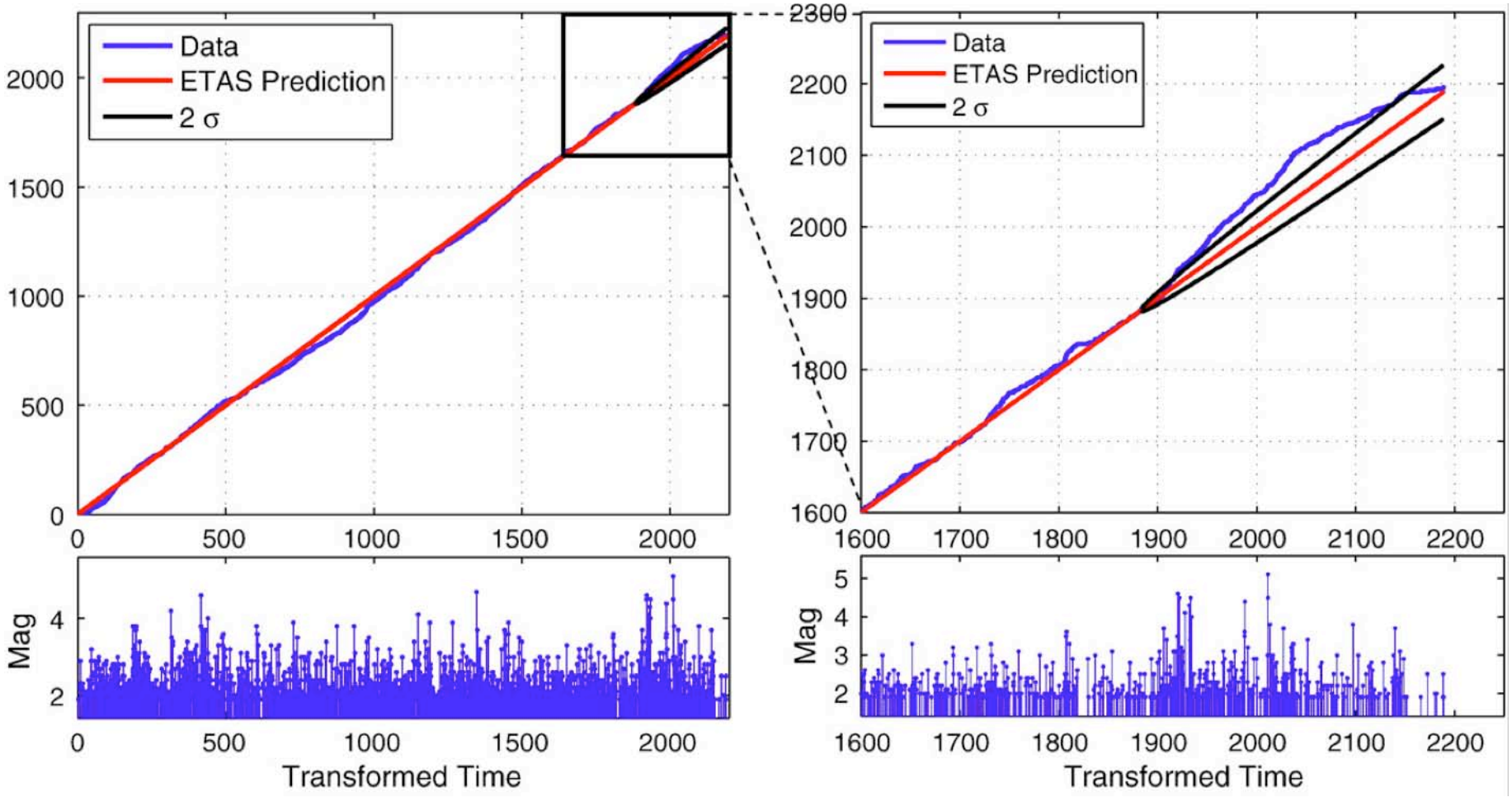
- Is clustering in California described sufficiently well by ETAS-like models?

- If not, what does the residual non-Poissonian behavior look like and what's the best form to describe it? Is the double-branching model's exponential decay the best time function?

- The need for the empirical model implies that there is long-term behavior not captured by ETAS-like models. But, if it represents a stress shadow or a true background rate change, a clustering model is probably not the best way to represent it.

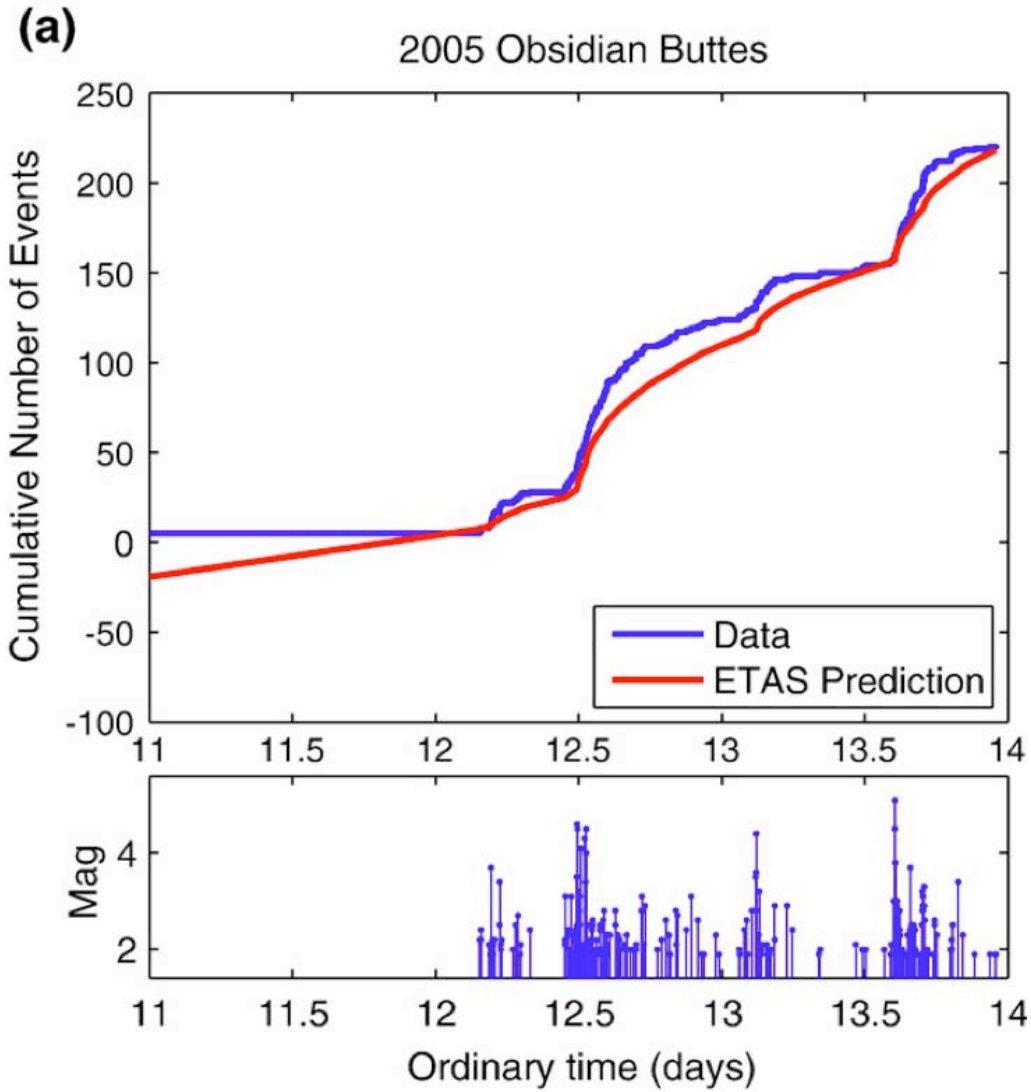
Earthquake Swarms

2005 Obsidian Buttes (Salton Trough) swarm



Llenos, McGuire, Ogata, 2009

Increase background rate by ~7000 times -> change in loading rate.



Llenos, McGuire, Ogata, 2009

How to model swarms?

- Driven by changes in loading rate. Can we detect and model changes in background rate quickly enough for useful forecasts?

- Can we approximate swarms with an ETAS-like model without a background rate change? Each swarm event has model aftershocks, keeping the modeled rate high - is this a good enough approximation of a background rate change for practical purposes?