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Vienna, Austria & Online | 23–27 May 2022

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Are initial phases of seismic swarms driven by a cascade of events or precursory slow slip?

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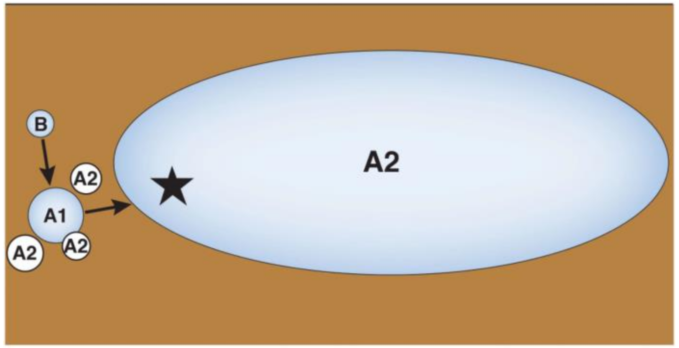
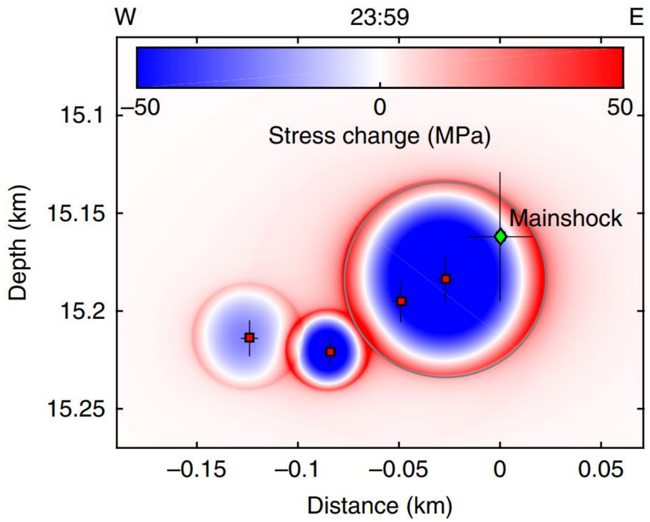
There are two leading hypotheses for earthquake nucleation.

Cascading model

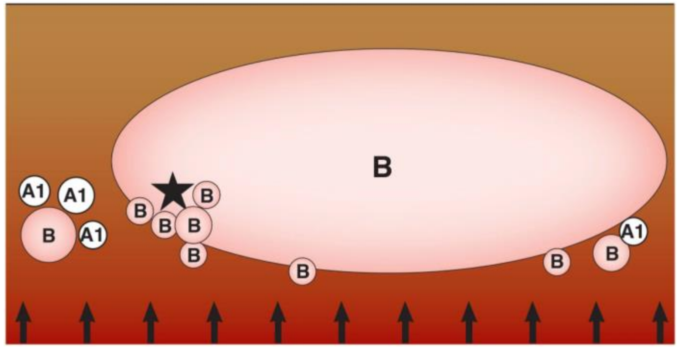


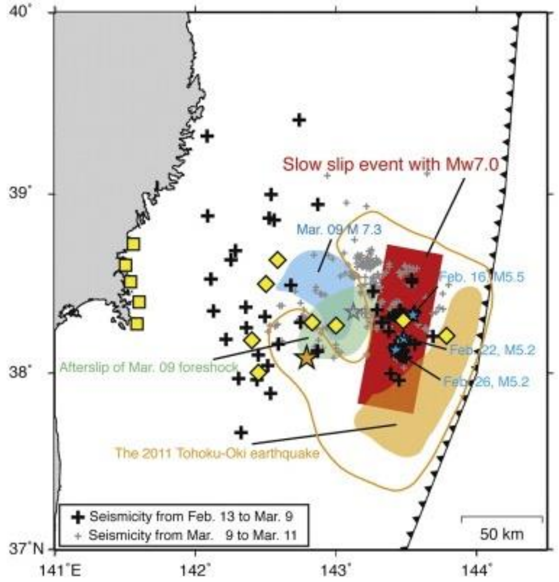


1999 Izmit earthquake

- Fore-shock
- Main-shock

Pre-slipping model





2011 Tohoku-Oki earthquake

- Slow slip
- Main-shock epicentre & rupture

Mignan, *Science Report*, 2014; Gomberg, *Nature*, 2018; Ellsworth and Bulut, *Nature*, 2018; Ito et al., Tectonophysics, 2013.

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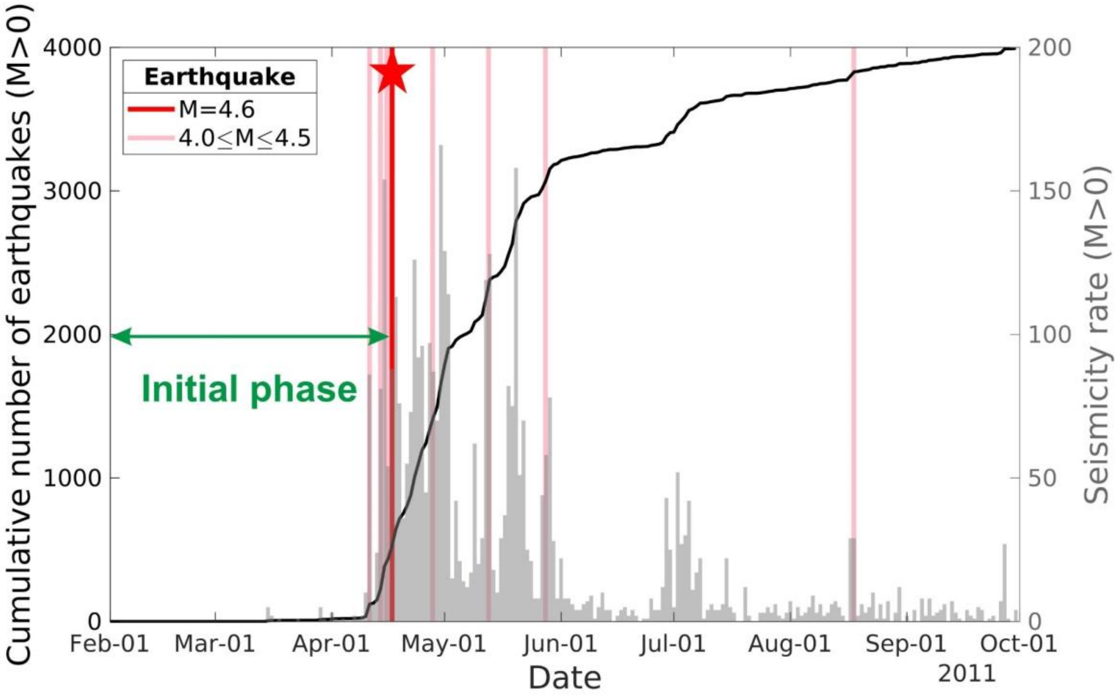
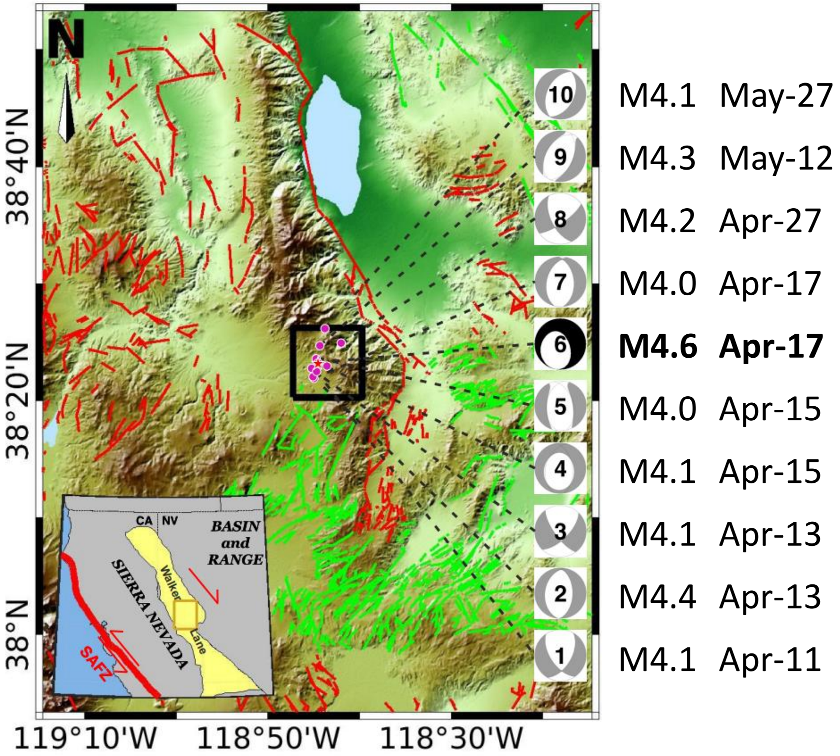
How could we make advances to this debate?

Initial phases of seismic swarms



Example: 2011 Hawthorne (Nevada) shallow seismic swarm



Jiang, Y., Samsonov, S. and González, P. J., *JGR*: *Solid Earth* (under review).

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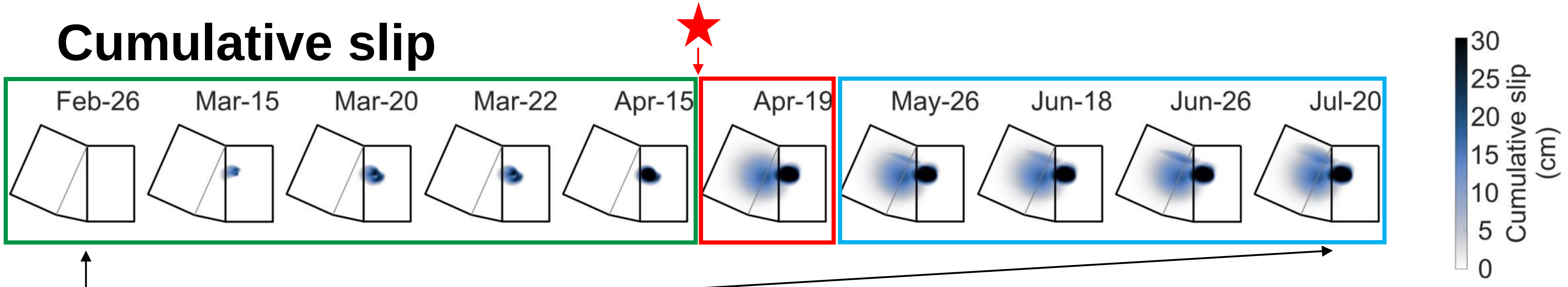
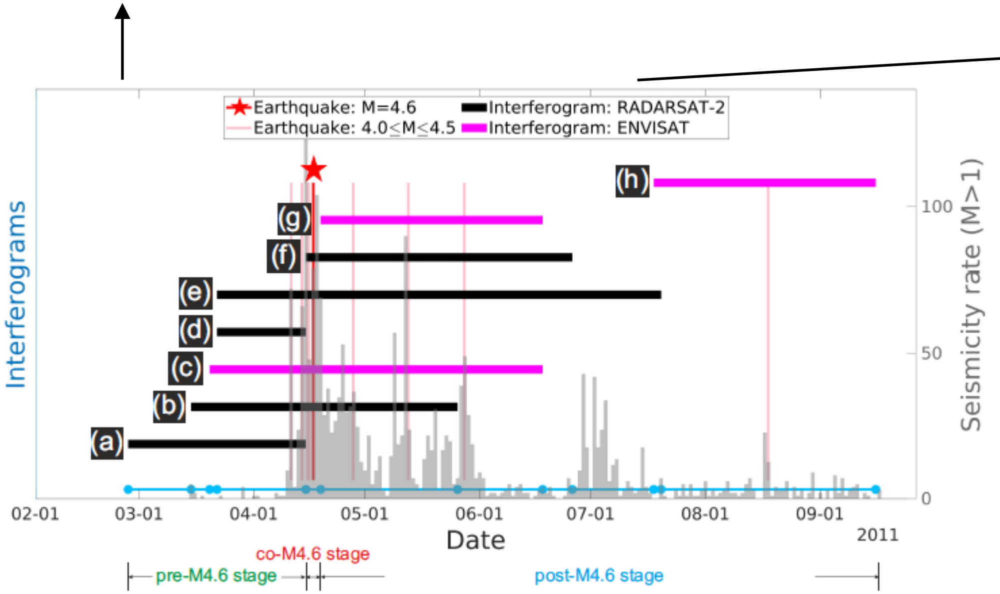
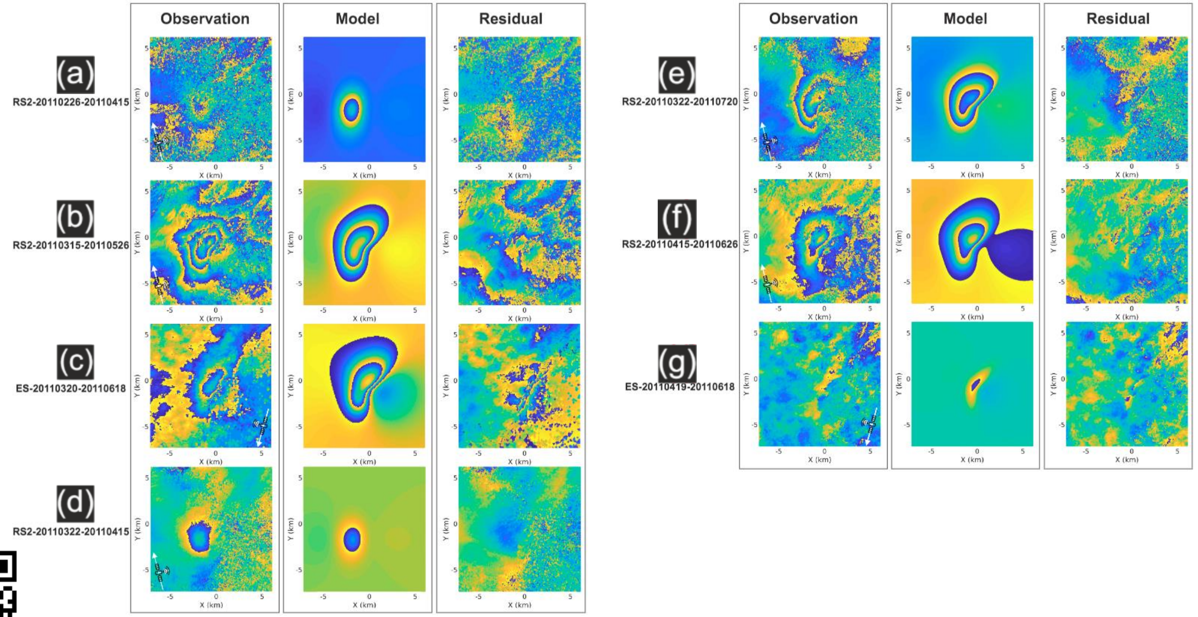
Fault slip evolution is constrained by the surface displacement.

Cumulative slip







Jiang, Y., Samsonov, S. and González, P. J., *JGR: Solid Earth* (under review).

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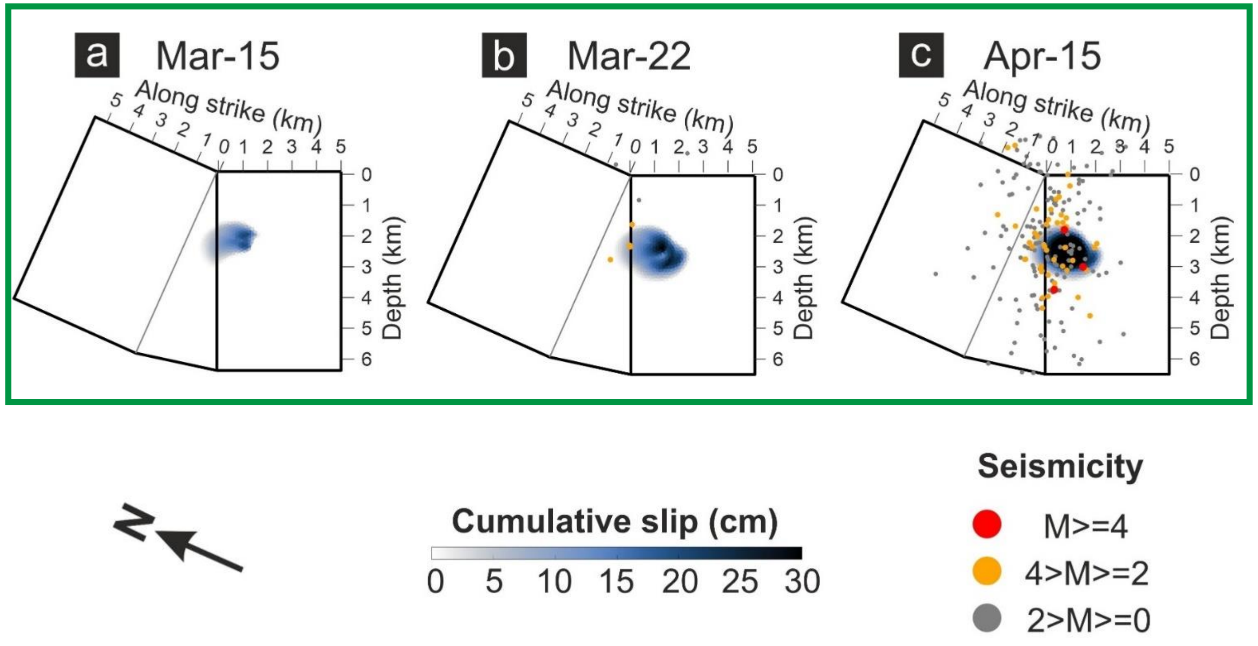
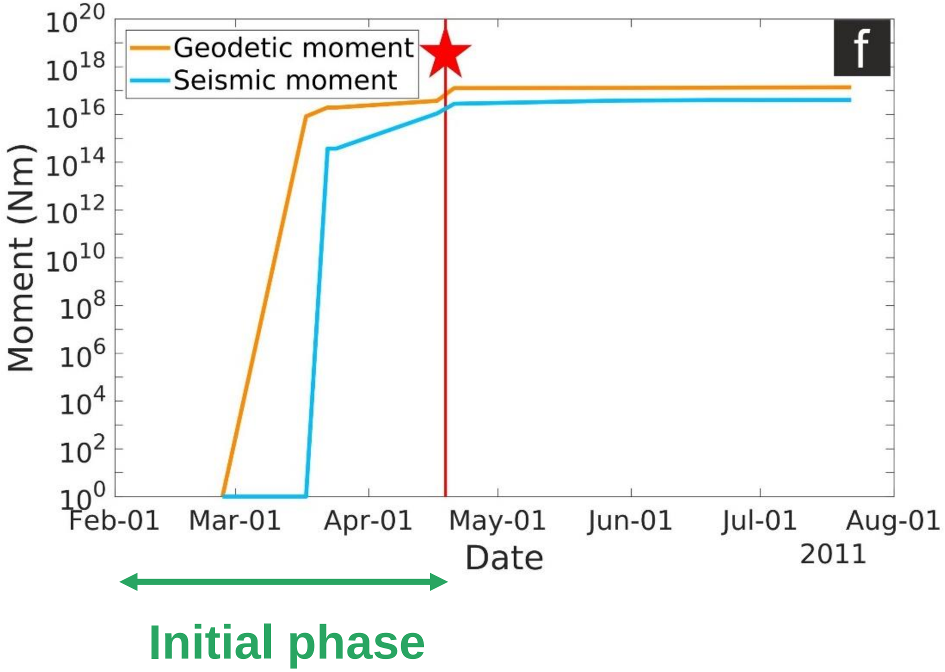
During the initial phase, aseismic slip dominated the fault behaviour, because geodetic moment >> seismic moment.

Cumulative slip

Initial phase



Moment release



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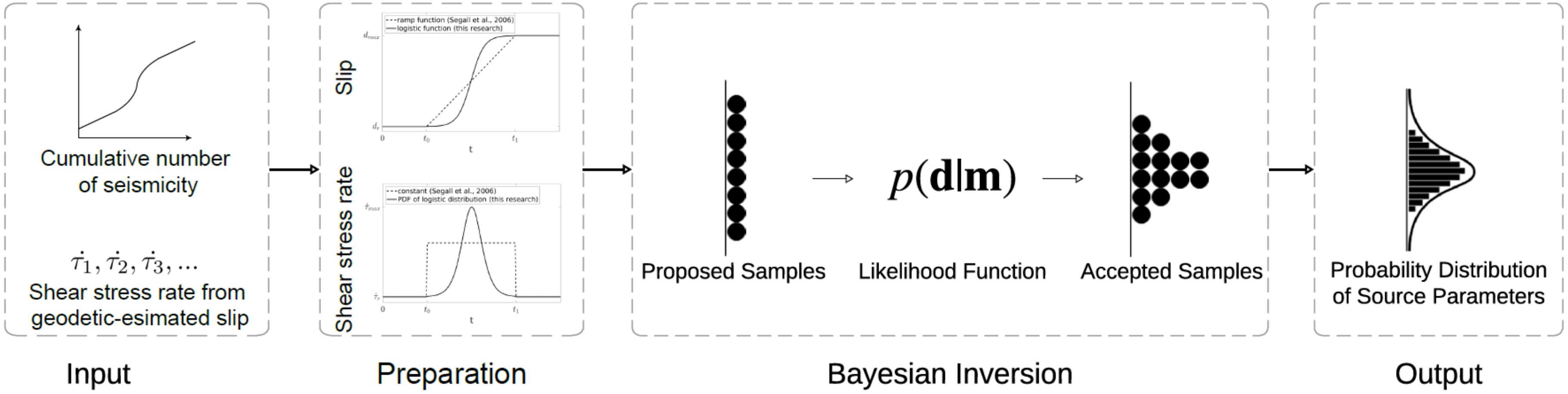
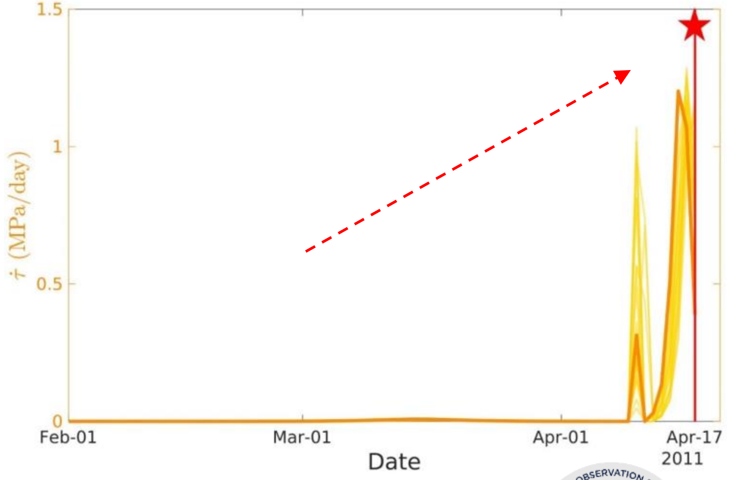
The modelled slow slip is accelerating during the initial phase.

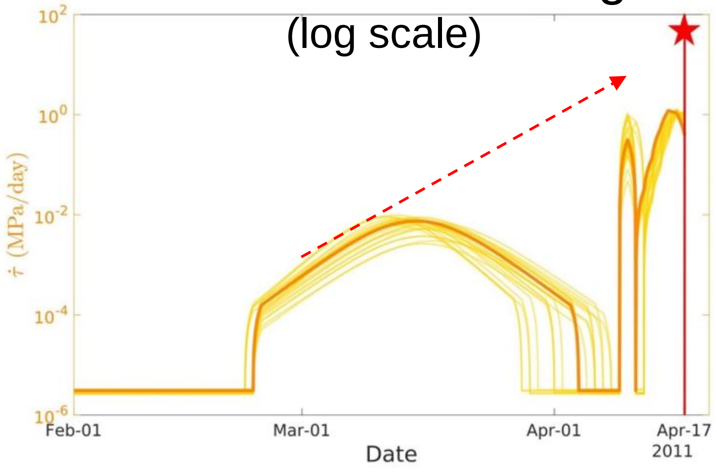
Framework



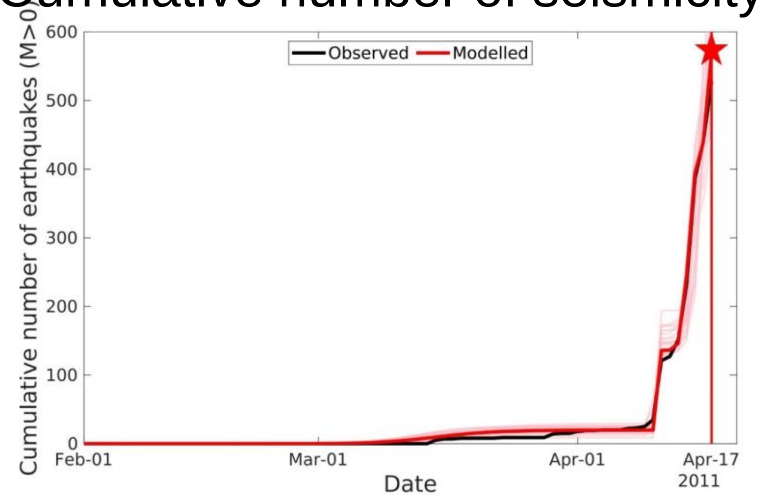
Modelled shear stressing rate



Modelled shear stressing rate
(log scale)



Cumulative number of seismicity



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Jiang and González, *JGR*, 2020; Segall et al., *Nature*, 2006; Jiang and González, (in prep.)

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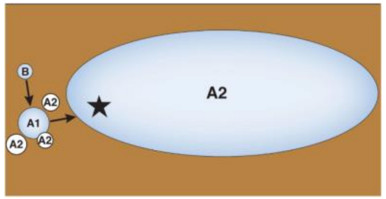
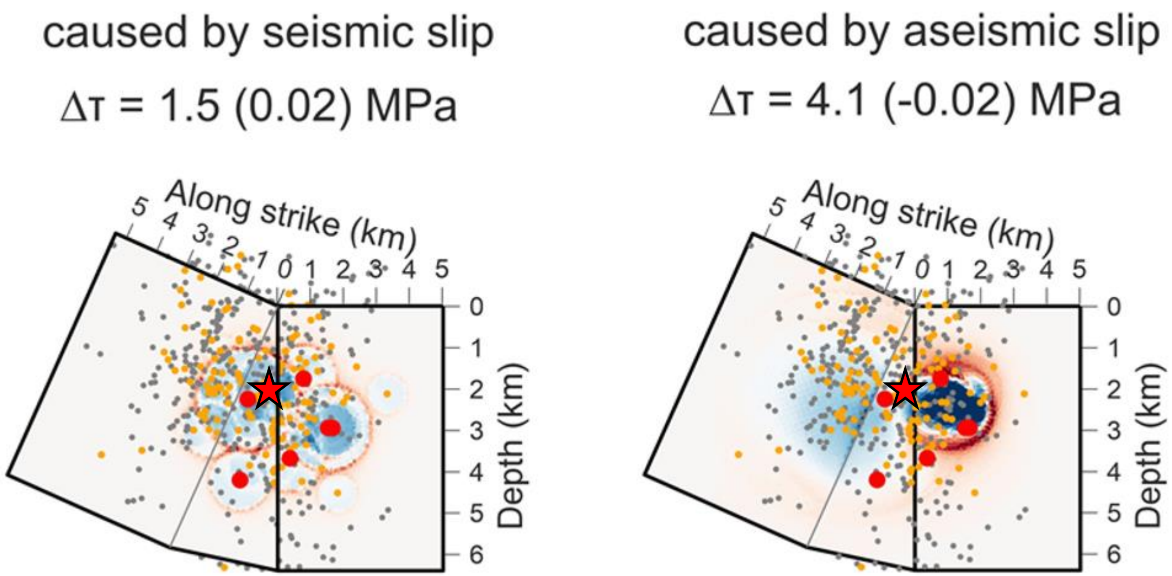
The largest M4.6 event could be triggered by a slow slip, nearby preceding seismicity, or both of them.

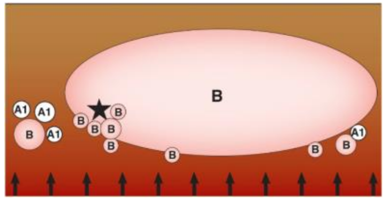
Cascading model



Coulomb shear stress change on the M4.6 event



Pre-slipping model



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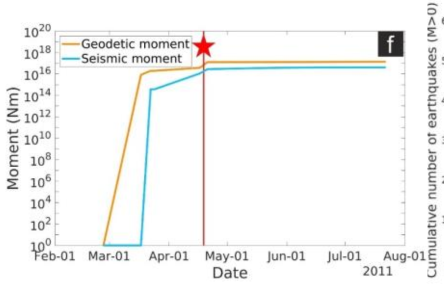
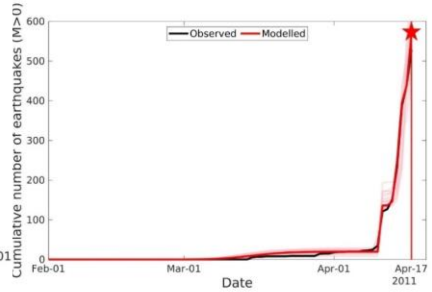
Take-home message:

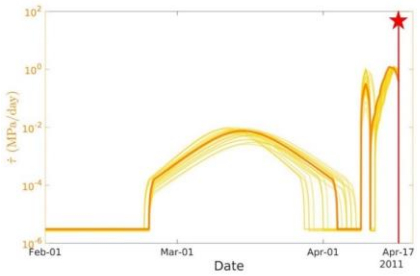
(1) A slow slip event is required to explain the observed deformation and seismicity, and the cascade model alone cannot explain the deformation.

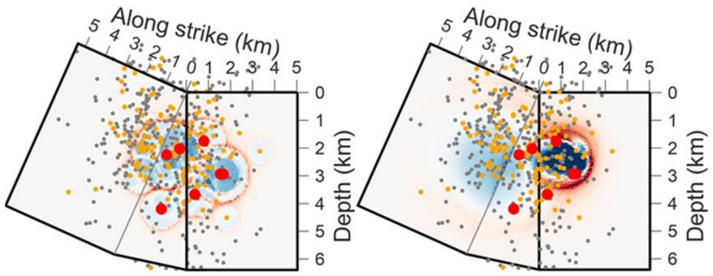
(2) The geodetic slip and the seismicity rate is connected via a modified rate-and-state frictional law. The modelled slow slips accelerate during the initial phase.

(3) The most energetic event (M4.6) could have been triggered by a slow slip event, nearby preceding seismicity, or both of them.









Jiang, Y., Samsonov, S. and González, P. J. Aseismic fault slip during a shallow normal-faulting seismic swarm constrained using a physically-informed geodetic inversion method. *JGR: Solid Earth* (under review)

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