Rupture Cycles on a Multiscale Rough Fault

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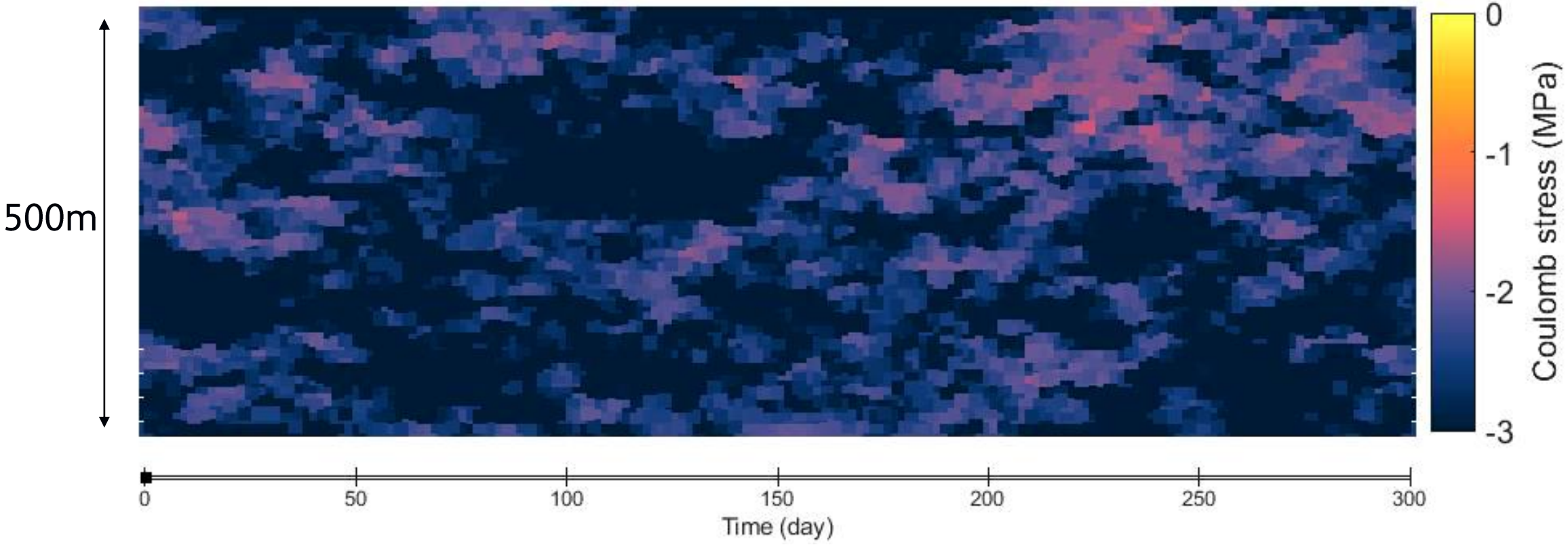
UNIVERSITÉ CÔTE D'AZUR

TNO innovation for life

What is the effect of fault roughness on seismicity?



Others looked at it already… but effect of fault roughness was masked by other modelling ingredients…

Effects of Fault Roughness on Coseismic Slip and Earthquake Locations

A. A. Allam[1], K. A. Kroll[2], C. W. D. Milliner[3], and K. B. Richards-Dinger[4]

→ Rate & State friction

Additional shear resistance from fault roughness and stress levels on geometrically complex faults

Zijun Fang[1] and Eric M. Dunham[2,3]

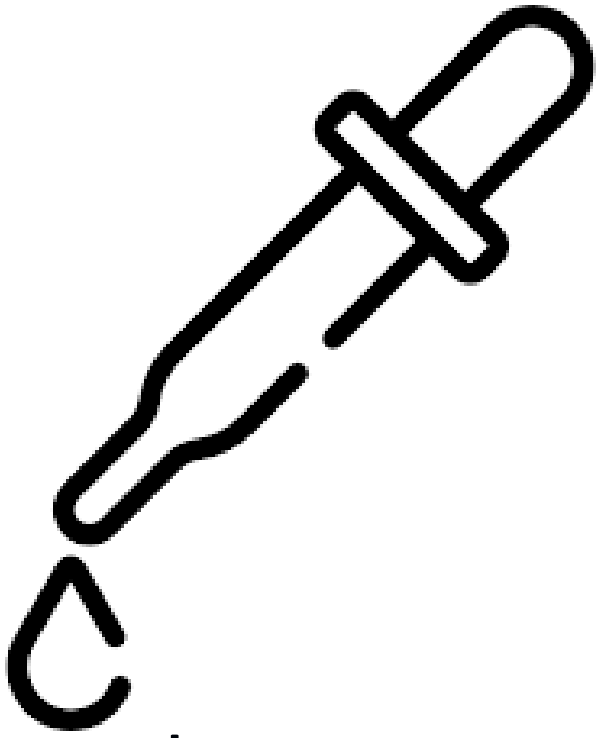
→ 2D
Off-fault plasticity
Single events

MCQsim: A Multicycle Earthquake Simulator

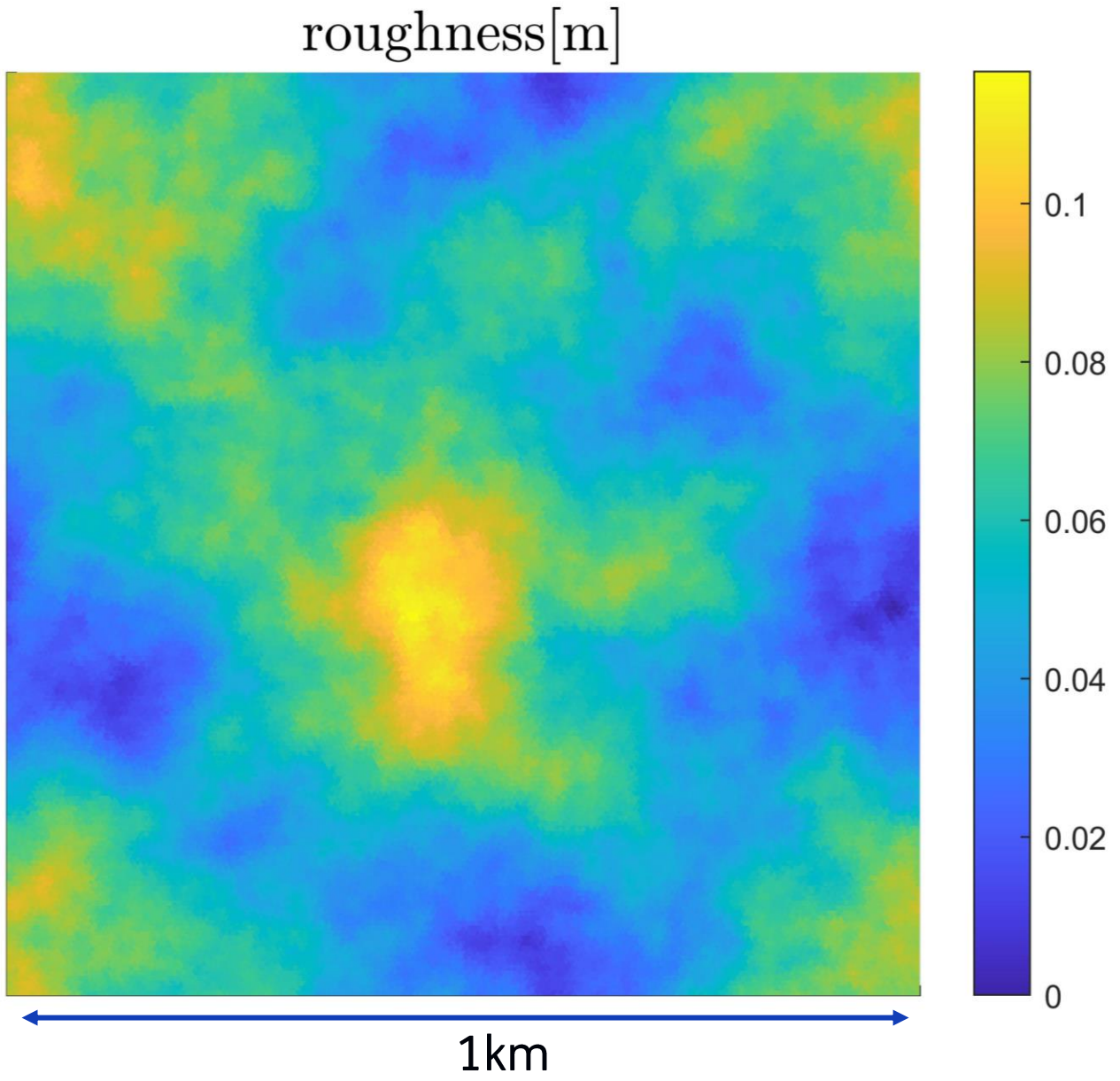
Olaf Zielke[*1] and Paul Martin Mai[1]

→ Heterogenous field of frictional strength disconned from fault roughness

Our approach



Fault roughness

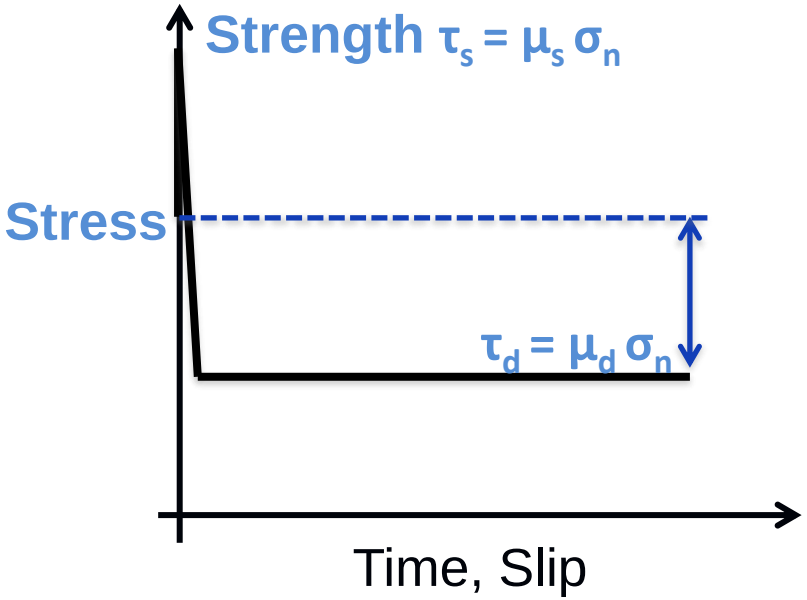


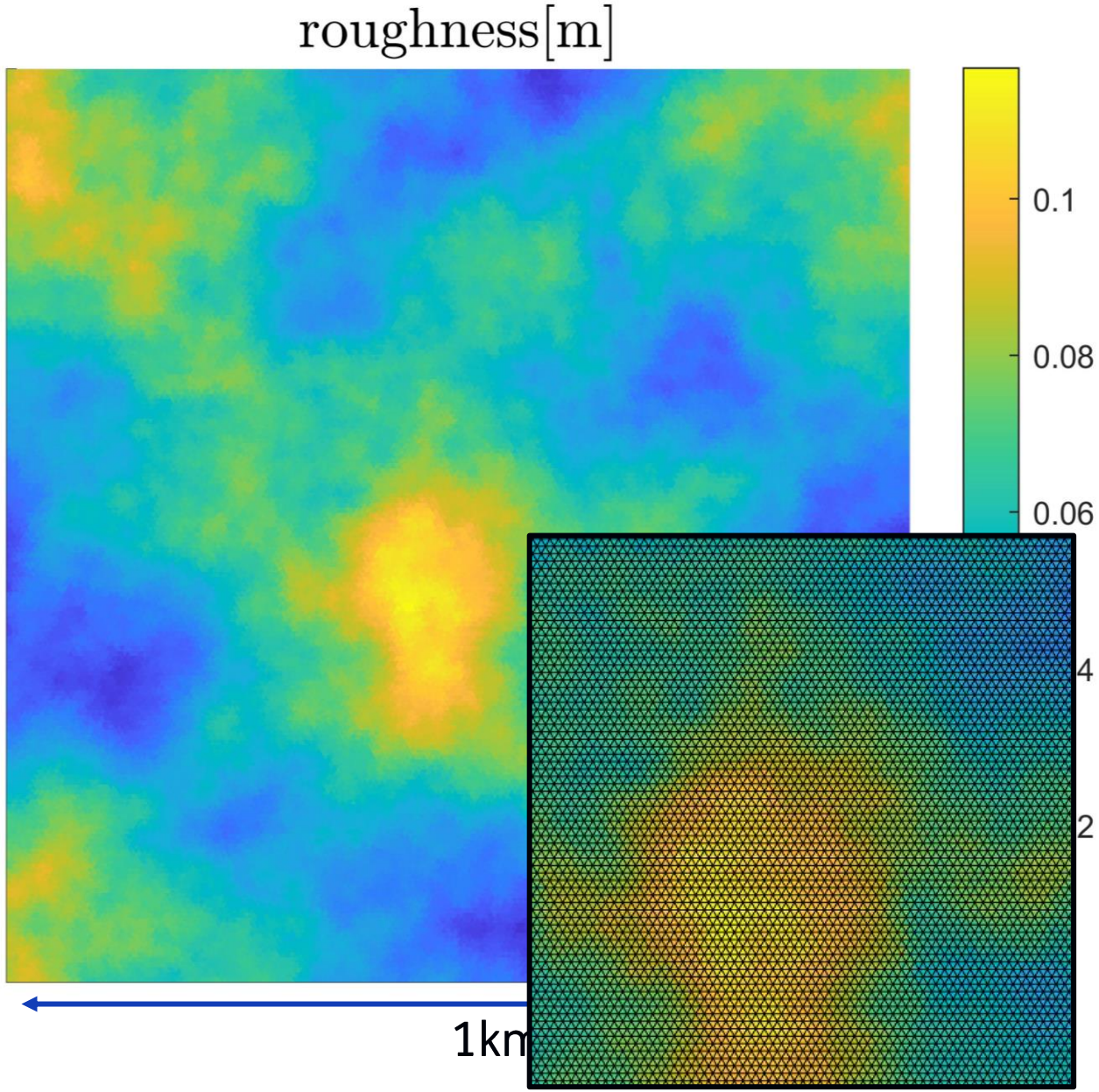
Our approach

1. Self-affine fractal fault surface (with amplitude range matching natural observations)

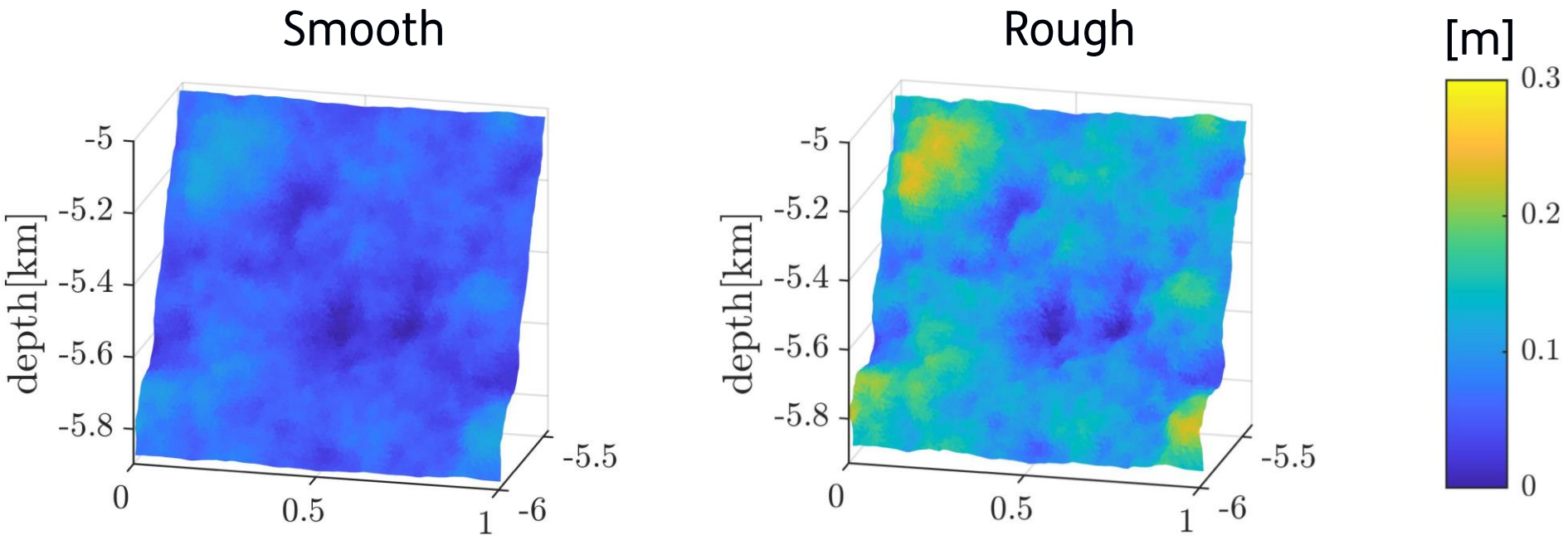
2. Elasto-static stress transfer (boundary element method)

3. Friction drops instantaneously from static to dynamic, then heals immediately after slip stops





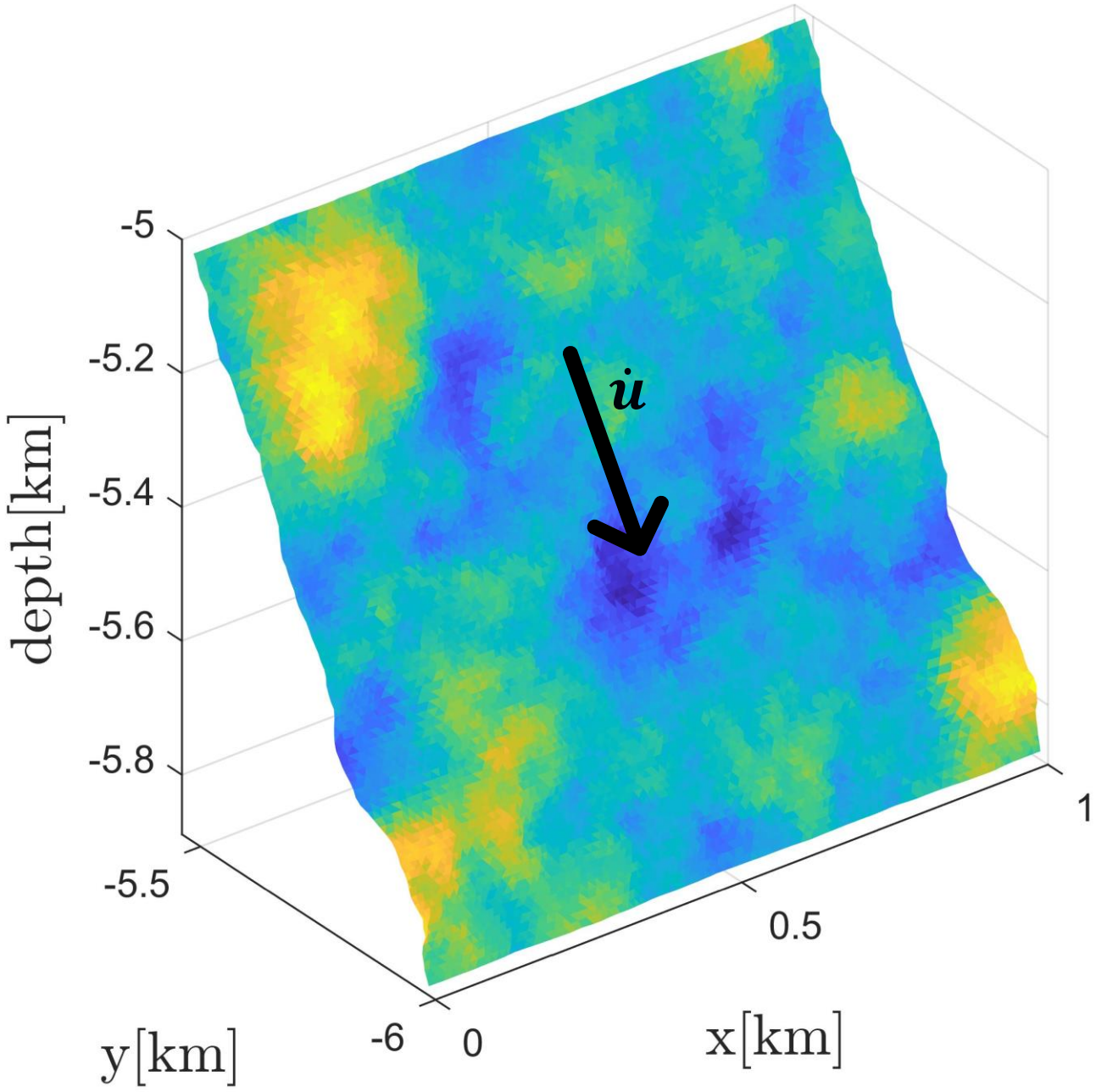
From smooth to rough fault



Two types of loading

1. **Tectonic-loading: back-slip approach with uniform shear and normal stress as starting point**

2. Injection-induced loading: project background stress tensor on each triangle and then start to inject



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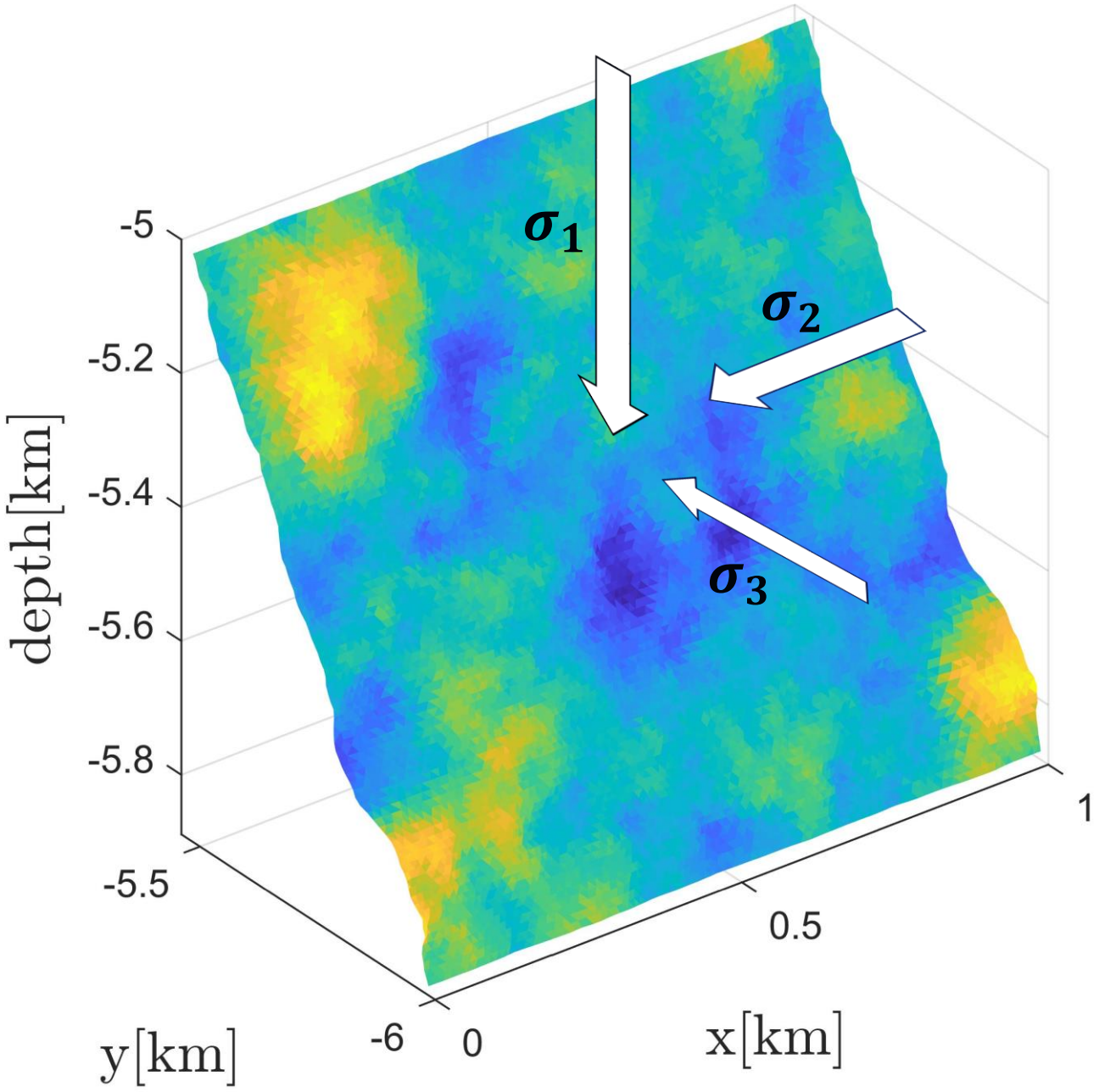

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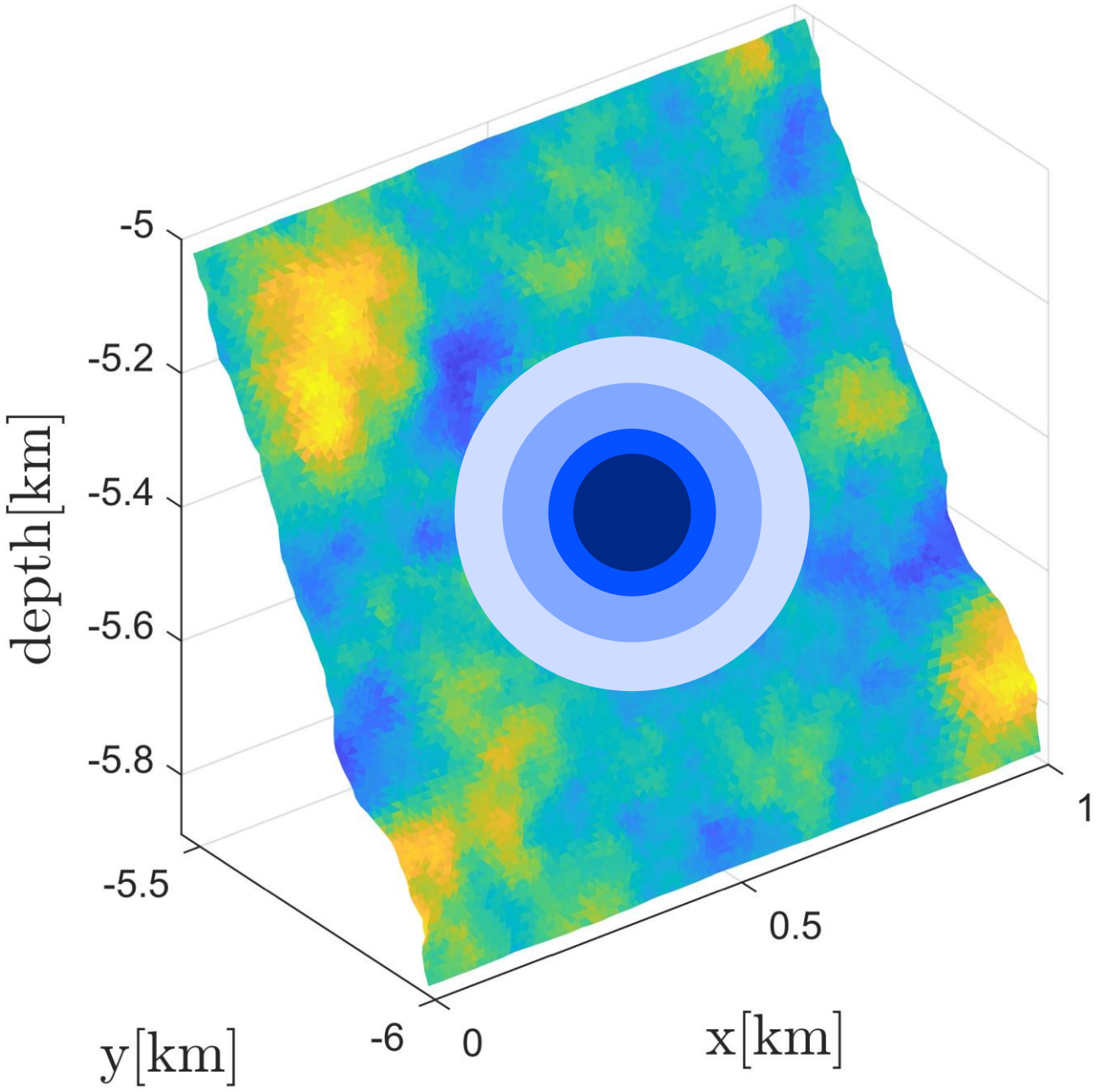
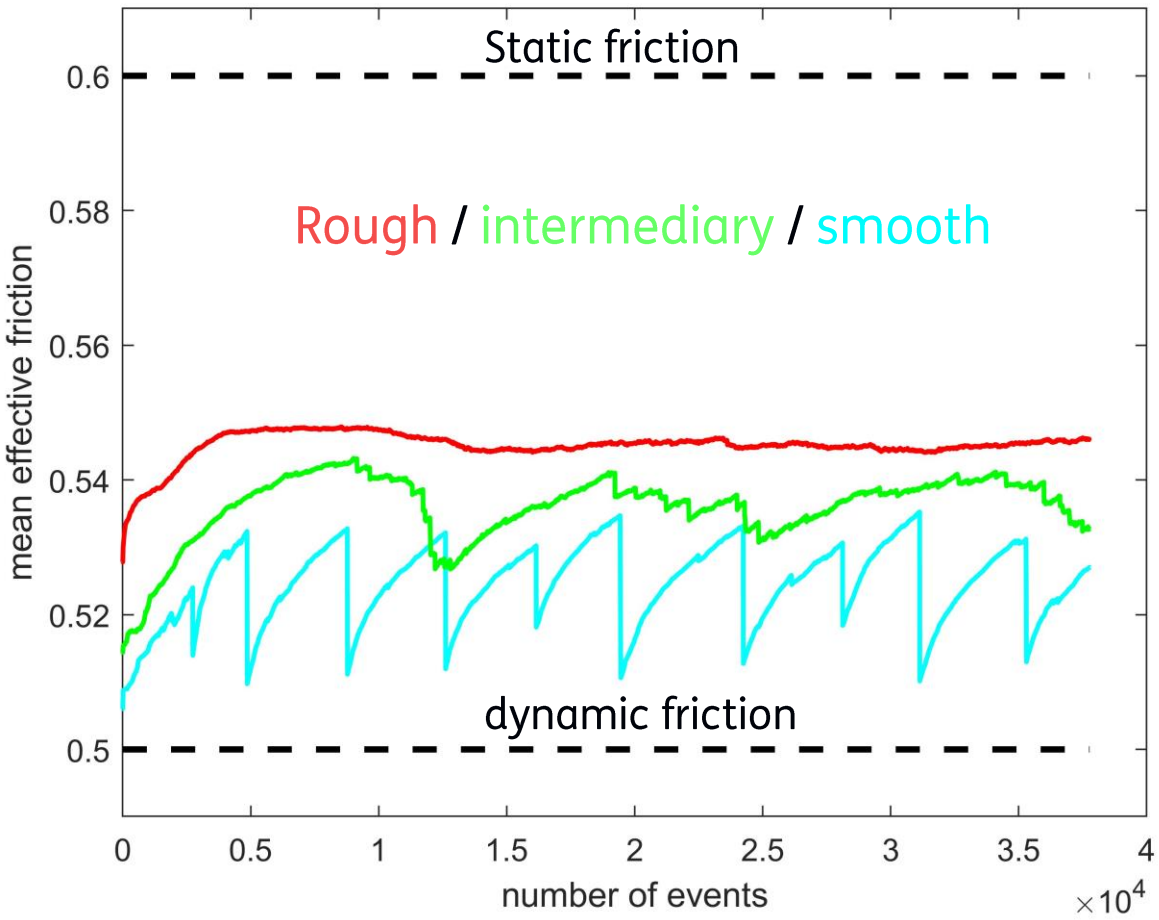
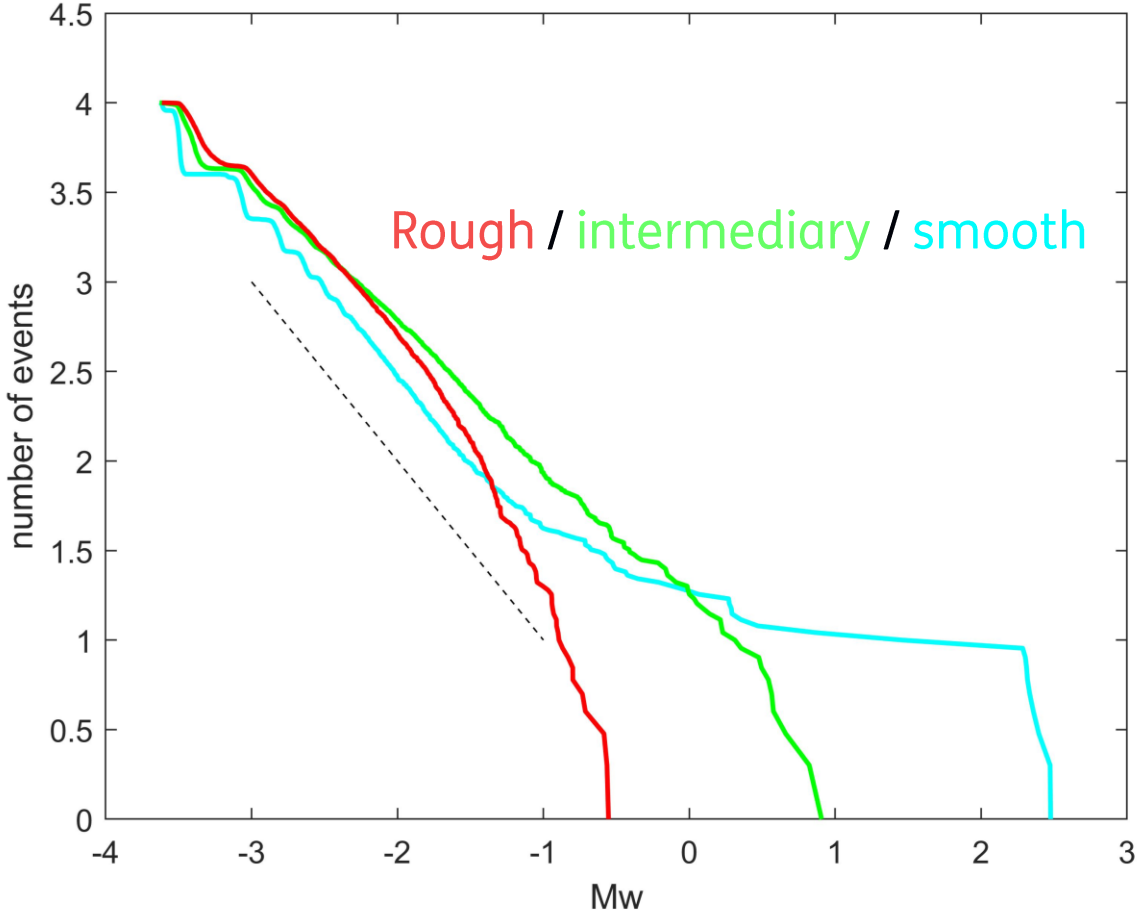
$$P(t) = \frac{v\eta}{4\pi kh} E_1\left(\frac{r^2}{4D_0 t}\right) + p_0$$



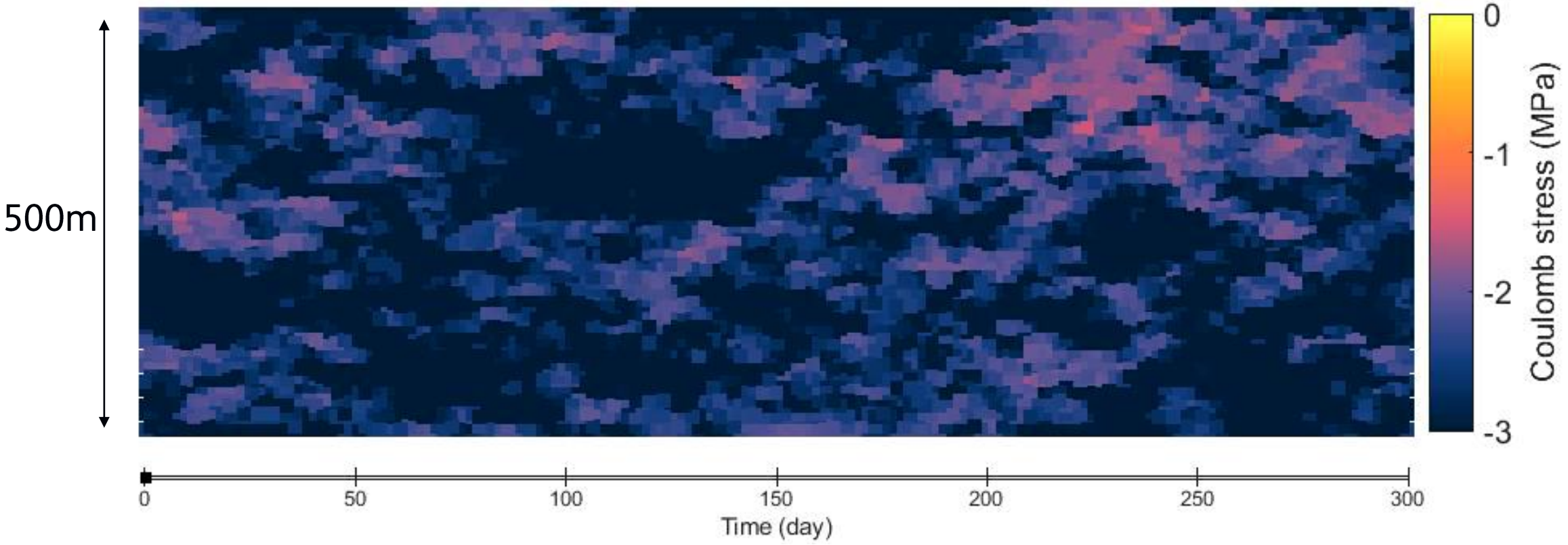
First: tectonic loading (back-slip approach)

Smoother faults operate at a lower shear/normal stress ratio (effective friction)
Rough fault: GR-type distribution / arrested-type rupture events
Smooth fault: Bimodal-type distribution / runaway-type rupture events



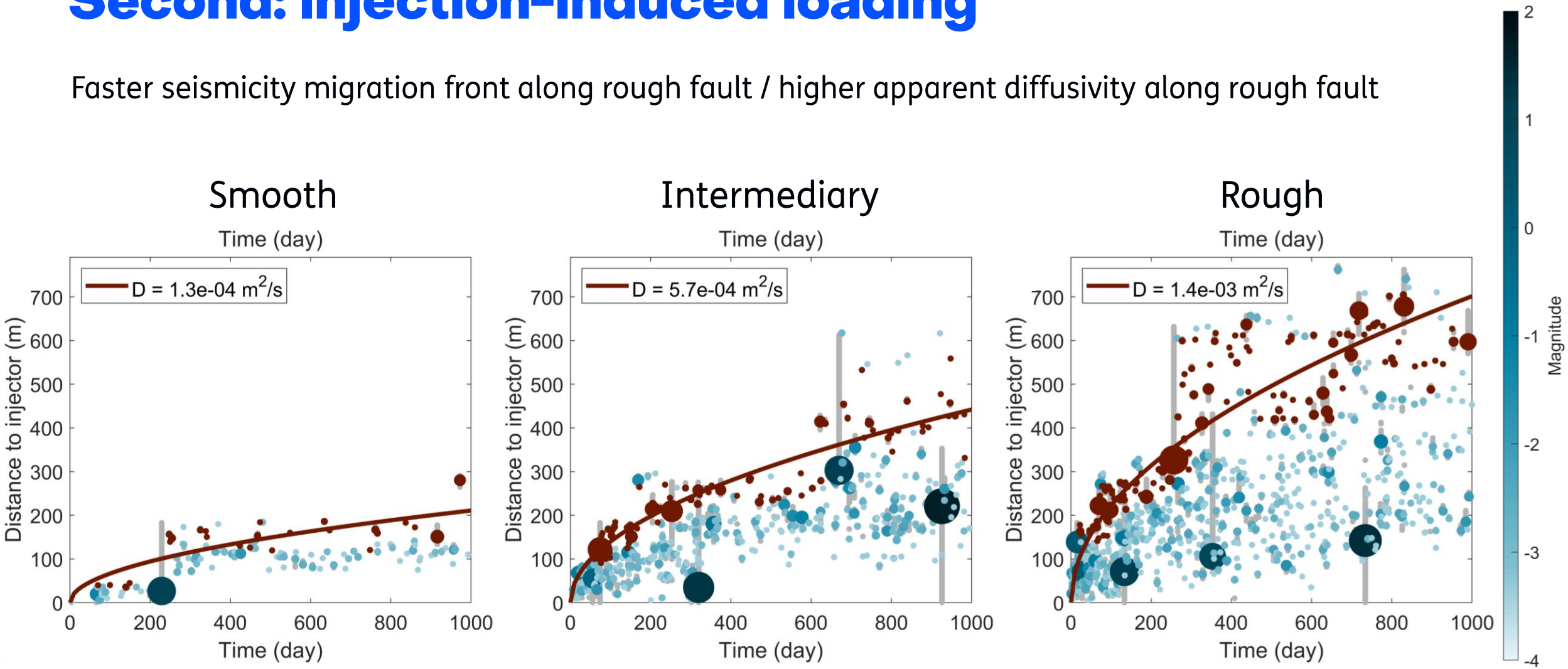


Second: injection-induced loading



Second: injection-induced loading

Faster seismicity migration front along rough fault / higher apparent diffusivity along rough fault



Look at Hsiao-Fan Lin's poster !

Conclusions

We presented a simple rupture model solely focusing on the effect of fault rougness with:

- Amplitude range matching natural observations
- No other heterogeneities

(1) Tectonic loading: a broad range of Magnitude-Frequency Distribution.

Rough : GR-type

Smooth : bimodal-type

(2) Injection-induced loading: a broad range of seismicity migration speed.

Rough: fast

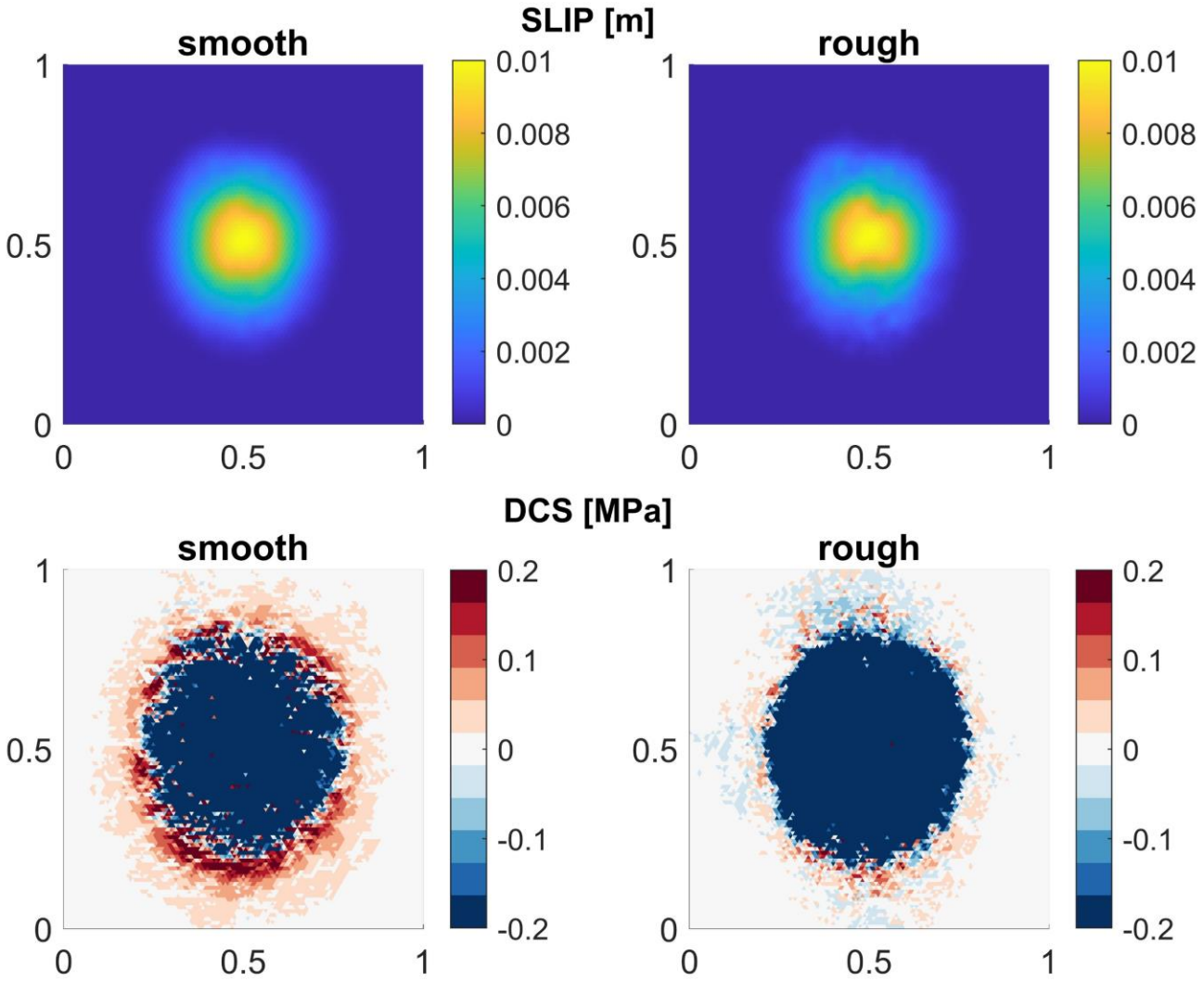
Smooth: slow

Questions

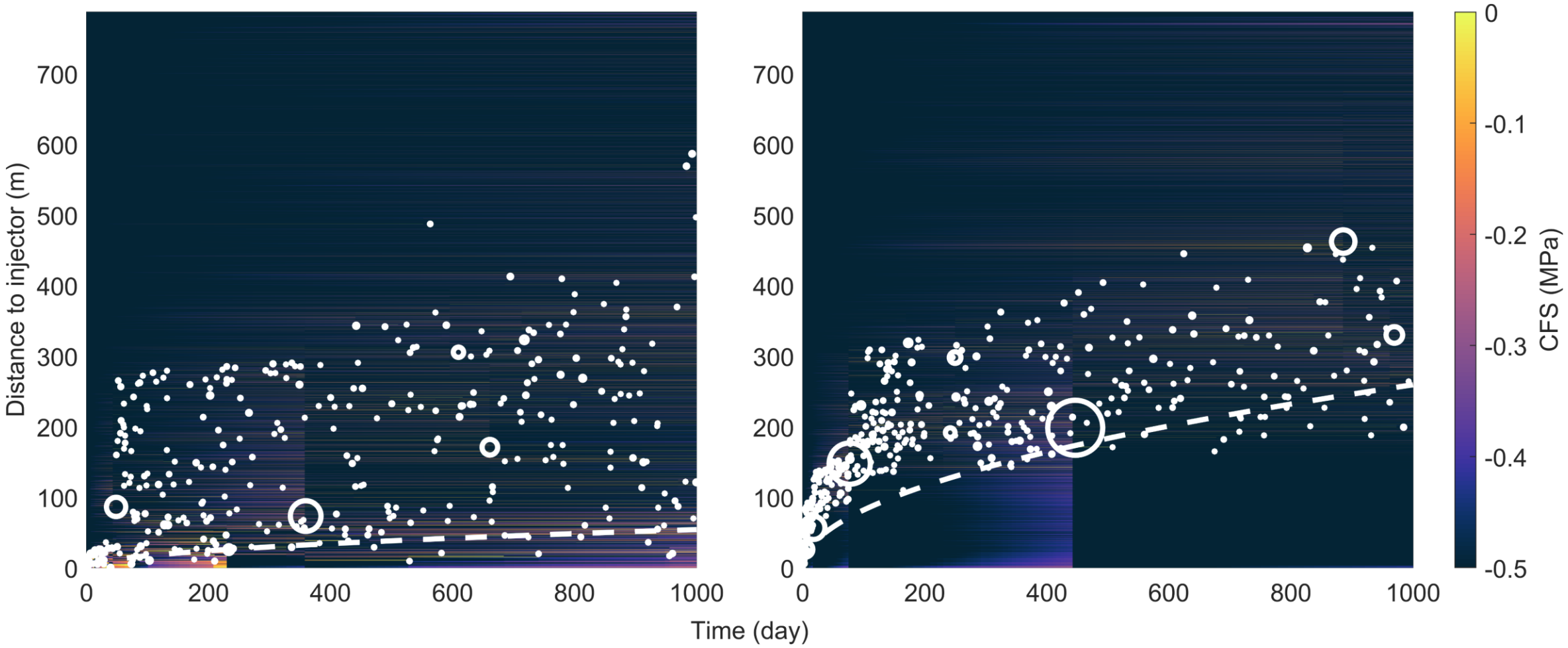
What do you want to know more? Food? … Yes me too I am starving ☺

THANK YOU

“Potency” of the stress transfer



Back-front


Distance to injector (m)
0
100
200
300
400
500
600
700
0
200
400
600
800
1000
Time (day)
CFS (MPa)
0
-0.1
-0.2
-0.3
-0.4
-0.5