# Rupture Cycles on a Multiscale Rough Fault

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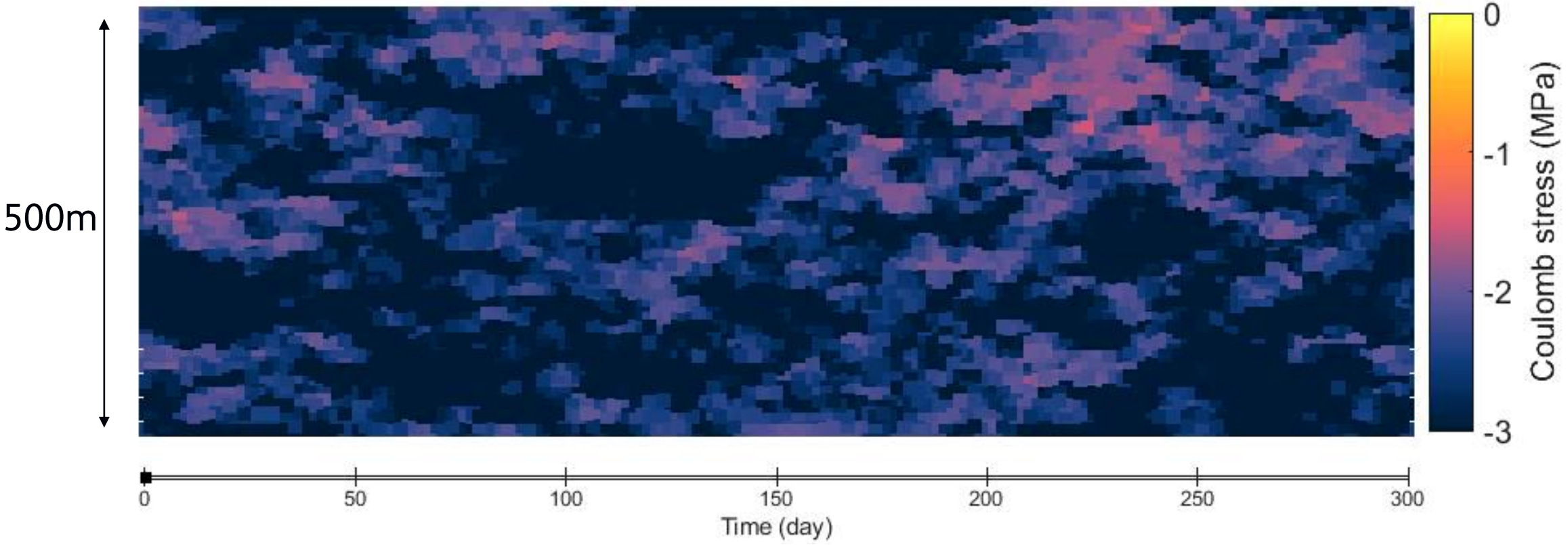
UNIVERSITÉ CÔTE D'AZUR

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]

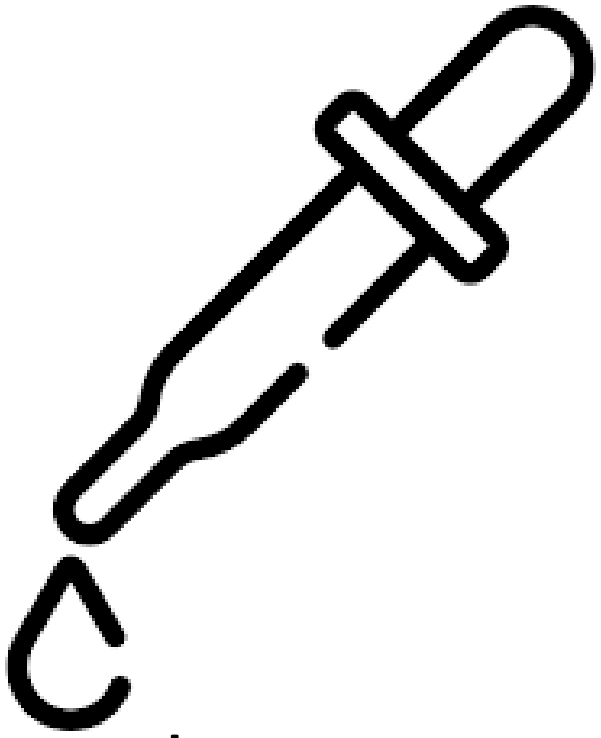
→ 2D
Off-fault plasticity
Single events

MCQsim: A Multicycle Earthquake Simulator

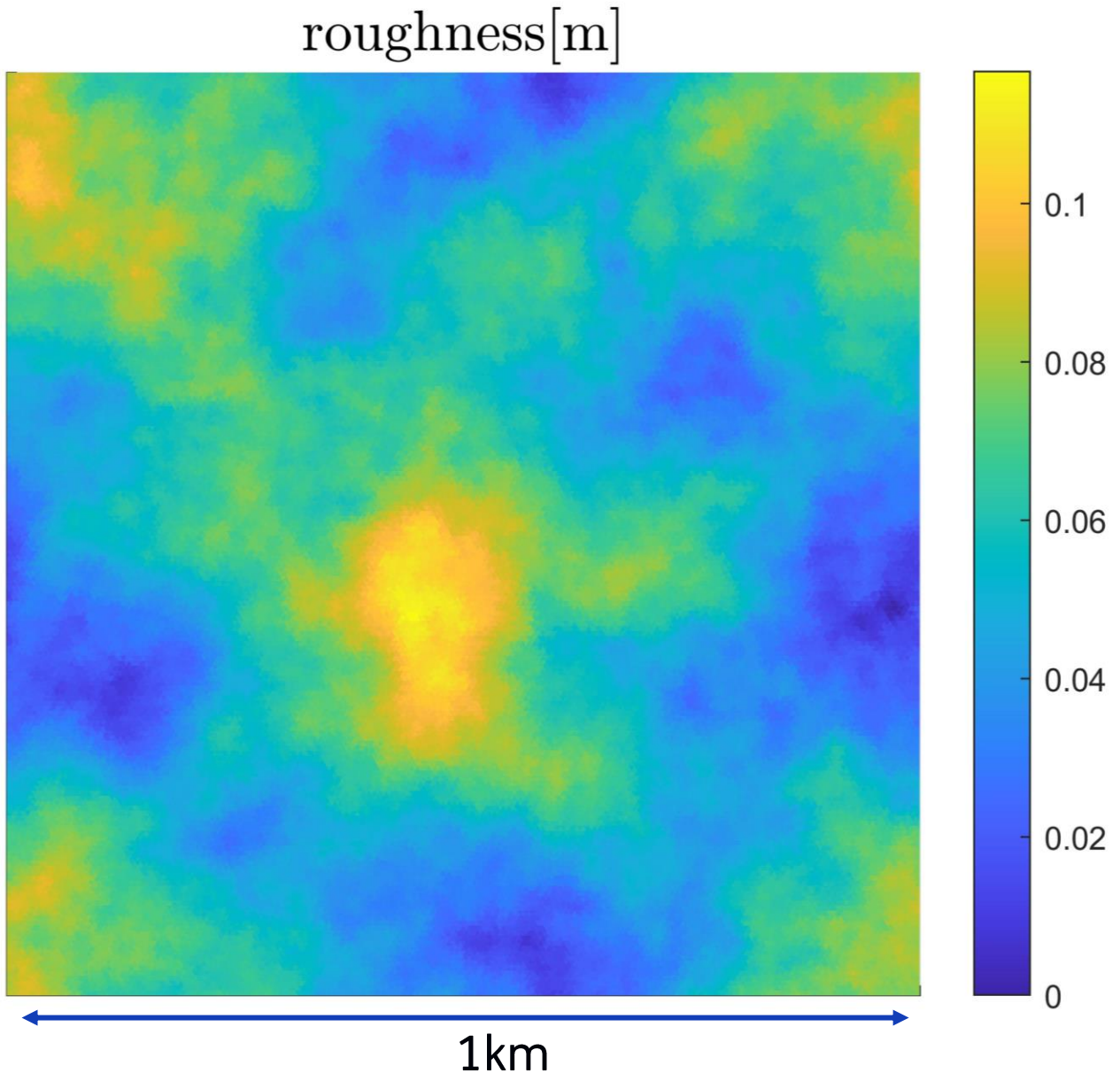
Olaf Zielke[*1] and Paul Martin Mai[1]

→ Heterogenous field of frictional strength disconned from fault roughness

# Our approach



Fault roughness

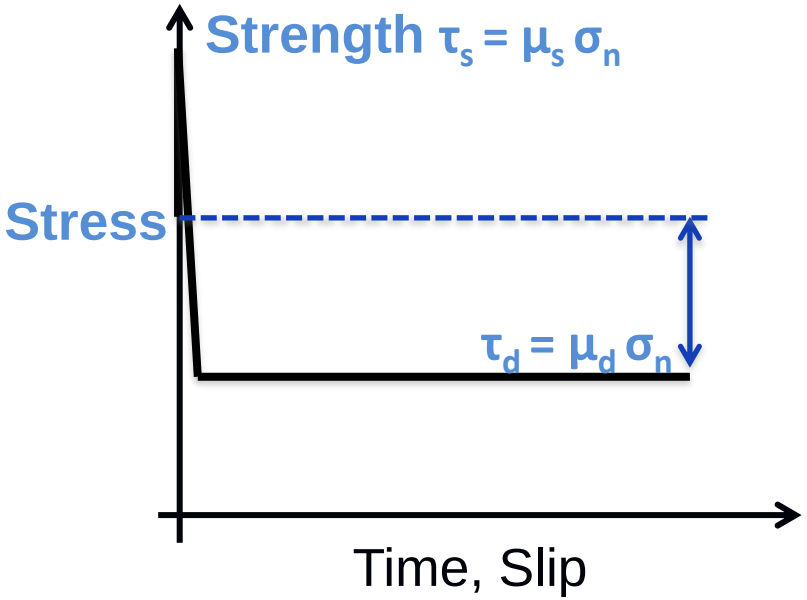


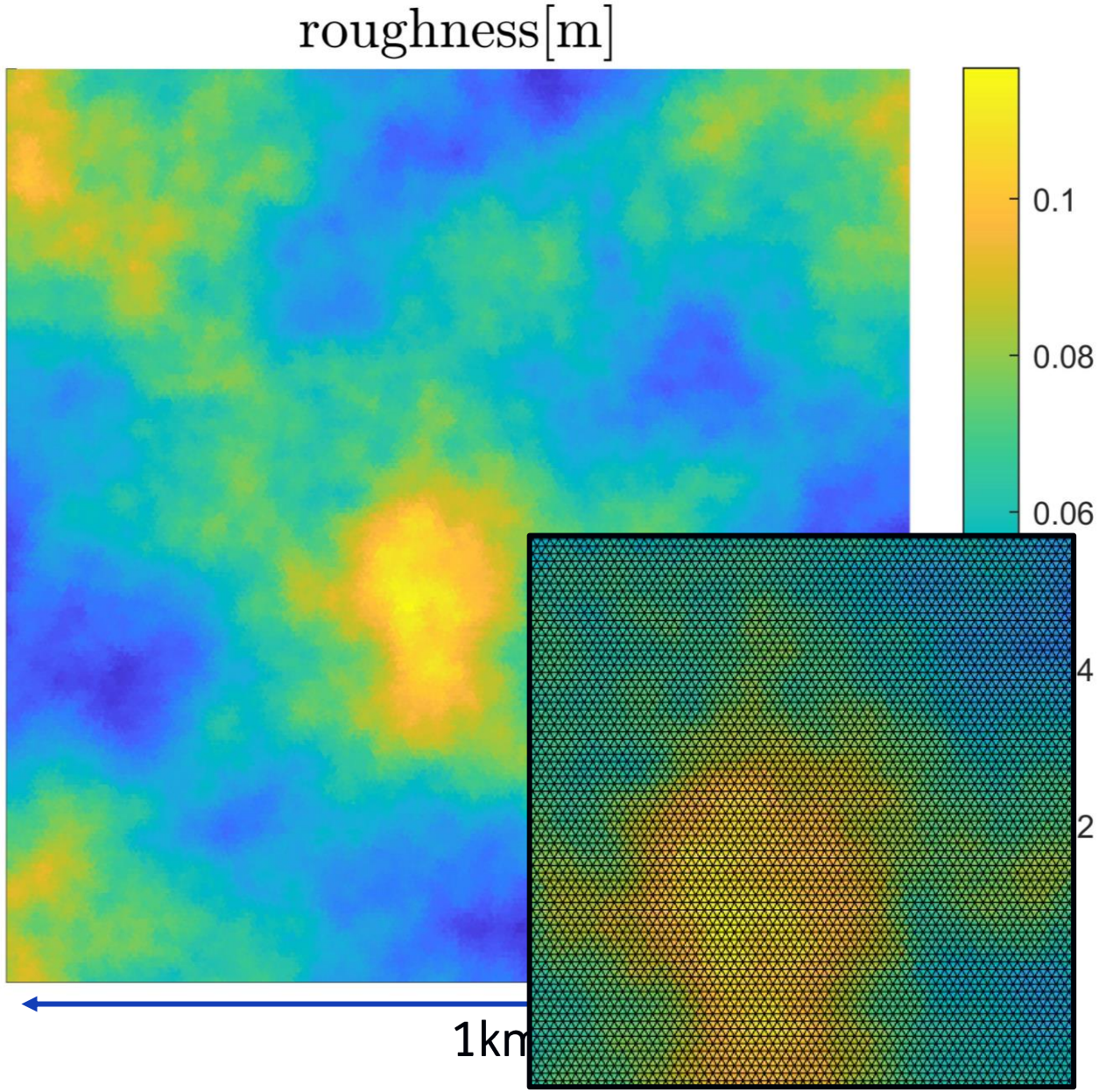
# Our approach

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

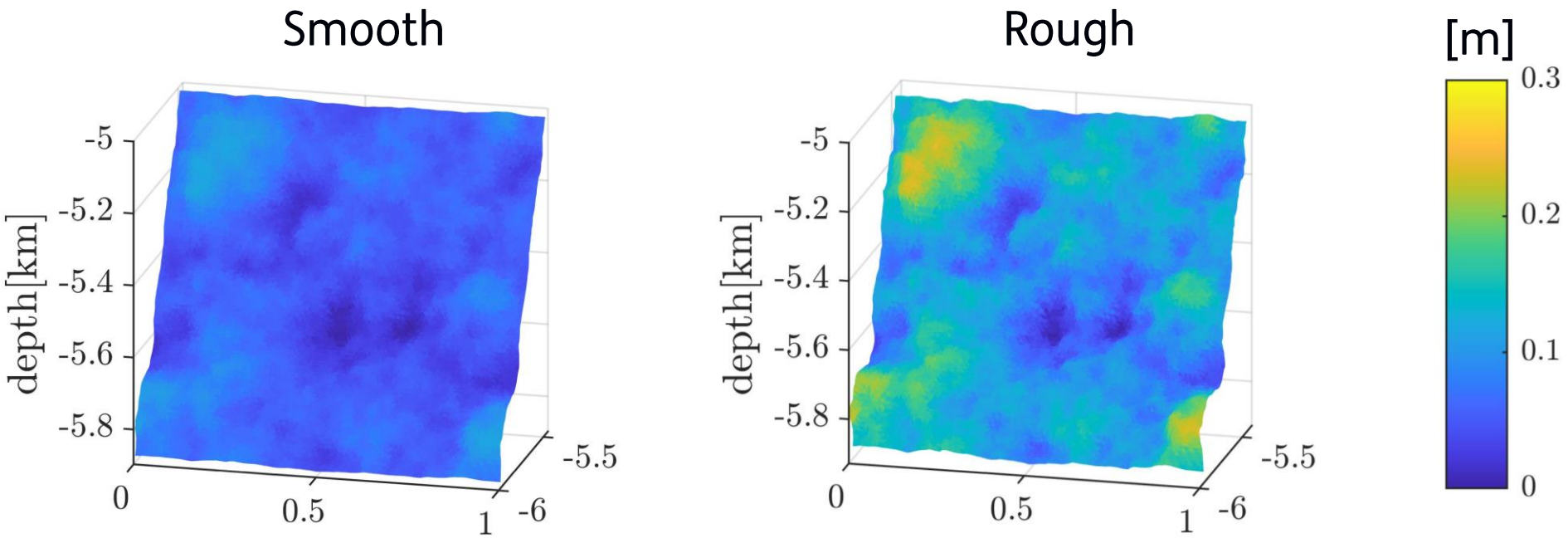
2. Elasto-static stress transfer (boundary element method)

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



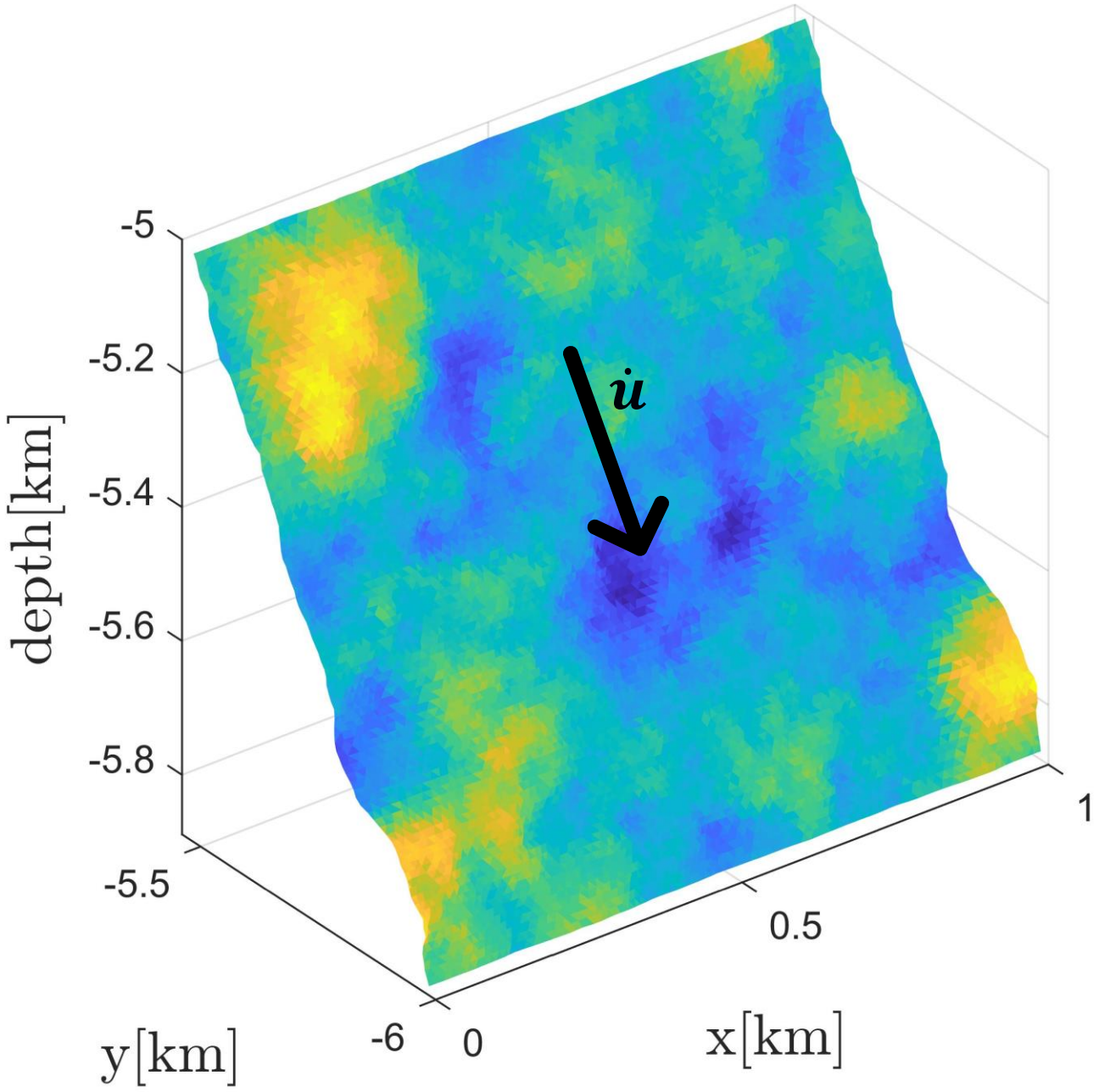
# From smooth to rough fault



# 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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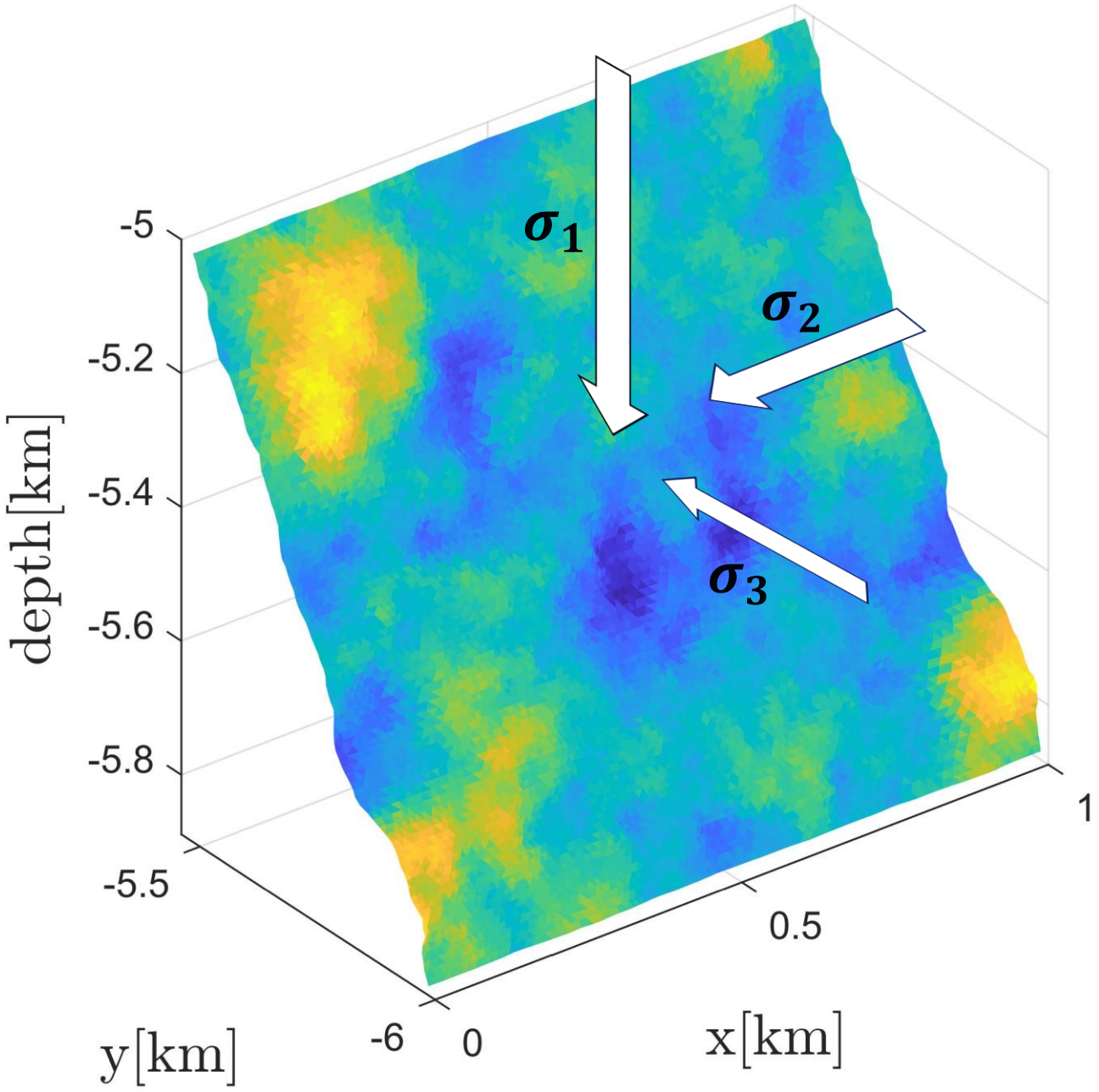

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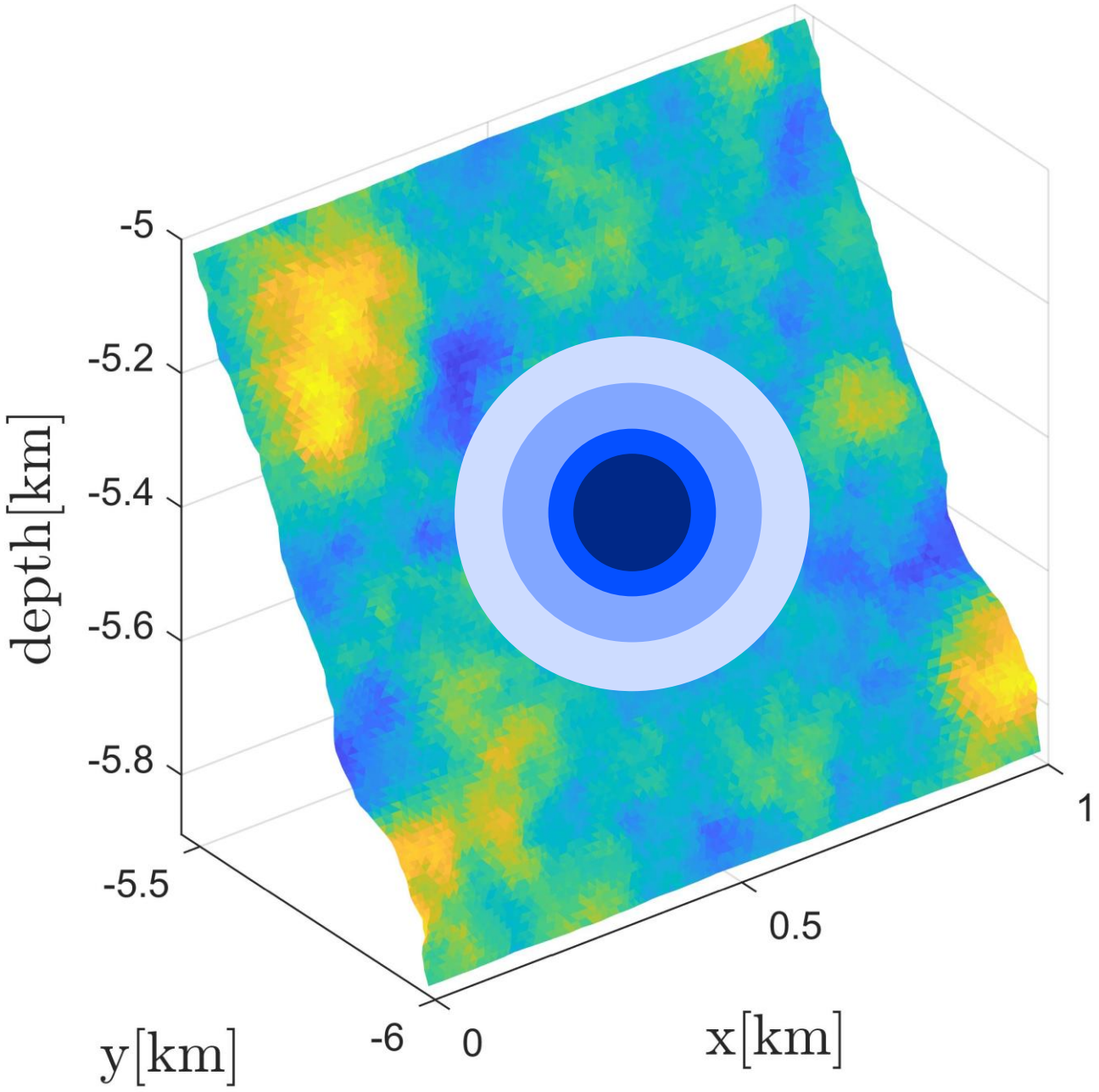
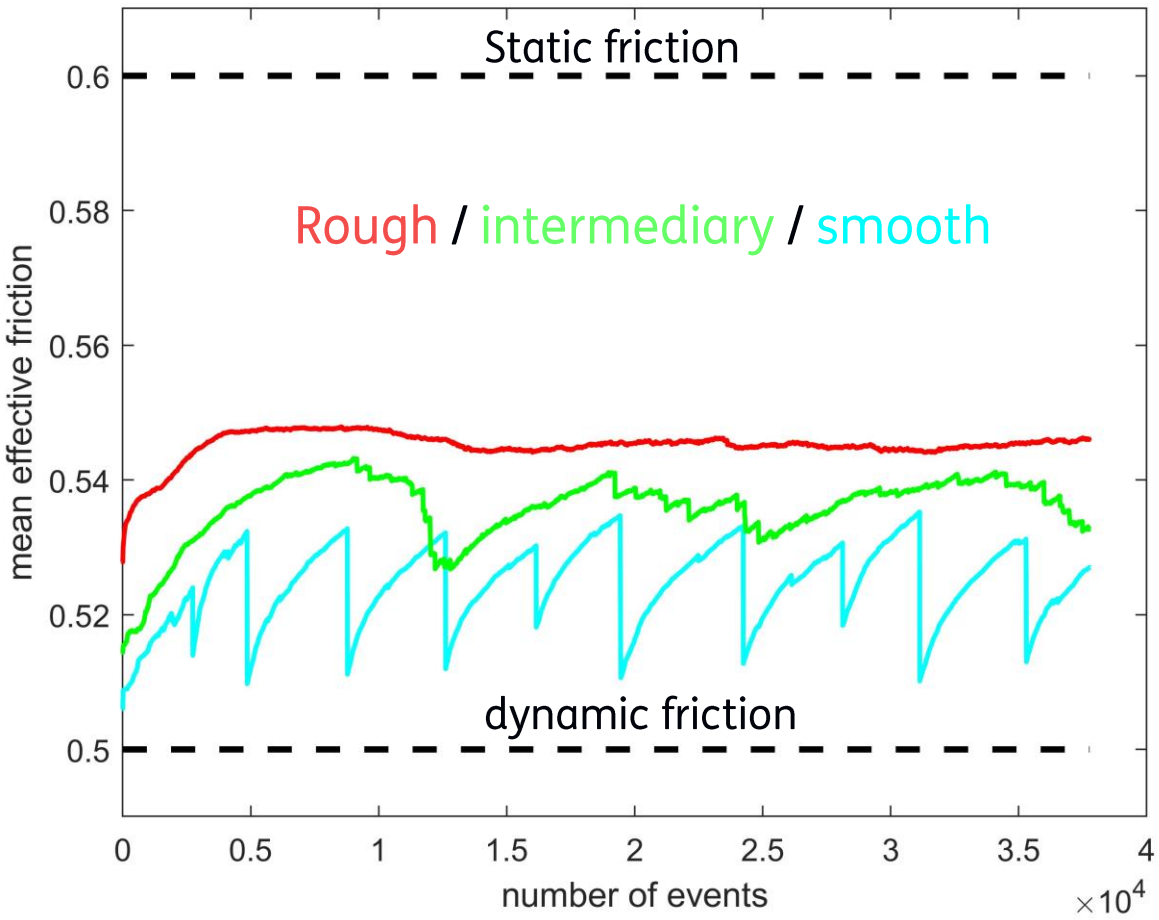
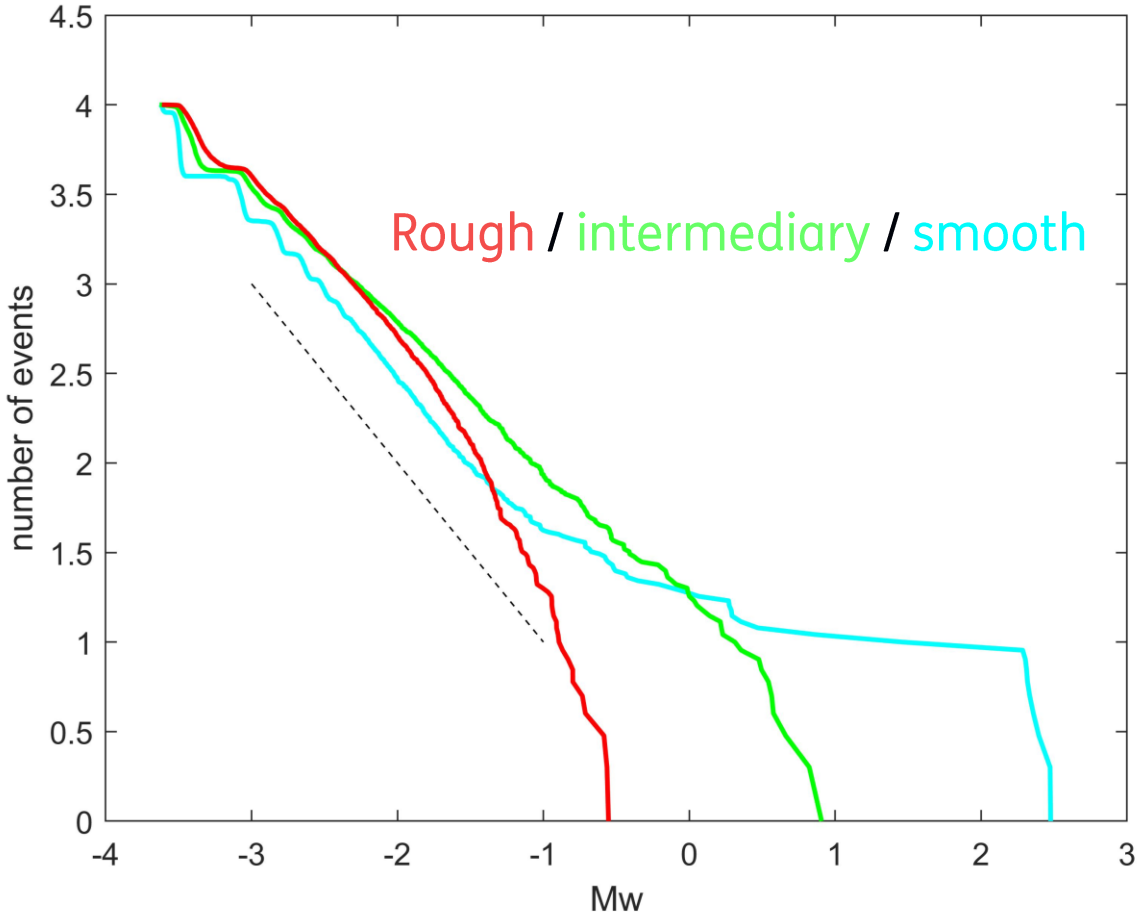
$$P(t) = \frac{v\eta}{4\pi kh} E_1\left(\frac{r^2}{4D_0 t}\right) + p_0$$



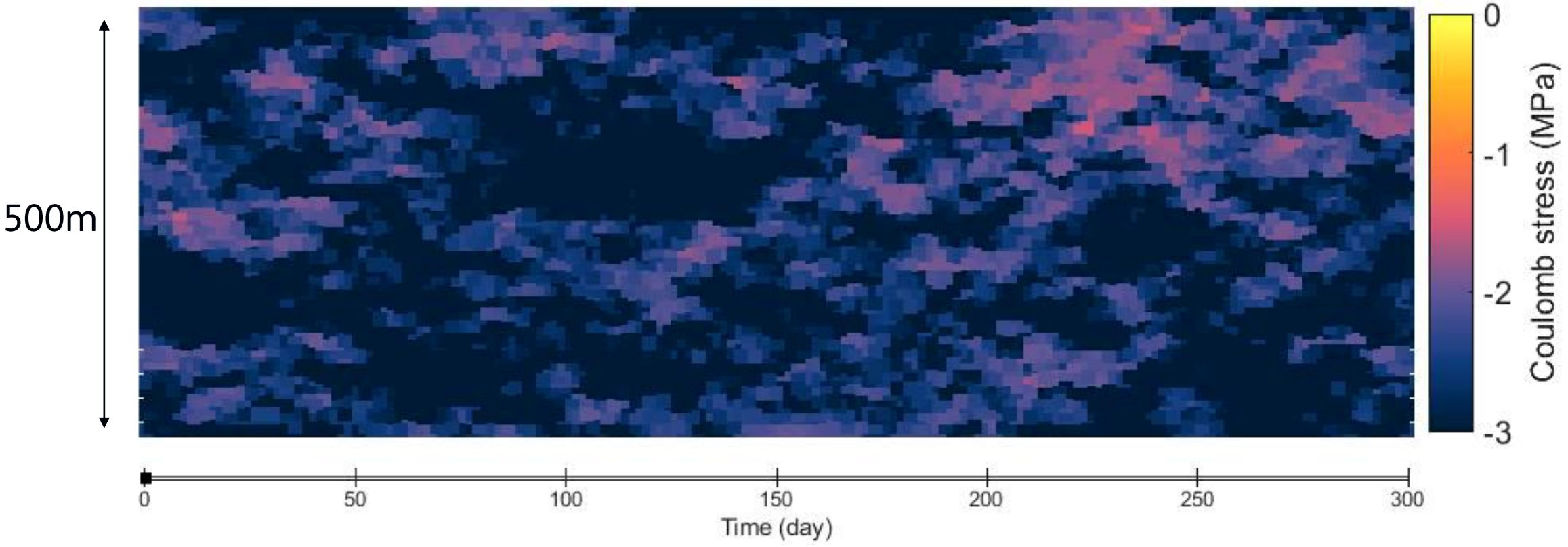
# First: tectonic loading (back-slip approach)

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



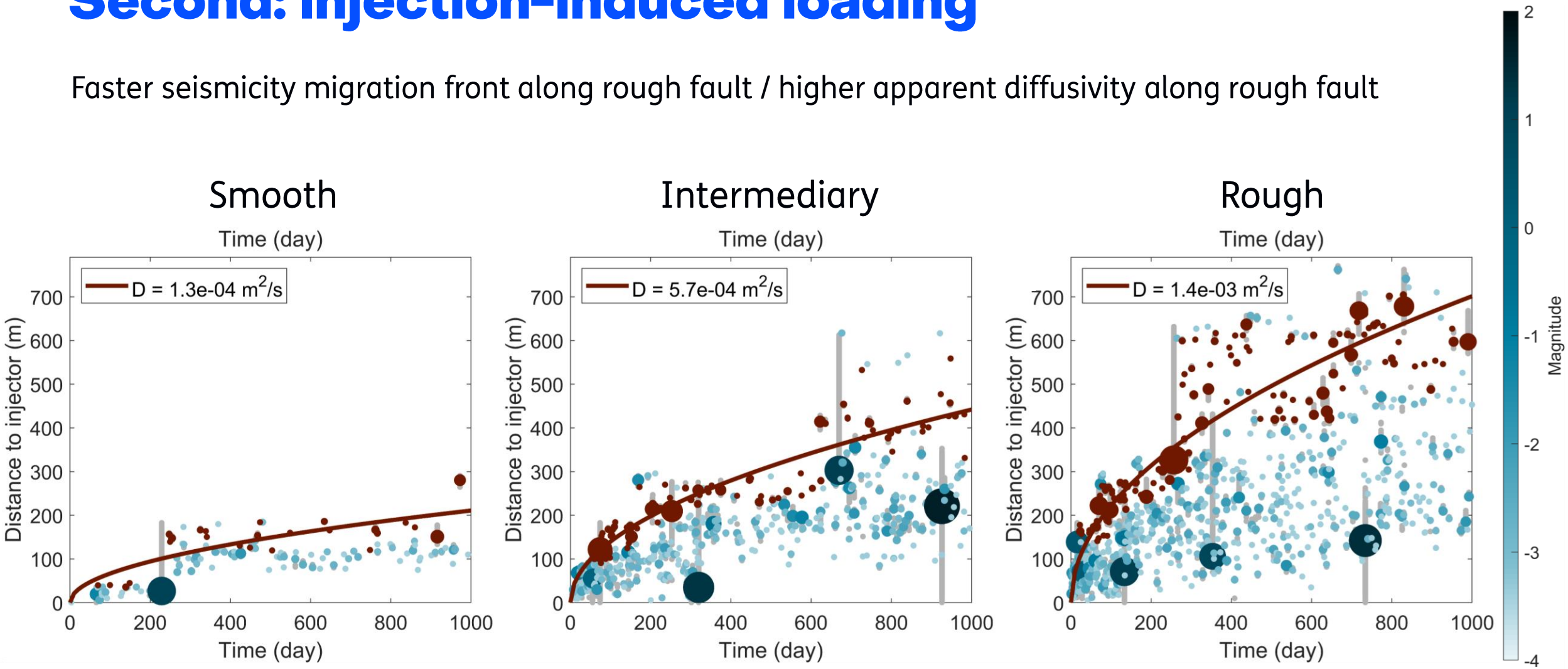



# Second: injection-induced loading



# 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

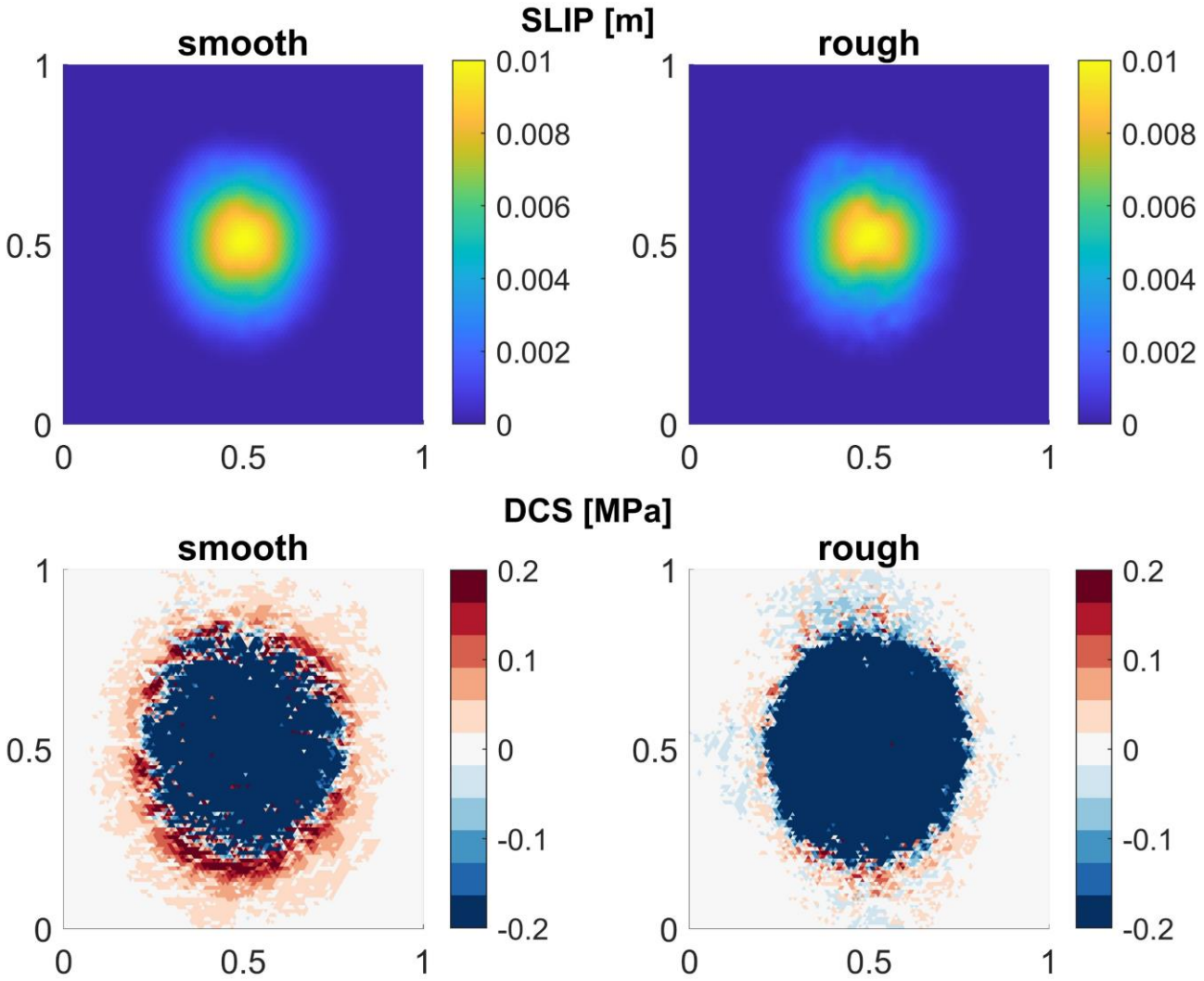
Smooth: slow

# Questions

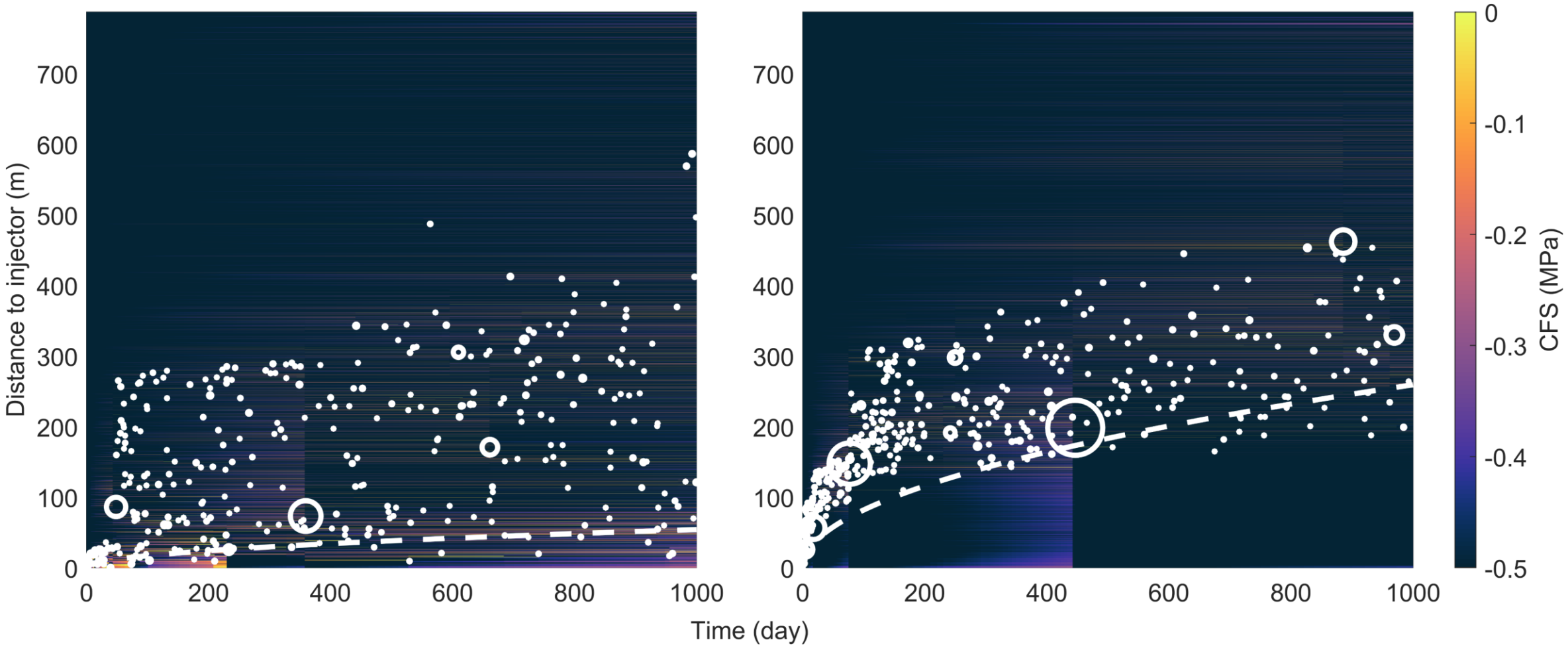
What do you want to know more? Food? … Yes me too I am starving ☺

# 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