Regularized Extended Finite Volume Method (XFVM) for Flow Induced Shear Failure

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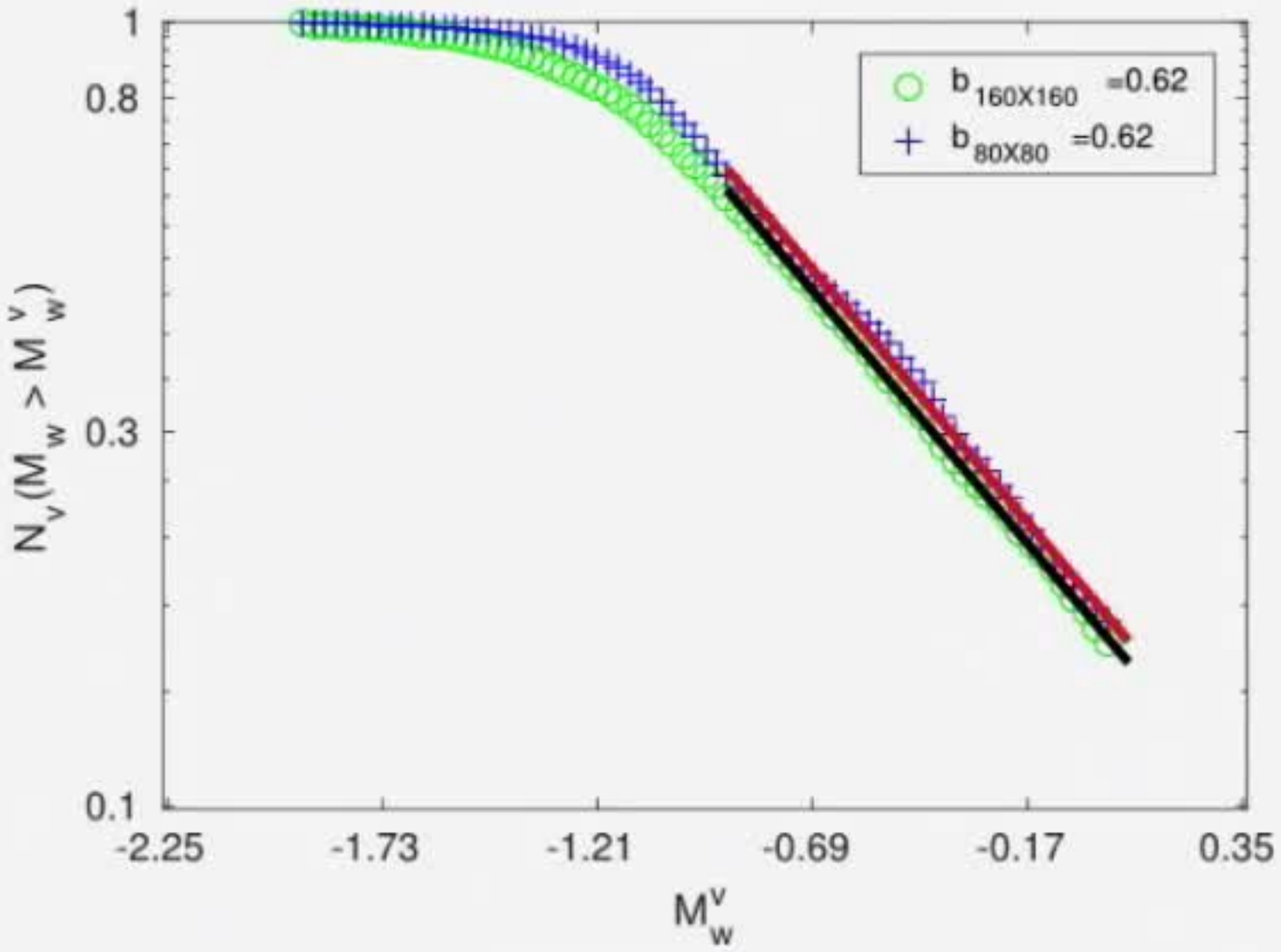
Conclusions

- Embedded discrete fracture model for flow induced shear failure
- XFVM to deal with discontinuities
- Shear strength relaxation to regularize failure events
- Realistic, grid independent seismic magnitude statistics
- Realistic response on matrix permeability
- Strong effect of matrix heterogeneity
- 3D XFVM EDFM with shear failure and tensile opening

- Next: tensile failure

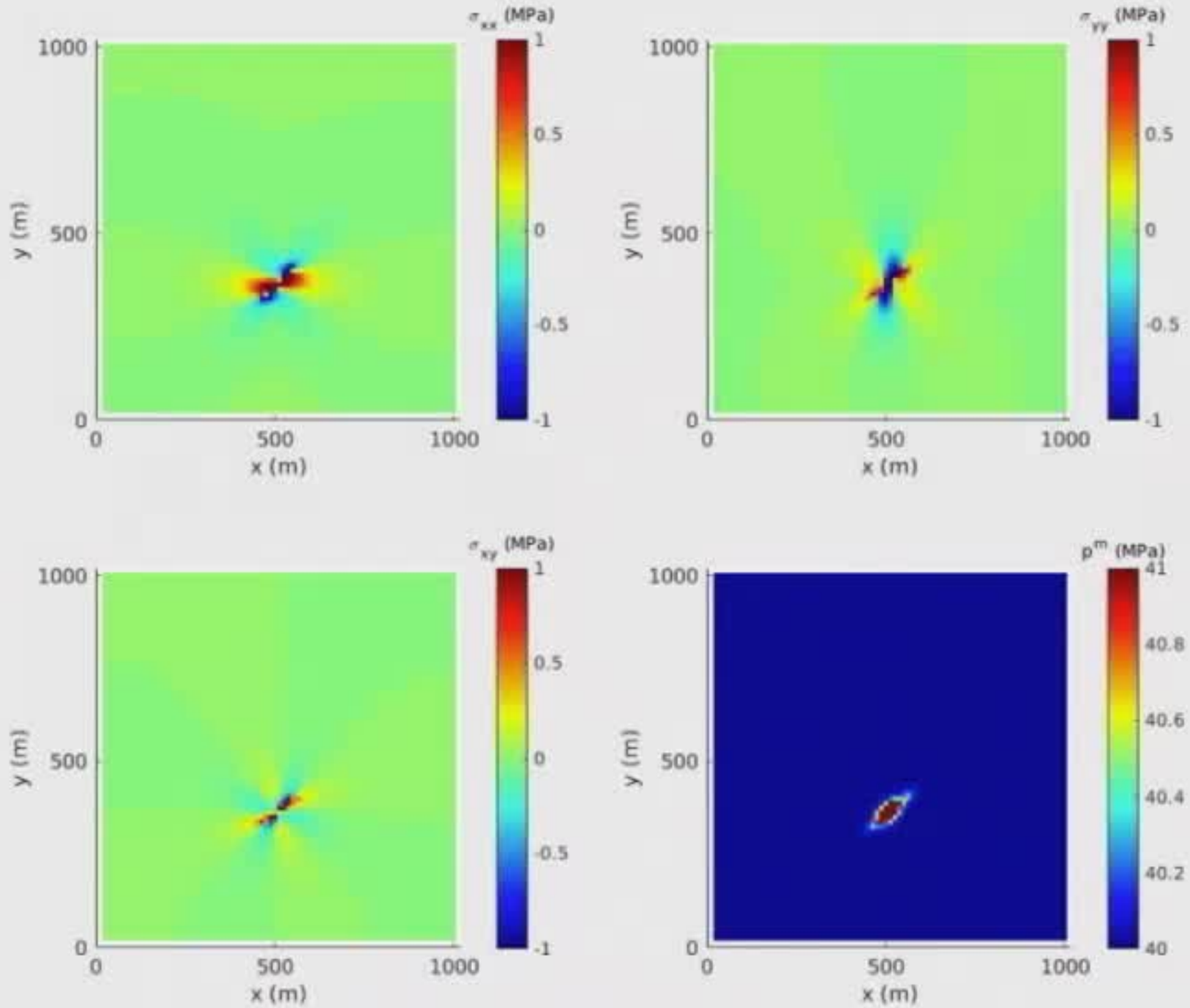
Flow Induced Shear Failure: Seismicity



$$M_w = \frac{2}{3}\log\left(GA\sum|\triangle s_i|\right) - 10.73$$

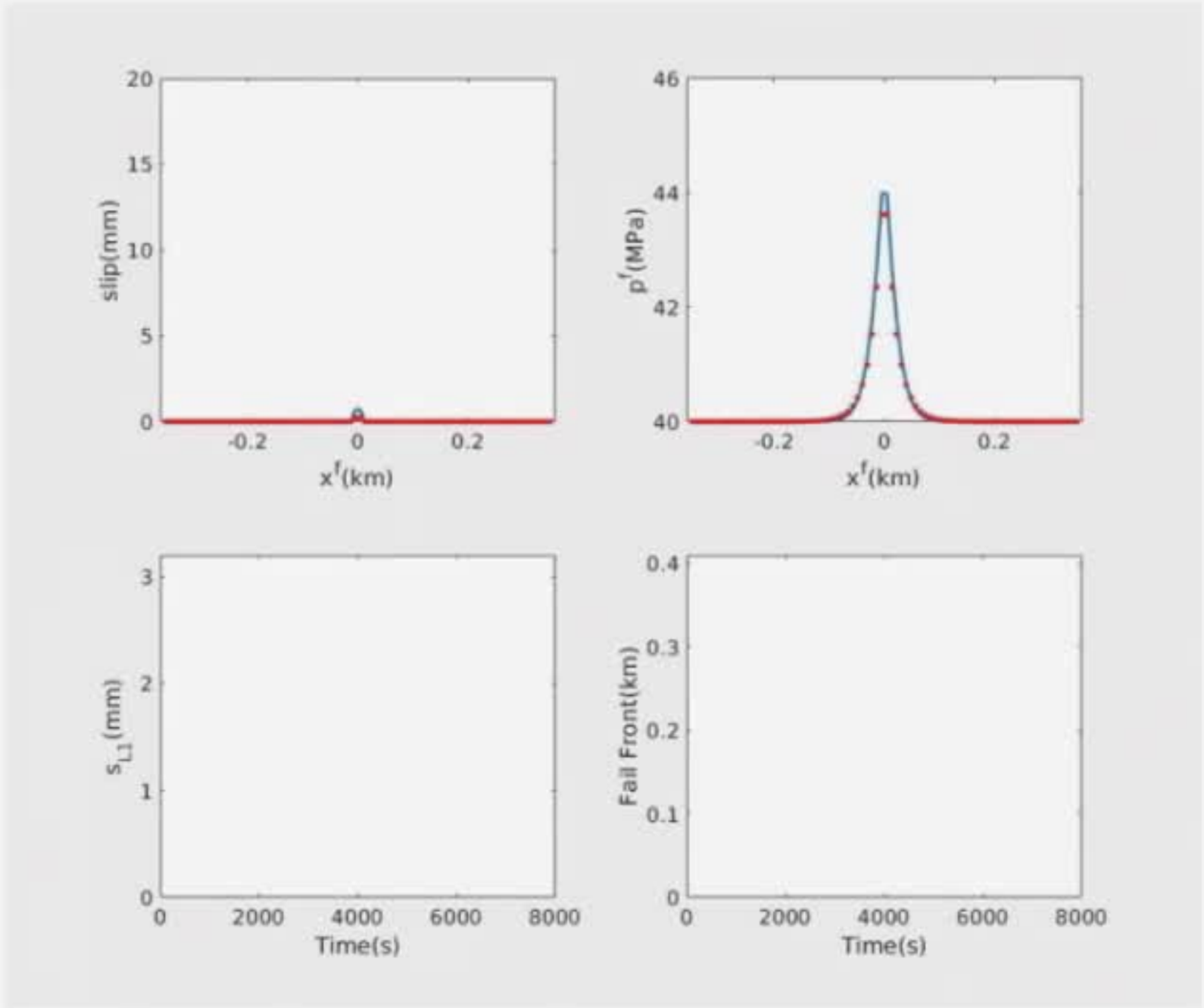
[Hanks and Kanamori, JGR, 84, 1975]

Flow Induced Shear Failure: Multiple Fractures

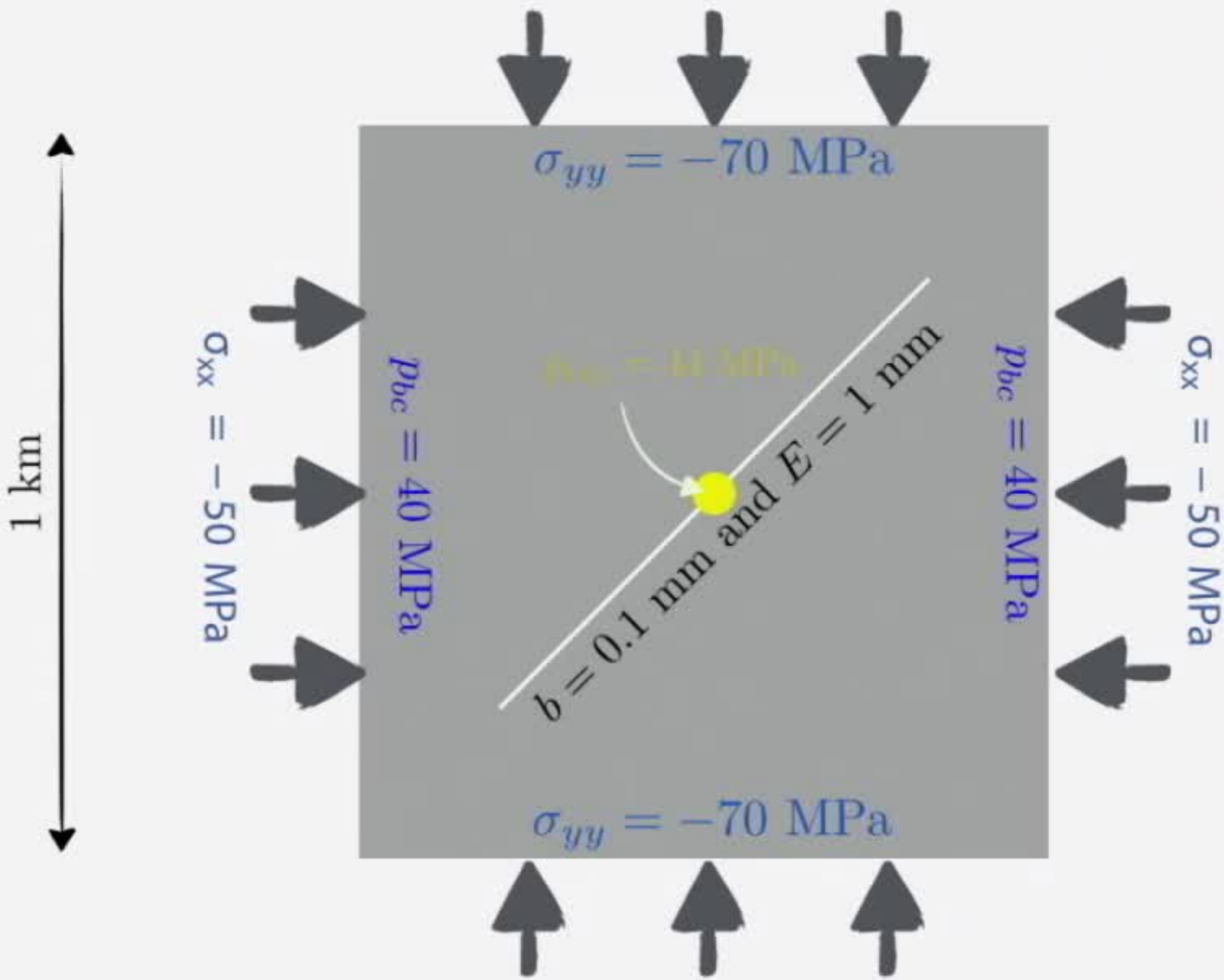


Flow Induced Shear Failure: Effect of Regularization

Time step comparison without relaxation

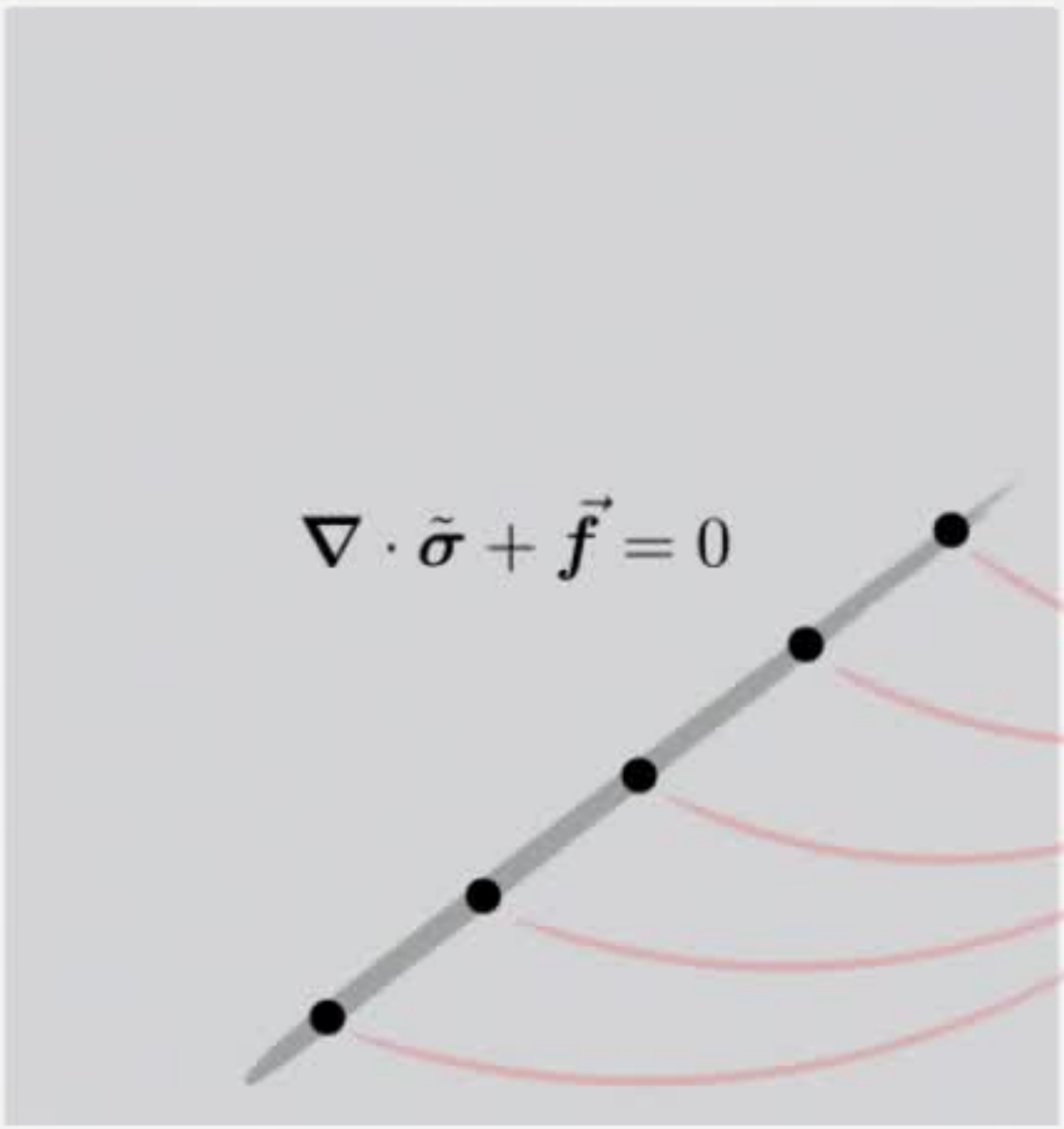


Flow Induced Shear Failure: Single Fracture



Flow Induced Shear Failure: Regularization

Regularization achieved via shear strength relaxation:



[Prakash and Clifton, ASME 1993]

$$\frac{d\tau_{max}}{dt} = -\frac{1}{t_f}(\tau_{max} - \mu_s(\sigma_c - p))$$

$$\sigma^{net} = (\sigma_c - p^f)$$

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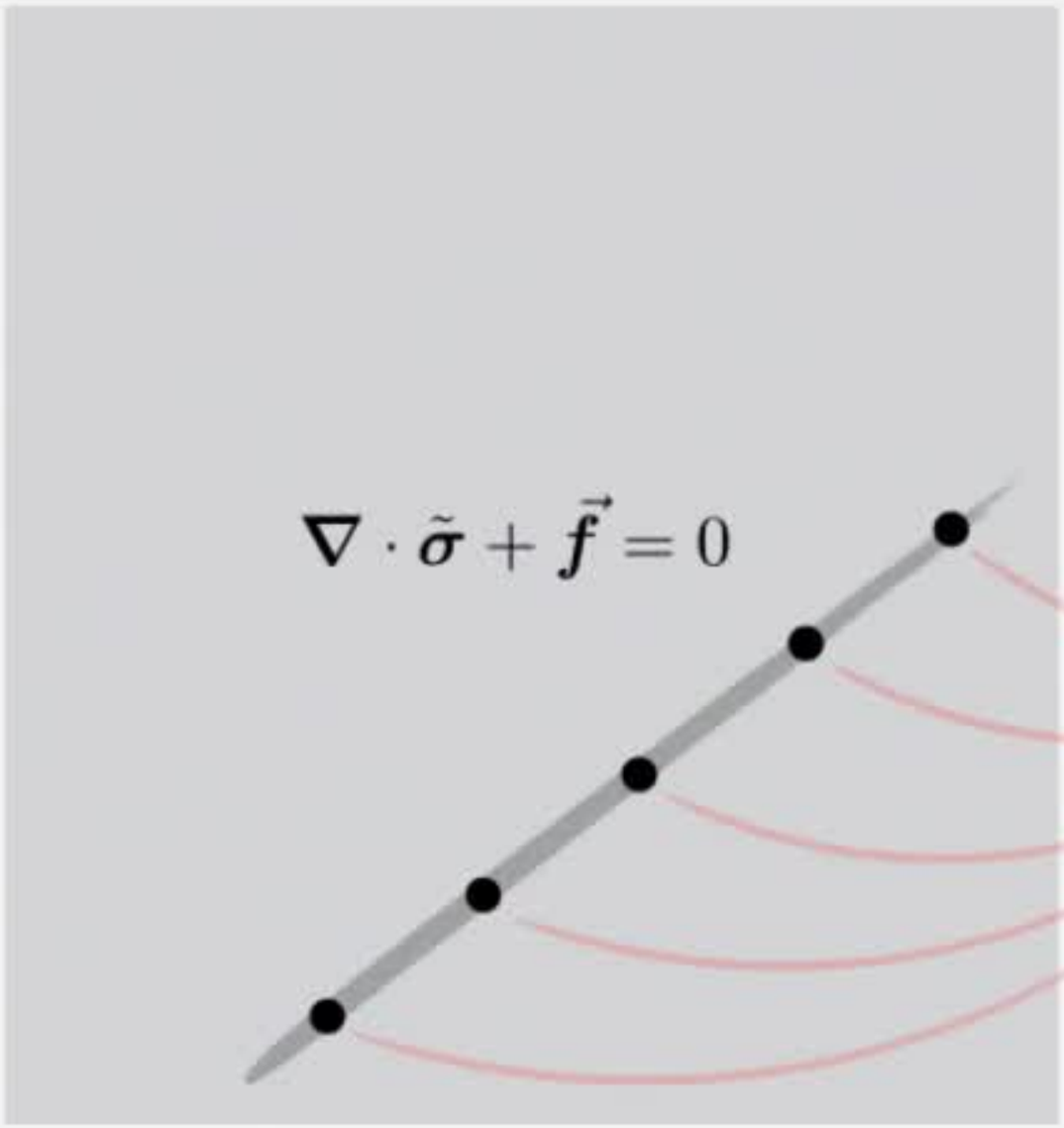
Flow Induced Shear Failure: Regularization

Immediate change in traction maximum due to change in compressive stress:



Coulomb friction law:

$$\tau_{max} = \mu_s(\sigma_c - p^f)$$

$$\sigma^{net} = (\sigma_c - p^f)$$

t

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Immediate change in traction maximum du

$$\nabla \cdot \tilde{\sigma} + \vec{f} = 0$$

Transitions

Dissolve

Change | Preview

Duration 1.50 s

Start Transition: On Click | Delay: 0.50 s

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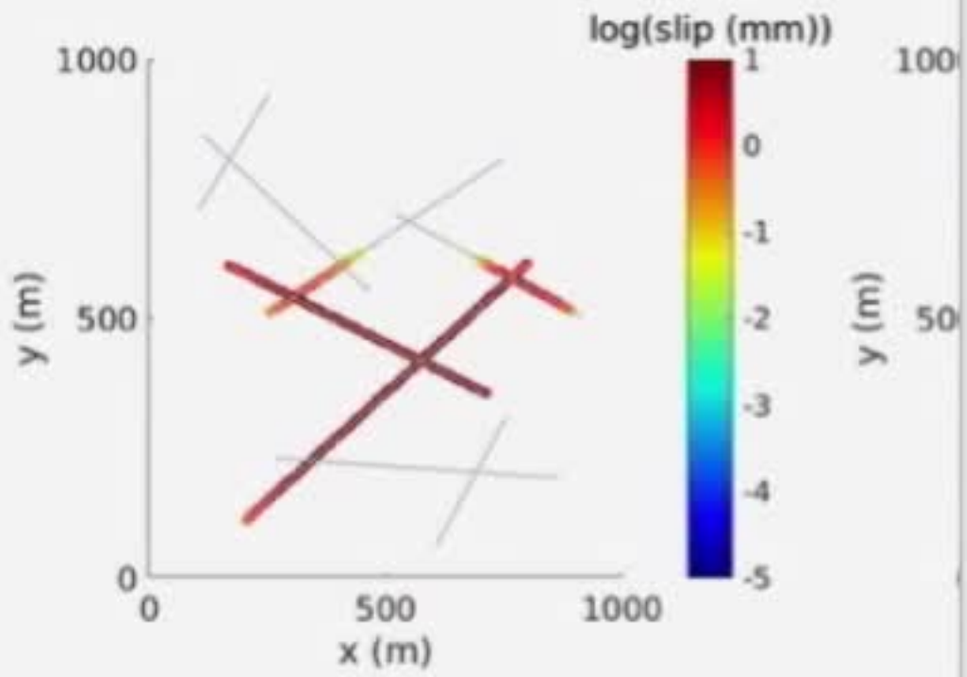
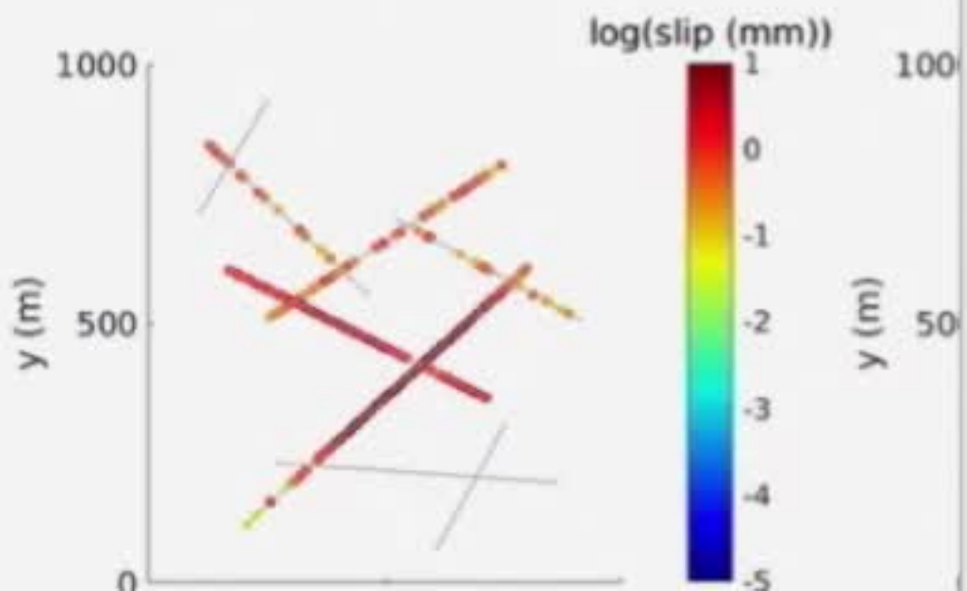
Flow Induced Shear Failure:

Homogeneous:



Heterogeneous:



Transitions

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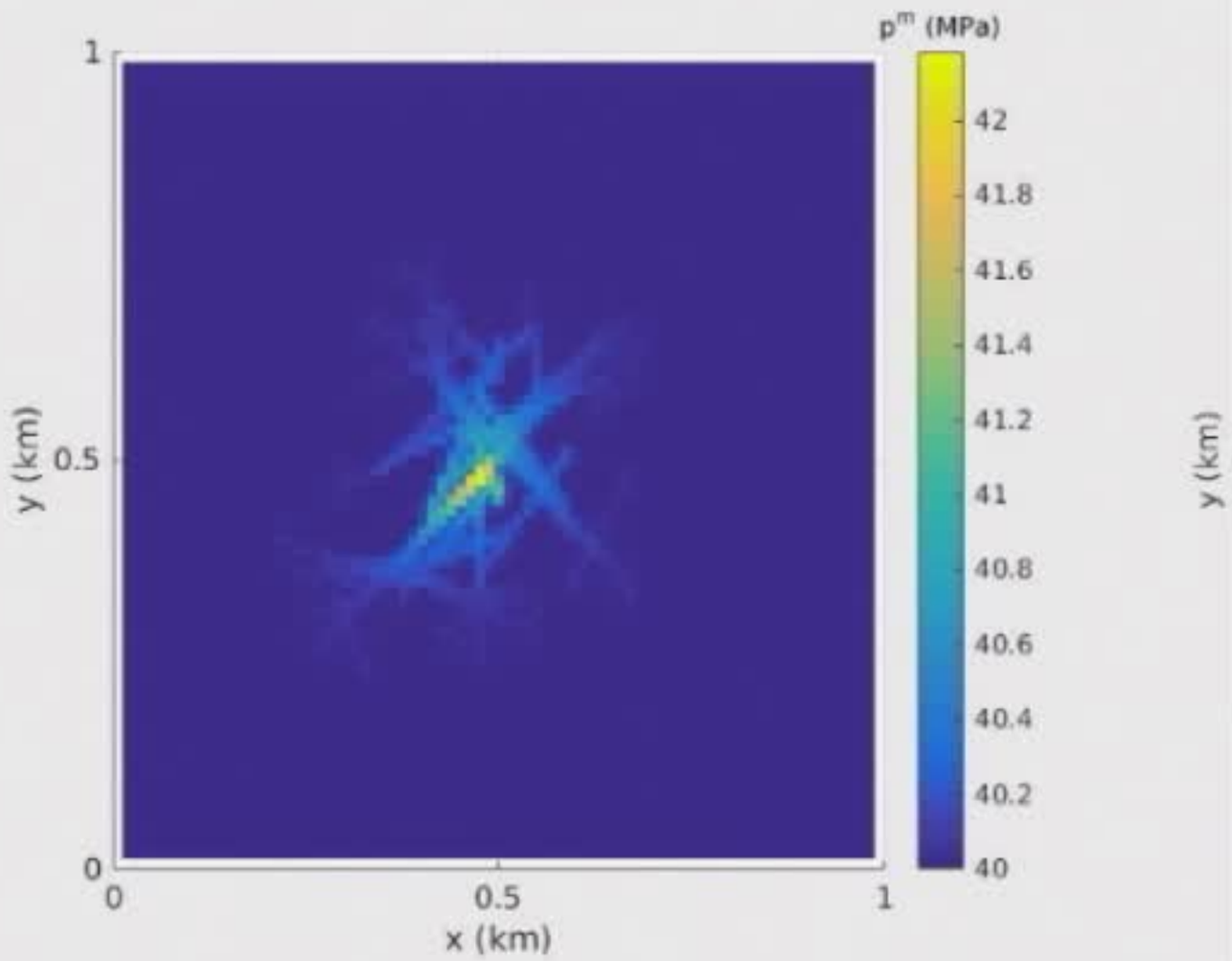

Transitions

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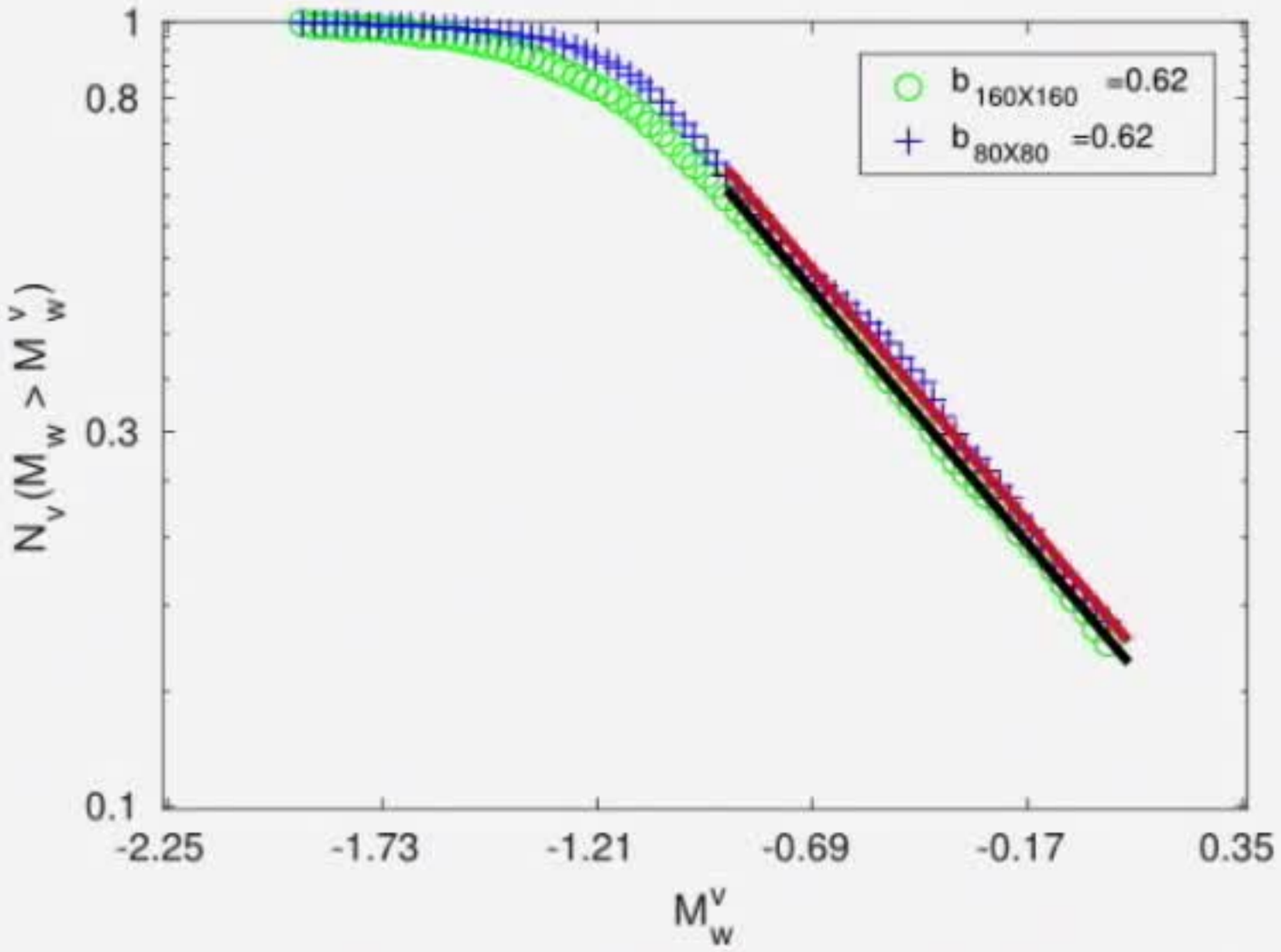
Flow Induced Shear Failure: Seismicity



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