EGU General Assembly 2022 (EGU22-5140)

Basal Hydrofractures near Sticky Patches

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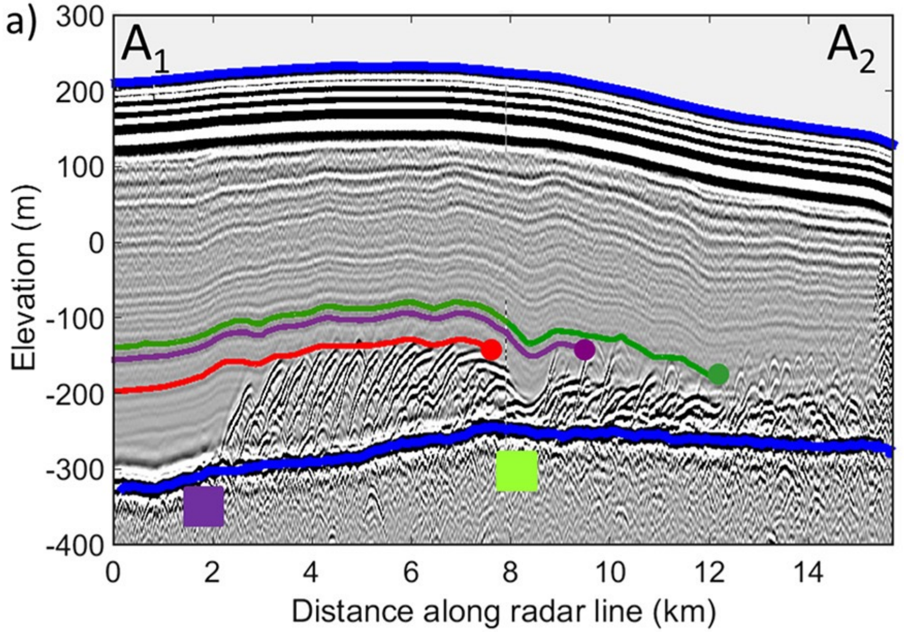
Observations on basal crevasses and sticky patches

Basal crevasses

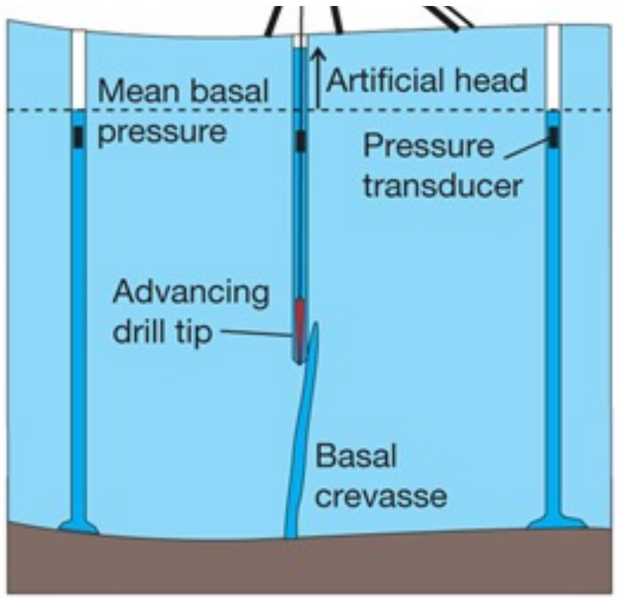
- Radar profile
- Borehole experiments

Sticky patches (sticky spots)

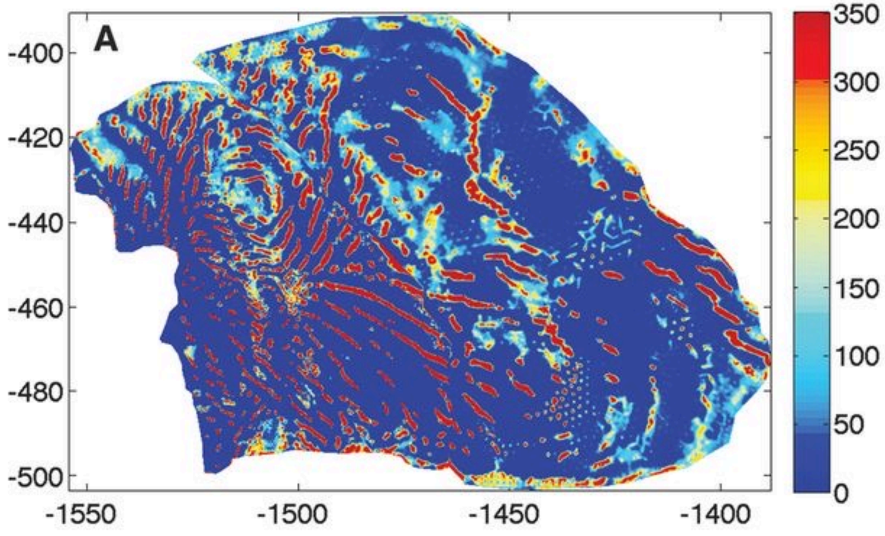
- Inversion
- Icequakes



Wearing and Kingslake, 2019



Harper et al., 2010

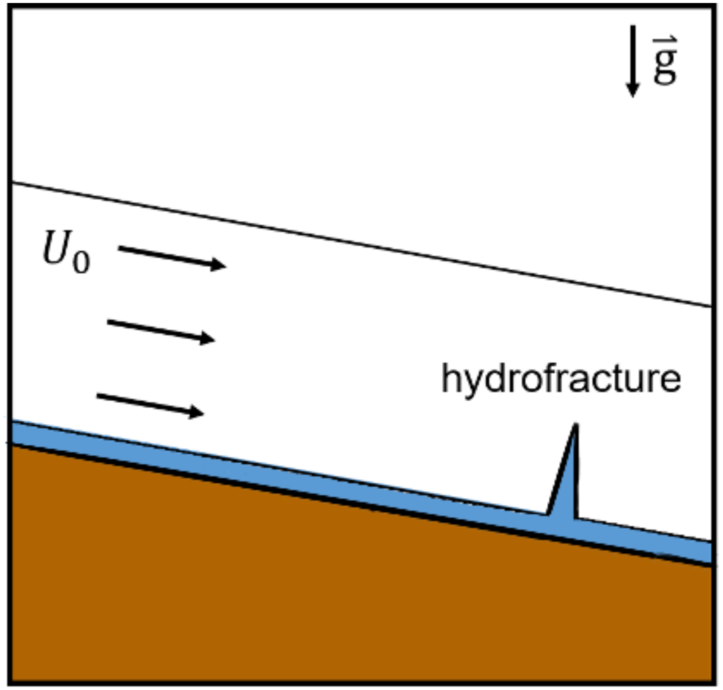


Sergienko and Hindmarsh., 2010

What determines the propagation of basal crevasses?

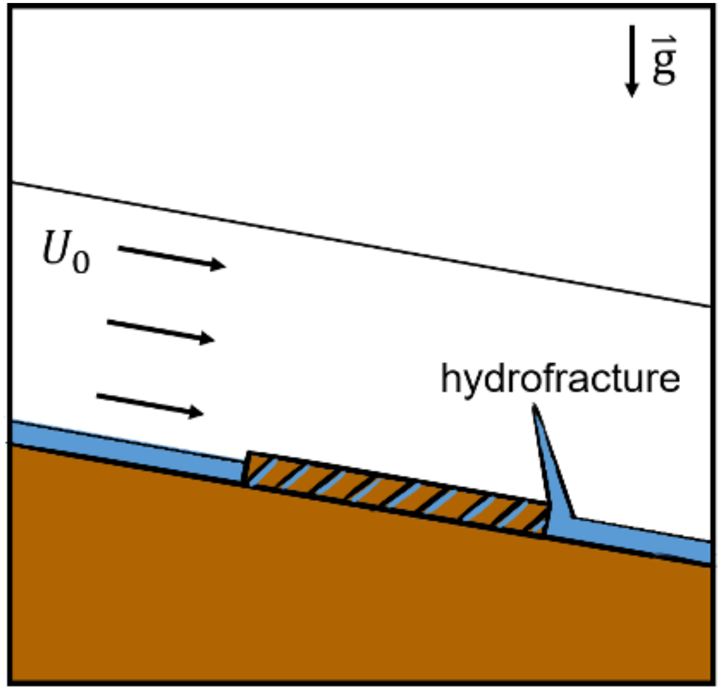
- Basal water pressure
- Hypothesis: sticky patch (excess shear stress on the ice-bed interface)

No sticky patches



Crack length and direction change!

With a sticky patch



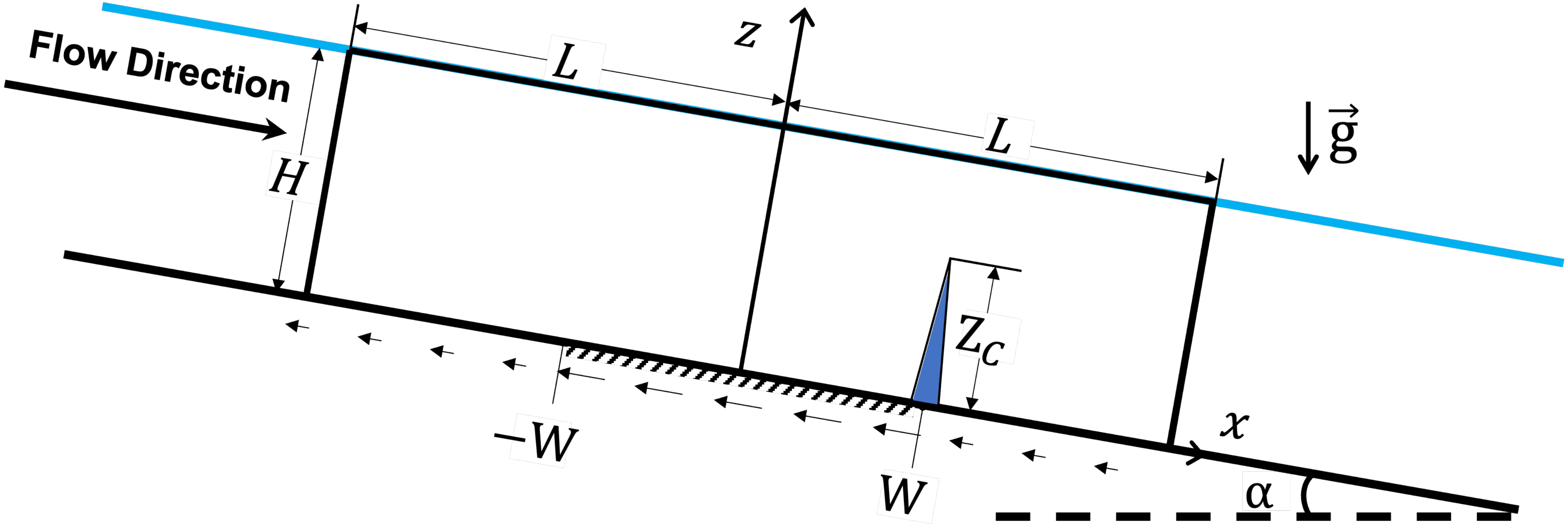
Model Setup

Assumption:

- A hydrofracture on the downstream end of the sticky patch
- Force balance in x-direction

Nondimensional parameters:

- Flotation fraction $f = \frac{p_w}{\rho_i g H}$
- Sticky-patch size $W' = \frac{W}{H}$
- Excess shear stress $\Delta\tau' = \frac{\Delta\tau}{\rho_i g H}$

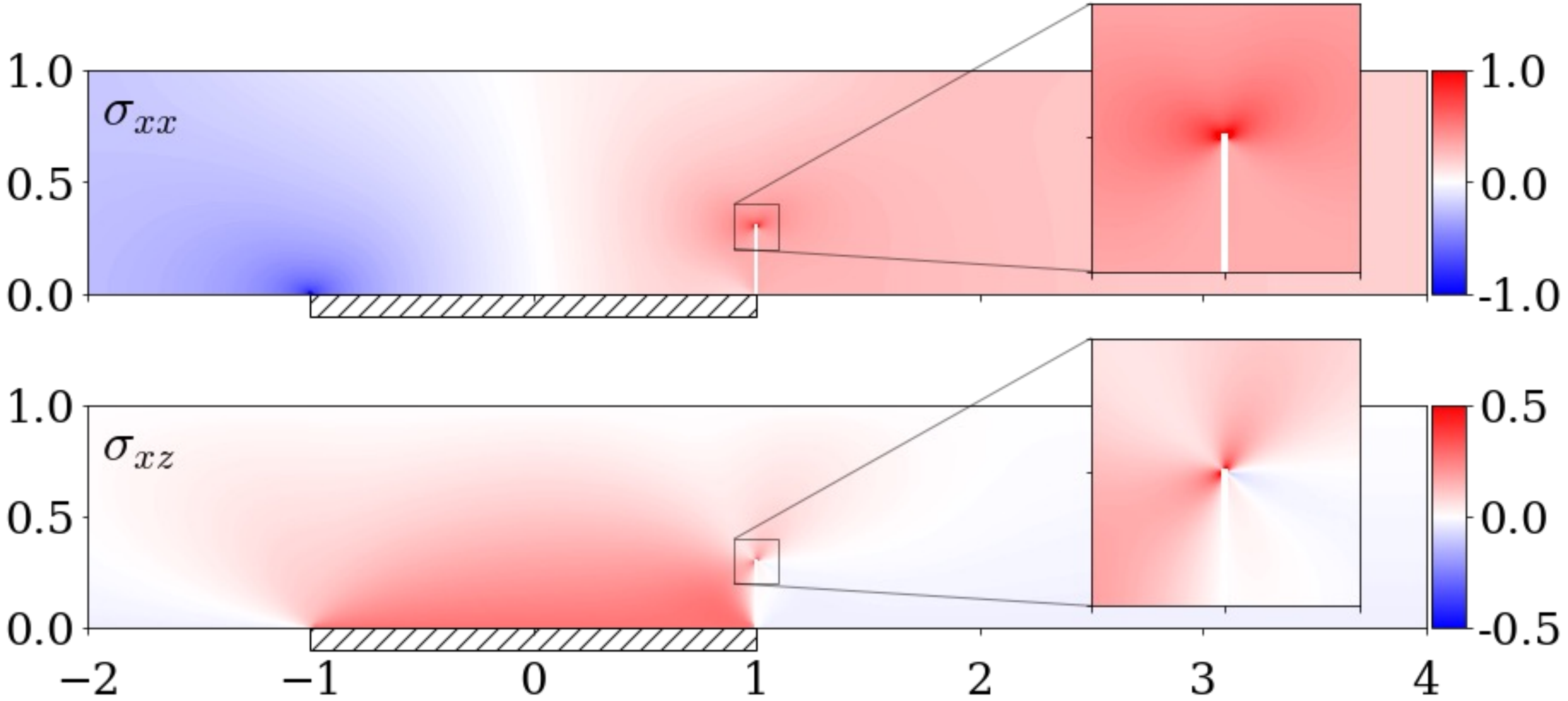


Results: Stress around a mode-I crack

Stress caused by the sticky patch

- (a) Horizontal tension on the downstream end
- (b) Excess shear stress localised around the patch

vertical extent



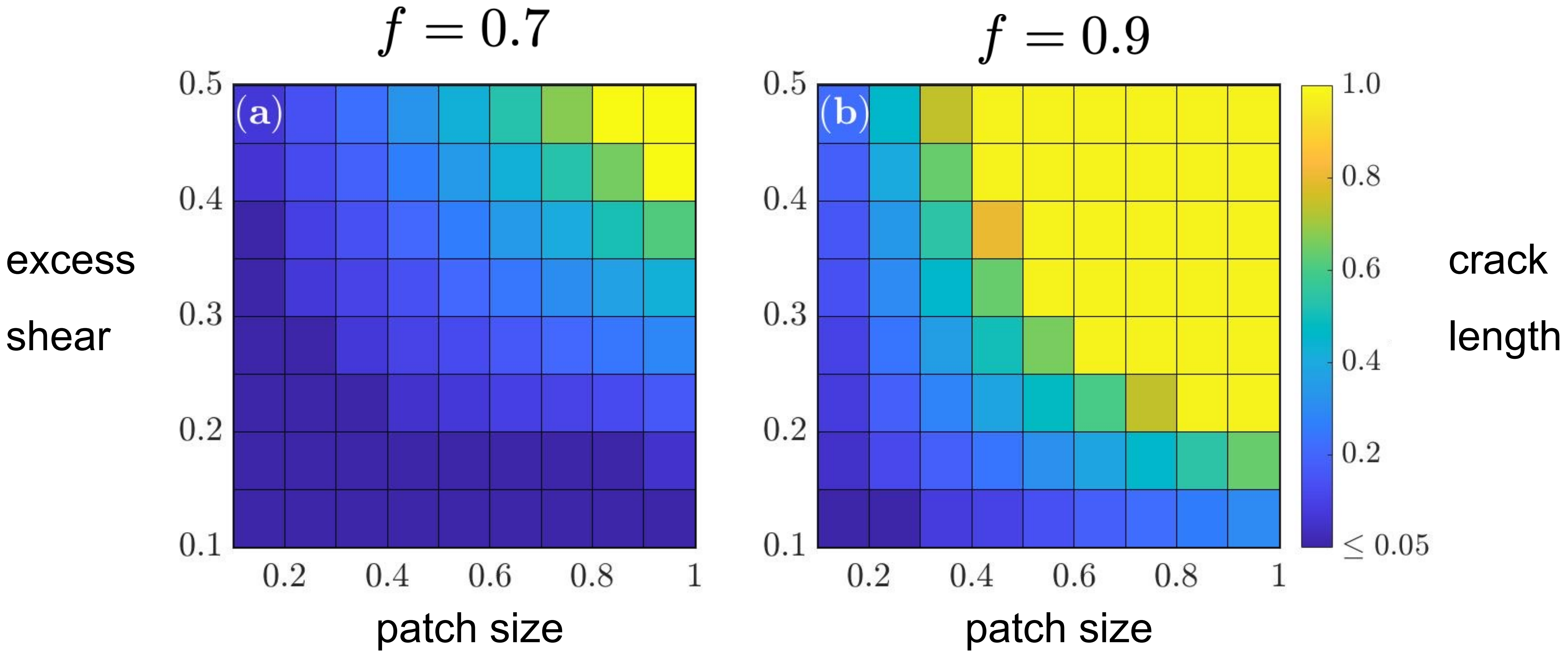
horizontal extent

red = tension,

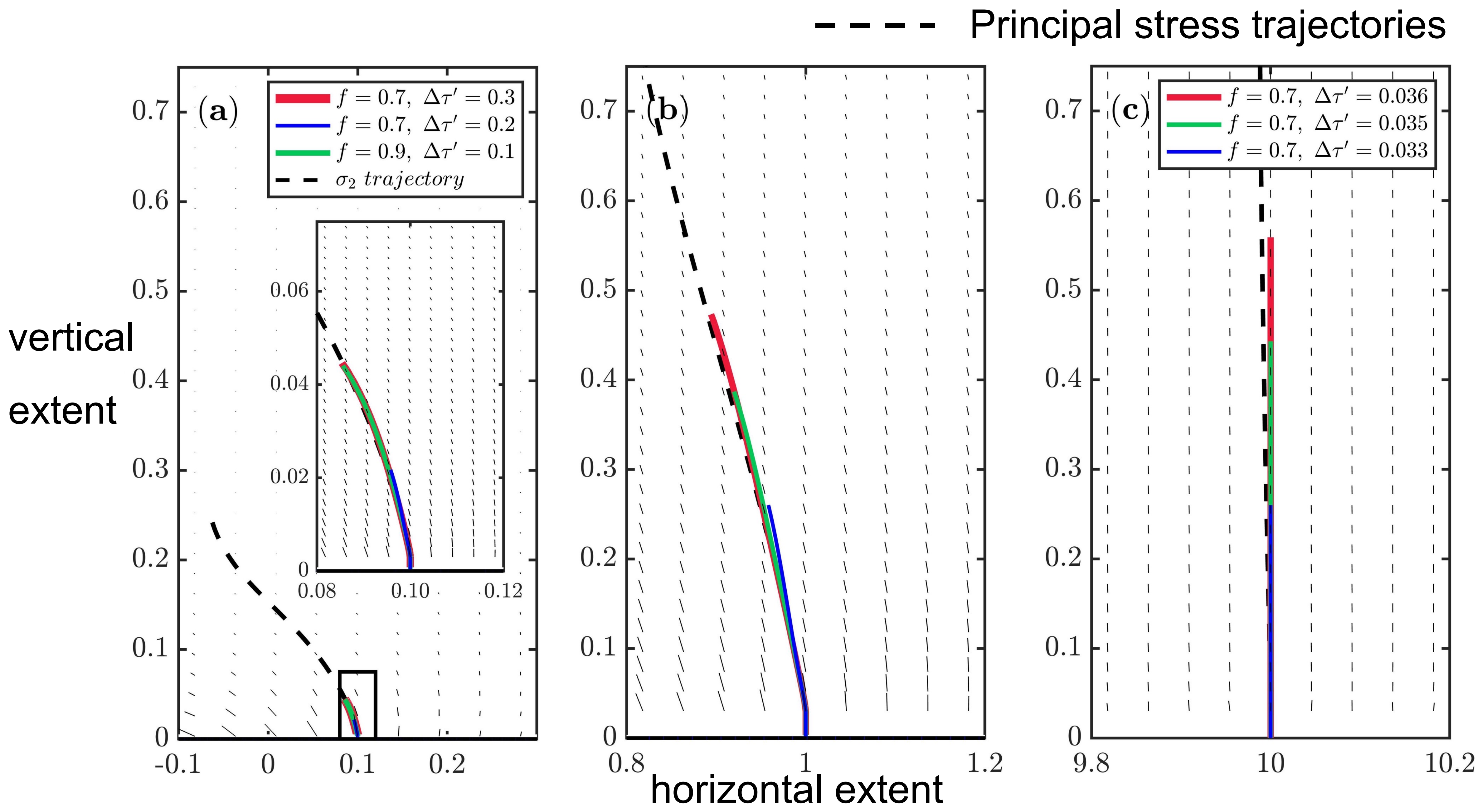
blue = compression

Results: Exploration on the stable crack length

- Maximum stable crack length controlled by dimensionless patch size W' and dimensionless excess shear stress $\Delta\tau'$.



Results: Curved paths of cracks



Conclusions

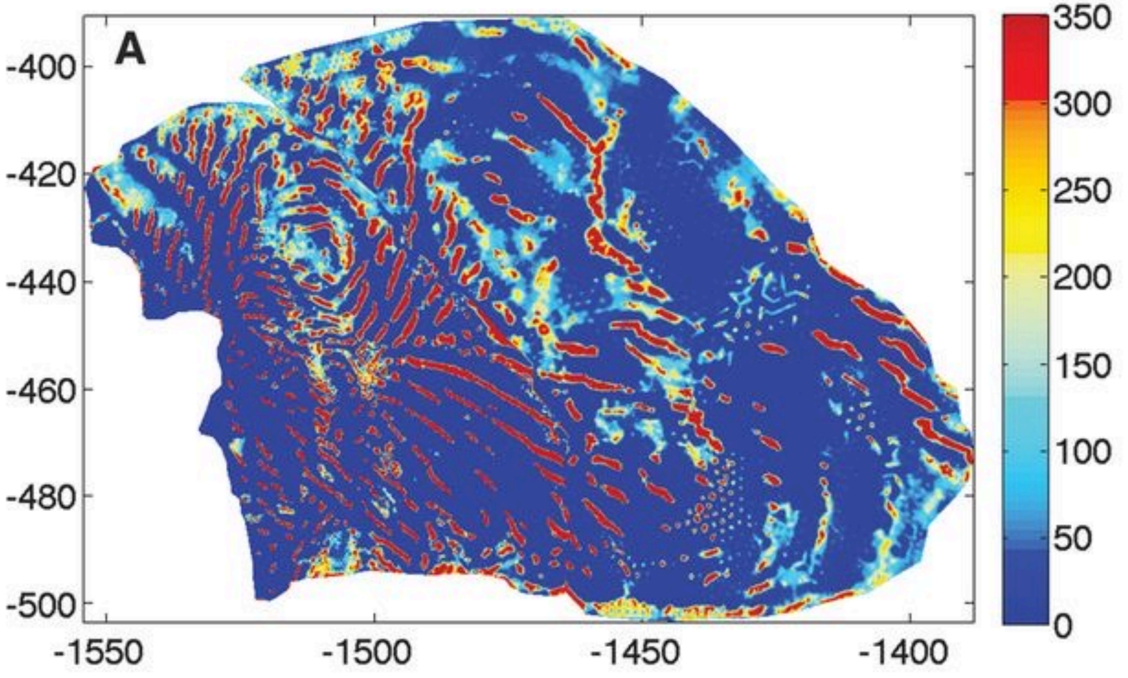
- Sticky patches can produce tension and shear stress, promoting the propagation of basal hydrofractures.
  - Small patches produce curved cracks.
  - Large patches produce vertical cracks.

- Future work includes viscoelastic rheology and hydrofractures near the grounding line, which may also undergo shear stress

Additional slide 1

- Potential application to real cases (Thwaites Glacier)
  - Patch size $\frac{W}{H} \sim 10$
  - Excess shear stress $\frac{\Delta\tau}{\rho_i g H} \sim 0.03$

- Shear stress variation can contribute to the cracklength of basal crevasses, but the paths remain vertical lines



Sergienko and Hindmarsh., 2010

Additional slide 2

- Superposition
  - (a) stable sliding
  - (b) excess stress