Interfacial stresses at the grounding line of the Whillans Ice Plain control the initial stick-slip rupture speed

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With

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Whillans Ice Plain, West Antarctica

- stick-slip events
- Interesting behavior when they start near the grounding line
- Small-scale friction experiments
Slip Event in the Near-field

Walter et al., 2011
Bindschadler et al., 2003
Wiens et al., 2008
Winberry et al., 2009
Walter et al., 2011
Winberry et al., 2011
Pratt et al., 2014
Walter et al., in revision
Barcheck et al., in prep.
Analogous to Large Earthquakes

2011 Tohoku Earthquake (Yue and Lay, 2011)

2010 Chile Earthquake (Moreno et al., 2010)
Discrete zones of varying frictional properties

(Bilek and Lay, 2002)

Walter et al., in prep.
Rupture Speed

$V_r = $ rupture speed
$\beta = $ shear wave speed

$\beta_{\text{ice}} \sim 1800 \text{ m/s}$
$\beta_{\text{till}} \sim 200 \text{ m/s}$

Slope = 150 m/s/day
$R^2 = 0.73$
$p = 0.0012$

Walter et al., 2011
Chance to collect more data
Whillans Ice Plain, West Antarctica observations

- Variable rupture speeds for different events (~ranging by factor of two)
- Variable rupture speed along rupture path
- Some correspondence between fast rupture and interfacial stresses
\[ \sigma'_n = \sigma_n - P_w \]

Note: Not drawn to scale

Ice flow direction and motion during stick-slip event

Laboratory loading conditions during stick-slip event

Rigid body

Ball bearings

Laser Sheet

Walter et al., in revision
$V_{\text{rupture}} \sim \tau/\sigma$
$V_{\text{rupture}} \sim \frac{\tau}{\sigma}$
What we learn about frictional stick-slip, in general:

- No characteristic failure threshold
- Interfacial loading “steers” rupture at local and broad scales
- Nucleation (slip initiation) is still a big unknown (i.e. when do earthquakes start?)

\[ V_{\text{rupture}} \sim \frac{\tau}{\sigma} \]
Questions?