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Investigating the Role of Buoyancy in Iceberg Calving Dynamics

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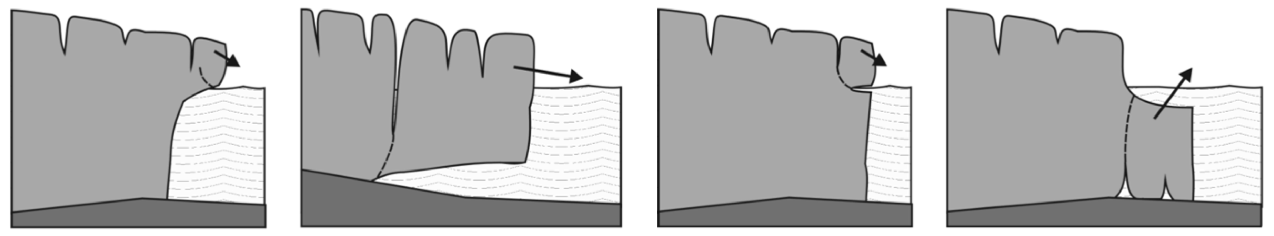
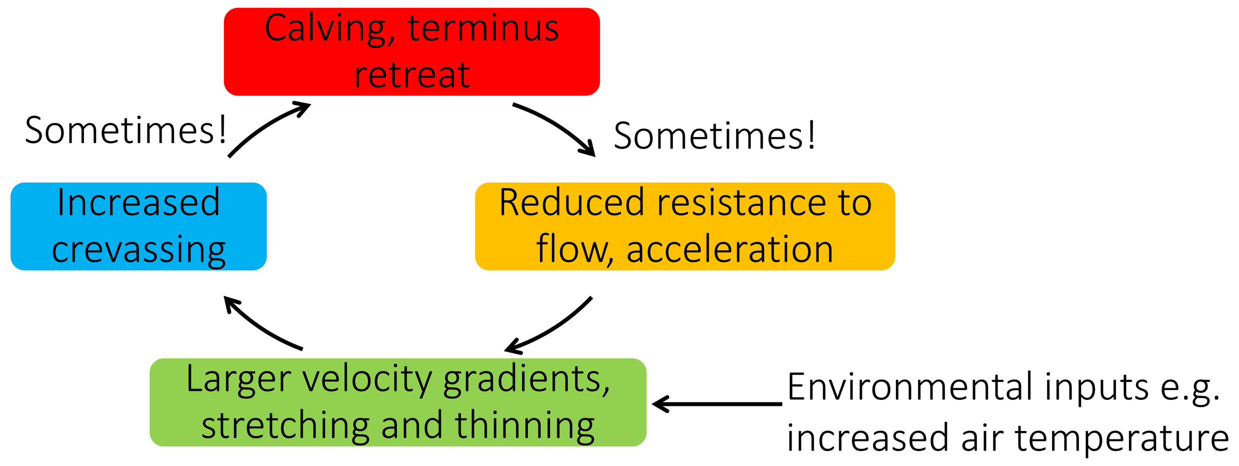
1) Iceberg calving

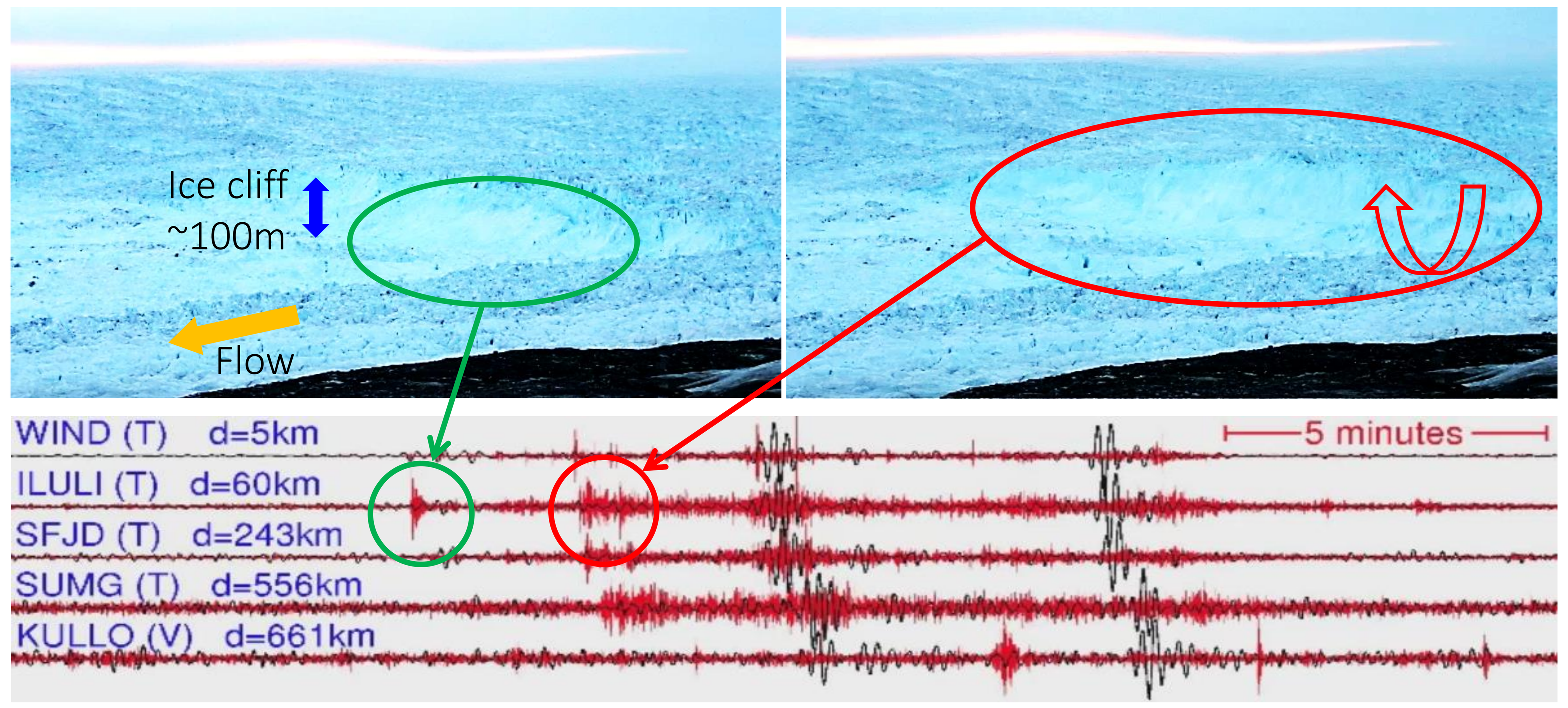
- ~50% of the mass loss from the Greenland Ice Sheet is from the front of marine-terminating glaciers
- Still poorly understood – major source of uncertainty in our projections for future sea level rise



- Range of processes operating on different length- and time-scales [1]
- Calving is part of a complex feedback cycle along with dynamic thinning and acceleration – difficult to separate cause and effect



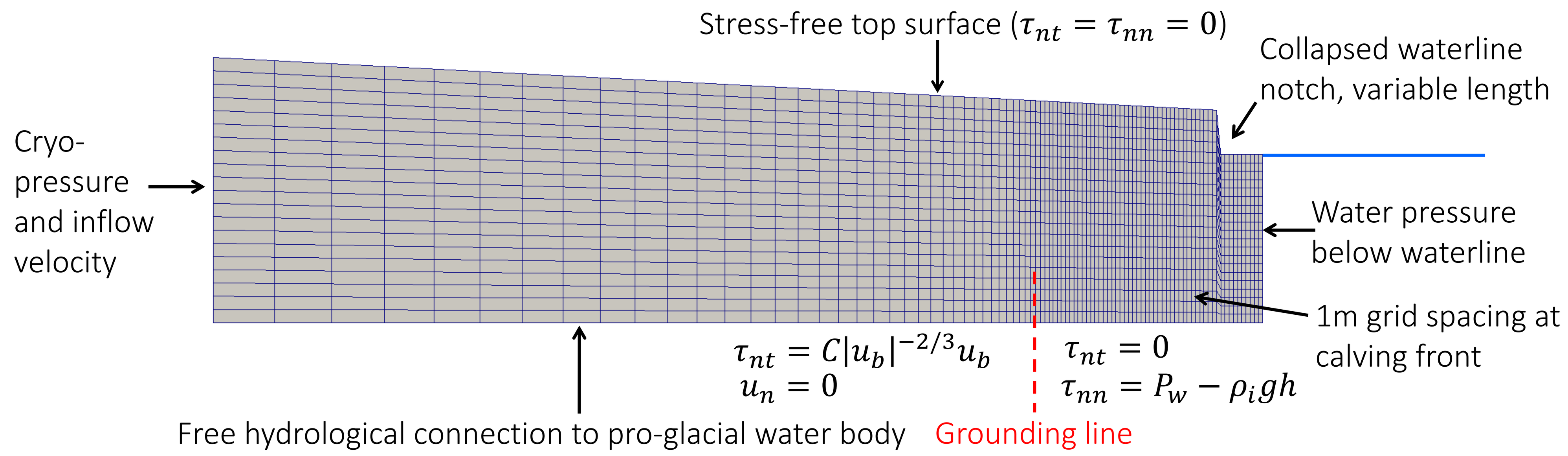
2) Jakobshavn Isbræ calving event



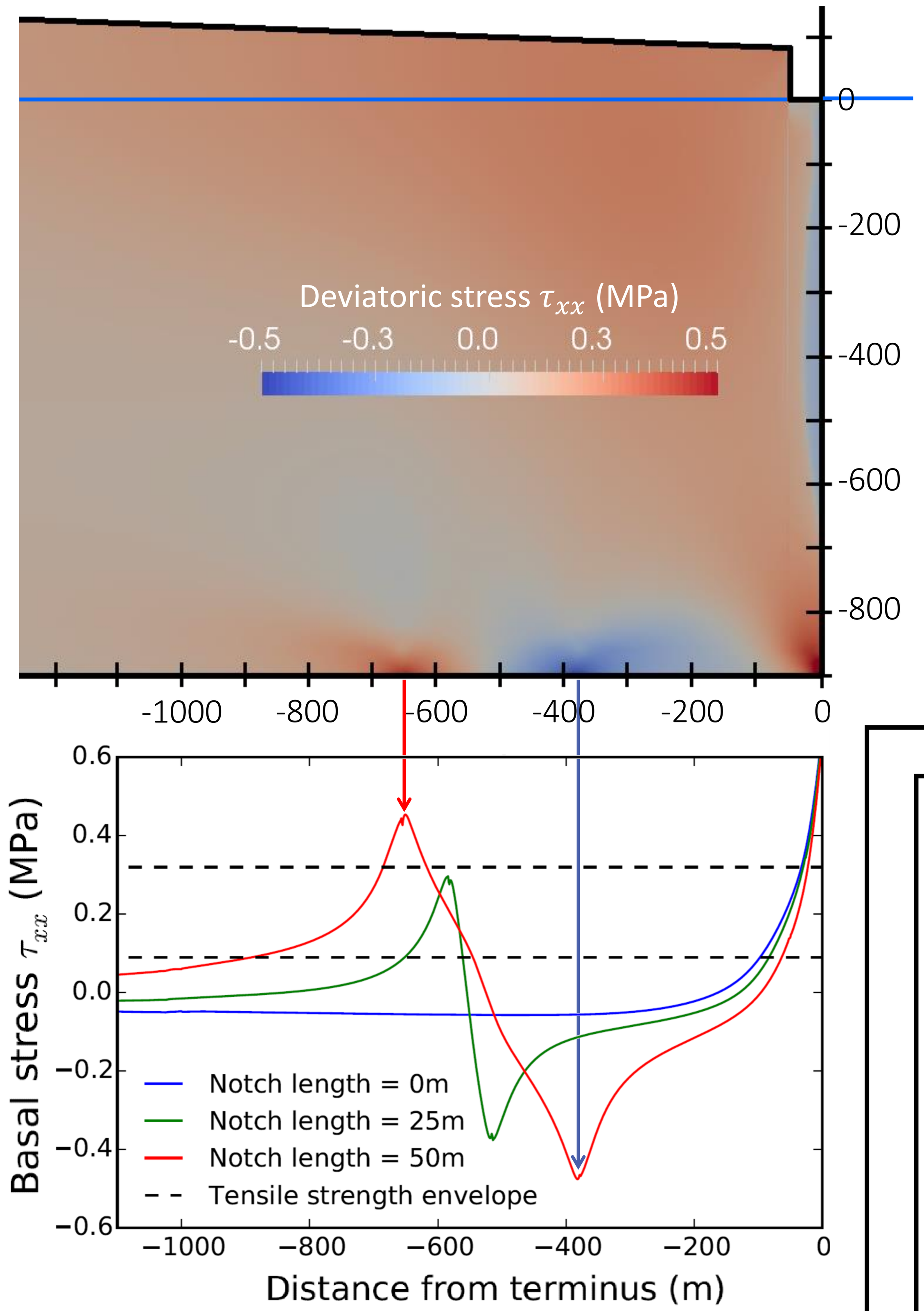
- Video footage and seismic data of a large calving event in August 2009 [2]
- Initial small subaerial slump calving event
- Followed 5 minutes later by a larger full-depth rotating-slab calving event
- Our research aim is to find a mechanism linking the two events

4) Elmer/Ice[3] model

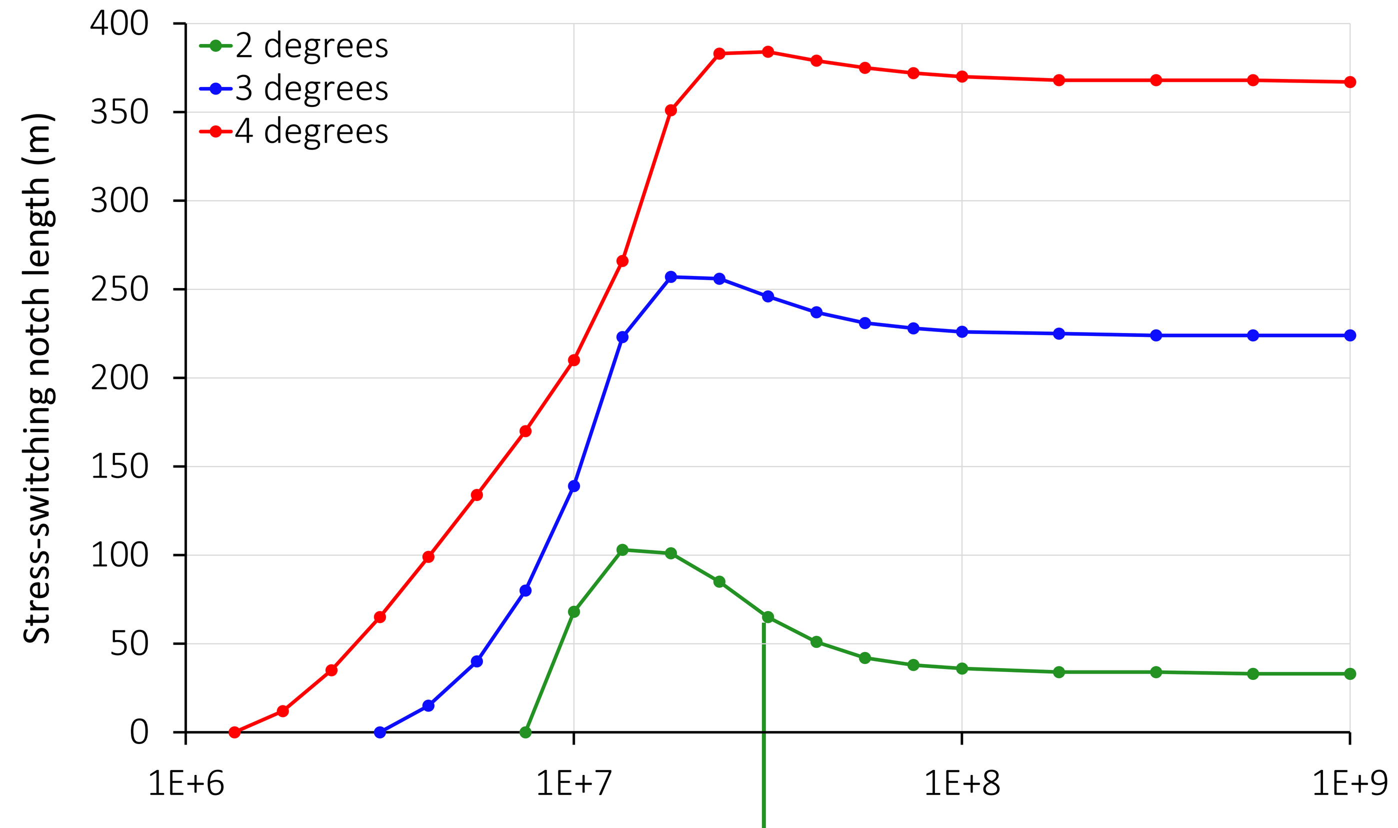
- Simple 2D diagnostic flowline model of an idealised grounded glacier near flotation

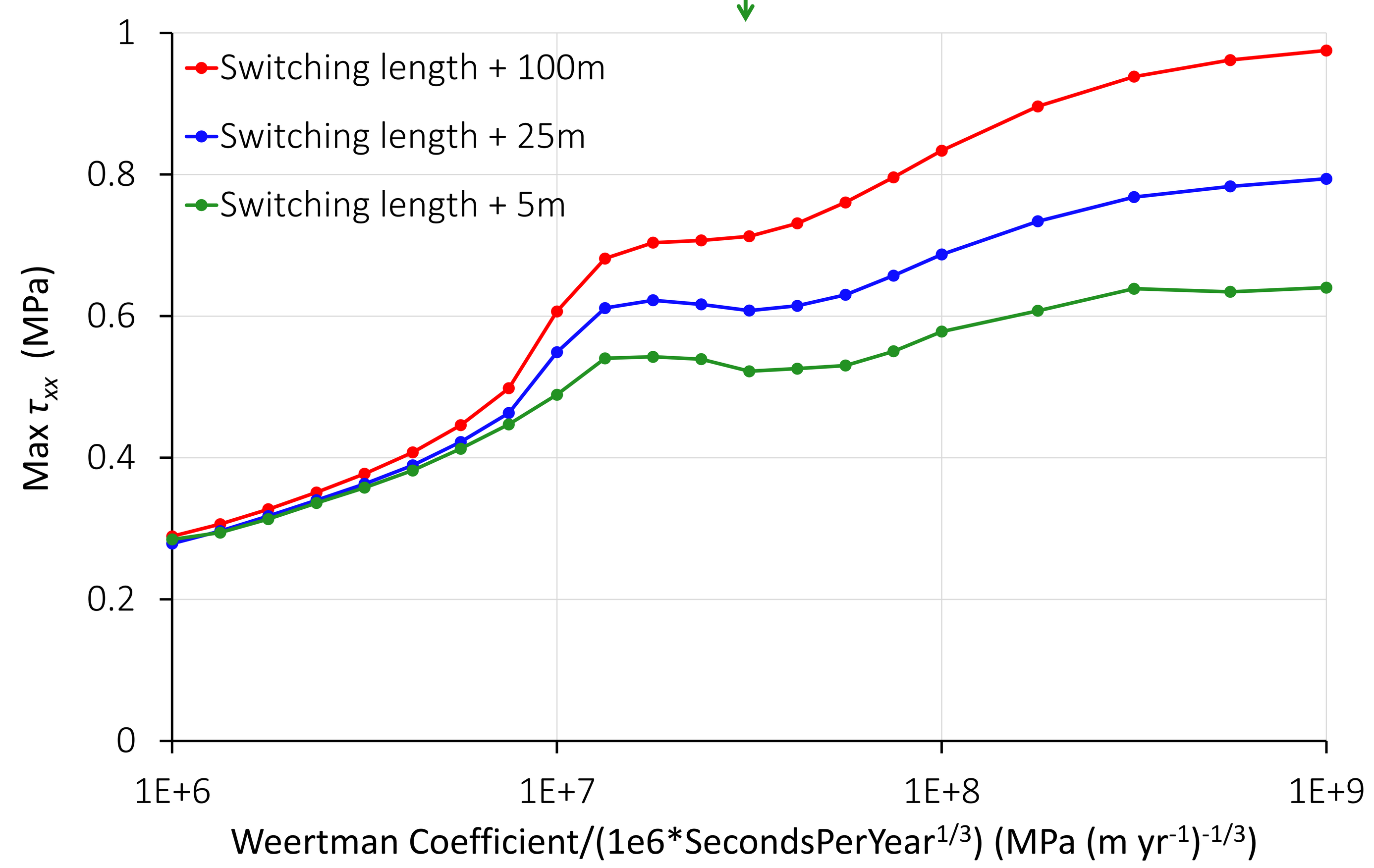


5) Stress concentration



- Water depth = 900m, terminus thickness = 980m, surface slope = 2°
- Varying notch lengths produce dramatically different deviatoric stress profiles
- **Switch in the stress regime** between 0m and 25m notch lengths as a result of the superbuoyant front
- Tensile stress peaks overcome the tensile strength envelope [4]
- Suggests **plausibility of the buoyancy-driven calving mechanism**

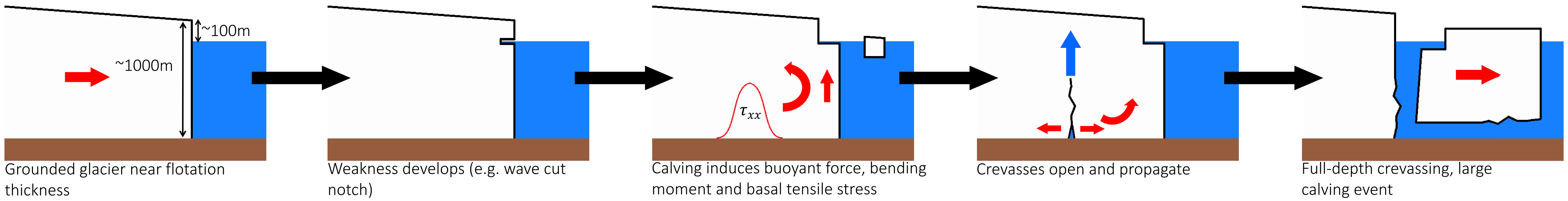




6) Basal conditions and stress-switching

- Water depth = 900m, terminus thickness = 980m, varying surface slopes
- Notch length required to switch basal stress regimes plotted across a range of basal conditions (bed stickiness increases with Weertman Coefficient)
- For 2° surface slope, we plotted the basal deviatoric stress maximum at the stress-switching notch length, and at a range of additional lengths to lose the noisy signal at the switching length
- General rising trend suggests that a **sticky bed favours larger basal tensile stresses** (and therefore calving)
- It is clear that **basal conditions play an important role in calving** (i.e. not solely dependent on buoyant forces)
- In this **new** buoyancy-driven calving mechanism, **calving rate is greater than the notch-melting rate**

3) Buoyancy driven calving



References and Acknowledgements

1) C. J. van der Veen, Calving glaciers (2002), *Progress in Physical Geography*, 26, 96-122
2) F.Walter et al, Analysis of low-frequency seismic signals generated during a multiple-iceberg calving event at Jakobshavn Isbræ, Greenland (2012), *J. Geophysical Research*, 117, 1-11: Supplementary Material
3) O. Gagliardini, et al, Capabilities and performance of Elmer/Ice, a new-generation ice sheet model (2013), *Geoscientific Model Development*, 6, 1299–1318
4) D. G. Vaughan, Relating the occurrence of crevasses to surface strain rates (1993), *J. Glaciology*, 39, 255-266

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