Summary:

Title: Changes to glacier friction law due to solid friction
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1. We study how Weertman friction law is modified when we introduce a tangential force - i.e. when we drop the pure sliding assumption -, and we propose an expression to represent the effect it has on the law.
2. FEM results validate our analytical model; the shape of the law stays almost the same, with sliding parameter and maximum attainable stresses being changed.

Next pages contain the reduced version of the ppt presentation shown in the video.

Changes to glacier friction law due to solid friction

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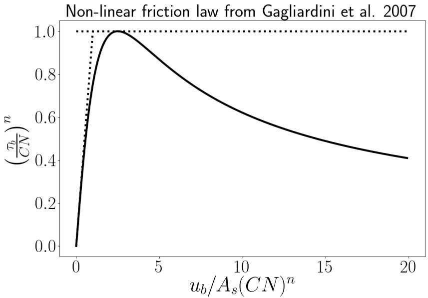
- Glacier friction law: Critical component in glacier dynamics modelling - e.g. Brondex et al. 2017.
- Gagliardini et al. 2007 proposed a friction law with cavities for non-linear ice over hard beds.
  - 2D bed
  - **Pure sliding**
  - Steady state
- What happens if we drop the pure-sliding assumption?



$$\left(\frac{\tau_b}{CN}\right)^n = \frac{\chi}{1+\alpha\chi^q}$$

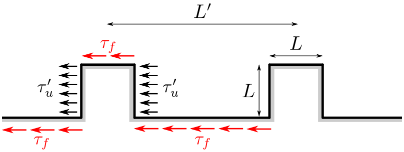
$$\chi = \frac{u_b}{C^n N^n A_s}$$

Mathematical model for $n = 3$

- $\underbrace{\tau_b}_{\text{basal drag}} = \underbrace{\tau_u}_{\textit{viscous}} + \underbrace{\tau_f}_{\text{solid friction}}$
- Bound of $max(\tau_b/N)$: $C < max(slope) + \tau_f/N$; greater!
- Reduced solid friction $T = \frac{\tau_f}{\tau_b} \implies T = 0$, for pure sliding

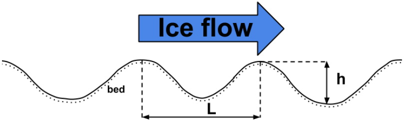
$$u_b = \tau_b^3 \, A_s[\underbrace{(1-T)^3}_{\Delta\tau_u} + \underbrace{\beta(1-T)T^2 + \gamma(1-T)^2 T}_{\text{Reduction of viscosity}}]$$

- $\beta \propto r^2$ and $\gamma \propto r^2$



$\tau'_u = \tau_u \frac{L'^2}{L^2}$

$r = \frac{1}{2}\frac{h}{L}$

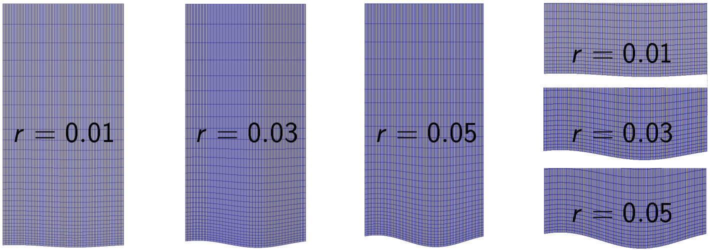


Numerical tests

Objective:

$$\frac{A_s^F}{A_s^S} = (1 - T)^3 + \beta(1 - T)T^2 + \gamma(1 - T)^2 T$$

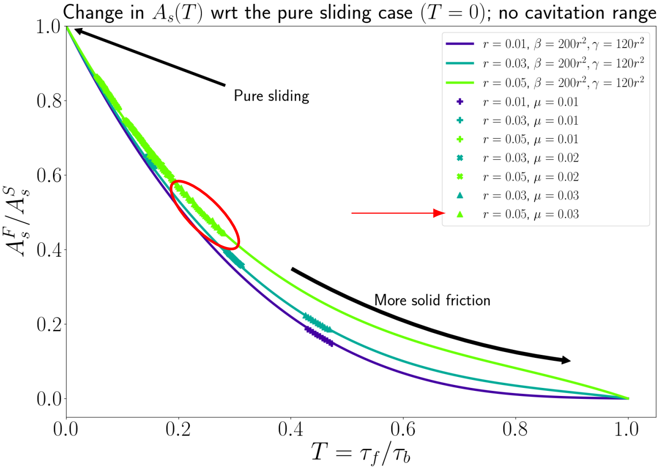
- Similar set-up as in Gagliardini et al. 2007
- Coulomb friction law $\tau_f = \mu N \rightarrow T = \frac{\mu N}{\tau_b}$
- Test several values of μ, N and r



Results: Change in A_s

Good fit with $\beta = 200r^2$ and $\gamma = 120r^2$

Relative error between the fit and the numerical tests $< 2\%$

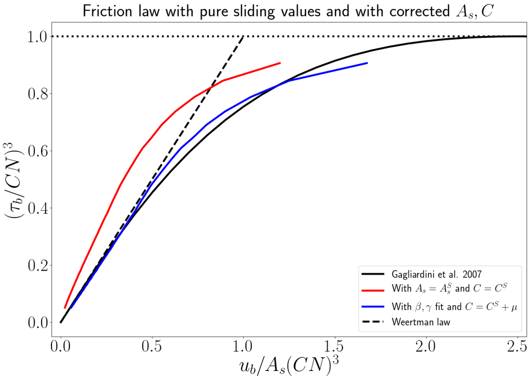


Results: Shape of the friction law

Showing: $r = 0.05$, T from 0.3 to 0.2 (approximately)

$A_s^F = A_s^S$, $C^F = C^S$

$A_s^F = A_s^S[(1-T)^3 + 200r^2(1-T)T^2 + 120r^2(1-T)^2T]$, $C^F = C^S + \mu$



Shape is more or less kept, but C and A_s change!

Conclusions

- We found an expression for sliding over hard 2D beds when considering tangential friction at the ice-bed interface
- Scaling parameters are modified: The bed sustains higher basal drag and ice slides slower
- The overall shape of a law such as the one proposed in Gagliardini et al. 2007 is more or less maintained:

  Difficulty to assess whether there is or not τ_f

Thanks for watching!
More details in the upcoming paper...

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