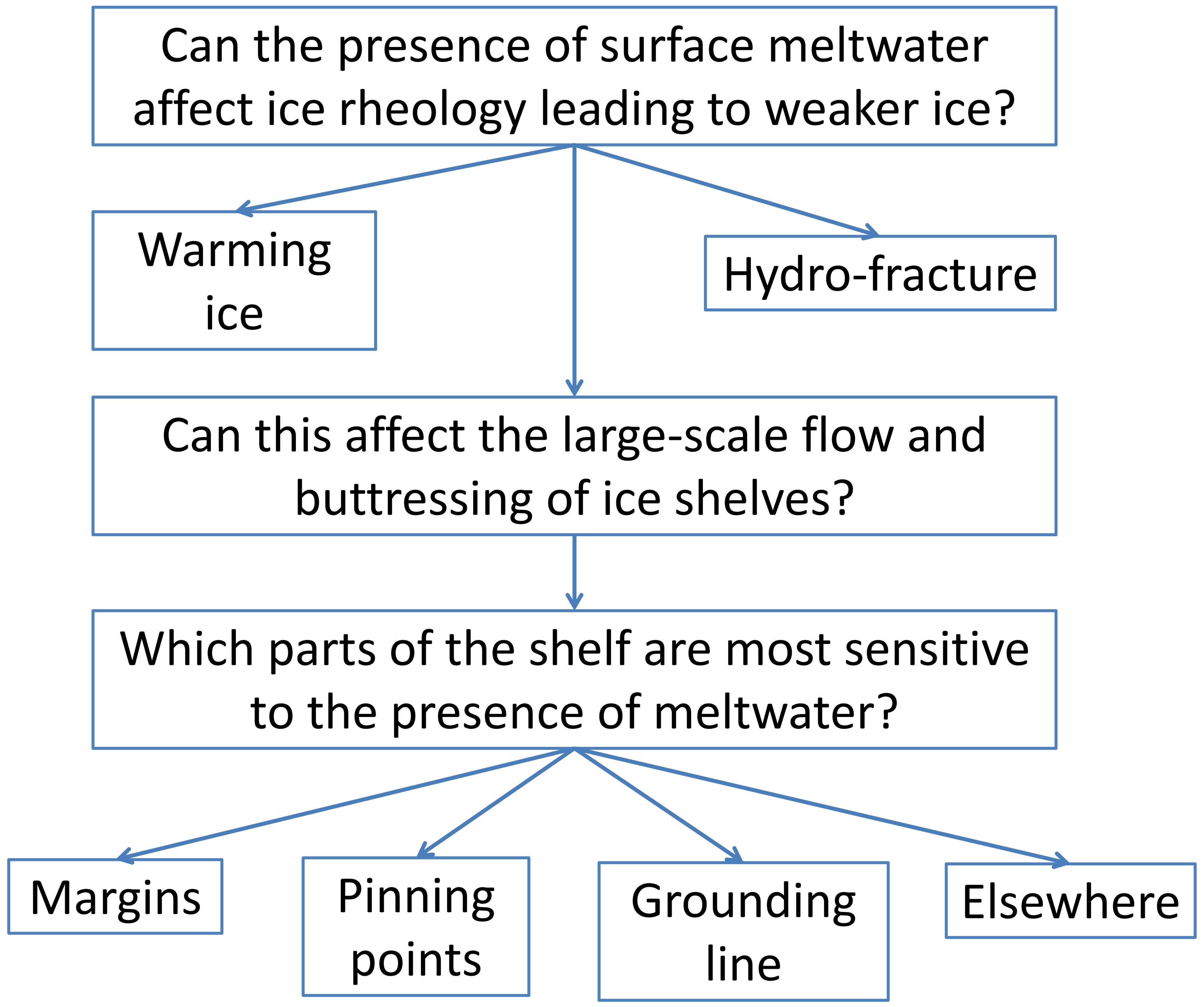
Does Ice Surface Hydrology Impact Large-Scale Ice Flow?

Martin Wearing (LDEO)

Motivation:



Idealized Ice-Shelf Model:

- Parallel Channel
- Flow in along-channel (x) direction only. No-slip condition along sides.
- Uniform shelf-thickness across channel width

Force Balance $$4\frac{\partial}{\partial x}\left(\mu H\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial y}\left(\mu H\frac{\partial u}{\partial y}\right)=\rho g' H\frac{\partial H}{\partial x}$$

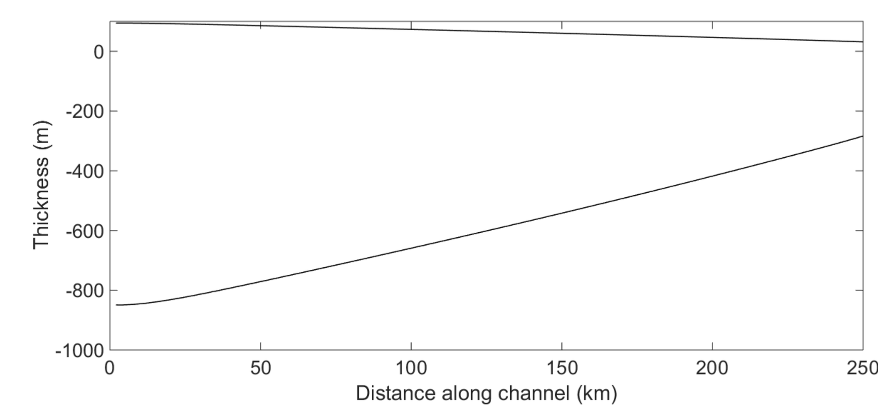
Rheology $$\mu=(1-D)B\varepsilon_{II}{}^{(1-n)/2n}$$

Evolve Thickness $$\frac{\partial H}{\partial t}+\nabla.(Hu)=0$$

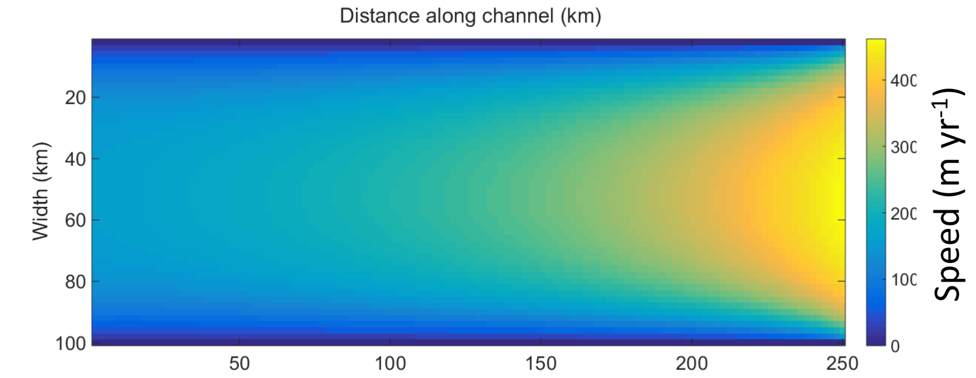
- Vertical uniform rheology.
- Specify spatial variation in flow-law parameter *B* and damage *D*.
- Run to steady state
- Calculate vertically and horizontally integrated buttressing from shear stress

Base Case:

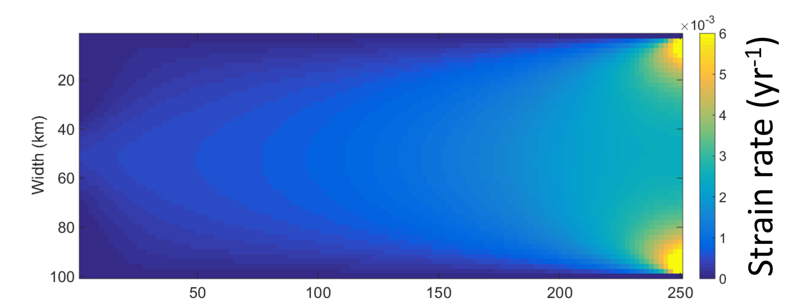
- Ice shelf rheology uniform with no damage (D=0) and flow-law parameter B appropriate for at -15°C: $B(-15C)=1.68\times10^{8}$Pa s$^{1/3}$

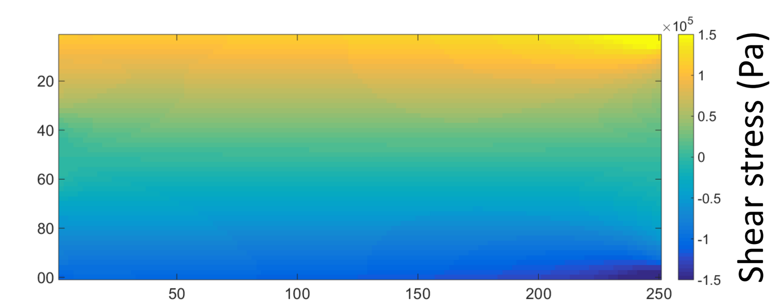


Ice-Shelf Thickness Profile



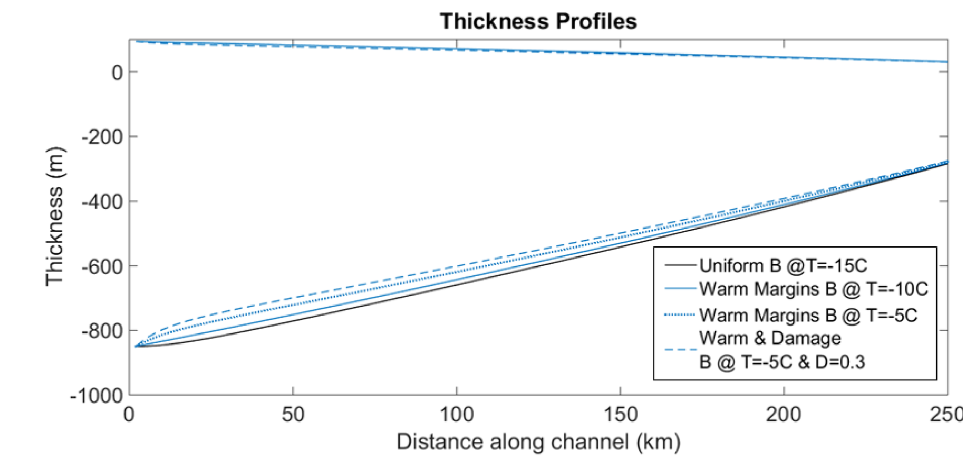
Ice-Shelf Flow Field



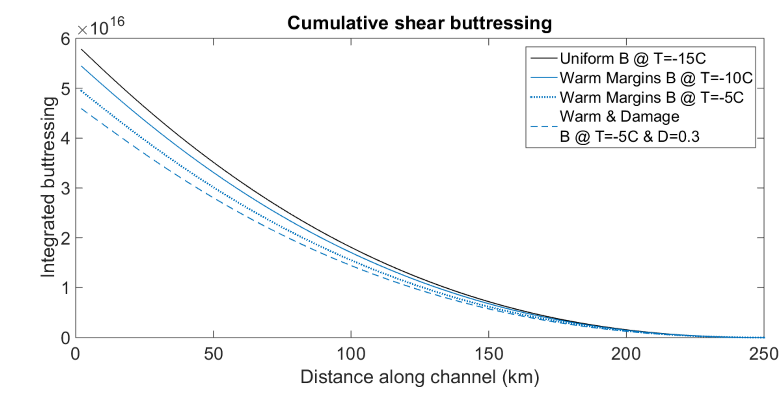


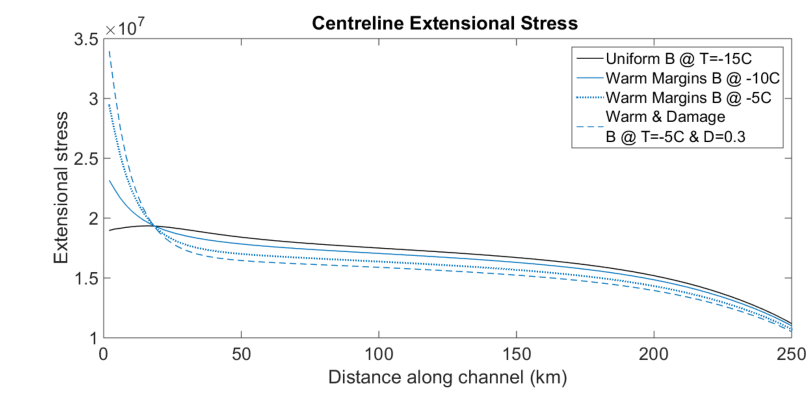
Margins: (within 6 km (3 grid points) of walls)

- Warm: *B*(-10C) & *B*(-5C)
- Warm and damage ice: *B*(-5C) with *D*=0.3

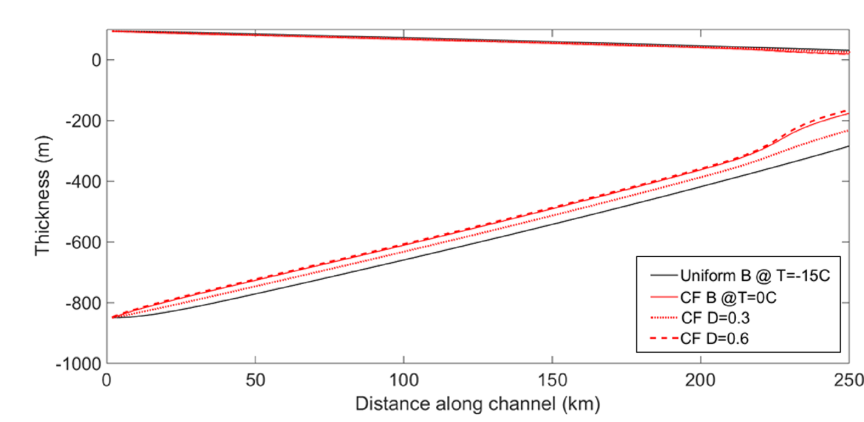


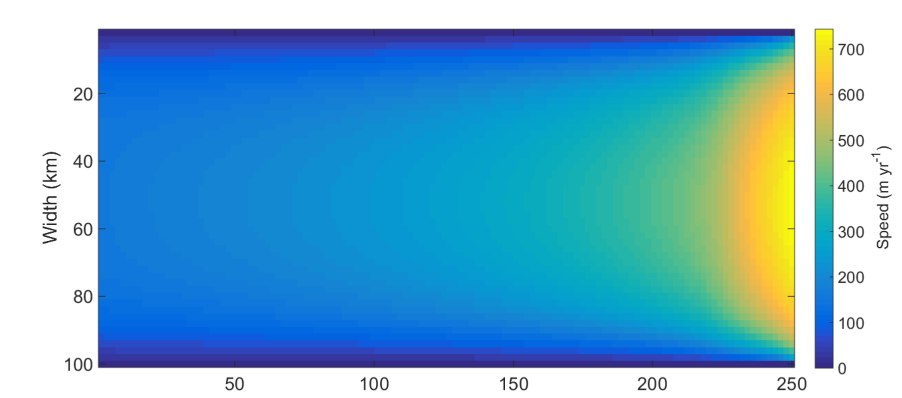
- Horizontal and vertically integrated shear stress back from calving front.
- Vertically integrated extensional stress along centreline.

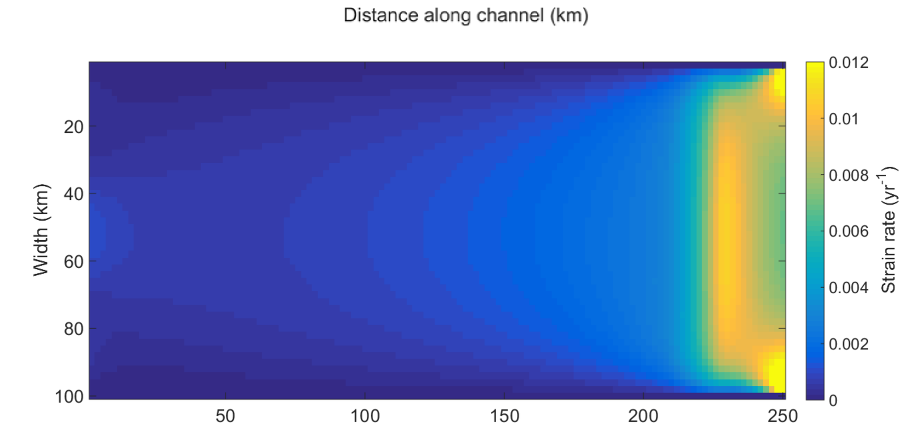


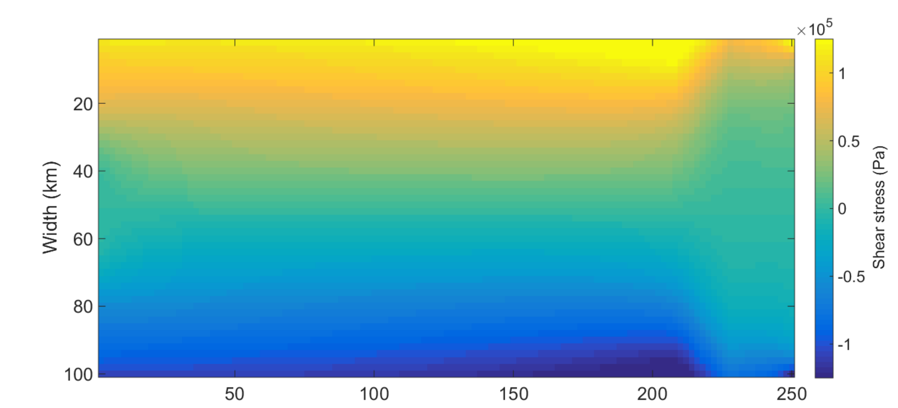


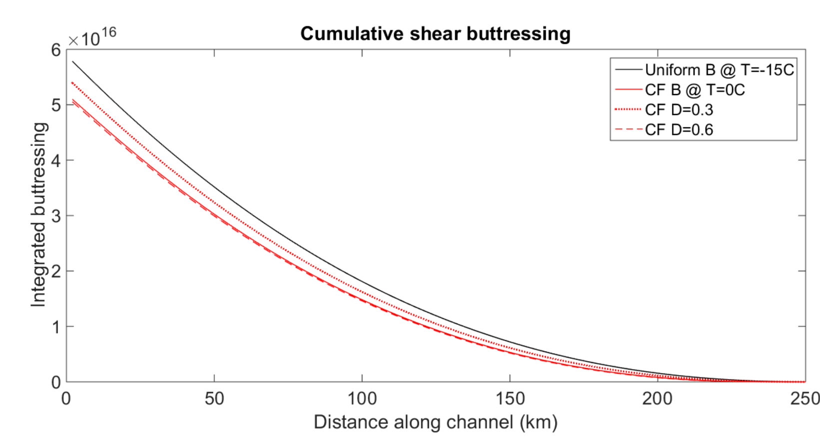
Calving front: Warm or damage final 30 km of shelf

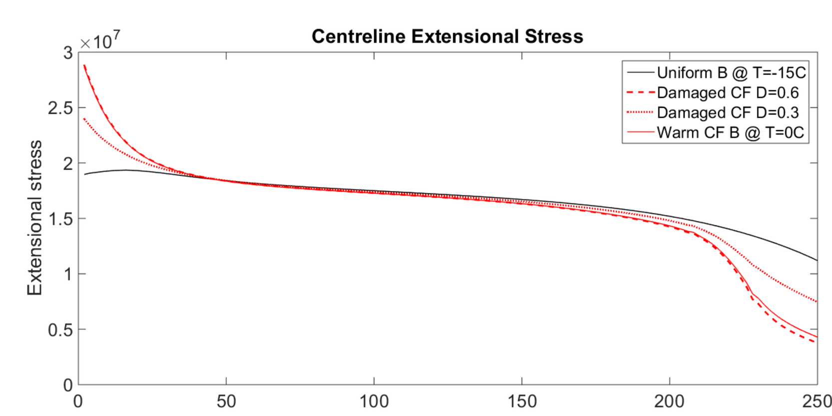








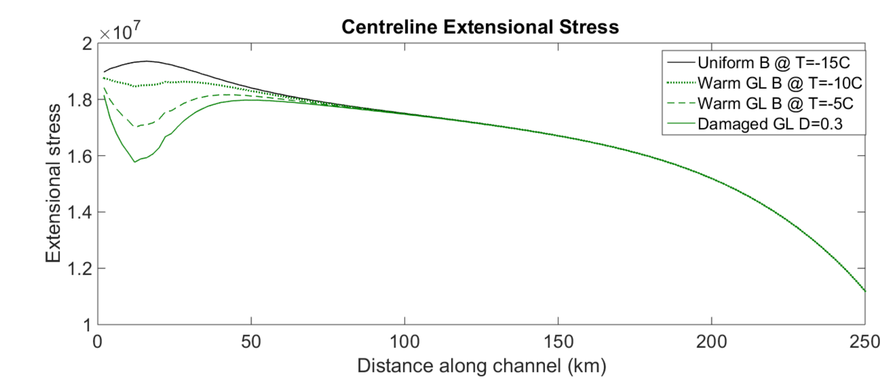




Grounding Line (GL):

(Warm/damage 10 km downstream of GL)

- Thickness profile and shear buttressing similar in all cases.



Findings:

In these simple experiments, warming or damaging the margins and calving front of the ice shelf had the biggest impact on large-scale flow. Confining this effect to the grounding line had least affect. However, this ice would advect into the whole shelf potentially leading to weakening

Lamont-Doherty Earth Observatory
Columbia University | Earth Institute