Glaciology
EESCGU4220

Practical 7: Non-steady heat equation

Aims:

Learn about boundary conditions

Learn more about "parameter space" and how to *search* it.

Understand what controls temperature in cold-based ice sheets.

$$\boxed{\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial z^2} - w \frac{\partial T}{\partial z}}$$

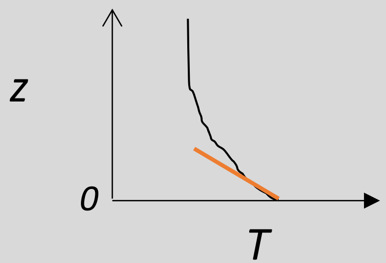
Boundary conditions

- Surface energy balance (Lecture 4)
- Basal energy balance

--- **geothermal heat flux**, friction: $\tau_b u_b$, hydrology

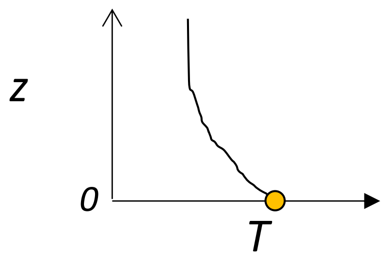
Cold-based ice:
Geothermal heat flux is set at the base.

Neumann boundary condition
(one that fixes the derivative of *T*)



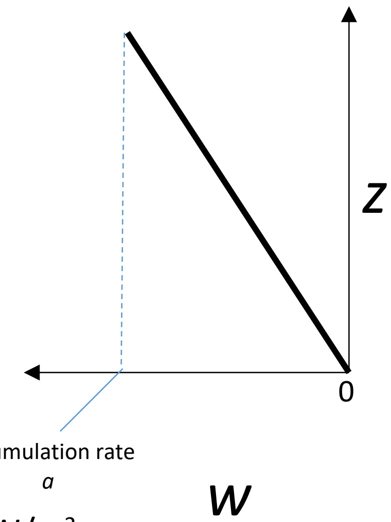
Warm-based ice:
T_b = melting point

Dirichlet boundary condition
(one that fixes the value of *T*)



1. Solve the heat equation:

$$\boxed{\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial z^2} - w \frac{\partial T}{\partial z}}$$



basal boundary condition:

dT/dz = G/k at the bed
where G is geothermal heat flux and k is thermal conductivity in the ice: 0.060 W/m^2

Steady-state T (parameter space)

2. Plot steady-state basal *T* against ice thickness

3. Plot steady-state basal *T* against accumulation rate

4. Plot steady-state basal *T* against ice thickness AND accumulation rate on the same plot (2-D parameter space)

$$\boxed{T(0,t) = \mathrm{A}\sin\left(\frac{2\pi}{\lambda}t\right)}$$

Time-varying T (phase space)
5. Phase space plot (surface *T* vs. basal *T*) and how that varies with λ