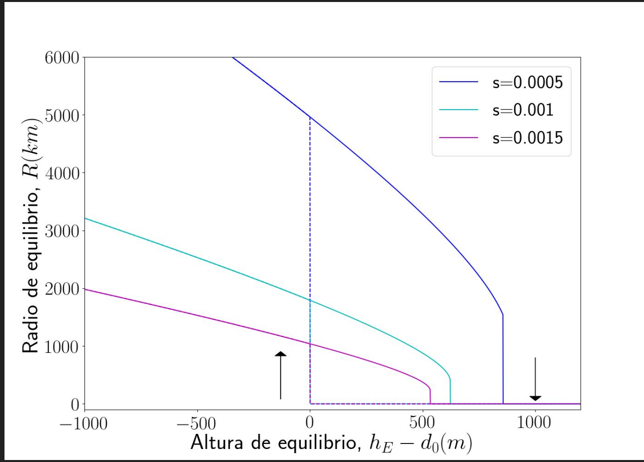
oerlemans-spm model

- Based on Oerlemans, J.: A quasi-analytical ice-sheet model for climate studies, Nonlin. Processes Geophys., 10, 441–452, https://doi.org/10.5194/npg-10-441-2003, 2003.
- Available at: https://github.com/sperezmont/oerlemans-spm.git

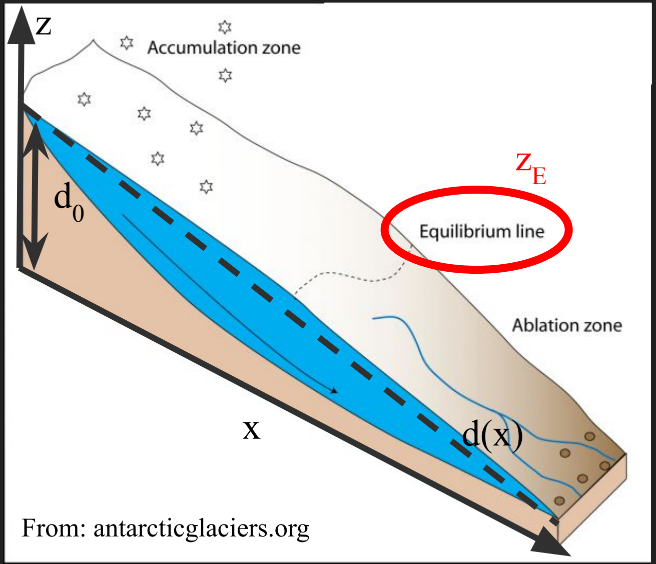
Context | Model | Results | Conclusions

- ➔ Bachelor's degree final thesis (TFG): "*Conceptual Climate Models, Ice sheets*"
- ➔ Aim:
  - ◆ "In this work we will **build a conceptual model** for being able to study the possible **equilibrium states** of these ice-sheets as well as its **response to transient forcing**"
  - ◆ Some results and conclusions from this work:
    - Ice hysteresis due to the melt-surface height (positive) feedback
    - Sea level projections close to those made with more complex models
    - Simple models are very useful
- ➔ oerlemans-spm
  - ◆ Objective: harness the simplicity
    - Conceptual, easy to use and adaptable model
    - Structure:
      - ○ runmodel
        - ◆ oerlemans_main.py > oerlemans2D.nc
        - ◆ plot_results.py > oerlemans-plot.gif



Main assumptions (fixed, originally made)

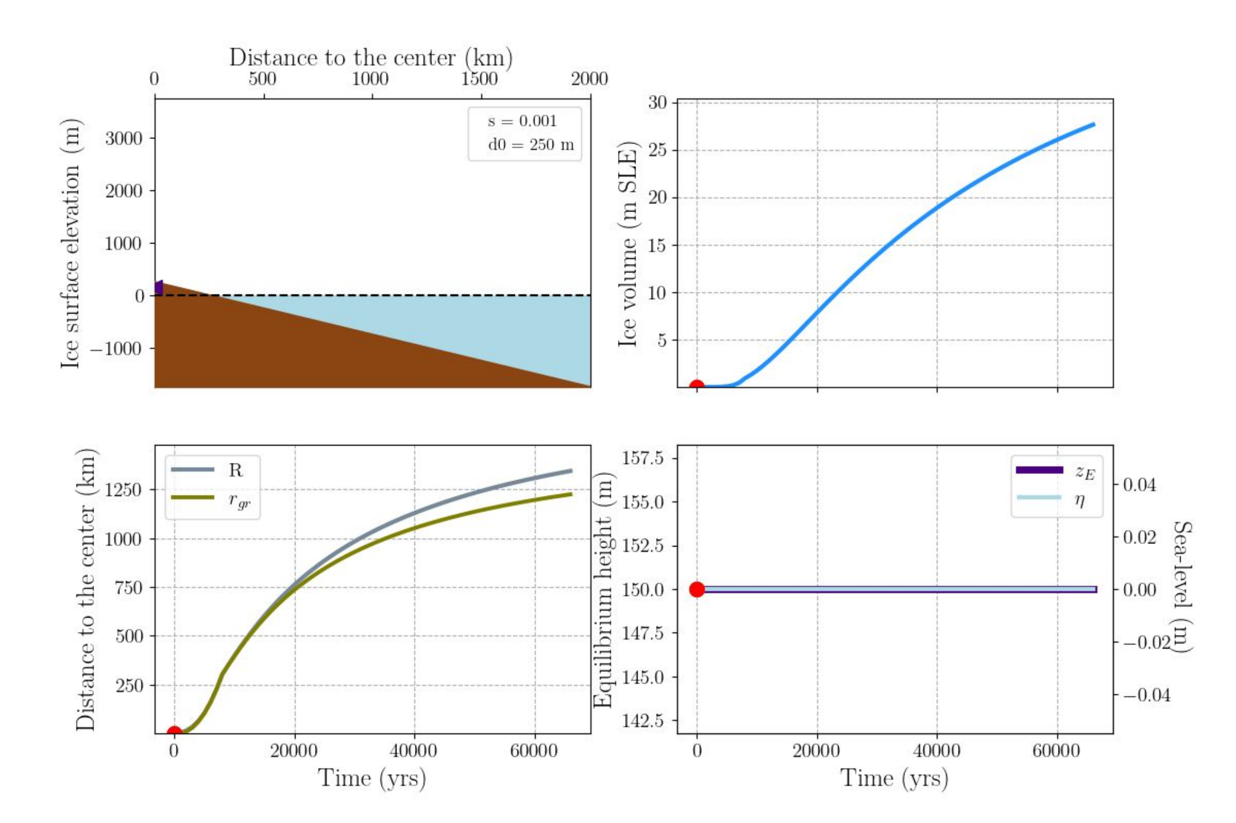
- Purely geometric model
    - sources of forcing are the equilibrium line (z_E) and the sea level (η)
- Axi-symmetric geometry (1D model)
- Perfectly plastic ice (Oerlemans (2001), page 60)
    - Ice thickness, $H(x) = [\mu \cdot (R - x)]^{1/2}$
        - R = ice sheet radius μ = profile parameter
- Bedrock (unperturbed bed)
    - $d(x) = d_0 - s \cdot x$
        - d_0 = height of the center s = bed slope
- Mass budget
    - $B = A - \beta \cdot (z_R - z)$ where $z_R = z_E + A/\beta$
    - B = A if z above the runoff height
        - A $\propto$ Constant if continental ice sheet
        - A $\propto$ exp(-constant/R) if marine ice sheet



Time evolution

- Mass balance, MB = $dV_{tot}/dt = M \cdot dR/dt$
  - $M = dV^*/dR$ where $V^* = (1+\varepsilon_1) \cdot V(R) - \varepsilon_2 \cdot V_{sea}(R,\eta)$
    - $V = 2\pi\int H(x)dx$ where $H(x)$ is the ice thickness
    - Vsea, volume of water displaced by the marine ice sheet
- Ice sheet evolution
  - $R(t+1) = R(t) + MB/M \cdot dt$
    - $MB = \iiint B\,dV$ if continental ice sheet
    - If marine ice sheet, $MB = \iiint B\,dV - F_{gr}$ where F_{gr} is the flux across the grounding line
      - $F_{gr} = F_{gr}(\eta)$

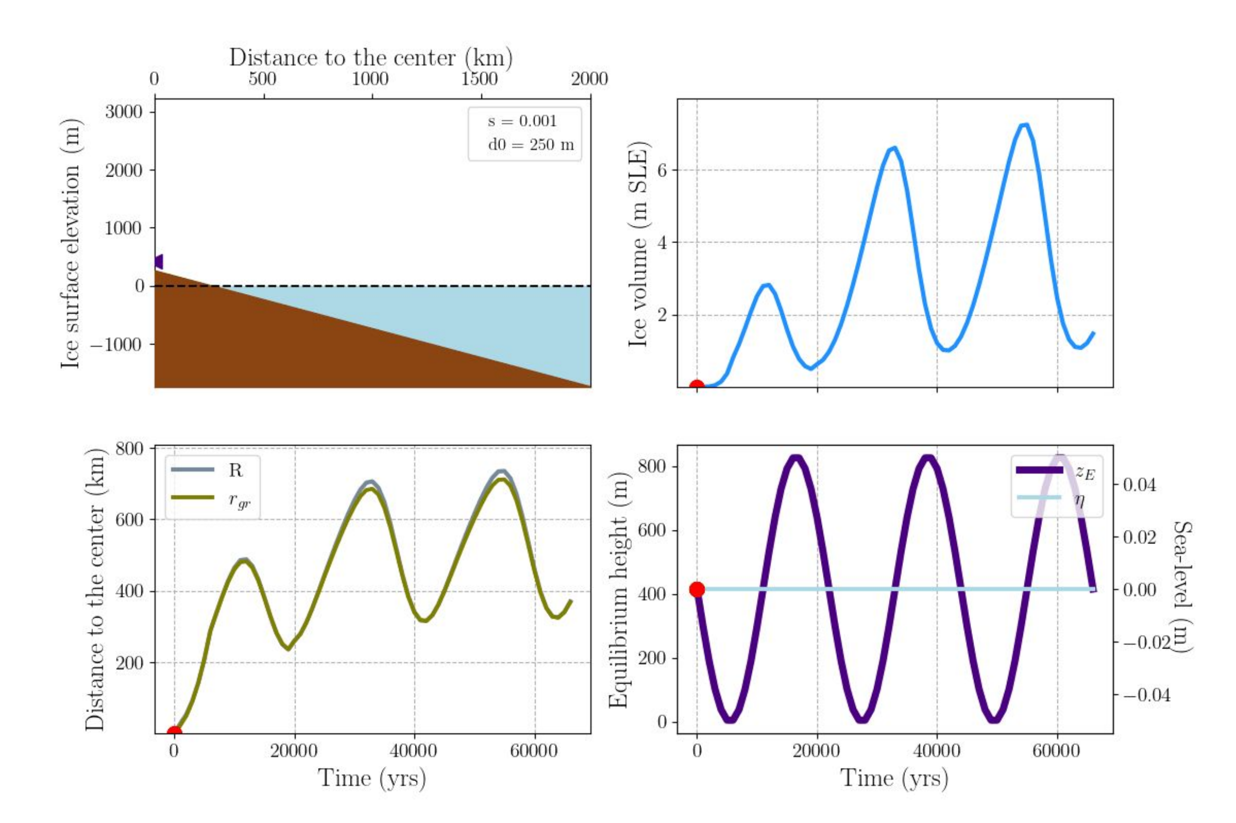
Test 1: No forcing



Test 2: Periodical forcing in z_E

$z_E(t) = z_{E,0} - z_{E,A} \sin(2\pi t/P)$

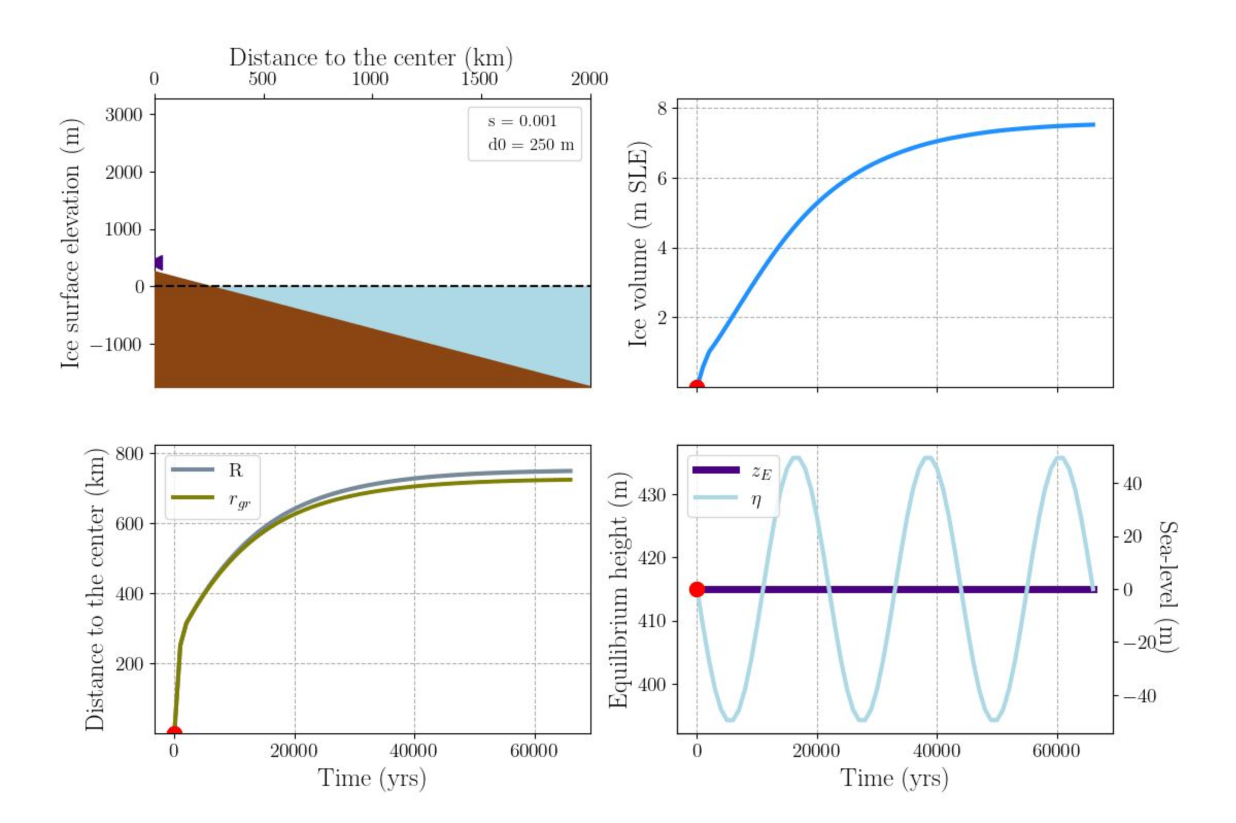
$z_{E,0}$ = reference z_E
$z_{E,A}$ = amplitude of forcing
P = forcing period



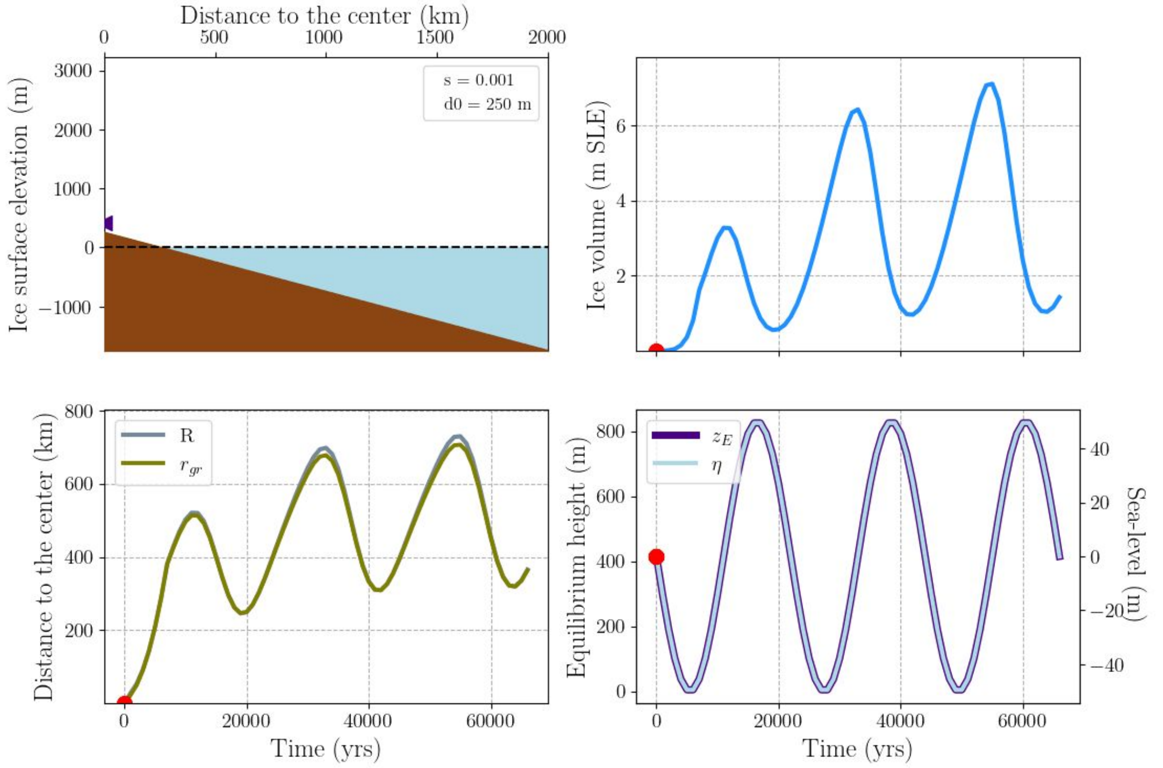
Test 3: Periodical forcing in η

$\eta(t) = \eta_0 - \eta_A \sin(2\pi t/P)$

η_0 = reference η
η_A = amplitude of forcing
P = forcing period

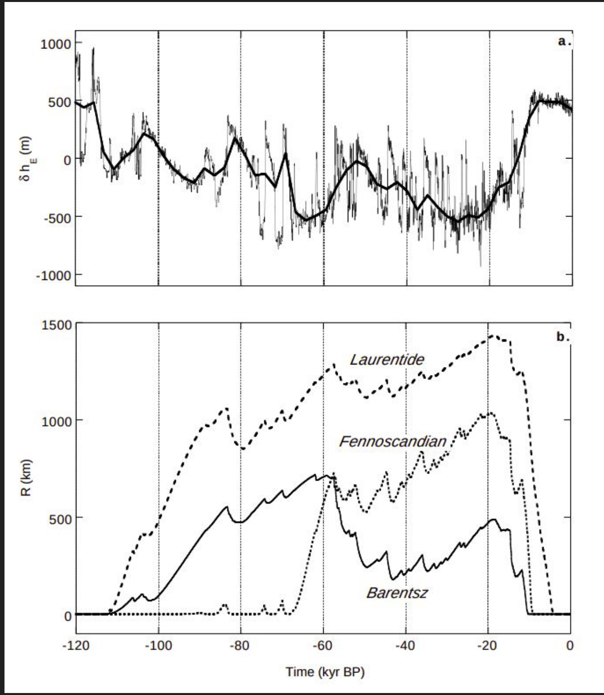


Test 4: Periodical forcing in z_E and η



Context | Model | Results | *Conclusions*

- ➔ Summary
  - ◆ Simple and easy to use model
  - ◆ Adaptability
- ➔ Implement
  - ◆ More forcing types and from different sources
  - ◆ Ice shelves
- ➔ Test other experiments from Oerlemans (2003)
  - ◆ Coupling of ice-sheets
  - ◆ Glacial cycles



From: Oerlemans (2003)