Numerical modeling of glacier and ice sheet dynamics

Lab 3 – Ice Shelves and Grounding Lines

In this lab, we will explore the behavior of an ice shelf and ice stream system under different conditions. Specifically, we will investigate how changes in the geometry of the ice shelf affect the overall flow of the system for two cases: a confined ice shelf and an unconfined ice shelf with free slip as lateral boundary conditions.

We use a configuration where the bed is sloping downward with a constant slope (see Fig.1) in a domain of 800 km by 50 km. We slowly build the ice stream and ice shelf from the accumulation of snow over 50,000 years until it reaches a steady-state. We then test the impact of changes in the ice shelf geometry by retreating the front of the ice shelf and changing the thickness of the ice shelf.

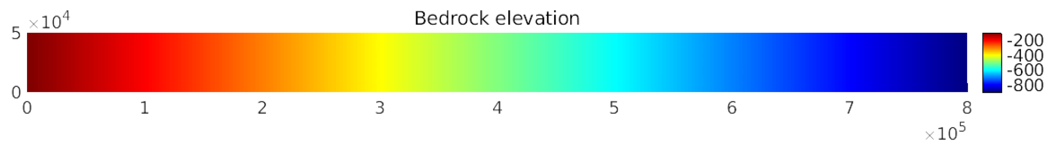

Figure 1: Bedrock elevation of the system

1 Confined ice shelf

The runme provided creates a model for the confined ice shelf and runs a transient simulation until it reaches a steady state (this takes a couple of hours on a cluster using 5 cpus). You first want to use these results (stored in md.results.TransientSolution(end)) as the new initial conditions for your simulations and then run three experiments (using either a stress balance or a short transient).

1. Rerun with the exact same conditions to check your results and make sure the system is indeed in steady-state
2. Change the thickness over the floating part of the ice shelf and test how it impacts the dynamics of this system
3. Change the ice front position (retreating it over part of the ice shelf) to test how it impacts the dynamics of the system

What are the results when you keep the same geometry? How are the ice shelf and ice stream responding to the changes in ice shelf thickness and to the ice front retreat?

2 Unconfined ice shelf

We now want do similar experiments for an unconfined ice shelf. Another steady-state for this unconfined ice stream and ice shelf (so with free slip on a walls at $y = 0$ and $y = 50$ km). Starting from the unconfined ice shelf steady-state, you want to do the same experiments to:

1. Rerun with the exact same conditions to check your results and make sure the system is indeed in steady-state
2. Change the thickness over the floating part of the ice shelf and test how it impacts the dynamics of this system
3. Change the ice front position (retreating it over part of the ice shelf) to test how it impacts the dynamics of the system

What are the results when you keep the same geometry? How are the ice shelf and ice stream responding to the changes in ice shelf thickness and to the ice front retreat?

3 Conclusions

How do the cases of the confined and unconfined ice shelves compare? How can you explain this difference?

4 Additional information

1. You want to make sure to correctly initialize your system from the steady-state conditions, so look at all the fields in `md.results.TransientSolution(end)` and put the values of these fields in the correct places (e.g., `md.geometry`, `md.initialization`, `md.mask`, etc.).
2. The location of the grounded and floating ice are stored in `md.mask.ocean_levelset` with negative values for vertices where there is ocean water (either floating ice and just ocean) and positive values for grounded ice vertices.
3. The location of the ice front position is defined in `md.mask.ice_levelset` with negative values for vertices where there is ice and positive values for vertices with no-ice. This field can be changed by putting positive/negative values for some indices of the vector.