**Earth and Planetary Surface Processes**

**Winter 2020 - Lab 2. The flow of ice.**

**Wieboldt 310C, 9a-9:50a**

*Grades are not assigned for lab, but attendance is required.*

*If you are unable to make a lab, email* [*kite@uchicago.edu*](mailto:kite@uchicago.edu) *to set up an alternate time.*

This lab is based on the PSU/University-of-Chicago ice flowline model. The model was built by Byron Parizek, working under the supervision of Doug Macayeal. The model should not be redistributed without permission of Dr. Parizek and Dr. Parizek’s permission must be sought before using the model for a research project.

Download the PSU/UofC flowline model.

Unzip the file.

Open MATLAB, and enter

cd /PUBLIC

cd psuuofcflowlinemodel

driverpsu

Movies and plots should be generated, showing a West-to-East cross-section of a simulated Greenland Ice Sheet. Organize the plots so you can watch all variables simultaneously. Always enter ‘clear’ to zero out variables between runs of the model.

Enter

ls \*.m

to see the MATLAB script list. Enter

open driverpsu.m

and review the main-driver code. Enter

open prelimpsu.m

and review the model constants and assumptions.

(1) *In some places the ice flows uphill (relative to the black line representing bedrock topography). How is this possible? If the ice surface profile was the same but the adverse bedrock slope was even steeper, could the ice flow back up toward the high point of the ice sheet? Why or why not?*

1. *What is the pressure gradient from the center of the ice sheet to the edge? Modeling the ice as a Bingham plastic with yield strength 10^5 Pa, what should the thickness of the ice sheet be? How good is this approximation relative to the more-detailed calculation in the model?*

(3) Change movie\_frame to 50 and nsteps to 3000. Insert a new line

CO2warming=12

below the frame\_count line. CO2 warming is measured in degrees C.

*Run driverpsu and note how long it takes the ice sheet to shrink. Use Ctrl+C to break out of the model as needed. What happens to ice flow velocity as the ice sheet shrinks? Over what timescale does the bedrock (black line) rebound as the ice load is removed? How does this compare to the thermal conduction timescale for an ice sheet of initial thickness 1 km? Comment on the discrepancy.*

(4) Repeat the calculation, but with CO2warming = -10 (cooling).

*How long does it take to reach steady state (in kyr?) What limits the ice extent in the horizontal direction? Why is the transient behavior in West Greenland different from the transient behavior in East Greenland?*

(5) *“Drive our ships to new lands.” Suppose that measurements using Rayleigh waves of the elastic thickness of the lithosphere beneath Greenland return a thickness of 40 km. If that is true, then what will be the approximate topographic elevation under central Greenland if all the ice has melted and enough time has elapsed for the lithosphere and mantle to re-equilibrate to the removal of the load? (No need to wait for the code to output this for you).*