Description/Objectives: Glaciers and ice sheets are one of the most important elements of Earth’s global climate system. This course introduces undergraduate and graduate students to the history of ice on Earth, contemporary glaciology, and the interactions between climate, glaciers, landforms, and sea level. Drawing from basic physical concepts (mass, momentum and energy conservation), lab experiments, numerical modeling, and a variety of geological and geophysical observations, we tackle important glaciological questions, and equip students with some of the data analysis and modeling skills used in glacier and climate science. Students will gain an appreciation for the variety of physical processes studied by glaciologists, the outsized importance of ice sheets for the global climate system, and the large gaps that remain in our understanding.

Main Text

Secondary Texts

Requirements/Grading:
Problem Sets and Labs: 55%
Midterm Exam: 20%
Final Exam (376) 25%
Four-Page Research Paper (576) 25%

Prerequisites and Restrictions:
MAT 104 & PHY 103, or permission of instructors.

Other Information:
There is one optional weekend field trip to Upstate New York in April. If you do not attend the trip, you will turn in a short essay in lieu of the field notes.

Schedule/Classroom Assignment:
3:00 pm – 4:20 pm M W
Guyot Hall (GUYOT) 154
M Jan 24  The history of ice on Earth, and other planets and moons

Glacier mass balance and response to climate forcing

W Jan 26  Surface mass balance; ablation and accumulation zones
Readings: Cuffey & Paterson Chapter 4.2

M Jan 31  The simplest glacier model
Readings: Oerlemans pp. 5–13
PS01: Simple glacier model and the glacial history of tropical Africa, due Feb 08

W Feb 02  Earth’s radiative balance and climate science primer
Readings: Hooke TBD

M Feb 07  Sensitivity of glaciers to climate forcing part II (the geometric glacier model)
Readings: Oerlemans et al. (2011)
PS02: Geometric model and hysteresis in glaciers, due Feb 13

Ice Sheets

W Feb 09  Ice as a non-linear fluid
Readings: Hooke pp. 68–73; Millstein et al. 2021

M Feb 14  Ice sheets part I
Readings: Hooke pp. 352–366

W Feb 16  Ice sheets lab experiment
PS03: Ice sheet experiment and model, due Feb 25

M Feb 21  Ice sheets part II
Readings: Hooke pp. 352–366

W Feb 23  Heat flow in ice sheets
Readings: Cuffey & Paterson pp. 245-281

M Feb 28  The binge-purge model and Heinrich events
Readings: MacAyeal (1993)

W Mar 02  Midterm Exam

Mar 05–13  Spring Recess
ICE SHELVES

M Mar 14 Ice shelves part I
Readings: Hooke pp. 366–387

W Mar 16 Ice shelves lab experiment
PS04: Ice Shelves experiment and model, due Mar 25

M Mar 21 Ice shelves part II
Readings: Hooke pp. 366–387

GLACIAL HYDROLOGY

W Mar 23 Superglacial and subglacial hydrology part I
Readings: Cuffey & Paterson Chapter 6.2

M Mar 28 Superglacial and subglacial hydrology part II
Readings: Cuffey & Paterson Chapter 6.2

GLACIAL GEOMORPHOLOGY

W Mar 30 Glacial Landforms
Readings: Benn TBD

M Apr 04 Glacial Sedimentology
Readings: Benn TBD

PALEOCLIMATE AND THE FUTURE OF ICE ON EARTH

W Apr 06 Snowball Earth
Readings: Hoffman & Schrag 2002
PS05: Snowball Earth, due April 19

M Apr 11 Cenozoic ice ages and orbital climate forcing
Readings: Imbrie & Imbrie TBD

W Apr 13 Climate records from ice cores
Readings: Abram et al. (2013)

M Apr 18 Sea level change
Readings: Clark et al. 2002; Dyer et al. 2021

W Apr 20 Predictions of future ice volume and sea level
Readings: Geyman et al. 2021

M May 2 Due: 4-page Research paper or Three-hour take-home Final Exam