

# GEOL 362 - Glaciology

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Office Hours: 10:45-12:45 Tu/Th, or by appointment. Booking via [ehultee.ycb.me](mailto:ehultee.ycb.me)



Image: Kaskawulsh Glacier, Yukon.  
F. Barbagallo/Getty Images

## Course description:

In this course we will detail the fundamental role of ice in Earth's climate system, integrating insights from observation, theory, and computer modelling to form a cohesive understanding of glaciers and ice sheets. We will study the unique physics that allow glaciers to flow and break, the power of ice in shaping the landscape, and the flow of water from atmosphere to glacier to ocean and back again. Discussions will treat recent developments in glaciology, as well as the role of glaciology in society. A final project will invite students to develop expertise on a glaciological question of their choosing.

## Objectives:

At the conclusion of this course, you will be able to

- Explain the factors that determine how much ice is stored in glaciers and ice sheets;
- Describe glacier flow mathematically, in the context of other Earth processes;
- Design, generate, and interpret a quantitative estimate of glacier change; and
- Identify meaningful avenues to contribute to society through glaciology.

Our work together will help you develop skills including

- Mathematical intuition,
- Scientific communication for professional and non-expert audiences,
- Metacognition (thinking about thinking), and
- Navigating the scholarly literature.

## Resources:

We will draw on selected textbooks and journal articles, shared electronically via the course Canvas page. As an additional resource, the following textbooks are on reserve at the Science Library:

- Van der Veen, *Fundamentals of Glacier Dynamics* ("VdV" in schedule below)
- Cuffey & Paterson, *The Physics of Glaciers*
- Benn & Evans, *Glaciers & glaciation*

## Final project:

A final research project will take the place of a final exam. You will be asked to choose your own topic, develop your research approach, and summarize your results in a poster presentation. Your topic selection sheet will be due Oct 22, and an annotated bibliography Nov 12. I will provide written feedback and be available for meetings to support your progress. The poster presentation will be held during the final lab meeting time, December 7.

**Collaborative annotation:**

I have posted each assigned course reading as a PDF or link on Canvas. Before each class session, I will ask you to use the Hypothesis tool to post comments and/or questions on the assigned reading. This collaborative annotation will help me see common themes in your thinking, and ideally help you all learn from each other's perspectives. We can practice accessing Hypothesis during the first class session.

**Assessment and grading:**

We will use frequent check-ins, not all of which will be graded, to gauge progress and evolving needs. Example assessments could include

- Short in-class writing assignments ("minute papers"),
- Surveys,
- Group exercises and brief presentations,
- Online annotation of readings,
- Lab reports,
- Problem sets, and
- Reflective writing

Your course mark will be assigned according to the suggested weighting and ranges listed below. **You have the opportunity to adjust the weighting to better reflect your strengths and goals. There will be a quiz available on Canvas until the midterm recess for you to revise the weighting for your course mark.**

<b>35%</b>	Final research project
<b>20%</b>	Lab reports
<b>20%</b>	Class preparation (annotation)
<b>15%</b>	Problem sets and assignments
<b>10%</b>	In-class participation

Course mark	Numerical range
<b>A</b>	90-100
<b>A-</b>	85-89
<b>B+</b>	82-84
<b>B</b>	78-81
<b>B-</b>	75-77
<b>C+</b>	72-74
<b>C</b>	68-71
<b>C-</b>	65-67
<b>D</b>	55-64
<b>F</b>	<50

## Course schedule:

Below is a course schedule, subject to adjustments according to our class needs and wants. Most course readings have an annotation assignment on Canvas. It is essential to do the assigned preparation, as we will spend class time discussing these resources.

**Dates** - Topics - [Class preparation](#) - [Assignments](#)

**Week 1, 9/13-9/17:** Preliminaries - learning agreements, what makes a glacier, distribution of ice on Earth. [“How to Mourn a Glacier”](#). [Learning agreement](#).

**Week 2, 9/20-9/24:** Building a glacier - surface mass balance. Getting to know the stress tensor and non-Newtonian flow. [“How Do Glaciers Move” video](#); [VdV Ch1](#). [Lab report 1](#); [Prob. Set 1](#).

**Week 3, 9/27-10/1:** Continuum mechanics - a mathematical description for the deformation of solids and flow of fluids. [Stress tensor video](#); [VdV Ch 2-3](#). [Theory workshop report](#).

**Week 4, 10/4-10/8:** Modelling glacier flow - Stokes flow, the Shallow Ice Approximation, special limiting cases, what a numerical model does. [Stokes equation video](#); [VdV Ch 4](#). [Prob. Set 2](#).

**Week 5, 10/11-10/15:** Numerical modelling - getting to know the Open Global Glacier Model. Indigenous People’s Day discussion. [“The Maori Vision...”](#) and [OGGM-Edu walkthrough](#). [Lab report 2](#).

**Week 6, 10/18-10/22:** Glacier thermodynamics & hydrology. Midterm recess - no Tuesday class or lab. [VdV Ch 6](#). [Final project topic selection](#).

**Week 7, 10/25-10/29:** Basal processes - flow around obstacles, basal sliding, subglacial hydrologic systems, glacial erosion, postglacial landforms. [VdV Ch7 and Egholm et al; glacial landforms video](#). [Lab report 3](#).

**Week 8, 11/1-11/5:** Fracture - crevasses, ice damage, iceberg calving, tidewater glaciers and ice shelves. [VdV Ch8 and Nick & Oerlemans paper](#). [Assignment 3](#).

**Week 9, 11/8-11/12:** Ice sheet instabilities and sea level rise. [Alex Robel IGS Seminar video](#); [Huss & Hock 2018](#) and [Immerzeel et al. 2020](#). [Poster annotated bibliography](#).

**Week 10, 11/15-11/19:** Glacial water resources - seasonal runoff, “peak water”, drought in glaciated basins. [Soruco et al 2015](#), [“La Paz adapts”](#), and [Lemos et al 2012](#); [Tuni glacier video](#). [Lab report 4 \(Tuesday\)](#).

**Week 11, 11/22-11/26:** Glacial hazards - jokulhlaups, surges, collapses. Thursday Thanksgiving - no class. [In the Shadow of Melting Glaciers Ch2](#). [Assignment 4](#).

**Week 12, 11/29-12/3:** From knowledge to action - adaptation to glacier change, science usability. [Orlove 2009](#) and [\[science usability paper\]](#). [Lab report 5](#).

**Week 13, 12/6-12/10:** Making meaning of glaciology - what to do with what we’ve learned, reflecting on the important considerations of the field and who determines them. [Qoyllur Rit’i gallery](#). [Poster presentation](#); [reflective essay](#).

## **Policies & resources**

### **What to bring to class**

A notebook, pen, and laptop (for lab). In-class activities will often ask you to write things down. Numerical modelling and data exploration labs will be on the computer, and it is probably easiest for you to use your own laptop. For lab in Week 2: anyone who has a digital watch and anyone who has a smartphone with camera, please bring them along!

### **How to participate in class**

There are lots of ways to be an active participant in class. Here are some options for how you can participate, according to what best suits your style:

- Sharing your ideas and questions with the class
- Making space for others to contribute to class discussions
- Submitting ungraded assignments and activity sheets in class
- Posting thoughtful questions and comments in our online spaces (Canvas, Hypothesis, etc.)
- Responding promptly if I email you about class business
- Working together with classmates on graded assignments
- Attending office hours

### **Honor Code**

I am required to remind you that this course is subject to the Undergraduate Honor System ([go.middlebury.edu/honorcode](http://go.middlebury.edu/honorcode)). Plagiarism, cheating, duplication of work, and falsifying data are all prohibited under the Code. I do encourage you to work together on assignments and labs; simply ensure that you each write up your own version of anything you hand in unless otherwise specified, and make note of anyone you worked with. I also encourage you to consult the course materials and the glaciological literature to inform your work; simply ensure you cite as required by the Code. I tend to use APA style citation, but I'm not too picky. If you are confused about a point relating to the Honor Code, including any troubles with attribution, please come and talk to me.

### **Late work**

Some assignments, such as annotating readings in Hypothesis or completing an in-class writing exercise, are very specific to what we're doing in class on a given day, so it doesn't really make sense to turn them in late. For bigger assignments, such as lab reports or your final project milestones, I would like to have everyone's work as close to the deadline as possible so that I can return it to you with feedback as fast as possible. Plus, when you hand things in on time, you can move on to handling other important things in your life. *Let's decide as a class how to handle late work (to be updated).*

### **Extra credit**

In the interest of an equitable grading approach for everyone in class, I don't give individual opportunities for extra credit. Sometimes, really cool and unexpected events that relate directly to our course will come up in the middle of the semester. In that case, I might entice you to

participate in those events by announcing an extra credit opportunity to the whole class. In general, if you are worried about your course mark, please get in touch with me to make a plan.

### **Attendance**

It is my goal to provide you with an excellent learning environment in class. I hope you will attend every class in order to benefit from that environment. Please contact me if you know you will be missing more than two regular class sessions or one lab session. If you miss several sessions and I don't hear from you, I will contact you so we can make a plan together.

### **Communication expectations**

Cultivating a healthy work-life balance helps me keep doing work I love for the long term. I encourage you to consciously create your best schedule as well. Part of that, for me, means not checking email outside of College business hours. That means that it might take up to 36 hours (or more on the weekend) to get a response to an email you send me. If you really need a faster response, the best thing to do is to stop by my office (MBH 415). You can also try sending an email with [URGENT] in the subject line. The best time to discuss course questions is during office hours or a scheduled appointment.

### **Extenuating circumstances**

Life happens. There are lots of circumstances that can make it hard to learn: food insecurity, health concerns, and family crises, to name just a few. If you are struggling, please do reach out to me, your student life Dean, or to another trusted advisor on campus so that we can connect you with resources to support you. I will do what I can to ensure you have what you need and can focus on learning.

### **Mental health services**

I encourage you to seek help anytime you need it. The office of Health and Wellness can provide free and confidential mental health evaluations, urgent care, group therapy, medication management, and referrals to off-campus providers. This year, Middlebury Counseling is prioritizing as-needed services, in many cases offering appointments on the same day they're requested. I am not a qualified mental health provider, but I can direct you to additional resources on campus as needed.

### **Accommodations and adjustments**

I am committed to fostering an inclusive and encouraging classroom environment. Please come to me any time to discuss things I could start, stop, or continue doing to promote inclusion. In addition, if you have a Letter of Accommodation, please contact me as early in the semester as possible to ensure that we can implement the necessary accommodations in a timely fashion. For eligible students without current Letters of Accommodation, assistance is available through the Disability Resource Center (DRC). Please contact ADA Coordinators Jodi Litchfield and Peter Ploegman of the DRC at [ada@middlebury.edu](mailto:ada@middlebury.edu) for more information. All discussions will remain confidential.

**IT services and open software**

Wherever possible, I will point you to open software alternatives to paid software. I view this as a support for your career: it ensures that you can continue working with familiar software no matter where you go after graduation. This said, the College does have a site license for several paid software packages you might like to use for this course or others: for example, MATLAB and the Adobe Creative Cloud. Definitely check in with ITS ([go.middlebury.edu/software](http://go.middlebury.edu/software)) or visit a campus computer lab before you consider buying software yourself.

**Library helpdesk**

Libraries are amazing. Librarians are information wizards. Did you know that every department at the College has a specialist librarian to help researchers find information they need? We will have a class visit with a librarian around the middle of the semester to help with final project research. The College libraries have a number of tools you may like to explore, but for general inquiries, you can navigate to the library homepage ([go.middlebury.edu/library](http://go.middlebury.edu/library)) and click “Chat with a Librarian”. During business hours, someone will respond to you via text chat; outside business hours, your message will be sent to an inbox and handled when the librarians return. No need to even leave the house!