

Syllabus: GEOG 5303 – Geocryology [V4 final]

Department: Geography and Environmental Studies

Instructor: Stephan Gruber

Hours: By appointment.

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Office: Loeb B443

Prerequisites: GEOG 4108 Permafrost, or permission of the Department

Preclusions: none

Meeting location: Loeb A211

Meeting times: Mondays, 11:35–14:25 (January 5 to April 6)

Brightspace: <https://brightspace.carleton.ca/d2l/home/365771>

Calendar description: Development of ground ice in permafrost regions of Canada; ice segregation and pore-water expulsion during ground freezing; analytical and numerical approaches to modeling permafrost conditions.

Course Description

This course builds understanding of processes and phenomena in permafrost and seasonally frozen soil. Special emphasis is placed on ground ice and temperature, and the disequilibria caused by climate change and disturbance. The ground thermal regime, including the surface energy balance, translates climate change and disturbance into ice loss at depth. This ice loss causes most relevant effects of permafrost thaw. The focus on quantitatively understanding the transient ground thermal regime is at the heart of understanding permafrost change and integrating between Earth sciences and atmospheric science.

Learning addresses four core modules: A) permafrost knowledge: systems and frameworks; B) ground ice and temperature: processes, phenomena, transient simulation, C) properties of water: determinants of cold-regions phenomena, D) ground ice and materials: observation, landforms, landscapes.

The course will draw on differing fields such as geomorphology, glaciology, geotechnics, and micrometeorology. Methods and tools for quantitatively studying processes and phenomena will be introduced and help solidify understanding via written assignments.

The course consists of lectures, reading assignments, exercises to train the application of methods and tools, and project work presented in seminar style. Data analysis and simulation experiments are important for understanding the transient ground thermal regime. This course will provide you with tools and guidance for their use and customization to a given problem.

Learning outcomes

To pass this course, you must demonstrate the ability to:

- (a) **apply** key concepts, theories, and methods in Geocryology to a given problem; connect these theories and methods with basic science;
- (b) critically **discuss** the limitations of your work or that of others;
- (c) **create, apply** and **evaluate** computer-aided tools to solve typical problems;
- (d) **communicate** in a concise, accurate, traceable, and effective manner; and
- (e) **discuss current topics** in Geocryology.

This implies a good understanding of: (i) the physical properties of water and how they give rise to the phenomena studied in Geocryology and Glaciology, (ii) the ground thermal regime and its changes over time, (iii) the processes and phenomena affecting the interaction of climate and subsurface, (iv) permafrost as a geologic or geotechnical material, (v) landforms that are typically found in permafrost landscapes and how they are caused by the physical properties of water, and (vi) permafrost thaw and how it is driven by climate change and disturbance.

Course Materials

This is an in-person course. Lecture slides will not be shared; please take notes as needed.

The course **Brightspace** and can be accessed from a web browser on most internet-enabled devices by going to: <https://brightspace.carleton.ca>. **Brightspace Support** is available at <https://carleton.ca/brightspace/students>, and in the course under 'Help'. For help with general technical problems, please visit Carleton's **Information Technology Services** at <https://carleton.ca/its/contact>.

We will use **Python** for data analysis, simulation, and visualization, as well as **Microsoft Excel** for simple data analysis. Students must have access to a computer that can run this software and have installed it before the first course meeting.

Preparation

This course **builds on the basic understanding of permafrost** as taught in GEOG 4108 Permafrost. The topics covered there include the distribution, thermal characteristics, and characteristics of permafrost as well as the origin of geomorphological features and hazards associated with permafrost aggradation and degradation.

Use the sources below to **thoroughly refresh or acquire the basis** that we will build on. It is important that the concepts and terms presented there are familiar to you, even though some processes may remain unclear. If you have not taken GEOG 4108, please take this **preparation before** the current course very seriously. Trying to follow this course and learn the basics about permafrost at the same time will get you into problems.

The Periglacial Environment, Wiley

If you have the **4th edition (French, H.M. 2018)** review Chapters 2 'Periglacial Climates', 4 'Ground Freezing, Permafrost and the Active Layer', 5 'Permafrost Distribution and Stability', 6 'Ground Ice and Cryostratigraphy', 7 'Aggradational Permafrost Landforms', 8

'Thermokarst Processes and Landforms', 16 'Urban and Social Infrastructure', 17 'Transportation and Resource Development'.

If you have the **3rd edition (French, H.M. 2007)** review Chapters 3 'Periglacial Climates', 5 'Permafrost', 6 'Surface Features of Permafrost', 7 'Ground Ice', 8 'Thermokarst', 14 'Geotechnical and Engineering Aspects', and 15 'Climate Change and Periglacial Environments'.

The Frozen Earth: Fundamentals of Geocryology, Cambridge University Press, by Williams, P.J. and Smith, M.W. 1989.

Review Chapters 3 'Climate and Frozen Ground', 4 'The Ground Thermal Regime', 5 'The Forms of the Ground Surface 1: Slopes and Subsidences', 6 'The Forms of the Ground Surface 2: Structures and Microtopography of Level Ground', and 7 'Thermodynamic Behaviour of Frozen Soils.'

Recent glossary and illustrated dictionary – use these resources to clarify terms and concepts.

Lewkowicz, A.G., O'Neill, H.B., Wolfe, S.A., Roy-Léveillé, P., Roujanski V.E., Hoeve, E., Gruber, S., Brooks, H., Rudy, A.C.A., Koenig, C.E.M., Brown, N., Bonnaventure, P.P. (2025). Glossary of Permafrost Science and Engineering. Canadian Permafrost Association. <http://doi.org/10.3138/cpa-gpse>

Lewkowicz, A. G., Wolfe, S. A., Roujanski, V. E., Hoeve, E., O'Neill, H. B., Gruber, S., Roy-Leveillee, P., Brown, N., Koenig, C. E. M., Brooks, H., Rudy, A. C. A., Bonnaventure, P. P. & Paquette, M. (2024). An Illustrated Permafrost Dictionary. 102. Canadian Permafrost Association. <https://doi.org/10.52381/CPA.permafrostdictionary.1>

Course Calendar

Date	Theme	Module	S1	S2	S3	S4	B1	B2
Jan 05, 2026	Introduction: Systems and frameworks for learning	A	■					
Jan 12, 2026	Ground ice and temperature simulation I	B	■	■			■	
Jan 19, 2026	Phase change	C		■				
Jan 26, 2026	Atmosphere-ground interaction	B		■	■		■	
Feb 02, 2026	Snow	B			■	■		
Feb 09, 2026	Subsurface materials	D				■	■	
Feb 16, 2026	WINTER BREAK							
Feb 23, 2026	Present water assignment	C				■	■	
Mar 02, 2026	Ground ice and temperature simulation II	B					■	■
Mar 09, 2026	Ground ice and temperature simulation III	B						■
Mar 16, 2026	Formation and melt of ground ice	D						■
Mar 23, 2026	Measurement and monitoring of permafrost change	B						■
Mar 30, 2026	Present simulation assignment	A						■
Apr 06, 2026	Synthesis	A						■

S1–S4 are the small assignments; B1 and B2 are the big assignments. Black squares indicate the class meeting before which assignments need to be submitted. During the first grey square assignments will be handed out. In the first half of the course, there will be practical (small) assignments and a big assignment based on literature review in parallel.

Evaluation

All grading uses the percentage scale of 0–100 points. The **final grade** is determined by weighting individual components and then converting from percentage to alphabetical:

Final exam	30%
Two big assignments	50%
Four small assignments	20%
Total	100%

Final exam: The final exam will be formally scheduled, consist of essay and short answer questions, and have a maximum duration of three hours. No materials will be permitted.

Big assignments will combine scientific writing, simulation, and calculations that require independent research and finding of literature as well as preparation of figures from the data you analyse and work with. You may collaborate with others to obtain common data and discuss open issues, but must submit your own individually written text, containing your own analyses, computer code and answers. The grade will be based on a **written essay** (80%) and an **in-class presentation** (20%). Drafts submitted by the draft-deadline and of high quality (language and form) will receive detailed feedback within three days; plan well and front-load your work to make use of this opportunity. The assignments will be due one week after the in-class presentation and sharing your essays with classmates, giving you time for further revisions. The grading criteria will be described on the assignment task.

Small assignments are programming tasks, applying and working practically with lecture content. They are important for solidifying understanding and for preparing the basis for the second big assignment. The grading criteria will be described on the assignment task.

Late submission: Assignments have to be submitted before the date/time indicated. Late submission will have the score reduced by 20 points per started 24 hours of delay.

Technical problems: It is your responsibility to submit assignments on time. For instance, if your Internet connection may be unstable, make sure that you have either an alternative plan or enough reserve time. If you cannot submit your material because of a technical problem caused by the instructor or Carleton University, please document (screenshot) that problem and note the date and time to avoid a late penalty.

Deferred Term Work: For short-term illness, injury or other extraordinary circumstances beyond one's control students may request accommodation as per the rules and guidelines of the Academic Consideration Policy: <https://carleton.ca/registrar/academic-consideration-policy/>. Students are responsible for informing the instructor as soon as possible and for making alternate arrangements to complete the missed work. This must occur no later than three (3) working days after the term work was due.

Deferred Final Examinations: In cases of serious illness/emergency or other circumstances that will cause students to miss the final exam, students may petition the Registrar's Office or Graduate Registrar to write a deferred exam, see <https://carleton.ca/FASS-FPA-teaching-regulations/assignments-and-exams>. Students must apply for a deferral to the Registrar's Office no later than three (3) working days after the original final examination or the due date of the take-home examination.

Appealing your grade: See <https://carleton.ca/registrar/appeal-of-grade/>. For the informal appeal, please send me a short (one page maximum) summary of what point(s) you would like to

have revisited and why you believe you deserve more points that you have received. Based on this, a personal meeting will be scheduled aimed at finding a resolution in agreement.

Standing in this course is determined by the course instructor subject to the approval of the Faculty Dean. This means that grades submitted by the instructor may be subject to revision. No grades are final until they have been approved by the Dean.

Generative Artificial Intelligence (AI)

AI process notes: You may use AI tools to support your work in this course. You must include a short AI process note with each assignment stating whether you used them, and if so, how.

Not having an AI process note will automatically result in 0 points for the assignment concerned. Appropriate uses are brainstorming, finding sources and explanations, style feedback, support in code development, and checking syntax. **You remain fully responsible for the consistency, accuracy, and originality of your submissions.**

Referencing: Exact referencing and citation is the foundation of scientific research. AI frequently produces errors in citing material and invents references. It is your responsibility to ensure that your citations are exact and that your references are accurate. **A non-existing reference or DOI will automatically result in 0 points for the assignment concerned.**

In-person explanation: To support learning and ensure that submitted work reflects your own understanding, students may occasionally be asked to briefly explain their assignments in class or during office hours. For example, you may be asked to “walk me through how you approached this assignment” or “explain what assumptions you made and why they matter.” These short discussions are meant to reinforce learning and accountability. If a student is unable to explain their own submission, this may significantly reduce the grade for that assignment, since demonstrated understanding is a core requirement. AI should enhance—not replace—your own thinking and analysis.

Language quality: Digitally submitted text must be of very high quality in terms of spelling, grammar, and consistency of conventions (e.g., referencing). Even if this is not your strength, it can be accomplished with available AI tools, provided you use them responsibly and with final proofreading of your own. Up to 20% of an assignments marks can be subtracted for low quality language and spelling.

Citing generative AI: <https://library.carleton.ca/guides/help/generative-ai-chatgpt-and-citations>

Statement on Academic Integrity

The University Senate defines plagiarism as “*presenting, whether intentional or not, the ideas, expression of ideas or work of others as one’s own.*” This can include:

- reproducing or paraphrasing portions of someone else’s published or unpublished material, regardless of the source, and presenting these as one’s own without proper citation or reference to the original source;
- submitting a take-home examination, essay, laboratory report or other assignment written, in whole or in part, by someone else (**this includes computer code**) or by AI without appropriate explanation in the **AI process note**;

- using ideas or direct, verbatim quotations, or paraphrased material, concepts, or ideas without appropriate acknowledgment in any academic assignment;
- using another's data or research findings;
- failing to acknowledge sources through the use of proper citations when using another's works and/or failing to use quotation marks;
- handing in "*substantially the same piece of work for academic credit more than once without prior written permission of the course instructor in which the submission occurs.*"

Plagiarism is a serious offence, which cannot be resolved directly with the course's instructor. The Associate Deans of the Faculty conduct a rigorous investigation, including an interview with the student, when an instructor suspects a piece of work has been plagiarized. Penalties are not trivial. They range from a mark of zero for the plagiarized work to a final grade of "F" for the course, and even suspension from all studies or expulsion from the University. For more information, see the page on Academic Integrity (<https://carleton.ca/registrar/academic-integrity>).

Copyright and Policy on Classroom Recording

Student or professor materials created for this course—including presentations and posted notes, labs, case studies, assignments and exams—remain the intellectual property of the author(s). They are intended for personal use and may not be photographed, reproduced, or re-distributed (hardcopy or electronically/online) without prior written consent of the author(s).

Student Mental Health

As a student you may experience a range of mental health challenges that significantly impact your academic success and overall well-being. If you need help, please speak to someone. There are numerous resources available both on- and off-campus to support you. For more information, please consult <https://wellness.carleton.ca>.

Requests for Academic Accommodations

Carleton is committed to providing academic accessibility for all individuals. You may need special arrangements to meet your academic obligations during the term. The accommodation request processes, including information about the Academic Consideration Policy for Students in Medical and Other Extenuating Circumstances, are outlined on the Academic Accommodations website: <https://students.carleton.ca/course-outline>.