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## **GEOG 320 – THE CRYOSPHERE**

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Instructor: Claude Duguay  
Room: EV1 309  
Office hours: Monday 12:00-13:30 and Tuesday 10:30-12:00

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### **Course Description**

The cryosphere collectively describes elements of the earth system containing water in its frozen state and includes ice sheets, ice caps and glaciers, sea ice, snow cover, solid precipitation, freshwater (lake and river) ice, as well as seasonally frozen ground and permafrost. The cryosphere is an integral part of the global climate system with important linkages and feedbacks operating through its influence on energy, moisture and gas fluxes.

This course will provide a physical introduction to the cryosphere and cryosphere-climate interactions. Topics covered will include the material and thermodynamic properties of snow and ice, the role of the cryosphere in the climate system, and the response of the cryosphere to climate change (past, present and future). Students will be introduced to, and get the opportunity to experiment with, snow and ice process models.

### **Prerequisite**

GEOG 303 or GEOG 309 (or permission of the instructor)

### **Class Meetings**

Lecture section:

Monday: 14:30-16:20 (EV3 4412)

Lab section:

Monday: 16:30-18:20 (EV2 1001)

## Evaluation

### Lab assignments (3):

Analysis and interpretation of winter surface-based measurements:	10%
Snow modeling:	10%
Lake ice modeling:	10%

Midterm exam: 25%

### Term paper:

Proposal:	10%
Paper:	25%
Oral presentation:	10%

### Lab Assignments:

- Assignments are to be turned in during the lab sections on the specified dates (hard copies and in “Dropbox” folders). *No late assignments will be accepted.* Consultation and discussion of lecture/lab material with classmates is acceptable BUT all assignments are to be completed individually.
- Access to the computer lab is restricted by code to those enrolled in particular courses including this one. Food and/or drink are NOT permitted in the lab.
- Students are responsible for maintaining their own backups of their work. There are a number of options available for backing up your work, including the N: drive for FE students. It is suggested that you keep two copies of your work in separate locations. Remember that you are only as far ahead as your latest backup!

### Term Paper:

Students are to produce a term paper (15-20 pages double spaced, exclusive of title page, abstract, figures, and tables) on a topic of their choice relevant to the course (25% of grade) and make a 15-minute presentation to the class (10% of grade). Students must first have their topic approved by the instructor. In this respect, students must submit a one-page summary of their proposed project (proposal) (10% of grade). Deadlines for each deliverable can be found in the “Lecture and Lab Schedule” below.

The term project involves completion of an extensive survey of the scientific literature on a relevant topic (e.g. remote sensing, numerical modeling or in-situ studies of any element of the cryosphere; cryosphere-climate interactions on a variety of space and time scales; representation of elements of the cryosphere in climate or weather prediction models; impact of changes in any element or a group of elements of the cryosphere on Society). The review paper is single-authored.

## Lecture and Lab Schedule

Week	Date	Lecture	Lab	Readings
1	Jan 6	Introduction to the Cryosphere	<i>No lab this week</i>	Chap. 1
2	Jan 13	Material Properties of Snow and Ice	<i>Assignment #1: Surface-based measurements</i>	Chap. 2
3	Jan 20	Snow and Ice Thermodynamics <b><i>Proposal due</i></b>	<i>Assignment #1: Surface-based measurements</i>	Chap. 3
4	Jan 27	Seasonal Snow – Part 1 <b><i>Assignment #1 due</i></b>	<i>Assignment #2: Snow modeling</i>	Chap. 4
5	Feb 3	Seasonal Snow – Part 2	<i>Assignment #2: Snow modeling</i>	Chap. 4
6	Feb 10	Freshwater Ice – Part 1	<i>Assignment #2: Snow modeling</i>	Chap. 4
7	<b><i>Family Day (Feb 17) and Mid-Term Study Break (Feb 18-21)</i></b>			
8	Feb 24	<b><i>Midterm exam</i></b> Freshwater Ice – Part 2 <b><i>Assignment #2 due</i></b>	<i>Assignment #3: Lake ice modeling</i>	Chap. 4
9	Mar 2	Sea Ice	<i>Assignment #3: Lake ice modeling</i>	Chap. 5
10	Mar 9	Glaciers and Ice Sheets	<i>Assignment #3: Lake ice modeling</i>	Chap. 6
11	Mar 16	Permafrost and Seasonally Frozen Ground The Cryosphere and Climate Change – Part 1 <b><i>Assignment #3 due</i></b>		Chap. 7
12	Mar 23	The Cryosphere and Climate Change – Part 2 <b><i>Oral presentations – Part 1</i></b>		Chap. 8
13	Mar 30	<b><i>Oral presentations – Part 2</i></b> <b><i>Term paper due</i></b>		Chap. 9

## Textbooks and Other Resources

### 1. Recommended Textbook

Marshall, S.J., 2012. *The Cryosphere*. Princeton University Press series Primers in Climate Science: Princeton, NJ, 278 pp.

Some copies are available at the UW Bookstore or as eBook (price \$30-40).

### 2. Other Textbooks

Barry, R.G. and T.Y. Gan, 2011. *The Global Cryosphere: Past, Present, and Future*. Cambridge University Press: New York, NY, 472 pp.

Slymaker, O. and R.E.J. Kelly, 2007. *The Cryosphere and Global Environmental Change*. Blackwell Publishing Environmental Systems and Global Change Series: Malden, MA, 261 pp.

Copies have been placed on reserve at the Dana Porter library.

### 3. Journal

*The Cryosphere* – An interactive open access journal of the European Geosciences Union (EGU) accessible at <http://www.the-cryosphere.net/home.html>

*“The Cryosphere (TC) is an international scientific journal dedicated to the publication and discussion of research articles, short communications and review papers on all aspects of frozen water and ground on Earth and on other planetary bodies.”*

### 4. Lecture Materials

PDF Acrobat versions of the PowerPoint presentations and other relevant documents (numerical models documentation, reports, articles) will be distributed through LEARN.

## University of Waterloo LEARN Course Environment

This course uses the LEARN course environment for course material dissemination and information exchange. LEARN is a web-based course management system that enables instructors to manage course materials (posting of lecture notes etc.), interact with their students, and provide feedback. YOU NEED TO ENSURE THAT YOU CAN ACCESS LEARN. Note that lecture slides are posted on LEARN prior to each lecture. Assignment materials are also distributed through LEARN.

### *Logging into LEARN*

Since LEARN is a web-based system, you will need a browser.

Once you have started up your browser, you can access LEARN via: <http://learn.uwaterloo.ca>

### *Checking your Userid and Password*

Your password can be checked and reset (if needed) by going to:

<https://watiam.uwaterloo.ca/idm/user/login.jsp>

If you still cannot get on LEARN after checking and resetting your password, please confirm with your instructor that you are on the class roster.

### *Getting Help*

Documentation for LEARN is available at:

<https://uwaterloo.ca/learn-help/students>

## **Academic Integrity**

In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. The University's guiding principles on academic integrity can be found here: <http://uwaterloo.ca/academicintegrity/>

ENV students are strongly encouraged to review the material provided by the university's Academic Integrity office specifically for students: <http://uwaterloo.ca/academicintegrity/Students/index.html>

Students are also expected to know what constitutes academic integrity, to avoid committing academic offenses, and to take responsibility for their actions. Students who are unsure whether an action constitutes an offense, or who need help in learning how to avoid offenses (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course professor, academic advisor, or the Undergraduate Associate Dean. Students may also complete the following tutorial: <https://uwaterloo.ca/library/get-assignment-and-research-help/academic-integrity/academic-integrity-tutorial>

When misconduct has been found to have occurred, disciplinary penalties will be imposed under Policy 71 – Student Discipline. For information on categories of offenses and types of penalties, students should refer to Policy 71 - Student Discipline, <https://uwaterloo.ca/secretariat-general-counsel/policies-procedures-guidelines/policy-71>

Students who believe that they have been wrongfully or unjustly penalized have the right to grieve; refer to Policy #70, Student Grievance: <https://uwaterloo.ca/secretariat-general-counsel/policies-procedures-guidelines/policy-70>

**Note for students with disabilities:** AccessAbility Services, located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

**Mental Health:** The University of Waterloo, the Faculty of Environment and our Departments consider students' well-being to be extremely important. We recognize that throughout the term students may face health challenges - physical and / or emotional. **Please note that help is available.** Mental health is a serious issue for everyone and can affect your ability to do your best work. Counselling Services <http://www.uwaterloo.ca/counselling-services> is an inclusive, non-judgmental, and

confidential space for anyone to seek support. They offer confidential counselling for a variety of areas including anxiety, stress management, depression, grief, substance use, sexuality, relationship issues, and much more.

**Religious Observances:** Student needs to inform the instructor at the beginning of term if special accommodation needs to be made for religious observances that are not otherwise accounted for in the scheduling of classes and assignments.

**Grievance:** A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. See Policy 70 - Student Petitions and Grievances, Section 4, [www.adm.uwaterloo.ca/infosec/Policies/policy70.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm). When in doubt please contact your Undergraduate Advisor for details.

**Appeals:** Decision made or penalty imposed under Policy 70 - Student Petitions and Grievances (other than a petition) or Policy 71 – (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) [www.adm.uwaterloo.ca/infosec/Policies/policy72.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm)

**Unclaimed assignments:** Unclaimed assignments will be retained until one month after term grades become official in Quest. After that time, they will be destroyed in compliance with UW's confidential shredding procedures <http://www.adm.uwaterloo.ca/infostor/Confidential%20Shredding%20procedures%202008.htm>

**Communications with Instructor and Teaching Assistants:** All communication with students must be through either the student's University of Waterloo email account or via Learn. If a student emails the instructor or TA from a personal account they will be requested to resend the email using their personal University of Waterloo email account.

**Recording lectures:**

- Use of recording devices during lectures is only allowed with explicit permission of the instructor of the course.
- If allowed, video recordings may only include images of the instructor and not fellow classmates.
- Posting of videos or links to the video to any website, including but not limited to social media sites such as: Facebook, Twitter, etc., is strictly prohibited.

**Co-op interviews and class attendance:** Co-op students are encouraged to try and choose interview time slots that result in the least amount of disruption to class schedules. When this is challenging, or not possible, a student may miss a portion of a class meeting for an interview. Instructors are asked for leniency in these situations; but, a co-op interview does not relieve the student of any requirements associated with that class meeting.

When a co-op interview conflicts with an in-class evaluation mechanism (e.g., test, quiz, presentation, critique), class attendance takes precedence and the onus is on the student to reschedule the interview. CECA provides an interview conflict procedure to manage these situations. Students will be required to provide copies of their interview schedules (they may be printed from JobMine) should there be a need to verify class absence due to co-op interviews.

## Intellectual Property (IP)

Students should be aware that their courses contain the IP of their instructor, TA, and/or the University of Waterloo. IP includes items such as:

- Lecture content, spoken and written (and any audio/video recording thereof);
- Lecture handouts, presentations, and other materials prepared for the course (e.g., PowerPoint slides);
- Questions or solution sets from various types of assessments (e.g., assignments, quizzes, tests, final exams); and
- Work protected by copyright (e.g., any work authored by the instructor or TA or used by the instructor or TA with permission of the copyright owner).

Sharing this IP without the IP owner's permission is a violation of IP rights. For this reason, **it is necessary to ask the instructor, TA and/or the University of Waterloo for permission before uploading and sharing the IP of others online** (e.g., to an online repository).

**Permission from an instructor, TA or the University is also necessary before sharing the intellectual property of others from completed courses with students taking the same/similar courses in subsequent terms/years.** In many cases, instructors might be happy to allow distribution of certain materials. However, doing so without expressed permission is considered a violation of IP rights.

**Please alert the instructor if you become aware of IP belonging to others (past or present) circulating, either through the student body or online.** The intellectual property rights owner deserves to know (and may have already given their consent).

## Turnitin®

Text matching software (Turnitin®) may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin® in this course.

It is the responsibility of the student to notify the instructor if they, in the first week of term or at the time assignment details are provided, wish to submit the alternate assignment.