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**GEOG 408: Modeling Our Future Climate
and
GEOG 652/GEMCC610: Climate Prediction, Modeling and
Scenarios
Winter 2017**

Instructor

Dr. Christopher Fletcher

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Class Hours: Thu 8:30am-11:20am in EV3-3412 and EV2-2052 (computing lab)

Office Hours: Wed 1-3:30pm, or by appointment.

COURSE DESCRIPTION: The aim of this course is to provide students with detailed understanding about, and experience using, dynamical climate models used to understand changes in Earth's climate. Building on their knowledge of the fundamental physical processes governing the climate system, students in this course will learn how to apply and evaluate climate models to a range of societally-important questions related to climate variability and change. In each topic, students will develop understanding of the theory, and then apply this knowledge to example-based assignments in computing labs.

COURSE LEARNING OBJECTIVES

By the end of the course students will have detailed knowledge of:

- What climate models are, and how they are formulated and tuned.
- How climate models are evaluated, what they do well, and continuing challenges.
- How a hierarchy of models helps to answer critical problems in climate science
- Appreciation of the diverse range of applications for climate models.

The skills learned will be applicable to those seeking to study in a physical science discipline at graduate school, as well as more advanced research topics in climate.

PREREQUISITES: GEOG309 (for GEOG408), GEOG641 (for GEOG652), or contact instructor.

RECOMMENDED READING MATERIALS: Students are not required to purchase a textbook for this course; we will make use of free online texts and materials.

The primary text for this course is the excellent new primer by Andrew Gettelman (NCAR) and Ricky Rood (University of Michigan):

- Gettelman, A., and R. B. Rood, 2016: *Demystifying Climate Models*. Springer Berlin Heidelberg, Berlin, Heidelberg. Available online [here](#).

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Other relevant texts:

- McGuffie, K and Henderson-Sellers, A. (2011) *A Climate Modelling Primer*. Third Edition. Wiley. [available in the library]
- Hansen, J., et al. 1983: [Efficient three-dimensional global models for climate studies: Models I and II](#). *M. Weather Rev.*, **111**, 609-662.. [This paper describes the climate model that underpins the EdGCM software used in the course]
- Stocker, T. (2011) *Introduction to Climate Modelling*, Springer. Available online via the UW library [here](#).
- Goosse H., P.Y. Barriat, W. Lefebvre, M.F. Loutre and V. Zunz, (2010). Introduction to climate dynamics and climate modeling. Online textbook freely available [here](#).
- Archer, D. (2011) *Global Warming: Understanding the Forecast*. Online course available [here](#).

ADDITIONAL REFERENCE TEXT: *Climate Change, The Physical Science Basis*, IPCC-WG1 Fifth Assessment report, Sep 2013 [available [here](#)].

In addition to the recommended texts above, reading material specific to particular topics or labs will also be provided periodically through LEARN (see Class Schedule for details).

CLASS SCHEDULE:

| Wk | Date | Topic | Learning Activity [% final grade] |
|----|---------------|---|---|
| 1 | 5-Jan | A brief history of climate models | Intro to EdGCM (computing lab) |
| 2 | 12-Jan | Climate model formulation | Readings and discussion [5%] |
| 3 | 19-Jan | Model evaluation vs validation | Grad student presentations. [10%] Confronting models with observations (computing lab) [10%] |
| 4 | 26-Jan | Quantifying model performance | Readings and discussion [5%] |
| 5 | 2-Feb | Tuning the climate | Readings and discussion [5%] |
| 6 | 9-Feb | Hierarchies of climate models | Readings and discussion [5%] |
| 7 | 16-Feb | Ongoing challenges in climate modelling | Grad student presentations. [10%] Begin developing project topics. |
| | 23 Feb | <u>No class or lab: Reading week</u> | |
| 8 | 2-Mar | Estimating uncertainty | Projects start. [40%] Climate sensitivity (computing lab) [10%] |
| 9 | 9-Mar | Attribution of climate change | Readings and discussion [5%] |
| 10 | 16-Mar | Geoengineering | Geoengineering (computing lab) |

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|----|--------|-------------------------------|------------------------------------|
| | | | [10%] |
| 11 | 23-Mar | Quantifying climate feedbacks | Readings and discussion [5%] |
| 12 | 30-Mar | Project presentations | Projects due Apr 6 th . |

COURSE WORKLOAD: The total workload for undergraduate courses is approximately 10-hours per week; since this is a 1.0 credit course, the expected workload is roughly doubled. The expectation is that students spend 4-5x the in-class time working on the course outside of class. The rough breakdown of the expected weekly workload in this course is:

- Lectures: 1.5-3 hrs
- Labs: 6.5 hours (1.5 hrs in class, 5 hrs outside class; weeks 1-7 only)
- Readings, preparing discussion points and/or presentations: 5-7 hrs
- Term project: (5 hrs outside class; weeks 8-12 only)

STUDENT ASSESSMENT: This course is offered to both graduate and undergraduate students, and there are different assessment activities for each group (see below).

UNDERGRADUATES (GEOG408):

| | Total mark | Breakdown | Notes |
|-------------------------|------------|-----------|---|
| Group project | 40% | 30% + 10% | Written project and presentation |
| Computing Labs | 30% | 3 x 10% | |
| Readings and Discussion | 30% | 6 x 5% | 3% readings, 2% discussion; Best 6 out of 7 |

GRADUATE STUDENTS (GEOG652-GEMCC610):

| | Total mark | Breakdown | Notes |
|----------------------------|------------|-----------|---|
| Group project | 40% | 30% + 10% | Written project and presentation |
| Computing Labs | 30% | 3 x 10% | |
| Grad student presentations | 20% | 2 x 10% | Preparing and delivering a 15-min lecture on a given topic. |
| Discussion participation | 10% | 5 x 2% | Best 5 out of 7 |

GRADES FOR READING AND DISCUSSION: Students are expected to do considerable independent reading and study devoted to this course (see above). The quality and depth of this reading will be assessed in two ways: 1) students will earn 3% for submitting two questions and/or discussion points into the quiz on LEARN by 11:59pm on the day before class (undergrad only); and 2) 2% is available for students' active and engaged participation in the in-class discussion activity (grad and undergrad).

COMPUTING LABS: This course applies the theory learned in lectures with seven practical computing lab assignments during weeks 3, 8 and 10. All lab assignments will be made available on LEARN and then worked through during lab sessions and

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finished in your own time. While I encourage collaboration and discussion in all aspects of the course, the submitted lab assignments are to be completed individually. Students should upload their answers to the Dropbox on LEARN in a Word or PDF document not exceeding 5 pages in length (12pt, single spaced, including all tables, figures and references). Each lab is worth 10% of the final course grade.

GROUP PROJECT: Working in teams of two, the group projects will be selected by the students in consultation with the instructor. A list of pre-approved topics will be provided; students are also free to devise their own topic. 30% of the final mark is available for the written project (due April 6th at 11:59pm), and an additional 10% is available for an oral presentation in the final week of class outlining the methods, results and conclusions from the project. At least one student from each group should upload their assignment to UW LEARN. Both assignments will receive exactly the same mark, unless written documentation supporting a different weighting is provided to the instructor within two business days of submission.

COURSE WEB PAGE: Students registered in the course can access the course website via UW LEARN (<http://www.learn.uwaterloo.ca>). The course website provides access to lecture presentations and selected research papers as well as lab assignments (and associated data). In addition, the course website supports announcements, discussion groups and e-mail.

BACKING UP YOUR DATA: Students are 100% responsible for maintaining backups of any files and data you have modified. In computing the mantra is: *if it's not in at least two places it doesn't exist*. Suitable options for backups include: portable USB flash drives; external hard drives; laptops, or home desktop PCs; online "cloud" storage. No accommodation will be made for assignments handed in late due to lost or corrupted data.

SUBMITTING WORK: Unless otherwise noted, all work should be submitted by uploading to UW LEARN in PDF format. Each assignment will have a specified due date and time on UW LEARN. Grades will be posted on UW LEARN about one week after submission.

LATE SUBMISSION: Failure to submit your work on time will result in a grade of zero for that assignment. There are no late penalties in this course, and deadline extensions will not be accommodated (see below).

ILLNESS DURING TERM

Please refer to the University of Waterloo Policies regarding documentation and the management of requests for accommodation due to illness during the term. Illness verification forms are required for any student seeking accommodation for any course requirement missed due to an illness. Please refer to http://www.registrar.uwaterloo.ca/students/accom_illness.html for more information.

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ACCOMMODATIONS DUE TO ILLNESS OR COMPASSIONATE REASONS:

MISSED DUE DATES: If an assignment due date or a term test is missed because of illness, or other compassionate reasons, and all of the proper documentation is submitted on time, the weight of the remaining assignments or tests will be increased accordingly. Assignment due dates will not be extended.

POLICY ON REGRADING ASSIGNMENTS:

If you notice an error in the assessment of your work please follow these steps:

1. Wait 72 hours after the assignment was returned before requesting a regrade
2. All regrade requests must be submitted as a hard-copy to the instructor, describing the errors you believe were made. **Verbal or emailed requests will not be accepted.** Be as specific as possible and list all relevant details, e.g., “*my marks were summed incorrectly for questions 1–5*”.
3. If another student’s assignment is cited as an example or reason for an error in grading, both assignments must be submitted for a regrade.
4. The entire assignment will be regraded, not the just the errors indicated in the written request. The resulting grade may increase or decrease depending on the result of the regrading.

POLICY ON EMAIL CORRESPONDENCE: Face-to-face contact time with the instructor is available through office hours, during and after class, and in the labs. Discussion forums are available in LEARN for any inquiries that are of general interest (e.g., clarification of assignment instructions, or a concept introduced in class). Students are strongly encouraged to attend office hours to discuss any issues related to the course, and email should only be used when none of these other options is appropriate.

However, *if your question or concern cannot wait until the next lecture or office hour* then please remember these policies when sending email to the instructor or TAs:

- Always send emails from your University of Waterloo email account.
- All emails should have the following subject line: “GEOG408-652/GEMCC610: <<your subject here>>”
- If your email includes an attachment, describe the contents of the attachment in the email.
- Be polite, respectful and professional.
- Proofread your email and use correct grammar and punctuation.
- Always use an appropriate greeting, and sign your full name.
- Allow the instructor or TA at least two business days to respond before sending the request again. Mark all urgent matters “URGENT” in the subject line.
- The instructor or TA reserves the right to reply to you along with the entire class if the question is deemed to be relevant to other students on the course.

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Academic Policies

- **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. www.uwaterloo.ca/academicintegrity/ Students who are unsure what constitutes an academic offence are requested to visit the on-line tutorial at <http://www.lib.uwaterloo.ca/ait/>
- **Discipline:** A student is expected to know what constitutes academic integrity, to avoid committing academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs 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. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, www.adm.uwaterloo.ca/infosec/Policies/policy71.htm . For typical penalties, check Guidelines for Assessment of Penalties, www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm
- **Note for students with disabilities:** The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, 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 the OPD at the beginning of each academic term.
- **Research Ethics:** The University of Waterloo requires all research conducted by its students, staff, and faculty which involves humans as participants to undergo prior ethics review and clearance through the Director, Office of Human Research and Animal Care (Office). The ethics review and clearance processes are intended to ensure that projects comply with the Office’s Guidelines for Research with Human Participants (Guidelines) as well as those of provincial and federal agencies, and that the safety, rights and welfare of participants are adequately protected. The Guidelines inform researchers about ethical issues and procedures which are of concern when conducting research with humans (e.g. confidentiality, risks and benefits, informed consent process, etc.). If the development of your research proposal consists of research that involves humans as participants, the please contact the course instructor for guidance and see <http://iris.uwaterloo.ca/ethics/>
- **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. Read Policy 70 - Student Petitions and Grievances, Section 4, www.adm.uwaterloo.ca/infosec/Policies/policy70.htm . When in doubt please contact your Undergraduate Advisor for details.
- **Appeals:** A 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
- **Turnitin:** Plagiarism detection software (Turnitin) will *not* be used in this course.
- **LEARN:** Users can login to LEARN via: <http://learn.uwaterloo.ca/> ; use your WatIAM/Quest username and password. Documentation is available at: http://av.uwaterloo.ca/uwace/training_documentation/index.html
- **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.