Department of Geography and Environmental Studies

GEOG5001: Modelling Environmental Systems

Fall 2024

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Office Hours: Drop-in or by appointment
Meetings: Tuesdays and Thursdays 9:35 a.m. to 11:25 a.m. Loeb A220

INTRODUCTION

Calendar description: Methods and problems of research on the physical environment, with illustrative material taken from the atmospheric and surface earth sciences. Issues such as the identification and behaviour of environmental systems, temporal and spatial scale, experimental method under field conditions, and simulation and model development are considered.

Summary/Objectives: This course aims to provide students beginning their MSc program (or those entering a PhD if interested) with a structured overview of environmental modelling with application to physical geography and the environmental sciences. The course is geared to focusing students' efforts on identification of potential thesis research topics and methods at the earliest part of their graduate program. The course provides an overview of a range of modelling approaches employed and methods of data analysis (and their limitations) commonly used among the environmental sciences. We will meet twice a week, typically alternating between a seminar format when we will focus on readings and discussions, and a workshop format to develop your skills in empirical and process-based environmental modelling.

LEARNING OUTCOMES

By the end of this course, successful students will be able to:

1. Differentiate among the various environmental modelling approaches used in physical geography and environmental science, and understand/explain their different purposes, strengths and weaknesses.
2. Use the R programming language for data manipulation, descriptive statistics, inferential statistics, model fitting and model evaluation, at a level that is appropriate for graduate level research in physical geography.
3. Formulate and justify a geographic research question that can be addressed using an environmental modelling approach, implement the steps required to answer the question, and document the analysis and results in a formal scientific report.
4. Synthesize and actively discuss key findings and themes within journal articles from physical geography and environmental sciences.
5. Communicate effectively with scientific writing and oral presentations, at a level that is appropriate for an entry-level research position.

READINGS

Required Textbooks:

Harris, R., and Jarvis, C. 2011. *Statistics for Geography and Environmental Science*.
(There will be one copy of this book available on reserve at the library under GEOG5001)

Heard, S.B., 2022. *The scientist's guide to writing: How to write more easily and effectively throughout your scientific career (Second Edition)*

Douglas, A., Roos, D., Mancini, F., Couto, A., and Lusseau, D. 2024. An Introduction to R (intro2r.com).
(Free digital book to help you with R programming and problem sets).

Seminar Readings (Articles and Book Chapters):

A preliminary list of our seminar readings is provided below. These will form the basis of our biweekly seminar discussions and writing assignment topics. A Zotero library will be shared with students containing these bibliographic entries and

Seminar 1: On Geography and Modelling

Baker, V. R. Geological fluvial geomorphology. Geological Society of America Bulletin 100, 1157–1167 (1988).

Burt, W. General/particular,[in:] Castries N., Rogers A., Sherman D.,(eds.) Questioning Geography. Fundamental Debates. (2005).

Demeritt, D. & Wainwright, J. Models, modelling, and geography. Questioning Geography. Oxford: Blackwell 206–25 (2005).

Gregory, K. J., Gurnell, A. M. & Petts, G. E. Restructuring physical geography. Transactions of the Institute of British Geographers 27, 136–154 (2002).

Seminar 2: Environmental Systems and Feedbacks

Chapin, F. S. et al. Arctic and boreal ecosystems of western North America as components of the climate system. Global Change Biology 6, 211–223 (2000).

Chorley, Richard & Kennedy, Barbara. Systems. in Physical Geography: a systems approach (1971).

Davidson, E. A. & Janssens, I. A. Temperature sensitivity of soil carbon decomposition and feedbacks to climate change. Nature 440, 165–173 (2006).

Fewster, R. E. et al. Imminent loss of climate space for permafrost peatlands in Europe and Western Siberia. Nature Climate Change 12, 373–379 (2022).

Seminar 3: Model Complexity

Arismendi, I., Safeeq, M., Dunham, J. B. & Johnson, S. L. Can air temperature be used to project influences of climate change on stream temperature? Environmental Research Letters 9, 084015 (2014).

Hrachowitz, M., Soulsby, C., Imholt, C., Malcolm, I. A. & Tetzlaff, D. Thermal regimes in a large upland salmon river: a simple model to identify the influence of landscape controls and climate change on maximum temperatures. Hydrol. Process. 24, 3374–3391 (2010).

Qiu, H., Hamilton, S. K. & Phanikumar, M. S. Modeling the effects of vegetation on stream temperature dynamics in a large, mixed land cover watershed in the Great Lakes region. Journal of Hydrology 581, 124283 (2020).

Weierbach, H. et al. Stream temperature predictions for river basin management in the Pacific Northwest and mid-Atlantic regions using machine learning. Water 14, 1032 (2022).

Seminar 4: Model Calibration and Validation

Ferguson, R. I. Magnitude and modelling of snowmelt runoff in the Cairngorm mountains, Scotland. Hydrological Sciences Journal 29, 49–62 (1984).

Kirchner, J. W. Getting the right answers for the right reasons: Linking measurements, analyses, and models to advance the science of hydrology: GETTING THE RIGHT ANSWERS FOR THE RIGHT REASONS. Water Resour. Res. 42, (2006).

Oreskes, N., Shrader-Frechette, K. & Belitz, K. Verification, Validation, and Confirmation of. Science 263, 4 (1994).

Weiler, M. & McDonnell, J. Virtual experiments: a new approach for improving process conceptualization in hillslope hydrology. Journal of Hydrology 285, 3–18 (2004).

Seminar 5: Spatial Variability and Scale

Ferguson, R. I. Magnitude and modelling of snowmelt runoff in the Cairngorm mountains, Scotland. Hydrological Sciences Journal 29, 49–62 (1984).

Kirchner, J. W. Getting the right answers for the right reasons: Linking measurements, analyses, and models to advance the science of hydrology. Water Resour. Res. 42, (2006).

Oreskes, N., Shrader-Frechette, K. & Belitz, K. Verification, validation, and confirmation of numerical models in the Earth Sciences. Science 263, 4 (1994).

Weiler, M. & McDonnell, J. Virtual experiments: a new approach for improving process conceptualization in hillslope hydrology. Journal of Hydrology 285, 3–18 (2004).

ASSESSMENT
Data Modelling Exercises: 20%
Online stats quizzes: 10%
Seminar Readings Syntheses: 20%
Journal Article Critique: 10%
Seminar Participation and Engagement: 10%
Data Modelling Project: 20%
Presentations: 10%

Participation: I expect all students to come to class prepared, to participate fully in seminar activities and engage effectively in discussions. I will check in with students mid-way through the course to discuss the participation grade, if needed. The following things will be used to award a high participation grade: Regular attendance and punctuality; Making effort in class to help carry discussions; Taking initiative to help the class run more smoothly and effectively for everyone; Respecting other people's opinions and their opportunities to contribute; Asking questions and seeking help where needed including during class time (rather than leaving things to the last minute); Embracing new challenges and not letting fear of failure negatively impact performance.

ACADEMIC ACCOMMODATION

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Informal accommodation due to short-term incapacitation: Please discuss short-term accommodation needs with your supervisor.

Pregnancy obligation: Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For accommodation regarding a formally-scheduled final exam, you must complete the Pregnancy Accommodation Form (click here).

Religious obligation: Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details click here.

Academic Accommodations for Students with Disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, please request your accommodations for this course through the Ventus Student Portal at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (*if applicable*). Requests made within two weeks will be reviewed on a case-by-case basis. For final exams, the deadlines to request accommodations are published in the University Academic Calendars. After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable).

Survivors of Sexual Violence: As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: https://carleton.ca/equity/sexual-assault-support-services

Accommodation for Student Activities: Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation will be provided to students who compete or perform at the national or international level. Write to you supervisor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf

Student Conduct:

The University has adopted a policy to deal with allegations of academic misconduct. This policy is expressed in the document Carleton University Academic Integrity Policy, effective July 1, 2006. The policy describes in detail its scope of application, principles, definitions, rights and responsibilities, academic integrity standards, procedures, sanctions, transcript notations, appeal process, and records implications. The complete policy is available at: http://www.carleton.ca/studentaffairs/student-rights-and-responsibilities/

Academic Integrity:

Carleton University has clear and firm policies regarding instructional and conduct offences. Instructional offences include among other activities cheating, contravening examination regulations, plagiarism, and disrupting classes. Conduct offences apply in areas of discrimination and sexual harassment. Further information about the University's Academic Integrity Policy can be found at:

https://carleton.ca/secretariat/wp-content/uploads/Academic-Integrity-Policy-2021.pdf

Plagiarism is one kind of instructional offence. Examples of plagiarism 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;
- 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;
- the *unauthorized* use of generative AI tools (e.g., ChatGPT);

Plagiarism is a serious offence which cannot be resolved directly with the course's instructor. The Associate Dean of the Faculty conducts 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 can include a final grade of "F" for the course.

For more information on how to cite sources, refer to the library web page "*Citing Your Sources*", available at http://www.library.carleton.ca/help/citing-your-sources.

STATEMENT ON STUDENT MENTAL HEALTH

As a university 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:

Emergency Resources (on and off campus): https://carleton.ca/health/emergencies-and-crisis/emergency-numbers/

Carleton Resources:

- Mental Health and Wellbeing: https://carleton.ca/wellness/
- Health & Counselling Services: https://carleton.ca/health/
- Paul Menton Centre: https://carleton.ca/pmc/
- Academic Advising Centre (AAC): https://carleton.ca/academicadvising/
- Centre for Student Academic Support (CSAS): https://carleton.ca/csas/
- Equity & Inclusivity Communities: https://carleton.ca/equity/

Off Campus Resources:

- Distress Centre of Ottawa and Region: (613) 238-3311 or TEXT: 343-306-5550, https://www.dcottawa.on.ca/
- Mental Health Crisis Service: (613) 722-6914, 1-866-996-0991, http://www.crisisline.ca/
- Empower Me: 1-844-741-6389, https://students.carleton.ca/services/empower-me-counselling-services/
- Good2Talk: 1-866-925-5454, https://good2talk.ca/
- The Walk-In Counselling Clinic: https://walkincounselling.com

Other Campus Resources for Students:

Student Experience Office http://www.carleton.ca/seo/
Health and Counselling Services http://www.carleton.ca/health
International Student Services Office http://www.carleton.ca/isso
Academic Advising https://carleton.ca/academicadvising/
Career Services https://carleton.ca/career/

Course Schedule: A meeting schedule with class topics/activities will be posted on Brightspace at the beginning of term and will be periodically updated as needed. A preliminary version is provided below, but it is subject to change.

Preliminary Course Schedule

Week/Week of	Tuesday Meeting	Thursday Meeting
1 – Sep 2	No classes on Tuesday	Course Introduction
2 – Sep 9	R Workshop: Intro to R and **Exercise 1**	**Seminar 1:** On Geography and Modelling (theory and practice)
3 – Sep 16	Central Limit Theorem and **Exercise 2**	Writing workshop
4 – Sep 25	Hypothesis testing and power analysis with R workshop	**Seminar 2:** Environmental Systems Identification (soil carbon and global change)
5 – Sep 23	Model fitting with R workshop	Writing workshop
6 – Sep 30	R Workshop a and **Exercise 3**	Cross validation and bootstrapping with R workshop
7 – Oct 7	*relaimpo* package in R for MLR; CART and Random Forest	**Seminar 3:** Model complexity and model selection (stream temperature modelling)
8 – Oct 14	Curve Fitting and optimization with R workshop and **Exercise 4**	Writing workshop
Oct 21	Reading Week	
9 – Oct 28	Time Series Analysis with R workshop and **Exercise 5**	Journal Article Critique Lightning Presentations with Peer Evaluations
10 – Nov 4	Project proposal presentations (lightning talks)	**Seminar 4:** Model Evaluation
11 – Nov 11	Work Period/Project Consultations	Work Period/Project Consultations
12 – Nov 18	Work Period/Project Consultations	**Seminar 5:** Spatial variability and scale seminar (snow distribution)
13 – Nov 25	Work Period/Project Consultations	Work Period/Project Consultations
13 – Dec 2	Modelling project presentations	Modelling project presentations