Department of Geography and Environmental Studies

# GEOG5001: Modelling Environmental Systems

Fall 2025

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**Office Hours:** Drop-in or by appointment
**Meetings**: Tuesdays and Thursdays 9:35 a.m. to 11:25 a.m. Location TBA.
**Brightspace Page:** Homepage - GEOG5001F Modelling Environmental System (SEM) Fall 2025

## 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 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. Synthesise and actively discuss key arguments, findings and themes within journal articles from physical geography and environmental sciences.
3. Think critically and convey your ideas through scientific writing and oral presentations, at a level that is appropriate for an entry-level research position.
4. 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 research in physical geography.
5. 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.

**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) (Tentative - do not order yet).*

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 Resources (Articles and Book Chapters or Other):**

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.

***Seminar 1: The Structure of Arguments***

In preparation for this seminar, please complete the first two modules of the free "Structure and Function of Arguments" Harvard University online course. Complete up to the end of the second module "The Reason Rule". Please alot approximately 3 hours to complete this and be sure to complete the quizzes throughout so that you are prepared for our meeting.

Structure and Function of Argument: Introduction to Critical Thinking | Harvard Online

Other reading TBA

***Seminar 2: On Models and Modelling***

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).

Other TBA

***Seminar 3: 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 4: 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 5: 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: Water Resour. Res. 42, (2006).

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

**ASSESSMENT**

Writing Assignments (4): **20%**
Data Modelling Exercises (5): **15%**
Online stats quizzes (5): **10%**
In person stats quiz (1): **10%**
Journal Article Critique (1): **10%**
Data Modelling Project (1): **15%**
Presentations (3): **10%**
Participation and Engagement: **10%**

**Participation and Engagement:** I expect all students to come to class prepared and to participate fully in seminar activities and engage effectively in all 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 evaluate

your participation grade: Regular attendance and punctuality; Demonstrating curiosity; 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.

**Final Grade Approval:** Standing in a 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.

**ACADEMIC ACCOMMODATION**

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).
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 me directly and as at the earliest possible time.

**ACADEMIC INTEGRITY**

a) Permissibility of submitting substantially the same piece of work more than once for academic credit

If you would like to use any aspect of previous work you have completed in other previous courses or work positions towards your assignments in this class, you must discuss with the instructor ahead of time to obtain permission.

b) Permissibility of group or collaborative work

There is minimal group work in this course. You are encouraged to discuss the course material with each other to brainstorm and share ideas, and to provide peer evaluation. Beyond this, all work submitted must clearly be your own and work that appears in duplication between two or more students will be treated as a case of plagiarism for all students involved.

c) Statement on Plagiarism

The University Academic Integrity Policy defines plagiarism as 'presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one's own.' This includes 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. Examples of sources from which the ideas, expressions of ideas or works of others may be drawn from include but are not limited to books, articles, papers, literary compositions and phrases, performance compositions, chemical compounds, artworks, laboratory reports, research

results, calculations and the results of calculations, diagrams, constructions, computer reports, computer code/software, material on the internet and/or conversations.

Examples of plagiarism include, but are not limited to:

- any submission prepared in whole or in part, by someone else, including the unauthorized use of generative AI tools as described in the course AI use policy
- using ideas or direct, verbatim quotations, paraphrased material, algorithms, formulae, scientific or mathematical concepts, or ideas without appropriate acknowledgment in any academic assignment
- using another's data or research findings without appropriate acknowledgement
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own
- failing to acknowledge sources with proper citations when using another's work and/or failing to use quotations marks.

Plagiarism is a serious offence that cannot be resolved directly by the course's instructor. The Associate Dean of the Faculty follows a rigorous process for academic integrity allegations, including reviewing documents and interviewing the student, when an instructor suspects a violation has been committed. Penalties for violations may 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.

**AI USE POLICY (GEOG5001)**

In this course, AI is treated as a supportive collaborator, not a substitute for critical thinking or scholarly integrity. Students are encouraged to use AI tools to enhance their learning, deepen their understanding of course concepts and scientific literature, and streamline technical tasks while emphasising the importance of original thought and scholarly integrity. Since AI is relatively new and evolving rapidly, we will also use this course to explore and discuss our collective experiences in using AI as a collaborator in research and learning.

***Permitted Uses of AI***

- Literature Searches, Explorations and Understanding

    - Use tools such as Elicit, Notebook LM, ResearchRabbit, or Connected Papers to locate, summarise, and synthesise scientific literature and web sources. AI may assist in identifying key themes, generating summaries, and organising references. However, students must critically evaluate all AI-generated outputs and be prepared to justify their selection of sources, explain how they interpreted the material, and demonstrate a clear understanding of the content beyond what the AI tool provided.

- Writing Support

- AI tools such as ChatGPT, Microsoft Copilot and Notebook LM may be used to support academic writing for this course in the following ways:

    1. Generating initial outlines for papers or presentations in response to your own ideas and prompts supplied to the tool.
    2. Refining written work, including clarifying, condensing, and enhancing specific sections through advanced editing suggestions as well as spelling and grammar checking. However, these tools must be used to enhance - not replace - your original thinking. You are expected to write the initial drafts yourself, and AI-generated content should never substitute for your own analysis or argumentation. You must remain the author of your work and be able to explain, defend, and take full responsibility for all content submitted.
    3. Assisting with routine formatting and editorial tasks, such as checking references for consistency, identifying duplication, and improving structural formatting.

• Coding Assistance

- AI tools may be used to assist with R programming, including syntax help, debugging, and code optimisation/formatting. Students must ensure they understand the code and can interpret the results of their analyses independently.

• Creative Content Generation

- AI may be used to generate explanatory graphics and design presentation slides, and to *help* you generate scientific figures/data visualisations. You are responsible for ensuring that all generated outputs are relevant and accurate. For scientific figures/data visualisations, you may use AI to help generate the code to create the figure from your data sources. However, the figures themselves cannot be generated by directly providing the data to the AI tool. Therefore, if asked, you must be able to supply the code used to generate any scientific figures/data visualisations.

***Documentation Requirements***

To maintain transparency and academic integrity in relation to AI use, students must:

• Clearly document AI usage in all submitted work. E.g. “Outline generated with ChatGPT based on my research notes”; “Code generation and debugging assisted by Copilot.” *See also the example at the end of this AI use policy.
• Critically evaluate and revise any AI-generated content to ensure originality, precision of wording and accuracy of information.
• Avoid over-reliance: AI should enhance—not replace—student learning, analysis, and creativity.

***Prohibited Uses***

• AI-generated first drafts of complete (or major sections of) essays, reports or presentation scripts.
• Using AI to bypass understanding of core concepts, especially in coding or statistical modelling.
• Presenting AI-generated summaries or interpretations without personal insight or evaluation.
• Presenting any AI-generated content as though it is your original thought/analysis/research.

***Suspected Violations of AI Use Policy and Instructor Recourse***

If there is reason to believe that a student has submitted work that violates the AI use policy—whether through unacknowledged AI-generated content, lack of original analysis, or misrepresentation of authorship—the instructor may take one or more of the following steps:

- Oral Evaluation: The student may be required to participate in an oral evaluation to demonstrate their understanding of the submitted material and clarify the extent of their own contribution.
- Formal Academic Integrity Review: The case may be referred for formal review under Carleton's Academic Integrity Policy. This process may involve documentation, investigation, and potential academic consequences as outlined by university regulations.

Students are expected to take full intellectual ownership of their work and be able to defend their choices, interpretations, and arguments - regardless of whether AI tools were used in the process.

***Rationale***

This policy is designed to help students develop critical thinking and research literacy in the age of AI. It encourages effective collaboration with AI tools while maintaining academic rigour. By using AI to enhance literature searches and analysis, consolidate complex information, facilitate coding, and streamline other routine tasks, students can focus on higher-order learning such as interpretation, synthesis, critiquing and evaluation, especially in support of research.

*Note: I used Microsoft Copilot to assist with refining the language, structure, and clarity of this policy, which was adapted from Carleton University's sample policies: Sample Syllabus Statements for AI Use in Courses - Artificial Intelligence. All substantive ideas, examples, and decisions reflect my own judgment. Copilot's role was editorial, and I have reviewed and edited all AI-assisted content to ensure it aligns with my intent.

**STATEMENT ON 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/.

**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/

## Tentative Course Schedule

| Week/Week of | Tuesday Meeting | Thursday Meeting |
|---|---|---|
| 1 – Sep 1 | No classes on Tuesday | Course Introduction |
| 2 – Sep 8 | R Workshop: Intro to R and **Problem Set 1** | **Seminar 1:** The structure of arguments |
| 3 – Sep 15 | Central Limit Theorem and Hypothesis Testing | **Seminar 2:** On models and modelling |
| 4 – Sep 22 | **Problem Set 2** | Writing workshop<br>*Writing Assignment 1 due today |
| 5 – Sep 29 | Murray away no class today | **Seminar 3:** Environmental Systems Identification |
| 6 – Oct 6 | Power analysis with R workshop and **Problem Set 3** | Writing workshop<br>*Writing Assignment 2 due today |
| 7 – Oct 13 | R Workshop: *relaimpo* package in R for MLR; | **Seminar 4:** Model complexity and model selection (stream temperature modelling) |
| Oct 20 | Reading Week | |
| 8 – Oct 27 | R Workshop: Cross-validation, CART, Random Forest in R Workshop<br>**Problem Set 4** | Journal Article Critique Lightning Presentations (5 mins) with Peer Evaluations |
| 9 – Nov 3 | R Workshop: Time Series Analysis<br>**Problem Set 5**<br>*Writing Assignment 3 due today | Work Period/Project Consultations |
| 10 – Nov 10 | Project Proposal Presentations (lightning talks 3-5 mins) | **Seminar 5:** Model Evaluation |
| 10 – Nov 17 | In person stats quiz<br>Work Period/Project Consultations | *Writing Assignment 4 due today |
| 11 – Nov 24 | Work Period/Project Consultations | Work Period/Project Consultations |
| 12 – Dec 1 | Modelling Project Presentations | Modelling Project Presentations |