GEOG*6550 - Environmental Modelling

Provisional Course Outline Winter 2025, 0.5 Credits
Department of Geography, Environment and Geomatics
University of Guelph

Instructor	Ben DeVries
Office	HUTT-131
Contact	bdv@uoguelph.ca
Office Hours	By appointment
Time	Mondays, 2:30pm - 5:20pm
Venue	HUTT-234

---

1 Synopsis

This course will provide students with a background on the application of geospatial, machine learning, and other types of models to geographical and environmental research. An introduction to numerical programming in python will also be given. Class sessions will comprise a mix of lectures, student-led discussion, and computer practicals. Students will undertake an independent project applying modelling tools to an environmental research topic of their choice.

2 Description

Modelling is an integral component to research in the environmental sciences. Models used to understand the complex processes and phenomena in geographical systems can take the form of process-based models, statistical learning (ie. machine learning) models, agent-based models, among others. In many cases, these models are tied to very specific applications (e.g., hydro-dynamic models for flood prediction) and require a substantial amount of disciplinary knowledge and skill to operate and understand. As such, this course does not attempt to provide a comprehensive overview of such specific applications-driven models, but will rather emphasize the use of data-driven, machine learning models in environmental research.

Machine Learning (ML) models have emerged as some of the most frequently used modelling approaches to study geographical phenomenon. Advances in computing infrastructures, geographical information systems (GIS), and remote sensing have resulted in a proliferation of powerful ML models, including deep learning, in the various sub-disciplines within geography. Applications of ML in geographical and environmental sciences include land cover mapping, change detection, species distribution modelling, retrieval of biophysical land surface parameters, among many other applications.

This course will necessarily touch on some of the statistical aspects of ML models, particularly topics related to sampling, model training, and model validation. I assume minimal background in statistics and favour an emphasis on the applications of ML models to problems in environmental

research over detailed theoretical discussions. Spatial relationships and scale are inherent in most environmental models, and while I do not assume any background in spatial methods (e.g. GIS and remote sensing), this course will necessarily touch on some aspects of these fields. As part of this exposure, students will gain experience with open source geospatial tools during in-class practicals as well as through individual projects.

ML models are inexorably linked to numerical programming. The python programming language is one of the most extensively used, but by no means only, languages for this purpose. A key advantage of python is the abundance of open-source modules that are designed to facilitate various aspects of ML workflows, from data input, sampling, model fitting, prediction, and model validation. Computer programming is therefore an essential skill when working with machine learning in the geospatial sciences. No previous programming experience is required to take this course, as students will learn basic programming skills through in-class practicals and an independent research project. Regardless of students' prior programming experience, a willingness to learn will go a long way in this course.

Class sessions will consist of a mixture of lectures, paper presentations and student-led discussions, and interactive demonstrations. Additionally, students will carry out a major independent project on a topic of their choosing. This project will demonstrate the use of modelling techniques to address a research objective. This project will also be an opportunity for students to further develop their programming skills. While in-class demonstrations will be carried out mostly in python, students are welcome to implement their project using other software tools as necessary and appropriate.

3 Learning Objectives

By the end of this course, students will have met the following learning objectives:

- Gain exposure to a wide array of modelling approaches in the environmental sciences.
- Develop a basic understanding of data-driven (machine learning) models and their applications in the environmental sciences.
- Become familiar with python and open-source modules for geospatial data analysis.
- Learn how to develop modelling workflows to address specific research objectives.
- Demonstrate an ability to present and discuss research in both written and oral forms.

4 Assessment

4.1 Paper Presentation (15%)

Each student will give a short presentation on an original research paper describing a topic of their choosing. This presentation will outline the background, research objectives or questions, the methods used to address the objectives, and key results and conclusions. The focus of the presentation will be on the modelling workflow described in the paper, including input data, output predictions, and implicit and explicit assumptions underlying the models used. I will post a schedule of paper presentations during the first few weeks of the course.

4.2 Final Project Report (55%)

Students will implement an independent project on a topic related to environmental models. This project will be centred on an original research project using "real world" data addressing a research question of the student's choosing. Students will be expected to meet with me directly near the beginning of the semester to discuss project ideas, objectives and questions, and at least one more time in the middle of the semester to review progress on independent projects. Students will submit a final report detailing their final project at the end of the semester. Reports will be structured similarly to an original research paper. Specific requirements of the report, including overall word limits, will be discussed at the beginning of the course. Final project reports will be due on the final day of Winter 2025 classes.

4.3 Poster Presentation (15%)

Students will design and present a poster summarizing their project. They will present their posters during a designated poster session near the end of the session.

4.4 Participation (15%)

Students will be expected to attend class sessions and participate in discussions. The participation grade will be drawn from in-class participation, 1-on-1 meetings between me and the students, and a separate, written personal reflection submitted with the final project report, which describes how the student met their learning goals in the course.

5 Course Format and Schedule

Weekly sessions will consist of a mix of lectures on selected topics and hands-on practicals. Lectures will cover concepts related to modelling in general or specific types of modelling approaches, with an emphasis on machine learning. Most lectures will be held as a seminar and will be based on assigned readings. Students will be expected to contribute to discussions on the topics. All class sessions will be held in a face-to-face format. Table 1 outlines the *tentative* schedule for the course. These dates and topics are subject to change in the future.

Table 1: Tentative schedule of topics.

Week	Date	Lecture topic	Practical topic(s)
1	January 6	Introduction	
2	January 13	Principles of Environmental Models	Introduction to python
3	January 20	Model calibration and validation	Arrays: `numpy`
4	January 27	Statistical Models and Machine Learning	Tabular data: `pandas`
5	February 3	Unsupervised Learning	Geospatial data: `geopandas`
6	February 10	Linear and Logistic Regression	Geospatial data: `rasterio` and `gdal`
7	February 17	Winter Break (no classes)	
8	February 24	Supervised Classification I Paper Presentations	Machine learning: `scikit-learn`
9	March 3	Supervised Classification II Paper Presentations	Machine learning: `scikit-learn`
10	March 10	Spatial Models and Scale Paper Presentations	Project Work Session
11	March 17	Time Series Models	Project Work Session
12	March 24	Bayesian Models	Project Work Session
13	March 31	Poster Presentations	

6 University Policies and Other Details

6.1 Email Communication

As per university regulations, all students are required to check their ¡uoguelph.ca¿ e-mail account regularly: e-mail is the official route of communication between the University and its students.

6.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons, please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, ID, and e-mail contact. See the Undergraduate Calendar for information on regulations and procedures for Academic Consideration.

6.3 Drop Date

Courses that are one semester long must be dropped by the end of the last day of classes; two-semester courses must be dropped by the last day of classes in the second semester. The regulations and procedures for Dropping Courses are available in the Undergraduate Calendar.

6.4 Copies of Out-Of-Class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

6.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student. When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required, however, interim accommodations may be possible while that process is underway. Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability. Use of the SAS Exam Centre requires students to make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

More information: uoguelph.ca/sas

6.6 Academic Misconduct

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community - faculty, staff, and students - to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection. Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

The Academic Misconduct Policy is outlined in the Undergraduate Calendar.

6.7 Recording of Materials

Presentations which are made in relation to course work—including lectures—cannot be recorded or copied without the permission of the presenter, whether the instructor, a classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

6.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies and regulations which apply to undergraduate, graduate and diploma programs.

6.9 Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, changes in classroom protocols, and academic schedules. Any such changes will be announced via Courselink and/or class email. This includes on-campus scheduling during the semester, mid-terms and final examination schedules. All University-wide decisions will be posted on the COVID-19 website (https://news.uoguelph.ca/2019-novel-coronavirus-information/) and circulated by email.

6.10 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g., final exam or major assignment). Students are also responsible for the course content for period of absence due to illness and should be prepared to get notes shared by classmates who were able to attend.

6.11 COVID-19 Safety Protocols

For information on current safety protocols, follow these links:

- https://news.uoguelph.ca/return-to-campuses/how-u-of-g-is-preparing-for-your-safe-return/
- https://news.uoguelph.ca/return-to-campuses/spaces/#ClassroomSpaces

Please note that these guidelines may be updated as required in response to evolving University, Public Health or government directives.