Quantitative Methods in Earth and Environmental Sciences Syllabus

Department of Earth and Environmental Sciences

ERTH 6353 Fall 2026

Dalhousie University operates in the unceded territories of the Mi'kmaw, Wolastoqey, and Peskotomuhkati Peoples. These sovereign nations hold inherent rights as the original peoples of these lands, and we each carry collective obligations under the Peace and Friendship Treaties. Section 35 of the Constitution Act, 1982, recognizes and affirms Aboriginal and Treaty rights in Canada.

We recognize that African Nova Scotians are a distinct people whose histories, legacies, and contributions have enriched the part of Mi'kma'ki known as Nova Scotia for over 400 years.

Course Instructor(s)

Name	Email	Office Hours
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Course Description

The course focuses on the understanding and application of key quantitative methods in Earth and Environmental Sciences. This course introduces quantitative methods and their application including data processing and analysis, numerical modelling methods, inversion methods, etc. Labs provide practical exercises for strengthening understanding of the quantitative methods. Necessary software or computer codes will be provided. Other faculty members will occasionally give guest lectures.

Course Prerequisites

This course is open to undergraduate and graduate students majoring in Earth and Environmental Sciences. Calculus (MATH 1000 or similar) and linear algebra (MATH 1030 or similar) are required prerequisites.

Student Resources

Similar prerequisite courses for self-learning:

- Calculus: https://ocw.mit.edu/courses/mathematics/18-01sc-single-variable-calculus-fall-2010/index.htm
- Linear Algebra: https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/

Programming in Python:

- https://www.python.org/
- https://www.w3schools.com/python/python_intro.asp
- Python Full Course for Beginners (https://www.youtube.com/watch?v=K5KVEU3aaeQ)

Course Structure

Course Delivery: In-person

Lectures: Tuesdays and Thursdays, 1:05 – 2:25 pm, LSC-BIOL&EARTH B4082

Laboratories/Tutorials: Mondays, 10:35 – 11:25 pm, LSC-COMMON AREA C210

Course Materials

Essential reading material will be emailed or handed out in class or posted on Brightspace.
Recommended reading book: Python Recipes for Earth Sciences
Laptop is required for the labs.

Learning Objectives

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

- Evaluate quantitative methods and uncertainty/error
- Design mathematical/physical models for specific problems
- Employ numerical modelling for simulating specific processes
- Practice problem solving using various inversion methods
- Assess the strengths and weaknesses of different methods
- Solve problems through computer software/programming

Assessment

The final grade of the class will be based on the following:

Assignments (4)	60%
Take-home Final Examination	25%
Quizzes	10%
Participation	5%

Detailed descriptions could be found as below:

1. Assignments

Assignment 1, coverage: review of prerequisites, lessons 1.1-1.5, Due date: TBD (15%)

Assignment 2, coverage: data processing and analysis, lessons 2.1-2.5, Due date: TBD (15%)

Assignment 3, coverage: numerical modelling, lessons 3.1- 3.6, Due date: TBD (15%)

Assignment 4, coverage: inversion problem, lessons 4.1- 4.6, Due date: TBD (15%)

For assignments, necessary Python codes will be provided. Students will work on the performance comparison of the method with different parameter settings. For some problems, students may need to modify the codes as needed. Synthetic or field data would be provided if applicable.

2. Take-home Final Examination

Solve comprehensive problems with quantitative methods (e.g., data processing -> forward modelling -> inversion -> error analysis). Necessary open-source software/codes and synthetic/field data will be provided. (25%)

3. Quizzes

Review the past lectures. (10%)

4. Participation

Active participation in discussions and question sessions. Also see course policies. (5%)

Conversion of numerical grades to final letter grades follows the **undergraduate*** [Dalhousie Grade Scale]

*(*for graduate courses, be sure to include the graduate grade scale)*

A+ (90-100)	B+ (77-79)	C+ (65-69)	D (50-54)
A (85-89)	B (73-76)	C (60-64)	F (0-49)
A- (80-84)	B- (70-72)	C- (55-59)	

Course Policies on Missed or Late Academic Requirements

Assignments handed in late will be deducted 10% per day. Assignments handed in more than 5 days late will not be graded. There will be no make-up mid-term or final exams. If you must miss an exam due to illness or unavoidable circumstances (please notify the instructor in advance), the missing exam will have its weight redistributed among your assignments. For example, if you missed the final exam, the 20% weight will be equally distributed among your four assignments. Students must use the Student Declaration of Absence form for missed lectures or tutorials (at most twice). If you have absences lasting longer than three consecutive days, you need to contact the instructor and your advisor to explore other accommodations.

Course Policies related to Academic Integrity & Artificial Intelligence

Students are not permitted to work together on individual assignments, but they are encouraged to discuss the questions fully when preparing group presentations. Students are not permitted to use AI tools for assignments, presentations or exams. Additional information from the syllabus template is provided below: According to Dalhousie and Nova Scotia privacy laws, instructors are not permitted to require students to use generative AI tools other than Microsoft 365 Copilot Chat, which is a free AI-powered tool included with all Dalhousie accounts. More policies can be found at the Syllabus Appendix.

Course Accessibility

You are eligible for accommodations based on protected characteristics such as religion. If you have religious, cultural, or community-significant observances that conflict with course requirements, reach out to me to collaboratively find alternatives for completing the course requirements. To begin the process of requesting a formal academic accommodation, contact the Student Accessibility Centre. Please refer to the Student Accommodation Policy for more information.

Course Content

Lecture#	Lecture Content	Lab
	Unit 1. Review of Prerequisites	
Lecture 1	1.1 Introduction	
Lecture 2	1.2 Python Programming I	Lab 1
Lecture 3	1.3 Python Programming II	
Lecture 4	1.4 Review of Matrix Algebra	Lab 2
Lecture 5	1.5 Review of Calculus	
	Unit 2. Data Processing and Analysis	
Lecture 6	2.1 Uncertainty and Error	Lab 3
Lecture 7	2.2 Frequency Analysis	
Lecture 8	2.3 Filtering and Correlation	Lab 4
Lecture 9	2.4 Data Distribution and Fitting	
Lecture 10	2.5 Principal Component Analysis and Cluster Analysis	Lab 5
	Unit 3: Numerical Modelling	
Lecture 11	3.1 Partial Differential Equation (PDE)	
Lecture 12	3.2 Examples of Important PDEs	Lab 6
Lecture 13	3.3 First Order Finite-difference Method	
Lecture 14	3.4 High Order Finite-difference Method	Lab 7
Lecture 15	3.5 Hands-on Example with Codes	
Lecture 16	3.6 Accuracy, Stability and Boundary Condition	Lab 8
	Unit 4: Inverse Problem	
Lecture 17	4.1 Least Squares Inversion & Regularization Methods	
Lecture 18	4.2 Deterministic Inversion I: Newton’s Method	Lab 9
Lecture 19	4.3 Deterministic Inversion II: Gradient Descent	
Lecture 20	4.4 Stochastic Inversion: Monte Carlo & Simulated Annealing	Lab 10
Lecture 21	4.5 How Deep Learning Works	
Lecture 22	4.6 Guest Lecture: Specific Applications in EES	Lab 11

Syllabus Appendix

(Formerly University Policies and Statements)

Syllabus Appendix: Student Supports & University Statements, Policies, and Guidelines