



Course Outline  
 University of Guelph  
 Analysis of Spatial-Temporal Data  
 DATA\*6500  
 Summer 2024

**1) General information**

Calendar Description: (0.5 credits)

This course introduces software tools and data science techniques for analyzing big geospatial data. An overview of raster-based geographic information systems (GIS) for identifying patterns and clusters in spatial-temporal data using state-of-the-art software and programming languages is provided. Concepts such as kriging/Gaussian processes, variograms and autoregressive correlation structures are discussed. Data summaries and visualizations specific to spatial-temporal problems will be introduced.

**Restriction(s):** Restricted Master of Data Science students.

**Department(s):** Department of Mathematics and Statistics

**Prerequisite(s):** None

Preferred pre-requisite knowledge:

- Some experience with data wrangling, visualization, and statistical modelling/machine learning in R.
- Understanding of statistics/ML fundamentals such as random variables, probability distributions, linear regression, resampling methods, prediction, etc.

**2) Learning Objectives**

- Understand the different types of spatial data, and the advantages and disadvantages of each type.
- Learn how to import/export, merge, subset, join etc. spatial data sets in R.
- Learn about available open data sources, and how to query exactly what you need from petabytes of data.
- Implement statistical/machine learning modelling methods to make informed decisions from spatial-temporal data.
- Practice creating reproducible documentation of all analyses performed.
- Practice effective communication of results to both technical and non-technical audiences.

**3) Course content and timeline**

Class meetings will involve a combination of lectures, class discussions, and in-class coding exercises. Below is a **TENTATIVE** outline of what will be covered in the course, as well as **TENTATIVE** important dates. Your instructor will notify you of key dates as they approach.

Lecture Dates	Content	Key dates (Tentative)
Thursday May 9	Course Introduction	

Tuesday May 14 Thursday May 16	Getting started with spatial data: vector and raster data in R	<a href="#">May 13th R Workshop 1 (online)</a> <a href="#">May 17th R Workshop 2 (online)</a>
Tuesday May 21 Thursday May 23	Raster-vector interactions and operations	
Tuesday May 28 Thursday May 30	OpenStreetMap Data Visualization using <i>tmap</i>	Assignment 1 due May 31st
Tuesday June 4 Thursday June 6	GIS lab part 1 (Tentatively in THRN 1313) GIS lab part 2 (Tentatively in THRN 1313)	
Tuesday June 11 Thursday June 13	GIS Bridges in R Spatial prediction models	
Tuesday June 18 Thursday June 20	Spatial prediction models and cross-validation.	Assignment 2 due June 21st
Tuesday June 25 Thursday June 27	Analysis of Point data	
Tuesday July 2 Thursday July 4	Spatial regression models	Proposal + EDA Due July 5 <sup>th</sup> .
Tuesday July 9 Thursday July 11	Spatial-temporal prediction/interpolation	
Tuesday July 16 Thursday July 18	Spatial-temporal prediction/interpolation	Assignment 3 due July 19th
Tuesday July 23 Thursday July 25	Presentations	Presentation materials (e.g slides) should be sent to the instructor by 11:59pm the night before your presentation.
Tuesday July 30	Presentations	Drop date: Aug 2 <sup>nd</sup>
Tuesday Aug 16		Final Report Due Aug 16 <sup>th</sup> at 11:59pm

#### 4) Methods of Assessment

**No late assessments will be accepted without prior permission from the instructor.**

Discussing problems with your classmates or using search engines/chatbots is encouraged in this class, as this is how you solve problems in the real world. **However, any work that you submit must be entirely your own.** Academic dishonesty, such as plagiarism (including copying all or part of an assignment) and impersonation is grounds for loss of course credit and dismissal. However, you may use any code that your instructor provides without restriction.

Grade breakdown:

**Assignments (45%):** There will be (approximately) 3 assignments, each carrying equal weight. Assignments are due at 11:59pm on the due date. A single compiled pdf, alongside the code that produced that pdf are to be submitted on Dropbox through CourseLink. I expect your assignments to be reproducible, meaning that I should be able to compile your code and reproduce your pdf with minimal effort. You may also submit a readme.txt file with your assignments, if there is an extra step that is required on my end for reproducibility.

**Final Project (45%):** In small groups, students will complete an original research project involving spatial-temporal analysis. The project will culminate in a presentation and written report. Your instructor will provide a rubric which will outline, in detail, what is expected of you for each stage of the project. The final project will be composed of the following milestones:

- Project proposal and exploratory data analysis (10%)
- Presentation (10%)
- Final report (25%) – Due August 16<sup>th</sup>

See Section 3 for tentative due dates. All project milestones will be submitted on the dropbox via Courselink. The project proposal/EDA should be submitted as a single pdf. Presentation slides (and other materials, if applicable), should be submitted in .pdf, .ppt, or .key format by 11:59pm the day before your presentation. The proposal/EDA and final report should be submitted as a single .pdf or .html document, alongside the .Rmd file (or another similar format) that was used to create the pdf/html file. I should be able to reproduce your pdf with minimal effort.

**Participation (10% + 2% Bonus):** In the first few weeks of the course, students will attend two in-person GIS labs with Quin Shirk-Luckett, a GIS analyst here at the University of Guelph. Attendance and completion of the labs will be worth 5% of your final grade.

2.5% will be allocated towards class participation (asking questions, doing in-class activities, participating in discussions).

The final 2.5% will be allocated towards attendance, active listening, and asking questions during the final presentations.

**Bonus 2%:** Attending R workshops near beginning of semester. You will receive an email about this.

### Missed assessment policy:

If 1 or 2 assignments are missed for a legitimate reason, and solutions have been posted for that (those) assignment(s), the weight of the missed assignment(s) will be allocated to the other assignments. At least two assignments must be submitted to obtain credit for the course.

If a project milestone deadline is missed for a legitimate reason, the instructor, in consultation with the student, will set a new deadline for that milestone for that student.

If one GIS lab is missed for a legitimate reason, the weight will be redistributed to the other participation components, such that the other GIS lab is worth 3.34%, and the other two participation components are each worth 3.33%. If two GIS labs are missed, a meeting with the instructor and makeup lab will be required.

## **5) Course Resources**

### Course Website:

Course material, news, announcements, and grades will be posted to the DATA\*6500 Courselink website. You are responsible for checking this site regularly.

### Essential e-books (Online, free, open source):

Students in this course do not need to purchase any books or software. Some of the books mentioned below offer a hard copy, but the e-book versions are better because the code is more easily accessible, and they are constantly updated.

- Lovelace, R., Nowosad, J., & Muenchow, J. (2024). *Geocomputation with R*. CRC Press. <https://r.geocompx.org/>
- Pebesma, E., & Bivand, R. (2023). *Spatial data science*. <https://r-spatial.org/book/>

#### Other useful references (freely available online):

These are likely only useful for snippets of the course. Other resources will be introduced as needed.

- Walker, K. (2023). *Analyzing U.S census data: methods, maps, and models in R*. CRC Press. <https://walker-data.com/census-r/>
- Wikle, C. K., Zammit-Mangion, A., & Cressie, N. (2019). *Spatio-temporal statistics with R*. CRC Press. <https://spacetimewithr.org/>
- Gómez-Rubio, V. (2020). *Bayesian inference with INLA*. CRC Press. <https://becarioprecario.bitbucket.io/inla-gitbook/ch-spatial.html>

#### R resources:

- R and Rstudio: <https://rstudio-education.github.io/hopr/starting.html>
- Rmarkdown: <https://rmarkdown.rstudio.com/>
- Quarto: <https://quarto.org/>

A wide variety of R-packages will be introduced throughout the course.

#### Desktop Geographic Information System (GIS) software:

- ArcGIS Pro: <https://uoguelphca.sharepoint.com/sites/ccs/SitePages/software/supported-products/esri-arcgis.aspx> (free for UoGuelph students, login with your Guelph ID once your account is set up)
- QGIS: <https://www.qgis.org/en/site/> (free, open source)

#### Data resources:

A wide variety of open, and quickly evolving spatial-temporal data sets are available on the internet. In this course, we will be using such data in class activities, assignments, and your final project. **It is imperative that data is properly cited on anything you submit or present.**

## **6) Additional Course Policies**

#### Email communication:

Students are expected to check their *@uoguelph.ca* email regularly, as this is the official mode of communication between the University and its students. The best time to ask questions is during class or during office hours. Students may email the instructor with questions about course material, but it may take up to 48 business hours to get a reply.

#### 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 in writing, with your name, id#, and e-mail contact. See the Graduate Calendar for information on regulations and procedures for Academic Consideration.

#### Accommodation of Religious Obligations:

If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the Academic calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations.

#### 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).

#### 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 10 business days in advance, and no later than the first business day in November, March or July as appropriate for the semester. Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time. More information: [www.uoguelph.ca/sas](http://www.uoguelph.ca/sas).

#### 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.

#### Important dates:

The University published important dates for the summer semester here: <https://www.uoguelph.ca/registrar/scheduleofdatesgr>

The last day to drop this course without academic penalty is August 2<sup>nd</sup>. The regulations and procedures for [Dropping Courses](#) are available in the Graduate Calendar.

### Course Evaluations:

Students are provided an opportunity to provide course feedback via a formal course evaluation in the last two weeks of the semester. Your instructor will inform you of when these are available. Note that evaluations will not be reviewed until after your instructor has submitted your final grades.

### Academic Integrity:

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 Graduate Calendar.

### Online behaviour:

Inappropriate online behaviour will not be tolerated. Examples of inappropriate online behaviour include:

- Posting inflammatory messages about your instructor or fellow students
- Using obscene or offensive language online
- Copying or presenting someone else's work as your own
- Adapting information from the Internet without using proper citations or references
- Buying or selling term papers or assignments
- Posting or selling course materials to course notes websites
- Having someone else complete your quiz or completing a quiz for/with another student
- Making false claims about lost quiz answers or other assignment submissions
- Threatening or harassing a student or instructor online
- Discriminating against fellow students, instructors or TAs
- Using the course website to promote profit-driven products or services
- Attempting to compromise the security or functionality of the learning management system

### Recording of materials:

Any presentation made in relation to coursework, including lectures, student presentations, and GIS labs, cannot be recorded without permission from the presenter. Material recorded with permission is restricted to use for this course unless further permission is granted.

### 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.

## **7) Health and Wellbeing**

The University of Guelph provides a wide range of health and wellbeing services at the Vaccarino Centre for Student Wellness. If you are concerned about your mental health and not sure where to start, connect with a Student Wellness Navigator who can help develop a plan to manage and support your mental health or check out our mental wellbeing resources. The Student Wellness team are here to help and welcome the opportunity to connect with you.