Course Syllabus
Analysis of Spatial-Temporal Data
DATA*6500
Summer 2023

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.

Instructor: Justin Slater, PhD
Office: MacNaughton 521
Email: jslate04@uoguelph.ca
Office hours: Thursdays 2pm-3pm in MacN 521 (or by appointment).
Lecture day/time: Tuesday/Thursday 11:30am-12:50pm in MCKN 306

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.

Course Principles:

- **Practice practice practice:** Data science is best learned by doing. In this course, students will gain valuable hours of experience manipulating, analyzing, and interpreting real world spatial-temporal data sets.
- **Know your model well:** In this course, we will learn a variety of modelling/analysis methods. I believe it is important for you to understand, at least conceptually, how your model works. This allows for better understanding of model strengths, limitations, and implications. Furthermore, it enables better communication with non-technical audiences and fellow data scientists.
- **Reproducibility:** Your future self and colleagues will thank me for this one. Data scientists often must share projects with collaborators, or revisit projects in the future. Reproducible workflows ensure that everyone (including future you) knows exactly what you did and how you did it.
- **Critical thinking:** On assignments or in-class activities, I won't always give you explicit instructions on how to do something. This is because, in data science, there often isn't one solution to a problem. In this course, I encourage you to practice making decisions using the information available to you, alongside your best judgement.
- **Autonomy:** There will be points in this course, particularly for your project, that I may not be able to answer all your questions. Feel encouraged to leverage all the resources at your

disposable to gain the answers/knowledge that you require for your task at hand. Data science is a field where you constantly need to be learning, and you should treat obstacles as an opportunity to learn a new skill.

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

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 of you of key dates as they approach.

Lecture Dates	Content	Key dates (Tentative)
Thursday May 11	Course Introduction	
Tuesday May 16 Thursday May 18	Getting started with spatial data	
Tuesday May 23 Thursday May 25	Spatial data sources & visualization	
Tuesday May 30 Thursday June 1	GIS lab part 1 (location TBD) Spatial data sources & visualization	Assignment 1 due Thurs June 1
Tuesday June 6 Thursday June 8	GIS lab part 2 (location TBD) GIS bridges in R	Project proposal due Thurs. June 8
Tuesday June 13 Thursday June 15	Measuring and visualizing autocorrelation	Assignment 2 due Thurs June 15
Tuesday June 20 Thursday June 22	Regression models in a spatial context	
Tuesday June 27 Thursday June 29	Spatial-temporal prediction/interpolation	Assignment 3 due Thurs June 29
Tuesday July 4 Thursday July 6	Spatial-temporal prediction/interpolation	
Tuesday July 11 Thursday July 13	Modelling point patterns	Project EDA due Thurs July 13
Tuesday July 18 Thursday July 20	Spatial ML/case studies Presentation skills	Assignment 4 due Thurs July 20th
Tuesday July 25 Thursday July 27th	Presentations	Presentation materials (e.g slides) should be sent to the

		instructor by 11:59pm the night before your presentation.
Tuesday Aug 1	Presentations	
Tuesday Aug 8		**Final report due August 8th**

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.

Grade breakdown:

Assignments (40%): There will be 4 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 assignment, if there is an extra step that is required on my end for reproducibility.

Projects (50%): 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 (2.5% of final grade)
- Exploratory data analysis (EDA), which includes an analysis plan, preliminary results (optional), and references (7.5%)
- Presentation (20%)
- Final report (20%) – Due August 8th

See Section 3 for tentative due dates. All project milestones will be submitted on Dropbox via Courselink. The project proposal 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 EDA and Final report should be submitted as a single .pdf document, alongside the .Rmd file (or other similar format) that was used to create the pdf. I should be able to reproduce your pdf with minimal effort.

Participation (10%): 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, posting/answering questions on Courselink discussion).

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

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 & discussion board

Course material, news, announcements, and grades will be posted to the DATA*6500 Courselink website. You are responsible for checking this site regularly. There will also be a discussion board where students can ask questions or discuss course concepts.

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. (2019). *Geocomputation with R*. CRC Press. https://r.geocompx.org/
- Pebesma, E., & Bivand, R. (2019). *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 etiquette:

Students are expected to check their *@uoguelph.ca* email regularly, as this is the official mode of communication between the University and its students. Students may email the instructor, but if it pertains to course material or an assignment question, please check the Courselink discussion board to make sure your question has not already been answered.

When you cannot meet a course requirement:

If you find yourself unable to meet a course requirement because of illness or compassionate reasons, please advise the instructor in writing (email), with your name and student id.

Consideration may be granted at the instructor's discretion. Please note that consideration for medical or compassionate reasons may require additional discussion with your program counsellor. Consideration is generally more likely when the student is proactive in notifying the instructor of issues as soon as the student is aware of them.

Accessibility:

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodations is a shared responsibility of the University, the instructor, and the student. The instructor will do their best to accommodate accessibility needs of the student. The student a, email or approach the instructor with your accessibility concerns.

If the instructor is unable to accommodate the student, or if the student wants a formal accommodation, the student should register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required, however, interim accommodation may be possible while that is underway.

Important dates:

The University published important dates for the summer semester here:

https://calendar.uoguelph.ca/graduate-calendar/schedule-dates/summer-semester-12-week/

The last day to drop this course without academic penalty is August 4th.

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.
Graduate Calendar – Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/2018-2019/genreg/sec_d0e2632.shtml

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, may not be recorded without permission from the presenter. Material recorded with permission is restricted to use for this course unless further permission is granted.

Saving assessments

Please save copies of your assessments. You may be asked to resubmit your work at any time.

7) Mental Health services

One out of every five students in Canada experiences some sort of mental health issue at some point in their academic career. If you find yourself facing a mental health crisis, or just need to talk to someone, please consider taking advantage of one of the following resources available to University of Guelph students:

Counselling Services: Visit the Counselling Services website (https://wellness.uoguelph.ca/counselling) to get information on resources available to you, both online and in-person. You can also visit them at Health Services (J.T. Powell Building, ext 53244) where they offer individual and group counselling sessions by appointment or walk-in.

Student Support Network: is in the Wellness & Education Promotion Centre in the J.T. Powell Building and offers confidential, peer-based, drop-in support.

Good2Talk: (1-866-925-5454) is a free, 24/7 student hotline that provides professional counselling and referrals for mental health, addictions and well-being.

Here 24/7: (1-844-437-3247) specializes in assessment, referral and appointment booking and is available 24/7 for crisis support.

You are not alone, and you will not be judged for asking for help.