MATH 6384 001 – Spatial Data Analysis
Department of Mathematical and Statistical Sciences
University of Colorado Denver
College of Liberal Arts and Sciences
Fall 2025

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Class Meeting Times: Tuesday and Thursday from 2:00-3:15PM in Student Commons Building 4113.

Office Hours: Tuesday and Thursday from 11a-noon and by appointment.

Course Description: This course will cover various statistical methods for spatial data. This will include assessing cluster identification for point process and regional data, as well as quantifying spatial dependence and making predictions for regional and geostatistical spatial data.

Prerequisite: This course assumes that students have the equivalent of advanced undergraduate-level coursework in statistics and regression analysis.

Optional Textbook: *Applied Spatial Statistics for Public Health Data* by Lance Waller and Carol Gotway. ISBN: 978-0-471-38771-8.

Also, see: https://www.paulamoraga.com/book-spatial/

Computing: We will use the freely available R statistical software for data analysis in this class. R is a free, cross-platform statistical package that is extremely powerful. It is the standard statistical computing language in academia and becoming more popular in the public and private sector. R may be downloaded at www.r-project.org. In-class lectures will include substantial focus on using R to perform analysis. RStudio is a free and open source integrated development environment (IDE) for R available at https://posit.co. RStudio is also cross-platform and has many nice features (like the ability to scroll through your plots, syntax highlighting, viewing the objects in your environment, etc.) that you may find useful.

Couse Goals and Outcomes:

Overall Learning Objectives

By the end of this course, students should:
- Understand and apply common statistical methods for the three areas of spatial statistics.
- Formulate statistical problems from a verbal or written description.
- Understand and know how to recreate proofs discussed in the book or in class.
- Solve problems requiring proofs and derivations.
- Interpret statistical results in complete and understandable English in either written or verbal form.

Learning Outcomes

Several specific learning outcomes will be strengthened in this course. Among them are:
- Critical Thinking
- Inquiry and Analysis
- Quantitative Literacy

Critical thinking will be necessary to some degree in every course assignment, including homework, presentations, and exams. Specifically, when making statistical inference, one will have to weigh the evidence before accepting a conclusion.

Inquiry and Analysis will be required in all homework assignments and presentations. All of these assignments will require you to determine questions of interest, analyze data, and evaluate evidence provided by the data before coming to a conclusion.

Quantitative Literacy will be promoted in all homework assignments and presentations. Each of these assignments will require you to work with data and numbers to answer questions and convincingly argue for certain conclusions.

Major Topics

This course will focus on covering fundamentals in spatial statistics. In the field of spatial statistics, we should cover statistical methods for point processes, areal data, and geostatistical data. The course will involve using the R statistical software package to do much of the analysis. Some proofs will be required for the course, and examples of the expected types of proofs will be supplied during the course.

Rationale
Responses observed in standard statistical settings are generally assumed to be independent. This assumption is violated in many different contexts, e.g., longitudinal data, time series data, spatial and spatio-temporal data. We will learn about how to analyze spatially-correlated, geographically-referenced data.

Besides the statistical methods, this course will emphasize valuable skills important in the real world: computing, data analysis with real data, and presentation of statistical results. All of these will help better prepare students for entering the workforce.

Grades:

Homework: Homework problems will be assigned for each section of material. Submission should be made electronically via Canvas. Some of the assigned problems will be selected for grading (as few as one problem and as many as all of them). These problems alone will be used to determine a student's grade for that assignment. Assignments must be typed in an appropriate word processor (like Microsoft Word or Libre Office) or typeset using an appropriate program (like LaTeX) and should use appropriate mathematical notation. Individual problems should be clearly numbered, and problem parts should be clearly labeled. Relevant computer code and output should be provided with your answer to each problem. The font used for computer code should be fixed-width (e.g., `Courier New`, `Monaco`, or `Consolas`) to preserve formatting. Your short answers should use a different font from your computer code, e.g., Times New Roman, Cambria, or Arial in order to distinguish your answer from the computer code.

Exams: There will be two exams during the semester.
Exam 1: Tuesday, October 7th
Exam 2: Thursday, November 13th.

Exam due dates are fixed now so plan accordingly. Without prior approval or a documented health, disability, or emergency reason, missed exams will be scored as a zero.

Project: All students are expected to complete a project utilizing spatial statistics. Each student will analyze a data set of interest, describe their results in a written report, and present their results on **Thursday, December 4th**. A written report and 3-5 minute video presentation will be due during Finals week**.** The project grade will be determined based on the accuracy of the statistical analysis and the quality of the paper and presentation. More details about this project will be given in the future.

Grade determination

Final grades will be determined according to the following weighting scheme:

Homework	20%
Final Project/Presentation	20%
Exam 1	30%
Exam 2	30%

Letter grades will be determined by the following scale:

Percentage	Letter Grade	Percentage	Letter Grade
92 or higher	A	72 up to 78	C
90 up to 92	A-	70 up to 72	C-
88 up to 90	B+	68 up to 70	D+
82 up to 88	B	62 up to 68	D
80 up to 82	B-	60 up to 62	D-
78 up to 80	C+	Below 60	F

I reserve the right to lower or raise this scale as needed. This is generally only necessary to ensure borderline grades are appropriately assigned a letter grade, although it may be necessary to adjust for overly difficult or overly easy exams.

Grade/Assignment Dissemination

Grades will be provided via the course's Canvas course shell. You can access your scores at any time within the Canvas gradebook.

Homework, quizzes, exams, etc. will be returned in class or in my office directly to you or online via Canvas.

Expected effort and tips for success:
- This class requires certain prerequisite knowledge (especially about probability and statistical distributions. This knowledge is essential for success in this class.
- This is an advanced graduate level course. Expect to work hard. Expect to work between 6 to 9 hours per homework assignment. (Maybe more!) Expect to study for exams and spend many hours on the project.
- Class attendance and participation is expected.
- Students are expected to ask questions (during class or office hours) if they are confused. It is your responsibility to ask for help!
- Students are expected to read the relevant sections of the book. The book provides additional details that I will not cover in class. Material should be read BEFORE the appropriate lectures.
- Homework should be completed as the homework sets are assigned. Students will find little benefit in rushing to complete homework assignments.

Class pedagogy:
- There will typically be some aspect of lecturing during our usual course times.
- I sometimes use video lectures to supplement in-class learning and may even use them to facilitate in-depth classroom activities and data analysis.
- Course announcements will be made frequently through Canvas and/or email. Emails will be sent to your ucdenver.edu email address in accordance with university policy. You are responsible for the information contained in any announcements or messages I send you, regardless of whether the information is repeated in class. It is your responsibility to frequently check Canvas and to maintain your university email address.

Classroom policies:

- Students are expected to enter class **on time** and remain in class for the duration of the class period.
- Students should not eat during class time.
- Students are expected to behave in a professional manner during class time.
- Discussion and questions are highly encouraged!
- Cell phones and other electronic devices should be silenced during class.
- Computers should not be used during class time unless it is directly related to the course (note taking, executing computer code, etc.)

Absences, Tardiness, Homework, Quizzes, Exams, etc.: Except for documented health, disability, emergency reasons, or prior approval, I will not accept excuses for absences or tardiness. Unless otherwise specified, missed or late homework, quizzes, projects, or exams will be scored as a zero.

I reserve the right to modify this syllabus as the semester progresses.

Date	Day	Week	Tentative Agenda	Topic/Reading	Assignment Due
19-Aug	T	1	Syllabus	Notes	
21-Aug	R	1	Point Patterns	Ch 5	
26-Aug	T	2	Point Patterns	Ch 5	
28-Aug	R	2	Point Patterns	Ch 5	
2-Sep	T	3	Point Patterns	Ch 5	
4-Sep	R	3	Point Patterns	Ch 5	Hw 1
9-Sep	T	4	Point Patterns	Ch 5	
11-Sep	R	4	Case-control Point Patterns	Ch 6	Hw 2
16-Sep	T	5	Case-control Point Patterns	Ch 6	
18-Sep	R	5	Case-control Point Patterns	Ch 6	
23-Sep	T	6	Case-control Point Patterns	Ch 6	Hw 3
25-Sep	R	6	Case-control Point Patterns	Ch 6	
30-Sep	T	7	Areal data	Ch 7	
2-Oct	R	7	Areal data	Ch 7	Hw 4
7-Oct	T	8	Exam 1		
9-Oct	R	8	Areal data	Ch 7	
14-Oct	T	9	Areal data	Ch 7	Hw 5
16-Oct	R	9	Areal data	Ch 7	
21-Oct	T	10	Geostatistics	Ch 8	
23-Oct	R	10	Geostatistics	Ch 8	Hw 6
28-Oct	T	11	Geostatistics	Ch 8	
30-Oct	R	11	Geostatistics	Ch 8	
4-Nov	T	12	Geostatistics	Ch 8	Hw 7
6-Nov	R	12	Smoothing	Ch 9	
11-Nov	T	13	Smoothing	Ch 9	Hw 8
13-Nov	R	13	Exam 2		
18-Nov	T	14	Smoothing		
20-Nov	R	14	Project		
25-Nov	T	14	Fall Break		
27-Nov	R	14	Fall Break		
2-Dec	T	15	Project	Ch 9	Hw 9
4-Dec	R	15	Project Presentations		
8-13 Dec			Report		

University, college, and department policies

Academic Calendar

For university deadlines and procedures (such as the last day to withdraw from a course), please see the Academic Calendar. https://www.ucdenver.edu/student/calendars/academic/

Academic Support

Instructor office hours or other appointments are the best way to get additional help. I'm happy to help with questions not answered during class, additional explanation, or homework assistance.

Other sources of support are

- The Math and Stat Support office is located in the Learning Commons Building Room 1225 and regularly offers CU Denver students free drop-in assistance. Hours of operation, zoom links for virtual options, and other forms of support for mathematics and statistics courses are available on the Math and Stat Support webpage. https://clas.ucdenver.edu/mathematical-and-statistical-sciences/math-and-stat-support
- The Learning Resources Center (LRC) provides individual and group tutoring, Supplemental Instruction (SI), study skills workshops, and ESL support.

https://www.ucdenver.edu/learning-resources-center

- The College of Liberal Arts and Sciences has a summary of campus academic support and school/college advising offices. https://clas.ucdenver.edu/faculty-staff/content/clas-academic-policies-deadlines

Recording of Class Meetings

Class meetings held on or streamed over a video conferencing platform (such as Zoom, Microsoft Teams, etc) may be recorded and posted for all members of the class. Student participation and interaction may be included in the recording. If you have any concerns about this, please contact the instructor.

Diversity Statement

It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of diversity: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture, etc. I would like to create a learning environment for my students that supports a diversity of thoughts, perspectives and experiences, and honors your identities (including race, gender, class, sexuality, religion, ability, etc). To help accomplish this:

- If you have a name and/or set of pronouns that differ from those that appear in your official records, please let me know!
- If you feel like your performance in the class is being impacted by your experiences outside of class, please don't hesitate to come and talk with me. I want to be a resource for you. Remember that you can also submit anonymous feedback (which will lead to me making a general announcement to the class, if necessary to address your concerns). If you prefer to speak with someone outside of the course, the Office of Diversity, Equity and Inclusion, is an excellent resource.
- I (like many people) am still in the process of learning about diverse perspectives and identities. If something was said in class (by anyone) that made you feel uncomfortable, including by me, please talk to me about it. (Again, anonymous feedback is always an option).

Your suggestions are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious or other cultural events, please let me know so that we can make arrangements for you.

Health and Wellness

As a student, you may experience a range of challenges that can interfere with learning, such as strained relationships, traumas, increased anxiety, substance use, feeling down, difficulty concentrating, and/or lack of motivation. These mental health concerns or stressful events may diminish your academic performance and/or reduce your ability to participate in daily activities. If you or someone you know is struggling, you can find supportive campus and community resources at the Health Center at Auraria or the CU Denver Counseling Center. On weekends, holidays or after-hours you can contact the 24/7 Mental Health Crisis and Victim Assistance Line at 303-615-9911.

The University of Colorado Denver is committed the health and well-being of all students. We recognize that diminished mental health, including significant stress, mood changes, excessive worry, or problems with eating and/or sleeping can interfere with optimal academic performance. The source of such symptoms can be quite varied, and include experiences of

trauma (such as sexual and relationship violence, stalking, discrimination, crimes, and accidents), responses to course work, family worries, loss, personal struggle, or crisis. If you or someone you know is struggling, you can find supportive campus and community resources at

https://www.ucdenver.edu/counseling-center

or by calling the CU Denver Counseling Center (303-315-7270) or the Health Center at Auraria (303-615-9999). On weekends, holidays or after-hours you can contact the 24/7 Mental Health Crisis and Victim Assistance Line at 303-615-9911.

Disability Accommodation and Access

The University of Colorado Denver is committed to ensuring the full participation of all students in its programs, including students with disabilities. If you have a disability or think you have a disability and need accommodations to succeed in this course, I encourage you to contact Disability Resources and Services (DRS) and/or speak with me as soon as you can. DRS is located in Student Commons Building Suite 2116, and can be reached at disabilityresources@ucdenver.edu and online at https://www.ucdenver.edu/offices/disability-resources-and-services. I am committed to providing equal access as required by federal law, and I am interested in developing strategies for your success in this course.

Nondiscrimination and Sexual Misconduct

The University of Colorado Denver is committed to maintaining a positive learning, working and living environment. University policy and Title IX prohibit discrimination on the basis of race, color, national origin, sex, age, disability, pregnancy, creed, religion, sexual orientation, veteran status, gender identity, gender expression, political philosophy or political affiliation in admission and access to, and treatment and employment in, its educational programs and activities. University policy prohibits sexual misconduct, including harassment, domestic and dating violence, sexual assault, stalking, or related retaliation. If you have experienced any sort of sexual misconduct or discrimination, please visit the Office of Equity web site at https://www.ucdenver.edu/offices/equity to understand the resources available to you or contact the Office of Equity/Title IX Coordinator at equity@ucdenver.edu.

Please note that I am a Responsible Employee, which means that if I witness or receive information regarding possible prohibited protected characteristic discrimination or harassment, any form of sexual misconduct, and/or related retaliation, I am required to promptly report the information to the Office of Equity or their designee.

Religious Holiday Accommodation

Faculty in the University of Colorado system provide reasonable accommodations to students who must be absent from classes because of religious holidays. If you will miss class or graded assignments in order to observe religious holidays, you must contact me with all course conflicts by the end of the first week of classes.

Student Code of Conduct

As members of the University community, students are expected to uphold university standards, which include abiding by state civil and criminal laws and all University policies and standards of conduct. These standards are outlined in the student code of conduct, which can be found at https://www.ucdenver.edu/student/wellness/student-conduct

Academic Honesty

Students are expected to know, understand, and comply with the ethical standards of the university. A university's reputation is built on a standing tradition of excellence and scholastic integrity. As members of the University of Colorado Denver academic community, faculty and students accept the responsibility to maintain the highest standards of intellectual honesty and ethical conduct.

Academic dishonesty is defined as a student's use of unauthorized assistance with intent to deceive an instructor or other such person who may be assigned to evaluate the student's work in meeting course and degree requirements. This course assumes your knowledge of the policies and definitions. University policies allow the instructor to decide how to respond to an ethics violation, whether by lowering the assignment grade, lowering the course grade, and/or filing charges against the student with the campus Office of Student Conduct. For more information regarding the Office of Student Conduct policies and procedures, please refer to https://www.ucdenver.edu/student/wellness/student-conduct/academic-integrity. Violating the academic honor code can lead to expulsion from the University.

Examples of academic dishonesty include, but are not limited to, the following:

Plagiarism.

Plagiarism is the use of another person's distinctive words or ideas without acknowledgment. Examples include:
1. Word-for-word copying of another person's ideas or words;
2. The mosaic (the interspersing of one's own words here and there while, in essence, copying another's work);
3. The paraphrase (the rewriting of another's work, yet still using their fundamental idea or theory);
4. Fabrication of references (inventing or counterfeiting sources);
5. Submission of another's work as one's own;

6. Neglecting quotation marks on material that is otherwise acknowledged.

Acknowledgment is not necessary when the material used is common knowledge.

Cheating.
Cheating involves the possession, communication, or use of information, materials, notes, study aids or other devices not authorized by the instructor in an academic exercise, or communication with another person during such an exercise. Examples include:
1. Copying from another's paper or receiving unauthorized assistance from another during an academic exercise or in the submission of academic material;
2. Using a calculator when its use has been disallowed;
3. Collaborating with another student or students during an academic exercise without the consent of the instructor.

Note on use of Generative AI.
Generative AI tools such as ChatGPT may not be used on exams, tests, or quizzes that do not permit the use of outside resources. The instructor will provide guidelines on whether such tools can be used for assignments and projects.

Fabrication and Falsification.
Fabrication involves inventing or counterfeiting information, i.e., creating results not obtained in a study or laboratory experiment. Falsification, on the other hand, involves the deliberate alteration of results to suit one's needs in an experiment or other academic exercise.

Multiple Submissions.
This is the submission of academic work for which academic credit has already been earned, when such submission is made without instructor authorization.

Misuse of Academic Materials.
The misuse of academic materials includes, but is not limited to, the following:
1. Stealing or destroying library or reference materials or computer programs;
2. Stealing or destroying another student's notes or materials, or having such materials in one's possession without the owner's permission;
3. Receiving assistance in locating or using sources of information in an assignment when such assistance has been forbidden by the instructor;
4. Illegitimate possession, disposition, or use of examinations or answer keys to examinations;
5. Unauthorized alteration, forgery, or falsification;
6. Unauthorized sale or purchase of examinations, papers, or assignments.

Complicity in Academic Dishonesty.
Complicity involves knowingly contributing to another's acts of academic dishonesty. Examples include:
1. Knowingly aiding another in any act of academic dishonesty;
2. Allowing another to copy from one's paper for an assignment or exam;
3. Distributing test questions or information about the materials to be tested before the scheduled exercise;
4. Taking an exam or test for someone else;
5. Signing another's name on attendance roster or on an academic exercise.

Incomplete Policy
When a student has special circumstances that make it impossible to complete course assignments, faculty members may choose to award an incomplete grade. All incomplete courses are assigned a grade of Incomplete (I). Incomplete grades are not awarded for poor academic performance or as a way of extending assignment deadlines. Faculty are not required to award an Incomplete.
To be eligible for an Incomplete grade, students MUST:
- Have participated in the class for a significant proportion of the term.
- Have successfully completed a significant proportion of the course assignments.
- Have special circumstances (verification may be required) that preclude the student from attending class and/or completing graded assignments.
- Make arrangements to complete missing assignments with the original instructor by a mutually agreed upon date but within one calendar year. Note that it is not the instructor's responsibility to teach the student missed material.
- Both the instructor and student should complete and sign a Course Completion Agreement found at

- The instructor gives a copy of the signed Course Completion Agreement to the department.

Incompletes cannot:
- require a student to repeat the entire course,
- repeat or replace existing grades,
- allow the student an indeterminate period of time to complete a course, or
- allow the student to repeat the course with a different instructor.

Student Grievances

Students who have concerns about the course or instructor should first contact the instructor to discuss the issue. If the issue is not resolved, the student should next contact the Associate Chair of the Department of Mathematical and Statistical Sciences (currently Stephen Hartke <stephen.hartke@ucdenver.edu>). If not satisfied, the student should then appeal to the appropriate Associate Dean of the student's home school or college (for CLAS, this is the Associate Dean for Student Success). No step in this process should be skipped.