USC Dornsife
Dana and David Dornsife
College of Letters, Arts and Sciences
Spatial Sciences Institute

SSCI 381, Statistics for the Spatial Sciences

Syllabus

Units: 4

Term Day Time: Fall 2021, Wed/Fri 9-10:50am PT

Location: VDP LL101

Instructor: Orhun Aydin, PhD
Office: AHF B56G
Regular Office Hours: TBD. Also available most days and times by appointment via email.
Contact Info: oaydin@usc.edu, (213) 740-5910, see contact page on Blackboard for Zoom Room

Library Help: Andy Rutkowski
Office: VKC 36B
Office Hours: Thu 10 a.m.-12 p.m.
Contact Info: arutkows@usc.edu, see contact page on Blackboard for Zoom Room

IT Help: Richard Tsung
Office: AHF 145D
Office Hours: By appointment
Contact Info: spatial_support@usc.edu, 213-821-4415

Course Scope and Purpose

This is an introductory course to statistics fundamentals in spatial analysis. The emphasis will be on the theory and applications of spatial statistics as it pertains to analysis and problem solving. Statistics foundations and their spatial counterparts frequently used in spatial analysis will be introduced with real-world use cases. The course is designed to provide statistical principles necessary to conduct and understand fundamental analysis methods in spatial problem solving.

This course will assume no prior knowledge of statistics and it will build on the fundamentals with use cases from spatial sciences. The topics will include descriptive and inferential statistics, sampling, estimation and hypothesis testing. Commonly used spatial analysis methodologies such as spatial centrality and dispersion metrics, hot-spot analysis, and spatial regression will be introduced. Methodologies will be applied to case studies ranging from exploratory crime analysis to understanding earthquake occurrence patterns.

Learning Outcomes

Upon successful completion of this course, a student will be able to:

- Describe mathematical and statistical foundations for spatial statistics
- Identify spatial statistical methodologies for solving real-world problems
- Explore the strengths and limitations of statistical methodologies that are frequently used in spatial analysis
- Design a solution for a spatial modelling problem using spatial statistics

Students may vary in their competency levels on these abilities. You can expect to acquire these abilities only if you honor all course policies, attend classes regularly, complete all assigned work in good faith and on time, and meet all other course expectations of you as a student.

Prerequisite(s): None
Co-Requisite(s): None

Class Conduct

Harassment, sexual misconduct, interpersonal violence, and stalking are not tolerated by the university. All faculty and most staff are considered Responsible Employees by the university and must forward all information they receive about these types of situations to the Title IX Coordinator. The Title IX Coordinator is responsible for assisting students with supportive accommodations, including academic accommodations, as well as investigating these incidents if the reporting student wants an investigation. The Title IX office is also responsible for coordinating supportive measures for transgender and nonbinary students such as faculty notifications, and more. If you need supportive accommodations, you may contact the Title IX Coordinator directly (titleix@usc.edu or 213-821-8298) without sharing any personal information with me. If you would like to speak with a confidential counselor, Relationship and

Sexual Violence Prevention Services (RSVP) provides 24/7 confidential support for students (213-740-9355 (WELL); press 0 after hours)

Course Structure

The course will be taught as a series of classes that will introduce concepts, theory and use-cases behind spatial statistics. Teaching strategies are designed to empower the students with broad knowledge of the theory of spatial statistics and practical skills to solve real-world problems. Classes will consist of lectures on fundamentals and discussions about reading materials. Students will be required to complete theoretical and hands-on assignments to fortify their knowledge.

Additional readings will be assigned to expand on the text when needed. The course will generally unfold on a biweekly basis. When possible, assignments will be given in advance, but usually they will be posted on or before Mondays. Practical exercises utilize published tutorial materials using ArcGIS and a final project allows students to demonstrate their ability to apply spatial analytical tools in an appropriate, informed manner.

Technological and Communication Requirements

ArcGIS is provided on-line via the GIST Server; hence, you do not need to install it on your own computer. Instead, every student must have the following technology requirements:

- A computer with a fast Internet connection.
- A functional webcam and a microphone for use whenever a presentation or meeting is scheduled.
- An up-to-date web browser to access the Server

If a student does not have access to any of these, please speak with the instructor at the start of the semester. Also, see the USC ITS Student Toolkit here: https://keepteaching.usc.edu/students/student-toolkit/

SSI Server and Tech Support – This course utilizes the SSI Server which is a virtual desktop giving access to many different professional software. If you are unable to connect to the server or experience any type of technical issues, send an email using your USC account to SSI Tech Support at spatial_support@usc.edu, making sure to copy (cc) me on the email.

Communications – All materials to be handed in will be submitted via Blackboard. It is each student's responsibility to stay informed about what is going on in our course. In addition to email about time-sensitive topics, any important announcements will be posted on the Announcement page in Blackboard. Be sure to check these each time you log onto Blackboard.

I will send via email through Blackboard any notices that are time-sensitive. Please be sure that you read as soon as possible all emails sent from Blackboard or from me. Do not ignore course email until the day before assignments are due. Also double check to be sure that email sent from the USC blackboard account does not go into your junk mail!

While I am usually on-line all day and will probably respond to emails from students very quickly, I will endeavor to respond to all email within 24 hours of receipt, aiming for no more than 72 hours delay. In the rare case when I expect to be off-line for more than 72 hours, I will post an announcement on the Blackboard site.

Required Readings and Supplementary Materials

Please acquire the text listed below. All other supplementary readings listed in the syllabus are available on-line through USC Libraries or under the tab marked "Readings" on the course Blackboard.

The required textbook for this course is:

- Burt, James E., Gerald M. Barber, and David L. Rigby. Elementary statistics for geographers. Guilford Press, 2009.

Supplementary readings will be assigned from various sources, including:

- Legendre, Pierre. "Spatial autocorrelation: trouble or new paradigm?." Ecology 74, no. 6 (1993): 1659-1673.
- Getis, Arthur, and J. Keith Ord. "The analysis of spatial association by use of distance statistics." In Perspectives on spatial data analysis, pp. 127-145. Springer, Berlin, Heidelberg, 2010.
- Ripley, Brian D. "Tests of 'randomness' for spatial point patterns." Journal of the Royal Statistical Society: Series B (Methodological) 41, no. 3 (1979): 368-374.
- Guo, Diansheng. "Local entropy map: A nonparametric approach to detecting spatially varying multivariate relationships." International Journal of Geographical Information Science 24, no. 9 (2010): 1367-1389.
- Brunsdon, Chris, A. Stewart Fotheringham, and Martin E. Charlton. "Geographically weighted regression: a method for exploring spatial nonstationarity." Geographical analysis 28, no. 4 (1996): 281-298.

Description and Assessment of Assignments

This course includes various assignments that allow students to practice spatial statistics and demonstrate their theoretical grasp of foundations. Assignment types are described below, and their point value to final grades is listed in the following Grading Breakdown section.

Weekly Assignments

There are several different kinds of assignments, with at least one due weekly. These are described in the Weekly Folders on Blackboard. Due dates are shown in the summary that follows.

Hands-On Assignment – 5 worth 18.75 points. These hands-on experiences are designed to give students practical experience utilizing spatial statistics, describing results, and quality metrics to perform spatial analysis. Hands-on assignments are linked to the lectures and class discussions and build on the theoretical fundamentals introduced during lectures. ArcGIS Pro and R will be used for hands-on assignments.

Theoretical Assignments 7 worth a total of 26.25 points. Theoretical assignments involve solving spatial analysis problems to reinforce the fundamentals of spatial statistics. All academic assignments entail solving numerical problems and describing the underpinning of methodologies.

Midterm Exam

Midterm Exam – 1 worth of 15 points A written midterm exam will be conducted to gauge your understanding of mathematical fundamentals and spatial statistics applications to GIS problems behind the course.

Final Project

Final project – 1 worth a total of 20 points. In the second half of the course, each student will work on a project determined in consultation with the instructor. These projects will focus on a spatial analysis problem that is aligned with student's research/interests. The final report (15%) in the form of a story-map and the class presentation (15%) will summarize and visualize the research statement, range of approaches attempted shortcomings/assumptions of approaches and the range of solutions that have been attempted thus far, as reported in the published literature.

The main components of the project are:

Midterm Proposal – 5 points. A brief description of the spatial question(s) you would like to ask or the spatial problem you want to solve and briefly how you plan to solve it. The midterm proposal will be a short, written document (max two pages) that describes the scope of your final project, methodologies you will explore, reasons for choosing these methodologies, and your expected findings. Breakdown of an effective midterm proposal is as follows:

- Research question
- Scope of the project
- Data Sources (You are required to use open data that you can publish)
- Tentative Workflow/Methodology
- Link to a Blank Story Map with your Proposed Title (needs to be publicly accessible)

Final Story Map – 15 points. The final project Story Map should consist of Scope, Methodology, Case Study, Results, Conclusions, and Future Work. The scope should communicate the research question and data sources with maps. The methodology should detail your approach to solve the research question using techniques learned in class. The case study should demonstrate the application of methods to data that pertains to the research problem. Results should contain maps, charts, and statistical diagnostics to present your findings and metrics that support them. Conclusions should map and chart what you have learned about your research question considering your statistical analysis. Future work

should present the shortcomings of the methods you applied and propose how you can address these shortcomings. Bonus points will be given to final projects that juxtapose spatial statistics to generic statistical methods and showcase spatial approaches' value to spatial problems. In your Story Map, you are expected to distill your knowledge of spatial statistics and present your analysis clearly to a non-expert.

Grading Breakdown

The table below shows the breakdown of the assessments and their weight in the final grade. The emphasis is on regularly completing weekly assignments and solid performance on the Story map project (including the midterm proposal).

Assessment	Number	Points Each	Total Points (% of grade)
Hands-On Assignments	5	3.75	18.75
Theoretical Assignments	7	3.75	26.25
Class Discussions	15	1	15
Midterm Exam	1	20	20
Final Project Story Map	1	20	20
Totals	29	--	100

Assignment Submission Policy

Unless otherwise noted, assignments must be submitted via Blackboard by the due dates specified in the Course Schedule below and on the assignment instructions.

Project components have different due dates as indicated on the Course Schedule below. Your attention to on-time assignment submission is essential if I am to meet my goal to return comments on your submitted assignments before the next one is due. Sometimes this is impossible, so I will post a notice on anticipated delays if needed.

Strict penalties apply for late assignments as follows:

- All assignments will be penalized 2 points up to FOUR days late. No points will be given for submissions more than FOUR days late. Note that all assignments worth 2 points will receive 0 points if submitted late.
- Additionally, no written work will be accepted for grading after 5 pm PT on the last day of classes.

Schedule

Date	Topics	Readings	Assignments	Deliverables/Due Dates
Module 1 | Descriptive Spatial Statistics				
Week 1				
8/25	Introduction to Statistics in GIS Preliminary Mathematical notation	Burt et al, Chapter 1, Sections 2.2, 3.1, 3.2	Theoretical Assignment 1	Class Discussion 1: Introductions – Due by the end of the week (8/29)
8/27	Descriptive statistics Measures of Central Tendency-Variation Descriptive Statistics for Spatial Data	Burt et al, Chapter 5		
Week 2				
9/1	Measures of Spatial Autocorrelation	No reading assignment	Theoretical Assignment 2	Theoretical Assignment 1: Due 9/3 in class
9/3	Measures of Spatial Autocorrelation Measures of Spatial Clustering (Heterogeneity)	Burt et al, Ch. 14.2, 14.3 Legendre, P. (1993)		Class Discussion 2: Concept of Autocorrelation – Due by the end of the week (9/5)
Week 3				
9/8	Point-pattern analysis	Burt et al, Ch. 14.1	Hands-On Assignment 1	

Date	Topics	Readings	Assignments	Deliverables/Due Dates
9/10	Hot-Spot Analysis	Getis and Ord (2010)		Theoretical Assignment 2: Due 9/10 in class Class Discussion 3: Use of distances in statistics – Due by the end of the week (9/12)
Week 4				
9/15	Spatial Statistics in Action: Earthquakes in Oklahoma	No reading assignment	Hands-On Assignment 2	Hands-On Assignment 1: Due 9/17 on-line
9/17	Introduction to R in GIS Introduction to the R-ArcGIS Bridge	No reading assignment	Midterm Proposal	Class Discussion 4: Why use spatial statistics? – Due by the end of the week (9/19)
Module 2 | Spatial Statistical Modelling				
Week 5				
9/22	Random Variables Discrete Probability Distributions	Burt et al, 5.1, 5.2, 5.3, Appendix 5.a, Appendix 5.b	Theoretical Assignment 3	Hands-On Assignment 2: Due 9/24 on-line
9/24	Continuous Probability Distributions The Gaussian Distribution	Burt et al, 5.4		Class Discussion 5: Probability in spatial sciences – Due by the end of the week (9/26)
Week 6				

Date	Topics	Readings	Assignments	Deliverables/Due Dates
9/29	Estimation Point Estimation	Burt et al., 7.1, 7.2	Theoretical Assignment 4	Theoretical Assignment 3: Due 10/1 in class
10/1	Confidence Interval Classical Hypothesis Testing	Burt et al., 7.3, 8.1		Class Discussion 6: Estimating vs quantifying – Due by the end of the week (10/3)
Week 7				
10/6	The P-value One sample Z-test and t-test	Burt et al., Chapter 8.2, 8.3, 8.4, 8.5		Theoretical Assignment 4: Due 10/8 in class Midterm Proposal: Due
10/8	Spatial Hypothesis Testing	Ripley, B. D. (1979)		10/8 in class Class Discussion 7: Why is CSR the null hypothesis?: – Due by the end of the week (10/10)
Week 8*				
10/13	Spatial Statistics in Action: Inferring spatial distribution of diseases outbreak patterns	No reading assignment	Hands-On Assignment 3	

Date	Topics	Readings	Assignments	Deliverables/Due Dates
10/15	Midterm Examination	No reading assignment		Class Discussion 8: COVID-19 and Hypothesis Testing: – Due by the end of the week (10/17)
Module 3 | Modeling Spatial Relationships				
Week 9				
10/20	Pearson's correlation coefficient Linear Regression	Burt et al, 12.1, 12.2., 12.3	Theoretical Assignment 5	
10/22	Bivariate Regression	Burt et al, 13.1		Hands-On Assignment 3: Due 10/22 on-line Class Discussion 9: Correlation or Causation? – Due by the end of the week (10/24)
Week 10				
10/27	Bivariate Association	Guo, D. (2010)	Hands-On Assignment 4	Theoretical Assignment 5:

Date	Topics	Readings	Assignments	Deliverables/Due Dates
10/29	Geographically Weighted Regression	Brunsdon et al. (1996)		Due 10/29 in class Class Discussion 10: When to use geographic weighting? – Due by the end of the week (10/31)
Week 11				
11/3	Spatial Statistics in Action: Understanding House Prices in King County, WA	No reading assignment		
Module 4 | Spatial Data Collection & Wrangling				
11/5	Sampling Geographic Sampling	Burt et al, Chapter 6	Theoretical Assignment 6	Hands-On Assignment 4: Due 11/5 on-line Class Discussion 11: When and how to sample? – Due by the end of the week (11/7)
Week 12				
11/10	Bridging the Scale Gap: Interpolation	Lecture Notes	Theoretical Assignment 7	Theoretical Assignment 6:

Date	Topics	Readings	Assignments	Deliverables/Due Dates
11/12	Wrangling Missing Values in Spatial Data	Lecture Notes		Due 11/12 in class Class Discussion 12: To impute or not to impute? – Due by the end of the week (11/14)
Week 13				
11/17	Geoenrichment in GIS	Lecture Notes	Hands-On Assignment 5	Class Discussion 13: Pitfalls of working with various data sources? – Due by the end of the week (11/21)
11/19	Spatial Statistics in Action: Wrangling San Francisco Crime Data	No reading assignment		
Week 14				
11/24 * 11/27-12/1 is a university holiday	Thanksgiving Break. No classes.	No reading assignment		Class Discussion 14: Bonus Discussion

Date	Topics	Readings	Assignments	Deliverables/Due Dates
Week 15 11/29	Review of the Spatial Statistics and Data Science Workflow			Last Day of Classes (12/3) Study Days (12/4-12/7) Theoretical Assignment 7: Due 11/19 in class Hands-On Assignment 5: Due 12/2 on-line Class Discussion 15: The data science workflow – Due by the end of the week (12/5)
Final Exams 12/8-12/15				

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards https://policy.usc.edu/files/2020/07/SCampus-Part-B-1.pdf. Other forms of academic dishonesty are equally unacceptable. See additional information in

SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems

Counseling and Mental Health– (213) 740-9355 – 24/7 on call
engemannshc.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline – 1 (800) 273-8255 – 24/7 on call
www.suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-9355(WELL), press "0" after hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) – (213) 740-5086 |Title IX Compliance – (213) 821-8298
equity.usc.edu, titleix.usc.edu
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment– (213) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity | Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs – (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Campus Support and Intervention – (213) 821-4710
campussupport.usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC – (213) 740-2101
diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety – - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.