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

SSCI 599: Special Topics - Advanced Quantitative Methods for Population, Health and Place

Units: 4

Term—Day—Time: Fall, 2020, Mondays, 1:00-3:50 p.m.

Location: CPA 102 & Online

Instructor: Orhun Aydin, Ph.D.
Office: AHF B56G
Office Hours: Mondays, 11:00 am -12:30 p.m. or by appointment
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Course Description

This class will be offered in a hybrid format. One meeting per week will be held hybrid/in person, one meeting per week will be held online.

Time has become an indispensable dimension in spatial analysis. Whether it is the dynamics of our planet, our cities or our social patterns, time is a common denominator that unlocks the full potential of spatial data. In this PhD-level course, the fundamentals of temporal and spatiotemporal data analysis will be introduced with hands-on applications. In particular, modern methods to evaluate, visualize and manage spatiotemporal data will be explored. Applied examples will be performed in R and ArcGIS Pro. A working knowledge of R and ArcGIS is required.

Learning Objectives

On completion of this course, students will be able to:

- Identify the principles and approaches that might be used to solve various spatiotemporal problems in GIS
- Learn how to wrangle and visualize spatiotemporal field data
- Identify strategies for analyzing different temporal data in spatial analysis
- Communicate and derive insights from spatiotemporal data.

Prerequisite(s): None
Co-Requisite (s): None
Concurrent Enrollment: None
Recommended Preparation: Students must be enrolled in an existing USC Ph.D. program

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 Notes

The course will be taught as a series of classes that will introduce concepts, theory and use-cases behind spatio-temporal analysis. Teaching strategies are designed to empower the students with broad knowledge of spatio-temporal 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 hands-on

assignments that explore data wrangling, visualization and forecasting for spatio-temporal problems.

Technological Proficiency and Hardware/Software Required

We have several technologies that will facilitate our course work and our interactions, despite our dispersed locations. These include the following pair of elements.

Blackboard – All course materials and correspondence will be posted on the course Blackboard site. As a registered student, you will find this class will show up in your available classes no later than 12:00 p.m., PST on the first day of the semester.

SSI server and tech support – This course utilizes the SSI Server, which is a virtual desktop giving access to many different professional software applications. If you are unable to connect to the server or experience any type of technical issues, send an email to SSI Tech Support at spatial_support@usc.edu and make sure to copy (cc) me on the email. You will need: (1) a computer with a fast Internet connection; (2) a functional webcam and microphone for use whenever a presentation or meeting is scheduled; and (3) a modern web browser.

Required Readings and Supplementary Materials

There is two books required for this class. The first by Cressie and Wikle (2015) needs to be purchased from either the USC Bookstore or an online outlet such as Amazon. The second is a companion textbook that is available online. We will need both of these books from the first day of class.

- Cressie, N., & Wikle, C. K. (2015). *Statistics for spatio-temporal data.* New York, NY: John Wiley & Sons. ISBN: 978-0-471-69274-4 (required)
- Wikle, C. K., Zammit-Mangion, A., & Cressie, N. (2019). *Spatio-temporal statistics with R.* Boca Raton, FL: Chapman & Hall/CRC (Online Companion Textbook)

The two aforementioned books will be supplemented with class notes and a mixture of readings from academic journals, books, professional reports, and authoritative websites. The following book chapters and journal articles will be posted to Blackboard in the Course Documents folder:

- De Gooijer, J. G., & Hyndman, R. J. (2006). 25 years of time series forecasting. *International Journal of Forecasting, 22*(3), 443-473.
- Ferreira, N., Poco, J., Vo, H. T., Freire, J., & Silva, C. T. (2013). Visual exploration of big spatio-temporal urban data: A study of new york city taxi trips. IEEE Transactions on Visualization and Computer Graphics, 19(12), 2149-2158.
- Fischer, M. M. (1998). Computational neural networks: a new paradigm for spatial analysis. *Environment & Planning A, 30*(10), 1873-1891.
- Fischer, M. M. (2006). Computational neural networks: Tools for spatial data analysis. In Fischer, M. M. (Ed.), *Spatial analysis and geocomputation: Selected essays* (pp. 79-102). Berlin, Germany: Springer.
- Harris, N. L., Goldman, E., Gabris, C., Nordling, J., Minnemeyer, S., Ansari, S., ... & Potapov, P. (2017). Using spatial statistics to identify emerging hot spots of forest loss. Environmental Research Letters, 12(2), 024012.

- Patterson, T. A. (2016). moveHMM: An R package for the statistical modelling of animal movement data using hidden Markov models. *Methods in Ecology & Evolution, 7*(11), 1308-1315.

- Peuquet, D. J. (1999). Time in GIS and geographical databases. In P. A. Longley, M. F. Goodchild, D. J. Maguire, & D. W. Rhind (Eds.), *New developments in Geographical Information Systems: Principles, techniques, management and applications* (vol. 1, pp. 91-103). New York, NY: John Wiley & Sons.

- Ramsay, J. O. (2004). Functional data analysis. In S. Kotz, C. B. Read, N. Balakrishnan, B. Vidakovic, & N. L. Johnson (Eds.), *Encyclopedia of statistical sciences* (pp. 1-8). New York, NY: John Wiley & Sons.

- Seidel, D. P., Dougherty, E., Carlson, C., & Getz, W. M. (2018). Ecological metrics and methods for GPS movement data. *International Journal of Geographical Information Science, 32*(11), 2272-2293.

- Yuan, M. (1996). Temporal GIS and spatio-temporal modeling. In *Proceedings of Third International Conference Workshop on Integrating GIS and Environment Modeling.* Santa Fe, NM.

Description and Assessment of Assignments

Students must prepare a seminar, a research paper and presentation, a series of weekly briefs, and participate in class discussion on a regular basis.

Class Participation (5%): A class participation grade will be assigned based upon how actively students engage in the course. Students will be required to read all material outlined for each week of the course, and be prepared to lead and participate in group discussions about the readings in class. Failure to attend, or not be adequately prepared to discuss the readings will lead to the assignment of a lower grade for that week.

Lab Assignments (60%): Each week students will be given a lab assignment to apply spatio-temporal analysis to real world data. The labs will be use ArcGIS Pro and R language. RStudio, although not required, is highly recommended.

Class Presentation (15%): Each student will present their final project in the last week. The presentation will be divided in to four main categories: Introduction of the Problem, Methods (Spatial, Temporal and Spatio-Temporal), Case Study, Results and Visualizations. Members of project groups are expected to be well-versed in every aspect of their team's research as the instructor will randomly assign group members to present different sections of the class presentation. Group members are expected to answer questions from the audience. Members of the audience taking the class are expected to ask questions and draw parallels from their work.

Final Project (20%): 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 spatio-temporal problem that is aligned with student's research/interests. The final report (20%) 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 and the range of solutions that have been attempted thus far, as reported in the published literature.

Grading Breakdown

Assignment	No. of Assignments	% of Grade
Class Participation	14	5
Class Presentation	1	15
Final Projects	1	20
Lab Assignments	12	60
TOTAL	**28**	**100**

Assignment Submission Policy

Assignments will be submitted for grading via Blackboard using the due dates specified in the Course Schedule below.

Additional Policies

Students are expected to attend and participate in every class session and to complete and upload all assignments before the deadlines noted in the Course Schedule below. Late work will be assessed a penalty of 10% per day and zero grades will be assigned for work more than one week late.

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings and Homework	Deliverables/Due Dates
Week 1 8/17	**Introduction to Spatiotemporal Analysis & R Review** Brief introductions coupled with a discussion of class goals, projects, and reading assignments.	Read Cressie & Wikle, Ch. 1 and Wikle et al., Ch. 1 For the first lab assignment, students will perform simple analysis using R. In addition, the R-ArcGIS bridge will be tested to ensure students are ready for the upcoming assignments.	Students will complete and submit R-Review assignment (Lab #1) that will assess their previous R language knowledge. Submit Lab #1 on Bb no later than 11:59 p.m. on Tuesday, 9/3.
Week 2 8/24	**Time Series Representation in GIS** This class will focus on the use space-time cubes to summarize spatiotemporal data.	Read Yuan (1996) and Peuquet (1999). For the second lab assignment, students will explore the fundamentals of time series analysis in GIS.	Students will complete Lab #2 that will assess: (a) the time-related terminology used in GIS; and (b) their understanding of space-time data structures in GIS. Submit Lab #2 on Bb no later than

			11:59 p.m. on Tuesday, 9/17.
Week 3 8/31	**Classical Time Series Models** This class will focus on recognizing the differences in the suitability of different models of time-series	Read Cressie & Wikle, Ch. 3.3, 3.4 For the third lab assignment, students will explore ARMA and ARIMA models to explain time-series characteristics.	Students will complete Lab #3 that will assess: (a) the applications of different statistical models for time series; and (b) their understanding of the mathematical fundamentals behind different models. Submit Lab #3 on Bb no later than 11:59 p.m. on Tuesday, 9/24.
Week 4 9/7	**Labor Day – No Class**		
Week 5 9/14	**Time Series Prediction** This class will focus on the generation of forecasts for different time series.	Read De Gooijer & Hyndman (2006). For the fifth lab assignment, students will practice with the metrics used to select a method for predicting time series. In addition, students will explore the metrics to describe a good forecast model.	Students will complete Lab #5 that will assess: (a) their understanding of the core concepts behind forecast & estimation; and (b) the utilization of diagnostic metrics for assessing results. Submit Lab #4 on Bb no later than 11:59 p.m. on Tuesday, 10/8.
Week 6 9/21	**Visualizing and Wrangling Spatiotemporal Data**	Read Cressie & Wikle, Ch. 5.1 Ferreira al (2013) For the sixth lab assignment, students will learn modern methods for visualizing and managing spatiotemporal data in GIS.	Students will complete Lab #6 that will assess: (a) the ability to clean-up data spatiotemporally; (b) the utilization of different methods to visualize spatiotemporal data; and (c) their understanding of the utility and

			shortcomings of Hovmoller plots. Submit Lab #6 on Bb no later than 11:59 p.m. on Tuesday, 10/15.
Week 7 9/28	**Exploratory Methods for Spatiotemporal Data**	Read Cressie & Wikle, Ch. 5.2, 5.3, 5.4, 5.5, 5.6 For the seventh lab assignment, students will explore exploratory analysis of spatio-temporal data using Empirical Orthogonal Functions and Canonical Correlation Analysis.	Students will complete Lab #7 that will assess: (a) their understanding of the application of cross-spectral analysis to uncover temporal relationships; (b) the utilization of EOF for spatiotemporal problems; and (c) the ability to explore spatiotemporal relationships using CCA. Submit Lab #7 on Bb no later than 11:59 p.m. on Tuesday, 10/22.
Week 8 10/5	**Spatiotemporal Pattern Mining** This class will focus on the underlying theory and assumptions of different approaches for performing spatiotemporal pattern mining.	Harris et al (2017) For the eighth lab assignment, students will use ArcGIS's space-time pattern mining tools to map space-time data.	Students will complete Lab #8 that will assess: (a) the uses of hot spot analysis for spatio-temporal data; and (b) the ability to explain changes to hot and cold spots in space-time. Submit Lab #8 on Bb no later than 11:59 p.m. on Tuesday, 10/29.
Week 9 10/12	**General Dynamic Spatio-Temporal Models (DSTMs)**	Read Cressie & Wikle, Ch. 8.1, 8.2, 8.3, Pick 2 out of 9.1, 9.2, 9.3 and 9.4 For the ninth lab assignment, students will practice using DSTMs for modelling space-time data.	Students will complete Lab #9 that will assess: (a) the ability to perform spatiotemporal analysis using

			DSTMs; and (b) their understanding the fundamentals of spatio-temporal forecasts via DSTMs. Submit Lab #9 on Bb no later than 11:59 p.m. on Tuesday, 11/5.
Week 10 10/19	**Recurring Neural Networks for Spatiotemporal Models**	Read Fischer (1998, 2006). For the tenth lab assignment, students will experiment with the uses of RNNs and LSTMs for predicting time-series.	Students will complete Lab #10 that will assess: (a) the use of neural network applications for space-time analysis; (b) their understanding of neural network topology for time data; and (c) the differences of LSTM-based prediction. Submit Lab #10 on Bb no later than 11:59 p.m. on Tuesday, 11/12.
Week 11 10/26	**Movement and Trajectory Analysis in GIS**	Read Seidel et al. (2018) For the eleventh lab assignment, students will explore movement data and its uses in GIS analysis.	Students will complete Lab #11 that will assess: (a) the differences between movement data and ordinary time-series data; and (b) the types of problems pertaining to movement in GIS that are typically studied. Submit briefs on Bb no later than 11:59 p.m. on Tuesday, 11/19.
Week 12 11/2	**Hidden Markov Models**	Read Patterson (2016). For the twelfth lab assignment, students will explore uses of Hidden Markov Models to study movement data.	Students will complete Lab #12 that will assess: (a)

			the utilization of HMM to understand and explore movement data; and (b) their understanding of fundamentals of HMMs and how they relate to movement. Submit Lab #12 on Bb no later than 11:59 p.m. on Tuesday, 11/26.
Week 13 11/9	**Final Project Presentations**	Students will present their final projects, summarizing the insights gathered from their research of the specific problem context.	Students will present their final projects and answer questions from audience. Allow 20-25 minutes per student assuming a maximum of three to six students in this class.
FINAL 11/23			Final research papers to be uploaded to Bb no later than 11:59 p.m. on Friday, 12/6.

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/scampus-part-b/. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems

Student Counseling Services (SCS) - (213) 740-7711 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. https://engemannshc.usc.edu/counseling/.

National Suicide Prevention Lifeline - 1-800-273-8255
Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. http://www.suicidepreventionlifeline.org.

Relationship & Sexual Violence Prevention Services (RSVP) - (213) 740-4900 - 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender-based harm. https://engemannshc.usc.edu/rsvp/.

Sexual Assault Resource Center
For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: http://sarc.usc.edu/.

Office of Equity and Diversity (OED)/Title IX compliance – (213) 740-5086
Works with faculty, staff, visitors, applicants, and students around issues of protected class. https://equity.usc.edu/.

Bias Assessment Response and Support
Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. https://studentaffairs.usc.edu/bias-assessment-response-support/.

Student Support & Advocacy – (213) 821-4710
Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. https://studentaffairs.usc.edu/ssa/.

Diversity at USC – https://diversity.usc.edu/
Tabs for Events, Programs and Training, Task Force (including representatives for each school), Chronology, Participate, Resources for Students.