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

SSCI 683: Principles of Spatial Data Analysis

Units: 4

Term—Day—Time: Spring 2021, Thursdays 11 a.m. – 1:50 p.m.

Location: Online (See the Blackboard course site for the zoom link)

Instructor: An-Min Wu, Ph.D.
Office: AHF B55B
Office Hours: Tuesdays 11:30 a.m.–12:30 p.m. and Thursdays 3-4 p.m. Pacific Time via zoom – please contact me via email in advance to ensure I will be online. Also available most days between 9 a.m. – 6 p.m. by appointment via email.
Contact Info: anminwu@usc.edu

Library Help: Andrzej (Andy) Rutkowski
Office: VKC Library 36B
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IT Help: Richard Tsung
Office: AHF B57E
Office Hours: By appointment
Contact Info: ctsung@usc.edu

Course Description

This course explores theoretical foundations, methods, techniques, and software systems for spatial data analysis. The course aims to provide students with the fundamental knowledge and hands-on skills necessary to investigate research questions, with a focus on population and health problems, using spatial analysis approaches. Including fundamental spatial concepts and the core components of geospatial data analysis techniques, this course intends to explore a broad range of principle spatial data analysis methods, from exploratory spatial data analysis and surface analysis, remote sensing to spatial statistics to network and locational analysis. The latest research in a variety of topics related to population, health, and place that are central to spatial analysis are also examined. Students will gain an in-depth understanding and hands-on experience in the ways to explore a variety of applications through a combination of homework, presentations and projects. Students will learn about the wide variety of geospatial data and analytical tools available, including how to find relevant data and transform it as needed so that it can be used for solving specific socio-economic challenges and problems.

This course will be offered in a hybrid format. Lectures will be offered in person and streamed for remote access.

Learning Objectives

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

- Describe key theoretical concepts of spatial analysis approaches.
- Evaluate spatial analysis approaches and techniques for working on research that investigate places and their roles in shaping environmental exposures, health-related impacts and outcomes, and the efficacy of health care delivery systems.
- Analyze spatial problems by applying appropriate and relevant spatial analysis techniques.

Prerequisite(s): None.
Co-Requisite (s): Students must be enrolled in an existing USC PhD program
Concurrent Enrollment: None
Recommended Preparation: Some experience in GIS software or GIS coursework (e.g. SSCI 581) is strongly recommended; contact the instructor if you have no prior experience in GIS.

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 delivered with multiple methods including lectures, class discussion, presentations and hands-on practice. During the first half of each class session, the instructor will present the core topics and students will give presentations on the selective subtopics. The remaining time in the class will be group discussions on the readings or hands-on practices related to the lecture topics covered. Student participation is encouraged through reading discussions, hands-on practices, homework assignments, and class presentations.

Throughout the semester, hands-on practice and homework assignments provide students first-hand experience in spatial analysis using the software R and ArcGIS Pro, and reading assignments help students evaluate and integrate the information acquired from the weekly readings. Students will design and conduct final projects to learn more in-depth spatial analysis approaches in a specific topic of research interest and demonstrate their ability to apply appropriate spatial analysis methods in resolving problems related to population, health and place.

Technological Requirements

The course will be focused on using R and ArcGIS Pro. Students can access the software for course assignments using computing resources provided by the Spatial Sciences Institute. Students will be given login credentials and instructions to sign-in to the remote Spatial Sciences Institute Server for the required software.

Required Readings and Supplementary Materials

The required textbooks for this course are:

- de Smith, Michael J., Michael F. Goodchild, and Paul A. Longley. 2020. *Geospatial analysis: a comprehensive guide to principles, techniques and software tools* (6th Ed.). Winchelsea, UK: Winchelsea Press. (Available online: http://www.spatialanalysisonline.com/index.html.)
- O'Sullivan, David, and David Unwin. 2010. *Geographic Information Analysis*, 2nd Edition. New York, NY: John Wiley & Sons. (Available online via USC Libraries.)

Supplementary readings will be assigned from various sources and will be accessed via the USC Library's electronic collections and/or provided by the instructor via Blackboard, including:

- Baker, David M., and Alain-Jacques Valleron. 2014. "An open source software for fast grid-based data-mining in spatial epidemiology (FGBASE)." *International journal of health geographics* 13, (1): 46.
- Barreto, Moises Colares, Doris Kosminsky, and Claudio Esperança. 2018. "Hexagonal hierarchical cartogram: Towards a thematic map of Brazil." *InfoDesign-Revista Brasileira de Design da Informação* 15 (1): 45-62.
- Berrigan, David, Zaria Tatalovich, Linda W. Pickle, Reid Ewing, and Rachel Ballard-Barbash. 2014. "Urban sprawl, obesity, and cancer mortality in the United States: cross-sectional analysis and methodological challenges." *International Journal of Health Geographics* 13 (1): 3.
- Choi, Hyungyun and Ho Kim. 2017. "Analysis of the relationship between community characteristics and depression using geographically weighted regression." Epidemiology and Health, 39.
- Cooper, Crispin HV. 2015. "Spatial localization of closeness and betweenness measures: A self-contradictory but useful form of network analysis." *International Journal of Geographical Information Science 29* (8): 1293-1309.
- Dogru, Ahmet Ozgur, Ruusa Magano David, Necla Ulugtekin, Cigdem Goksel, Dursun Zafer Seker, and Seval Sözen. 2017. "GIS based spatial pattern analysis: Children with Hepatitis A in Turkey." *Environmental research* 156: 349-357.
- Goovaerts, Pierre. 2005. "Geostatistical analysis of disease data: estimation of cancer mortality risk from empirical frequencies using Poisson kriging." *International Journal of Health Geographics* 4 (1): 1.
- Hanna-Attisha, Mona, Jenny LaChance, Richard Casey Sadler, and Allison Champney Schnepp. 2016. "Elevated blood lead levels in children associated with the Flint drinking water crisis: a spatial analysis of risk and public health response." *American Journal of Public Health* 106 (2): 283-290.
- Harris, Nancy L., Elizabeth Goldman, Christopher Gabris, Jon Nordling, Susan Minnemeyer, Stephen Ansari, Michael Lippmann et al. 2017. Using spatial statistics to identify emerging hot spots of forest loss. *Environmental Research Letters* 12(2): 024012.
- Hohl, Alexander, Minrui Zheng, Wenwu Tang, Eric Delmelle, and Irene Casas. 2017. "Spatiotemporal point pattern analysis using Ripley's K function." In *Geospatial data science: techniques and applications*. CRC Press, Boca Raton, FL.
- Kwan, Mei-Po. 2018. "The limits of the neighborhood effect: Contextual uncertainties in geographic, environmental health, and social science research." *Annals of the American Association of Geographers* 108 (6): 1482-1490.
- Langford, Mitchel, Gary Higgs, and Richard Fry. 2016. "Multi-modal two-step floating catchment area analysis of primary health care accessibility." *Health & place* 38: 70-81.

- Liu, Qiannan, Zhiyun Ouyang, Ainong Li, and Weihua Xu. 2016. "Spatial Distribution Characteristics of Biomass and Carbon Storage in Forest Vegetation in Chongqing Based on RS and GIS." *Nature Environment and Pollution Technology* 15 (4): 1381.
- Louis, Valérie R., Revati Phalkey, Olaf Horstick, Pitcha Ratanawong, Annelies Wilder-Smith, Yesim Tozan, and Peter Dambach. 2014. "Modeling tools for dengue risk mapping-a systematic review." *International Journal of Health Geographics* 13 (1): 50.
- Martins-Melo, Francisco Rogerlândio, Alberto Novaes Ramos, Carlos Henrique Alencar, Wolfram Lange, and Jorg Heukelbach. 2012. "Mortality of Chagas' disease in Brazil: spatial patterns and definition of high-risk areas." *Tropical Medicine & International Health* 17 (9): 1066-1075.
- Marx, Andrew, and Donald McFarlane. 2019. "Combining Unmanned Aerial Systems and Satellite Data to Monitor Phenological Changes in Tropical Forests: A Case Study from Costa Rica." *Case Studies in the Environment*.
- Mobley, Lee R., Tzy-Mey Kuo, Matthew Urato, Sujha Subramanian, Lisa Watson, and Luc Anselin. 2012. "Spatial heterogeneity in cancer control planning and cancer screening behavior." *Annals of the Association of American Geographers* 102 (5): 1113-1124.
- Mulrooney, Timothy, Kathi Beratan, Christopher McGinn, and Benjamin Branch. 2017. "A comparison of raster-based travel time surfaces against vector-based network calculations as applied in the study of rural food deserts." *Applied geography* 78: 12-21.
- Nilsson, Pia. 2014. "Natural amenities in urban space – A geographically weighted regression approach." *Landscape and Urban Planning* 121: 45-54.
- Pattinson, Woodrow, Ian Longley, and Simon Kingham. 2015. "Proximity to busy highways and local resident perceptions of air quality." *Health & place* 31: 154-162.
- Perchoux, Camille, Basile Chaix, Ruben Brondeel, and Yan Kestens. 2016. "Residential buffer, perceived neighborhood, and individual activity space: New refinements in the definition of exposure areas–The RECORD Cohort Study." *Health and Place* 40: 116-122.
- Rezaeian, Mohsen, Graham Dunn, Selwyn St Leger, and Louis Appleby. 2007. "Geographical epidemiology, spatial analysis and geographical information systems: a multidisciplinary glossary." *Journal of Epidemiology & Community Health 61* (2): 98-102.
- Shi, Xun, Jennifer Alford-Teaster, Tracy Onega, and Dongmei Wang. 2012. "Spatial access and local demand for major cancer care facilities in the United States." *Annals of the Association of American Geographers* 102(5): 1125-1134.
- Spencer, John, and Gustavo Angeles. 2007. "Kernel density estimation as a technique for assessing availability of health services in Nicaragua." *Health Services and Outcomes Research Methodology* 7: 145-157.

- Spielman, Seth E., and John R. Logan. 2013. “Using high-resolution population data to identify neighborhoods and establish their boundaries.” *Annals of the Association of American Geographers* 103 (1): 67-84.
- Tatalovich, Zaria, John P. Wilson and Myles Cockburn. 2006a. A comparison of thiessen polygon, kriging, and spline models of potential UV exposure. *Cartography and Geographic Information Science*, 33 (3): 217-231.
- Tatalovich, Zaria, John P. Wilson, Thomas Mack, Ying Yan, and Myles Cockburn. 2006b. “The objective assessment of lifetime cumulative ultraviolet exposure for determining melanoma risk.” *Journal of Photochemistry and Photobiology B: Biology* 85 (3): 198-204.
- Vaz, Eric, Michael Cusimano, and Tony Hernandez. 2015. "Land use perception of self-reported health: Exploratory analysis of anthropogenic land use phenotypes." *Land Use Policy* 46: 232-240.
- VoPham, Trang, John P. Wilson, Darren Ruddell, Tarek Rashed, Maria M. Brooks, Jian-Min Yuan, Evelyn O. Talbott, Chung-Chou H. Chang, and Joel L. Weissfeld. 2015. “Linking pesticides and human health: A geographic information system (GIS) and Landsat remote sensing method to estimate agricultural pesticide exposure.” *Applied Geography* 62: 171-181.
- Weiss, D. J, A. Nelson, H. S. Gibson, W. Temperley, S. Peedell, A. Lieber, M. Hancher , E. Poyart, S. Belchior, N. Fullman and B. Mappin. 2018. "A global map of travel time to cities to assess inequalities in accessibility in 2015." *Nature* 553 (7688): 333.
- Yin, Chaohui, Man Yuan, Youpeng Lu, Yaping Huang, and Yanfang Liu. 2018. "Effects of urban form on the urban heat island effect based on spatial regression model." *Science of the Total Environment* 634: 696-704.
- Yu, Wenhao, Tinghua Ai, and Shiwei Shao. 2015. "The analysis and delimitation of Central Business District using network kernel density estimation." *Journal of Transport Geography* 45: 32-47.

Description and Assessment of Assignments

There are several different types of assignments due nearly each week in our course that make up a significant part of your final grade. These different types of assignments are described below.

In-Class Engagement - 12 worth a total of 12%. An in-class engagement grade for the semester will be assigned based upon student engagement in the class sessions. The activities of in-class engagement can be, but not limited to, one-minute writing, quiz, group discussion, or hands-on practice. Failure to participate in in-class engagement activities will receive no grade for that week.

Reading Assignments – 6 worth a total of 12%. These will focus on the theory portion of the course as presented in the weekly readings. The objective is to help you evaluate and integrate the information you have acquired from the course readings. You are strongly recommended to read all material outlined for each week before the class session, but are free to choose to submit any six of the 13 subsequent assignments. You must

complete and submit them for grading in the weeks specified in the Course Schedule at the end of this syllabus.

Homework Assignments -- 3, worth a total of 24%: Students will be assigned a total of 4 homework assignments in this course. These hands-on assignments are to practice spatial analysis techniques explored in theory in the texts. You will analyze the data of your own choice using ArcGIS and/or R scripts, and write a short report to answer the questions in each assignment.

Class Lead Discussion - 1 worth a total of 12%: Students will conduct a 30-minute class presentation based on the specific subtopic areas of the chosen week determined in consultation with the instructor. Students will be expected to present the selected subtopic conetents focused with both concepts and applications.

Final Project

To integrate your learning of all the material covered in the course, in the final project, you will design, undertake, and report on a spatial analysis research project that will be the context of the assignments throughout the semester. Students can conduct either an independent or 2-person team projects. The four components of the project will be due at different times throughout the semester. The grading rubric for each project component will be provided at the time the assignment is released. The four final project components include:

Project Idea Presentation - 5%. An in-class presentation for your final project idea, including the spatial questions you would like to investigate, how you plan to solve them, the data to be used for analysis, and expected outcomes.

Proposal - 10%. A proposal document developed from the project idea presentation and the feedback received.

Final Presentation - 10%. A final presentation during the final week of the class session.

Report - 15%. A written report in the format of a research paper on your final project methodology and outcomes.

Grading Breakdown

Assessments	Number	% Each	Total % of Grade
In-Class Engagement		12	12
Reading Assignments	6	2	12
Homework Assignments	3	8	24
Class Lead Discussion	1	12	12
Project Components			
Idea Presentation & Discussion	1	5	5
Project Proposal	1	10	10
Final Presentation	1	10	10
Project Report	1	15	15
Total	-	-	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.

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

Course Schedule: A Weekly Breakdown

	Topics	Readings	Deliverables/Dues
Module 1: Concept Framework for Spatial Data Analysis			
Week 1 1/21	Introduction to Spatial Data Analysis and Conceptual Framework	de Smith et al. (2018) Ch. 2 O'Sullivan & Unwin (2010) Ch.1 Rezaeian et al. (2007) Perchoux et al. (2016)	
Week 2 1/28	Geospatial Data Analysis Potentials and Problems	O'Sullivan & Unwin (2010) Ch.2 Spielman and Logan (2013) Kwan (2018)	Sign-up for class presentations
Week 3 2/4	Maps for Spatial Analysis and Processes	O'Sullivan & Unwin (2010) Ch.3 & 4 Mobley et al. (2012) Barreto et al. (2018) Homework Assignment 1	Reading Assignment 1 due by 12 pm, Wednesday 2/3
Module 2: Exploratory Spatial Data Analysis			
Week 4 2/11	Point Pattern Analysis	de Smith et al. (2018). Ch. 5-§5.2 & §5.4 Spencer and Angeles (2007) Yu et al. (2015) Hohl et al. (2017)	Reading Assignment 2: due by 12 pm, Wednesday 2/10
Week 5 2/18	Spatial Autocorrelation	O'Sullivan & Unwin (2010) Ch. 7 & 8 Martins-Melo et al. (2012) Vaz et al. (2015) Harris et al. (2017) Dogru et al. (2017)	Reading Assignment 3: due by 12 pm, Wednesday, 2/17 Homework Assignment 1: due Friday, 2/19
Module 3: Regression-based modeling			
Week 6 2/25	Regression Analysis in GIS	De Smith et al. (2018). §5.6.1-5.6.2 Berrigan et al. (2014) Pattinson et al. (2015) Homework Assignment 2	Reading Assignment 4: due by 12 pm, Wednesday, 2/24 Project Idea Presentation/Discussion

Week 7 3/4	Spatial Regression I: Spatial Autoregressive Models	De Smith et al. (2018). §5.6.3-5.6.4 Yin et al. (2018)	Reading Assignment 5: due by 12 pm, Wednesday, 3/3
Week 8 3/11	Spatial Regression II: Geographically Weighted Regression	Choi and Kim (2017) Nilsson (2014) Homework Assignment 3	Reading Assignment 6: due by 12 pm, Wednesday, 3/10 Homework Assignment 2: due Thursday, 3/11
Module 4: Spatial Interpolations			
Week 9 3/18	Deterministic & Geostatistical Interpolations	de Smith et al. (2018). §6.5-§6.6 O'Sullivan &Unwin (2010) §10.3-§10.4 Tatalovich et al. (2006a) Tatalovich et al. (2006b) Goovaerts (2005)	Reading Assignment 7: due by 12 pm, Wednesday, 3/17 Project Proposal due Friday, 3/19
Week 10 3/25	Geostatistical Interpolation II	Louis et al. (2014) Hanna-Attisha et al. (2016)	Reading Assignment 8: due by 12 pm, Wednesday, 3/24 Homework Assignment 3: due Friday, 3/26
Module 5: Network and Spatial Accessibility			
Week 11 4/1	Network and Spatial Health Accessibility	Cooper et al. (2015) Weiss et al. (2018) Shi et al. (2012) Landford et al. (2016)	Reading Assignment 9: due by 12 pm, Wednesday, 3/31
Module 6: Grid-Based Analysis			
Week 12 4/8	Surface and Field Analysis	O'Sullivan & Unwin (2010) §9.4-9.5 Baker and Valleron (2014) Mulrooney et al. (2017)	Reading Assignment 10: due by 11:59 pm, Tuesday, 4/6
Week 13 4/15	Remote Sensing for GIS Application	VoPham et al. (2015) Liu et al. (2016) Marx and McFarland (2019)	Reading Assignment 11: due by 12 pm, Wednesday, 4/14
No class on the week of 4/19-4/23* *4/22 is a university Wellness Day			
Week 14 4/29* 4/29 is last day of class	Final Presentations		Final presentation during the class session
Final Exam	TBD – Final report due		

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" 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

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
uscsa.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.