SSCI 683: Principles of Spatial Data Analysis

Units: 4

Term—Day—Time: Spring 2019, Thursdays, 2-4:50 pm

Location: Spatial Sciences Institute, AHF 145D

Instructor: An-Min Wu, Ph.D.
Office: AHF B55B
Office Hours: Tuesdays, 3 – 4 p.m. and Thursdays, 12 – 1 p.m. Also available most days and times by appointment via email.
Contact Info: anminwu@usc.edu, 213-740-2876 (office)

Library Help: Andrzej (Andy) Rutkowski
Office: VKC Library 36B
Office Hours: By appointment
Contact Info: arutkows@usc.edu, 213-740-6390 (office), http://bit.ly/andyhangout

IT Help: Richard Tsung
Office: AHF B57E
Office Hours: By appointment
Contact Info: ctsung@usc.edu, 213-821-4415 (office)

Course Description

This course explores the theoretical foundations, methods, techniques, and software systems for spatial data analysis. The course aims to provide students with the knowledge and skills necessary to investigate research questions, with a focus on spatial health problems, using spatial analysis methods. Essential concepts of quantitative geographic information are presented, including the fundamental spatial concepts, the core components of geospatial analysis techniques, exploratory spatial data analysis and spatial statistics, surface analysis, and 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 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 health-related challenges and problems.

Learning Objectives

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

➢ Describe key theoretical concepts of spatial analysis approaches.
➢ Identify spatial and non-spatial data required to investigate the place and its role in shaping environmental exposures, health-related impacts and outcomes, and the efficacy of health care delivery systems.
➢ Evaluate spatial analysis approaches and techniques for working with health-related geospatial data.
➢ Apply appropriate and relevant spatial analysis techniques to solve spatial health problems.

Prerequisite(s): Some experience in any GIS software is strongly recommended but not required
Co-Requisite (s): Students must be enrolled in an existing USC PhD program
Concurrent Enrollment: None
Recommended Preparation: None

Course Structure

The course will be delivered using both lectures, class discussion and hands-on practice formats. During the first half of each class session, the instructor will present the core topics and selected students will give presentations on some of the 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, homework assignments will give students first-hand experience in spatial analysis and weekly written briefings will ensure students keep up with the related readings. Students will design and conduct individual final projects to learn more in-depth spatial analysis approaches in a specific topic of research interest and demonstrate their ability to apply spatial analysis tools in resolving spatial health problems.

Technological Requirements

The analysis software and geospatial data required for course assignments will be accessed using computing resources provided by the Spatial Sciences Institute. Students are encouraged to sign-in Spatial Sciences Institute server remotely for the required software. The course will be focused on using ArcGIS and R.

Required Readings and Supplementary Materials

The required textbooks for this course are:

- Bolstad, Paul. 2016. *GIS Fundamentals: A First Text on Geographic Information Systems,* 5th Edition. White Bear Lake, Minnesota: Eider Press. (Available as a hardbound copy or e-book for purchase at: www.xanedu.com.)
- De Smith, Michael J., Michael F. Goodchild, and Paul A. Longley. 2018. *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:

- Anselin, Luc. 1995. "Local indicators of spatial association—LISA." *Geographical Analysis* 27 (2): 93-115.
- Auchincloss, Amy H., Rick L. Riolo, Daniel G. Brown, Jeremy Cook, and Ana V. Diez Roux. 2011. "An agent-based model of income inequalities in diet in the context of residential segregation." *American Journal of Preventive Medicine* 40 (3): 303-311.
- 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.
- Bell, B. Sue, Richard E. Hoskins, Linda Williams Pickle, and Daniel Wartenberg. 2006. "Current practices in spatial analysis of cancer data: mapping health statistics to inform policymakers and the public." *International Journal of Health Geographics* 5 (1): 49.

- Beyer, Kirsten MM, Chetan Tiwari, and Gerard Rushton. 2012. "Five essential properties of disease maps." *Annals of the Association of American Geographers* 102 (5): 1067-1075.

- Conley, Jamison F. 2011. "Estimation of exposure to toxic releases using spatial interaction modeling." *International Journal of Health Geographics* 10 (1): 20.

- Fisher, Peter F. and Nicholas J. Tate. 2006. "Causes and consequences of error in digital elevation models." *Progress in Physical Geography* 30: 467-489.

- Gatrell, Anthony C., Trevor C. Bailey, Peter J. Diggle, and Barry S. Rowlingson. 1996. "Spatial point pattern analysis and its application in geographical epidemiology." *Transactions of the Institute of British geographers*: 256-274.

- 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): 31.

- 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.

- Henry, Kevin A., Francis P. Boscoe, Christopher J. Johnson, Daniel W. Goldberg, Recinda Sherman, and Myles Cockburn. 2011. "Breast cancer stage at diagnosis: is travel time important?" Journal of Community Health 36 (6): 933.

- Kwan, Mei-Po. 2012. "The uncertain geographic context problem." *Annals of the Association of American Geographers* 102 (5): 958-968.

- 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.

- Luna, A. S., M. L. L. Paredes, G. C. G. de Oliveira, and S. M. Corrêa. 2014. "Prediction of ozone concentration in tropospheric levels using artificial neural networks and support vector machine at Rio de Janeiro, Brazil." *Atmospheric Environment* 98: 98-104.

- 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.

- Matthews, Stephen A., and Tse-Chuan Yang. 2012. "Mapping the results of local statistics: Using geographically weighted regression." *Demographic Research* 26: 151-166.

- 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.

- Nkoko, Didier Bompangue, Patrick Giraudoux, Pierre-Denis Plisnier, Annie Mutombo Tinda, Martine Piarroux, Bertrand Sudre, Stephanie Horion, Jean-Jacques Muyembe Tamfum, Benoit Kebela Ilunga, and Renaud Piarroux. 2011. "Dynamics of cholera outbreaks in Great Lakes region of Africa, 1978–2008." *Emerging Infectious Diseases* 17 (11): 2026.
- 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.
- Pijanowski, Bryan C., Amin Tayyebi, Jarrod Doucette, Burak K. Pekin, David Braun, and James Plourde. 2014. "A big data urban growth simulation at a national scale: configuring the GIS and neural network based land transformation model to run in a high performance computing (HPC) environment." *Environmental Modelling & Software* 51: 250-268.
- 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.
- Root, Elisabeth Dowling. 2012. "Moving neighborhoods and health research forward: using geographic methods to examine the role of spatial scale in neighborhood effects on health." *Annals of the Association of American Geographers* 102 (5): 986-995.
- Sexton, Joseph O., Xiao-Peng Song, Chengquan Huang, Saurabh Channan, Matthew E. Baker, and John R. Townshend. 2013. "Urban growth of the Washington, DC–Baltimore, MD metropolitan region from 1984 to 2010 by annual, Landsat-based estimates of impervious cover." *Remote Sensing of Environment* 129: 42-53.
- 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, Thomas Mack, Ying Yan, and Myles Cockburn. 2006. "The objective assessment of lifetime cumulative ultraviolet exposure for determining melanoma risk." *Journal of Photochemistry and Photobiology B: Biology* 85 (3) 2006: 198-204.
- 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.

- Wagner, Helene H., and Marie-Josée Fortin. 2005. "Spatial analysis of landscapes: concepts and statistics." *Ecology* 86 (8): 1975-1987.
- Wan, Neng, Bin Zou, and Troy Sternberg. 2012. "A three-step floating catchment area method for analyzing spatial access to health services." *International Journal of Geographical Information Science* 26 (6): 1073-1089.
- Wheeler, David C., Mary H. Ward, and Lance A. Waller. 2012. "Spatial-temporal analysis of cancer risk in epidemiologic studies with residential histories." *Annals of the Association of American Geographers* 102 (5): 1049-1057.
- Wu, Jilei, Jinfeng Wang, Bin Meng, Gong Chen, Lihua Pang, Xinming Song, Keli Zhang, Ting Zhang, and Xiaoying Zheng. 2004. "Exploratory spatial data analysis for the identification of risk factors to birth defects." *BMC Public Health* 4 (1): 23.
- Wu, Wei, Junqiao Guo, Peng Guan, Yingwei Sun, and Baosen Zhou. 2011. "Clusters of spatial, temporal, and space-time distribution of hemorrhagic fever with renal syndrome in Liaoning Province, Northeastern China." *BMC Infectious Diseases* 11 (1): 229.
- Xie, Yunfeng, Tong-bin Chen, Mei Lei, Jun Yang, Qing-jun Guo, Bo Song, and Xiao-yong Zhou. 2011. "Spatial distribution of soil heavy metal pollution estimated by different interpolation methods: Accuracy and uncertainty analysis." *Chemosphere* 82 (3): 468-476.

Description and Assessment of Assignments

Students must participate in class discussion, submit weekly briefings, prepare one small lecture-style presentation, and turn in homework assignments, including:

Weekly Briefings (10, worth a total of 10%): Each week students select one or more of the assigned readings and share a commentary with other students in the online Discussion Forum before the class session. Students are exempt from writing the weekly briefings on the weeks they have scheduled class presentations.

Class Participation (15, worth a total of 15%): A class participation grade for the semester will be assigned based upon how actively students engage in the class sessions. Students will be required to read all material outlined for each week of the course, and be prepared to participate in group discussions about the readings or to work on hands-on practices in class, depending on the class week (see Weekly Schedule below). Failure to attend or to be adequately prepared for discussion or hands-on practices will lead to the assignment of a lower grade for that week.

Homework Assignments (6, worth a total of 24%): Students will be assigned a total of 6 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 Presentation (1, worth a total of 12%): Students will conduct an in-class presentation based on topics determined in consultation with the instructor. Students will work alone and will be expected to become an expert on that topic and present a short lecture of 30-40 minutes on the topic.

Final Project

Each student will design, conduct and report on a research project related to spatial analysis topics covered in class. The students will propose their own project ideas and determine the topics to be included after consultation with the instructor. The project might take one of two forms: (1) You may have a specific problem in mind and some data you want to analyze; or (2) You may be interested in exploring a spatial analysis method more deeply. 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 (4%): An in-class presentation for your final project idea, including the spatial questions you would like to investigate, how you plan to solve them and the data to be used for analysis.
Proposal (5%): A proposal document developed from the proposal idea presentation and the feedback received.
Final Presentation (10%): A final presentation during the final week of the class session.
Report (20%): 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
Class Participation	15	1	15
Weekly Briefings	10	1	10
Homework Assignments	6	4	24
Class Presentation	1	12	12
Proposal Idea Presentation	1	4	4
Final Project Proposal	1	5	5
Final Project Presentation	1	10	10
Final Project Report	1	20	20
Total	36	-	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.

Additional Policies
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/Daily Activities	Readings and Assignments	Deliverables/Dues
Week 1 1/10	Introduction to Course	De Smith et al. (2018) Ch. 1 O'Sullivan & Unwin (2010) Ch.1 Rezaeian et al. (2007)	No deliverables
Week 2 1/17	Introduction to Geospatial Analysis	O'Sullivan & Unwin (2010) Ch.2 Bolstad (2016) Ch.3 Beyer et al. (2012) Roots (2012) **Homework Assignment #1**	Sign-up for class presentations Weekly Briefing: Wednesday, 1/16
Week 3 1/24* *Monday, 1/21 is a university holiday	Conceptual Framework and Methodological Context	De Smith et al. (2018) Ch2 & 3 Spielman and Logan (2013) Kwan (2012) Mobley et al. (2012)	Weekly Briefing: Wednesday, 1/23 Homework Assignment #1
Week 4 1/31	Maps for Spatial Analysis and Processes	O'Sullivan & Unwin (2010) Ch.3 & 4 Perchoux et al. (2016) Bell et al. (2006) **Homework Assignment #2**	Weekly Briefing: Wednesday, 1/30
Week 5 2/7	Exploratory Spatial Data Analysis	De Smith et al. (2018). Ch. 5-§5.2 Spencer and Angeles (2007) Wu et al. (2004)	Weekly Briefing: Wednesday, 2/6 Homework Assignment #2
Week 6 2/14	Spatial Point Pattern Analysis	De Smith et al. (2015). §5.3.3 & 5.4 O'Sullivan & Unwin (2010) Ch. 5-6 Gatrell et al. (1996) Nkoko et al. (2011) Wheeler et al. (2012) **Homework Assignment #3**	Final project idea presentation: Thursday, 2/14
Week 7 2/21* *Monday, 2/18 is a university holiday	Spatial Autocorrelation	De Smith et al. (2018). §5.5 O'Sullivan & Unwin (2010) Ch. 7- §8.4 Anselin (1995) Wu et al. (2011) Martins-Melo et al. (2012) **Homework Assignment #4**	Weekly Briefing: Wednesday, 2/20 Homework Assignment #3
Week 8 2/28	Spatial Regression	De Smith et al. (2018). §5.6 O'Sullivan & Unwin (2010) §8.5 Matthew and Yang (2012) Conley (2011) **Homework Assignment #5**	Weekly Briefing: Wednesday, 2/27 Homework Assignment #4

Week 9 3/7	Introduction to Raster Analysis	Bolstad (2016) Ch. 10 De Smith et al. (2015). §5.3.4 Baker and Valleron (2014) Wagner and Fortin (2005)	Weekly Briefing: Wednesday, 3/6 Homework Assignment #5
3/10-3/17	*Spring Recess*		
Week 10 3/18	Surface & Field Analysis	De Smith et al. (2015). Ch. 6-§6.4 Bolstad (2016) Ch. 11 Fisher et al. (2006)	Final Project Proposal due Monday, 3/18 Weekly Briefing: Wednesday, 3/20
Week 11 3/25	Deterministic Interpolation Methods	De Smith et al. (2015). §6.5-§6.6 Bolstad (2016) p. 519-533 Tatalovich et al. (2006) Xie et al. (2011) **Homework Assignment #6**	Weekly Briefing: Wednesday, 3/27
Week 12 4/4* *AAG week; schedule might change	Remote Sensing for GIS Applications	Bolstad (2016) Ch.6 Kesten et al. (2011) Sexton et al. (2013) VoPham et al. (2015)	Homework Assignment #6
Week 13 4/11	Geostatistical Interpolation Methods	De Smith et al. (2018). §6.7 Bolstad (2016) p. 539-545 Louis et al. (2014) Goovaerts (2005) Hanna-Attisha et al. (2016)	Weekly Briefing: Wednesday, 4/10
Week 14 4/18	Location and Service Area Problems	De Smith et al. (2018). Ch.7 Henry et al. (2011) Wan et al. (2012) Shi et al. (2012)	Weekly Briefing: Wednesday, 4/17
Week 15 4/25* *Friday, 4/26 is the last day of class	Emerging Spatial Analysis Methods (work on final project)	De Smith et al. (2018) Ch.8 - §8.3 O'Sullivan & Unwin Ch.12 Luna et al. (2014) Pijanowski et al. (2016) Auchincloss et al. (2011)	**Final Presentation**: Thursday, 4/25 (in class) Slides due before presentation starts
FINAL 5/1- 5/8		Final Presentation & final discussion	**Final Report**: Date/time based on USC final exam schedule

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

Student Counseling Services (SCS) – (213) 740-7711 – 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
Provides 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) 740-4900 – 24/7 on call
engemannshc.usc.edu/rsvp
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086
equity.usc.edu, titleix.usc.edu
Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support – (213) 740-2421
 studentaffairs.usc.edu/bias-assessment-response-support
Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation 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.

Student Support and Advocacy – (213) 821-4710
studentaffairs.usc.edu/ssa
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
Provides safety and other updates, 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.