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, 2017, Mondays, 9-12 noon

Location: Spatial Sciences Institute, AHF 145D

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Course Description

This course explores the theoretical foundations, methods, techniques, and software systems for spatial analysis. This includes the latest research in a variety of topics that are central to spatial analysis, including the fundamental spatial concepts, the core components of geospatial analysis (distance and directional analysis, geometrical processing, map algebra, grid models, kernels, nearest neighbor and K statistics, identifying hot spots, etc.), exploratory spatial data analysis and spatial statistics (spatial autocorrelation, spatial regression, geostatistics, etc.), surface analysis (surface form and flow analysis, gridding and interpolation methods, visibility analysis, etc.), and network and locational analysis (shortest path calculation, traveling salesman problems, facility location, arc routing, etc.). Students will also gain a deep understanding and hands-on experience in the ways in which these analysis techniques have been used to explore a variety of health-related 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 the theoretical foundations of geospatial analysis.
- Understand, create, and apply geographic and other data to learn more about the importance of place and its role in shaping or moderating environmental exposures, health-related impacts and outcomes, and the efficacy of health care delivery systems.
- Discuss the relevant spatial analysis approaches and techniques for working with health-related geospatial data.
- Apply relevant spatial analysis techniques to solve spatial health problems.

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

Course Notes

The course will be taught using a lecture format where the instructor will present the core topics and the students will participate and give lectures on some of the subtopics. There are weekly quizzes to ensure that students keep up with the material and readings. In the first half of the course there are also weekly homework assignments to give students first-hand experience with the wide variety of software and systems that can be used for spatial analysis. In the second half of the course, students will form teams and propose and conduct a class project that will give them more depth in one or more course topics of interest. The class will encourage student participation with ample discussion time for reviewing readings, homework, quizzes, and other course material.

Technological Proficiency and Hardware/Software Required

The analysis software and geospatial data required for course assignments will be accessed using computing resources provided by the Spatial Sciences Institute.

Required Readings and Supplementary Materials

Two books will be used throughout the course and you may consider purchasing one or both of these books from either the USC Bookstore or an online outlet such as Amazon.

- Bivand, R. S., Pebesma, E. J., & Gomez-Rubio, V. (2013). *Applied Spatial Analysis with R* (2nd Ed.). New York, NY: Springer.

- De Smith, M. J., Goodchild, M. F., & Longley, P. A. 2013. *Geospatial Analysis: A Comprehensive Guide to Principles, Techniques, and Software Tools* (5th Ed.). Winchelsea, UK: Winchelsea Press.

These books will be supplemented with weekly readings that will be accessed via the USC Library's electronic collections and/or provided by the instructors via Blackboard.

Description and Assessment of Assignments

Students must prepare a lecture, participate in a team project, participate in class discussion, take weekly quizzes, and turn in weekly homework assignments.

Class Participation (10%): A class participation grade for the semester 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.

Class Presentations (10%): Students will conduct two seminars based on topics determined in consultation with the instructor. Students will work alone or in teams (depending on class size) and will be expected to become an expert on that topic and present a short lecture of 30-45 minutes on the topic.

Weekly Quizzes (26%): Each week students take a quiz on the lectures and readings from the previous week. There is no final, so these quizzes will be used to assess how well the students have learned the material.

Homework Assignments (24%): Students will be assigned weekly homework during the first half of the course. This will usually involve gathering data and R scripts (this is an open source toolbox; see Bivand et al. 2013 for more details), running the script(s), analyzing the results, and writing a short report that answers each of the questions you were assigned.

Team Project (30%): In the second half of the course, students will work in teams on projects determined in consultation with the instructor. The teams will propose their own projects based on the topics covered in class. These might take one or other 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.

Grading Breakdown

Assignment	No. of Assignments	% of Grade
Class Participation	13	10
Class Presentations	2	10
Weekly Quizzes	13	26
Homework Assignments	6	24
Team Projects	1	20
TOTALS	**35**	**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 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 Homework	Deliverables/Due Dates
Week 1 1/9	**Spatial Data Analysis Basics** Brief introductions with a discussion of class goals, projects, technology, plans, and expectations. Basics of spatial data, including definitions, basic primitives, spatial relationships, spatial statistics, and spatial data infrastructures.	**De Smith et al. (2015).** *Geospatial Analysis: A Comprehensive Guide to Principles, Techniques, and Software Tools* (5th Ed.). Winchelsea, UK, Winchelsea Press (Ch. 1 – Introduction and Terminology, & Ch. 2 – Conceptual Frameworks for Spatial Analysis). **Beyer et al. (2012).** Five essential properties of disease maps. *Annals of the Association of American Geographers* 102: 1067-75. **Mobley et al. (2012).** Spatial heterogeneity in cancer control planning and cancer screening behavior. *Annals of the Association of American Geographers* 102: 1113-24. **Bivand et al. (2013).** *Applied Spatial Data Analysis with R* (2nd Ed.). New York, Springer.	Group discussion based on readings.
Week 2 1/16	**Methodological Context** A discussion of spatial analysis and the PPDAC (Problem, Plan, Data, Analysis, Conclusions) model.	**De Smith et al. (2015).** Methodological Context (Ch. 3). **Matthews & Yang (2013).** Spatial polygamy and contextual exposures (SPACEs): Promoting activity space approaches in research on place and health. *American Behavioral Scientist* 57: 1057-1081. **Hirsch et al. (2014).** Generating GPS activity spaces that shed light upon the mobility habits of older adults: A descriptive analysis. *International Journal of Health Geographics* 13: 51. **Shankardass (2012).** Place-based stress and chronic disease: A systems view of environmental determinants. In O'Campo & Dunn (Eds.), *Rethinking Social Epidemiology: Towards a Science of Change.* New York, Springer: 113-136. **Boone-Heinonen et al. (2011).** Environment and physical activity dynamics: The role of residential self-selection. *Psychology of Sport and Exercise* 12: 54-60. **Patz et al. (2014).** Climate change: Challenges and opportunities for global health. *Journal of the American Medical Association* 312: 1565-1580.	Quiz Assignment #1 Group discussion based on readings

Week 3 1/23	**Geometric Operations** A discussion of the role of points, lines, and polygons as well as tessellations and triangulations and various geometric measurements in supporting spatial analysis.	**De Smith et al. (2015).** Building Blocks of Spatial Analysis (Ch. 4; pp. 126-204). **Brownson et al. (2000).** Measuring the built environment for physical activity: State of the science. *American Journal of Preventive Medicine* 36(4 Suppl): S99-123. **Spielman & Yoo (2009).** The spatial dimensions of neighborhood effects. *Social Science and Medicine* 68: 1098-1105. **Gibson et al. (2011).** Housing and health inequalities: A synthesis of systematic reviews of interventions aimed at different pathways linking housing and health. *Health and Place* 17: 175-184. **Ding & Gebel (2012).** Built environment, physical activity, and obesity: What have we learned from reviewing the literature? *Health and Place* 18: 100-105. **Spielman & Logan (2013).** Using high-resolution population data to identify neighborhoods and establish their boundaries. *Annals of the Association of American Geographers* 103: 67-84.	Quiz Assignment #2 Group discussions based on readings
Week 4 1/30	**Distance, Directional, & Grid Operations** A discussion of some of the methods and approaches for performing simple calculations, a variety of distance and directional operations, grid operations and map algebra.	**De Smith et al. (2015).** Building Blocks of Spatial Analysis (Ch. 4; pp. 205-291). **James et al. (2014).** Do minority and poor neighborhoods have higher access to fast-food restaurants in the United States? *Health and Place* 29: 10-17. **Borst et al. (2009).** Influence of environmental street characteristics on walking choice of elderly people. *Journal of Environmental Psychology* 29: 477-484. **Coveney & O'Dwyer (2009).** Effects of mobility and location on food access. *Health and Place* 15: 45-55. **Cao et al. (2009).** Examining the impacts of residential self-selection on travel behavior: A focus on empirical findings. *Transport Reviews* 29: 359-395.	Quiz Assignment #3 Group discussion based on readings
Week 5 2/6	**Exploratory Spatial Data Analysis** A discussion of some of the methods and	**De Smith et al. (2015).** Data Exploration and Spatial Statistics (Ch. 5; pp. 292-320).	Quiz Assignment #4

	approaches for conducting exploratory spatial and spatio-temporal data analysis, including outlier detection, cross tabulations and conditional choropleth maps, trend analysis of continuous data, and cluster hunting and scan statistics.	**Jacquez (1996).** A K-nearest neighbor test for space-time interaction. *Statistics in Medicine* 15: 1935-1949. **Conley (2011).** Estimation of exposure to toxic releases using spatial interaction modeling. *International Journal of Health Geographics* 10: 20. **Nkoko & Piarroux (2011).** Dynamics of cholera outbreaks in Great Lakes region of Africa, 1978-2008. *Emerging Infectious Diseases* 17: 2026-2034. **Kwan (2012).** The uncertain geographic context problem. *Annals of the Association of American Geographers* 102: 958-968.	Group discussion based on readings
Week 6 2/13	**Grid-based Statistics & Models** A discussion of some of the methods and approaches for calculating grid-based statistics, including cross-tabulated grid data, the Kappa Index and Cramer's V statistic, quadrat analysis of grid datasets, and a variety of landscape metrics.	**De Smith et al. (2015).** Data Exploration and Spatial Statistics (Ch. 5; pp. 321-337). **Yang & Atkinson (2008a).** Individual space-time activity-based model: A model for simulation of airborne infectious disease transmission by activity bundle simulation. *Environment and Planning B* 35: 80-99. **Yang & Atkinson (2008b).** Parameter exploration of the raster space activity bundle simulation. *Journal of Geographical Systems* 10: 263-289. **Sexton et al. (2013)**. Urban growth of the Washington, D.C.-Baltimore, MD metropolitan region from 1984 to 2010 by annual, Landsat-based estimates of impervious cover. *Remote Sensing of Environment* 129: 42-53. **Nowak et al. (2013).** Modeled PM2.5 removal by trees in ten U.S. cities and associated health effects. *Environmental Pollution* 178: 395-402. **Baker & Valleron (2014).** An open source software for fast grid-based data-mining in spatial epidemiology (FGBASE). *International Journal of Health Geographics* 13: 46.	Quiz Assignment #5 Group discussion based on readings
Week 7 2/20	**Point Sets & Distance Statistics** A discussion of some of the methods and approaches for calculating distance-derived statistics, including nearest	**De Smith et al. (2015).** Data Exploration and Statistical Analysis (Ch. 5; pp. 338-358). **Kulldorff & Nagarwalla (1995).** Spatial disease clusters: Detection and inference. *Statistics in Medicine* 14: 799-810.	Quiz Assignment #6 Group discussion based on readings

	neighbor methods, pairwise distances, hot spot and cluster analysis, and proximity matrix comparisons.	**Kulldorff (2008).** A spatial scan statistic. *Communications in Statistics: Theory and Methods* 26: 1481-1496. **Anselin (1995).** Local indicators of spatial association; LISA. *Geographical Analysis* 27: 93-115.	
Week 8 2/27	**Spatial Autocorrelation** A discussion of some of the methods and approaches for identifying and quantifying spatial autocorrelation, including global spatial autocorrelation, local indicators of spatial association (LISA), and significance tests for autocorrelation indices.	**De Smith et al. (2015).** Data Exploration and Spatial Statistics (Ch. 5; pp. 359-387). **Klug et al. (2009).** Enhanced geographically restricted surveillance simulates sporadic Creutzfeldt-Jakob disease cluster. *Brain* 132: 493-501. **Wu et al. (2011).** Clusters of spatial, temporal, and space-time distribution of hemorrhagic fever with renal syndrome in Liaoning Province, northeastern China. *BMC Infectious Diseases* 11: 229. **Martins-Melo et al. (2012).** Mortality of Chagas' disease in Brazil: Spatial patterns and definition of high-risk areas. *Tropical Medicine and International Health* 17: 1066-1075. **Lemke et al. (2013).** Detecting cancer clusters in a regional population with local cluster tests and Bayesian smoothing methods: A simulation study. *International Journal of Health Geographics* 12: 54.	Quiz Group discussions based on readings Identify teams and propose team project topics
Week 9 3/6	**Spatial Regression** A discussion of some of the methods and approaches for performing simple regression and trend surface modeling, Geographically Weighted Regression (GWR), spatial autoregressive and Bayesian modeling, and spatial filtering models.	**De Smith et al. (2015).** Data Exploration and Spatial Statistics (Ch. 5; pp. 388-414). **O'Campo et al. (2015).** The Neighbourhood Effects on Health and Well-being (NEHW) study. *Health and Place* 31: 65-74. **Barakat-Haddad et al. (2012).** Does chronic exposure to air pollution in childhood impact long-term respiratory health? *Professional Geographer* 64: 446-463. **Root (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* 103: 986-995. **Wheeler et al. (2012).** Spatio-temporal analysis of cancer risk in epidemiological studies with residential histories. *Annals of the*	Quiz Group discussion based on readings

		Association of American Geographers 103: 1049-1057. **Pattinson et al. (2015).** Proximity to highways and local resident perceptions of air quality. *Health and Place* 31: 154-162.	
Week 10 3/20	**Surface & Field Analysis** A discussion of some of the methods and approaches for modeling surfaces with an emphasis on surface geometry calculations and metrics.	**De Smith et al. (2015).** Surface and Field Analysis (Ch. 6; pp. 415-430). **Kestens et al. (2011).** Modelling the variation of land surface temperature as determinant of risk of heat-related health events. *International Journal of Health Geographics* 10: 7. **Messina et al. (2012).** Climate change and risk projection: Dynamic spatial models of testse and African trypanosomiasis in Kenya. *Annals of the Association of American Geographers* 103: 1038-1048. **Bell et al. (2014).** Green space, health and well-being: Making space for individual agency. *Health and Place* 30: 287-292. **McCann et al. (2014).** Modeling larval malaria vector habitat locations using landscape features and cumulative precipitation measures. *International Journal of Health Geographics* 13: 17.	Quiz Group discussion based on readings
Week 11 3/27	**Deterministic Interpolation Methods** A discussion of some of the methods and approaches for gridding, interpolation, and contouring with a special focus on deterministic interpolation methods.	**De Smith et al. (2015).** Surface and Field Analysis (Ch. 6; pp. 471-504). **Tatalovich et al. (2006a).** A comparison of Thiessen polygon, kriging, and spline models of potential UV exposure. *Cartography and Geographic Information Science* 33: 217-237. **Tatalovich et al. (2006b).** The objective assessment of lifetime cumulative ultraviolet exposure for determining melanoma risk. *Journal of Photochemistry and Photobiology B: Biology* 85: 198-204. **Xia et al. (2015).** Traffic-related air pollution and health co-benefits of alternative transport in Adelaide, South Australia. *Environment International* 74: 281-290.	Quiz Group discussion based on readings
Week 12 4/3	**Geostatistical Interpolation Methods** A discussion of the core concepts in geostatistics and the kriging family of	**De Smith et al. (2015).** Surface and Field Analysis (Ch. 6; pp. 505-534). **Louis et al. (2014).** Modeling tools for dengue risk mapping: A systematic review. *International Journal of Health Geographics* 13: 50**.**	Quiz Group discussion based on readings

	interpolation techniques.	**Hampton et al. (2011).** Adjusting for sampling variability in sparse data: Geostatistical approaches to disease mapping. *International Journal of Health Geographics* 10: 54.	
Week 13 4/10	**Network Analysis Problems** A discussion of the core concepts and key challenges in network analysis along with methods and approaches for constructing networks and calculating optimal routes and tours.	**De Smith et al. (2015).** Network and Location Analysis **(**Ch. 7; pp. 535-587). **Kiss et al. (2006).** The network of sheep movements within Great Britain: Network properties and their implications for infectious disease control. *Journal of the Royal Society: Interface* 3: 669-677. **Henry et al. (2011).** Breast cancer stage at diagnosis: Is travel time important? *Journal of Community Health* 36: 933-942. **Emch et al. (2012).** Integration of spatial and social network analysis in disease transmission studies. *Annals of the Association of American Geographers* 103: 1004-1015. **Bian et al. (2012).** Modeling individual vulnerability to communicable diseases: A framework and design. *Annals of the Association of American Geographers* 103: 1016-1025. **Hirsch et al. (2014).** Generating GPS activity spaces that shed light upon the mobility habits of older adults: A descriptive analysis. *International Journal of Health Geographics* 13: 51.	Quiz Group discussion based on readings
Week 14 4/17	**Location & Service Area Problems** A discussion of the core concepts and key challenges in location analysis along with methods and approaches for solving service area and network traversal problems.	**De Smith et al. (2015).** Network and Location Analysis **(**Ch. 7; pp. 588-608). **Bell et al. (2012).** Access to primary health care: Does neighborhood of residence matter? *Annals of the Association of American Geographers* 103: 85-105. **Shi et al. (2012).** Spatial access and local demand for major cancer care facilities in the United States. *Annals of the Association of American Geographers* 103: 1125-1134. **Wan et al. (2012).** A three-step floating catchment area method for analyzing spatial access to health services. *International Journal of Geographical Information Science* 26: 1073-1089. **Jia et al. (2014).** Selecting the optimal healthcare centers with a modified P-median model: A visual analytic	Quiz Group discussion based on readings

		perspective. *International Journal of Health Geographics* 13: 42.	
Week 15 4/24	**Final Presentations** Students will present their team projects, summarizing the insights garnered from each phase of the analysis process as experienced in their specific problem context.		Team presentations
FINAL 5/5			Discussion and submission of team reports during the scheduled final examination from 8:00 to 10:00 a.m. on Friday, 5/5

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 Section 11, *Behavior Violating University Standards* https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions. 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.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* http://equity.usc.edu or to the *Department of Public Safety* http://adminopsnet.usc.edu/department/department-public-safety. This is important for the safety of the whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage http://sarc.usc.edu describes reporting options and other resources.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* http://emergency.usc.edu will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.