Stat 597a
Spatial Models
T R, 9:05–10:20am, 025 Deike Building

Prof. Ben Shaby
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Office Hours: Monday 10:00–11:00am, Wednesday 1:30–2:30pm

Course Description: Spatial data arises in a wide range of scientific disciplines, including the geosciences, environmental sciences, image processing, and public health. This course will introduce you to methods and models that have been developed for spatial data. We will cover three main types of spatial data: geostatistical (point-referenced) data, lattice or areal data, and point process data. One unifying theme will be the specification and fitting of probability models for such data, using stochastic processes and hierarchical models to represent the complex dependencies that often arise. My goals are that by end of the course, you will be able to

• Describe common methods and models for spatial data,
• Read and discuss new methods in the literature, based on an understanding of the basic spatial statistics approaches, principles, and main assumptions,
• Evaluate which methods to use for spatial datasets that may arise in your own research, and
• Implement methods using statistical software.

Course Structure The structure of this course is designed to give you both an overview of the main methods in spatial statistics, as well as to facilitate a deeper understanding of methods that are of particular interest to you. To that end, the course will include

• Readings - from the textbook and occasional outside sources
• Lectures - overviewing main ideas, showing illustrative examples (3/4 of class time)
• Student presentation and discussion sessions - see below (1/4 of class time)
• Assignments - 4-5 problem sets
• Project - including small literature review and data analysis

Prerequisites Probability and one semester of mathematical statistics (i.e. 513 and 514 or 414 and 415), or instructor permission. Familiarity with topics from matrix algebra and linear models in statistics is also assumed. Assignments will make use of the open source programming language
and environment called \texttt{R}, and I will occasionally do worked examples in class that involve \texttt{R} programming. Come talk to me if you are not comfortable using \texttt{R}.


I will assign specific sections of the book to be read before class. My lectures will draw from additional sources and may not cover everything in the assigned reading. Homework questions will be based on both the book and the lectures.

Some additional references I recommend are

- “Handbook of Spatial Statistics” by Gelfand, Diggle, Fuentes, and Guttorp
- “Statistics for Spatial Data” by Cressie
- “Model-based Geostatistics” by Diggle and Ribeiro
- “Gaussian Markov Random Fields” by Rue and Held
- “Statistical Analysis of Spatial Point Processes” by Diggle
- “Applied Spatial Data Analysis with R” by Bivand, Pebesma, and Gomez-Rubio

**In-class Presentations** You will choose a journal article to present to the class. These may be seminal works cited in the textbook, recent articles extending an idea we have discussed, or scientific applications. I will discuss your choice of article with you and make sure it serves the class as a whole. You will announce the article to the class at least one week prior to presenting it, and the rest of the class will read it. However, it is your job to deeply understand the article. This may involve reading additional sources, working through derivations, or implementing parts of an analysis yourself. The time you will have to present the article to the class will depend on the enrollment. I expect you to spend approximately two weeks reading and preparing. If the class has too many students to make presentations feasible, I may change the format.

**Assignments** I will post assignments to the class Canvas page. They will consist of both written problems and real data examples involving some computing. You will typically have two weeks to complete each assignment and turn in a hard copy at the beginning of class. As a general rule I will not accept late assignments. In special cases I may grant extensions; please talk to me well ahead of the due date.

**Final projects** You will carry out either a detailed simulation study, a novel analysis on a data set of your choosing, or an in-depth literature review on a relevant topic. For the data analysis option, I expect you to choose an appropriate method for the analysis, as well as carrying out a small review of the relevant literature (statistical and subject-matter appropriate). Additional details will be provided towards the end of the semester. You will have approximately three weeks to complete your project.

**Grading** Your final grade will be a weighted average of your homework average (60%), in-class presentation (20%), and final project (20%).
Academic Integrity:

Academic integrity is the pursuit of scholarly activity in an open, honest and responsible manner. Academic integrity is a basic guiding principle for all academic activity at The Pennsylvania State University, and all members of the University community are expected to act in accordance with this principle. Consistent with this expectation, the Universitys Code of Conduct states that all students should act with personal integrity, respect other students dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts. Academic integrity includes a commitment by all members of the University community not to engage in or tolerate acts of falsification, misrepresentation or deception. Such acts of dishonesty violate the fundamental ethical principles of the University community and compromise the worth of work completed by others.

Disability Accommodation:

Penn State welcomes students with disabilities into the Universitys educational programs. Every Penn State campus has an office for students with disabilities. Student Disability Resources (SDR) website provides contact information for every Penn State campus (http://equity.psu.edu/sdr/disability-coordinator). For further information, please visit Student Disability Resources website (http://equity.psu.edu/sdr/).

In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: See documentation guidelines (http://equity.psu.edu/sdr/guidelines). If the documentation supports your request for reasonable accommodations, your campus disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

Counseling and Psychological Services:

Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

Counseling and Psychological Services at University Park (CAPS) (http://studentaffairs.psu.edu/counseling/): 814-863-0395

Counseling and Psychological Services at Commonwealth Campuses (http://senate.psu.edu/faculty/counseling-services-at-commonwealth-campuses/)

Penn State Crisis Line (24 hours/7 days/week): 877-229-6400 Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741
Educational Equity / Reporting Bias:

Consistent with University Policy AD29, students who believe they have experienced or observed a hate crime, an act of intolerance, discrimination, or harassment that occurs at Penn State are urged to report these incidents as outlined on the University’s Report Bias webpage (http://equity.psu.edu/reportbias/).

ECOS Code of Mutual Respect:

The Eberly College of Science Code of Mutual Respect and Cooperation (http://science.psu.edu/climate/support-and-resources/code-of-mutual-respect-and-cooperation-pdf/view) embodies the values that we hope our faculty, staff, and students possess and will endorse to make the Eberly College of Science a place where every individual feels respected and valued, as well as challenged and rewarded.