

**Instructor:** Dr. Amanda S. Hering

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Office Hours: M 1-2, T 11-12, F 9-10. Other times by appointment only.

**Prereq:** (MATH 334 & 335), (MATH 530 & 531), (MATH 534 & 535), or equivalent

In particular, a strong background in fundamental statistical theory typically taught in a first year course in probability and inference (e.g., probability distributions, conditional expectation, maximum likelihood estimation) is needed. In addition, it is assumed that students will have a good working knowledge of linear model theory, linear algebra, and matrix algebra.

**Course Schedule:** MWF 2-2:50 pm, Location Coolbaugh Hall 210

**Web Page:** The username and password for the website will be given in class.

<http://inside.mines.edu/~ahering/guard/spatial.html>

**Course Description:** Spatial statistics is a branch of statistics used to analyze data observed on a 2 or 3-dimensional surface with either regular or irregular spacing. This type of data arises in almost every field of study, and much of the early development of spatial data was driven by the needs of scientists in geography, mining, meteorology, and geology. For example, petroleum companies collect wave strength information around off-shore oil platforms; when mining for natural resources, drill hole data covering the spatial area of interest is collected; construction companies compile information on soil type and compaction; geophysicists collect electromagnetic data to recreate images of subsurface features; criminologists collect data on the location and characteristics of crimes; traffic officers record the location and causes of vehicle collisions.

Spatial data must be handled carefully. As an example in geostatistics, observations in close spatial proximity tend to be more similar than would be expected if the observations are independent of each other. This correlation must be handled carefully since ignoring the correlation among observations can cause an investigator to seriously misrepresent (and frequently overstate) the confidence he or she has in applying conclusions drawn from a sample to an entire population. This course will give senior-level and graduate students the tools to analyze such data.

Many academic disciplines use software designed to meet their specific needs, but in this course, students will learn how to use a free programming language (called R,

which is closely related to S-PLUS) to develop the tools needed to properly analyze spatial data. Learning to program in R gives students the power to double-check their discipline-specific software, and it also gives them the flexibility to analyze data with methods that are not automatically provided by their software.

**Course Objectives:** By the end of the course, the student should be able to:

1. Understand the three basic types of spatial data and know the approaches used in analyzing each type.
2. Apply the concepts of spatial statistics to real datasets.
3. Use the R software (or other software package of your choosing) to perform spatial analysis of real data sets.

**Course Outline:** The following is a rough list of topics that will be covered in this course:

- Geostatistical Data: Random fields; Variograms; Covariances; Stationarity; Non-stationarity; Kriging; Simulations; Bayesian hierarchical models
- Lattice Data: Spatial regression; SAR, CAR, QAR, & MA models; Geary/Moran indices
- Point Patterns: Point processes; K-function; Complete spatial randomness; Homogeneous/inhomogeneous processes; Marked point processes
- Special Topics: Spatio-temporal modeling (if time permits)

**Textbook: (Required)** Schabenberger, O. and Gotway, C. A. (2005) *Statistical Methods for Spatial Data Analysis*. Chapman & Hall/CRC Press; ISBN: 1-58488-322-7

**(Optional)** Bivand, R. S., Pebesma, E. J., and Gómez-Rubio, V. (2008) *Applied Spatial Data Analysis with R*. Springer Science + Business Media; ISBN: 978-0-387-78171-6

Can be accessed for free through the university at the following website:

<http://www.springerlink.com/content/978-0-387-78170-9/#section=147789&page=13&locus=57>

**Other References:** This is a list of other commonly used texts in spatial and space-time statistics.

Banerjee, S., Carlin, B. P., and Gelfand, A. (2003) *Hierarchical Modeling and Analysis for Spatial Data*. Chapman & Hall/CRC.

Cressie, N. (1993) *Statistics for Spatial Data*. Wiley.

Cressie, N. and Wikle, C. (2011) *Statistics for Spatio-Temporal Data*. Wiley.

Diggle, P. J. (2003) *Statistical Analysis of Spatial Point Patterns*. Hodder Arnold.

Diggle, P. J. and Ribeiro, R. J. (2007) *Model-based Geostatistics*. Springer\*.

Haining, R. (1990) *Spatial data analysis in the social and environmental sciences*. Cambridge.

Le, N. D. and Zidek, J. V. (2006) *Statistical Analysis of Environmental Space-Time Processes*. Springer\*.

Møller, J. and Waagepetersen, R. P. (2003) *Statistical Inference and Simulation for Spatial Point Processes*. Chapman & Hall/CRC.

Stein, M. L. (1999) *Interpolation of Spatial Data. Some Theory for Kriging*. Springer.

Wackernagel, H. (2003) *Multivariate Geostatistics: An Introduction with Applications*. Springer.

Waller, L. and Gotway, C. A. (2004) *Applied Spatial Statistics for Public Health Data*. Wiley.

\*Denotes texts available through CSM's library access to Springer via <http://www.springerlink.com>.

**Course Work:** Your grade for the course will be based on the following (relative weights given in percentage):

- **Homework Assignments (30%):** Bi-weekly homework assignments will be given throughout the semester. Assignments will be collected at the START of class on the due date. Late assignments will not be accepted.
- **Exam (30%):** There will be one in-class closed book exam tentatively scheduled for Wednesday, April 6th.
- **Project (40%):** A project will be due at the end of the semester, and a poster session to present the work will be held in place of the class' 2-hour final exam. More details will be given as the semester progresses. Late projects will not be accepted.

The following letter grades are guaranteed:

A	B	C	D	F
100-90%	89-80%	79-70%	69-60%	59-0%

**Notes:** A few more things...

- Check the website frequently for updates.
- I would like to know about any particular academic difficulties or personal problems that are affecting a student's performance.