Geog 565 - Syllabus - Fall 2017

Spatio-temporal Variation in Ecology and Earth Science

Instructor: Dr. Julia Allen Jones (jonesj@geo.oregonstate.edu)

Credits: 4. CRN 25417 (lecture), 25418 (lab)

Meeting time: MWF 11:00 - 11:50, Wilkinson 207; Lab M 13:00-14:50, Wilkinson 210

Office hours: MWF 12:00-1:00, Wilkinson 220, 737 1224.

TA: Stephanie Bianco

Objective: To develop a working model of how to investigate ecological and physical processes and the spatio-temporal patterns they produce. By the end of the term you should have a working knowledge of:

1. Objectives of spatio-temporal studies in ecology and earth science
2. Concept of causation and experimentation vs. observational studies
3. Importance of designing a study around a testable hypothesis
4. Sampling designs for ecological and earth science studies
5. Basic concepts of spatio-temporal process and pattern
6. Autocorrelation: why it matters, how to measure and deal with it
7. Methods for measuring spatial structure: interpolation (e.g., inverse distance weighting, kriging), point patterns (e.g., nearest-neighbor, Ripley’s K), geostatistics (semi-variograms, correlograms), spectral analysis, wavelet analysis, fractals (including methods for dealing with tracking data from tagged organisms or other tagged objects)
8. Summary and comparison of methods

Course assessment:

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<tbody>
<tr>
<td>Exercises</td>
<td>50</td>
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<tr>
<td>Project</td>
<td>30</td>
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<td>Final</td>
<td>20</td>
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Readings:

(2) Selected journal articles available on Canvas
GEOG 565 – Spatiotemporal analysis in Ecology and Earth Science

Class structure and expectations

Flipped classroom: Students are expected to watch the lectures BEFORE each class meeting, and come to class prepared to discuss and ask questions.

Class meetings: These will be used for in-class exercises, questions, and discussion. Students are expected to lead during these times.

Lectures: All lectures will be online.

Quizzes: Quizzes will be given in class. Quizzes will not be announced in advance. Students are expected to be prepared for quizzes in any class meeting time.

Labs: All labs will be online. Labs will be discussed during the class meeting time prior to the lab. Students will be given two weeks to complete each lab (except Lab 3).

Meta-analysis. The meta-analysis is a research project that asks you to identify and evaluate the use of spatio-temporal statistics. It is due in the middle of the term.

Students are expected to:

Be patient with yourself: the concepts in this class may not come easily to you, but that is OK. Keep at it and be sure to ask lots of questions. Come to office hours for help, and talk to the TA.

Manage your time: Be sure to allow yourself one hour to watch the lecture before each class. Take notes, so you can remember your questions and ask them in class.

Don’t be intimidated: this class is basically about applied common sense. It is not fancy stuff, and you will get it!
## Lecture Topics and Readings

*Key: Lecture topics and required lecture preparation – black font. **Bold font = review this lecture online, before class. Lab and meta-analysis—red font.*

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Lecture topic and readings</th>
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<tbody>
<tr>
<td>0</td>
<td>9/20</td>
<td>Introduction, objectives Pattern/process interactions in ecology, earth science Lecture 1 and Chapter 1 of J.A. Jones draft text - “Why this book?”</td>
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<tr>
<td>0</td>
<td>9/22</td>
<td>Spatio-temporal analysis without Spatio-temporal Statistics Lecture 1, cont’d.</td>
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<tr>
<td>0</td>
<td>9/25</td>
<td>Framing questions in spatio-temporal analysis Lecture 3 (second half) and Chapter 3 of J.A. Jones draft text - “Framing questions with autocorrelation in mind” In class discussion of Lab 1 LAB: Lab 1</td>
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<tr>
<td>1</td>
<td>9/27</td>
<td>Framing questions in spatio-temporal analysis Lecture 3 (first half) and Chapter 3 of J.A. Jones draft text - “Framing questions with autocorrelation in mind” DUE: 1 p. description of spatio-temporal process for your meta-analysis (part A)</td>
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<td>1</td>
<td>9/29</td>
<td>Lecture 3 and Chapter 3, cont’d.</td>
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<tr>
<td>2</td>
<td>10/2</td>
<td>Types of pattern Lecture 4 (first half) and Chapter 4 of J.A. Jones draft text - “Pattern and scale” LAB: Lab 1</td>
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<tr>
<td>2</td>
<td>10/4</td>
<td>The importance of scale Lecture 4 (second half) Chapter 4 of J.A. Jones draft text - “Pattern and scale”</td>
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<tr>
<td>2</td>
<td>10/6</td>
<td>Sampling and experimental design Lecture 5 and Chapter 5 of J.A. Jones draft text – “Sampling strategy and experimental design” DUE: Lab 1 - Inter-point Distance, Spatial and Parametric Statistics</td>
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<tr>
<td>3</td>
<td>10/9</td>
<td>Lecture 5 and Chapter 5 of J.A. Jones draft text – “Sampling strategy and experimental design” In class discussion of Lab 2. LAB: Lab 2</td>
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3 10/11 Choosing a spatio-temporal statistic
Lecture 6 and Chapter 6 of J.A. Jones draft text – “How to get there from here: A roadmap of spatio-temporal statistical methods”

3 10/13 Plotting the data
Lecture 7 and Chapter 7 of J.A. Jones draft text- “Plotting the data”

4 10/16 Plotting the data
Lecture 7 and Chapter 7 of J.A. Jones draft text- “Plotting the data”
LAB: Lab 2

4 10/18 Spatial statistics: Analysis of patterns of points: quadrat, nearest neighbor
Lecture 8 and Chapter 8 of J.A. Jones draft text – “Presence/absence and occurrences of events: analysis of point processes”
DUE: Meta-analysis project: list of titles and abstracts of 30 articles (part B)

4 10/20 Spatial statistics: Analysis of patterns of points, cont’d.
Lecture 8 and Chapter 8 of J.A. Jones draft text – “Presence/absence and occurrences of events: analysis of point processes”
DUE: Lab 2 – Plotting the data: Moving windows/adjacency, spatial interpolation, filtering

5 10/23 Univariate analysis of continuous spatial processes: Geostatistics
Lecture 9 and Chapter 9 of J.A. Jones draft text, “Patches, gradients, and memory of the past”
LAB: Lab 3

5 10/25 Univariate analysis of continuous spatial processes: Geostatistics
Lecture 9 and Chapter 9, cont’d.

5 10/27 Univariate analysis of continuous spatial processes: Geostatistics
Lecture 9 and Chapter 9, cont’d.

6 10/30 Bi-, multi-variate analysis of continuous spatial processes: Mantel test
Lecture 9 and Chapter 9, cont’d.
LAB: Lab 4
DUE: Lab 3 - Quadrat Analysis, Nearest Neighbor, Ripley’s K

6 11/1 Multi-scale analysis of continuous spatial processes: Spectral analysis
Lecture 10 and Chapter 10 of J.A. Jones draft text, “A world of cycles and patches at multiple scales”

6 11/3 Multi-scale analysis of continuous spatial processes: Spectral analysis
Lecture 10 and Chapter 10, cont’d.

7 11/6 Analysis of multiple scales of variation: Wavelet analysis
Lecture 11 and Chapter 11 of J.A. Jones draft text, “Edges and sudden changes”
Due: uploaded version of meta-analysis spreadsheet on canvas (part C)
LAB: Lab 4.

7 11/8 Analysis of multiple scales of variation: Wavelet analysis
Lecture 11 and Chapter 11 of J.A. Jones draft text, “Edges and sudden changes”
DUE: Lab 4 - Geostatistics (semi-variograms, correlograms)

7 11/10 Holiday - Veteran's Day

8 11/13 Scale-independence of patterns: Fractals
Lecture 12 and Chapter 12 of J.A. Jones draft text, “Self-similarity, and the importance of small, rare things”
LAB: Lab 5

8 11/15 Scale-independence of patterns: Fractals
Lecture 12 Chapter 12 of J.A. Jones draft text, “Self-similarity, and the importance of small, rare things”

8 11/17 Lags, synchrony, and alternate stable states
Lecture 13 and Chapter 13 of J.A. Jones text
Due: meta-analysis essays and articles (parts E and F)

9 11/20 Lags, synchrony, and alternate stable states
Lecture 13 and Chapter 13 of J.A. Jones text
LAB: Lab 5

9 11/22 Lecture 14: Summary and comparison of spatial statistical methods

9 11/24 Thanksgiving holiday

10 11/27 Review for final exam
DUE: Lab 5 – Spectral Analysis, Cross-Variograms, Cross-Correlograms, Wavelet Analysis, Fractal Dimension

10 11/29 Review for final exam
10 12/1 Review for final exam
F 12/6 Final – 9:30 – 11:30 AM, Wilkinson 207 OR Digital Earth.
Optional readings

Lecture 1/Chapter 1

Chapter 2 (no lecture)

Lecture 3/Chapter 3

Lecture 4/Chapter 4

Lecture 5/Chapter 5

Lecture 6/Chapter 6

Lecture 7/Chapter 7

Lecture 8/Chapter 8

Lecture 9/Chapter 9

Lecture 10/Chapter 10

Lecture 11/Chapter 11

Lecture 12/Chapter 12

Lecture 13/Chapter 13

Lecture 14
Objective
To critically evaluate the status of spatio-temporal analysis/landscape studies in the published literature in a topic area relevant to your research

Due dates
A. By September 27, 2017. Hand in a hard copy AND upload onto Canvas (assignment folder) a one-page description of your proposed topic area. Provide one paragraph describing the problem you are studying, and one paragraph that completes the sentence, “my meta-analysis will examine the literature on the spatial/temporal/spatio-temporal patterns of xxx.” Identify 5 keywords that you will use in your search.

B. Starting immediately, but for completion by October 18, 2017. Find abstracts/titles of 30 journal articles involving spatio-temporal analysis on your topic over the past three decades.

1) For each of the past 3 decades find ~10 articles that deal with some aspect of spatio-temporal analysis relevant to your topic. Use successive keywords to enlarge or restrict your search in order to get the required number. Keywords include those related to your topic, combined with any of these: spatial [temporal], spatial [temporal] pattern, spatial [temporal] pattern analysis, variation, variability, spatial [temporal] distribution, cycles [cyclical], gradients, edges, thresholds, scale, scaling, fractal, self-similar.

2) Use on-line journal and database access services through the Valley Library (http://osulibrary.oregonstate.edu/) to search for articles. The database link is: http://osulibrary.oregonstate.edu/research-databases.

3) At the top of the research database page, you'll find web search facilities like the ISI Web of Knowledge, Academic Search Premier, and Google Scholar www.scholar.google.com. Scrolling down, you'll find JSTOR, which is useful for older literature.

4) CHECK to make sure that each article in your collection contains data and statistical analysis of data. AVOID articles that (1) focus on methods but don’t analyze data; (2) present models or model output, including simulation and optimization models; (3) use data only as model input; (4) review or synthesize literature; (5) present theory without testing it on data; (6) involve GIS or remote sensing only; (7) contain controlled experiments with researcher-controlled treatments; (8) are case studies (only one or a couple of examples); or (9) present data on processes whose spatiotemporal patterns have trivial explanations.
5) On October 18, 2017. Upload onto Canvas (assignment folder) (a) a list of citations of articles and abstracts that you intend to review, organized by decade with a heading that indicates the topic of your meta-analysis, (b) abstracts of all the articles, formatted 3-4 to a page.

C. By November 6, 2017. Upload onto canvas (assignment folder) the spreadsheet of analysis of your articles, based on the checklist (p. 10-11 of syllabus).

ALSO, Hand in a hard copy of the graded list of your articles and abstracts, and the updated list that includes new articles you added based on feedback from Julia.

D. Some time in October/early November (time permitting). Bring your laptop to class to work on the meta-analysis and discuss your project with fellow students.

E. By November 17, 2017. Upload onto Canvas (assignment folder) a three part-essay (total 3-4 pages):

Part 1) A 1-2 p. essay titled “Meta-analysis of XX”, including 1 par. each on
   a. how the literature rated according to the criteria on the checklist,
   b. the most important/frequent questions or hypotheses,
   c. major pattern-process interactions identified in the analyses,
   d. which techniques were most/least useful, and
   e. possibilities for spatio-temporal analysis that weren’t use

Part 2) A 1-page essay titled “Science and management implications for XX” answering
   a. Has the use of spatio-temporal pattern analysis on your topic led to important scientific
discoveries or advances? If so, what are they?
   b. Has the use of spatio-temporal pattern analysis on your topic led to fundamental shifts in
   policy or management? If so, what are they?

Part 3) A 1-page essay titled “State of the art of spatio-temporal analysis for XX.” Do you agree
or disagree with each of these statements, based on your literature review?
   a. There has been a marked increase over time in the number of published studies dealing with
   physical and ecological phenomena at large scales.
   b. Spatio-temporal statistics often are used to address complex hypotheses that cannot be studied
   using standard statistics (regression, analysis of variance).
   c. Spatio-temporal studies use simple spatio-temporal statistics (geostatistics, correlograms) more
   often than complex methods (wavelet, fractals).
   d. Studies examining long-term (>5-yr) data are rare in ecology, but studies of long time series are
   common in earth sciences (climate, soils, hydrology).
   e. Question identification and analysis approach have been driven by data format/type and
   availability. A majority of spatio-temporal analyses are based on the patchwork rather than the
   network concept of space and time. Spatiotemporal analysis of flows (of organisms, materials)
   are scarce.
   f. Testing for spatio-temporal patterns has been technique-driven rather than question-driven.
   Most studies use off-the-shelf techniques.
g. Broad conceptual frameworks for spatio-temporal interactions are lacking in the literature. Few published studies deal with patch-net interactions or scaling-up of spatially interactive phenomena such as flows of organisms or materials.

h. "Pattern" is a more useful concept than "variability" for understanding and managing the environment, but studies of pattern are less common than studies of variability. It is easier to interpret ecological processes from explicit pattern types (e.g. patch size, cycle, edge, trend) than for variability (e.g. CV, fractal dimension).

i. In your topic area, is natural resource management and policy is based on "natural variability" or a pattern concept like cycles, trends, or edges?

F. By November 17, 2017. **Upload onto Canvas (assignment folder)** pdfs of the three articles that in your opinion make the best use of spatio-temporal statistics.
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Checklist of Key Attributes of Spatio-temporal Analyses

1. What is major hypothesis regarding pattern-process interaction in the paper?

2. How is the study system conceived?
   a. points or patches?
   b. how many dimensions?

3. Focus of study is on variation
   a. in space
   b. in time
   c. both space and time

4. Data consist of
   a. points
   b. continuous variables
   c. categories/classes

5. What is the scale of the study, in space and time?
   a. what is grain?
   b. what is extent?

6. Sampling design
   a. regular
   b. random
   c. clustered
   d. nested
   e. hierarchical/multi-scale
   f. stratified
   g. exhaustive
   h. opportunistic
   i. other - explain

7. Did the analysis use information primarily on
   a. location in space or time
   b. distances among points in space or time
   c. arrangement of points in space or time

8. Pattern analysis techniques used
   a. means and standard deviation
   b. regression or analysis of variance
   c. multivariate statistics (PCA, ordination, etc.)
d. spatial or temporal interpolation, smoothing
e. point pattern analysis
   i. quadrat method
   ii. nearest neighbor
   iii. Ripley's K (second-order)
f. geostatistics
   i. semivariance/semivariograms
   ii. spatio-temporal autocorrelation/correlograms
   iii. spectral analysis
   iv. kriging
g. wavelet analysis
h. fractal dimension
   i. cross-correlations, cross-spectral analysis, cross-Ripley's K, cross-wavelet
j. other

9. What types of pattern were identified?
   a. random
   b. clustered
   c. dispersed
   d. cycle or patch
   e. trend or gradient
   f. edge or abrupt change
g. other

10. Did the study relate the interpreted pattern to some process/hypothesis? Was the hypothesis supported?

11. Did this study miss opportunities to use spatio-temporal analysis? If so, which analyses could have been used?