Cornell University
PLSCS/NTRES 6200
Spatial Modelling and Analysis for agronomic, natural resources, environmental and regional studies

Spring semester 2019
Course information

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December 2, 2018

Orientation to course

1. for whom?
2. objectives
3. instructor
4. method
5. assignments & grading
6. project
7. schedule
8. some key references

For whom?

- **Graduate** and **senior undergraduate** students who want to advance their understanding of geographic information science and technology applied to problems in the agronomic, natural resources, environmental or regional studies sciences;
  - Most labs use the the **R environment** for (spatial) statistical computing and visualization, and the **QGIS** open-source GIS (these will be introduced)
  - Student should have followed an undergraduate-level or introductory graduate-level courses in **GIS theory and practice** (e.g., PLSCS 4200) and **inferential statistics** (e.g., STSCI 3200/BTRY 3020)
  - Helpful but not necessary: remote sensing, computer programming
- Especially useful for students starting a **graduate research project** that uses spatial information in agronomy, soil science, natural resource management, regional science, hydrology, ecology . . .
  - "spatial": information is from **known locations** with **known spatial extent**

Learning outcomes

- Student is able to analyze **complex spatial problems** with **appropriate theory and tools**
- Student is able to organize data analysis as **reproducible research** (literate data analysis)
- Student is competent to process and visualize spatial data; with emphasis on **open-source computer programs** and **publically-available data**
- Student has made progress in analyzing a spatial data set from their **own research project**, or a similar dataset

Instructor

David G. Rossiter

- Adjunct Associate Professor, PLSCS (8th year)
  - Graduate faculty *Soil & Crop Sciences* 'Environmental Information Systems' concentration
  - Graduate faculty *Regional Science* 'Environmental Studies' concentration
- Guest Researcher (*Gastmedewerker*), ISRIC–World Soil Information, Wageningen (NL) (5th year)
- Visiting Professor (客座教授), Chinese Academy of Sciences, Soil Science Research Institute Nanjing (中国科学院南京土壤研究所) (7th year)
- Visiting Professor (讲座教授), Nanjing Normal University, School of Geography (南京师范大学地理学学院) (5th year)
- Retired from University of Twente (NL), Faculty of Geoinformation Science & Earth Observation (after 17 years)

Instruction method

- Graduate-level course, emphasis is on **guided self-instruction**, including critical reading of primary literature, lab. self-paced tutorials
- Lectures are **overviews / orientations** to introduce **fundamental spatial analysis concepts and methods**
  - Each lecture period begins with ≈ 20 minutes discussion of an **assigned pre-class reading**, and with Q&A.
- Emphasise ability to read, understand and apply **methods in journal papers**, advanced **textbooks** and **reference** books; necessary in graduate career
- Student **project** allows you to apply ideas and techniques of spatial analysis from this course or elsewhere to your research
- First nine (of 13) labs. are tutorial exercises on **methods** and **computation**; example applications to illustrate these; other lab. periods for project work.

Assignments

- Weeks 1-5, 7–10: nine (**9**) set **lab. exercises**, small hand-in assignment; due before Tues. of following week

- (Week 11: spring break)

- Weeks 12–15 four (**4**) short **question sets** based on reading; due before Thursday lecture (to be discussed in class)

Grading

- Nine lab. exercise assignments: graded 0–3; 45% of final
  - 0 = not submitted; 1 = weak attempt; 2 = some incorrect answers or procedures; 3 = (close to) perfect
- Four question sets: graded 0–3; 15% of final
- Project: 40% of final (breakdown: 80% project, 10% reporting, 10% presentation/discussion)
- Grading on absolute scale; Letter equivalents:

≥ 97.5	A+	≥ 92.5	A	≥ 90.0	A-
≥ 87.5	B+	≥ 82.5	B	≥ 80.0	B-
≥ 77.5	C+	≥ 72.5	C	≥ 70.0	C-
≥ 67.5	D+	≥ 62.5	D	≥ 60.0	D-
< 60.0	F				

Project

- An independent project in which the student applies **spatial analysis** to a **problem of interest** relevant to student's field of study;
  - May work in pairs provided that independent contributions of team members can be evaluated.
- **Spatial** or **Spatio-temporal** analysis must be prominent;
- Prefer use of **own** data, **similar** obtained from colleague/advisor, or **publically-available** data; little credit for extensive data manipulation (not the main purpose of this course);
- Should be able to complete during allocated lab. time and related self-study time; graded as such;
- Milestones: (1) **brief proposal**: 12-March (week 8 Tuesday) ; (2) **proposal presentation** (literature review / detailed project plan): 26 or 27 March (week 12 lab); (3) **report**: ≈17-May (on scheduled exam date, TBD)

Week schedule

Lectures: Tuesday, Thursday 0840–0955 Bradfield 105

Content is equivalent to a 50-minute lecture, this gives more time for review and interaction. We always start with questions and discussion of the key points in the assigned papers, as motivation for the lecture.

Computer laboratory: Tuesday or Wednesday 1325–1625 Bradfield 108

- you can come to one or both labs; if space is limited, priority to those registered for that day
- brief orientation; most time is self-paced with instructor available to answer questions; a few breaks to review key points
- Bradfield 108 always available (card access for enrolled students)

Schedule – lectures

Week 1 Naïve analysis; The R environment; Literate data analysis; Spatial concepts (22, 24 Jan)

Week 2 Coördinate Reference Systems; review of GIS concepts; Introduction to spatial modelling (29, 31 Jan)

Week 3 Model-based methods: Feature-space regression, trend surfaces (05, 07 Feb)

Week 4 Spatial dependence, kriging (OK, UK, KED); introduction to spatial regression (12, 14 Feb)

Week 5 Spatial sampling (19, 21 Feb)

Week 6 Remote sensing as a data source; PCA (Th only; 28 Feb)

Week 7 Time series analysis; Spatio-temporal analysis (05, 07 Mar)

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Week 8 Area-Based spatial analysis (12, 14 Mar)

Week 9 Data-driven methods (19, 21 Mar)

Week 10 Point Pattern analysis (26, 28 Mar)

Week 11 (spring break)

Week 12 Uncertainty, data quality, metadata, simulation (09, 11 Apr)

Week 13 Spatial regression in detail (16, 18 Apr)

Week 14 Big data, open data (23, 25 Apr)

Week 15 Network analysis; Landscape pattern analysis (30-Apr, 02 May)

Week 16 Summary (Tu only, 07 May)

Schedule – labs

Week 1 The R environment; Literate Data Analysis (22/23 Jan)

Week 2 Open-source GIS (29/30 Jan)

Week 3 Feature-space regression; trend surfaces (05/06 Feb)

Week 4 Geostatistics with R/gstat (12/13 Feb)

Week 5 Spatial sampling (19/20 Feb)

Week 6 (Feb. break,no labs)

Week 7 Time series analysis (05/06 Mar)

Week 8 Area spatial data analysis: GeoDa (optional R/spdep) (12/13 Mar)

Week 9 Data-driven methods: random forests, thin-plate splines (19/20 Mar)

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Week 10 Point-pattern analysis: R/spatstat (27/28 Mar)

Week 11 (spring break, no lab)

Week 12 prelim project presentations (26/27 Mar)

Weeks 13–14 individual project work (instructor available for consultation)

Week 15 student project (ongoing) presentations/discussion (30 Apr/01 May)

Week 16 (Tuesday only, so no lab)

Key texts/references

Spatial modelling in general

O'Sullivan, D., & Unwin, D. (2010). **Geographic information analysis** (2nd ed). Wiley.
http://library.books24x7.com.edu/toc.aspx?site=KD708&bookid=35218

Ecological modelling

Legendre, P. (2012). **Numerical Ecology** (3rd ed.). San Diego: Elsevier Science & Technology Books.
http://www.sciencedirect.com.edu/science/bookseries/01678892/24

Borcard, D., & SpringerLink (Online service). (2011). **Numerical ecology with R**. New York: Springer.
http://link.springer.com.edu/book/10.1007%2F978-1-4419-7976-6

Statistics review

StatSoft Electronic Statistics Textbook: https://www.statsoft.com/textbook

Dalgaard, P. (2008). **Introductory Statistics with R** (2nd ed.). Springer. http://link.springer.com.edu/book/10.1007%2F978-0-387-79054-1

Spatial analysis in R

Bivand, R., Pebesma, E., & Gómez-Rubio, V. (2013). **Applied spatial data analysis with R** (2nd ed). New York: Springer. http://link.springer.com.edu/book/10.1007%2F978-1-4614-7618-4. Datasets etc. at http://www.asdar-book.org/

Kolaczyk, E. D., & Csárdi, G. (2014). **Statistical Analysis of Network Data with R**. Springer. IBSN:978-1-4939-0982-7 http://link.springer.com.edu/book/10.1007%2F978-1-4939-0983-4

General GIS

Burrough, P. A., McDonnell, R., & Lloyd, C. D. (2015). **Principles of geographical information systems** (3rd edition). Oxford University Press.

Geostatistics

Webster, R., & Oliver, M. A. (2008). **Geostatistics for environmental scientists**. John Wiley & Sons Ltd.
http://onlinelibrary.wiley.com.edu/book/10.1002/9780470517277

Goovaerts, P. (1997). **Geostatistics for natural resources evaluation**. New York; Oxford: Oxford University Press.

Diggle, P. J., & Ribeiro Jr., P. J. (2007). **Model-based geostatistics**. Springer.
http://link.springer.com.edu/book/10.1007%2F978-0-387-48536-2

Krivoruchko, K. (2011). **Spatial statistical data analysis for GIS users**. DVD containing book + data. Redlands: ESRI.

Statistical modelling

Fox, J. (2008). **Applied regression analysis and generalized linear models** (2nd ed.). Los Angeles: Sage.

Fox, J., & Weisberg, S. (2011). **An R companion to applied regression** (2nd ed.). Thousand Oaks, Calif.: SAGE Publications.

Venables, W., & Ripley, B. (2002). **Modern Applied Statistics with S**. Fourth Edition. Springer.
http://link.springer.com.edu/book/10.1007%2F978-0-387-21706-2

Hosmer, D. W., & Lemeshow, S. (2013). **Applied logistic regression** (3rd ed.). Wiley-Interscience Publication.
http://onlinelibrary.wiley.com.edu/book/10.1002/9781118548387

Machine learning

Hastie, T., Tibshirani, R., & Friedman, J. H. (2009). **The elements of statistical learning data mining, inference, and prediction** (2nd ed). New York: Springer. http://link.springer.com.edu/book/10.1007%2F978-0-387-84858-7

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). **An introduction to statistical learning: with applications in R**. New York: Springer. http://link.springer.com.edu/book/10.1007%2F978-1-4614-7138-7 (A simplified version of Hastie *et al.* 2009).

Land surface modelling

Hengl, T., & Reuter, H. I. (Eds.). (2009). **Geomorphometry: concept, software, applications**. Developments in soil science 33. http://www.sciencedirect.com.edu/science/bookseries/01662481/33

Spatial sampling

de Gruijter, J., Brus, D. J., Bierkens, M. F. P., & Knotters, M. (2006). **Sampling for Natural Resource Monitoring**. Springer. http://link.springer.com.edu/book/10.1007%2F3-540-33161-1

Time series, spatio-temporal

Shumway, R. H., , D. S. (2011). Time series analysis and its applications with R examples (3rd ed). New York: Springer. http://encompass.library.cornell.edu/cgi-bin/checkIP.cgi?access=gateway_standard%26url=http://dx.doi.org/10.1007/978-1-4419-7865-3

Cowpertwait, P. S. P., & Metcalfe, A. V. (2009). Introductory Time Series with R. Springer. https://doi.org/10.1007/978-0-387-88698-5

Christakos, G. (2012). Modern spatiotemporal geostatistics (Dover ed). Mineola, N.Y: Dover Publications. http://app.knovel.com/hotlink/toc/id:kpMSG00001/modern-spatiotemporal-geostatistics