GEOG 5330: Applied Spatial and Spatiotemporal Data Analysis

FALL 2018

*Tuesdays **6:00pm-8:50pm**, Holden **00221***

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1 Course description

With the continuing advances of geographic information science and geospatial technologies, spatially referenced information have been easily and increasingly available in the past decades and becoming important information sources in scientific research and decision making processes. To effectively take advantage of the rich collection of spatial (and temporal) data, statistical analysis is often necessary, e.g., to extract implicit knowledge such as spatial relations and patterns that are not explicit in the data. Spatial data analysis distinguishes itself from classical data analysis in that spatial analysis focuses on locations, areas, distances, relationships and interactions of measurements that are usually referenced as points, lines, and areal units in geographical spaces. In the past decades, a plethora of theory, methods and tools of spatial analysis have been developed from different perspectives, and together with GIS, converged as fruitful fields of geographic information science (GIScience) and spatial statistics.

The purpose of this class is to present the commonly used methods and current trends in spatial and spatiotemporal data analysis, and innovative applications in relevant fields (e.g., environmental science and engineering, natural resources management, ecology, public health, climate sciences, civil engineering, and social sciences). Students are expected to actively participate in class, finish the homework assignment, read assigned articles and develop a project of their own choice or directly related to their thesis/dissertation topics. I will review the basic principles and commonly used methods and tools in spatial and spatiotemporal analysis, and introduce how to conduct the analysis in popular computing platform (mainly R, sometimes Python). Students will be reading a collection of papers produced by key researchers and practitioners in various cognate fields that are closely related to the topics of the class. The topics include, but not limited to:

- Exploratory spatial data analysis and visual analytics
- Spatial point process (e.g., occurrence of wild life, crimes and diseases)

- Analysis of movement trajectories (e.g., movement trajectories of animals and birds)
- Spatiotemporal disease mapping
- Space-time geostatistics
- Statistical downscaling and change of spatial supports
- Spatial uncertainty mapping and impact assessment
- Time series remote sensing imagery analysis and change detection

2 Prerequisites

Prerequisites of this course includes an understanding of basic concepts of spatial analysis and spatial statistics, which could be fulfilled with *GIST 5302* or first-year graduate level of statistics courses. However, students from different disciplines are welcome, please contact the instructor should there any question about the prerequisites.

3 Learning outcomes

After completing this course, the students of this class are expected to be able to:

- formulate real-world problems in the context of spatial and spatiotemporal analysis with a knowledge of basic concepts and principles in this field;
- apply appropriate spatial and spatiotemporal analytical methods to solve the formulated problems, and be able to critically review alternative methods and other's work;
- utilize available scripting, programmable scientific computing tools (e.g., R) to make maps, solve spatial and spatiotemporal analysis problems, and evaluate and assess the results of alternative tools; The students are also expected to learn how to use the popular collaborative platform (e.g., GitHub) to share the codes;
- communicate effectively the results of analysis in forms of academic writing and presentation

4 Readings

- Handouts will be circulated as class progresses and **<u>no</u>** required textbook is needed for this course
- A reading list of articles are provided in Section 7 of this syllabus. The following books will be frequently referred to for reading:
  - Bivand Roger S., Pebesma, Edzer J., and Gmez-Rubio, Virgilio (2008), *Applied Spatial Data Analysis with R*, Springer (eBook available at TTU library).
  - Cressie, N., & Wikle, C. K. (2011). *Statistics for Spatio-temporal Data*. John Wiley & Sons.

5 Assessment

The assessment of students understanding of the learning outcomes will be based on the following items:

- Homework assignment: Each student will be expected to finish a hands-on programming assignment (using R) for each week and made available on GitHub.
- Final project: Each student will be expected to write a proposal of the final project in the middle of the semester, finish the proposed activities, present the results of the projects, and finally submit an associated project report.
  - Specifically the project proposal will be evaluated based on the following criteria:
    * The objective of the proposal is practical and can be finished during the class time, and the student already has the necessary data ready to be analyzed (30%)
    * The proposal will use appropriate methods of analysis for the proposed objectives (30%)
    * The proposal is well written and clearly stated, with all the following required elements included (40%): introduction, motivation and description of the problem, review of current literature (related to the assigned readings), sources of data, and anticipated results.
  - The final presentation and the final report will be both evaluated according to the following criteria:
    * Evidence that the student has finished the proposed analysis (40%)

- * Findings based on the analysis results have been clearly elaborated, and the proposed objective has been achieved (30%)
- * The report is well written and the presentation is clear, with all the following required elements included (30%): introduction, motivation and description of the problem, review of current literature (related to the assigned readings), sources of data, adopted methods of analysis, results and discussions.

6 Grading policy

- Class attendance (10%)
- Class presentation of readings (60%)
- Final project (30%): proposal (5%), presentation (10%) and paper (15%)

To ensure a specific grade in this course you must meet the following minimum requirements: A - 90%, B - 80%, C - 70%, D - 60%.

7 Sample course outline

Week#	Sample topics	Sample readings (*see the attached reference for details)*
1	Class overview	Anselin (1990), Haining (2003, 2009)
2	R Basics and Intro to GitHub	Lecture slides
3	Making maps in R	Lecture slides
4	Spatial and spatiotemporal analysis in R	Bivand et al. (2008)
5	Spatial point pattern analysis	Baddeley & Turner (2006), Baddeley et al. (2007), Diggle et al. (1983)
6	Species distribution modeling	Elith et al. (2011), Renner & Warton (2013), Stokland et al. (2011), Chefaoui & Lobo (2008), Anderson et al. (2006), Elith et al. (2008)
7	Movement trajectory analysis (*project proposal due*)	Calenge et al. (2009), Johnson et al. (2008)
8	Spatiotemporal disease mapping	Cromley & McLafferty (2011), Waller & Gotway (2004), Schrödle & Held (2011*b*), Schrödle & Held (2011*a*)
9	Model-based geostatistics & applications	(Diggle et al. 1998, Cameletti et al. 2013, Blangiardo et al. 2013)
10	Statistical downscaling, change of spatial supports	Kyriakidis (2004), Boucher & Kyriakidis (2006), Atkinson (2013), Hayhoe (2010);
11	Time series remote sensing imagery analysis	Verbesselt et al. (2010), Lu et al. (2004)
12	Uncertainty of spatial data	Goodchild (2008), Zhang & Goodchild (2002), Chiles & Delfiner (1999), Kyriakidis & Dungan (2001), Foody (2002), Congalton (1991), Congalton & Green (2008)
13	Student project	
14	Student project	
15	Student project presentation (*final report due*)	

8 Sample reading list

Anderson, R., Dudík, M., Ferrier, S., Guisan, A., J Hijmans, R., Huettmann, F., R Leathwick, J., Lehmann, A., Li, J., G Lohmann, L. et al. (2006), 'Novel methods improve prediction of species distributions from occurrence data', *Ecography* **29**(2), 129–151.

Anselin, L. (1990), What is special about spatial data? Alternative perspectives on spatial data analysis, *in* '\it Spatial Statistics, Past, Present and Future', Institute of Mathematical Geography.

Atkinson, P. M. (2013), ‘Downscaling in remote sensing’, *International Journal of Applied Earth Observation and Geoinformation* **22**, 106–114.

Baddeley, A., Bárány, I. & Schneider, R. (2007), ‘Spatial point processes and their applications’, *Stochastic Geometry: Lectures given at the CIME Summer School held in Martina Franca, Italy, September 13–18, 2004* pp. 1–75.

Baddeley, A. & Turner, R. (2006), Modelling spatial point patterns in R, *in* ‘Case studies in spatial point process modeling’, Springer, pp. 23–74.

Bivand, R. S., Pebesma, E. J., Gómez-Rubio, V. & Pebesma, E. J. (2008), *Applied Spatial Data Analysis with R*, Vol. 747248717, Springer.

Blangiardo, M., Cameletti, M., Baio, G. & Rue, H. (2013), ‘Spatial and spatio-temporal models with R-INLA’, *Spatial and spatio-temporal epidemiology* **7**, 39–55.

Boucher, A. & Kyriakidis, P. (2006), ‘Super-resolution land cover mapping with indicator geostatistics’, *Remote Sensing of Environment* **104**(3), 264–282.

Calenge, C., Dray, S. & Royer-Carenzi, M. (2009), ‘The concept of animals’ trajectories from a data analysis perspective’, *Ecological informatics* **4**(1), 34–41.

Cameletti, M., Lindgren, F., Simpson, D. & Rue, H. (2013), ‘Spatio-temporal modeling of particulate matter concentration through the spde approach’, *AStA Advances in Statistical Analysis* **97**(2), 109–131.

Chefaoui, R. M. & Lobo, J. M. (2008), ‘Assessing the effects of pseudo-absences on predictive distribution model performance’, *Ecological modelling* **210**(4), 478–486.

Chiles, J. & Delfiner, P. (1999), *Geostatistics: Modeling Spatial Uncertainty*, Vol. 136, Wiley-Interscience.

Congalton, R. G. (1991), ‘A review of assessing the accuracy of classifications of remotely sensed data’, *Remote sensing of environment* **37**(1), 35–46.

Congalton, R. G. & Green, K. (2008), *Assessing the Accuracy of Remotely Sensed Data: Principles and Practices*, CRC press.

Cromley, E. K. & McLafferty, S. L. (2011), *GIS and Public Health*, Guilford Publication.

Diggle, P. J. et al. (1983), *Statistical analysis of spatial point patterns.*, Academic press.

Diggle, P., Tawn, J. & Moyeed, R. (1998), ‘Model-based geostatistics’, *Applied Statistics* **47**(3), 299–350.

Elith, J., Leathwick, J. R. & Hastie, T. (2008), ‘A working guide to boosted regression trees’, *Journal of Animal Ecology* **77**(4), 802–813.

Elith, J., Phillips, S. J., Hastie, T., Dudík, M., Chee, Y. E. & Yates, C. J. (2011), ‘A statistical explanation of maxent for ecologists’, *Diversity and Distributions* **17**(1), 43–57.

Foody, G. M. (2002), 'Status of land cover classification accuracy assessment', *Remote sensing of environment* **80**, 185–201.

Goodchild, M. (2008), 'Statistical perspectives on geographic information science', *Geographical Analysis* **40**(3), 310–325.

Haining, R. (2003), *Spatial Data Analysis:Theory and Practice*, Cambridge: Cambridge University Press.

Haining, R. (2009), 'The special nature of spatial data', *The sage handbook of spatial analysis. Sage, Thousand Oaks, CA* .

Hayhoe, K. A. (2010), A standardized framework for evaluating the skill of regional climate downscaling techniques, PhD thesis, University of Illinois at Urbana-Champaign.

Johnson, D. S., London, J. M., Lea, M.-A. & Durban, J. W. (2008), 'Continuous-time correlated random walk model for animal telemetry data', *Ecology* **89**(5), 1208–1215.

Kyriakidis, P. C. (2004), 'A geostatistical framework for area-to-point spatial interpolation', *Geographical Analysis* **36**, 259C289.

Kyriakidis, P. C. & Dungan, J. L. (2001), 'A geostatistical approach for mapping thematic classification accuracy and evaluating the impact of inaccurate spatial data on ecological model predictions', *Environmental and ecological statistics* **8**(4), 311–330.

Lu, D., Mausel, P., Brondizio, E. & Moran, E. (2004), 'Change detection techniques', *International journal of remote sensing* **25**(12), 2365–2401.

Renner, I. W. & Warton, D. I. (2013), 'Equivalence of maxent and poisson point process models for species distribution modeling in ecology', *Biometrics* **69**(1), 274–281.

Schrödle, B. & Held, L. (2011*a*), 'A primer on disease mapping and ecological regression using INLA', *Computational statistics* **26**(2), 241–258.

Schrödle, B. & Held, L. (2011*b*), 'Spatio-temporal disease mapping using INLA', *Environmetrics* **22**(6), 725–734.

Stokland, J. N., Halvorsen, R. & Støa, B. (2011), 'Species distribution modelling-effect of design and sample size of pseudo-absence observations', *Ecological Modelling* **222**(11), 1800–1809.

Verbesselt, J., Hyndman, R., Newnham, G. & Culvenor, D. (2010), 'Detecting trend and seasonal changes in satellite image time series', *Remote sensing of Environment* **114**(1), 106–115.

Waller, L. A. & Gotway, C. A. (2004), *Applied spatial statistics for public health data*, Vol. 368, John Wiley & Sons.

Zhang, J. & Goodchild, M. (2002), *Uncertainty in Geographic Information*, Taylor & Francis, London.

9 University policy

- Academic honesty (OP 34.12):

  From OP 34.12: "It is the aim of the faculty of Texas Tech University to foster a spirit of complete honesty and high standard of integrity. The attempt of students to present as their own any work not honestly performed is regarded by the faculty and administration as a most serious offense and renders the offenders liable to serious consequences, possibly suspension. "Scholastic dishonesty" includes, but it not limited to, cheating, plagiarism, collusion, falsifying academic records, misrepresenting facts, and any act designed to give unfair academic advantage to the student (such as, but not limited to, submission of essentially the same written assignment for two courses without the prior permission of the instructor) or the attempt to commit such an act."

- Americans with Disabilities Act (ADA) and Section 504 of the Rehabilitation Act (OP 10.08)

  Any student who, because of a disability, might require special arrangements in order to meet the course requirements should contact the instructor as soon as possible to make necessary arrangements either at the beginning of the semester or upon diagnosis of disability. Students must present appropriate verification from Student Disability Services during the instructors office hours. Please note that instructors are not allowed to provide classroom accommodation to a student until appropriate verification from Student Disability Services has been provided. For additional information, please contact Student Disability Services office in 335 West Hall or call 806-742-2405.

- Students absence for observance of a religious holy day (OP 34.19):

  - "Religious holy day" means a holy day observed by a religion whose places of worship are exempt from property taxation under Texas Tax Code §11.20.
  - A student who intends to observe a religious holy day should make that intention known in writing to the instructor prior to the absence. A student who is absent from classes for the observance of a religious holy day shall be allowed to take an examination or complete an assignment scheduled for that day within a reasonable time after the absence.
  - A student who is excused under section 2 may not be penalized for the absence; however, the instructor may respond appropriately if the student fails to complete the assignment satisfactorily.

- Safety Procedures: In the event of a fire alarm or building alarm that is not for a tornado students should follow the instructor to the exit that has been established in the building safety document. To exit students should proceed to the right of the room, down the hall to the exit doors facing east. Students should proceed to the south east and wait by the fire stairs outside the xx building until the all clear has been sounded. In the event of a tornado students should follow the instructor along the hall that runs north of the class room, then to the nearest stairway that leads to the basement.