UP 519, SPRING 2016 Advanced Applications of GIS (CRN 60215)

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Lecture Time: M 3:30–4:50 PM (Room 19)
Lab Session: W 3:30–4:50 PM (Room 227)
Location: Temple Hoyne Buell Hall
Office Hours: Th: 9:00–10:00 AM (or by appt.)

COURSE DESCRIPTION

This course provides instruction in the application of many of the more sophisticated functions of geographic information systems (GIS) and introduces key spatial analysis concepts. Both GIS and related tools have become increasingly common resources for planning practice and research and are routinely leveraged for a variety of applications across the array of planning specializations. The course builds on basic concepts and principles of GIS, emphasizing the theory and tools of spatial analysis as well as hands-on exposure to software and real-world data. Completion of *UP 418: Introduction to GIS* or an equivalent introductory course is a prerequisite (the concepts and skills covered in UP 418 will not be repeated here and students are responsible for bringing those basic skills and knowledge to the table). Students who successfully complete this course will be able to:

- Explain the theoretical and technical aspects of common spatial data models;
- Apply many of the extensions and data analysis functionality available in ArcGIS to test hypotheses;
- Perform basic (satellite) image processing tasks;
- Apply fundamental concepts and tools for the visualization of big urban data;
- Write and execute basic geoprocessing scripts;
- Manipulate tabular and spatial data in R to produce intelligible graphics;
- Create basic interactive web maps;
- Apply and interpret basic exploratory data analysis tools;
- Specify, estimate, and interpret basic spatial regression models.

The class is not intended as an in-depth treatment of GIScience or spatial econometrics. It instead, provides a further introduction to the functionality available in ArcGIS and other software packages like R that are particularly relevant for more sophisticated planning applications. As such, we will make every attempt to link the technical aspects of the course to planning practice and common applications within the field.

COURSE FORMAT

This course covers advanced concepts of spatial analysis and GIS use and provides a sufficiently broad coverage of topics so that students will feel comfortable with some of its more complex functions. The class time will be divided into lecture and laboratory sessions that focus on conceptual and practical topics of interest, respectively. Lab reports are due at the beginning of the subsequent class period and should be written independently.

The first half of the semester will focus on building capacity and developing the technical skills needed to work on a term project in the second half of the semester. The term projects for the course will focus on applying geospatial data analysis for community development and environmental planning and will draw upon the

expertise of the City of Champaign's Neighborhood Services Department. Students will work with Neighborhood Services staff and members of community organizations to define the scope of the project and identify specific deliverables early in the semester. The **first option** for the term project involves assessing proposed scenarios for addressing drainage issues in the Washington Street watershed. The City of Champaign Public Works Department has developed several possible strategies for construction a network of storm water retention ponds, but in addition to hydrology several other considerations must be weighed including the needs of residents and desire to promote complete streets with any new construction. A parcel-level analysis to assess the costs and benefits of the candidate scenarios across hydrologic, social, and financial criteria is one potential focal point. The **second option** second involves building evidence to support community requests for additional parks and recreation facilities in the Garden Hills neighborhood. This could involve primary data collection to mobile apps like ArcGIS Collector or Open Data Kit, remote sensing, and/or the creation of web maps to visualize existing and potential parks and recreation opportunities in the neighborhood and surrounding areas.

Students are expected to contribute to one of these initiatives as a **group term project** or to propose an **individual term project**.

REQUIREMENTS & EVALUATION

General participation in class discussion and exercises comprises 10% of the final grade and team members will be asked to evaluate (confidentially) one another at the end of the semester—this information received will also be used to determine each student's final grade for the course. Students are expected to attend both the lecture (Monday) and lab (Wednesday) components of the course. Most weeks there will be a lab exercise on Wednesday. Each student is expected to submit a short report and the details will be specified in each of the assignments distributed at the beginning of the lab session.

There will also be a midterm examination that focuses on the concepts covered in lecture and applied in the lab sessions. On Monday May 2nd students will present their term projects to the class and City of Champaign staff. The remainder of the grade is based on the term project report due on Wednesday May 11th during exam week. This report will be of professional quality and be supplemented with maps, spatial datasets, and other materials as appropriate. The weight assigned to each of these elements is shown in the table below:

ASSIGNMENT	DUE DATE	PERCENTAGE
Participation	Ongoing	10%
Lab Exercises (10)	Ongoing	30%
Midterm Exam	March 14th	20%
Term Project Presentation	May 2nd (or 4th)	10%
Term Project Report	May 11th	30%

In fairness to all students, ten points will be deducted for late assignments, with an additional ten points deducted for each subsequent day. No exceptions can be made without a written medical excuse from your doctor and a proposed new deadline. Due dates for assignments are not flexible, so please make your travel plans and schedule other commitments accordingly.

The overall assessment of student performance in this course is derived from the components listed above, subject to the percentage weights listed in the preceding table. All of these components are scored on a 100 point scale, which should make it easy for each student to gauge their standing as the semester progresses—grades are not curved.

FINAL GRADE	TOTAL
A+	98 to 100
A	94 to 97
A-	91 to 93
B+	88 to 90
B	84 to 87
B-	81 to 83
C+	78 to 80

FINAL GRADE	TOTAL
C	74 to 77
C-	71 to 73
D+	68 to 70
D	64 to 67
D-	61 to 63
F	0 to 60

READING MATERIAL

The primary text for this course is available as an e-Book through the UIUC library:

> Lloyd, Christopher D. 2010. *Spatial data analysis: an introduction for GIS users*. New York, NY: Oxford University Press. Available at http://vufind.carli.illinois.edu/vf-uiu/Record/uiu_7654987

All assigned readings that are not from the Lloyd text have been placed on the Compass web site:

> **Compass**: https://compass2g.illinois.edu

The instructor's presentation slides will be posted on *Compass* following the Monday lecture sessions.

SOFTWARE

The course will primarily focus on the ArcGIS suite, but a few additional software packages may be used for lab exercises and group projects.

- ArcGIS 10.3.1 is available for free through the UIUC Webstore and is in the DURP computer lab and on the DURP Applications Server.
- R 3.2.2 is free, open source, and downloadable here. It is also in the DURP computer lab and on the DURP Applications Server.

COURSE POLICIES

Disability Services: This course will accommodate students with documented disabilities. Please refer to the Disability Resource Guide (http://disability.illinois.edu/disability-resource-guide) for more information and inform the instructor of any requests at the beginning of the semester.

Academic Integrity: The UIUC Student Code requires all students to support academic integrity and abide by its provisions, which prohibit cheating, fabrication, plagiarism, and facilitation of these and related infractions. According to Section § 1-401, "students have been given notice of this rule by virtue of

its publication" and "regardless of whether a student has actually read this rule, a student is charged with knowledge of it." The provisions of the Student Code are applicable to this course. *In written work, all ideas (as well as data or other information) that are not your own must be cited.*

Diversity: The Department of Urban and Regional Planning (DURP) is committed to creating an environment of inclusion and opportunity that is rooted in the very goals and responsibilities of practicing planners. Conduct that interferes with the rights of another or creates an atmosphere of intimidation or disrespect is inconsistent with the environment of learning and cooperation that the program requires. By enrolling a course in the Department of Urban and Regional Planning, students agree to be responsible for maintaining a respectful environment in all DURP activities, including lectures, discussions, labs, projects, and extracurricular programs. We will be governed by the University Student Code. Please see the *Student Code Article 1—Student Rights and Responsibilities* for further details (http://www.admin.illinois.edu/policy/code).

UP 519 – SPRING 2016
SUMMARY SCHEDULE OF SESSIONS

WEEK	SESSION	DATE	DAY	TOPIC
1	1	20-Jan	W	Course Overview & Refresher Exercises
2	2	25-Jan	M	Visit from City of Champaign Neighborhood Services Staff
2	3	27-Jan	W	**Term Project**: Scope, Goals, & Deliverables (TBH Room 19)
3	4	1-Feb	M	Basic Hydrology & Landscape Ecology Concepts
3	5	3-Feb	W	Suitability Analysis: Spatial Analyst
4	6	8-Feb	M	What Is Remote Sensing & How Does It Work?
4	7	10-Feb	W	Remote Sensing Part I: Image Registration
5	8	15-Feb	M	Acquiring & Working with Satellite Imagery
5	9	17-Feb	W	Remote Sensing Part II: Image Classification
5	9	17-Feb	W	*** MIDTERM REVIEW GUIDE ***
6	10	22-Feb	M	**Term Project**: Data Collection & Analysis Strategy Session
6	11	24-Feb	W	**Term Project**: Data Collection & Storage Work Session
7	12	29-Feb	M	Analyzing & Presenting Data in Three Dimensions
7	13	2-Mar	W	3D Visualization with ArcScene & ArcGlobe
8	14	7-Mar	M	Open & Big(ger) Urban Data: Concepts
8	15	9-Mar	W	Analyzing Chicago's Divvy Bike Share Data with Hadoop
9	16	14-Mar	M	MIDTERM EXAM (In Class)
9	17	16-Mar	W	*** NO CLASS (**Term Project**: Work Session) ***
		21-Mar	M	*** SPRING VACATION ***
		23-Mar	W	*** SPRING VACATION ***
10	18	28-Mar	M	Data Visualization & Introduction to R
10	19	30-Mar	W	Manipulating & Displaying Spatial Data with R
11	20	4-Apr	M	Spatial Point Pattern Analysis
11	21	6-Apr	W	ESDA with Point Data using R
12	22	11-Apr	M	Scripting Overview & Introduction to ModelBuilder
12	23	13-Apr	W	**Term Project**: Work Session (Optional Scripting Lab Exercise)
13	24	18-Apr	M	Global & Local Measures of Spatial Autocorrelation
13	25	20-Apr	W	ESDA with Lattice Data using R
14	26	25-Apr	M	OLS Refresher & Spatially Lagged Variables
14	27	27-Apr	W	Spatial Regression using R
15	28	2-May	M	**Term Project**: Team Presentations
15	29	4-May	W	Course Wrap-Up & Evaluations
		11-May	W	*** FINAL PAPERS DUE ***

SESSION TOPICS AND READINGS

Session 1: Course Overview & Refresher Exercises (1/20)

Themes and Topics: metadata, geodesy, datum, coordinate system, projection, geocoding.

ESRI. 2004. *Understanding map projections*. Redlands, CA: ESRI. (pp. 1-34)

Lloyd, Christopher D. 2010. "GIS." In *Spatial data analysis: an introduction for GIS users*. New York, NY: Oxford University Press. (pp. 6-23)

Lab Exercise: This session presents basic concepts in geodesy and cartography and demonstrates how coordinate systems and map projections are managed within ArcGIS. The lab exercise focuses on practical aspects of managing coordinate systems and map projections in ArcGIS and geocoding.

Session 2: Visit from City of Champaign Neighborhood Services Staff (1/25)

Themes and Topics: Community development specialist will visit class and talk about two ongoing initiatives with neighborhood organizations. The first involves assessing proposed scenarios for addressing drainage issues in the Washington Street watershed and the second involves building evidence to support community requests for additional parks and recreation facilities in the Garden Hills neighborhood.

Students are expected to contribute to one of these initiatives as a group term project or to propose an individual term project.

No required readings. No lab exercise

Session 3: Term Project—Scope, Goals, & Deliverables (1/27)

Themes and Topics: We will meet in TBH 19 (lecture room) to discuss the three term project opportunities presented by City of Champaign Neighborhood Services staff.

No required readings. No lab exercise.

Session 4: Basic Hydrology & Landscape Ecology Concepts (2/1)

Themes and Topics: raster data, hydrologic tools in ArcGIS, overland flow, watershed, connectivity, landscape metrics, scale and hierarchy.

Lloyd, Christopher D. 2010. "Analysis of grids and surfaces." In *Spatial data analysis: an introduction for GIS users*. New York, NY: Oxford University Press. (pp. 155-170)

Dramstad, W.E., J.D. Olson, and R.T.T. Forman. 1996. "Part one: Principles." In *Landscape ecology principles in landscape architecture and land-use planning*. Washington, DC: Island Press. (pp. 19-45)

Session 5: Suitability Analysis—Spatial Analyst (2/3)

Lab Exercise: This lab exercise focuses on applying the hydrologic tools available in ArcGIS and working with raster data.

Session 6: What Is Remote Sensing & How Does It Work? (2/8)

Themes and Topics: types of sensors, geometric correction, georeferencing, ground control points, positional accuracy, spatial resolution.

Liu, J.G. and P.J. Mason. 2009. "Image geometric operations." In *Essential image processing and GIS for remote sensing*. Chichester, UK: Wiley-Blackwell. (pp. 105-119)

Session 7: Remote Sensing Part I—Image Registration (2/10)

Lab Exercise: Aerial photographs are one of the fundamental sources of information about urban areas. This exercise introduces the use of image data sources and the focuses on registering two aerial photographs from different time points to support change detection.

Session 8: Acquiring & Working with Satellite Imagery (2/15)

Themes and Topics: electromagnetic spectrum, band combinations, supervised and unsupervised classification, data acquisition, change detection, radiometric resolution, temporal resolution, object-based image analysis.

Liu, J.G. and P.J. Mason. 2009. "Image classification." In *Essential image processing and GIS for remote sensing*. Chichester, UK: Wiley-Blackwell. (pp. 91-103)

Optional:

Blaschke, T., Hay, G. J., Kelly, M., Lang, S., et al. (2014). Geographic Object-Based Image Analysis–Towards a new paradigm. *ISPRS Journal of Photogrammetry and Remote Sensing*. 87(100): 180–191.

Session 9: Remote Sensing Part II—Image Classification (2/17)

Lab Exercise: This session builds upon the previous session and provides an overview of how remote sensing works. As part of the lab exercise, we will perform a supervised classification of Landsat imagery from two time periods and identify areas of significant land use change.

Session 10: Term Project—Data Collection and Analysis Strategy (2/22)

Themes and Topics: This session allows time for each team to discuss and finalize a data collection and data analysis strategy.

No required readings. No lab exercise.

Session 11: Term Project— Data Collection & Storage Work Session (2/24)

Themes and Topics: This session allows time for each team to begin downloading data and organizing storage in support of the term project.

No required readings. No lab exercise.

Session 12: Analyzing & Presenting Data in Three Dimensions (2/29)

Themes and Topics: triangulated irregular networks, 3D rendering, viewsheds, LiDAR, scenario planning.

Lai, P.C., K-H. Kwong, and A.S.H. Mak. 2010. Assessing the applicability and effectiveness of 3D visualisation in environmental impact assessment. *Environment and Planning B: Planning and Design.* 37: 221-233.

Optional:

Gill, L., E. Lange, E. Morgan, and D. Romano. 2013. An analysis of usage of different types of visualisation media within a collaborative planning workshop environment. *Environment and Planning B: Planning and Design*. 40: 742-754.

Session 13: 3D Visualization—ArcScene & ArcGlobe (3/2)

Lab Exercise: There are a variety of tools available that support 3D visualization and some evidence suggests a link between visualization and increased public engagement in the planning process. We will use both ArcScene and ArcGlobe to manipulate spatial data and inform planning decisions.

Session 14: Open & Big(ger) Urban Data—Concepts (3/7)

Themes and Topics: data, information, knowledge, wisdom, data-driven science, computational social science.

Kitchen, R. 2014. "Conceptualising data" and "The reframing of science, social science, and humanities research." In *The data revolution: big data, open data, data infrastructures and their consequences*. Los Angeles, CA: SAGE. (pp. 1-26 and 128-149)

Session 15: Analyzing Chicago's Divvy Bike Share Data with Hadoop (3/9)

Lab Exercise: This lab session focuses on visualizing and mining big data provided by the City of Chicago to understand travel behavior of the city's Divvy bike share program patrons. We will make use of R deployed within a Hadoop environment.

Session 16: Midterm Exam (3/14)

The midterm exam will be administered during this session.

Session 17: No Class (3/16)

We will not meet as a class. Please use this time to work on the term project.

Session 18: Data Visualization & Introduction to R (3/28)

Themes and Topics: vectors, matrices, factors, operators, data frames, plot function, spatial data classes, projections in R (EPSG Codes), web mapping, image tiles, GeoJSON, leaflet package

Cheng, J. 2015. "Leaflet for R." Available at http://rstudio.github.io/leaflet

Bivand, R., E.J. Pebesma, and V. Gómez-Rubio. 2013. "Classes for spatial data in R." In *Applied spatial data analysis with R, 2nd edition*. New York, NY: Springer. (pp. 21-57)

Skim as Needed:

Monogan III, J.E. 2015. "Obtaining R and Downloading Packages", "Loading and Manipulating Data", and "Visualizing Data." In *Political analysis using R*. New York, NY: Springer. (pp. 1-50)

Session 19: Manipulating & Displaying Spatial Data—R (3/30)

Lab Exercise: This exercise focuses on the basics of working with tabular and spatial data in the R environment. Input-output functionality, managing projections, and producing graphics is emphasized. We will also use the leaflet package to create basic interactive web maps.

Session 20: Spatial Point Pattern Analysis (4/4)

Themes and Topics: kernel estimation (intensity), stationarity, complete spatial randomness, spatial clustering, quadrat analysis, nearest neighbor indices, Poisson processes, working with point data, geocoding.

Lloyd, Christopher D. 2010. "Exploring spatial point patterns." In *Spatial data analysis: an introduction for GIS users*. New York, NY: Oxford University Press. (pp. 86-105)

Optional:

O'Sullivan, D. and D.J. Unwin. 2010. "Practical point pattern analysis." In *Geographic information analysis, 2nd edition*. Hoboken, NJ: John Wiley & Sons. (pp. 157-186)

Session 21: ESDA with Point Data—R (4/6)

Lab Exercise: This session introduces many of the exploratory spatial data analysis techniques applicable to point data. The lab session provides an opportunity to apply these techniques to epidemiological data using the Spatial Statistics functionality available in R (and ArcGIS to a lesser extent).

Session 22: Scripting Overview & Introduction to ModelBuilder (4/11)

Themes and Topics: scripting, ModelBuilder, geoprocessing.

ESRI. 2010. "ModelBuilder: Creating tools tutorial." Redlands, CA: ESRI.

Python Software Foundation. 2015. *Python tutorial: release 3.5.1*. Wilmington, DE: Python Software Foundation. Available at https://docs.python.org/3/tutorial/index.html
(scan the tutorial and pay closer attention to Chapter 3)

Session 23: Geoprocessing with Scripts—Python & IDLE (4/13)

Lab Exercise: Many common tasks performed in ArcGIS are simple, but can become tedious when repeated over and over again. This session focuses on the use of scripting to automate repetitive geoprocessing tasks, allowing the analyst to work more efficiently.

Session 24: Global & Local Measures of Spatial Autocorrelation (4/18)

Themes and Topics: spatial weights matrix, global and local measures of spatial association, permutation versus randomization significance testing, modifiable areal unit problem.

Lloyd, Christopher D. 2010. "Spatial data analysis" and "Exploring spatial patterning in data values." In *Spatial data analysis: an introduction for GIS users*. New York, NY: Oxford University Press. (pp. 43-64 & pp. 106-128)

Session 25: ESDA with Lattice Data—R (4/20)

Lab Exercise: Basic exploratory spatial data analysis techniques are introduced and applied for lattice data (polygons and grid cells). The lab session involves testing for evidence of a spatial pattern in the distribution of poverty using Census data across scales.

Session 26: OLS Refresher & Spatially Lagged Variables (4/25)

Themes and Topics: impact of spatial autocorrelation on parametric statistics, spatial regression in the OLS context, tests and diagnostics.

Ward, M.D. and K.S. Gleditsch. 2008. *Spatial regression models: Quantitative applications in the social sciences, No. 155*. Thousand Oaks, CA: SAGE Publications. (pp. 29-64)

Skim as Needed:

Monogan III, J.E. 2015. "Linear Models and Regression Diagnostics." In *Political analysis using R*. New York, NY: Springer. (pp. 79-97)

Optional:

Lloyd, Christopher D. 2010. "Statistics." In *Spatial data analysis: an introduction for GIS users*. New York, NY: Oxford University Press. (pp. 24-42)

McMillen, D.P. 2003. Spatial autocorrelation or model misspecification? *International Regional Science Review*. 26 (2): 208-217.

Session 27: Spatial Regression—R (4/27)

Lab Exercise: The presence of spatial autocorrelation is problematic within a regression context. However, there are established procedures that allow for sound statistical inference despite evidence of its presence. The lab session applies the spatial econometric concepts and techniques discussed in class to examine the spatial distribution of poverty using Census data.

Session 28: Term Project—Team Presentations (5/2)

Themes and Topics: Each team will present their work and findings to the rest of the class and City of Champaign staff.

No required readings. No lab exercise.

Session 29: Course Wrap-Up & Evaluations (5/4)

Themes and Topics: This entire session is set aside to clarify revisions to be made to the final paper based on the presentation, reflect on the semester, complete team peer reviews, and complete the course evaluations.

No required readings. No lab exercise.

FINAL PAPERS DUE (5/11)

Please submit your final paper for the term project (via Compass) by 5:00 pm.