

Spatial Statistics and Hierarchical Modeling for Dependent Data

ABE6933/STA6934 section SPAT, 3 credit hours

Class Periods: T6-7 (12:50 PM - 2:45 PM), R6 (12:50 PM - 1:40 PM)

Location: 211 Rogers Hall; traditional classroom (offline)

Academic Term: Fall 2021

Instructor:

Dr. Nikolay Bliznyuk

Email: n[myLastName]@ufl.edu; replace [myLastName] by instructor's last name without adding extra characters

Phone: 352-392-1864 (only by prior appointment)

Office Hours: 239 Rogers Hall, times TBA

Teaching Assistant/Peer Mentor/Supervised Teaching Student:

Please contact through the Canvas website

- N/A

Course Description

Methodology and application spatial statistics targeted at graduate students in data sciences, engineering and quantitative life sciences. Topics include models for point-referenced/geostatistical, areal and spatial point process patterns data, spatial regression, hierarchical Bayesian framework for spatial (generalized) linear models; advanced topics: spatio-temporal processes, multivariate random fields, approximate Bayesian inference using INLA.

Course Pre-Requisites / Co-Requisites

Prerequisites: mathematical statistics emphasizing inference (e.g., PHC6092 or STA6327) and regression (e.g., STA6207). Knowledge of scientific/statistical computing (e.g., in R, Python or Matlab) and undergraduate mathematics (multivariate calculus and linear algebra) appropriate for a graduate student in data sciences will also be assumed. A pretest will be given on the first day of classes to determine if a student has the prerequisites met.

Course Objectives

- Learn the language of and the principles behind spatial data analysis - modeling, inference and prediction
- Describe the three main areas of spatial statistics: models for geostatistical, areal, and point process data;
- Read and discuss new spatial statistics methods in the literature based on an understanding of the basic spatial statistics approaches, principles and main assumptions.
- Learn and be able to use R to implement and apply models to analyze for different types of spatial data.
- Establish command of methods through homework and a final project
- Reinforce the use of R as a statistical computing language for data science – for statistical inference, prediction, scientific computing and data visualization

Materials and Supply Fees

None

Required Textbooks and Software

No required textbooks

R and Python languages and appropriate computing environments (e.g., R Studio and Anaconda) are freely available

Recommended Textbooks

- *Hierarchical Modeling and Analysis for Spatial Data*, 2nd ed (referred to as the BCG2 book)
- Banerjee, Carlin and Gelfand
- 2014, 2nd edition; CRC press
- ISBN 1439819173

Course Schedule

week	topic
1	Overview Of Spatial Data Problems
	CORE TOPICS
2,3	Gaussian Processes (GPs): Prediction, Interpolation And Smoothing
4,5	Point-Referenced (Geostatistical) Data Models
6,7	Areal Data Models
7,8	Models for Point Patterns
9	Essentials Of Bayesian Inference
10,11	Hierarchical Modeling For Univariate Spatial Data
	SPECIAL TOPICS
12	Nongeostatistical Approaches To Interpolation And Smoothing
13	Multivariate Spatial Modeling
14	Spatiotemporal Modeling
15	Approximate Bayesian Inference Using Integrated Nested Laplace Approximation (INLA)
	Project Presentations

Depending on the student backgrounds and interests, some of the special topics above may vary by year. A more detailed version of this schedule is in the Supplements at the end this syllabus.

Attendance Policy, Class Expectations, and Make-Up Policy

Attendance at all times is expected. Excused absences must be in compliance with university policies in the Graduate Catalog (<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance>) and require appropriate documentation. Make-ups are not allowed except for documented health, family emergency or work reasons.

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Homework Sets (approx. 4-5)	100 each	50%
Project	100	50%
		100%

Homework will be assigned regularly (approximately, biweekly). Project (requiring about 40 hours to complete) will consist of a proposal (10 pts), report (60 pts) and presentation (30 pts). Project details are provided in the Supplements at the end of the syllabus.

Grading Policy

Tentatively, the following grading scale will be adopted; grades may be curved to the advantage of students.

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:
<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.ua.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.ua.ufl.edu/public-results/>.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every

person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

COVID-19

- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF

Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions about returning to campus.

- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the [UF Health Screen, Test & Protect website](#) for more information.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://care.dso.ufl.edu>.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.

SUPPLEMENTS: Project description

The project will emphasize creative application of the methods/knowledge developed in the course. Ideally, the application would be to your line of research and data (your own or of your immediate collaborators - advisor or fellow students). If you do not have suitable data, please check out the sources at the end of this description for the publicly available datasets. Otherwise, a good project could be a replication and extension of the results of a methodological paper of interest (select papers will be provided, or you may propose your own). "Creative application" does not allow merely running someone else's code without making other contributions. **Plagiarism is totally inappropriate and prohibited (just do not do it); it will result in a failing grade for the course. Course staff will run all project reports through UF Ithenticate. All work should be done individually (unless explicitly permitted by the instructor – for more ambitious projects).** *Projects already completed for other classes/causes are not acceptable. Example 1 - unacceptable: in a previous semester, a student wrote a paper for a journal or did a project for a different class, and now wants to submit it without major changes or additional relevant work as the class project. Example 2 – acceptable: in a previous semester, a student wrote a paper for a journal or did a project for a different class, but wants to do a major extension of the work using the techniques learned in this class. This would make a potentially very good project, but the student needs to be explicit about what is new and what not. Only the new work will constitute the course project in this case.* The project will be used to assess the knowledge and skills that students acquired in the course; for that reason, the work must be done individually and without assistance from the course staff.

Deliverables: a one-page proposal, a short technical report as described below, and a 10-12 minute presentation during the last week of classes followed by 3-5 minutes of questions.

Deadlines: (very tentative; will be revised appropriately each year)

01-November-2021, by 5:00PM EST: submit your proposal by email to nbliznyuk@ufl.edu if you are planning to complete the optional project, so that we can meet on Thursday during the class time (individual slots TBA after your proposals have been received).

10-December-2021, by 8:00AM EST: final report (in pdf format, accompanying code and the actual data that you used, if using a publicly available source; put all in a folder named after you and create a zip or rar archive; test archive before submitting), submit using Dropbox file request (same link as above): tinyurl.com/nbliznyuk-submit-files

Expectations for the proposal (1 page):

The main goal behind the proposals is to ensure that the projects are neither too simple nor too ambitious (i.e., will require about 40 hours to complete – loosely, an equivalent of 4-5 weeks of homework effort, where writing will play a significant role), there is no duplication among students and that you have the necessary relatively clean data to analyze. Please specifically discuss what you propose to do (e.g., “big picture” and specific methods), why you focus on this particular problem (significance, motivation and relevance to the course) and available data (specifically, what are primary response variable(s) and features, what are n and p, etc). Your project should be “shovel ready”, i.e., a bit of data preprocessing may be necessary but you should not be spending more than 20% (ideally, 10%) of your total time budget on cleaning and data manipulation. The typesetting format of the proposal should be the same as for the project (please read below).

Expectations for the report (8 pages):

Report should be organized as a short paper appropriate to your field; e.g., a short abstract (100 words), intro (including motivation), background and data, methods, analysis/results, conclusions/discussion. *Any software/languages/environments may be used for the project (i.e., not necessarily R).* The length is about 8 pages (not counting references, appendices or supplements) double-spaced, using 12 pt font: roughly 6 pages of text and 2 pages for your most essential tables and figures; **single-column only**. If necessary, the paper may have an Appendix with additional figures and tables. Data, code and other supplemental information should be made available as part of “Supplementary Materials” unless the data are confidential (please discuss “deliverables” in the proposal). Please check out the project evaluation rubric in a separate file.

SUPPLEMENTS: Detailed Syllabus

week	topics
1	Overview Of Spatial Data Problems Introduction To Spatial Data And Models Fundamentals Of Cartography
2,3	Gaussian Processes (GPs): Prediction, Interpolation And Smoothing GPs As An Extension Of Multivariate Normal Distribution Best Linear Unbiased Prediction Under A Gp Model Computation
4,5	Basics Of Point-Referenced (Geostatistical) Data Models Elements Of Point-Referenced Modeling Spatial Process Models Exploratory Approaches For Point-Referenced Data Classical Spatial Prediction
6,7	Basics Of Areal Data Models Exploratory Approaches For Areal Data Brook's Lemma And Markov Random Fields Conditionally Autoregressive (CAR) Models Simultaneous Autoregressive (SAR) Models
7,8	Models for Point Patterns Homogeneous and Inhomogeneous Poisson Point Processes Related Models
9	Basics Of Bayesian Inference Introduction To Hierarchical Modeling And Bayes Theorem Bayesian Inference Bayesian Computation
10,11	Hierarchical Modeling For Univariate Spatial Data Stationary Spatial Process Models Generalized Linear Spatial Process Modeling Nonstationary Spatial Process Models Areal Data Models General Linear Areal Data Modeling
12	Nongeostatistical Approaches To Interpolation And Smoothing Generalized Additive Models (GAMs) Nonstatistical Approaches
13	Multivariate Spatial Modeling Separable Models Coregionalization Models Other Constructive Approaches Multivariate Models For Areal Data
14	Spatiotemporal Modeling General Modeling Formulation Point-Level Modeling With Continuous Time Nonseparable Spatio-Temporal Models Dynamic Spatio-Temporal Models
15	Bayesian Inference using Integrated Nested Laplace Approximation (INLA)