

# Stochastic modeling in ecology and hydrology

## ABE6017 Section STOC

**Time: Mondays – Period 5 (11:45 AM - 12:35 PM)**

**Wednesdays – Period 5-6 (11:45 AM - 1:40 PM)**

**Rogers Hall 211**

**FALL 2024**

**Instructor:** Rachata Muneeppeerakul, PhD  
rmuneepe@ufl.edu; Phone: (352) 294-6729  
Frazier Rogers Hall 227; Office Hours: by appointments  
**Graduate Teaching Assistants (email, office hours and location):** N/A

### Course Description

Stochastic modeling is introduced through a problem-based approach. Selected papers are studied in depth; derivation of their main results unpacked. Examples include stochastic models of biodiversity, soil moisture, and rainfall. Students pick stochastic models to study for final projects. Students enjoy deeper understanding from unpacking these otherwise seemingly mysterious results. 3 credit hours.

**Pre-requisites:** Basic calculus and college-level probability courses; MAC2312 or equivalent

### Learning Objectives:

Upon completion of this course, students will be able to:

- Unpack and explain the derivations of the basic results of stochastic models
- Apply the analytical techniques discussed in class to solve problems in other stochastic models
- Articulate the effects of stochastic fluctuation on the resulting dynamics based on the analysis of stochastic models

### Sample Readings (No textbook required)

(Notes: we would likely *not* have time to cover all papers listed below; we may cover them in a different order; and we may even switch to different papers, depending on the interest and progress of the class.)

Leigh, E.G. Jr. 2007. Neutral theory: a historical perspective. *Journal of Evolutionary Biology* **20**: 2075-2091.

Volkov, I., J.R. Banavar, S.P. Hubbell, & A. Maritan. 2003. Neutral theory and relative species abundance in ecology. *Nature* **424**: 1035-1037.

McKane, A.J., D. Alonso, & R. V. Solé. 2004. Analytical solution of Hubbell's model of local community dynamics. *Theoretical Population Biology* **65**: 67-73.

Chave, J. & E.G. Leigh Jr. 2002. A spatially explicit neutral model of  $\beta$ -diversity in tropical forests. *Theoretical Population Biology* **62**: 153-166.

Rodriguez-Iturbe, I., A. Porporato, L. Ridolfi, V. Isham, & D.R. Cox. 1999. Probabilistic modeling of water balance at a point: the role of climate, soil and vegetation. *Proceedings of the Royal Society, London, A* **455**: 3789-3805.

- Laio, F., A. Porporato, L. Ridolfi, & I. Rodriguez-Iturbe. 2001. Mean first passage times of processes driven by white shot noise. *Physical Review E* **63**, 036105.
- Leigh, E.G. Jr. 1981. The average lifetime of a population in a varying environment. *Journal of Theoretical Biology* **90**: 213-239.
- Rodriguez-Iturbe, I., D.R. Cox, & V. Isham. 1987. Some models for rainfall based on stochastic point processes. *Proceedings of the Royal Society, London, A* **410**: 269-288.

### Tentative Weekly course schedule:

Week	TOPIC*
1	<b>Basic concepts in probability theory:</b> random variables, expected value, variance, probability mass function (PMF), probability density function (PDF); Properties of selected standard random variables (binomial, exponential, Gaussian)
2	<b>Basic concepts</b> continued: Moment generating function (MGF) <b>Examples of simple stochastic processes:</b> Markov chain, 1st-order autoregressive (AR) model
3	<i>Leigh, EG Jr. (2007)</i> – <b>Neutral theory of diversity:</b> Relative species abundance (RSA)
4	RSA (cont'd); Probability of two random individuals belonging to the same species ( $F$ )
5	$F$ under spatial settings; Generating function of the branching process
6	<i>Rodriguez-Iturbe et al. (1999)</i> – <b>Soil moisture dynamic:</b> Introduction and intuitive understanding of the process; Marked Poisson process; Memorylessness of exponential pulses; loss function
7	Combining the discussed elements; Derive forward Kolmogorov equation
8	Solve forward Kolmogorov equation for steady-state probability density function for soil moisture; Crossing properties
9	<b>Wiener process:</b> Introduction; Forward & backward Kolmogorov eqs; First passage time (FPT)
10	First passage time (FPT) <i>Rodriguez-Iturbe et al. (1987)</i> – <b>Rectangular pulse models of rainfall:</b> Introduction; Derive expected value and variance of the process
11	Moment generation function of the rainfall process <i>PROJECT PROGRESS REPORTS</i>
12	Derive autocorrelation coefficient, PDF of the number of active rain cells
13	Neyman-Scott process: Introduction; Derive expected value, variance, autocovariance
14	<i>PROJECT PROGRESS REPORTS</i> <i>WORKSHOPS TO HELP WITH FINAL PROJECTS</i>
15	TBD*
16	<b>FINAL PROJECT PRESENTATIONS</b>

\* The schedule is tentative. Actual schedule would depend on progress and interest in class.

## Assignments

Assignments are usually due within 1-1.5 weeks after the date they are assigned.

HW	Will be assigned in week	Brief description*
1	2	State problems of your interest Calculate expected value and variance of a random variable Analyze 1 <sup>st</sup> -order autoregressive model of annual stream flow
2	4	Memo on <i>Leigh (2007)**</i> Calculate the probability that two random selected individuals belong to the same species in a neutral model Analyze a property of moment generating function
3	7	Memo on <i>Rodriguez-Iturbe et al. (1999)**</i> Derive statistics of a compound Poisson random variable Derive the probability density function (pdf) for a marked Poisson process with a constant loss function Compile potential papers for your project
4	9	Derive steady-state probabilities of different states in a random telegraph process Derive the autocovariance of Wiener process
5	11	Memo on <i>Rodriguez-Iturbe et al. (1987)**</i> Derive the pdf of the number of active rain cells in a rectangular pulse model of rainfall

\* The assignment descriptions are based on a recent offering and are subject to change.

\*\* For memos, please refer to the papers in Sample Readings below. The papers to be discussed in class may change based on the class interests.

For the final project, students will form groups based on their common interest. Each group will select, with the instructor's guidance and approval, a stochastic modeling paper in their field, in which some basic results of the stochastic model are reported the derivation of those results are omitted or unclear. The group's main task is to work out the detailed derivation of these results and report to the class. Throughout the semester, each group will present 2 or 3 progress reports to inform the instructor and the class on where they are and, importantly, what difficulty they are facing in deriving the results in their selected paper, so that the instructor can provide assistance in a timely manner. These progress reports are designed to keep the group's work on track and are not worth any points.

### Attendance Policy, Class Expectation, and Make-Up Policy

Students are expected to attend class, participate in discussion of the materials, and contribute to a group project. Excused absences must be consistent with university policies in the Graduate Catalog (<https://catalog.ufl.edu/graduate/regulations>) and require appropriate documentation. Additional information can be found here: <https://gradcatalog.ufl.edu/graduate/regulations/>

## Evaluation of Grades:

Class participation: 15% | Assignments: 55% | Final project: 30%

## Grading Policy

Final grade will be rounded to the nearest integer; 85.5 will be rounded to 86.

**91-100 = A | 86-90 = A- | 81-85 = B+ | 76-80 = B | 71-75 = B- | 66-70 = C+ | 61-65 = C  
| 56-60 = C- | 51-55 = D+ | 46-50 = D | 41-45 = D- | 0-40 = E**

More information on UF grading policy may be found at:

[UF Graduate Catalog](#)

[Grades and Grading Policies](#)

## *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.aa.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.aa.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 Conduct Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. 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
- Jennifer Nappo, Director of Human Resources, 352-392-0904, [jpennacc@ufl.edu](mailto:jpennacc@ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto: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](mailto: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:** <https://counseling.ufl.edu>, 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](mailto: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/>.

### 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://career.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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>; <https://care.dso.ufl.edu>.

**On-Line Students Complaints:** <https://distance.ufl.edu/state-authorization-status/#student-complaint>.