ABE 6933: Stochastic modeling in ecology and hydrology

FALL 2018

Time & Location: M 11:45AM-12:35PM, W 11:45AM-1:40PM, Frazier Rogers Hall 283
Credit hours: 3
Pre-requisites: Basic calculus and college-level probability courses

Instructor: Rachata Muneepeerakul, PhD
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Frazier Rogers Hall 227; Office Hours: by appointments

Graduate Teaching Assistants (email, office hours and location): N/A

Course Description

This course takes a problem-based approach to introduce stochastic modeling in context of ecology and hydrology. The students will be asked to study selected papers in detail, through reading and in-class discussion, such that they understand how to set up the problems and derive some results and mathematical expressions reported therein. In the first few lectures, some basic concepts in probability and stochastic processes will be discussed. During the first part of the course, the instructor will lead the discussion. Afterwards, the students may take turn to lead the discussion. Depending on their interest and progress, the students may suggest papers on stochastic modeling in the field related to their own research during a later phase of the course. Examples of topics to be covered include neutral model of biodiversity (in which birth, death, dispersal, and speciation are stochastic), soil moisture dynamics driven by stochastic (Poisson) rainfall, stochastic models of rainfall (pulse model), etc.

Learning Objectives:

Upon completion of this course, students will:

- Understand and be able to derive the basic results in the papers covered in class.
- Be able to apply the techniques used in the covered papers to solve problems related to other stochastic processes.
- Be able to formulate problems and construct models to study the effects of stochastic fluctuation on the resulting dynamics.

Assessment and Evaluation:

The final grade breakdown: Class participation: 15% | Assignments: 55% | Final project: 30%

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 | 51-60 = D | 0-50 = E

Textbooks: None

Tentative Weekly course schedule:

Week	TOPIC*
1	**Basic concepts in probability theory:** random variables, expected value, variance, probability mass function (PMF), probability density function (PDF); Properties of selected standard random variables (binomial, exponential, Gaussian)
2	**Basic concepts** continued: Moment generating function (MGF) **Examples of simple stochastic processes:** Markov chain, 1st-order autoregressive (AR) model
3	***Leigh, EG Jr.* (2007)—Neutral theory of diversity:** 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	***Rodriguez-Iturbe et al.* (1999)—Soil moisture dynamic:** 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	**Wiener process:** Introduction; Forward & backward Kolmogorov eqs; First passage time (FPT)
10	First passage time (FPT) ***Rodriguez-Iturbe et al.* (1987)—Rectangular pulse models of rainfall:** Introduction; Derive expected value and variance of the process
11	Moment generation function of the rainfall process *PROJECT PROGRESS REPORTS*
12	Derive autocorrelation coefficient, PDF of the number of active rain cells
13	Neyman-Scott process: Introduction; Derive expected value, variance, autocovariance
14	*PROJECT PROGRESS REPORTS* *WORKSHOPS TO HELP WITH FINAL PROJECTS*
15	TBD*
16	**FINAL PROJECT PRESENTATIONS**

* 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	Brief description*,**
1	State problems of your interest Calculate expected value and variance of a random variable 1st-order autoregressive model of annual stream flow
2	Memo on *Leigh* (2007) Calculate the probability that two random selected individuals belong to the same species Analyze a property of moment generating function
3	Memo on *Volkov et al.* (Nature, 2003) Derive the expressions for birth and death processes
4	Memo on *Rodriguez-Iturbe et al.* (1999) Derive PDF for a case with a constant loss function Project prospectus
5	Memo on *Rodriguez-Iturbe et al.* (1987) Random telegraph process Derive PDF of the number of active rain cells. Project progress report

* The assignment descriptions are based on previous offering and are subject to change.

** For memos, please refer to the papers in Sample Readings below.

Sample Readings:

(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 β-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.

Grades and Grade Points

For information on current UF policies for assigning grade points, see https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Attendance and Make-Up Work

Requirements for class attendance and make-up exams, assignments and other work are consistent with university policies that can be found at: https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx.

Online Course Evaluation Process

Student assessment of instruction is an important part of efforts to improve teaching and learning. At the end of the semester, students are expected to provide feedback on the quality of instruction in this course using a standard set of university and college criteria. These evaluations are conducted online at https://evaluations.ufl.edu. Evaluations are typically open for students to complete during the last two or three weeks of the semester; students will be notified of the specific times when they are open. Summary results of these assessments are available to students at https://evaluations.ufl.edu/results.

Academic Honesty

As a student at the University of Florida, you have committed yourself to uphold the Honor Code, which includes the following pledge: *"We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity."* You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit 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.*"

It is assumed that you will complete all work independently in each course unless the instructor provides explicit permission for you to collaborate on course tasks (e.g. assignments, papers, quizzes, exams). Furthermore, as part of your obligation to uphold the Honor Code, you should report any condition that facilitates academic misconduct to appropriate personnel. It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor Code. Violations of the Honor Code at the University of Florida will not be tolerated. Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For more information regarding the Student Honor Code, please see: http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code.

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

Services for Students with Disabilities

The Disability Resource Center coordinates the needed accommodations of students with disabilities. This includes registering disabilities, recommending academic accommodations within the classroom, accessing special adaptive computer equipment, providing interpretation services and mediating faculty-student disability related issues. Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation

0001 Reid Hall, 352-392-8565, www.dso.ufl.edu/drc/

Campus Helping Resources

Students experiencing crises or personal problems that interfere with their general well-being are encouraged to utilize the university's counseling resources. The Counseling & Wellness Center provides confidential counseling services at no cost for currently enrolled students. Resources are available on campus for students having personal problems or lacking clear career or academic goals, which interfere with their academic performance.

- *University Counseling & Wellness Center, 3190 Radio Road, 352-392-1575,* www.counseling.ufl.edu/cwc/
  Counseling Services
  Groups and Workshops
  Outreach and Consultation
  Self-Help Library
  Wellness Coaching
- *Career Resource Center,* First Floor JWRU, 392-1601, www.crc.ufl.edu/