CEE 266F Stochastic Hydrology

Online Course Syllabus
Winter 2021

Course Description

Hydrological processes like precipitation, streamflow, and groundwater flow are highly variable over time and across locations. Quantifying the uncertainty in hydrological models and simulating future conditions is critical for informing the development and management of civil infrastructure systems. This course introduces students to statistical methods used in hydrology for data analysis, risk and uncertainty analysis, and simulation. Topics include: flood and drought frequency, time series analysis, synthetic streamflow generation. Methods include: applied probability theory, extreme value theory, parameter estimation, regression, time series analysis, Bayesian methods.

Prerequisites

CEE 266A or equivalent and a class in probability and/or statistics.

Learning Objectives

After successful completion of this course, students will be able to:

- Explain the importance of considering uncertainty in hydrology and water resources management
- Apply appropriate parametric and non-parametric statistical methods to common hydrological problems
- Evaluate the adequacy of statistical models based on the problem and data
- Identify some open research areas in stochastic hydrology

Contact Information

Primary Instructor:
Prof. Sarah Fletcher (she/her): sfletcher@stanford.edu

Teaching Assistants (TA):
Nathan Dadap (he/him): ndadap@stanford.edu
Yash Gaur (he/him): yashgaur@stanford.edu

Preferred communication methods:
We will use Piazza as the primary venue for questions about course logistics or asynchronous help with assignments, so that all students can benefit from the responses. Please sign up for Piazza here: piazza.com/stanford/winter2021/cee266f

Help with assignments or course material can also be addressed in office hours. Feel free to contact the teaching team by email for individual questions or concerns. We aim to respond within 48 hours except on weekends.

Office Hours

Virtual office hours are times you can meet with your instructors to: discuss the material being covered in class, get help with assignments, ask questions, or raise concerns you might have.

TA office hours will focus on help with problem-solving in groups. This is the best place to start for questions about assignments.

Nathan's office hours: TBD
Yash's office hours: TBD

Prof. Fletcher's office hours will allow students to discuss general concepts, questions, and any concerns you may have about the class. Her office hours are scheduled for: TBD

Compassion during Crisis

This is a tough year. We are all doing the best we can to navigate our professional and personal obligations during an unprecedented crisis while physically separated from many of our loved ones. You may be stressed about friends or family impacted by COVID, increased work or family care responsibilities, and/or financial concerns. Your health and well-being are the most important thing, now and always. This class should challenge you to grow as scientists and engineers, but never at the expense of your well-being.

I am fully committed to supporting you. I will make whatever accommodations I can to help you finish your exercises, do well on your projects, and learn and understand the class material. Under ordinary conditions, I am flexible and lenient with grading and course expectations when students face difficult challenges. Under pandemic conditions, that flexibility and leniency is intensified. If you tell me you're having trouble or feeling behind, I will not judge you or think less of you. I hope you'll extend me the same grace.

If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. You can learn more about the broad range of confidential mental health services available on campus here: https://vaden.stanford.edu/caps-and-wellness/counseling-and-psychological-services-caps

Course Structure

This course is scheduled from 12:30 – 2 pm on Tuesdays and Thursdays. However, we will only be using half of this class time for synchronous meetings to reduce Zoom fatigue and provide greater flexibility for students to watch lectures asynchronously.

This course will be facilitated online through Canvas. Any suggested reading and other course material will be posted on Canvas. Homework assignments, project proposals, and papers should be submitted via the Canvas Assignments tab.

Synchronous meetings (on Zoom):
Tuesday 12:30 – 1:15 pm: Beginning of week meeting to introduce the week's topic, discuss in small groups, and address questions and logistics

Thursday 12:30 – 1:15 pm: Interactive problem-solving session. Pre-recorded lectures for the week should be completed in advance of this session.

Asynchronous lectures:
Lectures will be recorded and posted on canvas in advance to watch at your convenience. Lectures will total approximately 1.5 hours each week, broken into 20-30 min segments.

Course Materials

In order to ensure class material are accessible to all students without posing a financial burden, all of the readings and computational tools used in this class are available to all students free of charge.

Optional Texts:
There are no required textbooks for this class. Any required readings will be posted on Canvas. Some optional texts you may find useful as a reference include:

Naghettini, M. (2017). Fundamentals of Statistical Hydrology. https://searchworks.stanford.edu/view/13714852 (Available electronically on course reserve)

Birkens, M.F., & van Geer, F. C. (2007). Stochastic Hydrology. http://www.earthsurfacehydrology.nl/wp-content/uploads/2012/01/Syllabus_Stochastic-Hydrology.pdf

Helsel, D. R. and Hirsch, R.M. (2002). Statistical Methods in Water Resources. Techniques of Water-Resources Investigations 04-A3. USGS. https://doi.org/10.3133/twri04A3

Loucks, D.P., & Van Beek, E. (2017). An Introduction to Probability, Statistics and Uncertainty. In: Water Resources Systems Planning and Management: An Introduction to Methods, Models and Applications. https://link.springer.com/book/10.1007/978-3-319-44234-1

Required Computing Software:
In this course, coding examples and support will be provided in Python. Students are welcome to use R or MATLAB to complete assignments if they prefer, but the teaching team will not provide programming support for languages other than Python.

If you do not have Python installed on your computer, we recommend you install it from anaconda: https://www.anaconda.com/download/

Course Schedule

This schedule is a guide for the course and is subject to change with advance notice. Pre-recorded lectures should be watched before class on Thursday and will be posted on Canvas a week in advance along with any accompanying readings.

Week	Topics	Assignments
1/11	**Introduction**: Why care about uncertainty? **Python Tutorial**	Pre-course survey
1/18	**Applied probability review**: random variables; probability density functions; moments; joint distributions; conditional probability; independence; Bayes' theorem; common pdfs **Statistics review:** parameter estimation using method of moments and maximum likelihood; linear regression; hypothesis testing; model evaluation	Problem set 1 assigned (due Jan 29)
1/25	**Hydrological extremes – Floods and Droughts I:** Flow duration curve; recurrence times; partial duration series; annual flow maximum; extreme value distributions; L moments	Problem set 2 assigned (due Feb 12)
2/1	**Hydrological extremes – Floods and Droughts II:** Minimum low flow; frequency-duration-severity; 7Q10 streamflow estimation; regionalization methods	Project proposal due Feb 5
2/8	**Time series analysis I**: linear regression revisited; autocorrelation; cycles and seasonality; stationarity; AR models; MA models	Problem set 3 assigned (due Feb 26)
2/15	**Time series analysis II**: ARMA, ARIMA processes; model identification, estimation, and diagnostics; trend and change point detection	Quiz 1: Hydrological extremes
2/22	**Synthetic Streamflow Generation I**: Motivation and approaches; Monte Carlo simulation; AR(1) for annual flows; validation	Problem set 4 assigned (due Mar 9)
3/1	**Synthetic Streamflow Generation II**: Nonparametric methods; bootstrap resampling; K-nn; nonstationary approaches for climate impact assessment; multisite methods	Quiz 2: Time series analysis
3/8	**Advanced Topics TBD**	
3/15	**Advanced Topics TBD** **Project Presentations**	

Course Policies

Grade Breakdown

Participation/Attendance	10%
Problem Sets	30%
Quiz (higher score)	20%
Quiz (lower score)	10%
Project	30%

Grading Basis

Because of the pandemic, this class is available S/NC only. This means as long as you score at minimum a C-, you will receive full credit for the class and you can still use it toward the CEE degree requirements. This policy is meant to alleviate stress about coursework during COVID. However, I will still calculate and provide letter grade scores for all assignments.

Quizzes

There are two quizzes that together comprise 30% of your grade. However, I will weight whichever one you score higher on twice as much as the lower grade.

Both quizzes are take-home. You will have two hours to complete each quiz, but you will have a window of two days in which you can open the exam and complete it within two hours. I don't expect you to need the full two hours to complete each quiz. The two hours start when you open the quiz in Canvas. If you foresee or encounter extenuating circumstances that would not allow you to complete the exam within the two-hour limit or before the deadline, please contact me as soon as possible.

Late Homework Policy

The due dates for all four problem sets have been posted on Canvas and noted above to help you plan.

I can think of many reasons, especially during this pandemic, why your homework might be submitted late. For these reasons, you are allowed 4 "late days" for your assignments. In other words, there would be no penalty if you submitted one of the assignments 4 days late, or each of the four assignments 1 day late, or two assignments 2 days late, etc. After those 4 "late days" are used, you will be docked 20% of the maximum possible points for each late.

If extenuating circumstances arise that require more than the 4 late days, please reach out to me and I will work with you to find a solution.

Project

The course project is an opportunity to learn about a method in stochastic hydrology that we don't explicitly cover in class and apply it to a real-world dataset. Details about the project expectations will be posted on Canvas.

Participation

Your participation grade will be based on both engagement in discussions and problem-solving sessions during synchronous class sessions and responding to brief comprehension surveys after asynchronous lectures. If you are not able to attend synchronous class sessions, you can instead participate through the discussion board on Piazza. Remember that engagement means not only sharing your ideas but also listening and responding to what others have to say.

Expectations

Given potential constraints associated with online learning, attendance in synchronous class activities is not required, though many find that the learning experience is enhanced by regular, synchronous engagement. If you cannot attend the synchronous sessions, it is your responsibility to be informed of the content discussed in class by watching the recordings, and to participate in class discussions online.

You are expected to treat your classmates, the teaching team, and yourself with respect at all times, both in and out of the (virtual) classroom, and in writing (over email, on discussion boards). Your success in this course will be enhanced if you: are prepared for active participation, having watched the pre-recoded lectures and read the assigned readings; ask questions about any material you don't understand (in-class or on the course Discussion Board); contribute your ideas to discussions and problem-solving sessions.

You can expect that we, the teaching team, will facilitate a respectful and inclusive learning environment, both in and out of the classroom. You can expect that we will post course materials in a timely fashion (one week before each session), and be available for consultation during office hours and over email (we will respond within 48 hours). You can expect that we will provide opportunities for you to give us (anonymous) feedback during and at the end of term.

Justice, Equity, Diversity, and Inclusion

Justice, equity, diversity, and inclusion are central to our work in the classroom and beyond. I echo the Civil and Environmental Engineering department's statements on diversity and inclusion https://cee.stanford.edu/our-culture/diversity-equity-inclusion :

> *As a Civil & Environmental Engineering community, our mission to advance education and research in engineering the built and natural environment is inextricably tied with environmental issues, and therefore, racial and social issues. We want to encourage each member of the CEE community to continue to grow, listen, learn, and reflect. We must also recognize how the field of engineering has historically failed to prioritize the value of diversity in experience, and work to change that.*

Diversity is a source of strength, creativity, and innovation for Stanford. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals.

It should go without saying that in this classroom Black Lives Matter. For resources on dismantling anti-Black racism in academia, please see: https://www.particlesforjustice.org and https://shutdownstem.com.

Land Acknowledgment

We acknowledge that Stanford sits on the ancestral and unceded land of the Muwekma Ohlone Tribe comprised of all known surviving American Indian lineages of the San Francisco Bay region traced through Missions Dolores, Santa Clara, and San Jose and that were also members of the historic Federally Recognized Verona Band of Alameda County. Consistent with our values of community and diversity, we have a responsibility to acknowledge benefit from use and occupation of this land and to honor and make visible the university's historic and ongoing relationships to Native peoples.

The field of stochastic hydrology and its use in water resources engineering is inextricably linked to infrastructure development that has displaced Indigenous peoples and harmed endangered fish species of importance to Indigenous communities. As one example, you can learn more about the impacts of California's Shasta Dam on the Winnemem Wintu Tribe here: https://mavensnotebook.com/2020/04/08/the-shasta-dam-raise-project-history/

To learn about other places of significance to you or land acknowledgements in general, please see: https://native-land.ca.

Academic Integrity

It is expected that you and I will follow Stanford's Honor Code in all matters relating to this online course. You are encouraged to virtually meet and exchange ideas with your classmates while studying and working on homework assignments, but you are individually responsible for your own work and for understanding the material. You are not permitted to copy or otherwise reference another student's homework or computer code. Compromising your academic integrity may lead to serious consequences, including (but not limited to) one or more of the following: failure of the assignment, failure of the course, disciplinary probation, suspension from the university, or dismissal from the university.

You, as students, are responsible for understanding the University's Honor Code policy and must make proper use of citations of sources for writing papers, creating, presenting, and performing their work, taking examinations, and doing research. For tips on how to uphold the honor code in an online learning environment, read these recommendations. If you have any questions regarding this policy, please contact me.

Academic Accommodation

I am committed to making this class accessible for all students, including upholding all university disability policies:

Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty dated in the current quarter in which the request is being made. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (phone: 723-1066, URL: http://oae.stanford.edu).

Additionally, I recognize that accessibility needs may arise that are not explicitly covered by these policies. You are invited to contact me directly to discuss any situation that impacts your ability to engage with this course and how I can best support you and your learning.

Course Material Copyrights

I share with you Stanford's statement on copyright of course materials:

The materials provided to you for this course are copyrighted or licensed to Stanford University. Stanford grants you a limited license to use the materials solely in connection with the course for your own personal educational purposes. Any use of the materials outside of the course may be in violation of copyright law. You agree that you will not post, share or copy the materials. You agree that you will only save the materials for the duration of the course.

Penalties for copyright infringement can be harsh. Fines of up to $150,000 in civil statutory damages may apply for each separate willful infringement, regardless of the actual damages involved. Stanford may also take administrative action against copyright infringement, including loss of networking privileges and SUNet ID, or disciplinary action up to and including termination for faculty and staff, and expulsion for students.

Proceeding with this course indicates that you have read the above statement, agree to be bound by its terms and you agree to delete course materials on the earlier date of 14 days from the conclusion of the course or 14 days after withdrawing from the course.