2019

CE 5500: Stochastic Hydrology, University of Virginia

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CE 5500: Stochastic Hydrology

TR 12:30-1:45 pm

MEC 305

Instructor:

Julianne Quinn, jdq6nn@virginia.edu
OH: TR 2:00-3:30 pm, 102D Olsson, 243-3179

Course Description:

This course introduces students to statistical methods used in hydrology for data analysis, risk and uncertainty analysis, and simulation. Topics include applications of extreme value theory to estimate flood and drought statistics, regionalization methods for predictions in ungauged basins, and trend analysis of historical time series.

Course Objective:

The goal of this course is to illustrate the importance of uncertainty analysis in hydrology. Whether data-driven or mechanistically-driven, all hydrologic models have errors. Quantifying the uncertainty in hydrologic model predictions due to those errors is important for informing the development and management of civil infrastructure systems. In this course, students will learn stochastic methods used in hydrology for this purpose related to flood frequency analysis, drought frequency analysis, predictions in ungauged basins, and time series analysis. Students should leave the course with an understanding of how to apply these methods in practice to design civil infrastructure systems that are robust to hydrologic uncertainty.

Prerequisites:

APMA 3110 and EVSC 3600 or equivalent.

Required Software:

In this course, R, Python or Matlab can be used for data analysis.

- R Studio – `https://www.rstudio.com/`
- Python – `https://www.anaconda.com/download/`
- MATLAB – `https://www.mathworks.com/academia/tah-portal/university-of-virginia-40704757.html`

Course Communication Platform:

In this course, we will use Piazza outside of class for course communications: https://piazza.com/class/jqmmg3pu8qg6la. Students should utilize this resource instead of e-mailing the professor directly with questions. Questions should be posted on the discussion board referencing the appropriate assignment. Questions will be responded to within 24 hours. Piazza is also used as one component of measuring class participation, so students are encouraged to actively engage by answering other students' questions and discussing course content.

Optional Texts:

- Bierkens, M.F., & van Geer, F. C. (2007). Stochastic hydrology. http://www.earthsurfacehydrology.nl/wp-content/uploads/2012/01/Syllabus_Stochastic-Hydrology.pdf
- 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.* Springer, Cham. https://link.springer.com/chapter/10.1007/978-3-319-44234-1_6
- Stedinger, J.R., Vogel, R.M., Foufoula-Georgiou, E. (1993). Frequency Analysis of Extreme Events. In: Maidment, D.R. (Ed.) *Handbook of Hydrology.* (pp. 18.1-18.66). New York: McGraw-Hill. https://engineering.tufts.edu/cee/people/vogel/documents/frequencyAnalysis.pdf
- Wilks, D.S. (2011). Statistical methods in the atmospheric sciences (3rd ed.). Oxford; Waltham, MA: Academic Press.

Learning Resources:

- Coursera Courses on R Programming–https://www.coursera.org/courses?query=R
- Coursera Courses on Python Programming–https://www.coursera.org/courses?query=python
- Coursera Courses on Matlab Programming–https://www.coursera.org/courses?query=MATLAB
- University of Virginia Writing Center– https://virginia.mywconline.com/.

Nominal Class Outline:

Week	Dates	Topics	Readings
1	1/15, 1/17	Introduction and statistics review	———
2	1/22, 1/24	Floods: Annual Maxima Series (AMS)	Thomas, 1985
3	1/29, 1/31	Model Adequacy and Uncertainty	Stedinger et al., 1993
4	2/5, 2/7	Floods: Partial Duration Series (PDS)	Madsen et al., 1997
5	2/12, 2/14	Floods: Historical information	Cohn et al., 1997
6	2/19, 2/21	Droughts: Low flow estimation	Vogel & Kroll, 1989
7	2/26, 2/28	Fitting multivariate distributions	———
8	3/5, 3/7	Modeling dependency with copulas	Hao & AghaKouchak, 2013
9	3/12, 3/14	——— Spring break ———	——— Spring break ———
10	3/19, 3/21	Review, Midterm	———
11	3/26, 3/28	Spatial Regression	Stedinger & Tasker, 1985
12	4/2, 4/4	Regression diagnostics	———
13	4/9, 4/11	Non-stationarity discussion	Milly et al., 2008; Rosner et al., 2014; Koutsoyiannis & Montanari, 2015; Cohn & Lins, 2005; Trenberth, 2011; Huntington, 2006
14	4/16, 4/18	Time series analysis	———
15	4/23, 4/25	Trend detection	Wi et al., 2016
16	4/30	Project presentations	———

References:

Cohn, T. A., Lane, W. L., & Baier, W. G. (1997). An algorithm for computing moments-based flood quantile estimates when historical flood information is available. *Water Resources Research*, *33*(9), 2089-2096.

Cohn, T. A., & Lins, H. F. (2005). Nature's style: Naturally trendy. *Geophysical Research Letters*, *32*(23).

Hao, Z., & AghaKouchak, A. (2013). Multivariate standardized drought index: a parametric multi-index model. *Advances in Water Resources*, *57*, 12-18.

Huntington, T. G. (2006). Evidence for intensification of the global water cycle: review and synthesis. *Journal of Hydrology*, *319*(1-4), 83-95.

Koutsoyiannis, D., & Montanari, A. (2015). Negligent killing of scientific concepts: the stationarity case. *Hydrological Sciences Journal*, *60*(7-8), 1174-1183.

Madsen, H., Rasmussen, P. F., & Rosbjerg, D. (1997). Comparison of annual maximum series and partial duration series methods for modeling extreme hydrologic events: 1. At-site modeling. *Water Resources Research*, *33*(4), 747-757.

Milly, P. C. D., Betancourt, J., Falkenmark, M., Hirsch, R. M., Kundzewicz, Z. W., Lettenmaier, D. P., & Stouffer, R. J. (2008). Stationarity is dead: Whither water management?. *Science*, *319*(5863), 573-574.

Rosner, A., Vogel, R. M., & Kirshen, P. H. (2014). A risk-based approach to flood management decisions in a nonstationary world. *Water Resources Research*, *50*(3), 1928-1942.

Stedinger, J. R., & Tasker, G. D. (1985). Regional hydrologic analysis: 1. Ordinary, weighted, and generalized least squares compared. *Water Resources Research*, *21*(9), 1421-1432.

Stedinger, J. R., Vogel, R. M., & Foufoula-Georgiou, E. (1993). Frequency analysis of extreme events. *Handbook of Hydrology*, 18-1.

Thomas Jr., W.O. (1985). A Uniform technique for flood frequency analysis. *Journal of Water Resources Planning and Management*, *111*(3), 321-337.

Trenberth, K. E. (2011). Changes in precipitation with climate change. *Climate Research*, *47*(1-2), 123-138.

Vogel, R. M., & Kroll, C. N. (1989). Low-flow frequency analysis using probability-plot correlation coefficients. *Journal of Water Resources Planning and Management*, *115*(3), 338-357.

Wi, S., Valds, J. B., Steinschneider, S., & Kim, T. W. (2016). Non-stationary frequency analysis of extreme precipitation in South Korea using peaks-over-threshold and annual maxima. *Stochastic Environmental Research and Risk Assessment*, *30*(2), 583-606.

Student Evaluation and Assessment

Grade Breakdown:

Homework Assignments	30%
Midterm Exam	30%
Final Project	30%
Participation	10%

Homework Assignments (30%): One reading and one problem set will be assigned approximately every other week. Readings should be done by the next class. Problem sets can be submitted in class or electronically through Collab.

Midterm Exam (30%): There will be a midterm exam, tentatively the week following spring break, on all of the material covered up to that point. A review session will be held the class before.

Final Project (30%): In lieu of a final exam, all students will do an individual project on a topic of their choosing. It should include at least one application of a method learned prior to the midterm and at least one application of a method learned after the midterm. More details will be given later in the semester.

Participation (10%): Students will be expected to participate in class discussions on the weekly readings. In addition, students will be divided into groups that will each lead one lecture and class discussion over the course of the semester. Students can also earn bonus points for participation by answering other students' questions on Piazza (see section on *Course Communication Platform* above).

Course Policies

Honor Policy:

For homework assignments, you may consult the instructor and your classmates. While you may work with others on the assignments, you must submit your own work.

The midterm exam will be in-class and will cover all material taught before spring break. There will be a written and coding component.

Each student will have his/her own individual final project to be submitted at the end of the semester. Students may consult the instructor for guidance on the project.

If you cheat, copy from someone else on an exam, or copy someone else's work on an assignment or project that you do not cite, then you will fail the course.

The final project must include acknowledgment that you abided by the honor code. Failure to include this acknowledgment will mean that your submission will not be graded.

Late Work Policy:

Requests for extensions must be made to the instructor prior to the due date, unless there is a true emergency. Assignments submitted late will be penalized by 10 points per day if a request for an extension is not made in advance.

Learning Accommodations:

It is my goal to create a learning experience that is as accessible as possible. If you anticipate any issues related to the format, materials, or requirements of this course, please meet with me outside of class so we can explore potential options. Students with disabilities may also wish to work with the Student Disability Access Center to discuss a range of options for removing barriers in this course, including official accommodations. Please visit their website for information on this process and to apply for services online: `https://www.studenthealth.virginia.edu/sdac`. If you have already been approved for accommodations through SDAC, please send me your accommodation letter and meet with me so we can develop an implementation plan together. SDAC is located in the Department of Student Health and can be contacted at 243-5180/5181.

Religious Accommodations:

It is the University's long-standing policy and practice to reasonably accommodate students so that they do not experience an adverse academic consequence when sincerely held religious beliefs or observances conflict with academic requirements. Students who wish to request academic accommodation for a religious observance should submit their request in writing directly to me by Piazza private message as far in advance as possible. Students who have questions or concerns about academic accommodations for religious observance or religious beliefs may contact the University's Office for Equal Opportunity and Civil Rights (EOCR) at UVAEOCR@virginia.edu or 434-924-3200.

Discrimination and power-based violence:

The University of Virginia is dedicated to providing a safe and equitable learning environment for all students. To that end, it is vital that you know two values that I and the University hold as critically important:

1. Power-based personal violence will not be tolerated.
2. Everyone has a responsibility to do their part to maintain a safe community on Grounds.

If you or someone you know has been affected by power-based personal violence, more information can be found on the UVA Sexual Violence website that describes reporting options and resources available - `www.virginia.edu/sexualviolence`.

As your professor and as a person, know that I care about you and your well-being and stand ready to provide support and resources as I can. As a faculty member, I am a responsible employee, which means that I am required by University policy and federal law to report what you tell me to the University's Title IX Coordinator. The Title IX Coordinator's job is to ensure that the reporting student receives the resources and support that they need, while also reviewing the information presented to determine whether further action is necessary to ensure survivor safety and the safety of the University community. If you wish to report something that you have seen, you can do so at the Just Report It portal. The worst possible situation would be for you or your friend to remain silent when there are so many here willing and able to help.