Western University - Faculty of Engineering

Department of Civil and Environmental Engineering

CEE 9535a – Advanced Methods in Hydroscience: Applications and Design
Course Outline – Fall 2021

DESCRIPTION

Design, planning, and management of civil infrastructure require understanding, simulation and prediction of hydrological and environmental components. This course gives students a working knowledge of probabilistic and statistical approaches to analyze and interpret growing observed and simulated spatial and temporal data (e.g. climate, hydrology, environment, ecology, geology, population etc.). The emphasis will be on developing analytical skills to simulate and predict natural disasters including floods and droughts in an uncertain and changing climate. Topics covered in this class will be supplemented with computer exercises, which will use graphical and statistical software packages such as R, MATLAB, and ArcGIS to perform numerical analysis of real-world data.

ENROLLMENT RESTRICTIONS

Enrollment in this course is restricted to graduate students in Civil and Environmental Engineering, as well as any student that has obtained special permission to enroll in this course from the course instructor as well as the Graduate Chair (or equivalent) from the student's home program.

INSTRUCTOR CONTACT INFORMATION

Dr. Mohammad Reza Najafi, Ph.D.
Claudette MacKay-Lassonde Pavilion
Room 1301
Email: mnajafi7@uwo.ca

COURSE FORMAT

This course will be delivered "in-person"

TOPICS

1. Fundamentals of probability and Statistics in Water Resources and Environmental Engineering
    - Random variables
    - Discrete and continuous probability distribution functions
    - Some common applications of probabilistic and statistical methods
    - Estimation of distributional parameters
2. Spatial Data Analysis
    - Point pattern analysis
    - Spatial autocorrelation

    - Spatial regression
3. Bayesian Inference Framework
    - Formulating the model hypothesis
    - From prior to posterior
    - Scrutiny of the model hypothesis
    - Markov Chain Monte Carlo sampling
4. Risk and Reliability
    - Understanding uncertainty, risk and reliability
    - Measures of reliability
    - Ways to handle the reliability
    - Decision making under uncertainty
5. Design Rainfall
    - Purpose of design rainfalls
    - Comparison of annual maximum series and partial duration series
    - Appropriate probability distributions
    - Regionalization
    - Deriving sub-daily and sub-hourly IDF relationships
    - Design spatial patterns
6. Flooding; Flood Frequency Analysis
    - Flood characteristics
    - Flood processes
    - Flood hydrograph estimation
    - Describing the chance of flood
    - Description of flood risk
    - Models of flood peaks
    - Index flood method
7. Low Flow and Drought Analysis
    - Significance of low flows in ecology and environmental flow management
    - Factors affecting low flows
    - Low flow indices
    - Drought, aridity, and water scarcity
    - Causes of drought
    - Drought properties based on statistical techniques
    - Indices for drought characterization
    - Statistical methods for drought forecasting
8. Inverse Problem Theory and Its Application in Model Optimization
    - General formulation of inverse problem
    - Hydrologic model calibration using global optimization
    - Shuffled complex evolution algorithm
9. Future Engineering Challenges in an Uncertain and Changing Climate

Note: The instructor may expand, or revise material presented in the course as appropriate.

SPECIFIC LEARNING OUTCOMES

Degree Level Expectation	Weight	Assessment Tools	Outcomes
Depth and breadth of knowledge	25%	• Assignments • Project • Examination	• Understanding of advanced concepts and theories in hydroscience • Awareness of important current problems in the application of data analytics in hydroscience • Understanding of probabilistic and statistical methodologies to solve related problems
Research & scholarship	15%	• Project	• Ability to conduct critical evaluation of current advancements in hydroscience • Ability to conduct coherent and thorough analyses of complex problems using established techniques/principles and judgment
Application of knowledge	30%	• Assignments • Project • Examinations	• Ability to apply knowledge in a rational way to analyze a particular problem • Ability to use coherent approach to design a particular engineering system using existing design tools
Professional capacity / autonomy	5%	• Project	• Awareness of academic integrity • Ability to implement established procedures and practices in the coursework • Defends own ideas and conclusions • Integrates reflection into his/her learning process
Communication skills	15%	• Project	• Ability to communicate (oral and/or written) ideas, issues, results and conclusions clearly and effectively
Awareness of limits of knowledge	10%	• Project	• Awareness of the need of assumptions in complex scientific analyses and their consequences • Understanding of the difference between theoretical and empirical approaches • Ability to acknowledge analytical limitation due to complexity of practical problems

ASSESSMENTS

The final course mark will be determined as follows:

Final Exam	30%
Assignments:	30%
Project:	30%
Participation:	10%

Total	100%

Note:

(a) Students must turn in all individual assignments and projects to pass this course. Students who do not satisfy this requirement will be assigned 48% or the aggregate mark, whichever is less.

(b) Students who have failed this course previously must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted.

(c) Should any of the quizzes conflict with a religious holiday that a student wishes to observe, the student must inform the instructor of the conflict no later than two weeks before the scheduled test.
(For further information on Accommodations for Religious Holidays see https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf)

(d) Participation will be tracked through forum posts and discussions during lecture hours.

Activities in which collaboration is permitted:

- Projects- Students within each group are encouraged to closely collaborate on their projects
- Assignments- Students are encouraged to ask their questions or provide hints to solve give problems using through forums on OWL. Students are not allowed to copy assignments, which will be considered as plagiarism.

Activities in which students must work alone (collaboration is not permitted):

- Final exam

COURSE MATERIALS

Prepared class notes by Dr. Najafi covering the material will be posted on OWL
References (optional):

- Handbook of Applied Hydrology, by Vijay P. Singh

- Fundamentals of Statistical Hydrology, by Mauri Naghettini
- Statistical Rethinking, by Richard McElreath
- Statistical Methods for Geography, by P. Rogerson
- Statistical Methods in Water Resources, U.S.G.S, by Helsel and Hirsch (https://pubs.usgs.gov/twri/twri4a3/pdf/twri4a3-new.pdf)

PREREQUISITE

This course is designed for graduate students (MEng, MESc, PhD) enrolled in civil engineering, environmental science, statistics and geography with an interest in data analysis, interpretation, and modelling. It is expected that students will have basic understanding of hydrology and statistics by taking suitable courses at the undergraduate or graduate levels. Students without a suitable background in these topics should consult with the instructor prior to registering for the course.

COREQUISITES

None.

ANTIREQUISITES

None.
Note: It is the student's responsibility to ensure that all Prerequisite conditions are met or that special permission to waive these requirements has been granted by the Faculty. It is also the student's responsibility to ensure that he/she has not taken a course listed as an Antirequisite. The student may be dropped from the course or not given credit for the course towards his/her degree if he/she violates the Prerequisite, Corequisite or Antirequisite conditions.

CONTACT HOURS

3 lecture hours per week.

COMPUTING

Assignments and term project will require the processing of observations and simulations using graphical and data-analysis software such as R, Python, MATLAB, ArcGIS or similar, and the students will be assumed to be proficient in the use of the software of their choice. All software environments used in this class are either freely available or can be accessed through Western Technology Services https://wts.uwo.ca/sitelicense/index.html

UNITS

SI units will be used in lectures and examinations.

GENERAL LEARNING OBJECTIVES

E=Evaluate, T=Teach, I=Introduce

Problem Analysis	E	Team Work	I	Ethics and Equity	I
Investigation	T	Communication	I	Economics and Project Management	
Design	T	Professionalism		Life-Long Learning	I
Engineering Tools	E	Impact on Society	T	Knowledge Base	E

ASSIGNMENTS AND PROJECT

There will be four assignments spaced throughout the course. The project will span the length of the course, and will involve critical review of some technical papers, programming, a report, and a class presentation.

EXAMINATION

A 3-hour examination is held during the examination period on all work covered during the course. The examination is an Open Book, and a calculator is allowed.

COURSE CONTENT

The lecture notes and any online lecture videos are copyrighted to the instructor and legally protected. Do not post these videos and lecture notes on any other website or online forums. The recording of the live/synchronous sessions of the course without the permission from the instructor is prohibited. The illegal posting and sharing of the copyrighted course content could be subjected to legal actions.

CHEATING, PLAGIARISM/ACADEMIC OFFENCES

Academic integrity is an essential component of learning activities. Students must have a clear understanding of the course activities in which they are expected to work alone (and what working alone implies) and the activities in which they can collaborate or seek help; see information above under “Assessments” and ask instructor for clarification if needed. Any unauthorized forms of help-seeking or collaboration will be considered an academic offense. University policy states that cheating is an academic offence. If you are caught cheating, there will be no second warning. Students must write their essays and assignments in their own words. Whenever students take an idea or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence. Academic offences are taken seriously and attended by academic penalties which may include expulsion from the program. Students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence (see Western's scholastic discipline regulations for graduate students).

SYNCHRONOUS LEARNING ACTIVITIES

Students are expected to participate in synchronous learning activities as outlined in the course syllabus and/or described by the instructor. If you have issues that will impede your ability to participate in synchronous activities, please discuss with the course instructor at the beginning of the course.

CONDUCT

Students are expected to follow proper etiquette during synchronous and asynchronous activities to maintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in the learning activities and/or is not following the associated rules and responsibilities, will be reported to the Associate Dean (Graduate) (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Associate Dean (Graduate), the student could be debarred from completing the assessment activities in the course as appropriate.

HEALTH/WELLNESS

As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several health and wellness related services (remotely accessible) to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. Information regarding health- and wellness-related services available to students may be found at http://www.health.uwo.ca/.

Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Campus mental health resources may be found at http://www.health.uwo.ca/mental_health/resources.html
https://www.uwo.ca/health/psych/index.html

SICKNESS

Students should immediately consult with the Instructor (for a particular course) or Associate Chair (Graduate) (for a range of courses) if they have problems that could affect their performance. The student should seek advice from the Instructor or Associate Chair (Graduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Graduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal. Obtaining appropriate documentation (e.g., a note from the doctor) is valuable when asking for accommodation due to illness.

ACCESSIBLITY

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education at 661-2111 x 82147 or http://academicsupport.uwo.ca/accessible_education/index.html, for any specific question regarding an accommodation.