CEE 5450/6450 Hydrologic Modeling

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Office Hour: M/W 1:30-2:30 pm

Class Hours: M/W 12:00-1:15 pm
Class Room: EL 227/CEE conference room
Website: groundwater.usu.edu
Last Updated: *2025-1-3*

Course Description

This course introduces the principles and practices of hydrologic modeling for groundwater and surface water systems, with an emphasis on physically based, fully distributed models. Taking a bottom-up approach, the course begins with groundwater modeling, covering applications in both groundwater flow and solute transport. It then expands to integrated surface and subsurface models, enabling students to simulate key hydrologic processes—including evapotranspiration, snowmelt, infiltration, and runoff generation—at scales ranging from 2D hillslope to 3D watershed.

The course utilizes open-source software (e.g., PFLOTRAN and ATS) for developing numerical models, with Python programming for pre- and post-processing of model inputs and outputs. Additional topics include high-performance computing (HPC) basics, a Linux/Unix environment overview, and practical guidance on running models in HPC settings. The capstone project offers hands-on experience in building hydrologic models to address real-world water-related challenges tailored to students' areas of focus and interest.

Prerequisites

- CEE 6400 Physical Hydrology or a similar hydrology class.
- CEE 5430/6430 Groundwater Engineering or similar groundwater hydrology class.
- Some programming experiences (e.g., Python, R, and Matlab), including working in a Linux/Unix environment, is beneficial but not required.

Course Materials

This course has no required textbook. The following references are provided as supplemental material:

- Mary P. Anderson, William W. Woessner, and Randall J. Hunt. (2015) *Applied Groundwater Modeling*, 2nd Edition (hard copy available at USU library)
- Chunmiao Zheng, Gordon D. Bennett. (2002) *Applied Contaminant Transport Modeling*, 2nd Edition

- Jacob Bear and Alexander H.-D. Cheng. (2010) Modeling Groundwater Flow and Contaminant Transport, ISBN: 978-1-4020-6681-8, DOI: 10.1007/978-1-4020-6682-5. (Free eBook access through USU library)
- Keith J. Beven, (2012) *Rainfall-Runoff Modelling: The Primer*, 2nd Edition, ISBN: 978-0-470-71459-1. (Free eBook access through USU library)

If you need some refreshment on groundwater and surface water hydrology, here are several good textbooks.

- Freeze, R.A. and Cherry, J.A., (1979) *Groundwater*, Prentice-Hall, Englewood Cliffs, N.J., (A free, multilingual online version can be found at The Groundwater Project)
- Dingman, S. L., (2015), *Physical Hydrology*, 3rd Edition, Prentice Hall

Modeling codes and documentation:

- PFLOTRAN (website, documentation, source code)
- ATS (documentation, source code)

Communications

Course notes are available on Canvas. Canvas will be used to post course materials, homework assignments, and solutions. You are encouraged to post general questions about lecture material, homework, etc. using the "***Discussions***" feature on Canvas, so that all students can benefit. If you have a specific question or need a quick response, send me an email with the subject line starting with "***CEE 5430/6430***" so that I can respond in a timely way (usually within 1~2 business days). Unless you request that I don't, I may forward email questions and answers to the entire class who may be struggling with similar questions/issues.

Course Objectives

Successful students will be able to do all of the following:

1. Understand the general hydrologic modeling workflow
2. Explain the inner-workings of hydrological models, including their spatial discretization, parameterizations, and numerical methods
3. Use open source code to develop simple groundwater flow and transport models as well as more complex integrated groundwater-surface water models
4. Know how to run models on PC as well as High Performance Computing system
5. Know how to visualize modeling results
6. Use scripts (e.g., Python) to preprocess model inputs and postprocess model outputs
7. Know how to interpret modeling results against observation data
8. Know the procedure for model calibration and validation

9. Know how to use models to address real-world water issues. E.g., how does climate change impact groundwater dynamics?
10. Use best practices in hydrologic modeling, including code sharing, version control, and fully documented and reproducible workflows

Course Structure

Lectures

Lectures will be given twice a week unless otherwise notified. Students are encouraged to ask questions during the lectures. This course does not have a lab component.

Homework Assignments

There will be 9~10 homework assignments throughout the semester. They may include developing a simple hydrological model, analyzing output from existing hydrological models, running existing hydrological models on laptop/HPC. You will have 7-10 days to complete each assignment. You are encouraged to work with your classmates.

Capstone Project

The capstone project will provide students with the hands-on opportunity for applying hydrologic models. Students will build hydrologic models based on a synthetic or real-world case study to address water challenges. Topics will be approved by the instructor, and students are encouraged to discuss potential topics with the instructor early in the course. Details of the semester project will be made available via the Course Canvas website. Students will report on their project and make oral presentations.

Capstone presentation: Students will be expected to do a final oral presentation (10 - 15 minutes) in class to report their project results. The presentations will be given during the last week of class. We will also draw names to work out the order of all presentations.

Capstone report: Students will be expected to complete and submit a final project report that details the application of hydrologic models for the topic they chose. Expectations of the final project report for graduate students will be different than those for undergraduates.

Grading Policy

Assignment	Percentage
Class Participation	5%
Homework	50%
Capstone report	25%
Capstone presentation	20%
Total	100%

For class participation, high marks will be given when students contribute positively to classroom discussions, provide constructive feedback, and effectively share their unique perspectives. *Additionally, there will be in-class polls, quizzes, or assignments that become part of the class participation*.

Numerical grades on homework assignments, exams, and final projects will be rounded at the first decimal place (e.g. 89.50%→90%, 89.49%→89%). Letter grades for individual assignments will be computed using the standard grading scale.

A limited number of extra credit opportunities (up to 2% of final grade) related to assisting in field or lab research or attending a special lecture on campus will arise throughout the course. The instructor will make every effort to inform the students of these extra credit opportunities as far ahead of time as possible to try to accommodate a range of schedules. These events, however, tend to be relatively spontaneous and hard to predict at the outset of the course.

Important Dates

Description	Date
First Day of Classes	Jan 06
Martin Luther King, Jr. Day - no class	Jan 20
Presidents' Day - no class	Feb 17
Spring Break	Mar 10 - 14
Last Day of Classes	Apr 22
Final Examinations	Apr 23 - 29

Course Policies

During Class

I understand that the electronic recording of notes will be important for class and so computers will be allowed in class. Please refrain from using computers for anything but activities related to the class. Phones are prohibited as they are rarely useful for anything in the course. Disruptive classroom behavior will not be tolerated. An individual engaging in such behavior may be subject to disciplinary action. Read Student Code of Conduct for more information.

Attendance Policy

Attendance is expected in all lectures. Valid excuses for absence will be accepted before class. In extenuating circumstances, valid excuses with proof will be accepted after class.

If a student misses a class it is that student's responsibility to catch up on what they missed relying on assigned readings, posted lectures and copying notes from a classmate. To achieve a good grade each student must take responsibility for learning the course material covered in class. There are no "make-up" classes. The instructor will not re-teach entire classroom lectures to the students outside of the class time.

Late Assignment and Makeup Work Policy

Late assignments will be accepted for no penalty if a valid excuse is communicated to the instructor before the deadline. After the deadline, assignments will be accepted for a *25% deduction* to the score up to 2 days after the deadline. **After this any assignments handed in will be given 0**.

In the case of when a student misses a quiz or an exam, the student must have an official medical, religious, and university excused absence (with adequate documents provided to the instructor) to be allowed to take the test another time. Students should consult Student Code of Conduct for attendance and excused absence.

Academic Integrity and Honesty

Each student has the right and duty to pursue his or her academic experience free of dishonesty. To enhance the learning environment at Utah State University and to develop student academic integrity, each student agrees to the following Honor Pledge:

"***I pledge, on my honor, to conduct myself with the foremost level of academic integrity.***"

A student who lives by the Honor Pledge is a student who does more than not cheat, falsify, or plagiarize. A student who lives by the Honor Pledge:

- Espouses academic integrity as an underlying and essential principle of the Utah State University community;
- Understands that each act of academic dishonesty devalues every degree that is awarded by this institution; and
- Is a welcomed and valued member of Utah State University.

The instructor of this course will take appropriate actions in response to Academic Dishonesty, as defined the University's Student Code. Acts of academic dishonesty include but are not limited to:

Cheating: using, attempting to use, or providing others with any unauthorized assistance in taking quizzes, tests, examinations, or in any other academic exercise or activity. Unauthorized assistance includes:

- Working in a group when the instructor has designated that the quiz, test, examination, or any other academic exercise or activity be done "individually;"
- Depending on the aid of sources beyond those authorized by the instructor in writing papers, preparing reports, solving problems, or carrying out other assignments;
- Substituting for another student, or permitting another student to substitute for oneself, in taking an examination or preparing academic work;
- Acquiring tests or other academic material belonging to a faculty member, staff member, or another student without express permission;
- Continuing to write after time has been called on a quiz, test, examination, or any other academic exercise or activity;
- Submitting substantially the same work for credit in more than one class, except with prior approval of the instructor; or engaging in any form of research fraud.

Falsification: altering or fabricating any information or citation in an academic exercise or activity.

Plagiarism: representing, by paraphrase or direct quotation, the published or unpublished work of another person as one's own in any academic exercise or activity without full and clear acknowledgment. It also includes using materials prepared by another person or by an agency engaged in the sale of term papers or other academic materials.

For additional information go to: ARTICLE VI. University Regulations Regarding Academic Integrity

Accommodations for Disabilities

USU welcomes students with disabilities. If you have, or suspect you may have, a physical, mental health, or learn- ing disability that may require accommodations in this course, please contact the Disability Resource Center (DRC) as early in the semester as possible (University Inn # 101, (435) 797-2444, drc@usu.edu). All disability related accommodations must be approved by the DRC. Once approved, the DRC will coordinate with faculty to provide accommodations.