Civil and Environmental Engineering

Introduction to Physical Hydrology

Instructor: Professor Tyler Waterman (he/him)

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Time: Tu/Th 2:30-3:45
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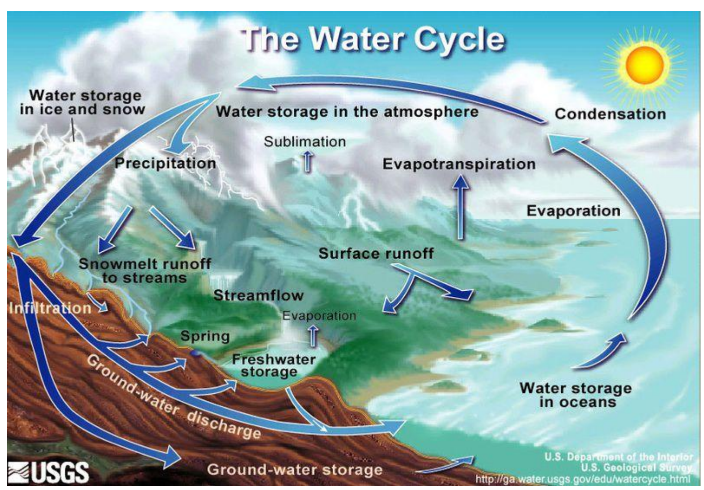
Course Overview: Access to water is a necessary condition for all life on earth. Society faces numerous problems relating to water today, including anthropogenic climate change, extreme weather events, clean drinking water availability, food insecurity, and public health crises related to water sanitation. Understanding and being able to predict how water moves through and is stored within the environment is essential to tackling these problems. In this course, we will develop the skills to analyze and model the water cycle. Course material will cover groundwater, surface water (rivers, lakes etc.), exchange of water between the land and atmosphere (precipitation, evapotranspiration) and the surface energy balance. These core concepts will be connected back to the broader climate system, as well as modern challenges relating to the water cycle.

The course will emphasize approaching these concepts through computational methods and project based learning. These methods will include some basic statistical analysis as well as writing and using python-based modeling software to model and analyze how water moves through the core areas of the earth, land surface, vegetation and the atmosphere. Many graded activities in the course require in class attendance as well as outside work on both individual and group projects.

Course Objectives:



- For each of the key elements of the water cycle (figure to the right) including, storage, soil water infiltration, precipitation, evapotranspiration, runoff, surface flow, and subsurface flow:
  - Analyze statistical trends in their values (Project 1/3)
  - Develop the skills necessary to model the term (Project 2/3)
  - Outline key parameters controlling it (Project 2/3)
- Articulate the connections of the hydrologic cycle to other important systems, including the broader climate system, agriculture, land surface energy balance, civil infrastructure, and ecosystem dynamics

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Prerequisites:

Required: Basic computational/coding skills in any language (satisfied by CS 101, CS 98, ENG 123) or consent of the instructor
Recommended: Completion of introductory math sequence (MATH 101, 102, 103 or MATH 201 202 203) and college level Physics (PHY 101) or equivalent. Basic familiarity with differential equations, satisfied by MATH 103

Grading and Assessment

In Class Exercises (17.5%): Small in class exercises, some in groups some as individuals, will occur during most class periods. These will be designed to assess understanding of concepts and comprehension of video lectures/readings. Some will be graded for content, some for completion and students will be made aware of the grading scheme before the class activity begins. The 4 lowest in class exercise scores will be dropped.

Homework (20%): Most homeworks will be started in class but must be completed at home. The 2 lowest homework scores will be dropped

Midterm Exam (17.5%): Comprehensive exam consisting of short answer and long form problems covering material through the first two-thirds of the course.

Projects (45%): There are three projects in the course, described in greater detail below. Each project will be 15% of your overall grade in the course.

> **Project 1 (15%):** This project will require students, in groups of 3-4, to analyze the water balance of the Illilouette Basin using data provided by the instructor. The required final deliverable will include a zip file of any code as well as a 5-10 page project report. Details on the expectations of the report will be released in advance of the project.
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> **Project 2 (15%):** This project, also in new groups of 3-4, will require students to use one of the models discussed as part of the course to predict how the flow or flux of water changes in response to changing properties of the environment (for example, how changing soil conductivity changes the flow of water in the soil during a rain event). This project requires a one page proposal, a zip file of any code, and a 10 minute in class presentation covering your results.
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> **Project 3 (15%):** The final project is individual. Synthesizing the various elements of the course, use models and publicly available data to answer a unique hydrology question, decided by the student with review by the instructor. See example projects here. A proposal and a mid project update are required in addition to a 10 page maximum final report.

Late/Incomplete Work Policy

I do not accept late homework, I do not accept late projects, nor make up in class exercises.
For in class exercises, the lowest 4 scores are dropped.
For homework, the lowest 2 scores are dropped.

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Course Schedule Would Go Here

Readings/Materials

Most pre-class work will be through watching recorded 10-20 minute videos in advance of the class period. A few readings from journal articles or online sources will be made available to you on Sakai.

Regular access to a computer is required, including access to an electronic device capable of running python code in class sessions

Collaboration

Collaboration, helping your peers through a difficult problem, is encouraged on homework assignments and is fundamental to the setup of in class activities and the projects. The written answers on the homework, however, should be your own and directly copying from another student or allowing a student to directly copy from you would be considered a violation of academic integrity.

Academic Integrity

Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and non-academic endeavors, and to protect and promote a culture of integrity.

To uphold the Duke Community Standard: I will not lie, cheat, or steal in my academic endeavors; I will conduct myself honorably in all my endeavors; and I will act if the Standard is compromised.

The Duke Compact is also in effect for this semester.