FALL 2023

# CUAHSI VIRTUAL UNIVERSITY

## CUAHSI Specialized Online Hydrology Modules

## Overview

The Consortium of Universities for the Advancement of the Hydrologic Sciences Inc. (CUAHSI) has organized these inter-university modules to enhance the depth and breadth of graduate course offerings at universities across the nation, increase the rate of uptake of new research, and facilitate networking among our hydrologic sciences community.

The format of the course is designed to give students flexibility to select up to three topics most relevant to you from a list of modules that are being offered by leading faculty from across the country in these specialized research niches. Each module, which is equivalent to one-third of a semester course[1], is designed to facilitate interaction among the instructor and students and contain some evaluation elements (problem sets, projects, presentations, exams etc.). The instructor at each student's home university will assign a grade based on the student scores and class distribution provided by the module instructor.

The course will run from September to December with each module being conducted for 4 weeks.

## Instructors

**Boise State University**
Qifei Niu | qifeiniu@boisestate.edu

**Northern Arizona University**
Benjamin Ruddell | benjamin.ruddell@nau.edu

**Pennsylvania State University**
Elizabeth Boyer | ewb100@psu.edu

**University of Kansas**
Samuel Zipper | samzipper@ku.edu

**University of Nevada – Reno**
Justin Huntington | justinh@dri.edu

**University of Washington**
Jessica Lundquist | jdlund@uw.edu

**University of Wisconsin – Madison**
Steven Loheide | loheide@wisc.edu

**University of Zurich**
Jan Seibert | jan.seibert@geo.uzh.ch

**Utah State University**
David Tarboton | david.tarboton@usu.edu

**Virginia Tech**
Landon Marston | lmarston@vt.edu

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[1] As University of Washington is on the quarter semester system one module is equivalent to half a quarter.

## Modules dates and times

Module 1: September 6 through October 4
Module 2: October 9 through November 2
Module 3: November 8 through December 7

| | **Module 1**<br>Sep. 6 - Oct. 4 | **Module 2**<br>Oct. 9 - Nov. 2 | **Module 3**<br>Nov. 8 - Dec. 7 |
|---|---|---|---|
| Monday/Wednesday<br>11:00am - 12:30pm ET | Ecohydrology of Groundwater Dependent Ecosystems<br><br>Instructor: Loheide | Geophysical Data Interpretation for Critical Zone Hydrology<br><br>Instructor: Qifei Niu | |
| Monday/Wednesday<br>2:30pm - 4:00pm ET | | | Sustainable Human-Water Systems<br><br>Instructor: Marston |
| Monday/Wednesday<br>3:30 - 5:00pm ET | Food, Energy, & Water Systems: Informatics and Resilience<br>Instructor: Ruddell | Food, Energy, & Water Systems: Informatics and Resilience<br>Instructor: Ruddell | Snow Hydrology: Focus on Modeling<br><br>Instructor: Lundquist |
| Tuesday/Thursday<br>11:00am - 12:30pm ET | Applying Geographic Information Systems for Terrain and Watershed Analysis in Hydrology<br><br>Instructor: Tarboton | Hydrologic Data Visualization<br><br>Instructor: Zipper | Hydrological Catchment Modeling Using Bucket-Type Models<br><br>Instructor: Seibert |
| Tuesday/Thursday<br>3:30 - 5:00pm ET | | Water Quality and the Critical Zone<br><br>Instructor: Boyer | Applications of Climate and Remote Sensing Data in Hydrology<br><br>Instructor: Huntington |

ET: Times are given in the US Eastern Time Zone.

## Registration and Credit

To register for the CUAHSI Virtual University modules, students must follow these steps:

1. Register with your university during the normal registration period for the course number listed for your university (e.g. CivEng 619 for University of Wisconsin - Madison). Registration is limited to 45 module registrations per university.
2. CUAHSI will handle student sign up for individual modules across universities. Fill out this form to sign up with CUAHSI for the Virtual University. Module sign up is also limited and will be accommodated on a first-come, first-served basis. Registration for a module will close when capacity is met. Each module is limited to 45 students.
3. Students should sign up for one to three modules based on their learning needs and interests, recognizing that three modules typically equate to a full semester course (University of Washington two modules equal a full quarter course). Students should recognize the time demands of these modules and avoid multiple modules in the same four week block unless they are fully confident in having the time to commit to this.
4. The number of university credits given for each module taken will be determined by the home university instructor as credit systems vary among institutions (e.g quarter vs. semester system).
5. Each student will be notified when a Canvas account is established for them. Canvas is the online learning management system that will be used for CUAHSI Virtual University.

## Benefits to Students

- Access to national experts in specialized sub-disciplines of hydrologic sciences
- Wider selection of course offerings with greater depth than typically available at a single university
- Networking and collaboration with students and faculty nationwide
- Greater collaboration and community awareness of research activities

## Goals

- Evaluate the literature, theory, and/or models associated with distinct advanced topics within hydrologic sciences
- Network and effectively collaborate virtually with peers from multiple institutions
- Share data and resources across the hydrologic community
- Specific learning objectives will be provided in the syllabus for each module

## Requirements

- Participate in on-campus organization, synthesis, and debriefing sessions held by instructor at home university.
- Register for and complete one to three modules[2]. Each module will have an individual syllabus that outlines the expectations and requirements for that component of the course.

## Evaluation

The evaluation criteria for each module will be outlined in the individual module syllabus. The module instructor will provide a score to each home university instructor for each student as well as the class distribution for their module. Grades at each institution are the responsibility of the home institution instructor, based on input from the instructors for each module. In addition to scheduled modules, there may be campus coordination and synthesis meetings at the beginning and in between modules. Home institution instructors may assign a portion of the grade based on participation in these meetings.

[2] Flexibility in the number of modules is limited at some universities.

## Students with Disabilities

If you need accommodations for a physical or learning disability, please see the instructor at your home university.

## Academic Integrity

The Honor Code is a cornerstone of this course. It is an undertaking of the students, individually and collectively:

1. that they will not give or receive aid in examinations; that they will not give or receive unpermitted aid in class work, in the preparation of reports, or in any other work that is to be used by the instructor as the basis of grading;
2. that they will do their share and take an active part in seeing to it that others as well as themselves uphold the spirit and letter of the Honor Code.

## Guidelines for Online Etiquette

The goal of these guidelines is to encourage online interaction in a positive and engaging manner. They will be posted and discussed in greater detail on the course website.

- Participate
- Report glitches
- Help others
- Be patient
- Be brief
- Use proper writing style
- Cite your sources
- Refrain from emoticons and texting lingo
- Respect diversity
- No YELLING!
- No flaming
- You can’t un-ring the bell

## Non-discriminating Environment

CUAHSI is committed to creating a dynamic, diverse, and welcoming learning environment for all students and has a non-discrimination policy that reflects this philosophy. Disrespectful behavior or comments addressed toward any group or individual, regardless of race/ethnicity, sexuality, gender, religion, ability, or any other difference is deemed unacceptable in this class, and will be addressed by the professor.

## Code of Conduct

All CUAHSI Virtual University participants are expected to adhere to the CUAHSI Code of Conduct. The full Code can be found here.

## Module Descriptions (in alphabetical order)

### *Applications of Spatial Climate and Satellite Remote Sensing Data in Hydrology*

Justin Huntington, University of Nevada – Reno
Module 3 (Nov. 8 - Dec 7)
Tuesday/Thursday 3:30-5:00 ET

This module focuses on the integration of spatial climate and satellite remote sensing data into hydrology, specifically addressing the combined use of these data to assess and separate impacts from climate vs. management. . We will begin with an overview and background of different climate and remote sensing datasets, fundamental concepts, and tools to access, process, and visualize the datasets. . Next, we explore various climate and land surface model datasets, multi-timescale drought indices, and satellite derived vegetation indices and evapotranspiration products in the context of changing climate, vegetation, and the complementary relationship of evaporation.. In the final module we focus on application of different datasets and tools for use cases of student interests, and that are common in basic and applied research such as atmospheric-land surface feedbacks, riparian restoration, drought, and agricultural water use. Students will have access to GIS and remote sensing software as well as a suite of data sets. Google Earth Engine and Climate Engine will be the primary software tools and data catalogs used.

**Prerequisites:** Undergraduate or graduate level introductory hydrology

### *Applying Geographic Information Systems for Terrain and Watershed Analysis in Hydrology*

David Tarboton, Utah State University
Module 1 (Sep. 6 – Oct. 4)
Tuesday/Thursday 11:00am – 12:30pm ET

Digital mapping of hydrology and water resources information using content from publicly available sources such as the US national map, and other climate and hydrography datasets. Hydrologic terrain analysis using digital elevation models (DEMs) and DEM based delineation of channel networks and watersheds. Flood hydrology modeling and inundation mapping based on height above the nearest drainage derived from digital elevation models. There will be four detailed computer exercises that introduce (1) Building a watershed basemap using publicly available hydrography and watershed boundary data in the US; (2) Spatial analysis. Calculation of slope, land use and precipitation over subwatersheds; (3) Watershed delineation from digital elevation models; and (4) Basic GIS Programming using Python, using calculation of river hydraulic properties using height above the nearest drainage (HAND) as an example.

**Prerequisite:** This course will use ArcGIS Pro from ESRI. The prerequisite is basic knowledge of GIS through any prior GIS course or self-preparation through the 3 hour free Predict Deforestation in the Amazon rain forest online lesson from ESRI at https://learn.arcgis.com/en/projects/predict-deforestation-in-the-amazon-rain-forest/. Arrangements will be made for students to use ArcGIS Pro through their university site license.

### *Food, Energy, & Water Systems: Informatics and Resilience*

Benjamin Ruddell, Northern Arizona University

Module 1 (Sep. 6 – Oct. 4)
Monday/Wednesday 3:30pm – 5:00pm ET

Module 2 (Oct. 9 – Nov. 2)
Monday/Wednesday 3:30pm – 5:00pm ET

This is a set of two Modules that can be taken in sequence. The first module covers fundamentals of Food Energy and Water Systems, including their resilience and data sources. The second module, which requires completion of the first as a prerequisite, employs the FEWSION for Community Resilience (F4R) process to engage participants in collecting data on the physical structure and stakeholder networks of local FEW supply chains and infrastructures. Training on software and data systems specialized for FEW supply chains will be delivered. The sustainability, equity, and security of the system will be studied and measured. Student projects will create reports of the FEW inflows and outflows of the state and county using FEW-View™, and employ these relationships and data to study how policy and action can improve local systems. Students can choose to participate in Module 1 only.

### *Geophysical data interpretation for critical zone hydrology*

Qifei Niu, Boise State University
Module 2 (Oct. 9 – Nov. 2)
Monday/Wednesday 11:00am – 12:30pm ET
Geophysical methods play an essential role in studying the hydrologic processes in the critical zone (CZ). This module will introduce the fundamentals for interpreting two common geophysical test results in critical zone sciences (i.e., seismic refraction and electrical resistivity). The module will focus on (1) extracting subsurface CZ structural information from seismic refraction tests and (2) estimating moisture content from electrical resistivity measurements. Field geophysical data acquired from typical CZ sites will be used in the teaching. Commonly-used seismic velocity and resistivity models will be introduced for quantitative interpretations. After this module, students are expected to interpret the seismic refraction and electrical resistivity field data to characterize CZ structure and estimate relevant hydrologic properties.

**Prerequisites:** Undergraduate course in Hydrology or Hydrogeology (Groundwater/Geohydrology); undergraduate course in Applied Geophysics or Environmental Geophysics. Prior coding experience is advantageous, but not required.

### *Hydrologic data visualization*

Sam Zipper, University of Kansas
Module 2 (Oct. 9 – Nov. 2)
Tuesday/Thursday 11:00am – 12:30pm ET

A picture is worth 1000 words, but only if the graphic is well-designed to convey the appropriate message to the target audience of the visualization. This module will provide hydrology-oriented but broadly applicable training in data visualization that will help students understand the hydrologic phenomena they are investigating and clearly convey their findings. Students will get hands-on experience with the development of both quantitative figures and conceptual models, with a focus on best practices for designing effective visualizations. The module will include strategies to design visualizations to meet the needs of different target audiences (scientists, stakeholders, public). Module participants will develop and improve figures using their own data, provide peer-to-peer feedback, and leave the course with a portfolio of visualizations and strategies that can be used in future presentations and publications.

**Prerequisites:**
1. Experience with a programming-based approach to data analysis and visualization such as R, Python, MATLAB, etc.
2. Students will work with their own data throughout the course, so students should be prepared with a dataset they want to develop visuals for.

### *Hydrological catchment modeling using bucket-type models*

Jan Seibert, University of Zurich

Module 3 (Nov. 8 – Dec. 7)
Tuesday/Thursday 11:00am – 12:30pm ET
Hydrological models are essential tools for decision making at the catchment scale. These models are crucial for forecasting hydrological conditions, ranging from the short-term forecasts of flooding in the coming hours or days to long-term forecasts of hydrological climate change impacts. This module will focus on bucket-type models as a representation of catchment hydrology using the HBV model as an example. After a general overview and motivation, the history of catchment models and a detailed introduction to the HBV model, we will address issues like model uncertainties, automatic model calibration, model-performance measures, multi-criteria calibration, the value of data. Furthermore, we will address the use of models to quantify land-use and climate changes and will discuss how tracer data can be included into this type of models. Hands-on modeling exercises will provide further opportunities to get familiar with typical modeling issues.

**Prerequisites:** Undergraduate course in hydrology. Ability to process data in a computing program (e.g., Matlab, Python, R).

***Snow Hydrology: Focus on Modeling***
Jessica Lundquist, University of Washington
Module 3 (Nov. 8 – Dec. 7)
Monday/Wednesday 3:30pm – 5:00pm ET

Modeling the hydrologic regime in snow-dominated ecosystems requires an understanding of data sources (to drive the model, to update the model, and to evaluate the model's performance); of model architecture (how to set up the model, run the model and make decisions regarding model parameters and model physics); and how to optimally combine data and modeling (data assimilation and model evaluation). The course objective is to learn modeling concepts with hands-on experience, as opposed to being a tutorial on how to run a particular model. We will use a modular modeling framework, SUMMA, which incorporates components from most snow models used in land surface and hydrologic modeling today. The class will include hands-on computer laboratory exercises using existing datasets and models. The target audience is people who will benefit from an understanding of snow modeling but who are not already experts.

**Prerequisites:** Students should have some prior undergraduate course covering mass and energy balances (most hydrology classes would include this). Prior coding experience (in any language) will be a great asset, but dedicated students who put in extra time can learn to code during this class. We will be using python to run the model.

***Sustainable Human-Water Systems***
Landon Marston, Virginia Tech
Module 3 (Nov. 8 – Dec. 7)
Monday/Wednesday 2:30pm – 4:00pm ET

"Sustainable Human-Water Systems" is a course that examines the relationship between humans and water resources, with a focus on developing and implementing sustainable water management practices in agricultural settings. Throughout the course, students will learn about the various ways in which water is used and managed, including two-way feedback and dynamics between social (e.g., policy, regulation, institutions, economics, behavior) and environmental (e.g., groundwater, surface water, ecosystems) systems. Students will also explore the environmental, social, and economic impacts of different water management practices and the challenges of balancing the needs of society with those of the natural environment. This transdisciplinary course will blend theory, empirical data, and modeling to explore topics such as water scarcity, groundwater governance and management, human behavior and institutions, and the evolution of cooperation, decision-making, and social dilemmas. Throughout the course, students will have the opportunity to engage with case studies, participate in group discussions and debates, and work on group projects that involve developing and evaluating sustainable water management strategies. By the end of the course, students will have gained a deep understanding of the complex interplay between humans and water resources and the skills and knowledge necessary to develop and implement sustainable water management practices.

**Prerequisites:** None

### ***Ecohydrology of groundwater dependent ecosystems***

Steve Loheide, University of Wisconsin-Madison
Module 1 (Sep. 6 – Oct. 4)
Monday/Wednesday 11:00am – 12:30pm ET

Ecohydrologic research investigates the effects of hydrological processes on the distribution, structure, and function of ecosystems, and the effects of biotic processes on elements of the water cycle. Groundwater dependent ecosystems are ecosystems that have their species composition and natural ecologic processes determined by groundwater processes. In this class, we discuss and quantify ecohydrologic processes in groundwater dependent ecosystems. We will develop techniques to exploit the signal contained within diurnal watertable fluctuations to quantify the groundwater component of ET. We will explore a variety of approaches for quantitatively describing how groundwater controls vegetation composition. We will integrate the understanding we develop about the ecohydrologic functioning of groundwater dependent ecosystems to simulate coupled hydrologic and ecologic processes for prediction of vegetation patterning.

**Prerequisites:** Course in hydrogeology or groundwater. Data processing experience (Matlab will be the preferred platform; R can be used but without instructor support).

### ***Water Quality and the Critical Zone***

Elizabeth Boyer, Penn State University
Module 2 (Oct. 9 – Nov. 2)
Tuesday/Thursday 3:30-5:00 ET

This course focuses on the critical zone and its components from the treetops to bedrock, and how they interact to influence water quality. Topics will introduce: 1) physical, chemical, biological, and human processes shaping water quality of the critical zone; 2) water quality parameters and indicators of watershed health; 3) water quality data collection and quality assurance; and 4) tools for data analysis. Activities will include obtaining and analyzing water quality data for watersheds of varying land use.

**Prerequisites:** None

### Questions?

For questions on the module content, please contact the instructor.

For questions related to specifics about your Institution (such as grading policies), contact the CVU instructor at your home Institution.

For general questions, please Veronica Sosa Gonzalez at vgonzalez@cuahsi.org