Soil Science 327

Environmental Monitoring and Soil Characterization for Earth's Critical Zone

4 credits

Diversity & Inclusion Statement

Diversity is a source of strength, creativity, and innovation for UW-Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals. The University of Wisconsin-Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background – people who as students, faculty, and staff serve Wisconsin and the world.

Background

Recent development of Earth's Critical Zone sciences (https://czo-archive.criticalzone.org/national/research/the-critical-zone-1national/) improve our fundamental understanding of the human-environmental interactions under a changing climate and enable us better manage our environment under human disturbance. Students interested in Critical Zone Sciences not only need to obtain the theoretical knowledge of environmental monitoring (e.g., soil contamination) and soil physical processes (e.g., water, heat, gas, and solute transport), but also hands-on skills in describing soil variations across the landscape and installing soil sensors and processing environmental data from the sensors.

Course Description

Characterization of a soil in the field. Monitoring water flow, heat exchange, solute transport and greenhouse gas emission using soil physical models and state-of-the-art soil sensing technologies.

Course Designations and attributes

Physical Science, LAS Intermediate level, 50% Graduate credit, Sustainability

Requisites

SOIL SCI/ENVIR ST/GEOG 230 or SOIL SCI 301 or graduate/professional standing

Meeting Time and Location

Lecture on Tuesdays and Thursdays mornings:	8:00 to 9:15 am in Soils room 270
Field studies on two Tuesdays afternoons:	1:00 to 4:00 pm off campus
One day fieldtrip:	8:00 to 5:00 pm off campus

Instructional Modality

In-person

Course components

- Lectures — Tuesday and Thursday morning
- Fieldtrips — Two Tuesday afternoons West Madison and Arlington (13 and 20 September 2022) Hancock (full day) (24 September 2022)
- Assignments – Problem sets, Fieldtrip report (two afternoons plus one full day), Soils of your home area (Individual)
- Test Final

Credit hours specifications

This course meets for 75 minutes two times per week. For each week, there is a minimum of eight hours of out of class student work over 15 weeks, that includes homework, reading, report and assignment writing, and preparation for exams. There are two half day fieldtrips to West Madison, and one full day fieldtrip to Arlington and Hancock – all three CALS Agricultural Research Station. The report for the fieldtrips requires about six hours, the Soils of the Home area assignment requires about six hours, and the weekly assignments of problem sets require about four hours. **Note that** the course will require more work outside of class than students might expect for a class that meets twice a week for 75 minutes.

Field studies and field trip

Field studies are held on two Tuesday afternoons in September. A one-day field trip is held full Saturday late September. Refer to the course schedule at the end of the Syllabus. Bring water, sunscreen, hat, long pants and shoes. More instructions closer to the date.

The problem sets

This course contains six problem sets that focus on environmental monitoring and soil characterization. Each set will include homework, readings and group discussion during class hours. The problem sets are essential for understanding of the calculation-based assignments.
Note: the calculation problem sets are different for undergraduate students and graduate students. **Undergraduate** students are required to work on specific problems to understand the effects of soil texture, organic carbon, soil depth, and other soil physical and chemical properties on soil processes (e.g., water retention and flow, nutrient flux, greenhouse gas emissions, temperature fluctuation) in a qualitatively manner and use the soil sensor measurements to support their explanation. They also need to use the case studies from the reading materials to design sustainable management practices for soil and water conservation under climate change and human disturbance.
In terms of **graduate** students, the problem sets require reading of scientific articles in soil and environmental issues provided by the instructors and critically evaluate and compare the advantages and disadvantages of different management practices on soil and water conservation. Also, the problem sets require the graduate students to apply various soil physical models

discussed in the lectures to quantitatively estimate fluxes of water, heat, gas, and solute transport in soils using soil sensor measurements and soil physical models.

Assignments

There are three types of assignments for this course, and each will be separately and individually graded:

1. Soils of your home area (written report + 10 minute presentation, individual)
2. Report of field trips (one written report for two Tuesday and one full day fieldtrip, individual)
3. Six problem sets (refer to course timetable) on the web soil survey, calculation of water, heat, gas, and solute movement in soils using soil sensor measurements and soil physical models

Instructors Title and Name

Jingyi Huang, Room 71A, Department of Soil Science
Alfred Hartemink, Room 263, Department of Soil Science

Instructor Availability

Office hours flexible, please send an email to jhuang426@wisc.edu or hartemink@wisc.edu

Course Learning Outcomes

This course is intended for the undergraduate and graduate level. After this course, **undergraduate and graduate** students will:

1. Explain soil variations within the profile and across the landscape within the Critical Zone
2. Explain the processes that control differences and similarities in soils
3. Summarize how soils are described, mapped, and classified
4. Explain the concepts of the soil physical properties used to describe the characteristics of soil solid, liquid, and gas phases
5. Explain the social, economic, and/or environmental dimensions of the sustainability challenges of the Critical Zone
6. Obtain field experiences on soil description and collection of soil sensor measurements to monitor water, heat, gas, and solute transport in soils
7. Analyze the causes of and solutions for the sustainability challenge of the Critical Zone
8. Prepare and present an oral presentation

In addition, **graduate** students need to:

9. Critically evaluate the scientific articles in soil and environmental issues.
10. Apply models to estimate fluxes of water, heat, gas, and solute transport in soils using soil sensor measurements and soil physical models

Grading

The following categories count toward your final grade:

Soils of your home area	20%
Fieldtrip report	20%
Problem sets	40%

Final exam	20%

Grading scale:
- 93-100 = A
- 85-92 = AB
- 77-84 = B
- 69-76 = BC
- 61-68 = C
- 60-53 = D
- <53 = F

All activities are on the honor system and you are responsible for your own work.

Important Dates

Field report due	4 October
Soils of your home area report due	25 October
Problem sets due	TBD

Course Website

Required Textbook and study material

Buol, S.W., R.J. Southard, R.C. Graham, and P.A. McDaniel. 2011. Soil genesis and classification (6th edition). Wiley-Blackwell, UK. 543 pp. Freely available as e-book: http://onlinelibrary.wiley.com.ezproxy.library.wisc.edu/book/10.1002/9780470960622

Healy, J. 2018. Rural America's Own Private Flint: Polluted Water Too Dangerous to Drink. New York Times, November, 3, 2018.

Jury, W. A., and R. Horton. 2004. Soil physics. (6th edition). John Wiley & Sons, USA. 384 pp.

Viscarra Rossel, R. Adamchuk, V. I., Sudduth, K. A., McKenzie, N. J., & Lobsey, C. 2011. Proximal soil sensing: An effective approach for soil measurements in space and time. Advances in agronomy, 113, 243-291.

Waldron, P. 2020, Critical zone science comes of age, Eos, 101, https://doi.org/10.1029/2020EO148734.

Web Soil Survey, 2022. Frequently Asked Questions. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcseprd1456814

Campus Spaces for Virtual Learning & Testing

Dedicated on-campus spaces with high-speed internet are available for students to reserve for any exam/quiz taken during the semester. Computers can also be requested.

Exams, Assignments

Exams will be closed book; mid-term will be focused on facts and interactions, final exam will be more holistic and integration of everything learned in the course.

Reports of fieldtrips should be factual, descriptive and illustrations and photograps are suggested. A template of the fieldtrips report will be provided for reference.

Regular and Substantive Student-Instructor Interaction

The firt part of the course there will be direct instruction, followed gy feedback on student work, discussion of course content. Substantive interaction will occur during fieldwork in West Madison and during the two day field trip to Door County, the Central Sands and Arlington. There will be weekly interactions.

Privacy

The privacy and security of faculty, staff and students' personal information is a top priority for UW-Madison. The university carefully reviews and vets all campus-supported digital tools used to support teaching and learning, to help support success through learning analytics, and to enable proctoring capabilities. UW-Madison takes necessary steps to ensure that the providers of such tools prioritize proper handling of sensitive data in alignment with FERPA, industry standards and best practices.

Under the Family Educational Rights and Privacy Act (FERPA which protects the privacy of student education records), student consent is not required for the university to share with school officials those student education records necessary for carrying out those university functions in which they have legitimate educationl interest. 34 CFR 99.31(a)(1)(i)(B). FERPA specifically allows universities to designate vendors such as digital tool providers as school officials, and accordingly to share with them personally identifiable information from student education records if they perform appropriate services for the university and are subject to all applicable requirements governing the use, disclosure and protection of student data.

Lecture materials and recordings for this course are protected intellectual property at UW-Madison. Students in this course may use the materials and recordings for their personal use related to participation in this class. Students may also take notes solely for their personal use. If a lecture is not already recorded, you are not authorized to record my lectures without my permission unless you are considered by the university to be a qualified student with a disability requiring accommodation. [Regent Policy Document 4-1] Students may not copy or have lecture materials and recordings outside of class, including posting on internet sites or selling to commercial entities. Students are also prohibited from providing or selling their personal notes to anyone else or being paid for taking notes by any person or commercial firm without the instructor's express written permission. Unauthorized use of these copyrighted lecture materials and recordings constitutes copyright infringement and may be addressed under the university's policies, UWS Chapters 14 and 17, governing student academic and non-academic misconduct.

How to Succeed in This Course

Students that are successful in this course attend all lectures, prepare for the lectures, attend the fieldtrips (which are mandatory also) and make ample notes.

There are lots of services within UW for help:

- University Health Services
- Undergraduate Academic Advising and Career Services

- Office of the Registrar
- Office of Student Financial Aid
- Dean of Students Office

Students' Rules, Rights & Responsibilities

During the global COVID-19 pandemic, we must prioritize our collective health and safety to keep ourselves, our campus, and our community safe. As a university community, we must work together to prevent the spread of the virus and to promote the collective health and welfare of our campus and surrounding community.

Academic Integrity Statement

By virtue of enrollment, each student agrees to uphold the high academic standards of the University of Wisconsin-Madison; academic misconduct is behavior that negatively impacts the integrity of the institution. Cheating, fabrication, plagiarism, unauthorized collaboration, and helping others commit these previously listed acts are examples of misconduct which may result in disciplinary action. Examples of disciplinary action include, but is not limited to, failure on the assignment/course, written reprimand, disciplinary probation, suspension, or expulsion.

Accommodations for Students with Disabilities Statement

The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform faculty [me] of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. Faculty [I], will work either directly with the student [you] or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA. (See: McBurney Disability Resource Center)

Course Schedule

Week	Day	Lecture	Fieldrips	Reading assignments
1				
	Thursday, Sep. 8	Introduction (Soil and Ecosystem Services)		Soil genesis and classification. Ch. 1
2	Tuesday, Sep. 13	Soil Morphology	Half-day field studies in West Madison (soil description, and pXRF surveys)	Soil genesis and classification. Ch. 2
	Thursday, Sep. 15	Soil formation I		Soil genesis and classification. Ch. 3
3	Tuesday, Sep. 20	Soil formation II	Half-day field studies in Arlington (soil description, and pXRF surveys)	Soil genesis and classification. Ch. 3
	Thursday, Sep. 22	Soil processs I		Soil genesis and classification. Ch. 5
	Saturday, Sep. 24	Fieldtrip	One-day field trip to Hancock (soil description, installing soil sensors)	Field trip guide
4	Tuesday, Sep. 27	Soil processs II		Soil genesis and classification. Ch. 5

	Thursday, Sep. 29	*Problem 1 – Web Soil Survey exercise*		Soil genesis and classification. Ch. 6
5	Tuesday, Oct. 4	Weathering and minerals		Soil genesis and classification. Ch. 4
	Thursday, Oct. 6	Earth's Critical Zone		Waldron, P. 2020.
6	Tuesday, Oct. 11	Soil classification and data		Soil genesis and classification. Ch. 7
	Thursday, Oct. 13	Soil survey and soil maps		Soil genesis and classification. Ch. 7
7	Tuesday, Oct. 18	Sensor data analysis		Web Soil Survey
	Thursday, Oct. 20	Soil water content and potential		Soil physics. Ch. 2
8	Tuesday, Oct. 25	National and global environmental monitoring networks (CZO, NEON, Fluxnet, LTER, LTAR, ISMN) /Present Soils of the home area		Soil physics. Ch. 3
	Thursday, Oct. 27	Water flow in soil (Darcy's law)		Soil physics. Ch. 4
9	Tuesday, Nov. 1	Field water balance equation and preferential flow		
	Thursday, Nov. 3	*Problem 2 – Water resource management (California vs. Central Sands: ET and drainage calculation)*		Soil physics. Ch. 7
10	Tuesday, Nov. 8	Solute transport in soil (breakthrough curve)		Viscarra Rossel et al., 2011
	Thursday, Nov. 10	Soil sensors (TDR, EMI, vis-NIR, MIR, pXRF, XRD)		Healy, 2018
11	Tuesday, Nov. 15	*Problem 3 – Nitrate leaching (NYT article) and phosphorus runoff (legacy nutrient) – Paper discussion*		Soil physics. Ch. 5
	Thursday, Nov. 17	Surface energy balance and albedo		Soil physics. Ch. 5
12	Tuesday, Nov. 22	Soil thermal properties and heat flow in soil (Fourier's law)		COP26
	Thursday, Nov. 24	Thanksgiving		
13	Tuesday, Nov. 29	*Problem 4 – Global warming impacts (Permafrost thawing and positive feedbacks) - Paper Discussion*		Soil physics. Ch. 6
	Thursday, Dec. 1	Soil gas greenhouse emission (Fick's law)		Vanwalleghem et al., 2017
14	Tuesday, Dec. 6	Soil in the Anthropocene		Minasny et al., 2017
	Thursday, Dec. 8	*Problem 5 – Carbon credit and GHG emission – Calculation and Paper Discussion*		Soil physics. Ch. 7
15	Tuesday, Dec. 13	Heavy metals in soil (distribution coefficient – Kd)		
	Thursday, Dec. 15	*Problem 6 – Heavy metal and microplastics contamination in soils – Paper Discussion*		
16	Dec. 20	Final Exam		