ESS 192 Syllabus: Critical Zone Science Fall Semester 2015

This course targets undergraduate science and engineering majors interested in learning about the more about Critical Zone, defined as the Earth's outer layer from vegetation canopy to the soil and groundwater that sustains human life. Multiple processes (climate, biology, geology, topography, disturbances) work together to form and evolve the CZ.   The introductory portion of this course will provide participants with the framework and tools for considering Critical Zone (CZ) science. The CZ will be introduced by stressing the importance and overall functioning of the CZ, and the temporal and spatial scales at which the CZ may be studied. This part of the course will focus on outstanding questions in CZ science, how to obtain and use baseline data from various federal agencies to help understand the CZ, and an introduction to the basic concepts of system modeling.

The body of the course will focus on cross-disciplinary science in the CZ and will focus on the large quantity of interdisciplinary data available from the existing NSF-funded CZOs. The material will be organized topically in the following categories: CZ Methods; Land-Atmosphere exchange; Water transfer through the CZ, Landform and landscape evolution; and, Geochemistry/biogeochemistry.

The final portion of the course will focus on how interdisciplinary and collective CZ science is accomplished, with consideration of the state and management of the CZ. The course content will be focused on reading, field-trips, and learning activities that access CZO data.

The broad overarching goals of this course are to:

- Examine the Earth's critical zone, extending from tree top to the groundwater zone, to better understand the relative role and importance of land-based biogeochemical interactions.
- Use a large variety of scientific and mathematical principles to analyze how Earth's land surface works (to develop the ability to solve interdisciplinary problems).
- Analyze technological advances, breakthroughs in interpretation, and new observations to build an understanding of the critical zone in and beyond the class (to develop geoscientific habits of mind).
- Apply data sets and observations from six existing CZO sites to test ideas and summarize critical zone services (to use geoscience data as a method of inquiry).
- Describe the critical zone as a complex system of interacting regolith, water, air, and life (to illustrate broad principals of systems thinking).

Course Goals: At the end of the course the students will be able to:

- Integrate multiple lines of data to explain critical zone processes
- Summarize the effects of anthropogenic activities on local and global critical zone processes
- Explain the role of critical zone services on supporting terrestrial life, including humanity
- Analyze how the water, carbon, nutrient and energy flow through the critical zone and how they drives critical zone processes

- Interpret the role of critical zone processes in the evolution of landscapes and landforms through time
- Evaluate how critical zone structure influences modern critical zone processes/services
- Participate in integrative critical zone science activities and research

Instructor (*Questions about class content and instructional material)***:**

- Dr. Martha Conklin, Instructor
- Email: mconklin@ucmerced.edu
- Office: SE1 220 - Office Hours: TBD

Course Time,Location & Format:

- MW – 1:30-2:45 (75 min), Location: COB 262
- Readings, In-class Activities, Homework, Lecture Slides on UCMCROPS

Integrate Course Site: http://serc.carleton.edu/s/integrate/critical_zone/index.html
Course Website: CatCourse (login in with your NetID and password) (content will be populated as semester progresses)

Required Texts and Reading Supplements:

- Other readings, as assigned, mostly accessed on-line.

Evaluation

Grade Points	
Pre/post test credit @ 10 pts each	20 (4%)
5 Group Reading Reports @ 5 pts each	100 (21%)
5 Homeworks @ 20 pts each	100 (21%)
10 Data Activities @ 20 pts each	200 (26%)
1 class presentation and paper	90 (11%)
Sub total	510

A note about the experimental nature of this course:
This course is being developed and piloted by a team of instructors affiliated with the CZO network as part of an NSF grant called InTeGrate at SERC, which is based at Carleton College, Northfield, MN. Your feedback of the course content and learning activities is thus particularly important to us. From time-to-time, we anticipate having you fill out surveys or other assessment items that are associated with the larger curriculum development effort. While your participation is important to this study, your participation in this aspects of the course is entirely voluntary, *please let the instructor know if you do not want to participate*. Of course, we would like to have as close to 100% participation in this study as possible. These special materials will be identified by a header or title of “InTeGrate Curriculum Study” and coded with the last four digits of your SID.

Basic Philosophy:
Team interdisciplinary science is becoming the norm, particularly for field efforts that are assessing the complex interaction between many earth processes, as exemplified by Critical Zone Observatories. We think this makes for an extremely engaging and practical course that will help you apply the basic scientific and mathematical tools you have been developing to this point. We look forward to your active participation!

Classroom Participation:
This course has been developed to make it as engaging as possible through the active use of geoscientific data sets derived from the various CZO sites. Thus, the in-class activities make up almost 26% of your course grade. You cannot pass this course if you do not play an active role by attending every class and constructively contributing to your group.

Homework:
Homework problems will be assigned once a week to reinforce and extend activities and concepts that have been introduced in class. Homework is to be completed individually and is due 1 week after it is assigned. Late homework is not accepted.

Policies - Classroom Participation, Attendance, Cell Phones:
This course has been developed to make it as engaging as possible through the active use of geoscientific data sets derived from the various CZO sites. Thus, the in-class activities make up a majority of your course grade. You cannot pass this course if you do not play an active role by attending every class and constructively contributing to your group. Students with more than 3 un-excused absences will be dropped from the course. Student's making unauthorized/disruptive use of cell phones or lap-tops will be asked to turn them off; after a second offense, they will be confiscated for the rest of the class period. Threatening behavior by students will not be tolerated.

Holidays and Special Events:
• All holidays or special events observed by organized religions will be honored for those students who show affiliation with that particular religion,
• Absences pre-approved by your School Dean (or Dean's designee) will be honored.

Homework:
Homework problems or reading will be assigned almost every class to reinforce and extend activities and concepts that have been introduced in class. Homework is to be completed individually (unless otherwise marked) and is generally due the following class period.

In-class Activities:
In-class activities are a major part of your grade and are designed to be completed in small groups and by the end of the week in which they are introduced. In-class use of a laptop is expected but your use of the laptop must be exclusively devoted to the activity of the day, please refrain from: unrelated surfing, use of social media or personal email, outside assignments or catching up with homework.

Field Trip & Course fee:
If there is enough interest, we will conduct an optional Saturday field trip to Kings River Experimental Watershed to visit the Southern Sierra CZO field sites. This may require paying a $5-10 fee if we get a University van.

Paper and Presentation:
Each class participant is required to complete a 6-10 page research paper and a related 10-minute class presentation on a topic related to a NEW critical zone site that you would be interested in studying. Your paper should be structured as an informal research proposal and include the following sections: abstract, research questions, methods, baseline data sources, expected outcomes and significance. Papers should use titles and sub-titles, have 1" margins and use 1.5 line spacing. Your paper should also include a list of at least 5 significant sources (wiki/google do not count) and you should use either footnotes or in-line citations (author, year, page) to reference material in the body of the paper.

Deadlines:
All important dates and deadlines are included in the syllabus. It is the responsibility of the student to be aware of all deadlines. Unless otherwise noted, assignments are due at the Start of Class (SoC) on the day they are due. If you can't make it to class, your assignment must be dropped off early or emailed to the instructor (mconklin@ucmerced.edu) by the start of class.

Plagiarism and Plagiarism:
Papers and the final will be processed using plagiarism detection software. Plagiarized writing will receive an automatic zero and an immediate report to UCM academic authorities. We expect that any technical discussions, direct quotations and paraphrased citations will reference ***specific*** books, papers or web sites. Examples of required formatting for references and citations will be provided for use when writing papers. In general, standard MLA rules should be followed. For more detailed discussion of the definition of and consequences of plagiarism, please refer to the UC Standards of Conduct (http://studentlife.ucmerced.edu/content/uc-conduct-standards) and review the UCLA citation and how to avoid plagiarism guide (http://guides.library.ucla.edu/citing)

Special Needs:

If you anticipate accessibility issues related to the format or requirements of this course, please contact me. I would like is to discuss ways to ensure your full participation in the course. If you determine that formal, disability-related accommodations are necessary, it is very important that you be registered with Disability Resources (http://disability.ucmerced.edu/content/student-resources) and notify me of your eligibility for reasonable accommodations. We can then plan how to best coordinate your accommodations.

Reasonable Notice
Due to unforeseeable circumstances, information contained in the course syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.

Preliminary Course Outline:

<table>
<tr><th>Unit</th><th>Wk</th><th>Content</th></tr>
<tr><td>1</td><td>1-3</td><td>Background (White)

• Goal: Use a large variety of science principles to analyze the Critical Zone as a complex system of interacting regolith, water, air, and life. After defining the critical zone and how CZO’s operate, the process and function of each CZO will be reviewed, including the importance of various data sets in that environment. The students will be introduced to system modeling, research approaches, infrastructure and sample design .

Learning objectives – Students will be able to:
• Describe the critical zone and the main earth processes affecting it.
• Use earth system model principals to describe the interaction and feedback between various earth systems.
• Compare and contrast various strategies for running a large-scale field observation program.
• Explain the connection between various CZO primary research questions and the underlying earth system processes.
• Compare and contrast various field sampling strategies.

Activities
• Locate, compare and contrast various CZO sites and fundamental science questions
• Explore the importance of soil forming factors
• Review Systems theory and its applicability to CZO’s</td></tr>
<tr><td>2</td><td>4-5</td><td>Methods – Science in the CZ (White)

Goal: Introduce different types of data and the techniques for interpreting data. Students analyze data and use simple models to interpret spatial and temporal trends. Students work with data that has been analyzed and learn how to effectively plot or visualized different data sets..

Learning objectives – Students will be able to:
• Effectively organize data from different data sources, including online data sources
• Interpret spatial and temporal trend from data records
• Summarize system modeling and geoscientific research approaches to design a sampling program
• Infer trends from multiple strands of data to answer questions about critical zone services

Activities
• Data analysis - Use data sets with different spatial and temporal scales to answer a question about the effect of the critical zone on anthropogenic activities</td></tr>
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		• Field methods - Design a sampling program with different spatial and temporal scales to answer a question about the effects of anthropogenic activities on local critical zone processes
3	6-7	**Applications - Land-atmosphere exchange** (Washburne) Goal: Analyze how energy and carbon flow through the critical zone and how they drive critical zone processes. Students analyze data and use simple models to interpret spatial and temporal trends in energy flow and reservoirs in a catchment and subcatchment context to answer questions about critical zone processes. They complete activities to follow carbon through different reservoirs in the critical zone. Learning objectives – Students will be able to: • Use radiative forcing data to study a site's energy budget • Compare and contrast basic climate and boundary layer variables • Explain the fluxes and reservoirs of carbon cycling within the critical zone • Evaluate the role and importance of climate change by using climate change predictions and model results Activities • Energy budgets - Use CZO datasets to describe the differences between the main atmospheric fluxes at each CZO site. Then use these data to trace the primary radiative forcings through the critical zone at each CZO site. • Carbon budgets - Analyze carbon flux data collected at various scales to understand the regional exchange of carbon at a CZO site. Then apply projections of future climate conditions to assess the impact of those conditions on CZO processes.
4	8-9	**Applications - Water transfers** (Conklin) The students are introduced to the importance of water movement in linking the key components of the critical zone: atmosphere, biology and landforms. Students analyze data and use simple models to interpret spatial and temporal trends in water flow and reservoirs in a catchment and subcatchment context to answer questions about critical zone services. They complete activities to follow water through different reservoirs in the critical zone, emphasizing residence time, and the relationship between the biologic and abiotic processes. Learning objectives – Students will be able to: • Explain the fluxes and reservoirs of water cycling within the critical zone • Analyze the water budget of a catchment that includes both biotic and abiotic processes • Interpret the feedbacks between ecological and hydrological processes • Analyze the anthropogenic induced changes to the water cycling in a catchment

		Activities • Water balance on a tree (roots to leaves) - Do an annual water balance on tree and ask the question is there enough water in the soil to account for transpiration. Assess the role of trees in moving water from subsurface to the atmosphere • Water balance for a catchment - Do an annual water balance on a montane forested catchment in snow/rain transition and explore the hypothesis that thinning trees will increase water yield. Assess whether forest management is a useful tool in optimizing runoff from catchments
5	10-11	**Applications - Landscape Evolution** (White/Gill) Analyze how landscape terrain, erosion, soil development and cover affect critical zone processes. Learning objectives – Student will be able to: • Accurately recognize processes of erosion, sediment transport and deposition, hillslope movement, and regolith production, all linked to tectonic processes of uplift and subsidence. • Effectively summarize the interactions between organisms and the development of landforms. • Convincingly infer changes in landscapes through time. • Describe how environmental factors form soil profiles. • Identify and describe typical characteristics of at least three soil orders. • Define and characterize soil horizons, ped structures, cation exchange capacity, base status and bulk density. • Use the above information to categorize soil orders. Activities • Access the National Geologic Map database • Explore generic landforms and associated landscapes
6	12-13	**Applications - Geochemistry/biochemistry** (Hoffman/McDowell) Analyze how nutrients flow through the critical zone and how they drive critical zone processes. Learning objectives – Students will be able to: • Evaluate the chemical, physical, geological and biological processes and reactions that govern the composition of the critical zone. • Explain the role of critical zone services on supporting terrestrial life, including humanity • Use data to explain critical zone functions • Use data to evaluate how agricultural systems differ in nutrient cycling from forest ecosystems • Define the causes and effects of eutrophication

		Activities • Atmospheric deposition - "Borne on the wind: Significance of rain and dust from distant sources on CZ function": an examination of the relationship between large rain and dust inputs from afar, relative to what leaves in streams and weathers from rocks, in a local watershed. • Nutrient fluxes - Student derived data set of P in various compartments in an agricultural system and forest ecosystem (Graphic showing the change in agricultural soil carbon over 15 years).
7	14-15	**Impact - Humans in the CZ** (Gill) Goal: Apply various methods and data analyses to identify and quantify the anthropogenic influences on the critical zone. Learning objectives– Students will be able to: • Identify and describe mechanisms that produce or reduce human perturbations on the critical zone. • Identify and describe political, economic and cultural impacts of perturbations in the critical zone. • Identify and describe human perturbations to the hydrological cycle. • Identify and describe human alterations to land surfaces. • Identify and describe human influences on biogeochemical cycles at the local and global scale. Activities • Watershed modeling - Use the Model My Watershed model to reduce human perturbations on the critical zone while maintaining or improving economic, political and social conditions.
8		Final Exam period (12/12 11:30-2:30): Student Project Presentations

Critical Zone Science; MW 1:30-2:45, COB 262, Dr. Conklin (v.8/30/15)

List of Topics by Day/Date – Fall 2015

Day	Date	Unit	Topic
1	8/31	0.1	Introductions & Integrate docs
2	9/2	1.1.1	CZ Background; **CZO Science reports**
	9/7		Labor Day
3	9/9	1.2.1	Soil forming Factors
4	9/14	1.2.2	Web Soil Survey
5	9/16	1.3.1	Systems - Five-spheres
6	9/21	2.1.2	Spreadsheet Skills
7	9/23	2.2.1	CZ Concepts & Methods
8	9/28	2.1.1	Research methods – Jim out
9	9/30	2.2.2	**Methods reports**
10	10/5	3.1.1	Water & Energy Budgets and Fluxes
11	10/7	3.1.2	CZO database graphs
12	10/12	3.2.1	Carbon Budgets and Fluxes
13	10/14	3.2.2	Eddy Correlation
14	10/19	4.1.1	Water Balance - point
15	10/21	4.1.2	Water Balance - tree
16	10/26	4.2.1	Water Balance - Watershed
17	10/28	4.2.2	Sim Water
18	11/2	5.1.1	Rock Cycle and Tectonics
19	11/4	5.1.2	National Geologic Map Database
20	11/9	5.2.1	**Landforms reports**
21	11/11	5.2.2	Aerial Photographs
22	11/16	6.1.1	BioGeoChemical Cycle
23	11/18	6.1.2	Carbon & Nitrogen
24	11/23	6.2.1	Deadzone activity
	11/25		Thanksgiving
25	11/30	6.2.2	Eutrophication
26	12/2	7.1.1	Human Impacts
27	12/7	7.1.2	Model My Watershed
28	12/9	7.2.1	Soil Carbon
	12/12	8.1	11:30-2:30 Final Presentations