How does the water cycle change us, and how do we change it?

GENED 1158: Water and the Environment

Spring 2025

Lectures: Tuesday and Thursday 1:30 pm â€“ 2:45 pm, in Geological Museum 100.

Attendance is mandatory for all classes and sections. This course is not designed to be taken remotely. However, specific classes may be missed for reasonable causes by emailing both the instructor and TF in advance. **Some examples of reasonable causes for missing class include: a student must isolate due to a positive COVID test, or due to recent exposure to a person with COVID, or due to experiencing symptoms consistent with COVID.** We will follow guidance from the college to handle situations in which students must isolate: one-off Zoom sessions or recordings will be made available to the isolated student, and students will not be penalized for missing classes in this case.

Instructor: Prof. Kaighin McColl (first name is pronounced like the surname of Elena Kagan), he/him/his

Office: Museum of Comparative Zoology, 435E

Email: kmccoll@seas.harvard.edu

Office Hours: I'm always happy to meet with students. It's difficult to find a time that works for everyone in a class this size, so I'll hold office hours on request. Please feel free to send me an email to schedule a time to chat.

Head TF: Dr. Chloe Anderson, chloeanderson@fas.harvard.edu

Office hours: Tuesdays 10:30-11:30AM and 3PM-4PM, GeoMuseum 101 or by appointment

TFs:

Val Aguilar (vaguilar@g.harvard.edu)

Office Hours: Fridays 10:30-11:30AM, Lowell Lecture Hall B-13

Disha Ganjegunte (dishaganjegunte@hsph.harvard.edu)

Office Hours: Fridays 9:30-10:30AM, Sever 111

Mariam Khursheed (mariam_khursheed@hsph.harvard.edu)

Office Hours: Wednesdays 3:00-4:00PM, Memorial Hall 303

Allen Wang (allenwang@gsd.harvard.edu)

Office Hours: Tuesdays 11:30-12:30PM, Barker 103

Section Times:

Tuesday 10:30-11:30 am; Barker Center 218 (Wang)
Tuesday 12:00-1:00 pm; GeoMuseum 103A (Anderson)
Tuesday 3:00-4:00 pm; Harvard Hall 103 (Aguilar)
Tuesday 4:30-5:30 pm; Harvard Hall 103 (Aguilar)
Thursday 3:00-4:00 pm; Northwest Bldg B107 (Aguilar)
Thursday 4:30-5:30 pm; Robinson 223 (Khursheed)
Friday 10:30-11:30 am; Sever 111 (Ganjegunte)

Class Website: https://canvas.harvard.edu/courses/129660

And it never failed that during the dry years

the people forgot about the rich years,

and during the wet years

they lost all memory of the dry years.

- John Steinbeck, *East of Eden*

Description: What do landslides in Brazil, droughts in California, mass migration in Syria and the collapse of Mayan civilization all have in common? Water. This course introduces students to the terrestrial water cycle: how it works, how humans manipulate it, and how it manipulates us. Students will learn about the major components of the terrestrial water cycle, including precipitation, evapotranspiration, runoff and streamflow, and saturated and unsaturated subsurface flow. We will also learn about the causes and consequences of natural hazards associated with the water cycle -- including floods, landslides and droughts â€“ and examine several case studies, with a focus on human impacts. The course will consider how the water cycle has contributed to the demise of past civilizations, and explore implications for modern society in a warming world.

Course Goals and Objectives: By the end of this course, you will be able to:

- Reason systematically about how humans impact the water cycle.
- Reason systematically about how the water cycle impacts humans.
- Describe each major component of the hydrological cycle.

Prerequisites: None.

Text: Two textbooks are used in this class:

1. Margulis, S. (2017) *Introduction to Hydrology*, freely available at https://margulis-group.github.io/teaching/.
2. Hakim, G. and Patoux, J. (2021) *Weather: a concise introduction*. Second Edition. Cambridge University Press.

Margulis (2017) is a more technical reference that may be of interest for those with a more quantitative background. Hakim and Patoux (2021) is less technical and more accessible to those without a quantitative background. You should have access to both textbooks: questions on the mid-term will be similar to those in Hakim and Patoux (2021).

Section: You will attend a weekly 1-hour section. These will begin in Week 2. **Attendance is mandatory for all classes and sections**. Specific classes may be missed for reasonable causes by communicating in advance with the Head TF and your section TF.

Grades:

Your grade in the course will be based on your weighted scores on all assignments, the midterm exam, and participation in lecture, section and the discussion board.

Final Grade breakdown

Assessment	% of final grade
3 x Event analysis assignments	36%

Water profile assignment	20%
Participation in class and section (including weekly discussion board posts)	9%
Midterm	25%
Art analysis assignment	10%

Letter grades will be assigned based on the below grade breakdown:

Final Grade Score Ranges

Letter Grade	Score Range (%)
A	100-93
A-	92-90
B+	89-87
B	86-83
B-	82-80
C+	79-77
C	76-73
C-	72-70
D+	69-67
D	66-63
D-	62-60
E	59

*****BONUS POINTS***: if there are at least three questions per class throughout the semester, everyone in the class will get their final score increased by 1 point.**

Additionally, we will conduct â€œexit surveysâ€ after lectures. These anonymous surveys are a place for you to reflect on your understanding of topics covered during lecture and for you to indicate areas or topics that need clarification in lecture or sections.

Assessment:

Water profile assignment

You will write a "water profile" for a particular place that has meaning or significance to you (for example, your hometown, state or country; other choices are also welcome!). The weekly prompts on the Canvas discussion board are designed to incrementally contribute towards this assignment over the course of the semester.
The assignment should be up to four pages (single-spaced, Times New Roman, 12-point font), excluding references. It should address the following:

- Provide some background on the region, including its climate. Why is it meaningful to you?
- Define a control volume for the region, and provide a figure. What are the major fluxes of water in and out of the region?
- Describe the main characteristics of precipitation in the region. Provide a reasonable estimate of the annual mean precipitation for the region (note: the precise value matters less than your reasoning here). What are the dominant mechanisms controlling precipitation in the region?
- Are floods ever a problem in the region? If so, what are the main causes and impacts? If not, why do they rarely occur?
- Describe the main characteristics of evapotranspiration in the region. Provide a reasonable estimate of the annual mean evapotranspiration for the region (note: the precise value matters less than your reasoning here). What are the dominant mechanisms controlling evapotranspiration in the region?
- Are droughts ever a problem in the region? If so, what are the main causes and impacts? If not, why do they rarely occur?
- Describe the main characteristics of runoff and streamflow in the region. What are the major

waterways? Provide a reasonable estimate of the annual mean flow of the largest stream or river for the region (note: the precise value matters less than your reasoning here).
- What, if anything, is known about groundwater storage in the region?
- Describe how drinking water is treated and supplied in the region.
- For each of the hydrological fluxes and storages discussed, how are they expected to change in future with global warming? How will these changes impact the aspects of the region that are meaningful or significant to you?

In many cases, information may be limited for your particular region. That is OK, but the highest grades will be awarded to those who think creatively to provide reasonable estimates, while also clearly discussing the limitations of their approach.

You should appropriately cite your sources for data where applicable.

You must submit your assignment by 6 pm on the day it is due (see subject schedule below) by uploading it to Canvas.

The assignments will be graded using the following rubric:

Water Profile Rubric

Quality of argument/thoroughness/completeness (60%)

- Clearly and completely addresses each point listed above (30%)
- Provides sufficient detail/support for their statements, and appropriately justifies assumptions (20%)
- Makes connections to material covered in class, and to broader issues/topics in the field (10%)

Scientific/technical accuracy (35%)

- Factually correct statements (20%)
- Writing demonstrates a clear understanding of the scientific concepts (15%)

Quality of writing and organization (5%)

- Writing is clearly organized (3%)
- Formatting, spelling/grammar, style (2%)

Event analysis assignments

You will complete three written assignments analyzing and discussing a news article (or other relevant document, including government documents related to water policy) on three events related to the water cycle. The topics are as follows:

- Assignment 1: An article on an event in which an excess of water has impacted humans.
- Assignment 2: An article on an event in which a deficit of water has impacted humans.
- Assignment 3: An article on an event in which humans modify the water cycle.

The news articles should be from a reputable source. You will briefly discuss the main points of the article, why it is important/relevant, and how it fits into the broader context of the water cycle.

You will then present two different potential arguments for why the event occurred. Good arguments will refer to specific hydrological fluxes and storages. Your arguments may be obtained from the article itself,

another source, or your own understanding of the hydrologic cycle. You will discuss the strengths and weaknesses of each argument, and make the case for which argument you find most compelling.

This exercise will require thorough background research on the topic covered in your news article â€“ it is important that you examine the issue beyond the information in the article you have selected. Please check in with your TF to make sure your chosen article is appropriate.

Each assignment will be up to two pages (single-spaced, Times New Roman, 12-point font), excluding references. Figures are welcome if useful in making your argument.

You must submit your assignment by 6 pm on the day it is due (see subject schedule below) by uploading it to Canvas.

The assignments will be graded using the following rubric:

Event Analysis Rubric

Quality of argument/thoroughness/completeness (60%)

- Proposed hydrologic mechanisms are plausible and their strengths and weaknesses are discussed clearly (30%)
- Provides sufficient detail/support for their statements (20%)
- Makes connections to material covered in class, and to broader issues/topics in the field (10%)

Scientific/technical accuracy (35%)

- Factually correct statements (20%)
- Writing demonstrates a clear understanding of the scientific concepts (15%)

Quality of writing and organization (5%)

- Writing is clearly organized (3%)
- Formatting, spelling/grammar, style (2%)

Midterm

The midterm will take place in class on ***March 6***. It will cover all material from Module 1. You will be given 60 minutes. Practice mid-terms will be made available on Canvas. The midterm is closed-book.

Art Analysis assignment

We will visit the Harvard Art Museum on ***April 3 and April 8***. Working with experts from the museum, you will analyze several pieces in the museum relevant to water. You will then be asked to complete a similar analysis based on a different piece in the museum of your own choosing. We will provide further guidance on this assignment closer to the visit.

The class is too large to visit the Museum in one group. We will split the class into two groups. **You will only visit the Museum on one of the two dates listed above. You will be assigned a date based on your section -- please be sure to attend on your assigned date**. **On the date that you are not attending the Museum, attend class as usual**. I will repeat the same lecture on April 3 and April 8.

Participation

Your overall contribution to class discussions will be graded. This includes your contribution in both sections and lectures. **Attendance in sections and lectures is mandatory**. Specific classes may be missed for reasonable causes by communicating in advance with the instructor or TF.

In addition, each week, you will write 100 words responding to a discussion prompt. You will submit this on a discussion board for the class on Canvas, which will be viewable by anyone enrolled in the class. Your submission may be a response to another studentâ€™s submission, but please be respectful, if so. The thoughtfulness of your response will be graded: either two, one or zero points per week. The discussion board posts will be due each week on **Wednesday by 6 pm**.

Late policy:

Please submit assignments on time. You may submit one assignment up to 24 hours late without penalty. After that, assignments will be penalized for being late. The grade will be reduced by 10% per day for three days. The grade will be zero if submitted more than three days late.

Policy on collaboration:

Discussion and the exchange of ideas are essential to doing academic work. For assignments in this course, you are encouraged to consult with your classmates as you work on problem sets. However, after discussions with peers, make sure that you can work through the problem yourself and ensure that any answers you submit for evaluation are the result of your own efforts. In addition, you must cite any books, articles, websites, lectures, etc that have helped you with your work using appropriate citation practices. Similarly, you must list the names of students with whom you have collaborated on problem sets. Absolutely no collaboration or use of auxiliary materials is allowed during exams. All exams must be completed independently with no aids.

Honor Code: All students are expected to follow the Harvard College Honor Code.

Members of the Harvard College community commit themselves to producing academic work of integrity â€“ that is, work that adheres to the scholarly and intellectual standards of accurate attribution of sources, appropriate collection and use of data, and transparent acknowledgement of the contribution of others to their ideas, discoveries, interpretations, and conclusions. Cheating on exams or problem sets, plagiarizing or misrepresenting the ideas or language of someone else as oneâ€™s own, falsifying data, or any other instance of academic dishonesty violates the standards of our community, as well as the standards of the wider world of learning and affairs.

Generative AI policy: *We expect that all work students submit for this course will be their own. In instances when collaborative work is assigned, we expect for the assignment to list all team members who participated.* ***We specifically forbid the use of ChatGPT or any other generative artificial intelligence (AI) tools at all stages of the work process, including preliminary ones. Violations of this policy will be considered academic misconduct****. We draw your attention to the fact that different classes at Harvard could implement different AI policies, and it is the studentâ€™s responsibility to conform to expectations for each course.*

Email policy:

To keep email loads manageable, I will aim to respond to your email within 48 hours, excluding weekends. For example, if you email me on Monday morning, I will respond by Wednesday morning. If you email me on Thursday morning, I will respond by Monday morning. Where possible, I will try to respond sooner, particularly around due dates for problem sets or tests, but cannot guarantee it.

Academic accommodations:

Harvard University values inclusive excellence and providing equal educational opportunities for all students. Our goal is to remove barriers for disabled students related to inaccessible elements of instruction or design in this course. If reasonable accommodations are necessary to provide access, please contact the Disability Access Office (DAO). Accommodations do not alter fundamental requirements of the course and are not retroactive. Students should request accommodations as early as possible, since they may take time to implement. Students should notify DAO at any time during the semester if adjustments to their communicated accommodation plan are needed.

Simultaneous enrollment:

As attendance is required in all Gen Ed courses, Gen Ed courses are not eligible for course-wide simultaneous enrollment waivers. Students pursuing simultaneous enrollment in a Gen Ed course and a non-Gen Ed course must attend the Gen Ed course.

Pass/fail: this course may not be taken pass/fail.

Subject Schedule:

Week 1 (starting January 27): Introduction and class overview. Overview of the global hydrologic cycle.

Discussion board prompt: Introduce yourself to the rest of the class. What do you hope to get out of this course?

Recommended reading:

- Chapter 1 of Hakim and Patoux (2021).

Module 1: Too much

Week 2 (starting February 3): Climate. Atmospheric composition and thermodynamics. Radiation. Sections start this week.

Discussion board prompt: Choose a region for the "water profile" assignment. Why is it meaningful to you? Provide some background on the region.

Recommended reading:

- Chapters 3, 4 and 5 of Hakim and Patoux (2021).
- Chapter 2 of Margulis (2017).

Week 3 (starting February 10): Climate. Large-scale atmospheric circulation. Why are some areas wet and some areas dry?

Discussion board prompt: Describe the climate of the region you have chosen for the "water profile" assignment.

Recommended reading:

- Chapters 8, 9 and 10 of Hakim and Patoux (2021).
- Chapters 3 and 4 of Margulis (2017).

Week 4 (starting February 17): Precipitation. **Guest lecture (February 18): Dr. Chloe Anderson, on oceans, ENSO and other ocean-mediated modes of climate variability.**

Discussion board prompt: Describe the main characteristics of precipitation in the region you have selected for your "water profile" assignment. Provide a reasonable estimate of the annual mean precipitation for the region (note: the precise value matters less than your reasoning here).

Recommended reading:

- Chapters 6 and 7 of Hakim and Patoux (2021).
- Chapter 5 of Margulis (2017).

Week 5 (starting February 24): Precipitation. Floods and landslides. ***Event analysis assignment 1 due by 6 pm on February 26.***

Discussion board prompt: What are the dominant mechanisms controlling precipitation in the region you have selected for your "water profile" assignment?

Recommended reading:

- Chapters 7 and 10 of Margulis (2017).

Module 2: Too little

Week 6 (starting March 3): Evapotranspiration. ***Midterm in-class on March 6.***

No discussion board prompt this week.

Recommended reading:

- Chapter 8 of Margulis (2017).

Week 7 (starting March 10): Evapotranspiration. Droughts.

Discussion board prompt: Are floods ever a problem in the region you have selected for your "water profile" assignment? If so, what are the main causes and impacts? If not, why do they rarely occur?

Recommended reading:

- Chapter 8 of Margulis (2017).

NO CLASS WEEK OF MARCH 17 (SPRING BREAK).

Week 8 (starting March 24): Case study: collapse of Mayan civilization. Case study: the Dust Bowl.

Discussion board prompt: Describe the main characteristics of evapotranspiration in the region you have selected for your "water profile" assignment. Provide a reasonable estimate of the annual mean evapotranspiration for the region (note: the precise value matters less than your reasoning here).

Recommended reading:

- â€œThe Maya Collapsesâ€: Chapter 5 of Diamond, J. (2006), *Collapse: How societies choose to fail or succeed*. Penguin.
- William Cronon (1972), "A Place for Stories: Nature, History and Narrative".

Week 9 (starting March 31): Irrigation and agriculture. Unsaturated flow and infiltration. ***Event analysis assignment 2 due by 6 pm on April 2. Half the class will visit the Harvard Art Museum on April 3. Attend class as usual if you are not visiting the Museum.***

Discussion board prompt: What are the dominant mechanisms controlling evapotranspiration in the region you have selected for your "water profile" assignment?

Recommended reading:

- Chapter 7 of Margulis (2017).

Module 3: Just right?

Week 10 (starting April 7): Runoff and streamflow. ***Half the class will visit the Harvard Art Museum on April 8. Attend class as usual if you are not visiting the Museum.*** **Guest lecture (April 10): Dr. Chloe Anderson**

Discussion board prompt: Are droughts ever a problem in the region you have selected for your "water profile" assignment? If so, what are the main causes and impacts? If not, why do they rarely occur?

Recommended reading:

- Chapter 10 of Margulis (2017)

Week 11 (starting April 14): Groundwater. Mining of water resources. ***Art Analysis assignment due by 6 pm on April 16.*** **Guest lecture (April 17): Dr. Bryan Yoon, connections between the carbon and water cycles, and implications for water quality.**

Discussion board prompt: Describe the main characteristics of runoff and streamflow in the region you have selected for your "water profile" assignment. What are the major waterways? Provide a reasonable estimate of the annual mean flow of the largest stream or river for the region (note: the precise value matters less than your reasoning here).

Recommended reading:

- Chapter 9 of Margulis (2017).
- â€œMining Australiaâ€: Chapter 13 of Diamond, J. (2006), *Collapse: How societies choose to fail or succeed*. Penguin.

Week 12 (starting April 21): Water treatment and supply.

Discussion board prompt: What, if anything, is known about groundwater storage in your "water profile" assignment region?

Recommended reading:

- â€œGrowing old thanks to water treatmentâ€: Chapter 4 of Sedlak, D. (2014), *Water 4.0*. Yale University Press.

Week 13 (starting April 28): The future: the water cycle in a warming world. Climate change. Expected impacts on the water cycle. ***Event analysis assignment 3 due by 6 pm on April 30***. ***Water profile assignment due by 6 pm on April 30***.

Recommended reading:

- Chapter 15 of Hakim and Patoux (2018)
- Executive Summary of IPCC report: Jimenez Cisneros, B.E. et al. (2014), *Freshwater Resources*. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the IPCC*. Field, C.B. et al. (eds). Cambridge University Press.