

Master of Science in Sustainability Management

SUMA K4147: Water Resources and Climate (WR&C)

Dates: Session B (Jul 1 - Aug 9), Tuesdays and Thursdays 6:10 pm - 8:00 pm **Location: TBD**

3 Credits

[Area 3]

Instructor: Laia Andreu-Hayles, PhD, lah@ldeo.columbia.edu
Indrani Pal, PhD, ip2235@columbia.edu

Office Hours: Location: TBD | Tuesday & Thursdays 5:30-6:10pm EST & By Appointment
Response Policy: Preferred means of communication is via email and students can expect responses typically within 24 hours during the work week. Weekend communication will be limited with delayed response.

Teaching Assistant: TBA
Office Hours: TBD
Response Policy: TBD

Course Overview

Water stress, a growing threat to human development under a changing climate, made TIME's top 10 global risks of 2023. This has spurred public and private institutions to develop innovative solutions, tackling the rising challenge of water scarcity through various "water lenses" across the world. Water resources security hinges on the complex interplay between the hydrologic cycle, climate system, land use, and human society. As the global population surpasses 9 billion in 2050, with over 70% residing in urban areas, and a future characterized by an increasingly variable and extreme climate looms, understanding the interconnectedness of climate, water, and society becomes paramount for sustainably managing water resources and assessing future risks across all water- and climate-linked systems. The distribution of global water resources depends on both climate change and socioeconomic inequity issues. Some countries will be more affected than others unless appropriate strategies and technological resources are available to cope with new scenarios. This course provides the necessary context for everyone in the program and/or those pursuing a water track to understand how environmental changes connect to both natural and human-caused factors, including environment justice and social equity-related issues, both locally and globally. Drawing on peer-reviewed evidence, project-based learning, and a hands-on training workshop, this course covers: Science needed to understand the interactions between water resources and the climate system; Analysis of water-climate data on online web tools to teach students how to make data-driven decisions; How to read scientific papers and write critical opinions on cutting-edge research; Opportunities for exciting discussions with classmates and instructors about ongoing socio-economic issues around the world related to water and climate. Finally, using their new knowledge and skills, students will choose a real-world issue related to water, climate, and society as a case study. They will propose solutions they care about, supported by reasoning and evidence. The interactions between water and climate play an integral role in the coupling between natural and human systems. Therefore, the valuable scientific and hands-on training experience gained in this course will be an asset for other courses and the Sustainability Management Program in general.

While an elective, the WR&C course is mandatory for the water certificate track. This course welcomes eligible cross-registrants from other fields and Columbia programs, space permitting. No prior experience or coursework in the field is necessary. The course will be held on campus.

Learning Objectives

- L1: Critique science relevant to global & local water resources and its connection to climate.
- L2: Analyze how variability and changes in the climate affect/will affect water supply and availability on the land.
- L3: Evaluate how water impacts society & ecosystems at large and vice versa.

Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition**, Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3. Available as an E-Book from Wiley at:

<https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493>

- L4: Critically evaluate scientific articles and write reviews / opinions supported by evidence.
L5: Apply web tools to analyze water-climate data independently.
L6: Design a project to analyze a water resources problem, its connections to the climate system & society, and propose solutions for them.

Readings

There is no assigned textbook for this class. Readings will be taken from peer-reviewed scientific reports and journal articles of high standard, and will be supplemented with on-going issues and articles that are supported by peer-reviewed science and/or based on scientific evidence. During the course, the students are expected to be critical about non-peer-reviewed reports and articles. Discussions of what can be considered “reliable sources” will be held during the course in order to help students in the search for information for their final project. For instance, outlets such as “ScienceDaily” and “AGU-Eos” that are based on fact-based science or news based on peer-reviewed articles can be a good source of information that helps students find ‘real’ sources of scientific information. Search for information on environment justice and equity issues associated with water and climate topics will be encouraged and integrated in class discussions.

Required

Allen, Craig D., and David D. Breshears. "Drought-induced shift of a forest–woodland ecotone: rapid landscape response to climate variation." *Proceedings of the National Academy of Sciences* 95.25 (1998): 14839-14842.

Buckley, Brendan M., et al. "Climate as a contributing factor in the demise of Angkor, Cambodia." *Proceedings of the National Academy of Sciences* 107.15 (2010): 6748-6752.

Cook, Edward R., et al. (a) "Megadroughts in North America: Placing IPCC projections of hydroclimatic change in a long-term palaeoclimate context." *Journal of Quaternary Science* 25.1 (2010): 48-61.

Fyfe, John C., et al. "Making sense of the early-2000s warming slowdown." *Nature Climate Change* 6.3 (2016): 224-228.

Greene, Arthur M., Lisa Goddard, and Rémi Cousin. "Web tool deconstructs variability in twentieth-century climate." *Eos, Transactions American Geophysical Union* 92.45 (2011): 397-398.

Oki, Taikan, and Shinjiro Kanae. "Global hydrological cycles and world water resources." *science* 313.5790 (2006): 1068-1072.

Sedláček, Jan, and Reto Knutti. "Half of the world's population experience robust changes in the water cycle for a 2° C warmer world." *Environmental Research Letters* 9.4 (2014): 4008.

Trenberth, Kevin E. "Changes in precipitation with climate change." *Climate Research* 47.1-2 (2011): 123-138.

Recommended

Aragão, Luiz EOC. "Environmental science: The rainforest's water pump." *Nature* 489.7415 (2012): 217-218.

Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., 2008: *Climate Change and Water*. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp.

Bonan, Gordon B. "Forests and climate change: forcings, feedbacks, and the climate benefits of forests." *science* 320.5882 (2008): 1444-1449.

Cobb, Kim M., et al. "El Nino/Southern Oscillation and tropical Pacific climate during the last millennium." *Nature* 424.6946 (2003): 271-276.

Cook, Edward R., et al. (b) "Asian monsoon failure and megadrought during the last millennium." *Science* 328.5977 (2010): 486-489.

Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition**, Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3. Available as an E-Book from Wiley at:

<https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493>

del Corral J, Blumenthal MB, Mantilla G, Ceccato P, Connor SJ, Thomson MC. (2012), Climate information for public health: the role of the IRI climate data library in an integrated knowledge system. *Geospat Health*. 2012 Sep;6(3):S15-24.

deMenocal, Peter B. "Climate and human evolution." *Science* 331 (2011): 540.

de Loe, R.C. & Kreutzwiser, R. Climate variability, climate change and water resource management in the Great Lakes. *Climatic Change* 45 (2000), pp. 163-179

Dingman, S. Lawrence. *Physical hydrology*. Waveland press, 2015.

Dinku, T., Block, P., Sharoff, J. et al. *Earth Perspectives* (2014) 1: 15. <https://doi.org/10.1186/2194-6434-1-15>

Folland, C.K. Karl, T. Salinger, M. Observed climate variability and change. *Weather*, 57 (2002), pp. 269-278

Gemenne, François. "Why the numbers don't add up: A review of estimates and predictions of people displaced by environmental changes." *Global Environmental Change* 21 (2011): S41-S49.

Gleick, Peter H., and Meena Palaniappan. "Peak water limits to freshwater withdrawal and use." *Proceedings of the National Academy of Sciences* 107.25 (2010): 11155-11162.

Goddard, L, Baethgen W, Bhojwani H, and Robertson A, (2014) The International Research Institute for Climate & Society: why, what and how. *Earth Perspectives* 2014, 1:10.

Hawkins, Ed. "Our evolving climate: communicating the effects of climate variability." *Weather* 66.7 (2011): 175-179.

Hegerl, Gabriele C., et al. "Challenges in quantifying changes in the global water cycle." *Bulletin of the American Meteorological Society* 96.7 (2015): 1097-1115.

Held, Isaac M., and Brian J. Soden. "Robust responses of the hydrological cycle to global warming." *Journal of Climate* 19.21 (2006): 5686-5699.

Khoo, Teng Chye. "Singapore water: yesterday, today and tomorrow." *Water Management in 2020 and Beyond*. Springer Berlin Heidelberg, 2009. 237-250.

Milly, P.C.D, et al. Stationarity is Dead: Whither Water Management? *Science* 319 (2008).

Moss, R. H., et al. Hell and High Water: Practice-Relevant Adaptation Science. *Science* 342 (6159), 696-698.(2017)

Pederson, Neil, et al. "Pluvials, droughts, the Mongol Empire, and modern Mongolia." *Proceedings of the National Academy of Sciences* 111.12 (2014): 4375-4379.

Schwarz, Andrew, et al. "Climate change handbook for regional water planning." (2011).

Sivapalan, M., Savenije, H.H.G., and Blöschl, G., *Socio-hydrology: a new science of people and water*.

Hydrological Processes, 26, (2012): 1270–1276.

Sweeney, Alexandra, et al. "Utilizing remote sensing to explore environmental factors of visceral leishmaniasis in South Sudan." *EO Heal* (2014).

Taylor, Karl E., Ronald J. Stouffer, and Gerald A. Meehl. "An overview of CMIP5 and the experiment design." *Bulletin of the American Meteorological Society* 93.4 (2012): 485-498.

Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition**, Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3. Available as an E-Book from Wiley at:

<https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493>

Thomson, Madeleine C., et al. "Africa needs climate data to fight disease." *Nature* 471.7339 (2011): 440-442.

Trenberth, Kevin E. "Has there been a hiatus?." *Science* 349.6249 (2015): 691-692.

Wilby, R.L., and Dessai S. "Robust adaptation to climate change." *Weather* 65.7 (2010): 180-185.

Williams, A. Park, et al. "Forest responses to increasing aridity and warmth in the southwestern United States." *Proceedings of the National Academy of Sciences* 107.50 (2010): 21289-21294.

Zhang, M., and Wei, X. "Deforestation, forestation, and water supply". *Science*. 371(6533): pp990.

Assignments and Assessments

Attendance (5% of final grade)

Students are expected to arrive on time, attend all classes, and stay until the end of class unless they have notified the instructors otherwise. 5% is allocated for attendance grading. We encourage attendance in-class because it is the most effective way to take full advantage of the learning/training in this course. Lectures will not be recorded and participation in discussions needs to be in-person.

Written critiques (35% of final grade)

Written assignments will be requested for 6 scientific papers discussed in class. For all students, these written critiques are due via Courseworks/Canvas at 3PM on the day of class. The grades of the 6 written critiques will make up 35% of the student's total grade.

Each critique must include:

- A short essay giving an overview of the reading (not less than 200 and no more than 300 words). This shouldn't just be a copy and paste the abstract.
- Two strengths and two weaknesses of the investigation/reading not based on personal thoughts. These should be based on scientific facts and evidence.
- One critical question that can be used as a part of the class discussion.

The critique should discuss, in the student's own language, the readings in terms of the topics covered, the strengths and weaknesses of the articles, and critical aspects of the research presented. We have included the following list to act as a guideline for preparing a critique.

- Provide a general overview
- Explain main ideas
- Explain important numbers/facts
- Incorporate original thoughts based on scientific evidence/methodologies.
- Tie the paper into the overarching theme of the course

Late Submission Policy:

Written critiques are due before 3PM on the day of class. Please inform the acting professor/associate of any extenuating circumstances that may prevent you from meeting this deadline. It is crucial that all the students read and write a thoughtful review before class. For this reason, critiques received after 3PM will be subject to deductions (on a scale 0-100):

- 3:01 PM to 6:00 PM (day of class) – 5 points deduction

Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition**, Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3. Available as an E-Book from Wiley at:

<https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493>

- 6:01 PM to Midnight on day of class – 10 points deduction
- Day after class – 15 points deduction
- Later than the day after class – maximum grade possible will be 80. Feedback from the instructor is not guaranteed.

Participation (10% of final grade)

Participation on the topics of discussion of the course will account for 10% of the final grade, while the 7% will be based on the student's in-class active participation and 3% on Courseworks forum participation (discussion forum). This grade will be an average from the individual evaluation of the instructors.

The students are expected to show critical thinking, respectful interactions with classmates and a positive attitude towards learning and freely discussing the topics proposed. Students are encouraged to share the critical questions from their assignments with their peers. These recommendations apply for both class and forum discussions.

Discussion Forum:

Throughout the semester, students are encouraged to post news or information of interest on the CANVAS discussion forum. Thoughtful thinking connecting the topics learned in class to real world problems are very much welcome, as well as connection with DEI issues.

Exam (20% of final grade)

There will be one two-hour quiz that will evaluate concepts, ideas, themes and issues that were covered in class until the evaluation date. It will be composed of short-answer essay questions and multiple-choice questions. The specific point value of each question will be detailed at the time of the exam.

Final project (30% of final grade)

The final project for this course will be a paper on an issue of the student's choice related to the class theme "Water Resources and Climate". A real-world problem in relation to water and climate should be presented. The total grade for the final project (30%) will be based on the written paper (15%) and the presentation (15%).

A mandatory project proposal will be due on Sunday July 23rd for topic approval. The proposal will not be graded; it is meant to ensure an appropriate topic and it is a prerequisite for the acceptance of the final project. For the proposal we request the submission of a document of less than one page describing the project and how you plan to approach your paper. Failing to turn the proposal in a timely manner will forfeit the submission of the final project or points removal from the final written project.

The student will be responsible for reading primary source peer-reviewed material on the topic, evaluating the scientific uncertainty behind the issue, and recommending adaptation options, management approaches and/or strategies as appropriate depending on the topic discussed.

We reiterate – any issue proposed, studied or solutions discussed should be backed by scientific consensus, data, and/or facts, no personal thoughts or discovery is needed. The student will also be responsible for making the appropriate links and associations with the relevant theoretical material covered during the course. Students are expected to choose an interesting topic with societal good as focus.

The written paper will be due on Wednesday August 9th. This paper will be evaluated based on: 1) demonstrating a critical understanding of the peer-reviewed ONLY scientific literature and consensus knowledge that addresses the self-selected topic; and 2) proposing a creative, but feasible solution/management/adaptation strategy to the issue. A wide range of strategies can be proposed, but an approach demonstrated in the paper should have proven to be realistic or adapted elsewhere. The written paper grades will be an average from the individual evaluation of the instructors.

The presentations will take place on Thursday August 10th. The presentation will be evaluated by the ability to

Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition**, Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3. Available as an E-Book from Wiley at:

<https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493>

clearly present the problem and potential solutions to your peers, to address any questions and to defend the proposed adaptation strategy in a timely manner (TBD before the presentation).

Presentation grades will be an average from the individual evaluations of the instructors. Complete final project guidelines will be circulated through Courseworks/Canvas.

Final Grading

The final grade will be calculated as described below:

FINAL GRADING SCALE

Grade	Percentage
A+	98–100 %
A	93–97.9 %
A-	90–92.9 %
B+	87–89.9 %
B	83–86.9 %
B-	80–82.9 %
C+	77–79.9 %
C	73–76.9 %
C-	70–72.9 %
D	60–69.9 %
F	59.9% and below

Assignment/Assessment	% Weight	Individual or Group/Team Grade
Attendance	5%	Individual
Written Critiques	35%	Individual
Participation	10%	Individual
Exam	20%	Individual
Final project	30%	Individual

Course Schedule/Course Calendar

Date	Topics and Activities	Readings (due on this day)	Assignments (due on this date)
7/2	Water resources and climate: an overview		
7/4 [will potentially be offered as an online	Connections between climate and water	Oki & Kanae (2006)	Written Critique 1 *Students get full grade in this first exercise, and instructor feedback for preparing better for following critiques
7/9	Impact of climate change on the water cycle	Trenberth (2011)	Written Critique 2
7/11	Impact of climate change on the water cycle	Fyfe et al. (2016)	Written Critique 3

Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition**, Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3. Available as an E-Book from Wiley at:

<https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493>

7/16	The role of ecosystems to changes in the hydrological cycle	Allen & Breshears (1998)	Written Critique 4
7/17			PROJECT PROPOSAL
7/18	Paleo-perspectives on hydroclimate variability	Cook et al. (2010)	Written Critique 5
7/23	7/23 Workshop Tools for Analyses I. IRI Timescales decomposition tool II. Climate Explorer	Greene et al. (2011)	
7/25	7/25 The coupling of hydroclimate variability with human systems	Buckley et al. (2010)	Written Critique 6
7/30	7/30 Climate Change Projections (Global Climate Models)	Sedláček & Knutti (2014)	
8/1	EXAM		
8/6	Water management approaches to climate variability and change		
8/7			FINAL PROJECT REPORT
8/8			FINAL PROJECT PRESENTATIONS

Course Policies

Attendance, late papers, missed tests, class behavior and civility:

Students are expected to complete all assigned readings and homework, attend all class sessions, and engage with others in online discussions. Your participation will require that you answer questions, defend your point of view, and challenge the point of view of others. If you need to miss a class for any reason, please discuss the absence with me in advance.

Late work

There will be no credit granted to any written assignment that is not submitted on the due date noted in the course syllabus without advance notice and permission from the instructor.

Citation & Submission

Students must use standard citation format (e.g., MLA, APA, Chicago), cite sources (where applicable), and be submitted to the course website (not via email).

School and University Policies and Resources

Copyright Policy

Please note—Due to copyright restrictions, online access to this material is limited to instructors and students currently registered for this course. Please be advised that by clicking the link to the electronic materials in this course, you have read and accept the following:

Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition**, Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3. Available as an E-Book from Wiley at:
<https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493>

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted materials. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specified conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

Academic Integrity

Columbia University expects its students to act with honesty and propriety at all times and to respect the rights of others. It is fundamental University policy that academic dishonesty in any guise or personal conduct of any sort that disrupts the life of the University or denigrates or endangers members of the University community is unacceptable and will be dealt with severely. It is essential to the academic integrity and vitality of this community that individuals do their own work and properly acknowledge the circumstances, ideas, sources, and assistance upon which that work is based. Academic honesty in class assignments and exams is expected of all students at all times. SPS holds each member of its community responsible for understanding and abiding by the SPS Academic Integrity and Community Standards posted at <https://sps.columbia.edu/students/student-support/academic-integrity-community-standards>. You are required to read these standards within the first few days of class. Ignorance of the School's policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

Diversity Statement

It is our intent that students from all diverse backgrounds and perspectives be well-served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that the students bring to this class be viewed as a resource, strength and benefit. It is our intent to present materials and activities that are respectful of diversity: gender identity, sexuality, disability, age, socioeconomic status, ethnicity, race, nationality, religion, and culture.

Accessibility

Columbia is committed to providing equal access to qualified students with documented disabilities. A student's disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this service, please visit the University's Health Services website: <https://health.columbia.edu/content/disability-services>.

Class Recordings

All or portions of the class may be recorded at the discretion of the Instructor to support your learning. At any point, the Instructor has the right to discontinue the recording if it is deemed to be obstructive to the learning process.

If the recording is posted, it is confidential and it is prohibited to share the recording outside of the class.

SPS Academic Resources

The Division of Student Affairs provides students with academic counseling and support services such as online tutoring and career coaching: <https://sps.columbia.edu/students/student-support/student-support-resources>.

Columbia University Information Technology

Columbia University Information Technology (CUIT) provides Columbia University students, faculty and staff with central computing and communications services. Students, faculty and staff may access University-provided and discounted software downloads.

Adapted from: **The Course Syllabus: A Learning-Centered Approach, 2nd Edition**, Judith Grunert O'Brien, Barbara J. Millis, Margaret W. Cohen. ISBN: 978-0-470-60549-3. Available as an E-Book from Wiley at:
<https://www.wiley.com/en-us/The+Course+Syllabus%3A+A+Learning+Centered+Approach%2C+2nd+Edition-p-9780470605493>

Columbia University Library

Columbia's extensive library system ranks in the top five academic libraries in the nation, with many of its services and resources available online.

The Writing Center

The Writing Center provides writing support to undergraduate and graduate students through one-on-one consultations and workshops. They provide support at every stage of your writing, from brainstorming to final drafts. If you would like writing support, please visit the following site to learn about services offered and steps for scheduling an appointment. This resource is open to Columbia graduate students at no additional charge. Visit <http://www.college.columbia.edu/core/uwp/writing-center>.

Career Design Lab

The Career Design Lab supports current students and alumni with individualized career coaching including career assessment, resume & cover letter writing, agile internship job search strategy, personal branding, interview skills, career transitions, salary negotiations, and much more. Wherever you are in your career journey, the Career Design Lab team is here to support you. Link to <https://careerdesignlab.sps.columbia.edu/>

Netiquette

[Only applies to courses using online platforms]

Online sessions in this course will be offered through Zoom, accessible through Canvas. A reliable Internet connection and functioning webcam and microphone are required. It is your responsibility to resolve any known technical issues prior to class. Your webcam should remain turned on for the duration of each class, and you should expect to be present the entire time. Avoid distractions and maintain professional etiquette.

Please note: Instructors may use Canvas or Zoom analytics in evaluating your online participation.

More guidance can be found at: https://jolt.merlot.org/vol6no1/mintu-wimsatt_0310.htm

Netiquette is a way of defining professionalism for collaborations and communication that take place in online environments. Here are some Student Guidelines for this class:

- Avoid using offensive language or language that is not appropriate for a professional setting.
- Do not criticize or mock someone's abilities or skills.
- Communicate in a way that is clear, accurate and easy for others to understand.
- Balance collegiality with academic honesty.
- Keep an open-mind and be willing to express your opinion.
- Reflect on your statements and how they might impact others.
- Do not hesitate to ask for feedback.
- When in doubt, always check with your instructor for clarification.