GEOG 430/530 The Climate System
Spring 2025

This course is intended for upper-level undergraduates and graduate students and intensively reviews the fundamental physical processes that control the features and patterns of variability and change in the Earth's climate system with a particular focus on energy in the Earth system. The course includes hands-on experience and exploration including quantitative evaluation of physical climate processes and analysis of climate observational and model data. Specific topics include the Earth's energy balance and the greenhouse effect and the role of the biosphere and carbon cycle in controlling energy and temperature in the Earth system, the circulation of the oceans and atmosphere, observations of past and present climate change and simulation for predicting future climate, and specific anticipated impacts of future climate change including drought, glacier and ice sheet changes, and sea level rise.

The goal of the course is to provide students with an *intensive* and *physically-based* understanding of the fundamental processes that control climate variability and climate change at a range of temporal and spatial scales. Students will develop process-based knowledge, learn to quantitatively evaluate climate data, and provide them with the necessary understanding of the physical, chemical, and dynamical processes and phenomena of the climate system to incorporate these within their own scholarship and research.

This syllabus and course schedule are subject to change.
Please check regularly for updated information on D2L
Last Updated 6 March 2025

Locations and Times

Tuesday and Thursday 11:00AM to 12:15PM
Saguaro Hall, Room 225
Course materials online via D2L (`http://d2l.arizona.edu`)

Instructor Information

Kevin Anchukaitis
Professor, School of Geography, Development, and Environment
Laboratory of Tree Ring Research
Room S514, Environment and Natural Resources Building 2 (ENR2)
Room 419, Bannister Tree Ring Lab Building
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Office Hours

Office Hours: with advance notice (appointment) on Tuesday between 1pm to 3pm and/or by appointment at other times

Course Information

Prerequisites

Undergraduates: GEOG230 or the equivalent or permission of instructor. Graduates: Degree-seeking in good standing and with continuing graduate student status. The instructor reserves the right to administratively drop any student who he considers to be behaving in a threatening or disruptive manner.

Course Objectives

This course has the following learning objective:

- Factual: You will acquire knowledge related to processes and phenomena of the Earth's climate system

- Conceptual: You will develop understanding of fundamental principles foundational theories, and general physical and qualitative models concerning the climate system.
- Procedural: You will learn how and when to apply subject-specific knowledge and skills, concepts, and scientific reasoning when interpreting or evaluating observations of, theories on, and claims about the climate system. You will be able to differentiate between magnitudes of effects or processes, identify reasonable inferences or conclusions, and recognize likely outcomes, based on your understanding of the integrated climate system.
- Metacognitive: You will learn how to develop strategies to analyze data, and learn how to critique (and accept criticism) of your technical and scientific writing

Undergraduate Learning Outcomes
For Geography undergraduate majors (GEOG 430), this course addresses the following learning outcomes:

1. Demonstrate knowledge of core principles of physical geography in climatology and water resources
2. Recognize the key factors influencing global and regional climate in the past, present, and future.
3. Evaluate linkages between the natural environment and human systems
4. Demonstrate ability to create, refine, and interpret graphical data.
5. Understand human dimensions of environmental issues
6. Understand causes and effects of regional and global environmental change.
7. Understand concepts required for success in an environmental profession

Recommended Text
There is no required textbook for this course; however, *particularly for graduate students*, I recommend purchasing *Global Physical Climatology*, 2nd Edition, by Dennis Hartmann, available online. Any additional required readings will be posted on D2L.

Assignments and Methods of Assessment

'Lab' Exercises: [50%] These 6 assignments ask you to analyze data about the climate system, develop hypotheses, make observations, and justify conclusions. These are an opportunity for you to apply what you've learned in class to new but related data, observations, phenomena, or situations. The mode of the assignment (e.g. in-class, group, individual) will vary from assignment to assignment. When appropriate, graduate students are very strongly encouraged to make use of a high-level programming language (R, Python, or MATLAB, etc) when completing their assignments. I will drop the lowest grade, so each of these assignment is essentially worth 10% of your grade.

Exams [30%] Two exams worth 30% total of your final grade (15% each). Format is short answers including calculations, making and interpreting diagrams and sketches, and analysis of scientific figures or schematics. A study sheet will be posted prior to the midterm exam.

Final Project [20%]
Students will propose and complete either (1) an quantitative analytical exercise on a topic of their choice related to the class (typical length will be 5 to 8 pages, 10 to 12 point font, 1.5 or double spaced, normal margins, and usually several figures or related materials, including code), or (2) a creative science communication exercise on some quantitative aspect of the climate system. Either version of this element of the class should incorporate and explore some physical and/or quantitative aspect of planetary climate systems. Such an exercise can take several forms and these will be discussed in more detail in class. There is considerable latitude in developing this exercise, *so long as the topic, data, and/or analysis is grounded in a physical and quantitative understanding of the climate system aligned with a topic we cover in the course.*

The students will first develop a brief (1-2 paragraphs) proposal and/or summary (a Précis) prior to doing the assignment itself (this Précis is due Thursday, April 3rd on D2L and is worth 20 points of the total assignment grade). The final product (100 points on the total assignment grade) is due on Tuesday, May 6th on D2L.

Graduate Student Supplement [Required for Graduate Credit] In order to receive graduate-level credit, graduate students will be required to complete up to 8 additional readings from the primary scientific literature and complete a 1 to 2 page guided response related to each. Assignments and reading will be posted on D2L. Undergraduates are welcome to complete these if they wish, but they are not required.

Grade polices and Letter Grade Distribution:
University policies regarding grades and grading systems are available at:
`https://catalog.arizona.edu/policy/courses-credit/grading/grading-system`

Grade distribution for this course:
A: 90% and above
B: 80% to 89%
C: 70% to 79%
D: 65% to 69%
E: below 65%

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at `https://catalog.arizona.edu/policy/courses-credit/grading/grading-system`. Please be aware of deadlines for requesting these grades. Requests for reconsideration of a grade received on a paper, project, or exam must be made to the instructor no later than 1 week after the assignment is made available to be returned to the student. Whether a reconsideration will be granted is entirely at the discretion of the instructor.

Late Work Policy
Assignments that are not completed or handed in on time, without prior arrangement with the instructor, can receive no more than 50% of the assigned points and may receive an automatic zero depending on the assignment (e.g. it will not be possible to complete in-class exercises late). Assignments not completed within 1 week of the original deadline, without prior arrangement with the instructor, will always receive no points for the assignment.

University Policies

Course Communications
All communications concerning class are via your official UA email addresses. It is the student's responsibility to regularly check for email communications concerning class information and policies, and to contact the instructor from the student's official UA email address.

Course materials
Course materials will be available online via D2L (`http://d2l.arizona.edu`)

Absence and Class Participation Policy
The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at `https://catalog.arizona.edu/policy/registration-tuition-fees/registration-enrollment/change-schedule`. The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable: `http://policy.arizona.edu/human-resources/religious-accommodation-policy`. Absences pre-approved by the UA Dean of Students will be honored.

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all class meetings. Absences may affect a student's final course grade. If

you anticipate being absent, are unexpectedly absent, or are unable to participate in class online activities, please contact me as soon as possible. To request a disability-related accommodation to this attendance policy, please contact the Disability Resource Center at (520) 621-3268 or drc-info@email.arizona.edu. If you are experiencing unexpected barriers to your success in your courses, the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office is located in the Robert L. Nugent Building, room 100, or call 520-621-7057.

Assignment and Grading Policy for Students Who Register Late
Students who register late for the course will be required to complete all assignments. Due dates for assignments given prior to the student adding the course will be agreed upon my both student and the instructor.

Classroom Behavior Policy
To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.). Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

Threatening Behavior Policy
The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See https://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students. Your instructor takes this extremely seriously.

Accessibility and Accommodations
Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcome to contact the Disability Resource Center (520-621-3268) to establish reasonable accommodations. For additional information on the Disability Resource Center and reasonable accommodations, please visit http://drc.arizona.edu. If you have reasonable accommodations, please plan to meet with me by appointment or during office hours to discuss accommodations and how my course requirements and activities may impact your ability to fully participate.

Code of Academic Integrity
Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See https://deanofstudents.arizona.edu/student-rights-responsibilities/academic-integrity.

The University Libraries have some excellent tips for avoiding plagiarism, available at:
https://lib.arizona.edu/research/write-cite/plagiarism.

Selling or posting without permission class notes and/or other course materials for other students or to a third party (e.g. such as Chegg) is not permitted without the instructor's express written consent. Violations to this are subject to the Code of Academic Integrity and may result in sanctions to anyone providing or using such materials, including loss of credit in the class. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. Finally, this conduct may also constitute copyright infringement.

UA Nondiscrimination and Anti-harassment Policy
The University is committed to creating and maintaining an environment free of discrimination; see https://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy. Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed

without resorting to bullying or discrimination toward others.

Additional Resources for Students
UA Academic policies and procedures are available at:
http://catalog.arizona.edu/policies.

Student Assistance and Advocacy information is available at:
https://deanofstudents.arizona.edu/support/student-assistance

Confidentiality of Student Records
Please see the University's policy on the confidentiality of student records here: https://registrar.arizona.edu/privacy-ferpa/ferpa

Subject to Change Statement
Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.

Course Schedule

Date	Content and Assignments
Thursday, January 16	*No classes - class begins on Tuesday, January 21st*
Tuesday, January 21	Course logistics Introduction to the climate system The physics to energy
Thursday, January 23	Radiative Balance I
Tuesday, January 28	Radiative Balance II
Thursday, January 30	*Cancelled class*
Tuesday, February 4	Radiative Balance III
Thursday, February 6	**Lab (#1)** Radiative Balance
Tuesday, February 11	Greenhouse gases, climate forcing, and the carbon cycle I
Thursday, February 13	Greenhouse gases, climate forcing, and the carbon cycle II
Tuesday, February 18	Greenhouse gases and water in the climate system Introduction to **Lab (#2)** Greenhouse gases, climate forcing, and the carbon cycle Fundamentals of Latent and Sensible Heating I
Thursday, February 20	Fundamentals of Latent and Sensible Heating II Adiabatic Processes
Tuesday, February 25	Introduction to Vertical Motion, Convection, and Turbulent Fluxes **Lab (#2) Due**
Thursday, February 27	Surface Energy Balance I
Tuesday, March 4	Surface Energy Balance II
Thursday, March 6	Introduction to **Lab (#3)** Surface Energy Balance
Tuesday, March 11	**No Class** - *Spring Break*
Thursday, March 13	**No Class** - *Spring Break*
Tuesday, March 18	General Circulation I
Thursday, March 20	General Circulation II (Recorded lecture, Kevin at NAS in Washington DC) **Lab (#3) Due**
Tuesday, March 25	General Circulation III
Thursday, March 27	**Lab (#4)** General Circulation
Tuesday, April 1	Climate Variability and Climate Observations I
Thursday, April 3	Climate Variability and Climate Observations II Introduction to **Lab (#5)** Climate Variability and Climate Observations **Final Project Précis Due on D2L**

Date	Content and Assignments
Tuesday, April 8	**Midterm in class**
Thursday, April 10	Paleoclimatology and Climate Forcing I
Tuesday, April 15	Paleoclimatology and Climate Forcing II Introduction to **Lab (#6)** Paleoclimate and Climate Forcing
Thursday, April 17	Climate Modeling **Lab (#5)** Due
Tuesday, April 22	Hydroclimate Change Wildland Fire
Thursday, April 24	Cryosphere Sea Level Rise **Lab (#6) Due**
Tuesday, April 29	Tropical Cyclones
Thursday, May 1	Extremes and Compound Hazards
Tuesday, May 6	Graduate Student Lightning Talks Synthesis and the Future
Tuesday, May 13	**Final Project Due**