

## GEOG 430/530 The Climate System Spring 2019

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 3 January 2019

### Locations and Times

Monday, Wednesday, and Friday, 10:00AM to 10:50AM  
ENR2 Room S223  
Course materials online via D2L (<http://d2l.arizona.edu>)

### Instructor Information

Kevin Anchukaitis  
Associate Professor, School of Geography and Development  
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: Monday, 3pm to 5pm, ENR2 S514 or by appointment

### Course Information

#### Prerequisites

Undergraduates: GEOG230 or equivalent or permission of instructor. Graduates: Continuing graduate student status or permission from instructor.

#### 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 at the bookstore or online. Any additional required readings will be posted on D2L.

### **Assignments and Methods of Assessment**

Lab Exercises and Problem Sets: [40%] These 8 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 exercises will be available simultaneously with designated class ('lab') periods as part of the normal course schedule, and will be due approximately a week afterwards. Unless otherwise stated for a specific assignment, you may work with *up to one* additional person (therefore, a maximum group size of two) on these assignments. 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.

Exams [30%] One in-class midterm exam and one take home final exam, each worth 15% of your final grade. Format for both is short answers including calculations and potentially including sketches and analysis of scientific figures or schematics. A study sheet will be available prior to the exam.

Term Paper [30% undergraduates; 25% graduate students + 5% for presentations]

Students will propose (20 points) and write (100 points) an analytical paper on a topic of their choice related to the class (typical length will be 10 to 15 pages, 10 to 12 point font, 1.5 or double spaced, normal margins). The paper should incorporate and explore some physical, quantitative aspect of planetary climate systems. Such a paper can take several forms. Students may choose to explore in-depth a controversial or developing area of climate science, synthesizing up-to-date literature and evaluating the relative merits of scientific data, methods, and conclusions. Student may also undertake their own quantitative analysis of some climate or environmental data, describing the data sources, methods,

results, and conclusions in the manner of a peer-review manuscript. Finally, students may choose to examine a specific policy or management topic in light of the relevant aspects of the physical climate system. Such a paper could, for instance, evaluate or develop a policy or management plan reflecting the observed or expected impact on some aspect of the climate system, ecosystem, or human population. There is considerable latitude in developing this paper, *so long as the topic and analysis is grounded in a physical and quantitative understanding of the climate system* and goes beyond simply summarizing existing or general knowledge.

The students will first develop a brief (1-2 paragraphs) proposal and summary (or Précis) prior to writing the paper itself (this Précis is due Monday, March 18th and is worth 20 points of the total assignment grade), in order to allow time for feedback between the instructor and the student. Students must also have a complete first draft reviewed by another student in the class. This draft, comments, and markup should be turned in with the final paper (100 points on the total assignment grade) on April 29th in class.

Graduate students will also create and deliver a presentation on their term paper during the last few class periods.

Graduate Student Supplement [Required for Graduate Credit] Graduate students will be required to complete 8 additional readings from the primary scientific literature and complete a 1 to 2 page guided response related to each. A supplemental document will be posted for graduate students with these topics and dates, and assignments and reading posted on D2L.

### **Grade policies and Letter Grade Distribution:**

University policies regarding grades and grading systems are available at:

<http://catalog.arizona.edu/2015-16/policies/grade.htm>

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 <http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete> and <http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal> respectively. 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.

### **Late Work Policy**

Assignments that are not completed or handed in on time, without prior arrangement with the instructor, will receive no more than 50% of the assigned points. Assignments not completed within 1 week of the original deadline, without prior arrangement with the instructor, receive no points for the assignment.

## **University Policies**

### **Course Communications**

All communications concerning class are via 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 <http://catalog.arizona.edu/policy/class-attendance-participation-and-administrative-drop>. 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 (or the Dean's designee) will be honored. See <http://uhap.web.arizona.edu/policy/appointed-personnel/7.04.02>.

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](mailto: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 by 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 <http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>.

### **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 <http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity>.

The University Libraries have some excellent tips for avoiding plagiarism, available at: <http://www.library.arizona.edu/help/tutorials/plagiarism/index.html>.

Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructors express written consent. Violations to this and other course rules are

subject to the Code of Academic Integrity and may result in course sanctions. 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. 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 <http://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 of 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:  
<http://deanofstudents.arizona.edu/student-assistance/students/student-assistance>

### **Confidentiality of Student Records**

Please see the University's policy on the confidentiality of student records here: <http://www.registrar.arizona.edu/ferpa/default.htm>

### **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
Wednesday, January 9	Introduction to the Climate System Structure of course, lectures, and labs
Friday, January 11	<b>Lab (#1)</b> Introduction to Climate Data
Monday, January 14	Radiative Balance I
Wednesday, January 16	Radiative Balance II
Friday, January 18	Radiative Balance III <b>Lab (#1) DUE</b>
Monday, January 21	<b>No Lecture</b> , <i>Martin Luther King Jr. Day</i>
Wednesday, January 23	Radiative Balance IV
Friday, January 25	<b>Lab (#2)</b> Radiative Balance
Monday, January 28	Greenhouse gases and the carbon cycle I
Wednesday, January 30	Greenhouse gases and the carbon cycle II
Friday, February 1	<b>Lab (#3)</b> Greenhouse gases and the carbon cycle <b>Lab (#2) DUE</b>
Monday, February 4	Water in the Earth System
Wednesday, February 6	Latent and Sensible Heating
Friday, February 8	Adiabatic Processes <b>Lab (#3) DUE</b>
Monday, February 11	Vertical Motion, Convection, Turbulent Fluxes
Wednesday, February 13	Surface Energy Balance I
Friday, February 15	Surface Energy Balance II
Monday, February 18	<i>No Lecture - Kevin at PACLIM meeting</i>
Wednesday, February 20	<i>No Lecture - Kevin at PACLIM meeting</i>
Friday, February 22	Surface Energy Balance III <b>Lab (#4)</b> Surface Energy Balance
Monday, February 25	General Circulation I
Wednesday, February 27	General Circulation II
Friday, March 1	General Circulation III <b>Lab (#4) DUE</b>
Monday, March 4	<i>No Lecture - Spring Break</i>
Wednesday, March 6	<i>No Lecture - Spring Break</i>
Friday, March 8	<i>No Lecture - Spring Break</i>
Monday, March 11	General Circulation IV
Wednesday, March 13	Midterm Review
Friday, March 15	<b>Midterm Exam</b>

Date	Content and Assignments
Monday, March 18	<b>Term Paper Précis DUE</b> General Circulation V and Ocean Circulation
Wednesday, March 20	Ocean Circulation and El Niño-Southern Oscillation I
Friday, March 22	El Niño-Southern Oscillation II <b>Lab (#5) El Niño-Southern Oscillation</b>
Monday, March 25	Paleoclimate Observations
Wednesday, March 27	Paleoclimate
Friday, March 29	<b>Lab (#6) Paleoclimate</b> <b>Lab (#5) DUE</b>
Monday, April 1	Climate Sensitivity I
Wednesday, April 3	Climate Sensitivity II
Friday, April 5	<b>Lab #7 - Recent Climate Observations</b> <b>Lab (#6) DUE</b>
Monday, April 8	Climate Modeling II
Wednesday, April 10	Climate Modeling II
Friday, April 12	<i>No Lecture - Kevin at VICS meeting in Cambridge</i> <b>Lab (#8) Future Climate Change</b> <b>Lab (#7) DUE</b>
Monday, April 15	<i>No Lecture - Kevin at VICS meeting in Cambridge</i>
Wednesday, April 17	<i>No Lecture - Kevin at VICS meeting in Cambridge</i>
Friday, April 19	Future Climate Change: Drought <b>Lab (#8) DUE</b>
Monday, April 22	Future Climate Change: Cryosphere
Wednesday, April 24	Future Climate Change: Sea Level
Friday, April 26	Future Climate Change: Wildland Fire
Monday, April 29	Graduate Student Presentations <b>Term Paper including revisions due in class</b>
Wednesday, May 1	Synthesis and the Future
Monday, May 6	<b>Final Exam Due by 5pm on D2L</b>