GEOG 430/530 The Climate System
Spring 2017

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 *physical* 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 9 January 2017

Locations and Times

Monday, Wednesday, and Friday, 10:00AM to 10:50AM
ENR2, Room S547
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
Office Phone: (520) 626-8054
Email: kanchukaitis@email.arizona.edu

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.

Exam [30%] In-class midterm exam covering basic concepts covered in the first part of the course. Format 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 chose 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 ('Précis') prior to writing the paper itself (this Précis is due Monday, March 20th 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).

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 polices 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.

There is no final exam for this course.

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 UAs 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 deans designee) will be honored. See http://uhap.web.arizona.edu/policy/appointed-personnel/7.04.02.

Active participation in the course is vital to the learning process. As such, attendance is strongly encouraged at all meetings of the class.

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 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 11th	Introduction to the Climate System Structure of course, lectures, and labs
Friday, January 13th	**Lab (#1)** Introduction to Climate Data
Monday, January 16th	**No Lecture**, *Martin Luther King Jr. Day*
Wednesday, January 18th	Radiative Balance I
Friday, January 20th	Radiative Balance II **Lab (#1) DUE**
Monday, January 23rd	Radiative Balance III
Wednesday, January 25th	Radiative Balance IV
Friday, January 27th	**Lab (#2)** Radiative Balance
Monday, January 30th	Greenhouse gases and the carbon cycle I
Wednesday, February 1st	Greenhouse gases and the carbon cycle II
Friday, February 3rd	**Lab (#3)** Greenhouse gases and the carbon cycle **Lab (#2) DUE**
Monday, February 6th	Water in the Earth System
Wednesday, February 8th	Latent and Sensible Heating
Friday, February 10th	Adiabatic Processes I **Lab (#3) DUE**
Monday, February 13th	Adiabatic Processes II
Wednesday, February 15th	Surface Energy Balance I
Friday, February 17th	Surface Energy Balance II
Monday, February 20th	Surface Energy Balance III
Wednesday, February 22nd	**Lab (#4)** Surface Energy Balance
Friday, February 24th	General Circulation I
Monday, February 27th	General Circulation II
Wednesday, March 1st	General Circulation III **Lab (#4) DUE**
Friday, March 3rd	Ocean Circulation
Monday, March 6th	Ocean Circulation
Wednesday, March 8th	Climate Modes
Friday, March 10th	***Midterm Exam***
Monday, March 13rd	*No Lecture - Spring Break*
Friday, March 15th	*No Lecture - Spring Break*
Friday, March 17th	*No Lecture - Spring Break*

Date	Content and Assignments
Monday, March 20th	El Niño-Southern Oscillation I **Term Paper Précis DUE**
Wednesday, March 22nd	El Niño-Southern Oscillation II
Friday, March 24th	**Lab (#5)** El Niño-Southern Oscillation
Monday, March 27th	Recent Climate Observations I
Wednesday, March 29th	Recent Climate Observations II
Friday, March 31st	**Lab (#6)** Recent Climate Observations **Lab (#5) DUE**
Monday, April 3rd	*No Lecture - Association of American Geographers meeting*
Wednesday, April 5th	*No Lecture - Association of American Geographers meeting*
Friday, April 7th	*No Lecture - Association of American Geographers meeting*
Monday, April 10th	Paleoclimate I **Lab (#6) DUE**
Wednesday, April 12th	Paleoclimate II
Friday, April 14th	**Lab (#7)** Paleoclimate
Monday, April 17th	Climate Sensitivity I
Wednesday, April 19th	Climate Sensitivity II
Friday, April 21st	Climate Modeling **Lab (#8)** Future Climate Change **Lab (#7) DUE**
Monday, April 24th	Future Climate Change
Wednesday, April 26th	Future Climate Change
Friday, April 28th	*No Lecture - Kevin at the American Philosophical Society meeting*
Monday, May 1st	Graduate Student Presentations **Lab (#8) DUE**
Wednesday, May 3rd	Graduate Student Presentations