GEOG 430/540 The Climate System
Kevin Anchukaitis
MWF 10:00 to 10:50pm, ENR2 S547

Welcome to GEOG430 and GEOG530 'The Climate System'!

There are a few important documents on D2L that will guide you through this course. The first is this ***overview*** (this document you're reading right now)**,** which contains my overall goals for the class as well as descriptions of the syllabus and course schedule. I want the lectures, 'labs', assignments, and exams to assist us in achieving the course goals and objectives, give us an idea of where were going, and what we hope to accomplish along the way, and allow us to understand and integrate the information, concepts, and methods we'll discuss in lecture.

Next is the ***syllabus*** – this contains important information about the class, including how to contact me, my office hours, information about the textbook (optional), the type of assignments and grading approach, and links to important information about campus resources available to all students. The ***syllabus*** is -- in part -- a statement of *policies* from the University, the College, the School, and from me, so please review it early in the class and consult it frequently if you have any questions. Finally, there is the ***course schedule***, which is a detailed, day-by-day description of the topics we'll cover and any assignment due dates. This ***course schedule*** is subject to change, to adapt to current events or change the balance of topics we cover, but I'll inform you in advance whenever there are any changes to the plan.

Overview

The goal of the course is to provide you with the opportunity to gain an understanding of the processes that control climate variability (and climate change) at a range of temporal and spatial scales. Together we will develop the knowledge, skills, and conceptual and procedural understanding to allow you to independently analyze climate data, understand climate variability, and incorporate a quantitative, dynamic, and physically based knowledge of the climate system into your own scholarship and research.

For those of you that have had me as an instructor in GEOG230, you'll find this class moves quicker, will be a bit more intense, and we'll get more in-depth on some of the fundamental physical processes. There is a greater focus on applying concepts to real data as a way of bridging the theoretical or idealized and the actual climate system. There is also a greater focus on quantitative analysis and data than GEOG230, and we don't get much into policy in this class. For those of you coming from GEOG170 or ATMO170, you'll find some of the concepts familiar, but some of the material will be new and we'll approach it from a different point of view – the anchoring concept of the class is how energy gets into the earth system, how it leaves, and what it does while it is here, and how that determines the suite of phenomena and physical processes we call climate, in both space and time.

Graduate students in this class will come from a range of backgrounds and have a range of research interests. This class is intended to provide the fundamentals that you can take back to your own work on environment, climate, society, economics, politics, and the humanities. We also hope you'll share your unique perspective, ideas, and energy with us. There are some additional tasks you'll have to complete as graduate students in this class, but I hope you'll find them useful and stimulating and applicable to your career progression and academic activities.

Welcome and I'm looking forward to our semester together!

GEOG 430/530 THE CLIMATE SYSTEM

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, sea level rise, and alterations in the frequency and intensity of tropical cyclones.

The goal of the course is to provide students with an intensive 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.

Locations and Times

Monday, Wednesday, and Friday, 10:00AM to 10:50AM
ENR2, Room S547

Instructor Information

Kevin Anchukaitis
Associate Professor, School of Geography and Development
Room S514, Environment and Natural Resources Building 2 (ENR2)
Office Phone: (520) 626-8054
Email: kanchukaitis@email.arizona.edu

Office Hours: Monday, 3pm to 5pm, ENR2 S514 or by appointment
All communications concerning class are via official UA email addresses.

Course materials online via D2L (http://d2l.arizona.edu)

Course Objectives and Expected Learning Outcomes

This course has the following expected learning outcomes:

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.
Cognitive: You will learn how to develop strategies to analyze data, and learn how to critique (and accept criticism) of your technical and scientific writing

For Geography undergraduate majors, 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

Topics

Introduction to the Climate System
Planetary Radiative Balance
The Greenhouse Effect
Carbon Cycle and the Biosphere
The General Circulation of the Atmosphere and Oceans
El Nino Southern Oscillation
Surface Energy Balance
Climate and paleoclimate observations
Climate sensitivity to radiative changes
Climate modeling and the enhanced (anthropogenic) greenhouse effect and future impacts
Changes in the water cycle and drought
Cryosphere, glaciers, and sea ice
Sea level rise
Tropical storms and other extreme events

Recommended (*but not required*) Text

The Earth System (3rd Edition) Kump, Kasting, Crane

In addition, I'll ask you to read (for Monday, March 28) the Intergovernmental Panel on Climate Change's 'Summary for Policymakers' from their 2013 Report (Working Group 1, Fifth Assessment Report): http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf

Methods of Evaluation

Lab Exercises (20% undergraduates and graduates)

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 two additional person (a maximum group size of three) on these assignments.* Graduate students are strongly encouraged to make use of a high-level programming language (R, Python, or MATLAB, etc) when completing their assignments.

Term Paper (30% undergraduates, 25% graduate students + 5% for presentations)

Students will propose and write an analytical paper on a topic of their choice related to the class (length 10 to 15 pages). 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 knowledge. The students will ***first*** develop a brief (1-2 paragraphs) proposal/summary prior to writing the paper itself (**due Monday, March 21st**), 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.

Graduate students will also create and present a 10-minute presentation on their term paper during the last 2 class periods.

Midterm Exam (20% undergraduates and graduates)

In-class (short) exam covering basic concepts covered in class up until that point. Format is short answers, potentially including sketches and analysis of scientific figures or schematics. A study sheet will be available prior to the exam.

Final Exam (30% undergraduates, 20% graduate students)

The final exam will be comprehensive (that is, cover topics throughout the semester, including from the Midterm). Format is short answers, potentially including sketches and analysis of scientific figures or schematics. The goal of the final exam is to allow you to apply what you've learned during the semester (and not simply regurgitate facts). A study sheet will be provided prior to the exam. A review session can be scheduled if there is sufficient interest.

Paper evaluation, précis, and discussion (10% graduate students)

As part of the graduate student (GEOG530) component of this class, graduate students will be required to complete **1** scientific paper evaluation. Papers will be from major peer-reviewed scientific journals. This evaluation and review will be posted on D2L and each graduate student will be required to **respond** to each discussion posted by their peers. Graduate students should identify papers by looking at current journal contents in their field, as well as major 'flagship' journals (*Science, Nature, Proceedings of the US National Academy of Sciences*). Further information will be provided to graduate students.

Grading Policy

University policy regarding grades and grading systems is 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 incompletes (I) and withdrawal (W) must be made in accordance with university policies which are available at http://catalog.arizona.edu/2015-16/policies/grade.htm#I and http://catalog.arizona.edu/2015-16/policies/grade.htm#W respectively.

Requests that I reconsider the grading of any individual assignment must be made within 48 hours of that assignment being returned.

Course Format and Teaching Methods

Lecture with additional laboratory activities and problem sets, in-class discussion, and web-based discussion.

Required/Recommended Knowledge

Official course requisites: GEOG170 or ATMO170 and/or GEOG 230 or equivalent course.

Honors Credit

Students wishing to contract this course for Honors Credit should email me to set up an appointment to discuss the terms of the contact and to sign the Honors Course Contract Request Form. Additional information is available here: http://www.honors.arizona.edu/future-students/honors-credit-across-campus

Late Work Policy

In general, work will not be accepted late except in case of documented emergency or illness. You may petition me in writing for an exception if you feel you have a compelling reason for turning work in late.

Please note this policy applies to the Term Paper.

Laboratory assignments can be turned in up to one week late for up to half (50%) of the original credit.

Attendance Policy

The UA's policy concerning Class Attendance and Administrative Drops is available at: http://catalog.arizona.edu/2015-16/policies/classatten.htm

The UA policy regarding absences on and accommodation of religious holidays is available at http://deanofstudents.arizona.edu/policies-and-codes/accommodation-religious-observance-and-practice.

Absences pre-approved by the UA Dean of Students (or Dean designee) will be honored. See: http://uhap.web.arizona.edu/chapter_7#7.04.02

Participating in course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Students who miss class due to illness or emergency are required to bring documentation from their healthcare provider or other relevant, professional third parties. Failure to submit third-party documentation will result in unexcused absences.

Classroom Behavior

To foster a positive learning environment, ***please*** do not text, chat, make phone calls, play games, read the newspaper, or surf the web during lecture and discussion. Please refrain from disruptive conversations with people sitting around them during lecture. Students who continue to disrupt despite being asked to cease this behavior the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

The Arizona Board of Regents' Student Code of Conduct, ABOR Policy 5-308, prohibits threats of physical harm to any member of the University community, including to one's self. See: http://policy.arizona.edu/threatening-behavior-students.

Accessibility and Accommodations

It is the University's goal 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 Disability Resources (520-621-3268) to establish reasonable accommodations. For additional information on Disability Resources 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.

Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

Student Code of Academic Integrity

Students are responsible for ensuring their own work and conduct meets the University's Standards.

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 instructor's 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 email to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student email addresses. This conduct may also constitute copyright infringement.

Additional Resources for Students

UA Non-discrimination and Anti-harassment policy:
http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy
UA Academic policies and procedures are available at:
http://catalog.arizona.edu/2015-16/policies/aaindex.html
Student Assistance and Advocacy information is available at:
http://deanofstudents.arizona.edu/student-assistance/students/student-assistance

Confidentiality of Student Records

University policies are available here: http://www.registrar.arizona.edu/ferpa/default.htm

Subject to Change Statement

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

#	DATE	TOPIC	ASSIGNMENTS
1	Wednesday, January 13	Introduction to the Climate System & the course, lectures, and labs	**Post Personal Introduction to D2L** Suggested Reading: Kump, Chapter 1
2	Friday, January 15	Introduction to Climate Data **Lab (1)**	**Lab 1 (Climate Data) Posted**
	Monday, January 18	*No Lecture*	*Martin Luther King Day*
3	Wednesday, January 20	Radiative Balance I	Suggested Reading: Kump Chapter 3
	Friday, January 22	*No Lab*	**Lab 1 *Due***
4	Monday, January 25	Radiative Balance II	
5	Wednesday, January 27	Radiative Balance III	
6	Friday, January 29	Radiative Balance **Lab (2)**	**Lab 2 (Radiative Balance) Posted**
7	Monday, February 1	Biosphere and the Carbon Cycle I	Suggested Reading: Kump, Chapter 8
8	Wednesday, February 3	Biosphere and the Carbon Cycle II	Suggested Reading: Kump, Chapter 9
9	Friday, February 5	Biosphere and the Carbon Cycle **Lab (3)**	**Lab 2 Due** **Lab 3 (Biosphere and the Carbon Cycle) Posted**
10	Monday, February 8	Water in the Earth System	
11	Wednesday, February 10	Latent and Sensible Heating	
	Friday, February 12	*No Lab*	**Lab 3 Due**
12	Monday, February 15	Vertical Motion in the Atmosphere I	
13	Wednesday, February 17	Vertical Motion in the Atmosphere II	
14	Friday, February 19	Surface Energy Budget I	
15	Monday February 22	Surface Energy Budget II	
16	Wednesday, February 24	Surface Energy Budget III	
17	Friday February 26	Surface Energy Budget **Lab (4)**	**Lab 4 (Surface energy budget) Posted**

18	Monday, February 29	General Circulation I	Suggested Reading: Kump Chapter 4
19	Wednesday, March 2	General Circulation II	
20	Friday, March 4	General Circulation III	**Lab 4 due**
21	Monday, March 7	Ocean Circulation	**Paper Topics Due to Instructor** Suggested Reading: Kump Chapter 5
22	Wednesday, March 9	Midterm Topical Review	
23	Friday, March 11	***Midterm Exam***	
	Monday, March 14	*No Lecture*	*Spring Break*
	Wednesday, March 16	*No Lecture*	*Spring Break*
	Friday, March 18	*No Lecture*	*Spring Break*
24	Monday, March 21	El Nino Southern Oscillation I	**Paper Proposal Due**
25	Wednesday, March 23	El Nino Southern Oscillation II	
26	Friday, March 25	El Nino Southern Oscillation **Lab**	**Lab 5 (El Nino Southern Oscillation) Posted**
27	Monday, March 28	Recent Climate Observations I	
28	Wednesday, March 29	Recent Climate Observations II	
29	Friday, April 1	Recent Climate Observations **Lab**	**Lab 5 due** **Lab 6 (Recent Climate Observations) Posted**
30	Monday, April 4	Paleoclimate Observations I	
31	Wednesday, April 6	Paleoclimate Observations II	Suggested Reading: Kump Chapter 14
32	Friday, April 8	Paleoclimate Lab	**Lab 6 Due** **Lab 7 (Paleoclimate) Posted**
33	Monday, April 11	Climate Sensitivity I	Suggested Reading: Kump Chapter 15
34	Wednesday, April 13	Climate Sensitivity II	

35	Friday, April 15	Climate Modeling I	**Lab 7 Due** **Lab 8 (Future Climate Changes) Posted**
36	Monday, April 18	Climate Modeling II	
37	Wednesday, April 20	Future Climate Change: Drought	
38	Friday, April 22	Future Climate Change: Cryosphere	**Lab 8 Due** Suggested Reading: Kump, Chapter 6
39	Monday, April 25	Future Climate Change: Sea Level Rise	
40	Wednesday, April 27	Future Climate Change: Tropical Cyclones	
41	Friday, April 29	Summary and Synopsis	**Final Paper + Draft with Peer Comments Due**
42	Monday, May 2	*Graduate Student Presentations*	
43	Wednesday, May 4	*Graduate Student Presentations*	
	Thursday, May 5	Review session? TBD	
	Friday, May 6 10:30am to 12:30 pm	**Final Exam (in same room as lecture)**	

Notes:

1. The course schedule is subject to change, based on the interests of the students, current events, or to ensure certain topics receive sufficient time and attention.

2. For reading assignments, 'Kump' refers to: *Kump, Kasting, Crane, The Earth System, 3rd Edition*

3. The complete Spring 2016, Final Exam Schedule is here:
https://www.registrar.arizona.edu/schedule2161/exams/2161exams.htm

4. The University and Faculty Senate provide Final Exam Regulations and Information here:
https://www.registrar.arizona.edu/schedule2161/exams/examrules.htm