GEOG – GEOL – ENVIR ST – ATMOS OCN

335: CLIMATIC ENVIRONMENTS OF THE PAST

FALL 2018

UNIVERSITY OF WISCONSIN-MADISON

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Office Hours: Wednesdays 2-3pm and Thursdays 1-2pm, or by appointment.
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Lectures: 350 Science Hall, Monday/Wednesday 4-5:15pm

Course Website: LearnUW/Canvas
(https://coursedashboard.learnuw.wisc.edu/)

INTRODUCTION

This class focuses on climatic changes during the Quaternary Period, which encompasses the last 2.6 million years, includes the rise of human civilizations, and extends to the present day. Climatically, the defining characteristics of the Quaternary are 1) regular cycles between glacial and interglacial periods and 2) abrupt shifts in the state of the climate system. Understanding the sources and causes of past climatic variability is a necessary precondition to understanding why climates are changing today and making informed projections for the future. The field is changing rapidly and new discoveries appear every month. The learning goals for this class are fourfold:

1) **History**: Review the major climatic events and trends during the Quaternary, spanning timescales from the last 1,000,000 years to the last 1,000 years. Emphasis will be placed on the global climate system, with some attention to regional climate changes.
2) **Mechanism**: Understand the physical processes controlling the behavior of the earth system and its components (atmosphere, oceans, cryosphere, biosphere, etc.). Understand also how climatic variability results from a combination of external forcings and internal dynamics within the earth system.
3) **Method**: Learn how paleoclimatologists collect, date, and analyze a staggering variety of paleoclimatic records, including ocean and lake sediment cores, ice cores, tree rings, corals, and speleothems. Learn how to analyze and critically evaluate climate experiments that are simulated by earth system models.
4) **Communication**: Continue to develop skills in thinking and writing clearly, with particular attention to critically reading the scientific literature and critically employing the climate proxies and models used by paleoclimatologists.

COURSE INFORMATION AND POLICIES

CREDITS

3-credits, based on 150 minutes/week of in-class time (mostly lecture) and at least six hours per week on average of coursework outside of class time. This out-of-class coursework takes the form of readings, homeworks, exam preparation, and the term project.

GRADING

Homework	20%
Term Project	30%
Exam I	25%
Exam II	25%

Readings and Homeworks

Readings are drawn from the course textbook Earth's Climate: Past and Future (ECPAF) and from supplementary articles, available as PDFs through LearnUW.

The homework exercises are designed to give hands-on experience analyzing paleoclimatic datasets, conducting paleoclimatic experiments with global climate models, reading the scientific literature, and writing. Homework assignments should be turned in at class on the due date. Overdue assignments will be penalized by 10% per day after the due date. Please contact me if emergencies arise.

Examinations

Two non-cumulative exams, with mostly short-answer or problem-solving questions.

Term Project

This project gives you the opportunity to learn more about the workings of earth system models (ESMs) and how climatologists use them to test hypotheses about the mechanisms governing past and potential future climates. We will use a model called EdGCM, specifically designed for educational applications. EdGCM is based on a NASA model called GISS (for the Goddard Institute of Space Science). NASA-GISS was developed in the 1980's, and became famous because it was used to provide some of the earliest quantitative estimates of 20th-and 21st-century global warming. EdGCM's 'guts' are identical to this version of NASA-GISS but extensive visualization and analysis tools have been added. Personal computers are powerful enough now that runs that once required weeks of supercomputer time now can be completed in a few hours to a day(!) on a desktop PC or Mac.

You will first learn how to use EdGCM and how to design climate model experiments through several homework exercises. Then, working in teams of 2-3 students, you will design your own experiment, run EdGCM, prepare visualizations of key results, and write a term paper based on your findings. More details on the term project will be given early in the semester.

Missed Lectures and Medical Absences

Campus pandemic policy places a premium on minimizing the risk of spreading disease. Specifically, if you are running a fever over 100°F with a cough or sore

throat, stay home! Wait until 24 hours after your fever breaks before returning to class. The flu usually takes 3 to 5 days to run its course.

If you miss a lecture for any reason, and would like to learn about what you missed, either visit me during office hours or talk to a classmate. All lecture slides will be available at LearnUW.

Prerequisites and Requirements Fulfilled

Prequisites: Geog/IES 120, Geog/IES 127, or AOS 100, or equivalent coursework with permission of instructor. This class counts toward the physical science course requirement at UW-Madison and toward degree requirements for majors in Geography, Geosciences, Atmospheric and Ocean Studies, Environmental Science, and Environmental Studies and certificates in International Studies and Archaeology.

RESOURCES

TEXTBOOKS

Earth's Climate: Past and Future (ECPAF), 3rd Edition by William F. Ruddiman. W. H. Freeman and Company, New York, 2014. (**Required**) Note: you may also use the earlier editions of ECPAF. The three editions are similarly organized, except that Chapter 2: Earth's Climate System Today was deleted from the second edition and restored in the 3rd edition. Hence, Chapters 3-15 in the third edition directly match to Chapters 2-14 in the second edition.

Paleoclimatology: Reconstructing Climates of the Quaternary (3rd edition) by Raymond S. Bradley. Academic Press, San Diego, 2015. (**Optional**, available on reserve. Selected readings are available on-line at Learn@UW.)

OTHER GOOD BOOKS

After the Ice Age: The Return of Life to Glaciated North America by E. C. Pielou, University of Chicago Press, Chicago, 1991. (Great, fun-to-read book about the ecological changes in North America since the last age.)

Ice Ages: Solving the Mystery by John Imbrie and Katherine P. Imbrie. MacMillan, London, 1979. (Written as a history of science for a general audience and fascinating for those interested in understanding the historical roots of modern paleoclimtology.)

The Two-Mile Time Machine: Ice Cores, Abrupt Climate Change and Our Future by Richard B. Alley. Princeton University Press, Princeton, 2000. (A fun read about ice cores by one of the leading experts.)

The Eternal Frontier: An Ecological History of North America and its Peoples by Tim Flannery. Grove Press, 2002. (A fascinating history of the multiple transformations of North American ecosystems over multiple big events in Earth's history.)

A Climate Modeling Primer (3rd ed.), by Kendal McGuffie and A. Henderson-Sellers. John Wiley and Sons, 2005. (Good textbook about climate models.)

Climate Change and Climate Modeling, by J. David Neelin. Cambridge University Press, 2011. (Ditto, another good textbook about climatology and climate models.)

Principles of Paleoclimatology by Thomas M. Cronin. Columbia University Press, New York, 1999. (A good paleoclimatology textbook.)

The Discovery of Global Warming by Spencer R. Weart, Harvard University Press, Cambridge, 2003. (A remarkably complete set of foundational papers in climate-change science. The commentaries by Pierrehumbert and Archer are especially valuable.)

Global Climates since the Last Glacial Maximum by Herbert E. Wright, Jr. et al. University of Minnesota Press, Minneapolis, 1993. (Edited volume with a comprehensive review of Earth's climate since the last ice age. A summary and synthesis of knowledge resulting from the COHMAP project.)

The Quaternary Period in the United States by A. R. Gillespie et al. Elsevier Science Ltd, Amsterdam, 2004. (A comprehensive academic edited volume, intended for graduate-level and professional audiences.)

SOFTWARE

EdGCM by Mark Chandler and others at NASA-GISS and Columbia University. http://edgcm.columbia.edu/ (**Required**) The EdGCM global climate model will be the foundation of the term paper and several homeworks. EdGCM is installed in the computers in the Science Hall M376 computer lab, which is available to all students. Instructions on how to download EdGCM will be provided separately.

PALEOCLIMATOLOGY (AND GENERAL-SCIENCE) JOURNALS

Nature; Science; Geology; Quaternary Science Reviews; Quaternary Research; The Holocene; Palaeogeography, Palaeoclimatology, Palaeoecology ('P-cubed'); Global and Planetary Change, Climates of the Past, Open Quaternary

ON-LINE RESOURCES

https://coursedashboard.learnuw.wisc.edu/ -- password-protected website that I use to post lecture slides and course-related announcements. Please check this website at least once a week.

https://www.macmillanlearning.com/Catalog/product/earthsclimate-thirdedition-ruddiman -- Publisher's website for the Ruddiman textbook.

http://edgcm.columbia.edu/ The home page for the EdGCM climate model. Website resources include a discussion board where you can post questions to the EdGCM developers and scientists, video tutorials, manuals, and FAQs.

http://www.ncdc.noaa.gov/data-access/paleoclimate-data NOAA National Center for Environmental Information,Paleoclimatology. This is the major repository for individual paleoclimatic proxy records (ice cores, corals, marine sediment records, etc.)

http://www.neotomadb.org A major repository for paleoecological records (fossil pollen, vertebrates, ostracodes, etc.) that are often used as indicators of past climates or to study biotic responses to past climate changes.

Geog/Geol/AOS/IES 335 Schedule, Fall 2018

Date	#	Topic	Readings	HWs and Due Dates
9/5	1	Introduction, The Earth System	ECPAF CH 1	
9/10	2	Review: Earth System Processes	ECPAF1 CH 2, Neelin Chapter 2	Hand out Daisyworld HW
9/12	3	Review: Earth System Processes		
9/17	4	Sedimentary Archives	ECPAF CH3, Bradley 3e Ch 6 pp. 195-214, 319-343	
9/19	5	Earth System Models	Kolbert, Field Notes from a Catastrophe pp. 97-110. Neelin Chapter 5.	Daisyworld HW due.
9/24	6	Stable Isotopes	ECPAF Appendices 1,2	
9/26	7	The Last 500 million years	ECPAF CH 4, 5, 7	
10/1	8	EdGCM/Panoply Workshop		Hand out EdGCM/Library HW
10/3	9	EdGCM/Panoply Workshop		
10/8	10	Dating I - Fundamentals & Radiocarbon	ECPAF CH 3.2 (p60-62), Bradley 3e 3.1-3.2.1, 3.2.3, 3.2.4	EdGCM/Library HW due. Hand out Dating HW.
10/10	11	Dating II - Other Methods		**Choose a Partner**
10/15	12	Astronomical Controls on Climate	ECPAF CH 8	
10/17	13	Detecting Astronomical Controls in Climate Records	ECPAF CH 8	Dating HW due
10/22	14	Insolation Control of Ice Sheets and the Mystery of the 100kyr Cycle	ECPAF CH 10, 12, Raymo & Huybers 2008	Hand out Orbital HW **Choose a Project**
10/24	15	**Exam I**		
10/29	16	CO2 and the Glacial-Interglacial Carbon Cycle	ECPAF CH 11, 12	
10/31	17	CO2 and the Glacial-Interglacial Carbon Cycle	ECPAF CH 11, 12	
11/5	18	Insolation Control of Monsoons	ECPAF CH 9	Orbital HW due.
11/7	19	The Last Glacial Maximum	ECPAF CH 13, COHMAP 1988, Toggweiler & Russell 2008	
11/12	20	Ice Cores	ECPAF CH 11.1-11.3, Alley, *Two Mile Time Machine* , pp. 31-75	**Initial Results due**
11/14	21	Millennial Oscillations	ECPAF CH 15	
11/19	22	The Last Deglaciation	ECPAF CH 14	
11/21	23	Biological Responses to Past Climate Change	Williams and Burke, in press; Williams et al. 2004	Hand out Neotoma HW
11/26	24	The Holocene	Marsicek et al. 2018, US CCSP SAP 3.4, pp 86-	
11/28	25	High-Resolution Climate Proxies	ECPAF CH 17, Smith & Lewis 2007	
12/3	26	Climate Changes During the Last 1000 years	Mann et al. 1999, Trouet et al. 2013, NAS 2006 Exec. Summary	Neotoma HW due
12/5	27	Welcome to the Anthropocene	ECPAF CH 16, Ruddiman 2013, He et al. 2014	
12/10	28	Climate Changes During the Last 1000 years	Mann et al. 1999, Trouet et al. 2013, NAS 2006 Exec. Summary	
12/12	29	Looking to the Future, Lessons from the Past	ECPAF CH 17,18, Kolbert 2005 'Climates and Man (I, II, III)'	**Term Papers due**
12/17		**Exam II**		