

## Syllabus

# **GSE-GEOG-BIOL 792 Introduction to Global Climate Change**

**Meeting Times:** Mondays and Wednesdays @ 10:00 – 11:30 AM

**Meeting Location:** Wecota 100

**Instructor:** Professor Mark A. Cochran, 115H Wecota, 688-5353,  
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**Office Hours for Spring 2010:** Tuesdays & Thursdays 2:00-3:30 PM; or by appointment

**Course Objectives:** The specific objectives of the course are to provide the student with:

1. Basic understanding of the underlying physics behind global and regional climate.
2. Knowledge of various proxy data used for assessing past climates, with particular focus on climate variations.
3. Integrated and up to date knowledge of the science being developed to explain and understand various components of the Earth's present climate dynamic.
4. Information on how natural events/phenomena and anthropogenic activities can influence regional and global climate.
5. A synthetic view of climate change predictions for the coming century with particular focus on the assumptions and uncertainties inherent in climate modeling and future emissions scenarios as developed by the Intergovernmental Panel on Climate Change (IPCC).

**Required Text:** Burroughs W.J. 2007. *Climate Change: A Multidisciplinary Approach* (second edition). Cambridge University Press, Cambridge, U.K. 378pp.

**Optional Texts:** (a) **Climate Change 2007: The Physical Science Basis** by IPCC. 2007. Cambridge University Press. *This is the source for the latest synthesis on climate change and it is currently driving global policy. Note, you can access this for free in pdf form at <http://ipcc-wg1.ucar.edu/wg1/wg1-report.html>.* (b) **Global Warming: The Complete Briefing (Fourth Edition)** by John Houghton. 2009. Cambridge University Press. *This is the Reader's Digest version of the 3 IPCC Working Group documents. It condenses about 3,000 pages to a mere 438....* (c) **The Rough Guide to Climate Change** by Robert Henson. 2008. Rough Guides Ltd. *This is a breezier overview than the Houghton book but gives a broad coverage of climate change issues.* (d) **What We Know About Climate Change** by Kerry Emanuel. 2007. MIT Press. *This is the shortest book of any worth you are likely to find on climate change! It's not comprehensive but it still manages to be useful, informative and readable.* (e) **The Discovery of Global Warming** by Spencer R. Weart. 2008. Harvard University Press. *If you want to know the history of the whole climate change debate then this is the book you want. It is relatively light on the science but it does give you a good idea of who did what, when and why.*

**Course Grade:** Participation in class discussions (and/or quizzes) (40%), Problem sets/assignments (30%), Course paper/project (30%).

Class discussions will be integral to the course. While there will be lecture materials, students are expected to interact with the instructor and each other in moderated discussion of each day's materials. Students are expected to contribute at least one question for class discussion each week.

Quizzes or problem sets will be given for the different sections of the course to verify understanding of important concepts and definitions. Since the course is designed to provide a synthetic understanding of the Earth's climate, it is critical that concepts of each section are understood.

**Course paper/project:** The paper or project is a flexible assignment that must be approved by the instructor. The purpose is to provide the student with vehicle for applying the course materials to their own research or to a topic, ecosystem or region of interest. A literature review can be used for this but the student is expected to explore the concepts from the course and synthesize materials. The project may also be related to data analysis or similar work if pertinent to the course.

Lecture	Date	Lecture Topic	Text Reading	Discussion Readings
1	1/20/10	Course Introduction/Energy Balance and the Greenhouse Effect		
2	1/25/10	A short history of global climate change		Arrhenius (1896) Sawyer (1972) Broecker (1975)
3	1/27/10	Radiation – principles, propagation, solar luminosity	Burroughs - Chapter 2	Rind (2002) Zachos et al. (2001)
4	2/1/10	Radiation – solar cycles and Earth cycles	Burroughs – Chapter 6.5, 6.7	Hays et al. (1976) Hansen (2005)
5	2/3/10	Albedo – Land, Sea, Clouds and the Cryosphere	Burroughs – Chapter 6	Hansen et al. (1992) *Kerr (2009) *Clement et al. (2009)
6	2/8/10	Atmospheric circulation	Burroughs – Chapter 3	Seidel et al. (2008) Sterman & Sweeney (2007)
7	2/10/10	Ocean circulation	Burroughs – Chapter 3	Toggweiler & Russell (2008)
*****	2/15/10	President's Day	*****	*****
8	2/17/10	Paleoclimates – Temperature/climate proxies	Burroughs – Chapter 4	Jones et al. (2001) Huber (2008) *Noone (2009) *Sime et al. (2009)
9	2/22/10	Paleoclimates – Plate tectonics, volcanoes and atmospheric changes	Burrough – Chapter 6.4, 6.8	Sagan & Mullen (1972) deMenocal (2001)
10	2/24/10	Greenhouse gases (sources, sinks and effects)	Burroughs – Chapter 7	Hoffman et al. (1998) Le Quere et al. (2009)
11	3/1/10	Biogeochemical cycles		Heimann & Reichstein (2008) Gruber & Galloway (2008) Khatiwala et al. (2009)
12	3/3/10	Ice ages, glaciers and sea level changes	Burroughs – Chapter 8	Mitrovica et al. (2009) Kopp et al. (2009) Pearson et al. (2009)
*****	<b>3/8/10</b>	<b>Spring Break</b>	*****	*****
*****	<b>3/10/10</b>	<b>Spring Break</b>	*****	*****
13	3/15/10	Life, Ecosystems and Climate		Davis & Shaw (2001) Peterson (2003)
14	3/17/10	Methods - Measuring	Burroughs –	Stott et al. (2004)

		Climate 1	Chapter 5	Huber (2009)
15	3/22/10	Methods - Measuring Climate 2	Burroughs – Chapter 5	Liu et al. (2009) Zachos et al. (2008)
16	3/24/10	Climate Modeling 1	Burroughs – Chapter 10	Crowley (2000) Cox et al. (2000)
17	3/29/10	Climate Modeling 2	Burroughs – Chapter 10	Sokolov et al. (2009) Cochrane and Barber (2009)
18	3/31/10	Climate variability and thresholds	Burroughs – Chapter 10	*Salinger (2005a) *Salinger (2005b) Lenton et al. (2008) Kump (2009)
*****	4/5/10	Easter Recess	*****	*****
19	4/7/10	Future Climates – Probabilities of change, Novel/disappearing climates	Burroughs- Chapter 11	Williams et al. (2007) Walker (2007)
20	4/12/10	Future climates- global, regional and local changes	Burroughs – Chapter 11	Seager et al. (2007) Saunders et al. (2008)
21	4/14/10	Consequences of climate change – Hydrology and Hurricanes	Burroughs – Chapter 9	Emanuel (2005) Barnett et al. (2008) Barnett et al. (2005)
22	4/19/10	<u>Guest speaker:</u> Mike Wimberly – Human Health and Climate Change	Burroughs – Chapter 9	Patz et al. (2005)
23	4/21/10	<u>Guest speaker:</u> Tom Loveland – Land Cover and Land Use Change connections to Climate Change	Burroughs – Chapter 9	Ruddiman (2003)
24	4/26/10	Consequences – Biodiversity and Disturbance	Burroughs – Chapter 9	Thomas et al. (2004) Brown et al. (2004) Westerling et al. (2006)
25	4/28/10	Consequences – Agriculture and Society	Burroughs – Chapter 9	Friedlingstein (2008) Motha & Baier (2005) Pacala and Socolow (2004)

\* indicates related readings

## Supplemental Readings:

Arrhenius S. 1896. On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground. *Philosophical Magazine and Journal of Science*, 5(41) 237-276.

Barnett T.P., J.C. Adam and D.P. Lettenmaier. 2005. Potential impacts of a warming climate on water availability in snow dominated regions. *Nature* 438: 303-309.

Barnett, T.P., D.W. Pierce, H.G. Hidalgo, C. Bonfils, B.D. Santer, T. Das, G. Bala, A.W. Wood, T. Nozawa, A.A. Mirin, D.R. Cayan and M.D. Dettinger. 2008. Human-induced changes in the hydrology of the Western United States. *Science* 319: 1080-1083.

Broecker W.S. 1975. Climate Change: Are We on the Brink of a Pronounced Global Warming? *Science* 189: 460-463.

Brown T.J., B.T. Hall and A. L. Westerling. 2004. The Impact of Twenty-first Century Climate Change on Wildland Fire Danger in the Western United States: An Applications Perspective. *Climatic Change* 62: 365-388.

Clement A.C., R. Burgman and J.R. Norris. 2009. Observational and Model Evidence for Positive Low-Level Cloud Feedback. *Science* 325: 460-464 (plus supplemental information).

Cochrane, M.A. and C.P. Barber. 2009. Future Fire Regimes of the Amazon: Climate Change and Human Land Use. *Global Change Biology* 15: 601-612.

Cox P.M., R.A. Betts, C.D. Jones, S.A. Spall, and I.J. Totterdell. 2000. Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. *Nature* 408: 184-187.

Crowley T.J. 2000. Causes of Climate Change Over the Past 1000 Years. *Science* 289: 270-277.

Davis M.B. and R.G. Shaw. 2001. Range Shifts and Adaptive Response to Quaternary Climate Change. *Science* 292: 673-679.

deMenocal P.B. 2001. Cultural Responses to Climate Change During the Late Holocene. *Science* 292: 667-673.

Friedlingstein P. 2008. A steep road to climate stabilization. *Nature* 451: 297-298.

Emanuel K. 2005. Increasing destructiveness of tropical cyclones over the past 30 years. *Nature* 436: 686-688.

Gruber N. and J.N. Galloway. 2008. An Earth-system perspective of the global nitrogen cycle. *Nature* 451: 293-296.

Hansen J., A. Lacis, R. Ruedy and M. Sato. 1992. Potential Climate Impact of Mount Pinatubo Eruption. *Geophysical Research Letters* 19: 215-218.

- Hansen J.E. 2005. A Slippery Slope: How Much Global Warming Constitutes “Dangerous Anthropogenic Interference”? *Climatic Change* 68: 269-279.
- Hays, J.D., J. Imbrie and N.J. Shackleton. 1976. Variations in the Earth’s Orbit: Pacemaker of the Ice Ages. *Science* 194: 1121-1132.
- Heimann M. and M. Reichstein. 2008. Terrestrial ecosystem carbon dynamics and climate feedbacks. *Nature* 451: 289-292.
- Hoffman P.F., A.J. Kaufman, G.P. Halverson and D.P. Schrag. 1998. A Neoproterozoic Snowball Earth. *Science* 281: 1342-1346.
- Huber M. 2009. Snakes tell a torrid tale. *Nature* 457: 669-671.
- Huber M. 2008. A Hotter Greenhouse? *Science* 321: 353-354.
- Jones P.D., T.J. Osborn and K.R. Briffa. 2001. The Evolution of Climate Over the Last Millenium. *Science* 292: 662-667.
- Kerr R.A. 2009. Clouds Appear to Be Big, Bad Player in Global Warming. *Science* 325: 376.
- Khatiwala S., F. Primeau and T. Hall. 2009. Reconstruction of the history of anthropogenic CO<sub>2</sub> concentrations in the ocean. *Nature* 462: 346-349 (plus supplementary information)
- Kopp, R.E., F.J. Simons, J.X. Mitrovica, A.C. Maloof and M. Oppenheimer. 2009. Probabilistic assessment of sea level during the last interglacial stage. *Nature* 462: 863-867.
- Kump L.R. 2009. Tipping Pointedly Colder. *Science* 323: 1175-1176.
- Lenton T.M., H. Held, E. Kriegler, J.W. Hall, W. Lucht, S. Rahmstorf and H.J. Schellnhuber. 2008. Tipping elements in the Earth’s climate system. *PNAS* 105: 1786-1793.
- Le Quere C., M.R. Raupach, J.G. Canadell, G. Marland, et al. 2009. Trends in the sources and sinks of carbon dioxide. *Nature Geoscience* DOI: 10.1038/NGEO689 1-6 (plus supplement)
- Liu Z., M. Pagani, D. Zinniker, R. DeConto, M. Huber, H. Brinkuis, S.R. Shah, R.M. Leckie and A. Pearson. 2009. Global Cooling During the Eocene-Oligocene Climate Transition. *Science* 323: 1187-1190.
- Mitrovica, J.X. N. Gomez and P.U. Clark. 2009. The Sea-level Fingerprint of West Antarctic Collapse. *Science* 323: 753.
- Motha R.P. and W. Baier. 2005. Impacts of Present and Future Climate Change and Climate Variability on Agriculture in the Temperate Regions: North America. *Climatic Change* 70: 137-164.

- Noone D. 2009. Kink in the thermometer. *Nature* 462: 295-296.
- Pacala S. and R. Socolow. 2004. Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies. *Science* 305: 968-972.
- Patz J.A., D. Campbell-Lendrum, T. Holloway and J.A. Foley. 2005. Impact of regional climate change on human health. *Nature* 438: 310-317.
- Pearson, P.N., G.L. Foster and B.S. Wade. 2009. Atmosphere carbon dioxide through the Eocene-Oligocene climate transition. *Nature* 461: 1110-1113.
- Peterson A.T. 2003. Projected climate change effects on Rocky Mountain and Great Plains birds: generalities of biodiversity consequences. *Global Change Biology* 9: 647-655.
- Raymo M.E. and P. Huybers. 2008. Unlocking the mysteries of the ice ages. *Nature* 451: 284-285.
- Rind D. 2002. The Sun's Role in Climate Variations. *Science* 296: 673-677.
- Ruddiman W.F. 2003. The Anthropogenic Greenhouse Era Began Thousands of Years Ago. *Climatic Change* 61: 261-293.
- Sagan C. and G. Mullen. 1972. Earth and Mars: Evolution of Atmospheres and Surface Temperatures. *Science* 177: 52-56.
- Salinger J.M. 2005. Increasing Climate Variability and Change: Reducing the Vulnerability. *Climatic Change* 70: 1-3.
- Salinger J.M. 2005. Climate Variability and Change: Past, Present and Future – An Overview. *Climatic Change* 70: 9-29.
- Saunders S., C. Montgomery, T. Easley and T. Spencer. 2008. Hotter and Drier: the West's Changed Climate. RMCO and NRDC report.
- Sawyer J.S. 1972. Man-made Carbon Dioxide and the "Greenhouse" Effect. *Nature* 239: 23-26.
- Seager, R., M. Ting, I. Held, Y. Kushnir, J. Lu, G. Vecchi, H. Huang, N. Harnik, A. Leetmaa, N. Lau, C. Li, J. Velez and N. Naik. 2007. Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America. *Science* 316: 1181-1184.
- Seidel D.J., Q. Fu, W.J. Randel, and T.J. Reichler. 2008. Widening of the tropical belt in a changing climate. *Nature Geoscience* 1: 21-24.
- Sime L.C., E.W. Wolff, K.I.C. Oliver and J.C. Tindall. 2009. Evidence for warmer interglacials in East Antarctic ice cores. *Nature* 462: 342-345 (plus supplementary information)

Sokolov A.P., P.H. Stone, C.E. Forest, R. Prinn, M.C. Sarofim, M. Webster, S. Palstev and C.A. Schlosser. 2009. Probabilistic Forecast for Twenty-First-Century Climate Based on Uncertainties in Emissions (Without Policy) and Climate Parameters. *Journal of Climate* 22: 5175-5204.

Sterman J.D. and L.B. Sweeney. 2007. Understanding public complacency about climate change: adults' mental models of climate change violate conservation of matter. *Climatic Change* 80: 213-238.

Stott P.A., D.A. Stone and M.R. Allen. 2004. Human contribution to the European heatwave of 2003. *Nature* 432: 610-614.

Thomas C.D., A. Cameron, R.E. Green, M. Bakkenes, L.J. Beaumont et al. 2004. Extinction risk from climate change. *Nature* 427: 145-148.

Toggweiler and J. Russell. 2008. Ocean circulation in a warming climate. *Nature* 451: 286-288.

Walker G. 2007. A World Melting from the Top Down. *Nature* 446: 718-721.

Westerling A.L., H.G. Hidalgo, D.R. Cayan and T.W. Swetnam. 2006. Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. *Science* 313: 940-943.

Williams J.W., S.T. Jackson and J.E. Kutzbach. 2007. Projected distributions of novel and disappearing climates by 2100 AD. *PNAS* 104: 5738-5742.

Zachos J.C., G.R. Dickens and R.E. Zeebe. 2008. An early Cenozoic perspective on greenhouse warming and carbon-cycle dynamics. *Nature* 451: 279-283.

Zachos J. M. Pagani, L. Sloan, E. Thomas and K. Billups. 2001. Trends, Rhythms, and Aberrations in Global Climate 65 Ma to Present. *Science* 292: 686-693.

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### ACADEMIC FREEDOM AND RESPONSIBILITY STATEMENT:

Freedom in learning. Students are responsible for learning the content of any course of study in which they are enrolled. Under Board of Regents and University policy, student academic performance shall be evaluated solely on an academic basis and students should be free to take reasoned exception to the data or views offered in any course of study. Students who believe that an academic evaluation is unrelated to academic standards but is related instead to judgment of their personal opinion or conduct should first contact the instructor of the course. If the student remains unsatisfied, the student may contact the department head and/or dean of the college which offers the class to initiate a review of the evaluation.

### CHEATING AND DISHONESTY POLICY:

The consequences of academic cheating and dishonesty range from any and all plagiarized or compromised assignments, tests, and other forms of evaluations being given zero credit as per offense to a student being given a failing grade for the class in which the offense took place. There is also the possibility that any student who has committed a cheating offense may face disciplinary probation or expulsion from the University. The full policies are found in Chapter 1 of the Student Code (01: 10:23:01-1: 10:23:04) of the SDSU Student Policies Manual.

**Freedom in learning.** *Under Board of Regents and University policy student academic performance may be evaluated solely on an academic basis, not on opinions or conduct in matters unrelated to academic standards. Students should be free to take reasoned exception to the data or views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled. Student who believe that an academic evaluation reflects prejudiced or capricious consideration of student opinions or conduct unrelated to academic standards should first contact the instructor of the course to initiate a review of the evaluation. If the student remains unsatisfied, the student may contact the department head and/ or dean of the college which offers the class to initiate a review of the evaluation.*