SYLLABUS

Paleoclimatology and Paleoceanography

Professor Jean Lynch-Stieglitz

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Audience: This course is intended for advanced undergraduate and graduate students who are interested in learning about the history of the earth's climate, and how paleoclimate studies can help us learn more about the workings of the climate system. No specific perquisites are required, but some coursework in atmospheric science or geochemistry is helpful.

Format: Tuesday's class period is devoted to an overview/background lecture on each weekly topic, and Thursday's class is a discussion of 1 or 2 important papers related to the weekly topic.

Requirements: Readings (1-2 papers plus appropriate material from textbook) must be completed before Thursday's class. Each student must bring at least one question to each discussion. Each student will be responsible for leading two Thursday discussions. The discussion leader will provide a summary of the methods and findings of the paper(s) including all important figures, relevant background material, and a series of discussion questions. There will also be a final exam.

Text: Ruddiman, W. F., 2001. Earth's Climate: past and future. W.H. Freeman & Son

Schedule:

Week 1:
Jan 6 Introduction and overview
Jan 8 Global Energy Balance and Faint Young Sun
Week 1 Reading : Ruddiman Ch 2 (pp. 19-31) and 3 for reference

Week 2:
Jan 13 CO2-Weathering Climate regulation
Jan 15 Discussion: Snowball Earth
Week 2 Reading: Ruddiman Ch 4 and 5 for reference
P. F. Hoffman, A. J. Kaufman, G. P. Halverson and D. P. Schrag, A Neoproterozoic Snowball Earth in *Science*, Vol. 281, pages 1342-1346; 28 August 1998.
Hoffman, Paul F. and Schrag, Daniel P., Snowball Earth, *Scientific American*, January 2000, pp 68-75.

Week 3:

Jan 20 Greehouse Earth: Cretaceous Climate

Jan 22 Discussion: Late Paleocene Thermal Maximum

Week 3 Reading: Ruddiman Ch 6

Dickens, GR, O'Neil JR, Rea DK, Owen RM, Dissociation of oceanic methane hydrate as a cause of the carbon-isotope excursion at the end of the Paleocene, *Paleoceanography, 10*, 965-971, 1995.

Kent DV, Cramer BS, Lanci L, Wang D, Wright JD, Van der Voo R, A case for a comet impact trigger for the Paleocene/Eocene thermal maximum and carbon isotope excursion, *Earth and Planetary Science Letters, 211*, 13-26, 2003.

Week 4:

Jan 27 Cenozoic Cooling and Glaciation

Jan 29 Discussion: Closing the tropical ocean

Week 4 Reading: Ruddiman Ch 7

Haug GH, Tiedemann R, Effect of the formation of the Isthmus of Panama on Atlantic Ocean thermohaline circulation, Nature, 393, 673-676, 1998.

Cane MA, Molnar P, Closing of the Indonesian seaway as a precursor to east African aridircation around 3-4 million years ago, Nature, 411, 157-162, 2001.

Week 5:

Feb 3 Milankovitch and Monsoons

Feb 5 Milankovitch and Glaciation

Week 5 Reading: Ruddiman Ch 8-10

Week 6:

Feb 10 Ice Core Records of Atmospheric Composition

Feb 12 Discussion: Climate History, Leads and Lags from the Vostok Ice Core

Week 6 Reading: Ruddiman Ch 11

Petit, JR, et al, Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica, Nature, 399, 429-436, 1999.

Shackleton, NJ, The 100,000-year ice-age cycle identified and found to lag temperature, carbon dioxide, and orbital eccentricity, Science, 289, 1897-1902, 2000.

Week 7:

Feb 17 Last Glacial Maximum: Ice Sheets, Sea Level, Dust, Dating

Feb 19 Discussion: Reconstructing Ocean $\delta^{18}O$ and Salinity from Porewaters

Week 7 Reading: Ruddiman Ch 13

J.F. Adkins, K. McIntyre and D.P. Schrag, The salinity, temperature, and d18O of the glacial deep ocean. *Science* **298** (2002), pp. 1769–1773.

D.P. Schrag, J.F. Adkins, K. McIntyre, J. Alexander, D.A. Hodell, C.D. Charles and J.F. McManus, The oxygen isotopic composition of seawater during the Last Glacial Maximum.*Quat. Sci. Rev.* **21** (2002), pp. 331–342.

Week 8:

Feb 24 Last Glacial Maximum: Temperature reconstructions

Feb 26 Discussion: Tropical SST reconstructions

Week 8 Reading:

A. Koutavas, J. Lynch-Stieglitz and T. Marchitto, El Nino–Like Pattern in Ice Age Tropical Pacific Sea SurfaceTemperature, *Science* **297** (2002), pp. 226–230.

Mix AC, Morey AE, Pisias NG, Hostetler SW, Foraminiferal faunal estimates of paleotemperature: Circumventing the no-analog problem yields cool ice age tropics, Paleoceanography 14 (3), 350-359, 1999.

Week 9:

Mar 2 Last Glacial Maximum: Ocean Circulation

Mar 4 Discussion: Zn/Ca ratios and North Atlantic Circulation

Week 9 Reading:

Class:

J. Lynch-Stieglitz, Tracers of past ocean circulation, pp. 433-452. In *The Oceans and Marine Geochemistry* (ed. H. Elderfield) Vol. 6 *Treatise on Geochemistry* (eds. H.D. Holland and K.K. Turekian), Elsevier-Pergamon, Oxford, 2003.

Discussion:

Marchitto, T. M., D. W. Oppo, and W. B. Curry, Paired benthic foraminiferal Cd/Ca and Zn/Ca evidence for a greatly increased presence of Southern Ocean Water in the glacial North Atlantic, *Paleoceanography*, *17*(3), 1038, doi:10.1029/2000PA000598, 2002.

Week 10:

Mar 16 Last Glacial Maximum: CO_2

Mar 18 Discussion: Nitrogen Inventory Changes and Glacial CO_2

Week 10 Reading:

Falkowski, P. G., Evolution of the nitrogen cycle and its influence on the biological sequestration of CO2 in the ocean, *Nature*, *387*, 272–274, 1997.

Ganeshram, R. S., T. F. Pedersen, S. E. Calvert, and R. Francois, Reduced nitrogen fixation in the glacial ocean inferred from changes in marine nitrogen and phosphorus inventories, *Nature, 415*, 156-160, 2002.

Week 11:

Mar 23 Rapid Climate Change – Records from Ice Cores and Land

Mar 26 Discussion: Magnitude and timing of abrupt change from gasses in ice cores.

Week 12 Reading:

Ruddiman Chapter 15

Severinghaus, J.P., Sowers, T., Brook, E.J., Alley, R.B., Bender, M.L. Timing of abrupt climate change at the end of the Younger Dryas interval from thermally fractionated gases in polar ice, *Nature*, *391*, 141-146, 1998.

Week 12:
Mar 30 Rapid Climate Change – Oceanic Records and Mechanisms
Apr 1 Discussion: Modelling Rapid Climate Change
Week 12 Reading:
Class:
Rahmstorf, S. Ocean circulation and climate during the past 120,000 years, *Nature, 419*, 209-214, 2002.
Discussion: Ganopolski, A. and S. Rahmstorf, Rapid changes of glacial climate simulated in a coupled climate model, *Nature, 409*, 153-158, 2001.

Week 13:
Apr 6 Holocene Climate
Apr 8 No class
Week 13 Reading:
Ruddiman Chapter 14

Week 14:
Apr 13 Climate records from Corals
Apr 15 Discussion: Past ENSO variability
Week 14 Reading:
Ruddiman Chapter 16
Tudhope, AW, CP Chilcott, MT McCulloch, ER Cook, J Chappell, RM Ellam, DW Lea, JM Lough and GB Simmield, Variability in the El Niño-Southern Oscillation Through a Glacial-Interglacial Cycle, Science, 291, 1511-1517, 2001.

Week 15:
Apr 20 Climate of the last 1000 years
Apr 22 Final Exam Review- Bring questions

Grading:

30% Participation in discussions
40% Leading discussions
30% Final Exam