Joint Rutgers-Princeton Graduate Seminar: Geological Constraints on Climate Sensitivity
Rutgers 16:460:611:01 / Princeton GEO534

Meets: Tuesdays, 2:30pm-5:30pm
Alternatively meets Lipman House, Cook Campus, Rutgers University
and Guyot Hall, Princeton University

Instructors:

Professor Bob Kopp	Professor John Higgins
Wright 225	Guyot 212
robert.kopp@rutgers.edu	jahiggin@princeton.edu

Climate sensitivity and Earth system sensitivity relate changes in greenhouse gas concentrations and other radiative forcers to changes in temperature, both in Earth's past and in the future. The Cenozoic record provided by paleo-temperature and paleo-carbon dioxide proxies can constrain these parameters and thus also the projected response of the planet to human-induced changes in greenhouse gas concentrations. This seminar will explore the concepts of climate and Earth system sensitivity, the methods and records of paleo-temperature and paleo-carbon dioxide proxies in the Cenozoic, and the statistical challenges of inferring sensitivities from these proxies.

Students will be expected to attend every class, to lead discussion of the week's paper on a rotating basis, and write a *Nature*-style critical review article related to the topic of the course that will be presented during the final week of the course. (The exact nature of the presentation will depend on enrollment, but we expect it to consist of roughly 15 minutes of prepared talk followed by 15 minutes of discussion.)

Grades will be based on participation throughout the term (25%), discussion leadership (50%), and the research project (25%).

Schedule

Week 0: DIMACS Workshop on Geological Data Fusion
January 17-18, 2013

Students are strongly encouraged to attend the DIMACS workshop on Geological data fusion, January 17-18, 2013, at Rutgers University. See http://tinyurl.com/b9odcgo for more information. Registration is free for Rutgers and Princeton affiliates but is required.

Week 1: Introducing the Problem / Thinking like a Bayesian (Rutgers)
January 29, 2013

McGrayne, S.B., 2011. The Theory That Would Not Die: How Bayes' Rule Cracked the Enigma Code, Hunted Down Russian Submarines, & Emerged Triumphant from Two Centuries of Controversy. Yale University Press.

Tingley, M.P., Craigmile, P.F., Haran, M., Li, B., Mannshardt, E., Rajaratnam, B., 2012. Piecing together the past: statistical insights into paleoclimatic reconstructions. Quaternary Science Reviews 35, 1–22.

Annan, J.D., Hargreaves, J.C., 2006. Using multiple observationally-based constraints to estimate climate sensitivity. Geophys. Res. Lett 33, L06704.

The Tingley piece is rather dense; I would skim the whole thing, but focus on sections 1, 2, and 3.

Week 2: Planetary Energy Balance (Princeton)
February 5, 2013

Charney, J.G., 1979. Carbon dioxide and climate: a scientific assessment : report of an Ad Hoc Study Group on Carbon Dioxide and Climate, Woods Hole, Massachusetts, July 23-27, 1979 to the Climate Research Board, Assembly of Mathematical and Physical Sciences, National Research Council. National Academies.

Hansen, J., Johnson, D., Lacis, A., Lebedeff, S., Lee, P., Rind, D., Russell, G., 1981. Climate Impact of Increasing Atmospheric Carbon Dioxide. Science 213, 957–966.

Hansen, J.E., Sato, M., 2012. Paleoclimate Implications for Human-Made Climate Change, in: Berger, A., Mesinger, F., Sijacki, D. (Eds.), Climate Change. Springer Vienna, pp. 21–47.

Week 3: Climate and Earth system Sensitivity (Rutgers)
February 12, 2013

Knutti, R., Hegerl, G.C., 2008. The equilibrium sensitivity of the Earth's temperature to radiation changes. Nature Geoscience 1, 735–743.

Hegerl, G.C., Crowley, T.J., Hyde, W.T., Frame, D.J., 2006. Climate sensitivity constrained by temperature reconstructions over the past seven centuries. Nature 440, 1029–1032.

PALAEOSENS Project, 2012. Making sense of palaeoclimate sensitivity. Nature 491, 683–691.

Lunt, D.J., Haywood, A.M., Schmidt, G.A., Salzmann, U., Valdes, P.J., Dowsett, H.J., 2010. Earth system sensitivity inferred from Pliocene modelling and data. Nature Geoscience 3, 60–64.

Week 4: The Carbon Cycle (Princeton)
February 19, 2013

Sarmiento, J., and Gruber, 2006, The Carbon Cycle, CO2, and Climate, in Ocean Biogeochemical Dynamics, Princeton University Press.

Zachos, J. ,et al., 2001, Trends, Rhythms, and Abberations in global climate 65 Ma to the present, Science, 292, 5517, 686-693.

Berner, R., 1991, A model for atmospheric CO2 over Phanerozoic time, American Journal of Science, 291, 339-376.

Week 5: Non-CO_2 forcing factors (Rutgers)
February 26, 2013

Barron, Eric J., and Warren M. Washington. 1984. "The Role of Geographic Variables in Explaining Paleoclimates: Results from Cretaceous Climate Model Sensitivity Studies." Journal of Geophysical Research: Atmospheres 89 (D1): 1267–1279. doi:10.1029/JD089iD01p01267.

Bartdorff, Oliver, Klaus Wallmann, Mojib Latif, and Vladimir Semenov. 2008. "Phanerozoic Evolution of Atmospheric Methane." Global Biogeochemical Cycles 22 (1): GB1008. doi:10.1029/2007GB002985.

Week 6: Temperature Proxies 1 – Carbonate Thermometers (Princeton)
March 5, 2013

Lea, D. W. in Treatise on Geochemistry (Editors-in-Chief: Heinrich D. Holland & Karl K. Turekian) 1–26 (Pergamon, 2003). at <http://www.sciencedirect.com/science/article/pii/B0080437516061144>

Jouzel, J. et al. Validity of the temperature reconstruction from water isotopes in ice cores. J. Geophys. Res.-Oceans 102, 26471–26487 (1997).

Week 7: Temperature Proxies 2 – Organic Thermometers (Rutgers)
March 12, 2013

Rommerskirchen, F., Condon, T., Mollenhauer, G., Dupont, L. & Schefuss, E. Miocene to Pliocene development of surface and subsurface temperatures in the Benguela Current system. Paleoceanography 26, PA3216 (2011).

Eglinton, T. I. & Eglinton, G. Molecular proxies for paleoclimatology. Earth and Planetary Science Letters 275, 1–16 (2008).

**** SPRING BREAK – no class on March 19, 2013 ****

Week 8: Carbon Dioxide Proxies 1 – **Carbonate CO_2 Barometers** (Rutgers)
March 26, 2013

Foster, G. L., Lear, C. H. & Rae, J. W. B. The evolution of pCO(2), ice volume and climate during the middle Miocene. *Earth Planet. Sci. Lett.* 341, 243–254 (2012).

Pearson, P. N. & Palmer, M. R. Atmospheric carbon dioxide concentrations over the past 60 million years. *Nature* 406, 695–699 (2000).

Week 9: Carbon Dioxide Proxies 2 – Organic CO_2 Barometers (Princeton)
April 2, 2013

Popp, B.N., Takigiku, R., Hayes, J. M., Louda J. W., and Baker E. W., 1989. The Post-Paleozoic Chronology And Mechanism Of ^{13}C Depletion In Primary Marine Organic Matter. *American Journal of Science* 289, 436–454.

Zhang et al., 2013. A 40-million-year history of atmospheric CO2.

Week 10: Miocene Climate (Rutgers)
April 9, 2013

Herold, N., Huber, M., Muller, R. D. & Seton, M. Modeling the Miocene climatic optimum: Ocean circulation. Paleoceanography 27, (2012).'

You, Y., Huber, M., Mueller, R. D., Poulsen, C. J. & Ribbe, J. Simulation of the Middle Miocene Climate Optimum. Geophys. Res. Lett. 36, (2009).

Week 11: Numerical Analysis (Princeton)
April 16, 2013

Tingley, M.P., Craigmile, P.F., Haran, M., Li, B., Mannshardt, E., Rajaratnam, B., 2012. Piecing together the past: statistical insights into paleoclimatic reconstructions. Quaternary Science Reviews 35, 1–22.

Tingley, M.P., Huybers, P., 2010. A Bayesian algorithm for reconstructing climate anomalies in space and time. Part I: Development and applications to paleoclimate reconstruction problems. Journal of Climate 23, 2759–2781.

Tingley, M.P., Huybers, P., 2013. Recent temperature extremes at high northern latitudes unprecedented in the past 600 years. Nature 496, 201–205.

Week 12: Working session (Rutgers)
April 23, 2013

Week 13: Student Research Project Presentations (Princeton)
April 30, 2013