Great Papers in the Earth Sciences

Great Papers, EPS 281r

(Spring 2009)

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Day & time: Wednesday 3-5

Location: Geological Museum room 413

1st meeting: Wednesday Jan 28, 3pm

Bibliography: papers to be posted to the course web page and linked from this document.

this document: http://www.seas.harvard.edu/climate/eli/Courses/EPS281r/2009spring/great-papers-detailed-syllabus.pdf

Announcements Last updated: January 28, 2009. Feel free to write, call or visit us with any questions.

1 Administrative

Prerequisites: This is a basic introductory breadth course, should be accessible to all Earth and Planetary Science graduate students.

Requirements: Apart from reading all assigned papers, students will be asked to prepare presentations on one or more of the topics to be covered during the course and based on the appropriate papers posted on the course web page, and lead a discussion during class.

Guidelines for student presentations

Each subject will require two presentations by the students leading the corresponding discussion. You are welcome to organize in groups of 2-3 for this purpose.

The first presentation is 5-slide, 10 minute long, minimum font size 24, and is given the week before the subject is discussed in class. The purpose of this brief presentation is to motivate the subject, explain its importance, and especially help the other students understand the reading material by providing them some guidance and explanation about the paper(s) and the relevant background.

The second presentation is about 30-slide long, minimum font size 24, and is to be used during the discussion. Please provide some background for the other students, and then get to the actual paper asap (within 5-6 slides). The purpose of this presentation is to guide the discussion, rather than be a lecture. We may not cover all 30 slides if the discussion takes all the class time, and that would be just fine... Show the figures/ equations from the paper, explain them, provide interesting guiding questions. In particular, make an effort to find the optimal way to excite a discussion about the reading material.

Grading: Based on presentations, discussion, participation and (mandatory) attendance.

2 Outline

A survey of historic breakthrough papers in all of the earth sciences, as well as modern papers that put the classic papers in perspective. Some possible topics to be covered via these papers are the Ozone hole, atmospheric Hadley circulation cell, Indian monsoons, the Gulf Stream, thermohaline circulation, plate tectonics, earth magnetic field and dynamo, the thermal structure and history of the earth and the implications on the age of the earth, glacial cycles, abrupt past climate changes, the KT boundary and extinction of the dinosaurs, appearance of oxygen on earth, and more. Participating students will be invited to present some of these papers and lead some of the discussions.

3 An evolving syllabus

The blue links below lead to the reading material for each lecture. All of the reading material referred to here is provided in these links.

1. First, introduction lecture, also in pdf.

2. Greenhouse effect (climate). Read (A) from IPCC chapter 2: executive summary, sections 2.1, 2.2 (including FAQ 2.1), 2.3.1, 2.3.2; (B) Arrhenius (1896).

3. Hadley cell (atmospheric dynamics). Read (A) wikipedia entry, (B) Hadley (1735), (C) Schneider (2006) until the end of section 2.1 (pp 655-663).

4. Extinctions and the KT impact hypothesis (geology). Read (A) wikipedia entry on Chicxulub crater, (B) wikipedia entry on KT boundary, (C) Alvarez et al (1980), (D) Raup and Sepkoski (1982).

5. Snowball, Budyko-Sellers (geology, climate). Read the two page Kirschvink (1992) paper (that's our classic this time) and then Hoffman et al (1998). Finally, read the 1 page notes file energy_balance_0d for the Budyko-Sellers model which predicted the existence of a snowball earth in 1969.

6. Ozone hole (atmospheric chemistry). Read the Wikipedia entry on Ozone depletion, and then the two classic papers: Molina and Rowland (1974) who predicted the ozone hole and its formation mechanism, and Farman, Gardiner and Shanklin (1985) who later observed it. Finally, to get an idea of the policy process that led to the successful ban on CFCs, read the Wikipedia entry on the Montreal Protocol and the Greenpeace summary of the DuPont position on CFCs and ozone hole.

7. Thermohaline circulation (physical oceanography). Read the Rahmstorf (2006) encyclopedia entry first, then the classic Stommel (1961) paper, and then the Rahmstorf et al (2005) GRL paper. Pages 1,2,8,10 in the slides of the lecture from www.phys.uu.nl contain a simpler and clearer version of the (not so complex anyway) math involved.

8. Stable isotopes and paleoclimate (geochemistry) Read the two wikipedia entries on $\delta^{13}C$ and $\delta^{18}O$, and then the Urey (1948) and Epstein et al (1953) classic papers.

9. Glacial cycles (geology, climate) Read the Wikipedia entry about Milankovitch cycles (changes in the orbital parameters of the earth around the sun which affect climate). Next, read our classic paper by Hays, Imbrie and Shackleton (1976). For the personality perspective in this case read the wikipedia entry about Louis Agassiz and the article by E.P. Evans in the file "did-agassiz-discover-glacial-cycles.pdf". Note the contrast between (1) his objection to Darwin's ideas, his "work" on "Racial classification", and the suspicion that he may have stolen the glacial cycle idea from someone else, and (2) the fact that he was such a beloved, admired and influential scientist (especially wikipedia entry about him).

10. Continental drift and Plate tectonics (geology, geophysics). Read first the two wikipedia entries, then the few pages from the book by Wegener. All this reading so far is quite simple. Finally, for the geophysical treatment of plate tectonics on a sphere, please read the Morgan 1968 paper. This subject has a very interesting history, see the fascinating LePichon notes which tell the story of why the McKenzie-Parker paper came out first although Morgan came up with the idea (and submitted the paper) before them. [Optional: McKenzie-Parker 1967 and the original 1967 Morgan notes in the file MorganTectonoph91.pdf.]

11. Thermal history of the earth (geophysics): read the wikipedia entry about the age of the earth, and then the England et al (2007) historical review and the short address by Kelvin 1869 ("On geological dynamics"). Finally, read our classic paper for this time: Davies (1980). Optional: read the beginning of the two Lord Kelvin piece from 1868 to learn more about Kelvin's opinion of geologists. For many more Kelvin papers, see here.

12. Chaos and weather prediction (atmospheric dynamics). Read the brief introduction to chaos and then the wikipedia entry about fractals (better read this one on-line, for the nice animations in wikipedia), and then Lorenz 1963 paper itself. Note that Lorenz does not use the terms "chaos" or "fractals" which were only coined later, yet but he clearly understands both. For a nice on-line fractals demo, see here.

13. Reactivity of OH (atmospheric chemistry) Read the wikipedia entry and the two brief introductory web pages from www.atmosphere.mpg.de and www.niwa.cri.nz, then our classic paper by Levy (1971); and then read pages 147-149 in the AR4 IPCC report (section 2.3.5); optional: paper by Prinn in the `more/` directory.

14. The Gulf Stream (physical oceanography)

15. Abyssal ocean circulation and deep western boundary current (physical oceanography).