Course Syllabus, MSCI/GEOL 711; Paleoclimatology

Course Description: This course will examine the methods, materials, and principles used to reconstruct Earth’s past climate.

Instructor: Dr. Howie Scher  Email: hscher@geol.sc.edu
PSC 519B  Phone: 777-2410

Office hours: by appointment

Website: USC Blackboard: http//blackboard.sc.edu

Class schedule: Tuesday and Thursday, 10:05 to 11:20 am, Wardlaw College 122

Texts: Recommended texts:
Earth’s Climate Past and Future; Ruddiman, W
The Earth System; Kump, L., Kasting, J., Crane, R.

Papers from the literature, handouts, and reliable Internet sources will be available on Blackboard

Grading: Midterm 15%
Final 20%
Homework/Problem sets 25%
Proposal, presentation, review 20%
Participation during group 20%
  presentations and class discussions

Grades are awarded as straight percentages (> 90% = A, 87-89% = B+, 80-86% = B, etc.)

Attendance is MANDATORY: Following University Policy: Failure to attend class will affect your grade. For every 5 days of missed class, your final grade will be reduced by one letter.

Exams: The midterm and final will require completing quantitative problems and interpreting diagrams. Both will be take home exams with at least three days given to complete the exams.

Problem sets: Problem sets will be based on material covered in class and from papers in the literature.
1. Enter Wardlaw at yellow star above
2. Walk through the museum/lobby to the double doors
3. Turn left and walk to the end of the hallway
4. Room 122 is to your left
Course Outline:

1. Earth System Science and present-day climate (Dr. L. Ziolkowski)
   - Earth’s energy budget
   - Scales of climate change
   - Geologic time

2. Paleoclimate archives and dating/correlation methods (Dr. K. Gibson)
   - Review of stable isotopes (hydrogen, oxygen, carbon)
   - Terrestrial archives (Ice cores, loess, speleothems, lake sediments)
   - Marine archives (coral, hydrogenous sediments, marine sediments)
   - Radiometric dating
   - Magnetostratigraphy & biostratigraphy
   - Astronomical tuning
     
     Owens Lake sediment cores presentation and discussion

3. Earth’s earliest climate (Dr. S. Lang)
   - The faint young sun paradox
   - Precambrian climate
   - Snowball Earth hypothesis

     Snowball Earth group presentation and discussion

4. Tectonic scale climate change
   - carbonate-silicate cycle and CO₂ regulation
   - Past CO₂ reconstructions
   - Ocean gateways and ocean circulation
   - Orogeny and climate; the role of mountain building

     Tectonics and climate change presentation and discussion

5. Greenhouse-Icehouse transition; the last 50 million years
   - Scientific Ocean Drilling
   - Paleotemperatures and the equable climate problem
   - Reconstructing the carbonate compensation depth
   - Hyperthermals & hidden glaciations
   - The Eocene Oligocene Transition

     Eocene Oligocene Transition presentation and discussion
     Abrupt climate events presentation and discussion
6. Astronomical control of insolation
   Changes in Earth’s orbit
   Pre-Pleistocene orbital scale climate variability
   Milankovitch theory; orbital control of global ice volume
   Orbital scale changes in CO₂

   *Astronomically controlled ice volume and sea level discussion*

7. The deglacial
   Last glacial maximum
   Millennial scale climate variation
   The human imprint on climate

   *The glacial world discussion*

**LEARNING OUTCOMES:** By the end of the semester it is anticipated that students will have acquired the following:

- Knowledge of the different types of paleoclimate archives
- An understanding of the use of paleoclimate proxies
- How to calculate climate sensitivity to CO₂
- An ability to understand linkages between tectonics and climate
- Mastery of Earth’s orbital changes through time
- The ability to work efficiently with large datasets
- Improved ability to read and understand scientific literature
- Improved oral and written communication skills
- Improved ability to work collaboratively

**Collaboration:** Earth Science is an inherently interdisciplinary field and Earth scientists often work collaboratively on projects. I expect that many of you will choose to work in groups on assignments for this course. Please review the definitions below and come talk to me if you are unclear about how these apply to working together on projects.

**University of South Carolina Honor Code**

“It is the responsibility of every student at the University of South Carolina Columbia to adhere steadfastly to truthfulness and to avoid dishonesty, fraud, or deceit of any type in connection with any academic program. Any student who violates this Honor Code or who knowingly assists another to violate this Honor Code shall be subject to discipline.”
Forms of academic dishonesty:

**Plagiarism:** 1. The action or practice of taking someone else's work, idea, etc., and passing it off as one's own; literary theft.

**Cheating:** 1. To defraud; to deprive of by deceit. 2. To deceive, impose upon, trick. 3. To deal fraudulently, practice deceit.

**Fabrication:** 1. The use of invented information or the falsification of research or other findings.

**Academic Misconduct:** 1. An act that disrupts the educational process or provides a student with an academic advantage over another student.

*I deal swiftly and harshly with all instances of academic dishonesty*
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Lecture</th>
<th>Topic</th>
<th>Discussion</th>
<th>Deadlines/due dates</th>
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</thead>
<tbody>
<tr>
<td>1/13</td>
<td>lecture</td>
<td>1</td>
<td>Earth's Energy budget and climate (Dr. L Ziolkowski)</td>
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<tr>
<td>1/15</td>
<td>lecture</td>
<td>2</td>
<td>Scales of climate change (Dr. L. Ziolkowski)</td>
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<tr>
<td>1/20</td>
<td>lecture</td>
<td>3</td>
<td>stable isotopes, climate archives (Dr. K. Gibson)</td>
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<tr>
<td>1/22</td>
<td>lecture</td>
<td>4</td>
<td>dating and correlation (Dr. K. Gibson) Owls Lake</td>
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<tr>
<td>1/27</td>
<td>lecture</td>
<td>5</td>
<td>Earth's early climate; Neoproterozoic glaciations (Dr. S. Lang)</td>
<td></td>
<td>Research topic and 5 references in writing due</td>
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<tr>
<td>1/29</td>
<td>lecture</td>
<td>6</td>
<td>Snowball Earth hypothesis (Dr. S. Lang)</td>
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<tr>
<td>2/3</td>
<td>lecture</td>
<td>7</td>
<td>long term regulation of carbon dioxide, past CO2 levels</td>
<td>Snowball Earth</td>
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<tr>
<td>2/5</td>
<td>lecture</td>
<td>8</td>
<td>Tectonics and ocean/atmosphere circulation</td>
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<tr>
<td>2/10</td>
<td>lecture</td>
<td>9</td>
<td>Tectonics and ocean/atmosphere circulation</td>
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<tr>
<td>2/12</td>
<td>lecture</td>
<td>10</td>
<td>Scientific Ocean Drilling</td>
<td>Tectonics and climate</td>
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<tr>
<td>2/17</td>
<td>lecture</td>
<td>11</td>
<td>Paleotemperatures</td>
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<td>Outline and references due</td>
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<tr>
<td>2/19</td>
<td>lecture</td>
<td>12</td>
<td>Reconstructing the CCD</td>
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<tr>
<td>2/24</td>
<td>lecture</td>
<td>13</td>
<td>Abrupt climate shifts I</td>
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<tr>
<td>2/26</td>
<td>lecture</td>
<td>14</td>
<td>Abrupt climate shifts II</td>
<td>Eocene Oligocene Transition</td>
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<tr>
<td>3/3</td>
<td>lecture</td>
<td>15</td>
<td>Abrupt climate events I; warm events (MECO and PETM)</td>
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<tr>
<td>3/5</td>
<td>lecture</td>
<td>16</td>
<td>Abrupt climate events II; cool events (PrOM and EOT)</td>
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<td>first draft of proposal due</td>
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<td>3/10</td>
<td>Break</td>
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<td>No lecture</td>
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<tr>
<td>3/12</td>
<td>Break</td>
<td></td>
<td>No lecture</td>
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<td>Date</td>
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<td>Discussion</td>
<td>Deadlines/due dates</td>
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<tr>
<td>3/17</td>
<td>lecture</td>
<td>17</td>
<td>Milankovitch theory</td>
<td>Abrupt climate events</td>
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<td>3/19</td>
<td>Syracuse</td>
<td>No lecture</td>
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<td>Midterm due</td>
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<td>3/24</td>
<td>lecture</td>
<td>18</td>
<td>Orbital control of solar radiation</td>
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<tr>
<td>3/26</td>
<td>lecture</td>
<td>19</td>
<td>Astronomical tuning of geological time</td>
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<tr>
<td>3/31</td>
<td>lecture</td>
<td>20</td>
<td>CO2 changes on orbital time scales</td>
<td>Orbitally paced ice volume/sealevel</td>
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<td>4/2</td>
<td>lecture</td>
<td>21</td>
<td>The last glacial maximum</td>
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<tr>
<td>4/7</td>
<td>Passover</td>
<td>No lecture</td>
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<tr>
<td>4/9</td>
<td>lecture</td>
<td>22</td>
<td>Millennial and centennial climate change and the human climate footprint</td>
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<tr>
<td>4/14</td>
<td>lecture</td>
<td>22</td>
<td>Polar amplification past and present</td>
<td>The glacial world</td>
<td>Final draft of proposal due</td>
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<tr>
<td>4/16</td>
<td>talks</td>
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<td>Presentations</td>
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<tr>
<td>4/21</td>
<td>talks</td>
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<td>Presentations</td>
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<tr>
<td>4/23</td>
<td>talks</td>
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<td>Presentations</td>
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<td>Proposal reviews due</td>
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<tr>
<td>5/6</td>
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<td>Final exam due; 3:30</td>
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EXPECTATIONS: PRESENTING ARTICLES FOR CLASS DISCUSSION

One of the requirements for this course is that you participate in a group (2-3 people) to present a topic covered in the course and lead a class discussion on the topic. The presentation will focus on a set of related articles on a particular topic.

Each class participant should lead two discussions.

Each group will consult with me at least once prior to the presentation and discussion. Everyone in the group will fill out a peer evaluation form assessing the individual group members.

For presentations and discussions, I expect that:

• The group becomes familiar with the scientific content of the articles and the relationship to the material presented in this course.

• The group will identify key parts of the reading prior to the discussion and communicate these sections to the rest of the class at least one week period prior to the discussion.

• The group will collaborate to prepare questions (3-5) about the important points of the article(s) as well as a summary of the articles (ideally one page, no more than two pages). The summary can NOT be an outline of the slides from the presentation. It must be a standalone document in the form of an extended abstract. The questions and summary will be handed out to the class on the day of the presentation.

• The group will work collaboratively to prepare a BRIEF presentation for the class with visual aids (e.g., PowerPoint). Everyone in the group will contribute to the presentation, but not everyone needs to speak. The presentation should be coherent and well organized, so that the material is clear to the class. The presentation is followed by a class discussion led by the group. Total time should be <10 minutes.

• Other class members should come to group presentations prepared to discuss key points raised by the presenting group. The discussion will be in the context of the course material.
EXPECTATIONS: Proposals

You are responsible for developing a proposal about some aspect of paleoclimate. The proposal can be no more than 15 pages, including figures, tables, and captions. Refer to the NSF formatting guide for minimum font size, line spacing, etc.

http://www.nsf.gov/pubs/policydocs/pappguide/nsf11001/gpg_2.jsp#IIB

You must frame your research proposal with hypotheses and specific objectives. These will form the questions for which you will describe the objectives, scientific background, justification/rationale, proposed approach (methods), anticipated results, and their significance to the field. You are strongly encouraged to discuss any budgetary and/or logistical constraints of your project (e.g., will you need to request 10 years of submersible time? Will you need $10K or $1000K?).

The final proposal will focus on five to seven journal articles as primary references (though you will probably use and cite many more than that number in the development and writing of your proposal).

It is expected that you develop your own proposal for this course, and cite your sources. You may not use a proposal from a previous class or your thesis proposal, but it is acceptable that the research questions be related. A useful discussion on defining and avoiding plagiarism can be found at: http://www.wpacouncil.org/node/9

You will also be responsible for reviewing at least two of your classmates’ proposals. Reviews will be graded as part of your proposal score.

Proposal target dates:

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
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<tbody>
<tr>
<td>January 31</td>
<td>Statement of topic and 5 references in writing</td>
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<tr>
<td>February 19</td>
<td>Outline and reference list due</td>
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<tr>
<td>March 7</td>
<td>First draft</td>
</tr>
<tr>
<td>April 10</td>
<td>Final draft</td>
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<tr>
<td>April 18, 23, 25</td>
<td>Presentations</td>
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</table>

Outlines, first drafts, and reference lists are not expected to be finished documents but rather will serve as a framework for developing your finished proposal. We will schedule time to discuss your outlines and first drafts.

You will give a 15-minute presentation on your proposal topic in AGU oral session format. There will be 12 minutes for the presentation followed by 3 minutes of questions from the audience.
Review Criteria for GEOL/MSCI 545 proposals

1. Does the proponent clearly state the question to be addressed and/or the hypothesis to be tested? If not, provide a suggestion for how the proponent could make the hypothesis clearer.

2. Are the specific objectives of the proposal outlined? Will the objectives allow the proponent to test the hypothesis?

3. Is the work plan well designed? Is it clear that the sampling strategy, tests, models, and/or other analytical approaches will result in data that can be used to test the hypotheses?

4. Provide your assessment of the scholarship of the review of the existing knowledge base.

5. Are there adequate resources to carry out the proposed research?

NSF Review Criteria (for your information)

All NSF proposals are evaluated through use of two National Science Board approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities. For example, proposals for large facility projects also might be subject to special review criteria outlined in the program solicitation.

The two merit review criteria are listed below. The criteria include considerations that help define them. These considerations are suggestions, and not all will apply to any given proposal. While proposers must address both merit review criteria, reviewers will be asked to address only those considerations that are relevant to the proposal being considered and for which the reviewer is qualified to make judgments.

What is the intellectual merit of the proposed activity?
How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields? How well qualified is the proposer (individual or team) to conduct the project? (If appropriate, the reviewer will comment on the quality of prior work.) To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to resources?

What are the broader impacts of the proposed activity?
How well does the activity advance discovery and understanding while promoting teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)? To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships? Will the results be disseminated broadly to enhance scientific and technological understanding? What may be the benefits of the proposed activity to society?

NSF staff will give careful consideration to the following in making funding decisions:

Integration of Research and Education
One of the principal strategies in support of NSF’s goals is to foster integration of research and education through the programs, projects and activities it supports at academic and research institutions. These institutions provide abundant opportunities where individuals may concurrently assume responsibilities as researchers, educators, and students, and where all can engage in joint efforts that infuse education with the excitement of discovery and enrich research through the diversity of learning perspectives.
Integrating Diversity into NSF Programs, Projects, and Activities

Broadening opportunities and enabling the participation of all citizens, women and men, underrepresented minorities, and persons with disabilities, are essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.
<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>Unacceptable (Below Standards)</th>
<th>Acceptable (Meets Standards)</th>
<th>Good (Occasionally Exceeds)</th>
<th>Excellent (Exceeds Standards)</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to the problem/question (10 points)</td>
<td>Does not adequately convey topic or questions. Does not convey hypotheses or objectives. Does not discuss context.</td>
<td>Introduces topic either the topic or key question(s). Conveys either hypothesis or objectives. General discussion of context.</td>
<td>Introduction of both topic and key questions; conveys hypotheses &amp; objectives. Discusses context of proposed work.</td>
<td>Strong introduction of key question(s) &amp; terms. Clear hypotheses, objectives &amp; approach. Places proposed work in appropriate context.</td>
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<tr>
<td>Focus &amp; Sequencing (15 points)</td>
<td>Little evidence that material is related to proposed work or organized around hypotheses, objectives, or approach.</td>
<td>Most material related to proposed work. All material is not organized around hypotheses, objectives, and approach.</td>
<td>All material clearly related to proposed work. Organization around hypotheses, objectives, and approach.</td>
<td>All material related to proposed work. Strong, consistent organization around hypotheses, objectives &amp; approach.</td>
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<tr>
<td>Scholarship &amp; prior work (15 points)</td>
<td>No evidence to support understanding of prior work (poor scholarship). Does not convey how proposed work fills knowledge gap.</td>
<td>Either shows understanding of prior work or describes how work will fill a gap in knowledge.</td>
<td>Shows understanding of prior work. Describes how proposed work will fill a gap in knowledge.</td>
<td>Strong peer-reviewed research based support for proposed work. Clear description of prior work and gap in current knowledge.</td>
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<td>Work plan (15 points)</td>
<td>No clear work plan, or work plan is not related to stated objectives</td>
<td>Work plan is clearly outlined or description of work to be completed is clearly related to objectives.</td>
<td>Work plan is clearly outlined and the description of work to be completed is closely linked to proposal objectives.</td>
<td>Work plan outlined and summarized in a cohesive manner with a linkage to proposal objectives.</td>
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<tr>
<td>Grammar &amp; Mechanics (15 points)</td>
<td>Grammatical errors or spelling &amp; punctuation substantially detract from the proposal.</td>
<td>Very few grammatical, spelling or punctuation errors interfere with reading the proposal.</td>
<td>Grammatical errors or spelling &amp; punctuation are rare and do not detract from the proposal.</td>
<td>The proposal is free of grammatical errors and spelling &amp; punctuation.</td>
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<tr>
<td>Science writing style &amp; Communication (20 points)</td>
<td>Poor style detracts substantially from the paper. Word choice is informal in tone. Writing is choppy, with many awkward or unclear passages.</td>
<td>Poor style is noticeable. Word choice occasionally informal in tone. Writing has a few awkward or unclear passages.</td>
<td>Style does not detract from the paper. Scholarly style. Writing has minimal awkward or unclear passages.</td>
<td>Scholarly style. Writing is flowing and easy to follow.</td>
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<tr>
<td>Citations &amp; References (10 points)</td>
<td>Reference and citation errors detract significantly from paper.</td>
<td>Two references or citations missing or incorrectly written.</td>
<td>One reference or citations missing or incorrectly written.</td>
<td>All references and citations are correctly written and present.</td>
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Comments:  
Total: 0.0