Idealized Models of Climate Processes
EESC 6926
Department of Earth and Environmental Science, Columbia University

Instructors
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Meeting Times
MW 1-2:15

Office hours
At LDEO, by appointment

Course website
Courseworks

Prerequisites
Previous graduate-level coursework in atmosphere and/or ocean physics
and/or chemistry. One year of calculus. GR6901 or equivalent
programming experience. Or permission of instructor.

Textbook
There is no textbook. Readings will be posted on Courseworks.

COURSE DESCRIPTION:
This course teaches students to design and apply idealized models to study the fundamental
properties of climate system processes and their interactions. Though these models typically have
at their core only a handful of interacting differential equations, they can significantly advance
process understanding. We cover three topical areas in climate system science: (1) the interpretation
and attribution of atmospheric methane trends (2) the role of the ocean in regulating atmospheric
carbon dioxide, and (3) the influence of climate system feedbacks on the Earth’s energy balance.
Throughout the course, emphasis is placed on identifying assumptions underlying conclusions
drawn from simple models and the time scales over which different processes operate.

COURSE COMPONENTS:
Lecture: Lecture will be used to introduce basic principles of simple modeling and to introduce
each of the three modules.
Lab: Much class time will be devoted to working through modeling exercises relevant to each
module. Students will run existing models and modify these models to add new processes.
Discussion: Interspersed with lab sessions, discussions that integrate the models run in class and
the peer-reviewed literature will be held.
Final Project: Students will propose a unique final project in which they will further explore an
existing model or create their own new model. Students will prepare a presentation and short-format
style paper to summarize their work.

GRADING:
1. Labs 50%
2. Final Project 30%
3. Participation 20%

LATE WORK:
Submitting work on time is critical so that you can stay fully engaged with our discussions. Work
will receive a 10% reduction in credit for each day late.

ACADEMIC INTEGRITY:
Academic integrity is essential. Please make you are familiar with expectations and consequences
as outlined in the Faculty Statement on Academic Integrity and Honor Code established by the
students of Columbia College and the School of General Studies. If you have any further questions,
please contact the Professors. In this course, all infractions will result in loss of credit for the assignment in question, and will be reported per University policy.
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<th>Week</th>
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<th>Topic</th>
<th>Reading, Assignment Due</th>
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<td>1</td>
<td>4-Sep</td>
<td>Introduction</td>
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<td>2</td>
<td>9-Sep</td>
<td>Principles of mechanistic modeling</td>
<td>Sarmiento and Gruber, Ch 1</td>
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<td></td>
<td>11-Sep</td>
<td>Principles of mechanistic modeling</td>
<td>Jacob Ch3 (through 3.2); Brasseur&amp;Jacob (2017), Ch1 &amp; Ch4.7</td>
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<td>3</td>
<td>16-Sep</td>
<td>Introduction to Methane</td>
<td>Kirschke et al., 2013</td>
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<td>18-Sep</td>
<td>Lab 1: Methane (1 &amp; 2 box, OH constant)</td>
<td>Dlugokencky et al., 2003</td>
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<td>23-Sep</td>
<td>Discussion of Lab 1</td>
<td>Montzka et al., 2011</td>
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<td>25-Sep</td>
<td>Lab 2: Methane ( isotopes)</td>
<td>Lab 1 write up due; Schaefer et al., 2016</td>
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<td>Discussion of Lab 2</td>
<td>Nisbet et al., 2016</td>
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<td>2-Oct</td>
<td>Paper Discussion</td>
<td>Sections of Prather, 2007 (1,2,4); Naus et al., 2019</td>
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<td>6</td>
<td>7-Oct</td>
<td>Final Discussion, Methane</td>
<td>Lab 2 write up due; Turner et al. 2017; 2019; Prather &amp; Holmes, 2017</td>
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<td>9-Oct</td>
<td>Introduction to Ocean Carbon</td>
<td>Williams and Follows, Ch 5,6</td>
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<td>14-Oct</td>
<td>Lab 3: Ocean Carbon (2 box, biotic, no carbon)</td>
<td>Sarmiento and Gruber, Ch 8</td>
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<td>16-Oct</td>
<td>Discussion of Lab 3</td>
<td>Marinov et al. 2006</td>
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<td>21-Oct</td>
<td>Lab 4: Ocean Carbon (3 box, abiotic with carbon)</td>
<td>Lab 3 write up due; Sarmiento and Toggweiler, 1984; Knox and McElroy 1984; Sigenthaler and Wenk, 1984; Broecker et al. 1999</td>
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<td>Discussion of Lab 4</td>
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<td>Final Discussion, Ocean Carbon</td>
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<td>Election day holiday</td>
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<td>6-Nov</td>
<td>Student Project Proposals</td>
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<td>Introduction to Energy Balance Climate Models</td>
<td>Held 2005 BAMS</td>
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<td>13-Nov</td>
<td>Lab 5: Budyko-Sellers EBCM</td>
<td>Sellers 1969, Budyko 1970</td>
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<td>Discussion Lab 5</td>
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<td>20-Nov</td>
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<td>Pierrehumbert et al., 2011</td>
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Preliminary Bibliography


