Idealized Models of Climate Processes

EESC GR6926 – SPRING 2021 (REMOTE)

Department of Earth and Environmental Sciences, Columbia University

Instructors	Prof. Arlene Fiore / af2544@columbia.edu Prof. Galen A. McKinley / gam2156@columbia.edu
Meeting Times	MW 9:45-11:00
Office hours	By appointment or directly after class
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 and/or use observations to evaluate the model or add constraints from observations.

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	(includes co-presenting a paper)	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.

Week	Date	Topic	Reading (subject to change), ***Assignment Due***
1	11-Jan	Introduction	
	13-Jan	Lecture: Principles of mechanistic modeling	Jacob Ch3 (through 3.2); Brasseur&Jacob (2017), Ch1 & Ch4.7
2	18-Jan	*No class, MLK day*	
	20-Jan	Lecture: Principles of mechanistic modeling	Sarmiento and Gruber, Ch 1; Held 2005
3	25-Jan	Lecture: Introduction to Methane	Saunois et al., 2016; Kirschke et al., 2013
	27-Jan	Lab 1: Methane (1 & 2 box - constant lifetime)	Dlugokencky et al., 2003
4	1-Feb	Discussion: Lab 1	Prinn et al., 2005; Montzka et al., 2011.
	3-Feb	Lab 2: Methane (changing emissions, lifetime)	***Lab 1 write up due*** ; Patra et al., 2014
5	8-Feb	Discussion: Lab 2	Turner et al., 2018. Sections of Prather, 2007 (1,2,4)
	10-Feb	Discussion: Papers (student-led)	Nisbet et al. 2016; Schaefer et al., 2016;
6	15-Feb	Final Discussion, Methane	***Lab 2 write up due;*** Turner et al. 2017; Rigby et al., 2017; Prather & Holmes, 2017
	17-Feb	Lecture: Introduction to Ocean Biology and Carbon	Williams and Follows, Ch 5, 6
7	22-Feb	Lab 3: Ocean Bio & Carbon (3 box, biotic, carbon)	review Lab 3 assignment
	24-Feb	Discussion: Lab 3	Siegel et al. 2016, pg 1-5 *Encouraged to submit Lab 3 by end of week*
8	1-Mar	SPRING	
	3-Mar	BREAK	
9	8-Mar	Lab 4: Ocean Bio & Carbon (1 box, abiotic with carbon)	***Lab 3 write up; Project Proposal (BRIEF synopsis)*** Review lab 4 materials
	10-Mar	Discussion: Lab 4	McKinley et al. 2020; Peters et al. 2017
10	15-Mar	Discussion: Papers (student-led)	Broecker et al. 1999; Sarmiento, Toggweiler 1984; Siegenthaler, Wenk 1984; SG2006 pg 435-460
	17-Mar	Student Project Proposals Final Discussion: Ocean Bio & Carbon	***Lab 4 write up due*** Sigman et al. 2010
11	22-Mar	Lecture: Introduction to Energy Balance Climate Models	Sellers 1969, Budyko 1970
	24-Mar	Lab 5: Budyko-Sellers EBCM	
12	29-Mar	OFFICE HOURS with profs on project (Model status? What science questions are you trying to address?)	
	31-Mar	Discussion: Lab 5 Lightning talks on projects (30 min)	***lightning talk project update--*** 1 slide per project
13	5-Apr	Final Discussion, EBCM	***Lab 5 write up due***
	7-Apr	Project updates: working model & plan for sensitivity runs	***project update --*** 2 slides: model, sensitivity runs
14	12-Apr	Student Presentations	
	14-Apr	Student Presentations	
	19-Apr	PAPER DUE	