OCN 310L: Global Environmental Change Laboratory
(cross-listed as MET 310L and OEST 310L)

Marine Science Building, Room 307/314, Wed 1:30–4:00 pm

Instructor:

Joji Uchikawa, MSB 504, Email: uchikawa@hawaii.edu

TA:

Adam Jenkins, MSB 409, Email: adam9@hawaii.edu

Textbook:

"Consider a spherical cow: A course in environmental problem solving"
by John Harte
University Science Books, Sausalito, CA, 1988. ISBN: 0-935702-58-X.

Grading:

Weekly homework assignments: 30%
Homework presentation and class participation: 40%
Draft, paper and oral presentation: 30%
No midterm! No final!

Rules:

In fairness to other students, draft or paper turned in 1 and 2 days late will receive a grade corresponding to 2/3 and 1/3 of the points scored, respectively. After 2 days, zero credit will be given. Homework not turned in before class receives 0 points. These rules apply unless there is a documented reason such as medical emergency or funeral.

In this class you will develop and improve skills in working out strategies and ideas how to quantitatively solve problems. The topics will focus on Earth's environment. Your challenge will be to develop concepts and approaches to various problems and finally provide useful solutions to them (calculating sophisticated, highly accurate answers will not be the goal, rather useful approaches and reasonable values will be required). This is sometimes not a trivial task and you should **anticipate to spend a considerable amount of time on your homework**, but – as the famous physicist Richard Feynman has put it – you will have "the pleasure of finding things out"!

If necessary, contact Adam regarding your homework – but only after in-depth consideration of the problem and with a preliminary idea or a precise question.

Course Outline:

The first part of the class will be concerned with problems and exercises of the textbook. Every week, homework will be assigned and turned in before class the week after. The homework will be discussed in class and every week some of you will present their solutions to the other students. The presentation will rotate and at the end of the semester each student will have presented approximately the same number of exercises.

The second part of the class will be concerned with developing and using numerical tools for quantitative problem solving. The scientific topic will focus on phosphorus cycling in the ocean. You will develop a numerical algorithm (in groups of two) to solve the equations of a box model of the ocean's phosphorus cycle (Toggweiler, 1999). The software used for this application will be MATLAB (**bring a memory key to every class in order to save your files!**). After development of the base model, you will choose a project which will serve as the subject of your paper and oral presentation. A typical project will require changes to the existing numerical code in order to perform a sensitivity study or tackle a related/advanced problem.

Tentative Schedule:

August 28

- Introduction
- Chapter I.1–I.6
- Homework (due Sept 04):
  - Related exercises, to be assigned
  - Read p. 21–33, Chapter II.1–II.4

September 4

- Chapter II.1–II.4
- Homework (due Sep 11):
  - Related exercises, to be assigned
  - Read p. 34–44, Chapter II.5–II.7

September 11

- Chapter II.5–II.7
- Homework (due Sep 18):
  - Related exercises, to be assigned
  - Read p. 45–58, Chapter II.8–II.10

September 18

- Chapter II.8–II.10
- Homework (due Sep 25):
  - Related exercises, to be assigned
  - Read p. 59–69, Chapter IIC (II.11–II.13)

September 25

Chapter II.11–II.13

Homework (due Oct 02):

Related exercises, to be assigned

Read p. 95–108, Chapter IIC (II.19–II.20)

October 2

Introduction to chemical equilibria

Chapter II.19–II.20

Homework (due Oct 09):

Related exercises, to be assigned

Read p. 111–113, 138–149, Chapter (II.22, III.4)

October 9

Non-steady state box models and carbonate chemistry

Chapter II.22, III.4

Homework (due Oct 16):

Related exercises, to be assigned

Read MATLAB Intro

October 16

Introduction to MATLAB

Homework (due Oct 23):

Solve analytically $dy/dt = l\,y$, $y(0) = y_0$

Write and E-mail MATLAB "m-file" for plotting of the results

October 23

Solve numerically $dy/dt = l\,y$, $y(0) = y_0$

Develop routines for base model (PO_4 in 3-box model)

Homework (due Oct 30):

Write and E-mail MATLAB "m-file" for numerically solving $dy/dt = l\,y$, $y(0) = y_0$

Read description of the final project

October 30

Discussion of Toggweiler box-model

Discussion/Assignment of the final project

Develop routines for base model (PO_4 in 3-box model)

Homework:

Work on model/Read project description

November 6

Develop routines for base model (PO_4 in 3-box model)

Homework:

Work on model

November 13

Finalize routines for base model (PO_4 in 3-box model)
Model modifications/runs for the project
Homework (due Nov 20):
- E-mail MATLAB “m-file” for PO_4 in 3-box model
- Work on model/draft paper

November 20

Model modifications/runs for the project
Work on draft paper
Homework:
- Work on model/draft paper

November 27

Finalize model runs for the project
Work on draft paper
- Homework:
- Draft paper

Wednesday, November 27, 6:00 PM

Draft Paper Due for Review → Mailbox, MSB 502

December 4

Discussion of reviewed draft paper
Work on presentation/final paper in class
Homework:
- Work on final paper
- Prepare oral presentation

Friday, December 6, 4:00 PM

Final Paper Due → Mailbox, MSB 502

December 11

Group presentations of the final project

Final Projects

Address one of the following problems.

I. The ocean's conveyor and biological particle export. There is a possibility that due to human induced climate change the ocean's conveyor (thermohaline circulation, overturning) may slow down or even shut down completely in the future. Use Toggweiler's (1999) box-model to estimate the potential effect of a conveyor slowdown on the low-latitude particle export (corresponding atmospheric CO_2 concentrations will be supplied). Summarize your results using tables and graphs. What is the reason for the change in particle export and pCO_2 in the model?

References.

Schmittner, A., Decline of the marine ecosystem caused by a reduction in the Atlantic overturning circulation. *Nature* 434, p. 628, 2005.

Rahmstorf, S. Shifting seas in the greenhouse? *Nature* 399, p. 523, 1999.

II. Ocean fertilization and high-latitude nutrients. Atmospheric CO_2 has increased by more than 30% over its natural level over the past 250 years due to anthropogenic CO_2 emissions from fossil fuel burning and cement manufacturing. It has been suggested to fertilize biological unproductive areas such as the Southern Ocean with iron in order to stimulate the biological carbon pump (particle export) and sequester CO_2 in the ocean. Use Toggweiler's (1999) box-model to estimate the potential effect of high-latitude fertilization on highlatitude nutrients (corresponding atmospheric CO_2 concentrations will be supplied). Summarize your results using tables and graphs. What is the maximum PO_4 (pCO_2) reduction that can be achieved in the model?

References.

www.planktos.com

www.greenseaventure.com

Zeebe, R.E., and D. Archer, Feasibility of ocean fertilization and its impact on future atmospheric CO_2 levels. *Geophys. Res. Lett.*, 32, L09703, doi:10.1029/2005GL022449, 2005.

Schiermeier, Q., Iron seeding creates fleeting carbon sink in Southern Ocean, *Nature* 428, p. 788, 2004.

Important: Discuss your results and note that the model employed is an extremely simple one. List **all** literature references you have used for this project. Cite appropriately (cf. Toggweiler, 1999). All figure axes must have labels and units (if applicable). Use a spelling checker.

Paper format: 5–10 pages, excluding figures, tables, and references. 10–12 point type, double-spaced. More than 10 pages is unacceptable.

Title.
Abstract. Brief summary of content and conclusions of the paper (this is not an introduction). < 1/2 page.

Introduction: 1 – 2 pages.
Outline the problem and provide background information on the problem you worked on. Why is this issue important?

Methodology: 1 – 2 pages.
Briefly describe the model. Put emphasis on the changes you applied.

Results: 1 – 2 pages.
Present your results. No discussion or interpretation here (see next section). Include graphics/tables and refer to them. The figures must be numbered, figure axes must have labels and units (if applicable).

Discussion: 1 – 2 pages.
Discuss your results, also with respect to their relevance in a broader context. If possible discuss potential shortcomings of the model.

Conclusions: < 1 page.
Brief summary of what has been done and learned. Possible directions for future studies.

References.
List **all** literature references/data sources used. Cite appropriately (cf. Toggweiler, 1999). A reader of your paper must be able to find the references.

Note on WWW-Refs
You can use the web to search for information on your topic. In your paper, however, references to articles in scientific journals and books are much preferred. Do not use web-references to prove a controversial point. In contrast to scientific journals or books, web-documents are not peer-reviewed. In other words, you can find useful information as well as absolute nonsense on the web.