12.747 SYLLABUS

Modeling, Data Analysis, and Numerical Techniques for Geochemistry

David M. Glover, William J. Jenkins and Scott C. Doney
Dept. Marine Chemistry and Geochemistry
Woods Hole Oceanographic Institution

Fall 2008

July 7, 2008

Overview

This course is aimed primarily at JP students in the MC&G department with the goal of providing these students with the computational underpinnings necessary for them to complete their theses, more and more of which today require numerical techniques and modeling. The course is designed in such a way that students from other departments may find the material geochemical, but useful. The course is divided into three units. The first two emphasize the basic skills needed for data assimilation, handling and the basic tool-set for modeling. The last section is aimed at a representative series of case studies of models with the goal of understanding, analyzing and critiquing the numerical approaches. Our goal is to instill a good conceptual grasp of the basic tools. We like to say, "the course is correct, but not mathematically rigorous". Throughout the course the general principles and goals of scientific visualization will be emphasized through technique and tools. This course uses MATLAB as its computational engine and some programming in MATLAB is required, consequently a certain amount of MATLAB instruction occurs throughout the course.

Marking Policy

- There is no final exam.
- Course grade will be based on marks for the assignments.
- There are 10 assignments.
- Assignments will be "handed out" on Thursdays, and due the following Thursday (some assignments will be two weeks).
- Assignments handed in late but by the Monday following the due date will be penalized 10%
- Answers to the assignments ("model answers") will be posted the Tuesday following the due date. Assignments not handed in by that time will receive a grade of zero.

Lectures and Lecture Notes

Notes for lectures will be posted on the web page (http://w3eos.whoi.edu/12.747) at least 24 hours before the lecture. The student can print the notes and bring a copy to class for annotation during the lecture if he or she so desires. While the lecture notes are fairly comprehensive, the student is advised that additional material, demonstrations, and alternate explanations will be provided in the lectures. This additional instruction may prove useful for successful completion of the assignments. A recitation will be provided once a week with a TA and at least one lecturer in attendance. Questions and requests for clarification are welcome at any time before, during and after class. Lecture attendance is strongly advised.

Schedule

A. Data analysis and statisitics (9 lectures)

(**1**) *4 Sep 2008*: Resources, MATLAB primer and intro to linear algebra (SVD)

(**2**) *9 Sep 2008*: Measurement theory, probability distributions, error propagation and analysis

(**3**) *11 Sep 2008*: Least Squares and regression techniques, goodness of fit and tests, non-linear least squares techniques

(**4**) *16 Sep 2008*: Principle Components and Factor Analysis, part 1

(**5**) *18 Sep 2008*: Principle Components and Factor Analysis, part 2

(**6**) *23 Sep 2008*: Time Series Analysis, Correlation and Autocorrelation

(**7**) *30 Sep 2008*: Fourier and Spectral Analysis

(**8**) *2 Oct 2008*: Objective mapping and Kriging, part 1

(**9**) *7 Oct 2008*: Objective mapping and Kriging, part 2

B. Modeling Techniques (7 lectures)

(**10**) *9 Oct 2008*: Ordinary differential equations and 0-D box models

(**11**) *14 Oct 2008*: Tutorial of numerical modeling

(**12**) *16 Oct 2008*: Model analysis and optimization

(**13**) *21 Oct 2008*: Advection-Diffusion Equations, part 1

(**14**) *23 Oct 2008*: Advection-Diffusion Equations, part 2

(**15**) *28 Oct 2008*: Introduction to finite difference techniques, part 1

(**16**) *30 Oct 2008*: Introduction to finite difference techniques, part 2

C. Modeling Case Studies (8 lectures)

(**17**) *4 Nov 2008*: 1-D Open Ocean Models

(**18**) *6 Nov 2008*: 1-D Sedimentary Systems

(**19**) *13 Nov 2008*: 1-D Upper-Ocean Seasonal Models

(**20**) *18 Nov 2008*: 2-D Gyre models

(**21**) *20 Nov 2008*: 3-D General Circulation Models

(**22**) *25 Nov 2008*: Inverse Methods and Assimilation Techniques

(**23**) *2 Dec 2008*: 3-D Ocean Inversions

(**24**) *4 Dec 2008*: Scientific Visualization: principles, techniques, tips

Main Texts:
Press *et al.*: Numerical Recipes, 2nd or 3rd Ed.
Bevington and Robinson: Data Reduction and Error Analysis for the Physical Sciences

Additional Texts:
Reyment and Jöreskog: Applied Factor Analysis in the Natural Sciences
Strang: Introduction to Applied Mathematics
Clark: Practical Geostatistics
Davis: Statistics and Data Analysis in Geology, 2nd or 3rd Ed.
Roache: Computational Fluid Dynamics, 2nd Ed.

MATLAB used as computational environment