21-460-375: Quantitative Methods in the Geosciences
Fall 2014 Syllabus

Instructors: Dr. Kristina Keating and Dr. Lee Slater
Offices: 139 (Keating) and 137 (Slater) Smith Hall
Office Hours: W 10:30-11:30
Meeting Time: Mon 1-3:50 (lecture), Wed 11:30-2:20 lab

Course Description
This course provides an overview of the basic quantitative and computing methods used to understand geoscience datasets. The student will gain confidence in the quantitative interpretation of geoscience datasets and acquire skills that are required to fully understand many earth and environmental science subject areas. Concepts covered include [1] plotting and visualizing geoscience data, [2] basic data analysis using Excel and Matlab, [3] linear regression and curve fitting models to geoscience datasets, [4] krigging methods, [5] time series analysis. Examples illustrating each concept will be drawn from the geosciences.

Learning objectives
The primary learning objective of this course is also a key learning objective for the environmental science and geology major programs offered by the department of earth and environmental sciences: Acquisition of quantitative skills relevant to the geosciences and environmental sciences through the collection, analysis, and synthesis of scientific data

Course specific learning goals that fall under this department level goal include:
- Mastery of basic numeric manipulation and literacy
- Mastery of basic processing, curve fitting and graphical analysis of data using Excel and Matlab
- Ability to apply simple models to geoscience datasets and estimation of model parameters, along with uncertainty assessment
- Familiarity with basic time series analysis methods for extracting geoscience information from time series datasets

Schedule of readings and assignments (weekly)

Weeks 1-2 are designed to introduce fundamental basic quantitative skills. Weeks 3-5 are directed at gaining expertise and confidence in Excel and Matlab, two of the most extensively used tools for quantitatively investigating geoscience data. Weeks 6-14 will use these tools to interpret different aspects of data drawing from examples across a broad range of the geosciences.

Week 1: Introduction: Why do we need quantitative analysis of geoscience data? Examples from scientific literature and popular media (e.g. the hockey stick curve). Solving problems. Approaches for problem solving (what are the data, what are the unknowns, what are the constraints, drawing a diagram, etc).

**Week 3: Introduction to the spreadsheet**: Basic Excel skills (entering data, making calculations, plotting two variables).

**Week 4: Understanding variables and numerical relations I (single variable functions)**: Defining independent and dependent variables. Review of basic numerical relations (linear, polynomial, exponential, trigonometric, logarithmic etc). Verbal descriptions of numerical relations.


**Week 6: Understanding variables and numerical relations II: Multiple variable functions.** Difference between vectors and scalars. Simple 2D and 3D plots (no contouring).

**Week 7: Data collection and analysis I: basic statistics**: Assessing data quality. Calculating means and standard deviations and probability density functions. Understanding a histogram.

**Week 8: Data collection and analysis II: Interpreting results**: Developing logical conclusions based on numerical relations. Understanding sources of error and error propagation rules. Understanding assumptions and how that affects numerical relations.

**Week 9: Numerical models in the geosciences**: the difference between data (inputs) and model parameters (unknowns). Understanding fluxes and rates. Developing flow charts.

**Week 10: Predicting geoscience data with a model**: the ‘forward’ problem

**Week 11: Estimating model parameters from geoscience observations**: the ‘inverse’ problem

**Week 12: Time series analysis**: Extracting the important information from long geoscience datasets.

**Week 13: Time-frequency analysis**: Analyzing the frequency content of time series data and what it means. Identifying wave characteristics (wavelength, period, amplitude, frequency). Recognizing periodic phenomena (in time and space).

**Week 14: Interpolation, kriging and contouring spatial geoscience data**: Developing a meaningful interpolation. Understanding kriging artifacts.

**Texts**: There is no required text for this book as all material for this course (both lecture and lab) will be constructed by the Professors using examples of their own work in the geosciences, along with the extensive resources developed by the Science Education Resource Center (SERC) at Carlton College in recognition of the need to improve quantitative training in undergraduate geosciences (http://serc.carleton.edu/quantskills/about.html).

**Assignments**

- **Take home assignments**: –Weekly labwork assignments are due in class the following week†
- **Data analysis assignment**: an extended project that the student will work on using data provided by the instructor
- **Mid-term**: in class (closed-book) format – time TBA
Final: (closed book) format – time determined by Rutgers Exam Schedule
Quick quizzes: in-class (closed book) format

†Electronic completion of the laboratory work is due by the beginning of the class in the week following the lab.

Grading:

The breakdown for the grading is as follows.

• Take home assignments/lab write-ups: 30%
• Data analysis assignment: 10%
• Mid-term: 25%
• Final: 25%
• Quick quizzes: 10%

Student responsibilities

Students are responsible for attending class, arriving on time, and participating in class discussions and classroom activities. Students are responsible for handing in assignments on time as no late assignments will be accepted. Students that do not hand in the assignment in the day it is due will receive 0 for that assignment.

The problems and labs assigned in this class are designed to help improve student problem solving abilities and to encourage independent learning. As such, to answer some of the problems students may be required to do research beyond what is directly taught in class. To facility this approach, students are strongly encouraged to take advantage of the faculty office hours and to work in groups.

SERIOUS STUFF:

Americans with Disabilities Act Statement: If you need accommodations because of a documented disability, contact the Disabled Student Services Office on x5300

Academic Honesty Policy: Cheating in any form will not be tolerated. The first occurrence of any of this behavior will result in a grade of "F".