Syllabus: SIO 221B, Data Analysis

Sarah Gille
Lectures: Monday/Wednesday/Friday 10:00-10:50, Nierenberg Hall 101
SIO Office: Nierenberg Hall 348
Telephone: 822-4425 *e-mail:* sgille@ucsd.edu
Course website: http://www-mae.ucsd.edu/∼sgille/sio221b
Grading:

- 50% homework
- 20% midterm
- 30% final exam

No Class: October 21, 23. We will arrange one or two make up lectures.
Midterm: Take home exam due October 25.
Final exam: Friday, December 13, 8:00-11:00 am, subject to change.

Course Outline

I. Principles of ocean instruments (2)
   A. How are sea water properties, velocity, air-sea fluxes, and surface waves measured?
      1. How do instruments work?
      2. How are observations made?
      3. What does data look like?
   B. Some simple observational problems
      1. Drake Passage transport
      2. Observing the Ekman spiral

II. Randomness and statistics (6)
   A. The origin of “randomness” in dynamical systems.
      1. The concepts of dynamical degrees of freedom and unpredictability based on a simple chaos model.
      2. Relevance to scale ranges in the ocean/atmosphere system.
   B. Basic probability.
      1. Probability density functions (PDFs) and joint probability density functions.
      2. Averages and moments.
      3. Averages from PDFs.
      4. Scatter plots, covariance and correlation.
      5. Conditional probability and the approach to determinism.
      6. Correlation of independent events.
      7. PDFs of functions.
   C. Discrete random walks.
      1. Central limit theorem.
      2. Serially correlated discrete random walks.
      3. Continuous random walks (Taylor diffusion).
      4. The diffusion equation from random walk and central limit theorem.

III. Decomposition of signals (1)
   A. The philosophy of signal vs. noise decompositions.

1. The algebraic problem: Inverse theory.
2. The statistical problem: Statistical Estimation.

B. Some examples.

1. Function fitting.
2. Fourier analysis of time series.

IV. Inverse problems (9)

A. Examples of oceanographic inverse problems.

1. Beta spiral.
2. Control volumes.

B. Least-squares problems.

1. "Over-" and "under-" determined problems.
2. Constraints.
3. Simultaneous minimization of misfit to data and solution size.

C. A practical review of linear algebra.

D. Singular value decomposition.

1. Relationship to the simultaneous minimization problem.

E. Resolution and error as measures of goodness.

V. Applying probability concepts to data (3)

A. Construction "ensembles" for statistical treatment of observations.

1. What stationarity really means.
2. Ergodicity.

B. Sampling errors of mean and variance.

1. $1/\sqrt{N}$ convergence.
2. Bias, mean-square error and probable error of sample estimates.
3. Estimating variance: an introduction to statistical "beauty" principles.
4. Effect of serial correlation on sampling errors.

VI. Statistical estimation (6)

A. Regression models.

1. Joint-normal distributions.
2. Statistical forecasting.
3. Improving persistence forecasts.

B. Objective mapping as multivariate regression.

1. Unbiased estimates and the mean.
2. Mixing observations of different types.
3. Imposing constraints.
4. Model testing from mapped fields vs. statistical tests.

VII. Efficiency of representations (3)

A. Principal axes.

B. Review of Fourier spectra.

C. Empirical Orthogonal Functions (EOFs).

1. Relation of EOFs to Fourier analysis.

Texts for SIO 221B: Analysis of Ocean Observations

Bendat, J. S. and A. G. Piersol, 1986: *Random Data: Analysis and Measurement Procedures*. John Wiley & Sons, 566 pp.

Daley, R., 1991: *Atmospheric Data Analysis*. Cambridge University Press, 457 pp.

Emery, W. J. and R. E. Thomson, 2001: *Data Analysis Methods in Physical Oceanography*, 2nd edition. Elsevier, 638 pp.

Lawson, C. L. and R. J. Hanson, 1974: *Solving Least Squares Problems*. Prentice-Hall, 340 pp. (reprinted 1997)

Menke, W., 1989: *Geophysical Data Analysis: Discrete Inverse Theory*. Academic Press, 289 pp.

Noble, B., and J. W. Daniel, 1988: *Applied Linear Algebra*, 3rd edition. Prentice-Hall, 521 pp.

Preisendorfer, R. W., 1988: *Principal Component Analysis in Meteorology and Oceanography*, Elsevier, 425 pp.

Press, W. H., B. P. Flannery, S. A. Teukolsky and W. T. Vetterline, 1986: *Numerical Recipes*. Cambridge University Press, 818 pp.

Strang, G., 1976: *Linear Algebra and Its Applications*. Academic Press, 414 pp.

Strang, G., 1986: *Introduction to Applied Mathematics*. Wellesley-Cambridge Press, 758 pp.

Taylor, J. R., 1982: *An Introduction to Error Analysis*. University Science Books, 270 pp.

Wunsch, C., 1996: *The Ocean Circulation Inverse Problem*. Cambridge University Press, 442 pp.