METO630 STATISTICAL METHODS IN METEOROLOGY AND OCEANOGRAPHY (3)
Updated January 2004 (Eugenia Kalnay/Huug vanden Dool)

Prerequisite: STAT 400 or equivalent. Tests of significance; time series analysis; multiple regression and screening multiple regression; statistical weather and climate prediction.

1. Introduction, probability distributions, tests of significance (3 weeks)
   (1) Introduction - concepts of probability, random variables and probability distributions. Wilks: Chapters 2, 3, 5.1
   (2) Probability distributions, discrete, continuous - the normal distribution, Central Limit theorem, χ^2 -distribution, t-distribution, and Fisher's F-distribution. Gumbel, Gamma and other distributions. Wilks: 4.1-4.5; 4.7
   (3) Tests of hypothesis - Type I error, Type II error, level of significance, one tailed tests and two tailed tests. Parametric tests of significance against non-parametric tests and Monte Carlo methods. Bootstrapping. Wilks: 5.1-5.4

II. Statistical Weather forecasting (3.0 weeks) Wilks: Chapter 6; other refs.
   (1) Simple regression - estimation of regression line, analysis of variance, confidence interval for regression coefficients, and confidence band for regression line.
   (2) Multiple regression - estimation of regression plane, partial correlation, and multiple correlation.
   (3) Screening regression - explained variance and incrementally explained variance, all possible regression, forward selection, stepwise regression, and stagewise regression.
   (4) Model Output Statistics, Perfect Prog, Adaptive Regression (Kalman Filtering). Guest Lecturer: Paul Dallavalle or Mark Antolik.
   (5) Nonlinear regression, neural networks (guest lecturer, V. Krasnopolsky).
   (6) Probabilistic forecasting and verification from ensembles (guest lecturer, Zoltan Toth).

III. Time series (3.0 weeks) Wilks: Chapter 8, plus additional refs.
   (1) Introduction - definitions of stochastic processes: purely random process, stationary process, auto-regressive process and non-stationary process.
   (2) Analysis of discrete time series - harmonic analysis, smoothing and filtering, frequency response of smoothing and filtering functions, and construction of low-pass, band pass and high-pass filters.
   (3) Power spectrum analysis - Methods of estimating power spectra: Lag-correlation, Fast Fourier Transform, Maximum Entropy. Aliasing.
   (4) Cross-spectrum analysis - Estimation of co-spectrum, quadrature-spectrum and coherence.
   (5) Wavelets (guest lecturer: S. Schubert)

IV. Statistical methods for climate prediction (5.0 weeks, lecturer: Huug vanden Dool)
   (1) Introduction: Empirical orthogonal functions (principal components) - rotated and complex empirical orthogonal functions. Canonical correlation analysis. Discriminant analysis, clustering (Wilks, Chapter 9)
   (2) Applications developed at CPC: Empirical Wave Propagation; Natural analogues; Constructed analogues; Empirical Basis Functions; Teleconnections; Empirical Orthogonal Teleconnections: examples from reanalysis; Empirical Orthogonal Functions; Compact representation of data sets

V. Forecast verification (0.5 week)
   (1) Currently used operational forecast scores

Required Text:
Daniel Wilks: Statistic Methods in Atmospheric Sciences (1995) Academic Press. ISBN 0-12-751965-3

Recommended reference textbook:
Hans von Storch and Francis Zwiers (1999): Statistical Analysis in Climate Research. Cambridge University Press (now in paperback).