HWR/CE 655 STOCHASTIC HYDROLOGY
Fall 2004

Catalog Description

HWR 655 Stochastic Hydrology. Topics and applications will vary with instructor. Advanced application of statistics and probability to hydrology, time series analysis and synthesis, and artificial neural network methods, as applied in the modeling of hydro-climatic sequences. A combination of theory and application to the fields of hydrology, environmental and water resources engineering, climatic modeling, and other related natural resource modeling. (Identical with CE 655)

Instructor: Dr. Juan B. Valdés
Class Time & Place: TR 2:00-3:15 CE201
Office Hours: By appointment, call 621-6564
Offices: CE 206C
e-mail: jvaldes@u.arizona.edu
Web: http://civil.web.arizona.edu/~civil/staff/valdes.html
Prerequisites: HWR 545 Statistical Hydrology (recommended)

Objectives: To present modern techniques of time series analysis and synthesis to be applied in the modeling of hydro-climatic sequences. The course presents a combination of theory and real world applications of these techniques to the fields of hydrology, environmental and water resources engineering, climatic modeling and other related natural resources modeling.

Tentative Outline

1 Introduction.
1. Definitions.
2. Review of probability distributions most frequently used in hydro-climatic modeling.
3. Examples of hydroclimatic time series. Sample statistics: mean, variance, auto-correlation and cross-correlation functions, periodogram.
4. Derived distributions. Why is stochastic modeling needed? Montecarlo simulations.

2 Univariate Models for Sequential Generation of Hydro-Climatic Series: Time domain.
1. Introduction. Definitions: stationary/non-stationary processes. Strict and second order stationarity. The auto-correlation (ACF) and autocovariance (ACVF) functions.
2. Simple stochastic processes: white noise, random walk, moving average (MA), autoregressive (AR).
3. Annual autoregressive lag-1 model, AR (1). Discrete and continuous versions. Normal and Non-normal Versions
4. Other univariate generation models: ARMA(p,q) and ARIMA(p,d,q).
5. Seasonal AR(1) model. Mixed Distributions
6. General Linear Process. Continuous Processes.

7. Estimation: Introduction. Methods of estimation. Time and frequency domains.
8. Time domain estimation: Estimation of ACVF and ACF functions. Interpretation. Partial Autocorrelation Function (PACF).
9. Model identification and parameter estimation of Box-Jenkins models (AR, MA, ARMA and ARIMA).
10. Applications to environmental and water resources engineering.

3 Univariate Models for Sequential Generation of Hydro-Climatic Series: Frequency domain.

1. Frequency domain analysis and estimation. Introduction.
2. The spectral distribution and density functions.
3. Spectrum of a continuous process. Spectra of selected stochastic processes.
4. Periodogram analysis. Nyquist frequency. Relationship between ACVF and periodogram. Properties.
5. Spectral analysis: consistent estimation procedures. Fourier transform of ACVF. Windows: Tukey, Parzen. Hanning and Hamming. Smoothing of the periodogram. Fast Fourier transform. Confidence intervals for the spectrum.
6. Analysis of continuous time series.
7. Applications to environmental and water resources engineering.

4 Frequency Domain: Singular Spectrum Analysis (SSA)

1. Introduction
2. Reconstruction in Time Domain
3. White Noise SSA
4. Red Noise SSA
5. Multi Channel SSA (MSSA)

5 Spatial Issues: Definition of Homogeneous Regions

1. Geographical Methods
2. Statistical Characterization Methods
3. Specific Characterization Methods
4. Homogenous Test Methods

6 Empirical Orthogonal Functions (EOFs)

1. Introduction
2. Empirical Orthogonal Functions
3. Rotated EOFs
4. Other Approaches:
    a. Combined PCA
    b. Complex EOF
    c. Extended EOF
    d. Periodic Extended EOF
5. Principal Oscillation Patterns (POP)

7 Canonical Correlation Analysis (CCA)

8 Multivariate Models for Sequential Generation of Hydro-Climatic Series

1. Introduction. Crosscorrelation Function, CCF.
2. Multivariate Stationary AR(1) Model. Definition. Parameter Estimation. Generation.
3. Multivariate Seasonal AR(1) Model. Definition. Parameter Estimation.
4. Disaggregation Model. Definition. Parameter Estimation.
5. Introduction to Long Term Stochastic Processes and Phenomena.
6. Applications to environmental and water resources engineering.

9 Forecasting Methods

1. Introduction
2. Adaptive State-Space Models
3. The Kalman Filter
4. Applications of the Kalman Filter
5. Forecasting Performance Measures

10 Point Processes and Multidimensional Models

Evaluation

Homeworks	40%
Term Paper/Presentation	60%

Main Reference:

"The Analysis of Time Series: An Introduction, **"** C. Chatfield, Chapman and Hall, Sixth Edition, 2003. (QA280.C4) (required)

Other References:

"Statistical Analysis in Climate Research," von Storch and Zweirs, Cambridge University Press, 1999. (QC981.S735)

"Random Functions and Hydrology"; R. Bras and I. Rodriguez-Iturbe, Dover Publ., 1992 (previous version was published by Addison Wesley Publ., 1984). (GB656.2.M33.B73)

"Statistical Hydrology", C.T. Haan, Iowa State University Press, Second Edition, 2002. (GB656.2.S7.H3)

"Applied Modeling of Hydrologic Time Series", J.D. Salas, J.W. Delleur, V. Yevjevich and W.L. Lane, Water Resources Publications, 1980.