Lecture – Tues., 5/9/06

ANNOUNCEMENTS
• HW2 and the midterm exams will be returned on Thursday
• HW3 will be posted on the course webpage soon
• Final Project – will be introduced in class on Tues., 5/16

THIS WEEK – Analysis of Time-Series Data
TODAY
• examples
• descriptive methods
THURSDAY
• statistical models for time-series data
• forecasting

Times Series -- Examples

U.S. Population (every 10 years)

from Brockwell and Davis (1996)
Times Series -- Examples

UK Lung Cancer Deaths

from Diggle (1990)

Times Series -- Examples

Atmospheric Concentrations of CO₂ in Mauna Loa, Hawaii

from Cleveland (1993)
Times Series -- Examples

Yearly Number of Sunspots

from Tong (1996)

Times Series -- Examples

Water Levels in Lake Huron

from Brockwell and Davis (1996)
Times Series -- Examples

Temperature Proxy Data

from Jones et al. (1998)

Common Features of Time-Series Data:
1. 
2. 
3. 
4. 
5.
Common Goals of Statistical Analyses of Time-Series Data:
1.
2.
3.
4.

Fundamentals
• Stochastic/time-series process
• Realization of a time-series process
• Continuous versus discrete time processes
Time-Series – Descriptive Methods

Consider a discrete time-series process \( \{X_t; t = 0, 1, \ldots \} \) and a realization of this process \( \{x_t; t = 0, 1, \ldots \} \).

**Trend Process:** \( X_t = \mu_t + \varepsilon_t \)

**Trend Estimation**

Idea: Assume some appropriate form for the trend.

- Linear

- Regression

- Nonlinear Parametric Form
Time-Series – Descriptive Methods

Trend Removal
- First-order differencing

- Second-order differencing
- General $p^{th}$-order differencing
Time-Series – Descriptive Methods

- Linear filters for smoothing time-series data

**Periodic (Seasonal) Process:** $X_t = s_t + \varepsilon_t$

**Estimating Periodicities** (assuming the period, $p$, is known)
- *Ad hoc* approach: average observations with a time separation $p$
- Regression on sine/cosine terms

**Removing Periodicities**
- differencing at separations of $p$
- smoothing
QUESTIONS
How can we estimate/remove periodicities if we don’t know the period, $p$? What if there is more than one cyclical component of the time-series?

Sunspots Example

Autocorrelation at lag $k$:

SAMPLE AUTOCORRELATION FUNCTION
(sometimes called the correlogram)