Summer 2008
Bayesian Spatio-Temporal Data Analysis

http://www.stat.ncsu.edu/people/fuentes/courses/barcelonaspatial/

Instructor:

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Description:

The course will cover the methodology and modern developments for spatial-temporal modeling estimation and prediction, Bayesian spatial statistics and hierarchical frameworks, spatial point processes, and spectral analysis of spatial processes. This course goes beyond standard practices and exposes the students to all the new developments and state of the art modern techniques for spatial data. All the methods presented will be introduced in the context of a specific dataset, then the motivation behind a particular method will be evident as it is developed. Some of the lectures will be held in the computer lab using the software R and WinBUGS, previous knowledge of R will not required.

Course prerequisites:

Linear Models and Variance Components.

Textbook:

The course material will be based on a set of notes being prepared by the instructor. This book is a good reference:

- *Hierarchical Modeling and Analysis for Spatial Data.* Banerjee, Carlin and Gelfand. Chapman and Hall.

Other recommended books:

- *Statistics for Spatial Data.* Noel Cressie. Wiley & Sons. 1993. (more complete and more advance level. It is a very good reference book but at an advance level.)
- *Interpolation of Spatial Data.* M. Stein. Springer, 1999. (Very advance level, this is a good reference book for spatial statistics in the spectral domain)

Schedule:

The course will be from 3-7pm on June 19, June 20, June 25, June 26 and June 27.

From 3-5:45pm the class will be held in the regular classroom, and from 5:45 to 7pm in the computer lab (except for June 25). On June 25 the class will be held from 3-7pm in the regular classroom.

See the website of the course for additional information about the material covered in class:

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Labs:

The software used for this course is R and WinBUGS. The lab classes will be from 5:45-7pm everyday (except for June 25), and the notes will be posted on the course website.

Lecture Notes:

Lecture notes and handouts will be available on the web.

Objectives:

This course will cover a number of areas of spatial statistics and data assimilation applied to real, scientific and interesting problems. A tentative list of more specific topics is as follows:

- Introduction to spatial statistics:
  - Point level models
  - Areal (lattice) models
  - Spatial point processes.
- Estimation and modeling of spatial correlations:
  - estimating variogram
  - fitting parametric models: Matern class
  - maximum likelihood estimation
  - restricted maximum likelihood
- Prediction and Interpolation (kriging):
  - Spatial regression
  - Kriging
  - frequentist corrections for unknown covariance structure
  - model misspecification in kriging
- Bayesian spatial statistics:
  - Bayesian estimation
  - Bayesian kriging
  - Bayesian priors for covariance parameters
  - Hierarchical Bayesian methods.
- Spatial-temporal processes.
  - point-level modeling with continuous time
  - nonseparable models
  - dynamic space-time models
  - block-level modeling

  - misaligment problem.

- Nonstationary spatial processes:
  - Bayesian deformation approaches
  - eigenfunction expansion of the covariance (EOFs)
  - kernel based methods
  - mixing of process distributions

- Spectral domain:
  - Fourier Theory
  - Spectral Representation of a Spatial Process
  - Spectral Density and periodogram
  - Spectral methods to approximate the likelihood
  - Increasing domain asymptotics
  - Infill asymptotics

  Some of the lectures will be conducted in the computer lab. Students will learn how to use existing software, the emphasis of the course is to learn the methodology needed to do research on spatial statistics and to analyze real data from the environmental, biomedical, geological and agricultural sciences. The methods will be introduced with examples.