UMBC
ENCE 658/GES 623/ STAT 700/ ECON 691
Modeling and Spatial Statistics with Applications to the Urban Environment

Spring 2010
Course Syllabus

Instructors
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Class Meeting Time: MW 10 – 11:15
Class Meeting Place: Public Policy 367

Pre-requisites for enrolling in course
Permission of Instructor

Required and recommended textbooks
The course will use selected readings from a variety of sources drawn from a list of references, rather than any one or two assigned textbooks.

Course requirements, including evaluation methods and contribution of each academic activity to the final grade in percentages
Weekly problem sets, including example model applications (30%); midterm (30%); final (30%); paper write up and presentation (10%)

Problem Sets
Due per schedule handout.
No faxing of problem sets.
Problem sets should be done on 8-1/2 x11" paper with pages stapled together. (Alternatively can be typed and e-mailed as an attachment.) No partial credit will be given for wrong answers if calculations are not shown. Rules regarding significant digits are to be followed (see http://en.wikipedia.org/wiki/Significant_figures; http://www.physics.uoguelph.ca/tutorials/sig_fig/SIG_dig.htm).

Exams Midterm: 8th week; Final: Exam week

Plagiarism Policy Homework assignments submitted for grading are to be each student's own work. Plagiarism will not be tolerated. Students turning in plagiarized work will receive a grade of zero on such work.

UMBC Policy on Academic Integrity By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. To read the full Student Academic Conduct Policy, consult the UMBC Student Handbook, the Faculty Handbook, or the UMBC Policies section of the UMBC Directory [or for graduate courses, the Graduate School website]."

Course Description

The goal of this course is to provide students with knowledge of mathematical models for the urban environment from various disciplinary perspectives, and how such models might be coupled to address urban water problems. Simple models from the fields of environmental contaminant transport, economics, and ecology will be used as examples. Material covered will include time series analysis and geostatistical analysis of spatially distributed data in the physical, biological, and social sciences. The course will highlight challenges of the interdisciplinary perspective, including (1) space and time scales of concern to different disciplines; (2) issues with uncertainty in data and models; and (3) examples of models that are available to the different disciplines. The course will include hands-on exercises and the challenge for students to combine models from different disciplines.

Course academic objectives

The academic objectives for this course are as follows.

1. Spatial statistics module: (a) To understand the underlying data structure of spatially and/or time correlated data; (b) to learn how to apply basic descriptive tools of analyzing time series and spatial data; (c) to learn how to interpret basic theoretical tools of describing time series and spatial models; (d) to obtain a broad understanding of common approaches to model time series and spatial data;

2. Contaminant transport module: (a) To understand the fundamental principles that govern contaminant transport and transformations in multimedia environments; (b) to learn model development skills, starting from simple conceptual models and building more complex and realistic models that couple component process modules at the appropriate spatial and temporal scales of resolution; (c) to learn to use statistical methods and data sources to ensure input parameters and characterize model sensitivity and uncertainty; (d) to gain hands-on experience with computer implementation and evaluation of fate and transport models using realistic case examples;

3. Economic modeling module: (a) to understand and modify basic theoretical economic models; (b) to understand how policy levers (such as regulation or taxes) alter systems; (c) to apply regression and simulation analysis to an economic data set; and (d) to provide a basic framework of a new problem that involves both a natural and an economic system.

4. Ecological modeling module: (a) to define an ecosystem and the modeling approaches used to describe them; (b) to identify the pros and cons of various approaches, their assumptions, and how parameters can be acquired; (c) To create a simple model of an ecosystem, define realistic relationships for stocks and fluxes, and parameterize their model using data from the literature; (d) to compare the output of a model using mean values for parameter to those using means and variances via a simulation exercise.

5. To integrate course concepts across disciplines.

General course outline for 2010, including weekly class topics

Wk	Lec	Date	Topic	Assign-ment due dates	Model review due dates	Instructor
1	1	Jan 27	Overview and Goals of Course; Types of Models, Philosophy of Modeling; Issues of Scale; Integrating Across Disciplines	-		Welty and all
2	2	Feb 1	Estimating Trends			Neerchal
	3	Feb 3			Topic of interest plus initial list of candidate papers	Neerchal
3	4	Feb 8	Basic concepts in Spatial Data Analysis	#1		Neerchal
	5	Feb 10				Neerchal
4	6	Feb 15	Statistical Modeling of Spatial Data	#2		Neerchal
	7	Feb 17			Choice of paper to review plus summary	Neerchal
5	8	Feb 22	Motivation for study; roles of models in quantifying transport processes	#3		Welty
	9	Feb 24	Components of an environmental model; solution techniques; model evaluation			Welty
6	10	Mar 1	Examples of two simple environmental model applications	#4		Welty
	11	Mar 3	Tools for implementing models			Welty
7	12	Mar 8	Introduction to Stella	#5		Welty
	13	Mar 10	Example Stella applications			Welty
-		Mar 15	Spring break, no class	-		-
		Mar 17		-		-
8	14	Mar 22	Midterm in class	Midterm		-
	15	Mar 24	Human systems modeling with economics			Farrow
9	16	Mar 29	Empirical approaches to economic modeling	#6		Farrow
	17	Mar 31	Links between natural and economic system modeling – Constraints, Externalities, Inputs (natural resources)		Progress report on paper review project	Farrow
10	18	Apr 5		#7		Farrow
	19	Apr 7	Empirical approaches to integrating natural and economic systems			Farrow
11	20	Apr 12		#8		Farrow
	21	Apr 14	Ecosystems & ecosystem ecology; types of models used, their assumptions & requirements			Swan
12	22	Apr 19		#9		Swan

	23	Apr 21	Types of models used, their assumptions & requirements, cont'd			Swan
13	24	Apr 26		#10		Swan
	25	Apr 28	Ecosystem modeling - case study and simulation tools			Swan
14	26	May 3		#11		Swan
	27	May 5	Oral presentations of paper review (3)	#12a	Oral presentations	All
15	28	May 10	Oral presentations of paper review (3)	#12b	Oral presentations; Written summary and critique of paper	All
	29	May 12	Integrative assessment, summary of course	Answer course questions		All
		May 17	Final Exam 10:30 – 12:30	Final		-

Detailed Course Outline

1. Introductlon
    a. Goals of course
    b. Philosophy of modeling
    c. Types of models
    d. Issues of scale
    e. The modeling process
    f. Integrating models across disciplines

2. Spatial Statistics Module

    a. Estimating Trends in Water Quality Data
        (1) Regression and nonparametric methods
        (2) Correcting for seasonality
        (3) Autocorrelation in the data and how to deal with it
        (4) Simulation example to evaluate the impact autocorrelation on trend estimation
        (5) Case Study: Estimating Total Phosphorus trends in the Chesapeake Bay Monitoring data

    b. Basic concepts in Spatial Data Analysis
        (1) Review of basic probability distributions using a simulation example
        (2) Spatial data structure and sampling
        (3) Descriptive statistics for spatial data
        (4) Variograms, Covariograms, Correlograms
        (5) Case Study: Analysis of benthic [invertebrate] index data from the Maryland Long Term Benthic Monitoring program

    c. Statistical Modeling of Spatial Data
        (1) Statistical framework for analyzing spatial data
            (a) Random functions
            (b) Stationarity, isotropy
        (2) Spatial prediction, kriging
        (3) Trend surface and regression models
        (4) Simulating spatial data: Examples to show the connection between specific random function models and associated variogram structure

3. Contaminant Transport Modeling Module

    a. Motivation for study
        (1) Source-pathway-receptor framework
        (2) Sources and effects of environmental contaminants
        (3) Transport phenomena

    b. Roles of models in quantifying transport processes
        (1) Understanding
        (2) Prediction
        (3) Answer scientific questions
        (4) Develop environmental policy

    c. Components of an environmental model
        (1) Control volume
        (2) Statement of mass, momentum, or energy conservation
        (3) Source mechanisms and types
        (4) Transport mechanisms

(4) Problem dimensionality and mixing regimes
(5) Interphase transfers
(6) Chemical transformations
(7) Issues of scale

d. Solution techniques
(1) Analytical vs numerical
(2) Deterministic vs stochastic

e. Model evaluation
(1) Benchmarking
(2) Calibration
(3) Sensitivity and uncertainty analysis

f. Examples of simple environmental models
(1) Completely mixed system: Indoor air quality example
(2) Plug flow system: DO sag example

g. Tools for implementing models
(1) Spreadsheet-based software
(2) Equation-solver-based software
(3) Dynamic simulation-based software

h. Stella
(1) Stella basics
(2) Example Stella applications

4. Economic Modeling Module

a. Human systems modeling with economics
(1) Consumption
(2) Supply
(3) Government policy
(4) Where are space, time, uncertainty?

b. Links between natural and economic system modeling
(1) Inputs (water quantity)
(2) Water quality/Externalities: pollution trading
(3) Natural hazards

c. Empirical approaches to economic policy and modeling
(1) Instrument choice: technology and performance regulation, taxes, permits, voluntary
(2) Regression: (road salt example)
(3) Supply/investment decision (net present value, benefit-cost,
Cost-effectiveness, multi-attribute)

d. Empirical approaches to integrating natural and economic systems
(1) Salt on road cost-effectiveness example
(2) Costs and benefits of the Clean Water Act
(3) Integrated simulation

5. Ecological Modeling Module

a. Ecosystems & ecosystem ecology; types of models used, their assumptions & requirements
(1) General modeling framework for ecosystems (Shugart, 2000; DeAngelis)

(2) Models of ecosystem processes (DeAngelis)
(3) Population models vs. compartmental models (Shugart, 2000)
(4) Static energy flow models (DeAngelis)

b. Types of models used, their assumptions & requirements, cont'd (Week 12)
(1) nutrient cycling, stoichiometry & bioenergetics (DeAngelis, Beaucham)
(2) linear & nonlinear fluxes

c. Ecosystem modeling - case study and simulation tools (Week 13)
(1) Model parameterization, case study (Meyer & Poepperl, 2004)
(2) Model output and simulation tools

6. Integrative assessment