GEO 493/593:

Dynamic Modeling of Human and Environmental Systems

This course provides hands-on experience in the construction and simulation of dynamic models of human and environmental systems. The paradigm case of such systems is diffusion over space and time: diffusion of ideas by word of mouth, diffusion of disease by contact between individuals, and diffusion of forest fires and invasive species across landscapes. A range of paradigms will be covered, from continuous representations of system dynamics to the discrete interactions of individual/agent-based models. Computer exercises will utilize free versions of Vensim (for constructing feedback loops and stock-flow structures) and NetLogo (for agent-based representations), as well as the AnyLogic software, which enables multiple modeling paradigms to be applied to a given project. Calculus and programming experience may be helpful but are not required. In addition to the textbook, exercises and readings will be provided from a variety of sources as needed.

Course Topics:

- Feedback
    - reinforcing (positive) dynamics
    - balancing (negative) dynamics
- Delays
    - stocks accumulate (integral)
    - flows occur in time (differential)
- Agents
    - Mobile individuals
    - Rule-based (heuristics), discrete dynamics
        - Complex system(s) dynamics may be agent/individual-based or differential equation-based – or both
- The modeling process
    - Problem formulation
    - boundary setting
    - hypothesis building
    - model building
    - boundary testing
    - policy (what-if) scenarios
- Modeling the modeler
    - the human element of modeling
    - mental models learn and forget
- The art of modeling
    - authenticity – evalutation of model relative to real system
    - parsimony – keep it simple! avoid unnecessary complication
    - transparency – clear documentation, user-friendly organization
    - *patience* – it takes time to construct and/or deconstruct a model

Course Requirements and Grades:

Class Participation (15%): A class participation grade for the semester will be assigned based upon how actively students engage in the course. Students should maintain a written log (in a composition book) of insights and observations from the classroom exercises.

Weekly Briefs (20%): Each week students will use the *UBlearns* discussion board to respond to an assigned article or critique one of their own choosing. These electronic commentaries are for sharing among the class, and the overall quality of the contributions will be considered in the semester evaluation. To stimulate discussion, each student should comment on at least one other student's critique each week.

Model Reports (25%): Written reports will be assigned regularly to document steps of model formulation and/or reflect upon assigned readings. Different criteria will be specified for model construction and deconstruction.

Special Topic Demonstration (10%): Students will conduct a seminar on a topic determined in consultation with the instructor. A one-page summary will be distributed with the class demonstration. The topic may be an evaluation of software (RePast, SWARM), a complex systems subject (artificial life, neural networks, fractals), or specific technique or application that is relevant but not otherwise covered in the course.

Team Project (30%): In the second part of the course, students will work in teams on projects determined in consultation with the instructor. The team will construct a model to address a geographically-relevant problem. The final report and class presentation will summarize insights from each phase of the modeling process as experienced in the problem context.

Textbook:

Ford, Andrew. 2009. *Modeling the Environment: An Introduction to System Dynamics Models of Environmental Systems.* 2nd Edition. Washington, DC: Island Press.

Supplementary Texts:

Grimm, Volker and Steven F. Railsback. 2005. *Individual-Based Modeling and Ecology*. Princeton, NJ: Princeton University Press.

Hannon, Bruce and Matthias Ruth. 1994. *Dynamic Modeling*. New York, NY: Springer.

Resnick, Mitchell. 1994. *Turtles, Termites, and Traffic Jams: Explorations in Massively Parallel Microworlds*. Cambridge, MA: MIT Press.

Starfield, Anthony M., Karl A. Smith and Andrew L. Bleloch. 1990. *How to Model It: Problem Solving for the Computer Age*. New York: McGraw-Hill.

Sterman, John. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World.* Boston, MA: McGraw-Hill.