DEPARTMENT OF GEOGRAPHY

GEOG 501 Modelling Environmental Systems 2011-12

Instructors

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Course Description: This course introduces you to the modelling of environmental systems. It is designed to help you develop a systems intuition to analyze environment problems. This intuition can be gained by conceptualizing and constructing simple models and generally simple systems, but that often display quite complex and therefore difficult to predict behaviours. It is important that you be exposed to the basics of building systems because their use has become so wide spread in environmental research and the environment profession. A past student of this course said "GEOG 501 is not about mathematical model but about a way of thinking".

Environmental systems are inherently difficult to deal with. They tend to be complex, poorly defined with fuzzy boundaries and weakly constrained relationships between variables. They often contain feedbacks. However, with the practice gained in this course you will begin to develop a clearer and more structured way of conceptualizing environmental problems using a systems approach. The course deals with the conceptualization and construction of simple models. This process begins with the development of a clear question and a well-defined modelling objective. With an objective you can then begin to map out what you feel are the critical components of the system. This is done by defining the reservoirs or stocks (state variables), flows among reservoirs (fluxes), and/or connecting inputs and outputs across the system's boundary (structure). In the mapping process it becomes apparent that few systems in environmental science are a linear sequence of reservoirs, but comprise several components that might have multiple links. These often produce positive or negative feedbacks to other components of the system. Once the mapping is completed the functional relationship between the variables can be defined, usually by examining the published literature. At this stage you will have developed a model that runs, but this does not mean it is a "good" representation of the actual system. The latter is examined through stability tests and evaluation using various objective criteria. This is followed by sensitivity analysis that gives you a tool to determine the critical relationships and parameters of the system you have modelled.

The model development above is presented as a set of linear steps, but in reality model development is a much more heuristic process - i.e. failure at various steps (the

negative heuristic) requires reformulation of earlier steps, beginning with the immediately previous one (the positive heuristic).

Many of you have not been given an opportunity to develop a modelling intuition or system thinking. Other courses tend to focus on the necessary background skills required for modelling such as mathematics, particularly differential equations, matrix algebra and numerical methods, and computer programming. However, with recent developments in computer aided modelling packages (e.g. STELLA®, POWERISM®, VENISM®, SIMILIE®, etc.) one can gain a modelling intuition without much mathematics beyond algebra and very basic calculus. The focus of this course is on the intuitive part of modelling and not on skills development.

This course is taught interactively (see below about the BH 511 classroom we are in). There will be very few formal lectures – most of the learning will take place in structured workshops followed by assignments based on questions at the end of the chapters of the course text. I addition you will be asked to build your own model, or add another component to an existing model to help you gain a greater understanding of some problem in the environment that interests you. The modelling software package STELLA® Version 9.1.4 will be used for assignments and the project. It has been installed on the computers in BH 511and the library area of the 5th floor. If you want STELLA on your own computer you can purchase a student's version of STELLA (Perpetual License is ~ $125 USD or a 6 Month limited license ~ $60.00 USD) from ISEE (http://www.iseesystems.com/store/university.aspx). The non-student version of STELLA costs ~ $600 USD. To be eligible for the student versions I have to send to ISEE a list of names and student numbers to confirm you are registered in this course. BUT you are not required to purchase the software – all the computers on the 5th floor Burnside Hall have STELLA installed and there is ample access for this course.

I assume that you have a basic knowledge of first year university mathematics (i.e. introductory calculus and algebra) and a familiarity with Windows or Apple operating systems. In addition, you require an adequate knowledge of some aspect of the physical, chemical, and/or socio-ecological components of an environmental system so you can pose a basic question that you will study through modelling.

BH 511 Active Learning Classroom: In 2009 the BH 511 classroom was built and GEOG 501 was one of the first course taught in the new classroom (the first formal class of GEOG 501 in September 2009 was the first class held in BH 511).

The new classroom has many features that enhance your learning experience and it is an ideal classroom for a course like GEOG 501. There are three sets of a pair wall screens and projectors so every student can see the material being projected from two different tools – i.e. I can have an instruction slide up along with live demonstration of a model. I can also switch the main screens to any of the 38 work stations in the room so, when appropriate, we can collectively find solutions to commonly occurring problems. This is where the "active" part of the active learning comes in. The tables you sit at have

6 work stations (one has 8). The tables have a shape little like a banana-slip bowl so 3 students on one side can see each other's screens. The screens are also set down in the tables so you can easily interact with the 3 students across from you on the other side of the table. This arrangement should allow for much more and broader interactions, and collaborative and collective learning.

There are 38 workstations in BH511. There is also the general work area on the 5th floor where all the computers will be imaged in the same way as the classroom computers. You have access to BH 511 for class times and the open area computers all the time (there may be a period in the early hours of the morning when the 5th floor is not accessible but it appears this will be limited to a few hours a day).

Warning – this classroom and this course involves teaching and learning that may be quite different than you have experienced before. This classroom does require you as a student to commit to learning differently. You cannot remain passive in this course (you actually can remain passive but you lose out on the benefits of the shared learning experiences you will soon begin to see emerging). During the class session we will spend a lot of time developing model examples. When problems are being experienced I will often project one or more of your work stations' screens so we can all work on the problem together. Last year this was a very rewarding and profound way of learning. However for it to succeed it does require you participation. When you are experiencing problems let me or a TA know and we can help you out or the rest of the class can help. When I project a student's problem you can all help find a solution, but the success of this active learning requires that we all respect and trust all those participating in the course. You may find someone else's problem easy to solve, but on another occasion the tables may well be turned. These are great 'teaching moments' and displaying your problem is not meant to be a form of group evaluation – I can assure from teaching this course for over a decade that more than one half of your peers are having the same problem. You will find that some student's have already experienced your particular problem and resolved it but at other times you will be the one providing a solution. The best way to learn is to be given an opportunity to teach. Every year some of you generate problems with either the software or your model approach that I cannot solve immediately. In these cases I will attempt to solve it over the week and either through the course website, or in the next class meeting, report back. But one or two of you will generate a problem that I cannot solve or it exposes some of the limitations of STELLA. It is an excellent piece of software but it accessibility also limits it range. Another thing to remember is I can see all your screens on the instructors work station.

Components of This Course: There are four different activities in this course:

Lectures: There are 4 formal lectures in this course. You will largely learn environmental systems modelling by doing, hence the emphasis on workshops.

Workshops: There will be either a 1 ½ hour or a 3 hour workshop in this course each week depending on whether there is a lecture that class session. In the workshops you

will be shown and asked to work with examples of model structures. These examples come from the text book so it is important you bring your textbook to every class. In March the workshop time is for you to build your own model for the model project. In these workshops Avni and I will be available to provide assistance and advice. I strongly recommend that you take advantage of these structured workshops – we do not have a lot of sympathy for students seeking help outside of class time who have not attended these in-class workshops.

Modelling Project: The modelling project requires you to conceptualize, develop, build and test a model, or module for an existing model, for an environmental system that interests you. Many pick an aspect of the system they are studying in their graduate or undergraduate research. You need to submit by midnight Dec. 06, 2011a manuscript describing your model in a format that would be suitable for Ecological Modeling (http://www.elsevier.com/wps/find/journaldescription.cws_home/503306/authorinstructions). With the submission of your manuscript you need include an appendix of the STELLA model code and send the instructor a copy on your completed model. It is unacceptable to submit a model that does not run, but many of your models will not work as well as you would like and their output may be quite unrealistic. As part of your modelling project you are required to submit a one page maximum description of the environmental problem you plan to address, the actual question you model will attempt to answer, and a statement of the objective of your model.

Warning: In this course it is critical that you stay on-top of the work. The activities in this course are cumulative and you need time at each stage to digest what you have done before moving on to the next stage. In the past students who have let things slip have never been able to recover and this ends up having serious repercussions on the development of a success model for the project (not to mention your and my level of stress)!

Evaluation

Assignments (8 @ 7.5% each) ...	60%
Research	
Individual modelling Project	
Research problem and model objectives	5%
Research paper	35%

Course Text and Websites: The following course text is available at the McGill University Bookstore.

Ford, Andrew (2009). Modeling Environment: An Introduction to Systems Dynamic Modeling of Environmental Systems – 2nd edition, Island Press, Washington DC, 380 pp.

It is absolutely essential that you have constant access to the course text since the assignments and many of the in-class examples come directly from the text. We use 16

or more chapters of the text extensively and reference. In addition to the textbook there is a good web support for the material in the book at http://www.wsu.edu/~forda/AAOpen.html. Bring the text each class as we use it regularly during class. I will say "Turn to page ## and create the model found in Figure ##" – if you do not have your text you will not be able to do this.

In addition to the text book there are 8 papers from scholarly journals that have been assigned for reading. This are:

Aber, J.D. Why don't we believe the models? Bulletin of the Ecological Society of America 78 (3): 232-233, 1997.

Aumann, C. A. (2007). "A methodology for developing simulation models of complex systems." Ecological Modelling **202**(3-4): 385-396.

Blanco, J.A. (2010) Seven steps to create ecological models for natural resource management. SciTopics (http://www.scitopics.com/)

Jackson, L.J., A.S. Trebitz & K.L. Cottingham. An introduction to the practice of ecological modeling. Bioscience 50:694-706, 2000.

Oreskes, N., K. Shrader_Frechette, and K. Belitz (1994). "Verification, validation, and confirmation of numerical models in the earth sciences." Science **263**: 641-646.

Rastetter, E.B. Validating models of ecosystem response to global change. Bioscience 46:190-198, 1996.

Rykiel, E.J. Testing ecological models: the meaning of validation. Ecological Modeling 90:229-244, 1996.

Scheffer, M. & J. Beets. Ecological models and the pitfalls of causality. Hydrobiologia 275/276:115-124, 1994.

Van Nes, E. H. and M. Scheffer (2005). "A strategy to improve the contribution of complex simulation models to ecological theory." Ecological Modelling **185**(2-4): 153-164.

All the journal articles can be found by going to the MUSE course reserves (http://catalogue.mcgill.ca/F/?func=find-b&find_code=wcn&request=GEOG+501&local_base=u-course_reserves). These readings are to help you gain a better understanding of the modelling process. They provide a discussion of some of the more philosophical questions. They will be very useful in helping you write you independent modelling paper.

There are several websites that contain a good introduction and/or discussion of systems

modelling. One particularly good one you may wish to refer from time-to-time during the course to is: http://www.outsights.com/systems/welcome.htm

There are also a number of books on environmental modelling and systems thinking that can help you out over the term. I have placed several of these on course reserves.

Case, Ted. *An illustrated guide to theoretical ecology*. Oxford, 2000.
Meadows, Donella H. *Thinking in Systems*, earthscan, 2008.
Morecroft, John. *Strategic modelling and business dynamics: a feedback systems approach*, John Wiley & Sons, 2007.
Senge, Peter. *The fifth discipline: the art and practice of the learning organization*. Doubleday, 2006.
Smith, Jo. *Introduction to Environmental Modelling*, Oxford, 2007.
Wainwright, John. *Environmental modelling: finding simplicity in complexity*,Wiley, 2004.

Use of the 5th floor of Burnside Hall: Your student ID gives you access if you are registered in the course. Access is put on your card at the beginning of the term. During the off-hours of the library, such as the 08:30 start to this class, you need to swipe your ID card to gain access to the classroom and open area.

Policy on Late Assignments: All submitted material will be considered late after the due date. Late laboratory assignments and modelling projects will have 25% deducted for the first day they are late and 10% for each additional day thereafter.

NOTE: There will be no supplemental examination and no additional work will be accepted to upgrade marks of D, F, or J.

In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.

McGill University values academic integrity. Therefore all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures (see www.mcgill.ca/students/srr/honest/ for more information).

L'université McGill attache une haute importance à l'honnêteté académique. Il incombe par conséquent à tous les étudiants de comprendre ce que l'on entend par tricherie, plagiat et autres infractions académiques, ainsi que les conséquences que peuvent avoir de telles actions, selon le Code de conduite de l'étudiant et des procédures disciplinaires (pour de plus amples renseignements, veuillez consulter le site www.mcgill.ca/students/srr/honest/).